SELECTED LINEAR I.C. CATALOGUE

OPERATIONAL AMPLIFIERS
COMPARATORS, REGULATORS
& CONVERTERS
REFERENCE DIODES
DRIVERS & RECEIVERS
TRANSISTOR & DIODE ARRAYS

THE
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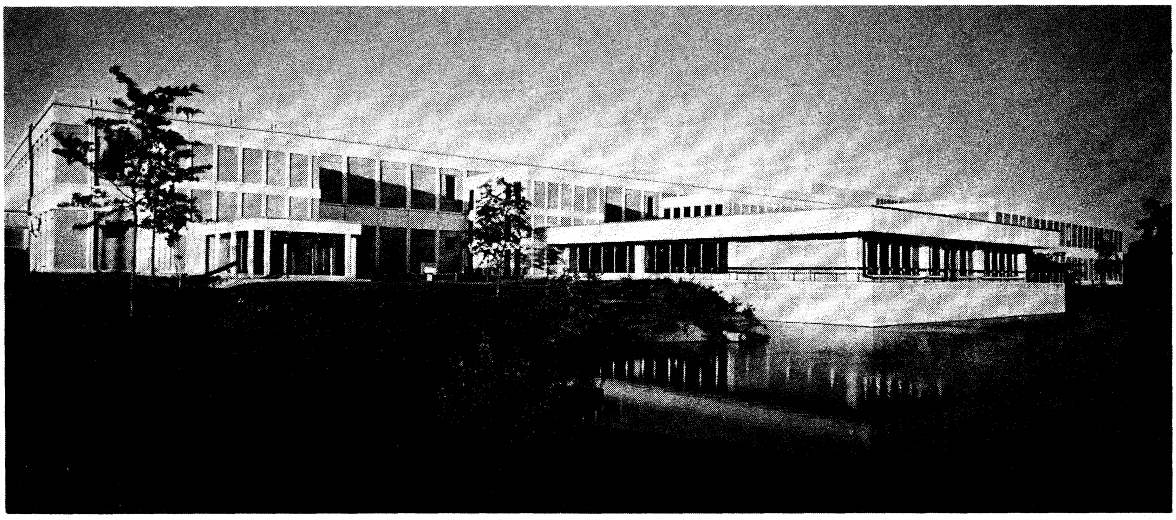
SELECTED LINEAR I.C. CATALOGUE

MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STATION C, OTTAWA, CANADA, K1Y 4J1

microsystems international limited

Research, development and manufacturing centre in Ottawa, Canada. The Company occupies a $31 million, 340 thousand square foot research, development and manufacturing facility in Ottawa, designed specifically for the production of semiconductor products. This facility, staffed with more than 350 engineers and other professionals, many with international experience, and over 1000 production and support personnel, is the Company's principal operating base.



products

• Computer Components

Random access memories
Read only memories
Programmable read only memories
Shift registers
Central processing units
Custom circuits

• Linear Integrated Circuits

General purpose operational amplifiers
Precision operational amplifiers
Micropower operational amplifiers
High voltage operational amplifiers
Multiple operational amplifiers
Voltage regulators
Line drivers and receivers
Transitor arrays
Reference diodes
Comparators
Custom circuits

• Telecom Circuits

Tone generators
Tone receivers
Tone ringers
Microphone amplifiers
Custom circuits

• Discrete Components

Diodes
Transistors
Custom components

head office

1600 Dorchester Boulevard West, Montreal, Canada

research, development and manufacturing centre

75 Moodie Drive, Ottawa, Canada

assembly plant

Bayan Lepas, Penang, West Malaysia

subsidiaries

Germany: Microsystems International GmbH
Malaysia: Microsystems International Sendirian Berhad
United States: Microsystems International Inc.

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  7 Stuttgart 1(W), West Germany: Gustav-Siegle-Strasse, 96, Tel. (0711) 65 31 16/26, Telex 722290
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  Paris: 18 Rue Thiboumercy, 75015, Tel. PARIS 5337878, Telex 20123

distributors and representatives

in 18 countries throughout the world

NOTES

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SELECTED LINEAR I.C. CATALOGUE

Important Information

1

NOTES

How to use Microsystems' Selected Linear I.C. Catalogue:

For your convenience, this catalogue has been divided into sections, each with a coded tab to enable you to easily turn to the functional category of interest to you:

When you have determined which parts you need, you will find "How To Order Parts" in this section.

1

If you are trying to choose the best device for your application, consult the "Selection Guide" and "Functional Index".

If you know the correct device type number, find which page it is on, with the "Numerical Index".

If you need a Microsystems device which is a direct equivalent to another manufacturer's device, consult the "Cross Reference Index".

2

3

4

5

6

This is the technical portion of the catalogue. It is divided into eight sections according to device function. (Package availability for each device is indicated at the beginning of every section.)

7

8

9

10

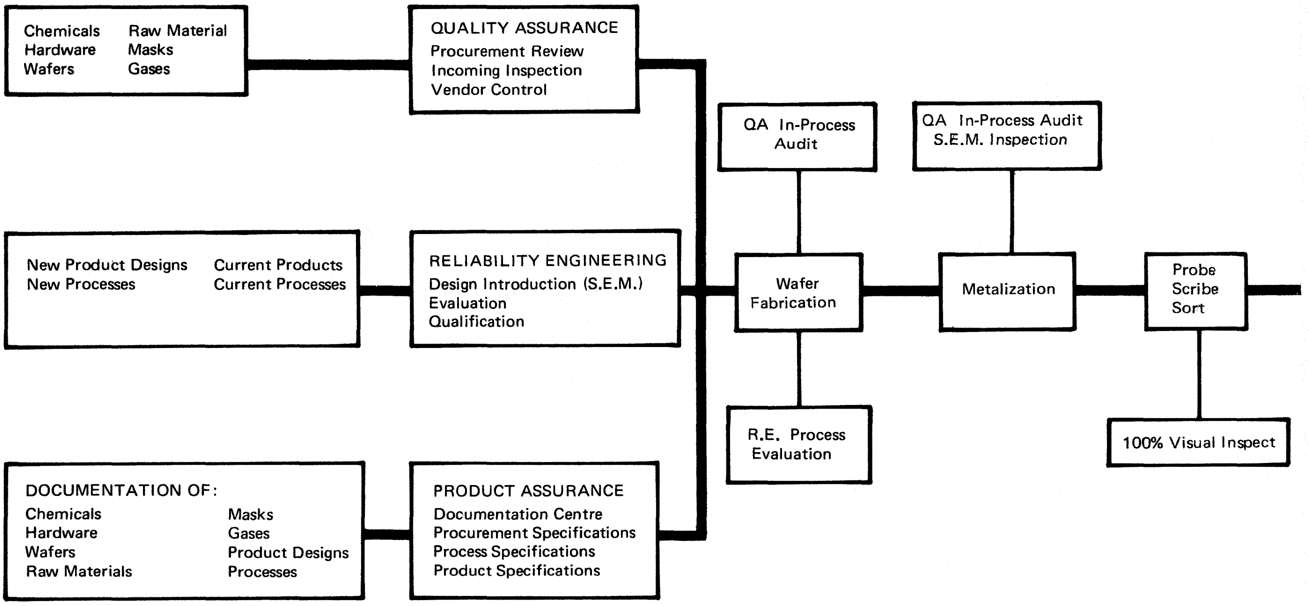
If you need to know the package dimensions or availability for a specific device, see "Package Information".

11

If you would like more information relating to certain devices, see "Application Bulletins".

12

Microsystems' Standard Product



MICROSYSTEMS QUALITY & RELIABILITY

Microsystems' Q. & R. system is accepted and approved by the Canadian Department of National Defense to DND–1015. It is also a "Certified Manufacturer" to MIL–M–38510A and maintains a "Certified" (Lab certification No. F11155) qualification laboratory to MIL–STD–883/38510A.

Microsystems' Q. & R. policy is that there can be no compromise regarding the quality and reliability of the products of the company. To ensure this, the Q. & R. department has been established as a major independent branch of the company. The Director of Quality & Reliability has the authority and responsibility to implement and maintain the total Q. & R. system, thus ensuring that all products delivered meet or exceed customer requirements.

Three major departments exist within the Quality & Reliability organization:

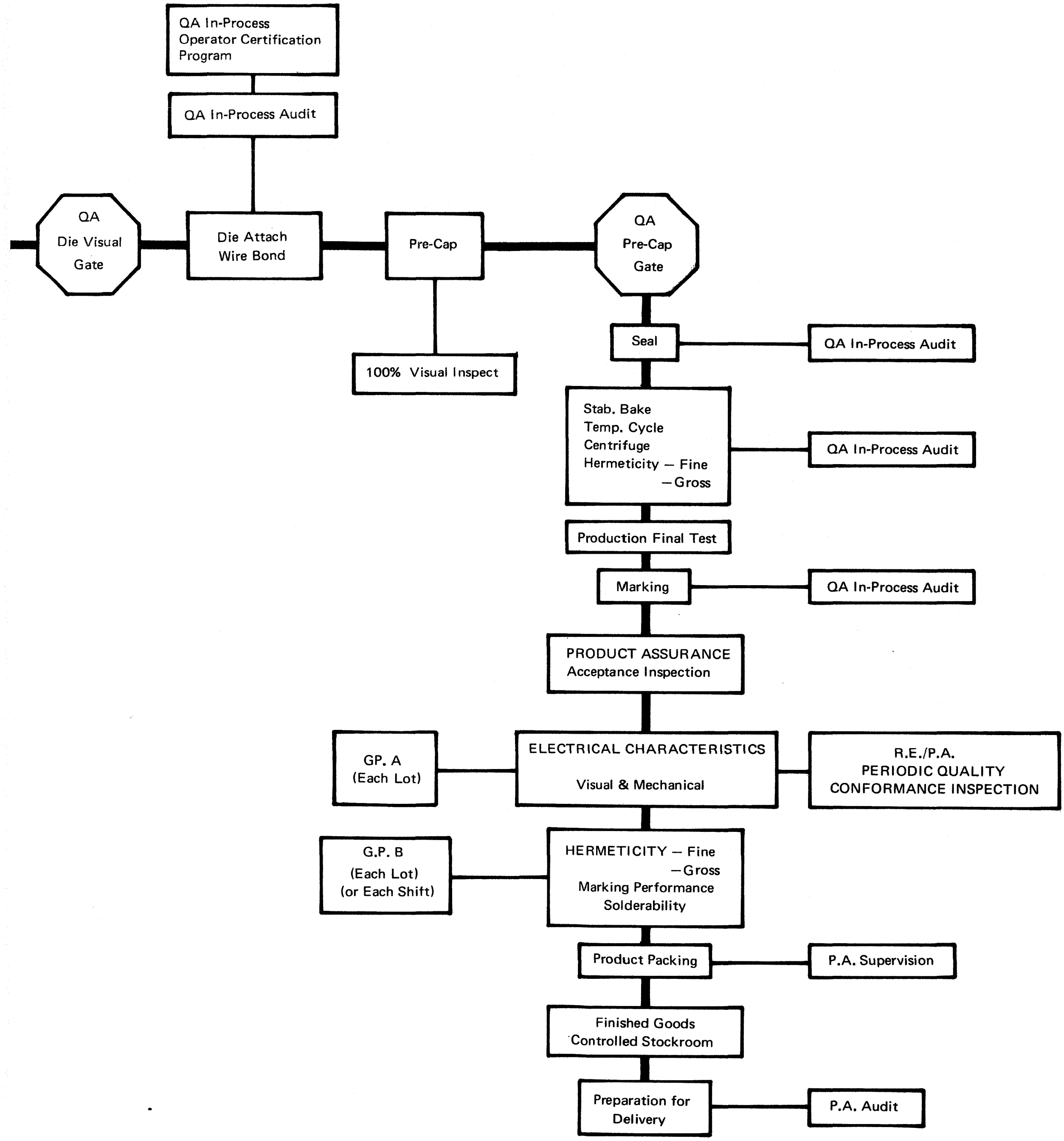
Quality Assurance
Product Assurance
Reliability Engineering

Each department is responsible to the Director of Quality & Reliability, and although maintained as separate operational organizations, they function as a single entity to provide a total Quality & Reliability system.

Microsystems has developed, within the Q. & R. department, a number of unique state-of-the-art methods and techniques for Quality Control, many of which surpass the capabilities of other microcircuit manufacturers. Three on-line terminals linked to the company's main computer are utilized daily by Quality & Reliability to provide rapid statistical data feed-back to manufacturing operations. Two Scanning Electron Microscopes are operated and maintained within the department for product development, failure analysis and in-process control. Many of the sophisticated methods utilized were developed within the organization.

At Microsystems International the Quality & Reliability responsibility encompasses the total scope of product manufacturing, from raw materials through to delivery.

Processing and 100% Screening



How to order parts:

MICROSYSTEMS MANUFACTURES SELECTED LINEARS IN A VARIETY OF PACKAGES AND TEMPERATURE RANGES. TO ORDER CORRECTLY, PLEASE FOLLOW THE FORMAT SHOWN BELOW.

DEVICE ORDER NUMBER FORMAT

ML 4136C P

MICROSYSTEMS PREFIX	DEVICE TYPE (SEE NOTE)	PACKAGE TYPE
ML	4136C	P

PACKAGE CODE

T – METAL CAN
M – HERMETIC DUAL IN LINE CERAMIC
P – PLASTIC MOLDED DUAL IN LINE (14 LEAD OR 16 LEAD)
S – PLASTIC MOLDED DUAL IN LINE (8 LEAD)
F – FLAT PACK
D – HERMETIC DUAL-IN-LINE CERAMIC (CERDIP)
K – CHIP

NOTE THE DEVICE TYPE IS COMPRISED OF 3 TO 5 DIGITS AND MAY INCLUDE AN ALPHABETICAL SUFFIX, WHICH WOULD INDICATE EITHER TEMPERATURE RANGE OR A SELECTED VERSION. IF NO SUFFIX IS INCLUDED, THE TEMPERATURE RANGE IS DESIGNATED BY NUMERICAL SERIES. SEE INDIVIDUAL DATA SHEET FOR DETAILS.

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SELECTED LINEAR I.C. CATALOGUE

Indexes and Selection Charts

2

INDEXES

FUNCTIONAL INDEX

INDEXES

NUMERICAL INDEX

INDEXES

CIRCUIT CROSS REFERENCE INDEX

	MICROSYSTEMS INTERNATIONAL	
FAIRCHILD	**DIRECT REPLACEMENT**	**NEAREST EQUIVALENT**
μA709	ML709	
μA709A	ML709A	
μA709C	ML709C	
μA723	ML723	
μA723C	ML723C	
μA741	ML741	
μA741A	ML741A	
μA741C	ML741C	
μA747	ML747	
μA747C	ML747C	
μA748	ML748	
μA748C	ML748C	
1458	ML1458	
1558	ML1558	
101A	ML101A	
201A	ML201A	
301A	ML301A	
101	ML101	
201	ML201	
301	ML301	
107	ML107	
207	ML207	
307	ML307	
108	ML108	
208	ML208	
308	ML308	
CA3045	ML3045	ML3145
CA3046	ML3046	
CA3018		ML3118
CA3036		ML3136
CA3054		ML3154
CA3019		ML3119
CA3039		ML3139
111	ML111	
211	ML211	
311	ML311	
107	ML107	
207	ML207	
307	ML307	
108A	ML108A	
208A	ML208A	
308A	ML308A	
μA776	ML776	
μA776C	ML776C	
μA777	ML777	
μA777C	ML777C	
75492		ML4102
9616C		ML1488
9617C		ML1489
μA702		ML101
μA702C		ML301
μA734		ML111
μA734C		ML311
μA715		ML118
μA715C		ML318

	MICROSYSTEMS INTERNATIONAL	
RCA	**DIRECT REPLACEMENT**	**NEAREST EQUIVALENT**
CA3741	ML741	
CA3741C	ML741C	
CA747	ML747	
CA747C	ML747C	
CA3748	ML748	
CA3748C	ML748C	
CA3458	ML1458	
CA3558	ML1558	
CA3045	ML3045	
CA3046	ML3046	
CA3083	ML3083	
CA3183	ML3183	
CA3118	ML3118	
CA3136	ML3136	
CA3145	ML3145	

	MICROSYSTEMS INTERNATIONAL	
RCA	**DIRECT REPLACEMENT**	**NEAREST EQUIVALENT**
CA3154	ML3154	
CA3484	ML3484	
CA3923	ML3923	
CA3119	ML3119	
CA3139	ML3139	
CA3033		ML709
CA3033A		ML709
CA3037		ML709
CA3037A		ML709
CA3038		ML709
CA3038A		ML709
CA3047		ML709
CA3078		ML776
CA3085		ML723

	MICROSYSTEMS INTERNATIONAL	
NATIONAL	**DIRECT REPLACEMENT**	**NEAREST EQUIVALENT**
LM709	ML709	
LM709A	ML709A	
LM709C	ML709C	
LM723	ML723	
LM723C	ML723C	
LM741	ML741	
LM741C	ML741C	
LM747	ML747	
LM747C	ML747C	
LM748	ML748	
LM748C	ML748C	
LM1458	ML1458	
LM1558	ML1558	
LM101A	ML101A	
LM201A	ML201A	
LM301A	ML301A	
LM101	ML101	
LM201	ML201	
LM301	ML301	
LM107	ML107	
LM207	ML207	
LM307	ML307	
LM108	ML108	
LM208	ML208	
LM308	ML308	
LM118	ML118	
LM218	ML218	
LM318	ML318	
LM111	ML111	
LM211	ML211	
LM311	ML311	
LM107	ML107	
LM207	ML207	
LM307	ML307	
LM108A	ML108A	
LM208A	ML208A	
LM308A	ML308A	
LM4250	ML4250	
LM4250C	ML4250C	
LM4251	ML4251	
LM4251C	ML4251C	
LM113	ML113	
LM213	ML213	
LM313	ML313	
LM124		ML4202
LM324		ML4202C
LM3900		ML4136
LM100		ML723
LM200		ML723
LM300		ML723C
LM112		ML776
LM312		ML776C
LM114		ML3100
LM114A		ML3100
LM115		ML3100
LM115A		ML3100

	MICROSYSTEMS INTERNATIONAL	
SIGNETICS	**DIRECT REPLACEMENT**	**NEAREST EQUIVALENT**
μA709	ML709	
μA709C	ML709C	
μA723	ML723	
μA723C	ML723C	
μA741	ML741	
μA741C	ML741C	
μA747	ML747	
μA747C	ML747C	
μA748	ML748	
μA748C	ML748C	
N5558	ML1458	
S5558	ML1558	
LM101A	ML101A	
LM201A	ML201A	
LM301A	ML301A	
LM101	ML101	
LM201	ML201	
LM107	ML107	
LM207	ML207	
LM307	ML307	
LM308	ML308	
SE511		ML3045
NE511		ML3046
SE533		ML776
NE533		ML776C
S5556		ML107
N5556		ML307
SE531		ML118
NE531		ML318
SE537		ML108
NE537		ML308

	MICROSYSTEMS INTERNATIONAL	
RAYTHEON	**DIRECT REPLACEMENT**	**NEAREST EQUIVALENT**
RM709	ML709	
RM709A	ML709A	
RC709	ML709C	
RM723	ML723	
RC723	ML723C	
RM741	ML741	
RC741	ML741C	
RM747	ML747	
RC747	ML747C	
RM748	ML748	
RC748	ML748C	
RC1458	ML1458	
RM4558	ML1558	
LM101A	ML101A	
LM101	ML101	
LM108	ML108	
LM308	ML308	
LM118	ML118	
RM318	ML318	
LM111	ML111	
LM311	ML311	
LM107	ML107	
LM307	ML307	
LM108A	ML108A	
LM308A	ML308A	
RM1537	ML1537	
RC1437	ML1437	
RM4136	ML4136	
RC4136	ML4136C	
RC1488	ML1488	
RC1489	ML1489	
RC1489A	ML1489A	
RM702		ML101
RC702		ML301

	MICROSYSTEMS INTERNATIONAL	
TELEDYNE	**DIRECT REPLACEMENT**	**NEAREST EQUIVALENT**
709A	ML709	
709B	ML709C	
723B	ML723	
723C	ML723C	
741B	ML741	

INDEXES

CIRCUIT CROSS REFERENCE INDEX

TELEDYNE	MICROSYSTEMS INTERNATIONAL	
	DIRECT REPLACEMENT	NEAREST EQUIVALENT
741C	ML741C	
747B	ML747	
747C	ML747C	
811		ML709
841		ML101

TEXAS INST	MICROSYSTEMS INTERNATIONAL	
	DIRECT REPLACEMENT	NEAREST EQUIVALENT
SN52709	ML709	
SN52709A	ML709A	
SN72709	ML709C	
SN52741	ML741	
SN52741A	ML741A	
SN72741	ML741C	
SN52747	ML747	
SN72747	ML747C	
SN52748	ML748	
SN72748	ML748C	
SN72558	ML1458	
SN52558	ML1558	
SN52101A	ML101A	
SN72301A	ML301A	
SN52101	ML101	
SN72301	ML301	
SN52107	ML107	
SN72307	ML307	
SN52108	ML108	
SN72308	ML308	
SN52108A	ML108A	
SN72308A	ML308A	
SN72400		ML723C
SN52702A		ML101A
SN72702A		ML301A
SN52770		ML108
SN72770		ML308
SN75492		ML4102

MOTOROLA	MICROSYSTEMS INTERNATIONAL	
	DIRECT REPLACEMENT	NEAREST EQUIVALENT
MC1709	ML709	
MC1709C	ML709C	
MC1723	ML723	
MC1723C	ML723C	
MC1741	ML741	
MC1741C	ML741C	
MC1748	ML748	
MC1748C	ML748C	
MC1458	ML1458	
MC1558	ML1558	
MC1537	ML1537	
MC1437	ML1437	
MC1488	ML1488	
MC1489	ML1489	
MC1489A	ML1489A	
MC1776	ML776	
MC1536	ML1536	
MC1436	ML1436	
MC1436C	ML1436C	
MC1460		ML723C
MC1560		ML723
MC1561		ML723
MC1461		ML723C
MC1563		ML723
MC1463		ML723C
MC1566		ML723
MC1466		ML723C
MC1569		ML723
MC1469		ML723C
MC1539		ML101
MC1439		ML301
MC1530		ML101
MC1430		ML301
MC1531		ML101
MC1431		ML301
MC1533		ML101
MC1433		ML301
MC3401		ML4136

SILICON GENERAL	MICROSYSTEMS INTERNATIONAL	
	DIRECT REPLACEMENT	NEAREST EQUIVALENT
SG723	ML723	
SG723C	ML723C	
SG741	ML741	
SG741C	ML741C	
SG747	ML747	
SG747C	ML747C	
SG748	ML748	
SG748C	ML748C	
SG1458	ML1458	
SG1558	ML1558	
SG101A	ML101A	
SG201A	ML201A	
SG301A	ML301A	
SG101	ML101	
SG201	ML201	
SG301	ML301	
SG107	ML107	
SG207	ML207	
SG307	ML307	
SG108	ML108	
SG208	ML208	
SG308	ML308	
SG3821	ML3045	
SG3053	ML3083	
SG3183	ML3183	
SG108A	ML108A	
SG208A	ML208A	
SG308A	ML308A	
SG1536	ML1536	
SG1436	ML1436	
SG1436C	ML1436C	
SG777	ML777	
SG777C	ML777C	
SG1488	ML1488	
SG1489	ML1489	
SG1489A	ML1489A	
SG4250	ML4250	
SG4250C	ML4250C	

PACKAGE CROSS REFERENCE INDEX

PACKAGES	MIL	FSC	MOTA	NSC	TI	SIG	SI GEN	RAY	RCA	TELEDYNE
8 PIN MINIDIP PLASTIC	S	T	P1	N	P	V	M	DN	—	—
14 PIN DIP PLASTIC	P	P	P2	N	N	A	N	DP	E	J
16 PIN DIP PLASTIC	P	P	P2	N	N	B	N	MP	E	—
18 PIN DIP PLASTIC	P	—	—	—	—	XA	—	—	—	—
14 PIN DIP CERAMIC (CERDIP)	D	D	L	J	J	F	J	DC	F	N
16 PIN DIP CERAMIC (CERDIP)	D	D	L	J	J	F	J	DD	—	—
14 PIN DIP METAL OR METAL CERAMIC	M	—	—	D	—	I	D	D	D	L
16 PIN DIP METAL OR METAL CERAMIC	M	—	—	D	—	I	D	M	D	—
8 PIN TO METAL CAN (HIGH PROFILE)	T	—	G	H	L	—	—	—	T	—
10 PIN TO METAL CAN (LOW PROFILE)	T	H	G	H	L	K	T	TF	T	E
10 LEAD METAL FLAT PACK	F	—	—	F	F,S,T	—	F	Q	—	H
8 PIN TO METAL CAN (LOW PROFILE)	T	H	G	H	L	T	T	TE	T	E
10 PIN TO METAL CAN (HIGH PROFILE)	T	—	G	H	L	L	—	—	T	—
14 LEAD METAL FLAT PACK	F	—	—	F	F,S,T	—	—	J	K	—
CHIPS	K	X	MCC—	—	—	—	—	CG CH	H	—

SELECTION CHARTS

OPERATIONAL AMPLIFIER SELECTION CHART

PRODUCT CODE	OPERATING TEMP. RANGE[1] (°C)	OPERATING SUPPLY VOLTAGE RANGE[1] (±V)	MAX. INPUT OFFSET VOLTAGE (mV)	MAX. INPUT OFFSET CURRENT (nA)	MAX. INPUT BIAS CURRENT (μA)	MIN. INPUT RESIS-TANCE (MΩ)	TYP. OUTPUT RESIS-TANCE (Ω)	MIN. INPUT VOLTAGE RANGE (±V)	TYP. OUTPUT VOLTAGE SWING (±V)
			$R_S \leqslant 10\ k\Omega$ $*R_S \leqslant 50\ k\Omega$ $\dagger \pm 9V \leqslant V_S \leqslant \pm 15V$			$T_A = 25°C$	$T_A = 25°C$	$V_S = \pm 15V$ $*V_S = \pm 20V$	$V_S = \pm 15V$ $R_L \geqslant 2\ k\Omega$ $*R_L = 10\ k\Omega$
ML 101	−55 to +125	5 to 20	6.0	500	1.5	0.3	–	12	13
ML 101A		5 to 20	3.0 *	20	0.1	1.5	–	15 *	13
ML 107		5 to 20	3.0 *	20	0.1	1.5	–	15 *	13
ML 108		5 to 20	3.0	0.4	0.003	30	–	13.5	14 *
ML 108A		5 to 20	1.0	0.4	0.003	30	–	13.5	14 *
ML 118		5 to 20	6.0	100	0.5	1.0	–	11.5	13
ML 709		9 to 15	6.0†	500	1.5	0.15	150	8.0†	13
ML 709A		9 to 15	3.0†	250	0.6	0.35	150	8.0†	13
ML 741		5 to 15	6.0	500	1.5	0.3	75	12	13
ML 741A		5 to 20	3.0 *	20	0.1	1.5	–	15 *	13
ML 747 DUAL(2)		5 to 15	6.0	500	1.5	0.3	75	12	13
ML 748		5 to 15	6.0	500	1.5	0.3	75	12	13
ML 776		3 to 15	6.0	15	50	5.0	1000	10	13 *
ML 777		5 to 15	3.0 *	10	0.075	2.0	100	12	13
ML 1536		5 to 36	7.0	7.0	0.035	2.0	–	24	30 *
ML 1537 DUAL(2)		9 to 15	6.0†	500	1.5	0.15	30	8.0 †	13
ML 1558 DUAL(2)		5 to 15	6.0	500	1.5	0.3	75	12	13
ML 4136 QUAD(2)		5 to 15	5.0	500	1.5	0.3	250	12	13 *
ML 4202 QUAD(2)		5 to 15	5.0	500	1.5	0.1	250	12	13 *
ML 4236		5 to 36	7.0	7.0	0.035	2.0	–	24	30
ML 4250		1.5 to 15	4.0	8.0	0.015	3.0	–	–	13 *
ML 4251		1.5 to 9	4.0	8.0	0.015	3.0	–	–	8 *
ML 201	−25 to +85	5 to 20	6.0	500	1.5	0.3	–	12	13
ML 201A		5 to 20	3.0 *	20	0.1	1.5	–	15 *	13
ML 207		5 to 20	3.0 *	20	0.1	1.5	–	15 *	13
ML 208		5 to 20	3.0	0.4	0.003	30	–	13.5	14 *
ML 208A		5 to 20	1.0	0.4	0.003	30	–	13.5	14 *
ML 218		5 to 20	6.0	100	0.5	1.0	–	11.5	12
ML 301	0 to +70	5 to 15	10	750	2.0	0.1	–	12	13
ML 301A		5 to 15	10 *	70	0.3	0.5	–	+15, −12	13
ML 307		5 to 15	10 *	70	0.3	0.5	–	+15, −12	13
ML 308		5 to 15	10	1.5	0.01	10	–	13.5	14 *
ML 308A		5 to 15	0.73	1.5	0.01	10	–	13.5	14 *
ML 318		5 to 18	15	300	1.0	0.5	–	11.5	12
ML 709C		9 to 15	10 †	750	2.0	0.05	150	8.0 †	13
ML 741C		5 to 15	7.5	300	0.8	0.3	75	12	13
ML 747C DUAL(2)		5 to 15	7.5	300	0.8	0.3	75	12	13
ML 748C		5 to 15	7.5	300	0.8	0.3	75	12	13
ML 776C		3 to 15	7.5	40	0.10	5.0	1000	10	13 *
ML 777C		5 to 15	5.0 *	40	0.2	1.0	100	12	13
ML 1436		5 to 28	14	14	0.055	2.0	–	22	22 *
ML 1436C		5 to 28	16	25	0.09	1.5	–	18	22
ML 1437 DUAL(2)		9 to 15	10	750	2.0	0.05	30	8.0 †	14
ML 1458 DUAL(2)		5 to 15	7.5	300	0.8	0.3	75	12	13
ML 4136C QUAD(2)		5 to 15	5.0	500	1.5	0.3	250	12	13 *
ML4202C QUAD(2)		5 to 15	6.0	500	1.5	0.1	250	12	13 *
ML 4236C		5 to 28	12	25	0.09	1.5	–	18	32
ML 4250C		1.5 to 15	7.5	15.0	0.05	3.0	–	–	13 *
ML 4251C		1.5 to 9	7.5	15.0	0.05	3.0	–	–	8 *

NOTES:
1. All specifications given in this chart are guaranteed over the respective operating supply voltage ranges and the respective operating temperature ranges unless otherwise noted.
2. Each amplifier.

MIN. OPEN LOOP VOLTAGE GAIN (V/mV)	ABSOLUTE MAX. SUPPLY VOLTAGE (±V)	MAX. SUPPLY CURRENT (mA)	MIN. COM. MODE REJECT. RATIO (dB)	TYP. SUPPLY VOLTAGE REJECT. RATIO (μV/V)	TYP. SLEW RATE (V/μS) @ 25°C	OFFSET VOLTAGE ADJUSTABLE	OUTPUT SHORT-CIRCUIT PROT.	INTERNAL FREQ. COMP.	PRODUCT CODE
$V_S = \pm 15V$ $V_{OUT} = \pm 10V$ $R_L \geqslant 2\,k\Omega$ $*R_L \geqslant 10\,k\Omega$	STRESS LIMIT ONLY	$V_S = \pm 15V$ $*V_S = \pm 20V$ $T_A = 25^\circ C$ $\dagger V_S = \pm 9V$	$R_S \leqslant 10\,k\Omega$ $*R_S \leqslant 50\,k\Omega$	$R_S \leqslant 10\,k\Omega$ $*R_S \leqslant 50\,k\Omega$	$R_L \geqslant 2\,k\Omega$ $T_A = 25^\circ C$ GAIN = 1 $R_L \geqslant 10\,k$ *				
25	22	3.0*	70	31	–	Yes	Yes	–	**ML 101**
25	22	3.0*	80*	16*	–	Yes	Yes	–	**ML 101A**
25	22	3.0*	80*	16*	–	–	Yes	Yes	**ML 107**
25*	20	0.6*	85	16	–	–	Yes	–	**ML 108**
40*	20	0.6*	96	16.0	–	–	Yes	–	**ML 108A**
25	20	8.0	80	100	70	–	Yes	Yes	**ML 118**
25	18	5.5	70	25	–	–	–	–	**ML 709**
25	18	3.6	80	40	–	–	–	–	**ML 709A**
25	22	2.8	70	30	0.5	Yes	Yes	Yes	**ML 741**
25	22	3.0*	80*	16*	–	Yes	Yes	Yes	**ML 741A**
25	22	2.8	70	30	0.5	Yes	Yes	Yes	**ML 747 DUAL(2)**
25	22	2.8	70	30	0.5	Yes	Yes	–	**ML 748**
75*	22	0.17	70	25	0.8	Yes	Yes	Yes	**ML 776**
25	22	3.3*	80	13	–	Yes	Yes	–	**ML 777**
–	40	4.0	80	100	2.0	Yes	Yes	Yes	**ML 1536**
25	18	3.8	70†	25.0	0.25	–	–	–	**ML 1537 DUAL(2)**
25	22	2.5	70	30.0	0.5	–	Yes	Yes	**ML 1558 DUAL(2)**
50*	22	3.5	70	30	1.0	–	Yes	Yes	**ML 4136 QUAD(2)**
25*	22	3.5	70	50	1.2	–	Yes	Yes	**ML 4202 QUAD(2)**
–	40	4.0	80	100	2.0	Yes	Yes	–	**ML 4236**
50*	18	0.1	70	30	0.2*	Yes	Yes	Yes	**ML 4250**
50*	10	0.1†	70	30	0.2*	Yes	Yes	Yes	**ML 4251**
25	22	3.0*	70	31	–	Yes	Yes	–	**ML 201**
25	22	3.0*	80*	16*	–	Yes	Yes	–	**ML 201A**
25	22	3.0*	80*	16*	–	–	Yes	Yes	**ML 207**
25*	20	0.6*	85	16	–	–	Yes	–	**ML 208**
40*	20	0.6*	96	16	–	–	Yes	–	**ML 208A**
25	20	7.0	80	40	70.0	–	Yes	Yes	**ML 218**
15	18	3.0	65	31	–	Yes	Yes	–	**ML 301**
25	18	3.0	70*	16*	–	Yes	Yes	–	**ML 301A**
25	18	3.0	70*	16*	–	–	Yes	Yes	**ML 307**
15*	18	0.3 (TYP.)	80	16	–	–	Yes	–	**ML 308**
60*	18	0.8	96	16	–	–	Yes	–	**ML 308A**
20	18	10.0	70	40	70.0	–	Yes	Yes	**ML 318**
15	18	6.7	65†	25†	–	–	–	–	**ML 709C**
15	18	2.8	70	30	0.5	Yes	Yes	Yes	**ML 741C**
25	18	2.8	70	30	0.5	Yes	Yes	Yes	**ML 747C DUAL(2)**
15	18	2.8	70	30	0.5	Yes	Yes	–	**ML 748C**
50*	18	0.17	70	25	0.8	Yes	Yes	Yes	**ML 776C**
15	18	3.3	70	15	–	Yes	Yes	–	**ML 777C**
–	34	5	70	200	2.0	Yes	Yes	Yes	**ML 1436**
–	30	5.0	50	200	5.0	Yes	Yes	Yes	**ML 1436C**
15	18	3.8	65†	25.0	0.25	–	–	–	**ML 1437 DUAL(2)**
15	18	2.8	70	30	0.5	–	Yes	Yes	**ML 1458 DUAL(2)**
25*	18	4.0	70	30	1.0	–	Yes	Yes	**ML 4136C QUAD(2)**
5*	18	4.0	70	50	1.2	–	Yes	Yes	**ML 4202C QUAD(2)**
–	30	5.0	50	200	2.0	Yes	Yes	–	**ML 4236C**
50*	18	0.1	70	30	0.2*	Yes	Yes	Yes	**ML4250C**
50*	10	0.1†	70	30	0.2*	Yes	Yes	Yes	**ML 4251C**

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SELECTION CHARTS

VOLTAGE COMPARATORS

PRODUCT CODE	OPERATING TEMP. RANGE (°C)		TYPICAL INPUT OFFSET VOLTAGE (mV)	TYPICAL INPUT BIAS CURRENT (nA)	TYPICAL INPUT OFFSET CURRENT (nA)	TTL/DTL FAN OUT	SUPPLY VOLTAGE (V)	RESPONSE TIME (ns)	OUTPUT VOLTAGE SWING (V)
	MIN.	MAX.							
ML111	–55	125	0.7	60	4	8	±18 to +5 and GND	200	0 to +5 (+50) (1)
ML211	–25	85	0.7	60	4	8		200	0 to +5 (+50) (1)
ML311	0	70	2.0	100	6	8		200	0 to +5 (+40) (1)

NOTE:
1. Maximum output voltage switching capability.

VOLTAGE REGULATORS

PRODUCT CODE	OPERATING TEMP. RANGE (°C)		INPUT VOLTAGE RANGE (V)		OUTPUT VOLTAGE RANGE (V)		INPUT-OUTPUT DIFFERENTIAL (V)		LOAD REGULATION		LINE REGULATION $\% V_{OUT}/\Delta V_{IN}$
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	%	I_L (mA)	
ML723	–55	125	9.5	40	2	37	3	38	0.6	1 to 50	0.3
ML723C	0	70	9.5	40	2	37	3	38	0.6	1 to 50	0.3

DC–DC CONVERTERS (AT +25°C)

PRODUCT CODE	OPERATING TEMP. RANGE (°C)		INPUT VOLTAGE RANGE (V)	MAXIMUM SUPPLY CURRENT (1) V_{IN} = 7.5V (mA)	MAXIMUM SUPPLY CURRENT (2) V_{IN} = 7.5V (mA)	TYPICAL REF. VOLTAGE T_A = 0°C to +70°C (V)
	MIN.	MAX.				
ML4270	0	70	3 to 12	2.6	12.0	7.65
ML4270–15	0	70	3 to 12	2.6	12.0	15.0

NOTES:
1. Switch (pin 4) OFF
2. Switch (pin 4) ON

LINE DRIVERS (AT +25°C)

PRODUCT CODE	OPERATING TEMP. RANGE (°C)		OUTPUT VOLTAGE HIGH (V) V_{IN} = 0.8V (1)	OUTPUT VOLTAGE LOW (V) V_{IN} = 1.9V (1)	POSITIVE PROPAGATION DELAY TIME (2) (ns)	NEGATIVE PROPAGATION DELAY TIME (2) (ns)	FALL TIME (2) (ns)	RISE TIME (2) (ns)
	MIN.	MAX.						
ML1488 QUAD	0	75	7.0	–7.0	150	65	45	55

NOTES:
1. $R_L = 3.0k\Omega$, $V^+ = +9V$ and $V^- = -9V$
2. $Z_L = 3.0k\Omega$ and 15pF, $V^+ = +9V$ and $V^- = -9V$

LINE RECEIVERS (AT +25°C)

PRODUCT CODE	OPERATING TEMP. RANGE (°C)		INPUT TURN-ON THRESHOLD (V) $V_{OL} \leq 0.45V$	INPUT TURN-OFF THRESHOLD (V) $V_{OH} \geq 2.5V$	OUTPUT VOLTAGE HIGH (V) V_{IN} = 0.75V I_L = –0.5mA	OUTPUT VOLTAGE LOW (V) V_{IN} = 3.0V I_L = 10mA	PROPAGATION DELAY TIME (ns)	RISE TIME (ns)	FALL TIME (ns)
	MIN.	MAX.							
ML1489 QUAD	0	75	1.25	1.0	4.0	0.2	25	120	10
ML1489A QUAD	0	75	1.95	0.8	4.0	0.2	25	120	10

SELECTION CHARTS

DIGIT DRIVERS

PRODUCT CODE	OPERATING TEMP. RANGE (°C)		OUTPUT ON VOLTAGE I_{OUT} = 40mA V_{IN}= 5V		MAXIMUM OUTPUT OFF CURRENT V_{OUT} = 10V I_{IN} = 25μA	INPUT CURRENT V_{IN} = 10V		MAXIMUM INPUT OFF CURRENT V_{OUT} = 10V I_{OUT} = 300μA
	MIN.	MAX.	TYP.	MAX.		TYP.	MAX.	
ML4102	0	70	0.85	1.0	300	250	400	25

REFERENCE DIODES

PRODUCT CODE	OPERATING TEMP. RANGE RANGE (°C)		REVERSE BREAKDOWN VOLTAGE (1)		TYP. REVERSE BREAKDOWN VOLTAGE TEMP. COEFF. (%/°C)	WORST CASE REVERSE BREAKDOWN VOLTAGE CHANGE OVER TEMP. (mV) 0.5mA ⩽ I_R ⩽ 10mA	TYP. REVERSE DYNAMIC IMPEDANCE (Ω)	
	MIN.	MAX.	MIN.	MAX.			I_R = 1mA	I_R = 10mA
ML113	–55	125	1.160	1.280	0.01	15	0.2	0.25
ML213	–25	85	1.160	1.280	0.01	15	0.2	0.25
ML313	0	70	1.160	1.280	0.01	15	0.2	0.25

NOTE:
1. Standard Tolerance is ±5%. Tolerances of ±1% and ±2% are available on special order.

TRANSISTOR ARRAYS

PRODUCT CODE	TYP. V_{BE} (V) V_{CE} = 5V I_C = 1mA	$V_{CE\ (SAT)}$ (V) I_B = 1mA I_C = 10mA	MAXIMUM $V_{(BR)\ CBO}$ (V) I_C = 10μA I_E = 0	MAXIMUM $V_{(BR)\ CEO}$ (V) I_C = 1mA I_B = 0	MAXIMUM I_{CBO} (μA) V_{CB} = 10V I_E = 0	MINIMUM H_{FE} V_{CE} = 5V I_C at:			MAXIMUM V_{io} AND V_{io} BETWEEN TRANSISTORS V_{CE} = 5V; I_C = 1mA	
						10μA	1mA	50mA	mV	μA
ML3045	.715	.23	20	15	0.04	–	40	–	5	2.5
ML3046	.715	.23	20	15	0.04	54	40	–	5	2.5
ML3083	.68	.4	20	15	1.0	–	–	40	5	2.5
ML3183	.62	.2	60	45	.1 (1)	150	150	–	5 (2)	2.5 (2)
ML3100	.72	.35	60	45	.1 (1)	150	150	–	5 (2)	2.5 (2)
ML3118	.72	.35	60	45	.1 (1)	150	150	–	5 (2)	2.5 (2)
ML3136	.72	.35	60	45	.1 (1)	150	150	–	5 (2)	2.5 (2)
ML3145	.72	.35	60	45	.1 (1)	150	150	–	5 (2)	2.5 (2)
ML3154	.72	.35	60	45	.1 (1)	150	150	–	5 (2)	2.5 (2)
ML3484	.72	.35	60	45	.1 (1)	150	150	–	5 (2)	2.5 (2)
ML3923	.72	.35	60	45	.1 (1)	150	150	–	5 (2)	2.5 (2)

NOTES:
1. V_{CB} = 40V.
2. Measured between Q_1 and all other transistors in the array.

DIODE ARRAYS

PRODUCT CODE	OPERATING TEMP. RANGE (°C)		P_{IV} (V) I_R = 10μA	V_F (V) I_F = 1mA	I_R (A) V_R = 5V	ΔV_F (mV/DECADE) I_{pA} ⩽ I_F ⩽ 1mA	C_D (pF) V_R = I_V
	MIN.	MAX.					
ML3119(1)	0	+70	7.5	0.72	$3 + 10^{-13}$	60	0.3
ML3139(1)	0	+70	7.5	0.72	$3 + 10^{-13}$	60	0.3

NOTE:
1. Values given apply to individual diodes.

NOTES

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SELECTED LINEAR I.C. CATALOGUE

G.P. and H.V. Op. Amps.

3

MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STATION C, OTTAWA, CANADA, K1Y 4J1

package availability

PRODUCT CODE	PACKAGE CODE					
	T Metal Can	D Hermetic D.I.L. Ceramic	P Molded D.I.L. Plastic	M Hermetic D.I.L. Metal	S Molded D.I.L. Plastic	F Flat Pack
ML101A	●	●		●		●
ML201A	●	●		●		●
ML301A	●	●	●		●	
ML101	●	●		●		●
ML201	●	●		●		●
ML301	●	●	●		●	
ML107	●	●		●		●
ML207	●	●		●		●
ML307	●	●	●		●	
ML709A	●	●		●		●
ML709	●	●		●		●
ML709C	●	●	●		●	
ML741A	●	●		●		●
ML741	●	●		●		●
ML741C	●	●	●		●	
ML748	●	●		●		●
ML748C	●	●	●		●	
ML777	●	●		●		●
ML777C	●	●	●		●	
ML1436	●					
ML1536	●					

ML101, ML201, ML301
OPERATIONAL AMPLIFIERS ML101A, ML201A, ML301A

features

- Input and Output Overload Protection
- Continuous Short-Circuit Protection
- Fast Recovery From Thermal Transients
- Available in Metal Can, Dual In-Line and Flat Packages
- No Latch-up even when Common-mode Range is Exceeded
- Frequency Compensation with a Single 30 pF Capacitor
- Low Current Drain — 1.8 mA Typ.

description

The ML101, 101A family are general-purpose operational amplifiers with differential inputs and class AB outputs. The inputs and outputs are protected against overload, and the amplifiers may be frequency compensated with an external 30pF capacitor. The unity-gain compensation specified makes the circuit stable for all feedback configurations, even with capacitive loads. However, compensation can be optimized 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 low power dissipation simplifies packaging in full-temperature-range systems and is attractive for portable equipment.

In addition, the ML101A series provides better accuracy and lower noise in high impedance circuitry. Due to the low input currents these devices are particularly well suited for sample and hold circuits, long interval integrators or timers, and low frequency waveform generators. Also, replacing circuits where the inputs of conventional IC op amps are buffered by matched transistor pairs, they can give lower offset voltage and drift at a lower cost.

absolute maximum ratings

Supply Voltage ML101A, ML201A	±22 V
ML301A	±18 V
Internal Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30 V
Input Voltage (Note 2)	±15 V
Output Short-Circuit Duration	Indefinite

Operating Temperature Range		
	ML101A	−55°C to +125°C
	ML201A	−25°C to +85°C
	ML301A	0°C to +70°C
Storage Temperature Range		−65°C to +150°C
Lead Temperature (Soldering, 60 sec)		300°C

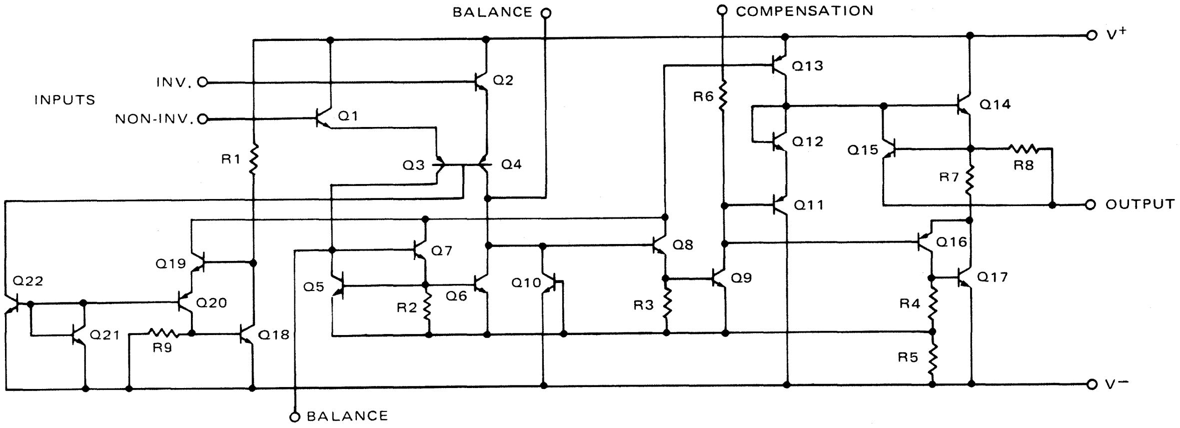
NOTES:

(1) Rating applies for case temperatures up to respective maximum operating temperature. Derate Metal Can package 6.5mW/°C for operation at ambient temperatures above 75°C, the Dual-in-Line package at 8.6mW/°C for operation at ambient temperatures above 95°C, and the Flat package at 5.6mW/°C for operation at ambient temperatures above 60°C; and for Plastic Dual-in-Line package derate linearly at 6.7mW/°C for ambient temperatures above +55°C.

(2) For supply voltages less than ±15V, the maximum input voltage is equal to the supply voltage.

ML101, ML201, ML301
OPERATIONAL AMPLIFIERS ML101A, ML201A, ML301A

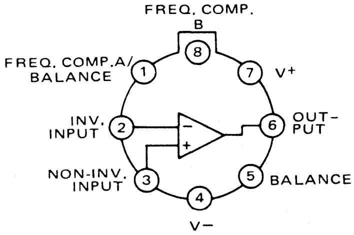
schematic diagram



connection diagrams

METAL CAN PACKAGE

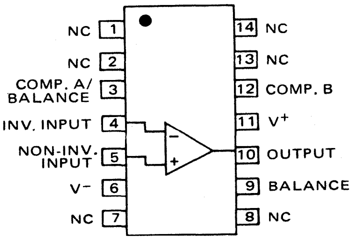
(Top View)



NOTE: Pin 4 connected to case

DUAL IN-LINE PACKAGE

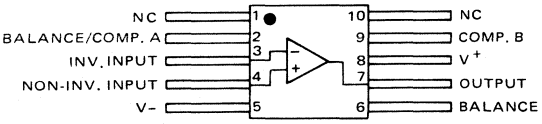
(Top View)



NOTE: Pin 6 connected to case

FLAT PACKAGE

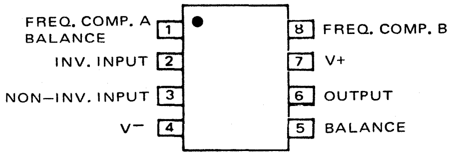
(Top View)



NOTE: Pin 5 connected to case bottom of package

DUAL IN–LINE PACKAGE

(Top View)



electrical characteristics (ML101A, ML201A, ML301A)

$T_A = 25°C$, $\pm 5V \leqslant V_S \leqslant \pm 20V$ for ML101A and ML201A, $\pm 5V \leqslant V_S \leqslant \pm 15V$ for ML301A unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	ML101A, ML201A			ML301A			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 50\ k\Omega$	–	0.7	2.0	–	2.0	7.5	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	1.5	10	–	3	50	nA
Input Bias Current	I_b	–	–	30	75	–	70	250	nA
Input Resistance	R_{in}	–	1.5	4	–	0.5	2	–	MΩ
Supply Current	I_S	$V_S = \pm 20\ V$	–	1.8	3.0	–	–	–	mA
		$V_S = \pm 15\ V$	–	–	–	–	1.8	3.0	mA
Large Signal Voltage Gain	A_{VOL}	$V_S = \pm 15\ V$, $V_{out} = \pm 10V$, $R_L > 2\ k\Omega$	50	160	–	25	160	–	V/mV

over respective operating temperature ranges, $\pm 5V \leqslant V_S \leqslant \pm 20V$ for ML101A and ML201A, $\pm 5V \leqslant V_S \leqslant \pm 15V$ for ML301A unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	ML101A, ML201A			ML301A			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 50\ k\Omega$	–	–	3.0	–	–	10	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	–	20	–	–	70	nA
Average Temperature Coefficient of Input Offset Voltage	$\lvert TC_{Vio} \rvert$	$T_{A(min)} \leqslant T_A \leqslant T_{A(max)}$	–	3.0	15	–	6.0	30	μV/°C
Average Temperature Coefficient of Input Offset Current	$\lvert TC_{Iio} \rvert$	$25°C \leqslant T_A \leqslant T_{A(max)}$	–	0.01	0.1	–	0.01	0.3	nA/°C
		$T_{A(min)} \leqslant T_A \leqslant 25°C$	–	0.02	0.2	–	0.02	0.6	nA/°C
Input Bias Current	I_b	–	–	–	100	–	–	300	nA
Large Signal Voltage Gain	A_{VOL}	$V_S = \pm 15\ V$, $V_{out} = \pm 10V$, $R_L > 2\ k\Omega$	25	–	–	25	–	–	V/mV
Input Voltage Range	V_{ICM}	$V_S = \pm 20\ V$	± 15	–	–	–	–	–	V
		$V_S = \pm 15\ V$	–	–	–	+15, –12	–	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leqslant 50\ k\Omega$	80	96	–	70	90	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leqslant 50\ k\Omega$	80	96	–	70	96	–	dB
Output Voltage Swing	V_{out}	$V_S = \pm 15\ V$, $R_L = 10\ k\Omega$,	± 12	± 14	–	± 12	± 14	–	V
		$R_L = 2\ k\Omega$,	± 10	± 13	–	± 10	± 13	–	V
Supply Current	I_S	$T_A = +125°C$, $V_S = \pm 20\ V$	–	1.2	2.5	–	–	–	mA

electrical characteristics (ML101, ML201, ML301)

$T_A = 25°C$, $\pm 5V \leqslant V_S \leqslant \pm 20V$ for ML101 and ML201, $\pm 5V \leqslant V_S \leqslant \pm 15V$ for ML301, $C_1 = 30pF$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	ML101, ML201			ML301			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 10\ k\Omega$	–	1.0	5.0	–	2.0	7.5	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	40	200	–	100	500	nA
Input Bias Current	I_b	–	–	120	500	–	250	1500	nA
Input Resistance	R_{in}	–	0.3	0.8	–	0.1	0.4	–	MΩ
Supply Current	I_S	$V_S = \pm V_{S\ max}$	–	1.8	3.0	–	1.8	3.0	mA
Large Signal Voltage Gain	A_{VOL}	$V_S = \pm 15V$, $V_{out} = \pm 10V$, $R_L > 2\ k\Omega$	50	160	–	20	150	–	V/mV

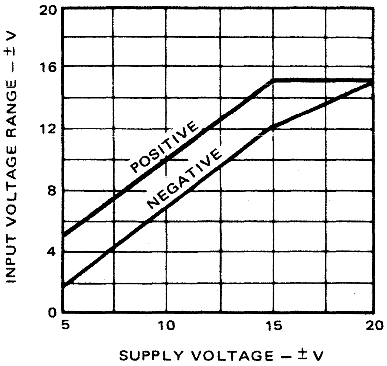
over respective operating temperature ranges, $\pm 5V \leqslant V_S \leqslant \pm 20V$ for ML101 and ML201, $\pm 5V \leqslant V_S \leqslant \pm 15V$ for ML301, $C_1 = 30pF$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	ML101, ML201			ML301			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 10\ k\Omega$	–	–	6.0	–	–	10	mV
Input Offset Current	$\lvert I_{io} \rvert$	$T_A = T_{A(min)}$	–	100	500	–	150	750	nA
		$T_A = T_{A(max)}$	–	10	200	–	50	400	nA
Input Bias Current	I_b	$T_A = T_{A(min)}$	–	0.28	1.5	–	0.32	2	μA
Large Signal Voltage Gain	A_{VOL}	$V_S = \pm 15V$, $V_{out} = \pm 10V$, $R_L > 2\ k\Omega$	25	–	–	15	–	–	V/mV
Input Voltage Range	V_{ICM}	$V_S = \pm 15V$	±12	–	–	± 12	–	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leqslant 10\ k\Omega$	70	90	–	65	90	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leqslant 10\ k\Omega$	70	90	–	70	90	–	dB
Output Voltage Swing	V_{out}	$V_S = \pm 15V$, $R_L = 10\ k\Omega$	± 12	± 14	–	± 12	± 14	–	V
		$R_L = 2\ k\Omega$	±10	± 13	–	± 10	± 13	–	V
Supply Current	I_S	$T_A = +125°C$, $V_S = \pm V_{S\ max}$	–	1.2	2.5	–	–	–	mA

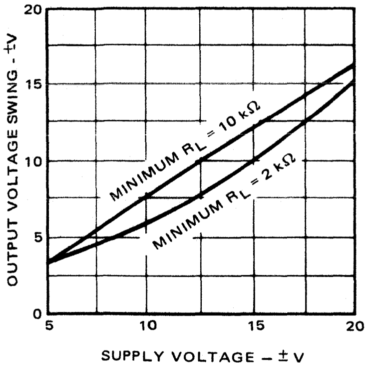
guaranteed performance curves over the respective operating temperature ranges,

± 5V ⩽ V_S ⩽ ± 20V for ML101A and ML201A, ± 5V ⩽ V_S ⩽ ± 15V for ML301A

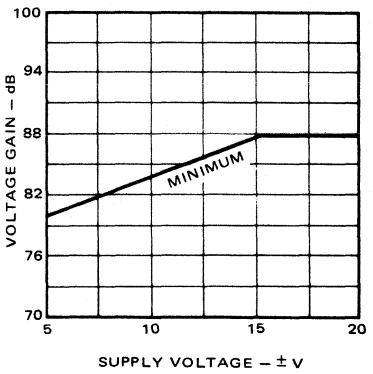
INPUT VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE



OUTPUT VOLTAGE SWING AS A FUNCTION OF SUPPLY VOLTAGE



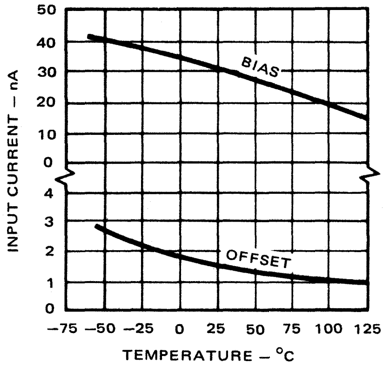
VOLTAGE GAIN AS A FUNCTION OF SUPPLY VOLTAGE



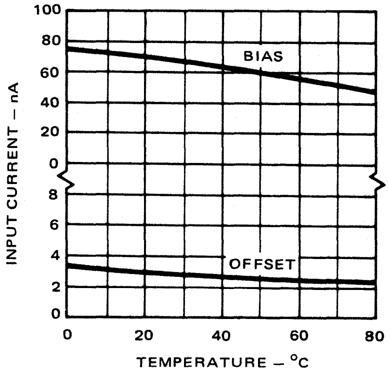
typical performance curves (ML101A, ML201A, ML301A)

± 5V ⩽ V_S ⩽ ± 20V for ML101A and ML201A, ± 5V ⩽ V_S ⩽ ± 15V for ML301A

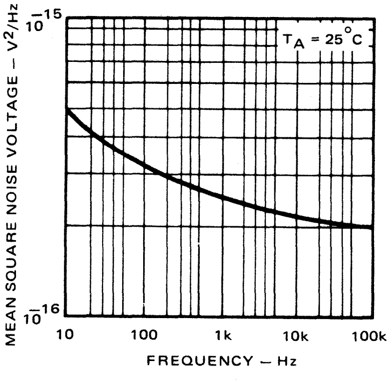
INPUT CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE – ML101A, ML201A



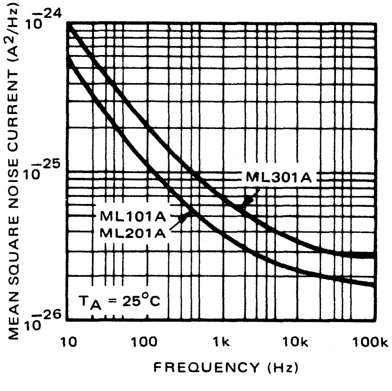
INPUT CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE – ML301A



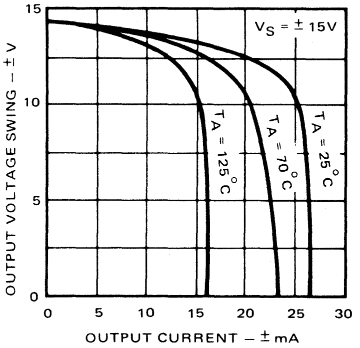
INPUT NOISE VOLTAGE AS A FUNCTION OF FREQUENCY



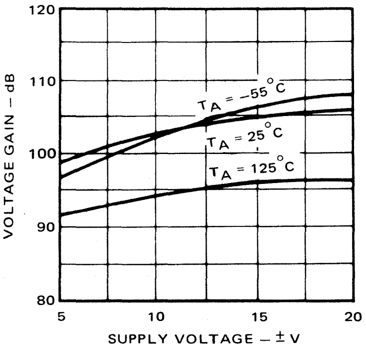
INPUT NOISE CURRENT AS A FUNCTION OF FREQUENCY



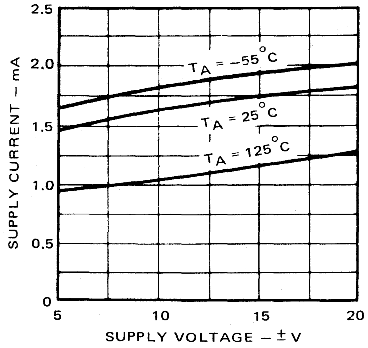
OUTPUT VOLTAGE SWING AS A FUNCTION OF OUTPUT CURRENT (CURRENT LIMITING)



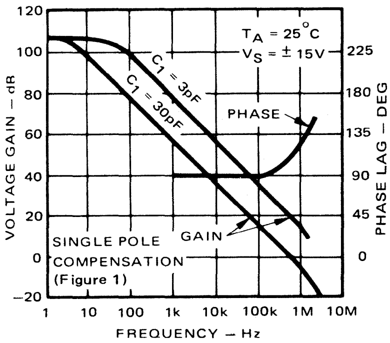
VOLTAGE GAIN AS A FUNCTION OF SUPPLY VOLTAGE



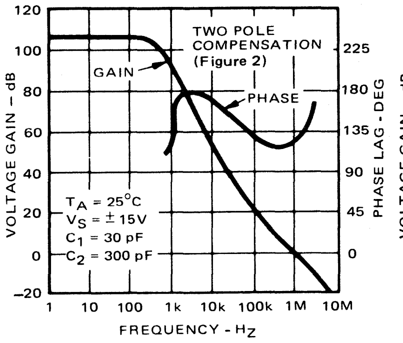
SUPPLY CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



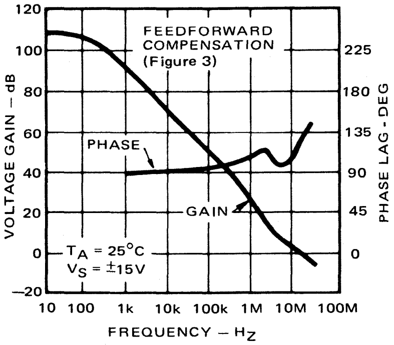
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



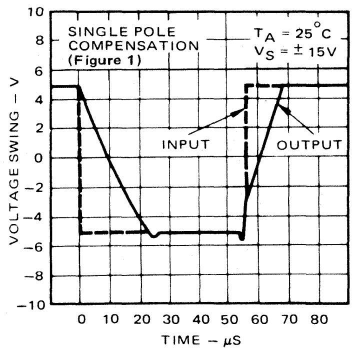
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



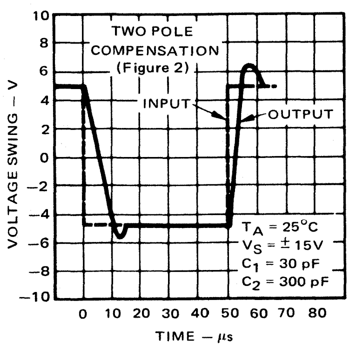
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



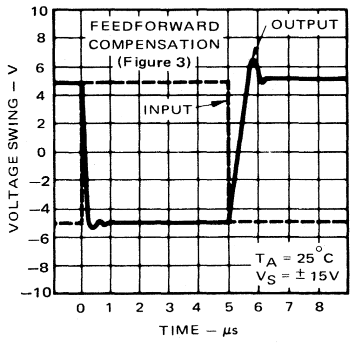
VOLTAGE FOLLOWER PULSE RESPONSE



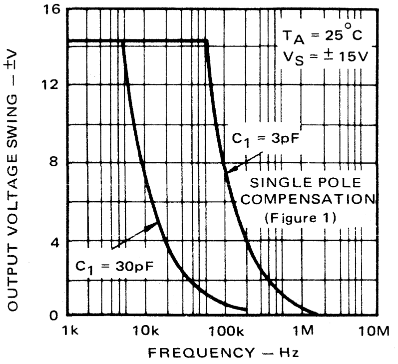
VOLTAGE FOLLOWER PULSE RESPONSE



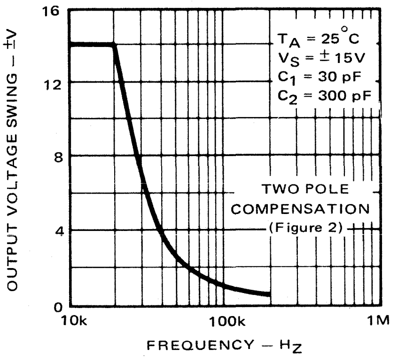
INVERTER PULSE RESPONSE



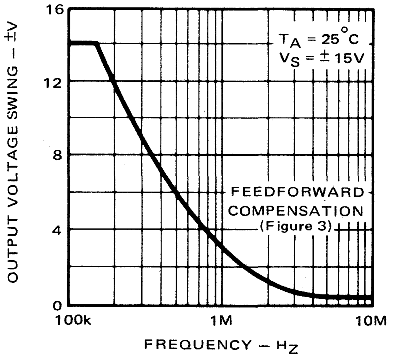
OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY



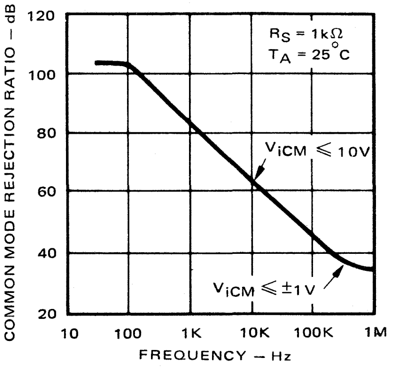
OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY



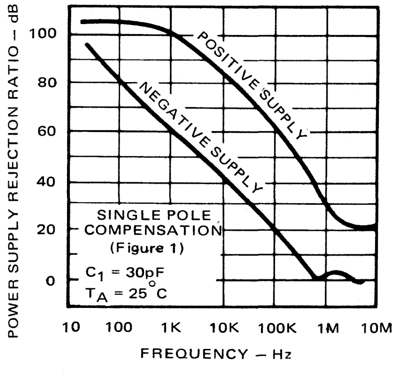
OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY



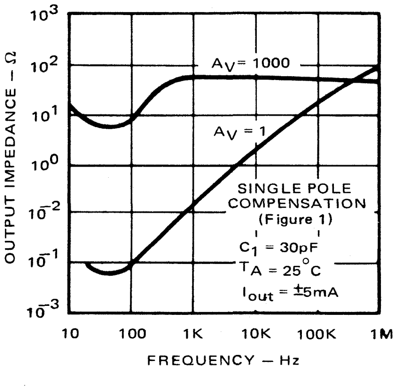
COMMON MODE REJECTION RATIO AS A FUNCTION OF FREQUENCY



POWER SUPPLY REJECTION RATIO AS A FUNCTION OF FREQUENCY



CLOSED LOOP OUTPUT IMPEDANCE AS A FUNCTION OF FREQUENCY



frequency compensation circuits

FIGURE 1. SINGLE POLE COMPENSATION

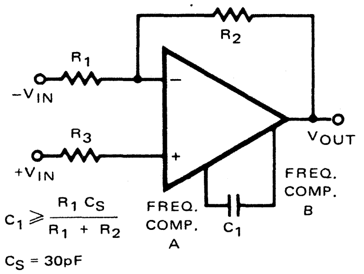


FIGURE 2. TWO POLE COMPENSATION

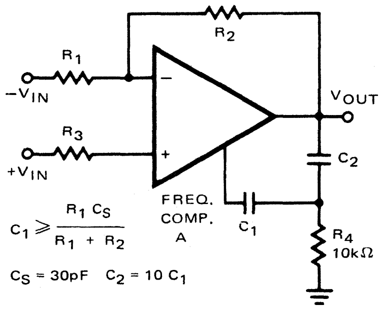
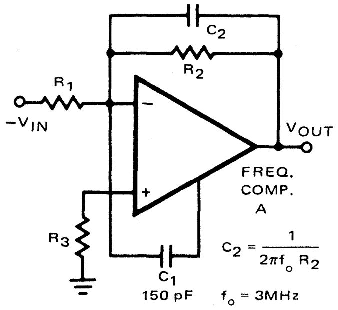


FIGURE 3. FEEDFORWARD COMPENSATION



Power supplies should be bypassed to ground at one point, minimum, on each card. More bypass points should be considered for five or more amplifiers on a single card. For applications using feed-forward compensation, the power supply leads of each amplifier should be bypassed with low inductance capacitors.

