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Military Hybrid Op Amp Selection Guide

MILITARY TEMPERATURE RANGE: -55°C to +125°C

Devices	Input Offset Voltage Max (mV)	Input Offset Voltage Drift Typ (μV/C)	Input Offset Current Max (nA)	Input Bias Current Max (nA)	Voltage Gain Min (Volts/V)	Bandwidth $A_v = 1$ Typ (MHz)	Slow Rate $A_v = 1$ Typ (V/μs)	Output Current (mA)	Supply Voltage Min (V)	Supply Voltage Max (V)	Common Mode Range (V)	Differential Input Voltage (V)	Supply Current Max (mW)	Compensation Components	Package Types
LH0001	1	4	20	100	25,000	1	.25	±5	±5	±20	±V _s	±7	.5	2	TO-5
LH0001A	2.5	3	20	100	25,000	1	.25	±5	±5	±20	±V _s	±7	.5	2	TO-5 DIP F.P.
LH0002	30	(Note 2)	10 × 10 ³	10 ⁴	.95	50	100	±100	±5	±22	±V _s	(Note 2)	100	0	TO-5 DIP
LH0003	3	4	200	2000	15	30	30	±50	±5	±20	±V _s	±7	30	2	TO-5
LH0004	1	4	20	100	30	1	.25	±15	±5	±45	±V _s	±7	1.5	2	TO-5
LH0005	10	20	20	50	2	30	20	±50	±9	±20	±V _s	±15	90	3	TO-5
LH0020	2.5	10	50	250	100,000	1	.25	±40	±5	±22	±V _s	±30	50	2	TO-5
LH0021	3	3	100	300	100,000	1	3	±1000	±5	±18	±V _s	±30	35	0	TO-3
LH0022	4	5	.002	.01	100,000	1	3	±10	±5	±22	±V _s	±30	35	0	TO-5 DIP F.P.
LH0024	4	20	3 × 10 ³	20 × 10 ³	4000	50	400	±100	±9	±18	±V _s	±5	252	1	TO-5
LH0032	5	25	.01	.02	1000	50	500	±100	±5	±18	±V _s	±30	200	2	TO-8
LH0033	10	(Note 3)	(Note 3)	.1	.97	100	1500	±100	±5	±20	±V _s	(Note 3)	220	0	TO-8 PIN J
LH0041	3	3	100	300	100,000	1	.3	±200	±5	±18	±V _s	±30	35	0	TO-8 PIN J
LH0042	20	5	.005	.025	50,000	1	3	±10	±5	±22	±V _s	±30	35	0	TO-5 DIP F.P.
LH0052	.5	2	.0001	.001	100,000	1	3	±10	±5	±22	±V _s	±30	25	0	TO-5 DIP
LH0061	4	5	100	300	50,000	15	70	±500	±5	±18	±V _s	(Note 4)	100	1	TO-3
LH0062	5	5	.001	.025	50,000	15	70	±6	±5	±20	±V _s	±30	80	0	TO-5 DIP
LH0063	25	(Note 1)	(Note 3)	.2	.96	150	6000	±400	±5	±18	±V _s	(Note 3)	500	0	TO-3

Note 1: Specified for $A_v = -10$.

Note 2: Current booster.

Note 3: Voltage follower.

Note 4: Input has shunt-diode protection; current must be limited to ±10 mA.

Military Op Amp Selection Guide

MILITARY TEMPERATURE RANGE: $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$

Device	Input Offset Voltage Max (mV)	Input Offset Voltage Drift Max ($\mu\text{V}/^{\circ}\text{C}$)	Input Offset Current Max (nA)	Input Bias Current Max (nA)	Voltage Gain [†] (Volts/V)	Bandwidth $A_v = 1$ Typ (MHz)	Slew Rate $A_v = 1$ Typ (V/ μs)	Output Current Max (mA)	Supply Voltage Min Typ (V)	Supply Voltage Max (V)	Common Mode Range (V)	Differential Input Voltage (V)	Supply Current Max (mA)	Compensation Components	Package Types
LH101	6	6	500	1500	50k	1	.5	5	± 3	± 22	± 12	± 30	3	0	TO-5 F.P.P.
LM101	6	6	500	1500	50k	1	.5	5	± 3	± 22	± 12	± 30	3	1	TO-5 F.P.P.
LM101A	3	15	20	100	50k	1	.5	7.5	± 3	± 22	± 12	± 30	3	1	TO-5 DIP F.P.P.
LM102	7.5	6 typ	*	100	.989	10	10	1	± 12	± 18	± 10	*	5.5	1	TO-5
LM107	3	15	20	100	50k	1	.5	7.5	± 3	± 22	± 12	± 30	3	0	TO-5 DIP F.P.P.
LM108	3	15	.4	3	50k	1	.3	1	± 2	± 20	± 14	(Note 2)	.6	1	TO-5 DIP F.P.P.
LH2108 (Note 1)															
LM108A	1	5	.4	3	80k	1	.3	1	± 2	± 20	± 14	(Note 2)	.6	1	TO-5 DIP F.P.P.
LH2108A (Note 1)															
LM110	6	12	*	10	.989	20	30	1	± 5	± 18	± 10	*	5.5	0	TO-5 DIP
LH2110 (Note 1)															
LM112	3	15	.4	3	50k	1	.2	1	± 2	± 20	± 14	(Note 2)	.6	0	TO-5 DIP F.P.P.
LM118	4	*	50	250	50k	15	90 min [†]	5	± 5	± 18	± 11.5	(Note 2)	7	0	TO-5 DIP F.P.P.
LM124 (Quad)	5	*	30	300	100k	1	*	40	5 (± 1.5)	32 (± 15)	$V^{\dagger} - 1.5$	32	2	0	DIP F.P.P.
LM709	6	6	500	1500	25k	1	.3	5	± 9	± 18	± 8	± 5	5.5	3	TO-5
LM725	1.5	5	40	200	1000	.5	.005	5	± 3	± 22	± 13.5	± 5	3.5	4	TO-5 F.P.P.
LM741	6	*	500	1500	50k	1	.5	5	± 3	± 22	± 12	± 30	2.9	0	TO-5 DIP F.P.P.
LM747	6	*	500	1500	50k	1	.5	5	± 3	± 22	± 12	± 30	5.6	0	TO-5 DIP F.P.P.
LM748	6	6	500	1500	50k	1	.5	5	± 3	± 22	± 12	± 30	2.9*	1	TO-5
LM1558 (Dual)	6	*	500	1500	50k	1	.5	5	± 3	± 22	± 12	± 30	2.9	0	TO-5
LM4250	4	*	5	15	100k	.25	.16	.75	± 1	± 18	± 12	± 15	.03 set	0	TO-5
LH24250 (Note 1)															

*Not specified.

[†]Guaranteed at $+25^{\circ}\text{C}$.

Note 1: Dual version of device.

Note 2: Inputs have shunt-diode protection; current must be limited.

Industrial Hybrid Op Amp Selection Guide

INDUSTRIAL TEMPERATURE RANGE: -25°C to +85°C

Device	Input Offset Voltage Max (mV)	Input Offset Voltage Drift Typ ($\mu\text{V}/^\circ\text{C}$)	Input Offset Current Max (nA)	Input Bias Current Max (nA)	Voltage Gain Min (Volts/V)	Bandwidth Av = 1 Typ (MHz)	Slew Rate Av = 1 Typ (V/ μs)	Output Current (mA)	Supply Voltage Min (V)	Supply Voltage Max (V)	Common Mode Range (V)	Differential Input Voltage (V)	Supply Current Max (mW)	Compensation Components	Package Types
LH0001AC	5	3	60	200	25	1	.25	± 5	± 5	± 20	$\pm V_s$	± 7	1.3	2	TO-5 DIP F.P.
LH0002C	30	(Note 2)	10×10^3	10^4	95 (Note 2)	50	100	± 100	± 5	± 22	$\pm V_s$	(Note 2)	100	0	TO-5 DIP
LH0003C	3	4	200	2000	15,000	30 (Note 1)	30	± 50	± 5	± 20	$\pm V_s$	± 7	30	2	TO-5
LH0004C	1.5	4	45	120	30,000	1	.25	± 15	± 5	± 45	$\pm V_s$	± 7	1.5	2	TO-5
LH0005C	10	25	25	100	2000	30 (Note 1)	20	± 50	± 9	± 20	$\pm V_s$	± 15	90	3	TO-5
LH0020C	6	10	200	500	50,000	1	.25	± 100	± 5	± 18	$\pm V_s$	± 30	50	2	TO-5
LH0021C	6	5	200	500	100,000	1	3	± 1000	± 5	± 18	$\pm V_s$	± 30	40	0	TO-3
LH0022C	6	5	.005	.025	75,000	1	3	± 10	± 5	± 22	$\pm V_s$	± 30	24	0	TO-5 DIP F.P.
LH0024C	8	25	5×10^3	22×10^3	3500	50	400	± 100	± 9	± 18	$\pm V_s$	± 5	252	1	TO-5
LH032C	15	25	.02	.5	700	50	500	± 100	± 5	± 20	$\pm V_s$	± 30	220	2	TO-8
LH0033C	20	(Note 3)	(Note 3)	.15	96 (Note 3)	100	1500	± 100	± 5	± 20	$\pm V_s$	(Note 3)	240	0	TO-8 PIN J
LH0041C	6	5	200	500	100,000	1	3	± 200	± 5	± 18	$\pm V_s$	± 30	40	0	TO-8 PIN J
LH0042C	20	10	.01	.05	25,000	1	3	± 10	± 5	± 22	$\pm V_s$	± 30	28	0	TO-5 DIP F.P.
LH0052C	1	5	.0002	.005	75,000	1	3	± 10	± 5	± 22	$\pm V_s$	± 30	30	0	TO-5 DIP
LH0061C	10	5	200	200	25,000	15	70	± 500	± 5	± 18	$\pm V_s$	(Note 4)	150	1	TO-3
LH0062C	15	10	.002	.065	25,000	15	70	± 6	± 5	± 20	$\pm V_s$	± 30	120	0	TO-5 DIP
LH0063C	50	(Note 3)	(Note 3)	.2	96 (Note 3)	150	6000	± 400	± 5	± 18	$\pm V_s$	(Note 3)	500	0	TO-3

Note 1: Specified for AV = -10.

Note 2: Current booster.

Note 3: Voltage follower.

Note 4: Inputs have shunt-diode protection; current must be limited to ± 10 mA.

INDUSTRIAL TEMPERATURE RANGE: $-25^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$

Device	Input Offset Voltage Max (mV)	Input Offset Voltage Drift Max ($\mu\text{V}/^{\circ}\text{C}$)	Input Offset Current Max (nA)	Input Bias Current Max (nA)	Voltage Gain (Volts/V)	Bandwidth $A_v = 1$ Typ (MHz)	Slew Rate $A_v = 1$ Typ (V/ μs)	Output Current Max (mA)	Supply Voltage Min Typ (V)	Supply Voltage Max (V)	Common Mode Range (V)	Differential Input Voltage (V)	Supply Current Max (mA)	Compensation Components	Package Types
LM201A	2	15	20	75	25k	1	.5	.5	± 3	± 22	± 12	± 30	3	1	TO-5 DIP F.P.
LH2201A (Note 1)	10	15 typ	*	15	.989	10	10	1	± 12	± 18	± 10	*	5.5	C	TO-5
LM202	2	20	20	75	25k	1	.5	5	± 3	± 22	± 12	± 30	3	0	TO-5 DIP F.P.
LM207	2	15	.2	2	50k	1	.3	1	± 2	± 20	± 14	(Note 2)	.4	1	TO-5 DIP F.P.
LM208	2	15	.2	2	50k	1	.3	1	± 2	± 20	± 14	(Note 2)	.4	1	TO-5 DIP F.P.
LH2208 (Note 1)	.5	5	.2	2	80k	1	.3	1	± 2	± 20	± 14	(Note 2)	.4	1	TO-5 DIP F.P.
LM208A	4	*	*	3	.999	20	30	1	± 5	± 18	± 10	*	5.5	0	TO-5 DIP F.P.
LM210	2	15	.2	2	50k	1	.3	1	± 2	± 20	± 14	(Note 2)	.6	0	TO-5 DIP F.P.
LH2210 (Note 1)	10	*	.05	.15	10k	1	.3	1	± 5	± 20	± 13	(Note 2)	.8	0	TO-5 DIP F.P.
LM212	3	*	.015	.05	20k	1	.3	1	± 5	± 20	± 13	(Note 2)	.6	0	TO-5 DIP F.P.
LM216A	4	*	50	500	50k	15	50 min†	5	± 5	± 18	± 11.5	(Note 2)	7.5	0	TO-5 DIP F.P.
LM218	7	*	50	500	100k	1	*	40	3 (± 1.5)	30 (± 15)	$V^+ - 1.5$	32	2	0	DIP
LM224 (Quad)	1.5	10	20	100	500k	.5	.005	5	± 3	± 22	± 13.5	± 5	4	4	TO-5 DIP
LM725B	*	*	*	200	2.8k	2.5	20	18	4	36	*	*	10	0	DIP

*Not specified.
†Guaranteed at $+25^{\circ}\text{C}$.

Note 1: Dual version of device.
Note 2: Inputs have shunt-diode protection; current must be limited.

Commercial Op Amp Selection Guide

COMMERCIAL TEMPERATURE RANGE: $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$

Device	Input Offset Voltage ¹ Max (mV)	Input Offset Voltage Drift Max ($\mu\text{V}/^{\circ}\text{C}$)	Input Offset Current Max (nA)	Input Bias Current Max (nA)	Voltage Gain (Volts/V)	Bandwidth $A_v = 1$ Typ (MHz)	Slew Rate $A_v = 1$ Typ (V/ μs)	Output Current		Supply Voltage		Common Mode Range (V)	Differential Input Voltage (V)	Supply Current Max (mA)	Compensation Components	Package Types
								Max (mA)	Typ (mA)	Min (V)	Typ (V)						Max (V)	Typ (V)
LH201	7.5	10	500	1500	20k	1	.5	5	5	± 3	± 22	± 12	± 30	3	0	TO-5 F.P.
LM201	7.5	10	500	1500	20k	1	.5	5	5	± 3	± 22	± 12	± 30	3	1	TO-5 F.P.
LM301A	7.5	30	50	250	25k	1	.5	5	5	± 3	± 18	± 12	± 30	3	1	TO-5 DIP
LM302	15	20 typ	*	30	.9985	10	10	1	1	± 12	± 18	± 10	*	5.5	0	TO-5
LM307	7.5	30	50	250	25k	1	.5	5	5	± 3	± 18	± 12	± 30	3	0	TO-5 DIP F.P.
LM308	7.5	30	1	7	25k	1	.3	1	1	± 2	± 18	± 14	(Note 2)	.8	1	TO-5 DIP F.P.
LM308A	.5	5	1	7	80k	1	.3	1	1	± 2	± 20	± 14	(Note 2)	.8	1	TO-5 DIP F.P.
LM310	7.5	*	*	7	.999	20	30	1	1	± 5	± 18	± 10	*	5.5	0	TO-5 DIP F.P.
LH2310 (Note 1)	7.5	30	1	7	25k	1	.3	1	1	± 2	± 18	± 14	(Note 2)	.8	0	TO-5 DIP F.P.
LM312	10	*	.05	.15	20k	1	.3	1	1	± 5	± 20	± 13	(Note 2)	.8	0	TO-5 DIP F.P.
LM316A	3	*	.015	.05	40k	1	.3	1	1	± 5	± 20	± 13	(Note 2)	.6	0	TO-5 DIP F.P.
LM318	12	*	200	600	25k	15	50 min	5	5	± 5	± 18	± 11.5	(Note 2)	10	0	TO-5 DIP
LM324 (Quad)	7	*	50	500	100k	1	*	40	40	3 (± 1.5)	30 (± 15)	$V^+ - 1.5$	32	2	0	DIP
LM709C	7.5	12	500	1500	25k	1	.3	5	5	± 9	± 18	± 8	± 5	6.6	3	TO-5 DIP
LM725C	2.5	2	35	125	250k	.5	.005	5	5	± 3	± 22	± 13.5	± 5	5	4	TO-5 DIP
LM741C	6	*	200	500	20k	1	.5	5	5	± 3	± 18	± 12	± 30	2.9	0	TO-5 DIP
LM747C	6	*	200	500	20k	1	.5	5	5	± 3	± 18	± 12	± 30	5.6	0	TO-5 DIP F.P.
LM748C	6	6	200	500	50k	1	.5	5	5	± 3	± 18	± 12	± 30	2.9	1	TO-5 DIP
LM1458 (Dual)	6	*	200	500	20k	1	.5	5	5	± 3	± 18	± 12	± 30	2.9	0	TO-5 DIP
LM3900 (Quad)	*	*	*	200	2.8k	2.5	20	10	10	4 (± 2)	36 (± 18)	*	*	10	0	DIP
LM4250C	6	*	10	30	75k	.25	.16	.75	.75	± 1	± 18	± 12	± 15	.03 set	0	TO-5 DIP
LH24250C (Note 1)																

*Not specified.
¹Guaranteed at $+25^{\circ}\text{C}$.
 Note 1: Dual version of device.
 Note 2: Inputs have shunt-diode protection; current must be limited.

Fixed Voltage Regulator Guide

Product Type No.	Input Voltage (V)		Output Voltage (V)	Load Regulation (mV)	Line Regulation (mV)	Ripple Rejection (dB)	Long Term Stability (mV)	Output Noise Voltage (µV)	Quiescent Current (mA)	Operating Temperature Range (°C)		Output Current (Amps)	Package Type
	Min	Max								Min	Max		
LM109K*	7	35	5	50	4	75	10	40	6	-55	125	>1	TO-3, TO-5
LM209K*	7	35	5	50	4	75	10	40	6	-25	85	>1	TO-3, TO-5
LM309K*	7	35	5	50	4	75	20	40	6	0	70	>1	TO-3, TO-5
LM123K	7.5	20	5	50	4	75	10	40	6	-55	125	3	TO-3
LM223K	7.5	20	5	50	4	75	10	40	6	-25	85	3	TO-3
LM323K	7.5	20	5	50	4	75	20	40	6	0	70	3	TO-3
LM340-05	7	35	5	100 max	100 max	70	20	40	6	0	70	>1	TO-3, TO-220
LM340-06	8	35	6	120 max	120 max	65	24	45	6	0	70	>1	TO-3, TO-220
LM340-08	10	35	8	160 max	160 max	62	32	52	6	0	70	>1	TO-3, TO-220
LM340-12	14	35	12	240 max	240 max	61	48	75	6	0	70	>1	TO-3, TO-220
LM340-15	17	35	15	300 max	300 max	60	60	90	6	0	70	>1	TO-3, TO-220
LM340-18	20	35	18	360 max	360 max	59	72	110	6	0	70	>1	TO-3, TO-220
LM340-24	26	40	24	480 max	480 max	56	96	170	6	0	70	.8	TO-3, TO-220
LM120K-5*	-6	-25	-5	50	10	67	50	150	2	-55	125	>1	TO-3, TO-5
LM220K-5*	-6	-25	-5	50	10	67	50	150	2	-25	85	>1	TO-3, TO-5
LM320K-5*	-6	-25	-5	50	10	67	50	150	2	0	70	>1	TO-3, TO-5
LM120K-5.2*	-6.2	-25	-5.2	50	10	67	50	150	2	-55	125	>1	TO-3, TO-5
LM220K-5.2*	-6.2	-25	-5.2	50	10	67	50	150	2	-25	85	>1	TO-3, TO-5
LM320K-5.2*	-6.2	-25	-5.2	50	10	67	50	150	2	0	70	>1	TO-3, TO-5
LM120K-12*	-13	-30	-12	30	4	80	120	400	4	-55	125	>1	TO-3, TO-5
LM220K-12*	-13	-30	-12	30	4	80	120	400	4	-25	85	>1	TO-3, TO-5
LM320K-12*	-13	-30	-12	30	4	80	120	400	4	0	70	>1	TO-3, TO-5
LM120K-15*	-16	-30	-15	30	5	80	150	400	4	-55	125	>1	TO-3, TO-5
LM220K-15*	-16	-30	-15	30	5	80	150	400	4	-25	85	>1	TO-3, TO-5
LM320K-15*	-16	-30	-15	30	5	80	150	400	4	0	70	>1	TO-3, TO-5

* Ratings are for TO-3(K) package; device also available in TO-5(H) package.
 † Max output current depends on package type, heat sinking, and input voltage differential.

Variable Voltage Regulator Guide

Specifications Are Worst Case Over Operating Temperature Unless Noted.

Product Type No.	Input Voltage Range (V)		Output Voltage Range (V)		Load Regulation (%)		Line Regulation (%V _{OUT} /ΔV _{IN})		Ripple Rejection (%)		Input-Output Differential (V)		Temperature Stability (%)		Quiescent Current (mA)		Operating Temperature Range (°C)		Output Current* (mA)		Package Type
	Min	Max	Min	Max	Typ	I _L (mA)	Typ	Typ	Typ	Min	Max	Min	Max	Typ	Min	Max	Min	Max			
LM100	8.5	40	2.0	30	0.1	12	0.05	0.02	0.02	3	30	1.0	1.0	1.0	-55	125	20	20	TO-5, Flat Pack		
LM200	8.5	40	2.0	30	0.1	12	0.05	0.02	0.02	3	30	1.0	1.0	1.0	-25	85	20	20	TO-5, Flat Pack		
LM300	8.5	30	2.0	20	0.1	12	0.05	0.02	0.02	3	20	2.0	2.0	2.0	0	70	20	20	TO-5, Flat Pack		
LM105	8.5	50	4.5	40	0.02	12	0.015	0.003	0.003	3	30	1.0	1.0	1.0	-55	125	20	20	TO-5, Flat Pack		
LM205	8.5	50	4.5	40	0.02	12	0.015	0.003	0.003	3	30	1.0	1.0	1.0	-25	85	20	20	TO-5, Flat Pack		
LM305	8.5	40	4.5	30	0.02	12	0.015	0.003	0.003	3	30	1.0	1.0	1.0	0	70	20	20	TO-5, Flat Pack		
LM305A	8.5	50	4.5	40	0.02	45	0.015	0.003	0.003	3	30	1.0	1.0	1.0	0	70	45	45	TO-5		
LM376	9.0	40	5.0	37	0.2 max	25	0.03 max	0.1 max	0.1 max	3	30	—	—	—	0	70	25	25	Molded DIP		
LM723	9.5	40	2.0	37	0.03	50	0.01	0.02	0.02	3	38	0.015%/°C	0.015%/°C	1.3	-55	125	150	150	TO-5, Cavity DIP		
LM723C	9.5	40	2.0	37	0.03	50	0.01	0.02	0.02	3	38	0.015%/°C	0.015%/°C	1.3	0	70	150	150	TO-5, Cavity & Molded DIP		
LM704	-50	-8	-40	-15 mV	0.01	20	.05	0.01	0.01	2	50	1.0	1.0	1.0	-55	125	20	20	TO-5, Flat Pack		
LM204	-50	-8	-40	-15 mV	0.01	20	.05	0.01	0.01	2	50	1.0	1.0	1.0	-25	85	20	20	TO-5, Flat Pack		
LM304	-40	-8	-30	-15 mV	0.01	20	.05	0.01	0.01	2	40	1.0	1.0	1.0	0	70	20	20	TO-5, Flat Pack		
LM723	-40	-9.5	-37	-2	0.03	50	0.01	0.02	0.02	3	38	0.015%/°C	0.015%/°C	1.3	-55	125	150	150	TO-5, Cavity & Molded DIP		
LM723C	-40	-9.5	-37	-2	0.03	50	0.01	0.02	0.02	3	38	0.015%/°C	0.015%/°C	1.3	0	70	150	150	TO-5, Cavity & Molded DIP		

Note: The maximum power dissipation for the LM100, LM105, and LM104 regulators is 800 mW. For most cases of the LM100, LM105, and the LM104, output current will be limited by maximum junction temperature and thermal resistance as indicated.

Package	Thermal Resistance Junction to Air	Thermal Resistance Junction to Case
TO-5	150°C/W	45°C/W
Flat Pack	185°C/W Mounted	15°C/W
Solid Kovar TO-5	150°C/W	15°C/W
TO-3	35°C/W	—

*The output currents given, as well as the load regulation for the LM100, LM105, LM205 and LM104 family of regulators can be increased by the addition of external transistors. The increase will be roughly equal to the composite current gain of the added transistors.

Variable Voltage Regulator Guide

Voltage Comparator Guide

Device	Temperature Range*	DTL/TTL Fanout	Supply Voltage Typ (Volts)	Input Bias Current (Max) (uA)	Input Offset Current (Max) (uA)	Input Offset Voltage (Max) (mV)	Response Time† Typ (ns)	Voltage Gain Typ	Package Type	Comments
LM106	Military	10	V ⁺ = +12	20	3	2	40 max	40k	TO-5 F.P.	Single comparator with strobe, high speed and sensitivity, large fanout.
LM206	Industrial	10	V ⁺ = -3	20	3	2	40 max	40k	TO-5 F.P.	
LM306	Commercial	10	To -12	25	5	5	40 max	40k	TO-5 F.P.	
LM111 (Note 1)	Military	5	±15	.1	.04	.7	200	200k	TO-5 DIP F.P.	Single, with strobe, will work from single supply, low bias current.
LM211	Industrial	5	To +5	.1	.04	.7	200	200k	TO-5 DIP F.P.	
LM311 (Note 1)	Commercial	5	And GND	.25	.06	2	200	200k	TO-5 DIP F.P.	
LM119	Military	2 (each side)	±15	.5	.075	4	80	40k	TO-5 DIP F.P.	High speed dual comparator.
LM219	Industrial	2 (each side)	To +5	.5	.075	4	80	40k	TO-5 DIP F.P.	
LM319	Commercial	2 (each side)	And GND	1	.2	8	80	40k	TO-5 DIP	
LM139	Military	1	±1	.1	.025	5	1.3 μs	200k	DIP F.P.	Quad comparator designed for single supply operation; input common mode range includes ground.
LM239	Industrial	1	To ±18	.25	.050	5	1.3 μs	200k	DIP	
LM339	Commercial	1	Or From	.25	.050	5	1.3 μs	200k	DIP	
LM139A	Military	1	+2	.1	.025	2	1.3 μs	200k	DIP F.P.	Low offset voltage Quad comparator with DTL/TTL logic levels.
LM239A	Industrial	1	To +36	.25	.050	2	1.3 μs	200k	DIP	
LM339A	Commercial	1	And GND	.25	.050	2	1.3 μs	200k	DIP	
LM160	Military	2	±4.5	10	2	2	16	3k	TO-5 DIP F.P.	Very high speed, outputs compatible with DTL/TTL logic levels.
LM260	Industrial	2	To	10	2	2	16	3k	TO-5 DIP	
LM360	Commercial	2	±6.5	15	4	4	16	3k	TO-5 DIP	
LM161	Military	2	±5	10	2	2	12	3k	TO-5 DIP F.P.	Very high speed, with individual strobes, DTL/TTL compatible.
LM261	Industrial	2	To ±15	10	2	2	12	3k	TO-5 DIP	
LM361	Commercial	2	And +5	15	4	4	12	3k	TO-5 DIP	
LM710	Military	1	V ⁺ = +12	20	3	2	40	1750	TO-5	Single, differential in, single output.
LM710C	Commercial	1	V ⁺ = -6	25	5	5	40	1500	TO-5 DIP	
LM711	Military	1	V ⁺ = +12	75	10	3.5	40	1500	TO-5	Dual differential, common output, individual strobes.
LM711C	Commercial	1	V ⁺ = -6	100	15	5	40	1500	TO-5 DIP	
LM1514	Military	1	V ⁺ = +14	20	3	3	30	1250	DIP	Dual LM710 with separate strobes, individual outputs.
LM1414	Commercial	1	V ⁺ = -7	25	5	4	30	1000	DIP	

*Response time is specified for 100 mV step input with 5 mV override.
 †Military: -55°C to +125°C
 Industrial: -25°C to +85°C
 Commercial: 0°C to +70°C
 Note 1: Dual version of device.

DATA COMMUNICATION CIRCUITS

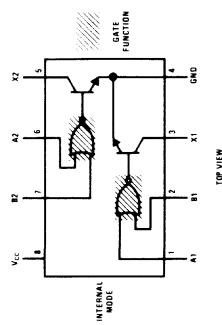
LINE DRIVERS DEVICE NO.	LINE RECEIVERS DEVICE NO.	DESCRIPTION	POWER SUPPLY	COMMENTS
LM1488/LM1588	LM1489A/LM1589A (quad) or DM7822/DM8822 (dual)	Communication to EIA standard RS 232C.	±12V LM1489A & DM7822 +5V only.	Twisted pair single ended. Unidirectional termination recommended up to 100 feet.
DM7830/DM8830	DM7820A/DM8820A	Dual differential line driver and receiver.	+5V	True differential, ±15 volt common mode rejection. Unidirectional. Use of internal receiver termination recommended up to 100 feet.
DM7831/DM8831	DM7820A/DM8820A	Dual differential line driver and receiver.	+5V	True differential, bidirectional. Driver includes upper and lower level clamps to combat transients. Use of internal receiver termination optional.
DM7832/DM8832	DM7820A/DM8820A	Dual differential line driver and receiver.	+5V	As above, but without upper level clamping, so party line buses may be used, even with some peripherals powered down.
DM7831/DM8831	DM7837/DM8837 (hex) or DM7835/DM8835 (quad)	Quad single-ended line driver and hex receiver, or a quad 2 input NOR receiver.	+5V	If used unidirectionally, receiver should be terminated. In party line applications disabled driver clamps line. Receiver input current is 15 μA typical, has no hysteresis.
LM75109 LM75110	LM75107A LM75108A	Dual differential line driver and receiver. Dual differential line driver and receiver.	±5V ±5V	May be used in party-line or data-bus systems. May be used in party-line or data-bus systems.
TRANSCEIVER DEVICE NO.	DESCRIPTION	POWER SUPPLY	COMMENTS	
DM7836/DM8836	Quad open collector transceiver.	+5V	Receiver has typical 15 μA input current one-volt hysteresis. Driver will pull down double terminated 120Ω line.	
DM7839/DM8839	Quad TRI-STATE™ transceiver. Four transmitters all disabled by control NOR gate.	+5V	Drivers have 10.4 mA forward drive at 2.4V, sink 32 mA at 0.4 volts. Receivers have 1 volt hysteresis, input current is 15 μA typical. Disabled driver clamps undershoots. A transceiver on the bus may be powered down without affecting bus logic levels.	
DM7833/DM8833	Quad TRI-STATE transceiver. One control disables all transmitters; one control disables all receiver outputs.	+5V		
DM7834/DM8834	Quad TRI-STATE transceiver. Controls same as DM7839 but driver and receiver are inverting.	+5V		
DM7835/DM8835	Quad TRI-STATE transceiver. Controls same as DM7833 but driver and receiver are inverting.	+5V		

SENSE AMPLIFIER CIRCUITS

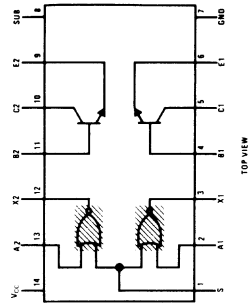
The core sense amplifiers are monolithic circuits comprising a reference amplifier and two sense channels. The output circuit changes state when the absolute difference in input voltage to the sense amp exceeds the absolute difference in voltage applied to the reference amplifier (threshold voltage). These parts with even numbers have a tighter guaranteed input threshold uncertainty.

DEVICE NO.	OUTPUT FORM	COMMENTS
LM7520, LM7521	AND/OR common output and complement	By coupling back complement output to true gate, latch may be formed. Set by (Strobe A, Memory A + Strobe B, Memory B) reset by complement gate.
LM7522, LM7523	AND-OR-INVERT common output high current open collector	Convenient for wire-OR'ed memory expansion.
LM7524, LM7525	An AND gate for each independent channel	Separate channels for small memories.
LM7534, LM7535	Open collector NAND gate for each independent channel	Convenient — for wire-OR'ed memory expansion in small memories. Useful for direct setting of flip flop.
LM7528, LM7529	AND gate, plus test point for each sense amp	
LM7538, LM7539	NAND gate, plus test point for each sense amp	

PERIPHERAL DRIVER CONNECTION DIAGRAMS

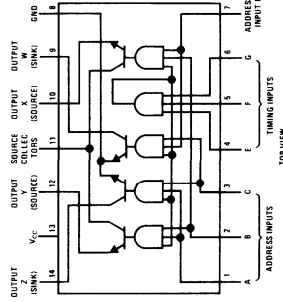


LM351(LM75453),
LM75451, LM75452, LM75454

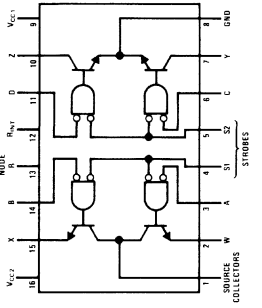


LM350, LM75450

MEMORY DRIVER CONNECTION DIAGRAMS



LM55324/LM75234



LM55325/LM75325

PERIPHERAL DRIVERS

The peripheral drivers are dual monolithic circuits, each consisting of a logic gate and a large geometry NPN transistor. The transistor is guaranteed to sink 300 mA, and to hold off collector voltage of 30 volts even when powered down.

DEVICE NO.	GATE FUNCTION	MODE OF CONNECTION	NO. OF PINS
LM350	NOR	External	14
LM351 (LM75453)	NOR	Internal	8
LM75450	NAND	External	14
LM75451	NAND	Internal	8
LM75454	NOR	Internal	8

MEMORY DRIVERS

DEVICE NO.	OUTPUT FORM	COMMENTS
LM55324, LM75324	AND gate decoding to two sink and two source output transistors	High Current output transistors; single timing input control
LM55325, LM75325	NAND gate decoding to two sink and two source output transistors	Separate strobe control for sink and source output devices

FET OP AMP Cross Reference

DEVICE NO.	PACKAGE	NEAREST NATIONAL EQUIVALENT	DEVICE NO.	PACKAGE	NEAREST NATIONAL EQUIVALENT	NEAREST NATIONAL EQUIVALENT	PACKAGE	NEAREST NATIONAL EQUIVALENT	DEVICE NO.	PACKAGE	NEAREST NATIONAL EQUIVALENT
Analog Devices											
AD503 (J, K)	TO-5	LH0042C pin for pin	Fairchild	US87740312	LH0042 pin for pin	Siliconix	TO-5	LH0042	Zetex	DIP	LH0042C
AD504 (J, K)	TO-5	LH0042C pin for pin	(μA)7401	U0393	LH0042C pin for pin	L120A	TO-5	LH0042C	ZA801 (M1, M2)	DIP	LH0042C
AD506 (J, K)	TO-5	LH0022C pin for pin	(μA)7403	U0393	LH0042C pin for pin	L120C	TO-5	LH0042C	ZA801 (M3)	DIP	LH0022C
AD506 (SI)	TO-5	LH0022C* pin for pin	(μA)740C			L137CA	TO-5	LH0022C	ZA802 (M1)	TO-8	LH0022C
AD511	MOD	LH0042C							ZA802 (M1, M2)	MOD	LH0022C
AD513 (J, K)	TO-5	LH0042C* pin for pin	Intech						ZA803 (M1)	MOD	LH0022C
AD513 (SI)	TO-5	LH0042C* pin for pin	A100		LH0042C	Teledyne Semiconductor (Amelco)	TO-8	LH0042C	ZA804 (M1, M2)	MOD	LH0042C
AD516 (J, K)	TO-5	LH0022C* pin for pin	A101		LH0042C	2404BG	TO-8	LH0042C	ZA903 (M1, M2)	MOD	LH0022C
AD516 (SI)	TO-5	LH0022C* pin for pin	A102		LH0042C	2405BG	TO-8	LH0042C	133	MOD	LH0022C
AD517 (A, B, C)	TO-8	LH0042C	A103		LH0022C	2709BG	TO-8	LH0042C	133-03	MOD	LH0022C
40 (J, K, L)	MOD	LH0042C	A105		LH0022C	2809BG	TO-8	LH0042C	133-04	MOD	LH0022C
41 (J, K, L)	MOD	LH0052C	A123		LH0052C	2841BE	TO-5	LH0042C	134	MOD	LH0042C
42 (J, K, L)	MOD	LH0022C	A125		LH0052C	2741BF	TO-8	LH0042C	134D	MOD	LH0042C
43 (J, L)	MOD	LH0022C	A130		LH0062C	2741BH	TO-8	LH0042C	135	MOD	LH0062C
44 (J, K)	MOD	LH0062C	A131		LH0062C						
45 (J, K)	MOD	LH0062C	A136		LH0062C						
142 (A, B, C)	MOD	LH0042C	A137		LH0062C	Teledyne Nexus Philbrick					
146 (J, K)	MOD	LH0022C	A1026		LH0042C	OET	MOD	LH0042C			
149 (J, K)	MOD	LH0062C	A148 (A, B, C)		LH0042C	OET	MOD	LH0052C			
			A1027		LH0022C	OFT-26	MOD	LH0052C			
*These amps use feedforward compensation to boost slew rate. For true high slew rate amp see LH0062/LH0062C.											
Bell and Howell											
20-008	MOD	LH0042C	Intersil	ICH8500	LH0052 pin for pin	1003	MOD	LH0052C			
20-108	MOD	LH0042C	ICH8500A		LH0052 pin for pin	1006	MOD	LH0042C			
20-208	TO-8	LH0022C	ICH8500C		LH0052C pin for pin	1008	MOD	LH0042C			
20-248	TO-8	LH0022C	ICL8007 (C)		LH0042C pin for pin	100901	MOD	LH0042C			
			ICL8007 (A)		LH0042C pin for pin	100902	MOD	LH0042C			
			ICL8007 (AM)		LH0042C pin for pin	1011	MOD	LH0062C			
			ICL8007 (AC)		LH0042C pin for pin	101101	MOD	LH0062C			
						101102	MOD	LH0062C			
Burr-Brown											
3097112C	MOD	LH0042C	OEI			1021	MOD	LH0022C			
3098112C	MOD	LH0042C				1023	MOD	LH0022C			
312112C	MOD	LH0042C				102301	MOD	LH0052C			
3313112C	MOD	LH0042C				108	MOD	LH0032C			
3313115C	MOD	LH0032C				1408	MOD	LH0032C			
3342115C	MOD	LH0032C				140801	MOD	LH0052C			
3348103	MOD	LH0052C				140810	MOD	LH0052C			
3349103	MOD	LH0026C				140820	TO-8	LH0042C			
3500103	MOD	LH0042C				140201	TO-8	LH0042C			
3400 (A, B)	MOD	LH0062C				1407	TO-8	LH0042C			
3402 (A, B)	MOD	LH0062C				140701	TO-8	LH0042C			
3403 (A, B)	MOD	LH0062C	Signetics			140820	TO-8	LH0062C			
3420 (J, K, L)	MOD	LH0062C	SU536T			141410	DIP	LH0062C			
3421 (J, K, L)	MOD	LH0052C	SU740C			1421	TO-5	LH0042C			

FET OP AMP Cross Reference

Linear Cross Reference Guide

TEXAS INSTRUMENTS DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT	TEXAS INSTRUMENTS DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT	TEXAS INSTRUMENTS DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT	TEXAS INSTRUMENTS DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
SN6500F	LM5524J	LM7524J	SN52711N	LM711H	LM741CH	SN72741L	LM741CH	LM748CN	SN72741L	LM741CH	LM748CN
SN6510F	LM723H	LM723H	SN52713L	LM733H	LM741CN-14	SN72741P	LM741CN-14	LM748CH	SN72748J	LM748CH	LM748CH
SN6510L	LM733H	LM733H	SN52711J	LM733H	LM741CN	SN72741P	LM741CN	LM748CH	SN72748J	LM748CH	LM748CH
SN6511L	LM733H	LM733H	SN52741J	LM741F	LM741CF	SN72741J	LM741CF	LM748CH	SN72748J	LM748CH	LM748CH
SN6524J	LM5524J	LM7524J	SN52747J	LM747F	LM747CF	SN72747J	LM747CF	LM748CN	SN72748J	LM748CN	LM748CN
LM6525J	LM5525J	LM7524J	SN52747Z	LM747F	LM747CF	SN72748N	LM748CN	LM748CN	SN72748N	LM748CN	LM748CN
SN7501F	LM7524J	LM7524J	SN52748L	LM748H	LM748H	SN72748L	LM748H	LM748CN	SN72748L	LM748CN	LM748CN
SN7502F	LM7524J	LM7524J	SN52748L	LM748H	LM748H	SN72748L	LM748H	LM748CN	SN72748L	LM748CN	LM748CN
SN7502F	LM733CH	LM733CH	SN52770L	LM733CH	LM733CH	SN72770J	LM733CH	LM748CN	SN72770N	LM748CN	LM748CN
SN7502L	LM733CH	LM733CH	SN52770L	LM733CH	LM733CH	SN72770N	LM733CH	LM748CN	SN72770N	LM748CN	LM748CN
SN7511L	LM7520J	LM7520J	SN52771L	LM7520J	LM7520J	SN72771P	LM7520J	LM748CN	SN72771P	LM748CN	LM748CN
SN7520N	LM7521N	LM7521N	SN52771L	LM7520J	LM7520J	SN72771P	LM7520J	LM748CN	SN72771P	LM748CN	LM748CN
SN7521N	LM7522J	LM7522J	SN52771Z	LM7520J	LM7520J	SN72771Z	LM7520J	LM748CN	SN72771Z	LM748CN	LM748CN
SN7522J	LM7523N	LM7523N	SN52771Z	LM7520J	LM7520J	SN72771Z	LM7520J	LM748CN	SN72771Z	LM748CN	LM748CN
SN7523N	LM7523N	LM7523N	SN55108J	LM5510J	LM5510J	SN75108J	LM5510J	LM748CN	SN75108J	LM748CN	LM748CN
SN7523N	LM7523N	LM7523N	SN55108J	LM5510J	LM5510J	SN75109N	LM75109N	LM748CN	SN75109N	LM748CN	LM748CN
SN7523N	LM7523N	LM7523N	SN55110J	LM5510J	LM5510J	SN75110N	LM75110N	LM748CN	SN75110N	LM748CN	LM748CN
SN7524J	LM7524N	LM7524N	SN55182J	DM7820AJ	DM7820AJ	SN75150J	DM7820AJ	LM75107J	SN75150J	LM75107J	LM75107J
SN7524N	LM7525J	LM7525J	SN55183J	DM7830J	DM7830J	SN75150N	DM7830J	LM75107N	SN75150N	DM7830J	DM7830J
SN7525J	LM7525N	LM7525N	SN68514L	LM301AD	LM301AD	SN75150P	LM301AD	LM75108J	SN75150P	LM301AD	LM301AD
SN7525N	LM7528J	LM7528J	SN72301AJ	LM301AH	LM301AH	SN75182J	LM301AH	LM75108J	SN75182J	LM301AH	LM301AH
SN7528J	LM7528N	LM7528N	SN72301AJ	LM301AH	LM301AH	SN75182N	LM301AH	LM75108J	SN75182N	LM301AH	LM301AH
SN7528N	LM7528N	LM7528N	SN72301AP	LM301AH	LM301AH	SN75183J	LM301AH	LM75108J	SN75183J	LM301AH	LM301AH
SN7529J	LM7529N	LM7529N	SN72301AN	LM301AH	LM301AH	SN75183J	LM301AH	LM75108J	SN75183J	LM301AH	LM301AH
SN7529N	LM7529N	LM7529N	SN72301AZ	LM301AF	LM301AF	SN75183N	LM301AF	LM75108J	SN75183N	LM301AF	LM301AF
SN62101AJ	LM101AD	LM101AD	SN72307L	LM307D	LM307D	SN75183N	LM307D	LM75108J	SN75183N	LM307D	LM307D
SN62101AL	LM101AH	LM101AH	SN72307N	LM307H	LM307H	SN75183N	LM307H	LM75108N	SN75183N	LM307H	LM307H
SN62101AZ	LM101AF	LM101AF	SN72307N	LM307N	LM307N	SN75183N	LM307N	LM75108N	SN75183N	LM307N	LM307N
SN62107J	LM107D	LM107D	SN72307P	LM307F	LM307F	SN75183N	LM307F	LM75108N	SN75183N	LM307F	LM307F
SN62107L	LM107E	LM107E	SN72307P	LM307F	LM307F	SN75183N	LM307F	LM75108N	SN75183N	LM307F	LM307F
SN62107Z	LM107F	LM107F	SN72358R	LM1458N	LM1458N	SN75183N	LM1458N	LM75110N	SN75183N	LM1458N	LM1458N
SN62558R	LM1558H	LM1558H	SN72558R	LM1458N	LM1458N	SN75183N	LM1458N	LM75110N	SN75183N	LM1458N	LM1458N
SN62702AF	LM101AF	LM101AF	SN72702F	LM101AF	LM101AF	SN75182J	LM101AF	LM75110N	SN75182J	LM101AF	LM101AF
SN62702AL	LM101AH	LM101AH	SN72702L	LM101AH	LM101AH	SN75182N	LM101AH	LM75110N	SN75182N	LM101AH	LM101AH
SN62702AN	LM101AF	LM101AF	SN72702N	LM101AH	LM101AH	SN75182N	LM101AH	LM75110N	SN75182N	LM101AH	LM101AH
SN62702F	LM101AF	LM101AF	SN72709L	LM101AH	LM101AH	SN75182N	LM101AH	LM75110N	SN75182N	LM101AH	LM101AH
SN62702L	LM101AH	LM101AH	SN72709N	LM101AH	LM101AH	SN75182N	LM101AH	LM75110N	SN75182N	LM101AH	LM101AH
SN62702Z	LM101AF	LM101AF	SN72709P	LM101AH	LM101AH	SN75182N	LM101AF	LM75110N	SN75182N	LM101AF	LM101AF
SN62709AF	LM709AH	LM709AH	SN72709S	LM101AF	LM101AF	SN75182N	LM709AH	LM75110N	SN75182N	LM709AH	LM709AH
SN62709AL	LM709AH	LM709AH	SN72710L	LM709AH	LM709AH	SN75182N	LM709AH	LM75110N	SN75182N	LM709AH	LM709AH
SN62709AN	LM709AH	LM709AH	SN72710L	LM709AH	LM709AH	SN75182N	LM709AH	LM75110N	SN75182N	LM709AH	LM709AH
SN62709F	LM709H	LM709H	SN72710N	LM709AH	LM709AH	SN75182N	LM709AH	LM75110N	SN75182N	LM709AH	LM709AH
SN62709L	LM710H	LM710H	SN72710S	LM710H	LM710H	SN75182N	LM710H	LM75110N	SN75182N	LM710H	LM710H
SN62710J	LM710H	LM710H	SN72711N	LM711CH	LM711CH	SN75182N	LM711CH	LM75110N	SN75182N	LM711CH	LM711CH
SN62710L	LM710H	LM710H	SN72711N	LM711CH	LM711CH	SN75182N	LM711CH	LM75110N	SN75182N	LM711CH	LM711CH
SN62710N	LM710H	LM710H	SN72811S	LM1414N	LM1414N	SN75182N	LM1414N	LM75110N	SN75182N	LM1414N	LM1414N
SN62710S	LM7233CH	LM7233CH	SN72720N	LM733CH	LM733CH	SN75182N	LM7233CH	LM75110N	SN75182N	LM7233CH	LM7233CH
SN62711J	LM711H	LM711H	SN72733N	LM733CH	LM733CH	SN75182N	LM733CH	LM75110N	SN75182N	LM733CH	LM733CH
SN62711L	LM711H	LM711H	SN72741J	LM741CD	LM741CD	SN75182N	LM741CD	LM75110N	SN75182N	LM741CD	LM741CD

Linear Cross Reference Guide

SIGNETICS DEVICE NUMBER	NATIONAL PIN FOR PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT	SIGNETICS NUMBER	NATIONAL PIN FOR PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT	SIGNETICS NUMBER	NATIONAL PIN FOR PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
NS501A		LM301AD	NE510A		LM371H	SS58T	LM1558H	
NS307A	LM307H		NE515A		LM373CN	SS59K	LM1598H	
NS308T	LM308H		NE515G		LM733CH	SS70T	LM710H	
NS3A1T	LM301AH		NE518A		LM733CH	SS711K	LM711H	LM711H
NS3A8T	LM308AH		NE518K		LM306H	SS723L	LM723H	
NS595V	LM1458N	LM307N	NE520A		LM306H	SS733F	LM733D	
NS558T	LM1458H		NE526K		LM306H	SS739K	LM733H	
NS598K	LM1498H	LM1496N	NE529K		LM306H	SS741T	LM741H	
NS5709A	LM709CN		NE529A	LM361H		SS747K	LM747H	
NS709V	LM709CH	LM709CN	NE531G	LM361N	LM318H	SS748T	LM748H	
NS710A	LM710CN		NE531T		LM318H	SE501G	LM733H	LM733H
NS710B	LM710CH		NE533G		LM318H	SE510A	LM717H	LM717H
NS711A	LM711CN		NE533T		LM4250CH	SE515G	LM717H	LM717H
NS711K	LM711CH		NE533V		LM4250CH	SE515K	LM733H	LM733H
NS723A	LM723CN		NE536T		LM316H	SE518A	LM106H	LM106H
NS723L	LM723CH		NE537G		LM308H	SE518K	LM106H	LM106H
NS733A	LM733CN		NE537T		LM308H	SE526A	LM106H	LM106H
NS733K	LM733CH		NE540A		LM723CH	SE526K	LM106H	LM106H
NS741A	LM741CN		NE540L		LM723CH	SE529K	LM106H	LM106H
NS741B	LM741CH	LM741CN-14	NE550L			SE531G		
NS741T	LM741CN		NE555V	LM555CN		SE531G	LM161H	
NS747A	LM747CN		NE555T	LM555CH		SE533G		LM118H
NS747F	LM747CH		NE565A	LM565CN		SE533T	LM4250CH	LM4250CH
NS747K	LM747CH		NE565K	LM565CH		SE537G	LM108H	LM108H
NS748A	LM748CN	LM748CH	NE565L	LM565CH		SE537T	LM108H	LM108H
NS748B	LM748CH		NE567V	LM567CN		SE550L	LM0021K	LM0021K
NS748V	LM748CH		NE567T	LM567CN	LM381N	SE550L	LM723H	LM723H
N7520B	LM7520N		NE567V	LM567CN		SE555V		
N7521B	LM7521N		PA239A			SE555V	LM555H	LM555H
N7522B	LM7522N		S5101T	LM101H		SE555V	LM555H	LM555H
N7523B	LM7523N		S5107T	LM107H		SE565K	LM566H	LM566H
N7524B	LM7524N		S5108T	LM108H		SE566T	LM567H	LM567H
N7525B	LM7525N		S5148T	LM108AH		SE567T		
NE501A		LM733CN	S5556L	LM108AH		SU536T		
NE501K		LM733CH			LM107H		LM216H	LM216H

Linear Cross Reference Guide

Linear Cross Reference Guide

FAIRCHILD DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT	FAIRCHILD DEVICE NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT	FAIRCHILD NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT	FAIRCHILD NUMBER	NATIONAL PIN-FOR-PIN EQUIVALENT	NATIONAL FUNCTIONAL EQUIVALENT
U5F710131 [UA101AE]	LM101AF	LM101AF	U6A7749393	LM301AH	LM703LH	U6A7749393	LM301AH	LM703LH	U6A7749393	LM301AH	LM703LH
U3F710133 [UA201AF]	LM201AF	LM101AF	U6D7750312	LM703LH	LM703LH	U6D7750312	LM703LH	LM703LH	U6D7750312	LM703LH	LM703LH
U3F7702312	LM101AF	LM101AF	U6E7703393	LM3064H	LM3064H	U6E7703393	LM3064H	LM3064H	U6E7703393	LM3064H	LM3064H
U3F7709311	LM709AH	LM709AH	U5E7746394 [UA3064]	LM3064H	LM3064H	U5E7746394	LM3064H	LM3064H	U5E7746394	LM3064H	LM3064H
U3F7709312	LM709H	LM709H	U5E7754393	LM1596H	LM1596H	U5E7754393	LM1596H	LM1596H	U5E7754393	LM1596H	LM1596H
U3F7710311	LM710AH	LM710AH	U5E7796393	LM711CH	LM711CH	U5E7796393	LM711CH	LM711CH	U5E7796393	LM711CH	LM711CH
U3F7710312	LM711H	LM711H	U5F7711393	LM711CH	LM711CH	U5F7711393	LM711CH	LM711CH	U5F7711393	LM711CH	LM711CH
U3F7733312	LM733H	LM733H	U5F7715312	LM733H	LM733H	U5F7715312	LM733H	LM733H	U5F7715312	LM733H	LM733H
U3F7733313	LM733H	LM733H	U5F7719312	LM733H	LM733H	U5F7719312	LM733H	LM733H	U5F7719312	LM733H	LM733H
U3F7744311	LM741F	LM741F	U5F7719393	LM733CH	LM733CH	U5F7719393	LM733CH	LM733CH	U5F7719393	LM733CH	LM733CH
U3F7748312	LM101AF	LM101AF	U5F7733312	LM733CH	LM733CH	U5F7733312	LM733CH	LM733CH	U5F7733312	LM733CH	LM733CH
U3F7748313	LM201AF	LM201AF	U5F7734312	LM733CH	LM733CH	U5F7734312	LM733CH	LM733CH	U5F7734312	LM733CH	LM733CH
U31962051X	U31962059X	DM7820D	U5F7734393	LM747H	LM747H	U5F7734393	LM747H	LM747H	U5F7734393	LM747H	LM747H
U31962151X	U31962151X	DM8220N	U5F7747312	LM747H	LM747H	U5F7747312	LM747H	LM747H	U5F7747312	LM747H	LM747H
U31962251X	U31962251X	DM8300N	U5F7747393	LM747CH	LM747CH	U5F7747393	LM747CH	LM747CH	U5F7747393	LM747CH	LM747CH
U31962591X	U31962591X	DM8820N	U5R7723312	LM723H	LM723H	U5R7723312	LM723H	LM723H	U5R7723312	LM723H	LM723H
U3M7722333	U3M7722333	DM8820N	U5T7725393	LM723CH	LM723CH	U5T7725393	LM723CH	LM723CH	U5T7725393	LM723CH	LM723CH
U41961451X	U41961451X	LMWAC 01	U5T7725312	LMWAC 01	LMWAC 01	U5T7725312	LMWAC 01	LMWAC 01	U5T7725312	LMWAC 01	LMWAC 01
U41961459X	U41961459X	DM7830D	U5T7725393	LM725AH	LM725AH	U5T7725393	LM725AH	LM725AH	U5T7725393	LM725AH	LM725AH
U41961551X	U41961551X	DM7830D	U5U7726312	LM725H	LM725H	U5U7726312	LM725H	LM725H	U5U7726312	LM725H	LM725H
U41961651X	U41961651X	DM8220N	U5U7727312	LM114H	LM114H	U5U7727312	LM114H	LM114H	U5U7727312	LM114H	LM114H
U41961659X	U41961659X	DM8820N	U5U7730393	LM1725H	LM1725H	U5U7730393	LM1725H	LM1725H	U5U7730393	LM1725H	LM1725H
U41961751X	U41961751X	LM1488N	U6A7065394 [UA3065]	LM3065N	LM3065N	U6A7065394	LM3065N	LM3065N	U6A7065394	LM3065N	LM3065N
U41961759X	U41961759X	LM1489AN	U6A7101311 [UA101AD]	LM101AD	LM101AD	U6A7101311	LM101AD	LM101AD	U6A7101311	LM101AD	LM101AD
U5A7064394 [UA3064]	LM3064H	LM1489AN	U6A7101312 [UA101D]	LM101AD	LM101AD	U6A7101312	LM101AD	LM101AD	U6A7101312	LM101AD	LM101AD
U6F7101317 [UA101H]	LM101H	LM1489AN	U6A7101332 [UA201AD]	LM201AD	LM201AD	U6A7101332	LM201AD	LM201AD	U6A7101332	LM201AD	LM201AD
U6F7101332 [UA201AH]	LM101AH	LM1489AN	U6A7101393 [UA301AD]	LM301AD	LM301AD	U6A7101393	LM301AD	LM301AD	U6A7101393	LM301AD	LM301AD
U587101392 [UA301AH]	LM301AH	LM1489AN	U6A7201393 [UA201D]	LM201D	LM201D	U6A7201393	LM201D	LM201D	U6A7201393	LM201D	LM201D
U587201393 [UA201H]	LM201H	LM1489AN	U6A7702393	LM201D	LM201D	U6A7702393	LM201D	LM201D	U6A7702393	LM201D	LM201D
U587702312	LM201H	LM1489AN	U6A7709311	LM709AH	LM709AH	U6A7709311	LM709AH	LM709AH	U6A7709311	LM709AH	LM709AH
U587702393	LM709AH	LM1489AN	U6A7709393	LM709CN	LM709AH	U6A7709393	LM709CN	LM709AH	U6A7709393	LM709CN	LM709AH
U587706311	LM709H	LM1489AN	U6A7710312	LM710CN	LM710AH	U6A7710312	LM710CN	LM710AH	U6A7710312	LM710CN	LM710AH
U587706393	LM710AH	LM1489AN	U6A7710393	LM710CN	LM710AH	U6A7710393	LM710CN	LM710AH	U6A7710393	LM710CN	LM710AH
U587710312	LM710AH	LM1489AN	U6A7711393	LM711CN	LM711H	U6A7711393	LM711CN	LM711H	U6A7711393	LM711CN	LM711H
U587710393	LM710CH	LM1489AN	U6A7715312	LM711CN	LM711H	U6A7715312	LM711CN	LM711H	U6A7715312	LM711CN	LM711H
U587716393	LM380N	LM1489AN	U6A7723312	LM723D	LM723D	U6A7723312	LM723D	LM723D	U6A7723312	LM723D	LM723D
U587730312	LM114H	LM1489AN	U6A7723393	LM723CD	LM723CD	U6A7723393	LM723CD	LM723CD	U6A7723393	LM723CD	LM723CD
U587735312	LM4250H	LM1489AN	U6A7732394	LM1364N	LM1364N	U6A7732394	LM1364N	LM1364N	U6A7732394	LM1364N	LM1364N
U587735393	LM4250H	LM1489AN	U6A7733312	LM733D	LM733D	U6A7733312	LM733D	LM733D	U6A7733312	LM733D	LM733D
U587735393	LM4250H	LM1489AN	U6A7733393	LM733CD	LM733CD	U6A7733393	LM733CD	LM733CD	U6A7733393	LM733CD	LM733CD
U587740312	LM740AH	LM1489AN	U6A7739312	LM741D	LM741D	U6A7739312	LM741D	LM741D	U6A7739312	LM741D	LM741D
U587740393	LM740AC	LM1489AN	U6A7739393	LM745CN	LM745CN	U6A7739393	LM745CN	LM745CN	U6A7739393	LM745CN	LM745CN
U587741312	LM741H	LM1489AN	U6A7741312	LM745CN	LM745CN	U6A7741312	LM745CN	LM745CN	U6A7741312	LM745CN	LM745CN
U587741393	LM741CH	LM1489AN	U6A7746394	LM745CN	LM745CN	U6A7746394	LM745CN	LM745CN	U6A7746394	LM745CN	LM745CN
U587748312	LM748CH	LM1489AN	U6A7748312	LM101AD	LM101AD	U6A7748312	LM101AD	LM101AD	U6A7748312	LM101AD	LM101AD
U587748393	LM748CH	LM1489AN	U6A7748393	LM301AD	LM301AD	U6A7748393	LM301AD	LM301AD	U6A7748393	LM301AD	LM301AD
U587749394	LM4250H	LM1489AN	U6A7749312	LM301AD	LM301AD	U6A7749312	LM301AD	LM301AD	U6A7749312	LM301AD	LM301AD
U587776312	LM4250H	LM1489AN									
U587776393	LM4250H	LM1489AN									
U587777312	LM101AH	LM1489AN									

Linear Cross Reference Guide



Voltage Regulators

LM100/LM200/LM300

LM100/LM200/LM300 voltage regulator general description

The LM100, LM200 and LM300 are integrated voltage regulators designed for a wide range of applications from digital power supplies to precision regulators for analog circuitry. Built on a single silicon chip, these devices are encapsulated in either an 8-lead, low profile TO-5 header or a 1/4 x 1/4 metal flat package. Outstanding characteristics are:

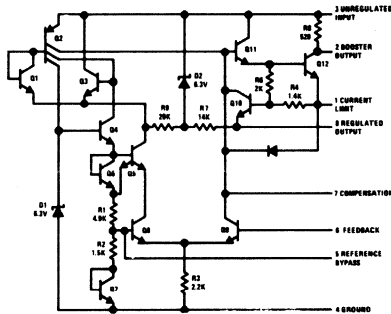
- Output voltage adjustable from 2V to 30V (LM300 adjustable from 2V to 20V)
- Better than one percent load and line regulation
- One percent temperature stability
- Adjustable short-circuit limiting
- Output currents in excess of 5A possible by adding external transistors

- Can be used as either a linear or high-efficiency switching regulator.

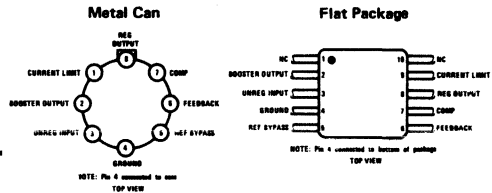
Additional features are fast response to both load and line transients, small standby power dissipation, freedom from oscillations with varying resistive and reactive loads, and the ability to start reliably on any load within rating.

The LM100 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LM200 and LM300 are low cost, commercial-industrial versions of the LM100. They are identical to the LM100 except that they are specified for operation from -25°C to 85°C and from 0°C to 70°C respectively.

schematic and connection diagrams



Pin connections shown are for TO-5 package

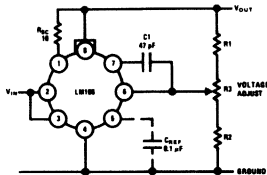


Order Number LM100H
or LM200H or LM300H
See Package 11

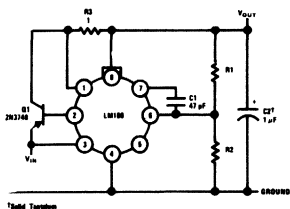
Order Number LM100F
or LM200F or LM300F
See Package 3

typical applications

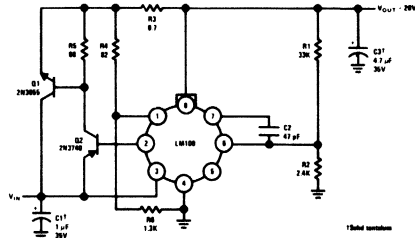
Basic Regulator Circuit



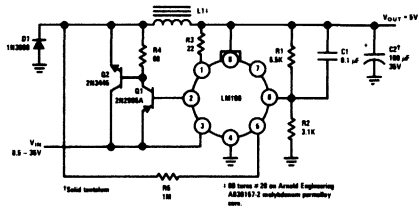
200 mA Regulator



2A Regulator With Foldback Current Limiting



4A Switching Regulator



1

absolute maximum ratings

Input Voltage	
LM100, LM200	40V
LM300	35V
Input-Output Voltage Differential	
LM100, LM200	40V
LM300	30V
Power Dissipation (Note 1)	
LM100, LM200	800 mW
LM300	500 mW
Operating Temperature Range	
LM100, LM200	-55°C to +150°C
LM300	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range					
LM100/LM200		8.5		40	V
LM300		8.5		30	V
Output Voltage Range					
LM100/LM200		2.0		30	V
LM300				20	V
Output-Input Voltage Differential					
LM100/LM200		3.0		30	V
LM300				20	V
Load Regulation (Note 3)	$R_{SC} = 0, I_O < 12 \text{ mA}$		0.1	0.5	%
Line Regulation	$V_{IN} - V_{OUT} \leq 5V$ $V_{IN} - V_{OUT} \geq 5V$		0.1 0.05	0.2 0.1	%/V %/V
Temperature Stability					
LM100	$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		0.3	1.0	
LM200	$-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$		0.3	1.0	%
LM300	$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$		0.3	2.0	
Feedback Sense Voltage		1.63	1.7	1.81	V
Output Noise Voltage	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}$ $C_{REF} = 0$ $C_{REF} = 0.1 \mu\text{F}$				% %
Long Term Stability			0.1	1.0	%
Standby Current Drain					
LM100/LM200	$V_{IN} = 40V$		1.0	3.0	mA
LM300	$V_{IN} = 30V$				
Minimum Load Current					
LM100/LM200	$V_{IN} - V_{OUT} = 30V$		1.5	3.0	mA
LM300	$V_{IN} - V_{OUT} = 20V$				

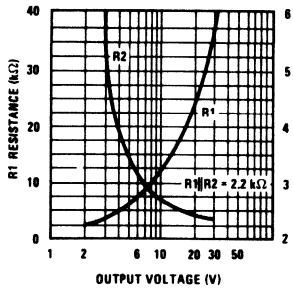
Note 1: The maximum junction temperature of the LM100 is 150°C, while that of the LM200 is 100°C, and the LM300 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W junction to ambient or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. Peak dissipations to 1.0W are allowable providing the dissipation rating is not exceeded with the power averaged over a five second interval for the LM100 and LM200, and a two second interval for the LM300.

Note 2: These specifications apply for an operating temperature between -55°C to +125°C for the LM100, between -25°C to 85°C for the LM200 and between 0°C to 70°C for the LM300 devices for input and output voltages within the ranges given, and for a divider impedance seen by the feedback terminal of 2 k Ω , unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.

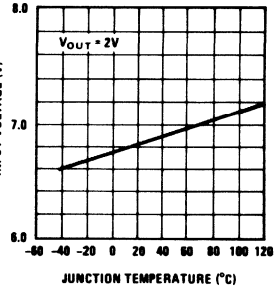
Note 3: The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

typical performance characteristics

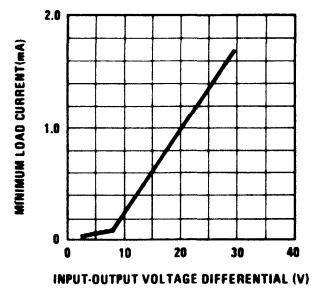
Optimum Divider Resistance Values vs Output Voltage



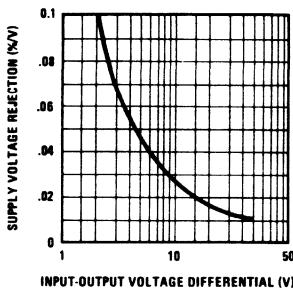
Minimum Input Voltage vs Junction Temperature



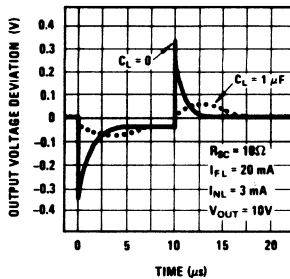
Minimum Load Current vs Input-Output Voltage Differential



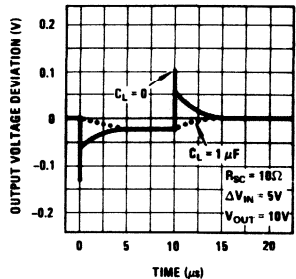
Supply Voltage Rejection vs Input-Output Voltage Differential



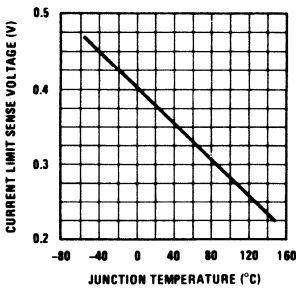
Load Transient Response



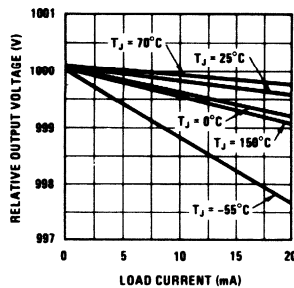
Line Transient Response



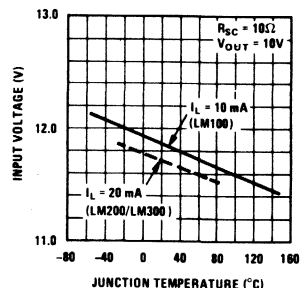
Current Limit Sense Voltage vs Junction Temperature



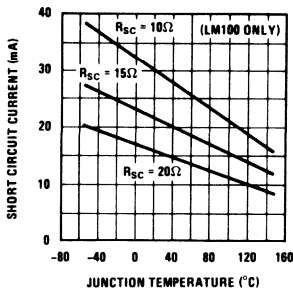
Regulation Characteristics Without Current Limiting



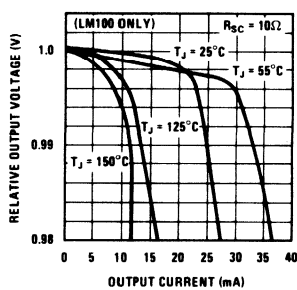
Regulator Dropout Voltage vs Junction Temperature



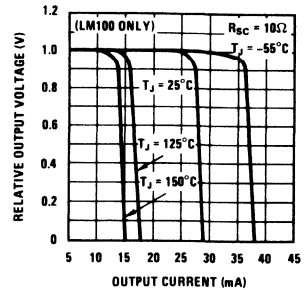
Short Circuit Current vs Junction Temperature



Regulation Characteristics With Current Limiting



Current Limiting Characteristics





Voltage Regulators

LM103 regulator diode **

general description

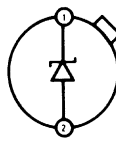
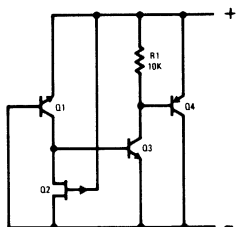
The LM103 is a two-terminal monolithic regulator diode electrically equivalent to a breakdown diode. The device makes use of the reverse punch-through of double-diffused transistors, combined with active circuitry, to produce a breakdown characteristic which is ten times sharper than single-junction zener diodes at low voltages. Breakdown voltages from 1.8V to 5.6V are available; and, although the design is optimized for operation between 100 μ A and 1 mA, it is completely specified from 10 μ A to 10 mA. Noteworthy features of the device are:

- Exceptionally sharp breakdown
- Low dynamic impedance from 10 μ A to 10 mA

- Performance guaranteed over full military temperature range
- Planar, passivated junctions for stable operation
- Low capacitance.

The LM103, packaged in a hermetically sealed, modified TO-46 header is useful in a wide range of circuit applications from level shifting to simple voltage regulation. It can also be employed with operational amplifiers in producing breakpoints to generate nonlinear transfer functions. Finally, its unique characteristics recommend it as a reference element in low voltage power supplies with input voltages down to 4V.

schematic and connection diagrams

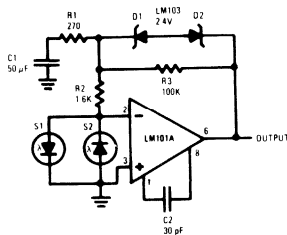


NOTE: Pin 2 connected to case
TOP VIEW

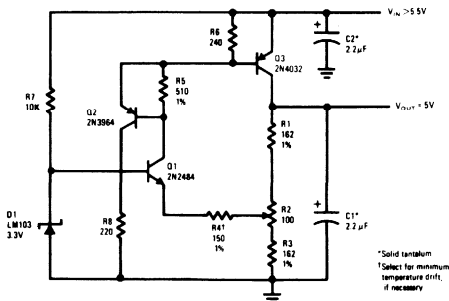
Order Number LM103H
See Package 8

typical applications

Saturating Servo Preampifier with Rate Feedback



200 mA Positive Regulator



*Solid tantalum
†Select for minimum temperature drift, if necessary

**Covered by U.S. Patent Number 3,571,630

absolute maximum ratings

Power Dissipation (note 1)	250 mW
Reverse Current	20 mA
Forward Current	100 mA
Operating Temperature Range	-55°C to 125°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (soldering, 60 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Reverse Breakdown Voltage Change	$10 \mu\text{A} \leq I_R \leq 100 \mu\text{A}$		60	120	mV
	$100 \mu\text{A} \leq I_R \leq 1 \text{ mA}$		15	50	mV
	$1 \text{ mA} \leq I_R \leq 10 \text{ mA}$		50	150	mV
Reverse Dynamic Impedance (Note 3)	$I_R = 3 \text{ mA}$		5	25	Ω
	$I_R = 0.3 \text{ mA}$		15	60	Ω
Reverse Leakage Current	$V_R = V_Z - 0.2\text{V}$		2	5	μA
Forward Voltage Drop	$I_F = 10 \text{ mA}$	0.7	0.8	1.0	V
Peak-to-Peak Broadband Noise Voltage	$10 \text{ Hz} \leq f \leq 100 \text{ kHz}, I_R = 1 \text{ mA}$		300		μV
Reverse Breakdown Voltage Change (Note 4)	$10 \mu\text{A} \leq I_R \leq 100 \mu\text{A}$			200	mV
	$100 \mu\text{A} \leq I_R \leq 1 \text{ mA}$			60	mV
	$1 \text{ mA} \leq I_R \leq 10 \text{ mA}$			200	mV
Breakdown Voltage Temperature Coefficient (Note 4)	$100 \mu\text{A} \leq I_R \leq 1 \text{ mA}$		-5.0		$\text{mV}/^\circ\text{C}$

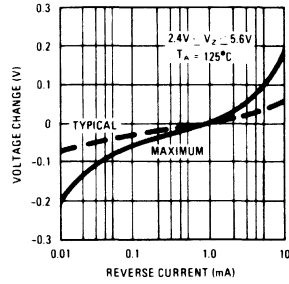
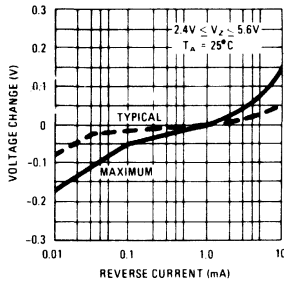
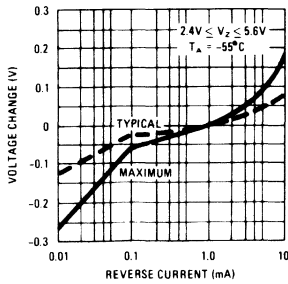
NOTE 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 80°C/W junction to case or 440°C/W junction to ambient (see curve).

NOTE 2: These specifications apply for $T_A = 25^\circ\text{C}$ and $1.8\text{V} < V_Z < 5.6\text{V}$ unless stated otherwise. The diode should not be operated with shunt capacitances between 100 pF and 0.01 μF , unless isolated by at least a 50 Ω resistor, as it may oscillate at some currents.

NOTE 3: Measured with the peak-to-peak change of reverse current equal to 10 percent of the dc reverse current.

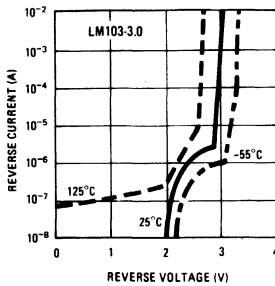
NOTE 4: These specifications apply for $-55^\circ\text{C} < T_A < 125^\circ\text{C}$.

guaranteed reverse characteristics

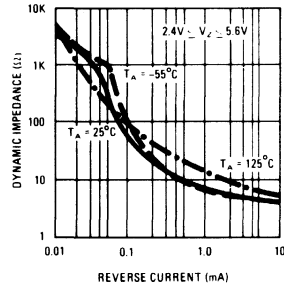


typical performance characteristics

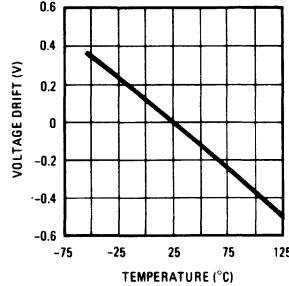
Reverse Characteristics



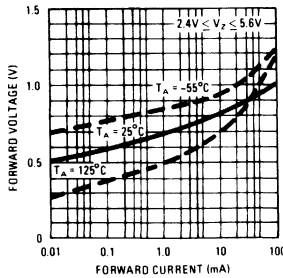
Reverse Dynamic Impedance



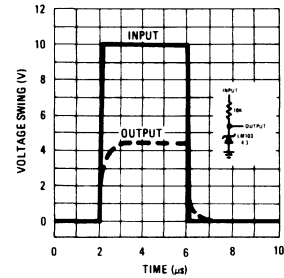
Temperature Drift



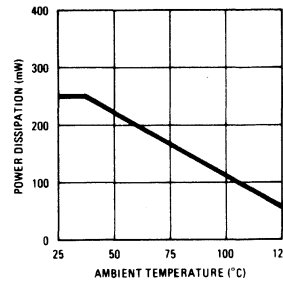
Forward Characteristics



Response Time



Maximum Power Dissipation



BREAKDOWN VOLTAGE*

PART NUMBER

1.8	LM103-1.8
2.0	LM103-2.0
2.2	LM103-2.2
2.4	LM103-2.4
2.7	LM103-2.7
3.0	LM103-3.0
3.3	LM103-3.3
3.6	LM103-3.6
3.9	LM103-3.9
4.3	LM103-4.3
4.7	LM103-4.7
5.1	LM103-5.1
5.6	LM103-5.6

*Measured at $I_R = 1 \text{ mA}$.

Standard tolerance is $\pm 10\%$.



Voltage Regulators

LM104/LM204

LM104/LM204 negative regulator general description

The LM104 and LM204 are precision voltage regulators which can be programmed by a single external resistor to supply any voltage from 40V down to zero while operating from a single unregulated supply. They can also provide 0.01-percent regulation in circuits using a separate, floating bias supply, where the output voltage is limited only by the breakdown of external pass transistors. Although designed primarily as linear, series regulators, the circuits can be used as switching regulators, current regulators or in a number of other control applications. Typical performance characteristics are:

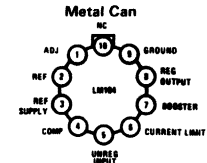
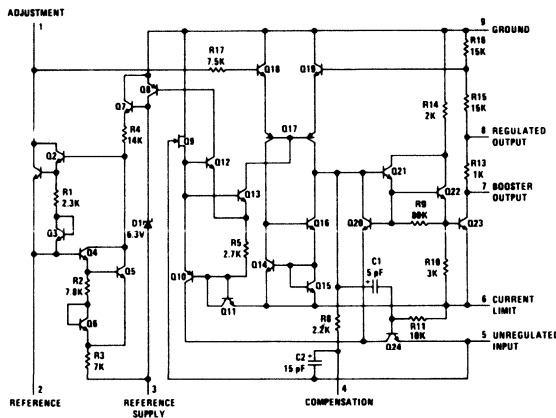
- 1 mV regulation no load to full load
- 0.01%/V line regulation
- 0.2 mV/V ripple rejection

- 0.3% temperature stability over military temperature range

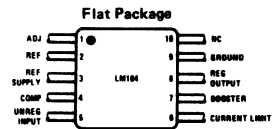
The LM104 and LM204 are complements of the LM100 and LM105 positive regulators, intended for systems requiring regulated negative voltages which have a common ground with the unregulated supply. By themselves, they can deliver output currents to 25 mA, but external transistors can be added to get any desired current. The output voltage is set by external resistors, and either constant or foldback current limiting is made available.

The LM104 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LM204 is specified for operation over the -25°C to $+85^{\circ}\text{C}$ temperature range.

schematic and connection diagrams



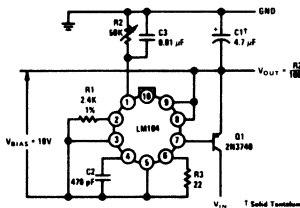
Note: Pin 5 connected to case.
TOP VIEW
Order Number LM104H or LM204H
See Package 12



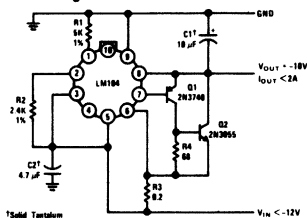
Note: Pin 5 connected to bottom of package.
TOP VIEW
Order Number LM104F or LM204F
See Package 3

typical applications

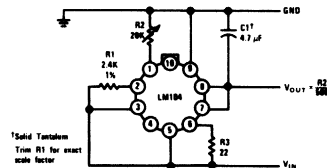
Operating with Separate Bias Supply



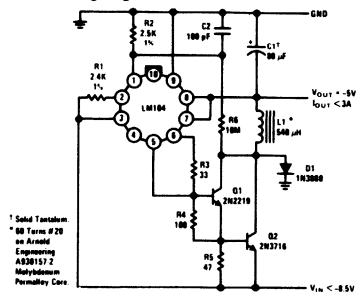
High Current Regulator



Basic Regulator Circuit



Switching Regulator



¹ Solid Tantalum
² 50 Term # 20
as Araldite
Engineering
AS38157 2
Military
Permissible Case

absolute maximum ratings

Input Voltage	50V
Input-Output Voltage Differential	50V
Power Dissipation (Note 1)	500 mW
Operating Temperature Range	
LM104	-55°C to 125°C
LM204	-25°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		-50		-8	V
Output Voltage Range		-40		-0.015	V
Output-Input Voltage Differential (Note 3)	$I_O = 20 \text{ mA}$ $I_O = 5 \text{ mA}$	2.0 0.5		50 50	V V
Load Regulation (Note 4)	$0 \leq I_O \leq 20 \text{ mA}$ $R_{SC} = 15\Omega$		1	5	mV
Line Regulation (Note 5)	$V_{OUT} \leq -5V$ $\Delta V_{IN} = 0.1 V_{IN}$		0.056	0.1	%
Ripple Rejection	$C_{19} = 10 \mu\text{F}$, $f = 120 \text{ Hz}$ $V_{IN} < -15V$ $-7V \geq V_{IN} \geq -15V$		0.2 0.5	0.5 1.0	mV/V mV/V
Output Voltage Scale Factor	$R_{23} = 2.4k$	1.8	2.0	2.2	V/k Ω
Temperature Stability	$V_O \leq -1V$		0.3	1.0	%
Output Noise Voltage	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}$ $V_O \leq -5V$, $C_{19} = 0$ $C_{19} = 10 \mu\text{F}$		0.007 15		% μV
Standby Current Drain	$I_L = 5 \text{ mA}$, $V_O = 0$ $V_O = -40V$		1.7 3.6	2.5 5.0	mA mA
Long Term Stability	$V_O \leq -1V$		0.1	1.0	%

Note 1: The maximum junction temperature of the LM104 is 150°C, while that of the LM204 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors.

Note 2: These specifications apply for junction temperatures between -55°C and 150°C (between -25°C and 100°C for the LM204) and for input and output voltages within the ranges given, unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.

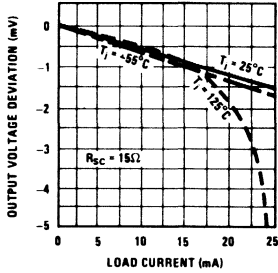
Note 3: When external booster transistors are used, the minimum output-input voltage differential is increased, in the worst case, by approximately 1V.

Note 4: The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

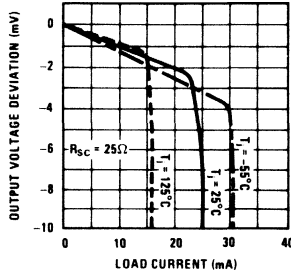
Note 5: With zero output, the dc line regulation is determined from the ripple rejection. Hence, with output voltages between 0V and -5V, a dc output variation, determined from the ripple rejection, must be added to find the worst-case line regulation.

typical performance characteristics

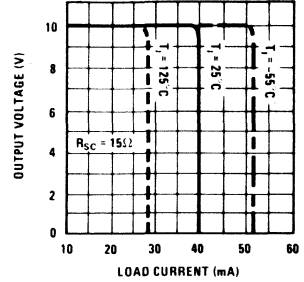
Load Regulation



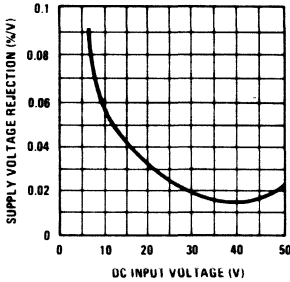
Load Regulation



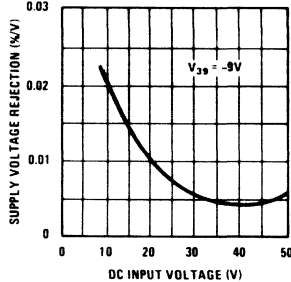
Current Limiting



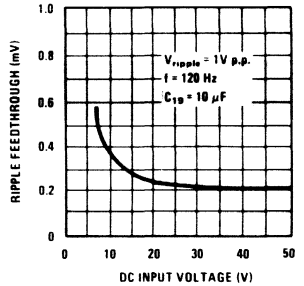
Supply Voltage Rejection



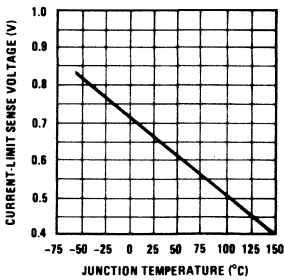
Supply Voltage Rejection With Preregulated Reference Supply



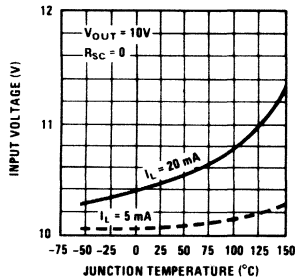
Ripple Rejection



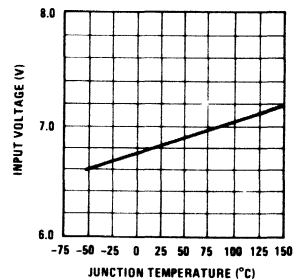
Current Limit Sense Voltage



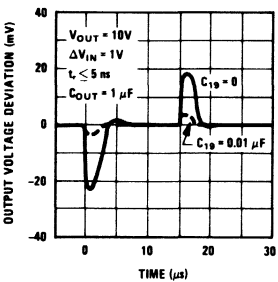
Regulator Dropout Voltage



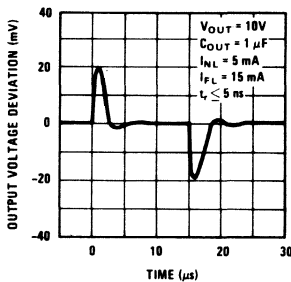
Minimum Input Voltage



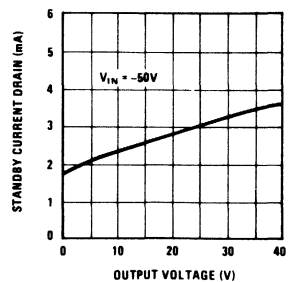
Line Transient Response



Load Transient Response



Standby Current Drain





Voltage Regulators

LM304 negative regulator general description

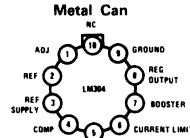
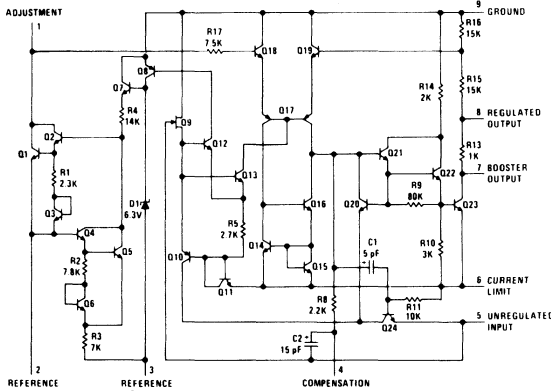
The LM304 is a precision voltage regulator which can be programmed by a single external resistor to supply any voltage from 30V down to zero while operating from a single unregulated supply. It can also provide 0.01-percent regulation in circuits using a separate, floating bias supply, where the output voltage is limited only by the breakdown of external pass transistors. Although designed primarily as a linear, series regulator, the circuit can be used as a switching regulator, a current regulator or in a number of other control applications. Typical performance characteristics are:

- 1 mV regulation no load to full load
- 0.01%/V line regulation

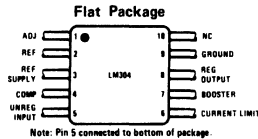
- 0.2 mV/V ripple rejection

The LM304 is a complement of the LM300 and LM305 positive regulators, intended for systems requiring regulated negative voltages which have a common ground with the unregulated supply. By itself, it can deliver output currents to 25 mA, but external transistors can be added to get any desired current. The output voltage is set by external resistors, and either constant or foldback current limiting is made available. The LM304 is a commercial/industrial version of the LM104 and LM204.

schematic and connection diagrams



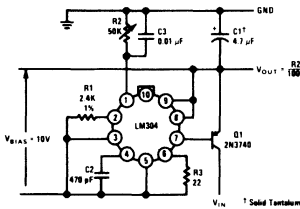
Note: Pin 5 connected to case.
TOP VIEW
Order Number LM304H
See Package 12



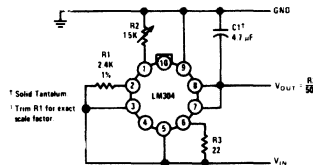
Note: Pin 5 connected to bottom of package.
TOP VIEW
Order Number LM304F
See Package 3

typical applications

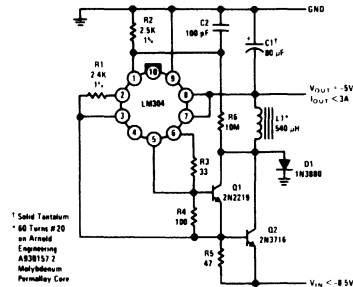
Operating with Separate Bias Supply



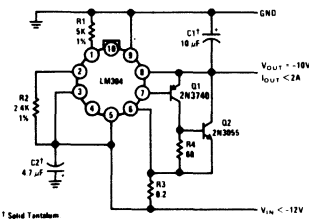
Basic Regulator Circuit



Switching Regulator



High Current Regulator



absolute maximum ratings

Input Voltage	40V
Input-Output Voltage Differential	40V
Power Dissipation (Note 1)	500 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		-40		-8	V
Output Voltage Range		-30		-0.035	V
Output-Input Voltage Differential (Note 3)	$I_O = 20 \text{ mA}$	2.0		40	V
	$I_O = 5 \text{ mA}$	0.5		40	V
Load Regulation (Note 4)	$0 \leq I_O \leq 20 \text{ mA}$ $R_{SC} = 15\Omega$		1	5	mV
Line Regulation (Note 5)	$V_{OUT} \leq -5V$ $\Delta V_{IN} = 0.1 V_{IN}$		0.056	0.1	%
Ripple Rejection	$C_{19} = 10 \mu\text{F}$, $f = 120 \text{ Hz}$ $V_{IN} < -15V$		0.2	0.5	mV/V
	$-7V \geq V_{IN} \geq -15V$		0.5	1.0	mV/V
Output Voltage Scale Factor	$R_{23} = 2.4K$	1.8	2.0	2.2	V/K Ω
Temperature Stability	$V_O \leq -1V$, $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$		0.3	1.0	%
Output Noise Voltage	$10 \text{ Hz} \leq f \leq 10 \text{ KHz}$ $V_O \leq -5V$, $C_{19} = 0$		0.007		%
	$C_{19} = 10 \mu\text{F}$		15		μV
Standby Current Drain	$I_L = 5 \text{ mA}$, $V_O = 0$		1.7	2.5	mA
	$V_O = -30V$		3.6	5.0	mA
Long Term Stability	$V_O \leq -1V$		0.1	1.0	%

Note 1: For operating at elevated temperatures, the device must be derated based on an 85°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient. Peak dissipations to 1.0W are allowable providing the dissipation rating is not exceeded with the power averaged over a two second interval.

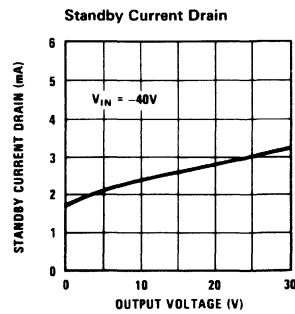
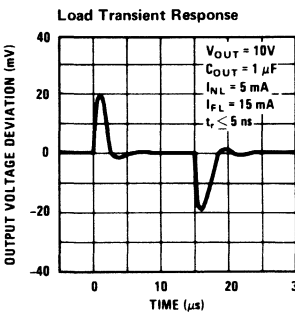
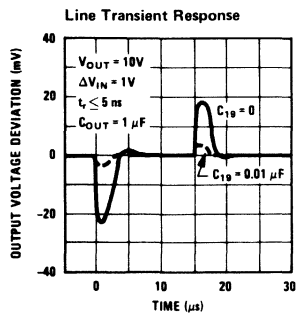
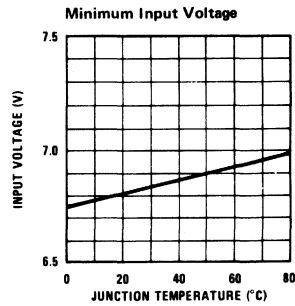
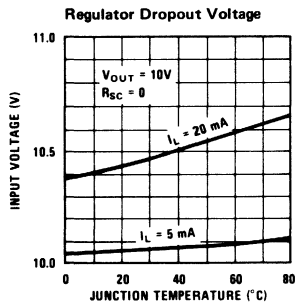
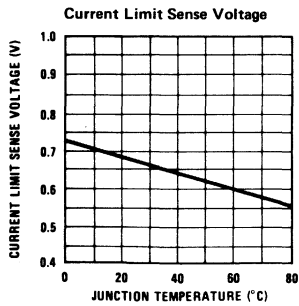
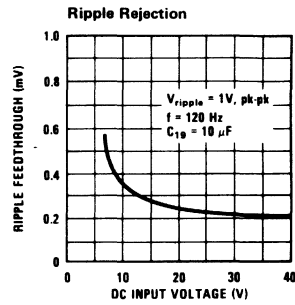
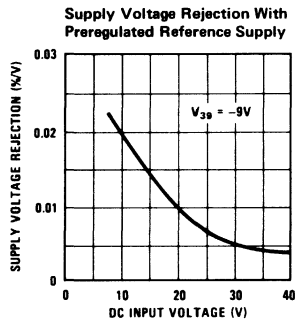
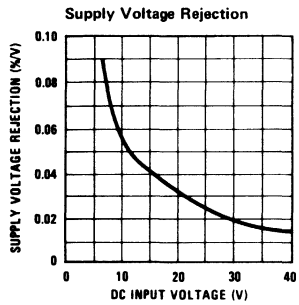
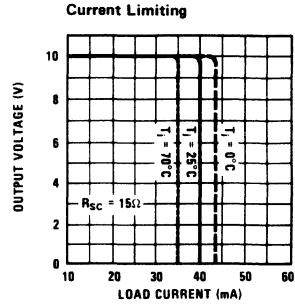
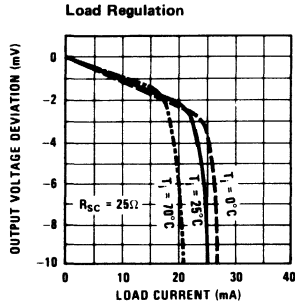
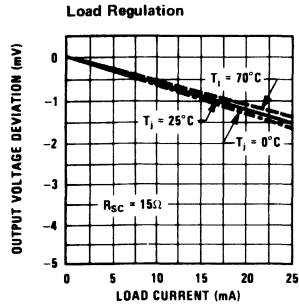
Note 2: These specifications apply for junction temperatures between 0°C and 85°C and for input and output voltages within the ranges given, unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.

Note 3: When external booster transistors are used, the minimum output-input voltage differential is increased, in the worst case, by approximately 1V.

Note 4: The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

Note 5: With zero output, the dc line regulation is determined from the ripple rejection. Hence, with output voltages between 0V and -5V, a dc output variation, determined from the ripple rejection, must be added to find the worst-case line regulation.

typical performance characteristics





Voltage Regulators

LM105/LM205/LM305

LM105/LM205/LM305 voltage regulator

general description

The LM105, LM205 and LM305 are positive voltage regulators similar to the LM100, except that an extra gain stage has been added for improved regulation. A redesign of the biasing circuitry removes any minimum load current requirement and at the same time reduces standby current drain, permitting higher voltage operation. They are direct, plug-in replacements for the LM100 in both linear and switching regulator circuits with output voltages greater than 4.5V. Important characteristics of the circuits are:

- Output voltage adjustable from 4.5V to 40V
- Output currents in excess of 10A possible by adding external transistors
- Load regulation better than 0.1%, full load with current limiting

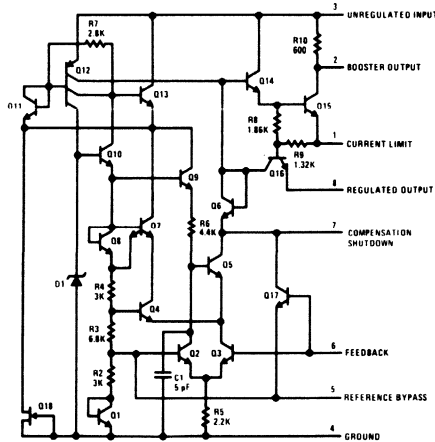
- DC line regulation guaranteed at 0.03%/V
- Ripple rejection of 0.01%/V

Like the LM100, they also feature fast response to both load and line transients, freedom from oscillations with varying resistive and reactive loads and the ability to start reliably on any load within rating. The circuits are built on a single silicon chip and are supplied in either an 8-lead, TO-5 header or a 1/4" x 1/4" metal flat package.

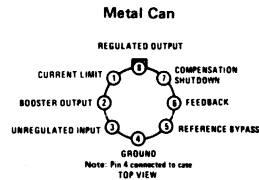
The LM205 is identical to the LM105 except that it is specified for operation from -25°C to 85°C.

The LM305 is specified for operation from 0°C to 70°C and for output voltages to 30V.

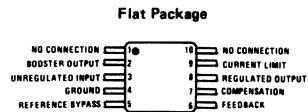
schematic and connection diagrams



Pin connections shown are for metal can.



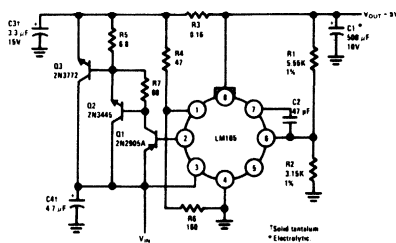
Order Number LM105H
or LM205H or LM305H
See Package 11



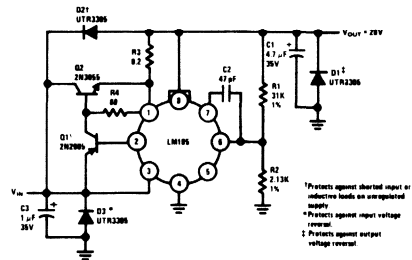
Order Number LM105F
or LM205F or LM305F
See Package 3

typical applications

10A Regulator with Foldback Current Limiting



1.0A Regulator with Protective Diodes



absolute maximum ratings

Input Voltage	
LM105, LM205	50V
LM305	40V
Input-Output Voltage Differential	40V
Power Dissipation (Note 1)	
LM105, LM205	800 mW
LM305	500 mW
Operating Temperature Range	0°C to 70°C
LM105	-55°C to +125°C
LM205	-25°C to +85°C
LM305	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

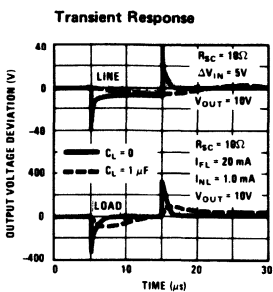
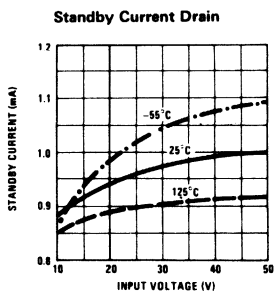
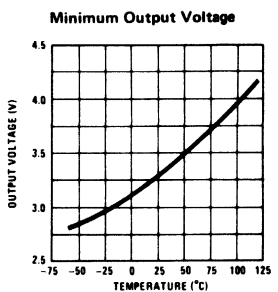
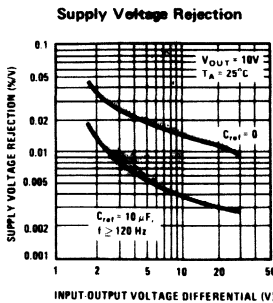
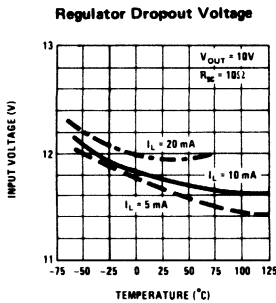
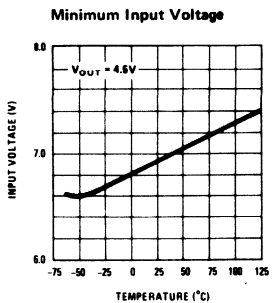
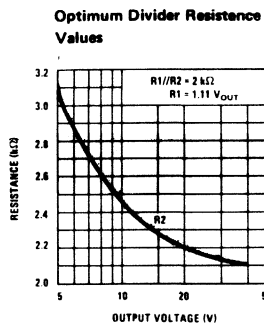
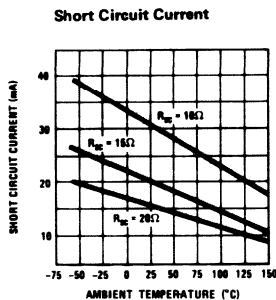
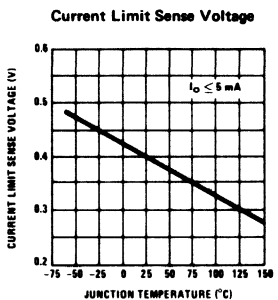
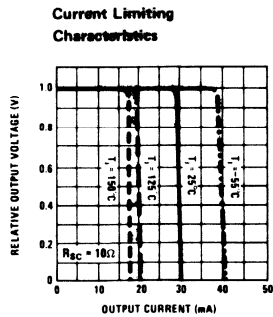
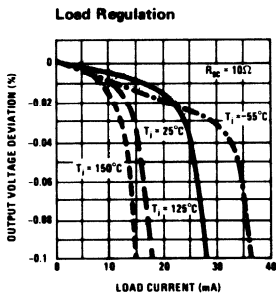
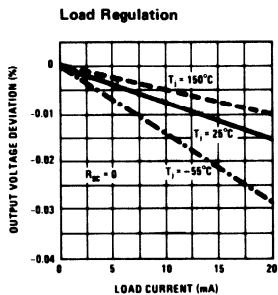
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range					
LM105, LM205		8.5		50	V
LM305		8.5		40	V
Output Voltage Range					
LM105, LM205		4.5		40	V
LM305		4.5		30	V
Output-Input Voltage Differential		3.0		30	V
Load Regulation (Note 3)					
LM105	0 ≤ I _O ≤ 12 mA R _{SC} = 10Ω, T _A = 25°C R _{SC} = 10Ω, T _A = 125°C R _{SC} = 10Ω, T _A = -55°C		0.02 0.03 0.03	0.05 0.1 0.1	%
LM205	0 ≤ I _O ≤ 12 mA R _{SC} = 10Ω, T _A = 25°C R _{SC} = 10Ω, T _A = 85°C R _{SC} = 10Ω, T _A = -25°C		0.02 0.03 0.03	0.05 0.1 0.1	%
LM305	0 ≤ I _O ≤ 12 mA R _{SC} = 10Ω, T _A = 25°C R _{SC} = 15Ω, T _A = 70°C R _{SC} = 10Ω, T _A = 0°C		0.02 0.03 0.03	0.05 0.1 0.1	%
Line Regulation	V _{IN} - V _{OUT} ≤ 5V V _{IN} - V _{OUT} > 5V		0.025 0.015	0.06 0.03	%/V
Ripple Rejection	C _{REF} = 10 μF, f = 120 Hz		0.003	0.01	%/V
Temperature Stability					
LM105	-55°C ≤ T _A ≤ 125°C		0.3	1.0	%
LM205	-25°C ≤ T _A ≤ 85°C		0.3	1.0	%
LM305	0°C ≤ T _A ≤ 70°C		0.3	1.0	%
Feedback Sense Voltage		1.63	1.7	1.81	V
Output Noise Voltage	10 Hz ≤ f ≤ 10 kHz C _{REF} = 0 C _{REF} > 0.1 μF R _{SC} = 10Ω, T _A = 25°C, V _{OUT} = 0V		0.005 0.002		%
Current Limit Sense Voltage		225	300	315	mV
Standby Current Drain					
LM105, LM205	V _{IN} = 50V		0.8	2.0	mA
LM305	V _{IN} = 40V		0.8	2.0	mA
Long Term Stability			0.1	1.0	%

Note 1: The maximum junction temperature of the LM105 is 150°C, while that for the LM205 is 100°C, and that for the LM305 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. Peak dissipations to 1W are allowable providing the dissipation rating is not exceeded with the power averaged over a five second interval for the LM105 and LM205, and averaged over a two second interval for the LM305.

Note 2: These specifications apply for input and output voltages within the ranges given, and for a divider impedance seen by the feedback terminal of 2 kΩ, unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation. Unless otherwise specified, T_A = 25°C.

Note 3: The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

typical performance characteristics





Voltage Regulators

LM305A voltage regulator general description

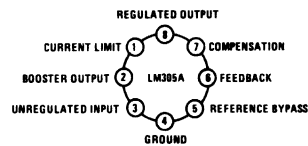
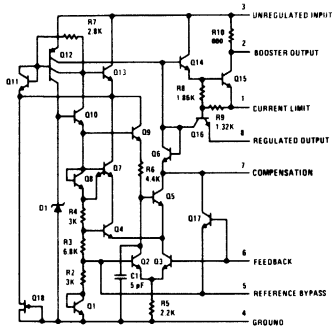
The LM305A is a positive voltage regulator designed primarily for commercial series regulator applications. By itself, it will supply output currents up to 45 mA; but external transistors can be added to provide any desired load current. The circuit features extremely low standby current drain, and provision is made for either linear or foldback current limiting. Important characteristics are:

- 45 mA output current without external pass transistor

- Output currents in excess of 10A possible by adding external transistors
- Maximum input voltage = 50V
- Output voltage adjustable from 4.5V to 40V
- Can be used as either a linear or a switching regulator

The LM305A is also useful in a wide range of other applications such as a shunt regulator, a current regulator or a temperature controller.

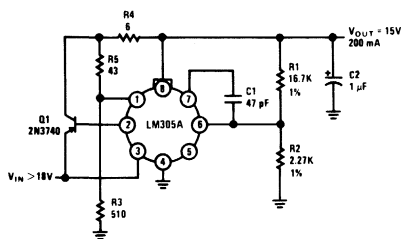
schematic and connection diagrams



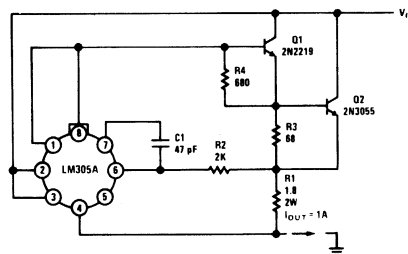
Order Number LM305AH
See Package 11

typical applications

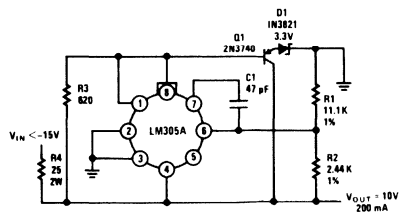
Linear Regulator with Foldback Current Limiting



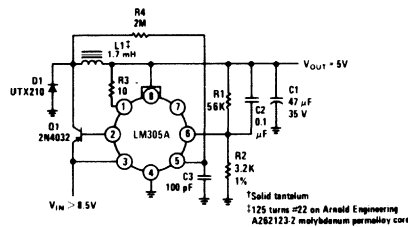
Current Regulator



Shunt Regulator



Switching Regulator



¹Solid tantalum
²125 turns #22 on Aramid Engineering
A282123-2 molybdenum permalloy core

absolute maximum ratings

Input Voltage	50V
Input-Output Voltage Differential	40V
Power Dissipation (Note 1)	800 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 60 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		8.5		50	V
Output Voltage Range		4.5		40	V
Output Input Voltage Differential		3.0		30	V
Load Regulation (Note 3)	$0 \leq I_O \leq 45 \text{ mA}$ $R_{SC} = 0\Omega, T_A = 25^\circ\text{C}$ $R_{SC} = 0\Omega, T_A = 70^\circ\text{C}$ $R_{SC} = 0\Omega, T_A = 0^\circ\text{C}$		0.02 0.03 0.03	0.2 0.4 0.4	%
Line Regulation	$V_{IN} - V_{OUT} \leq 5\text{V}$ $V_{IN} - V_{OUT} > 5\text{V}$		0.025 0.015	0.06 0.03	%/V %/V
Ripple Rejection	$C_{REF} = 10 \mu\text{F}, f = 120 \text{ Hz}$		0.003		%/V
Temperature Stability	$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$		0.3	1.0	%
Feedback Sense Voltage		1.55	1.7	1.85	V
Output Noise Voltage	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}$ $C_{REF} = 0$ $C_{REF} > 0.1 \mu\text{F}$		0.005 0.002		% %
Current Limit Sense Voltage (Note 4)	$R_{SC} = 10\Omega, T_A = 25^\circ\text{C},$ $V_{OUT} = 0\text{V}$	225	300	375	mV
Standby Current Drain	$V_{IN} = 50\text{V}$		0.8	2.0	mA
Long Term Stability			0.1	1.0	%

Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient.

Note 2: These specifications apply for an operating temperature between 0°C and 70°C, for input and output voltages within the ranges given, and for a divider impedance seen by the feedback terminal of 2 K Ω , unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.

Note 3: The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

Note 4: With no external pass transistor.



Voltage Regulators

LM109/LM209 five-volt regulator

general description

The LM109 and LM209 are complete 5V regulators fabricated on a single silicon chip. They are designed for local regulation on digital logic cards, eliminating the distribution problems associated with single-point regulation. The devices are available in two common transistor packages. In the solid-kovar TO-5 header, it can deliver output currents in excess of 200 mA, if adequate heat sinking is provided. With the TO-3 power package, the available output current is greater than 1A.

The regulators are essentially blow-out proof. Current limiting is included to limit the peak output current to a safe value. In addition, thermal shutdown is provided to keep the IC from overheating. If internal dissipation becomes too great, the regulator will shut down to prevent excessive heating.

Considerable effort was expended to make these devices easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient

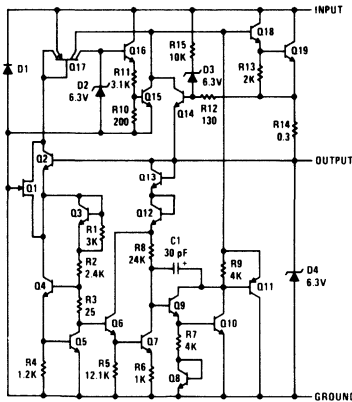
response somewhat. Input bypassing is needed, however, if the regulator is located very far from the filter capacitor of the power supply. Stability is also achieved by methods that provide very good rejection of load or line transients as are usually seen with TTL logic.

Although designed primarily as a fixed-voltage regulator, the output of the LM109 and LM209 can be set to voltages above 5V, as shown below. It is also possible to use the circuits as the control element in precision regulators, taking advantage of the good current-handling capability and the thermal overload protection.

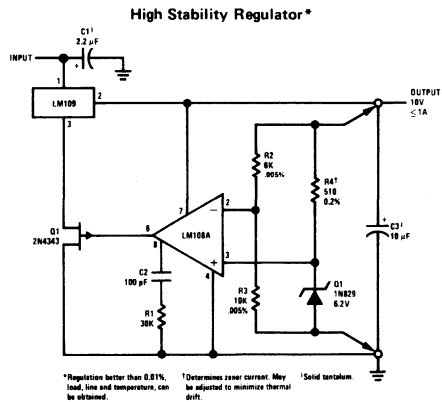
To summarize, outstanding features of the regulator are:

- Specified to be complete, worst case, with TTL and DTL
- Output current in excess of 1A
- Internal thermal overload protection
- No external components required

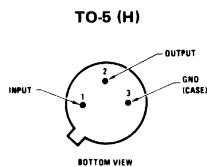
schematic diagram



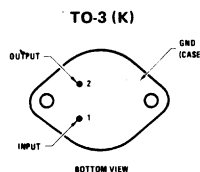
typical application



connection diagrams



Order Number LM109H or LM209H
See Package 9



Order Number LM109K or LM209K
See Package 18

absolute maximum ratings

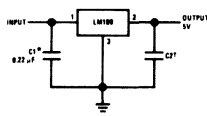
Input Voltage	35V
Power Dissipation	Internally Limited
Operating Junction Temperature Range	-55°C to 150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

design characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_j = 25^\circ\text{C}$	4.7	5.05	5.3	V
Line Regulation	$T_j = 25^\circ\text{C}$ $7\text{V} \leq V_{IN} \leq 25\text{V}$		4	50	mV
Load Regulation	$T_j = 25^\circ\text{C}$				
LM109H	$5\text{ mA} \leq I_{OUT} \leq 0.5\text{A}$		20	50	mV
LM109K	$5\text{ mA} \leq I_{OUT} \leq 1.5\text{A}$		50	100	mV
Output Voltage	$7\text{V} \leq V_{IN} \leq 25\text{V}$ $5\text{ mA} \leq I_{OUT} \leq I_{max}$ $P < P_{max}$	4.6		5.4	V
Quiescent Current	$7\text{V} \leq V_{IN} \leq 25\text{V}$		5.2	10	mA
Quiescent Current Change	$7\text{V} \leq V_{IN} \leq 25\text{V}$ $5\text{ mA} \leq I_{OUT} \leq I_{max}$			0.5 0.8	mA mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$ $10\text{ Hz} \leq f \leq 100\text{ kHz}$		40		μV
Long Term Stability				10	mV
Thermal Resistance	Junction to Case (Note 2)				$^\circ\text{C}/\text{W}$
LM109H			15		$^\circ\text{C}/\text{W}$
LM109K			3		$^\circ\text{C}/\text{W}$

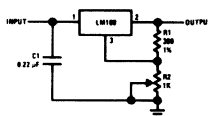
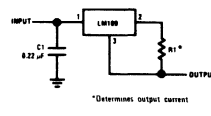
Note 1: Unless otherwise specified, these specifications apply for $-55^\circ\text{C} \leq T_j \leq 150^\circ\text{C}$ ($-25^\circ\text{C} \leq T_j \leq 150^\circ\text{C}$ for the LM209), $V_{IN} = 10\text{V}$ and $I_{OUT} = 0.1\text{A}$ for the TO-5 package or $I_{OUT} = 0.5\text{A}$ for the TO-3 package. For the TO-5 package, $I_{max} = 0.2\text{A}$ and $P_{max} = 2.0\text{W}$. For the TO-3 package, $I_{max} = 1.0\text{A}$ and $P_{max} = 20\text{W}$.

Note 2: Without a heat sink, the thermal resistance of the TO-5 package is about $150^\circ\text{C}/\text{W}$, while that of the TO-3 package is approximately $35^\circ\text{C}/\text{W}$. With a heat sink, the effective thermal resistance can only approach the values specified, depending on the efficiency of the sink.

typical applications(con't)**Fixed 5V Regulator**

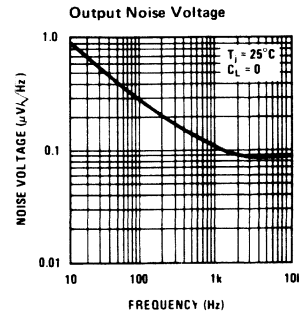
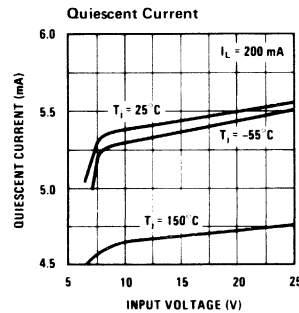
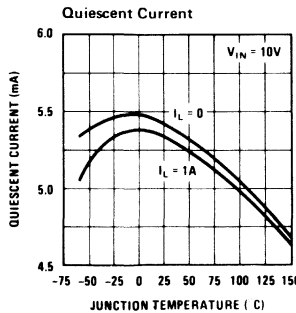
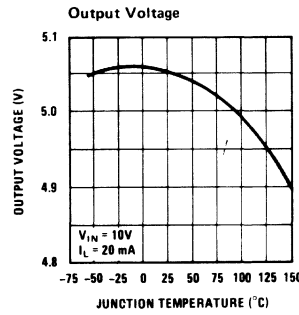
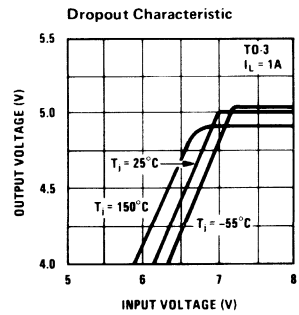
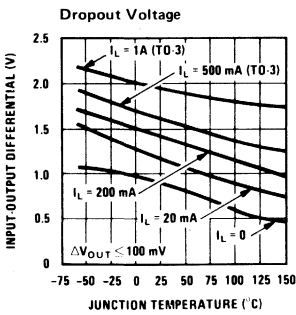
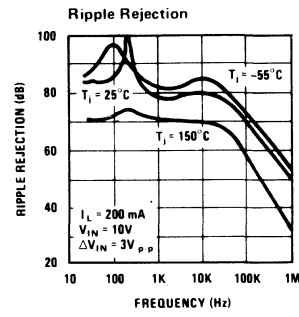
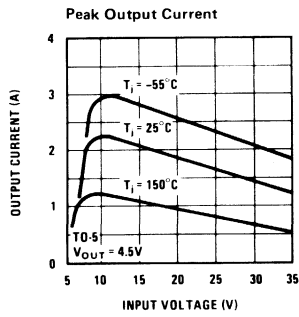
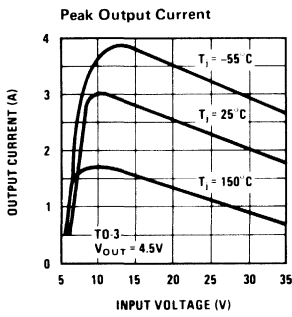
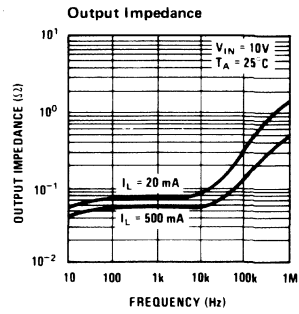
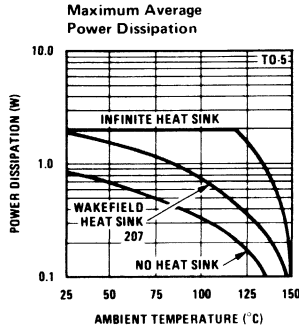
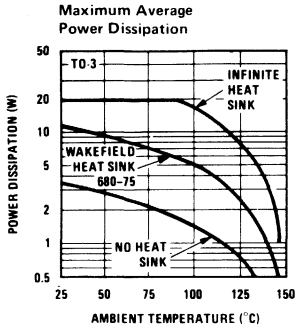
* Required if regulator is located an appreciable distance from power supply filter.

† Although no output capacitor is needed for stability, it does improve transient response.

Adjustable Output Regulator**Current Regulator**

* Determine output current

typical performance characteristics





Voltage Regulators

LM309 five-volt regulator

general description

The LM309 is a complete 5V regulator fabricated on a single silicon chip. It is designed for local regulation on digital logic cards, eliminating the distribution problems associated with single-point regulation. The device is available in two common transistor packages. In the solid-kovar TO-5 header, it can deliver output currents in excess of 200 mA, if adequate heat sinking is provided. With the TO-3 power package, the available output current is greater than 1A.

The regulator is essentially blow-out proof. Current limiting is included to limit the peak output current to a safe value. In addition, thermal shutdown is provided to keep the IC from overheating. If internal dissipation becomes too great, the regulator will shut down to prevent excessive heating.

Considerable effort was expended to make the LM309 easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient

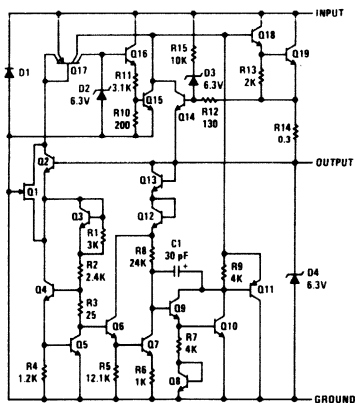
response somewhat. Input bypassing is needed, however, if the regulator is located very far from the filter capacitor of the power supply. Stability is also achieved by methods that provide very good rejection of load or line transients as are usually seen with TTL logic.

Although designed primarily as a fixed-voltage regulator, the output of the LM309 can be set to voltages above 5V, as shown below. It is also possible to use the circuit as the control element in precision regulators, taking advantage of the good current-handling capability and the thermal overload protection.

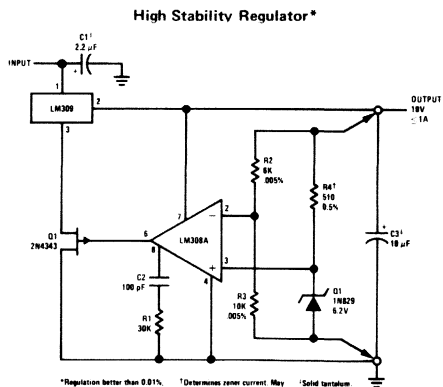
To summarize, outstanding features of the regulator are:

- Specified to be compatible, worst case, with TTL and DTL
- Output current in excess of 1A
- Internal thermal overload protection
- No external components required

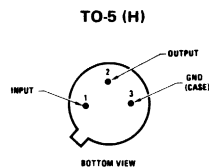
schematic diagram



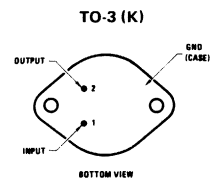
typical application



connection diagrams



Order Number LM309H
See Package 9



Order Number LM309K
See Package 18

absolute maximum ratings

Input Voltage	35V
Power Dissipation	Internally Limited
Operating Junction Temperature Range	0°C to 125°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

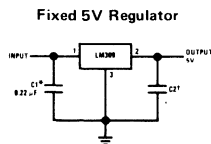
design characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_j = 25^\circ\text{C}$	4.8	5.05	5.2	V
Line Regulation	$T_j = 25^\circ\text{C}$ $7\text{V} \leq V_{IN} \leq 25\text{V}$		4.0	50	mV
Load Regulation	$T_j = 25^\circ\text{C}$				
LM309H	$5\text{ mA} \leq I_{OUT} \leq 0.5\text{A}$		20	50	mV
LM309K	$5\text{ mA} \leq I_{OUT} \leq 1.5\text{A}$		50	100	mV
Output Voltage	$7\text{V} \leq V_{IN} \leq 25\text{V}$ $5\text{ mA} \leq I_{OUT} \leq I_{max}$ $P < P_{max}$	4.75		5.25	V
Quiescent Current	$7\text{V} \leq V_{IN} \leq 25\text{V}$		5.2	10	mA
Quiescent Current Change	$7\text{V} \leq V_{IN} \leq 25\text{V}$ $5\text{ mA} \leq I_{OUT} \leq I_{max}$			0.5	mA
				0.8	mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$ $10\text{ Hz} \leq f \leq 100\text{ kHz}$		40		μV
Long Term Stability				20	mV
Thermal Resistance					
Junction to Case (Note 2)					$^\circ\text{C/W}$
LM309H			15		$^\circ\text{C/W}$
LM309K			3.0		$^\circ\text{C/W}$

Note 1: Unless otherwise specified, these specifications apply for $0^\circ\text{C} \leq T_j \leq 125^\circ\text{C}$, $V_{IN} = 10\text{V}$ and $I_{OUT} = 0.1\text{A}$ for the LM309H or $I_{OUT} = 0.5\text{A}$ for the LM309K. For the LM309H, $I_{max} = 0.2\text{A}$ and $P_{max} = 2.0\text{W}$. For the LM309K, $I_{max} = 1.0\text{A}$ and $P_{max} = 20\text{W}$.

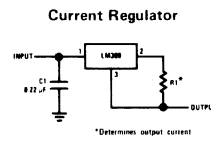
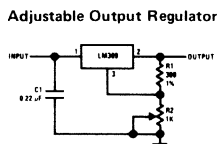
Note 2: Without a heat sink, the thermal resistance of the TO-5 package is about 150°C/W , while that of the TO-3 package is approximately 35°C/W . With a heat sink, the effective thermal resistance can only approach the values specified, depending on the efficiency of the sink.

typical applications(con't)



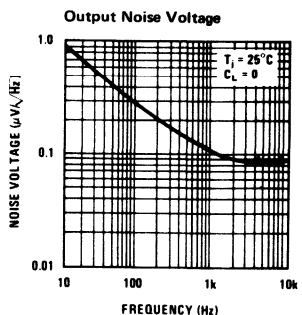
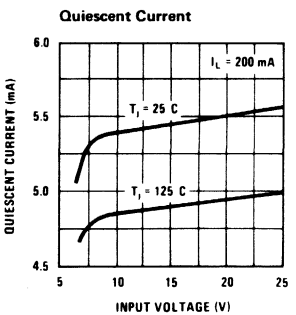
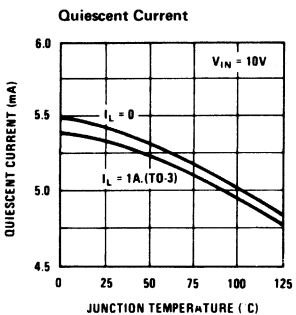
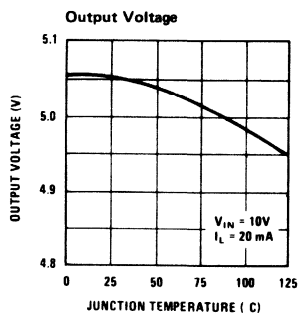
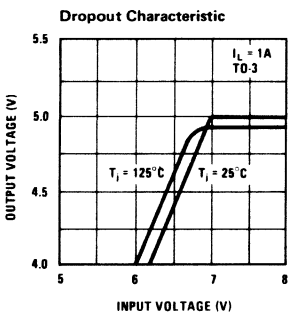
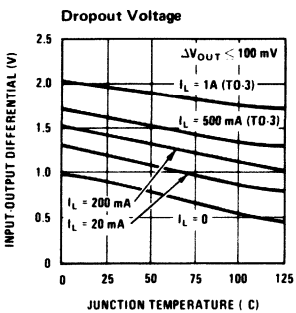
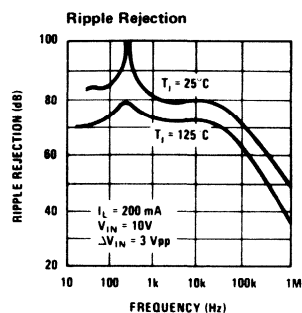
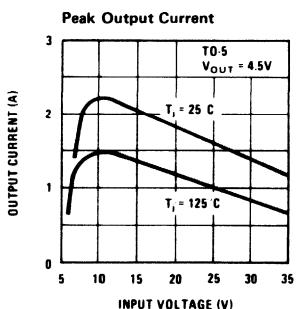
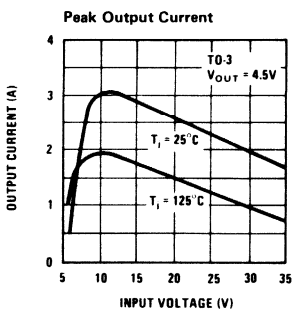
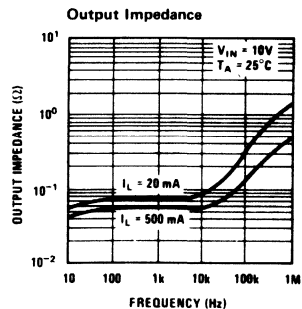
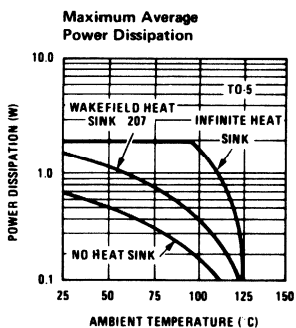
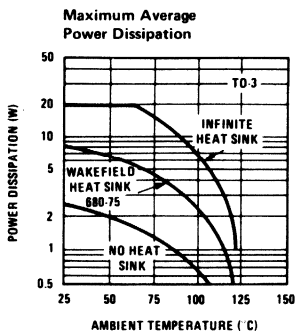
*Required if regulator is located an appreciable distance from power supply filter.

†Although no output capacitor is needed for stability, it does improve transient response.



*Determines output current

typical performance characteristics



1



Voltage Regulators

LM113 reference diode

general description

The LM113 is a temperature-compensated, low-voltage reference diode. It features extremely-tight regulation over a wide range of operating currents in addition to an unusually-low breakdown voltage and good temperature stability.

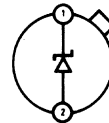
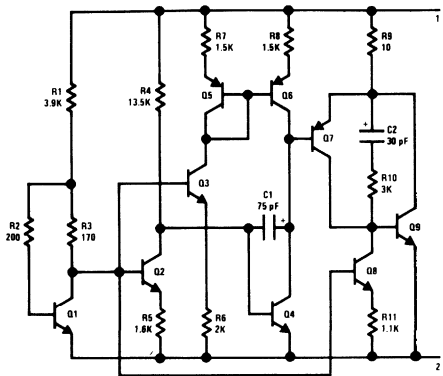
The diode is synthesized using transistors and resistors in a monolithic integrated circuit. As such, it has the same low noise and long term stability as modern IC op amps. Further, output voltage of the reference depends only on highly-predictable properties of components in the IC; so it can be manufactured and supplied to tight tolerances. Outstanding features include:

- Low breakdown voltage: 1.220V

- Dynamic impedance of 0.3Ω from $500\mu\text{A}$ to 20mA
- Temperature stability typically 1% over -55°C to 125°C range
- Tight tolerance: $\pm 5\%$ standard, $\pm 2\%$ and $\pm 1\%$ on special order.

The characteristics of this reference recommend it for use in bias-regulation circuitry, in low-voltage power supplies or in battery powered equipment. The fact that the breakdown voltage is equal to a physical property of silicon—the energy-band-gap voltage—makes it useful for many temperature-compensation and temperature-measurement functions.

schematic and connection diagrams

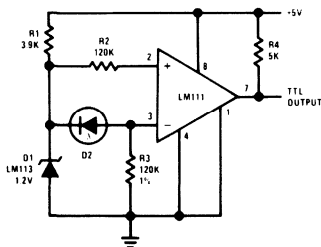


NOTE: Pin 2 connected to case
TOP VIEW

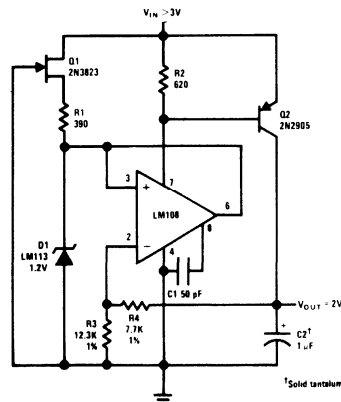
Order Number LM113H
See Package 8

typical applications

Level Detector for Photodiode



Low Voltage Regulator



absolute maximum ratings

Power Dissipation (Note 1)	100 mW
Reverse Current	50 mA
Forward Current	50 mA
Operating Temperature Range	-55°C to 125°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

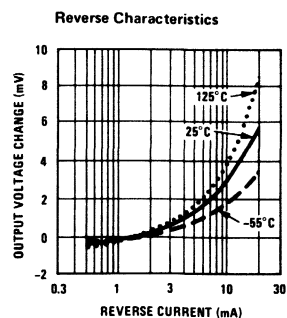
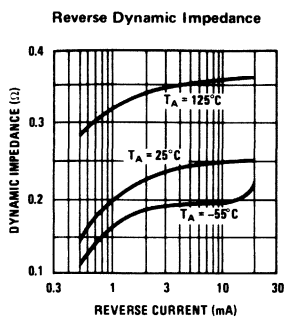
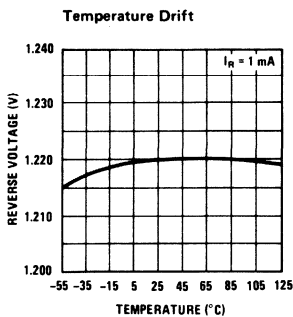
electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Reverse Breakdown Voltage	$I_R = 1 \text{ mA}$	1.160	1.220	1.280	V
Reverse Breakdown Voltage Change	$0.5 \text{ mA} \leq I_R \leq 20 \text{ mA}$		6.0	15	mV
Reverse Dynamic Impedance	$I_R = 1 \text{ mA}$ $I_R = 10 \text{ mA}$		0.2 0.25	1.0 0.8	Ω Ω
Forward Voltage Drop	$I_F = 1.0 \text{ mA}$		0.67	1.0	V
RMS Noise Voltage	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}$ $I_R = 1 \text{ mA}$		5		μV
Reverse Breakdown Voltage Change	$0.5 \text{ mA} \leq I_R \leq 10 \text{ mA}$ $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$			15	mV
Breakdown Voltage Temperature Coefficient	$1.0 \text{ mA} \leq I_R \leq 10 \text{ mA}$ $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$		0.01		%/ $^\circ\text{C}$

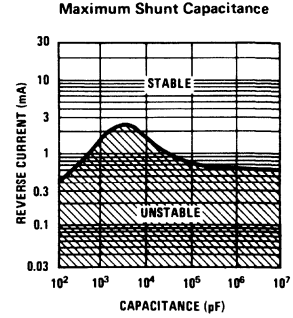
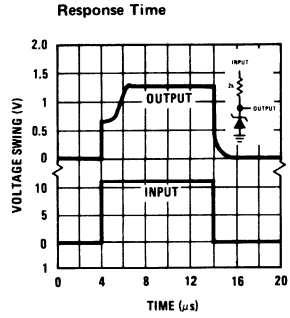
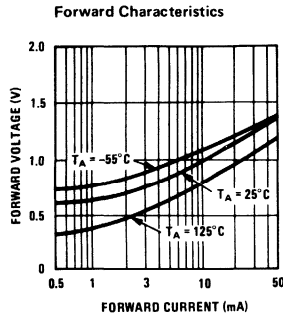
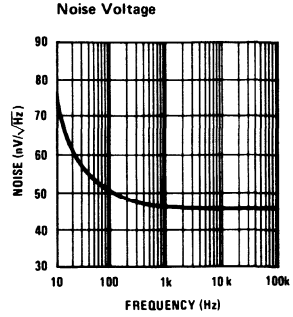
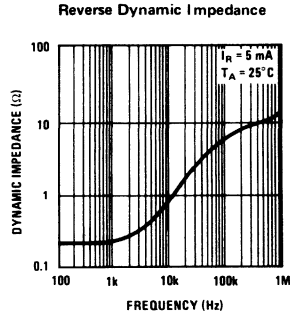
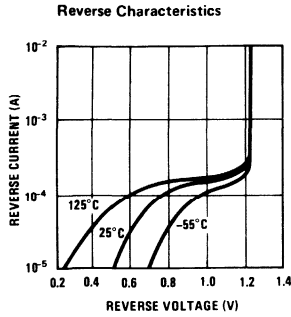
Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction and a thermal resistance of 80°C/W junction to case or 440°C/W junction to ambient.

Note 2: These specifications apply for $T_A = 25^\circ\text{C}$, unless stated otherwise. At high currents, breakdown voltage should be measured with lead lengths less than 1/4 inch. Kelvin contact sockets are also recommended. The diode should not be operated with shunt capacitances between 200 pF and 0.1 μF , unless isolated by at least a 100 Ω resistor, as it may oscillate at some currents.

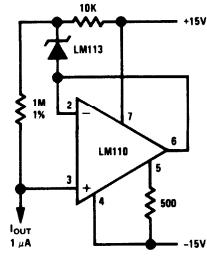
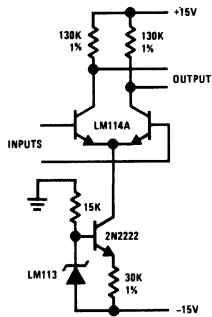
typical performance characteristics



typical performance characteristics (con't)

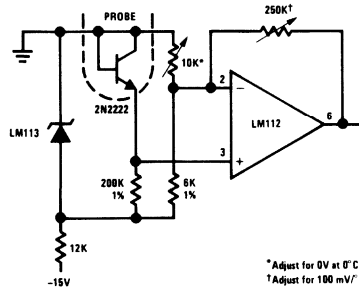


typical applications (con't)



Amplifier Biasing for Constant Gain with Temperature

Constant Current Source



* Adjust for 0V at 0°C
 † Adjust for 100 mV/°C

Thermometer



Voltage Regulators

LM120 series three-terminal negative regulators

general description

The LM120 Series are three-terminal negative regulators with a fixed output voltage of $-5V$, $-5.2V$, $-12V$, and $-15V$ and up to 1.5A load current capability. These devices need only one external component – a compensation capacitor at the output, making them easy to apply. Worst case guarantees on output voltage deviation due to any combination of line, load or temperature variation assure satisfactory system operation.

Exceptional effort has been made to make the LM120 Series immune to overload conditions. The regulators have current limiting which is independent of temperature, combined with thermal overload protection. Internal current limiting protects against momentary faults while thermal shutdown prevents junction temperatures from exceeding safe limits during prolonged overloads.

Although primarily intended for fixed output voltage applications, the LM120 Series may be pro-

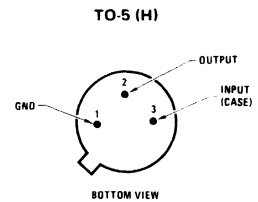
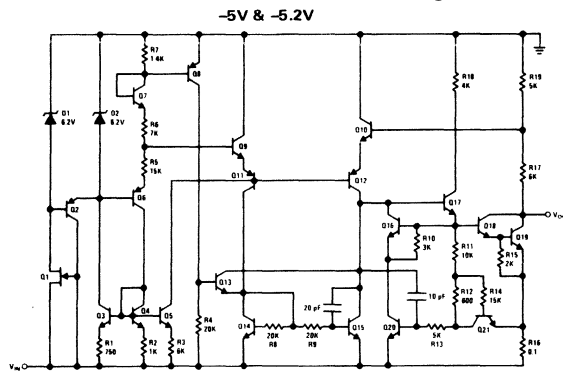
grammed for higher output voltages with a simple resistive divider. The low quiescent drain current of the devices allows this technique to be used with good regulation.

The LM120 Series is available in TO-5 and TO-3 packages. The TO-5 is rated at 200 mA and 2W; the TO-3 at 1A and 20W.

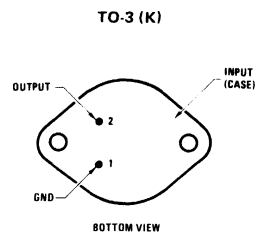
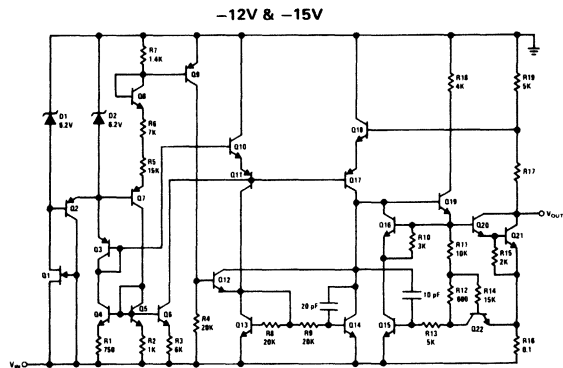
features

- Preset output voltage error less than $\pm 3\%$
- Preset current limit
- Internal thermal shutdown
- Operates with input-output voltage differential down to 1V
- Excellent ripple rejection
- 50 mV load regulation

schematic and connection diagrams



Order Numbers:
 LM120H-05 LM120H-5.2 LM120H-12 LM120H-15
 LM220H-05 LM220H-5.2 LM220H-12 LM220H-15
 LM320H-05 LM320H-5.2 LM320H-12 LM320H-15
 See Package 9



Order Numbers:
 LM120K-05 LM120K-5.2 LM120K-12 LM120K-15
 LM220K-05 LM220K-5.2 LM220K-12 LM220K-15
 LM320K-05 LM320K-5.2 LM320K-12 LM320K-15
 See Package 18

absolute maximum ratings

Device Type	Input Voltage	Input-Output Differential	Power Dissipation Operating Junction Temperature Range	Internally Limited
LM120 Series: 5.0V	-25V	25V	LM120	-55°C to +150°C
LM120 Series: 5.2V	-25V	25V	LM220	-25°C to +150°C
LM120 Series: 12V	-35V	30V	LM320	0°C to +125°C
LM120 Series: 15V	-40V	30V	Storage Temperature Range	-65°C to +150°C
			Lead Temperature (Soldering 10 sec)	300°C

electrical characteristics (-5V & -5.2V) (Note 1)

PARAMETER	CONDITIONS	LM120 LM220		TYP	LM320		UNITS
		MIN	MAX		MIN	MAX	
Output Voltage	$T_j = 25^\circ\text{C}$ -5V	-5.1	-4.9	-5.0	-5.2	-4.8	V
	-5.2V	-5.3	-5.1	-5.2	-5.4	-5.0	V
Line Regulation (Note 2)	$T_j = 25^\circ\text{C}$ $-25\text{V} \leq V_{IN} \leq -7\text{V}$		25	10		50	mV
Load Regulation (Note 2)	$T_j = 25^\circ\text{C}$						
H Package	$5\text{ mA} \leq I_{OUT} \leq 0.5\text{A}$		50	20		50	mV
K Package	$5\text{ mA} \leq I_{OUT} \leq 1.5\text{A}$		75	50		100	mV
Output Voltage	$-25\text{V} \leq V_{IN} < -7\text{V}$ $5\text{ mA} \leq I_{OUT} < I_{MAX}$ $P \leq P_{MAX}$						
	-5V	-5.20	-4.80		-5.25	-4.75	V
	-5.2V	-5.40	-5.00		-5.45	-4.95	V
Quiescent Current	$-25\text{V} \leq V_{IN} \leq -7\text{V}$		2.0	1.0		2.0	mA
Quiescent Current Change	$T_A = 25^\circ\text{C}$						
	$-25\text{V} \leq V_{IN} \leq -7\text{V}$		0.4	0.1		0.4	mA
	$5\text{ mA} \leq I_{OUT} < I_{MAX}$		0.4	0.1		0.4	mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$, $C_L = 1\ \mu\text{F}$ $10\text{ Hz} \leq f \leq 100\text{ kHz}$			150			μV
Long Term Stability			50	5		50	mV
Thermal Resistance Junction to Case							$^\circ\text{C/W}$
H Package				15			$^\circ\text{C/W}$
K Package				3			$^\circ\text{C/W}$

electrical characteristics (-12V) (Note 1)

PARAMETER	CONDITIONS	LM120 LM220		TYP	LM320		UNITS
		MIN	MAX		MIN	MAX	
Output Voltage	$T_j = 25^\circ\text{C}$	-12.3	-11.7	-12	-12.4	-11.6	V
Line Regulation (Note 2)	$T_j = 25^\circ\text{C}$ $-32\text{V} \leq V_{IN} \leq -14\text{V}$		10	4		20	mV
Load Regulation	$T_j = 25^\circ\text{C}$						
H Package	$5\text{ mA} \leq I_{OUT} \leq 0.2\text{A}$		25	10		40	mV
K Package (Note 2)	$5\text{ mA} \leq I_{OUT} \leq 1.0\text{A}$		80	30		80	mV
Output Voltage	$-32\text{V} \leq V_{IN} \leq -14\text{V}$ $5\text{ mA} \leq I_{OUT} \leq I_{MAX}$ $P \leq P_{MAX}$	-12.5	-11.5		-12.6	-11.4	V
Quiescent Current	$-32\text{V} \leq V_{IN} \leq -14\text{V}$		4	2		4	mA
Quiescent Current Change	$T_j = 25^\circ\text{C}$						
	$-32\text{V} \leq V_{IN} < -14\text{V}$			0.1			mA
	$5\text{ mA} \leq I_{OUT} < I_{MAX}$			0.1			mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$ $10\text{ Hz} < f \leq 100\text{ kHz}$			400			μV
Long Term Stability			120	15		120	mV

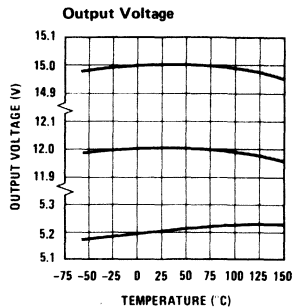
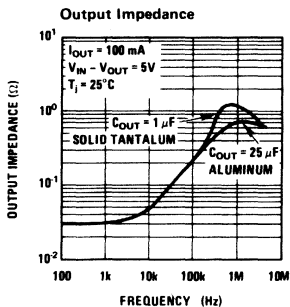
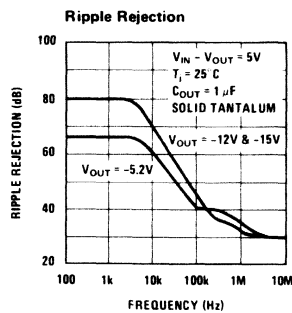
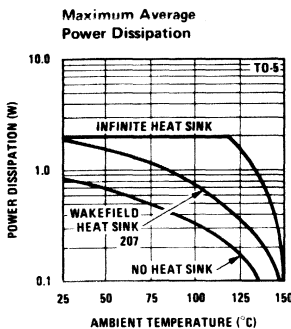
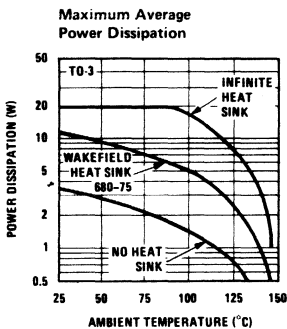
electrical characteristics (-15V) (Note 1)

PARAMETER	CONDITIONS	LM120 LM220		TYP	LM320		UNITS
		MIN	MAX		MIN	MAX	
Output Voltage	$T_J = 25^\circ\text{C}$	-15.3	-14.7	-15	-15.4	-14.6	V
Line Regulation (Note 2)	$T_J = 25^\circ\text{C}$ $-35\text{V} \leq V_{IN} \leq -17\text{V}$		10	5		20	mV
Load Regulation	$T_J = 25^\circ\text{C}$						
H Package (Note 2)	$5\text{ mA} \leq I_{OUT} \leq 0.2\text{A}$		25	10		40	mV
K Package (Note 2)	$5\text{ mA} \leq I_{OUT} \leq 1.0\text{A}$		80	30		80	mV
Output Voltage	$-35\text{V} \leq V_{IN} \leq -17\text{V}$ $5\text{ mA} \leq I_{OUT} \leq I_{MAX}$ $P \leq P_{MAX}$	15.5	14.5		15.6	14.4	V
Quiescent Current	$-35\text{V} \leq V_{IN} \leq -17\text{V}$		4	2		4	mA
Quiescent Current Change	$T_J = 25^\circ\text{C}$ $-35\text{V} \leq V_{IN} \leq -17\text{V}$ $5\text{ mA} \leq I_{OUT} \leq I_{MAX}$			0.1			mA
Output Noise Voltage				400			μV
Long Term Stability			150	15		150	mV

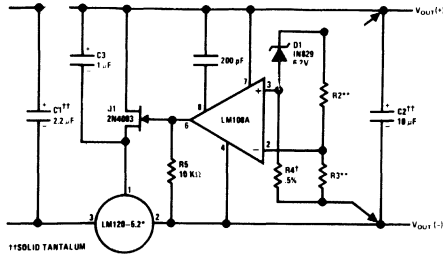
Note 1: Unless otherwise specified, these specifications apply: $-55^\circ\text{C} < T_J < 150^\circ\text{C}$ for the LM120; $-25^\circ\text{C} < T_J < 150^\circ\text{C}$ for the LM220, and $0^\circ\text{C} < T_J < 125^\circ\text{C}$ for the LM320; $V_{IN} = (V_{OUT} + 5\text{V})$ and $I_{OUT} = 0.1\text{A}$ for the TO-5 package and $I_{OUT} = 0.5\text{A}$ for the TO-3 package. For the TO-5 package, $I_{MAX} = 0.2\text{A}$ and $P_{MAX} = 2.0\text{W}$. For the TO-3 package, $I_{MAX} = 1.0\text{A}$ and $P_{MAX} = 20\text{W}$. Although power dissipation is internally limited, electrical specifications apply only for power levels up to P_{MAX} . For calculations of junction temperature rise due to power dissipation, use a thermal resistance of 150°C/W for the TO-5 and 35°C/W for the TO-3. With an infinite heat sink, the thermal resistance is 15°C/W and 3°C/W respectively.

Note 2: Regulation is measured at constant junction temperature. Changes in output voltage due to heating effects must be taken into account separately. To ensure constant junction temperature, pulse testing with a low duty cycle is used.

typical performance characteristics

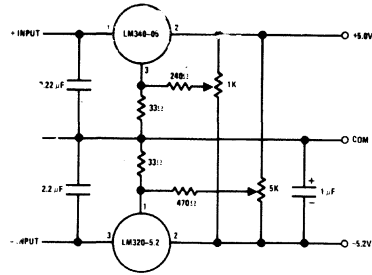


typical applications

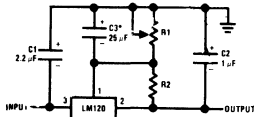


1. SOLID TANTALUM
 LOAD & LINE REGULATION
 < 0.5% TEMPERATURE
 STABILITY < 0.1%
 2. DETERMINES ZENER CURRENT
 MAY BE ADJUSTED TO MINIMIZE
 TEMPERATURE DRIFT
 3. SELECT RESISTORS TO SET
 OUTPUT VOLTAGE. 1 PPM/°C TRACKING
 SUGGESTED.
 AN LM120-12 OR LM120-15 MAY
 BE USED TO PERMIT HIGHER
 INPUT VOLTAGES, BUT THE
 REGULATED OUTPUT VOLTAGE
 MUST BE AT LEAST -15V WHEN
 USING THE LM120-12 AND -18V
 FOR THE LM120-15.

High Stability 1 Amp Regulator

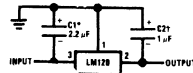


Dual Trimmed Supply



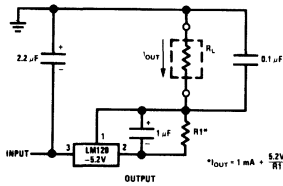
1. Optional. Improves
 transient response and
 ripple rejection.
 $V_{out} = V_{ref} \left(\frac{R1 + R2}{R2} \right)$
 SELECT R2 AS FOLLOWS
 LM120S - 300:
 LM120S-2 - 300:
 LM120-12 - 750:
 LM120-15 - 1 K:

Variable Output



1. REQUIRED IF REGULATOR
 IS SEPARATED FROM
 FILTER CAPACITOR. FOR
 VALUE GIVEN, CAPACI-
 TOR MUST BE SOLID TAN-
 TALUM. 25µF ALUMINUM
 ELECTROLYTIC MAY BE
 SUBSTITUTED.
 2. REQUIRED FOR STABILITY. FOR
 VALUE GIVEN, CAPACITOR MUST
 BE SOLID TANTALUM. 25µF
 ALUMINUM ELECTROLYTIC MAY
 BE SUBSTITUTED. VALUES GIVEN
 MAY BE INCREASED WITHOUT
 LIMIT.
 3. FOR OUTPUT CAPACITANCE
 IN EXCESS OF 100µF. A HIGH
 CURRENT DIODE FROM INPUT
 TO OUTPUT (14MB01, ETC) WILL
 PROTECT THE REGULATOR FROM
 MOMENTARY INPUT SHORTS.

Fixed Regulator



Current Source



LM123/LM223/LM323 3 amp - 5 volt positive regulator

general description

The LM123 is a three-terminal positive regulator with a preset 5V output and a load driving capability of 3 amps. New circuit design and processing techniques are used to provide the high output current without sacrificing the regulation characteristics of lower current devices.

The 3 amp regulator is virtually blowout proof. Current limiting, power limiting, and thermal shutdown provide the same high level of reliability obtained with these techniques in the LM109 1 amp regulator.

No external components are required for operation of the LM123. If the device is more than 4 inches from the filter capacitor, however, a 1μF solid tantalum capacitor should be used on the input. A 0.1μF or larger capacitor may be used on the output to reduce load transient spikes created by fast switching digital logic, or to swamp out stray load capacitance.

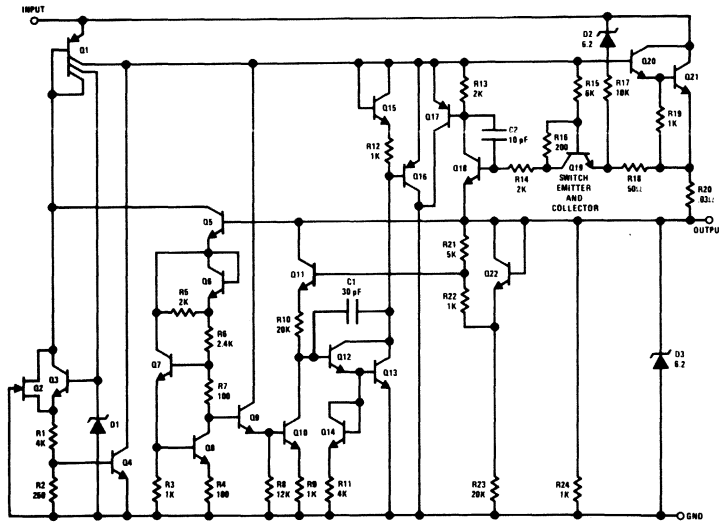
An overall worst case specification for the combined effects of input voltage, load currents, ambient temperature, and power dissipation ensure that the LM123 will perform satisfactorily as a system element.

Operation is guaranteed over the junction temperature range -55°C to +150°C. An electrically identical LM223 operates from -25°C to +150°C and the LM323 is specified from 0°C to +125°C junction temperature. A hermetic TO-3 package is used for high reliability and low thermal resistance.

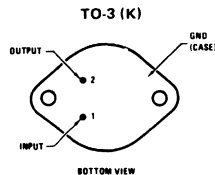
features

- 3 amp output current
- Internal current and thermal limiting
- 0.01Ω typical output impedance
- 7.5 minimum input voltage
- 30W power dissipation

schematic diagram



connection diagram

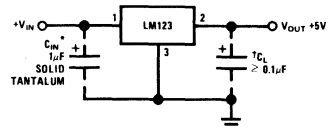


Order Number LM123K,
LM223K, or LM323K

See Package 18

typical applications

Basic 3 Amp Regulator



*REQUIRED IF LM123 IS MORE THAN 4" FROM FILTER CAPACITOR
REGULATOR IS STABLE WITH NO LOAD CAPACITOR INTO RESISTIVE LOADS

absolute maximum ratings

Input Voltage	20V
Power Dissipation	Internally Limited
Operating Junction Temperature Range	
LM123	-55°C to +150°C
LM223	-25°C to +150°C
LM323	0°C to +125°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LM123/LM223			LM323			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage	$T_j = 25^\circ\text{C}$ $V_{IN} = 7.5\text{V}, I_{OUT} = 0$	4.7	5	5.3	4.8	5	5.2	V
Output Voltage	$7.5\text{V} \leq V_{IN} \leq 15\text{V}$ $0 \leq I_{OUT} \leq 3\text{A}, P \leq 30\text{W}$	4.6		5.4	4.75		5.25	V
Line Regulation (Note 3)	$T_j = 25^\circ\text{C}$ $7.5\text{V} \leq V_{IN} \leq 15\text{V}$		5	25		5	25	mV
Load Regulation (Note 3)	$T_j = 25^\circ\text{C}, V_{IN} = 7.5\text{V}$ $0 \leq I_{OUT} \leq 3\text{A}$		25	100		25	100	mV
Quiescent Current	$7.5\text{V} \leq V_{IN} \leq 15\text{V}$ $0 \leq I_{OUT} \leq 3\text{A}$		12	20		12	20	mA
Output Noise Voltage	$T_j = 25^\circ\text{C}$ $10\text{ Hz} \leq f \leq 100\text{ kHz}$		40			40		μV_{rms}
Short Circuit Current Limit	$T_j = 25^\circ\text{C}$ $V_{IN} = 15\text{V}$ $V_{IN} = 7.5\text{V}$		3	4.5		3	4.5	A
			4	5		4	5	A
Long Term Stability				35			35	mV
Thermal Resistance Junction to Case (Note 2)			2			2		$^\circ\text{C}/\text{W}$

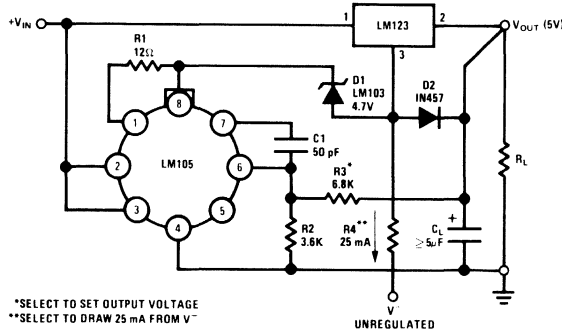
Note 1: Unless otherwise noted, specifications apply for $-55^\circ\text{C} \leq T_j \leq +150^\circ\text{C}$ for the LM123, $-25^\circ\text{C} \leq T_j \leq +150^\circ\text{C}$ for the LM223, and $0^\circ\text{C} \leq T_j \leq +125^\circ\text{C}$ for the LM323. Although power dissipation is internally limited, specifications apply only for $P \leq 30\text{W}$.

Note 2: Without a heat sink, the thermal resistance of the TO-3 package is about $35^\circ\text{C}/\text{W}$. With a heat sink, the effective thermal resistance can only approach the specified values of $2^\circ\text{C}/\text{W}$, depending on the efficiency of the heat sink.

Note 3: Load and line regulation are specified at constant junction temperature. Pulse testing is required with a pulse width $\leq 1\text{ ms}$ and a duty cycle $\leq 5\%$.

typical applications (con't)

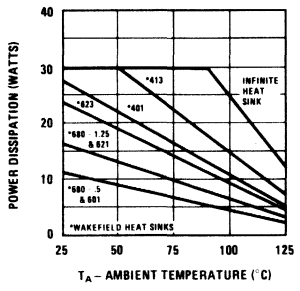
Adjustable Output 5V – 10V 0.1% Regulation



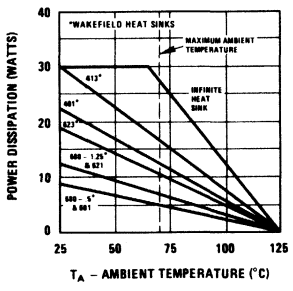
*SELECT TO SET OUTPUT VOLTAGE
**SELECT TO DRAW 25 mA FROM V⁻

typical performance characteristics

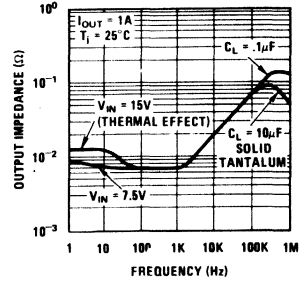
Maximum Average Power Dissipation For LM123; LM223



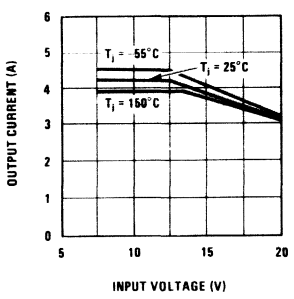
Maximum Average Power Dissipation For LM323



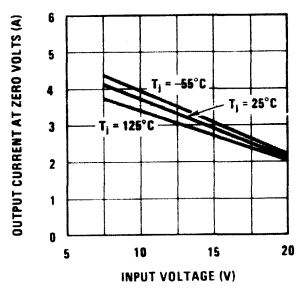
Output Impedance



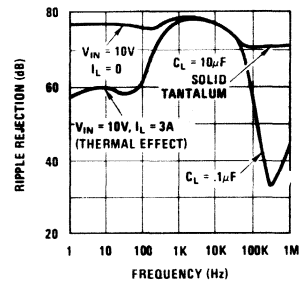
Peak Available Output Current



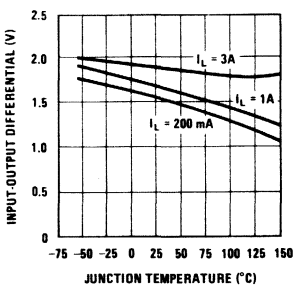
Short Circuit Current



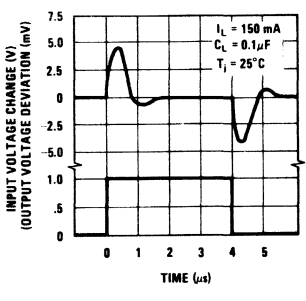
Ripple Rejection



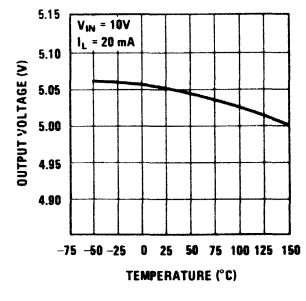
Dropout Voltage



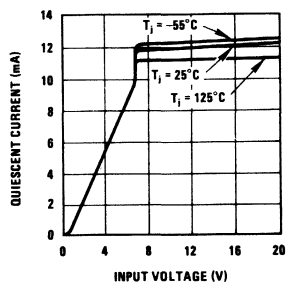
Line Transient Response



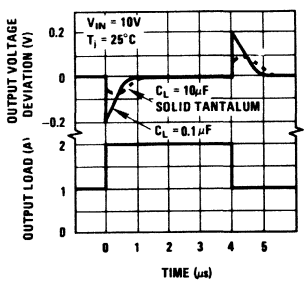
Output Voltage



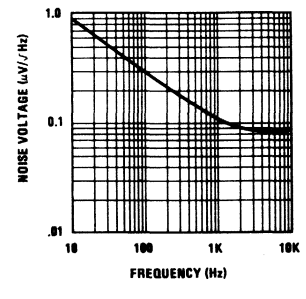
Quiescent Current



Load Transient Response

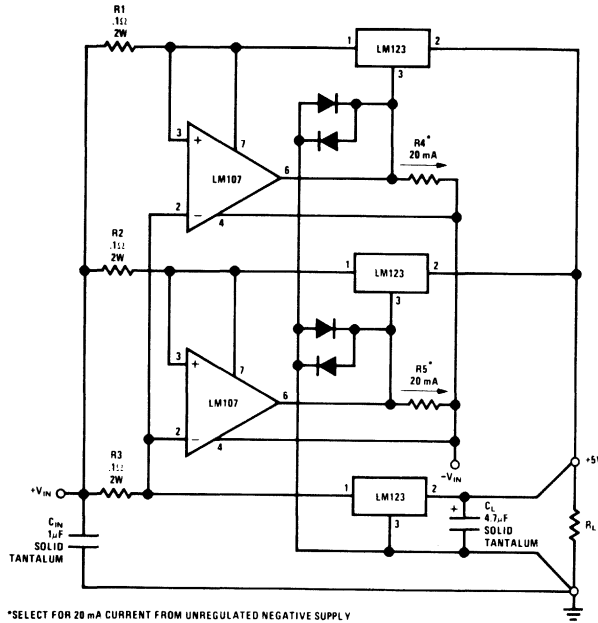


Output Noise Voltage

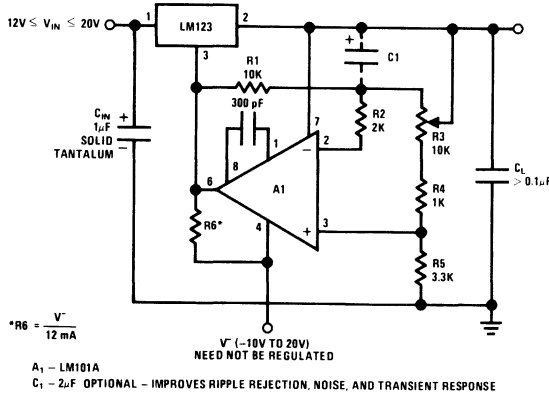


typical applications (con't)

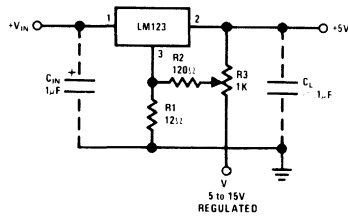
10 Amp Regulator With Complete Overload Protection



Adjustable Regulator 0-10V @ 3A



Trimming Output to 5V





Voltage Regulators

LM340 series 3-terminal positive regulators

general description

The LM340-XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents.

The LM340-XX series is available in two power packages. Both the plastic TO-220 and metal TO-3 packages allow these regulators to deliver over 1.0A if adequate heat sinking is provided. Even with over 1.0A of output current available the regulators are essentially blow-out proof. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

Considerable effort was expended to make the LM340-XX series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

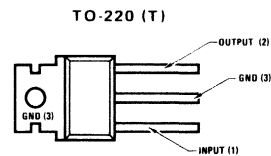
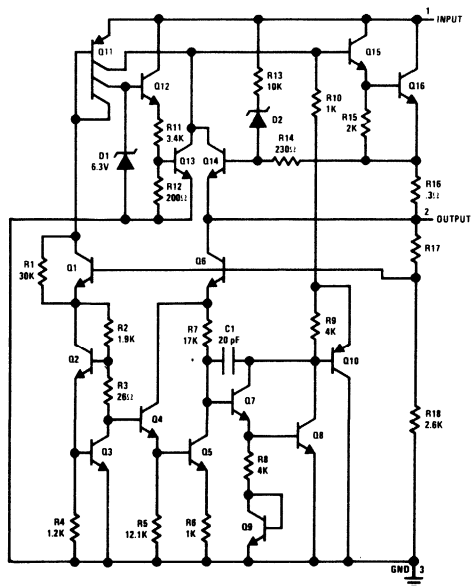
features

- Output current in excess of 1A
- Internal thermal overload protection
- No external components required
- Output transistor safe area protection
- Internal short circuit current limit
- Available in plastic TO-220 and metal TO-3 packages

voltage range

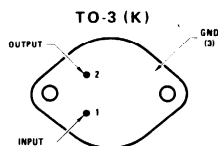
LM340-5	5V	LM340-15	15V
LM340-6	6V	LM340-18	18V
LM340-8	8V	LM340-24	24V
LM340-12	12V		

schematic and connection diagrams



TOP VIEW
Order Numbers:
 LM340T-5 LM340T-15
 LM340T-6 LM340T-18
 LM340T-8 LM340T-24
 LM340T-12

See Package 26



BOTTOM VIEW
Order Numbers:
 LM340K-5 LM340K-15
 LM340K-6 LM340K-18
 LM340K-8 LM340K-24
 LM340K-12

See Package 18

absolute maximum ratings

Input Voltage ($V_O = 5V$ through $18V$)	35V
($V_O = 24V$)	40V
Internal Power Dissipation (Note 1)	Internally Limited
Operating Temperature Range	0°C to 70°C
Maximum Junction Temperature	
TO-3 Package	150°C
TO-220 Package	150°C
Storage Temperature Range	-65°C to $+150^\circ\text{C}$
Lead Temperature	
TO-3 Package (Soldering, 10 sec)	300°C
TO-220 Package (Soldering, 10 sec)	230°C

electrical characteristics

LM340-5 ($V_{IN} = 10V$, $I_{OUT} = 500\text{ mA}$, $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_J = 25^\circ\text{C}$	4.8	5	5.2	V
Line Regulation	$T_J = 25^\circ\text{C}$, $7V \leq V_{IN} \leq 25V$ $I_{OUT} = 100\text{ mA}$ $I_{OUT} = 500\text{ mA}$			50 100	mV mV
Load Regulation	$T_J = 25^\circ\text{C}$, $5\text{ mA} \leq I_{OUT} \leq 1.5A$			100	mV
Output Voltage	$7V \leq V_{IN} \leq 20V$, $5\text{ mA} \leq I_{OUT} \leq 1.0A$ $P_D \leq 15W$	4.75		5.25	V
Quiescent Current	$T_J = 25^\circ\text{C}$		7	10	mA
Quiescent Current Change	$7V \leq V_{IN} \leq 25V$ $5\text{ mA} \leq I_{OUT} \leq 1.5A$			1.3 .5	mA mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$		40		μV
Long Term Stability				20	mV/1000 hr
Ripple Rejection	$I_{OUT} = 20\text{ mA}$, $f = 120\text{ Hz}$		60		dB
Dropout Voltage	$T_J = 25^\circ\text{C}$, $I_{OUT} = 1.0A$		2		V

LM340-6 ($V_{IN} = 11V$, $I_{OUT} = 500\text{ mA}$, $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_J = 25^\circ\text{C}$	5.75	6	6.25	V
Line Regulation	$T_J = 25^\circ\text{C}$, $8V \leq V_{IN} \leq 25V$ $I_{OUT} = 100\text{ mA}$ $I_{OUT} = 500\text{ mA}$			60 120	mV mV
Load Regulation	$T_J = 25^\circ\text{C}$, $5\text{ mA} \leq I_{OUT} \leq 1.5A$			120	mV
Output Voltage	$8V \leq V_{IN} \leq 21V$, $5\text{ mA} \leq I_{OUT} \leq 1.0A$ $P_D \leq 15W$	5.7		6.3	V
Quiescent Current	$T_J = 25^\circ\text{C}$		7	10	mA
Quiescent Current Change	$8V \leq V_{IN} \leq 25V$ $5\text{ mA} \leq I_{OUT} \leq 1.5A$			1.3 .5	mA mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$		45		μV
Long Term Stability				24	mV/1000 hr
Ripple Rejection	$I_{OUT} = 20\text{ mA}$, $f = 120\text{ Hz}$		57		dB
Dropout Voltage	$T_J = 25^\circ\text{C}$, $I_{OUT} = 1.0A$		2		V

Note 1: Thermal resistance without a heat sink for junction to case temperature is 4°C/W for the TO-3 package and 6°C/W for the TO-220 package. Thermal resistance for case to ambient temperature is 35°C/W for the TO-3 package and 50°C/W for the TO-220 package.

electrical characteristics (con't)

LM340-8 ($V_{IN} = 14V$, $I_{OUT} = 500\text{ mA}$, $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_J = 25^\circ\text{C}$	7.7	8	8.3	V
Line Regulation	$T_J = 25^\circ\text{C}$, $10.5V \leq V_{IN} \leq 25V$ $I_{OUT} = 100\text{ mA}$ $I_{OUT} = 500\text{ mA}$			80 160	mV mV
Load Regulation	$T_J = 25^\circ\text{C}$, $5\text{ mA} \leq I_{OUT} \leq 1.5A$			160	mV
Output Voltage	$10.5V \leq V_{IN} \leq 23V$, $5\text{ mA} \leq I_{OUT} \leq 1.0A$ $P_D \leq 15W$	7.6		8.4	V
Quiescent Current	$T_J = 25^\circ\text{C}$		7	10	mA
Quiescent Current Change	$10.5V \leq V_{IN} \leq 25V$ $5\text{ mA} \leq I_{OUT} \leq 1.5A$			1 .5	mA mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$		52		μV
Long Term Stability				32	mV/1000 hr
Ripple Rejection	$I_{OUT} = 20\text{ mA}$, $f = 120\text{ Hz}$		55		dB
Dropout Voltage	$T_J = 25^\circ\text{C}$, $I_{OUT} = 1.0A$		2		V

LM340-12 ($V_{IN} = 19V$, $I_{OUT} = 500\text{ mA}$, $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_J = 25^\circ\text{C}$	11.5	12	12.5	V
Line Regulation	$T_J = 25^\circ\text{C}$, $14.5V \leq V_{IN} \leq 30V$ $I_{OUT} = 100\text{ mA}$ $I_{OUT} = 500\text{ mA}$			120 240	mV mV
Load Regulation	$T_J = 25^\circ\text{C}$, $5\text{ mA} \leq I_{OUT} \leq 1.5A$			240	mV
Output Voltage	$14.5V \leq V_{IN} \leq 27V$, $5\text{ mA} \leq I_{OUT} \leq 1.0A$ $P_D \leq 15W$	11.4		12.6	V
Quiescent Current	$T_J = 25^\circ\text{C}$		7	10	mA
Quiescent Current Change	$14.5V \leq V_{IN} \leq 30V$ $5\text{ mA} \leq I_{OUT} \leq 1.5A$			1 .5	mA mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$		75		μV
Long Term Stability				48	mV/1000 hr
Ripple Rejection	$I_{OUT} = 20\text{ mA}$, $f = 120\text{ Hz}$		52		dB
Dropout Voltage	$T_J = 25^\circ\text{C}$, $I_{OUT} = 1.0A$		2		V

LM340-15 ($V_{IN} = 23V$, $I_{OUT} = 500\text{ mA}$, $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_J = 25^\circ\text{C}$	14.4	15	15.6	V
Line Regulation	$T_J = 25^\circ\text{C}$, $17.5V \leq V_{IN} \leq 30V$ $I_{OUT} = 100\text{ mA}$ $I_{OUT} = 500\text{ mA}$			150 300	mV mV
Load Regulation	$T_J = 25^\circ\text{C}$, $5\text{ mA} \leq I_{OUT} \leq 1.5A$			300	mV
Output Voltage	$17.5V \leq V_{IN} \leq 30V$, $5\text{ mA} \leq I_{OUT} \leq 1.0A$ $P_D \leq 15W$	14.25		15.75	V
Quiescent Current	$T_J = 25^\circ\text{C}$		7	10	mA
Quiescent Current Change	$17.5V \leq V_{IN} \leq 30V$ $5\text{ mA} \leq I_{OUT} \leq 1.5A$			1 .5	mA mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$, $10\text{ Hz} \leq f \leq 100\text{ kHz}$		90		μV
Long Term Stability				60	mV/1000 hr
Ripple Rejection	$I_{OUT} = 20\text{ mA}$, $f = 120\text{ Hz}$		50		dB
Dropout Voltage	$T_J = 25^\circ\text{C}$, $I_{OUT} = 1.0A$		2		V

electrical characteristics (con't)

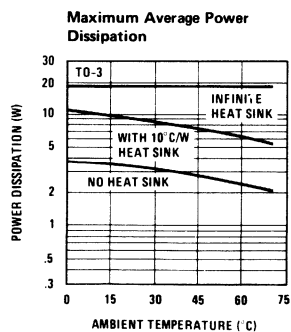
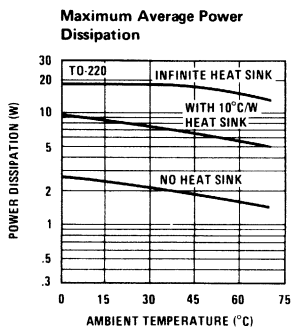
LM340-18 ($V_{IN} = 27V$, $I_{OUT} = 500\text{ mA}$, $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_j = 25^\circ\text{C}$	17.3	18	18.7	V
Line Regulation	$T_j = 25^\circ\text{C}$, $21V < V_{IN} < 33V$ $I_{OUT} = 100\text{ mA}$ $I_{OUT} = 500\text{ mA}$			180	mV
				360	mV
Load Regulation	$T_j = 25^\circ\text{C}$, $5\text{ mA} \leq I_{OUT} < 1.0\text{ A}$			360	mV
Output Voltage	$21V \leq V_{IN} \leq 33V$, $5\text{ mA} \leq I_{OUT} < 1.0\text{ A}$ $P_D \leq 15W$	17.1		18.9	V
Quiescent Current	$T_j = 25^\circ\text{C}$		7	10	mA
Quiescent Current Change	$21V \leq V_{IN} \leq 33V$ $5\text{ mA} \leq I_{OUT} \leq 1.0\text{ A}$			1	mA
				.5	mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$, $10\text{ Hz} < f < 100\text{ kHz}$		110		μV
Long Term Stability				72	mV/1000 hr
Ripple Rejection	$I_{OUT} = 20\text{ mA}$, $f = 120\text{ Hz}$		48		dB
Dropout Voltage	$T_j = 25^\circ\text{C}$, $I_{OUT} = 1.0\text{ A}$		2		V

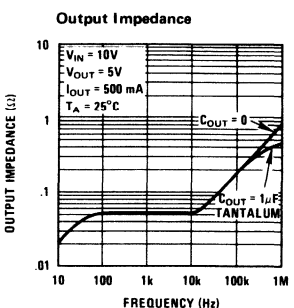
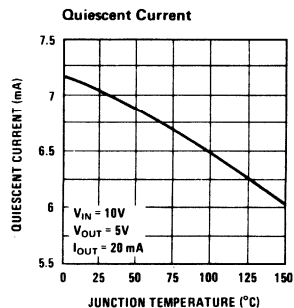
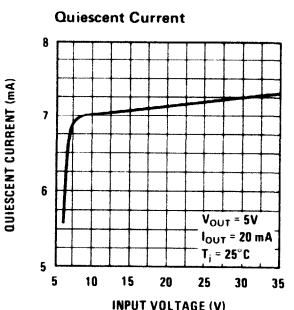
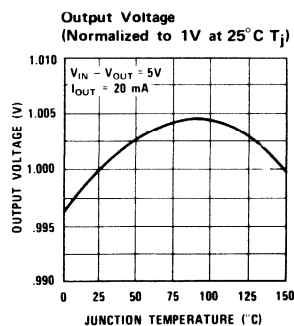
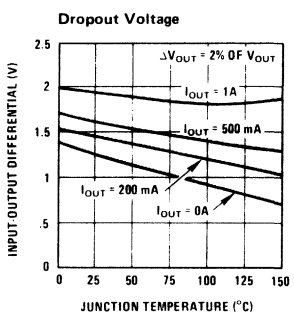
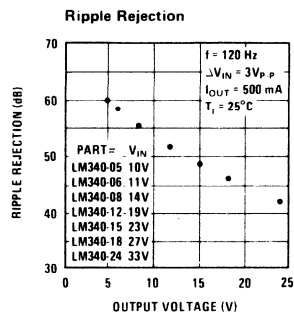
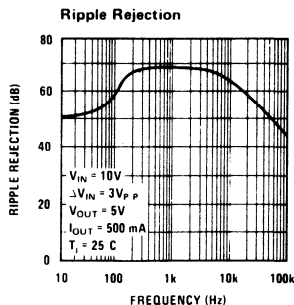
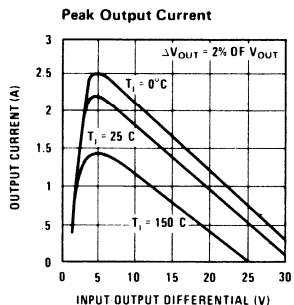
LM340-24 ($V_{IN} = 33V$, $I_{OUT} = 500\text{ mA}$, $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	$T_j = 25^\circ\text{C}$	23	24	25	V
Line Regulation	$T_j = 25^\circ\text{C}$, $27V \leq V_{IN} < 38V$ $I_{OUT} = 100\text{ mA}$ $I_{OUT} = 500\text{ mA}$			240	mV
				480	mV
Load Regulation	$T_j = 25^\circ\text{C}$, $5\text{ mA} \leq I_{OUT} < 1.0\text{ A}$			480	mV
Output Voltage	$27V \leq V_{IN} \leq 38V$, $5\text{ mA} \leq I_{OUT} < 1.0\text{ A}$ $P_D \leq 15W$	22.8		25.2	V
Quiescent Current	$T_j = 25^\circ\text{C}$		7	10	mA
Quiescent Current Change	$27V \leq V_{IN} \leq 38V$ $5\text{ mA} \leq I_{OUT} \leq 1.0\text{ A}$			1	mA
				.5	mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$, $10\text{ Hz} \leq f < 100\text{ kHz}$		170		μV
Long Term Stability				96	mV/1000 hr
Ripple Rejection	$I_{OUT} = 20\text{ mA}$, $f = 120\text{ Hz}$		44		dB
Dropout Voltage	$T_j = 25^\circ\text{C}$, $I_{OUT} = 1.0\text{ A}$		2		V

typical performance characteristics

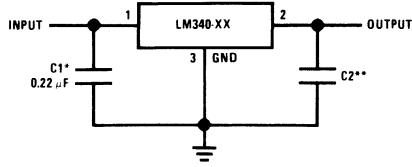


typical performance characteristics (con't)



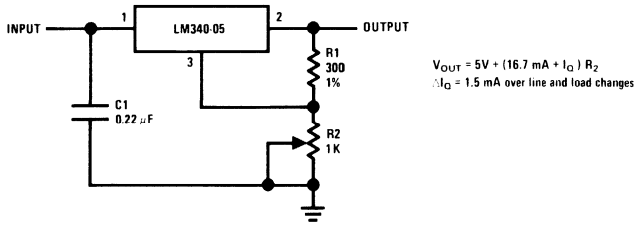
typical applications

Fixed Output Regulator

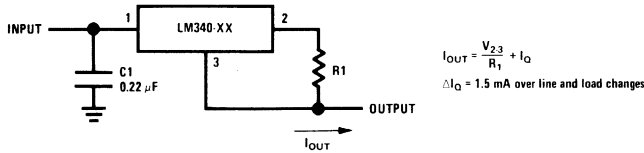


*REQUIRED IF THE REGULATOR IS LOCATED FAR FROM THE POWER SUPPLY FILTER.
 **ALTHOUGH NO OUTPUT CAPACITOR IS NEEDED FOR STABILITY, IT DOES HELP TRANSIENT RESPONSE. (IF NEEDED USE 0.1μF, CERAMIC, DISC.)

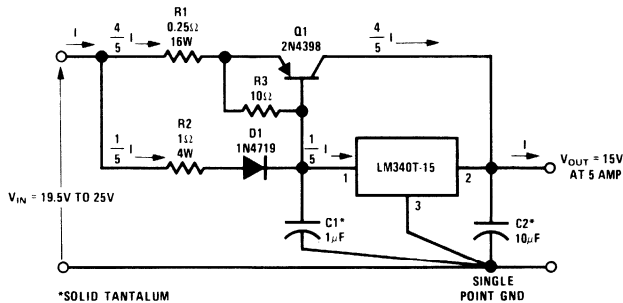
Adjustable Output Regulator



Current Regulator



15V 5 Amp Regulator With Short Circuit Current Limit



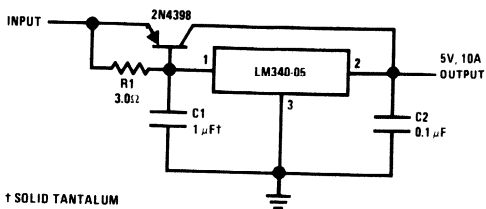
NOTE 1: CURRENT SHARING BETWEEN THE LM340 AND Q1 ALLOWS THE EXTENSION OF SHORT CIRCUIT CURRENT LIMIT, SAFE OPERATING AREA PROTECTION, AND (ASSUMING Q1'S HEAT SINK HAS FOUR OR MORE TIMES THE CAPACITY OF THE LM340 HEAT SINK) THERMAL SHUTDOWN PROTECTION.

NOTE 2: $I_{SHORT \text{ CIRCUIT}}$ IS APPROXIMATELY 5.5 AMP.

NOTE 3: $I_{OUT \text{ MAX}}$ AT $V_{OUT} = 15V$ IS APPROXIMATELY 9.5 AMP.

typical applications (con't)

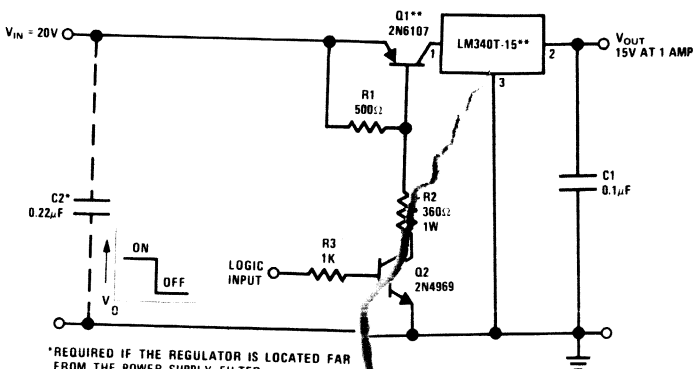
High Current Voltage Regulator



$T_A = 25\text{ C}$
 @ $V_{IN} = 10V, 0A < I_L < 10A$
 Load Regulation = 2 mV
 @ $I_L = 10A, 9V < V_{IN} < 12V$
 Line Regulation = 20 mV

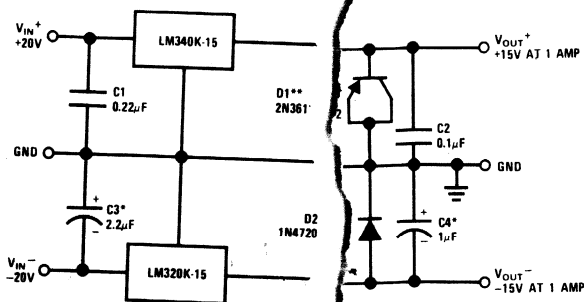
† SOLID TANTALUM

Electronic Shutdown Circuit



* REQUIRED IF THE REGULATOR IS LOCATED FAR FROM THE POWER SUPPLY FILTER
 ** HEAT SINK Q1 AND THE LM340

Dual Power Supply



* SOLID TANTALUM
 ** GERMANIUM DIODE (USING A PNP GERMANIUM WITH THE COLLECTOR SHORTED TO THE EMITTER)
 NOTE 1: DIODES D1 AND D2 ASSURE REGULATOR STARTUP INTO A COMMON LOAD STARTUP SEQUENCE.





Voltage Regulators

LM376 voltage regulator

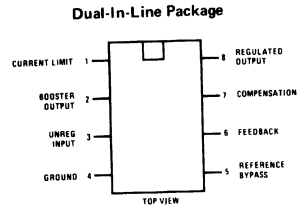
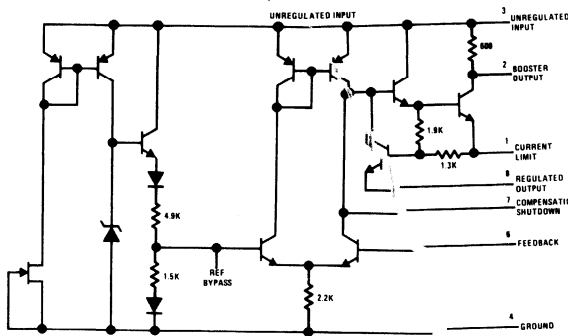
general description

The LM376 is a positive voltage regulator designed primarily for commercial product applications. The device is especially useful because it is packaged in an 8-pin mini-DIP which has the advantage of reduced size and low cost. Used independently, the device will supply 25 mA; but with the addition of external pass elements any desired load current can be achieved. The circuit features extremely low standby current drain, and provision

is made for either linear or foldback current limiting. Important characteristics of the LM376 are:

- Output voltage range +5V to 37V
- Output current 25 mA
- Load regulation 0.2%
- Line regulation 0.03%/V

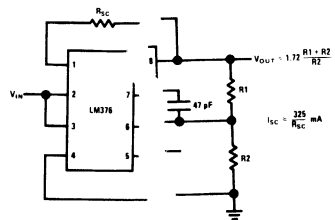
simplified schematic and connection diagrams



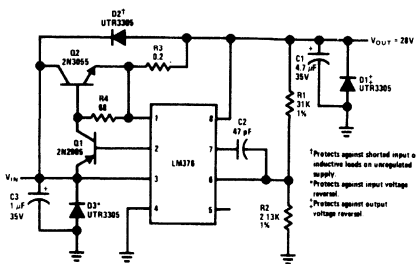
Order Number LM376N
See Package 20

typical applications

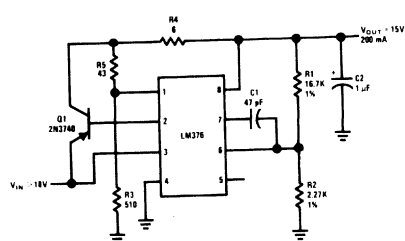
Basic Positive Regulator with Current Limiting



1.0A Regulator with Protective Diodes



Linear Regulator with Foldback Current Limiting



absolute maximum ratings

Input Voltage	40V
Input-Output Voltage Differential	40V
Power Dissipation (Note 1)	400 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

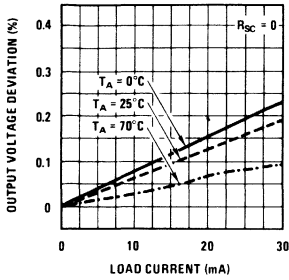
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		9.0		40	V
Output Voltage Range		5.0		37	V
Output-Input Voltage Differential		3.0		30	V
Load Regulation	$0 \leq I_O \leq 25 \text{ mA}$ $R_{SC} = 0\Omega, T_A = 25^\circ\text{C}$ $R_{SC} = 0\Omega, T_A = 70^\circ\text{C}$ $R_{SC} = 0\Omega, T_A = 0^\circ\text{C}$			0.2 0.5 0.5	% % %
Line Regulation	$T_A = 25^\circ\text{C}$			.03 .1	%/V %/V
Ripple Rejection	$f = 120 \text{ Hz}, T_A = 25^\circ\text{C}$			0.1	%/V
Standby Current Drain	$V_{IN} = 30\text{V}, T_A = 25^\circ\text{C}$			2.5	mA
Reference Voltage		1.60	1.72	1.80	V
Current Limit Sense Voltage			.360		V

Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 187°C/W junction to ambient.

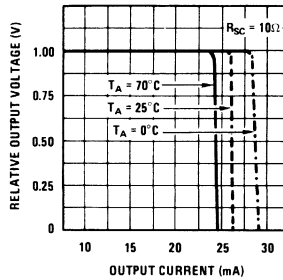
Note 2: These specifications apply for an operating temperature between 0°C and 70°C.

typical performance characteristics

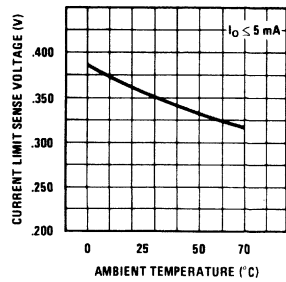
Load Regulation



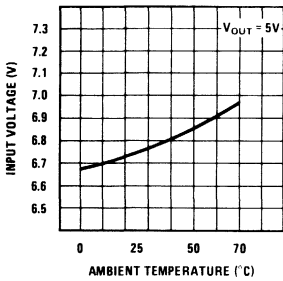
Current Limiting Characteristics



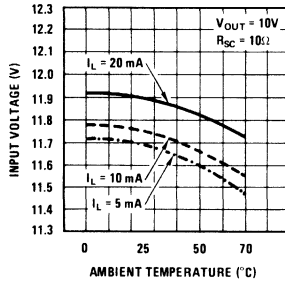
Current Limit Sense Voltage



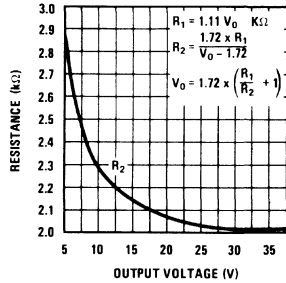
Minimum Input Voltage



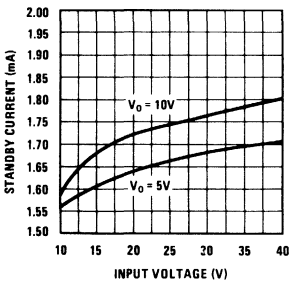
Regulator Dropout Voltage



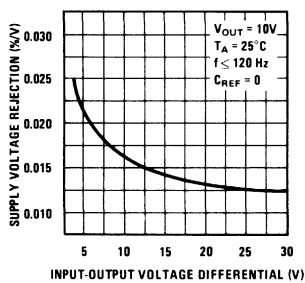
Optimum Divider Resistance



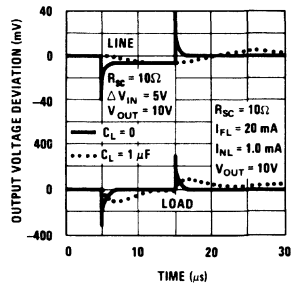
Standby Current Drain
TA = 25°C



Supply Voltage Rejection



Transient Response





Voltage Regulators

LM723/LM723C voltage regulator

general description

The LM723/LM723C is a voltage regulator designed primarily for series regulator applications. By itself, it will supply output currents up to 150 mA; but external transistors can be added to provide any desired load current. The circuit features extremely low standby current drain, and provision is made for either linear or foldback current limiting. Important characteristics are:

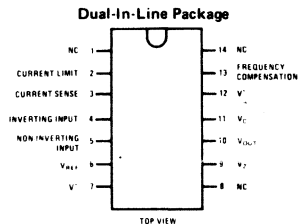
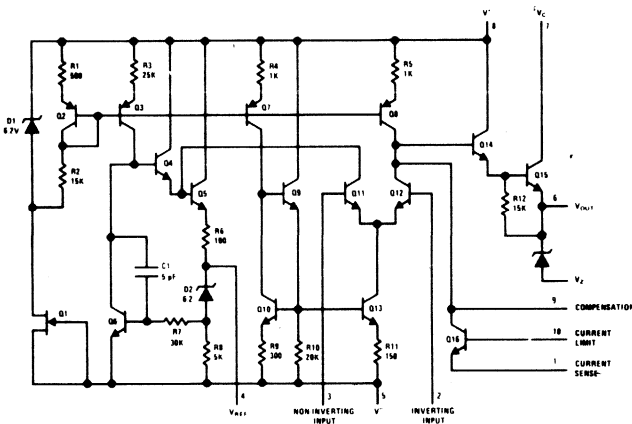
- 150 mA output current without external pass transistor
- Output currents in excess of 10A possible by adding external transistors

- Input voltage 40V max
- Output voltage adjustable from 2V to 37V
- Can be used as either a linear or a switching regulator.

The LM723/LM723C is also useful in a wide range of other applications such as a shunt regulator, a current regulator or a temperature controller.

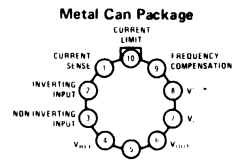
The LM723C is identical to the LM723 except that the LM723C has its performance guaranteed over a 0°C to 70°C temperature range, instead of -55°C to +125°C.

schematic and connection diagrams *



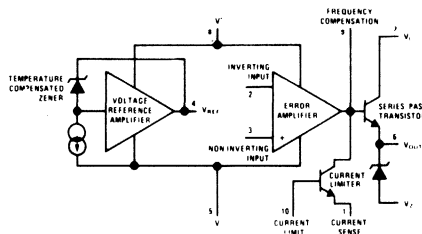
Order Number LM 723D or LM723CD
See Package 1

Order Number LM723N or LM723CN
See Package 22



Note: Pin 5 is connected to case.
TOP VIEW
Order Number LM723H or LM723CH
See Package 13

equivalent circuit *



* Pin numbers for metal can package only.
Note 1

absolute maximum ratings

Pulse Voltage from V^+ to V^- (50 ms)	50V
Continuous Voltage from V^+ to V^-	40V
Input-Output Voltage Differential	40V
Maximum Amplifier Input Voltage (Either Input)	7.5V
Maximum Amplifier Input Voltage (Differential)	5V
Current from V_Z	25 mA
Current from V_{REF}	15 mA
Internal Power Dissipation Metal Can (Note 1)	800 mW
Cavity DIP (Note 1)	900 mW
Molded DIP (Note 1)	660 mW
Operating Temperature Range LM723	-55°C to +125°C
LM723C	0°C to +70°C
Storage Temperature Range Metal Can	-65°C to +150°C
DIP	-55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	LM723			LM723C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Line Regulation	$V_{IN} = 12V$ to $V_{IN} = 15V$		.01	0.1		.01	0.1	% V_{OUT}
	$-55^\circ C \leq T_A \leq +125^\circ C$			0.3				% V_{OUT}
	$0^\circ C \leq T_A \leq +70^\circ C$						0.3	% V_{OUT}
	$V_{IN} = 12V$ to $V_{IN} = 40V$		.02	0.2		0.1	0.5	% V_{OUT}
Load Regulation	$I_L = 1$ mA to $I_L = 50$ mA		.03	0.15		.03	0.2	% V_{OUT}
	$-55^\circ C \leq T_A \leq +125^\circ C$			0.6				% V_{OUT}
	$0^\circ C \leq T_A \leq +70^\circ C$						0.6	% V_{OUT}
Ripple Rejection	$f = 50$ Hz to 10 kHz, $C_{REF} = 0$		74			74		dB
	$f = 50$ Hz to 10 kHz, $C_{REF} = 5 \mu F$		86			86		dB
Average Temperature Coefficient of Output Voltage	$-55^\circ C \leq T_A \leq +125^\circ C$		.002	.015				%/°C
	$0^\circ C \leq T_A \leq +70^\circ C$					.003	.015	%/°C
Short Circuit Current Limit	$R_{SC} = 10\Omega$, $V_{OUT} = 0$		65			65		mA
Reference Voltage		6.95	7.15	7.35	6.80	7.15	7.50	V
Output Noise Voltage	$BW = 100$ Hz to 10 kHz, $C_{REF} = 0$		20			20		μV_{rms}
	$BW = 100$ Hz to 10 kHz, $C_{REF} = 5 \mu F$		2.5			2.5		μV_{rms}
Long Term Stability			0.1			0.1		%/1000 hrs
Standby Current Drain	$I_L = 0$, $V_{IN} = 30V$		1.3	3.5		1.3	4.0	mA
Input Voltage Range		9.5		40	9.5		40	V
Output Voltage Range		2.0		37	2.0		37	V
Input-Output Voltage Differential		3.0		38	3.0		38	V

Note 1: See derating curves for maximum power rating above 25°C.

Note 2: Unless otherwise specified, $T_A = 25^\circ C$, $V_{IN} = V^+ = V_C = 12V$, $V^- = 0$, $V_{OUT} = 5V$, $I_L = 1$ mA, $R_{SC} = 0$, $C_1 = 100$ pF, $C_{REF} = 0$ and divider impedance as seen by error amplifier ≤ 10 k Ω connected as shown in Figure 1. Line and load regulation specifications are given for the condition of constant chip temperature. Temperature drifts must be taken into account separately for high dissipation conditions.

Note 3: L_1 is 40 turns of No. 20 enameled copper wire wound on Ferroxcube P36/22-3B7 pot core or equivalent with 0.009 in. air gap.

Note 4: Figures in parentheses may be used if R1/R2 divider is placed on opposite input of error amp.

Note 5: Replace R1/R2 in figures with divider shown in Figure 13.

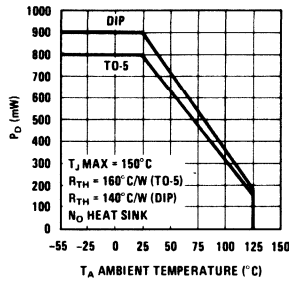
Note 6: V^+ must be connected to a +3V or greater supply.

Note 7: For metal can applications where V_Z is required, an external 6.2 volt zener diode should be connected in series with V_{OUT} .

maximum power ratings

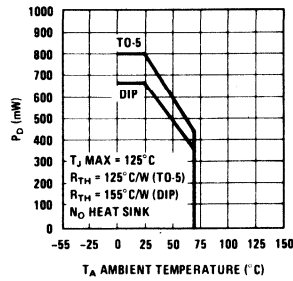
LM723

Power Dissipation vs Ambient Temperature



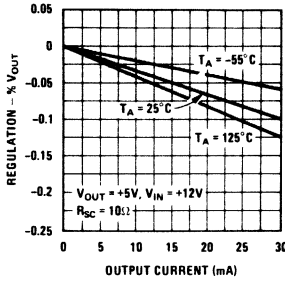
LM723C

Power Dissipation vs Ambient Temperature

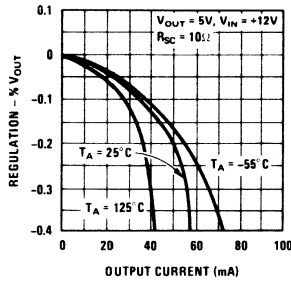


typical performance characteristics

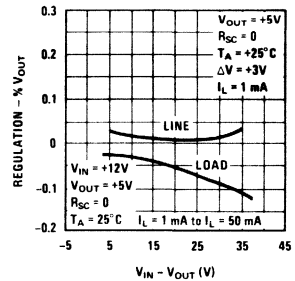
Load Regulation Characteristics with Current Limiting



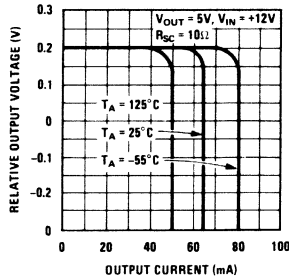
Load Regulation Characteristics with Current Limiting



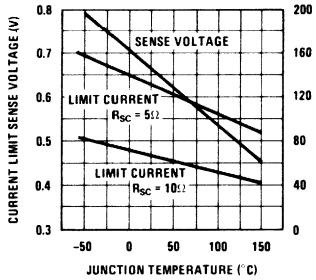
Load & Line Regulation vs Input-Output Voltage Differential



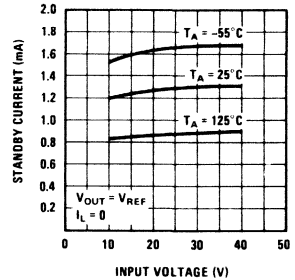
Current Limiting Characteristics



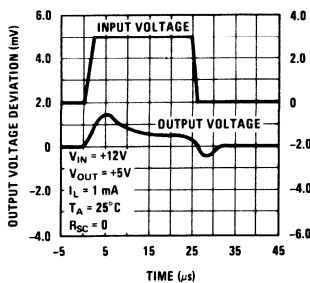
Current Limiting Characteristics vs Junction Temperature



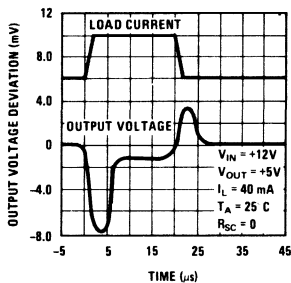
Standby Current Drain vs Input Voltage



Line Transient Response



Load Transient Response



Output Impedance vs Frequency

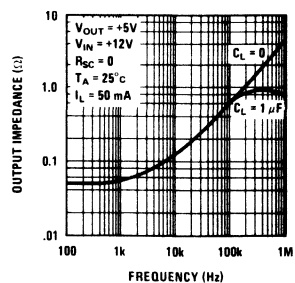


TABLE I RESISTOR VALUES (kΩ) FOR STANDARD OUTPUT VOLTAGE

POSITIVE OUTPUT VOLTAGE	APPLICABLE FIGURES	FIXED OUTPUT ±5%		OUTPUT ADJUSTABLE ±10% (Note 5)			NEGATIVE OUTPUT VOLTAGE	APPLICABLE FIGURES	FIXED OUTPUT ±5%		5% OUTPUT ADJUSTABLE ±10%		
		R1	R2	R1	P1	R2			R1	R2	R1	P1	R2
+3.0	(Note 4) 1, 5, 6, 9, 12 (4)	4.12	3.01	1.8	0.5	1.2	+100	7	3.57	102	2.2	10	91
+3.6	1, 5, 6, 9, 12 (4)	3.57	3.65	1.5	0.5	1.5	+250	7	3.57	255	2.2	10	240
+5.0	1, 5, 6, 9, 12 (4)	2.15	4.99	.75	0.5	2.2	-6 (Note 6)	3, (10)	3.57	2.43	1.2	0.5	.75
+6.0	1, 5, 6, 9, 12 (4)	1.15	6.04	0.5	0.5	2.7	-9	3, 10	3.48	5.36	1.2	0.5	2.0
+9.0	2, 4, (5, 6, 12, 9)	1.87	7.15	.75	1.0	2.7	-12	3, 10	3.57	8.45	1.2	0.5	3.3
+12	2, 4, (5, 6, 9, 12)	4.87	7.15	2.0	1.0	3.0	-15	3, 10	3.65	11.5	1.2	0.5	4.3
+15	2, 4, (5, 6, 9, 12)	7.87	7.15	3.3	1.0	3.0	-28	3, 10	3.57	24.3	1.2	0.5	10
+28	2, 4, (5, 6, 9, 12)	21.0	7.15	5.6	1.0	2.0	-45	8	3.57	41.2	2.2	10	33
+45	7	3.57	48.7	2.2	10	39	-100	8	3.57	97.6	2.2	10	91
+75	7	3.57	78.7	2.2	10	68	-250	8	3.57	249	2.2	10	240

TABLE II FORMULAE FOR INTERMEDIATE OUTPUT VOLTAGES

<p>Outputs from +2 to +7 volts [Figures 1, 5, 6, 9, 12, (4)]</p> $V_{OUT} = [V_{REF} \times \frac{R2}{R1 + R2}]$	<p>Outputs from +4 to +250 volts [Figure 7]</p> $V_{OUT} = [\frac{V_{REF}}{2} \times \frac{R2 - R1}{R1}]; R3 = R4$	<p>Current Limiting</p> $I_{LIMIT} = \frac{V_{SENSE}}{R_{SC}}$
<p>Outputs from +7 to +37 volts [Figures 2, 4, (5, 6, 9, 12)]</p> $V_{OUT} = [V_{REF} \times \frac{R1 + R2}{R2}]$	<p>Outputs from -6 to -250 volts [Figures 3, 8, 10]</p> $V_{OUT} = [\frac{V_{REF}}{2} \times \frac{R1 + R2}{R1}]; R3 = R4$	<p>Foldback Current Limiting</p> $I_{KNEE} = [\frac{V_{OUT} R3}{R4} + \frac{V_{SENSE} (R3 + R4)}{R4}]$ $I_{SHORT\ CKT} = [\frac{V_{SENSE}}{R_{SC}} \times \frac{R3 + R4}{R4}]$

typical applications

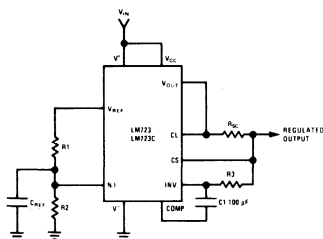


FIGURE 1. Basic Low Voltage Regulator (V_{OUT} = 2 to 7 Volts)

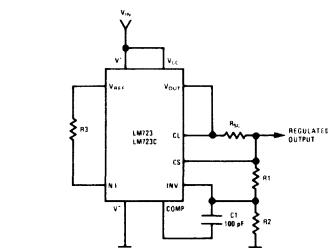


FIGURE 2. Basic High Voltage Regulator (V_{OUT} = 7 to 37 Volts)

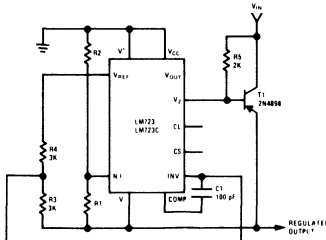


FIGURE 3. Negative Voltage Regulator

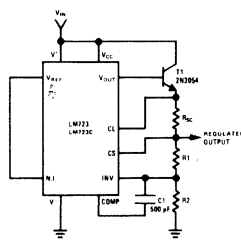


FIGURE 4. Positive Voltage Regulator (External NPN Pass Transistor)

typical applications (con't.)

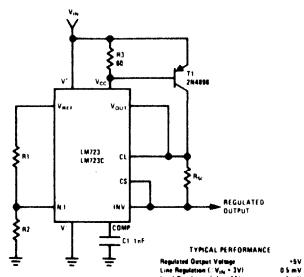


FIGURE 5. Positive Voltage Regulator (External PNP Pass Transistor)

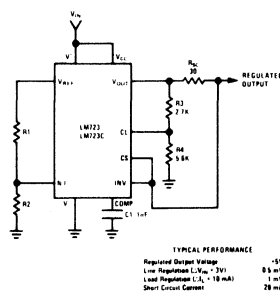


FIGURE 6. Foldback Current Limiting

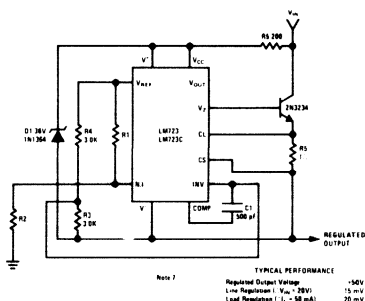


FIGURE 7. Positive Floating Regulator

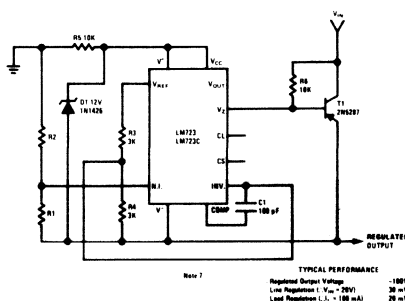


FIGURE 8. Negative Floating Regulator

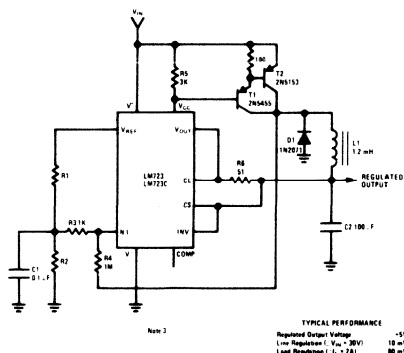


FIGURE 9. Positive Switching Regulator

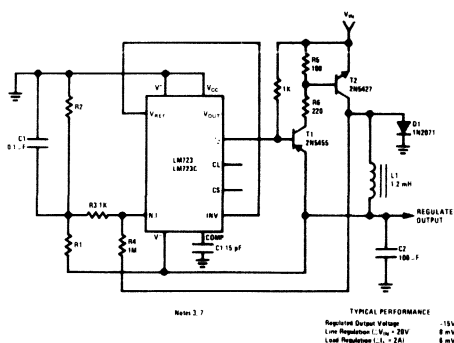


FIGURE 10. Negative Switching Regulator

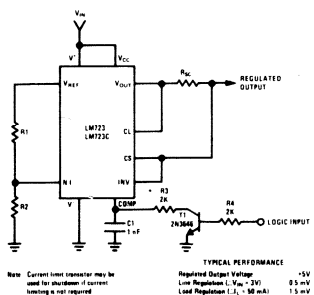


FIGURE 11. Remote Shutdown Regulator with Current Limiting

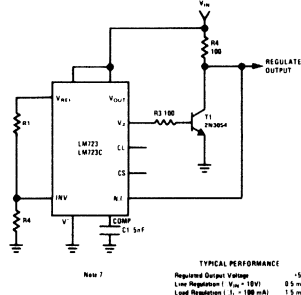


FIGURE 12. Shunt Regulator

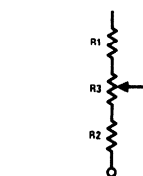


FIGURE 13. Output Voltage Adjust (See Note 5)





Operational Amplifiers

LH0001

LH0001* low power operational amplifier

general description

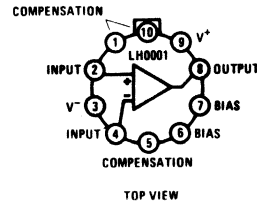
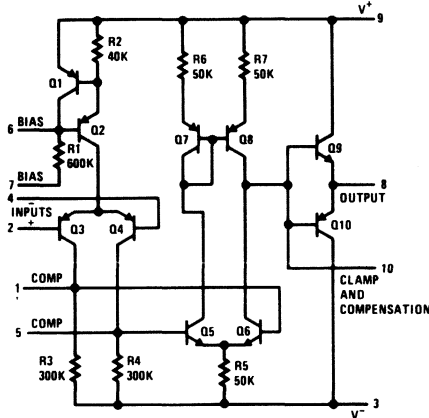
The LH0001 is a general purpose operational amplifier designed for extremely low quiescent power. Typical NO-load dissipation at 25°C is 2 milliwatts at $V_S = \pm 15$ volts, and 0.5 milliwatts at $V_S = \pm 5$ volts. Even with this low power dissipation, the LH0001 will deliver ± 10 volts into a 2K load with ± 15 volt supplies, and typical short circuit currents of 20 to 30 milliamps. Additional features are:

- Operation from $\pm 5V$ to $\pm 20V$
- Very low offset voltage: typically 200 μV at 25°C, 600 μV at -55°C to 125°C

- Very low input offset current: typically 3 nA at 25°C, 6 nA at -55°C
- Low noise: typically 3 μV rms
- Frequency compensation with 2 small capacitors
- Output may be clamped at any desired level
- Output is continuously short circuit proof

The LH0001 is ideally suited for space borne applications or where battery operated equipment requires extremely low power dissipation.

schematic and connection diagrams

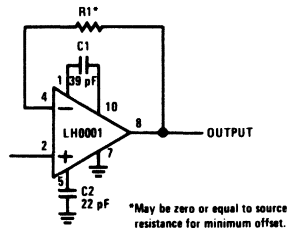


Note: Pin 7 must be grounded or connected to a voltage at least 5 volts more negative than the positive supply (Pin 9). Pin 7 may be connected to the negative supply, however the standby current will be increased. A resistor may be inserted in series with Pin 7 up to a maximum of 100 k Ω per volt between Pin 3 and Pin 9.

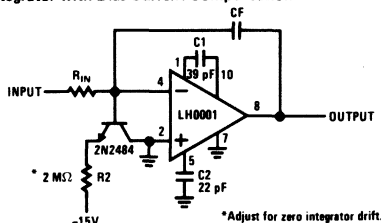
Order Number LH0001H
See Package 14

typical applications

Voltage Follower

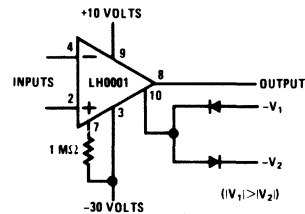


Integrator with Bias Current Compensation

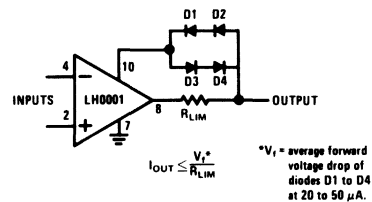


*Previously called NH0001

Voltage Comparator for Driving MOS Circuits



External Current Limiting Method



2

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (see Curve)	400 mW
Differential Input Voltage	±7V
Input Voltage	Equal to supply
Short Circuit Duration (Note 1)	Continuous
Operating Temperature Range	-55°C to +125°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering 10 sec.)	300°C

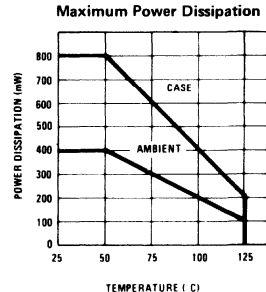
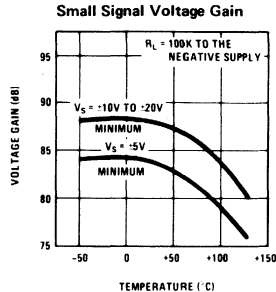
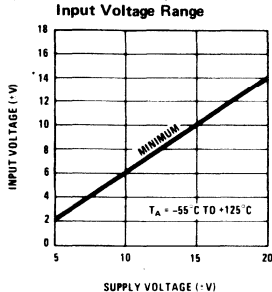
electrical characteristics (Note 2)

PARAMETER	TEMP (°C)	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	25	$R_S \leq 5K$		0.2	1.0	mV
	-55 to 125	$R_S \leq 5K$		0.6	2.0	mV
Input Offset Current	25 to 125				20	nA
	-55				100	nA
Input Bias Current	25 to 125				100	nA
	-55				300	nA
Supply Current (+)	25	$V_S = \pm 20V$		90	125	μA
	125	$V_S = \pm 20V$		70	100	μA
	-55	$V_S = \pm 20V$		100	150	μA
Supply Current (-)	25	$V_S = \pm 20V$		60	90	μA
	125	$V_S = \pm 20V$		45	75	μA
	-55	$V_S = \pm 20V$		75	125	μA
Voltage Gain	-55 to 25	$R_L = 100 K\Omega, V_S = \pm 15V, V_{OUT} = \pm 10V$	25	60		V/mV
	125	$R_L = 100 K\Omega, V_S = \pm 15V, V_{OUT} = \pm 10V$	10	30		V/mV
V_{OUT}	25	$V_S = \pm 15V, R_L = 2K$	10	11.5		V
	-55	$V_S = \pm 15V, R_L = 2K$	9	10.5		V
	125	$V_S = \pm 15V, R_L = 2K$	11	12.5		V
Common Mode Rejection Ratio	-55 to 125	$V_S = \pm 15V, V_{IN} = \pm 10V, R_S \leq 5K$	70	90		dB
Power Supply Rejection Ratio	-55 to 125	$V_S = \pm 15V, \Delta V = 5V \text{ to } 20V, R_S = \leq 5K$	70	90		dB
Input Resistance	25		0.5	1.5		MΩ
Average Temperature Coefficient of Offset Voltage	-55 to 125	$R_S \leq 5K$		4		μV/°C
Average Temperature Coefficient of Bias Current	-55 to 125			0.4		μA/°C
Equivalent Input Noise Voltage	25	$R_S = 1K, f = 5 \text{ Hz to } 1000 \text{ Hz}, V_S = \pm 15V$		3.0		μV rms

Note 1: Based on maximum short circuit current of 50 mA, device may be operated at any combination of supply voltages, and temperature to be within rated power dissipation (see Curve).

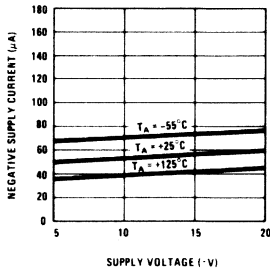
Note 2: These specifications apply for Pin 7 grounded, for $\pm 5V \leq V_S \leq \pm 20V$, with Capacitor C1 = 39 pF from Pin 1 to Pin 10, and C2 = 22 pF from Pin 5 to ground, unless otherwise specified.

guaranteed performance

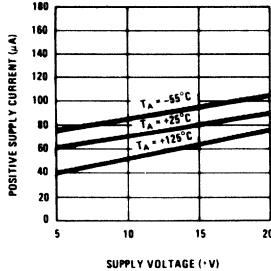


typical performance characteristics

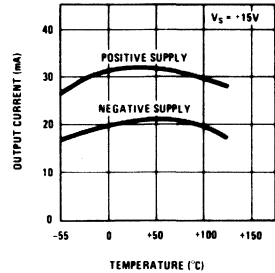
Negative Supply Current



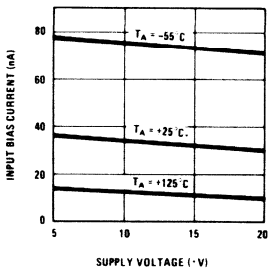
Positive Supply Currents



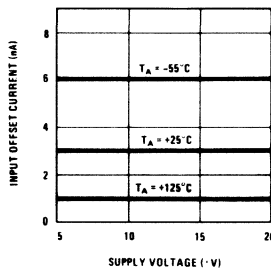
Short Circuit Output Current



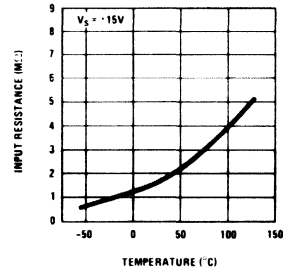
Input Bias Current



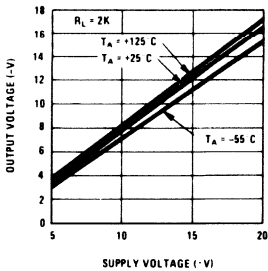
Input Offset Current



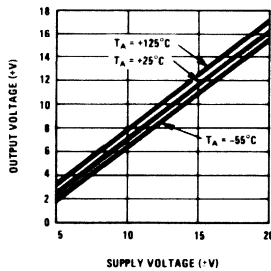
Input Resistance



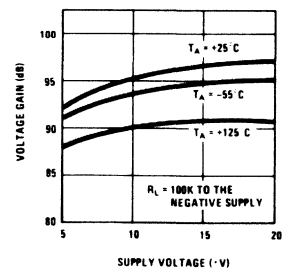
Negative Output Voltage Swing



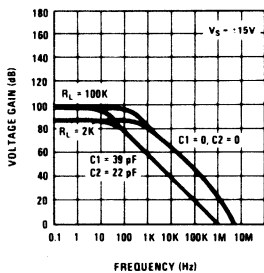
Positive Output Voltage Swing



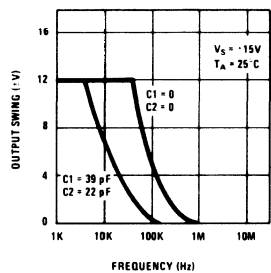
Voltage Gain



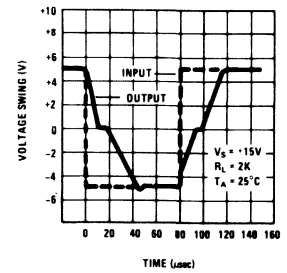
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response





Operational Amplifiers

LH0001A/LH0001AC micropower operational amplifier

general description

The LH0001A/LH0001AC is a micropower, high performance integrated circuit operational amplifier designed to have a no load power dissipation of less than 0.5 mW at $V_S = \pm 5V$ and less than 2 mW at $V_S = \pm 20V$. Open loop gain is greater than 50k and input bias current is typically 20 nA.

features

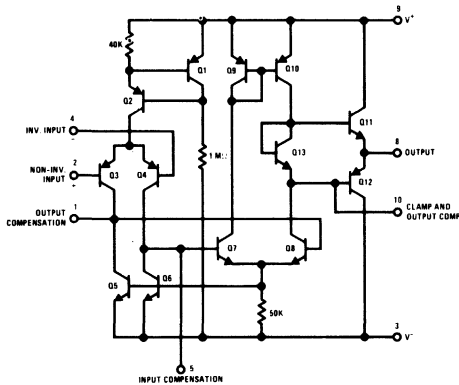
- 1.0 mV Typical low offset voltage
- 5 nA Typical low offset current
- $3\mu V_{rms}$ Typical low noise
- Simple frequency compensation
- Moderate bandwidth and slewrate

- Output short circuit proof

The LH0001A/LH0001AC may be substituted directly for the LH0001/LH0001C. Low power consumption, high open loop gain, and excellent input characteristics make the LH0001A an ideal amplifier for many low power applications such as battery powered instrument or transducer amplifiers.

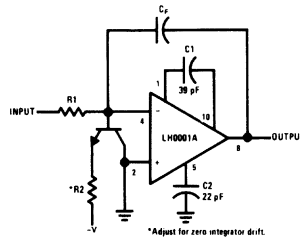
The LH0001A is specified for operation over the $-55^{\circ}C$ to $+125^{\circ}C$ military temperature range. The LH0001AC is specified for operation over the $0^{\circ}C$ to $+85^{\circ}C$ temperature range.

schematic diagram*



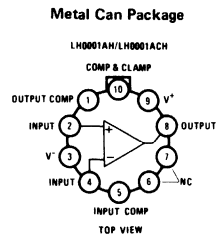
*Pin shown for TO-5 package

typical application*

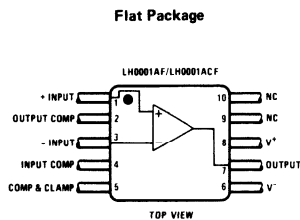


Integrator with Bias Compensation

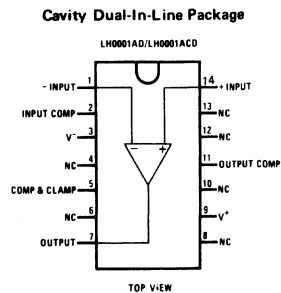
connection diagrams



Order Number
LH0001AH or LH0001ACH
See Package 14



Order Number
LH0001AF or LH0001ACF
See Package 3



Order Number
LH0001AD or LH0001ACD
See Package 1

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (See curve)	400 mW
Differential Input Voltage	±7V
Input Voltage	±V _S
Short Circuit Duration	Continuous
Operating Temperature Range	LH0001A -55°C to 125°C
	LH0001AC -25°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

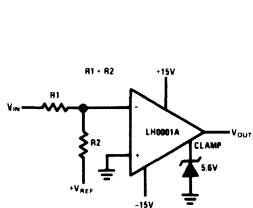
electrical characteristics (Note 1)

PARAMETERS	CONDITIONS	LH0001A			LH0001AC			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	R _S ≤ 1k, T _A = 25°C		1.0	2.5		2.0	5.0	mV
				4.0		7.0		mV
Input Bias Current	T _A = 25°C		20	100		20	200	nA
				300		300		nA
Input Offset Current	T _A = 25°C		5	20		20	60	nA
				100		100		nA
Supply Current	V _S = ±20V, T _A = 25°C V _S = ±20V		80	125		80	125	μA
				150		150		nA
Voltage Gain	V _S = ±15V, V _{OUT} = 10V, R _L = 100k, T _A = 25°C		25	60		25	60	V/mV
			25	60		25	60	
			10	30		10		V/mV
Output Voltage	V _S = ±15V, R _L = 2k, T _A = 25°C V _C = ±15V, R _L = 2k		10	11.5		10	11.5	V
			9			9		V
Common Mode Rejection Ratio	V _S = ±15V, V _{IN} = 10V, R _S = 1k	70	90		70	90	db	
Power Supply Rejection Ratio	V _S = ±15V, R _S = 1k, V _S = ±5V to ±20V	70	90		70	90	db	
Equivalent Input Noise Voltage	V _S = ±15V, R _S = 1k, T _A = 25°C f = 500 Hz to 5 kHz		3.0			3.0	μVrms	
Average Temperature Coefficient of Offset Voltage	R _S ≤ 1k		3.0			3.0	μV/°C	
Average Temperature Coefficient of Bias Current			0.3			0.3	nA/°C	

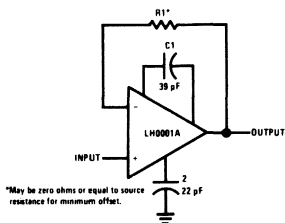
2

Note 1: The specifications apply for +5V ≤ V_S ≤ 20V, with output compensation capacitor, C₁ = 39 pF, input compensation capacitor, C₂ = 22 pF, -55°C to 125°C for the LH0001A and -25°C to +85°C for the LH0001AC unless otherwise specified.

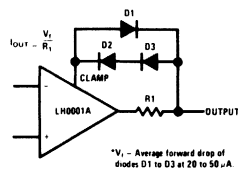
typical applications



TTL/DTL Compatible Comparator



Voltage Follower

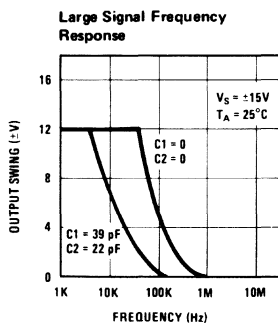
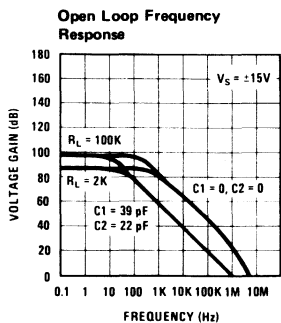
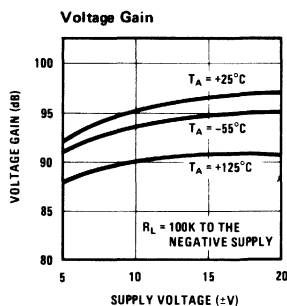
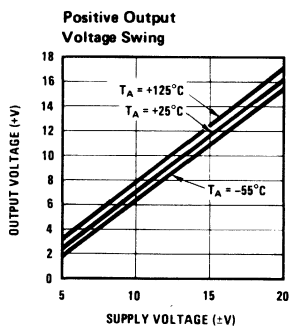
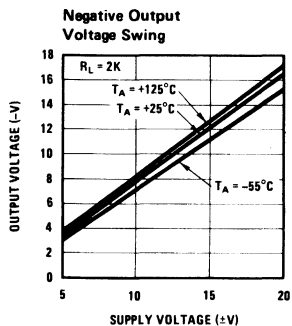
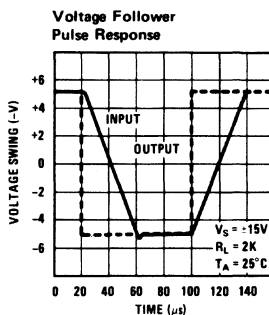
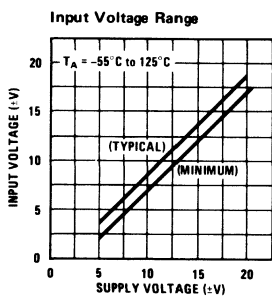
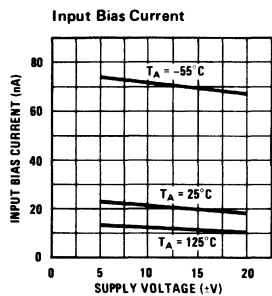
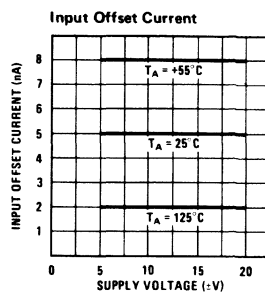
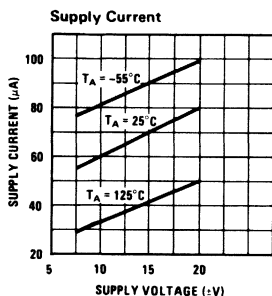
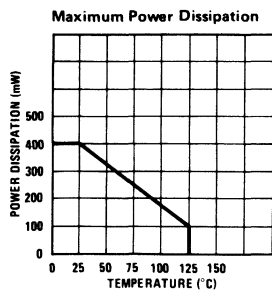


External Output Current Limiting

*V_i - Average forward drop of diodes D1 to D3 at 20 to 50 μA

*May be zero ohms or equal to source resistance for minimum offset.

typical performance characteristics





Operational Amplifiers

LH0002/LH0002C

LH0002/LH0002C* current amplifier

general description

The LH0002/LH0002C is a general purpose thick film hybrid current amplifier that is built on a single substrate. The circuit features:

- High Input Impedance 400 k Ω
- Low Output Impedance 6 Ω
- High Power Efficiency
- Low Harmonic Distortion
- DC to 30 MHz Bandwidth
- Output Voltage Swing that Approaches Supply Voltage
- 400 mA Pulsed Output Current
- Slew rate is typically 200V/ μ s
- Operation from ± 5 V to ± 20 V

These features make it ideal to integrate with an operational amplifier inside a closed loop configuration to increase current output. The symmetrical

output portion of the circuit also provides a low output impedance for both the positive and negative slopes of output pulses.

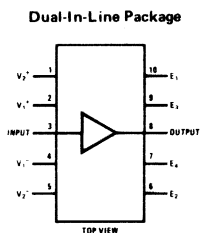
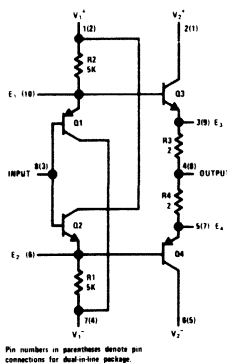
The LH0002 is available in an 8-lead low-profile TO-5 header; the LH0002C is also available in an 8-lead TO-5, and a 10-pin molded dual-in-line package.

The LH0002 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LH0002C is specified for operation over the 0°C to $+85^{\circ}\text{C}$ temperature range.