FIGURE 4. COMPENSATING FOR STRAY INPUT CAPACITANCE/LARGE FEEDBACK RESISTANCE

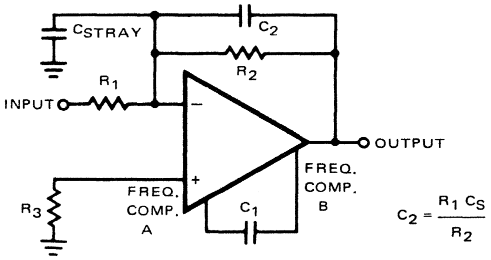
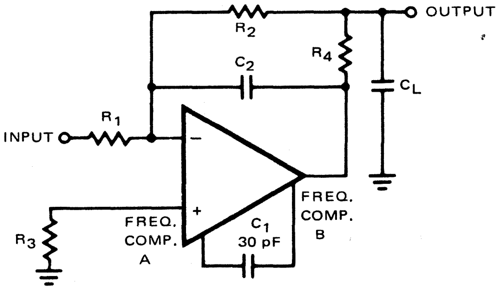
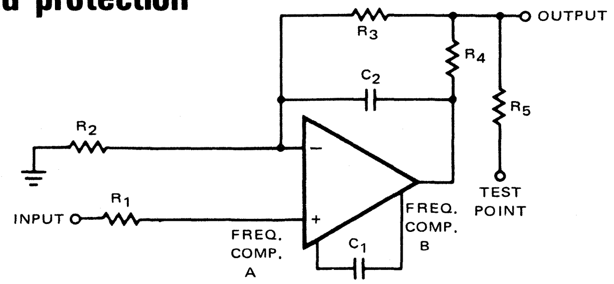


FIGURE 5. ISOLATING LARGE CAPACITIVE LOADS



The values given for the frequency compensation capacitor guarantee stability only for source resistances less than 10kΩ, stray capacitances on the summing junction less than 5pF and capacitive loads smaller than 100pF. If any of these conditions is not met, it is necessary to use 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.

input/output overload protection



If an input is driven from a low-impedance source, a series resistor, R_1 should be used to limit the peak instantaneous output current of the source to less than 100mA. A large capacitor (>0.1μF) is equivalent to a low source impedance and should be protected against by an isolation resistor.

The amplifier output is protected against damage from shorts to ground or to the power supplies by device design. Protection of the output from voltages exceeding the specified operating power supplies can be obtained by isolating the output via limiting resistors R_4 or R_5.

The power supplies must never become reversed, even under transient conditions. Reverse voltages as low as 1 volt can cause damage through excessive current. This hazard can be reduced by using clamp diodes of high peak current rating connected to the device supply lines.

ML107, ML207, ML307
FREQUENCY-COMPENSATED OPERATIONAL AMPLIFIERS . . . .

features

- Improved Performance due to Large Reductions in Offset Voltage, Offset Current and Input Current
- Guaranteed Drift Characteristics
- Offsets Guaranteed Over Entire Common-mode and Supply Voltage Ranges
- Input and Output Overload Protection
- Continuous Short-Circuit Protection
- No Latch-up even when Common-mode Range is Exceeded
- Internal Frequency Compensation
- Fast Recovery From Thermal Transients
- Available in Metal Can, Dual In-Line and Flat Packages
- Low Current Drain — 1.8 mA Typ.

description

The ML107, ML207 and ML307 operational amplifiers are identical to the ML101A, ML201A and ML301A with the added feature of internal frequency compensation. They also offer all the improvements that the latter devices have over the ML101, ML201 and ML301, such as an order-of-magnitude reduction in input currents. In addition, the ML107, ML207 and ML307 provide better accuracy and lower noise in high impedance circuitry. Due to the low input currents these devices are particularly well suited for sample and hold circuits, long interval integrators or timers, and low frequency waveform generators. Also, replacing circuits where the inputs of conventional IC op amps are buffered by matched transistor pairs, they can give lower offset voltage and drift at a lower cost.

absolute maximum ratings

Supply Voltage ML107, ML207	±22 V
ML307	±18 V
Internal Power Dissipation (Note 1)	500 mW
Differential Input Voltage	±30 V
Input Voltage (Note 2)	±15 V
Output Short-Circuit Duration	Indefinite

Operating Temperature Range		
	ML107	−55°C to +125°C
	ML207	−25°C to +85°C
	ML307	0°C to +70°C
Storage Temperature Range		−65°C to +150°C
Lead Temperature (Soldering, 60 sec)		300°C

NOTES: 1. Rating applies for case temperatures up to respective maximum operating temperature. Derate Metal Can package at 6.8 mW/°C for operation at ambient temperatures above 75°C, the Dual In-Line package at 9 mW/°C for operation at ambient temperatures above 95°C, and the Flat package at 5.6 mW/°C for operation at ambient temperatures above 60°C.
2. For supply voltages less than ± 15V, the maximum input voltage is equal to the supply voltage.

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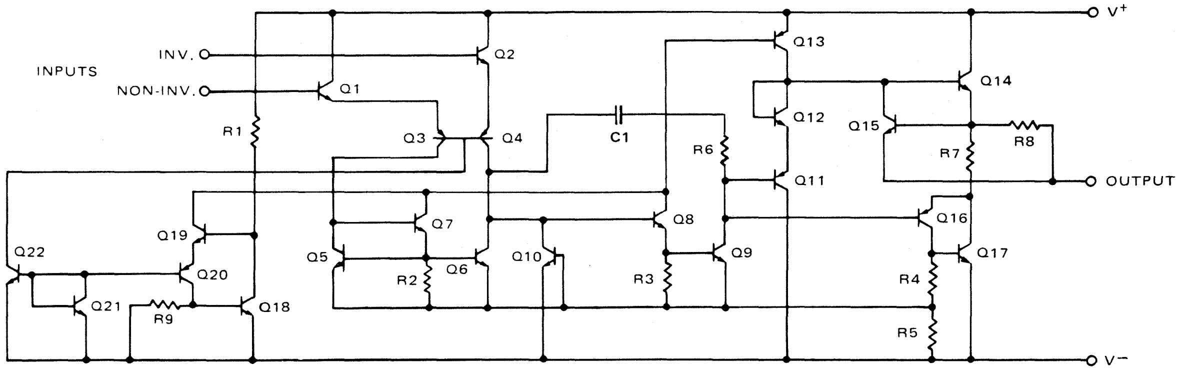
microsystems
international

ML107, ML207, ML307

FREQUENCY-COMPENSATED OPERATIONAL AMPLIFIERS . . . .

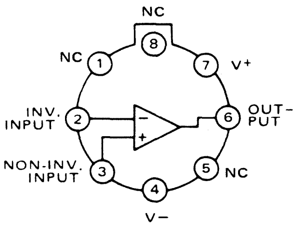
schematic diagram



connection diagrams

METAL CAN PACKAGE

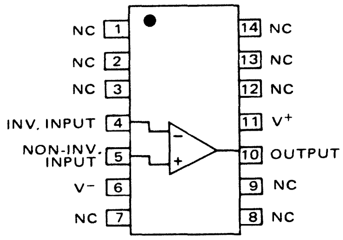
(Top View)



NOTE: Pin 4 connected to case

DUAL IN-LINE PACKAGE

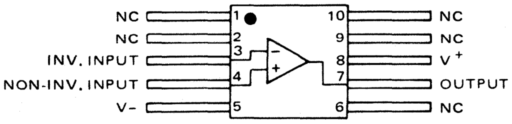
(Top View)



NOTE: Pin 6 connected to case

FLAT PACKAGE

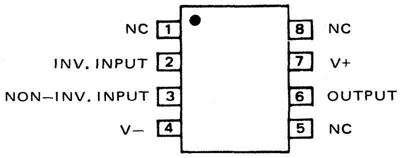
(Top View)



NOTE: Pin 5 connected to bottom of package

DUAL IN–LINE PACKAGE

(Top View)



electrical characteristics (T_A = 25°C, ±5V ⩽ V_S ⩽ ±20V for ML107 and ML207, ±5V ⩽ V_S ⩽ ±15V for ML307 unless otherwise specified)

			ML107, ML207			ML307			
PARAMETERS	**SYMBOLS**	**CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
Input Offset Voltage	$\|V_{io}\|$	R_S ⩽ 50 kΩ	–	0.7	2.0	–	2.0	7.5	mV
Input Offset Current	$\|I_{io}\|$	–	–	1.5	10	–	3	50	nA
Input Bias Current	I_b	–	–	30	75	–	70	250	nA
Input Resistance	R_{in}	–	1.5	4	–	0.5	2	–	MΩ
Supply Current	I_S	V_S = ± 20 V	–	1.8	3.0	–	–	–	mA
		V_S = ± 15 V	–	–	–	–	1.8	3.0	mA
Large Signal Voltage Gain	A_{VOL}	V_S = ± 15 V, V_{out} = ± 10V, R_L > 2 kΩ	50	160	–	25	160	–	V/mV

electrical characteristics (over respective operating temperature ranges, ±5V ⩽ V_S ⩽ ±20V for ML107 and ML207, ±5V ⩽ V_S ⩽ ±15V for ML307 unless otherwise specified)

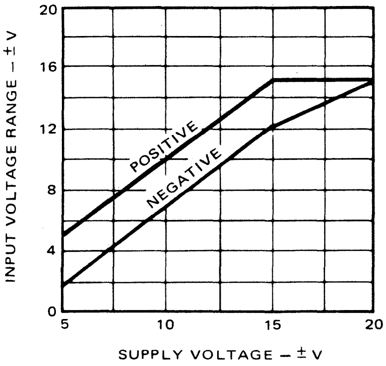
			ML107, ML207			ML307			
PARAMETERS	**SYMBOLS**	**CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
Input Offset Voltage	$\|V_{io}\|$	R_S ⩽ 50 kΩ	–	–	3.0	–	–	10	mV
Input Offset Current	$\|I_{io}\|$	–	–	–	20	–	–	70	nA
Average Temperature Coefficient of Input Offset Voltage	$\|TC_{V_{io}}\|$	$T_{A(min)} \leqslant T_A \leqslant T_{A(max)}$	–	3.0	15	–	6.0	30	μV/°C
Average Temperature Coefficient of Input Offset Current	$\|TC_{I_{io}}\|$	25°C ⩽ $T_A \leqslant T_{A(max)}$	–	0.01	0.1	–	0.01	0.3	nA/°C
		$T_{A(min)} \leqslant T_A \leqslant$ 25°C	–	0.02	0.2	–	0.02	0.6	nA/°C
Input Bias Current	I_b	–	–	–	100	–	–	300	nA
Large Signal Voltage Gain	A_{VOL}	V_S = ± 15 V, V_{out} = ± 10V, R_L > 2 kΩ	25	–	–	25	–	–	V/mV
Input Voltage Range	V_{ICM}	V_S = ± 20 V	± 15	–	–	–	–	–	V
		V_S = ± 15 V	–	–	–	+15, −12	–	–	V
Common Mode Rejection Ratio	CMRR	R_S ⩽ 50 kΩ	80	96	–	70	90	–	dB
Supply Voltage Rejection Ratio	PSRR	R_S ⩽ 50 kΩ	80	96	–	70	96	–	dB
Output Voltage Swing	V_{out}	V_S = ± 15 V, R_L = 10 kΩ,	± 12	± 14	–	± 12	± 14	–	V
		R_L = 2 kΩ,	± 10	± 13	–	± 10	± 13	–	V
Supply Current	I_S	T_A = +125°C, V_S = ± 20 V	–	1.2	2.5	–	–	–	mA

ML107, ML207, ML307

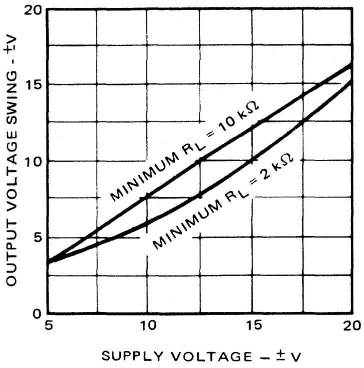
FREQUENCY-COMPENSATED OPERATIONAL AMPLIFIERS . . . .

guaranteed performance curves (applicable over the respective operating temperature ranges, ±5V ⩽ V_S ⩽ ±20V for ML107 and ML207, ±5V ⩽ V_S ⩽ ±15V for ML307)

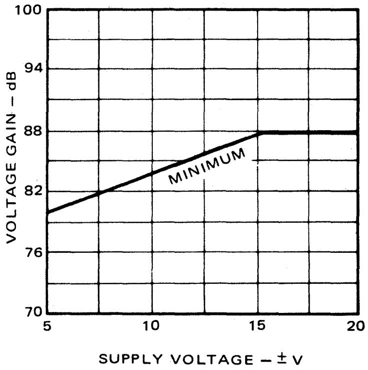
INPUT VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE



OUTPUT VOLTAGE SWING AS A FUNCTION OF SUPPLY VOLTAGE

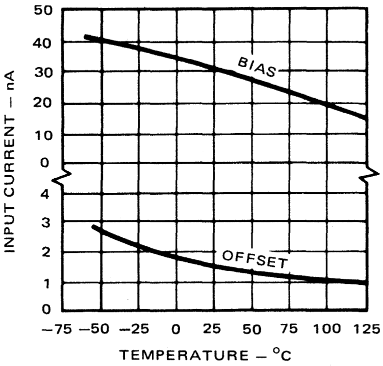


VOLTAGE GAIN AS A FUNCTION OF SUPPLY VOLTAGE

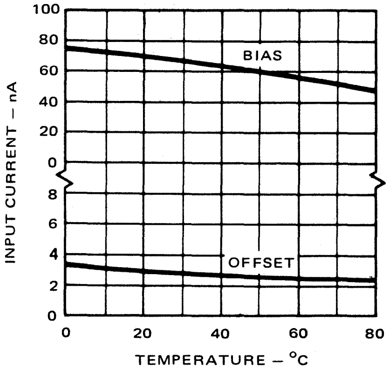


typical performance curves (±5V ⩽ V_S ⩽ ±20V for ML107 and ML207, ±5V ⩽ V_S ⩽ ±15V for ML307)

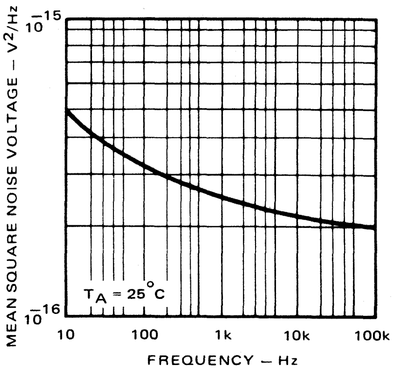
INPUT CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE – ML107, ML207



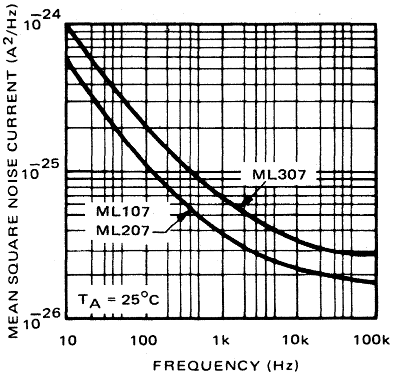
INPUT CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE – ML307



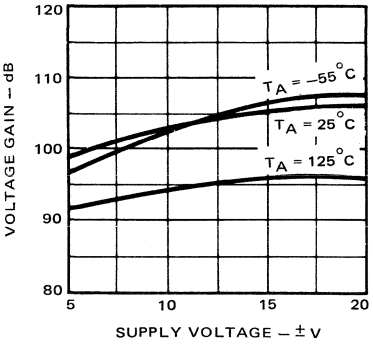
INPUT NOISE VOLTAGE AS A FUNCTION OF FREQUENCY



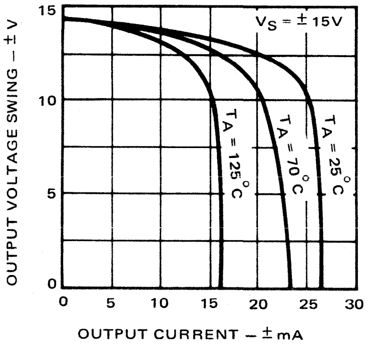
INPUT NOISE CURRENT AS A FUNCTION OF FREQUENCY



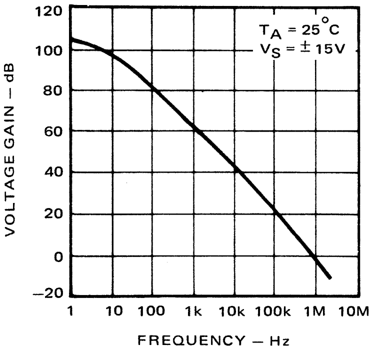
**VOLTAGE GAIN
AS A FUNCTION OF
SUPPLY VOLTAGE**



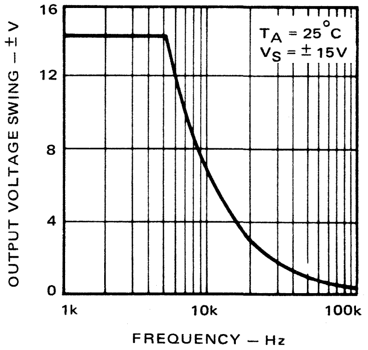
**OUTPUT VOLTAGE SWING
AS A FUNCTION OF
OUTPUT CURRENT (CURRENT LIMITING)**



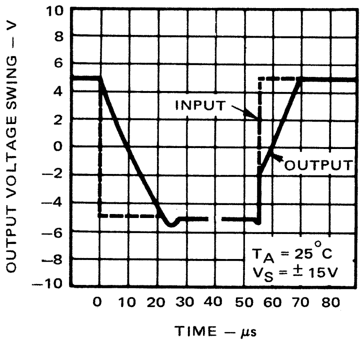
**OPEN LOOP VOLTAGE GAIN
AS A FUNCTION OF
FREQUENCY**



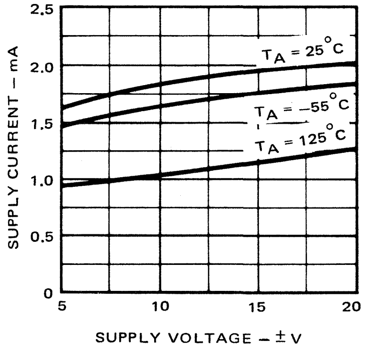
**OUTPUT VOLTAGE SWING
AS A FUNCTION OF
FREQUENCY**



**VOLTAGE FOLLOWER
PULSE RESPONSE**

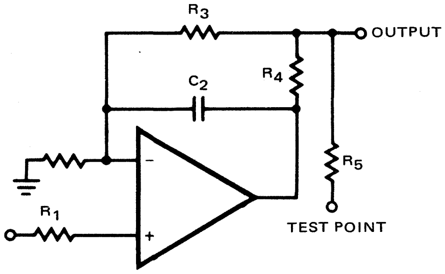


**SUPPLY CURRENT
AS A FUNCTION OF
SUPPLY VOLTAGE**



FREQUENCY-COMPENSATED OPERATIONAL AMPLIFIERS

input/output overload protection



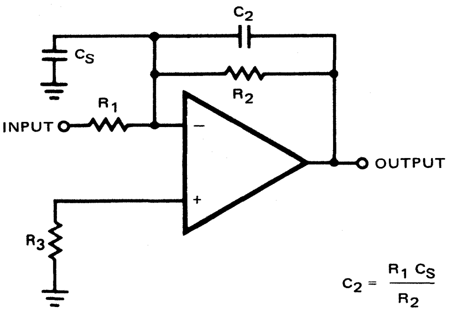
If an input is driven from a low-impedance source, a series resistor, R_1 should be used to limit the peak instantaneous output current of the source to less than 100mA. A large capacitor ($>0.1\mu F$) is equivalent to a low source impedance and should be protected against by an isolation resistor.

The amplifier output is protected against damage from shorts to ground or to the power supplies by device design. Protection of the output from voltages exceeding the specified operating power supplies can be obtained by isolating the output via limiting resistors R_4 or R_5.

The power supplies must never become reversed, even under transient conditions. Reverse voltages as low as 1 volt can cause damage through excessive current. This hazard can be reduced by using clamp diodes of high peak current rating connected to the device supply lines.

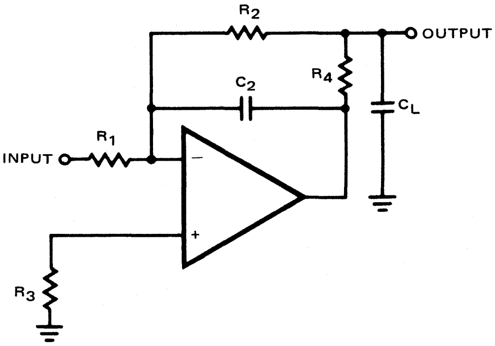
frequency compensation

STRAY INPUT CAPACITANCE/LARGE FEEDBACK RESISTANCE



$$C_2 = \frac{R_1 C_S}{R_2}$$

LARGE CAPACITIVE LOADS



Stability is guaranteed 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 is not met, lead capacitors may 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. Power supplies should be bypassed to ground at one point, minimum, on each card. More bypass points should be considered for five or more amplifiers on a single card.

ML709A, ML709, ML709C
HIGH PERFORMANCE OPERATIONAL AMPLIFIER . . . .

features

- Low offset
- High input impedance
- Low power consumption
- Large input common mode range
- High output swing under load

description

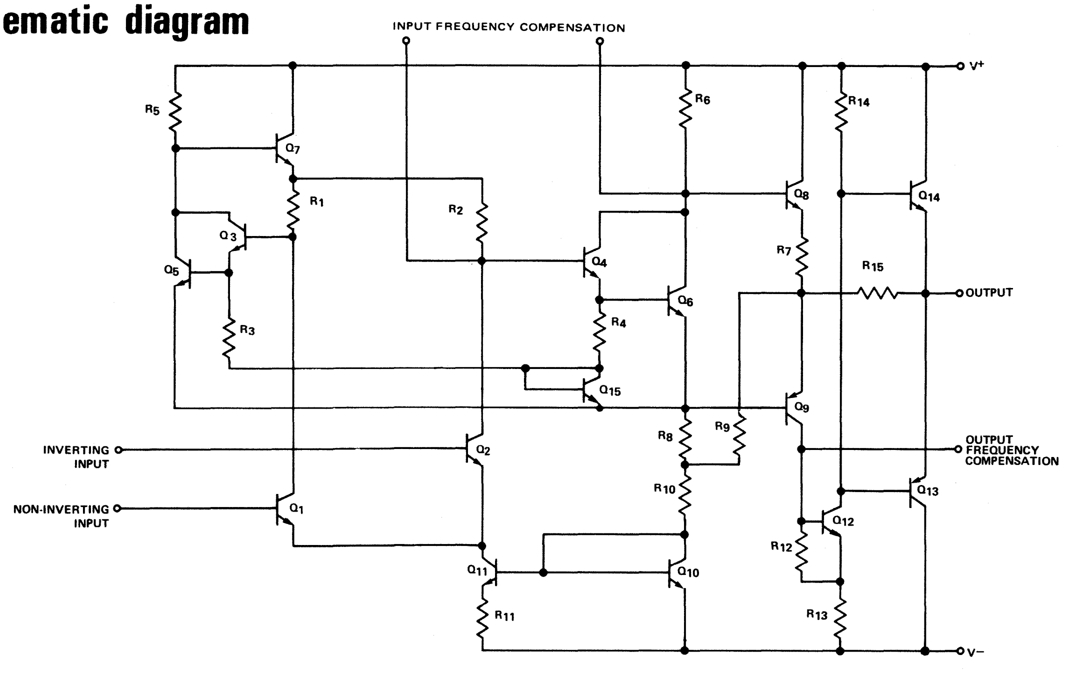
The ML709 family displays exceptional temperature stability and will operate over a wide range of supply voltages with little degradation of performance. The amplifier is intended for use in DC servo systems, high impedance analog computers, in low-level instrumentation applications and for the generation of special linear and non-linear transfer functions.

absolute maximum ratings

Supply Voltage	± 18 V	Storage Temperature Range	–65°C to + 150°C
Internal Power Dissipation*	300 mW	Operating Temperature Range:	
Differential Input Voltage	± 5.0 V	ML709A, 709	–55°C to + 125°C
Input Voltage	± 10 V	ML709C	0°C to + 70°C
Output Short-Circuit Duration (T_A = 25°C)	5 sec	Lead Temperature (Soldering, 60 sec)	300°C

* 1. TO-99 rating applies for case temperatures to +125°C; derate linearly at 6.5mW/°C for ambient temperatures above +115°C.
2. Dual-in-Line rating applies for case temperatures to +125°C; derate linearly at 8.6mW/°C for ambient temperatures above +115°C.
3. Flat Package rating applies for case temperatures to +125°C; derate linearly at 5.6mW/°C for ambient temperatures above +95°C.
4. Plastic Dual-in-Line rating applies for case temperatures to +70°C; derate linearly at 6.7mW/°C for ambient temperatures above +55°C.

schematic diagram



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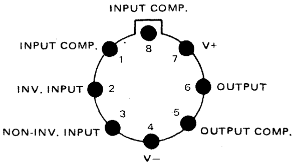
microsystems
international

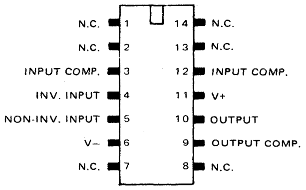
ML709A, ML709, ML709C
HIGH PERFORMANCE OPERATIONAL AMPLIFIER . . . .

connection diagrams (Top View)

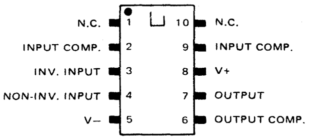
METAL CAN PACKAGE



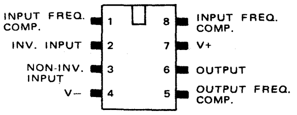
DUAL-IN-LINE PACKAGE



FLAT PACKAGE



DUAL-IN-LINE PACKAGE



electrical characteristics (ML709A)

$T_A = 25°C$, $\pm9V \leq V_S \leq \pm15V$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leq 10$ kΩ	–	0.6	2.0	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	10	50	nA
Input Bias Current	I_b	–	–	100	200	nA
Input Resistance	R_{in}	–	350	700	–	kΩ
Output Resistance	R_{out}	–	–	150	–	Ω
Supply Current	I_s	$V_S = \pm 15$ V	–	2.5	3.6	mA
Power Consumption	P_d	$V_S = \pm 15$ V	–	75	108	mW
Transient Response		$V_S = \pm 15$ V, V_{in} = 20 mV, R_L = 2 kΩ, C_1 = 5nF R_1 = 1.5 kΩ,				
Risetime	t_R	C_2 = 200 pF, R_2 = 50 Ω	–	–	1.5	µS
Overshoot	t_O	$C_L \leq 100$ pF	–	–	30	%

$-55°C \leq T_A \leq +125°C$, $\pm9V \leq V_S \leq \pm15V$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leq 10$ kΩ	–	–	3.0	mV
Average Temperature Coefficient of Input Offset Voltage	$\lvert TC_{Vio} \rvert$	R_S = 50 Ω, $T_A = +25°C$ to $T_A = +125°C$	–	1.8	10	µV/°C
		R_S = 50 Ω, $T_A = +25°C$ to $T_A = -55°C$	–	1.8	10	µV/°C
		R_S = 10 kΩ, $T_A = +25°C$ to $T_A = +125°C$	–	2.0	15	µV/°C
		R_S = 10 kΩ, $T_A = +25°C$ to $T_A = -55°C$	–	4.8	25	µV/°C
Input Offset Current	$\lvert I_{io} \rvert$	$T_A = +125°C$	–	3.5	50	nA
		$T_A = -55°C$	–	40	250	nA
Average Temperature Coefficient of Input Offset Current	$\lvert TC_{Iio} \rvert$	$T_A = +25°C$ to $T_A = +125°C$	–	0.08	0.5	nA/°C
		$T_A = +25°C$ to $T_A = -55°C$	–	0.45	2.8	nA/°C

–55°C ≤ T_A ≤ +125°C, ±9V ≤ V_S ≤ ±15V unless otherwise specified (cont'd)

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Bias Current	I_b	T_A = –55°C	–	300	600	nA
Input Resistance	R_{in}	T_A = –55°C	85	170	–	kΩ
Input Voltage Range	V_{iCM}	V_S = ± 15 V	± 8.0	–	–	V
Common Mode Rej. Ratio	CMRR	R_S ≤ 10 kΩ	80	110	–	dB
Supply Voltage Rej. Ratio	PSRR	R_S ≤ 10 kΩ	–	40	100	μV/V
Large-Signal Voltage Gain	Δ_{VOL}	V_S = ± 15 V, R_L ≥ 2 kΩ, V_{out} = ± 10V	25,000	–	70,000	–
Output Voltage Swing	V_{out}	V_S = ± 15 V, R_L ≥ 10 kΩ	± 12	± 14	–	V
		V_S = ± 15 V, R_L ≥ 2 kΩ	± 10	± 13	–	V
Supply Current	I_s	T_A = +125°C, V_S = ± 15 V	–	2.1	3.0	mA
		T_A = –55°C, V_S = ± 15 V	–	2.7	4.5	mA
Power Consumption	P_d	T_A = +125°C, V_S = ± 15 V	–	63	90	mW
		T_A = –55°C, V_S = ± 15 V	–	81	135	mW

electrical characteristics (ML709)

T_A = +25°C, ±9V ≤ V_S ≤ ±15V unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	R_S ≤ 10 kΩ	–	1.0	5.0	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	50	200	nA
Input Bias Current	I_b	–	–	200	500	nA
Input Resistance	R_{in}	–	150	400	–	kΩ
Output Resistance	R_{out}	–	–	150	–	Ω
Power Consumption	P_d	V_S = ± 15 V	–	80	165	mW
Transient Response Risetime	t_R	V_{in} = 20 mV, R_L = 2 kΩ, C_1 = 5000 pF, R_1 = 1.5 kΩ, C_2 = 200 pF, R_2 = 50Ω	–	0.3	1.0	μs
Overshoot	t_O	C_L ≤ 100 pF	–	10	30	%

-55°C ≤ T_A ≤ +125°C, ±9V ≤ V_S ≤ ±15V unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	R_S ≤ 10 kΩ	–	–	6.0	mV
Average Temperature Coefficient of Input Offset Voltage	$\lvert TC_{Vio} \rvert$	R_S = 50 Ω	–	3.0	–	μV/°C
		R_S ≤ 10 kΩ	–	6.0	–	μV/°C
Large-Signal Voltage Gain	Δ_{VOL}	V_S = ± 15 V, R_L ≥ 2 kΩ, V_{out} = ± 10 V	25,000	45,000	70,000	–
Output Voltage Swing	V_{out}	V_S = ± 15 V, R_L ≥ 10 kΩ	± 12	± 14	–	V
		V_S = ± 15 V, R_L ≥ 2 kΩ	± 10	± 13	–	V
Input Voltage Range	V_{iCM}	V_S = ± 15 V	± 8.0	± 10	–	V
Common Mode Rej. Ratio	CMRR	R_S ≤ 10 kΩ	70	90	–	dB
Supply Voltage Rej. Ratio	PSRR	R_S ≤ 10 kΩ	–	25	150	μV/V

$-55°C \leqslant T_A \leqslant +125°C$, $\pm 9V \leqslant V_S \leqslant \pm 15V$ unless otherwise specified (cont'd)

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Current	$\lvert I_{io} \rvert$	$T_A = +125°C$	–	20	200	nA
		$T_A = -55°C$	–	100	500	nA
Input Bias Current	I_b	$T_A = -55°C$	–	0.5	1.5	μA
Input Resistance	R_{in}	$T_A = -55°C$	40	100	–	kΩ

electrical characteristics (ML709C)

$V_S = \pm 15V$, $T_A = 25°C$ unless otherwise specified

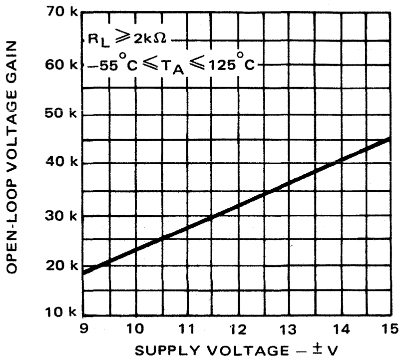
PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 10\ k\Omega$, $\pm 9\ V \leqslant V_S \leqslant \pm 15\ V$	–	2.0	7.5	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	100	500	nA
Input Bias Current	I_b	–	–	0.3	1.5	μA
Input Resistance	R_{in}	–	50	250	–	kΩ
Output Resistance	R_{out}	–	–	150	–	Ω
Large-Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2\ k\Omega$, $V_{out} = \pm 10\ V$	15,000	45,000	–	–
Output Voltage Swing	V_{out}	$R_L \geqslant 10\ k\Omega$	± 12	± 14	–	V
		$R_L \geqslant 2\ k\Omega$	± 10	± 13	–	V
Input Voltage Range	V_{iCM}	–	± 8.0	± 10	–	V
Common Mode Rej. Ratio	CMRR	$R_S \leqslant 10\ k\Omega$	65	90	–	dB
Supply Voltage Rej. Ratio	PSRR	$R_S \leqslant 10\ k\Omega$	–	25	200	μV/V
Power Consumption	Pd	–	–	80	200	mW
Transient Response Risetime	t_R	$V_{in} = 20\ mV$, $R_L = 2\ k\Omega$, $C_1 = 5000\ pF$, $R_1 = 1.5\ k\Omega$, $C_2 = 200\ pF$, $R_2 = 50\ \Omega$	–	0.3	–	μs
Overshoot	t_O	$C_L \leqslant 100\ pF$	–	10	–	%

$V_S = \pm 15V$, $0°C \leqslant T_A \leqslant +70°$ unless otherwise specified

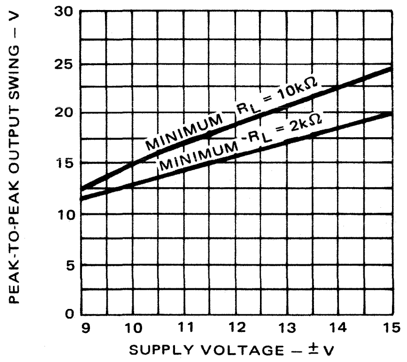
PARAMETERS	SYMBOLS	CONDITIONS	MIN.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 10\ k\Omega$, $\pm 9\ V \leqslant \pm 15\ V$	–	10	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	750	nA
Input Bias Current	I_b	–	–	2.0	μA
Large-Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2\ k\Omega$, $V_{out} = \pm 10\ V$	12,000	–	–
Input Resistance	R_{in}	–	35	–	kΩ

guaranteed electrical characteristics (ML709A)

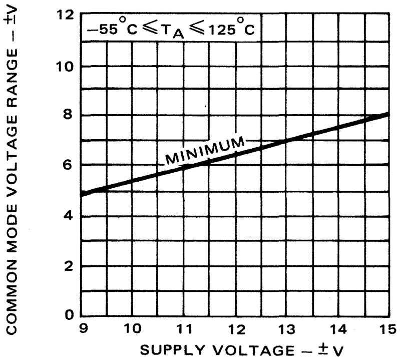
VOLTAGE GAIN



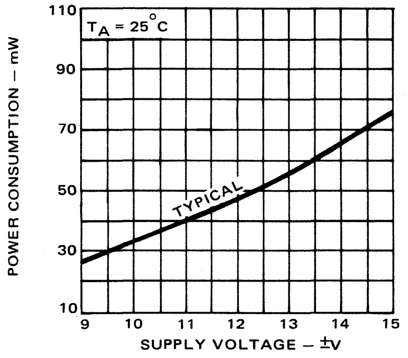
OUTPUT VOLTAGE SWING



INPUT COMMON MODE VOLTAGE RANGE

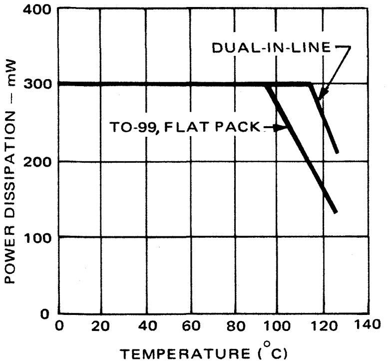


POWER CONSUMPTION

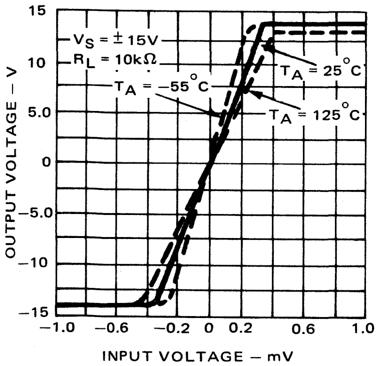


typical performance curves (ML709A)

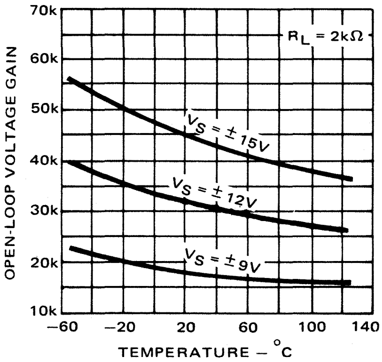
ABSOLUTE MAXIMUM POWER DISSIPATION AS A FUNCTION OF AMBIENT TEMPERATURE



VOLTAGE TRANSFER CHARACTERISTIC



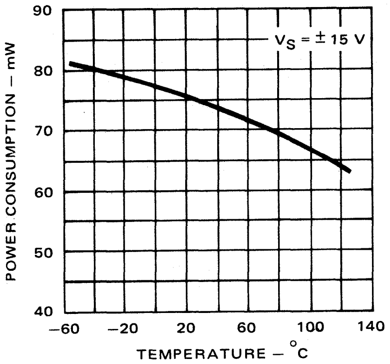
VOLTAGE GAIN AS A FUNCTION OF AMBIENT TEMPERATURE



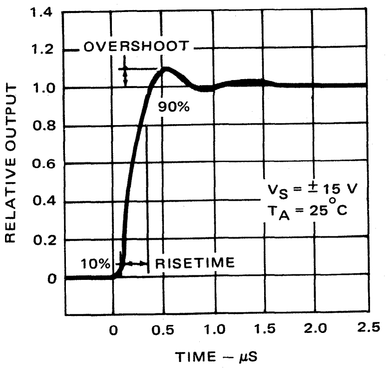
ML709A, ML709, ML709C

HIGH PERFORMANCE OPERATIONAL AMPLIFIER . . . .

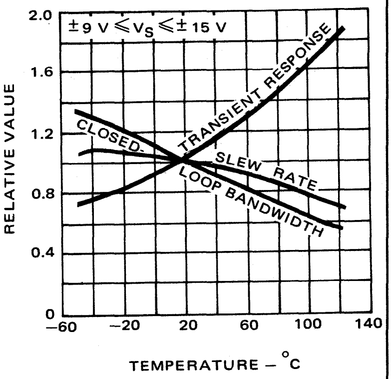
POWER CONSUMPTION AS A FUNCTION OF AMBIENT TEMPERATURE



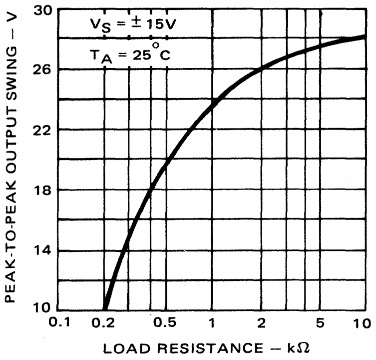
TRANSIENT RESPONSE



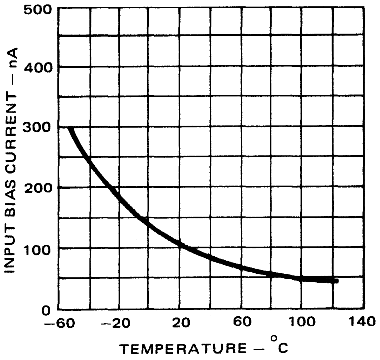
FREQUENCY CHARACTERISTICS AS A FUNCTION OF AMBIENT TEMPERATURE



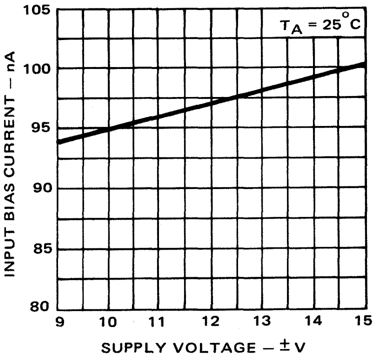
OUTPUT VOLTAGE SWING AS A FUNCTION OF LOAD RESISTANCE



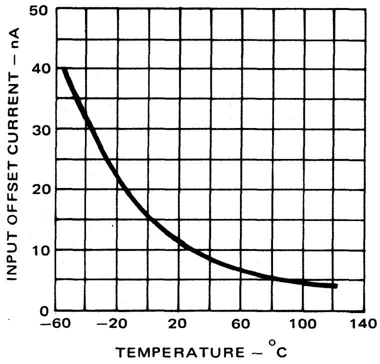
INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



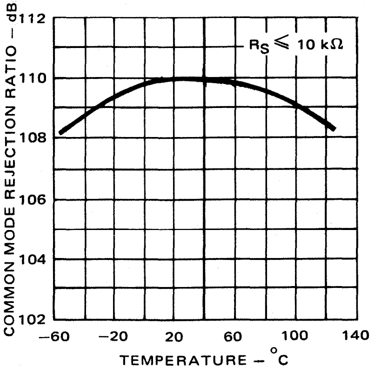
INPUT BIAS CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



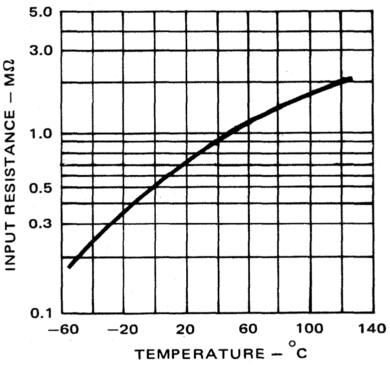
INPUT OFFSET CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



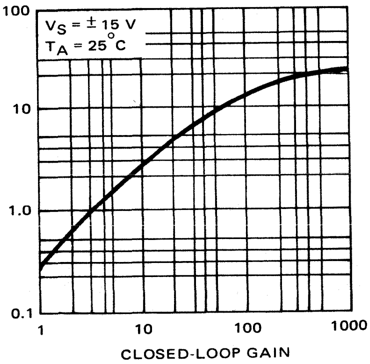
COMMON MODE REJECTION RATIO AS A FUNCTION OF AMBIENT TEMPERATURE



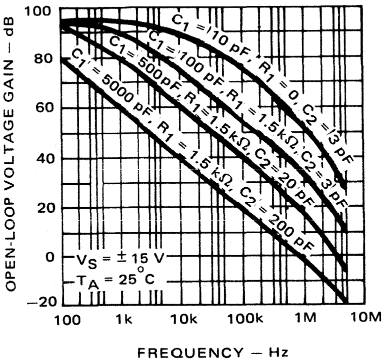
INPUT RESISTANCE AS A FUNCTION OF AMBIENT TEMPERATURE



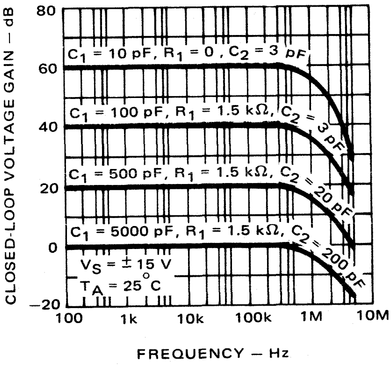
SLEW RATE AS A FUNCTION OF CLOSED-LOOP GAIN USING RECOMMENDED COMPENSATION NETWORKS



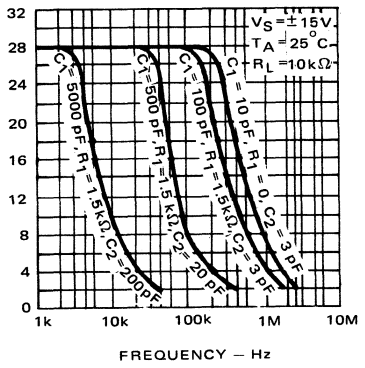
OPEN-LOOP FREQUENCY RESPONSE FOR VARIOUS VALUES OF COMPENSATION



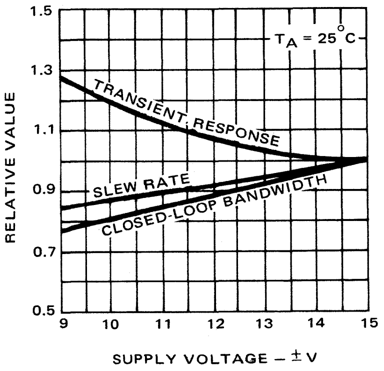
FREQUENCY RESPONSE FOR VARIOUS CLOSED-LOOP GAINS



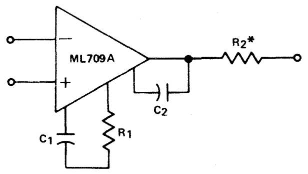
OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY FOR VARIOUS COMPENSATION NETWORKS



FREQUENCY CHARACTERISTICS AS A FUNCTION OF SUPPLY VOLTAGE



FREQUENCY COMPENSATION CIRCUIT



*USE R_2 = 50Ω WHEN THE AMPLIFIER IS OPERATED WITH CAPACITIVE LOADING

ML741A ML741 ML741C
FREQUENCY COMPENSATED OPERATIONAL AMPLIFIER . . . . . .

features

- No frequency compensation required
- Short-circuit protection
- Offset voltage null capability
- Large common-mode and differential voltage ranges
- Low power consumption
- No latch-up
- Available in TO-99, dual-in-line and flat packages

description

The ML741 family is intended for a wide range of analog applications. High common mode voltage range and absence of "latch-up" tendencies make the ML741 ideal for use as a voltage follower. The high gain and wide range of operating voltages of the ML741 provide superior performance in such mathematical functions as differentiation, integration, analog comparison, and summation. In addition it may be used for the generation of numerous linear and nonlinear transfer functions. The ML741 is short-circuit protected, has the same pin configuration as the ML709 operational amplifier, but requires no external components for frequency compensation. The internal 6dB/octave roll-off ensures stability in closed loop applications. The ML741A is selected for improved performance by reduction of offset voltage, offset current and input current; the ML741C for relaxed, commercial performance specifications.

absolute maximum ratings

Supply Voltage:		Storage Temperature Range	−65°C to +150°C
ML741A, 741	±22 V	Operating Temperature Range:	
ML741C	±18 V	ML741A, 741	−55°C to +125°C
Internal Power Dissipation (Note 1)	500 mW	ML741C	0°C to +70°C
Differential Input Voltage	±30 V	Lead Temperature (Soldering, 60 sec)	300°C
Input Voltage (Note 2)	±15 V	Output Short-Circuit Duration (Note 3)	Indefinite
Voltage between Offset Null and V−	±0.5 V		

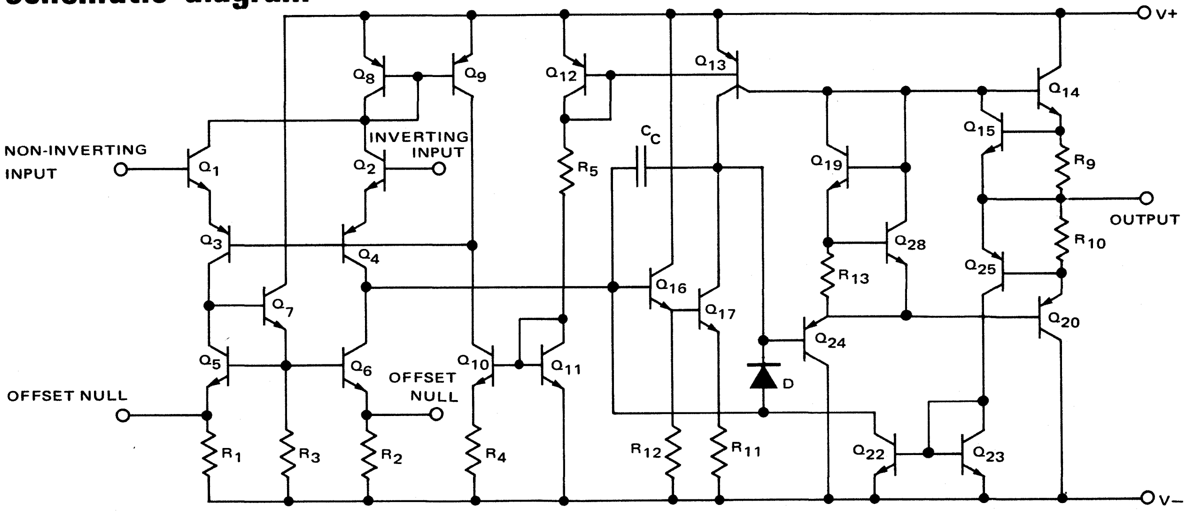
NOTES:

(1) TO-99 rating applies for case temperatures to +125°C; derate linearly at 6.5mW/°C for ambient temperatures above +75°C.
Dual-in-line rating applies for case temperatures to 125°C; derate linearly at 8.6mW/°C for ambient temperatures above +95°C.
Flat Package rating applies for case temperatures to +125°C; derate linearly at 5.6mW/°C for ambient temperatures above +95°C.
Plastic Dual-in-line rating applies for case temperatures to +70°C; derate linearly at 6.7mW/°C for ambient temperatures above +55°C.

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

(3) Short-circuit may be to ground or either supply. Rating applies to +125°C case temperature or +75°C ambient temperature.

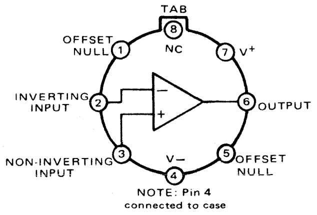
schematic diagram



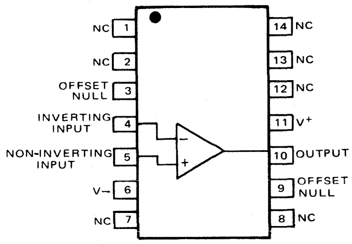
ML741A ML741 ML741C
FREQUENCY COMPENSATED OPERATIONAL AMPLIFIER . . . .

connection diagrams

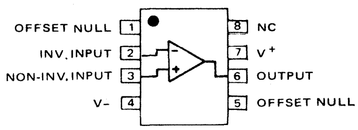
TO-99 PACKAGE (Top View)



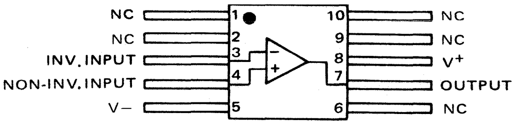
DUAL IN-LINE PACKAGE (Top View)



DUAL IN–LINE PACKAGE (Top View)



FLAT PACKAGE (Top View)



electrical characteristics (ML741A)

±5V ≤ V_S ≤ ±20V, T_A = 25°C unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leq 50k\Omega$	–	0.7	2.0	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	1.5	10	nA
Input Bias Current	I_b	–	–	30	75	nA
Input Resistance	R_{in}	–	1.4	4.0	–	MΩ
Input Capacitance	C_{in}	–	–	1.4	–	pF
Offset Voltage Adjustment Range	ΔV_{io}	–	–	±15	–	mV
Large-Signal Voltage Gain	A_{VOL}	$R_L \geq 2$ kΩ, $V_S = \pm 15V$	50,000	200,000	–	–
Output Resistance	R_{out}	–	–	75	–	Ω
Output Short-Circuit Current	I_{OS}	–	–	25	–	mA
Supply Current	I_S	$V_S = \pm 20V$	–	2.2	3.0	mA
Power Consumption	P_D	–	–	88	120	mW
Transient Response (Unity gain)		V_{in} = 20 mV, R_L = 2 kΩ				
Risetime	t_r	$C_L \leq 100pF$	–	0.3	–	μs
Overshoot	t_O		–	5.0	–	%
Slew Rate	SR	$R_L \geq 2$ kΩ	–	0.5	–	V/μs

±5V ≤ V_S ≤ ±20V, −55°C ≤ T_A ≤ +125°C unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leq 50k\Omega$	–	–	3.0	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	–	20	nA
Input Bias Current	I_b	–	–	–	100	nA
Input Voltage Range	V_{ICM}	$V_S = \pm 20V$	±15	–	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leq 50k\Omega$	80	96	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leq 50k\Omega$	80	96	–	dB
Large-Signal Voltage Gain	A_{VOL}	$R_L \geq 2k\Omega$, $V_S = \pm 15V$	25,000	–	–	–

$\pm 5V \leqslant V_S \leqslant \pm 20V$, $-55°C \leqslant T_A \leqslant +125°C$ unless otherwise specified (Continued)

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Output Voltage Swing	V_{out}	$V_S = \pm 15V$ $T_A = +125°C$	± 12	± 14	–	V
		$V_S = \pm 15V$ $T_A = -55°C$	± 10	± 13	–	V
Supply Current	I_S	$T_A = +125°C$	–	1.5	2.5	mA
		$T_A = -55°C$	–			mA
Power Consumption	P_D	$T_A = +125°C$	–	45	100	mW
		$T_A = -55°C$	–	60	–	mW
Average Temperature Coefficient of Input Offset Voltage	$\lvert TC_{Vio} \rvert$	$-55°C \leqslant T_A \leqslant +125°C$	–	3.0	15	μV/°C
Average Temperature Coefficient of Input Offset Current	$\lvert TC_{Iio} \rvert$	$25°C \leqslant T_A \leqslant +125°C$	–	0.01	0.1	nA/°C
		$-55°C \leqslant T_A \leqslant 25°C$	–	0.02	0.2	nA/°C

electrical characteristics (ML741)

$V_S = \pm 15$ V, $T_A = 25°C$ unless otherwise specified

PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 10$ kΩ	–	1.0	5.0	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	20	200	nA
Input Bias Current	I_b	–	–	80	500	nA
Input Resistance	R_{in}	–	0.3	2.0	–	MΩ
Input Capacitance	C_{in}	–	–	1.4	–	pF
Offset Voltage Adjustment Range	ΔV_{io}	–	–	± 15	–	mV
Large-Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2$ kΩ, $V_{out} = \pm 10$ V	50,000	200,000	–	–
Output Resistance	R_{out}	–	–	75	–	Ω
Output Short-Circuit Current	I_{OS}	–	–	25	–	mA
Supply Current	I_S	–	–	1.7	2.8	mA
Power Consumption	P_D	–	–	50	85	mW
Transient Response (Unity gain)		$V_{in} = 20$ mV, $R_L = 2$ kΩ $C_L \leqslant 100$pF				
Risetime	t_R		–	0.3	–	μs
Overshoot	t_O		–	5.0	–	%
Slew Rate	SR	$R_L \geqslant 2$ kΩ	–	0.5	–	V/μs

$V_S = \pm 15$ V, $-55°C \leqslant T_A \leqslant +125°C$ unless otherwise specified

PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 10$ kΩ	–	1.0	6.0	mV
Input Offset Current	$\lvert I_{io} \rvert$	$T_A = +125°C$	–	7.0	200	nA
		$T_A = -55°C$	–	85	500	nA
Input Bias Current	I_b	$T_A = +125°C$	–	0.03	0.5	μA
		$T_A = -55°C$	–	0.3	1.5	μA
Input Voltage Range	V_{ICM}	–	± 12	± 13	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leqslant 10$ kΩ	70	90	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leqslant 10$ kΩ	–	30	150	μV/V
Large-Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2$kΩ, $V_{out} = \pm 10$ V	25,000	–	–	–

V_S = ±15 V, −55°C ⩽ T_A ⩽ +125°C unless otherwise specified (Continued)

PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Output Voltage Swing	V_{out}	$R_L \geqslant 10$ kΩ	±12	±14	–	V
		$R_L \geqslant 2$ kΩ	±10	±13	–	V
Supply Current	I_S	T_A = + 125°C	–	1.5	2.5	mA
		T_A = −55°C	–	2.0	3.3	mA
Power Consumption	P_D	T_A = + 125°C	–	45	75	mW
		T_A = −55°C	–	60	100	mW

electrical characteristics (ML741C)

V_S = ±15 V, T_A = 25°C unless otherwise specified

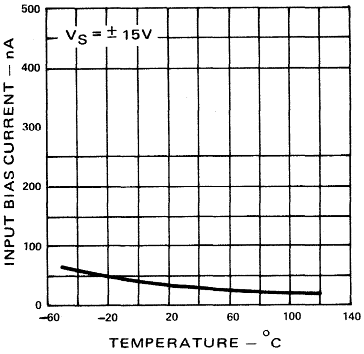
PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 10$ kΩ	–	2.0	6.0	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	20	200	nA
Input Bias Current	$\lvert I_b \rvert$	–	–	80	500	nA
Input Resistance	R_{in}	–	0.3	2.0	–	MΩ
Input Capacitance	C_{in}	–	–	1.4	–	pF
Offset Voltage Adjustment Range	ΔV_{io}	–	–	±15	–	mV
Input Voltage Range	V_{iCM}	–	±12	±13	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leqslant 10$ kΩ	70	90	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leqslant 10$ kΩ	–	30	150	μV/V
Large-Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2$ kΩ, V_{out} = ± 10 V	25,000	200,000	–	–
Output Voltage Swing	V_{out}	$R_L \geqslant 10$ kΩ	±12	±14	–	V
		$R_L \geqslant 2$ kΩ	±10	±13	–	V
Output Resistance	R_{out}	–	–	75	–	Ω
Output Short-Circuit Current	I_{OS}	–	–	25	–	mA
Supply Current		–	–	1.7	2.8	mA
Power Consumption	P_D	–	–	50	85	mW
Transient Response (Unity gain)		V_{in} = 20 mV, R_L = 2 kΩ,				
Risetime	t_R	$C_L \leqslant 100$ pF	–	0.3	–	μs
Overshoot	t_O		–	5.0	–	%
Slew Rate	SR	$R_L \geqslant 2$ kΩ	–	0.5	–	V/μs

V_S = ±15 V, 0°C ⩽ T_A ⩽ +70°C unless otherwise specified

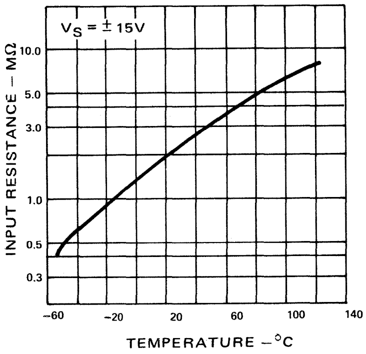
PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	–	–	–	7.5	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	–	300	nA
Input Bias Current	$\lvert I_b \rvert$	–	–	–	800	nA
Large-Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2$ kΩ, V_{out} = ± 10 V	15,000	–	–	–
Output Voltage Swing	V_{out}	$R_L \geqslant 2$ kΩ	±10	±13	–	V

typical performance curves (ML741A)

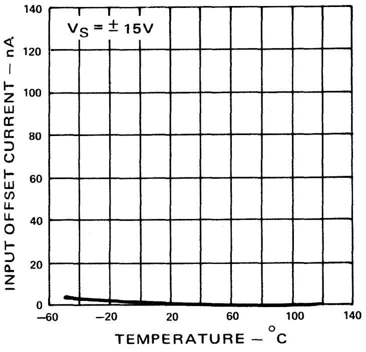
INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



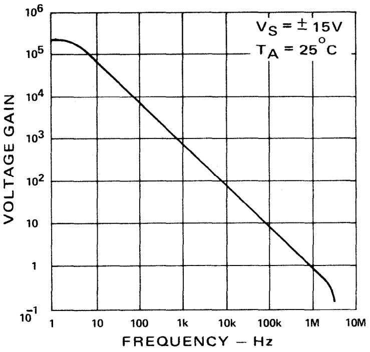
INPUT RESISTANCE AS A FUNCTION OF AMBIENT TEMPERATURE



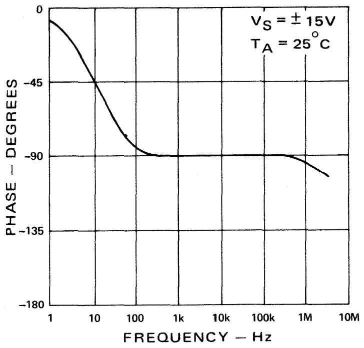
INPUT OFFSET CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



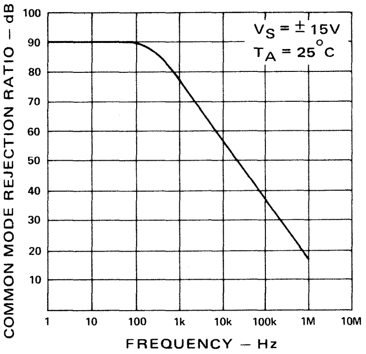
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



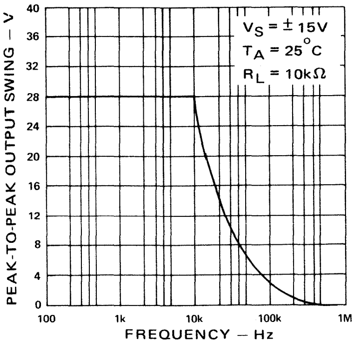
OPEN LOOP PHASE RESPONSE AS A FUNCTION OF FREQUENCY



COMMON MODE REJECTION RATIO AS A FUNCTION OF FREQUENCY



OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY



HIGH PERFORMANCE OPERATIONAL AMPLIFIER ML748, ML748C

features

- Short Circuit Protection
- Offset Voltage Null Capability
- Large Common-mode and Differential Voltage Ranges
- Low Power Consumption
- No Latch-up
- Available in Metal Can, Dual In-Line and Flat Packages

description

The ML748 family is intended for a wide range of analog applications, especially those requiring tailoring of frequency characteristics. Wide common mode voltage range and absence of "latch-up" tendencies make the ML748 ideal for use as a voltage follower. The ML748 has the same pin configuration as the ML741 operational amplifier in the Metal Can and Dual In-Line packages. Unity-gain frequency-compensation can be achieved by means of a single 30pF capacitor.

absolute maximum ratings

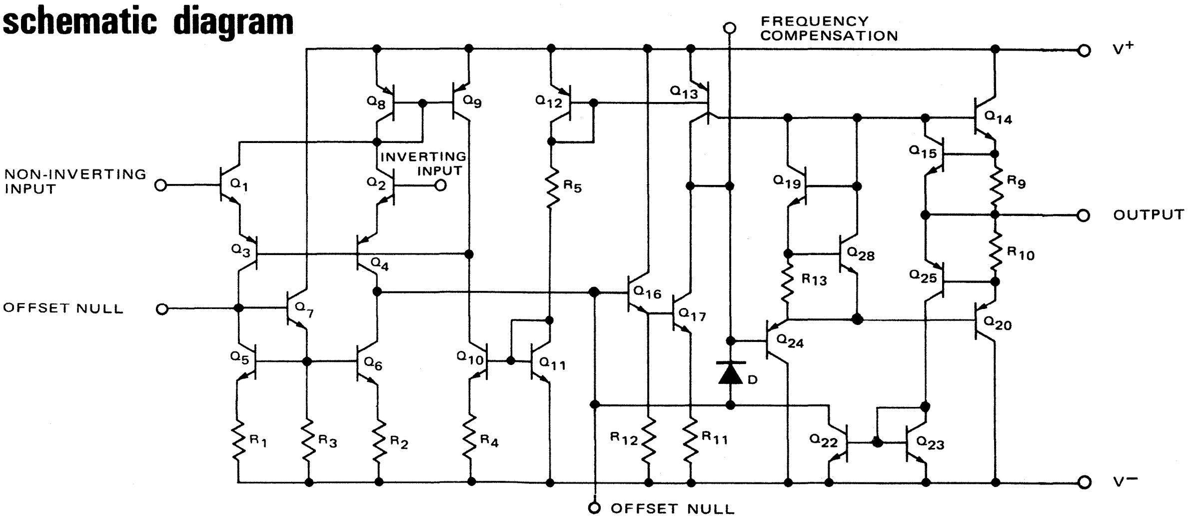
Supply Voltage:	
ML748	± 22 V
ML748C	± 18 V
Internal Power Dissipation*	500 mW
Differential Input Voltage	± 30 V
Input Voltage (Note 5)	± 15 V

Storage Temperature Range	−65°C to + 150°C
Operating Temperature Range:	
ML748	−55°C to + 125°C
ML748C	0°C to + 70°C
Lead Temperature (Soldering, 60 sec)	300°C
Output Short-Circuit (Note 6)	Indefinite

* NOTES:

(1) TO-99 rating applies for case temperatures to +125°C; derate linearly at 6.5mW/°C for ambient temperatures above +115°C.
(2) Dual-in-Line rating applies for case temperatures to +125°C; derate linearly at 8.6mW/°C for ambient temperatures above +115°C.
(3) Flat Package rating applies for case temperatures to +125°C; derate linearly at 5.6mW/°C for ambient temperatures above +95°C.
(4) Plastic Dual-in-Line rating applies for case temperatures to +70°C; derate linearly at 6.7mW/°C for ambient temperatures above +55°C.
(5) For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
(6) Short-circuit may be to ground or either supply. Rating applies to +125°C case temperature or +75°C ambient temperature.

schematic diagram

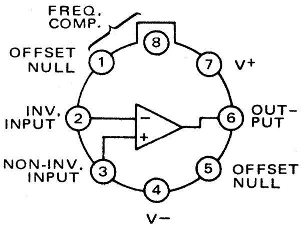


HIGH PERFORMANCE OPERATIONAL AMPLIFIER . . . ML748, ML748C

connection diagrams

METAL CAN PACKAGE

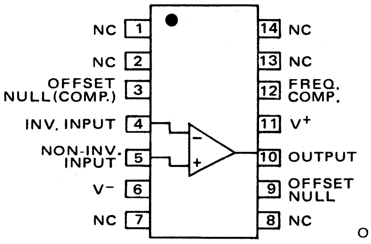
(Top View)



NOTE: Pin 4 connected to case

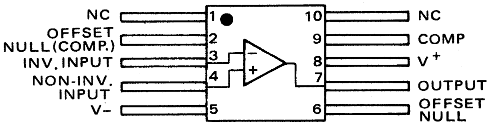
DUAL IN-LINE PACKAGE

(Top View)



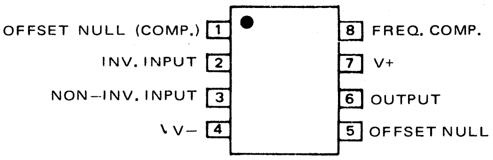
FLAT PACKAGE

(Top View)



DUAL IN–LINE PACKAGE

(Top View)



electrical characteristics (ML748, ML748C)

$V_S = \pm 15V$, $T_A = 25°C$, $C_C = 30$ pF unless otherwise specified

			ML748			ML748C			
PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\|V_{io}\|$	$R_S \leqslant 10$ kΩ	–	1.0	5.0	–	2.0	6.0	mV
Input Offset Current	$\|I_{io}\|$	–	–	20	200	–	20	200	nA
Input Bias Current	I_b	–	–	80	500	–	80	500	nA
Input Resistance	R_{in}	–	0.3	2.0	–	0.3	2.0	–	MΩ
Input Capacitance	C_{in}	–	–	2.0	–	–	2.0	–	pF
Offset Voltage Adjustment Range	ΔV_{io}	–	–	±15	–	–	±15	–	mV
Large-Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2$kΩ, $V_{out} = \pm 10$ V	50,000	150,000	–	25,000	150,000	–	–
Output Resistance	R_{out}	–	–	75	–	–	75	–	Ω
Output Short-Circuit Current	I_{SC}	–	–	25	–	–	25	–	mA
Supply Current	I_S	–	–	1.9	2.8	–	1.9	2.8	mA
Power Consumption	P_i	–	–	60	85	–	60	85	mW
Transient Response (Voltage Follower, Gain of 1) Risetime	t_r	$V_{IN} = 20$ mV, $C_L \leqslant 100$ pF $C_C = 30$ pF, $R_L = 2$kΩ,	–	0.3	–	–	0.3	–	µS
Overshoot	t_O		–	5.0	–	–	5.0	–	%
Slew Rate (Voltage Follower, Gain of 1)	SR	$R_L \geqslant 2$kΩ	–	0.5	–	–	0.5	–	V/µS
Transient Response (Voltage Follower, Gain of 10) Risetime	t_r	$V_{IN} = 20$ mV, $C_L \leqslant 100$ pF $C_C = 3.5$ pF, $R_L = 2$kΩ,	–	0.2	–	–	0.2	–	µS
Overshoot	t_O		–	5.0	–	–	5.0	–	%
Slew Rate (Voltage Follower, Gain of 10)	SR	$R_L \geqslant 2$kΩ, $C_C = 3.5$ pF	–	5.5	–	–	5.5	–	V/µS

HIGH PERFORMANCE OPERATIONAL AMPLIFIER . . . ML748, ML748C

electrical characteristics (ML748)

$V_S = \pm 15V$, $-55°C \leq T_A \leq +125°C$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\|V_{io}\|$	$R_S \leq 10\,k\Omega$	–	1.0	6.0	mV
Input Offset Current	$\|I_{io}\|$	$T_A = +125°C$	–	10	200	nA
		$T_A = -55°C$	–	50	500	nA
Input Bias Current	I_b	$T_A = +125°C$	–	0.03	0.5	μA
		$T_A = -55°C$	–	0.3	1.5	μA
Input Voltage Range	V_{iCM}	–	±12	±13	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leq 10\,k\Omega$	70	90	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leq 10\,k\Omega$	–	30	150	μV/V
Large-Signal Voltage Gain	A_{VOL}	$R_L \geq 2\,k\Omega$, $V_{out} = \pm 10\,V$	25,000	–	–	–
Output Voltage Swing	V_{out}	$R_L \geq 10\,k\Omega$	±12	±14	–	V
		$R_L \geq 2\,k\Omega$	±10	±13	–	V
Supply Current	I_S	$T_A = +125°C$	–	1.5	2.5	mA
		$T_A = -55°C$	–	2.0	3.3	mA
Power Consumption	P_i	$T_A = +125°C$	–	45	75	mW
		$T_A = -55°C$	–	60	100	mW

electrical characteristics (ML748C)

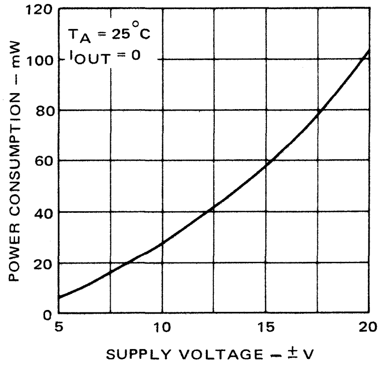
$V_S = \pm 15V$, $0°C \leq T_A \leq +70°C$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\|V_{io}\|$	$R_S \leq 10\,k\Omega$	–	–	7.5	mV
Input Offset Current	$\|I_{io}\|$	–	–	–	300	nA
Input Bias Current	I_b	–	–	–	800	nA
Input Voltage Range	V_{iCM}	–	±12	±13	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leq 10\,k\Omega$	70	90	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leq 10\,k\Omega$	–	30	150	μV/V
Large-Signal Voltage Gain	A_{VOL}	$R_L \geq 2\,k\Omega$, $V_{out} = \pm 10\,V$	15,000	–	–	–
Output Voltage Swing	V_{out}	$R_L \geq 10\,k\Omega$	±12	±14	–	V
		$R_L \geq 2\,k\Omega$	±10	±13	–	V
Power Consumption	P_i	–	–	60	100	mW

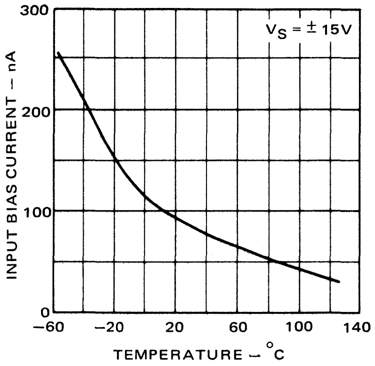
HIGH PERFORMANCE OPERATIONAL AMPLFIER. . . . ML748, ML748C

typical performance curves (ML748)

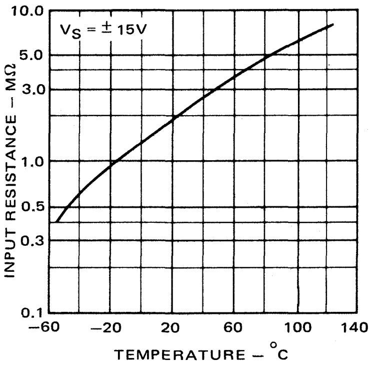
POWER CONSUMPTION AS A FUNCTION OF SUPPLY VOLTAGE



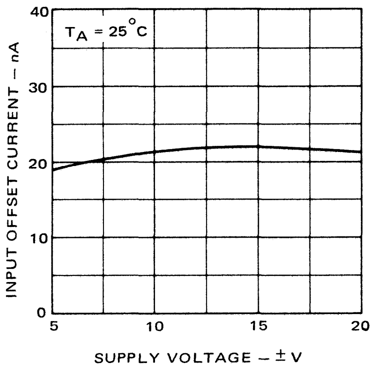
INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



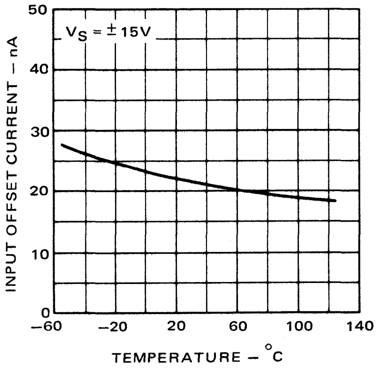
INPUT RESISTANCE AS A FUNCTION OF AMBIENT TEMPERATURE



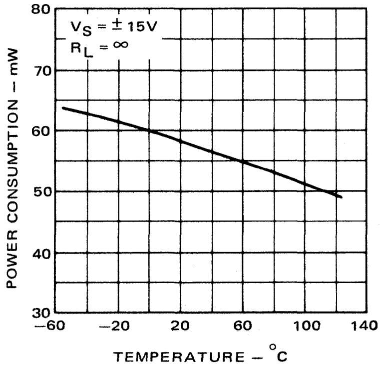
INPUT OFFSET CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



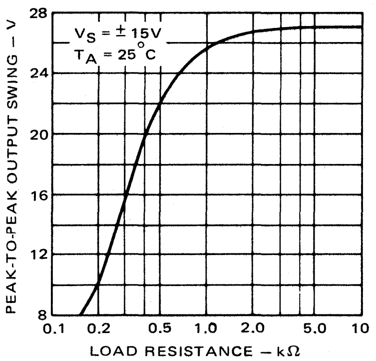
INPUT OFFSET CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



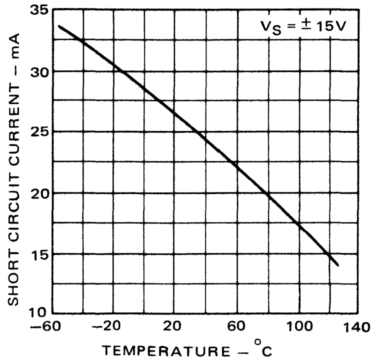
POWER CONSUMPTION AS A FUNCTION OF AMBIENT TEMPERATURE



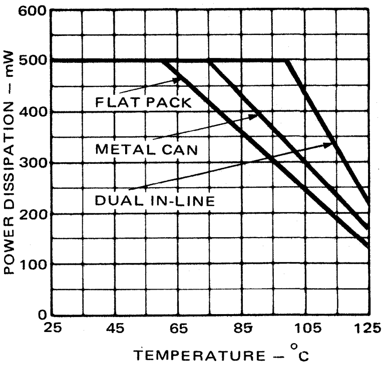
OUTPUT VOLTAGE SWING AS A FUNCTION OF LOAD RESISTANCE



OUTPUT SHORT-CIRCUIT CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE

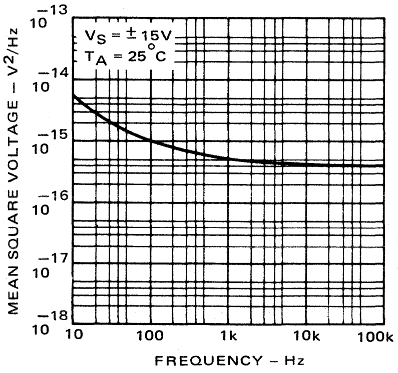


ABSOLUTE MAXIMUM POWER DISSIPATION AS A FUNCTION OF AMBIENT TEMPERATURE

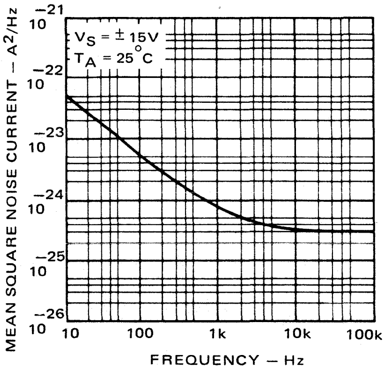


HIGH PERFORMANCE OPERATIONAL AMPLIFIER ML748, ML748C

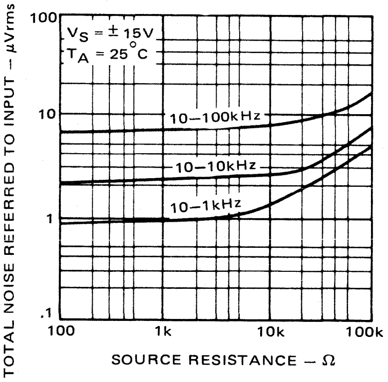
INPUT NOISE VOLTAGE AS A FUNCTION OF FREQUENCY



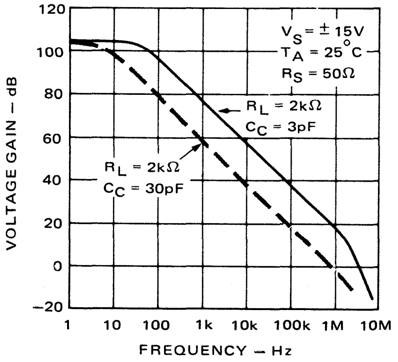
INPUT NOISE CURRENT AS A FUNCTION OF FREQUENCY



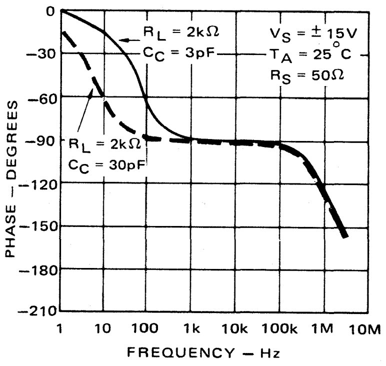
BROADBAND NOISE FOR VARIOUS BANDWIDTHS



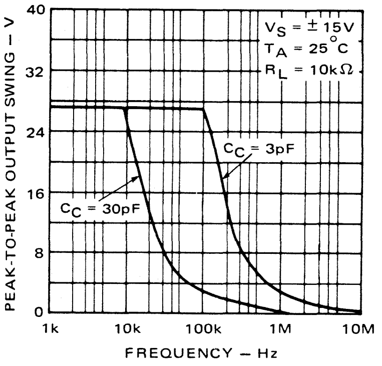
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



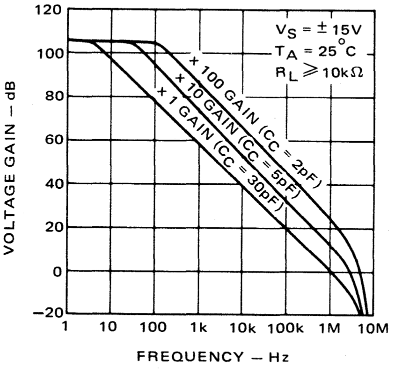
OPEN LOOP PHASE RESPONSE AS A FUNCTION OF FREQUENCY



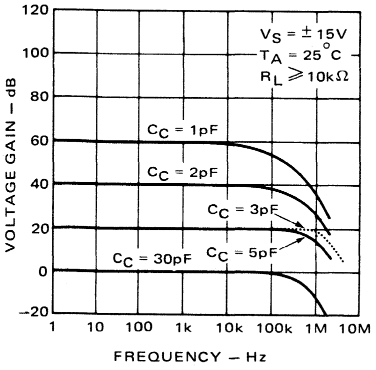
OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY



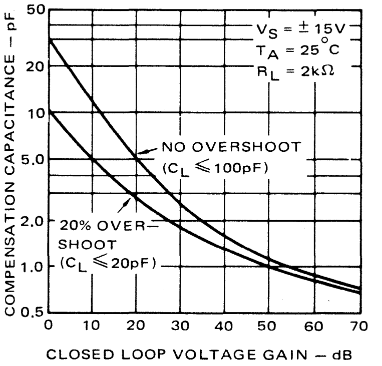
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY FOR VARIOUS GAIN/COMPENSATION OPTIONS



FREQUENCY RESPONSE FOR VARIOUS CLOSED LOOP GAINS

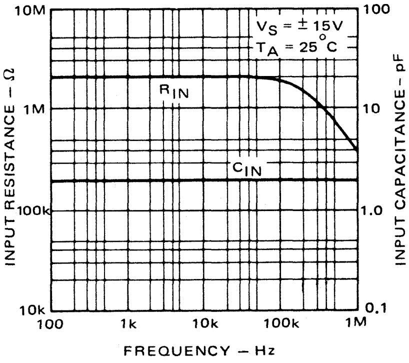


COMPENSATION CAPACITANCE AS A FUNCTION OF CLOSED LOOP VOLTAGE GAIN

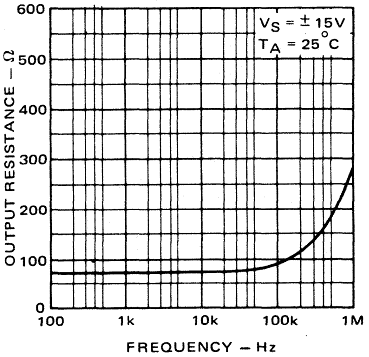


HIGH PERFORMANCE OPERATIONAL AMPLIFIER . . . ML748, ML748C

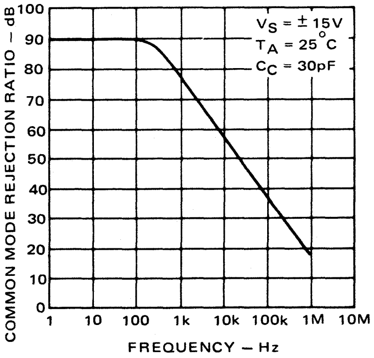
INPUT RESISTANCE AND INPUT CAPACITANCE AS A FUNCTION OF FREQUENCY



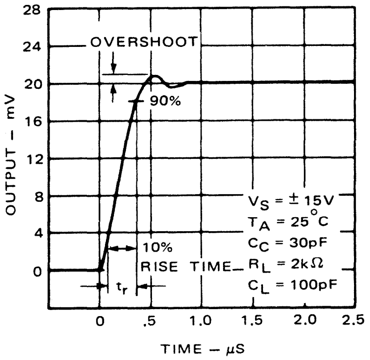
OUTPUT RESISTANCE AS A FUNCTION OF FREQUENCY



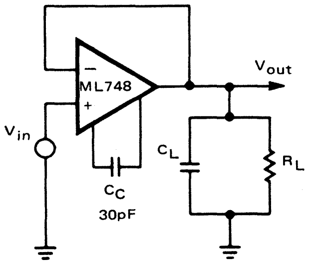
COMMON MODE REJECTION RATIO AS A FUNCTION OF FREQUENCY



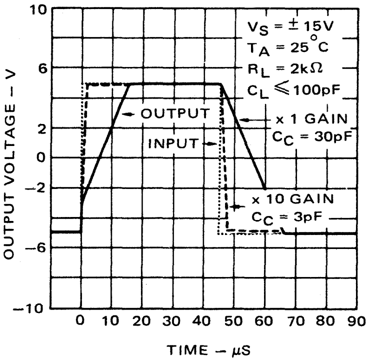
VOLTAGE FOLLOWER TRANSIENT RESPONSE (GAIN OF 1)



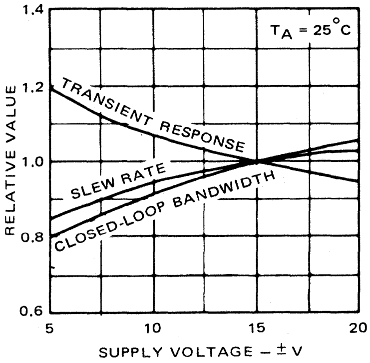
TRANSIENT RESPONSE TEST CIRCUIT



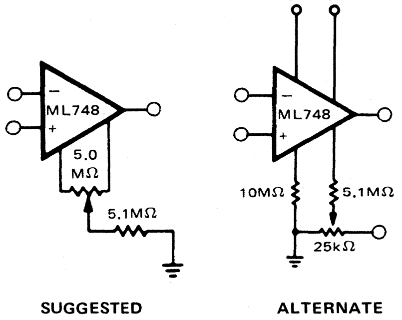
VOLTAGE FOLLOWER LARGE–SIGNAL PULSE RESPONSE



FREQUENCY CHARACTERISTICS AS A FUNCTION OF SUPPLY VOLTAGE



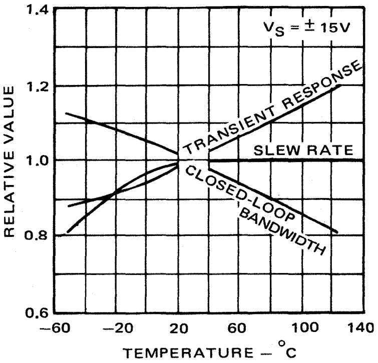
VOLTAGE OFFSET NULL CIRCUIT



SUGGESTED

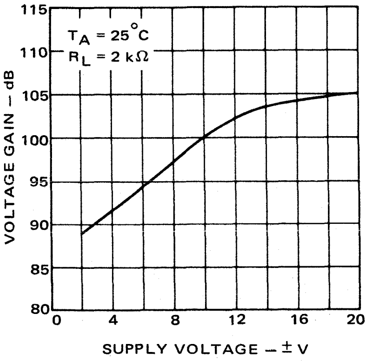
ALTERNATE

FREQUENCY CHARACTERISTICS AS A FUNCTION OF AMBIENT TEMPERATURE

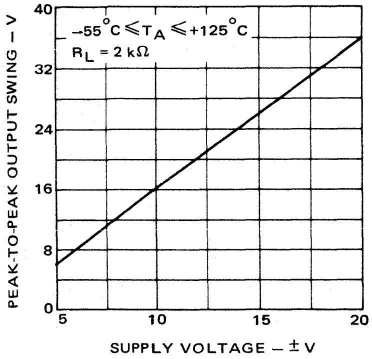


HIGH PERFORMANCE OPERATIONAL AMPLIFIER . . . ML748, ML748C

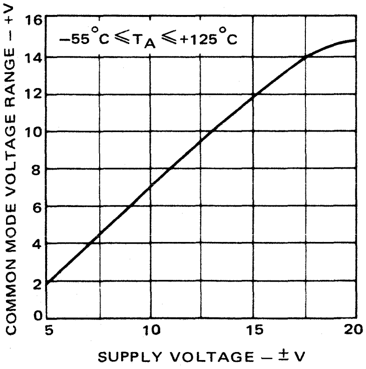
OPEN LOOP VOLTAGE GAIN
AS A FUNCTION OF
SUPPLY VOLTAGE



OUTPUT VOLTAGE SWING
AS A FUNCTION OF
SUPPLY VOLTAGE



INPUT COMMON MODE
VOLTAGE RANGE (V_{iCM}) AS A
FUNCTION OF SUPPLY VOLTAGE



OPERATIONAL AMPLIFIER ML777, ML777C

features

- Low Offset Voltage and Offset Current
- Low Offset Voltage and Offset Current Drift
- Large Common Mode and Differential Voltage Ranges
- Low Input Bias Current
- Low Input Noise Voltage

description

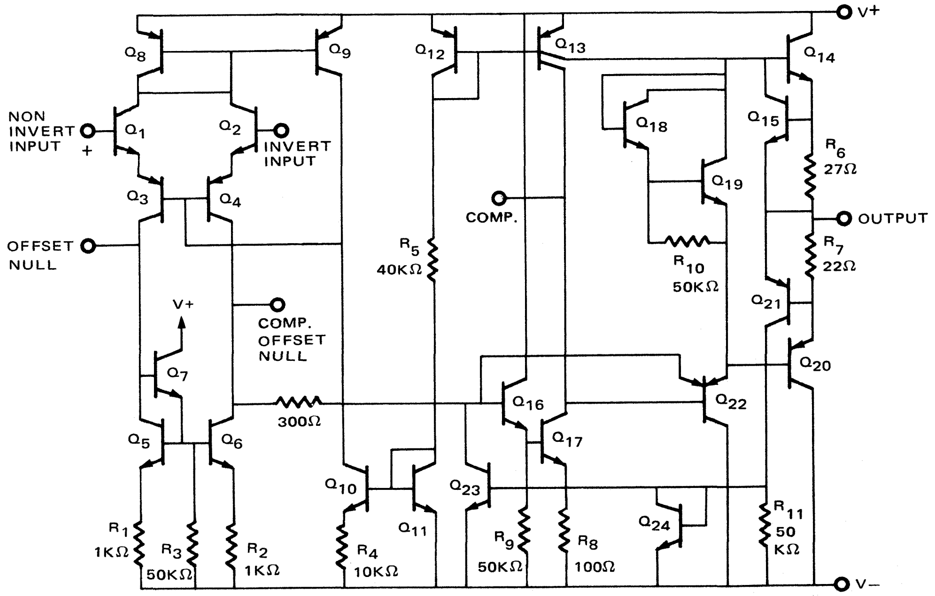
Fabricated using a low noise process, the ML777, ML777C Precision Operational Amplifier is an ideal choice when performance versus cost trade-off is possible between super beta or FET input operational amplifiers and low cost general purpose amplifiers. System accuracy improves with the low offset and bias currents when used for long term integrators, sample and hold circuits and high source impedance summing amplifiers. Versatility and ease of use result from the high common mode input voltage range, latch-up protection, simple frequency compensation and short circuit protection. Despite the low input bias current, full 30V differential voltage range is maintained.

absolute maximum ratings

Supply Voltage:	
ML777	±22V
ML777C	±18V
Differential Input Voltage	±30V
Input Voltage (1)	±15V
Internal Power Dissipation (3):	
Metal Can	500mW
D.I.L.	670mW
D.I.L. (8 lead)	310mW
Flatpack	570mW

Storage Temperature Range:	
Metal Can, D.I.L. and Flatpack	−65°C to +150°C
D.I.L. (8 lead)	−55°C to +125°C
Operating Temperature Range:	
ML777	−55°C to +125°C
ML777C	0°C to +70°C
Lead Temperature (soldering):	
Metal Can, D.I.L. and Flatpack (60 sec.)	+300°C
D.I.L. (8 lead) (10 sec.)	+260°C
Output Short-Circuit (2)	Indefinite

schematic diagram



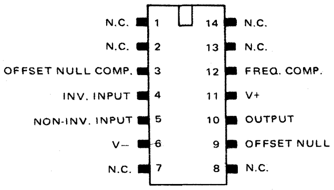
MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STA.C, OTTAWA, CANADA K1Y 4J1

microsystems international

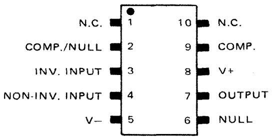
OPERATIONAL AMPLIFIER ML777, ML777C

connection diagrams (Top View)

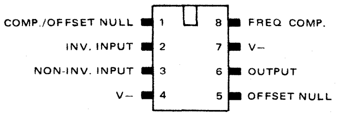
DUAL-IN-LINE PACKAGE



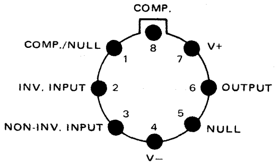
FLAT PACKAGE



DUAL-IN-LINE PACKAGE



METAL CAN PACKAGE



electrical characteristics

T_A = + 25°C, V_S = ± 15V, C_C = 30pF , unless otherwise specified

PARAMETERS		SYMBOLS	CONDITIONS	ML777 MIN.	ML777 TYP.	ML777 MAX.	ML777C MIN.	ML777C TYP.	ML777C MAX.	UNITS
Input Offset Voltage		$\|V_{io}\|$	R_s≤50KΩ	–	0.5	2	–	0.7	5	mV
Input Offset Current		$\|I_{io}\|$	–	–	0.25	3	–	0.7	20	nA
Input Bias Current		I_b	–	–	8	25	–	25	100	nA
Input Resistance		R_{in}	–	–	10	–	1	2	–	MΩ
Input Capacitance		C_{in}	–	–	3	–	–	3	–	pF
Offset Voltage Adjustment Range		ΔV_{io}	–	–	±25	–	–	±25	–	mV
Large Signal Voltage Gain		A_{VOL}	R_L≥2KΩ V_{OUT}=±10V	50	250	–	25	250	–	KV/V
Output Resistance		R_{out}	–	–	100	–	–	100	–	Ω
Output Short-Circuit Current		I_{sc}	–	–	±25	–	–	±25	–	mA
Supply Current		I_s	–	–	1.9	2.8	–	1.9	2.8	mA
Power Consumption		P_i	–	–	60	85	–	60	85	mW
Transient Response (Voltage Follower, Gain of 1)	Risetime	t_r	C_C=30pF V_{IN}=20mV R_L=2KΩ C_L≤100pF	–	0.3	–	–	0.3	–	μs
	Overshoot	t_o		–	5	–	–	5	–	%
Slew Rate (Voltage Follower, Gain of 1)		dV_{out}/dt	R_L≥2KΩ	–	0.5	–	–	0.5	–	V/μs
Transient Response (Voltage Follower, Gain of 10)	Risetime	t_r	C_C=3.5pF V_{IN}=20mV R_L=2KΩ C_L≤100pF	–	0.2	–	–	0.2	–	μs
	Overshoot	t_o		–	5	–	–	5	–	%
Slew Rate (Voltage Follower, Gain of 10)		dV_{out}/dt	R_L≥2KΩ C_C=3.5pF,	–	5.5	–	–	5.5	–	V/μs

OPERATIONAL AMPLIFIER ML777, ML777C

electrical characteristics

$-55°C \leq T_A \leq +125°C$ (ML777), $0°C \leq T_A \leq 70°C$ (ML777C) $V_S = \pm 15V$, $C_C = 30pF$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	ML777 MIN.	ML777 TYP.	ML777 MAX.	ML777C MIN.	ML777C TYP.	ML777C MAX.	UNITS
Input Offset Voltage	$\|V_{io}\|$	$R_S \leq 50K\Omega$	–	0.5	3	–	0.8	5	mV
Average Input Offset Voltage Drift	$\|TCV_{io}\|$	$R_S \leq 50K\Omega$	–	2.5	15	–	4	30	$\mu V/°C$
Input Offset Current	$\|I_{io}\|$	–	–	–	10	–	–	40	nA
Average Input Offset Current Drift **ML777**	$\|TCI_{io}\|$	$+25°C \leq T_A \leq +125°C$	–	2.5	30	–	–	–	$pA/°C$
		$-55°C \leq T_A \leq +25°C$	–	6.5	150	–	–	–	$pA/°C$
ML777C		$+25°C \leq T_A \leq +70°C$	–	–	–	–	10	300	$pA/°C$
		$0°C \leq T_A \leq +25°C$	–	–	–	–	20	600	$pA/°C$
Input Bias Current	I_b	–	–		75	–	–	200	nA
Input Voltage Range	V_{iCM}	–	±12	±13	–	±12	±13	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leq 50K\Omega$	80	95	–	70	95	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leq 50K\Omega$	–	13	100	–	15	150	$\mu V/V$
Large Signal Voltage Gain	A_{VOL}	$R_L \geq 2K\Omega$, $V_{OUT} = \pm 10V$	25	–	–	15	–	–	KV/V
Output Voltage Swing	V_{out}	$R_L \geq 10K\Omega$	±12	±14	–	±12	±14	–	V
		$R_L \geq 2K\Omega$	±10	±13	–	±10	±13	–	V
Supply Current	I_s	$T_A = +125°C$	–	1.5	2.5	–	–	–	mA
		$T_A = -55°C$	–	2	3.3	–	–	–	mA
Power Consumption	P_i	$T_A = T_{AMAX}$	–	40	75	–	60	100	mW
		$T_A = T_{AMIN}$	–	60	100	–	60	100	mW

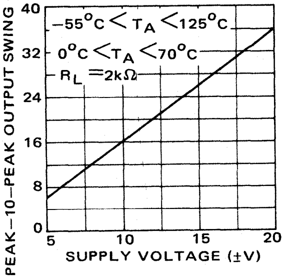
NOTES:

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

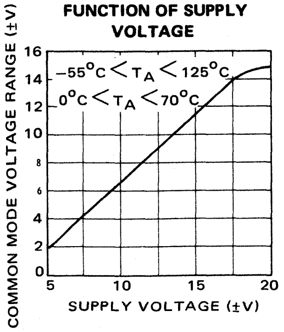
(2) Short circuit may be to ground or either supply. Rating applies to +125°C case temperature or +75°C ambient temperature.

(3) Rating applies to ambient temperatures up to +70°C. Above +70°C ambient derate linearly at 6.3 mW/°C for Metal Can, 8.3 mW/°C for the D.I.L., 5.6 mW/°C for the D.I.L. (8 lead) and 7.1 mW/°C for the flatpack.

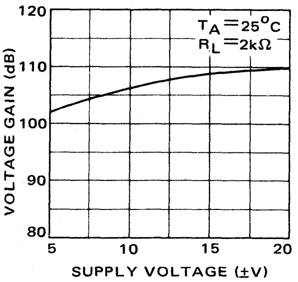
typical characteristic curves



OUTPUT VOLTAGE SWING AS A FUNCTION OF SUPPLY VOLTAGE



INPUT COMMON MODE VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE

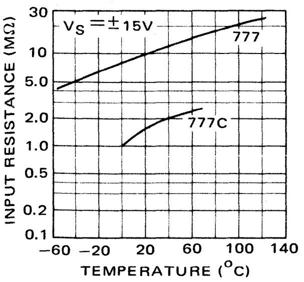


OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF SUPPLY VOLTAGE

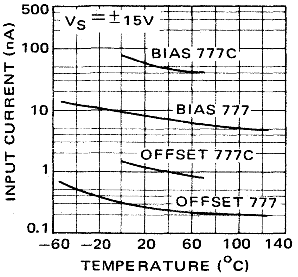
OPERATIONAL AMPLIFIER ML777, ML777C

typical characteristic curves

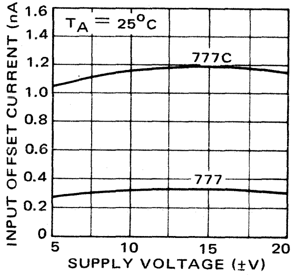
INPUT RESISTANCE AS A FUNCTION OF AMBIENT TEMPERATURE



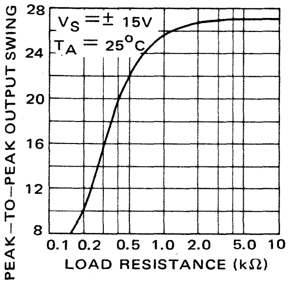
INPUT CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



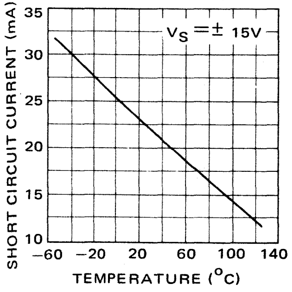
INPUT OFFSET CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



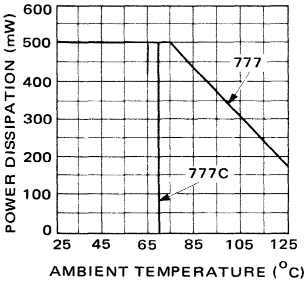
OUTPUT VOLTAGE SWING AS A FUNCTION OF LOAD RESISTANCE



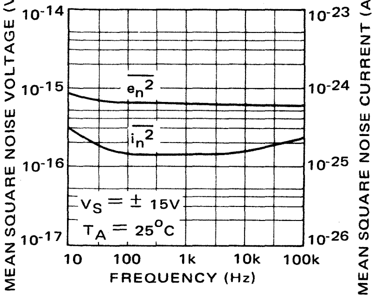
OUTPUT SHORT-CIRCUIT CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



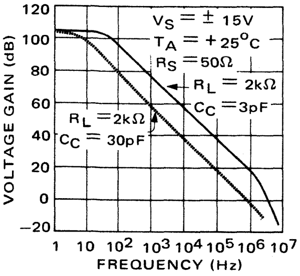
ABSOLUTE MAXIMUM POWER DISSIPATION AS A FUNCTION OF AMBIENT TEMPERATURE



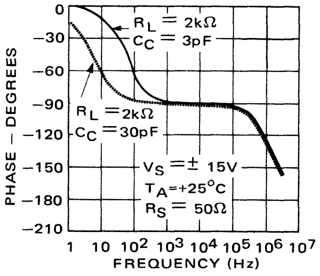
INPUT NOISE VOLTAGE AND CURRENT AS A FUNCTION OF FREQUENCY



OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



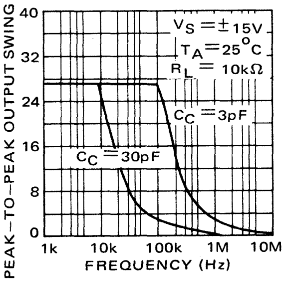
OPEN LOOP PHASE RESPONSE AS A FUNCTION OF FREQUENCY



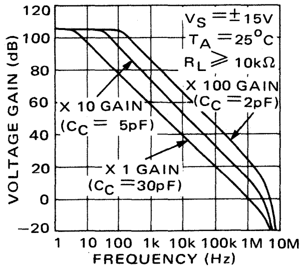
OPERATIONAL AMPLIFIER ML777, ML777C

typical characteristic curves

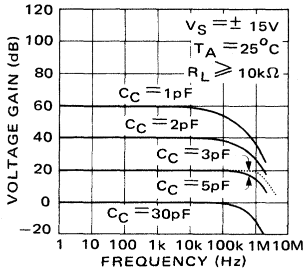
OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY



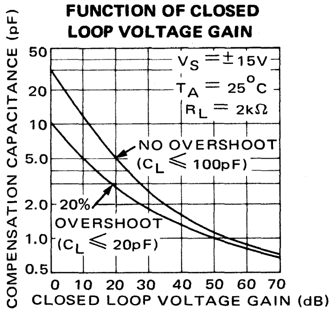
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY FOR VARIOUS GAIN/COMPENSATION OPTIONS



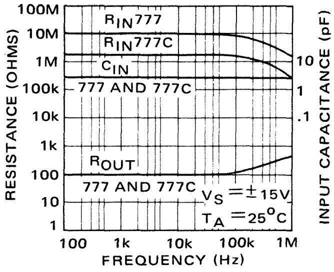
FREQUENCY RESPONSE FOR VARIOUS CLOSED-LOOP GAINS



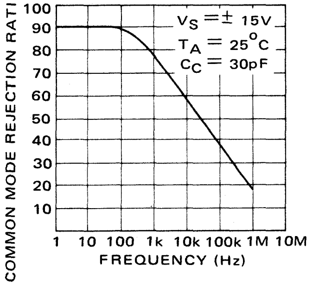
COMPENSATION CAPACITANCE AS A FUNCTION OF CLOSED LOOP VOLTAGE GAIN



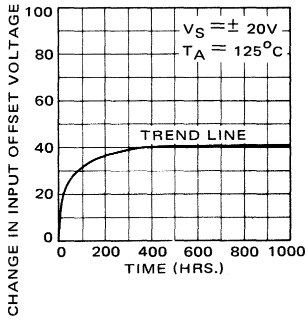
INPUT RESISTANCE, OUTPUT RESISTANCE, AND INPUT CAPACITANCE AS A FUNCTION OF FREQUENCY



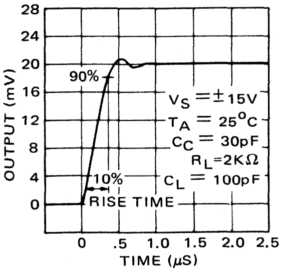
COMMON MODE REJECTION RATIO AS A FUNCTION OF FREQUENCY



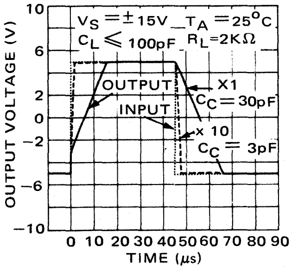
INPUT OFFSET VOLTAGE DRIFT AS A FUNCTION OF TIME



VOLTAGE FOLLOWER TRANSIENT RESPONSE (GAIN OF 1)

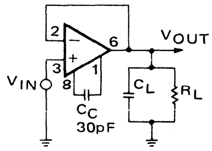


VOLTAGE FOLLOWER LARGE SIGNAL PULSE RESPONSE

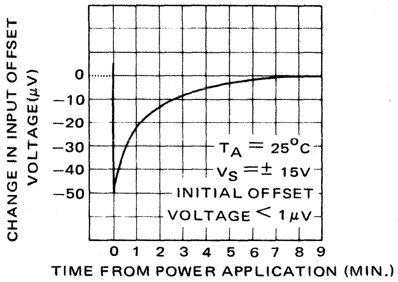


typical characteristic curves

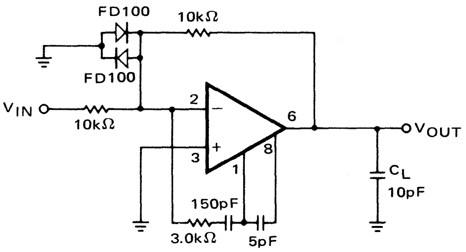
TRANSIENT RESPONSE TEST CIRCUIT



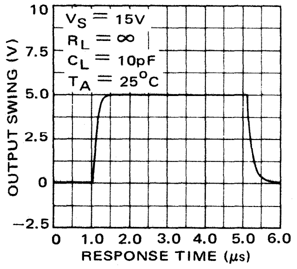
STABILIZATION TIME OF INPUT OFFSET VOLTAGE FROM POWER TURN-ON



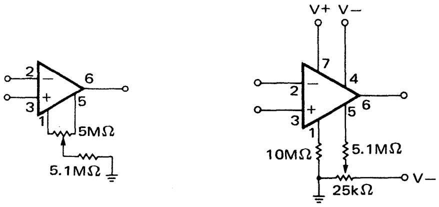
FEED-FORWARD COMPENSATION



LARGE SIGNAL FEEDFORWARD TRANSIENT RESPONSE

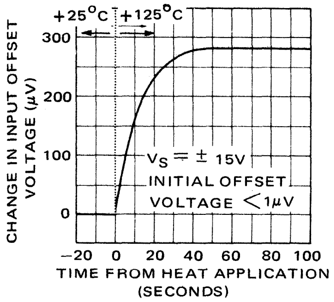


VOLTAGE OFFSET NULL CIRCUIT



SUGGESTED **ALTERNATE**

THERMAL RESPONSE OF INPUT OFFSET VOLTAGE TO STEP CHANGE OF CASE TEMPERATURE



HIGH VOLTAGE OPERATIONAL AMPLIFIER ML1536, ML1436

features

- Wide Supply Range — ±40 VDC
- Input Bias Current — 20 nA Max.
- Input Offset Current — 3 nA Max.
- Fast Slew Rate — 2 V/µs Typ
- Offset Voltage Null Capability
- Internally Compensated

description

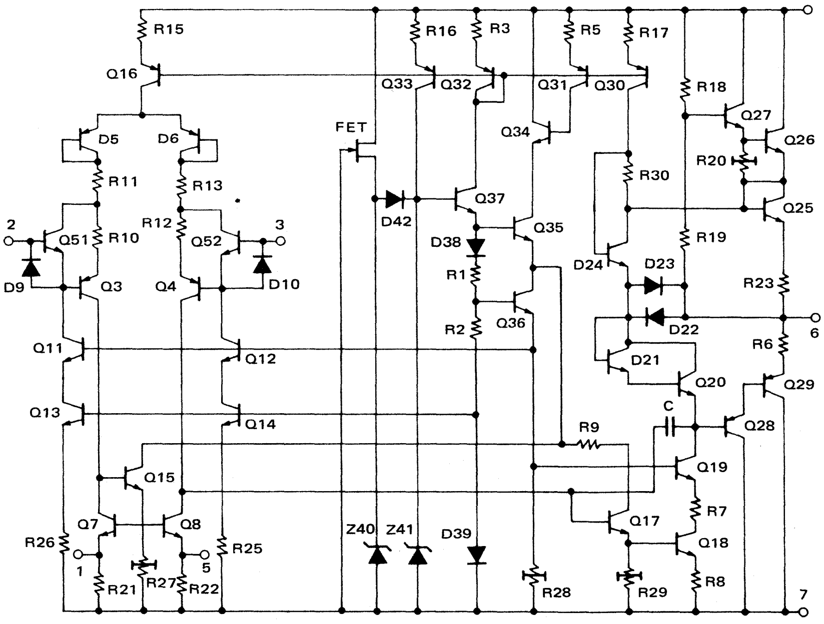
The ML1536, ML1436 operational amplifier family has been designed for device operation at voltage ranges higher than general purpose op amps. Wide output voltage swings of ±30Vpk are made possible, with open loop gain of 500,000. It features input over-voltage protection and other characteristics independent of supply voltages. Pin configuration is compatible with the ML741.

absolute maximum ratings

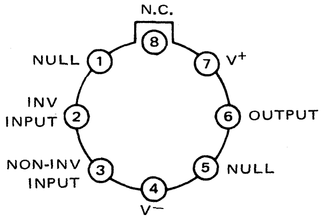
Supply Voltage:		Power Dissipation (Note 1)	300 mW
ML1536	±40V		
ML1436	±34V	Operating Temperature Range:	
		ML1536	−55°C to +125°C
Differential Input Signal	$\pm(V^+ + \lvert V^- \rvert - 3)$	ML1436	0°C to +70°C
Common Mode Range	$+V^+, -(\lvert V^- \rvert - 3)$	Storage Temperature Range	−65°C to +150°C
Output Short Circuit Duration	5 Sec		

NOTE 1. To be derated above +25°C at 2.5 mW/°C.

schematic diagram



connection diagram



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international

HIGH VOLTAGE OPERATIONAL AMPLIFIER. ML1536, ML1436

electrical characteristics

$V^+ = +28$ Vdc, $V^- = -28$ Vdc, $T_A = +25°C$ unless otherwise noted

PARAMETERS	SYMBOLS	CONDITIONS	ML1536			ML1436			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Input Bias Current	I_b	$T_A = +25°C$	–	8.0	20	–	15	40	nAdc
		$T_A = T_{low}$ to T_{high}(1)	–	–	35	–	–	55	
Input Offset Current	$\|I_{io}\|$	$T_A = +25°C$	–	1.0	3.0	–	5.0	10	nAdc
		$T_A = +25°C$	–	–	4.5	–	–	14	
		$T_A = T_{low}$ to T_{high}	–	–	7.0	–	–	14	
Input Offset Voltage	$\|V_{io}\|$	$T_A = +25°C$	–	2.0	5.0	–	5.0	10	mVdc
		$T_A = T_{low}$ to T_{high}	–	–	7.0	–	–	14	
Differential Input Impedance		Open loop, $f \leq 5.0$ Hz							
	R_p	Parallel Input Resistance:	–	10	–	–	10	–	MΩ
	C_p	Parallel Input Capacitance:	–	2.0	–	–	2.0	–	pF
Common Mode Input Impedance	$Z_{(in)}$	$f \leq 5.0$ Hz	–	250	–	–	250	–	MΩ
Common Mode Input Voltage Swing	CMV_{in}		±24	±25	–	±22	±25	–	V_{pk}
Equivalent Input Noise Voltage	e_n	$A_V = 100$, $R_S = 10$ kΩ, f = 1.0 kHz, BW = 1.0 Hz	–	50	–	–	50	–	nV/(Hz)½
Common Mode Rejection Radtio (dc)	CMRR		80	110	–	70	110	–	dB
Large Signal dc Open Loop Voltage Gain	A_{VOL}	$V_o = \pm 10V$, $R_L = 100$ kΩ							V/V
		$T_A = +25°C$:	100k	500k	–	70k	500k	–	
		$T_A = T_{low}$ to T_{high}:	50k	–	–	50k	–	–	
		$V_o = \pm 10V$, $R_L = 10$ kΩ,							
		$T_A = +25°C$	–	200k	–	–	200k	–	
Power Bandwidth (Voltage Follower)	P_{BW}	$A_V = 1$, $R_L = 5.0$ kΩ, THD $\leq 5\%$, $V_o = 40$ Vp-p	–	23	–	–	23	–	kHz
Unity Gain Cross-over Frequency (open-loop)	f_T		–	1.0	–	–	1.0	–	MHz
Phase Margin (open-loop, unity gain)	ϕ		–	50	–	–	50	–	deg.
Gain Margin	A_{GM}		–	18	–	–	18	–	dB
Slew Rate (Unity Gain)	dV_{out}/dt		–	2.0	–	–	2.0	–	V/μs
Output Impedance	Z_{out}	$f \leq 5.0$ Hz	–	1.0	–	–	1.0	–	kΩ
Short Circuit Output Current	I_{SC}		–	±17	–	–	±17	–	mAdc
Output Voltage Swing	V_o	$R_L = 5.0$ kΩ							V_{pk}
		$V^+ = +28$Vdc, $V^- = -28$Vdc	±22	±23	–	±20	±22	–	
		$V^+ = +36$Vdc, $V^- = -36$ Vdc	±30	±32	–	–	–	–	

HIGH VOLTAGE OPERATIONAL AMPLIFIER. ML1536, ML1436

V+ = +28 Vdc, V– = –28 Vdc, T_A = +25°C unless otherwise noted (Cont'd)

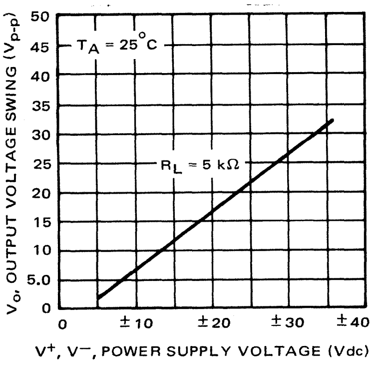
PARAMETERS	SYMBOLS	CONDITIONS	ML1536 MIN.	ML1536 TYP.	ML1536 MAX.	ML1436 MIN.	ML1436 TYP.	ML1436 MAX.	UNITS
Power Supply Sensitivity (dc)	S+ S–	V– = constant, $R_s \leqslant 10\ k\Omega$ V+ = constant, $R_s \leqslant 10\ k\Omega$	– –	15 15	100 100	– –	35 35	200 200	µV/V
Power Supply Current: Positive Negative	I_D+ I_D-	See Note 2.	– –	2.2 2.2	4.0 4.0	– –	2.6 2.6	5.0 5.0	mAdc
DC Quiescent Power Dissipation	P_D	$V_o = 0$	–	124	224	–	146	280	mW

NOTE 1. T_{low}: 0°C for ML1436
–55°C for ML1536
T_{high}: +75°C for ML1436
+125°C for ML1536

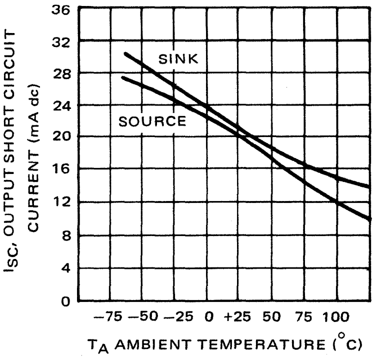
NOTE 2. V+ = |V–| = 5.0 Vdc to 36 Vdc for ML1536
V+ = |V–| = 5.0 Vdc to 30 Vdc for ML1436

typical characteristic curves

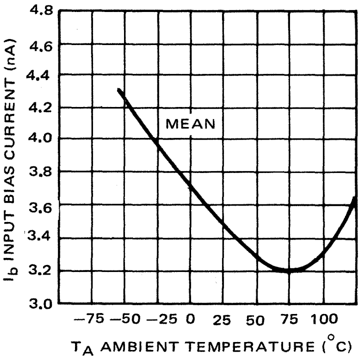
PEAK OUTPUT VOLTAGE SWING versus POWER SUPPLY VOLTAGE



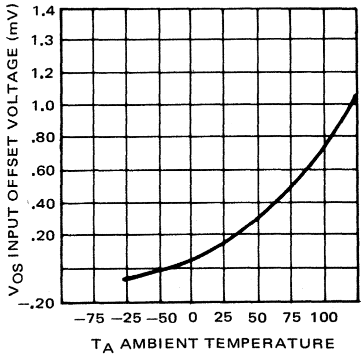
TYPICAL SHORT CIRCUIT CURRENT



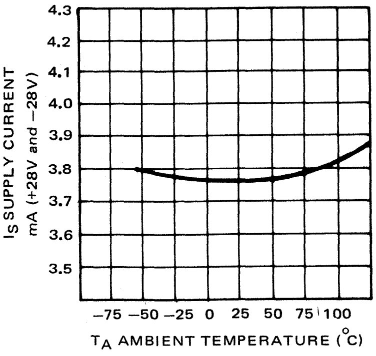
TYPICAL INPUT BIAS CURRENT versus TEMPERATURE



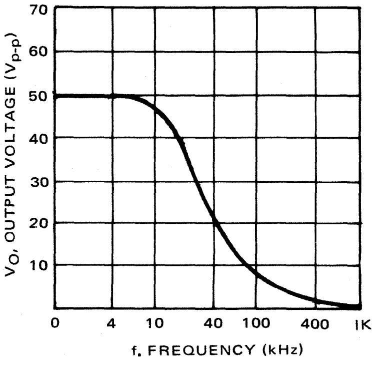
TYPICAL INPUT OFFSET VOLTAGE versus TEMPERATURE



SUPPLY CURRENT versus TEMPERATURE



POWER BANDWIDTH R_L = 10 kΩ



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SELECTED LINEAR I.C. CATALOGUE

Precision Op. Amps.