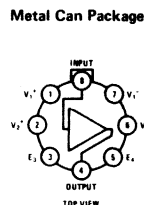
applications

- Line driver
- 30 MHz buffer
- High speed D/A conversion
- Instrumentation buffer
- Precision current source

schematic and connection diagrams



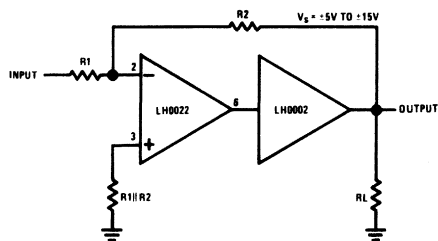
Order Number LH0002CN
See Package 21



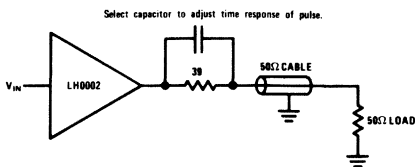
Order Number LH0002H or LH0002CH
See Package 11

typical applications

High Current Operational Amplifier



Line Driver



*Previously called NH0002/NH0002C



absolute maximum ratings

Supply Voltage		±22V
Power Dissipation Ambient		600 mW
Input Voltage (Equal to Power Supply Voltage)		
Storage Temperature Range		-65°C to +150°C
Operating Temperature Range	LH0002	-55°C to +125°C
	LH0002C	0°C to +85°C
Steady State Output Current		±100 mA
Pulsed Output Current (50 ms On/1 sec Off)		±400 mA

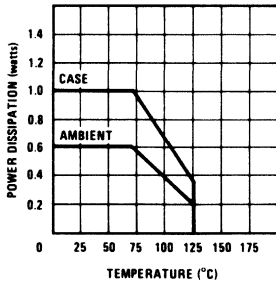
electrical characteristics (Note 1)

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
Voltage Gain	$R_S = 10\text{ k}\Omega$, $R_L = 1.0\text{ k}\Omega$ $V_{IN} = 3.0\text{ V}_{pp}$, $f = 1.0\text{ kHz}$ $T_A = -55^\circ\text{C}$ to 125°C	.95	.97		
AC Current Gain	$V_{IN} = 1.0\text{ V}_{rms}$ $f = 1.0\text{ kHz}$		40		A/mA
Input Impedance	$R_S = 200\text{ k}\Omega$, $V_{IN} = 1.0\text{ V}_{rms}$, $f = 1.0\text{ kHz}$, $R_L = 1.0\text{ k}\Omega$	180	400	—	k Ω
Output Impedance	$V_{IN} = 1.0\text{ V}_{rms}$, $f = 1.0\text{ kHz}$ $R_L = 50\Omega$, $R_S = 10\text{ k}\Omega$	—	6	10	Ω
Output Voltage Swing	$R_L = 1.0\text{ k}\Omega$, $f = 1.0\text{ kHz}$	±10	±11	—	V
Output Voltage Swing	$V_S = \pm 15\text{V}$, $V_{IN} = \pm 10\text{V}$, $R_L = 100\Omega$, $T_A = 25^\circ\text{C}$	±9.5V			
DC Output Offset Voltage	$R_S = 300\Omega$, $R_L = 1.0\text{ k}\Omega$ $T_A = -55^\circ\text{C}$ to 125°C	—	±10	±30	mV
DC Input Offset Current	$R_S = 10\text{ k}\Omega$, $R_L = 1.0\text{ k}\Omega$ $T_A = -55^\circ\text{C}$ to 125°C	—	±6.0	±10	μA
Harmonic Distortion	$V_{IN} = 5.0\text{ V}_{rms}$, $f = 1.0\text{ kHz}$	—	0.1	—	%
Bandwidth	$V_{IN} = 1.0\text{ V}_{rms}$, $R_L = 50\Omega$, $f = 1\text{ MHz}$	30	50	—	MHz
Positive Supply Current	$R_S = 10\text{ k}\Omega$, $R_L = 1\text{ k}\Omega$	—	+6.0	+10.0	mA
Negative Supply Current	$R_S = 10\text{ k}\Omega$, $R_L = 1\text{ k}\Omega$	—	-6.0	-10.0	mA

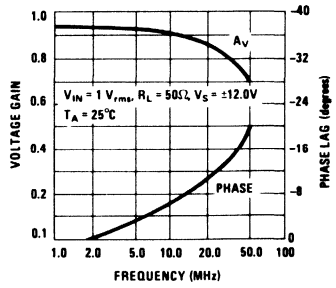
Note 1: Specification applies for $T_A = 25^\circ\text{C}$ with +12V on Pins 1 and 2; -12V on Pins 6 and 7 for the metal can package and +12V on Pins 1 and 2; -12V on Pins 4 and 5 for the dual-in-line package unless otherwise specified. The parameter guarantees for LH0002C apply over the temperature range of 0°C to +85°C, while parameters for the LH0002 are guaranteed over the temperature range -55°C to 125°C.

typical performance

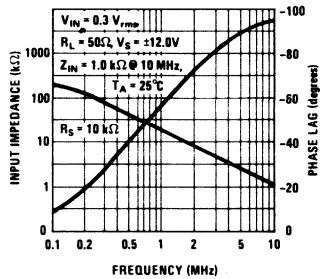
Maximum Power Dissipation



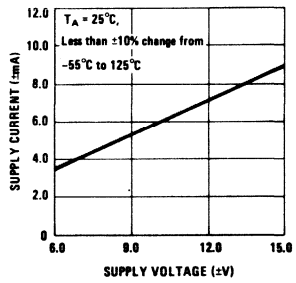
Frequency Response



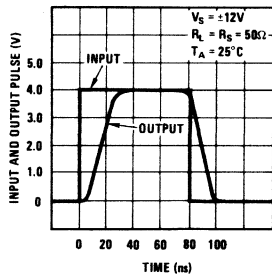
Input Impedance (Magnitude & Phase)



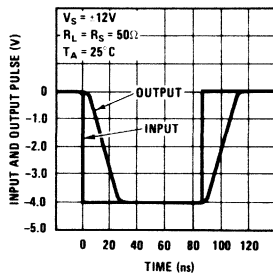
Supply Current



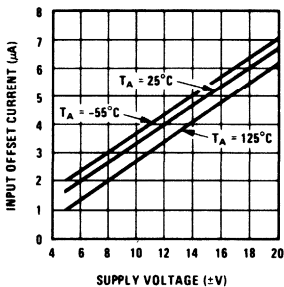
Positive Pulse



Negative Pulse



Input Offset Current





Operational Amplifiers

LH0003/LH0003C* wide bandwidth operational amplifier

general description

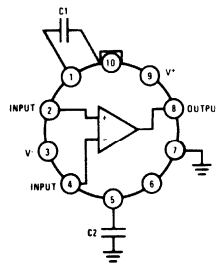
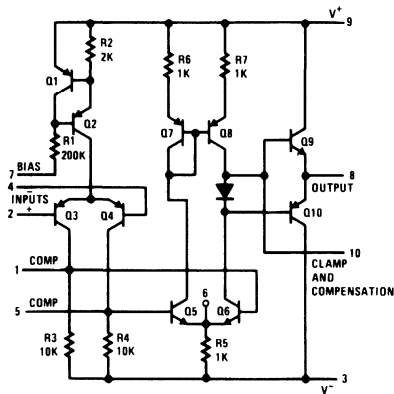
The LH0003/LH0003C is a general purpose operational amplifier which features: slewing rate up to 70 volts/ μ sec, a gain bandwidth of up to 30 MHz, and high output currents. Other features are:

- Very low offset voltage Typically 0.4 mV
- Large output swing $> \pm 10V$ into 100Ω load

- High CMRR Typically > 90 dB
- Good large signal frequency response 50 kHz to 400 kHz depending on compensation

The LH0003 is specified for operation over the $-55^\circ C$ to $+125^\circ C$ military temperature range. The LH0003C is specified for operation over the $0^\circ C$ to $+85^\circ C$ temperature range.

schematic and connection diagrams



TOP VIEW

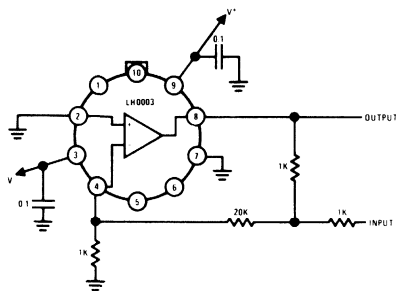
Order Number LH0003H or LH0003CH
See Package 14

Circuit Gain	C ₁ pF	C ₂ pF	Slew Rate R _L > 200 Ω , V/ μ sec	Full Output Frequency R _L = 200 Ω , V _{OUT} = 10 V
≥ 40	0	0	70	400
≥ 10	5	30	30	350
≥ 5	15	30	15	250
≥ 2	50	50	5	100
≥ 1	90	90	2	50

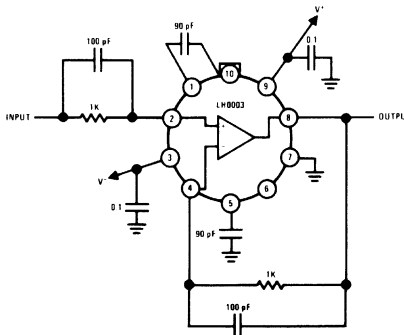
Typical Compensation

typical applications

High Slew Rate Unity Gain Inverting Amplifier



Unity Gain Follower



*Previously called NH0003/NH0003C

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation	See curve
Differential Input Voltage	±7V
Input Voltage	Equal to supply
Load Current	120 mA
Operating Temperature Range	NH0003 -55°C to +125°C
	NH0003C 0°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Notes 1 & 2)

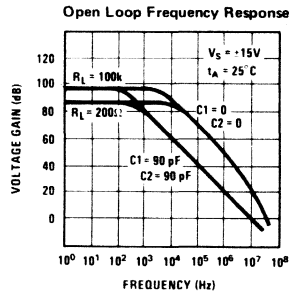
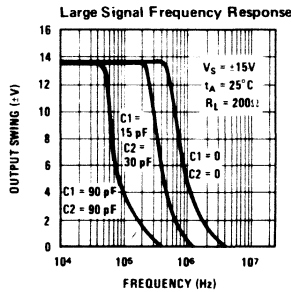
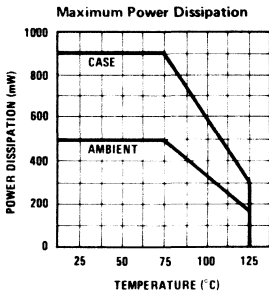
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$R_S < 1k$		0.4	3.0	mV
Input Offset Current			0.02	0.2	μA
Input Bias Current			0.4	2.0	μA
Supply Current	$V_S = \pm 20V$		1.2	3	mA
Voltage Gain	$R_L = 100k, V_S = \pm 15V, V_{OUT} = \pm 10V$	20	70		V/mV
Voltage Gain	$R_L = 2k, V_S = \pm 15V, V_{OUT} = \pm 10V$	15	40		V/mV
Output Voltage Swing	$V_S = \pm 15, R_L = 100\Omega$	±10	±12		V
Input Resistance			100		k Ω
Average Temperature Coefficient of Offset Voltage	$R_S < 5k$		4		$\mu V/^\circ C$
Average Temperature Coefficient of Bias Current			8		nA/°C
CMRR	$R_S < 1k, V_S = \pm V, V_{IN} = \pm 10V$	70	90		dB
PSRR	$R_S < 1k, V_S = \pm 15V, \Delta V = 5V$ to 20V	70	90		dB
Equivalent Input Noise Voltage	$R_S = 1K, f = 10$ kHz to 100 kHz $V_S = \pm 15V$ dc		1.8		μV_{rms}

Note 1. These specifications apply for Pin 7 grounded, for $\pm 5V < V_S < \pm 20V$, with capacitor $C_1 = 90$ pF from Pin 1 to Pin 10 and $C_2 = 90$ pF from Pin 5 to ground, over the specified operating temperature range, unless otherwise specified.

Note 2. Typical values are for $t_{AMBIENT} = 25^\circ C$ unless otherwise specified.



typical performance





Operational Amplifiers

LH0004/LH0004C* high voltage operational amplifier

general description

The LH0004/LH0004C is a general purpose operational amplifier designed to operate from supply voltages up to $\pm 40V$. The device dissipates extremely low quiescent power, typically 8 mW at $25^\circ C$ and $V_S = \pm 40V$. Additional features include:

- Capable of operation over the range of $\pm 5V$ to $\pm 40V$.
- Large output voltage typically $\pm 35V$ for the LH0004 and $\pm 33V$ for the LH0004C into a 2 K Ω load with $\pm 40V$ supplies
- Low input offset current typically 20 nA for the LH0004 and 45 nA for the LH0004C
- Low input offset voltage typically 0.3 mV
- Frequency compensation with two small capacitors.

- Low power consumption 8 mW at $\pm 40V$

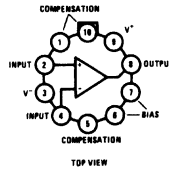
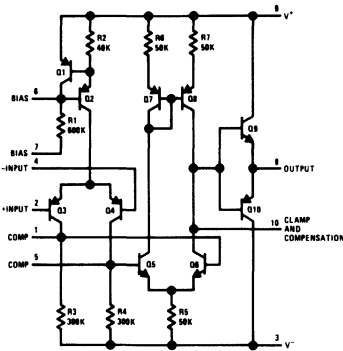
The LH0004's high gain and wide range of operating voltages make it ideal for applications requiring large output swing and low power dissipation.

The LH0004 is specified for operation over the $-55^\circ C$ to $+125^\circ C$ military temperature range. The LH0004C is specified for operation over the $0^\circ C$ to $+85^\circ C$ temperature range.

applications

- Precision high voltage power supply.
- Resolver excitation.
- Wideband high voltage amplifier.
- Transducer power supply.

schematic and connection diagrams

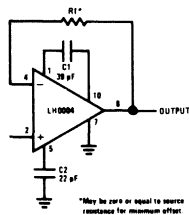


Note: Pin 7 must be grounded or connected to a voltage at least 5 volts more negative than the positive supply (Pin 9). Pin 7 may be connected to the negative supply; however, the standby current will be increased. A resistor may be inserted in series with Pin 7 to Pin 9. The value of the resistor should be a maximum of 100 K Ω per volt of potential between Pin 3 and Pin 9.

Order Number LH0004H or LH0004CH
See Package 14

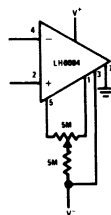
typical applications

Voltage Follower

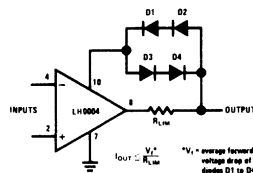


*May be zero or equal to source resistance for minimum offset.

Input Offset Voltage Adjust

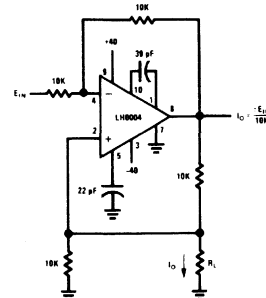


External Current Limiting Method



* V_{f1} = average forward voltage drop of diodes D1 to D4 at 20 to 50 μA .

High Compliance Current Source



*Previously called NH0004/NH0004C

absolute maximum ratings

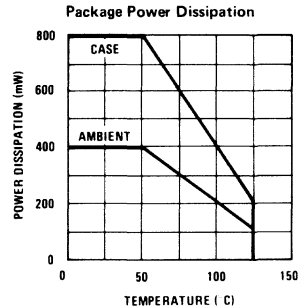
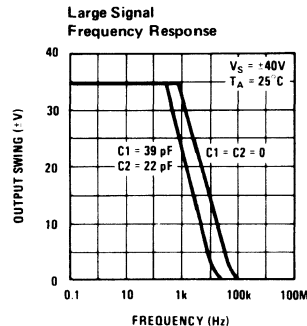
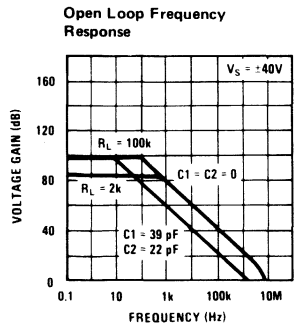
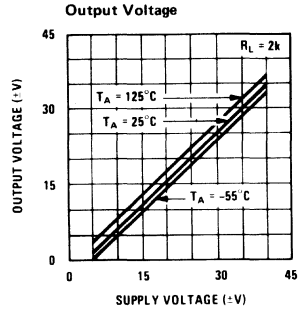
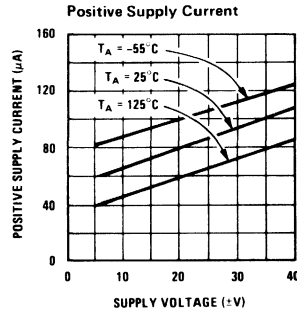
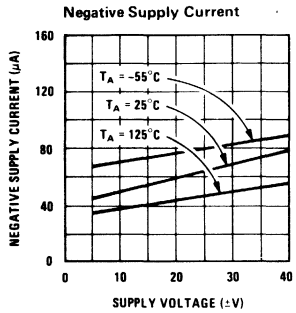
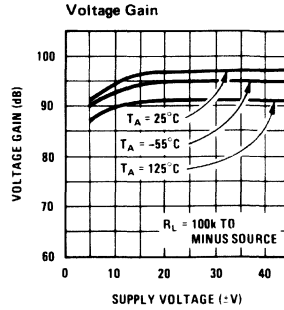
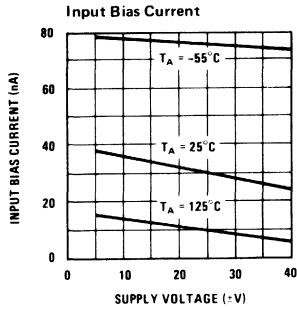
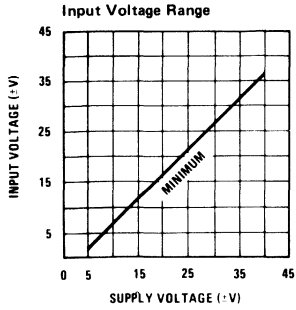
Supply Voltage, Continuous	±45V
Supply Voltage, Transient (≤ 0.1 sec, no load)	±60V
Power Dissipation (See curve)	400 mW
Differential Input Voltage	±7V
Input Voltage	Equal to supply
Short Circuit Duration	3 sec
Operating Temperature Range LH0004	-55°C to +125°C
LH0004C	0°C to 85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LH0004			LH0004C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 5k, T_A = 25^\circ\text{C}$		0.3	1.0		0.3	1.5	mV
	$R_S \leq 5k$			2.0			3.0	mV
Input Bias Current	$T_A = 25^\circ\text{C}$		20	100		30	120	nA
	$= -55^\circ\text{C}$			300			300	nA
Input Offset Current	$T_A = 25^\circ\text{C}$		3	20		10	45	nA
	$= -55^\circ\text{C}$			100			150	nA
Positive Supply Current	$V_S = \pm 40V, T_A = 25^\circ\text{C}$		110	150		110	150	μA
	$V_S = \pm 40V$			175			175	μA
Negative Supply Current	$V_S = \pm 40V, T_A = 25^\circ\text{C}$		80	100		80	100	μA
	$V_S = \pm 40V$			135			135	μA
Voltage Gain	$V_S = \pm 40V, R_L = 100k, T_A = 25^\circ\text{C}$ $V_{OUT} = \pm 30V$	30	60		30	60		V/mV
	$V_S = \pm 40V, R_L = 100k$ $V_{OUT} = \pm 30V$	10			10			V/mV
Output Voltage	$V_S = \pm 40V, R_L = 2k$	±30	±35		±30	±33		V
	$V_S = \pm 40V, R_L = 4k$	±34	±36		±33	±35		V
CMRR	$V_S = \pm 40V, R_S \leq 5k$ $V_{IN} = \pm 33V$	70	90		70	90		dB
PSRR	$V_S = \pm 40V, R_S \leq 5k$ $\Delta V = 20V$ to 40V	70	90		70	90		dB
Average Temperature Coefficient Offset Voltage	$R_S \leq 5k$		4.0			4.0		$\mu\text{V}/^\circ\text{C}$
Average Temperature Coefficient of Offset Current			0.4			0.4		$\mu\text{A}/^\circ\text{C}$
Equivalent Input Noise Voltage	$R_S = 1k, V_S = \pm 40V$ $f = 500$ Hz to 5 kHz, $T_A = 25^\circ\text{C}$		3.0			3.0		μVrms

Note 1: These specifications apply for $\pm 5V \leq V_S \leq \pm 40V$, Pin 7 grounded, with capacitors $C_1 = 39$ pF between Pin 1 and Pin 10, $C_2 = 22$ pF between Pin 5 and ground, -55°C to 125°C for the LH0004, and 0°C to 85°C for the LH0004C unless otherwise specified.

typical performance





Operational Amplifiers

LH0005/LH0005A

LH0005/LH0005A* operational amplifier

general description

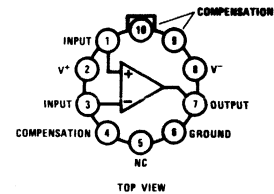
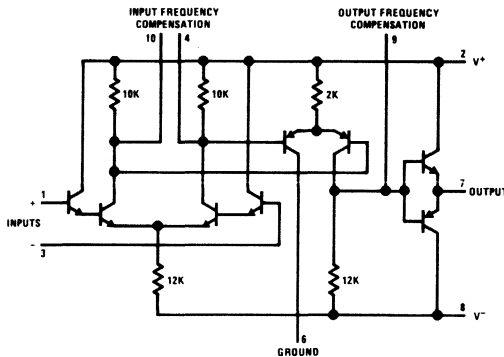
The LH0005/LH0005A is a hybrid integrated circuit operational amplifier employing thick film resistors and discrete silicon semiconductors in its design. The select matching of the input pairs of transistors results in low input bias currents and a very low input offset current, both of which exhibit excellent temperature tracking. In addition, the device features:

- Very high output current capability: ± 50 mA into a 100 ohm load
- Low standby power dissipation: typically 60 mW at ± 12 V
- High input resistance: typically 2M at 25°C

- Full operating range: -55°C to $+125^\circ\text{C}$
- Good high frequency response: unity gain at 30 MHz

With no external roll-off network, the amplifier is stable with a feedback ratio of 10 or greater. By adding a 200 pF capacitor between pins 9 and 10, and a 200 ohm resistor in series with a 75 pF capacitor from pin 4 to ground, the amplifier is stable to unity gain. The unity gain loop phase margin with the above compensation is typically 70 degrees. With a gain of 10 and no compensation the loop phase margin is typically 50 degrees.

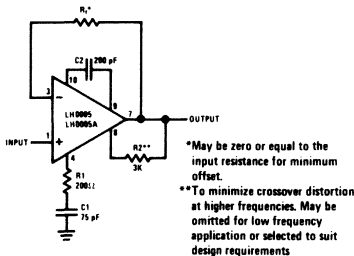
schematic and connection diagrams



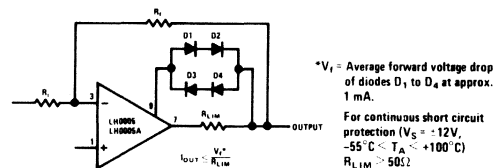
Order Number LH0005H or LH0005AH
See Package 14

typical applications

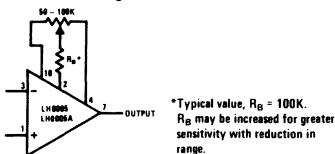
Voltage Follower



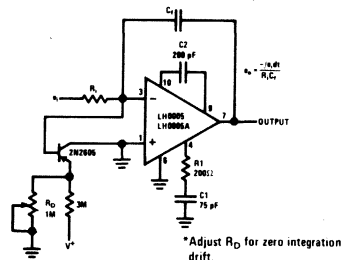
External Current Limiting



Offset Balancing Circuit



Integrator with Bias Current Compensation



*Previously called NH0005/NH0005A

2

absolute maximum ratings

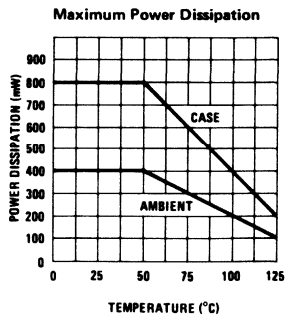
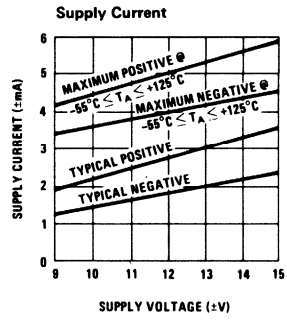
Supply Voltage	±20V
Power Dissipation (see Curve)	400 mW
Differential Input Voltage	±15V
Input Voltage	Equal to supply voltages
Peak Load Current	±100 mA
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	-55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

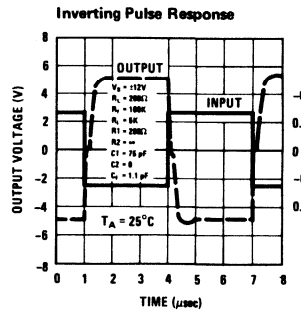
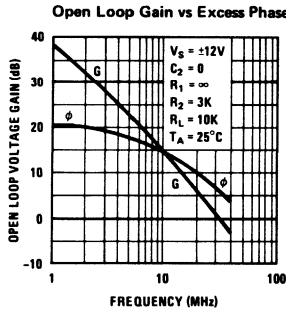
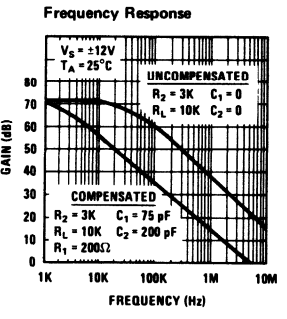
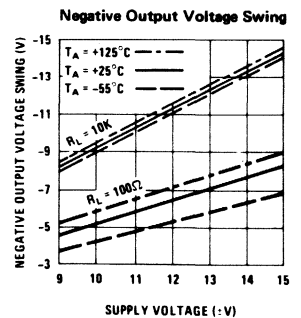
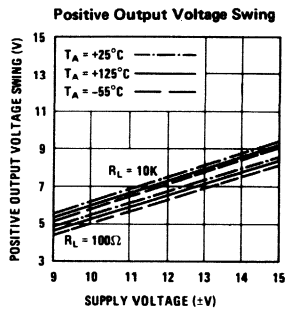
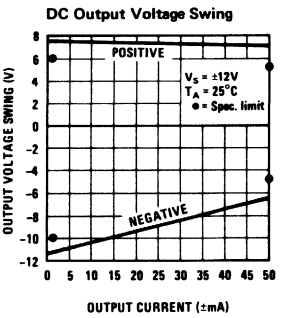
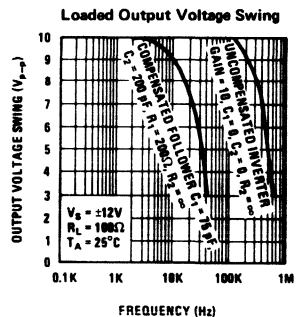
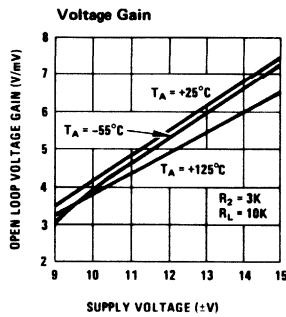
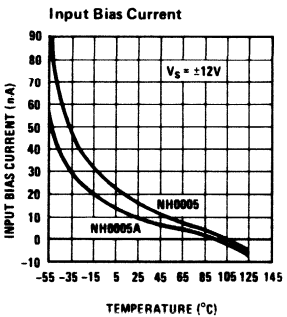
PARAMETER	CONDITIONS	LH0005			LH0005A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage 25°C -55°C, 125°C	$R_S \leq 20 \text{ k}\Omega$ $R_S \leq 20 \text{ k}\Omega$		5	10		1	3	mV
				10			4	mV
Input Offset Current 25°C to 125°C -55°C			10	20		2	5	nA
			25	75		10	25	nA
Input Bias Current 25°C to 125°C -55°C			15	50		8	25	nA
			100	250		60	125	nA
Large Signal Voltage Gain -55°C to 25°C 125°C	$R_L = 10\text{K}, R_2 = 3\text{K}, V_{OUT} = \pm 5\text{V}$	2	4		4	5.5		V/mV
		1.5	3		3	5		V/mV
Output Voltage Swing -55°C to 125°C 25°C to 125°C -55°C	$R_L = 10 \text{ k}\Omega$ $R_L = 100\Omega$ $R_L = 100\Omega$	-10		+6	-10		+6	V
		-5		+5	-5		+5	V
		-4		+4	-4		+4	V
Input Resistance 25°C		1	2		1	2	M Ω	
Common Mode Rejection Ratio 25°C	$V_{IN} = \pm 4\text{V}, R_S \leq 20 \text{ k}\Omega$	55	60		60	66		dB
Power Supply Rejection Ratio 25°C		55	60		60	66		dB
Supply Current (+) -55°C to 125°C			3	5		3	5	mA
Supply Current (-) -55°C to 125°C			2	4		2	4	mA
Average Temperature Coefficient of Input Offset Voltage -55°C to 125°C	$R_S \leq 20 \text{ k}\Omega$		20			10		$\mu\text{V}/^\circ\text{C}$
Output Resistance 25°C						70		Ω

Note 1: These specifications apply for pin 6 grounded, $V_S = \pm 12\text{V}$, with Resistor $R_1 = 200\Omega$ in series with Capacitor $C_1 = 75 \text{ pF}$ from pin 4 to ground, and $C_2 = 200 \text{ pF}$ between pins 9 and 10 unless otherwise specified.

guaranteed performance characteristics



typical performance characteristics





Operational Amplifiers

LH0005C* operational amplifier

general description

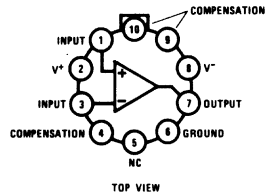
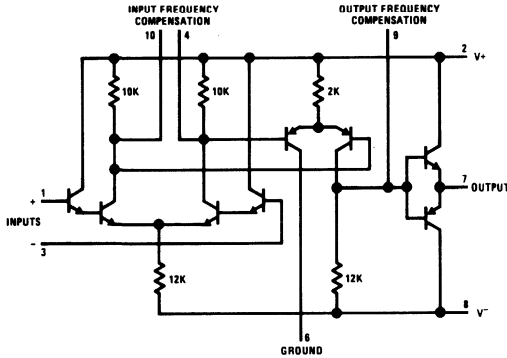
The LH0005C is a hybrid integrated circuit operational amplifier employing thick film resistors and discrete silicon semiconductors in its design. The select matching of the input pairs of transistors results in low input bias currents and a very low input offset current both of which exhibit excellent temperature tracking. In addition, the device features:

- Very high output current capability: ± 40 mA into a 100 ohm load
- Low standby power dissipation: typically 60 mW at ± 12 V
- High input resistance: typically 2M at 25°C

- Operating range: 0° to 70°C
- Good high frequency response: unity gain at 30 MHz

With no external roll-off network, the amplifier is stable with a feedback ratio of 10 or greater. By adding a 200 pF capacitor between pins 9 and 10, and a 200 ohm resistor in series with a 75 pF capacitor from pin 4 to ground, the amplifier is stable to unity gain. The unity gain loop phase margin with the above compensation is typically 70 degrees. With a gain of 10 and no compensation the loop phase margin is typically 50 degrees.

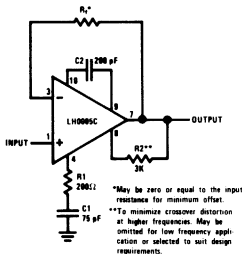
schematic and connection diagrams



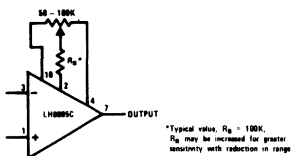
Order Number LH0005CH
See Package 14

typical applications

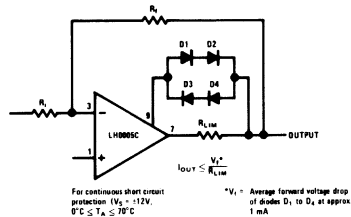
Voltage Follower



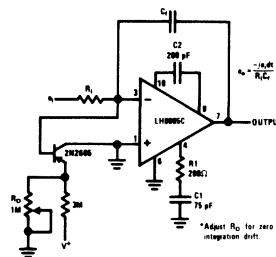
Offset Balancing Circuit



External Current Limiting



Integrator With Bias Current Compensation



*Previously called NH0005C

absolute maximum ratings

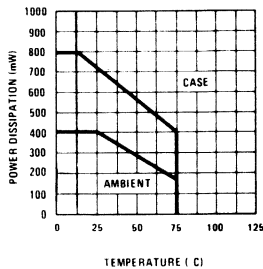
Supply Voltage	±20V
Power Dissipation (see Curve)	400 mW
Differential Input Voltage	±15V
Input Voltage	Equal to supply voltages
Peak Load Current	±100 mA
Storage Temperature Range	-55°C to +125°C
Operating Temperature Range	0°C to 85°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics

PARAMETER	CONDITIONS	LH0005C			UNITS
		MIN	TYP	MAX	
		(Note 2)			
Input Offset Voltage	$R_S \leq 20 \text{ k}\Omega$		3	10	mV
Input Offset Current			5	25	nA
Input Bias Current			20	100	nA
Large Signal Voltage Gain	$R_L = 10\text{K}, R_2 = 3\text{K}, V_{OUT} = \pm 5\text{V}$	2	5		V/mV
Output Voltage Swing	$R_L = 10 \text{ k}\Omega$	-10		+6	V
	$R_L = 100\Omega$	-4	±6	+4	V
Input Resistance	$T_A = 25^\circ\text{C}$	0.5	2		MΩ
Common Mode Rejection Ratio	$V_{IN} = \pm 4\text{V}, R_S \leq 20 \text{ k}\Omega, T_A = 25^\circ\text{C}$	50	60		dB
Power Supply Rejection Ratio	$T_A = 25^\circ\text{C}$	50	60		dB
Supply Current (+)			3	5	mA
Supply Current (-)			2	4	mA

Note 1: These specifications apply for pin 6 grounded, $V_S = \pm 12\text{V}$, with Resistor $R_1 = 200\Omega$ in series with Capacitor $C_1 = 75 \text{ pF}$ from pin 4 to ground, and $C_2 = 200 \text{ pF}$ between pins 9 and 10, over the temperature range of 0°C to +85°C unless otherwise specified.

Note 2: Typical values are for 25°C only.



Maximum Power Dissipation





Operational Amplifiers

LH0020/LH0020C* high gain instrumentation operational amplifier

general description

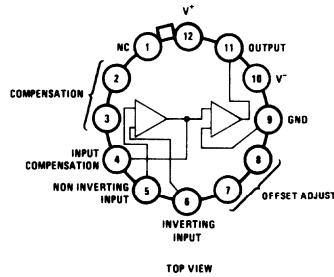
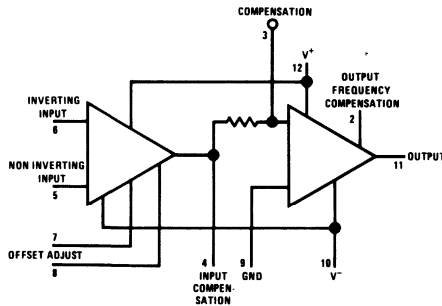
The LH0020/LH0020C is a general purpose operational amplifier designed to source and sink 50 mA output currents. In addition to its high output capability, the LH0020/LH0020C exhibits excellent open loop gain, typically in excess of 100 dB. The parameters of the LH0020 are guaranteed over the temperature range of -55°C to $+125^{\circ}\text{C}$ and $\pm 15\text{V} \leq V_S \leq \pm 22\text{V}$, while those of the LH0020C are guaranteed over the temperature range of 0°C to 85°C and $\leq \pm 5\text{V} \leq V_S \leq \pm 18\text{V}$. Additional features include:

- Low offset voltage typically 1.0 mV at 25°C over the entire common mode voltage range.

- Low offset current typically 10 nA at 25°C for the LH0020 and 30 nA for the LH0020C.
- Offset voltage is adjustable to zero with a single potentiometer.
- $\pm 14\text{V}$, 50 mA output capability.

Output current capability, excellent input characteristics, and large open loop gain make the LH0020/LH0020C suitable for application in a wide variety of applications from precision dc power supplies to precision medium power comparator.

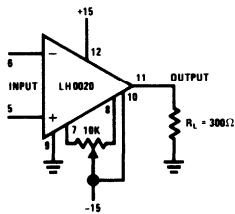
schematic and connection diagrams



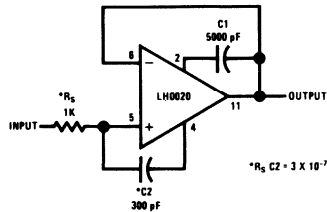
Order Number LH0020G or LH0020CG
See Package 6

typical applications

Offset Adjustment



Unity Gain Frequency Compensation



*Previously called NH0020/NH0020C

absolute maximum ratings

Supply Voltage		±22V
Power Dissipation		1.5W
Differential Input Voltage		±30V
Input Voltage (Note 1)		±15V
Output Short Circuit Duration		Continuous
Operating Temperature Range	LH0020	-55°C to +125°C
	LH0020C	0°C to 85°C
Storage Temperature		-65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics

PARAMETER	CONDITIONS	LH0020			LH0020C			UNITS			
		TEMP °C	MIN	TYP	MAX	TEMP °C	MIN		TYP	MAX	
Input Offset Voltage	$R_S \leq 10k$	25		1.0	2.5	25		1.0	6.0	mV	
		-55 to +125		2.0	4.0	0 to 85		3.0	7.5	mV	
Input Offset Current		25		10	50	25		30	200	nA	
		-55 to +125			100	0 to 85			300	nA	
Input Bias Current		25		60	250	25		200	500	nA	
		-55 to +125			500	0 to 85			800	nA	
Supply Current	$V_S = +15V$	25		3.5	5.0	25		3.6	6.0	mA	
Input Resistance		25		0.6	1.0	25		0.3	1.0	MΩ	
Large Signal Voltage Gain	$V_S = \pm 15V, R_L = 300\Omega, V_O = \pm 10V$	25		100	300	25		50	150	V/mV	
		-55 to +125		50		0 to 85		30		V/mV	
Output Voltage Swing	$V_S = \pm 15V, R_L = 300\Omega$	25		14.2	14.5	25		14.0	14.2	V	
		-55 to +125		14.0		0 to 85		13.5		V	
Output Short Circuit Current	$V_S = \pm 15V$ $R_L = 0\Omega$	25		100	130	25		25	120	140	mA
Input Voltage Range	$V_S = \pm 15V$	-55 to +125		±12		0 to 85		±12		V	
Common Mode Rejection Ratio	$R_S \leq 10k$	-55 to +125		90	96	0 to 85		90	96	dB	
Power Supply Rejection Ratio	$R_S \leq 10k$	-55 to +125		90	96	0 to 85		90	96	dB	

Note 1: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 2: These specifications apply for $\pm 5V \leq V_S \leq \pm 22V$ for the LH0020, $\pm 5V \leq V_S \leq \pm 18V$ for the LH0020C, pin 9 grounded, and a 5000 pF capacitor between pins 2 and 3, unless otherwise specified.



Operational Amplifiers

LH0021/LH0021C 1.0 amp power operational amplifier LH0041/LH0041C 0.2 amp power operational amplifier

general description

The LH0021/LH0021C and LH0041/LH0041C are general purpose operational amplifiers capable of delivering large output currents not usually associated with conventional IC Op Amps. The LH0021 will provide output currents in excess of one ampere at voltage levels of $\pm 12V$; the LH0041 delivers currents of 200 mA at voltage levels closely approaching the available power supplies. In addition, both the inputs and outputs are protected against overload. The devices are compensated with a single external capacitor and are free of any unusual oscillation or latch-up problems.

- High slew rate 3.0V/ μ s
- High open loop gain 100 dB

The excellent input characteristics and high output capability of the LH0021 make it an ideal choice for power applications such as DC servos, capstan drivers, deflection yoke drivers, and programmable power supplies.

The LH0041 is particularly suited for applications such as torque driver for internal guidance systems, diddle yoke driver for alpha-numeric CRT displays, cable drivers, and programmable power supplies for automatic test equipment.

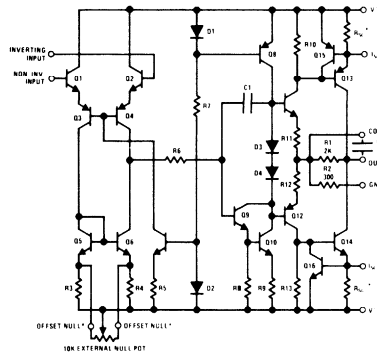
The LH0021 is supplied in a 8 pin TO-3 package rated at 20 watts with suitable heatsink. The LH0041 is supplied in both 12 pin TO-8 (2.5 watts with clip on heatsink) and a power 8 pin ceramic DIP (2 watts with suitable heatsink). The LH0021 and LH0041 are guaranteed over the temperature range of $-55^{\circ}C$ to $+125^{\circ}C$ while the LH0021C and LH0041C are guaranteed from $-25^{\circ}C$ to $+85^{\circ}C$.

For information on other National op amps, see listing on last page.

features

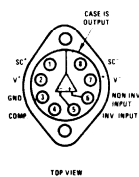
- Output current 1.0 Amp (LH0021)
0.2 Amp (LH0041)
- Output voltage swing $\pm 12V$ into 10Ω (LH0021)
 $\pm 14V$ into 100Ω (LH0041)
- Wide full power bandwidth 15 kHz
- Low standby power 100 mW at $\pm 15V$
- Low input offset voltage and current 1 mV and 20 nA

schematic and connection diagrams



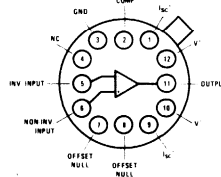
* R_{10} internal on TO-8 and TO-3 packages; R_{10} internal on \bar{J} package
Offset Null connections available only on TO-8 \bar{G} package

TO-3 Package



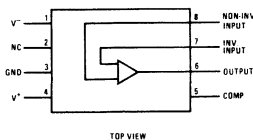
Order Number
LH0021K or LH0021CK
See Package 19

TO-8 Package



Order Number
LH0041G or LH0041CG
See Package 6

Ceramic DIP



Order Number
LH0041CJ
See Package 15

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation	See curves
Differential Input Voltage	±30V
Input Voltage (Note 1)	±15V
Peak Output Current (Note 2)	LH0021/LH0021C 2.0 Amps
	LH0041/LH0041C 0.5 Amps
Output Short Circuit Duration (Note 3)	Continuous
Operating Temperature Range	LH0021/LH0041 -55°C to +125°C
	LH0021C/LH0041C -25°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics for LH0021/LH0021C (Note 4)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0021			LH0021C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S < 10\text{ k}\Omega, T_C = 25^\circ\text{C}$		1.0	3.0		3.0	6.0	mV
	$R_S \leq 10\text{ k}\Omega$			5.0			7.5	mV
Voltage Drift with Temperature	$R_S < 10\text{ k}\Omega$		3	25		5	30	$\mu\text{V}/^\circ\text{C}$
Offset Voltage Drift with Time			5			5		$\mu\text{V}/\text{week}$
Offset Voltage Change with Output Power			5	15		5	20	$\mu\text{V}/\text{watt}$
Input Offset Current	$T_C = 25^\circ\text{C}$		30	100		50	200	nA
				300			500	nA
Offset Current Drift with Temperature			0.1	1.0		0.2	1.0	$\text{nA}/^\circ\text{C}$
Offset Current Drift with Time			2			2		nA/week
Input Bias Current	$T_C = 25^\circ\text{C}$		100	300		200	500	nA
				1.0			1.0	μA
Input Resistance	$T_C = 25^\circ\text{C}$	0.3	1.0		0.3	1.0		M Ω
Input Capacitance			3			3		pF
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega, \Delta V_{CM} = \pm 10\text{V}$	70	90		70	90		dB
Input Voltage Range	$V_S = \pm 15\text{V}$	± 12			± 12			V
Power Supply Rejection Ratio	$R_S \leq 10\text{ k}\Omega, \Delta V_S = \pm 10\text{V}$	80	96		70	90		dB
Voltage Gain	$V_S = \pm 15\text{V}, V_O = \pm 10\text{V}$ $R_L = 1\text{ k}\Omega, T_C = 25^\circ\text{C}$	100	200		100	200		V/mV
	$V_S = \pm 15\text{V}, V_O = \pm 10\text{V}$ $R_L = 100\Omega$	25			20			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}, R_L = 100\Omega$	± 13.5	14		± 13	± 14		V
	$V_S = \pm 15\text{V}, R_L = 10\Omega$	± 11.0	± 12		± 10	± 12		V
Output Short Circuit Current	$V_S = \pm 15\text{V}, T_C = 25^\circ\text{C}, R_{SC} = 0.5\Omega$	0.8	1.2	1.6	0.8	1.2	1.6	Amps
Power Supply Current	$V_S = \pm 15\text{V}, V_{OUT} = 0$		2.5	3.5		3.0	4.0	mA
Power Consumption	$V_S = \pm 15\text{V}, V_{OUT} = 0$		75	105		90	120	mW

ac electrical characteristics for LH0021/LH0021C ($T_A = 25^\circ\text{C}, V_S = \pm 15\text{V}, C_C = 3000\text{ pF}$)

Slew Rate	$A_V = +1, R_L = 100\Omega$	1.5	3.0		1.0	3.0		V/ μs
Power Bandwidth	$R_L = 100\Omega$		40			40		kHz
Small Signal Transient Response			0.3	1.0		0.3	1.5	μs
Small Signal Overshoot			5	20		10	30	%
Settling Time (0.1%)	$\Delta V_{IN} = 10\text{V}, A_V = +1$		4			4		μs
Overload Recovery Time			3			3		μs
Harmonic Distortion	$f = 1\text{ kHz}, P_O = 0.5\text{W}$		0.2			0.2		%
Input Noise Voltage	$R_S = 50\Omega, B.W. = 10\text{ Hz to } 10\text{ kHz}$		5			5		$\mu\text{V}/\text{rms}$
Input Noise Current	$B.W. = 10\text{ Hz to } 10\text{ kHz}$		0.05			0.05		nA/rms

dc electrical characteristics for LH0041/LH0041C (Note 4)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0041			LH0041C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 10 \text{ k}\Omega$, $T_A = 25^\circ\text{C}$		1.0	3.0		3.0	6.0	mV
	$R_S \leq 10 \text{ k}\Omega$			5.0			7.5	mV
Voltage Drift with Temperature	$R_S \leq 10 \text{ k}\Omega$		3			5		$\mu\text{V}/^\circ\text{C}$
Offset Voltage Drift with Time			5			5		$\mu\text{V}/\text{week}$
Offset Voltage Change with Output Power			15			15		$\mu\text{V}/\text{watt}$
Offset Voltage Adjustment Range	(Note 5)		20			20		mV
Input Offset Current	$T_A = 25^\circ\text{C}$		30	100		50	200	nA
				300			500	nA
Offset Current Drift with Temperature			0.1	1.0		0.2	1.0	$\text{nA}/^\circ\text{C}$
Offset Current Drift with Time			2			2		nA/week
Input Bias Current	$T_A = 25^\circ\text{C}$		100	300		200	500	nA
				1.0			1.0	μA
Input Resistance	$T_A = 25^\circ\text{C}$	0.3	1.0		0.3	1.0		$\text{M}\Omega$
Input Capacitance			3			3		pF
Common Mode Rejection Ratio	$R_S \leq 10 \text{ k}\Omega$, $\Delta V_{\text{CM}} = \pm 10\text{V}$		70	90		70	90	dB
Input Voltage Range	$V_S = \pm 15\text{V}$		± 12			± 12		V
Power Supply Rejection Ratio	$R_S \leq 10 \text{ k}\Omega$, $\Delta V_S = \pm 10\text{V}$		80	96		70	90	dB
Voltage Gain	$V_S = \pm 15\text{V}$, $V_O = \pm 10\text{V}$ $R_L = 1 \text{ k}\Omega$, $T_A = 25^\circ\text{C}$		100	200		100	200	V/mV
	$V_S = \pm 15\text{V}$, $V_O = \pm 10\text{V}$ $R_L = 100\Omega$		25			20		V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 100\Omega$	± 13.0	14.0		± 13.0	± 14.0		V
Output Short Circuit Current	$V_S = \pm 15\text{V}$, $T_A = 25^\circ\text{C}$ (Note 6)		200	300		200	300	mA
Power Supply Current	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = 0$		2.5	3.5		3.0	4.0	mA
Power Consumption	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = 0$		75	105		90	120	mW

ac electrical characteristics for LH0041/LH0041C ($T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $C_C = 3000 \text{ pF}$)

Slew Rate	$A_V = +1$, $R_L = 100\Omega$	1.5	3.0		1.0	3.0		V/ μs
Power Bandwidth	$R_L = 100\Omega$		40			40		kHz
Small Signal Transient Response			0.3	1.0		0.3	1.5	μs
Small Signal Overshoot			5	20		10	30	%
Settling Time (0.1%)	$\Delta V_{\text{IN}} = 10\text{V}$, $A_V = +1$		4			4		μs
Overload Recovery Time			3			3		μs
Harmonic Distortion	$f = 1 \text{ kHz}$, $P_O = 0.5\text{W}$		0.2			0.2		%
Input Noise Voltage	$R_S = 50\Omega$, B.W. = 10 Hz to 10 kHz		5			5		$\mu\text{V}/\text{rms}$
Input Noise Current	B.W. = 10 Hz to 10 kHz		0.05			0.05		nA/rms

Note 1: Rating applies for supply voltages above $\pm 15\text{V}$. For supplies less than $\pm 15\text{V}$, rating is equal to supply voltage.

Note 2: Rating applies for LH0041G and LH0021K with $R_{\text{SC}} = 0\Omega$.

Note 3: Rating applies as long as package power rating is not exceeded.

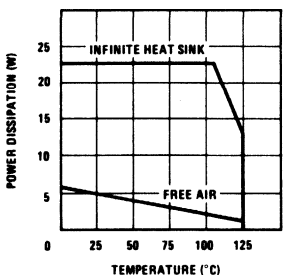
Note 4: Specifications apply for $\pm 5\text{V} \leq V_S \leq 18\text{V}$, and $-55^\circ\text{C} \leq T_C \leq 125^\circ\text{C}$ for LH0021K and LH0041G, and $-25^\circ\text{C} \leq T_C \leq +85^\circ\text{C}$ for LH0021CK, LH0041CG and LH0041CJ unless otherwise specified. Typical values are for 25°C only.

Note 5: TO-8 "G" packages only.

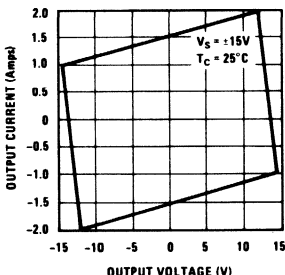
Note 6: Rating applies for "J" DIP package and for TO-8 "G" package with $R_{\text{SC}} = 3.3 \text{ ohms}$.

typical performance characteristics

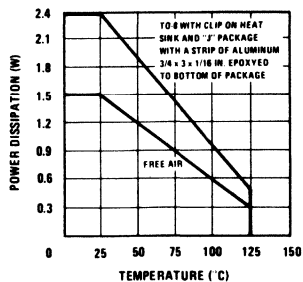
Power Derating-LH0021



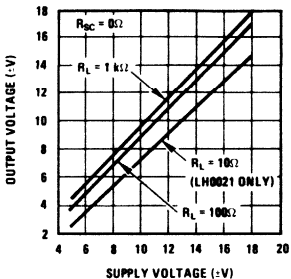
Safe Operating Area - LH0021



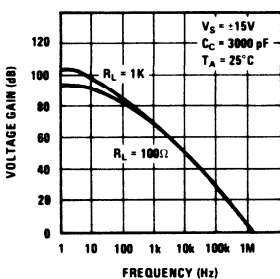
Package Power Dissipation LH0041/LH0041C



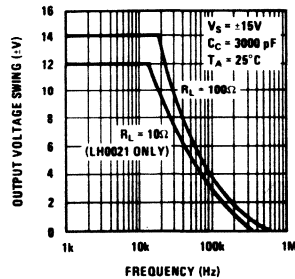
Output Voltage Swing



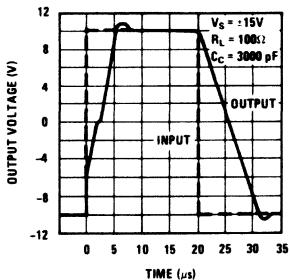
Open Loop Frequency Response



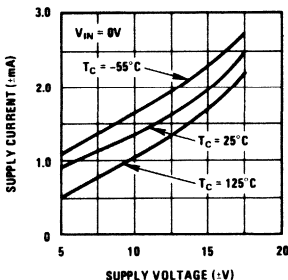
Large Signal Frequency Response



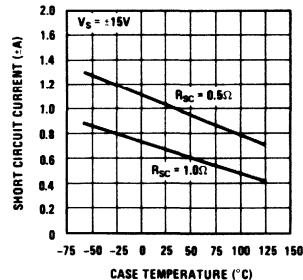
Voltage Follower Pulse Response



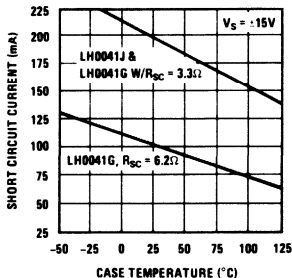
No Load Supply Current



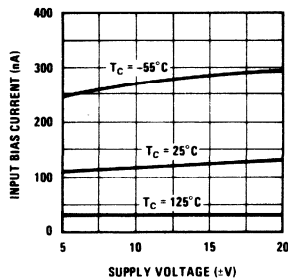
Short Circuit Current vs Temperature LH0021/LH0021C



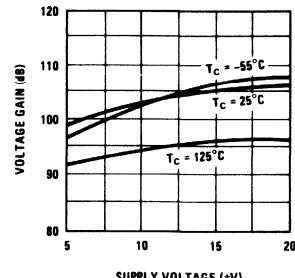
Short Circuit Current vs Temperature LH0041/LH0041C



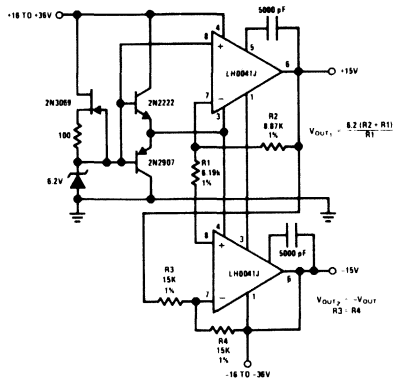
Input Bias Current



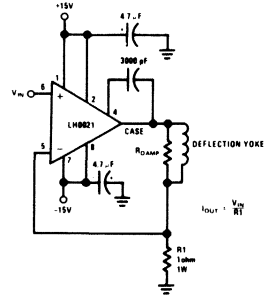
Voltage Gain



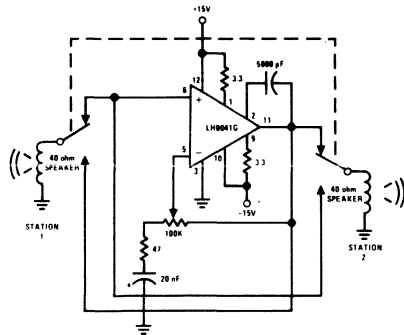
typical applications (con't)



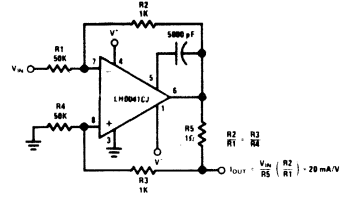
Dual Tracking One Amp Power Supply



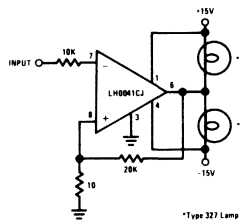
CRT Deflection Yoke Driver



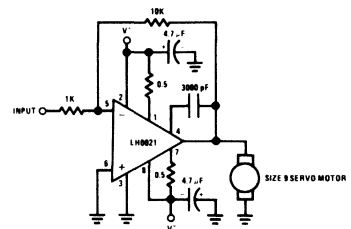
Two Way Intercom



Programmable High Current Source/Sink

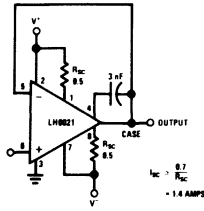


Power Comparator

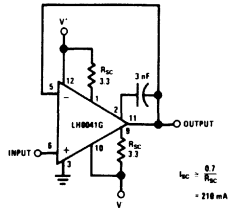


DC Servo Amplifier

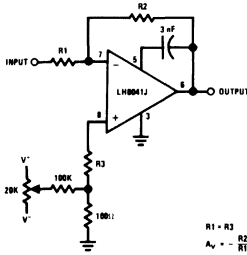
auxiliary circuits



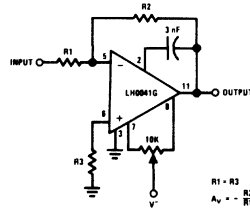
LH0021 Unity Gain Circuit with Short Circuit Limiting



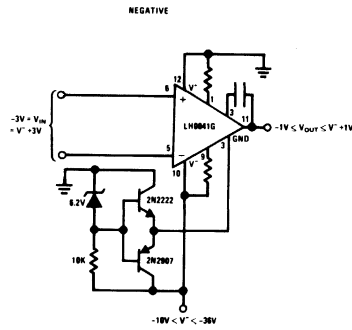
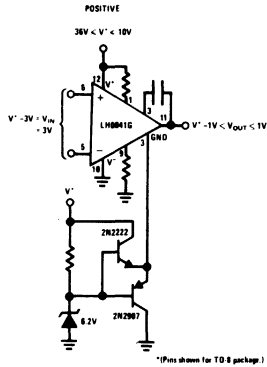
LH0041G Unity Gain with Short Circuit Limiting



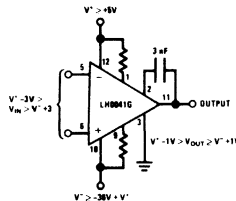
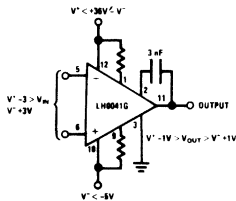
LH0041/LH0021 Offset Voltage Null Circuit (LH0041CJ Pin Connections Shown)*



LH0041G Offset Voltage Null Circuit



Operation from Single Supplies*



Operation from Non-Symmetrical Supplies

*For additional offset null circuit techniques see National Linear Applications Handbook.



Operational Amplifiers

LH0022/LH0022C* high performance FET op amp
LH0042/LH0042C low cost FET op amp
LH0052/LH0052C precision FET op amp

general description

The LH0022/LH0042/LH0052 are a family of FET input operational amplifiers with very closely matched input characteristics, very high input impedance, and ultra-low input currents with no compromise in noise, common mode rejection ratio, open loop gain, or slew rate. The internally laser nulled LH0052 offers 200 microvolts maximum offset and $5 \mu\text{V}/^\circ\text{C}$ offset drift. Input offset current is less than 100 femtoamps at room temperature and 100 pA maximum at 125°C . The LH0022 and LH0042 are not internally nulled but offer comparable matching characteristics. All devices in the family are internally compensated and are free of latch-up and unusual oscillation problems. The devices may be offset nulled with a single 10k trimpot with negligible effect in offset drift or CMRR.

The LH0022, LH0042 and LH0052 are specified for operation over the -55°C to $+125^\circ\text{C}$ military temperature range. The LH0022C, LH0042C and LH0052C are specified for operation over the -25°C to $+85^\circ\text{C}$ temperature range.

features

- Low input offset current – 100 femtoamps max. (LH0052)

- Low input offset drift – $5 \mu\text{V}/^\circ\text{C}$ max (LH0052)
- Low input offset voltage – 100 microvolts-typ.
- High open loop gain – 100 dB typ.
- Excellent slew rate – $3.0 \text{ V}/\mu\text{s}$ typ.
- Internal 6 dB/octave frequency compensation
- Pin compatible with standard IC op amps (TO-5 package)

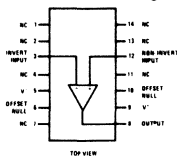
The LH0022/LH0042/LH0052 family of IC op amps are intended to fulfill a wide variety of applications for process control, medical instrumentation, and other systems requiring very low input currents and tightly matched input offsets. The LH0052 is particularly suited for long term high accuracy integrators and high accuracy sample and hold buffer amplifiers. The LH0022 and LH0042 provide low cost high performance for such applications as electrometer and photocell amplification, pico-ammmeters, and high input impedance buffers.

Special electrical parameter selection and custom built circuits are available on special request.

For additional application information and information on other National operational amplifiers, see *Available Linear Applications Literature*.

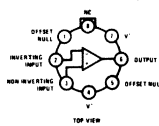
schematic and connection diagrams

Dual-In-Line Package



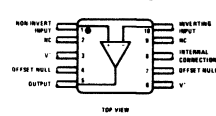
Order Number LH0022D or LH0022CD or LH0042D or LH0042CD or LH0052D or LH0052CD
See Package 1

Metal Can Package

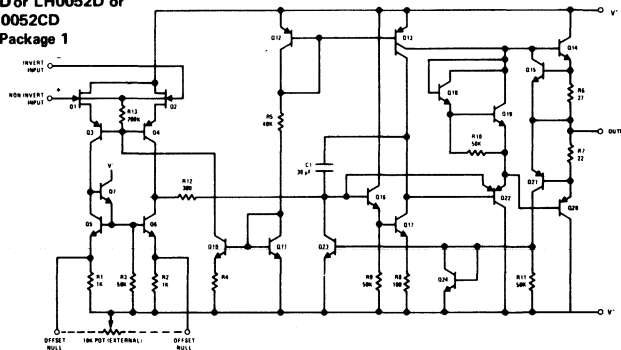


Order Number LH0022H or LH0022CH or LH0042H or LH0042CH or LH0052H or LH0052CH
See Package 11

Flat-Package



Order Number LH0022F or LH0022CF or LH0042F or LH0042CF
See Package 3



*Previously Called NH0022/NH0022C

absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (see graph)	500 mW
Input Voltage (Note 1)	±15V
Differential Input Voltage (Note 2)	±30V
Voltage Between Offset Null and V ⁻	±0.5V
Short Circuit Duration	Continuous
Operating Temperature Range	
LH0022, LH0042, LH0052	-55°C to +125°C
LH0022C, LH0042C, LH0052C	-25°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics For LH0022/LH0022C (Note 3)

PARAMETER	CONDITIONS	LIMITS						UNITS	
		LH0022			LH0022C				
		MIN	TYP	MAX	MIN	TYP	MAX		
Input Offset Voltage	R _S ≤ 100 kΩ; T _A = 25°C		2.0	4.0		3.5	6.0	mV	
	R _S ≤ 100 kΩ			5.0			10.0	mV	
Temperature Coefficient of Input Offset Voltage	R _S ≤ 100 kΩ		5	10		5	15	μV/°C	
Offset Voltage Drift with Time			3			4		μV/week	
Input Offset Current	T _A = 25°C		0.2	2.0		1.0	5.0	pA	
				200			200	pA	
Temperature Coefficient of Input Offset Current			Doubles every 20°C			Doubles every 20°C			
Offset Current Drift with Time			0.1			0.1		pA/week	
Input Bias Current	T _A = 25°C		5	10		10	25	pA	
				1.0			1.0	nA	
Temperature Coefficient of Input Bias Current			Doubles every 20°C			Doubles every 20°C			
Differential Input Resistance				10 ¹²			10 ¹²	Ω	
Common Mode Input Resistance				10 ¹²			10 ¹²	Ω	
Input Capacitance				4.0			4.0	pF	
Input Voltage Range	V _S = ±15V	±12	±13.5		±12	±13.5		V	
Common Mode Rejection Ratio	R _S ≤ 10 kΩ, V _{IN} = ±10V	80	90		70	90		dB	
Supply Voltage Rejection Ratio	R _S ≤ 10 kΩ, ±5V ≤ V _S ≤ ±15V	80	90		70	90		dB	
Large Signal Voltage Gain	R _L = 2 kΩ, V _{OUT} = ±10V, T _A = 25°C, V _S = ±15V	100	200		75	160		V/mV	
	R _L = 2 kΩ, V _{OUT} = ±10V, V _S = ±15V		50			50		V/mV	
Output Voltage Swing	R _L = 1 kΩ, T _A = 25°C, V _S = ±15V	±10	±12.5		±10	±12		V	
	R _L = 2 kΩ, V _S = ±15V	±10			±10			V	
Output Current Swing	V _{OUT} = ±10V, T _A = 25°C	±10	±15		±10	±15		mA	
Output Resistance			75			75		Ω	
Output Short Circuit Current			25			25		mA	
Supply Current	V _S = ±15V		2.0	2.5		2.4	2.8	mA	
Power Consumption	V _S = ±15V			75			85	mW	



dc electrical characteristics for LH0042/LH0042C

($T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$, unless otherwise specified)

PARAMETER	CONDITIONS	LIMITS						UNITS	
		LH0042			LH0042C				
		MIN	TYP	MAX	MIN	TYP	MAX		
Input Offset Voltage	$R_S \leq 100\text{ k}\Omega$, $\pm 5\text{V} \leq V_S \leq 20\text{V}$		5.0	20		6.0	20	mV	
Temperature Coefficient of Input Offset Voltage	$R_S \leq 100\text{ k}\Omega$		5	20		10	25	$\mu\text{V}/^\circ\text{C}$	
Offset Voltage Drift with Time			7			10		$\mu\text{V}/\text{week}$	
Input Offset Current			1	5		2	10	pA	
Temperature Coefficient of Input Offset Current			Doubles every 20°C			Doubles every 20°C			
Offset Current Drift with Time			0.1			0.1		pA/week	
Input Bias Current			10	25		15	50	pA	
Temperature Coefficient of Input Bias Current			Doubles every 20°C			Doubles every 20°C			
Differential Input Resistance			10^{12}			10^{12}		Ω	
Common Mode Input Resistance			10^{12}			10^{12}		Ω	
Input Capacitance			4.0			4.0		pF	
Input Voltage Range		± 12	± 13.5		± 12	± 13.5		V	
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$, $V_{IN} = \pm 10\text{V}$	70	86		70	80		dB	
Supply Voltage Rejection Ratio	$R_S \leq 10\text{ k}\Omega$, $\pm 5\text{V} \leq V_S \leq \pm 15\text{V}$	70	86		70	80		dB	
Large Signal Voltage Gain	$R_L = 1\text{ k}\Omega$, $V_{OUT} = \pm 10\text{V}$	50	150		25	100		V/mV	
Output Voltage Swing	$R_L = 1\text{ k}\Omega$	± 10	± 12.5		± 10	± 12		V	
Output Current Swing	$V_{OUT} = \pm 10\text{V}$	± 10	± 15		± 10	± 15		mA	
Output Resistance			75			75		Ω	
Output Short Circuit Current			20			20		mA	
Supply Current			2.5	3.5		2.8	4.0	mA	
Power Consumption				105			120	mW	

dc electrical characteristics For LH0052/LH0052C (Note 3)

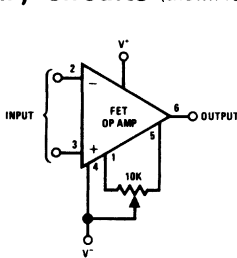
PARAMETER	CONDITIONS	LIMITS						UNITS	
		LH0052			LH0052C				
		MIN	TYP	MAX	MIN	TYP	MAX		
Input Offset Voltage	$R_S \leq 100\text{ k}\Omega$, $V_S = \pm 15\text{V}$, $T_A = 25^\circ\text{C}$		0.1	0.5		0.2	1.0	mV	
Temperature Coefficient of Input Offset Voltage	$R_S \leq 100\text{ k}\Omega$, $V_S = \pm 15\text{V}$			1.0			1.5	mV	
Offset Voltage Drift with Time			2	5		5	10	$\mu\text{V}/^\circ\text{C}$	
Input Offset Current	$T_A = 25^\circ\text{C}$		0.01	0.1		0.02	0.2	pA	
Temperature Coefficient of Input Offset Current			Doubles every 20°C			Doubles every 20°C			
Offset Current Drift with Time			<0.1			<0.1		pA/week	
Input Bias Current	$T_A = 25^\circ\text{C}$		0.5	1.0		1.0	5.0	pA	
Temperature Coefficient of Input Bias Current			Doubles every 20°C			Doubles every 20°C			
Differential Input Resistance			10^{12}			10^{12}		Ω	
Common Mode Input Resistance			10^{12}			10^{12}		Ω	
Input Capacitance			4.0			4.0		pF	
Input Voltage Range	$V_S = \pm 15\text{V}$	± 12	± 13.5		± 12	± 13.5		V	
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$, $V_{IN} = \pm 10\text{V}$	80	90		76	90		dB	
Supply Voltage Rejection Ratio	$R_S \leq 10\text{ k}\Omega$, $\pm 5\text{V} \leq V_S \leq \pm 15\text{V}$	80	90		76	90		dB	
Large Signal Voltage Gain	$R_L = 2\text{ k}\Omega$, $V_{OUT} = \pm 10\text{V}$, $V_S = \pm 15\text{V}$, $T_A = 25^\circ\text{C}$	100	200		75	160		V/mV	
Output Voltage Swing	$R_L = 2\text{ k}\Omega$, $V_{OUT} = \pm 10\text{V}$, $V_S = \pm 15\text{V}$	50			50			V/mV	
Output Current Swing	$R_L = 1\text{ k}\Omega$, $T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$	± 10	± 12.5		± 10	± 12		V	
Output Resistance	$R_L = 2\text{ k}\Omega$, $V_S = \pm 15\text{V}$	± 10	± 15		± 10	± 15		mA	
Output Short Circuit Current	$V_{OUT} = \pm 10\text{V}$, $T_A = 25^\circ\text{C}$	± 10	± 15		± 10	± 15		mA	
Supply Current	$V_S = \pm 15\text{V}$		2.0	2.5		2.5	3.0	mA	
Power Consumption	$V_S = \pm 15\text{V}$			75			90	mW	

ac electrical characteristics For all amplifiers ($T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$)

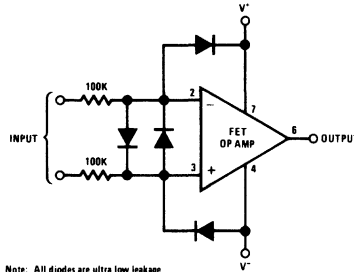
PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0022/42/52			LH0022C/42C/52C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Slew Rate	Voltage Follower	1.5	3.0		1.0	3.0		V/ μs
Large Signal Bandwidth	Voltage Follower		40			40		kHz
Small Signal Bandwidth			1.0			1.0		MHz
Rise Time			0.3	1.5		0.3	1.5	μs
Overshoot			10	30		15	40	%
Settling Time (0.1 %)	$\Delta V_{IN} = 10\text{V}$		4.5			4.5		μs
Overload Recovery			4.0			4.0		μs
Input Noise Voltage	$R_S = 10\text{ k}\Omega$, $f_o = 10\text{ Hz}$		150			150		$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Voltage	$R_S = 10\text{ k}\Omega$, $f_o = 100\text{ Hz}$		55			55		$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Voltage	$R_S = 10\text{ k}\Omega$, $f_o = 1\text{ kHz}$		35			35		$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Voltage	$R_S = 10\text{ k}\Omega$, $f_o = 10\text{ kHz}$		30			30		$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Voltage	$\text{BW} = 10\text{ Hz to } 10\text{ kHz}$, $R_S = 10\text{ k}\Omega$		12			12		μVrms
Input Noise Current	$\text{BW} = 10\text{ Hz to } 10\text{ kHz}$		<.1			<.1		pArms

Note 1: For supply voltages less than $\pm 15\text{V}$, the absolute maximum input voltage is equal to the supply voltage.
Note 2: Rating applies for minimum source resistance of $10\text{ k}\Omega$, for source resistances less than $10\text{ k}\Omega$, maximum differential input voltage is $\pm 5\text{V}$.
Note 3: Unless otherwise specified, these specifications apply for $-5\text{V} \leq V_S \leq \pm 20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq \pm 125^\circ\text{C}$ for the LH0022, LH0042 and LH0052 and $-25^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ for the LH0022C, LH0042C and LH0052C. Typical values are given for $T_A = 25^\circ\text{C}$.

auxiliary circuits (shown for TO-5 pin out)

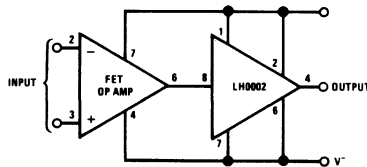


Offset Null



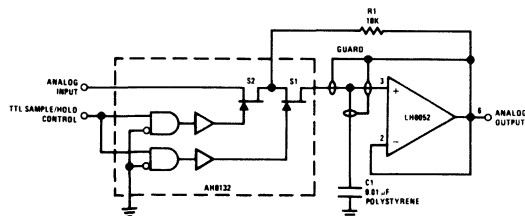
Note: All diodes are ultra low leakage

Protecting Inputs From $\pm 150\text{V}$ Transients

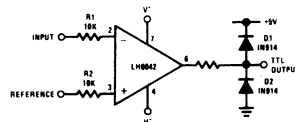


Boosting Output Drive to $\pm 100\text{ mA}$

typical applications

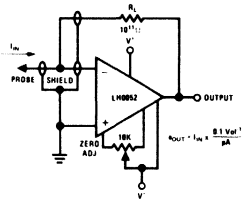


Alternate Low Drift Sample

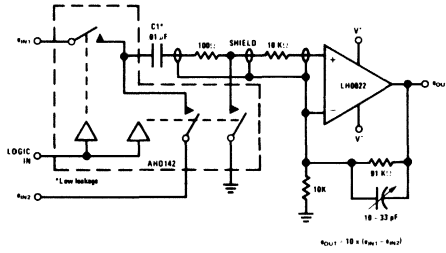


Precision Voltage Comparator

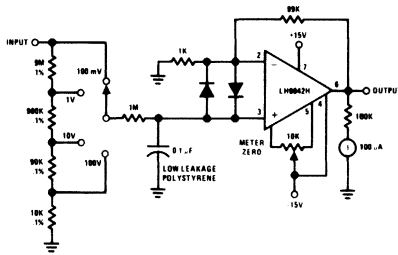
typical applications (con't)



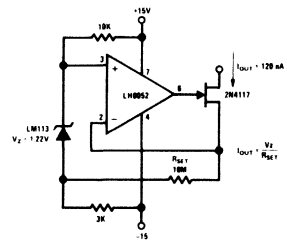
Picoamp Amplifier for pH Meters and Radiation Detectors



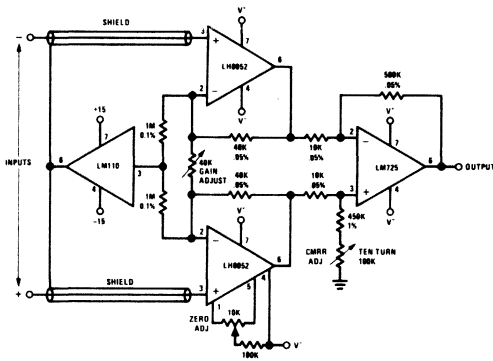
Precision Subtractor for Automatic Test Gear



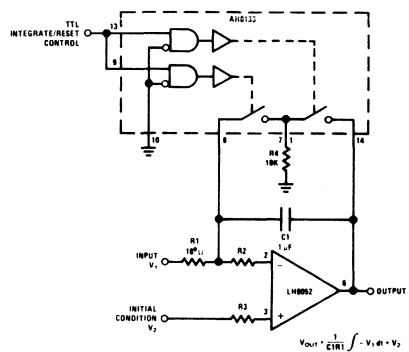
Sensitive Low Cost "VTVM"



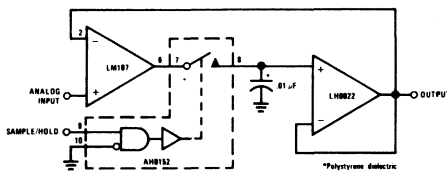
Ultra Low Level Current Source



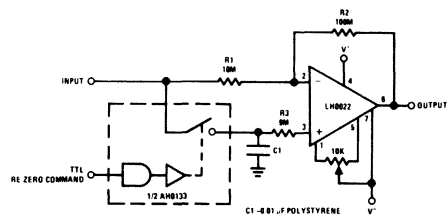
True Instrumentation Amplifier



Precision Integrator

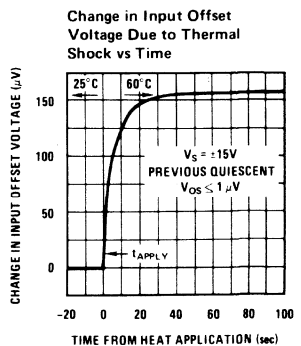
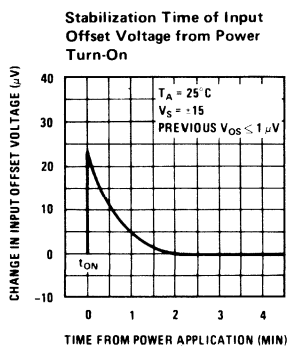
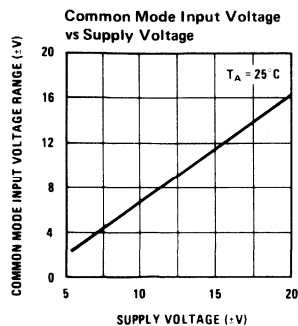
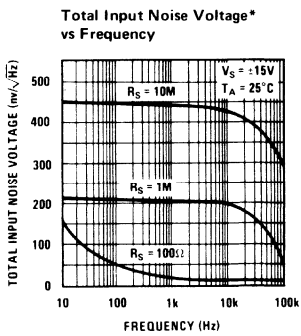
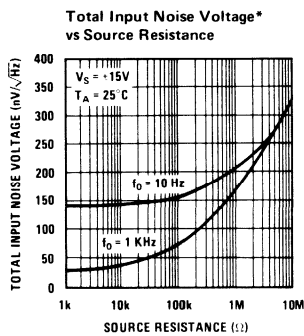
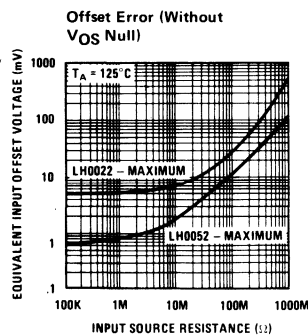
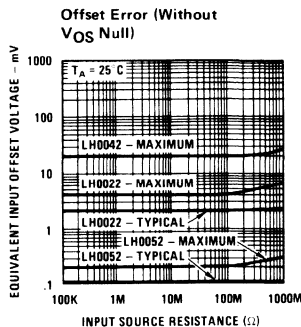
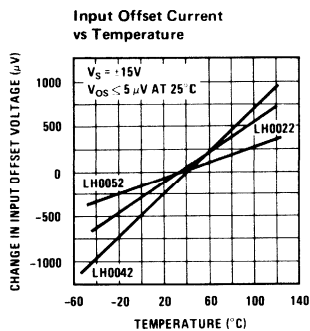
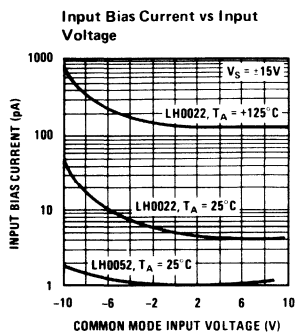
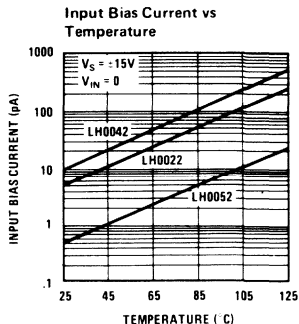
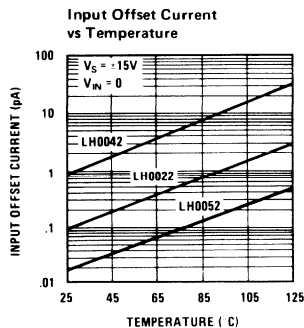
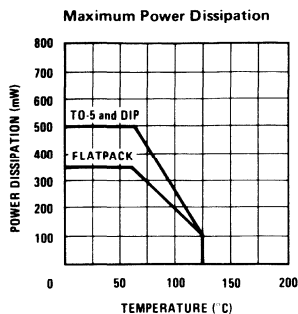


Precision Sample and Hold



Re-Zeroing Amplifier

typical performance characteristics

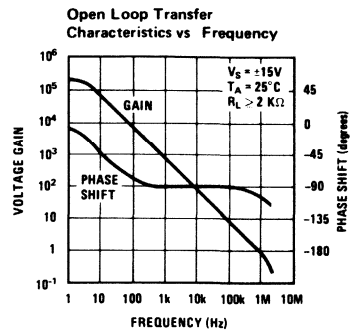
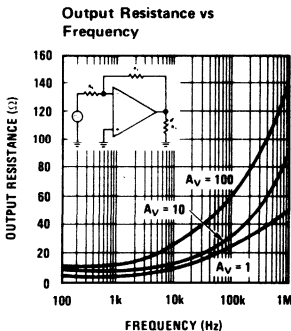
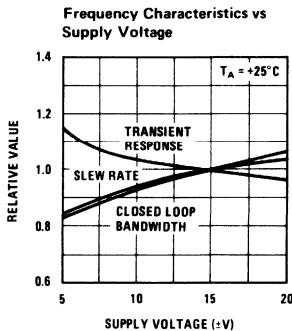
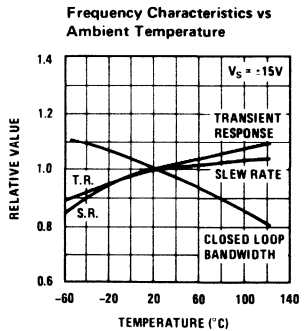
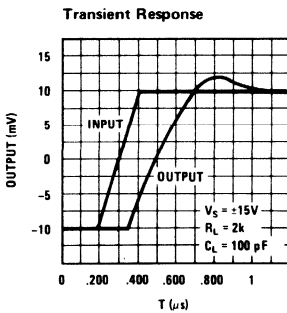
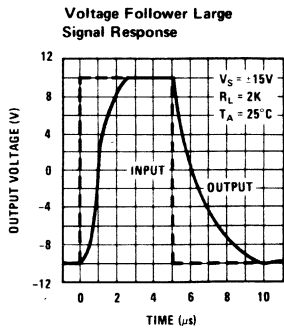
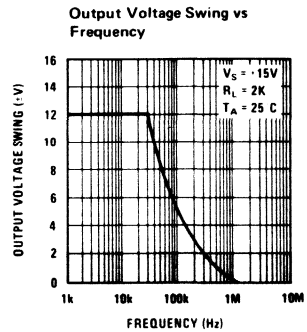
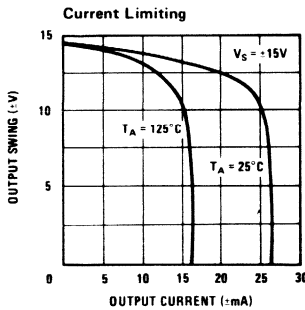
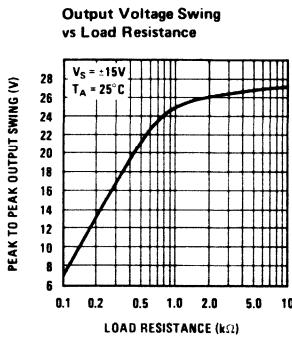
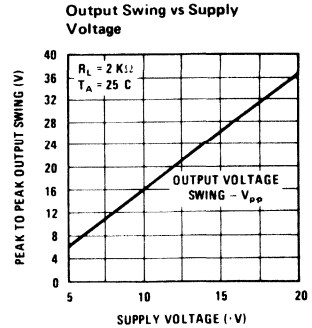
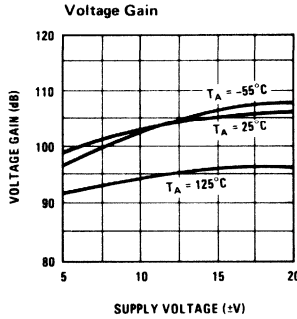
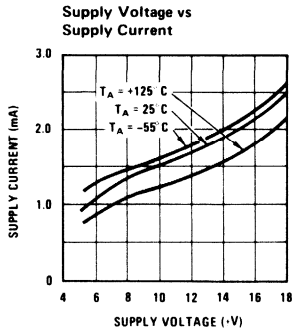


*Noise Voltage Includes Contribution from Source Resistance

typical performance characteristics (con't)

LH0022/LH0022C,
LH0042/LH0042C, LH0052/LH0052C

2





Operational Amplifiers

LH0023/LH0023C, LH0043/LH0043C sample and hold circuits

general description

The LH0023/LH0023C and LH0043/LH0043C are complete sample and hold circuits including input buffer amplifier, FET output amplifier, analog signal sampling gate, TTL compatible logic circuitry and level shifting. They are designed to operate from standard $\pm 15V$ DC supplies, but provision is made on the LH0023/LH0023C for connection of a separate +5V logic supply in minimum noise applications. The principal difference between the LH0023/LH0023C and the LH0043/LH0043C is a 10:1 trade-off in performance on sample accuracy vs sample acquisition time. Devices are pin compatible except that TTL logic is inverted between the two types.

The LH0023/LH0023C and LH0043/LH0043C are ideally suited for a wide variety of sample and

hold applications including data acquisition, analog to digital conversion, synchronous demodulation, and automatic test setup. They offer significant cost and size reduction over equivalent module or discrete designs. Each device is available in a hermetic TO-8 package and are completely specified over both full military and instrument temperature ranges.

The LH0023 and LH0043 are specified for operation over the $-55^{\circ}C$ to $+125^{\circ}C$ military temperature range. The LH0023C and LH0043C are specified for operation over the $-25^{\circ}C$ to $+85^{\circ}C$ temperature range.

For information on other National analog products, see *Available Linear Applications Literature*.

features

LH0023/LH0023C

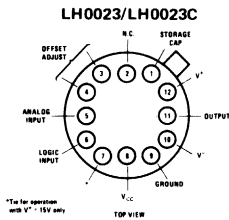
- Sample accuracy—0.01% max
- Hold drift rate—0.5 mV/sec typ
- Sample acquisition time—100 μs max for 20V
- Aperture time—150 ns typ
- Wide analog range— $\pm 10V$ min
- Logic input—TTL/DTL
- Offset adjustable to zero with single 10k pot
- Output short circuit proof

features

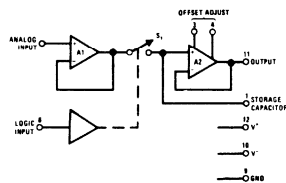
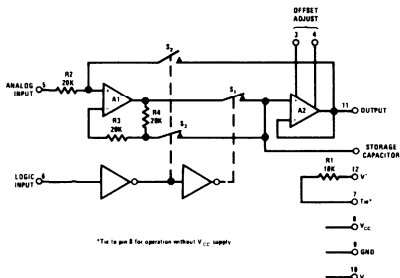
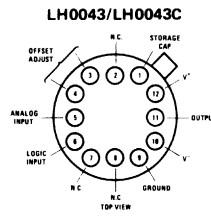
LH0043/LH0043C

- Sample acquisition time—15 μs max for 20V
4 μs typ for 5V
- Aperture time—20 ns typ
- Hold drift rate—1 mV/sec typ
- Sample accuracy—0.1% max
- Wide analog range— $\pm 10V$ min
- Logic input—TTL/DTL
- Offset adjustable to zero with single 10k pot
- Output short circuit proof

block and connection diagrams



Order Number LH0023G or
LH0023CG or LH0043G or
LH0043CG
See Package 6



absolute maximum ratings

Supply Voltage (V^+ and V^-)	$\pm 20V$
Logic Supply Voltage (V_{CC}) LH0023, LH0023C	+7.0V
Logic Input Voltage (V_6)	+5.5V
Analog Input Voltage (V_5)	$\pm 15V$
Power Dissipation	See graph
Output Short Circuit Duration	Continuous
Operating Temperature Range LH0023, LH0043	-55°C to +125°C
LH0023C, LH0043C	-25°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Soldering (10 sec)	300°C

electrical characteristics LH0023/LH0023C (Note 1)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0023			LH0023C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Sample (Logic "1") Input Voltage	$V_{CC} = 4.5V$	2.0			2.0			V
Sample (Logic "1") Input Current	$V_6 = 2.4V, V_{CC} = 5.5V$			5.0			5.0	μA
Hold (Logic "0") Input Voltage	$V_{CC} = 4.5V$			0.8			0.8	V
Hold (Logic "0") Input Current	$V_6 = 0.4V, V_{CC} = 5.5V$			0.5			0.5	mA
Analog Input Voltage Range		± 10	± 11		± 10	± 11		V
Supply Current – I_{10}	$V_5 = 0V, V_6 = 2V,$ $V_{11} = 0V$		4.5	6		4.5	6	mA
Supply Current – I_{12}	$V_5 = 0V, V_6 = 0.4V,$ $V_{11} = 0V$		4.5	6		4.5	6	mA
Supply Current – I_8	$V_8 = 5.0V, V_5 = 0$		1.0	1.6		1.0	1.6	mA
Sample Accuracy	$V_{OUT} = \pm 10V$ (Full Scale)		0.002	0.01		0.002	0.01	%
DC Input Resistance	Sample Mode	500	1000		300	1000		k Ω
	Hold Mode	20	25		20	25		k Ω
Input Current – I_5	Sample Mode		0.2	1.0		0.3	1.5	μA
Input Capacitance			3.0			3.0		pF
Leakage Current – pin 1	$V_5 = \pm 10V; V_{11} = \pm 10V,$ $T_A = 25^\circ C$		100	200		200	500	pA
	$V_5 = \pm 10V; V_{11} = \pm 10V$		0.6	1.0		1.0	2	nA
Drift Rate	$V_{OUT} = \pm 5V, C_S = 0.01 \mu F,$ $T_A = 25^\circ C$		0.5			0.5		mV/s
Drift Rate	$V_{OUT} = \pm 10V,$ $C_S = 0.01 \mu F, T_A = 25^\circ C$		10	20		20	50	mV/s
Drift Rate	$V_{OUT} = \pm 10V,$ $C_S = 0.01 \mu F$			0.1			0.2	mV/ms
Aperture Time			150			150		ns
Sample Acquisition Time	$\Delta V_{OUT} = 20V,$ $C_S = 0.01 \mu F$		50	100		50	100	μs
Output Amplifier Slew Rate		1.5	3.0		1.5	3.0		V/ μs
Output Offset Voltage (without null)	$R_S \leq 10k, V_5 = 0V, V_6 = 0V$			± 20			± 20	mV
Analog Voltage	$R_L \geq 1k, T_A = 25^\circ C$	± 10	± 11		± 10	± 11		V
Output Range	$R_L \geq 2k$	± 10	± 12		± 10	± 12		V

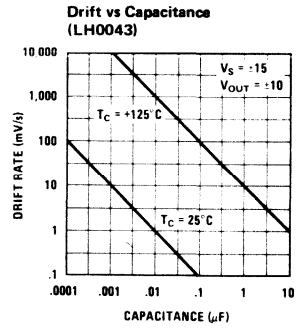
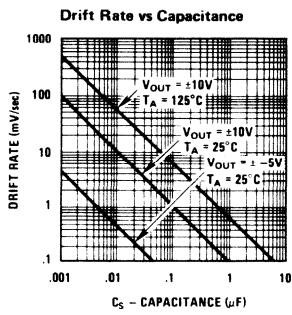
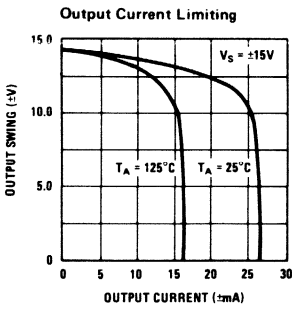
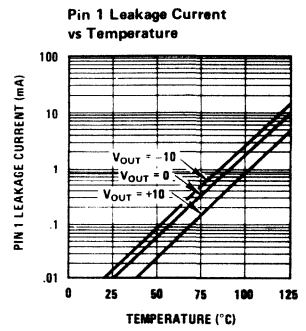
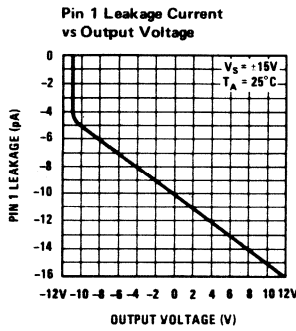
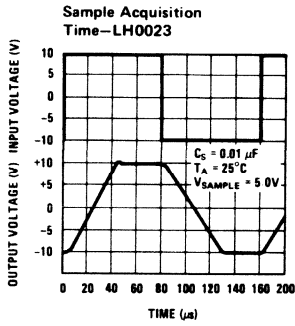
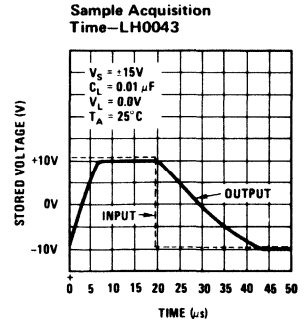
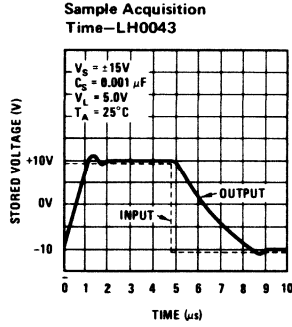
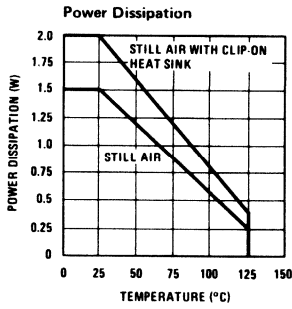
NOTE 1: Unless otherwise noted, these specifications apply for $V^+ = +15V, V_{CC} = +5V, V^- = -15V,$ pin 9 grounded, a 0.01 μF capacitor connected between pin 1 and ground over the temperature range -55°C to +125°C for the LH0023, and -25°C to 85°C for the LH0023C. All typical values are for $T_A = 25^\circ C$.

electrical characteristics LH0043/LH0043C: (Note 2)

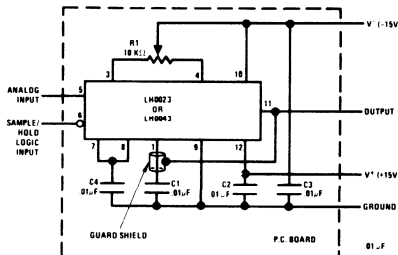
PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0043			LH0043C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Hold (Logic "1") Input Voltage		2.0			2.0			V
Hold (Logic "1") Input Current	$V_6 = 2.4V$			5.0			5.0	μA
Sample (Logic "0") Input Voltage				0.8			0.8	V
Sample (Logic "0") Input Current	$V_6 = 0.4V$			1.5			1.5	mA
Analog Input Voltage Range		± 10	± 11		± 10	± 11		V
Supply Current	$V_5 = 0V, V_6 = 2V, V_{11} = 0V$		20	22		20	22	mA
	$V_5 = 0V, V_6 = 0.4V,$ $V_{11} = 0V$		14	18		14	18	mA
Sample Accuracy	$V_{OUT} = \pm 10V$ (Full Scale)		0.02	0.1		0.02	0.3	%
DC Input Resistance	$T_C = 25^\circ C$	10^{10}	10^{12}		10^{10}	10^{12}		Ω
Input Current – I_5			1.0	5.0		2.0	10.0	nA
Input Capacitance			1.5			1.5		pF
Leakage Current – pin 1	$V_5 = \pm 10V; V_{11} = \pm 10,$ $T_C = 25^\circ C$		10	25		20	50	pA
	$V_5 = \pm 10V; V_{11} = \pm 10V$		10	25		2	5	nA
Drift Rate	$V_{OUT} = \pm 10V, C_S = 0.001 \mu F,$ $T_A = 25^\circ C$		10	25		20	50	mV/s
Drift Rate	$V_{OUT} = \pm 10V, C_S = 0.001 \mu F$		10	25		2	5	mV/ms
Drift Rate	$V_{OUT} = \pm 10V, C_S = 0.01 \mu F,$ $T_A = 25^\circ C$		1	2.5		2	5	mV/s
Drift Rate	$V_{OUT} = \pm 10V, C_S = 0.01 \mu F$		1	2.5		0.2	0.5	mV/ms
Aperture Time			20	60		20	60	ns
Sample Acquisition Time	$\Delta V_{OUT} = 20V, C_S = 0.001 \mu F$		10	15		10	15	μs
	$\Delta V_{OUT} = 20V, C_S = 0.01 \mu F$		30	50		30	50	μs
	$\Delta V_{OUT} = 5V, C_S = 0.001 \mu F$		4			4		μs
Output Amplifier Slew Rate	$V_{OUT} = 5V, C_S = 0.001 \mu F$	1.5	3.0		1.5	3.0		V/ μs
Output Offset Voltage (without null)	$R_S \leq 10k, V_5 = 0V, V_6 = 0V$			± 40			± 40	mV
Analog Voltage	$R_L \geq 1k, T_A = 25^\circ C$	± 10	± 11		± 10	± 11		V
Output Range	$R_L \geq 2k$	± 10	± 12		± 10	± 12		V

Note 2: Unless otherwise noted, these specifications apply for $V^+ = +15V, V^- = -15V$, pin 9 grounded, a 5000 pF capacitor connected between pin 1 and ground over the temperature range $-55^\circ C$ to $+125^\circ C$ for the LH0043, and $-25^\circ C$ to $85^\circ C$ for the LH0043C. All typical values are for $T_C = 25^\circ C$.

typical performance characteristics



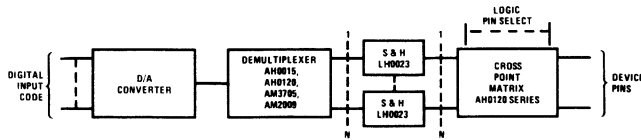
typical applications



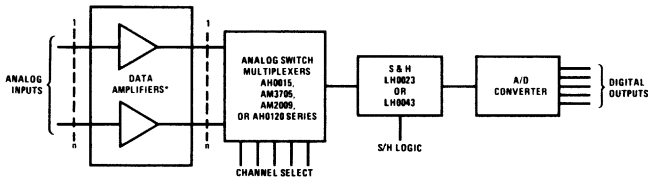
Note 1: C1 is polystyrene
 Note 2: C2, C3, C4 are ceramic disc
 Note 3: Jumper J1, J2 and C4 not required for LH0043
 Note 4: R1 optional if zero trim is required

How to Build a Sample and Hold Module

typical applications (con't)

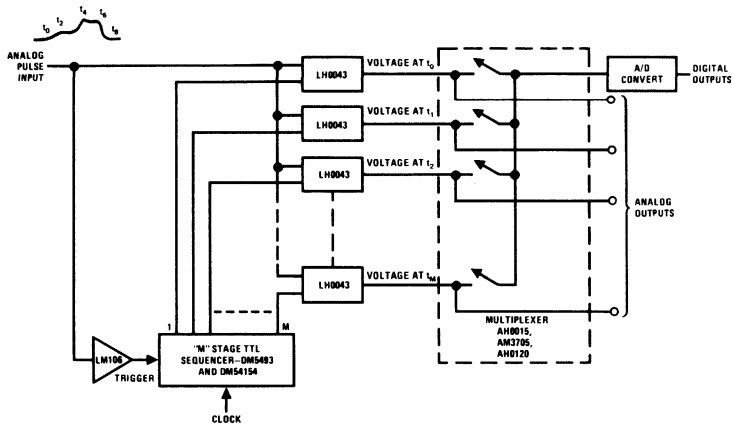


Forcing Function Setup for Automatic Test Gear

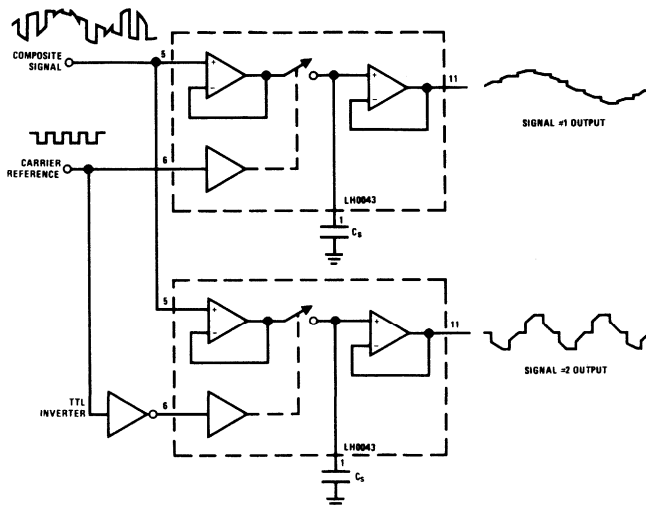


*See op. amp. selection guide for details. Most popular types include LH0052, LH1725, LM108, LM112 and LM116.

Data Acquisition System



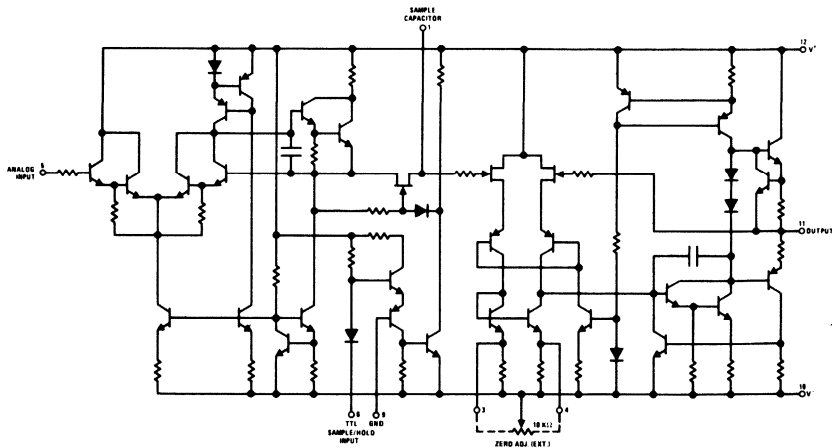
Single Pulse Sampler



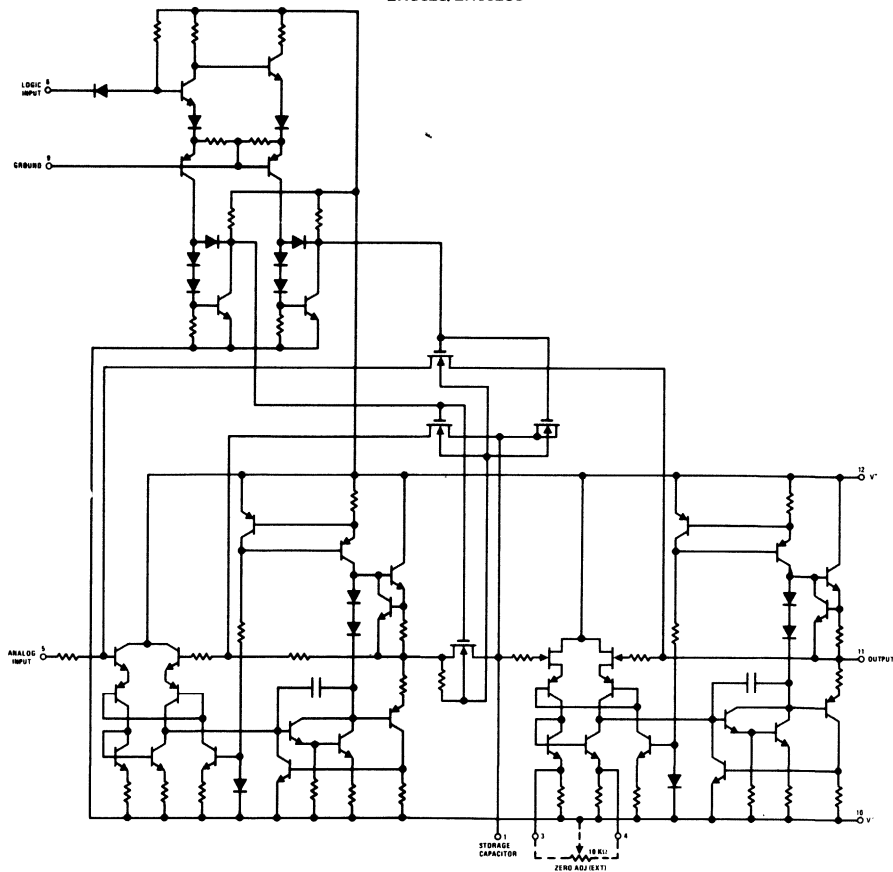
Two Channel Double Sideband Demodulator

schematic diagrams

LH0043/LH0043C



LH0023/LH0023C



applications information

1.0 Drift Error Minimization

In order to minimize drift error, care in selection of C_S and layout of the printed circuit board is required. The capacitor should be of high quality Teflon, polycarbonate, or polystyrene construction. Board cleanliness and layout are critical particularly at elevated temperatures. See AN-63 for detailed recommendations. A guard conductor connected to the output surrounding the storage node (pin 1) will be helpful in meeting severe environmental conditions which would otherwise cause leakage across the printed circuit board.

2.0 Capacitor Selection

The size of the capacitor is dictated by the required drift rate and acquisition time. The drift is determined by the leakage current at pin 1 and may be calculated by $\frac{dV}{dt} = \frac{I_L}{C_S}$, where I_L is the total leakage current at pin 1 of the device, and C_S is the value of the storage capacitor.

2.1 Capacitor Selection – LH0023

At room temperature leakage current for the LH0023 is approximately 100 pA. A drift rate of 10 mV/sec would require a 0.01 μ F capacitor.

For values of C_S up to 0.01 μ F the acquisition time is limited by the slew rate of the input buffer amplifier, A1, typically 0.5 V/ μ s. Beyond this point, current availability to charge C_S also enters the picture. The acquisition time is given by:

$$t_A \cong \sqrt{\frac{2\Delta e_O R C_S}{0.5 \times 10^6}} = 2 \times 10^{-3} \sqrt{\Delta e_O R C_S}$$

where: R = the internal resistance in series with C_S

Δe_O = change in voltage sampled

An average value for R is approximately 600 ohms. The expression for t_A reduces to:

$$t_A \cong \frac{\sqrt{\Delta e_O C_S}}{20}$$

For a -10V to +10V change and $C_S = .05 \mu$ F, acquisition time is typically 50 μ s.

2.2 Capacitor Selection—LH0043

At 25°C case temperature, the leakage current for the LH0043G is approximately 10 pA, so a drift rate of 5 mV/s would require a capacitor of $C_S = 10 \cdot 10^{-12} / 5 \cdot 10^{-3} = 2000$ pF or larger.

For values of C_S below about 5000 pF, the acquisition time of the LH0043G will be limited by the slew rate of the output amplifier (the signal will be acquired, in the sense that the voltage

will be stored on the capacitor, in much less time as dictated by the slew rate and current capacity of the input amplifier, but it will not be available at the output). For larger values of storage capacitance, the limitation is the current sinking capability of the input amplifier, typically 10 mA. With $C_S = 0.01 \mu$ F, the slew rate can be estimated by $\frac{dV}{dt} = \frac{10 \cdot 10^{-3}}{0.01 \cdot 10^{-6}} = 1V/\mu$ s or a slewing time for a 5 volt signal change of 5 μ s.

3.0 Offset Null

Provision is made to null both the LH0023 and LH0043 by use of a 10k pot between pins 3 and 4. Offset null should be accomplished in the sample mode at one half the input voltage range for minimum average error.

4.0 Switching Spike Minimization—LH0043

A capacitive divider is formed by the storage capacitor and the capacitance of the internal FET switch which causes a small error current to be injected into the storage capacitor at the termination of the sample interval. This can be considered a negative DC offset and nulled out as described in (3.0), or the transient may be nulled by coupling an equal but opposite signal to the storage capacitor. This may be accomplished by connecting a capacitor of about 30 pF (or a trimmer) between the logic input (pin 6) and the storage capacitor (pin 1). Note that this capacitor must be chosen as carefully as the storage capacitor itself with respect to leakage. The LH0023 has switching spike minimization circuitry built into the device.

5.0 Elimination of the 5V Logic Supply—LH0023

The 5V logic supply may be eliminated by shorting pin 7 to pin 8 which connects a 10k dropping resistor between the +15V and V_C . Decoupling pin 8 to ground through 0.1 μ F disc capacitor is recommended in order to minimize transients in the output.

6.0 Heat Sinking

The LH0023 and LH0043G may be operated without damage throughout the military temperature range of -55 to +125°C (-25 to +85°C for the LH0023CG and LH0043CG) with no explicit heat sink, however power dissipation will cause the internal temperature to rise above ambient. A simple clip-on heat sink such as Wakefield #215-1.9 or equivalent will reduce the internal temperature about 20°C thereby cutting the leakage current and drift rate by one fourth at max. ambient. There is no internal electrical connection to the case, so it may be mounted directly to a grounded heat sink.

7.0 Theory of Operation—LH0023

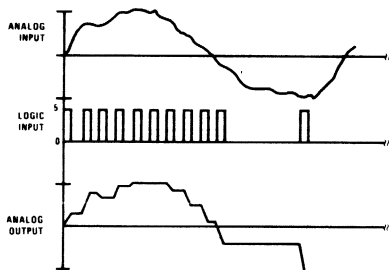
The LH0023/LH0023C is comprised of input buffer amplifier, A1, analog switches, S1 and S2, a

applications information (con't)

TTL to MOS level translator, and output buffer amplifier, A2. In the "sample" mode, the logic input is raised to logic "1" ($V_6 \geq 2.0V$) which opens S1 and closes S2. Storage capacitor, C_S , is charged to the input voltage through S2 and the output slews to the input voltage. In the "hold" mode, the logic input is lowered to logic "0" ($V_6 \leq 0.8V$) opening S2 and closing S1. C_S retains the sample voltage which is applied to the output via A2. Since S1 is closed, the input signal is overridden, and leakage across the MOS switch is therefore minimized. With S2 open, drift is primarily determined by input bias current of A2, typically 100 pA at 25°C.

7.1 Theory of Operation—LH0043

The LH0043/LH0043C is comprised of input buffer amplifier A1, FET switch S1 operated by a TTL compatible level translator, and output buffer amplifier A2. To enter the "sample" mode, the logic input is taken to the TTL logic "0" state ($V_6 = 0.8V$) which commands the switch S1



closed and allows A1 to make the storage capacitor voltage equal to the analog input voltage. In the "hold" mode ($V_6 = 2.0V$), S1 is opened isolating the storage capacitor from the input and leaving it charged to a voltage equal to the last analog input voltage before entering the hold mode. The storage capacitor voltage is brought to the output by low leakage amplifier A2.

8.0 Definitions

- V_5 : The voltage at pin 5, e.g., the analog input voltage.
- V_6 : The voltage at pin 6, e.g., the logic control input signal.
- V_{11} : The voltage at pin 11, e.g., the output signal.
- T_A : The temperature of the ambient air.
- T_C : The temperature of the device case at the center of the bottom of the header.

Acquisition Time:

The time required for the output (pin 11) to settle within the rated accuracy after a specified input change is applied to the input (pin 5) with the logic input (pin 6) in the low state.

Aperture Time:

The time indeterminacy when switching from sample mode to hold including the delay from the time the mode control signal (pin 6) passes through its threshold (1.4 volts) to the time the circuit actually enters the hold mode.

Output Offset Voltage:

The voltage at the output terminal (pin 11) with the analog input (pin 5) at ground and logic input (pin 6) in the "sample" mode. This will always be adjustable to zero using a 10k pot between pins 3 and 4 with the wiper arm returned to V^- .



Operational Amplifiers

LH0024/LH0024C high slew rate operational amplifier

general description

The LH0024/LH0024C is a very wide bandwidth, high slew rate operational amplifier intended to fulfill a wide variety of high speed applications such as buffers to A to D and D to A converters and high speed comparators. The device exhibits useful gain in excess of 50 MHz making it possible to use in video applications requiring higher gain accuracy than is usually associated with such amplifiers.

features

- Very high slew rate – 500 V/ μ s at $A_v = +1$
- Wide small signal bandwidth – 70 MHz
- Wide large signal bandwidth – 15 MHz
- High output swing – $\pm 12V$ into 1K

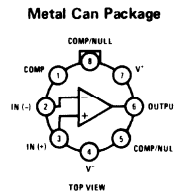
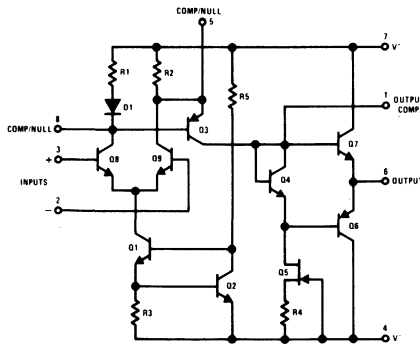
- Offset null with single pot
- Low input offset – 2 mV
- Pin compatible with standard IC op amps

The LH0024/LH0024C's combination of wide bandwidth and high slew rate make it an ideal choice for a variety of high speed applications including active filters, oscillators, and comparators as well as many high speed general purpose applications.

The LH0024 is guaranteed over the temperature range $-55^{\circ}C$ to $+125^{\circ}C$, whereas the LH0024C is guaranteed $-25^{\circ}C$ to $+85^{\circ}C$.

For information on other National operational amplifiers, see listing on last page.

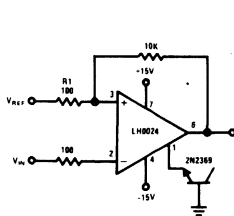
schematic and connection diagrams



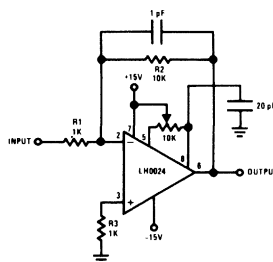
Note: For heat sink use Thermalloy 2230-S series.
Order Number LH0024H or LH0024CH
See Package 11

typical applications

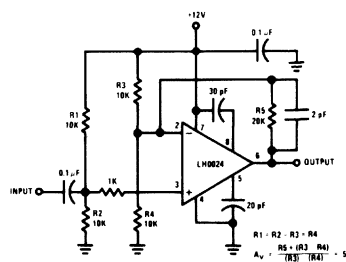
TTL Compatible Comparator



Offset Null



Video Amplifier



absolute maximum ratings

Supply Voltage	±18V
Input Voltage	Equal to Supply
Differential Input Voltage	±5V
Power Dissipation	600 mW
Operating Temperature Range	LH0024 -55°C to +125°C
	LH0024C -25°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LH0024			LH0024C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S = 50\Omega, T_A = 25^\circ\text{C}$ $R_S = 50\Omega$		2.0	4.0 6.0		5.0 8.0	10.0	mV mV
Average Temperature Coefficient of Input Offset Voltage	$V_S = \pm 15\text{V}, R_S = 50\Omega$ -55°C to 125°C		20			25		$\mu\text{V}/^\circ\text{C}$
Input Offset Current	$T_A = 25^\circ\text{C}$		2.0	5.0 10.0		4.0 15.0	20.0	μA μA
Input Bias Current	$T_A = 25^\circ\text{C}$		15	30 40		18 40	50	μA μA
Supply Current			12.5	13.5		12.5	13.5	mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}, R_L = 1\text{k}, T_A = 25^\circ\text{C}$ $V_S = \pm 15\text{V}, R_L = 1\text{k}$	4 3	5		3 2.5	4		V/mV V/mV
Input Voltage Range	$V_S = \pm 15\text{V}$	±12	±13		±12	±13		V
Output Voltage Swing	$V_S = \pm 15\text{V}, R_L = 1\text{k}, T_A = 25^\circ\text{C}$ $V_S = \pm 15\text{V}, R_L = 1\text{k}$	±12 ±10	±13		±10 ±10	±13		V V
Slew Rate	$V_S = \pm 15\text{V}, R_L = 1\text{k},$ $C_1 = C_2 = 30\text{ pF}$ $A_V = +1, T_A = 25^\circ\text{C}$	400	500		250	400		V/ μs
Common Mode Rejection Ratio	$V_S = \pm 15\text{V}, \Delta V_{IN} = \pm 10\text{V}$ $R_S = 50\Omega$		60			60		dB
Power Supply Rejection Ratio	$\pm 5\text{V} \leq V_S \leq \pm 18\text{V}$ $R_S = 50\Omega$		60			60		dB

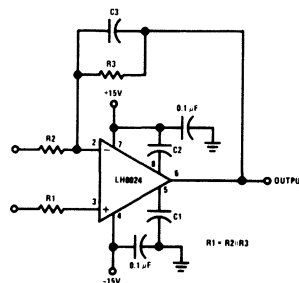
Note 1: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 18\text{V}$ and -55°C to $+125^\circ\text{C}$ for the LH0024 and -25°C to $+85^\circ\text{C}$ for the LH0024C.

frequency compensation

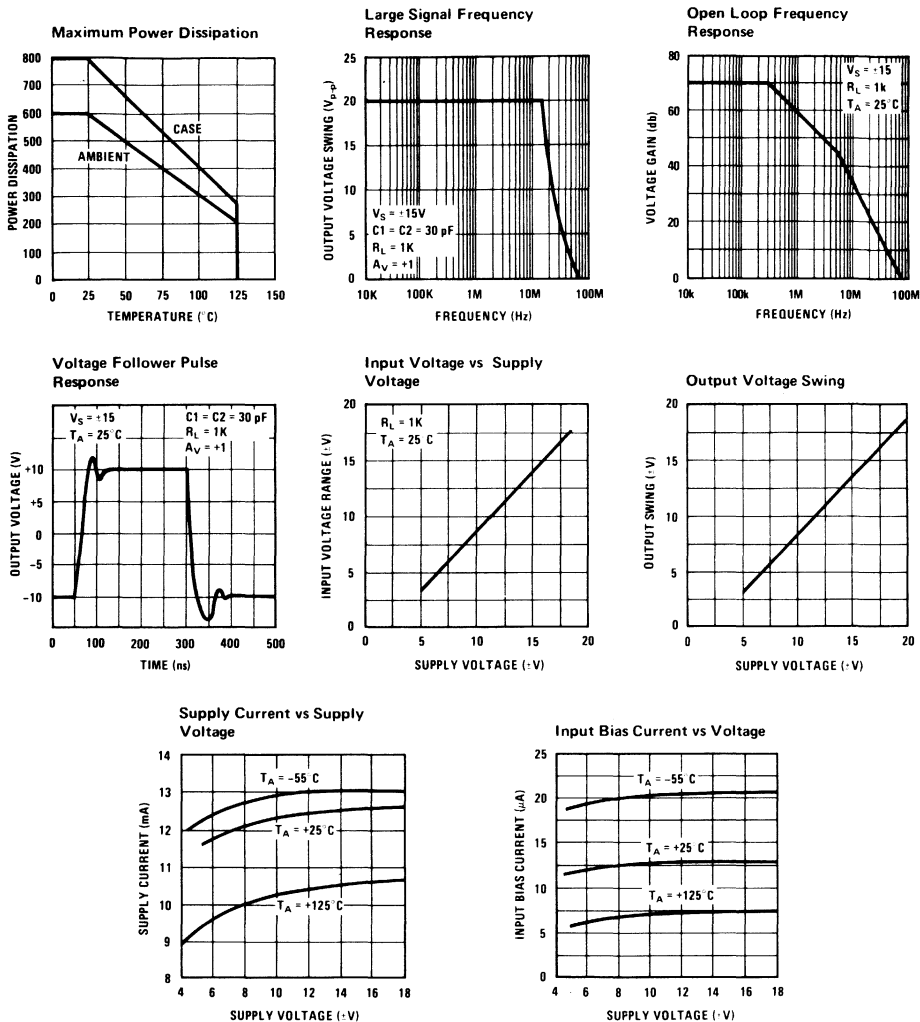
TABLE I

CLOSED LOOP GAIN	C ₁	C ₂	C ₃
100	0	0	0
20	0	0	0
10	0	20 pF	1 pF
1	30 pF	30 pF	3 pF

Frequency Compensation Circuit



typical performance characteristics



applications information

1. Layout Considerations

The LH0024/LH0024C, like most high speed circuitry, is sensitive to layout and stray capacitance. Power supplies should be by-passed as near the device as is practicable with at least .01 µF disc type capacitors. Compensating capacitors should also be placed as close to device as possible.

2. Compensation Recommendations

Compensation schemes recommended in Table 1 work well under typical conditions. However, poor layout and long lead lengths can degrade the performance of the LH0024 or cause the device to oscillate. Slight adjustments in the values for C1, C2, and C3 may be necessary for a given layout. In particular, when operating at a gain of

-1, C3 may require adjustment in order to perfectly cancel the input capacitance of the device. When operating the LH0024/LH0024C at a gain of +1, the value of R1 should be at least 1K ohm. The case of the LH0024 is electrically isolated from the circuit; hence, it may be advantageous to drive the case in order to minimize stray capacitances.

3. Heat Sinking

The LH0024/LH0024C is specified for operation without the use of an explicit heat sink. However, internal power dissipation does cause a significant temperature rise. Improved offset voltage drift can be obtained by limiting the temperature rise with a clip-on heat sink such as the Thermalloy 2228B or equivalent.



Operational Amplifiers

LH0032/LH0032C

LH0032/LH0032C ultra fast FET operational amplifier

general description

The LH0032/LH0032C is a high slew rate, high input impedance differential operational amplifier suitable for diverse application in fast signal handling. The high allowable differential input voltage, ease of output clamping, and high output drive capability particularly suit it for comparator applications. It may be used in applications normally reserved for video amplifiers allowing the use of operational gain setting and frequency response shaping into the megahertz region.

- Low input bias current 20 pA max
- Offset null with single pot
- Low input offset voltage 2 mV max
- No compensation for gains above 50

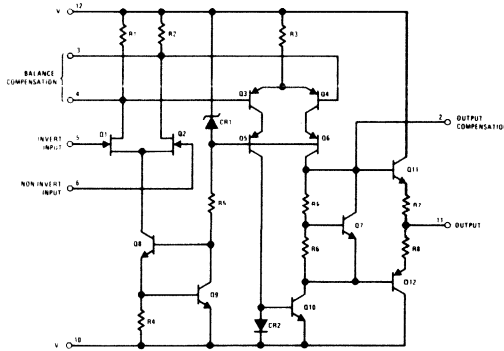
The LH0032's wide bandwidth, high input impedance and high output capacity make it an ideal choice for applications such as summing amplifiers in high speed D to A's, buffers in data acquisition systems, and sample and hold circuits. Additional applications include high speed integrators and video amplifiers. The LH0032 is guaranteed over the temperature range -55°C to $+125^{\circ}\text{C}$ and the LH0032C is guaranteed from -25°C to $+85^{\circ}\text{C}$.

For information on other National operational amplifiers, see listing on last page.

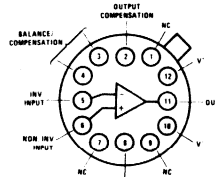
features

- High slew rate 500 V/ μs
- High bandwidth 70 MHz
- High input impedance $10^{12}\Omega$

schematic and connection diagrams



Metal Can Package

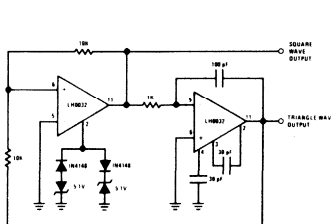


Note: For heat sink use thermally 2240 series or Wakefield 215-XX series.

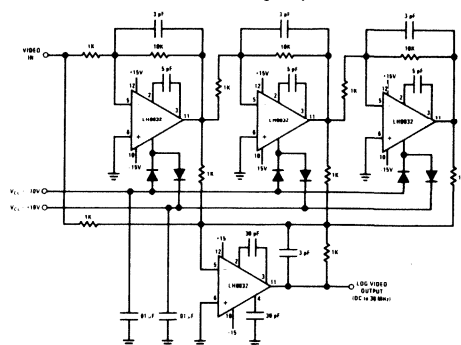
Order Number LH0032G or LH0032CG
See Package 6

typical applications

1 MHz Function Generator



DC to Video Log Amplifier



Note: All diodes must be low stored charge, high speed. Decouple power supplies at each amp with 0.01 μF ceramic discs.

2

absolute maximum ratings

Supply Voltage	±18V
Input Voltage	±V _S
Differential Input Voltage	±30V
Power Dissipation	See curve
Operating Temperature Range	LH0032 -55°C to +125°C LH0032C -25°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LH0032			LH0032C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V _S = ±15V, R _S ≤ 100k, T _A = 25°C V _S = ±15V, R _S ≤ 100k		2	5 10		5 15	15 20	mV mV
Average Offset Voltage Drift	R _S ≤ 100k		25			25		μV/°C
Input Bias Current	T _A = 25°C		10	100 50		25	200 15.0	pA nA
Input Offset Current	T _A = 25°C		5	25 25		10	50 5	pA nA
Large Signal Voltage Gain	V _S = ±15V, V _{OUT} = ±10V, f = 1 kHz R _L = 1 kΩ, T _A = 25°C	60	70		60	70		dB
	V _S = ±15V, V _{OUT} = ±10V, f = 1 kHz R _L = 1 kΩ	57			57			dB
Input Voltage Range	V _S = ±15V	±10	±12		±10	±12		V
Output Voltage Swing	V _S = ±15V, R _L = 1 kΩ	±10	±13.5		±10	±13		V
Power Supply Rejection Ratio	V _S = ±15V, ΔV _S = ±10V	50	60		50	60		dB
Common Mode Rejection Ratio	V _S = ±15V, ΔV _{IN} = 10V	50	60		50	60		dB
Supply Current	V _S = ±15V, T _A = 25°C		18	20		20	22	mA

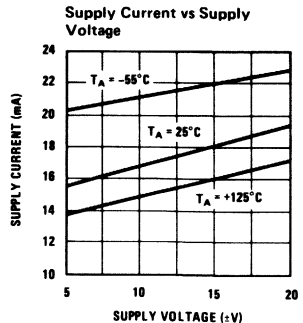
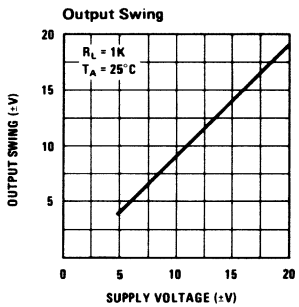
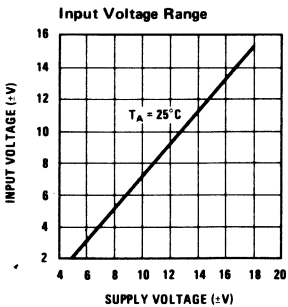
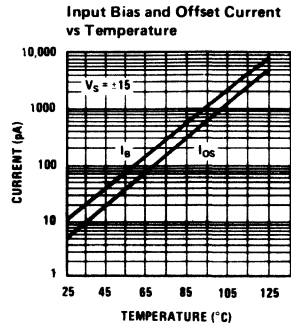
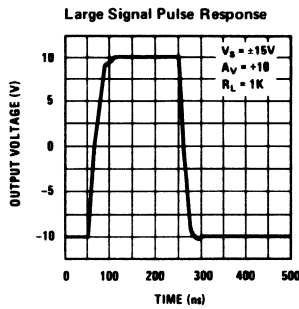
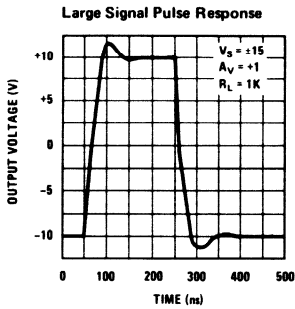
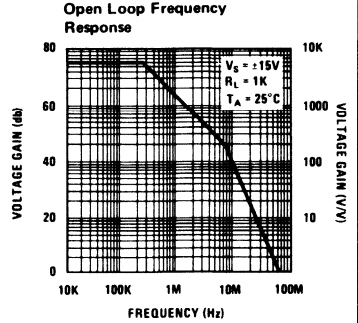
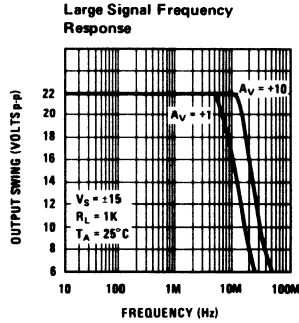
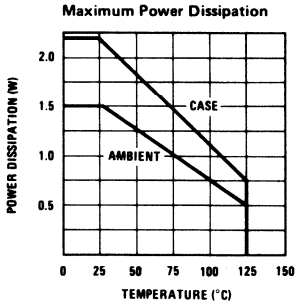
ac electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Slew Rate	A _V = +1, ΔV _{IN} = 20V	350	500		V/μs
Settling Time to 1% of Final Value	A _V = -1, ΔV _{IN} = 20V		100		ns
Settling Time to 0.1% of Final Value	A _V = -1, ΔV _{IN} = 20V		300		ns
Small Signal Rise Time	A _V = +1, ΔV _{IN} = 1V		8	20	ns
Small Signal Delay Time	A _V = +1, ΔV _{IN} = 1V		10	25	ns

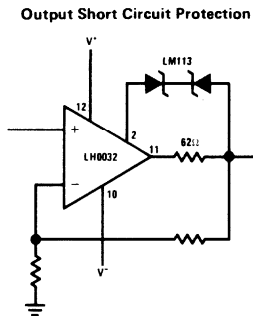
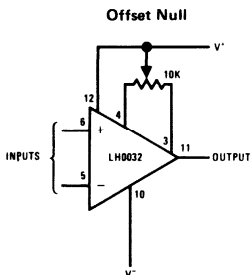
Note 1: These specifications apply for ±5V ≤ V_S ≤ ±18V and -55°C to +125°C for the LH0032 and -25°C to +85°C for the LH0032C.

Note 2: These specifications apply for V_S = ±15V, R_L = 1 kΩ and T_A = 25°C.

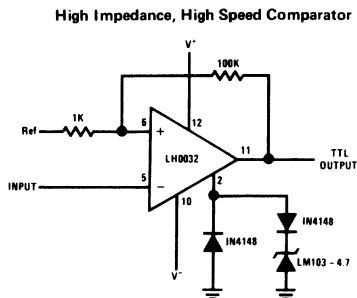
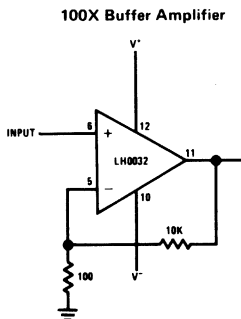
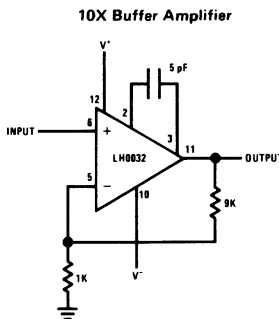
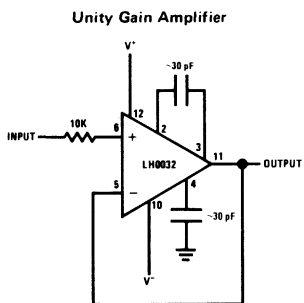
typical performance characteristics



auxiliary circuits

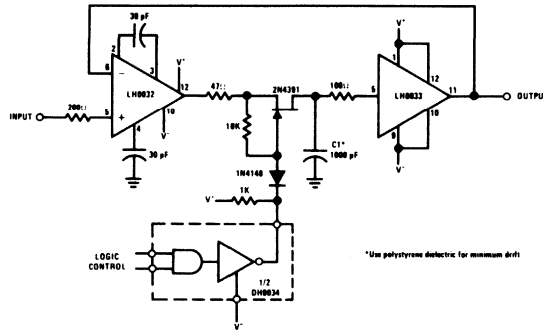


typical applications (con't)

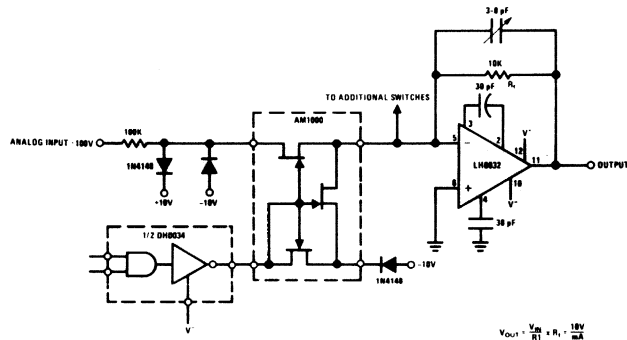


typical applications (con't)

High Speed Sample and Hold



Current Mode Multiplexer



applications information

Power Supply Decoupling

The LH0032/LH0032C like most high speed circuits is sensitive to layout and stray capacitance. Power supplies should be by-passed as near to Pins 10 and 12 as practicable with low inductance capacitors such as 0.01 μ F disc ceramics. Compensation components should also be located close to the appropriate pins to minimize stray reactances.

Input Capacitance

The input capacitance to the LH0032/LH0032C is typically 5 pF and thus may form a significant time constant with high value resistors. For optimum performance, the input capacitance to the inverting input should be compensated by a small capacitor across the feedback resistor. The value is strongly dependent on layout and closed loop gain, but will typically be in the neighborhood of several picofarads.

In the non-inverting configuration, it may be advantageous to bootstrap the case and/or a guard conductor to the inverting input. This serves both to divert leakage currents away from the non-inverting input and to reduce the effective input capacitance. A unity gain follower so treated will have an input capacitance under a picofarad.

Heat Sinking

While the LH0032/LH0032C is specified for operation without any explicit heat sink, internal power dissipation does cause a significant temperature rise. Improved bias current performance can thus be obtained by limiting this temperature rise with a small heat sink such as the Thermalloy No. 2241 or equivalent. The case of the device has no internal connection, so it may be electrically connected to the sink if this is advantageous. Be aware, however, that this will affect the stray capacitances to all pins and may thus require adjustment of circuit compensation values.



Operational Amplifiers

LH0033/LH0033C, LH0063/LH0063C fast and damn fast buffer amplifiers

general description

The LH0033/LH0033C and LH0063/LH0063C are high speed, FET input, voltage follower/buffers designed to provide high current drive at frequencies from DC to over 100 MHz. The LH0033/LH0033C will provide ± 10 mA into 1 k Ω loads (± 100 mA peak) at slew rates of 1500V/ μ s. The LH0063/LH0063C will provide ± 250 mA into 50 Ω loads (± 500 mA peak) at slew rates of up to 6000V/ μ s. In addition, both exhibit excellent phase linearity up to 20 MHz.

Both are intended to fulfill a wide range of buffer applications such as high speed line drivers, video impedance transformation, nuclear instrumentation amplifiers, op amp isolation buffer for driving reactive loads and high impedance input buffers for high speed A to D's and comparators. In addition, the LH0063/LH0063C can continuously drive 50 Ω coaxial cables or be used as a diddle yoke driver for high resolution CRT displays. For additional applications information, see AN-48.

advantages

- Only +10V supply needed for 5 V_{P-P} video out
- Speed does not degrade system performance
- Wide data rate range for phase encoded systems

- Output drive adequate for most loads
- Single pre-calibrated package

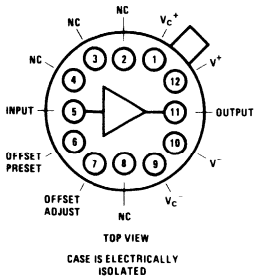
features

- Damn fast (LH0063) 6000V/ μ s
- Wide range single or dual supply operation
- Wide power bandwidth DC to 100 MHz
- High output drive ± 10 V with 50 Ω load
- Low phase non-linearity 2 degrees
- Fast rise times 2 ns
- High current gain 120 dB
- High input resistance 10^{10} Ω

These devices are constructed using specially selected junction FET's and active laser trimming to achieve guaranteed performance specifications. The LH0033 and LH0063 are specified for operation from -55°C to $+125^{\circ}\text{C}$; whereas, the LH0033C and LH0063C are specified from -25°C to $+85^{\circ}\text{C}$. The LH0033/LH0033C is available in a 1.5W metal TO-8 package and a special 1/2 x 1 inch 8 pin ceramic dual-in-line package while the LH0063/LH0063C is available in a 5W 8-pin TO-3 package.

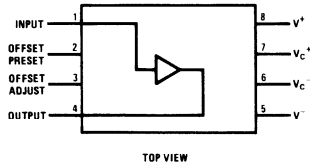
connection diagrams

LH0033/LH0033C
Metal Can Package



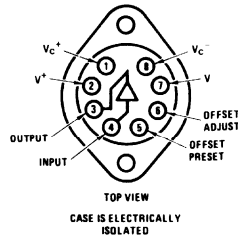
Order Number LH0033G or LH0033CG
See Package 6

LH0033/LH0033C
Dual-In-Line Package



Order Number LH0033J or LH0033CJ
See Package 15

LH0063/LH0063C
Metal Can Package



Order Number LH0063K or LH0063CK
See Package 19

absolute maximum ratings

Supply Voltage ($V^+ - V^-$)	40V	Peak Output Current	
Maximum Power Dissipation (See Curves)		LH0063/LH0063C	±500 mA
LH0063/LH0063C	5W	LH0033/LH0033C	±250 mA
LH0033/LH0033C	1.5W	Operating Temperature Range	
Maximum Junction Temperature	175°C	LH0033 and LH0063	-55°C to +125°C
Input Voltage	Equal to Supplies	LH0033C and LH0063C	-25°C to +85°C
Continuous Output Current		Storage Temperature Range	-65°C to +150°C
LH0063/LH0063C	±250 mA	Lead Temperature (Soldering, 10 sec)	300°C
LH0033/LH0033C	±100 mA		

dc electrical characteristics LH0033/LH0033C: (Note 1)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0033			LH0033C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Output Offset Voltage	$R_S = 100\text{ k}\Omega$, $T_C = 25^\circ\text{C}$ $R_S = 100\text{ k}\Omega$		5	10 15		12	20 25	mV mV
Average Temperature Coefficient of Offset Voltage	$R_S = 100\text{ k}\Omega$, $-55^\circ\text{C} \leq T_C \leq 125^\circ\text{C}$		25			25		$\mu\text{V}/^\circ\text{C}$
Input Bias Current	$T_C = 25^\circ\text{C}$		.05	.1 10		.05	.15 5	nA nA
Voltage Gain	$V_{IN} = 1\text{V}_{rms}$, $f = 1\text{ kHz}$, $R_L = 1\text{ k}\Omega$, $R_S = 100\text{ k}\Omega$	.97	.98	1	.96	.98	1	V/V
Input Impedance	$V_{IN} = 1\text{V}_{rms}$, $f = 1\text{ kHz}$, $R_L = 1\text{ k}\Omega$	10^{10}	10^{11}		10^{10}	10^{11}		Ω
Output Impedance	$V_{IN} = 1\text{V}_{rms}$, $f = 1\text{ kHz}$, $R_S = 100\text{ k}\Omega$, $R_L = 1\text{ k}\Omega$		6	10		6	10	Ω
Output Voltage Swing	$R_L = 1\text{ k}\Omega$, $R_L = 100\Omega$, $T_C = 25^\circ\text{C}$ $V_S = \pm 5\text{V}$, $R_L = 1\text{ k}\Omega$	±12 ±9	±13		±12 ±9	±13		V V V_{P-P}
Supply Current	$V_{IN} = 0\text{V}$, $V_S = \pm 15\text{V}$ $V_S = \pm 5\text{V}$		20 18	22		21 18	24	mA mA
Power Consumption	$V_{IN} = 0\text{V}$, $V_S = \pm 15\text{V}$ $V_S = \pm 5\text{V}$		600 180	660		630 180	720	mW mW

ac electrical characteristicsLH0033/LH0033C ($T_C = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $R_S = 50\Omega$, $R_L = 1\text{ k}\Omega$)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0033			LH0033C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Slew Rate	$V_{IN} = \pm 10\text{V}$	1000	1500		1000	1400		V/ μs
Bandwidth	$V_{IN} = 1\text{V}_{rms}$		100			100		MHz
Phase Non-Linearity	BW = 1 to 20 MHz		2			2		degrees
Rise Time	$\Delta V_{IN} = 0.5\text{V}$		2.9			3.2		ns
Propagation Delay	$\Delta V_{IN} = 0.5\text{V}$		1.2			1.5		ns
Harmonic Distortion			<0.1			<0.1		%

Note 1: Unless otherwise specified, these specifications apply for +15V applied to pins 1 and 12, -15V applied to pins 9 and 10, and pin 6 shorted to pin 7 for the LH0033/LH0033C. For the LH0063/LH0063C, specifications apply for +15V applied to pins 1 and 2, -15V applied to pins 7 and 8, and pin 5 shorted to pin 6. Unless otherwise noted, specifications apply over a temperature range of $-55^\circ\text{C} \leq T_C \leq +125^\circ\text{C}$ for the LH0033 and LH0063; and $-25^\circ\text{C} \leq T_C \leq +85^\circ\text{C}$ for the LH0033C and LH0063C. Typical values shown are for $T_C = 25^\circ\text{C}$.

dc electrical characteristics LH0063/LH0063C (Note 1)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0063			LH0063C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Output Offset Voltage	$R_S \leq 100 \text{ k}\Omega$, $T_C = 25^\circ\text{C}$ $R_S \leq 100 \text{ k}\Omega$		10	25 100		10	50 100	mV mV
Average Temperature Coefficient of Output Offset Voltage	$R_S \leq 100 \text{ k}\Omega$		300			300		$\mu\text{V}/^\circ\text{C}$
Input Bias Current	$T_C = 25^\circ\text{C}$		.1	.2 10		.1	.2 5	nA nA
Voltage Gain	$V_{IN} = \pm 10\text{V}$, $R_S \leq 100 \text{ k}\Omega$, $R_L = 1 \text{ k}\Omega$	.96	.98	1	.96	.98	1	V/V
Voltage Gain	$V_{IN} = \pm 10\text{V}$, $R_S \leq 100 \text{ k}\Omega$, $R_L = 50\Omega$	.94	.96	.98	.94	.96	.98	V/V
Input Resistance		10^{10}	10^{11}		10^{10}	10^{11}		Ω
Input Capacitance	Case Shorted to Output		8			8		pF
Output Impedance	$V_{OUT} = \pm 10\text{V}$, $R_S = 100 \text{ k}\Omega$		1	4		1	4	Ω
Output Current Swing	$V_{IN} = \pm 10\text{V}$, $R_S \leq 100 \text{ k}\Omega$	.2	.25		.2	.25		Amps
Output Voltage Swing	$R_L = 50\Omega$	± 10	± 13		± 10	± 13		V
Output Voltage Swing	$V_S = \pm 5\text{V}$, $R_L = 50\Omega$, $T_C = 25^\circ\text{C}$	5	7		5	7		V_{P-P}
Supply Current	$T_C = 25^\circ\text{C}$, $R_L = \infty$, $V_S = \pm 15\text{V}$		60	75		60	80	mA
Supply Current	$V_S = \pm 5\text{V}$		50			50		mA
Power Consumption	$T_C = 25^\circ\text{C}$, $R_L = \infty$, $V_S = \pm 15\text{V}$		1.80	2.25		1.80	2.40	W
Power Consumption	$V_S = \pm 5\text{V}$		500			500		mW

ac electrical characteristics

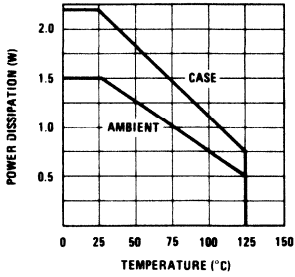
LH0063/LH0063C: ($T_C = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $R_S = 50\Omega$, $R_L = 50\Omega$)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0063			LH0063C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Slew Rate	$R_L = 1 \text{ k}\Omega$, $V_{IN} = \pm 10\text{V}$		6000			6000		V/ μs
Slew Rate	$R_L = 50\Omega$, $V_{IN} = \pm 10\text{V}$ $T_C = 25^\circ\text{C}$	2000	4000		2000	4000		V/ μs
Bandwidth	$V_{IN} = 1 \text{ V}_{rms}$		200			200		MHz
Phase Non-Linearity	BW = 1 to 20 MHz		2			2		degrees
Rise Time	$\Delta V_{IN} = .5\text{V}$		1.6			1.9		ns
Propagation Delay	$\Delta V_{IN} = .5\text{V}$		1.9			2.1		ns
Harmonic Distortion			<0.1			<0.1		%

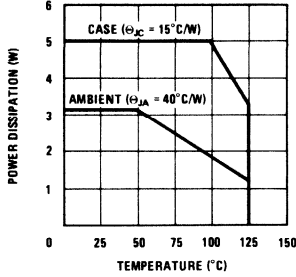
Note 1: Unless otherwise specified, these specifications apply for +15V applied to pins 1 and 12, -15V applied to pins 9 and 10, and pin 6 shorted to pin 7 for the LH0033/LH0033C. For the LH0063/LH0063C, specifications apply for +15V applied to pins 1 and 2, -15V applied to pins 7 and 8, and pin 5 shorted to pin 6. Unless otherwise noted, specifications apply over a temperature range of $-55^\circ\text{C} \leq T_C \leq +125^\circ\text{C}$ for the LH0033 and LH0063, and $-25^\circ\text{C} \leq T_C \leq +85^\circ\text{C}$ for the LH0033C and LH0063C. Typical values shown are for $T_C = 25^\circ\text{C}$.

typical performance characteristics

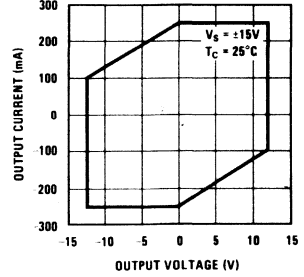
LH0033 Power Dissipation



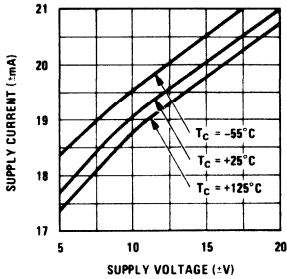
LH0063 Power Dissipation



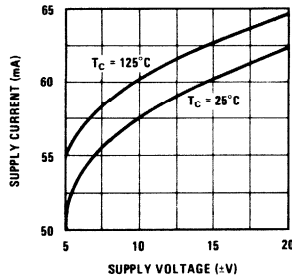
LH0063 DC Safe Operating Area



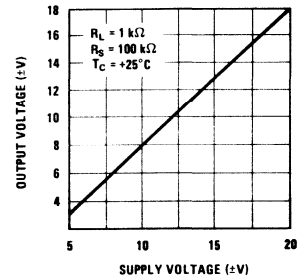
LH0033 Supply Current vs Supply Voltage



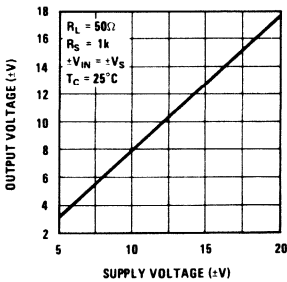
LH0063 Supply Current vs Supply Voltage



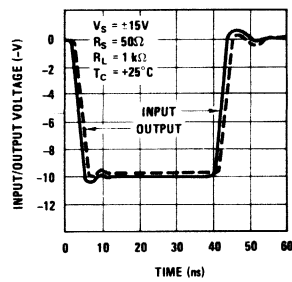
LH0033 Output Voltage vs Supply Voltage



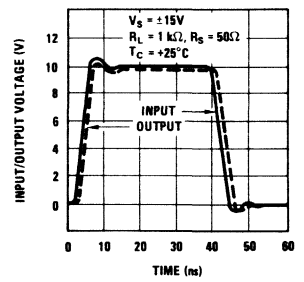
LH0063 Output Voltage vs Supply Voltage



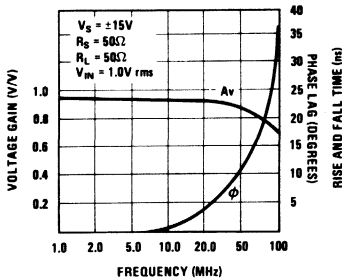
LH0033 Negative Pulse Response



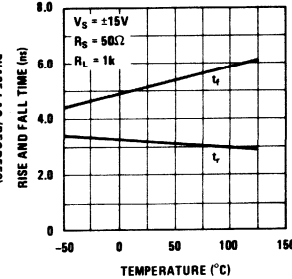
LH0033 Positive Pulse Response



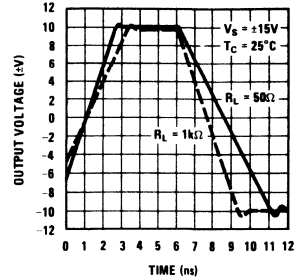
LH0033 Frequency Response



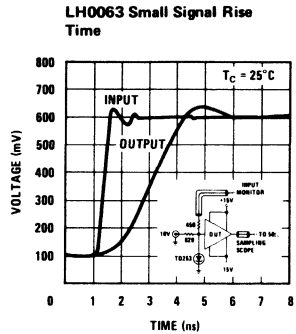
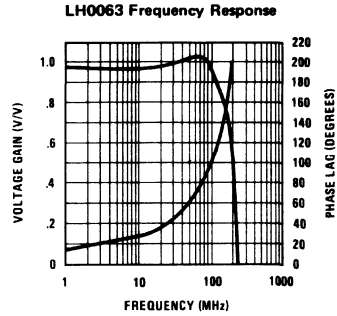
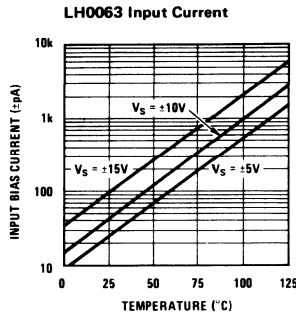
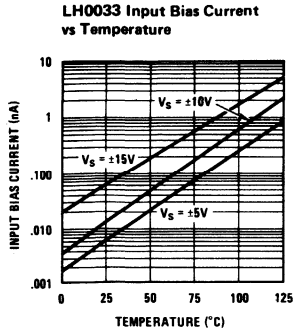
LH0033 Rise and Fall Time vs Temperature



LH0063 Large Signal Pulse Response



typical performance characteristics (con't)



application hints

Recommended Layout Precautions: RF/video printed circuit board layout rules should be followed when using the LH0033 and LH0063 since they will provide power gain to frequencies over 100 MHz. Ground planes are recommended and power supplies should be decoupled at each device with low inductance 0.1μF disc capacitors. In addition, ground plane shielding may be extended to the metal case of the device since it is electrically isolated from internal circuitry. Alternatively the case should be connected to the output to minimize input capacitance.

Offset Voltage Adjustment: Both the LH0033's and LH0063's offset voltages have been actively trimmed by laser to meet guaranteed specifications when the offset preset pin is shorted to the offset adjust pin. This pre-calibration allows the devices to be used in most DC or AC applications without individually offset nulling each device. If offset null is desirable, it is simply obtained by leaving the offset preset pin open and connecting a trim pot of 100Ω for the LH0033 or 1 kΩ for the LH0063 between the offset adjust pin and V⁻ as illustrated in Figures 1 and 2.

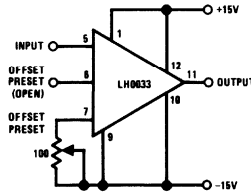


FIGURE 1. Offset Zero Adjust for LH0033 (Pin nos. shown for TO-8)

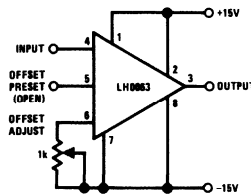


FIGURE 2. Offset Zero Adjust for LH0063

application hints (con't)

Operation from Single or Asymmetrical Power Supplies: Both device types may be readily used in applications where symmetrical supplies are unavailable or not desirable. A typical application might be an interface to a MOS shift register where $V^+ = +5V$ and $V^- = -12V$. In this case, an apparent output offset occurs due to the device's voltage gain of less than unity. This additional output offset error may be predicted by:

$$\Delta V_O \cong (1 - A_V) \frac{(V^+ - V^-)}{2} = .005 (V^+ - V^-)$$

where:

- A_V = No load voltage gain, typically .99
- V^+ = Positive supply voltage
- V^- = Negative supply voltage

For the above example, ΔV_O would be -35 mV. This may be adjusted to zero as described in Section 2. For AC coupled applications, no additional offset occurs if the DC input is properly biased as illustrated in the "typical applications" section.

Short Circuit Protection: In order to optimize transient response and output swing, output current limit has been omitted from the LH0033 and LH0063. Short circuit protection may be added by inserting appropriate value resistors between V^+ and V_C^+ pins and V^- and V_C^- pins as illustrated in Figures 3 and 4. Resistor values may be predicted by:

$$R_{LIM} \cong \frac{V^+}{I_{SC}} = \frac{V^-}{I_{SC}}$$

- where: $I_{SC} \leq 100$ mA for LH0033
- $I_{SC} \leq 250$ mA for LH0063

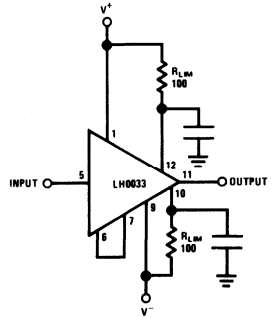


FIGURE 3. LH0033 Using Resistor Current Limiting

The inclusion of limiting resistors in the collectors of the output transistors reduces output voltage swing. Decoupling V_C^+ and V_C^- pins with capacitors to ground will retain full output swing for transient pulses. Alternate active current limit techniques that retain full DC output swing are shown in Figures 5, 6 and 7. In Figures 5 and 6, the current sources are saturated during normal operation thus apply full supply voltage to the V_C pins. Under fault conditions, the voltage decreases as required by the overload. For Figure 5:

$$R_{LIM} = \frac{V_{BE}}{I_{SC}} = \frac{.6V}{60 \text{ mA}} = 10\Omega$$

In Figure 6, quad transistor arrays are used to minimize can count and:

$$R_{LIM} = \frac{V_{BE}}{1/3 (I_{SC})} = \frac{.6V}{1/3 (200 \text{ mA})} = 8.2\Omega$$

Foldback current has been added in Figure 7 to minimize power dissipation under fault conditions. Output transistor collector current is sensed and input stage voltage is reduced as required by fault load. Resistor values may be predicted by:

$$R_{LIM} \cong \frac{V_{BE}}{I_{KNEE}}$$

$$R_{FB} \cong \frac{(V_S \times R_1)}{V_{BE} - (R_{LIMIT} \times I_{SHORT \text{ CIRCUIT}})}$$

Thus for the LH0033 with $I_{KNEE} = 60$ mA and $I_{SHORT} = 10$ mA, $R_{LIM} = 10\Omega$ and $R_{FB} = 30$ k Ω . For the LH0063 with $I_{KNEE} = 200$ mA and $I_{SHORT} = 50$ mA, $R_{LIM} = 3\Omega$ and $R_{FB} = 33$ k Ω .

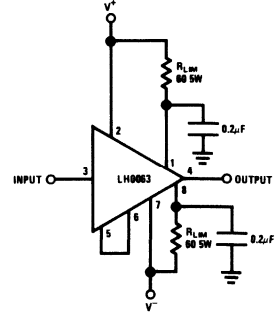


FIGURE 4. LH0063 Using Resistor Current Limiting

application hints (con't)

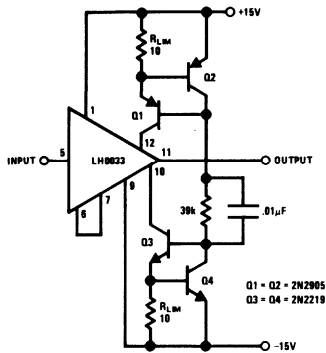


FIGURE 5. LH0033 Current Limiting Using Current Sources

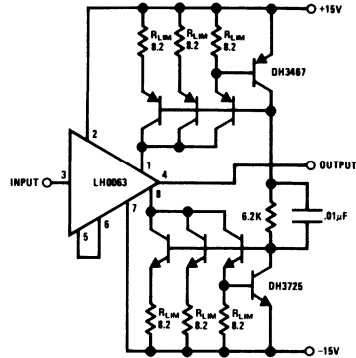


FIGURE 6. LH0063 Current Limiting Using Current Sources

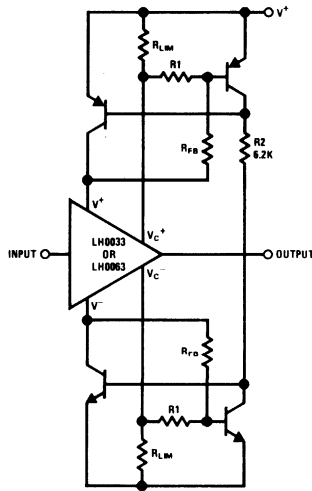


FIGURE 7. Foldback Current Limit

Capacitive Loading: Both the LH0033 and LH0063 are designed to drive capacitive loads such as coaxial cables in excess of several thousand picofarads without susceptibility to oscillation. However, peak current resulting from $(C \times dV/dt)$ should be limited below absolute maximum peak current ratings for the devices.

Thus for the LH0033:

$$\left(\frac{\Delta V_{IN}}{\Delta T}\right) \times C_L \leq I_{OUT} \leq \pm 250 \text{ mA}$$

and for the LH0063:

$$\left(\frac{\Delta V_{IN}}{\Delta T}\right) \times C_L \leq I_{OUT} \leq \pm 500 \text{ mA}$$

Peak current limiting may be accomplished by controlling input large signal rise time, inserting 20 to 100Ω resistors between V^+ and V_C^+ pins and V^- and V_C^- pins, using active current limit as described in Section 4, Figures 5, 6 and 7, or inserting a small value resistor in series with the output.

application hints (con't)

In addition, power dissipation resulting from driving capacitive loads plus standby power should be kept below total package power rating:

$$P_{diss}^{pkg} \geq P_{DC} + P_{AC}$$

$$P_{diss}^{pkg} \geq (V^+ - V^-) \times I_S + P_{AC}$$

$$P_{AC} \cong (V_{P-P})^2 \times f \times C_L /$$

where V_{P-P} = Peak-to-peak output voltage swing
 f = frequency
 C_L = Load Capacitance

Operation Within an Op Amp Loop: Both devices may be used as a current booster or isolation buffer within a closed loop with op amps such as LH0032, LH0062, or LM118. An isolation

resistor of 47Ω should be used between the op amp output and the input of LH0033. The wide bandwidths and high slew rates of the LH0033 and LH0063 assure that the loop has the characteristics of the op amp and that additional rolloff is not required.

Hardware: In order to utilize the full drive capabilities of both devices, each should be mounted with a heat sink particularly for extended temperature operation. The cases of both are isolated from the circuit and may be connected to system chassis. Heat sinks are commercially available at low cost; the following or their equivalents are recommended:

LH0033G (TO-8 pkg): Thermalloy #2240A
 Wakefield #215-CB

LH0063K (TO-3 pkg): IERC #LAIC3B4V

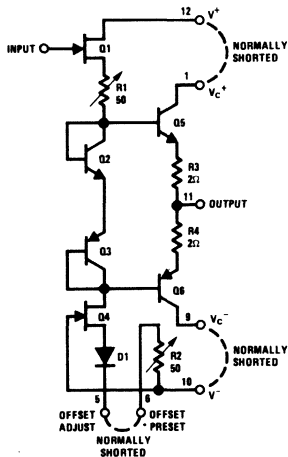
Mounting and test sockets are available from:

LH0033G (TO-8 pkg): Barnes Corp. #MGX-12

LH0063K (TO-3 pkg): Keystone Elect. (N.Y.)
 #4626 or #4627

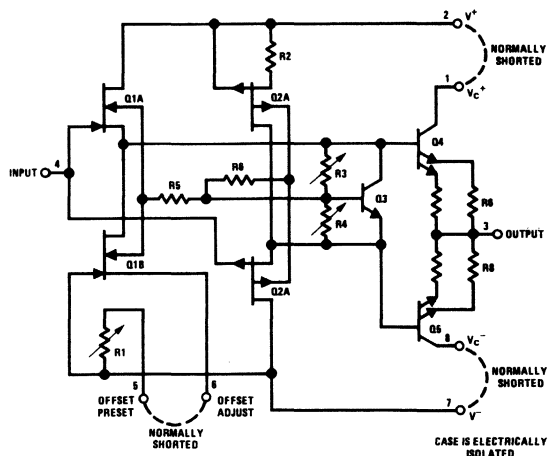
schematic diagrams

LH0033/LH0033C



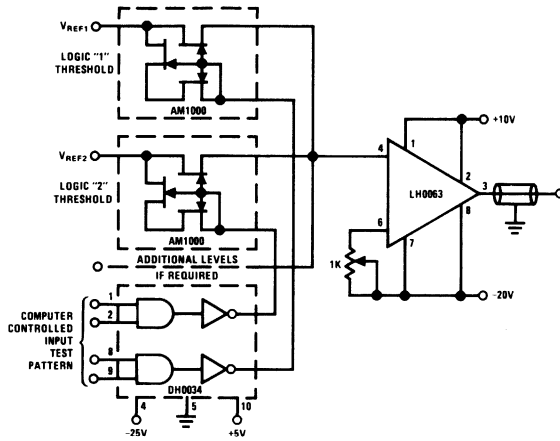
PIN NUMBERS SHOWN FOR TO-8 ("G") PACKAGE.

LH0063/LH0063C

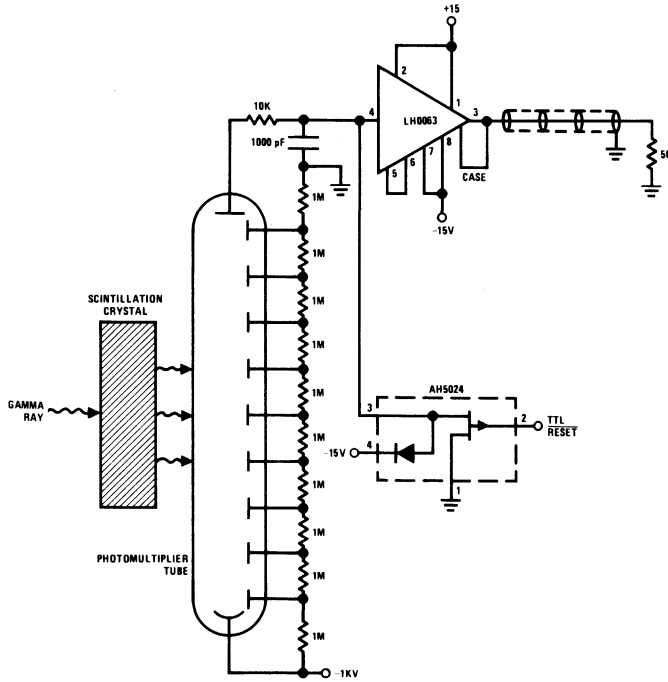


typical applications

High Speed Automatic Test Equipment
Forcing Function Generator

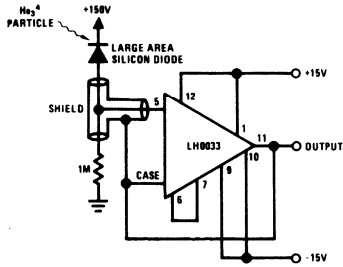


Gamma Ray Pulse Integrator

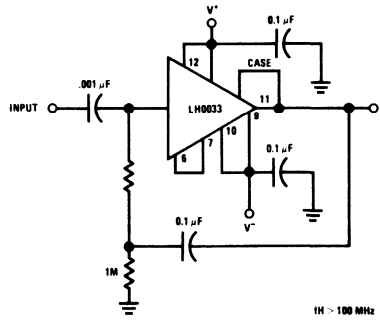


typical applications (con't)

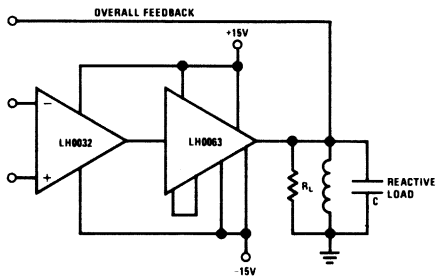
Nuclear Particle Detector



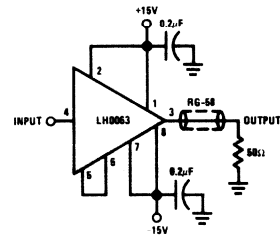
High Input Impedance AC Coupled Amplifier



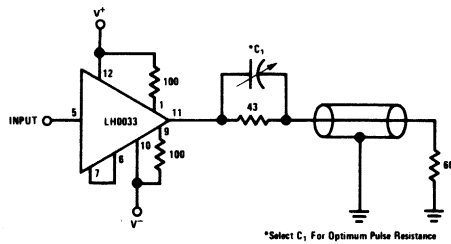
Isolation Buffer



Coaxial Cable Driver

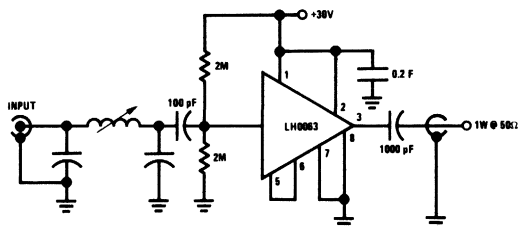


Coaxial Cable Driver



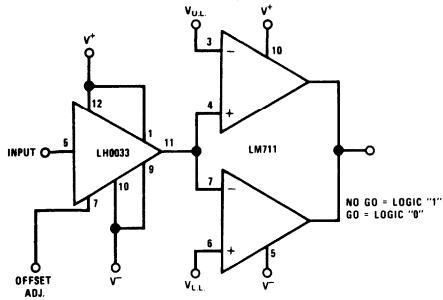
*Select C₁ For Optimum Pulse Resistance

1W CW Final Amplifier

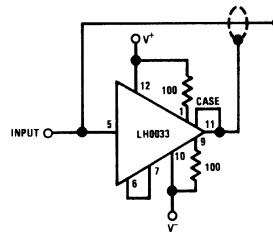


typical applications (con't)

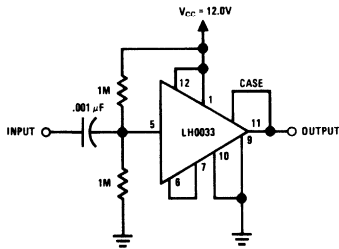
High Input Impedance Comparator
With Offset Adjust



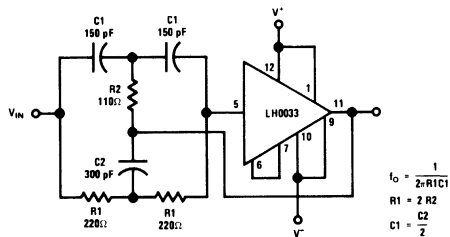
Instrumentation Shield/Line Driver



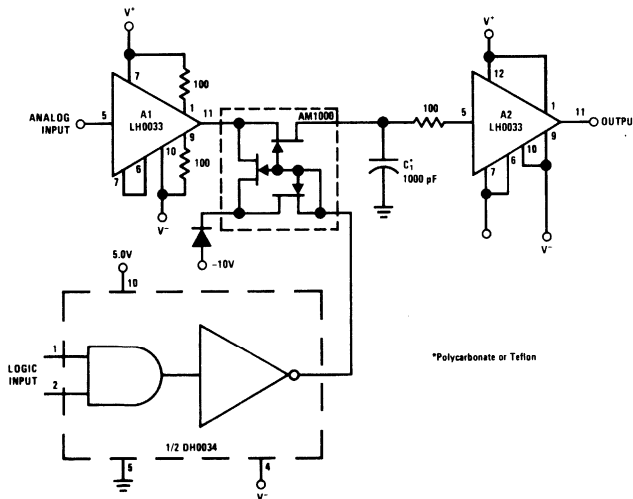
Single Supply AC Amplifier



4.5 MHz Notch Filter



High Speed Sample & Hold





LH0061/LH0061C 0.5 amp wide band operational amplifier

general description

The LH0061/LH0061C is a wide band, high speed, operational amplifier capable of supplying currents in excess of 0.5 ampere at voltage levels of $\pm 12V$. Output short circuit protection is set by external resistors, and compensation is accomplished with a single external capacitor. With a suitable heat sink the device is rated at 20 Watts.

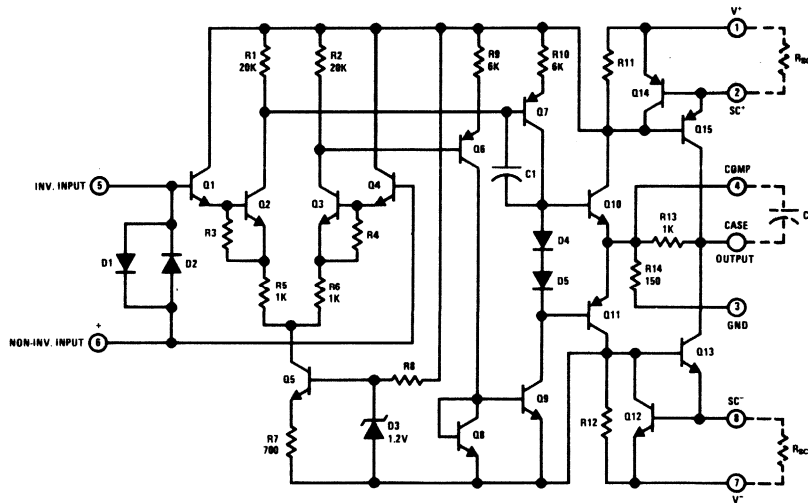
The wide bandwidth and high output power capabilities of the LH0061/LH0061C make it ideal for such applications as AC servos, deflection yoke drivers, capstan drivers, and audio amplifiers. The

LH0061 is guaranteed over the temperature range $-55^{\circ}C$ to $+125^{\circ}C$; whereas, the LH0061C is guaranteed from $-25^{\circ}C$ to $+85^{\circ}C$.

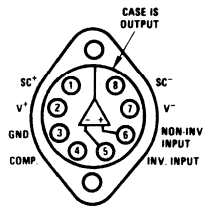
features

- Output current 0.5 Amp
- Wide large signal bandwidth 1 MHz
- High slew rate 75 V/ μ s
- Low standby power 240 mW
- Low input current 300 nA Max

schematic and connection diagrams



TO-3 Package



TOP VIEW

Order Numbers:

LH0061K ($-55^{\circ}C$ to $+125^{\circ}C$)

LH0061CK ($-25^{\circ}C$ to $+85^{\circ}C$)

See Package 19

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation	See Curve
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Peak Output Current	2A
Output Short Circuit Duration (Note 4)	Continuous
Operating Temperature Range LH0061	-55°C to +125°C
LH0061C	-25°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0061			LH0061C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 10 \text{ k}\Omega$, $T_C = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $R_S \leq 10 \text{ k}\Omega$, $V_S = \pm 15\text{V}$		1.0	4.0 6.0		3.0 15		mV mV
Voltage Drift with Temperature	$R_S \leq 10 \text{ k}\Omega$		5			5		$\mu\text{V}/^\circ\text{C}$
Offset Voltage Change with Output Power			5			5		$\mu\text{V}/\text{watt}$
Input Offset Current	$T_C = 25^\circ\text{C}$		30	100 300		50 200 500		nA nA
Offset Current Drift with Temperature			1			1		$\text{nA}/^\circ\text{C}$
Input Bias Current	$T_C = 25^\circ\text{C}$		100	300 1.0		200 500 1.0		nA μA
Input Resistance	$T_C = 25^\circ\text{C}$	0.3	1.0		0.3	1.0		$\text{M}\Omega$
Input Capacitance			3			3		pF
Common Mode Rejection Ratio	$R_S \leq 10 \text{ k}\Omega$, $\Delta V_{\text{CM}} = \pm 10\text{V}$	70	90		60	80		dB
Input Voltage Range	$V_S = \pm 15\text{V}$	±11			±11			V
Power Supply Rejection Ratio	$R_S \leq 10 \text{ k}\Omega$, $\Delta V_S = \pm 10\text{V}$	70	80		50	70		dB
Voltage Gain	$V_S = \pm 15\text{V}$, $V_O = \pm 10\text{V}$ $R_L = 1 \text{ k}\Omega$, $T_C = 25^\circ\text{C}$ $V_S = \pm 15\text{V}$, $V_O = \pm 10\text{V}$ $R_L = 20\Omega$	50	100		25	50		V/mV V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 20\Omega$	±10	±12		±10	±12		V
Output Short Circuit Current	$V_S = \pm 15\text{V}$, $T_C = 25^\circ\text{C}$, $R_{\text{SC}} = 1.0\Omega$		600			600		mA
Power Supply Current	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = 0$		7	10		10	15	mA
Power Consumption	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = 0$		210	300		300	450	mW

ac electrical characteristics ($T_C = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $C_C = 3000 \text{ pF}$)

Slew Rate	$A_V = +1$, $R_L = 100\Omega$	50	70		50	70		V/ μs
Power Bandwidth	$R_L = 100\Omega$		1			1		MHz
Small Signal Transient Response			30			30		ns
Small Signal Overshoot			5	20		10	30	%
Settling Time (0.1%)	$\Delta V_{\text{IN}} = 10\text{V}$, $A_V = +1$		0.8			0.8		μs
Overload Recovery Time			1			1		μs
Harmonic Distortion	$f = 1 \text{ kHz}$, $P_O = 0.5\text{W}$		0.2			0.2		%

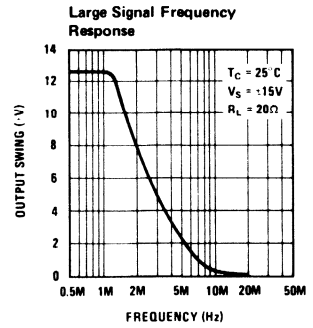
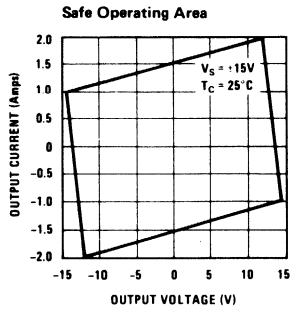
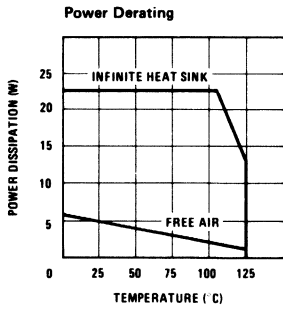
Note 1: Specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 18\text{V}$, $C_C = 3000 \text{ pF}$, and $-55^\circ\text{C} \leq T_C \leq +125^\circ\text{C}$ for the LH0061K and $-25^\circ\text{C} \leq T_C \leq +85^\circ\text{C}$ for the LH0061CK. Typical values are for $T_C = 25^\circ\text{C}$.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Excessive current will flow if a differential voltage in excess of 1V is applied between the inputs without limiting resistors.

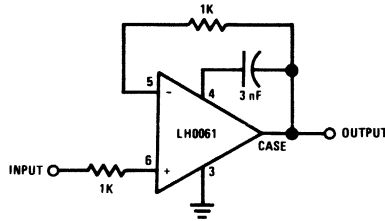
Note 3: For supply voltages less than $\pm 15\text{V}$, the absolute maximum input voltage is equal to the supply voltage.

Note 4: Rating applies as long as package power rating is not exceeded.

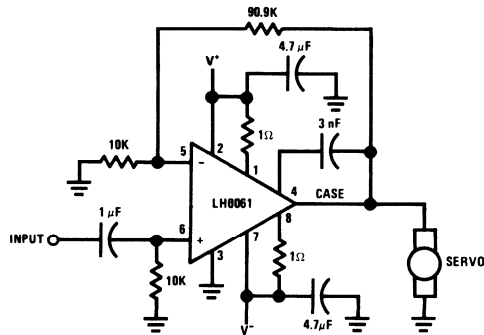
typical performance characteristics



typical applications



Unity Gain Driver



AC Servo Amplifier



LH0062/LH0062C high speed FET op amp general description

The LH0062/LH0062C is a precision, high speed FET input operational amplifier with more than an order of magnitude improvement in slew rate and bandwidth over conventional FET IC op amps. In addition it features very closely matched input characteristics, very high input impedance, and ultra low input currents with no compromise in noise, common mode rejection ratio or open loop gain. The device has internal unity gain frequency compensation, thus assuring stability in all normal applications. This considerably simplifies its application, since no external components are necessary for operation. However, unlike most internally compensated amplifiers, external frequency compensation may be added for optimum performance. For inverting applications, feed-forward compensation will boost the slew rate to over 120 V/ μ s and almost double the bandwidth. (See LB-2, LB-14, and LB-17 for discussions of the application of feed-forward techniques). Over-compensation can be used with the amplifier for greater stability when maximum bandwidth is not needed. Further, a single capacitor can be added to reduce the 0.1% settling time to under 1 μ s. In addition it is free of latch-up and may be simply offset nulled with negligible effect on offset drift or CMRR.

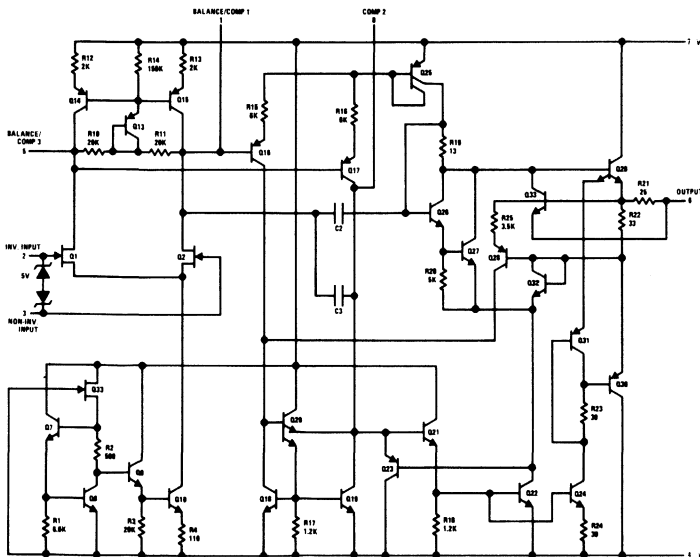
The LH0062 is also available on special order with offset voltage internally laser nulled and ultra low (0.1 pA) offset current.

The LH0062 is designed for applications requiring wide bandwidth, high slew rate and fast settling time while at the same time demanding the high input impedance and low input currents characteristic of FET inputs. Thus it is particularly suited for such applications as video amplifiers, sample/hold circuits, high speed integrators, and buffers for A/D conversion and multiplex system. The LH0062 is specified for the full military temperature range of -55° to $+125^{\circ}$ C while the LH0062C is specified to operate over a -25° C to $+85^{\circ}$ C temperature range.

features

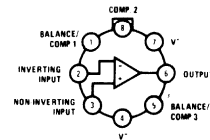
- High slew rate 70 V/ μ s
- Wide bandwidth 15 MHz
- Settling time (0.1%) 1 μ s
- Low input offset voltage 2 mV
- Low input offset current 1 pA
- Wide supply range ± 5 V to ± 20 V
- Internal 6 dB/octave frequency compensation
- Pin compatible with std IC op amps (TO-5 pkg)

schematic and connection diagrams*



*Pin Numbers Shown for TO-5 Package

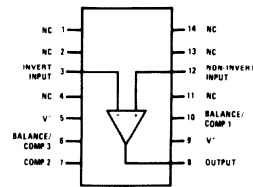
Metal Can Package



TOP VIEW

Order Number
LH0062H or LH0062CH
See Package 11

Dual-In-Line Package



TOP VIEW

Order Number
LH0062D or LH0062CD
See Package 1

absolute maximum ratings

Supply Voltage	±20V	Operating Temperature	
Power Dissipation (see graph)	500 mW	LH0062,	-55°C to +125°C
Input Voltage (Note 1)	±15V	LH0062C,	-25°C to +85°C
Differential Input Voltage (Note 2)	±30V	Storage Temperature Range	-65°C to +150°C
Short Circuit Duration	Continuous	Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics (Note 3)

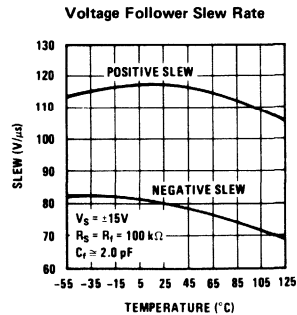
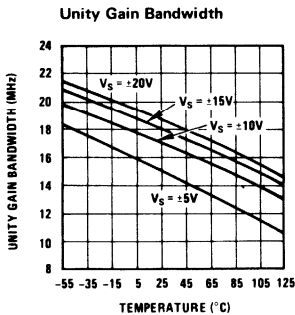
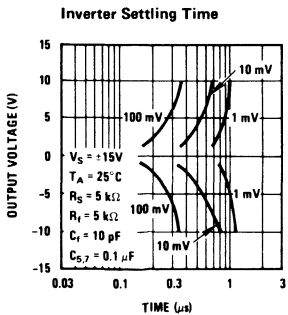
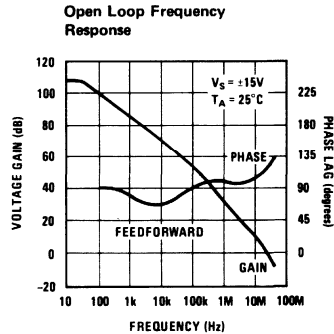
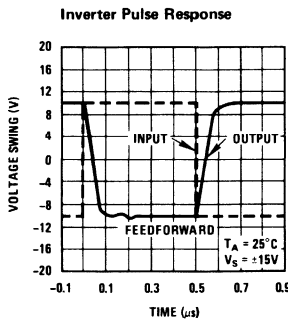
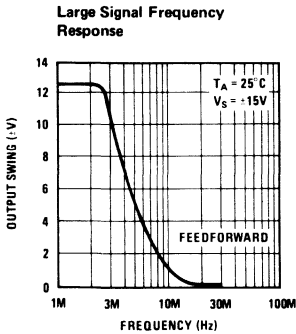
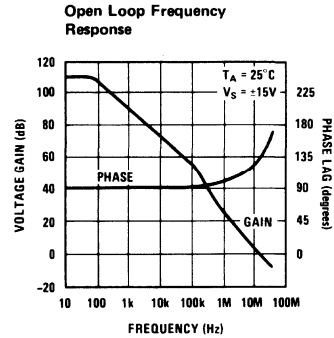
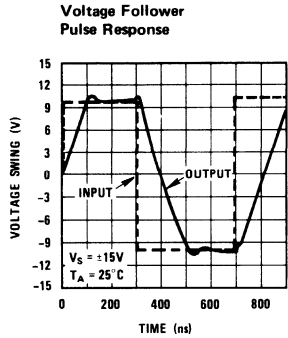
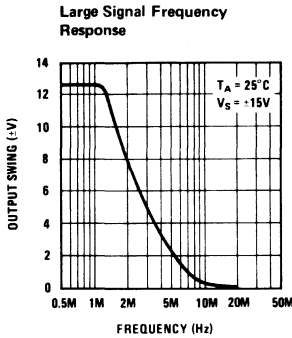
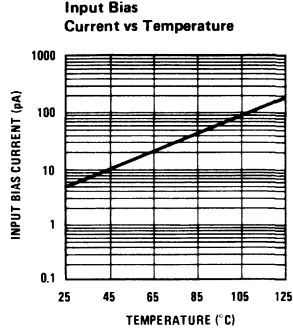
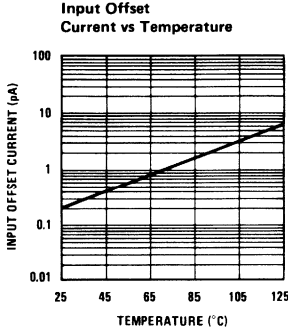
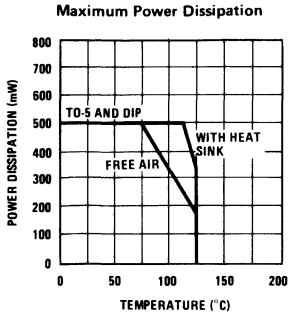
PARAMETER	CONDITIONS	LIMITS						UNITS	
		LH0062			LH0062C				
		MIN	TYP	MAX	MIN	TYP	MAX		
Input Offset Voltage	$R_S \leq 100 \text{ k}\Omega$; $T_A = 25^\circ\text{C}$		2	5		10	15	mV	
	$R_S \leq 100 \text{ k}\Omega$			7			20	mV	
Temperature Coefficient of Input Offset Voltage	$R_S \leq 100 \text{ k}\Omega$		5	25		10	35	$\mu\text{V}/^\circ\text{C}$	
Offset Voltage Drift with Time			4			5		$\mu\text{V}/\text{week}$	
Input Offset Current	$T_A = 25^\circ\text{C}$		0.2	2		1	5	pA	
				500			200	pA	
Temperature Coefficient of Input Offset Current			Doubles every 20°C			Doubles every 20°C			
Offset Current Drift with Time			0.1			0.1		pA/week	
Input Bias Current	$T_A = 25^\circ\text{C}$		5	25		10	65	pA	
				5			2	nA	
Temperature Coefficient of Input Bias Current			Doubles every 20°C			Doubles every 20°C			
Differential Input Resistance			10^{12}			10^{12}			Ω
Common Mode Input Resistance			10^{12}			10^{12}			Ω
Input Capacitance			4			4			pF
Input Voltage Range	$V_S = \pm 15\text{V}$	±10	±12			±10			V
Common Mode Rejection Ratio	$R_S \leq 10 \text{ k}\Omega$, $V_{IN} = \pm 10\text{V}$	80	90			70			dB
Supply Voltage Rejection Ratio	$R_S \leq 10 \text{ k}\Omega$, $\pm 5\text{V} \leq V_S \leq \pm 15\text{V}$	80	90			70			dB
Large Signal Voltage Gain	$R_L = 2 \text{ k}\Omega$, $V_{OUT} = \pm 10\text{V}$, $T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$	50	200			25			V/mV
	$R_L = 2 \text{ k}\Omega$, $V_{OUT} = \pm 10\text{V}$, $V_S = \pm 15\text{V}$	25				25			V/mV
Output Voltage Swing	$R_L = 2 \text{ k}\Omega$, $T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$	±12	±13			±12			V
	$R_L = 2 \text{ k}\Omega$, $V_S = \pm 15\text{V}$	±10				±10			V
Output Current Swing	$V_{OUT} = \pm 10\text{V}$, $T_A = 25^\circ\text{C}$	±10	±15			±10			mA
Output Resistance			75			75			Ω
Output Short Circuit Current	$T_A = 25^\circ\text{C}$		25			25			mA
Supply Current	$V_S = \pm 15\text{V}$		5			7			mA
			8			12			mA
Power Consumption	$V_S = \pm 15\text{V}$		240			360			mW

ac electrical characteristics ($T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$)

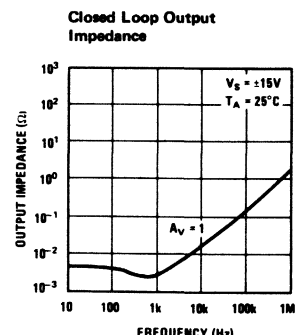
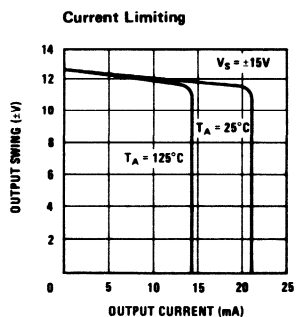
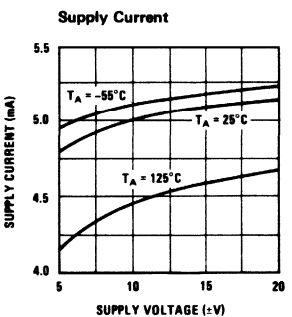
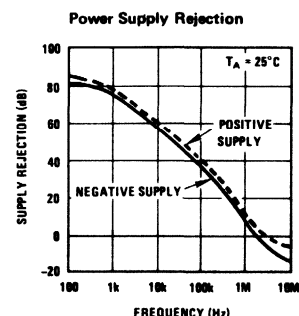
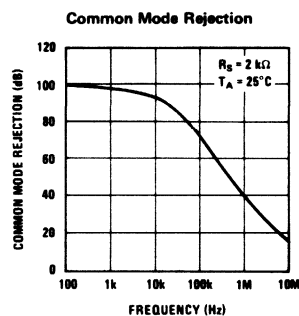
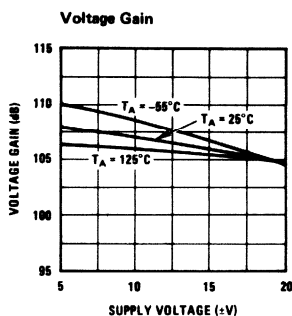
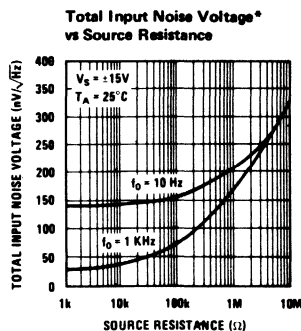
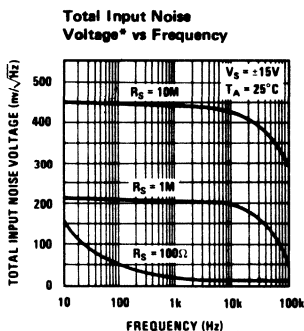
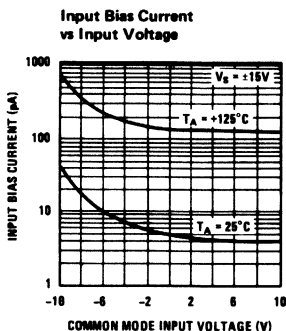
PARAMETER	CONDITIONS	LIMITS						UNITS	
		LH0062			LH0062C				
		MIN	TYP	MAX	MIN	TYP	MAX		
Slew Rate	Voltage Follower	50	70			50			V/ μs
Large Signal Bandwidth	Voltage Follower		2			2			MHz
Small Signal Bandwidth			15			15			MHz
Rise Time			25			25			ns
Overshoot			10			15			%
Settling Time (0.1%)	$\Delta V_{IN} = 10\text{V}$		1			1			μs
Overload Recovery			0.9			0.9			μs
Input Noise Voltage	$R_S = 10 \text{ k}\Omega$, $f_o = 10 \text{ Hz}$		150			150			$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Voltage	$R_S = 10 \text{ k}\Omega$, $f_o = 100 \text{ Hz}$		55			55			$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Voltage	$R_S = 10 \text{ k}\Omega$, $f_o = 1 \text{ kHz}$		35			35			$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Voltage	$R_S = 10 \text{ k}\Omega$, $f_o = 10 \text{ kHz}$		30			30			$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Voltage	$\text{BW} = 10 \text{ Hz to } 10 \text{ kHz}$, $R_S = 10 \text{ k}\Omega$		12			12			μVrms
Input Noise Current	$\text{BW} = 10 \text{ Hz to } 10 \text{ kHz}$		<.1			<.1			pArms

Note 1: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
 Note 2: Rating applies for minimum source resistance of 10 k Ω , for source resistances less than 10 k Ω , maximum differential input voltage is ±5V.
 Note 3: Unless otherwise specified, these specifications apply for ±5V < V_S < ±20V and -55°C < T_A < +125°C for the LH0062 and -25°C < T_A < +85°C for LH0062C. Typical values are given for T_A = 25°C. Power supplies should be bypassed with 0.1 μF ceramic capacitors.

typical performance characteristics



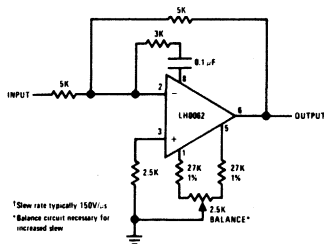
typical performance characteristics (con't)



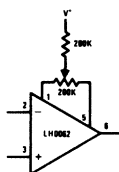
*Noise Voltage Includes Contribution from Source Resistance

auxiliary circuits

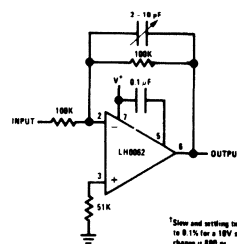
Feedforward Compensation for Greater Inverting Slew Rate†



Offset Balancing

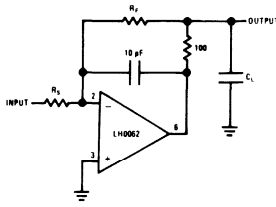


Compensation for Minimum Settling† Time

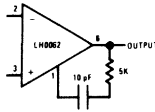


auxiliary circuits (con't)

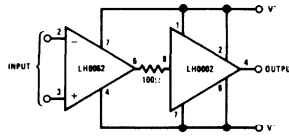
Isolating Large Capacitive Loads



Overcompensation

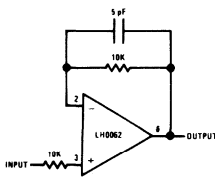


Boosting Output Drive to ±100 mA

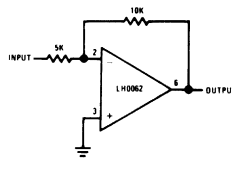


typical applications*

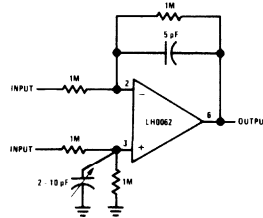
Fast Voltage Follower



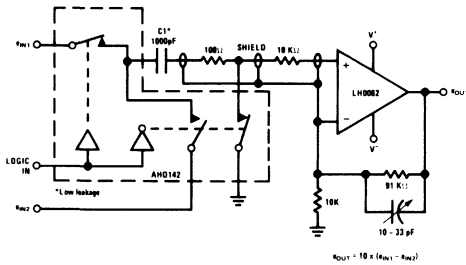
Fast Summing Amplifier



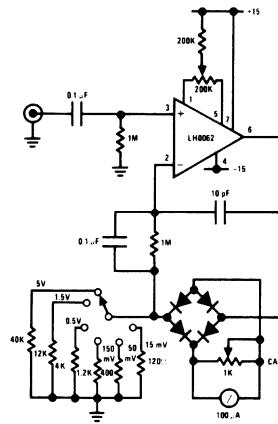
Differential Amplifier



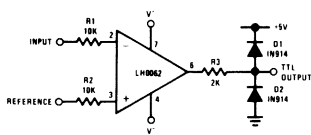
High Speed Subtractor



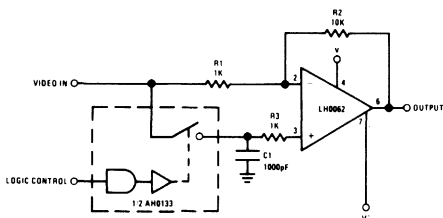
Wide Range AC Voltmeter



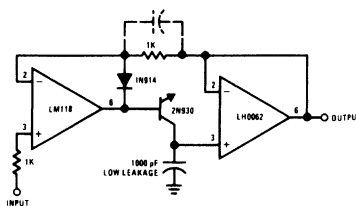
Fast Precision Voltage Comparator



Video DC Restoring Amplifier

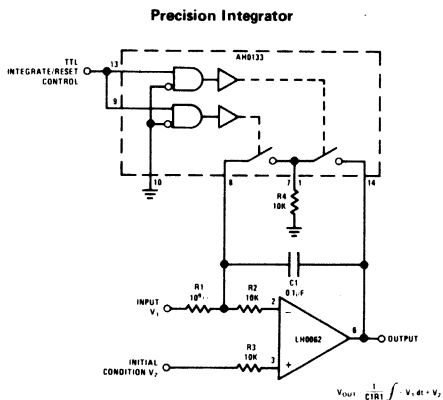


High Speed Positive Peak Detector



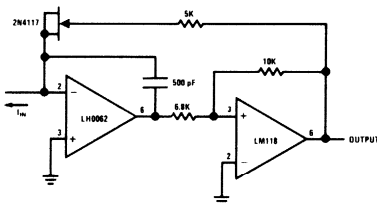
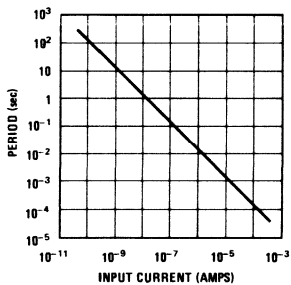
*Pin numbers shown for TO-5 package

typical applications* (con't)



*Pin numbers shown for TO-5 package

Precision Wide Range Current to Period Converter





Operational Amplifiers

LH101 operational amplifier general description

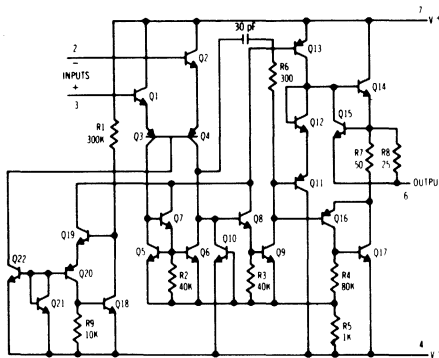
The LH101 is a general-purpose operational amplifier which is internally compensated for unity-gain feedback. The device combines a LM101 operational amplifier and the 30 pF compensation capacitor in a single package. As such, it is a direct, plug-in replacement for both the LM101 and the LM709 in the majority of applications. Features of the amplifier include:

- Operation guaranteed for supply voltages from $\pm 5V$ to $\pm 20V$
- Low current drain — even with the output saturated

- No latch-up when common-mode range is exceeded
- Continuous short-circuit protection
- Input transistors protected from excessive input voltage.

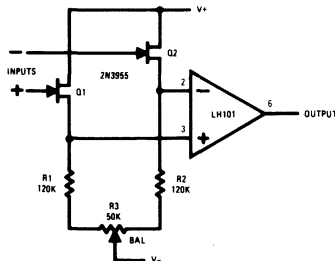
The LH101 is available in either an 8-lead, low-profile TO-5 header or a 1/4" x 1/4" metal flat package.

schematic** and connection diagrams

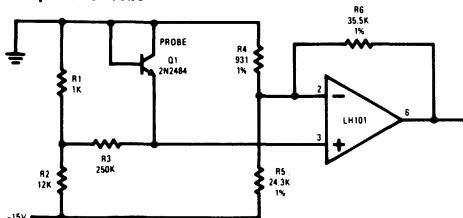


typical applications **

FET Operational Amplifier

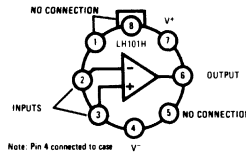


Temperature Probe



**Pin connections shown are for metal can.

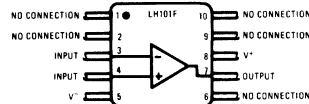
Metal Can



Note: Pin 4 connected to case V^-

Order Number LH101H
See Package 11

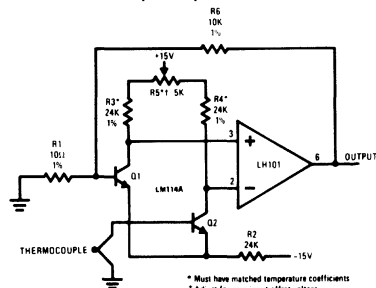
Flat Pack



NOTE: Pin 5 connected to bottom of package

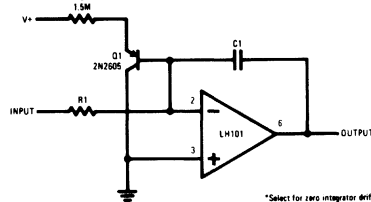
Order Number LH101F
See Package 3

Low Drift Thermocouple Amplifier†



* Must have matched temperature coefficients
† Adjust for zero input offset voltage
‡ Drifts less than 0.5 $\mu V/^\circ C$ can be obtained consistently

Integrator with Bias Current Compensation



*Select for zero integrator drift

absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	-55°C to +125°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 60 sec)	300°C

electrical characteristics (note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{k}\Omega$		1.0	5.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		40	200	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		120	500	nA
Input Resistance	$T_A = 25^\circ\text{C}$	300	800		k Ω
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 20\text{V}$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 2\text{k}\Omega$	50	160		V/mV
Input Offset Voltage	$R_S \leq 10\text{k}\Omega$			6.0	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S \leq 50\Omega$		3.0		$\mu\text{V}/^\circ\text{C}$
	$R_S \leq 10\text{k}\Omega$		6.0		$\mu\text{V}/^\circ\text{C}$
Input Offset Current	$T_A = +125^\circ\text{C}$ $T_A = -55^\circ\text{C}$		10 100	200 500	nA nA
Input Bias Current	$T_A = -55^\circ\text{C}$		0.28	1.5	μA
Supply Current	$T_A = +125^\circ\text{C}$, $V_S = \pm 20\text{V}$		1.2	2.5	mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 2\text{k}\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{k}\Omega$ $R_L = 2\text{k}\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15\text{V}$	±12			V
Common Mode Rejection Ratio	$R_S \leq 10\text{k}\Omega$	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\text{k}\Omega$	70	90		dB

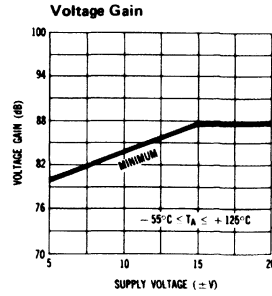
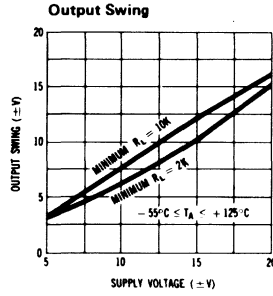
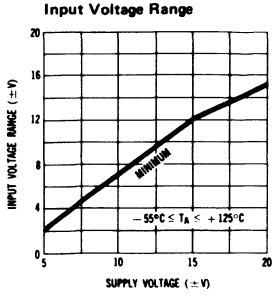
Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors (see curve).

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

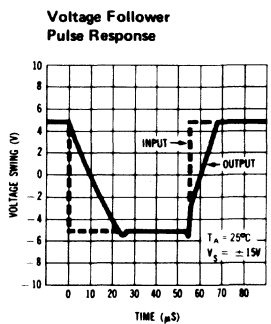
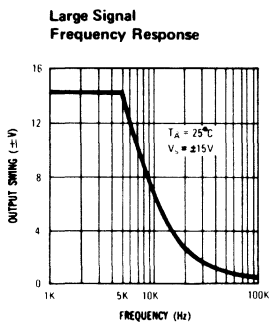
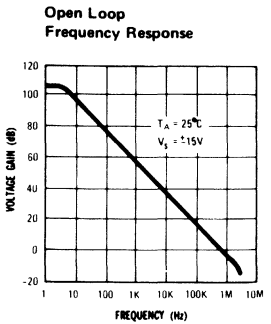
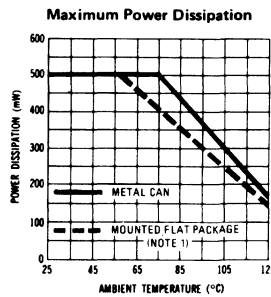
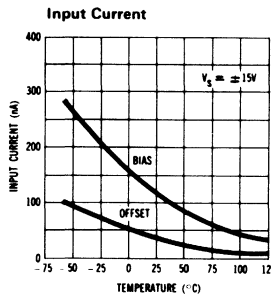
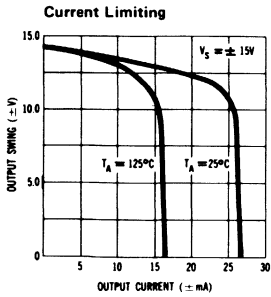
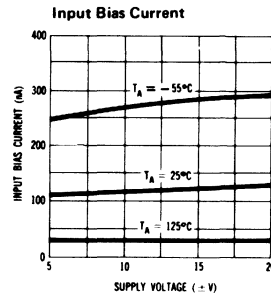
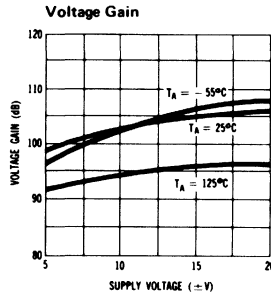
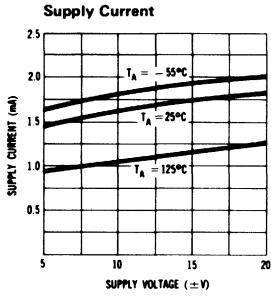
Note 3: Continuous short circuit is allowed for case temperatures to +125°C and ambient temperatures to +70°C.

Note 4: These specifications apply for $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$ and $C1 = 30\text{ pF}$ unless otherwise specified.

guaranteed performance characteristics



typical performance characteristics





Operational Amplifiers

LH201

LH201 operational amplifier general description

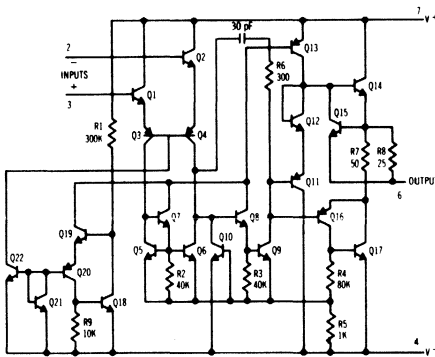
The LH201 is a general-purpose operational amplifier which is internally compensated for unity-gain feedback. The device combines a LM201 operational amplifier and the 30 pF compensation capacitor in a single package. As such, it is a direct, plug-in replacement for both the LM201 and the LM709C in the majority of applications. It is identical to the LH101 except that operation is specified over a 0 to 70°C temperature range. Features of the amplifier include:

- Operation guaranteed for supply voltages from $\pm 5V$ to $\pm 20V$

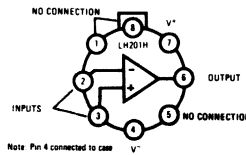
- Low current drain – even with the output saturated
- No latch-up when common-mode range is exceeded
- Continuous short-circuit protection
- Input transistors protected from excessive input voltage.

The LH201 is available in either an 8-lead, low-profile TO-5 header or a 1/4" x 1/4" metal flat package.

schematic** and connection diagrams

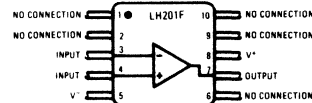


Metal Can



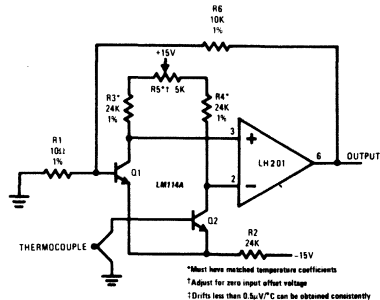
Order Number LH201H
See Package 11

Flat Pack



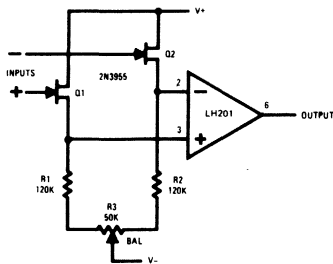
Order Number LH201F
See Package 3

Low Drift Thermocouple Amplifier

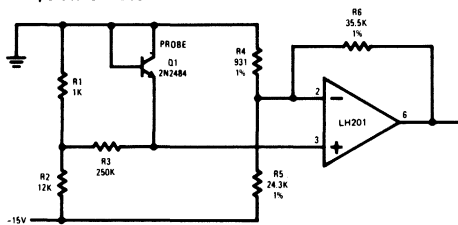


typical applications **

FET Operational Amplifier

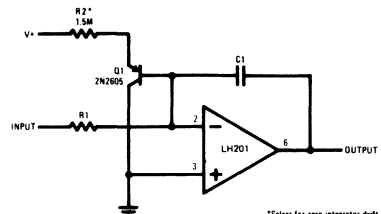


Temperature Probe



**Pin connections shown are for metal can.

Integrator with Bias Current Compensation



2

absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (Note 1)	250 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 60 sec)	300°C

electrical characteristics (note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{k}\Omega$		2.0	7.5	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		100	500	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		0.25	1.5	μA
Input Resistance	$T_A = 25^\circ\text{C}$	150	400		$\text{k}\Omega$
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 20\text{V}$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{\text{OUT}} = \pm 10\text{V}$, $R_L \geq 2\text{k}\Omega$	20	150		V/mV
Input Offset Voltage	$R_S \leq 10\text{k}\Omega$			10	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S \leq 50\Omega$		6		$\mu\text{V}/^\circ\text{C}$
	$R_S \leq 10\text{k}\Omega$		10		$\mu\text{V}/^\circ\text{C}$
Input Offset Current	$T_A = +70^\circ\text{C}$ $T_A = 0^\circ\text{C}$		50 150	400 750	nA nA
Input Bias Current	$T_A = 0^\circ\text{C}$		0.32	2.0	μA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = \pm 10\text{V}$ $R_L \geq 2\text{k}\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{k}\Omega$ $R_L = 2\text{k}\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15\text{V}$	±12			V
Common Mode Rejection Ratio	$R_S \leq 10\text{k}\Omega$	65	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\text{k}\Omega$	70	90		dB

Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors (see curve).

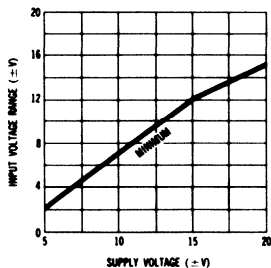
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Continuous short circuit is allowed for case temperatures to +125°C and ambient temperatures to +70°C.

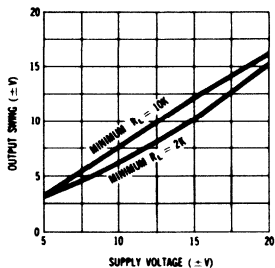
Note 4: These specifications apply for $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$ and $C1 = 30\text{ pF}$ unless otherwise specified.

guaranteed performance characteristics

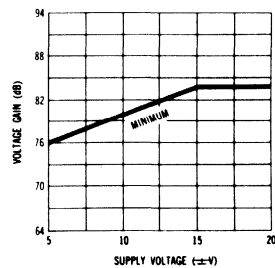
Input Voltage Range



Output Swing

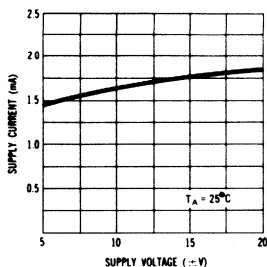


Voltage Gain

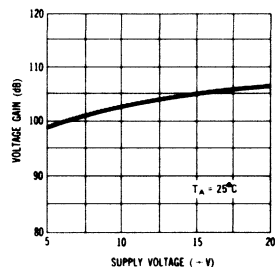


typical performance characteristics

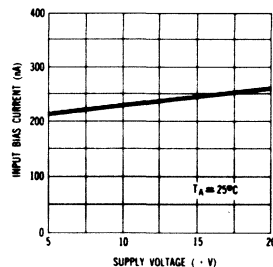
Supply Current



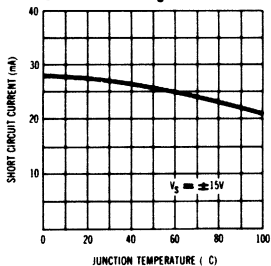
Voltage Gain



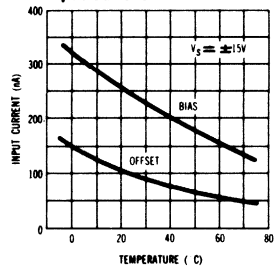
Input Bias Current



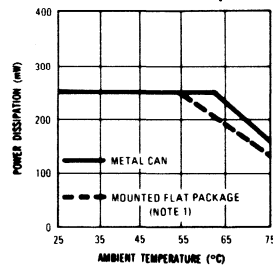
Current Limiting



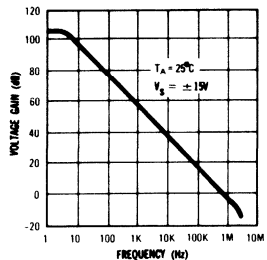
Input Current



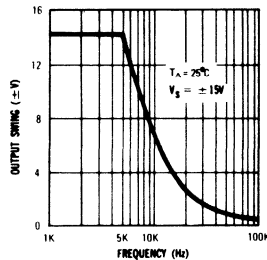
Maximum Power Dissipation



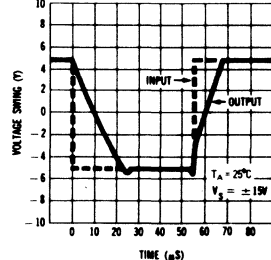
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response





Operational Amplifiers

LM101 operational amplifier general description

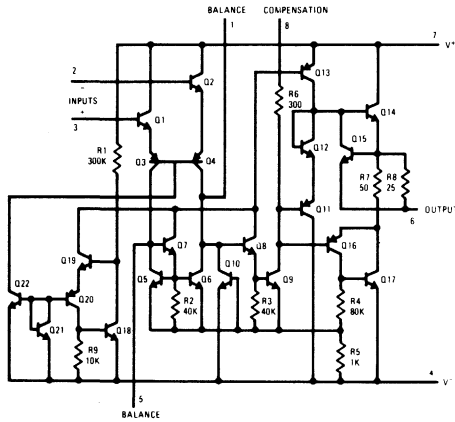
The LM101 is a general-purpose operational amplifier built on a single silicon chip. The resulting close match and tight thermal coupling gives low offsets and temperature drift as well as fast recovery from thermal transients. In addition, the device features:

- Frequency compensation with a single 30 pF capacitor
- Operation from $\pm 5V$ to $\pm 20V$
- Low current drain: 1.8 mA at $\pm 20V$
- Continuous short-circuit protection
- Operation as a comparator with differential inputs as high as $\pm 30V$

- No latch-up when common mode range is exceeded
- Same pin configuration as the LM709.

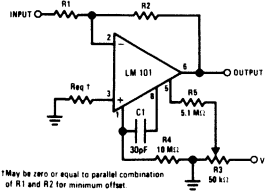
The unity-gain compensation specified makes the circuit stable for all feedback configurations, even with capacitive loads. However, it is possible to optimize compensation for best high frequency performance at any gain. As a comparator, the output can be clamped at any desired level to make it compatible with logic circuits. Further, the low power dissipation permits high-voltage operation and simplifies packaging in full-temperature-range systems.

schematic** and connection diagrams

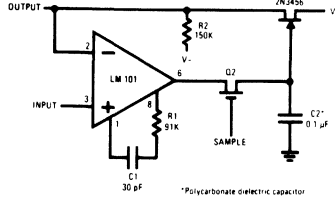


typical applications **

Inverting Amplifier with Balancing Circuit

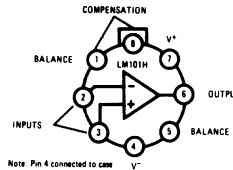


Low Drift Sample and Hold



**Pin connections shown are for metal can.

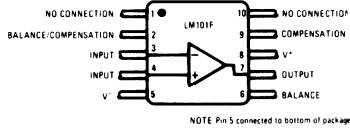
Metal Can



Note: Pin 4 connected to case.

Order Number LM101H
See Package 11

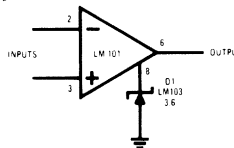
Flat Package



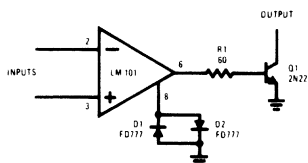
NOTE: Pin 5 connected to bottom of package.

Order Number LM101F
See Package 3

Voltage Comparator for Driving DTL or TTL Integrated Circuits



Voltage Comparator for Driving RTL Logic or High Current Driver



absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	-55°C to +125°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 60 sec)	300°C

electrical characteristics (note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{k}\Omega$		1.0	5.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		40	200	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		120	500	nA
Input Resistance	$T_A = 25^\circ\text{C}$	300	800		k Ω
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 20\text{V}$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{\text{OUT}} = \pm 10\text{V}$, $R_L \geq 2\text{k}\Omega$	50	160		V/mV
Input Offset Voltage	$R_S \leq 10\text{k}\Omega$			6.0	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S \leq 50\Omega$ $R_S \leq 10\text{k}\Omega$		3.0 6.0		$\mu\text{V}/^\circ\text{C}$ $\mu\text{V}/^\circ\text{C}$
Input Offset Current	$T_A = +125^\circ\text{C}$ $T_A = -55^\circ\text{C}$		10 100	200 500	nA nA
Input Bias Current	$T_A = -55^\circ\text{C}$		0.28	1.5	μA
Supply Current	$T_A = +125^\circ\text{C}$, $V_S = \pm 20\text{V}$		1.2	2.5	mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = \pm 10\text{V}$ $R_L \geq 2\text{k}\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{k}\Omega$ $R_L = 2\text{k}\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15\text{V}$	±12			V
Common Mode Rejection Ratio	$R_S \leq 10\text{k}\Omega$	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\text{k}\Omega$	70	90		dB

Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors (see curve).

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

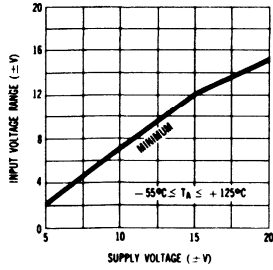
Note 3: Continuous short circuit is allowed for case temperatures to +125°C and ambient temperatures to +70°C.

Note 4: These specifications apply for $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$ and $C1 = 30\text{ pF}$ unless otherwise specified.

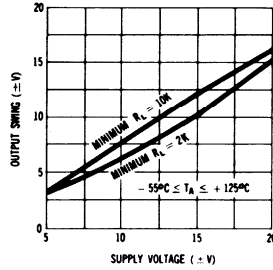
2

guaranteed performance characteristics

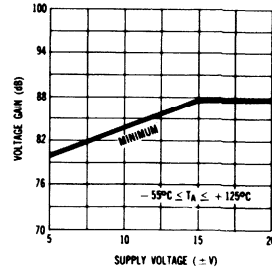
Input Voltage Range



Output Swing

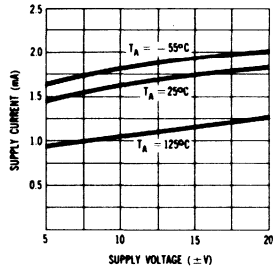


Voltage Gain

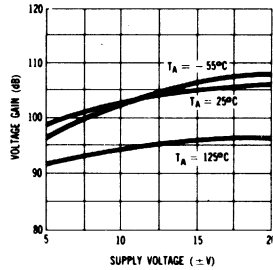


typical performance characteristics

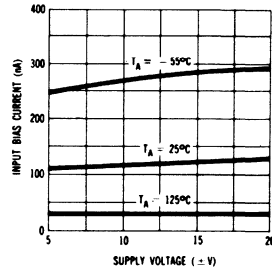
Supply Current



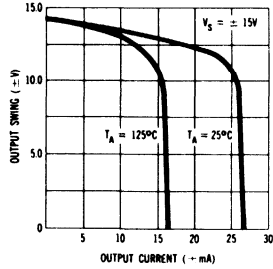
Voltage Gain



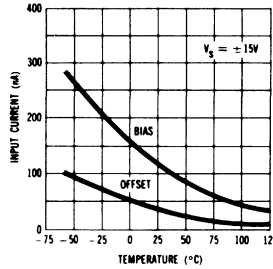
Input Bias Current



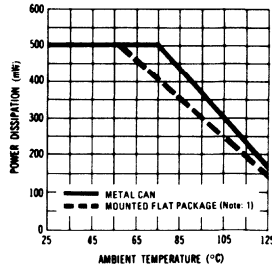
Current Limiting



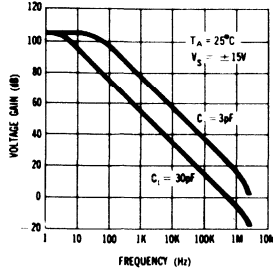
Input Current



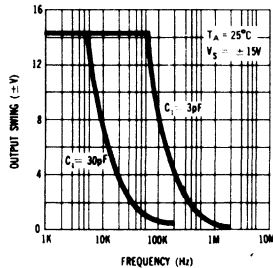
Maximum Power Dissipation



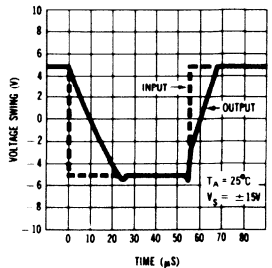
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response





Operational Amplifiers

LM201

LM201 operational amplifier general description

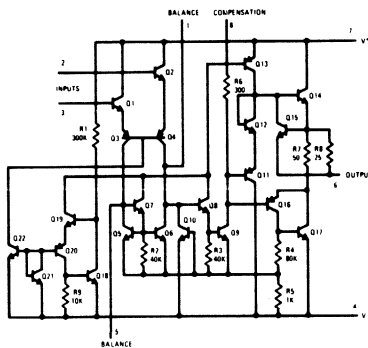
The LM201 is a general-purpose operational amplifier built on a single silicon chip. It is identical to the LM101 except that operation is specified over a 0 to 70°C temperature range. The device features:

- Frequency compensation with a single 30 pF capacitor
- Operation from $\pm 5V$ to $\pm 20V$
- Low current drain: 1.8 mA at $\pm 20V$
- Continuous short-circuit protection
- Operation as a comparator with differential inputs as high as $\pm 30V$

- No latch-up when common mode range is exceeded
- LM709 lead configuration in metal cans and flat-packages.

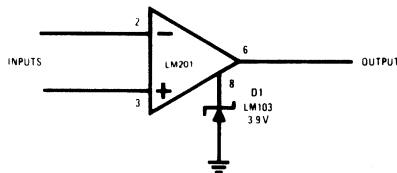
The unity-gain compensation specified makes the circuit stable for all feedback configurations, even with capacitive loads. However, it is possible to optimize compensation for best high frequency performance at any gain. As a comparator, the output can be clamped at any desired level to make it compatible with logic circuits. Further, the low power dissipation permits high-voltage operation and simplifies packaging.

schematic** and connection diagrams

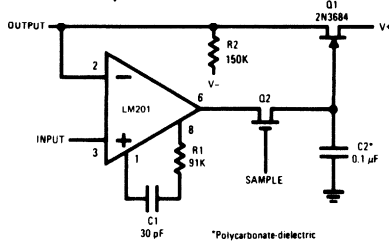


typical applications**

Voltage Comparator for Driving DTL or TTL Integrated Circuits

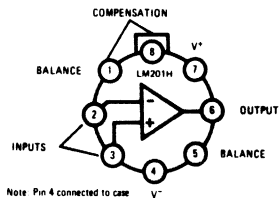


Low Drift Sample and Hold



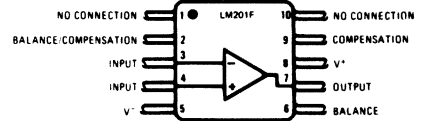
**Pin connections shown are for metal can.

Metal Can



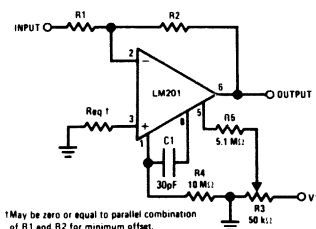
Order Number LM201H
See Package 11

Flat Pack

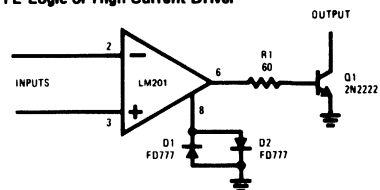


Order Number LM201F
See Package 3

Inverting Amplifier with Balancing Circuit



Voltage Comparator for Driving RTL Logic or High Current Driver



2

absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (Note 1)	250 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{k}\Omega$		2.0	7.5	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		100	500	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		0.25	1.5	μA
Input Resistance	$T_A = 25^\circ\text{C}$	100	400		$\text{k}\Omega$
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 20\text{V}$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{\text{OUT}} = \pm 10\text{V}$, $R_L \geq 2\text{k}\Omega$	20	150		V/mV
Input Offset Voltage	$R_S \leq 10\text{k}\Omega$			10	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S \leq 50\Omega$ $R_S \leq 10\text{k}\Omega$		6 10		$\mu\text{V}/^\circ\text{C}$ $\mu\text{V}/^\circ\text{C}$
Input Offset Current	$T_A = +70^\circ\text{C}$ $T_A = 0^\circ\text{C}$		50 150	400 750	nA nA
Input Bias Current	$T_A = 0^\circ\text{C}$		0.32	2.0	μA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = \pm 10\text{V}$ $R_L \geq 2\text{k}\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{k}\Omega$ $R_L = 2\text{k}\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15\text{V}$	±12			V
Common Mode Rejection Ratio	$R_S \leq 10\text{k}\Omega$	65	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\text{k}\Omega$	70	90		dB

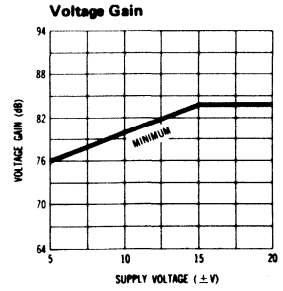
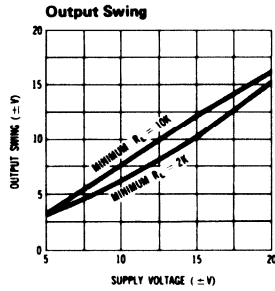
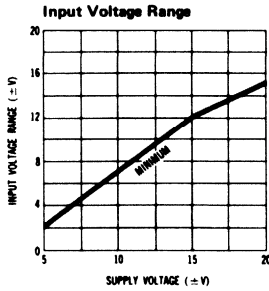
Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch thick, epoxy-glass board with ten, 0.03-inch wide, 2-ounce copper conductors (see curve).

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

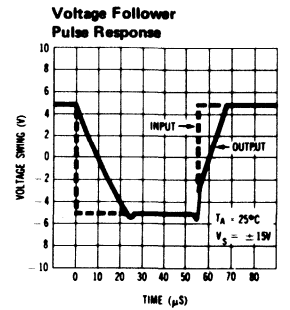
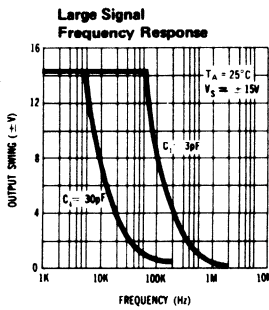
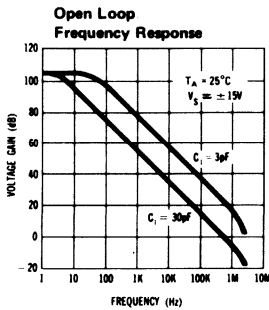
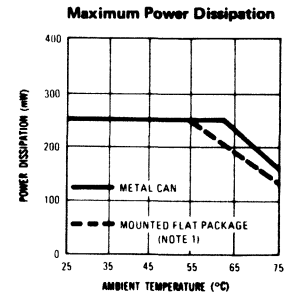
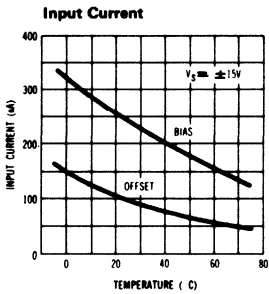
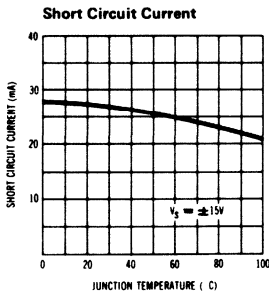
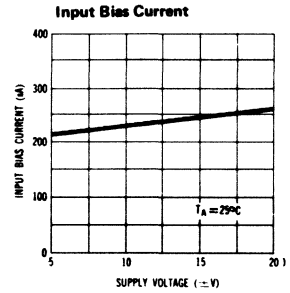
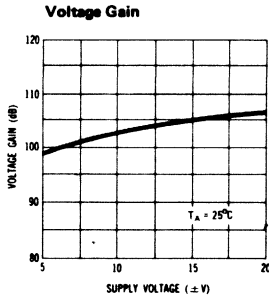
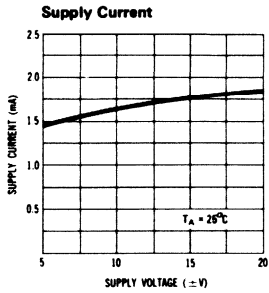
Note 3: Continuous short circuit is allowed for case temperatures to 70°C and ambient temperatures to 55°C.

Note 4: These specifications apply for 0°C ≤ T_A ≤ 70°C, ±5V ≤ V_S ≤ ±20V and C_1 = 30 pF unless otherwise specified.

guaranteed performance characteristics



typical performance characteristics



2



Operational Amplifiers

LM101A/LM201A operational amplifier general description

The LM101A and LM201A are general purpose operational amplifiers which feature improved performance over industry standards like the LM101 and the 709. Advanced processing techniques make possible an order of magnitude reduction in input currents, and a redesign of the biasing circuitry reduces the temperature drift of input current. Improved specifications include:

- Offset voltage 3 mV maximum over temperature
- Input current 100 nA maximum over temperature
- Offset current 20 nA maximum over temperature
- Guaranteed drift characteristics
- Offsets guaranteed over entire common mode and supply voltage ranges
- Slew rate of 10V/μs as a summing amplifier

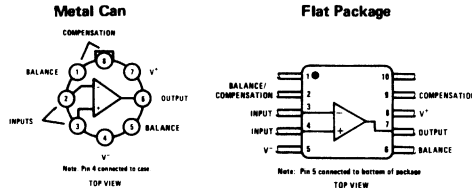
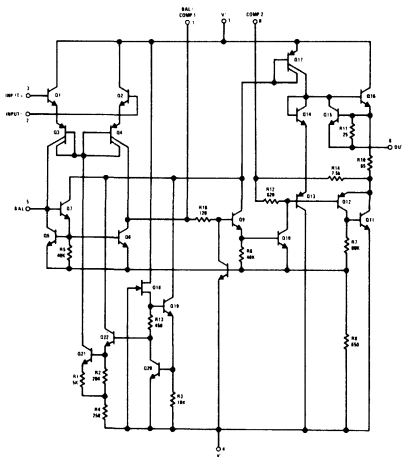
This amplifier offers many features which make its application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, freedom from oscillations and compensation with a single 30 pF

capacitor. It has advantages over internally compensated amplifiers in that the frequency compensation can be tailored to the particular application. For example, in low frequency circuits it can be overcompensated for increased stability margin. Or the compensation can be optimized to give more than a factor of ten improvement in high frequency performance for most applications.

The LM101A series offers the features of the LM101, which makes its application nearly foolproof. In addition, the device provides better accuracy and lower noise in high impedance circuitry. The low input currents also make it particularly well suited for long interval integrators or timers, sample and hold circuits and low frequency waveform generators. Further, replacing circuits where matched transistor pairs buffer the inputs of conventional IC op amps, it can give lower offset voltage and drift at a lower cost.