4

MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STATION C, OTTAWA, CANADA, K1Y 4J1

package availability

PRODUCT CODE	PACKAGE CODE					
	T Metal Can	**D** Hermetic D.I.L. Ceramic	**P** Molded D.I.L. Plastic	**M** Hermetic D.I.L. Metal	**S** Molded D.I.L. Plastic	**F** Flat Pack
ML108A	●			●		●
ML208A	●			●		●
ML308A	●			●		
ML108	●			●		●
ML208	●			●		●
ML308	●		●	●	●	

ML108, ML208, ML308
PRECISION OPERATIONAL AMPLIFIERS . . ML108A, ML208A, ML308A

features

- Very High Input Resistance
- Low Input Offset Voltage and Current
- Continuous Short-Circuit Protection
- No Latch-up even when Common-mode Range is Exceeded
- Low Power Consumption
- Frequency Compensation with a Single External Capacitor
- Guaranteed Drift Characteristics
- Available in Metal Can, Dual In-Line and Flat Packages

description

The ML108/ML108A series are precision operational amplifiers which, in many cases, exhibit performance superior to that of high quality FET-input and chopper-stabilized amplifiers. Extremely low input currents and offset voltages obviate the need for offset adjustments in many applications. The high power-supply rejection ratios permit the use of unregulated supplies, and certain frequency compensation arrangements can make the devices particularly insensitive to power supply noise. The very low input offset current minimizes errors due to source resistance and allows the use of values well in excess of 10 MΩ. Integrators with drifts less than 500 μV/sec (108A series) and analog time delays in excess of one hour can be made using capacitors no larger than 1 μF. Other applications include use with piezo-electric, electrostatic, or other capacitive transducers, and low-frequency active filters with small capacitor values only. The extremely low power consumption makes these amplifiers well suited for battery powered applications.

absolute maximum ratings

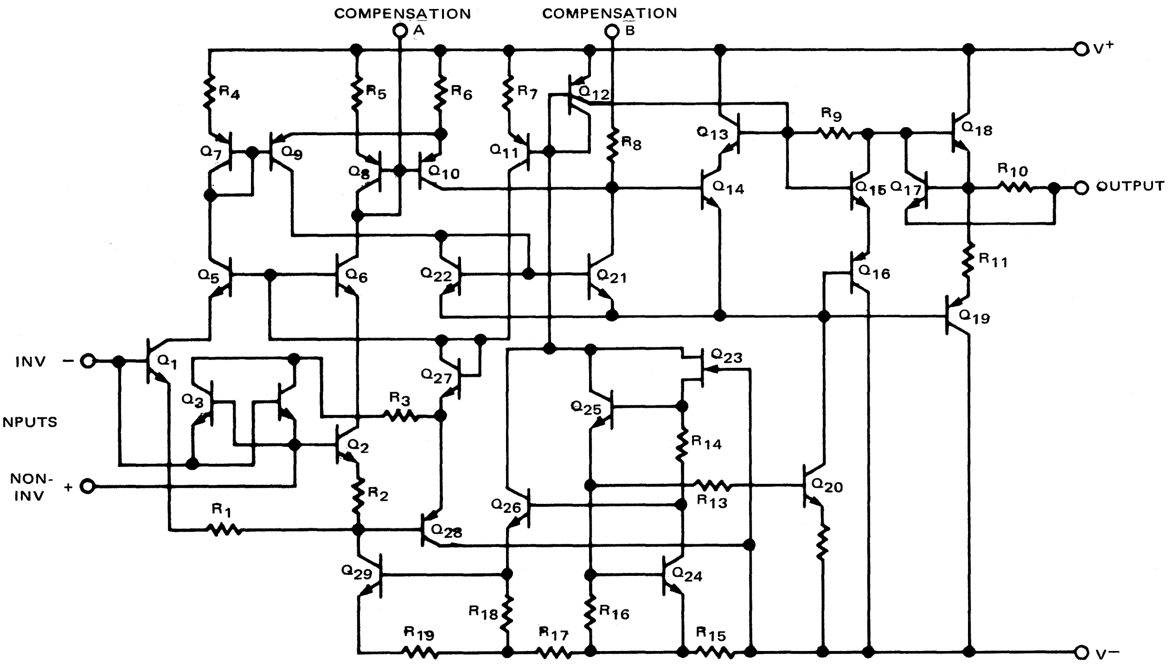
Supply Voltage	
ML108, ML208, ML108A, ML208A	±20 V
ML308, ML308A	±18 V
Internal Power Dissipation (Note1)	500 mW
Differential Input Current (Note 2)	±10 mA
Input Voltage (Note 3)	±15 V
Output Short-Circuit Duration	Indefinite

Operating Temperature Range	
ML108, ML108A	–55°C to +125°C
ML208, ML208A	–25°C to +85°C
ML308, ML308A	0°C to +70°C
Storage Temperature Range	–65°C to +150°C
Lead Temperature (Soldering, 60 sec)	300°C

NOTES:
1. Rating applies for case temperatures up to respective maximum operating temperature. Derate Metal Can package at 6.8 mW/°C for operation at ambient temperatures above 75°C, the Dual In-Line package at 9 mW/°C for operation at ambient temperatures above 95°C, and the Flat package at 5.6 mW/°C for operation at ambient temperatures above 60°C.
2. The inputs are shunted with back-to-back diodes for over-voltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1 V is applied between the inputs unless some limiting resistance is used.
3. For supply voltages less than ± 15 V, the maximum input voltage is equal to the supply voltage.

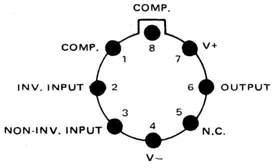
ML108, ML208, ML308
PRECISION OPERATIONAL AMPLIFIERS . . ML108A, ML208A, ML308A

schematic diagram



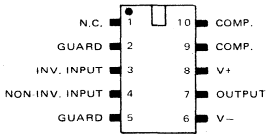
connection diagrams (Top View)

METAL CAN PACKAGE



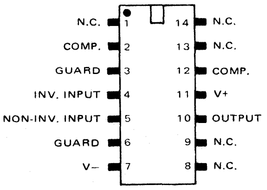
NOTE: Pin 4 connected to case

FLAT PACKAGE



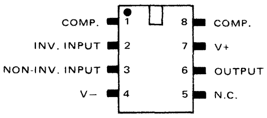
NOTE: Pin 6 connected to bottom of package

DUAL-IN-LINE PACKAGE



NOTE: Pin 7 connected to case

DUAL-IN-LINE PACKAGE



ML108, ML208, ML308
PRECISION OPERATIONAL AMPLIFIERS . . ML108A, ML208A, ML308A

electrical characteristics

($T_A = 25°C$; $\pm 5\ V \leqslant V_S \leqslant \pm\ 20V$ for ML108, ML208, ML108A, ML208A; $\pm\ 5V \leqslant V_S \leqslant \pm\ 15V$ for ML308, ML308A unless otherwise specified)

PARAMETERS	SYM.	CONDITIONS	ML108, ML208			ML108A, ML208A			ML308			ML308A			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Input Offset Voltage	$\lvert V_{io} \rvert$	–	–	0.7	2.0	–	0.3	0.5	–	2.0	7.5	–	0.3	0.5	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	0.05	0.2	–	0.05	0.2	–	0.2	1.0	–	0.2	1.0	nA
Input Bias Current	I_b	–	–	0.8	2.0	–	0.8	2.0	–	1.5	7	–	1.5	7	nA
Input Resistance	R_{in}	–	30	70	–	30	70	–	10	40	–	10	40	–	MΩ
Supply Current	I_S	$V_S = \pm 20V$ $V_S = \pm 15V$	–	0.3	0.6	–	0.3	0.6	–	0.3	–	–	0.3	0.8	mA
Large Signal Voltage Gain	A_{VOL}	$V_S = \pm 15V$, $R_L \geqslant 10\ k\Omega$ $V_{out} = \pm 10V$	50	300	–	80	300	–	25	300	–	80	300	–	V/mV

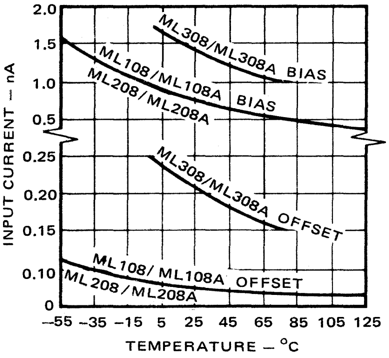
electrical characteristics

(over respective operating temperature ranges; $\pm\ 5V \leqslant V_S \leqslant \pm 20V$ for ML108, ML208, ML108A, ML208A; $\pm\ 5V \leqslant V_S \leqslant \pm 15V$ for ML308, ML308A unless otherwise specified)

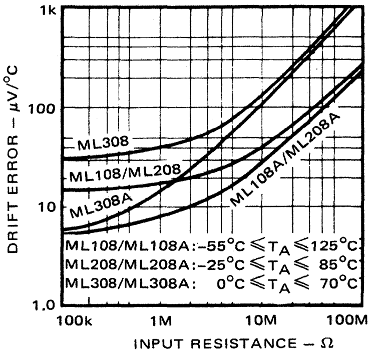
PARAMETERS	SYM.	CONDITIONS	ML108, ML208			ML108A, ML208A			ML308			ML308A			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Input Offset Voltage	$\lvert V_{io} \rvert$	–	–	–	3.0	–	–	1.0	–	–	10	–	–	0.73	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	–	0.4	–	–	0.4	–	–	1.5	–	–	1.5	nA
Average Temperature Coefficient of Input Offset Voltage	$\lvert TC_{Vio} \rvert$	–	–	3.0	15	–	1.0	5.0	–	6.0	30	–	1.0	5.0	μV/°C
Average Temperature Coefficient of Input Offset Current	$\lvert TC_{Iio} \rvert$	–	–	0.5	2.5	–	0.5	2.5	–	2	10	–	2.0	10	pA/°C
Input Bias Current	I_b	–	–	–	3.0	–	–	3.0	–	–	10	–	–	10	nA
Large Signal Voltage Gain	A_{VOL}	$V_S = \pm 15V$, $R_L \geqslant 10\ k\Omega$ $V_{out} = \pm 10V$	25	–	–	40	–	–	15	–	–	60	–	–	V/mV
Input Voltage Range	V_{iCM}	$V_S = \pm 15V$	±13.5	–	–	±13.5	–	–	±13.5	–	–	±13.5	–	–	V
Common Mode Rejection Ratio	CMRR	–	85	100	–	96	110	–	80	100	–	96	110	–	dB
Supply Voltage Rejection Ratio	PSRR	–	80	96	–	96	110	–	80	96	–	96	110	–	dB
Output Voltage Swing	V_{out}	$V_S = \pm 15V$, $R_L = 10\ k\Omega$	±13	±14	–	±13	±14	–	±13	±14	–	±13	±14	–	V
Supply Current	I_S	$T_A = +125°C$ $V_S = \pm 20V$	–	0.15	0.4	–	0.15	0.4	–	–	–	–	–	–	mA

typical performance curves

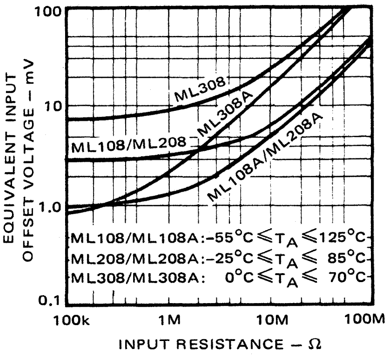
INPUT CURRENT
AS A FUNCTION OF
AMBIENT TEMPERATURE



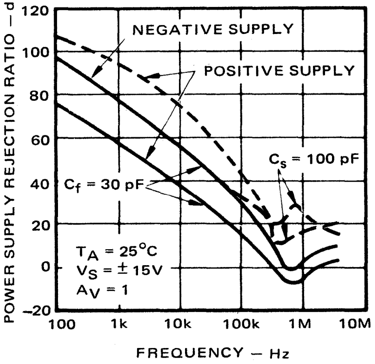
MAXIMUM DRIFT ERROR
AS A FUNCTION OF
INPUT RESISTANCE



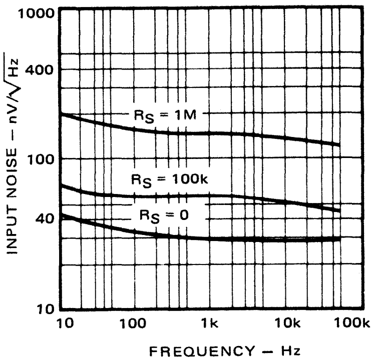
MAXIMUM OFFSET ERROR
AS A FUNCTION OF
INPUT RESISTANCE



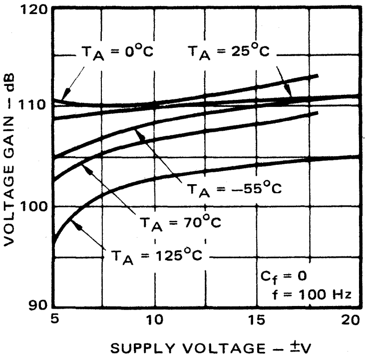
POWER SUPPLY REJECTION RATIO
AS A FUNCTION OF
FREQUENCY



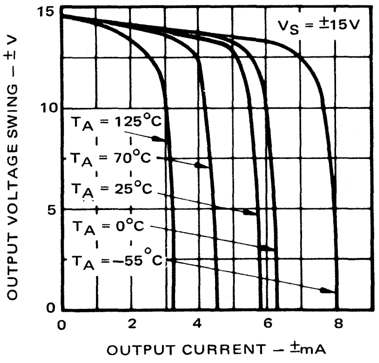
INPUT NOISE VOLTAGE
AS A FUNCTION OF
FREQUENCY



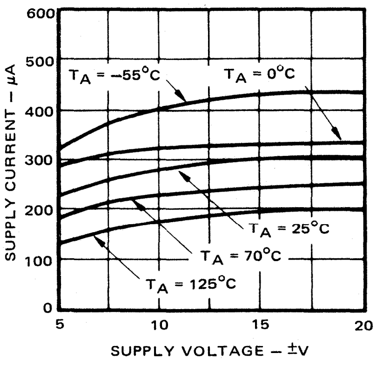
VOLTAGE GAIN
AS A FUNCTION OF
SUPPLY VOLTAGE



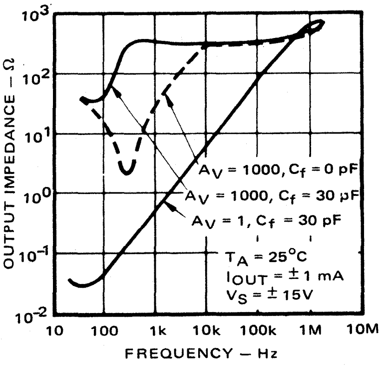
OUTPUT VOLTAGE SWING
AS A FUNCTION OF
OUTPUT CURRENT (CURRENT LIMITING)



SUPPLY CURRENT
AS A FUNCTION OF
SUPPLY VOLTAGE

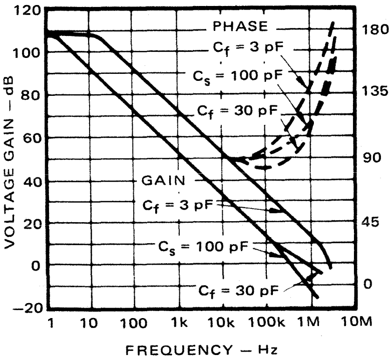


OPEN LOOP VOLTAGE GAIN
AS A FUNCTION OF
FREQUENCY

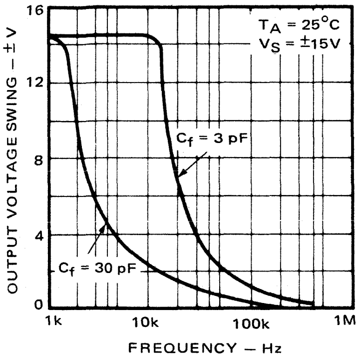


ML108, ML208, ML308
PRECISION OPERATIONAL AMPLIFIERS . . ML108A, ML208A, ML308A

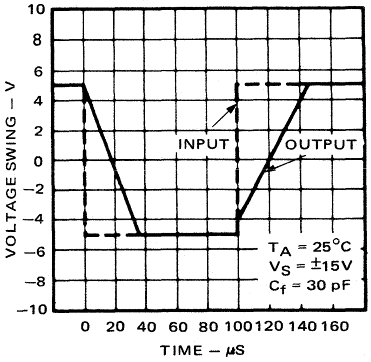
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY

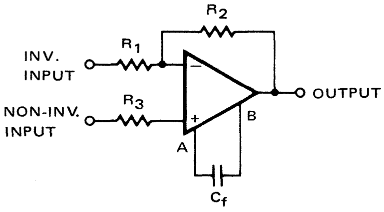


VOLTAGE FOLLOWER PULSE RESPONSE



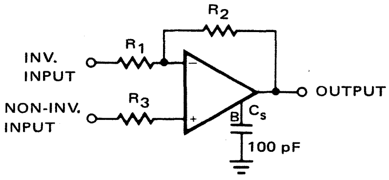
frequency compensation circuits

STANDARD COMPENSATION CIRCUIT



$$C_f \geqslant C_o \left(\frac{1}{1 + \frac{R_2}{R_1}} \right) \text{ with } C_o = 30 \text{ pF}$$

ALTERNATE COMPENSATION CIRCUIT *



* Improves rejection of power supply noise by a factor of ten.

guarding

Extra care must be taken in the assembly of printed circuit boards to take full advantage of the low input currents of the ML108 amplifier. Boards must be thoroughly cleaned with TCE or alcohol and blown dry with compressed air. After cleaning, the boards should be coated with epoxy or silicone rubber to prevent contamination.

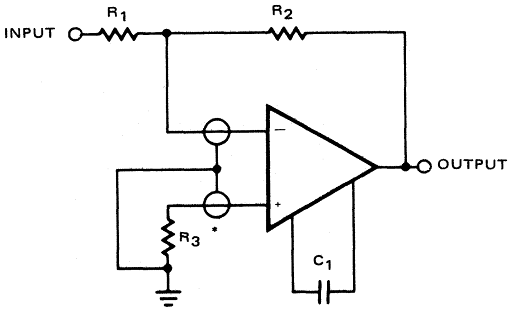
Even with properly cleaned and coated boards, leakage currents may cause trouble at 125°C, particularly since the input pins are adjacent to pins that are at supply potentials. This leakage can be significantly reduced by using guarding to lower the voltage difference between the inputs and adjacent metal runs. Input guarding of the 8-lead Metal Can (TO-99) package is accomplished by using a 10-lead pin circle, with the leads of the device formed so that the holes adjacent to the inputs are empty when it is inserted in the board. The guard, which is a conductive ring surrounding the inputs, is connected to a low impedance point that is at approximately the same voltage at the inputs. Leakage currents from high-voltage pins are then absorbed by the guard.

The pin configurations of both the Dual In-Line and Flat packages are designed to facilitate guarding, since the pins adjacent to the inputs are not used. (These are different from the standard ML741 and ML101A pin configurations.)

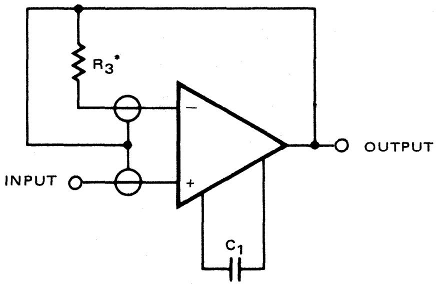
ML108, ML208, ML308
PRECISION OPERATIONAL AMPLIFIERS . . ML108A, ML208A, ML308A

CONNECTION OF INPUT GUARDS

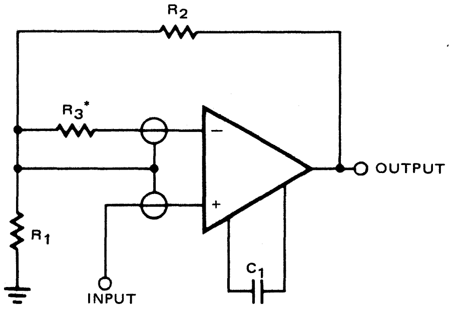
INVERTING AMPLIFIER



FOLLOWER



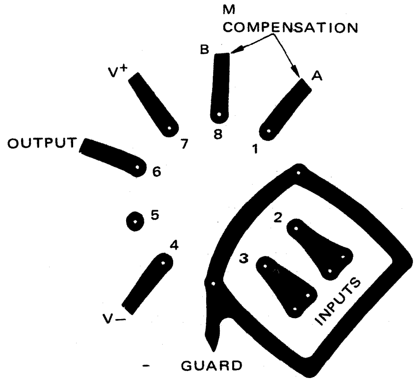
NON-INVERTING AMPLIFIER



NOTE: $\left(\frac{R_1 R_2}{R_1 + R_2}\right)$ must be LOW impedance

* Use to compensate for large source resistances

BOARD LAYOUT FOR INPUT GUARDING
WITH METAL CAN PACKAGE (BOTTOM VIEW)



microsystems
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SELECTED LINEAR I.C. CATALOGUE

Wide Band Op. Amps.

5

MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STATION C, OTTAWA, CANADA, K1Y 4J1

package availability

PRODUCT CODE	PACKAGE CODE					
	T Metal Can	**D** Hermetic D.I.L. Ceramic	**P** Molded D.I.L. Plastic	**M** Hermetic D.I.L. Metal	**S** Molded D.I.L. Plastic	**F** Flat Pack
ML118	●	●		●		●
ML218	●	●		●		●
ML318	●	●		●	●	

HIGH SPEED OPERATIONAL AMPLIFIERS . . ML118, ML218, ML318

features

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

description

Precision high speed operational amplifiers designed for applications requiring wide bandwidth and high slew rate, the ML118, 218 and 318 feature a factor of ten increase in speed over general purpose op amps without sacrificing dc performance.

With high speed and fast settling time, these op amps make useful A/D converters, oscillators, active filters, sample and hold circuits, or general purpose amplifiers. They offer substantially better ac performance than industry standards such as the ML709.

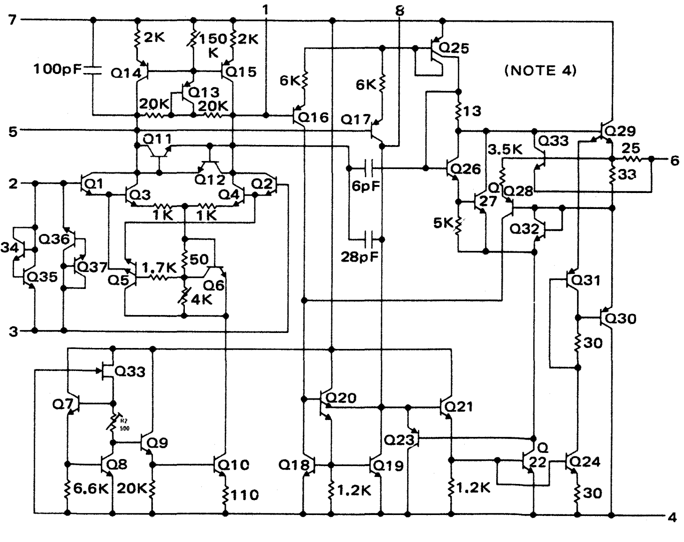
In particular, the ML118 incorporates internal unity gain frequency compensation, thus permitting operation independent of external components. Unlike most internally compensated amplifiers, external frequency compensation may be added in order to optimize performance for a particular application. For inverting applications, feedforward compensation boosts the slew rate to over 150V/μs and almost double the bandwidth. Overcompensation can be used in applications stressing stability rather than bandwidth. Moreover, a single added capacitor reduces the 0.1% settling time to under 1μs.

absolute maximum ratings

Supply voltage: ML118, ML218	±20V
ML318	±18V
Power dissipation (NOTE 1)	500mW
Differential input current (NOTE 2)	±10mA
Input Voltage (NOTE 3)	±15V

Operating temperature range	ML118	−55°C to 125°C
	ML218	−25°C to 85°C
	ML318	0°C to 70°C
Storage temperature range		−65°C to 150°C
Lead temperature (soldering, 60 sec)		300°C
Output short-circuit duration		Indefinite

schematic diagram



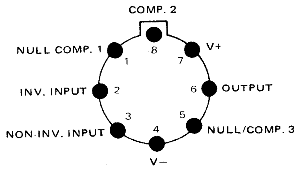
NOTES

1. The maximum junction temperature of the ML118 is 150°C, whereas that of the ML218 is 100°C and of the ML318 is 85°C. For operating at higher temperatures, devices in the TO—5 package must be derated on the basis of a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating should be 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.
2. Since inputs are shunted with back-to-back diodes for overvoltage protection, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs. Some limiting resistance must therefore be used as a countermeasure.
3. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
4. Pin connections shown on schematic diagram and typical applications are for TO—5 package.

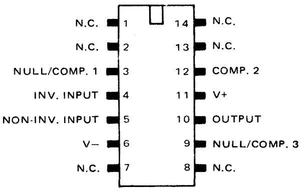
HIGH SPEED OPERATIONAL AMPLIFIERS . . ML118, ML218, ML318

connection diagrams (top view)

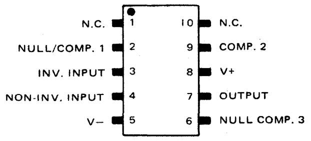
METAL CAN PACKAGE



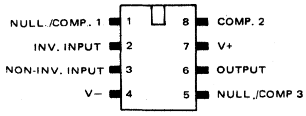
DUAL-IN-LINE PACKAGE



FLAT PACKAGE



DUAL-IN-LINE PACKAGE



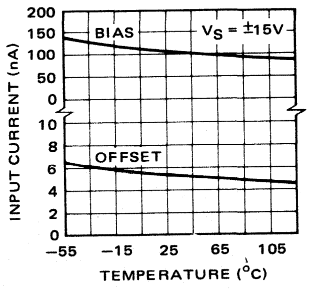
electrical characteristics

These specifications apply for ±5V ⩽ V_S ⩽ ±20V and –55°C ⩽ T_A ⩽ 125°C for the ML118, –25°C ⩽ T_A ⩽ 85°C for the ML218, and ±5V ⩽ V_S ⩽ ±18V and 0°C ⩽ T_A ⩽ 70°C for the ML318; unless otherwise specified. Also, power supplies must be bypassed with 0.1μF disc capacitors.

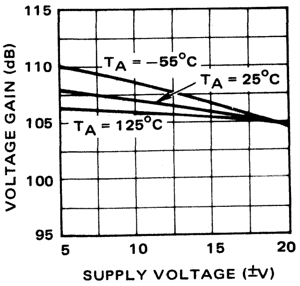
PARAMETER	CONDITIONS	ML118 AND ML218			ML318			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Input offset voltage	T_A = 25°C	–	2	4	–	–	10	mV
Input offset current	T_A = 25°C	–	6	50	–	–	200	nA
Input bias current	T_A = 25°C	–	120	250	–	–	600	nA
Input resistance	T_A = 25°C	1	3	–	0.5	3	–	MΩ
Supply current	T_A = 25°C	–	5	8	–	5	10	mA
Large signal voltage gain	T_A = 25°C, V_S = ±15V V_{OUT} = ±10V, $R_L \geqslant 2k\Omega$	50	200	–	25	–	–	V/mV
Slew rate	T_A = 25°C, V_S = ±15V, A_V = 1	50	70	–	50	70	–	V/μs
Small signal bandwidth	T_A = 25°C, V_S = ±15V	–	15	–	–	15	–	MHz
Input offset voltage		–	–	6	–	–	15	mV
Input offset current		–	–	100	–	–	300	nA
Input bias current		–	–	500	–	–	1000	nA
Supply current	$T_A = T_{max}$	–	4.5	7	–	4.5	10	mA
Large signal voltage gain	V_S = ±15V, V_{OUT} = ±10V $R_L \geqslant 2k\Omega$	25	–	–	20	–	–	V/mV
Output voltage swing	V_S = ±15V, R_L = 2kΩ	±12	±13	–	±12	±13	–	V
Input voltage range	V_S = ±15V	±11.5	–	–	±11.5	–	–	V
Common mode rejection ratio		80	100	–	70	–	–	dB
Supply voltage rejection ratio		70	80	–	65	–	–	dB

typical performance curves

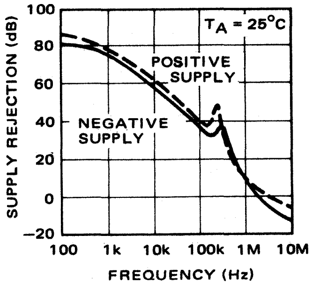
INPUT CURRENT



VOLTAGE GAIN

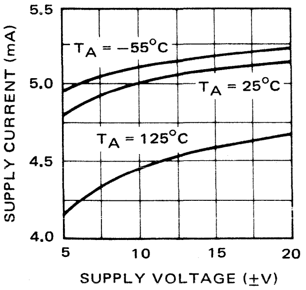


POWER SUPPLY REJECTION

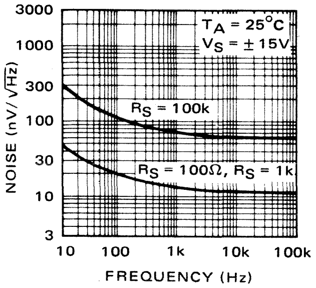


typical performance curves (cont'd)

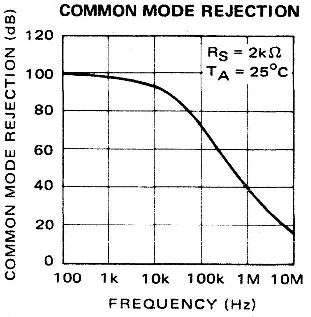
SUPPLY CURRENT



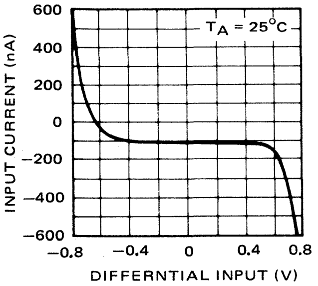
INPUT NOISE VOLTAGE



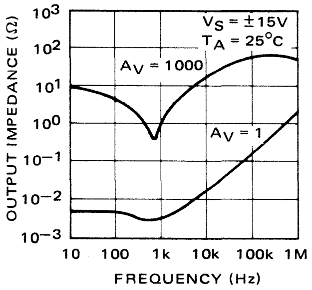
COMMON MODE REJECTION



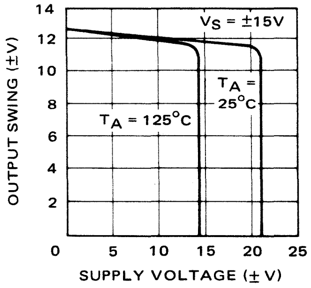
INPUT CURRENT



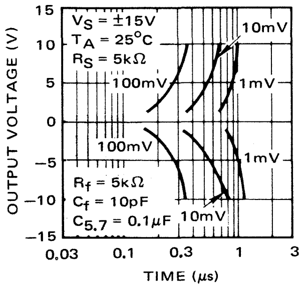
CLOSED LOOP OUTPUT IMPEDANCE



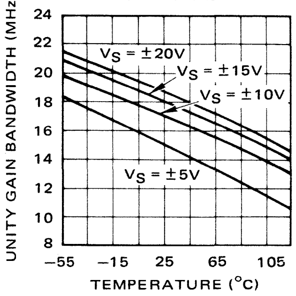
CURRENT LIMITING



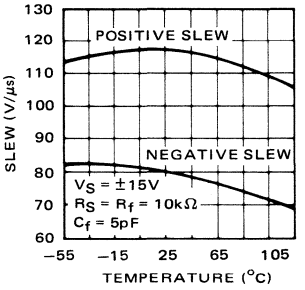
INVERTER SETTLING TIME



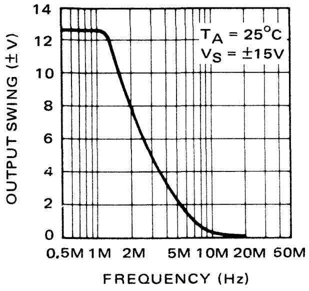
UNITY GAIN BANDWIDTH



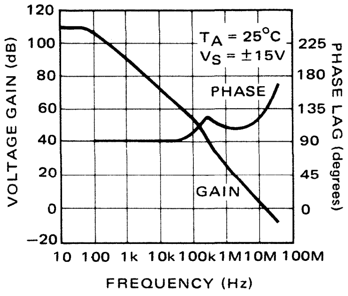
VOLTAGE FOLLOWER SLEW RATE



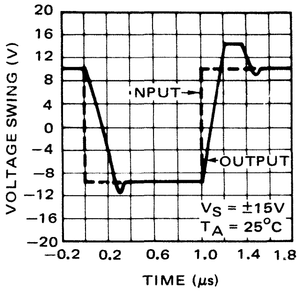
LARGE SIGNAL FREQUENCY RESPONSE



OPEN LOOP FREQUENCY RESPONSE



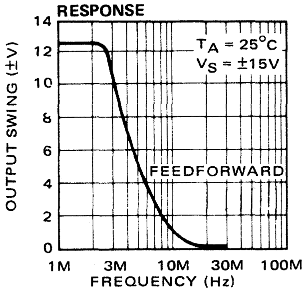
VOLTAGE FOLLOWER PULSE RESPONSE



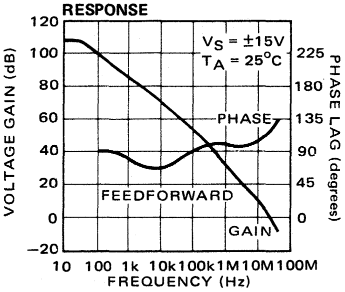
HIGH SPEED OPERATIONAL AMPLIFIERS. . ML118, ML218, ML318

typical performance curves (cont'd)

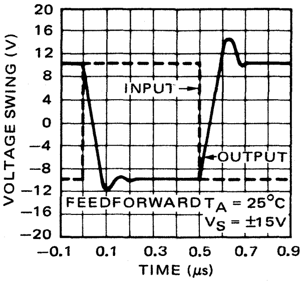
LARGE SIGNAL FREQUENCY RESPONSE



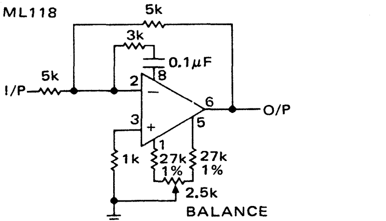
OPEN LOOP FREQUENCY RESPONSE



INVERTER PULSE REPONSE

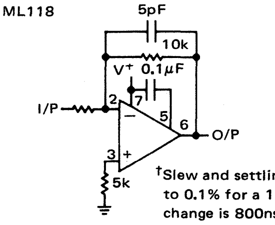


typical applications



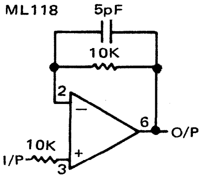
†Slew rate typically 150V/µs

FEEDFORWARD COMPENSATION FOR GREATER INVERTING SLEW RATE†

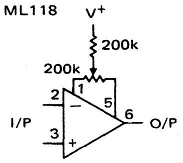


†Slew and settling time to 0.1% for a 10V step change is 800ns.

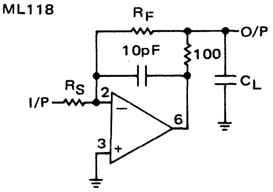
COMPENSATION FOR MINIMUM SETTLING† TIME



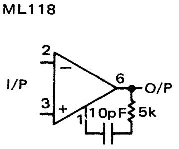
FAST VOLTAGE FOLLOWER



OFFSET BALANCING



ISOLATING LARGE CAPACITIVE LOADS



OVERCOMPENSATION

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SELECTED LINEAR I.C. CATALOGUE

Micropower Op. Amps.

6

MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STATION C, OTTAWA, CANADA, K1Y 4J1

package availability

PRODUCT CODE	PACKAGE CODE					
	T Metal Can	D Hermetic D.I.L. Ceramic	P Molded D.I.L. Plastic	M Hermetic D.I.L. Metal	S Molded D.I.L. Plastic	F Flat Pack
ML776	●	●		●		
ML776C	●	●	●	●	●	
ML4250	●	●				
ML4250C	●	●			●	
ML4251	●	●				
ML4251C	●	●			●	

PROGRAMMABLE OPERATIONAL AMPLIFIER . . . ML776, ML776C

features

- Micropower Consumption
- Low Noise
- Offset Null Capability
- High Slew Rate
- Short Circuit Protection
- Wide Programming Range
- No Frequency Compensation Required
- ±1.2V to ±18V Operation
- Low Input Bias Currents
- No Latch Up

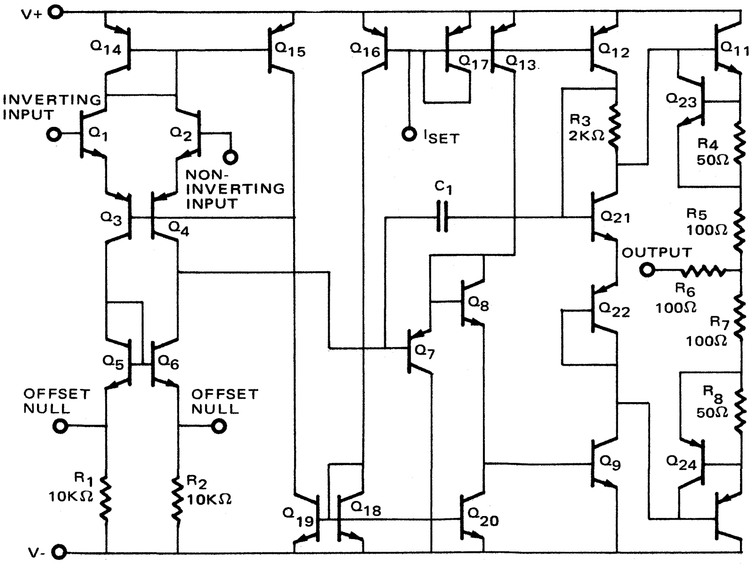
description

The ML776 Programmable Operational Amplifier is characterized by high input impedance, low supply currents, and low input noise over a wide range of operating supply voltages. Considering these features and programmability of the electrical characteristics, it is an extremely versatile amplifier for use in high accuracy, low power consumption analog applications. Input noise voltage and current, power consumption, and input current can be optimized by a single resistor or current source that sets the quiescent current for nano-watt power consumption or for characteristics similar to the ML741. Internal frequency compensation, absence of latch up, high slew rate and short circuit current protection assure ease of use in long time integrators, active filters, and sample and hold circuits.

absolute maximum ratings

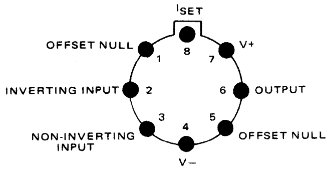
Supply Voltage	±18 V
Differential Input Voltage	±30 V
Input Voltage(2)	±15 V
I_{SET} (Maximum Current at I_{SET})	50μA
Storage Temperature Range	
Metal Can, D.I.L.	−65°C to +150°C
8 lead D.I.L.	−55°C to + 125°C
Lead Temperature (Soldering, 60 seconds)	
Metal Can, D.I.L.	+300°C
8 lead D.I.L.	+260°C
Internal Power Dissipation(1)	
Metal Can	500 mW
D.I.L.	670 mW
8 lead D.I.L.	310 mW
Voltage Between Offset Null and V−	±0.5 V
V_{SET} (Maximum Voltage to Ground at I_{SET})	$(V_+ - 2.0\ V) \leqslant V_{SET} \leqslant V_+$
Operating Temperature Range	
Military ML776	−55°C to +125°C
Commercial ML776C	0°C to + 70°C
Output Short-Circuit Duration(3)	Indefinite

schematic diagram

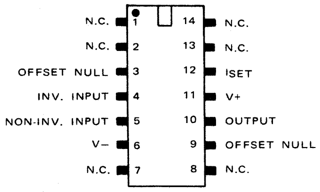


connection diagrams

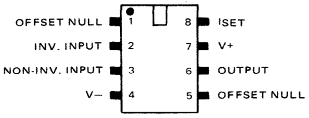
METAL CAN PACKAGE (Top View)



DUAL-IN-LINE PACKAGE (Top View)



DUAL-IN-LINE PACKAGE (Top View)



MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STA.C, OTTAWA, CANADA K1Y 4J1

microsystems
international

PROGRAMMABLE OPERATIONAL AMPLIFIERS . . . ML776, ML776C

electrical characteristics (ML776)

(V_S = ±15V, −55°C ⩽ T_A ⩽ +125°C unless otherwise specified)

PARAMETERS	SYMBOLS	CONDITIONS	I_{SET}=1.5µA MIN.	TYP.	MAX.	I_{SET}=15.0µA MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\|V_{io}\|$	R_S=10K, T_A=+ 25°C	–	2.0	5.0	–	2.0	5.0	mV
Input Offset Voltage	$\|I_{io}\|$	R_S=10K, T_A=+25°C	–	.7	3.0	–	2.0	15.0	nA
Input Bias Current	I_b	T_A=+25°C	–	2.0	7.5	–	15.0	50.0	nA
Input Resistance	R_{in}	T_A=+25°C	–	50.0	–	–	5.0	–	MΩ
Input Capacitance	C_{in}	T_A=+25°C	–	2.0	–	–	2.0	–	pF
Offset Voltage Adjustment Range	ΔV_{io}	T_A=+25°C	–	9.0	–	–	18.0	–	mV
Large Signal Voltage Gain (4)	A_{VOL}	R_L⩾75KΩ V_{out}=±10V	200	400	–	–	–	–	V/mV
		R_L⩾5KΩ V_{out}=±10V	–	–	–	100	400	–	
Output Resistance	R_{out}	T_A=+25°C	–	5.0	–	–	1.0	–	KΩ
Output Short Circuit	I_{SC}	T_A = +25°C	–	3.0	–	–	12.0	–	mA
Supply Current	I_S	T_A = +25°C	–	20.0	25.0	–	160.0	180.0	µA
Power Consumption	P_i	T_A = +25°C	–	–	.75	–	–	5.4	mW
Transient Response (Unity Gain): Risetime	t_r	V_{IN}=20mV R_L⩾5.0KΩ,T_A=+25°C C_L=100pF	–	1.6	–	–	.35	–	µs
Overshoot	t_o		–	0	–	–	10.0	–	%
Slew Rate	dV_{out}/dt	R_L⩾5.0KΩ, T_A=+25°C	–	0.1	–	–	0.8	–	V/µs
Output Voltage Swing	V_{out}	R_L⩾75KΩ, T_A=+25°C	–	±12.0	±14.0	–	–	–	V
		R_L⩾5.0KΩ, T_A=+25°C	–	–	–	±10.0	±13.0	–	
Input Offset Voltage	$\|V_{io}\|$	R_S=10K	–	–	6.0	–	–	6.0	mV
Input Offset Current	$\|I_{io}\|$	T_A=+125°C	–	–	5.0	–	–	15.0	nA
		T_A=-55°C	–	–	10.0	–	–	40.0	
Input Bias Current	I_b	T_A=+125°C	–	–	7.5	–	–	50.0	nA
		T_A=-55°C	–	–	20	–	–	120.0	
Input Voltage Range	V_{iCM}	–	±10.0	–	–	±10.0	–	–	V
Common Mode Rejection Ratio	CMRR	R_S⩽10K	70.0	90.0	–	70.0	90.0	–	dB
Supply Voltage Rejection Ratio	PSRR	R_S⩽10K	–	25.0	150.0	–	25.0	150.0	µV/V
Large-Signal Voltage Gain	A_{VOL}	R_L⩾75KΩ V_{out} = ±10.0V	100.0	–	–	75.0	–	–	V/mV
Output Voltage Swing	V_{out}	R_L⩾75KΩ	±10.0	–	–	±10.0	–	–	V
Supply Current	I_S	–	–	–	30.0	–	–	200.0	µA
Power Consumption	P_i	–	–	–	0.9	–	–	6.0	mW

PROGRAMMABLE OPERATIONAL AMPLIFIERS . . . ML776, ML776C

$V_S = \pm$ 3V ($-55°C \leqslant T_A \leqslant +125°C$, unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	$I_{SET}=1.5\mu A$ MIN.	TYP.	MAX.	$I_{SET}=15.0\mu A$ MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\|V_{io}\|$	$R_S \leqslant 10K, T_A = +25°C$	–	2.0	5.0	–	2.0	5.0	mV
Input Offset Current	$\|I_{io}\|$	$T_A=+25°C$	–	0.7	3.0	–	2.0	15.0	nA
Input Bias Current	I_b	$T_A=+25°C$	–	2.0	7.5	–	15.0	50.0	nA
Input Resistance	R_{in}	$T_A=+25°C$	–	50.0	–	–	5.0	–	MΩ
Input Capacitance	C_{in}	$T_A=+25°C$	–	2.0	–	–	2.0	–	pF
Offset Voltage Adjustment Range	ΔV_{io}	$T_A=+25°C$	–	9.0	–	–	18.0	–	mV
Large Signal Voltage Gain (4)(5)	A_{VOL}	$R_L \geqslant 75K$, $R_L \geqslant 5K$	50 –	200 –	– –	– 50	– 200	– –	V/mV
Output Resistance	R_{out}	$T_A=+25°C$		5.0	–	–	1.0	–	KΩ
Output Short Circuit Current	I_{SC}	$T_A=+25°C$	–	3.0	–	–	5.0	–	mA
Supply Current	I_S	$T_A=+25°C$	–	13.0	20.0	–	130.0	160.0	μA
Power Consumption	P_i	$T_A=+25°C$	–	78.0	120.0	–	780.0	960.0	μW
Transient Response (Unity Gain): Risetime Overshoot	 t_r t_o	$V_{IN}=20mV, R_L \geqslant 5K\Omega$ $C_L=100pF, T_A=+25°C$ –	– –	3.0 0	– –	– –	0.6 5.0	– –	μs %
Slew Rate	dV_{out}/dt	$R_L \geqslant 5K\Omega$ $T_A=+25°C$	–	0.03	–	–	0.35	–	V/μs
Input Offset Voltage	$\|V_{io}\|$	$R_S=10K$	–	–	6.0	–	–	6.0	mV
Input Offset Current	$\|I_{io}\|$	$T_A=+125°C$ $T_A=55°C$	– –	– –	5.0 10.0	– –	– –	15.0 40.0	nA
Input Bias Current	I_b	$T_A=+125°C$ $T_A=-55°C$	– –	– –	7.5 20.0	– –	– –	50.0 120.0	nA
Input Voltage Range	V_{iCM}	–	±1.0	–	–	±1.0	–	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leqslant 10K\Omega$	70	86	–	70	86	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leqslant 10K\Omega$	–	25.0	150.0	–	25.0	150.0	μV/V
Large Signal Voltage Gain (5)	A_{VOL}	$R_L \geqslant 75K\Omega$ $R_L \geqslant 5.0K\Omega$	25.0 –	– –	– –	– 25.0	– –	– –	V/mV
Output Voltage Swing	V_{out}	$R_L \geqslant 75\ K\Omega$ $R_L \geqslant 5.0K\Omega$	±2.0 –	±2.4 –	– –	– ±1.9	– ±2.1	– –	V
Supply Current	I_S	–	–	–	25.0	–	–	180.0	μA
Power Consumption	P_i	–	–	–	150.0	–	–	1080	μW

PROGRAMMABLE OPERATIONAL AMPLIFIERS . . . ML776, ML776C

electrical characteristics (cont'd) (ML776C)

$V_S = \pm 15V$, 0°C ≤ TA ≤ +70°C unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	$I_{SET}=1.5\mu A$ MIN.	TYP.	MAX.	$I_{SET}=15.0\mu A$ MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\|V_{io}\|$	R_S=10K T_A = +25°C	–	2.0	6.0	–	2.0	6.0	mV
Input Offset Current	$\|I_{io}\|$	T_A = +25°C	–	0.7	6.0	–	2.0	25.0	nA
Input Bias Current	I_b	T_A = +25°C	–	2.0	10.0	–	15.0	50.0	nA
Input Resistance	R_{in}	T_A = +25°C	–	50.0	–	–	5.0	–	MΩ
Input Capacitance	C_{in}	T_A = +25°C	–	2.0	–	–	2.0	–	pF
Offset Voltage Adjustment Range	ΔV_{io}	T_A = +25°C	–	9.0	–	–	18.0	–	mV
Large Signal Voltage Gain[4]	A_{VOL}	$R_L \geqslant 75K$, V_{out}=+10V	50.0	400.0	–	–	–	–	V/mV
		$R_L \geqslant 5K$, V_{out}=+10V	–	–	–	50.0	400.0	–	V/mV
Output Resistance	R_{out}	T_A=+25°C	–	5.0	–	–	1.0	–	KΩ
Output Short Circuit Current	I_{SC}	T_A=+25°C	–	3.0	–	–	12.0	–	mA
Supply Current	I_S	T_A=+25°C	–	20.0	30.0	–	160.0	190.0	µA
Power Consumption	P_i	T_A=+25°C	–	–	0.4	–	–	5.7	mW
Transient Response (Unity Gain): Risetime Overshoot	t_r t_o	V_{in}=20mV $R_L \geqslant 5K\Omega$ $C_L \leqslant 100pF$ TA=+25°C	– –	1.6 0	– –	– –	0.35 10.0	– –	µs %
Slew Rate	dV_{out}/dt	$R_L \geqslant 5K\Omega$, T_A=+25°C	–	0.1	–	–	0.8	–	V/µs
Output Voltage Swing	V_{out}	$R_L \geqslant 75K\Omega$ $R_L \geqslant 5.0K\Omega$	±12.0 –	±14.0 –	– –	– ±10.0	– ±13.0	– –	V V
Input Offset Voltage	$\|V_{io}\|$	R_S=10K	–	–	7.5	–	–	7.5	mV
Input Offset Current	$\|I_{io}\|$	T_A=+70°C T_A=0°C	– –	– –	6.0 10.0	– –	– –	25.0 40.0	nA nA
Input Bias Current	I_b	T_A=+70°C T_A=+0°C	– –	– –	10.0 20.0	– –	– –	50.0 100.0	nA nA
Input Voltage Range	V_{ICM}	–	±10.0	–	–	±10.0	–	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leqslant 10K\Omega$	70	90	–	70	90	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leqslant 10K\Omega$	–	25.0	200.0	–	25.0	200.0	µV/V
Large Signal Voltage Gain	A_{VOL} $V_{out}=\pm 10V$	$R_L \geqslant 75K\Omega$ V_{out} =±10V	50	–	–	50	–	–	V/mV V
Output Voltage Swing	V_{OUT}	$R_L \geqslant 75$ KΩ	±10.0	–	–	±10.0	–	–	V
Supply Current	I_S	–	–	–	35.0	–	–	200.0	µA
Power Consumption	P_i	–	–	–	1.05	–	–	6.0	mW

PROGRAMMABLE OPERATIONAL AMPLIFIERS . . . ML776, ML776C

V_S=±3.0V, 0°C≤T_A≤+70°C unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	I_{SET}=1.5μA MIN.	TYP.	MAX.	I_{SET}=15.0μA MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	R_S=10K T_A=+25°C	–	2.0	6.0	–	2.0	6.0	mV
Input Offset Current	$\lvert I_{io} \rvert$	T_A=+25°C	–	0.7	6.0	–	2.0	25.0	nA
Input Bias Current	I_b	T_A=+25°C	–	2.0	10.0	–	15.0	50.0	nA
Input Resistance	R_{in}	T_A=+25°C	–	50.0	–	–	5.0	–	MΩ
Input Capacitance	C_{in}	T_A=+25°C	–	2.0	–	–	2.0	–	pF
Offset Voltage Adjustment Range	ΔV_{io}	T_A=+25°C	–	9.0	–	–	18.0	–	mV
Large Signal Voltage Gain (4)(5)	A_{VOL}	R_L≥75KΩ		25	200				
		R_L≥5KΩ	–	–	–	25	200	–	V/mV
Output Resistance	R_{out}	T_A = +25°C	–	5.0	–	–	1.0	–	KΩ
Output Short Circuit Current	I_{SC}	T_A = +25°C	–	3.0	–	–	5.0	–	mA
Supply Current	I_S	T_A = +25°C	–	13.0	20.0	–	130.0	170.0	μA
Power Consumption	P_i	T_A = +25°C	–	78.0	120.0	–	780.0	1020.0	μW
Transient Response (Unity Gain) Risetime:	t_r	V_{in}=20mV R_L≥5KΩ, C_L = 100pF	–	– 3.0	–	–	0.6	–	μs
Overshoot			–	0	–	–	5.0	–	%
Slew Rate	dV_{out}/dt	R_L≥5KΩ, T_A= +25°C	–	0.03	–	–	0.35	–	V/μs
Input Offset Voltage	$\lvert V_{io} \rvert$	R_S=10K	–	–	7.5	–	–	7.5	mV
Input Offset Current	$\lvert I_{io} \rvert$	T_A = +70°C T_A = +0°C	– –	– –	6.0 10.0	– –	– –	25.0 40.0	nA
Input Bias Current	I_b	T_A = +70°C T_A = +0°C	– –	– –	10.0 20.0	– –	– –	50.0 100.0	nA
Input Voltage Range	V_{iCM}	–	±1.0	–	–	±1.0	–	–	V
Common Mode Rejection Ratio	CMRR	R_S≤10KΩ	70.0	86.0	–	70.0	86.0	–	dB
Supply Voltage Rejection Ratio	PSRR	R_S≤10KΩ	–	25.0	200.0	–	25.0	200.0	μV/V
Large Signal Voltage Gain(5)	A_{VOL}	R_L≥75KΩ R_L≥5.0KΩ	25.0 –	– –	– –	– 25.0	– –	– –	V/mV
Output Voltage Swing	V_{out}	R_L≥75.KΩ R_L≥5.0KΩ	±2.0 –	±2.4 –	– –	– ±2.0	– ±2.1	– –	V
Supply Current	I_S	–	–	–	25.0	–	–	180.0	μA
Power Consumption	P_i	–	–	–	150.0	–	–	1080	μW

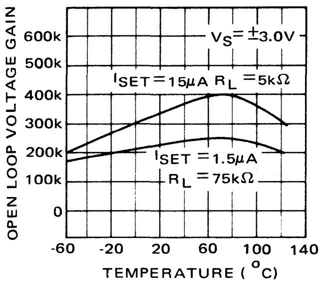
NOTES:

1. Rating applies to ambient temperatures up to +70°C. Above +70°C ambient, derate linearly at 6.3mW/°C for metal can, and 5.6mW/°C for 8 lead D.I.L.
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Short circuit may be to ground or either supply; rating applies to +125°C case temperature or +75°C ambient temperature for I_{SET} ≤30μA.
4. T_A=+25°C
5. V_{out}=±1V

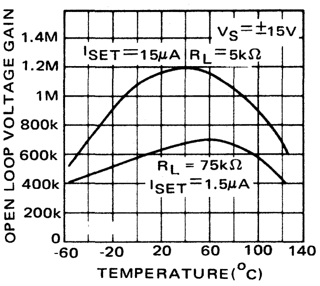
PROGRAMMABLE OPERATIONAL AMPLIFIERS . . . ML776, ML776C

typical characteristic curves

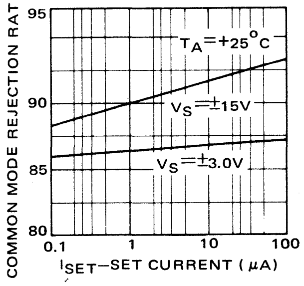
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF AMBIENT TEMPERATURE



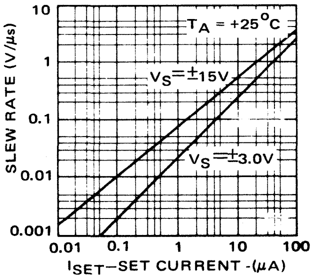
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF AMBIENT TEMPERATURE



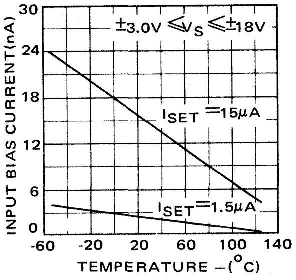
COMMON MODE REJECTION RATIO AS A FUNCTION OF SET CURRENT



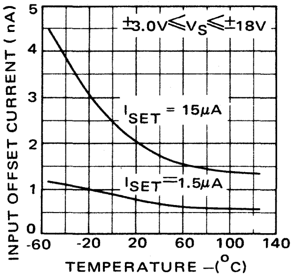
SLEW RATE AS A FUNCTION OF SET CURRENT



INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE

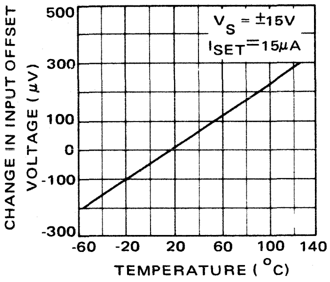


INPUT OFFSET CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE

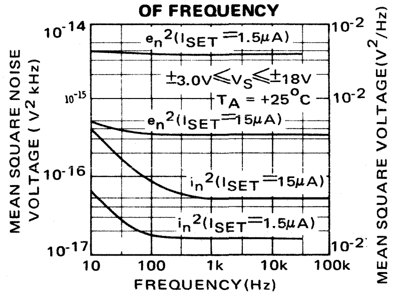


PROGRAMMABLE OPERATIONAL AMPLIFIERS . . . ML776, ML776C

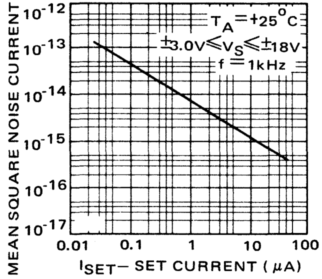
typical characteristic curves (cont'd)



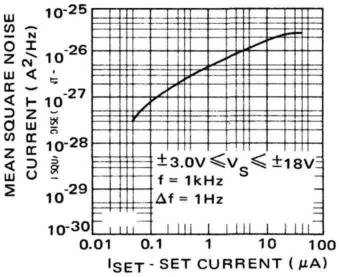
CHANGE IN INPUT OFFSET VOLTAGE AS A FUNCTION OF AMBIENT TEMPERATURE (UNNULLED)



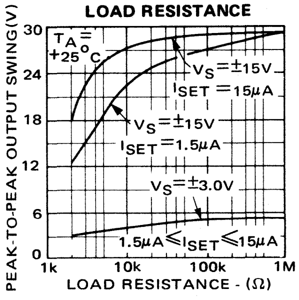
INPUT NOISE VOLTAGE AND CURRENT AS A FUNCTION OF FREQUENCY



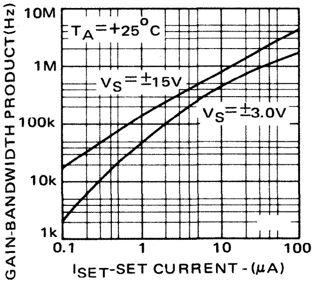
INPUT NOISE VOLTAGE AS A FUNCTION OF SET CURRENT



INPUT NOISE CURRENT AS A FUNCTION OF SET CURRENT



OUTPUT VOLTAGE SWING AS A FUNCTION OF LOAD RESISTANCE

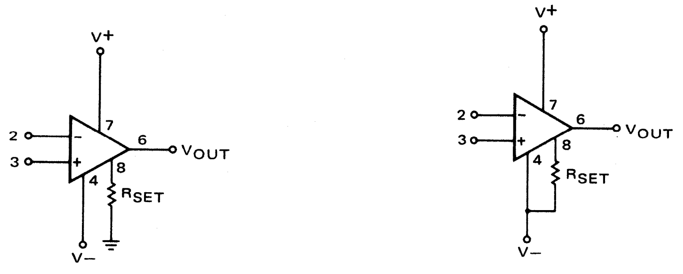


GAIN-BANDWIDTH PRODUCT AS A FUNCTION OF SET CURRENT

PROGRAMMABLE OPERATIONAL AMPLIFIERS . . . ML776, ML776C

biasing circuits

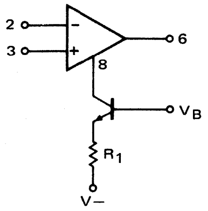
a) **RESISTOR BIASING**



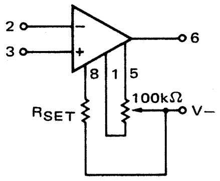
R_{SET} CONNECTED TO GROUND

R_{SET} CONNECTED TO V^-
Recommended for
supply voltages less than ±6V.