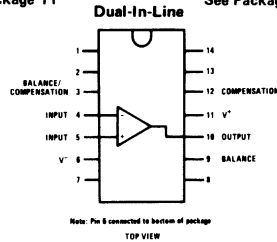
The LM201A is identical to the LM101A, except that the LM201A has its performance guaranteed over a -25°C to 85°C temperature range, instead of -55°C to 125°C.

schematic** and connection diagrams



Order Number
LM101AH or LM201AH
See Package 11

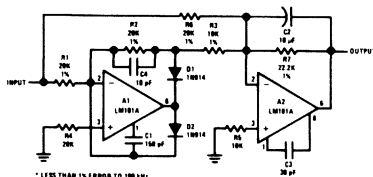
Order Number
LM101AF or LM201AF
See Package 3



Order Number LM101AD or LM201AD
See Package 1

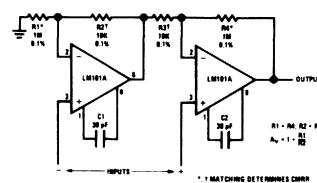
typical applications**

Fast AC/DC Converter*



**Pin connections shown are for metal can.

Instrumentation Amplifier



absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range LM101A	-55°C to 125°C
LM201A	-25°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 50\text{ k}\Omega$		0.7	2.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		1.5	10	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		30	75	nA
Input Resistance	$T_A = 25^\circ\text{C}$	1.5	4		M Ω
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 20\text{V}$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 2\text{ k}\Omega$	50	160		V/mV
Input Offset Voltage	$R_S \leq 50\text{ k}\Omega$			3.0	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	15	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				20	nA
Average Temperature Coefficient of Input Offset Current	$25^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ $-55^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$		0.01 0.02	0.1 0.2	nA/ $^\circ\text{C}$ nA/ $^\circ\text{C}$
Input Bias Current				100	nA
Supply Current	$T_A = +125^\circ\text{C}$, $V_S = \pm 20\text{V}$		1.2	2.5	mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 2\text{ k}\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	± 12 ± 10	± 14 ± 13		V V
Input Voltage Range	$V_S = \pm 20\text{V}$	± 15			V
Common Mode Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	80	96		dB
Supply Voltage Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	80	96		dB

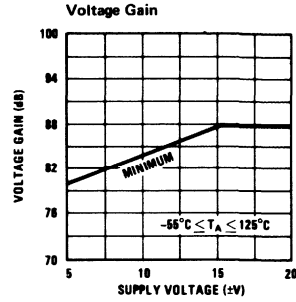
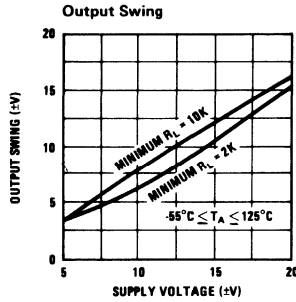
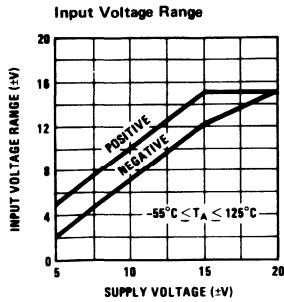
Note 1: The maximum junction temperature of the LM101A is 150°C, while that of the LM201A is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

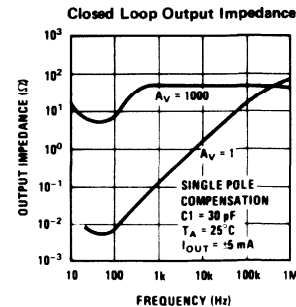
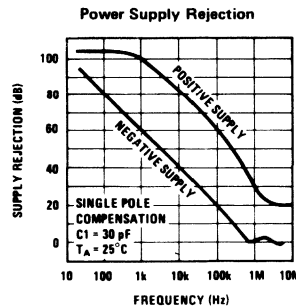
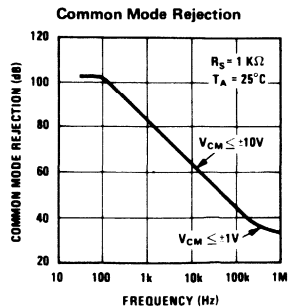
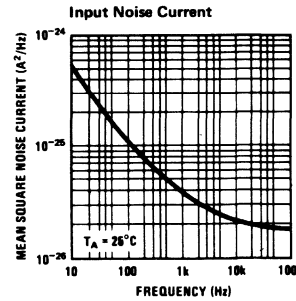
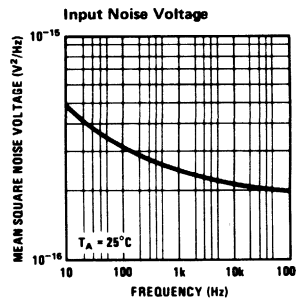
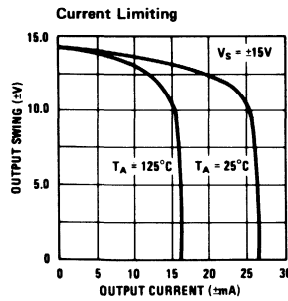
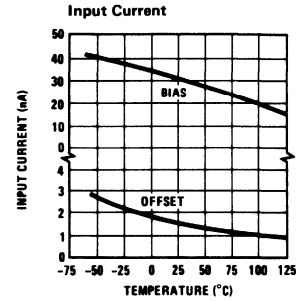
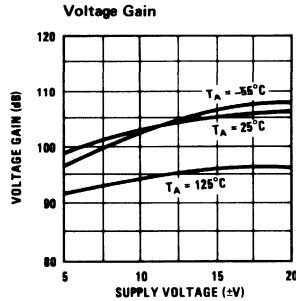
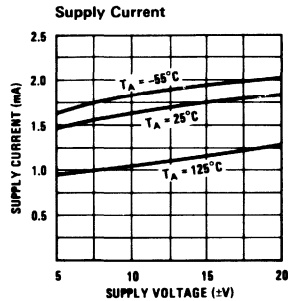
Note 3: Continuous short circuit is allowed for case temperatures to +125°C and ambient temperatures to +75°C.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM201A, however, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$.

guaranteed performance characteristics

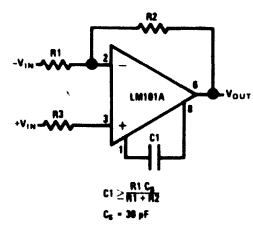


typical performance characteristics

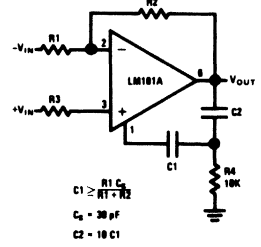


compensation circuits **

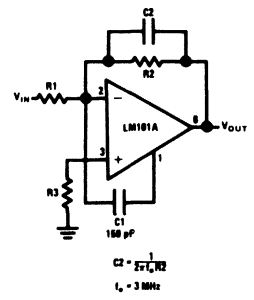
Single Pole Compensation



Two Pole Compensation

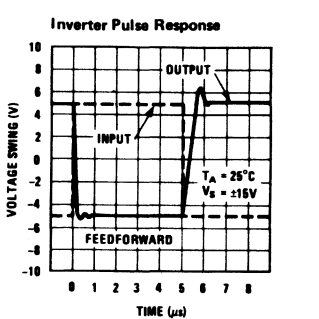
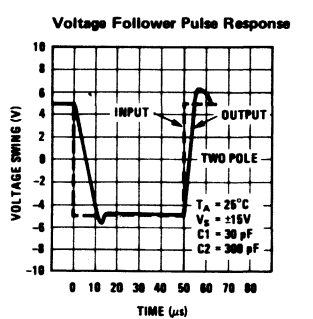
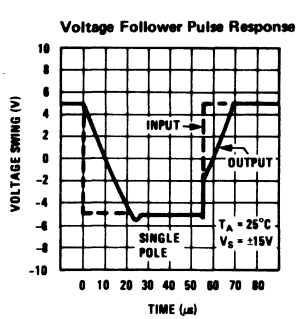
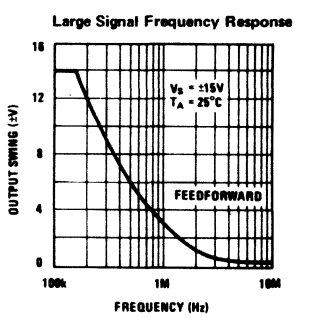
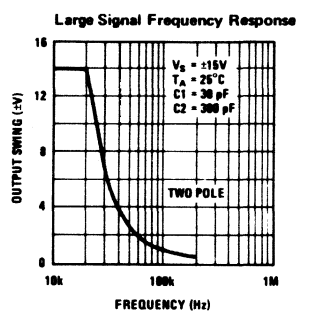
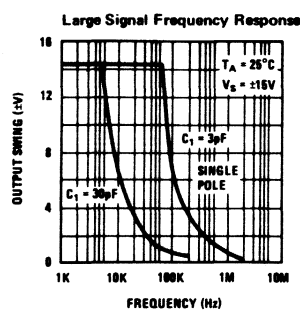
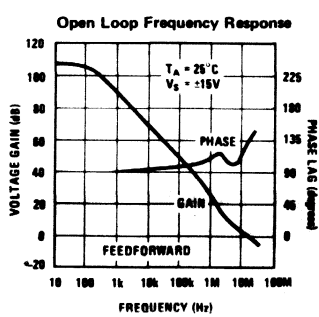
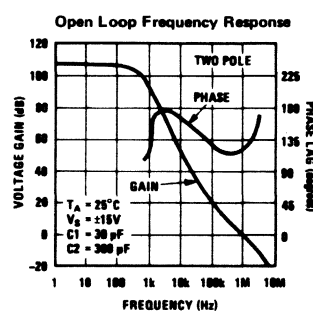
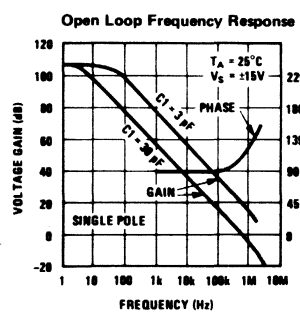


Feedforward Compensation



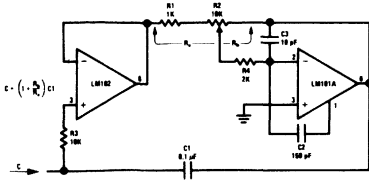
**Pin connections shown are for metal can.

typical performance characteristics (con't)

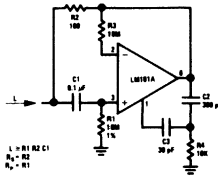


typical applications ** (con't)

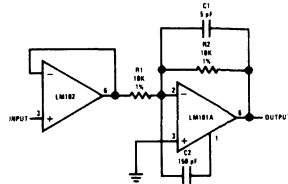
Variable Capacitance Multiplier



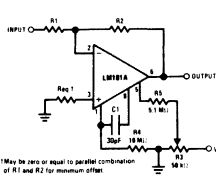
Simulated Inductor



Fast Inverting Amplifier With High Input Impedance

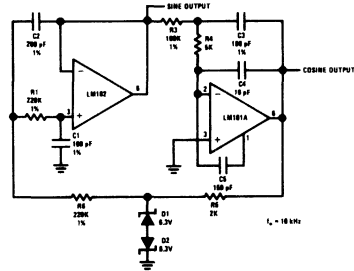


Inverting Amplifier with Balancing Circuit

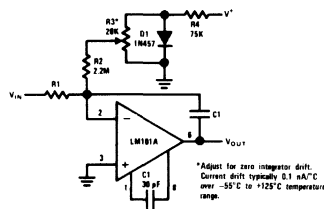


*May be used as equal to double combination of R1 and R2 for minimum offset.

Sine Wave Oscillator



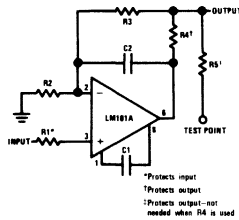
Integrator with Bias Current Compensation



*Adjust for zero integrator drift. Current drift typically 0.1 nA/°C over -55°C to +125°C temperature range.

application hints**

Protecting Against Gross Fault Conditions

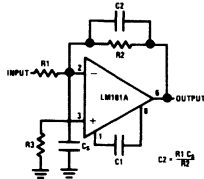


1 Protects input
2 Protects output
3 Protects output-not needed when R4 is used

Although the LM101A is designed for trouble free operation, experience has indicated that it is wise to observe certain precautions given below to protect the devices from abnormal operating conditions. It might be pointed out that the advice given here is applicable to practically any IC op amp, although the exact reason why may differ with different devices.

When driving either input from a low-impedance source, a limiting resistor should be placed in series with the input lead to limit the peak instantaneous output current of the source to something less than 100 mA. This is especially important when the inputs go outside a piece of equipment where they could accidentally be connected to high voltage sources. Large capacitors on the input (greater than 0.1 μF) should be treated as a low source impedance and isolated with a resistor. Low impedance sources do not cause a problem unless their output voltage exceeds the supply voltage. However, the supplies go to zero when they are turned off, so the isolation is usually needed.

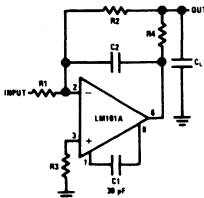
Compensating For Stray Input Capacitances Or Large Feedback Resistor



The output circuitry is protected against damage from shorts to ground. However, when the amplifier output is connected to a test point, it should be isolated by a limiting resistor, as test points frequently get shorted to bad places. Further, when the amplifier drives a load external to the equipment, it is also advisable to use some sort of limiting resistance to preclude mishaps.

Precautions should be taken to insure that the power supplies for the integrated circuit never become reversed—even under transient conditions. With reverse voltages greater than 1V, the IC will conduct excessive current, fusing internal aluminum interconnects. If there is a possibility of this happening, clamp diodes with a high peak current rating should be installed on the supply lines. Reversal of the voltage between V⁺ and V⁻ will always cause a problem, although reversals with respect to ground may also give difficulties in many circuits.

Isolating Large Capacitive Loads



The minimum values given for the frequency compensation capacitor are stable only for source resistances less than 10 kΩ, stray capacitances on the summing junction less than 5 pF and capacitive loads smaller than 100 pF. If any of these conditions are not met, it becomes necessary to overcompensate the amplifier with a larger compensation capacitor. Alternately, lead capacitors can be used in the feedback network to negate the effect of stray capacitance and large feedback resistors or an RC network can be added to isolate capacitive loads.

Although the LM101A is relatively unaffected by supply bypassing, this cannot be ignored altogether. Generally it is necessary to bypass the supplies to ground at least once on every circuit card, and more bypass points may be required if more than five amplifiers are used. When feed-forward compensation is employed, however, it is advisable to bypass the supply leads of each amplifier with low inductance capacitors because of the higher frequencies involved.

**Pin connections shown are for metal can.



Operational Amplifiers

LM301A

LM301A operational amplifier general description

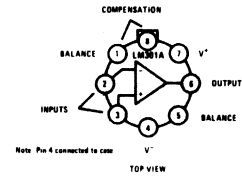
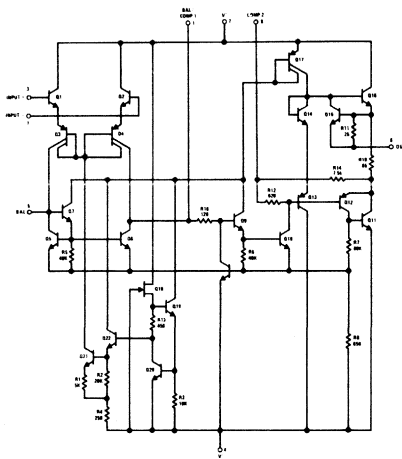
The LM301A is a general-purpose operational amplifier which features improved performance over the 709C and other popular amplifiers. Advanced processing techniques make possible an order of magnitude reduction in input currents, and a redesign of the biasing circuitry reduces the temperature drift of input current.

This amplifier offers many features which make its application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, freedom from oscillations and compensation with a single 30 pF capacitor. It has advantages over internally compensated amplifiers in that the compensation can be tailored to the particular application. For

example, as a summing amplifier, slew rates of 10 V/ μ s and bandwidths of 10 MHz can be realized. In addition, the circuit can be used as a comparator with differential inputs up to ± 30 V; and the output can be clamped at any desired level to make it compatible with logic circuits.

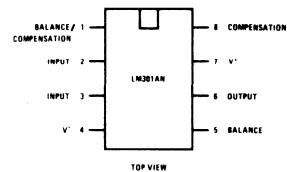
The LM301A provides better accuracy and lower noise than its predecessors in high impedance circuitry. The low input currents also make it particularly well suited for long interval integrators or timers, sample and hold circuits and low frequency waveform generators. Further, replacing circuits where matched transistor pairs buffer the inputs of conventional IC op amps, it can give lower offset voltage and drift at reduced cost.

schematic** and connection diagrams



Note: Pin 4 connected to case V⁻

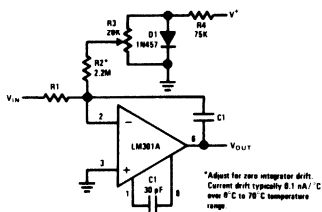
Order Number LM301AH
See Package 11



Order Number LM301AN
See Package 20

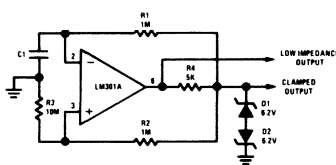
typical applications **

Integrator with Bias Current Compensation

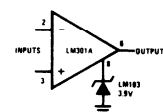


*Adjust for zero integrator drift. Current drift typically 0.1 nA/ $^{\circ}$ C over 0° C to 70° C temperature range.

Low Frequency Square Wave Generator



Voltage Comparator for Driving DTL or TTL Integrated Circuits



**Pin connections shown are for metal can.

2

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 50\text{ k}\Omega$		2.0	7.5	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		3	50	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		70	250	nA
Input Resistance	$T_A = 25^\circ\text{C}$	0.5	2		M Ω
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 2\text{ k}\Omega$	25	160		V/mV
Input Offset Voltage	$R_S \leq 50\text{ k}\Omega$			10	mV
Average Temperature Coefficient of Input Offset Voltage			6.0	30	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				70	nA
Average Temperature Coefficient of Input Offset Current	$25^\circ\text{C} < T_A < 70^\circ\text{C}$ $0^\circ\text{C} < T_A < 25^\circ\text{C}$		0.01 0.02	0.3 0.6	nA/ $^\circ\text{C}$ nA/ $^\circ\text{C}$
Input Bias Current				300	nA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 2\text{ k}\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15\text{V}$	±12			V
Common Mode Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	70	96		dB

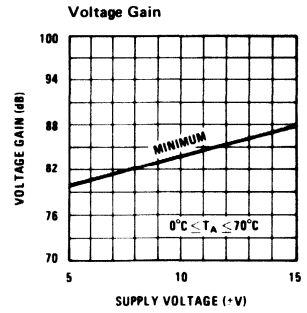
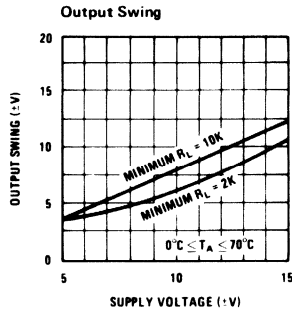
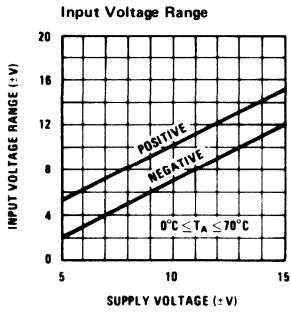
Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

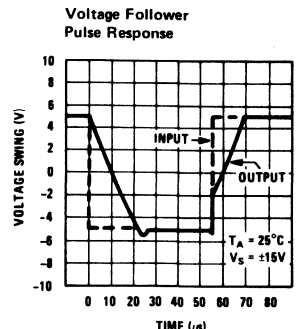
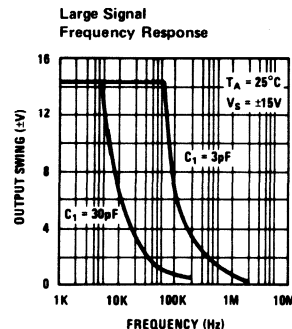
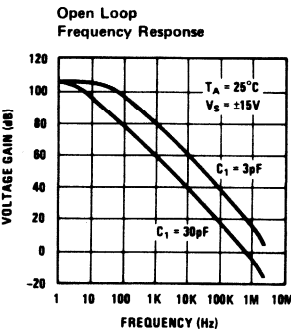
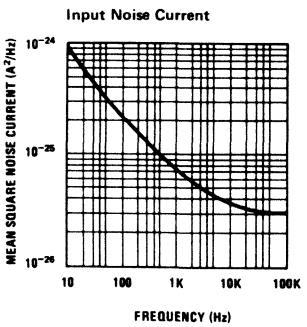
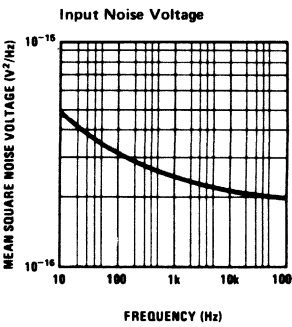
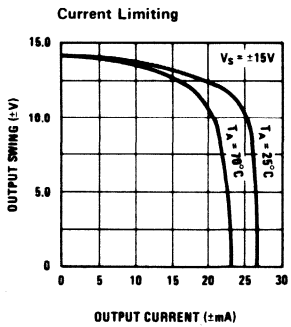
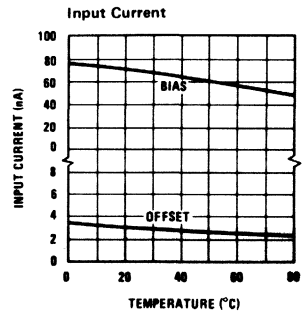
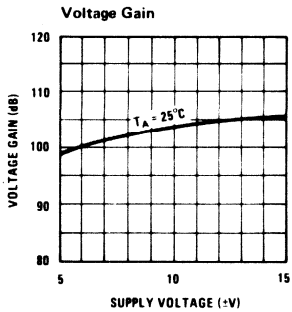
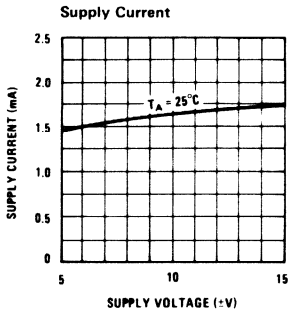
Note 3: Continuous short circuit is allowed for case temperatures to 70°C and ambient temperatures to 55°C.

Note 4: These specifications apply for $0^\circ\text{C} \leq T_A < 70^\circ\text{C}$, $\pm 5\text{V} \leq V_S \leq \pm 15\text{V}$ and $C1 = 30\text{ pF}$ unless otherwise specified.

guaranteed performance characteristics

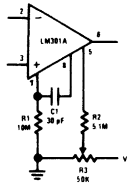


typical performance characteristics

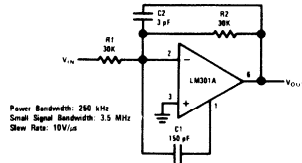


typical applications ** (con't)

Standard Compensation and Offset Balancing Circuit

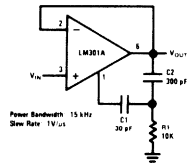


Fast Summing Amplifier



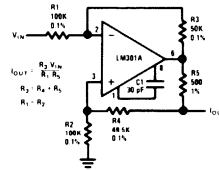
Power Bandwidth: 260 kHz
 Small Signal Bandwidth: 3.5 MHz
 Slew Rate: 10V/μs

Fast Voltage Follower



Power Bandwidth: 15 kHz
 Slew Rate: 1V/μs

Bilateral Current Source



**Pin connections shown are for metal can.



Operational Amplifiers

LM102

LM102 voltage follower general description

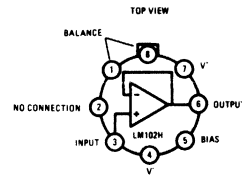
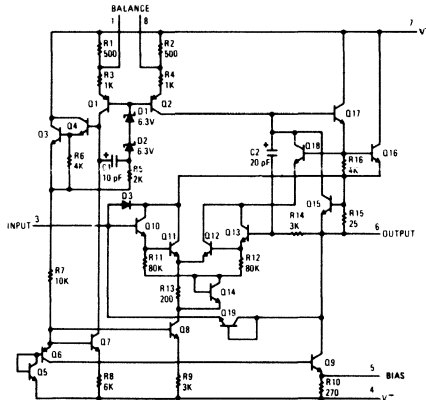
The LM102 is a high-gain operational amplifier designed specifically for unity-gain voltage follower applications. Built on a single silicon chip, the device incorporates advanced processing techniques to obtain very low input current and high input impedance. Further, the input transistors are operated at zero collector-base voltage to virtually eliminate high temperature leakage currents. It can therefore be operated in a temperature stabilized component oven to get extremely low input currents and low offset voltage drift. Other outstanding characteristics of the device include:

- Fast slewing – 10V/ μ s
- Low input current – 10 nA (max)

- High input resistance – 10,000 M Ω
- No external frequency compensation required
- Simple offset balancing with optional 1K potentiometer
- Plug-in replacement for both the LM101 and LM709 in voltage follower applications.

The LM102, which is designed to operate with supply voltages between ± 12 V and ± 15 V, also features low input capacitance as well as excellent small signal and large signal frequency response – all of which minimize high frequency gain error. Because of the low wiring capacitances inherent in monolithic construction, this fast operation can be realized without increasing power consumption.

schematic** and connection diagrams

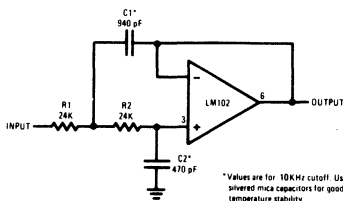


NOTE: Pin 4 connected to case

Order Number LM102H
See Package 11

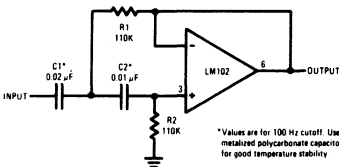
typical applications **

Low Pass Active Filter



*Values are for 10KHz cutoff. Use silvered mica capacitors for good temperature stability.

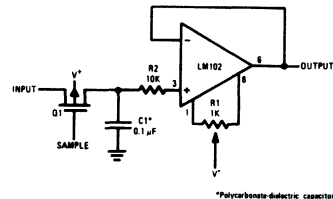
High Pass Active Filter



*Values are for 100 Hz cutoff. Use metallized polycarbonate capacitors for good temperature stability.

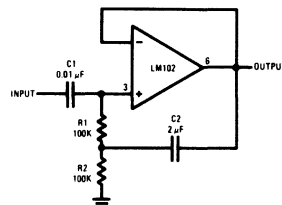
**Pin connections shown are for metal can.

Sample and Hold With Offset Adjustment



*Polycarbonate-dielectric capacitor.

High Input Impedance AC Amplifier



2

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	-55°C to 125°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Offset Voltage			2	5	mV
Average Temperature Coefficient of Offset Voltage			6		μV/°C
Input Current			3	10	nA
Input Resistance		10 ¹⁰	10 ¹²		Ω
Voltage Gain	R _L ≥ 10 kΩ	0.999	0.9996		
Output Resistance			0.8	2.5	Ω
Output Voltage Swing (Note 5)	R _L ≥ 8 kΩ	±10	±13		V
Supply Current			3.5	5.5	mA
Positive Supply Rejection		60			dB
Negative Supply Rejection		70			dB
Input Capacitance				3.0	pF
Offset Voltage	-55°C ≤ T _A ≤ 125°C			7.5	mV
Input Current	T _A = 125°C T _A = -55°C		3 30	10 100	nA nA
Voltage Gain	-55°C ≤ T _A ≤ 125°C R _L ≥ 10 kΩ	0.999			
Output Voltage Swing (Note 5)	R _L ≥ 10 kΩ	±10			V
Supply Current	T _A = 125°C		2.6	4.0	mA

Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient (see curve).

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

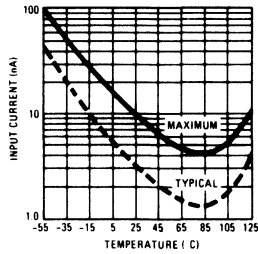
Note 3: Continuous short circuit is allowed for case temperatures to 125°C and ambient temperatures to 70°C. It is necessary to insert a resistor greater than 2 kΩ in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.

Note 4: These specifications apply for T_A = 25°C, V_S = ±15V and C_L ≤ 100 pF unless otherwise noted.

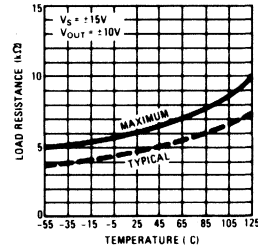
Note 5: Increased output swing under load can be obtained by connecting an external resistor between the booster and V⁻ terminals. See curve.

guaranteed performance characteristics

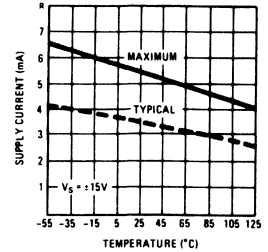
Input Current



Output Swing

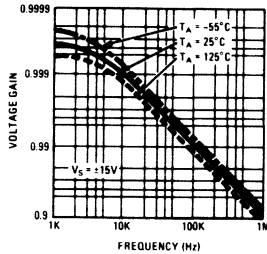


Supply Current

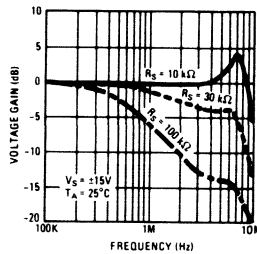


typical performance characteristics

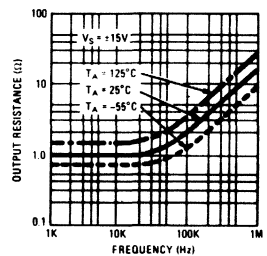
Voltage Gain



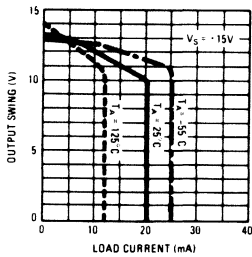
Voltage Gain



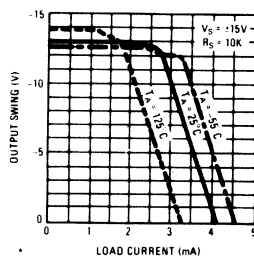
Output Resistance



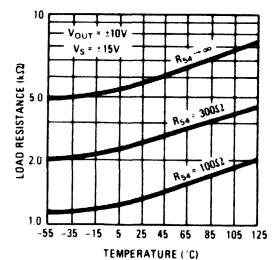
Positive Output Swing



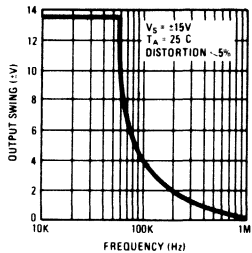
Negative Output Swing



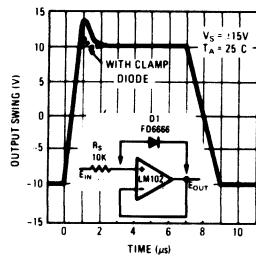
Output Swing



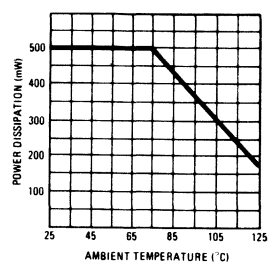
Large Signal Frequency Response



Large Signal Pulse Response



Maximum Power Dissipation





Operational Amplifiers

LM202 voltage follower general description

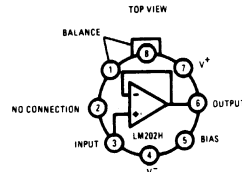
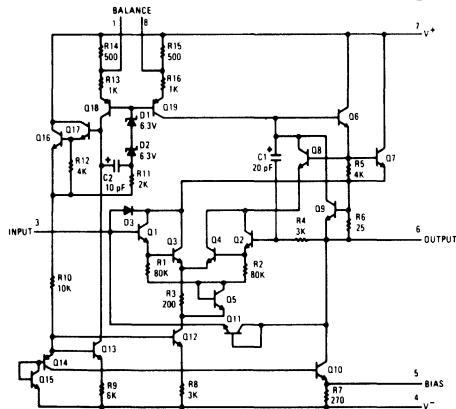
The LM202, a limited temperature range version of the LM102, is a high-gain operational amplifier designed specifically for unity-gain voltage follower applications. Built on a single silicon chip, the device incorporates advanced processing techniques to obtain very low input current and high input impedance. Further, the input transistors are operated at zero collector-base voltage to virtually eliminate high temperature leakage currents. It can therefore be operated in a temperature stabilized component oven to get extremely low input currents and low offset voltage drift. Other outstanding characteristics of the device include:

- Fast slewing: 10V/μs
- Low input current: 15 nA (max)

- High input resistance: 10,000 MΩ
- No external frequency compensation required
- Simple offset balancing with optional 1K potentiometer
- Specified for operation from -25°C to 85°C
- Plug-in replacement for both the LM201 and LM709C voltage follower applications.

The LM202, which is designed to operate with supply voltages between ±12V and ±15V, also features low input capacitance as well as excellent small signal and large signal frequency response — all of which minimize high frequency gain error. Because of the low wiring capacitances inherent in monolithic construction, this fast operation can be realized without increasing power consumption.

schematic and connection diagrams

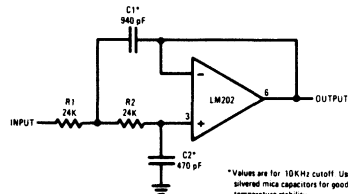


NOTE: Pin 4 connected to GND

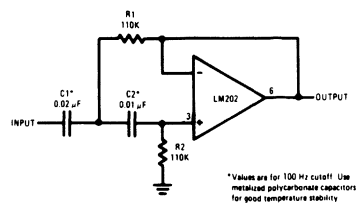
Order Number LM202H
See Package 11

typical applications

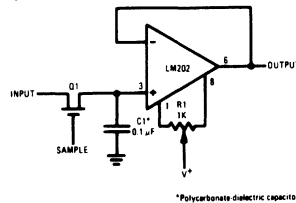
Low Pass Active Filter



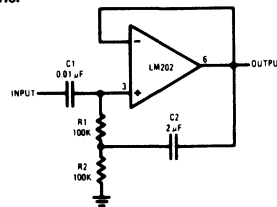
High Pass Active Filter



Sample and Hold With Offset Adjustment



High Input Impedance AC Amplifier



absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Input Voltage (Note 2)	±15V
Output Short Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	-25°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Offset Voltage			3	10	mV
Average Temperature Coefficient of Offset Voltage			15		μV/°C
Input Current			7	15	nA
Input Resistance		10 ¹⁰	10 ¹²		Ω
Voltage Gain	R _L ≥ 8 KΩ	.999	0.9995	1.000	
Output Resistance			0.8	2.5	Ω
Output Voltage Swing	R _L ≥ 8 KΩ	±10			V
Supply Current			3.5	5.5	mA
Positive Supply Rejection		60			
Negative Supply Rejection		70			
Input Capacitance			3.0		pF
Offset Voltage	-25°C ≤ T _A ≤ 85°C			15	mV
Input Current	T _A = 85°C		1.5	5.0	nA
	T _A = -25°C		30	50	nA

2

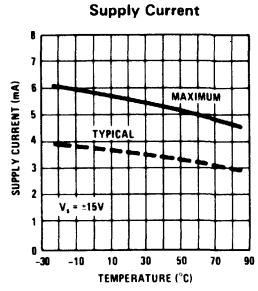
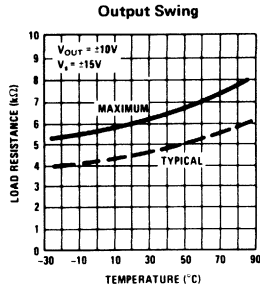
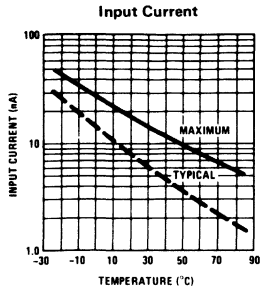
Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient (see curve).

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

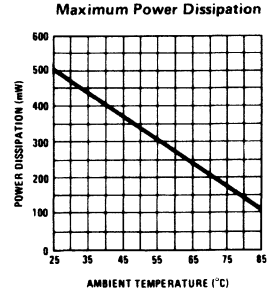
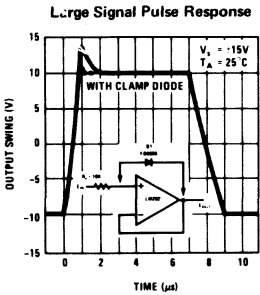
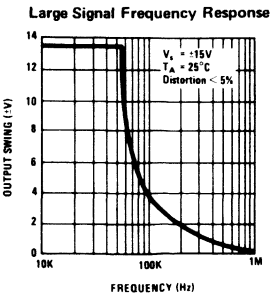
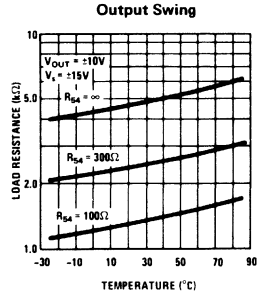
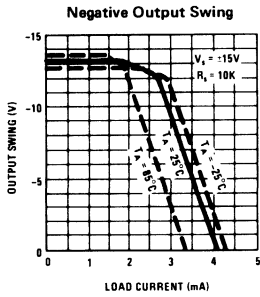
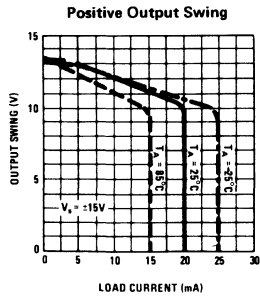
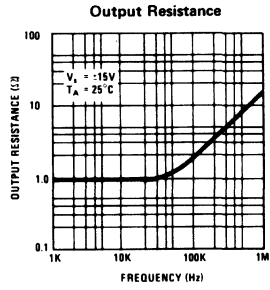
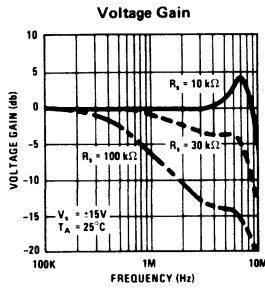
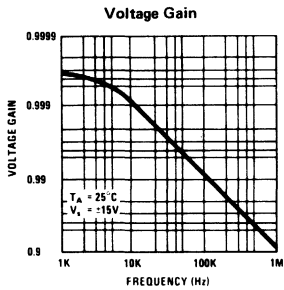
Note 3: Continuous short circuit is allowed for case temperatures to 85°C and ambient temperatures to 55°C. It is necessary to insert a resistor greater than 2 kΩ in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.

Note 4: These specifications apply for T_A = 25°C, V_S = ±15V and C_L ≤ 100 pF unless otherwise noted.

guaranteed performance characteristics



typical performance characteristics





Operational Amplifiers

LM302

LM302 voltage follower general description

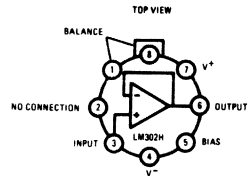
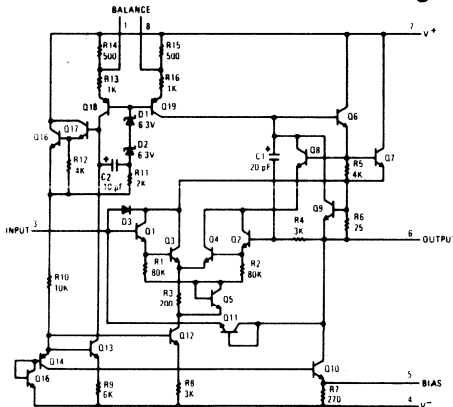
The LM302, an epoxy encapsulated version of the LM102, is a high gain operational amplifier designed specifically for unity-gain voltage follower applications. Built on a single silicon chip, the device incorporates advanced processing techniques to obtain very low input current and high input impedance. Further, the input transistors are operated at zero collector-base voltage to virtually eliminate high temperature leakage currents. It can therefore be operated in a temperature stabilized component oven to get extremely low input currents and low offset voltage drift. Other outstanding characteristics of the device include:

- Fast Slewling – 10V/μs
- Low input current – 30 nA (max)

- High input resistance – 1,000 MΩ
- No external frequency compensation required
- Simple offset balancing with optional 1K potentiometer
- Specified for operation from 0°C to 70°C
- Plug-in replacement for both the LM201 and LM709C in voltage follower applications.

The LM302, which is designed to operate with supply voltages between ±12V and ±15V, also features low input capacitance as well as excellent small signal and large signal frequency response – all of which minimize high frequency gain error. Because of the low wiring capacitances inherent in monolithic construction, this fast operation can be realized without increasing power consumption.

schematic and connection diagrams

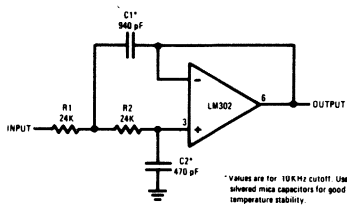


NOTE: Pin 4 connected to case

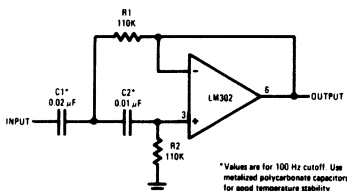
Order Number LM302H
See Package 11

typical applications

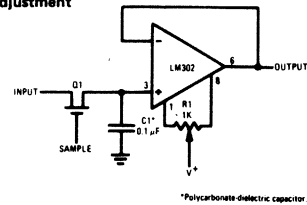
Low Pass Active Filter



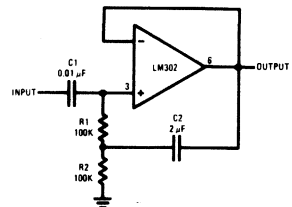
High Pass Active Filter



Sample and Hold With Offset Adjustment



High Input Impedance AC Amplifier



2

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	400 mW
Input Voltage (Note 2)	±15V
Output Short Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Offset Voltage			5	15	mV
Average Temperature Coefficient of Offset Voltage			20		$\mu\text{V}/^\circ\text{C}$
Input Current			10	30	nA
Input Resistance		10^9	10^{12}		Ω
Voltage Gain	$R_L > 8 \text{ K}\Omega$	0.9985	0.9995	1.000	
Output Resistance			0.8	2.5	Ω
Output Voltage Swing	$R_L \geq 8 \text{ K}\Omega$	±10			V
Supply Current			3.5	5.5	mA
Positive Supply Rejection		60			dB
Negative Supply Rejection		70			dB
Input Capacitance			3.0		pF
Offset Voltage	$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$			20	mV
Input Current	$T_A = 70^\circ\text{C}$ $T_A = 0^\circ\text{C}$		3.0 20	15 50	nA nA

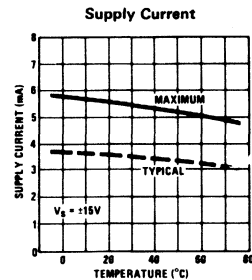
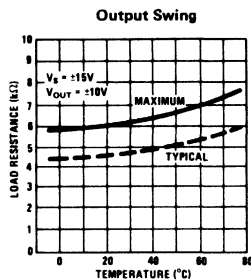
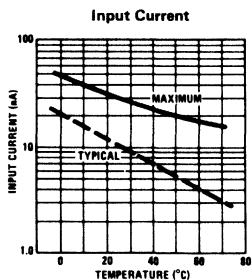
Note 1: For operating at elevated temperatures, the device must be derated based on a 85°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient (see curve).

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

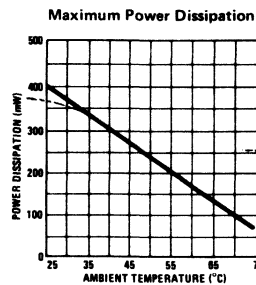
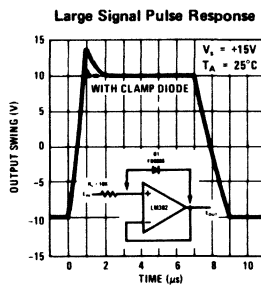
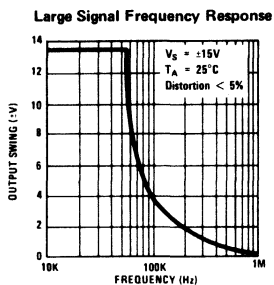
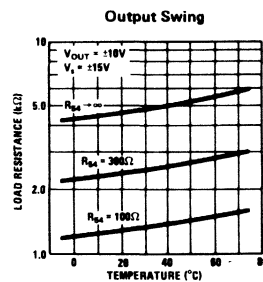
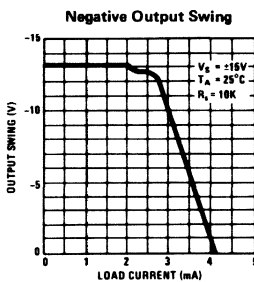
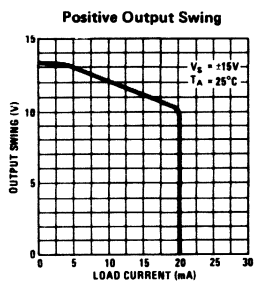
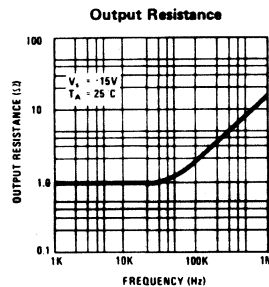
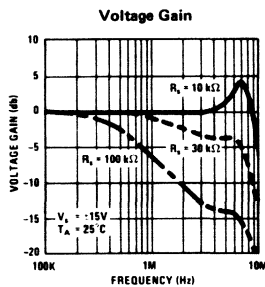
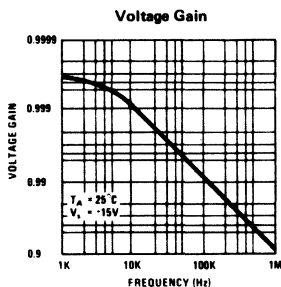
Note 3: Continuous short circuit is allowed for case temperatures to 70°C and ambient temperatures to 55°C. It is necessary to insert a resistor greater than 2 K Ω in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.

Note 4: These specifications apply for $T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ and $C_L \leq 100 \text{ pF}$ unless otherwise noted.

guaranteed performance characteristics



typical performance characteristics





Operational Amplifiers

LM107/LM207 operational amplifier

general description

The LM107 and LM207 are complete, general purpose operational amplifiers, with the necessary frequency compensation built into the chip. Advanced processing techniques make the input currents a factor of ten lower than industry standards like the 709. Yet, they are a direct, plug-in replacement for the 709, LM101, LM101A and 741. Specifications which have been improved include:

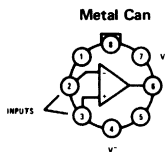
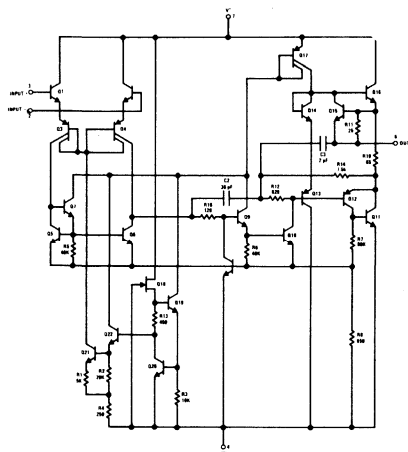
- Offset voltage 3 mV maximum over temperature
- Input current 100 nA maximum over temperature
- Offset current 20 nA maximum over temperature
- Guaranteed drift characteristics

- Offsets guaranteed over entire common mode range

The LM107 series offers the features of the LM101, which makes its application nearly fool-proof. In addition, the device provides better accuracy and lower noise in high impedance circuitry. The low input currents also make it particularly well suited for long interval integrators or timers, sample and hold circuits and low frequency waveform generators. Further, replacing circuits where matched transistor pairs buffer the inputs of conventional IC op amps, it can give lower offset voltage and drift at a lower cost.

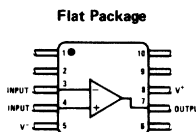
The LM207 is identical to the LM107, except that the LM207 has its performance guaranteed over a -25°C to 85°C temperature range, instead of -55°C to 125°C.

schematic** and connection diagrams



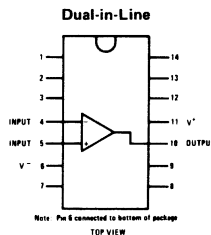
Note: Pin 4 connected to can.
TOP VIEW

Order Number
LM107H or LM207H
See Package 11



Note: Pin 5 connected to bottom of package.
TOP VIEW

Order Number
LM107F or LM207F
See Package 3

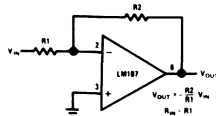


Note: Pin 6 connected to bottom of package.
TOP VIEW

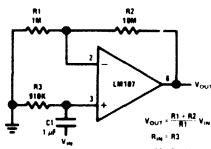
Order Number LM107D or LM207D
See Package 1

typical applications**

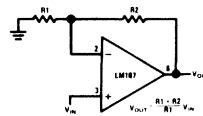
Inverting Amplifier



Non-Inverting AC Amplifier



Non-Inverting Amplifier



**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage		±22V
Power Dissipation (Note 1)		500 mW
Differential Input Voltage		±30V
Input Voltage (Note 2)		±15V
Output Short-Circuit Duration		Indefinite
Operating Temperature Range	LM107	-55°C to 125°C
	LM207	-25°C to 85°C
Storage Temperature Range		-65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 50\text{ k}\Omega$		0.7	2.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		1.5	10	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		30	75	nA
Input Resistance	$T_A = 25^\circ\text{C}$	1.5	4		M Ω
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 20\text{V}$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{\text{OUT}} = \pm 10\text{V}$, $R_L \geq 2\text{ k}\Omega$	50	160		V/mV
Input Offset Voltage	$R_S \leq 50\text{ k}\Omega$			3.0	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	15	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				20	nA
Average Temperature Coefficient of Input Offset Current	$25^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ $-55^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$		0.01 0.02	0.1 0.2	nA/ $^\circ\text{C}$ nA/ $^\circ\text{C}$
Input Bias Current				100	nA
Supply Current	$T_A = +125^\circ\text{C}$, $V_S = \pm 20\text{V}$		1.2	2.5	mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = \pm 10\text{V}$ $R_L \geq 2\text{ k}\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 20\text{V}$	±15			V
Common Mode Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	80	96		dB
Supply Voltage Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	80	96		dB

Note 1: The maximum junction temperature of the LM107 is 150°C, while that of the LM207 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

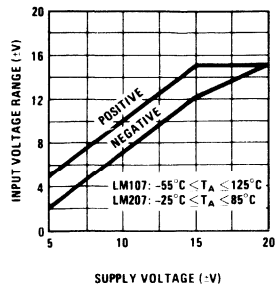
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ for the LM107 or $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ for the LM207, unless otherwise specified.

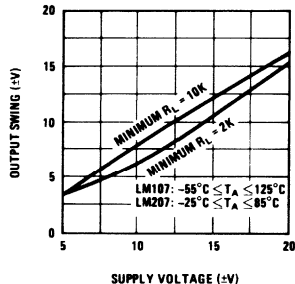
2

guaranteed performance characteristics

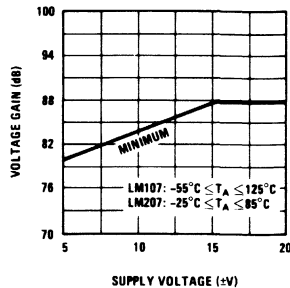
Input Voltage Range



Output Swing

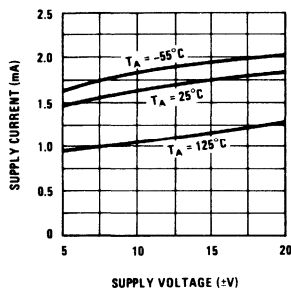


Voltage Gain

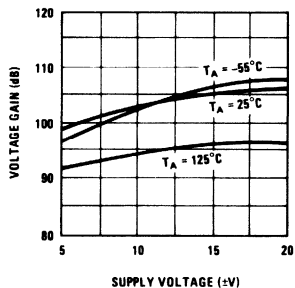


typical performance characteristics

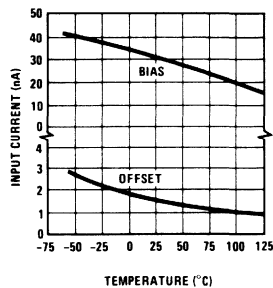
Supply Current



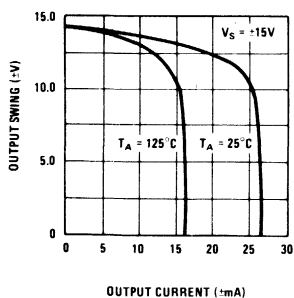
Voltage Gain



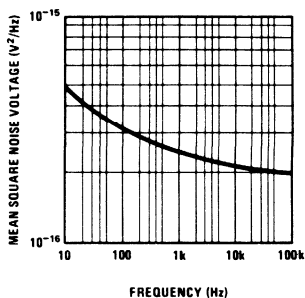
Input Current



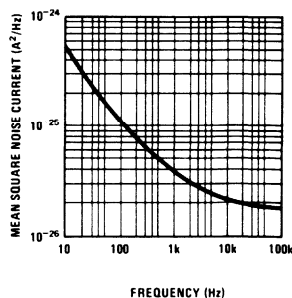
Current Limiting



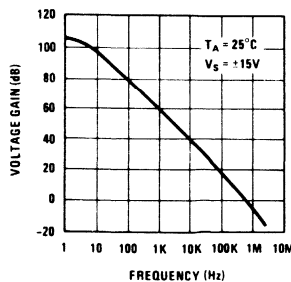
Input Noise Voltage



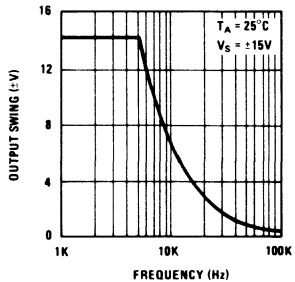
Input Noise Current



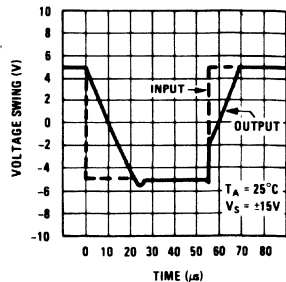
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response





Operational Amplifiers

LM307

LM307 operational amplifier general description

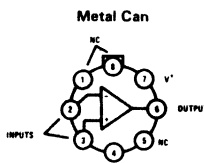
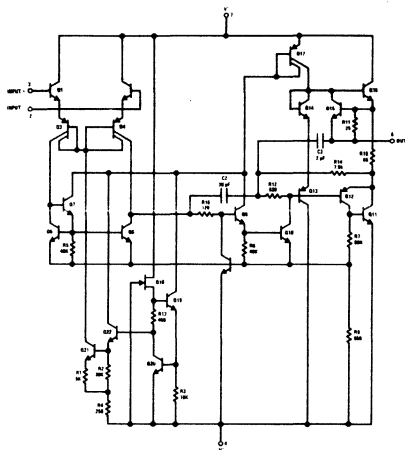
The LM307 is a complete, general purpose operational amplifier, with the necessary frequency compensation built into the chip. Advanced processing techniques make the input currents a factor of ten lower than industry standards like the 709C. Yet, it is a direct, plug-in replacement for the 709C, LM201, MC1439 and 741 in most applications.

In addition to reduced input current, the offset voltage and offset current are guaranteed over the entire common mode range and maximum drift specifications are given. The amplifier also offers many features which make its application nearly

foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

The LM307 provides better accuracy and lower noise than its predecessors in high impedance circuitry. The low input currents also make it particularly well suited for long interval integrators or timers, sample and hold circuits and low frequency waveform generators. Further, replacing circuits where matched transistor pairs buffer the inputs of conventional IC op amps, it can give lower offset voltage and drift at reduced cost.

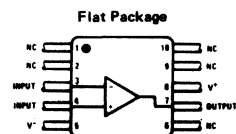
schematic** and connection diagrams



Metal Can

NOTE: Pin 4 connected to case
TOP VIEW

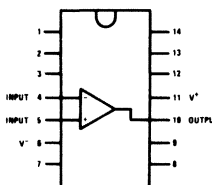
Order Number LM307H
See Package 11



NOTE: Pin 5 connected to bottom of package
TOP VIEW

Order Number LM307F
See Package 3

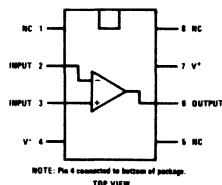
Cavity Dual-In-Line Package



NOTE: Pin 6 connected to bottom of package
TOP VIEW

Order Number LM307D
See Package 1

Molded Dual-In-Line Package

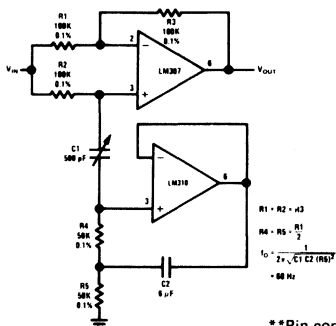


NOTE: Pin 4 connected to bottom of package
TOP VIEW

Order Number LM307N
See Package 20

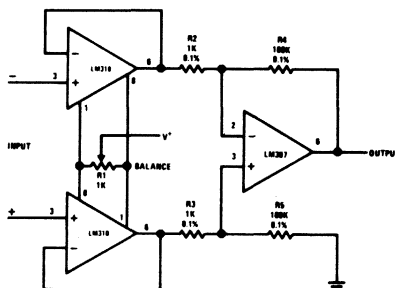
typical applications**

Tunable Notch Filter



**Pin connections shown are for metal can.

Differential Input Instrumentation Amplifier



2

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 50\text{ k}\Omega$		2.0	7.5	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		3	50	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		70	250	nA
Input Resistance	$T_A = 25^\circ\text{C}$	0.5	2		M Ω
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 2\text{ k}\Omega$	25	160		V/mV
Input Offset Voltage	$R_S \leq 50\text{ k}\Omega$			10	mV
Average Temperature Coefficient of Input Offset Voltage			6.0	30	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				70	nA
Average Temperature Coefficient of Input Offset Current	$25^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ $0^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$		0.01 0.02	0.3 0.6	nA/ $^\circ\text{C}$ nA/ $^\circ\text{C}$
Input Bias Current				300	nA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 2\text{ k}\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	± 12 ± 10	± 14 ± 13		V V
Input Voltage Range	$V_S = \pm 15\text{V}$	± 12			V
Common Mode Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	70	96		dB

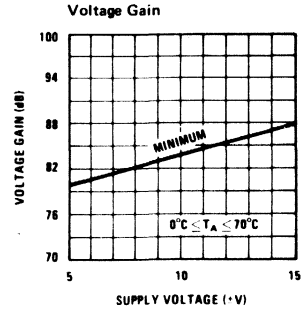
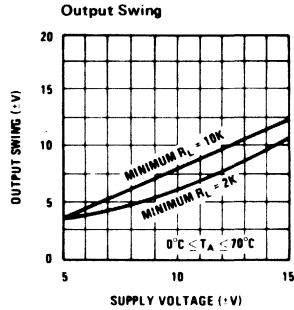
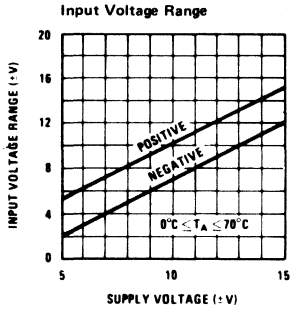
Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

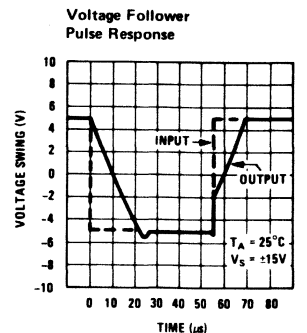
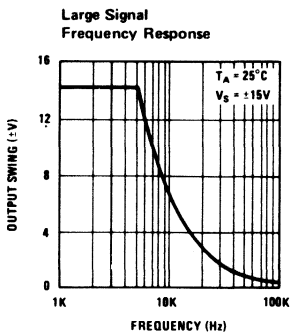
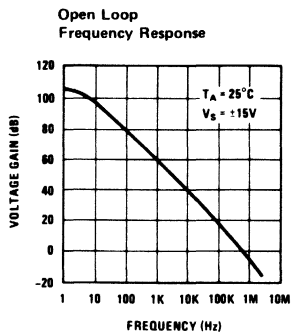
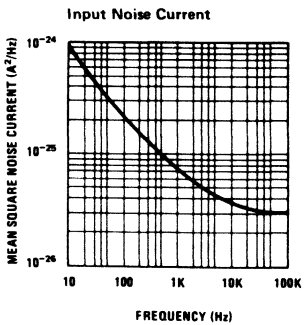
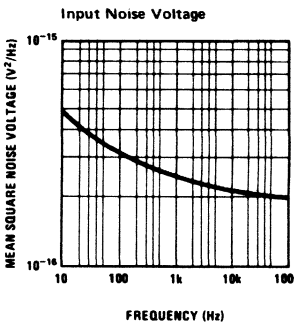
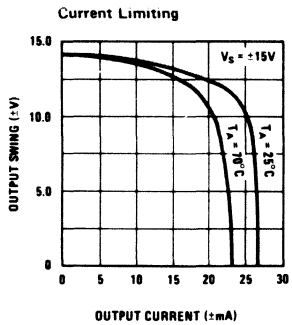
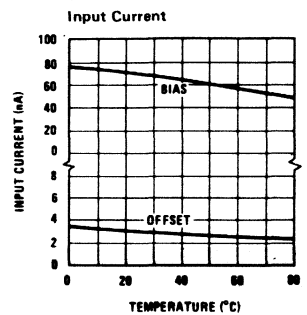
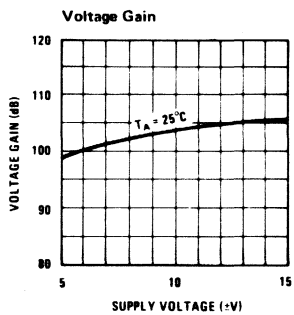
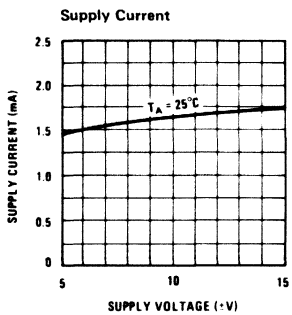
Note 3: Continuous short circuit is allowed for case temperatures to 70°C and ambient temperatures to 55°C.

Note 4: The specifications apply for $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ and $\pm 5\text{V} \leq V_S \leq \pm 15\text{V}$, unless otherwise specified.

guaranteed performance characteristics



typical performance characteristics





Operational Amplifiers

LM108/LM208 operational amplifier

general description

The LM108 and LM208 are precision operational amplifiers having specifications a factor of ten better than FET amplifiers over a -55°C to 125°C temperature range. Selected units are available with offset voltages less than 1.0 mV and drifts less than $5\ \mu\text{V}/^{\circ}\text{C}$, again over the military temperature range. This makes it possible to eliminate offset adjustments, in most cases, and obtain performance approaching chopper stabilized amplifiers.

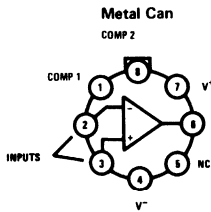
The devices operate with supply voltages from $\pm 2\text{V}$ to $\pm 20\text{V}$ and have sufficient supply rejection to use unregulated supplies. Although the circuit is interchangeable with and uses the same compensation as the LM101A, an alternate compensation scheme can be used to make it particularly insensitive to power supply noise and to make supply bypass capacitors unnecessary. Outstanding characteristics include:

- Maximum input bias current of 3.0 nA over temperature
- Offset current less than 400 pA over temperature
- Supply current of only 300 μA , even in saturation
- Guaranteed drift characteristics

The low current error of the LM108 series makes possible many designs that are not practical with conventional amplifiers. In fact, it operates from $10\ \text{M}\Omega$ source resistances, introducing less error than devices like the 709 with $10\ \text{k}\Omega$ sources. Integrators with drifts less than 500 $\mu\text{V}/\text{sec}$ and analog time delays in excess of one hour can be made using capacitors no larger than $1\ \mu\text{F}$.

The LM208 is identical to the LM108, except that the LM208 has its performance guaranteed over a -25°C to 85°C temperature range, instead of -55°C to 125°C .

connection diagrams *

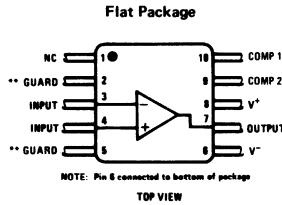


NOTE: Pin 4 connected to can.

*Pin connections shown on schematic diagram are for TO-5 package.

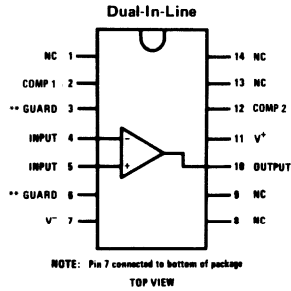
**Unused pin (no internal connection) to allow for input anti-leakage guard ring on printed circuit board layout

Order Number LM108H or LM208H
See Package 11



NOTE: Pin 6 connected to bottom of package

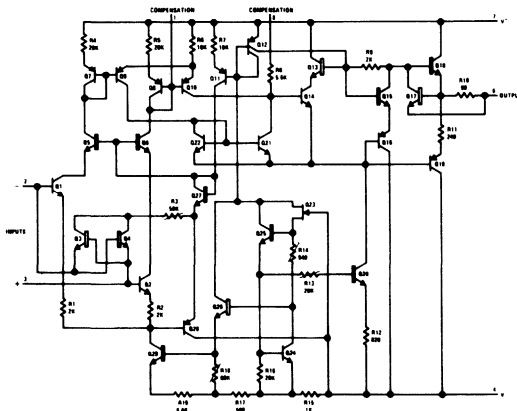
Order Number LM108F or LM208F
See Package 3



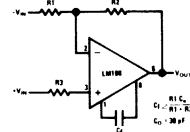
NOTE: Pin 7 connected to bottom of package

Order Number LM108D or LM208D
See Package 1

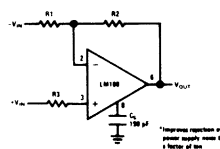
schematic diagram* and compensation circuits



Standard Compensation Circuit



Alternate* Frequency Compensation



absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	LM108 -55°C to 125°C
	LM208 -25°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Note 5)	$T_A = 25^\circ\text{C}$		0.7	2.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		0.05	0.2	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		0.8	2.0	nA
Input Resistance	$T_A = 25^\circ\text{C}$	30	70		MΩ
Supply Current	$T_A = 25^\circ\text{C}$		0.3	0.6	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 10\text{ k}\Omega$	50	300		V/mV
Input Offset Voltage (Note 5)				3.0	mV
Average Temperature Coefficient of Input Offset Voltage (Note 5)			3.0	15	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				0.4	nA
Average Temperature Coefficient of Input Offset Current			0.5	2.5	$\text{pA}/^\circ\text{C}$
Input Bias Current				3.0	nA
Supply Current	$T_A = +125^\circ\text{C}$		0.15	0.4	mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 10\text{ k}\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	±13	±14		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±13.5			V
Common Mode Rejection Ratio		85	100		dB
Supply Voltage Rejection Ratio		80	96		dB

Note 1: The maximum junction temperature of the LM108 is 150°C, while that of the LM208 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with t_{ep} , 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

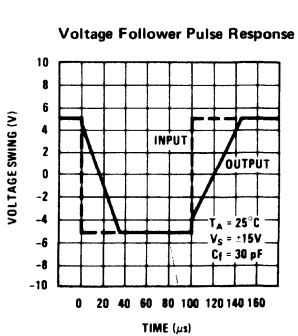
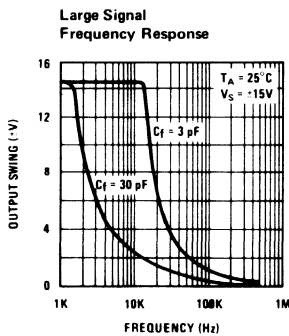
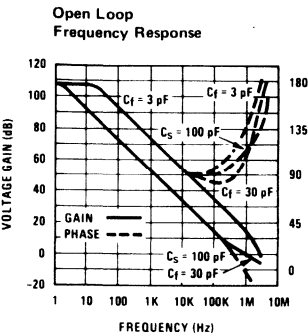
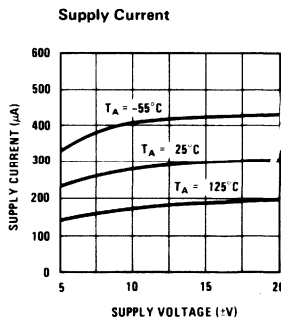
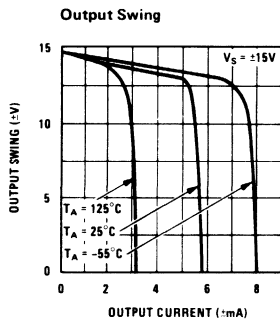
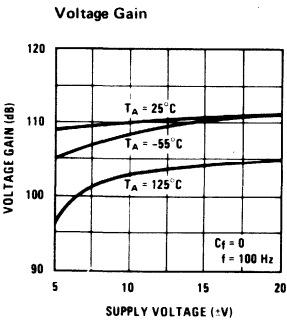
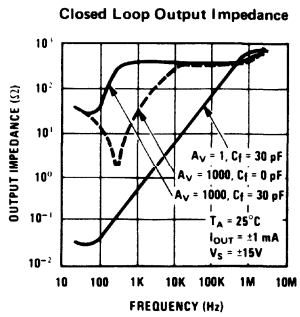
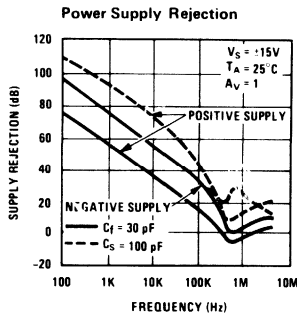
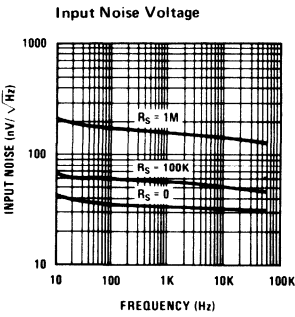
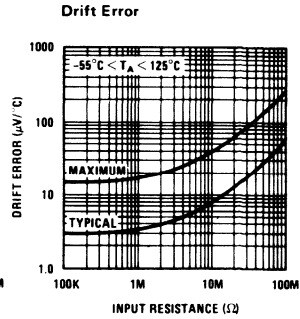
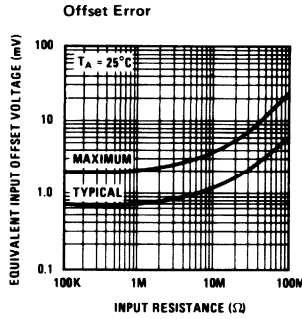
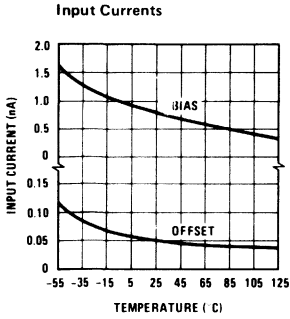
Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM208, however, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$.

Note 5: The LM108A has a guaranteed offset voltage less than 0.5 mV at 25°C and 1.0 mV for $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ and $V_S = \pm 15\text{V}$. The average temperature coefficient of input offset voltage is guaranteed to be less than 5 $\mu\text{V}/^\circ\text{C}$ for these same conditions.

typical performance characteristics





Operational Amplifiers

LM308 operational amplifier

general description

The LM308 is a precision operational amplifier featuring input currents nearly a thousand times lower than industry standards like the LM709C. In fact, its performance approaches that of high quality FET amplifiers. The circuit is directly interchangeable with the LM301A in low frequency circuits and incorporates the same protective features which make its application nearly foolproof.

The device operates with supply voltages from $\pm 2V$ to $\pm 15V$ and has sufficient supply rejection to use unregulated supplies. Although the circuit is designed to work with the standard compensation for the LM301A, an alternate compensation scheme can be used to make it particularly insensitive to power supply noise and to make supply bypass capacitors unnecessary. Power consumption is extremely low, so the amplifiers are ideally suited for battery powered applications. Out-

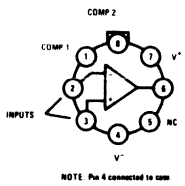
standing characteristics include:

- Maximum input bias current of 7.0 nA
- Offset current less than 1.0 nA
- Supply current of only 300 μA , even in saturation
- Guaranteed drift characteristics

The low current error of the LM308 makes possible many designs that are not practical with conventional amplifiers. In fact, it operates from 10 M Ω source resistances, introducing less error than devices like the 709C with 10 k Ω sources. Integrators with worst case drifts less than 1 mV/sec and analog time delays in excess of one hour can be made using capacitors no larger than 1 μF . The device is well suited for use with piezoelectric, electrostatic or other capacitive transducers, in addition to low frequency active filters with small capacitor values.

connection diagrams *

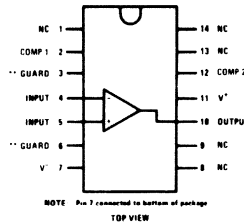
Metal Can Package



NOTE: Pin 4 connected to case

Order Number LM308H
See Package 11

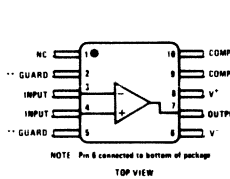
Dual-In-Line Package



NOTE: Pin 7 connected to bottom of package

Order Number LM308D
See Package 1

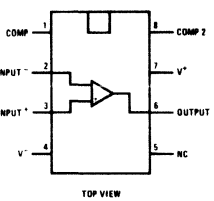
Flat Package



NOTE: Pin 8 connected to bottom of package

Order Number LM308F
See Package 3

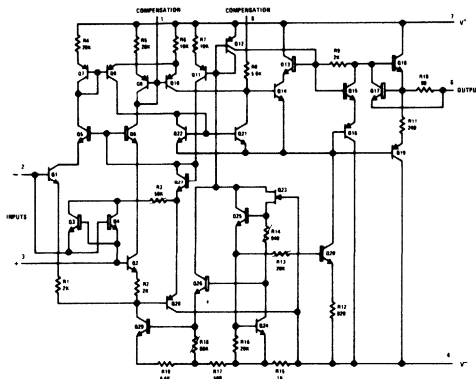
Dual-In-Line Package



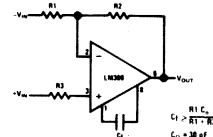
Order Number LM308N
See Package 20.

2

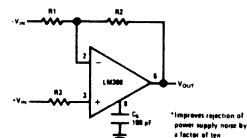
schematic diagram * and compensation circuits



Standard Compensation Circuit



Alternate* Frequency Compensation



absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$		2.0	7.5	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		0.2	1	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		1.5	7	nA
Input Resistance	$T_A = 25^\circ\text{C}$	10	40		MΩ
Supply Current	$T_A = 25^\circ\text{C}, V_S = \pm 15\text{V}$		0.3	0.8	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}, V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}, R_L \geq 10\text{ k}\Omega$	25	300		V/mV
Input Offset Voltage				10	mV
Average Temperature Coefficient of Input Offset Voltage			6.0	30	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				1.5	nA
Average Temperature Coefficient of Input Offset Current			2.0	10	$\text{pA}/^\circ\text{C}$
Input Bias Current				10	nA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}, V_{OUT} = \pm 10\text{V}$ $R_L \geq 10\text{ k}\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}, R_L = 10\text{ k}\Omega$	±13	±14		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±14			V
Common Mode Rejection Ratio		80	100		dB
Supply Voltage Rejection Ratio		80	96		dB

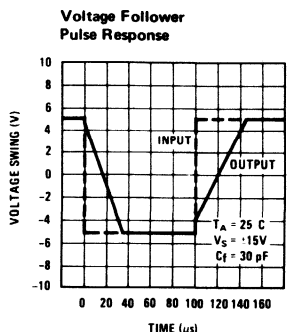
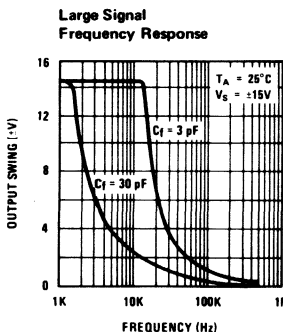
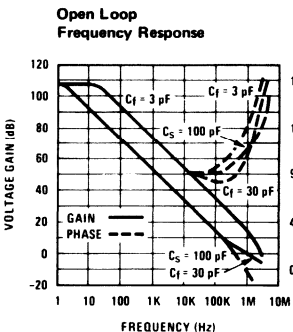
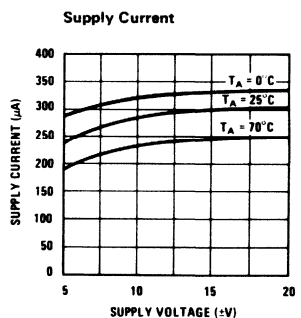
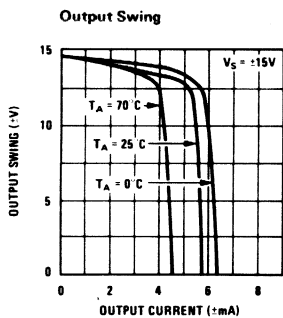
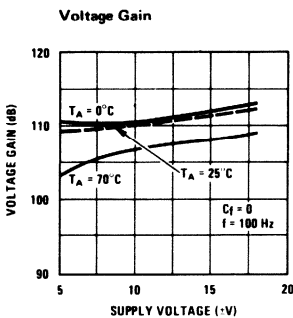
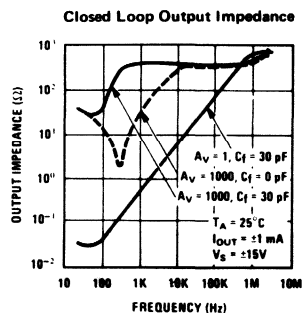
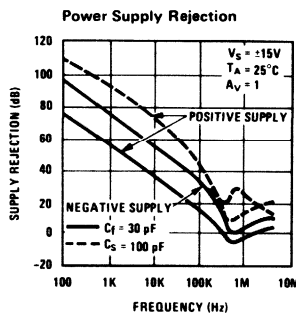
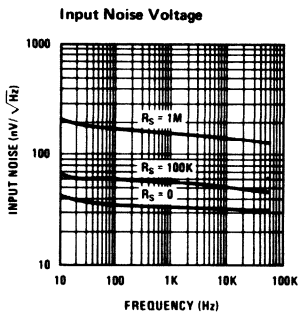
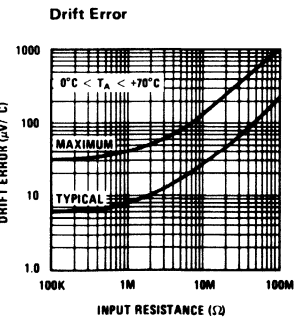
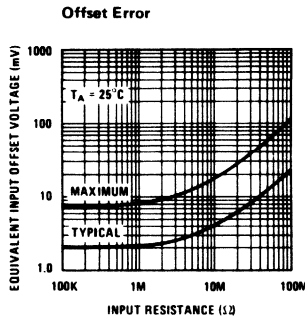
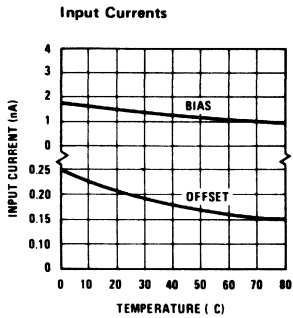
Note 1: The maximum junction temperature of the LM308 is 85°C. For operating at elevated temperatures, devices in the TQ-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 15\text{V}$ and $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified.

typical performance characteristics





Operational Amplifiers

LM108A/LM208A/LM308A operational amplifier general description

The LM108A, LM208A and LM308A are precision operational amplifiers having specifications about a factor of ten better than FET amplifiers over their operating temperature range. In addition to low input currents, these devices have extremely low offset voltage, making it possible to eliminate offset adjustments, in most cases, and obtain performance approaching chopper stabilized amplifiers.

The devices operate with supply voltages from $\pm 2V$ to $\pm 20V$ and have sufficient supply rejection to use unregulated supplies. Although the circuit is interchangeable with and uses the same compensation as the LM101A, an alternate compensation scheme can be used to make it particularly insensitive to power supply noise and to make supply bypass capacitors unnecessary. Outstanding characteristics include:

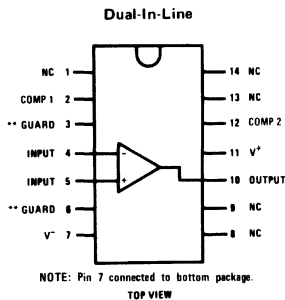
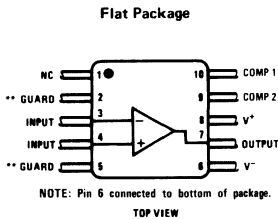
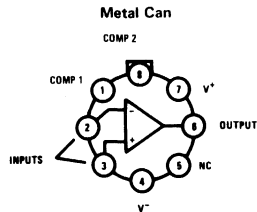
- Offset voltage guaranteed less than 0.5 mV
- Maximum input bias current of 3.0 nA over temperature

- Offset current less than 400 pA over temperature
- Supply current of only 300 μA , even in saturation
- Guaranteed 5 $\mu V/^\circ C$ drift.

The low current error of the LM108A series makes possible many designs that are not practical with conventional amplifiers. In fact, it operates from 10 M Ω source resistances, introducing less error than devices like the 709 with 10 k Ω sources. Integrators with drifts less than 500 $\mu V/sec$ and analog time delays in excess of one hour can be made using capacitors no larger than 1 μF .

The LM208A is identical to the LM108A, except that the LM208A has its performance guaranteed over a $-25^\circ C$ to $85^\circ C$ temperature range, instead of $-55^\circ C$ to $125^\circ C$. The LM308A has slightly-relaxed specifications and has its performance guaranteed over a $0^\circ C$ to $70^\circ C$ temperature range.

connection diagrams *



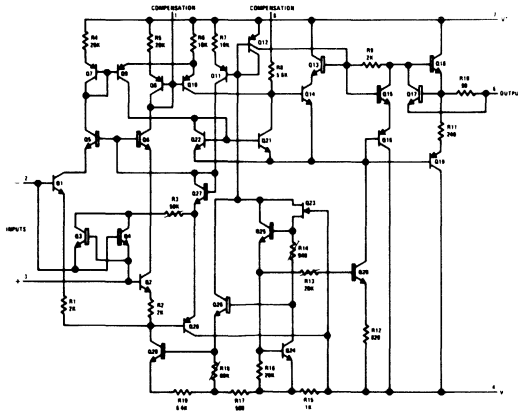
*Pin connections shown on schematic diagram are for TO 5 package
 **Unused are (no internal connection) to allow for input anti-leakage guard ring on printed circuit board layout

Order Number LM108AH or LM208AH or LM308AH
 See Package 11

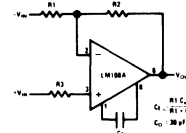
Order Number LM108AF or LM208AF or LM308AF
 See Package 3

Order Number LM108AD or LM208AD or LM308AD
 See Package 1

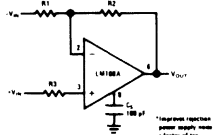
schematic diagram * and compensation circuits



Standard Compensation Circuit



Alternate* Frequency Compensation



LM108A/LM208A**absolute maximum ratings**

Supply Voltage	±20V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	LM108A -55°C to 125°C
	LM208A -25°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$		0.3	0.5	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		0.05	0.2	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		0.8	2.0	nA
Input Resistance	$T_A = 25^\circ\text{C}$	30	70		MΩ
Supply Current	$T_A = 25^\circ\text{C}$		0.3	0.6	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{\text{OUT}} = \pm 10\text{V}$, $R_L \geq 10\text{ k}\Omega$	80	300		V/mV
Input Offset Voltage				1.0	mV
Average Temperature Coefficient of Input Offset Voltage			1.0	5.0	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				0.4	nA
Average Temperature Coefficient of Input Offset Current			0.5	2.5	$\text{pA}/^\circ\text{C}$
Input Bias Current				3.0	nA
Supply Current	$T_A = +125^\circ\text{C}$		0.15	0.4	mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = \pm 10\text{V}$ $R_L \geq 10\text{ k}\Omega$	40			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	±13	±14		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±13.5			V
Common Mode Rejection Ratio		96	110		dB
Supply Voltage Rejection Ratio		96	110		dB

Note 1: The maximum junction temperature of the LM108A is 150°C, while that of the LM208A is 100°C. For operating at elevated temperatures, devices in the TQ-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM208A, however, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$.

LM308A**absolute maximum ratings**

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$		0.3	0.5	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		0.2	1	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		1.5	7	nA
Input Resistance	$T_A = 25^\circ\text{C}$	10	40		MΩ
Supply Current	$T_A = 25^\circ\text{C}, V_S = \pm 15\text{V}$		0.3	0.8	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}, V_S = \pm 15\text{V}$ $V_{\text{OUT}} = \pm 10\text{V}, R_L \geq 10\text{ k}\Omega$	80	300		V/mV
Input Offset Voltage				0.73	mV
Average Temperature Coefficient of Input Offset Voltage			1.0	5.0	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				1.5	nA
Average Temperature Coefficient of Input Offset Current			2.0	10	$\text{pA}/^\circ\text{C}$
Input Bias Current				10	nA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}, V_{\text{OUT}} = \pm 10\text{V}$ $R_L \geq 10\text{ k}\Omega$	60			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}, R_L = 10\text{ k}\Omega$	±13	±14		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±14			V
Common Mode Rejection Ratio		96	110		dB
Supply Voltage Rejection Ratio		96	110		dB

Note 1: The maximum junction temperature of the LM308A is 85°C. For operating at elevated temperatures, devices in the TQ-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 15\text{V}$ and $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified.



Operational Amplifiers

LM110/LM210

LM110/LM210 voltage follower

general description

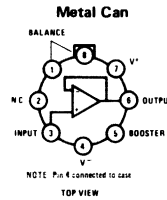
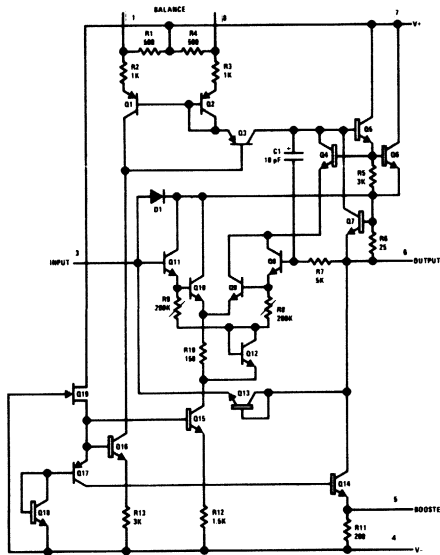
The LM110 and LM210 are monolithic operational amplifiers internally connected as unity-gain non-inverting amplifiers. They use super-gain transistors in the input stage to get low bias current without sacrificing speed. Directly interchangeable with 101, 741 and 709 in voltage follower applications, these devices have internal frequency compensation and provision for offset balancing. Outstanding characteristics include:

- Input current: 10 nA max. over temperature
- Small signal bandwidth: 20 MHz
- Slew rate: 30V/ μ s
- Supply voltage range: $\pm 5V$ to $\pm 18V$

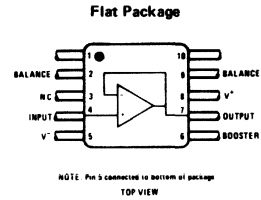
The LM110 and LM210 are useful in fast sample and hold circuits, active filters or as general-purpose buffers. Further, the frequency response is enough better than standard IC amplifiers that the followers can be included in the feedback loop without introducing instability. They are plug-in replacements for the LM102 or LM202 voltage followers, offering lower offset voltage, drift, bias current and noise in addition to higher speed and wider operating voltage range.

The LM210 is identical to the LM110, except that its performance is specified over a $-25^{\circ}C$ to $85^{\circ}C$ temperature range instead of $-55^{\circ}C$ to $125^{\circ}C$.

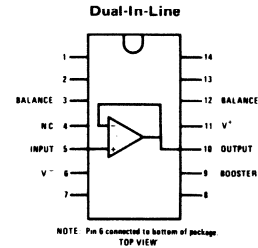
schematic** and connection diagrams



Order Number
LM110H or LM210H
See Package 11

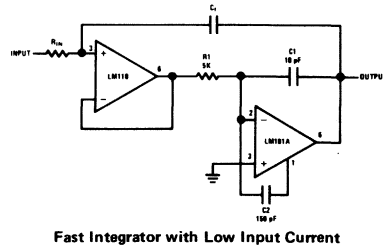
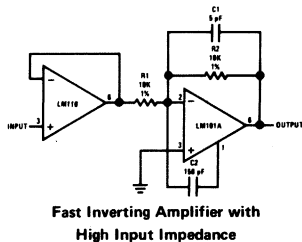


Order Number
LM110F or LM210F
See Package 3



Order Number LM110D or LM210D
See Package 1

typical applications**



**Pin connections shown are for metal can.

2

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Input Voltage (Note 2)	±15V
Output Short Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	LM110 -55°C to 125°C
	LM210 -25°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$		1.5	4.0	mV
Input Bias Current	$T_A = 25^\circ\text{C}$		1.0	3.0	nA
Input Resistance	$T_A = 25^\circ\text{C}$	10^{10}	10^{12}		Ω
Input Capacitance			1.5		pF
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{\text{OUT}} = \pm 10\text{V}$, $R_L = 8\text{K}\Omega$	0.999	0.9997		V/V
Output Resistance	$T_A = 25^\circ\text{C}$		0.75	2.5	Ω
Supply Current	$T_A = 25^\circ\text{C}$		3.9	5.5	mA
Input Offset Voltage				6.0	mV
Offset Voltage Temperature Drift	$-55^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ $T_A = 125^\circ\text{C}$		6 12		$\mu\text{V}/^\circ\text{C}$ $\mu\text{V}/^\circ\text{C}$
Input Bias Current				10	nA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = \pm 10\text{V}$ $R_L = 10\text{K}\Omega$	0.999			V/V
Output Voltage Swing (Note 5)	$V_S = \pm 15\text{V}$, $R_L = 10\text{K}\Omega$	±10			V
Supply Current	$T_A = 125^\circ\text{C}$		2.0	4.0	mA
Supply Voltage Rejection Ratio	$\pm 5\text{V} \leq V_S \leq \pm 18\text{V}$	70	80		dB

Note 1: The maximum junction temperature of the LM110 is 150°C, while that of the LM210 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

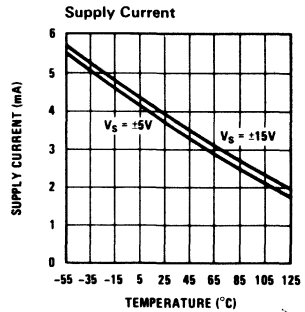
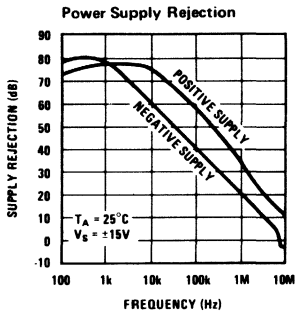
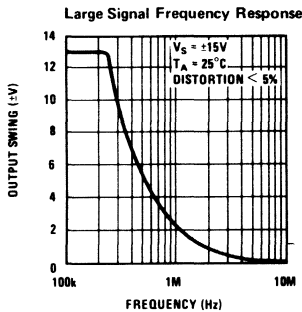
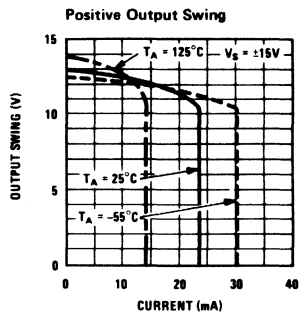
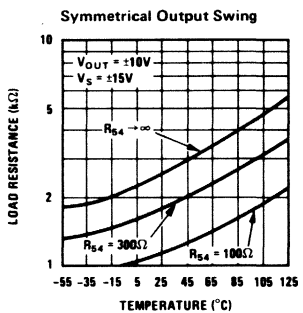
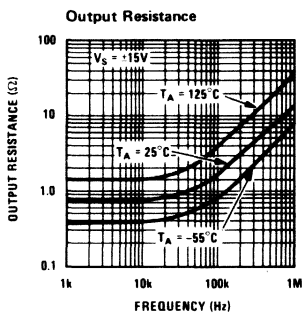
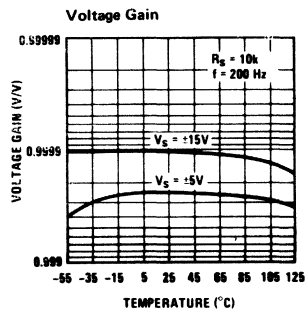
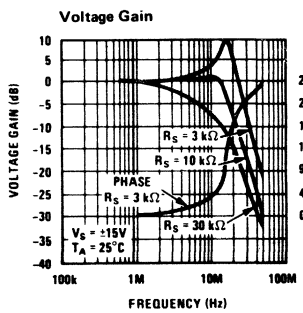
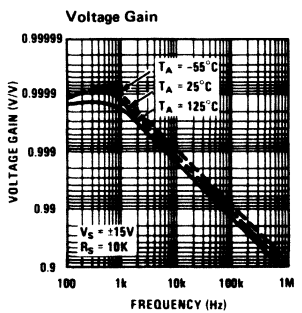
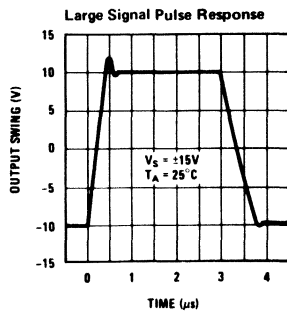
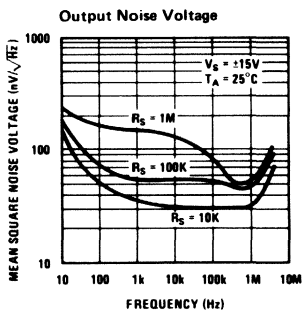
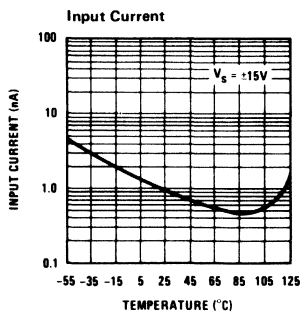
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Continuous short circuit is allowed for case temperatures to 125°C and ambient temperatures to 70°C. It is necessary to insert a resistor greater than 2k Ω in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.

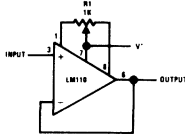
Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 18\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM210, however, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$.

Note 5: Increased output swing under load can be obtained by connecting an external resistor between the booster and V^- terminals. See curve.

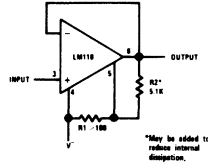
typical performance characteristics



auxiliary circuits



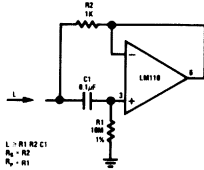
Offset Balancing Circuit



Increasing Negative Swing Under Load

*May be added to reduce internal dispersion.

typical applications** (con't)

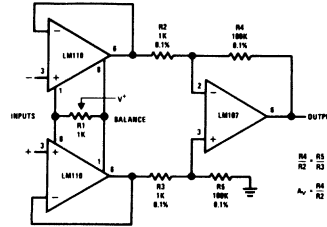


Simulated Inductor

$L = R1 R2 C1$

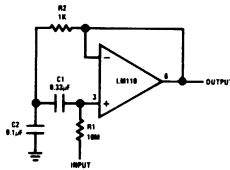
$A_v = R2$

$R_v = R1$

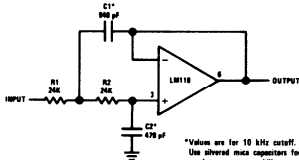


Differential Input Instrumentation Amplifier

$A_v = R4 / R2$

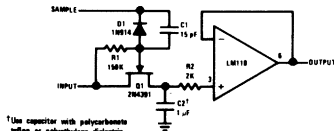


Bandpass Filter



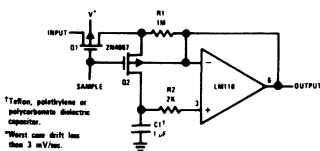
Low Pass Active Filter

*Values are for 10 kHz cutoff. Use silver mica capacitors for good temperature stability.



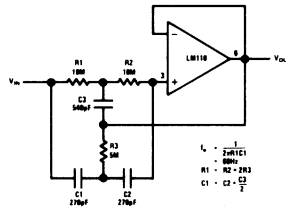
Sample and Hold

*Use capacitor with polycarbonate, nylon or polyethylene dielectric.



Low Drift Sample and Hold*

*Teflon, polystyrene or polyethylene dielectric capacitor.
*Worst case drift less than 3 mV/sec.

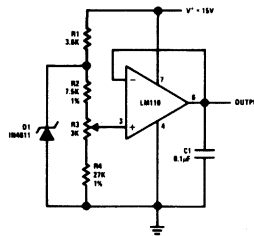


High Q Notch Filter

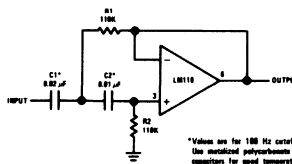
$L = \frac{1}{2\pi R1 C1}$

$R1 = R2 = 2R3$

$C1 = C2 = \frac{1}{L}$



Buffered Reference Source

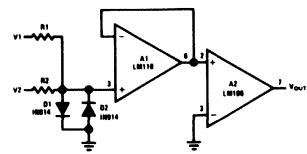


High Pass Active Filter

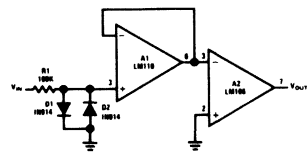
*Values are for 100 Hz cutoff. Use electrical polycarbonate capacitors for good temperature stability.

**Pin connections shown are for metal can.

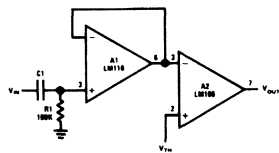
typical applications** (con't)



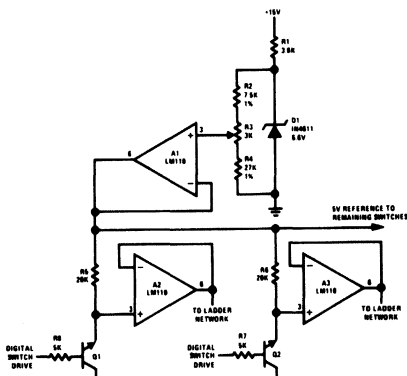
Comparator for Signals of Opposite Polarity



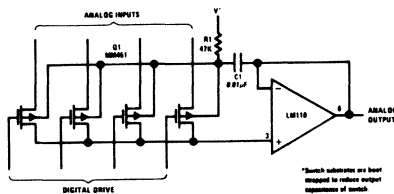
Zero Crossing Detector



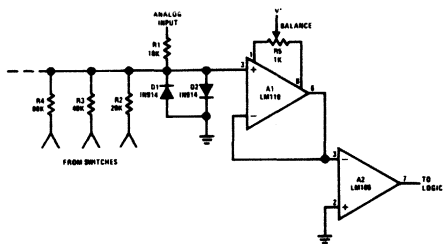
Comparator for AC Coupled Signals



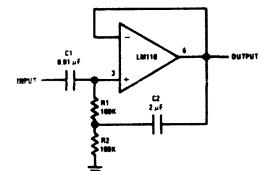
Driver for A/D Ladder Network



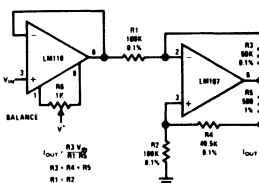
Buffer for Analog Switch*



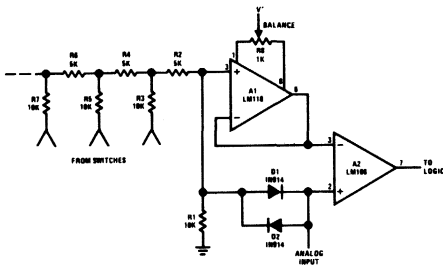
Comparator for A/D Converter Using a Binary-Weighted Network



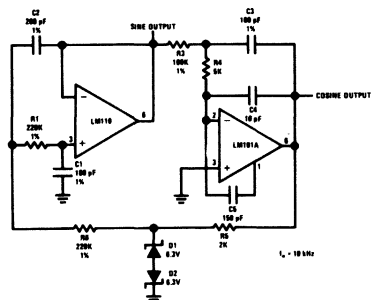
High Input Impedance AC Amplifier



Bilateral Current Source



Comparator for A/D Converter Using a Ladder Network



Sine Wave Oscillator

**Pin connections shown are for metal can.



Operational Amplifiers

LM310 voltage follower general description

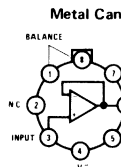
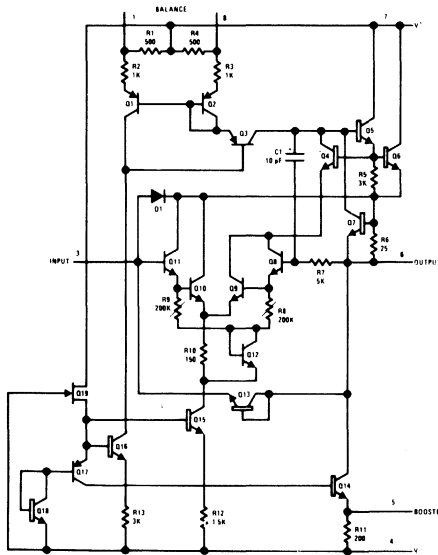
The LM310 is a monolithic operational amplifier internally connected as a unity-gain non-inverting amplifier. It uses super-gain transistors in the input stage to get low bias current without sacrificing speed. Directly interchangeable with 301, 741C and 709C in voltage follower applications, this device has internal frequency compensation and provision for offset balancing. Outstanding characteristics include:

- Input current: 10 nA max. over temperature
- Small signal bandwidth: 20 MHz

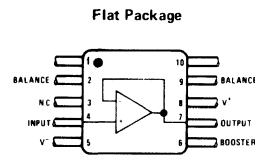
- Slew rate: 30V/μs
- Supply voltage range: ±5V to ±18V

The LM310 is useful in fast sample and hold circuits, active filters or as a general-purpose buffer. Further, the frequency response is enough better than standard IC amplifiers that the follower can be included in the feedback loop without introducing instability. It is a plug-in replacement for the LM302 voltage follower, offering lower offset voltage, drift, bias current and noise in addition to higher speed and wider operating voltage range.

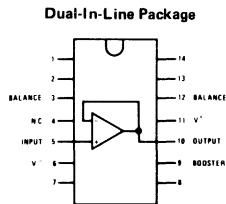
schematic** and connection diagrams



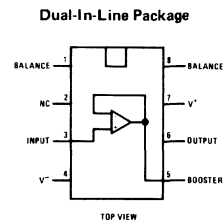
NOTE: Pin 4 connected to case
TOP VIEW
Order Number LM310H
See Package 11



NOTE: Pin 5 connected to bottom of package
TOP VIEW
Order Number LM310F
See Package 3

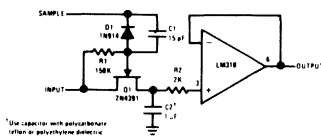


NOTE: Pin 6 connected to bottom of package
TOP VIEW
Order Number LM310D
See Package 1

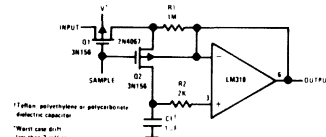


Order Number LM310N
See Package 20.

typical applications**



Sample and Hold



Low Drift Sample and Hold*

**Pin connections shown are for metal can.

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Input Voltage (Note 2)	±15V
Output Short Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$		2.5	7.5	mV
Input Bias Current	$T_A = 25^\circ\text{C}$		2.0	7.0	nA
Input Resistance	$T_A = 25^\circ\text{C}$	10^{10}	10^{12}		Ω
Input Capacitance			1.5		pF
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L = 8\text{K}\Omega$	0.999	0.9999		V/V
Output Resistance	$T_A = 25^\circ\text{C}$		0.75	2.5	Ω
Supply Current	$T_A = 25^\circ\text{C}$		3.9	5.5	mA
Input Offset Voltage				10	mV
Offset Voltage Temperature Drift			10		$\mu\text{V}/^\circ\text{C}$
Input Bias Current				10	nA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L = 10\text{K}\Omega$	0.999			V/V
Output Voltage Swing (Note 5)	$V_S = \pm 15\text{V}$, $R_L = 10\text{K}\Omega$	±10			V
Supply Voltage Rejection Ratio	$\pm 5\text{V} \leq V_S \leq \pm 18\text{V}$	70	80		dB

Note 1: The maximum junction temperature of the LM310 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

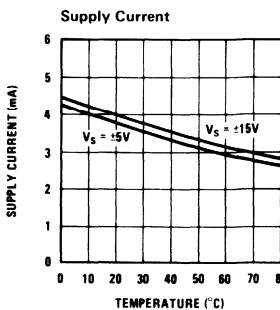
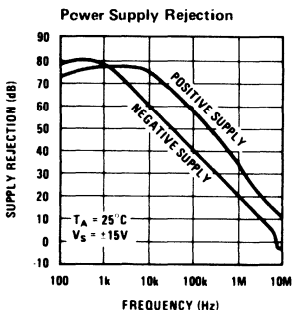
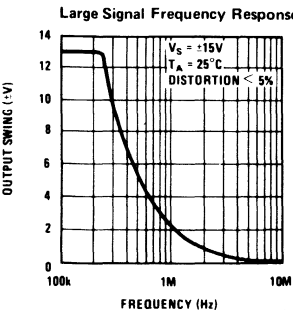
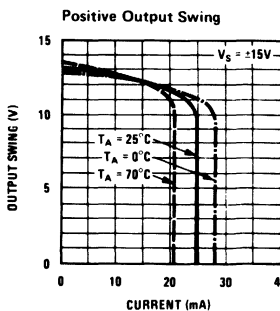
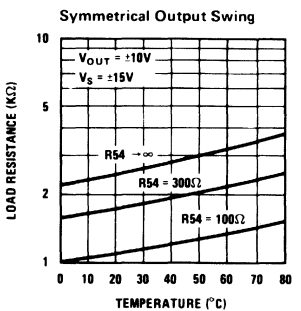
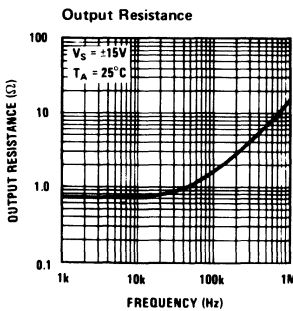
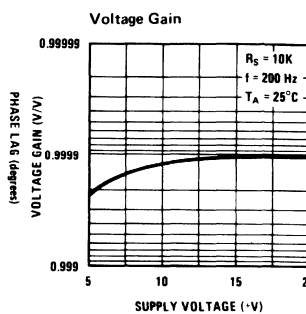
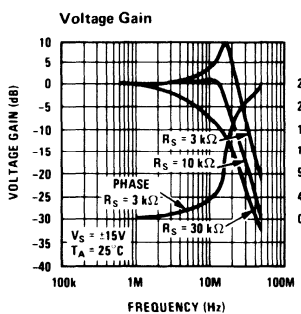
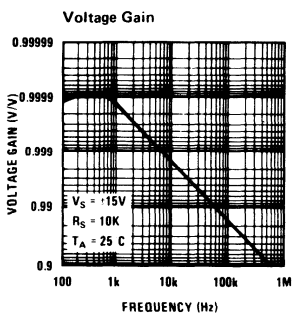
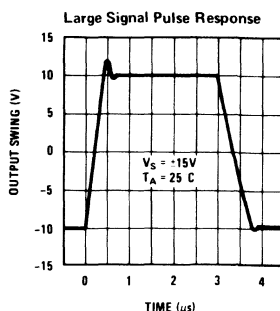
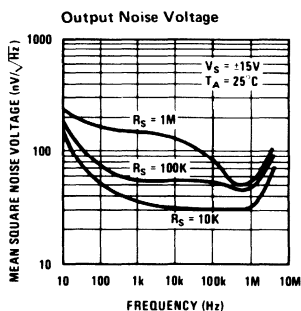
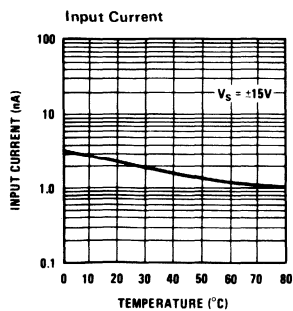
Note 3: Continuous short circuit is allowed for case temperatures to 70°C and ambient temperatures to 55°C. It is necessary to insert a resistor greater than 2 k Ω in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 18\text{V}$ and $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified.

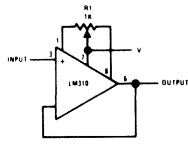
Note 5: Increased output swing under load can be obtained by connecting an external resistor between the booster and V⁻ terminals. See curve.

2

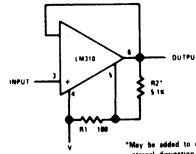
typical performance characteristics



auxiliary circuits **



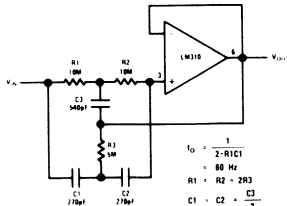
Offset Balancing Circuit



Increasing Negative Swing Under Load

*May be added to reduce internal dissipation.

typical applications** (con't)



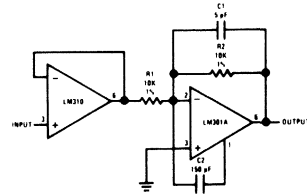
High Q Notch Filter

$$f_0 = \frac{1}{2\sqrt{R1C1}}$$

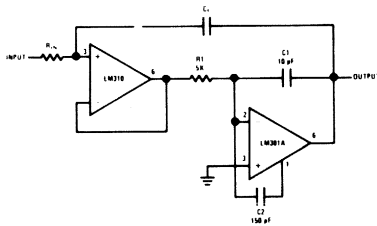
$$= 88 \text{ Hz}$$

$$R1 = R2 = 2R3$$

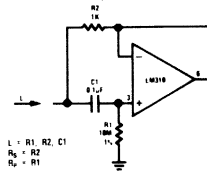
$$C1 = C2 = \frac{C3}{2}$$



Fast Inverting Amplifier with High Input Impedance



Fast Integrator with Low Input Current

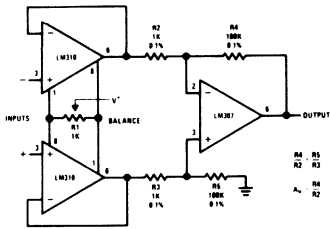


Simulated Inductor

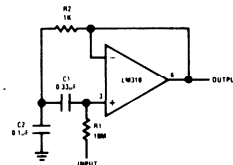
$$L = R1 R2 C1$$

$$R3 = R2$$

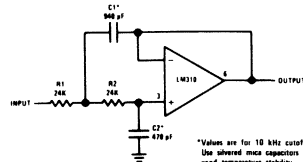
$$R3 = R1$$



Differential Input Instrumentation Amplifier

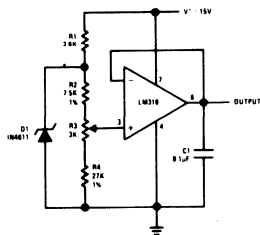


Bandpass Filter

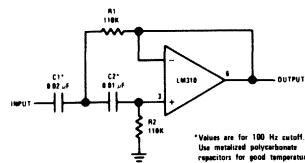


Low Pass Active Filter

*Values are for 10 kHz cutoff. Use silver mica capacitors for good temperature stability.



Buffered Reference Source

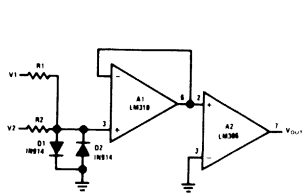


High Pass Active Filter

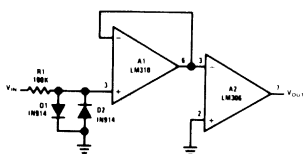
*Values are for 100 Hz cutoff. Use metallized polycarbonate capacitors for good temperature stability.

**Pin connections shown are for metal can.

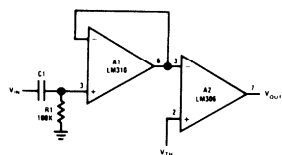
typical applications** (con't)



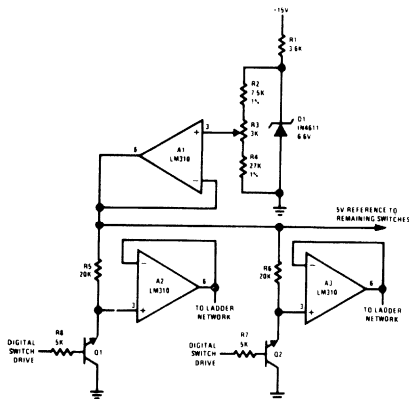
Comparator for Signals of Opposite Polarity



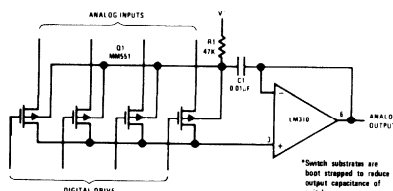
Zero Crossing Detector



Comparator for AC Coupled Signals

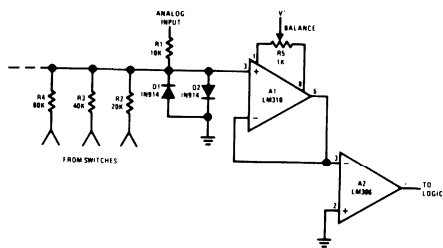


Driver for A/D Ladder Network

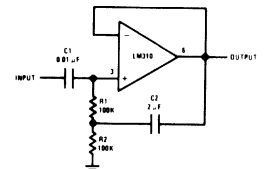


Buffer for Analog Switch*

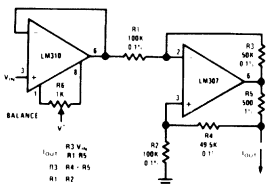
*Switch substrates are boot strapped to reduce output capacitance of switch



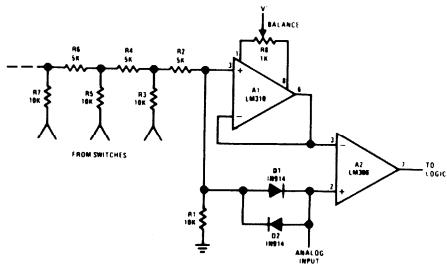
Comparator for A/D Converter Using a Binary-Weighted Network



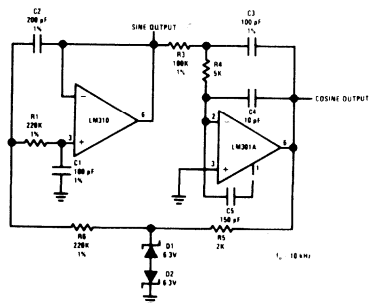
High Input Impedance AC Amplifier



Bilateral Current Source



Comparator for A/D Converter Using a Ladder Network



Sine Wave Oscillator

**Pin connections shown are for metal can.



Operational Amplifiers

LM112/LM212 operational amplifier

general description

The LM112 and LM212 are micropower operational amplifiers with very low offset-voltage and input-current errors—at least a factor of ten better than FET amplifiers over a -55°C to 125°C temperature range. Similar to the LM108 series, that also use supergain transistors,* they differ in that they include internal frequency compensation and have provisions for offset adjustment with a single potentiometer.

These amplifiers will operate on supply voltages of $\pm 2\text{V}$ to $\pm 20\text{V}$, drawing a quiescent current of only $300\ \mu\text{A}$. Performance is not appreciably affected over this range of voltages, so operation from unregulated power sources is easily accomplished. They can also be run from a single supply like the 5V used for digital circuits. Some noteworthy features are:

- Maximum input bias current of $3.0\ \text{nA}$ over temperature

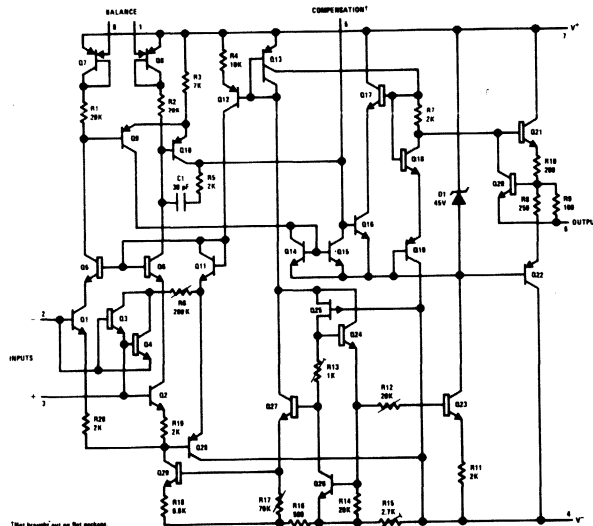
- Offset current less than $400\ \text{pA}$ over temperature
- Low noise
- Guaranteed drift specifications

The LM112 series are the first IC amplifiers to improve reliability by including overvoltage protection for the MOS compensation capacitor. Without this feature, IC's have been known to suffer catastrophic failure caused by short-duration overvoltage spikes on the supplies. Unlike other internally-compensated IC amplifiers, it is possible to overcompensate with an external capacitor to increase stability margin.

The LM212 is identical to the LM112, except that the LM212 has its performance guaranteed over a -25°C to 85°C temperature range instead of -55°C to 125°C .

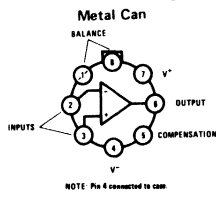
*Patent pending

schematic diagram**

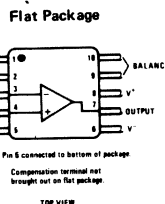


**Pin brought out on flat package.
**Pin connections shown are for metal can.

connection diagrams



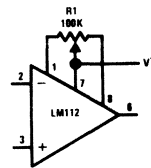
Order Number LM112H or LM212H
See Package 11



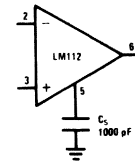
Order Number LM112F or LM212F
See Package 3

auxiliary circuits**

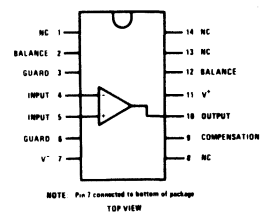
Offset Balancing



Overcompensation for Greater Stability Margin



Dual-In-Line



Order Number LM112D or LM212D
See Package 1

2

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	LM112 -55°C to 125°C
	LM212 -25°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$		0.7	2.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		0.05	0.2	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		0.8	2.0	nA
Input Resistance	$T_A = 25^\circ\text{C}$	30	70		MΩ
Supply Current	$T_A = 25^\circ\text{C}$		0.3	0.6	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{\text{OUT}} = \pm 10\text{V}$, $R_L \geq 10\text{ k}\Omega$	50	300		V/mV
Input Offset Voltage				3.0	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	15	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				0.4	nA
Average Temperature Coefficient of Input Offset Current			0.5	2.5	$\text{pA}/^\circ\text{C}$
Input Bias Current				3.0	nA
Supply Current	$T_A = +125^\circ\text{C}$		0.15	0.4	mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = \pm 10\text{V}$ $R_L \geq 10\text{ k}\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	±13	±14		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±13.5			V
Common Mode Rejection Ratio		85	100		dB
Supply Voltage Rejection Ratio		80	96		dB

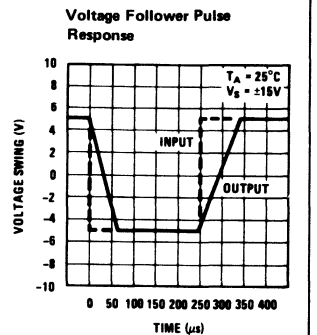
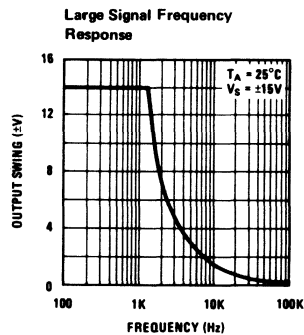
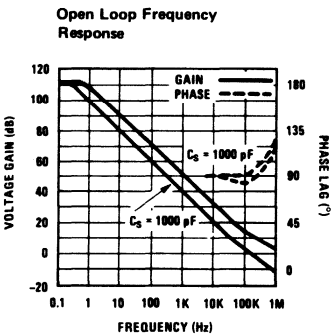
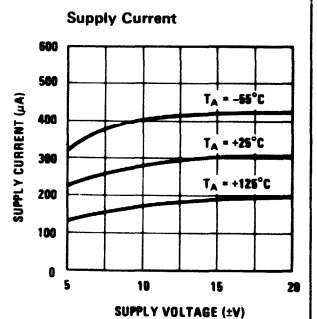
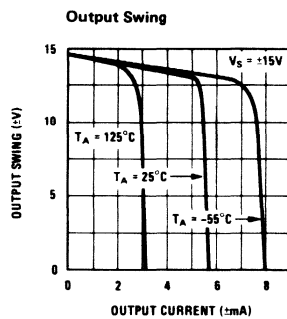
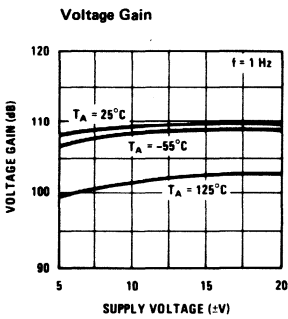
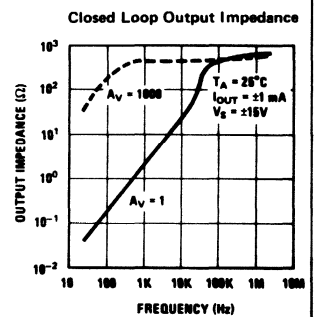
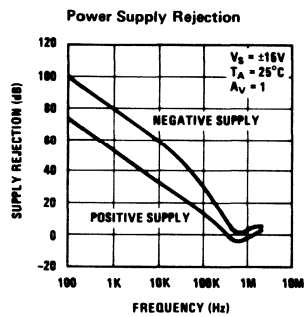
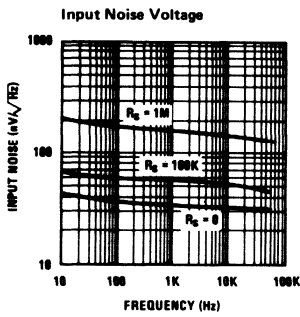
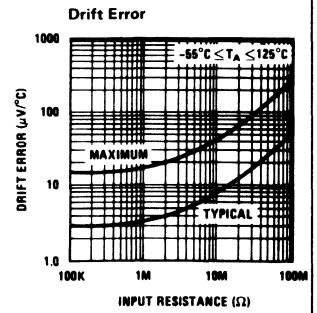
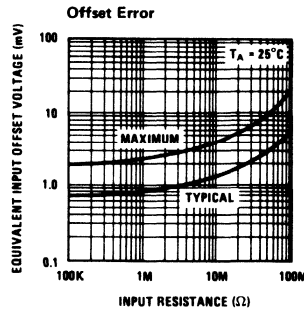
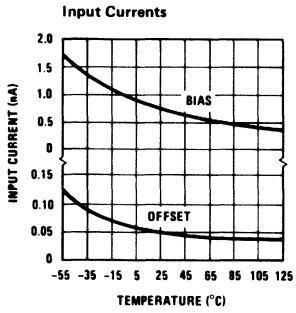
Note 1: The maximum junction temperature of the LM112 is 150°C, while that of the LM212 is 100°C. For operating at elevated temperatures, devices in the TQ-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with shunt diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM212, however, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$.

typical performance characteristics





Operational Amplifiers

LM312 operational amplifier general description

The LM312 is a micropower operational amplifier with very low offset voltage and input-current errors—approaching that of FET amplifiers over its operating temperature range. Similar to the LM308 series, that also uses supergain transistors†, it differs in that it includes internal frequency compensation and has provisions for offset adjustment with a single potentiometer.

This amplifier will operate on supply voltages of $\pm 2V$ to $\pm 20V$, drawing a quiescent current of only $300 \mu A$. Performance is not appreciably affected over this range of voltages, so operation from unregulated power sources is easily accomplished. It can also be run from a single supply like the 5V used for digital circuits. Some noteworthy features are:

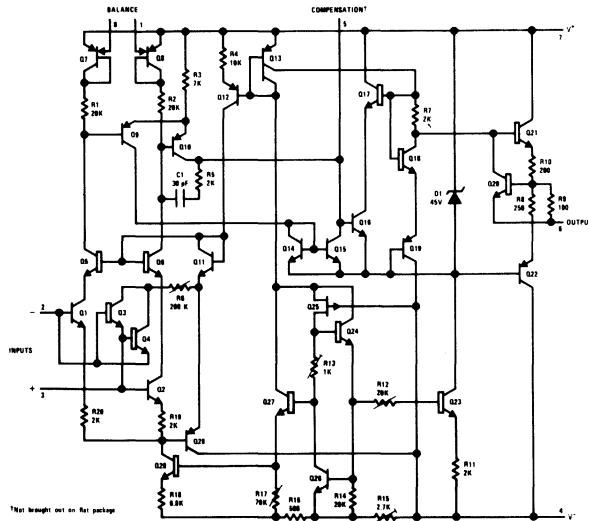
- Maximum input bias current of 7.0 nA
- Offset current less than 1.0 nA
- Low noise
- Guaranteed drift specifications

The LM312 series is the first IC amplifier to improve reliability by including overvoltage protection for the MOS compensation capacitor. Without this feature, IC's have been known to be sensitive to catastrophic failure caused by short-duration overvoltage spikes on the supplies. Unlike other internally-compensated IC amplifiers, it is possible to overcompensate with an external capacitor to increase stability margin.

The low current error of the LM312 makes possible many designs that are not practical with conventional amplifiers. In fact, it operates from $10 M\Omega$ source resistances, introducing less error than devices like the 709C with $10 k\Omega$ sources. Integrators with worst case drifts less than 1 mV/sec and analog time delays in excess of one hour can be made using capacitors no larger than $1 \mu F$. The device is well suited for use with piezo-electric, electrostatic or other capacitive transducers, in addition to low frequency active filters with small capacitor values.

†Patent pending

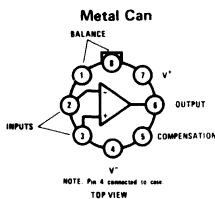
schematic diagram**



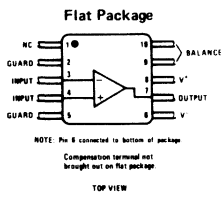
*Not brought out on flat package

**Pin connections shown are for metal can.

connection diagrams



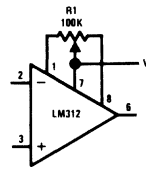
Order Number LM312H
See Package 11



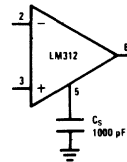
Order Number LM312F
See Package 3

auxiliary circuits**

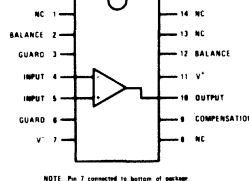
Offset Balancing



Overcompensation for Greater Stability Margin



Dual-In-Line



NOTE: Pin 7 connected to bottom of package

Order Number LM312D
See Package 1

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$		2.0	7.5	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		0.2	1	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		1.5	7	nA
Input Resistance	$T_A = 25^\circ\text{C}$	10	40		MΩ
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		0.3	0.8	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 10\text{ k}\Omega$	25	300		V/mV
Input Offset Voltage				10	mV
Average Temperature Coefficient of Input Offset Voltage			6.0	30	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				1.5	nA
Average Temperature Coefficient of Input Offset Current			2.0	10	$\text{pA}/^\circ\text{C}$
Input Bias Current				10	nA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 10\text{ k}\Omega$	15			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	±13	±14		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±14			V
Common Mode Rejection Ratio		80	100		dB
Supply Voltage Rejection Ratio		80	96		dB

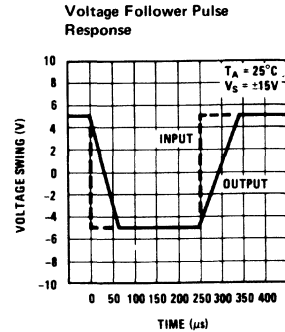
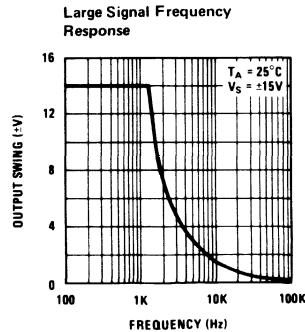
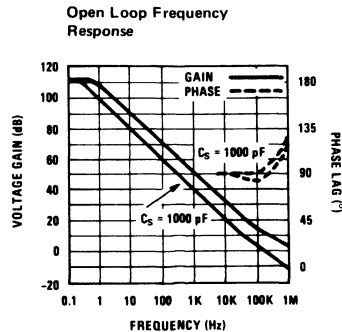
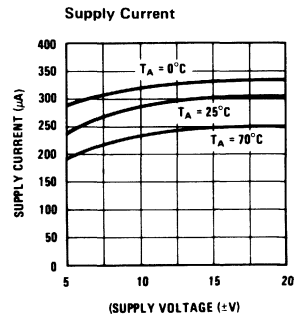
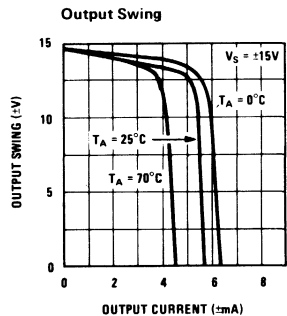
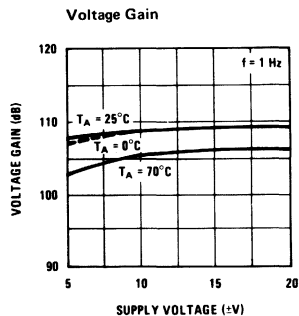
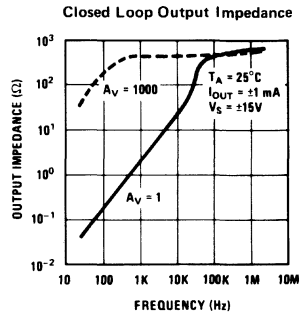
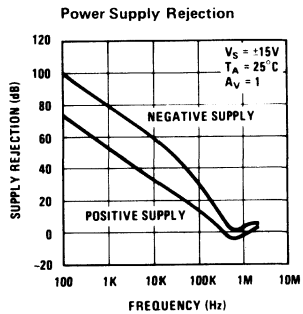
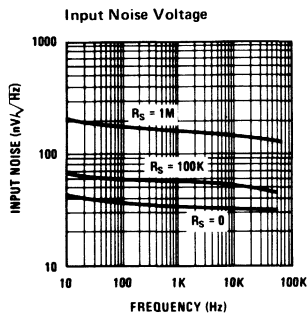
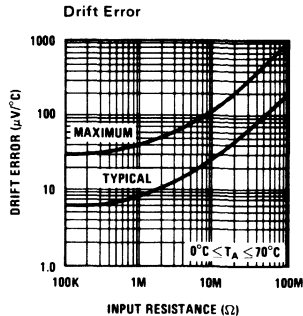
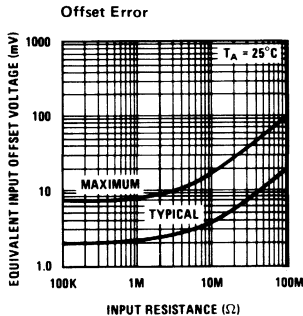
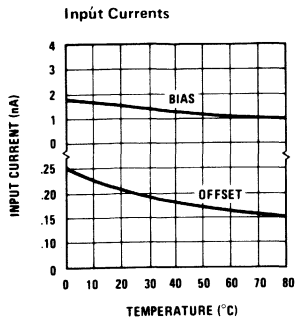
Note 1: The maximum junction temperature of the LM312 is 85°C. For operating at elevated temperatures, devices in the TQ-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.031-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with shunt diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 15\text{V}$ and $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified.

typical performance characteristics





Operational Amplifiers

LM216/LM216A/LM316/LM316A operational amplifier

general description

These devices are precision, high input impedance operational amplifiers designed for applications requiring extremely low input-current errors. They use supergain transistors in a Darlington input stage to get input bias currents that are equal to high-quality FET amplifiers—even in limited temperature range operation. The low input current is, however, obtained with some sacrifice to offset voltage, offset voltage drift and noise when compared to the non-Darlington LM112 series. Noteworthy specifications include:

- Guaranteed bias currents as low as 50 pA
- Maximum offset currents down to 15 pA
- Operates from supplies of $\pm 3V$ to $\pm 20V$
- Supply current only 300 μA at $\pm 20V$

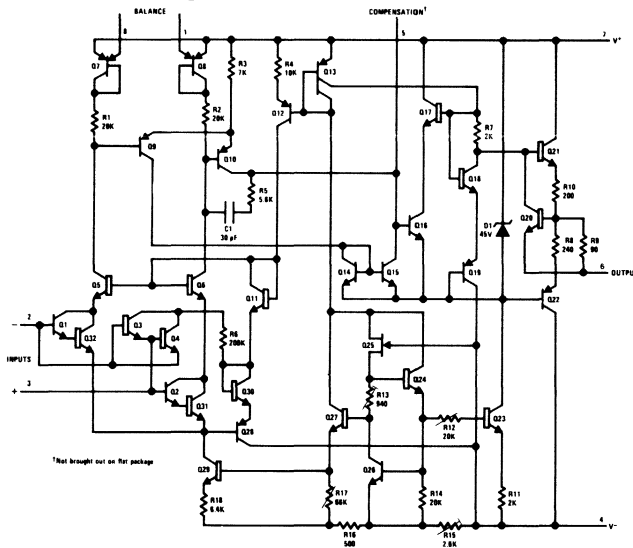
These operational amplifiers are internally frequency compensated and have provisions for offset balancing with a single external potentiometer.

Further, unlike most other internally compensated amplifiers, the MOS compensation capacitor is protected to prevent catastrophic failure from overvoltage spikes on the supplies.

The low current error of these amplifiers make possible many designs that were previously impractical with monolithic amplifiers. They will operate from 100 M Ω source resistances, introducing less error than general purpose amplifiers with 10 k Ω sources. Integrators with worst case drifts less than 10 $\mu V/sec$ and analog time delays in excess of one day can also be made using capacitors no larger than 1 μF .

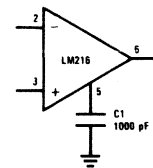
The LM216A and LM316A are high performance versions of the LM216 and LM316. The LM216 and LM216A are specified for operation from $-25^{\circ}C$ to $85^{\circ}C$, while the LM316 and LM316A are specified from $0^{\circ}C$ to $55^{\circ}C$.

schematic diagram

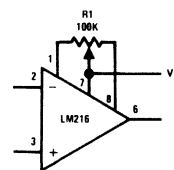


auxiliary circuits**

Overcompensation for Greater Stability Margin

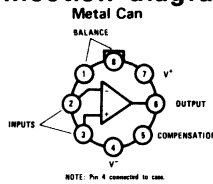


Offset Balancing

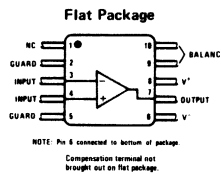


**Pin connections shown are for metal can.

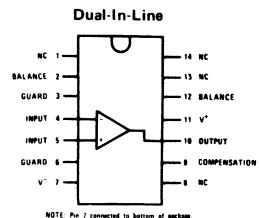
connection diagrams



Order Number LM216H or LM216AH or LM316H or LM316AH
See Package 11



Order Number LM216F or LM216AF or LM316F or LM316AF
See Package 3



Order Number LM216D or LM216AD or LM316D or LM316AD
See Package 1



absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	LM216/LM216A -25°C to 85°C LM316/LM316A 0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	LM216	LM216A	LM316	LM316A	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$	10	3	10	3	mV
Input Offset Current	$T_A = 25^\circ\text{C}$	50	15	50	15	pA
Input Bias Current	$T_A = 25^\circ\text{C}$	150	50	150	50	pA
Input Resistance	$T_A = 25^\circ\text{C}$	1	5	1	5	GΩ
Supply Current	$T_A = 25^\circ\text{C}$	0.8	0.6	0.8	0.6	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 10\text{ k}\Omega$	20	40	20	40	V/mV
Input Offset Voltage		15	6	15	6	mV
Input Offset Current		100	30	100	30	pA
Input Bias Current		250	100	250	100	pA
Supply Current	$T_A = T_{MAX}$		0.5		0.5	mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 10\text{ k}\Omega$	10	20	15	30	V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	±13	±13	±13	±13	V
Input Voltage Range	$V_S = \pm 15\text{V}$	±13	±13	±13	±13	V
Common Mode Rejection Ratio		80	80	80	80	dB
Supply Voltage Rejection Ratio		80	80	80	80	dB

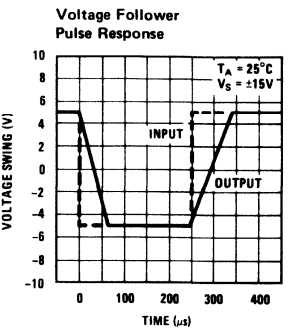
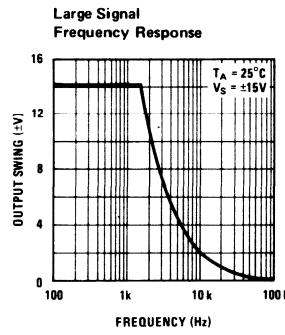
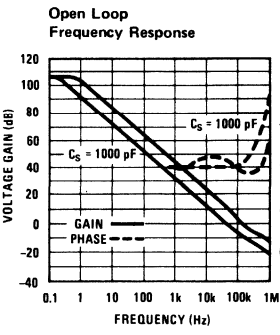
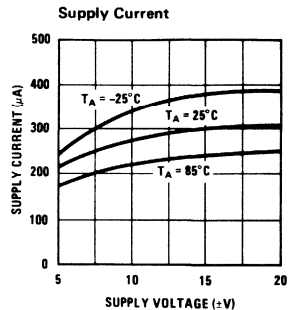
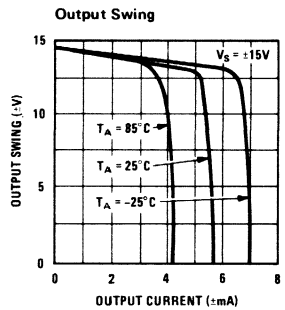
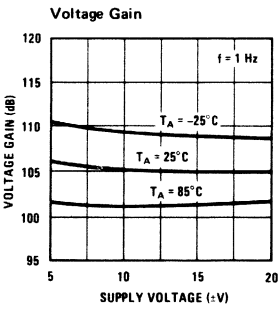
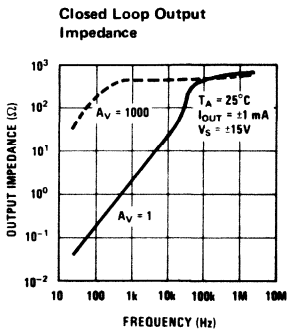
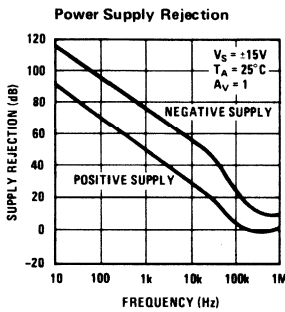
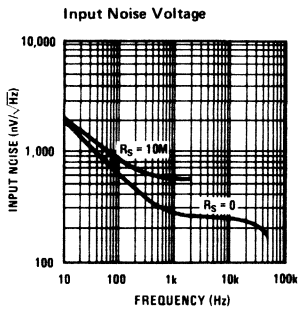
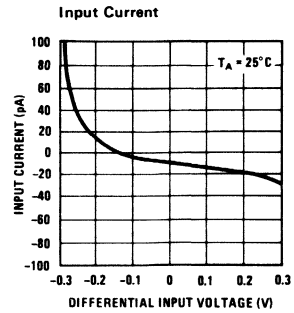
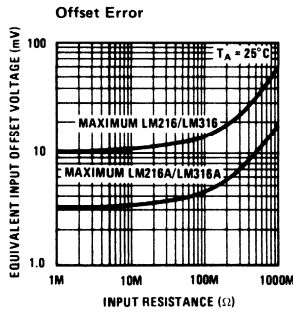
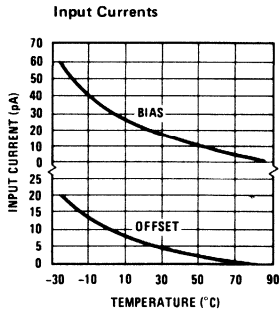
Note 1: The maximum junction temperature of the LM216 and LM216A is 100°C, while that of the LM316 and LM316A is 70°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm 5\text{V} < V_S < \pm 20\text{V}$ and $-25^\circ\text{C} < T_A < 85^\circ\text{C}$, unless otherwise specified. With the LM316 and LM316A however, all temperature specifications are limited to $0^\circ\text{C} < T_A < 55^\circ\text{C}$.

typical performance characteristics





Operational Amplifiers

LM118/LM218 operational amplifier

general description

The LM118 and LM218 are precision high speed operational amplifiers designed for applications requiring wide bandwidth and high slew rate. They feature a factor of ten increase in speed over general purpose devices without sacrificing DC performance.

features

- 15 MHz small signal bandwidth
- Guaranteed 50V/ μ s slew rate
- Maximum bias current of 250 nA
- Operates from supplies of ± 5 V to ± 20 V
- Internal frequency compensation
- Input and output overload protected
- Pin compatible with general purpose op amps

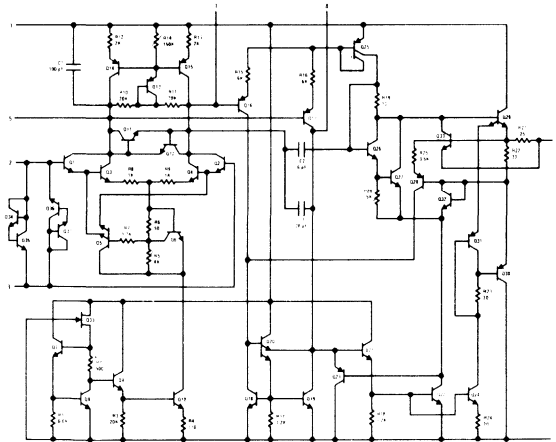
The LM118 has internal unity gain frequency compensation. This considerably simplifies its application since no external components are necessary for operation. However, unlike most internally

compensated amplifiers, external frequency compensation may be added for optimum performance. For inverting applications, feedforward compensation will boost the slew rate to over 150V/ μ s and almost double the bandwidth. Overcompensation can be used with the amplifier for greater stability when maximum bandwidth is not needed. Further, a single capacitor can be added to reduce the 0.1% settling time to under 1 μ s.

The high speed and fast settling time of these op amps make them useful in A/D converters, oscillators, active filters, sample and hold circuits, or general purpose amplifiers. These devices are easy to apply and offer an order of magnitude better AC performance than industry standards such as the LM709.

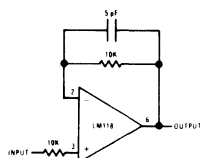
The LM218 is identical to the LM118 except that the LM218 has its performance specified over a -25°C to 85°C temperature range, instead of -55°C to 125°C .

schematic and connection diagrams

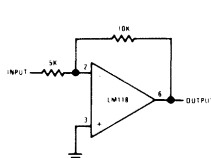


*Pin connections shown on schematic diagram and typical applications are for TO-5 package.

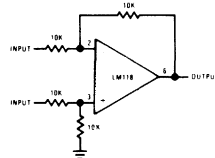
typical applications



Fast Voltage Follower

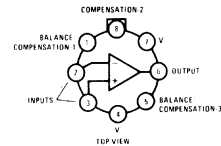


Fast Summing Amplifier



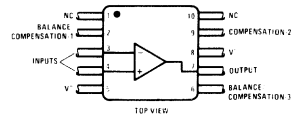
Differential Amplifier

Metal Can Package



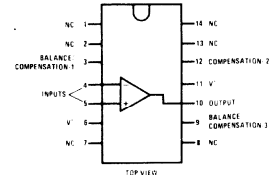
Order Number LM118H or LM218H
See Package 11

Flat Package



Order Number LM118F or LM218F
See Package 3

Dual-In-Line Package



Order Number LM118D or LM218D
See Package 1

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range LM118	-55°C to 125°C
LM218	-25°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$		2	4	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		6	50	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		120	250	nA
Input Resistance	$T_A = 25^\circ\text{C}$	1	3		MΩ
Supply Current	$T_A = 25^\circ\text{C}$		5	8	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{\text{OUT}} = \pm 10\text{V}$, $R_L \geq 2\text{ k}\Omega$	50	200		V/mV
Slew Rate	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $A_V = 1$	50	70		V/ μs
Small Signal Bandwidth	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		15		MHz
Input Offset Voltage				6	mV
Input Offset Current				100	nA
Input Bias Current				500	nA
Supply Current	$T_A = +125^\circ\text{C}$		4.5	7	mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = \pm 10\text{V}$ $R_L \geq 2\text{ k}\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 2\text{ k}\Omega$	±12	±13		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±11.5			V
Common Mode Rejection Ratio		80	100		dB
Supply Voltage Rejection Ratio		70	80		dB

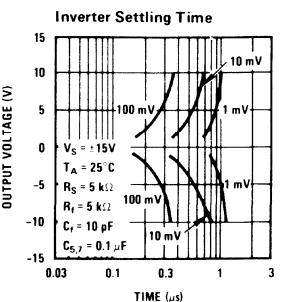
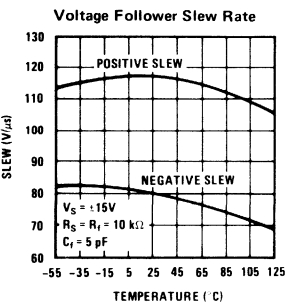
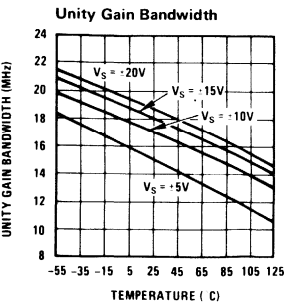
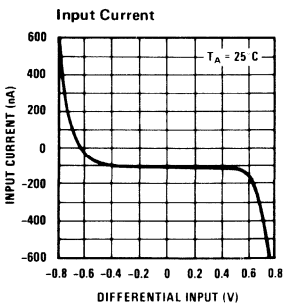
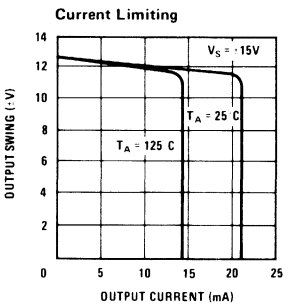
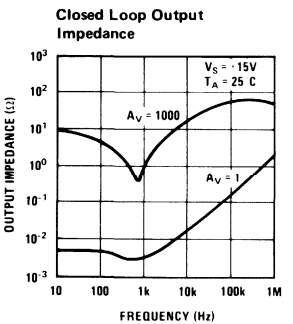
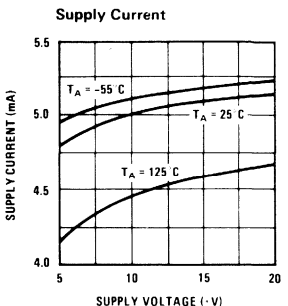
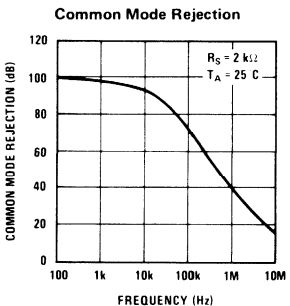
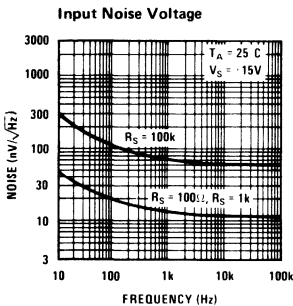
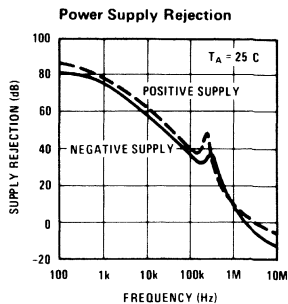
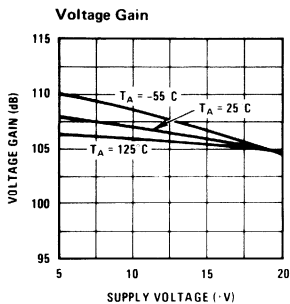
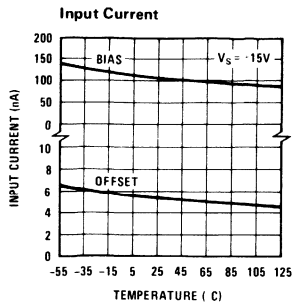
Note 1: The maximum junction temperature of the LM118 is 150°C, while that of the LM218 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

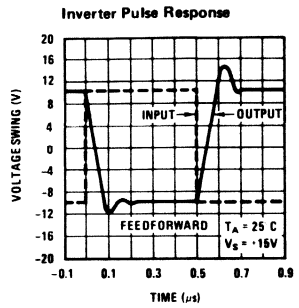
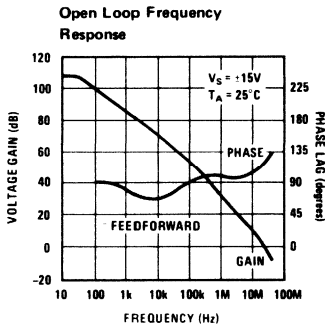
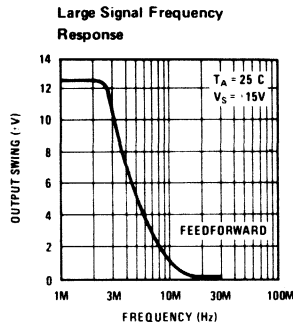
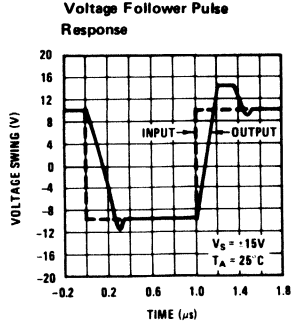
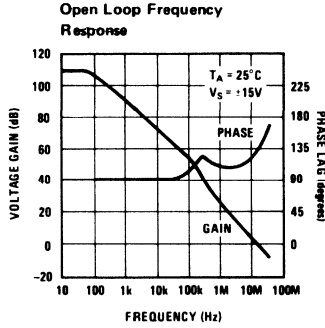
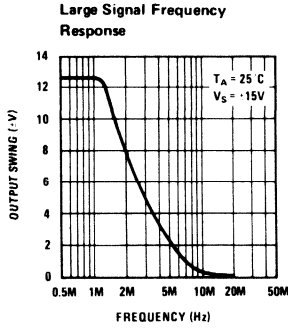
Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM218, however, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$. Also, power supplies must be bypassed with 0.1 μF disc capacitors.

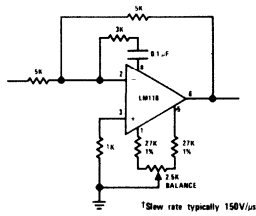
typical performance characteristics



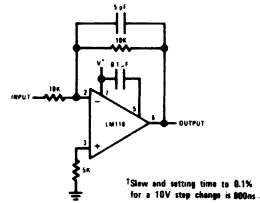
typical performance characteristics (con't)



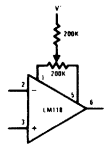
auxiliary circuits



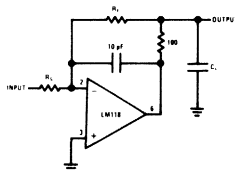
Feedforward Compensation for Greater Inverting Slew Rate†



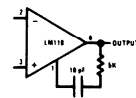
Compensation for Minimum Settling Time



Offset Balancing

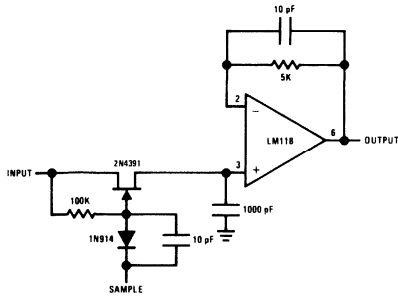


Isolating Large Capacitive Loads

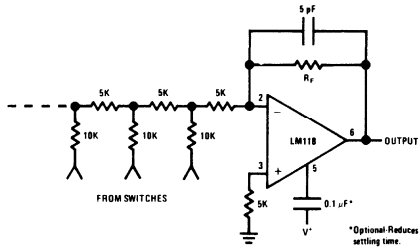


Overcompensation

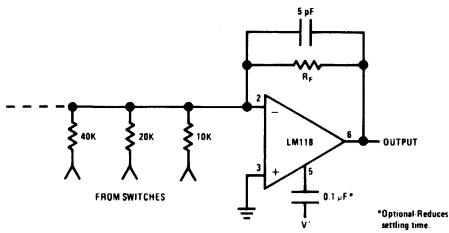
typical applications (con't)



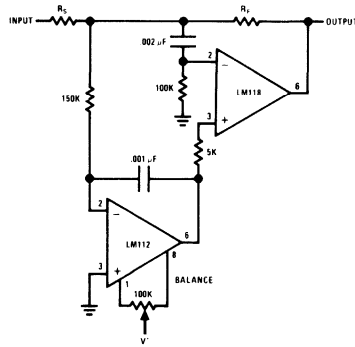
Fast Sample and Hold



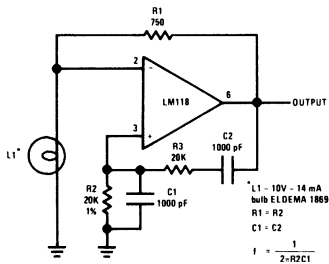
D/A Converter Using Ladder Network



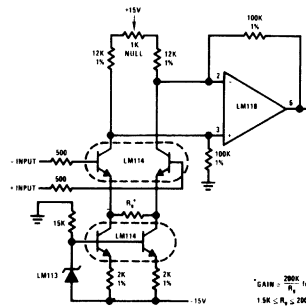
D/A Converter Using Binary Weighted Network



Fast Summing Amplifier with Low Input Current



Wein Bridge Sine Wave Oscillator



Instrumentation Amplifier



Operational Amplifiers

LM318 operational amplifier

general description

The LM318 is a precision high speed operational amplifier designed for applications requiring wide bandwidth and high slew rate. It features a factor of ten increase in speed over general purpose devices without sacrificing DC performance.

features

- 15 MHz small signal bandwidth
- Guaranteed 50V/ μ s slew rate
- Maximum bias current of 500 nA
- Operates from supplies of ± 5 V to ± 20 V
- Internal frequency compensation
- Input and output overload protected
- Pin compatible with general purpose op amps

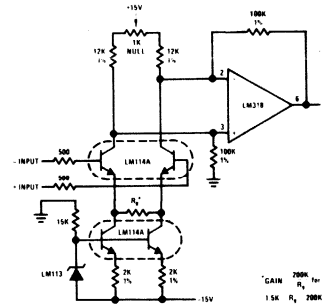
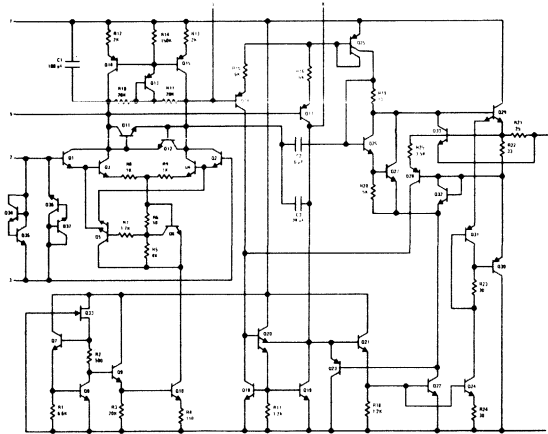
The LM318 has internal unity gain frequency compensation. This considerably simplifies its application since no external components are necessary

for operation. However, unlike most internally compensated amplifiers, external frequency compensation may be added for optimum performance. For inverting applications, feedforward compensation will boost the slew rate to over 150V/ μ s and almost double the bandwidth. Overcompensation can be used with the amplifier for greater stability when maximum bandwidth is not needed. Further, a single capacitor can be added to reduce the 0.1% settling time to under 1 μ s.

The high speed and fast settling time of these op amps make them useful in A/D converters, oscillators, active filters, sample and hold circuits, or general purpose amplifiers. These devices are easy to apply and offer an order of magnitude better AC performance than industry standards such as the LM709.

The LM318 is specified for operation over 0°C to 70°C.

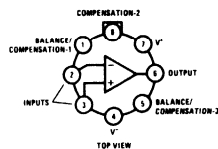
schematic diagram and typical application



Instrumentation Amplifier

connection diagrams

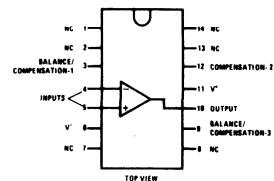
Metal Can Package*



*Pin connections shown on schematic diagram and typical applications are for TO-5 package.

Order Number LM318H
See Package 11

Dual-In-Line Package



Order Number LM318D
See Package 1

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (Note 1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$		4	10	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		30	200	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		150	500	nA
Input Resistance	$T_A = 25^\circ\text{C}$	0.5	3		MΩ
Supply Current	$T_A = 25^\circ\text{C}$		5	10	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{\text{OUT}} = \pm 10\text{V}$, $R_L \geq 2\text{ k}\Omega$	25	200		V/mV
Slew Rate	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $A_V = 1$	50	70		V/ μs
Small Signal Bandwidth	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		15		MHz
Input Offset Voltage				15	mV
Input Offset Current				300	nA
Input Bias Current				750	nA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = \pm 10\text{V}$ $R_L \geq 2\text{ k}\Omega$	20			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 2\text{ k}\Omega$	±12	±13		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±11.5			V
Common Mode Rejection Ratio		70	100		dB
Supply Voltage Rejection Ratio		65	80		dB

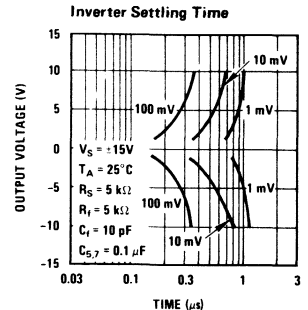
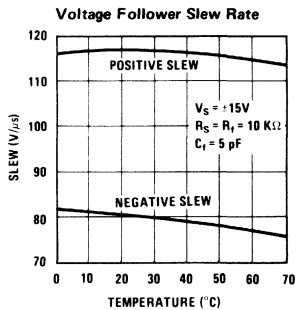
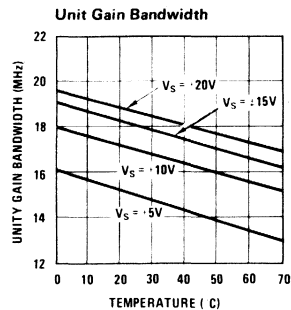
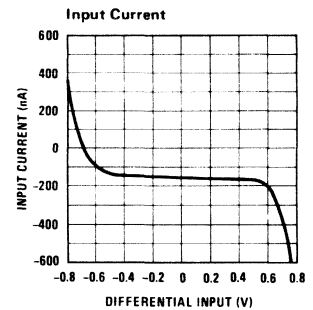
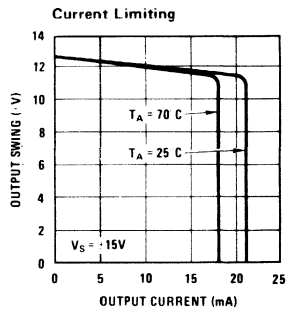
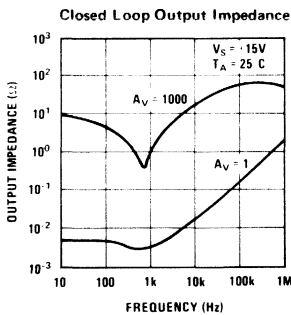
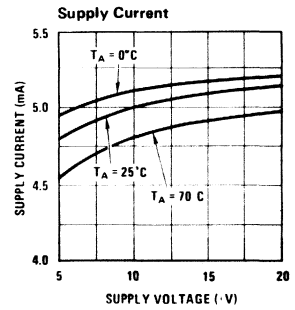
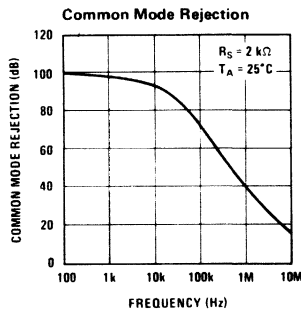
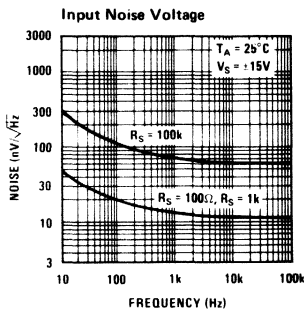
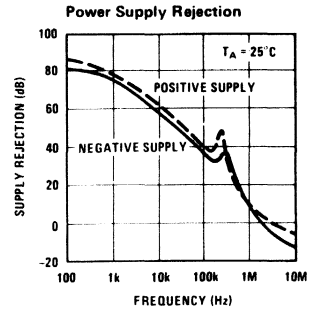
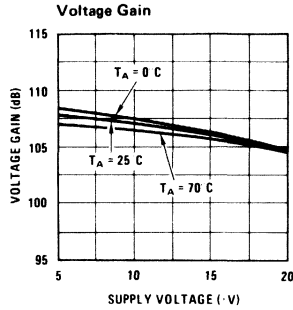
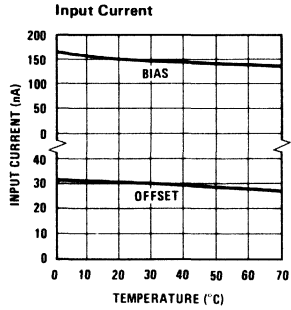
Note 1: The maximum junction temperature of the LM318 is 85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

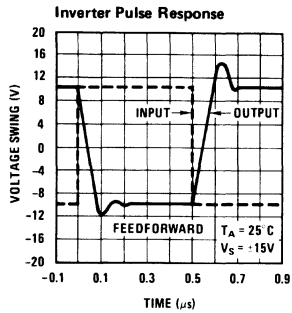
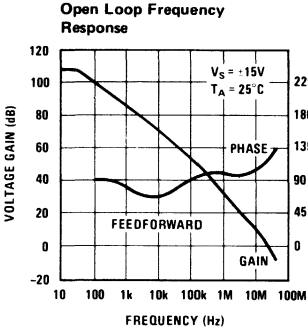
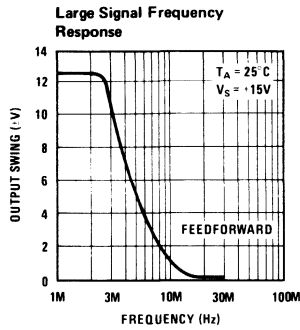
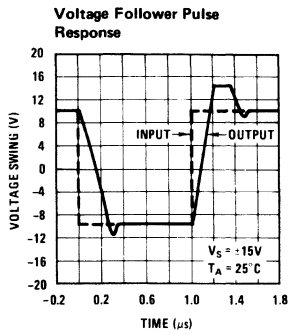
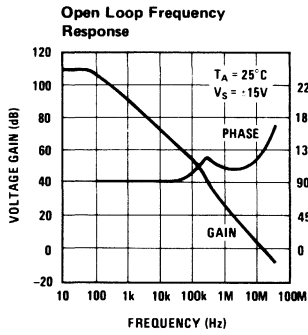
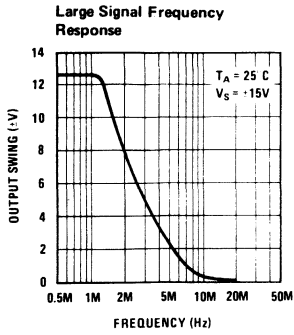
Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$ and $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise specified. For proper operation, the power supplies must be bypassed with 0.1 μF disc capacitors.

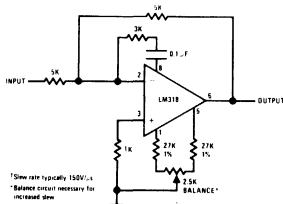
typical performance characteristics



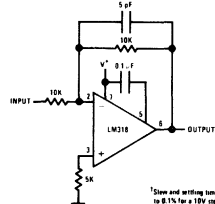
typical performance characteristics (con't)



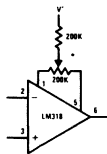
auxiliary circuits



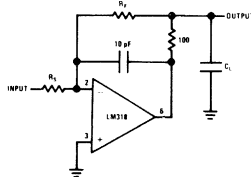
Feedforward Compensation for Greater Inverting Slew Rate[†]



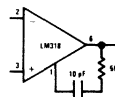
Compensation for Minimum Settling[†] Time



Offset Balancing

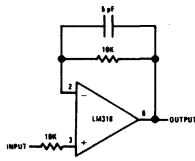


Isolating Large Capacitive Loads

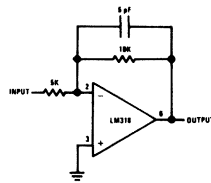


Overcompensation

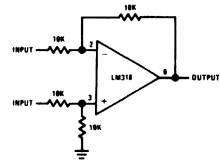
typical applications (con't)



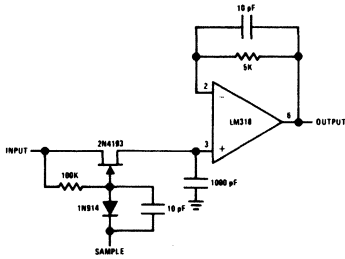
Fast Voltage Follower



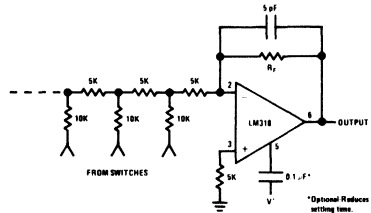
Fast Summing Amplifier



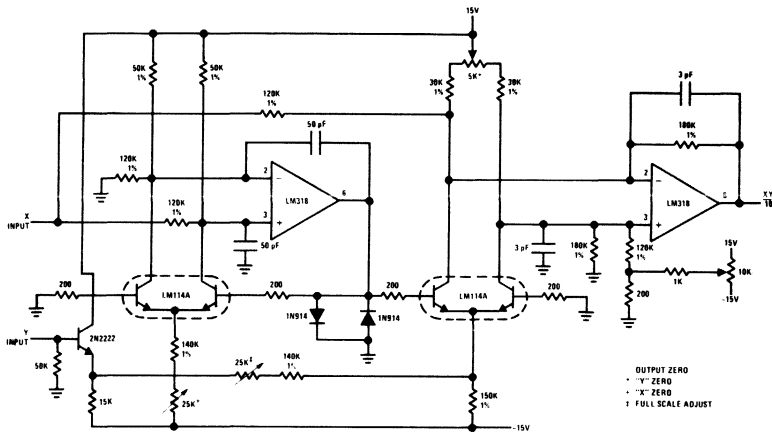
Differential Amplifier



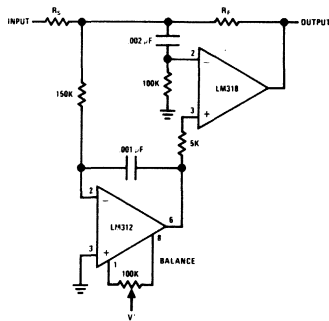
Fast Sample and Hold



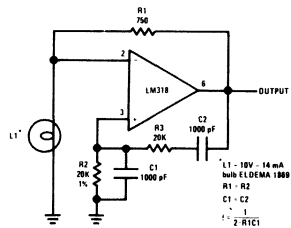
D/A Converter Using Ladder Network



Four Quadrant Multiplier



Fast Summing Amplifier with Low Input Current



Wein Bridge Sine Wave Oscillator



Operational Amplifiers

LM121/LM221/LM321 precision preamplifier

general description

The LM121 series are precision preamplifiers designed to operate with general purpose operational amplifiers to drastically decrease DC errors. Drift, bias current, common mode and supply rejection are more than a factor of 10 better than standard op amps alone. Further, the added DC gain of the LM121 decreases the closed loop gain error.

The LM121 operates with supply voltages from $\pm 3V$ to $\pm 20V$ and has sufficient supply rejection to operate from unregulated supplies. The operating current is programmable from $5\mu A$ to $200\mu A$ so bias current, offset current, gain and noise can be optimized for the particular application while still realizing very low drift. Super-gain transistors are used for the input stage so input error currents are lower than conventional amplifiers at the same operating current. Further, the initial offset voltage is easily nulled to zero.

advantages

- Permits optimization of general purpose op amps
- Replaces many specialized op amps

features

- Guaranteed drift less than $1\mu V/^{\circ}C$ when nulled
- Offset voltage less than 0.7 mV

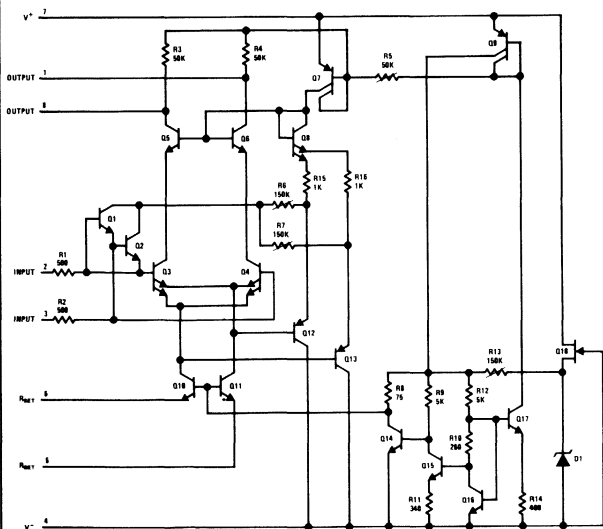
- Bias current less than 10 nA at $10\mu A$ operating current
- CMRR 120 dB minimum
- 114 dB supply rejection
- Easily nulled offset voltage

The extremely low drift of the LM121 will improve accuracy on almost any precision DC circuit. For example, instrumentation amplifier, strain gauge amplifiers and thermocouple amplifiers now using chopper amplifiers can be made with the LM121. The full differential input and high common mode rejection are another advantage over choppers. For applications where low bias current is more important than drift, the operating current can be reduced to low values. High operating currents can be used for low voltage noise with low source resistance. The programmable operating current of the LM121 allows tailoring the input characteristics to match those of specialized op amps.

The LM121 is specified over a $-55^{\circ}C$ to $125^{\circ}C$ temperature range, the LM221 over a $-25^{\circ}C$ to $85^{\circ}C$ range and the LM321 over a $0^{\circ}C$ to $70^{\circ}C$ temperature range.

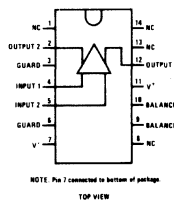
A lower drift version of the LM121 — the LM121A series — is available for applications requiring $0.2\mu V/^{\circ}C$ offset voltage drift.

schematic and connection diagrams

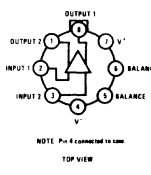


*Pin connections shown on schematic diagram and typical applications are for TO-5 package.

Dual-In-Line Package



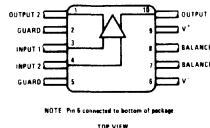
Metal Can Package



Order Number LM121D, LM221D or LM321D See Package 1

Order Number LM121H, LM221H or LM321H See Package 11

Flat Package



Order Number LM121F, LM221F or LM321F See Package 3

Note: Outputs are inverting from the input of the same number.

absolute maximum ratings

Supply Voltage	±20V
Power Dissipation (Note 1)	500mW
Differential Input Voltage (Notes 2, 3)	±15V
Input Voltage (Note 3)	±15V
Operating Temperature Range	
LM121	−55°C to 125°C
LM221	−25°C to 85°C
LM321	0°C to 70°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	LM121 LM221	LM321	UNITS	
Input Offset Voltage	$T_A = 25^\circ\text{C}$ $6.4\text{k} \leq R_{\text{Set}} \leq 70\text{k}$	0.7	1.5	mV	Max
Input Offset Current	$T_A = 25^\circ\text{C}$ $R_{\text{Set}} = 70\text{k}$ $R_{\text{Set}} = 6.4\text{k}$	1	2	nA	Max
		10	20	nA	Max
Input Bias Current	$T_A = 25^\circ\text{C}$ $R_{\text{Set}} = 70\text{k}$ $R_{\text{Set}} = 6.4\text{k}$	10	18	nA	Max
		100	180	nA	Max
Input Resistance	$T_A = 25^\circ\text{C}$ $R_{\text{Set}} = 70\text{k}$ $R_{\text{Set}} = 6.4\text{k}$	4	2	MΩ	Min
		0.4	0.2	MΩ	Min
Supply Current	$T_A = 25^\circ\text{C}$	1.5	2.2	mA	Max
Input Offset Voltage	$6.4\text{k} \leq R_{\text{Set}} = 70\text{k}$	1	2.5	mV	Max
Input Bias Current	$R_{\text{Set}} = 70\text{k}$ $R_{\text{Set}} = 6.4\text{k}$	30	28	nA	Max
		300	280	nA	Max
Input Offset Current	$R_{\text{Set}} = 70\text{k}$ $R_{\text{Set}} = 6.4\text{k}$	3	4	nA	Max
		30	40	nA	Max
Average Temperature Coefficient of Input Offset Voltage	$R_S \leq 200\Omega$ $6.4\text{k} \leq R_{\text{Set}} \leq 70\text{k}$ Offset Voltage Nullified	1	1	μV/°C	Max
Supply Current		2.5	3.5	mA	Max
Input Voltage Range	$V_S = \pm 15\text{V}$ $R_{\text{Set}} = 70\text{k}$ $R_{\text{Set}} = 6.4\text{k}$ (Note 5)	±13	±13	V	Min
		+7 −13	+7 −13	V	Min
Common Mode Rejection Ratio	$R_{\text{Set}} = 70\text{k}$ $R_{\text{Set}} = 6.4\text{k}$	120	114	dB	Min
		114	114	dB	Min
Supply Voltage Rejection Ratio	$R_{\text{Set}} = 70\text{k}$ $R_{\text{Set}} = 6.4\text{k}$	120	114	dB	Min
		114	114	dB	Min
Voltage Gain	$T_A = 25^\circ\text{C}$ $R_{\text{Set}} = 70\text{k}$ $R_L > 3\text{ meg}$	16	12	V/V	Min

Note 1: The maximum junction temperature of the LM121 is 150°C, while that of the LM221 is 100°C. The maximum junction temperature of the LM321 is 85°C. For operating at elevated temperature, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/6-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes in series with a 500Ω resistor for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $\pm 5 \leq V_S < \pm 20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM221, however, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$, and for the LM321 the specifications apply over a 0°C to 70°C temperature range.

Note 5: External precision resistors—0.1%—can be placed from pins 1 and 8 to 7 to increase positive common mode range.

typical applications

Low Drift Op Amp Using the LM121 as a Preamp

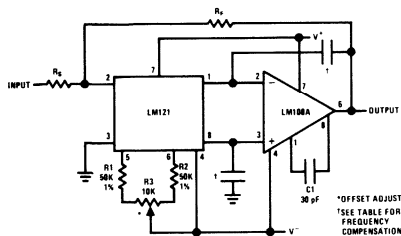


FIGURE 1.

Gain of 1000 Instrumentation Amplifier ‡

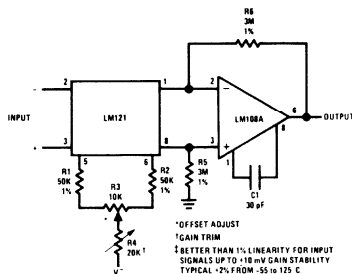


FIGURE 2.

frequency compensation

Universal Frequency Compensation

The additional gain of the LM121 preamplifier when used with an operational amplifier usually necessitates additional frequency compensation. When the closed loop gain of the op amp with the LM121 is less than the gain of the LM121 alone, more compensation is needed. The worst case situation is when there is 100% feedback — such as a voltage follower or integrator — and the gain of the LM121 is high. When high closed loop gains are used — for example $A_V = 1000$ — and only an addition gain of 200 is inserted by the LM121, the frequency compensation of the op amp will usually suffice.

The frequency compensation shown here is designed to operate with any unity-gain stable op amp. Figure 1 shows the basic configuration of frequency stabilizing network. In operation the output of the LM121 is rendered single ended by a $0.01\mu\text{F}$ bypass capacitor to ground. Overall frequency compensation then is achieved by an integrating capacitor around the op amp.

$$\text{Bandwidth at unity gain} \approx \frac{12}{2\pi R_{\text{Set}} C}$$

$$\text{for } 0.5 \text{ MHz bandwidth } C = \frac{4}{10^6 R_{\text{Set}}}$$

For use with higher frequency op amps such as the LM118 the bandwidth may be increased to about 2 MHz.

If the closed loop gain is greater than unity "C" may be decreased by

$$C = \frac{4}{10^6 A_{\text{CL}} R_{\text{Set}}}$$

Alternate Compensation

The two compensation capacitors can be made equal for improved power supply rejection. In this case the formula for the compensation capacitor is

$$C = \frac{8}{10^6 A_{\text{CL}} R_{\text{Set}}}$$

Table 1 shows typical values for the two compensating capacitors for various gains and operating currents.

TABLE 1.

CLOSED LOOP GAIN	CURRENT SET RESISTOR				
	120k Ω	60k Ω	30k Ω	12k Ω	6k Ω
$A_V = 1$	68	130	270	680	1300
$A_V = 5$	15	27	56	130	270
$A_V = 10$	10	15	27	68	130
$A_V = 50$	1	3	5	15	27
$A_V = 100$	-	1	3	5	10
$A_V = 500$	-	-	1	1	3
$A_V = 1000$	-	-	-	-	-

This table applies for the LM108, LM101A, LM741, LM118. Capacitance is in pF.

Design equations for the LM121 series:

$$\text{Gain } A_V \approx \frac{1.2 \times 10^6}{R_{\text{Set}}}$$

Null Pot Value should be 10% of R_{Set}

$$\text{Operating Current} \approx \frac{2 \times 0.65V}{R_{\text{Set}}}$$

$$\text{Positive Common Mode Limit} \approx V^+ - 0.6 + \frac{0.65V \times 50k}{R_{\text{Set}}}$$



Operational Amplifiers

LM124/LM224/LM324 quad op amps

general description

The LM124 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM124 series can be directly operated off of the standard +5V_{DC} power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ± 15 V_{DC} power supplies.

unique characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage.
- The unity gain cross frequency is temperature compensated.
- The input bias current is also temperature compensated.

advantages

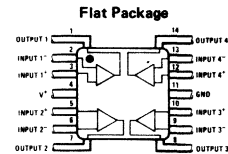
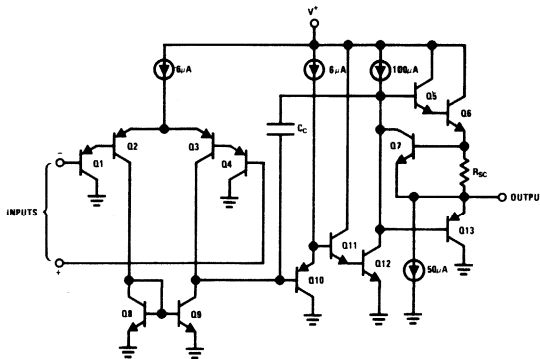
- Eliminates need for dual supplies

- Four internally compensated op amps in a single package
- Allows directly sensing near GND and V_{OUT} also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

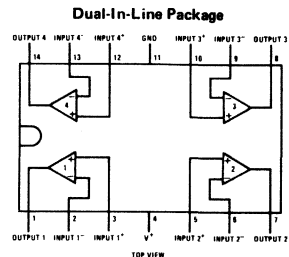
features

- Internally frequency compensated for unity gain
- Large DC voltage gain 100 dB
- Wide bandwidth (unity gain) 1 MHz (temperature compensated)
- Wide power supply range:
 - Single supply 3V_{DC} to 30V_{DC}
 - or dual supplies ± 1.5 V_{DC} to ± 15 V_{DC}
- Very low supply current drain (800 μ A) – essentially independent of supply voltage (1 mW/op amp at +5V_{DC})
- Low input biasing current (temperature compensated) 45 nA_{DC}
- Low input offset voltage 2 mV_{DC} and offset current 5 nA_{DC}
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage 0V_{DC} to V⁺ - 1.5V_{DC} swing

schematic and connection diagrams



Order Number LM124F
See Package 4



Order Number LM124D, LM224D,
LM324D, or LM324N
See Package 1 or 22

absolute maximum ratings

Supply Voltage, V^+	$32 V_{DC}$ or $\pm 16 V_{DC}$
Differential Input Voltage	$32 V_{DC}$
Input Voltage	$-0.3 V_{DC}$ to $+32 V_{DC}$
Power Dissipation (Note 1)	
Molded DIP (LM324N)	570 mW
Cavity DIP (LM124D, LM224D & LM324D)	900 mW
Flat Pack (LM124F)	800 mW
Output Short-Circuit to GND (Note 2)	Continuous
$V^+ \leq 15 V_{DC}$ and $T_A = 25^\circ C$	
Operating Temperature Range	
LM324	$0^\circ C$ to $+70^\circ C$
LM224	$-25^\circ C$ to $+85^\circ C$
LM124	$-55^\circ C$ to $+125^\circ C$
Storage Temperature Range	$-65^\circ C$ to $+150^\circ C$
Lead Temperature (Soldering, 10 sec)	$300^\circ C$

electrical characteristics ($V^+ = +5 V_{DC}$ and $T_A = 25^\circ C$ unless otherwise noted)

PARAMETER	CONDITIONS	LM124			LM224, LM324			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S = 0\Omega$		2	5		2	7	mV _{DC}
Input Bias Current (Note 3)	$I_{IN(+)}$ or $I_{IN(-)}$		45	300		45	500	nA _{DC}
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$		± 3	± 30		± 5	± 50	nA _{DC}
Input Common-Mode Voltage Range (Note 4)		0		$V^+ - 1.5$	0		$V^+ - 1.5$	V _{DC}
Supply Current	$R_L = \infty$ On All Op Amps		0.8	2		0.8	2	mA _{DC}
Large Signal Voltage Gain	$R_L \geq 2 k\Omega$		100			100		V/mV
Output Voltage Swing	$R_L = 2 k\Omega$	0		$V^+ - 1.5$	0		$V^+ - 1.5$	V _{DC}
Common Mode Rejection Ratio	DC		85			85		dB
Power Supply Rejection Ratio	DC		100			100		dB
Amplifier-to-Amplifier Coupling	$f = 1 \text{ kHz to } 20 \text{ kHz}$ (Input Referred)			-120			-120	dB
Output Current Source	$V_{IN}^+ = +1 V_{DC}$, $V_{IN}^- = 0 V_{DC}$	20	40		20	40		mA _{DC}
Output Current Sink	$V_{IN}^- = +1 V_{DC}$, $V_{IN}^+ = 0 V_{DC}$	10	20		10	20		mA _{DC}

Note 1: For operating at high temperatures, the LM324 must be derated based on a $+125^\circ C$ maximum junction temperature and a thermal resistance of $175^\circ C/W$ which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM224 and LM124 can be derated based on a $+150^\circ C$ maximum junction temperature.

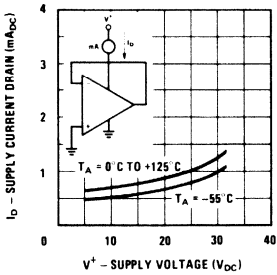
Note 2: Short circuits from the output to V^+ can cause excessive heating and eventual destruction. The maximum output current is approximately 40 mA independent of the magnitude of V^+ . At values of supply voltage in excess of $+15V_{DC}$, continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction.

Note 3: The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.

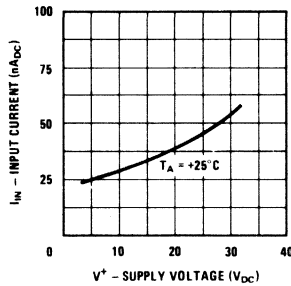
Note 4: The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is $V^+ - 1.5V$, but either or both inputs can go to $+30V_{DC}$ without damage.

typical performance characteristics

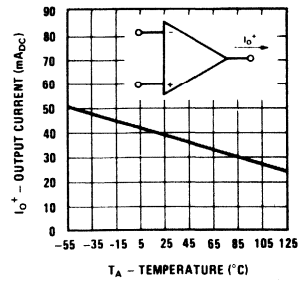
Supply Current



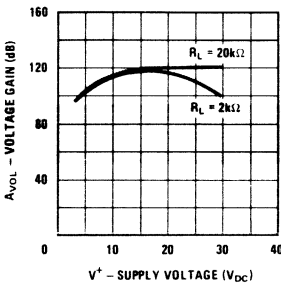
Input Current



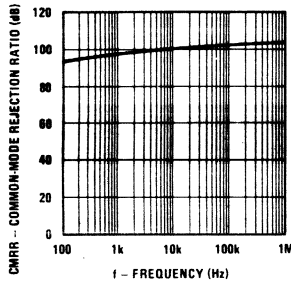
Current Limiting



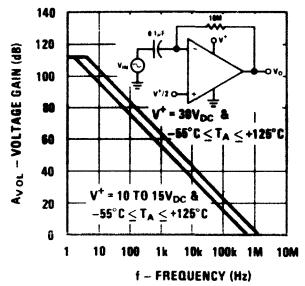
Voltage Gain



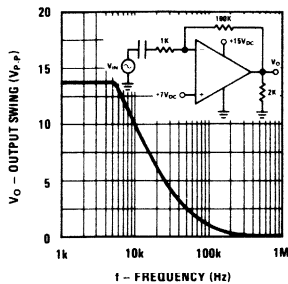
Common-Mode Rejection Ratio



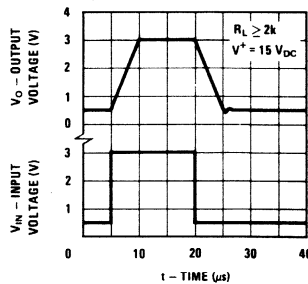
Open Loop Frequency Response



Large Signal Frequency Response



Voltage Follower Pulse Response



application hints

The LM124 series are op amps which operate with only a single power supply voltage, have true-differential inputs, and remain in the linear mode with an input common-mode voltage of $0V_{DC}$. These amplifiers operate over a wide range of power supply voltage with little change in performance characteristics. At $25^{\circ}C$ amplifier operation is possible down to a minimum supply voltage of $2.3V_{DC}$.

The pinouts of the package have been designed to simplify PC board layouts. Inverting inputs are adjacent to outputs for all of the amplifiers and the outputs have also been placed at the corners of the package (pins 1, 7, 8, and 14).

Precautions should be taken to insure that the power supply for the integrated circuit never becomes reversed in polarity or that the unit is not inadvertently installed backwards in a test socket as an unlimited current surge through the resulting forward diode within the IC could cause fusing of the internal conductors and result in a destroyed unit.

Large differential input voltages can be easily accommodated and, as input differential voltage protection diodes are not needed, no large input currents result from large differential input voltages. The differential input voltage may be larger than V^+ without damaging the device. Protection should be provided to prevent the input voltages from going negative more than $-0.3V_{DC}$ (at $25^{\circ}C$). An input clamp consisting of a diode-connected NPN transistor (C-B short) can be used.

To reduce the power supply current drain, the amplifiers have a class A output stage for small signal levels which converts to class B in a large signal mode. This allows the amplifiers to both source and sink large output currents. Therefore both NPN and PNP external current boost transistors can be used to extend the power capability of the basic amplifiers. The output voltage needs to raise approximately 1 diode drop above ground to bias the on-chip vertical PNP transistor for output current sinking applications.

For AC applications, where the load is capacitively coupled to the output of the amplifier, a resistor

should be used, from the output of the amplifier to ground to increase the class A bias current and prevent crossover distortion. Where the load is directly coupled, as in DC applications, there is no crossover distortion.

Capacitive loads which are applied directly to the output of the amplifier reduce the loop stability margin. Values of 50 pF can be accommodated using the worst-case non-inverting unity gain connection. Large closed loop gains or resistive isolation should be used if larger load capacitance must be driven by the amplifier.

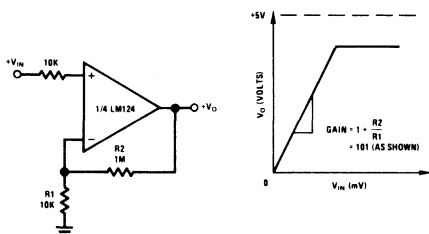
The bias network of the LM124 establishes a drain current which is independent of the magnitude of the power supply voltage over the range of from $3V_{DC}$ to $30V_{DC}$.

Output short circuits either to ground or to the positive power supply should be of short time duration. Units can be destroyed, not as a result of the short circuit current causing metal fusing, but rather due to the large increase in IC chip dissipation which will cause eventual failure due to excessive junction temperatures. Putting direct short-circuits on more than one amplifier at a time will increase the total IC power dissipation to destructive levels, if not properly protected with external dissipation limiting resistors in series with the output leads of the amplifiers. The larger value of output source current which is available at $25^{\circ}C$ provides a larger output current capability at elevated temperatures (see typical performance characteristics) than a standard IC op amp.

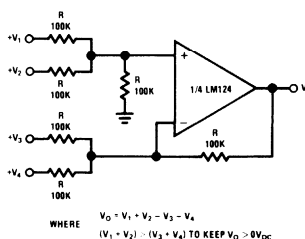
The circuits presented in the section on typical applications emphasize operation on only a single power supply voltage. If complementary power supplies are available, all of the standard op amp circuits can be used. In general, introducing a pseudo-ground (a bias voltage reference of $V^+/2$) will allow operation above and below this value in single power supply systems. Many application circuits are shown which take advantage of the wide input common-mode voltage range which includes ground. In most cases, input biasing is not required and input voltages which range to ground can easily be accommodated.

typical single-supply applications ($V^+ = 5V_{DC}$)

Non-Inverting DC Gain ($0V$ Input = $0V$ Output)

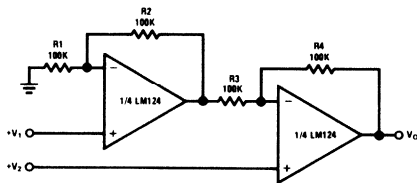


DC Summing Amplifier
($V_{IN'S} \geq 0V_{DC}$ AND $V_O \geq 0V_{DC}$)



typical single-supply applications (con't) ($V^+ = 5V_{DC}$)

High Input Z, DC Differential Amplifier

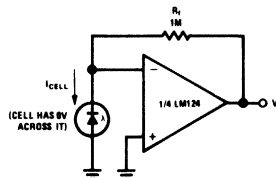


FOR $\frac{R1}{R2} = \frac{R4}{R3}$ (CMRR DEPENDS ON THIS RESISTOR RATIO MATCH)

$$V_O = \left(1 + \frac{R4}{R3}\right) (V_2 - V_1)$$

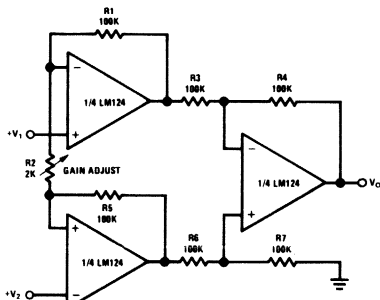
AS SHOWN: $V_O = 2(V_2 - V_1)$

Photo Voltaic-Cell Amplifier



(CELL HAS BY ACROSS IT)

High Input Z Adjustable-Gain DC Instrumentation Amplifier

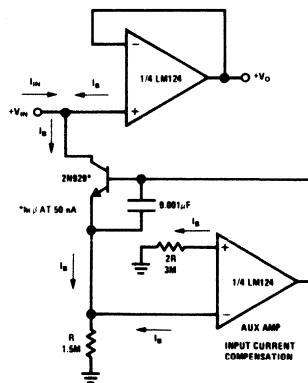


IF $R1 = R5$ & $R3 = R4 = R6 = R7$ (CMRR DEPENDS ON MATCH)

$$V_O = 1 + \frac{2R1}{R2} (V_2 - V_1)$$

AS SHOWN $V_O = 101 (V_2 - V_1)$

Using Symmetrical Amplifiers to Reduce Input Current (General Concept)

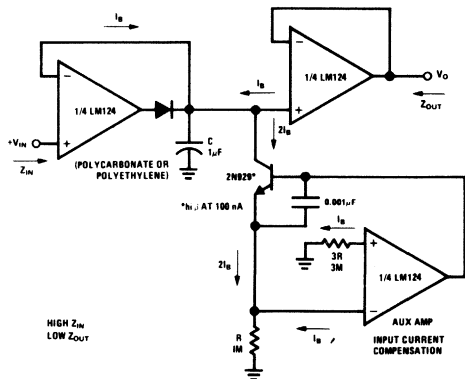


I_{in} AT 50 nA

INPUT CURRENT COMPENSATION

2

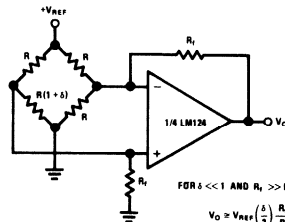
Low Drift Peak Detector



HIGH Z_{in}
LOW Z_{out}

AUX AMP
INPUT CURRENT
COMPENSATION

Bridge Current Amplifier

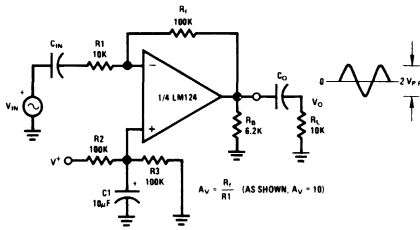


FOR $\delta \ll 1$ AND $R_f \gg R$

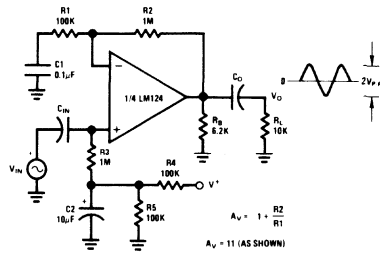
$$V_O \approx V_{REF} \left(\frac{\delta}{2}\right) \frac{R_f}{R}$$

typical single-supply applications (con't) ($V^+ = 5V_{DC}$)

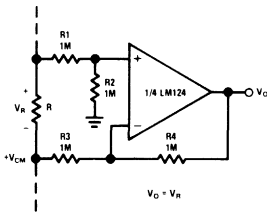
AC Coupled Inverting Amplifier



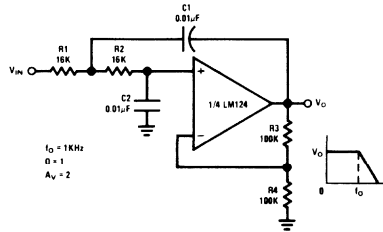
AC Coupled Non-Inverting Amplifier



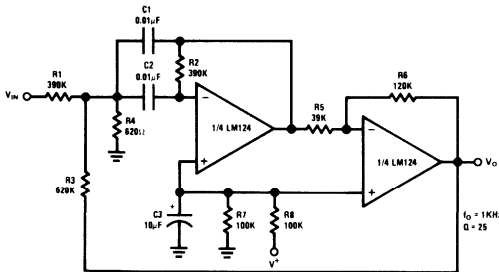
Ground Referencing A Differential Input Signal



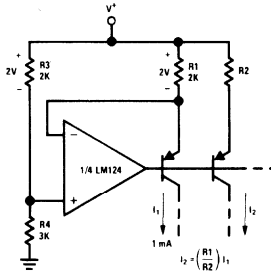
DC Coupled Low-Pass RC Active Filter



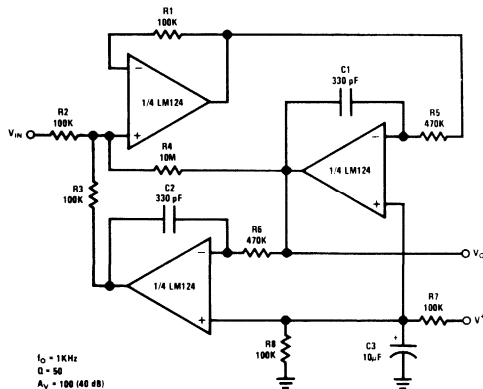
Bandpass Active Filter



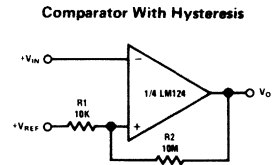
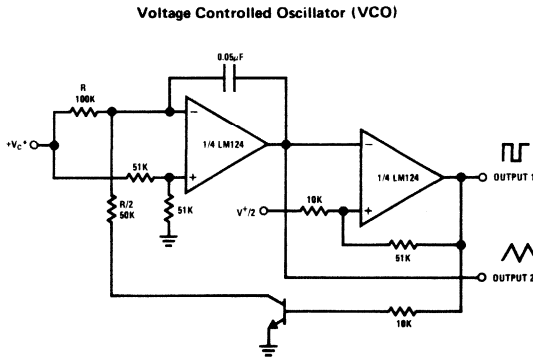
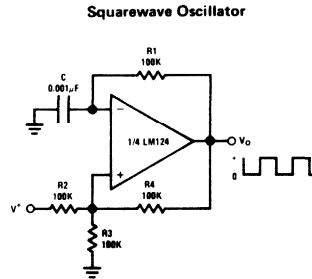
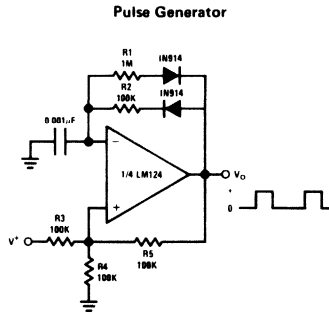
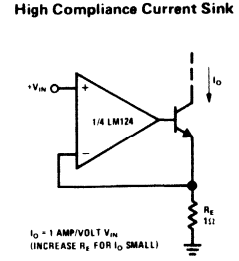
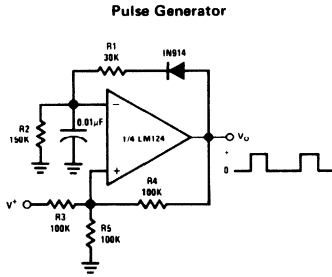
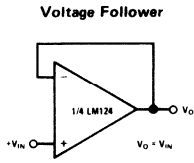
Fixed Current Sources



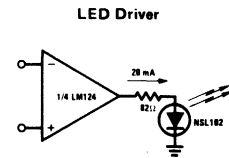
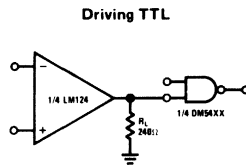
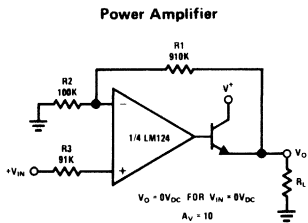
"BI-QUAD" RC Active Bandpass Filter



typical single-supply applications (con't) ($V^+ = 5V_{DC}$)



*WIDE CONTROL VOLTAGE RANGE: $0V_{DC} \leq V_c \leq 2(V^+ - 1.5V_{DC})$





Operational Amplifiers

LM709 operational amplifier

general description

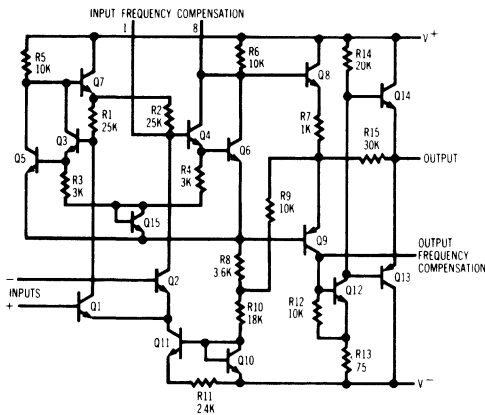
The LM709 is a monolithic operational amplifier intended for general-purpose applications. Operation is completely specified over the range of voltages commonly used for these devices. The design, in addition to providing high gain, minimizes both offset voltage and bias currents. Further, the class-B output stage gives a large output capability with minimum power drain.

External components are used to frequency compensate the amplifier. Although the unity-gain com-

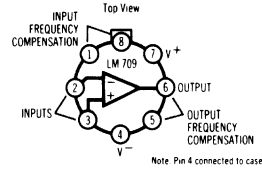
pensation network specified will make the amplifier unconditionally stable in all feedback configurations, compensation can be tailored to optimize high-frequency performance for any gain setting.

The fact that the amplifier is built on a single silicon chip provides low offset and temperature drift at minimum cost. It also ensures negligible drift due to temperature gradients in the vicinity of the amplifier.

schematic and connection diagrams



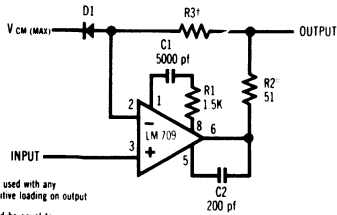
Metal Can



Order Number LM709H
See Package 11

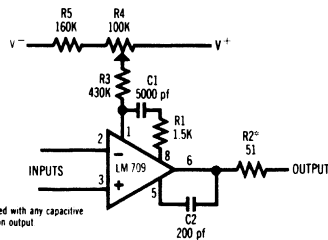
typical applications*

Voltage Follower



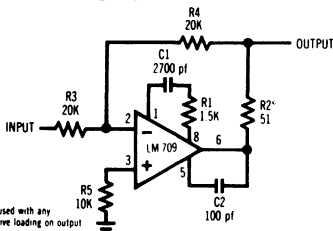
*To be used with any capacitive loading on output
f should be equal to dc source resistance on input

Offset Balancing Circuit



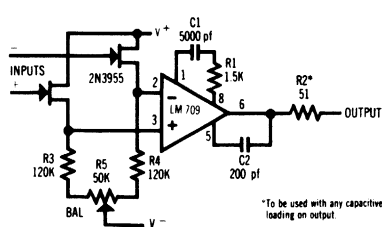
To be used with any capacitive loading on output

Unity Gain Inverting Amplifier



*To be used with any capacitive loading on output

FET Operational Amplifier



*To be used with any capacitive loading on output

* Pin connections shown are for Metal Can package.

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	300 mW
Differential Input Voltage	±5V
Input Voltage	±10V
Output Short-Circuit Duration ($T_A = 25^\circ\text{C}$)	5 sec
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	-55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

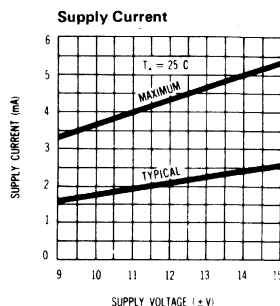
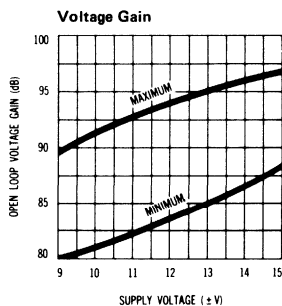
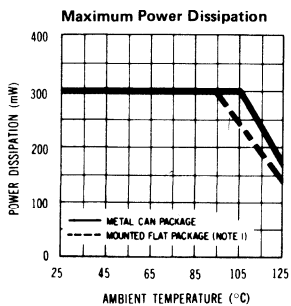
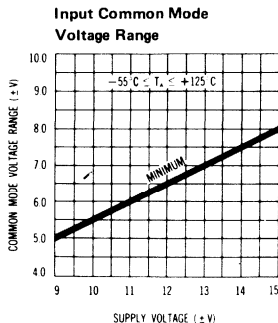
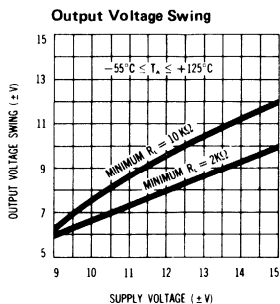
electrical characteristics (Note 2)

PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		1.0	5.0	mV
Input Bias Current	$T_A = 25^\circ\text{C}$		200	500	nA
Input Offset Current	$T_A = 25^\circ\text{C}$		50	200	nA
Input Resistance	$T_A = 25^\circ\text{C}$	150	400		k Ω
Output Resistance	$T_A = 25^\circ\text{C}$		150		Ω
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		2.6	5.5	mA
Transient Response	$V_{IN} = 20\text{ mV}$, $C_L \leq 100\text{ pF}$				
Risetime	$T_A = 25^\circ\text{C}$		0.3	1.0	μs
Overshoot			10	30	%
Slewing Rate	$T_A = 25^\circ\text{C}$		0.25		V/ μs
Input Offset Voltage	$R_S \leq 10\text{ k}\Omega$			6.0	mV
Average Temperature					
Coefficient of Input	$R_S = 50\text{ }\Omega$		3.0		$\mu\text{V}/^\circ\text{C}$
Offset Voltage	$R_S = 10\text{ k}\Omega$		6.0		$\mu\text{V}/^\circ\text{C}$
Large-Signal	$V_S = \pm 15\text{V}$, $R_L \geq 2\text{ k}\Omega$				
Voltage Gain	$V_{OUT} = \pm 10\text{V}$	25,000	45,000	70,000	
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	±12	±14		V
	$V_S = \pm 15\text{V}$, $R_L = 2\text{ k}\Omega$	±10	±13		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±8.0	±10		V
Common Mode					
Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	70	90		db
Supply Voltage					
Rejection Ratio	$R_S \leq 10\text{ k}\Omega$		25	150	$\mu\text{V}/\text{V}$
Input Offset Current	$T_A = +125^\circ\text{C}$		20	200	nA
	$T_A = -55^\circ\text{C}$		100	500	nA
Input Bias Current	$T_A = -55^\circ\text{C}$		0.5	1.5	μA
Input Resistance	$T_A = -55^\circ\text{C}$	40	100		k Ω

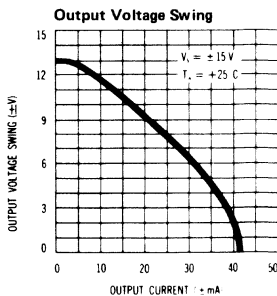
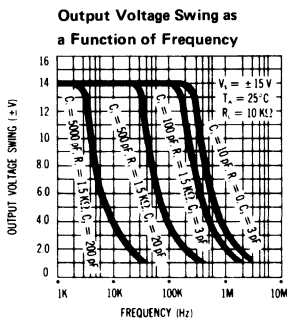
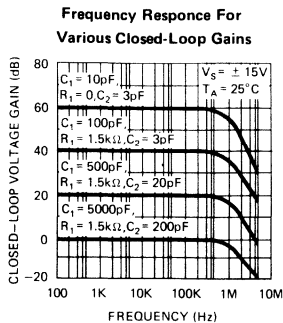
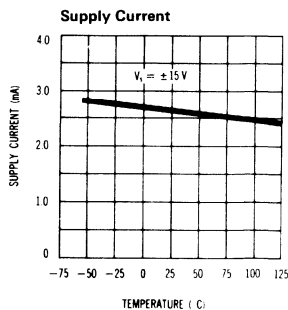
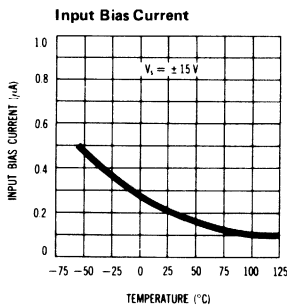
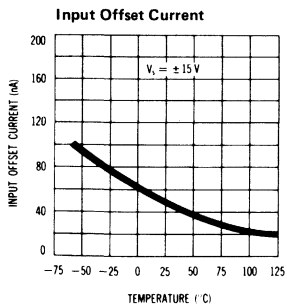
Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors (see curve).

Note 2: These specifications apply for $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$, $\pm 9\text{V} \leq V_S \leq \pm 18\text{V}$, $C_1 = 5000\text{ pF}$, $R_1 = 1.5\text{ k}\Omega$, $C_2 = 200\text{ pF}$ and $R_2 = 51\Omega$ unless otherwise specified.

guaranteed performance characteristics



typical performance characteristics





Operational Amplifiers

LM709A

LM709A operational amplifier general description

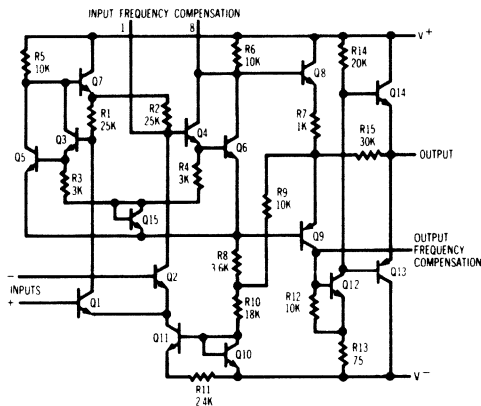
The LM709A is a monolithic operational amplifier intended for general-purpose applications. Operation is completely specified over the range of voltages commonly used for these devices. The design, in addition to providing high gain, minimizes both offset voltage and bias currents. Further, the class-B output stage gives a large output capability with minimum power drain.

External components are used to frequency compensate the amplifier. Although the unity-gain com-

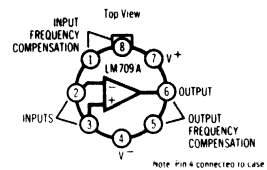
pensation network specified will make the amplifier unconditionally stable in all feedback configurations, compensation can be tailored to optimize high-frequency performance for any gain setting.

The fact that the amplifier is built on a single silicon chip provides low offset and temperature drift at minimum cost. It also ensures negligible drift due to temperature gradients in the vicinity of the amplifier.

schematic and connection diagrams



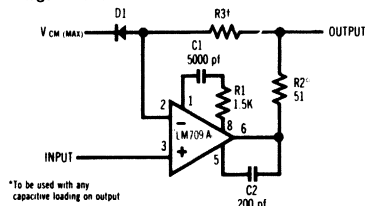
Metal Can



Order Number LM709AH
See Package 11

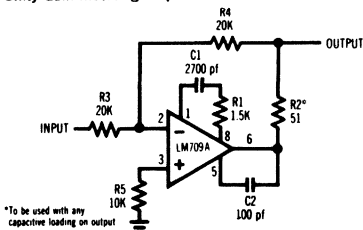
typical applications

Voltage Follower



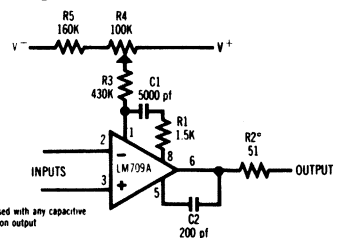
*To be used with any capacitive loading on output
†Should be equal to dc source resistance on input

Unity Gain Inverting Amplifier



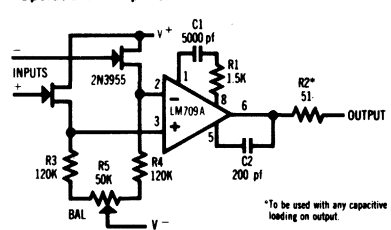
*To be used with any capacitive loading on output

Offset Balancing Circuit



To be used with any capacitive loading on output

FET Operational Amplifier



*To be used with any capacitive loading on output

2

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	300 mW
Differential Input Voltage	±5V
Input Voltage	±10V
Output Short-Circuit Duration ($T_A = 25^\circ\text{C}$)	5 sec
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	-55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

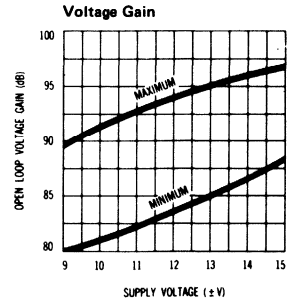
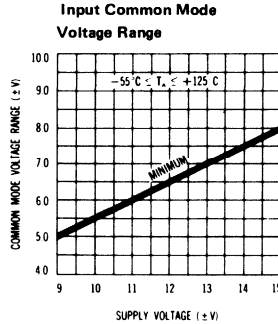
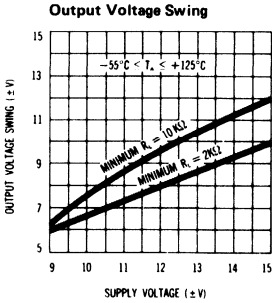
electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		0.6	2.0	mV
Input Bias Current	$T_A = 25^\circ\text{C}$		100	200	nA
Input Offset Current	$T_A = 25^\circ\text{C}$		10	50	nA
Input Resistance	$T_A = 25^\circ\text{C}$	350	700		k Ω
Output Resistance	$T_A = 25^\circ\text{C}$		150		Ω
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		2.5	3.6	mA
Transient Response	$V_{IN} = 20\text{ mV}$, $C_L \leq 100\text{ pF}$				
Risetime	$T_A = 25^\circ\text{C}$			1.5	μs
Overshoot				30	%
Slewing Rate	$T_A = 25^\circ\text{C}$		0.25		V/ μs
Input Offset Voltage	$R_S \leq 10\text{ k}\Omega$			3.0	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S = 50\text{ k}\Omega$ $T_A = 25^\circ\text{C}$ to +125°C		1.8	10	$\mu\text{V}/^\circ\text{C}$
	$T_A = 25^\circ\text{C}$ to -55°C		1.8	10	$\mu\text{V}/^\circ\text{C}$
	$R_S = 10\text{ k}\Omega$ $T_A = 25^\circ\text{C}$ to +125°C		2.0	15	$\mu\text{V}/^\circ\text{C}$
	$T_A = 25^\circ\text{C}$ to -55°C		4.8	25	$\mu\text{V}/^\circ\text{C}$
Large-Signal Voltage Gain	$V_S = \pm 15\text{V}$, $R_L \geq 2\text{ k}\Omega$	25,000		70,000	
	$V_{OUT} = \pm 10\text{V}$				
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	±12	±14		V
	$V_S = \pm 15\text{V}$, $R_L = 2\text{ k}\Omega$	±10	±13		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±8.0			V
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	80	110		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\text{ k}\Omega$		40	100	$\mu\text{V}/\text{V}$
Input Offset Current	$T_A = +125^\circ\text{C}$		3.5	5.0	nA
	$T_A = -55^\circ\text{C}$		40	250	nA
Input Bias Current	$T_A = -55^\circ\text{C}$		300	600	nA
Input Resistance	$T_A = -55^\circ\text{C}$	85	170		k Ω

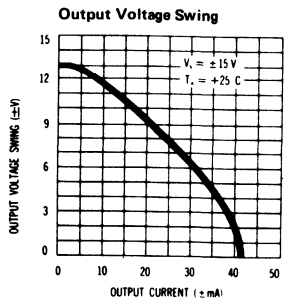
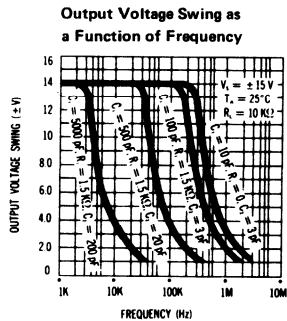
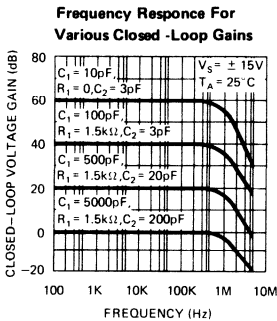
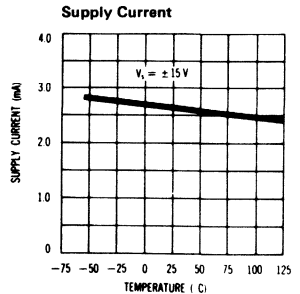
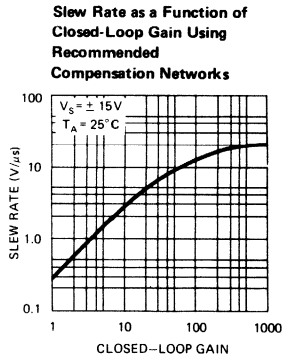
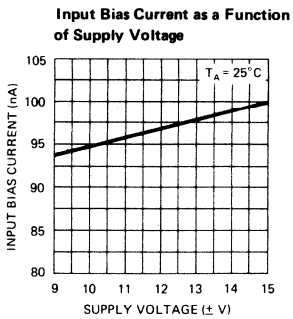
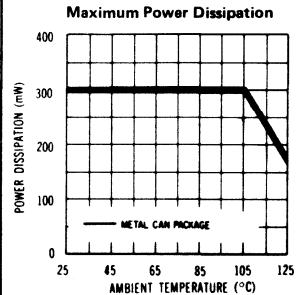
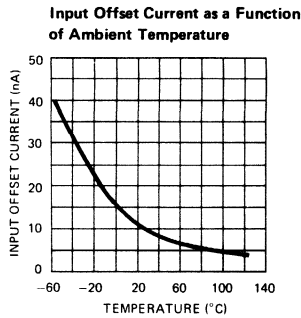
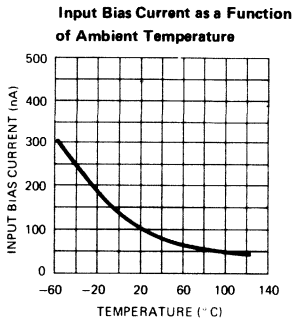
Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case for the metal-can package.

Note 2: These specifications apply for $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$, $\pm 9\text{V} \leq V_S \leq \pm 15\text{V}$, $C_1 = 5000\text{ pF}$, $R_1 = 1.5\text{K}$, $C_2 = 200\text{ pF}$ and $R_2 = 51\text{ k}\Omega$ unless otherwise specified.

guaranteed performance characteristics



typical performance characteristics





Operational Amplifiers

LM709C operational amplifier

general description

The LM709C is a monolithic operational amplifier intended for general-purpose applications. Operation is completely specified over the range of voltages commonly used for these devices. The design, in addition to providing high gain, minimizes both offset voltage and bias currents. Further, the class-B output stage gives a large output capability with minimum power drain.

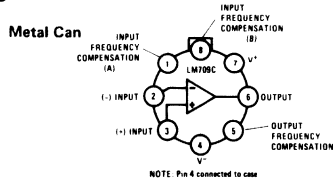
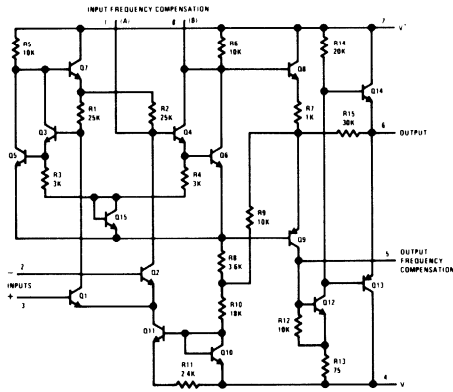
External components are used to frequency compensate the amplifier. Although the unity-gain compensation network specified will make the amplifier unconditionally stable in all feedback

configurations, compensation can be tailored to optimize high-frequency performance for any gain setting.

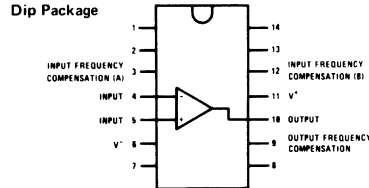
The fact that the amplifier is built on a single silicon chip provides low offset and temperature drift at minimum cost. It also ensures negligible drift due to temperature gradients in the vicinity of the amplifier.

The LM709C is commercial-industrial version of the LM709. It is identical to the LM709 except that it is specified for operation from 0°C to 70°C.

schematic** and connection diagrams



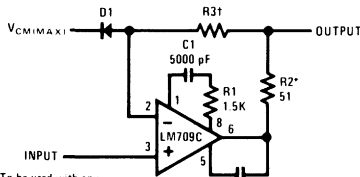
Order Number LM709CH
See Package 11



Order Number LM709CN
See Package 22

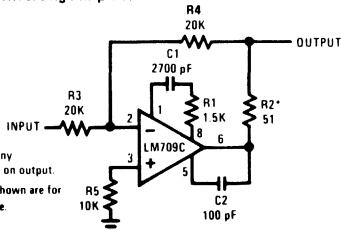
typical applications**

Voltage Follower



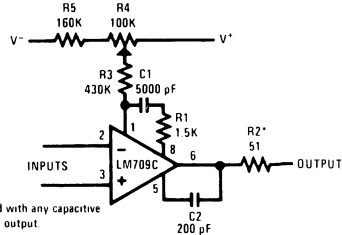
*To be used with any capacitive loading on output.
†Should be equal to dc source resistance on input.

Unity Gain Inverting Amplifier



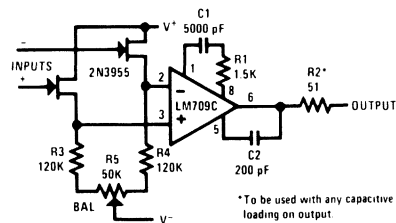
*To be used with any capacitive loading on output.
** Pin connections shown are for metal can package.

Offset Balancing Circuit



*To be used with any capacitive loading on output.

FET Operational Amplifier



*To be used with any capacitive loading on output.

absolute maximum ratings

Supply Voltage	±18V
Power Dissipation (Note 1)	250 mW
Differential Input Voltage	±5V
Input Voltage	±10V
Output Short-Circuit Duration ($T_A = 25^\circ\text{C}$)	5 sec
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	300°C

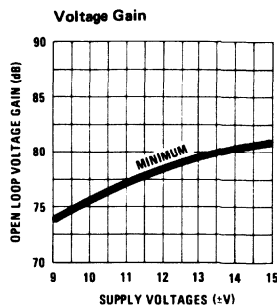
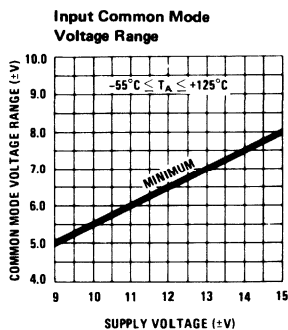
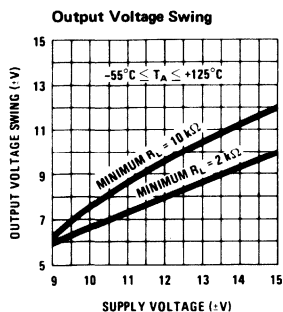
electrical characteristics (Note 2)

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		2.0	7.5	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		100	500	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		0.3	1.5	μA
Input Resistance	$T_A = 25^\circ\text{C}$	50	250		$\text{k}\Omega$
Output Resistance	$T_A = 25^\circ\text{C}$		150		Ω
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		2.6	6.6	mA
Transient Response	$V_{IN} = 20\text{ mV}$, $C_L \leq 100\text{ pF}$				
Risettime	$T_A = 25^\circ\text{C}$		0.3	1.0	μs
Overshoot			10	30	%
Slewing Rate	$T_A = 25^\circ\text{C}$		0.25		V/ μs
Input Offset Voltage	$R_S \leq 10\text{ k}\Omega$			10	mV
Average Temperature					
Coefficient of Input	$R_S = 50\Omega$		6.0		$\mu\text{V}/^\circ\text{C}$
Offset Voltage	$R_S = 10\text{ k}\Omega$		12		$\mu\text{V}/^\circ\text{C}$
Large-Signal	$V_S = \pm 15\text{V}$, $R_L \geq 2\text{ k}\Omega$				
Voltage Gain	$V_{OUT} = \pm 10\text{V}$	15,000	45,000		
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	±12	±14		V
	$V_S = \pm 15\text{V}$, $R_L = 2\text{ k}\Omega$	±10	±13		V
Input Voltage Range	$V_S = \pm 15\text{V}$	±8.0	±10		V
Common Mode					
Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	65	90		dB
Supply Voltage					
Rejection Ratio	$R_S \leq 10\text{ k}\Omega$		25	200	$\mu\text{V}/\text{V}$
Input Offset Current	$T_A = +70^\circ\text{C}$		75	400	nA
	$T_A = 0^\circ\text{C}$		125	750	nA
Input Bias Current	$T_A = 0^\circ\text{C}$		0.36	2.0	μA

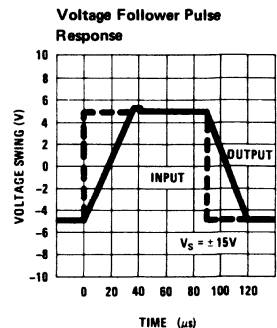
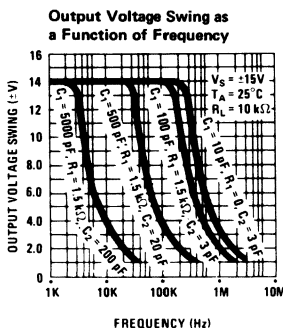
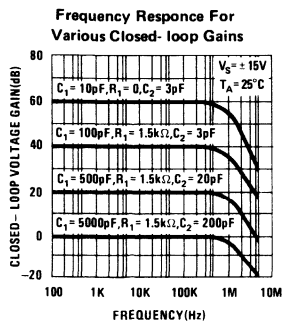
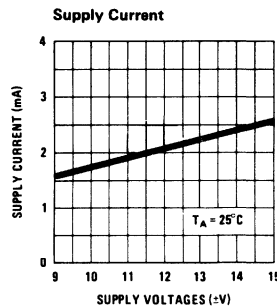
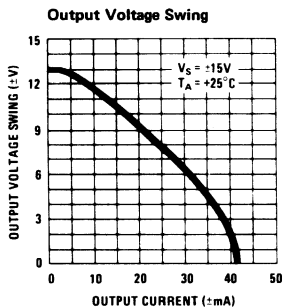
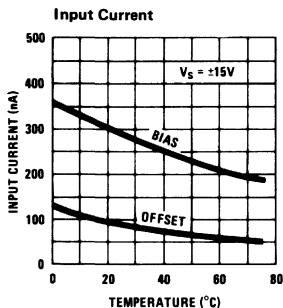
Note 1: For operating at elevated temperatures, the device must be derated based on a 100°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient for the metal can package. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick, epoxy-glass board with ten, 0.03-inch-wide, 2-ounce copper conductors.

Note 2: These specifications apply for $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$, $\pm 9\text{V} \leq V_S \leq \pm 15\text{V}$, $C_1 = 5000\text{ pF}$, $R_1 = 1.5\text{K}$, $C_2 = 200\text{ pF}$ and $R_2 = 511\Omega$ unless otherwise specified.

guaranteed performance characteristics



typical performance characteristics





Operational Amplifiers

LM725A/LM725/LM725C

LM725A/LM725/LM725C instrumentation operational amplifier

general description

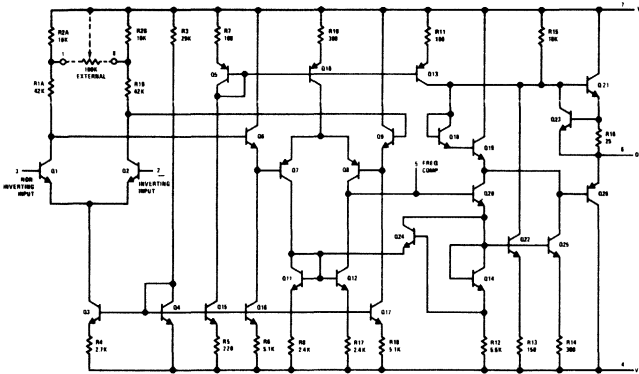
The LM725A/LM725/LM725C are operational amplifiers featuring superior performance in applications where low noise, low drift, and accurate closed-loop gain are required. With high common mode rejection and offset null capability, it is especially suited for low level instrumentation applications over a wide supply voltage range.

The LM725A has tightened electrical performance with higher input accuracy and like the LM725, is guaranteed over a -55°C to $+125^{\circ}\text{C}$ temperature range. The LM725C has slightly relaxed specifications and has its performance guaranteed over a 0°C to 70°C temperature range.

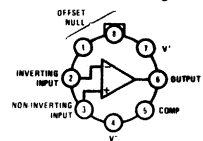
features

- High open loop gain 3,000,000
- Low input voltage drift $0.6 \mu\text{V}/^{\circ}\text{C}$
- High common mode rejection 120 dB
- Low input noise current $0.15 \text{ pA}/\sqrt{\text{Hz}}$
- Low input offset current 2 nA
- High input voltage range $\pm 14\text{V}$
- Wide power supply range $\pm 3\text{V}$ to $\pm 22\text{V}$
- Offset null capability
- Output short circuit protection

schematic and connection diagrams



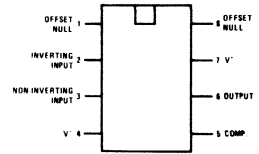
Metal Can Package



TOP VIEW

Order Number LM725H or LM725AH or LM725CH
See Package 11

Dual-In-Line Package

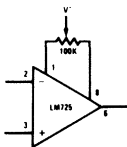


TOP VIEW

Order Number LM725CN
See Package 20

auxiliary circuits

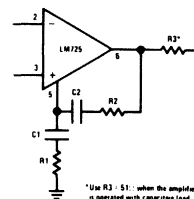
Voltage Offset Null Circuit



Compensation Component Values

A_{VCL}	R1 (Ω)	C1 (μF)	R2 (Ω)	C2 (μF)
10,000	10K	50 pF	—	—
1,000	470	.001	—	—
100	47	.01	—	—
10	27	.05	270	.0015
1	10	.05	39	.02

Frequency Compensation Circuit



*Use R3 = 51 Ω when the amplifier is operated with capacitive load

2

LM725A

absolute maximum ratings

Supply Voltage	±22V
Internal Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±5V
Input Voltage (Note 2)	±22V
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	-55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Without External Trim)	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$			0.5	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		2.0	5.0	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		42	80	nA
Input Noise Voltage	$T_A = 25^\circ\text{C}$, $f_o = 10\text{ Hz}$		15		$\text{nV}/\sqrt{\text{Hz}}$
	$f_o = 100\text{ Hz}$		9.0		$\text{nV}/\sqrt{\text{Hz}}$
	$f_o = 1\text{ kHz}$		8.0		$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Current	$T_A = 25^\circ\text{C}$, $f_o = 10\text{ Hz}$		1.0		$\text{pA}/\sqrt{\text{Hz}}$
	$f_o = 100\text{ Hz}$		0.3		$\text{pA}/\sqrt{\text{Hz}}$
	$f_o = 1\text{ kHz}$		0.15		$\text{pA}/\sqrt{\text{Hz}}$
Input Resistance	$T_A = 25^\circ\text{C}$		1.5		M Ω
Input Voltage Range	$T_A = 25^\circ\text{C}$	±13.5	±14		V
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $R_L \geq 2\text{ k}\Omega$, $V_{\text{OUT}} = \pm 10\text{V}$	1,000,000	3,000,000		
Common Mode Rejection Ratio	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$	120			dB
Power Supply Rejection Ratio	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		2.0	5.0	$\mu\text{V}/\text{V}$
Output Voltage Swing	$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$	±12.5	±13.5		V
	$R_L \geq 2\text{ k}\Omega$	±12.0	±13.5		V
Power Consumption	$T_A = 25^\circ\text{C}$		80	105	mW
Input Offset Voltage (Without External Trim)	$R_S \leq 10\text{ k}\Omega$			0.7	mV
Average Input Offset Voltage Drift (Without External Trim)	$R_S = 50\Omega$			2.0	$\mu\text{V}/^\circ\text{C}$
Average Input Offset Voltage Drift (With External Trim)	$R_S = 50\Omega$		0.6	1.0	$\mu\text{V}/^\circ\text{C}$
Input Offset Current	$T_A = +125^\circ\text{C}$		1.2	4.0	nA
	$T_A = -55^\circ\text{C}$		7.5	18.0	nA
Average Input Offset Current Drift			35	90	$\text{pA}/^\circ\text{C}$
Input Bias Current	$T_A = +125^\circ\text{C}$		20	70	nA
	$T_A = -55^\circ\text{C}$		80	180	nA
Large Signal Voltage Gain	$R_L \geq 2\text{ k}\Omega$, $T_A = +125^\circ\text{C}$	1,000,000			
	$R_L \geq 2\text{ k}\Omega$, $T_A = -55^\circ\text{C}$	500,000			
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	110			dB
Power Supply Rejection Ratio	$R_S \leq 10\text{ k}\Omega$			8.0	$\mu\text{V}/\text{V}$
Output Voltage Swing	$R_L \geq 2\text{ k}\Omega$	±12			V

Note 1: Derate at 150°C/W for operation at ambient temperatures above 75°C.

Note 2: For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: These specifications apply for $V_S = \pm 15\text{V}$ unless otherwise specified.

LM725

absolute maximum ratings

Supply Voltage	±22V
Internal Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±5V
Input Voltage (Note 2)	±22V
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	-55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Without External Trim)	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		0.5	1.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		2.0	20	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		42	100	nA
Input Noise Voltage	$T_A = 25^\circ\text{C}$, $f_o = 10\text{ Hz}$		15		$\text{nV}/\sqrt{\text{Hz}}$
	$f_o = 100\text{ Hz}$		9.0		$\text{nV}/\sqrt{\text{Hz}}$
	$f_o = 1\text{ kHz}$		8.0		$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Current	$T_A = 25^\circ\text{C}$, $f_o = 10\text{ Hz}$		1.0		$\text{pA}/\sqrt{\text{Hz}}$
	$f_o = 100\text{ Hz}$		0.3		$\text{pA}/\sqrt{\text{Hz}}$
	$f_o = 1\text{ kHz}$		0.15		$\text{pA}/\sqrt{\text{Hz}}$
Input Resistance	$T_A = 25^\circ\text{C}$		1.5		M Ω
Input Voltage Range	$T_A = 25^\circ\text{C}$	±13.5	±14		V
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $R_L \geq 2\text{ k}\Omega$, $V_{OUT} = \pm 10\text{V}$	1,000,000	3,000,000		
Common Mode Rejection Ratio	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$	110	120		dB
Power Supply Rejection Ratio	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		2.0	10	$\mu\text{V}/\text{V}$
Output Voltage Swing	$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$	±12	±13.5		V
	$R_L \geq 2\text{ k}\Omega$	±10	±13.5		V
Power Consumption	$T_A = 25^\circ\text{C}$		80	105	mW
Input Offset Voltage (Without External Trim)	$R_S \leq 10\text{ k}\Omega$			1.5	mV
Average Input Offset Voltage Drift (Without External Trim)	$R_S = 50\Omega$		2.0	5.0	$\mu\text{V}/^\circ\text{C}$
Average Input Offset Voltage Drift (With External Trim)	$R_S = 50\Omega$		0.6		$\mu\text{V}/^\circ\text{C}$
Input Offset Current	$T_A = +125^\circ\text{C}$		1.2	20	nA
	$T_A = -55^\circ\text{C}$		7.5	40	nA
Average Input Offset Current Drift			35	150	$\text{pA}/^\circ\text{C}$
Input Bias Current	$T_A = +125^\circ\text{C}$		20	100	nA
	$T_A = -55^\circ\text{C}$		80	200	nA
Large Signal Voltage Gain	$R_L \geq 2\text{ k}\Omega$, $T_A = +125^\circ\text{C}$	1,000,000			
	$R_L \geq 2\text{ k}\Omega$, $T_A = -55^\circ\text{C}$	250,000			
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	100			dB
Power Supply Rejection Ratio	$R_S \leq 10\text{ k}\Omega$			20	$\mu\text{V}/\text{V}$
Output Voltage Swing	$R_L \geq 2\text{ k}\Omega$	±10			V

Note 1: Derate at 150°C/W for operation at ambient temperatures above 75°C.

Note 2: For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: These specifications apply for $V_S = \pm 15\text{V}$ unless otherwise specified.

LM725C

absolute maximum ratings

Supply Voltage	±22V
Internal Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±5V
Input Voltage (Note 2)	±22V
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Without External Trim)	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		0.5	2.5	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		2.0	35	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		42	125	nA
Input Noise Voltage	$T_A = 25^\circ\text{C}$, $f_o = 10\text{ Hz}$		15		$\text{nV}/\sqrt{\text{Hz}}$
	$f_o = 100\text{ Hz}$		9.0		$\text{nV}/\sqrt{\text{Hz}}$
	$f_o = 1\text{ kHz}$		8.0		$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Current	$T_A = 25^\circ\text{C}$, $f_o = 10\text{ Hz}$		1.0		$\text{pA}/\sqrt{\text{Hz}}$
	$f_o = 100\text{ Hz}$		0.3		$\text{pA}/\sqrt{\text{Hz}}$
	$f_o = 1\text{ kHz}$		0.15		$\text{pA}/\sqrt{\text{Hz}}$
Input Resistance	$T_A = 25^\circ\text{C}$		1.5		M Ω
Input Voltage Range	$T_A = 25^\circ\text{C}$	±13.5	±14		V
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $R_L \geq 2\text{ k}\Omega$, $V_{\text{OUT}} = \pm 10\text{V}$	250,000	3,000,000		
Common Mode Rejection Ratio	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$	94	120		dB
Power Supply Rejection Ratio	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		2.0	35	$\mu\text{V}/\text{V}$
Output Voltage Swing	$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$	±12	±13.5		V
	$R_L \geq 2\text{ k}\Omega$	±10	±13.5		V
Power Consumption	$T_A = 25^\circ\text{C}$		80	150	mW
Input Offset Voltage (Without External Trim)	$R_S \leq 10\text{ k}\Omega$			3.5	mV
Average Input Offset Voltage Drift (Without External Trim)	$R_S = 50\Omega$		2.0		$\mu\text{V}/^\circ\text{C}$
Average Input Offset Voltage Drift (With External Trim)	$R_S = 50\Omega$		0.6		$\mu\text{V}/^\circ\text{C}$
Input Offset Current	$T_A = +70^\circ\text{C}$		1.2	35	nA
	$T_A = 0^\circ\text{C}$		4.0	50	nA
Average Input Offset Current Drift			10		$\text{pA}/^\circ\text{C}$
Input Bias Current	$T_A = +70^\circ\text{C}$			125	nA
	$T_A = 0^\circ\text{C}$			250	nA
Large Signal Voltage Gain	$R_L \geq 2\text{ k}\Omega$, $T_A = +70^\circ\text{C}$	125,000			
	$R_L \geq 2\text{ k}\Omega$, $T_A = 0^\circ\text{C}$	125,000			
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$		115		dB
Power Supply Rejection Ratio	$R_S \leq 10\text{ k}\Omega$		20		$\mu\text{V}/\text{V}$
Output Voltage Swing	$R_L \geq 2\text{ k}\Omega$	±10			V

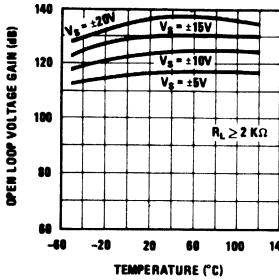
Note 1: Rating applies for case temperature to 70°C.

Note 2: For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.

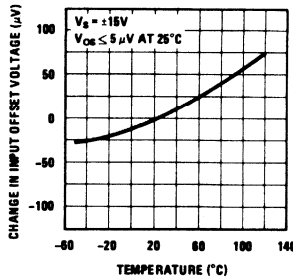
Note 3: These specifications apply for $V_S = \pm 15\text{V}$ unless otherwise specified.

typical performance characteristics

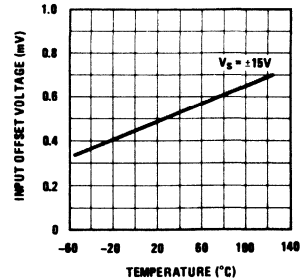
Open Loop Voltage Gain vs Temperature for Various Supply Voltages



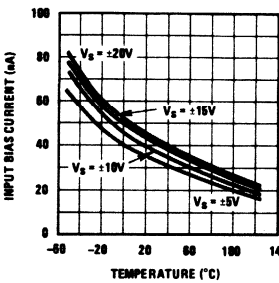
Nulled Input Offset Voltage vs Temperature



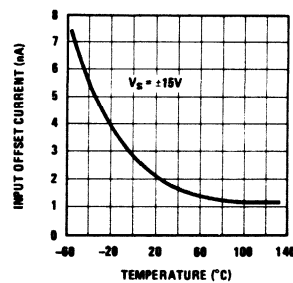
Unnulled Input Offset Voltage vs Temperature



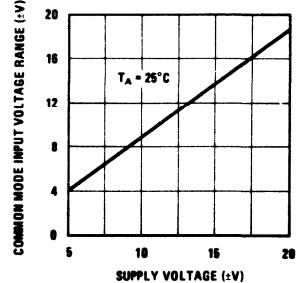
Input Bias Current vs Temperature



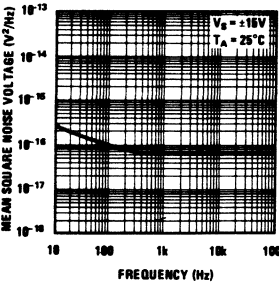
Input Offset Current vs Temperature



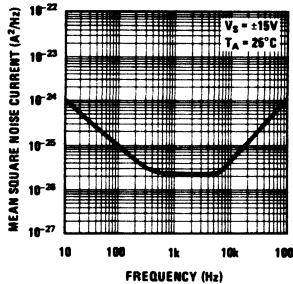
Common Mode Input Voltage vs Supply Voltage



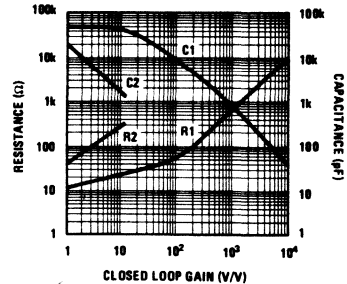
Input Noise Voltage vs Frequency



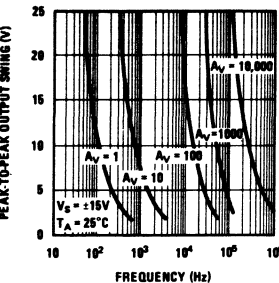
Input Noise Current vs Frequency



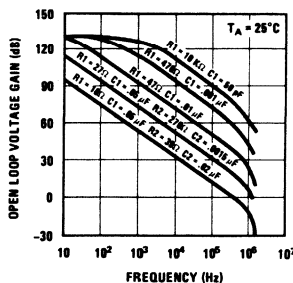
Values for Suggested Compensation Networks for Various Closed Loop Voltage Gains



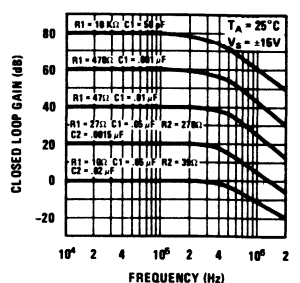
Output Voltage Swing vs Frequency for Recommended Compensation Networks



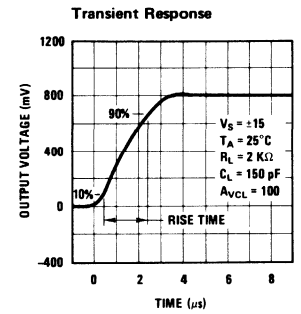
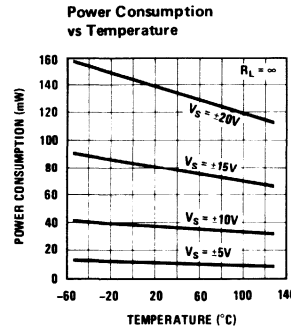
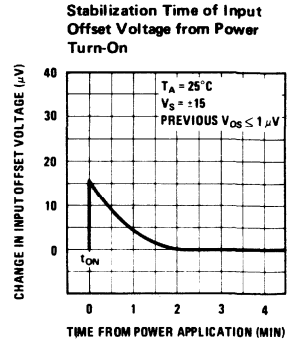
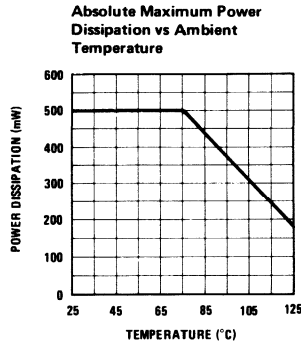
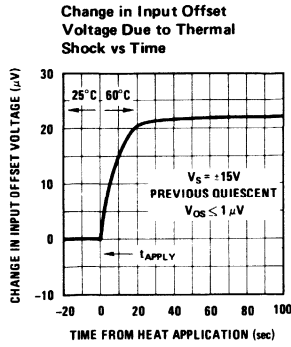
Open Loop Voltage Gain vs Frequency Using Recommended Compensation Networks



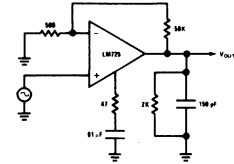
Frequency Response for Various Closed-Loop Gains Using Recommended Compensation Networks



typical performance characteristics (con't)



Transient Response Test Circuit





Operational Amplifiers

LH740A/LH740AC

LH740A/LH740AC FET input operational amplifier

general description

The LH740A/LH740AC is a FET input, general purpose operational amplifier with high input impedance, closely matched input characteristics, and good slew rates. Input offset voltage is typically 10.0 mV at 25°C, while input bias current is less than 100 pA at 25°C. Offset current is typically less than 40 pA at 25°C. Other important design features include:

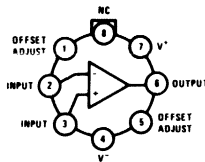
- Internal 6 dB/octave frequency compensation
- Unity gain slew rate in excess of 6 V/μs
- Unity gain bandwidth of 1 MHz
- Input offset is adjustable with a single 10k pot
- Pin compatible with LM741, LM709, LM101A, and μA740
- Excellent offset current match over temperature, typically 100 pA

- Output is continuously short-circuit proof
- Excellent open loop gain, typically in excess of 100 dB
- Guaranteed over the full military temperature range

The LH740A/LH740AC is intended to fulfill a wide variety of applications requiring extremely low bias currents such as integrators, sample and hold amplifiers, and general purpose operational amplifier applications.

The LH740A is specified for operation over the -55°C to +125°C military temperature range. The LH740AC is specified for operation over the 0°C to +85°C temperature range.

connection diagram

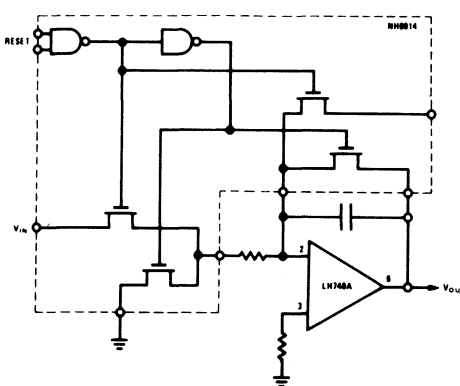


TOP VIEW

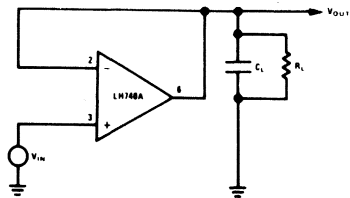
Order Number LH740AH or LH740ACH
See Package 11

typical applications

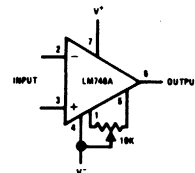
Integrator



Transient Response



Offset Null



2

absolute maximum ratings

Supply Voltage		±22V
Maximum Power Dissipation		500 mW
Differential Input Voltage		±5V
Input Voltage		±15V
Short Circuit Duration		Continuous
Operating Temperature Range	LH740A	-55°C to +125°C
	LH740AC	0°C to +85°C
Storage Temperature Range		-65°C to +150°C
Lead Temperature (soldering, 10 sec.)		300°C

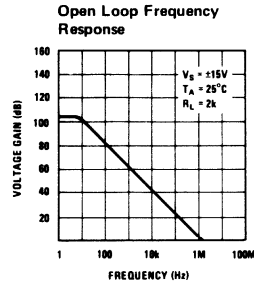
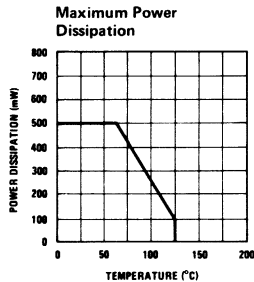
electrical characteristics (Notes 1 & 2) ($V_S = \pm 15V$, $T_A = 25^\circ C$ unless otherwise noted)

PARAMETER	CONDITIONS	LH740A			LH740AC			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 100 \text{ k}\Omega$		10	15		10	20	mV
Input Offset Current			40	100		60	150	pA
Input Current (either input)			100	200		100	500	pA
Input Resistance			1,000,000			1,000,000		M Ω
Large Signal Voltage Gain	$R_L \geq 2 \text{ k}\Omega$, $V_{OUT} = \pm 10V$	50,000	100,000		50,000	100,000		V/V
Output Resistance			75			75		Ω
Output Short Circuit Current			20			20		mA
Common Mode Rejection Ratio		80			80			dB
Supply Voltage Rejection Ratio		80			80			dB
Supply Current			3.0	4.0		3.0	4.0	mA
Slew Rate			6.0			6.0		V/ μ s
Unity Gain Bandwidth			1.0			1.0		MHz
Transient Response (Unity Gain)	$C_L \leq 100 \text{ pF}$, $R_L = 2 \text{ k}\Omega$, $V_{IN} = 100 \text{ mV}$		110			300		ns
Risetime			10	20		10		%
Overshoot								
(These specifications apply for $-55^\circ C \leq T_A \leq 125^\circ C$ for the LH740A and $0^\circ C \leq T_A \leq 85^\circ C$ for the LH740AC unless otherwise noted.)								
Input Voltage Range		±12			±12			V
Common Mode Rejection Ratio		80			80			dB
Supply Voltage Rejection Ratio		80			80			dB
Large Signal Voltage Gain		40,000			40,000			V/V
Output Voltage Swing	$R_L \geq 10 \text{ k}\Omega$		±12			±14		V
	$R_L \geq 2 \text{ k}\Omega$		±10			±13		V
Input Offset Voltage			15	20		30		mV
Input Offset Current			100	500		60	500	pA
Input Current (either input)			2.5	4.0		1.1	5.0	nA
Offset Voltage Drift	$R_S \leq 100K$		5.0			5.0		μ V/ $^\circ$ C

Note 1: Unless otherwise noted these specifications apply to $\pm 5V \leq V_S \leq \pm 20V$ and $-55^\circ C$ to $+125^\circ C$ for the LH740A and $0^\circ C$ to $85^\circ C$ for the LH740AC.

Note 2: For supply voltages less than $\pm 10V$, the absolute maximum input voltage is equal to the supply voltage.

typical performance characteristics





Operational Amplifiers

LM741/LM741C operational amplifier

general description

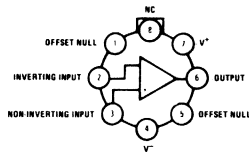
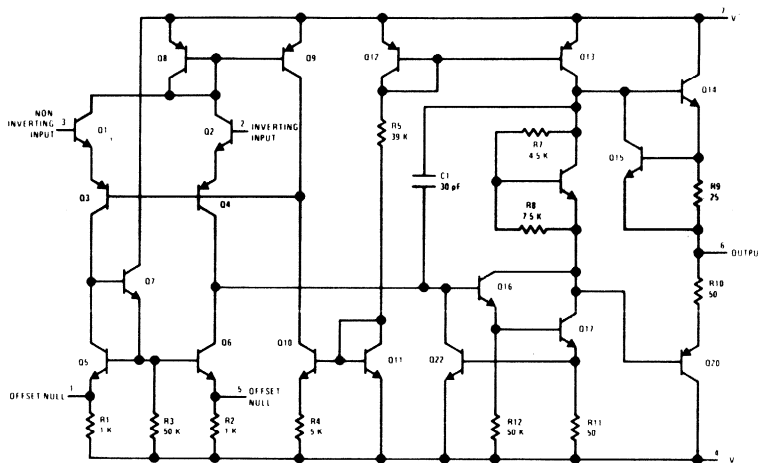
The LM741 and LM741C are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications.

The offset voltage and offset current are guaranteed over the entire common mode range. The amplifiers also offer many features which make

their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

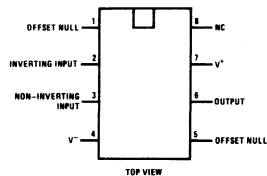
The LM741C is identical to the LM741 except that the LM741C has its performance guaranteed over a 0°C to 70°C temperature range, instead of -55°C to 125°C.

schematic and connection diagrams

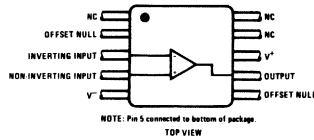


NOTE: Pin 4 connected to com.
TOP VIEW

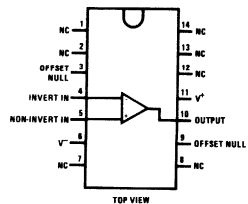
Order Number LM741H or LM741CH
See Package 11



Order Number LM741CN
See Package 20



NOTE: Pin 5 connected to bottom of package.
TOP VIEW
Order Number LM741C
See Package 3



Order Number LM741CD or LM741CN-14
See Package 1 See Package 22

absolute maximum ratings

Supply Voltage	LM741	±22V
	LM741C	±18V
Power Dissipation (Note 1)		500 mW
Differential Input Voltage		±30V
Input Voltage (Note 2)		±15V
Output Short Circuit Duration		Indefinite
Operating Temperature Range	LM741	-55°C to 125°C
	LM741C	0°C to 70°C
Storage Temperature Range		-65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	LM741			LM741C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		1.0	5.0		1.0	6.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		30	200		30	200	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		200	500		200	500	nA
Input Resistance	$T_A = 25^\circ\text{C}$	0.3	1.0		0.3	1.0		M Ω
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		1.7	2.8		1.7	2.8	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 2\text{ k}\Omega$	50	160		25	160		V/mV
Input Offset Voltage	$R_S \leq 10\text{ k}\Omega$			6.0			7.5	mV
Input Offset Current				500			300	nA
Input Bias Current				1.5			0.8	μA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 2\text{ k}\Omega$	25			15			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	±12 ±10	±14 ±13		±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15\text{V}$	±12			±12			V
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	77	96		77	96		dB

Note 1: The maximum junction temperature of the LM741 is 150°C, while that of the LM741C is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to case.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: These specifications apply for $V_S = \pm 15\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM741C, however, all specifications are limited to $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ and $V_S = \pm 15\text{V}$.



Operational Amplifiers

LM747/LM747C

LM747/LM747C dual operational amplifier

general description

The LM747 and the LM747C are general purpose dual operational amplifiers. The two amplifiers share a common bias network and power supply leads. Otherwise, their operation is completely independent.

- Low-power consumption
- No latch-up
- Balanced offset null

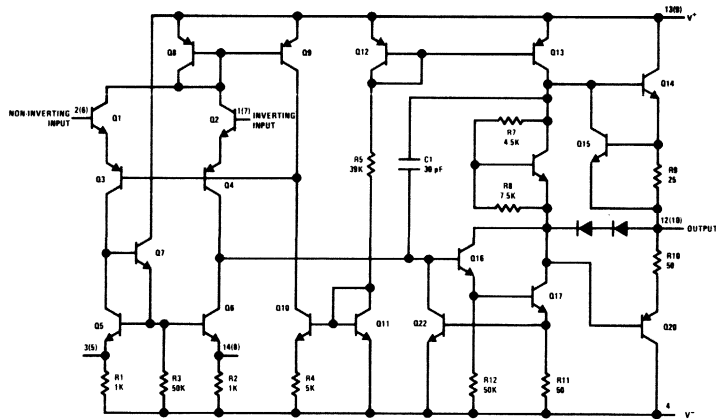
features

- No frequency compensation required
- Short-circuit protection
- Wide common-mode and differential voltage ranges

Additional features of the LM747 and LM747C are: no latch-up when input common mode range is exceeded, freedom from oscillations, and package flexibility.

The LM747C is identical to the LM747 except that the LM747C has its specifications guaranteed over the temperature range from 0°C to 70°C instead of -55°C to +125°C.

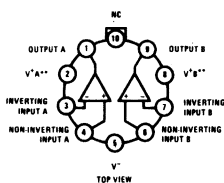
schematic diagram (each amplifier)



Note: Numbers in Parentheses Are Pin Numbers for Amplifier B. DIP Only

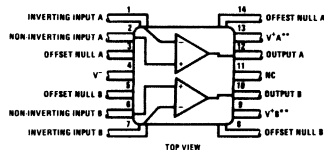
connection diagrams

Metal Can Package



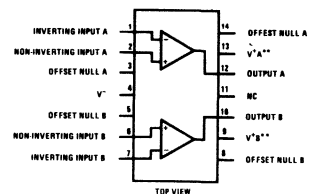
Order Number LM747H or LM747CH
See Package 14

Flat Package



Order Number LM747F or LM747FC
See Package 4

Dual-In-Line Packages



Order Number LM747D or LM747CD
See Package 1
Order Number LM747CN
See Package 22

**V'A and V'B are internally connected.

2

absolute maximum ratings

Supply Voltage	LM747	±22V
	LM747C	±18V
Power Dissipation (Note 1)		800 mW
Differential Input Voltage		±30V
Input Voltage (Note 2)		±15V
Output Short-Circuit Duration		Indefinite
Operating Temperature Range	LM747	-55°C to 125°C
	LM747C	0°C to 70°C
Storage Temperature Range		-65°C to 150°C
Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	LM747			LM747C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		1.0	5.0		1.0	6.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		80	200		80	200	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		200	500		200	500	nA
Input Resistance	$T_A = 25^\circ\text{C}$	0.3	1.0		0.3	1.0		M Ω
Supply Current Both Amplifiers	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		3.0	5.6		3.0	5.6	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 2\text{ k}\Omega$	50	160		50	160		V/mV
Input Offset Voltage	$R_S \leq 10\text{ k}\Omega$			6.0			7.5	mV
Input Offset Current				500			300	nA
Input Bias Current				1.5			0.8	μA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 2\text{ k}\Omega$	25			25			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	±12 ±10	±14 ±13		±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15\text{V}$	±12			±12			V
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	77	96		77	96		dB

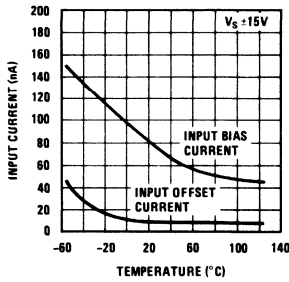
Note 1: The maximum junction temperature of the LM747 is 150°C, while that of the LM747C is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

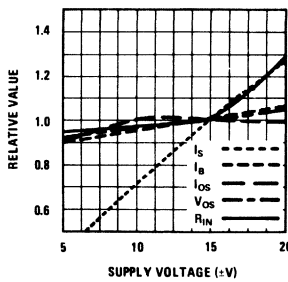
Note 3: These specifications apply for $V_S = \pm 15\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM747C, however, all specifications are limited to $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ $V_S = \pm 15\text{V}$.

typical performance characteristics

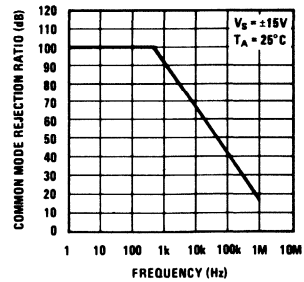
Input Bias and Offset Currents vs Ambient Temperature



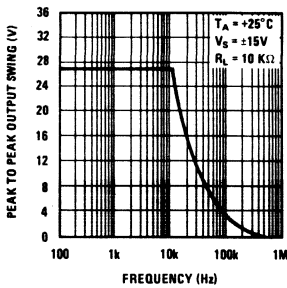
DC Parameters vs Supply Voltage



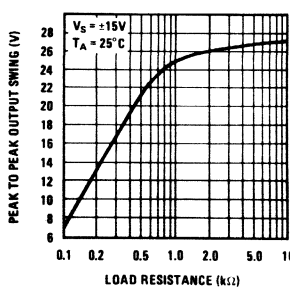
Common Mode Rejection Ratio vs Frequency



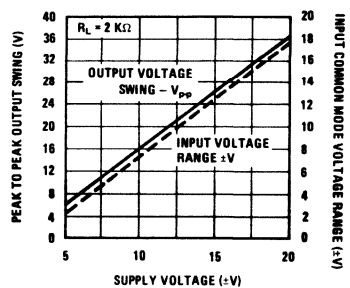
Output Voltage Swing vs Frequency



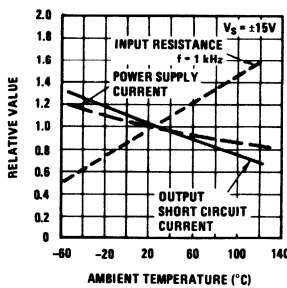
Output Voltage Swing vs Load Resistance



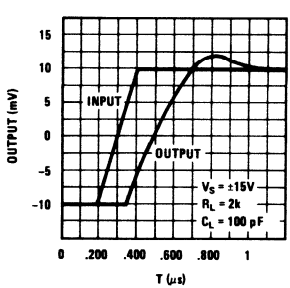
Output Swing and Input Range vs Supply Voltage



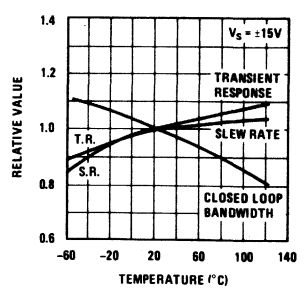
Normalized DC Parameters vs Ambient Temperature



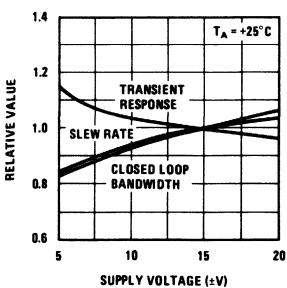
Transient Response



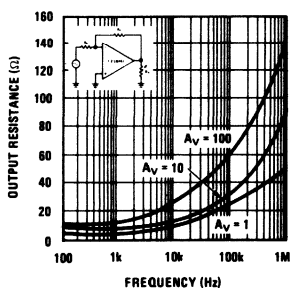
Frequency Characteristics vs Ambient Temperature



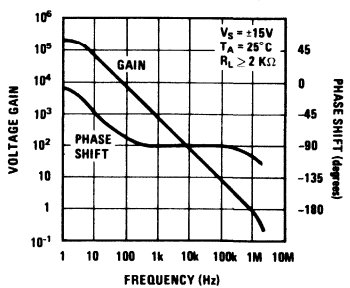
Frequency Characteristics vs Supply Voltage



Output Resistance vs Frequency

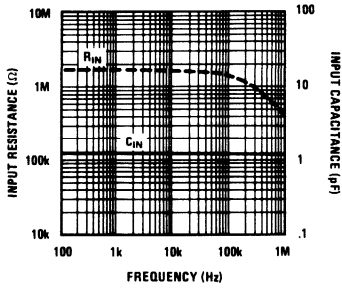


Open Loop Transfer Characteristics vs Frequency

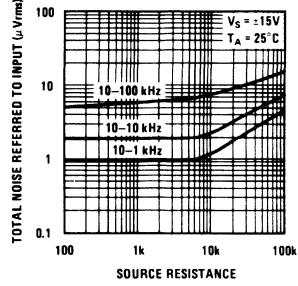


typical performance characteristics (con't)

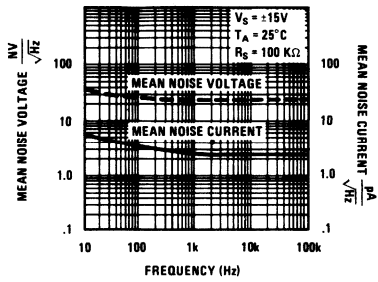
Input Resistance and Input Capacitance vs Frequency



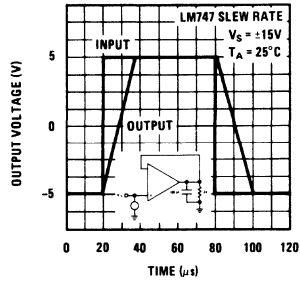
Broadband Noise for Various Bandwidths



Input Noise Voltage and Current vs Frequency



Voltage Follower Large Signal Pulse Response





Operational Amplifiers

LM748/LM748C

LM748/LM748C operational amplifier

general description

The LM748/LM748C is a general purpose operational amplifier built on a single silicon chip. The resulting close match and tight thermal coupling gives low offsets and temperature drift as well as fast recovery from thermal transients. In addition, the device features:

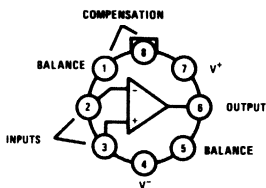
- Frequency compensation with a single 30 pF capacitor
- Operation from $\pm 5V$ to $\pm 20V$
- Low current drain: 1.8 mA at $\pm 20V$
- Continuous short-circuit protection
- Operation as a comparator with differential inputs as high as $\pm 30V$

- No latch-up when common mode range is exceeded.
- Same pin configuration as the LM101.

The unity-gain compensation specified makes the circuit stable for all feedback configurations, even with capacitive loads. However, it is possible to optimize compensation for best high frequency performance at any gain. As a comparator, the output can be clamped at any desired level to make it compatible with logic circuits.

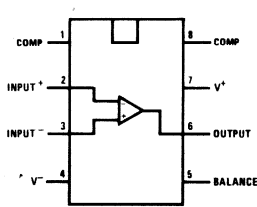
The LM748 is specified for operation over the $-55^{\circ}C$ to $+125^{\circ}C$ military temperature range. The LM748C is specified for operation over the $0^{\circ}C$ to $+70^{\circ}C$ temperature range.

connection diagrams



NOTE: Pin 4 connected to case.

Order Number LM748H or LM748CH
See Package 11



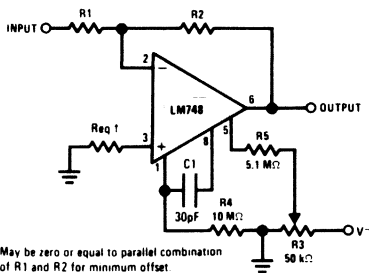
TOP VIEW

Order Number LM748CN
See Package 20

2

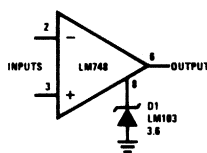
typical applications

Inverting Amplifier with Balancing Circuit

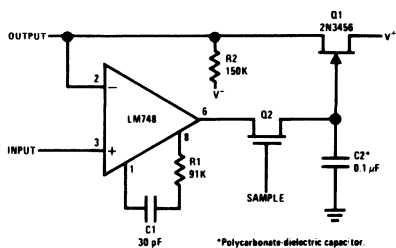


[†]May be zero or equal to parallel combination of R1 and R2 for minimum offset.

Voltage Comparator for Driving DTL or TTL Integrated Circuits

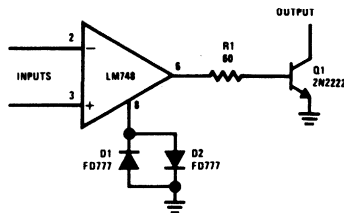


Low Drift Sample and Hold



*Polycarbonate dielectric capacitor.

Voltage Comparator for Driving RTL Logic or High Current Driver



absolute maximum ratings

Supply Voltage	±22V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range: LM748	-55°C to +125°C
LM748C	0°C to +70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		1.0	5.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		40	200	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		120	500	nA
Input Resistance	$T_A = 25^\circ\text{C}$	300	800		k Ω
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		1.8	2.8	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{\text{OUT}} = \pm 10\text{V}$, $R_L \geq 2\text{ k}\Omega$	50	160		V/mV
Input Offset Voltage	$R_S \leq 10\text{ k}\Omega$			6.0	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S \leq 50\Omega$		3.0		$\mu\text{V}/^\circ\text{C}$
	$R_S \leq 10\text{ k}\Omega$		6.0		$\mu\text{V}/^\circ\text{C}$
Input Offset Current	$T_A = 0^\circ\text{C}$ to 70°C $T_A = -55^\circ\text{C}$ to 125°C			300 500	nA nA
Input Bias Current	$T_A = 0^\circ\text{C}$ to 70°C $T_A = -55^\circ\text{C}$ to 125°C			0.8 1.5	μA μA
Supply Current	$T_A = +125^\circ\text{C}$, $V_S = \pm 15\text{V}$ $T_A = -55^\circ\text{C}$ to 125°C		1.2 1.9	2.25 3.3	mA mA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{\text{OUT}} = \pm 10\text{V}$ $R_L \geq 2\text{ k}\Omega$	25			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\Omega$ $R_L = 2\text{ k}\Omega$	±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15\text{V}$	±12			V
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	77	90		dB

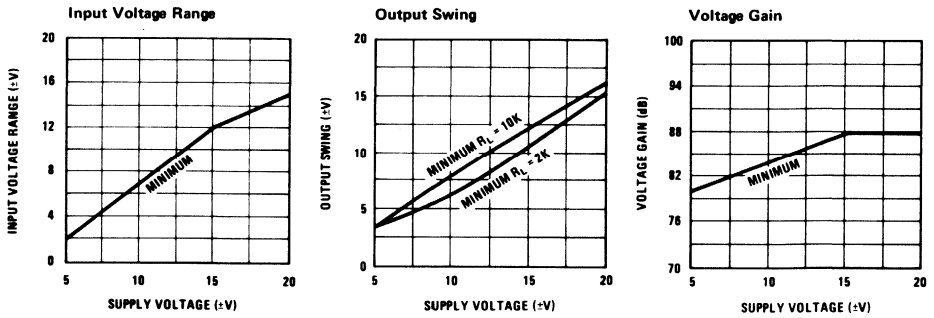
Note 1: For operating at elevated temperatures the devices must be derated based on a maximum junction to case thermal resistance of 45°C per watt, or 150°C per watt junction to ambient. (See Curves).

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

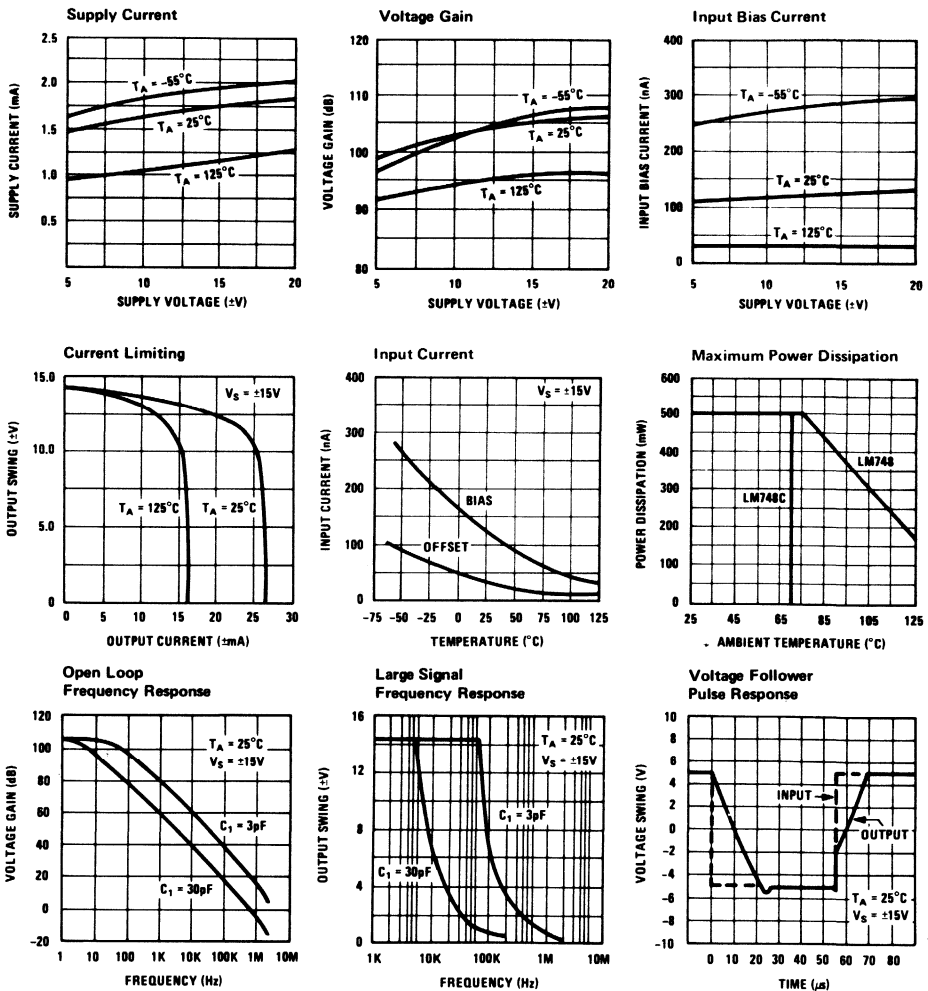
Note 3: Continuous short circuit is allowed for case temperatures to +125°C and ambient temperatures to +70°C.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq +15\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM748C, however, all temperature specifications are limited to $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$.

guaranteed performance characteristics (Note 4)



typical performance characteristics



2



Operational Amplifiers

LM1558/LM1458 dual operational amplifier

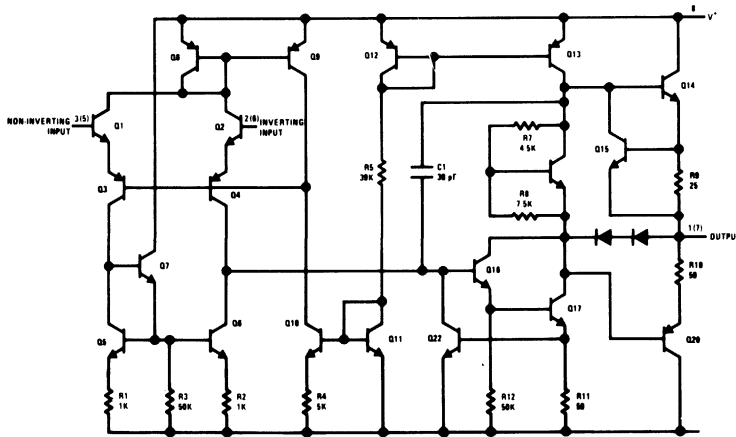
general description

The LM1558 and the LM1458 are general purpose dual operational amplifiers. The two amplifiers share a common bias network and power supply leads. Otherwise, their operation is completely independent. Features include:

- No frequency compensation required
- Short-circuit protection
- Wide common-mode and differential voltage ranges
- Low-power consumption
- 8-lead TO-5 and 8-lead mini DIP
- No latch up when input common mode range is exceeded

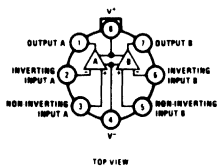
The LM1458 is identical to the LM1558 except that the LM1458 has its specifications guaranteed over the temperature range from 0°C to 70°C instead of -55°C to +125°C.

schematic and connection diagrams



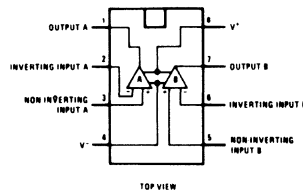
Note: Numbers in Parentheses Are Pin Numbers for Amplifier B

Metal Can Package



Order Number LM1458H or LM1558H
See Package 11

Dual-In-Line Package



Order Number LM1458N
See Package 20

absolute maximum ratings

Supply Voltage LM1558	±22V	Output Short-Circuit Duration	Indefinite
LM1458	±18V	Operating Temperature Range LM1558	-55°C to 125°C
Power Dissipation (Note 1) LM1558H/LM1458H	500 mW	LM1458	0°C to 70°C
LM1458N	400 mW	Storage Temperature Range	-65°C to 150°C
Differential Input Voltage	±30V	Lead Temperature (Soldering, 10 sec)	300°C
Input Voltage (Note 2)	±15V		

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	LM1558			LM1458			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$		1.0	5.0		1.0	6.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		80	200		80	200	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		200	500		200	500	nA
Input Resistance	$T_A = 25^\circ\text{C}$	0.3	1.0		0.3	1.0		M Ω
Supply Current Both Amplifiers	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		3.0	5.0		3.0	5.6	mA
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 2\text{ k}\Omega$	50	160		20	160		V/mV
Input Offset Voltage	$R_S \leq 10\text{ k}\Omega$			6.0			7.5	mV
Input Offset Current				500			300	nA
Input Bias Current				1.5			0.8	μA
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 2\text{ k}\Omega$	25			15			V/mV
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	±12 ±10	±14 ±13		±12 ±10	±14 ±13		V V
Input Voltage Range	$V_S = \pm 15\text{V}$	±12			±12			V
Common Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	77	96		77	96		dB

Note 1: The maximum junction temperature of the LM1558 is 150°C, while that of the LM1458 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient or 45°C/W, junction to case. For the DIP the device must be derated based on a thermal resistance of 187°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: These specifications apply for $V_S = \pm 15\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM1458, however, all specifications are limited to $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ and $V_S = \pm 15\text{V}$.



Operational Amplifiers

LH2101A/LH2201A/LH2301A dual high performance op amp general description

The LH2101A series of dual operational amplifiers are two LM101A type op amps in a single hermetic package. Featuring all the same performance characteristics of the single, these duals offer in addition closer thermal tracking, lower weight, reduced insertion cost, and smaller size than two singles. For additional information, see the LM101A data sheet and National's Linear Application Handbook.

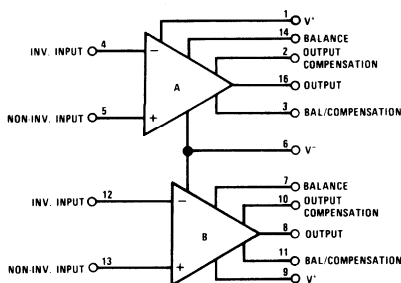
The LH2101A is specified for operation over the -55°C to +125°C military temperature range. The LH2201A is specified for operation over the

-25°C to +85°C temperature range. The LH2301A is specified for operation over the 0°C to +70°C temperature range.

features

- Low offset voltage
- Low offset current
- Guaranteed drift characteristics
- Offsets guaranteed over entire common mode and supply voltage ranges
- Slew rate of 10V/μs as a summing amplifier

connection diagram

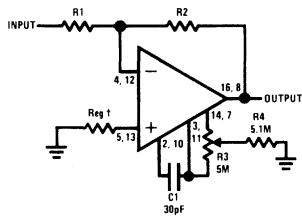


Order Number LH2101AD or LH2201AD or LH2301AD
See Package 2

Order Number LH2101AF or LH2201AF or LH2301AF
See Package 5

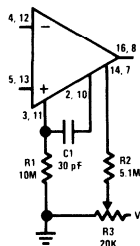
auxiliary circuits

Inverting Amplifier with Balancing Circuit

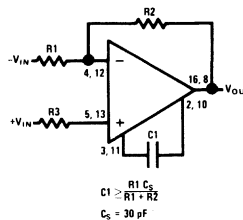


*May be zero or equal to parallel combination of R1 and R2 for minimum offset

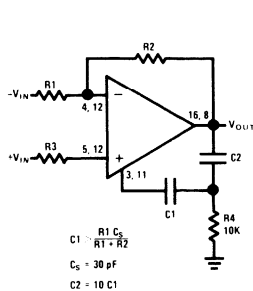
Alternate Balancing Circuit



Single Pole Compensation

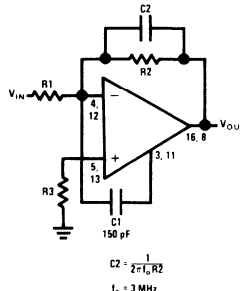


Two Pole Compensation



$C1 = \frac{R1 C2}{R1 + R2}$
 $C2 = 30 \text{ pF}$
 $C2 = 10 C1$

Feedforward Compensation



$C2 = \frac{1}{2f_c R2}$
 $f_c = 3 \text{ MHz}$

absolute maximum ratings

Supply Voltage	±22V	Operating Temperature Range	LH2101A	-55°C to 125°C
Power Dissipation (Note 1)	500 mW		LH2201A	-25°C to 85°C
Differential Input Voltage	±30V		LH2301A	0°C to 70°C
Input Voltage (Note 2)	±15V	Storage Temperature Range		-65°C to 150°C
Output Short-Circuit Duration	Continuous	Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics each side (Note 3)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LH2101A	LH2201A	LH2301A	
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 50\text{ k}\Omega$	2.0	2.0	7.5	mV Max
Input Offset Current	$T_A = 25^\circ\text{C}$	10	10	50	nA Max
Input Bias Current	$T_A = 25^\circ\text{C}$	75	75	250	nA Max
Input Resistance	$T_A = 25^\circ\text{C}$	1.5	1.5	0.5	M Ω Min
Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 20\text{V}$	3.0	3.3	3.0	mA Max
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 2\text{ k}\Omega$	50	50	25	V/mV Min
Input Offset Voltage	$R_S \leq 50\text{ k}\Omega$	3.0	3.0	10	mV Max
Average Temperature Coefficient of Input Offset Voltage		15	15	30	$\mu\text{V}/^\circ\text{C}$ Max
Input Offset Current		20	20	70	nA Max
Average Temperature Coefficient of Input Offset Current	$25^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ $-55^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$	0.1 0.2	0.1 0.2	0.3 0.6	nA/ $^\circ\text{C}$ Max nA/ $^\circ\text{C}$ Max
Input Bias Current		100	100	300	nA Max
Supply Current	$T_A = +125^\circ\text{C}$, $V_S = \pm 20\text{V}$	2.5	2.5		mA Max
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 2\text{ k}\Omega$	25	25	15	V/mV Min
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	± 12 ± 10	± 12 ± 10	± 12 ± 10	V Min V Min
Input Voltage Range	$V_S = \pm 20\text{V}$	± 15	± 15	± 12	V Min
Common Mode Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	80	80	70	dB Min
Supply Voltage Rejection Ratio	$R_S \leq 50\text{ k}\Omega$	80	80	70	dB Min

Note 1: The maximum junction temperature of the LH2101A is 150°C, while that of the LH2201A is 100°C. For operating temperatures, devices in the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: These specifications apply for $+15\text{V} \leq V_S \leq +20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LH2201A, however, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$. For the LH2301A these specifications apply for $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, $+5\text{V}$ and $\leq V_S \leq +15\text{V}$. Supply current and input voltage range are specified as $V_S = +15\text{V}$ for the LH2301A. $C_1 = 30\text{ pF}$ unless otherwise specified.



Operational Amplifiers

LH2108/LH2208/LH2308, LH2108A/LH2208A/LH2308A

dual super beta op amp

general description

The LH2108A/LH2208A/LH2308A and LH2108/LH2208/LH2308 series of dual operational amplifiers are two LM108A or LM108 type op amps in a single hermetic package. Featuring all the same performance characteristics of the single device, these duals also offer closer thermal tracking, lower weight, reduced insertion cost, and smaller size than two single devices. For additional information see the LM108A or LM108 data sheet and National's Linear Application Handbook.

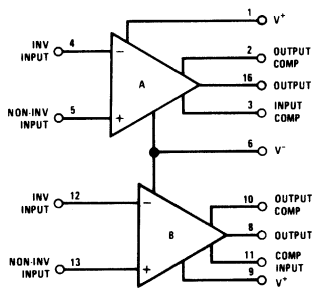
The LH2108A/LH2108 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LH2208A/LH2208 is specified for operation over the -25°C to $+85^{\circ}\text{C}$ temperature

range. The LH2308A/LH2308 is specified for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

features

- Low offset current 50 pA
- Low offset voltage 0.7 mV
- Low offset voltage LH2108A 0.3 mV
LH2108 0.7 mV
- Wide input voltage range $\pm 15\text{V}$
- Wide operating supply range $\pm 3\text{V}$ to $\pm 20\text{V}$

connection diagram

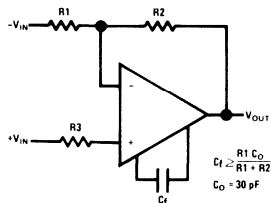


Order Number LH2108AD, LH2208AD,
LH2308AD, or LH2108D, LH2208D,
or LH2308D
See Package 2

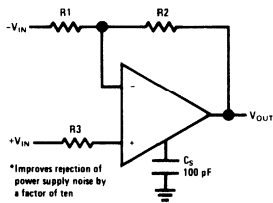
Order Number LH2108F, LH2208F,
or LH2308F
See Package 5

auxiliary circuits

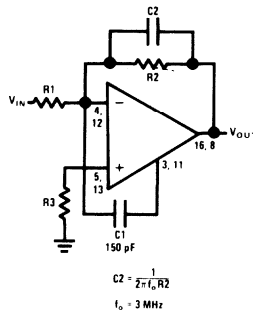
Standard Compensation Circuit



Alternate * Frequency Compensation



Feedforward Compensation



absolute maximum ratings

Supply Voltage	±20V	Operating Temperature Range	
Power Dissipation (Note 1)	500 mW	LH2108A/LH2108	-55°C to +125°C
Differential Input Current (Note 2)	±10 mA	LH2208A/LH2208	-25°C to +85°C
Input Voltage (Note 3)	±15V	LH2308A/LH2308	0°C to +70°C
Output Short Circuit Duration	Continuous	Storage Temperature Range	-65°C to +150°C
		Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics each side (Note 4)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LH2108	LH2208	LH2308	
Input Offset Voltage	$T_A = 25^\circ\text{C}$	2.0	2.0	7.5	mV Max
Input Offset Current	$T_A = 25^\circ\text{C}$	0.2	0.2	1.0	nA Max
Input Bias Current	$T_A = 25^\circ\text{C}$	2.0	2.0	7.0	nA Max
Input Resistance	$T_A = 25^\circ\text{C}$	30	30	10	M Ω Min
Supply Current	$T_A = 25^\circ\text{C}$	0.6	0.6	0.8	mA Max
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$ $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L \geq 10\text{ k}\Omega$	50	50	25	V/mV Min
Input Offset Voltage		3.0	3.0	10	mV Max
Average Temperature Coefficient of Input Offset Voltage		15	15	30	$\mu\text{V}/^\circ\text{C}$ Max
Input Offset Current		0.4	0.4	1.5	nA Max
Average Temperature Coefficient of Input Offset Current		2.5	2.5	10	$\text{pA}/^\circ\text{C}$ Max
Input Bias Current		3.0	3.0	10	nA Max
Supply Current	$T_A = +125^\circ\text{C}$	0.4	0.4	-	mA Max
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 10\text{ k}\Omega$	25	25	15	V/mV Min
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	±13	±13	±13	V Min
Input Voltage Range	$V_S = \pm 15\text{V}$	±13.5	±13.5	±14	V Min
Common Mode Rejection Ratio		85	85	80	dB Min
Supply Voltage Rejection Ratio		80	80	80	dB Min

electrical characteristics each side (Note 4)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LH2108A	LH2208A	LH2308A	
Input Offset Voltage	$T_A = 25^\circ\text{C}$	0.5	0.5	0.5	mV Max
Input Offset Current	$T_A = 25^\circ\text{C}$	0.2	0.2	1.0	nA Max
Input Bias Current	$T_A = 25^\circ\text{C}$	2.0	2.0	7.0	nA Max
Input Resistance	$T_A = 25^\circ\text{C}$	30	30	10	M Ω Min
Supply Current	$T_A = 25^\circ\text{C}$	0.6	0.6	0.8	mA Max
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$ $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L > 10\text{ k}\Omega$	80	80	80	V/mV Min
Input Offset Voltage		1.0	1.0	0.73	mV Max
Average Temperature Coefficient of Input Offset Voltage		5	5	5	$\mu\text{V}/^\circ\text{C}$ Max
Input Offset Current		0.4	0.4	1.5	nA Max
Average Temperature Coefficient of Input Offset Current		2.5	2.5	10	$\text{pA}/^\circ\text{C}$ Max
Input Bias Current		3.0	3.0	10	nA Max
Supply Current	$T_A = +125^\circ\text{C}$	0.4	0.4	-	mA Max
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L \geq 10\text{ k}\Omega$	40	40	60	V/mV Min
Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	±13	±13	±13	V Min
Input Voltage Range	$V_S = \pm 15\text{V}$	±13.5	±13.5	±14	V Min
Common Mode Rejection Ratio		96	96	96	dB Min
Supply Voltage Rejection Ratio		96	96	96	dB Min

Note 1: The maximum junction temperature of the LH2108A/LH2108 is 150°C, while that of the LH2208A/LH2208 is 100°C and the LH2308A/LH2308 is 85°C. For operating at elevated temperatures, devices in the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $-15\text{V} \leq V_S \leq \pm 20\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LH2208A/LH2208, however, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ and with the LH2308A/LH2308 for $\pm 5\text{V} \leq V_S \leq 15\text{V}$ and $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$.



Operational Amplifiers

LH2110/LH2210/LH2310 dual voltage follower

general description

The LH2110 series of dual voltage followers are two LM110 type followers in a single hermetic package. Featuring all the same performance characteristics of the single, these duals offer in addition closer thermal tracking, lower weight, reduced insertion cost and smaller size than two singles. For additional information, see the LM110 data sheet and National's Linear Application Notebook.

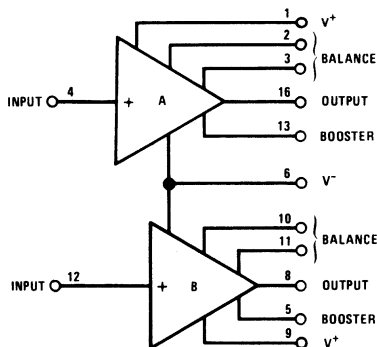
The LH2110 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LH2210 is specified for operation over the -25°C to $+85^{\circ}\text{C}$ temperature range. The LH2310 is speci-

fied for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

features

- Low input current 1 nA
- High input resistance 10^{10} ohms
- High slew rate $30\text{V}/\mu\text{s}$
- Wide bandwidth 20 MHz
- Wide operating supply range $\pm 5\text{V}$ to $\pm 18\text{V}$
- Output short circuit proof

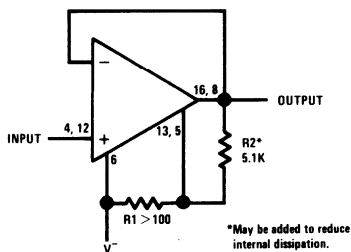
connection diagram



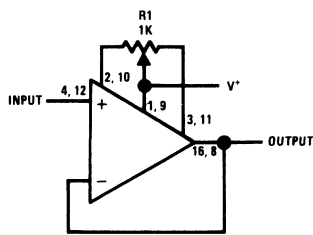
Order Number LH2110D or
LH2210D or LH2310D
See Package 2

Order Number LH2110F or
LH2210F or LH2310F
See Package 5

auxiliary circuits



Increasing Negative Swing Under Load



Offset Balancing Circuit

absolute maximum ratings

Supply Voltage	±18V	Operating Temperature Range	LH2110	-55°C to 125°C
Power Dissipation (Note 1)	500 mW		LH2210	-25°C to 85°C
Input Voltage (Note 2)	±15V		LH2310	0°C to 70°C
Output Short Circuit Duration (Note 3)	Continuous	Storage Temperature Range		-65°C to 150°C
		Lead Temperature (Soldering, 10 sec)		300°C

electrical characteristics Each side (Note 4)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LH2110	LH2210	LH2310	
Input Offset Voltage	$T_A = 25^\circ\text{C}$	4.0	4.0	7.5	mV Max
Input Bias Current	$T_A = 25^\circ\text{C}$	3.0	3.0	7.0	nA Max
Input Resistance	$T_A = 25^\circ\text{C}$	10^{10}	10^{10}	10^{10}	Ω Min
Input Capacitance		1.5	1.5	1.5	pF Typ
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$ $V_{OUT} = \pm 10\text{V}$, $R_L = 8\text{ k}\Omega$	.999	.999	.999	V/V Min
Output Resistance	$T_A = 25^\circ\text{C}$	2.5	2.5	2.5	Ω Max
Supply Current (Each Amplifier)	$T_A = 25^\circ\text{C}$	5.5	5.5	5.5	mA Max
Input Offset Voltage		6.0	6.0	10	mV Max
Offset Voltage	$-55^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	6	6	10	$\mu\text{V}/^\circ\text{C}$ Typ
Temperature Drift	$T_A = 125^\circ\text{C}$	12	12	-	$\mu\text{V}/^\circ\text{C}$ Typ
Input Bias Current		10	10	10	nA Max
Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_{OUT} = \pm 10\text{V}$ $R_L = 10\text{ k}\Omega$	.999	.999	.999	V/V Min
Output Voltage Swing (Note 5)	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	±10	±10	±10	V Min
Supply Current (Each Amplifier)	$T_A = 125^\circ\text{C}$	4.0	4.0	-	mA Max
Supply Voltage Rejection Ratio	$\pm 5\text{V} \leq V_S \leq \pm 18\text{V}$	70	70	70	dB Min

Note 1: The maximum junction temperature of the LH2110 is 150°C, while that of the LH2210 is 100°C and the LH2310 is 85°C. For operating at elevated temperatures, devices in the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Continuous short circuit is allowed for case temperatures to 125°C and ambient temperatures to 70°C. It is necessary to insert a resistor greater than 2 k Ω in series with the input when the amplifier is driven from low impedance sources to prevent damage when the output is shorted.

Note 4: These specifications apply for $\pm 5\text{V} \leq V_S \leq \pm 18\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$, unless otherwise specified. With the LM210, however, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ and for the LH2310, all temperature specifications are limited to $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$.

Note 5: Increased output swing under load can be obtained by connecting an external resistor between the booster and V⁻ terminals.



Operational Amplifiers

LH2111/LH2211/LH2311 dual voltage comparator general descriptio

The LH2111 series of dual voltage comparators are two LM111 type comparators in a single hermetic package. Featuring all the same performance characteristics of the single, these duals offer in addition closer thermal tracking, lower weight, reduced insertion cost and smaller size than two singles. For additional information see the LM111 data sheet and National's Linear Application Handbook.

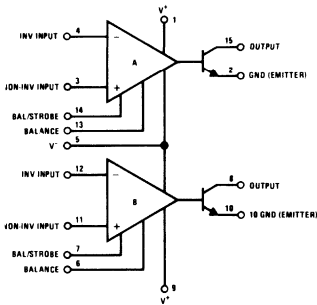
The LH2111 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LH2211 is specified for operation over the -25°C to $+85^{\circ}\text{C}$ temperature range. The LH2311 is speci-

fied for operation over the 0°C to 70°C temperature range.

features

- Wide operating supply range ±15V to a single +5V
- Low input currents 6 nA
- High sensitivity 10 μV
- Wide differential input range ±30V
- High output drive 50 mA, 50V

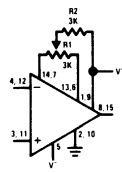
connection diagram



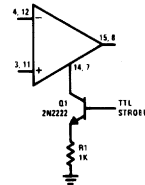
Order Number LH2111D or
LH2211D or LH2311D
See Package 2

Order Number LH2111F or
LH2211F or LH2311F
See Package 5

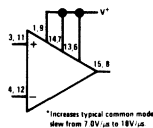
auxiliary circuits



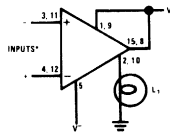
Offset Balancing



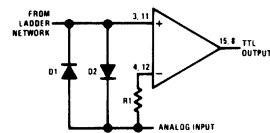
Strobing



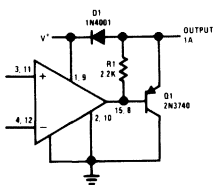
Increasing Input Stage Current*



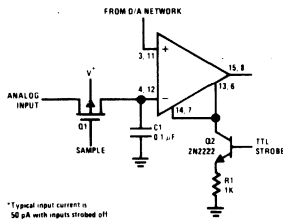
Driving Ground-Referred Load



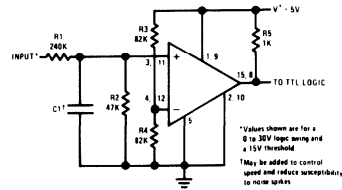
Using Clamp Diodes to Improve Responses



Comparator and Solenoid Driver



Strobing off Both Input*
and Output Stages



TTL Interface with High Level Logic

absolute maximum ratings

Total Supply Voltage ($V^+ - V^-$)	36V	Output Short Circuit Duration	10 sec
Output to Negative Supply Voltage ($V_{OUT} - V^-$)	50V	Operating Temperature Range LH2111	-55°C to 125°C
Ground to Negative Supply Voltage (GND - V^-)	30V	LH2211	-25°C to 85°C
Differential Input Voltage	±30V	LH2311	0°C to 70°C
Input Voltage (Note 1)	±15V	Storage Temperature Range	-65°C to 150°C
Power Dissipation (Note 2)	500 mW	Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics — each side (Note 3)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LH2111	LH2211	LH2311	
Input Offset Voltage (Note 4)	$T_A = 25^\circ\text{C}$, $R_S \leq 50\text{k}$	3.0	3.0	7.5	mV Max
Input Offset Current (Note 4)	$T_A = 25^\circ\text{C}$	10	10	50	nA Max
Input Bias Current	$T_A = 25^\circ\text{C}$	100	100	250	nA Max
Voltage Gain	$T_A = 25^\circ\text{C}$	200	200	200	V/mV Typ
Response Time (Note 5)	$T_A = 25^\circ\text{C}$	200	200	200	ns Typ
Saturation Voltage	$V_{IN} \leq -5\text{ mV}$, $I_{OUT} = 50\text{ mA}$ $T_A = 25^\circ\text{C}$	1.5	1.5	1.5	V Max
Strobe On Current	$T_A = 25^\circ\text{C}$	3.0	3.0	3.0	mA Typ
Output Leakage Current	$V_{IN} \geq 5\text{ mV}$, $V_{OUT} = 35\text{V}$ $T_A = 25^\circ\text{C}$	10	10	50	nA Max
Input Offset Voltage (Note 4)	$R_S \leq 50\text{k}$	4.0	4.0	10	mV Max
Input Offset Current (Note 4)		20	20	70	nA Max
Input Bias Current		150	150	300	nA Max
Input Voltage Range		±14	±14	±14	V Typ
Saturation Voltage	$V^+ \geq 4.5\text{V}$, $V^- = 0$ $V_{IN} \leq -5\text{ mV}$, $I_{SINK} \leq 8\text{ mA}$	0.4	0.4	0.4	V Max
Positive Supply Current	$T_A = 25^\circ\text{C}$	6.0	6.0	7.5	mA Max
Negative Supply Current	$T_A = 25^\circ\text{C}$	5.0	5.0	5.0	mA Max

Note 1: This rating applies for ±15V supplies. The positive input voltage limit is 30V above the negative supply. The negative input voltage limit is equal to the negative supply voltage or 30V below the positive supply, whichever is less.

Note 2: The maximum junction temperature is 150°C. For operating at elevated temperatures, devices in the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with 0.03-inch-wide, 2 ounce copper conductor. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

Note 3: These specifications apply for $V_S = \pm 15\text{V}$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ for the LH2111, $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ for the LH2211, and $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ for the LH2311, unless otherwise stated. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to ±15V supplies. For the LH2311, $V_{IN} = \pm 10\text{ mV}$.

Note 4: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1 mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

Note 5: The response time specified is for a 100 mV input step with 5 mV overdrive.



Operational Amplifiers

LM2900 quad amplifier

general description

The LM2900 consists of four independent, dual input, internally compensated amplifiers which were designed specifically for automotive and industrial applications. They operate off a single power supply voltage and provide a large output voltage swing. These amplifiers make use of a current mirror to achieve the non-inverting input function.

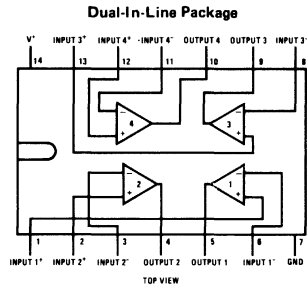
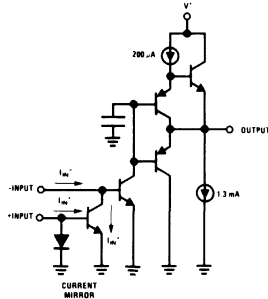
Applications include: AC amplifiers, RC active filters; low frequency triangle, squarewave and pulse waveform generation circuits; tachometers and low speed, high voltage digital logic gates.

For additional information, see Application Note 72, "The LM3900 - A New Current-Differencing Quad of \pm Input Amplifiers."

features

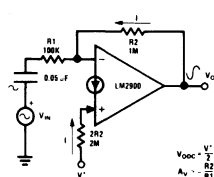
- Wide single supply voltage range 4 V_{DC} to 36 V_{DC}
- Supply current drain independent of supply voltage
- Low input biasing current 30 nA
- High open-loop gain 70 dB
- Wide bandwidth 2.5 MHz (Unity Gain)
- Larger gain-bandwidth product in non-inverting mode ($A_V = 100 @ f = 1 \text{ MHz}$)
- Large output voltage swing $(V^+ - 1) V_{PP}$
- Internally frequency compensated for unity gain
- Output short-circuit protection
- Eliminates need for dual supplies
- Reduces package count

schematic and connection diagrams

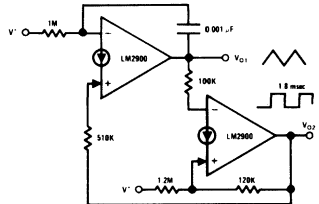


Order Number LM2900N
See Package 22

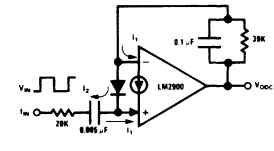
typical applications ($V^+ = 15V_{DC}$)



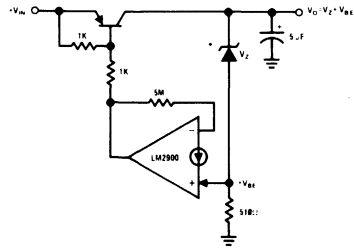
Inverting Amplifier



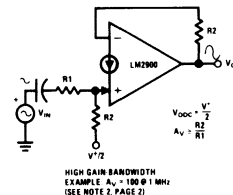
Triangle/Square Generator



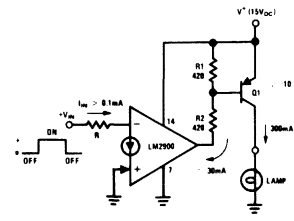
Frequency-Doubling Tachometer



Low V_{IN} - V_{OUT} Voltage Regulator



Non-Inverting Amplifier



Boosting to 300 mA Loads

absolute maximum ratings

Supply Voltage	+36 V _{DC} ±18 V _{DC}
Power Dissipation (T _A = 25°C) (Note 1)	570 mW
Input Currents, I _{IN+} or I _{IN-}	20 mA DC
Output Short Circuit Duration – One Amplifier T _A = 25°C (See Application Hints)	Continuous
Operating Temperature Range	-40°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (V⁺ = +15 V_{DC} and T_A = 25°C unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Open Loop					
Voltage Gain	f = 100 Hz	1200	2800		V/V
Input Resistance	Inverting Input		1		MΩ
Output Resistance			8		kΩ
Unity Gain Bandwidth	Inverting Input (Note 2)		2.5		MHz
Input Bias Current	Inverting Input		30	200	nA
Slew Rate	Positive Output Swing		0.5		V/μs
	Negative Output Swing		20		V/μs
Supply Current	R _L = ∞ On All Amplifiers		6.2	10	mA DC
Output Voltage Swing	R _L = 5.1k				
V _{OUT} High	I _{IN-} = 0, I _{IN+} = 0	13.5	14.2		V _{DC}
V _{OUT} Low	I _{IN-} = 10 μA, I _{IN+} = 0		0.09	0.2	V _{DC}
Output Current Capability					
Source		3	18		mA DC
Sink	(Note 3)	0.5	1.3		mA DC
Power Supply Rejection	f = 100 Hz		70		dB
Mirror Gain	I _{IN+} = 200 μA (Note 4)	0.90	1	1.1	μA/μA
Mirror Current	(Note 5)		10	500	μA DC
Negative Input Current	(Note 6)		1.0		mA DC

Note 1: For operating at high temperatures, the device must be derated based on a 125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient.

Note 2: When used as a "non-inverting amplifier" (see bottom of page 1) the gain-bandwidth product is not limited to 2.5 MHz. The isolation provided by the "current mirror" allows a constant unity voltage gain feedback for the main inverting amplifier. This means that large values of gain can be achieved at high frequencies and the dominate limit is due to the slew rate of the amplifier. For example: a voltage gain of 100 is easily obtained at 1 MHz and an output voltage swing of 160 mVp-p can be achieved prior to slew rate limiting. This operational mode is useful for signal frequencies in the 50 kHz to 1 MHz range as would be encountered in IF or carrier frequency applications.

Note 3: The output current sink capability can be increased for large signal conditions by overdriving the inverting input. This is shown in the section on Typical Characteristics.

Note 4: This spec indicates the current gain of the current mirror which is used as the non-inverting input.

Note 5: Input V_{BE} match between the non-inverting and the inverting inputs occurs for a mirror current (non-inverting input current) of approximately 10 μA. This is therefore a typical design center for many of the application circuits.

Note 6: Clamp transistors are included on the IC to prevent the input voltages from swinging below ground more than approximately -0.3 V_{DC}. The negative input currents which may result from large signal overdrive with capacitance input coupling need to be externally limited to values of approximately 1 mA. Negative input currents in excess of 4 mA will cause the output voltage to drop to a low voltage. This maximum current applies to any one of the input terminals. If more than one of the input terminals are simultaneously driven negative smaller maximum currents are allowed. Common-mode current biasing can be used to prevent negative input voltages; for example, see the "Differentiator Circuit" in the applications section.



Operational Amplifiers

LM3900 quad amplifier

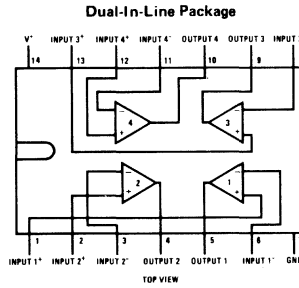
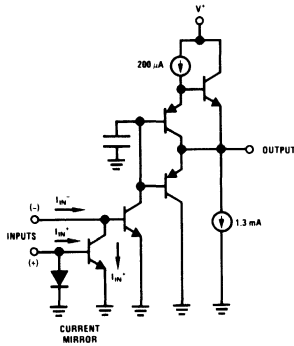
general description

The LM3900 consists of four independent, dual input, internally compensated amplifiers which were designed specifically to operate off of a single power supply voltage and to provide a large output voltage swing. These amplifiers make use of a current mirror to achieve the non-inverting input function. Application areas include: AC amplifiers, RC active filters; low frequency triangle, squarewave and pulse waveform generation circuits, tachometers and low speed, high voltage digital logic gates.

features

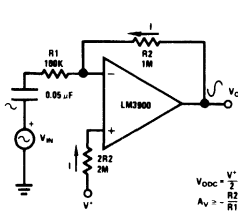
- Wide single supply voltage range $4 V_{DC}$ to $36 V_{DC}$ or dual supplies $\pm 2 V_{DC}$ to $\pm 18 V_{DC}$
- Supply current drain independent of supply voltage
- Low input biasing current 30 nA
- High open-loop gain 70 dB
- Wide bandwidth 2.5 MHz (Unity Gain)
- Large output voltage swing $(V^+ - 1) V_{p-p}$
- Internally frequency compensated for unity gain
- Output short-circuit protection

schematic and connection diagrams

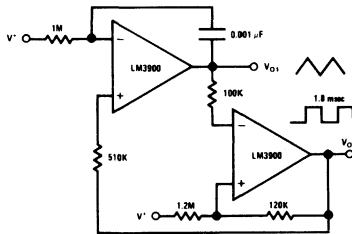


Order Number LM3900N
See Package 22

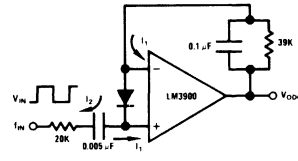
typical applications ($V^+ = 15V_{DC}$)



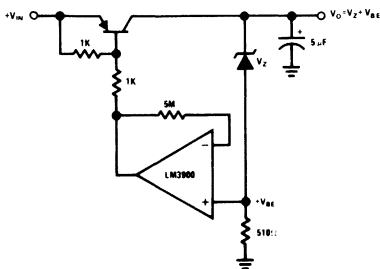
Inverting Amplifier



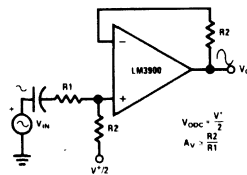
Triangle/Square Generator



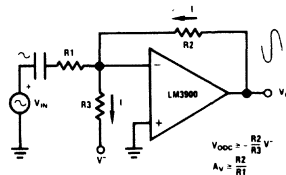
Frequency-Doubling Tachometer



Low V_{IN} - V_{OUT} Voltage Regulator



Non-Inverting Amplifier



Negative Supply Biasing

absolute maximum ratings

Supply Voltage	+36 VDC ±18 VDC
Power Dissipation ($T_A = 25^\circ\text{C}$) (Note 1)	570 mW
Input Currents, I_{IN+} or I_{IN-}	20 mA DC
Output Short Circuit Duration – One Amplifier $T_A = 25^\circ\text{C}$ (See Application Hints)	Continuous
Operating Temperature Range	0°C to $+70^\circ\text{C}$
Storage Temperature Range	-65°C to $+150^\circ\text{C}$
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics ($V^+ = +15\text{ VDC}$ and $T_A = 25^\circ\text{C}$ unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Open Loop					
Voltage Gain	$f = 100\text{ Hz}$	1200	2800		V/V
Input Resistance	Inverting Input		1		$\text{M}\Omega$
Output Resistance			8		$\text{k}\Omega$
Unity Gain Bandwidth	Inverting Input		2.5		MHz
Input Bias Current	Inverting Input		30	200	nA
Slew Rate	Positive Output Swing		0.5		$\text{V}/\mu\text{s}$
	Negative Output Swing		20		$\text{V}/\mu\text{s}$
Supply Current	$R_L = \infty$ On All Amplifiers		6.2	10	mA DC
Output Voltage Swing	$R_L = 5.1\text{ k}$				
V_{OUT} High	$I_{IN-} = 0, I_{IN+} = 0$	13.5	14.2		VDC
V_{OUT} Low	$I_{IN-} = 10\ \mu\text{A}, I_{IN+} = 0$		0.09	0.2	VDC
Output Current Capability					
Source		3	18		mA DC
Sink	(Note 2)	0.5	1.3		mA DC
Power Supply Rejection	$f = 100\text{ Hz}$		70		dB
Mirror Gain	$I_{IN+} = 200\ \mu\text{A}$ (Note 3)	0.9	1	1.1	$\mu\text{A}/\mu\text{A}$
Mirror Current	(Note 4)		10	500	μA DC
Negative Input Current	(Note 5)		1.0		mA DC

Note 1: For operating at high temperatures, the device must be derated based on a 125°C maximum junction temperature and a thermal resistance of $175^\circ\text{C}/\text{W}$ which applies for the device soldered in a printed circuit board, operating in a still air ambient.

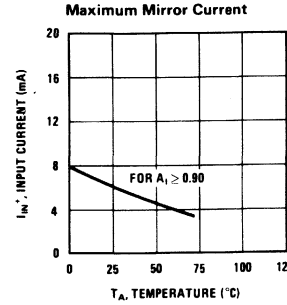
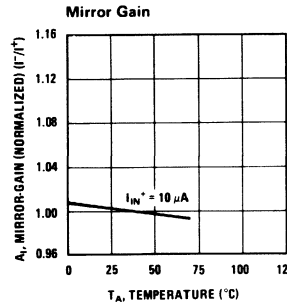
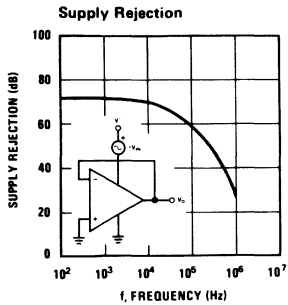
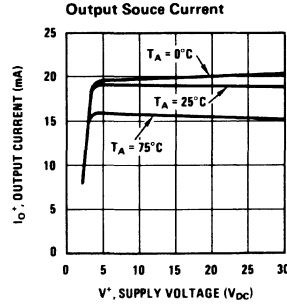
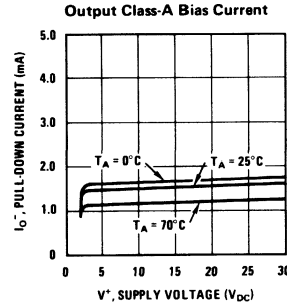
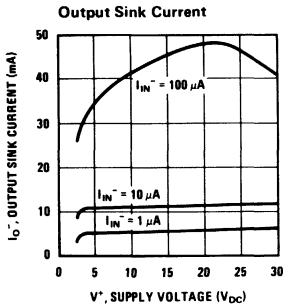
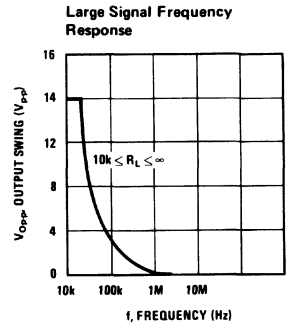
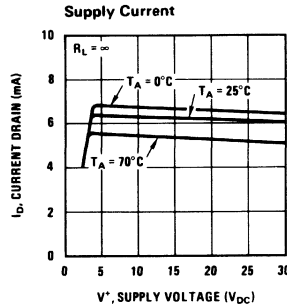
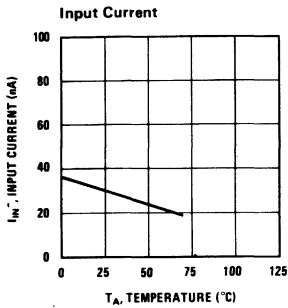
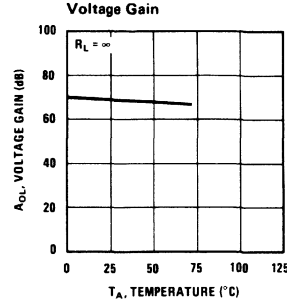
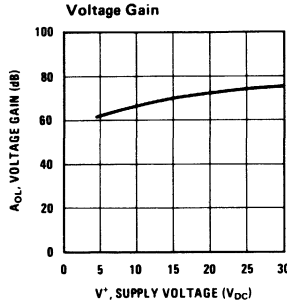
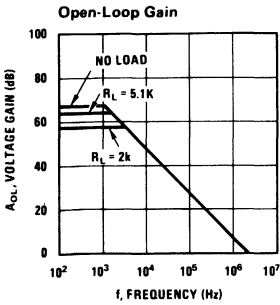
Note 2: The output current sink capability can be increased for large signal conditions by overdriving the inverting input. This is shown in the section on Typical Characteristics.

Note 3: This spec indicates the current gain of the current mirror which is used as the non-inverting input.

Note 4: Input V_{BE} match between the non-inverting and the inverting inputs occurs for a mirror current (non-inverting input current) of approximately $10\ \mu\text{A}$. This is therefore a typical design center for many of the application circuits.

Note 5: Clamp transistors are included on the IC to prevent the input voltages from swinging below ground more than approximately -0.3 VDC . The negative input currents which may result from large signal overdrive with capacitance input coupling need to be externally limited to values of approximately 1 mA . Negative input currents in excess of 4 mA will cause the output voltage to drop to a low voltage. This maximum current applies to any one of the input terminals. If more than one of the input terminals are simultaneously driven negative smaller maximum currents are allowed. Common-mode current biasing can be used to prevent negative input voltages; see for example the "Differentiator Circuit" in the applications section.

typical performance characteristics



application hints

When driving either input from a low-impedance source, a limiting resistor should be placed in series with the input lead to limit the peak input current. Currents as large as 20 mA will not damage the device, but the current mirror on the non-inverting input will saturate and cause a loss of mirror gain at mA current levels – especially at high operating temperatures.

Precautions should be taken to insure that the power supply for the integrated circuit never becomes reversed in polarity or that the unit is not inadvertently installed backwards in a test socket as an unlimited current surge through the resulting forward diode within the IC could cause fuzing of the internal conductors and result in a destroyed unit.

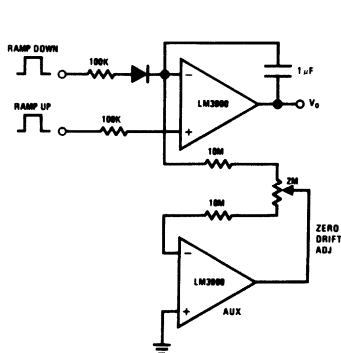
Output short circuits either to ground or to the positive power supply should be of short time duration. Units can be destroyed, not as a result of the short circuit current causing metal fuzing, but rather due to the large increase in IC chip dissipation which will cause eventual failure due to excessive junction temperatures. For example, when operating from a well-regulated +15 VDC power supply at $T_A = 25^\circ\text{C}$ with a 100 k Ω shunt-feedback resistor (from the output to the inverting input) a short directly to the power supply will not cause catastrophic failure but the current magnitude will be approximately 50 mA and the junction temperature will be above T_J max. Larger feedback resistors will reduce the current, 11 M Ω provides approximately 30 mA, an open circuit provides 1.3 mA, and a direct connection from the output to the non-inverting input will result in catastrophic failure when the output is shorted to V^+ as this then places the base-emitter junction of the input transistor directly across the power supply. Short-circuits to ground will have magnitudes of approximately 30 mA and will not cause catastrophic failure at $T_A = 25^\circ\text{C}$.

Unintentional signal coupling from the output to the non-inverting input can cause oscillations. This is likely only in breadboard hook-ups with long component leads and can be prevented by a more careful lead dress or by locating the non-inverting input biasing resistor close to the IC. A quick check of this condition is to bypass the non-inverting input to ground with a capacitor. High impedance biasing resistors used in the non-inverting input circuit make this input lead highly susceptible to unintentional AC signal pickup.

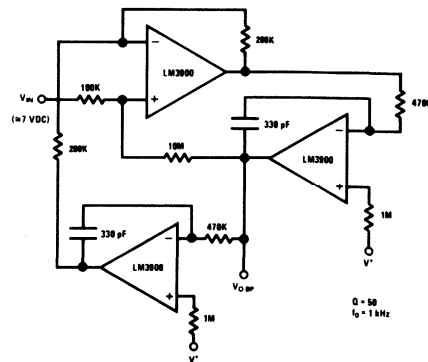
Operation of this amplifier can be best understood by noticing that input currents are differenced at the inverting-input terminal and this difference current then flows through the external feedback resistor to produce the output voltage. Common mode current biasing is generally useful to allow operating with signal levels near ground or even negative as this maintains the inputs biased at $+V_{BE}$. Internal clamp transistors (see note 5) catch negative input voltages at approximately -0.3 VDC but the magnitude of current flow has to be limited by the external input network. For operation at high temperature, this limit should be approximately 100 μA .

This new "Norton" current-differencing amplifier can be used in most of the applications of a standard IC op amp. Performance as a DC amplifier using only a single supply is not as precise as a standard IC op amp operating with split supplies but is adequate in many less critical applications. New functions are made possible with this amplifier which are useful in single power supply systems. For example, biasing can be designed separately from the AC gain as was shown in the "inverting amplifier", the "difference integrator" allows controlling the charging and the discharging of the integrating capacitor using only positive voltages, and the "frequency doubling tachometer" provides a simple circuit which reduces the ripple voltage on a tachometer output DC voltage.

typical applications (con't)

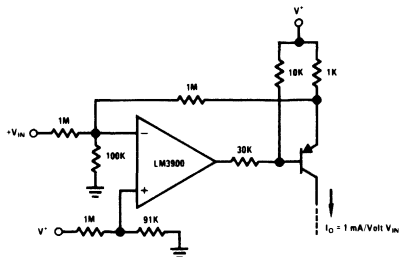


Low-Drift Ramp & Hold Circuit

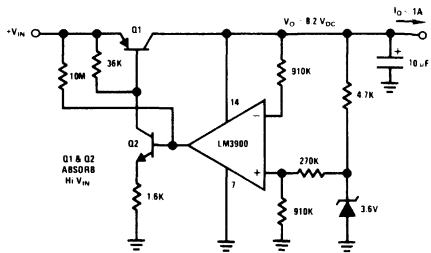


Bi-Quad Active Filter
(2nd Degree State-Variable Network)

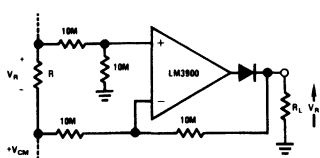
typical applications (con't)



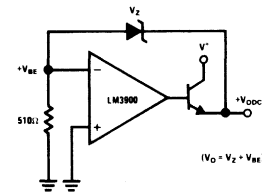
Voltage-Controlled Current Source
(Transconductance Amplifier)



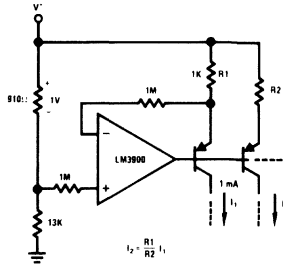
Hi V_{IN} , Lo ($V_{IN}-V_O$) Self-Regulator



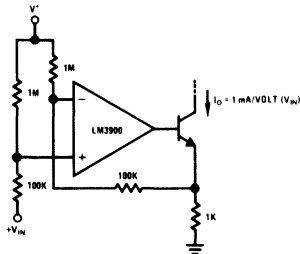
Ground-Referencing a
Differential Input Signal



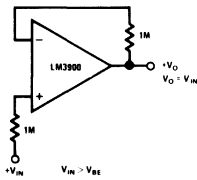
Voltage Regulator



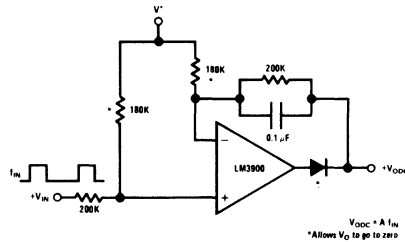
Fixed Current Sources



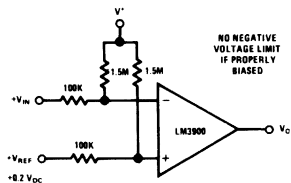
Voltage-Controlled Current Sink
(Transconductance Amplifier)



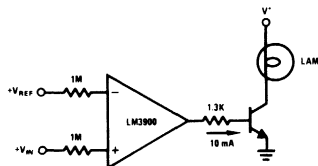
Buffer Amplifier



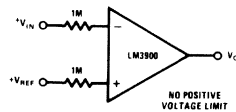
Tachometer



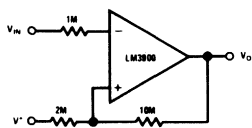
Low-Voltage Comparator



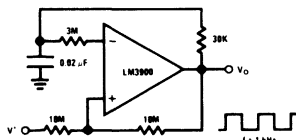
Power Comparator



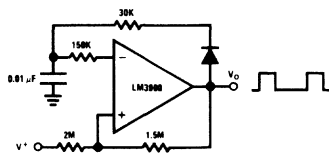
Comparator



Schmitt-Trigger

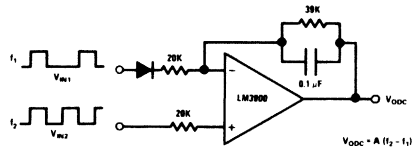


Square-Wave Oscillator

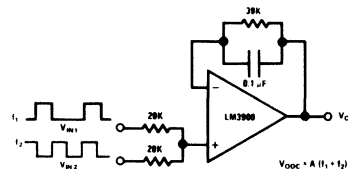


Pulse Generator

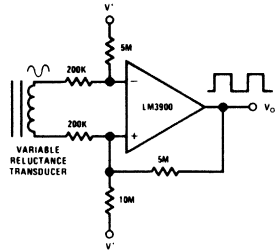
typical applications (con't)



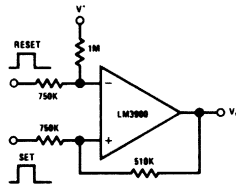
Frequency Differencing Tachometer



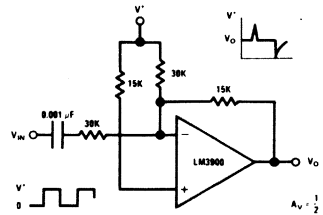
Frequency Averaging Tachometer



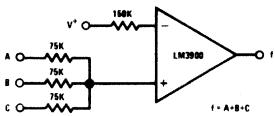
Squaring Amplifier (W/Hysteresis)



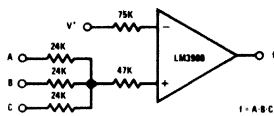
Bi-Stable Multivibrator



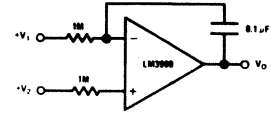
Differentiator (Common-Mode Biasing Keeps Input at +V_{BE})



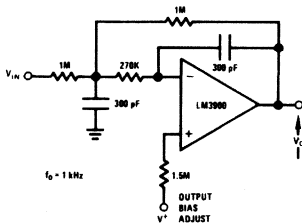
"OR" Gate



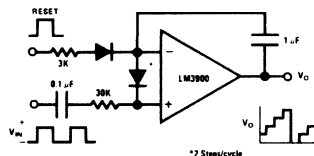
"AND" Gate



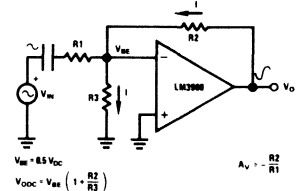
Difference Integrator



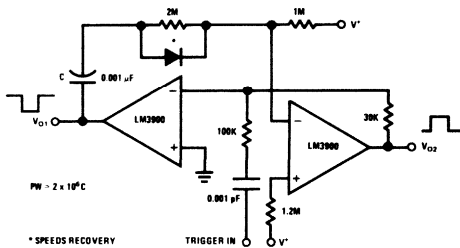
Low Pass Active Filter



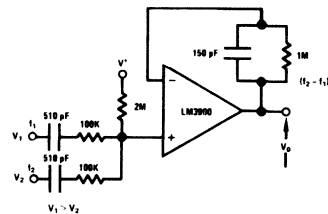
Staircase Generator



V_{BE} Biasing

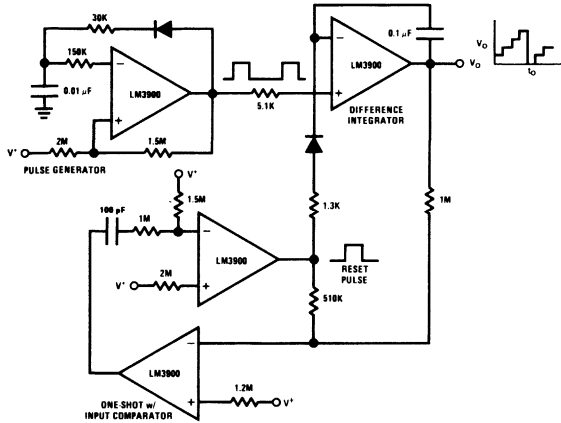


One-Shot Multivibrator

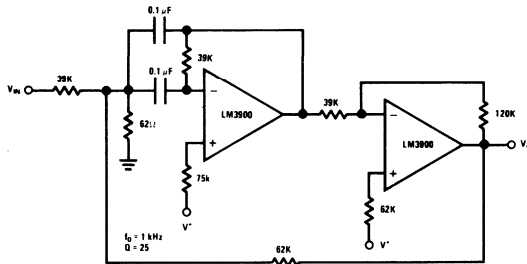


Low-Frequency Mixer

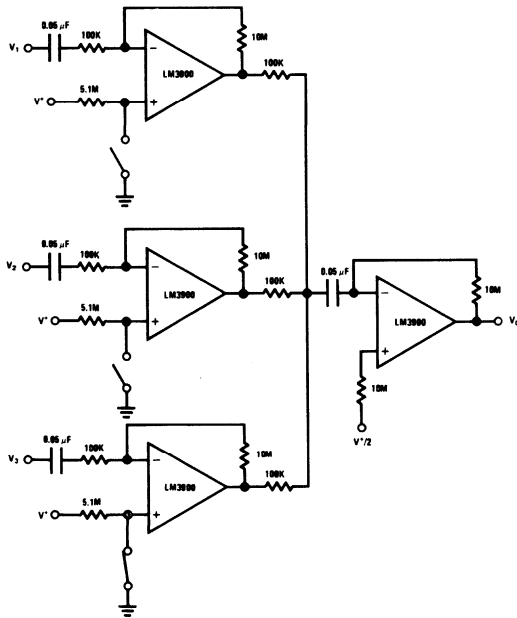
typical applications (con't)



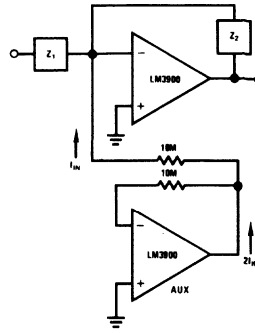
Free-Running Staircase Generator/Pulse Counter



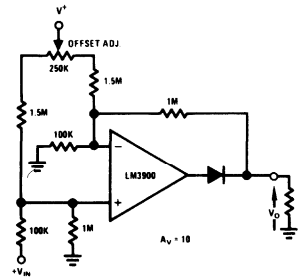
Bandpass Active Filter



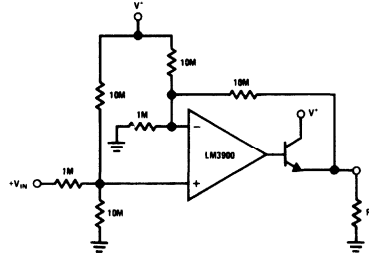
Channel Selection by DC Control (or Audio Mixer)



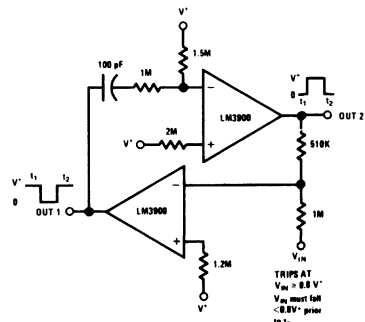
Supplying I_{IN} with Aux. Amp (to Allow High Z Feedback Networks)



Non-Inverting DC Gain to (0,0)



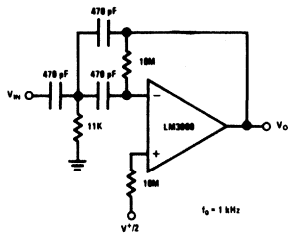
Power Amplifier



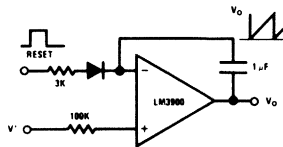
One-Shot w/ DC Input Comparator

TRIPS AT
 $V_{IN} = 0.8 V'$
 V_{IN} must fall
 $< 0.8 V'$ prior
to t_2

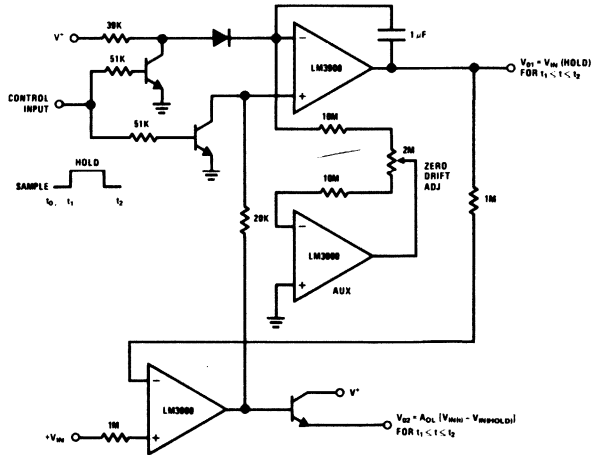
typical applications (con't)



High Pass Active Filter

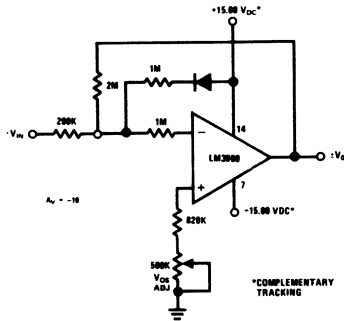


Sawtooth Generator

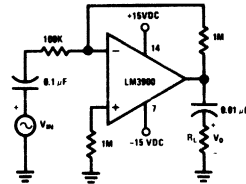


Sample-Hold & Compare with New +V_{IN}

split-supply applications ($V^+ = +15V_{DC}$ & $V^- = -15V_{DC}$)



Inverting DC Gain



AC Amplifier



Operational Amplifiers

LM4250/LM4250C programmable operational amplifier

general description

The LM4250 and LM4250C are extremely versatile programmable monolithic operational amplifiers. A single external master bias current setting resistor programs the input bias current, input offset current, quiescent power consumption, slew rate, input noise, and the gain-bandwidth product. The device is a truly general purpose operational amplifier.

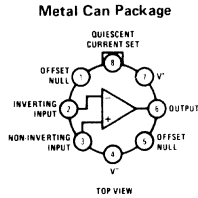
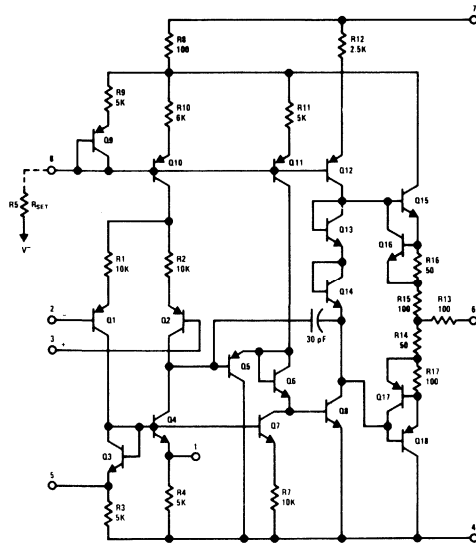
- Standby power consumption as low as 500 nW
- No frequency compensation required
- Programmable electrical characteristics
- Offset Voltage nulling capability
- Can be powered by two flashlight batteries
- Short circuit protection

features

- $\pm 1V$ to $\pm 18V$ power supply operation
- 3 nA input offset current

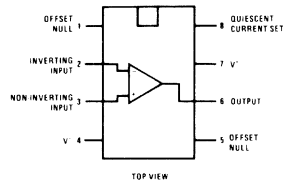
The LM4250C is identical to the LM4250 except that the LM4250C has its performance guaranteed over a $0^{\circ}C$ to $70^{\circ}C$ temperature range instead of the $-55^{\circ}C$ to $+125^{\circ}C$ temperature range of the LM4250.

schematic and connection diagrams



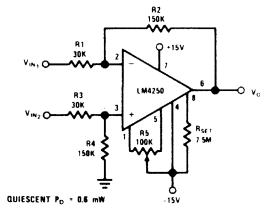
Order Number LM4250H or LM4250CH
See Package 11

Dual-in-Line Package

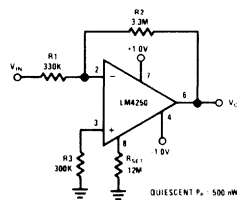


Order Number LM4250CN
See Package 20

typical applications



X5 Difference Amplifier



500 Nano-Watt X10 Amplifier

absolute maximum ratings

Supply Voltage	±18V	Output Short Circuit Duration	Indefinite
Power Dissipation (Note 1)	500 mW	Operating Temperature Range	LM4250 -55°C < T _A < 125°C
Differential Input Voltage	±30V	LM4250C	0°C < T _A < 70°C
Input Voltage (Note 2)	±15V	Storage Temperature Range	-65°C to 150°C
I _{SET} Current	150 μA	Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics LM4250 (-55°C ≤ T_A ≤ 125°C unless otherwise specified)

PARAMETERS	CONDITIONS	V _S = ±1.5V			
		I _{SET} = 1 μA		I _{SET} = 10 μA	
		MIN	MAX	MIN	MAX
V _{OS}	T _A = 25°C R _S < 100 kΩ		3 mV		5 mV
I _{OS}	T _A = 25°C		3 nA		10 nA
I _{bas}	T _A = 25°C		7.5 nA		50 nA
Large Signal Voltage Gain	T _A = 25°C R _L = 100 kΩ	40k		50k	
	V _O = ±0.6V R _L = 10 kΩ				
Supply Current	T _A = 25°C		7.5 μA		80 μA
Power Consumption	T _A = 25°C		23 μW		240 μW
V _{OS}	R _S ≤ 100 kΩ		4 mV		6 mV
I _{OS}	T _A = 125°C		5 nA		10 nA
	T _A = -55°C		3 nA		10 nA
I _{bas}			7.5 nA		50 nA
Input Voltage Range			±0.7V		±0.7V
Large Signal Voltage Gain	V _O = ±0.6V R _L = 100 kΩ	30k			
	R _L = 10 kΩ				30k
Output Voltage Swing	R _L = 100 kΩ		±0.6V		
	R _L = 10 kΩ				±0.6V
Common Mode Rejection Ratio	R _S ≤ 10 kΩ	70 dB		70 dB	
Supply Voltage Rejection Ratio	R _S ≤ 10 kΩ	76 dB		76 dB	
Supply Current			8 μA		90 μA
Power Consumption			24 μW		270 μW
PARAMETERS	CONDITIONS	V _S = ±15V			
		I _{SET} = 1 μA		I _{SET} = 10 μA	
		MIN	MAX	MIN	MAX
V _{OS}	T _A = 25°C R _S ≤ 100 kΩ		3 mV		5 mV
I _{OS}	T _A = 25°C		3 nA		10 nA
I _{bas}	T _A = 25°C		7.5 nA		50 nA
Large Signal Voltage Gain	T _A = 25°C R _L = 100 kΩ	100k		100k	
	V _O = ±10V R _L = 10 kΩ				
Supply Current	T _A = 25°C		10 μA		90 μA
Power Consumption	T _A = 25°C		300 μW		2.7 mW
V _{OS}	R _S ≤ 100 kΩ		4 mV		6 mV
I _{OS}	T _A = 125°C		25 nA		25 nA
	T _A = -55°C		3 nA		10 nA
I _{bas}			7.5 nA		50 nA
Input Voltage Range			±13.5V		±13.5V
Large Signal Voltage Gain	V _O = ±10V R _L = 100 kΩ	50k			
	R _L = 10 kΩ				50k
Output Voltage Swing	R _L = 100 kΩ		±12V		
	R _L = 10 kΩ				±12V
Common Mode Rejection Ratio	R _S ≤ 10 kΩ	70 dB		70 dB	
Supply Voltage Rejection Ratio	R _S ≤ 10 kΩ	76 dB		76 dB	
Supply Current			11 μA		100 μA
Power Consumption			330 μW		3 mW

Note 1: The maximum junction temperature of the LM4250 is 150°C, while that of the LM4250C is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W junction to ambient, or 45°C/W junction to case. The thermal resistance of the dual-in-line package is 125°C/W.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

electrical characteristics LM4250C ($0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ unless otherwise specified)

PARAMETERS	CONDITIONS	$V_S = \pm 1.5\text{V}$			
		$I_{SET} = 1\ \mu\text{A}$		$I_{SET} = 10\ \mu\text{A}$	
		MIN	MAX	MIN	MAX
V_{OS}	$T_A = 25^{\circ}\text{C}$ $R_S \leq 100\ \text{k}\Omega$		5 mV		6 mV
I_{OS}	$T_A = 25^{\circ}\text{C}$		6 nA		20 nA
I_{BIAS}	$T_A = 25^{\circ}\text{C}$		10 nA		75 nA
Large Signal Voltage Gain	$T_A = 25^{\circ}\text{C}$ $R_L = 100\ \text{k}\Omega$ $V_O = \pm 0.6\text{V}$ $R_L = 10\ \text{k}\Omega$	25k		25k	
Supply Current	$T_A = 25^{\circ}\text{C}$		8 μA		90 μA
Power Consumption	$T_A = 25^{\circ}\text{C}$		24 μW		270 μW
V_{OS}	$R_S \leq 10\ \text{k}\Omega$		6.5 mV		7.5 mV
I_{OS}			8 nA		25 nA
I_{BIAS}			10 nA		80 nA
Input Voltage Range		$\pm 0.6\text{V}$		$\pm 0.6\text{V}$	
Large Signal Voltage Gain	$V_O = \pm 0.6\text{V}$ $R_L = 100\ \text{k}\Omega$ $R_L = 10\ \text{k}\Omega$	25k		25k	
Output Voltage Swing	$R_L = 100\ \text{k}\Omega$ $R_L = 10\ \text{k}\Omega$	$\pm 0.6\text{V}$		$\pm 0.6\text{V}$	
Common Mode Rejection Ratio	$R_S \leq 10\ \text{k}\Omega$	70 dB		70 dB	
Supply Voltage Rejection Ratio	$R_S \leq 10\ \text{k}\Omega$	74 dB		74 dB	
Supply Current			8 μA		90 μA
Power Consumption			24 μW		270 μW

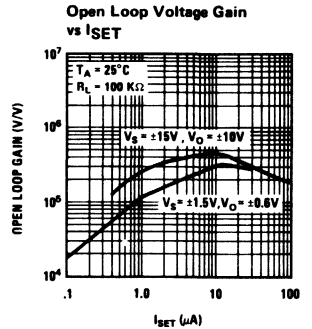
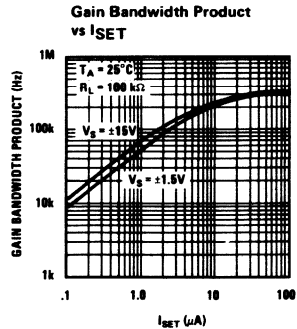
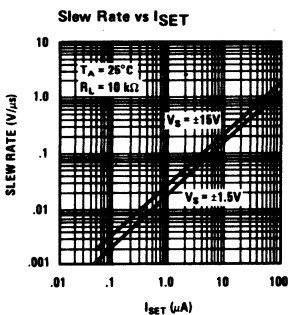
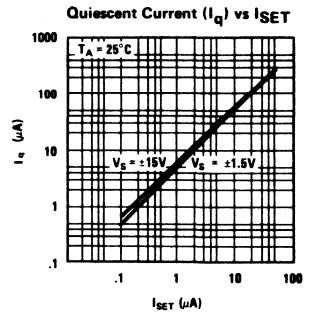
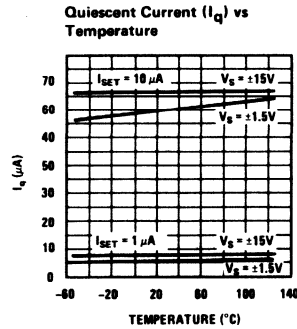
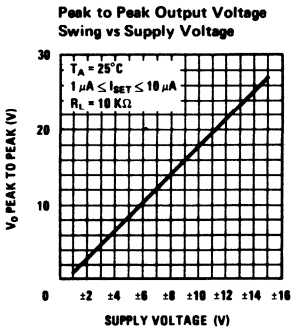
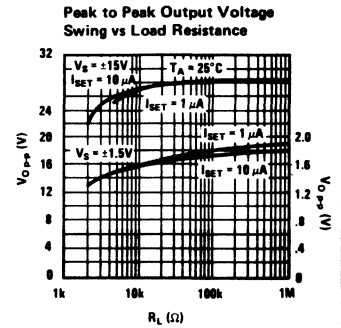
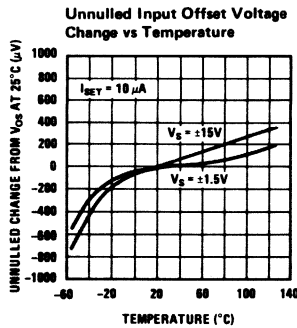
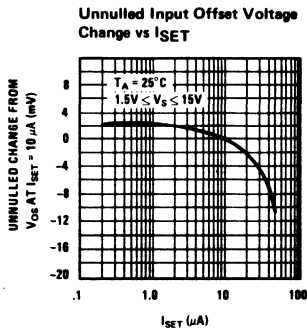
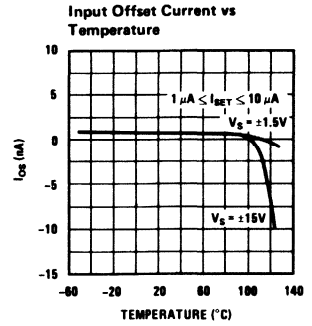
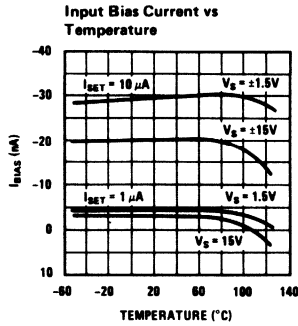
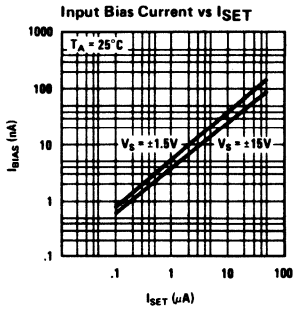
PARAMETERS	CONDITIONS	$V_S = \pm 15\text{V}$			
		$I_{SET} = 1\ \mu\text{A}$		$I_{SET} = 10\ \mu\text{A}$	
		MIN	MAX	MIN	MAX
V_{OS}	$T_A = 25^{\circ}\text{C}$ $R_S \leq 100\ \text{k}\Omega$		5 mV		6 mV
I_{OS}	$T_A = 25^{\circ}\text{C}$		6 nA		20 nA
I_{BIAS}	$T_A = 25^{\circ}\text{C}$		10 nA		75 nA
Large Signal Voltage Gain	$T_A = 25^{\circ}\text{C}$ $R_L = 100\ \text{k}\Omega$ $V_O = \pm 10\text{V}$ $R_L = 10\ \text{k}\Omega$	60k		60k	
Supply Current	$T_A = 25^{\circ}\text{C}$		11 μA		100 μA
Power Consumption	$T_A = 25^{\circ}\text{C}$		330 μW		3 mW
V_{OS}	$R_S \leq 10\ \text{k}\Omega$		6.5 mV		7.5 mV
I_{OS}			8 nA		25 nA
I_{BIAS}			10 nA		80 nA
Input Voltage Range		$\pm 13.5\text{V}$		$\pm 13.5\text{V}$	
Large Signal Voltage Gain	$V_O = \pm 10\text{V}$ $R_L = 100\ \text{k}\Omega$ $R_L = 10\ \text{k}\Omega$	50k		50k	
Output Voltage Swing	$R_L = 100\ \text{k}\Omega$ $R_L = 10\ \text{k}\Omega$	$\pm 12\text{V}$		$\pm 12\text{V}$	
Common Mode Rejection Ratio	$R_S \leq 10\ \text{k}\Omega$	70 dB		70 dB	
Supply Voltage Rejection Ratio	$R_S \leq 10\ \text{k}\Omega$	74 dB		74 dB	
Supply Current			11 μA		100 μA
Power Consumption			300 μW		3 mW

resistor biasing

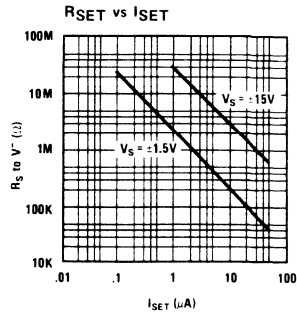
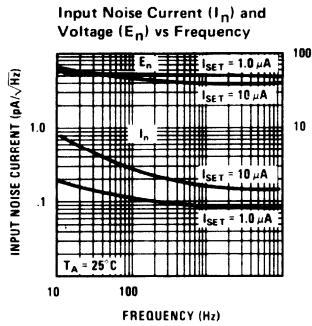
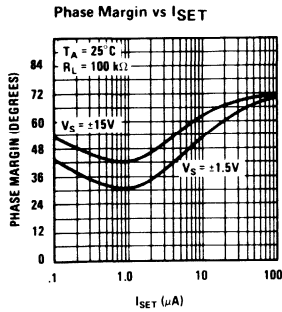
Set Current Setting Resistor to V^-

V_S	I_{SET}				
	0.1 μA	0.5 μA	1.0 μA	5 μA	10 μA
$\pm 1.5\text{V}$	25.6 M Ω	5.04 M Ω	2.5 M Ω	492 k Ω	244 k Ω
$\pm 3.0\text{V}$	55.6 M Ω	11.0 M Ω	5.5 M Ω	1.09 M Ω	544 k Ω
$\pm 6.0\text{V}$	116 M Ω	23.0 M Ω	11.5 M Ω	2.29 M Ω	1.14 M Ω
$\pm 9.0\text{V}$	176 M Ω	35.0 M Ω	17.5 M Ω	3.49 M Ω	1.74 M Ω
$\pm 12.0\text{V}$	236 M Ω	47.0 M Ω	23.5 M Ω	4.69 M Ω	2.34 M Ω
$\pm 15.0\text{V}$	296 M Ω	59.0 M Ω	29.5 M Ω	5.89 M Ω	2.94 M Ω

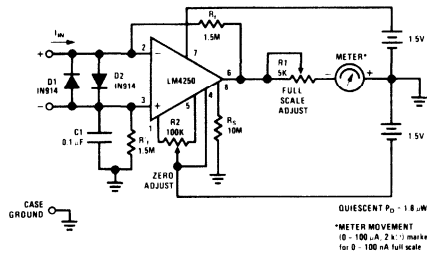
typical performance characteristics



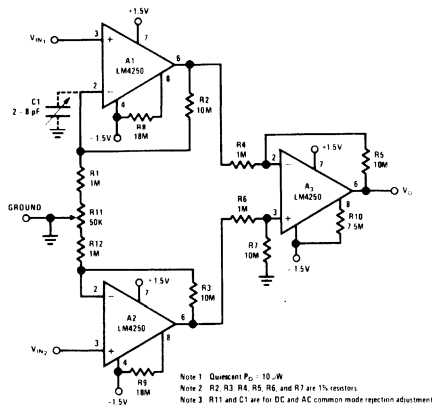
typical performance characteristics (con't)



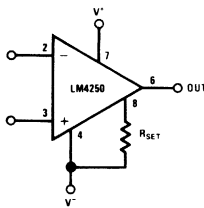
typical applications (con't)



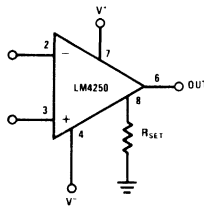
Floating Input Meter Amplifier
100 Nano-Ampere Full Scale



X100 Instrumentation Amplifier 10 μW



RSET Connected to V^-



RSET Connected to Ground

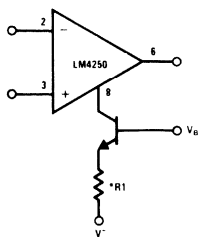
I_{SET} EQUATIONS

$$I_{SET} = \frac{V^+ + V^- - 0.5}{R_{SET}}$$

where R_{SET} is connected to V^-

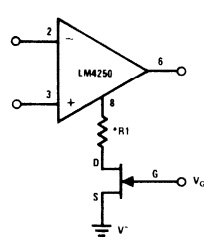
$$I_{SET} = \frac{V^+ - 0.5}{R_{SET}}$$

where R_{SET} is connected to ground

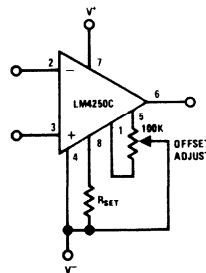


Transistor Current Source Biasing

*R1 limits I_{SET} maximum



FET Current Source Biasing



Offset Null Circuit



Operational Amplifiers

LH24250/LH24250C

LH24250/LH24250C dual programmable micropower op amp

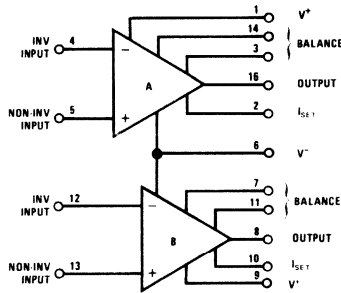
general description

The LH24250/LH24250C series of dual programmable micropower operational amplifiers are two LM4250 type op amps in a single hermetic package. Featuring all the same performance characteristics of the LM4250, the LH24250/LH24250C duals also offer closer thermal tracking, lower weight, reduced insertion cost and smaller size than two single devices. For additional information, see the LM4250 data sheet and National's Linear Application Handbook.

features

- $\pm 1V$ to $\pm 18V$ power supply operation
- Standby power consumption as low as $20 \mu W$
- Offset current programmable from less than 0.5 nA to 30 nA
- Programmable slew rate
- May be shut-down using standard open collector TTL
- Internally compensated and short circuit proof

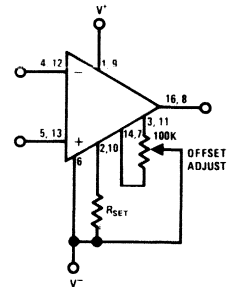
connection diagram and auxiliary circuit



Order Number LH24250F or LH24250CF
See Package 5

Order Number LH24250D or LH24250CD
See Package 2

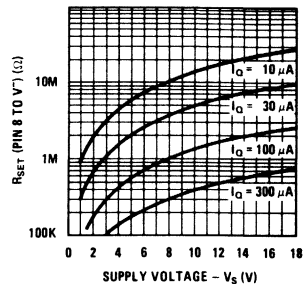
Offset Null Circuit



typical quiescent current setting resistor

(Pin 8 to V-)

V_S	$10 \mu A$	$30 \mu A$	$100 \mu A$	$300 \mu A$
± 1.5	$1.5 \text{ M}\Omega$	$470 \text{ k}\Omega$	$150 \text{ k}\Omega$	
± 3	$3.3 \text{ M}\Omega$	$1.1 \text{ M}\Omega$	$330 \text{ k}\Omega$	$100 \text{ k}\Omega$
± 6	$7.5 \text{ M}\Omega$	$2.7 \text{ M}\Omega$	$750 \text{ k}\Omega$	$220 \text{ k}\Omega$
± 9	$13 \text{ M}\Omega$	$4 \text{ M}\Omega$	$1.3 \text{ M}\Omega$	$350 \text{ k}\Omega$
± 12	$18 \text{ M}\Omega$	$5.6 \text{ M}\Omega$	$1.5 \text{ M}\Omega$	$510 \text{ k}\Omega$
± 15	$22 \text{ M}\Omega$	$7.5 \text{ M}\Omega$	$2.2 \text{ M}\Omega$	$620 \text{ k}\Omega$



absolute maximum ratings

Supply Voltage	±18V	Operating Temperature Range	-55°C to +125°C
Power Dissipation (Note 1)	500 mW	LH24250	0°C to +70°C
Differential Input Voltage (Note 2)	±15V	LH24250C	-65°C to +150°C
Input Voltage (Note 3)	±15V	Storage Temperature Range	300°C
Output Short Circuit Duration	Continuous	Lead Temperature (Soldering, 10 sec)	

electrical characteristics — each side (Note 4)

PARAMETER	CONDITIONS	LIMITS		UNITS
		LH24250	LH24250C	
Input Offset Voltage	$T_A = 25^\circ\text{C}, R_S \leq 100\text{ k}\Omega$	3.0	6.0	mV Max
Input Offset Current	$T_A = 25^\circ\text{C}$	5	10	nA Max
Input Bias Current	$T_A = 25^\circ\text{C}$	15	30	nA Max
Input Resistance	$T_A = 25^\circ\text{C}$	3	3	M Ω Min
Power Consumption	$T_A = 25^\circ\text{C}, V_O = 0, R_{SET} = 2.7\text{ M}\Omega$	480	600	μW Max
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}, R_L \geq 10\text{ k}\Omega$	100	75	V/mV Min
Input Offset Voltage	$R_S \geq 10\text{ k}\Omega$	4.0	7.5	mV Max
Input Offset Current		5	15	nA Max
Input Bias Current		15	50	nA Max
Large Signal Voltage Gain	$R_L \geq 10\text{ k}\Omega$	50	50	V/mV Min
Output Voltage Swing	$R_L \geq 10\text{ k}\Omega, V_S = \pm 15\text{V}$	±10	±10	V Min
Input Voltage Range	$T_A = 25^\circ\text{C}, V_S = \pm 15\text{V}$	±12	±12	V Min
Common Mode Rejection Ratio	$T_A = 25^\circ\text{C}, R_S \leq 10\text{ k}\Omega$	70	70	dB Min
Supply Voltage Rejection Ratio	$T_A = 25^\circ\text{C}, R_S \leq 10\text{ k}\Omega$	76	76	dB Min

Note 1: Derate linearly 2 mW/°C case temperature above 25°C.

Note 2: This rating applies to maximum voltage differential between input terminals. The maximum input voltage on either input terminal is limited to $\pm V_S$ up to $\pm 15\text{V}$.

Note 3: This rating limited to \pm supply voltage to a maximum of $\pm 15\text{V}$.

Note 4: These specifications apply for $V_S = \pm 6\text{V}$, $I_q = 30\text{ }\mu\text{A}$, and $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ unless otherwise specified. With the LH24250C, however, all temperature specifications are limited to $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$.



Voltage Comparators/Buffers

LM106/LM206 voltage comparator/buffer

general description

The LM106 and LM206 are high-speed voltage comparators designed to accurately detect low-level analog signals and drive a digital load. They are equivalent to an LM710, combined with a two input NAND gate and an output buffer. The circuits can drive RTL, DTL or TTL integrated circuits directly. Furthermore, their outputs can switch voltages up to 24V at currents as high as 100 mA. Other features include:

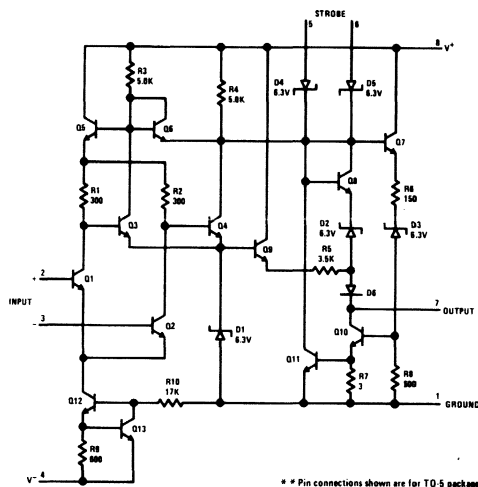
- Improved accuracy: 2 mV maximum worst case offset.
- Fan-out of 10 with DTL or TTL
- Added logic or strobe capability
- Useful as a relay or lamp driver
- Plug-in replacement for the LM710.

- 40 ns maximum response time

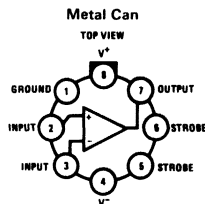
The devices have short-circuit protection which limits the inrush current when it is used to drive incandescent lamps, in addition to preventing damage from accidental shorts to the positive supply. The speed is equivalent to that of an LM710. However, they are even faster where buffers and additional logic circuitry can be eliminated by the increased flexibility of the LM106 and LM206. They can also be operated from any negative supply voltage between -3V and -12V with little effect on performance.

The LM106 is specified for operation over the -55°C to +125°C military temperature range. The LM206 is specified for operation over the -25°C to +85°C temperature range.

schematic and connection diagrams **

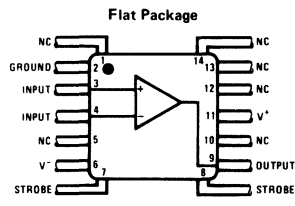


** Pin connections shown are for TO 5 package



Note: Pin 4 connected to case.

Order Number LM106H or LM206H
See Package 11

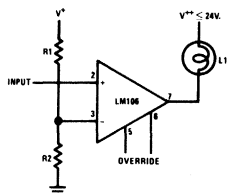


Note: Pin 6 connected to bottom of package.

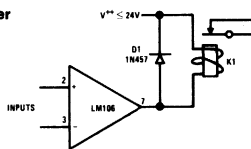
Order Number LM106F or LM206F
See Package 4

typical applications **

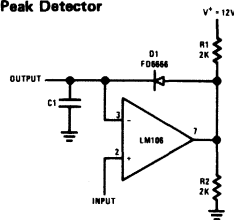
Level Detector and Lamp Driver



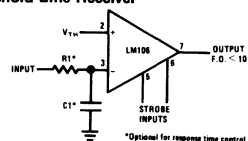
Relay Driver



Fast Response Peak Detector



Adjustable Threshold Line Receiver



*Optional for response time control.

absolute maximum ratings

Positive Supply Voltage	15V	Power Dissipation (Note 1)	600 mW
Negative Supply Voltage	-15V	Output Short Circuit Duration	10 sec
Output Voltage	24V	Operating Temperature Range	LM106 -55°C to 125°C
Output to Negative Supply Voltage	30V	LM206	-25°C to 85°C
Differential Input Voltage	±5V	Storage Temperature Range	-65°C to 150°C
Input Voltage	±7V	Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	Note 3		0.5	2.0	mV
Input Offset Current	Note 3		0.7	3.0	μA
Input Bias Current			10	20	μA
Response Time	Note 4, $R_L = 390\Omega$ to +5V, $C_L = 15$ pF		28	40	ns
Saturation Voltage	$V_{IN} \leq -5$ mV, $I_{OUT} = 100$ mA		1.0	1.5	V
Output Leakage Current	$V_{IN} > 5$ mV, $8V \leq V_{OUT} \leq 24V$		0.02	1.0	μA

electrical characteristics

The following specifications apply for $T_L \leq T_A \leq T_H$ (Note 5)

Input Offset Voltage	Note 3			3.0	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	10	μV/°C
Input Offset Current	Note 3, $T_L \leq T_A \leq 25^\circ\text{C}$ $25^\circ\text{C} \leq T_A \leq T_H$		1.8 0.25	7.0 3.0	μA μA
Average Temperature Coefficient of Input Offset Current	$25^\circ\text{C} \leq T_A \leq T_H$ $T_L \leq T_A \leq 25^\circ\text{C}$		5.0 15	25 75	nA/°C nA/°C
Input Bias Current	$T_L \leq T_A \leq 25^\circ\text{C}$ $25^\circ\text{C} \leq T_A \leq T_H$			45 20	μA μA
Input Voltage Range	$-7V \geq V^- \geq -12V$	:5.0			V
Differential Input Voltage Range		:5.0			V
Saturation Voltage	$V_{IN} \leq -5$ mV, $I_{OUT} = 50$ mA			1.0	V
Saturation Voltage	$V_{IN} \leq -5$ mV, $I_{OUT} = 16$ mA			0.4	V
Positive Output Level	$V_{IN} \geq 5$ mV, $I_{OUT} = -400$ μA	2.5		5.5	V
Output Leakage Current	$V_{IN} \geq 5$ mV, $8V \leq V_{OUT} \leq 24V$ $T_L \leq T_A \leq 25^\circ\text{C}$ $25^\circ\text{C} < T_A \leq T_H$			1.0 100	μA μA
Strobe Current	$V_{strobe} = 0.4V$		-1.7	-3.2	mA
Strobe ON Voltage		0.9	1.4		V
Strobe OFF Voltage	$I_{sink} \leq 16$ mA		1.4	2.2	V
Positive Supply Current	$V_{IN} = -5$ mV		5.5	10	mA
Negative Supply Current			-1.5	-3.6	mA

Note 1: The maximum junction temperature of the LM106 is 150°C, while that of the LM206 is 110°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors.

Note 2: These specifications apply for $-3V \geq V^+ > -12V$, $V^- = 12V$ and $T_A = 25^\circ\text{C}$ unless otherwise specified. All currents into device pins are considered positive.

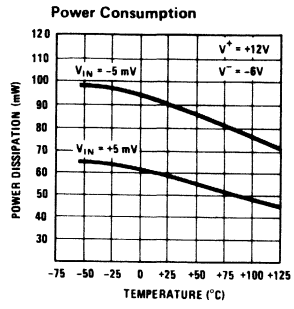
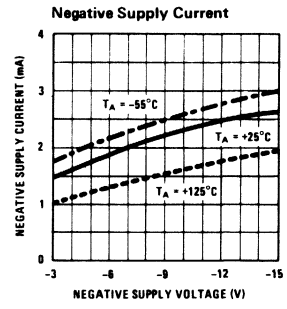
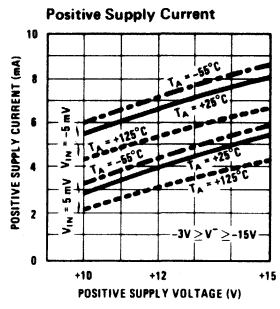
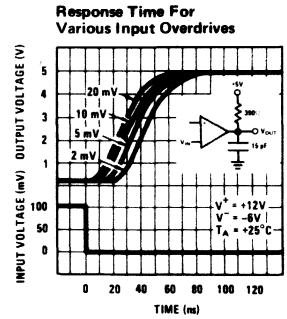
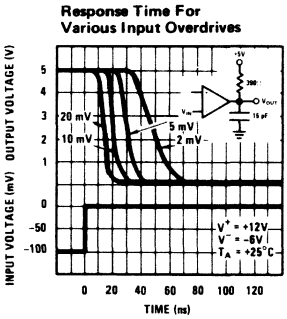
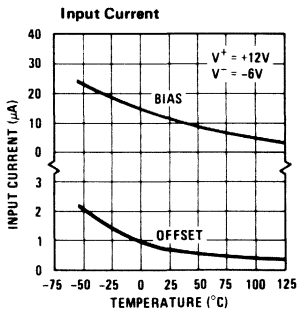
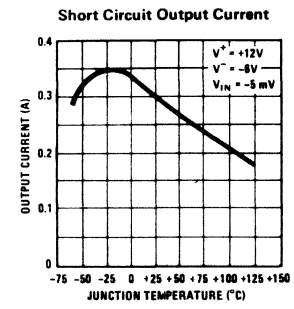
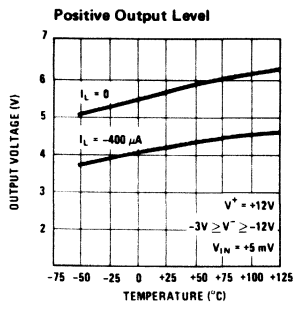
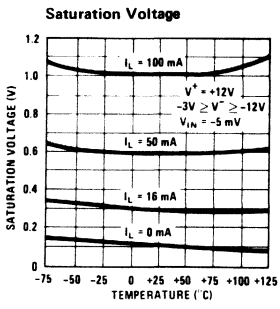
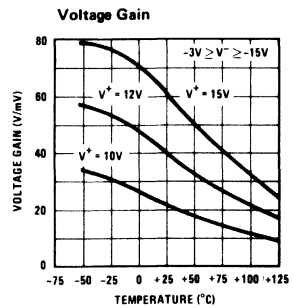
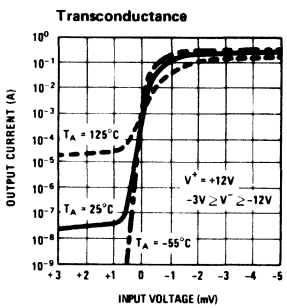
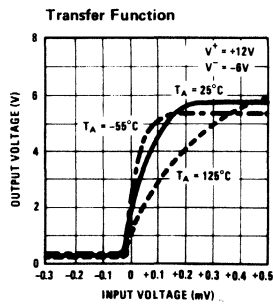
Note 3: The offset voltages and offset currents given are the maximum values required to drive the output down to 0.5V or up to 5.0V. Thus, these parameters actually define an error band and take into account the worst-case effects of voltage gain, specified supply voltage variations, and common mode voltage variations.

Note 4: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

Note 5: All currents into device pins are considered positive.

	T_L	T_H
LM106	-55°C	+125°C
LM206	-25°C	+85°C

typical performance characteristics





Voltage Comparators/Buffers

LM306 voltage comparator/buffer general description

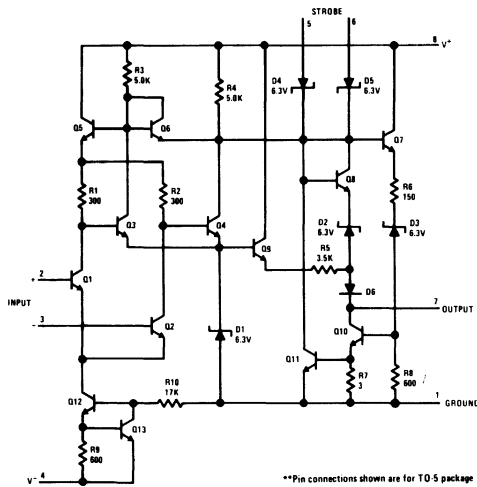
The LM306 is a high-speed voltage comparator designed to accurately detect low-level analog signals and drive a digital load. It is equivalent to an LM710C, combined with a two input NAND gate and an output buffer. The circuit can drive RTL, DTL or TTL integrated circuits directly. Furthermore, the output can switch voltages up to 24V at currents as high as 100 mA. Other features include:

- Improved accuracy: 5 mV (max) offset
- Fan-out of 10 with DTL or TTL
- Added logic or strobe capability
- Useful as a relay or lamp driver

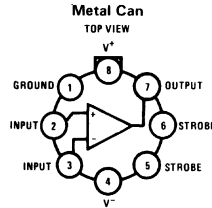
- Plug-in replacement for the LM710C.
- 40 ns maximum response time

The device has short-circuit protection which limits the inrush current when it is used to drive incandescent lamps, in addition to preventing damage from accidental shorts. The speed is equivalent to that of an LM710C. However, it is even faster where buffers and additional logic circuitry can be eliminated by the increased flexibility of the LM306. It can also be operated from any negative supply voltage between -3V and -12V with little effect on performance. The LM306 is identical to the LM106, except that it is specified over a 0°C to 70°C temperature range.

schematic and connection diagrams**



**Pin connections shown are for TO-5 package

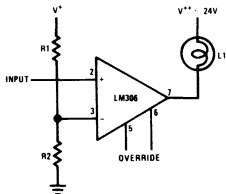


Note: Pin 4 connected to case.

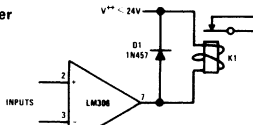
Order Number LM306H
See Package 11

typical applications**

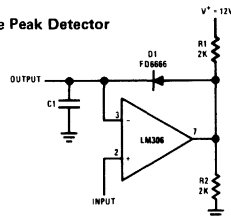
Level Detector and Lamp Driver



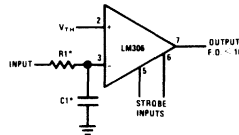
Relay Driver



Fast Response Peak Detector



Adjustable Threshold Line Receiver



**Optional for response time control

absolute maximum ratings

Positive Supply Voltage	15V
Negative Supply Voltage	-15V
Output Voltage	24V
Output to Negative Supply Voltage	30V
Differential Input Voltage	±5V
Input Voltage	±7V
Power Dissipation (Note 1)	600 mW
Output Short Circuit Duration	10 sec
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	Note 3		1.6	5.0	mV
Input Offset Current	Note 3		1.8	5.0	μA
Input Bias Current			16	25	μA
Response Time	Note 4, $R_L = 390\Omega$ to +5V, $C_L = 15$ pF		28	40	ns
Saturation Voltage	$V_{IN} \leq -7$ mV, $I_{OUT} = 100$ mA		0.8	2.0	V
Output Leakage Current	$V_{IN} \geq 7$ mV, $8V \leq V_{OUT} \leq 24V$		0.02	2.0	μA

electrical characteristics

The following specifications apply for $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ (Note 5)

Input Offset Voltage	Note 3			6.5	mV
Average Temperature Coefficient of Input Offset Voltage			5	20	μV/°C
Input Offset Current	Note 3, $0^\circ\text{C} \leq T_A < 25^\circ\text{C}$ $25^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$		2.4	7.5 5.0	μA μA
Average Temperature Coefficient of Input Offset Current	$25^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ $0^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$		15 24	50 100	nA/°C nA/°C
Input Bias Current	$0^\circ\text{C} \leq T_A < 25^\circ\text{C}$ $25^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$		25	40 25	μA μA
Input Voltage Range	$-7V \geq V^- \geq -12V$	±5.0			V
Differential Input Voltage Range		±5.0			V
Saturation Voltage	$V_{IN} \leq -8$ mV, $I_{OUT} = 50$ mA			1.0	V
Saturation Voltage	$V_{IN} \leq -8$ mV, $I_{OUT} = 16$ mA			0.4	V
Positive Output Level	$V_{IN} \geq 8$ mV, $I_{OUT} = -400$ μA	2.5		5.5	V
Output Leakage Current	$V_{IN} \geq 8$ mV, $8V \leq V_{OUT} \leq 24V$ $0^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$ $25^\circ\text{C} < T_A \leq 70^\circ\text{C}$			2.0 100	μA μA
Strobe Current	$V_{strobe} = 0.4V$		-1.7	-3.2	mA
Strobe ON Voltage		0.9	1.4		V
Strobe OFF Voltage	$I_{sink} \leq 16$ mA		1.4	2.2	V
Positive Supply Current	$V_{IN} = -8$ mV		5.5	10	mA
Negative Supply Current			-1.5	-3.6	mA

Note 1: For operating at elevated temperatures, the device must be derated based on a 85°C maximum junction temperature and a thermal resistance of 45°C/W junction to case or 150°C/W junction to ambient.

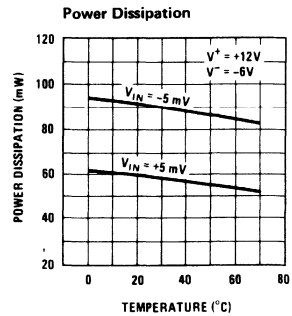
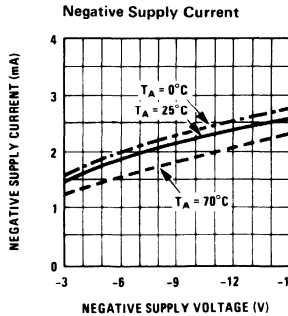
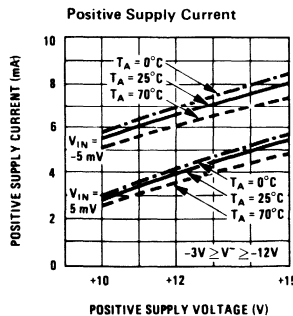
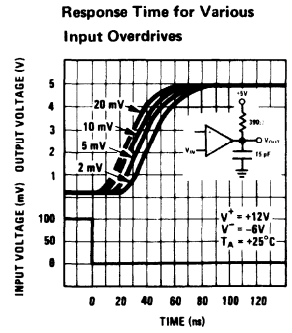
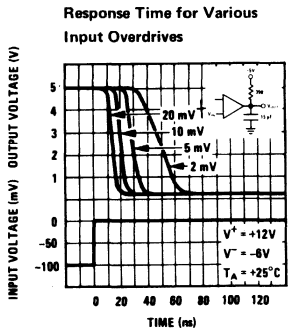
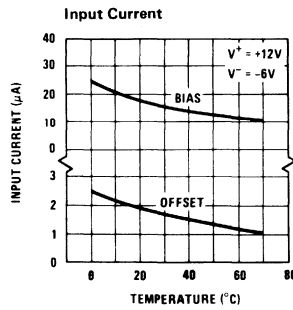
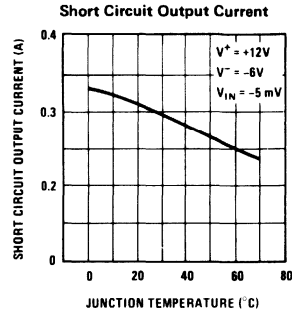
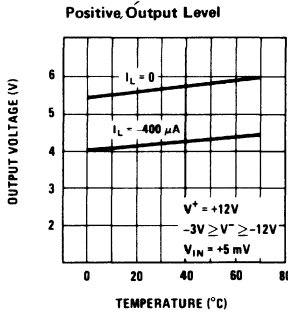
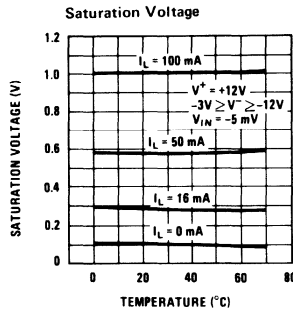
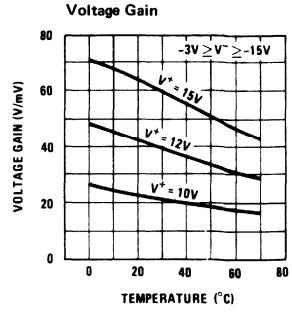
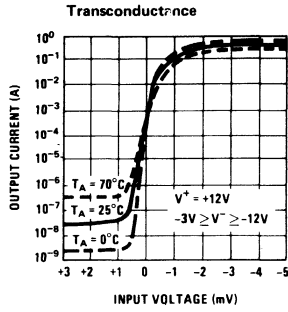
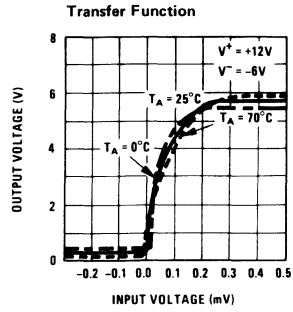
Note 2: These specifications apply for $-3V \geq V^- \geq -12V$, $V^+ = 12V$ and $T_A = 25^\circ\text{C}$ unless otherwise specified. All currents into pins are considered positive.

Note 3: The offset voltages and offset currents given are the maximum values required to drive the output down to 0.5V or up to 5.0V. Thus, these parameters actually define an error band and take into account the worst-case effects of voltage gain, and input impedance, specified supply voltage variations, and common mode voltage variations.

Note 4: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

Note 5: All currents into device pins are considered positive.

typical performance characteristics





Voltage Comparators/Buffers

LM111/LM211

LM111/LM211 voltage comparator

general description

The LM111 and LM211 are voltage comparators that have input currents nearly a thousand times lower than devices like the LM106 or LM710. They are also designed to operate over a wider range of supply voltages: from standard $\pm 15V$ op amp supplies down to the single 5V supply used for IC logic. Their output is compatible with RTL, DTL and TTL as well as MOS circuits. Further, they can drive lamps or relays, switching voltages up to 50V at currents as high as 50 mA. Outstanding characteristics include:

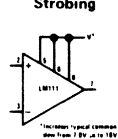
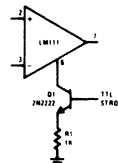
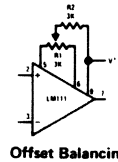
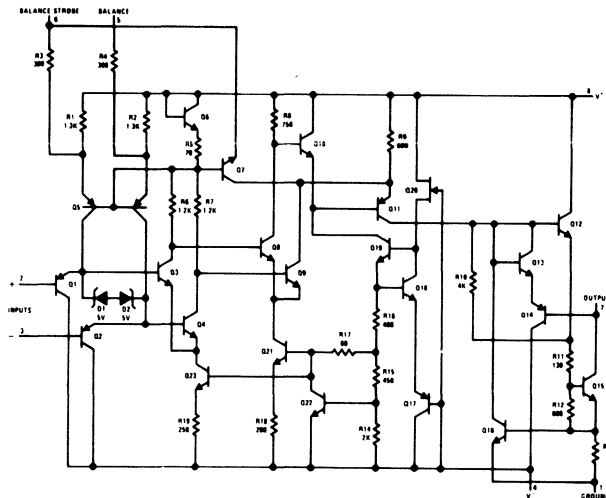
- Operates from single 5V supply
- Input current: 150 nA max. over temperature
- Offset current: 20 nA max. over temperature

- Differential input voltage range: $\pm 30V$
- Power consumption: 135 mW at $\pm 15V$

Both the inputs and the outputs of the LM111 or the LM211 can be isolated from system ground, and the output can drive loads referred to ground, the positive supply or the negative supply. Offset balancing and strobe capability are provided and outputs can be wire OR'ed. Although slower than the LM106 and LM710 (200 ns response time vs 40 ns) the devices are also much less prone to spurious oscillations. The LM111 has the same pin configuration as the LM106 and LM710.

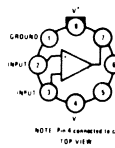
The LM211 is identical to the LM111, except that its performance is specified over a $-25^{\circ}C$ to $85^{\circ}C$ temperature range instead of $-55^{\circ}C$ to $125^{\circ}C$.

schematic diagram and auxiliary circuits**

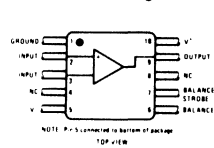


connection diagrams**

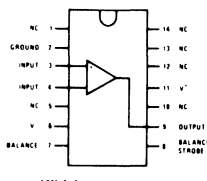
Metal Can



Flat Package



Dual-In-Line

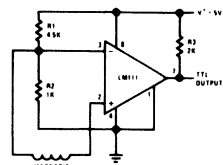


Order Number
LM111H or LM211H
See Package 11

Order Number
LM111F or LM211F
See Package 3

Order Number
LM111D or LM211D
See Package 1

typical application



Detector for Magnetic Transducer

**Pin connections shown are for metal can.

3

absolute maximum ratings

Total Supply Voltage (V_{84})	36V
Output to Negative Supply Voltage (V_{74})	50V
Ground to Negative Supply Voltage (V_{14})	30V
Differential Input Voltage	$\pm 30V$
Input Voltage (Note 1)	$\pm 15V$
Power Dissipation (Note 2)	500 mW
Output Short Circuit Duration	10 sec
Operating Temperature Range LM111	-55°C to 125°C
LM211	-25°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Note 4)	$T_A = 25^{\circ}\text{C}$, $R_S \leq 50k$		0.7	3.0	mV
Input Offset Current (Note 4)	$T_A = 25^{\circ}\text{C}$		4.0	10	nA
Input Bias Current	$T_A = 25^{\circ}\text{C}$		60	100	nA
Voltage Gain	$T_A = 25^{\circ}\text{C}$		200		V/mV
Response Time (Note 5)	$T_A = 25^{\circ}\text{C}$		200		ns
Saturation Voltage	$V_{IN} \leq -5\text{ mV}$, $I_{OUT} = 50\text{ mA}$ $T_A = 25^{\circ}\text{C}$		0.75	1.5	V
Strobe On Current	$T_A = 25^{\circ}\text{C}$		3.0		mA
Output Leakage Current	$V_{IN} \geq 5\text{ mV}$, $V_{OUT} = 35V$ $T_A = 25^{\circ}\text{C}$		0.2	10	nA
Input Offset Voltage (Note 4)	$R_S \leq 50k$			4.0	mV
Input Offset Current (Note 4)				20	nA
Input Bias Current				150	nA
Input Voltage Range			± 14		V
Saturation Voltage	$V^+ \geq 4.5V$, $V^- = 0$ $V_{IN} \leq -6\text{ mV}$, $I_{SINK} \leq 8\text{ mA}$		0.23	0.4	V
Output Leakage Current	$V_{IN} \geq 5\text{ mV}$, $V_{OUT} = 35V$		0.1	0.5	μA
Positive Supply Current	$T_A = 25^{\circ}\text{C}$		5.1	6.0	mA
Negative Supply Current	$T_A = 25^{\circ}\text{C}$		4.1	5.0	mA

Note 1: This rating applies for $\pm 15V$ supplies. The positive input voltage limit is 30V above the negative supply. The negative input voltage limit is equal to the negative supply voltage or 30V below the positive supply, whichever is less.

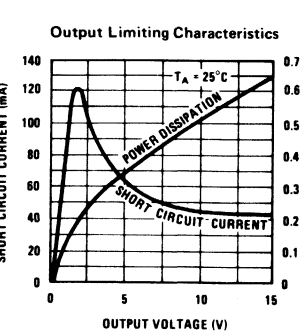
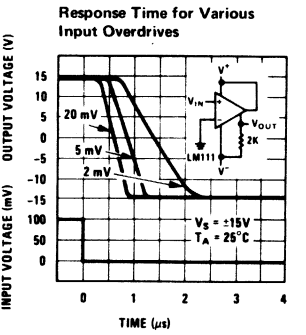
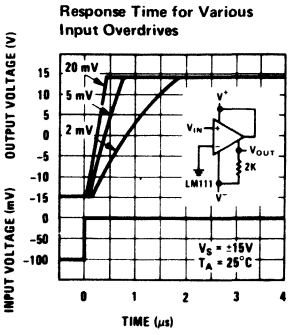
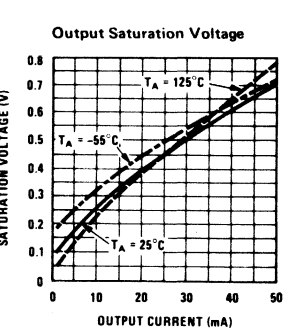
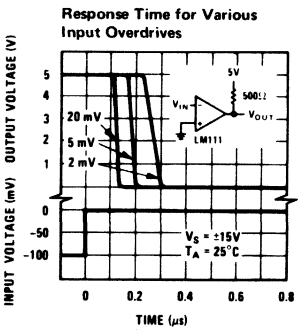
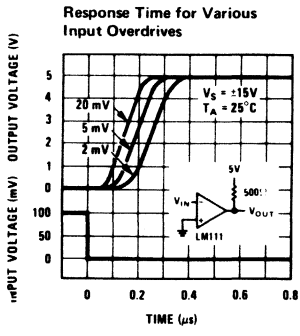
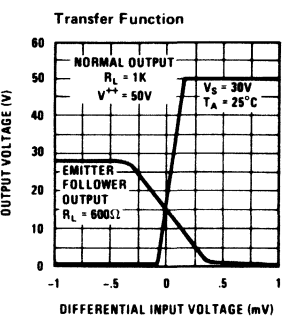
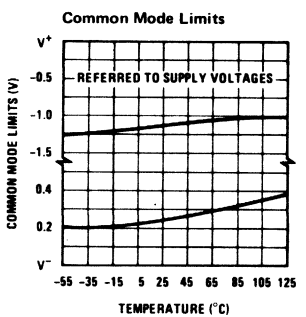
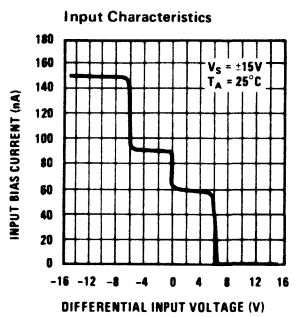
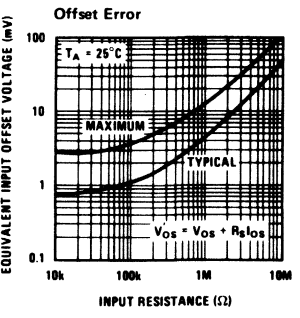
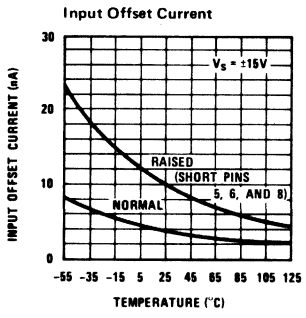
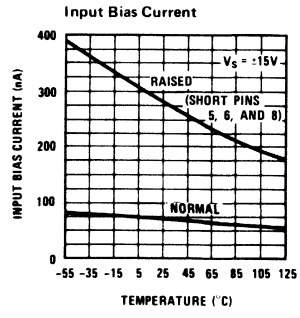
Note 2: The maximum junction temperature of the LM111 is 150°C , while that of the LM211 is 110°C . For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of $150^{\circ}\text{C}/\text{W}$, junction to ambient, or $45^{\circ}\text{C}/\text{W}$, junction to case. For the flat package, the derating is based on a thermal resistance of $185^{\circ}\text{C}/\text{W}$ when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is $100^{\circ}\text{C}/\text{W}$, junction to ambient.

Note 3: These specifications apply for $V_S = \pm 15V$ and $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$, unless otherwise stated. With the LM211, however, all temperature specifications are limited to $-25^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to $\pm 15V$ supplies.

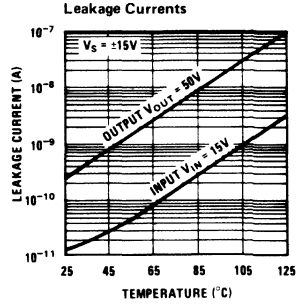
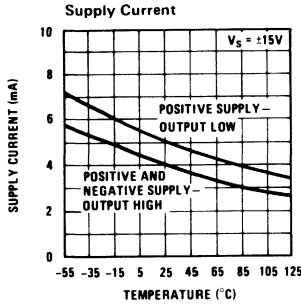
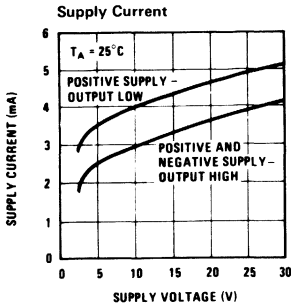
Note 4: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1 mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

Note 5: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

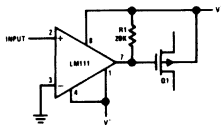
typical performance characteristics



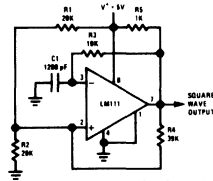
typical performance characteristics (con't)



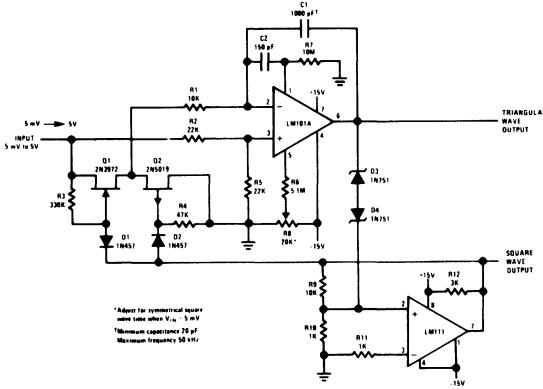
typical applications (con't)



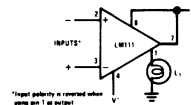
Zero Crossing Detector Driving MOS Switch



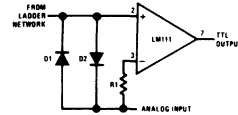
100 kHz Free Running Multivibrator



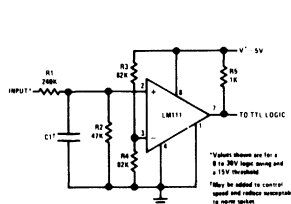
10 Hz to 10 kHz Voltage Controlled Oscillator



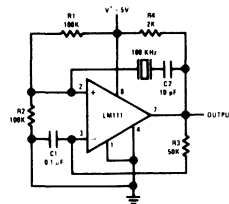
Driving Ground-Referred Load



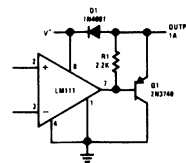
Using Clamp Diodes to Improve Response



TTL Interface with High Level Logic

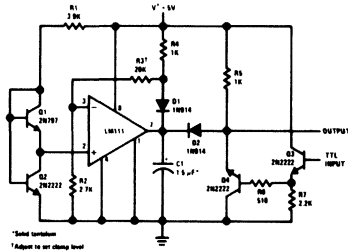


Crystal Oscillator

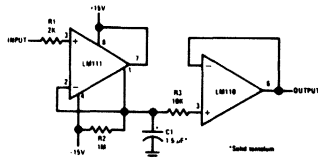


Comparator and Solenoid Driver

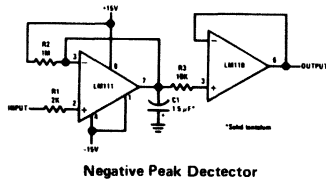
typical applications (con't)



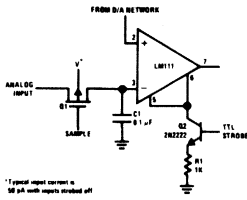
Precision Squarer



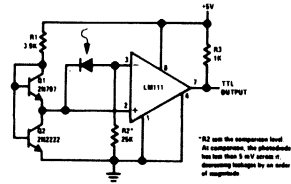
Positive Peak Detector



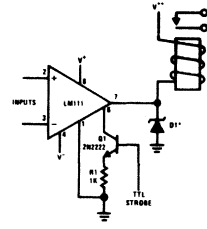
Negative Peak Detector



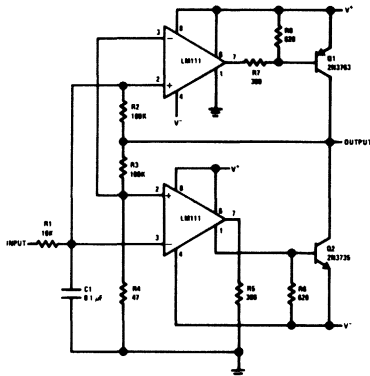
Strobing off Both Input* and Output Stages



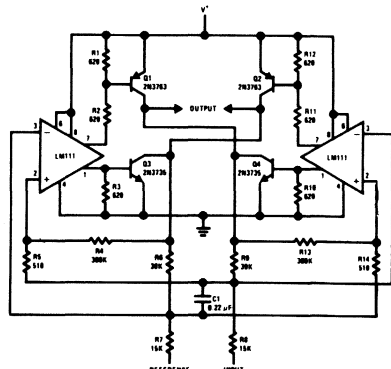
Precision Photodiode Comparator



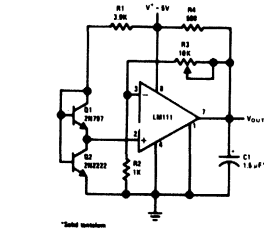
Relay Driver with Strobe



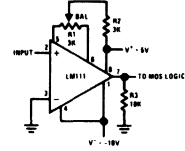
Switching Power Amplifier



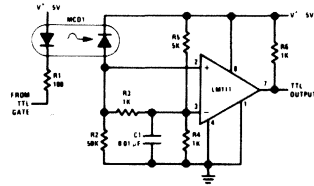
Switching Power Amplifier



Low Voltage Adjustable Reference Supply



Zero Crossing Detector driving MOS logic



Digital Transmission Isolator



Voltage Comparators/Buffers

LM311 voltage comparator general description

The LM311 is a voltage comparator that has input currents more than a hundred times lower than devices like the LM306 or LM710C. It is also designed to operate over a wider range of supply voltages: from standard $\pm 15V$ op amp supplies down to the single 5V supply used for IC logic. Its output is compatible with RTL, DTL and TTL as well as MOS circuits. Further, it can drive lamps or relays, switching voltages up to 40V at currents as high as 50 mA.

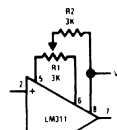
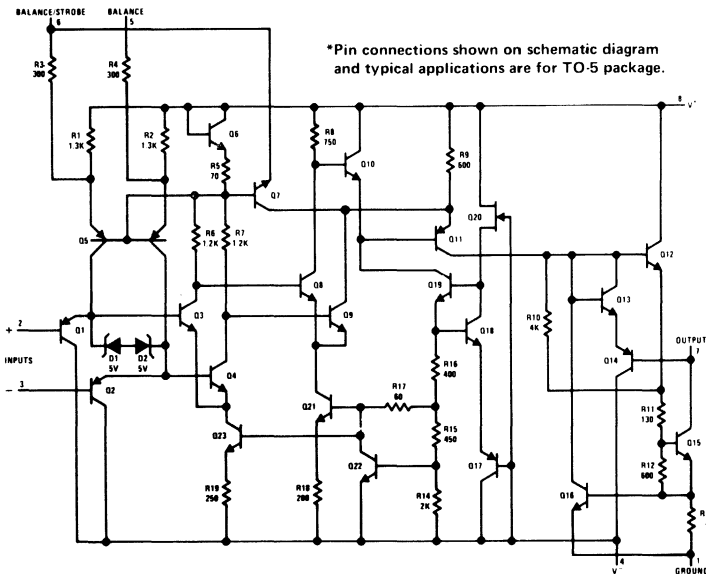
features

- Operates from single 5V supply
- Maximum input current: 250 nA

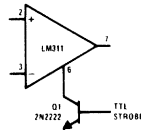
- Maximum offset current: 50 nA
- Differential input voltage range: $\pm 30V$
- Power consumption: 135 mW at $\pm 15V$

Both the input and the output of the LM311 can be isolated from system ground, and the output can drive loads referred to ground, the positive supply or the negative supply. Offset balancing and strobe capability are provided and outputs can be wire OR'ed. Although slower than the LM306 and LM710C (200 ns response time vs 40 ns) the device is also much less prone to spurious oscillations. The LM311 has the same pin configuration as the LM306 and LM710C.

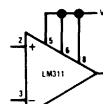
schematic diagram and auxiliary circuits



Offset Balancing



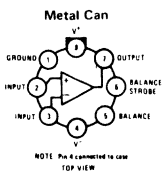
Strobing



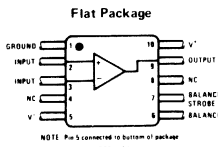
*Increases typical common mode slew from 7.0V/μs to 18V/μs

Increasing Input Stage Current*

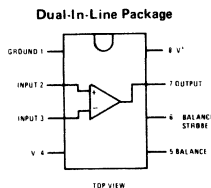
connection diagrams *



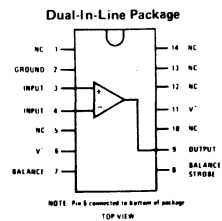
Order Number LM311H
See Package 11



Order Number LM311F
See Package 3



Order Number LM311N
See Package 20



Order Number LM311D
See Package 1 or
Order Number LM311N-14
See Package 22

absolute maximum ratings

Total Supply Voltage ($V_{8,4}$)	36V
Output to Negative Supply Voltage ($V_{7,4}$)	40V
Ground to Negative Supply Voltage ($V_{1,4}$)	30V
Differential Input Voltage	$\pm 30V$
Input Voltage (Note 1)	$\pm 15V$
Power Dissipation (Note 2)	500 mW
Output Short Circuit Duration	10 sec
Operating Temperature Range	$0^{\circ}C$ to $70^{\circ}C$
Storage Temperature Range	$-65^{\circ}C$ to $150^{\circ}C$
Lead Temperature (soldering, 10 sec)	$300^{\circ}C$

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Note 4)	$T_A = 25^{\circ}C, R_S \leq 50K$		2.0	7.5	mV
Input Offset Current (Note 4)	$T_A = 25^{\circ}C$		6.0	50	nA
Input Bias Current	$T_A = 25^{\circ}C$		100	250	nA
Voltage Gain	$T_A = 25^{\circ}C$		200		V/mV
Response Time (Note 5)	$T_A = 25^{\circ}C$		200		ns
Saturation Voltage	$V_{IN} \leq -10$ mV, $I_{OUT} = 50$ mA $T_A = 25^{\circ}C$		0.75	1.5	V
Strobe On Current	$T_A = 25^{\circ}C$		3.0		mA
Output Leakage Current	$V_{IN} \geq 10$ mV, $V_{OUT} = 35V$ $T_A = 25^{\circ}C$		0.2	50	nA
Input Offset Voltage (Note 4)	$R_S \leq 50K$			10	mV
Input Offset Current (Note 4)				70	nA
Input Bias Current				300	nA
Input Voltage Range			± 14		V
Saturation Voltage	$V^+ \geq 4.5V, V^- = 0$ $V_{IN} \leq -10$ mV, $I_{SINK} \leq 8$ mA		0.23	0.4	V
Positive Supply Current	$T_A = 25^{\circ}C$		5.1	7.5	mA
Negative Supply Current	$T_A = 25^{\circ}C$		4.1	5.0	mA

Note 1: This rating applies for $\pm 15V$ supplies. The positive input voltage limit is 30V above the negative supply. The negative input voltage limit is equal to the negative supply voltage or 30V below the positive supply, whichever is less.

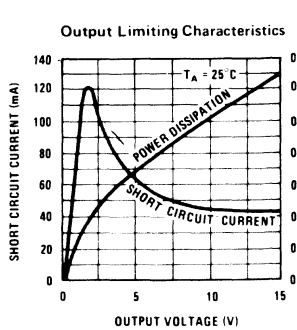
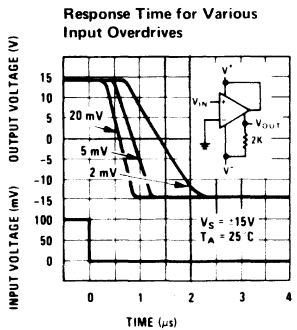
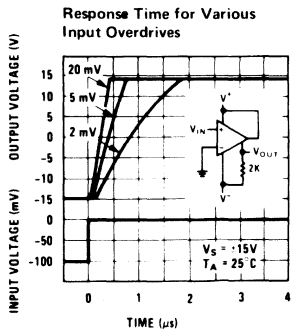
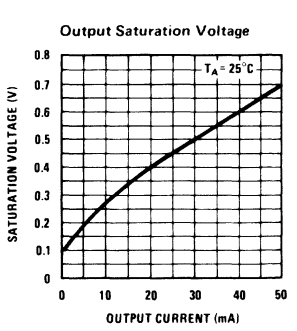
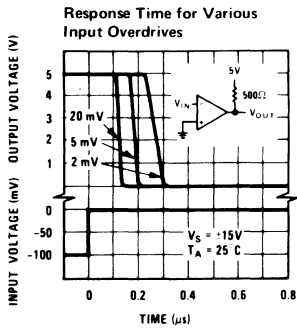
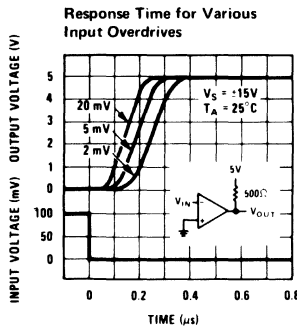
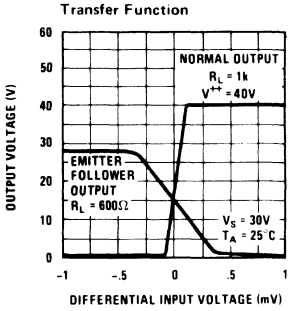
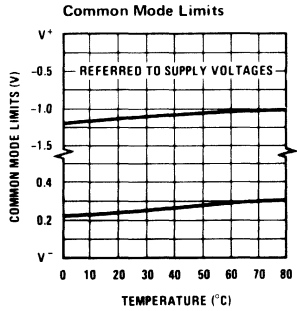
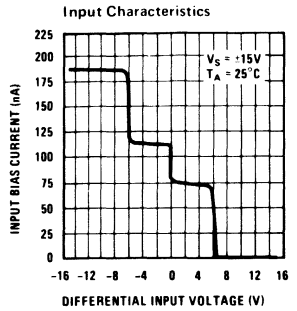
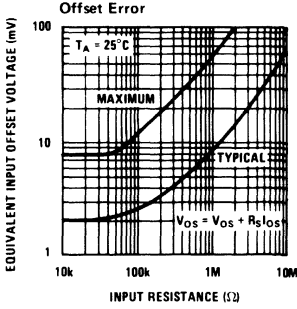
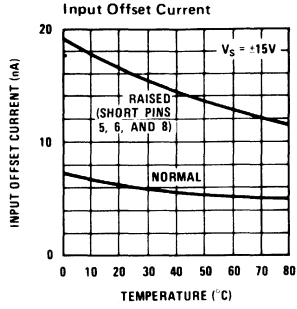
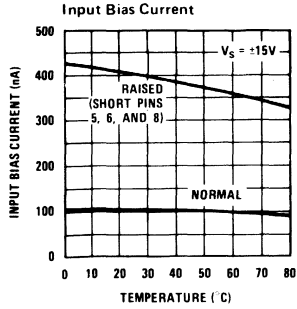
Note 2: The maximum junction temperature of the LM311 is $85^{\circ}C$. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of $150^{\circ}C/W$, junction to ambient, or $45^{\circ}C/W$, junction to case. For the flat package, the derating is based on a thermal resistance of $185^{\circ}C/W$ when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is $100^{\circ}C/W$, junction to ambient.

Note 3: These specifications apply for $V_S = \pm 15V$ and $0^{\circ}C < T_A < 70^{\circ}C$, unless otherwise specified. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to $\pm 15V$ supplies.

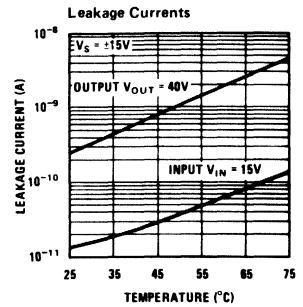
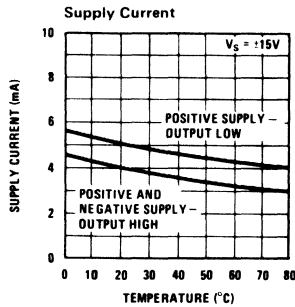
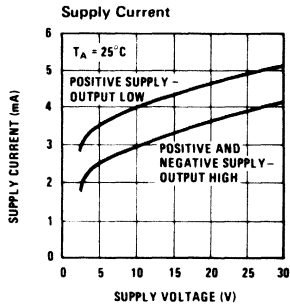
Note 4: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with 1 mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

Note 5: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

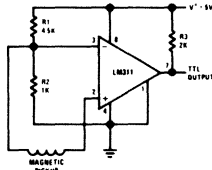
typical performance characteristics



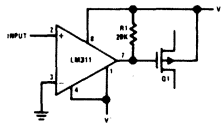
typical performance characteristics (con't)



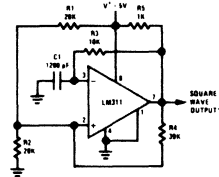
typical applications



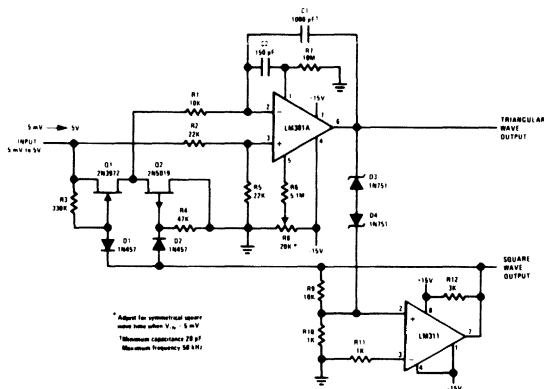
Detector for Magnetic Transducer



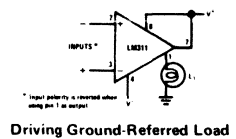
Zero Crossing Detector Driving MOS Switch



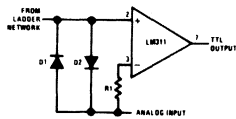
100 kHz Free Running Multivibrator



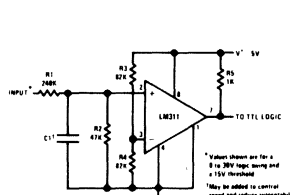
10 Hz to 10 kHz Voltage Controlled Oscillator



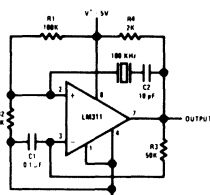
Driving Ground-Referred Load



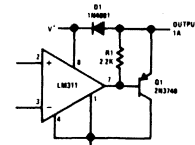
Using Clamp Diodes to Improve Response



TTL Interface with High Level Logic

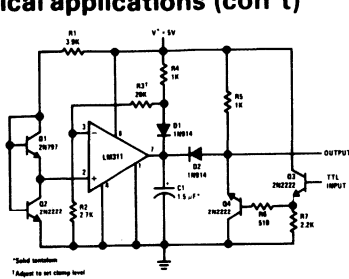


Crystal Oscillator

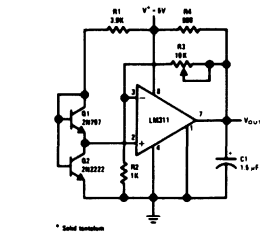


Comparator and Solenoid Driver

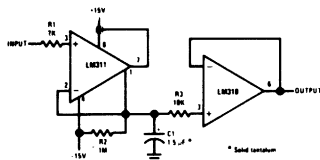
typical applications (con't)



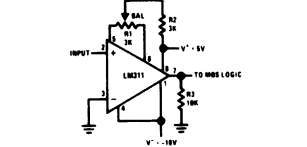
Precision Squarer



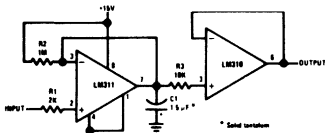
Low Voltage Adjustable Reference Supply



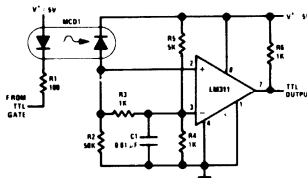
Positive Peak Detector



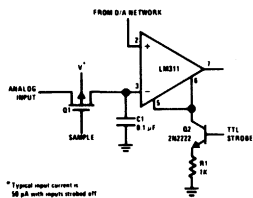
Zero Crossing Detector driving MOS logic



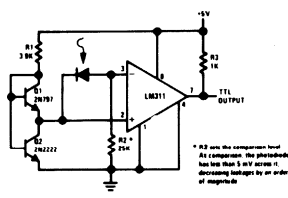
Negative Peak Detector



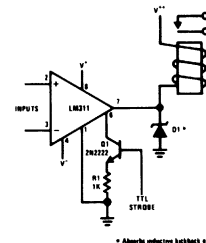
Digital Transmission Isolator



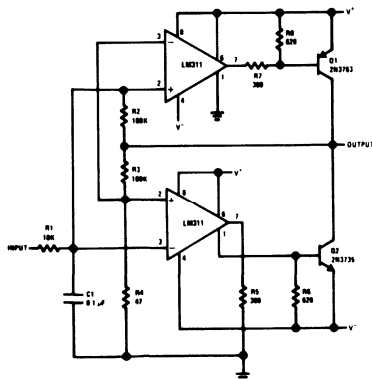
Strobing off Both Input* and Output Stages



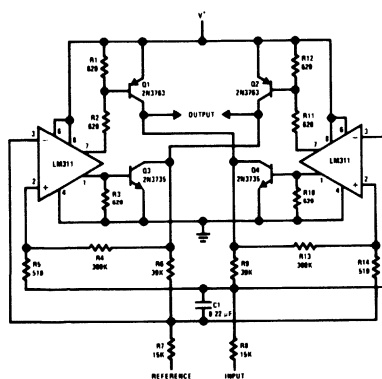
Precision Photodiode Comparator



Relay Driver with Strobe



Switching Power Amplifier



Switching Power Amplifier



Voltage Comparators/Buffers

LM119/LM219 high speed dual comparator general description

The LM119/LM219 are precision high speed dual comparators fabricated on a single monolithic chip. They are designed to operate over a wide range of supply voltages down to a single 5V logic supply and ground. Further, they have higher gain and lower input currents than devices like the LM710. The uncommitted collector of the output stage makes the LM119 compatible with RTL, DTL and TTL as well as capable of driving lamps and relays at currents up to 25 mA. Outstanding features include:

- Maximum input current of 1 μ A over temperature
- Inputs and outputs can be isolated from system ground
- High common mode slew rate

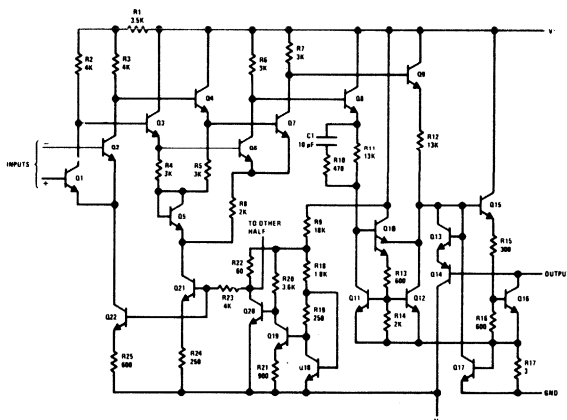
Although designed primarily for applications requiring operation from digital logic supplies, the LM119 is fully specified for power supplies up to ± 15 V. It features faster response than the LM111 at the expense of higher power dissipation. However, the high speed, wide operating voltage range and low package count make the LM119 much more versatile than older devices like the LM711.

The LM219 is identical to the LM119, except that its performance is specified over a -25°C to 85°C temperature range instead of -55°C to 125°C .

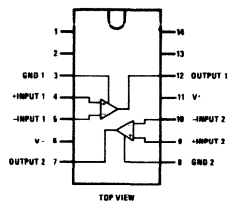
features

- Two independent comparators
- Operates from a single 5V supply
- Typically 80 ns response time at ± 15 V
- Minimum fan-out of 2 each side

schematic and connection diagrams

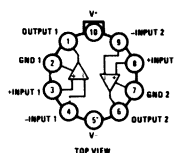


Dual-In-Line-Package



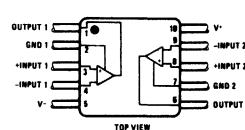
Order Number LM119D or LM219D
See Package 1

Metal Can Package



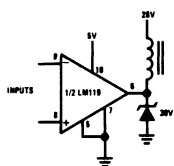
Order Number LM119H or LM219H
See Package 12

Flat Package

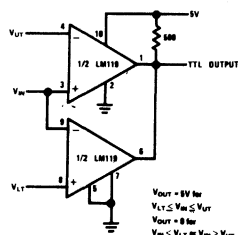


Order Number LM119F or LM219F
See Package 3

typical applications



Relay Driver



Window Detector

$V_{OUT} = 5V$ for
 $V_{L1} \leq V_{IN} \leq V_{UT}$
 $V_{OUT} = 8$ for
 $V_{IN} \leq V_{L1} = V_{IN} \leq V_{UT}$

absolute maximum ratings

Total Supply Voltage	36V	Power Dissipation (Note 2)	500 mW
Output to Negative Supply Voltage	36V	Output Short Circuit Duration	10 sec
Ground to Negative Supply Voltage	25V	Operating Temperature Range LM119	-55°C to 125°C
Ground to Positive Supply Voltage	18V	LM219	-25°C to 85°C
Differential Input Voltage	+5V	Storage Temperature Range	-65°C to 150°C
Input Voltage (Note 1)	±15V	Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Note 4)	$T_A = 25^\circ\text{C}$, $R_S \leq 5k$		0.7	4.0	mV
Input Offset Current (Note 4)	$T_A = 25^\circ\text{C}$		30	75	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		150	500	nA
Voltage Gain	$T_A = 25^\circ\text{C}$	10	40		V/mV
Response Time (Note 5)	$T_A = 25^\circ\text{C}$ $V_S = \pm 15\text{V}$		80		ns
Saturation Voltage	$V_{IN} \leq -5\text{ mV}$, $I_{OUT} = 25\text{ mA}$ $T_A = 25^\circ\text{C}$		0.75	1.5	V
Output Leakage Current	$V_{IN} \geq 5\text{ mV}$, $V_{OUT} = 35\text{V}$ $T_A = 25^\circ\text{C}$		0.2	2	μA
Input Offset Voltage (Note 4)	$R_S \leq 5k$			7	mV
Input Offset Current (Note 4)				100	nA
Input Bias Current				1000	nA
Input Voltage Range	$V_S = \pm 15\text{V}$ $V^+ = 5\text{V}$, $V^- = 0$	1	±13	3	V
Saturation Voltage	$V^+ \geq 4.5\text{V}$, $V^- = 0$ $V_{IN} \leq -6\text{ mV}$, $I_{SINK} \leq 3.2\text{ mA}$ $T_A \geq 0^\circ\text{C}$ $T_A \leq 0^\circ\text{C}$		0.23	0.4 0.6	V V
Output Leakage Current	$V_{IN} \geq 5\text{ mV}$, $V_{OUT} = 35\text{V}$		1	10	μA
Differential Input Voltage				±5	V
Positive Supply Current	$T_A = 25^\circ\text{C}$, $V^+ = 5\text{V}$, $V^- = 0$		4.3		mA
Positive Supply Current	$T_A = 25^\circ\text{C}$ $V_S = \pm 15\text{V}$		8	11.5	mA
Negative Supply Current	$T_A = 25^\circ\text{C}$ $V_S = \pm 15\text{V}$		3	4.5	mA

Note 1: For supply voltages less than $\pm 15\text{V}$ the absolute maximum input voltage is equal to the supply voltage.

Note 2: The maximum junction temperature of the LM119 is 150°C , while that of the LM219 is 110°C . For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W , junction to ambient, or 45°C/W , junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. The thermal resistance of the dual-in-line package is 100°C/W , junction to ambient.

Note 3: These specifications apply for $V_S = \pm 15\text{V}$ and $-55^\circ\text{C} < T_A \leq 125^\circ\text{C}$, unless otherwise stated. With the LM219, however, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to $\pm 15\text{V}$ supplies.

Note 4: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1 mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

Note 5: The response time specified is for a 100 mV input step with 5 mV overdrive.



Voltage Comparators/Buffers

LM319

LM319 high speed dual comparator general description

The LM319 is a precision high speed dual comparator fabricated on a single monolithic chip. It is designed to operate over a wide range of supply voltages down to a single 5V logic supply and ground. Further, it has higher gain and lower input currents than devices like the LM710. The uncommitted collector of the output stage makes the LM319 compatible with RTL, DTL and TTL as well as capable of driving lamps and relays at currents up to 25 mA.

- Minimum fan-out of 2 each side
- Maximum input current of 1 μ A
- Inputs and outputs can be isolated from system ground
- High common mode slew rate

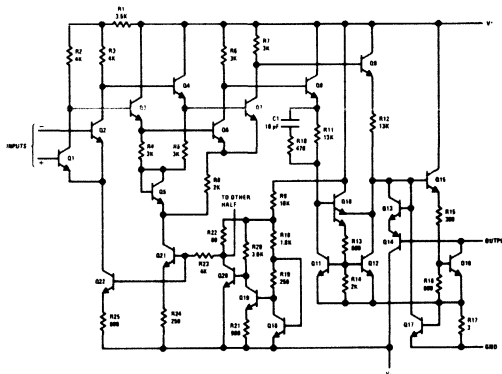
Although designed primarily for applications requiring operation from digital logic supplies, the LM319 is fully specified for power supplies up to ± 15 V. It features faster response than the LM111 at the expense of higher power dissipation. However, the high speed, wide operating voltage range and low package count make the LM319 much more versatile than older devices like the LM711.

The LM319 has its performance specified over a 0°C to 70°C temperature range.

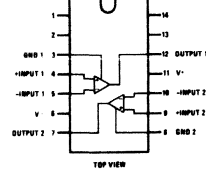
features

- Two independent comparators
- Operates from a single 5V supply
- Typically 80 ns response time at ± 15 V

schematic and connection diagrams



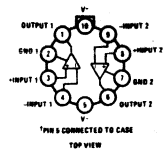
Dual In-Line-Package



TOP VIEW

Order Number
LM319D
See package 1
LM319N
See Package 22

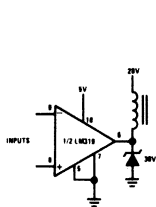
Metal Can Package†



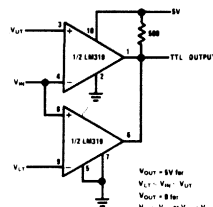
TOP VIEW

Order Number
LH319H
See Package 12

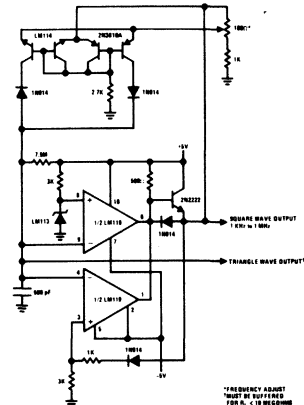
typical applications



Relay Driver



Window Detector



Wide Range Variable Oscillator

†FREQUENCY ADJUST
RANGE BY SWAPPING
FOR A, ≤ 10 DECIMALS

3

absolute maximum ratings

Total Supply Voltage	36V	Power Dissipation (Note 2)	500 mW
Output to Negative Supply Voltage	36V	Output Short Circuit Duration	10 sec
Ground to Negative Supply Voltage	25V	Operating Temperature Range LM319	0°C to 70°C
Ground to Positive Supply Voltage	18V	Storage Temperature Range	-65°C to 150°C
Differential Input Voltage	±5V	Lead Temperature (Soldering, 10 sec)	300°C
Input Voltage (Note 1)	±15V		

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage (Note 4)	$T_A = 25^\circ\text{C}$, $R_S \leq 5\text{k}$		2.0	8.0	mV
Input Offset Current (Note 4)	$T_A = 25^\circ\text{C}$		80	200	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		250	1000	nA
Voltage Gain	$T_A = 25^\circ\text{C}$	8	40		V/mV
Response Time (Note 5)	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		80		ns
Saturation Voltage	$V_{IN} \leq -10\text{ mV}$, $I_{OUT} = 25\text{ mA}$ $T_A = 25^\circ\text{C}$		0.75	1.5	V
Output Leakage Current	$V_{IN} \geq 10\text{ mV}$, $V_{OUT} = 35\text{V}$ $T_A = 25^\circ\text{C}$		0.2	10	μA
Input Offset Voltage (Note 4)	$R_S \leq 5\text{k}$			10	mV
Input Offset Current (Note 4)				300	nA
Input Bias Current				1200	nA
Input Voltage Range	$V_S = \pm 15\text{V}$ $V^+ = 5\text{V}$, $V^- = 0$	1	±13	3	V
Saturation Voltage	$V^+ \geq 4.5\text{V}$, $V^- = 0$ $V_{IN} \leq -10\text{ mV}$, $I_{SINK} \leq 3.2\text{ mA}$		0.3	0.4	V
Differential Input Voltage				±5	V
Positive Supply Current	$T_A = 25^\circ\text{C}$, $V^+ = 5\text{V}$, $V^- = 0$		4.3		mA
Positive Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		8	12.5	mA
Negative Supply Current	$T_A = 25^\circ\text{C}$, $V_S = \pm 15\text{V}$		3	5	mA

Note 1: For supply voltages less than $\pm 15\text{V}$ the absolute maximum input voltage is equal to the supply voltage.

Note 2: The maximum junction temperature of the LM319 is 85°C . For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W , junction to ambient, or 45°C/W , junction to case. The thermal resistance of the dual-in-line package is 100°C/W , junction to ambient.

Note 3: These specifications apply for $V_S = \pm 15\text{V}$ and $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, unless otherwise stated. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to $\pm 15\text{V}$ supplies.

Note 4: The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1 mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

Note 5: The response time specified is for a 100 mV input step with 5 mV overdrive.



Voltage Comparators/Buffers

LM139/LM239/LM339 quad comparators

general description

The LM139 series consists of four independent voltage comparators which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. These comparators also have a unique characteristic in that the input common-mode voltage range includes ground, even though operated from a single power supply voltage.

Application areas include limit comparators, simple analog to digital converters; pulse, squarewave and time delay generators; wide range VCO; MOS clock timers; multivibrators and high voltage digital logic gates. The LM139 series was designed to directly interface with TTL and CMOS. When operated from both plus and minus power supplies, the LM339 will directly interface with MOS logic — where the low power drain of the LM339 is a distinct advantage over standard comparators.

advantages

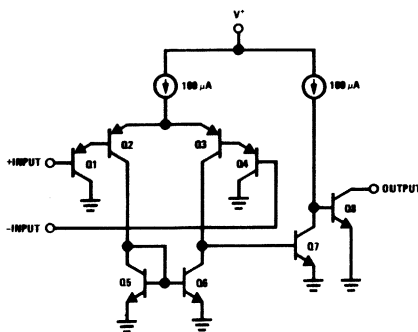
- Eliminates need for dual supplies

- Allows sensing near GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

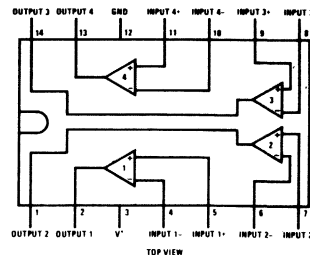
features

- Wide single supply Voltage range
 $2 V_{DC}$ to $36 V_{DC}$
 or dual supplies $\pm 1 V_{DC}$ to $\pm 18 V_{DC}$
- Very low supply current drain (0.8 mA) — independent of supply voltage (1 mW/comparator at $+5 V_{DC}$)
- Low input biasing current 35 nA
- Low input offset current 3 nA and offset voltage 3 mV
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Low output saturation voltage
 1 mV at $5 \mu\text{A}$
 70 mV at 1 mA
- Output voltage compatible with TTL (fanout of 3), DTL, ECL, MOS and CMOS logic systems

schematic and connection diagrams

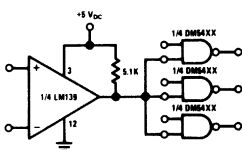


Dual-In-Line and Flat Package

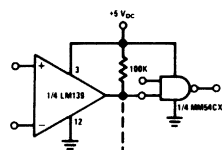


Order Number	Order Number	Order Number
LM139F	LM139D, LM239D,	LM339N
See Package 4	or LM339D	See Package 22
	See Package 1	

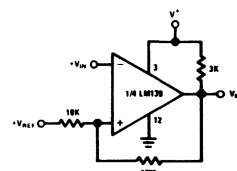
typical applications ($V^+ = 5 V_{DC}$)



Driving TTL



Driving CMOS



Comparator with Hysteresis

absolute maximum ratings

Supply Voltage, V^+	36 V_{DC} or $\pm 18 V_{DC}$
Differential Input Voltage	36 V_{DC}
Input Voltage	-0.3 V_{DC} to +36 V_{DC}
Power Dissipation (Note 1)	
Molded DIP (LM339N)	570 mW
Cavity DIP (LM139D, LM239D & LM339D)	900 mW
Flat Pack (LM139F)	800 mW
Output Short-Circuit to GND (Note 2)	Continuous
Operating Temperature Range	
LM339	0°C to +70°C
LM239	-25°C to +85°C
LM139	-55°C to +125°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics ($V^+ = +5 V_{DC}$ and $T_A = 25^\circ\text{C}$ unless otherwise noted)

PARAMETER	CONDITIONS	LM139			LM239, LM339			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	At Output Switch Point, $V_0 \cong 1.4 V_{DC}$. $V_{REF} = +1.4 V_{DC}$ and $R_S = 0\Omega$		2	5		2	5	mV _{DC}
Input Bias Current (Note 3)	$I_{IN(+)}$ or $I_{IN(-)}$ With Output in Linear Range		25	100		25	250	nA _{DC}
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$		3	25		5	50	nA _{DC}
Input Common-Mode Voltage Range (Note 4)		0		$V^+ - 1.5$	0		$V^+ - 1.5$	V_{DC}
Supply Current	$R_L = \infty$ On All Comparators		0.8	2		0.8	2	mA _{DC}
Voltage Gain	$R_L = 15 k\Omega$		200			200		V/mV
Response Time (Note 5)	$V_{RL} = 5.0 V_{DC}$ and $R_L = 5.1 k\Omega$		1.3			1.3		μs
Output Sink Current	$V_{IN(-)} = +1 V_{DC}$, $V_{IN(+)} = 0$ and $V_0 \leq +1.5 V_{DC}$	6	16		6	16		mA _{DC}
Saturation Voltage	$V_{IN(-)} = +1 V_{DC}$, $V_{IN(+)} = 0$ and $I_{SINK} = 3 \text{ mA}$		200	400		200	400	mV _{DC}
Output Leakage Current	$V_{IN(+)} = +1 V_{DC}$, $V_{IN(-)} = 0$ and $V_{OUT} = 5 V_{DC}$		0.1			0.1		nA _{DC}

Note 1: For operating at high temperatures, the LM339 must be derated based on a +125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM239 and LM139 must be derated based on a +150°C maximum junction temperature. The low bias dissipation and the ON-OFF characteristic of the outputs keeps the chip dissipation very small ($P_d \leq 100 \text{ mW}$), provided the output transistors are allowed to saturate.

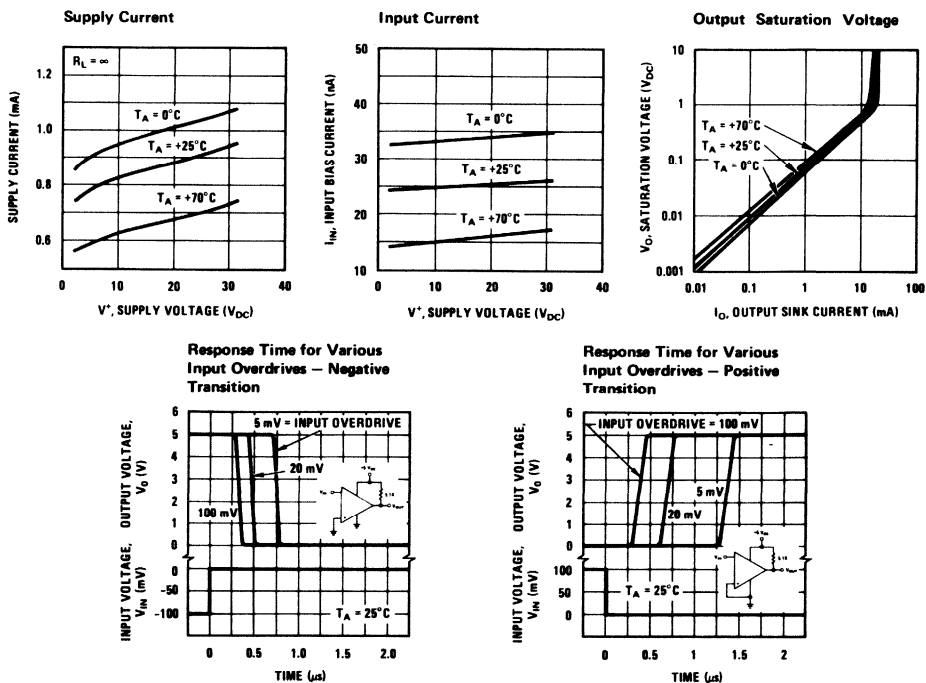
Note 2: Short circuits from the output to V^+ can cause excessive heating and eventual destruction. The maximum output current is approximately 20 mA independent of the magnitude of V^+ .

Note 3: The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the reference or input lines.

Note 4: The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is $V^+ - 1.5V$, but either or both inputs can go to +30 V_{DC} without damage.

Note 5: The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals 300 ns can be obtained, see typical performance characteristics section.

typical performance characteristics



application hints

The LM139 is a high gain, wide bandwidth device; which, like most comparators, can easily oscillate if the output lead is inadvertently allowed to capacitively couple to the inputs via stray capacitance. This shows up only during the output voltage transition intervals as the comparator changes states. Power supply bypassing is not required to solve this problem. Standard PC board layout is helpful as it reduces stray input-output coupling. Reducing the input resistors to $<10\text{ k}\Omega$ reduces the feedback signal levels and finally, adding even a small amount (1 to 10 mV) of positive feedback (hysteresis) causes such a rapid transition that oscillations due to stray feedback are not possible. Simply socketing the IC and attaching resistors to the pins will cause input-output oscillations during the small transition intervals unless hysteresis is used. If the input signal is a pulse waveform, with relatively fast rise and fall times, hysteresis is not required.

All pins of any unused comparators should be grounded.

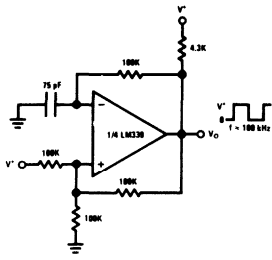
The bias network of the LM139 establishes a drain current which is independent of the magnitude of the power supply voltage over the range of from $2V_{DC}$ to $30V_{DC}$.

It is usually unnecessary to use a bypass capacitor across the power supply line.

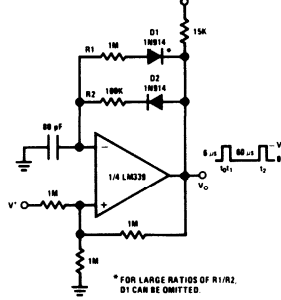
The differential input voltage may be larger than V^+ without damaging the device. Protection should be provided to prevent the input voltages from going negative more than $-0.3V_{DC}$ (at 25°C). An input clamp diode can be used as shown in the applications section.

The output of the LM139 is the uncommitted collector of a grounded-emitter NPN output transistor. Many collectors can be tied together to provide an output OR'ing function. An output pull-up resistor can be connected to any available power supply voltage within the permitted supply voltage range and there is no restriction on this voltage due to the magnitude of the voltage which is applied to the V^+ terminal of the LM139 package. The output can also be used as a simple SPST switch to ground (when a pull-up resistor is not used). The amount of current which the output device can sink is limited by the drive available (which is independent of V^+) and the β of this device. When the maximum current limit is reached (approximately 16 mA), the output transistor will come out of saturation and the output voltage will rise very rapidly. The output saturation voltage is limited by the approximately 60Ω r_{sat} of the output transistor. The low offset voltage of the output transistor (1 mV) allows the output to clamp essentially to ground level for small load currents.

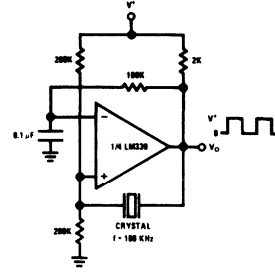
typical applications (con't) ($V^+ = 15\text{ V}_{DC}$)



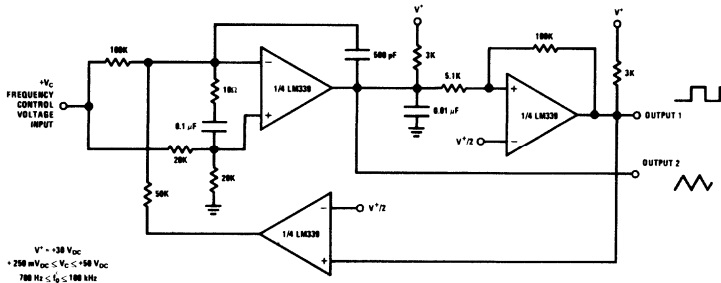
Squarewave Oscillator



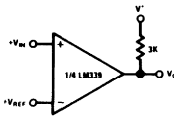
Pulse Generator



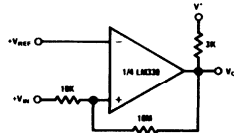
Crystal Controlled Oscillator



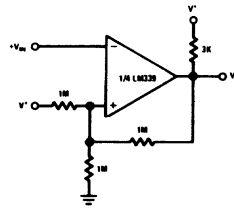
Two-Decade High-Frequency VCO



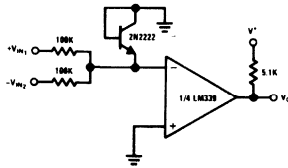
Basic Comparator



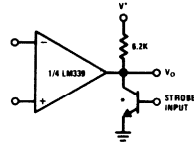
Non-Inverting Comparator with Hysteresis



Inverting Comparator with Hysteresis

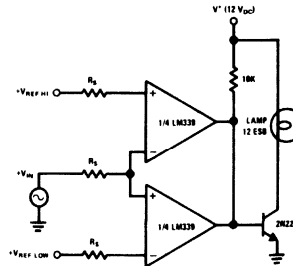


Comparing Input Voltages of Opposite Polarity



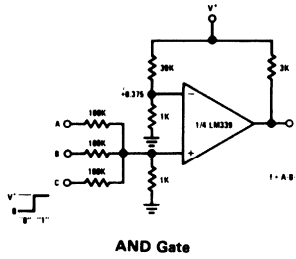
* OR LOGIC GATE WITHOUT PULL UP RESISTOR

Output Strobing

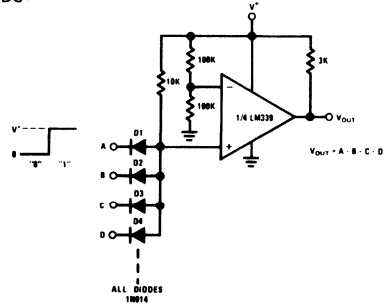


Limit Comparator

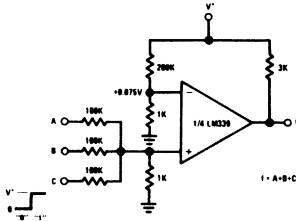
typical applications (con't) ($V^+ = 15 V_{DC}$)



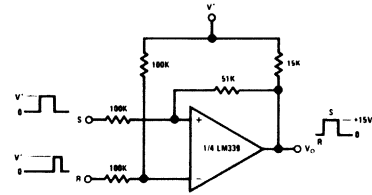
AND Gate



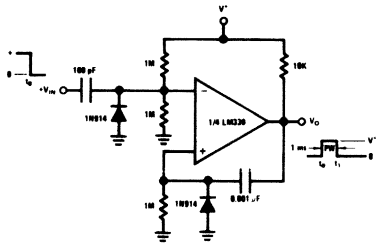
Large Fan-in AND Gate



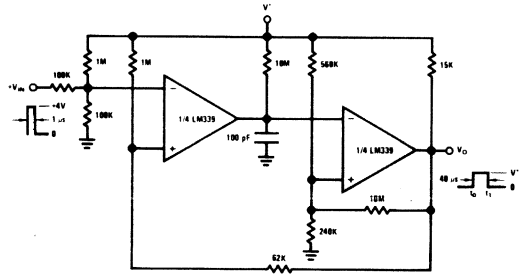
OR Gate



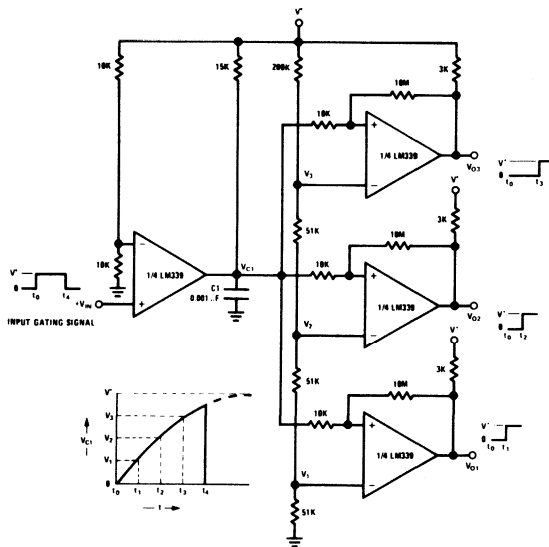
Bi-Stable Multivibrator



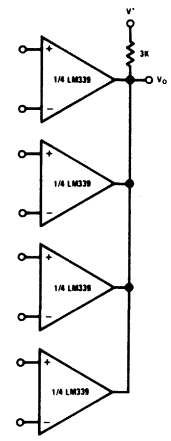
One-Shot Multivibrator



One-Shot Multivibrator with Input Lock Out

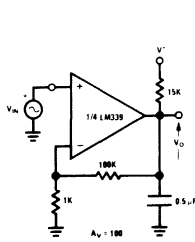


Time Delay Generator

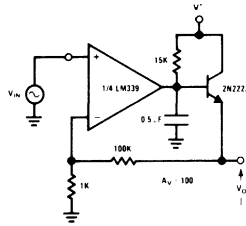


ORing the Outputs

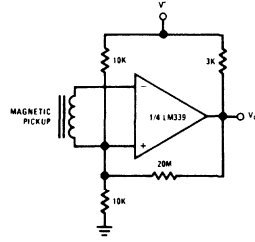
typical applications (con't) ($V^+ = 15 V_{DC}$)



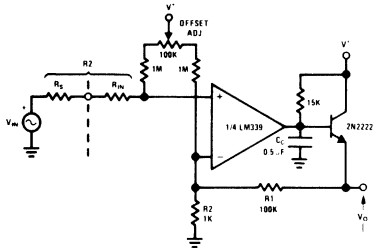
Low Frequency Op Amp



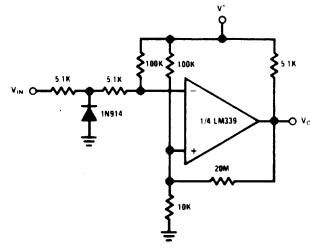
Low Frequency Op Amp ($V_O = 0V$ for $V_{IN} = 0V$)



Transducer Amplifier

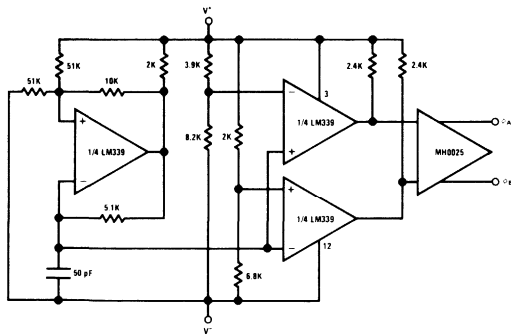


Low Frequency Op Amp with Offset Adjust

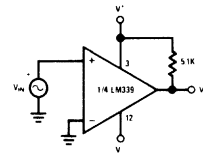


Zero Crossing Detector (Single Power Supply)

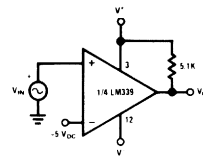
split-supply applications ($V^+ = +15 V_{DC}$ & $V^- = -15 V_{DC}$)



MOS Clock Driver



Zero Crossing Detector



Comparator With a Negative Reference



Voltage Comparators/Buffers

LM139A/LM239A/LM339A

LM139A/LM239A/LM339A low offset voltage quad comparators

general description

The LM139A series consists of four independent precision voltage comparators with an offset voltage specification of 2 mV max. for all four comparators which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. These comparators also have a unique characteristic in that the input common-mode voltage range includes ground, even though operated from a single power supply voltage.

Application areas include limit comparators, simple analog to digital converters; pulse, squarewave and time delay generators; wide range VCO; MOS clock timers; multivibrators and high voltage digital logic gates. The LM139A series was designed to directly interface with TTL and CMOS. When operated from both plus and minus power supplies, the LM339A will directly interface with MOS logic — where the low power drain of the LM339A is a distinct advantage over standard comparators.

advantages

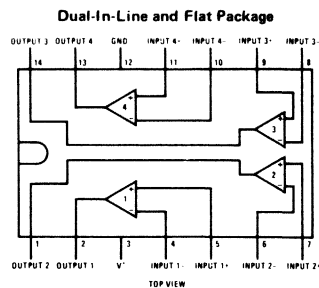
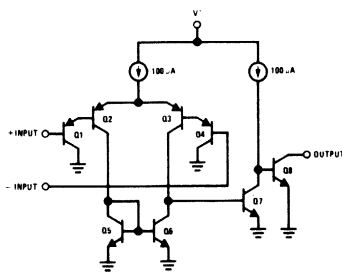
- High precision comparators
- Reduced V_{OS} drift over temperature

- Eliminates need for dual supplies
- Allows sensing near GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

features

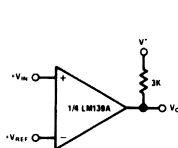
- Wide single supply Voltage range $2 V_{DC}$ to $36 V_{DC}$ or dual supplies $\pm 1 V_{DC}$ to $\pm 18 V_{DC}$
- Very low supply current drain (0.8 mA) — independent of supply voltage (2 mW/comparator at +5 V_{DC})
- Low input biasing current 35 nA
- Low input offset current 3 nA and maximum offset voltage 2 mV
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Low output saturation voltage 1 mV at 5 μA 70 mV at 1 mA
- Output voltage compatible with TTL, DTL, ECL, MOS and CMOS logic systems

schematic and connection diagrams

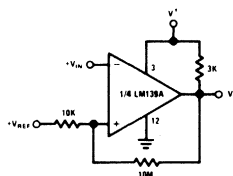


Order Number LM139AF See Package 4	Order Number LM139AD, LM239AD or LM339AD See Package 1	Order Number LM339AN See Package 22
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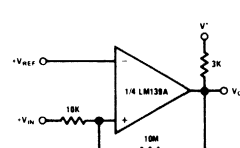
typical applications ($V^+ = 5 V_{DC}$)



Basic Comparator



Comparator with Hysteresis



Non-Inverting Comparator with Hysteresis



absolute maximum ratings

Supply Voltage, V^+	$36 V_{DC}$ or $\pm 18 V_{DC}$
Differential Input Voltage	$36 V_{DC}$
Input Voltage	$-0.3 V_{DC}$ to $+36 V_{DC}$
Power Dissipation (Note 1)	
Molded DIP (LM339AN)	570 mW
Cavity DIP (LM139AD, LM239AD & LM339AD)	900 mW
Flat Pack (LM139AF)	800 mW
Output Short-Circuit to GND (Note 2)	Continuous
Operating Temperature Range	
LM339A	0°C to $+70^\circ\text{C}$
LM239A	-25°C to $+85^\circ\text{C}$
LM139A	-55°C to $+125^\circ\text{C}$
Storage Temperature Range	-65°C to $+150^\circ\text{C}$
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics ($V^+ = 15 V_{DC}$ and $T_A = 25^\circ\text{C}$ unless otherwise noted)

PARAMETER	CONDITIONS	LM139A			LM239A, LM339A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	At Output Switch Point, $V_O \cong 1.4 V_{DC}$; $V_{REF} = +1.4 V_{DC}$ and $R_S = 0\Omega$		1	2		1	2	mV_{DC}
Input Bias Current (Note 3)	$I_{IN(+)}$ or $I_{IN(-)}$ With Output in Linear Range		25	100		25	250	nA_{DC}
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$		3	25		5	50	nA_{DC}
Input Common-Mode Voltage Range (Note 4)				$V^+ - 1.5$			$V^+ - 1.5$	V_{DC}
Supply Current	$R_L = \infty$ On All Comparators		.8	2		.8	2	mA_{DC}
Voltage Gain	$R_L = 15 k\Omega$		200			200		V/mV
Response Time (Note 5)	$V_{RL} = 5.0 V_{DC}$ and $R_L = 5.1 k\Omega$		1.3			1.3		μs
Output Sink Current	$V_{IN(-)} = +1 V_{DC}$, $V_{IN(+)} = 0$ and $V_O \leq +1.5 V_{DC}$	6	16		6	16		mA_{DC}
Saturation Voltage	$V_{IN(-)} = +1 V_{DC}$, $V_{IN(+)} = 0$ and $I_{SINK} = 3 mA$		200	400		200	400	mV_{DC}
Output Leakage Current	$V_{IN(+)} = +1 V_{DC}$, $V_{IN(-)} = 0$ and $V_{OUT} = 5 V_{DC}$		0.1			.1		nA_{DC}

Note 1: For operating at high temperatures, the LM339A must be derated based on a $+125^\circ\text{C}$ maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM239A and LM139A must be derated based on a $+150^\circ\text{C}$ maximum junction temperature. The low bias dissipation and the ON-OFF characteristic of the outputs keeps the chip dissipation very small ($P_d \leq 100 mW$), provided the output transistors are allowed to saturate.

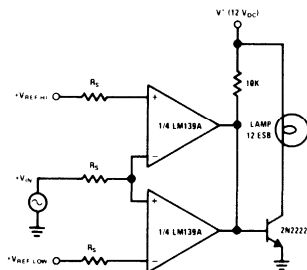
Note 2: Short circuits from the output to V^+ can cause excessive heating and eventual destruction. The maximum output current is approximately 20 mA independent of the magnitude of V^+ .

Note 3: The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the reference or input lines.

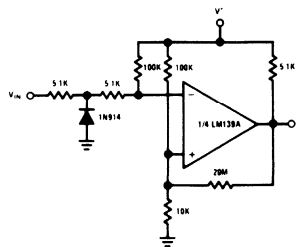
Note 4: The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is $V^+ - 1.5V$, but either or both inputs can go to $+30 V_{DC}$ without damage.

Note 5: The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals 300 ns can be obtained, see typical performance characteristics section.

typical applications (con't) ($V^+ = 5 V_{DC}$)



Limit Comparator



Zero Crossing Detector (Single Power Supply)

For more applications and design information, see LM139 data sheet.



Voltage Comparators/Buffers

LM160/LM260/LM360

LM160/LM260/LM360 high speed differential comparator

general description

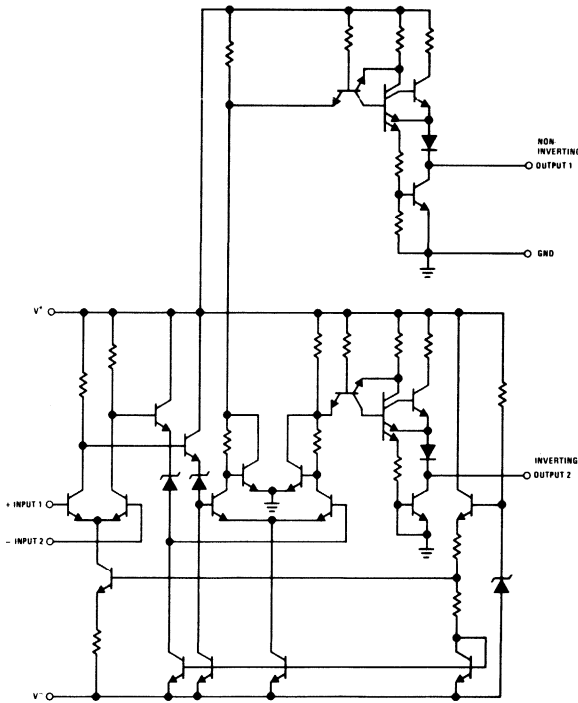
The LM160/LM260/LM360 is a very high speed differential input, complementary TTL output voltage comparator with improved characteristics over the μ A760/ μ A760C, for which it is a pin-for-pin replacement. The device has been optimized for greater speed, input impedance and fan-out, and lower input offset voltage. Typically delay varies only 3 ns for overdrive variations of 5 mV to 500 mV.

Complementary outputs having minimum skew are provided. Applications involve high speed analog to digital converters and zero-crossing detectors in disc file systems.

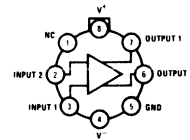
features

- Guaranteed high speed 20 ns max
- Tight delay matching on both outputs
- Complementary TTL outputs
- High input impedance
- Low speed variation with overdrive variation
- Fan-out of 4
- Low input offset voltage
- Series 74 TTL compatible

schematic and connection diagrams



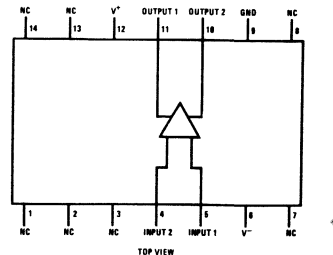
Metal Can Package



TOP VIEW

Order Number LM160H, LM260H, or LM360H
See Package 11

Dual-In-Line and Flat Packages



TOP VIEW

Order Number LM360N
See Package 22

or

Order Number LM160D, LM260D, or LM360D
See Package 1

or

Order Number LM160F
See Package 4

3

absolute maximum ratings

Positive Supply Voltage	+8V	Operating Temperature Range	-55°C to +125°C
Negative Supply Voltage	-8V	LM160	-25°C to +85°C
Peak Output Current	20 mA	LM260	0°C to +70°C
Differential Input Voltage	±5V	LM360	-65°C to +150°C
Input Voltage	$V^+ \geq V_{IN} \geq V^-$	Storage Temperature Range	300°C
		Lead Temperature (Soldering, 10 sec)	

electrical characteristics ($T_{MIN} \leq T_A \leq T_{MAX}$)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Conditions					
Supply Voltage V_{CC}^+		4.5	5	6.5	V
Supply Voltage V_{CC}^-		-4.5	-5	-6.5	V
Input Offset Voltage	$R_S \leq 200\Omega$		1		mV
Input Offset Current			.5		μA
Input Bias Current			5		μA
Output Resistance (Either Output)	$V_{OUT} = V_{OH}$		100		Ω
Response Time	$T_A = 25^\circ C, V_S = \pm 5V$ (Note 1)		16	30	ns
	$T_A = 25^\circ C, V_S = \pm 5V$ (Note 2)			25	ns
	$T_A = 25^\circ C, V_S = \pm 5V$ (Note 3)		14		ns
Response Time Difference Between Outputs					
$(t_{pd} \text{ of } +V_{IN1}) - (t_{pd} \text{ of } -V_{IN2})$	$T_A = 25^\circ C$, (Note 1)		2		ns
$(t_{pd} \text{ of } +V_{IN2}) - (t_{pd} \text{ of } -V_{IN1})$	$T_A = 25^\circ C$, (Note 1)		2		ns
$(t_{pd} \text{ of } +V_{IN1}) - (t_{pd} \text{ of } +V_{IN2})$	$T_A = 25^\circ C$, (Note 1)		2		ns
$(t_{pd} \text{ of } -V_{IN1}) - (t_{pd} \text{ of } -V_{IN2})$	$T_A = 25^\circ C$, (Note 1)		2		ns
Input Resistance	$f = 1 \text{ MHz}$		17		k Ω
Input Capacitance	$f = 1 \text{ MHz}$		3		pF
Average Temperature Coefficient of Input Offset Voltage	$R_S = 50\Omega$		5		$\mu V/^\circ C$
Average Temperature Coefficient of Input Offset Current			7		nA/ $^\circ C$
Common Mode Input Voltage Range	$V_S = \pm 6.5V$	±4	±4.5		V
Differential Input Voltage Range		±5			V
Output High Voltage (Either Output)	$I_{OUT} = -320\mu A, V_S = \pm 4.5V$	2.4			V
Output Low Voltage (Either Output)	$I_{SINK} = 6.4 \text{ mA}$		.25	.4	V
Positive Supply Current	$V_S = \pm 6.5V$		18	32	mA
Negative Supply Current	$V_S = \pm 6.5V$		-9	-16	mA

Note 1: Response time measured from the 50% point of a 30 mVp.p 10 MHz sinusoidal input to the 50% point of the output.

Note 2: Response time measured from the 50% point of a 2 Vp.p 10 MHz sinusoidal input to the 50% point of the output.

Note 3: Response time measured from the start of a 100 mV input step with 5 mV overdrive to the time when the output crosses the logic threshold.



Voltage Comparators/Buffers

LM161/LM261/LM361 high speed differential comparators

general description

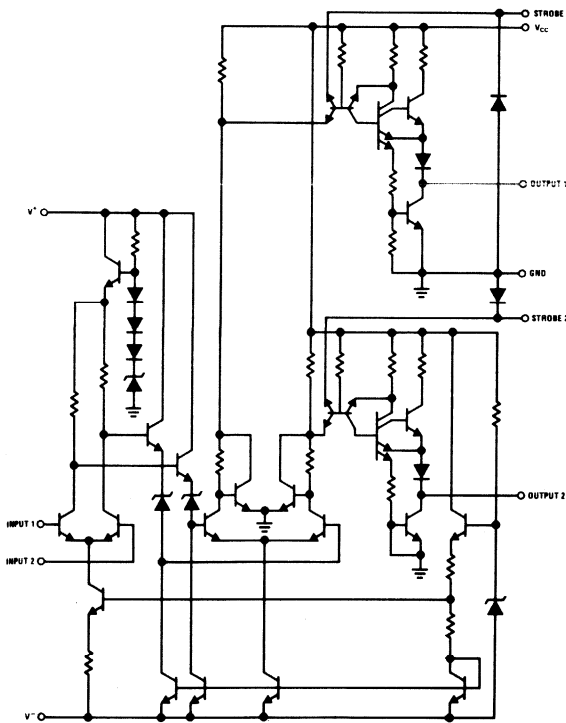
The LM161/LM261/LM361 is a very high speed differential input, complementary TTL output voltage comparator with improved characteristics over the SE529/NE529 for which it is a pin-for-pin replacement. The device has been optimized for greater speed performance and lower input offset voltage. Typically delay varies only 3 ns for over-drive variations of 5 mV to 500 mV. It may be operated from op amp supplies ($\pm 15V$).

Complementary outputs having minimum skew are provided. Applications involve high speed analog to digital converters and zero-crossing detectors in disc file systems.

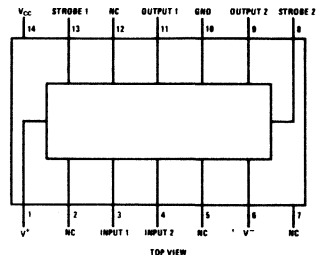
features

- Independent strobes
- Guaranteed high speed 20 ns max
- Tight delay matching on both outputs
- Complementary TTL outputs
- Operates from op amp supplies $\pm 15V$
- Low speed variation with overdrive variation
- Low input offset voltage
- Versatile supply voltage range

schematic and connection diagrams



Dual-In-Line and Flat Package



Order Number LM361N
See Package 22

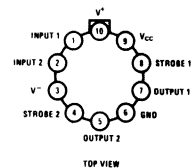
or

Order Number LM161D, LM261D or LM361D
See Package 1

or

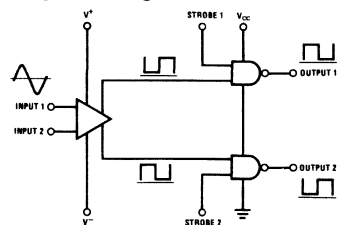
Order Number LM161F
See Package 4

Metal Can Package



Order Number LM161H or LM261H
See Package 11

logic diagram



absolute maximum ratings

Positive Supply Voltage, V^+	+16V
Negative Supply Voltage, V^-	-16V
Gate Supply Voltage, V_{CC}	+7V
Output Voltage	+7V
Differential Input Voltage	$\pm 5V$
Input Common Mode Voltage	$\pm 6V$
Power Dissipation	600 mW
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	
LM161	-55°C to +125°C
LM261	-25°C to +85°C
LM361	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	300°C

operating conditions

	MIN	TYP	MAX
Supply Voltage V^+			
LM161/LM261	5V		15V
LM361	5V		15V
Supply Voltage V^-			
LM161/LM261	-6V		-15V
LM361	-6V		-15V
Supply Voltage V_{CC}			
LM161/LM261	4.5V	5V	5.5V
LM361	4.75V	5V	5.25V

electrical characteristics

($V^+ = +10V$, $V_{CC} = +5V$, $V^- = -10V$, $T_{MIN} \leq T_A \leq T_{MAX}$, unless noted)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM161/LM261			LM361			
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25^\circ C$		1			1		mV
Input Bias Current	$T_A = 25^\circ C$		5	10		5	20	μA
				36			50	
Input Offset Current	$T_A = 25^\circ C$		2	3		2	5	μA
				9			15	
Voltage Gain	$T_A = 25^\circ C$		5			5		V/mV
Input Resistance	$T_A = 25^\circ C$, $f = 1$ kHz		20			20		k Ω
Logical "1" Output Voltage	$V_{CC} = 4.75V$, $I_{SOURCE} = -5$ mA	2.4	3.3		2.4	3.3		V
Logical "0" Output Voltage	$V_{CC} = 4.75V$, $I_{SINK} = 6.4$ mA			4			4	V
Strobe Input "1" Current	$V_{CC} = 5.25V$, $V_{STROBE} = 2.4V$, $T_A = 25^\circ C$			200			200	μA
				50			100	
Strobe Input "0" Current	$V_{CC} = 5.25V$, $V_{STROBE} = 4V$			-1.6			-1.6	mA
Strobe Input "0" Voltage	$V_{CC} = 4.75V$			8			8	V
Strobe Input "1" Voltage	$V_{CC} = 4.75V$	2			2			V
Output Short Circuit Current	$V_{CC} = 5.25V$, $V_{OUT} = 0V$	-18		-55	-18		-55	mA
Supply Current I^+	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 125^\circ C$			3.25				mA
Supply Current I^+	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 25^\circ C$			3.75				mA
Supply Current I^+	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = -55^\circ C$			4				mA
Supply Current I^+	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $0^\circ C \leq T_A \leq 70^\circ C$						5	mA
Supply Current I^-	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 125^\circ C$			7				mA
Supply Current I^-	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 25^\circ C$			7.5				mA
Supply Current I^-	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = -55^\circ C$			8.5				mA
Supply Current I^-	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $0^\circ C \leq T_A \leq 70^\circ C$						10	mA
Supply Current I_{CC}	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 125^\circ C$			15				mA
Supply Current I_{CC}	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = 25^\circ C$			16				mA
Supply Current I_{CC}	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $T_A = -55^\circ C$			18				mA
Supply Current I_{CC}	$V^+ = 10V$, $V^- = -10V$, $V_{CC} = 5.25V$, $0^\circ C \leq T_A \leq 70^\circ C$						20	mA
TRANSIENT RESPONSE		$V_{IN} = 50$ mV Overdrive						
Propagation Delay Time ($t_{pd(0)}$)	$T_A = 25^\circ C$		11	20		11	20	ns
Propagation Delay Time ($t_{pd(1)}$)	$T_A = 25^\circ C$		12	22		12	22	ns
Delay Between Output A and B	$T_A = 25^\circ C$		2	5		2	5	ns
Strobe Delay Time ($t_{pd(0)}$)	$T_A = 25^\circ C$		6			6		ns
Strobe Delay Time ($t_{pd(1)}$)	$T_A = 25^\circ C$		6			6		ns



Voltage Comparators/Buffers

LM710

LM710 voltage comparator general description

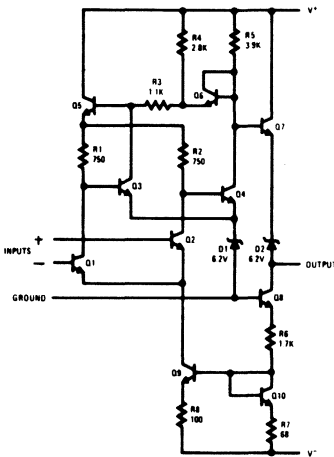
The LM710 is a high-speed voltage comparator intended for use as an accurate, low-level digital level sensor or as a replacement for operational amplifiers in comparator applications where speed is of prime importance. The circuit has a differential input and a single-ended output, with saturated output levels compatible with practically all types of integrated logic.

The device is built on a single silicon chip which insures low offset and thermal drift. The use of a minimum number of stages along with minority-carrier lifetime control (gold doping) makes the circuit much faster than operational amplifiers in

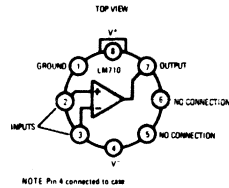
saturation applications. In fact, the low stray and wiring capacitances that can be realized with monolithic construction make the device difficult to duplicate with discrete components operating at equivalent power levels.

The LM710 is useful as a pulse height discriminator, a voltage comparator in high-speed A/D converters or a go, no-go detector in automatic test equipment. It also has applications in digital systems as an adjustable-threshold line receiver or an interface between logic types. In addition, the low cost of the unit suggests it for applications replacing relatively simple discrete component circuitry.

schematic* and connection diagrams



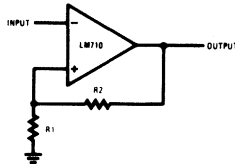
Metal Can



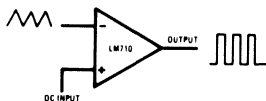
Order Number LM710H
See Package 11

typical applications*

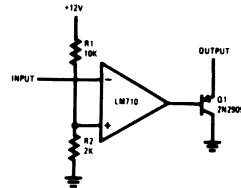
Schmidt Trigger



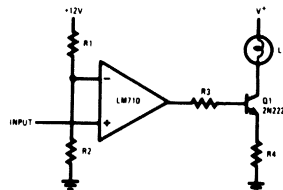
Pulse Width Modulator



Line Receiver With
Increased Output
Sink Current



Level Detector With
Lamp Driver



*Pin connections shown are for metal can.

3

absolute maximum ratings

Positive Supply Voltage	14.0V
Negative Supply Voltage	-7.0V
Peak Output Current	10 mA
Differential Input Voltage	±5.0V
Input Voltage	±7.0V
Power Dissipation	
TO-99 (Note 1)	300 mW
Flat Package (Note 2)	200 mW
Operating Temperature Range	-55°C to +125°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S \leq 200\Omega$ $V_{CM} = 0\text{V}$		0.6	2.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$, $V_{OUT} = 1.4\text{V}$		0.75	3.0	μA
Input Bias Current	$T_A = 25^\circ\text{C}$		13	20	μA
Voltage Gain	$T_A = 25^\circ\text{C}$	1250	1700		
Output Resistance	$T_A = 25^\circ\text{C}$		200		Ω
Output Sink Current	$T_A = 25^\circ\text{C}$, $V_{IN} \leq -5\text{ mV}$ $V_{OUT} = 0$	2.0	2.5		mA
Response Time (Note 4)	$T_A = 25^\circ\text{C}$		40		ns
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0\text{V}$			3.0	mV
Average Temperature Coefficient of Input Offset Voltage	$-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ $R_S \leq 50\Omega$		3.0	10	$\mu\text{V}/^\circ\text{C}$
Input Offset Current	$T_A = 125^\circ\text{C}$ $T_A = -55^\circ\text{C}$		0.25 1.8	3.0 7.0	μA μA
Average Temperature Coefficient of Input Offset Current	$25^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ $-55^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$		5.0 15	25 75	$\text{nA}/^\circ\text{C}$ $\text{nA}/^\circ\text{C}$
Input Bias Current	$T_A = -55^\circ\text{C}$		27	45	μA
Input Voltage Range	$V^- = -7.0\text{V}$	±5.0			V
Common Mode Rejection Ratio	$R_S \leq 200\Omega$	80	100		dB
Differential Input Voltage Range		±5.0V			V
Voltage Gain		1000			
Positive Output Level	$V_{IN} \geq 5\text{ mV}$, $0 \leq I_{OUT} \leq -5\text{ mA}$	2.5	3.2	4.0	V
Negative Output Level	$V_{IN} \leq -5\text{ mV}$	-1.0	-0.5	0	V
Output Sink Current	$T_A = 125^\circ\text{C}$, $V_{IN} \leq -5\text{ mV}$ $V_{OUT} = 0\text{V}$ $T_A = -55^\circ\text{C}$, $V_{IN} \leq -5\text{ mV}$ $V_{OUT} = 0$	0.5 1.0	1.7 2.3		mA mA
Positive Supply Current	$V_{IN} \leq -5\text{ mV}$		5.2	9.0	mA
Negative Supply Current			4.6	7.0	mA
Power Consumption	$V_{IN} \leq -5\text{ mV}$ $I_{OUT} = 0\text{ mA}$		90	150	mW

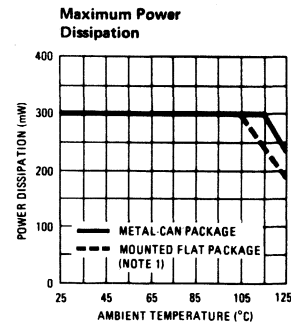
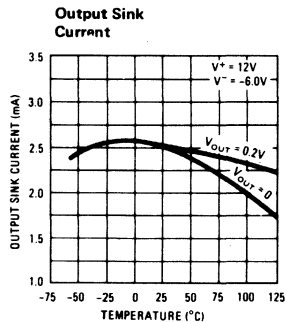
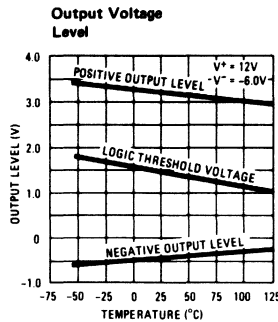
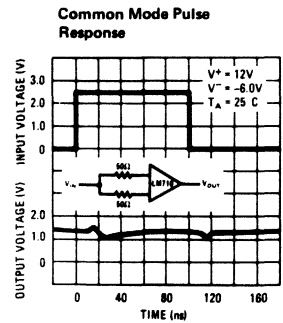
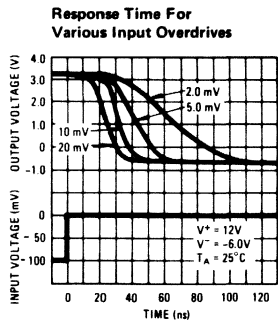
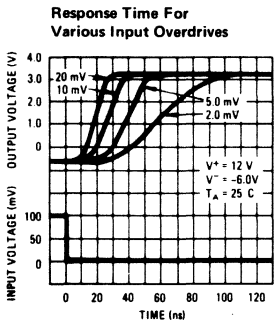
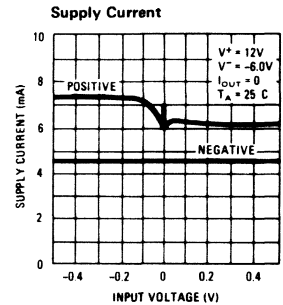
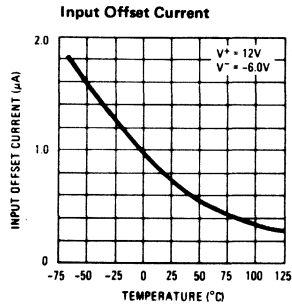
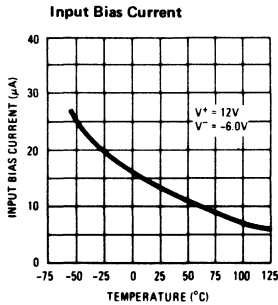
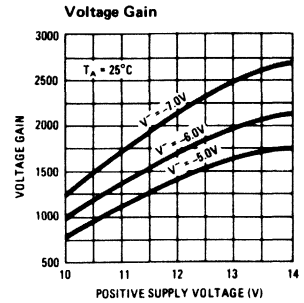
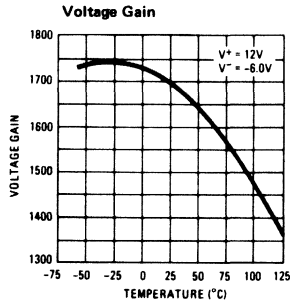
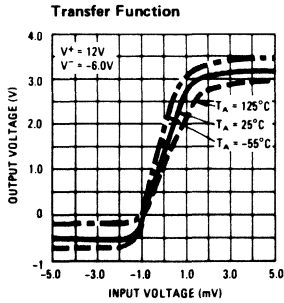
Note 1: Rating applies for case temperatures to +125°C; derate linearly at 5.6 mW/°C for ambient temperatures above +105°C.