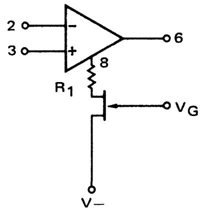
b) **TRANSISTOR CURRENT SOURCE BIASING**



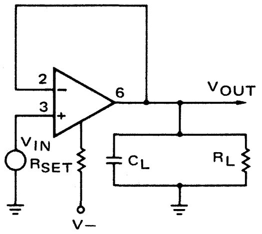
c) **VOLTAGE OFFSET NULL CIRCUIT**



d) **FET CURRENT SOURCE BIASING**



e) **TRANSIENT RESPONSE TEST CIRCUIT**



QUIESCENT CURRENT SETTING RESISTOR
(I_{SET} TO V^-)

V_S	I_{SET}	
	1.5μA	15μA
±1.5V	1.7MΩ	170kΩ
±3.0V	3.6MΩ	360kΩ
±6.0V	7.5MΩ	750kΩ
±15V	20MΩ	2.0MΩ

Note: The ML776 may be operated with R_{SET} connected to ground or V−.

I_{SET} EQUATIONS:

$$I_{SET} = \frac{V^+ - 0.7 - V^-}{R_{SET}}$$

where R_{SET} is connected to V^-

$$I_{SET} = \frac{V^+ - 0.7}{R_{SET}}$$

where R_{SET} is connected to ground.

PROGRAMMABLE OPERATIONAL AMPLIFIER . . ML4250, ML4250C ML4251, ML4251C

features

- ±1V to ±10V Power Supply Operation (ML4251, 4251C)
  ±1V to ±18V Power Supply Operation (ML4250, 4250C)
- 3 nA Input Offset Current
- Standby Power Consumption down to 500nW
- Two-Flashlight Battery Operation
- Short Circuit Protection
- Offset Voltage Nulling
- Internal Frequency Compensation
- Programmable Electrical Characteristics

description

The ML4250, 4251 series are micropower programmable operational amplifiers. Designed for operation in applications where power consumption is critical, they can be tailored by external components for a wide range of quiescent current and operating voltage values. Internally compensated, they are pin compatible with the ML741 series.

absolute maximum ratings

Supply Voltage:	
ML4251, 4251C	±10 V
ML4250, 4250C	±18 V
Power Dissipation (Note 1)	500 mW
Differential Input Voltage:	
ML4251, 4251C	±10 V
ML4250, 4250C	±30 V
Input Voltage (Note 2):	
ML4251, 4251C	±10 V
ML4250, 4250C	±15 V

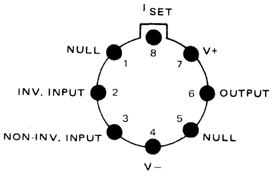
I_{SET} Current	150 μA
Output Short Circuit Duration	Indefinite
Operating Temperature Range:	
ML4250, ML4251	$-55°C \leqslant T_A \leqslant 125°C$
ML4250, ML4251C	$0°C \leqslant T_A \leqslant 70°C$
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering 10 sec)	300°C

NOTE 1: The maximum junction temperature of the ML4251, 4250 is 150°C, while that of the ML4251C, 4250C 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.

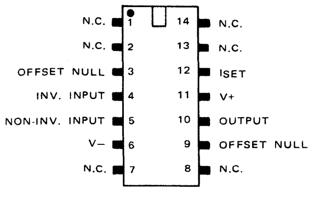
NOTE 2: For supply voltages less than ± 15 V, the absolute maximum input voltage is equal to the supply voltage.

connection diagrams (Top View)

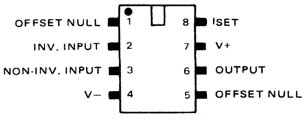
METAL CAN PACKAGE



DUAL-IN-LINE PACKAGE



DUAL-IN-LINE PACKAGE



MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STA.C, OTTAWA, CANADA K1Y 4J1

microsystems international

electrical characteristics (ML4251, ML4250)

$-55^\circ C \leqslant T_A \leqslant 125^\circ C$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	ML4251				ML4250				UNITS
			$V_S = \pm 1.5$ V				$V_S = \pm 1.5$ V				
			$I_{SET} = 1\ \mu A$		$I_{SET} = 10 \mu A$		$I_{SET} = 1\ \mu A$		$I_{SET} = 10 \mu A$		
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
Input Offset Voltage	$\lvert V_{io} \rvert$	$T_A = 25^\circ C$ $R_S \leqslant 100\ k\Omega$	–	3	–	5	–	3	–	5	mV
Input Offset Current	$\lvert I_{io} \rvert$	$T_A = 25^\circ C$	–	3	–	10	–	3	–	10	nA
Input Bias Current	I_b	$T_A = 25^\circ C$	–	7.5	–	50	–	7.5	–	50	nA
Large Signal Voltage Gain	A_{VOL}	$T_A = 25^\circ C$ $R_L = 100\ k\Omega$ *	40k	–		–	40k	–	–	–	–
		$T_A = 25^\circ C$ $R_L = 10\ k\Omega$ *	–	–	50k	–	–	–	50k	–	–
Supply Current	I_S	$T_A = 25^\circ C$	–	7.5	–	80	–	7.5	–	80	µA
Power Consumption	P_i	$T_A = 25^\circ C$	–	23	–	240	–	23	–	240	µW
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 100\ k\Omega$	–	4	–	6	–	4	–	6	mV
Input Offset Current	I_{io}	$T_A = 125^\circ C$	–	5	–	10	–	5	–	10	nA
		$T_A = -55^\circ C$	–	3	–	10	–	3	–	10	nA
Input Bias Current	I_b	–	–	7.5	–	50	–	7.5	–	50	nA
Input Voltage Range	$-V_{ICM}$	–	±0.7	–	±0.7	–	±0.7	–	±0.7	–	V
Large Signal Voltage Gain	A_{VOL}	$R_L = 100\ k\Omega$ *	30k	–	–	–	30k	–	–	–	–
		$R_L = 10\ k\Omega$ *	–	–	30k	–	–	–	30k	–	–
Output Voltage Swing	V_{out}	$R_L = 100\ k\Omega$	±0.6	–	–	–	±0.6	–	–	–	V
		$R_L = 10\ k\Omega$	–	–	±0.6	–	–	–	±0.6	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leqslant 10\ k\Omega$	70	–	70	–	70	–	70	–	dB
Power Supply Rejection Ratio	PSRR	$R_S \leqslant 10\ k\Omega$	76	–	76	–	76	–	76	–	dB
Supply Current	I_S	–	–	8	–	90	–	8	–	90	µA
Power Consumption	P_i	–	–	24	–	270	–	24	–	270	µW

* $V_{out} = \pm 0.6V$ for ML4250/ML4251

$-55°C \leqslant T_A \leqslant 125°C$ unless otherwise specified (Continued)

PARAMETERS	SYMBOLS	CONDITIONS	ML4251				ML4250				UNITS
			$V_S = \pm 9$ V				$V_S = \pm 15$ V				
			$I_{SET} = 1\ \mu A$		$I_{SET} = 10 \mu A$		$I_{SET} = 1\ \mu A$		$I_{SET} = 10 \mu A$		
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
Input Offset Voltage	$\|V_{io}\|$	$T_A = 25°C$, $R_S \leqslant 100$ kΩ	–	3	–	5	–	3	–	5	mV
Input Offset Current	$\|I_{io}\|$	$T_A = 25°C$	–	3	–	10	–	3	–	10	nA
Input Bias Current	I_b	$T_A = 25°C$	–	7.5	–	50	–	7.5	50	50	nA
Large Signal Voltage Gain	A_{VOL}	$T_A = 25°C$, $R_L = 100$ kΩ **	100k	–	–	–	100k	–	–	–	–
		$T_A = 25°C$ $R_L = 10$ kΩ **	–	–	100k	–	–	–	100k	–	–
Supply Current	I_S	$T_A = 25°C$	–	10	–	90	–	10	–	90	μA
Power Consumption	P_i	$T_A = 25°C$	–	180	–	1620	–	300	–	2700	μW
Input Offset Voltage	$\|V_{io}\|$	$R_S \leqslant 100$ kΩ	–	4	–	6	–	4	–	6	mV
Input Offset Current	I_{io}	$T_A = 125°C$	–	25	–	25	–	25	–	25	nA
		$T_A = -55°C$	–	3	–	10	–	3	–	10	nA
Input Bias Current	I_b	–	–	7.5	–	50	–	7.5	–	50	nA
Input Voltage Range	$-V_{iCM}$	–	±7.5	–	±7.5	–	±13.5	–	±13.5		V
Large Signal Voltage Gain	A_{VOL}	$R_L = 100$ kΩ **	50k	–	–	–	50k	–	–	–	–
		$R_L = 10$ kΩ **	–	–	50k	–	–	–	50k	–	–
Output Voltage Swing	V_{out}	$R_L = 100$ kΩ	±7	–		–	±12	–		–	V
		$R_L = 10$ kΩ	–	–	±7	–	–	–	±12	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leqslant 10$ kΩ	70	–	70	–	70	–	70	–	dB
Power Supply Rejection Ratio	PSRR	$R_S \leqslant 10$ kΩ	76	–	76	–	76	–	76	–	dB
Supply Current	I_S	–	–	11	–	100	–	11	–	100	μA
Power Consumption	P_i	–	–	198	–	1800	–	330	–	3000	μW

** $V_{out} = \pm 6$V for ML4251
$V_{out} = \pm 10$V for ML4250

electrical characteristics (ML4251C, ML4250C)

(0°C ⩽ T_A ⩽ 70°C unless otherwise specified

			ML4251C				ML4250C				
			V_S = ±1.5 V				V_S = ±1.5 V				
PARAMETERS	SYMBOLS	CONDITIONS	I_{SET} = 1 µA		I_{SET} = 10µA		I_{SET} = 1 µA		I_{SET} = 10µA		UNITS
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
Input Offset Voltage	|Vio|	T_A = 25°C R_S ⩽ 100 kΩ	–	5	–	6	–	5	–	6	mV
Input Offset Current	Iio	T_A = 25°C	–	6	–	20	–	6	–	20	nA
Input Bias Current	I_b	T_A = 25°C	–	10	–	75	–	10	–	75	nA
Large Signal Voltage Gain	A_{VOL}	T_A = 25°C R_L = 100 kΩ *	25k	–	–	–	25k	–	–	–	–
		T_A = 25°C R_L = 10 kΩ *	–	–	25k	–	–	–	25k	–	–
Supply Current	I_S	T_A = 25°C	–	8	–	90	–	8	–	90	µA
Power Consumption	P_i	T_A = 25°C	–	24	–	270	–	24	–	270	µW
Input Offset Voltage	|Vio|	R_S ⩽ 10 kΩ	–	6.5	–	7.5	–	6.5	–	7.5	mV
Input Offset Current	Iio	–	–	8	–	25	–	8	–	25	nA
Input Bias Current	I_b	–	–	10	–	80	–	10	–	80	nA
Input Voltage Range	$-V_{iCM}$	–	±0.6	–	±0.6	–	±0.6	–	±0.6	–	V
Large Signal Voltage Gain	A_{VOL}	R_L = 100 kΩ *	25k	–	–	–	25k	–	–	–	–
		R_L = 10 kΩ *	–	–	25k	–	–	–	25k	–	–
Output Voltage Swing	V_{out}	R_L = 100 kΩ	±0.6	–	–	–	±0.6	–	–	–	V
		R_L = 10 kΩ	–	–	±0.6	–	–	–	±0.6	–	V
Common Mode Rejection Ratio	CMRR	R_S ⩽ 10 kΩ	70	–	70	–	70	–	70	–	dB
Power Supply Rejection Ratio	PSRR	R_S ⩽ 10 kΩ	74	–	74	–	74	–	74	–	dB
Supply Current	I_S	–	–	8	–	90	–	8	–	90	µA
Power Consumption	P_i	–	–	24	–	270	–	24	–	270	µW

* V_{out} = ±0.6V for ML4251C/ML4250C

0°C ⩽ T_A ⩽ 70°C unless otherwise specified (Continued)

PARAMETERS	SYMBOLS	CONDITIONS	ML4251C				ML4250C				UNITS
			$V_S = \pm 9$ V				$V_S = \pm 15$ V				
			$I_{SET} = 1\ \mu A$		$I_{SET} = 10 \mu A$		$I_{SET} = 1\ \mu A$		$I_{SET} = 10 \mu A$		
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
Input Offset Voltage	$\lvert V_{io} \rvert$	$T_A = 25°C$ $R_S \leqslant 100\ k\Omega$	–	5	–	6	–	5	–	6	mV
Input Offset Current	I_{io}	$T_A = 25°C$	–	6	–	20	–	6	–	20	nA
Input Bias Current	I_b	$T_A = 25°C$	–	10	–	75	–	10	–	75	nA
Large Signal Voltage Gain	A_{VOL}	$T_A = 25°C$ $R_L = 100\ k\Omega$ **	60k	–	–	–	60k	–	–	–	–
		$T_A = 25°C$ $R_L = 10\ k\Omega$ **	–	–	60k	–	–	–	60k	–	–
Supply Current	I_S	$T_A = 25°C$	–	11	–	100	–	11	–	100	µA
Power Consumption	P_i	$T_A = 25°C$	–	198	–	1800	–	330	–	3000	µW
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 10\ k\Omega$	–	6.5	–	7.5	–	6.5	–	7.5	mV
Input Offset Current	I_{io}	–	–	8	–	25	–	8	–	25	nA
Input Bias Current	I_b	–	–	10	–	80	–	10	–	80	nA
Input Voltage Range	$-V_{iCM}$	–	±7.5	–	±7.5	–	±13.5	–	±13.5	–	V
Large Signal Voltage Gain	A_{VOL}	$R_L = 100\ k\Omega$ **	50k	–	–	–	50k	–	–	–	–
		$R_L = 10\ k\Omega$ **	–	–	50k	–	–	–	50k	–	–
Common Mode Rejection Ratio	CMRR	$R_S \leqslant 10\ k\Omega$	70	–	70	–	70	–	70	–	dB
Power Supply Rejection Ratio	PSRR	$R_S \leqslant 10\ k\Omega$	74	–	74	–	74	–	74	–	dB
Supply Current	I_S	–	–	11	–	100	–	11	–	100	µA
Power Consumption	P_i	–	–	198	–	1800	–	300	–	3000	µW
Output Voltage Swing	V_{out}	$R_L = 100k\Omega$	±7				±12				V
		$R_L = 10k\Omega$			±7				±12		V

** $V_{out} = \pm 6V$ for ML4251C
$V_{out} = \pm 10V$ for ML4250C

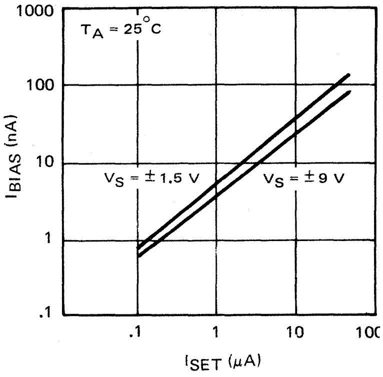
resistor biasing

Set Current Setting Resistor to V^-

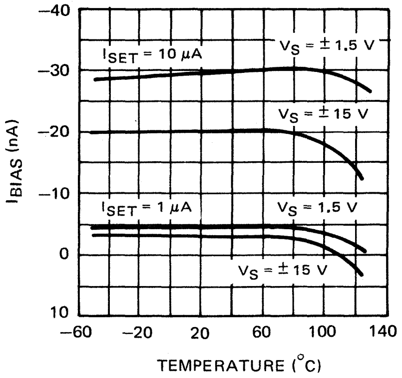
	I_{SET}						
	V_S	0.1 µA	0.5 µA	1.0 µA	5 µA	10 µA	
ML4251, 4251C	±1.5 V	25.6 MΩ	5.04 MΩ	2.5 MΩ	492 kΩ	244 kΩ	ML4250, 4250C
	±3.0 V	55.6 MΩ	11.0 MΩ	5.5 MΩ	1.09 MΩ	544 kΩ	
	±6.0 V	116 MΩ	23.0 MΩ	11.5 MΩ	2.29 MΩ	1.14 MΩ	
	±9.0 V	176 MΩ	35.0 MΩ	17.5 MΩ	3.49 MΩ	1.74 MΩ	
	±12.0 V	236 MΩ	47.0 MΩ	23.5 MΩ	4.69 MΩ	2.34 MΩ	
	±15.0 V	296 MΩ	59.0 MΩ	29.5 MΩ	5.89 MΩ	2.94 MΩ	

typical performance curves

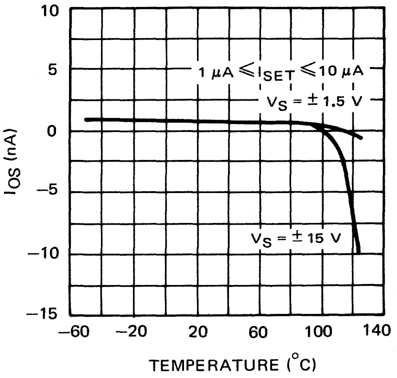
INPUT BIAS CURRENT vs I_{SET}



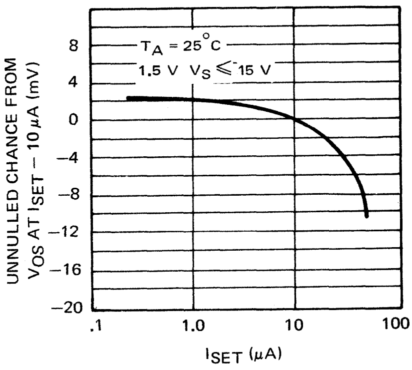
INPUT BIAS CURRENT vs TEMPERATURE



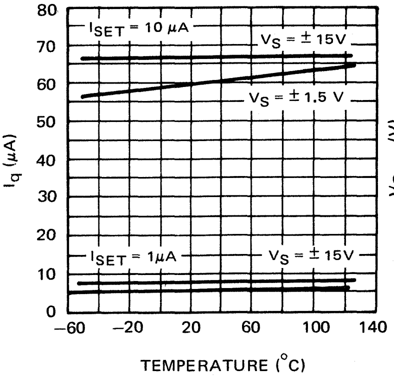
INPUT OFFSET CURRENT vs TEMPERATURE



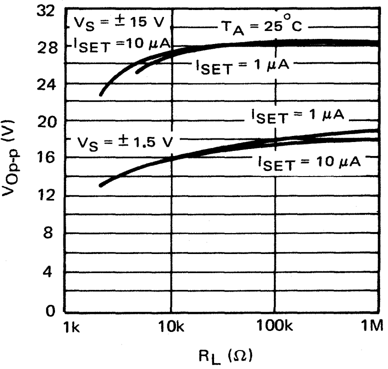
UNULLED INPUT OFFSET VOLTAGE CHANGE vs I_{SET}



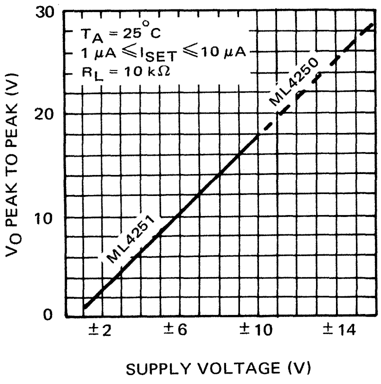
QUIESCENT CURRENT (I_q) vs TEMPERATURE



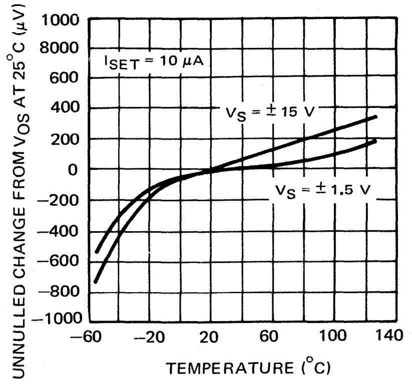
PEAK TO PEAK OUTPUT VOLTAGE SWING vs LOAD RESISTANCE



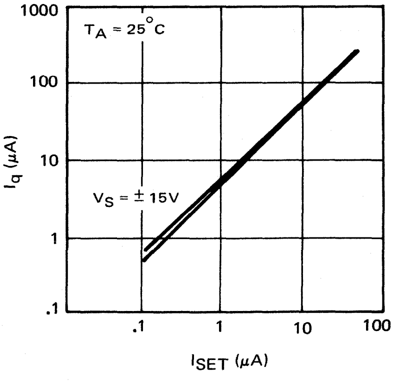
PEAK TO PEAK OUTPUT VOLTAGE SWING vs SUPPLY VOLTAGE



UNNULLED INPUT OFFSET VOLTAGE CHANGE vs TEMPERATURE

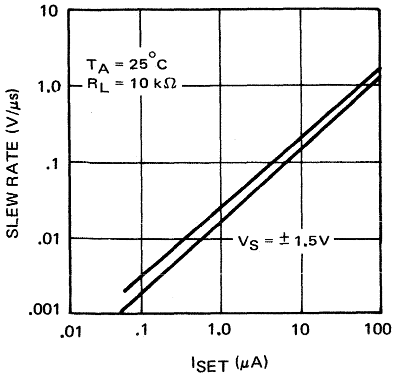


QUIESCENT CURRENT (I_q) vs I_{SET}

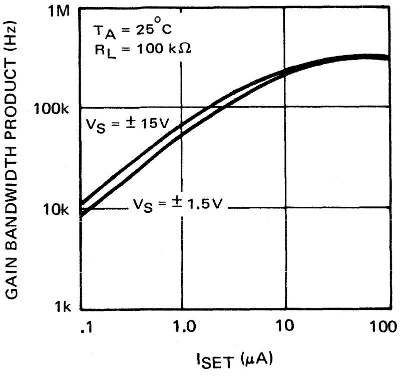


ML4250, ML4250C
PROGRAMMABLE OPERATIONAL AMPLIFIER . . ML4251, ML4251C

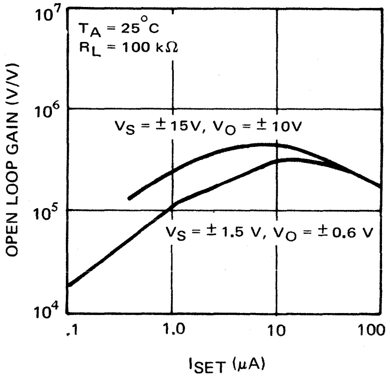
SLEW RATE vs I_{SET}



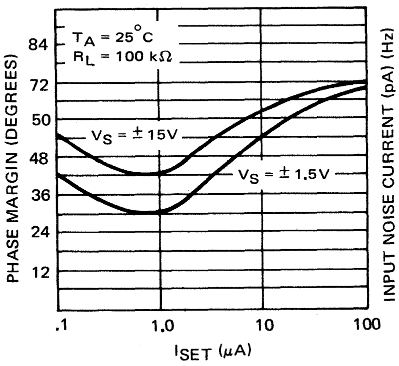
GAIN BANDWIDTH PRODUCT vs I_{SET}



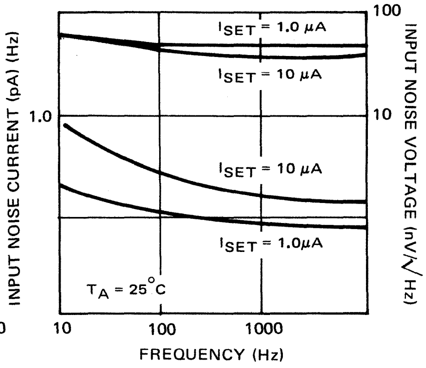
OPEN LOOP VOLTAGE GAIN vs I_{SET}



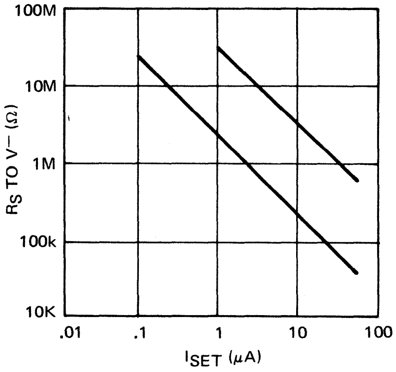
PHASE MARGIN vs I_{SET}



INPUT NOISE CURRENT (I_n) AND VOLTAGE (E_n) vs FREQUENCY



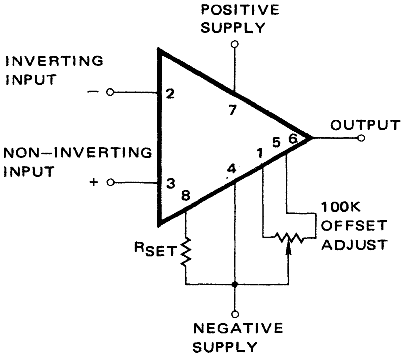
R_{SET} vs I_{SET}



quiescent current setting resistor (pin 8 to pin 4)

VS \ IQ	10µA	30µA	100µA	300µA
±1.5V	1.5MΩ	470kΩ	150kΩ	–
±3V	3.3MΩ	1.1MΩ	330kΩ	100kΩ
±6V	7.5MΩ	2.7MΩ	750kΩ	220kΩ
±9V	13MΩ	4.0MΩ	1.3MΩ	350kΩ
± 12V	18MΩ	5.6MΩ	1.5MΩ	510kΩ *
± 15V	22MΩ	7.5MΩ	2.2MΩ	620kΩ *

* ML4250, ML4250C only



NOTE: R_{SET} is required to establish the internal current. Its value may be determined from the table on the left.

NOTES

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SELECTED LINEAR I.C. CATALOGUE

Dual and Quad. Op. Amps.

7

MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STATION C, OTTAWA, CANADA, K1Y 4J1

package availability

PRODUCT CODE	PACKAGE CODE					
	T Metal Can	**D** Hermetic D.I.L. Ceramic	**P** Molded D.I.L. Plastic	**M** Hermetic D.I.L. Metal	**S** Molded D.I.L. Plastic	**F** Flat Pack
ML747	●			●		●
ML747C	●	●	●			
ML1537		●		●		
ML1437		●	●			
ML1558	●	●		●		
ML1458	●	●	●		●	
ML4136		●	●	●		
ML4136C		●	●			
ML4202C		●	●			

ML747 ML747C
DUAL FREQUENCY-COMPENSATED OPERATIONAL AMPLIFIER. . . . . .

features

- No Frequency Compensation Required
- Short-circuit Protection
- Offset Voltage Null Capability
- Large Common-mode and Differential Voltage Ranges
- Low Power Consumption
- No Latch-up

description

The ML747 family is comprised of a pair of high performance monolithic operational amplifiers constructed on a single silicon chip. The high gain and wide range of operating voltages of the ML747 provide superior performance in such mathematical functions as differentiation, integration, analog comparison, and summation where board space or weight are important. In addition it may be used for the generation of numerous linear and non-linear transfer functions. High common mode voltage range and absence of "latch-up" make the ML747 ideal for use as a voltage follower. The ML747 is short-circuit protected and requires no external components for frequency compensation. The internal 6dB/octave roll-off ensures stability in closed loop applications.

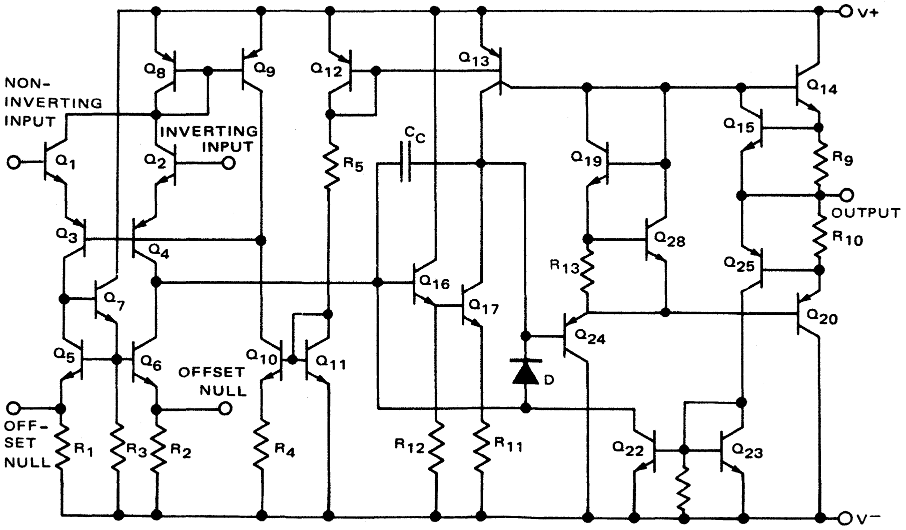
absolute maximum ratings

Supply Voltage:	
ML747	±22 V
ML747C	±18 V
Internal Power Dissipation *	800 mW
Differential Input Voltage	±30 V
Input Voltage (Note 5)	±15 V
Voltage Between Offset Null and V−	±0.5 V

Storage Temperature Range	−65°C to +150°C
Operating, Temperature Range:	
ML747	−55°C to +125°C
ML747C	0°C to + 70°C
Lead Temperature (Soldering, 60 Second)	300°C
Output Short-Circuit Duration (Note 6)	Indefinite

*NOTE 1. TO-99 rating applies for case temperature to +125°C; derate linearly at 6.5mW/°C for ambient temperatures above +95°C.
2. Dual-in-Line rating applies for case temperatures to +125°C; derate linearly at 8.6 mW/°C for ambient temperatures above +115°C.
3. Flat Package rating applies for case temperatures to +125°C; derate linearly at 5.6 mW/°C for ambient temperatures above +95°C.
4. Plastic Dual-in-Line rating applies for case temperatures to +70°C; derate linearly at 6.7mW/°C for ambient temperatures above +55°C.
5. For supply voltages less than ± 15 V, the absolute maximum input voltage is equal to the supply voltage.
6. Short-circuit may be to ground or either supply.

schematic diagram



MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STA.C, OTTAWA, CANADA K1Y 4J1

microsystems
international

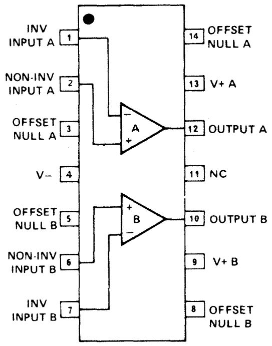
ML747 ML747C

DUAL FREQUENCY-COMPENSATED OPERATIONAL AMPLIFIER . . . . . .

connection diagrams

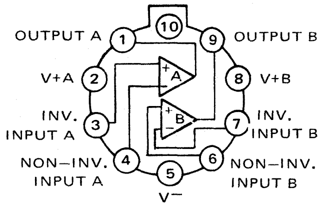
DUAL IN-LINE PACKAGE

(Top View)



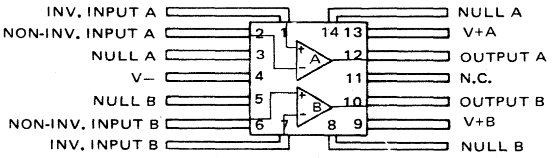
METAL CAN PACKAGE

(Top View)



FLAT PACKAGE

(Top View)



electrical characteristics (ML747, ML747C)

$V_S = \pm 15$ V, $T_A = 25°C$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS		MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leq 10$ kΩ	ML747		1.0	5.0	
			ML747C	–	1.0	6.0	mV
Input Offset Current	$\lvert I_{io} \rvert$	–		–	20	200	nA
Input Bias Current	I_b	–		–	80	500	nA
Input Resistance	R_{in}	–		0.3	2.0	–	MΩ
Input Capacitance	C_{in}	–		–	1.4	–	pF
Offset Voltage Adjustment Range	$\Delta V_{io(ADJ)}$	–		–	± 15	–	mV
Large-Signal Voltage Gain	A_{VOL}	$R_L \geq 2$ kΩ, $V_{out} = \pm 10$ V		50,000	200,000	–	–
Output Resistance	R_{out}	–		–	75	–	Ω
Output Short-Circuit Current	I_{DS}	–		–	25	–	mA
Supply Current	I_S	–		–	1.7	2.8	mA
Power Consumption	P_D	–		–	50	85	mW
Transient Response (unity gain)		$V_{in} = 20$ mV, $R_L = 2$ kΩ, $C_L \leq 100$ pF					
Risetime	t_R			–	0.3	–	μS
Overshoot	t_o			–	5.0	–	%
Slew Rate	S_R	$R_L \geq 2$ kΩ		–	0.5	–	V/μS
Channel Separation	–	–		–	120	–	dB

ML747 ML747C
DUAL FREQUENCY-COMPENSATED OPERATIONAL AMPLIFIER ......

electrical characteristics (ML747)

$V_S = \pm 15V, -55°C \leqslant T_A \leqslant +125°C$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 10\ k\Omega$	–	1.0	6.0	mV
Input Offset Current	$\lvert I_{io} \rvert$	$T_A = +125°C$	–	7.0	200	nA
		$T_A = -55°C$	–	85	500	nA
Input Bias Current	I_b	$T_A = +125°C$	–	0.03	0.5	μA
		$T_A = -55°C$	–	0.3	1.5	μA
Input Voltage Range	V_{iCM}	–	±12	±13	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leqslant 10\ k\Omega$	70	90	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leqslant 10\ k\Omega$	–	30	150	μV/V
Large-Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2\ k\Omega, V_{out} = \pm 10\ V$	25,000	–	–	–
Output Voltage Swing	V_{out}	$R_L \geqslant 10\ k\Omega$	± 12	± 14	–	V
		$R_L \geqslant 2\ k\Omega$	± 10	± 13	–	V
Supply Current	I_S	$T_A = +125°C$	–	1.5	2.5	mA
		$T_A = -55°C$	–	2.0	3.3	mA
Power Consumption	P_i	$T_A = +125°C$	–	45	75	mW
		$T_A = -55°C$	–	60	100	mW

electrical characteristics (ML747C)

$V_S = \pm 15V, 0°C \leqslant T_A \leqslant +70°C$ unless otherwise specified

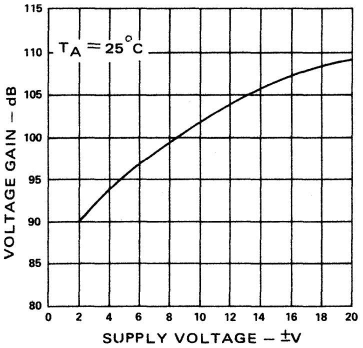
PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 10\ k\Omega$	–	1.0	7.5	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	7.0	300	nA
Input Bias Current	I_b	–	–	0.03	0.8	μA
Input Voltage Range	V_{iCM}	–	±12	±13	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leqslant 10\ k\Omega$	70	90	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leqslant 10\ k\Omega$	–	30	150	μV/V
Large-Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2\ k\Omega, V_{out} = \pm 10\ V$	15,000	–	–	–
Output Voltage Swing	V_{out}	$R_L \geqslant 10\ k\Omega$	± 12	± 14	–	V
		$R_L \geqslant 2\ k\Omega$	± 10	± 13	–	V
Supply Current	I_S	–	–	2.0	3.3	mA
Power Consumption	P_i	–	–	60	100	mW

ML747 ML747C

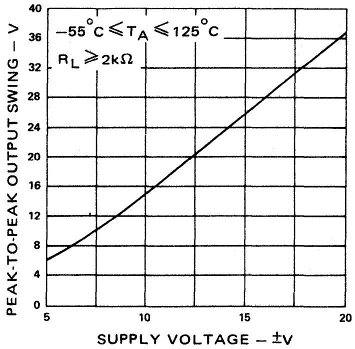
DUAL FREQUENCY-COMPENSATED OPERATIONAL AMPLIFIER . . . . . .

typical performance curves (ML747)

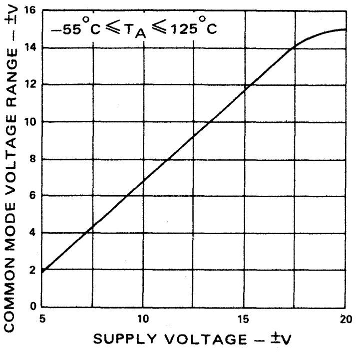
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF SUPPLY VOLTAGE



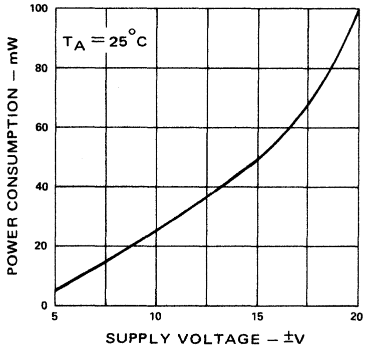
OUTPUT VOLTAGE SWING AS A FUNCTION OF SUPPLY VOLTAGE



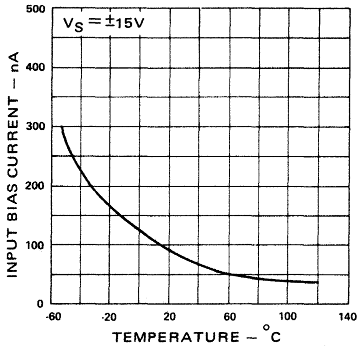
INPUT COMMON MODE VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE



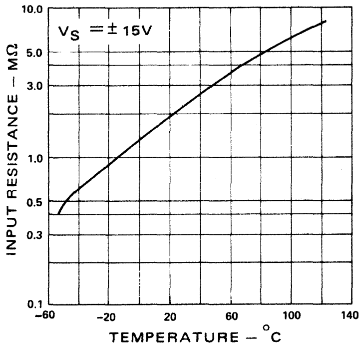
POWER CONSUMPTION AS A FUNCTION OF SUPPLY VOLTAGE



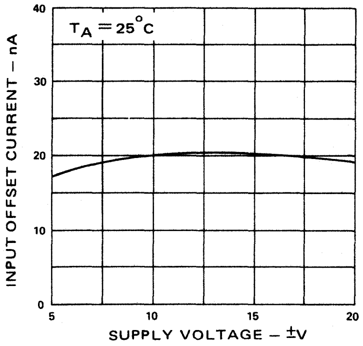
INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



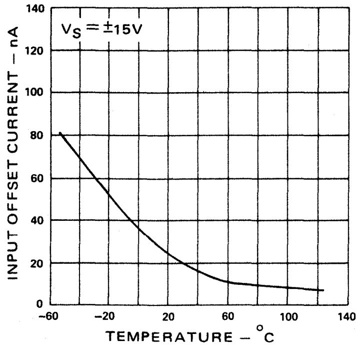
INPUT RESISTANCE AS A FUNCTION OF AMBIENT TEMPERATURE



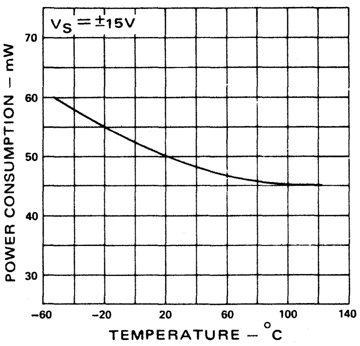
INPUT OFFSET CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



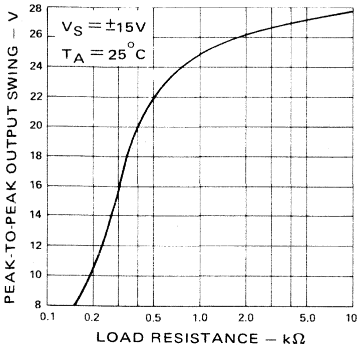
INPUT OFFSET CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



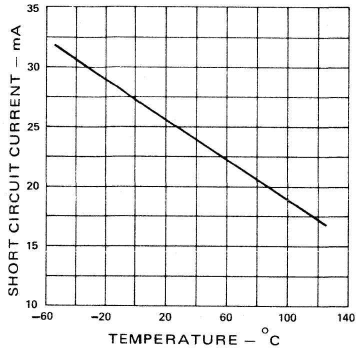
POWER CONSUMPTION AS A FUNCTION OF AMBIENT TEMPERATURE



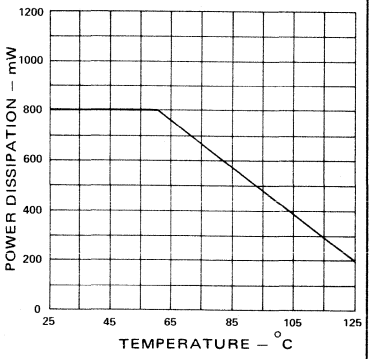
OUTPUT VOLTAGE SWING AS A FUNCTION OF LOAD RESISTANCE



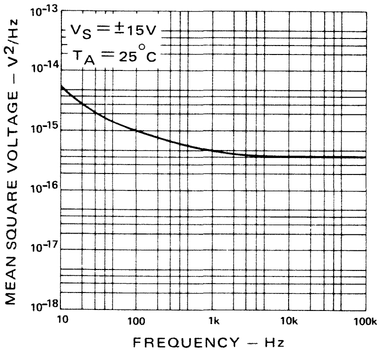
OUTPUT SHORT-CIRCUIT CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



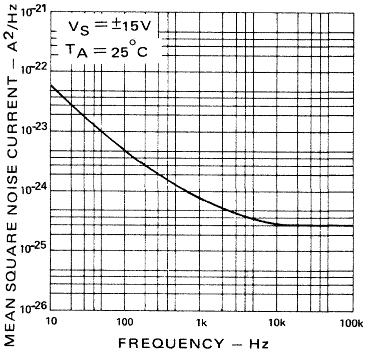
ABSOLUTE MAXIMUM POWER DISSIPATION AS A FUNCTION OF AMBIENT TEMPERATURE



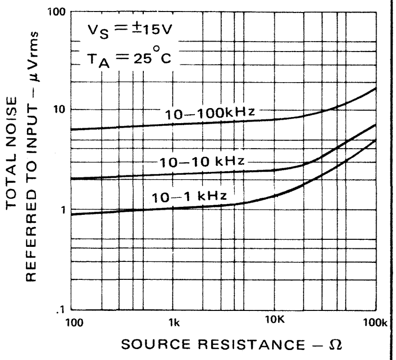
INPUT NOISE VOLTAGE AS A FUNCTION OF FREQUENCY



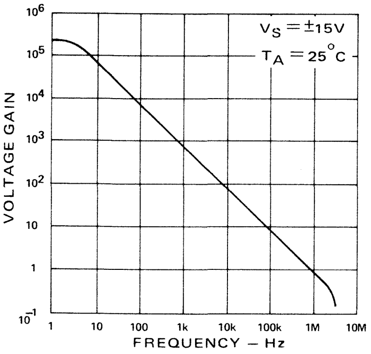
INPUT NOISE CURRENT AS A FUNCTION OF FREQUENCY



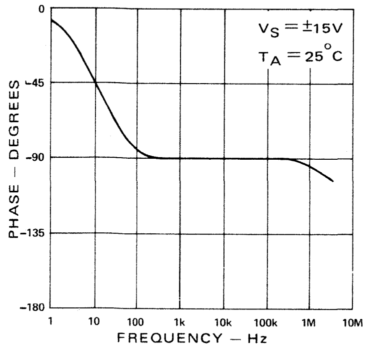
BROADBAND NOISE FOR VARIOUS BANDWIDTHS



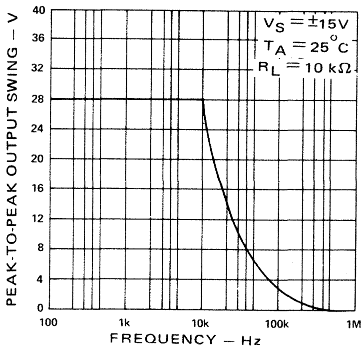
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



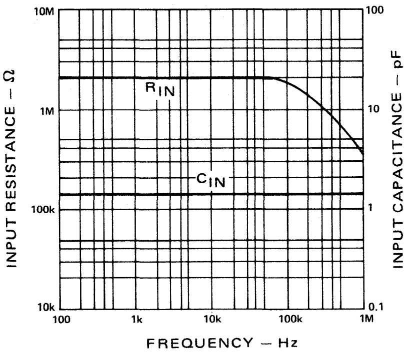
OPEN LOOP PHASE RESPONSE AS A FUNCTION OF FREQUENCY



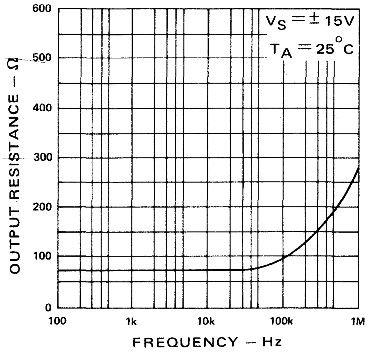
OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY



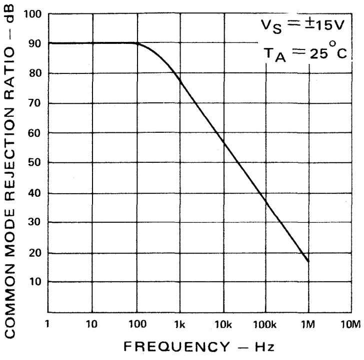
INPUT RESISTANCE AND INPUT CAPACITANCE AS A FUNCTION OF FREQUENCY



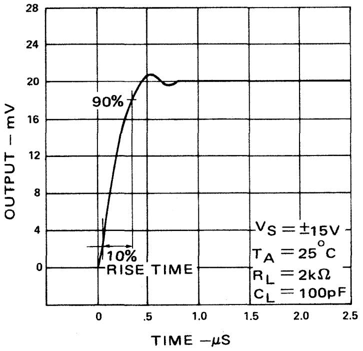
OUTPUT RESISTANCE AS A FUNCTION OF FREQUENCY



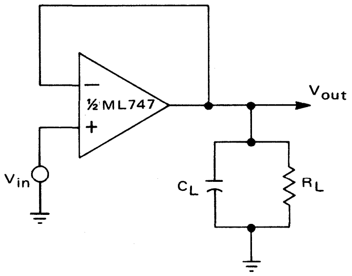
COMMON MODE REJECTION RATIO AS A FUNCTION OF FREQUENCY



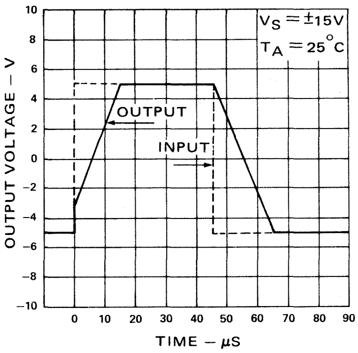
TRANSIENT RESPONSE



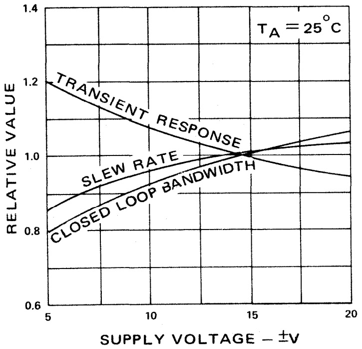
TRANSIENT RESPONSE TEST CIRCUIT



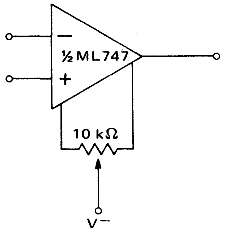
VOLTAGE FOLLOWER LARGE-SIGNAL PULSE RESPONSE



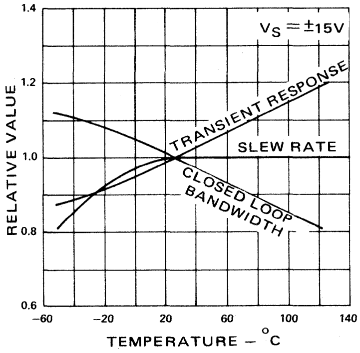
FREQUENCY CHARACTERISTICS AS A FUNCTION OF SUPPLY VOLTAGE



VOLTAGE OFFSET NULL CIRCUIT



FREQUENCY CHARACTERISTICS AS A FUNCTION OF AMBIENT TEMPERATURE



DUAL OPERATIONAL AMPLIFIER ML1537, ML1437

features

- **High-Performance Open Loop Gain Characteristics A_{VOL} = 45,000 typical**
- **Low Temperature Drift – ±3 μV/°C**
- **Large Output Voltage Swing – ±14 V typical @ ±15 V Supply**
- **Low Output Impedance – Z_{out} = 30 ohms typical**

description

The ML1537 family is comprised of a pair of operational amplifiers. Electrically equivalent to a dual ML709 or ML709C, the devices are designed for use as functions of the external feedback components.

absolute maximum ratings

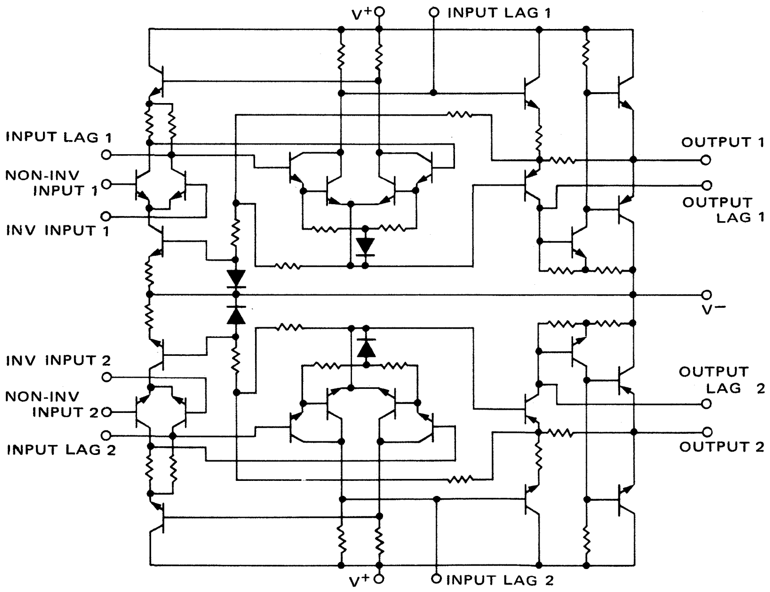
Power Supply Voltage (V+ or V−)	± 18 Vdc	Power Dissipation (Note 1)	750mW
Differential Input Signal	± 5.0 V	Operating Temperature Range:	
Common-Mode Input Swing	± V+	ML1537	−55°C to + 125°C
Output Short-Circuit Duration	5.0 sec	ML1437	0°C to 75°C
		Storage Temperature Range	−65°C to + 150°C

NOTES:

(1) Dual-in-Line rating applies for case temperatures to +125°C; derate linearly at 8.6mW/°C for ambient temperatures above +115°C.

(2) Plastic Dual-in-Line rating applies for case temperatures to +70°C; derate linearly at 6.7mW/°C for ambient temperatures above +55°C.

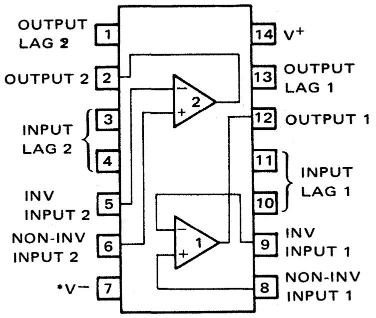
schematic diagram



connection diagram

DUAL-IN-LINE PACKAGE

(Top View)



* Pin 7 is connected to substrate and is at V− potential.