Note 2: Derate linearly at 4.4 mW/°C for ambient temperatures above +100°C.

Note 3: These specifications apply for $V^+ = 12.0\text{V}$, $V^- = -6.0\text{V}$, $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ unless otherwise specified. The input offset voltage and input offset current (see definitions) are specified for a logic threshold voltage of 1.8V at -55°C, 1.4V at +25°C, and 1.0V at +125°C.

Note 4: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

typical performance characteristics





Voltage Comparators/Buffers

LM710C voltage comparator

general description

The LM710C is a high-speed voltage comparator intended for use as an accurate, low-level digital level sensor or as a replacement for operational amplifiers in comparator applications where speed is of prime importance. The circuit has a differential input and a single-ended output, with saturated output levels compatible with practically all types of integrated logic.

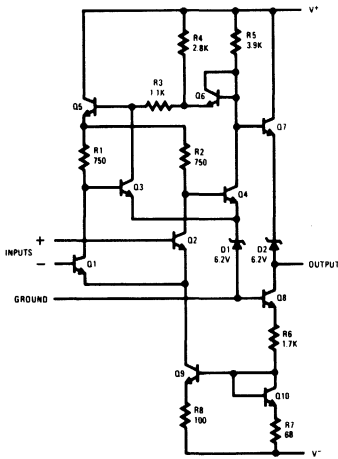
The device is built on a single silicon chip which insures low offset and thermal drift. The use of a minimum number of stages along with minority-carrier lifetime control (gold doping) makes the circuit much faster than operational amplifiers in saturating comparator applications. In fact, the low stray and wiring capacitances that can be realized

with monolithic construction make the device difficult to duplicate with discrete components operating at equivalent power levels.

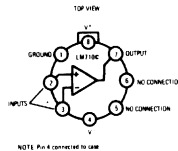
The LM710C is useful as a pulse height discriminator, a voltage comparator in high-speed A/D converters or a go, no-go detector in automatic test equipment. It also has applications in digital systems as an adjustable-threshold line receiver or an interface between logic types. In addition, the low cost of the unit suggests it for applications replacing relatively simple discrete component circuitry.

The LM710C is the commercial/industrial version of the LM710A. It is identical to the LM710A except that operation is specified over a 0°C to 70°C temperature range.

schematic* and connection diagrams

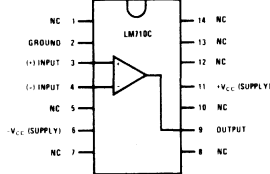


Metal Can Package



Order Number LM710CH
See Package 11

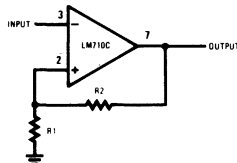
Dual-In-Line Package



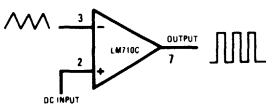
Order Number LM710CN
See Package 22

typical applications*

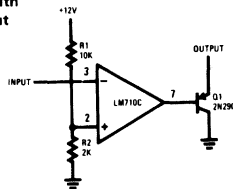
Schmidt Trigger



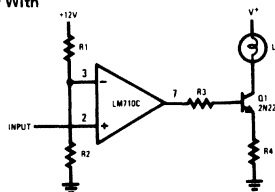
Pulse Width Modulator



Line Receiver With Increased Output Sink Current



Level Detector With Lamp Driver



*Pin connections shown are for metal can.

absolute maximum ratings

Positive Supply Voltage	14.0V
Negative Supply Voltage	-7.0V
Peak Output Current	10 mA
Differential Input Voltage	±5.0V
Input Voltage	±7.0V
Power Dissipation (Note 1)	
TO-99	300 mW
Flat Package	200 mW
Output Short Circuit Duration	10 sec
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

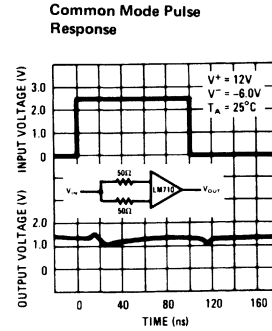
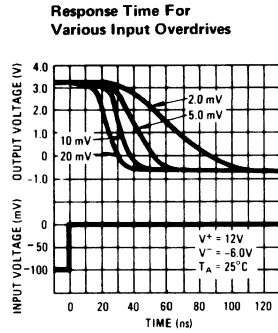
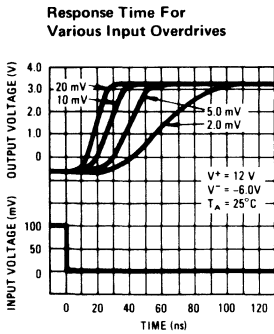
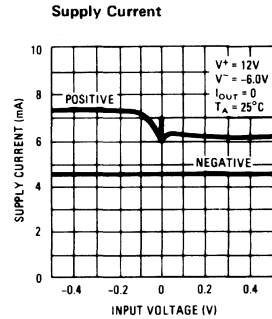
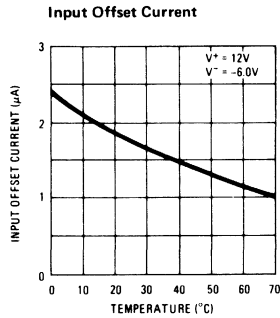
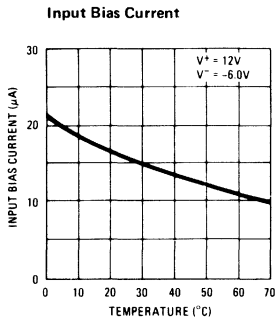
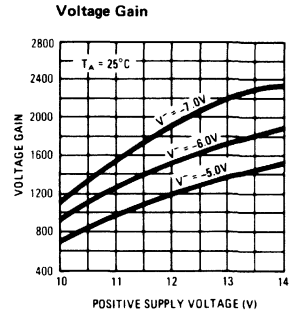
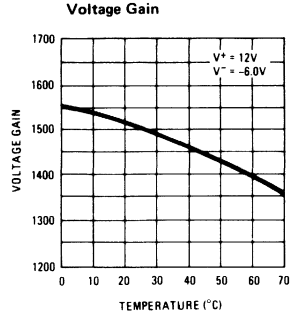
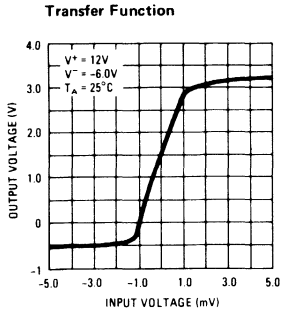
PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$T_A = 25^\circ\text{C}$, $R_S < 200\Omega$ $V_{CM} = 0\text{V}$		1.6	5.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$, $V_{OUT} = 1.4\text{V}$		1.8	5.0	μA
Input Bias Current	$T_A = 25^\circ\text{C}$		16	25	μA
Voltage Gain	$T_A = 25^\circ\text{C}$	1000	1500		
Output Resistance	$T_A = 25^\circ\text{C}$		200		Ω
Output Sink Current	$T_A = 25^\circ\text{C}$, $\Delta V_{IN} \geq 10\text{ mV}$ $V_{OUT} = 0$	1.6	2.5		mA
Response Time (Note 3)	$T_A = 25^\circ\text{C}$		40		ns
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0\text{V}$			6.5	mV
Average Temperature Coefficient of Input Offset Voltage	$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ $R_S \leq 50\Omega$		5.0	20	$\mu\text{V}/^\circ\text{C}$
Input Offset Current				7.5	μA
Average Temperature Coefficient of Input Offset Current	$25^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ $0^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$		15 24	50 100	$\text{nA}/^\circ\text{C}$ $\text{nA}/^\circ\text{C}$
Input Bias Current	$T_A = 0^\circ\text{C}$		25	40	μA
Input Voltage Range	$V^- = -7.0\text{V}$	±5.0			V
Common Mode Rejection Ratio	$R_S \leq 200\Omega$	70	98		dB
Differential Input Voltage Range		±5.0			V
Voltage Gain		800			
Positive Output Level	$V_{IN} \geq 10\text{ mV}$ $0 \leq I_{OUT} \leq -5\text{ mA}$	2.5	3.2	4.0	V
Negative Output Level	$V_{IN} \leq -10\text{ mV}$	-1.0	-0.5	0	V
Output Sink Current	$V_{IN} \leq -10\text{ mV}$, $V_{OUT} = 0\text{V}$	0.5			mA
Positive Supply Current	$V_{IN} \leq -10\text{ mV}$		5.2	9.0	mA
Negative Supply Current			4.6	7.0	mA
Power Consumption				150	mW

Note 1: Ratings apply for ambient temperatures to 70°C.

Note 2: These specifications apply for $V^+ = 12.0\text{V}$, $V^- = 6.0\text{V}$, $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ unless otherwise specified. The input offset voltage and input offset current (see definitions) are specified for a logic threshold voltage of 1.5V at 0°C, 1.4V at 25°C and 1.2V at 70°C.

Note 3: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

typical performance characteristics





Voltage Comparators/Buffers

LM711

LM711 dual comparator

general description

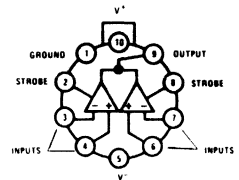
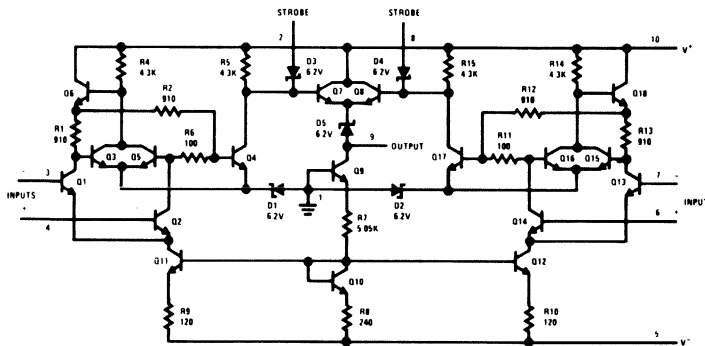
The LM711 contains two voltage comparators with separate differential inputs, a common output and provision for strobing each side independently. Similar to the LM710, the device features low offset and thermal drift, a large input voltage range, low power consumption, fast recovery from large overloads and compatibility with most integrated logic circuits.

With the addition of an external resistor network, the LM711 can be used as a sense amplifier for core memories. The input thresholding, combined with the high gain of the comparator, eliminates many of the inaccuracies encountered with con-

ventional sense amplifier designs. Further, it has the speed and accuracy needed for reliably detecting the outputs of cores as small as 20 mils.

The LM711 is also useful in other applications where a dual comparator with OR'ed outputs is required, such as a double-ended limit detector. By using common circuitry for both halves, the device can provide high speed with lower power dissipation than two single comparators. The LM711 is available in either an 10-lead low profile TO-5 header or a 1/4" by 1/4" metal flat package.

schematic** and connection diagrams

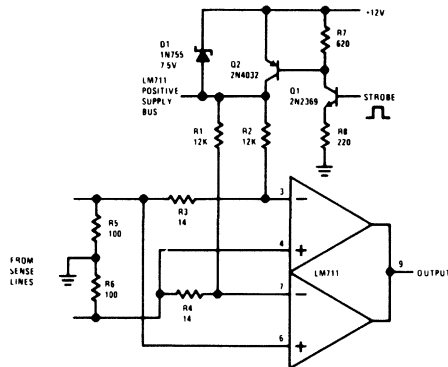


NOTE: Pin 5 connected to case

Order Number LM711H
See Package 14

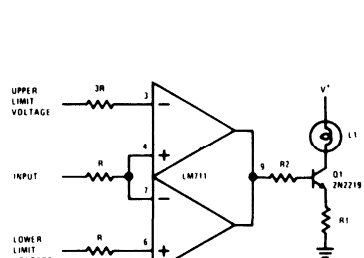
typical applications**

Sense Amplifier With Supply Strobing for Reduced Power Consumption*



*Standby dissipation is about 40 mW

Double-Ended Limit Detector With Lamp Driver



**Pin connections shown are for metal can.

3

absolute maximum ratings

Positive Supply Voltage	+14.0V
Negative Supply Voltage	-7.0V
Peak Output Current	25 mA
Differential Input Voltage	±5.0V
Input Voltage	±7.0V
Strobe Voltage	0 to +6.0V
Internal Power Dissipation (Note 1)	300 mW
Operating Temperature Range	-55°C to 125°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics

 (These specifications apply for $T_A = 25^\circ\text{C}$, $V^+ = 12\text{V}$, $V^- = -6\text{V}$)

PARAMETER	CONDITIONS (Note 2)	MIN.	TYP.	MAX.	UNIT
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0$		1.0	3.5	mV
	$R_S \leq 200\Omega$, $-5\text{V} \leq V_{CM} \leq +5\text{V}$		1.0	5.0	mV
Input Offset Current			0.5	10.0	μA
Input Bias Current			25	75	μA
Voltage Gain		750	1500		
Response Time (Note 3)			40		ns
Strobe Release Time			12		ns
Input Voltage Range	$V^- = -7.0\text{V}$	±5.0			V
Differential Input Voltage Range		±5.0			V
Output Resistance			200		Ω
Positive Output Level	$V_{IN} \geq 10\text{ mV}$		4.5	5.0	V
Loaded Positive Output Level	$V_{IN} \geq 10\text{ mV}$, $I_{OUT} = -5\text{ mA}$	2.5	3.5		V
Negative Output Level	$V_{IN} \leq -10\text{ mV}$	-1.0		0	V
Strobed Output Level	$V_{STROBE} \leq 0.3\text{V}$	-1.0		0	V
Output Sink Current	$V_{IN} \leq -10\text{ mV}$, $V_{OUT} \geq 0$	0.5	0.8		mA
Strobe Current	$V_{STROBE} = 100\text{ mV}$		1.2	2.5	mA
Positive Supply Current	$V_{IN} \leq -10\text{ mV}$		8.6		mA
Negative Supply Current			3.9		mA
Power Consumption			130	200	mW

The following specifications apply for $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$:

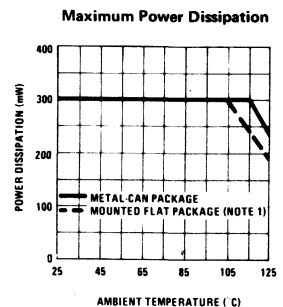
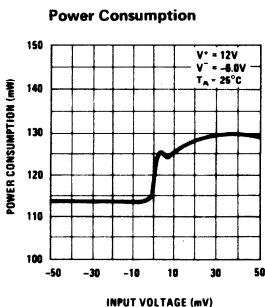
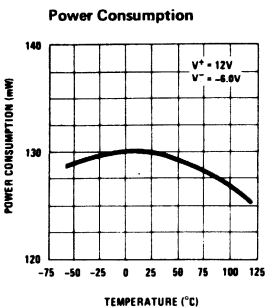
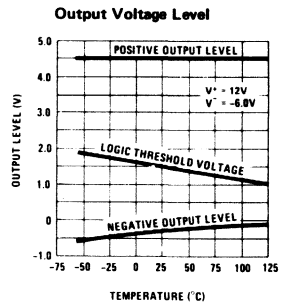
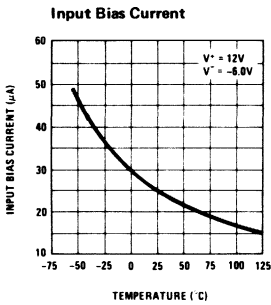
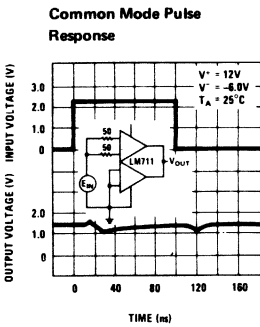
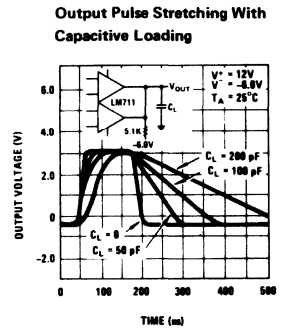
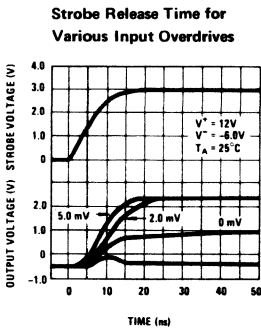
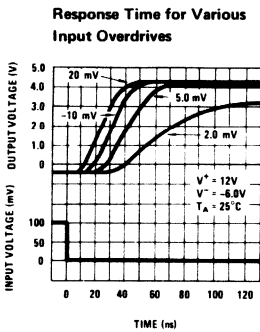
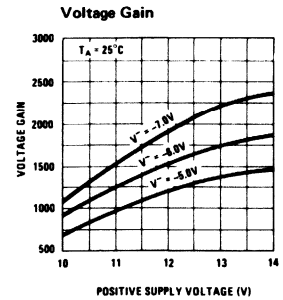
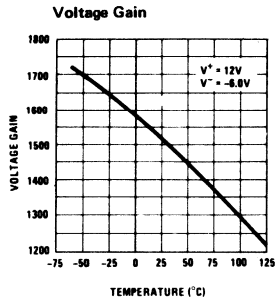
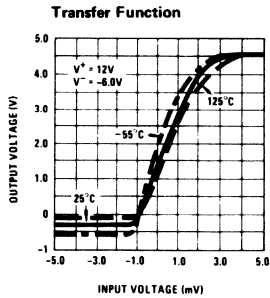
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0$			4.5	mV
	$R_S \leq 200\Omega$			6.0	mV
Input Offset Current				20	μA
Input Bias Current				150	μA
Average Temperature Coefficient of Input Offset Voltage			5.0		$\mu\text{V}/^\circ\text{C}$
Voltage Gain		500			

Note 1: Rating applies for case temperatures to $+125^\circ\text{C}$; derate linearly at $5.6\text{ mW}/^\circ\text{C}$ for ambient temperatures above 105°C .

Note 2: The input offset voltage and input offset current (see definitions) are specified for a logic threshold voltage of 1.8V at -55°C , 1.4V at $+25^\circ\text{C}$, and 1.0V at $+125^\circ\text{C}$.

Note 3: The response time specified is for a 100 mV input step with 5 mV overdrive (see definitions).

typical performance characteristics



3



Voltage Comparators/Buffers

LM711C dual comparator

general description

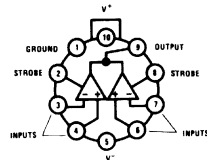
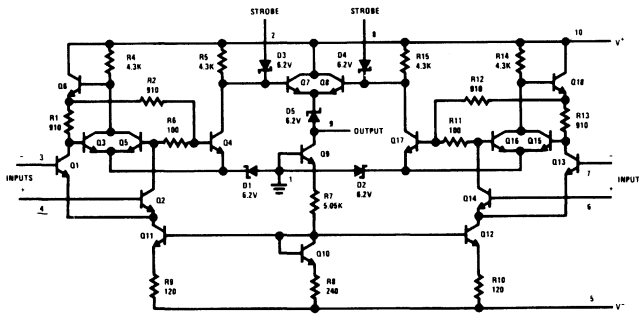
The LM711C contains two voltage comparators with separate differential inputs, a common output and provision for strobing each side independently. Similar to the LM710C, the device features low offset and thermal drift, a large input voltage range, low power consumption, fast recovery from large overloads and compatibility with most integrated logic circuits.

With the addition of an external resistor network, the LM711C can be used as a sense amplifier for core memories. The input thresholding, combined with the high gain of the comparator, eliminates many of the inaccuracies encountered with con-

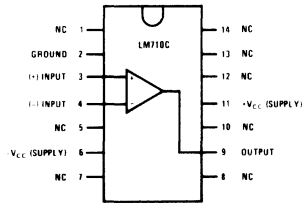
ventional sense amplifier designs. Further, it has the speed and accuracy needed for reliably detecting the outputs of cores as small as 20 mils.

The LM711C is also useful in other applications where a dual comparator with OR'ed outputs is required, such as a double-ended limit detector. By using common circuitry for both halves, the device can provide high speed with lower power dissipation than two single comparators. The LM711C is the commercial/industrial version of the LM711. It is identical to the LM711, except that operation is specified over a 0°C to 70°C temperature range.

schematic** and connection diagrams



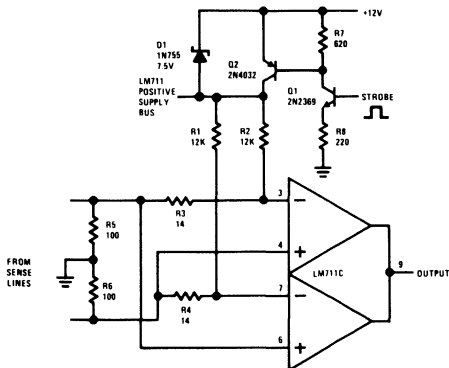
NOTE: Pin 5 connected to com
Order Number LM711CH
 See Package 14



Order Number LM711CN
 See Package 22

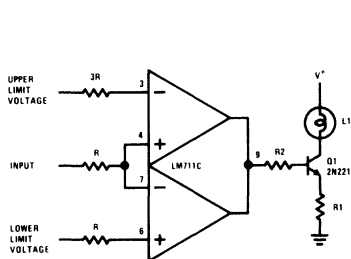
typical applications**

Sense Amplifier With Supply Strobing for Reduced Power Consumption*



*Standby dissipation is about 40 mW

Double-Ended Limit Detector With Lamp Driver



**Pin connections shown are for metal can.

absolute maximum ratings

Positive Supply Voltage	+14.0V
Negative Supply Voltage	-7.0V
Peak Output Current	25 mA
Differential Input Voltage	±5.0V
Input Voltage	±7.0V
Strobe Voltage	0 to +6.0V
Internal Power Dissipation (Note 1)	300 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics

(The following specifications apply for $T_A = 25^\circ\text{C}$, $V^+ = 12.0\text{V}$, $V^- = -6.0\text{V}$ unless otherwise specified)

PARAMETER	CONDITIONS (Note 2)	MIN.	TYP.	MAX.	UNIT
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0$		1.0	5.0	mV
	$R_S \leq 200\Omega$, $-5V \leq V_{CM} \leq +5V$		1.0	7.5	mV
Input Offset Current			0.5	15	μA
Input Bias Current			25	100	μA
Voltage Gain		700	1500		
Response Time (Note 3)			40		ns
Strobe Release Time			12		ns
Input Voltage Range	$V^- = -7.0\text{V}$	±5.0			V
Differential Input Voltage Range		±5.0			V
Output Resistance			200		Ω
Positive Output Level	$V_{IN} \geq 10\text{ mV}$		4.5	5.0	V
Loaded Positive Output Level	$V_{IN} \geq 10\text{ mV}$, $I_{OUT} = -5\text{ mA}$	2.5	3.5		V
Negative Output Level	$V_{IN} \leq -10\text{ mV}$	-1.0	-0.5	0	V
Strobed Output Level	$V_{STROBE} \leq 0.3\text{V}$	-1.0		0	V
Output Sink Current	$V_{IN} \leq -10\text{ mV}$, $V_{OUT} \geq 0$	0.5	0.8		mA
Strobe Current	$V_{STROBE} = 100\text{ mV}$		1.2	2.5	mA
Positive Supply Current	$V_{IN} \leq -10\text{ mV}$		8.6		mA
Negative Supply Current			3.9		mA
Power Consumption			130	230	mW

The following specifications apply for $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$:

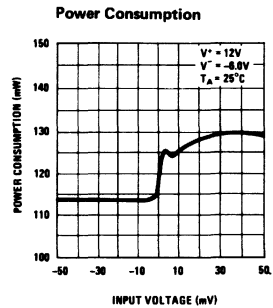
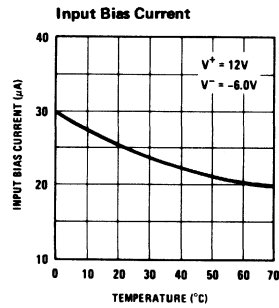
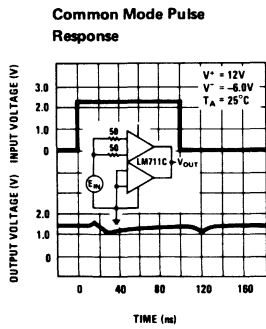
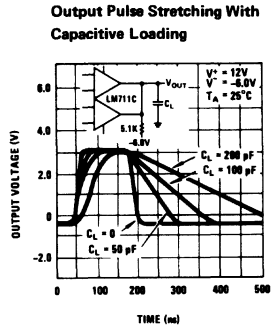
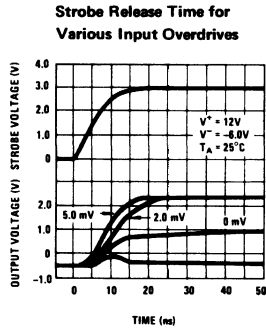
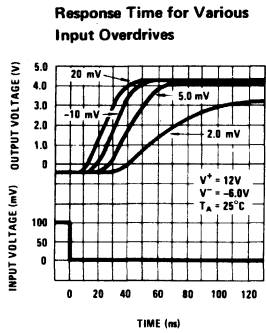
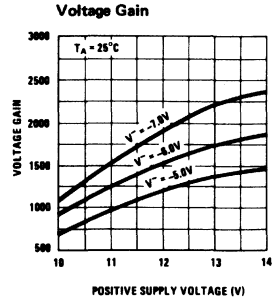
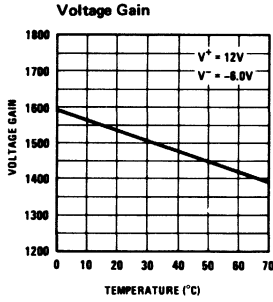
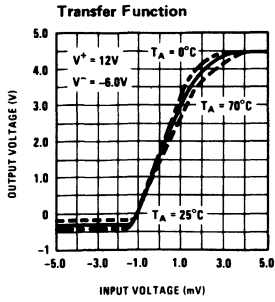
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0$			6.0	mV
	$R_S \leq 200\Omega$, $-5V \leq V_{CM} \leq +5V$			10	mV
Input Offset Current				25	μA
Input Bias Current				150	μA
Average Temperature Coefficient of Input Offset Voltage			5.0		$\mu\text{V}/^\circ\text{C}$
Voltage Gain		500			

Note 1: Ratings apply for ambient temperatures to 70°C .

Note 2: The input offset voltage and input offset current (see definitions) are specified for a logic threshold voltage of 1.5V at 0°C , 1.4V at 25°C , and 1.2V at $+70^\circ\text{C}$.

Note 3: The response time specified (see definitions) is for a 100 mV input step with 5 mV overdrive.

typical performance characteristics





Voltage Comparators/Buffers

LM1514/LM1414

LM1514/LM1414 dual differential voltage comparator

general description

The LM1514/LM1414 is a dual differential voltage comparator intended for applications requiring high accuracy and fast response times. The device is constructed on a single monolithic silicon chip.

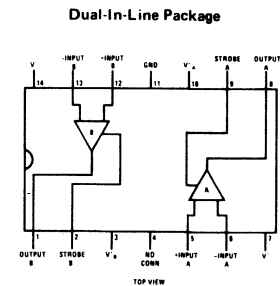
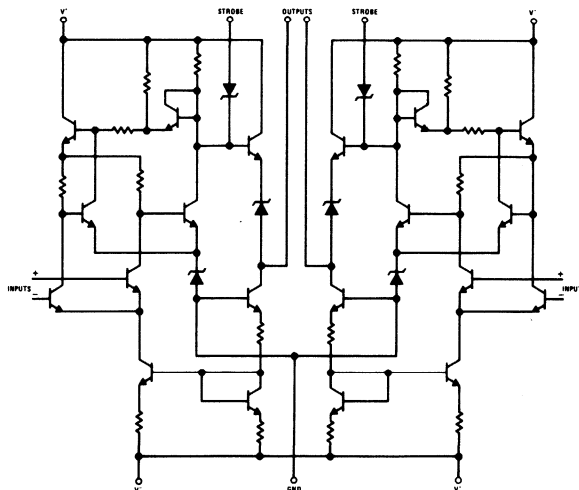
The LM1514/LM1414 is useful as a variable threshold Schmitt trigger, a pulse height discriminator, a voltage comparator in high-speed A-D converters, a memory sense amplifier or a high noise immunity line receiver. The output of the comparator is compatible with all integrated logic forms. The LM1514/LM1414 meet or exceed the specifications for the MC1514/MC1414 and are pin-for-pin replacements. The LM1514 is available in the ceramic dual-in-line package. The LM1414 is available in either the ceramic or molded dual-in-line package.

The LM1514 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LM1414 is specified for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

features

- Two totally separate comparators per package
- Independent strobe capability
- High speed 30 ns typ
- Low input offset voltage and current
- High output sink current over temperature
- Output compatible with TTL/DTL logic
- Molded or ceramic dual-in-line package

schematic and connection diagram



Order Number LM1414J or LM1514J
See Package 16

Order Number LM1414N
See Package 22

3

absolute maximum ratings (Note 1)

Positive supply voltage	+14.0V	Power dissipation (Note 2)	600 mW
Negative supply voltage	-7.0V	Operating temperature Range: LM1514	-55°C to +125°C
Peak output current	10 mA	LM1414	0°C to +70°C
Differential input voltage	±5.0V	Storage temperature range	-65°C to +150°C
Input voltage	±7.0V	Lead temperature (soldering, 10 sec)	300°C

electrical characteristics for $T_A = 25^\circ\text{C}$, $V^+ = +12\text{V}$, $V^- = -6\text{V}$, unless otherwise specified

PARAMETER	CONDITIONS	LM1514			LM1414			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 200\Omega$, $V_{CM} = 0\text{V}$, $V_{OUT} = 1.4\text{V}$		0.6	2.0		1.0	5.0	mV
Input Offset Current	$V_{CM} = 0\text{V}$, $V_{OUT} = 1.4\text{V}$		0.8	3.0		1.2	5.0	μA
Input Bias Current				20			25	μA
Voltage Gain		1250			1000			
Output Resistance			200			200		Ω
Differential Input Voltage Range		±5.0			±5.0			V
Input Voltage Range	$V^- = -7.0\text{V}$	±5.0			±5.0			V
Common Mode Rejection Ratio	$R_S \leq 200\Omega$, $V^- = -7.0\text{V}$	80	100		70	100		dB
Positive Output Voltage	$V_{IN} \geq 7.0\text{ mV}$, $0 \leq I_{OUT} \leq -5.0\text{ mA}$	2.5	3.2	4.0	2.5	3.2	4.0	V
Negative Output Voltage	$V_{IN} \leq -7.0\text{ mV}$	-1.0	-0.5	0	-1.0	-0.5	0	V
Strobed Output Voltage	$V_{STROBE} \leq 0.3\text{V}$	-1.0	-0.5	0	-1.0	-0.5	0	V
Stroke "0" Current	$V_{STROBE} = 100\text{ mV}$		-1.2	-2.5		-1.2	-2.5	mA
Positive Supply Current	$V_{IN} \leq 7\text{ mV}$			18			18	mA
Negative Supply Current	$V_{IN} \leq -7\text{ mV}$			-14			-14	mA
Power Consumption			180	300		180	300	mW
Response Time	(Note 3)		30			30		ns

LM1514/LM1414: The following apply for $T_L \leq T_A \leq T_H$ (Note 4) unless otherwise specified

Input Offset Voltage	$R_S \leq 200\Omega$, $V_{OUT} = 1.8\text{V}$ for $T_A = T_L$ $V_{CM} = 0\text{V}$, $V_{OUT} = 1.0\text{V}$ for $T_A = T_H$			3.0			6.5	mV
Input Bias Current				45			40	μA
Temperature Coefficient of Input Offset Voltage			3.0			5.0		$\mu\text{V}/^\circ\text{C}$
Input Offset Current	$V_{CM} = 0\text{V}$, $V_{OUT} = 1.8\text{V}$, $T_A = T_L$ $V_{CM} = 0\text{V}$, $V_{OUT} = 1.0\text{V}$, $T_A = T_H$			7.0			7.5	μA
Voltage Gain		1000				800		
Output Sink Current	$V_{IN} \leq -9.0\text{ mV}$, $V_{OUT} \geq 0\text{V}$	2.8	4.0		1.6	2.5		mA

Note 1: Voltage values are with respect to network ground terminal. Positive current is defined as current into the referenced pin.**Note 2:** LM1514 ceramic package: The maximum junction temperature is +150°C, for operating at elevated temperatures, devices must be derated linearly at 12.5 mW/°C. LM1414 ceramic package: The maximum junction temperature is +95°C, for operating at elevated temperatures, devices must be derated linearly at 12.5 mW/°C. LM1414 molded package: The maximum junction temperature is +115°C, for operating at elevated temperatures, devices must be derated linearly at 6.7 mW/°C.**Note 3:** The response time specified (see Definitions) for a 100 mV input step with 5 mV overdrive.**Note 4:** For LM1514, $T_L = -55^\circ\text{C}$, $T_H = +125^\circ\text{C}$. For LM1414, $T_L = 0^\circ\text{C}$, $T_H = +70^\circ\text{C}$.



Functional Blocks

LM122/LM222/LM322 precision timer

general description

The LM122 is a precision timer that offers great versatility with high accuracy. It operates off unregulated supplies from 4.5V to 40V while maintaining constant timing periods from microseconds to hours. Internal logic and regulator circuits complement the basic timing function enabling the LM122 to operate in many different applications with a minimum of external components.

The output of the timer is a floating transistor with built in current limiting. It can drive either ground referred or supply referred loads up to 40V and 50 mA. The floating nature of this output makes it ideal for interfacing, lamp or relay driving, and signal conditioning where an open collector or emitter is required. A "logic reverse" circuit can be programmed by the user to make the output transistor either "on" or "off" during the timing period.

The trigger input to the LM122 has a threshold of 1.6V independent of supply voltage, but it is fully protected against inputs as high as $\pm 40V$ – even when using a 5V supply. The circuitry reacts only to the rising edge of the trigger signal, and is immune to any trigger voltage during the timing periods.

An internal 3.15V regulator is included in the timer to reject supply voltage changes and to provide the user with a convenient reference for applications other than a basic timer. External loads up to 5 mA can be driven by the regulator. An internal 2V divider between the reference and ground sets the timing period to 1 RC. The timing period can be voltage controlled by driving this divider

with an external source through the V_{ADJ} pin. Timing ratios of 50:1 can be easily achieved.

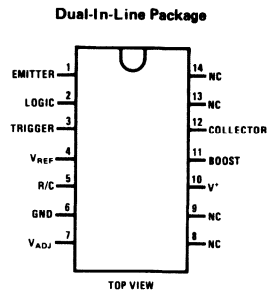
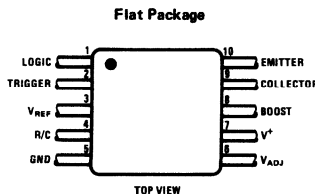
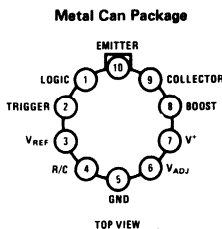
The comparator used in the LM122 utilizes high gain PNP input transistors to achieve 300 pA typical input bias current over a common mode range of 0V to 3V. A boost terminal allows the user to increase comparator operating current for timing periods less than 1 ms. This lets the timer operate over a 3 μ s to multi-hour timing range with excellent repeatability.

The LM122 operates over a temperature range of $-55^{\circ}C$ to $+125^{\circ}C$. An electrically identical LM222 is specified from $-25^{\circ}C$ to $+85^{\circ}C$. The timer is available in TO-5, flat package, and dual-in-line packages.

features

- Immune to changes in trigger voltage during timing interval
- Timing periods from microseconds to hours
- Internal logic reversal
- Immune to power supply ripple or noise during the timing interval
- Operates from 4.5V to 40V supplies
- Input protected to $\pm 40V$
- Floating transistor output with internal current limiting
- Internal regulated reference
- Timing period can be voltage controlled
- TTL compatible input and output

connection diagrams



absolute maximum ratings

Power Dissipation	500 mW
V ⁺ Voltage	40V
Collector Output Voltage	40V
V _{REF} Current	5 mA
Trigger Voltage	±40V
V _{ADJ} Voltage (Forced)	5V
Logic Reverse Voltage	5.5V
Output Short Circuit Duration (Note 1)	
Lead Temperature (Soldering, 10 sec)	300°C

LM122/LM222

electrical characteristics (Note 2)

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
Timing Ratio (Note 3)	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V	.626	.632	.638	
	Boost Tied to V ⁺	.620	.632	.644	
Comparator Input Current	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V		.3	1	nA
	Boost Tied to V ⁺		30	100	nA
Trigger Voltage	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V	1.2	1.6	2	V
Trigger Current	T _A = 25°C, V _{TRIG} = 2V		25		μA
Supply Current	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V		2.5	4	mA
Timing Ratio	4.5V ≤ V ⁺ ≤ 40V	.620		.644	
	Boost Tied to V ⁺	.620		.644	
Comparator Input Current (Note 4)	4.5V ≤ V ⁺ ≤ 40V	-5		5	nA
	Boost Tied to V ⁺			100	nA
Trigger Voltage	4.5V ≤ V ⁺ ≤ 40V	.8		2.5	V
Trigger Current	V _{TRIG} = 2.5V			100	μA
Output Leakage Current	V _{CE} = 40V			1	μA
Capacitor Saturation Voltage	R _t ≥ 1 MΩ		2.5		mV
	R _t = 10 kΩ		25		mV
Reset Resistance			150		Ω
Reference Voltage	T _A = 25°C	3	3.15	3.3	V
Reference Regulation	0 ≤ I _{OUT} ≤ 3 mA		20	50	mV
	4.5V ≤ V ⁺ < 40V		6	25	mV
Collector Saturation Voltage	I _L = 8 mA		.25	.4	V
	I _L = 50 mA		.7	1.4	V
Emitter Saturation Voltage	I _L = 3 mA		1.8	2.2	V
	I _L = 50 mA		2.1	3	V
Average Temperature				.003	%/°C
Coefficient of Timing Ratio					
Minimum Trigger Width	V _{TRIG} = 2.5V		.25		μs

Note 1: Continuous output shorts are not allowed. Short circuit duration at ambient temperatures of 40°C may be calculated from $t = 120/V_{CE}$ seconds, where V_{CE} is the collector to emitter voltage across the output transistor during the short.

Note 2: Specifications include the temperature range, $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ for the LM122 and $-25^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for the LM222.

Note 3: Output pulse width can be calculated from the following equation: $t = (R_t)(C_t)[1 - 2(0.632 - r) - V_C/V_{REF}]$ where r is timing ratio and V_C is capacitor saturation voltage. This reduces to $t = (R_t)(C_t)$ for all but the most critical applications.

Note 4: Sign reversal may occur at high temperatures ($> 100^{\circ}\text{C}$) where comparator input current is predominately leakage. See typical curves.

absolute maximum ratings

Power Dissipation	500 mW
V ⁺ Voltage	40V
Collector Output Voltage	40V
V _{REF} Current	5 mA
Trigger Voltage	±40V
V _{ADJ} Voltage (Forced)	5V
Logic Reverse Voltage	5.5V
Output Short Circuit Duration (Note 1)	
Lead Temperature (Soldering, 10 sec)	300°C

LM322**electrical characteristics** (Note 2)

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
Timing Ratio (Note 3)	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V	.620	.632	.644	
	Boost Tied to V ⁺	.620	.632	.644	
Comparator Input Current	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V		.3	1	nA
	Boost Tied to V ⁺		30	100	nA
Trigger Voltage	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V	1.2	1.6	2	V
Trigger Current	T _A = 25°C, V _{TRIG} = 2V		25		μA
Supply Current	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V		2.5	4.5	mA
Timing Ratio	4.5V ≤ V ⁺ ≤ 40V	.610		.654	
	Boost Tied to V ⁺	.610		.654	
Comparator Input Current (Note 4)	4.5V ≤ V ⁺ ≤ 40V	-2		2	nA
	Boost Tied to V ⁺			150	nA
Trigger Voltage	4.5V ≤ V ⁺ ≤ 40V	.8		2.5	V
Trigger Current	V _{TRIG} = 2.5V			200	μA
Output Leakage Current	V _{CE} = 40V			5	μA
Capacitor Saturation Voltage	R _t ≥ 1 MΩ		2.5		mV
	R _t = 10 kΩ		25		mV
Reset Resistance			150		Ω
Reference Voltage	T _A = 25°C	3	3.15	3.3	V
Reference Regulation	0 ≤ I _{OUT} ≤ 3 mA		20	50	mV
	4.5V ≤ V ⁺ < 40V		6	25	mV
Collector Saturation Voltage	I _L = 8 mA		.25	.4	V
	I _L = 50 mA		.7	1.4	V
Emitter Saturation Voltage	I _L = 3 mA		1.8	2.2	V
	I _L = 50 mA		2.1	3	V
Average Temperature				.003	%/°C
Coefficient of Timing Ratio					
Minimum Trigger Width	V _{TRIG} = 2.5V		.25		μs

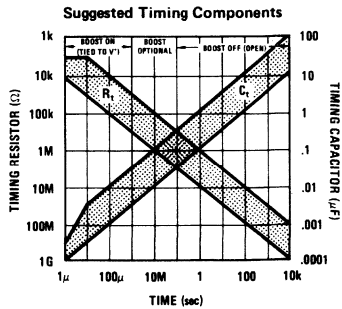
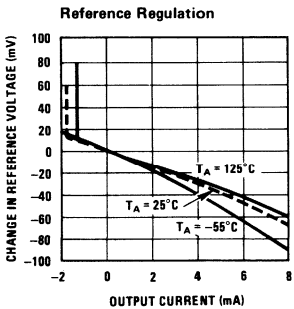
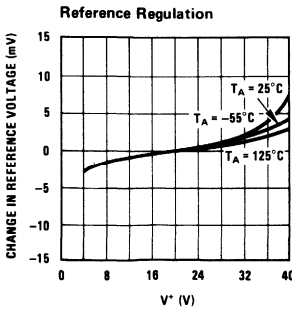
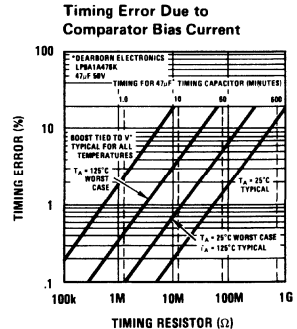
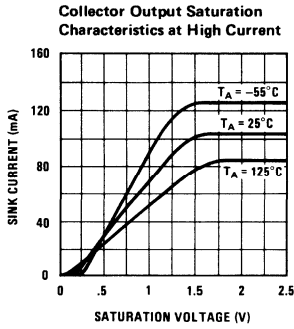
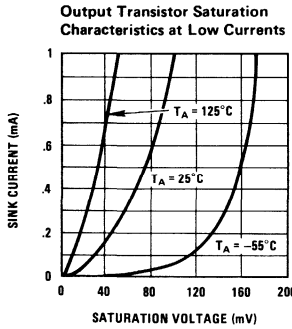
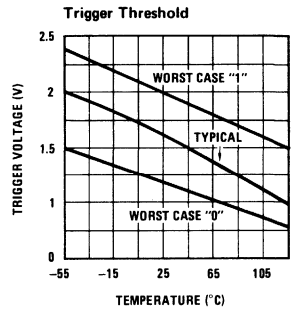
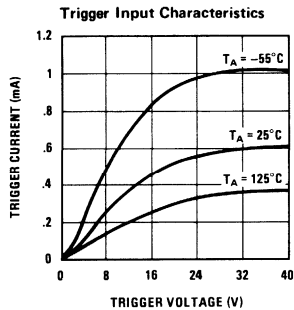
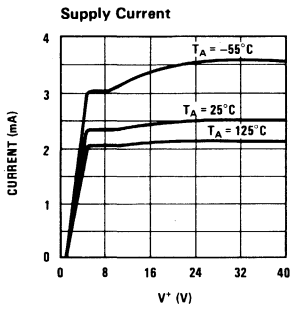
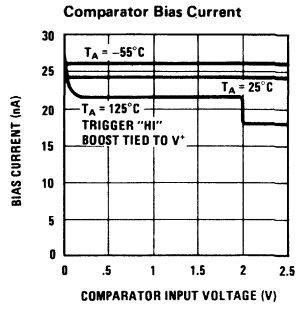
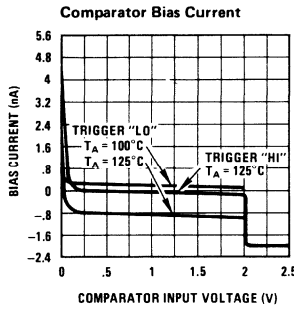
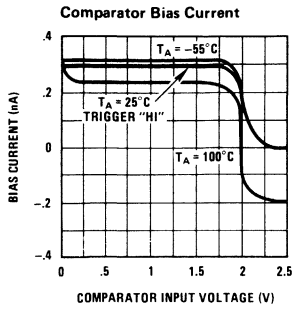
Note 1: Continuous output shorts are not allowed. Short circuit duration at ambient temperatures of 40°C may be calculated from $t = .120/V_{CE}$ seconds, where V_{CE} is the collector to emitter voltage across the output transistor during the short.

Note 2: Specifications include the temperature range 0°C to +70°C for the LM322 unless otherwise noted.

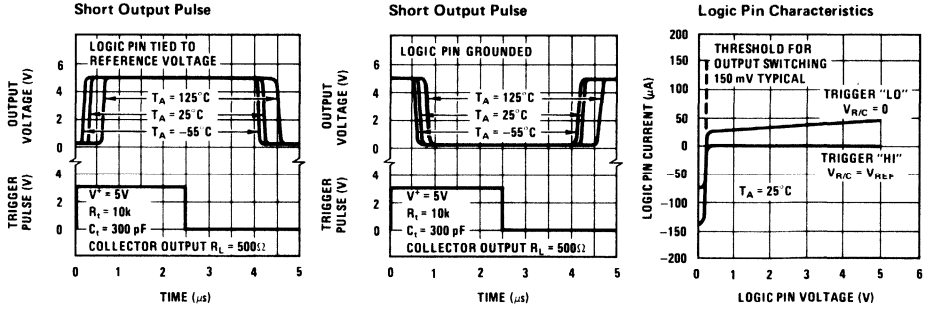
Note 3: Output pulse width can be calculated from the following equation: $t = (R_t)(C_t) [1 - 2(0.632 - r) - V_C/V_{REF}]$ where r is timing ratio and V_C is capacitor saturation voltage. This reduces to $t = (R_t)(C_t)$ for all but the most critical applications.

Note 4: Sign reversal may occur at high temperatures (> 70°C) where comparator input current is predominately leakage. See typical curves.

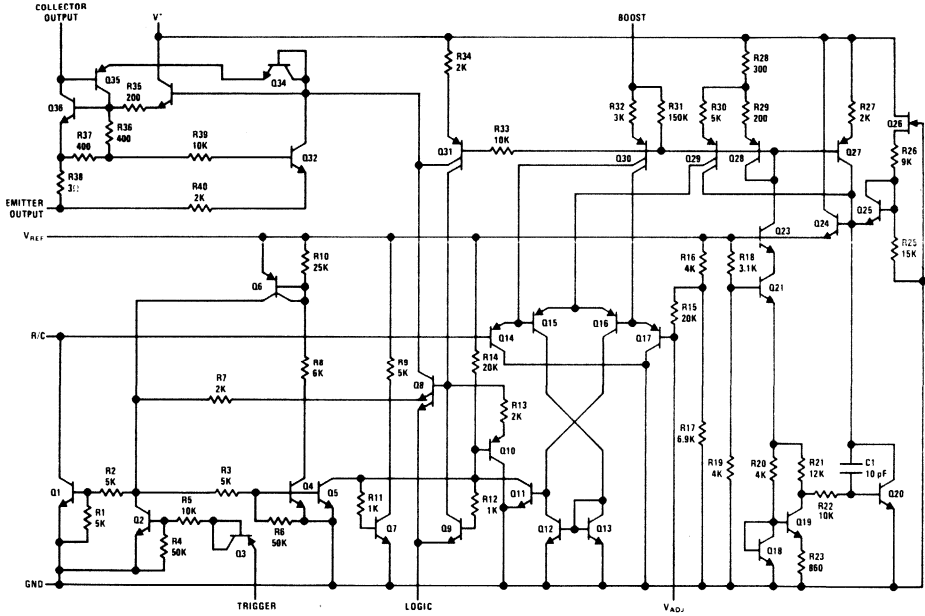
typical performance characteristics



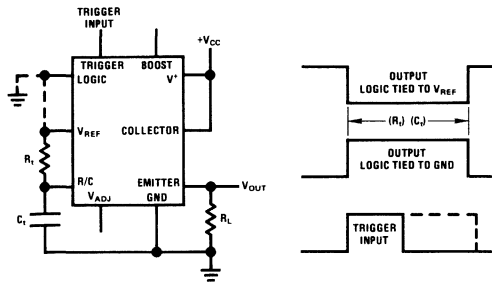
typical performance characteristics (con't)



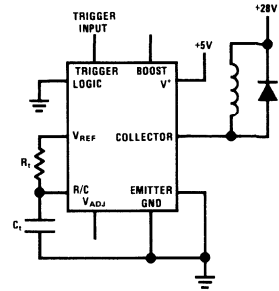
schematic diagram



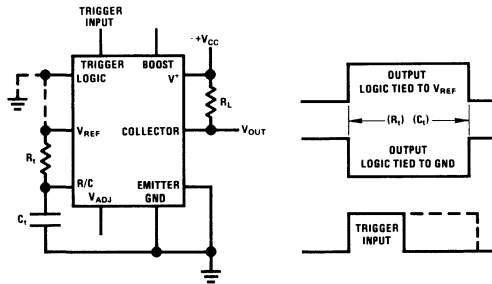
typical applications



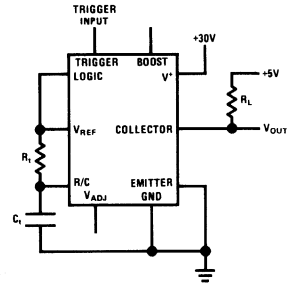
Basic Timer-Emitter Output and Timing Chart



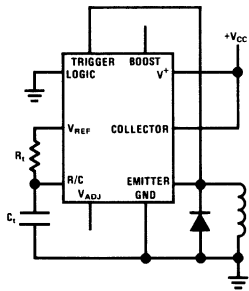
5V Logic Supply Driving 28V Relay



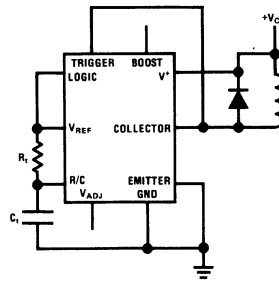
Basic Timer-Collector Output and Timing Chart



30V Supply Interfacing to 5V Logic

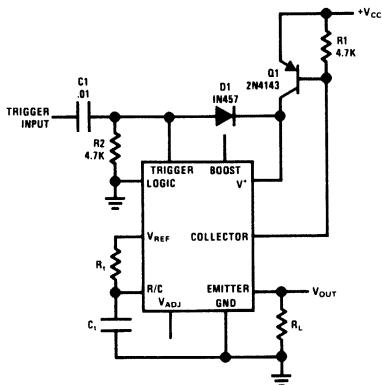


Time Out On Power Up
Relay Energized Until $R_1 C_1$ Seconds After V_{CC} is Applied

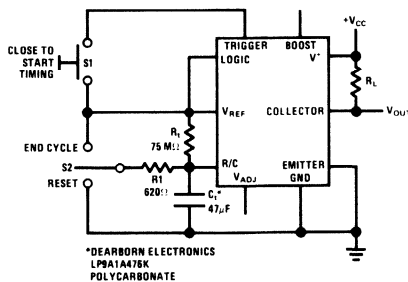


Time Out On Power Up
Relay Energized $R_1 C_1$ Seconds After V_{CC} is Applied

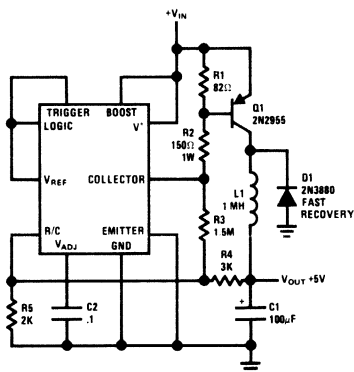
typical applications (con't)



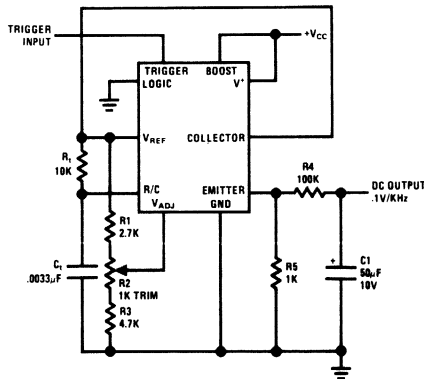
Zero Power Dissipation Between Timing Intervals



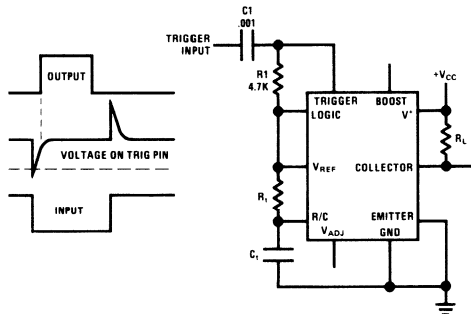
One Hour Timer with Reset & Manual Cycle End



5V Switching Regulator with 1 Amp Output and 5.5V Minimum Input

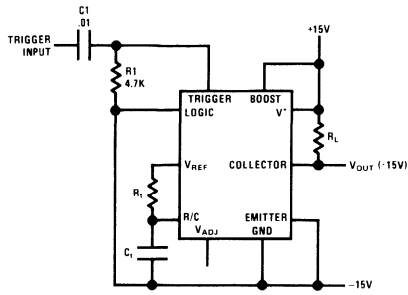


Frequency to Voltage Converter (Tachometer)
Output Independent of Supply Voltage



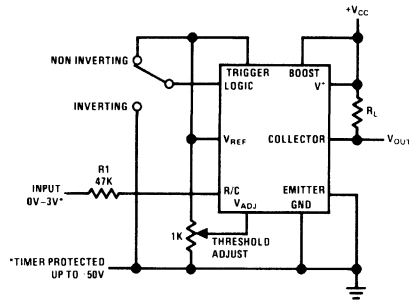
Timer Triggered by Negative Edge of Input Pulse

typical applications (con't)



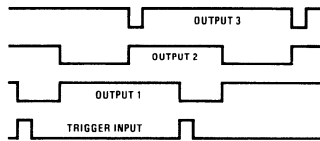
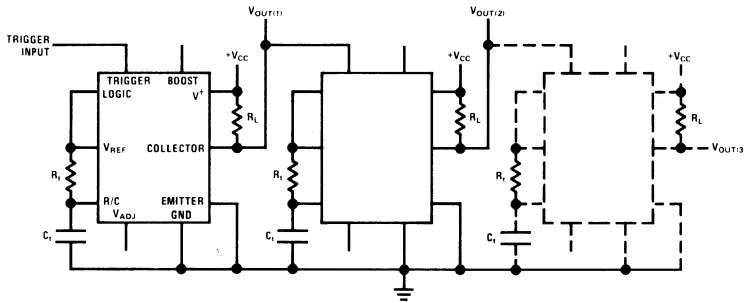
*EMITTER TERMINAL OR EMITTER LOAD MUST BE TIED TO "GND" PIN OF TIMER.

Operating off ±15V Supplies*



*TIMER PROTECTED UP TO 50V

Comparator with 0V to 3V Threshold



Chain of Timers and Timing Chart



Functional Blocks

LM555/LM555C timer

general description

The LM555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For astable operation as an oscillator, the free running frequency and duty cycle are accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output circuit can source or sink up to 200 mA or drive TTL circuits.

features

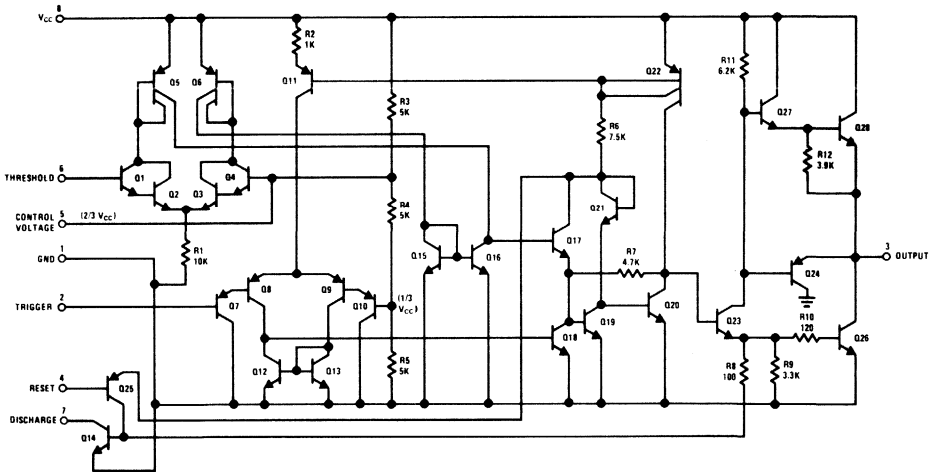
- Direct replacement for SE555/NE555
- Timing from microseconds through hours
- Operates in both astable and monostable modes

- Adjustable duty cycle
- Output can source or sink 200mA
- Output and supply TTL compatible
- Temperature stability better than .005% per °C
- Normally on and normally off output

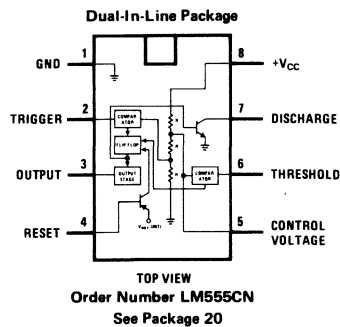
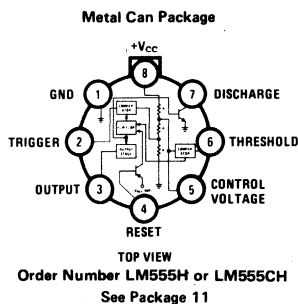
applications

- Precision timing
- Pulse generation
- Sequential timing
- Time delay generation
- Pulse width modulation
- Pulse position modulation
- Linear ramp generator

schematic diagram



connection diagrams



absolute maximum ratings

Supply Voltage	+18V
Power Dissipation	600 mW
Operating Temperature Ranges	
LM555C	0°C to +70°C
LM555	-55°C to +125°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics ($T_A = 25^\circ\text{C}$, $V_{CC} = +5\text{V}$ to $+15\text{V}$ unless otherwise specified)

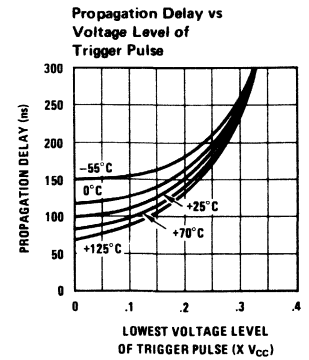
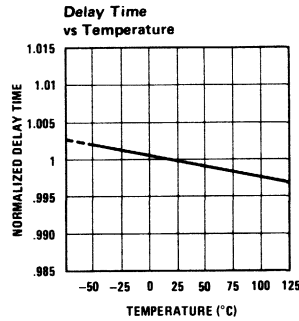
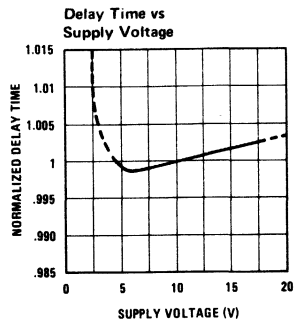
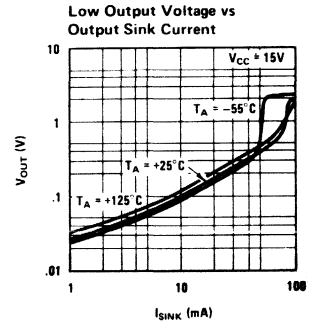
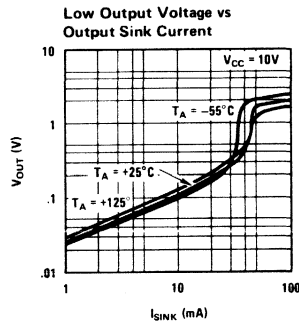
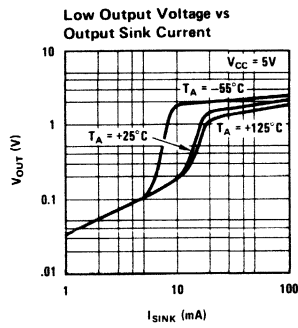
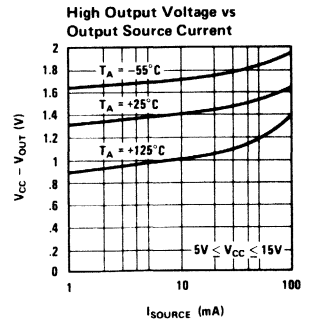
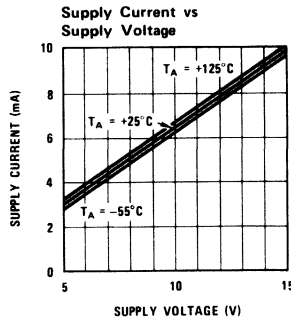
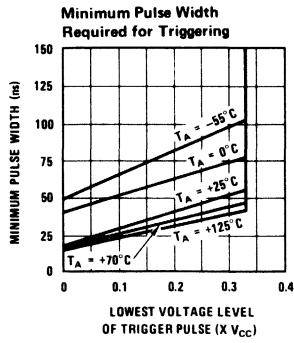
PARAMETER	CONDITIONS	LIMITS						UNITS
		LM555			LM555C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Supply Voltage		4.5		18	4.5		16	V
Supply Current	$V_{CC} = 5\text{V}$, $R_L = \infty$ $V_{CC} = 15\text{V}$, $R_L = \infty$ (Low State) (Note 1)		3 10	5 12		3 10	6 15	mA mA
Timing Error, Monostable Initial Accuracy	$R_A, R_B = 1\text{k}$ to 100k , $C = .1\mu\text{F}$, (Note 2)		.5	2		1		%
Drift with Temperature			30	100		50		ppm/°C
Drift with Supply			.005	.02		.01		% V
Threshold Voltage			.667			.667		$\times V_{CC}$
Trigger Voltage	$V_{CC} = 15\text{V}$ $V_{CC} = 5\text{V}$	4.8 1.45	5 1.67	5.2 1.9		5 1.67		V V
Trigger Current			.5			.5		μA
Reset Voltage		.4	.7	1	.4	.7	1	V
Reset Current			.1			.1		mA
Threshold Current	(Note 3)		.1	.25		.1	.25	μA
Control Voltage Level	$V_{CC} = 15\text{V}$ $V_{CC} = 5\text{V}$	9.6 2.9	10 3.33	10.4 3.8	9 2.6	10 3.33	11 4	V V
Output Voltage Drop (Low)	$V_{CC} = 15\text{V}$ $I_{SINK} = 10\text{ mA}$ $I_{SINK} = 50\text{ mA}$ $I_{SINK} = 100\text{ mA}$ $I_{SINK} = 200\text{ mA}$ $V_{CC} = 5\text{V}$ $I_{SINK} = 8\text{ mA}$ $I_{SINK} = 5\text{ mA}$		.1 .4 2 2.5	.15 .5 2.2 2.5		.1 .4 2 2.5	.25 .75 2.5 2.5	V V V V V V V
Output Voltage Drop (High)	$I_{SOURCE} = 200\text{ mA}$ $V_{CC} = 15\text{V}$ $I_{SOURCE} = 100\text{ mA}$ $V_{CC} = 15\text{V}$ $V_{CC} = 5\text{V}$		12.5 13 3			12.5 13.3 2.75	12.5 13.3 3	V V V
Rise Time of Output			100			100		ns
Fall Time of Output			100			100		ns

Note 1: Supply current when output high typically 1 mA less at $V_{CC} = 5\text{V}$.

Note 2: Tested at $V_{CC} = 5\text{V}$ and $V_{CC} = 15\text{V}$.

Note 3: This will determine the maximum value of $R_A + R_B$ for 15V operation. The max total $(R_A + R_B) = 20\text{ M}\Omega$.

typical performance characteristics



applications information

MONOSTABLE OPERATION

In this mode of operation, the timer functions as a one-shot (Figure 1). The external capacitor is initially held discharged by a transistor inside the timer. Upon application of a negative trigger pulse of less than $1/3 V_{CC}$ to pin 2, the flip flop is set which both releases the short circuit across the capacitor and drives the output high. The voltage

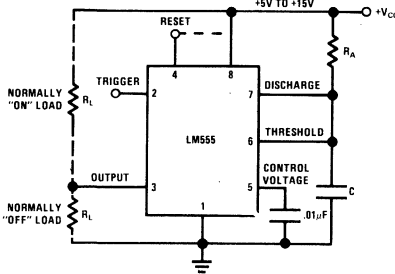
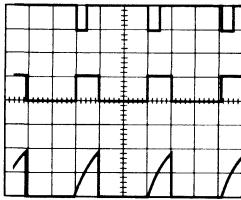


FIGURE 1. Monostable

across the capacitor then increases exponentially for a period of $t = 1.1 R_A C$, at the end of which time the voltage equals $2/3 V_{CC}$. The comparator then resets the flip flop which in turn discharges the capacitor and drives the output to its low state. Figure 2 shows the waveforms generated in this mode of operation. Since the charge and the threshold level of the comparator are both directly proportional to supply voltage, the timing interval is independent of supply.



$V_{CC} = 5V$
 TIME = 0.1 ms/DIV.
 $R_A = 9.1 k\Omega$
 $C = .01\mu F$
 TOP TRACE: INPUT 5V/DIV.
 MIDDLE TRACE: OUTPUT 5V/DIV.
 BOTTOM TRACE: CAPACITOR VOLTAGE 2V/DIV.

FIGURE 2. Monostable Waveforms

During the timing cycle when the output is high, the further application of a trigger pulse will not effect the circuit. However the circuit can be reset during this time by the application of a negative pulse to the reset terminal (pin 4). The output will then remain in the low state until a trigger pulse is again applied.

When the reset function is not in use, it is recommended that it be connected to V_{CC} to avoid any possibility of false triggering.

Figure 3 is a nomograph for easy determination of R, C values for various time delays.

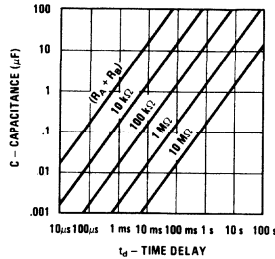


FIGURE 3. Time Delay

ASTABLE OPERATION

If the circuit is connected as shown in Figure 4 (pins 2 and 6 connected) it will trigger itself and free run as a multivibrator. The external capacitor charges through $R_A + R_B$ and discharges through R_B . Thus the duty cycle may be precisely set by the ratio of these two resistors.

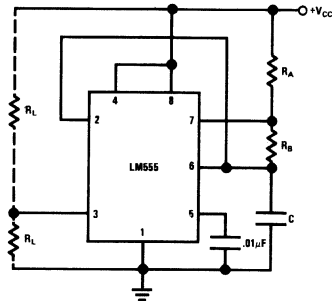
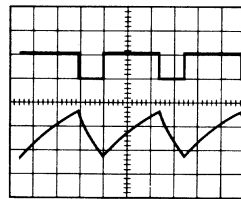


FIGURE 4. Astable

In this mode of operation, the capacitor charges and discharges between $1/3 V_{CC}$ and $2/3 V_{CC}$. As in the triggered mode, the charge and discharge times, and therefore the frequency are independent of the supply voltage.



$V_{CC} = 5V$
 TIME = 20µs/DIV.
 $R_A = 3.0 k\Omega$
 $R_B = 3 k\Omega$
 $C = .01\mu F$
 TOP TRACE: OUTPUT 5V/DIV.
 BOTTOM TRACE: CAPACITOR VOLTAGE 1V/DIV.

FIGURE 5. Astable Waveforms

Figure 5 shows the waveforms generated in this mode of operation.

applications information (con't)

The charge time (output high) is given by:
 $t_1 = 0.693 (R_A + R_B) C$

And the discharge time (output low) by:
 $t_2 = 0.693 (R_B) C$

Thus the total period is:
 $T = t_1 + t_2 = 0.693 (R_A + 2R_B) C$

The frequency of oscillation is:

$$f = \frac{1}{T} = \frac{1.44}{(R_A + 2R_B) C}$$

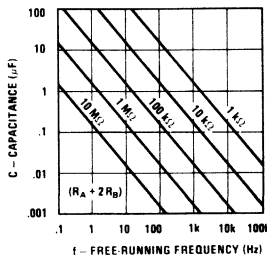


FIGURE 6. Free Running Frequency

Figure 6 may be used for quick determination of these RC values.

The duty cycle is: $D = \frac{R_B}{R_A + 2R_B}$

FREQUENCY DIVIDER

The monostable circuit of Figure 1 can be used as a frequency divider by adjusting the length of the timing cycle. Figure 7 shows the waveforms generated in a divide by three circuit.

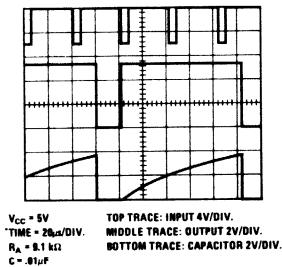


FIGURE 7. Frequency Divider

PULSE WIDTH MODULATOR

When the timer is connected in the monostable mode and triggered with a continuous pulse train,

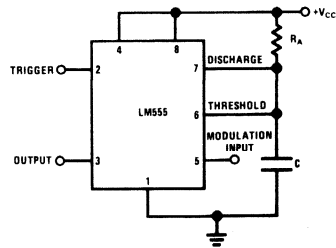
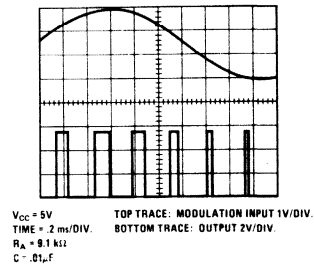


FIGURE 8. Pulse Width Modulator

the output pulse width can be modulated by a signal applied to pin 5. Figure 8 shows the circuit, and in Figure 9 are some waveform examples.



V_{CC} = 5V
 TIME = 2ms/DIV.
 R_A = 9.1 kΩ
 C = .01μF

FIGURE 9. Pulse Width Modulator

PULSE POSITION MODULATOR

This application uses the timer connected for astable operation, as in Figure 10, with a modulating signal again applied to the control voltage terminal. The pulse position varies with the modulating signal, since the threshold voltage and hence

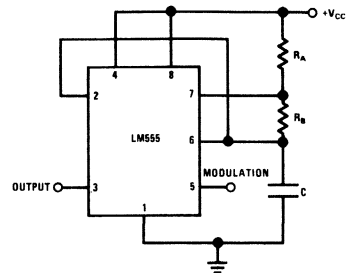


FIGURE 10. Pulse Position Modulator

applications information (con't)

the time delay is varied. Figure 11 shows the waveforms generated for a triangle wave modulation signal.

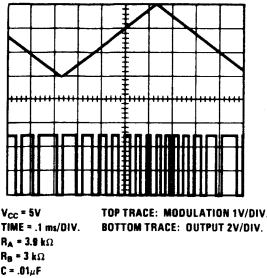


FIGURE 11. Pulse Position Modulator

LINEAR RAMP

When the pullup resistor, R_A, in the monostable circuit is replaced by a constant current source, a

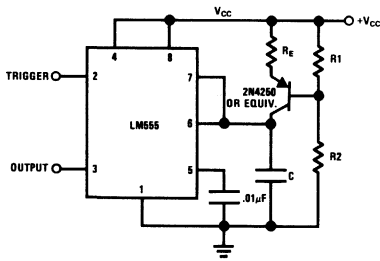


FIGURE 12.

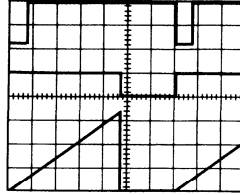
linear ramp is generated. Figure 12 shows a circuit configuration that will perform this function.

Figure 13 shows waveforms generated by the linear ramp.

The time interval is given by:

$$T = \frac{2/3 V_{CC} R_E (R_1 + R_2) C}{R_1 V_{CC} - V_{DE} (R_1 + R_2)}$$

$$V_{BE} \approx 0.6V$$



V_{CC} = 5V
 TIME = 20μs/DIV.
 R₁ = 47 kΩ
 R₂ = 100 kΩ
 R₃ = 2.7 kΩ
 C = .01μF

TOP TRACE: INPUT 3V/DIV.
 MIDDLE TRACE: OUTPUT 5V/DIV.
 BOTTOM TRACE: CAPACITOR VOLTAGE 1V/DIV.

FIGURE 13. Linear Ramp

50% DUTY CYCLE OSCILLATOR

For a 50% duty cycle, the resistors R_A and R_B may be connected as in Figure 14. The time period for the output positive is the same as previous,

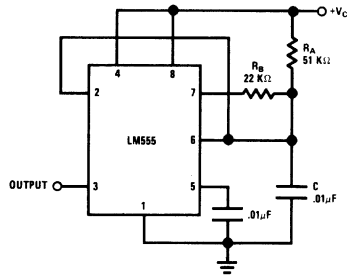


FIGURE 14. 50% Duty Cycle Oscillator

t₁ = .693 R_A C. For the output negative it is t₂ =

$$[(R_A R_B)/(R_A + R_B)] C \ln \left[\frac{R_B - 2R_A}{2R_B - R_A} \right]$$

Thus the frequency of oscillation is $f = \frac{1}{t_1 + t_2}$

Note that this circuit will not oscillate if R_B is greater than 1/2 R_A because the junction of R_A and R_B cannot bring pin 2 down to 1/3 V_{CC} and trigger the lower comparator.



Functional Blocks

LM2905/LM3905 precision timer

general description

The LM3905 is a precision timer that offers great versatility with high accuracy. It operates off unregulated supplies from 4.5V to 40V while maintaining constant timing periods from milliseconds to hours. Internal logic and regulator circuits complement the basic timing function enabling the LM3905 to operate in many different applications with a minimum of external components.

The output of the timer is a floating transistor with built in current limiting. It can drive either ground referred or supply referred loads up to 40V and 50 mA. The floating nature of this output makes it ideal for interfacing, lamp or relay driving, and signal conditioning where an open collector or emitter is required. A "logic reverse" circuit can be programmed by the user to make the output transistor either "on" or "off" during the timing period.

The trigger input to the LM3905 has a threshold of 1.6V independent of supply voltage, but it is fully protected against inputs as high as $\pm 40V$ - even when using a 5V supply. The circuitry reacts only to the rising edge of the trigger signal, and is immune to any trigger voltage during the timing periods.

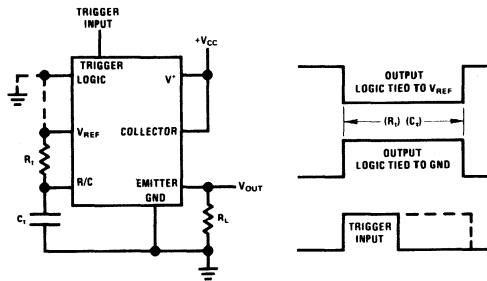
An internal 3.15V regulator is included in the timer to reject supply voltage changes and to provide the user with a convenient reference for applications other than a basic timer. External loads up to 5 mA can be driven by the regulator. An internal 2V divider between the reference and ground sets the timing period to 1 RC.

The comparator used in the LM3905 utilizes high gain PNP input transistors to achieve 300 pA typical input bias current over a common mode range of 0V to 3V.

features

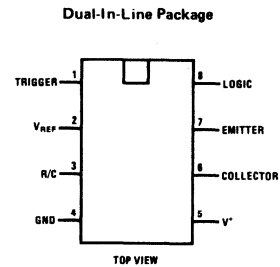
- Immune to changes in trigger voltage during timing interval
- Timing periods from milliseconds to hours
- Internal logic reversal
- Immune to power supply ripple or noise during the timing interval
- Operates from 4.5V to 40V supplies
- Input protected to $\pm 40V$
- Floating transistor output with internal current limiting
- Internal regulated reference
- TTL compatible input and output

typical applications



Basic Timer-Emitter Output and Timing Chart

connection diagram



Order Number LM2905N or LM3905N
See Package 20

absolute maximum ratings

Power Dissipation	500 mW
V ⁺ Voltage	40V
Collector Output Voltage	40V
V _{REF} Current	5 mA
Trigger Voltage	±40V
Logic Reverse Voltage	5.5V
Output Short Circuit Duration (Note 1)	
Lead Temperature (Soldering, 10 sec)	300°C

LM2905/LM3905

electrical characteristics (Note 2)

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
Timing Ratio (Note 3)	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V	.620	.632	.644	
Comparator Input Current	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V		.3	1	nA
Trigger Voltage	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V	1.2	1.6	2	V
Trigger Current	T _A = 25°C, V _{TRIG} = 2V		25		μA
Supply Current	T _A = 25°C, 4.5V ≤ V ⁺ ≤ 40V		2.5	4.5	mA
Timing Ratio	4.5V ≤ V ⁺ ≤ 40V	.610		.654	
Comparator Input Current (Note 4)	4.5V ≤ V ⁺ ≤ 40V	-2		2	nA
Trigger Voltage	4.5V ≤ V ⁺ ≤ 40V	.8		2.5	V
Trigger Current	V _{TRIG} = 2.5V			200	μA
Output Leakage Current	V _{CE} = 40V			5	μA
Capacitor Saturation Voltage	R _t ≥ 1 MΩ		2.5		mV
	R _t = 10 kΩ		25		mV
Reset Resistance			150		Ω
Reference Voltage	T _A = 25°C	3	3.15	3.3	V
Reference Regulation	0 ≤ I _{OUT} ≤ 3 mA		20	50	mV
	4.5V ≤ V ⁺ ≤ 40V		6	25	mV
Collector Saturation Voltage	I _L = 8 mA		.25	.4	V
	I _L = 50 mA		.7	1.4	V
Emitter Saturation Voltage	I _L = 3 mA		1.8	2.2	V
	I _L = 50 mA		2.1	3	V
Average Temperature Coefficient of Timing Ratio				.003	%/°C
Minimum Trigger Width	V _{TRIG} = 2.5V		.25		μs

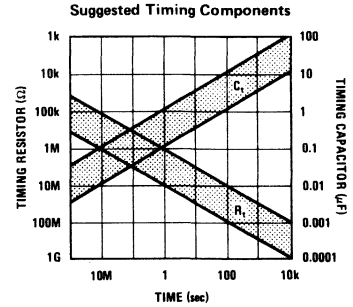
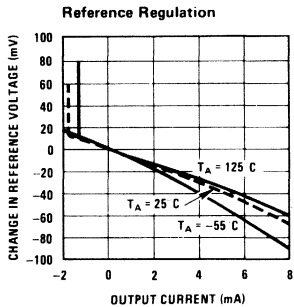
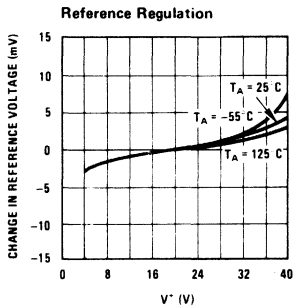
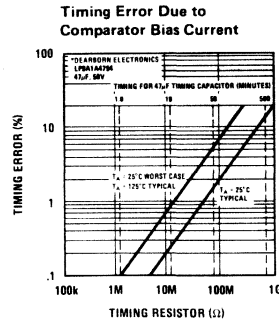
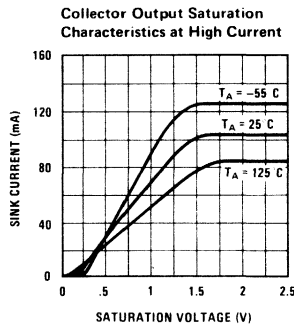
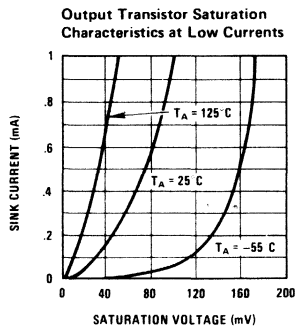
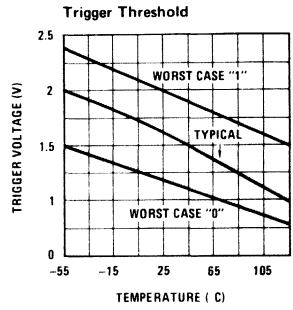
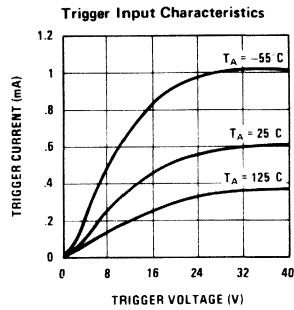
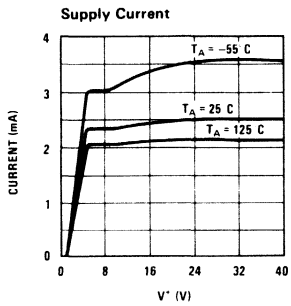
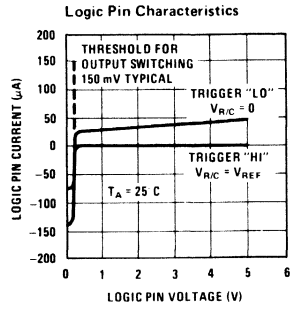
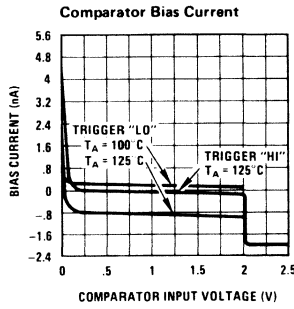
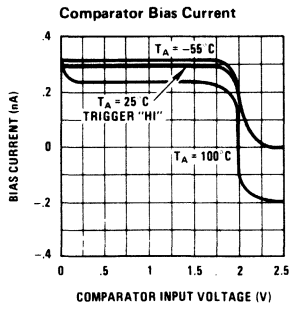
Note 1: Continuous output shorts are not allowed. Short circuit duration at ambient temperatures of 40°C may be calculated from $t = 50/V_{CE}$ seconds, where V_{CE} is the collector to emitter voltage across the output transistor during the short.

Note 2: Specifications include the temperature range -40°C ≤ T_A ≤ +85°C for the LM2905 and 0°C ≤ T_A ≤ +70°C for the LM3905 unless otherwise noted.

Note 3: Output pulse width can be calculated from the following equation: $t = (R_t)(C_p)[1 - 2(0.632 - r) - V_C/V_{REF}]$ where r is timing ratio and V_C is capacitor saturation voltage. This reduces to $t = (R_t)(C_p)$ for all but the most critical applications.

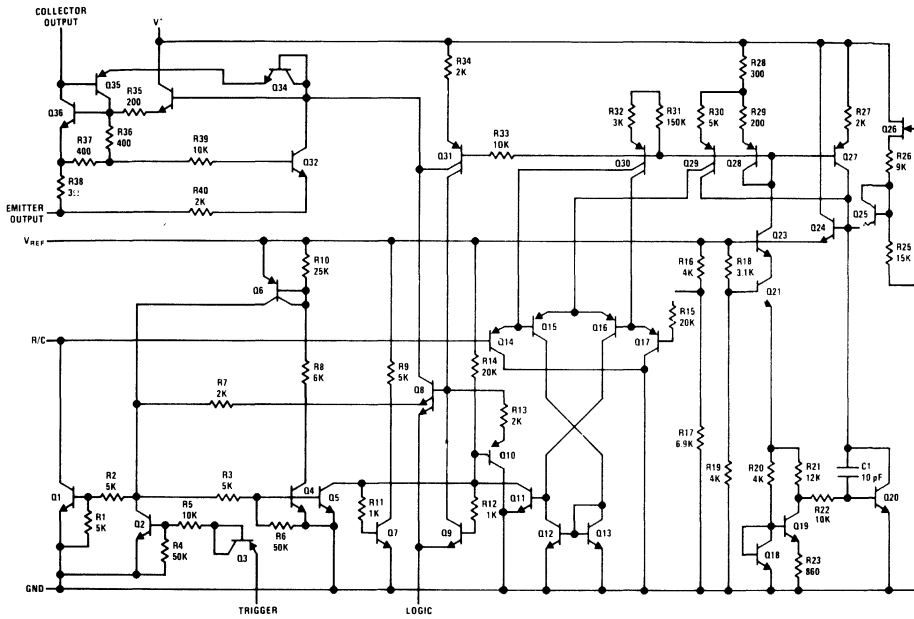
Note 4: Sign reversal may occur at high temperatures (> 70°C) where comparator input current is predominately leakage. See typical curves.

typical performance characteristics

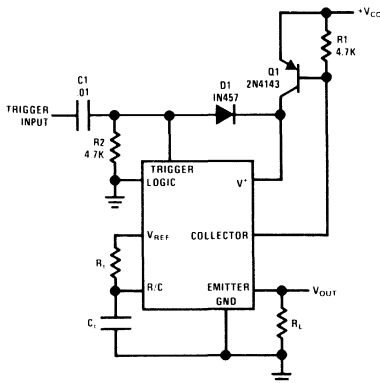


4

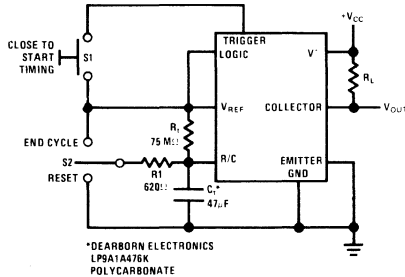
schematic diagram



typical applications(con't)



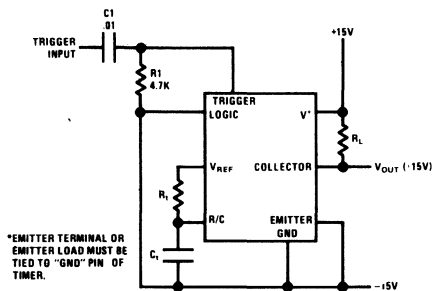
Zero Power Dissipation Between Timing Intervals



One Hour Timer with Reset & Manual Cycle End

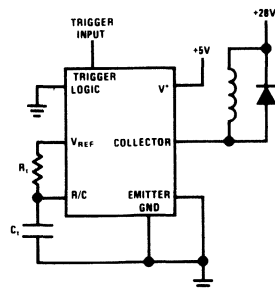
*DEARBORN ELECTRONICS
LP9A1A4/78K
POLYCARBONATE

typical applications (con't)

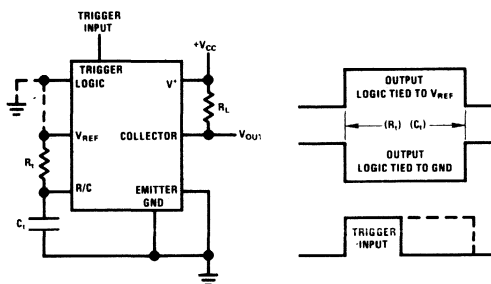


*EMITTER TERMINAL OR EMITTER LOAD MUST BE TIED TO "GND" PIN OF TIMER.

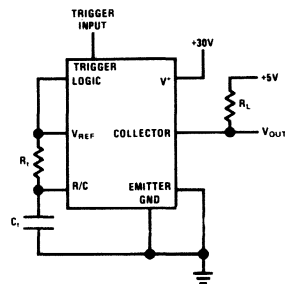
Operating off ±15V Supplies*



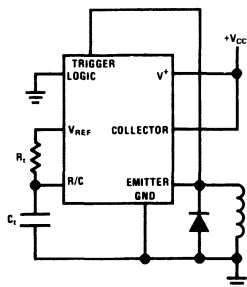
5V Logic Supply Driving 28V Relay



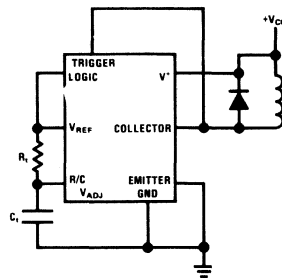
Basic Timer-Collector Output and Timing Chart



30V Supply Interfacing to 5V Logic



Time Out On Power Up
Relay Energized Until $R_t C_t$ Seconds After V_{CC} is Applied



Time Out On Power Up
Relay Energized $R_t C_t$ Seconds After V_{CC} is Applied



Functional Blocks

LX1600A

LX1600A absolute pressure transducer

general description

The LX1600A is a highly accurate, completely field interchangeable, temperature compensated, absolute pressure transducer. It contains in one small package all four of the basic transduction elements shown below in the block diagram — diaphragm and vacuum reference, piezoresistive sensor, signal discriminator and conditioner, and signal amplifier and processor. The first three elements are contained in one single silicon die and the fourth is provided by various standard National linear integrated circuit operational amplifiers.

By applying automatic laser trimming techniques, the output of each LX1600A is factory adjusted so that it meets the nominal values within the specified tolerances. This eliminates the need for user evaluation and calibration — **for each unit the specified nominal output is the "best straight line actual" value.**

The particular design chosen leads to an equivalent circuit for the LX1600A that can be described as a simple potentiometer without a potentiometer's loading problems — the input impedance is thousands of ohms and the output impedance is millions of ohms. Included in this transducer is protection for both input over-voltage and output short circuits.

High volume integrated circuit processing and simplicity of both electrical and mechanical design allows the LX1600A to be price competitive with individual basic sensor elements such as strain gauges, piezoelectric crystals and differential transformers, even though it performs the total pressure transducer function.

features

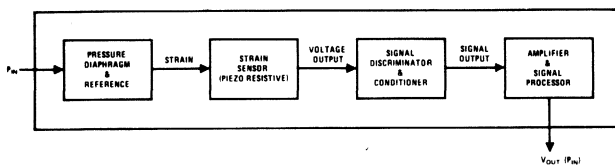
- Absolute Pressure Measurement — each unit contains a vacuum reference.
- Accuracy — maximum static error band of $\pm 3\%$ of full scale. Includes calibration error.
- Field interchangeability — all units meet one guaranteed characteristic curve.
- Easily installed with standard 3/16" flexible tubing and standard 5 pin electronic component sockets.
- Equivalent circuit is a simple potentiometer.
- Flexibility — single ended op amp configuration permits arithmetic functions, digital format, and multiplexing of 2 or more LX1600A's.
- Input overvoltage and output short circuit protection.
- Temperature measurement capability at point of pressure sensing.
- Extended pressure and temperature range capability.
- Availability through local National distributors.

applications

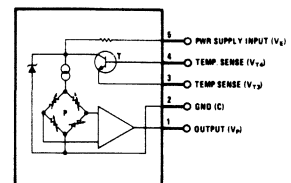
- Fuel metering and ignition controls.
- Heating and ventilation, refrigeration and air conditioning controls.
- Altimetry, air data, and meteorology.
- Automotive safety and diagnostics.
- Pneumatic and pneumatic thermostat controls.
- Utility metering.
- Fluid systems proportional control.

4

block and connection diagrams



Total Useful Pressure Transducer



Order Number LX1600A
See Package 31

absolute maximum ratings

Excitation Voltage	30 V _{DC}
Output Current I _p	5 mA
Calibrated Pressure Range	0 to 1.0 Satm.
Pressure Over-Range	3.0 Satm.
Temperature Sensing Current I _{T34}	100 μA
Operating Temperature Range	-40 to +240°F
Extended Pressure Range	0 to 1.9 Satm.
Storage Temperature Range	-40 to +240°F
Lead Temperature (Soldering, 10 sec)	572°F

* electrical characteristics

PARAMETER	CONDITIONS (Note 1)	NOMINAL VALUE	MAXIMUM DEVIATION
Pressure			
Null Voltage (V _{PN})	T = 78°F, P = 0 atm., V _E = 12.5V	2.5 V _{DC}	±2% FS
Full Scale Voltage (V _{FFS})	T = 78°F, P = 1.0 Satm., V _E = 12.5V	7.5 V _{DC}	±2% FS
Null Temp. Coeff. (TC _{N1})	78°F ≤ T ≤ 180°F, P = 0 atm	0	±1.0 mV/°F
Full Scale Temp. Coeff. (TC _{FS1})	78°F ≤ T ≤ 180°F, P = 1.0 Satm.	0	±1.5 mV/°F
Null Temp. Coeff. (TC _{N2})	-40°F ≤ T ≤ 240°F, P = 0 atm.	0	±1.5 mV/°F
Full Scale Temp. Coeff. (TC _{FS2})	-40°F ≤ T ≤ 240°F, P = 1.0 Satm.	0	±2.0 mV/°F
Linearity	T = 78°F, P = 0.5 Satm.		±0.5% FS
Deadband	T = 78°F, P = 1.0 Satm.	0	±0.1% FS
Hysteretic Error	T = 78°F, P = 0.5 Satm.	0	±0.1% FS
Accuracy			
Static Error Band	T = 78°F,		±3.0% FS
Total Error Band	78°F ≤ T ≤ 180°F,		±3.5% FS
Total Error Band	-40°F ≤ T ≤ 240°F		±4.0% FS
Temperature			
Ref Voltage (V _{TREF})	T = 78°F, I _{T34} = 10 μA	TYP 7.0V	
Sensitivity (ΔV _T /ΔT)	-40°F ≤ T ≤ 240°F, I _{T34} = 10.0 μA	1.1 mV/°F	

*See Pg. 4 for Definition of Terms

Note 1: 78°F = 25°C, 180°F = 82°C, 240°F = 105°C, -40°F = -40°C, 572°F = 300°C, 1 mV/°F = 1.8 mV/°C.

typical applications

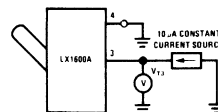
Absolute Pressure Transducer — Figure 1 — As would be expected a minimum of work is required — just combine one voltmeter, one LX1600A, and one 12.5 V_{DC} power supply as shown.

Differential Pressure Transducer — Figure 2 — The differential output between Pin 1 of the two LX1600A may be amplified by the addition of an LM107 and scaled to the output required by the proper selection of the resistor ratio R₄/R₃ and R₂/R₁.

It is possible to maintain the specified accuracies over the 10V min to 30V max useable range of excitation voltage (V_E). However, the regulation of the power supply voltage must be maintained within ±1% and for voltages other than 12.5V, a new calibration curve is necessary.

The LX1600A with its small size and standard electronic and pneumatic connections has been designed for ease of installation in other packages when the application involves harsh or corrosive environments.

The temperature sensor of the LX1600A is activated by grounding Pin 4 and connecting Pin 3 to a 10 μA constant current source as shown. Then V_{TE} measured with a 10 megohm voltmeter indicates the temperature being sensed. With measurements at several different known temperatures the unit is easily calibrated.



For Temperature Sensing

typical applications (con't)

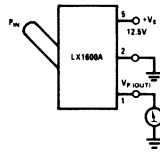


Figure 1. Absolute Pressure Transducer

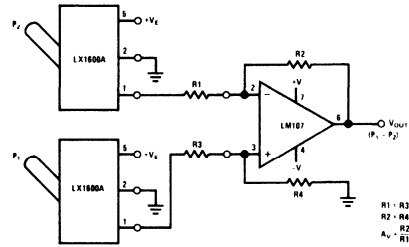


Figure 2. Differential Pressure Transducer

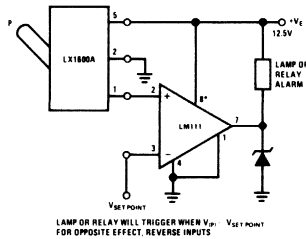


Figure 3. Single Ended LIMIT Detector

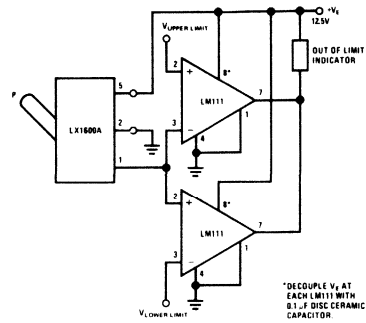
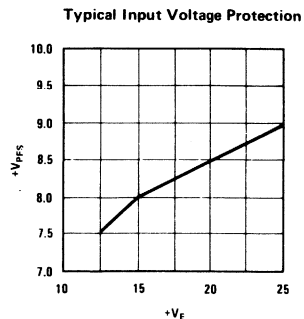
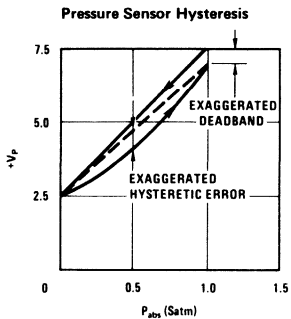
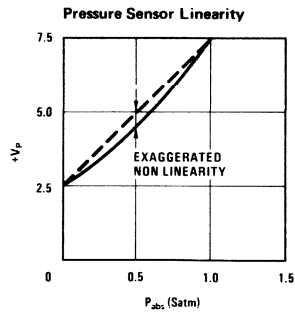
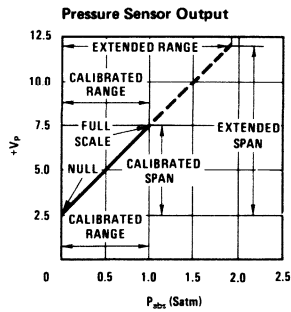


Figure 4. Double Ended LIMIT Detector

typical performance characteristics





Functional Blocks

**LX1601A/LX1602A/LX1603A,
LX1701A/LX1702A/LX1703A absolute
LX1601G/LX1602G/LX1603G/LX1604G,
LX1701G/LX1702G/LX1703G/LX1704G gage
LX1601D/LX1602D/LX1603D/LX1604D differential
pressure transducers 0–30psi**

general description

These rugged devices are highly accurate, completely field interchangeable, temperature compensated linear pressure transducers.

All of the basic transduction elements are incorporated in one hybrid package. A totally useful pressure transducer is shown in the block diagram below—the diaphragm and pressure reference, piezo-resistive sensor, signal discriminator, and signal amplifier and processor. The first three functional elements are contained in a single silicon die and the fourth is provided by standard National linear IC operational amplifiers.

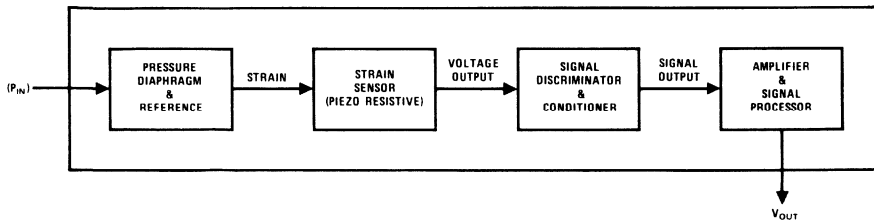
applications

- Medical electronics
- Altimetry, air data, and meteorology
- Computer pneumatics
- Fluid system proportional control
- Hydraulics
- Pneumatic controls
- Heating, ventilation, refrigeration and air conditioning controls
- Automotive emission control, safety, and diagnostic systems

features

- Field interchangeability—by using computerized laser trim all units meet one guaranteed characteristic curve.
- Accuracy—maximum calibration error band of $\pm 1.5\%$ of span
- Temperature compensated—transducer temperature effects offset by computerized laser trimming
- Flexibility—arithmetic functions, digital format and multiplexing are easily attainable because of the single ended op amp configuration
- Input overvoltage and output short circuit protection
- Low mass, no moving parts, good frequency response
- Temperature measurement capability at point of pressure sensing
- Available from local National distributor

block diagram



Total Useful Pressure Transducer

PRODUCT SELECTION GUIDE

absolute maximum ratings

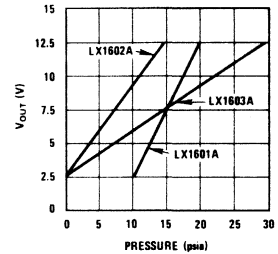
Excitation Voltage	30 V _{DC}
Output Current	5 mA
Temperature Sensing Current	100µA
Operating and Storage Temperature Range	-40°F to +240°F
Bias Current at 15V Excitation	15 mA
Lead Temperature (Soldering, 10 sec)	572°F

(See Note 5 and 6)

nominal characteristics (+70°F, 15V excitation)

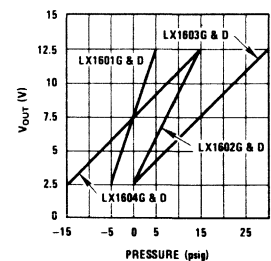
ABSOLUTE TRANSDUCERS

OUTPUT VOLTAGE ±1.5% Span (±150 mV)	CALIBRATED PRESSURE RANGE (psia)		
	LX1601A LX1701A	LX1602A LX1702A	LX1603A LX1703A
2.5V Low Pressure End Point	10	0	0
7.5V Mid-Range	15	7.5	15
12.5V High Pressure End Point	20	15	30
Maximum Allowable Over-Pressure	40	40	50



GAGE AND DIFFERENTIAL TRANSDUCERS

OUTPUT VOLTAGE ±1.5% Span (±150 mV)	CALIBRATED PRESSURE RANGE (psig)			
	LX1601G LX1701G LX1601D	LX1602G LX1702G LX1602D	LX1603G LX1703G LX1603D	LX1604G LX1704G LX1604D
2.5V Low Pressure End Point	-5	0	0	-15
7.5V Mid-Range	0	7.5	15	0
12.5V High Pressure End Point	+5	15	30	+15
Maximum Allowable Over-Pressure	30	40	50	40



Note 1: All nominal characteristics calibrated with 15V excitation and +70° Fahrenheit.

Note 2: The 17 series package is available for absolute and gage units only.

Note 3: Refer to the physical specifications, page 4, for the proper pressure connections to all differential units.

Note 4: To maintain the specified tolerances, the power supply must be regulated to within ±1%. These transducers can be calibrated for any excitation voltage from 10V to 30V.

Note 5: The unit may not withstand corrosive working fluid. In addition to standard die passivation a chemical coating is added to permit use with many common non-conductive working gas and liquids. For specific requirements, consult the factory.

Note 6: The transducers are not electrically isolated from the working fluid.

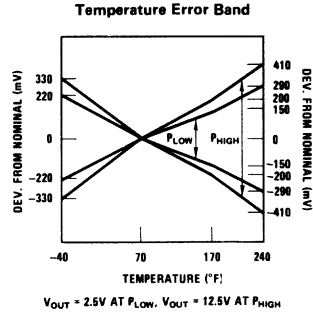
ELECTRICAL SPECIFICATIONS

combined linearity and hysteresis

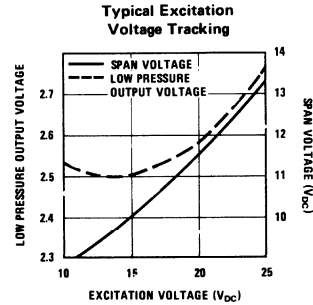
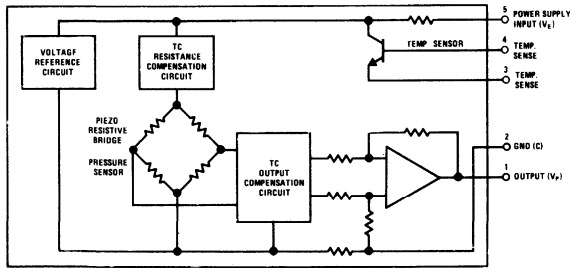
±50 mV (±0.5% Span)

output voltage temperature tolerance

NOMINAL OUTPUT VOLTAGE	MAX TEMP COEFFICIENT ±mV/°F	MAX ERROR OVER TEMP RANGE ±mV	MAX ERROR OVER TEMP RANGE % SPAN
Calibrated Temp Range +70°F ≤ T ≤ +170°F			
2.5V Low Pressure End Point	1.5	150	1.5%
12.5V High Pressure End Point	2	200	2%
Full Temp Range -40°F ≤ T ≤ 240°F			
2.5V Low Pressure End Point	2	290	3%
12.5V High Pressure End Point	3	410	4%



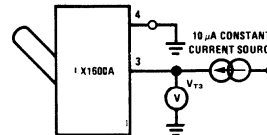
connection diagram



temperature sensor

The temperature sensor of the transducer is activated by grounding pin 4 and connecting pin 3 to a 10µA constant current source as shown. Then V_{T3} measured with a 10 MΩ voltmeter indicates the temperature being sensed. With measurements at several different known temperatures the unit is easily calibrated. When connected in this fashion the typical reference voltage is 7V with a sensitivity of 1.1 mV/°F.

Temperature Sensing Connection



Note: 70°F = 21°C, 170°F = 78°C, 240°F = 116°C, -40°F = -40°C, 572°F = 300°C, 1 mV/°F = 1.8 mV/°C
 1 psi = 51.71 TORR (mmHg) = 2.036 in Hg = 27.67 in H₂O = 2.307 ft H₂O = 68.95 mbar.



Functional Blocks

**LX1610A/LX1620A/LX1630A, LX1710A/LX1720A/LX1730A absolute
LX1610G/LX1620G/LX1630G, LX1710G/LX1720G/LX1730G gage
LX1610D/LX1620D differential
pressure transducers 0–300psi**

general description

These rugged devices are highly accurate, completely field interchangeable, temperature compensated linear pressure transducers.

All of the basic transduction elements are incorporated in one hybrid package. A totally useful pressure transducer is shown in the block diagram below—the diaphragm and pressure reference, piezoresistive sensor, signal discriminator, and signal amplifier and processor. The first three functional elements are contained in a single silicon die and the fourth is provided by standard National linear IC operational amplifiers.

applications

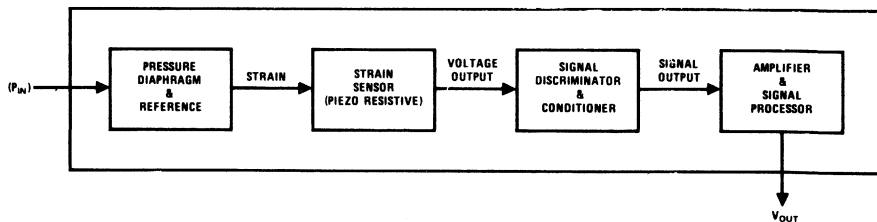
- Medical electronics
- Altimetry, air data, and meteorology
- Computer pneumatics
- Fluid system proportional control
- Hydraulics
- Pneumatic controls
- Heating, ventilation, refrigeration and air conditioning controls
- Automotive emission control, safety, and diagnostic systems

features

- Field interchangeability—by using computerized laser trim all units meet one guaranteed characteristic curve.
- Accuracy—maximum calibration error band of $\pm 1.5\%$ of span
- Temperature compensated—transducer temperature effects offset by computerized laser trimming
- Flexibility—arithmetic functions, digital format and multiplexing are easily attainable because of the single ended op amp configuration
- Input overvoltage and output short circuit protection
- Low mass, no moving parts, good frequency response
- Temperature measurement capability at point of pressure sensing
- Available from local National distributor

4

block diagram



Total Useful Pressure Transducer

PRODUCT SELECTION GUIDE

absolute maximum ratings

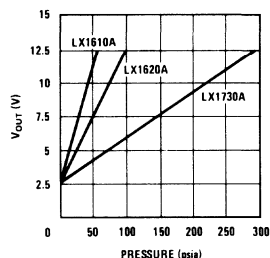
Excitation Voltage	30 V _{DC}
Output Current	5 mA
Temperature Sensing Current	100μA
Operating and Storage Temperature Range	-40°F to +240°F
Bias Current at 15V Excitation	15 mA
Lead Temperature (Soldering, 10 sec)	572°F

(See Note 5 and 6)

nominal characteristics (+70°F, 15V excitation)

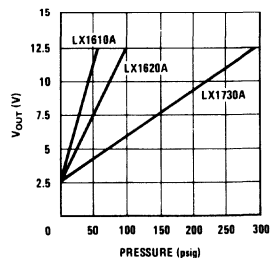
ABSOLUTE TRANSDUCERS

OUTPUT VOLTAGE		CALIBRATED PRESSURE RANGE (psia)		
±1.5% Span (±150 mV)		LX1610A LX1710A	LX1620A LX1720A	LX1730A
2.5V	Low Pressure End Point	0	0	0
7.5V	Mid-Range	30	50	150
12.5V	High Pressure End Point	60	100	300
Maximum Allowable Over-Pressure		100	150	500



GAGE AND DIFFERENTIAL TRANSDUCERS

OUTPUT VOLTAGE		CALIBRATED PRESSURE RANGE (psig)		
±1.5% Span (±150 mV)		LX1610G LX1710G LX1610D	LX1620G LX1720G LX1620D	LX1730G
2.5V	Low Pressure End Point	0	0	0
7.5V	Mid-Range	30	50	150
12.5V	High Pressure End Point	60	100	300
Maximum Allowable Over-Pressure		100	150	500



- Note 1:** All nominal characteristics calibrated with 15V excitation and +70° Fahrenheit.
- Note 2:** The 17 series package is available for absolute and gage units only.
- Note 3:** Refer to the physical specifications, page 4, for the proper pressure connections to all differential units.
- Note 4:** To maintain the specified tolerances, the power supply must be regulated to within ±1%. These transducers can be calibrated for any excitation voltage from 10V to 30V.
- Note 5:** The unit may not withstand corrosive working fluid. In addition to standard die passivation a chemical coating is added to permit use with many common non-conductive working gas and liquids. For specific requirements, consult the factory.
- Note 6:** The transducers are not electrically isolated from the working fluid.

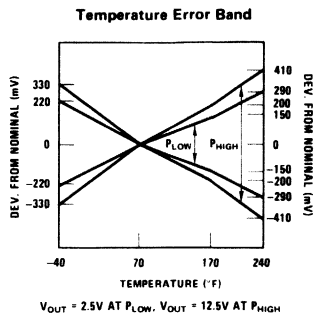
ELECTRICAL SPECIFICATIONS

combined linearity and hysteresis

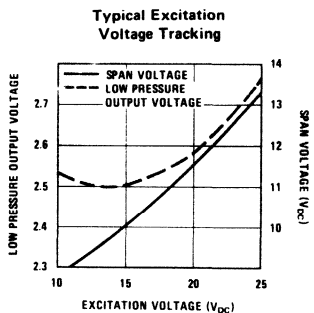
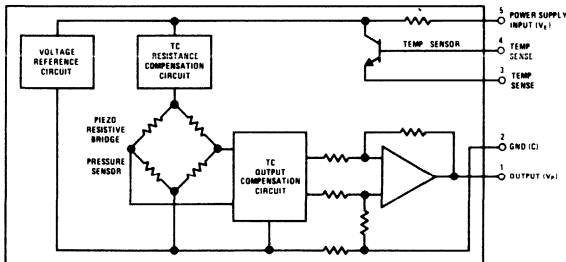
±75 mV (±0.75% Span)

output voltage temperature tolerance

NOMINAL OUTPUT VOLTAGE	MAX TEMP COEFFICIENT ±mV/°F	MAX ERROR OVER TEMP RANGE ±mV	MAX ERROR OVER TEMP RANGE % SPAN
Calibrated Temp Range +70°F ≤ T ≤ +170°F			
2.5V Low Pressure End Point	1.5	150	1.5%
12.5V High Pressure End Point	2	200	2%
Full Temp Range -40°F ≤ T ≤ 240°F			
2.5V Low Pressure End Point	2	290	3%
12.5V High Pressure End Point	3	410	4%



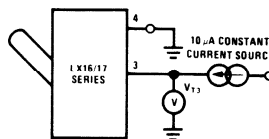
connection diagram



temperature sensor

The temperature sensor of the transducer is activated by grounding pin 4 and connecting pin 3 to a 10μA constant current source as shown. Then V_{T3} measured with a 10 MΩ voltmeter indicates the temperature being sensed. With measurements at several different known temperatures the unit is easily calibrated. When connected in this fashion the typical reference voltage is 7V with a sensitivity of 1.1 mV/°F.

Temperature Sensing Connection



Note: 70°F = 21°C, 170°F = 78°C, 240°F = 116°C, -40°F = -40°C, 572°F = 300°C, 1 mV/°F = 1.8 mV/°C, 1 psi = 51.71 TORR (mmHg) = 2.036 in Hg = 27.67 in H₂O = 2.307 ft H₂O = 68.95 mbar.



Functional Blocks

PSM6501 $\pm 15V$, 100mA power supply module

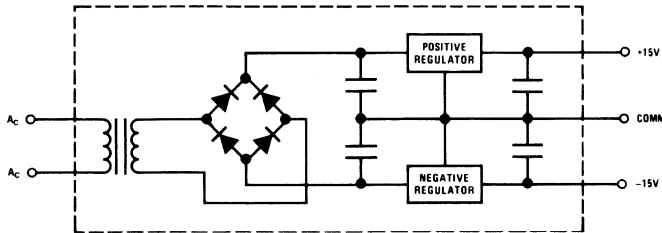
general description

The PSM6501 is a $\pm 15V$ modular power supply capable of continuously delivering 100 mA DC minimum. The required input voltage is 105V to 125V AC at 50 Hz to 440 Hz. This supply incorporates short circuit protection, thermal shut-down protection to prevent thermal runaway and safe operating area compensation in the output devices to limit internal power dissipation. Integrated circuits are used extensively to improve reliability.

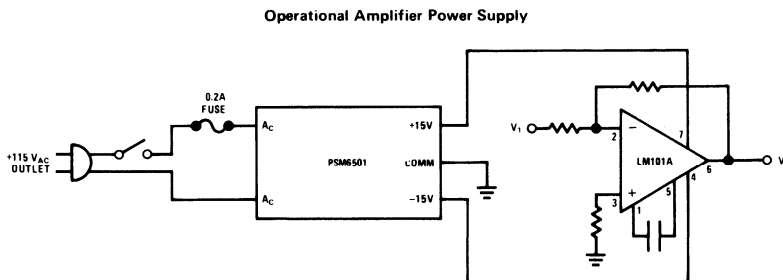
features

- Complete compact plug-in module
- Excellent line and load regulation
- AC input, DC output
- Output short circuit protection
- Thermal shutdown – avoids runaway
- Safe area compensation

equivalent circuit



typical application



Order Number PSM6501
(For Matching Socket Order Part Number SKT0001)
See Package 34

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN}	50 Hz - 440 Hz	105		125	V_{AC}
V_{OUT} Positive		15		15.30	V_{DC}
V_{OUT} Negative		-15		-15.30	V_{DC}
I_{OUT}		±100			mA
V_{OUT} Tracking				0.1	%
V_{OUT} Tempco				0.015	%/°C
Line Regulation	±10 V_{AC}		0.02	0.05	%
Load Regulation	0 mA - 100 mA		0.03	0.1	%
Isolation			50		MΩ
f_{OUT}	10 kHz		0.2		Ω
Ripple & Noise				0.5	mVrms
Warm-up Drift				45	mV

Note 1: All parameters apply for $T_A = 25^\circ\text{C}$, $V_{IN} = 115\text{ Vrms}$ @ 60 Hz, unless otherwise noted.

The PSM6501 replaces the following part types:

902	ZM15100
543	MD15D
2212	P1106
LCD2.15.100	SE902
SP5902	



Functional Blocks

SHM6401 sample and hold module

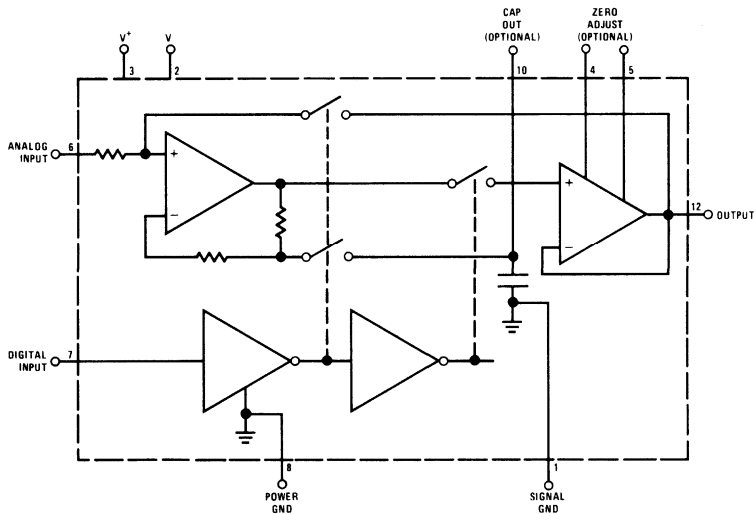
general description

The SHM6401 is a compact sample and hold module capable of acquiring and holding an analog signal upon command of a digital pulse. A high impedance input buffer, complete digital logic, 3 analog switches, hold capacitor and a FET input hold amplifier are all included within the package. Higher accuracy may be obtained by adding an external trim pot and capacitor.

features

- Self contained plug-in module
- High accuracy 0.01%
- TTL, DTL compatible logic
- Analog signal range $\pm 10V$
- Low droop rate 10 mV/sec max
- High input impedance
- Standard power supplies $\pm 15V$
- Low acquisition time

equivalent circuit



NOTE: HOLD MODE (LOGIC "0") SHOWN. ALL OTHER PINS NO CONNECT

Order Number SHM6401
See Package 35

absolute maximum ratings

Analog Input Voltage Range	±15V
Digital Input Voltage	5.5V
Analog Supply Voltage (V^+ to V^-)	40V
Short Circuit	Indefinite
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	-55°C to +85°C
Lead Temperature (Soldering, 10 sec)	300°C

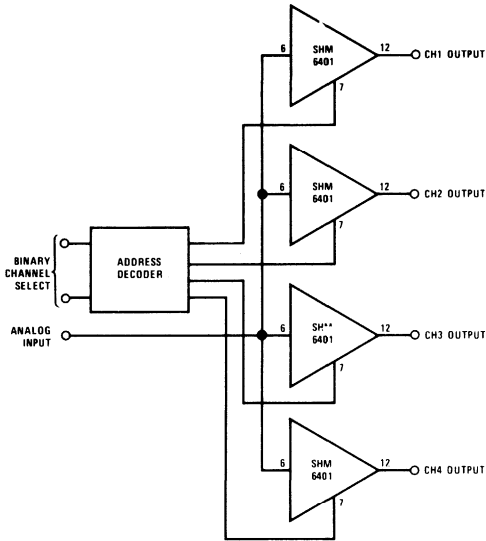
electrical characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
DC Accuracy	$R_L = 2k\Omega$			±0.01	%
Voltage Gain			1		
Voltage Gain Temperature Coefficient				±1	PPM/°C
Frequency Response	Tracking, -3 dB, Small Signal		50		kHz
Frequency Response	Tracking, Full Power 20V _{pp} Sine Wave		10		kHz
Slew Rate			0.5		V/μs
Sample Mode Settling Time	To ±1 mV, 10V Step Input		75		μs
Input Overload Recovery	To ±1 mV, 50% Overvoltage		150		μs
Input Voltage Range		±10			V
Input Resistance	Sample Mode	100			MΩ
Input Bias Current	Sample Mode		400		nA
Input Offset Voltage	Sample Mode		20		mV
Input Offset Voltage Temperature Coefficient	0°C to +70°C		10		μV/°C
Power Supply Rejection Ratio				0.015	mV/%ΔV _S
Output Swing	$R_L = 2k\Omega$	±10			V
Output Current	$R_L = 2k\Omega$	±10			mA
Load Capacitance	No Oscillation		1000		pF
Wide Band Output Noise	Hold Mode, Grounded Input		1		mVrms
Droop Rate	Hold Mode, +25°C			10	mV/s
Droop Rate	0°C to +70°C		Doubles Every 10°C		
Signal Feed Through	Hold Mode, 20V _{pp} Sine Wave, 10 kHz			2	mV _{pp}
Aperature Time	Sample to Hold Transition			50	ns
Offset Step	Sample to Hold Transition			1	mV
Transition Settling Time	To ±1 mV of Final Value, Sample to Hold Transition			10	μs
Transition Settling Time	To ±1 mV, Hold to Sample Transition			100	μs
Acquisition Time	20V Step to ±1 mV of Final Value, Hold to Sample Transition			130	μs
Logic High	I = 5μA Max	2		5.5	V
Logic Low	I = 0.5 mA Max	-0.5		0.8	V
Supply Current				8	mA

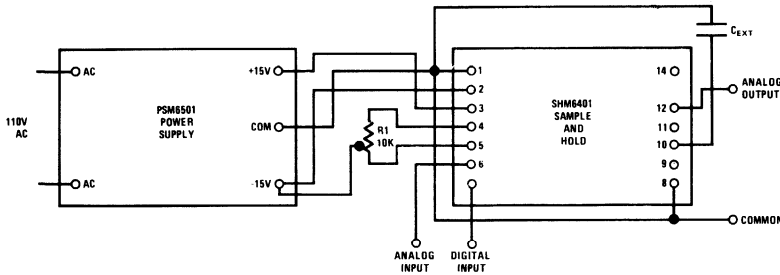
Note 1: All specifications apply for $V_S = \pm 15V$, $T_A = 25^\circ C$ unless otherwise specified.

typical application

Analog Data Distribution System

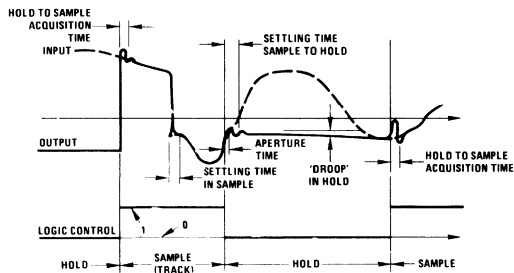


high accuracy connection



- NOTE 1: MAX DROOP RATE = $d_v/d_t = (0.1 \times 10^{-9} / (10 \times 10^{-9} + C_{EXT}))$ V/SEC.
- NOTE 2: TO ZERO ADJUST, SET DIGITAL INPUT TO SAMPLE MODE, APPLY 0V TO THE ANALOG INPUT, AND TRIM R1 UNTIL ANALOG OUTPUT READS 0V.
- NOTE 3: SIGNAL GROUND AND ANALOG GROUND SHOULD BE TIED TOGETHER AT ONE POINT NEAR THE SUPPLY.
- NOTE 4: C_{EXT} SHOULD BE LOW LEAKAGE TEFLON, POLYCARBONATE OR POLYSTYRENE.

explanation of terminology





Consumer Circuits

LM170/LM270/LM370

LM170/LM270/LM370 agc/squelch amplifier

general description

The LM170 is a direct coupled monolithic amplifier whose voltage gain is controlled by an external DC voltage. The device features:

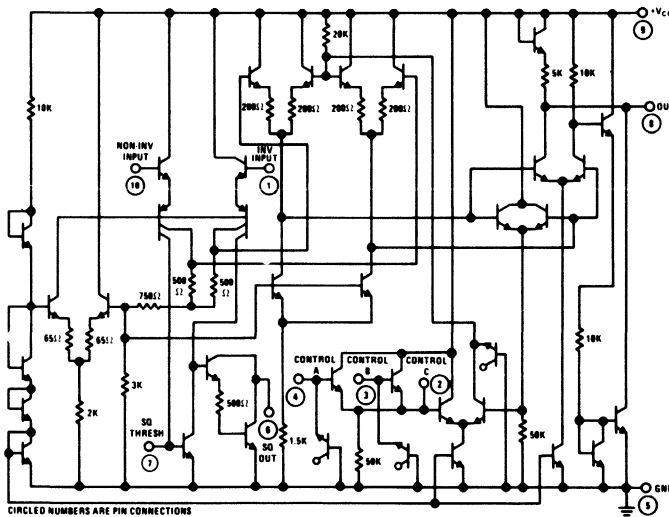
- Large Gain Control Range
- Self-contained AGC/Squelch system, with fast-attack, slow-release.
- Low Distortion
- Minimum DC output shift as gain is varied
- Differential inputs, with large common-mode input range
- Outputs of several amplifiers may be directly summed in multichannel systems.
- Dissipates only 18 mW from +4.5V supply, usable with supply up to +24V.

- Sensitive squelch threshold set by single external resistor.

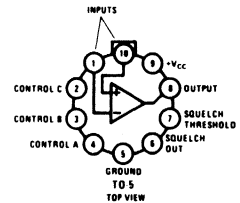
In addition to communication system squelch and AGC applications, the LM170 is useful as constant-amplitude audio oscillator, linear low frequency modulator, single-sideband automatic load control, and as a variable DC gain element in analog computation.

The LM170 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LM270 is specified for operation over the -25°C to $+75^{\circ}\text{C}$ temperature range. The LM370 is specified for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

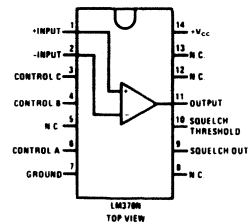
schematic** and connection diagrams



CIRCLED NUMBERS ARE PIN CONNECTIONS



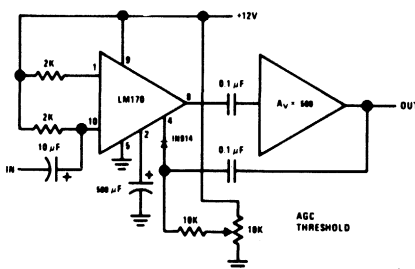
Order Number LM170H or LM270H or LM370H See Package 14



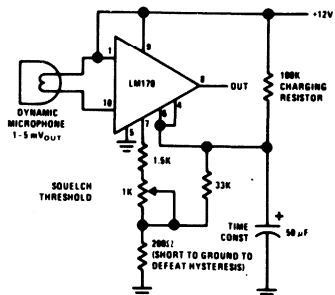
Order Number LM370N See Package 22

typical applications**

AGC Using Built-in Detection, Driven By Additional System Gain



Squelched Preampifier with Hysteresis



**Pin connections shown are for metal can.

5

absolute maximum ratings

Supply Voltage	24V
Storage Temperature	-65°C to +150°C
Operating Temperature LM170	-55°C to +125°C
LM270	-25°C to +75°C
LM370	0°C to +70°C
Differential Input Voltage	±19.5V
Common-mode Input Voltage	(V _{CC} + 0.4)V
Output Short Circuit Duration	Indefinite
Voltage applied to Pin 3 or 4	+6.0V
Voltage applied to Pin 2	+12.0V
Surge power into Pin 6 (1 second max.)	1000 mW
Continuous power into Pin 6	100 mW

electrical characteristics (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC CHARACTERISTICS						
DC Output Voltage	V _O (DC)	V _{IN} (dd) = 0, V (gain control) = 0	+5.0	+6.0	+7.0	V
DC Output Voltage	V _O (DC)	V _{IN} (dd) = 0 V (gain control) = +3.0	+5.0	+6.0	+7.0	V
DC Output Shift	ΔV _O (DC)	V _{IN} (dd) = 0 V (gain control) changed from 0 to +3.0V				
		LM170	-200	0	+200	mV
		LM270	-500	0	+500	mV
		LM370	-1000	0	1000	
Power Supply Drain	I _{PS}	V _{CC} = +24V V _{CC} = +4.5V V _{CC} = +12V LM170, 270 LM370		13.5 4.0 8.0 8.0		mA mA mA
Input Bias Current	I _{IB}	LM170, 270 LM370		5.0 5.0	10.0 12.0	μA
AC CHARACTERISTICS						
Voltage Gain	A _v	V (gain control) = 0 LM170, 270 LM370 f = 1 KHz	37.5 35.0	40.0 40.0		dB
Gain Reduction Range	ΔA _v	V (gain control) changed from 0 to +3.0V. Gain reduction occurs for control voltages between +2.1 and +2.5 volts, pin 3 or pin 4. f = 1 KHz		-80.0		dB

Note 1: T_A = 25°C. V_{CC} = +12V. V_{IN(c.m.)} = +6V

operating notes

Voltage gain is continuously variable from a maximum value, dependent upon supply voltage, to a minimum value, by application of a DC control voltage at Pin 3 or 4. DC output voltage is substantially independent of gain changes, provided that differential DC input voltage is minimized, so that direct-coupled or fast gain-control operation is possible with minimum disturbance of succeeding amplifiers.

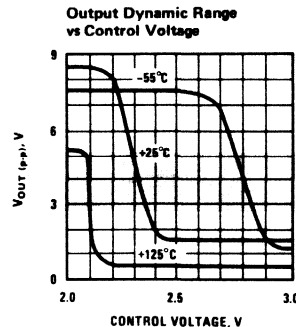
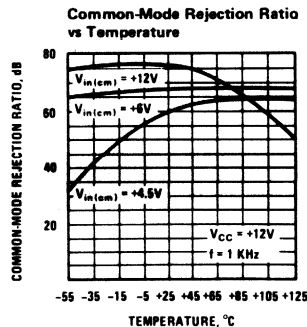
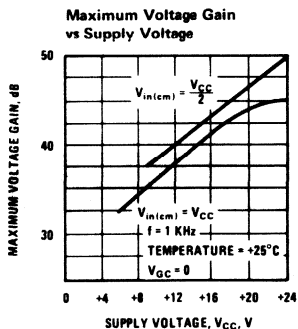
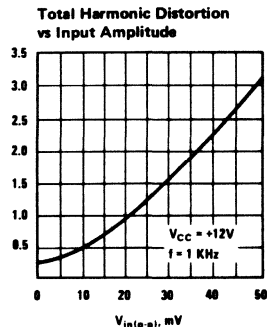
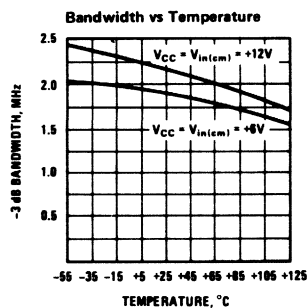
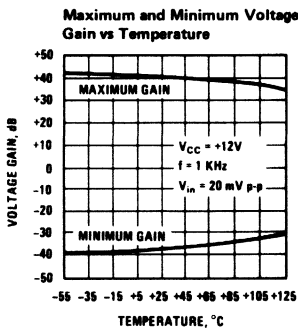
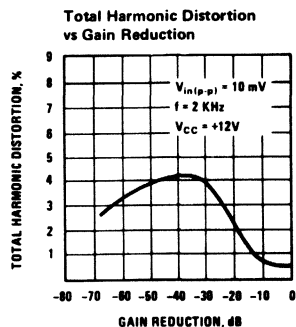
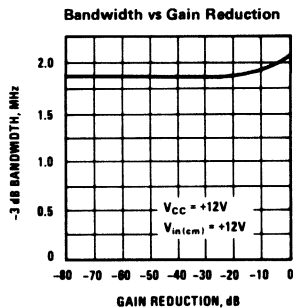
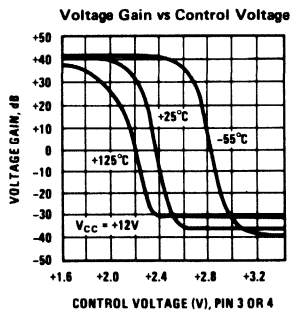
Input characteristics are similar to those of an operational amplifier, with common-mode input range extending from +4.5 volts up to and including the positive supply voltage. Lowest distortion occurs at input levels of 20 mV p-p or less. Outputs of several amplifiers, which will have quiescent DC levels approximately half of the positive

supply, may be directly connected together in multi-channel summing systems, without damage.

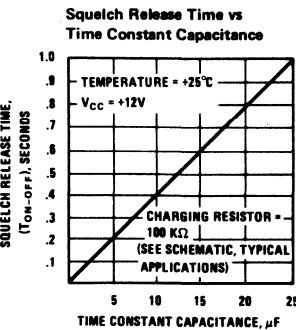
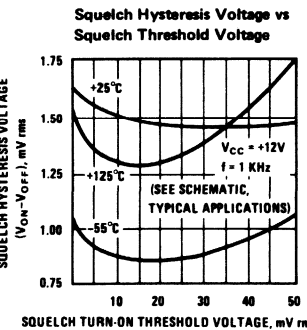
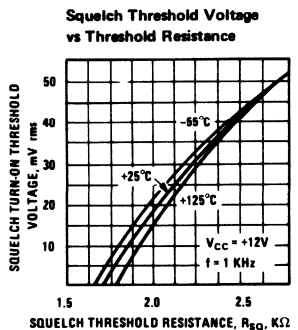
Emitter-follower control inputs, Pins 3 and 4, may be used as positive peak detectors by connecting a smoothing capacitor at Pin 2, in AGC applications.

A sensitive squelch detector, independent of the amplifier's gain, provides fast-attack, slow release control at Pin 6, with threshold set by an external resistance from Pin 7 to ground. Injecting a portion of the control voltage at Pin 6 into this threshold results in a hysteresis, reducing response to erratic inputs. Since threshold is dependent on DC levels, differential DC input voltage should be held constant for squelch operation.

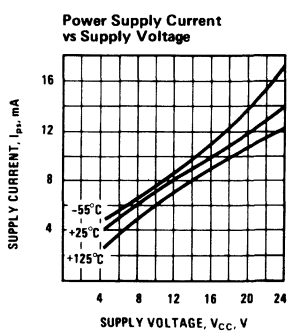
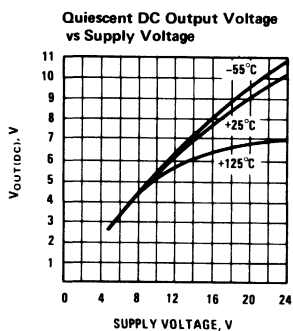
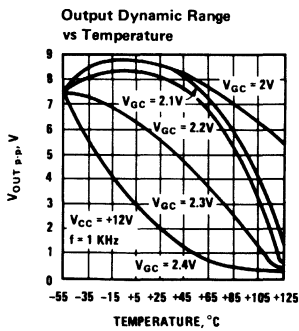
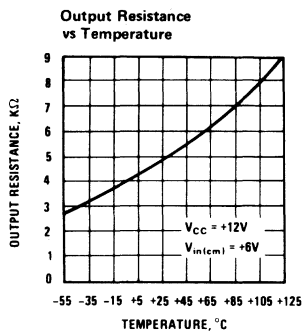
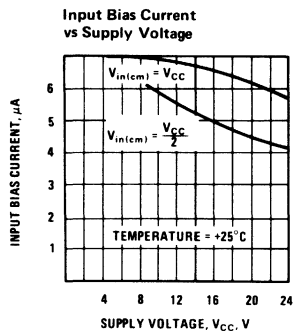
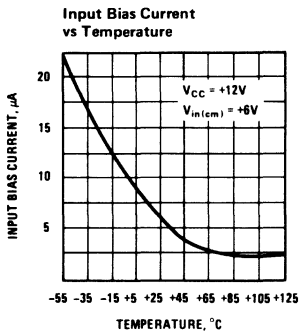
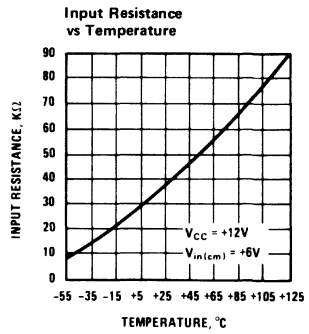
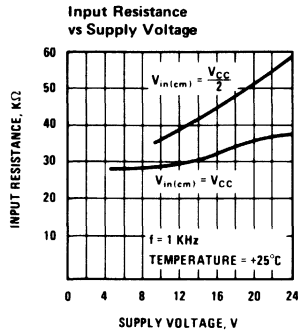
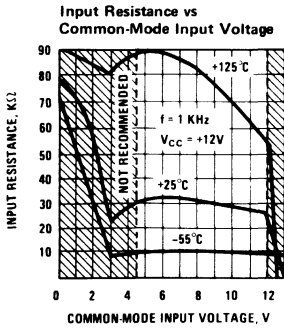
variable gain characteristics



squelch characteristics



input and output characteristics





Consumer Circuits

LM171/LM271/LM371

LM171/LM271/LM371 integrated rf/lf amplifier general description

The LM171/LM271/LM371 is a monolithic RF-IF amplifier capable of emitter coupled or cascode operation from DC to 250 MHz. Wide versatility is offered by having all inputs and outputs brought out so many circuit configurations are possible.

features

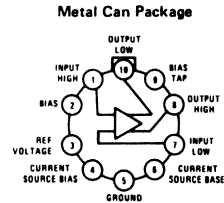
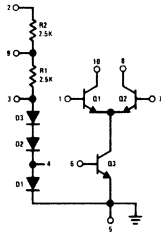
- Low internal feedback, allowing high stability-limited gain
- Versatility through user-connected configurations
- As emitter coupled amplifier, symmetrical, non-saturated limiting

- As cascode, wide AGC range with constant input admittance
- As differential DC amplifier, low input offset voltage and wide dynamic range
- As video amplifier, externally selected gain, and high gain-bandwidth product
- 100 MHz tuned power gain

(Emitter Coupled)	24.6 dB
(Cascode)	27.5 dB

In addition to amplifier service, the circuit is useful in mixer, oscillator, detector, modulator, and numerous other applications. The LM271 is a plug-in replacement for the 911C type.

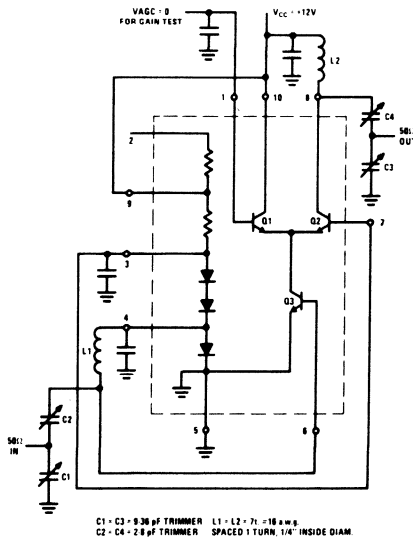
schematic and connection diagrams



Order Number LM171H
or LM271H or LM371H
See Package 14

typical applications

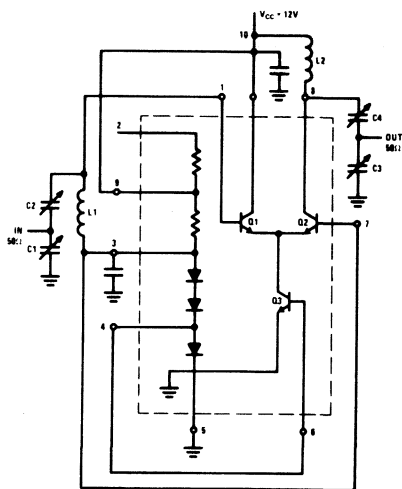
100 MHz Cascode Test Circuit



C1 - C3 - 0.30 μ F TRIMMER L1 - L2 - 71 - 18 μ m
C2 - C4 - 2.0 μ F TRIMMER SPACED 1 TURN, 1/4" INSIDE DIAM

FIGURE 1

100 MHz Emitter Coupled Test Circuit



C1 - C3 - 0.30 μ F TRIMMER L1 - L2 - 71 - 18 μ m
C2 - C4 - 2.0 μ F TRIMMER SPACED 1 TURN, 1/4" INSIDE DIAM

FIGURE 2

Note: All unmarked bypass capacitors 1000 pF.

5

absolute maximum ratings

Supply Surge Voltage	30V
Supply Operating Voltage	24V
Storage Temperature	-65°C to +150°C
Operating Temperature	LM171 -55°C to +125°C
	LM271 0°C to +100°C
Power Dissipation	230 mW
Voltage between 1 and 7	±5V
Voltage between 4 and 6	±5V

electrical characteristics

These specifications apply for $V^+ = +12V$ and $T_A = 25^\circ C$

PARAMETER	CONDITIONS	LM171			LM271			LM371			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
DC CHARACTERISTICS											
Input Offset Voltage (V_{OS})	$I_B = I_{10} = 500 \mu A$			3			3			10	mV
Input Bias Current (I_{BIAS})		1.30		2.65	1.3		2.65	1.3		2.65	mA
Ratio of R1/R2		0.895		1.12	0.895		1.12	0.895		0.895	
Voltage at Pin 3 (V_3)	$V_2 = +12V$	2.0			2.0			2.0			V
Current Through Current Source Q3 (I_C)	$I_C = I_B + I_{10}$	2.45		5.70	2.45		5.70	2.45		5.70	mA
Current Gain (β)		40			40			40			
Power Supply Current Drain (I_{PS})	$I_{PS} = I_{BIAS} + I_B + I_{10}$			9.0			9.0			10.5	mA
EMITTER COUPLED CHARACTERISTICS (Input Signal < 10 mVrms) LM171, LM271, LM371											
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS						
Input Conductance (G_{11})	455 kHz		0.30	0.40	mmhos						
Output Conductance (G_{22})	455 kHz		0.01	0.04	mmhos						
Magnitude of Forward Transadmittance ($|Y_{21}|$)	455 kHz	17.0	27.0		mmhos						
Magnitude of Reverse Transadmittance ($|Y_{12}|$)	200 MHz		0.1		mmhos						
Tuned Power Gain (A_p)	10.7 MHz BW = 470 kHz		24.6		dB						
Tuned Power Gain (A_p)	100 MHz BW = 5 MHz		22.7		dB						
CASCADE CHARACTERISTICS (Input Signal < 10 mVrms) LM171, LM271, LM371											
Input Conductance (G_{11})	455 kHz		1.1	2.5	mmhos						
Output Conductance (G_{22})	455 kHz Connect Pin 1 to 7		0.01	0.04	mmhos						
Magnitude of Forward Transadmittance ($|Y_{21}|$)	455 kHz Pin 1 GND	25.0	50.0		mmhos						
Magnitude of Reverse Transadmittance ($|Y_{12}|$)	200 MHz 100 MHz		0.001		mmhos						
Tuned Power Gain (A_p)	Pin 1 GND BW = 5 MHz		27.5		dB						
Tuned Power Gain (A_p)	Pin 1 GND BW = 6 MHz		25.0		dB						
THE FOLLOWING PARAMETERS APPLY FOR THE LM171 FOR $-55^\circ C < T_A < +125^\circ C$											
Magnitude of Forward Transadmittance (Emitter Coupled) ($|Y_{21}|$)	455 kHz $e_{in} < 10$ mV rms	17.0			mmhos						
Magnitude of Forward Transadmittance (Cascode) ($|Y_{21}|$)	455 kHz $e_{in} < 10$ mV rms Pin 1 GND	21.0			mmhos						

biasing considerations

The active portion of the 171 is biased by monolithic matching of constant-current transistor Q3 and diode D1. R1 and R2 may be connected in one of four ways to force a current from V_{CC} through three diodes. Alternatively, an external resistor may be used. If pin 4 is connected to pin 6, directly, or through an inductor or resistor having less than 100 ohms DC resistance, the current drawn by Q3 will approximately equal that forced through D1.

Pin 3 may be used as a DC reference voltage, to bias pins 1 and 7, and is approximately the minimum voltage required to guarantee proper current source collector characteristics.

Typical Biasing for Emitter Coupled Amplifier

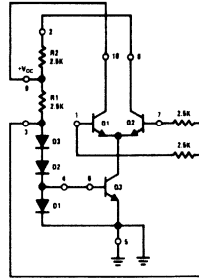
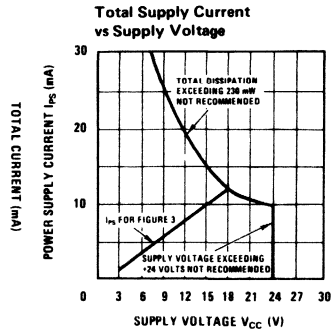
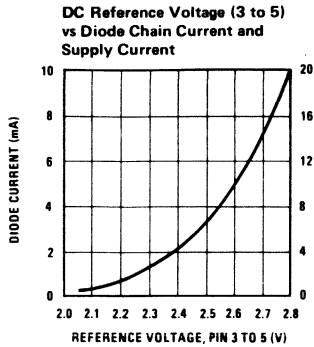
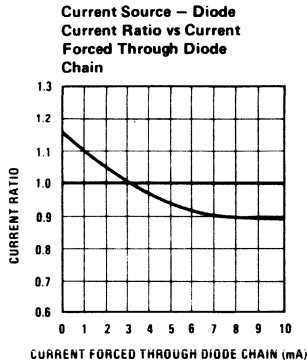
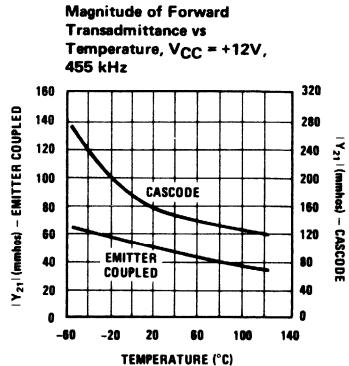
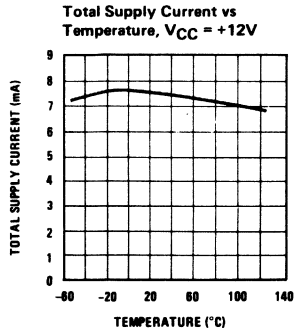


FIGURE 3



typical temperature characteristics



cascode configuration

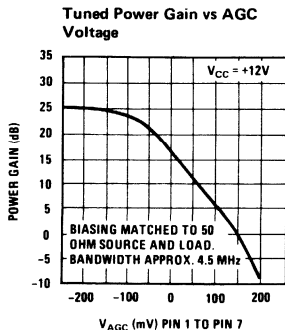
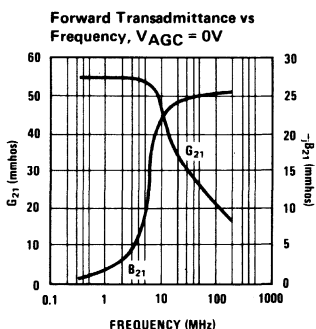
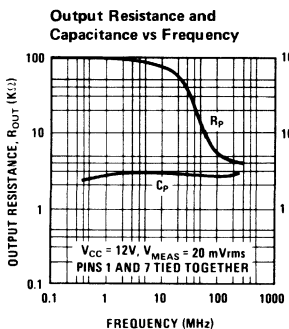
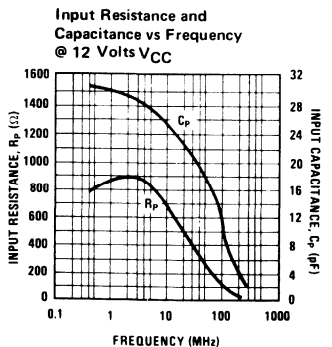
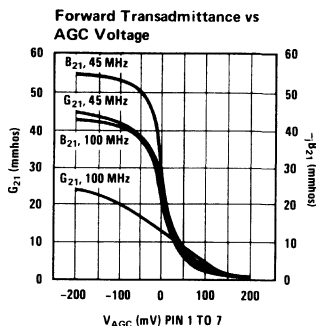
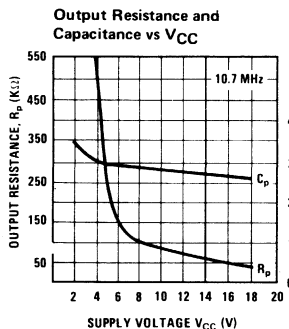
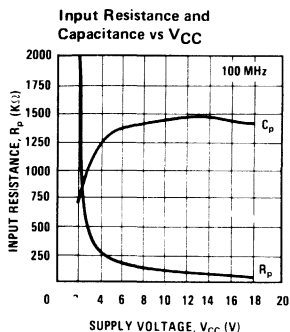
The common-emitter, common-base, or cascode, configuration is useful as a tuned RF or IF amplifier to 250 MHz. Two common-base stages are formed by the differential pair, Q1 and Q2, which may be used as a gain control system by applying a differential gain control voltage between pins 1 and 7. With Q1 cut off, maximum gain is obtained, being reduced as Q1 is progressively turned on and Q2 turned off. The input common-emitter transistor presents a nearly constant input admittance as AGC is applied.

DC input bias is obtained through the input inductor from the bias chain, pin 4.

Pin 3 may be used as the DC reference for the AGC input, to assure adequate bias voltage for the collector of Q3. Where large AGC voltages are used, an external resistive divider, from pin 3 to 1 to the

AGC voltage may be used to optimize the DC AGC requirements. V_{AGC} is defined as the voltage between pin 1 and 7.

At some frequencies, bypassing may be required at pins 1, 3, 4 or the V_{CC} connection.



emitter coupled configuration

The common-collector, common-base, or emitter-coupled configuration is useful as a symmetrical non-saturated limiting RF or IF amplifier to 150 MHz. Basically a differential amplifier, this configuration is especially suited to FM IF strips using conventional interstage tuning. While available gain is lower and noise figure higher than the cascode, emitter coupled operation may be considered wherever fast recovery from large-signal overdrive or excellent AM rejection is required.

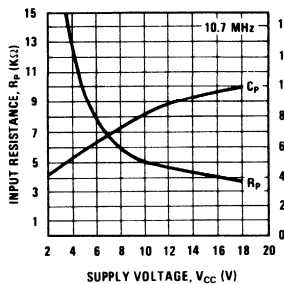
Q3 is used as a current source, obtaining its bias from the diode chain. Current available from Q3 is shunted through Q1 or Q2, depending on input sig-

nal, and is equally divided when no signal is present, assuring inherently symmetrical operation. DC bias for pin 7 is obtained from the divider chain, and through the input inductor, the same bias is applied to pin 1.

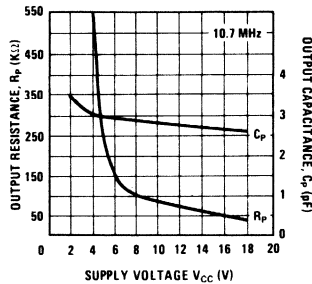
For non-saturated operation, the output load must be chosen so that the collector voltage of the output transistor is higher than the DC reference voltage, with all source current shunted into the output, for the particular bias levels used.

At some frequencies, bypassing of pins 3, 6, 7, or the V_{CC} connection may be required.

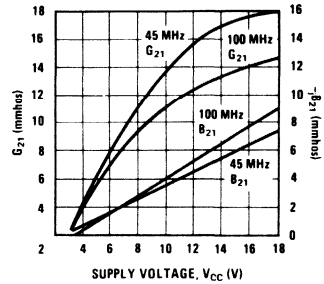
Input Resistance and Capacitance vs V_{CC}



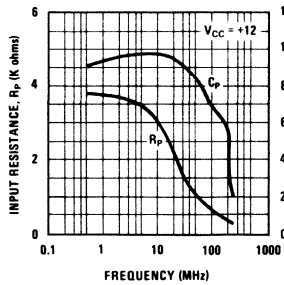
Output Resistance and Capacitance vs V_{CC}



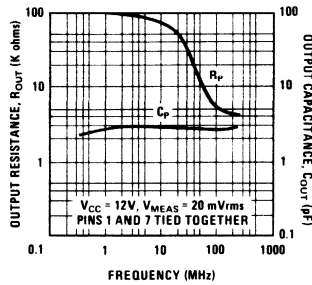
Forward Transadmittance vs V_{CC}



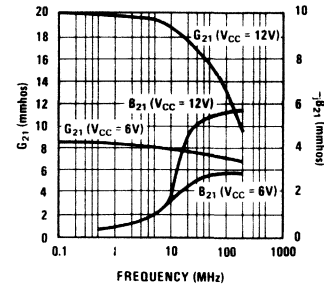
Input Resistance and Capacitance vs Frequency



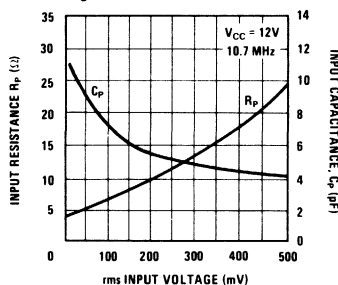
Output Resistance and Capacitance vs Frequency



Forward Transadmittance vs Frequency



Input Resistance and Capacitance vs Input Signal Level



dc, audio and video configuration

Convenient self-contained biasing, excellent monolithic matching, and high gain-bandwidth product make a wide variety of applications possible using resistive loads.

The biasing shown in Figure 3 uses R2 as collector load for a single-ended output, differential input amplifier. By choosing the proper external load resistor, bias configuration, and supply voltage, video amplifiers may be constructed to meet specific gain and bandwidth requirements, in either cascode or emitter coupled form.

With matched pairs of external load resistors, true differential DC amplifiers may be constructed, with large common-mode input range, input offset voltages typically 0.3 mV, and monolithically matched, self-contained current sources easily tailored to specific operating point requirements.

Direct Coupled Test Circuit
(Connect R_L Between Pins 8 and 10, or Connect Pin 2 to 8 for Internal R_L)

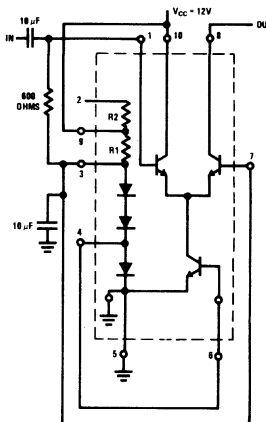
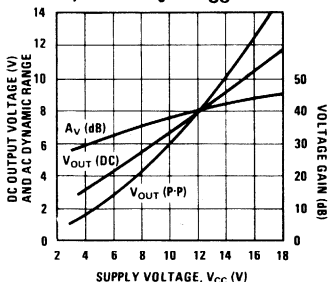
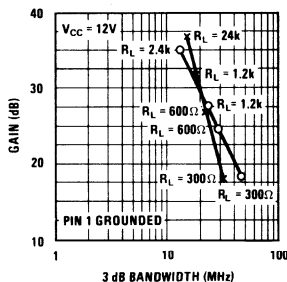


FIGURE 4

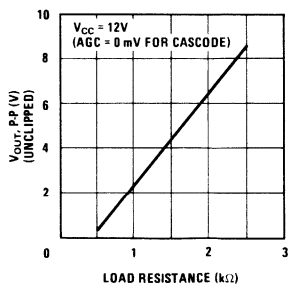
Voltage Gain, DC Output Voltage ($R_L = R_2$) & Dynamic Range vs V_{CC}



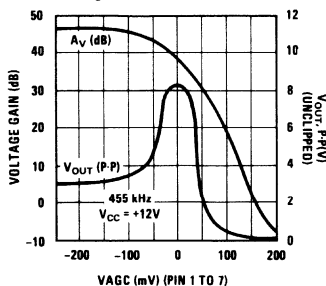
Cascode and Emitter Coupled Video Amplifiers Voltage Gain and Load Resistance vs Bandwidth



Cascode & Emitter Coupled Video Amplifiers Dynamic Range vs Load Resistance



Cascode Video Amplifier Voltage Gain & Dynamic Range vs AGC Voltage





Consumer Circuits

LM172/LM272/LM372

LM172/LM272/LM372 am if strip general description

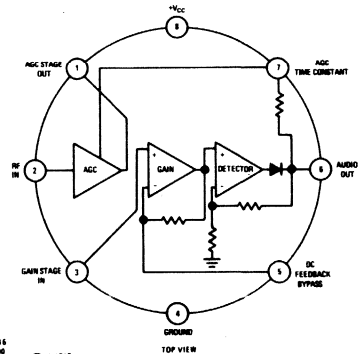
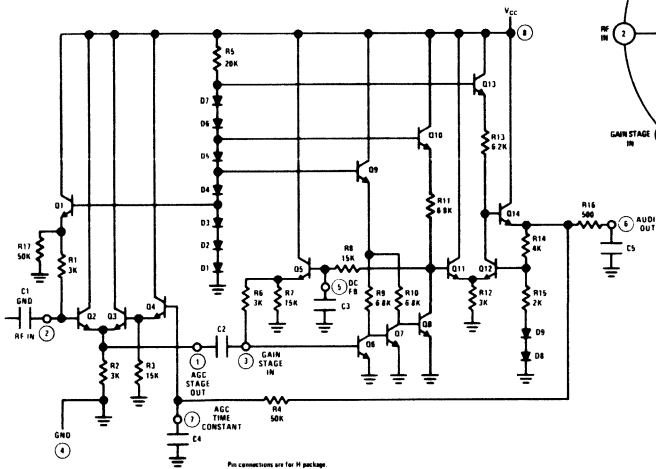
The LM172/LM272/LM372 is a broadband AM receiver subsystem, including a high gain amplifier, an active detector, and self-contained automatic gain control. It is intended for IF or TRF applications from 50 kHz to 2 MHz. Bandpass shaping is performed by a single, external filter, which may be ceramic, crystal, mechanical, or LC, having single or multiple poles. The IF strip features:

- AGC Range: 60 dB
- Audio Output of 0.8V p-p for 80% modulated inputs, at carrier levels as low as 50 μ V rms.
- Total dissipation only 8.4 mW from +6V supply, usable with supply up to +15V.

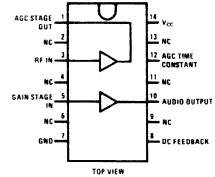
- AGC time constant and audio frequency response selected by choice of external capacitors.
- Internal supply regulators eliminate individual stage decoupling.
- AGC voltage available to drive receiver "front end."

The LM172 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LM272 is specified for operation over the -25°C to $+75^{\circ}\text{C}$ temperature range. The LM372 is specified for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

schematic and connection diagrams

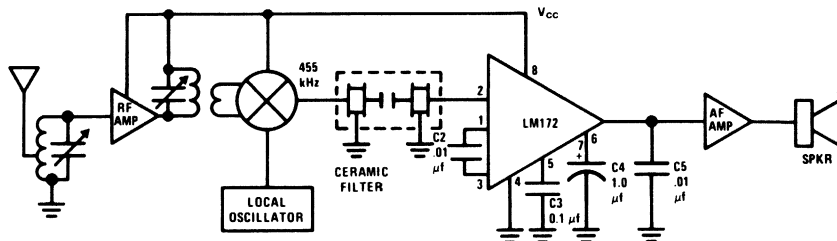


Order Number LM172H
or LM272H or LM372H
See Package 11



Order Number LM272N or LM372N
See Package 22

typical application



5

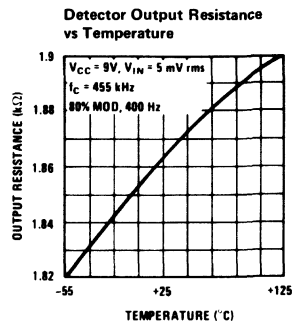
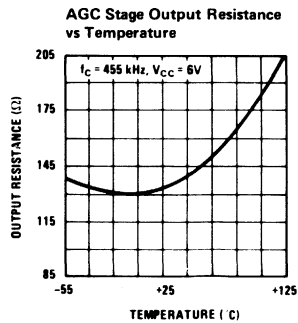
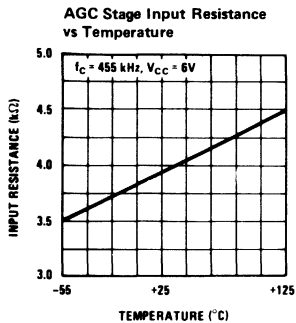
absolute maxium ratings

Supply Voltage Range	+6V to +15V
Storage Temperature	-65°C to +150°C
Operating Temperature	-55°C to +125°C
	-25°C to +75°C
	0°C to +70°C
RF Input Level, Pin 2	500 mV rms

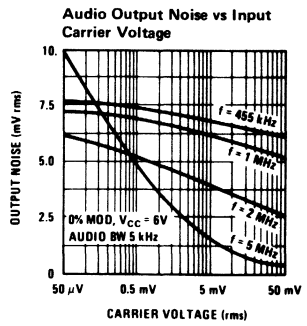
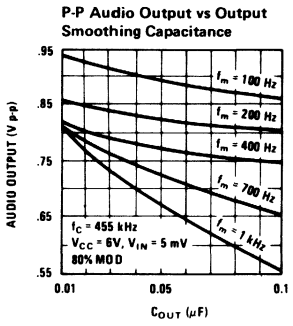
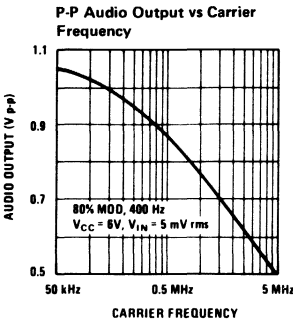
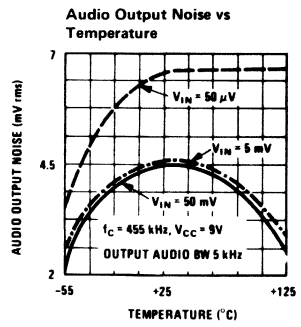
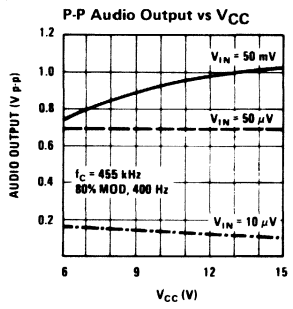
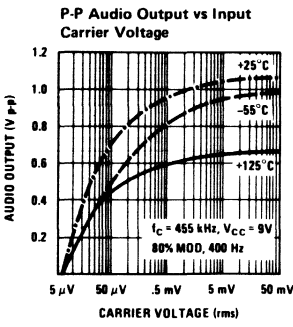
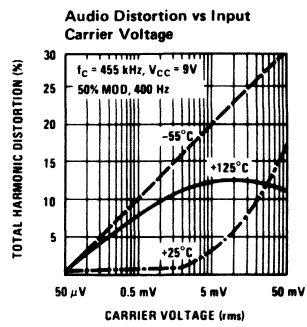
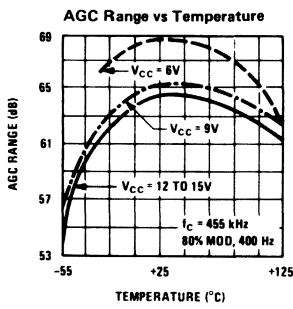
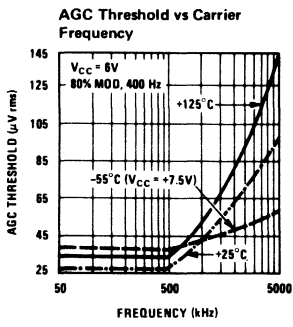
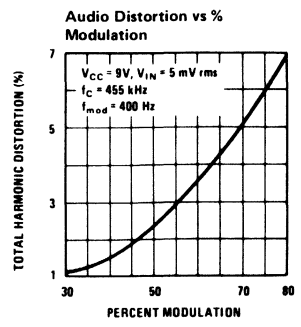
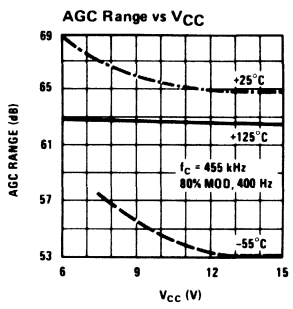
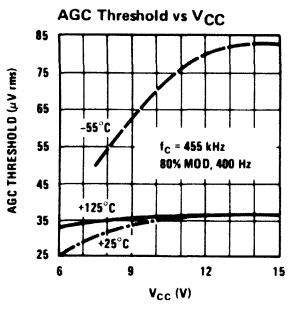
electrical characteristics (T_A = 25°C)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Power Supply Drain	I _{ps}	V _{CC} = 6V, Input = 50 mV f = 455 kHz		1.4		mA
		V _{CC} = 6V, Input = 50 μV f = 455 kHz		1.7		mA
		V _{CC} = 15V, Input = 50 mV f = 455 kHz		2.5	2.65	mA
		LM172/272		2.5	3.2	mA
		LM372				
AGC Range	AGCR	V _{CC} = 6V, f = 455 kHz LM172/272 LM372	50	69		dB
			47	69		dB
AGC Threshold	V _{IN(th)}	V _{CC} = 6V, f = 455 kHz		50		μV, rms
Maximum Usable Frequency	MUF	V _{CC} = 6V		2.0		MHz
Audio Output Voltage	V _{OUT}	V _{IN} Between 50 μV and 50 mV, 455 kHz, 80% modulated by 100 Hz, V _{CC} = 6V LM172/272 LM372	0.4	0.8		V, p-p
			0.35	0.8		V, p-p
			0.45	0.9		V, p-p
			0.40	0.9		V, p-p

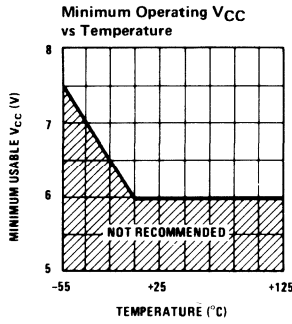
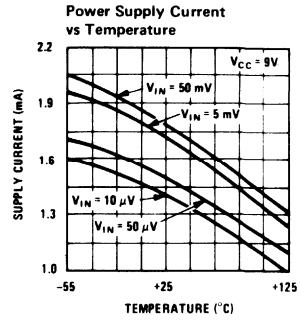
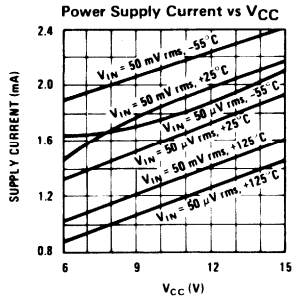
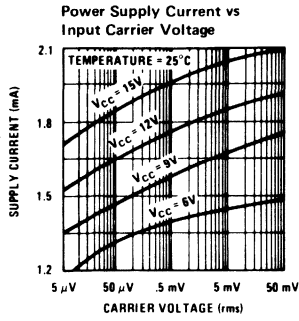
input-output impedance characteristics



typical characteristics



power supply characteristics





Consumer Circuits

LM273/LM373, LM274/LM374

LM273/LM373 am/fm/ssb if amp/detector

LM274/LM374 am/fm/ssb if video amp/detector

general description

The LM273/LM373 and LM274/LM374 are broad-band communications subsystems, capable of performing the diverse functions required in AM, FM or single sideband receivers and transmitters. In addition, the LM274/LM374 may operate as high gain AGC'd video amplifier. Bandpass shaping may be performed by a single external filter, connected between amplifier sections, at frequencies from audio up to 30 MHz. The first section of the LM273/LM373 is optimized to drive low impedance loads, such as mechanical or ceramic filters. The LM274/LM374 has a high output impedance, ideal for high-Z crystal, LC or ceramic filters.

The LM273 and LM274 are specified for operation over the -25°C to $+100^{\circ}\text{C}$ military temperature range. The LM373 and LM374 are specified for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

features

CONNECTED FOR AM OPERATION

- High gain; typical sensitivity of $10\ \mu\text{V}$ at 455 kHz
- Wide bandwidth; 30 MHz capability
- Self-contained detector and AGC system
- Wide AGC range, greater than 60 dB for a 10 dB output change at 27 MHz
- Less than ± 1 dB change in audio output -20°C to $+100^{\circ}\text{C}$, typically
- Access to detector input for S/N improvement
- No DC paths required through external filters

- Low feedthrough between amplifier sections, typically better than 65 dB

CONNECTED FOR FM OPERATION

- Three emitter coupled limiting stages and simple quadrature detector
- Detection of ± 5 kHz deviation FM at either 455 kHz or 10.7 MHz
- Two separated amplifier blocks, allowing filtering in two or more blocks
- No DC paths required through external filters or through quadrature network

CONNECTED FOR SSB OPERATION

- Double balanced product detector
- Self contained audio peak AGC system
- Easy external tailoring of AGC characteristic for desired AGC figure of merit

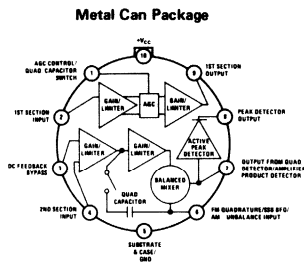
CONNECTED FOR VIDEO AMPLIFIER OPERATION

- Internal video peak detector for video AGC
- High and low level video outputs
- Gated video AGC capability

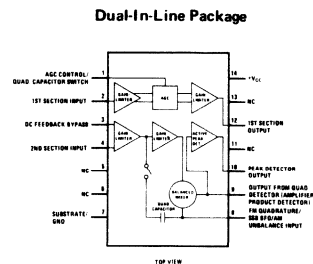
In addition, these versatile microcircuits may be used as:

- Constant amplitude or amplitude modulated RF oscillator
- Synchronous demodulating IF strip
- Mixer and IF, using AGC section as a mixer
- Double sideband modulator with audio AGC

connection diagrams



TOP VIEW
Order Number LM273H or LM373H
LM274H or LM374H
See Package 14



TOP VIEW
Order Number LM373N or LM374N
See Package 22

5

absolute maximum ratings

Supply Voltage, Operating	18V	DC Voltage Applied to Any Other Pin	+8V, -0.5V
Supply Voltage, Surge (100 ms max)	24V	Junction Temperature (Note 1)	150°C
AC Voltage Applied to Any Pin	1.4V _{p-p}	Storage Temperature Range	-65°C to +150°C
DC Voltage Applied to AGC Section Output Pin	+10V, -0.5V	Operating Temperature Range	-25°C to +100°C
LM273/LM373	+18V, -0.5V	LM273, LM274	0°C to +70°C
LM274/LM374		LM373, LM374	

electrical characteristics

(T_A = 25°C, V_{CC} = +12V unless otherwise noted) (Subscript numbers in parentheses are DIP pin numbers)

DC CHARACTERISTICS

PARAMETER	SYMBOL	CONDITIONS	LM273/LM274			LM373/LM374			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Power Supply Current	I ₁₀₍₁₄₎	V _{CC} = 12V, AM Mode -20°C ≤ T _A ≤ +100°C		14	20		14	20	mA
AGC Input Current	I ₁	V _{AGC} ≤ 5V -20°C ≤ T _A ≤ +100°C		50	110		50	110	μA
AGC Section Quiescent Output	V ₉₍₁₂₎	V _{AGC} = 0V, LM273/LM373		4.75			4.75		V
	I ₉₍₁₂₎	V _{AGC} = 0V, LM274/LM374	0.5	0.7	1.0	0.5	0.7	1.0	mA
AGC Section Output Shift	ΔV ₉₍₁₂₎	V _{AGC} = 0V to V _{AGC} = 5V LM273/LM373		0.1			0.1		V
	ΔI ₉₍₁₂₎	LM274/LM374		-0.1			-0.1		mA
Second Section Quiescent Output Voltage	V ₇₍₉₎			3.8			3.8		V
Peak Detector Quiescent Output Voltage	V ₈₍₁₀₎			3.8			3.8		V

VIDEO CHARACTERISTICS

AGC Section Voltage Gain	A ₂₋₉₍₁₁₎	V _{AGC} = 0V, f = 455 kHz V _{AGC} = 4.5V -20°C ≤ T _A ≤ 100°C LM273/LM373	30	32	-40	29	32	-40	dB
			28						dB
AGC Section Transconductance	g _{m2-9(11)}	V _{AGC} = 0V, f = 455 kHz -20°C ≤ T _A ≤ 100°C LM274/LM374	28	40		28	40		mmhos
			28						mmhos
AGC Section Bandwidth	BW _{AGC}	Z _L = 1k || 3 pF		30			30		MHz
AGC Section Output Swing	V _{9(12) max p-p}	R _L = 1k, V _{AGC} = 0V, V ₂ = ±300 mV, -20°C ≤ T _A ≤ 100°C	0.95	1.4		0.78	1.4		V _{p-p}
			0.7						V _{p-p}
AGC Section Conversion Voltage Gain	A _{C, AGC}	f ₁ = 30 MHz, f ₂ = 30.455 MHz, e ₂ = 800mVrms (See Figure 8)		22			22		dB
Second Section Voltage Gain	A ₄₋₇₍₁₁₎	f = 455 kHz T _A = 100°C	32.5	37	39	29.5	37		dB
				31					
Second Section Bandwidth	BW ₂	Z _L = 100k || 3 pF		20			20		MHz
Second Section Output Swing	V _{7(11) max p-p}	V ₃₋₄ = ±100 mV _{p-p} -20°C ≤ T _A ≤ 100°C	0.93	1.4		.83	1.4		V _{p-p}
			0.75						V _{p-p}

AC PORT PARAMETERS (Typical, e_{IN} = 20 mVrms)

TERMINAL	LM273/LM373			LM274/LM374		
	f = 455 kHz	f = 10.7 MHz	f = 27 MHz	f = 455 kHz	f = 10.7 MHz	f = 27 MHz
2 (V _{AGC} = 0V)	1.2k || 2.5 pF	1.2k || 2.5 pF	1.15k || 2.6 pF	1.2k || 2.5 pF	1.2k || 2.5 pF	1.15k || 2.6 pF
2 (V _{AGC} = 5V)	1.18k || 3 pF	1.18k || 3 pF	1.1k || 2.7 pF	1.18k || 3 pF	1.18k || 3 pF	1.1k || 2.7 pF
4	4.5k || 4 pF	5k || 5 pF	4.3k || 5.5 pF	4.5k || 4 pF	5k || 5 pF	4.3k || 5.5 pF
6(8)	3.0k || 7.7 pF	3.0k || 7.7 pF	3.0k || 8.0 pF	3.0k || 7.7 pF	3.0k || 7.7 pF	3.0k || 8.0 pF
7(9)	1.0k || 6 pF	1.0k || 6 pF	1.0k || 5 pF	1.0k || 6 pF	1.0k || 6 pF	1.0k || 5 pF
9(12)	70Ω || -100 pF	60Ω || 5 pF	200Ω || -90 pF	600k || 5.5 pF	100k || 3.3 pF	10k || 3.5 pF

Note 1: For operation at elevated temperatures, derate devices based on 150°C maximum junction temperature and 150°C/W junction to ambient or 45°C/W junction to case thermal coefficients for the metal can.

electrical characteristics (con't)

TYPICAL AM PERFORMANCE (See Figures 1 and 2)

PARAMETER	CONDITIONS	f = 455 kHz	f = 10.7 MHz	f = 27 MHz	UNITS
Sensitivity	(Signal + Noise)/Noise = 10 dB	10	15	30	μ Vrms
AGC Threshold	Output 3 dB below extrapolated low level gain curve value for same input	35	55	110	μ Vrms
AGC Figure of Merit	Number (dB) input change from 100 mVrms for 10 dB output change	68	63	60	dB
Gain Control Range	$V_i = 0$ to $V_i = +5V$	80	70	66	dB
Audio Output	$R_{AGC} = 2.4k$, $V_{IN} = 100$ mVrms $f_m = 1$ kHz, $m = 0.7$	100	100	100	mVrms
	As above, $T_A = 100^\circ C$ LM273 and LM274 only	90	90	90	mVrms
Signal to Noise Ratio	$M = 0.7$ to $M = 0$ $e_{IN} = 30$ mVrms	42	38	40	dB
Audio Distortion	$M = 0.7$, $f_m = 1$ kHz, $e_{IN} = 10$ mV	5	3.5	2.8	%

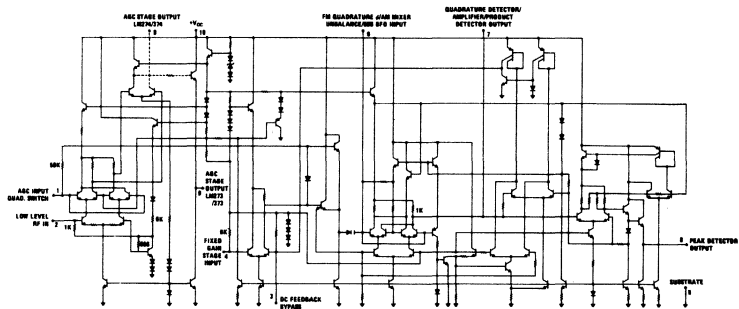
TYPICAL FM PERFORMANCE (See Figures 3 and 4)

Limiting Threshold	$e_O = 3$ dB from value at $e_{IN} = 100$ mVrms				μ Vrms
	$\Delta f = \pm 75$ kHz		800	—	μ Vrms
	$\Delta f = \pm 5$ kHz	800	800	—	μ Vrms
AM Rejection Ratio	$M_{fm} = 1$, $M_{am} = 0.3$ $e_{IN} = 10$ mVrms				dB
	$\Delta f = \pm 75$ kHz		45	—	dB
	$\Delta f = \pm 5$ kHz	35	—	—	dB
Audio Output	$e_{IN} = 10$ mVrms				mVrms
	$\Delta f = \pm 75$ kHz		80	—	mVrms
	$\Delta f = \pm 5$ kHz	70	38	—	mVrms
	@ $T_A = 100^\circ C$, $\Delta f = \pm 75$ kHz		50	—	mVrms
	@ $T_A = 100^\circ C$, $\Delta f = \pm 5$ kHz LM273 and LM274 only	40	19	—	mVrms
Audio Distortion	$e_{IN} = 10$ mVrms				%
	$\Delta f = \pm 75$ kHz		1.5	—	%
	$\Delta f = \pm 5$ kHz	2	1.0	—	%

TYPICAL SSB PERFORMANCE (See Figures 5 and 6)

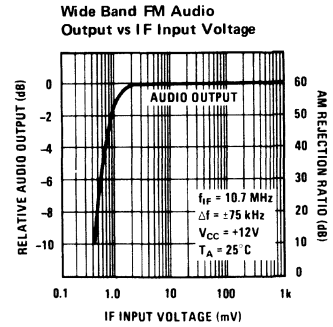
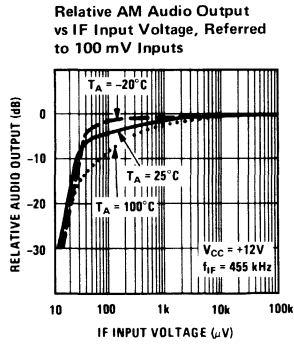
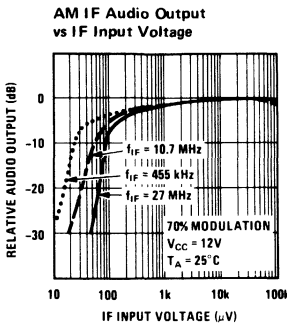
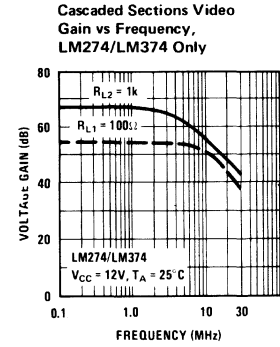
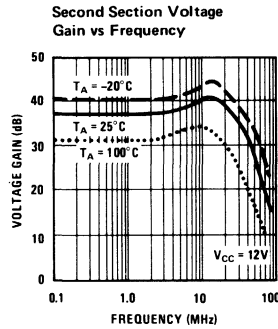
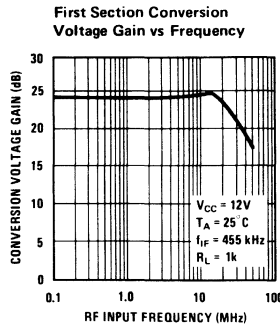
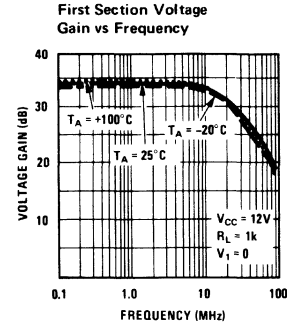
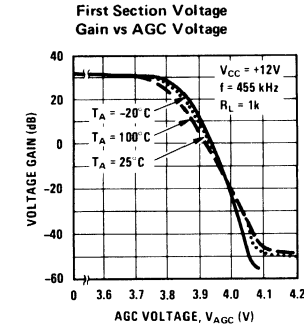
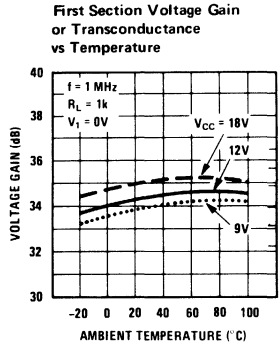
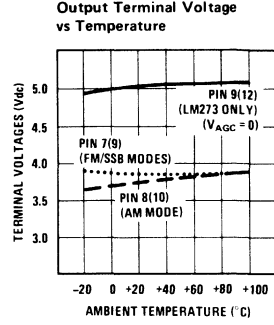
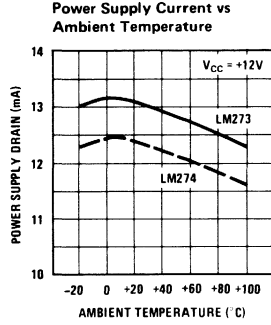
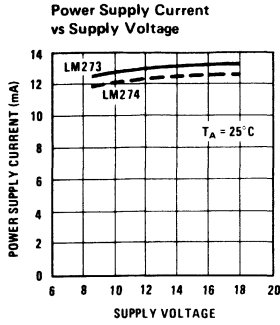
Sensitivity	(Signal + Noise)/Noise = 10 dB $e_{LO} = 60$ mVrms	25	30	60	μ Vrms
AGC Threshold	Same as AM	300	300	500	μ Vrms
AGC Figure of Merit	Same as for AM	60	60	50	dB
Audio Output Voltage	$e_{IN} = 100$ mVrms $T_A = 100^\circ C$	60	80	85	mVrms
	LM273 and LM274 only	40	55	60	mVrms

schematic diagram



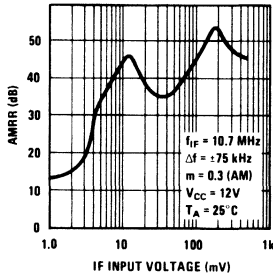
Pin connections shown are for TO-6 package only.

typical performance characteristics

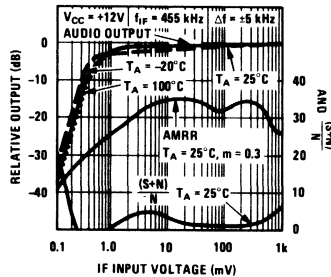


typical performance characteristics (con't)

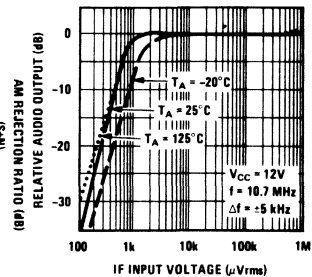
AM Rejection Ratio vs IF Input Voltage for Wide Band FM



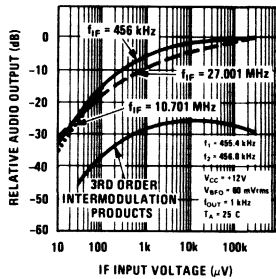
455 kHz NFM IF Audio Output, AM Rejection Ratio, and Signal to Noise vs IF Input Voltage



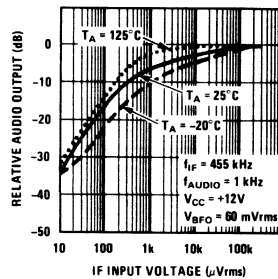
10.7 MHz NFM IF Audio Output vs IF Input Voltage



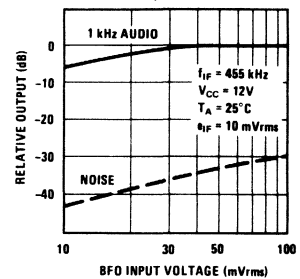
SSB IF Audio Output and Intermodulation Products vs IF Input Level



SSB IF Audio Output vs IF Input Voltage



SSB IF Audio Output vs BFO Voltage



APPLICATION HINTS

The LM273/LM373 and LM274/LM374 devices have been designed for stability and minimum usage of external components, while at the same time offering wide versatility through access to inputs and outputs of nearly every major functional block of the device. This makes possible the detection of AM, FM, and SSB signals with a single device with a minimum of circuitry switching. Experience has shown that for optimum performance of the multiple mode IF strip, the following suggestions should be noted.

First, as with any radio frequency gain device, proper layout and minimum lead length should be observed. The first gain block, Pin 2 to Pin 9, shows a typical gain of 32 dB and the second gain block, Pin 4 to Pin 7, shows a typical gain of 37 dB so it is clear why any stray coupling or long leads should be kept clear from any of the gain input pins. Despite its high gain, however, the device does not require any shielding between stages. Construction on a copperclad printed circuit type board is more than adequate. It should also be observed that good power supply bypassing directly at Pin 10 and DC feedback bypassing at Pin 3 is always necessary.

The devices can be wide-band coupled to provide video gain response up to approximately 50 MHz. For AM operation, however, it is much more desirable to limit the IF bandwidths. This will greatly increase both input sensitivity and AGC figure of merit by preventing the device from AGCing on wideband detected noise. There are two ways of accomplishing this. One is to insert filtering from the first gain block to the second, Pin 9 to Pin 4, but the most effective way is to AC couple an L-C tank from the input of the active peak detector to ground. A lossy filter from Pin 9 to Pin 4 should be avoided as this will greatly reduce the audio output and AGC figure merit. In addition the tank on Pin 7 should have high enough Q to limit noise yet low enough to pass the full IF signal. It should also have a high enough impedance (>5k) to avoid affecting the gain of that stage. Proper audio output is attained by a small capacitor at Pin 8 to peak detect the RF envelope, followed by a series RC roll off to shape the audio response. Here again excessive loading will reduce available output. There is a trade off available between audio level out and AGC range so the feedback resistor from Pin 8 to the AGC feedback, Pin 1, should be adjusted to give the desired results. Pin 1 must

be filtered well with approximately 15 μF capacitor or larger to prevent any AC variation from causing erratic AGC action.

For proper FM operation, the input level needs to be larger, on the order of 1 mV to give full limiting which is necessary for good AM rejection. Here again low loss coupling from Pin 9 to Pin 4 is desired. The phase shift network on Pin 6 should be shielded to prevent any extraneous RF pickup or radiation. Also the Q of the network should be adjusted to give the proper bandwidth for the type of signal to be detected, whether wideband or narrowband FM. Obviously, it should be tuned to the same center frequency as the IF input and the Pin 9 to Pin 4 filtering so that detection takes

place symmetrically around the resonant frequency of the tank. Since the audio output for FM is at Pin 7, it should be RF bypassed along with audio rolloff and de-emphasis.

For SSB operation, the devices operate almost the same as in the AM mode, with the exception that the product detector which was unbalanced and used as a simple gain stage for AM is now balanced and used for detection. The local oscillator signal is fed into Pin 6 at an optimum level around 60 mVrms. For better AGC, a capacitor may be added to Pin 8 in addition to the one already at Pin 1 to provide even more filtering for AGC feedback voltage. The output level and AGC figure of merit is still adjusted by the feedback resistors from Pin 8 to Pin 1.

typical applications

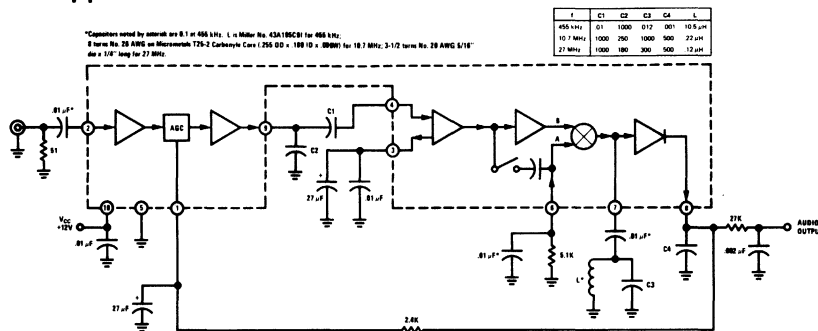


FIGURE 1. LM273/LM373 AM IF Connection

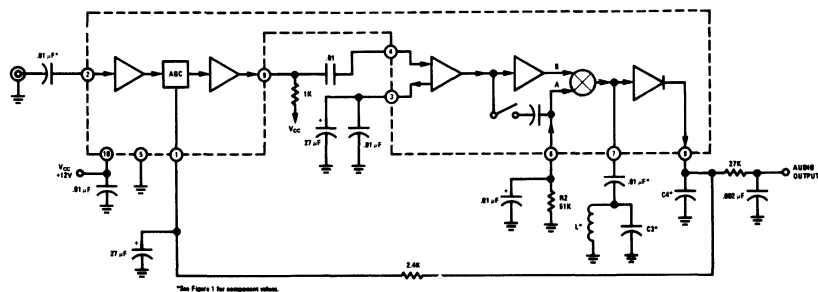


FIGURE 2. LM274/LM374 AM IF Connection

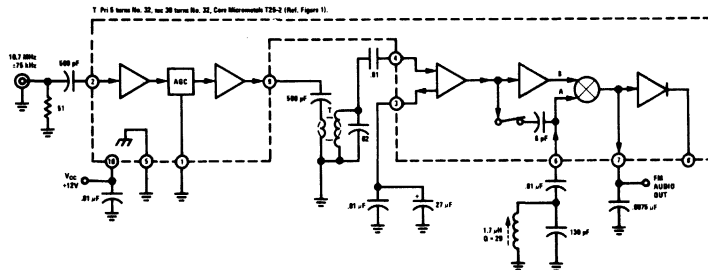


FIGURE 3. LM273/LM373 Wide Band FM IF Connection

typical applications (con't)

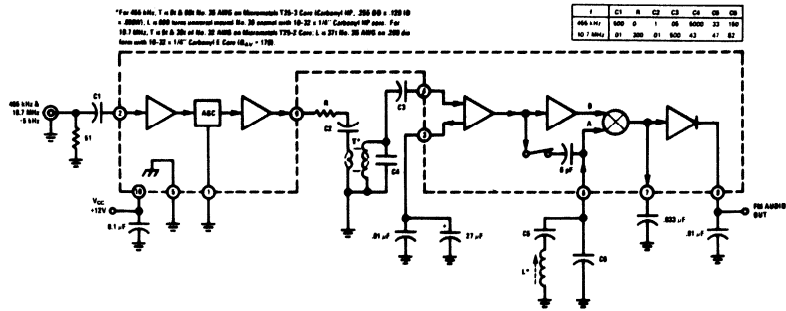


FIGURE 4. LM273/LM373 Narrow Band FM IF Connection

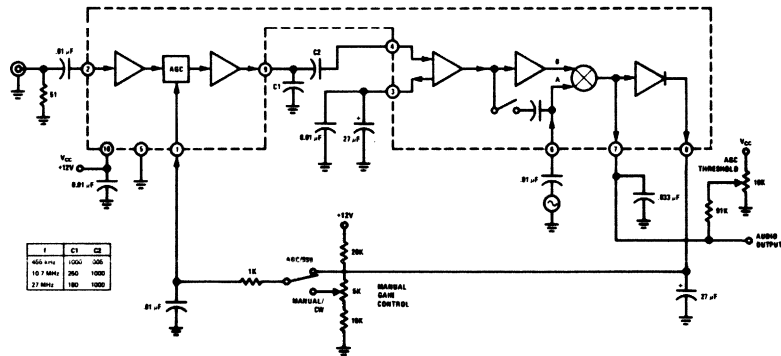


FIGURE 5. LM273/LM373 SSB & CW IF Connection

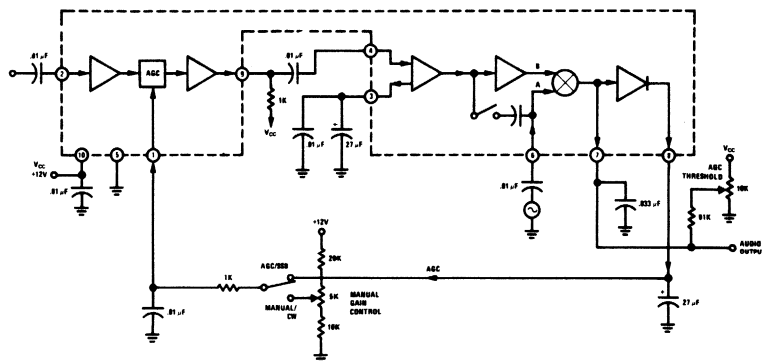


FIGURE 6. LM274/LM374 SSB & CW IF Connection

typical applications (con't)

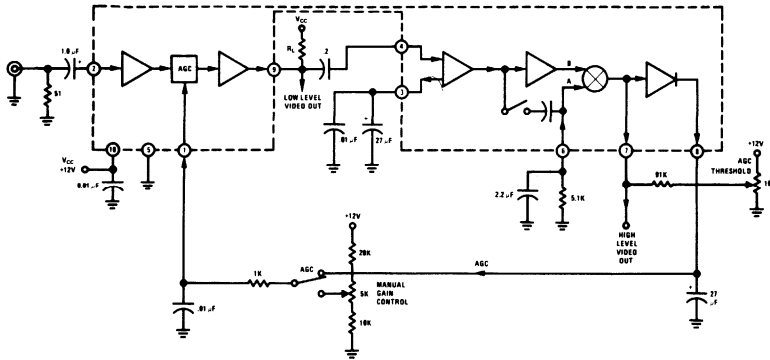


FIGURE 7. LM274/LM374 Video Amplifier Configuration

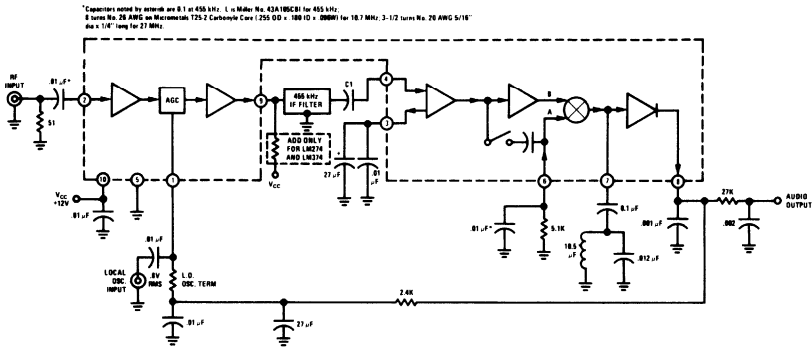


FIGURE 8. LM274/LM374, LM273/LM373 First Stage Converter Operation for AM Signal Detection @ 455 kHz



Consumer Circuits

LM175/LM275/LM375 oscillator and buffer with TTL output

general description

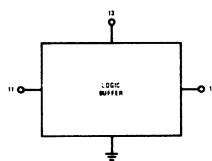
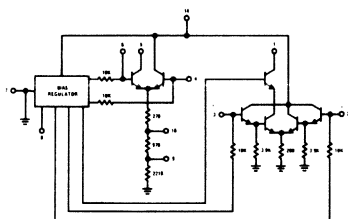
The LM175/LM275/LM375 is a monolithic, differential pair, general purpose oscillator. It may be used with crystal control or with LC or RC tanks. Two output configurations are possible. It may be connected to the internal isolating buffer to provide sine or square wave outputs, or to the internal logic buffer with output levels and switching times compatible with TTL and DTL logic circuitry. It provides extremely high temperature and power supply versus frequency rejection.

The LM175 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LM275 is specified for operation over the -25°C to $+85^{\circ}\text{C}$ temperature range. The LM375 is specified for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

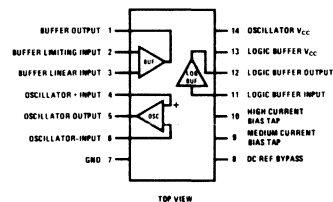
features

- Oscillation up to 200 MHz
- Operation from supplies from 4.5V to 24V (Logic buffer maximum supply at 7.0V)
- High supply voltage rejection, typically 0.1 ppm/V
- Low temperature coefficient, typically $0.05 \text{ ppm}/^{\circ}\text{C}$
- Variable drive to crystal to limit dissipation
- Capable of fundamental or overtone, series or parallel mode of operation
- Separate power supply lead for logic buffer for noise isolation
- Low power dissipation

schematic and connection diagrams



Dual-In-Line Package



Order Number LM175D
or LM275D or LM375D
See Package 1

Order Number LM375N
See Package 22

typical applications

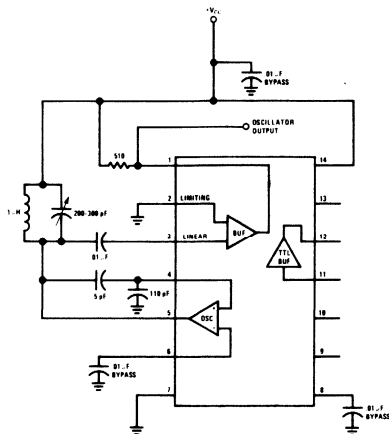


FIGURE 1. 10 MHz L-C Sine Wave Oscillator

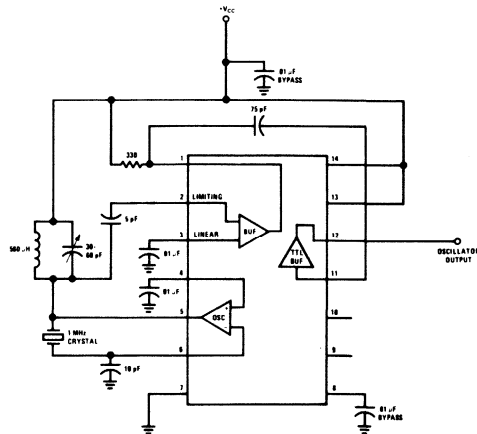


FIGURE 2. 1 MHz Crystal Oscillator with TTL Output

absolute maximum ratings

Supply Operating Voltage (Pin 14)	24V	Storage Temperature Range	-65°C to +150°C
Supply Operating Voltage (Pin 13)	7V	Operating Temperature Range LM175	-55°C to +125°C
Differential Input Voltage ΔV P ₄ to Pin 6	5V	LM275	-25°C to +85°C
ΔV P ₂ to Pin 3	5V	LM375	0°C to 70°C
Power Dissipation (Note 1)	500 mW	Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C, V_{CC} = 5V unless otherwise noted)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC CHARACTERISTICS						
Power Supply Current (Pin 14)	I _{PS14}	V _{CC} = 24V	4.0	6.0	12.0	mA
Power Supply Current (Pin 13)	I _{PS13}	No Load at Pin 12	4.0	6.0	14.0	mA
Oscillator Output Current	I _{OSC}	R _L (Pin 5) = 1 k Ω Pin 9 Open, Pin 10 Open	120	140		μ A _{p-p}
		Pin 9 Tied to Pin 10	160	190		μ A _{p-p}
		Pin 9 Grounded, Pin 10 Open	300	360		μ A _{p-p}
		Pin 10 Grounded, Pin 9 Open	750	1000		μ A _{p-p}
Buffer Output Current	I _{BUF}		2.5	3.0		mA _{p-p}
Logic Buffer Output Voltage	V _{TTL}	Input LOW Input HIGH I _{SINK} = 1.6 mA	2.1	2.7		
				200	400	mV

The Following Specifications apply to -55°C < T_A < +125°C

Oscillator Output Current	I _{OSC}	R _L (Pin 5) = 1 k Ω Pin 9 Open, Pin 10 Open	100			μ A _{p-p}
		Pin 9 Tied to Pin 10	130			μ A _{p-p}
		Pin 9 Grounded, Pin 10 Open	250			μ A _{p-p}
		Pin 10 Grounded, Pin 9 Open	600			μ A _{p-p}
Buffer Output Current	I _{BUF}		2.0			mA _{p-p}

AC CHARACTERISTICS

Oscillator Gain (at 1 kHz)	g _{mOSC}	Pin 9 Open, Pin 10 Open		1.4		mmhos
		Pin 9 Tied to Pin 10		1.9		mmhos
		Pin 9 Grounded, Pin 10 Open		3.6		mmhos
		Pin 9 Open, Pin 10 Grounded		10.0		mmhos
Oscillator 3 dB Bandwidth	BW _{OSC}	R _S = R _L (Pin 5) = 50 Ω		200		MHz
Buffer Gain (at 1 kHz)	g _{mBUF}	R _L (Pin 1) = 500 Ω Linear Mode		8		mmhos
		Limiting Mode		30		mmhos
Buffer 3 dB Bandwidth	BW _{BUF}	R _S = R _L (Pin 1) = 50 Ω Linear Mode		200		MHz
		Limiting Mode		80		MHz
Logic Buffer Rise Time				20	50	ns
Logic Buffer Fall Time				20	50	ns

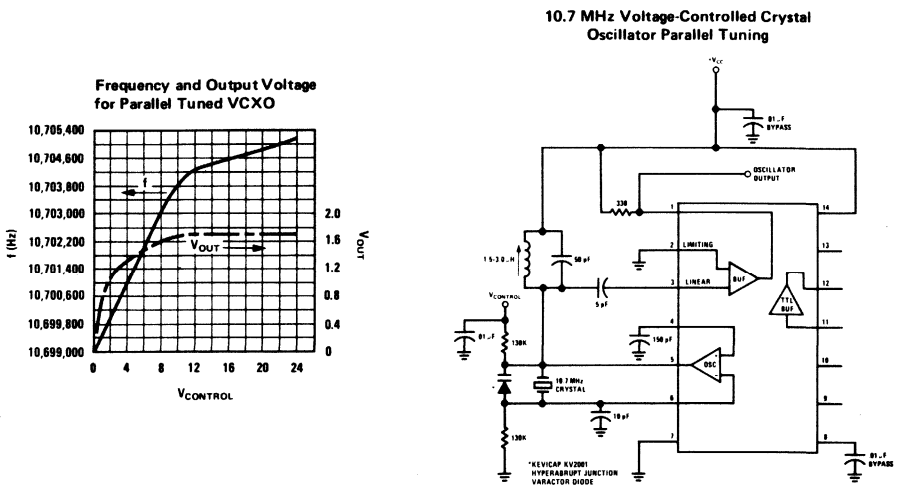
Note 1: For operation at elevated temperatures, the device must be operated based on a 150°C maximum junction temperature with a thermal resistance of 140°C/W for the metal DIP package and 100°C maximum junction temperature with a thermal resistance of 150°C/W for the plastic DIP package.

electrical characteristics (con't)

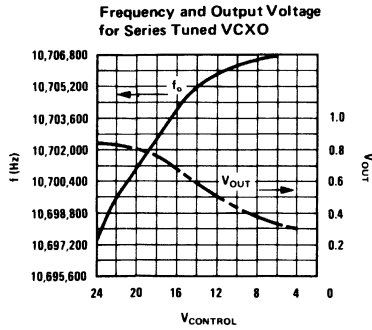
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
OSCILLATOR CHARACTERISTICS (See Oscillator Circuit)						
Frequency vs Power Supply Rejection		$5V < V_{CC} < 10V$		0.1		ppm/V
Frequency vs Temperature Rejection		$-55^{\circ}C < T_A < +125^{\circ}C$		0.05		ppm/ $^{\circ}C$
Load Pull (Change in Frequency vs Change in Buffer Load Impedance)		$0 \leq R_{L\text{ BUF}} < \infty$		0.01		ppm
INPUT-OUTPUT TERMINAL CHARACTERISTICS						
Oscillator Input Resistance	R_4	Minimum Current		10		k Ω
		Maximum Current		4.5		k Ω
Oscillator Input Capacitance	R_6	Minimum Current		10		k Ω
		Maximum Current		4.5		k Ω
Oscillator Output Resistance	C_4			3		pF
	C_6			3		pF
Oscillator Output Resistance	R_5	Minimum Current		100		k Ω
		Maximum Current		30		k Ω
Oscillator Output Capacitance	C_5			3		pF
Buffer Input Resistance	R_2			10		k Ω
	R_3			10		k Ω
Buffer Input Capacitance	C_2			2		pF
	C_3			2		pF
Buffer Output Resistance	R_1			100		k Ω
Buffer Output Capacitance	C_1			5		pF
Logic Buffer Input Resistance	R_{11}			1.2		k Ω
Logic Buffer Input Capacitance	C_{11}			4		pF

typical oscillator circuit connections

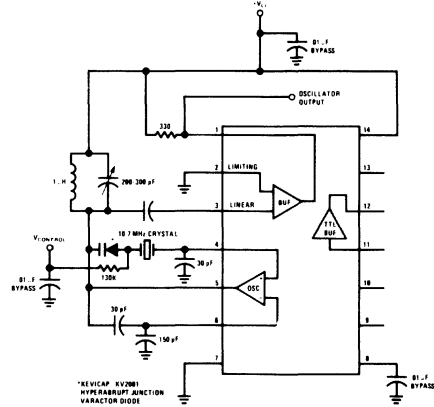
5



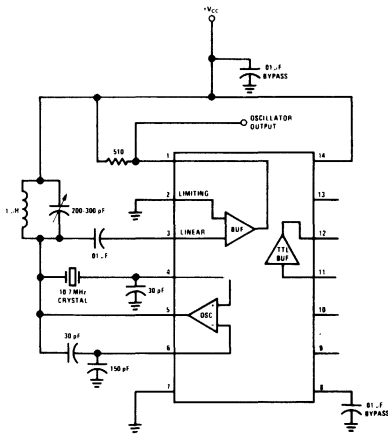
typical oscillator circuit connections (con't)



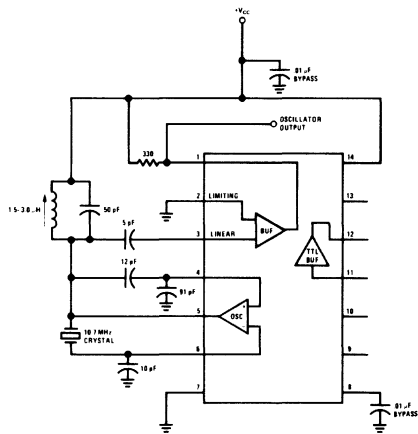
10.7 MHz Voltage Controlled Crystal Oscillator Series Tuning



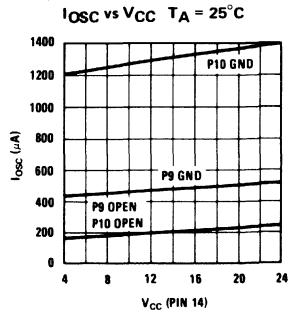
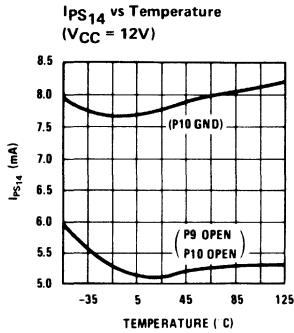
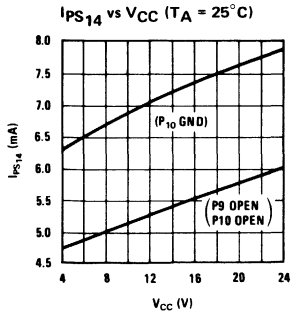
10.7 MHz Series Resonant Crystal Oscillator



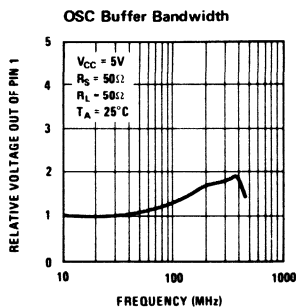
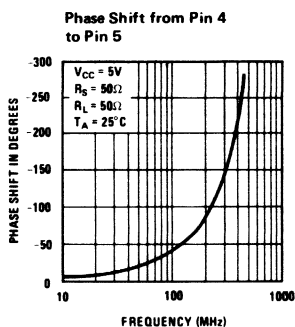
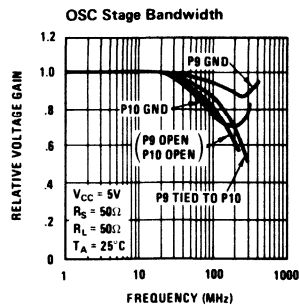
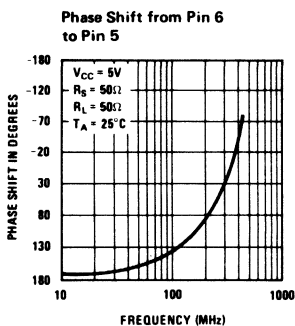
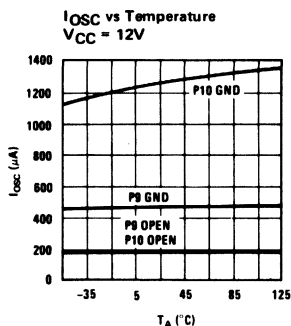
10.7 MHz Parallel Resonant Crystal Oscillator



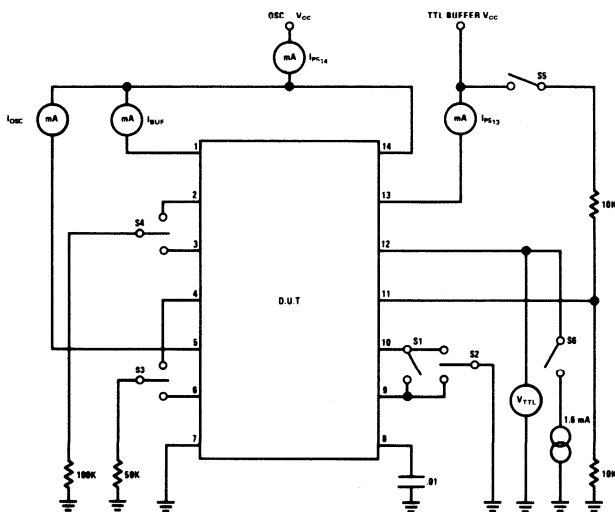
typical performance characteristics



typical performance characteristics (con't)



dc test circuit



- S1, S2 Used to select desired oscillator current
- S3 Used to swing oscillator output and measure I_{OSC}
- S4 Used to swing buffer output and measure I_{BUF}
- S5 Used to switch TTL buffer to high and low states
- S6 Switches in maximum guaranteed TTL load to measure V_{TTL} in the low state

absolute maximum ratings

Supply Voltage	26V
Input Voltage	0V to $V_{S\text{SUPPLY}}$
Operating Temperature	0°C to +70°C
Storage Temperature	-65°C to +150°C
Junction Temperature	150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics

$V_S = 20V$, $T_{\text{TAB}} = 25^\circ\text{C}$, $R_L = 8\Omega$, $A_V = 50$ (34 dB), unless otherwise specified.

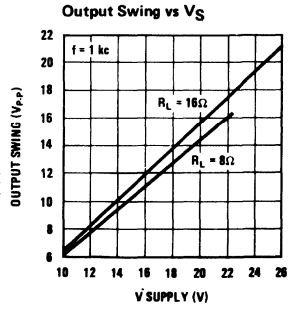
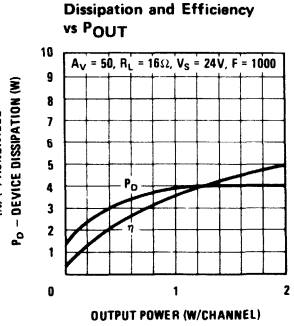
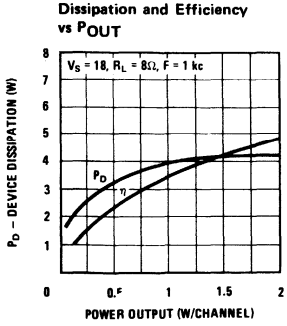
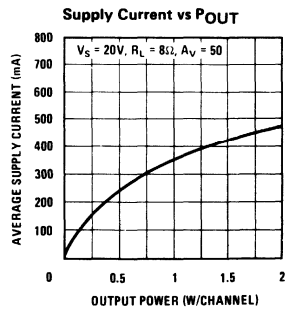
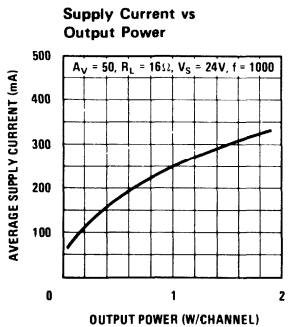
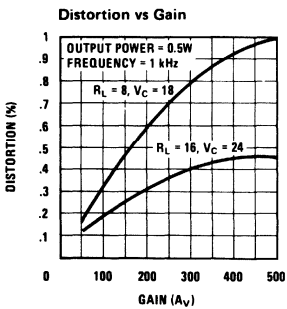
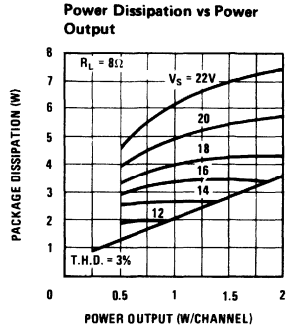
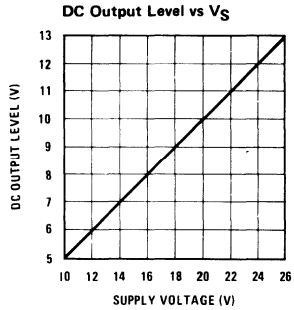
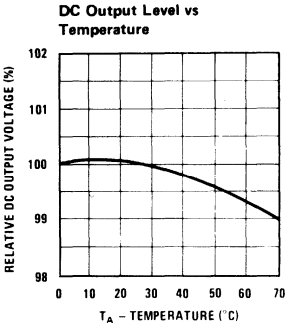
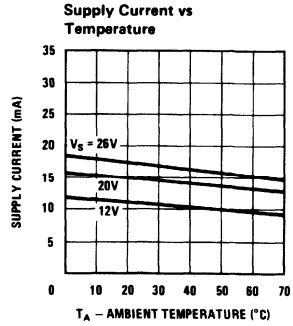
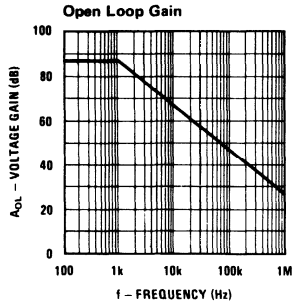
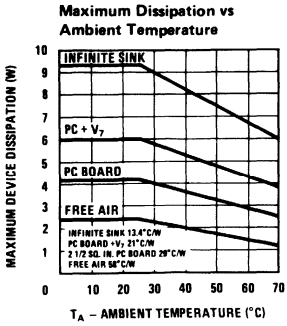
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Total Supply Current	$P_{\text{OUT}} = 0W$		15	50	mA
	$P_{\text{OUT}} = 1.5W/\text{Channel}$		430	500	mA
DC Output Level			10		V
Supply Voltage		10		26	V
Output Power	T.H.D. = < 5%	2	2.5		W
T.H.D.	$P_{\text{OUT}} = 0.05W/\text{Channel}$, $f = 1\text{ kHz}$		0.25		%
	$P_{\text{OUT}} = 1W/\text{Channel}$, $f = 1\text{ kHz}$		0.07	1	%
	$P_{\text{OUT}} = 2W/\text{Channel}$, $f = 1\text{ kHz}$		0.10		%
Offset Voltage			3		mV
Input Bias Current			500		nA
Input Impedance		3			M Ω
Open Loop Gain	$R_S = 0\Omega$	66	90		dB
Output Swing			$V_S - 6$		V_{P-P}
Channel Separation	$C_F = 250\mu\text{F}$, $f = 1\text{ kHz}$	50	70		dB
Ripple Rejection	$f = 120\text{ Hz}$, $C_F = 250\mu\text{F}$	60	80		dB
Current Limit			1.5		A
Slew Rate			1.4		V/ μs
Equivalent Input Noise Voltage	$R_S = 600\Omega$, 100 Hz – 10 kHz		3		μVrms

Note 1: For operation at ambient temperatures greater than 25°C the LM377 must be derated based on a maximum 150°C junction temperature using a thermal resistance which depends upon device mounting techniques.

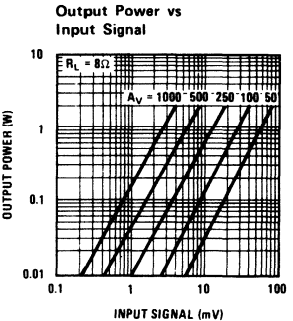
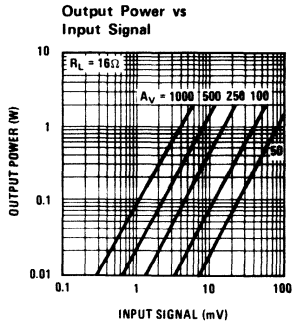
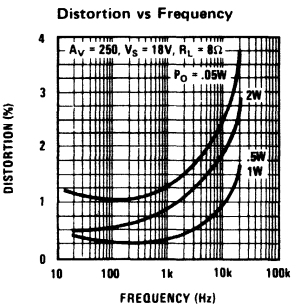
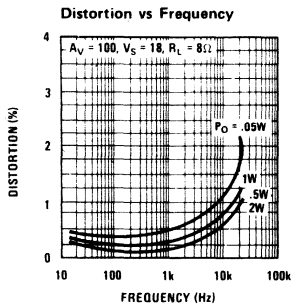
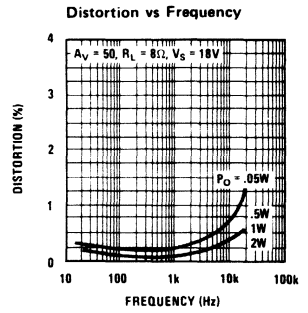
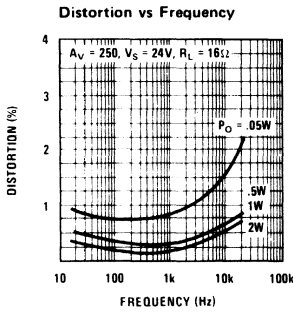
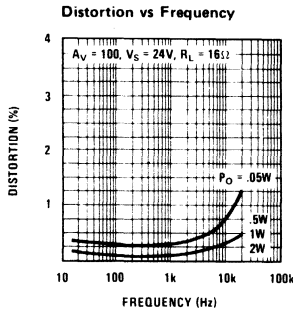
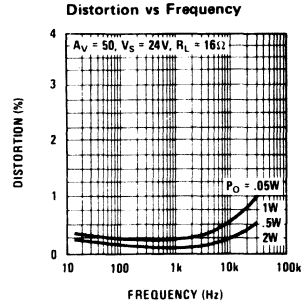
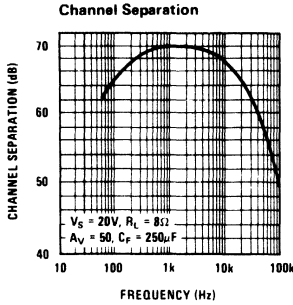
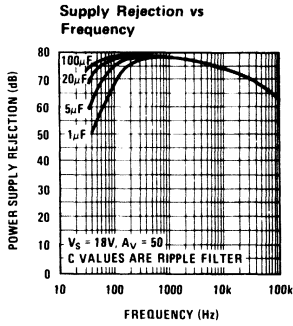
Note 2: Dissipation characteristics are shown for four mounting configurations.

- Infinite sink – 13.4°C/W
- P.C. board + V_7 sink – 21°C/W. P.C. board is 2 1/2 square inches. Staver V_7 sink is 0.02 inch thick cooper and has a radiating surface area of 10 square inches.
- P.C. board only – 29°C/W. Device soldered to 2 1/2 square inch P.C. board.
- Free air – 58°C/W.

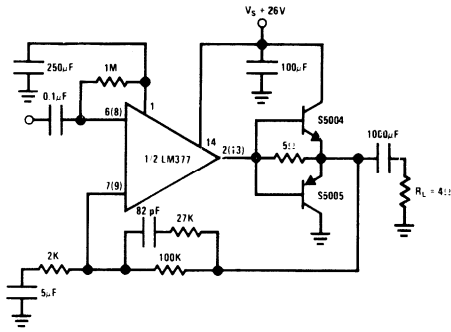
typical performance characteristics



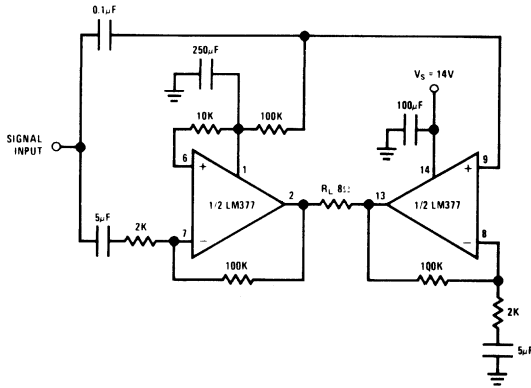
typical performance characteristics (con't)



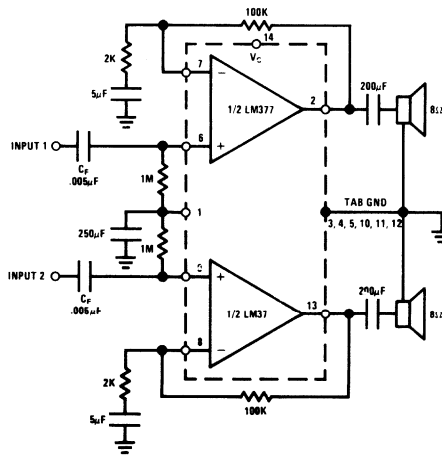
typical applications



15W Per Channel Audio Amplifier



4W Bridge Amplifier



Simple Stereo Amplifier



Consumer Circuits

LM380 audio power amplifier general description

The LM380 is a power audio amplifier for consumer application. In order to hold system cost to a minimum, gain is internally fixed at 34 dB. A unique input stage allows inputs to be ground referenced. The output is automatically self entering to one half the supply voltage.

The output is short circuit proof with internal thermal limiting. The package outline is standard dual-in-line. A copper lead frame is used with the center three pins on either side comprising a heat sink. This makes the device easy to use in standard p-c layout. A mini dual-in-line package version with reduced power capability also available.

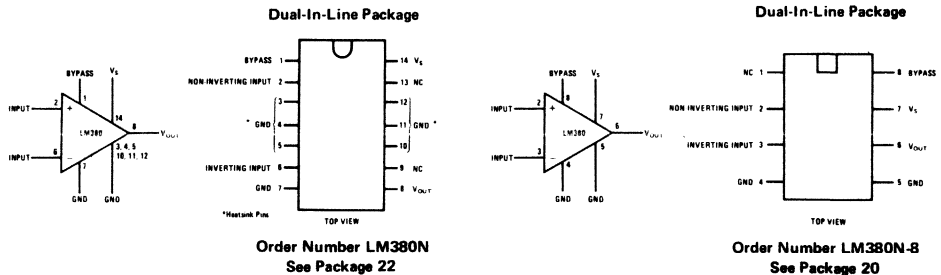
Uses include simple phonograph amplifiers, intercoms, line drivers, teaching machine outputs,

alarms, ultrasonic drivers, TV sound systems, AM-FM radio, small servo drivers, power converters, etc.

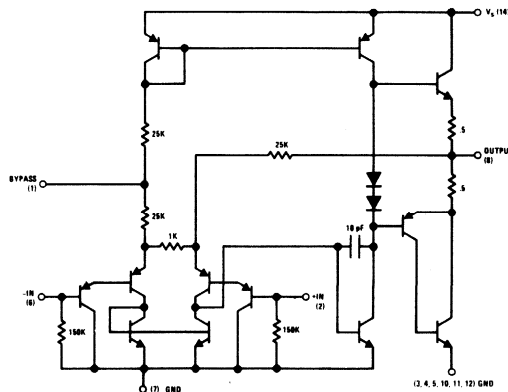
features

- Wide supply voltage range
- Low quiescent power drain
- Voltage gain fixed at 50
- High peak current capability
- Input referenced to GND
- High input impedance
- Low distortion
- Quiescent output voltage is at one-half of the supply voltage
- Standard dual-in-line package

block and connection diagrams



schematic diagram



absolute maximum ratings

Supply Voltage	22V
Peak Current	1.3A
Package Dissipation 14 Pin DIP (Note 6)	5.0W
Package Dissipation 8 Pin DIP (Note 7)	660 mW
Input Voltage	±0.5V
Storage Temperature	-65°C to +150°C
Operating Temperature	0°C to +70°C
Junction Temperature	+150°C
Lead Temperature (Soldering, 10 sec)	+300°C

electrical characteristics (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Power	$P_{OUT(RMS)}$	(Notes 3, 4) $R_L = 8\Omega$, THD = 3%	2.5			W
Gain	A_V		40	50	60	V/V
Output Voltage Swing	V_{OUT}	$R_L = 8\Omega$		14		V_{pp}
Input Resistance	Z_{IN}			150k		Ω
Total Harmonic Distortion	THD	(Note 4, 5)		0.2		%
Power Supply Rejection Ratio	PSRR	(Note 2)		38		dB
Supply Voltage	V_S		8		22	V
Bandwidth	BW	$P_{OUT} = 2W$, $R_L = 8\Omega$		100k		Hz
Quiescent Supply Current	I_Q			7	25	mA
Quiescent Output Voltage	V_{OUTQ}		8	9.0	10	V
Bias Current	I_{BIAS}	Inputs Floating		100		nA
Short Circuit Current	I_{SC}			1.3		A

Note 1: $V_S = 18V$ and $T_A = 25^\circ C$ unless otherwise specified.

Note 2: Rejection ratio referred to the output with $C_{BYPASS} = 5 \mu F$.

Note 3: With device Pins 3, 4, 5, 10, 11, 12 soldered into a 1/16" epoxy glass board with 2 ounce copper foil with a minimum surface of 6 square inches.

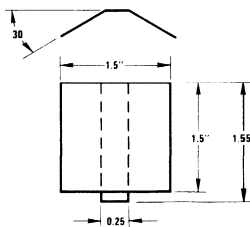
Note 4: If oscillation exists under some load conditions, add 2.7 Ω and 0.1 μF series network from Pin 8 to Gnd.

Note 5: $C_{BYPASS} = 0.47 \mu F$ on Pin 1.

Note 6: Pins 3, 4, 5, 10, 11, 12 at 25°C derate 25°C/W above 25°C case.

Note 7: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 187°C/W junction to ambient.

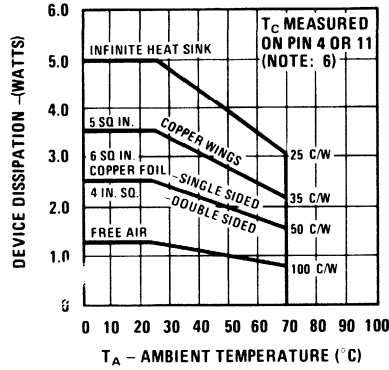
heat sink dimensions



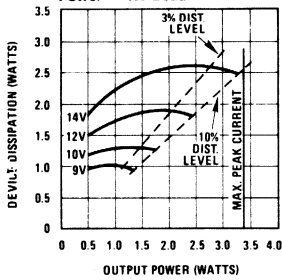
COPPER WINGS
2 REQUIRED
SOLDERED TO
PINS 3, 4, 5,
10, 11, 12
THICKNESS 0.04
INCHES

typical performance characteristics

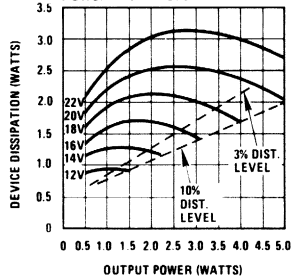
Maximum Device Dissipation vs Ambient Temperature



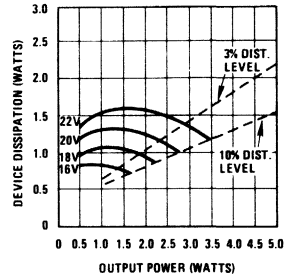
Device Dissipation vs Output Power - 4Ω Load



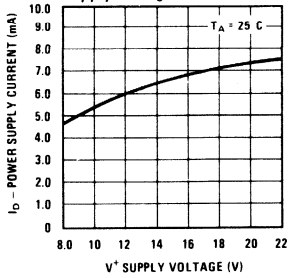
Device Dissipation vs Output Power - 8Ω Load



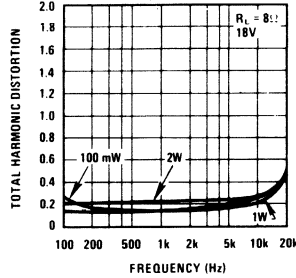
Device Dissipation vs Output Power - 16Ω Load



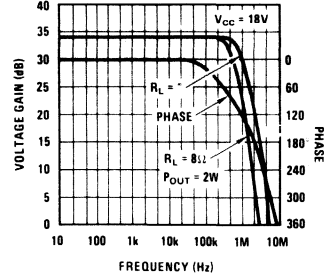
Power Supply Current vs Supply Voltage



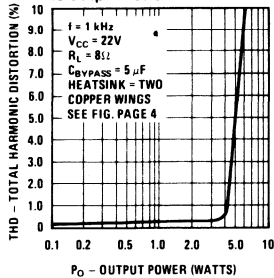
Total Harmonic Distortion vs Frequency



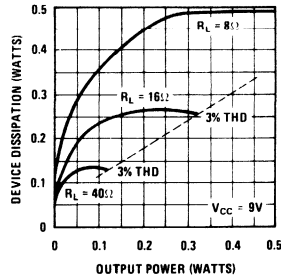
Output Voltage Gain and Phase vs Frequency



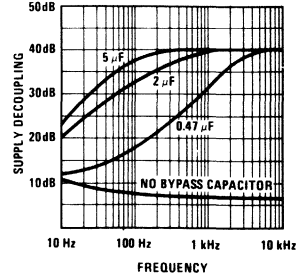
Total Harmonic Distortion vs Output Power



Device Dissipation vs Output Power

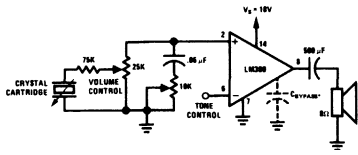


Supply Decoupling vs Frequency

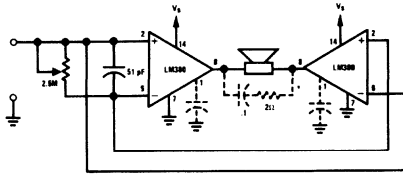


typical applications

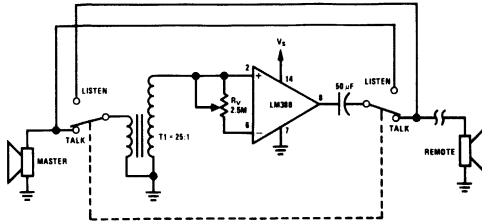
Phono Amplifier



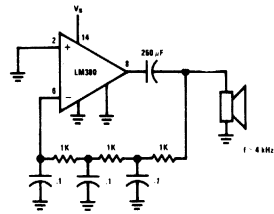
Bridge Amplifier



Intercom



Phase Shift Oscillator





Consumer Circuits

LM381

LM381 low noise dual preamplifier general description

The LM381 is a dual preamplifier for the amplification of low level signals in applications requiring optimum noise performance. Each of the two amplifiers is completely independent, with individual internal power supply decoupler-regulator, providing 120 dB supply rejection and 60 dB channel separation. Other outstanding features include high gain (112 dB), large output voltage swing ($V_{CC} - 2V$) p-p, and wide power bandwidth (75 kHz, 20V_{p-p}). The LM381 operates from a single supply across the wide range of 9 to 40V.

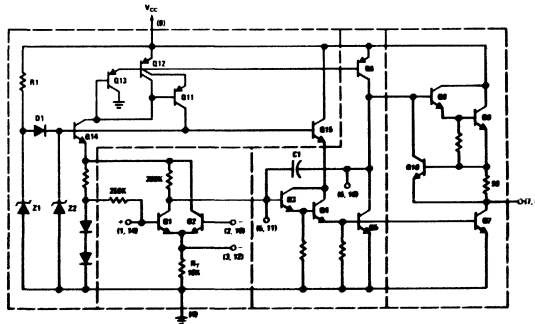
Either differential input or single ended input configurations may be selected. The amplifier is internally compensated with the provision for

additional external compensation for narrow band applications.

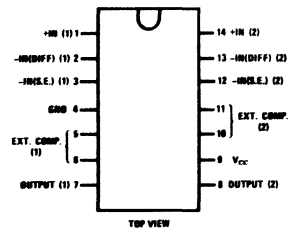
features

- Low Noise — .5 μV total input noise
- High Gain — 112 dB open loop
- Single Supply Operation
- Wide supply range 9–40V
- Power supply rejection 120 dB
- Large output voltage swing ($V_{CC} - 2V$)_{p-p}
- Wide bandwidth 15 MHz unity gain
- Power bandwidth 75 kHz, 20 V_{p-p}
- Internally compensated
- Short circuit protected

schematic and connection diagrams

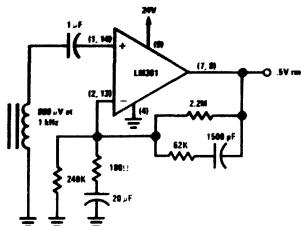


Dual-In-Line Package

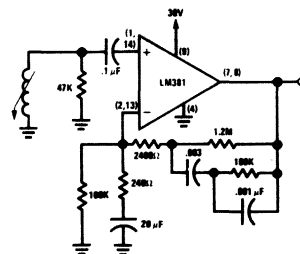


Order Number LM381N
See Package 22

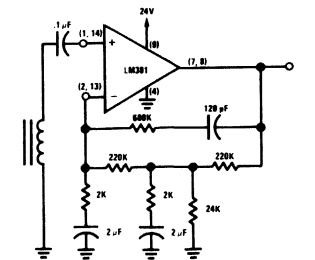
typical applications



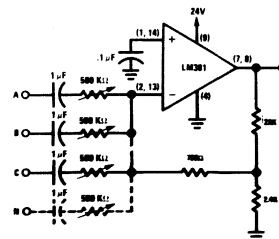
Typical Tape Playback Amplifier



Typical Magnetic Phono Preamp.



Two-Pole Fast Turn-On NAB Tape Preamp



Audio Mixer

5

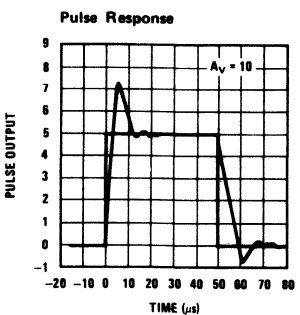
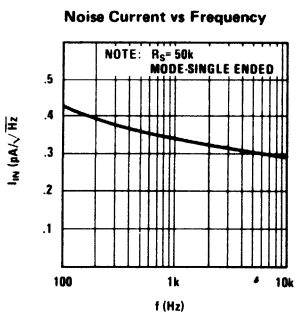
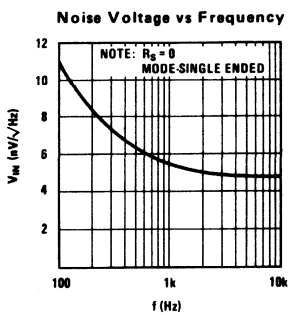
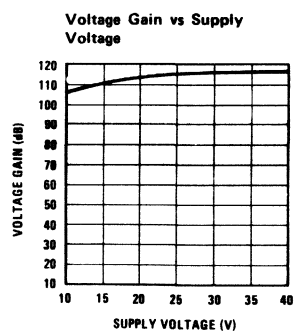
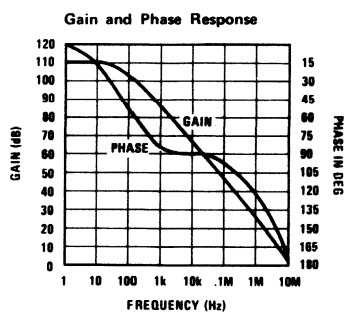
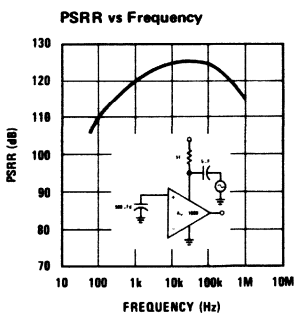
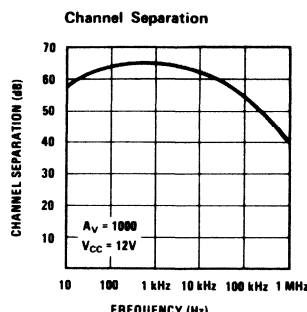
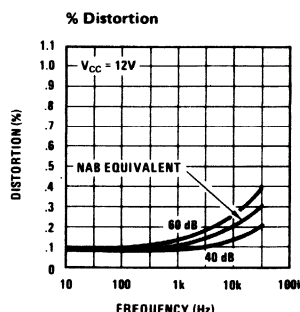
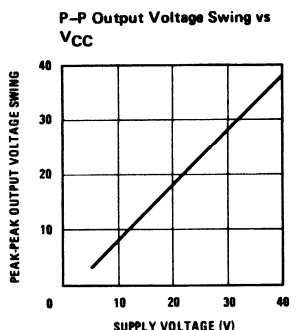
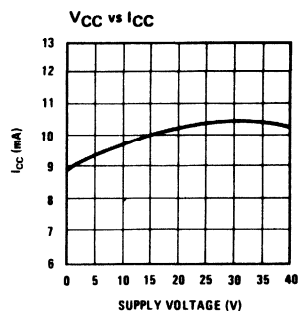
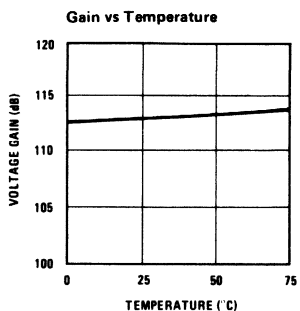
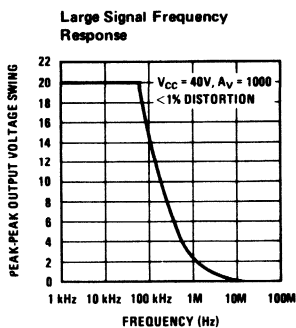
absolute maximum ratings

Supply Voltage	+40V
Power Dissipation	800 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics $T_A = 25^\circ\text{C}$, $V_{CC} = 14\text{V}$, unless otherwise stated.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS			
Voltage Gain	Open Loop (Differential Input)		160,000		V/V			
	Open Loop (Single Ended)		320,000		V/V			
Supply Current	V_{CC} 9 to 40V, $R_L = \infty$		10		mA			
Input Resistance								
(Positive Input)		100			k Ω			
(Negative Input)		200			k Ω			
Input Current								
(Negative Input)			0.5		μA			
Output Resistance	Open Loop		150		Ω			
Output Current	Source		8		mA			
	Sink		2		mA			
Output Voltage Swing	Peak-to-Peak		$V_{CC} - 2$		V			
Small Signal Bandwidth			15		MHz			
Power Bandwidth	20 V_{p-p} ($V_{CC} = 24\text{V}$)		75		kHz			
Maximum Input Voltage	Linear Operation			300	mVrms			
Supply Rejection Ratio	$f = 1$ kHz		120		dB			
Channel Separation	$f = 1$ kHz		60		dB			
Total Harmonic Distortion	75 dB Gain, $f = 1$ kHz		0.1		%			
Total Equivalent Input Noise	$R_S = 600\Omega$, 10 - 10,000 Hz (Single Ended Input)		0.5	0.7	μVrms			
LM381A			0.5	0.7	μVrms			
LM381			0.5	1.0	μVrms			
Noise Figure	50 k Ω , 10 - 10,000 Hz } 10 k Ω , 10 - 10,000 Hz } 5 k Ω , 10 - 10,000 Hz }							
						(Single Ended Input)	1.0	dB
						1.3	dB	
			1.6		dB			

typical performance characteristics





Consumer Circuits

LM382 low noise dual preamplifier general description

The LM382 is a dual preamplifier for the amplification of low level signals in applications requiring optimum noise performance. Each of the two amplifiers is completely independent, with individual internal power supply decoupler-regulator, providing 120 dB supply rejection and 60 dB channel separation. Other outstanding features include high gain (100 dB), large output voltage swing ($V_{CC} - 2V$) p-p, and wide power bandwidth (75 kHz, 20 V_{pp}). The LM382 operates from a single supply across the wide range of 9 to 40V.

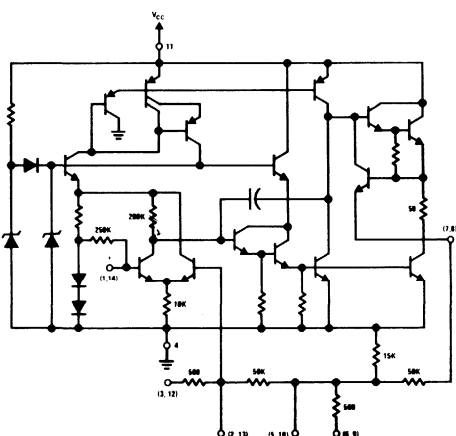
A resistor matrix is provided on the chip to allow the user to select a variety of closed loop gain options and frequency response characteristics such as flat-band, NAB or RIAA equalization. The

circuit is supplied in the 14 lead dual-in-line package.

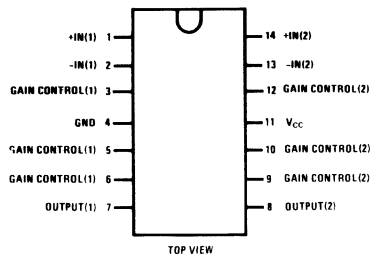
features

- Low noise — 0.8 μV total equivalent input noise
- High gain — 100 dB open loop
- Single supply operation
- Wide supply range 9 to 40V
- Power supply rejection — 120 dB
- Large output voltage swing
- Wide bandwidth — 15 MHz unity gain
- Power bandwidth — 75 kHz, 20 V_{pp}
- Internally compensated
- Short circuit protected.

schematic and connection diagrams

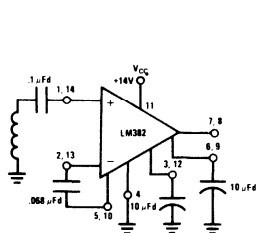


Dual-In-Line Package

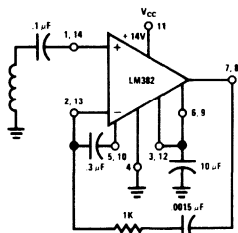


Molded Dual-In-Line Package (N)
Order Number LM382N
See Package 22

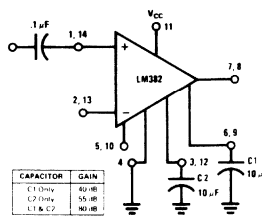
typical applications



Tape Reamplifier (NAB Equalization)



Phono Pre-Amp (RIAA Equalization)



Flat Response - Fixed Gain
Configuration

CAPACITOR	GAIN
C1	40-dB
C2	55-dB
L1 & C2	90-dB

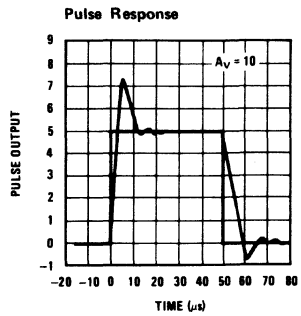
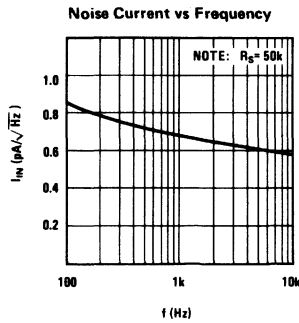
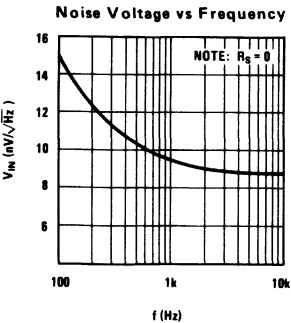
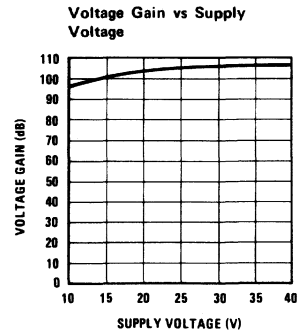
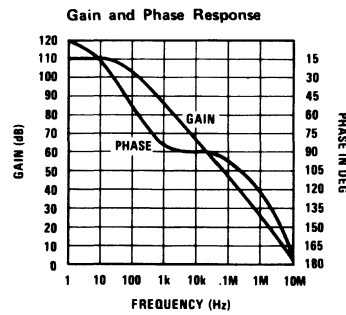
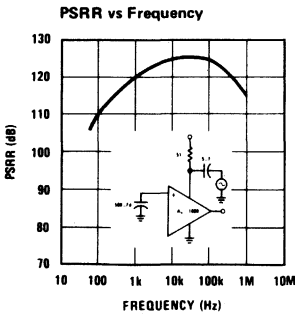
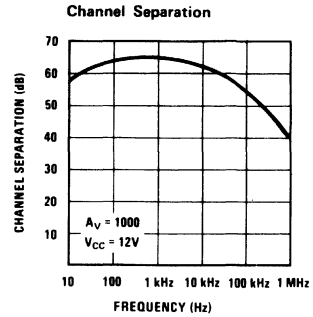
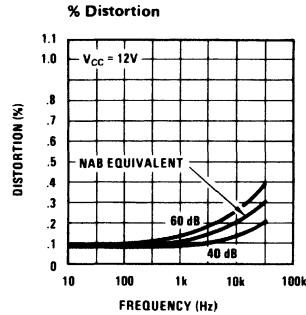
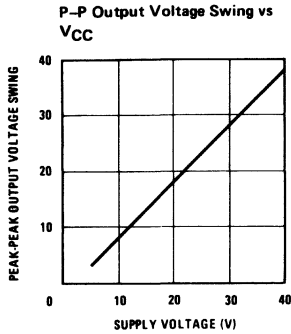
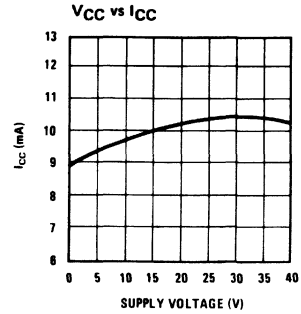
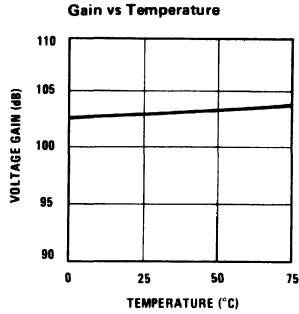
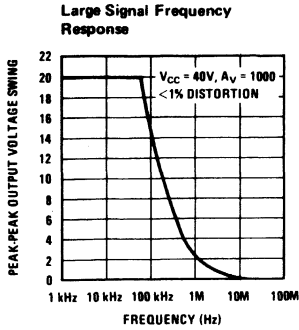
absolute maximum ratings

Supply Voltage	+40V
Power Dissipation	800 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics $T_A = 25^\circ\text{C}$, $V_{CC} = 14\text{V}$, unless otherwise stated.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Voltage Gain	Open Loop (Differential Input)		100,000		V/V
Supply Current	V_{CC} 9 to 40V, $R_L = \infty$		10	16	mA
Input Resistance (Positive Input)			100		k Ω
(Negative Input)			200		k Ω
Input Current (Negative Input)			0.5		μA
Output Resistance	Open Loop		150		Ω
Output Current	Source		8		mA
	Sink		2		mA
Output Voltage Swing	Peak-to-Peak, $R = 10\text{k}$		$V_{CC} - 2$		V
Small Signal Bandwidth			15		MHz
Power Bandwidth	20 V_{p-p} ($V_{CC} = 24\text{V}$)		75		kHz
Maximum Input Voltage	Linear Operation			300	mVrms
Supply Rejection Ratio	$f = 1\text{ kHz}$		120		dB
Channel Separation	$f = 1\text{ kHz}$	40	60		dB
Total Harmonic Distortion	60 dB Gain, $f = 1\text{ kHz}$		0.1	0.3	%
Total Equivalent Input Noise	$R_S = 600\Omega$, 100 – 10,000 Hz		0.8	1.2	μVrms
Noise Figure	50 k Ω , 100 – 10,000 Hz		1.0		dB
	10 k Ω , 100 – 10,000 Hz		1.6		dB
	5 k Ω , 100 – 10,000 Hz		2.8		dB

typical performance characteristics





Consumer Circuits

LM565/LM565C phase locked loop general description

The LM565 and LM565C are general purpose phase locked loops containing a stable, highly linear voltage controlled oscillator for low distortion FM demodulation, and a double balanced phase detector with good carrier suppression. The VCO frequency is set with an external resistor and capacitor, and a tuning range of 10:1 can be obtained with the same capacitor. The characteristics of the closed loop system—bandwidth, response speed, capture and pull in range—may be adjusted over a wide range with an external resistor and capacitor. The loop may be broken between the VCO and the phase detector for insertion of a digital frequency divider to obtain frequency multiplication.

The LM565H is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LM565CH and LM565CN are specified for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

features

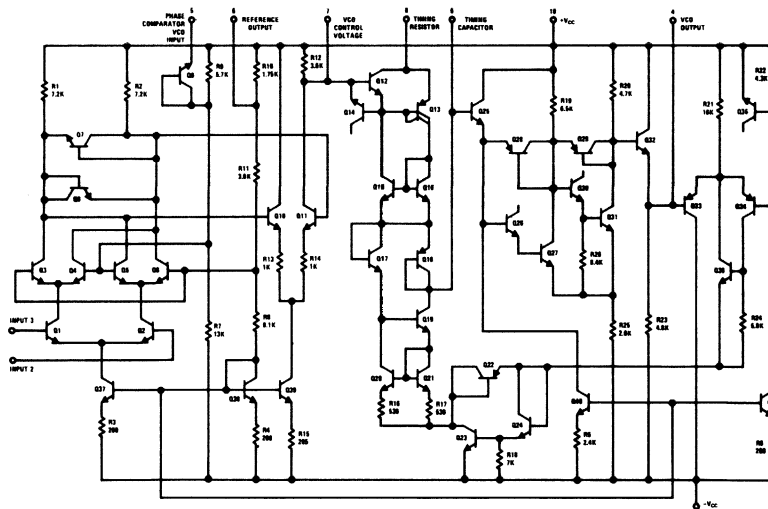
- 200 ppm/ $^{\circ}\text{C}$ frequency stability of the VCO
- Power supply range of ± 5 to ± 12 volts with 100 ppm/% typical

- 0.2% linearity of demodulated output
- Linear triangle wave with in phase zero crossings available
- TTL and DTL compatible phase detector input and square wave output
- Adjustable hold in range from $\pm 1\%$ to $> \pm 60\%$.

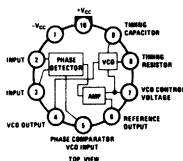
applications

- Data and tape synchronization
- Modems
- FSK demodulation
- FM demodulation
- Frequency synthesizer
- Tone decoding
- Frequency multiplication and division
- SCA demodulators
- Telemetry receivers
- Signal regeneration
- Coherent demodulators.

schematic and connection diagrams

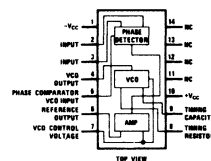


Metal Can Package



Order Number LM565H or LM565CH
See Package 14

Dual-In-Line Package



Order Number LM565CN
See Package 22



absolute maximum ratings

Supply Voltage	±12V
Power Dissipation (Note 1)	300 mW
Differential Input Voltage	±1V
Operating Temperature Range	-55°C to +125°C
LM565H	
LM565CH, LM565CN	0°C to 70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

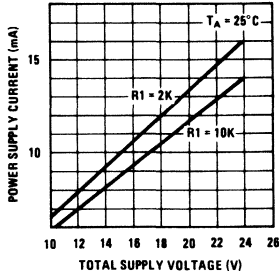
electrical characteristics (AC Test Circuit, $T_A = 25^\circ\text{C}$, $V_C = \pm 6\text{V}$)

PARAMETER	CONDITIONS	LM565			LM565C/LM565CN			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Power Supply Current			8.0	12.5		8.0	12.5	mA
Input Impedance (Pins 2, 3)	$-4\text{V} < V_2 = V_3 < 0\text{V}$		5			5		$k\Omega$
VCO Maximum Operating Frequency	$C_o = 2.7 \text{ pF}$		500			500		kHz
Operating Frequency Temperature Coefficient			100			200		ppm/ $^\circ\text{C}$
Frequency Drift with Supply Voltage			100			200		ppm/%
Triangle Wave Output Voltage		2	2.4		2	2.4		V_{PP}
Triangle Wave Output Linearity			.2			.5		%
Square Wave Output Level		4.7	5.4		4.7	5.4		V_{PP}
Output Impedance (Pin 4)			5			5		$k\Omega$
Square Wave Duty Cycle		45	50	55	40	50	60	%
Square Wave Rise Time			20			20		ns
Square Wave Fall Time			50			50		ns
Output Current Sink (Pin 4)			1			1		mA
VCO Sensitivity	$f_o = 10 \text{ kHz}$		6600			6600		Hz/V
Demodulated Output Voltage (Pin 7)	$\pm 10\%$ Frequency Deviation	250	300		200	300		mV_{DD}
Total Harmonic Distortion	$\pm 10\%$ Frequency Deviation		0.2	0.75		0.2	1.5	%
Output Impedance (Pin 7)			3.5			3.5		$k\Omega$
DC Level (Pin 7)			4.5			4.5		V
Output Offset Voltage $|V_7 - V_6|$			30	100		50	200	mV
Temperature Drift of $|V_7 - V_6|$			500			500		$\mu\text{V}/^\circ\text{C}$
AM Rejection			40			40		dB
Phase Detector Sensitivity K_D			.68			.68		V/radian

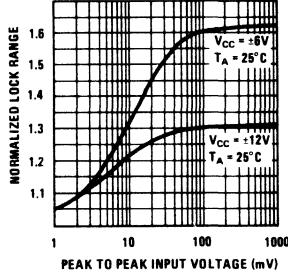
Note 1: The maximum junction temperature of the LM565 is 150°C, while that of the LM565C and LM565CN is 100°C. For operation at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case. Thermal resistance of the dual-in-line package is 100°C/W.

typical performance characteristics

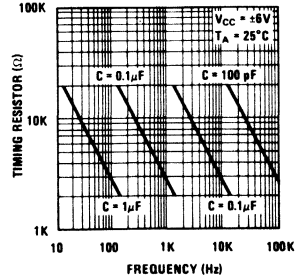
Power Supply Current as a Function of Supply Voltage



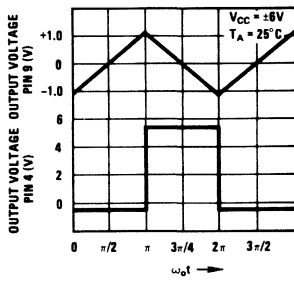
Lock Range as a Function of Input Voltage



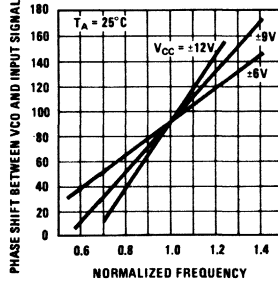
VCO Frequency



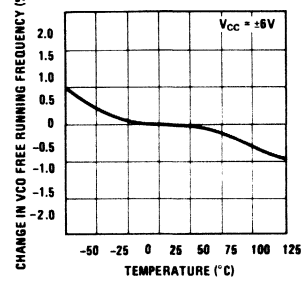
Oscillator Output Waveforms



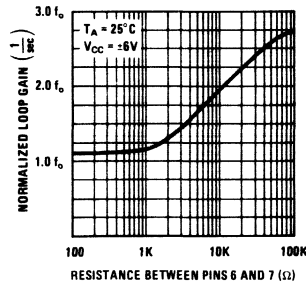
Phase Shift vs Frequency



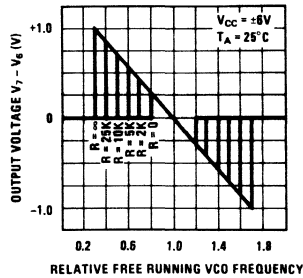
VCO Frequency as a Function of Temperature



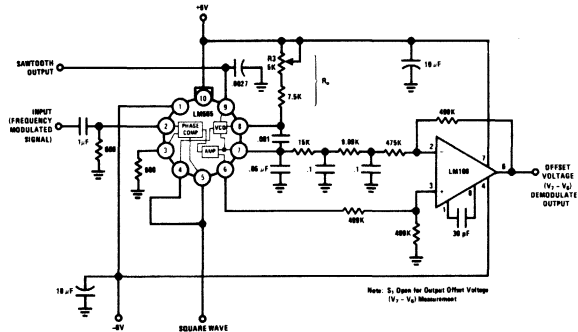
Loop Gain vs Load Resistance



Hold in Range as a Function of R6-7



ac test circuit



Note: 5. Open for Output Offset Voltage ($V_7 - V_6$) Measurement

applications information

In designing with phase locked loops such as the LM565, the important parameters of interest are:

FREE RUNNING FREQUENCY

$$f_o \cong \frac{1}{3.7 R_o C_o}$$

LOOP GAIN: relates the amount of phase change between the input signal and the VCO signal for a shift in input signal frequency (assuming the loop remains in lock). In servo theory, this is called the "velocity error coefficient".

$$\text{Loop gain} = K_o K_D \left(\frac{1}{\text{sec}} \right)$$

$$K_o = \text{oscillator sensitivity} \left(\frac{\text{radians/sec}}{\text{volt}} \right)$$

$$K_D = \text{phase detector sensitivity} \left(\frac{\text{volts}}{\text{radian}} \right)$$

The loop gain of the LM565 is dependent on supply voltage, and may be found from:

$$K_o K_D = \frac{33.6 f_o}{V_c}$$

$$f_o = \text{VCO frequency in Hz}$$

$$V_c = \text{total supply voltage to circuit.}$$

Loop gain may be reduced by connecting a resistor between pins 6 and 7; this reduces the load impedance on the output amplifier and hence the loop gain.

HOLD IN RANGE: the range of frequencies that the loop will remain in lock after initially being locked.

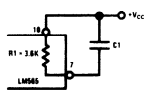
$$f_H = \pm \frac{8 f_o}{V_c}$$

$$f_o = \text{free running frequency of VCO}$$

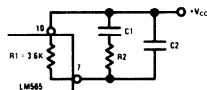
$$V_c = \text{total supply voltage to the circuit.}$$

THE LOOP FILTER

In almost all applications, it will be desirable to filter the signal at the output of the phase detector (pin 7) this filter may take one of two forms:



Simple Lag Filter



Lag-Lead Filter

A simple lag filter may be used for wide closed loop bandwidth applications such as modulation following where the frequency deviation of the carrier is fairly high (greater than 10%), or where wideband modulating signals must be followed.

The natural bandwidth of the closed loop response may be found from:

$$f_n = \frac{1}{2\pi} \sqrt{\frac{K_o K_D}{R_1 C_1}}$$

Associated with this is a damping factor:

$$\delta = \frac{1}{2} \sqrt{\frac{1}{R_1 C_1 K_o K_D}}$$

For narrow band applications where a narrow noise bandwidth is desired, such as applications involving tracking a slowly varying carrier, a lead lag filter should be used. In general, if $1/R_1 C_1 < K_o K_D$, the damping factor for the loop becomes quite small resulting in large overshoot and possible instability in the transient response of the loop. In this case, the natural frequency of the loop may be found from

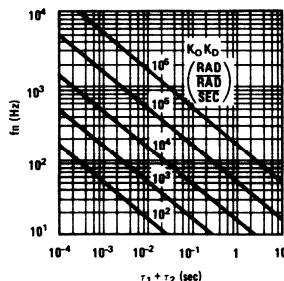
$$f_n = \frac{1}{2\pi} \sqrt{\frac{K_o K_D}{\tau_1 + \tau_2}}$$

$$\tau_1 + \tau_2 = (R_1 + R_2) C_1$$

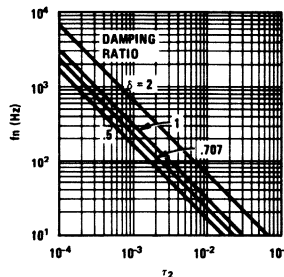
R_2 is selected to produce a desired damping factor δ , usually between 0.5 and 1.0. The damping factor is found from the approximation:

$$\delta \approx \pi \tau_2 f_n$$

These two equations are plotted for convenience.



Filter Time Constant vs Natural Frequency



Damping Time Constant vs Natural Frequency

Capacitor C_2 should be much smaller than C_1 since its function is to provide filtering of carrier. In general $C_2 \leq 0.1 C_1$.



Consumer Circuits

LM566/LM566C voltage controlled oscillator

general description

The LM566/LM566C are general purpose voltage controlled oscillators which may be used to generate square and triangular waves, the frequency of which is a very linear function of a control voltage. The frequency is also a function of an external resistor and capacitor.

The LM566 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LM566C is specified for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

features

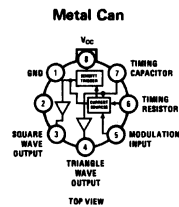
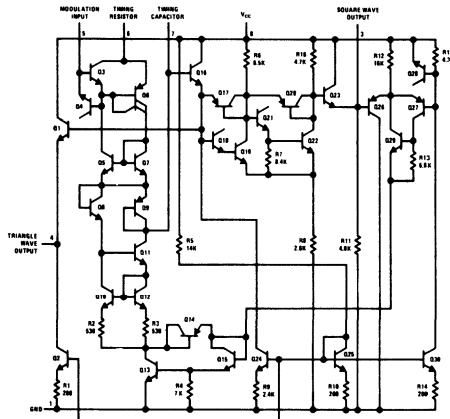
- Wide supply voltage range: 10 to 24 volts
- Very linear modulation characteristics

- High temperature stability
- Excellent supply voltage rejection
- 10 to 1 frequency range with fixed capacitor
- Frequency programmable by means of current, voltage, resistor or capacitor.

applications

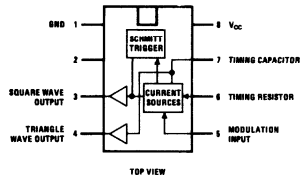
- FM modulation
- Signal generation
- Function generation
- Frequency shift keying
- Tone generation

schematic and connection diagrams



Order Number LM566H or LM566CH
See Package 11

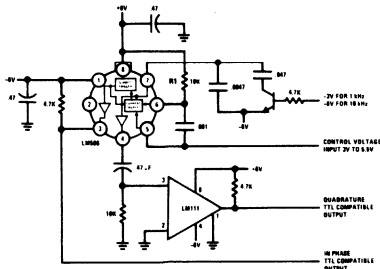
Dual-In-Line Package



Order Number LM566CN
See Package 20

typical application

1 kHz and 10 kHz TTL Compatible Voltage Controlled Oscillator



applications information

The LM566 may be operated from either a single supply as shown in this test circuit, or from a split (\pm) power supply. When operating from a split supply, the square wave output (pin 4) is TTL compatible (2 mA current sink) with the addition of a $4.7\text{ k}\Omega$ resistor from pin 3 to ground.

A $.001\ \mu\text{F}$ capacitor is connected between pins 5 and 6 to prevent parasitic oscillations that may occur during VCO switching.

$$f_o = \frac{2(V^+ - V_B)}{R_1 C_1 V^+}$$

where

$$2\text{K} < R_1 < 20\text{K}$$

and V_B is voltage between pin 5 and ground.

absolute maximum ratings

Power Supply Voltage		26V
Power Dissipation (Note 1)		300 mW
Operating Temperature Range	LM566	-55°C to +125°C
	LM566C	0°C to 70°C
Lead Temperature (Soldering, 10 sec)		300°C

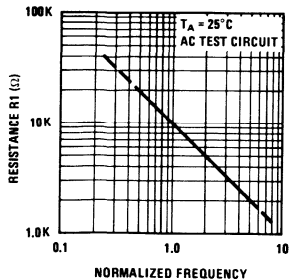
electrical characteristics $V_{CC} = 12V$, $T_A = 25^\circ C$, AC Test Circuit

PARAMETER	CONDITIONS	LM566			LM566C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Maximum Operating Frequency	$R_0 = 2k$ $C_0 = 2.7 \text{ pF}$		1			1		MHz
Input Voltage Range Pin 5		$3/4 V_{CC}$		V_{CC}	$3/4 V_{CC}$		V_{CC}	
Average Temperature Coefficient of Operating Frequency			100			200		ppm/°C
Supply Voltage Rejection			1			2		%/V
Input Impedance Pin 5			1			1		MΩ
VCO Sensitivity	$f_0 = 10 \text{ kHz}$		6600			6600		Hz/V
FM Distortion	$\pm 10\%$ Deviation		.2	.75		.2	1.5	%
Maximum Sweep Rate			1			1		MHz
Sweep Range			10:1			10:1		
Output Impedance Pin 3			50			50		Ω
Pin 4			50			50		Ω
Square Wave Output Level	$R_{L1} = 10k$	5.0	5.4		5.0	5.4		V p-p
Triangle Wave Output Level	$R_{L2} = 10k$	2.0	2.4					V p-p
Square Wave Duty Cycle		45		55	40		60	%
Square Wave Rise Time			20			20		ns
Square Wave Fall Time			50			50		ns
Triangle Wave Linearity			.2			.5		%

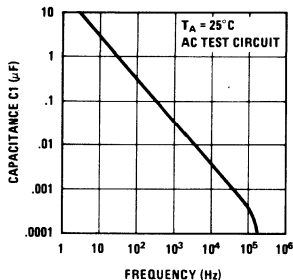
Note 1: The maximum junction temperature of the LM566 is 150°C, while that of the LM566C is 100°C. For operating at elevated junction temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W. The thermal resistance of the dual-in-line package is 100°C/W.

typical performance characteristics

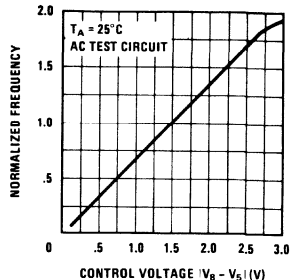
Operating Frequency as a Function of Timing Resistor



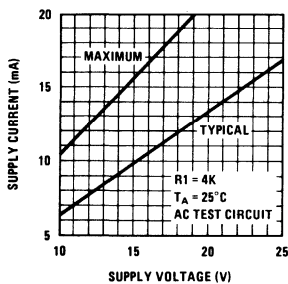
Operating Frequency as a Function of Timing Capacitor



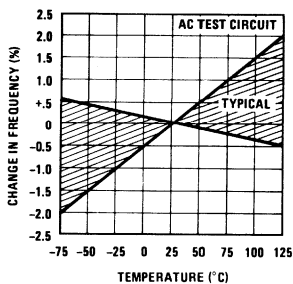
Normalized Frequency as a Function of Control Voltage



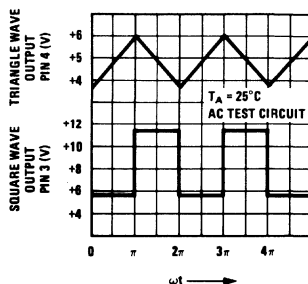
Power Supply Current



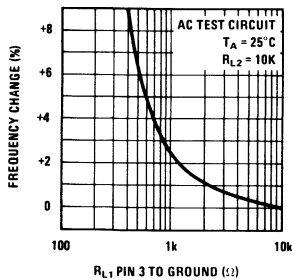
Temperature Stability



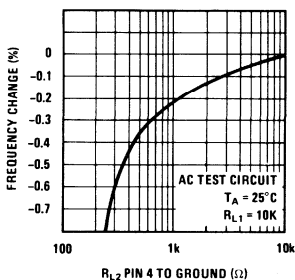
VCO Waveforms



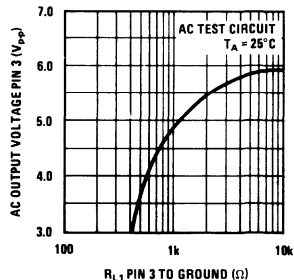
Frequency Stability vs Load Resistance (Square Wave Output)



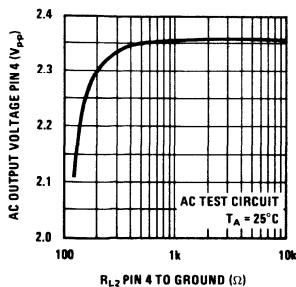
Frequency Stability vs Load Impedance (Triangle Output)



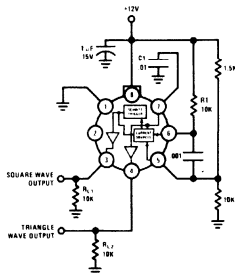
Square Wave Output Characteristics



Triangle Wave Output Characteristics



ac test circuit





Consumer Circuits

LM567/LM567C

LM567/LM567C tone decoder general description

The LM567 and LM567C are general purpose tone decoders designed to provide a saturated transistor switch to ground when an input signal is present within the passband. The circuit consists of an I and Q detector driven by a voltage controlled oscillator which determines the center frequency of the decoder. External components are used to independently set center frequency, bandwidth and output delay.

- High rejection of out of band signals and noise
- Immunity to false signals
- Highly stable center frequency
- Center frequency adjustable from 0.01 Hz to 500 kHz

applications

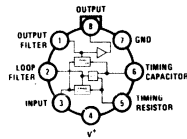
- Touch tone decoding
- Precision oscillator
- Frequency monitoring and control
- Wide band FSK demodulation
- Ultrasonic controls
- Carrier current remote controls
- Communications paging decoders

features

- 20 to 1 frequency range with an external resistor
- Logic compatible output with 100 mA current sinking capability
- Bandwidth adjustable from 0 to 14%

schematic and connection diagrams

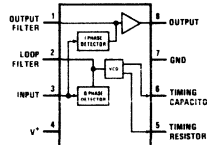
Metal Can Package



TOP VIEW

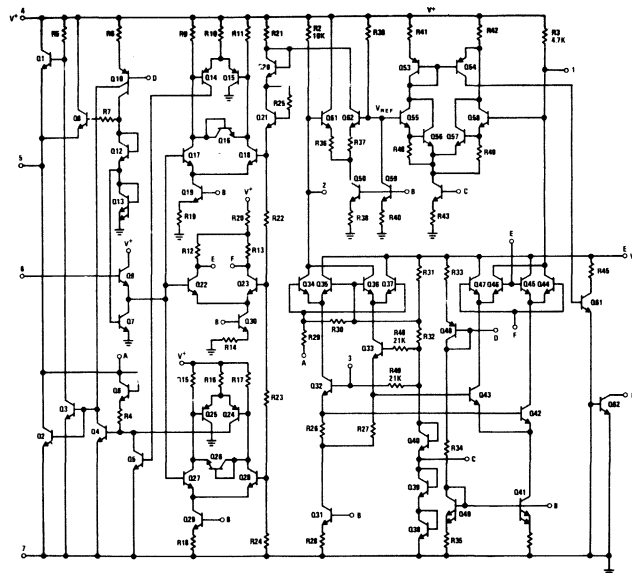
Order Number LM567H or LM567CH
See Package 11

Dual-In-Line Package



TOP VIEW

Order Number LM567CN
See Package 20



5

absolute maximum ratings

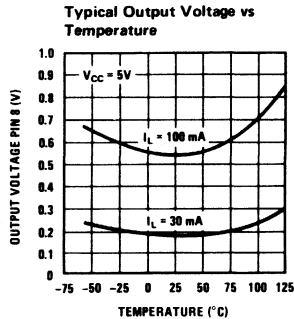
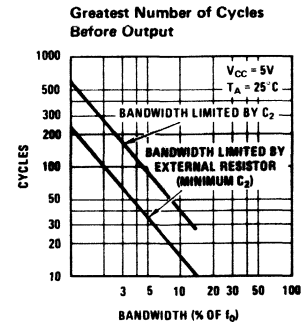
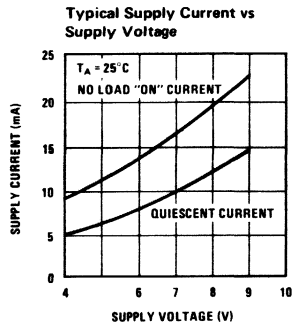
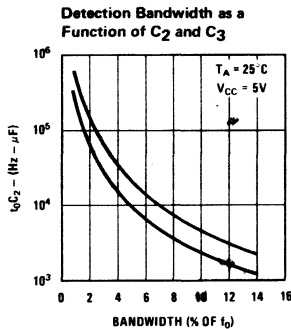
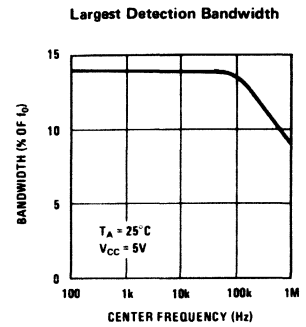
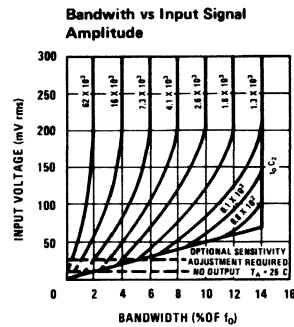
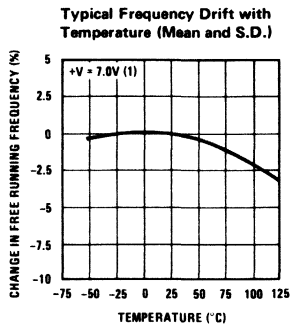
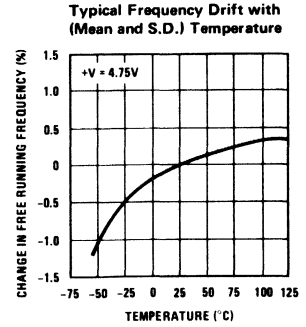
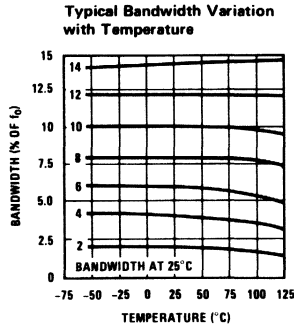
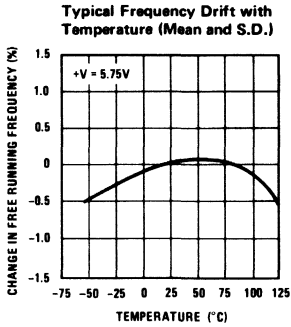
Supply Voltage Pin	10V
Power Dissipation (Note 1)	300 mW
V_B	15V
V_3	-10V
V_3	$V_B + 0.5V$
Storage Temperature Range	-65°C to +150°C

electrical characteristics (AC Test Circuit, $T_A = 25^\circ\text{C}$, $V_C = 5V$)

PARAMETERS	CONDITIONS	LM567			LM567C/LM567CN			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Power Supply Voltage Range		4.75		9.0	4.75		9.0	V
Power Supply Current	$R_L = 20k$							
Quiescent			6	8		7	10	mA
Power Supply Current	$R_L = 20k$							
Activated			11	13		12	15	mA
Input Resistance			20			20		k Ω
Smallest Detectable Input Voltage	$I_L = 100\text{ mA}$, $f_i = f_o$		20	25		20	25	mVrms
Largest No Output Input Voltage	$I_C = 100\text{ mA}$, $f_i = f_o$	10	15		10	15		mVrms
Largest Simultaneous Outband Signal to Inband Signal Ratio			6			6		dB
Minimum Input Signal to Wideband Noise Ratio	$B_n = 140\text{ kHz}$		-6			-6		dB
Largest Detection Bandwidth		12	14	16	10	14	18	% of f_o
Largest Detection Bandwidth Skew			1	2		2	3	% of f_o
Largest Detection Bandwidth Variation with Temperature			± 0.1			± 0.1		%/ $^\circ\text{C}$
Largest Detection Bandwidth Variation with Supply Voltage			± 2			± 2		%/V
Highest Center Frequency		100	500		100	500		kHz
Center Frequency Stability	$0 < T_A < 70$		35 \pm 60			35 \pm 60		ppm/ $^\circ\text{C}$
	$-55 < T_A < +125$		35 \pm 140					ppm/ $^\circ\text{C}$
Center Frequency Shift with Supply Voltage			0.5	1.0		2	7	%/V
Fastest ON-OFF Cycling Rate			$f_o/20$			$f_o/20$		
Output Leakage Current	$V_B = 15V$		0.01	25		0.01	25	μA
Output Saturation Voltage	$e_i = 25\text{ mV}$, $I_B = 30\text{ mA}$		0.2	0.4		0.2	0.4	V
	$e_i = 25\text{ mV}$, $I_B = 100\text{ mA}$		0.6	1.0		0.6	1.0	
Output Fall Time (Note 3)			30			30		ns
Output Rise Time (Note 3)			150			150		ns

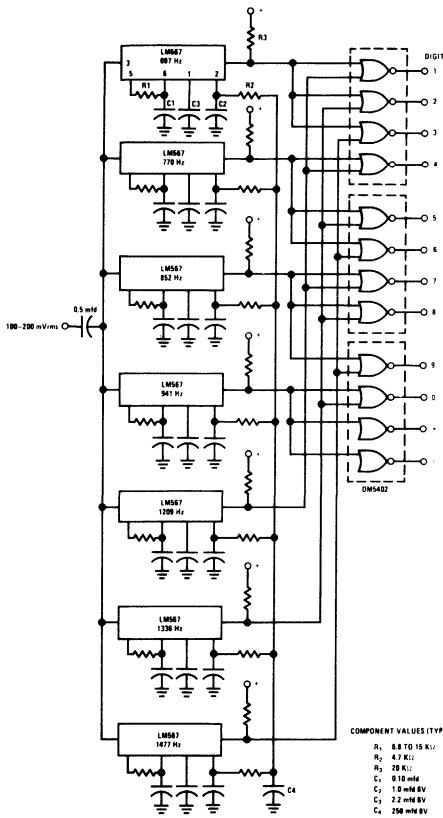
Note 1: The maximum junction temperature of the LM567 is 150°C, while that of the LM567C and LM567CN is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient or 45°C/W, junction to case. For the DIP the device must be derated based on a thermal resistance of 187°C/W, junction to ambient.

typical performance characteristics

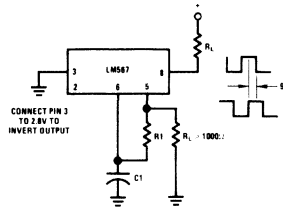


typical applications

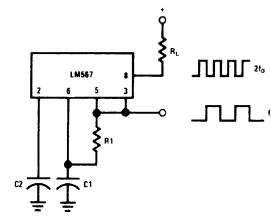
Touch-Tone Decoder



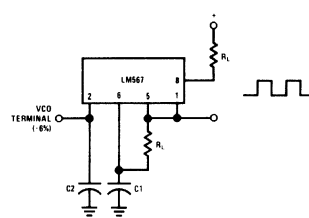
Oscillator with Quadrature Output



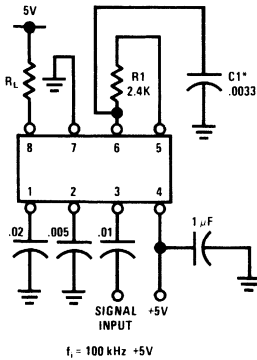
Oscillator with Double Frequency Output



Precision Oscillator Drive 100 mA Loads



ac test circuit



*Note: Adjust for f_o = 100 kHz

applications information

The center frequency of the tone decoder is equal to the free running frequency of the VCO. This is given by

$$f_o \cong \frac{1}{R_1 C_1}$$

The bandwidth of the filter may be found from the approximation

$$BW = 1070 \sqrt{\frac{V_i}{f_o C_2}}$$

Where:

V_i = Input voltage (volts rms)

C₂ = Capacitance at Pin 2 (μ F)



Consumer Circuits

LM703L

LM703L low power drain rf/if amplifier

general description

The LM703L is a monolithic RF-IF amplifier, having an efficient DC biasing system, reducing demands upon power supply and decoupling elements. Its low internal feedback guarantees a high stability-limited gain.

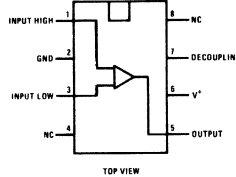
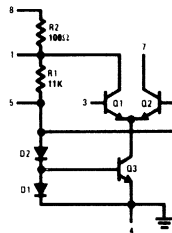
Applications include limiting and nonlimiting amplifiers, mixers, and RF oscillators. The LM703L is specifically characterized for operation in consumer applications such as TV sound IF, FM-IF

limiter amplifier, and Chroma reference oscillator for color TV.

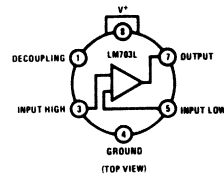
features

- Power Consumption 96 mW (max.)
- Forward Transadmittance 33 mmhos
- Input Conductance 0.35 mmhos
- Output Conductance 0.03 mmhos
- Peak-to-Peak Output Current 5.0 mA

schematic and connection diagrams



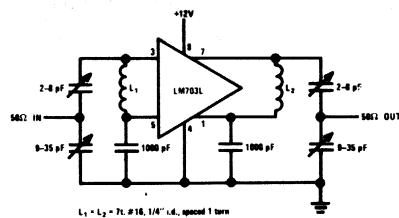
Order Number LM703LN
See Package 20.



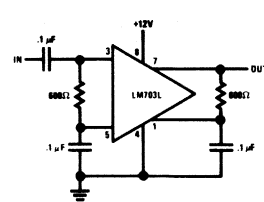
NOTE: Pin 4 connected to case.
Order Number LM703LH
See Package 10

typical applications

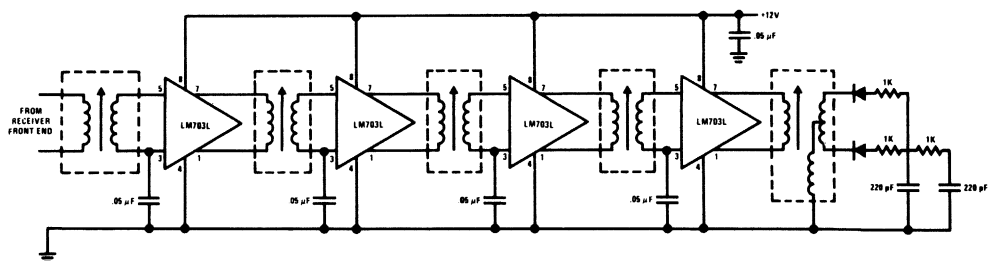
100 MHz Narrow Band Amplifier



RC Coupled Video Amplifier



Four Stage 10.7 MHz FM-IF Amplifier



5

absolute maximum ratings

Supply Voltage	20V
Output Collector Voltage	24V
Voltage Between Input Terminals	±5.0V
Internal Power Dissipation	200 mW

Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

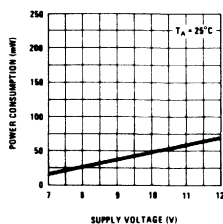
electrical characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Power Consumption	$e_{in} = 0$		71	96	mW
Quiescent Output Current	$e_{in} = 0$	1.5	2.5	3.3	mA
Peak-to-Peak Output Current	$e_{in} = 400$ mV rms, $f = 10.7$ MHz	3.0	5.0		mA
Output Saturation Voltage				1.7	V
Forward Transadmittance	$e_{in} = 10$ mV rms, $f \leq 10.7$ MHz	24.0	33.0		mmho
Reverse Transadmittance	$e_{in} = 10$ mV rms, $f \leq 10.7$ MHz		0.002		mmho
Input Conductance	$e_{in} < 10$ mV rms, $f \leq 10.7$ MHz		0.35	1.0	mmho
Input Capacitance	$e_{in} < 10$ mV rms, $f \leq 10.7$ MHz		9.0	12.5	pF
Output Capacitance	$f \leq 10.7$ MHz		2.6	4.0	pF
Output Conductance	$f \leq 10.7$ MHz		0.03	0.05	mmho
Noise Figure	$R_S = 500\Omega$, $f = 10.7$ MHz $R_S = 500\Omega$, $f = 100$ MHz		6.0 8.0		dB dB
Maximum Stable Gain	$f = 100$ MHz		28.0		dB

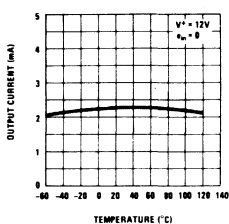
Note 1: These specifications apply for $T_A = 25^\circ\text{C}$, $V^+ = 12\text{V}$ unless otherwise specified.

typical performance characteristics

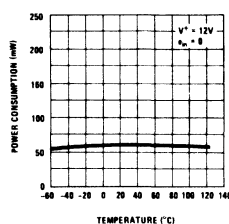
Power Consumption as a Function of Supply Voltage



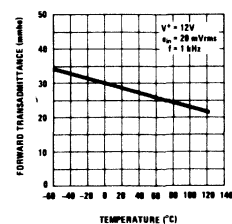
Output Current as a Function of Ambient Temperature



Power Consumption as a Function of Ambient Temperature



Forward Transadmittance as a Function of Ambient Temperature



Note: For additional performance curves, and packaging, see LM703/C/E data sheet.



Consumer Circuits

LM733/LM733C

LM733/LM733C differential video amp

general description

The LM733/LM733C is a two-stage, differential input, differential output, wide-band video amplifier. The use of internal series-shunt feedback gives wide bandwidth with low phase distortion and high gain stability. Emitter-follower outputs provide a high current drive, low impedance capability. Its 120 MHz bandwidth and selectable gains of 10, 100, and 400, without need for frequency compensation, make it a very useful circuit for memory element drivers, pulse amplifiers, and wide band linear gain stages.

The LM733 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The LM733C is specified for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

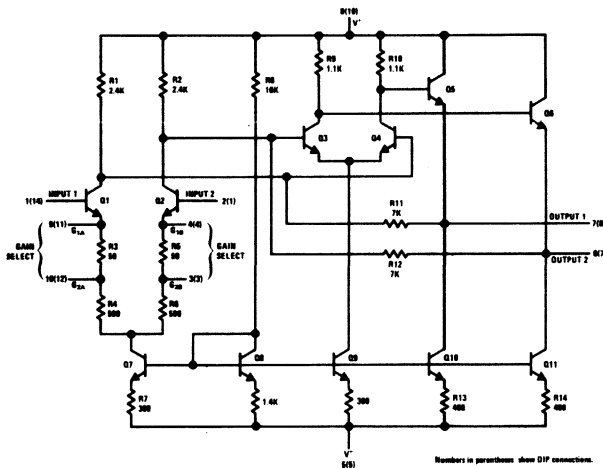
features

- 120 MHz bandwidth
- 250 k Ω input resistance
- Selectable gains of 10, 100, 400
- No frequency compensation
- High common mode rejection ratio at high frequencies.

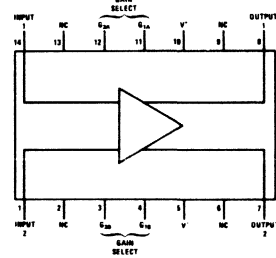
applications

- Magnetic tape systems
- Disk file memories
- Thin and thick film memories
- Woven and plated wire memories
- Wide band video amplifiers.

schematic and connection diagrams



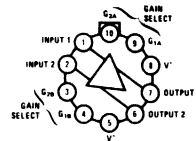
Dual-In-Line Package



Order Number LM733D or LM733CD
See Package 1

Order Number LM733CN
See Package 22

Metal Can Package

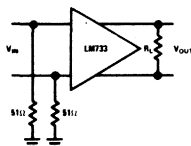


NOTE: Pin 5 connected to case
TOP VIEW

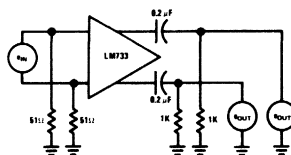
Order Number LM733H or LM733CH
See Package 14

test circuits

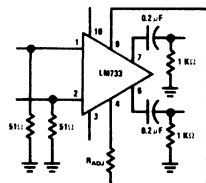
Test Circuit 1



Test Circuit 2



Voltage Gain Adjust Circuit



$V_{cc} = +5\text{V}$
 $T_a = 25^{\circ}\text{C}$
(Pin numbers apply to TO-8 package.)

5

absolute maximum ratings

Differential Input Voltage	±5V
Common Mode Input Voltage	±6V
V _{CC}	±8V
Output Current	10 mA
Power Dissipation (Note 1)	500 mW
Junction Temperature	+150°C
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range LM733	-55°C to +125°C
LM733C	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C, unless otherwise specified, see test circuits, V_S = ±6.0V)

CHARACTERISTICS	TEST CIRCUIT	TEST CONDITIONS	LM733			LM733C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Differential Voltage Gain									
Gain 1 (Note 2)	1	R _L = 2 kΩ V _{OUT} = 3 V _{PP}	300	400	500	250	400	600	
Gain 2 (Note 3)			90	100	110	80	100	120	
Gain 3 (Note 4)			9.0	10	11	8.0	10	12	
Bandwidth									
Gain 1	2			40			40		MHz
Gain 2				90			90		MHz
Gain 3				120			120		MHz
Rise Time									
Gain 1	2	V _{OUT} = 1 V _{PP}		10.5			10.5		ns
Gain 2				4.5	10		4.5	12	ns
Gain 3				2.5			2.5		ns
Propagation Delay									
Gain 1	2	V _{OUT} = 1 V _{PP}		7.5			7.5		ns
Gain 2				6.0	10		6.0	10	ns
Gain 3				3.6			3.6		ns
Input Resistance									
Gain 1				4.0			4.0		kΩ
Gain 2			20	30		10	30		kΩ
Gain 3				250			250		kΩ
Input Capacitance		Gain 2		2.0			2.0		pF
Input Offset Current				0.4	3.0		0.4	5.0	μA
Input Bias Current				9.0	20		9.0	30	μA
Input Noise Voltage		BW = 1 kHz to 10 MHz		12			12		μVrms
Input Voltage Range	1		±1.0			±1.0			V
Common Mode Rejection Ratio									
Gain 2	1	V _{CM} = ±1V f ≤ 100 kHz	60	86		60	86		dB
Gain 2		V _{CM} = ±1V f = 5 MHz	60			60			dB
Supply Voltage Rejection Ratio									
Gain 2	1	ΔV _S = ±0.5V	50	70		50	70		dB
Output Offset Voltage									
Gain 1	1	R _L = ∞		0.6	1.5		0.6	1.5	V
Gain 2 and 3				0.35	1.0		0.35	1.5	V
Output Common Mode Voltage	1	R _L = ∞	2.4	2.9	3.4	2.4	2.9	3.4	V
Output Voltage Swing	1	R _L = 2k	3.0	4.0		3.0	4.0		
Output Sink Current			2.5	3.6		2.5	3.6		mA
Output Resistance				20			20		Ω
Power Supply Current	1	R _L = ∞		18	24		18	24	mA

electrical characteristics

(The following specifications apply for $-55^{\circ}\text{C} < T_A < 125^{\circ}\text{C}$ for the LM733 and $0^{\circ}\text{C} < T_A < 70^{\circ}\text{C}$ for the LM733C, $V_S = \pm 6.0\text{V}$)

CHARACTERISTICS	TEST CIRCUIT	TEST CONDITIONS	LM733			LM733C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Differential Voltage Gain									
Gain 1			200		600	250		600	
Gain 2	1	$R_L = 2\text{ k}\Omega, V_{OUT} = 3 V_{PP}$	80		120	80		120	
Gain 3			8.0		12.0	8.0		12.0	
Input Resistance Gain 2			8			8		$\text{k}\Omega$	
Input Offset Current					5		6	μA	
Input Bias Current					40		40	μA	
Input Voltage Range	1		± 1			± 1		V	
Common Mode Rejection Ratio									
Gain 2	1	$V_{CM} = \pm 1\text{V}, f \leq 100\text{ kHz}$	50			50		dB	
Supply Voltage Rejection Ratio									
Gain 2	1	$\Delta V_S = \pm 0.5\text{V}$	50			50		dB	
Output Offset Voltage									
Gain 1	1	$R_L = \infty$			1.5		1.5	V	
Gain 2 and 3					1.2		1.5	V	
Output Voltage Swing	1	$R_L = 2\text{k}$	2.5			2.8		V_{PP}	
Output Sink Current			2.2			2.5		mA	
Power Supply Current	1	$R_L = \infty$			27		27	mA	

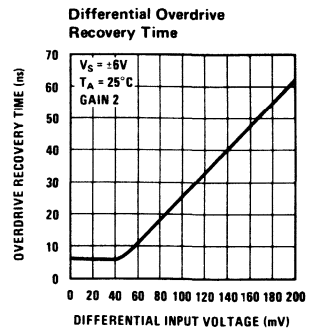
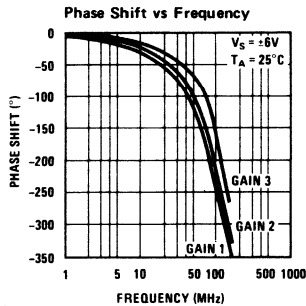
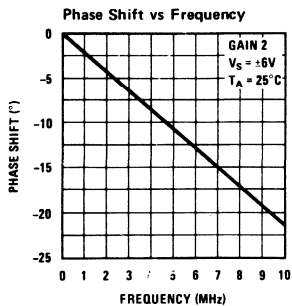
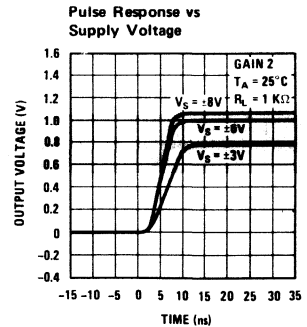
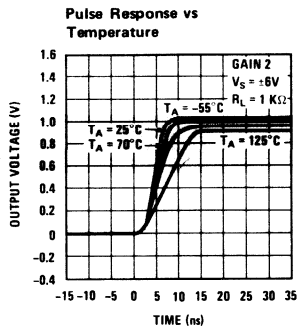
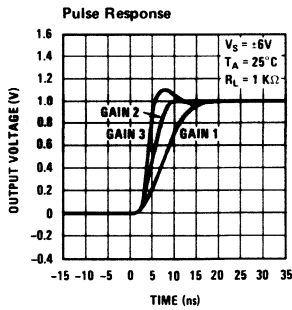
Note 1: The maximum junction temperature of the LM733 is 150°C , while that of the LM733C is 100°C . For operation at elevated temperatures, devices in the TO-100 package must be derated based on a thermal resistance of $150^{\circ}\text{C}/\text{W}$ junction to ambient or $45^{\circ}\text{C}/\text{W}$ junction to case. Thermal resistance of the dual-in-line package is $100^{\circ}\text{C}/\text{W}$.

Note 2: Pins G1A and G1B connected together.

Note 3: Pins G2A and G2B connected together.

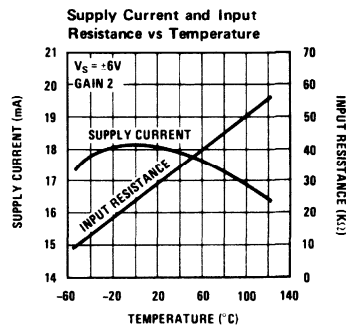
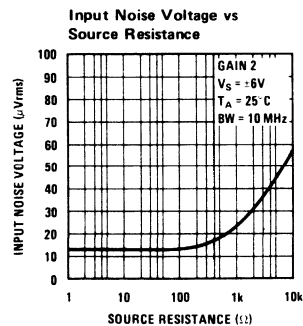
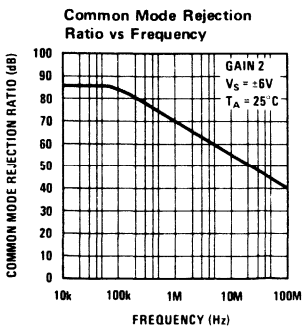
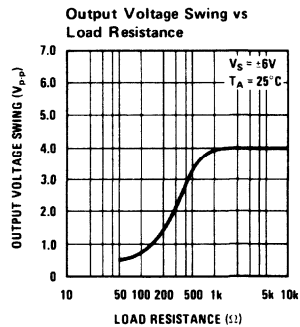
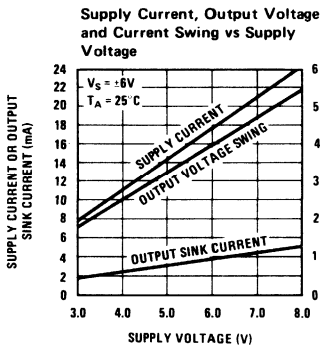
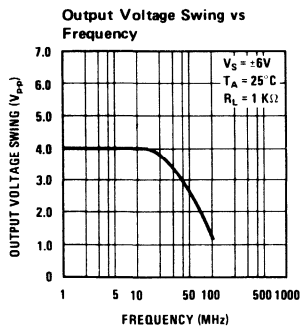
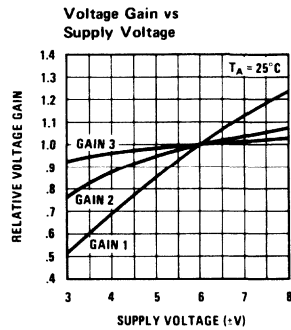
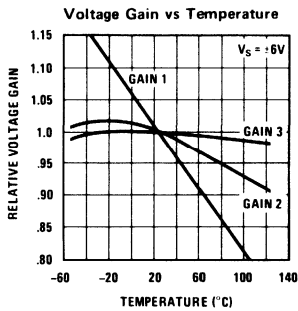
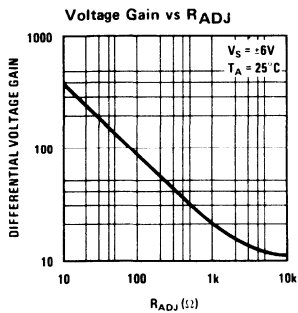
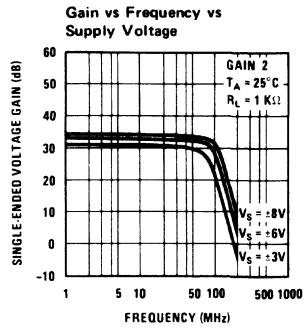
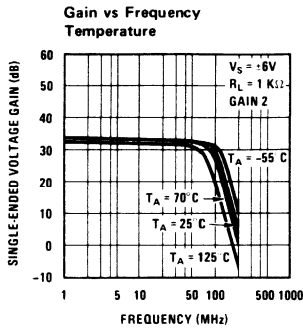
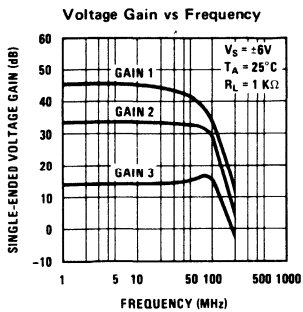
Note 4: Gain select pins open.

typical performance characteristics



5

typical performance characteristics (con't)





Consumer Circuits

LM746 color television chroma demodulator general description

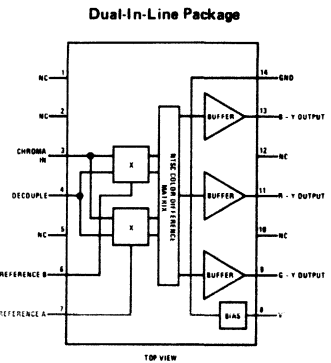
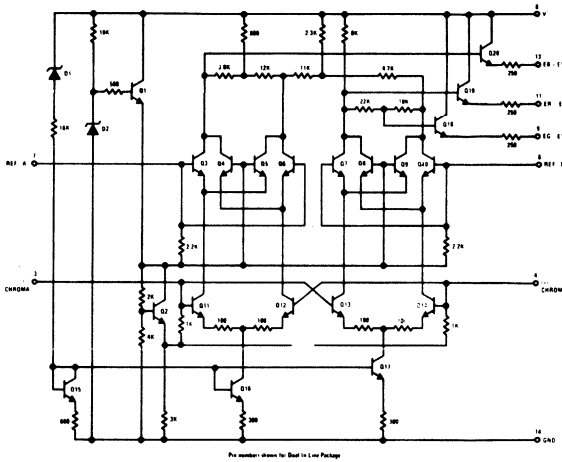
The LM746 is a monolithic silicon integrated circuit which demodulates the chroma subcarrier information contained in a color television video signal and provides color-difference signals at the outputs

The low DC voltage drift of the outputs insures excellent performance in direct-coupled chrominance output circuitry.

features

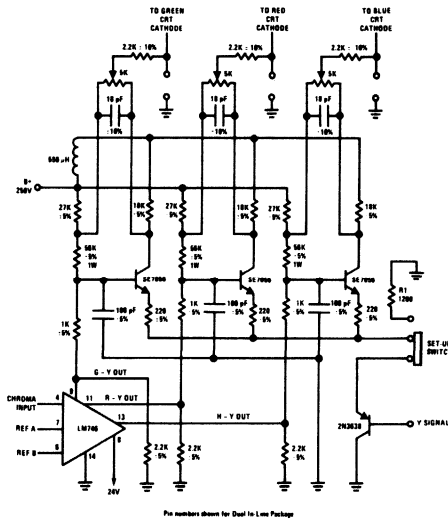
- Low output voltage drift with temperature
- Doubly balanced demodulation
- Internal color-difference matrix for NTSC color television
- 10V peak-to-peak $E_B - E_Y$ output

schematic and block diagrams

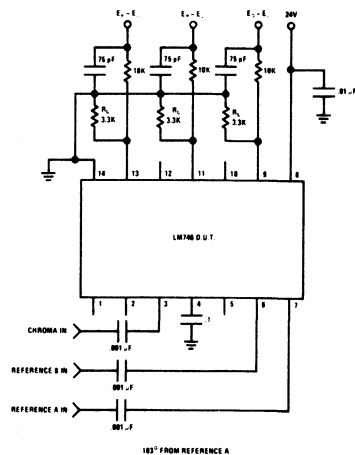


Order Number LM746N or LM746N-01
See Packages 22 and 24

typical application



test circuit 1



absolute maximum ratings

Power Dissipation
 $T_A = 70^\circ\text{C}$ or less
 $T_A = 70^\circ\text{C}$ or more

450 mW
 Derate Linearly
 8.2 mW/ $^\circ\text{C}$
 0°C to $+70^\circ\text{C}$

Storage Temperature
 Supply Voltage
 Reference Input Volt (p-p)
 Chroma Input Voltage (p-p)

-65°C to $+150^\circ\text{C}$
 +30V
 5V
 5V

electrical characteristics ($T_A = 25^\circ\text{C}$) ($V_{CC} = 24\text{V}$) ($R_L = 3.3\text{k}$)

PARAMETER	SYMBOL	TEST CKT	CONDITIONS	MIN	TYP	MAX	UNITS
STATIC							
Supply Current	I_S	1	$e_C = 0$ $R_L = 1\text{M}$	5.5	9.0	12.5	mA
Supply Current	I_S	1	$e_C = 0$ $R_L = 1\text{M}$ $T_A = 70^\circ\text{C}$		9.0	13.0	mA
Supply Current	I_S	1	$e_C = 0$ $R_L = 3.3\text{k}$	16.5	22	25.5	mA
Supply Current	I_S	1	$e_C = 0$ $R_L = 3.3\text{k}$ $T_A = 70^\circ\text{C}$		22		mA
Power Dissipation	P_D	1	$e_C = 0$		340	430	mW
Power Dissipation	P_D	1	$e_C = 0$ $T_A = 70^\circ\text{C}$		340	445	mW
DC Output Volts	V9, V11, V13	1	$e_C = 0$ $R_L = 3.3\text{k}$	13.2	14.5	15.8	V
DC Output Volts	V9, V11, V13	1	$e_C = 0$ $T_A = 70^\circ\text{C}$ $R_L = 3.3\text{k}$	13.0	14.5	16.0	V
Absolute Value of DC Difference Voltage Between any 2 Output Terminals	$|\Delta V_O|$		$e_C = 0$ $R_L = 3.3\text{k}$		.15	.6	V
Temperature Coefficient			$e_C = 0$	-5.0	-3	+5.0	mV/ $^\circ\text{C}$
DYNAMIC							
Chroma Input Voltage Sensitivity	e_C	1	$E_B - E_Y = 5 V_{pp}$		.4	.7	V_{pp}
$E_R - E_Y$ Output Voltage	V11	1	$E_B - E_Y = 5 V_{pp}$	3.5	3.8	4.2	V_{pp}
$E_G - E_Y$ Output Voltage	V9	1	$E_B - E_Y = 5 V_{pp}$	.75	1.0	1.25	V_{pp}
Maximum $E_B - E_Y$ Output Voltage	V13	1	$e_C = 1.5 V_{pp}$	8.0	10.0		V_{pp}
$E_B - E_Y$ Demod Angle Relative to $E_R - E_Y$	$E_R\phi$	1	$E_B - E_Y = 5 V_{pp}$	101	106	111	degrees
$E_B - E_Y$ Demod Angle Relative to $E_G - E_Y$	$E_G\phi$	1	$E_B - E_Y = 5 V_{pp}$	-96	-104	-112	degrees
AC Unbalance @ Any Output Terminal		1	$e_C = 0$		.1	.8	V_{pp}



LM1303 stereo preamplifier

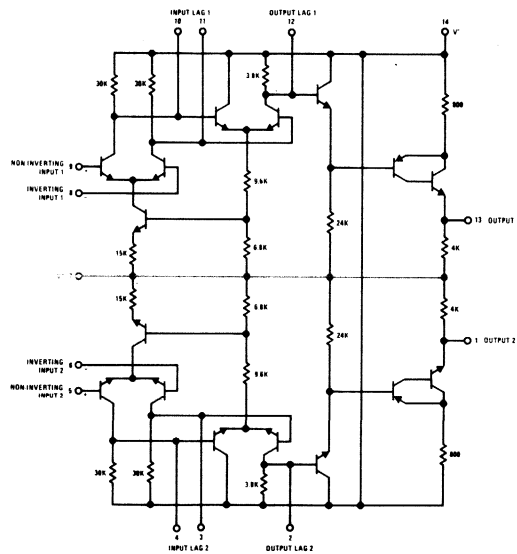
general description

The LM1303 consists of two identical operational amplifiers constructed on a single silicon chip. Intended for amplification of low-level stereo signals, the LM1303 features low input noise voltage, high open-loop voltage gain, large output voltage swing and short circuit protection.

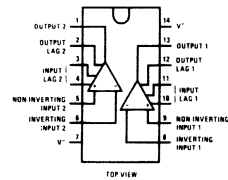
features

- Large Output Voltage Swing 4.0V rms min
- High Open-Loop Voltage Gain 6,000 min
- Channel Separation 60 dB min at 10 kHz

schematic and connection diagrams



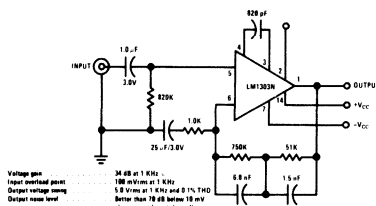
Dual-In-Line Package



Order Number LM1303N
See Package 22

typical application and characteristic

Magnetic Phono Playback Preamplifier/R IAA Equalized



Voltage gain 34 dB at 1 kHz
Input impedance 100 ohms at 1 kHz
Output voltage swing 5.8 Vrms at 1 kHz and 8% THD
Output noise level Better than 78 dB below 10 mV phono input (input referred)

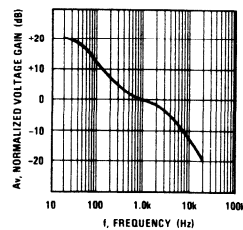


FIGURE 1

absolute maximum ratings

Supply Voltage	±15V
Power Dissipation (Note 1)	415 mW
Operating Temperature Range	0 to 75°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	MIN	TYP	MAX	UNITS
Input Offset Voltage		1.5	10	mV
Input Offset Current		0.2	0.4	μA
Input Bias Current		1.0	10	μA
Supply Current Both Amplifiers $V_{OUT} = 0V$			15	mA
Large Signal Voltage Gain	6,000	10,000		V/V
Channel Separation f = 10 kHz	60	70		dB
Output Voltage Swing $R_L = 10\text{ k}\Omega$	4.0	5.5		V _{rms}

Note 1: The maximum junction temperature of the LM1303 is 100°C. For operating at elevated temperatures, devices must be derated based on a thermal resistance of 150°C/W, junction to ambient.
 Note 2: These specifications apply for $V_S = \pm 13V$ and $T_A = 25^\circ C$, unless otherwise specified.

typical application and characteristic

Tape Head Playback Preamplifier/NAB Equalization

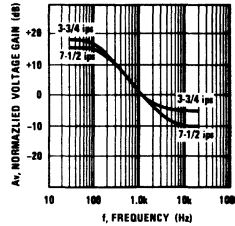
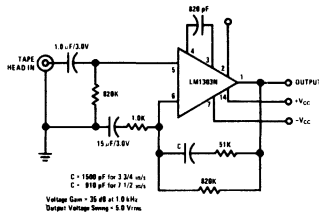
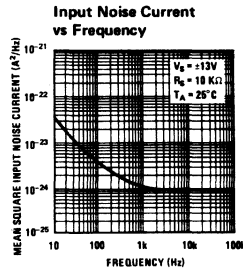
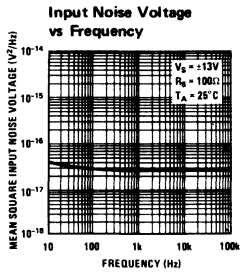


FIGURE 2

typical performance characteristics





Consumer Circuits

LM1304/LM1305/LM1307/LM1307E

LM1304/LM1305/LM1307/LM1307E FM multiplex stereo demodulator

general description

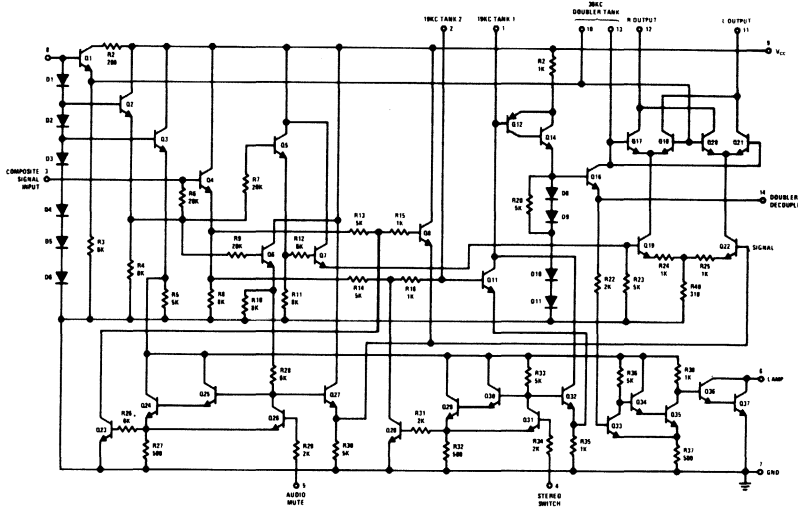
The LM1304, LM1305, LM1307 and LM1307E are designed to derive the left and right channel audio information from the detected composite stereo signal. The LM1304 eliminates the need for an external stereo-channel separation control. The LM1305 is similar to the LM1304 but permits the use of an external stereo-channel separation control for maximum separation. The LM1307 is also similar to the LM1304 but does not have the audio mute control, or the stereo/mono switch. The LM1307E is similar to the LM1307 but has the

option of emitter-follower output drivers for buffers or high current applications.

features

- Operation over a wide power supply range
- Built in stereo-indicator lamp driver — 100 mA typical
- Automatic switching between stereo and monaural
- Audio mute control

circuit schematics



LM1304

Order Number LM1304N
or LM1305N or LM1307N
or LM1307EN
See Package 22

Order Number LM1304N-01
or LM1305N-01 or LM1307N-01
or LM1307EN-01
See Package 24

5

absolute maximum ratings

Power Supply Voltage	+22V
Lamp Driver Current	120 mA
Power Dissipation	625 mW
Derate Above $T_A = +25^\circ\text{C}$	5.0 mW/ $^\circ\text{C}$
Operating Temperature Range (Ambient)	0°C to $+75^\circ\text{C}$
Storage Temperature Range	-65°C to $+150^\circ\text{C}$
Output Current (LM1307E)	25 mA
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics ($V_{CC} = 12\text{V}$, $T_A = 25^\circ\text{C}$, $75\ \mu\text{s}$ de-emphasis unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Impedance	$f = 1\ \text{kHz}$	12	20		$\text{k}\Omega$
Stereo Channel Separation (Note 1) (Note 3)	$f = 100\ \text{Hz}$		35		dB
	$f = 1\ \text{kHz}$	30	45		dB
	$f = 10\ \text{kHz}$		30		dB
Channel Balance	Monaural Input = 200 mV		0.2	1.0	dB
Total Harmonic Distortion (Note 1)	$f_{\text{MOD}} = 1\ \text{kHz}$		0.5	1.0	%
Ultrasonic Frequency Rejection (Note 2)	19 kHz		30		dB
	38 kHz	20	25		dB
Inherent SCA Rejection (Without De-Emphasis)	60 kHz, 67 kHz, 74 kHz		50		dB
Lamp Indicator	$R_A = 180\ \Omega$				
	Min 19 kHz Input Level for Lamp On		16	25	mVrms
	Max 19 kHz Input Level for Lamp Off	5.0	14		mVrms
Power Dissipation	Without Lamp		150	300	mW
Audio Muting (LM1304/5 Only)	Mute On (Pin 5 Voltage)	0.6	.8	1.0	V
	Mute Off (Pin 5 Voltage)	1.3	1.6	2.0	V
	Attenuation in Mute Mode		55		dB
Stereo-Monaural Switching (LM1304/5 Only)	Stereo (Pin 4 Voltage)	1.3	1.6	2.0	V
	Monaural (Pin 5 Voltage)	0.6	.8	1.0	V

Note 1: Measurement made with standard multiplex composite signal. L = 1, R = 0 or L = 0, R = 1; composite signal defined as 564 mV peak to peak (100 mVrms as read on Ballantine 310-A voltmeter) with a 20 mVrms 19 kHz pilot carrier.

Note 2: Referenced to 1 kHz output signal with signal per Note 1.

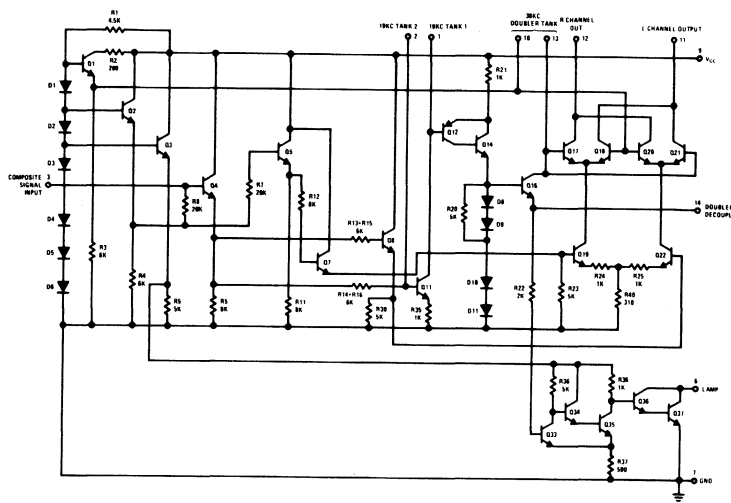
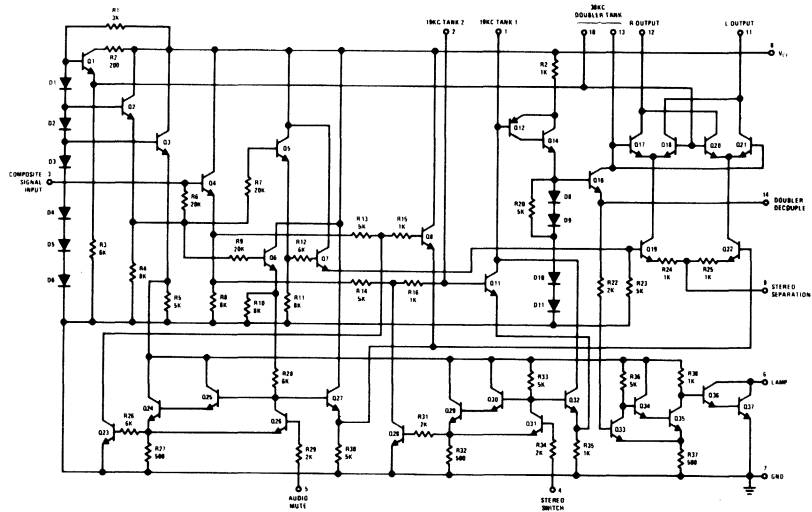
Note 3: Stereo channel separation is adjusted for maximum separation in the LM1305 with a resistor from Pin 9 to GND.

($R_A = 180\ \Omega$, All voltages measured with respect to GND)

($V_{CC} = 12\text{V}$, $2.7\ \text{k}\Omega$ in series w/Pin 8)

Pins	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LM1304	12	2.3	3.0	1.9	1.9	0.8	0	4.6	12	3.9	9.7	9.7	3.9	1.9
LM1305	12	2.3	3.0	1.9	1.9	0.8	0	12	0.36	3.9	9.7	9.7	3.9	1.9
LM1307	12	2.3	3.0	—	—	0.8	0	—	12	3.9	9.7	9.7	3.9	1.9
LM1307E	12	2.3	3.0	—	.8	12	0	9.7	9.0	9.0	9.7	3.9	3.9	1.9

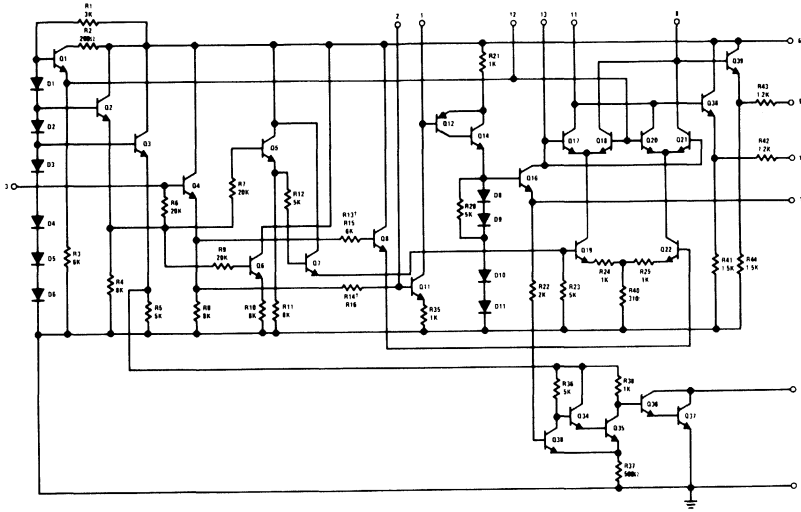
circuit schematics (con't)



LM1304/LM1305/LM1307/LM1307E

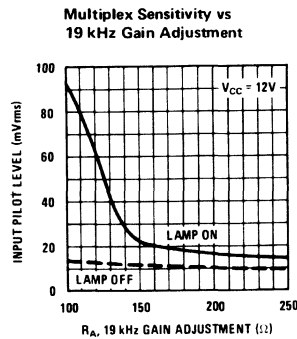
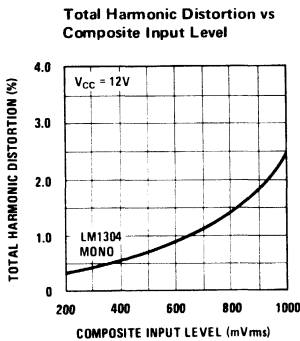
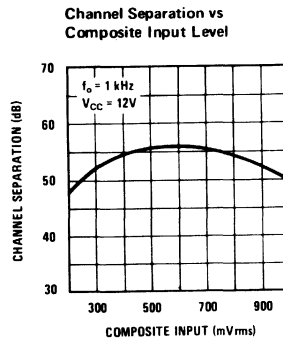
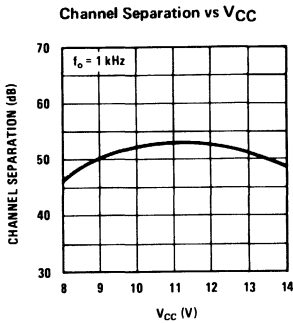
5

circuit schematics (con't)

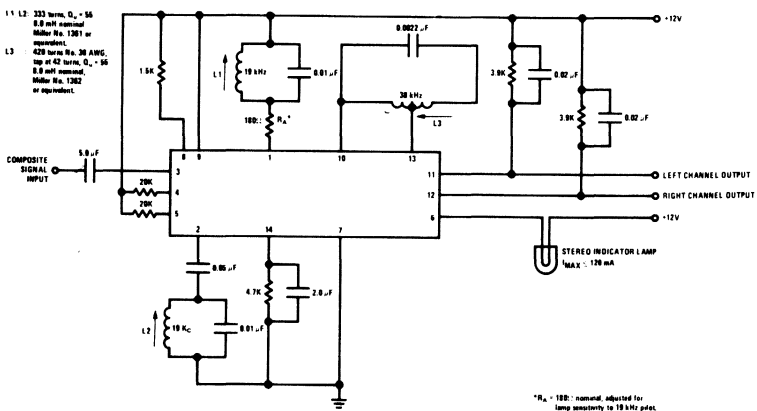


LM1307E

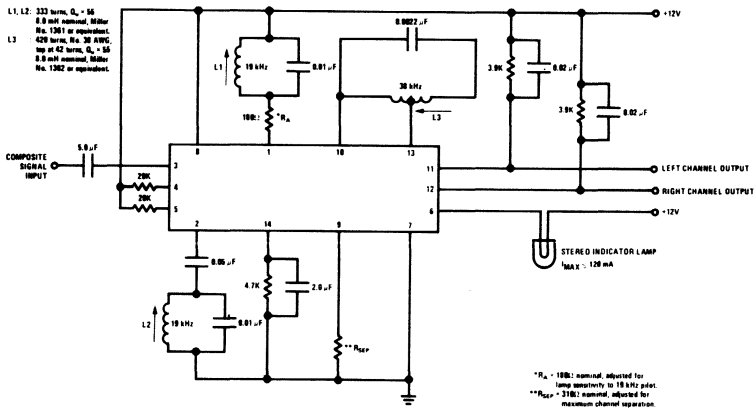
typical performance characteristics



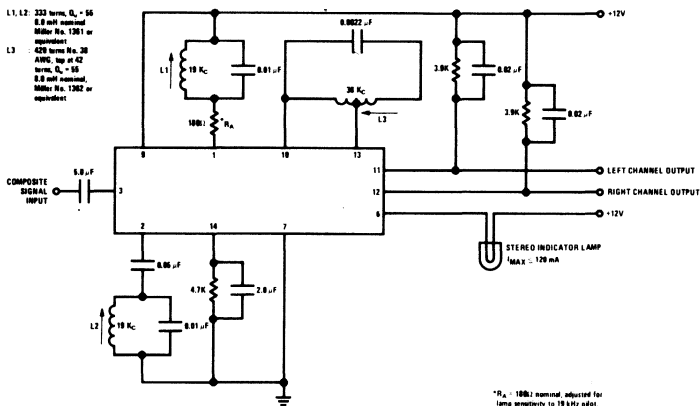
circuit configurations



LM1304 Typical Circuit Configuration

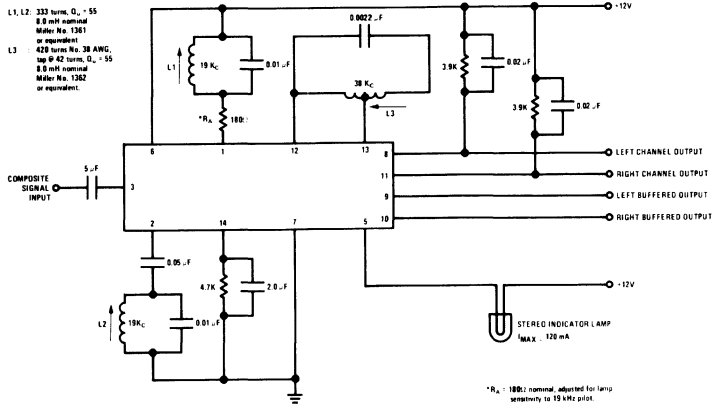


LM1305 Typical Circuit Configuration



LM1307 Typical Circuit Configuration

circuit configurations (con't)



LM1307E Typical Circuit Configuration



Consumer Circuits

LM1310/LM1310E

LM1310/LM1310E phase locked loop FM stereo demodulator general description

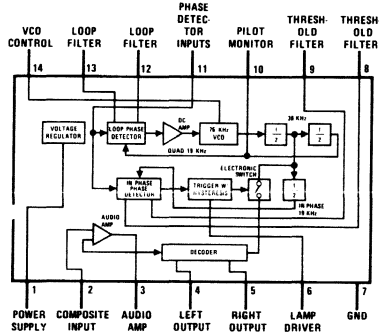
The LM1310 and LM1310E are integrated FM stereo demodulators using phase locked loop techniques to regenerate the 38 kHz subcarrier. The LM1310 is a 14 pin version while the LM1310E offers buffered emitter follower outputs in a 16 pin package. A third version, the LM1800, is also available (see separate data sheet) which adds superb power supply rejection to the basic phase locked decoder circuit. The features available in these integrated circuits make possible a system

delivering high fidelity sound within the cost restraints of inexpensive stereo receivers.

features

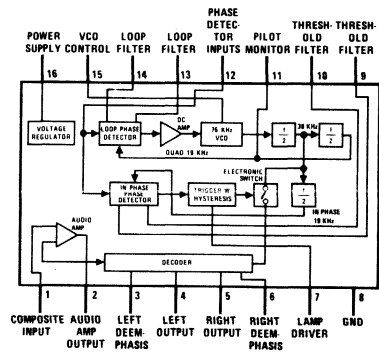
- Automatic stereo/monaural switching
- No coils, all tuning performed with single potentiometer
- Wide supply operating voltage range
- Excellent channel separation
- Emitter follower output buffers (on LM1310E)

connection diagrams



TOP VIEW

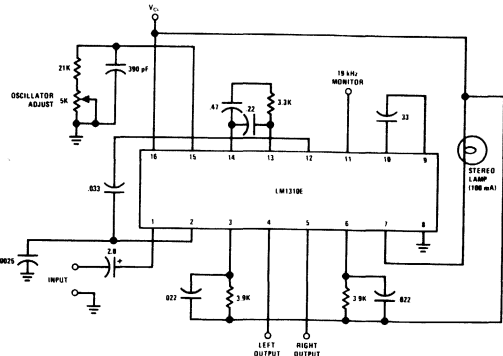
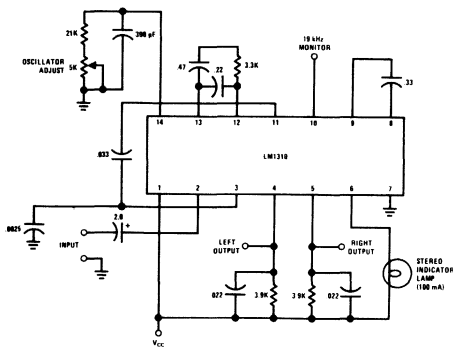
Order Number LM1310EN
See Package 22



TOP VIEW

Order Number LM1310N
See Package 23

typical applications



5

absolute maximum ratings

Supply Voltage	24V
Power Dissipation (Note 3)	575 mW
Operating Temperature Range	0°C to +70°C
Operating Supply Voltage Range	+10V to +24V
Storage Temperature Range	-55°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current					
LM1310E	Lamp "off"		22	30	mA
LM1310	Lamp "off"		19	30	mA
Lamp Driver Saturation	100 mA Lamp Current		1.3	1.8	V
Lamp Driver Leakage			1		nA
Pilot Level for Lamp "on"	Pin 11 Adjusted to 19.00 kHz		16	23	mVrms
Pilot Level for Lamp "off"	Pin 11 Adjusted to 19.00 kHz	3	8		mVrms
Stereo Lamp Hysteresis		3	6		dB
Stereo Channel Separation	100 Hz (Note 2)		40		dB
	1000 Hz (Note 2)	30	45		dB
	10000 Hz (Note 2)		45		dB
Monaural Channel Unbalance	200 mVrms, 1000 Hz Input		.3	1.5	dB
Recovered Audio	200 mVrms, 400 Hz Input	100		190	mVrms
Total Harmonic Distortion	500 mVrms, 1000 Hz Input			1	%
Capture Range	25 mVrms of Pilot	±2		±6	% of f_O
Ultrasonic Freq. Rejection	Combined 19 and 38 kHz, Ref. to Outputs		33		dB
Dynamic Input Resistance		20	45		k Ω
Dynamic Output Resistance	(LM1310E Only)	900	1300	2000	Ω
SCA Rejection	200 mVrms Composite at 67 kHz		50		dB

Note 1: T = 25°C and V⁺ = 12V unless otherwise specified.

Note 2: The stereo input signal is made by summing 123 mVrms LEFT or RIGHT modulated signal with 25 mVrms of 19 kHz pilot tone, measuring all voltages with an average responding meter calibrated in rms. The resulting waveform is about 800 mV_{p-p}.

Note 3: The maximum junction temperature is +125°C and the package should be derated at +175°C/W junction to ambient.



Consumer Circuits

LM1351

LM1351 FM detector, limiter and audio amplifier

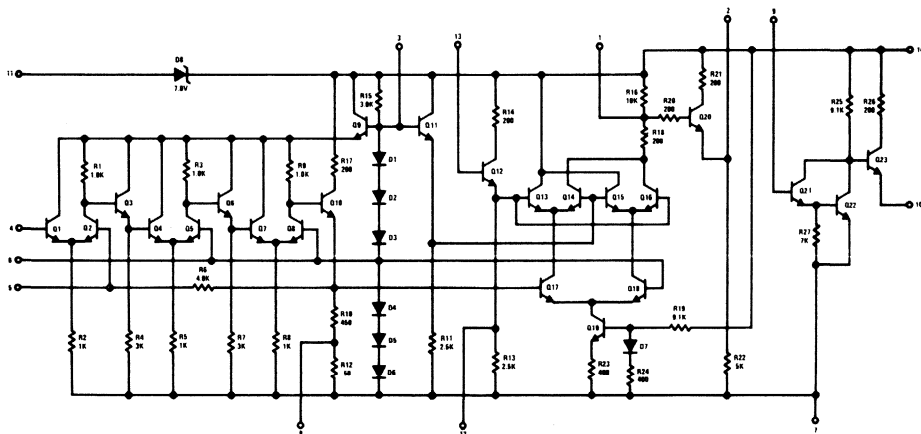
general description

The LM1351 is a monolithic integrated circuit FM detector, limiter and audio amplifier that requires a minimum of external components for operation. It includes three stages of IF limiting and a balanced product detector. The audio amplifier is capable of driving a single external transistor class A-audio output stage.

features

- A direct replacement for MC1351
- Simple detector alignment: one coil or ceramic filter.
- Sensitivity: 3 dB limiting voltage 80 μ V typ.
- Low harmonic distortion
- High IF voltage gain
- High audio preamplifier open loop gain

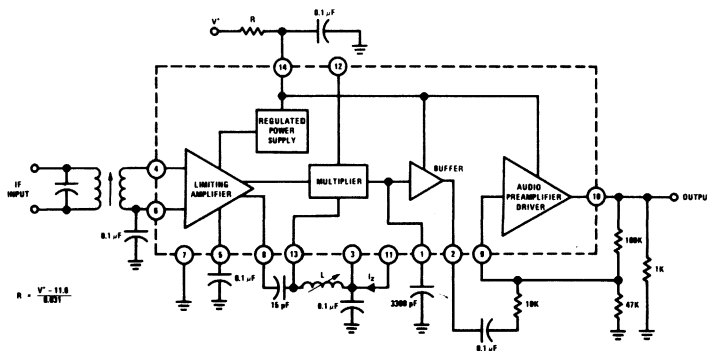
schematic diagram



Order Number LM1351N
See Package 22

Order Number LM1351N-01
See Package 24

block diagram



5

absolute maximum ratings

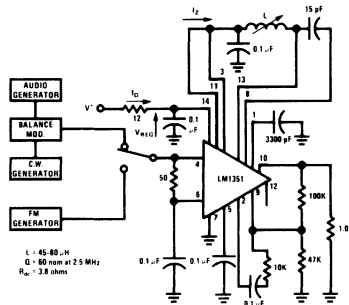
Supply Voltage 16V
 Input Signal Voltage (Pin 4) 0.7 Vrms
 Power Dissipation 850 mW
 $T_A = 25^\circ\text{C}$ or less
 $T_A = 25^\circ\text{C}$ or more Derate Linearly 6.67 mW/ $^\circ\text{C}$

Operating Temperature Range 0°C to 75°C
 Storage Temperature Range -65°C to $+150^\circ\text{C}$
 Lead Temperature (Soldering, 10 sec) 300°C

electrical characteristics ($T_A = 25^\circ\text{C}$, $V_{CC} = 12\text{V}$, unless otherwise noted)

PARAMETER	SYMBOL	CONDITIONS	LIMITS			UNITS
			MIN	TYP	MAX	
STATIC CHARACTERISTICS						
Supply Current	I_{14}	$I_Z = 5\text{ mA}$		31		mA
Power Dissipation	P_D	$I_Z = 5\text{ mA}$		300	375	mW
Nominal Zener Voltage	V_{14}	$I_Z = 5\text{ mA}$		11.6		V
DYNAMIC CHARACTERISTICS $f_0 = 4.5\text{ MHz}$, $\Delta F = \pm 25\text{ kHz}$, unless otherwise noted						
Amplifier Voltage Gain	$A_{V(IF)}$	$V_{IN} \leq 0.3\text{ mVrms}$		65		dB
Audio Preamplifier	$A_{V(AF)}$	$V_{IN} = 500\text{ mV} @ 400\text{ Hz}$		40		dB
Open Loop Gain						
Input Limiting Threshold	$V_{IN(LIM)}$	FM = 400 Hz		80	160	μVrms
Recovered Audio Output	$V_{O(AF)}$		0.35	0.50		Vrms
Recovered Audio Output	$V_{O(AF)}$	$f_0 = 5.5\text{ MHz}$, $AF = \pm 50\text{ kHz}$		0.8		Vrms
Total Harmonic Distortion	T_{HD}	$Q_L = 24$, $\Delta f = 7.5\text{ kHz}$		1.0		%
Maximum Undistorted		$Q_L = 24$				
Audio Output Voltage	$V_{O(MAX)}$	Audio Gain = 10		3.5		Vrms
AM Suppression	AMR	AM: 1 kHz @ 30%, $V_{IN} = 20\text{ mV}$	38	45		dB

test circuit



absolute maximum ratings

Internal Power Dissipation (Note 1)	500 mW
Applied Voltage (Note 2)	30V
Differential Input Signal ($V_7 - V_8$)	$\pm 5.0V$
Differential Input Signal ($V_4 - V_1$)	$\pm(5+I_B R_A)V$
Input Signal ($V_2 - V_1, V_3 - V_4$)	5.0V
Bias Current (I_B)	12 mA
Operating Temperature Range LM1596	$-55^\circ C$ to $+125^\circ C$
LM1496	$0^\circ C$ to $+70^\circ C$
Storage Temperature Range	$-65^\circ C$ to $+150^\circ C$
Lead Temperature (Soldering, 10 sec)	$300^\circ C$

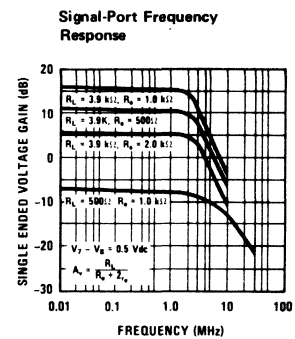
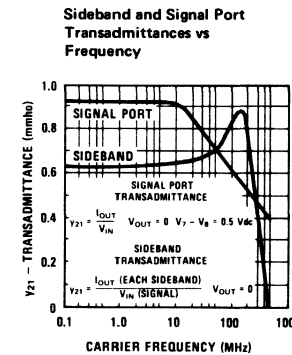
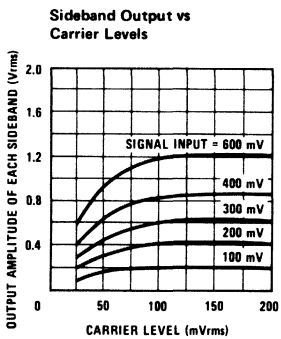
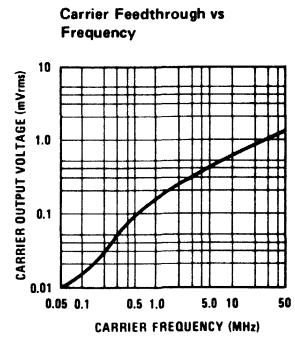
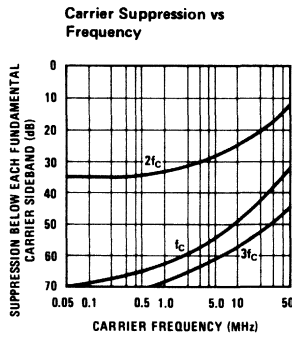
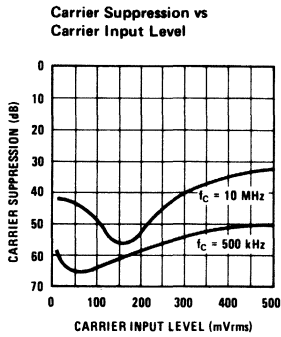
electrical characteristics ($T_A = 25^\circ C$, unless otherwise specified, see test circuit)

PARAMETER	CONDITIONS	LM1596			LM1496			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Carrier Feedthrough	$V_C = 60$ mVrms sine wave $f_C = 1.0$ kHz, offset adjusted		40		40			μV_{rms}
	$V_C = 60$ mVrms sine wave $f_C = 10$ MHz, offset adjusted		140		140			μV_{rms}
	$V_C = 300$ mV _{pp} square wave $f_C = 1.0$ kHz, offset adjusted			0.04 0.2		0.04 0.2		mVrms
	$V_C = 300$ mV _{pp} square wave $f_C = 1.0$ kHz, offset not adjusted		20	100	20	150		mVrms
Carrier Suppression	$f_S = 10$ kHz, 300 mVrms $f_C = 500$ kHz, 60 mVrms sine wave offset adjusted	50	65		50	65		dB
	$f_S = 10$ kHz, 300 mVrms $f_C = 10$ MHz, 60 mVrms sine wave offset adjusted		50			50		dB
Transadmittance Bandwidth	$R_L = 50\Omega$ Carrier Input Port, $V_C = 60$ mVrms sine wave $f_S = 1.0$ kHz, 300 mVrms sine wave		300		300			MHz
	Signal Input Port, $V_S = 300$ mVrms sine wave $V_7 - V_8 = 0.5V_{dc}$		80		80			MHz
Voltage Gain, Signal Channel	$V_S = 100$ mVrms, $f = 1.0$ kHz $V_7 - V_8 = 0.5V_{dc}$	2.5	3.5		2.5	3.5		V/V
Input Resistance, Signal Port	$f = 5.0$ MHz $V_7 - V_8 = 0.5 V_{dc}$		200		200			k Ω
Input Capacitance, Signal Port	$f = 5.0$ MHz $V_7 - V_8 = 0.5 V_{dc}$		2.0		2.0			pF
Single Ended Output Resistance	$f = 10$ MHz		40		40			k Ω
Single Ended Output Capacitance	$f = 10$ MHz		5.0		5.0			pF
Input Bias Current	$(I_1 + I_4)/2$		12	25	12	30		μA
Input Bias Current	$(I_7 + I_8)/2$		12	25	12	30		μA
Input Offset Current	$(I_1 - I_4)$		0.7	5.0	0.7	5.0		μA
Input Offset Current	$(I_7 - I_8)$		0.7	5.0	5.0	5.0		μA
Average Temperature Coefficient of Input Offset Current	$(-55^\circ C < T_A < +125^\circ C)$ $(0^\circ C < T_A < +70^\circ C)$		2.0			2.0		nA/ $^\circ C$ nA/ $^\circ C$
Output Offset Current	$(I_6 - I_9)$		14	50	14	60		μA
Average Temperature Coefficient of Output Offset Current	$(-55^\circ C < T_A < +125^\circ C)$ $(0^\circ C < T_A < +70^\circ C)$		90			90		nA/ $^\circ C$ nA/ $^\circ C$
Signal Port Common Mode Input Voltage Range	$f_S = 1.0$ kHz		5.0		5.0			V _{pp}
Signal Port Common Mode Rejection Ratio	$V_7 - V_8 = 0.5 V_{dc}$		-85		-85			dB
Common Mode Quiescent Output Voltage			8.0		8.0			V _{dc}
Differential Output Swing Capability			8.0		8.0			V _{pp}
Positive Supply Current	$(I_6 + I_9)$		2.0	3.0	2.0	3.0		mA
Negative Supply Current	(I_{10})		3.0	4.0	3.0	4.0		mA
Power Dissipation			33		33			mW

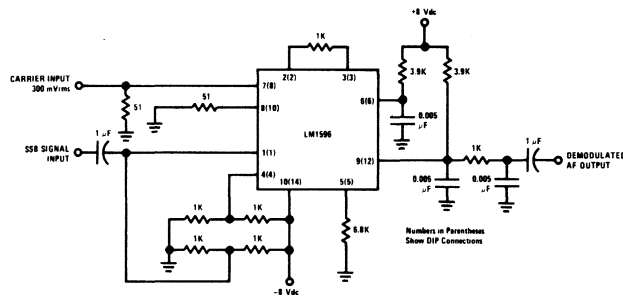
Note 1: LM1596 rating applies to case temperatures to $+125^\circ C$; derate linearly at 6.5 mW/ $^\circ C$ for ambient temperature above $75^\circ C$. LM1496 rating applies to case temperatures to $+70^\circ C$.

Note 2: Voltage applied between pins 6-7, 8-1, 9-7, 9-8, 7-4, 7-1, 8-4, 6-8, 2-5, 3-5.

typical performance characteristics



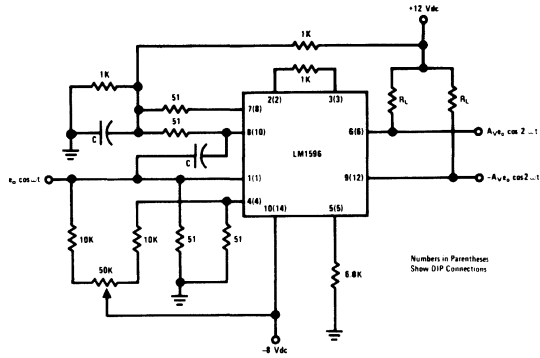
typical applications (con't)



SSB Product Detector

This figure shows the LM1596 used as a single sideband (SSB) suppressed carrier demodulator (product detector). The carrier signal is applied to the carrier input port with sufficient amplitude for switching operation. A carrier input level of 300 mVrms is optimum. The composite SSB signal is applied to the signal input port with an amplitude of 5.0 to 500 mVrms. All output signal components except the desired demodulated audio are filtered out, so that an offset adjustment is not required. This circuit may also be used as an AM detector by applying composite and carrier signals in the same manner as described for product detector operation.

typical applications (con't)



Broadband Frequency Doubler

The frequency doubler circuit shown will double low-level signals with low distortion. The value of C should be chosen for low reactance at the operating frequency.

Signal level at the carrier input must be less than 25 mV peak to maintain operation in the linear region of the switching differential amplifier. Levels to 50 mV peak may be used with some distortion of the output waveform. If a larger input signal is available a resistive divider may be used at the carrier input, with full signal applied to the signal input.



Consumer Circuits

LM1800

LM1800 phase locked loop FM stereo demodulator

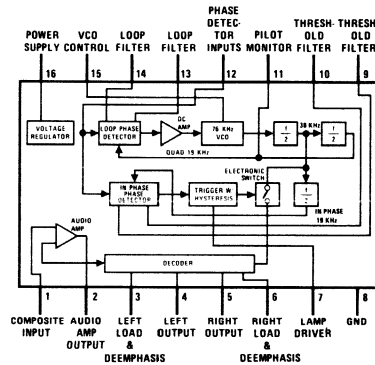
general description

The LM1800 is a second generation integrated FM stereo demodulator using phase locked loop techniques to regenerate the 38 kHz subcarrier. The numerous features integrated on the die make possible a system delivering high fidelity sound while still meeting the cost requirements of inexpensive stereo receivers.

features

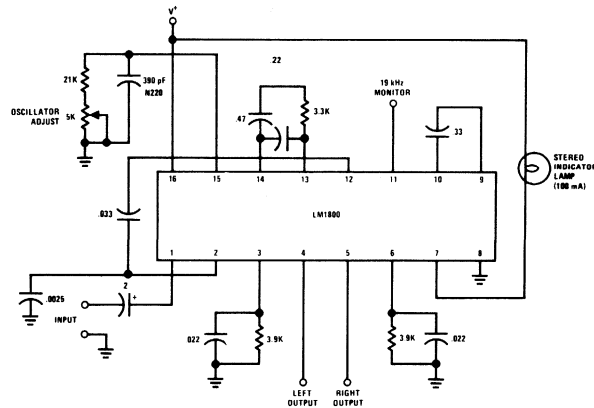
- Automatic stereo/monaural switching
- 45 dB power supply rejection
- No coils, all tuning performed with single potentiometer
- Wide operating supply voltage range
- Excellent channel separation
- Emitter follower output buffers

connection diagram



TOP VIEW
Order Number LM1800N
See Package 23

typical application



5

absolute maximum ratings

Supply Voltage	24V
Power Dissipation (Note 3)	575 mW
Operating Temperature Range	0°C to +70°C
Operating Supply Voltage Range	+10V to +24V
Storage Temperature Range	-55°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current	Lamp "off"		21	30	mA
Lamp Driver Saturation	100 mA Lamp Current		1.3	1.8	V
Lamp Driver Leakage			1		nA
Pilot Level for Lamp "on"	Pin 11 Adjusted to 19.00 kHz		16	23	mVrms
Pilot Level for Lamp "off"	Pin 11 Adjusted to 19.00 kHz	3	8		mVrms
Stereo Lamp Hysteresis		3	6		dB
Stereo Channel Separation	100 Hz (Note 2)		40		dB
	1000 Hz (Note 2)	30	45		dB
	10000 Hz (Note 2)		45		dB
Monaural Channel Unbalance	200 mVrms, 1000 Hz Input		.3	1.5	dB
Recovered Audio	200 mVrms, 400 Hz Input	140		260	mVrms
Total Harmonic Distortion	500 mVrms, 1000 Hz Input			1	%
Capture Range	25 mVrms of Pilot	±2		±6	% of f_o
Supply Ripple Rejection	600 mVrms of 200 Hz Ripple	35	45		dB
Dynamic Input Resistance		20	45		kΩ
Dynamic Output Resistance		900	1300	2000	Ω
SCA Rejection	200 mVrms composite at 67 kHz		50		dB
Ultrasonic Freq. Rejection	Combined 19 and 38 kHz, Ref. to Output		33		dB

Note 1: T = 25°C and V⁺ = 12V unless otherwise specified.

Note 2: The stereo input signal is made by summing 123 mVrms LEFT or RIGHT modulated signal with 25 mVrms of 19 kHz pilot tone, measuring all voltages with an average responding meter calibrated in rms. The resulting waveform is about 800 mV_{p-p}.

Note 3: The maximum junction temperature is +125°C and the package should be derated at +175°C/W junction to ambient.



Consumer Circuits

LM1820

LM1820 AM radio system

general description

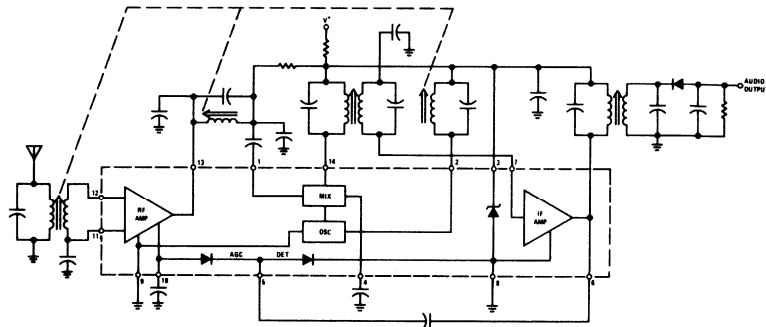
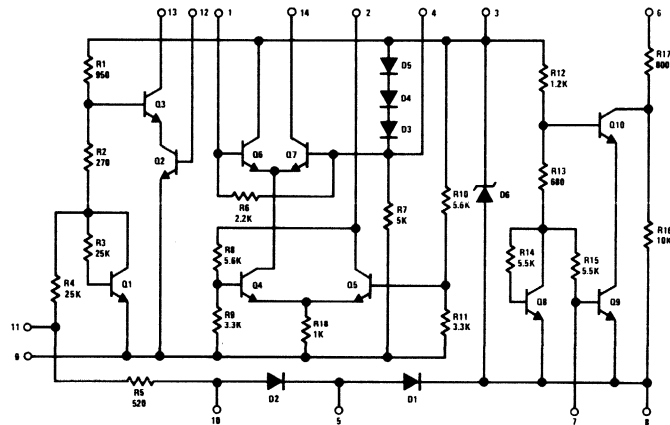
The LM1820 is a monolithic integrated circuit AM radio system. It includes two amplifiers a mixer-oscillator; an AGC detector and a zener regulator.

- Separately accessible amplifiers
- Regulated supply
- AGC for RF stage

features

- Overvoltage protection

schematic and block diagrams



Order Number LM1820N
See Package 22

5



Consumer Circuits

LM1841

LM1841 FM detector and limiter

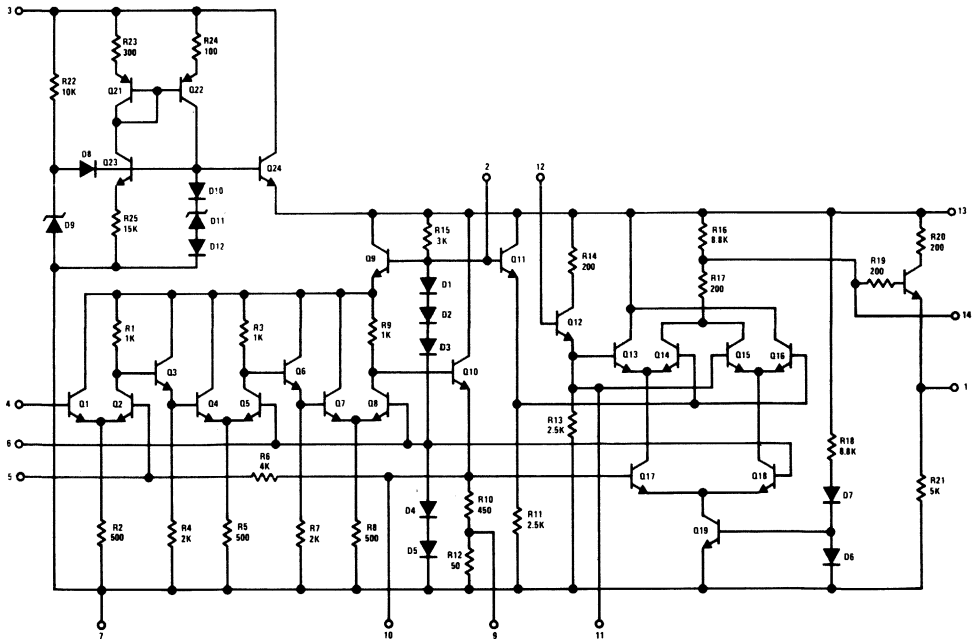
general description

The LM1841 is a monolithic integrated circuit FM detector and limiter that requires a minimum of external components for operation. It includes three stages of IF limiting, a balanced product detector and a 7.8V regulator.

features

- A direct replacement for ULN2136A
- Simple detector alignment: one coil
- Sensitivity: 3 dB limiting voltage 300 μ V typ.
- Low harmonic distortion
- High IF voltage gain
- Regulated 7.8V output

schematic diagram



Order Number LM1841N
See Package 22

5

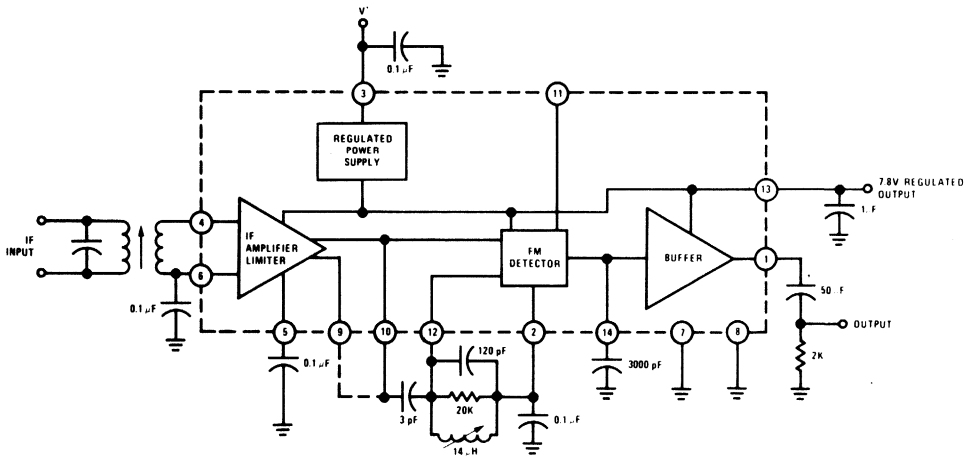
absolute maximum ratings

Supply Voltage	20V
Input Signal Voltage (Pin 4)	3.5V
Power Dissipation	
$T_A = 25^\circ\text{C}$ or Less	850 mW
$T_A = 25^\circ\text{C}$ or More	Derate Linearly 6.67 mW/ $^\circ\text{C}$
Operating Temperature Range	-25°C to $+85^\circ\text{C}$
Storage Temperature Range	-65°C to $+150^\circ\text{C}$
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics ($T_A = 25^\circ\text{C}$, $V^+ = 12\text{V}$ unless otherwise specified)

PARAMETER	CONDITIONS	LIMITS			UNITS
		MIN	TYP	MAX	
STATIC CHARACTERISTICS (amplifier and detector)					
Supply Current (I_3)	No Load at Pin 13	12	17	22	mA
Amplifier Input Reference (V_6)			1.45		V
Detector Input Reference (V_2)			3.65		V
Amplifier High Output Level (V_{10})		1.25	1.45	1.65	V
Amplifier Low Output Level (V_9)		0.125	0.145		V
Detector Output Level (V_1)		3	3.8	4.6	V
Temperature Stability of Detector Output Level ($\Delta V_1/\Delta T$)			+1		mV/ $^\circ\text{C}$
De-emphasis Resistance (R_d)			8.8		k Ω
STATIC CHARACTERISTICS (regulator)					
Output Voltage (V_{13})	$I_{LOAD} = 20\text{ mA}$		7.8		V
Line Regulation (V_{13})			5	10	mV/V
Temperature Stability (V_{13})			+1.6		mV/ $^\circ\text{C}$
DYNAMIC CHARACTERISTICS $f_0 = 4.5\text{ MHz}$, $\Delta f = \pm 25\text{ kHz}$, Peak Separation = 150 kHz, Source Resistance = 50 Ω					
Amplifier Voltage Gain (A_{VF})	$V_{IN} \leq 0.3\text{ mVrms}$ (Figure 1)		58		dB
Amplifier Output Voltage ($V_{10(F)}$)	$V_{IN} = 10\text{ mV}$ (Figure 1)		1.45		V _{P-P}
Input Limiting Threshold ($V_{IN(LIM)}$)	FM = 400 Hz (Figure 2)		300		μVrms
Recovered Audio Output ($V_{0(alt)}$)	$V_{IN} = 60\text{ mV}$, FM = 400 Hz (Figure 2)		0.5		Vrms
Output Distortion (T_{HD})	100% FM Modulation (Figure 2)		1.5		%
AM Rejection (AMR)	AM: 1 kHz @ 30%, $V_{IN} = 10\text{ mV}$ (Figure 2)		46		dB
DYNAMIC CHARACTERISTICS $f_0 = 10.7\text{ MHz}$, $\Delta f = \pm 75\text{ kHz}$, Peak Separation = 550 kHz, Source Resistance = 50 Ω					
Amplifier Voltage Gain (A_{VF})	$V_{IN} \leq 0.3\text{ mVrms}$ (Figure 1)		53		dB
Amplifier Output Voltage ($V_{10(F)}$)	$V_{IN} = 10\text{ mV}$ (Figure 1)		1.45		V _{P-P}
Input Limiting Threshold ($V_{IN(LIM)}$)	FM = 400 Hz (Figure 2)		400		μV
Recovered Audio Output ($V_{0(alt)}$)	$V_{IN} = 60\text{ mV}$, FM = 400 Hz (Figure 2)		0.3		Vrms
Output Distortion (T_{HD})	100% FM Modulation (Figure 2)		1		%
AM Rejection (AMR)	AM: 1 kHz @ 30%, $V_{IN} = 10\text{ mV}$ (Figure 2)		40		dB

block diagram



test circuits

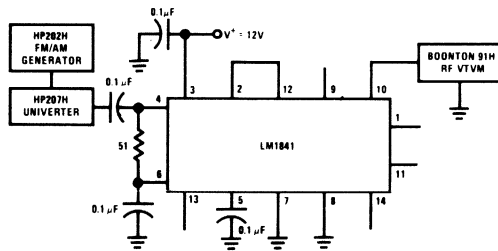


FIGURE 1.

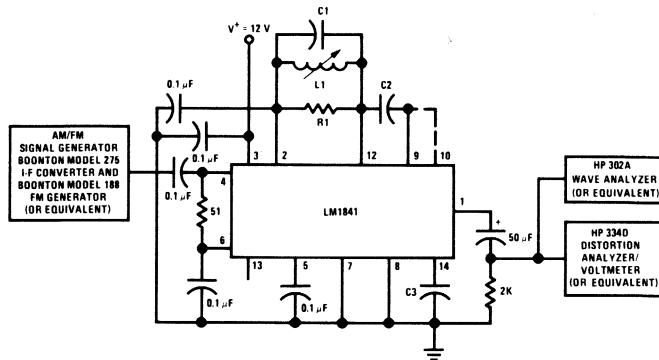


FIGURE 2.

COMPONENT VALUES

f	L1	C1	R1	Q(R1,L1)	C2	C3
MHz	µH	pF	kΩ		pF	µF
4.5	14	120	20	30	3.0	0.003
5.5	8.0	100	20	30	3.0	0.003
10.7	2.0	120	3.9	20	4.7	0.01



Consumer Circuits

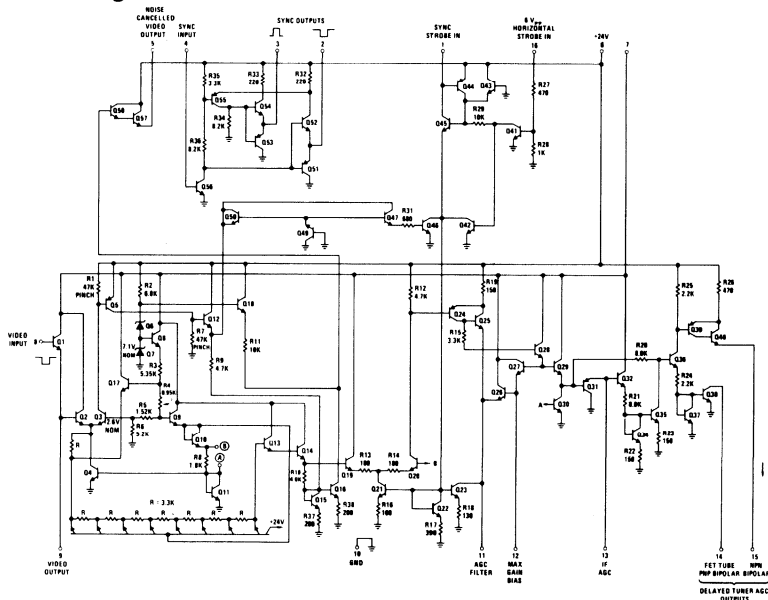
LM1845 signal processing system general description

The LM1845 is a signal processing system for television receivers which performs the functions of AGC and sync separation. It provides both positive and negative going sync signals and includes an internal AGC amplifier with noise cancelling. AGC outputs are available for both IF and tuner.

features

- Low impedance noise cancelled positive and negative going sync outputs
- No noise threshold or AGC detector level adjustment
- Low impedance video output for driving luminance channel or a video output stage
- Two delayed tuner AGC outputs; one for an NPN bipolar tuner and one for a FET, tube, or PNP

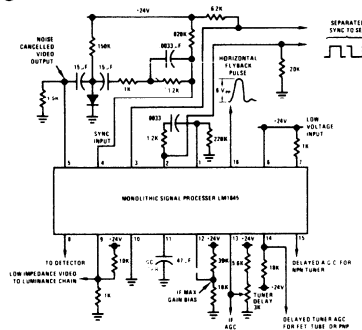
schematic diagram



Order Number LM1845N
See Package 23

Order Number LM1845N-01
See Package 25

typical circuit configuration



absolute maximum ratings

Supply Voltage	30V
Power Dissipation (Note 2)	625 mW
Operating Temperature Range	0°C to 70°C
Storage Temperature Range	-55°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 1)

PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
AGC Threshold		4.65		5.3	V
Threshold Separation			1.7		V
Negative Sync Output (Low)	$I_{P4} = 100 \mu A$			2.5	V
Negative Sync Output (High)	$V_{P4} = 0V$	23.9			V
Positive Sync Output (Low)	$V_{P4} = 0V$			0.1	V
Positive Sync Output (High)	$I_{P4} = 100 \mu A$	20.5			V
AGC Filter Discharge Current			1.70		mA
AGC Filter Charge Current			20		mA
Reverse Tuner AGC Maximum Current			3.2		mA
Forward Tuner AGC Maximum Current			9.8		mA
Internal AC Coupled Noise Gate Lockout Interval		1		55	μs
Supply Current	1 Kohm between P6 and P7		10		mA

Note 1: $T = 25^{\circ}C$ and $V_{CC} = 24V$.

Note 2: The maximum junction temperature of the LM1845 is 125°C. For operating at elevated temperatures the derating factor is 175°C/W junction to ambient.



Consumer Circuits

LM2111 FM detector and limiter

general description

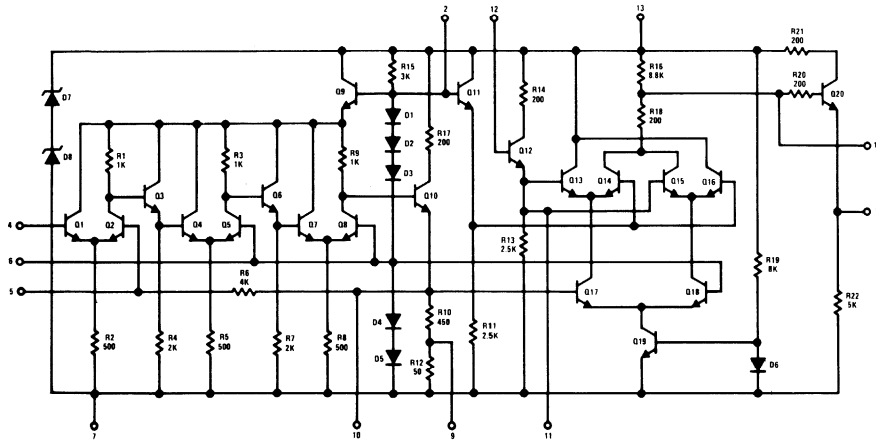
The LM2111 is a monolithic integrated circuit FM detector and limiter that requires a minimum of external components for operation. It includes three stages of IF limiting and a balanced product detector.

features

- A direct replacement for ULN2111A and MC1357

- Simple detector alignment: one coil or ceramic filter
- Sensitivity: 3 dB limiting voltage 300 μ V typ.
- Low harmonic distortion
- High IF voltage gain

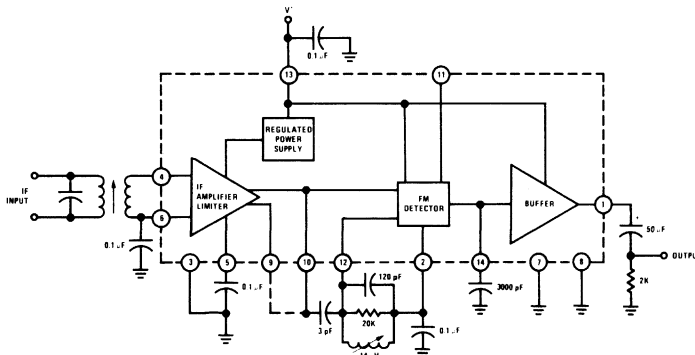
schematic diagram



Order Number LM2111N
See Package 22

Order Number LM2111N-01
See Package 24

block diagram



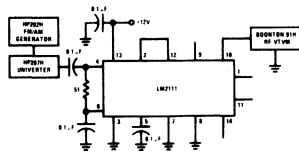
absolute maximum ratings

Supply Voltage	15V	Operating Temperature Range	0°C to +85°C
Input Signal Voltage (Pin 4)	3.5V	Storage Temperature Range	-65°C to +150°C
Power Dissipation	850 mW	Lead Temperature (Soldering, 10 sec)	300°C
T _A = 25°C or less			
T _A = 25°C or more	Derate Linearly 6.67 mW/°C		

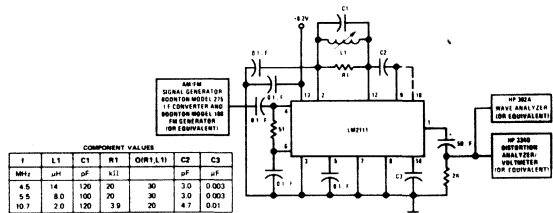
electrical characteristics (T_A = 25°C, V_{CC} = 12V)

PARAMETER	SYMBOL	TEST CIRCUIT	CONDITIONS	LIMITS			UNITS
				MIN	TYP	MAX	
STATIC CHARACTERISTICS							
Supply Current	I ₁₃			12	17	22	mA
Amplifier Input Reference	V ₆				1.45		V
Detector Input Reference	V ₂				3.65		V
Amplifier High Output Level	V ₁₀			1.25	1.45	1.65	V
Amplifier Low Output Level	V ₉			0.125	0.145	0.20	V
Detector Output Level	V ₁			4.3	5.0	5.7	V
De-emphasis Resistance	R _d			7.2	8.8	10.8	kΩ
DYNAMIC CHARACTERISTICS f ₀ = 4.5 MHz ΔF = ±25 kHz, Peak Separation = 15.0 kHz, Source Resistance = 50Ω							
Amplifier Voltage Gain	A _{IF}	1	V _{IN} ≤ 0.3 mVrms	55	58		dB
Amplifier Output Voltage	V _{10(IF)}	1	V _{IN} = 10 mV	1.25	1.45		V _{p-p}
Input Limiting Threshold	V _{IN(LIM)}	2	FM = 400 Hz		400	800	μVrms
Recovered Audio Output	V _{O(aF)}	2	V _{IN} = 60 mV, FM = 400 Hz	0.5	0.6		Vrms
Output Distortion	T _{HD}	2	100% FM Modulation		1.5		%
AM Suppression	AMR	2	AM: 1 kHz @ 30%, V _{IN} = 10 mV	40	46		dB
DYNAMIC CHARACTERISTICS f ₀ = 10.7 MHz, ΔF = ±75 kHz, Peak Separation = 1 MHz, Source Resistance = 50Ω							
Amplifier Voltage Gain	A _{IF}	1	V _{IN} ≤ 0.3 mVrms		53		dB
Amplifier Output Voltage	V _{10(IF)}	1	V _{IN} = 10 mV		1.45		V _{p-p}
Input Limiting Threshold	V _{IN(LIM)}	2	FM = 400 Hz		300		μVrms
Recovered Audio Output	V _{O(aF)}	2	V _{IN} = 60 mV, FM = 400 Hz		0.3		Vrms
Output Distortion	T _{HD}	2	100% FM Modulation		0.3		%
AM Suppression	AMR	2	AM: 1 kHz @ 30%, V _{IN} = 10 mV		40		dB

test circuit



TEST CIRCUIT 1



TEST CIRCUIT 2





Consumer Circuits

LM2113 FM detector and limiter

general description

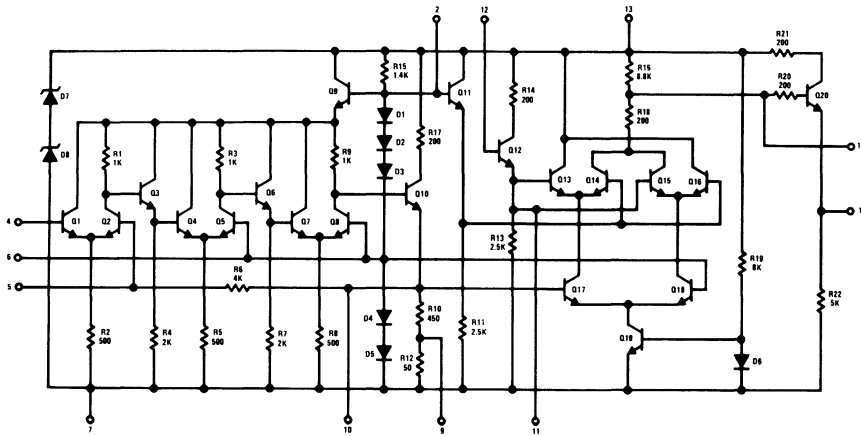
The LM2113 is a monolithic integrated circuit FM detector and limiter that requires a minimum of external components for operation. It includes three stages of IF limiting and a balanced product detector.

features

- A direct replacement for ULN 2113A

- Simple detector alignment: one coil or ceramic filter
- Sensitivity: 3 dB limiting voltage 300 μ V typ.
- Low harmonic distortion
- High IF voltage gain
- Nominal 8V supply

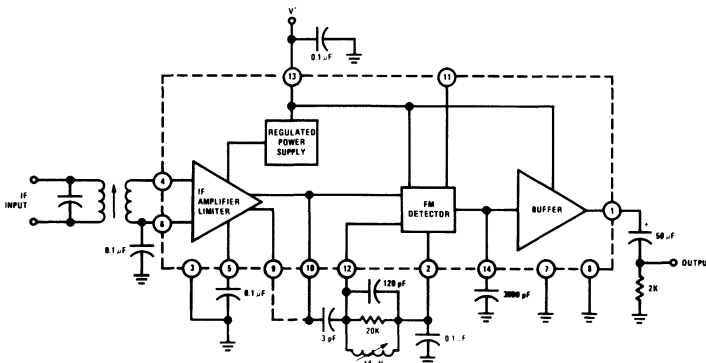
schematic diagram



Order Number LM2113N
See Package 22

Order Number LM2113N-01
See Package 24

block diagram



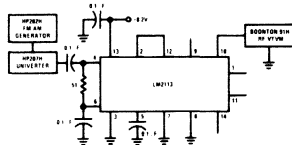
absolute maximum ratings

Supply Voltage	14V	Operating Temperature Range	0°C to +85°C
Input Signal Voltage (Pin 4)	3.5V	Storage Temperature Range	-65°C to +150°C
Power Dissipation	850 mW	Lead Temperature (Soldering, 10 sec)	300°C
$T_A = 25^\circ\text{C}$ or less $T_A = 25^\circ\text{C}$ or more	Derate Linearly 6.67 mW/°C		

electrical characteristics (T_A = 25°C, V_{CC} = 8.2V)

PARAMETER	SYMBOL	TEST CIRCUIT	CONDITIONS	LIMITS			UNITS
				MIN	TYP	MAX	
STATIC CHARACTERISTICS							
Supply Current	I ₁₃			11	16	22	mA
Amplifier Input Reference	V ₆				1.45		V
Detector Input Reference	V ₂				3.65		V
Amplifier High Output Level	V ₁₀			1.25	1.45	1.65	V
Amplifier Low Output Level	V ₉			0.125	0.145	0.20	V
Detector Output Level	V ₁			3.0	3.8	4.5	V
De-emphasis Resistance	R _d			7.2	8.8	10.8	kΩ
DYNAMIC CHARACTERISTICS f ₀ = 4.5 MHz, Δf = ±25 kHz, Peak Separation = 150 kHz, Source Resistance = 50Ω							
Amplifier Voltage Gain	A _{1F}	1	V _{IN} < 0.3 mVrms		58		dB
Amplifier Output Voltage	V _{10(IF)}	1	V _{IN} = 10 mV		1.45		V _{D-P}
Input Limiting Threshold	V _{IN(LIM)}	2	FM = 400 Hz		300		μVrms
Recovered Audio Output	V _{O(a)}	2	V _{IN} = 60 mV, FM = 400 Hz		0.5		Vrms
Output Distortion	T _{HD}	2	100% FM Modulation		1.5		%
AM Suppression	AMR	2	AM: 1 kHz @ 30%, V _{IN} = 10 mV		46		dB
DYNAMIC CHARACTERISTICS f ₀ = 10.7 MHz, Δf = ±75 kHz, Peak Separation = 550 kHz, Source Resistance = 50Ω							
Amplifier Voltage Gain	A _{1F}	1	V _{IN} < 0.3 mVrms		53		dB
Amplifier Output Voltage	V _{10(IF)}	1	V _{IN} = 10 mV		1.45		V _{D-P}
Input Limiting Threshold	V _{IN(LIM)}	2	FM = 400 Hz	230	300	500	μV
Recovered Audio Output	V _{O(a)}	2	V _{IN} = 60 mV, FM = 400 Hz	0.3	0.4	0.5	Vrms
Output Distortion	T _{HD}	2	100% FM Modulation		1.0		%
AM Suppression	AMR	2	AM: 1 kHz @ 30%, V _{IN} = 10 mV		40		dB

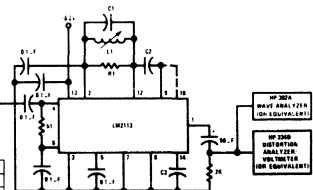
test circuits



TEST CIRCUIT 1

COMPONENT VALUES

f	L1	C1	R1	Q1(RLH)	C2	C3
4.5	14	120	20	30	3.0	0.003
5.5	8.0	100	20	30	3.0	0.003
10.7	2.0	120	3.0	20	4.7	0.01



TEST CIRCUIT 2



Consumer Circuits

LM3011 wide band amplifier

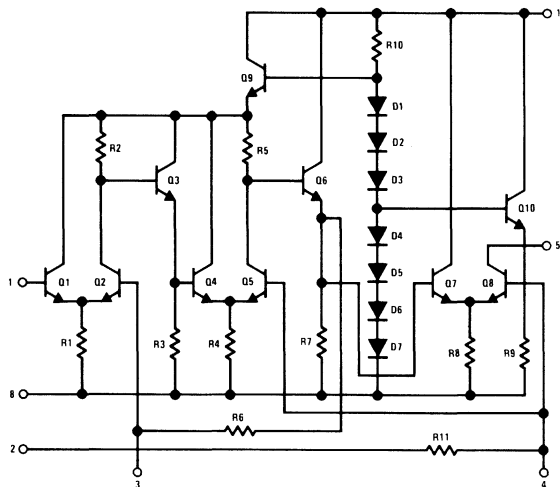
general description

The LM3011 is a monolithic wide band amplifier circuit that requires a minimum of external components for operation. It includes three stages of limiting.

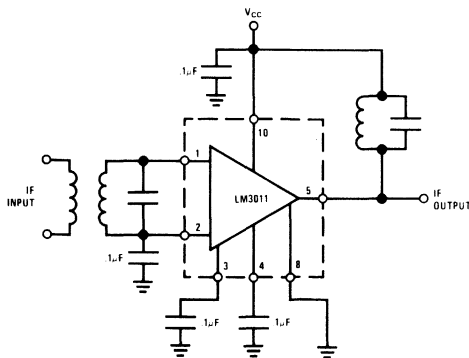
features

- A direct replacement for CA3011
- High amplifier gain
- Excellent limiting characteristics
- Wide frequency capability

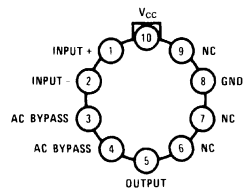
schematic diagram



block diagram



connection diagram



Order Number LM3011H
See Package 12

absolute maximum ratings

Supply Voltage	15V	Operating Temperature Range	-55°C to +125°C
Input Signal (P _{in})	±3V	Storage Temperature Range	-65°C to +150°C
Power Dissipation	300 mW	Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (T_A = 25°C)

PARAMETER	CONDITIONS	LIMITS			UNITS
		MIN	TYP	MAX	
STATIC CHARACTERISTICS					
Total Device Dissipation (P _T)	V _{CC} = 6V (Figure 1)	60	90	133	mW
Total Device Dissipation (P _T)	V _{CC} = 7.5V (Figure 1)	95	120	187	mW
DYNAMIC CHARACTERISTICS V _{CC} = 7.5V, F = 4.5 MHz, unless otherwise noted					
Voltage Gain (A)	V _{CC} = 6V, f = 1 MHz (Figure 2)	60	66		dB
Voltage Gain (A)	V _{CC} = 7.5V, f = 1 MHz (Figure 2)	65	70		dB
Voltage Gain (A)	V _{CC} = 7.5V, f = 10.7 MHz (Figure 2)	55	61		dB
Parallel Input Resistance (R _{IN})			3		kΩ
Parallel Input Capacitance (C _{IN})			7		pF
Parallel Output Resistance (R _{OUT})			31.5		kΩ
Parallel Output Capacitance (C _{OUT})			4.2		pF
Noise Figure (NF)			8.7		dB
Input Limiting Voltage (V _{IN(LIMIT)})	(-3 dB) (Figure 2)		300	400	μV

test circuits

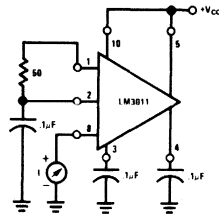


FIGURE 1

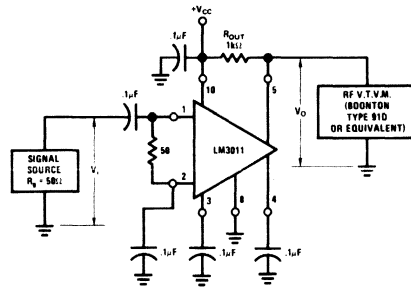


FIGURE 2



Consumer Circuits

LM3028A/LM3028B/LM3053 differential rf/lf amplifier

general description

The LM3028A/LM3028B/LM3053 is a monolithic RF/IF amplifier intended for emitter-coupled (differential) or cascode amplifier operation from DC to 120 MHz in industrial and communications equipment. The LM3028A/LM3028B and LM3053 are plug-in replacements for the CA3028A/CA3028B and CA3053 respectively. The LM3028B is similar to the LM3028A but has premium performance with tighter limits in offset voltage and current, bias current and voltage gain. The LM3053 is similar to the LM3028A/LM3028B but is recommended for IF amplifier operation with less critical DC parameters.

features

- Controlled for input offset voltage, input offset current, and input bias current*
- Balanced differential amplifier configuration with controlled constant-current source to provide unexcelled versatility

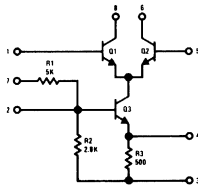
- Single- and dual-ended operation
- Operation from DC to 120 MHz*
- Balanced-AGC capability*
- Wide operating-current range.

*Does not apply to the LM3053.

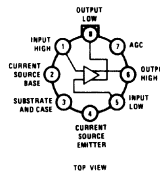
applications

- RF and IF linear amplifiers, both differential and cascode
- Mixers
- Oscillators
- Converters in commercial FM
- DC, audio and sense amplifiers
- Limiting IF amplifiers
- Hybrid building block
- Emitter coupled switches

schematic and connection diagrams

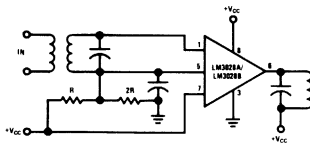


Metal Can Package

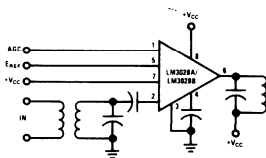


Order Number LM3028AH or
LM3028BH or LM3053H
See Package 11

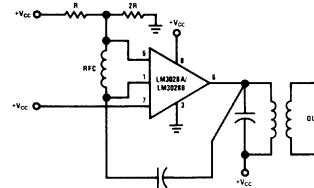
typical applications



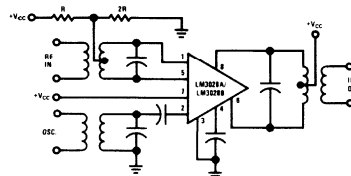
A Balanced Differential Amplifier with a Controlled
Constant-Current-Source Drive and AGC Capability



A Cascode Amplifier with a Constant-Impedance
AGC Capability



Oscillator



Mixer

absolute maximum ratings

	LM3028A LM3028B	LM3053		
Supply Operating Voltage	-15V	+12V	Storage Temperature	-65 C to 200° C
Differential Input Voltage	-5V	-5V	Operating Temperature	-55 C to 125° C
Voltage Between 1 & 8	0V to +20V	0V to +15V	Power Dissipation @ 25° C	450 mW
Voltage Between 5 & 6	0V to +20V	0V to +15V	Derate 5 mW/°C Above 85° C	
Voltage Between 2 & 3	-5V to -11V	+5V to -11V	Lead Temperature (Soldering, 10 sec)	300 C
Voltage Between 2 & 4	-5V to -1V	+5V to -1V		

dc electrical characteristics

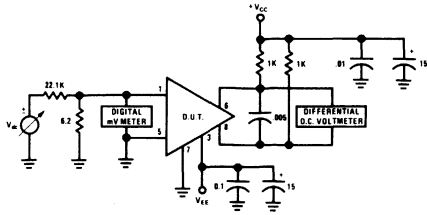
	SYMBOL	TEST CIRCUIT	V _{CC}	V _{EE}	LM3028A			LM3028B			LM3053			UNITS	
					MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX		
Input Offset Voltage	V _{OS}	A	6 12	-6 -12			5.0 5.0		0.4 0.4	2.0 2.0			mV mV		
Input Offset Current	I _{OS}	B	6 12	-6 -12			5.0 5.0		0.15 0.25	2.0 2.0			µA µA		
Input Bias Current	I _{BIAS}	B B C C	6 12 12 12	-6 -12 - -		7.5 17	5.0 106		7.5 17	4.0 80			µA µA µA µA		
Output Quiescent Operating Current	I _Q	B B C C	6 12 9 12	-6 -12 - -	0.9 2.3	1.25 3.15	2.0 5.0	1.1 2.5	1.25 3.15	1.5 4.0		1.2 2.3	2.2 3.15	3.5 5.0	mA mA
AGC Bias Current into Terminal 7	I _{AGC}	D D	12 12	V _{AGC} =9V V _{AGC} =12V			1.1 1.5		1.1 1.5					1.05 1.45	mA mA mA
Input Current into Terminal 7	I ₇	B B	6 12	-6 -12	0.5 1.0	0.7 1.5	1.1 2.2	0.5 1.0	0.7 1.5	1.1 2.2					mA mA
Power Dissipation	P _D	B B C C	6 12 9 12	-6 -12 - -	24 120	35 170	54 260	24 120	35 170	42 220			48 91	80 150	mW mW mW mW

ac electrical characteristics

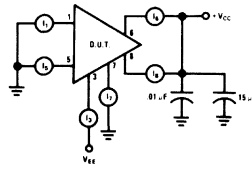
	SYMBOL	TEST CIRCUIT	V _{CC}	V _{EE}	LM3028A			LM3028B			LM3053			UNITS
					MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
100 MHz Power Gain	A _p	E(Cascode) F(Diff.)	9 9	- -	17 14.5	22 18.5		17 14.5	22 18.5					dB dB
10.7 MHz Power Gain	A _p	E(Cascode) F(Diff.)	9 9	- -	36 29	42 33.5		36 29	42 33.5					dB dB
100 MHz Noise Figure	NF	E(Cascode) F(Diff.)	9 9	- -		6.7 5.9	9.0 9.0		6.7 5.9	9.0 9.0				dB dB
Input Admittance at 10.7 MHz	Y ₁₁	Cascode Diff.	+9 +9	- -	0.5+j1.3 0.4-j0.58			0.5+j1.3 0.4-j0.58				0.5+j1.3 0.4-j0.58		mmho mmho
Reverse Transadmittance at 10.7 MHz	Y ₁₂	Cascode Diff.	+9 +9	- -	0.2+j0 10+j0.2			0.2+j0 10+j0.2				0.2+j0 10+j0.2		µmho µmho
Forward Transadmittance at 10.7 MHz	Y ₂₁	Cascode Diff.	+9 +9	- -	95-j27 -32+j1.5			95-j27 -32+j1.5				95-j27 -32+j1.5		mmho mmho
Output Admittance at 10.7 MHz	Y ₂₂	Cascode Diff.	+9 +9	- -	0+j100 20+j160			0+j100 20+j160				0+j100 20+j160		µmho µmho
Output Power (Untuned) at 10.7 MHz	P _o	G	+9	-		5.7			5.7			5.7		µW
AGC Range at 10.7 MHz	F		+9	-		76			76			76		dB
Voltage Gain at 10.7 MHz	A _v	H(Cascode) I(Diff.)	+9 +9	- -		40 30			40 30			40 30		dB dB
Differential 1 kHz Voltage Gain	A _{vD}	J	6 12	-6 -12				35 40	38 42.5	42 45				dB dB
Maximum Peak to Peak Output Voltage at 1 kHz	V _{MAX OUT, pp}	J R _L =2k J R _L =1.6k	6 12	-6 -12				8 16	11 22					V _{p-p} V _{p-p}
3 dB Bandwidth	BW	J R _L =2k J R _L =1.6k	6 12	-6 -12					11.2 12.7					MHz MHz
Common-Mode Input Voltage Range	V _{CM}	K K	6 12	-6 -12				-2.5 -5	-3.2 to +4.5 -7 to +9	4 7				V V
Common-Mode Rejection Ratio	CMRR	K K	6 12	-6 -12				60 60	110 90					dB dB
Peak to Peak Output Current V _{IN} = 400 mV at 10.7 MHz	I _{p-p}	Diff. Diff.	9 12	- -	2 3.5	4.7 6.5	7 10	2.5 4.5	4.7 6.5	6 8	2 3.5	4.7 6.5	7 10	mA mA



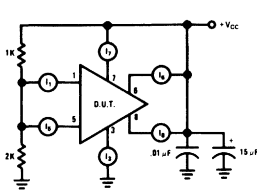
test circuits



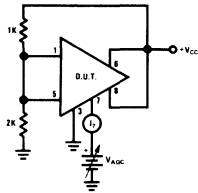
Test Circuit A: VOS LM3028A & LM3028B



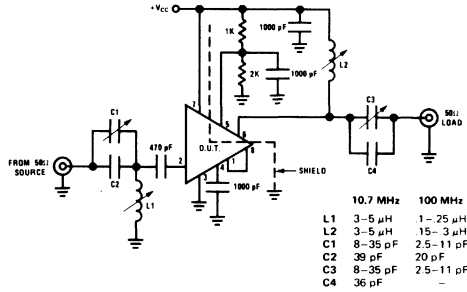
Test Circuit B: I_{QS} , I_{BIAS} , P_D , I_Q & I_7 for LM3028A & LM3028B



Test Circuit C: I_{BIAS} , P_D , I_Q for LM3053

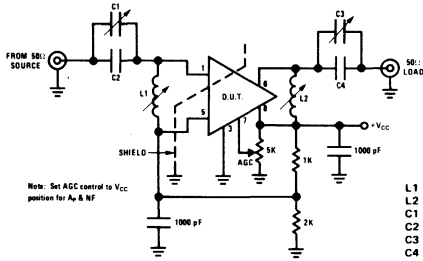


Test Circuit D: I_{AGC} vs V_{AGC} and I_7 for LM3028A & LM3028B



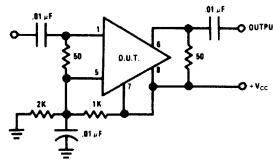
Test Circuit E: Cascode A_p & NF 10.7 MHz & 100 MHz

	10.7 MHz	100 MHz
L1	3-5 μ H	1-25 μ H
L2	3-5 μ H	.15-3 μ H
C1	8-35 pF	2.5-11 pF
C2	39 pF	20 pF
C3	8-35 pF	2.5-11 pF
C4	36 pF	-

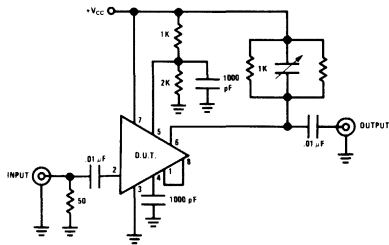


Test Circuit F: Differential A_p , NF and AGC Range, 10.7 MHz & 100 MHz

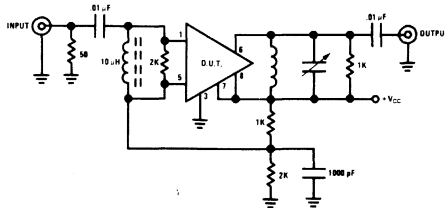
	10.7 MHz	100 MHz
L1	3-6 μ H	2-5 μ H
L2	3-6 μ H	2-.5 μ H
C1	8-35 pF	2.5-11 pF
C2	39 pF	...
C3	8-35 pF	2.5-11 pF
C4	36 pF	-



Test Circuit G: P_O (Untuned) for LM3028A & LM3028B

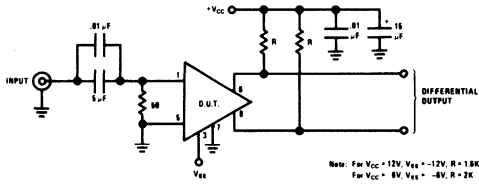


Test Circuit H: Cascode A_V and Transfer Function, 10.7 MHz

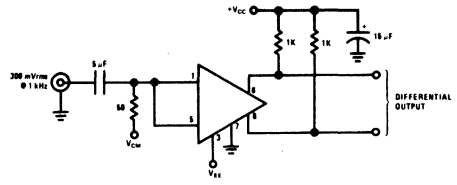


Test Circuit I: Differential Mode A_V and Transfer Function, 10.7 MHz

test circuits (con't)



Test Circuit J: A_v , $V_{OUT, MAX}$, p/p B.W. for LM3028B



Test Circuit K: CMRR and V_{CM} Range for LM3028B



Consumer Circuits

LM3064 television automatic fine tuning

general description

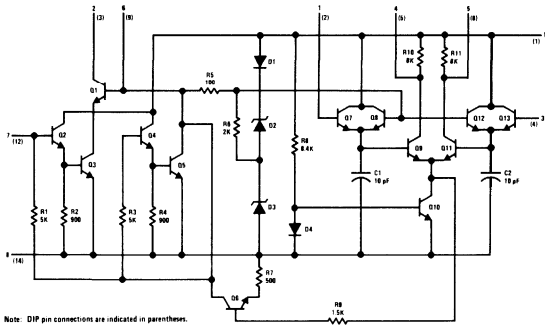
The LM3064 is a monolithic integrated circuit designed primarily for AFT (automatic fine tuning) applications. It includes a zener regulated power supply, IF amp, differential peak detector, and an AGC circuit.

The LM3064 is supplied in both the formed and straight lead TO-5 and 14 lead dual-in-line package.

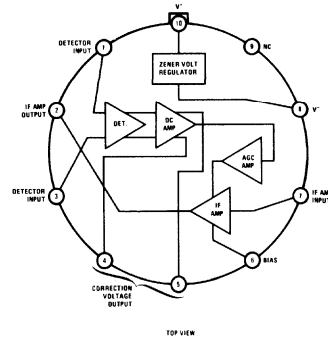
features

- Primarily intended for AFT applications
- High gain input amp (18 mV for rated output)
- Differential output correction voltage
- Wide operating temperature -40°C to $+85^{\circ}\text{C}$
- Formed leads available for easy PC board design

schematic and connection diagrams



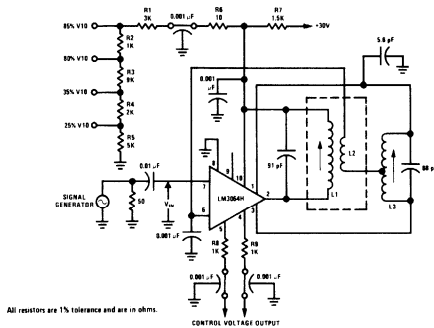
Metal Can Package



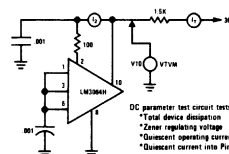
Order Number LM3064H
See Package 14&29

test circuits

Test Circuit 1
Correction Voltage Test Circuit



Test Circuit 2
DC Parameter Test Circuit



absolute maximum ratings

Power Dissipation
 $T_A = 25^\circ\text{C}$ or Less
 $T_A = 25^\circ\text{C}$ or More

700 mW
 Derate Linearly 5.6 mW/ $^\circ\text{C}$ for TO-5
 Derate Linearly 10 mW/ $^\circ\text{C}$ for DIP

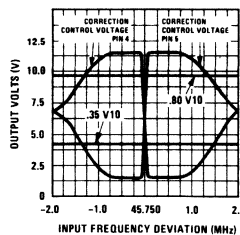
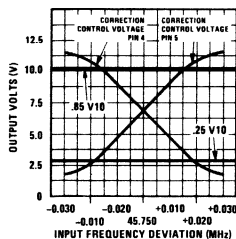
Operating Temperature Range
 Storage Temperature Range
 Power Supply Current

-40°C to $+85^\circ\text{C}$
 -65°C to $+150^\circ\text{C}$
 50 mA

electrical characteristics ($T_A = 25^\circ\text{C}$)

PARAMETER	SYMBOL	TEST CIRCUIT	CONDITIONS	LIMITS		UNITS
				MIN	MAX	
STATIC						
Device Dissipation	P_T	2	$V_{CC} = 30\text{V}; R_S = 1.5\text{k}$	130	150	mW
Current Drain	I_T	2	$V_{I0} = 10.5\text{V}$	4.0	9.5	mA
Zener Regulating Voltage	V_{I0}	2	$V_{CC} = 30\text{V}; R_S = 1.5\text{k}$	10.9	12.8	V
Quiescent Current into Pin 2	I_2	2	$V_{CC} = 30\text{V}; R_S = 1.5\text{k}$	1	4	mA
Quiescent Voltage at Pin 4	V_4	1	$V_{CC} = 30\text{V}; R_S = 1.5\text{k}$	5.0	8.0	V
Quiescent Voltage at Pin 5	V_5	1	$V_{CC} = 30\text{V}; R_S = 1.5\text{k}$	5.0	8.0	V
Output Offset Voltage between Pins 4 & 5	$V_4 - V_5$	1	$V_{CC} = 30\text{V}; R_S = 1.5\text{k}$	-1.0	+1.0	V
DYNAMIC – Output Voltage vs Frequency Deviation AFT						
Correction Control Voltage at Pin 4	V_4	1	$V_{CC} = 30\text{V}; R_S = 1.5\text{k}$ $V_i = 18\text{mV}$	Correction Voltage as Shown Below		V
				% of V_{I0}	% of V_{I0}	
Correction Control Voltage at Pin 5 See Curves	V_5	1	$V_{CC} = 30\text{V}; R_S = 1.5\text{k}$ $V_i = 18\text{mV}$	85	25	V
				80	35	V
				80	80	V
				35	80	V
				85	25	V
				35	35	V
				80	80	V
				35	80	V
				85	25	V
				80	35	V
				35	80	V
				80	80	V

correction control voltage



coil winding data

COIL DATA FOR DISCRIMINATOR WINDINGS

L₁ – Discriminator Primary: 3-1/6 turns; No. 20 Enamel-covered wire—close-wound, at bottom of coil form. Inductance of $L_1 = 0.165 \mu\text{H}$; $Q_0 = 120$ at $f_0 = 45.75 \text{ MHz}$.

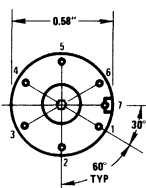
Start winding at Terminal No. 6; finish at Terminal No. 1. See Notes below.

L₂ – Tertiary Windings: 2-1/6 turns; No. 20 Enamel-covered wire—close-wound over bottom end of L_1 . Start winding at Terminal No. 3; finish at Terminal No. 4. See Notes below.

L₃ – Discriminator Secondary: 3-1/2 turns; center-tapped, space wound at bottom of coil form. Inductance of $L_3 = 0.180 \mu\text{H}$; $Q_0 = 150$ at $f_0 = 45.75 \text{ MHz}$.

Start winding at Terminal No. 2; finish at Terminal No. 5, connect center tap to Terminal No. 7. See Notes.

- Note 1: Coil Forms; Cylindrical, $-0.30''$ Dia. max.
 Note 2: Tuning Core: $0.250''$ Dia. \times $0.37''$ Length.
 Material: Carbinal J or equivalent.
 Note 3: Coil Form Base: See drawing below.
 Note 4: End of coil nearest terminal board to be designated the winding start end.



L_1 is aligned for symmetrical bandwidth on either side of 45.750 MHz .
 L_2 tertiary winding wound on L_1 coil form.
 L_3 is aligned for zero differential output between terminals 4 and 5 at $f_0 = 45.750 \text{ MHz}$.



Consumer Circuits

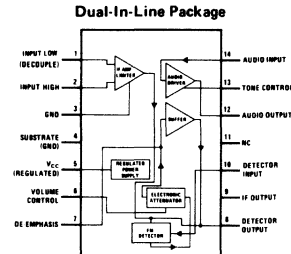
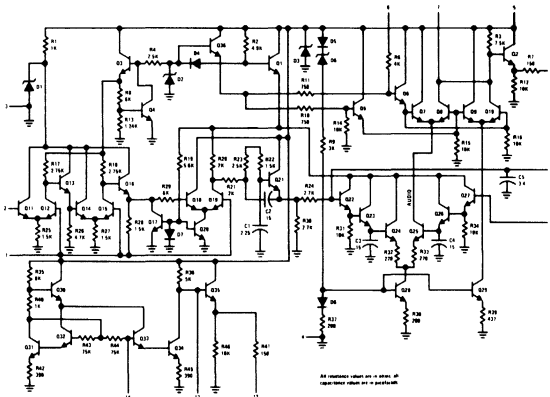
LM3065 television sound system general description

The LM3065 is a monolithic integrated circuit television sound system that requires a minimum of external components for operation. It includes three stages of IF limiting, an FM detector, an electronic attenuator or volume control, an audio amplifier-driver, and a temperature stable regulated power supply. Volume control is accomplished by varying bias levels of the electronic attenuator with a potentiometer between pin 6 and ground. Because no audio signal is present in this control, hum and noise pickup are easily filtered. Unshielded wire may be used for volume control. Features include:

- Electronic attenuator: replaces conventional ac volume control

- Volume reduction range: >60 dB
- Sensitivity: 3 dB limiting voltage— $200 \mu\text{V}$ typically
- High stability
- Low harmonic distortion
- Audio drive capability: 6 mA p-p
- Undistorted audio output voltage: 7V p-p
- Differential peak detector
- Simple detector alignment: one coil
- Internal zener diode regulator
- Excellent AM rejection—50 dB typ. @ 4.5 MHz

schematic and connection diagrams

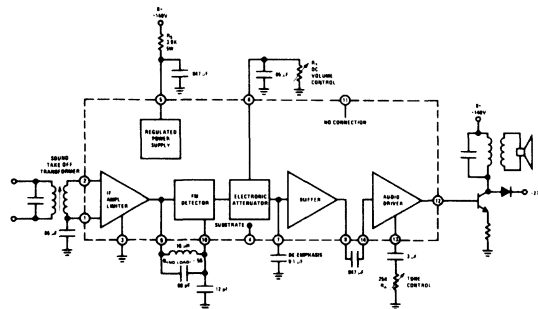


TOP VIEW

Order Number LM3065N
See Package 22

Order Number LM3065N-01
See Package 24

block diagram





Consumer Circuits

LM3066 chroma signal processor

general description

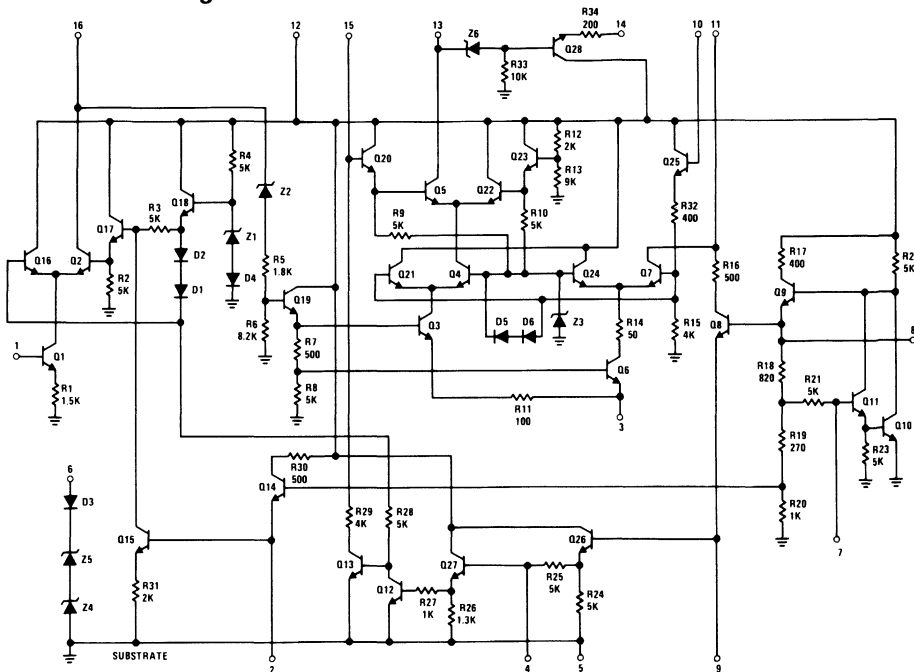
The LM3066 is a monolithic integrated circuit designed for color signal processing in color television receivers. It includes gain controlled chroma and bandpass amplifiers, chroma output stage, gated burst amplifier, 3.58 MHz injection-locked oscillator, automatic chroma control (ACC) detector-amplifier, killer detector-amplifier, and a zener-regulated voltage reference. The input chroma signal is applied to the chroma amplifier which is controlled by the ACC detector-amplifier maintaining a constant chroma level at terminal 16. The chroma amplifier feeds the chroma signal in parallel to the bandpass and burst amplifiers. The bandpass amplifier is gain controlled by the DC chroma gain control and is also controlled by the killer detector-amplifier. The horizontal keying pulse gates the burst signal from the bandpass amplifier to the burst amplifier which then injects the burst signal into the 3.58 oscillator. The ACC and killer detectors sense the oscillator amplitude.

Thresholds are set independently at terminals 9 and 4. The LM3066 and the LM3067 Chroma Demodulator constitute a complete chroma system for color television receivers.

features

- Complete color sync circuitry
- Blanked chroma amplifier
- Chroma bandpass amplifier
- Low output impedance chroma driver
- Color killer
- Automatic color control
- DC chroma gain control
- Zener regulated voltage reference
- Aligned independently
- Short circuit protection

schematic diagram



Note: All resistance values are in ohms.

Order Number LM3066N
See Package 23

Order Number LM3066N-01
See Package 25

absolute maximum ratings

Power Dissipation		600 mW
$T_A = 70^\circ\text{C}$ or less		
Above 70°C	derate linearly 7.7 mW/ $^\circ\text{C}$	
Ambient Temperature Range		
Operating		-40 to $+85^\circ\text{C}$
Storage		-65 to $+150^\circ\text{C}$
Power Supply Voltage (Pin 12)		+12V
Power Supply Current (Pin 12)		50 mA

electrical characteristics ($T_A = 25^\circ\text{C}$ and $V^+ = 11.2\text{V}$)

PARAMETERS	CONDITIONS	LIMITS			UNITS
		MIN	TYP	MAX	
STATIC CHARACTERISTICS (Test Circuit 1)					
ACC Reference (V_2)			.5		V
Burst-Chroma Bias (V_3)			2.9		V
Killer Reference (V_4)			1.0		V
Zener Reg. Reference (V_6)		10.6	11.9	12.6	V
Oscillator Input (V_7)			1.3		V
Oscillator Output (V_8)			2.3		V
Balance (ACC Control) (V_9)			1.65		V
Chroma Output (V_{14})			4.6		V
Burst-Sperator Output (I_{11})	S1 Closed		6.5		mA
Bandpass Amplifier Output (I_{13})			4.8		mA
Chroma Amplifier Output (I_{16})			1.27		mA
Quiescent Supply Current (I_5)		14	24	33	mA
DYNAMIC CHARACTERISTICS (Test Circuit 2)					
Oscillator Output (V_8)	$V_1 = 0 V_{p-p}$ $V_1 = 1.25 V_{p-p}$	0.8	1.05 2.5	3.5	V_{p-p} V_{p-p}
Chroma Output (V_{14}) 100% Killed	$V_1 = 1.25 V_{p-p}$ $V_1 = .025 V_{p-p}$	0.5	1.0	.02	V_{p-p} V_{p-p}
ACC Detector Output (V_2)	$V_1 = 1.25 V_{p-p}$		0.9		V
Small Signal Input Resistance (r_i)			50		k Ω
Small Signal Input Capacitance (C_i)			2.4		pF
Small Signal Output Impedance (r_o)			250		Ω

DYNAMIC CHARACTERISTICS TEST PROCEDURE

Note 1: $V_1 = 0 V_{p-p}$

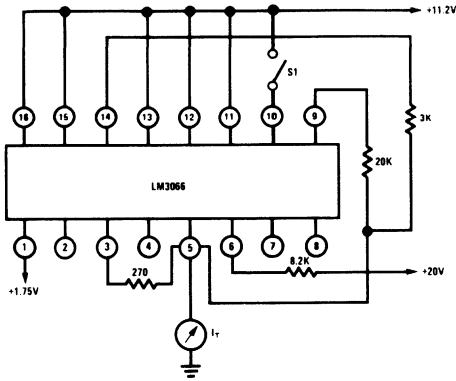
(A) Adjust $V_2 = +0.65\text{V}$

(B) Adjust $V_4 = +1.2\text{V}$

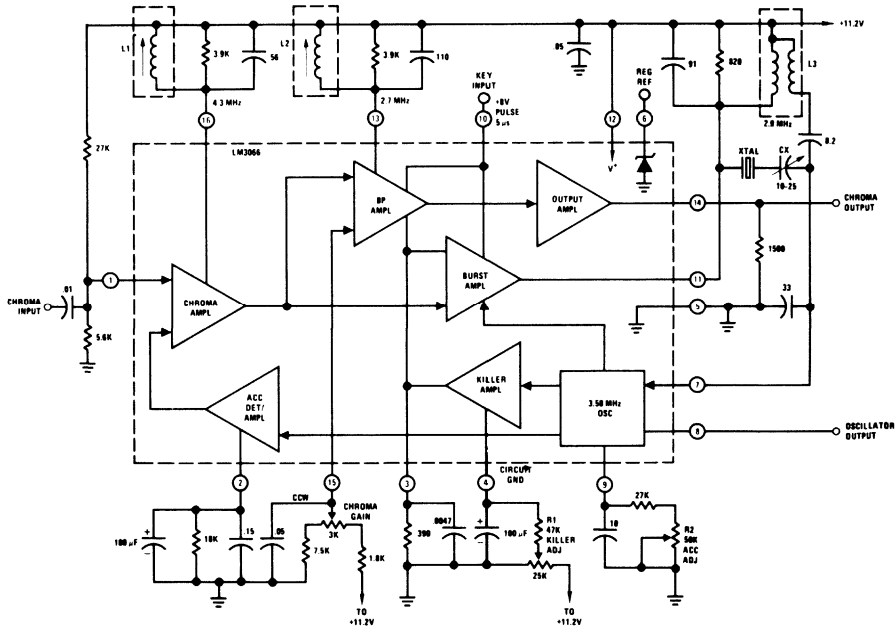
(C) Adjust C_X so $f_{OSC} = 3.579545\text{ MHz}$.

Note 2: Chroma input test signal (V_1) is a 52 μs line at subcarrier frequency and 10 cycles of burst at 46.5% of line amplitude.

test circuits



TEST CIRCUIT 1



All resistance values are in OHMS
 Unless otherwise indicated, all capacitance values less than 1.0 are in microfarads, 1.0 or greater are in picofarads
 All coils have a $Q_{OU} > 30$

TEST CIRCUIT 2



LM3067 chroma demodulator

general description

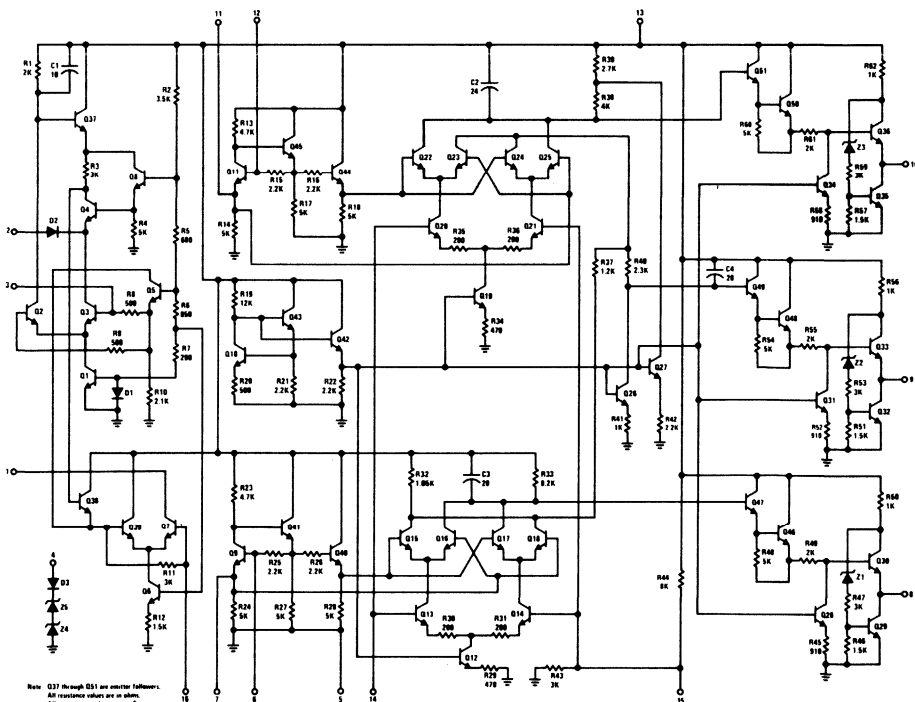
The LM3067 is a monolithic integrated circuit designed primarily for color signal demodulation in color television receivers. A DC tint control is also included. The reference subcarrier and chroma signals are applied and the three demodulated R-Y, G-Y, B-Y color difference signals are delivered with close DC balance and proper amplitude ratios. The tint control achieves a 100°+ phase adjustment by means of a customer-operated DC control. A limiting amplifier and phase shift network provide constant amplitude carriers phase shifted 76° which then feed demodulator drive amplifiers. The demodulators consist of two sets of balanced detectors which receive the reference subcarrier and chroma signal. The chroma signal is then demodulated, matrixed, and DC shifted in voltage. The LM3067 and LM3066

Chroma Signal Processor constitute a complete chroma system for color television receivers.

features

- Balanced chroma demodulators
- DC tint control
- Color difference matrix
- Low output impedance drivers for direct coupling
- Reference subcarrier limiter
- Zener regulated voltage reference
- Internal RF filtering of demodulation components

schematic diagram



Order Number LM3067N
See Package 23

Order Number LM3067N-01
See Package 25

absolute maximum ratings

Power Dissipation	600 mW
$T_A = 70^\circ\text{C}$ or less	derate linearly 7.7 mW/ $^\circ\text{C}$
Above 70°C	
Ambient Temperature Range	
Operating	-40 to $+85^\circ\text{C}$
Storage	-65 to $+150^\circ\text{C}$
Power Supply Voltage (Pin 13)	+12V
Power Supply Current (Pin 13)	50 mA

electrical characteristics ($T_A = 25^\circ\text{C}$ and $V^+ = 11.2\text{V}$)

PARAMETERS	CHARACTERISTICS	LIMITS			UNITS
		MIN	TYP	MAX	
Static Characteristics (Test Circuit 1)					
Voltage Inputs					
Tint Control Input (V_2)	$I_2 = 0.25$ mA		3.5		
Reference Subcarrier (V_3)			2.1		
Zener Regulator Ref. (V_4)		10.6	11.9	12.6	V
B-Y, R-Y Oscillator Ref. Inputs (V_6, V_{12})			5.7		
Balance (B-Y, R-Y) (V_7, V_{11})			5.0		
B-Y, G-Y, R-Y Outputs (V_8, V_{10})		4.2	5.0	5.8	
Difference Outputs (Note 1). ($\Delta V_B, \Delta V_G, \Delta V_{10}$)		-0.3		0.3	
Chroma Inputs (V_{14}, V_{15})			3.0		
Tint Amplifier Balance (V_{16})			4.7		
Input Currents					
Tint Amplifier Output (min.) (I_1 (min.))	$V_{16} = 8\text{V}$	0.16	0.37		mA
Total Supply ($I_1 + I_{13}$)		15	24	33	
Dynamic Characteristics (Test Circuit 2)					
Tint Amplifier Output					
Sensitivity (V_1)	$V_3 = 7$ mVRMS	160	250		mVRMS
Limiting Knee (V_1)	$V_3 = 35$ mVRMS		300		
Limiting (V_1)	$V_3 = 350$ mVRMS			380	
Tint Amplifier Phase Ref. (Note 2) (ϕ_6)	$V_3 = 70$ mVRMS	185	220	235	degrees
Tint Amplifier Phase Ref. (Note 3) ($\Delta\phi_6$)	$V_3 = 70$ mVRMS	90	105		degrees
Demodulated Chroma Outputs					
R-Y (V_{10})	$V_3 = 70$ mVRMS	0.15	0.25		VRMS
Ratio of G-Y to R-Y (V_9/V_{10})		0.28	0.36	0.44	
Ratio of B-Y to R-Y (V_8/V_{10})	$V_{14} = 35$ mVRMS	1.0	1.2	1.4	
Color Difference Output					
BW at 3.3 dB ($BW_{D,IF}$)		450	550		kHz
Color Difference Outputs (max. input signals):					
R-Y (V_{10})			3.0		
G-Y (V_9)	$V_3 = 70$ mVRMS		1.1		V_{P-P}
B-Y (V_8)	$V_{14} = 212$ mVRMS		3.6		
Small Signal Input Resistance					
Terminal Number 3 (r_i)			550		Ω
Terminal Numbers 6 and 12 (r_i)			22		
Small Signal Output Resistance					
Terminal Numbers 8, 9, and 10 (r_o)			5		

$$\text{Note 1: } \Delta V_B = V_8 - \left(\frac{V_8 + V_9 + V_{10}}{3} \right), \Delta V_G = V_9 - \left(\frac{V_8 + V_9 + V_{10}}{3} \right), \Delta V_{10} = V_{10} - \left(\frac{V_8 + V_9 + V_{10}}{3} \right)$$

Note 2: Terminal No. 3 is phase reference

Note 3: Read phase shift as tint control is varied



Consumer Circuits

LM3070 chroma subcarrier regenerator

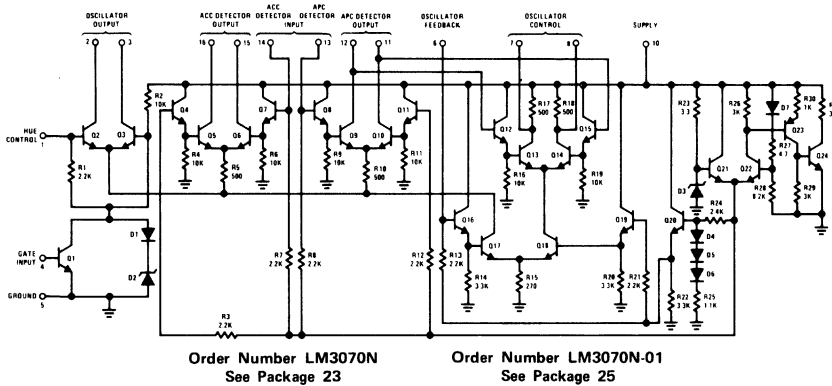
general description

The LM3070 integrated circuit is a phase locked loop oscillator controlled by an Automatic Phase Control (APC) detector, and an Automatic Chroma Control (ACC) detector which generates the correction voltage for the ACC amplifier of the LM3071. Both the APC and the ACC detectors are piloted by the burst signal present in the NTSC color video signal applied at Pins 13 and 14 in quadrature. The APC error output voltage controls the phase shift at Pin 7 in the oscillator feedback loop and locks the frequency of oscillation to the burst signal frequency. The APC and ACC detectors are

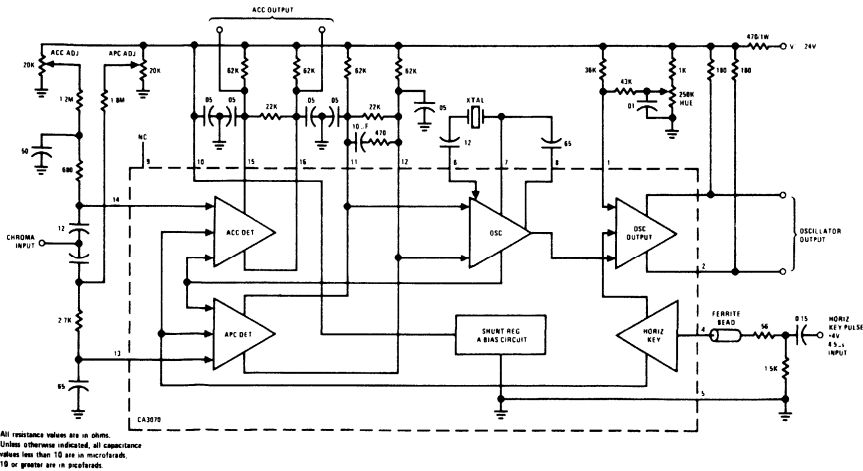
keyed by the horizontal pulse applied at Pin 4, which also inhibits the oscillator output amplifier during the burst interval. Balance adjustment of DC offsets are provided to establish an initial no-signal offset control in the ACC output, and a no-signal, on-frequency adjustment through the APC detector-amplifier circuit which controls the oscillator frequency. The oscillator output stage is differentially controlled at Pins 2 and 3 by the HUE control to Pin 1.

The circuit also includes a shunt regulator to establish a 12V DC supply.

schematic diagram



block diagram



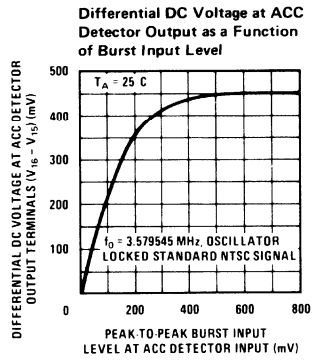
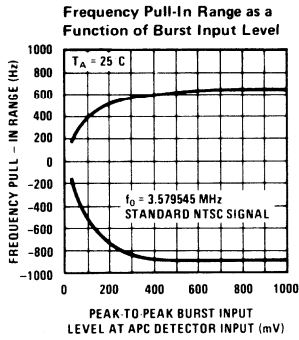
absolute maximum ratings

Supply Current	40 mA
Internal Power Dissipation up to 70°C	550 mW
Above 70°C Derate at 7 mW/°C	
Operating Temperature	-40°C to +85°C
Storage Temperature	-65°C to +150°C

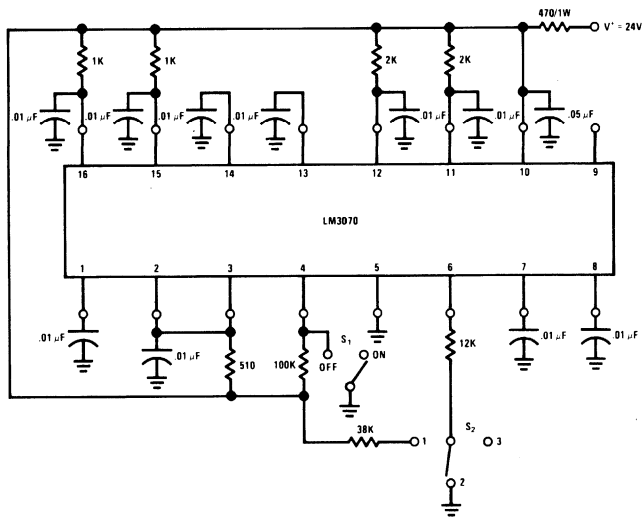
electrical characteristics $T_A = 25^\circ\text{C}$ $V^+ = 24\text{V}$

PARAMETER	SYMBOL	CONDITIONS	LIMITS			UNITS
			MIN	TYP	MAX	
STATIC (Refer to Test Circuit 1)						
Supply Current	I_S			25.5		mA
Voltage at Supply Terminal	V_{10}		11.3	12	12.8	V
Supply Regulation	ΔV_{10}	$V^+ = 21\text{V}$ to $V^+ = 27\text{V}$		30		mV
Total Current into Oscillator Output Terminals	$I_2 + I_3$	S_1 "OFF", S_2 Position 1, Pins 2 and 3 shorted together	4.2	5.8	7.8	mA
APC Output Current	I_{11}, I_{12}	S_1 "ON", S_2 Position 1		1.45		mA
ACC Output Current	I_{15}, I_{16}	S_1 "ON", S_2 Position 1		1.45		mA
APC Output Balance	$V_{11} - V_{12}$	S_1 "ON", S_2 Position 1	-350	0	+350	mV
ACC Output Balance	$V_{15} - V_{16}$	S_1 "ON", S_2 Position 1	-300	0	+300	mV
Oscillator Control Balance	$V_7 - V_8$	S_2 Position 2, $V_{11} - V_{12} = 9.5\text{V}$	-300	0	+300	mV
Voltage at Hue Control Terminal	V_1	S_1 "OFF"	7.1	7.7	8.3	V
Voltage at Oscillator Feedback Terminal	V_6	S_2 Position 3		2.8		V
Voltage at APC and ACC Input Terminal	V_{13}, V_{14}		5.8	6.3	6.9	V
DYNAMIC (Refer to Test Circuit 2)						
Oscillator Pullin Range				±650		Hz
Oscillator Control Sensitivity				12		Hz/mV
Oscillator Output at Pin 2	V_2	S_1 , Position 1	.75	1.0		V_{p-p}
Oscillator Output at Pin 3	V_3	S_1 , Position 2	.75	1.0		V_{p-p}
ACC Detected Output			120	150		mV

typical performance characteristics

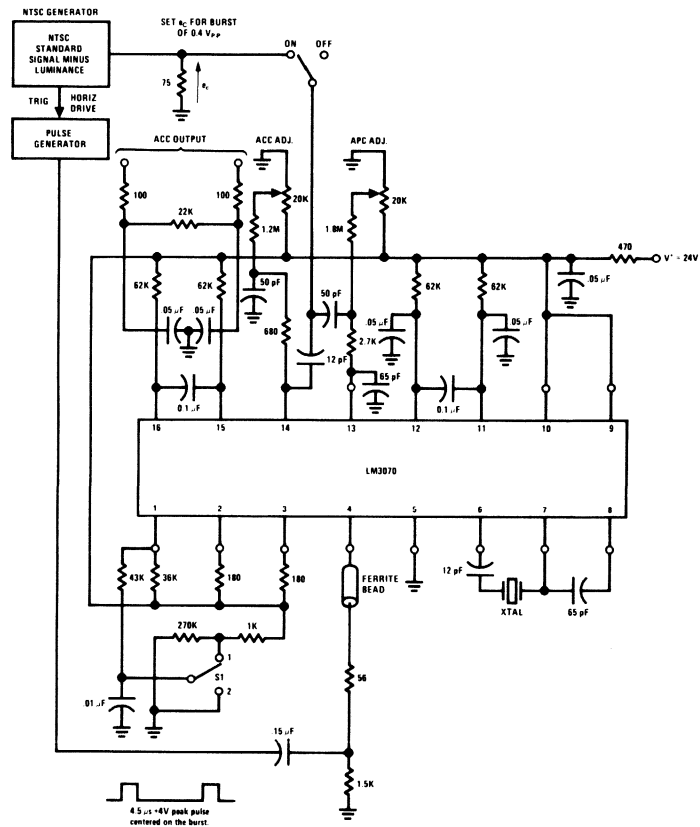


dc test circuit



TEST CIRCUIT 1

ac test circuit



TEST CIRCUIT 2



Consumer Circuits

LM3071 television chroma IF amplifier

general description

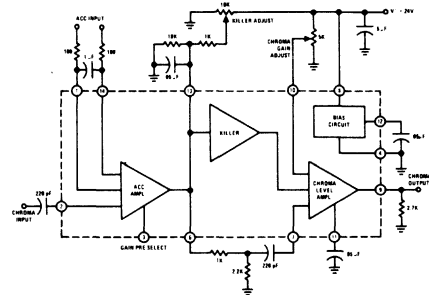
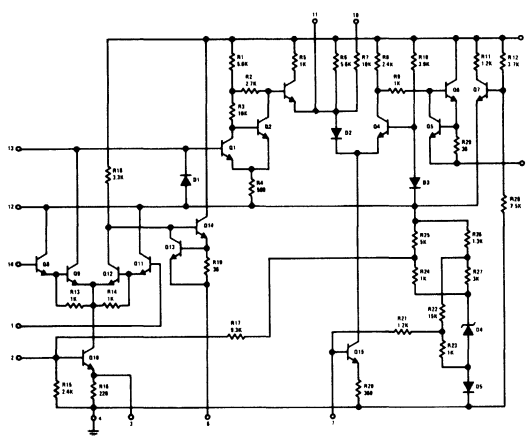
The LM3071 is a two stage chroma IF amplifier on a single silicon chip encapsulated in a 14 lead molded-Dual-In-Line Package. The first stage is an automatic gain controlled amplifier, and its output from Pin 6 is used to drive the ACC detector of the LM3070 or an equivalent circuit. The output from the ACC detector is applied to Pins 1 and 14 to control the gain of the stage. The second amplifier stage is driven from the output of the first at Pin 7, and the gain is controlled by adjusting the DC voltage at Pin 10. The output from Pin 9 supplies the chroma drive signal to the chroma demodulator circuit. In addition, the second stage

may be gated "OFF" to provide "color killing" action in the absence of color signal at the output of the first stage. The killer trip point is adjusted externally.

features

- Very effective gain control of both stages
- Good signal handling capability
- Excellent gain stability with temperature and supply voltage variations
- Low distortion

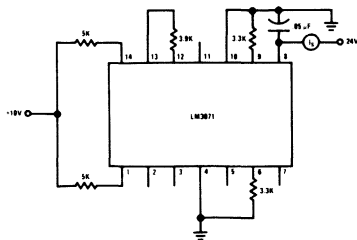
schematic and functional diagrams



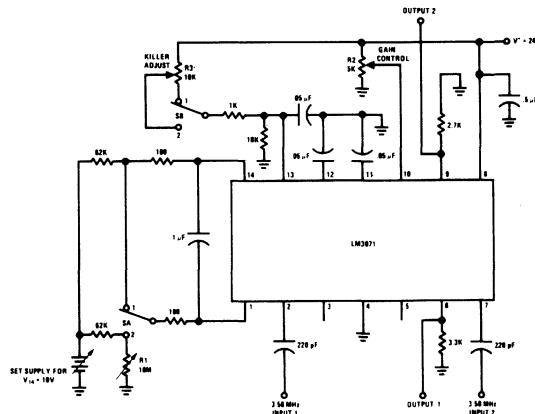
Order Number LM3071N
See Package 22

Order Number LM3071N-01
See Package 24

test circuits



Test Circuit 1



Test Circuit 2

absolute maximum ratings

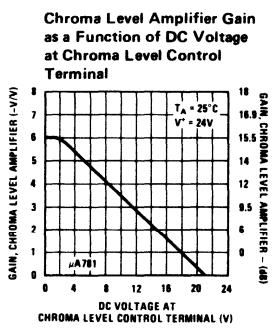
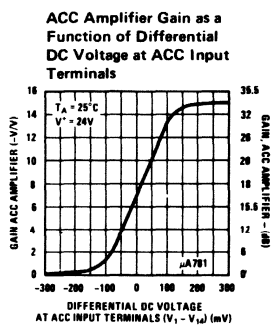
Supply Voltage	$V^+ = 30V$
Internal Power Dissipation at 70°C	550 mW
Above 70°C derate at 7 mW/°C	
Operating Temperature	-40°C to +85°C
Storage Temperature	-65°C to +150°C

electrical characteristics $T_A = 25^\circ C$ $V^+ = 24V$

PARAMETER	SYMBOL	CONDITIONS	LIMITS			UNIT
			MIN	TYP	MAX	
STATIC (Refer to Test Circuit 1)						
Supply Current	I_S		17	24	31	mA
Bias Voltage at Pin 12	V_{12}		14	15.3	16.5	V
Voltage at Input 1	V_2			1.7		V
Voltage at Input 2	V_7			1.4		V
Voltage at Output 1	V_6	$V_{ACC} = V_1 - V_{14} = 0V$	15.5	17.5	20	V
Voltage at Output 2	V_9	$V_{10} = 0V$	17.25	18.25	19	V
DYNAMIC (Refer to Test Circuit 2) $f = 3.58$ MHz						
Gain, ACC Amplifier Stage	A_{V1}	S_A Position 1, $V_1 = V_{14} = 10V$	14	16.5	19	db
Gain Reduction of ACC Amplifier		S_A Position 2, R_1 set for $V_{14} - V_1 = 75$ mV		14		db
Maximum Gain, Chroma Level Amplifier	A_{V2}	S_B Position 1, $V_{10} = 0V$	13	15.5	17	db
90% Chroma Gain Control Reference Voltage	V_{10}	S_B Position 1, R_2 set for 90% of Maximum Gain	2.3	3.5	4.8	V_{DC}
10% Chroma Gain Control Reference Voltage	V_{10}	S_B Position 1, R_2 Set for 10% of Maximum Gain	17	20	21.7	V_{DC}
Maximum Chroma Output Before Distorting	V_9	S_B Position 1, $V_{10} = 0V$		5.5		V_{p-p}
ACC Amplifier Bandwidth	BW_1	S_A Position 1		12		MHz
Level Amplifier Bandwidth	BW_2			30		MHz
Killer on Threshold	V_{13}	S_B Position 2, Adjust R_3 to Kill Output		16.5		V_{DC}
Gain Variation with V^+ , Level Amplifier Stage	ΔA_{V2}	R_2 set for 10% of maximum Gain $V^+ = 24 \pm 3V$		0.3		db
Gain Variation with Temperature, Level Amplifier Stage	ΔA_{V2}	R_2 set for 10% of Maximum Gain $T_A = 25^\circ C$ to $T_A = 70^\circ C$		0.5		db
ACC Amplifier Input Resistance	R_{I1}			2.0		k Ω
ACC Amplifier Input Capacitance	C_{I1}			5		pF
Level Amplifier Input Resistance	R_{I2}			2.2		k Ω
Level Amplifier Input Capacitance	C_{I2}			4.2		pF



typical performance characteristics





Consumer Circuits

LM3075 FM detector/limiter and audio preamplifier

general description

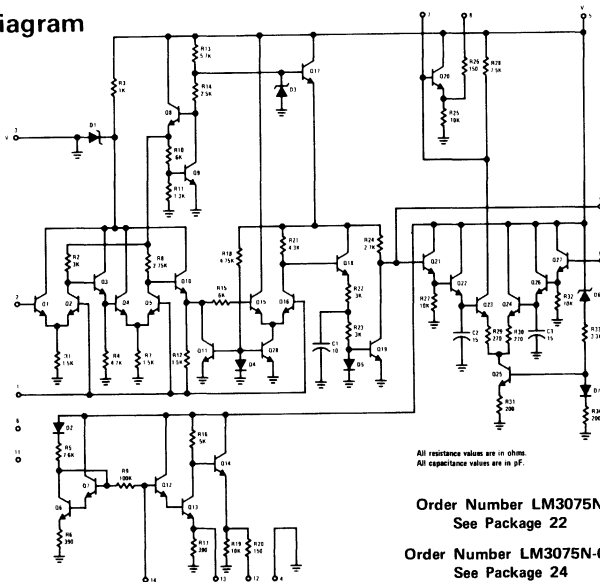
The LM3075 is a monolithic integrated circuit FM detector/limiter and audio preamplifier that requires a minimum of external components for operation. It includes three stages of IF limiting and a differential-peak-detection circuit.

- Simple detector alignment: one coil
- Sensitivity: 3 dB limiting voltage 250 μ V typical at 10.7 MHz
- Low harmonic distortion
- Excellent AM rejection 55 dB typ. at 10.7 MHz
- Internal audio preamplifier

features

- A direct replacement for the CA3075

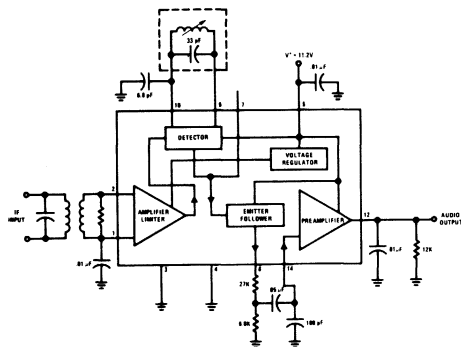
schematic diagram



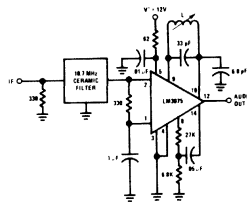
Order Number LM3075N
See Package 22

Order Number LM3075N-01
See Package 24

block diagram



typical application



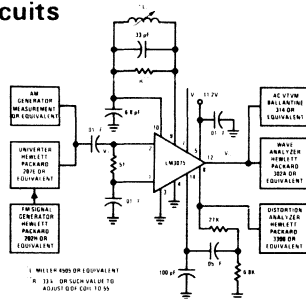
absolute maximum ratings

Power Supply Current (Pin 5)	30 mA	Operating Temperature Range	-40°C to +85°C
Supply Voltage (Pin 5)	12.5V	Storage Temperature Range	-65°C to +150°C
Power Dissipation		Lead Temperature (Soldering, 10 sec)	300°C
$T_A = 25^\circ\text{C}$ or less	850 mW		
$T_A = 25^\circ\text{C}$ or more	Derate Linearly 6.67 mW/°C		

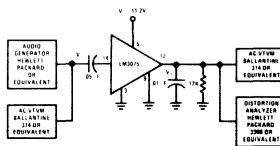
electrical characteristics $T_A = 25^\circ\text{C}$

PARAMETER	SYMBOL	TEST CIRCUIT	CONDITIONS	LIMITS			UNITS
				MIN	TYP	MAX	
STATIC CHARACTERISTICS							
Supply Current	I_S		$V_{CC} = 8.5\text{V}$ $V_{CC} = 11.2\text{V}$ $V_{CC} = 12.5\text{V}$	8.5	15 17.5 19	29	mA mA mA
Detector Output Level (High)	V_7				6.1		V
Detector Output Level (Low)	V_8		$V_{CC} = 11.2\text{V}$		5.4		V
Audio Amplifier Output Level	V_{12}				5.2		V
DYNAMIC CHARACTERISTICS AT $V^+ = 11.2\text{V}$, $f_0 = 10.7\text{ MHz}$, $\Delta f = \pm 75\text{ kHz}$, $f_m = 400\text{ Hz}$							
Input Limiting Threshold	$V_{IN(LIM)}$	1			250	600	μV
AM Rejection	AMR	1	AM: 1 kHz @ 30% $V_{IN} = 100\text{ mV}$		55		dB
Recovered AF Voltage (At Terminal 12)	V_O (AF)	1			1.5		V
Total Harmonic Distortion	T_{HD}	1			1	2	%
Audio Preamplifier							
Voltage Gain	$A_{V(af)}$	2	$V_{IN} = 100\text{ mV}$, $f = 400\text{ Hz}$		21		dB
Total Harmonic Distortion	T_{HD}	2	$V_{OUT} = 2\text{V}$, $f = 400\text{ Hz}$		1.5	5	%

test circuits



TEST CIRCUIT 1



TEST CIRCUIT 2



Transistor/Diode Arrays

LM114/LM114A/LM115/LM115A

LM114/LM114A/LM115/LM115A matched dual monolithic transistors

general description

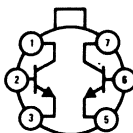
These devices contain a pair of junction-isolated NPN transistors fabricated on a single silicon substrate. This monolithic structure makes possible extremely-tight parameter matching at low cost. Further, advanced processing techniques yield exceptionally high current gains at low collector currents, virtual elimination of "popcorn noise," low leakages and improved long-term stability. Some of the major features of these pairs are indicated by the following specifications:

- Low offset voltage—0.5 mV maximum
- Low drift— $2 \mu\text{V}/^\circ\text{C}$ maximum from -55°C to 125°C

- High current gain—500 minimum at $10 \mu\text{A}$
- Tight beta match—10% maximum
- High breakdown voltage—to 60V
- Matching guaranteed over a 0V to 45V collector-base voltage range.

Although designed primarily for high breakdown voltage and exceptional dc characteristics, these transistors have surprisingly good high-frequency performance. The gain-bandwidth product is 450 MHz with 1 mA collector current and 5V collector-base voltage and 22 MHz with $10 \mu\text{A}$ collector current. Collector-base capacitance is only 1.3 pF at 5V.

connection diagram



TOP VIEW
Order Number LM114H or LM114AH
LM115H or LM115AH
See Package 10

absolute maximum ratings

	LM114 LM114A	LM115 LM115A
Collector-Base Voltage (BV_{CBO})	45V	60V
Collector-Emitter Voltage (BV_{CER})	45V	60V
Collector-Collector Voltage	45V	60V
Emitter-Emitter Voltage	45V	60V
Emitter-Base Voltage (BV_{EBO})	6V	
Collector Current	20 mA	
Total Power Dissipation (Note 1)	1.8W	
Operating Junction Temperature	-55°C to 150°C	
Storage Temperature	-65°C to 150°C	
Lead Temperature (soldering, 10 sec)	300°C	

Note 1: The maximum dissipation given is for a 25°C case temperature. For operation under other conditions, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of $70^\circ\text{C}/\text{W}$ junction to case or $230^\circ\text{C}/\text{W}$ junction to ambient.

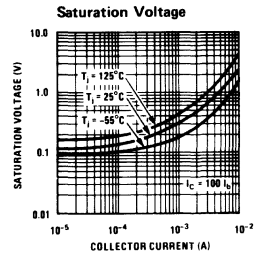
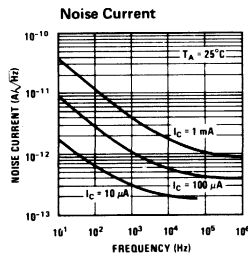
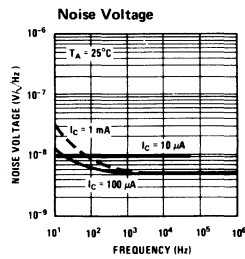
6

electrical characteristics (Note 2)

PARAMETER	CONDITIONS	MAXIMUM LIMITS				UNITS
		LM114	LM114A	LM115	LM115A	
Offset Voltage	$1 \mu\text{A} \leq I_C \leq 100 \mu\text{A}$	2.0	0.5	2.0	0.5	mV
Offset Current	$I_C = 10 \mu\text{A}$	10	2.0	10	2.0	nA
	$I_C = 1 \mu\text{A}$		0.5		0.5	nA
Bias Current	$I_C = 10 \mu\text{A}$	40	20	40	40	nA
	$I_C = 1 \mu\text{A}$		3.0		6.0	nA
Offset Voltage Change	$0\text{V} < V_{CB} \leq V_{\text{max}}$ $I_C = 10 \mu\text{A}$	1.5	0.2	2.0	0.3	mV
Offset Current Change	$0\text{V} < V_{CB} \leq V_{\text{max}}$ $I_C = 10 \mu\text{A}$	4.0	1.0	4.0	1.0	nA
Offset Voltage Drift	$-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ $I_C = 10 \mu\text{A}$	10	2.0	10	2.0	$\mu\text{V}/^\circ\text{C}$
Offset Current	$-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ $I_C = 10 \mu\text{A}$	50	12	50	20	nA
Bias Current	$-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ $I_C = 10 \mu\text{A}$	150	60	150	150	nA
Collector-Base Leakage Current	$V_{CB} = V_{\text{max}}$ $T_A = 25^\circ\text{C}$	50	10	50	10	pA
	$T_A = 125^\circ\text{C}$	50	10	50	10	nA
Collector-Emitter Leakage Current	$V_{CE} = V_{\text{max}}, V_{EB} = 0$ $T_A = 25^\circ\text{C}$	200	50	200	50	pA
	$T_A = 125^\circ\text{C}$	200	50	200	50	nA
Collector-Collector Leakage Current	$V_{CC} = V_{\text{max}}$ $T_A = 25^\circ\text{C}$	300	100	300	100	pA
	$T_A = 125^\circ\text{C}$	300	100	300	100	nA

Note 2: These specifications apply for $T_A = 25^\circ\text{C}$ and $0\text{V} < V_{CB} \leq V_{\text{max}}$, unless otherwise specified. For the LM114 and LM114A, $V_{\text{max}} = 30\text{V}$. For the LM115 and LM115A, $V_{\text{max}} = 45\text{V}$.

typical performance characteristics





Transistor/Diode Arrays

LM3018/LM3018A

LM3018/LM3018A matched monolithic transistor arrays

general description

The LM3018 and LM3018A consist of four general purpose silicon NPN transistors on a common monolithic substrate. Two of the four transistors are connected in the Darlington configuration. The substrate is connected to a separate terminal for maximum flexibility. The transistors are well suited to a wide variety of applications in low-power systems in the DC through VHF range. They may be used as discrete transistors in conventional circuits but in addition they provide the advantages of close electrical and thermal matching inherent in integrated circuit construction.

- V_{BE} matched

LM3018	± 5 mV
LM3018A	± 2 mV
- Operation from DC to 120 MHz
- Wide operating current range
- LM3018A performance controlled from $10\mu\text{A}$ to 10 mA
- Low noise figure 3.2 dB typical at 1 kHz
- Full military temperature range capability -55°C to $+125^{\circ}\text{C}$

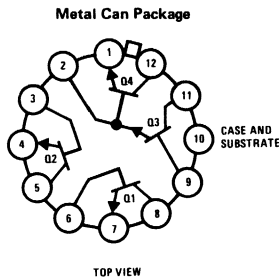
features

- Matched monolithic general purpose transistors
- H_{FE} matched $\pm 10\%$

applications

- General use in signal processing systems in DC through VHF range
- Custom designed differential amplifiers
- Temperature compensated amplifiers

schematic and connection diagram



Order Number LM3018H or LM3018AH
See Package 7

6

absolute maximum ratings

The following ratings apply for each transistor in the device:

	LM3018	LM3018A		LM3018	LM3018A
Power Dissipation (Note 1)			Collector to Emitter Voltage, V_{CE0}	15	15V
Any One Transistor	300	300 mW	Collector to Base Voltage, V_{CB0}	20	30V
Total Package	450	450 mW	Collector to Substrate Voltage, V_{C10}	20	40V
Operating Temperature Range		-55°C to +125°C	(Note 2)		
Storage Temperature Range		-65°C to +150°C	Emitter to Base Voltage, V_{EB0}	5	5V
Lead Temperature (Soldering, 10 sec)		300°C	Collector Current, I_C	50	50 mA

dc electrical characteristics $T_A = 25^\circ\text{C}$

PARAMETER	CONDITIONS	LIMITS						UNITS	
		LM3018			LM3018A				
		MIN	TYP	MAX	MIN	TYP	MAX		
STATIC CHARACTERISTICS									
Collector Cutoff Current (I_{CBO})	$V_{CB} = 10V, I_E = 0$		.002	100		.002	40	nA
Collector Cutoff Current (I_{CEO})	$V_{CE} = 10V, I_B = 0$			5			.5	μA	
Collector Cutoff Current Darlington Pair (I_{CE0D})	$V_{CE} = 10V, I_B = 0$						5	μA	
Collector to Emitter Breakdown Voltage ($V_{(BR)CEO}$)	$I_C = 1\text{ mA}, I_B = 0$	15	24		15	24		V	
Collector to Base Breakdown Voltage ($V_{(BR)CBO}$)	$I_C = 10\mu\text{A}, I_E = 0$	20	60		30	60		V	
Emitter to Base Breakdown Voltage ($V_{(BR)EB0}$)	$I_E = 10\mu\text{A}, I_C = 0$	5	7		5	7		V	
Collector to Substrate Breakdown Voltage ($V_{(BR)C10}$)	$I_C = 10\mu\text{A}, I_{C1} = 0$	20	60		40	60		V	
Collector to Emitter Saturation Voltage (V_{CES})	$I_B = 1\text{ mA}, I_C = 10\text{ mA}$			23			23	5	V
Static Forward Current Transfer Ratio (h_{FE})	$V_{CE} = 3V, \begin{cases} I_C = 10\text{ mA} \\ I_C = 1\text{ mA} \\ I_C = 10\mu\text{A} \end{cases}$	30	100		50	100			
Magnitude of Static Beta Ratio (Isolated Transistors Q_1 and Q_2)	$V_{CE} = 3V, I_{C1} = I_{C2} = 1\text{ mA}$	9	97		9	97			
Static Forward Current Transfer Ratio Darlington Pair (Q_3 and Q_4) (h_{FE0})	$V_{CE} = 3V, \begin{cases} I_C = 1\text{ mA} \\ I_C = 100\mu\text{A} \end{cases}$	1500	5400		2000	5400		2800	
Base to Emitter Voltage (V_{BE})	$V_{CE} = 3V, \begin{cases} I_E = 1\text{ mA} \\ I_E = 10\text{ mA} \end{cases}$		.715		600	.715	800	V
Input Offset Voltage ($\frac{V_{BE1}}{1 - V_{BE2}}$)	$V_{CE} = 3V, I_E = 1\text{ mA}$		.48	5		.48	2	mV
Temperature Coefficient - Base to Emitter Voltage Q_1, Q_2 ($\frac{1}{\Delta T} \frac{\Delta V_{BE1}}{\Delta T}$)	$V_{CE} = 3V, I_E = 1\text{ mA}$		-1.9			-1.9		mV/°C	
Base (Q_3) to Emitter (Q_4) Voltage Darlington Pair (V_{BED}) (V_{B1})	$V_{CE} = 3V, \begin{cases} I_E = 10\text{ mA} \\ I_E = 1\text{ mA} \end{cases}$		1.46		1.10	1.46	1.60	V	
Temperature Coefficient - Base to Emitter Voltage Darlington Pair Q_3, Q_4 ($\frac{1}{\Delta T} \frac{\Delta V_{BED1}}{\Delta T}$)	$V_{CE} = 3V, I_E = 1\text{ mA}$		4.4			4.4		mV/°C	
Temperature Coefficient - Magnitude of Input Offset Voltage ($\frac{1}{\Delta T} \frac{\Delta (V_{BE1} - V_{BE2})}{\Delta T}$)	$V_{CC} = +6V, V_{EE} = -6V, I_{C1} = I_{C2} = 1\text{ mA}$		10			10		$\mu\text{V}/^\circ\text{C}$	

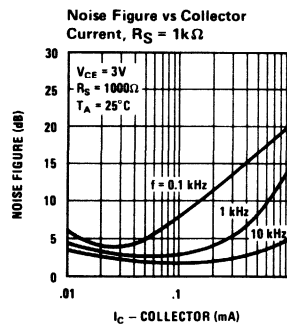
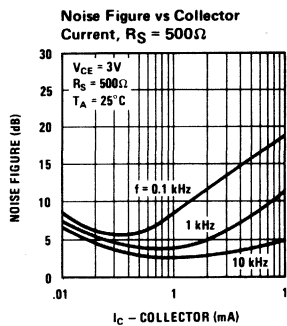
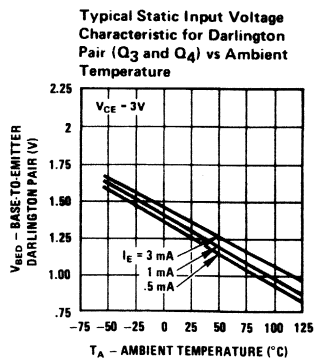
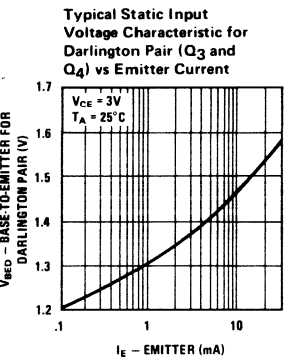
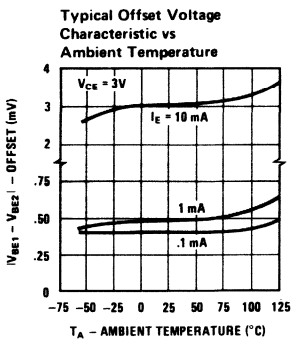
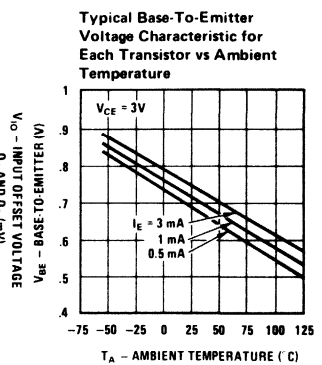
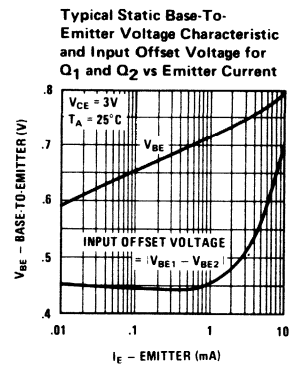
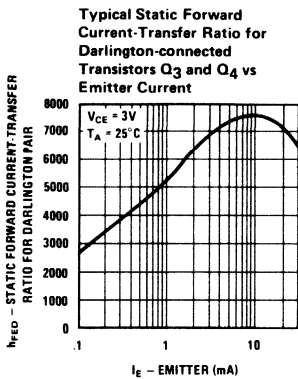
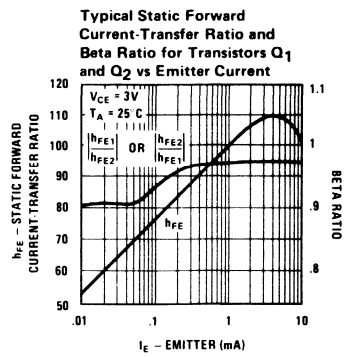
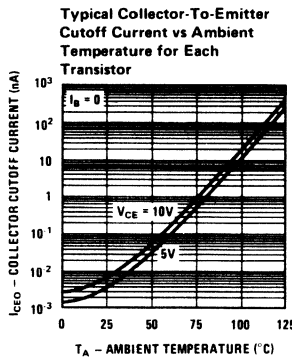
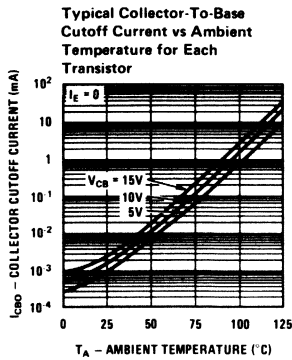
ac electrical characteristics $T_A = 25^\circ\text{C}$

DYNAMIC CHARACTERISTICS								
Low Frequency Noise Figure (NF)	$f = 1\text{ kHz}, V_{CE} = 3V, I_C = 100\mu\text{A}, \text{Source Resistance} = 1\text{ k}\Omega$		3.25			3.25		dB
Low Frequency, Small Signal Equivalent Circuit Characteristics								
Forward Current Transfer Ratio (h_{fe})	$f = 1\text{ kHz}, V_{CE} = 3V, I_C = 1\text{ mA}$		110			110		
Short Circuit Input Impedance (h_{ie})		3.5		3.5				
Open Circuit Output Impedance (h_{oe})		15.6		15.6				
Open Circuit Reverse Voltage Transfer Ratio (h_{re})		1.8×10^{-4}		1.8×10^{-4}				
Admittance Characteristics								
Forward Transfer Admittance (Y_{fe})	$f = 1\text{ MHz}, V_{CE} = 3V, I_C = 1\text{ mA}$		31 -j1.5			31 -j1.5		mmho
Input Admittance (Y_{ie})		3 +j0.04		3 +j0.04				
Output Admittance (Y_{oe})		.001 +j0.03		.001 +j0.03				
Reverse Transfer Admittance (Y_{re})		See Curve		See Curve				
Gain Bandwidth Product (f_T)	$V_{CE} = 3V, I_C = 3\text{ mA}$	300	500		300	500		MHz
Emitter to Base Capacitance (C_{EB})	$V_{EB} = 3V, I_E = 0$		.6			.6		pF
Collector to Base Capacitance (C_{CB})	$V_{CB} = 3V, I_C = 0$		.58			.58		pF
Collector to Substrate Capacitance (C_{C1})	$V_{C1} = 3V, I_C = 0$		2.8			2.8		pF

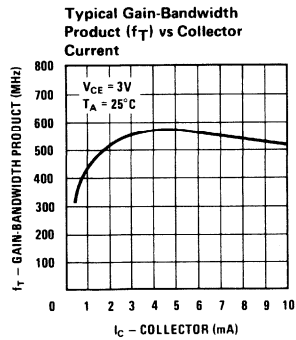
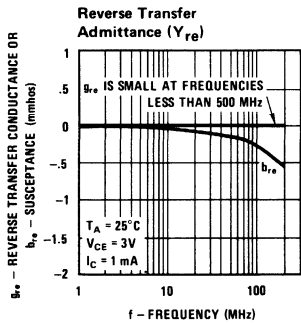
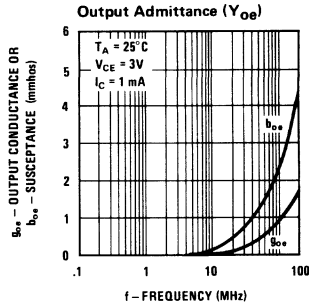
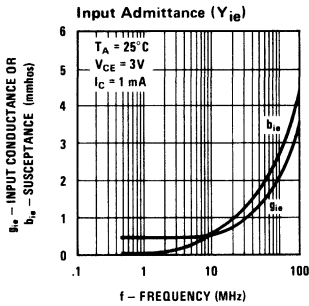
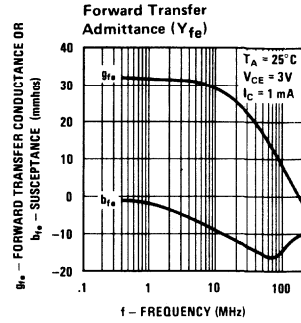
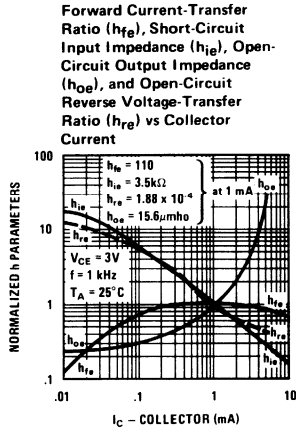
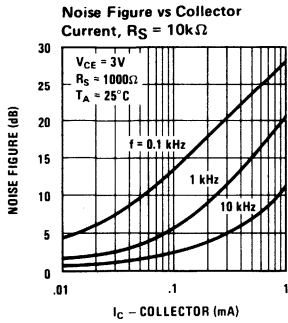
Note 1: Derate at 5 mW/°C for $T_A > 85^\circ\text{C}$

Note 2: The collector of each transistor of the LM3018 and LM3018A is isolated from the substrate by an integral diode. The substrate (terminal 10) must be connected to the most negative point in the external circuit to maintain isolation between transistors and to provide for normal transistor action.

typical performance characteristics



typical performance characteristics (con't)





Transistor/Diode Arrays

LM3019

LM3019 diode array

general description

The LM3019 consists of one silicon diode "quad" and two isolated silicon diodes on a common monolithic substrate.

features

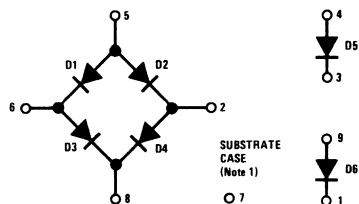
- Excellent diode match
- Low leakage current
- Low pedestal voltage when gating
- Built-in temperature stability for operation from -55°C to $+125^{\circ}\text{C}$

- 10-pin TO-5 package
- Hermetically sealed

applications

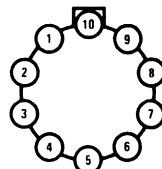
- Modulator
- Mixer
- Balanced modulator
- Analog switch
- Diode gate for chopper-modulator applications

schematic and connection diagrams



NOTE 1: CONNECT TO MOST NEGATIVE CIRCUIT POTENTIAL.

Metal Can Package



Order Number LM3019H
See Package 13

absolute maximum voltage limits $T_A = 25^{\circ}\text{C}$

TERMINAL	VOLTAGE LIMITS		CONDITIONS	
	NEGATIVE	POSITIVE	TERMINAL	VOLTAGE
1	-3	+12	7	-6
2	-3	+12	7	-6
3	-3	+12	7	-6
4	-3	+12	7	-6
5	-3	+12	7	-6
6	-3	+12	7	-6
7	-18	0	1, 2, 3, 6, 8	0
8	-3	+12	7	-6
9	-3	+12	7	-6
10	NO CONNECTION			
CASE	INTERNALLY CONNECTED TO TERMINAL 7 DO NOT GROUND			

6

absolute maximum ratings

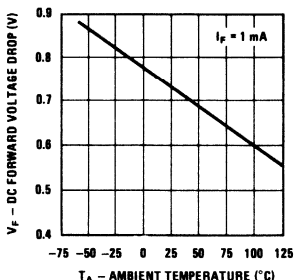
Power Dissipation	
Any One Diode Unit	20 mW
Total For Device	120 mW
Storage Temperature Range	-65°C to +200°C
Operating Temperature Range	-55°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics for each diode unit, unless otherwise specified, $T_A = 25^\circ\text{C}$.

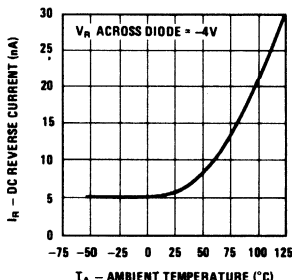
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
DC Forward Voltage Drop (V_F)	DC Forward Current $I_F = 1\text{ mA}$		.73	.78	V
DC Reverse Breakdown Voltage ($V_{(BR)R}$)	DC Reverse Current $I_R = -10\mu\text{A}$	4	6		V
DC Reverse Breakdown Voltage Between Any Diode Unit and Substrate ($V_{(BR)R}$)	DC Reverse Current $I_R = -10\mu\text{A}$	25	80		V
DC Reverse (Leakage) Current (I_R)	DC Reverse Voltage $V_R = -4\text{V}$		.0055	10	μA
DC Reverse (Leakage) Current Between Any Diode Unit and Substrate (I_R)	DC Reverse Voltage $V_R = -4\text{V}$		.010	10	μA
Magnitude of Diode Offset Voltage (Difference in DC Forward Voltage Drops of Any Two Diode Units) ($|V_{F1} - V_{F2}|$)	DC Forward Current $I_F = 1\text{ mA}$		1	5	mV
Single Diode Capacitance	Frequency $f = 1\text{ MHz}$ DC Reverse Voltage $V_R = -2\text{V}$		1.8		pF
Diode Quad-to-Substrate Capacitance (C_{DQ-1})	Frequency $f = 1\text{ MHz}$ DC Reverse Voltage V_R Between Terminal 2, 5, 6 or 8 of Diode Quad and Terminal 7 Substrate = -2V				
	Terminal 2 or 6 to Terminal 7		4.4		pF
	Terminal 5 or 8 to Terminal 7		2.7		pF
Series Gate Switching Pedestal Voltage (V_S)			10		mV

typical performance characteristics

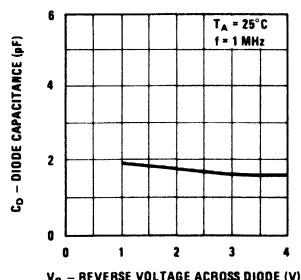
DC Forward Voltage Drop (Any Diode) vs Temperature



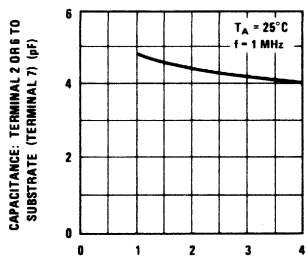
Reverse (Leakage) Current (Any Diode) vs Temperature



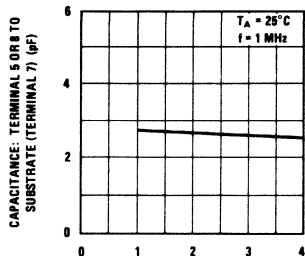
Diode Capacitance (Any Diode) vs Reverse Voltage



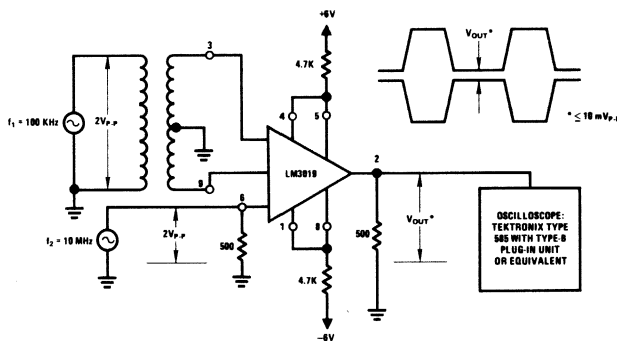
Diode Quad-To-Substrate Capacitance vs Reverse Voltage



Diode Quad-To-Substrate Capacitance vs Reverse Voltage



series gate switching test setup





Transistor/Diode Arrays

LM3026, LM3054 transistor arrays

general description

The LM3026 and LM3054 each consists of two independent differential amplifiers with associated constant-current transistors on a common monolithic substrate. The six NPN transistors which comprise the amplifiers are general purpose devices which exhibit low $1/f$ noise and a value of f_T in excess of 300 MHz. These features make the LM3026 and LM3054 useful from DC to 120 MHz. Bias and load resistors have been omitted to provide maximum application flexibility.

The monolithic construction of the LM3026 and LM3054 provides close electrical and thermal matching of the amplifiers. This feature makes these devices particularly useful in dual channel applications where matched performance of the two channels is required.

The LM3026 is supplied in a hermetic 12-lead TO-5 style package and is rated for full military operating temperature range of -55°C to $+125^{\circ}\text{C}$.