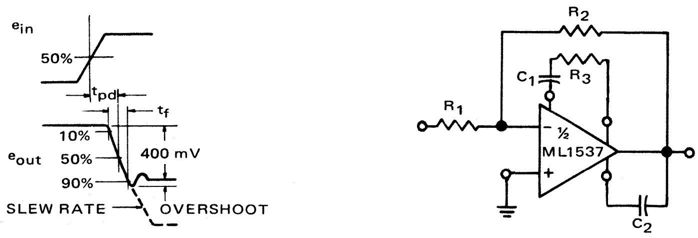
DUAL OPERATIONAL AMPLIFIER ML1537, ML1437

electrical characteristics (ML1537)

$V^+ = +15$ Vdc, $V^- = -15$ Vdc, $T_A = 25°C$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Open Loop Voltage Gain	A_{VOL}	$R_L = 5.0\ k\Omega$, $V_{out} = \pm 10V$, $T_A = 0°C$, $-55°C$ to $+125°C$	25,000	45,000	70,000	–
Output Impedance	Z_{out}	f = 20 Hz	–	30	–	Ω
Input Impedance	Z_{in}	f = 20 Hz	150	400	–	kΩ
Output Voltage Swing	V_{out}	$R_L = 10\ k\Omega$	± 12	± 14	–	V_{peak}
		$R_L = 2.0\ k\Omega$	± 10	± 13	–	
Input Common Mode Voltage Swing	V_{iCM}	–	± 8.0	± 10	–	V_{peak}
Common Mode Rejection Ratio	CMRR	–	70	100	–	dB
Input Bias Current	I_b	$T_A = +25°C$	–	0.2	0.5	μA
		$T_A = -55°C$	–	0.5	1.5	
Input Offset Current	$\|I_{io}\|$	$T_A = +25°C$	–	0.05	0.2	μA
		$T_A = -55°C$	–	–	0.5	
		$T_A = +125°C$	–	–	0.2	
Input Offset Voltage	$\|V_{io}\|$	$T_A = +25°C$	–	1.0	5.0	mV
		$T_A = -55°C$ to $+125°C$	–	–	6.0	
Step Response (See Fig. 1)						
Fall Time	t_f	Gain = 100, 5% overshoot,	–	0.8	–	μs
Propagation Delay Time	t_{pd}	$R_1 = 1\ k\Omega$, $R_2 = 100\ k\Omega$,	–	0.38	–	μs
Slew Rate	dV_{out}/dt	$R_3 = 1.5\ k\Omega$, $C_1 = 100pF$, $C_2 = 3.0pF$	–	12	–	V/μs
Fall Time	t_f	Gain = 10, 10% overshoot	–	0.6	–	μs
Propagation Delay Time	t_{pd}	$R_1 = 1\ k\Omega$, $R_2 = 10\ k\Omega$,	–	0.34	–	μs
Slew Rate	dV_{out}/dt	$R_3 = 1.5\ k\Omega$, $C_1 = 500pF$, $C_2 = 20pF$	–	1.7	–	V/μs
Fall Time	t_f	Gain = 1, 5% overshoot	–	2.2	–	μs
Propagation Delay Time	t_{pd}	$R_1 = 10\ k\Omega$, $R_2 = 10\ k\Omega$,	–	1.3	–	μs
Slew Rate	dV_{out}/dt	$R_3 = 1.5\ k\Omega$, $C_1 = 5000pF$, $C_2 = 200pF$	–	0.25	–	V/μs
Average Temperature Coefficient of Input Offset Voltage	$\|TC_{Vio}\|$	$R_S = 50\ \Omega$, $T_A = -55°C$ to $+125°C$	–	3.0	–	μV/°C
		$R_S \leqslant 10\ k\Omega$, $T_A = -55°C$ to $+125°C$	–	6.0	–	
Average Temperature Coefficient of Input Offset Current	$\|TC_{Iio}\|$	$T_A = -55°C$ to $+25°C$	–	0.7	–	nA/°C
		$T_A = +25°C$ to $+125°C$	–	0.7	–	
DC Power Dissipation (Total)	P_D	Power Supply = ± 15V, $V_{out} = 0$	–	160	225	mW
Positive Supply Sensitivity	S^+	V^- Constant	–	10	150	μV/V
Negative Supply Sensitivity	S^-	V^+ Constant	–	10	150	μV/V

FIGURE 1. STEP RESPONSE



electrical characteristics (ML1437)

$V^+ = +15$ Vdc, $V^- = -15$ Vdc, $T_A = 25°C$ unless otherwise specified

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Open Loop Voltage Gain	A_{VOL}	$R_L = 5.0\ k\Omega$, $V_{out} = \pm 10V$, $T_A = 0°C$ to $+75°C$	15,000	45,000	–	–
Output Impedance	Z_{out}	f = 20 Hz	–	30	–	Ω
Input Impedance	Z_{in}	f = 20 Hz	50	150	–	kΩ
Output Voltage Swing	V_{out}	$R_L = 10\ k\Omega$	± 12	± 14	–	V_{peak}
Input Common Mode Voltage Swing	V_{iCM}	–	± 8.0	± 10	–	V_{peak}
Common Mode Rejection Ratio	CMRR	–	65	100	–	dB
Input Bias Current	I_b	$T_A = +25°C$	–	0.4	1.5	μA
		$T_A = 0°C$	–	–	2.0	
Input Offset Current	$\lvert I_{io} \rvert$	$T_A = +25°C$	–	0.05	0.5	μA
		$T_A = 0°C$	–	–	0.75	
		$T_A = +75°C$	–	–	0.75	
Input Offset Voltage	$\lvert V_{io} \rvert$	$T_A = +25°C$	–	1.0	7.5	mV
		$T_A = 0°C, +75°C$	–	–	10	
Step Response (See Fig. 1) Fall Time	t_f	Gain = 100, 5% overshoot,	–	0.8	–	μs
Propagation Delay Time	t_{pd}	$R_1 = 1\ k\Omega$, $R_2 = 100\ k\Omega$,	–	0.38	–	μs
Slew Rate	dV_{out}/dt	$R_3 = 1.5\ k\Omega$, $C_1 = 100pF$, $C_2 = 3.0pF$	–	12	–	V/μs
Fall Time	t_f	Gain = 10, 10% overshoot	–	0.6	–	μs
Propagation Delay Time	t_{pd}	$R_1 = 1\ k\Omega$, $R_2 = 10\ k\Omega$,	–	0.34	–	μs
Slew Rate	dV_{out}/dt	$R_3 = 1.5\ k\Omega$, $C_1 = 500pF$, $C_2 = 20pF$	–	1.7	–	V/μs
Fall Time	t_f	Gain = 1, 5% overshoot	–	2.2	–	μs
Propagation Delay Time	t_{pd}	$R_1 = 10\ k\Omega$, $R_2 = 10\ k\Omega$,	–	1.3	–	μs
Slew Rate	dV_{out}/dt	$R_3 = 1.5\ k\Omega$, $C_1 = 5000pF$, $C_2 = 200pF$	–	0.25	–	V/μs
Average Temperature Coefficient of Input Offset Voltage	$\lvert TC_{V_{io}} \rvert$	$R_S = 50\ \Omega$, $T_A = 0°C$ to $+75°C$	–	1.5	–	μV/°C
		$R_S \leqslant 10\ k\Omega$, $T_A = 0°C$ to $+75°C$	–	3.0	–	
Average Temperature Coefficient of Input Offset Current	$\lvert TC_{I_{io}} \rvert$	$T_A = 0°$ to $+25°C$	–	0.7	–	nA/°C
		$T_A = +25°C$ to $+75°C$	–	0.7	–	
DC Power Dissipation (Total)	P_D	Power Supply = ± 15V, $V_{out} = 0$	–	150	225	mW
Positive Supply Sensitivity	S^+	V^- Constant	–	10	200	μV/V
Negative Supply Sensitivity	S^-	V^+ Constant	–	10	200	μV/V

DUAL OPERATIONAL AMPLIFIER ML1537, ML1437

matching characteristics (ML1537, ML1437)

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Open Loop Voltage Gain	$A_{VOL1}-A_{VOL2}$	–	–	± 1.0	–	dB
Input Bias Current	$I_{b1}-I_{b2}$	–	–	± 0.15	–	μA
Input Offset Current	$\lvert I_{io1}\rvert-\lvert I_{io2}\rvert$	–	–	± 0.02	–	μA
Average Temperature Coefficient	$\lvert TC_{Iio1}\rvert-\lvert TC_{Iio2}\rvert$	–	–	± 0.2	–	nA/°C
Input Offset Voltage	$\lvert V_{io1}\rvert-\lvert V_{io2}\rvert$	–	–	± 0.2	–	mV
Average Temperature Coefficient	$\lvert TC_{Vio1}\rvert-\lvert TC_{Vio2}\rvert$	–	–	± 0.5	–	μV/°C
Channel Separation	$\frac{e_{out1}}{e_{out2}}$	f = 10 kHz	–	90	–	dB

typical performance curves (ML1537)

FIGURE 2. TEST CIRCUIT

$V^+ = +15$ Vdc, $V^- = -15$ Vdc, $T_A = 25°C$

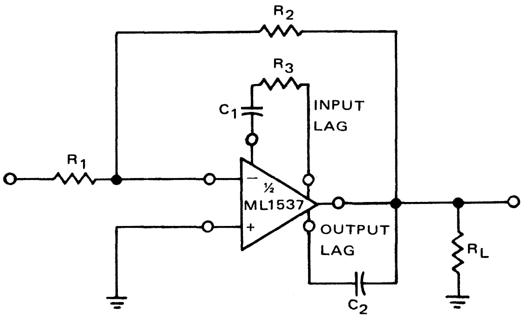


FIGURE NO.	CURVE NO.	VOLTAGE GAIN	TEST CONDITIONS					OUTPUT NOISE (mV rms)
			$R_1(\Omega)$	$R_2(\Omega)$	$R_3(\Omega)$	C_1(pF)	C_2(pF)	
3	1	1	10 k	10 k	1.5 k	5.0 k	200	0.10
	2	10	10 k	100 k	1.5 k	500	20	0.14
	3	100	10 k	1.0 M	1.5 k	100	3.0	0.7
	4	1000	1.0 k	1.0 M	0	10	3.0	5.2
4	1	1	10 k	10 k	1.5 k	5.0 k	200	0.10
	2	10	10 k	100 k	1.5 k	500	20	0.14
	3	100	10 k	1.0 M	1.5 k	100	3.0	0.7
	4	1000	1.0 k	1.0 M	0	10	3.0	5.2
5	1	A_{VOL}	0	∞	1.5 k	5.0 k	200	5.5
	2	A_{VOL}	0	∞	1.5 k	500	20	10.5
	3	A_{VOL}	0	∞	1.5 k	100	3.0	21.0
	4	A_{VOL}	0	∞	0	10	3.0	39.0
	5	A_{VOL}	0	∞	∞	0	3.0	——

DUAL OPERATIONAL AMPLIFIER ML1537, ML1437

FIGURE 3. LARGE SIGNAL SWING versus FREQUENCY

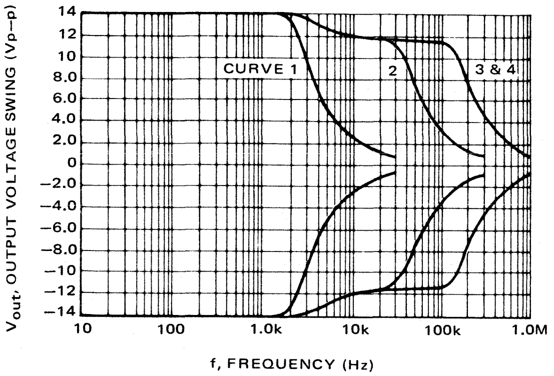


FIGURE 4. VOLTAGE GAIN versus FREQUENCY

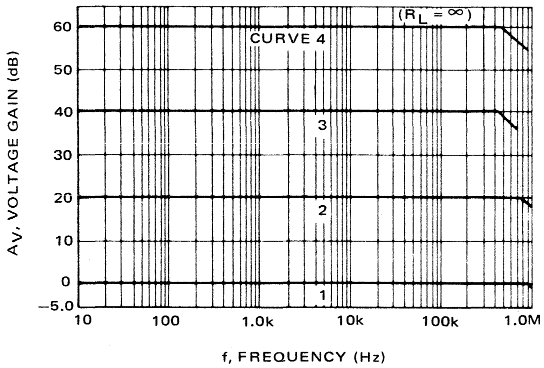


FIGURE 5. OPEN LOOP VOLTAGE GAIN versus FREQUENCY

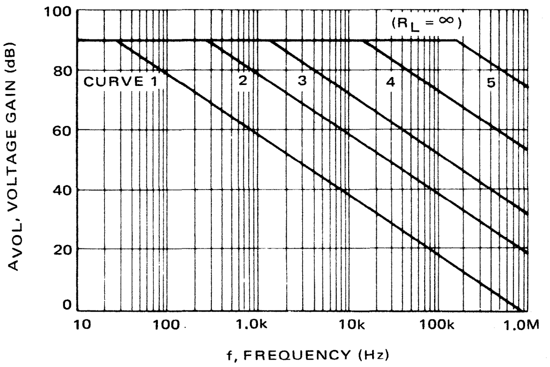


FIGURE 6. TOTAL POWER DISSIPATION versus POWER SUPPLY VOLTAGE

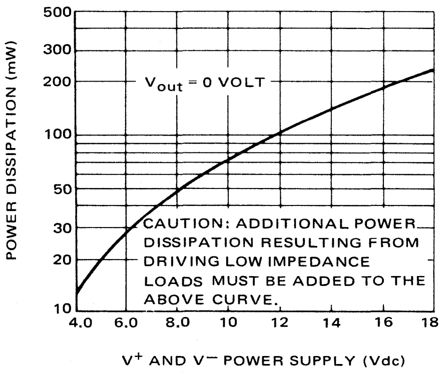


FIGURE 7. VOLTAGE GAIN versus POWER SUPPLY VOLTAGE

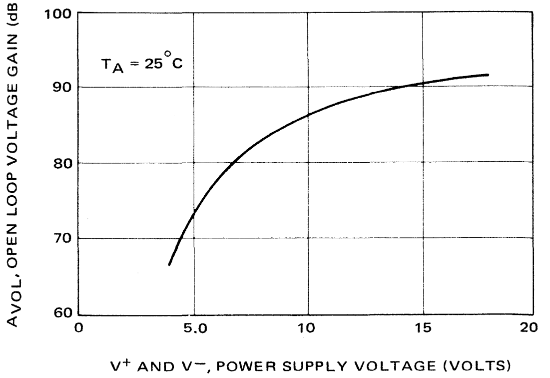


FIGURE 8. COMMON MODE INPUT SWING versus POWER SUPPLY VOLTAGE

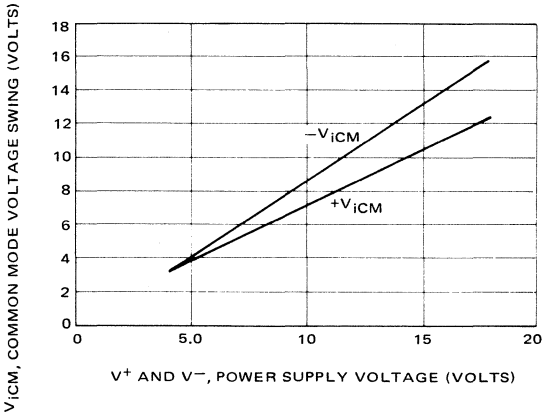


FIGURE 9. INPUT OFFSET VOLTAGE versus TEMPERATURE

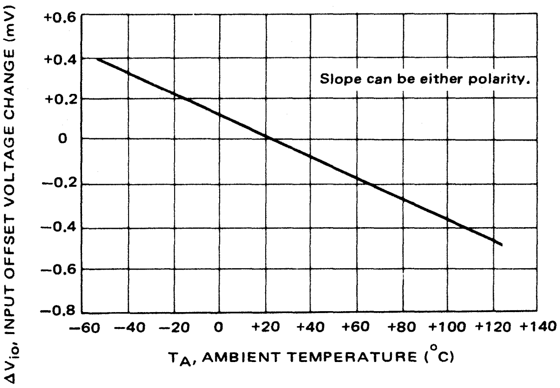


FIGURE 10. OUTPUT NOISE VOLTAGE versus SOURCE RESISTANCE

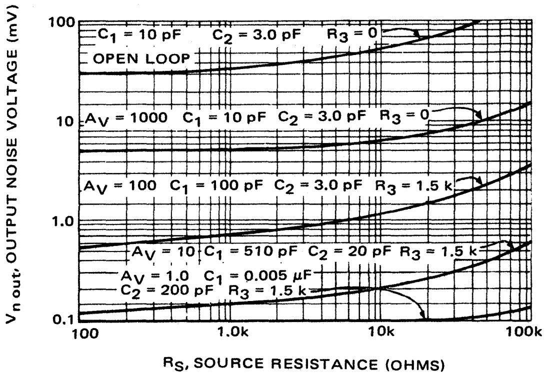
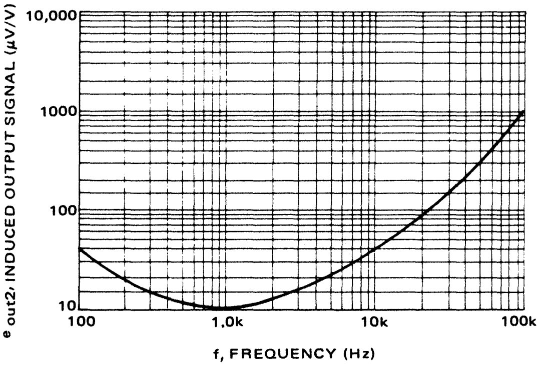
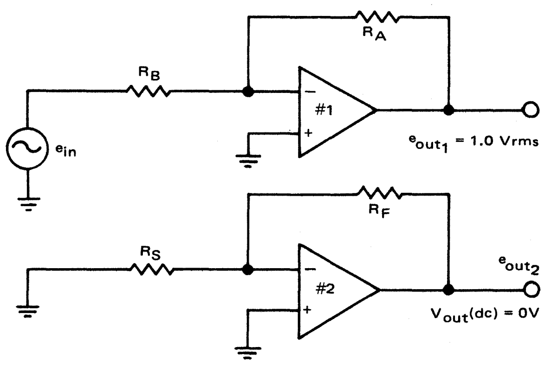


FIGURE 11. INDUCED OUTPUT SIGNAL (CHANNEL SEPARATION) versus FREQUENCY





Induced output signal (μV of induced output signal in amplifier #2 per volt of output signal at amplifier #1).

ML1558, ML1458
DUAL FREQUENCY-COMPENSATED OPERATIONAL AMPLIFIERS . . . . .

features

- Short-circuit Protection
- No Latch-up
- Low Power Consumption
- No Frequency Compensation Required
- Wide Common-mode and Differential Voltage Ranges
- Single External V^+ and V^- Connections
- ML1458 Soon Available in 8 and 14 Lead DIL Plastic Packages

description

The ML1558 and ML1458 are each comprised of a pair of high performance monolithic operational amplifiers constructed on a single silicon chip. The high gain and wide range of operating voltages of these devices provide superior performance in such mathematical functions as differentiation, integration, analog comparison, and summation where board space or weight are important. In addition they may be used for the generation of numerous linear and non-linear transfer functions. Wide common-mode voltage range and absence of "latch-up" make them ideal for use as voltage followers. The ML1558 and ML1458 are short-circuit protected and require no external components for frequency compensation. The internal 6dB/octave roll-off ensures stability in closed loop applications. For single amplifier performance, see the ML741 and ML741C data sheets, respectively.

absolute maximum ratings

Supply Voltage	ML1558	±22 V
	ML1458	±18 V
Internal Power Dissipation (Note 1)		680 mW
Differential Input Voltage		±30 V
Input Voltage (Note 2)		±15 V

Storage Temperature Range		−65°C to +150°C
Operating Temperature Range	ML1558	−55°C to +125°C
	ML1458	0°C to +75°C
Lead Temperature (Soldering, 60 sec)		300°C
Output Short-Circuit Duration (Note 3)		Indefinite

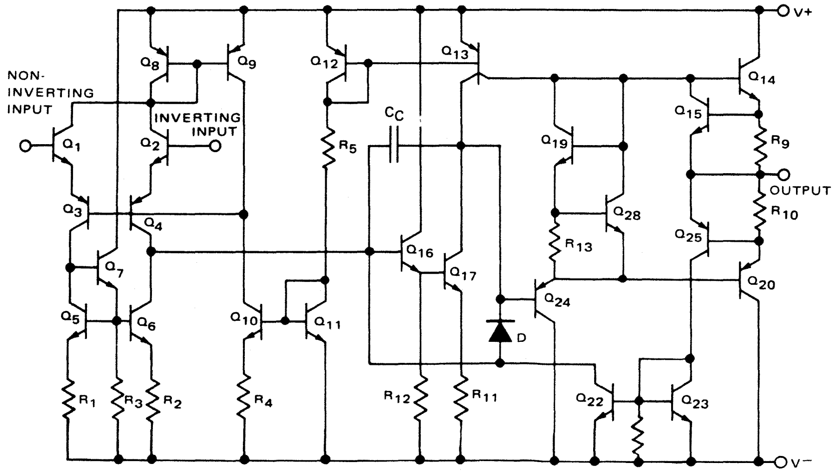
NOTES:

(1) Rating applies for case temperatures up to respective maximum operating temperature. Derate linearly at 4.6 mW/°C for ambient temperatures above +25°C.

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

(3) Short circuit may be to ground or either supply. Rating applies for case temperatures up to respective maximum operating temperature or +25°C ambient temperature for each side.

schematic diagram (each amplifier)



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microsystems
international

ML1558, ML1458
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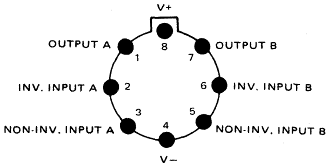
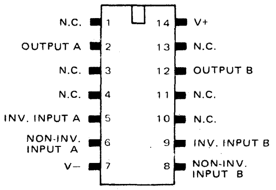
connection diagrams (Top View)

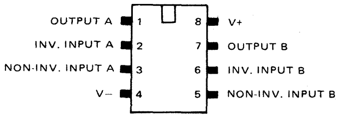
METAL CAN PACKAGE



DUAL-IN-LINE PACKAGE



DUAL-IN-LINE PACKAGE



electrical characteristics (each amplifier) (V_S = ± 15V, T_A = 25°C unless otherwise specified)

PARAMETERS	SYMBOLS	CONDITIONS	ML1558			ML1458			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Input Offset Voltage	$\lvert V_{io} \rvert$	$R_S \leqslant 10$ kΩ	–	1.0	5.0	–	1.0	6.0	mV
Input Offset Current	$\lvert I_{io} \rvert$	–	–	20	200	–	20	200	nA
Input Bias Current	I_b	–	–	80	500	–	80	500	nA
Input Resistance	R_{in}	–	0.3	2.0	–	0.3	2.0	–	MΩ
Input Capacitance	C_{in}	–	–	1.4	–	–	1.4	–	pF
Common Mode Input Impedance	Z_{iCM}	f = 20 Hz	–	200	–	–	200	–	MΩ
Large-Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2$ kΩ, $V_{out} = \pm 10$V	50,000	200,000	–	20,000	200,000	–	V/V
Output Resistance	R_{out}	–	–	75	–	–	75	–	Ω
Output Short-Circuit Current	I_{SC}	–	–	25	–	–	25	–	mA
Supply Current (Total)	I_S	–	–	2.3	5.0	–	2.3	5.6	mA
Power Consumption (Total)	P_i	–	–	70	150	–	70	170	mW
Transient Response (Unity gain)		V_{in} = 20 mV, R_L = 2 kΩ, $C_L \leqslant 100$ pF							
Risetime	t_r		–	0.3	–	–	0.3	–	μS
Overshoot	OS		–	5.0	–	–	5.0	–	%
Slew Rate	dV_{out}/dt	$R_L \geqslant 2$ kΩ	–	0.8	–	–	0.8	–	V/μS
Channel Separation	–	–	–	120	–	–	120	–	dB
Equivalent Input Noise Voltage	e_n	A_V = 100, R_S = 10 kΩ, f = 1.0 kHz, BW = 1.0 Hz	–	45	–	–	45	–	nV/$\sqrt{\text{Hz}}$
Power Bandwidth	P_{BW}	A_V = 1, R_L = 2.0 kΩ THD $\leqslant$ 5%, V_{out} = 20 $V_{p\text{-}p}$	–	14	–	–	14	–	kHz,
Unity Gain Crossover Frequency	–	Open Loop	–	1.1	–	–	1.1	–	MHz
Phase Margin	–	Open Loop, Unity Gain	–	65	–	–	65	–	deg.
Gain Margin	–	–	–	11	–	–	11	–	dB

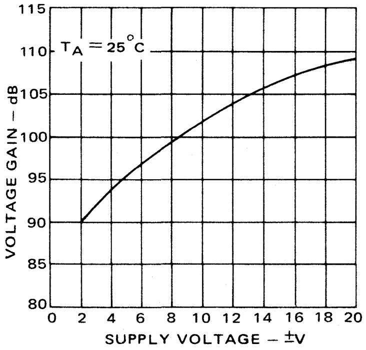
ML1558, ML1458
DUAL FREQUENCY-COMPENSATED OPERATIONAL AMPLIFIERS . . . . .

electrical characteristics (each amplifier) (V_S = ± 15V, −55°C ≤ T_A ≤ +125°C for ML1558, 0°C ≤ T_A ≤ +75°C for ML1458, unless otherwise specified)

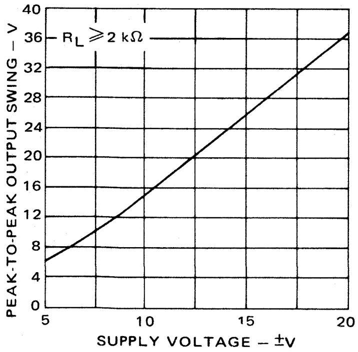
PARAMETERS	SYMBOLS	CONDITIONS	ML1558 MIN.	ML1558 TYP.	ML1558 MAX.	ML1458 MIN.	ML1458 TYP.	ML1458 MAX.	UNITS
Input Offset Voltage	$\|V_{io}\|$	$R_S \leq 10\ k\Omega$	–	1.0	6.0	–	1.0	7.5	mV
Input Offset Current	$\|I_{io}\|$	$T_A = T_{A_{max}}$	–	7.0	200	–	7.0	300	nA
		$T_A = T_{A_{min}}$	–	85	500	–	7.0	300	nA
Input Bias Current	I_b	$T_A = T_{A_{max}}$	–	0.03	0.5	–	0.03	0.8	μA
		$T_A = T_{A_{min}}$	–	0.3	1.5	–	0.03	0.8	μA
Input Voltage Range	V_{iCM}	–	±12	±13	–	±12	±13	–	V
Common Mode Rejection Ratio	CMRR	$R_S \leq 10\ k\Omega$	70	90	–	70	90	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_S \leq 10\ k\Omega$	–	30	150	–	30	150	μV/V
Large-Signal Voltage Gain	A_{VOL}	$R_L \geq 2\ k\Omega$, $V_{out} = \pm 10\ V$	25,000	–	–	15,000	–	–	V/V
Output Voltage Swing	V_{out}	$R_L \geq 10\ k\Omega$	±12	±14	–	±12	±14	–	V
		$R_L \geq 2\ k\Omega$	±10	±13	–	±10	±13	–	V

typical performance curves (each amplifier) (over respective operating temperature range unless otherwise specified)

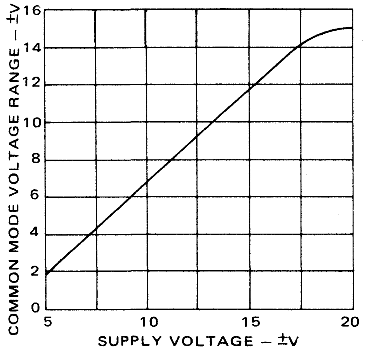
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF SUPPLY VOLTAGE



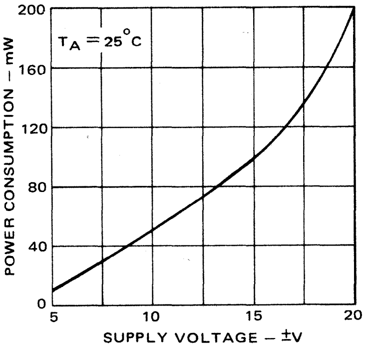
OUTPUT VOLTAGE SWING AS A FUNCTION OF SUPPLY VOLTAGE



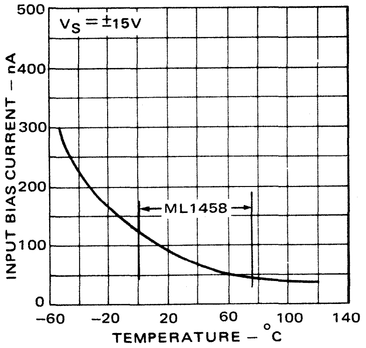
INPUT COMMON MODE VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE



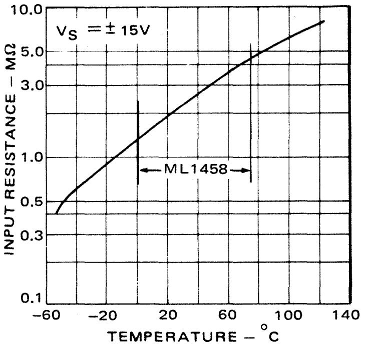
POWER CONSUMPTION AS A FUNCTION OF SUPPLY VOLTAGE



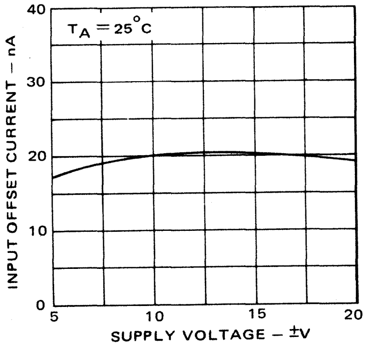
INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



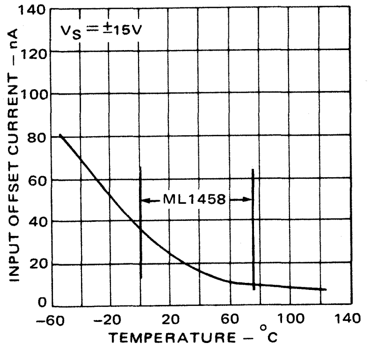
INPUT RESISTANCE AS A FUNCTION OF AMBIENT TEMPERATURE



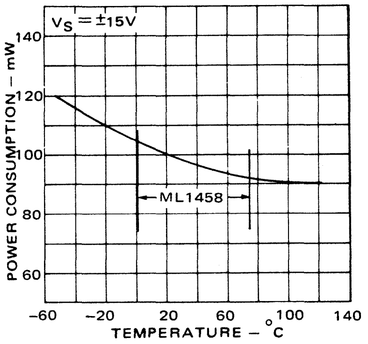
INPUT OFFSET CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



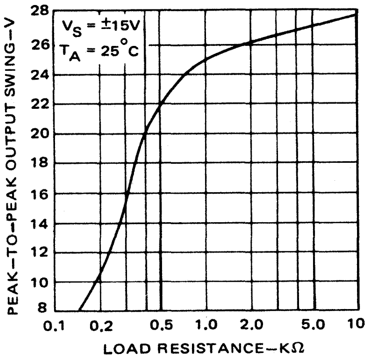
INPUT OFFSET CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



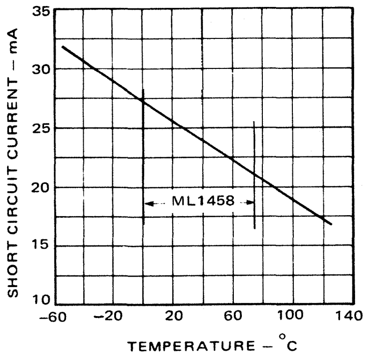
POWER CONSUMPTION AS A FUNCTION OF AMBIENT TEMPERATURE



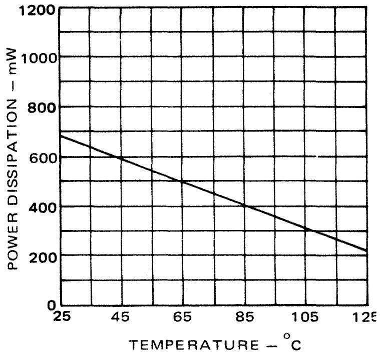
OUTPUT VOLTAGE SWING AS A FUNCTION OF LOAD RESISTANCE



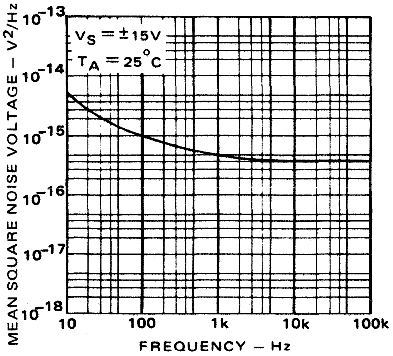
OUTPUT SHORT-CIRCUIT CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



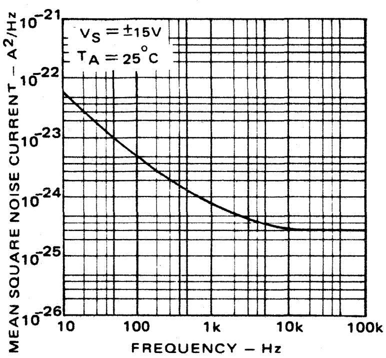
ABSOLUTE MAXIMUM POWER DISSIPATION AS A FUNCTION OF AMBIENT TEMPERATURE



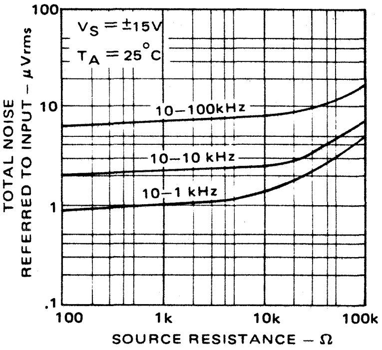
INPUT NOISE VOLTAGE AS A FUNCTION OF FREQUENCY



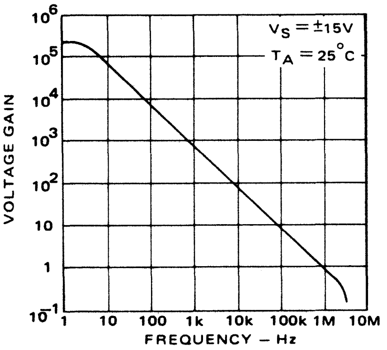
INPUT NOISE CURRENT AS A FUNCTION OF FREQUENCY



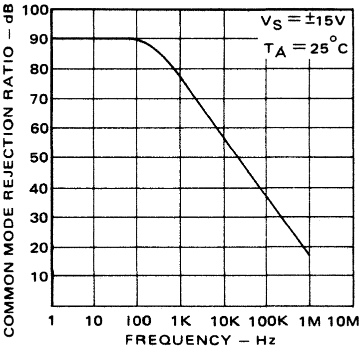
BROADBAND NOISE FOR VARIOUS BANDWIDTHS



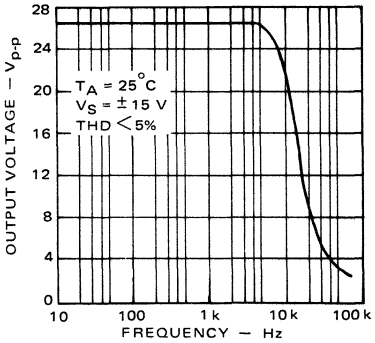
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



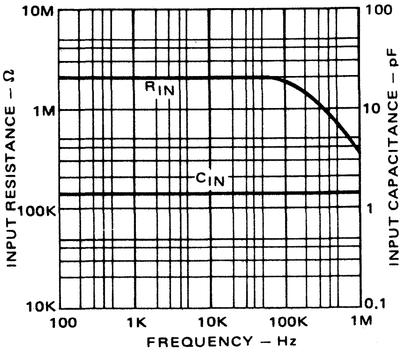
COMMON MODE REJECTION RATIO AS A FUNCTION OF FREQUENCY



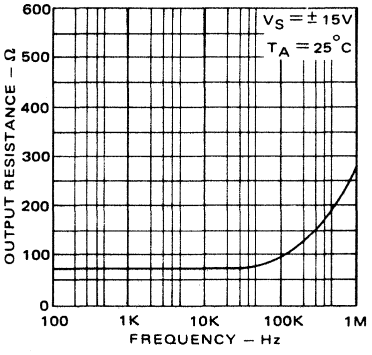
OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY (VOLTAGE FOLLOWER)



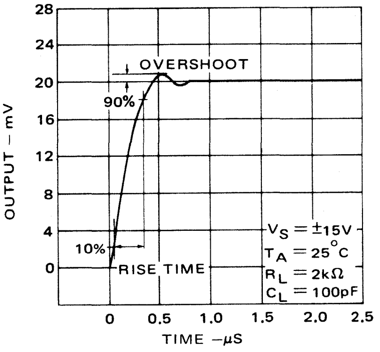
INPUT RESISTANCE AND INPUT CAPACITANCE AS A FUNCTION OF FREQUENCY



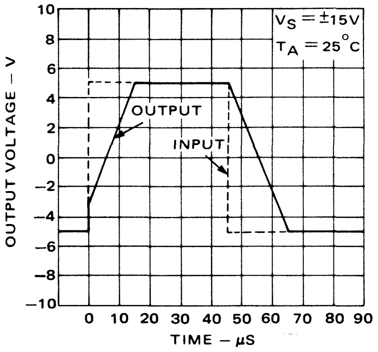
OUTPUT RESISTANCE AS A FUNCTION OF FREQUENCY



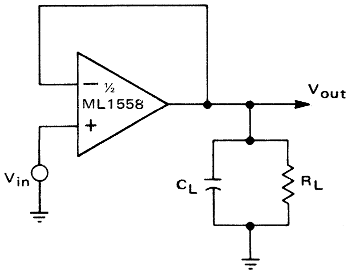
TRANSIENT RESPONSE



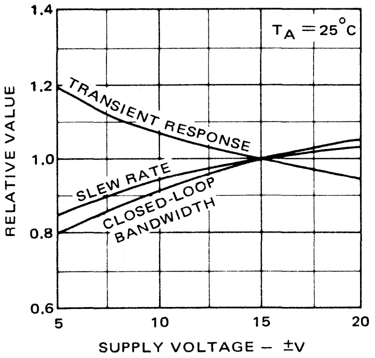
VOLTAGE FOLLOWER LARGE-SIGNAL PULSE RESPONSE



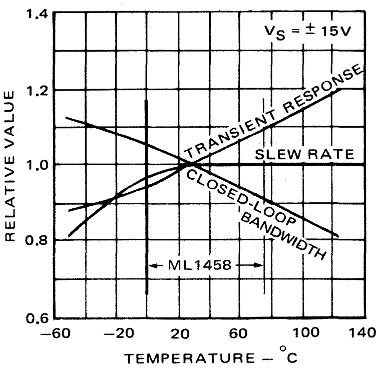
TRANSIENT RESPONSE TEST CIRCUIT



FREQUENCY CHARACTERISTICS AS A FUNCTION OF SUPPLY VOLTAGE



FREQUENCY CHARACTERISTICS AS A FUNCTION OF AMBIENT TEMPERATURE



QUAD OPERATIONAL AMPLIFIER ML4136, ML4136C

features

- Short-circuit Protection
- Internal Frequency Compensation
- No Latch-up
- Wide Common-mode and Differential Voltage Ranges
- Low Power Consumption
- Matched Gain-bandwidth

description

The ML4136, ML4136C is an array of four independent internally compensated operational amplifiers on a single silicon chip, each similar to the ML741. Good thermal tracking and matched gain-bandwidth products make these Quad Op-amps useful for active filter applications.

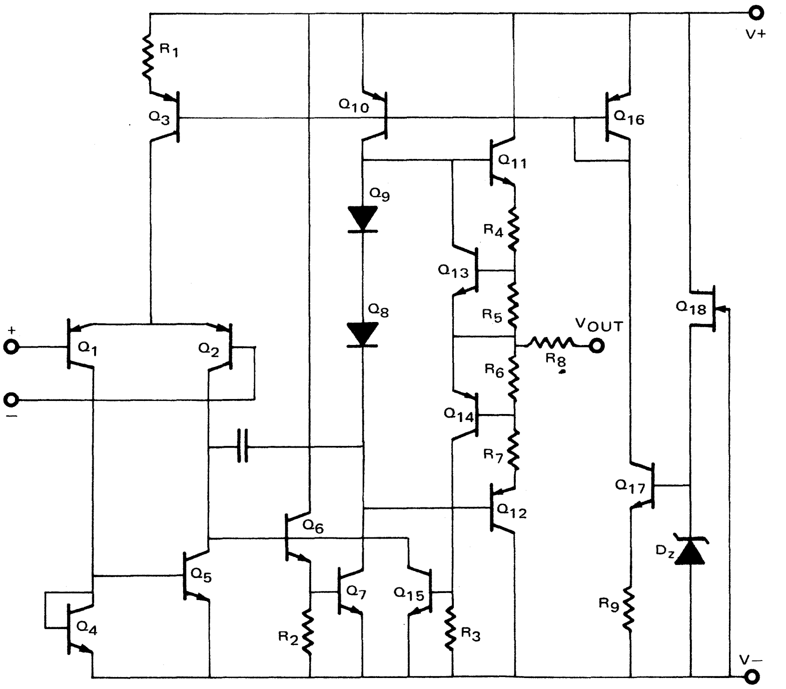
absolute maximum ratings

Supply Voltage	
ML4136	± 22V
ML4136C	± 18V
Common Mode Voltage Range	V_{EE} to V_{CC}
Output Short-circuit Duration(3)	Indefinite
Differential Input Voltage	± 30V
Internal Power Dissipation(2)	800mW
Operating Temperature Range:	
ML4136	−55°C to +125°C
ML4136C	0°C to +75°C
Storage Temperature Range	−65°C to +15°C

NOTES:

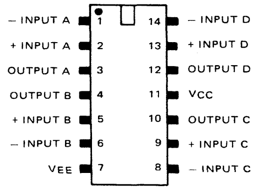
1. For supply voltages of less then ± 18 Volts, the absolute maximum input voltage may not be greater than the supply.
2. Flatpack rating applies for case temperatures +125°C; derate linearly at 5.6mW/°C for ambient temperatures above +25°C. Dual in-line ceramic package rating applies for case temperatures to +115°C; derate linearly at 8.3mW/°C for ambient temperatures above +95°C. Dual in-line plastic package rating applies for case temperatures to +70°C; derate linearly at 6-7mW/°C for ambient temperatures above +55°C.
3. Short circuit may be to either supply rail or ground on only one amplifier at one time.

schematic diagram



connection diagram

DUAL-IN-LINE PACKAGE
(Top View)



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microsystems international

QUAD OPERATIONAL AMPLIFIER ML4136, ML4136C

electrical characteristics

$T_A = +25°C$, $V_S = \pm 15V$ unless otherwise specified

			ML4136			ML4136C			
PARAMETER	**SYMBOLS**	**CONDITIONS**	**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	**UNITS**
Input Offset Voltage	$\|V_{io}\|$	$R_s \leqslant 10K\Omega$	–	0.5	5.0	–	0.5	6.0	mV
Input Offset Current	$\|I_{io}\|$	–	–	5	200	–	5	200	nA
Input Bias Current	$\|I_b\|$	–	–	40	500	–	40	500	nA
Input Resistance	R_{in}	–	0.3	2.0	–	0.3	2.0	–	MΩ
Large Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2K\Omega$ $V_{out} = \pm 10V$	50	300	–	20	300	–	V/mV
Output Voltage Swing	V_{out}	$R_L \geqslant 10K\Omega$	±12	±14	–	±12	±14	–	V
		$R_L \geqslant 2K\Omega$	±10	±13	–	±10	±13	–	V
Input Voltage Range	V_{iCM}		±12	±13	–	±12	±13	–	V
Common Mode Rejection Ratio	CMRR	$R_s \leqslant 10K\Omega$	70	90	–	70	90	–	dB
Supply Voltage Rejection Ratio	PSRR	$R_s \leqslant 10K\Omega$	–	30	150	–	30	150	μV/V
Power Consumption	P_i		–	210	340	–	210	340	mW
Transient Response (unity gain)		$V_{in} = 20mV$ $R_L = 2K\Omega$ $C_L \leqslant 100pF$							
Risetime	t_r		–	02	–		0.2		μs
Overshoot	t_o		–	50	–		5.0		%
Slew Rate (unity gain)	$dV_{out}/_{dt}$	$R_L \geqslant 2K\Omega$	–	1.0	–		1.0		V/μs
Channel Separation (open loop)	–	$f = 10 KHz$ $R_s = 1 K\Omega$	–	105	–		105		dB
(Gain of 100)		$f = 10 KHz$	–	105	–		105		dB
	–	$R_s = 1 K\Omega$	–	105	–		105		dB
The following specifications apply for $-55°C \leqslant T_A \leqslant +125°C$ for ML4136; $0°C \leqslant T_A \leqslant +70°C$ for ML4136C									
Input Offset Voltage	$\|V_{io}\|$	$R_s \leqslant 10 K\Omega$	–	–	6.0	–	–	7.5	mV
Input Offset Current	$\|I_{io}\|$	–	–	–	500	–	–	300	nA
Input Bias Current	I_b	–	–	–	1,500	–	–	800	nA
Large-Signal Voltage Gain	A_{VOL}	$R_L \geqslant 2K\Omega$ $V_{out} = \pm 10V$	25	–	–	15	–		V/mV
Output Voltage Swing	V_{out}	$R_L \geqslant 2 K\Omega$	±10	–	–	±10	–		V
Power Consumption	P_i	$V_s = \pm 15V$							
		$T_A = High$	–	180	300	–	180	300	mW
		$T_A = Low$	–	240	400	–	240	400	
Input Short-Circuit Current	I_{SC}	–	–	25	–	–	25	–	mA

TYPICAL PARAMETER MATCHING:

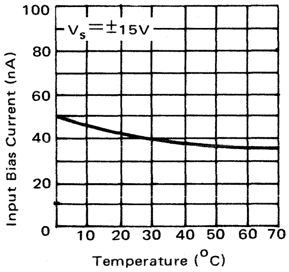
$T_A = +25°C$, $V_S = \pm 15V$ unless otherwise noted

PARAMETER	**SYMBOLS**	**CONDITIONS**	**TYP**	**TYP**	**UNITS**
Input Offset Voltage	$\|V_{io}\|$	$R_s \geqslant 10 K\Omega$	±1.0	±2.0	mV
Input Offset Current	$\|I_{io}\|$		±7.5	±7.5	nA
Input Bias Current	I_b		±15	±15	nA
Voltage Gain	A_{VOL}	$R_s \geqslant 2 K\Omega$	±0.5	±1.0	dB

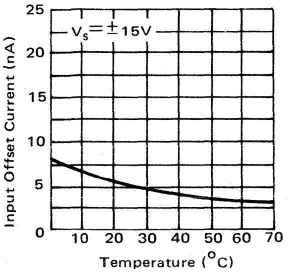
QUAD OPERATIONAL AMPLIFIER ML4136, ML4136C

typical dc characteristic curves

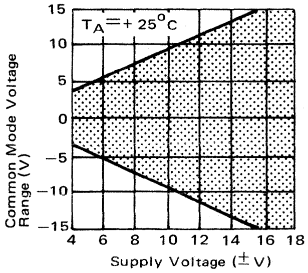
INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



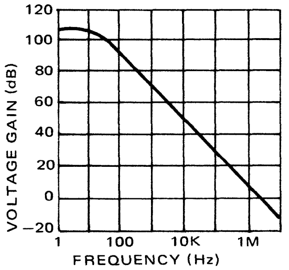
INPUT OFFSET CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



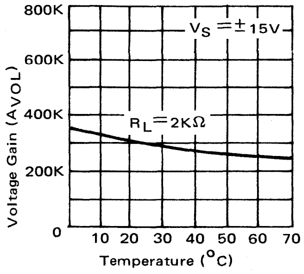
COMMON MODE RANGE AS A FUNCTION OF SUPPLY VOLTAGE



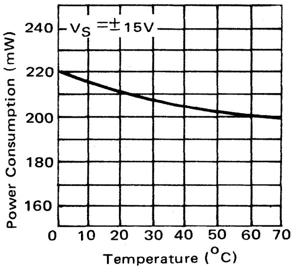
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



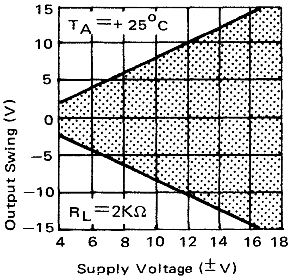
OPEN LOOP GAIN AS A FUNCTION OF TEMPERATURE



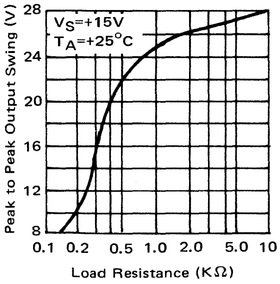
POWER CONSUMPTION AS A FUNCTION OF AMBIENT TEMPERATURE



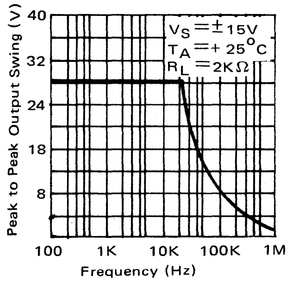
TYP. OUTPUT VOLTAGE AS A FUNCTION OF SUPPLY VOLTAGE



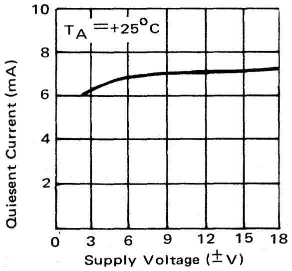
OUTPUT VOLTAGE SWING AS A FUNCTION OF LOAD RESISTANCE



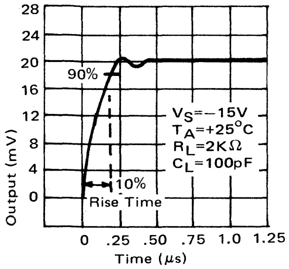
OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY



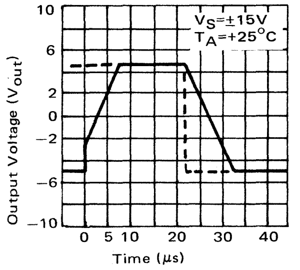
QUIESENT CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



TRANSIENT RESPONSE



VOLTAGE FOLLOWER LARGE–SIGNAL PULSE RESPONSE



PROGRAMMABLE QUAD OPERATIONAL AMPLIFIER . . . ML4202C

features

- Programmable
- Wide Input Voltage and Common Mode Range
- Internal Frequency Compensation
- No Latch-up
- Matched Parameters
- Short-circuit Protection

description

The ML4202C is an array of four independent operational amplifiers on a single silicon chip. The operating current of the array is externally controlled by a single resistor or current source, allowing the user to trade-off power dissipation for bandwidth.

absolute maximum ratings

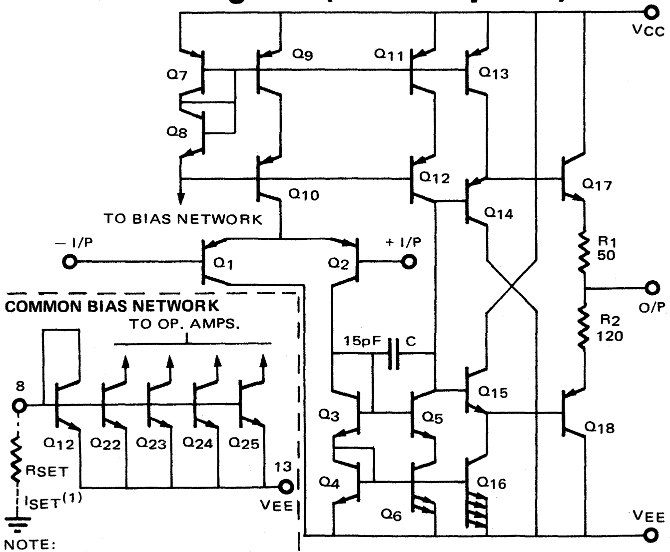
Supply Voltage	±18V	Short Circuit Duration	Indefinite
Differential Input Voltage	±30V	Operating Temperature	0°C to +70°C
Power Dissipation	800mW	Storage Temperature	−60°C to +150°C
Common Mode Range	V_{EE} to V_{CC}		

NOTES:

(1) Ceramic dual-in-line package rating applies for case temperatures to +125°C; derate linearly at 10mW/°C for ambient temperatures above +95°C: Plastic dual-in-line package rating applies for case temperatures to 70°C; derate linearly at 6.7mW/°C for ambient temperatures above +55°C.

(2) Short circuit may be taken to either supply line or ground on only one amplifier at a time.

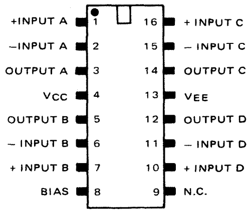
schematic diagram (each amplifier)



NOTE:
1. $I_{SET} = \frac{V_{EE} - V_D}{R_{SET}}$ where diode voltage ≈0.65V.

connection diagram

DUAL-IN-LINE PACKAGE
(Top View)



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international

electrical characteristics

HIGH POWER MODE (V_S=± 15V, I_{SET}=75µA and T_A=+25°C unless otherwise specified)

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Short Circuit Current	I_{SC}	–	–	20	–	mA
Supply Current	I_s	Note 3	1.6	2.5	4.0	mA
Input Offset Voltage	V_{io}	$R_s \leqslant 10K\Omega$	–	1.0	5.0	mV
Input Bias Current	I_b	–	–	200	500	nA
Input Off-set Current	I_{io}	–	–	5	50	nA
Input Resistance	R_{in}	–	20	200	–	KΩ
Input Common Mode Voltage Range	V_{iCM}	–	12	13	–	±V
Common Mode Rejection Ratio	CMRR	–	70	86	–	dB
Voltage Supply Rejection Ratio	PSRR	–	–	50	150	µV/V
Large Signal Voltage Gain	A_{VOL}	$R_L=3K\Omega; \Delta V_o=\pm 10V$	74	86	–	dB
Output Voltage Swing	V_{out}	$R_L=3K\Omega$	10	11	–	±V
Gain-Bandwidth Product	f_1	–	–	2.5	–	MHz
Phase Margin	–	–	–	45	–	Deg.
Rise Time	t_R	$\Delta V_o=\pm 20mV$	–	140	–	ns
Overshoot	t_o	$\Delta V_o=\pm 20mV$	–	20	–	%
Channel Separation	–	Any amp. pair: freq.=1Hz, $R_L=2K\Omega$	–	100	–	dB
		Any amp. pair: freq.=10KHz, $R_L=2K\Omega$	–	120	–	dB
Slew Rate	$dVout/_{dt}$	–	–	1.5	–	V/µs
Input Voltage Noise	e_n	Bandwidth 100Hz to 10KHz	–	25	–	$nV\sqrt{Hz}$.

PROGRAMMABLE QUAD OPERATIONAL AMPLIFIER . . . ML4202C

MICROPOWER MODE (I_{SET}= 1μA, V_S=±1.5V)

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Supply Current	I_s	Note 3	20	30	40	μA
Input Bias Current	I_B	–	–	10	100	nA
Input Offset Current	I_{OS}	–	–	1	10	nA
Input Offset Voltage	V_{os}	$R_s \leqslant 10K\Omega$	–	2	5	mV
Input Resistance	R_{in}	–	0.5	2	–	MΩ
Input Common Mode Voltage Range	V_{iCM}	–	0.3	0.5	–	±V
Common Mode Rejection Ratio	CMRR	–	60	80	–	dB
Voltage Supply Rejection Ratio	PSRR	–	–	50	200	μV/V
Large Signal Voltage Gain	A_{vol}	$R_L \geqslant 100\ K\Omega$	66	80	–	dB
Gain-bandwidth Product	f_1	–	–	50	–	KHz
Phase Margin	–	–	–	75	–	Deg.
Slew-rate	dV_{OUT}/dt	–	–	20	–	V/ms
Rise Time	t_R	ΔV_0=±20mv.	–	7	–	μs
Overshoot	t_o	ΔV_o=± 20mv.	–	0	–	%
Channel Separation	–	Freq. = Hz: R_L=2KΩ ΔV_o= ±0.5V	–	120	–	dB
		Freq. = 1 KHz: R_L =2KΩ ΔV_o = ±0.5V	–	120	–	dB
Equivalent Input Voltage Noise	–	Bandwidth =100Hz to 10KHz	–	200	–	nV$\sqrt{Hz}$

PARAMETER MATCHING (I_{SET} =75μA $^{(2)}$)

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Offset Voltage	V_{os}	$R_s \leqslant 10K\Omega$	–	1	–	±mV
Input Bias Current	I_B	–	–	10	–	±nA
Input Offset Current	I_{os}	–	–	2	–	±nA
Gain-bandwidth Product	f_1	–	–	100	–	±KHz
Slew Rate	$dV_o/dt.$	–	–	0.2	–	±V/μs

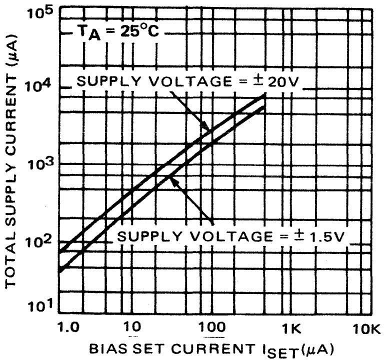
NOTES:

1. All tests refer to a single Op.-amp unless otherwise specified.
2. Tests apply for parameter matching between any Op.-amp pair.
3. Tests apply to four Op.-amps and bias network.

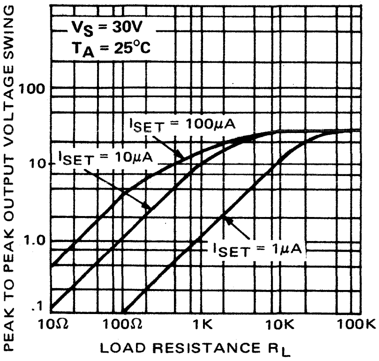
PROGRAMMABLE QUAD OPERATIONAL AMPLIFIER . . . ML4202C

typical characteristic curves

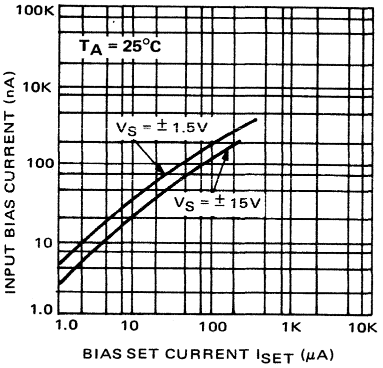
TOTAL SUPPLY CURRENT
VS
BIAS SET CURRENT



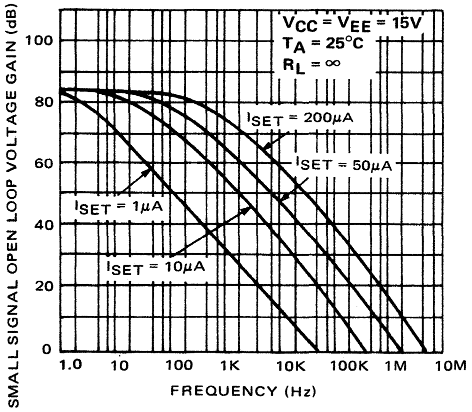
OUTPUT VOLTAGE SWING
VS
LOAD RESISTANCE



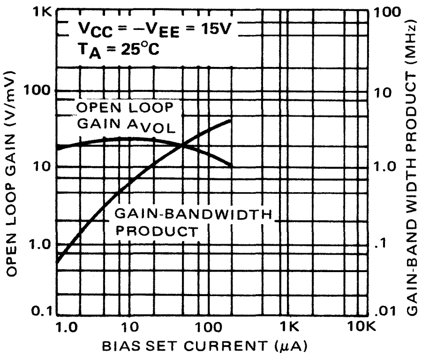
INPUT BIAS CURRENT
VS
BIAS SET CURRENT



TYPICAL FREQUENCY RESPONSES
FOR VARIOUS BIAS SET CURRENTS I_{SET}



GAIN-BAND WIDTH PRODUCT, A_{VOL}
VS
BIAS SET CURRENT



applications information

The following approximate relations are useful for design:

Gain-Bandwidth Product	≈	$50\ I_{SET}$	(KHz)
Power Supply Current	≈	$30\ I_{SET}$	(μA)
Slew Rate	≈	$20\ I_{SET}$	(V/ms)

Where: I_{SET} is in μA

NOTES

microsystems
international

SELECTED LINEAR I.C. CATALOGUE

Comparators, Regulators and Converters

8

MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STATION C, OTTAWA, CANADA, K1Y 4J1

package availability

PRODUCT CODE	PACKAGE CODE					
	T Metal Can	**D** Hermetic D.I.L. Ceramic	**P** Molded D.I.L. Plastic	**M** Hermetic D.I.L. Metal	**S** Molded D.I.L. Plastic	**F** Flat Pack
ML111	●	●		●		●
ML211	●	●		●		●
ML311	●	●		●	●	
ML723	●	●		●		●
ML723C	●	●	●	●		
ML4270			●			
ML4270–15			●			

PRECISION VOLTAGE COMPARATORS ML111, ML211, ML311

features

- Flexible Supply Voltages
- High Output Voltage/Current Drive Capability
- Low Input Bias Current
- Low Input Offset Voltage
- Strobing Facilities
- Output Offset Balancing

description

The Microsystems International ML111, ML211 and ML311 voltage comparators feature wide supply-voltage, differential and common-mode voltage ranges, low input currents, and outputs compatible with all bipolar and MOS circuitry. The inputs and outputs can be isolated from system ground, and the output can drive loads referenced to ground or to either supply. Offset balancing and strobing are available, and the outputs can be OR-tied.