The LM3054 is supplied in a 14-lead molded dual-in-line package with a limited temperature range. The availability of extra terminals allows the introduction of an independent substrate connection for maximum flexibility.

features

- Two differential amplifiers on a common substrate

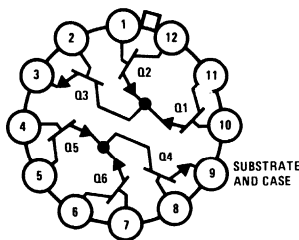
- Independently accessible inputs and outputs
- Maximum input offset voltage $\pm 5\text{ mV}$
- Full military temperature range capability -55°C to $+125^{\circ}\text{C}$
- Limited temperature range, LM3054 0°C to $+85^{\circ}\text{C}$

applications

- Dual sense amplifiers
- Dual Schmitt triggers
- Multifunction combinations RF mixer oscillator converter IF
- IF amplifiers (differential and or cascade)
- Product detectors
- Doubly balanced modulators and demodulators
- Balanced quadrature detectors
- Cascade limiters
- Synchronous detectors
- Pairs of balanced mixers
- Synthesizer mixers
- Balanced (push-pull) cascode amplifiers

schematic and connection diagrams

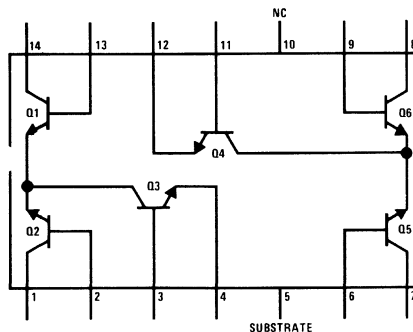
Metal Can Package



TOP VIEW

Order Number LM3026H
See Package 7

Dual-In-Line Package



TOP VIEW

Order Number LM3054N
See Package 22

absolute maximum ratings (T_A = 25°C)

	LM3026	LM3054		
Power Dissipation			The following ratings apply for each transistor in the device:	
Any One Transistor	300 mW	300 mW	Collector to Emitter Voltage (V _{CE0})	15V
Total Package	600 mW	750 mW	Collector to Base Voltage (V _{CB0})	20V
For T _A > 55°C	Derate at 5 mW/°C	6.67 mW/°C	Collector to Substrate Voltage (V _{CI0}) (Note)	20V
Operating Temperature Range	-55°C to +125°C	-40°C to +85°C	Emitter to Base Voltage (V _{EB0})	5V
Storage Temperature Range	-65°C to +150°C	-65°C to +150°C	Collector Current	50 mA
Lead Temperature (Soldering, 10 sec)		300°C		

dc electrical characteristics (T_A = 25°C)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
STATIC CHARACTERISTICS						
For Each Differential Amplifier						
Input Offset Voltage (V _{IO})	V _{CB} = 3V I _{E(Q3)} = I _{E(Q4)} = 2 mA		.45	5	mV	
Input Offset Current (I _{IO})			.3	2	μA	
Input Bias Current (I _I)			10	24	μA	
Quiescent Operating Current Ratio $\left(\frac{I_{C(Q1)}}{I_{C(Q2)}} \text{ or } \frac{I_{C(Q5)}}{I_{C(Q6)}} \right)$.98 to 1.02		
Temperature Coefficient Magnitude of Input Offset Voltage $\left( \frac{|\Delta V_{IO}|}{\Delta T} \right)$				1.1		μV/°C
For Each Transistor						
DC Forward Base to Emitter Voltage (V _{BE})	V _{CB} = 3V $\begin{cases} I_C = 50 \mu A \\ 1 \text{ mA} \\ 3 \text{ mA} \\ 10 \text{ mA} \end{cases}$		.630 .715 .750 .800	.700 .800 .850 .900	V
Temperature Coefficient of Base to Emitter Voltage $\left(\frac{\Delta V_{BE}}{\Delta T} \right)$	V _{CB} = 3V, I _C = 1 mA		-1.9		μV/°C	
Collector Cutoff Current (I _{CB0})	V _{CB} = 10V, I _E = 0		.002	100	nA	
Collector to Emitter Breakdown Voltage (V _{BRICE0})	I _C = 1 mA, I _B = 0	15	24		V	
Collector to Base Breakdown Voltage (V _{BRICB0})	I _C = 10μA, I _E = 0	20	60		V	
Collector to Substrate Breakdown Voltage (V _{BRICIO})	I _C = 10μA, I _{CI} = 0	20	60		V	
Emitter to Base Breakdown Voltage (V _{BRIEB0})	I _E = 10μA, I _C = 0	5	7		V	

ac electrical characteristics

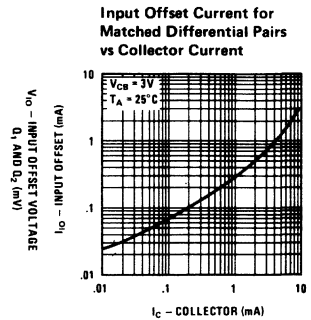
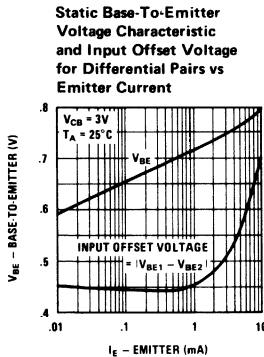
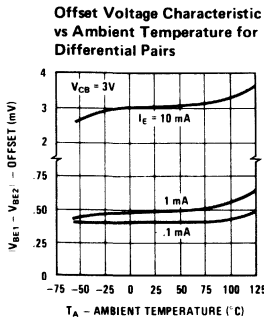
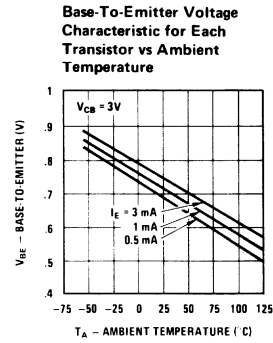
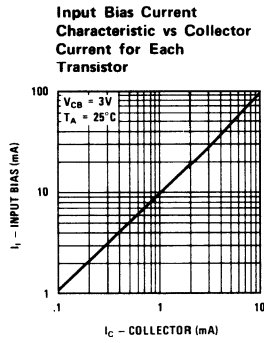
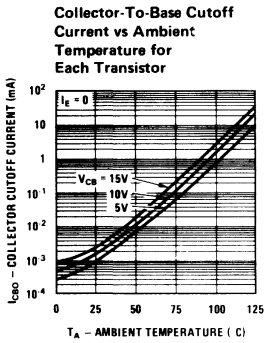
DYNAMIC CHARACTERISTICS					
Common Mode Rejection Ratio For Each Amplifier (CMR)			100		dB
AGC Range, One Stage (AGC)			75		dB
Voltage Gain, Single Stage Double Ended Output (A)	V _{CC} = 12V V _{EE} = -6V V _X = -3.3V f = 1 kHz		32		dB
AGC Range, Two Stage (AGC)			105		dB
Voltage Gain, Two Stage Double Ended Output (A)			60		dB
Low-Frequency, Small Signal Equivalent Circuit Characteristics: (For Single Transistor)					
Forward Current Transfer Ratio (h _{fb})			110		
Short Circuit Input Impedance (h _{ib})	f = 1 kHz, V _{CE} = 3V, I _C = 1 mA		3.5		kΩ
Open Circuit Output Impedance (h _{ob})			15.6		μmho
Open Circuit Reverse Voltage Transfer Ratio (h _{rb})			1.8 x 10 ⁻⁴		
1/f Noise Figure (For Single Transistor) (NF)	f = 1 kHz, V _{CE} = 3V		3.25		dB
Gain Bandwidth Product (For Single Transistor) (f _T)	V _{CE} = 3V, I _C = 3 mA		550		MHz
Admittance Characteristics; Differential Circuit Configuration: (For Each Amplifier)					

Note: The collector of each transistor of the LM3026 and LM3054 is isolated from the substrate by an integral diode. The substrate must be connected to a voltage which is more negative than any collector voltage in order to maintain isolation between transistors and provide for normal transistor action. The substrate should be maintained at signal (AC) ground by means of a suitable grounding capacitor, to avoid undesired coupling between transistors.

ac electrical characteristics (con't)

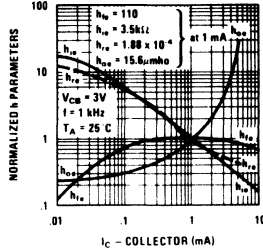
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
Forward Transfer Admittance (y_{21})	$V_{CB} = 3V$ Each Collector $I_C \approx 1.25 \text{ mA}$ $f = 1 \text{ MHz}$		$-20 + j0$		mmho	
Input Admittance (y_{11})			$.22 + j0.1$		mmho	
Output Admittance (y_{22})			$.01 + j0$		mmho	
Reverse Transfer Admittance (y_{12})				$-0.003 + j0$		mmho
Admittance Characteristics; Cascode Circuit Configuration: (For Each Amplifier)						
Forward Transfer Admittance (y_{21})	$V_{CB} = 3V$ Total Stage $I_C \approx 2.5 \text{ mA}$ $f = 1 \text{ MHz}$		$68 - j0$		mmho	
Input Admittance (y_{11})			$.55 + j0$		mmho	
Output Admittance (y_{22})			$0 + j0.02$		mmho	
Reverse Transfer Admittance (y_{12})				$.004 - j.005$		μmho
Noise Figure (NF)		$f = 100 \text{ MHz}$		8		dB

typical performance characteristics

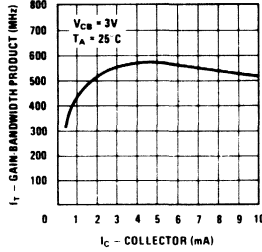


typical performance characteristics (con't)

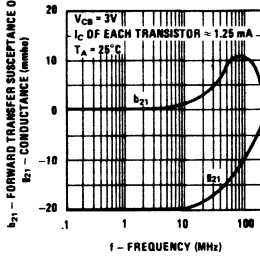
Forward Current-Transfer Ratio (h_{FE}), Short-Circuit Input Impedance (h_{ie}), Open-Circuit Output Impedance (h_{oe}), and Open-Circuit Reverse Voltage-Transfer Ratio (h_{re}) vs Collector Current for Each Transistor



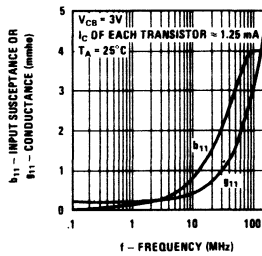
Gain-Bandwidth Product (f_T) vs Collector Current



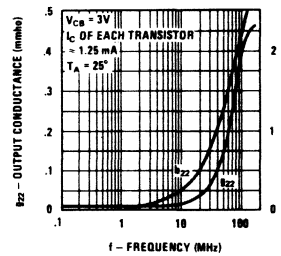
Forward Transfer Admittance (Y_{21}) vs Frequency



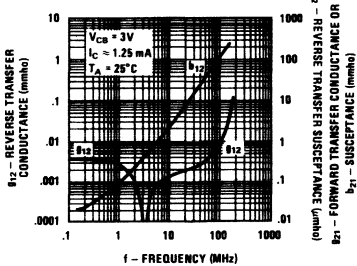
Input Admittance (Y_{11})



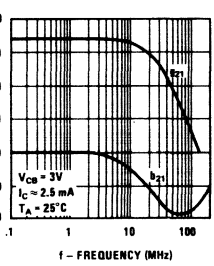
Output Admittance (Y_{22}) vs Frequency



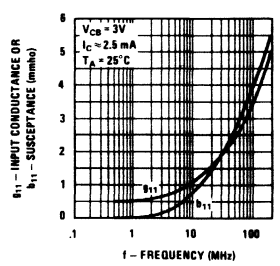
Reverse Transfer Admittance (Y_{21}) vs Frequency



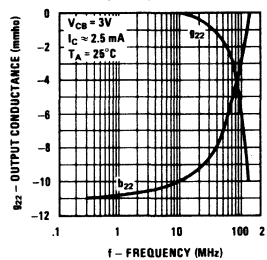
Forward Transfer Admittance (Y_{21}) vs Frequency



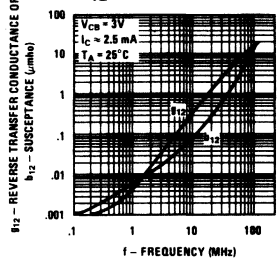
Input Admittance (Y_{11}) vs Frequency



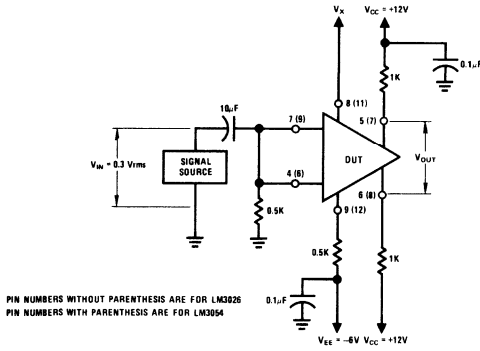
Output Admittance (Y_{22}) vs Frequency



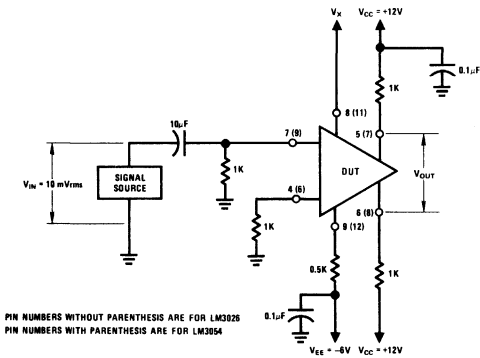
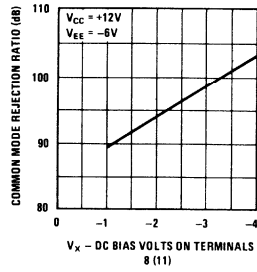
Reverse Transfer Admittance (Y_{12}) vs Frequency



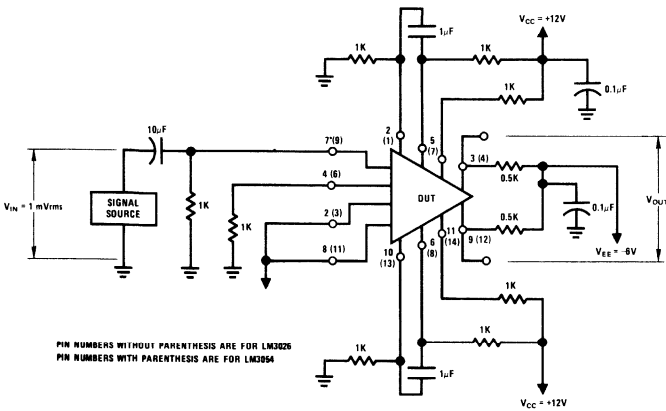
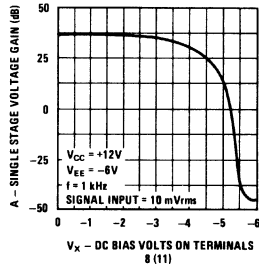
typical performance characteristics (con't)



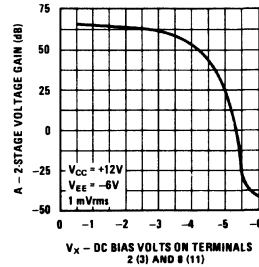
Common Mode Rejection Ratio



Single-Stage Voltage Gain



Two-Stage Voltage Gain



The following chart gives the range of voltages which can be applied to the terminals listed vertically with respect to the terminals listed horizontally. For example, the voltage range between vertical terminal 1† and horizontal terminal 3† is +15V to -5V.

LM3054 TERMINAL NO. ↓	LM3054 TERMINAL NO. →													(Note 2) 9	(Note 2) 9
	13	14	1	2	3	4	6	7	8	9	11	12	5		
	LM3026 TERMINAL NO.	10	11	12	1	2	3	4	5	6	7	8			
13	10		0 -20	*	+5 -5	*	+15 -5	*	*	*	*	*	*	*	*
14	11			*	*	*	+20 0	*	*	*	*	*	*	*	+20 0
1	12				+20 0	*	+20 0	*	*	*	*	*	*	*	+20 0
2	1				*	*	+15 -5	*	*	*	*	*	*	*	*
3	2						+1 -5	*	*	*	*	*	*	*	*
4	3							*	*	*	*	*	*	*	*
6	4								0 -20	*	*	*	+5 -5	+15 -5	*
7	5									*	*	*	*	*	+20 0
8	6											-20 0	*	*	+20 0
9	7												*	+15 -5	*
11	8													+1 -5	*
12	9														*
5	9														Ref Substrate

LM3054 TERMINAL NO. (Note 2)	LM3026 TERMINAL NO.	I _{IN} mA	I _{OUT} mA
13	10	5	.1
14	11	50	.1
1	12	50	.1
2	1	5	.1
3	2	5	.1
4	3	.1	-50
6	4	5	.1
7	5	50	.1
8	6	50	.1
9	7	5	.1
11	8	5	.1
12	9	.1	50

Note 1: In the LM3026 terminal No. 9 is connected to the emitter of Q₄, the reference substrate, and the case; therefore, the case should not be grounded. Two terminal 9 columns LM3026 appear in the voltage rating chart because it is a composite chart for both the LM3026 and the LM3054. Wherever an asterisk is shown in one column 9 and a rating is shown in the other column 9, the asterisk should be ignored.

Note 2: Terminal No. 10 of LM3054 is not used.

† LM3026; corresponding terminals for LM3054 are vertical terminal 2 and horizontal terminal 4.

* Voltages are not normally applied between these terminals. Voltages appearing between these terminals will be safe if the specified limits between all other terminals are not exceeded.



Transistor/Diode Arrays

LM3039 diode array

general description

The LM3039 consists of six ultra-fast, low capacitance silicon diodes on a common monolithic substrate. Five of the diodes are independently accessible, the sixth shares a common terminal with the substrate. Integrated circuit construction assures excellent static and dynamic matching of the diodes, making the array extremely useful for a wide variety of applications in communication and switching systems.

features

- Excellent reverse recovery time 1 ns typ
- Matched monolithic construction V_F matched within 5 mV

- Low diode capacitance

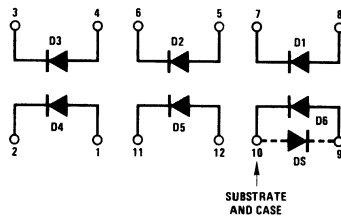
$$C_D = .65 \text{ pF typ} \\ \text{at } V_R = -2V$$

applications

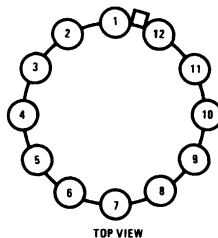
- Balanced modulators or demodulators
- Ring modulators
- High speed diode gates
- Analog switches

For applications such as balanced modulators or ring modulators where capacitive balance is important, the substrate should be returned to a DC potential which is significantly more negative (with respect to the active diodes) than the peak signal applied.

schematic and connection diagrams



Metal Can Package



TOP VIEW

Order Number LM3039H

See Package 7

absolute maximum ratings

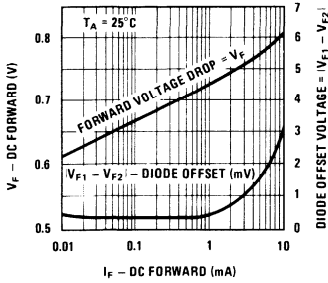
Power Dissipation	
Any One Diode	100 mW
Total For Device	600 mW
For $T_A > 55^\circ\text{C}$	Derate Linearly 5.7 mW/ $^\circ\text{C}$
Operating Temperature Range	-55°C to $+125^\circ\text{C}$
Storage Temperature Range	-65°C to $+150^\circ\text{C}$
Peak Inverse Voltage, PIV for: D1 – D5	5V
D6	.5V
Peak Diode to Substrate Voltage, V_{D1} for D1 – D5 (Term. 1, 4, 5, 8 or 12 to Term. 10)	+20, -1V
DC Forward Current, I_F	25 mA
Peak Recurrent Forward Current, I_r	100 mA
Peak Forward Surge Current, $I_{r(SURGE)}$	100 mA

electrical characteristics(T_A = 25°C) Characteristics apply for each diode unit, unless otherwise specified.

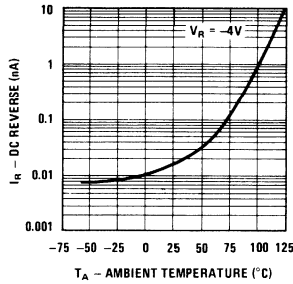
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
DC Forward Voltage Drop (V_F)	$I_F = 50\mu\text{A}$		.65	.69	V
	1 mA		.73	.78	V
	3 mA		.76	.80	V
	10 mA		.81	.90	V
DC Reverse Breakdown Voltage ($V_{(BR)R}$)	$I_R = -10\mu\text{A}$	5	7		V
DC Reverse Breakdown Voltage Between Any Diode Unit and Substrate ($V_{(BR)R}$)	$I_R = -10\mu\text{A}$	20			V
DC Reverse (Leakage) Current (I_R)	$V_R = -4\text{V}$		.016	100	nA
DC Reverse (Leakage) Current Between Any Diode Unit and Substrate (I_R)	$V_R = -10\text{V}$		.022	100	nA
Magnitude of Diode Offset Voltage (Difference in DC Forward Voltage Drops of Any Two Diode Units) ($|V_{F1} - V_{F2}|$)	$I_F = 1\text{ mA}$		.5	5	mV
Temperature Coefficient of $|V_{F1} - V_{F2}|$ $\left(\frac{\Delta|V_{F1} - V_{F2}|}{\Delta T}\right)$	$I_F = 1\text{ mA}$		1		$\mu\text{V}/^\circ\text{C}$
Temperature Coefficient of Forward Drop $\left(\frac{\Delta V_F}{\Delta T}\right)$	$I_F = 1\text{ mA}$		-1.9		$\text{mV}/^\circ\text{C}$
DC Forward Voltage Drop for Anode-to-Substrate Diode (D ₅) (V_F)	$I_F = 1\text{ mA}$		.65		V
Reverse Recovery Time (t_{rr})	$I_F = 10\text{ mA}$, $I_R = 10\text{ mA}$		1		ns
Diode Resistance (R_D)	$f = 1\text{ kHz}$, $I_F = 1\text{ mA}$	25	30	45	Ω
Diode Capacitance (C_D)	$V_R = -2\text{V}$, $I_F = 0$		.65		pF
Diode-to-Substrate Capacitance (C_{D1})	$V_{D1} = +4\text{V}$, $I_F = 0$		3.2		pF

typical performance characteristics

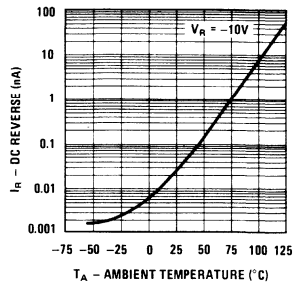
DC Forward Voltage Drop (Any Diode) and Diode Offset Voltage vs DC Forward Current



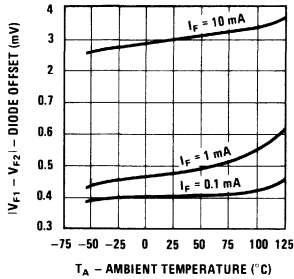
DC Reverse (Leakage) Current (Diodes 1, 2, 3, 4, 5) vs Temperature



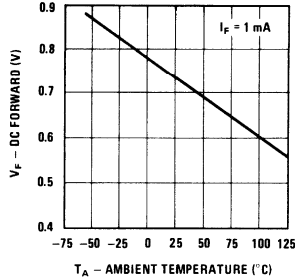
DC Reverse (Leakage) Current Between Diodes (1, 2, 3, 4, 5) and Substrate vs Temperature



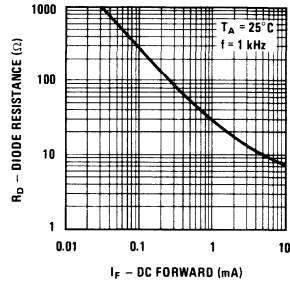
Diode Offset Voltage (Any Diode) vs Temperature



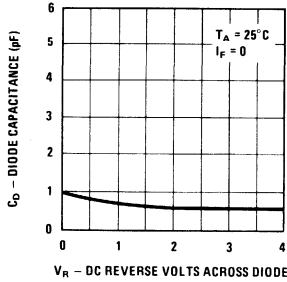
DC Forward Voltage Drop (Any Diode) vs Temperature



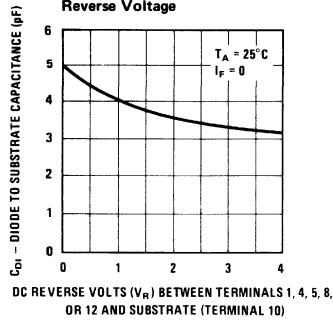
Diode Resistance (Any Diode) vs DC Forward Current



Diode Capacitance (Diodes 1, 2, 3, 4, 5) vs Reverse Voltage



Diode-to-Substrate Capacitance vs Reverse Voltage





Transistor/Diode Arrays

LM3045, LM3046, LM3086

LM3045, LM3046, LM3086 transistor arrays

general description

The LM3045, LM3046, and LM3086 each consist of five general purpose silicon NPN transistors on a common monolithic substrate. Two of the transistors are internally connected to form a differentially-connected pair. The transistors are well suited to a wide variety of applications in low power system in the DC through VHF range. They may be used as discrete transistors in conventional circuits however, in addition, they provide the very significant inherent integrated circuit advantages of close electrical and thermal matching. The LM3045 is supplied in a 14-lead cavity dual-in-line package rated for operation over the full military temperature range. The LM3046 and LM3086 are electrically identical to the LM3045 but are supplied in a 14-lead molded dual-in-line package for applications requiring only a limited temperature range.

features

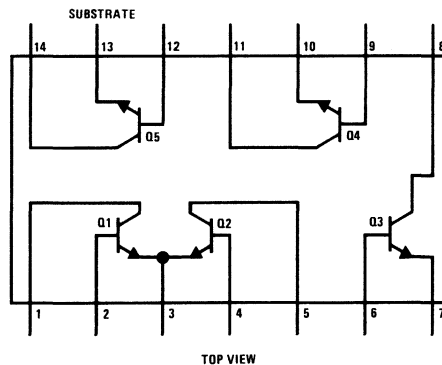
- Two matched pairs of transistors
 V_{BE} matched ± 5 mV
 Input offset current $2\mu\text{A}$ max at $I_C = 1$ mA
- Five general purpose monolithic transistors
- Operation from DC to 120 MHz
- Wide operating current range
- Low noise figure 3.2 dB typ at 1 kHz
- Full military temperature range (LM3045) -55°C to $+125^\circ\text{C}$

applications

- General use in all types of signal processing systems operating anywhere in the frequency range from DC to VHF
- Custom designed differential amplifiers
- Temperature compensated amplifiers

schematic and connection diagram

Dual-In-Line Package



Order Number LM3045D
 See Package 1

or

Order Number LM3046N or LM3086N
 See Package 22

6

absolute maximum ratings ($T_A = 25^\circ\text{C}$)

	LM3045		LM3046/LM3086		Units
	Each Transistor	Total Package	Each Transistor	Total Package	
Power Dissipation:					
$T_A = 25^\circ\text{C}$	300	750	300	750	mW
$T_A = 25^\circ\text{C}$ to 55°C			300	750	mW
$T_A > 55^\circ\text{C}$			Derate at 6.67		mW/ $^\circ\text{C}$
$T_A = 25^\circ\text{C}$ to 75°C	300	750			mW
$T_A > 75^\circ\text{C}$	Derate at 8				mW/ $^\circ\text{C}$
Collector to Emitter Voltage, V_{CE0}	15		15		V
Collector to Base Voltage, V_{CBO}	20		20		V
Collector to Substrate Voltage, V_{C10} (Note 1)	20		20		V
Emitter to Base Voltage, V_{EBO}	5		5		V
Collector Current, I_C	50		50		mA
Operating Temperature Range	-55°C to $+125^\circ\text{C}$		0°C to $+85^\circ\text{C}$		
Storage Temperature Range	-65°C to $+150^\circ\text{C}$		-25°C to $+85^\circ\text{C}$		
Lead Temperature (Soldering, 10 sec)	300		300		$^\circ\text{C}$

electrical characteristics ($T_A = 25^\circ\text{C}$ unless otherwise specified)

PARAMETER	CONDITIONS	LIMITS			LIMITS			UNITS
		LM3045, LM3046			LM3086			
		MIN	TYP	MAX	MIN	TYP	MAX	
Collector to Base Breakdown Voltage ($V_{(BR)CBO}$)	$I_C = 10\mu\text{A}, I_E = 0$	20	60		20	60		V
Collector to Emitter Breakdown Voltage ($V_{(BR)CEO}$)	$I_C = 1\text{mA}, I_B = 0$	15	24		15	24		V
Collector to Substrate Breakdown Voltage ($V_{(BR)C10}$)	$I_C = 10\mu\text{A}, I_{C1} = 0$	20	60		20	60		V
Emitter to Base Breakdown Voltage ($V_{(BR)EBO}$)	$I_E = 10\mu\text{A}, I_C = 0$	5	7		5	7		V
Collector Cutoff Current (I_{CBO})	$V_{CB} = 10\text{V}, I_E = 0$		.002	40		.002	100	nA
Collector Cutoff Current (I_{CEO})	$V_{CE} = 10\text{V}, I_B = 0$			5			5	μA
Static Forward Current Transfer Ratio (Static Beta) (h_{FE})	$V_{CE} = 3\text{V}$ $\begin{cases} I_C = 10\text{mA} \\ I_C = 1\text{mA} \\ I_C = 10\mu\text{A} \end{cases}$	40	100 100 54		40	100 100 54		
Input Offset Current for Matched Pair Q_1 and Q_2 ($I_{O1} - I_{O2}$)	$V_{CE} = 3\text{V}, I_C = 1\text{mA}$		.3	2				μA
Base to Emitter Voltage (V_{BE})	$V_{CE} = 3\text{V}$ $\begin{cases} I_E = 1\text{mA} \\ I_E = 10\text{mA} \end{cases}$		.715 .800			.715 .800		V
Magnitude of Input Offset Voltage for Differential Pair ($|V_{BE1} - V_{BE2}|$)	$V_{CE} = 3\text{V}, I_C = 1\text{mA}$		.45	5				mV
Magnitude of Input Offset Voltage for Isolated Transistors ($|V_{BE3} - V_{BE4}|, |V_{BE4} - V_{BE5}|, |V_{BE5} - V_{BE3}|$)	$V_{CE} = 3\text{V}, I_C = 1\text{mA}$		.45	5				mV
Temperature Coefficient of Base to Emitter Voltage ($\frac{\Delta V_{BE}}{\Delta T}$)	$V_{CE} = 3\text{V}, I_C = 1\text{mA}$		-1.9			-1.9		mV/ $^\circ\text{C}$
Collector to Emitter Saturation Voltage ($V_{CE(SAT)}$)	$I_B = 1\text{mA}, I_C = 10\text{mA}$		.23			.23		V
Temperature Coefficient of Input Offset Voltage ($\frac{\Delta V_{10}}{\Delta T}$)	$V_{CE} = 3\text{V}, I_C = 1\text{mA}$		1.1					$\mu\text{V}/^\circ\text{C}$

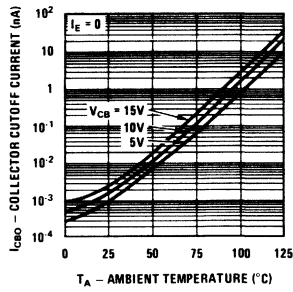
Note 1: The collector of each transistor of the LM3045, LM3046, and LM3086 is isolated from the substrate by an integral diode. The substrate (terminal 13) must be connected to the most negative point in the external circuit to maintain isolation between transistors and to provide for normal transistor action.

electrical characteristics (con't)

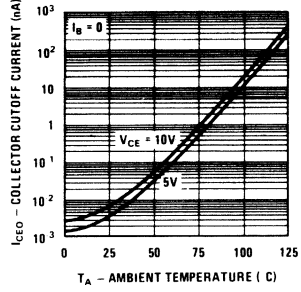
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Low Frequency Noise Figure (NF)	$f = 1 \text{ kHz}, V_{CE} = 3V, I_C = 100\mu A$ $R_S = 1 \text{ k}\Omega$		3.25		dB
Low Frequency, Small Signal Equivalent Circuit Characteristics:					
Forward Current Transfer Ratio (h_{FE})			110 (LM3045, LM3046) (LM3086)		
Short Circuit Input Impedance (h_{ie})	$f = 1 \text{ kHz}, V_{CE} = 3V, I_C = 1 \text{ mA}$		3.5		$\text{k}\Omega$
Open Circuit Output Impedance (h_{oe})			15.6		μmho
Open Circuit Reverse Voltage Transfer Ratio (h_{re})			1.8×10^{-4}		
Admittance Characteristics:					
Forward Transfer Admittance (Y_{fe})			$31 - j 1.5$		
Input Admittance (Y_{ie})			$0.3 + j 0.04$		
Output Admittance (Y_{oe})	$f = 1 \text{ MHz}, V_{CE} = 3V, I_C = 1 \text{ mA}$		$0.001 + j 0.03$		
Reverse Transfer Admittance (Y_{re})			See curve		
Gain Bandwidth Product (f_T)	$V_{CE} = 3V, I_C = 3 \text{ mA}$	300	550		
Emitter to Base Capacitance (C_{EB})	$V_{EB} = 3V, I_E = 0$		.6		pF
Collector to Base Capacitance (C_{CB})	$V_{CB} = 3V, I_C = 0$		.58		pF
Collector to Substrate Capacitance (C_{CI})	$V_{CS} = 3V, I_C = 0$		2.8		pF

typical performance characteristics

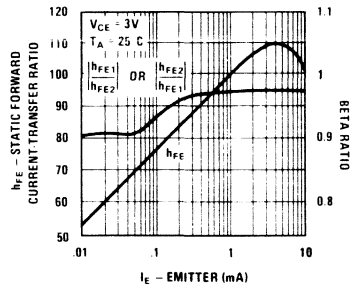
Typical Collector To Base Cutoff Current vs Ambient Temperature for Each Transistor



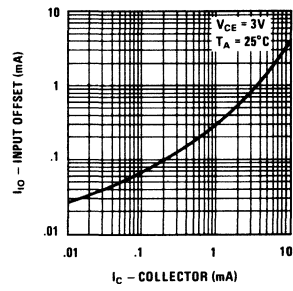
Typical Collector To Emitter Cutoff Current vs Ambient Temperature for Each Transistor



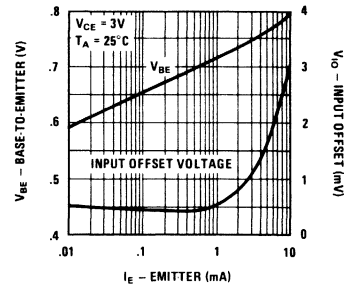
Typical Static Forward Current-Transfer Ratio and Beta Ratio for Transistors Q1 and Q2 vs Emitter Current



Typical Input Offset Current for Matched Transistor Pair Q1 Q2 vs Collector Current

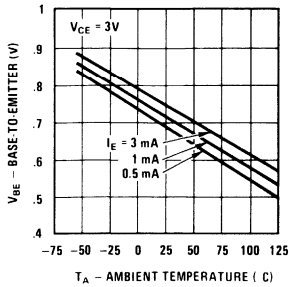


Typical Static Base To Emitter Voltage Characteristic and Input Offset Voltage for Differential Pair and Paired Isolated Transistors vs Emitter Current

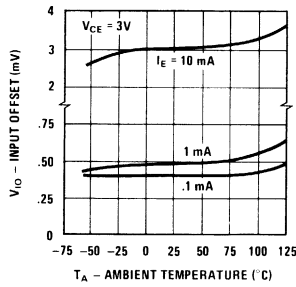


typical performance characteristics (con't)

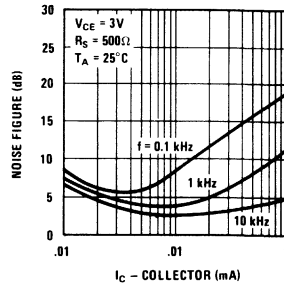
Typical Base To Emitter Voltage Characteristic for Each Transistor vs Ambient Temperature



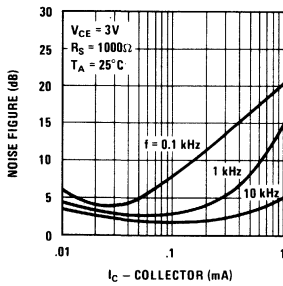
Typical Input Offset Voltage Characteristics for Differential Pair and Paired Isolated Transistors vs Ambient Temperature



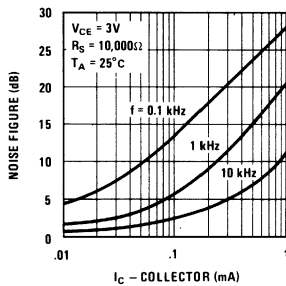
Typical Noise Figure vs Collector Current



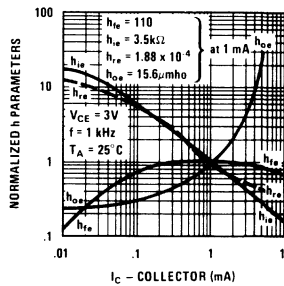
Typical Noise Figure vs Collector Current



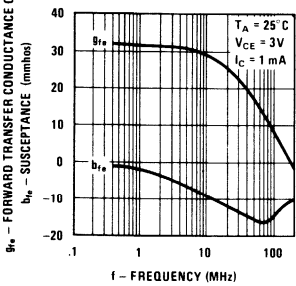
Typical Noise Figure vs Collector Current



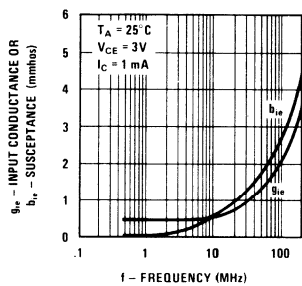
Typical Normalized Forward Current Transfer Ratio, Short Circuit Input Impedance, Open Circuit Output Impedance, and Open Circuit Reverse Voltage Transfer Ratio vs Collector Current



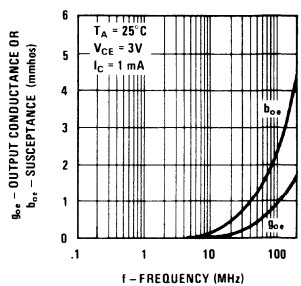
Typical Forward Transfer Admittance vs Frequency



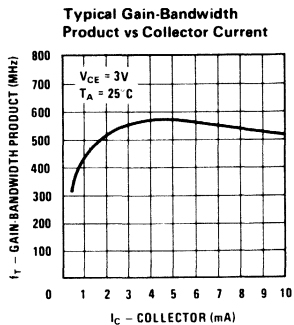
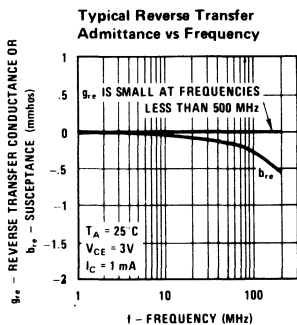
Typical Input Admittance vs Frequency



Typical Output Admittance vs Frequency



typical performance characteristics (con't)





Analog Switches

AH0014/AH0014C* DPDT, AH0015/AH0015C quad SPST, AH0019/AH0019C* dual DPST-TTL/DTL compatible MOS analog switches

general description

This series of TTL/DTL compatible MOS analog switches feature high speed with internal level shifting and driving. The package contains two monolithic integrated circuit chips: the MOS analog chip is similar to the MM450 type which consists of four MOS analog switch transistors; the second chip is a bipolar I.C. gate and level shifter. The series is available in both hermetic dual-in-line package and flatpack.

- Fully compatible with DTL or TTL logic
- Includes gating and level shifting

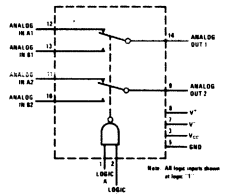
These switches are particularly suited for use in both military and industrial applications such as commutators in data acquisition systems, multiplexers, A/D and D/A converters, long time constant integrators, sample and hold circuits, modulators/demodulators, and other analog signal switching applications. For information on other National analog switches and analog interface elements, see listing on last page.

features

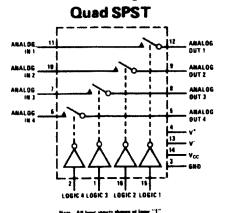
- Large analog voltage switching $\pm 10V$
- Fast switching speed 500 ns
- Operation over wide range of power supplies
- Low ON resistance 200 Ω
- High OFF resistance $10^{11}\Omega$

The AH0014, AH0015 and AH0019 are specified for operation over the $-55^{\circ}C$ to $+125^{\circ}C$ military temperature range. The AH0014C, AH0015C and AH0019C are specified for operation over the $-25^{\circ}C$ to $+85^{\circ}C$ temperature range.

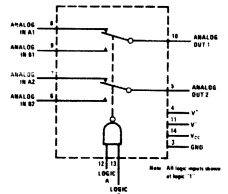
block and connection diagrams



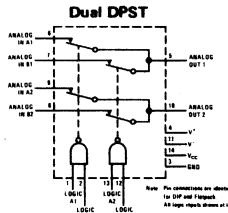
Order Number AH0014F or AH0014CF
See Package 4



Order Number AH0015D or AH0015CD
See Package 2

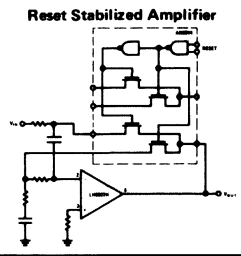
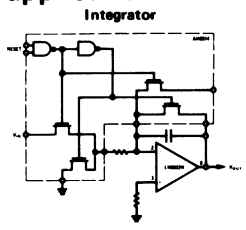


Order Number AH0014D or AH0014CD
See Package 1



Order Number AH0019F or AH0019CF
See Package 4
Order Number AH0019D or AH0019CD
See Package 1

typical applications



*Previously called NH0014/NH0014C and NH0019/NH0019C



absolute maximum ratings

V_{CC} Supply Voltage	7.0V
V^- Supply Voltage	-30V
V^+ Supply Voltage	+30V
V^+/V^- Voltage Differential	40V
Logic Input Voltage	5.5V
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	
AH0014, AH0015, AH0019	-55°C to +125°C
AH0014C, AH0015C, AH0019C	-25°C to +85°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Notes 1 and 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Logical "1" Input Voltage	$V_{CC} = 4.5V$	2.0			V
Logical "0" Input Voltage	$V_{CC} = 4.5V$			0.8	V
Logical "1" Input Current	$V_{CC} = 5.5V$ $V_{IN} = 2.4V$			5	μA
Logical "1" Input Current	$V_{CC} = 5.5V$ $V_{IN} = 5.5V$			1	mA
Logical "0" Input Current	$V_{CC} = 5.5V$ $V_{IN} = 0.4V$		0.2	0.4	mA
Power Supply Current Logical "1" Input – each gate (Note 3)	$V_{CC} = 5.5V$ $V_{IN} = 4.5V$		0.85	1.6	mA
Power Supply Current Logical "0" Input – each gate (Note 3)	$V_{CC} = 5.5V$ $V_{IN} = 0V$				
AH0014, AH0014C			1.5	3.0	mA
AH0015, AH0015C			0.22	0.41	mA
AH0019, AH0019C			0.22	0.41	mA
Analog Switch ON Resistance – each gate	V_{IN} (Analog) = +10V V_{IN} (Analog) = -10V		75 150	200 600	Ω Ω
Analog Switch OFF Resistance			10^{11}		Ω
Analog Switch Input Leakage Current – each input (Note 4)	$V_{IN} = -10V$				
AH0014, AH0015, AH0019	$T_A = 25^\circ C$ $T_A = 125^\circ C$		25 25	200 200	pA nA
AH0014C, AH0015C, AH0019C	$T_A = 25^\circ C$ $T_A = 70^\circ C$		0.1 30	10 100	nA nA
Analog Switch Output Leakage Current – each output (Note 4)	$V_{OUT} = -10V$				
AH0014, AH0015, AH0019	$T_A = 25^\circ C$ $T_A = 125^\circ C$		40 40	400 400	pA nA
AH0014C, AH0015C, AH0019C	$T_A = 25^\circ C$ $T_A = 70^\circ C$		0.05 4	10 50	nA nA
Analog Input (Drain) Capacitance	1 MHz @ Zero Bias		8	10	pF
Output Source Capacitance	1 MHz @ Zero Bias		11	13	pF
Analog Turn-OFF Time – t_{OFF}	See test circuit; $T_A = 25^\circ C$		400	500	ns
Analog Turn-ON Time – t_{ON}	See test circuit; $T_A = 25^\circ C$				
AH0014, AH0014C			350	425	ns
AH0015, AH0015C			100	150	ns
AH0019, AH0019C			100	150	ns

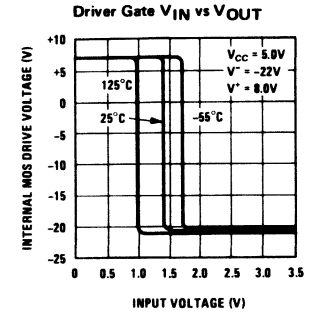
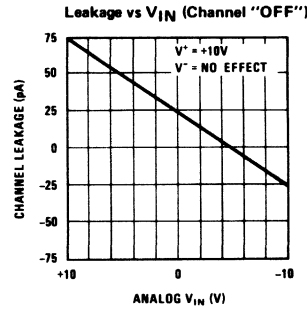
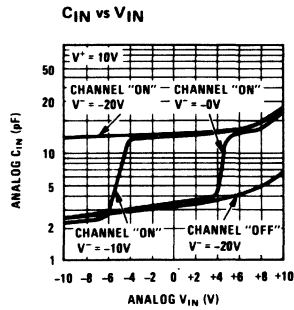
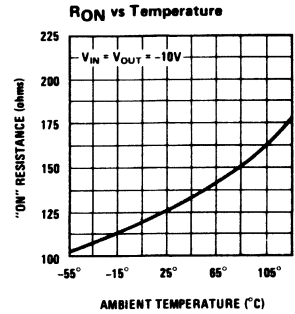
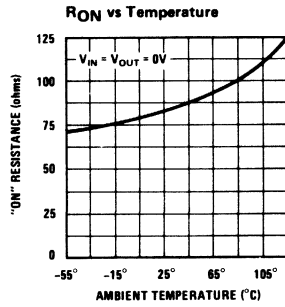
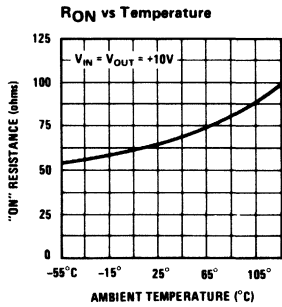
Note 1: Min/max limits apply across the guaranteed temperature range of -55°C to +125°C for AH0014, AH0015, AH0019 and -25°C to +85°C for AH0014C, AH0015C, AH0019C. $V^- = -20V$. $V^+ = +10V$ and an analog test current of 1 mA unless otherwise specified.

Note 2: All typical values are measured at $T_A = 25^\circ C$ with $V_{CC} = 5.0V$. $V^+ = +10V$, $V^- = -22V$.

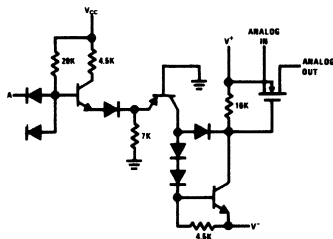
Note 3: Current measured is drawn from V_{CC} supply.

Note 4: All analog switch pins except measurement pin are tied to V^+ .

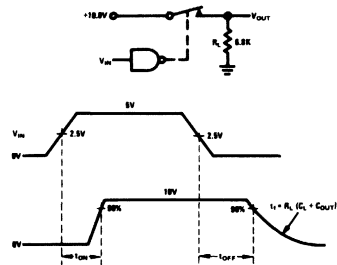
analog switch characteristics (Note 2)



Schematic (Single Driver Gate and MOS Switch Shown)

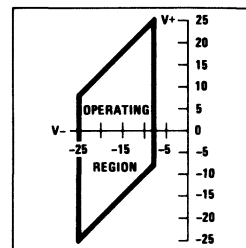


Analog Switching Time Test Circuit



selecting power supply voltage

The graph shows the boundary conditions which must be used for proper operation of the unit. The range of operation for power supply V^- is shown on the X axis. It must be between $-25V$ and $-8V$. The allowable range for power supply V^+ is governed by supply V^- . With a value chosen for V^- , V^+ may be selected as any value along a vertical line passing through the V^- value and terminated by the boundaries of the operating region. A voltage difference between power supplies of at least $5V$ should be maintained for adequate signal swing.





Analog Switches

AH0120/AH0130/AH0140/AH0150/AH0160 series analog switches

general description

The AH0100 series represents a complete family of junction FET analog switches. The inherent flexibility of the family allows the designer to tailor the device selection to the particular application. Switch configurations available include dual DPST, dual SPST, DPDT, and SPDT. $r_{ds(ON)}$ ranges from 10 ohms through 100 ohms. The series is available in both 14 lead flat pack and 14 lead cavity DIP. Important design features include:

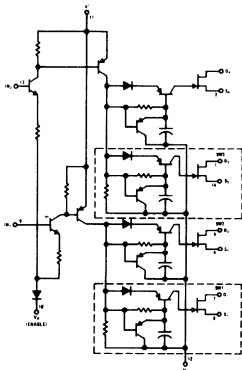
- TTL/DTL and RTL compatible logic inputs
- Up to 20V p-p analog input signal
- $r_{ds(ON)}$ less than 10Ω (AH0140, AH0141, AH0145, AH0146)
- Analog signals in excess of 1 MHz
- "OFF" power less than 1 mW

- Gate to drain bleed resistors eliminated
- Fast switching, t_{ON} is typically .4 μs, t_{OFF} is 1.0 μs
- Operation from standard op amp supply voltages, ±15V, available (AH0150/AH0160 series)
- Pin compatible with the popular DG 100 series.

The AH0100 series is designed to fulfill a wide variety of analog switching applications including commutators, multiplexers, D/A converters, sample and hold circuits, and modulators/demodulators. The AH0100 series is guaranteed over the temperature range -55°C to +125°C; whereas, the AH0100C series is guaranteed over the temperature range -25°C to +85°C.

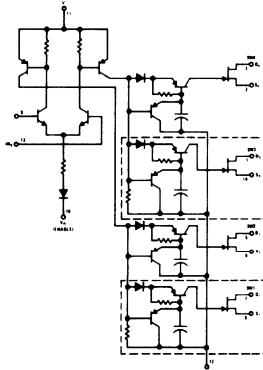
schematic diagrams

DUAL DPST and DUAL SPST



Note: Dotted line portions are not applicable to the dual SPST.

DPDT (diff.) and SPDT (diff.)

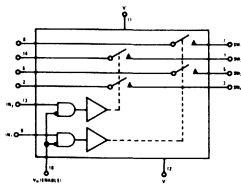


Note: Dotted line portions are not applicable to the SPDT (differential).

logic and connection diagrams

Order any of the devices below using the part number with a D or F suffix. See Packages 1 and 4.

DUAL DPST



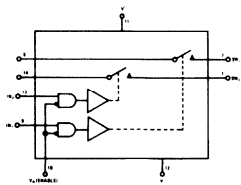
HIGH LEVEL (±10V)

- AH0140 (10Ω)
- AH0129 (30Ω)
- AH0126 (80Ω)

MEDIUM LEVEL (±7.5V)

- AH0153 (15Ω)
- AH0154 (50Ω)

DUAL SPST



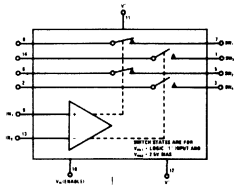
HIGH LEVEL (±10V)

- AH0141 (10Ω)
- AH0133 (30Ω)
- AH0134 (80Ω)

MEDIUM LEVEL (±7.5V)

- AH0151 (15Ω)
- AH0152 (50Ω)

DPDT (Diff)



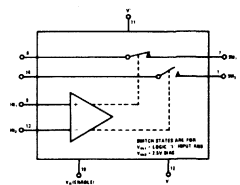
HIGH LEVEL (±10V)

- AH0145 (10Ω)
- AH0139 (30Ω)
- AH0142 (80Ω)

MEDIUM LEVEL (±7.5)

- AH0163 (15Ω)
- AH0164 (50Ω)

SPDT (Diff)



HIGH LEVEL (±10V)

- AH0146 (10Ω)
- AH0144 (30Ω)
- AH0143 (80Ω)

MEDIUM LEVEL (±7.5V)

- AH0161 (15Ω)
- AH0162 (50Ω)

absolute maximum ratings

	High Level	Medium Level
Total Supply Voltage ($V^+ - V^-$)	36V	34V
Analog Signal Voltage ($V^+ - V_A$ or $V_A - V^-$)	30V	25V
Positive Supply Voltage to Reference ($V^+ - V_R$)	25V	25V
Negative Supply Voltage to Reference ($V_R - V^-$)	22V	22V
Positive Supply Voltage to Input ($V^+ - V_{IN}$)	25V	25V
Input Voltage to Reference ($V_{IN} - V_R$)	$\pm 6V$	$\pm 6V$
Differential Input Voltage ($V_{IN} - V_{IN2}$)	$\pm 6V$	$\pm 6V$
Input Current, Any Terminal	30 mA	30 mA
Power Dissipation	See Curve	
Operating Temperature Range	AH0100 Series -55°C to +125°C AH0100C Series -25°C to +85°C	
Storage Temperature Range	-65°C to +150°C	
Lead Temperature (Soldering, 10 sec)	300°C	

electrical characteristics for "HIGH LEVEL" Switches (Note 1)

PARAMETER	SYMBOL	DEVICE TYPE				CONDITIONS $V^+ = 12.0V, V^- = -18.0V, V_R = 0.0V$	LIMITS		UNITS
		DUAL DPST	DUAL SPST	DPDT (DIFF)	SPDT (DIFF)		TYP	MAX	
Logic "1" Input Current	$I_{IN(ON)}$	All Circuits				Note 2	$T_A = 25^\circ C$ Over Temp. Range	2.0 120	60 μA
Logic "0" Input Current	$I_{IN(OFF)}$	All Circuits				Note 2	$T_A = 25^\circ C$ Over Temp. Range	.01 2.0	.1 μA
Positive Supply Current Switch ON	$I^+_{(ON)}$	All Circuits				One Driver ON Note 2	$T_A = 25^\circ C$ Over Temp. Range	2.2 3.3	3.0 mA
Negative Supply Current Switch ON	$I^-_{(ON)}$	All Circuits				One Driver ON Note 2	$T_A = 25^\circ C$ Over Temp. Range	-1.0 -2.0	-1.8 mA
Reference Input (Enable) ON Current	$I^+_{(RION)}$	All Circuits				One Driver ON Note 2	$T_A = 25^\circ C$ Over Temp. Range	-1.0 -1.6	-1.4 mA
Positive Supply Current Switch OFF	$I^+_{(OFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8V$	$T_A = 25^\circ C$ Over Temp. Range	1.0 25	10 μA
Negative Supply Current Switch OFF	$I^-_{(OFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8V$	$T_A = 25^\circ C$ Over Temp. Range	-1.0 -25	-10 μA
Reference Input (Enable) OFF Current	$I^+_{(RIOFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8V$	$T_A = 25^\circ C$ Over Temp. Range	-1.0 -25	-10 μA
Switch ON Resistance	$r_{d(ON)}$	AH0126	AH0134	AH0142	AH0143	$V_D = 10V$ $I_D = 1 mA$	$T_A = 25^\circ C$ Over Temp. Range	45 160	80 Ω
Switch ON Resistance	$r_{d(ON)}$	AH0129	AH0133	AH0139	AH0144	$V_D = 10V$ $I_D = 1 mA$	$T_A = 25^\circ C$ Over Temp. Range	25 60	30 Ω
Switch ON Resistance	$r_{d(ON)}$	AH0140	AH0141	AH0145	AH0146	$V_D = 10V$ $I_F = 1 mA$	$T_A = 25^\circ C$ Over Temp. Range	8 20	10 Ω
Driver Leakage Current	$(I_D + I_S)_{ON}$	All Circuits				$V_D = V_S = -10V$	$T_A = 25^\circ C$ Over Temp. Range	.01 100	1 nA
Switch Leakage Current	$I_{S(OFF)}$ OR $I_{D(OFF)}$	AH0126 AH0129	AH0134 AH0133	AH0142 AH0139	AH0143 AH0144	$V_{DS} = \pm 20V$	$T_A = 25^\circ C$ Over Temp. Range	0.8 100	1 nA
Switch Leakage Current	$I_{S(OFF)}$ OR $I_{D(OFF)}$	AH0140	AH0141	AH0145	AH0146	$V_{DS} = \pm 20V$	$T_A = 25^\circ C$ Over Temp. Range	4 1.0	10 μA
Switch Turn-ON Time	t_{ON}	AH0126 AH0129	AH0134 AH0133	AH0142 AH0139	AH0143 AH0144	See Test Circuit $V_A = \pm 10V$ $T_A = 25^\circ C$	0.5	0.8	μs
Switch Turn-ON Time	t_{ON}	AH0140	AH0141	AH0145	AH0146	See Test Circuit $V_A = \pm 10V$ $T_A = 25^\circ C$	0.8	1.0	μs
Switch Turn-OFF Time	t_{OFF}	AH0126 AH0129	AH0134 AH0133	AH0142 AH0139	AH0143 AH0144	See Test Circuit $V_A = \pm 10V$ $T_A = 25^\circ C$	0.9	1.6	μs
Switch Turn-OFF Time	t_{OFF}	AH0140	AH0141	AH0145	AH0146	See Test Circuit $V_A = \pm 10V$ $T_A = 25^\circ C$	1.1	2.5	μs

Note 1: Unless otherwise specified these limits apply for -55°C to +125°C for the AH0100 series and -25°C to +85°C for the AH0100C series. All typical values are for $T_A = 25^\circ C$.

Note 2: For the DPST and Dual DPST, the ON condition is for $V_{IN} = 2.5V$; the OFF condition is for $V_{IN} = 0.8V$. For the differential switches and SW1 and 2 ON, $V_{IN2} = 2.5V$, $V_{IN1} = 3.0V$. For SW3 and 4 ON, $V_{IN2} = 2.5V$, $V_{IN1} = 2.0V$.



electrical characteristics for "MEDIUM LEVEL" Switches (Note 1)

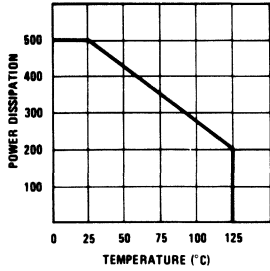
PARAMETER	SYMBOL	DEVICE TYPE				CONDITIONS	LIMITS		UNITS
		DUAL DPST	DUAL SPST	DUAL DPDT	SPDT (DIFF)		TYP	MAX	
Logic "1" Input Current	$I_{(INON)}$	All Circuits				Note 2 $T_A = 25^\circ\text{C}$ Over Temp. Range	20	60	μA
Logic "0" Input Current	$I_{(INOFF)}$	All Circuits				Note 2 $T_A = 25^\circ\text{C}$ Over Temp. Range	.01	0.1	μA
Positive Supply Current Switch ON	$I_{(ION)}$	All Circuits				One Driver ON Note 2 $T_A = 25^\circ\text{C}$ Over Temp. Range	2.2	3.0	mA
Negative Supply Current Switch ON	$I_{(ION)}$	All Circuits				One Driver ON Note 2 $T_A = 25^\circ\text{C}$ Over Temp. Range	-1.0	-1.8	mA
Reference Input (Enable) ON Current	$I_{(RON)}$	All Circuits				One Driver ON Note 2 $T_A = 25^\circ\text{C}$ Over Temp. Range	-1.0	-1.4	mA
Positive Supply Current Switch OFF	$I_{(IOFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8\text{V}$ $T_A = 25^\circ\text{C}$ Over Temp. Range	1.0	10	μA
Negative Supply Current Switch OFF	$I_{(IOFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8\text{V}$ $T_A = 25^\circ\text{C}$ Over Temp. Range	-1.0	-10	μA
Reference Input (Enable) OFF Current	$I_{(ROFF)}$	All Circuits				$V_{IN1} = V_{IN2} = 0.8\text{V}$ $T_A = 25^\circ\text{C}$ Over Temp. Range	-1.0	-10	μA
Switch ON Resistance	$r_{(SWON)}$	AH0153	AH0151	AH0163	AH0161	$V_D = 7.5\text{V}$ $I_D = 1\text{mA}$ $T_A = 25^\circ\text{C}$ Over Temp. Range	10	15	Ω
Switch ON Resistance	$r_{(SWON)}$	AH0154	AH0152	AH0164	AH0162	$V_D = 7.5\text{V}$ $I_D = 1\text{mA}$ $T_A = 25^\circ\text{C}$ Over Temp. Range	45	50	Ω
Driver Leakage Current	$(I_D + I_S)_{ON}$	All Circuits *				$V_D = V_S = -7.5\text{V}$ $T_A = 25^\circ\text{C}$ Over Temp. Range	.01	2	nA
Switch Leakage Current	$I_{(DIOFF)}$ OR $I_{(SIOFF)}$	AH0153	AH0151	AH0163	AH0161	$V_{DS} = \pm 15\text{V}$ $T_A = 25^\circ\text{C}$ Over Temp. Range	5	10	nA
Switch Leakage Current	$I_{(DIOFF)}$ OR $I_{(SIOFF)}$	AH0154	AH0152	AH0164	AH0162	$V_{DS} = \pm 15.0\text{V}$ $T_A = 25^\circ\text{C}$ Over Temp. Range	1.0	2.0	nA
Switch Turn-ON Time	t_{ON}	AH0153	AH0151	AH0163	AH0161	See Test Circuit $V_A = \pm 7.5\text{V}$ $T_A = 25^\circ\text{C}$	0.8	1.0	μs
Switch Turn-ON Time	t_{ON}	AH0154	AH0152	AH0164	AH0162	See Test Circuit $V_A = \pm 7.5\text{V}$ $T_A = 25^\circ\text{C}$	0.5	0.8	μs
Switch Turn-OFF Time	t_{OFF}	AH0153	AH0151	AH0163	AH0161	See Test Circuit $V_A = \pm 7.5\text{V}$ $T_A = 25^\circ\text{C}$	1.1	2.5	μs
Switch Turn-OFF Time	t_{OFF}	AH0154	AH0152	AH0164	AH0162	See Test Circuit $V_A = \pm 7.5\text{V}$ $T_A = 25^\circ\text{C}$	0.9	1.5	μs

Note 1: Unless otherwise specified, these limits apply for -55°C to $+125^\circ\text{C}$ for the AH0100 series and -25°C to $+85^\circ\text{C}$ for the AH0100C series. All typical values are for $T_A = 25^\circ\text{C}$.

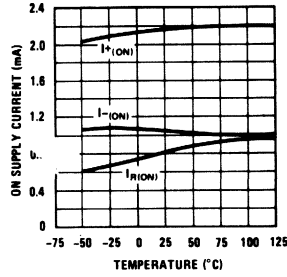
Note 2: For the DPST and Dual DPST, the ON condition is for $V_{IN} = 2.5\text{V}$; the OFF condition is for $V_{IN} = 0.8\text{V}$. For the differential switches and SW1 and 2 ON, $V_{IN2} = 2.5\text{V}$, $V_{IN1} = 3.0\text{V}$. For SW3 and 4 ON, $V_{IN2} = 2.5\text{V}$, $V_{IN1} = 2.0\text{V}$.

typical performance characteristics

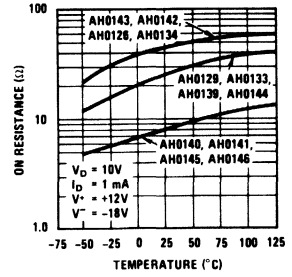
Power Dissipation vs Temperature



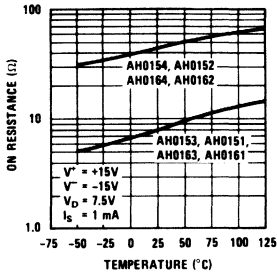
ON Supply Current vs Temperature



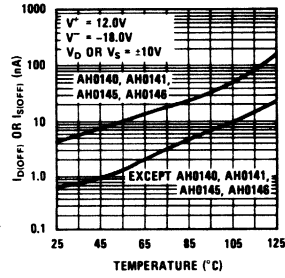
r_{ds(ON)} vs Temperature AH0120 thru AH0140 Series



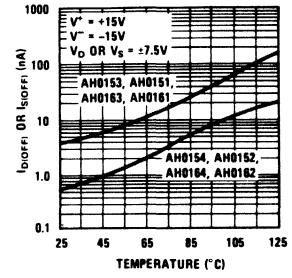
r_{ds(ON)} vs Temperature AH0150/AH0160 Series



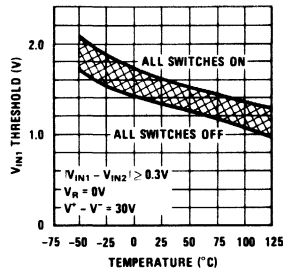
Leakage Current vs Temperature AH0120, AH0130, & AH0140



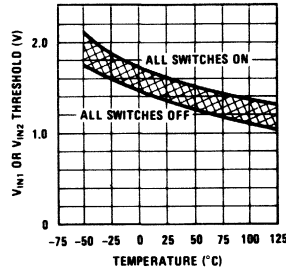
Leakage Current vs Temperature AH0150 & AH0160



Single Ended Switch Input Threshold vs Temperature

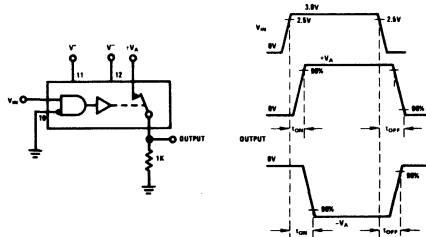


Differential Switch Input Threshold vs Temperature

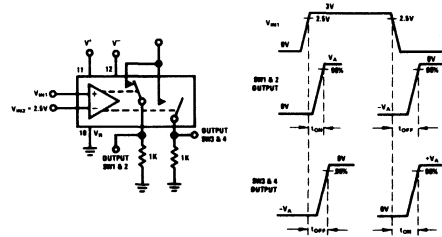


switching time test circuits

Single Ended Input



Differential Input



applications information

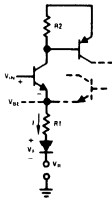
1. INPUT LOGIC COMPATIBILITY

A. Voltage Considerations

In general, the AH0100 series is compatible with most DTL, TTL, and RTL logic families. The ON-input threshold is determined by the V_{BE} of the input transistor plus the V_f of the diode in the emitter leg, plus $I \times R_1$, plus V_R . At room temperature and $V_R = 0V$, the nominal ON threshold is: $0.7V + 0.7V + 0.2V = 1.6V$. Over temperature and manufacturing tolerances, the threshold may be as high as 2.5V and as low as 0.8V. The rules for proper operation are:

$$V_{IN} - V_R \geq 2.5V \text{ All switches ON}$$

$$V_{IN} - V_R \leq 0.8V \text{ All switches OFF}$$



B. Input Current Considerations

$I_{IN(ON)}$, the current drawn by the driver with $V_{IN} = 2.5V$ is typically $20 \mu A$ at $25^\circ C$ and is guaranteed less than $120 \mu A$ over temperature. DTL, such as the DM930 series can supply $180 \mu A$ at logic "1" voltages in excess of 2.5V. TTL output levels are comparable at $400 \mu A$. The DTL and TTL can drive the AH0100 series directly. However, at low temperature, DC noise margin in the logic "1" state is eroded with DTL. A pull-up resistor of $10 k\Omega$ is recommended when using DTL over military temperature range.

If more than one driver is to be driven by a DM930 series (6K) gate, an external pull-up resistor should be added. The value is given by:

$$R_P = \frac{11}{N-1} \text{ for } N > 2$$

where:

R_P = value of the pull-up resistor in $k\Omega$

N = number of drivers.

C. Input Slew Rate

The slew rate of the logic input must be in excess of $0.3V/\mu s$ in order to assure proper operation of the analog switch. DTL, TTL, and RTL output rise times are far in excess of the minimum slew rate requirements. Discrete logic designs, however, should include consideration of input rise time.

2. ENABLE CONTROL

The application of a positive signal at the V_R

terminal will open all switches. The V_R (ENABLE) signal must be capable of rising to within 0.8V of $V_{IN(ON)}$ in the OFF state and of sinking $I_{R(ON)}$ milliamps in the ON state (at $V_{IN(ON)} - V_R > 2.5V$). The V_R terminal can be driven from most TTL and DTL gates.

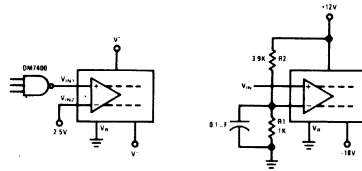
3. DIFFERENTIAL INPUT CONSIDERATIONS

The differential switch driver is essentially a differential amplifier. The input requirements for proper operation are:

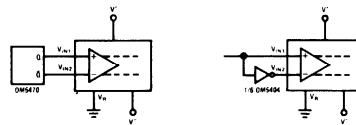
$$|V_{IN1} - V_{IN2}| \geq 0.3V$$

$$2.5 \leq (V_{IN1} \text{ or } V_{IN2}) - V_R \leq 5V$$

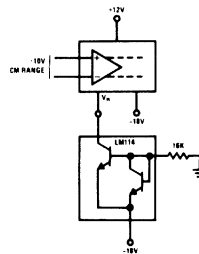
The differential driver may be furnished by a DC level as shown below. The level may be derived from a voltage divider to V^+ or the $5V V_{CC}$ of the DTL logic. In order to assure proper operation, the divider should be "stiff" with respect to I_{IN2} . Bypassing $R1$ with a $0.1 \mu F$ disc capacitor will prevent degradation of t_{ON} and t_{OFF} .



Alternatively, the differential driver may be driven from a TTL flip-flop or inverter.



Connection of a 1 mA current source between V_R and V^- will allow operation over a $\pm 10V$ common mode range. Differential input voltage must be less than the 6V breakdown, and input threshold of 2.5V and 300mV differential overdrive still prevail.



4. ANALOG VOLTAGE CONSIDERATIONS

The rules for operating the AH0100 series at supply voltages other than those specified essentially breakdown into OFF and ON considerations. The OFF considerations are dictated by the maximum negative swing of the analog signal and the pinch off of the JFET switch. In the OFF state, the gate of the FET is at $V^- + V_{BE} + V_{SAT}$ or about 1.0V above the V^- potential. The maximum V_P of the FET switches is 7V. The most negative analog voltage, V_A , swing which can be accommodated for any given supply voltage is:

$$|V_A| \leq |V^-| - V_P - V_{BE} - V_{SAT} \text{ or}$$

$$|V_A| \leq |V^-| - 8.0 \text{ or } |V^-| \geq |V_A| + 8.0V$$

For the standard high level switches, $V_A \leq | -18| + 8 = -10V$. The value for V^+ is dictated by the maximum positive swing of the analog input voltage. Essentially the collector to base junction of the turn-on PNP must remain reversed biased for all positive value of analog input voltage. The base of the PNP is at $V^+ - V_{SAT} - V_{BE}$ or $V^+ - 1.0V$. The PNP's collector base junction should have at least 1.0V reverse bias. Hence, the most positive analog voltage swing which may be accommodated for a given value of V^+ is:

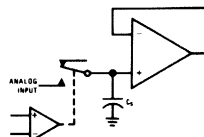
$$V_A \leq V^+ - V_{SAT} - V_{BE} - 1.0V \text{ or}$$

$$V_A \leq V^+ - 2.0V \text{ or } V^+ \geq V_A + 2.0V$$

For the standard high level switches, $V_A = 12 - 2.0V = +10V$.

5. SWITCHING TRANSIENTS

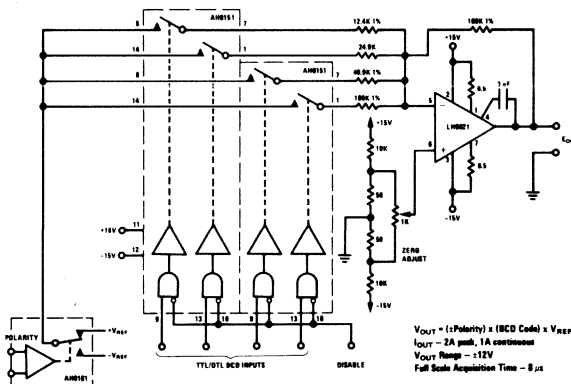
Due to charge stored in the gate-to-source and gate-to-drain capacitances of the FET switch, transients may appear in the output during switching. This is particularly true during the OFF to ON transition. The magnitude and duration of the transient may be minimized by making source and load impedance levels as small as practical.



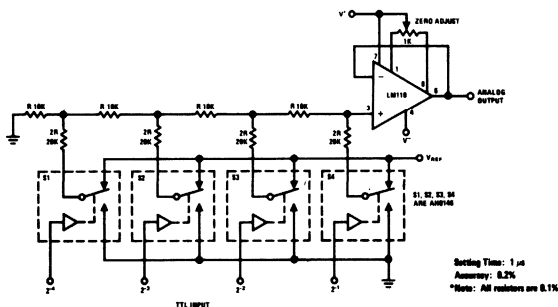
Furthermore, transients may be minimized by operating the switches in the differential mode; i.e., the charge delivered to the load during the ON to OFF transition is, to a large extent, cancelled by the OFF to ON transition.

typical applications

Programmable One Amp Power Supply

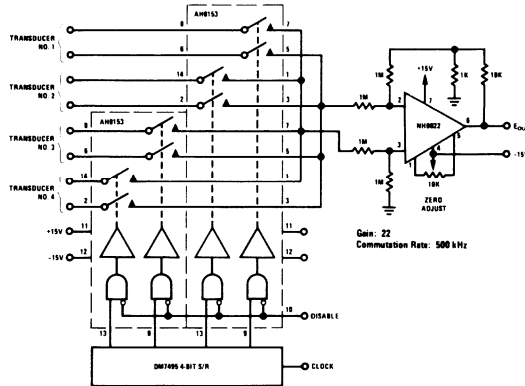


Four to Ten Bit D to A Converter (4 Bits Shown)

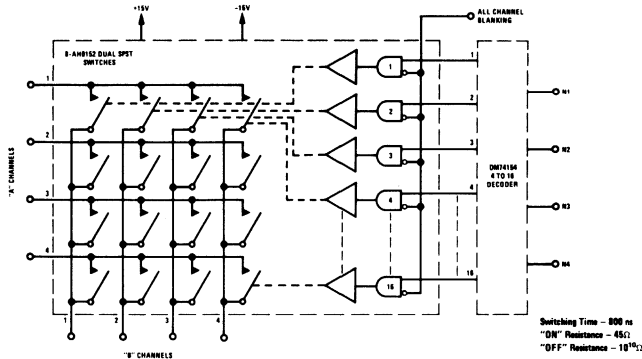


typical applications (con't)

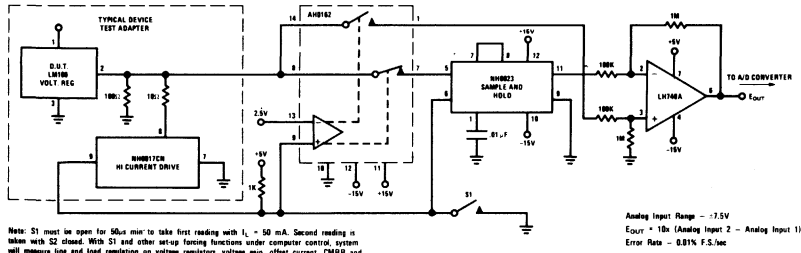
Four Channel Differential Transducer Commutator



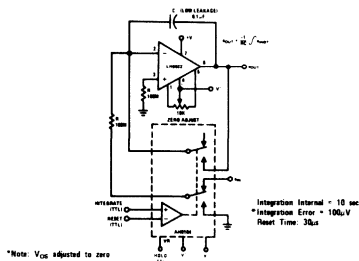
4 x 4 Cross Point Analog Switch



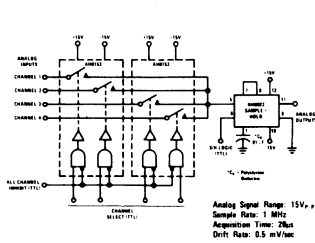
Delta Measurement System for Automatic Linear Circuit Tester



Precision Long Time Constant Integrator with Reset



Four Channel Commutator





Analog Switches

AH2114/AH2114C

AH2114 / AH2114C DPST analog switch general description

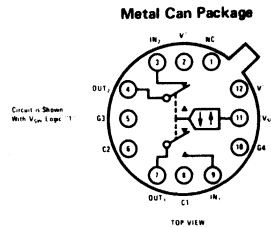
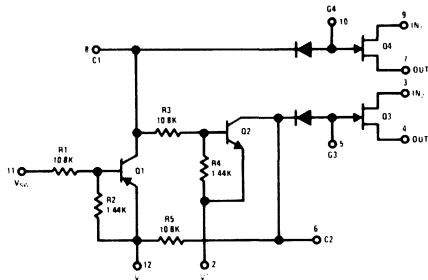
The AH2114 is a DPST analog switch circuit comprised of two junction FET switches and their associated driver. The AH2114 is designed to fulfill a wide variety of high level analog switching applications including multiplexers, A to D Converters, integrators, and choppers. Design features include:

- Low ON resistance, typically 75Ω
- High OFF resistance, typically $10^{11}\Omega$
- Large output voltage swing, typically $\pm 10V$

- Powered from standard op-amp supply voltages of $\pm 15V$
- Input signals in excess of 1 MHz
- Turn-ON and turn-OFF times typically $1\mu s$

The AH2114 is guaranteed over the temperature range $-55^{\circ}C$ to $+125^{\circ}C$ whereas the AH2114C is guaranteed over the temperature range $0^{\circ}C$ to $+85^{\circ}C$.

schematic and connection diagrams



Order Number AH2114G or AH2114CG
See Package 6A

ac test circuit and waveforms

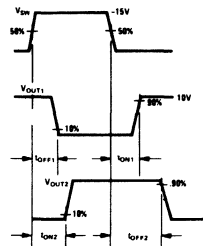
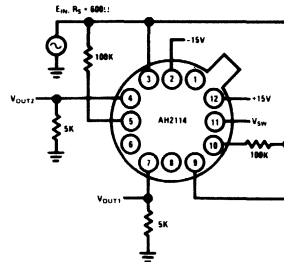
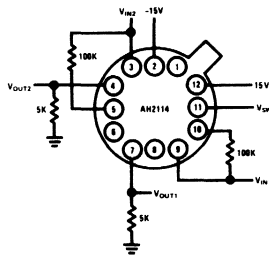


FIGURE 1.

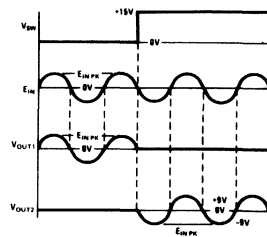


FIGURE 2.

7

absolute maximum ratings

Vplus Supply Voltage	+25V
Vminus Supply Voltage	-25V
Vplus-Vminus Differential Voltage	40V
Logic Input Voltage	25V
Power Dissipation (Note 3)	1.36W
Operating Temperature Range	
AH2114	-55°C to +125°C
AH2114C	0°C to +85°C
Storage Temperature Range	-65°C to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Notes 1 and 2)

PARAMETER	CONDITIONS	AH2114			AH2114C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Static Drain-Source "On" Resistance	$I_D = 1.0 \text{ mA}, V_{GS} = 0V, T_A = 25^\circ\text{C}$	75	100		75	125		Ω
	$I_D = 1.0 \text{ mA}, V_{GS} = 0V$			150		160		Ω
Drain-Gate Leakage Current	$V_{DS} = 20V, V_{GS} = -7V, T_A = 25^\circ\text{C}$	0.2	1.0		0.2	5.0		nA nA
FET Gate-Source Breakdown Voltage	$I_G = 1.0 \mu\text{A}$ $V_{DS} = 0V$	35			35			V
Drain-Gate Capacitance	$V_{DG} = 20V, I_S = 0$ $f = 1.0 \text{ MHz}, T_A = 25^\circ\text{C}$		4.0	5.0		4.0	5.0	pF
Source-Gate Capacitance	$V_{DG} = 20V, I_D = 0$ $f = 1.0 \text{ MHz}, T_A = 25^\circ\text{C}$		4.0	5.0		4.0	5.0	pF
Input 1 Turn-ON Time	$V_{IN1} = 10V, T_A = 25^\circ\text{C}$ (See Figure 1)		35	60		35	60	ns
Input 2 Turn-ON Time	$V_{IN2} = 10V, T_A = 25^\circ\text{C}$ (See Figure 1)		1.2	1.5		1.2	1.2	μs
Input 1 Turn-OFF Time	$V_{IN1} = 10V, T_A = 25^\circ\text{C}$ (See Figure 1)		0.6	0.75		0.6	0.75	μs
Input 2 Turn-OFF Time	$V_{IN2} = 10V, T_A = 25^\circ\text{C}$ (See Figure 1)		50	80		50	80	ns
DC Voltage Range	$T_A = 25^\circ\text{C}$ (See Figure 2)	± 9.0	± 10.0		± 9.0	± 10.0		V
AC Voltage Range	$T_A = 25^\circ\text{C}$ (See Figure 2)	± 9.0	± 10.0		± 9.0	± 10.0		V

Note 1: Unless otherwise specified these specifications apply for pin 12 connected to +15V, pin 2 connected to -15V, -55°C to 125°C for the AH2114, and 0°C to 85°C for the AH2114C.

Note 2: All typical values are for $T_A = 25^\circ\text{C}$.

Note 3: Derate linearly at 100°C/W above 25°C.



Analog Switches

AH5009

AH5009 series low cost analog current switches

general description

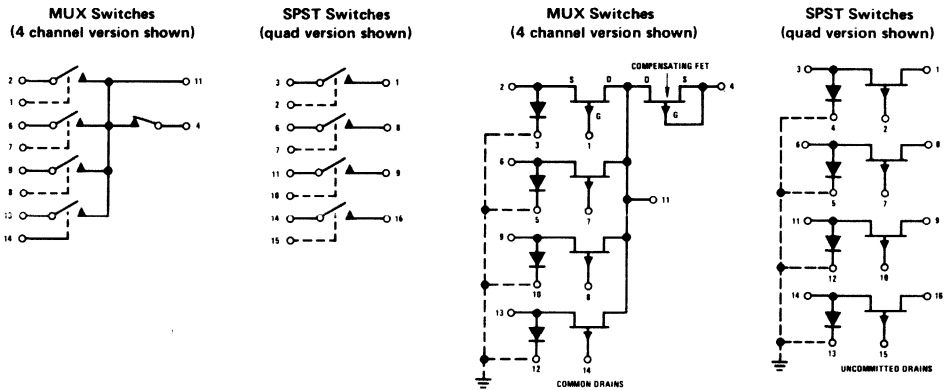
The AH5009 series is a versatile family of analog switches designed to economically fulfill a wide variety of multiplexing and analog switching applications.

Even numbered switches (AH5010, AH5012, AH5014, etc.,) may be driven directly from standard (5V) TTL; whereas the odd numbered switches (AH5009, AH5011, AH5013, etc.,) are intended for applications utilizing open-collector (15V) structures.

features

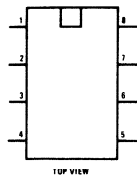
- Large analog signal range ±10V peak
- Excellent isolation between channels 80 dB at 1 kHz
- Very low leakage 50 pA
- High switching speed 150 ns
- Low on resistance 100Ω
- Interfaces with standard TTL

functional and schematic diagrams (See additional types on page 6.)



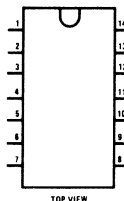
connection diagrams

Dual-In-Line Package



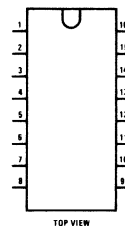
Order Number:
 AH5017CN
 AH5018CN
 AH5019CN
 AH5020CN
 AH5021CN
 AH5022CN
 AH5023CN
 AH5024CN
 See Package 20

Dual-In-Line Package



Order Number:
 AH5009CN
 AH5010CN
 AH5013CN
 AH5014CN
 See Package 22

Dual-In-Line Package



Order Number:
 AH5011CN
 AH5012CN
 AH5015CN
 AH5016CN
 See Package 23

7

absolute maximum ratings

Input Voltage (V_{IN})	$\pm 30V$
Positive Analog Signal Voltage (V_A)	30V
Negative Analog Signal Voltage (V_A)	-15V
Diode Current	10 mA
Drain Current (I_D)	30 mA
Power Dissipation (see graph)	500 mW
Operating Temperature Range	-25°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	300°C

electrical characteristics (each channel)

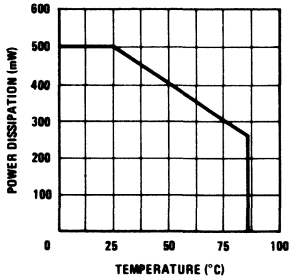
PARAMETER (Note 2)	CIRCUIT TYPE	CONDITIONS (Note 1)	TYP	MAX	UNITS
Input Current "ON" ($I_{IN(ON)}$)	All	$V_{IN} = 0V, I_D = 2 mA, T_A = 25^\circ C$	.01	.1	μA
Input Current "OFF" ($I_{IN(OFF)}$)	5VTTL	$V_{IN} = 0V, I_D = 2 mA$ $V_{IN} = 4.5V, V_A = \pm 10V, T_A = 25^\circ C$ $V_{IN} = 4.5V, V_A = \pm 10V$	.04	.2	nA
Input Current "OFF" ($I_{IN(OFF)}$)	15VTTL	$V_{IN} = 11V, V_A = \pm 10V, T_A = 25^\circ C$	.04	.2	nA
Channel Control Voltage "ON" ($V_{IN(ON)}$)	5VTTL	$V_A = \pm 10V, I_D = 1 mA$		.5	V
Channel Control Voltage "OFF" ($V_{IN(OFF)}$)	15VTTL	$V_A = \pm 10V, I_D = 1 mA$		1.5	V
Channel Control Voltage "OFF" ($V_{IN(OFF)}$)	5VTTL	$V_A = \pm 10V$		4.5	V
Channel Control Voltage "OFF" ($V_{IN(OFF)}$)	15VTTL	$V_A = \pm 10V$		11	V
Leakage Current "OFF" ($I_{D(OFF)}$)	5VTTL	$V_{IN} = 4.5V, V_A = \pm 10V, T_A = 25^\circ C$ $V_{IN} = 4.5V, V_A = \pm 10V$	.02	.2	nA
Leakage Current "OFF" ($I_{D(OFF)}$)	15VTTL	$V_{IN} = +11V, V_A = \pm 10V, T_A = 25^\circ C$ $V_{IN} = +11V, V_A = \pm 10V$	.02	.2	nA
Leakage Current "ON" ($I_{D(ON)}$)	5VTTL	$V_{IN} = 0V, I_S = 1 mA, T_A = 25^\circ C$ $V_{IN} = 0V, I_S = 1 mA$	.3	1	nA
Leakage Current "ON" ($I_{D(ON)}$)	15VTTL	$V_{IN} = 0V, I_S = 1 mA, T_A = 25^\circ C$ $V_{IN} = 0V, I_S = 1 mA$	.1	.5	nA
Leakage Current "ON" ($I_{D(ON)}$)	5VTTL	$V_{IN} = 0V, I_S = 2 mA, T_A = 25^\circ C$ $V_{IN} = 0V, I_S = 2 mA$		1	μA
Leakage Current "ON" ($I_{D(ON)}$)	15VTTL	$V_{IN} = 0V, I_S = 2 mA, T_A = 25^\circ C$ $V_{IN} = 0V, I_S = 2 mA$		10	μA
Leakage Current "ON" ($I_{D(ON)}$)	15VTTL	$V_{IN} = 0V, I_S = 2 mA, T_A = 25^\circ C$ $V_{IN} = 0V, I_S = 2 mA$		2	nA
Leakage Current "ON" ($I_{D(ON)}$)	15VTTL	$V_{IN} = 0V, I_S = 2 mA, T_A = 25^\circ C$ $V_{IN} = 0V, I_S = 2 mA$		1	μA
Drain-Source Resistance "ON" ($r_{DS(ON)}$)	5VTTL	$V_{IN} = 0.5V, I_D = 2 mA, T_A = 25^\circ C$ $V_{IN} = 0.5V, I_D = 2 mA$	90	150	Ω
Drain-Source Resistance "ON" ($r_{DS(ON)}$)	15VTTL	$V_{IN} = 0.5V, I_D = 2 mA, T_A = 25^\circ C$ $V_{IN} = 0.5V, I_D = 2 mA$	60	240	Ω
Drain-Source Resistance "ON" ($r_{DS(ON)}$)	15VTTL	$V_{IN} = 1.5V, I_D = 2 mA, T_A = 25^\circ C$ $V_{IN} = 1.5V, I_D = 2 mA$	60	100	Ω
Drain-Source Resistance "ON" ($r_{DS(ON)}$)	15VTTL	$V_{IN} = 1.5V, I_D = 2 mA, T_A = 25^\circ C$ $V_{IN} = 1.5V, I_D = 2 mA$	60	160	Ω
$r_{DS(ON)}$ Match (Effective $r_{DS(ON)}) / (r_{DS(ON)} \text{ EFF.})$	15VTTL MUX 5VTTL MUX	$V_{IN} = 1.5V, I_D = 2 mA$ $V_{IN} = 0.5V, I_D = 2 mA$		50	Ω
Turn-On Time (t_{ON})	All	See AC Test Circuits, $T_A = 25^\circ C$	150	500	ns
Turn-Off Time (t_{OFF})	All	See AC Test Circuits, $T_A = 25^\circ C$	300	500	ns
Cross Talk (CT)	All	See AC Test Circuits, $T_A = 25^\circ C$	120		dB

Note 1: Unless otherwise noted, these specifications apply for -25°C to +85°C for AH5009C through AH5012C.

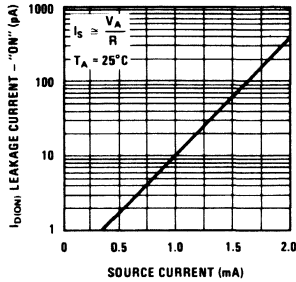
Note 2: "OFF" and "ON" notation refers to the conduction state of the FET switch.

typical performance characteristics

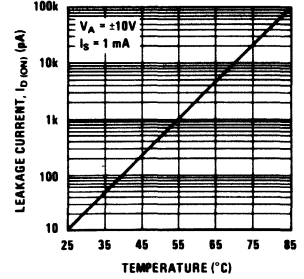
Maximum Power Dissipation



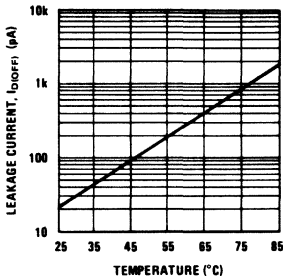
Leakage Current, $I_{D(ON)}$ vs I_S



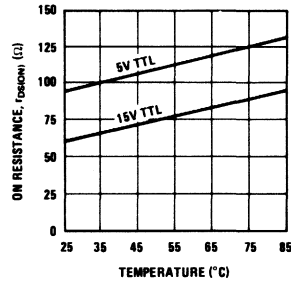
Leakage Current, $I_{D(ON)}$ vs Temperature



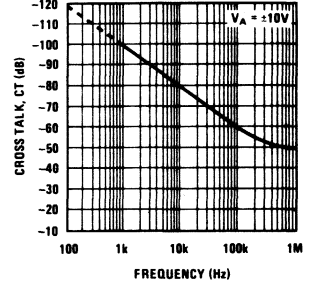
Leakage Current, $I_{D(OFF)}$ vs Temperature



On Resistance, $r_{DS(ON)}$ vs Temperature

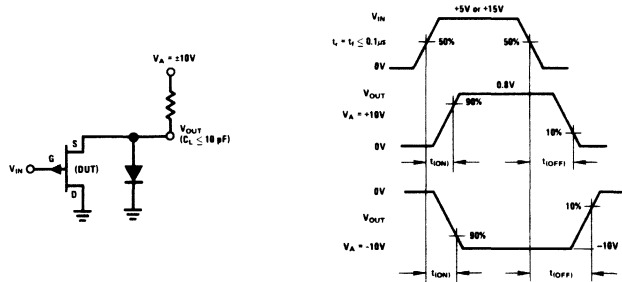


Cross Talk, CT vs Frequency

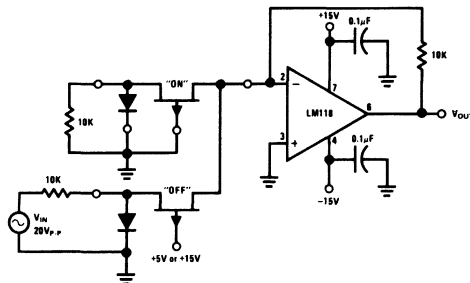


test circuits

AC Switching Test Circuits



Cross Talk Test Circuit



applications information

Theory of Operation

The AH5009 series of analog switches are primarily intended for operation in current mode switch applications; i.e., the drains of the FET switch are held at or near ground by operating into the summing junction of an operational amplifier. Limiting the drain voltage to under a few hundred mV eliminates the need for a special gate driver. Thus, the switch may be controlled with conventional TTL elements (5V) or with the open collector (15V) structures.

Two basic switch configurations are available: multiple independent switches (N by SPST) and multiple pole switches used for multiplexing (NPST-MUX). The MUX versions such as the AH5009 offer common drains and include a series FET operated at $V_{GS} = 0V$. The additional FET is placed in feedback path in order to compensate for the "ON" resistance of the switch FET as shown in Figure 1.

The closed-loop gain of Figure 1 is:

$$A_{VCL} = \frac{R_2 + r_{DS(ON)Q2}}{R_1 + r_{DS(ON)Q1}}$$

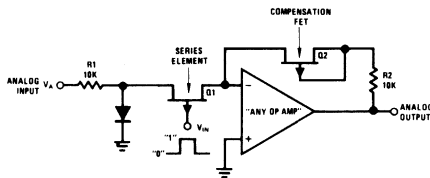


FIGURE 1. Use of Compensation FET

For $R_1 = R_2$, gain accuracy is determined by the $r_{DS(ON)}$ match between Q_1 and Q_2 . Standard match between Q_1 and Q_2 is 50Ω resulting in a gain accuracy of 0.5% (for $R_1 = R_2 = 10k$). Tighter $r_{DS(ON)}$ match versions are available.

Noise Immunity

The switches with the source diodes grounded exhibit improved noise immunity for positive analog signals in the "OFF" state. With $V_{IN} = 15V$ and the $V_A = +10V$, the source of Q_1 is clamped to about 0.6V by the diode ($V_{GS} = 14.4V$). The "ON" impedance of the diode is about 26Ω ensuring that AC signals imposed on the +10V will not gate the FET "ON."

Selection of Gain Setting Resistors

Since the AH5009 series of analog switches are operated current mode, it is generally advisable to make the signal current as large as possible. However, current through the FET switch tends to forward bias the gate to channel (source) diode resulting in leakage across the diode. This leakage, $I_{D(ON)}$, increases exponentially with increasing I_S . As shown in Figure 2, $I_{D(ON)}$ represents a finite error in the current reaching the summing junction of the op amp.

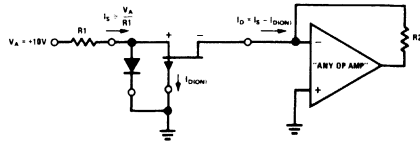


FIGURE 2. On Leakage Current, $I_{D(ON)}$

Secondly, the $r_{DS(ON)}$ of the FET begins to "round" as I_S approaches I_{DSS} . A practical rule of thumb is to maintain I_S at less than 1/10 of I_{DSS} .

Combining the criteria from the above discussion yields:

$$R_{1(MIN)} \geq \frac{V_{A(MAX)} A_D}{I_{D(ON)}} \quad (2a)$$

$$\text{or:} \quad \geq \frac{V_{A(MAX)}}{I_{DSS}/10} \quad (2b)$$

which ever is worse.

Where: $V_{A(MAX)}$ = Peak amplitude of the analog input signal

A_D = Desired accuracy

$I_{D(ON)}$ = Leakage at a given I_S

I_{DSS} = Saturation current of the FET switch
 $\cong 20 \text{ mA}$

In a typical application, V_A might = $\pm 10V$, $A_D = 0.1\%$, $0^\circ C \leq T_A \leq 85^\circ C$. The criterion of equation (2b) predicts:

$$R_{1(MIN)} \geq \frac{10V}{\frac{20mA}{10}} = 5k\Omega$$

For $R_1 = 5k$, $I_S \cong 10V/5k$ or 2 mA. The electrical characteristics guarantee an $I_{D(ON)} \leq 1\mu A$ at $85^\circ C$ for the AH5010C. Per the criterion of equation (2a):

$$R_{1(MIN)} \geq \frac{(10V)(10^{-3})}{1 \times 10^{-6}} \geq 10k\Omega$$

Since equation (2a) predicts a higher value, the 10k resistor should be used.

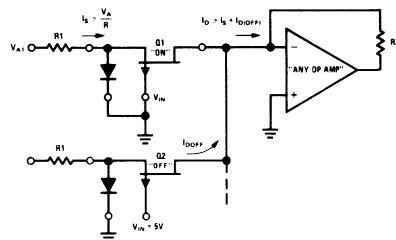


FIGURE 3.

The "OFF" condition of the FET also effects gain accuracy. As shown in Figure 3, the leakage across Q_2 , $I_{D(OFF)}$ represents a finite error in the current arriving at the summing junction of the op amp.

applications information (con't)

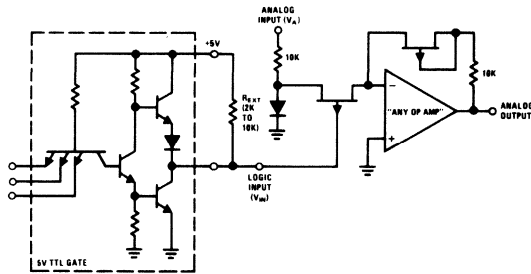


FIGURE 4. Interfacing with +5V Logic

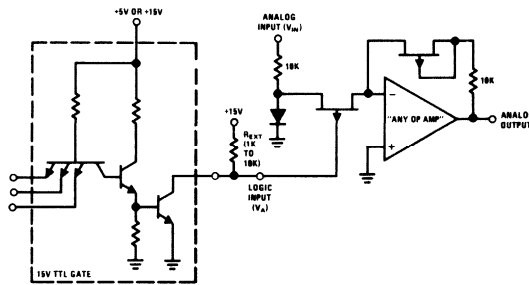


FIGURE 5. Interfacing with +15V Open Collector Logic

Accordingly:

$$R_{1(MAX)} \leq \frac{V_{A(MIN)} A_D}{(N) I_{D(OFF)}}$$

Where: $V_{A(MIN)}$ = Minimum value for the analog input signal

A_D = Desired accuracy

N = Number of channels

$I_{D(OFF)}$ = OFF leakage of a given FET switch

As an example, if $N = 10$, $A_D = 0.1\%$, and $I_{D(OFF)} \leq 10$ nA at 85°C for the AH5009C, $R_{1(MAX)}$ is:

$$R_{1(MAX)} \leq \frac{(1V)(10^{-3})}{(10)(10 \times 10^{-9})} = 10k$$

Selection of R_2 , of course, depends on the gain desired and for unity gain $R_1 = R_2$.

Lastly, the foregoing discussion has ignored resistor tolerances, input bias current and offset voltage of the op amp — all of which should be considered in setting the overall gain accuracy of the circuit.

TTL Compatibility

Two input logic drive versions of AH5009 series are available: the even numbered part types are specified to be driven from standard 5V-TTL logic

and the odd numbered types from 15V open collector TTL.

Standard TTL gates pull-up to about 3.5V (no load). In order to ensure turn-off of the even numbered switches such as AH5010, a pull-up resistor, R_{EXT} , of at least 10 k Ω should be placed between the 5V V_{CC} and the gate output as shown in Figure 4.

Likewise, the open-collector, high voltage TTL outputs should use a pull-up resistor as shown in Figure 5. In both cases, $t_{(OFF)}$ is improved for lower values of R_{EXT} and the expense of power dissipation in the low state.

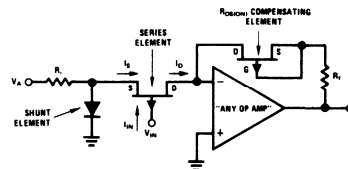


FIGURE 6. Definition of Terms

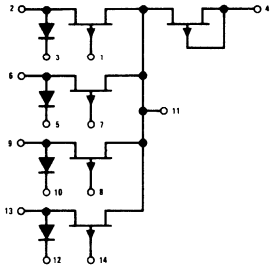
Definition of Terms

The terms referred to in the electrical characteristics tables are as defined in Figure 6.

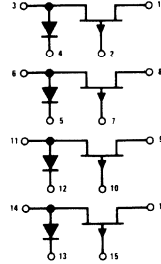
device schematics and pin connections

FOUR CHANNEL

AH5009CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
 AH5010CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
 14 PIN DIP

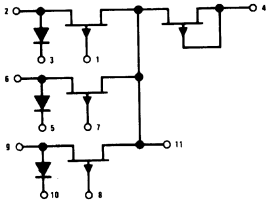


AH5011CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
 AH5012CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
 16 PIN DIP

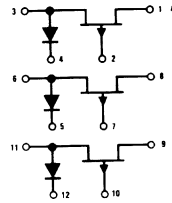


THREE CHANNEL

AH5013CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
 AH5014CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
 14 PIN DIP

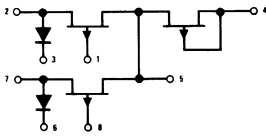


AH5015CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
 AH5016CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
 16 PIN DIP

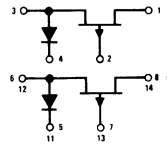


TWO CHANNEL

AH5017CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
 AH5018CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
 8 PIN DIP

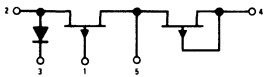


AH5019CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
 AH5020CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
 8 PIN DIP

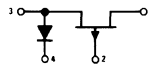


SINGLE CHANNEL

AH5021CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
 AH5022CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
 8 PIN DIP



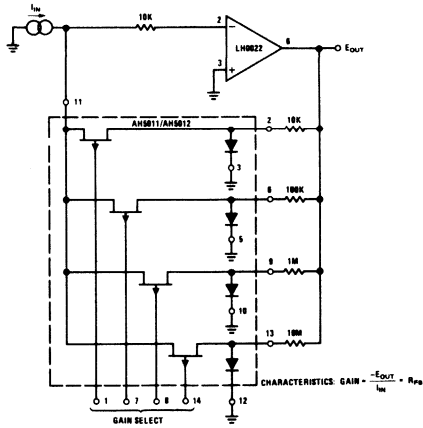
AH5023CN ($R_{DS(ON)} \leq 100\Omega$ 15V - TTL)
 AH5024CN ($R_{DS(ON)} \leq 150\Omega$ 5V - TTL)
 8 PIN DIP



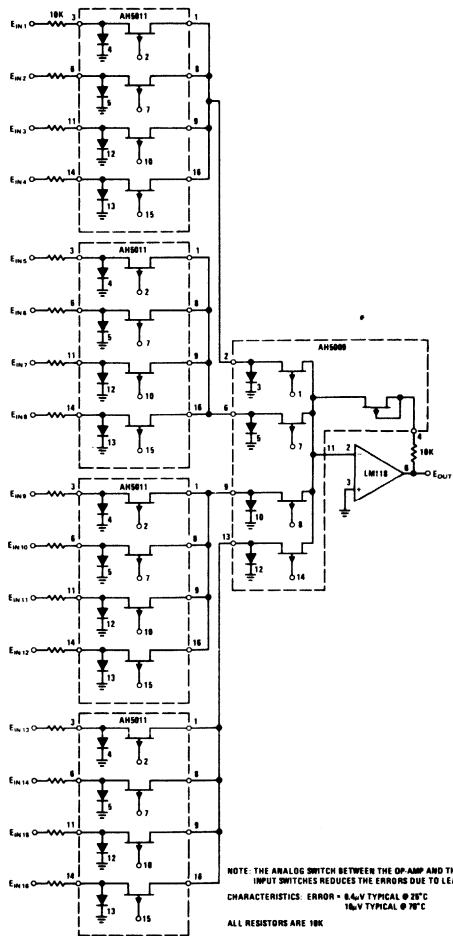
Package Types - 8, 14, 16 pin epoxy "B"

typical applications

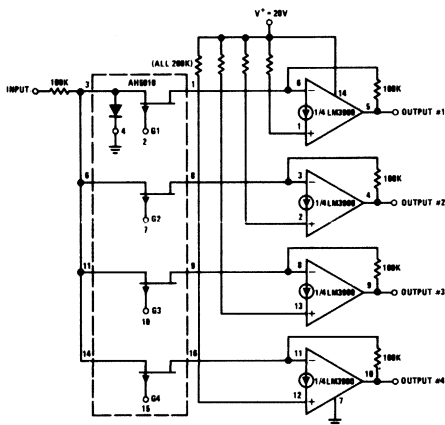
Gain Programmable Amplifier



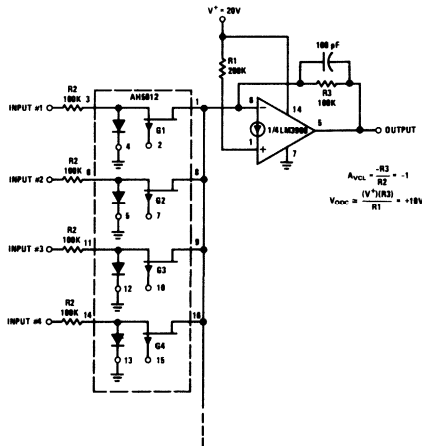
16-Channel Multiplexer



Low Cost Demultiplexer



Low Cost Multiplexer/Mixer





Analog Switches

AM1000, AM1001, AM1002 silicon N-channel high speed analog switch

general description

The AM1000 series are junction FET integrated circuit analog switches. These devices commute faster and with less voltage spiking than any other analog switch presently available. By comparison, discrete JFET switches require elaborate drive circuits to obtain reasonable performance for high toggle rates. Encapsulated in a four pin TO-72 package, these units require a minimum of circuit board area. Switching transients are greatly reduced by a monolithic integrated circuit process. The resulting analog switch device provides the following features:

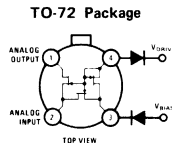
- Low ON Resistance 30Ω
- High Analog Signal Frequency 100 MHz

- High Toggle Rate 4 MHz
- Low Leakage Current 250 pA
- Large Analog Signal Swing ±15V
- Break Before Make Action

The AM1000 series of analog switches are particularly suitable for the following applications:

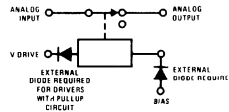
- High Speed Commutators
- Multiplexers
- Sample and Hold Circuits
- Reset Switching
- Video Switching

schematic and connection diagram



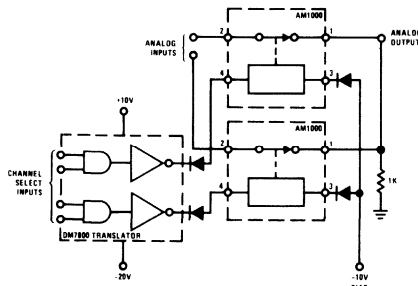
Order Number AM1000H
or AM1001H or AM1002H
See Package 9A

equivalent circuit

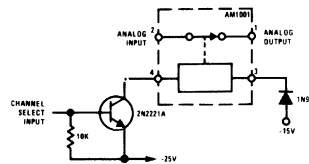


typical applications

±10 Volt Swing Analog Switch 0.5% Accuracy



±15 Volt Swing Analog Switch



absolute maximum ratings

	AM1001	AM1000 AM1002	Power Dissipation @ $T_A = 25^\circ\text{C}$	300 mW
			Linear Derating Factor	1.7 mW/ $^\circ\text{C}$
V_{IN} (Note 1)	+50V	+40V	Power Dissipation @ $T_C = 125^\circ\text{C}$	150 mW
V_{OUT} (Note 1)	+50V	+40V	Linear Derating Factor	6 mW/ $^\circ\text{C}$
V_{DRIVE} (Note 1)	-50V	-40V	Maximum Junction Operating Temperature	-55 $^\circ\text{C}$ to +150 $^\circ\text{C}$
V_{BIAS} (Note 1)	+50V	+40V	Storage Temperature	+200 $^\circ\text{C}$
			Lead Temperature (Soldering, 10 sec)	+300 $^\circ\text{C}$

electrical characteristics

ON CHARACTERISTICS (Note 2)								
PARAMETER	CONDITION		MIN	TYP	MAX	UNITS		
R_{ON}	$V_{DRIVE} = +15V, V_{BIAS} = -15V$ $I_{IN} = 1\text{ mA}, V_{OUT} = 0V$	AM1001	20	40	50	Ω		
R_{ON}	$V_{DRIVE} = +10V, V_{BIAS} = -10V$ $I_{IN} = 1\text{ mA}, V_{OUT} = 0V$	AM1000 AM1002	20	25 50	30 100	Ω Ω		
OFF CHARACTERISTICS								
PARAMETER	CONDITION	AM1000 AM1001			AM1002		UNITS	
		MIN	TYP	MAX	MIN	TYP		MAX
$I_{OUT(OFF)}$	$V_{DRIVE} = -20V, V_{BIAS} = -10V$ $V_{IN} = -10V, V_{OUT} = +10V$ $T_A = +25^\circ\text{C}$ $T_A = +125^\circ\text{C}$		05 025	.25 .25		0.5 0.2	1 1	nA μA
$I_{OUT(OFF)}$	$V_{DRIVE} = -20V, V_{BIAS} = -10V$ $V_{IN} = +10V, V_{OUT} = -10V$ $T_A = +25^\circ\text{C}$ $T_A = +125^\circ\text{C}$		05 05	.25 .25		0.5 0.2	1 1	nA μA
DRIVE CHARACTERISTICS (Note 3)								
PARAMETER	CONDITION		MIN	TYP	MAX	UNITS		
I_{DRIVE} (Switch OFF)	$V_{DRIVE} = -20V, V_{BIAS} = -10V$ $V_{IN} = \pm 10V, V_{OUT} = \pm 10V$	AM1000, 1001, 1002		5	10	mA		
SWITCHING CHARACTERISTICS								
PARAMETER	CONDITION	AM1000 MAX	AM1001 MAX	AM1002 MAX	UNITS			
t_{ON}	See Switching Time Test Circuit	100	150	200	ns			
t_{OFF}		100	100	100	ns			

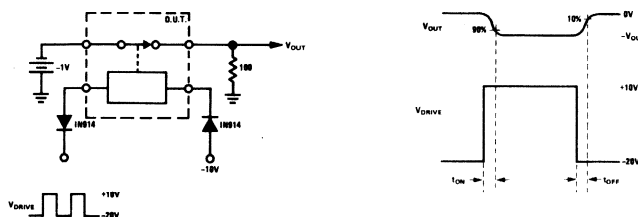
Note 1: The maximum voltage ratings may be applied between any pin or pins simultaneously. Power dissipation may be exceeded in some modes if the voltage pulse exceeds 10 ms. Normal operation will not cause excessive power dissipation even in a "D.C." switching application.

Note 2: All parameters are measured with external silicon diodes. See electrical connection diagram for proper diode placement.

Note 3: I_{BIAS} (Switch OFF) is equal to I_{DRIVE} (Switch OFF). I_{BIAS} (Switch ON), is equal to external diode leakage.

Note 4: Rise and fall times of V_{DRIVE} shall be 15 ns maximum for switching time testing.

switching time test circuit and waveforms





Analog Switches

AM2009/AM2009C/MM4504/MM5504 six channel MOS multiplex switches

general description

The AM2009/AM2009C/MM4504/MM5504 are six channel multiplex switches constructed on a single silicon chip using low threshold P-channel MOS process. The gate of each MOS device is protected by a diode circuit.

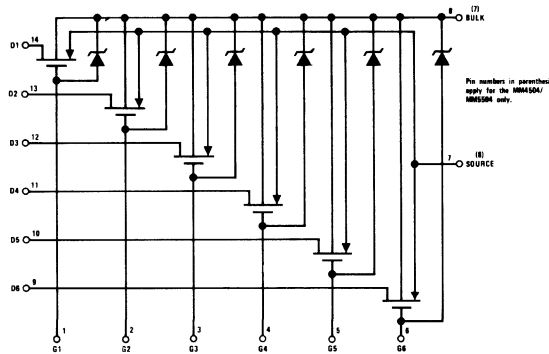
The AM2009/AM2009C/MM4504/MM5504 are designed for applications such as time division multiplexing of analog or digital signals. Switching speeds are primarily determined by conditions external to the device such as signal source impedance, capacitive loading and the total number of channels used in parallel.

features

- Typical low "on" resistance 150Ω
- Typical low "off" leakage 100 pA
- Typical large analog voltage range ±10V
- Zero inherent offset voltage
- Normally off with zero gate voltage

The AM2009/MM4504 are specified for operation over the -55°C to +125°C military temperature range. The AM2009C/MM5504 are specified for operation over the -25°C to +85°C temperature range.

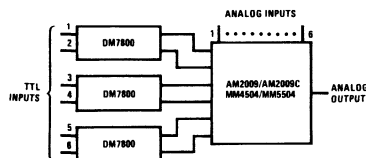
schematic diagram



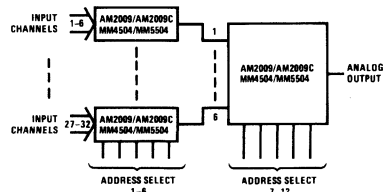
Order Number
AM2009F or AM2009CF
MM4504F or MM5504F
See Package 4

Order Number
AM2009D or AM2009CD
MM4504D or MM5504D
See Package 1

typical applications



TTL Compatible 6 Channel MUX



32 Channel MUX

absolute maximum ratings ($V_{BULK} = 0V$)

Voltage on Any Source or Drain	-30V	Total Power Dissipation (at $T_A = 25^\circ C$)	900 mW
Voltage on Any Gate	-35V	Power Dissipation – each gate circuit	150 mW
Positive Voltage on Any Pin	+0.3V	Operating Temperature Range	AM2009 -55°C to +125°C
Source or Drain Current	50 mA	AM2009C	-25°C to +85°C
Gate Current (forward direction of zener clamp)	0.1 mA	Storage Temperature Range	-65°C to +150°C
		Lead Temperature (Soldering, 10 sec)	300°C

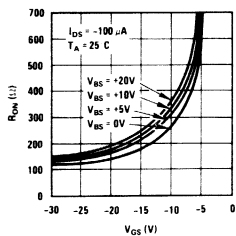
electrical characteristics (Note 1)

PARAMETER	CONDITIONS	LIMITS			UNITS
		MIN	TYP	MAX	
Threshold Voltage	$V_{GS} = V_{DS}, I_{DS} = -1 \mu A$	-1.0		-3.0	V
DC ON Resistance	$V_{GS} = -20V, I_{DS} = -100 \mu A, T_A = 25^\circ C$		150	250	Ω
DC ON Resistance	$V_{GS} = -10V, V_{SB} = -20V, I_{DS} = -100 \mu A, T_A = 25^\circ C$		500	1250	Ω
DC ON Resistance	$V_{GS} = -20V, I_{DS} = -100 \mu A$			325	Ω
DC ON Resistance	$V_{GS} = -10V, V_{SB} = -20V, I_{DS} = -100 \mu A$			1500	Ω
Gate Leakage	$V_{GS} = -20V, \text{Note 2}$ $V_{GS} = -20V, \text{Note 2}, T_A = 25^\circ C$		100	1.0	μA pA
Input Leakage	$V_{DS} = -20V, \text{Note 2}$ $V_{DS} = -20V, \text{Note 2}, T_A = 25^\circ C$		100	1.0	μA pA
Output Leakage	$V_{SD} = -20V, \text{Note 2}$ $V_{SD} = -20V, \text{Note 2}, T_A = 25^\circ C$		500	3.0	μA pA
Gate-Bulk Breakdown Voltage	$I_{GB} = -10 \mu A, \text{Note 2}$	-35			V
Source-Drain Breakdown Voltage	$I_{SD} = -10 \mu A, V_{GD} = 0, \text{Note 2}$	-30			V
Drain-Source Breakdown Voltage	$I_{DS} = -10 \mu A, V_{GS} = 0, \text{Note 2}$	-30			V
Transconductance			4000		mhos
Gate Capacitance	Note 3, $f = 1 \text{ MHz}$		4.7	8	pF
Input Capacitance	Note 3, $f = 1 \text{ MHz}$		4.6	8	pF
Output Capacitance	Note 3, $f = 1 \text{ MHz}$		16	20	pF

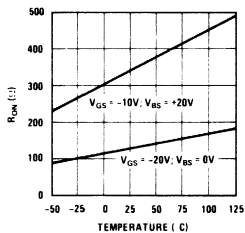
Note 1: Ratings apply over the specified temperature range and $V_{BULK} = 0$, unless otherwise specified.
 Note 2: All other pins grounded.
 Note 3: Capacitance measured on dual-in-line package between pin under measurement to all other pins. Capacitances are guaranteed by design.

typical performance characteristics

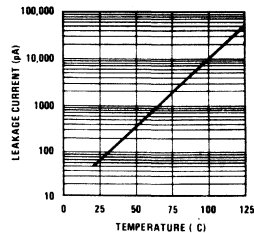
"ON" Resistance vs Gate-to-Source Voltage



"ON" Resistance vs T Temperature



Input Leakage Current vs Temperature



7



Analog Switches

AM3705/AM3705C 8-channel MOS analog multiplexer general description

The AM3705/AM3705C is an eight-channel MOS analog multiplex switch. TTL compatible logic inputs that require no level shifting or input pull-up resistors and operation over a wide range of supply voltages is obtained by constructing the device with low threshold P-channel enhancement MOS technology. To simplify external logic requirements, a one-of-eight decoder and an output enable are included in the device.

- Low ON resistance – 150Ω
- Input gate protection
- Low leakage currents – 0.5 nA

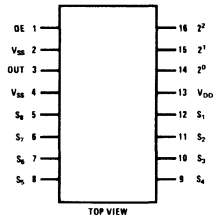
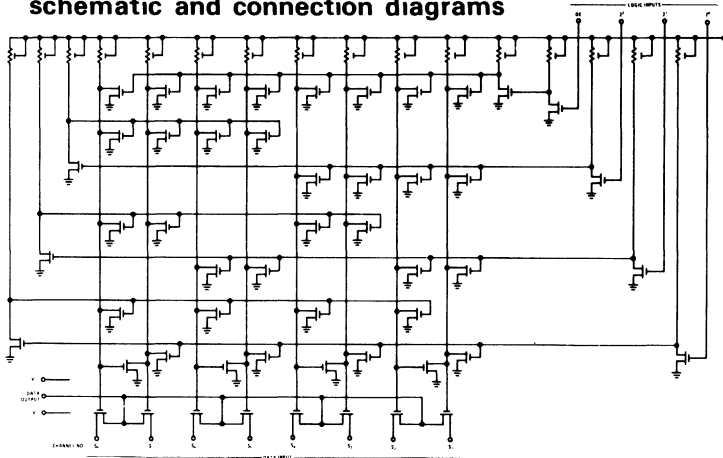
The AM3705/AM3705C is designed as a low cost analog multiplex switch to fulfill a wide variety of data acquisition and data distribution applications including cross-point switching, MUX front ends for A/D converters, process controllers, automatic test gear, programmable power supplies and other military or industrial instrumentation applications.

Important design features include:

- TTL/DTL compatible input logic levels
- Operation from standard +5V and -15V supplies
- Wide analog voltage range – ±5V
- One-of-eight decoder on chip
- Output enable control

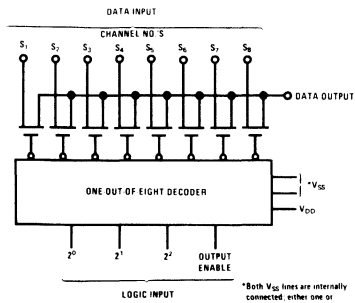
The AM3705 is specified for operation over the -55°C to +125°C military temperature range. The AM3705C is specified for operation over the -25°C to +85°C temperature range.

schematic and connection diagrams



Order Number
AM3705D or AM3705CD
 See Package 2
AM3705F or AM3705CF
 See Package 5

block diagram (MIL-STD-806B)



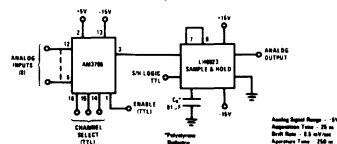
*Both V_{DD} lines are internally connected; either one or both may be used.

truth table

LOGIC INPUTS			CHANNEL	
2^0	2^1	2^2	OE	ON
L	L	L	H	S_1
L	L	L	H	S_2
L	L	L	H	S_3
L	L	L	H	S_4
L	L	L	H	S_5
L	L	L	H	S_6
L	L	L	H	S_7
L	L	L	H	S_8
X	X	X	L	OFF

typical application

Buffered 8-Channel Multiplex, Sample and Hold



Analog Input Range: ±5V
 Acquisition Time: 75 ns
 Hold Time: 100 ns (typical)
 Aperture Time: 75 ns

absolute maximum ratings

Positive Voltage on Any Pin (Note 1)	+0.3V
Negative Voltage on Any Pin (Note 1)	-35V
Source to Drain Current	±30 mA
Logic Input Current	±0.1 mA
Power Dissipation (Note 2)	500 mW
Operating Temperature Range AM3705	-55°C to +125°C
AM3705C	-25°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	SYMBOL	CONDITIONS	LIMITS			UNITS
			MIN	TYP	MAX	
ON Resistance	R _{ON}	V _{IN} = V _{SS} ; I _{OUT} = 100 μA		80	250	Ω
ON Resistance	R _{ON}	V _{IN} = -5V; I _{OUT} = -100 μA		160	400	Ω
ON Resistance	R _{ON}	V _{IN} = -5V; I _{OUT} = -100 μA			400	Ω
AM3705		T _A = +125°C			400	Ω
AM3705C		T _A = +70°C			400	Ω
ON Resistance	R _{ON}	V _{IN} = +5V; V _{DD} = -15V; I _{OUT} = 100 μA		100		Ω
ON Resistance	R _{ON}	V _{IN} = 0V; V _{DD} = -15V; I _{OUT} = -100 μA		150		Ω
ON Resistance	R _{ON}	V _{IN} = -5V; V _{DD} = -15V; I _{OUT} = -100 μA		250		Ω
OFF Resistance	R _{OFF}			10 ¹⁰		Ω
Output Leakage Current	I _{LO}	V _{SS} - V _{OUT} = 15V		0.5	10	nA
AM3705	I _{LO}	V _{SS} - V _{OUT} = 15V; T _A = 125°C		150	500	nA
AM3705C	I _{LO}	V _{SS} - V _{OUT} = 15V; T _A = 70°C		35	500	nA
Data Input Leakage Current	I _{LDI}	V _{SS} - V _{IN} = 15V		0.1	3.0	nA
AM3705	I _{LDI}	V _{SS} - V _{IN} = 15V; T _A = 125°C		25	500	nA
AM3705C	I _{LDI}	V _{SS} - V _{IN} = 15V; T _A = 70°C		0.5	500	nA
Logic Input Leakage Current	I _{LI}	V _{SS} - V _{Logic In} = 15V		.001	1	μA
AM3705	I _{LI}	V _{SS} - V _{Logic In} = 15V; T _A = 125°C		.05	10	μA
AM3705C	I _{LI}	V _{SS} - V _{Logic In} = 15V; T _A = 70°C		.05	10	μA
Logic Input LOW Level	V _{IL}	V _{SS} = +5.0V		0.5	1.0	V
Logic Input LOW Level	V _{IL}		V _{DD}		V _{SS} - 4.0	V
Logic Input HIGH Level	V _{IH}	V _{SS} = +5.0V	3.0	3.5		V
Logic Input HIGH Level	V _{IH}		V _{SS} - 2.0		V _{SS} + 0.3	V
Channel Switching Time-Positive	t ⁺	Switching Time		300		ns
Channel Switching Time-Negative	t ⁻	Test Circuit		600		ns
Channel Separation		f = 1 kHz		62		dB
Output Capacitance	C _{db}	V _{SS} - V _{OUT} = 0; f = 1 MHz		35		pF
Data Input Capacitance	C _{db}	V _{SS} - V _{DIP} = 0; f = 1 MHz		6.0		pF
Logic Input Capacitance	C _{cg}	V _{SS} - V _{Logic In} = 0; f = 1 MHz		6.0		pF
Power Dissipation	P _D	V _{DD} = -31V, V _{SS} = 0V		125	175	mW

Note 1: All voltages referenced to V_{SS}.

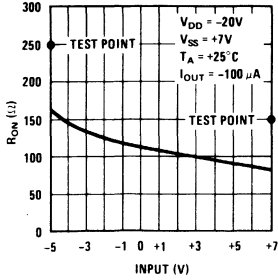
Note 2: Rating applies for ambient temperatures to +25°C, derate linearly at 3 mW/°C for ambient temperatures above +25°C.

Note 3: Specifications apply for T_A = 25°C, -24V ≤ V_{DD} ≤ -20V, and +5.0V ≤ V_{SS} ≤ +7.0V; unless otherwise specified (all voltages are referenced to ground).

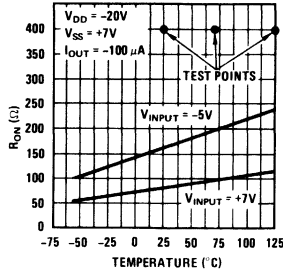


typical performance characteristics

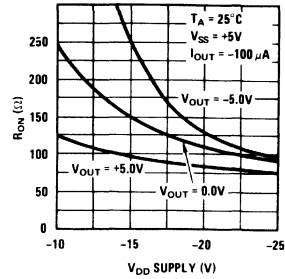
ON Resistance vs Analog Input Voltage



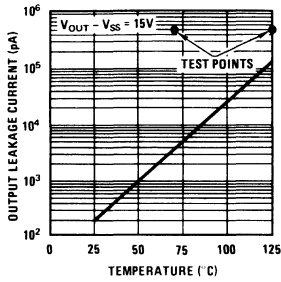
ON Resistance vs Ambient Temperature



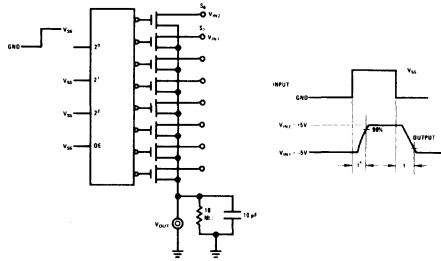
ON Resistance vs VDD Supply Voltage



Output Leakage Current vs Ambient Temperature

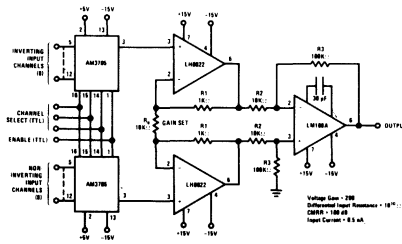


switching time test circuit

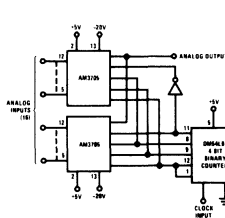


typical applications (con't.)

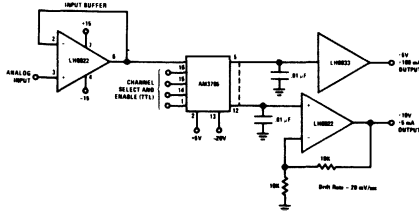
Differential Input MUX



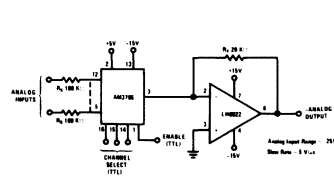
16-Channel Commutator



8-Channel Demultiplexer with Sample and Hold



Wide Input Range Analog Switch





Analog Switches

MM450/MM550, MM451/MM551

MM452/MM552, MM455/MM555 MOS analog switches

general description

The MM450, and MM550 series each contain four p channel MOS enhancement mode transistors built on a single monolithic chip. The four transistors are arranged as follows:

MM450, MM550	Dual Differential Switch
MM451, MM551	Four Channel Switch
MM452, MM552	Four MOS Transistor Package
MM455, MM555	Three MOS Transistor Package

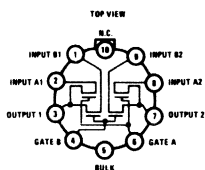
These devices are useful in many airborne and ground support systems requiring multiplexing, analog transmission, and numerous signal routing applications. The use of low threshold transistors ($V_{TH} = 2$ volts) permits operations with large analog input swings (± 10 volts) at low gate voltages (-20 volts). Significant features, then, include:

- Large Analog Input Swing ± 10 Volts
- Low Supply Voltage $V_{BULK} = +10$ Volts
 $V_{GG} = -20$ Volts
- Low ON Resistance $V_{IN} = -10V$ 150 Ω
 $V_{IN} = +10V$ 75 Ω
- Low Leakage Current 200 pA @ 25°C
- Input Gate Protection
- Zero Offset Voltage

Each gate input is protected from static charge build-up by the incorporation of zener diode protective devices connected between the gate input and device bulk.

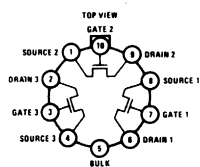
The MM450, MM451, MM452 and MM455 are specified for operation over the $-55^{\circ}C$ to $+125^{\circ}C$ military temperature range. The MM550, MM551, MM552 and MM555 are specified for operation over the $-25^{\circ}C$ to $+70^{\circ}C$ temperature range.

schematic and connection diagrams



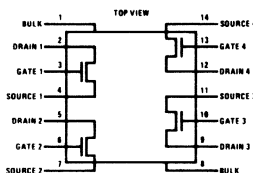
NOTE: Pin 5 connected to case and device bulk.
MM450, MM550

Order Number MM450H or MM550H
See Package 12



NOTE: Pin 5 connected to case and device bulk.
Drain and Source may be interchanged.
MM455, MM555

Order Number MM455H or MM555H
See Package 12

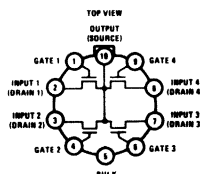


NOTE 1: Pins 1 and 8 connected to case and device bulk. Drain and Source may be interchanged. MM452F, MM552F.

NOTE 2: MM452D and MM552D (dual-in-line packages) have same pin connections as MM452F and MM552F shown above.

Order Number MM452F or MM552F
See Package 4

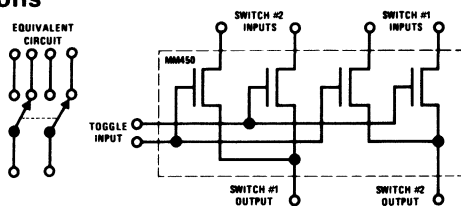
Order Number MM452D or MM552D
See Package 1



NOTE: Pin 5 connected to case and device bulk.
MM451, MM551

Order Number MM451H or MM551H
See Package 12

typical applications



DPDT Analog Switch



absolute maximum ratings

	MM450, MM451, MM452, MM455	MM550, MM551, MM552, MM555
Gate Voltage (V _{GG})	+10V to -30V	+10V to -30V
Bulk Voltage (V _{BULK})	+10V	+10V
Analog Input (V _{IN})	+10V to -20V	+10V to -20V
Power Dissipation	200 mW	200 mW
Operating Temperature	-55°C to +125°C	-25°C to 70°C
Storage Temperature	-65°C to +150°C	-65°C to +150°C

electrical characteristics

STATIC CHARACTERISTICS (Note 1)

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Analog Input Voltage Threshold Voltage (V _{GS(T)})	V _{DG} = 0, I _D = 1 μA	1.0	2.2	±10 3.0	V V
ON Resistance	V _{IN} = -10V		150	600	Ω
ON Resistance	V _{IN} = V _{SS}		75	200	Ω
OFF Resistance			10 ¹⁰		Ω
Gate Leakage Current (I _{GSB})	V _{GS} = -25V, V _{BS} = 0, T _A = 25°C		20		pA
Input (Drain) Leakage Current MM450, MM451, MM452, MM455	T _A = 25°C T _A = 85°C T _A = 125°C		.025 .002 .025	100 1.0 1.0	nA μA μA
Input (Drain) Leakage Current MM550, MM551, MM552, MM555	T _A = 25°C T _A = 70°C		0.1 .030	100 1.0	nA μA
Output (Source) Leakage Current MM450, MM451, MM452, MM455	T _A = 25°C		.040	100	nA
Output (Source) Leakage Current MM450	T _A = 85°C			1.0	μA
MM451	T _A = 85°C			1.0	μA
MM452, MM455	T _A = 85°C			1.0	μA
MM450, MM451, MM452, MM455	T _A = 125°C			1.0	μA
Output (Source) Leakage Current MM550	T _A = 70°C			1.0	μA
MM551	T _A = 70°C			1.0	μA
MM552, MM555	T _A = 70°C			1.0	μA

DYNAMIC CHARACTERISTICS

Large Signal Transconductance	V _{DS} = -10V, I _D = 10 mA f = 1 kHz		4000		μmhos
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CAPACITANCE CHARACTERISTICS (Note 2)

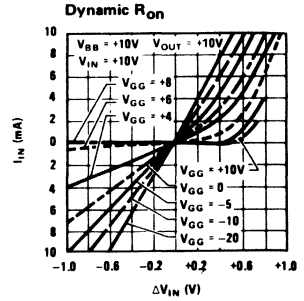
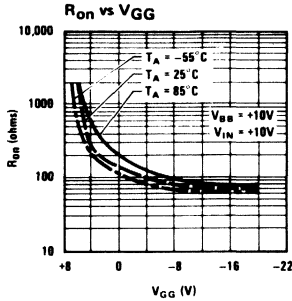
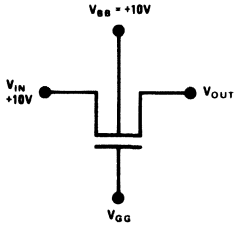
PARAMETER	DEVICE TYPE	MIN	TYP	MAX	UNITS
Analog Input (Drain) Capacitance (C _{DB})	ALL		8	10	pF
	MM450, MM550		11	14	pF
Output (Source) Capacitance (C _{SB})	MM451, MM551		20	24	pF
	MM452, MM552		7.5	11	pF
	MM455, MM555		7.5	11	pF
	MM450, MM550		10	13	pF
Gate Input Capacitance (C _{GB})	MM451, MM551		5.5	8	pF
	MM452, MM552		5.5	9	pF
	MM455, MM555		5.5	9	pF
Gate to Output Capacitance (C _{GS})	ALL		3.0	5	pF

Note 1: The resistance specifications apply for -55°C ≤ T_A ≤ +85°C, V_{GG} = -20V, V_{BULK} = +10V, and a test current of 1 mA. Leakage current is measured with all pins held at ground except the pin being measured which is biased at -25V.

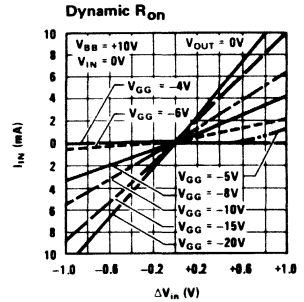
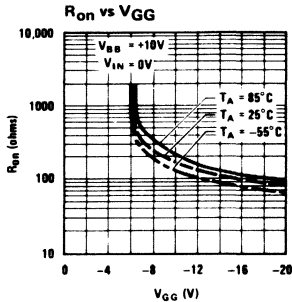
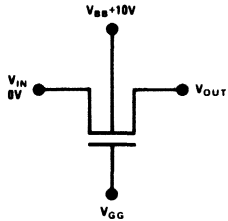
Note 2: All capacitance measurements are made at 0 volts bias at 1 MHz.

typical dynamic input characteristics (T_A = 25°C Unless Otherwise Noted)

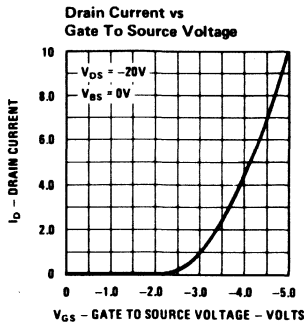
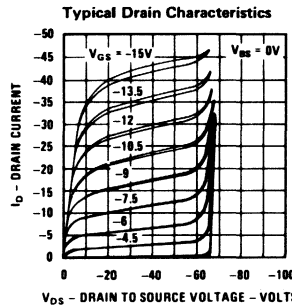
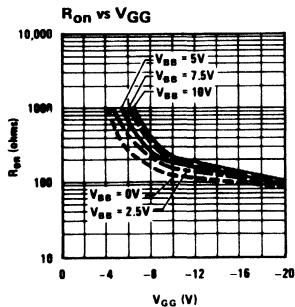
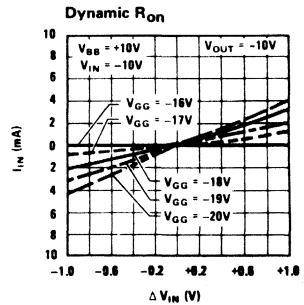
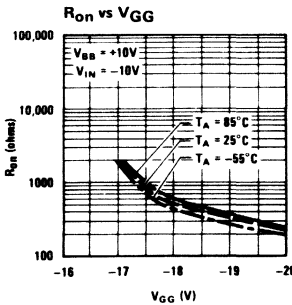
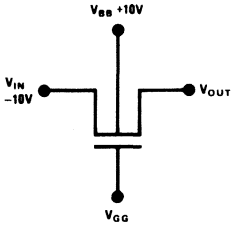
CONDITION 1:
ANALOG INPUT VOLTAGE
AT +10 VOLTS



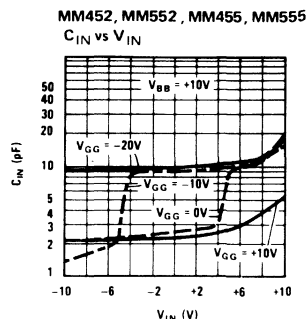
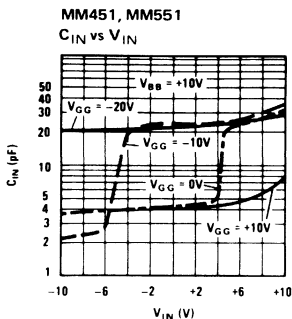
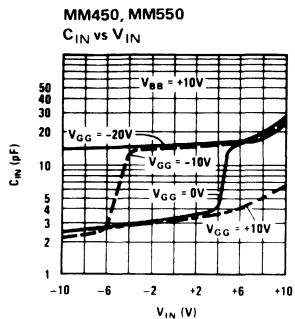
CONDITION 2:
ANALOG INPUT VOLTAGE
AT 0 VOLTS



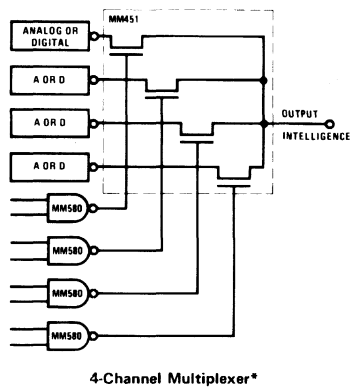
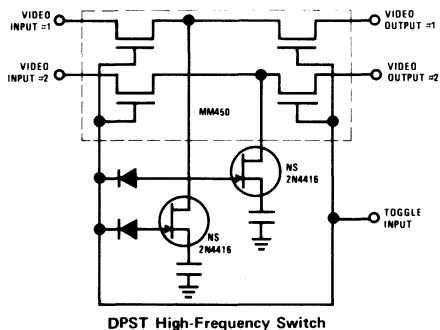
CONDITION 3:
ANALOG INPUT VOLTAGE
AT -10 VOLTS



typical input capacitance characteristics



typical applications (con't)



*Expansion in the number of data input lines is possible by using multiple level series switches allowing the same decode gates to be used for all lower rank decoding.



Analog Switches

MM454/MM554

MM454/MM554 four-channel commutator general description

The MM454/MM554 is a four-channel analog commutator capable of switching four analog input channels sequentially onto an output line. The device is constructed on a single silicon chip using MOS P Channel enhancement transistors; it contains all the digital circuitry necessary to sequentially turn ON the four analog switch transistors permitting multiplexing of the analog input data. The device features:

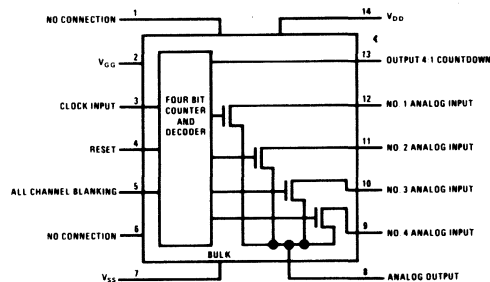
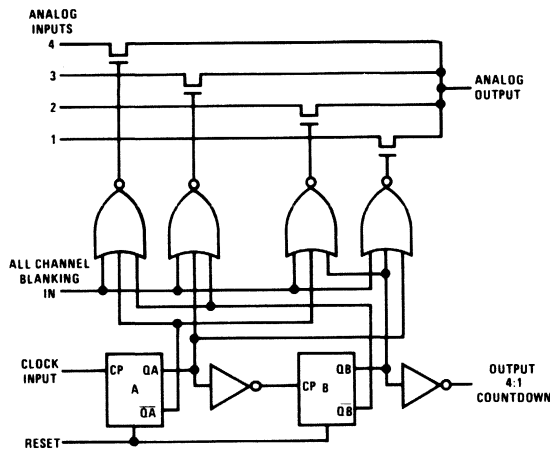
- High Analog Voltage Handling $\pm 10V$
- High Commutating Rate 500 kHz
- Low Leakage Current ($T_A = 25^\circ C$) 200 pA
($T_A = 85^\circ C$) 50 nA

- All Channel Blanking input provided
- Reset capability provided
- Low ON Resistance 200 Ω

In addition, the MM454/MM554 can easily be applied where submultiplexing is required since a 4:1 clock countdown signal is provided which can drive the clock input of subsequent MM454/MM554 units.

The MM454 is specified for operation over the $-55^\circ C$ to $+125^\circ C$ military temperature range. The MM554 is specified for operation over the $-25^\circ C$ to $+70^\circ C$ temperature range.

schematic and connection diagrams



NOTE: Pin 7 connected to case and to device bulk. Nominal Operating Voltages: $V_{CC} = -24V$, $V_{DD} = 0V$, $V_{SS} = +12V$, RESET BIAS = +12V (0V for RESET), ALL CHANNEL BLANKING BIAS = +12V (0V for BLANKING).

Order Number MM454F or MM554F
See Package 4

7

absolute maximum ratings (Note 1)

Gate Voltage (V_{GG})	+10V to -30V
Bulk Voltage (V_{SS})	+10V
Analog Input (V_{IN})	+10V to -20V
Power Dissipation	200 mW
Operating Temperature MM454	-55°C to +125°C
MM554	-25°C to +70°C
Storage Temperature	-65°C to +150°C

static characteristics (Note 2)

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Analog Input Voltage				±10	V
ON Resistance	$V_{IN} = -10V$		170	600	Ω
ON Resistance	$V_{IN} = V_{SS}$		90	200	Ω
OFF Resistance			10^{10}		Ω
Analog Input Leakage Current	MM454 $T_A = 25^\circ C$		.050	100	nA
	MM454 $T_A = 85^\circ C$		.006	1.0	μA
	MM554 $T_A = 25^\circ C$		.0001	100	nA
	MM554 $T_A = 70^\circ C$		.030	1.0	μA
Analog Output Leakage Current	MM454 $T_A = 25^\circ C$		0.100	100	nA
	MM454 $T_A = 85^\circ C$		30	1.0	μA
	MM554 $T_A = 25^\circ C$		.0001	100	nA
	MM554 $T_A = 70^\circ C$		.030	1.0	μA
V_{SS} Supply Current Drain	$V_{SS} = +12V$		3.8	5.5	mA
V_{GG} Supply Current Drain	$V_{GG} = -24V$		2.4	3.5	mA

capacitance characteristics

PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Analog Input Capacitance Channel OFF	$I_{IN} = 0$		4	6	pF
Analog Input Capacitance Channel ON	$I_{IN} = 0$		20	24	pF
Analog Output Capacitance	$I_{IN} = 0$		20	24	pF
Clock Input	$V_{CL} = +12V$		2.0		pF
Reset Input	$V_{RESET} = +12V$		2.0		pF
Blanking Input	$V_{BLANK} = +12V$		2.0		pF

clock characteristics (Note 3)

PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Clock Input (HIGH) ⁽¹⁾		$V_{SS} - 2$		V_{SS}	V
Clock Input (LOW)		-5	0	+5	V
Clock Input Rise Time (POS GOING)			No requirement		
Clock Input Fall Time (NEG GOING)				20	μsec
Countdown Output (POS) V_{OH}		$V_{SS} - 2$		V_{SS}	V
Countdown Output (NEG) V_{OL}			0		V
Maximum Commutation Rate		0.5	2.0		MHz
V_{SS}		+10.0	+12	+14	V

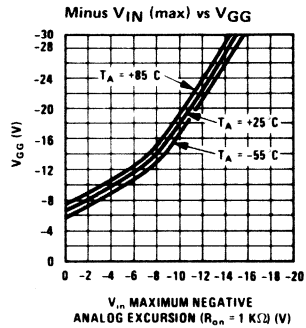
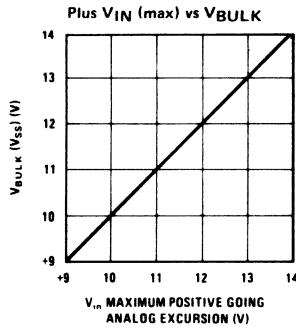
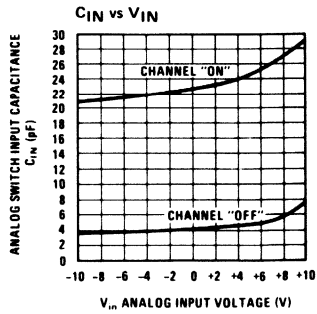
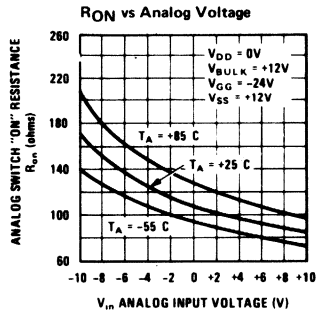
Note 1: Maximum ratings are limiting values above which the device may be damaged. All voltages referenced to $V_{DD} = 0$.

Note 2: These specifications apply over the indicated operating temperature range for $V_{GG} = -24V$, $V_{DD} = 0V$, $V_{SS} = +12V$, $V_{RESET} = +12V$, $V_{BLANK} = +12V$. ON resistance measured at 1 mA, OFF resistance and leakage measured with all analog inputs and output common. Capacitance measured at 1 MHz.

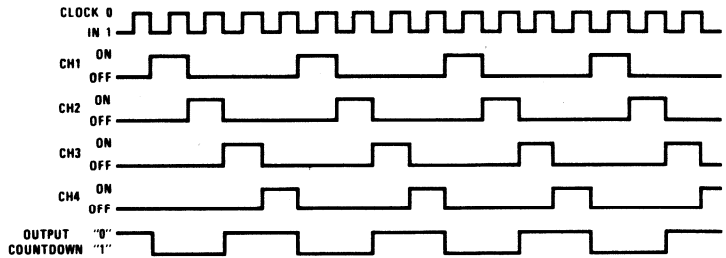
Note 3: Operating conditions in Note 2 apply. V_{SS} to V_{DD} (0V) voltage is applied to counting and gating circuits. V_{GG} is required only for analog switch biasing. All logic inputs are high resistance and are essentially capacitive.

Note 4: Logic input voltage must not be more positive than V_{SS} .

typical performance characteristics



timing diagram



NOTE: "0" LEVEL = +12V
 "1" LEVEL = 0V (GND)



Interface Circuits

LM1488

LM1488 quad line driver

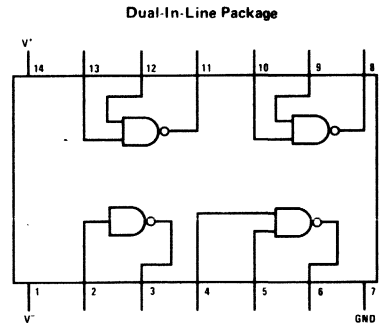
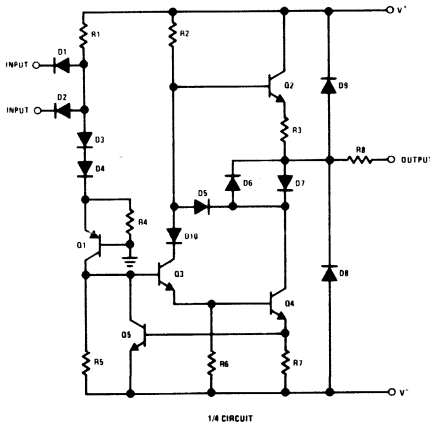
general description

The LM1488 is a quad line driver which converts standard DTL/TTL input logic levels through one stage of inversion to output levels which meet EIA Standard No. RS-232C and CCITT Recommendation V. 24.

features

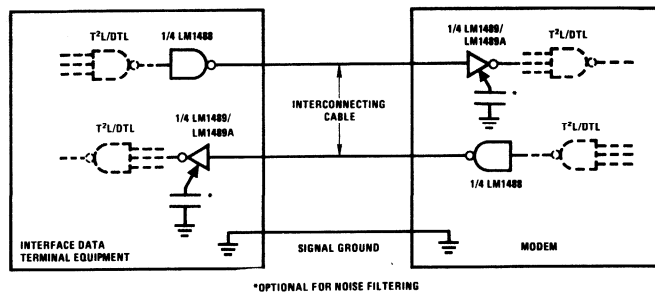
- Current limited output ± 10 mA typ
- Power-off source impedance 300Ω min
- Simple slew rate control with external capacitor
- Flexible operating supply range
- Inputs are DTL/TTL compatible

schematic and connection diagrams



typical applications

RS232C Data Transmission



absolute maximum ratings (Note 1)

Supply Voltage		
V^+		+15V
V^-		-15V
Input Voltage (V_{IN})		$-15V \leq V_{IN} \leq 7.0V$
Output Voltage		$\pm 15V$
Power Derating (Note 2)		
(Package Limitation, J Package)		1000 mW
Derating above $T_A = +25^\circ C$ ($1/\theta_{JA}$)		6.7 mW/ $^\circ C$
Operating Temperature Range		$0^\circ C$ to $+75^\circ C$
Storage Temperature Range		$-65^\circ C$ to $+175^\circ C$
Lead Temperature (Soldering, 10 sec)		$300^\circ C$

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Logic "0" Input Current	$V_{IN} = 0V$		-1.0	-1.3	mA
Logic "1" Input Current	$V_{IN} = +5.0V$		.005	10.0	μA
High Level Output Voltage	$R_L = 3.0k\Omega$ $V_{IN} = 0.8V$	$\left\{ \begin{array}{l} V^+ = 9.0V \\ V^- = -9.0V \end{array} \right.$	6.0	7.0	V
Low Level Output Voltage	$R_L = 3.0k\Omega$ $V_{IN} = 1.9V$	$\left\{ \begin{array}{l} V^+ = 13.2V \\ V^- = -13.2V \end{array} \right.$	9.0	10.5	V
High Level Output Short-Circuit Current	$V_{OUT} = 0V$ $V_{IN} = 0.8V$	$\left\{ \begin{array}{l} V^+ = 9.0V \\ V^- = -9.0V \end{array} \right.$	-6.0	-6.8	V
Low Level Output Short-Circuit Current	$V_{OUT} = 0V$ $V_{IN} = 1.9V$	$\left\{ \begin{array}{l} V^+ = 13.2V \\ V^- = -13.2V \end{array} \right.$	-9.0	-10.5	V
Output Resistance	$V^+ = V^- = 0V$ $V_{OUT} = \pm 2V$	300			Ω
Positive Supply Current (Output Open)	$V_{IN} = 1.9V$	$\left\{ \begin{array}{l} V^+ = 9.0V, V^- = -9.0V \\ V^+ = 12V, V^- = -12V \\ V^+ = 15V, V^- = -15V \end{array} \right.$	15.0 19.0 25.0	20.0 25.0 34.0	mA mA mA
Negative Supply Current (Output Open)	$V_{IN} = 0.8V$	$\left\{ \begin{array}{l} V^+ = 9.0V, V^- = -9.0V \\ V^+ = 12V, V^- = -12V \\ V^+ = 15V, V^- = -15V \end{array} \right.$	4.5 5.5 8.0	6.0 7.0 12.0	mA mA mA
Positive Supply Current (Output Open)	$V_{IN} = 1.9V$	$\left\{ \begin{array}{l} V^+ = 9.0V, V^- = -9.0V \\ V^+ = 12V, V^- = -12V \\ V^+ = 15V, V^- = -15V \end{array} \right.$	-13.0 -18.0 -25.0	-17.0 -23.0 -34.0	mA mA mA
Negative Supply Current (Output Open)	$V_{IN} = 0.8V$	$\left\{ \begin{array}{l} V^+ = 9.0V, V^- = -9.0V \\ V^+ = 12V, V^- = -12V \\ V^+ = 15V, V^- = -15V \end{array} \right.$	-.001 -.001 -.01	-1.0 -1.0 -2.5	mA mA mA
Power Dissipation	$V^+ = 9.0V, V^- = -9.0V$ $V^+ = 12V, V^- = -12V$		252 444	333 576	mW mW
Propagation Delay to "1" (t_{pd1})	$R_L = 3.0 k\Omega$ $C_L = 15 pF, T_A = 25^\circ C$		230	300	ns
Propagation Delay to "0" (t_{pd0})	$R_L = 3.0 k\Omega$ $C_L = 15 pF, T_A = 25^\circ C$		70	175	ns
Rise Time (t_r)	$R_L = 3.0 k\Omega$ $C_L = 15 pF, T_A = 25^\circ C$		75	100	ns
Fall Time (t_f)	$R_L = 3.0 k\Omega$ $C_L = 15 pF, T_A = 25^\circ C$		40	75	ns

Note 1: Voltage values shown are with respect to network ground terminal. Positive current is defined as current into the referenced pin.

Note 2: The maximum junction temperature of the LM1488 is $150^\circ C$. For operating at elevated temperatures the cavity Dual-In-Line Package (J) must be derated based on a thermal resistance of $85^\circ C/W$, junction to ambient.

Note 3: These specifications apply for $V^+ = +9.0V \pm 1\%$, $V^- = -9.0V \pm 1\%$, $T_A = 0^\circ C$ to $+75^\circ C$ unless otherwise noted. All typicals are for $V^+ = 9.0V$, $V^- = -9.0V$, and $T_A = 25^\circ C$.

applications

By connecting a capacitor to each driver output the slew rate can be controlled utilizing the output current limiting characteristics of the LM1488. For a set slew rate the appropriate capacitor value may be calculated using the following relationship

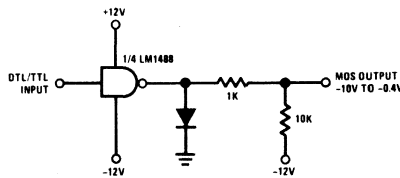
$$C = I_{SC} (\Delta T / \Delta V)$$

where C is the required capacitor, I_{SC} is the short circuit current value, and $\Delta V / \Delta T$ is the slew rate.

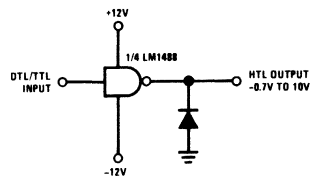
RS232C specifies that the output slew rate must not exceed 30V per microsecond. Using the worst case output short circuit current of 12 mA in the above equation, calculations result in a required capacitor of 400 pF connected to each output.

typical applications (con't)

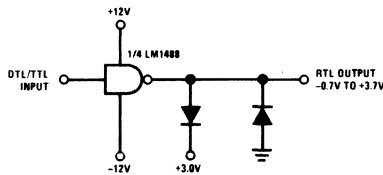
DTL/TTL-to-MOS Translator



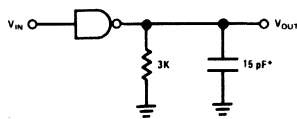
DTL/TTL-to-HTL Translator



DTL/TTL-to-RTL Translator

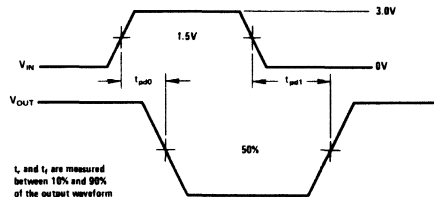


ac load circuit



*C_L includes probe and jig capacitance.

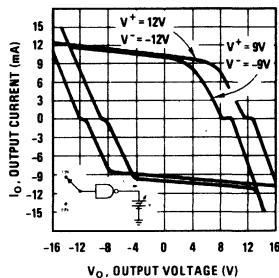
switching time waveforms



t_r and t_f are measured between 10% and 90% of the output waveform

typical performance characteristics

Output Voltage and Current-Limiting Characteristics





Interface Circuits

LM1489/LM1489A quad line receiver

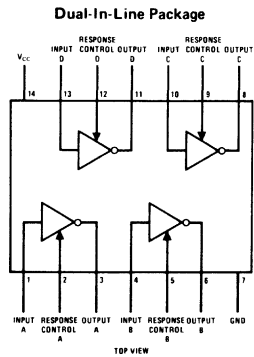
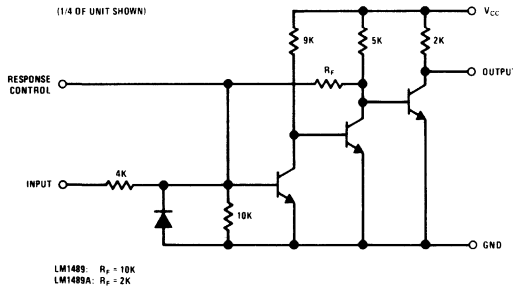
general description

The LM1489/LM1489A are quad line receivers designed to interface data terminal equipment with data communications equipment. They are constructed on a single monolithic silicon chip. These devices satisfy the specifications of EIA standard No. RS232C. The LM1489/LM1489A meet and exceed the specifications of MC1489/MC1489A and are pin-for-pin replacements. The LM1489/LM1489A are available in 14 lead ceramic dual-in-line package.

features

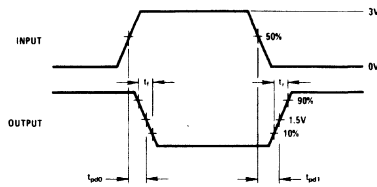
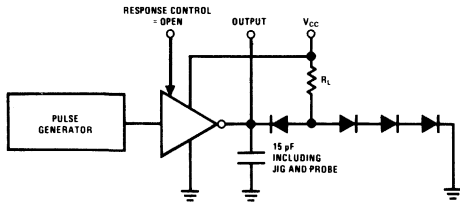
- Four totally separate receivers per package
- Programmable threshold
- Built-in input threshold hysteresis
- "Fail safe" operating mode
- Inputs withstand $\pm 30V$

schematic and connection diagrams

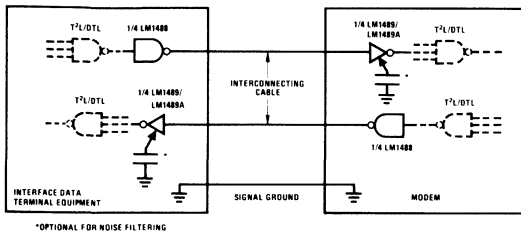


Order Number LM1489J or LM1489AJ
 See Package 16

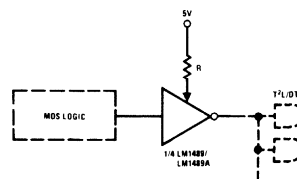
ac test circuit and voltage waveforms



typical applications



RS232C Data Transmission



MOS to T²L/DTL Translator

absolute maximum ratings (Note 1)

The following apply for $T_A = 25^\circ\text{C}$ unless otherwise specified.

Power Supply Voltage	10V
Input Voltage Range	$\pm 30\text{V}$
Output Load Current	20 mA

Power Dissipation (Note 2)	1W
Operating Temperature Range	0°C to $+75^\circ\text{C}$
Storage Temperature Range	-65°C to $+175^\circ\text{C}$

electrical characteristics (Note 3)

LM1489/LM1489A: The following apply for $V_{CC} = 5.0\text{V} \pm 1\%$, $0^\circ\text{C} \leq T_A \leq +75^\circ\text{C}$ unless otherwise specified.

PARAMETER	CONDITIONS	LM1489			LM1489A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input High Threshold Voltage	$T_A = 25^\circ\text{C}$, $V_{OUT} \leq 0.45\text{V}$, $I_{OUT} = 10\text{ mA}$	1.0		1.5	1.75		2.25	V
Input Low Threshold Voltage	$T_A = 25^\circ\text{C}$, $V_{OUT} \geq 2.5\text{V}$, $I_{OUT} = -0.5\text{ mA}$	0.75		1.25	0.75		1.25	V
Input Current	$V_{IN} = +25\text{V}$	+3.6	+5.6	+8.3	+3.6	+5.6	+8.3	mA
	$V_{IN} = -25\text{V}$	-3.6	-5.6	-8.3	-3.6	-5.6	-8.3	
	$V_{IN} = +3\text{V}$	+0.43	+0.53		+0.43	+0.53		mA
	$V_{IN} = -3\text{V}$	-0.43	-0.53		-0.43	-0.53		
Output High Voltage	$V_{IN} = 0.75\text{V}$, $I_{OUT} = -0.5\text{ mA}$	2.6	3.8	5.0	2.6	3.8	5.0	V
	Input = Open, $I_{OUT} = -0.5\text{ mA}$	2.6	3.8	5.0	2.6	3.8	5.0	V
Output Low Voltage	$V_{IN} = 3.0\text{V}$, $I_{OUT} = 10\text{ mA}$		0.33	0.45		0.33	0.45	V
Output Short Circuit Current	$V_{IN} = 0.75\text{V}$		3.0			3.0		mA
Supply Current	$V_{IN} = 5.0\text{V}$		14	26		14	26	mA
Power Dissipation	$V_{IN} = 5.0\text{V}$		70	130		70	130	mW

LM1489/LM1489A: The following apply for $V_{CC} = 5.0\text{V} \pm 1\%$, $T_A = 25^\circ\text{C}$

Input to Output "High" Propagation Delay (t_{pd1})	$R_L = 3.9\text{k}$ (Figure 1) (AC Test Circuit)		28	85		28	85	ns
Input to Output "Low" Propagation Delay (t_{pd0})	$R_L = 390\Omega$ (Figure 1) (AC Test Circuit)		20	50		20	50	ns
Output Rise Time	$R_L = 3.9\text{k}$ (Figure 1) (AC Test Circuit)		110	175		110	175	ns
Output Fall Time	$R_L = 390\Omega$ (Figure 1) (AC Test Circuit)		9	20		9	20	ns

Note 1: Voltage values shown are with respect to network ground terminal. Positive current is defined as current into the referenced pin.

Note 2: For operation at elevated temperatures, the device must be derated based on a 125°C maximum junction temperature and a thermal resistance of $85^\circ\text{C}/\text{W}$ junction to case.

Note 3: These specifications apply for response control pin = open.



Interface Circuits

**LM55107A/LM75107A, LM55108A/LM75108A,
LM163/LM363 dual line receivers
LM75207, LM75208, LM363A dual MOS sense amplifiers**

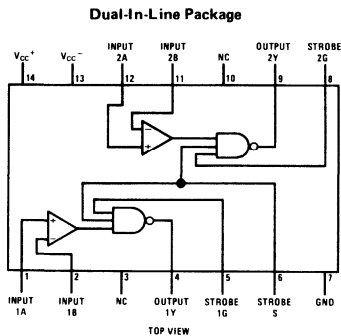
general description

The nine products described herein are TTL compatible dual high speed circuits intended for sensing in a broad range of system applications. While the primary usage will be for line receivers or MOS sensing, any of the products may effectively be used as voltage comparators, level translators, window detectors, transducer preamplifiers, and in other sensing applications. As digital line receivers the products are applicable with the LM55109/LM75109 and LM55110/LM75110 companion drivers, or may be used in other balanced or unbalanced party-line data transmission systems. The improved input sensitivity and delay specifications of the LM75207, LM75208 and LM363A make them ideal for sensing high performance MOS memories as well as high sensitivity line receivers and voltage comparators. TRI-STATE® products enhance based organizations.

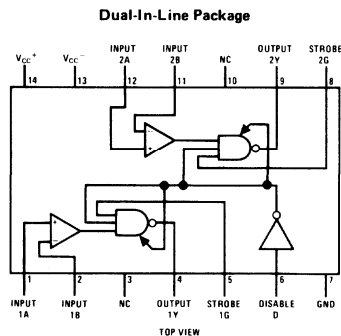
features

- High speed 17 ns typ
- TTL compatible
- Input sensitivity ± 10 mV or ± 25 mV
- Input common-mode range ± 3 V
- High input impedance with normal V_{CC} , or $V_{CC} = 0$ V
- Strobes for channel selection
- TRI-STATE outputs for high speed buses
- Dual circuits
- Sensitivity guaranteed over full common mode range
- Logic input clamp diodes
- 14 pin cavity or molded dual-in-line package
- Standard supply voltages ± 5 V

connection diagrams



Order Number:	Order Number:
LM55107AJ	LM75107AN
LM75107AJ	LM75108AN
LM55108AJ	LM75207N
LM75108AJ	LM75208N
LM75207J	See Package 22
LM75208J	
See Package 16	



Order Number:	Order Number:
LM163J	LM363N
LM363J	LM363AN
LM363AJ	See Package 22
See Package 16	

product selection guide

TEMPERATURE - PACKAGE - INPUT SENSITIVITY - OUTPUT LOGIC:	$-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$		$0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$	
	CAVITY DIP		CAVITY OR MOLDED DIP	
	± 25 mV		± 25 mV	± 10 mV
TTL Active Pull up	LM55107A	LM75107A	LM75207	
TTL Open Collector	LM55108A	LM75108A	LM75208	
TTL TRI-STATE	LM163	LM363	LM363A	

absolute maximum ratings

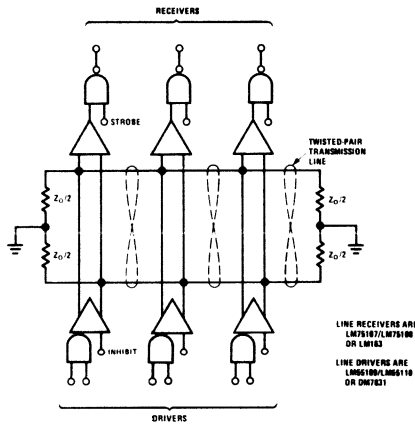
Supply Voltage, V_{CC}^+	7V	Strobe Input Voltage	5.5V
Supply Voltage, V_{CC}^-	-7V	Storage Temperature Range	-65°C to +150°C
Differential Input Voltage	±6V	Power Dissipation	600 mW
Common Mode Input Voltage	±5V	Lead Temperature (Soldering, 10 sec)	300°C

operating conditions

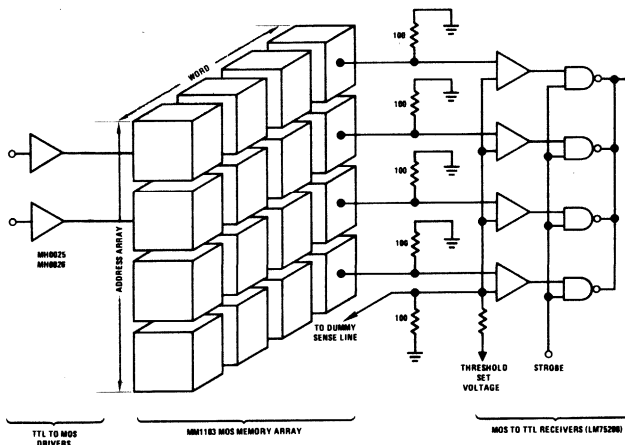
	LM55107A, LM55108A, LM163			LM75107A, LM75207 LM75108A, LM75208 LM363, LM363A		
	MIN	NOM	MAX	MIN	NOM	MAX
Supply Voltage V_{CC}^+	4.5V	5V	5.5V	4.75V	5V	5.25V
Supply Voltage V_{CC}^-	-4.5V	-5V	-5.5V	-4.75V	-5V	-5.25V
Operating Temperature Range	-55°C	to	+125°C	0°C	to	+70°C

typical applications

Line Receiver Used in a Party-Line or Data-Bus System

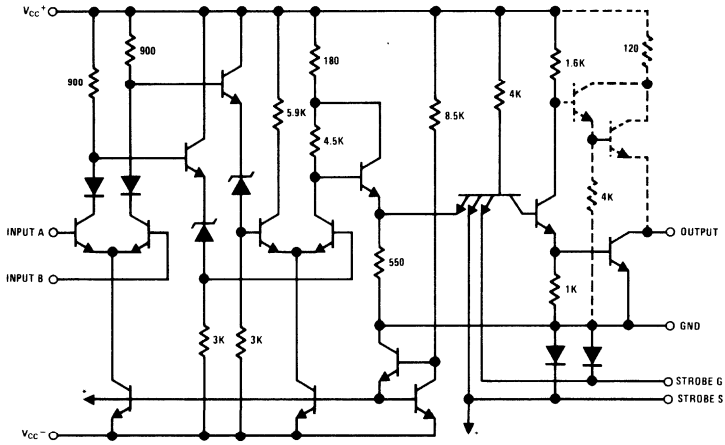


Line Receiver Used in MOS Memory System



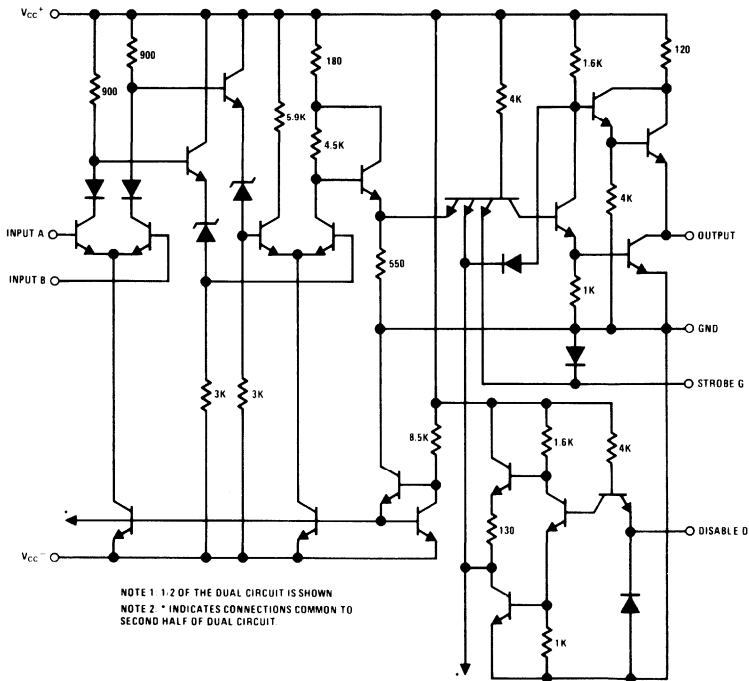
schematic diagrams

LM55107A/LM75107A, LM75207
LM55108A/LM75108A, LM75208



NOTE 1: 1/2 OF THE DUAL CIRCUIT IS SHOWN.
NOTE 2: * INDICATES CONNECTIONS COMMON TO SECOND HALF OF DUAL CIRCUIT.
NOTE 3: COMPONENTS SHOWN WITH DASH LINES ARE APPLICABLE TO THE LM55107A, LM75107A AND LM75207 ONLY.

LM163/LM363, LM363A



NOTE 1: 1/2 OF THE DUAL CIRCUIT IS SHOWN.
NOTE 2: * INDICATES CONNECTIONS COMMON TO SECOND HALF OF DUAL CIRCUIT.

LM55107A/LM75107A, LM55108A/LM75108A

dc electrical characteristics (T_{MIN} ≤ T_A ≤ T_{MAX})

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM55107A/LM75107A			LM55108A/LM75108A			
		MIN	TYP	MAX	MIN	TYP	MAX	
High Level Input Current Into 1A, 1B, 2A or 2B (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 0.5V, V _{IC} = -3V to 3V		30	75		30	75	μA
Low Level Input Current Into 1A, 1B, 2A or 2B (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = -2V, V _{IC} = -3V to 3V			-10			-10	μA
High Level Input Current Into 1G or 2G (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(S)} = 2.4V			40			40	μA
High Level Input Current Into 1G or 2G (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(S)} = Max V _{CC} ⁺			1			1	mA
Low Level Input Current Into 1G or 2G (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IL(S)} = 0.4V			-1.6			-1.6	mA
High Level Input Current Into S (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(S)} = 2.4V			80			80	μA
High Level Input Current Into S (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(S)} = Max V _{CC} ⁺			2			2	mA
Low Level Input Current Into S (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IL(S)} = 0.4V			-3.2			-3.2	mA
High Level Output Voltage (V _{OH})	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{LOAD} = -400μA, V _{ID} = 25 mV, V _{IC} = -3V to 3V	2.4						V
Low Level Output Voltage (V _{OL})	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{SINK} = 16 mA, V _{ID} = -25 mV, V _{IC} = -3V to 3V			0.4			0.4	V
High Level Output Current (I _{OH})	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, V _{OH} = Max V _{CC} ⁺						250	μA
Short Circuit Output Current (I _{OS})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max	-18		-70				mA
High Logic Level Supply Current From V _{CC} (I _{CCH} ⁺)	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 25 mV, T _A = 25°C		18	30		18	30	mA
High Logic Level Supply Current From V _{CC} (I _{CCH} ⁻)	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 25 mV, T _A = 25°C		-8.4	-15		-8.4	-15	mA
Input Clamp Voltage on G or S (V _I)	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{IN} = -12 mA, T _A = 25°C		-1	-1.5		-1	-1.5	V

ac switching characteristics (V_{CC}⁺ = 5V, V_{CC}⁻ = -5V, T_A = 25°C)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM55107A/LM75107A			LM55108A/LM75108A			
		MIN	TYP	MAX	MIN	TYP	MAX	
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) (t _{PLH(D)})	R _L = 390Ω, C _L = 50 pF		17	25				ns
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) (t _{PLH(D)})	R _L = 390Ω, C _L = 15 pF					19	25	ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to Output (Note 1) (t _{PHL(D)})	R _L = 390Ω, C _L = 50 pF		17	25				ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to Output (Note 1) (t _{PHL(D)})	R _L = 390Ω, C _L = 15 pF					19	25	ns
Propagation Delay Time, Low to High Level, From Strobe Input G or S to Output (t _{PLH(S)})	R _L = 390Ω, C _L = 50 pF			10	15			ns
Propagation Delay Time, Low to High Level, From Strobe Input G or S to Output (t _{PLH(S)})	R _L = 390Ω, C _L = 15 pF					13	20	ns
Propagation Delay Time, High to Low Level, From Strobe Input G or S to Output (t _{PHL(S)})	R _L = 390Ω, C _L = 50 pF		8	15				ns
Propagation Delay Time, High to Low Level, From Strobe Input G or S to Output (t _{PHL(S)})	R _L = 390Ω, C _L = 15 pF					13	20	ns

Note 1: Differential input is +100 mV to -100 mV pulse. Delays read from 0 mV on input to 1.5V on output.



LM75207, LM75208

dc electrical characteristics (0°C ≤ T_A ≤ +70°C)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM75207			LM75208			
		MIN	TYP	MAX	MIN	TYP	MAX	
High Level Input Current Into 1A, 1B, 2A or 2B (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 0.5V, V _{IC} = -3V to 3V		30	75		30	75	μA
Low Level Input Current Into 1A, 1B, 2A or 2B (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = -2V, V _{IC} = -3V to 3V			-10			-10	μA
High Level Input Current Into 1G or 2G (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(S)} = 2.4V			40			40	μA
High Level Input Current Into 1G or 2G (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(S)} = Max V _{CC} ⁺			1			1	mA
Low Level Input Current Into 1G or 2G (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IL(S)} = 0.4V			-1.6			-1.6	mA
High Level Input Current Into S (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(S)} = 2.4V			80			80	μA
High Level Input Current Into S (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(S)} = Max V _{CC} ⁺			2			2	mA
Low Level Input Current Into S (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IL(S)} = 0.4V			-3.2			-3.2	mA
High Level Output Voltage (V _{OH})	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{LOAD} = -400μA, V _{ID} = 10 mV, V _{IC} = -3V to 3V	2.4						V
Low Level Output Voltage (V _{OL})	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{SINK} = 16 mA, V _{ID} = -10 mV, V _{IC} = -3V to 3V			0.4			0.4	V
High Level Output Current (I _{OH})	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, V _{OH} = Max V _{CC} ⁺						250	μA
Short Circuit Output Current (I _{OS})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max	-18		-70				mA
High Logic Level Supply Current From V _{CC} (I _{CCH} ⁺)	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 10 mV, T _A = 25°C		18	30		18	30	mA
High Logic Level Supply Current From V _{CC} (I _{CCH} ⁻)	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 10 mV, T _A = 25°C		-8.4	-15		-8.4	-15	mA
Input Clamp Voltage on G or S (V _I)	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{IN} = -12 mA, T _A = 25°C		-1	-1.5		-1	-1.5	V

ac switching characteristics (V_{CC}⁺ = 5V, V_{CC}⁻ = -5V, T_A = 25°C)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM75207			LM75208			
		MIN	TYP	MAX	MIN	TYP	MAX	
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) (t _{PLH(D)})	R _L = 470Ω, C _L = 15 pF			35				ns
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) (t _{PLH(D)})	R _L = 470Ω, C _L = 15 pF						35	ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to output (Note 1) (t _{PHL(D)})	R _L = 470Ω, C _L = 15 pF			20				ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to Output (Note 1) (t _{PHL(D)})	R _L = 470Ω, C _L = 15 pF						20	ns
Propagation Delay Time, Low to High Level, From Strobe Input G or S to Output (t _{PLH(S)})	R _L = 470Ω, C _L = 15 pF			17				ns
Propagation Delay Time, Low to High Level, From Strobe Input G or S to Output (t _{PLH(S)})	R _L = 470Ω, C _L = 15 pF						17	ns
Propagation Delay Time, High to Low Level, From Strobe Input G or S to Output (t _{PHL(S)})	R _L = 470Ω, C _L = 15 pF			17				ns
Propagation Delay Time, High to Low Level, From Strobe Input G or S to Output (t _{PHL(S)})	R _L = 470Ω, C _L = 15 pF						17	ns

Note 1: Differential input is +10 mV to -30 mV pulse. Delays read from 0 mV on input to 1.5V on output.

LM163/LM363

dc electrical characteristics (T_{MIN} ≤ T_A ≤ T_{MAX})

PARAMETER	CONDITIONS	LIMITS			UNITS
		LM163/LM363			
		MIN	TYP	MAX	
High Level Input Current Into 1A, 1B, 2A or 2B (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 0.5V, V _{IC} = -3V to 3V		30	75	μA
Low Level Input Current Into 1A, 1B, 2A or 2B (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = -2V, V _{IC} = -3V to 3V			-10	μA
High Level Input Current Into 1G, 2G or D (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(S)} = 2.4V			40	μA
High Level Input Current Into 1G, 2G or D (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(S)} = Max V _{CC} ⁺			1	mA
Low Level Input Current Into D (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IL(D)} = 0.4V			-1.6	mA
Low Level Input Current Into 1G or 2G (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(D)} = 2V, V _{IL(G)} = 0.4V			-40	μA
Low Level Input Current into 1G or 2G (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IL(D)} = 0.8V, V _{IL(G)} = 0.4V			-1.6	mA
High Level Output Voltage (V _{OH})	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{LOAD} = -2 mA, V _{ID} = 25 mV, V _{IL(D)} = 0.8V, V _{IC} = -3V to 3V	2.4			V
Low Level Output Voltage (V _{OL})	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{SINK} = 16 mA, V _{ID} = -25 mV, V _{IL(D)} = 0.8V, V _{IC} = -3V to 3V			0.4	V
Output Disable Current (I _{OD})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(D)} = 2V, V _{OUT} = 2.4V			40	μA
Output Disable Current (I _{OD})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{IH(D)} = 2V, V _{OUT} = 0.4V			-40	μA
Short Circuit Output Current (I _{OS})	V _{CC} ⁺ = Max, V _{IL(D)} = 0.8V, V _{CC} ⁻ = Max	-18		-70	mA
High Logic Level Supply Current From V _{CC} ⁺ (I _{CCH} ⁺)	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 25 mV, T _A = 25°C		28	40	mA
High Logic Level Supply Current From V _{CC} ⁻ (I _{CCH} ⁻)	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 25 mV, T _A = 25°C		-8.4	-15	mA
Input Clamp Voltage on G or D (V _I)	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{IN} = -12 mA, T _A = 25°C		-1	-1.5	V

ac switching characteristics (V_{CC}⁺ = 5V, V_{CC}⁻ = -5V, T_A = 25°C)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LM163/LM363			
		MIN	TYP	MAX	
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) (t _{PLH(D)})	R _L = 390Ω, C _L = 50 pF		17	25	ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to Output (Note 1) (t _{PHL(D)})	R _L = 390Ω, C _L = 50 pF		17	25	ns
Propagation Delay Time, Low to High Level, From Strobe Input G to Output (t _{PLH(S)})	R _L = 390Ω, C _L = 50 pF		10	15	ns
Propagation Delay Time, High to Low Level, From Strobe Input G to Output (t _{PHL(S)})	R _L = 390Ω, C _L = 50 pF		8	15	ns
Disable Low to High to Output High to Off (t _{1H})	R _L = 390Ω, C _L = 5 pF			20	ns
Disable Low to High to Output Low to Off (t _{OH})	R _L = 390Ω, C _L = 5 pF			30	ns
Disable High to Low to Output Off to High (t _{H1})	R _L = 1k to 0V, C _L = 50 pF			25	ns
Disable High to Low to Output Off to Low (t _{HD})	R _L = 390Ω, C _L = 50 pF			25	ns

Note 1: Differential input is +100 mV to -100 mV pulse. Delays read from 0 mV on input to 1.5V on output.



LM363A

dc electrical characteristics (0°C ≤ T_A ≤ +70°C)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LM363A			
		MIN	TYP	MAX	
High Level Input Current Into 1A, 1B, 2A or 2B (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 0.5V, V _{IC} = -3V to 3V		30	75	μA
Low Level Input Current Into 1A, 1B, 2A or 2B (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = -2V, V _{IC} = -3V to 3V			-10	μA
High Level Input Current Into 1G, 2G or D (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{I(HIS)} = 2.4V			40	μA
High Level Input Current Into 1G, 2G or D (I _{IH})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{I(HIS)} = Max V _{CC} ⁺			1	mA
Low Level Input Current Into D (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{I(LD)} = 0.4V			-1.6	mA
Low Level Input Current Into 1G or 2G (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{I(HID)} = 2V, V _{I(LIG)} = 0.4V			-40	μA
Low Level Input Current Into 1G or 2G (I _{IL})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{I(LD)} = 0.8V, V _{I(LIG)} = 0.4V			-1.6	mA
High Level Output Voltage (V _{OH})	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{LOAD} = -2 mA, V _{ID} = 10 mV, V _{I(LD)} = 0.8V, V _{IC} = -3V to 3V	2.4			V
Low Level Output Voltage (V _{OL})	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{SINK} = 16 mA, V _{ID} = -10 mV, V _{I(LD)} = 0.8V, V _{IC} = -3V to 3V			0.4	V
Output Disable Current (I _{OD})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{I(HID)} = 2V, V _{OUT} = 2.4V			40	μA
Output Disable Current (I _{OD})	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{I(HID)} = 2V, V _{OUT} = 0.4V			-40	μA
Short Circuit Output Current (I _{OS})	V _{CC} ⁺ = Max, V _{I(LD)} = 0.8V, V _{CC} ⁻ = Max	-18		-70	mA
High Logic Level Supply Current From V _{CC} ⁺ (I _{CCH} ⁺)	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 10 mV, T _A = 25°C		28	40	mA
High Logic Level Supply Current From V _{CC} ⁻ (I _{CCH} ⁻)	V _{CC} ⁺ = Max, V _{CC} ⁻ = Max, V _{ID} = 10 mV, T _A = 25°C		-8.4	-15	mA
Input Clamp Voltage on G or D (V _I)	V _{CC} ⁺ = Min, V _{CC} ⁻ = Min, I _{IN} = -12 mA, T _A = 25°C		-1	-1.5	V

ac switching characteristics (V_{CC}⁺ = 5V, V_{CC}⁻ = -5V, T_A = 25°C)

PARAMETER	CONDITIONS	LIMITS			UNITS
		LM363A			
		MIN	TYP	MAX	
Propagation Delay Time, Low to High Level, From Differential Inputs A and B to Output (Note 1) (t _{PLH(D)})	R _L = 470Ω, C _L = 15 pF			35	ns
Propagation Delay Time, High to Low Level, From Differential Inputs A and B to Output (Note 1) (t _{PHL(D)})	R _L = 470Ω, C _L = 15 pF			20	ns
Propagation Delay Time, Low to High Level, From Strobe Input G to Output (t _{PLH(S)})	R _L = 470Ω, C _L = 15 pF			17	ns
Propagation Delay Time, High to Low Level, From Strobe Input G to Output (t _{PHL(S)})	R _L = 470Ω, C _L = 15 pF			17	ns
Disable Low to High to Output High to Off (t _{IH})	R _L = 470Ω, C _L = 5 pF			20	ns
Disable Low to High to Output Low to Off (t _{OH})	R _L = 470Ω, C _L = 5 pF			30	ns
Disable High to Low to Output Off to High (t _{HI})	R _L = 1k to 0V, C _L = 15 pF			25	ns
Disable High to Low to Output Off to Low (t _{HO})	R _L = 470Ω, C _L = 15 pF			25	ns

Note 1: Differential input is +10 mV to -30 mV pulse. Delays read from 0 mV on input to 1.5V on output.



Interface Circuits

LM55109/LM75109, LM55110/LM75110 dual line drivers

general description

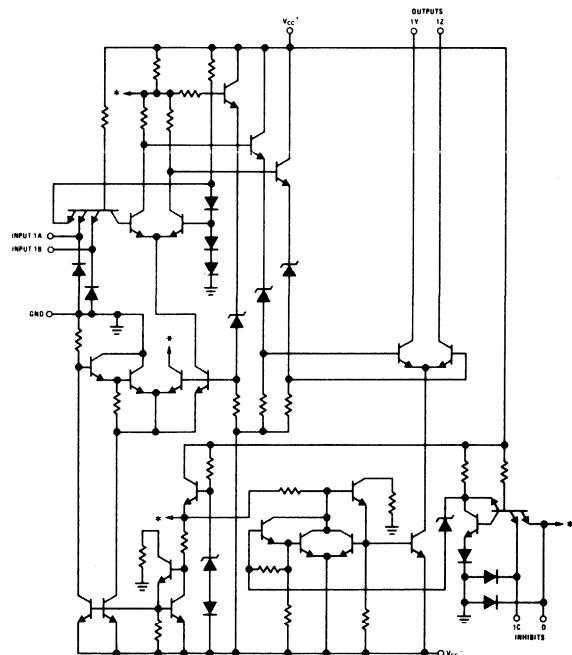
These products are TTL compatible high speed differential line drivers intended for use in terminated twisted-pair party-line data transmission systems. They may also be used for level shifting since output common-mode range is $-3V$ to $+10V$. An internal current sink is switched to either output dependent on input logic conditions. The current sink may be turned off by appropriate inhibit input conditions.

features

- Tightly controlled output currents over temperature, V_{CC} , and common-mode variations

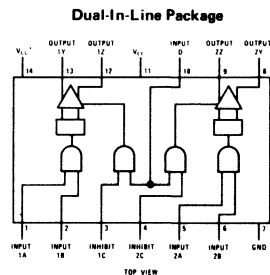
- High speed 15 ns max
- Wide output common-mode range
- High output impedance
- Inhibits for party-line applications
- Current sink outputs 6 or 12 mA
- Dual circuits
- Standard supply voltages $\pm 5V$
- Input clamp diodes
- 14 pin cavity or molded DIP

schematic diagram



NOTE 1: 1/2 OF THE DUAL CIRCUIT SHOWN.
NOTE 2: *INDICATES CONNECTIONS COMMON TO SECOND HALF OF CIRCUIT.

connection diagram



Order Number LM55109J, LM55110J, LM75109J, or LM75110J

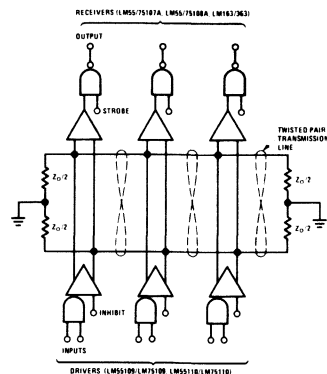
See Package 16

or

Order Number LM75109N or LM75110N
See Package 22

typical application

Party-Line Data Transmission System



absolute maximum ratings

Supply Voltage, V_{CC}^+	7V
Supply Voltage, V_{CC}^-	-7V
Logic and Inhibitor Input Voltages	5.5V
Common-mode Output Voltage	-5V to 12V
Storage Temperature Range	-65°C to +150°C
Power Dissipation	600 mW
Operating Temperature Range	
LM55109/LM55110	-55°C to +125°C
LM75109/LM75110	0°C to +70°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics ($T_{MIN} \leq T_A \leq T_{MAX}$)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM55109/LM75109			LM55110/LM75110			
		MIN	TYP	MAX	MIN	TYP	MAX	
Operating Conditions								
Supply Voltage V_{CC}^+		4.5	5	5.5	4.75	5	5.25	V
Supply Voltage V_{CC}^-		-4.5	-5	-5.5	-4.75	-5	-5.25	V
Positive Common Mode Output Voltage		0		10	0		10	V
Negative Common Mode Output Voltage		0		-3	0		-3	V
High Level Input Current Into 1A, 1B, 2A or 2B ($I_{IH(L)}$)	$V_{CC}^+ = \text{Max}, V_{CC}^- = \text{Max}, V_{IH(L)} = 2.4V$			40			40	μA
High Level Input Current Into 1A, 1B, 2A or 2B ($I_{IH(L)}$)	$V_{CC}^+ = \text{Max}, V_{CC}^- = \text{Max}, V_{IH(L)} = \text{Max } V_{CC}^+$			1			1	mA
Low Level Input Current Into 1A, 1B, 2A or 2B ($I_{IL(L)}$)	$V_{CC}^+ = \text{Max}, V_{CC}^- = \text{Max}, V_{IL(L)} = 0.4V$			-3			-3	mA
High Level Input Current Into 1C or 2C ($I_{IH(I)}$)	$V_{CC}^+ = \text{Max}, V_{CC}^- = \text{Max}, V_{IH(I)} = 2.4V$			40			40	μA
High Level Input Current Into 1C or 2C ($I_{IH(I)}$)	$V_{CC}^+ = \text{Max}, V_{CC}^- = \text{Max}, V_{IH(I)} = \text{Max } V_{CC}^+$			1			1	mA
Low Level Input Current Into 1C or 2C ($I_{IL(I)}$)	$V_{CC}^+ = \text{Max}, V_{CC}^- = \text{Max}, V_{IL(I)} = 0.4V$			-3			-3	mA
High Level Input Current Into D ($I_{IH(I)}$)	$V_{CC}^+ = \text{Max}, V_{CC}^- = \text{Max}, V_{IH(I)} = 2.4V$			80			80	μA
High Level Input Current Into D ($I_{IH(I)}$)	$V_{CC}^+ = \text{Max}, V_{CC}^- = \text{Max}, V_{IH(I)} = \text{Max } V_{CC}^+$			2			2	mA
Low Level Input Current Into D ($I_{IL(I)}$)	$V_{CC}^+ = \text{Max}, V_{CC}^- = \text{Max}, V_{IL(I)} = 0.4V$			-6			-6	mA
On State Output Current ($I_{O(ON)}$)	$V_{CC}^+ = \text{Max}, V_{CC}^- = \text{Max}, V_{CC}^+ = \text{Min}, V_{CC}^- = \text{Max}$	3.5		7	6.5		15	mA mA
Off State Output Current ($I_{O(OFF)}$)	$V_{CC}^+ = \text{Min}, V_{CC}^- = \text{Min}$			100			100	μA
Supply Current From V_{CC}^+ With Driver Enabled ($I_{CC^+(ON)}$)	$V_{IL(L)} = 0.4V, V_{IH(I)} = 2V$		18	30		23	35	mA
Supply Current From V_{CC}^- With Driver Enabled ($I_{CC^-(ON)}$)	$V_{IL(L)} = 0.4V, V_{IH(I)} = 2V$		-18	-30		-34	-50	mA
Supply Current From V_{CC}^+ With Driver Inhibited ($I_{CC^+(OFF)}$)	$V_{IL(L)} = 0.4V, V_{IL(I)} = 0.4V$		18			21		mA
Supply Current From V_{CC}^- With Driver Inhibited ($I_{CC^-(OFF)}$)	$V_{IL(L)} = 0.4V, V_{IL(I)} = 0.4V$		-10			-17		mA
Input Clamp Voltage on Inputs or Inhibits (V_I)	$V_{CC}^+ = \text{Min}, V_{CC}^- = \text{Min}, I_{IN} = -12 \text{ mA}, T_A = 25^\circ C$		-1	-1.5		-1	-1.5	V

ac switching characteristics ($V_{CC}^+ = 5V, V_{CC}^- = 5V, T_A = 25^\circ C$)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM55109/LM75109			LM55110/LM75110			
		MIN	TYP	MAX	MIN	TYP	MAX	
Propagation Delay Time, Low to High Level, From Logic Input A or B to Output Y or Z ($t_{PLH(L)}$)	$R_L = 50\Omega, C_L = 40\text{ pF}$		9	15		9	15	ns
Propagation Delay Time, High to Low Level, From Logic Input A or B to Output Y or Z ($t_{PHL(L)}$)	$R_L = 50\Omega, C_L = 40\text{ pF}$		9	15		9	15	ns
Propagation Delay Time, Low to High Level, From Inhibitor Input C or D to Output Y or Z ($t_{PLH(I)}$)	$R_L = 50\Omega, C_L = 40\text{ pF}$		16	25		16	25	ns
Propagation Delay Time, High to Low Level, From Inhibitor Input C or D to Output Y or Z ($t_{PHL(I)}$)	$R_L = 50\Omega, C_L = 40\text{ pF}$		13	25		13	25	ns





Interface Circuits

LM75324 memory driver with decode inputs general description

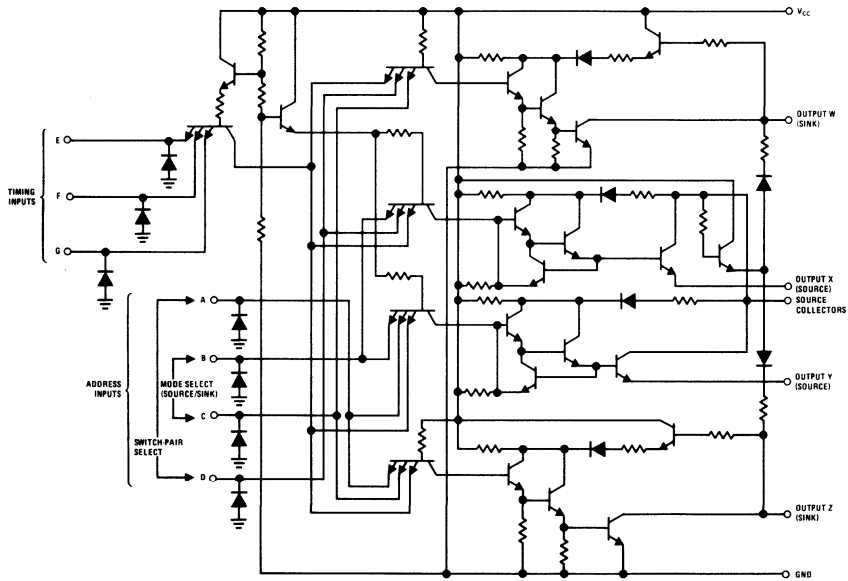
The LM75324 is a monolithic memory driver which features two 400 mA (source/sink) switch pairs along with decoding capability from four address lines. Inputs B and C function as mode selection lines (source or sink) while lines A and D are used for switch-pair selection (output pair Y/Z or W/X).

- High voltage outputs
- Dual sink/source outputs
- Internal decoding and timing circuitry
- Fast switching times
- Operation 0°C to +70°C
- DTL/TTL compatible
- Input clamping diodes

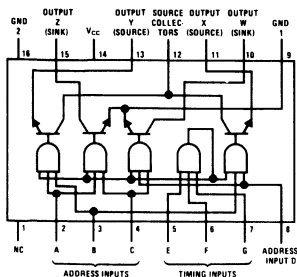
features

- Output capability 400 mA

schematic and connection diagrams



Dual-In-Line Package (J)

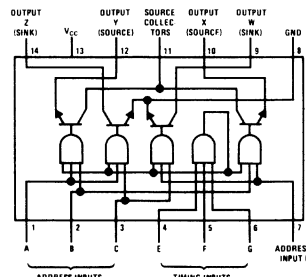


GND 1 AND GND 2 ARE TO BE USED IN PARALLEL
TOP VIEW

Order Number LM75324J

See Package 17

Dual-In-Line Package (N)



TOP VIEW

Order Number LM75324N

See Package 22

absolute maximum ratings

Supply Voltage V_{CC} (Note 1)	17V
Input Voltage (Note 2)	5.5V
Operating Case Temperature Range	0°C to +70°C
Continuous Total Power Dissipation at (or Below) +70°C Case Temperature	800 mW
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics ($V_{CC} = 14V$, $T_C = 0^\circ C$ to $+70^\circ C$ unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Required to Insure Logical "1" At Any Input ($V_{IN(1)}$)	Figure 1	3.5			V
Input Voltage Required to Insure Logical "0" At Any Input ($V_{IN(0)}$)	Figure 1			0.8	V
Logical "1" Level Address Input Current ($I_{IN(1)}$)	$V_{IN} = 5V$, Figure 1			200	μA
Logical "1" Level Timing Input Current ($I_{IN(1)}$)	$V_{IN} = 5V$, Figure 1			100	μA
Logical "0" Level Address Input Current ($I_{IN(0)}$)	$V_{IN} = 0V$, Figure 1			-6	mA
Logical "0" Level Timing Input Current ($I_{IN(0)}$)	$V_{IN} = 0V$, Figure 1			-12	mA
Sink Saturation Voltage (V_{sat})	$I_{SINK} \approx 420$ mA, $R_L = 53\Omega$, Figure 2		0.75	0.85	V
Source Saturation Voltage (V_{sat})	$I_{SOURCE} \approx -420$ mA, $R_L = 47.5\Omega$, Figure 2		0.75	0.85	V
Output Reverse Current (Off State) (I_{OFF})	$V_{IN} = 0V$, Figure 1		125	200	μA
Supply Current, All Sources and Sinks Off (I_{CC})	$V_{IN} = 0V$, Figure 3		12.5	15	mA
Supply Current, Either Sink Selected (I_{CC})	Figure 4		30	40	mA
Supply Current, Either Source Selected (I_{CC})	Figure 4		25	35	mA
Input Clamp Voltage (V_I)	$I_{IN} = -12$ mA, $T_A = 25^\circ C$			-1.5	V

ac switching characteristics ($V_{CC} = 14V$, $T_C = 25^\circ C$)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Propagation Delay Time to Logical "1" Level, Source Output (t_{pd1})	$R_{L1} = 53\Omega$, $R_{L2} = 500\Omega$, $C_L = 20$ pF, Figure 5			90	ns
Propagation Delay Time to Logical "0" Level, Source Output (t_{pd0})				50	ns
Propagation Delay Time to Logical "1" Level, Sink Output (t_{pd1})				110	ns
Propagation Delay Time to Logical "0" Level, Sink Output (t_{pd0})	$R_L = 53\Omega$, $C_L = 20$ pF, Figure 6			40	ns
Sink Storage Time (t_s)				70	ns

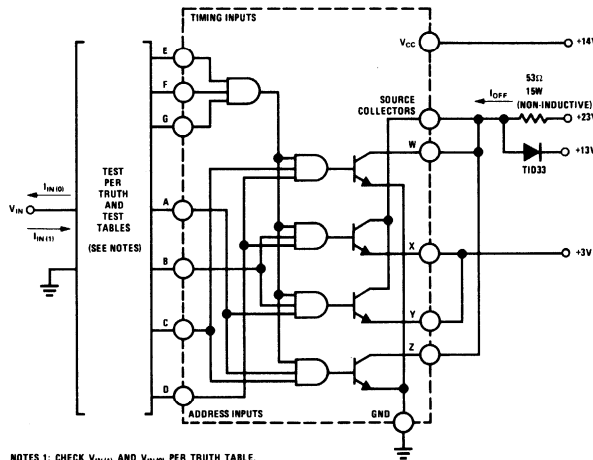
Note 1: Voltage values are with respect to network ground terminal.

Note 2: Input signals must be zero or positive with respect to network ground terminal.

truth table

INPUTS							OUTPUTS			
ADDRESS				TIMING			SINK	SOURCES		SINK
A	B	C	D	E	F	G	W	X	Y	Z
0	0	1	1	1	1	1	ON	OFF	OFF	OFF
0	1	0	1	1	1	1	OFF	ON	OFF	OFF
1	1	0	0	1	1	1	OFF	OFF	ON	OFF
1	0	1	0	1	1	1	OFF	OFF	OFF	ON
X	X	X	X	0	X	X	OFF	OFF	OFF	OFF
X	X	X	X	X	0	X	OFF	OFF	OFF	OFF
X	X	X	X	X	X	0	OFF	OFF	OFF	OFF

test circuits and switching time waveforms



NOTES 1: CHECK $V_{IN(1)}$ AND $V_{IN(0)}$ PER TRUTH TABLE.
 NOTES 2: MEASURE $I_{IN(0)}$ PER TEST TABLE.
 NOTES 3: WHEN MEASURING $I_{IN(1)}$, ALL OTHER INPUTS ARE AT GND. EACH INPUT IS TESTED SEPARATELY.

TEST TABLE FOR $I_{IN(0)}$

APPLY 3.5V	GROUND	TEST $I_{IN(0)}$
B, C, E, F, and G	A and D	A
B, C, E, F, and G	A and D	D
A, D, E, F, and G	B and C	B
A, D, E, F, and G	B and C	C
A, B, C, D, F, and G	E	E
A, B, C, D, E, and G	F	F
A, B, C, D, E, and F	G	G

FIGURE 1. $V_{IN(0)}$, $V_{IN(1)}$, $I_{IN(0)}$, $I_{IN(1)}$, and I_{OFF}

test circuits and switching time waveforms (con't)

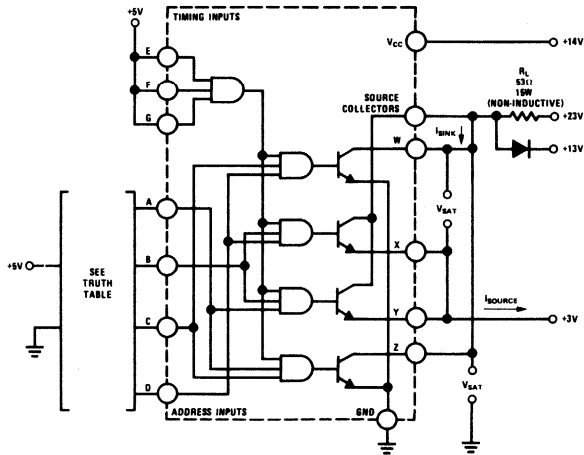


FIGURE 2. V_(SAT)

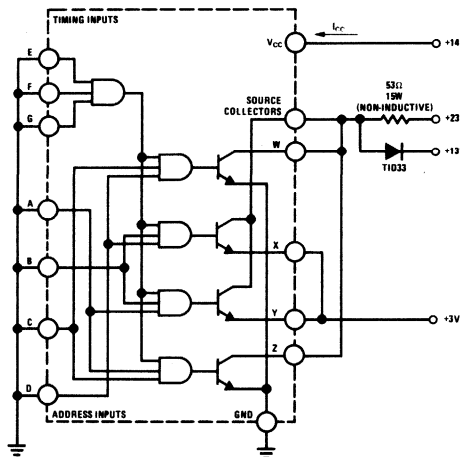
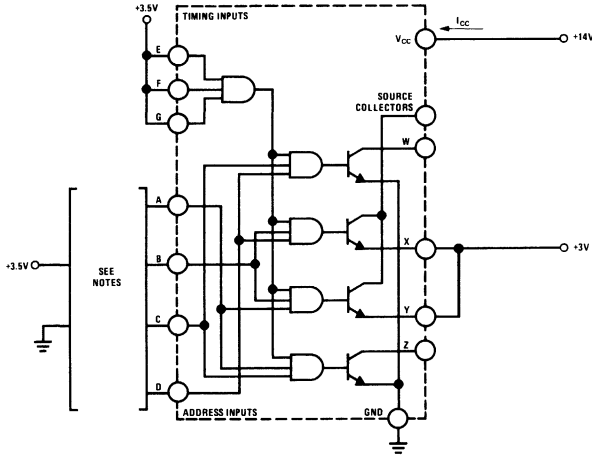


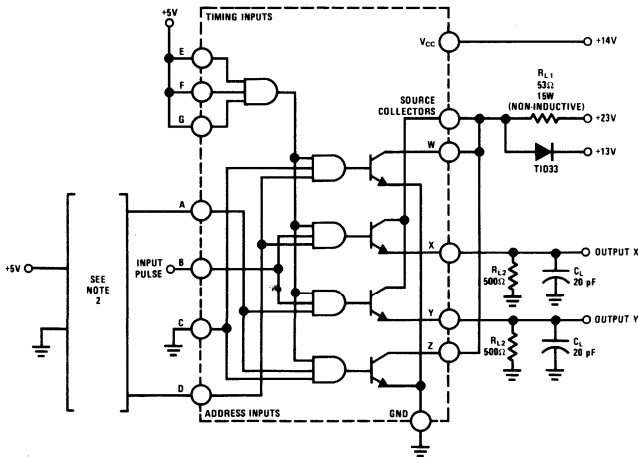
FIGURE 3. I_{CC} (All Outputs Off)

test circuits and switching time waveforms (con't)



- NOTE 1: GND A AND B, APPLY +3.5V TO C AND D, AND MEASURE I_{CC} (OUTPUT W IS ON).
- NOTE 2: GND B AND D, APPLY +3.5V TO A AND C, AND MEASURE I_{CC} (OUTPUT Z IS ON).
- NOTE 3: GND A AND C, APPLY +3.5V TO B AND D, AND MEASURE I_{CC} (OUTPUT X IS ON).
- NOTE 4: GND C AND D, APPLY +3.5V TO A AND B, AND MEASURE I_{CC} (OUTPUT Y IS ON).

FIGURE 4. I_{CC} (One Output On)



- NOTE 1: THE INPUT WAVEFORM IS SUPPLIED BY A GENERATOR WITH THE FOLLOWING CHARACTERISTICS: t_r = t_f = 10 ns, DUTY CYCLE ≤ 1%, AND Z_{OUT} = 50Ω.
- NOTE 2: WHEN MEASURING DELAY TIMES AT OUTPUT X, APPLY +5V TO INPUT D, AND GND A. WHEN MEASURING DELAY TIMES AT OUTPUT Y, APPLY +5V TO INPUT A, AND GND D.
- NOTE 3: C_L INCLUDES PROBE AND JIG CAPACITANCE.
- NOTE 4: UNLESS OTHERWISE NOTED ALL RESISTORS ARE 0.5W.

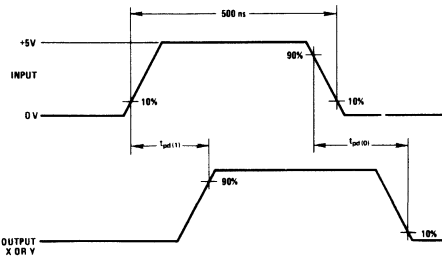
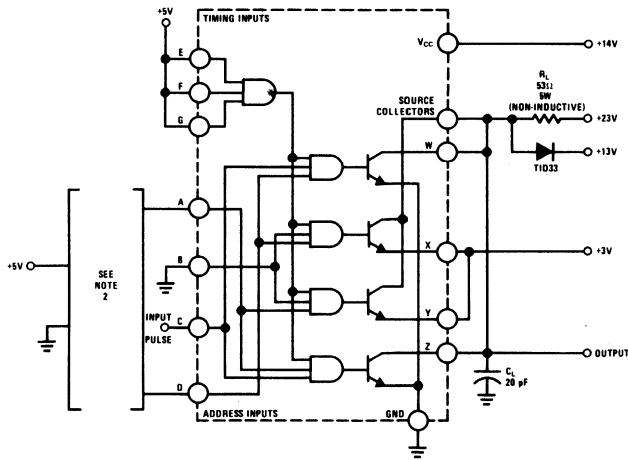


FIGURE 5. Source-Output Switching Times

test circuits and switching time waveforms (con't)



NOTE 1: THE INPUT WAVEFORM IS SUPPLIED BY A GENERATOR WITH THE FOLLOWING CHARACTERISTICS:
 $t_r = t_f = 10$ ns, DUTY CYCLE = 1%, $Z_{OUT} = 50\Omega$.
 NOTE 2: WHEN MEASURING DELAY TIMES AT OUTPUT W, APPLY +5V TO INPUT D, AND GND A. WHEN MEASURING DELAY TIMES AT OUTPUT Z, APPLY +5V TO INPUT A, AND GND D.
 NOTE 3: C_1 INCLUDES PROBE AND JIG CAPACITANCE.

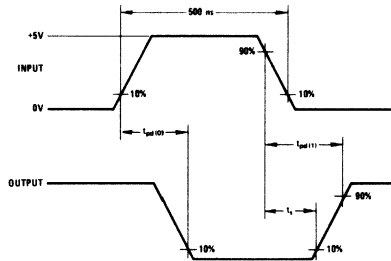


FIGURE 6. Sink-Output Switching Times



Interface Circuits

LM55325/LM75325 memory drivers general description

The LM55325 and LM75325 are monolithic memory drivers which feature high current outputs as well as internal decoding of logic inputs. These circuits are designed for use with magnetic memories.

The circuit contains two 600 mA sink-switch pairs and two 600 mA source-switch pairs. Inputs A and B determine source selection while the source strobe (S_1) allows the selected source turn on. In the same manner, inputs C and D determine sink selection while the sink strobe (S_2) allows the selected sink turn on.

Sink-output collectors feature an internal pull-up resistor in parallel with a clamping diode connected to V_{CC2} . This protects the outputs from voltage surges associated with switching inductive loads.

The source stage features Node R which allows extreme flexibility in source current selection by controlling the amount of base drive to each source transistor. This method of setting the base drive brings the power associated with the resistor outside the package thereby allowing the circuit to

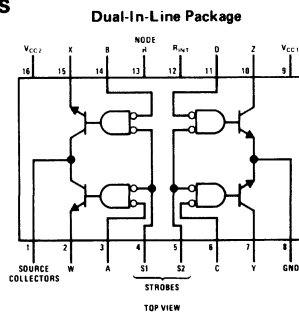
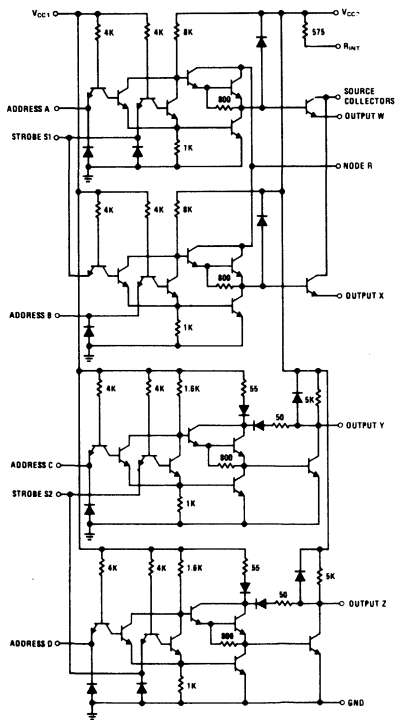
operate at higher source currents for a given junction temperature. If this method of source current setting is not desired, then Nodes R and R_{INT} can be shorted externally activating an internal resistor connected from V_{CC2} to Node R. This provides adequate base drive for source currents up to 375 mA with $V_{CC2} = 15V$ or 600 mA with $V_{CC2} = 24V$.

The LM55325 operates over the full military temperature range of $-55^{\circ}C$ to $+125^{\circ}C$, while the LM75325 operates from $0^{\circ}C$ to $+70^{\circ}C$.

features

- 600 mA output capability
- 24V output capability
- Dual sink and dual source outputs
- Fast switching times
- Source base drive externally adjustable
- Input clamping diodes
- DTL/TTL compatible

schematic and connection diagrams



Order Number LM55325J or LM75325J

See Package 17

Order Number LM75325N

See Package 23

truth table

ADDRESS INPUTS				STROBE INPUTS		OUTPUTS			
SOURCE		SINK		SOURCE	SINK	SOURCE	SINK	SOURCE	SINK
A	B	C	D	S1	S2	W	X	Y	Z
L	H	X	X	L	H	ON	OFF	OFF	OFF
H	L	X	X	L	H	OFF	ON	OFF	OFF
X	X	L	H	H	L	OFF	OFF	ON	OFF
X	X	H	L	H	L	OFF	OFF	OFF	ON
X	X	X	X	H	H	OFF	OFF	OFF	OFF
H	H	H	H	X	X	OFF	OFF	OFF	OFF

H = high level, L = low level, X = irrelevant
NOTE: Not more than one output is to be on at any one time

absolute maximum ratings

Supply Voltage V_{CC1} (Note 1)	7V
Supply Voltage V_{CC2} (Note 1)	25V
Input Voltage (Any Address or Strobe Input)	5.5V
Continuous Total Dissipation at (or Below) +70°C Free Air Temperature (Note 2)	800 mW
Operating Temperature Range LM55325	55°C to +125°C
LM75325	0°C to +70°C
Storage Temperature Range	65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics

PARAMETER	CONDITIONS	LIMITS						UNITS
		LM55325			LM75325			
		MIN	TYP*	MAX	MIN	TYP*	MAX	
High Level Input Voltage (V_{IH})	Figure 1 and 2	2			2			V
Low Level Input Voltage (V_{IL})	Figure 3 and 4			0.8			0.8	V
Input Clamp Voltage (V_I)	$V_{CC1} = 4.5V, V_{CC2} = 24V,$ $I_{IN} = -12 mA, T_A = 25^\circ C,$ Figure 5		-1.3	-1.7		-1.3	-1.7	V
Source Collectors Terminal Off State Current (I_{OFF})	$V_{CC1} = 4.5V, V_{CC2} = 24V,$ Full Range, Figure 1			500			200	μA
Source Collectors Terminal Off State Current (I_{OFF})	$V_{CC1} = 4.5V, V_{CC2} = 24V,$ $T_A = 25^\circ C,$ Figure 1		3	150		3	200	μA
High Level Sink Output Voltage (V_{OH})	$V_{CC1} = 4.5V, V_{CC2} = 24V,$ $I_{OUT} = 0V,$ Figure 2	19	23		19	23		V
Saturation Voltage Source Outputs** (V_{SAT})	$V_{CC1} = 4.5V, V_{CC2} = 15V,$ $R_L = 24\Omega, I_{SOURCE} \approx -600 mA,$ Full Range, (Note 3) Figure 3			0.9			0.9	V
Saturation Voltage Source Outputs** (V_{SAT})	$V_{CC1} = 4.5V, V_{CC2} = 15V,$ $R_L = 24\Omega, I_{SOURCE} \approx -600 mA,$ $T_A = 25^\circ C,$ (Note 3) Figure 3		0.43	0.7		0.43	0.75	V
Saturation Voltage Sink Outputs** (V_{SAT})	$V_{CC1} = 4.5V, V_{CC2} = 15V,$ $R_L = 24\Omega, I_{SINK} \approx 600 mA,$ Full Range, (Note 3) Figure 4			0.9			0.9	V
Saturation Voltage Sink Outputs** (V_{SAT})	$V_{CC1} = 4.5V, V_{CC2} = 15V,$ $R_L = 24\Omega, I_{SINK} \approx 600 mA,$ $T_A = 25^\circ C,$ (Note 3) Figure 4		0.43	0.7		0.43	0.75	V
Input Current at Maximum Input Voltage Address Inputs (I_I)	$V_{CC1} = 5.5V, V_{CC2} = 24V,$ $V_I = 5.5V,$ Figure 5			1			1	mA
Input Current at Maximum Input Voltage Strobe Inputs (I_I)	$V_{CC1} = 5.5V, V_{CC2} = 24V,$ $V_I = 5.5V,$ Figure 5			2			2	mA
High Level Input Current Address Inputs (I_{IH})	$V_{CC1} = 5.5V, V_{CC2} = 24V,$ $V_I = 2.4V,$ Figure 5		3	40		3	40	μA
High Level Input Current Strobe Inputs (I_{IH})	$V_{CC1} = 5.5V, V_{CC2} = 24V,$ $V_I = 2.4V,$ Figure 5		6	80		6	80	μA
Low Level Input Current Address Inputs (I_{IL})	$V_{CC1} = 5.5V, V_{CC2} = 24V,$ $V_I = 0.4V,$ Figure 5		-1	-1.6		-1	-1.6	mA
Low Level Input Current Strobe Inputs (I_{IL})	$V_{CC1} = 5.5V, V_{CC2} = 24V,$ $V_I = 0.4V,$ Figure 5		-2	-3.2		-2	-3.2	mA
Supply Current, All Sources and Sinks Off From V_{CC1} (I_{CCOFF})	$V_{CC1} = 5.5V, V_{CC2} = 24V,$ $T_A = 25^\circ C,$ Figure 6		14	22		14	22	mA
Supply Current, All Sources and Sinks Off From V_{CC2} (I_{CCOFF})	$V_{CC1} = 5.5V, V_{CC2} = 24V,$ $T_A = 25^\circ C,$ Figure 6		7.5	20		7.5	20	mA
Supply Current From V_{CC1} , Either Sink On (I_{CC1})	$V_{CC1} = 5.5V, V_{CC2} = 24V,$ $I_{SINK} = 50 mA, T_A = 25^\circ C,$ Figure 7		55	70		55	70	mA
Supply Current From V_{CC2} , Either Source On (I_{CC2})	$V_{CC1} = 5.5V, V_{CC2} = 24V,$ $I_{SOURCE} = -50 mA, T_A = 25^\circ C,$ Figure 8		32	50		32	50	mA

Note 1: Voltage values are with respect to network ground terminal.

Note 2: For operation of LM55325 above +70°C free-air temperature, refer to Dissipation Derating Curve (Figure 12).

Note 3: These parameters must be measured using pulse techniques. $t_{PW} = 200\mu s$, duty cycle $\leq 2\%$.

*All typical values are at $T_A = 25^\circ C$.

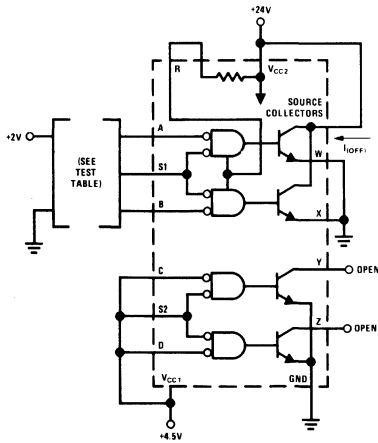
**Not more than one output is to be on at any one time.



ac switching characteristics ($V_{CC1} = 5V, T_A = 25^\circ C$)

PARAMETER	CONDITIONS	LIMITS			UNITS
		MIN	TYP	MAX	
Propagation Delay Time, Low to High Level Output to Source Collectors (t_{PLH})	$V_{CC2} = 15V, R_L = 24\Omega, C_L = 25 pF, \text{Figure 9}$		25	50	ns
Propagation Delay Time, High to Low Level Output to Source Collectors (t_{PHL})	$V_{CC2} = 15V, R_L = 24\Omega, C_L = 25 pF, \text{Figure 9}$		25	50	ns
Transition Time, Low to High Level Output to Source Outputs (t_{TLH})	$V_{CC2} = 20V, R_L = 1 k\Omega, C_L = 25 pF, \text{Figure 10}$		55		ns
Transition Time, High to Low Level Output to Source Outputs (t_{THL})	$V_{CC2} = 20V, R_L = 1 k\Omega, C_L = 25 pF, \text{Figure 10}$		7		ns
Propagation Delay Time, Low to High Level Output to Sink Outputs (t_{PLH})	$V_{CC2} = 15V, R_L = 24\Omega, C_L = 25 pF, \text{Figure 9}$		20	45	ns
Propagation Delay Time, High to Low Level Output to Sink Outputs (t_{PHL})	$V_{CC2} = 15V, R_L = 24\Omega, C_L = 25 pF, \text{Figure 9}$		20	45	ns
Transition Time, Low to High Level Output to Sink Outputs (t_{TLH})	$V_{CC2} = 15V, R_L = 24\Omega, C_L = 25 pF, \text{Figure 9}$		7	15	ns
Transition Time, High to Low Level Output to Sink Outputs (t_{THL})	$V_{CC2} = 15V, R_L = 24\Omega, C_L = 25 pF, \text{Figure 9}$		9	20	ns
Storage Time, Sink Outputs (t_s)	$V_{CC2} = 15V, R_L = 24\Omega, C_L = 25 pF, \text{Figure 9}$		15	30	ns

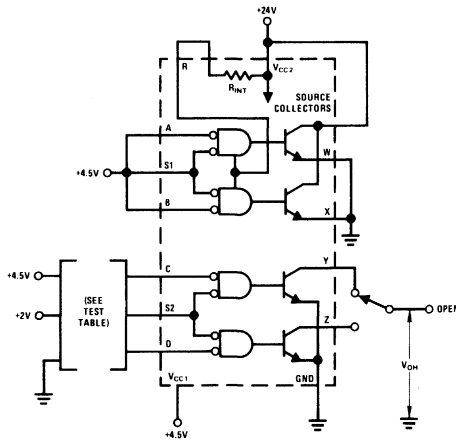
dc test circuits



TEST TABLE

A	B	S1
GND	GND	2V
2V	2V	GND

FIGURE 1. I_{OFF}

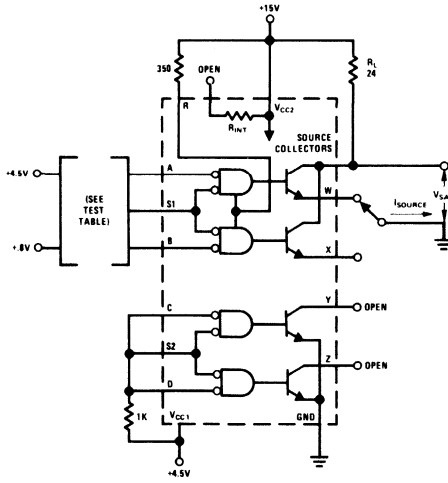


TEST TABLE

C	D	S2	Y	Z
2V	4.5V	GND	V_{OH}	OPEN
GND	4.5V	2V	V_{OH}	OPEN
4.5V	2V	GND	OPEN	V_{OH}
4.5V	GND	2V	OPEN	V_{OH}

FIGURE 2. V_{IH} and V_{OH}

dc test circuits(con't)

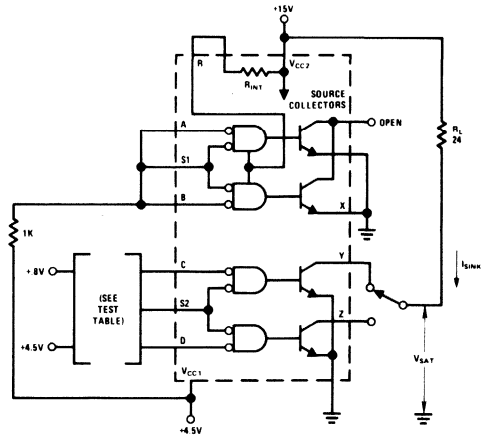


NOTE 1: FIGURE 3 AND 4 PARAMETERS MUST BE MEASURED USING PULSE TECHNIQUES. $t_w = 200\mu s$, DUTY CYCLE $\leq 2\%$

TEST TABLE

A	B	S1	W	X
0.8V	4.5V	0.8V	GND	OPEN
4.5V	0.8V	0.8V	OPEN	GND

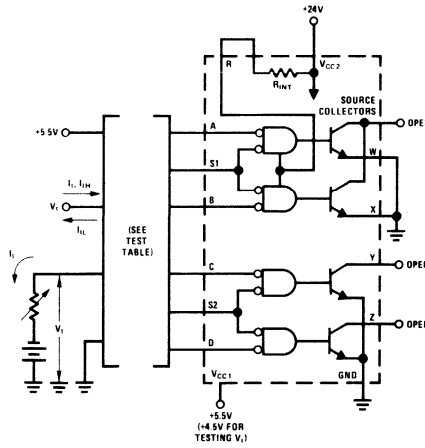
FIGURE 3. V_{IL} and Source V_{SAT}



TEST TABLE

C	D	S2	Y	Z
0.8V	4.5V	0.8V	R_L	OPEN
4.5V	0.8V	0.8V	OPEN	R_L

FIGURE 4. V_{IL} and Sink V_{SAT}



I_I, I_{IH}

APPLY $V_I = 5.5V$ MEASURE I_I	GROUND	APPLY 5.5V
APPLY $V_I = 2.4V$ MEASURE I_{IH}		
A	S1	B, C, S2, D
S1	A, B	C, S2, D
B	S1	A, C, S2, D
C	S2	A, S1, B, D
S2	C, D	A, S1, B
D	S2	A, S1, B, C

TEST TABLES

V_I, I_{IL}

APPLY $V_I = 0.4V$, MEASURE I_{IL}	APPLY 5.5V
APPLY $I_I = -10\text{ mA}$, MEASURE V_I	
A	S1, B, C, S2, D
S1	A, B, C, S2, D
B	A, S1, C, S2, D
C	A, S1, B, S2, D
S2	A, S1, B, C, D
D	A, S1, B, C, S2

FIGURE 5. V_I, I_I, I_{IH} , and I_{IL}



dc test circuits(con't)

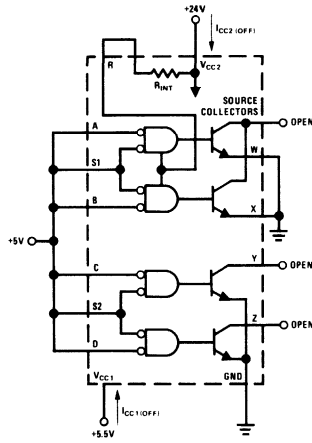
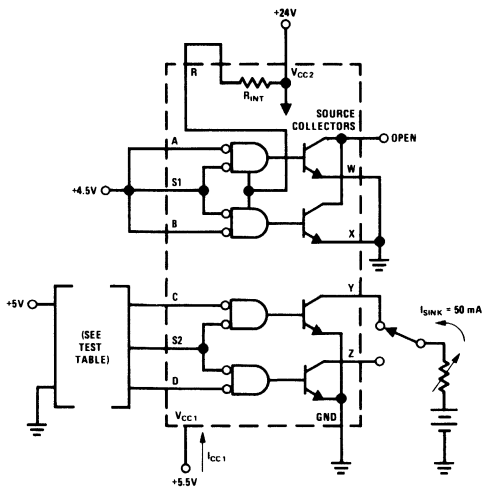


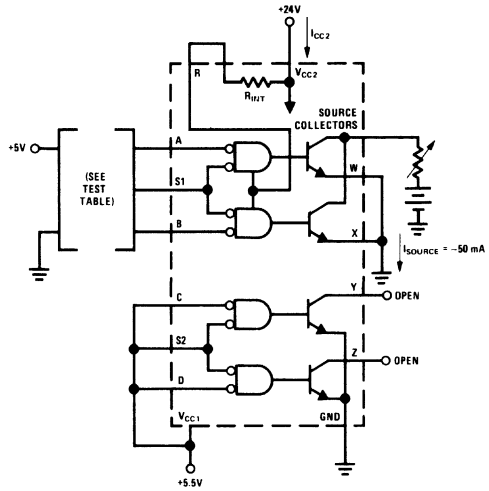
FIGURE 6. $I_{CC1(OFF)}$ and $I_{CC2(OFF)}$



TEST TABLE

C	D	S2	Y	Z
GND	5V	GND	$I_{(SINK)}$	OPEN
5V	GND	GND	OPEN	$I_{(SINK)}$

FIGURE 7. I_{CC1} , Either Sink On

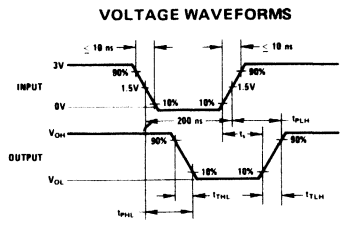
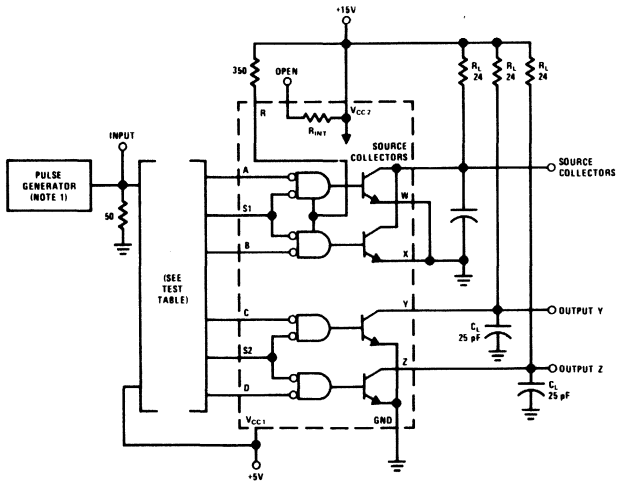


TEST TABLE

A	B	S1
GND	5V	GND
5V	GND	GND

FIGURE 8. I_{CC2} , Either Source On

dc test circuits(con't)

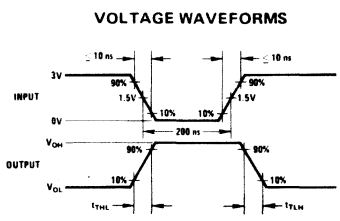
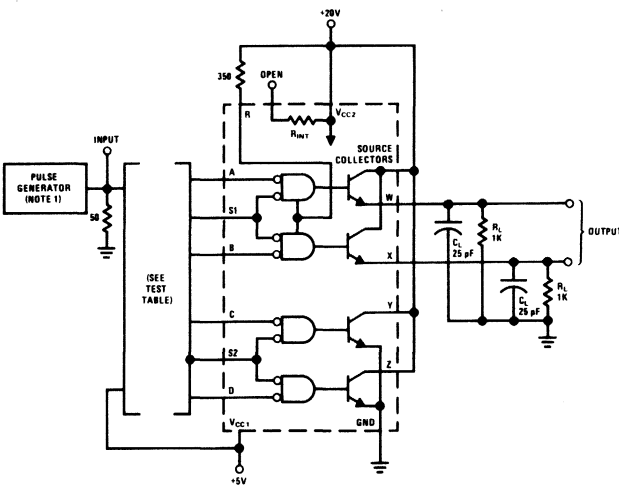


NOTE 1. THE PULSE GENERATOR HAS THE FOLLOWING CHARACTERISTICS $Z_{OUT} = 50\Omega$, DUTY CYCLE = 1%
NOTE 2. C_1 INCLUDES PROBE AND JIG CAPACITANCE.

TEST TABLE

PARAMETER	OUTPUT UNDER TEST	INPUT	CONNECT TO 5V
t_{PLH} and t_{PHL}	Source collectors	A and S1 B and S1	B, C, D and S2 A, C, D and S2
t_{PLH} , t_{PHL} , t_{TLH} , t_{THL} , and t_s	Sink output Y Sink output Z	C and S2 D and S2	A, B, D and S1 A, B, C and S1

FIGURE 9. Switching Times



NOTE 1. THE PULSE GENERATOR HAS THE FOLLOWING CHARACTERISTICS $Z_{OUT} = 50\Omega$, DUTY CYCLE = 1%
NOTE 2. C_1 INCLUDES PROBE AND JIG CAPACITANCE.

TEST TABLE

PARAMETER	OUTPUT UNDER TEST	INPUT	CONNECT TO 5V
t_{TLH} and t_{THL}	Source output W Source output X	A and S1 B and S1	B, C, D, and S2 A, C, D, and S2

FIGURE 10. Transition Times of Source Outputs

applications

External Resistor Calculation

A typical magnetic-memory word drive requirement is shown in Figure 11. A source-output transistor of one LM75325 delivers load current (I_L). The sink-output transistor of another LM75325 sinks this current.

The value of the external pull-up resistor (R_{ext}) for a particular memory application may be determined using the following equation:

$$R_{ext} = \frac{16 [V_{CC2(min)} - V_S - 2.2]}{I_L - 1.6 [V_{CC2(min)} - V_S - 2.9]} \quad (1)$$

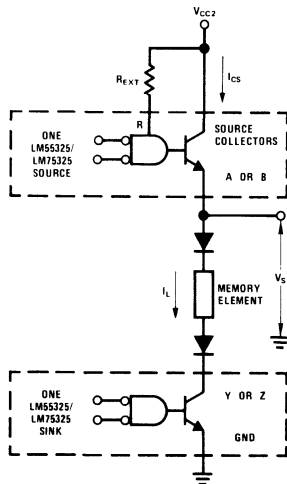
where: R_{ext} is in $k\Omega$,

$V_{CC2(min)}$ is the lowest expected value of V_{CC2} in volts, V_S is the source output voltage in volts with respect to ground, I_L is in mA.

The power dissipated in resistor R_{ext} during the load current pulse duration is calculated using Equation 2.

$$P_{R_{ext}} \approx \frac{I_L}{16} [V_{CC2(min)} - V_S - 2] \quad (2)$$

where: $P_{R_{ext}}$ is in mW.



NOTE 1: FOR CLARITY, PARTIAL LOGIC DIAGRAMS OF TWO LM55325'S ARE SHOWN.
NOTE 2: SOURCE AND SINK SHOWN ARE IN DIFFERENT PACKAGES.

FIGURE 11. Typical Application Data

After solving for R_{ext} , the magnitude of the source collector current (I_{CS}) is determined from Equation 3.

$$I_{CS} \approx 0.94 I_L \quad (3)$$

where: I_{CS} is in mA.

As an example, let $V_{CC2(min)} = 20V$ and $V_L = 3V$ while I_L of 500 mA flows. Using Equation 1:

$$R_{ext} = \frac{16 (20 - 3 - 2.2)}{500 - 1.6 (20 - 3 - 2.9)} = 0.5 k\Omega$$

and from Equation 2:

$$P_{R_{ext}} \approx \frac{500}{16} [20 - 3 - 2] \approx 470 \text{ mW}$$

The amount of the memory system current source (I_{CS}) from Equation 3 is:

$$I_{CS} \approx 0.94 (500) \approx 470 \text{ mA}$$

In this example the regulated source-output transistor base current through the external pull-up resistor (R_{ext}) and the source gate is approximately 30 mA. This current and I_{CS} comprise I_L .

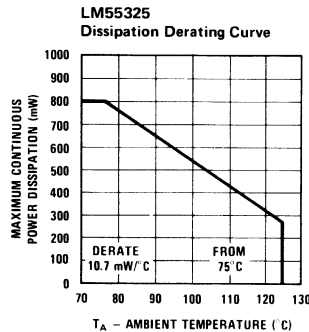


FIGURE 12. Thermal Information



Interface Circuits

LM75450, LM350

LM75450, LM350 dual peripheral driver

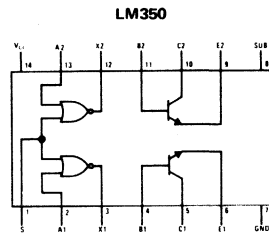
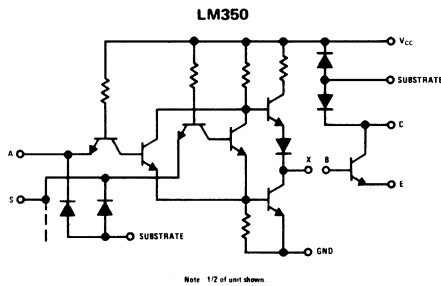
general description

The LM75450 and LM350 are general purpose dual peripheral drivers. The design employs two standard TTL gates (NOR in LM350, NAND in LM75450) and two totally uncommitted, high-voltage, high-current NPN transistors. These transistors are capable of sinking 300 mA and will withstand 30V in the OFF state. Inputs are fully DTL/TTL compatible. The LM75450 meets or exceeds the specifications for both the SN75450 and the SN75450A and is a pin-for-pin replacement.

features

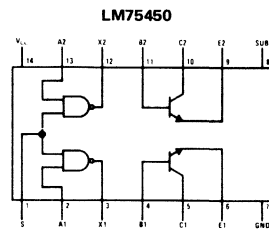
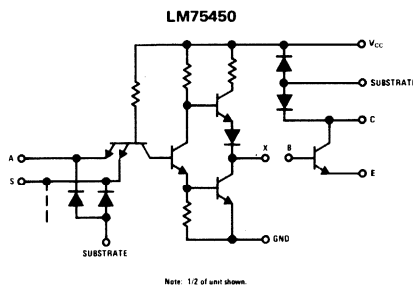
- High speed
- High sink current 300 mA
- Separate gates and transistors
- Both transistors can sink 300 mA simultaneously
- Transistors withstand 30V collector to emitter in the OFF state
- Input clamp diodes

schematic and connection diagrams



Positive Logic: $\overline{A} + \overline{S} = X$

Order Number LM350N
See Package 22



Positive Logic: $\overline{A} \cdot \overline{S} = X$

Order Number LM75450N
See Package 22



absolute maximum ratings (Note 1)

Supply Voltage V_{CC}	7V	Emitter-Base Voltage	5V
Input Voltage	5.5V	Continuous Collector Current	300 mA
V_{CC} -to-Substrate Voltage	35V	Continuous Total Power Dissipation (Note 3)	800 mW
Collector-to-Substrate Voltage	35V	Operating Free-Air Temperature Range	0°C to 70°C
Collector-Base Voltage	35V	Storage Temperature Range	-65°C to 150°C
Collector-Emitter Voltage (Note 2)	30V		

electrical characteristics

The following apply for 0°C ≤ T_A ≤ 70°C, V_{CC} = 5V ±5%, for LM75450 and LM350 unless otherwise specified.

TTL GATES

PARAMETER	COMMENTS	LOGIC INPUT	LOGIC OUTPUT	SUPPLY VOLTAGE	MIN	TYP	MAX	UNIT
Logical "1" Input Voltage	Logic Output ≤ 0.4V	V _{IN}	16 mA	4.75V	2			V
Logical "0" Input Voltage	Logic Output ≥ 2.4V	V _{IN}	-400 μA	4.75V			0.8	V
Logical "1" Output Voltage		0.8V	-400 μA	4.75V	2.4			V
Logical "0" Output Voltage		2V	16 mA	4.75V			0.4	V
Logical "1" Input Current	A Input	2.4V		5.25V			40	μA
	S Input	2.4V		5.25V			80	μA
	A Input	5.5V		5.25V			1	mA
	S Input	5.5V		5.25V			2	mA
Logical "0" Input Current	A Input	0.4V		5.25V			-1.6	mA
	S Input	0.4V		5.25V			-3.2	mA
Output Short Circuit Current	Note 4	0V	0V	5.25V	-18		-55	mA
Supply Current:								
Output Low								
LM350	Per Package	5V		5.25V		8	14	mA
LM75450	Per Package	5V		5.25V		6	11	mA
Output High								
LM350	Per Package	0V		5.25V		4	7	mA
LM75450	Per Package	0V		5.25V		2	4	mA
Input Diode Clamp Voltage	T _A = 25°C, V _{SUB} = 0V	-12 mA		5V			-1.5	V

TRANSISTORS

PARAMETER	COMMENTS	BASE	EMITTER	COLLECTOR	MIN	TYP	MAX	UNIT
BV _{CB0}	R _{BE} ≤ 500Ω	0V		100 μA	35			V
BV _{CE0}			0V	100 μA	30			V
BV _{EB0}		0V	100 μA		5			V
V _{BE}		10 mA	0V	100 mA	0.85	1		V
V _{CE(sat)}	V _{CE} = 3V, T _A = 0°C, Note 5	30 mA	0V	300 mA	1.05	1.2		V
		10 mA	0V	100 mA	0.25	0.4		V
h _{FE}	V _{CE} = 3V, T _A = 25°C, Note 5	30 mA	0V	300 mA	0.5	0.7		V
		I _B	0V	100 mA	20			
		I _B	0V	300 mA	25			
		I _B	0V	100 mA	25			
		I _B	0V	300 mA	30			

The following apply for V_{CC} = 5V, T_A = 25°C

TTL GATES (Note 6)

PARAMETER	TYP	MAX
t _{pd1}	10 ns	22 ns
t _{pd0}	5 ns	15 ns

TRANSISTORS

PARAMETER	TYP	MAX
t _d	6 ns	15 ns
t _r	12 ns	20 ns
t _s	6 ns	15 ns
t _f	8 ns	15 ns

GATES AND TRANSISTORS (Note 7)

PARAMETER	TYP
t _{pd1}	14 ns
t _{pd0}	18 ns
t _r	5 ns
t _f	10 ns

Note 1: All voltage values are with respect to ground terminal. Positive current is defined to be current into referenced pin.

Note 2: With base-emitter resistance < 500Ω.

Note 3: The maximum junction temperature is 150°C. For operating at elevated temperatures the package must be derated based on a thermal resistance of 150°C/W θ_{JA}.

Note 4: Only one output should be shorted at a time.

Note 5: These parameters are to be measured with less than 2% duty cycle.

Note 6: Delays measured with fanout of 10, 15 pF total load capacitance, measured from 1.5V input to 1.5V output.

Note 7: Delays measured with 50Ω load to 10V, 15 pF total load capacitance, measured from 1.5V input to 50% of output.



Interface Circuits

LM75451, LM75452, LM75453

LM75451, LM75452, LM75453 dual peripheral driver

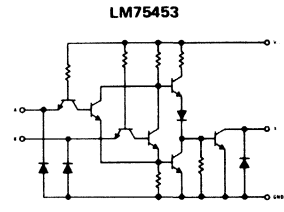
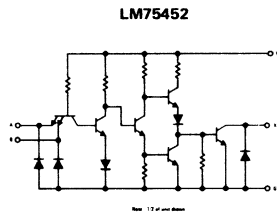
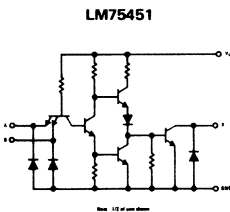
general description

These devices are general purpose dual peripheral drivers, each capable of sinking two independent 300 mA loads to ground. In the off state (or with $V_{CC} = 0V$) the outputs will withstand 30V. Inputs are fully DTL/TTL compatible. The LM75451 meets or exceeds the specifications for the SN75451 and is a pin-for-pin replacement. The LM75452 and LM75453 meet or exceed the specifications for SN75452 and SN75453, respectively, and are pin-for-pin replacements.

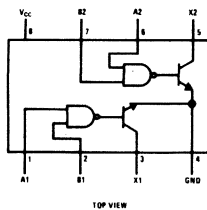
features

- High speed – 20 ns max (LM75451, LM75453)
25 ns max (LM75452)
- Both outputs can sink 300 mA simultaneously
- Withstands 30V on output with $V_{CC} = 0V$ for power strobing applications
- Input clamp diodes
- Two separate drivers per package

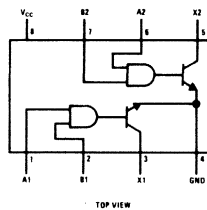
schematic diagrams



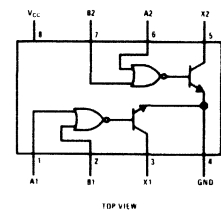
connection diagrams



Order Number LM75451N
See Package 20



Order Number LM75452N
See Package 20



Order Number LM75453N
See Package 20

truth tables

Positive logic: $AB=X$

A	B	OUTPUT X*
0	0	0
1	0	0
0	1	0
1	1	1

*"0" Output $\leq 0.7V$
*"1" Output $\leq 100 \mu A$

Positive logic: $\overline{AB}=X$

A	B	OUTPUT X*
0	0	1
1	0	1
0	1	1
1	1	0

*"0" Output $\leq 0.7V$
*"1" Output $\leq 100 \mu A$

Positive logic: $A + B = X$

A	B	OUTPUT X*
0	0	0
1	0	1
0	1	1
1	1	1

*"0" Output $\leq 0.7V$
*"1" Output $\leq 100 \mu A$



absolute maximum ratings (Note 1)

Supply Voltage V_{CC}	7V	Continuous Total Power Dissipation (Note 3)	800 mW
Input Voltage	5.5V	Operating Free Air Temperature Range	0°C to 70°C
Output Voltage (Note 2)	30V	Storage Temperature Range	-65°C to 150°C
Continuous Output Current	300 mA	Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics

The following apply for 0°C ≤ T_A ≤ 70°C, V_{CC} = 5V ±5%, unless otherwise specified. (Note 4)

PARAMETER	LOGIC INPUT	OUTPUT	SUPPLY VOLTAGE	COMMENTS	MIN	TYP	MAX	UNIT
Logic "1" Input Voltage	V_{IN}	30V (300 mA)	4.75V	Output ≤ 100 μA (≤0.7V)	2			V
Logic "0" Input Voltage	V_{IN}	300 mA (30V)	4.75V	Output ≤ 0.7V (≤100 μA)			0.8	V
Output Leakage Currents	2V (0.8V)	30V	4.75V				100	μA
		30V	0V				100	μA
Output LOW Voltages	0.8V (2V)	100 mA	4.75V			0.25	0.4	V
	0.8V (2V)	300 mA	4.75V			0.5	0.7	V
Logic "1" Input Currents	2.4V		5.25V				40	μA
	5.5V		5.25V				1	mA
Logic "0" Input Current	0.4V		5.25V			-1	-1.6	mA
Supply Currents:								
Output Low								
LM75451	0V		5.25V	Per Package		48	60	mA
LM75452	5V		5.25V	Per Package		51	65	mA
LM75453	0V		5.25V	Per Package		50	63	mA
Output High								
LM75451	5V		5.25V	Per Package		7	11	mA
LM75452	0V		5.25V	Per Package		9	14	mA
LM75453	5V		5.25V	Per Package		9	14	mA
Input Diode Clamp Voltage	-12 mA		5V	$T_A = 25^\circ\text{C}$			-1.5	V

The following apply for $V_{CC} = 5V$, $T_A = 25^\circ\text{C}$

PARAMETER	LOGIC INPUT	OUTPUT	SUPPLY VOLTAGE	COMMENTS	MIN	TYP	MAX	UNIT
Propagation Delay Times:								
Input to Output HIGH								
LM75451 & LM75453			(Note 5)			11	20	ns
LM75452			(Note 5)			13	25	ns
Input to Output LOW								
LM75451 & LM75453			(Note 5)			16	20	ns
LM75452			(Note 5)			19	25	ns
Output Risetime						4		ns
Output Falltime						10		ns

Note 1: All voltage values are with respect to ground terminal. Positive current is defined to be current into referenced pin.

Note 2: Maximum voltage to be applied to either output in the off state.

Note 3: The maximum junction temperature is 150°C. For operating at elevated temperatures, the package must be derated based on a thermal resistance of 110°C/W θ_{JA} .

Note 4: Test conditions in parentheses pertain to LM75452, other test conditions pertain to LM75451 and LM75453.

Note 5: Delays measured with 50Ω load to 10V, 15 pF total load capacitance; measured from 1.5V input to 50% of output.



Interface Circuits

LM75454

LM75454 dual peripheral driver

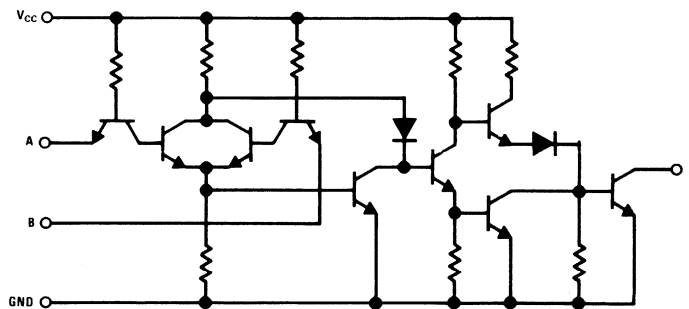
general description

The LM75454 is a dual NOR peripheral line driver with output transistors rated up to 300mA continuous current. Both output transistors can sink this current at the same time, bringing maximum chip power dissipation to 820mW. Switching speeds are compatible with standard TTL and logic levels interface directly with TTL, DTL, and LPTTL logic families. The overall input to output NOR function allows for pin replacement with TI's SN75454 positive logic NOR driver.

features

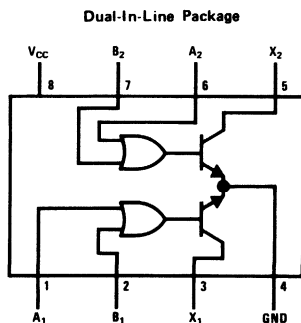
- High speed, 25 ns maximum
- Both outputs can sink 300 mA simultaneously
- Withstands 30V on outputs
- Input clamp diodes
- Maximum package power dissipation at maximum current rating ≤ 820 mW

schematic diagram



NOTE: 1/2 SCHEMATIC SHOWN

connection diagram



TOP VIEW

Order Number LM75454N

See Package 20

truth table

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0



absolute maximum ratings (Note 1)

Supply Voltage, V_{CC}	7V
Input Voltage	5.5V
Output Voltage (Note 4)	30V
Continuous Output Current	300mA
Continuous Total Power Dissipation (Note 2)	820mW
Operating Free Air Temperature Range	0°C to +70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (soldering, 10 sec)	300°C

electrical characteristics The following apply at 0°C $\leq T_A \leq$ +70°C, $V_{CC} = 5V \pm 5\%$ unless otherwise noted.

PARAMETER	LOGIC INPUT	OUTPUT	SUPPLY VOLTAGE	COMMENTS	MIN	TYP	MAX	UNITS
Logical "1" Input Voltage	V_{IH}	300mA	4.75V	Output $\leq 0.7V$	2.0			V
Logical "0" Input Voltage	V_{IL}	30V	4.75V	Output $\leq 100\mu A$			0.8	V
Logical "1" Input Current	2.4V		5.25V				40	μA
	5.5V		5.25V				1	mA
Logical "0" Input Current	0.4V		5.25V		-1.0		-1.6	mA
Output Low Voltage	2.0V	100mA	4.75V			0.25	0.4	V
	2.0V	300mA	4.75V			0.5	0.7	V
Output Leakage Current	0.8V	30V	4.75V				100	μA
	0.8V	30V	0V				100	μA
Supply Currents:								
Output Low	$A_1 = 5V$ $B_1 = 0V$		5.25V	Per Package		61	79	mA
Output High	$A_1 = B_1 = 0V$		5.25V	Per Package		13	17	mA
Input Clamp Diode Voltage	-12mA		5V	$T_A = 25^\circ C$			-1.5	V
Propagation Delay Times: The following Apply for $V_{CC} = 5V$, $T_A = 25^\circ C$								
t_{pd1} , Input "0" to Output "1"			(Note 3)			13	25	ns
t_{pd1} , Input "1" to Output "0"			(Note 3)			19	25	ns
Output Risetime								ns
Output Falltime								ns

Note 1: All voltage values are with respect to ground. Positive current is defined to be current into referenced pin.

Note 2: Maximum junction temperature is 150°C. For operating at elevated temperatures, the package must be derated based on a thermal resistance, θ_{JA} , of 110°C/W.

Note 3: Delay is measured with a 50Ω load to 10V, 15pF load capacitance, measured from 1.5V input to 50% point on output. Unused inputs should be grounded for this test.

Note 4: Maximum voltage to be applied to either output in the off state.



Interface Circuits

DM7820/DM8820

DM7820/DM8820 dual line receiver

general description

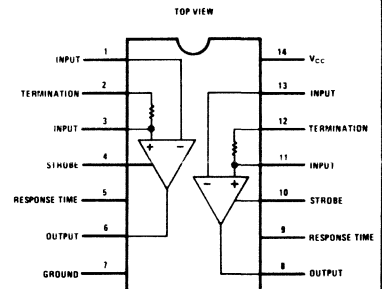
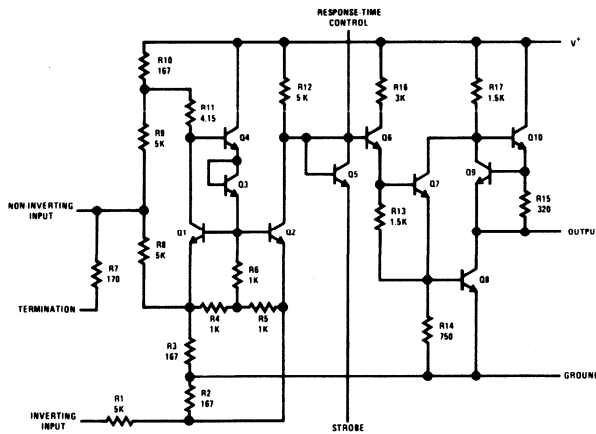
The DM7820, specified from -55°C to 125°C , and the DM8820, specified from 0°C to 75°C , are digital line receivers with two completely independent units fabricated on a single silicon chip. Intended for use with digital systems connected by twisted pair lines, they have a differential input designed to reject large common mode signals while responding to small differential signals. The output is directly compatible with RTL, DTL or TTL integrated circuits. Some important design features include:

- Operation from a single +5V logic supply
- Input voltage range of $\pm 15\text{V}$
- Each channel can be strobed independently

- High input resistance
- Fanout of two with either DTL or TTL integrated circuits
- Outputs can be wire OR'ed

The response time can be controlled with an external capacitor to eliminate noise spikes, and the output state is determined for open inputs. Termination resistors for the twisted pair line are also included in the circuit. Both the DM7820 and the DM8820 are specified, worst case, over their full operating temperature range, for ± 10 -percent supply voltage variations and over the entire input voltage range.

schematic and connection diagrams



Note: Pin 7 connected to bottom of package

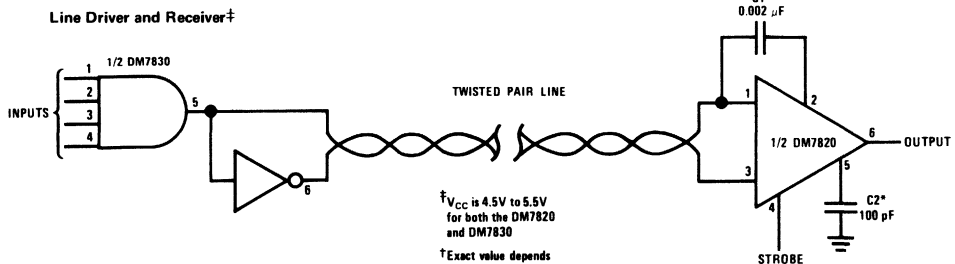
Order Number DM7820J or DM8820J
See Package 16

Order Number DM7820W
See Package 27

Order Number DM8820N
See Package 22

Order Number DM8820W
See Package 26

typical application



$\ddagger V_{CC}$ is 4.5V to 5.5V for both the DM7820 and DM7830

\dagger Exact value depends on line length

*Optional to control response time



absolute maximum ratings

Supply Voltage	8.0V
Input Voltage	±20V
Differential Input Voltage	±20V
Strobe Voltage	8.0V
Output Sink Current	25 mA
Power Dissipation (Note 1)	600 mW
Operating Temperature Range (DM7820)	-55°C to 125°C
Storage Temperature Range (DM8820)	0°C to 70°C
Lead temperature (soldering, 10 sec)	300°C

electrical characteristics (Notes 2 & 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Threshold Voltage	$V_{IN} = 0$	-0.5	0	0.5	V
	$-15V \leq V_{IN} \leq 15V$	-1.0	0	1.0	V
High Output Level	$I_{OUT} \leq 0.2 \text{ mA}$	2.5		5.5	V
Low Output Level	$I_{sink} \leq 3.5 \text{ mA}$	0		0.4	V
Inverting Input Resistance		3.6	5.0		k Ω
Non-inverting Input Resistance		1.8	2.5		k Ω
Line Termination Resistance	$T_A = 25^\circ\text{C}$	120	170	250	Ω
Response Time	$C_{delay} = 0$		40		ns
	$C_{delay} = 100 \text{ pF}$		150		ns
Strobe Current	$V_{strobe} = 0.4V$		1.0	1.4	mA
	$V_{strobe} = 5.5V$			-5.0	μA
Power Supply Current	$V_{IN} = 15V$		3.2	6.0	mA
	$V_{IN} = 0$		5.8	10.2	mA
	$V_{IN} = -15V$		8.3	15.0	mA
Non-inverting Input Current	$V_{IN} = 15V$		5.0	7.0	mA
	$V_{IN} = 0$	-1.6	-1.0		mA
	$V_{IN} = -15V$	-9.8	-7.0		mA
Inverting Input Current	$V_{IN} = 15V$		3.0	4.2	mA
	$V_{IN} = 0$		0	0.5	mA
	$V_{IN} = -15V$	-4.2	-3.0		mA

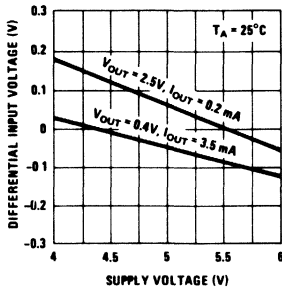
Note 1: For operating at elevated temperatures, the device must be derated based on a thermal resistance of 100°C/W and a maximum junction temperature of 160°C for the DM7820 or 105°C for the DM8820.

Note 2: These specifications apply for $4.5V \leq V_{CC} \leq 5.5V$, $-15V \leq V_{CM} \leq 15V$ and $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ for the DM7820 or $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ for the DM8820 unless otherwise specified; typical values given are for $V_{CC} = 5.0V$, $T_A = 25^\circ\text{C}$ and $V_{CM} = 0$ unless stated differently.

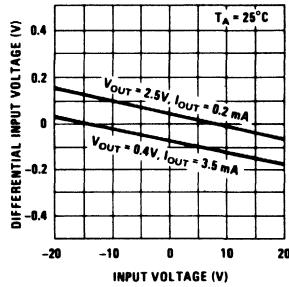
Note 3: The specifications and curves given are for one side only. Therefore, the total package dissipation and supply currents will be double the values given when both receivers are operated under identical conditions.

typical performance characteristics (Note 3)

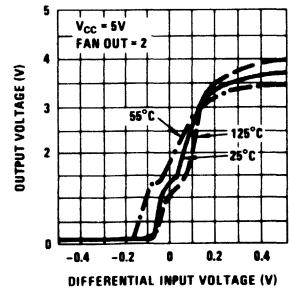
Supply Voltage Sensitivity



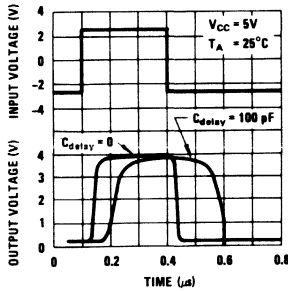
Common Mode Rejection



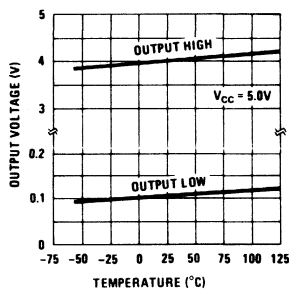
Transfer Function



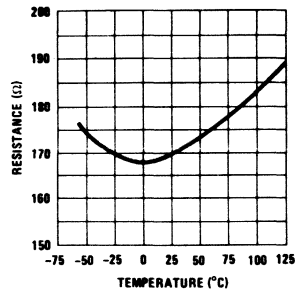
Response Time



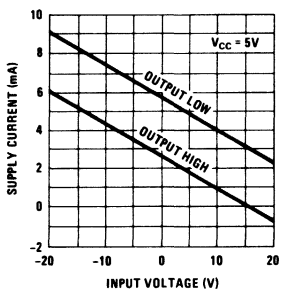
Output Voltage Levels



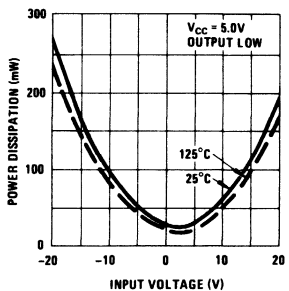
Termination Resistance



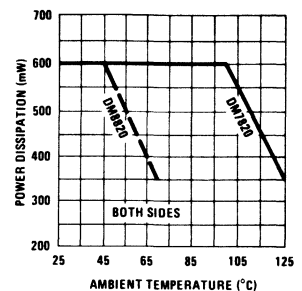
Positive Supply Current



Internal Power Dissipation



Maximum Power Dissipation





Interface Circuits

DM7820A/DM8820A dual line receiver

general description

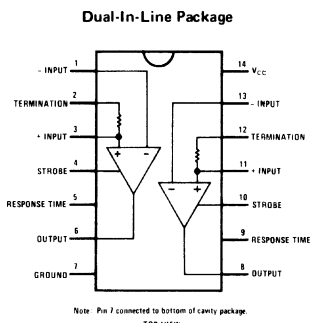
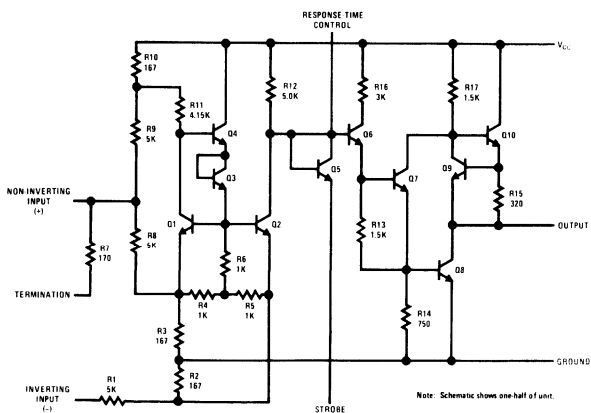
The DM7820A and the DM8820A are improved performance digital line receivers with two completely independent units fabricated on a single silicon chip. Intended for use with digital systems connected by twisted pair lines, they have a differential input designed to reject large common mode signals while responding to small differential signals. The output is directly compatible with RTL, DTL or TTL integrated circuits. Some important design features include:

- Operation from a single +5V logic supply
- Input voltage range of $\pm 15V$
- Strobe low forces output to "1" state
- High input resistance

- Fanout of ten with either DTL or TTL integrated circuits
- Outputs can be wire OR'ed
- Series 54/74 compatible

The response time can be controlled with an external capacitor to reject input noise spikes. The output state is a logic "1" for both inputs open. Termination resistors for the twisted pair line are also included in the circuit. Both the DM7820A and the DM8820A are specified, worst case, over their full operating temperature range ($-55^{\circ}C$ to $125^{\circ}C$ and $0^{\circ}C$ to $70^{\circ}C$ respectively), over the entire input voltage range, for $\pm 10\%$ supply voltage variations.

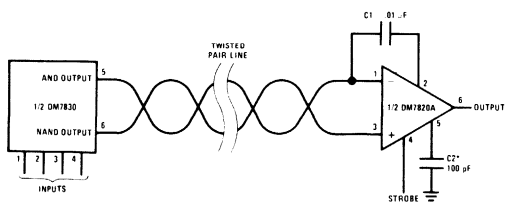
schematic and connection diagrams



Order Number DM7820AD
See Package 1
Order Number DM8820AN
See Package 22

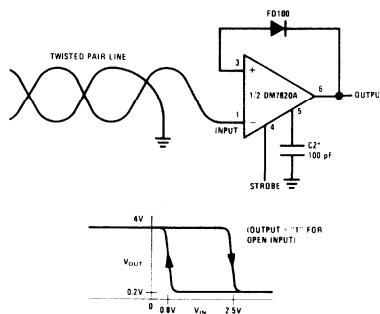
typical applications

Differential Line Driver and Receiver



*Optional to control response time

Single Ended (EIA-RS232C) Receiver with Hysteresis



absolute maximum ratings

Supply Voltage	8.0V
Common-Mode Voltage	±20V
Differential Input Voltage	±20V
Strobe Voltage	8.0V
Output Sink Current	50 mA
Power Dissipation (Note 1)	600 mW
Operating Temperature Range	
DM7820A	-55°C to 125°C
DM8820A	0°C to 70°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Notes 2, 3 & 4)

PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
	V _{CM}	OUTPUT	OTHER				
Differential Threshold Voltage	-3V ≤ V _{CM} ≤ +3V	-400 μA	V _{OUT} ≥ 2.5V		+0.06	+0.5	V
	-15V ≤ V _{CM} ≤ +15V	-400 μA	V _{OUT} ≥ 2.5V		+0.06	+1.0	V
	-3V ≤ V _{CM} ≤ +3V	+16 mA	V _{OUT} ≤ 0.4V		-0.08	-0.5	V
	-15V ≤ V _{CM} ≤ +15V	+16 mA	V _{OUT} ≤ 0.4V		-0.08	-1.0	V
Inverting Input Resistance	-15V ≤ V _{CM} ≤ +15V			3.6	5		kΩ
Non-Inverting Input Resistance	-15V ≤ V _{CM} ≤ +15V			1.8	2.5		kΩ
Line Termination Resistance			T _A = 25°C	120	170	250	Ω
Inverting Input Current	+15V				+3.0	+4.2	mA
	0V				0	-0.5	mA
	-15V				-3.0	-4.2	mA
Non-Inverting Input Current	+15V				+5.0	+7.0	mA
	0V				-1.0	-1.6	mA
	-15V				-7.0	-9.8	mA
Power Supply Current	+15V	Logic "0"	V _{DIFF} = -1V		+3.9	+6.0	mA
	0V	Logic "0"	V _{DIFF} = -0.5V		+6.5	+10.2	mA
	-15V	Logic "0"	V _{DIFF} = -1V		+9.2	+14.0	mA
Logical "1" Output Voltage		-400 μA	V _{DIFF} = +1V	2.5	4.0	5.5	V
Logical "0" Output Voltage		+16 mA	V _{DIFF} = -1V	0	0.22	0.4	V
Logical "1" Strobe Input Voltage		+16 mA	V _{OUT} ≤ 0.4V, V _{DIFF} = -3V	2.1			V
Logical "0" Strobe Input Voltage		-400 μA	V _{OUT} ≥ 2.5V, V _{DIFF} = -3V			0.9	V
Logical "1" Strobe Input Current			V _{STROBE} = 5.5V, V _{DIFF} = +3V		0.01	5.0	μA
Logical "0" Strobe Input Current			V _{STROBE} = 0.4V, V _{DIFF} = -3V		-1.0	-1.4	mA
Output Short Circuit Current		0V	V _{CC} = 5.5V, V _{STROBE} = 0V	-2.8	-4.5	-6.7	mA
Propagation Delays: (see waveforms)							
Differential Input to "0" Output			V _{CC} = 5V, T _A = 25°C		30	45	ns
Differential Input to "1" Output			V _{CC} = 5V, T _A = 25°C		24	40	ns
Strobe Input to "0" Output			V _{CC} = 5V, T _A = 25°C		16	25	ns
Strobe Input to "1" Output			V _{CC} = 5V, T _A = 25°C		18	30	ns

Note 1: For operating at elevated temperatures, the device must be derated based on a thermal resistance of 100°C/W and a maximum junction temperature of 160°C for the DM7820A, or 150°C/W and 115°C maximum junction temperature for the DM8820A.

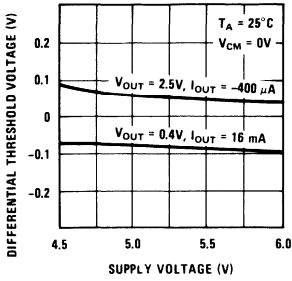
Note 2: These specifications apply for 4.5V ≤ V_{CC} ≤ 5.5V, -15V ≤ V_{CM} ≤ 15V and -55°C ≤ T_A ≤ 125°C for the DM7820A or 0°C ≤ T_A ≤ 70°C for the DM8820A unless otherwise specified. Typical values given are for V_{CC} = 5.0V, T_A = 25°C and V_{CM} = 0V unless stated differently.

Note 3: The specifications and curves given are for one side only. Therefore, the total package dissipation and supply currents will be double the values given when both receivers are operated under identical conditions.

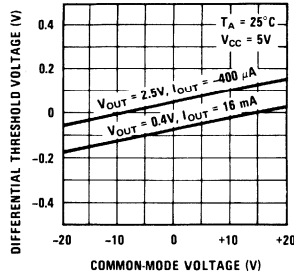
Note 4: Min and max limits apply to absolute values.

typical performance characteristics (Note 3)

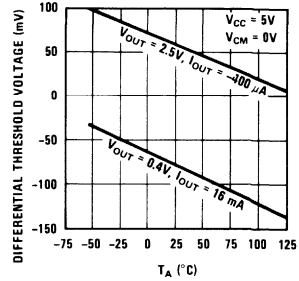
Supply Voltage Sensitivity



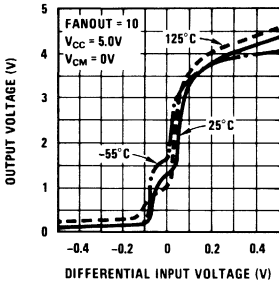
Common-Mode Voltage Sensitivity



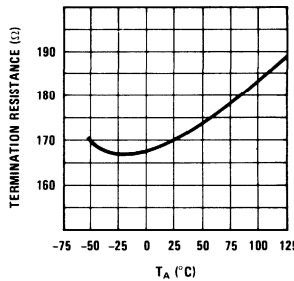
Temperature Sensitivity



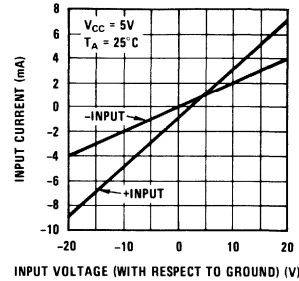
Transfer Function



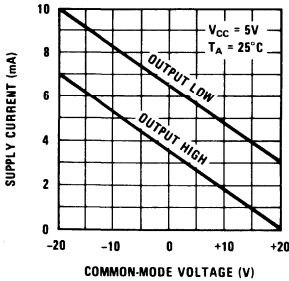
Termination Resistance



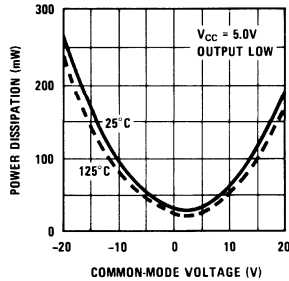
Input Characteristics



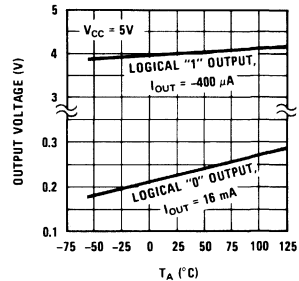
Power Supply Current



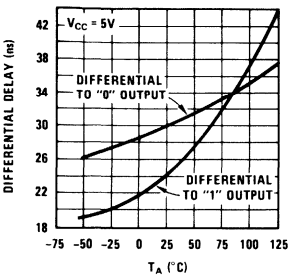
Internal Power Dissipation



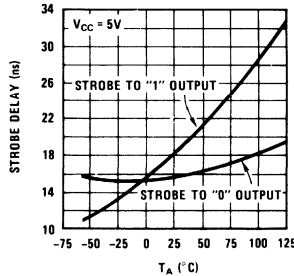
Output Voltage Levels



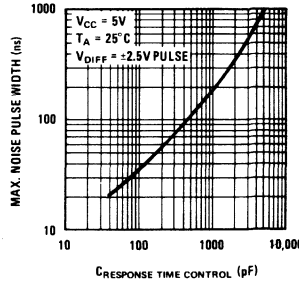
Differential Input Delays



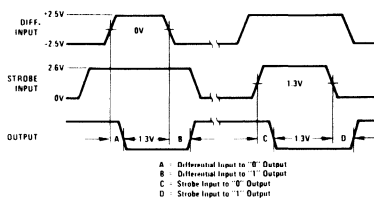
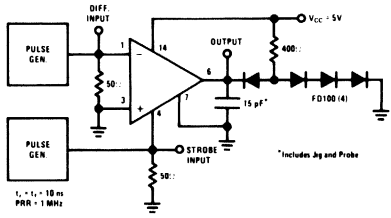
Strobe Delays



Noise Rejection



ac test circuit and waveforms





Interface Circuits

DM7822/DM8822 dual line receiver

general description

The DM7822/DM8822 is a dual inverting line receiver which meets the requirements of EIA specification RS232 Revision B. The device contains both receivers on a single monolithic silicon chip. The receivers share common power supply and ground connections, otherwise their operation is fully independent.

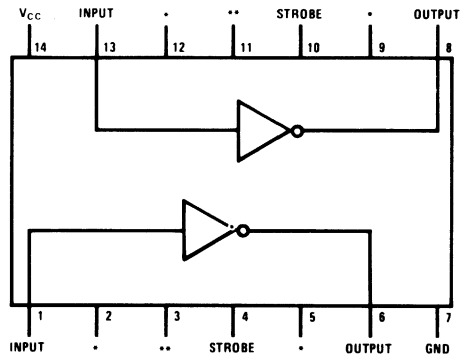
In addition to meeting the requirements of RS232, the DM7822/DM8822 also has independent strobe inputs which allow the receiver to be placed in the

high state independent of the information being received at the input.

The output of the DM7822/DM8822 is completely compatible with five volt DTL and TTL logic families.

The DM7822 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The DM8822 is specified for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

connection diagram



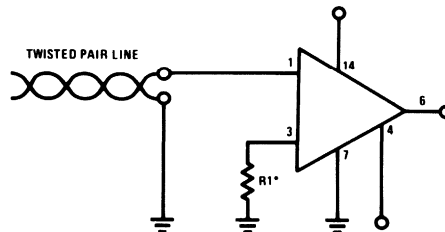
*Make no connection to these pins.

**For operation requiring "Mark Hold" with the input open connect a 470Ω resistors from each of these pins to ground.

Order Number DM7822J or DM8822J
See Package 16

Order Number DM8822N
See Package 22

typical connection



*For Mark Hold $R1 = 470\Omega$, otherwise connect pin 3 to ground.

absolute maximum ratings

Supply Voltage	8.0V
Input Voltage	±30V
Strobe Voltage	8.0V
Output Sink Current	25 mA
Power Dissipation (Note 1)	600 mW
Operating Temperature Range	DM7822 -55°C to +125°C
	DM8822 0°C to 70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 2)

PARAMETER	PARAGRAPH IN RS-232	CONDITIONS	MIN	TYP	MAX	UNITS
Negative Input Threshold Voltage	4.8 (8)	$V_{OUT} \geq 2.5V$	-2.0			V
Positive Input Threshold Voltage (Note 3)		$V_{OUT} \leq 0.4V$			2.0	V
Input Resistance	4.5 and 4.8 (5)		3.0	5.0	7.0	k Ω
Input Current		$V_{IN} = 25V$ $V_{IN} = 0V$ $V_{IN} = -25V$	3.57 0 -8.33	5 0 -5	8.33 -3.57	mA mA mA
Open Circuit input Voltage	4.5 and 4.8 (4)	$V_{IN} = 0V$		.03	0.5	V
Logical "1" Output Voltage		$I_{OUT} \leq -0.2 mA$	2.5			V
Logical "0" Output Voltage		$I_{OUT} = 3.5 mA$			0.4	V
Strobe Current		$V_{STROBE} = 0.4V$ $V_{STROBE} = 5.5V$		1.0 -5.0 μA	1.4 -1.0 mA	mA
Power Supply Current (Both Receivers)		$-25V \leq V_{IN} \leq 25V$			24.0	mA
Response Time, t_1 or t_2		$T_A = 25^\circ C$ $V_{CC} = 5.0V$ Input Ramp Rate $\leq 10 ns$		65	125	ns

Note 1. For operating at elevated temperatures, the device must be derated in accordance with the "Maximum Power Dissipation" curve.

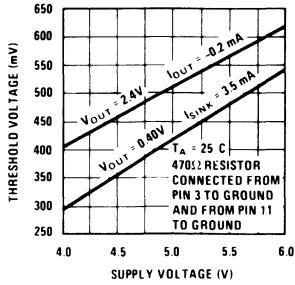
Note 2. Min/Max limits apply across the guaranteed temperature range of -55°C to +125°C for the DM7822 and 0°C to 70°C for the DM8822 unless otherwise specified. Likewise the limits apply across the guaranteed V_{CC} range of 4.5V to 5.5V for the DM7822 and 4.75V to 5.25V for the DM8822 unless otherwise specified. Typical values are given for $V_{CC} = 5.0V$ and $T_A = 25^\circ C$.

Note 3. Since the EIA RS-232 specification requires the threshold to be between -3V and +3V, the immunity limits shown here guarantee 1 volt additional noise immunity.

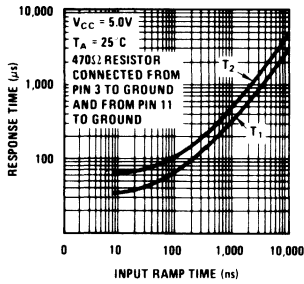


typical performance characteristics

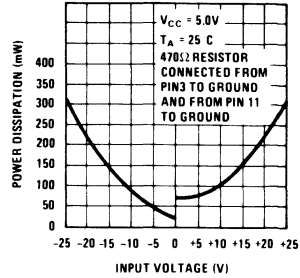
Threshold Voltage vs Supply Voltage



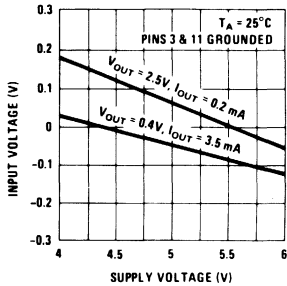
Response Time vs Input Ramp Time



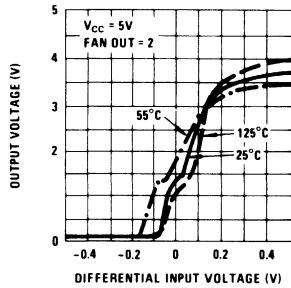
Internal Power Dissipation



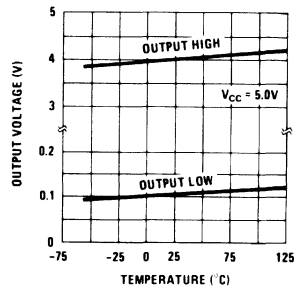
Threshold Voltage vs Supply Voltage



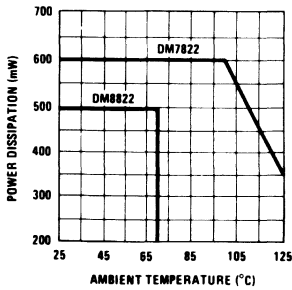
Transfer Function



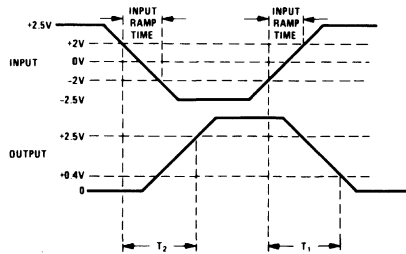
Output Voltage Levels



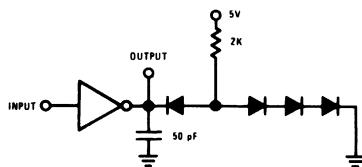
Maximum Power Dissipation



switching time waveforms



ac test circuit





Interface Circuits

DM7830/DM8830 dual differential line driver

general description

The DM7830/DM8830 is a dual differential line driver that also performs the dual four-input NAND or dual four-input AND function.

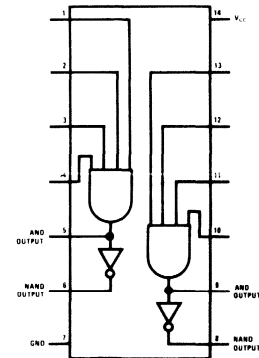
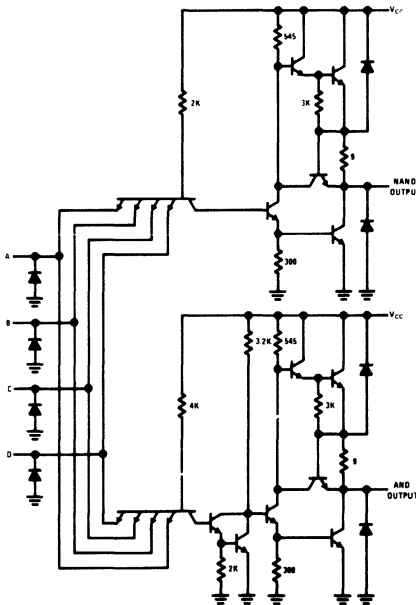
TTL (Transistor-Transistor-Logic) multiple emitter inputs allow this line driver to interface with standard TTL or DTL systems. The differential outputs are balanced and are designed to drive long lengths of coaxial cable, strip line, or twisted pair transmission lines with characteristic impedances of 50Ω to 500Ω . The differential feature of the output eliminates troublesome ground-loop errors normally associated with single-wire transmissions.

Key Features:

- Single 5 volt power supply
- Diode protected outputs for termination of positive and negative voltage transients
- Diode protected inputs to prevent line ringing
- High Speed
- Short Circuit Protection

The DM7830 is specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The DM8830 is specified for operation over the 0°C to $+70^{\circ}\text{C}$

schematic* and connection diagram



Order Number DM7830J or DM8830J
See Package 16

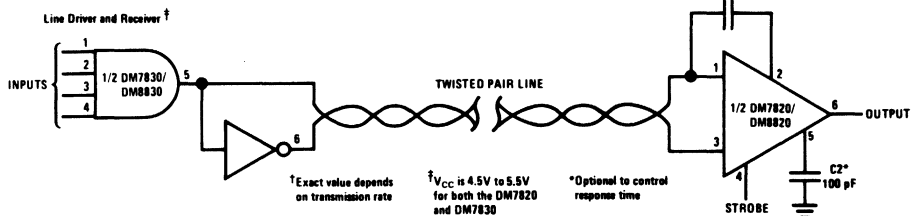
Order Number DM7830W or DM8830W
See Package 27

Order Number DM8830N
See Package 22

typical application

Digital Data Transmission

*2 per package



absolute maximum ratings

V_{CC}		7.0V
Input Voltage		5.5V
Operating Temperature	DM7830	-55°C to +125°C
	DM8830	0°C to 70°C
Storage Temperature		-65°C to +150°C
Lead Temperature (Soldering, 10 sec)		300°C
Output Short Circuit Duration (125°C)		1 second

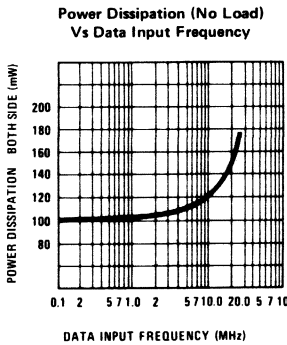
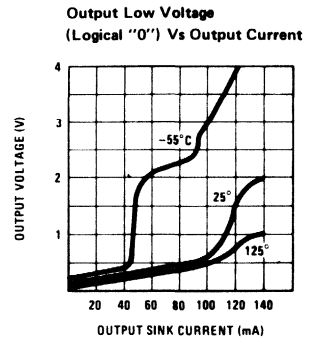
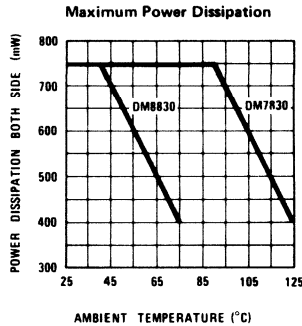
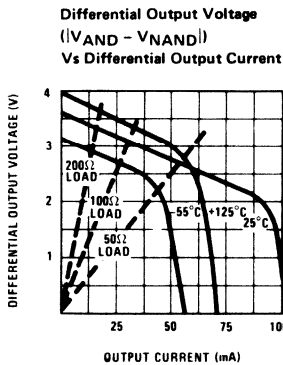
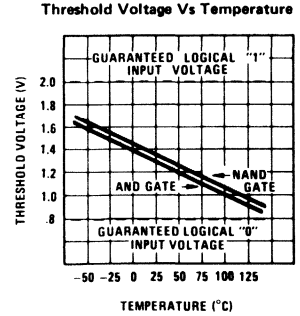
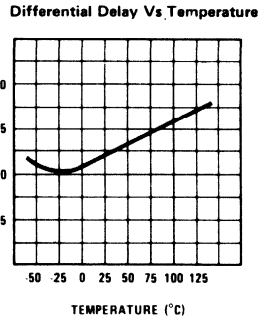
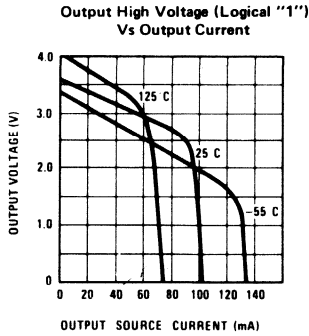
electrical characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Logical "1" Input Voltage		2.0			V
Logical "0" Input Voltage				0.8	V
Logical "1" Output Voltage	$V_{IN} = 0.8V$ $I_{OUT} = -0.8$ mA	2.4			V
Logical "1" Output Voltage	$V_{IN} = 0.8V$ $I_{OUT} = -40$ mA	1.8	2.9		V
Logical "0" Output Voltage	$V_{IN} = 2.0V$ $I_{OUT} = +32$ mA		0.2	0.4	V
Logical "0" Output Voltage	$V_{IN} = 2.0V$ $I_{OUT} = +40$ mA		0.22	0.5	V
Logical "1" Input Current	$V_{IN} = +2.4V$			120	μ A
Logical "1" Input Current	$V_{IN} = 5.5V$			2	mA
Logical "0" Input Current	$V_{IN} = 0.4V$			4.8	mA
Output Short Circuit Current	$V_{CC} = 5.0V$	Note 2 -40	-100	Note 2 -120	mA
Supply Current	$V_{CC} = 5.0V$ $V_{IN} = 5.0V$ (Each Driver)		11	18	mA
Propagation Delay AND Gate t_{pd1}	$T_A = 25^\circ C$ $V_{CC} = 5.0V$ $C_L = 15$ pF See Figure 1 and 1A		8	12	ns
t_{pd0}			11	18	ns
Propagation Delay NAND Gate t_{pd1}			8	12	ns
t_{pd0}			5	8	ns
Differential Delay t_1	t_1 } Load, 100 Ω and 5000 pF t_2 } See Figure 2		12	16	ns
Differential Delay t_2			12	16	ns

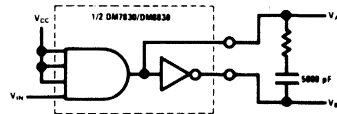
Note 1: Specifications apply for DM7830 $-55^\circ C \leq T_A \leq +125^\circ C$, $V_{CC} = +5V \pm 10\%$, DM8830 $0^\circ C \leq T_A \leq 70^\circ C$, $V_{CC} = +5V \pm 5\%$ unless otherwise stated. Typical values given are for $T_A = 25^\circ C$, $V_{CC} = 5.0V$.

Note 2: Applies for $T_A = +125^\circ C$ only.

typical performance characteristics



ac test circuit



switching time waveforms

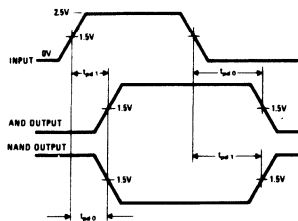


FIGURE 1

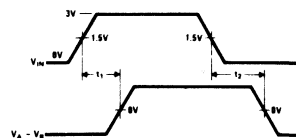


FIGURE 2



Interface Circuits

DM7831/DM8831, DM7832/DM8832 TRI-STATE™ line driver

general description

Through simple logic control, the DM7831/DM8831, DM7832/DM8832 can be used as either a quad single-ended line driver or a dual differential line driver. They are specifically designed for party line (bus-organized) systems. The DM7832/DM8832 does not have the V_{CC} clamp diodes found on the DM7831/DM8831.

The DM7831 & DM7832 are specified for operation over the -55°C to $+125^{\circ}\text{C}$ military temperature range. The DM8831 & DM8832 are specified for operation over the 0°C to $+70^{\circ}\text{C}$ temperature range.

Key features include:

- Series 54/74 compatible
- 17 ns propagation delay
- Very low output impedance—high drive capability
- 40 mA sink and source currents
- Gating control to allow either single-ended or differential operation

- High impedance output state which allows many outputs to be connected to a common bus line.

mode of operation

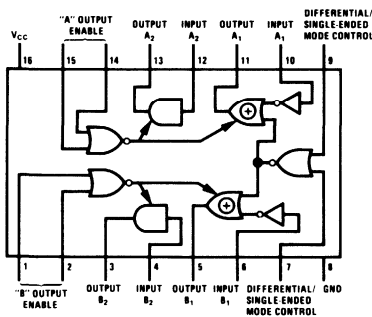
To operate as a quad single-ended line driver apply logical "0"s to the Output Disable pins (to keep the outputs in the normal low impedance mode) and apply logical "0"s to both Differential/Single-ended Mode Control inputs. All four channels will then operate independently and no signal inversion will occur between inputs and outputs.

To operate as a dual differential line driver apply logical "0"s to the Output Disable pins and apply at least one logical "1" to the Differential/Single-ended Mode Control inputs. The inputs to the A channels should be connected together and the inputs to the B channels should be connected to. In this mode the signals applied to the resulting inputs will pass non-inverted on the A_2 and B_2 outputs and inverted on the A_1 and B_1 outputs.

When operating in a bus-organized system with outputs tied directly to outputs of other

(continued on page 3)

connection and logic diagram



Order Number DM7831J or DM8831J
or DM7832J or DM8832J
See Package 17

Order Number DM7831W or DM8831W
or DM7832W or DM8832W
See Package 28

Order Number DM8831N or DM8832N
See Package 23

truth-table (Shown for A Channels Only)

"A" OUTPUT DISABLE	DIFFERENTIAL/SINGLE-ENDED MODE CONTROL	INPUT A_1	OUTPUT A_1	INPUT A_2	OUTPUT A_2
0 0	0 0	Logical "1" or Logical "0"	Same as Input A_1	Logical "1" or Logical "0"	Same as Input A_2
0 0	X 1	Logical "1" or Logical "0"	Opposite of Input A_1	Logical "1" or Logical "0"	Same as Input A_2
1 X	X X	X	High impedance state	X	High impedance state

X = Don't Care

absolute maximum ratings

Supply Voltage	7V
Input Voltage	5.5V
Output Voltage	5.5V
Storage Temperature Range	-65°C to +150°C
Operating Temperature Range	DM7831, DM7832 -55°C to +125°C
	DM8831, DM8832 0°C to +70°C
Lead Temperature (Soldering, 10 sec.)	300°C
Time that 2 bus-connected devices may be in opposite low impedance states simultaneously	10 ms

electrical characteristics (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Logical "1" Input Voltage	DM7831,DM7832 $V_{CC} = 4.5V$ DM8831,DM8832 $V_{CC} = 4.75V$	2.0			V
Logical "0" Input Voltage	DM7831,DM7832 $V_{CC} = 4.5V$ DM8831,DM8832 $V_{CC} = 4.75V$			0.8	V
Logical "1" Output Voltage	DM7831,DM7832 $V_{CC} = 4.5V$ $I_o = -40\text{ mA}$ $I_o = -2\text{ mA}$	1.8	2.3		V
	DM8831,DM8832 $V_{CC} = 4.75V$ $I_o = -40\text{ mA}$ $I_o = -5.2\text{ mA}$	1.8	2.5		V
Logical "0" Output Voltage	DM7831,DM7832 $I_o = 40\text{ mA}$ $I_o = 32\text{ mA}$		0.29	0.50	V
	DM8831,DM8832 $I_o = 40\text{ mA}$ $I_o = 32\text{ mA}$		0.29	0.50	V
Logical "1" Input Current	DM7831,DM7832 $V_{CC} = 5.5V$ $V_{IN} = 5.5V$			1	mA
	DM8831,DM8832 $V_{CC} = 5.25V$ $V_{IN} = 2.4V$			40	μA
Logical "0" Input Current	DM7831,DM7832 $V_{CC} = 5.5V$ DM8831,DM8832 $V_{CC} = 5.25V$		-1.0	-1.6	mA
	$V_{IN} = 0.4V$				
Output Disable Current	DM7831,DM7832 $V_{CC} = 5.5V$ DM8831,DM8832 $V_{CC} = 5.25V$	-40		40	μA
Output Short Circuit Current	DM7831,DM7832 $V_{CC} = 5.5V$	-40	-100	-120	mA
	DM8831,DM8832 $V_{CC} = 5.25V$	(Note 2)		(Note 2)	
Supply Current	DM7831,DM7832 $V_{CC} = 5.5V$ DM8831,DM8832 $V_{CC} = 5.25V$		65	90	mA
Input Diode Clamp Voltage	$V_{CC} = 5.0V, T_A = 25^\circ C$ $I_{IN} = -12\text{ mA}$			-1.5	V
Output Diode Clamp Voltage	DM7831,DM7832 $I_{OUT} = -12\text{ mA}, V_{CC} = 5.0V, T_A = 25^\circ C$			-1.5	V
	DM8831,DM8832 $I_{OUT} = +12\text{ mA}, V_{CC} = 5.0V, T_A = 25^\circ C$			$V_{CC} + 1.5$	V
Propagation Delay to a Logical "0" from Inputs A ₁ , A ₂ , B ₁ , B ₂ Differential Single-ended Mode Control to Outputs, t_{pd0}	$V_{CC} = 5.0V, T_A = 25^\circ C$		13	25	ns
Propagation Delay to a Logical "1" from Inputs A ₁ , A ₂ , B ₁ , B ₂ Differential Single-ended Mode Control to Outputs, t_{pd1}	$V_{CC} = 5.0V, T_A = 25^\circ C$		13	25	ns
Delay from Disable Inputs to High Impedance State (from Logical "1" Level), t_{1H}	$V_{CC} = 5.0V, T_A = 25^\circ C$		6	12	ns
Delay from Disable Inputs to High Impedance State (from Logical "0" Level), t_{0H}	$V_{CC} = 5.0V, T_A = 25^\circ C$		14	22	ns
Propagation Delay from Disable Inputs to Logical "1" Level (from High Impedance State), t_{H1}	$V_{CC} = 5.0V, T_A = 25^\circ C$		14	22	ns
Propagation Delay from Disable Inputs to Logical "0" Level (from High Impedance State), t_{H0}	$V_{CC} = 5.0V, T_A = 25^\circ C$		18	27	ns

Note 1: Unless otherwise specified min/max limits apply across the -55°C to +125°C temperature range for the DM7831, DM7832 and across the 0°C to 70°C temperature range for the DM8831, DM8832. All typicals are given for $V_{CC} = 5.0V$ and $T_A = 25^\circ C$.

Note 2: Applies for $T_A = 125^\circ C$ only. Only one output should be shorted at a time.



mode of operation (cont.)

DM7831/DM8831's, DM7832/DM8832's (Figure 1), all devices except one must be placed in the "high impedance" state. This is accomplished by ensuring that a logical "1" is applied to at least one of the Output Disable pins of each device which is to be in the "high impedance" state. A NOR gate was purposely chosen for this function since it is possible with only two DM5442/DM7442, BCD-to-decimal decoders, to decode as many as 100 DM7831/DM8831's, DM7832/DM8832's (Figure 2).

The unique device whose Disable inputs receive two logical "0" levels assumes the normal low

impedance output state, providing good capacitive drive capability and waveform integrity especially during the transition from the logical "0" to logical "1" state. The other outputs—in the high impedance state—take only a small amount of leakage current from the low impedance outputs. Since the logical "1" output current from the selected device is 100 times that of a conventional Series 54/74 device (40 mA vs. 400 μ A), the output is easily able to supply that leakage current for several hundred other DM7831/DM8831's, DM7832/DM8832's and still have available drive for the bus line (Figure 3).

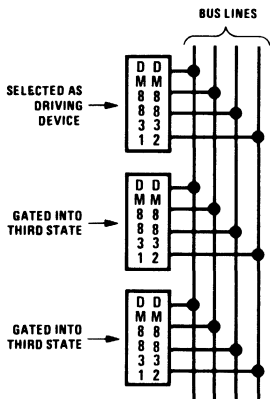


Figure 1

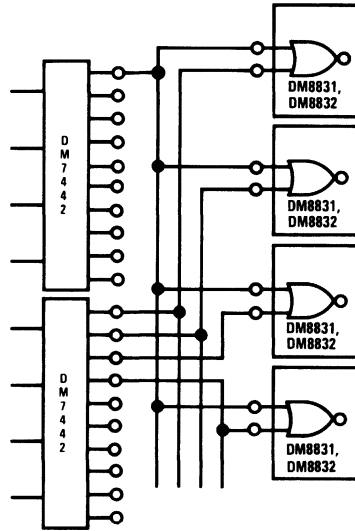


Figure 2

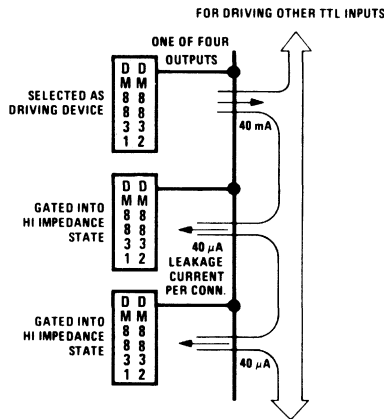
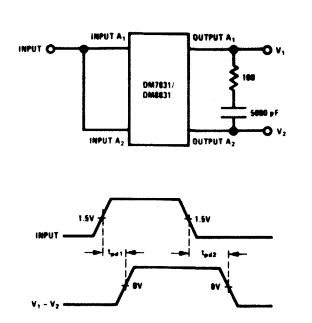
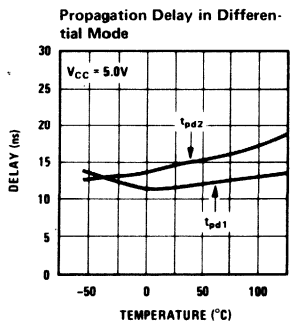
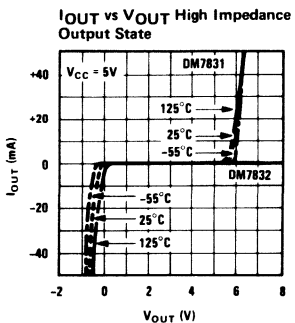
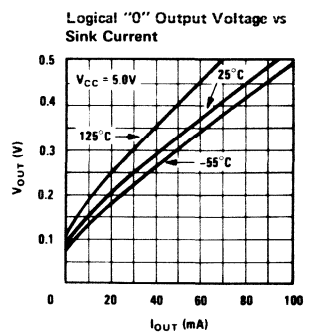
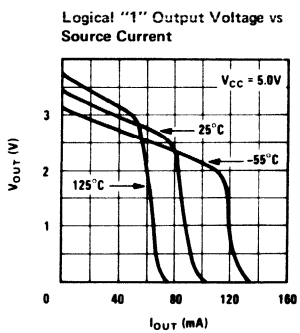
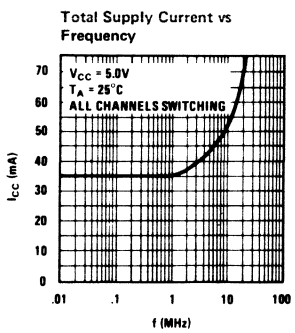
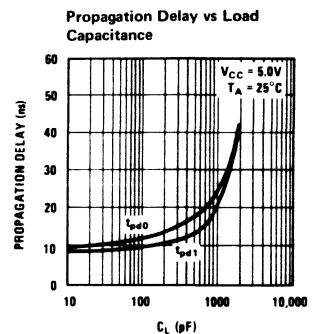
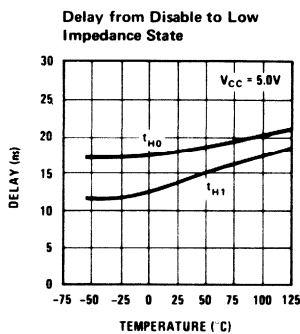
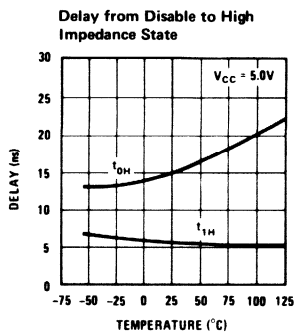
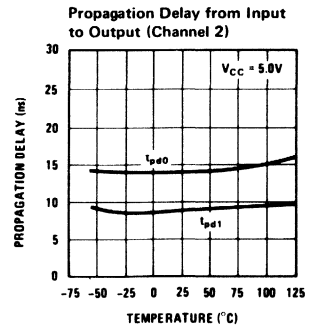
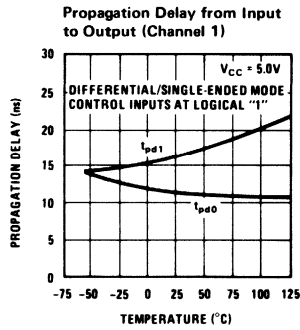
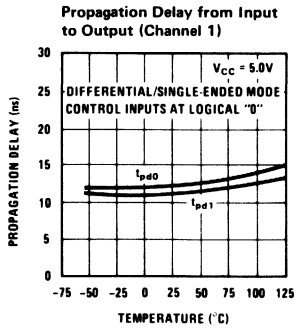
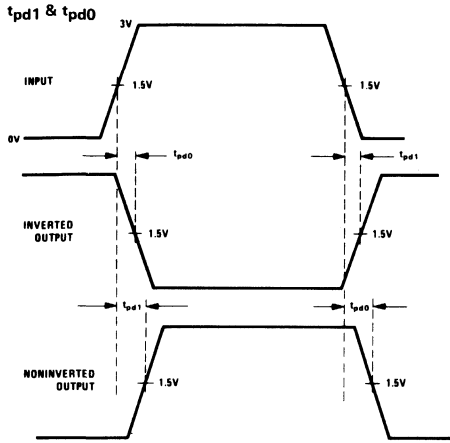


Figure 3

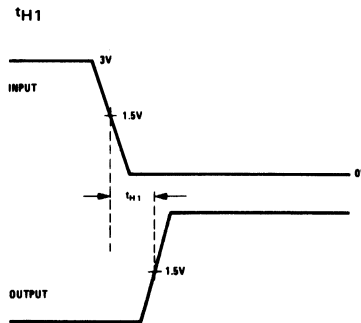
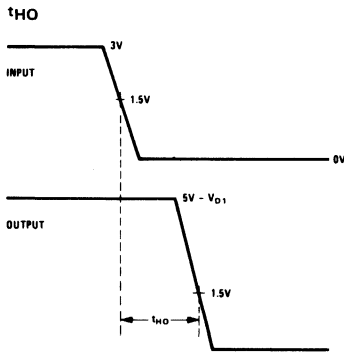
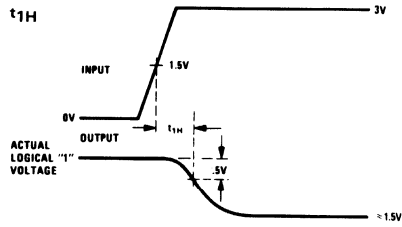
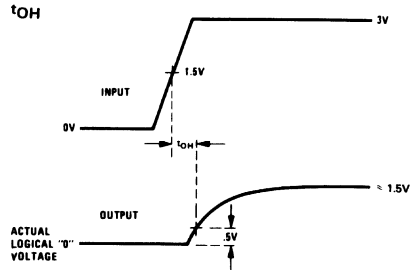
typical performance characteristics



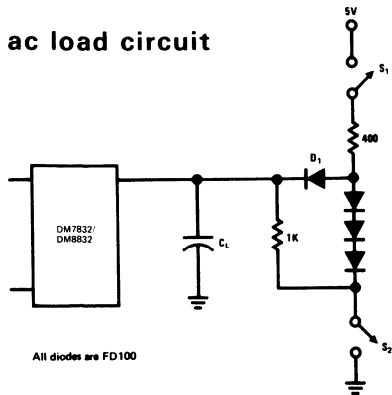
switching time waveforms



Input characteristic
 Amplitude = 3V
 Frequency = 1 MHz, 50% duty cycle
 $t_r = t_f \leq 10$ nsec (10% to 90%)



ac load circuit



	Switch S ₁	Switch S ₂	C _L
t _{pd1}	closed	closed	50 pF
t _{pe0}	closed	closed	50 pF
t _{OH}	closed	closed	5 pF
t _{1H}	closed	closed	5 pF
t _{HO}	closed	open	50 pF
t _{H1}	open	closed	50 pF

*jig capacitance



Interface Circuits

DM7836/DM8836 quad NOR unified bus receiver

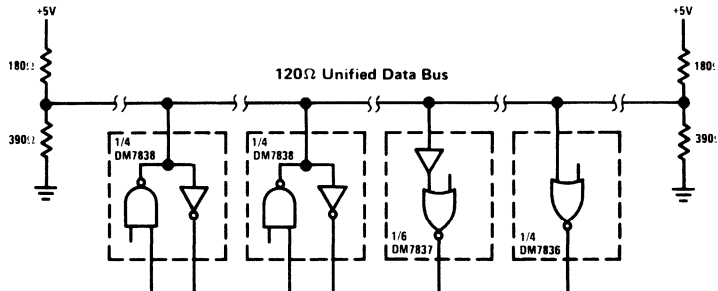
general description

The DM7836/DM8836 are quad 2-input receivers designed for use in bus organized data transmission systems interconnected by terminated 120Ω impedance lines. The external termination is intended to be 180Ω resistor from the bus to the +5V logic supply together with a 390Ω resistor from the bus to ground. The design employs a built-in input hysteresis providing substantial noise immunity. Low input current allows up to 27 driver/receiver pairs to utilize a common bus. This receiver has been specifically configured to replace the SP380 gate pin-for-pin to provide the distinct advantages of the DM7837 receiver design in existing systems. Performance is optimized for systems with bus rise and fall times $\leq 10\mu\text{s}$.

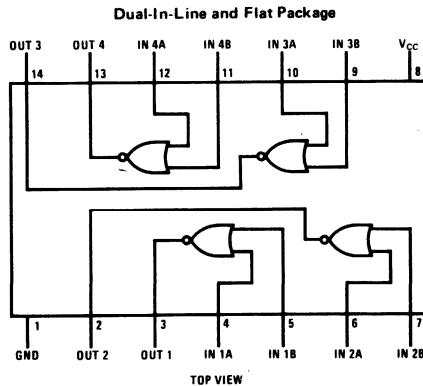
features

- Plug-in replacement for SP380 gate
- Low input current with normal V_{CC} or $V_{CC} = 0V$ ($15\mu\text{A}$ typ)
- Built-in input hysteresis ($1V$ typ)
- High noise immunity ($2V$ typ)
- Temperature-insensitive input thresholds track bus logic levels
- DTL/TTL compatible output
- Matched, optimized noise immunity for "1" and "0" levels
- High speed (18 ns typ)

typical application



connection diagram



Order Number DM7836F Order Number DM7836J Order Number DM8836N
 See Package 4 See Package 16 See Package 22

absolute maximum ratings (Note 1)

Supply Voltage	7.0V
Input Voltage	5.5V
Power Dissipation	600 mW
Operating temperature range:	
DM7836	-55°C to +125°C
DM8836	0°C to +70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics

The following apply for $V_L \leq V_{CC} \leq V_H$, $T_L \leq T_A \leq T_H$, unless otherwise specified (Note 2)

PARAMETER	INPUT	OUTPUT	COMMENTS	MIN	TYP	MAX	UNIT
High Level Input Threshold:							
DM7836	V_{TH}	16 mA	Output < 0.4V	1.85	2.25	2.65	V
DM8836	V_{TH}	16 mA	Output < 0.4V	2.00	2.25	2.50	V
Low Level Input Threshold:							
DM7836	V_{TH}	-400 μ A	Output > 2.4V	1.03	1.30	1.57	V
DM8836	V_{TH}	-400 μ A	Output > 2.4V	1.10	1.30	1.50	V
Maximum Input Current	4V		$V_{CC} = V_H$		15	50	μ A
Maximum Input Current	4V		$V_{CC} = 0V$		1	50	μ A
Logic "1" Output Voltage	0.5V	-400 μ A		2.4			V
Logic "0" Output Voltage	4V	16 mA			0.25	0.4	V
Output Short Circuit Current	0.5V	0V	$V_{CC} = V_H$	-18		-55	mA
Power Supply Current	4V		Per Package		25	40	mA
Input Clamp Diode Voltage	-12 mA		$T_A = 25^\circ\text{C}$		-1	-1.5	V
The following apply for $V_{CC} = 5V$, $T_A = 25^\circ\text{C}$ unless otherwise specified.							
Propagation Delays:							
Input to Logic "1" Output			Note 3		20	30	ns
Input to Logic "0" Output			Note 4		18	30	ns

Note 1: Voltage values are with respect to network ground terminal. Positive current is defined as current into the reference pin.

Note 2: For DM7836: $V_L = 4.5V$, $V_H = 5.5V$, $T_L = -55^\circ\text{C}$, $T_H = +125^\circ\text{C}$.

For DM8836: $V_L = 4.75V$, $V_H = 5.25V$, $T_L = 0^\circ\text{C}$, $T_H = +70^\circ\text{C}$.

Note 3: Fan-out of 10 load, $C_{LOAD} = 15\text{ pF}$ total, measured from $V_{IN} = 1.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.

Note 4: Fan-out of 10 load, $C_{LOAD} = 15\text{ pF}$ total, measured from $V_{IN} = 2.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.



Interface Circuits

DM7837/DM8837

DM7837/DM8837 hex unified bus receiver

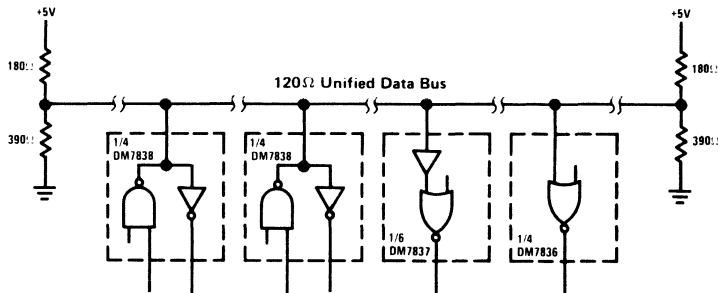
general description

The DM7837/DM8837 are high speed receivers designed for use in bus organized data transmission systems interconnected by terminated 120Ω impedance lines. The external termination is intended to be 180Ω resistor from the bus to the +5V logic supply together with a 390Ω resistor from the bus to ground. The receiver design employs a built-in input hysteresis providing substantial noise immunity. Low input current allows up to 27 driver/receiver pairs to utilize a common bus. Disable inputs provide time discrimination. Disable inputs and receiver outputs are DTL/TTL compatible. Performance is optimized for systems with bus rise and fall times $\leq 10\mu\text{s}$.

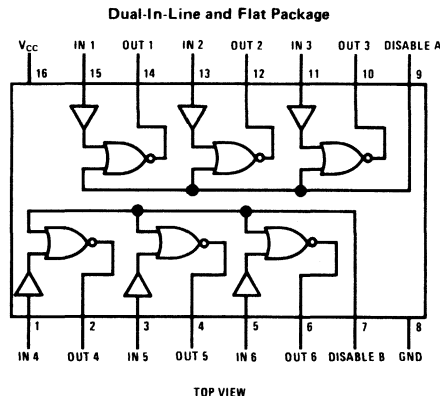
features

- Low receiver input current for normal V_{CC} or $V_{CC} = 0V$ ($15\mu\text{A}$ typ)
- Six separate receivers per package
- Built-in receiver input hysteresis ($1V$ typ)
- High receiver noise immunity ($2V$ typ)
- Temperature insensitive receiver input thresholds track bus logic levels
- DTL/TTL compatible disable and output
- Molded or cavity dual-in-line or flat package
- High speed

typical application



connection diagram



TOP VIEW

Order Number DM7837F Order Number DM7837J Order Number DM8837N
 See Package 5 See Package 17 See Package 23



absolute maximum ratings (Note 1)

Supply Voltage	7V
Input Voltage	5.5V
Power Dissipation	600 mW
Operating Temperature Range	
DM7837	-55°C to +125°C
DM8837	0°C to +70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics

The following apply for $V_L \leq V_{CC} \leq V_H$, $T_L \leq T_A \leq T_H$, unless otherwise specified (Note 2)

PARAMETER	RECEIVER INPUT	DISABLE INPUT	OUTPUT	COMMENTS	MIN	TYP	MAX	UNIT
High Level Receiver Threshold: DM7837	V_{TH}	0.8V	16 mA	Output < 0.4V	1.85	2.25	2.65	V
High Level Receiver Threshold: DM8837	V_{TH}	0.8V	16 mA	Output < 0.4V	2.00	2.25	2.50	V
Low Level Receiver Threshold: DM7837	V_{TL}	0.8V	-400 mA	Output > 2.4V	1.03	1.30	1.57	V
Low Level Receiver Threshold: DM8837	V_{TL}	0.8V	-400 mA	Output > 2.4V	1.10	1.30	1.50	V
Maximum Receiver Input Current	4V			$V_{CC} = V_H$		15.0	50.0	μ A
Maximum Receiver Input Current	4V			$V_{CC} = 0V$		1.0	50.0	μ A
Logic "1" Input Voltage: Disable	0.5V	V_{IN}	16 mA	Output < 0.4V	2.0			V
Logic "0" Input Voltage: Disable	0.5V	V_{IN}	-400 μ A	Output > 2.4V			0.8	V
Logic "1" Output Voltage	0.5V	0.8V	-400 μ A		2.4			V
Logic "0" Output Voltage	4V	0.8V	16 mA			0.25	0.4	V
Logic "1" Input Current: Disable		2.4V					80.0	μ A
Logic "1" Input Current: Disable		5.5V					2.0	mA
Logic "0" Input Current: Disable	4V	0.4V					-3.2	mA
Output Short Circuit Current	0.5V	0V	0V	$V_{CC} = V_H$	-18.0		-55.0	mA
Power Supply Current	4V	0V		Per Package		45.0	60.0	mA
Input Clamp Diode	-12 mA	-12 mA		$T_A = 25^\circ\text{C}$		-1.0	-1.5	V
The following apply for $V_{CC} = 5V$, $T_A = 25^\circ\text{C}$ unless otherwise specified.								
Propagation Delays:								
Receiver Input to Logic "1" Output		0V		Note 3		20	30	ns
Receiver Input to Logic "0" Output		0V		Note 4		18	30	ns
Disable Input to Logic "1" Output	0V			Note 5		9	15	ns
Disable Input to Logic "0" Output	0V			Note 5		4	10	ns

Note 1: Voltage values are with respect to network ground terminal. Positive current is defined as current into the referenced pin.

Note 2: For DM7837: $V_L = 4.5V$, $V_H = 5.5V$, $T_L = -55^\circ\text{C}$, $T_H = +125^\circ\text{C}$

For DM8837: $V_L = 4.75V$, $V_H = 5.25V$, $T_L = 0^\circ\text{C}$, $T_H = +70^\circ\text{C}$

Note 3: Fan-out of 10 load, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 1.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.

Note 4: Fan-out of 10 load, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 2.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.

Note 5: Fan-out of 10 load, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 1.5V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.



Interface Circuits

DM7838/DM8838

DM7838/DM8838 quad unified bus transceiver

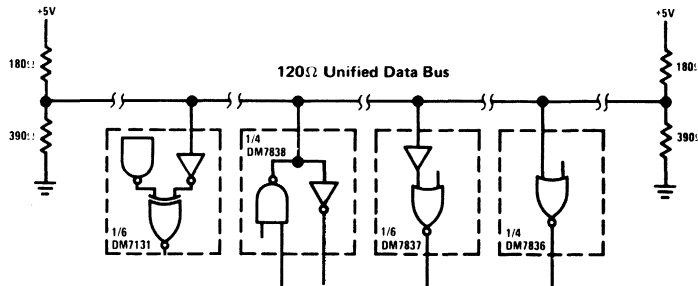
general description

The DM7838/DM8838 are quad high speed drivers/receivers designed for use in bus organized data transmission systems interconnected by terminated 120Ω impedance lines. The external termination is intended to be a 180Ω resistor from the bus to the +5V logic supply together with a 390Ω resistor from the bus to ground. The bus can be terminated at one or both ends. Low bus pin current allows up to 27 driver/receiver pairs to utilize a common bus. The bus loading is unchanged when $V_{CC} = 0V$. The receivers incorporate hysteresis to greatly enhance bus noise immunity. One two-input NOR gate is included to disable all drivers in a package simultaneously. Receiver performance is optimized for systems with bus rise and fall times $\leq 10\mu s$.

features

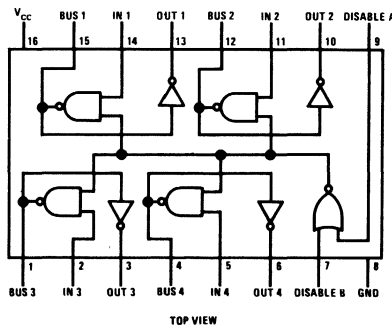
- 4 totally separate driver/receiver pairs per package
- 1V typical receiver input hysteresis
- Receiver hysteresis independent of receiver output load
- Guaranteed minimum bus noise immunity of 1.3V, 2V typ.
- Temperature-insensitive receiver thresholds track bus logic levels
- $20\mu A$ typical bus terminal current with normal V_{CC} or with $V_{CC} = 0V$
- Open collector driver output allows wire-OR connection
- High speed
- Series 74 TTL compatible driver and disable inputs and receiver outputs

typical application



connection diagram

Dual In-Line and Flat Package



Order Number DM7838F Order Number DM7838J Order Number DM8838
 See Package 5 See Package 17 See Package 23

8

absolute maximum ratings

Supply Voltage
Input and Output Voltage
Power Dissipation

7V
5.5V
600 mW

Operating Temperature Range
DM7838
DM8838
Storage Temperature Range
Lead Temperature (Soldering, 10 sec)

-55°C to +125°C
0°C to +70°C
-65°C to +150°C
300°C

electrical characteristics

DM7838/DM8838: The following apply for $V_L \leq V_{CC} \leq V_H$, $T_L \leq T_A \leq T_H$ unless otherwise specified (Note 2).

PARAMETER	DISABLE INPUT	DRIVER INPUT	BUS PIN	RECEIVER OUTPUT	COMMENTS	MIN	TYP	MAX	UNIT
Logic "1" Input Voltage: Disable	V_{IN}	2V	4V		Bus < 100 μ A	2.0			V
Logic "0" Input Voltage: Disable	V_{IN}	2V	50 mA		Bus < 0.7V			0.8	V
Logic "1" Input Voltage: Driver	0.8V	V_{IN}	50 mA		Bus < 0.7V	2.0			V
Logic "0" Input Voltage: Driver	0.8V	V_{IN}	4V		Bus < 100 μ A			0.8	V
High Level Receiver Threshold: DM7838		0.8V	V_{TH}	16 mA	Receiver output < 0.4V	1.85	2.25	2.65	V
High Level Receiver Threshold: DM8838		0.8V	V_{TH}	16 mA	Receiver output < 0.4V	2.00	2.25	2.50	V
Low Level Receiver Threshold: DM7838		0.8V	V_{TH}	-400 μ A	Receiver output > 2.4V	1.03	1.30	1.57	V
Low Level Receiver Threshold: DM8838		0.8V	V_{TH}	-400 μ A	Receiver output > 2.4V	1.10	1.30	1.50	V
Logic "1" Input Current: Disable and Driver	5.5V	5.5V						1	mA
Logic "1" Input Current: Disable and Driver	2.4V	2.4V						40	μ A
Logic "0" Input Current: Disable and Driver	0.4V	0.4V						-1.6	mA
Maximum Bus Current	0.8V	0.8V	4V		$V_{CC} = V_H$	20	100		μ A
Maximum Bus Current	0.8V	0.8V	4V		$V_{CC} = 0V$	2	100		μ A
Low Level Bus Voltage	0.8V	2V	50 mA				0.4	0.7	V
Logic "1" Output Voltage: Receiver	0.8V	0.8V	0.5V	-400 μ A		2.4			V
Logic "0" Output Voltage: Receiver	0.8V	0.8V	4V	16 mA			0.25	0.4	V
Output Short Circuit Current: Receiver	0.8V	0.8V	0.5V	0V	$V_{CC} = V_H$	-18		-55	mA
Supply Current	0V	2V			Per Package		50	70	mA
Input Diode Clamp Voltage	-12 mA	-12 mA	-12 mA		$T_A = 25^\circ\text{C}$		-1	-1.5	V
The following apply for $V_{CC} = 5V$, $T_A = 25^\circ\text{C}$ unless otherwise specified.									
Propagation Delays:									
Disable to Bus "1"					Note 3		19	30	ns
Disable to Bus "0"					Note 3		15	23	ns
Driver Input to Bus "1"					Note 3		17	25	ns
Driver Input to Bus "0"					Note 3		9	15	ns
Bus to Logic "1" Receiver Output					Note 4		20	30	ns
Bus to Logic "0" Receiver Output					Note 5		18	30	ns

Note 1: Voltage values are with respect to network ground terminal. Positive current is defined as current into the referenced pin.

Note 2: For DM7838: $V_L = 4.5V$, $V_H = 5.5V$, $T_L = -55^\circ\text{C}$, $T_H = 125^\circ\text{C}$.
For DM8838: $V_L = 4.75V$, $V_H = 5.25V$, $T_L = 0^\circ\text{C}$, $T_H = 70^\circ\text{C}$.

Note 3: 91 Ω from bus pin to V_{CC} and 200 Ω from bus pin to ground, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 1.5V$ to $V_{BUS} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.

Note 4: Fan-out of 10 load, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 1.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.

Note 5: Fan-out of 10 load, $C_{LOAD} = 15$ pF total. Measured from $V_{IN} = 2.3V$ to $V_{OUT} = 1.5V$, $V_{IN} = 0V$ to 3V pulse.



Display Drivers

DM75491, DM75492

DM75491 MOS-to-LED quad segment driver

DM75492 MOS-to-LED hex digit driver

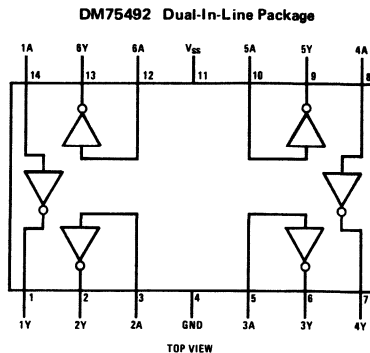
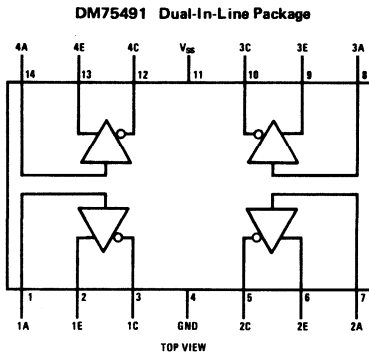
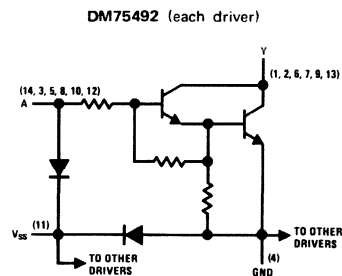
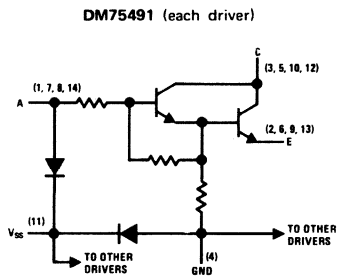
general description

The DM75491 and DM75492 are interface circuits designed to be used in conjunction with MOS integrated circuits and common-cathode LED's in serially addressed multi-digit displays. The number of drivers required for this time-multiplexed system is minimized as a result of the segment-address-and-digit-scan method of LED drive.

features

- Source or sink capability per driver (DM75491) 50 mA
- Sink capability per driver (DM75492) 250 mA
- MOS compatibility (low input current)
- Low standby power
- High-gain Darlington circuits

schematic and connection diagrams



Order Number DM75491N or DM75492N
See Package 22

absolute maximum ratings

	DM75491	DM75492
Input Voltage Range (Note 1)	-5V to V_{SS}	-5V to V_{SS}
Collector Output Voltage (Note 2)	10V	10V
Collector Output to Input Voltage	10V	10V
Emitter to Ground Voltage ($V_1 \geq 5V$)	10V	
Emitter to Input Voltage	5V	
Voltage at V_{SS} Terminal With Respect to Any Other Device Terminal	10V	10V
Collector Output Current		
Each Collector Output	50 mA	250 mA
All Collector Outputs	200 mA	600 mA
Continuous Total Dissipation	800 mW	800 mW
Operating Temperature Range	0°C to +70°C	0°C to +70°C
Storage Temperature Range	-65°C to +150°C	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C	300°C

dc electrical characteristicsDM75491 ($V_{SS} = 10V$, $T_A = 0^\circ C$ to +70°C unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
On State Collector Emitter Voltage ($V_{CE\ ON}$)	Input = 8.5V through 1 k Ω , $V_E = 5V$, $I_C = 50\ mA$, $T_A = 25^\circ C$		.9	1.2	V
On State Collector Emitter Voltage ($V_{CE\ ON}$)	Input = 8.5V through 1 k Ω , $V_E = 5V$, $I_C = 50\ mA$			1.5	V
Off State Collector Current ($I_{C\ OFF}$)	$V_C = 10V$, $V_E = 0$, $I_{IN} = 40\ \mu A$			100	μA
Off State Collector Current ($I_{C\ OFF}$)	$V_C = 10V$, $V_E = 0$, $V_{IN} = .7V$			100	μA
Input Current at Maximum Input Voltage (I_I)	$V_{IN} = 10V$, $V_E = 0$, $I_C = 20\ mA$		2.2	3.3	mA
Emitter Reverse Current (I_E)	$V_{IN} = 0$, $V_E = 5V$, $I_C = 0$			100	μA
Current Into V_{SS} Terminal (I_{SS})				1	mA

DM75492 ($V_{SS} = 10V$, $T_A = 0^\circ C$ to +70°C unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Low Level Output Voltage (V_{OL})	Input = 6.5V through 1 k Ω , $I_{OUT} = 250\ mA$, $T_A = 25^\circ C$		.9	1.2	V
Low Level Output Voltage (V_{OL})	Input = 6.5V through 1 k Ω , $I_{OUT} = 250\ mA$			1.5	V
High Level Output Current (I_{OH})	$V_{OH} = 10V$, $I_{IN} = 40\ \mu A$			200	μA
High Level Output Current (I_{OH})	$V_{OH} = 10V$, $V_{IN} = .5V$			200	μA
Input Current at Maximum Input Voltage (I_I)	$V_{IN} = 10V$, $I_{OL} = 20\ mA$		2.2	3.3	mA
Current Into V_{SS} Terminal (I_{SS})				1	mA

ac switching characteristicsDM75491 ($V_{SS} = 7.5V$, $T_A = 25^\circ C$)

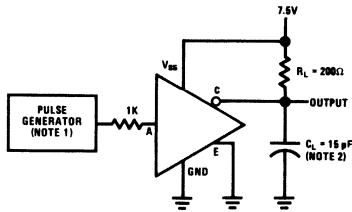
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Propagation Delay Time, Low to High Level Output (Collector) (t_{PLH})	$V_{IH} = 4.5V$, $V_E = 0$,		100		ns
Propagation Delay Time, High to Low Level Output (Collector) (t_{PHL})	$R_L = 200\ \Omega$, $C_L = 15\ pF$		20		ns

DM75492 ($V_{SS} = 7.5V$, $T_A = 25^\circ C$)

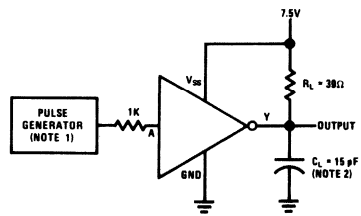
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Propagation Delay Time, Low to High Level Output (t_{PLH})	$V_{IH} = 7.5V$, $R_L = 39\ \Omega$,		300		ns
Propagation Delay Time, High to Low Level Output (t_{PHL})	$C_L = 15\ pF$		30		ns

Note 1: The input is the only device terminal which may be negative with respect to ground.**Note 2:** Voltage values are with respect to network ground terminal unless otherwise noted.

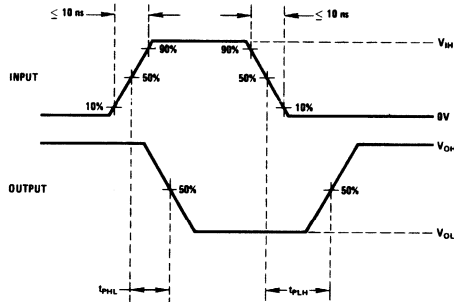
ac test circuits and switching time waveforms



DM75491



DM75492



NOTE 1: THE PULSE GENERATOR HAS THE FOLLOWING CHARACTERISTICS: $Z_{OUT} = 50\Omega$,
 PRR = 100 KHz, $t_{pw} = 1\mu s$.
 NOTE 2: C_L INCLUDES PROBE AND JIG CAPACITANCE.



Display Drivers

DM8861 MOS-to-LED 5-segment driver DM8863 MOS-to-LED 8-digit driver

general description

The DM8861 and DM8863 are designed to be used in conjunction with MOS integrated circuits and common-cathode LED's in serially addressed multi-digit displays.

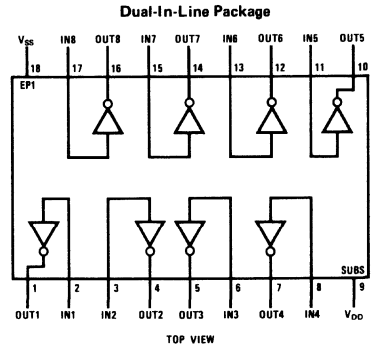
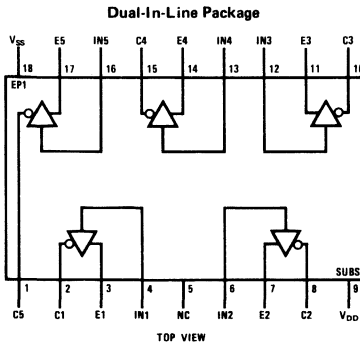
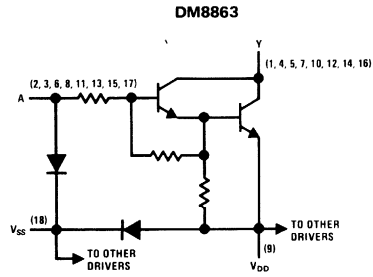
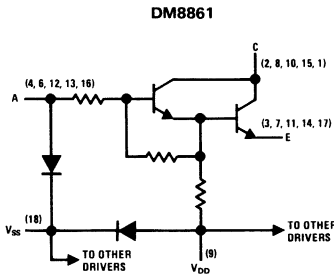
The DM8861 is a 5-segment driver capable of sinking or sourcing up to 50 mA from each driver.

The DM8863 is an 8-digit driver. Each driver is capable of sinking up to 500 mA.

features

- Source or sink capability per driver, DM8861 50 mA
- Sink capability per driver, DM8863 500 mA
- MOS compatibility (low input current)
- Low standby power
- High gain Darlington circuits

schematic and connection diagrams



Order Numbers DM8861N or DM8863N
See Package 29

absolute maximum ratings

	DM8861	DM8863
Input Voltage Range (Note 1)	-5V to V_{SS}	-5V to V_{SS}
Collector (Output) Voltage (Note 2)	10V	10V
Collector (Output)-to-Input Voltage	10V	10V
Emitter-to-Ground Voltage ($V_I \geq 5V$)	10V	
Emitter-to-Input Voltage	5V	
Voltage at V_{SS} Terminal With Respect to Any Other Device Terminal	10V	10V
Collector (Output) Current		
Each Collector (Output)	50 mA	500 mA
All Collectors (Output)	200 mA	600 mA
Continuous Total Dissipation	800 mW	800 mW
Operating Temperature Range	0°C to +70°C	0°C to +70°C
Storage Temperature Range	-65°C to +150°C	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C	300°C

dc electrical characteristicsDM8861 ($V_{SS} = 10V$, $T_A = 0^\circ C$ to +70°C unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
On State Collector Emitter Voltage ($V_{CE\ ON}$)	Input = 8.5V through 1 k Ω , $V_E = 5V$, $I_C = 50\ mA$, $T_A = 25^\circ C$		.9	1.2	V
On State Collector Emitter Voltage ($V_{CE\ ON}$)	Input = 8.5V through 1 k Ω , $V_E = 5V$, $I_C = 50\ mA$			1.5	V
Off State Collector Current ($I_{C\ OFF}$)	$V_C = 10V$, $V_E = 0$, $I_{IN} = 40\ \mu A$			100	μA
Off Set Collector Current ($I_{C\ OFF}$)	$V_C = 10V$, $V_E = 0$, $V_{IN} = .7V$			100	μA
Input Current at Maximum Input Voltage (I_I)	$V_{IN} = 10V$, $V_E = 0$, $I_C = 20\ mA$		2.2	3.3	mA
Emitter Reverse Current (I_E)	$V_{IN} = 0$, $V_E = 5V$, $I_C = 0$			100	μA
Current Into V_{SS} Terminal (I_{SS})				1	mA

DM8863 ($V_{SS} = 10V$, $T_A = 0^\circ C$ to +70°C unless otherwise noted)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Low Level Output Voltage (V_{OL})	$V_{IN} = 7V$, $I_{OUT} = 500\ mA$, $T_A = 25^\circ C$			1.5	V
Low Level Output Voltage (V_{OL})	$V_{IN} = 7V$, $I_{OUT} = 500\ mA$			1.6	V
High Level Output Current (I_{OH})	$V_{OH} = 10V$, $I_{IN} = 40\ \mu A$			250	μA
High Level Output Current (I_{OH})	$V_{OH} = 10V$, $V_{IN} = .5V$			250	μA
Input Current at Maximum Input Voltage (I_I)	$V_{IN} = 10V$, $I_{OL} = 20\ mA$			2	mA
Current Into V_{SS} Terminal (I_{SS})				1	mA

ac switching characteristicsDM8861 ($V_{SS} = 7.5V$, $T_A = 25^\circ C$)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Propagation Delay Time, Low to High Level Output (Collector) (t_{PLH})	$V_{IH} = 4.5V$, $V_E = 0$		100		ns
Propagation Delay Time, High to Low Level Output (Collector) (t_{PHL})	$R_L = 200\ \Omega$, $C_L = 15\ pF$		20		ns

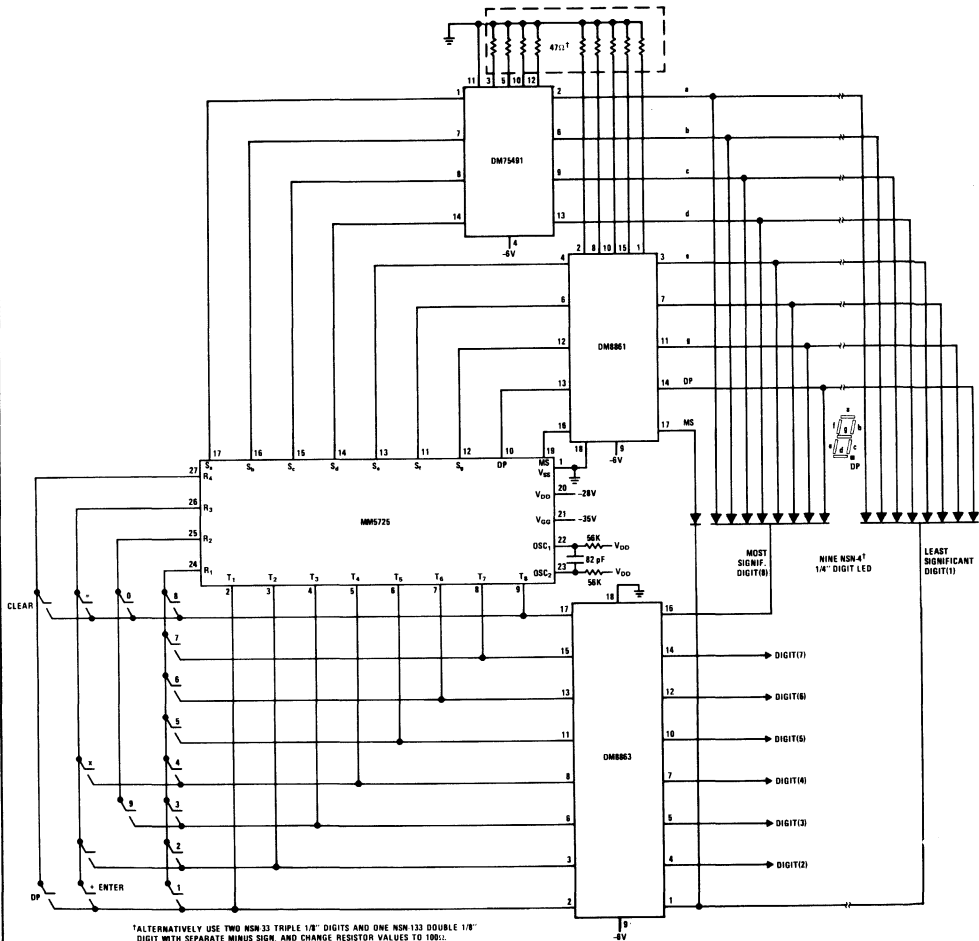
DM8863 ($V_{SS} = 7.5V$, $T_A = 25^\circ C$)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Propagation Delay Time, Low to High Level Output (t_{PLH})	$V_{IH} = 8V$, $R_L = 21\ \Omega$		300		ns
Propagation Delay Time, High to Low Level Output (t_{PHL})	$C_L = 15\ pF$		30		ns

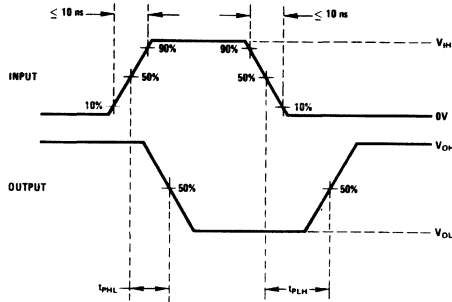
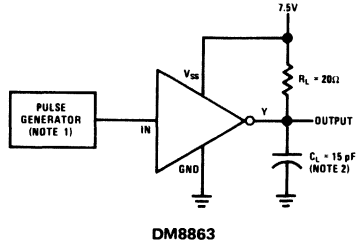
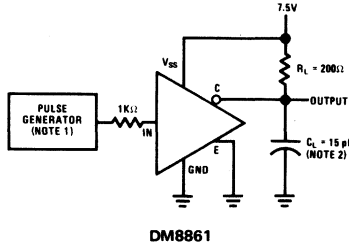
Note 1: The input is the only device terminal which may be negative with respect to ground.**Note 2:** Voltage values are with respect to network ground terminal unless otherwise noted.

typical application

8-Digit Calculator With LED Display



ac test circuits and waveforms



NOTE 1: THE PULSE GENERATOR HAS THE FOLLOWING CHARACTERISTICS: $Z_{OUT} = 50\Omega$,
 PRR = 100 KHz, $t_w = 1\mu s$
 NOTE 2: C_L INCLUDES PROBE AND JIG CAPACITANCE.



Display Drivers

DM7880/DM8880 high voltage 7-segment decoder/driver (for driving Sperry and Panaplex II™ displays)

general description

The DM7880/DM8880 is custom designed to decode four lines of BCD and drive a gas-filled seven-segment display tube.

The design employs a 112-bit read-only memory which provides BCD input to full hexadecimal output decoding in the standard DM7880/DM8880 product. For applications desiring other fonts, or not using standard BCD coding, the ROM contents can be custom modified to produce any 16 output displays for the 16 binary input combinations.

Each output constitutes a switchable, adjustable current sink which provides constant current to the tube segment, even with high tube anode supply tolerance or fluctuation. These current sinks have a voltage compliance from 3V to at least 80V; typically the output current varies 1% for output voltage changes of 3 to 50V. Each bit line of the ROM switches a current sink on or off as prescribed by the input code. Each current sink is ratioed to the b-output current as required for even illumination of all segments.

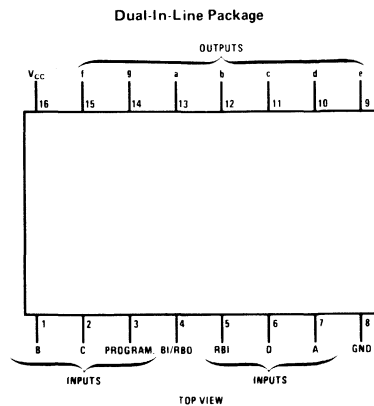
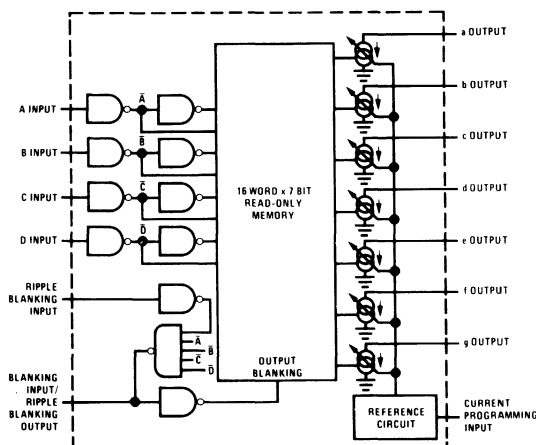
Output currents may be varied over the 0.2 to 1.5 mA range for driving various tube types or multiplex operation. The output current is adjusted by connecting an external program resistor (R_p) from V_{CC} to the Program input in accordance with the programming curve. The circuit design provides a one-to-one correlation between program input current and b-segment output current.

The Blanking Input provides unconditional blanking of any output display, while the Ripple Blanking pins allow simple leading- or trailing-zero blanking.

features

- Current sink outputs
- Adjustable output current – 0.2 to 1.5 mA
- High output breakdown voltage – 110V typ
- Suitable for multiplex operation
- Blanking and Ripple Blanking provisions
- Low fan-in and low power

logic and connection diagrams



Order Number DM7880J
See Package 17

Order Number DM8880N
See Package 23

absolute maximum ratings

operating conditions

			MIN	MAX	UNITS
V _{CC}	7V	Supply Voltage (V _{CC})			
Input Voltage (Except BI)	6V	DM7880	4.5	5.5	V
Input Voltage (BI)	V _{CC}	DM8880	4.75	5.25	V
Segment Output Voltage	80V				
Power Dissipation (Note 1)	600 mW	Temperature (T _A)			
Transient Segment Output Current (Note 2)	50 mA	DM7880	-55	+125	°C
Storage Temperature Range	-65°C to 150°C	DM8880	0	+70	°C
Lead Temperature (Soldering, 10 sec)	300°C				

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Logic "1" Input Voltage	V _{CC} = Min	2.0			V
Logic "0" Input Voltage	V _{CC} = Min			0.8	V
Logic "1" Output Voltage (RBO)	V _{CC} = Min, I _{OUT} = -200 μA	2.4	3.7		V
Logic "0" Output Voltage (RBO)	V _{CC} = Min, I _{OUT} = 8 mA		0.13	0.4	V
Logic "1" Input Current (Except BI)	V _{CC} = Max, V _{IN} = 2.4V		2	15	μA
	V _{CC} = Max, V _{IN} = 5.5V		4	400	μA
Logic "0" Input Current (Except BI)	V _{CC} = Max, V _{IN} = 0.4V		-300	-600	μA
Logic "0" Input Current (BI)	V _{CC} = Max, V _{IN} = 0.4V		-1.2	-2.0	mA
Power Supply Current	V _{CC} = Max, R _P = 2.2k All Inputs = 0V		27	43	mA
Input Diode Clamp Voltage	V _{CC} = Max, T _A = 25°C I _{IN} = -12 mA		-0.9	-1.5	V
Segment Outputs:					
Outputs a, f, g ON Current Ratio	All Outputs = 50V Output b Curr. = Ref.	0.84	0.93	1.02	
Output c ON Current Ratio	All Outputs = 50V, Output b Curr. = Ref.	1.12	1.25	1.38	
Output d ON Current Ratio	All Outputs = 50V Output b Curr. = Ref.	0.90	1.00	1.10	
Output e ON Current Ratio	All Outputs = 50V Output b Curr. = Ref.	0.99	1.10	1.21	
Output b ON Current	V _{CC} = 5V, V _{OUT} b = 50V T _A = 25°C, R _P = 18.1k	0.18	0.20	0.22	mA
	V _{CC} = 5V, V _{OUT} b = 50V T _A = 25°C, R _P = 7.03k	0.45	0.50	0.55	mA
	V _{CC} = 5V, V _{OUT} b = 50V T _A = 25°C, R _P = 3.40k	0.90	1.00	1.10	mA
	V _{CC} = 5V, V _{OUT} b = 50V T _A = 25°C, R _P = 2.20k	1.35	1.50	1.65	mA
Output Saturation Voltage	V _{CC} = Min, R _P = 1k±5% I _{OUT} b = 2 mA (Note 4)		0.8	2.5	V
Output Leakage Current	V _{OUT} = 75V, BI = 0V		.003	3	μA
Output Breakdown Voltage	I _{OUT} = 250 μA, BI = 0V	80	110		V
Propagation Delays:					
BCD Input to Segment Output	V _{CC} = 5V, T _A = 25°C		0.4	10	μs
BI to Segment Output	V _{CC} = 5V, T _A = 25°C		0.4	10	μs
RBI to Segment Output	V _{CC} = 5V, T _A = 25°C		0.7	10	μs
RBI to RBO	V _{CC} = 5V, T _A = 25°C		0.4	10	μs

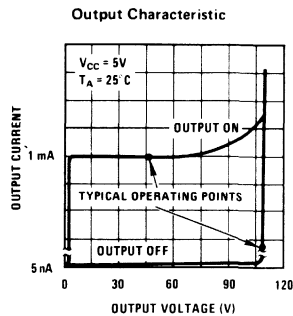
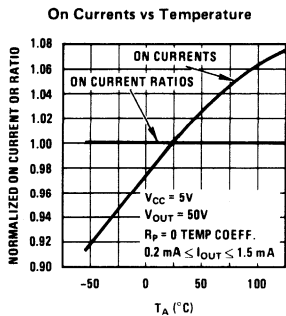
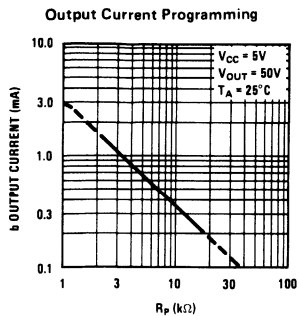
Note 1: Maximum junction temperature for DM7880 is 150°C whereas that for DM8880 is 130°C. For operating at elevated temperatures the device must be derated based on a thermal resistance of 85°C/W θ_{JA} for DM7880 and 150°C/W θ_{JA} for DM8880.

Note 2: In all applications transient segment output current must be limited to 50 mA. This may be accomplished in DC applications by connecting a 2.2k resistor from the anode-supply filter capacitor to the display anode, or by current limiting the anode driver in multiplex applications.

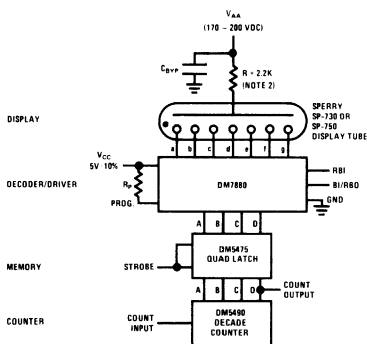
Note 3: Min/max limits apply across the guaranteed operating temperature range of -55°C to 125°C for DM7880 and 0°C to 70°C for DM8880, unless otherwise specified. Typical values are for V_{CC} = 5V, T_A = 25°C. Positive current is defined as current into the referenced pin.

Note 4: For saturation mode the segment output currents are externally limited and ratioed.

typical performance characteristics



typical application



truth table

DECIMAL OR FUNCTION	RBI	D	C	B	A	BI/RBO	a	b	c	d	e	f	g	DISPLAY
0	1	0	0	0	0	1	0	0	0	0	0	0	1	0
1	X	0	0	0	1	1	1	0	0	1	1	1	1	1
2	X	0	0	1	0	1	0	0	1	0	0	1	0	2
3	X	0	0	1	1	1	0	0	0	0	1	1	0	3
4	X	0	1	0	0	1	1	0	0	1	1	0	0	4
5	X	0	1	0	1	1	0	1	0	0	1	0	0	5
6	X	0	1	1	0	1	0	1	0	0	0	0	0	6
7	X	0	1	1	1	1	0	0	0	1	1	1	1	7
8	X	1	0	0	0	1	0	0	0	0	0	0	0	8
9	X	1	0	0	1	1	0	0	0	0	1	0	0	9
10	X	1	0	1	0	1	0	0	0	1	0	0	0	10
11	X	1	0	1	1	1	1	1	0	0	0	0	0	11
12	X	1	1	0	0	1	0	1	1	0	0	0	1	12
13	X	1	1	0	1	1	1	0	0	0	0	1	0	13
14	X	1	1	1	0	1	0	1	1	0	0	0	0	14
15	X	1	1	1	1	1	0	1	1	1	0	0	0	15
BI	X	X	X	X	X	0	1	1	1	1	1	1	1	BI
RBI	0	0	0	0	0	0	1	1	1	1	1	1	1	RBI





Display Drivers

DM8884A

DM8884A high voltage cathode decoder/driver (for driving Panaplex II™ and Sperry displays)

general description

The DM8884A is designed to decode four lines of BCD input and drive seven-segment digits of gas-filled readout displays. Two separate inputs are provided for driving the decimal point and comma cathodes.

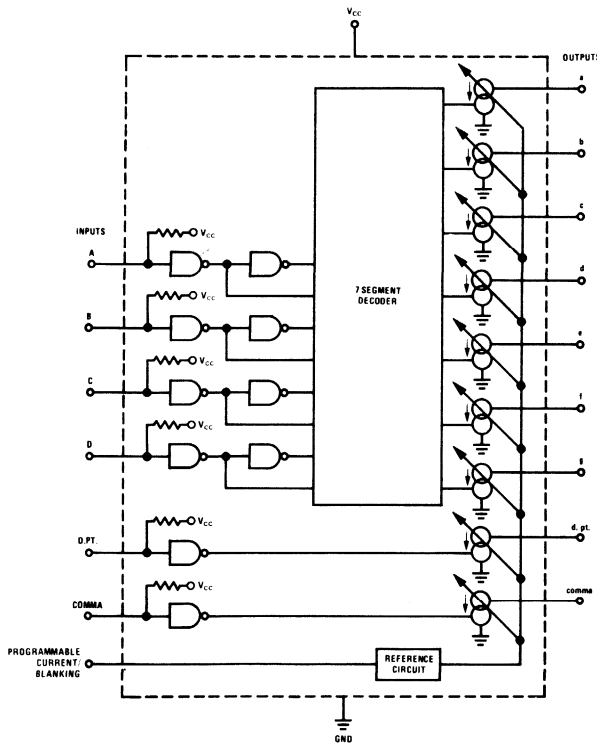
All outputs consist of switchable and programmable current sinks which provide constant current to the tube cathodes, even with high tube anode supply tolerance. Output currents may be varied over the 0.2 to 1.2 mA range for multiplex operation. The output current is adjusted by connecting an external program resistor (R_p) from V_{CC} to the

program input in accordance with the programming curve.

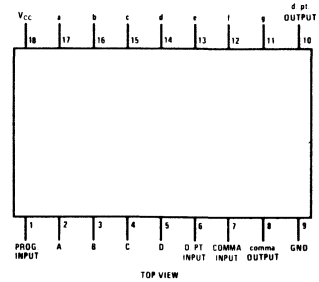
features

- Usable with AC or DC input coupling
- Current sink outputs
- High output breakdown voltage
- Low input load current
- Intended for multiplex operation.
- Input pullups increase noise immunity

logic and connection diagrams



Dual-In-Line Package



Order Number DM8884AN
See Package 29

absolute maximum ratings

V_{CC}	7V
Input Voltage (Note 1)	V_{CC}
Segment Output Voltage	80V
Power Dissipation (Note 2)	600 mW
Transient Segment Output Current (Note 3)	50 mA
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	-65°C to +150°C

electrical characteristics (0°C ≤ T_A ≤ 70°C – Unless otherwise noted), V_{CC} = 5V ± 5%.

PARAMETER	CONDITIONS	MIN	MAX	UNITS
Logic "1" Input Voltage	V _{CC} = 4.75V	2.0		V
Logic "0" Input Voltage	V _{CC} = 4.75V		1.0	V
Logic "1" Input Current	V _{CC} = 5.25V, V _{IN} = 2.4V		15	μA
Positive Input Clamp Voltage	V _{CC} = 4.75, I _{IN} = 1 mA	5.0		V
Logic "0" Input Current	V _{CC} = 5.25V, V _{IN} = 0.4V		-250	μA
Power Supply Current	V _{CC} = 5.25V, R _P = 2.8k, All Inputs = 5V		40	mA
Negative Input Clamp Voltage	V _{CC} = 5V, I _{IN} = -12 mA, T _A = 25°C		-1.5	V
Segment Outputs:				
All Outputs ON Current Ratio	All Outputs = 50V Output b Current = Ref.	0.9	1.1	
Output b ON Current	V _{CC} = 5V, V _{OUT b} = 50V, T _A = 25°C, R _P = 18.1k	0.18	0.22	mA
	R _P = 7.03k	0.45	0.55	mA
	R _P = 3.40k	0.90	1.10	mA
	R _P = 2.80k	1.08	1.32	mA
Output Leakage Current	V _{OUT} = 75V		5	μA
Output Breakdown Voltage	I _{OUT} = 250 μA	80		V
Propagation Delay:				
Any Input to Segment Output	V _{CC} = 5V, T _A = 25°C		10	μs

Note 1: This limit can be higher for a current limiting voltage source.

Note 2: The maximum junction temperature is 140°C. For operation at elevated temperatures, the device must be derated based on a thermal resistance of 140°C/W θ_{JA}.

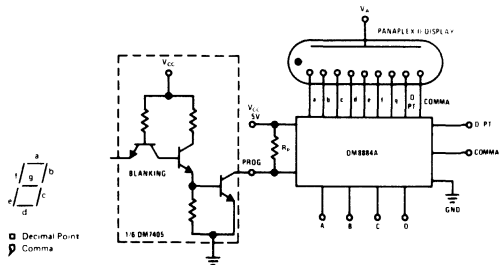
Note 3: In all applications transient segment output current must be limited to 50 mA. This may be accomplished in DC applications by connecting a 2.2k resistor from the anode-supply filter capacitor to the display anode, or by current limiting the anode driver in multiplex applications.

truth table

FUNCTION	D.P.T	COMMA	D	C	B	A	a	b	c	d	*	†	‡	DISPLAY
0	1	1	0	0	0	0	0	0	0	0	0	1		0
1	1	1	0	0	0	1	0	0	1	1	1	1		1
2	1	1	0	0	1	0	0	0	0	1	0	0		0
3	1	1	0	0	1	1	0	0	0	0	0	1		0
4	1	1	0	1	0	0	1	0	0	1	1	0		0
5	1	1	0	1	0	1	0	1	0	0	0	0		0
6	1	1	0	1	1	0	0	0	0	0	0	0		0
7	1	1	0	1	1	1	0	0	0	1	1	1		1
8	1	1	1	0	0	0	0	0	0	0	0	0		0
9	1	1	1	0	0	1	0	0	0	0	1	0		0
10	1	1	1	0	1	0	1	1	0	0	0	1		1
11	1	1	1	0	1	1	1	1	1	0	0	0		0
12	1	1	1	1	0	0	0	0	1	1	1	0		0
13	1	1	1	1	0	1	0	1	1	0	0	0		0
14	1	1	1	1	1	0	1	1	1	1	1	1		0
15	1	1	1	1	1	1	1	1	1	1	1	1		1
*D.P.T	0	1	X	X	X	X	X	X	X	X	X	X		X
†Comma	0	0	X	X	X	X	X	X	X	X	X	X		X

*Decimal point and comma can be displayed with or without any numerals.

typical application



typical performance characteristics (see DM7880 data sheet)



Display Drivers

DM8885

DM8885 MOS to high voltage cathode buffer

general discription

The DM8885 interfaces MOS calculator or counter-latch-decoder-driver circuits directly to seven-segment high-voltage gas-filled displays. The six inputs A, B, D, E, F, G are decoded to drive the seven segments of the tube.

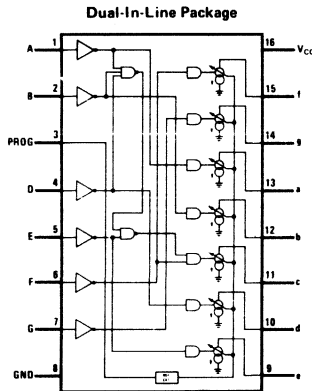
Each output constitutes a switchable, adjustable current source which provides constant current to the tube segment, even with high tube anode supply tolerance or fluctuation. These current sources have a voltage compliance from 3V to at least 80V. Each current source is ratioed to the b-output current as required for even illumination of all segments. Output currents may be varied over the 0.2 to 1.5 mA range for driving various tube types or

multiplex operation. The output current is adjusted by connecting a program resistor (R_P) from V_{CC} to the program input.

features

- Current source outputs
- Adjustable output currents 0.2 to 1.5 mA
- High output breakdown voltage 80V min
- Suitable for multiplex operation
- Low fan-in and low power
- Blanking via program input
- Also drives overrange, polarity, decimal point cathodes

connection diagram



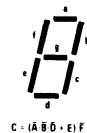
TOP VIEW
Order Number DM8885
See Package 23

truth tables

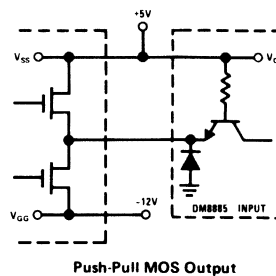
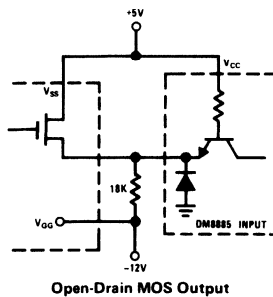
A	B	D	E	F	G	DISPLAY
1	1	1	1	1	0	0
0	1	0	0	0	0	1
1	1	1	1	0	1	2
1	1	1	0	0	1	3
0	1	0	0	1	1	4
1	0	1	0	1	1	5
1	0	1	1	1	1	6
1	1	0	0	0	0	7
1	1	1	1	1	1	8
1	1	1	0	1	1	9
0	0	1	1	1	1	0
1	1	0	0	1	1	1
1	1	0	1	1	1	2
0	1	0	1	1	1	3
0	1	1	1	1	0	4
0	0	0	0	0	1	5
0	0	0	0	0	0	6

INPUT*	OUTPUT*
0	1 (OFF)
1	0 (ON)

*Positive Logic



typical applications



absolute maximum ratings

V_{CC}	7V
Input Voltage	6V
Segment Output Voltage	80V
Power Dissipation (Note 1)	600 mW
Transient Segment Output Current (Note 2)	50 mA
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

electrical characteristics (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Logic "1" Input Voltage	$V_{CC} = 4.75V$	2.0			V
Logic "0" Input Voltage	$V_{CC} = 4.75V$			0.8	V
Logic "1" Input Current	$V_{CC} = 5.25V, V_{IN} = 2.4V$		2	15	μA
	$V_{CC} = 5.25V, V_{IN} = 5.5V$		4	400	μA
Logic "0" Input Current	$V_{CC} = 5.25V, V_{IN} = 0.4V$	-300		-600	μA
Power Supply Current	$V_{CC} = 5.25V, \text{All Inputs} = 0V, R_P = 2.2k$		22	31	mA
Input Diode Clamp Voltage	$V_{CC} = 5V, I_{IN} = -12 \text{ mA}, T_A = 25^\circ C$		-0.9	-1.5	V
Segment Outputs:					
Outputs a, f, g On Current Ratio	All Outputs = 50V, Output b Curr. = Ref.	0.84	0.93	1.02	
Output c On Current Ratio	All Outputs = 50V, Output b Curr. = Ref.	1.12	1.25	1.38	
Output d On Current Ratio	All Outputs = 50V, Output b Curr. = Ref.	0.90	1.00	1.10	
Output e On Current Ratio	All Outputs = 50V, Output b Curr. = Ref.	0.99	1.10	1.21	
Output b On Current	$V_{CC} = 5V, V_{OUT} = 50V, T_A = 25^\circ C, R_P = 18.1k$	0.18	0.20	0.22	mA
	$V_{CC} = 5V, V_{OUT} = 50V, T_A = 25^\circ C, R_P = 7.03k$	0.45	0.50	0.55	mA
	$V_{CC} = 5V, V_{OUT} = 50V, T_A = 25^\circ C, R_P = 3.40k$	0.90	1.00	1.10	mA
	$V_{CC} = 5V, V_{OUT} = 50V, T_A = 25^\circ C, R_P = 2.20k$	1.35	1.50	1.65	mA
Output Saturation Voltage	$V_{CC} = 4.75V, I_{OUT} = 2 \text{ mA}, R_P = 1k \pm 5\%$ (Note 4)		0.8	2.5	V
Output Leakage Current	$V_{OUT} = 75V, V_{IN} = 0.8V, R_P > 1k$		0.003	3	μA
	$V_{OUT} = 75V, V_{PROG} = 0.4V$		0.003	3	μA
Output Breakdown Voltage	$I_{OUT} = 250 \mu A, V_{IN} = 0.8V$	80	110		V
Propagation Delays:					
Input to Segment Output	$V_{CC} = 5V, T_A = 25^\circ C$		0.4	10	μs

Note 1: Maximum junction temperature is 130°C. For operating at elevated temperatures, the device must be derated based on a thermal resistance of 150°C/W θ_{JA} .

Note 2: In all applications transient segment output current must be limited to 50 mA. This may be accomplished in DC applications by connecting a 2.2k resistor from the anode-supply filter capacitor to the display anode, or by current limiting the anode driver in multiplex applications.

Note 3: Min/max limits apply across the guaranteed operating temperature range of 0°C to +70°C, unless otherwise specified. Typicals are for $V_{CC} = 5V, T_A = 25^\circ C$. Positive current is defined as current into the referenced pin.

Note 4: For saturation mode the segment output currents are externally limited and ratioed.

typical performance characteristics (see DM7880 data sheet)



Sense Amplifiers

LM5520/LM7520 series dual core memory sense amplifiers general description

The devices in this series of dual core sense amplifiers convert bipolar millivolt-level memory sense signals to saturated logic levels. The design employs a common reference input which allows the input threshold voltage level of both amplifiers to be adjusted. Separate strobe inputs provide time discrimination for each channel. Logic inputs and outputs are DTL/TTL compatible. All devices of the series have identical preamplifier configurations, while various logic connections are provided to suit the specific application.

The LM5520/LM7520 has output latch capability and provides sense, strobe, and memory function for two sense lines. The LM5522/LM7522 contains a single open collector output which may be used to expand the number of inputs of the LM5520/LM7520, or to drive an external Memory Data Register (MDR). Intended for small memories, the two channels of the LM5524/LM7524 are independent with two separate outputs. The LM5534/LM7534 is similar to the LM5524/LM7524 but has uncommitted, wire-ORable outputs. The LM5528/LM7528 has the same logic configuration of the LM5524/LM7524 and in addition provides separate low impedance Test Points at each preamplifier output. A similar device having uncommitted, wire-ORable outputs is the LM5538/LM7538.

features

- High speed
- Guaranteed narrow threshold uncertainty over temperature

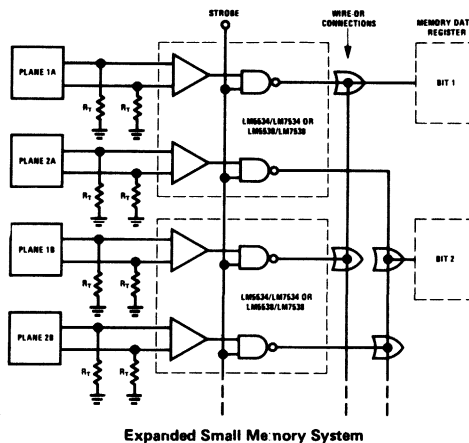
- Adjustable input threshold voltage
- Fast overload recovery times
- Two amplifiers per package
- Molded or cavity dual-in-line package
- Six logic configurations

The part number ending with an even number (e.g., LM5520) designates a tighter guaranteed input threshold uncertainty than the subsequent odd number ending (e.g., LM5521). The remaining specifications for the two are identical. All devices meet or exceed the specifications for the corresponding device (where applicable) in the SN5520/SN7520 series and are pin-for-pin replacements.

absolute maximum ratings

Supply Voltage	±7V
Differential or Reference Input Voltage	±5V
Logic Input Voltage	+5.5V
Operating Temperature Range	
LM55XX	-55°C to +125°C
LM75XX	0°C to +70°C
Storage Temperature Range	-65°C to +150°C

typical application



LM5520/LM7520 and LM5521/LM7521 electrical characteristics

LM5520/LM5521: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER)							LOGIC OUTPUT (NOTE 3)	SUPPLY VOLT.	COMMENTS
					DIFF. INPUT	REF. INPUT	STROBE INPUT	GATE Q INPUT	GATE \bar{Q} INPUT					
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5V			+16 mA(Q)	$\pm 5V$	Logic Output <0.4V Logic Output >2.4V Logic Output <0.4V Logic Output >2.4V	
		15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	+5V			-400 μA (Q)	$\pm 5V$		
		35(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+5V		+16 mA(Q)	$\pm 5V$		
			40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	+5V		-400 μA (Q)	$\pm 5V$		
Differential & Reference Input Bias Current		30	100	μA	0V	0V	+5.25V	+5.25V	+5.25V			$\pm 5.25V$		

LM7520/LM7521: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Differential Input Threshold Voltage (V_{TH}) (Note 4)	11(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5V			+16 mA(Q)	$\pm 5V$	Logic Output <0.4V Logic Output >2.4V Logic Output <0.4V Logic Output >2.4V
		15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	+5V			-400 μA (Q)	$\pm 5V$	
		36(33)	40		mV	$\pm V_{TH}$	40 mV	+5V	+5V		+16 mA(Q)	$\pm 5V$	
			40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	+5V		-400 μA (Q)	$\pm 5V$	
Differential & Reference Input Bias Current		30	75	μA	0V	0V	+5.25V	+5.25V	+5.25V			$\pm 5.25V$	

LM5520/LM5521: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$

LM7520/LM7521: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Differential Input Offset Current		0.5		μA	0V	0V	+5.25V	+5.25V	+5.25V			$\pm 5.25V$	
Logic "1" Input Voltage (Strobes) (Gate Q) (Gate \bar{Q})	2			V	40 mV	20 mV	+2V	+4.75V			-400 μA (Q)	$\pm 5V$	Logic Output >2.4V Logic Output <0.4V Logic Output <0.4V
	2			V	40 mV	20 mV	0V	+2V			+16 mA(Q)	$\pm 5V$	
	2			V	40 mV	20 mV	0V	0V	+2V		+16 mA(\bar{Q})	$\pm 5V$	
Logic "0" Input Voltage (Strobes) (Gate Q) (Gate \bar{Q})			0.8	V	40 mV	20 mV	+0.8V	+4.75V			+16 mA(Q)	$\pm 5V$	Logic Output <0.4V Logic Output >2.4V Logic Output >2.4V
			0.8	V	40 mV	20 mV	0V	+0.8V			-400 μA (Q)	$\pm 5V$	
			0.8	V	40 mV	20 mV	0V	0V	+0.8V		-400 μA (\bar{Q})	$\pm 5V$	
Logic "0" Input Current		-1	-1.6	mA	40 mV	20 mV	+0.4V	+0.4V	+0.4V			$\pm 5.25V$	Each Input
Logic "1" Input Current (Strobe & Gate Q) (Gate Q)	5	40	1	μA	0V	20 mV	+2.4V	+5.25V	+2.4V			$\pm 5.25V$	Each Input Each Input
	.02	40	1	μA	0V	20 mV	+5.25V	+5.25V	+5.25V			$\pm 5.25V$	
	5	40	1	μA	40 mV	20 mV	+5.25V	+2.4V	+5.25V			$\pm 5.25V$	
Logic "1" Output Voltage (Strobe) (Gate Q) (Gate \bar{Q})	2.4	3.9		V	40 mV	20 mV	+2.0V	+5.25V			-400 μA (Q)	$\pm 4.75V$	$\pm 4.75V$ $\pm 4.75V$ $\pm 4.75V$
	2.4	3.9		V	40 mV	20 mV	0V	+0.8V			-400 μA (Q)	$\pm 4.75V$	
	2.4	3.9		V	40 mV	20 mV	+4.75V	0V	+0.8V		-400 μA (\bar{Q})	$\pm 4.75V$	
Logic "0" Output Voltage (Strobe) (Gate Q) (Gate \bar{Q})		0.25	0.40	V	40 mV	20 mV	+0.8V	+4.75V			+16 mA(Q)	$\pm 4.75V$	$\pm 4.75V$ $\pm 4.75V$ $\pm 4.75V$
		0.25	0.40	V	0V	20 mV	0V	+2V			+16 mA(Q)	$\pm 4.75V$	
		0.25	0.40	V	0V	20 mV	0V	0V	+2V		+16 mA(\bar{Q})	$\pm 4.75V$	
Q Output Short Circuit Current	-3	-4	-5	mA	0V	20 mV	0V	0V	0V		0 V(Q)	$\pm 5.25V$	
\bar{Q} Output Short Circuit Current	-2.1	-2.8	-3.5	mA	0V	20 mV	0V	0V	0V		0 V(\bar{Q})	$\pm 5.25V$	
V+ Supply Current		21	35	mA	0V	20 mV	0V	0V	0V			$\pm 5.25V$	
V- Supply Current		-13	-18	mA	0V	20 mV	0V	0V	0V			$\pm 5.25V$	

Note 1: For $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ operation, electrical characteristics for LM5520 and LM5521 are guaranteed the same as LM7520 and LM7521, respectively.

Note 2: Limits in parentheses pertain to LM5521, other limits pertain to LM5520.

Note 3: Q or \bar{Q} in parentheses indicate Q or \bar{Q} logic output, respectively.

Note 4: Limits in parentheses pertain to LM7521, other limits pertain to LM7520.

Note 5: Positive current is defined as current into the referenced pin.

Note 6: Pin 1 to have ≥ 100 pF capacitor connected to ground.

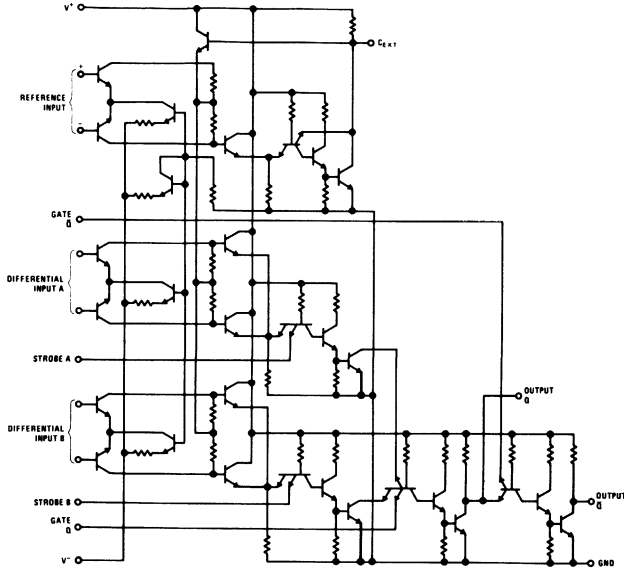
LM5520/LM7520 and LM5521/LM7521 electrical characteristics

LM5520/LM5521 and LM7520/LM7521: The following apply for $T_A = 25^\circ\text{C}$, $V^+ = 5\text{V}$, $V^- = -5\text{V}$

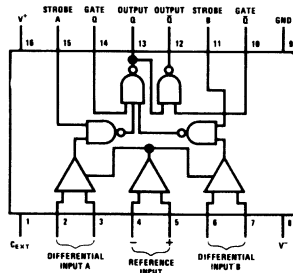
PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS				
					DIFF. INPUT	REF. INPUT	STROBE AND GATE INPUTS	Q LOGIC OUTPUT	AC TEST CIRCUIT
AC Common-Mode Input Firing Voltage		±2.5		V	PULSE	20 mV	+5V	SCOPE	
Propagation Delays									
Differential Input to Logical "1" Q Output		20	40	ns		20 mV			1
Differential Input to Logical "0" Q Output		28		ns		20 mV			1
Differential Input to Logical "1" Q Output		36		ns		20 mV			1
Differential Input to Logical "0" Q Output		28	55	ns		20 mV			1
Strobe Input to Logical "1" Q Output		10	30	ns		20 mV			1
Strobe Input to Logical "0" Q Output		20		ns		20 mV			1
Strobe Input to Logical "1" Q Output		33		ns		20 mV			1
Strobe Input to Logical "0" Q Output		16	55	ns		20 mV			1
Gate Q Input to Logical "1" Q Output		12	20	ns		20 mV			2
Gate Q Input to Logical "0" Q Output		6		ns		20 mV			2
Gate Q Input to Logical "1" Q Output		17		ns		20 mV			2
Gate Q Input to Logical "0" Q Output		19	30	ns		20 mV			2
Gate Q Input to Logical "1" Q Output		12		ns		20 mV			2
Gate Q Input to Logical "0" Q Output		6	20	ns		20 mV			2
Diff. Input Overload Recovery Time		10		ns					
Common-Mode Input Overload Recovery Time		5		ns					
Min. Cycle Time		200		ns					

LM5520/LM7520 and LM5521/LM7521

schematic diagram



connection diagram



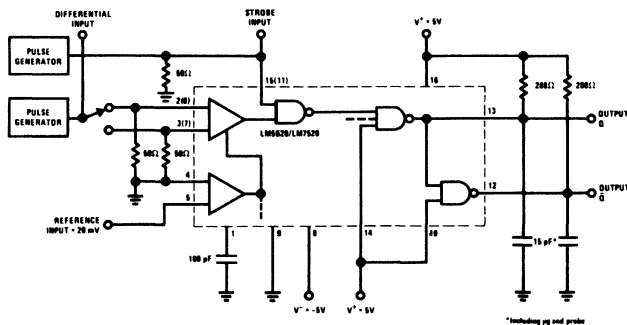
Order Number LM5520J or LM7520J
See Package 17

Order Number LM5520N or LM7520N
See Package 23

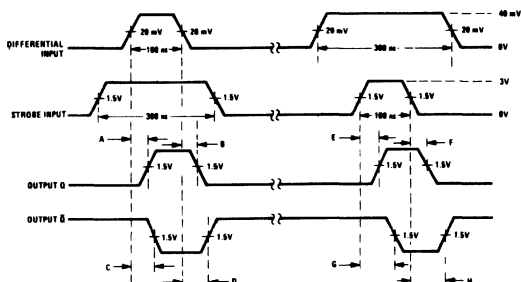
Order Number LM5521J or LM7521J
See Package 17

Order Number LM5521N or LM7521N
See Package 23

LM5520/LM7520 and LM5521/LM7521 AC test circuit (1)

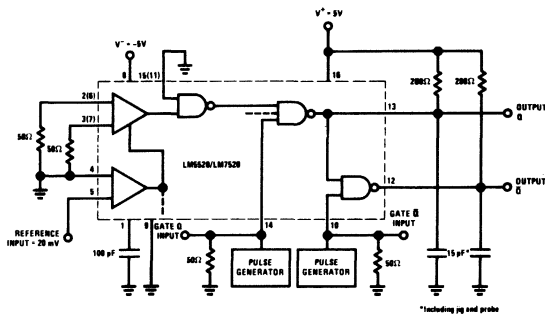


voltage waveforms (1)

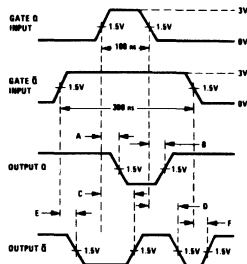


1. Pulse generator characteristics:
 $Z_{OUT} = 50\Omega$, $V_p = 1.5$ V, PRR = 1 MHz
2. Propagation delays:
A - Differential input to logical "1" output A
B - Differential input to logical "0" output A
C - Differential input to logical "1" output B
D - Differential input to logical "0" output B
E - Strobe input to logical "1" output A
F - Strobe input to logical "0" output A
G - Strobe input to logical "0" output B
H - Strobe input to logical "1" output B

AC test circuit (2)



voltage waveforms (2)



1. Pulse generator characteristics:
 $Z_{OUT} = 50\Omega$, $V_p = 1.5$ V, PRR = 1 MHz
2. Propagation delays:
A - Gate A input to logical "1" output A
B - Gate B input to logical "1" output A
C - Gate A input to logical "0" output A
D - Gate B input to logical "0" output A
E - Gate A input to logical "0" output B
F - Gate B input to logical "1" output B



LM5522/LM7522 and LM5523/LM7523 electrical characteristics

LM5522/LM5523: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$ (Note 1)

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER)							COMMENTS
					DIFF. INPUT	REF. INPUT	STROBE INPUT	GATE INPUT	LOGIC OUTPUT	SUPPLY VOLT.		
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8)	15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	+5V	-400 μA	$\pm 5\text{V}$	Logic Output $> 2.4\text{V}$	
	35(33)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5V	+16 mV	$\pm 5\text{V}$	Logic Output $< 0.4\text{V}$	
		40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	+5V	-400 μA	$\pm 5\text{V}$	Logic Output $> 2.4\text{V}$	
		40		mV	$\pm V_{TH}$	40 mV	+5V	+5V	+16 mV	$\pm 5\text{V}$	Logic Output $< 0.4\text{V}$	
Differential & Reference Input Bias Current	30	100		μA	0V	0V	+5.25V	+5.25V		$\pm 5.25\text{V}$		

LM7522/LM7523: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Differential Input Threshold Voltage (V_{TH}) (Note 3)	11(8)	15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	+5V	-400 μA	$\pm 5\text{V}$	Logic Output $> 2.4\text{V}$
	36(33)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5V	+16 mV	$\pm 5\text{V}$	Logic Output $< 0.4\text{V}$
		40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	+5V	-400 μA	$\pm 5\text{V}$	Logic Output $> 2.4\text{V}$
		40		mV	$\pm V_{TH}$	40 mV	+5V	+5V	+16 mV	$\pm 5\text{V}$	Logic Output $< 0.4\text{V}$
Differential & Reference Input Bias Current	30	75		μA	0V	0V	+5.25V	+5.25V		$\pm 5.25\text{V}$	

LM5522/LM5523: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$

LM7522/LM7523: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Diff. Input Offset Current		0.5		μA	0V	0V	+5.25V	+5.25V		$\pm 5.25\text{V}$	
Logic "1" Input Voltage (Strobes) (Gate)	2			V	40 mV	20 mV	+2V	+4.75V	+16 mA	$\pm 5\text{V}$	Logic Output $< 0.4\text{V}$
	2			V	40 mV	20 mV	0V	+2V	-400 μA	$\pm 5\text{V}$	Logic Output $> 2.4\text{V}$
Logic "0" Input Voltage (Strobes) (Gate)			0.8	V	40 mV	20 mV	+0.8V	+4.75V	-400 μA	$\pm 5\text{V}$	Logic Output $> 2.4\text{V}$
			0.8	V	40 mV	20 mV	0V	+0.8V	+16 mA	$\pm 5\text{V}$	Logic Output $< 0.4\text{V}$
Logic "0" Input Current		-1	-1.6	mA	40 mV	20 mV	+0.4V	+0.4V		$\pm 5.25\text{V}$	Each Input
Logic "1" Input Current (Strobes) (Gate)				μA	0V	20 mV	+2.4V	+5.25V		$\pm 5.25\text{V}$	
				mA	0V	20 mV	+5.25V	+5.25V		$\pm 5.25\text{V}$	
				μA	40 mV	20 mV	+5.25V	+2.4V		$\pm 5.25\text{V}$	
				mA	40 mV	20 mV	+5.25V	+5.25V		$\pm 5.25\text{V}$	
Logic "1" Output Voltage	2.4	3.9		V	40 mV	20 mV	+0.8V	+2V	-400 μA	$\pm 4.75\text{V}$	
Logic "0" Output Voltage (Strobes) (Gate)			0.25	V	40 mV	20 mV	+2V	+4.75V	+16 mA	$\pm 4.75\text{V}$	Tie Pins 10 and 12
			0.25	V	40 mV	20 mV	0V	+0.8V	+16 mA	$\pm 4.75\text{V}$	Tie Pins 10 and 12
Output Short Circuit Current	-2.1	-2.8	-3.5	mA	40 mV	20 mV	0V	+5.25V	0V	$\pm 5.25\text{V}$	Tie Pins 10 and 12
Output Leakage Current		0.01	250	μA	0V	20 mV	0V	+2V	+5.25V	$\pm 4.75\text{V}$	
V^+ Supply Current		23	36	mA	0V	20 mV	0V	0V		$\pm 5.25\text{V}$	
V^- Supply Current		-13	-18	mA	0V	20 mV	0V	0V		$\pm 5.25\text{V}$	

LM5522/LM5523 and LM7522/LM7523: The following apply for $T_A = 25^{\circ}\text{C}$, $V^+ = 5\text{V}$, $V^- = -5\text{V}$

AC Common Mode Input Firing Voltage	± 2.5			V	PULSE	20 mV	+5V	+5V	SCOPE		
Propagation Delays: Differential Input to Logical "1" Output		26		ns		20 mV					AC Test Circuit
Differential Input to Logical "0" Output		21	45	ns		20 mV					AC Test Circuit
Strobe Input to Logical "1" Output		22		ns		20 mV					AC Test Circuit
Strobe Input to Logical "0" Output		12	40	ns		20 mV					AC Test Circuit
Gate Input to Logical "1" Output		4		ns		20 mV					AC Test Circuit
Gate Input to Logical "0" Output		15	25	ns		20 mV					AC Test Circuit
Differential Input Overload Recovery Time		10		ns							
Common Mode Input Overload Recovery Time		5		ns							
Min. Cycle Time		200		ns							

Note 1: For $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ operation, electrical characteristics for LM5522 and LM5523 are guaranteed the same as LM7522 and LM7523, respectively.

Note 2: Limits in parentheses pertain to LM5623, other limits pertain to LM5522.

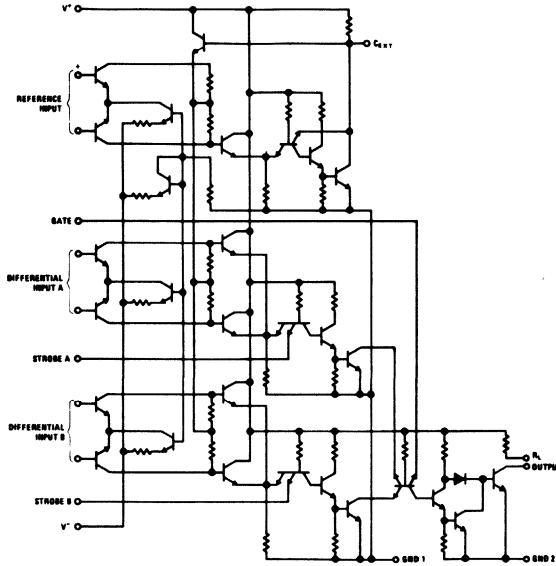
Note 3: Limits in parentheses pertain to LM7523, other limits pertain to LM7522.

Note 4: Positive current is defined as current into the referenced pin.

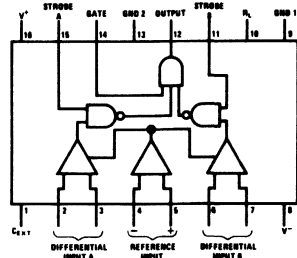
Note 5: Pin 1 to have $\geq 100\text{ pF}$ capacitor connected to ground.

LM5522/LM7522 and LM5523/LM7523

schematic diagram



connection diagram



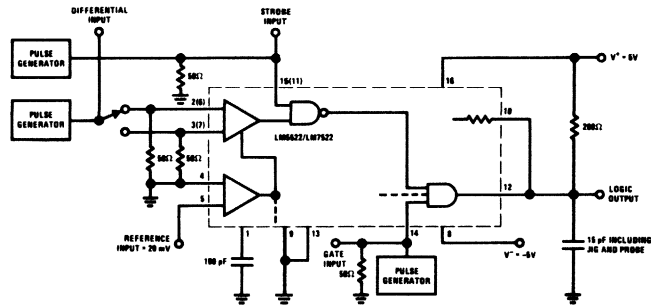
Order Number LM5522J or LM7522J
See Package 17

Order Number LM5522N or LM7522N
See Package 23

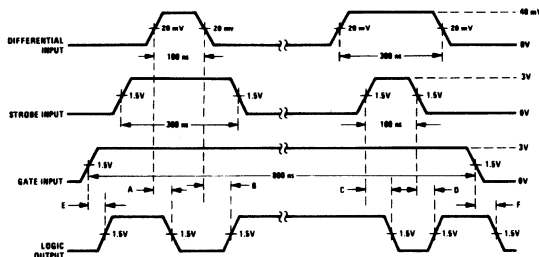
Order Number LM5523J or LM7523J
See Package 17

Order Number LM5523N or LM7523N
See Package 23

AC test circuit



voltage waveforms



1. One strobe is grounded when the other side is being tested
2. Pulse generator characteristics:
 $C_{OUT} = 50k\Omega$, $t_r = t_f = 10-15$ ns, PRR = 1 MHz
3. Propagation delays:
A = Differential input to logical "0" output
B = Differential input to logical "1" output
C = Strobe input to logical "0" output
D = Strobe input to logical "1" output
E = Gate input to logical "1" output
F = Gate input to logical "0" output



LM5524/LM7524 and LM5525/LM7525 electrical characteristics

LM5524/LM5525: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$ (Note 1)

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER)					COMMENTS
					DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8)	15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	+16 mA	$\pm 5V$	Logic Output <0.4V Logic Output >2.4V Logic Output <0.4V Logic Output >2.4V
	35(33)	15		mV	$\pm V_{TH}$	15 mV	+5V	-400 μA	$\pm 5V$	
		40	40	mV	$\pm V_{TH}$	40 mV	+5V	+16 mA	$\pm 5V$	
	40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	-400 μA	$\pm 5V$		
Differential & Reference Input Bias Current	30	100		μA	0V	0V	+5.25V		$\pm 5.25V$	

LM7524/LM7525: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Differential Input Threshold Voltage (V_{TH}) (Note 3)	11(8)	15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	+16 mA	$\pm 5V \pm 5\%$	Logic Output <0.4V Logic Output >2.4V Logic Output <0.4V Logic Output >2.4V
	36(33)	15		mV	$\pm V_{TH}$	15 mV	+5V	-400 μA	$\pm 5V \pm 5\%$	
		40	40	mV	$\pm V_{TH}$	40 mV	+5V	+16 mA	$\pm 5V \pm 5\%$	
	40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	-400 μA	$\pm 5V \pm 5\%$		
Differential & Reference Input Bias Current	30	75		μA	0V	0V	+5.25V		$\pm 5.25V$	

LM5524/LM5525: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$

LM7524/LM7525: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Diff. Input Offset Current		0.5		μA	0V	0V	+5.25V		$\pm 5.25V$	
Logic "1" Input Voltage	2			V	40 mV	20 mV	+2V	-400 μA	$\pm 5V$	Logic Output >2.4V Logic Output <0.4V
Logic "0" Input Voltage			0.8	V	40 mV	20 mV	+0.8V	+16 mA	$\pm 5V$	
Logic "0" Input Current		-1	-1.6	mA	40 mV	20 mV	+0.4V		$\pm 5.25V$	
Logic "1" Input Current		5	40	μA	0V	20 mV	+2.4V		$\pm 5.25V$	
Logic "1" Input Current		0.02	1	mA	0V	20 mV	+5.25V		$\pm 5.25V$	
Logic "1" Output Voltage	2.4	3.9		V	40 mV	20 mV	+2.0V	-400 μA	$\pm 4.75V$	
Logic "0" Output Voltage		0.25	0.40	V	40 mV	20 mV	+0.8V	+16 mA	$\pm 4.75V$	
Output Short Circuit Current	-2.1	-2.8	-3.5	mA	40 mV	20 mV	+5.25V	0V	$\pm 5.25V$	
V^+ Supply Current		29	40	mA	0V	20 mV	0V		$\pm 5.25V$	
V^- Supply Current		-13	-18	mA	0V	20 mV	0V		$\pm 5.25V$	

LM5524/LM5525 and LM7524/LM7525: The following apply for $T_A = 25^{\circ}\text{C}$, $V^+ = 5V$, $V^- = -5V$

AC Common-Mode Input Firing Voltage		± 2.5		V	PULSE	20 mV	+5V	SCOPE		
Propagation Delays:										
Differential Input to Logical "1" Output	20	40		ns		20 mV				AC Test Circuit
Differential Input to Logical "0" Output	28			ns		20 mV				AC Test Circuit
Strobe Input to Logical "1" Output	10	30		ns		20 mV				AC Test Circuit
Strobe Input to Logical "0" Output	20			ns		20 mV				AC Test Circuit
Differential Input Overload Recovery Time	10			ns						
Common-Mode Input Overload Recovery Time	5			ns						
Min. Cycle Time	200			ns						

Note 1: For $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ operation, electrical characteristics for LM5524 and LM5525 are guaranteed the same as LM7524 and LM7525 respectively.

Note 2: Limits in parentheses pertain to LM5525, other limits pertain to LM5524.

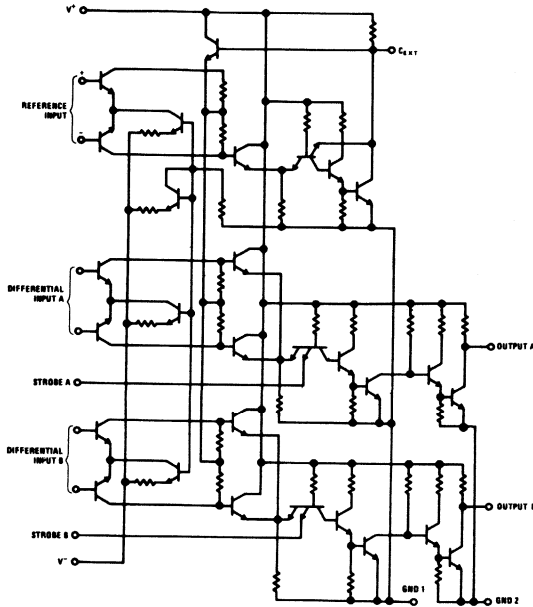
Note 3: Limits in parentheses pertain to LM7525, other limits pertain to LM7524.

Note 4: Positive current is defined as current into the referenced pin.

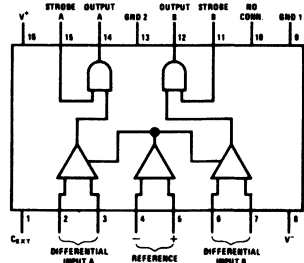
Note 5: Pin 1 to have ≥ 100 pF capacitor connected to ground.

LM5524/LM7524 and LM5525/LM7525

schematic diagram



connection diagram



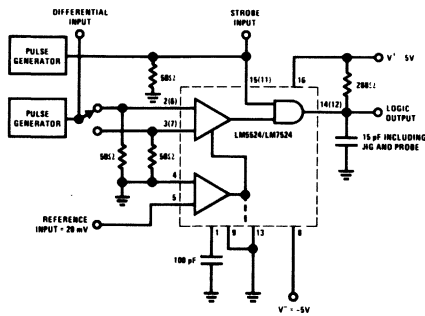
Order Number LM5524J or LM7524J
See Package 17

Order Number LM5524N or LM7524N
See Package 23

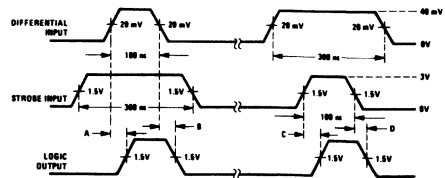
Order Number LM5525J or LM7525J
See Package 17

Order Number LM5525N or LM7525N
See Package 23

AC test circuit



voltage waveforms



1. Pulse generator characteristics:
 $f_{REP} = 500$ Hz, $t_r = t_f = 15$ ns, PRR = 1 MHz
2. Propagation delay:
A = Differential input to logical "1" output
B = Differential input to logical "0" output
C = Strobe input to logical "1" output
D = Strobe input to logical "0" output

LM5528/LM7528 and LM5529/LM7529 electrical characteristics

LM5528/LM5529: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$ (Note 1)

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER)					COMMENTS
					DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8)	15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	+16 mA	$\pm 5V$	Logic Output <0.4V
	35(33)	15		mV	$\pm V_{TH}$	15 mV	+5V	-400 μA	$\pm 5V$	Logic Output >2.4V
		40	40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	+16 mA	$\pm 5V$	Logic Output <0.4V
Differential & Reference Input Bias Current		30	100	μA	0V	0V	+5.25V		$\pm 5.25V$	Logic Output >2.4V

LM7528/LM7529: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Differential Input Threshold Voltage (V_{TH}) (Note 3)	11(8)	15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	+16 mA	$\pm 5V$	Logic Output <0.4V
	36(33)	15		mV	$\pm V_{TH}$	15 mV	+5V	-400 μA	$\pm 5V$	Logic Output >2.4V
		40	40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	+16 mA	$\pm 5V$	Logic Output <0.4V
Differential & Reference Input Bias Current		30	75	μA	0V	0V	+5.25V		$\pm 5.25V$	Logic Output >2.4V

LM5528/LM5529: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$

LM7528/LM7529: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Diff. Input Offset Current		0.5		μA	0V	0V	+5.25V		$\pm 5.25V$	
Logic "1" Input Voltage	2			V	40 mV	20 mV	+2V	-400 μA	$\pm 5V$	Logic Output >2.4V
Logic "0" Input Voltage			0.8	V	40 mV	20 mV	+0.8V	+16 mA	$\pm 5V$	Logic Output <0.4V
Logic "0" Input Current		-1	-1.6	mA	40 mV	20 mV	+0.4V		$\pm 5.25V$	
Logic "1" Input Current	5	40		μA	0V	20 mV	+2.4V		$\pm 5.25V$	
		0.02	1	mA	0V	20 mV	+5.25V		$\pm 5.25V$	
Logic "1" Output Voltage	2.4	3.9		V	40 mV	20 mV	+2.0V	-400 μA	$\pm 4.75V$	
Logic "0" Output Voltage		0.25	0.40	V	40 mV	20 mV	+0.8V	+16 mA	$\pm 4.75V$	
Output Short Circuit Current	-2.1	-2.8	-3.5	mA	40 mV	20 mV	+5.25V	0V	$\pm 5.25V$	
V^+ Supply Current		29	40	mA	0V	20 mV	0V		$\pm 5.25V$	
V^- Supply Current		-13	-18	mA	0V	20 mV	0V		$\pm 5.25V$	

LM5528/LM5529 and LM7528/LM7529: The following apply for $T_A = 25^{\circ}\text{C}$, $V^+ = 5V$, $V^- = -5V$

AC Common-Mode Input Firing Voltage		± 2.5		V	PULSE	20 mV	+5V	SCOPE		
Propagation Delays:										
Differential Input to Logical "1" Output		20	40	ns		20 mV				AC Test Circuit
Differential Input to Logical "0" Output		28		ns		20 mV				AC Test Circuit
Strobe Input to Logical "1" Output		10	30	ns		20 mV				AC Test Circuit
Strobe Input to Logical "0" Output		20		ns		20 mV				AC Test Circuit
Differential Input Overload Recovery Time		10		ns						
Common-Mode Input Overload Recovery Time		5		ns						
Min. Cycle Time		200		ns						

Note 1: For $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ operation, electrical characteristics for LM5528 and LM5529 are guaranteed the same as LM7528 and LM7529 respectively.

Note 2: Limits in parentheses pertain to LM5529, other limits pertain to LM5528.

Note 3: Limits in parentheses pertain to LM7529, other limits pertain to LM7528.

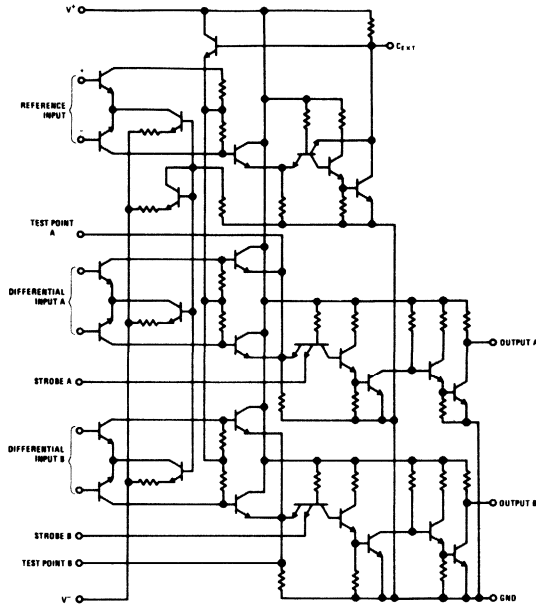
Note 4: Positive current is defined as current into the referenced pin.

Note 5: Pin 1 to have ≥ 100 pF capacitor connected to ground.

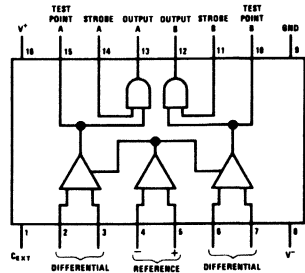
Note 6: Each test point to have ≤ 15 pF capacitive load to ground.

LM5528/LM7528 and LM5529/LM7529

schematic diagram



connection diagram



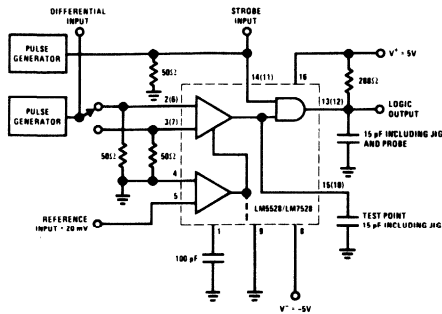
Order Number LM5528J or LM7528J
See Package 17

Order Number LM5528N or LM7528N
See Package 23

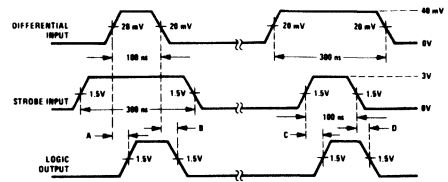
Order Number LM5529J or LM7529J
See Package 17

Order Number LM5529N or LM7529N
See Package 23

AC test circuit



voltage waveforms



- Pulse generator characteristics:
 $Z_{OUT} = 50\Omega$, $t_{R/F} = 10 - 15$ ns, PRR = 1 MHz
- Propagation delays:
A = Differential input to logical "1" output
B = Differential input to logical "0" output
C = Strobe input to logical "1" output
D = Strobe input to logical "0" output

LM5534/LM7534 and LM5535/LM7535 electrical characteristics

LM5534/LM5535: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$ (Note 1)

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER)					COMMENTS
					DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5.25V	+5V	Logic Output <250 μA
		15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	+20 mA	+5V	Logic Output <0.4V
	36(33)	40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	+5.25V	+5V	Logic Output <250 μA
Differential & Reference Input Bias Current		30	100	μA	0V	0V	+5.25V		+5.25V	Logic Output <0.4V

LM7534/LM7535: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Differential Input Threshold Voltage (V_{TH}) (Note 3)	11(8)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5.25V	+5V	Logic Output <250 μA
		15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	+20 mA	+5V	Logic Output <0.4V
	36(33)	40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	+5.25V	+5V	Logic Output <250 μA
Differential & Reference Input Bias Current		30	75	μA	0V	0V	+5.25V		+5.25V	Logic Output <0.4V

LM5534/LM5535: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$

LM7534/LM7535: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Diff. Input Offset Current		0.5		μA	0V	0V	+5.25V		+5.25V	
Logic "0" Input Voltage			0.8	V	40 mV	20 mV	+0.8V	+5.25V	+5V	Logic Output <250 μA
Logic "1" Input Voltage	2.0			V	40 mV	20 mV	+2.0V	+20 mA	+5V	Logic Output <0.4V
Logic "0" Input Current		-1	-1.6	mA	40 mV	20 mV	+0.4V		+5.25V	
Logic "1" Input Current		5	40	μA	0V	20 mV	+2.4V		+5.25V	
		0.02	1	mA	0V	20 mV	+5.25V		+5.25V	
Logic "0" Output Voltage		0.25	0.40	V	40 mV	20 mV	+2V	+20 mA	+4.75V	
Output Leakage Current		0.01	250	μA	40 mV	20 mV	+0.8V	+5.25V	+4.75V	
V^+ Supply Current		28	38	mA	0V	20 mV	0V		+5.25V	
V^- Supply Current		-13	-18	mA	0V	20 mV	0V		+5.25V	

LM5534/LM5535 and LM7534/LM7535: The following apply for $T_A = 25^{\circ}\text{C}$, $V^+ = 5\text{V}$, $V^- = -5\text{V}$

AC Common-Mode Input Firing Voltage		± 2.5		V	PULSE	20 mV	+5V	SCOPE		
Propagation Delays:										
Differential Input to Logical "1" Output		24		ns		20 mV				AC Test Circuit
Differential Input to Logical "0" Output		20	40	ns		20 mV				AC Test Circuit
Strobe Input to Logical "1" Output		16		ns		20 mV				AC Test Circuit
Strobe Input to Logical "0" Output		10	30	ns		20 mV				AC Test Circuit
Differential Input Overload Recovery Time		10		ns						
Common-Mode Input Overload Recovery Time		5		ns						
Min. Cycle Time		200		ns						

Note 1: For $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ operation, electrical characteristics for LM5534 and LM5535 are guaranteed the same as LM7534 and LM7535 respectively.

Note 2: Limits in parentheses pertain to LM5535, other limits pertain to LM5534

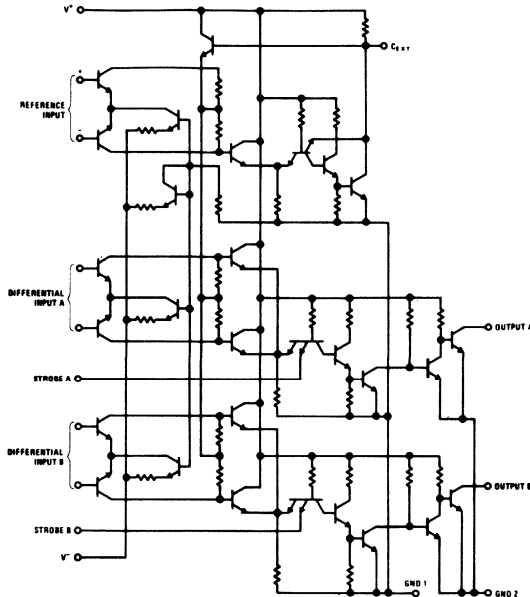
Note 3: Limits in parentheses pertain to LM7535, other limits pertain to LM7534

Note 4: Positive current is defined as current into the referenced pin

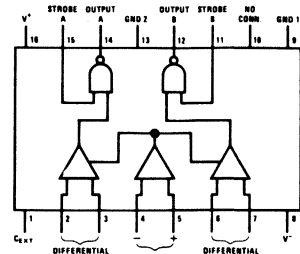
Note 5: Pin 1 to have ≥ 100 pF capacitor connected to ground.

LM5534/LM7534 and LM5535/LM7535

schematic diagram



connection diagram



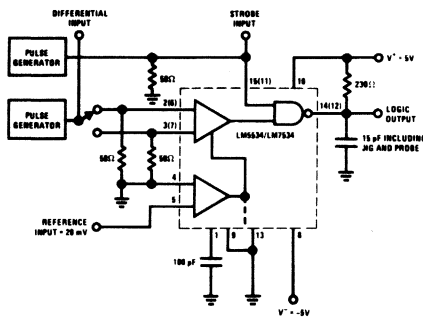
Order Number LM5534J or LM7534J
See Package 17

Order Number LM5534N or LM7534N
See Package 23

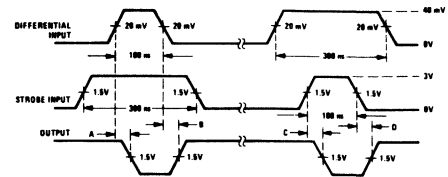
Order Number LM5535J or LM7535J
See Package 17

Order Number LM5535N or LM7535N
See Package 23

AC test circuit



voltage waveforms



1. Pulse generators have the following characteristics:
 $Z_{OUT} = 50\Omega$, $L = 1\mu$, $V = 15k/5k$ mV, $PRR = 1$ MHz
2. Propagation delays:
A = Differential input to logical "0" output
B = Differential input to logical "1" output
C = Strobe input to logical "0" output
D = Strobe input to logical "1" output

LM5538/LM7538 and LM5539/LM7539 electrical characteristics

LM5538/LM5539: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$ (Note 1)

PARAMETER	MIN	TYP	MAX	UNIT	TEST CONDITIONS (EACH AMPLIFIER)					COMMENTS
					DIFF. INPUT	REF. INPUT	STROBE INPUT	LOGIC OUTPUT	SUPPLY VOLT.	
Differential Input Threshold Voltage (V_{TH}) (Note 2)	10(8) 35(33)	15		mV	$\pm V_{TH}$	15 mV	+5V	+5.25V	$\pm 5V$	Logic Output <250 μA
		15	20(22)	mV	$\pm V_{TH}$	15 mV	+5V	+20 mA	$\pm 5V$	Logic Output <0.4V
		40		mV	$\pm V_{TH}$	40 mV	+5V	+5.25V	$\pm 5V$	Logic Output <250 μA
		40	45(47)	mV	$\pm V_{TH}$	40 mV	+5V	+20 mA	$\pm 5V$	Logic Output <0.4V
Differential & Reference Input Bias Current		30	100	μA	0V	0V	+5.25V		$\pm 5.25V$	

LM7538/LM7539: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Differential Input Threshold Voltage (V_{TH}) (Note 3)	11(8) 36(33)	15	19(22)	mV	$\pm V_{TH}$	15 mV	+5V	+5.25V	$\pm 5V$	Logic Output <250 μA
		15		mV	$\pm V_{TH}$	15 mV	+5V	+20 mA	$\pm 5V$	Logic Output <0.4V
		40	44(47)	mV	$\pm V_{TH}$	40 mV	+5V	+5.25V	$\pm 5V$	Logic Output <250 μA
		40		mV	$\pm V_{TH}$	40 mV	+5V	+20 mA	$\pm 5V$	Logic Output <0.4V
Differential & Reference Input Bias Current		30	75	μA	0V	0V	+5.25V		$\pm 5.25V$	

LM5538/LM5539: The following apply for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$

LM7538/LM7539: The following apply for $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$

Diff. Input Offset Current		0.5		μA	0V	0V	+5.25V		$\pm 5.25V$	
Logic "1" Input Voltage	2			V	40 mV	20 mV	+2V	+20 mA	$\pm 5V$	Logic Output <0.4V
Logic "0" Input Voltage			0.8	V	40 mV	20 mV	+0.8V	+5.25V	$\pm 5V$	Logic Output <250 μA
Logic "0" Input Current		-1	-1.6	mA	40 mV	20 mV	+0.4V		$\pm 5.25V$	
Logic "1" Input Current		5	40	μA	0V	20 mV	+2.4V		$\pm 5.25V$	
Logic "1" Input Current		0.02	1	mA	0V	20 mV	+5.25V		$\pm 5.25V$	
Logic "0" Output Voltage		0.25	0.40	V	40 mV	20 mV	+2.0V	+20 mA	$\pm 4.75V$	
Output Leakage Current		0.01	250	μA	40 mV	20 mV	+0.8V	+5.25V	$\pm 4.75V$	
V^+ Supply Current		28	38	mA	0V	20 mV	0V		$\pm 5.25V$	
V^- Supply Current		-13	-18	mA	0V	20 mV	0V		$\pm 5.25V$	

LM5538/LM5539 and LM7538/LM7539: The following apply for $T_A = 25^{\circ}\text{C}$, $V^+ = 5V$, $V^- = -5V$

AC Common-Mode Input Firing Voltage		± 2.5		V	PULSE	20 mV	+5V	SCOPE		
Propagation Delays:										
Differential Input to Logical "1" Output		24		ns		20 mV				AC Test Circuit
Differential Input to Logical "0" Output		20	40	ns		20 mV				AC Test Circuit
Strobe Input to Logical "1" Output		16		ns		20 mV				AC Test Circuit
Strobe Input to Logical "0" Output		10	30	ns		20 mV				AC Test Circuit
Differential Input Overload Recovery Time		10		ns						
Common-Mode Input Overload Recovery Time		5		ns						
Min. Cycle Time		200		ns						

Note 1: For $0^{\circ}\text{C} \leq T_A < 70^{\circ}\text{C}$ operation, electrical characteristics for LM5538 and LM5539 are guaranteed the same as LM7538 and LM7539 respectively.

Note 2: Limits in parentheses pertain to LM5539, other limits pertain to LM5538.

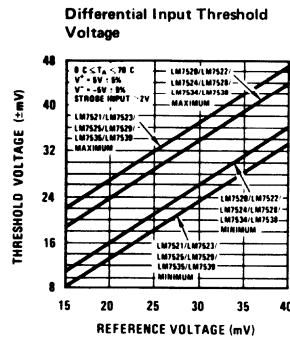
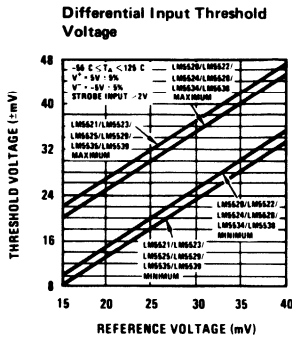
Note 3: Limits in parentheses pertain to LM7539, other limits pertain to LM7538.

Note 4: Positive current is defined as current into the referenced pin.

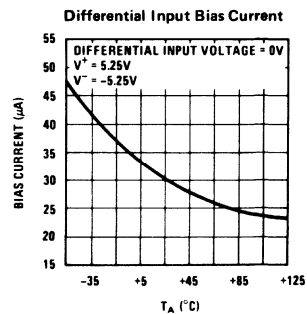
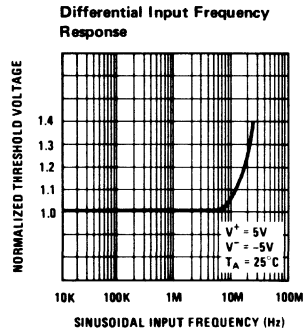
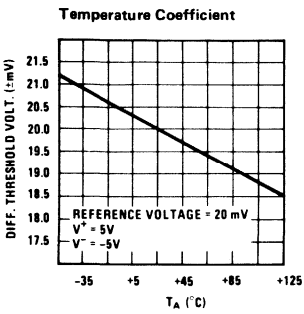
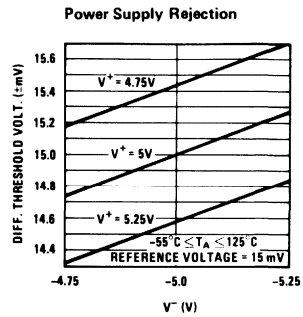
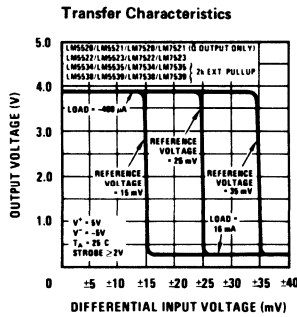
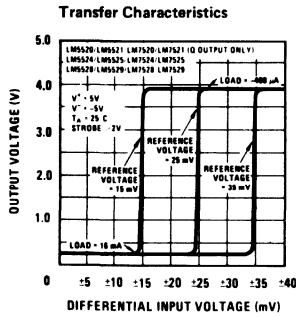
Note 5: Pin 1 to have ≥ 100 pF capacitor connected to ground.

Note 6: Each test point to have ≤ 15 pF capacitive load to ground.

guaranteed performance characteristics

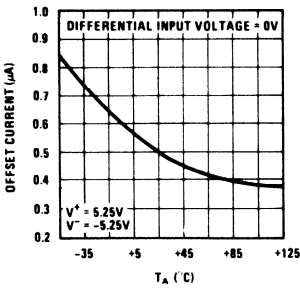


typical performance characteristics

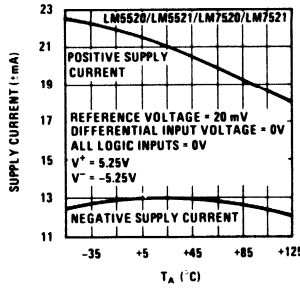


typical performance characteristics (cont.)

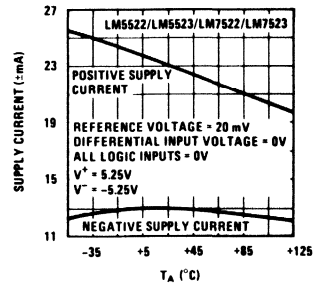
Differential Input Offset Current



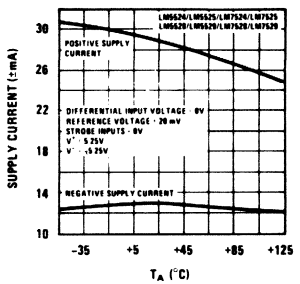
Power Supply Currents



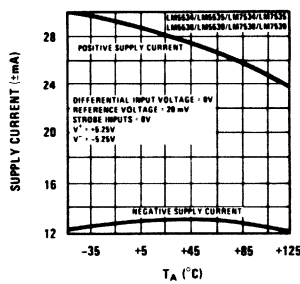
Power Supply Currents



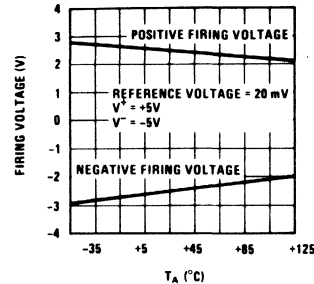
Power Supply Currents



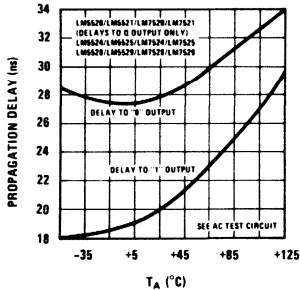
Power Supply Currents



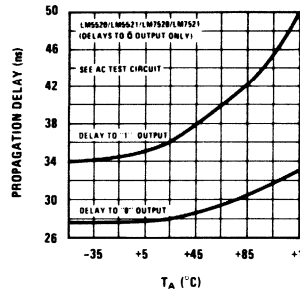
AC Common-Mode Firing Voltage



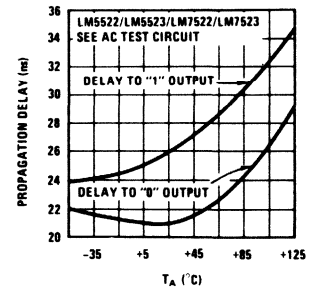
Differential Input to Output Propagation Delays



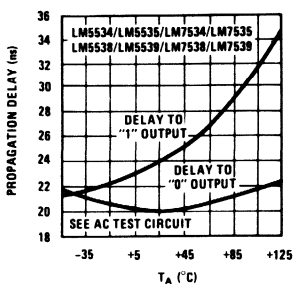
Differential Input to Output Propagation Delays



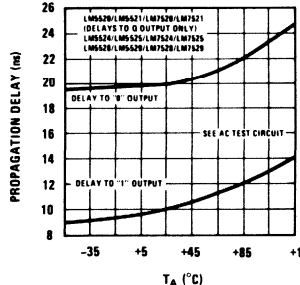
Differential Input to Output Propagation Delays



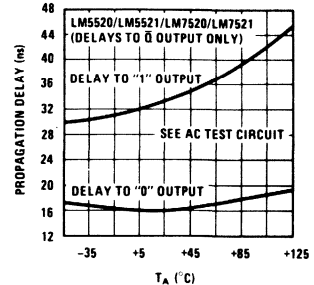
Differential Input to Output Propagation Delays



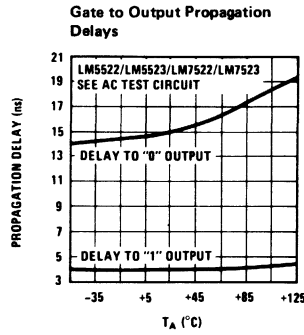
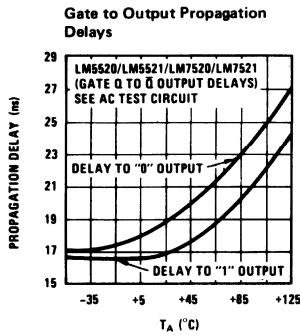
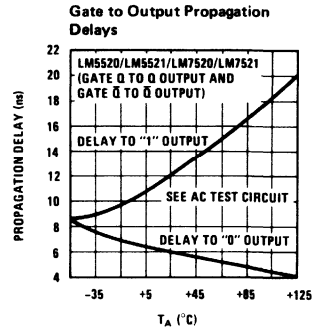
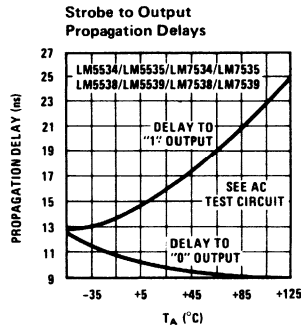
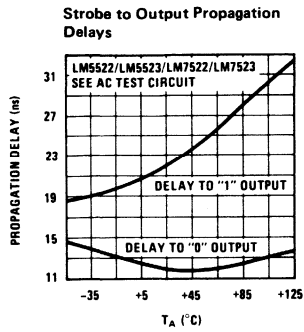
Strobe to Output Propagation Delays



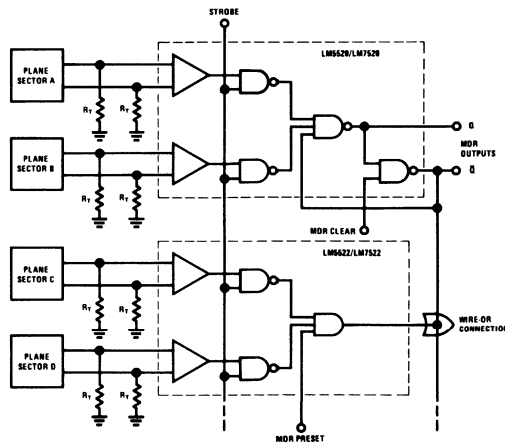
Strobe to Output Propagation Delays



typical performance characteristics (cont.)

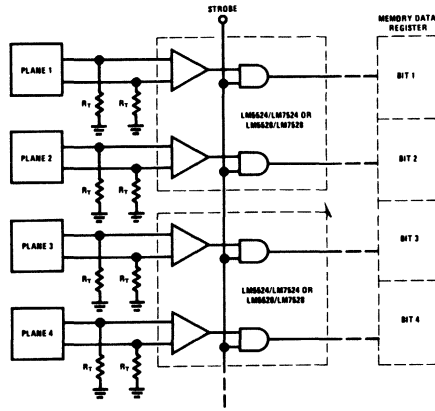


typical applications

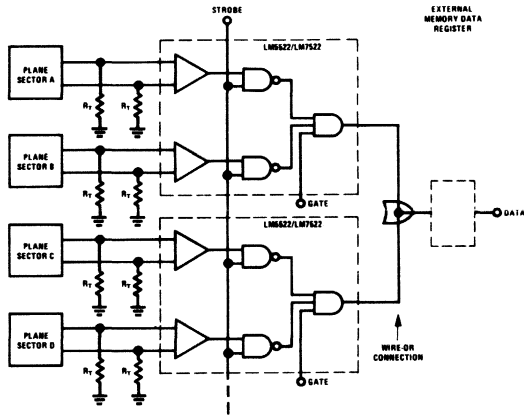


Large Memory System with Sector Core Planes

typical applications (cont.)



Small Memory System



Large Memory System



New Products

LM125, LM126, LM127 dual complementary tracking voltage regulators

general description

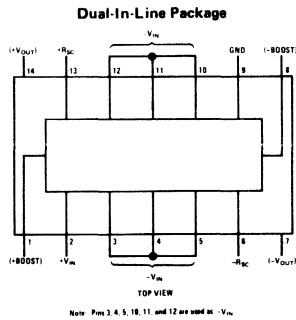
These are precision dual regulators with fixed outputs of $\pm 15V$ (LM125), $\pm 12V$ (LM126), and $+5V, -12V$ (LM127), accurate to $\pm 2\%$. Complete protection of the regulators is assured by internal short circuit current limit and thermal shutdown. Positive output voltage tracks negative output under all conditions. The circuit will be available in 9-lead power plastic dual-in-line and 10-lead TO-5 hermetic packages.

features

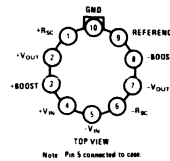
- Output currents ± 100 mA with provisions for current boost to 5 amps

- Low output drift $\pm 0.001\%/^{\circ}C$
- Output impedance $50 M\Omega$
- Internally compensated few external components
- Other specs
 - Line regulation 1 mV/V
 - Input/output differential $2.5V$ min.
 - Maximum input $\pm 40V$
 - Electronic shutdown TTL compatible

connection diagrams



Metal Can Package



LM143 high voltage operational amplifier

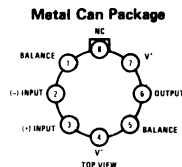
general description

A general purpose internally compensated super β operational amplifier with operation to $\pm 40V$. The circuit is pin-for-pin compatible with the Motorola MC1536 but has improved offset, drift and input over-voltage characteristics. It will be available in an 8-lead TO-5 metal can package.

connection diagram

features

- Low input bias 10 nA
- Low input offset current 2 nA
- High slew rate $\pm 2.5V/\mu s$
- Input over voltage protection Full $\pm 40V$
- Pin compatible with Motorola MC1536 but has improved offset, drift and breakdown characteristics



LM378 4 watt/channel stereo amplifier

general description

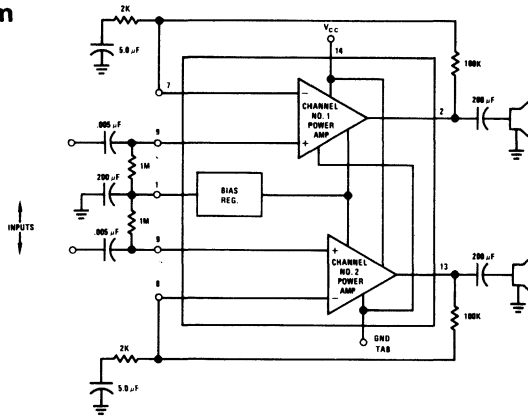
The LM378 is a monolithic dual power amplifier which offers high quality performance for stereo phonographs, tape players, and recorders, AM & FM stereo receivers, etc.

The LM378 will deliver 4 Watts/channel into a 16Ω load. The amplifier is designed to operate with a minimum of external components and contains an internal bias regulator to bias each amplifier and supply 80 dB supply rejection.

features

- High Gain 100 dB/channel
- Low Distortion 1% T.H.P.
- High Output Current 1.2A
- Supply Voltage 9-30V
- Internally Compensated
- Short Circuit Protection
- Thermal Limiting Protection

block diagram



LM383 5 watt power amplifier

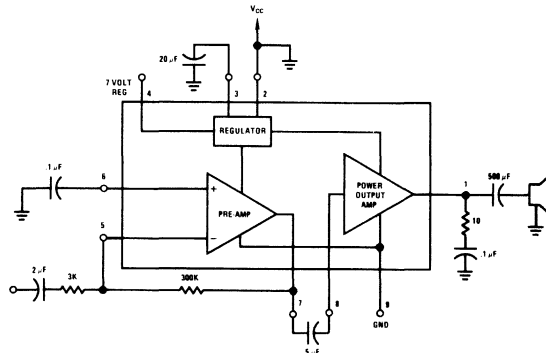
general description

The LM383 is a monolithic power amplifier capable of delivering 5 watts rms into a 4Ω load at 14V supply voltage. The amplifier includes a separate preamplifier and power amplifier giving an open loop gain of 15,000. Also provided on the chip is a power supply decoupler-regulator providing power supply rejection as well as an external 7V regulated reference voltage.

features

- Wide supply operating range 8 – 18V
- High gain – Preamplifier 1500 V/V
Power amplifier 10 V/V
- Low distortion 1% T.H.D.
- Wide power bandwidth 40 kHz
- Short circuit protection
- Thermal limiting protection

block diagram



LM1805 TV signal processor

general description

A complete two watt TV sound system, utilizing proven circuit techniques, has been incorporated in the LM1805. The FM IF portion utilizes a three stage limiting amplifier and a differential peak detector combined with a linear DC volume control. Designed for use with a minimum number of external components, the audio power amplifier section may be operated over a wide range of power supply and a speaker impedance combinations.

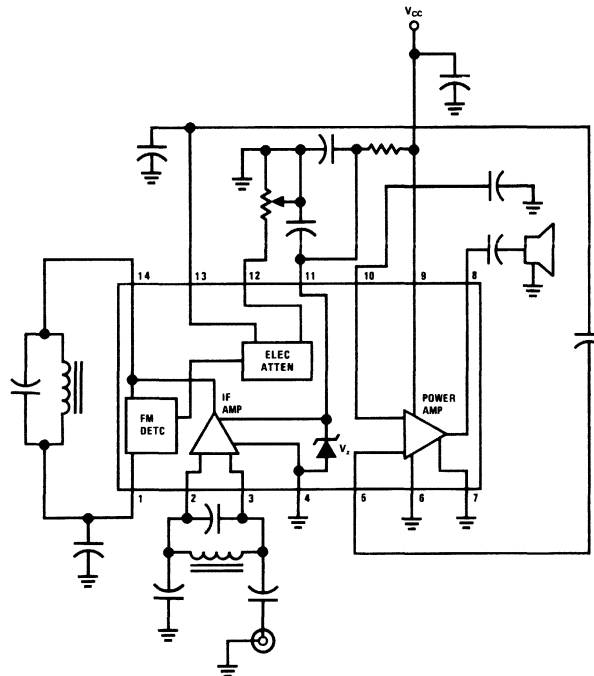
Thermal overload protection and current limiting

insure reliable, fail safe operation in adverse environments.

features

- Regulator for FM IF section
- Low harmonic distortion
- Excellent AM rejection
- Fixed voltage gain in audio power amplifier
- 1.3 amp current capability
- Linear volume control

block diagram



DM7833, DM7834, DM7835, DM7839

quad TRI-STATE[®] transceiver

general description

This family of TRI-STATE[™] party line transceivers offer extreme versatility in bus organized data transmission systems. The data bus may be unterminated, or terminated DC or AC at one or both ends. Drivers in the third (high impedance) state load the data bus with a negligible leakage current. The receiver input current is low allowing at least 100 driver/receiver pairs to utilize a single bus. The bus loading is unchanged when $V_{CC} = 0V$. The receiver incorporates hysteresis to provide greater noise immunity. All devices utilize a high current TRI-STATE output driver. The DM7833/DM8833 and DM7835/DM8835 employ TRI-STATE outputs on the receiver also, while on the DM7834/DM8834 and DM7839/DM8839 the receiver outputs are standard active pull up T²L.

The DM7833/DM8833 are non-inverting quad transceivers with a common inverter driver disable control.

The DM7839/DM8839 are non-inverting quad transceivers with a common two-input driver disable control.

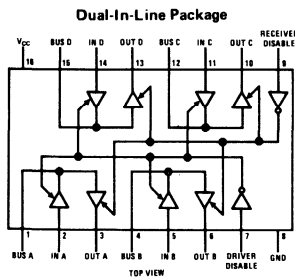
The DM7834/DM8834 are inverting quad transceivers with a common two input driver disable control.

The DM7835/DM8835 are inverting quad transceivers with a common inverter driver disable control and a common inverter receiver disable control.

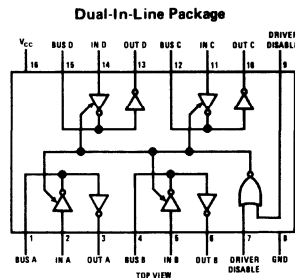
features

- Receiver hysteresis 450 mV (typ)
- Receiver noise immunity 1.4V (typ)
- Receiver input current 50 μA (max) for normal V_{CC} or $V_{CC} = 0V$
- Receivers
 - Sink 16 mA at 0.4V (max)
 - Source 2.0 mA (mil) 5.2 mA (com) at 2.4V (min)
- Drivers
 - Sink 50 mA at 0.5V (max) or 32 mA at 0.4V (max)
 - Source 10.4 mA at 2.4V (min)
- Drivers have TRI-STATE outputs
- DM7833/DM8833 and DM7835/DM8835 receivers have TRI-STATE outputs
- Capable of driving 100 Ω DC terminated buses
- 74 series TTL compatible

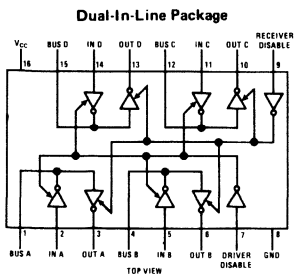
connection diagrams



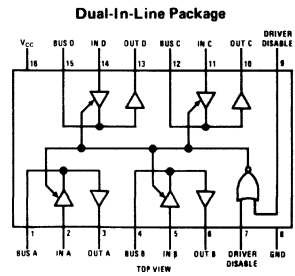
DM7833/DM8833



DM7834/DM8834



DM7835/DM8835



DM7839/DM8839

**DM5446A/DM7446A, DM5447A/DM7447A,
DM5448/DM7448 BCD to 7-segment decoder/drivers**

**DM7856/DM8856, DM8857,
DM7858/DM8858 BCD-to-7-segment LED drivers**

general description

This versatile series of 7-segment display drivers fullfills a wide variety of requirements for most active high or active low LED or lamp displays. Each device fully decodes a 4-bit BCD input into a number from 0 through 9 in the standard 7-segment display format, and BCD numbers above 9 into unique patterns that verify operation.

The DM5446A/DM7446A has active-low, open-collector outputs that will drive segments requiring up to 40 mA. The outputs will withstand 30V with a maximum reverse current of 250 μ A. In addition the circuit may be used to drive logic circuits with a normalized fanout of 25.

The DM5447A/DM7447A has the same output characteristics as the DM5446A/DM7446A except that the outputs withstand 15V at a maximum reverse current of 250 μ A.

The DM5448/DM7448 has active-high, passive-pull-up outputs with a fanout of 4 and typical source current of 2 mA at a voltage of 0.85V. It is normally used to drive logic circuits, operate high-voltage loads such as electroluminescent displays through buffer transistors or SCR switches, and in low current non-multiplex LED applications.

The DM7856/DM8856 has active-high, passive-pull-up outputs which provide a typical source current of 6 mA at an output voltage of 1.7V. The applications are the same as for the DM5448/DM7448 except that more design freedom is allowed with higher source levels.

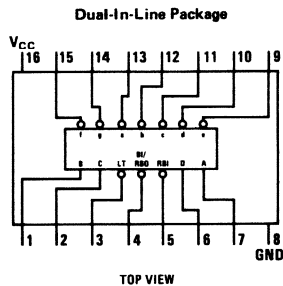
The DM8857 has active-high outputs and is designed for multiplexing applications. It provides a typical source current of 50 mA at an output voltage of 2.3V.

The DM7858/DM8858 has active high outputs with source current adjustable with an external resistor. This feature allows extreme flexibility in source current value selection for either multiplex or non-multiplex applications.

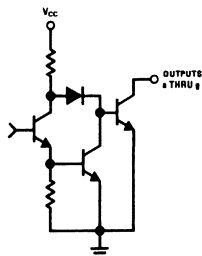
features

- Lamp-test input
- Leading/trailing zero suppression (RBI and RBO)
- Blanking input that may be used to modulate lamp intensity or inhibit output
- TTL and DTL compatible

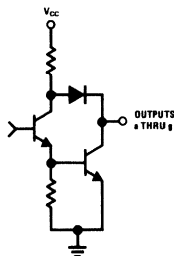
connection diagram



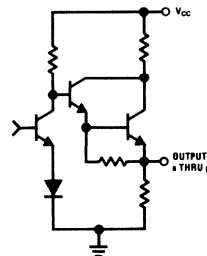
output stage schematics



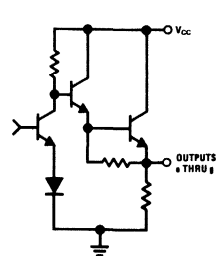
**DM5446A/DM7446A
DM5447A/DM7447A**



**DM5448/DM7448
DM7856/DM8856**



DM8857



DM7858/DM8858

DM8887 8-digit Panaplex II anode driver

general description

The DM8887 is designed to drive the individual anodes of a 7-segment high voltage gas-discharge panel in a time multiplexed fashion.

When driven with appropriate input signals, the driver will switch voltage and impedance levels at

the anode. This will allow or prevent ionization of gas around selected cathodes in order to form a numeric display. Its main application will be to act as a buffer between MOS outputs (fully decoded) and the anodes of a gas-discharge panel, since it can source up to 16 mA at a low impedance and can tolerate more than -55V in the off state.

DM8889 high voltage segment driver

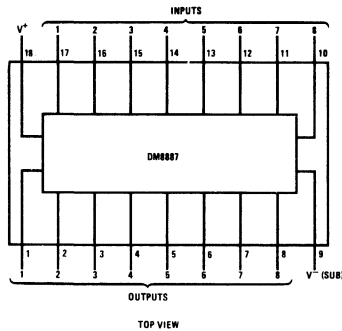
general description

DM8889 is capable of driving eight outputs with a constant output sink current programmable by an external resistor, R_p . The program current is

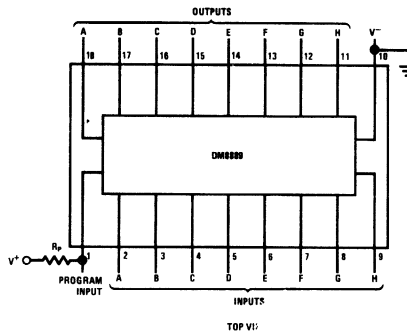
half that of output on current. In the off state the outputs can tolerate more than 80V. The ration of "on" currents is within $\pm 10\%$.

connection diagrams

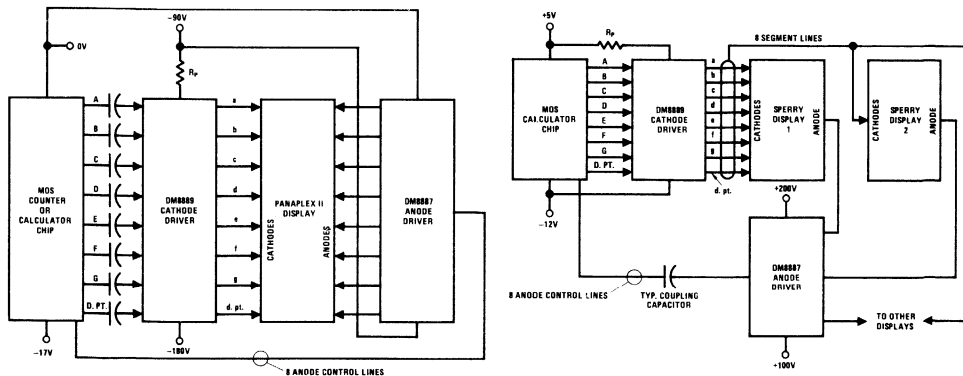
Dual-In-Line Package



Dual-In-Line Package



typical applications





MIL-STD-883/MIL-M-38510

MIL-STD-883/MIL-M-38510

MIL-STD-883

Mil-Standard-883 is a Test Methods and Procedures Document for Microelectronic Circuits. It was derived from MIL-S-19500, MIL-STD-750, and MIL-STD-202C for transistors and diodes at about the time that National Semiconductor Corporation was entering the military microelectronics market. As a result, our standard quality control operations are written around MIL-STD-883. The bonding control, visual inspections, and post seal screening requirements set forth by 883 (as well as added control procedures beyond the requirements of 883) have been part of National's quality control procedures almost from the start. Our Quality Assurance Procedures Manual is available upon request.

We offer a complete line of linear/883 (Class B) products as standard, off-the-shelf items. Special Linear/883 data sheets have been prepared to reflect this capability. They show process flow, electrical parameters, end of test criteria, and test circuits. We save you the problem of specifying test and inspection procedures, and offer significant cost savings by having an off-the-shelf, "to the letter" 883 program. In addition, we will test any of our integrated circuits to any class of MIL-STD-883.

The detailed information concerning MIL-STD-883 screening is contained in National's specification NSC10002.

MIL-M-38510

MIL-M-38510 specifies the general requirements for supplying microcircuits. These are; product assurance, which includes screening and quality conformance inspection; design and construction; marking; and workmanship. The screening and quality conformance inspection are conducted in accordance with MIL-STD-883.

The MIL-M-38510 specs for standard linear devices require 100% DC testing at 25°C, -55°C and +125°C. AC testing is performed at +25°C. The electrical parameters specified are tighter than the normal data sheet guaranteed limits. Additionally, MIL-M-38510 requires device traceability, extensive documentation and closely matched maintenance.

SCREENING

All microcircuits delivered in accordance with MIL-M-38510 must have been subjected to, and passed all the screening tests detailed in Method 5004 of MIL-STD-883 for the type of microcircuit and product assurance level.

The device electrical and package requirements of MIL-M-38510 are detailed by a device specification referred to as a slash sheet. Each slash sheet defines the microcircuit electrical performance and mechanical requirements. Each device listed on a slash sheet is referred to as a slash number and the group of the microcircuits contained on a slash sheet is defined as a family of devices. The device may be Class B or C as defined by MIL-STD-883, Method 5004 and 5005. Three lead finishes are allowed by the slash sheet, pot solder dip, bright tin plate, and gold plate.

QUALITY CONFORMANCE

Quality conformance inspection is conducted in accordance with the applicable requirements of Group A, (electrical test), Group B and C, (environmental test) of Method 5005, MIL-STD-883. These tests are conducted on a sample basis with Group A performed on each subplot, Group B on each lot, and Group C as specified (usually every three months).

To supply devices to MIL-M-38510, the IC manufacturer must qualify the devices he plans to supply to the detail specifications. Qualification consists of notifying the qualifying activity of one's intent to qualify to MIL-M-38510. After passing comprehensive audits of facilities and documentation systems, the IC manufacturer will subject the device to and demonstrate that they satisfy all of

MIL-M-38510 (con't)

the Group A, B, and C requirements of Method 5005 of MIL-STD-883 for the specified classes and types of IC. The qualification tests shall be monitored by the qualifying agency. Finally the IC manufacturer shall prepare and submit qualification test data to the qualifying agency. Groups A, B, and C inspections then shall be performed at intervals no greater than three months.

The purpose of qualification testing is to assure that the device and lot quality conform to certain standard limits. In effect, lot qualification tests tend to ensure that once a particular device type is demonstrated to be acceptable, its production, including materials, processing, and testing will continue to be acceptable. These limits are specified in MIL-STD-883 in terms of LTPD's (Lot Tolerance Percent Defective) for the various qualification test sub-groups. Qualification testing is

performed on a sample of devices which are chosen at random from a lot of devices that has satisfactorily completed the screening of Method 5004 must be performed on each device, i.e. on a 100% basis as opposed to qualification testing (Method 5005) which occurs on a random sample basis.

In summary, the entire purpose of MIL-M-38510 and MIL-STD-883 is to provide the military, through its contractors with standard devices.

We at National Semiconductor have supplied and are supplying devices to the MIL-M-38510 specifications. To order a MIL-M-38510 microcircuit, specify the following:

For example; to specify an LM741 in a DIP processed to the requirements of MIL-M-38510, Class B, with gold plated leads, specify M-38510/10101BCC.

<u>MM38510/</u>	<u>XXX</u>	<u>XX</u>	<u>X</u>	<u>X</u>	<u>X</u>
Specifies the General Require- ments of MIL-M-38510	Slash Sheet No.	Device Type	Device Class	Case Outline	Lead Finish



Definition of Terms

voltage regulators

Current-Limit Sense Voltage: The voltage across the current limit terminals required to cause the regulator to current-limit with a short circuited output. This voltage is used to determine the value of the external current-limit resistor when external booster transistors are used.

Dropout Voltage: The input-output voltage differential at which the circuit ceases to regulate against further reductions in input voltage.

Feedback Sense Voltage: The voltage, referred to ground, on the feedback terminal of the regulator while it is operating in regulation.

Input Voltage Range: The range of DC input voltages over which the regulator will operate within specifications.

Line Regulation: The change in output voltage for a change in the input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average chip temperature is not significantly affected.

Load Regulation: The change in output voltage for a change in load current at constant chip temperature.

Long Term Stability: Output voltage stability under accelerated life-test conditions at 125°C with maximum rated voltages and power dissipation for 1000 hours.

Maximum Power Dissipation: The maximum total device dissipation for which the regulator will operate within specifications.

Output-Input Voltage Differential: The voltage difference between the unregulated input voltage and the regulated output voltage for which the regulator will operate within specifications.

Output Noise Voltage: The RMS AC voltage at the output with constant load and no input ripple, measured over a specified frequency range.

Output Voltage Range: The range of regulated output voltages over which the specifications apply.

Output Voltage Scale Factor: The output voltage obtained for a unit value of resistance between the adjustment terminal and ground.

Quiescent Current: That part of input current to the regulator that is not delivered to the load.

Ripple Rejection: The line regulation for AC input signals at or above a given frequency with a specified value of bypass capacitor on the reference bypass terminal.

Standby Current Drain: That part of the operating current of the regulator which does not contribute to the load current.

Temperature Stability: The percentage change in output voltage for a thermal variation from room temperature to either temperature extreme.

operational amplifiers

Bandwidth: That frequency at which the voltage gain is reduced to $1/\sqrt{2}$ times the low frequency value.

Common Mode Rejection Ratio: The ratio of the input voltage range to the peak-to-peak change in input offset voltage over this range.

Harmonic Distortion: That percentage of harmonic distortion being defined as one-hundred times the ratio of the root-mean-square (rms) sum of the harmonics to the fundamental. % harmonic distortion =

$$\frac{(V_2^2 + V_3^2 + V_4^2 + \dots)^{1/2}}{V_1} (100\%)$$

where V_1 is the rms amplitude of the fundamental and V_2, V_3, V_4, \dots are the rms amplitudes of the individual harmonics.

Input Bias Current: The average of the two input currents.

Input Impedance: The ratio of input voltage to input current under the stated conditions for source resistance (R_S) and load resistance (R_L).

Input Offset Current: The difference in the currents into the two input terminals when the output is at zero.

Input Offset Voltage: That voltage which must be applied between the input terminals through two equal resistances to obtain zero output voltage.

Input Resistance: The ratio of the change in input voltage to the change in input current on either input with the other grounded.

Input Voltage Range: The range of voltages on the input terminals for which the amplifier operates within specifications.

operational amplifiers (con't)

Large-Signal Voltage Gain: The ratio of the output voltage swing to the change in input voltage required to drive the output from zero to this voltage.

Output Impedance: The ratio of output voltage to output current under the stated conditions for source resistance (R_S) and load resistance (R_L).

Output Resistance: The small signal resistance seen at the output with the output voltage near zero.

Output Voltage Swing: The peak output voltage swing, referred to zero, that can be obtained without clipping.

Offset Voltage Temperature Drift: The average drift rate of offset voltage for a thermal variation from room temperature to the indicated temperature extreme.

Power Supply Rejection: The ratio of the change in input offset voltage to the change in power supply voltages producing it.

Settling Time: The time between the initiation of the input step function and the time when the output voltage has settled to within a specified error band of the final output voltage.

Slew Rate: The internally-limited rate of change in output voltage with a large-amplitude step function applied to the input.

Supply Current: The current required from the power supply to operate the amplifier with no load and the output at zero.

Transient Response: The closed-loop step-function response of the amplifier under small-signal conditions.

Unity Gain Bandwidth: The frequency range from DC to the frequency where the amplifier open loop gain rolls off to one.

Voltage Gain: The ratio of output voltage to input voltage under the stated conditions for source resistance (R_S) and load resistance (R_L).

voltage comparators/buffers

Input Bias Current: The average of the two input currents.

Input Offset Current: The absolute value of the difference between the two input currents for which the output will be driven higher than or lower than specified voltages.

Input Offset Voltage: The absolute value of the voltage between the input terminals required to make the output voltage greater than or less than specified voltages.

Input Voltage Range: The range of voltage on the input terminals (common mode) over which the offset specifications apply.

Logic Threshold Voltage: The voltage at the output of the comparator at which the loading logic circuitry changes its digital state.

Negative Output Level: The negative DC output voltage with the comparator saturated by a differential input equal to or greater than a specified voltage.

Output Leakage Current: The current into the output terminal with the output voltage within a given range and the input drive equal to or greater than a given value.

Output Resistance: The resistance seen looking into the output terminal with the DC output level at the logic threshold voltage.

Output Sink Current: The maximum negative current that can be delivered by the comparator.

Positive Output Level: The high output voltage level with a given load and the input drive equal to or greater than a specified value.

Power Consumption: The power required to operate the comparator with no output load. The power will vary with signal level, but is specified as a maximum for the entire range of input signal conditions.

Response Time: The interval between the application of an input step function and the time when the output crosses the logic threshold voltage. The input step drives the comparator from some initial, saturated input voltage to an input level just barely in excess of that required to bring the output from saturation to the logic threshold voltage. This excess is referred to as the voltage overdrive.

Saturation Voltage: The low-output voltage level with the input drive equal to or greater than a specified value.

Strobe Current: The current out of the strobe terminal when it is at the zero logic level.

Strobed Output Level: The DC output voltage, independent of input conditions, with the voltage on the strobe terminal equal to or less than the specified low state.

Strobe ON Voltage: The maximum voltage on either strobe terminal required to force the output to the specified high state independent of the input voltage.

voltage comparators/buffers (con't)

Strobe OFF Voltage: The minimum voltage on the strobe terminal that will guarantee that it does not interfere with the operation of the comparator.

Strobe Release Time: The time required for the output to rise to the logic threshold voltage after the strobe terminal has been driven from zero to the one logic level.

Supply Current: The current required from the positive or negative supply to operate the comparator with no output load. The power will vary with input voltage, but is specified as a maximum for the entire range of input voltage conditions.

Voltage Gain: The ratio of the change in output voltage to the change in voltage between the input terminals producing it.

functional blocks

(LM122/LM222/LM322, LM2905/LM3905 only)

Maximum Power Dissipation: The maximum total device dissipation for which the timer will operate within specifications.

Timing Ratio: The ratio of the firing voltage at the R/C pin to the reference voltage.

Comparator Input Current: The average current flowing from the R/C pin during the timing cycle.

Trigger Voltage: The voltage required at the trigger terminal to initiate a timing cycle, referenced to the ground pin.

Output Leakage Current: The maximum current flowing into the collector of the output transistor when the transistor is in the "off" state.

Reset Resistor: The equivalent resistor which may be used to calculate the discharge time of the timing capacitor. $t_{DISCHARGE} = (5) (C_T) (R_{RESET})$.

Collector Saturation Voltage: The collector to emitter voltage on the output transistor when it is in the "on" state with specified sink current flowing into the collector terminal.

Emitter Saturation Voltage: The voltage across the output transistor when the collector is tied to V^+ , the transistor is in the "on" state, and the specified output current is flowing from the emitter terminal.

Capacitor Saturation Voltage: The offset voltage remaining on the timing capacitor after capacitor discharge current has dropped to zero.

Trigger Current: The current flowing into or out of the trigger terminal at the specified trigger voltage.

R_T : Timing resistor connected between V_{REF} and the R/C terminal.

C_T : Timing capacitor connected between the R/C terminal and the ground terminal.

consumer circuits

AGC DC Output Shift: The shift of the quiescent IC output voltage of the AGC section for a given change in AGC central voltage.

AGC Figure of Merit (AGC Range): The widest possible range of input signal level required to make the output drop by a specified amount from the specified maximum output level.

AGC Input Current: The current required to bias the central voltage input of the AGC section.

AM Rejection Ratio: The ratio of the recovered audio output produced by a desired FM signal of specified level and duration to the recovered audio output produced by an unwanted AM signal of specified amplitude and modulating index.

Channel Separation: The level of output signal of an undriven amplifier with respect to the output level of an adjacent driven amplifier.

Detection Bandwidth: That frequency range about the free running frequency of the tone decoder/phase locked loop where a signal above a specified level will cause a detected signal condition at the output.

Detection Bandwidth Skew: The measure of how well the detection bandwidth is centered about the free running frequency. It is equal to the maximum detection bandwidth frequency plus the minimum detection bandwidth frequency minus twice the free running frequency.

Hold In Range: That range of frequencies about the free running frequency for which the phase locked loop will stay in lock if initially starting out in lock.

Input Bias Current: The average of the two input currents.

consumer circuits (con't)

Input Resistance: The ratio of the change in input voltage to the change in input current on either input with the other grounded.

Input Sensitivity: The minimum level of input signal at a specified frequency required to produce a specified signal-to-noise ratio at the recovered audio output.

Input Voltage Range: The range of voltages on the input terminals for which the amplifier operates within specifications.

Large-Signal Voltage Gain: The ratio of the output voltage swing to the change in input voltage required to drive the output from zero to this voltage.

Limiting Threshold: In FM the input signal level which causes the recovered audio output level to drop 3 dB from the output level with a specified large signal input.

Lock In Range: That range of frequencies about the free running frequency for which the phase locked loop will come into lock if initially starting out of lock.

Maximum Sweep Rate: The maximum rate that the VCO may be made to vary its oscillating frequency over its Sweep Range.

Output Resistance: The ratio of the change in output voltage to the change in output current with the output around zero.

Output Voltage Swing: The peak output voltage swing, referred to zero, that can be obtained without clipping.

Phase Detector Sensitivity: The change in the output voltage of the phase detector for a given change in phase between the two input signals to the phase detector.

Power Bandwidth: That frequency at which the voltage gain reduces to $1/\sqrt{2}$ with respect to the flat band voltage gain specified for a given load and output power.

Power Supply Rejection: The ratio of the change in input offset voltage to the change in power supply voltages producing it.

Slew Rate: The internally limited rate of change in output voltage with a large amplitude step function applied to the input.

Supply Current: The current required from the power supply to operate the amplifier with no load and the output at zero.

Sweep Range: That ratio of maximum oscillating frequency to minimum operating frequency produced by varying the central voltage of the VCO from its maximum value to its minimum value with fixed values of timing resistance and capacitance.

VCO Sensitivity: The change in operating frequency for a given change in VCO central voltage.

analog switches

Driver Leakage Current: The sum of the currents into the source and drain switch terminals, with both held at the same specified voltage.

Logic "1" Input Voltage: The voltage level which is guaranteed to be interpreted by the device as a logical "true" signal.

Logic "0" Input Voltage: The voltage level which is guaranteed to be interpreted by the device as a logical "false" signal.

Logic Input Slew Rate: The voltage difference between the logic "1" and logic "0" states divided by the transition time.

Switch Leakage Current: The current seen when a specified voltage is applied between drain and source of a channel that is logically turned off.

Switch On Resistance: The equivalent resistance from source to drain, tested by forcing a specified current and measuring the resultant voltage drop.

Switch Turn-Off Time: The interval between the time that the logic input passes through the threshold voltage and the time that the output goes to a specified voltage level in the test circuit.

Switch Turn-On Time: The interval between the time that the logic input passes through the threshold voltage and the time that the output goes to 90% of its final value in the specified test circuit.

interface circuits

Common Mode Voltage: Arithmetic mean of voltages at the differential inputs referenced to ground pin at the receiver.

Common Mode Sensitivity: Rate of change of input differential voltage required to produce a given output level, against common mode voltage.

Supply Sensitivity: Rate of change of input dif-

ferential voltage required to produce a given output level, against power supply voltage (V Pin 14 – V Pin 7).

Disabled Output Clamp Current: The current which flows from the output of a disabled TRI-STATE gate when it is dragged below ground (for instance by a transmission-line-associated transient). It is derived from the V_{CC} power rail.

sense amplifiers

AC Common-Mode Input Firing Voltage: The peak level of a common-mode pulse which will exceed the input dynamic range and cause the logic output to switch. Pulse characteristics: $t_r = t_f \leq 15$ ns, $PW = 50$ ns.

Common-Mode Input Overload Recovery Time: The time necessary for the device to recover from a $\pm 2V$ common-mode pulse ($t_r = t_f = 20$ ns) prior to the strobe enable signal.

Differential Input Offset Current: The absolute difference in the two input bias currents of one differential input.

Differential Input Overload Recovery Time: The time necessary for the device to recover from a 2V differential pulse ($t_f = t_r = 20$ ns) prior to the strobe enable signal.

Differential Input Threshold Voltage: The DC input voltage which forces the logic output to the logic threshold voltage ($\sim 1.5V$) level.

Input Bias Current: The DC current which flows into each input pin with differential input of 0V.

Supply Current: The total DC current per package drawn from the voltage supply.

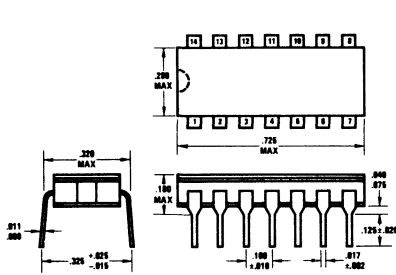
Offset Voltage: Difference between the absolute values of threshold voltage in positive- and negative-going directions.

Propagation Delay Time: Interval from switching input through 1.5V to output traversing its 50% voltage point. Measured with 50Ω load to +10V 15 pF total capacitance.

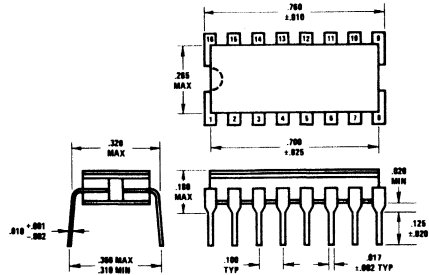


Physical Dimensions

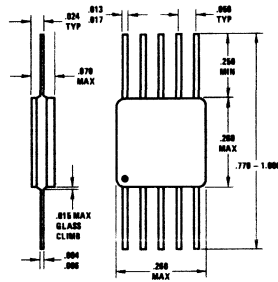
(All dimensions are in inches.)



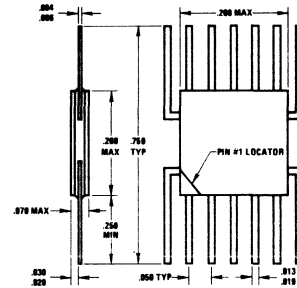
Package 1
14 Lead Cavity DIP (D)



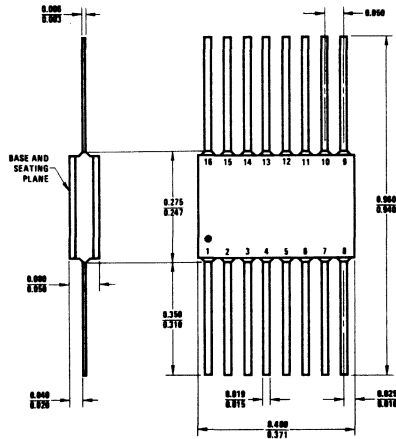
Package 2
16 Lead Cavity DIP (D)



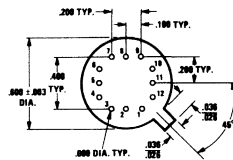
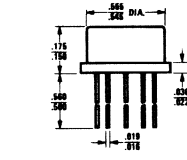
Package 3
10 Lead Flat Package (F)



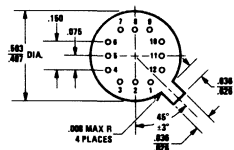
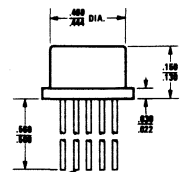
Package 4
14 Lead Flat Package (F)



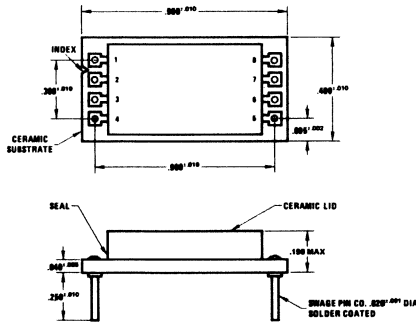
Package 5
16 Lead Flat Package (F)



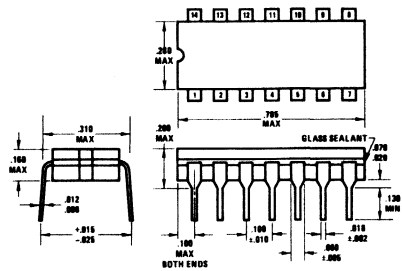
Package 6
12 Lead TO-8 Metal Can (G)



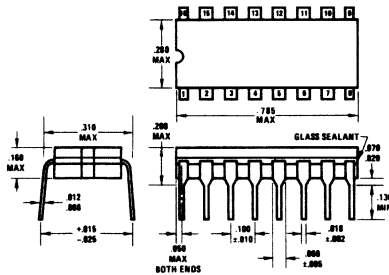
Package 6A
12 Lead TO-8 Metal Can (G)
(AH2114/AH2114C only)



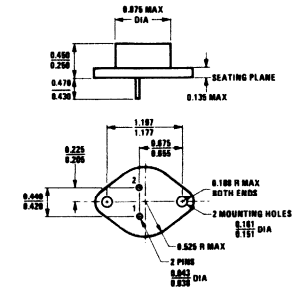
Package 15
8 Lead Cavity Package (J)



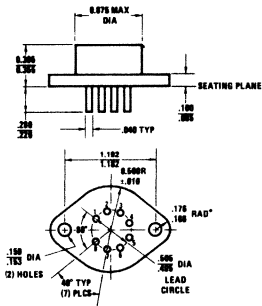
Package 16
14 Lead Cavity DIP (J)



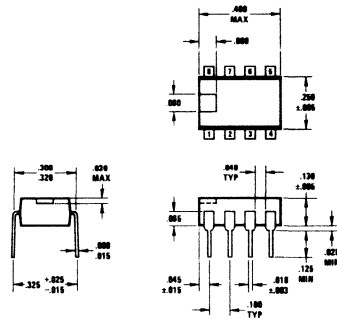
Package 17
16 Lead Cavity DIP (J)



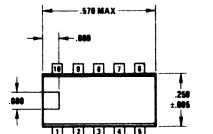
Package 18
2 Lead TO-3 Metal Can (K)



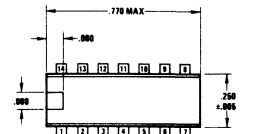
Package 19
8 Lead TO-3 Metal Can (K)



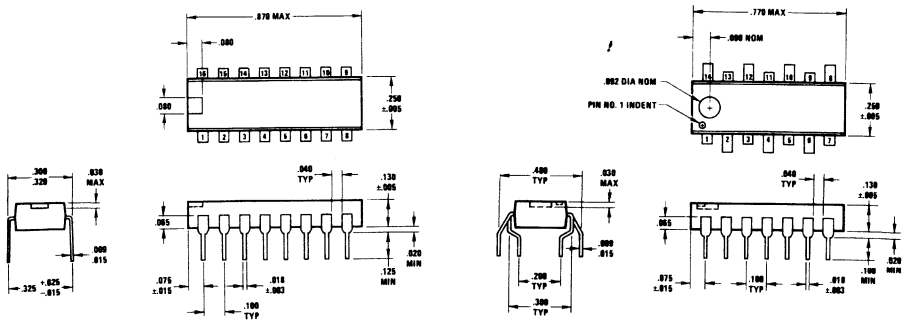
Package 20
8 Lead Molded Mini DIP (N)



Package 21
10 Lead Molded DIP (N)

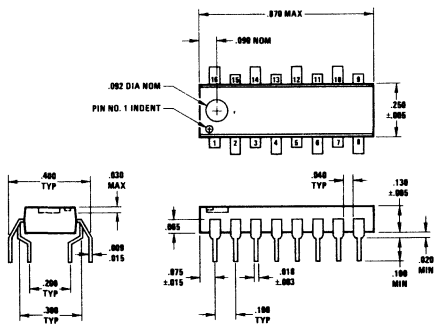


Package 22
14 Lead Molded DIP (N)

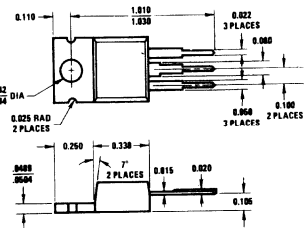


Package 23
16 Lead Molded DIP (N)

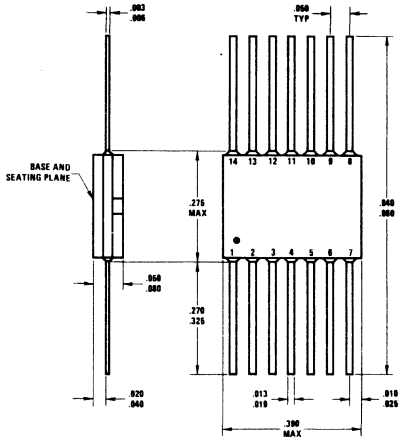
Package 24
14 Lead Molded DIP (N-01)
(Staggered Leads)



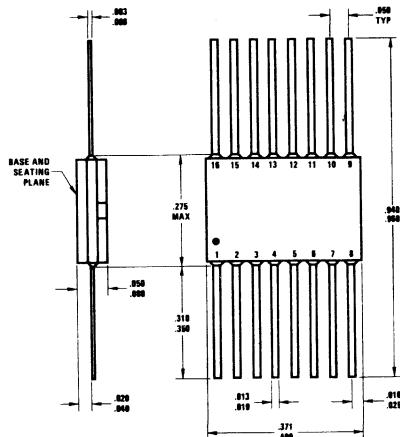
Package 25
16 Lead Molded DIP (N-01)
(Staggered Leads)



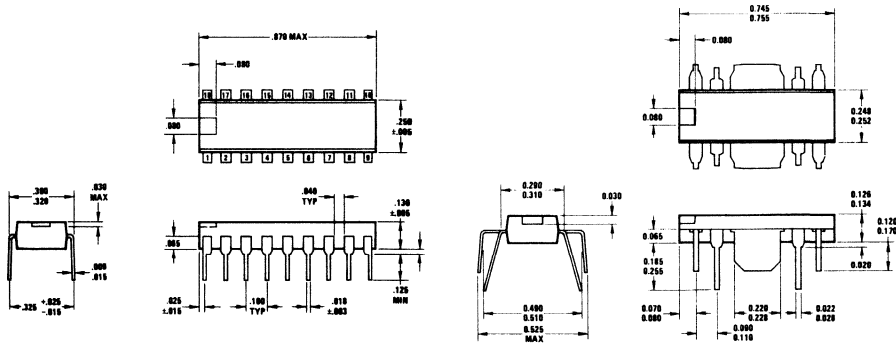
Package 26
3 Lead TO-220 Power Package (T)



Package 27
14 Lead Flat Package (W)

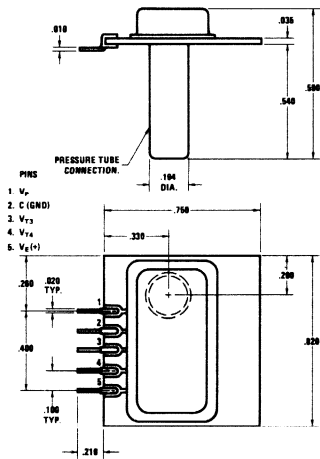


Package 28
16 Lead Flat Package (W)

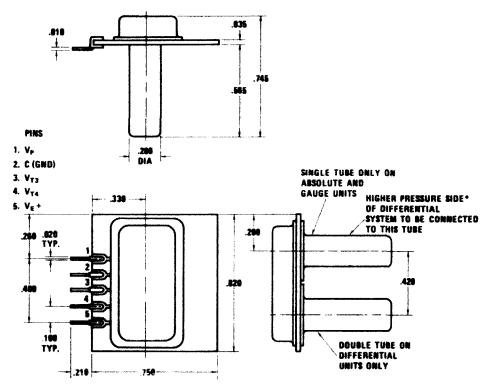


Package 29
18 Lead Molded DIP (N)

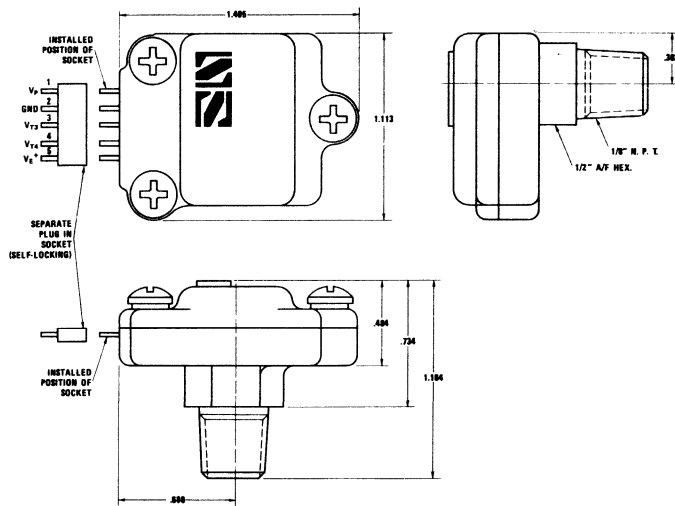
Package 30
14 Lead Batwing DIP (N)



Package 31
Pressure Transducer

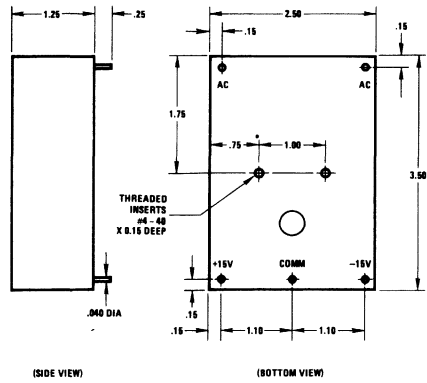


Package 32
Pressure Transducer

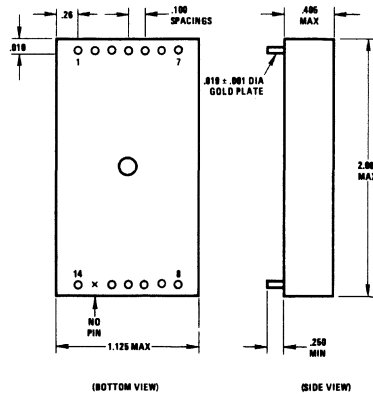


Package 33
Pressure Transducer

Physical Dimensions



Package 34
Molded Module



Package 35
Molded Module

INCHES TO MILLIMETERS CONVERSION TABLE

INCHES	MM	INCHES	MM	INCHES	MM
.001	.0254	.010	.254	.100	2.54
.002	.0508	.020	.508	.200	5.08
.003	.0762	.030	.762	.300	7.62
.004	.1016	.040	1.016	.400	10.16
.005	.1270	.050	1.270	.500	12.70
.006	.1524	.060	1.524	.600	15.24
.007	.1778	.070	1.778	.700	17.78
.008	.2032	.080	2.032	.800	20.32
.009	.2286	.090	2.286	.900	22.86