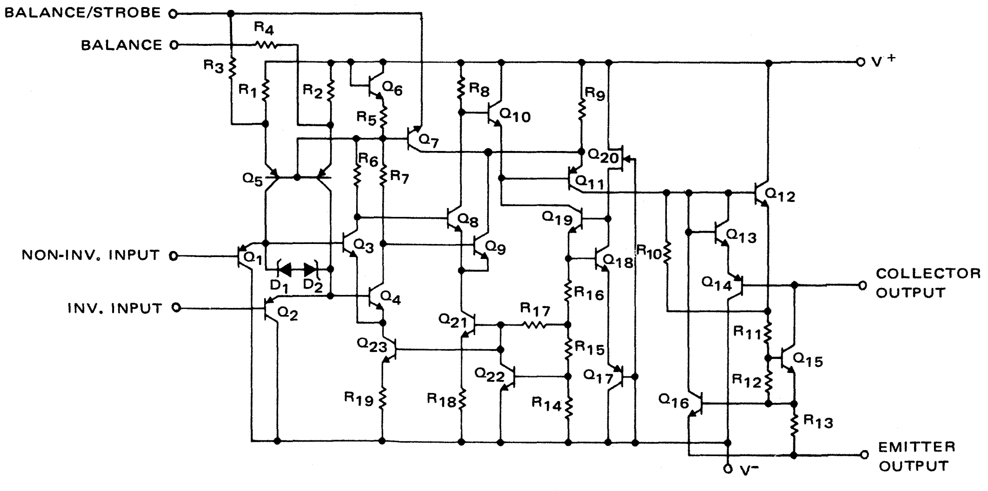
absolute maximum ratings

Voltage from V^+ to V^-	36 V
Voltage from Collector Output to V^-	
ML111, ML211	50 V
ML311	40 V
Voltage from Emitter Output to V^-	30 V
Voltage between Inputs	±30 V
Voltage from Inputs to V^-	+30 V, -0 V
Voltage from Inputs to V^+	-30 V

Power Dissipation (Note 1)	500 mW
Output Short-Circuit Duration	10 sec
Operating Temperature Range	
ML111	-55°C to +125°C
ML211	-25°C to +85°C
ML311	0°C to +70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (soldering, 10 sec)	300°C

Note 1. Rating applies for case temperatures up to respective maximum operating temperature. Derate Metal Can package at 6.8 mW/°C for operation at ambient temperatures above + 75°C, the Flat package at 5.4 mW/°C for operation at ambient temperatures above + 57°C, the hermetic Dual-in-Line package at 9 mW/°C for operation at ambient temperatures above + 95°C.

schematic diagram



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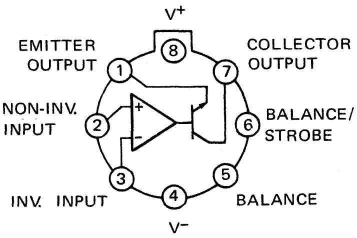
microsystems
international

PRECISION VOLTAGE COMPARATORS. ML111, ML211, ML311

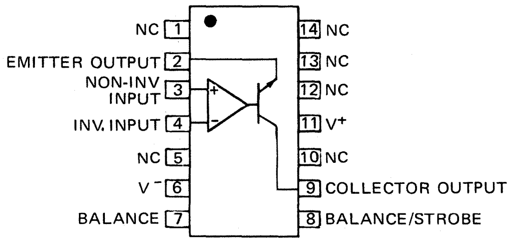
connection diagrams

METAL CAN PACKAGE
(Top View)



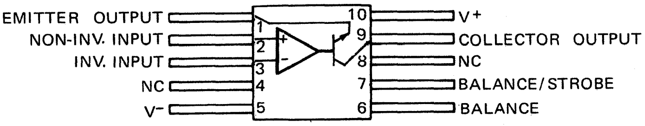
Pin 4 connected to case

DUAL-IN-LINE PACKAGE
(Top View)



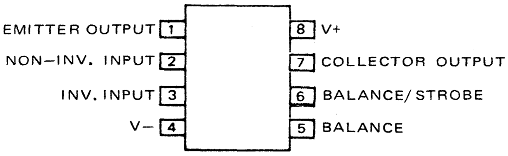
Pin 6 connected to bottom of hermetic package

FLAT PACKAGE
(Top View)



Pin 5 connected to bottom of package

DUAL–IN–LINE PACKAGE
(Top View)



Pin 4 connected to case

electrical characteristics

($T_A = +25°C$, $V^+ = +15$ V, $V^- = -15$ V, $V_E = -15$ V, and R_L at collector output = 7.5 kΩ to V^+ unless otherwise specified)

PARAMETERS	SYMBOLS	CONDITIONS	ML111, ML211 MIN.	ML111, ML211 TYP.	ML111, ML211 MAX.	ML311 MIN.	ML311 TYP.	ML311 MAX.	UNITS
Input Offset Voltage (Note 1, page 3)	$\lvert V_{io} \rvert$		–	0.7	3.0	–	2	7.5	mV
Input Offset Current (Note 1, page 3)	$\lvert I_{io} \rvert$		–	4.0	10.0	–	6.0	50.0	nA
Input Bias Current (Note 1, page 3)	I_b		–	60	100	–	100	250	nA
Response Time (Note 2, page 3)	T_R	$R_L = 500\ \Omega$ to + 5 V, $V_E = 0$	–	200	–	–	200	–	ns
Supply Current —Positive	I_S		–	5.1	6.0	–	5.1	7.5	mA
Supply Current —Negative			–	4.1	5.0	–	4.1	5.0	
Voltage Gain	A_{VOL}		–	200	–	–	200	–	V/mV
Saturation Voltage	V_{sat}	$V_{in} \leqslant -5$ mV, $I_C = 50$ mA	–	0.75	1.5	–	–	–	V
		$V_{in} \leqslant -10$ mV, $I_C = 50$ mA	–	–	–	–	0.75	1.5	
Output Leakage Current	I_{OL}	$V_{in} \geqslant +5$ mV, V_C to $V_E = 35$V	–	0.2	10.0	–	–	–	nA
		$V_{in} \geqslant +10$ mV, V_C to $V_E = 35$V	–	–	–	–	0.2	50.0	

electrical characteristics

(over respective operating temperature ranges, $V^+ = +15$ V, $V^- = -15$ V, $V_E = -15$ V, and R_L at collector output = 7.5 kΩ to V^+ unless otherwise specified.)

PARAMETERS	SYMBOLS	CONDITIONS	ML111, ML211			ML311			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Input Offset Voltage (Note 1)	$\lvert V_{io} \rvert$		–	–	4.0	–	–	10.0	mV
Input Offset Current (Note 1)	$\lvert I_{io} \rvert$		–	–	20.0	–	–	70.0	nA
Input Bias Current (Note 1)	I_b		–	–	150	–	–	300	nA
Saturation Voltage	V_{sat}	$V_{in} \leqslant -6$ mV, $I_C = 8$ mA	–	0.23	0.40	–	–	–	V
		$V_{in} \leqslant -10$ mV, $I_C = 8$ mA	–	–	–	–	0.23	0.40	
Output Leakage Current	I_{OL}	$V_{in} \geqslant +6$ mV, V_C to V_E = 35V	–	0.1	0.5	–	–	–	µA
Common Mode Input Voltage Range	V_{iCM}		±13	±14	–	±13	±14	–	V
Supply Current —Positive	I_S	$T_A = 125°C$	–	5.1	6.0	–	–	–	mA
Supply Current —Negative			–	4.1	5.0	–	–	–	

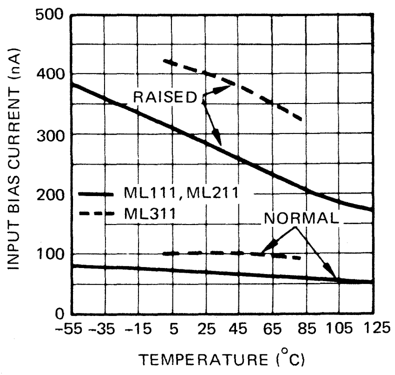
Note 1. The offset voltage, offset current and bias current given are the maximum values required to drive the collector output to within 1 V of the supplies with a 7.5 kΩ load. These parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

Note 2. The response time is the interval between the application of an input step function and the time at which the output crosses the logic threshold voltage. The input step drives the comparator from some initial saturated input voltage to an input level in excess of that required to bring the output from saturation to the logic threshold voltage. This is referred to as the voltage overdrive. The response time specified is for a 100 mV input step with 5 mV overdrive.

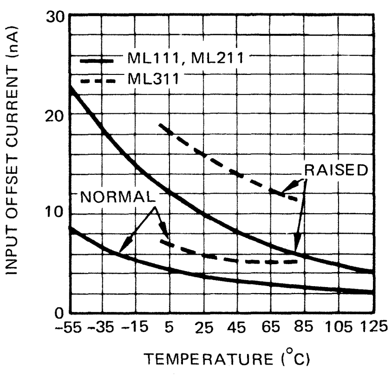
typical performance curves

($T_A = +25°C$, $V_S = ±15$ V unless otherwise noted)

INPUT BIAS CURRENT

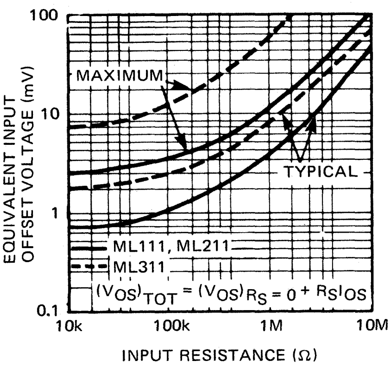


INPUT OFFSET CURRENT

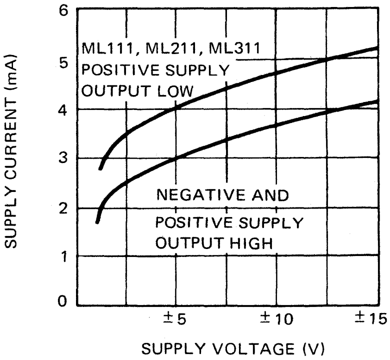


PRECISION VOLTAGE COMPARATORS ML111, ML211, ML311

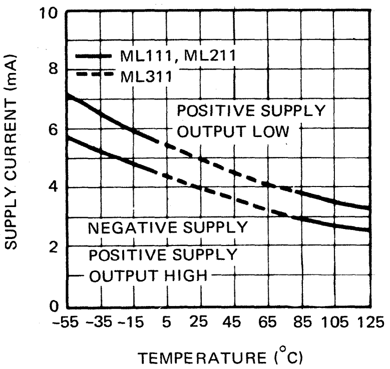
OFFSET ERROR



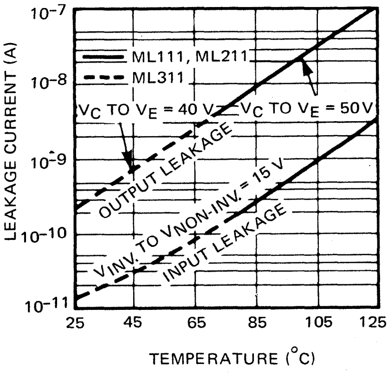
SUPPLY CURRENT



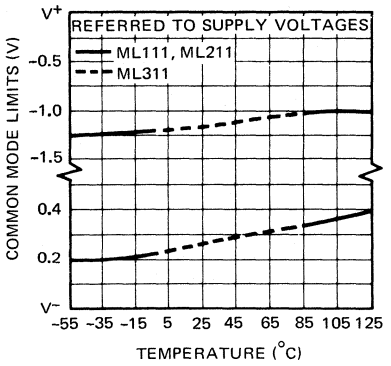
SUPPLY CURRENT



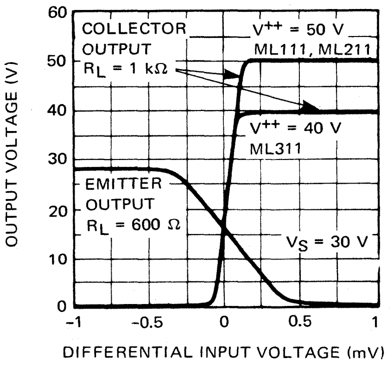
LEAKAGE CURRENT



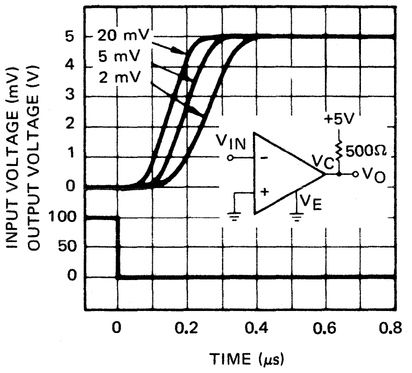
COMMON MODE LIMITS



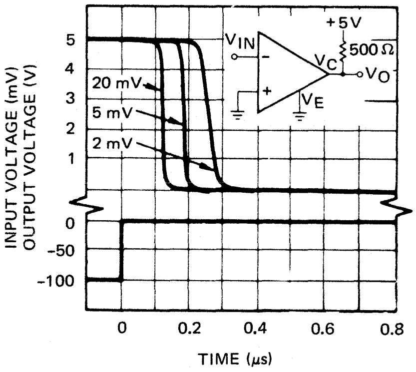
TRANSFER FUNCTION



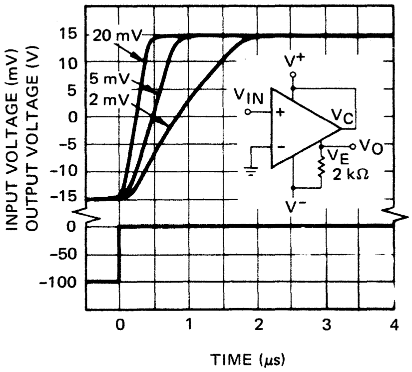
RESPONSE TIME FOR VARIOUS INPUT OVERDRIVES



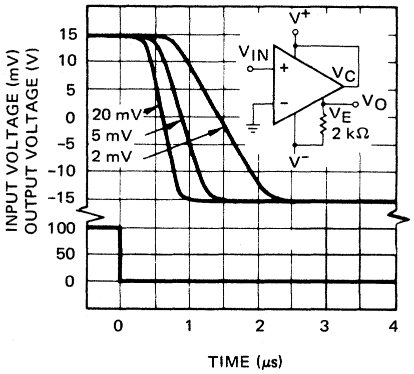
RESPONSE TIME FOR VARIOUS INPUT OVERDRIVES



RESPONSE TIME FOR VARIOUS INPUT OVERDRIVES

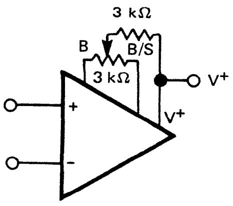


RESPONSE TIME FOR VARIOUS INPUT OVERDRIVES

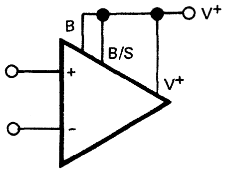


typical applications

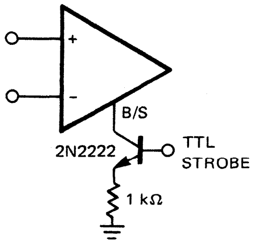
OFFSET BALANCING



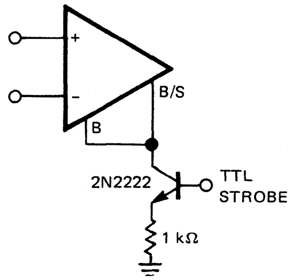
INCREASING INPUT STAGE CURRENT *



STROBING



STROBING OFF BOTH INPUT AND OUTPUT STAGES **



* Increases input bias current and common mode slew rate by a factor of 3

** Typical input current = 50 pA with inputs strobed OFF

PRECISION VOLTAGE REGULATOR ML723, ML723C

features

- Positive or Negative Supply Operation
- Series, Shunt, Switching or Floating Operation
- 0.01% Line and Load Regulation
- Low Standby Current Drain
- High Ripple Rejection
- Output Voltage Adjustable from 2 to 37 Volts
- Output Current to 150 mA without External Pass Transistor
- Low Temperature-Drift

description

The ML723 family is a monolithic, precision voltage regulator intended for use with positive or negative supplies as a series, shunt, switching or floating regulator. It consists of a temperature compensated reference amplifier, an error amplifier, a power series pass transistor and current limiting circuitry. When current outputs in excess of 150 mA are required, additional NPN or PNP pass transistors can be employed. Adjustable current limiting and remote shut-down are provided for. Apart from minimal performance differences the ML723C is identical to the ML723 but limited to a narrower, 0°C to + 70°C operating temperature range.

absolute maximum ratings

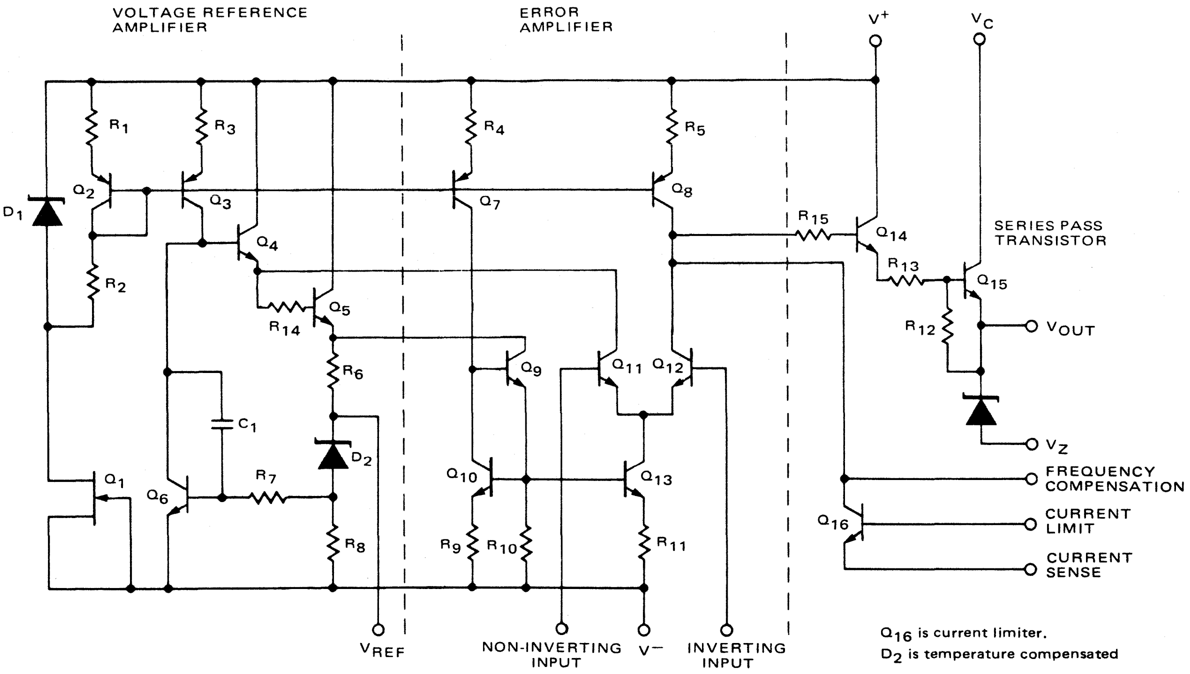
Pulse Voltage from V^+ to V^- (50 ms)	50 V
Continuous Voltage from V^+ to V^-	40 V
Input-Output Voltage Differential	40 V
Differential Input Voltage	± 5 V
Voltage Between Non-Inverting Input and V^-	+ 8 V
Current from V_Z	25 mA

Current from VREF	15mA
Internal Power Dissipation*	800mW
Operating Temperature Range:	
ML723	−55°C to + 125°C
ML723C	0°C to 70°C
Storage Temperature Range	−65°C to + 150°C
Lead Temperature (Soldering, 60 sec)	300°C

NOTE:
1. Rating applies for case temperatures of +25°C. For case temperatures above 25°C derate linearly at 6.3 mW/°C for Metal Can package and at 8.3 mW/°C for Dual in-Line package, and 5.6 mW/°C for the Flat package.

PRECISION VOLTAGE REGULATOR ML723, ML723C

schematic diagram



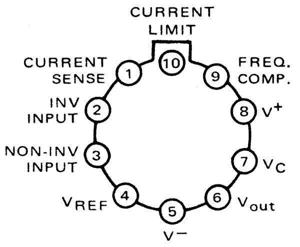
Q_{16} is current limiter.

D_2 is temperature compensated

connection diagrams

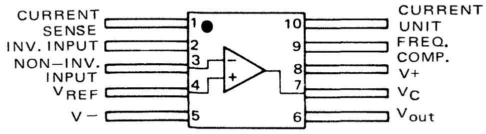
METAL CAN PACKAGE

(Top View)



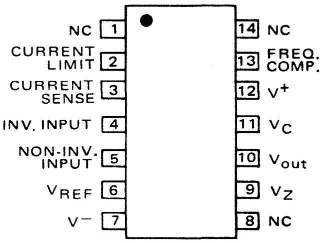
FLAT PACKAGE

(Top View)



DUAL-IN-LINE PACKAGE

(Top View)



NOTE: Pin 5 connected to case

PRECISION VOLTAGE REGULATOR.............. ML723, ML723C

electrical characteristics (ML723)

$T_A = 25°C$, $V_{IN} = V^+ = V_C = 12$ V, $V^- = 0$, $V_{OUT} = 5$ V, $I_L = 1$ mA, $R_{SC} = 0$, $C_1 = 100$ pF, $C_{REF} = 0$, unless otherwise specified and divider impedance as seen by error amplifier ⩽ 10 kΩ connected as shown in Fig. 1. (Also, see *)

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Line Regulation	–	$V_{IN} = 12$ V to $V_{IN} = 15$ V	–	.01	0.1	$\%V_{OUT}$
		$V_{IN} = 12$ V to $V_{IN} = 40$ V	–	.02	0.2	
		$-55°C \leqslant T_A \leqslant +125°C$ $V_{IN} = 12$ V to $V_{IN} = 15$ V	–	–	0.3	
Load Regulation	–	$I_L = 1$ mA to $I_L = 50$ mA	–	.03	0.15	$\%V_{OUT}$
		$-55°C \leqslant T_A \leqslant +125°C$, $I_L = 1$ mA to $I_L = 50$ mA	–	–	0.6	
Ripple Rejection	–	f = 50 Hz to 10 kHz, $C_{REF} = 0$	–	74	–	dB
		f = 50 Hz to 10 kHz, $C_{REF} = 5\ \mu F$	–	86	–	
Average Temperature Coefficient Of Output Voltage	$\lvert TC_{VO}\rvert$	$-55°C \leqslant T_A \leqslant +125°C$	–	.002	.015	%/°C
Short Circuit Current Limit	I_{SCL}	$R_{SC} = 10\ \Omega$, $V_{OUT} = 0$	–	65	–	mA
Reference Voltage	V_{REF}	–	6.95	7.15	7.35	V
Output Noise Voltage	V_{No}	BW = 100 Hz to 10 kHz, $C_{REF}=0$	–	20	–	μVrms
		BW = 100 Hz to 10 kHz, $C_{REF}=5\ \mu F$	–	2.5	–	
Long Term Stability	–	–	–	0.1	–	%/1000hrs
Standby Current Drain	I_{SD}	$I_L = 0$, $V_{IN} = 30$ V	–	2.3	3.5	mA
Input Voltage Range	–	–	9.5	–	40	V
Output Voltage Range	–	–	2.0	–	37	V
Input-Output Voltage Differential	$V_{DIFFi-o}$	–	3.0	–	38	V

electrical characteristics (ML723C)

$T_A = 25°C$, $V_{IN} = V^+ = V_C = 12$ V, $V^- = 0$, $V_{OUT} = 5$ V, $I_L = 1$ mA, $R_{SC} = 0$, $C_1 = 100$ pF, $C_{REF} = 0$, unless otherwise specified and divider impedance as seen by error amplifier ⩽ 10 kΩ connected as shown in Fig. 1. (Also, see *)

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Line Regulation	–	$V_{IN} = 12$V to $V_{IN} = 15$V	–	.01	0.1	$\%V_{OUT}$
		$V_{IN} = 12$V to $V_{IN} = 40$V	–	0.1	0.5	
		$0°C \leqslant T_A \leqslant 70°C$, $V_{IN} = 12$V to $V_{IN} = 15$V	–	–	0.3	
Load Regulation	–	$I_L = 1$ mA to $I_L = 50$ mA	–	.03	0.2	$\%V_{OUT}$
		$0°C \leqslant T_A \leqslant 70°C$, $I_L = 1$ mA to $I_L = 50$ mA	–	–	0.6	

* NOTE: 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.

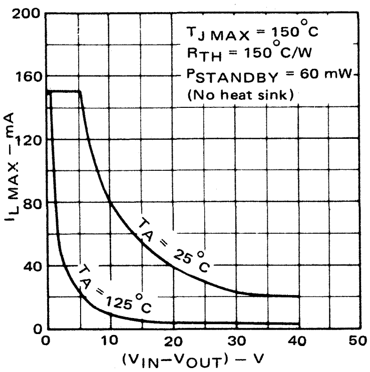
PRECISION VOLTAGE REGULATOR ML723, ML723C

T_A=25°C, V_{IN}=V+=V_C=12V, V−=0, V_{OUT}=5V, I_L=1mA, R_{SC}=0, C_1=100pF, C_{REF}=0, unless otherwise specified and divider impedance as seen by error amplifier ⩽ 10kΩ connected as shown in Fig. 1 (cont'd)

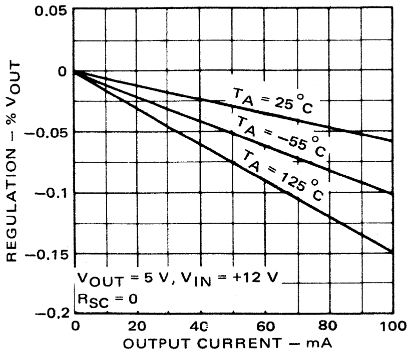
PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Ripple Rejection	–	f = 50 Hz to 10 kHz, C_{REF} = 0	–	74	–	dB
		f = 50 Hz to 10 kHz, C_{REF} = 5 μF	–	86	–	
Average Temperature Coefficient of Output Voltage	$\lvert TC_{V_O}\rvert$	0°C ⩽ T_A ⩽ 70°C	–	.003	.015	%/°C
Short Circuit Current Limit	I_{SCL}	R_{SC} = 10 Ω, V_{OUT} = 0	–	65	–	mA
Reference Voltage	V_{REF}	–	6.80	7.15	7.50	V
Output Noise Voltage	V_{No}	BW = 100 Hz to 10 kHz, C_{REF} = 0	–	20	–	μVrms
		BW = 100 Hz to 10 kHz, C_{REF} = 5 μF	–	2.5	–	
Long Term Stability	–	–	–	0.1	–	%/1000 hrs
Standby Current Drain	I_{SD}	I_L = 0, V_{IN} = 30V	–	2.3	4.0	mA
Input Voltage Range	–	–	9.5	–	40	V
Output Voltage Range	–	–	2.0	–	37	V
Input-Output Voltage Differential	$V_{DIFFi\text{-}o}$	–	3.0	–	38	V

typical performance curves (ML723)

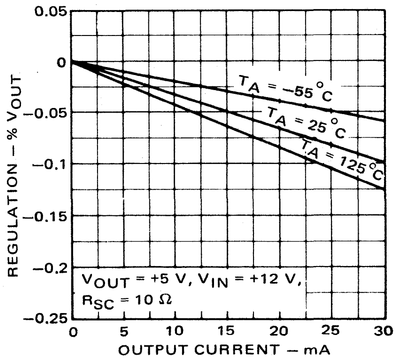
MAXIMUM LOAD CURRENT AS A FUNCTION OF INPUT-OUTPUT VOLTAGE DIFFERENTIAL (METAL CAN)



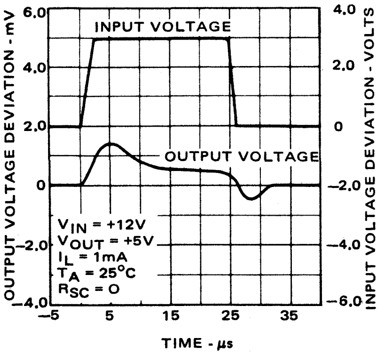
LOAD REGULATION CHARACTERISTICS WITHOUT CURRENT LIMITING



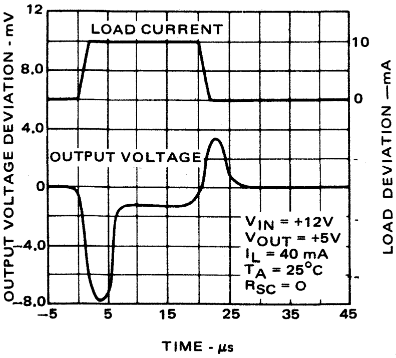
LOAD REGULATION CHARACTERISTICS WITH CURRENT LIMITING



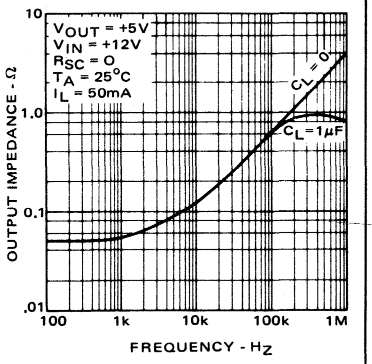
LINE TRANSIENT RESPONSE



LOAD TRANSIENT RESPONSE



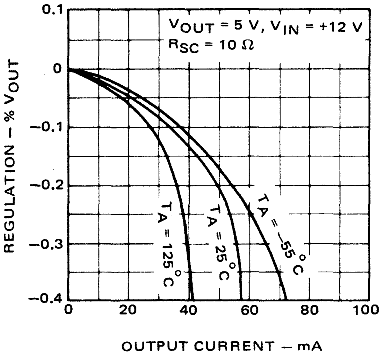
OUTPUT IMPEDANCE AS A FUNCTION OF FREQUENCY



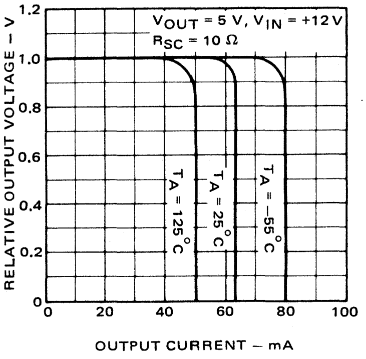
ML723, ML723C PRECISION VOLTAGE REGULATOR

PRECISION VOLTAGE REGULATOR ML723, ML723C

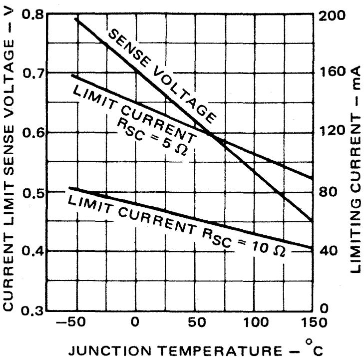
LOAD REGULATION CHARACTERISTICS WITH CURRENT LIMITING



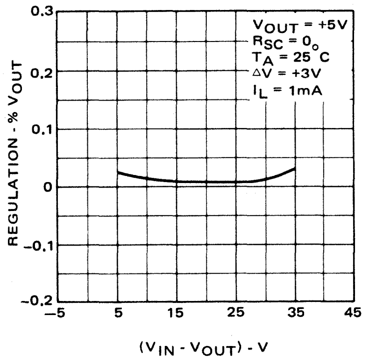
CURRENT LIMITING CHARACTERISTICS



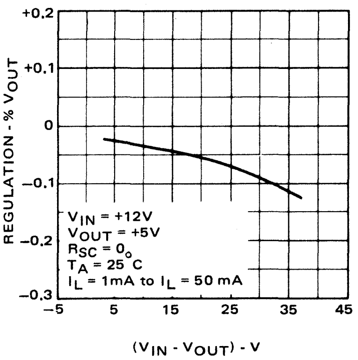
CURRENT LIMITING CHARACTERISTICS AS A FUNCTION OF JUNCTION TEMPERATURE



LINE REGULATION AS A FUNCTION OF INPUT-OUTPUT VOLTAGE DIFFERENTIAL



LOAD REGULATION AS A FUNCTION OF INPUT-OUTPUT VOLTAGE DIFFERENTIAL



STANDBY CURRENT DRAIN AS A FUNCTION OF INPUT VOLTAGE

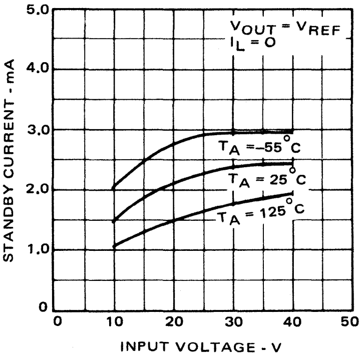
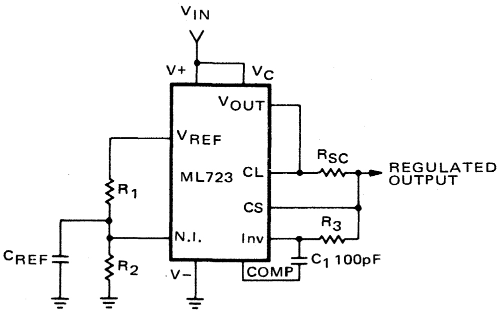


FIGURE 1. BASIC LOW VOLTAGE REGULATOR (V_{OUT}=2 to 7 Volts)



TYPICAL PERFORMANCE

Regulated Output Voltage	5V
Line Regulation (ΔV_{IN} = 3 V)	0.5mV
Load Regulation (ΔI_L=50mA)	1.5mV

Note: $R_3 = \frac{R_1\ R_2}{R_1+R_2}$ for minimum temperature drift.

DC-DC CONVERTER ML4270, ML4270-15

features

- Produces Regulated Output Voltage From Input as Low as 3 Volts
- Full Four Quadrant Polarity Operation
- High Conversion Efficiency
- Programmable Output Voltage to 27 Volts
- Output Voltage Well Regulated Over Line, Load, and Temperature Variations

description

The ML4270 DC-DC converter transforms an input voltage to a well regulated output voltage. Any polarity combination is possible and the output voltage can be either greater or less than the input. The device includes a voltage reference and comparator, a multivibrator with variable mark-space ratio, and an output current switch transistor to drive a pulse transformer. Normal output power is in the 100-200 mW range but can be increased with external booster transistors. Conversion efficiencies greater than 50% can be achieved.

Output voltage programming is done by varying the ratio of two external resistors. The ML4270-15 contains these resistors on the chip and provides a fixed 15 volt output.

Primary applications include inexpensive light-load power supply systems for calculators and other battery powered equipment, and substrate bias supplies for MOS circuitry.

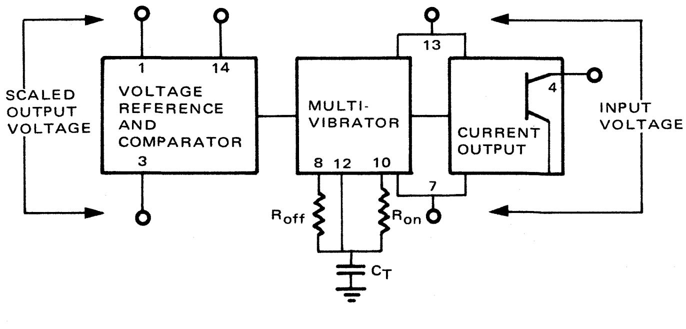
absolute maximum ratings

Internal Power Dissipation (1)	800 mW	Operating Temperature Range	0° C to + 70° C
Storage Temperature Range	–65° C to + 175° C		

NOTE 1:

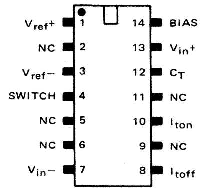
(1) Derate linearly at 6.7mW/°C for ambient temperatures above +25°C.

block diagram



connection diagram

DUAL-IN-LINE PACKAGE
(Top View)



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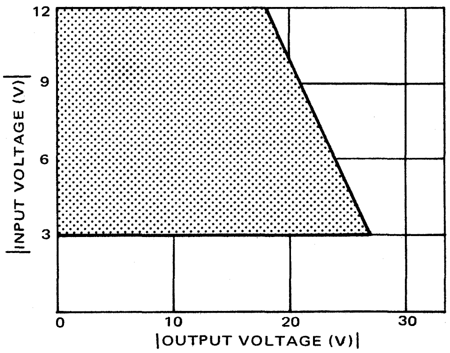
DC-DC CONVERTER ML4270, ML4270-15

electrical characteristics

$T_A = +25°C$ unless otherwise specified.

PARAMETERS	CONDITIONS		MIN.	TYP.	MAX.	UNITS
Input Voltage Range	–		3	–	12	V
Supply Current, V_{in} +	Switch (pin 4) OFF, $V_{in} = 7.5V$		–	1.7	2.6	mA
Supply Current, V_{in} +	Switch (pin 4) ON, $V_{in} = 7.5V$		–	7.5	12	mA
Upper Trip Point	–		–	2/3 V_{in}	–	–
Lower Trip Point	–		–	1/3 V_{in}	–	–
Reference Voltage	Measured at pin 1 with 0.5mA on pin 14.	**ML4270** **ML4270-15**	7.2 14.25	7.65 15	8.10 15.75	V V
Average Temperature Coefficient of Reference Voltage, (0 to +70°C)		**ML4270** **ML4270-15**	– –	+1 +2	– –	mV/°C mV/°C
Current Drawn by Reference		**ML4270** **ML4270-15**	– –	5 0.65	– –	μA mA
Switch Transistor BV_{CER} (pins 4–7)	$I_c = 10\mu A$		30	–	–	V
Switch Transistor Internal Current Limit (pin 4)	Maximum current that can be drawn by pin 4 when switch (pin 4) ON.		150	300	500	mA
Switch Transistor ON Resistance (Pins 4–7)	–		–	3	–	Ω

SAFE OPERATING CONDITIONS



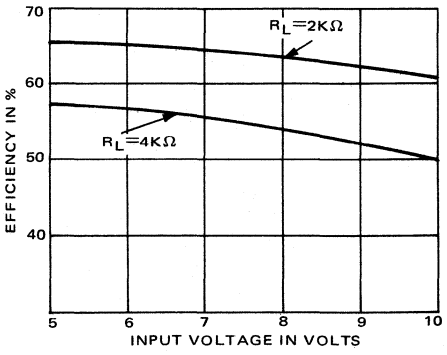
NOTE:

1. Assuming use of an output pulse transformer with 1:1 turns ratio;

$3V \leqslant |V_{in}| \leqslant 12V$

$|V_{in}| + |V_{out}| \leqslant 30V$

EFFICIENCY CURVES



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Drivers and Receivers

9

MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STATION C, OTTAWA, CANADA, K1Y 4J1

package availability

PRODUCT CODE	**PACKAGE CODE**					
	T Metal Can	**D** Hermetic D.I.L. Ceramic	**P** Molded D.I.L. Plastic	**M** Hermetic D.I.L. Metal	**S** Molded D.I.L. Plastic	**F** Flat Pack
ML1488		●		●		
ML1489		●		●		
ML1489A		●		●		
ML4102			●			

QUAD DTL LINE DRIVER ML1488

features

- Output Current Limiting – 10mA
- Source Impedance for Power-Off – 300Ω min.
- Simple Slew Rate Control by means of External Capacitor
- Wide Operating Supply Voltage Range
- DTL, TTL Compatible

description

The Microsystems International ML1488 monolithic quad line driver is designed mainly for use in interfacing data terminal equipment with data communications equipment and conforms with the specifications of EIA Standard No. RS-232C.

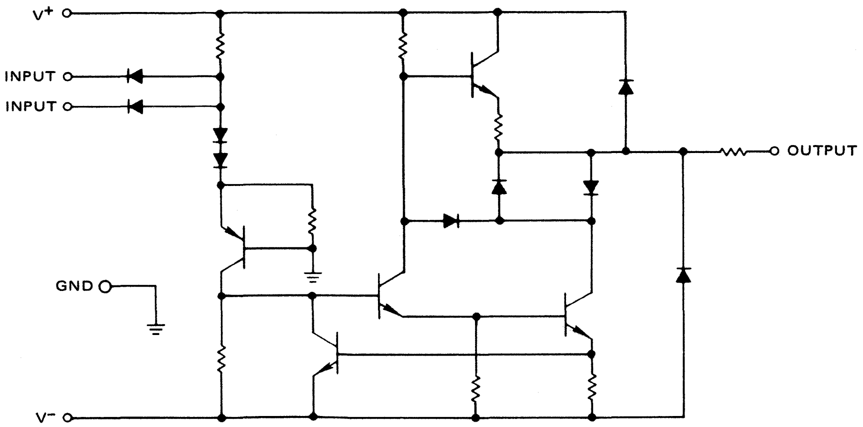
absolute maximum ratings (at $T_A = 25°C$)

Supply Voltage	V +	+15 Vdc
	V -	-15 Vdc
Input Signal Voltage		$-15 \leqslant V_{in} \leqslant 7.0$ Vdc
Output Signal Voltage		±15 Vdc

Internal Power Dissipation (Note 1)	1000 mW
Operating Temperature Range	0°C to +75°C
Storage Temperature Range	-65°C to +175°C

Note 1. Rating applies for case temperatures up to +75°C. Derate at 6.7 mW/°C for operation at ambient temperatures above +25°C.

schematic diagram (¼ of circuit shown)



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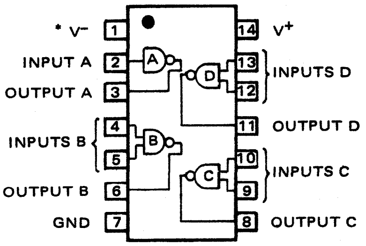
international

QUAD DTL LINE DRIVER ML1488

connection diagram

DUAL-IN-LINE PACKAGE
(Top View)



*Pin 1 connected to package bottom.

electrical characteristics

($V^+ = +9.0$ Vdc ±1%, $V^- = -9.0$ Vdc ±1%, 0°C $\leq T_A \leq$ +75°C unless otherwise specified) (See Test Circuits on pages 4 and 5.)

PARAMETERS	SYMBOLS	CONDITIONS		MIN.	TYP.	MAX.	UNITS
Forward Input Current	I_F	V_{in} = 0 Vdc		–	1.0	1.3	mA
Reverse Input Current	I_R	V_{in} = + 5.0 Vdc		–	–	10	μA
Output Voltage High	V_{OH}	V_{in} = 0.8 Vdc	V^+ = + 9.0 Vdc, V^- = - 9.0 Vdc	+6.0	+7.0	–	Vdc
		R_L = 3.0 kΩ	V^+ = + 13.2 Vdc, V^- = - 13.2 Vdc	+9.0	+10.5	–	
Output Voltage Low	V_{OL}	V_{in} = 1.9 Vdc	V^+ = + 9.0 Vdc, V^- = - 9.0 Vdc	-6.0	-7.0	–	Vdc
		R_L = 3.0 kΩ	V^+ = + 13.2 Vdc, V^- = - 13.2 Vdc	-9.0	-10.5	–	
Output Short Circuit Current	I_{SC}^+	–		+6.0	+10	+12	mA
	I_{SC}^-	–		-6.0	-10	-12	
Output Resistance	R_{out}	$V^+ = V^- = 0$, $\lvert V_o \rvert = \pm 2.0$ V		300	–	–	Ω
Positive Supply Current	I_S^+	$R_L = \infty$	V_{in} = 1.9 Vdc, V^+ = + 9.0 Vdc	–	+15	+20	mA
			V_{in} = 0.8 Vdc, V^+ = + 9.0 Vdc	–	+4.5	+6.0	
			V_{in} = 1.9 Vdc, V^+ = + 12 Vdc	–	+19.0	+25	
			V_{in} = 0.8 Vdc, V^+ = + 12 Vdc	–	+5.5	+7.0	
			V_{in} = 1.9 Vdc, V^+ = + 15 Vdc	–	–	+34	
			V_{in} = 0.8 Vdc, V^+ = +15 Vdc	–	–	+12	
Negative Supply Current	I_S^-	$R_L = \infty$	V_{in} = 1.9 Vdc, V^- = - 9.0 Vdc	–	-13	-17	mA
			V_{in} = 0.8 Vdc, V^- = - 9.0 Vdc	–	0	0	
			V_{in} = 1.9 Vdc, V^- = - 12 Vdc	–	-18	-23	
			V_{in} = 0.8 Vdc, V^- = - 12 Vdc	–	0	0	
			V_{in} = 1.9 Vdc, V^- = - 15 Vdc	–	–	-34	
			V_{in} = 0.8 Vdc, V^- = - 15 Vdc	–	–	-2.5	
Power Dissipation	P_D	V^+ = 9.0 Vdc, V^- = - 9.0 Vdc		–	–	333	mW
		V^+ = 12 Vdc, V^- = - 12 Vdc		–	–	576	

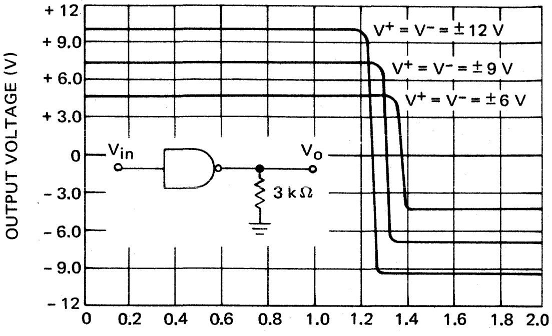
switching characteristics

($V^+ = +9.0$ Vdc ±1%, $V^- = -9.0$ Vdc ±1%, T_A = +25°C)

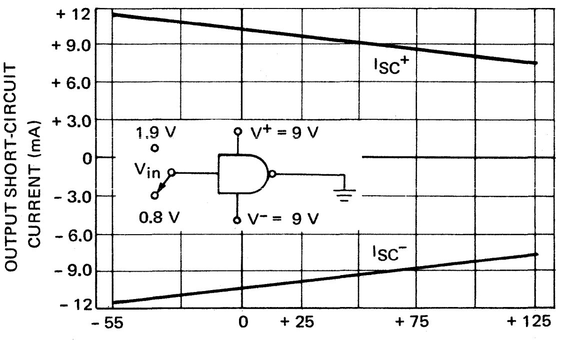
PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Propagation Delay Time	t_{pd}^+	Z_L = 3.0 kΩ and 15 pF	–	150	200	ns
Fall Time	t_f	Z_L = 3.0 kΩ and 15 pF	–	45	75	ns
Propagation Delay Time	t_{pd}^-	Z_L = 3.0 kΩ and 15 pF	–	65	120	ns
Rise Time	t_r	Z_L = 3.0 kΩ and 15 pF	–	55	100	ns

typical performance curves (T$_A$ = +25°C unless otherwise noted)

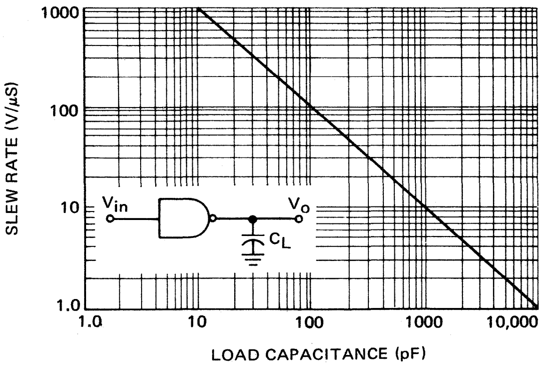
TRANSFER CHARACTERISTICS AS A FUNCTION OF POWER-SUPPLY VOLTAGE



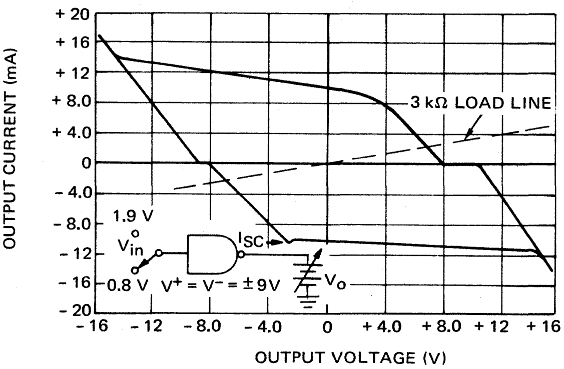
OUTPUT SHORT-CIRCUIT CURRENT AS A FUNCTION OF TEMPERATURE



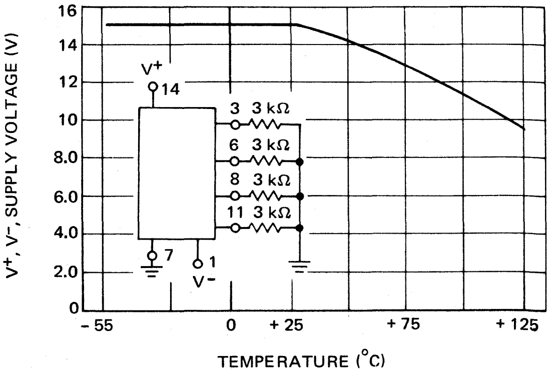
OUTPUT SLEW RATE AS A FUNCTION OF LOAD CAPACITANCE



OUTPUT VOLTAGE AND CURRENT LIMITING CHARACTERISTICS



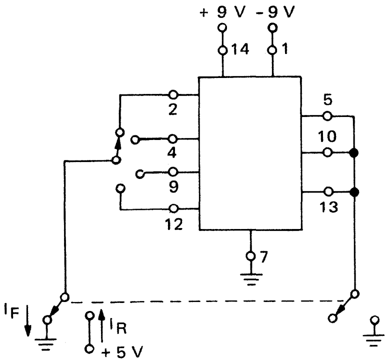
MAXIMUM OPERATING TEMPERATURE AS A FUNCTION OF POWER SUPPLY VOLTAGE



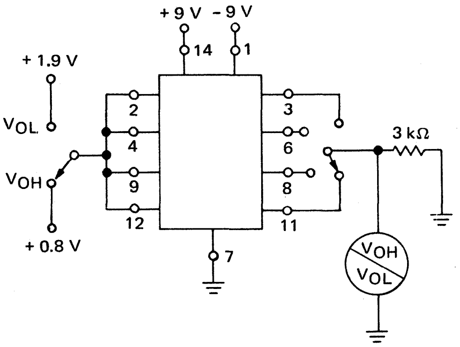
QUAD DTL LINE DRIVER ML1488

test circuits

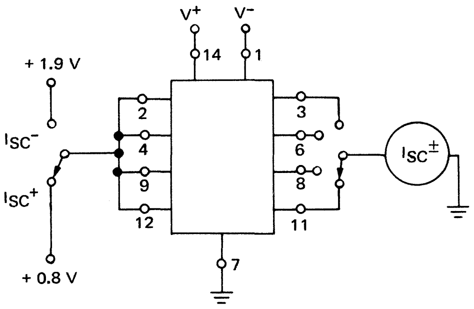
INPUT CURRENT



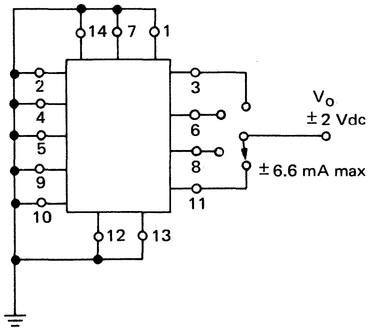
OUTPUT VOLTAGE



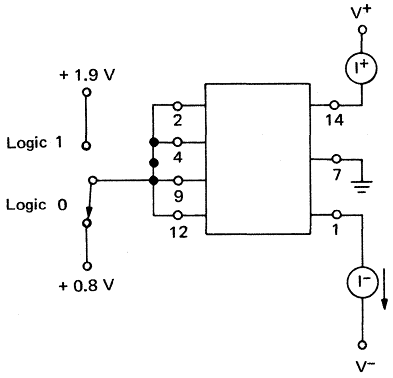
OUTPUT SHORT-CIRCUIT CURRENT



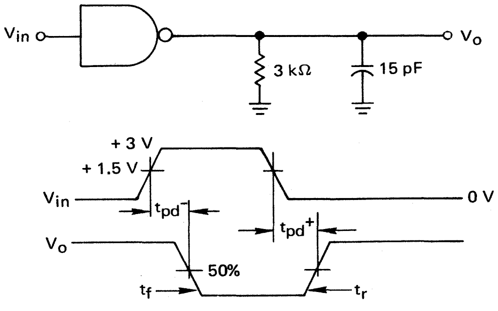
OUTPUT RESISTANCE (POWER-OFF)



POWER-SUPPLY CURRENTS



SWITCHING RESPONSE



t_r and t_f measured 10% to 90%

QUAD DTL LINE DRIVER ML1488

applications information

GENERAL

Specification RS-232C, released by the Electronic Industries Association (EIA), prescribes requirements for devices or systems used to interface data processing equipment with data communications equipment. This standard specifies the voltage levels to be used as well as the number and types of interface leads. The ML1488 and ML1489, quad line driver and quad line receiver, respectively, constitute a complete system for interfacing between DTL or TTL logic levels and the levels defined by RS-232C. The following paragraphs discuss the RS-232C requirements applicable to drivers, and Figure 1 shows a typical application.

RS-232C defines the required driver voltages as between 5 and 15 volts in magnitude, positive for logic "0" and negative for logic "1". These definitions also include that the drivers be terminated with a resistance of 3kΩ to 7kΩ. The ML1488 satisfies these requirements by the single-stage inversion of DTL/TTL logic levels to RS-232C levels.

RS-232C also specifies that the slew rate of the driver output must not exceed 30V/μs during transitions. The inherent slew rate of the ML1488 is much too fast for this requirement. This slew rate can be controlled by use of the current limited output of the ML1488. The method is to connect a capacitor to each driver output, the value of which can be calculated from the equation $C = I_{SC} \times \Delta T/\Delta V$. Figure 2 (derived from this relationship) shows that a 330pF capacitor on each output will guarantee a worst-case slew rate of 30V/μs.

FIGURE 1
TYPICAL RS-232C APPLICATION

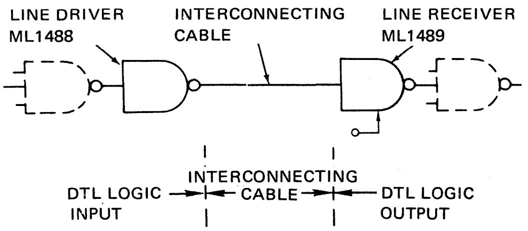
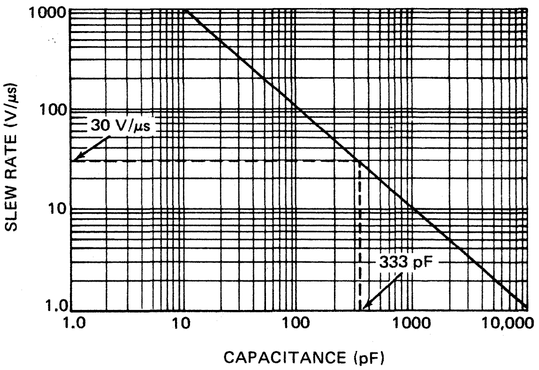


FIGURE 2
SLEW RATE
AS A FUNCTION OF
CAPACITANCE (FOR I_{SC} = 10 mA)

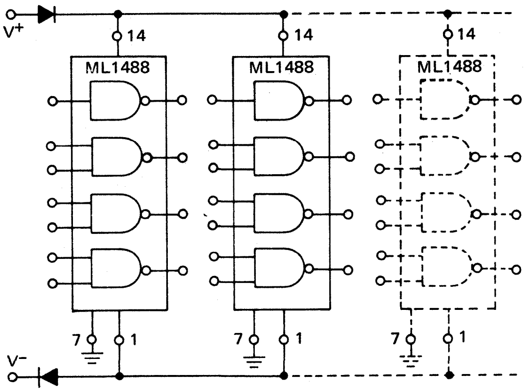


It is also a requirement of RS-232C that the interface driver be capable of withstanding an accidental short to any other conductor in an interconnecting cable. Another driver using a ±15V, 500mA source would be the worst possible signal on any conductor. The design of the ML1488 allows it to withstand indefinitely such a short to all four outputs in a package, provided the supply voltages are greater than 9.0V (i.e., $V^+ \geqslant +9.0V$, $V^- \leqslant -9.0V$). Some power supply designs are such that a loss of system power results in a low impedance on the supply outputs, and a low impedance to ground would exist at the ML1488 power inputs, effectively shorting the 300Ω output resistors to ground. These resistors would dissipate excessive power if all four outputs were then shorted to ±15V. Therefore, to prevent over-heating in a system designed to permit low impedances to ground at the driver supplies, a diode should be placed in each supply lead. Figure 3 shows how these two diodes could be used to decouple all the driver packages in a system. (These same two diodes make it possible for the ML1488 to withstand momentary shorts to the ±25V limits specified in the earlier Standard RS-232B.) The ML1488 can also withstand faults with supplies of less than the 9.0V stated previously if these diodes are employed.

The previously-mentioned 10mA output current limiting more than guarantees the maximum short-circuit current permissible under fault conditions.

applications information (cont'd)

FIGURE 3
POWER SUPPLY PROTECTION TO MEET POWER-OFF FAULT CONDITIONS



SPECIAL FEATURES

The ML1488 is extremely versatile and, as such, has countless possible applications. This versatility is enhanced by several features, some of which are discussed in the following paragraphs.

Output current limiting allows the designer to establish output voltage levels independent of power supplies and can be effected by the diode-clamping of the output pins. Figure 4 illustrates how the ML1488 can be used as a DTL-to-MOS translator where one diode clamps the high-level output voltage above ground. The resistor divider shown serves to reduce the output voltage to below the MOS input level limit (i.e. to < 300mV above ground).

As shown in the schematic diagram of the driver (front page), matching supplies are not required for the positive and negative driving elements of the ML1488 because these elements are essentially independent. It is permissible for the positive supply to vary from a minimum of +7V (required for driving the negative pull-down section) to the specified maximum +15V. The permissible variation for the negative supply is from −2.5V to −15V. Provided the output current limits are not exceeded, the ML1488 will drive the output to within 2V of the positive or negative supplies.

The combination of the two features of wide supply-voltage range and output-current-limiting allows for numerous combinations of possible outputs from the same quad package. If only some of the four drivers in a package are driving RS-232C lines, the remainder could be translating DTL-to-MOS or DTL-to-DTL. An illustrative combination is shown in Figure 5.

FIGURE 4
DTL/TTL-TO-MOS TRANSLATOR

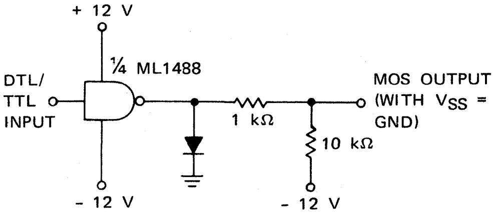
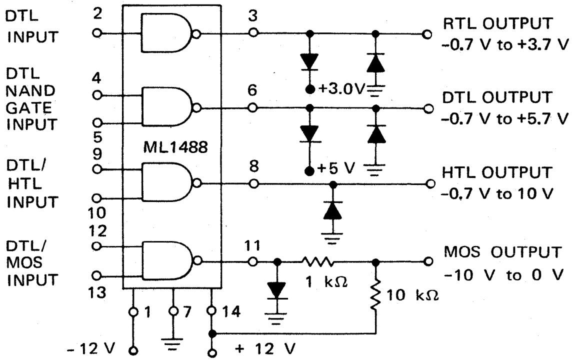


FIGURE 5
LOGIC TRANSLATOR APPLICATIONS



QUAD DTL LINE RECEIVERS ML1489, ML1489A

features

- Input Resistance of 3.0kΩ to 7.0kΩ
- Input Signal Range of ±30V
- Built-in Input Threshold Hysteresis
- Response Control to Achieve Logic Threshold Shifting and Input Noise Filtering

description

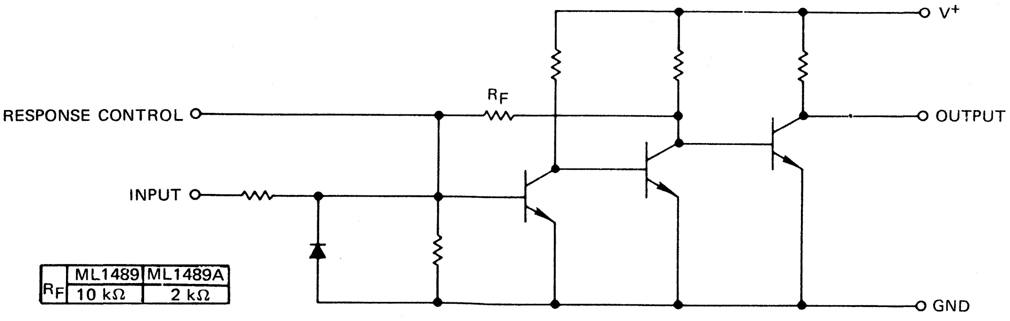
The Microsystems International ML1489 and ML1489A monolithic quad line receivers are designed mainly for use in interfacing data terminal equipment with data communications equipment and conform with the specifications of EIA Standard No. RS-232C.

absolute maximum ratings (at T_A = + 25°C)

Supply Voltage	+10 Vdc	Internal Power Dissipation (Note 1)	1 W
Input Signal Range	±30 Vdc	Operating Temperature Range	0°C to + 75°C
Output Load Current	20 mA	Storage Temperature Range	–65°C to +175°C

Note 1. Rating applies for case temperatures up to + 75°C. Derate at 6.7 mW/°C for operation at ambient temperatures above + 25°C.

schematic diagram (¼ of circuit shown)



	ML1489	ML1489A
R_F	10 kΩ	2 kΩ

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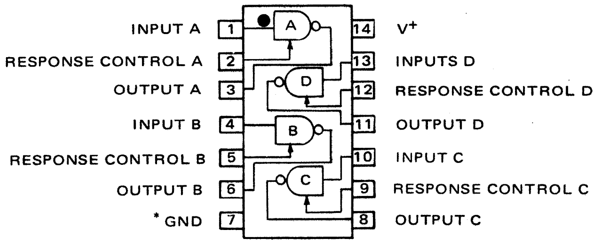
QUAD DTL LINE RECEIVERS ML1489, ML1489A

connection diagram

DUAL-IN-LINE PACKAGE
(Top View)



*Pin 7 connected to package bottom

electrical characteristics

(Response Control pin open) ($V^+ = +5.0$ Vdc ±1%, 0°C $\leqslant T_A \leqslant$ +75°C unless otherwise specified.) (See Test Circuits on pages 4 and 5.)

PARAMETERS	SYMBOLS	CONDITIONS		MIN.	TYP.	MAX.	UNITS
Positive Input Current	I_{IH}	V_{in} = + 25 Vdc		3.6	–	8.3	mA
		V_{in} = + 3.0 Vdc		0.43	–	–	
Negative Input Current	I_{IL}	V_{in} = - 25 Vdc		- 3.6	–	- 8.3	mA
		V_{in} = - 3.0 Vdc		- 0.43	–	–	
Input Turn-On Threshold Voltage	V_{IH}	T_A = + 25°C, $V_{OL} \leqslant 0.45$ V	ML1489	1.0	–	1.5	Vdc
			ML1489A	1.75	1.95	2.25	
Input Turn-Off Threshold Voltage	V_{IL}	T_A = + 25°C, $V_{OH} \geqslant 2.5$ V, I_L = - 0.5 mA	ML1489	0.75	–	1.25	Vdc
			ML1489A	0.75	0.8	1.25	
Output Voltage High	V_{OH}	V_{in} = 0.75 V, I_L = - 0.5 mA		2.6	4.0	5.0	Vdc
		Input Open Circuit, I_L = - 0.5 mA		2.6	4.0	5.0	
Output Voltage Low	V_{OL}	V_{in} = 3.0 V, I_L = 10 mA		–	0.2	0.45	Vdc
Output Short-Circuit Current	I_{SC}	–		–	3.0	–	mA
Supply Current	I_S^+	V_{in} = + 5.0 Vdc		–	20	26	mA
Power Dissipation	P_D	V_{in} = + 5.0 Vdc		–	100	130	mW

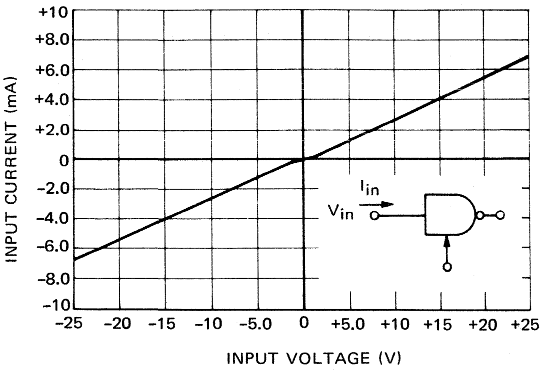
switching characteristics

(V^+ = 5.0 Vdc ±1%, T_A = +25°C)

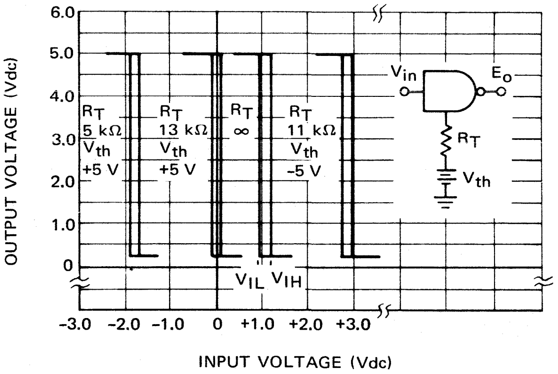
PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Propagation Delay Time	t_{pd}^+	R_L = 3.9 kΩ	–	25	85	ns
Rise Time	t_r	R_L = 3.9 kΩ	–	120	175	ns
Propagation Delay Time	t_{pd}^-	R_L = 390 Ω	–	25	50	ns
Fall Time	t_f	R_L = 390 Ω	–	10	20	ns

typical performance curves (V^+ = +5.0 Vdc, T_A = +25°C unless otherwise noted)

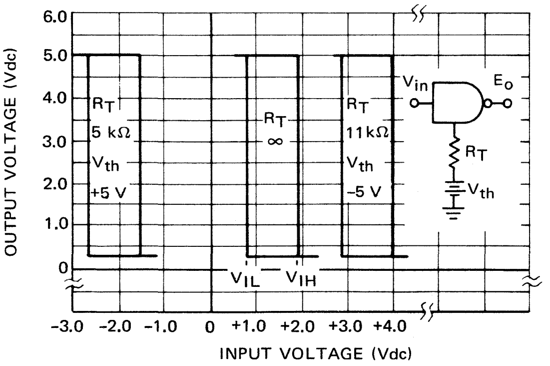
INPUT CURRENT



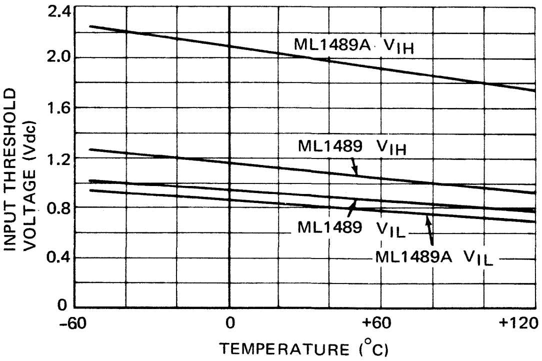
ML1489 INPUT THRESHOLD VOLTAGE ADJUSTMENT



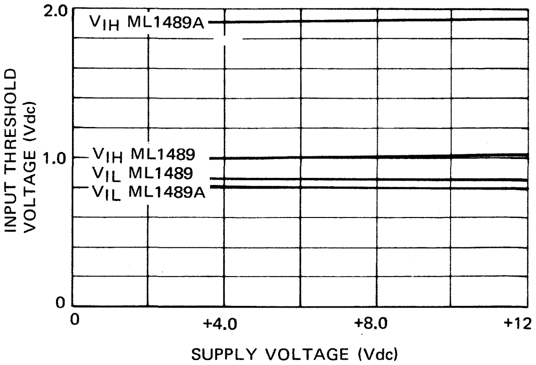
ML1489A INPUT THRESHOLD VOLTAGE ADJUSTMENT



INPUT THRESHOLD VOLTAGE AS A FUNCTION OF TEMPERATURE

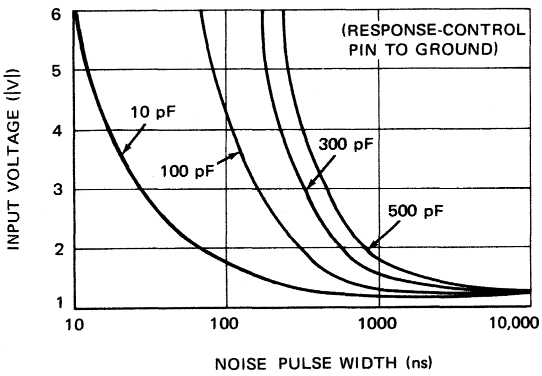


INPUT THRESHOLD VOLTAGE AS A FUNCTION OF POWER SUPPLY VOLTAGE

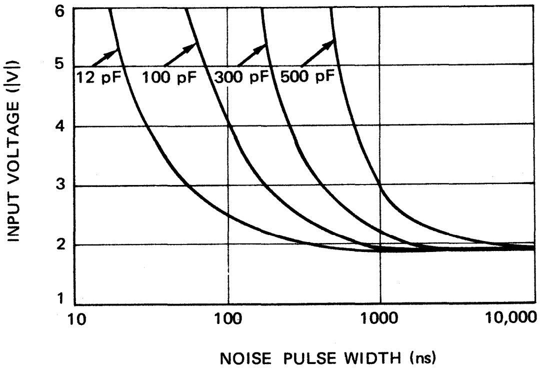


QUAD DTL LINE RECEIVERS ML1489, ML1489A

ML1489 NOISE REJECTION

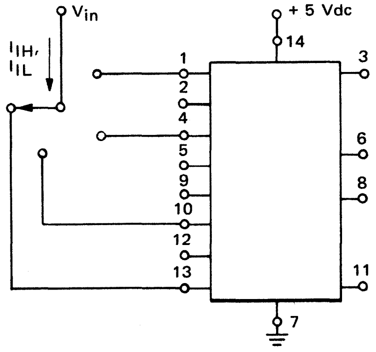


ML1489A NOISE REJECTION

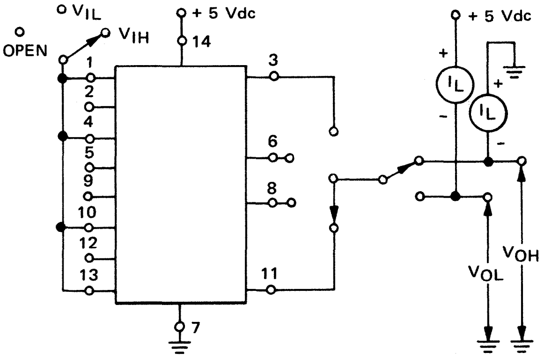


test circuits

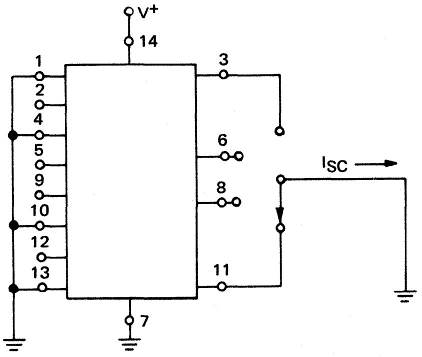
INPUT CURRENT



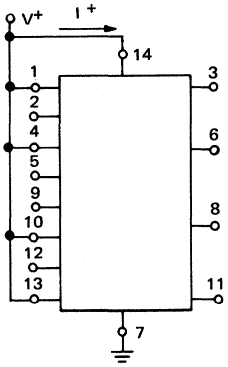
OUTPUT VOLTAGE and INPUT THRESHOLD VOLTAGE



OUTPUT SHORT-CIRCUIT CURRENT

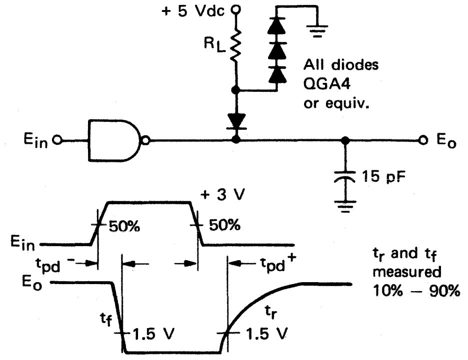


POWER-SUPPLY CURRENT

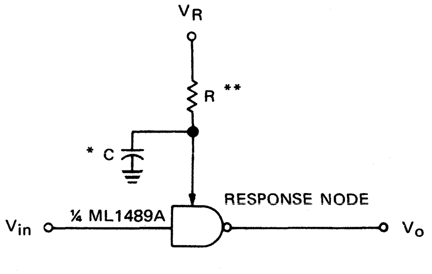


QUAD DTL LINE RECEIVERS ML1489, ML1489A

SWITCHING RESPONSE



RESPONSE CONTROL NODE



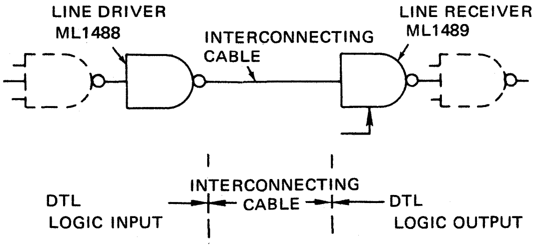
* capacitor C is for noise filtering
** resistor R is for threshold shifting

applications information

GENERAL

Specification RS-232C, released by the Electronic Industries Association (EIA), prescribes requirements for devices or systems used to interface data processing equipment with data communications equipment. This standard specifies the voltage levels to be used as well as the number and types of interface leads. The ML1488 and ML1489, quad line driver and quad line receiver, respectively, constitute a complete system for interfacing between DTL or TTL logic levels and the levels defined by RS-232C. The following paragraphs discuss the RS-232C requirements applicable to receivers, and Figure 1 shows a typical application.

FIGURE 1
TYPICAL RS-232C APPLICATION



RS-232C defines required input impedance as between 3kΩ and 7kΩ for the input voltage range of 3.0V to 25V in magnitude. In an open circuit condition the magnitude of any voltage on the receiver input must be below 2.0V. The ML1489 and ML1489A satisfy these requirements by having a maximum open circuit voltage of 1 V_{BE} (Ref. Sect. 2.4 of RS-232C).

Input voltages between −3.0V and −25V must be interpreted by the receiver as logic "1", and inputs between +3V and +25V as logic "0" (Ref. Sect. 2.3). Section 2.5 specifies that, on certain interchange leads, an open circuit or "Power OFF" condition (≥300Ω to ground) shall be detected as an "OFF" condition or logic "1". The input hysteresis thresholds of the ML1489, therefore, are all greater than ground potential. Consequently, an open or grounded input will result in the same output as a negative or logic "1" input.

applications information (cont'd)

DEVICE CHARACTERISTICS

Input hysteresis for noise rejection is provided in the ML1489 and ML1489A by internal feedback from the second stage to the input stage. The ML1489 input has a turn-on voltage of 1.25V (typ.) and turn-off of 1.0V (typ.), giving a hysteresis of 250mV (typ.). The ML1489A figures are 1.95V, 0.8V and 1.15V, respectively.

In addition to the input and output pins, each receiver section has an external response control node. This feature permits the designer to vary the input threshold voltage levels. A resistor can be connected between this node and an external power supply. The input threshold voltage shift possible through this technique is shown in the last test circuit (page 5) and the second and third performance curves (page 3).

This response node can also be used to filter high-frequency, high-energy noise pulses. The last two performance curves (page 4) illustrate typical noise-pulse rejection for various sizes of external capacitors.

Many different combinations of interfacing applications are possible by individual or combined use of these two response node operations. The ML1489 and ML1489A are well suited to applications involving interfacing between MOS circuits and DTL/TTL logic systems. In such a case, shown in Figure 2, the use of appropriate resistor and supply values adjusts the input threshold voltages to lie midway between the MOS logic levels.

It is possible to use the response node as the receiver input, provided this node is not driven with a low impedance source to a voltage removed from ground (either above or below) by greater than one diode. Figure 3 illustrates this feature, showing two receivers connected to the same line that must still satisfy the requirements of RS-232C.

FIGURE 2
TYPICAL TRANSLATOR APPLICATION
MOS-TO-DTL/TTL

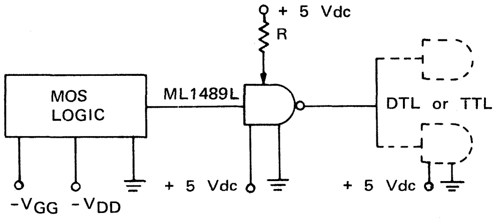
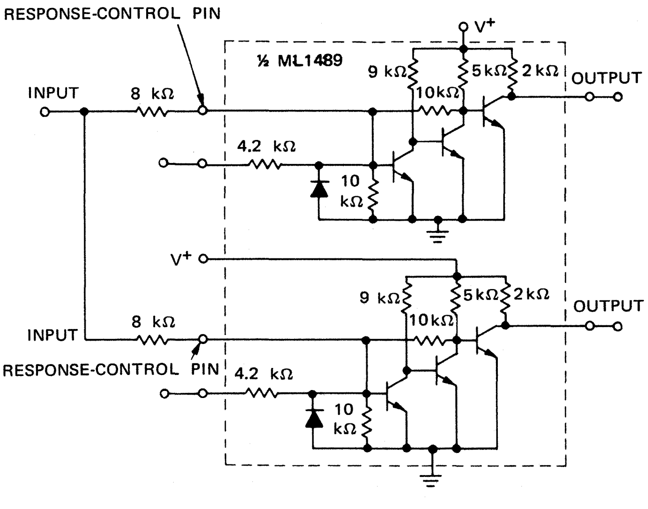


FIGURE 3
TYPICAL PARALLELING OF TWO
ML1489 RECEIVERS TO MEET RS-232C



DISPLAY DIGIT DRIVER ML4102

features

- Low Input Current
- 40mA Current Sink Capability
- Low Output on Voltage−0.85V Typ.

description

The ML4102 is an 8 channel digit driver with low input current requirement. It provides current sink capability for an 8 digit LED display in a single package.

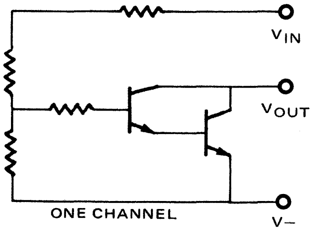
absolute maximum ratings

Voltage from V_{OUT} to V−	+12V, −0V	Voltage from V_{IN} to V−	+12V, −0V
Voltage from V_{IN} to V_{OUT}	±12V		
Internal Power Dissipation(1) Plastic D.I.P.	800 mV	Operating Temperature Range	0°C to +70°C
		Lead Temperature (Soldering, 10 sec.)	260°C
Storage Temperature	-55°C to +125°C		

NOTE

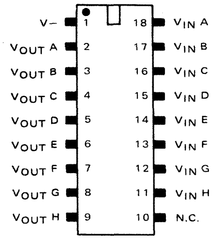
(1) Rating applies to ambient temperatures up to +45°C. Above +45°C ambient derate linearly at 10mW/°C.

schematic diagram



connection diagram

DUAL-IN-LINE PACKAGE
(Top View)



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DISPLAY DIGIT DRIVER ML4102

electrical characteristics (per channel)

T_A= +25°C, V−=0V,5V≤V_{IN}≤10V, unless otherwise specified.

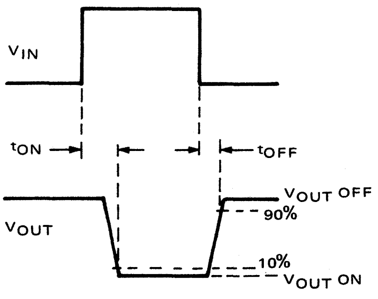
PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Output ON Voltage	V_O ON	I_{OUT}=40mA V_{IN}=5V	–	.85	1.0	V
Output OFF Current	I_O OFF	V_{OUT}=10V I_{IN}=25μA	–	–	300	μA
Input MAX. Current	I_I MAX.	V_{IN}=10V	–	250	400	μA

switching characteristics (per channel)

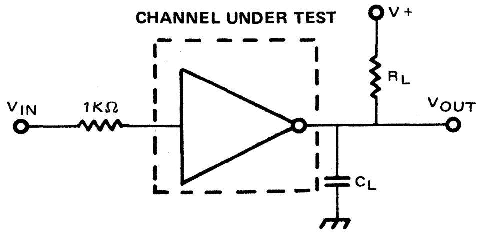
TA=+25°C, V− = 0V, V+ =5V

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Turn ON Time	t_{on}	V_{IN}=5V peak R_L=100Ω,C_L=100pF		2	5.0	μs
Turn OFF Time	t_{off}	V_{IN}=5V peak R_L=100Ω, C_L=100pF		.3	5.0	μs

SWITCHING WAVEFORMS



TEST CIRCUIT



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SELECTED LINEAR I.C. CATALOGUE

Ref. Diodes and Transistor/Diode Arrays

10

MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STATION C, OTTAWA, CANADA, K1Y 4J1

package availability

PRODUCT CODE	PACKAGE CODE					
	T Metal Can	**D** Hermetic D.I.L. Ceramic	**P** Molded D.I.L. Plastic	**M** Hermetic D.I.L. Metal	**S** Molded D.I.L. Plastic	**F** Flat Pack
ML113	●					
ML213	●					
ML313	●					
ML3045		●		●		
ML3046		●	●			
ML3083		●	●			
ML3100					●	
ML3118		●	●			
ML3119	●					
ML3136	●					
ML3139		●	●			
ML3145		●	●			
ML3154		●	●			
ML3183		●	●			
ML3484		●	●			
ML3923		●	●			

LOW-VOLTAGE REFERENCE DIODES. ML113, ML213, ML313

features

- Extremely Low Breakdown Voltage
- Good Temperature Stability
- Low Dynamic Impedance Over Wide Operating Current Range
- Tight Tolerance

description

The Microsystems International ML113, ML213 and ML313 are temperature-compensated, low-voltage reference diodes. They are synthesized by the fabrication of transistors and resistors in a monolithic integrated circuit. This technique provides for the same low noise and long-term stability as state-of-the-art IC operational amplifiers. The fact that the devices' output voltages are dependent only upon the highly-predictable properties of components in the integrated circuit permits them to be manufactured and supplied to close tolerances. Since the breakdown voltage is equal to the energy-band-gap voltage of silicon, these reference diodes are useful for numerous temperature compensation and temperature measurement applications. The characteristics of the ML113 family make it especially suited for uses in low-voltage power supplies, bias- regulation circuitry or in battery powered equipment.

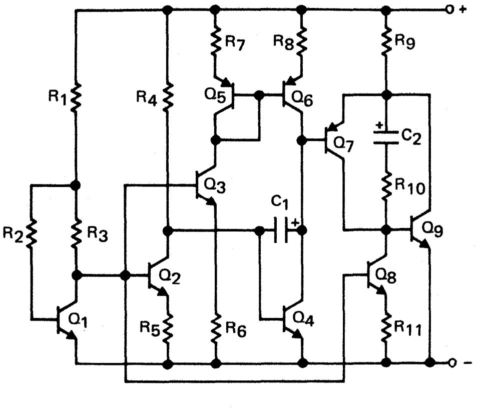
absolute maximum ratings

Power Dissipation (Note 1)	100mW
Reverse Current	50mA
Forward Current	50mA
Lead Temperature (soldering, 10 sec)	300°C

Operating Temperature Range		
	ML113	−55°C to +125°C
	ML213	−25°C to +85°C
	ML313	0°C to 70°C
Storage Temperature Range		−65°C to +150°C

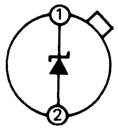
Note 1. Rating applies for case temperatures up to the respective maximum operating temperature. For the ML113 derate linearly at 2.3mW/°C for operation at ambient temperatures above +106°C.

schematic diagram



connection diagram

(Top View)



NOTE: Pin 2 connected to case

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international

LOW-VOLTAGE REFERENCE DIODES. ML113, ML213, ML313

electrical characteristics (T_A = 25°C unless otherwise specified) (See notes)

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Reverse Breakdown Voltage	BV_R	$I_R = 1mA$	1.160	1.220	1.280	V
Reverse Breakdown Voltage Change	ΔBV_R	$0.5mA \leqslant I_R \leqslant 20mA$	–	6.0	15	mV
Reverse Dynamic Impedance	Z_R	$I_R = 1mA$	–	0.2	1.0	Ω
		$I_R = 10mA$	–	0.25	0.8	
Forward Voltage Drop	V_F	$I_F = 1.0mA$	–	0.67	1.0	V
RMS Noise Voltage	V_N	$10Hz \leqslant f \leqslant 10kHz$ $I_R = 1mA$	–	5	–	μV_{rms}
Reverse Breakdown Voltage Change	ΔBV_R	$0.5mA \leqslant I_R \leqslant 10mA$ $T_{min} \leqslant T_A \leqslant T_{max}$	–	–	15	mV
Breakdown Voltage Coefficient	$\frac{\Delta BV_R}{\Delta T}$	$1.0mA \leqslant I_R \leqslant 10mA$ $T_{min} \leqslant T_A \leqslant T_{max}$	–	0.01	–	%/°C

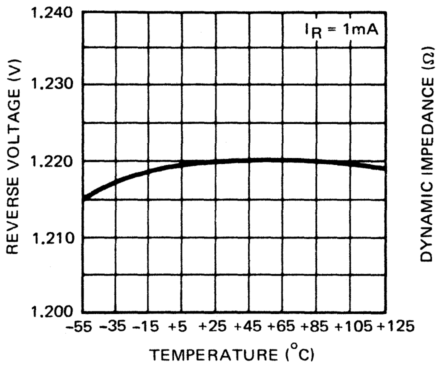
Notes: 1. T_{min} and T_{max} refer to the extremes of the respective operating temperature range.

2. The ML113 standard tolerance is ±5%. The ML113-1 and ML113-2, with tolerances of ±1% and ±2%, respectively, are available on special order (also applies to ML213 and ML313).

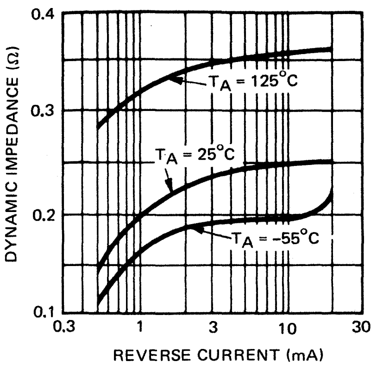
3. At high currents, breakdown voltage should be measured with lead lengths less than 0.25 inch. Kelvin contact sockets are also recommended. The diodes should not be operated with shunt capacitances between 200pF and 0.1µF, unless isolated by a least a 100Ω resistor, as they may oscillate at some currents.

typical performance curves (over respective operating temperature ranges)

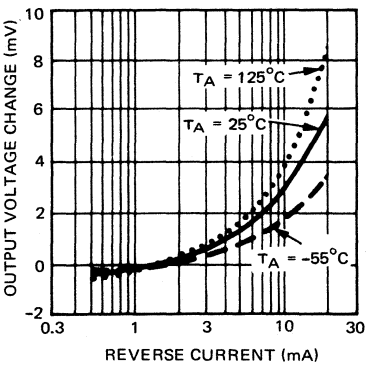
REVERSE VOLTAGE AS A FUNCTION OF AMBIENT TEMPERATURE



DYNAMIC IMPEDANCE AS A FUNCTION OF REVERSE CURRENT

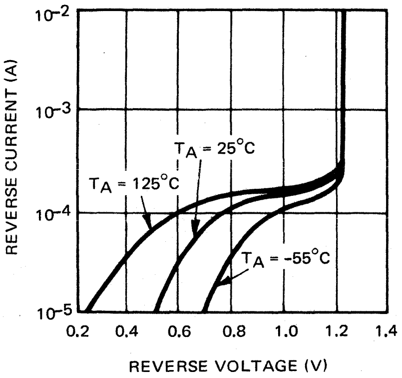


CHANGE IN OUTPUT VOLTAGE AS A FUNCTION OF REVERSE CURRENT

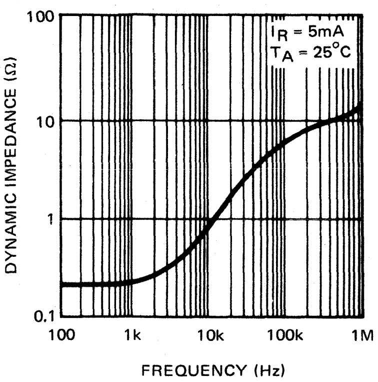


LOW-VOLTAGE REFERENCE DIODES ML113, ML213, ML313

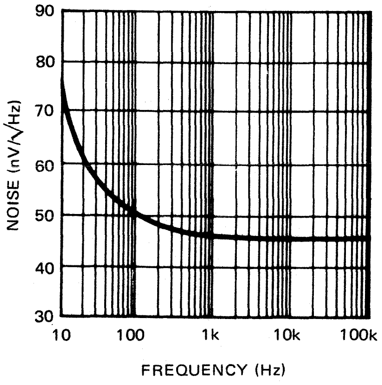
REVERSE CURRENT AS A FUNCTION OF REVERSE VOLTAGE



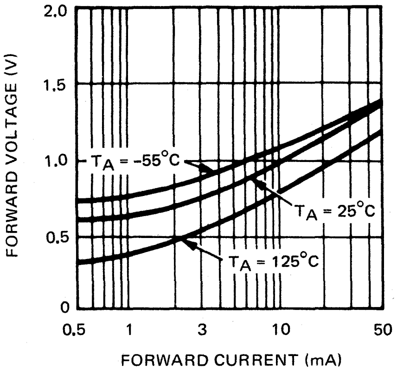
DYNAMIC IMPEDANCE AS A FUNCTION OF FREQUENCY



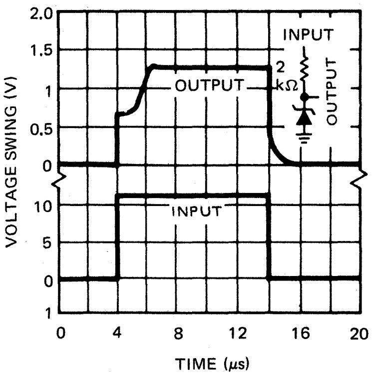
NOISE AS A FUNCTION OF FREQUENCY



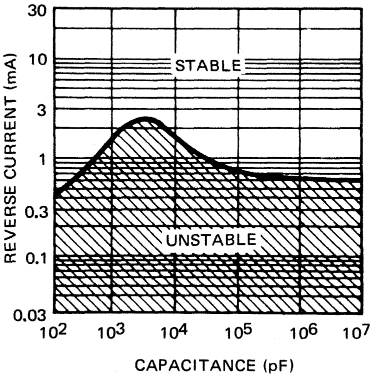
FORWARD VOLTAGE AS A FUNCTION OF FORWARD CURRENT



RESPONSE TIME

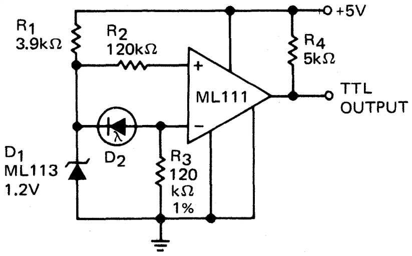


REVERSE CURRENT AS A FUNCTION OF SHUNT CAPACITANCE

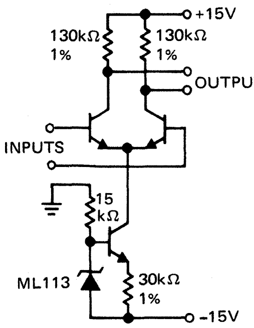


typical applications

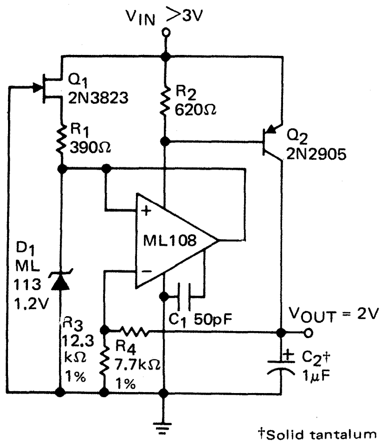
LEVEL DETECTOR FOR PHOTODIODE



AMPLIFIER BIASING FOR CONSTANT GAIN WITH TEMPERATURE



LOW VOLTAGE REGULATOR



†Solid tantalum

HIGH FREQUENCY TRANSISTOR ARRAYS. ML3045, ML3046

features

- Matching V_{BE} – ($\Delta V_{BE} \leqslant 5$ mV)
- Matching Current Gain – ($|I_{B1} - I_{B2}| \leqslant 2\mu$A at I_C = 1mA)
- Low Noise Figure – 3.2 dB Typ. at 1 kHz
- Operation From DC to 120 MHz
- Wide Operating Current Range
- ML3045 in High Rel. Hermetic Package
- ML3046 in Low Cost Plastic Package

description

The ML3045 and ML3046 are each monolithic arrays of five general-purpose, high frequency transistors arranged as three isolated transistors and a differential pair. These transistors are well suited to a wide variety of applications in low-power systems from DC through to VHF. They may be used as discrete transistors in conventional circuits, however, they also provide the very significant advantages of close electrical and thermal matching inherent in integrated circuits. Applications include general use in all types of signal processing systems in the DC to VHF range, custom designed differential amplifiers, and temperature compensated amplifiers.

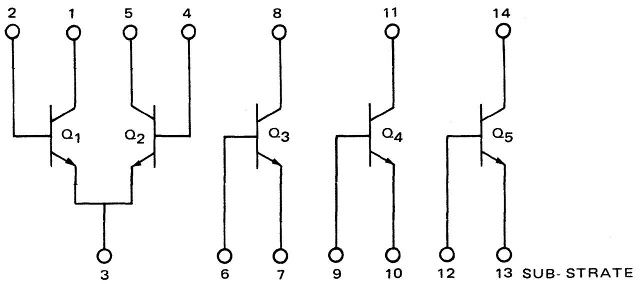
absolute maximum ratings (at T_A = 25°C)

Operating Temperature Range	
ML3045	–55°C to +125°C
ML3046	0°C to +85°C
Storage Temperature Range	
ML3045	–65°C to +150°C
ML3046	–25°C to +85°C
Internal Power Dissipation (Note 1)	
Each Transistor	300 mW
Total Package	750 mW
Collector-to-Emitter Voltage, V_{CEO}	15 V
Collector-to-Base Voltage, V_{CBO}	20 V
Collector to Substrate Voltage, V_{CIO} (Note 2)	20 V
Emitter-to-Base Voltage, V_{EBO}	5 V
Collector Current, I_C	50 mA

Notes:

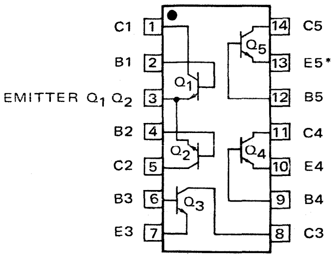
1. Rating applies for case temperatures up to respective maximum operating temperature. For the ML3045 derate linearly at 8 mW/°C for operation at ambient temperatures above +75°C; for the ML3046 derate linearly at 6.67 mW/°C for operation at ambient temperatures above +55°C.
2. The collector of each transistor of the ML3045 and ML3046 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.

schematic diagram



HIGH FREQUENCY TRANSISTOR ARRAYS ML3045, ML3046

connection diagram



* Emitter 5 connected to substrate

static electrical characteristics (at $T_A = 25°C$)

Characteristics apply for each transistor in the ML3045 and ML3046 as specified.

PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Collector-to-Base Breakdown Voltage	BV_{CBO}	$I_C = 10\,\mu A$, $I_E = 0$	20	60	–	V
Collector-to-Emitter Breakdown Voltage	BV_{CEO}	$I_C = 1$ mA, $I_B = 0$	15	24	–	V
Collector-to-Substrate Breakdown Voltage	BV_{CIO}	$I_{C1} = 10\,\mu A$, $I_B = 0$	20	60	–	V
Emitter-to-Base Breakdown Voltage	BV_{EBO}	$I_E = 10\,\mu A$, $I_C = 0$	5	7	–	V
Collector-Cutoff Current	I_{CBO}	$V_{CB} = 10$ V, $I_E = 0$	–	0.002	40	nA
Collector-Cutoff Current	I_{CEO}	$V_{CE} = 10$ V, $I_B = 0$	–	See Curve	0.5	μA
Static Forward Current-Transfer Ratio (Static Beta)	h_{FE}	$V_{CE} = 3$ V $\begin{cases} I_C = 10 \text{ mA} \\ I_C = 1 \text{ mA} \\ I_C = 10\,\mu A \end{cases}$	– 40 –	100 100 54	– – –	– – –
Input Offset Current for Matched Pair Q_1 and Q_2. $\lvert I_{B1} - I_{B2}\rvert$	–	$V_{CE} = 3$ V, $I_C = 1$ mA	–	0.3	2	μA
Base-to-Emitter Voltage	V_{BE}	$V_{CE} = 3$ V $\begin{cases} I_E = 1 \text{ mA} \\ I_E = 10 \text{ mA} \end{cases}$	– –	0.715 0.800	– –	V
Magnitude of Input Offset Voltage for Differential Pair $\lvert V_{BE_1} - V_{BE_2}\rvert$	–	$V_{CE} = 3$ V, $I_C = 1$ mA	–	0.45	5	mV
Magnitude of Input Offset Voltage for Isolated Transistors $\lvert V_{BE_3} - V_{BE_4}\rvert$, $\lvert V_{BE_4} - V_{BE_5}\rvert$, $\lvert V_{BE_5} - V_{BE_3}\rvert$	–	$V_{CE} = 3$ V, $I_C = 1$ mA	–	0.45	5	mV
Temperature Coefficient of Base-to-Emitter Voltage	$\frac{\Delta V_{BE}}{\Delta T}$	$V_{CE} = 3$ V, $I_C = 1$ mA	–	–1.9	–	mV/°C
Collector-to-Emitter Saturation Voltage	$V_{CE_{sat}}$	$I_B = 1$ mA, $I_C = 10$ mA	–	0.23	–	V
Temperature Coefficient: Magnitude of Input-Offset Voltage	$\frac{\lvert \Delta V_{IO}\rvert}{\Delta T}$	$V_{CE} = 3$ V, $I_C = 1$ mA	–	1.1	–	μV/°C

HIGH FREQUENCY TRANSISTOR ARRAYS........ ML3045, ML3046

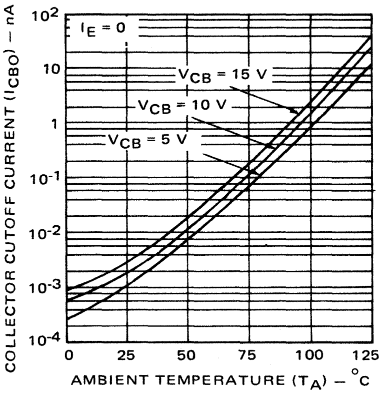
dynamic electrical characteristics (at $T_A = 25°C$)

Characteristics apply for each transistor in the ML3045 and ML3046 as specified.

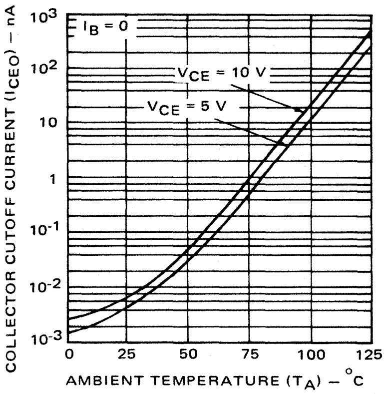
PARAMETERS	SYMBOLS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Low-Frequency Noise Figure	NF	f = 1 kHz, V_{CE} = 3 V, I_C = 100 μA R_S (Source Resistance) = 1 kΩ	–	3.25	–	dB
Low-Frequency, Small-Signal Equivalent-Circuit Characteristics:		f = 1 kHz, V_{CE} = 3 V, I_C = 1 mA				
Forward Current-Transfer Ratio	h_{fe}		–	110	–	–
Short-Circuit Input Impedance	h_{ie}		–	3.5	–	kΩ
Open-Circuit Output Impedance	h_{oe}		–	15.6	–	μmho
Open-Circuit Reverse Voltage-Transfer Ratio	h_{re}		–	1.8×10^{-4}	–	–
Admittance Characteristics:		f = 1 MHz, V_{CE} = 3 V, I_C = 1 mA				
Forward Transfer Admittance	Y_{fe}		–	31 – j1.5	–	–
Input Admittance	Y_{ie}		–	0.3 + j0.04	–	–
Output Admittance	Y_{oe}		–	0.001 + j0.03	–	–
Reverse Transfer Admittance	Y_{re}		–	See curve	–	–
Gain-Bandwidth Product	f_T	V_{CE} = 3 V, I_C = 3 mA	300	550	–	MHz
Emitter-to-Base Capacitance	C_{EB}	V_{EB} = 3 V, I_E = 0	–	0.6	–	pF
Collector-to-Base Capacitance	C_{CB}	V_{CB} = 3 V, I_C = 0	–	0.58	–	pF
Collector-to-Substrate Capacitance	C_{CI}	V_{CS} = 3 V, I_C = 0	–	2.8	–	pF

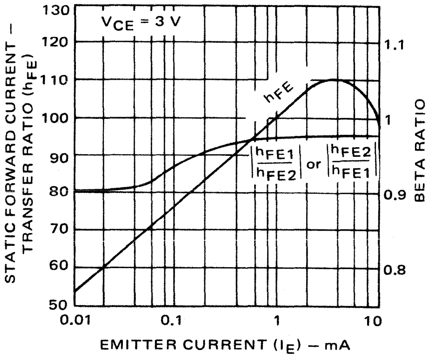
typical static characteristics ($T_A = 25°C$, unless otherwise specified)

COLLECTOR-TO-BASE CUTOFF CURRENT VS AMBIENT TEMPERATURE FOR EACH TRANSISTOR

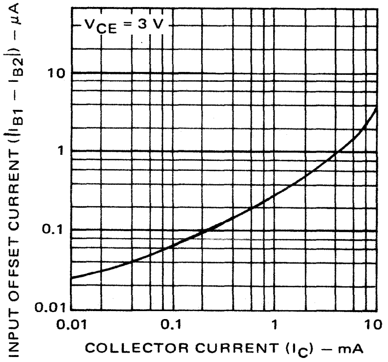


COLLECTOR-TO-EMITTER CUTOFF CURRENT VS AMBIENT TEMPERATURE FOR EACH TRANSISTOR

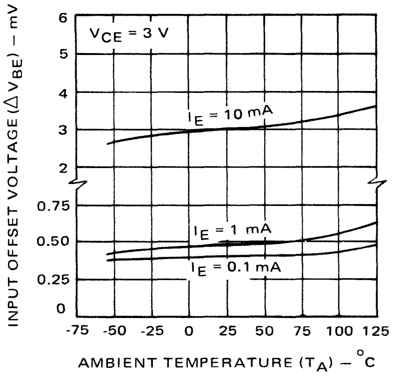




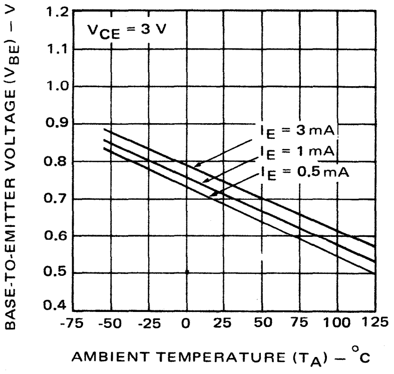
STATIC FORWARD CURRENT-TRANSFER RATIO AND BETA RATIO FOR TRANSISTORS Q_1 AND Q_2 VS EMITTER CURRENT



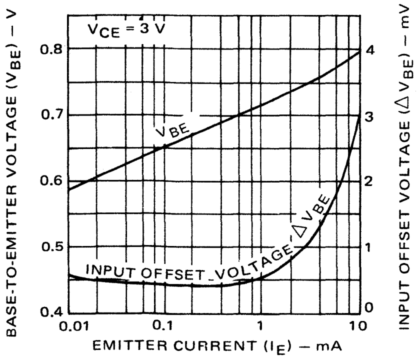
INPUT OFFSET CURRENT FOR MATCHED TRANSISTOR PAIR Q_1 Q_2 VS COLLECTOR CURRENT



INPUT OFFSET VOLTAGE CHARACTERISTICS FOR DIFFERENTIAL PAIR AND PAIRED ISOLATED TRANSISTORS VS AMBIENT TEMPERATURE



BASE-TO-EMITTER VOLTAGE CHARACTERISTIC VS AMBIENT TEMPERATURE FOR EACH TRANSISTOR

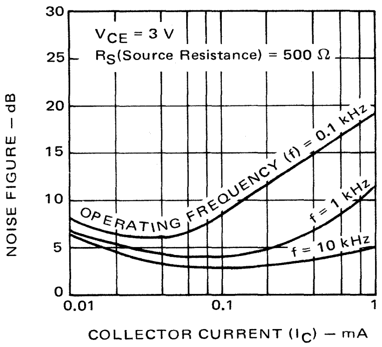


STATIC BASE-TO-EMITTER VOLTAGE CHARACTERISTIC AND INPUT OFFSET VOLTAGE FOR DIFFERENTIAL PAIR AND PAIRED ISOLATED TRANSISTORS VS EMITTER CURRENT

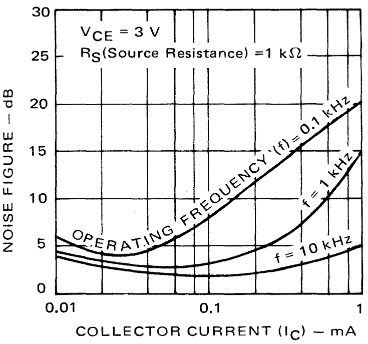
HIGH FREQUENCY TRANSISTOR ARRAYS. ML3045, ML3046

typical dynamic characteristics for each transistor (T_A = 25°C, unless otherwise specified)

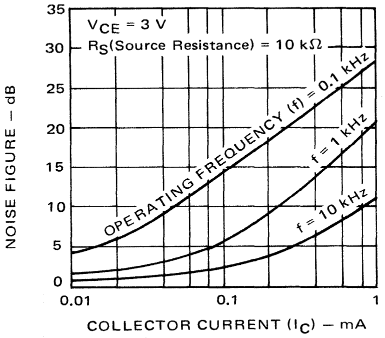
NOISE FIGURE VS COLLECTOR CURRENT



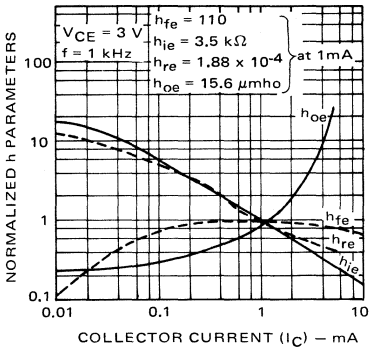
NOISE FIGURE VS COLLECTOR CURRENT



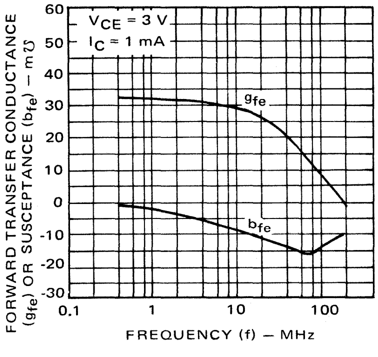
NOISE FIGURE VS COLLECTOR CURRENT



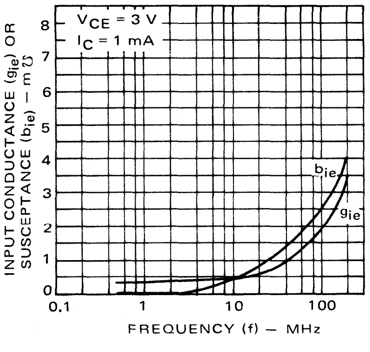
NORMALIZED FORWARD CURRENT-TRANSFER RATIO, SHORT-CIRCUIT INPUT IMPEDANCE, OPEN-CIRCUIT OUTPUT IMPEDANCE, AND OPEN-CIRCUIT REVERSE VOLTAGE-TRANSFER RATIO VS COLLECTOR CURRENT



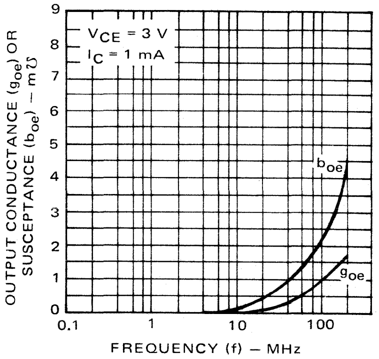
FORWARD TRANSFER ADMITTANCE VS FREQUENCY (COMMON-EMITTER CIRCUIT, BASE INPUT)



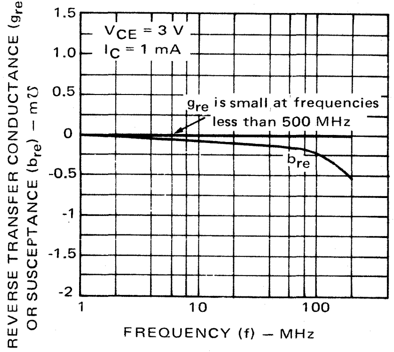
INPUT ADMITTANCE VS FREQUENCY (COMMON-EMITTER CIRCUIT, BASE INPUT)



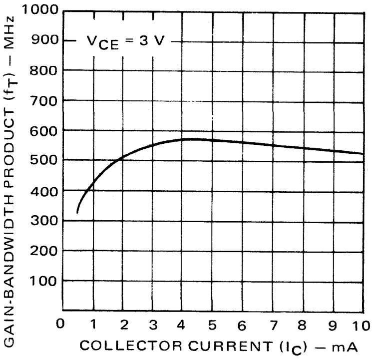
OUTPUT ADMITTANCE VS FREQUENCY (COMMON-EMITTER CIRCUIT, BASE INPUT)



REVERSE TRANSFER ADMITTANCE VS FREQUENCY (COMMON-EMITTER CIRCUIT, BASE INPUT)



GAIN-BANDWIDTH PRODUCT VS COLLECTOR CURRENT



GENERAL PURPOSE HIGH CURRENT N-P-N TRANSISTOR ARRAYS ML3183, ML3083

features

- Five Independent Transistors Plus Separate Substrate Connection
- High Current Gain .
- Good H_{FE} Linearity vs Collector Current
- Matched Pair (Q_1 and Q_2)
  Vio (V_{BE} Matched): ±5mV max.
  Iio (@ 1 mA): 0.5µA max.

description

Mounted on a common monolithic substrate, the ML3183, 3083 provides an array of five high performance NPN transistors; two of them, Q_1 and Q_2, matched at 1mA for applications having critical offset parameters. Independent terminals for transistor elements and a separate terminal for the substrate connection permit maximum flexibility in applications circuit design such as for thyristor firing, temperature compensated amplification, and signal processing, and for systems operating from dc to VHF.

The device features a 16 lead dual in line moulded package.

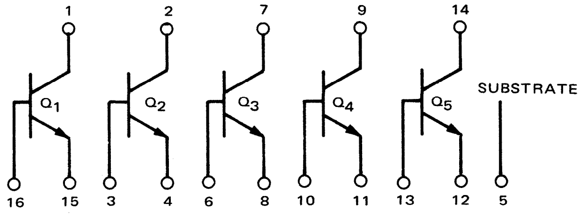
absolute maximum ratings

Power Dissipation:	
Any one transistor	500 mW
Total Package	750 mW
Above +25°C	Derate linearly 6.67 mW/°C
Ambient Temperature Range:	
Operating	−40 to +85°C
Storage	−55 to +150°C

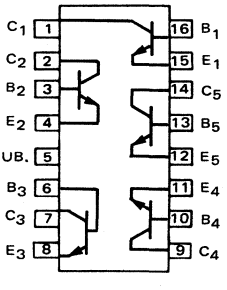
The following ratings apply for each transistor in the device:	ML3183	ML3083
Collector-to-Emitter Voltage (V_{CEO})	45 V	15V
Collector-to-Base Voltage (V_{CBO})	60 V	20V
Collector-to-Substrate Voltage (V_{CIO})*	60 V	20V
Emitter-to-Base Voltage (V_{EBO})	6.0 V	5V
Collector Current (I_C)	75 mA	100 mA
Base Current (I_R)	20 mA	20 mA

*
The collector of each transistor is isolated from the substrate by an integral diode. The substrate must be connected to a voltage more negative than any collector voltage in order to maintain isolation between transistors and provide normal transistor action. To avoid undesired coupling between transistors, the substrate terminal should be maintained at either d.c. or signal (ac) ground. A suitable bypass capacitor can be used to establish a signal ground.

schematic diagram



connection diagram



GENERAL PURPOSE HIGH CURRENT N-P-N TRANSISTOR ARRAYS ML3183, ML3083

electrical characteristics

at $T_A = +25°C$

For Each Transistor in the Array

PARAMETERS	SYMBOLS	ML3183				ML3083				
		CONDITIONS	MIN.	TYP.	MAX.	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$	$I_C = 100\ \mu A$, $I_E = 0$	60	95	–	$I_C = 100\ \mu A$, $I_E = 0$	20	60	–	V
Collector-to-Emitter Breakdown Voltage	$V_{(BR)CSO}$	$I_C = 1$ mA, $I_B = 0$	45	55	–	$I_C = 1$ mA, $I_B = 0$	15	24	–	V
Collector-to-Substrate Breakdown Voltage	$V_{(BR)CIO}$	$I_C = 100\ \mu A$, $I_B = 0$, $I_E = 0$	60	100	–	$I_C = 100\ \mu A$, $I_B = 0$, $I_E = 0$	20	60	–	V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$	$I_E = 500\ \mu A$, $I_C = 0$	6.0	7.1	–	$I_E = 500\ \mu A$, $I_C = 0$	5	6.9	–	V
Collector-Cutoff-Current	I_{CEO}	$V_{CE} = 30V$, $I_B = 0$	–	–	0.1	$V_{CE} = 10$ V, $I_B = 0$	–	–	10	μA
Collector-Cutoff-Current	I_{CBO}	$V_{CB} = 40$ V, $I_E = 0$	–	–	0.1	$V_{CB} = 10V$, $I_E = 0$	–	–	1	μA
DC Forward-Current Transfer Ratio	h_{FE}	$V_{CE} = 5V$ $I_C = 10\mu A$ $I_C = 1$ mA	150 150	320 410	– –	$V_{CE} = 3$ V, $I_C = 10$ mA $I_C = 50$ mA	40 40	76 75	– –	– –
Base-to-Emitter Voltage	V_{BE}	$V_{CE} = 5V$ $I_C = 10mA$	.55	.65	.75	$V_{CE} = 3V$, $I_C = 10mA$	0.65	0.74	0.85	V
Collector-to-Emitter Saturation Voltage	V_{CEsat}	$I_C = 10$ mA $I_B = 1$ mA	–	0.20	0.5	$I_C = 50$ mA, $I_B = 5$ mA	–	0.40	0.70	V

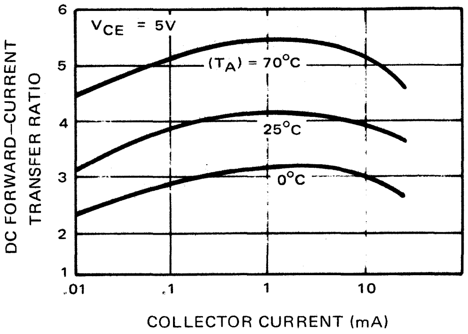
For Transistors Q_1 and Q_2 (ML3083) and Q_1 and Q_5 (ML3183) as a Differential Amplifier

Absolute Input Offset Voltage	$\lvert V_{IO} \rvert$	$V_{CE} = 5V$, $I_C = 1mA$	–	0.5	5	$V_{CE} = 3$ V, $I_C = 1$ mA	–	1.2	5	mV
Absolute Input Offset Current	$\lvert I_{IO} \rvert$		–	0.1	2.5		–	0.7	2.5	μA

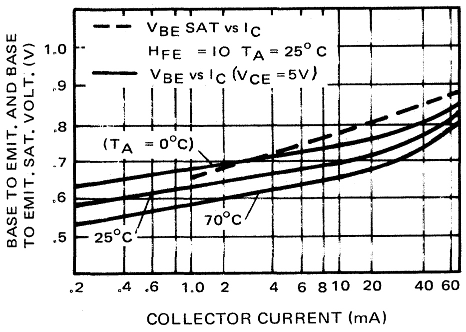
GENERAL PURPOSE HIGH CURRENT N-P-N TRANSISTOR ARRAYS ML3183, ML3083

typical characteristic curves (ML3183)

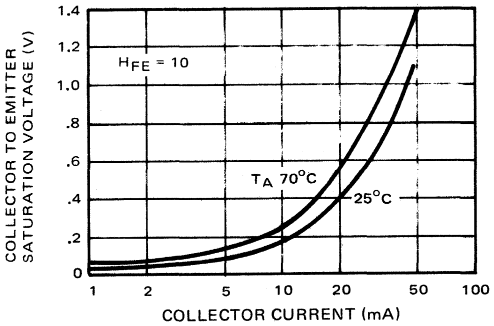
DC FWD. CURR. TRANSFER RATIO vs COLL. CURRENT



BASE TO EMIT. VOLTS AND V_{BE} SAT. vs COLL. CURR.

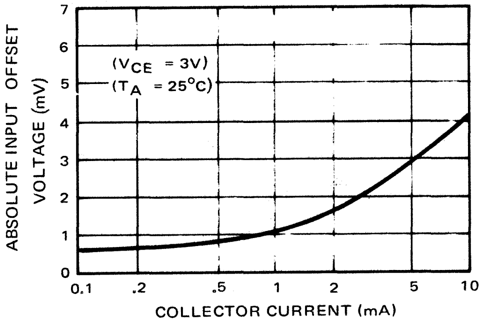


COLL. TO EMIT. VOLT. vs COLL. CURR.

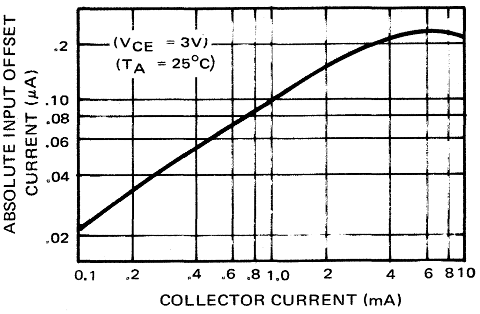


Q_1 – Q_2 MATCHING CHARACTERISTICS

ABS. INPUT OFFSET VOLT. vs COLL. CURR.

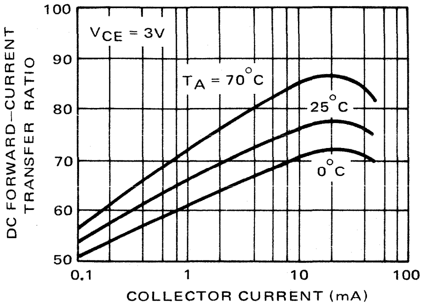


ABS. INPUT OFFSET CURR. vs COLL. CURR.

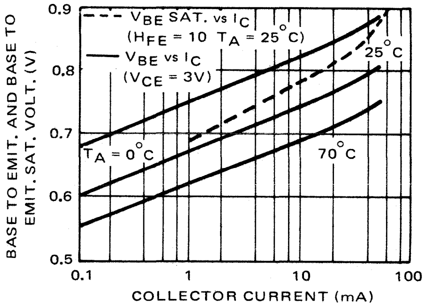


typical characteristic curves (ML3083)

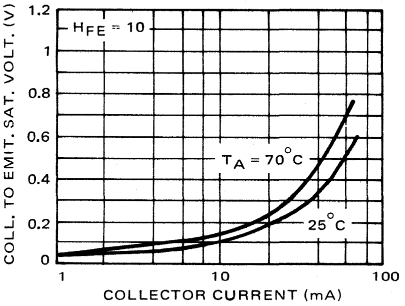
DC FWD.–CURR. TRANSFER RATIO vs COLL. CURR.



BASE TO EMIT. VOLT. vs COLL. CURR.

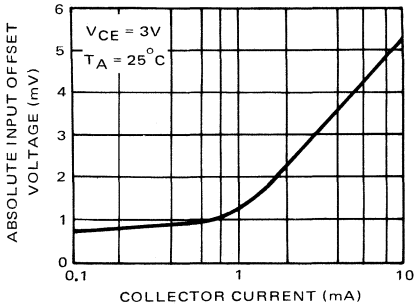


COLL. TO EMIT. SAT. VOLT. vs COLL. CURR.

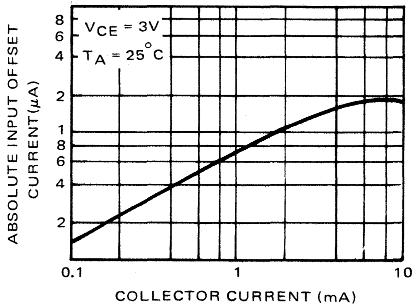


$Q_1 - Q_2$ MATCHING CHARACTERISTICS

ABS. INPUT OFFSET VOLT. vs COLL. CURR



ABS. INPUT OFFSET CURR. vs COLL. CURRENT



TRANSISTOR AND DIODE ARRAYS . . . . ML3000 FAMILY

features

- High Breakdown Voltages; $V_{(BR)CBO} = 90V$ Typically
- Good Diode and Transistor Matching Characteristics
- Low Noise Figure (1 dB Typically)
- Wide Range of Configurations Available
- High Current Gain Over a Wide Range of Collector Currents
- Excellent $V_{F1} = (V_{BE})$ Linearity Over a Wide Range of Diode Forward Current (60mV/DECADE TYPICALLY: $(1pA \leqslant V_F \leqslant 1mA)$

description

These transistor diode arrays consist of a series of high quality, high voltage, general purpose devices constructed on a single substrate. Monolithic construction produces closely matched devices suited to a wide range of general purpose applications. Transistor and diode arrays permit greater packaging density and cost savings, while providing better matching and temperature tracking than can be achieved with discrete devices.

absolute maximum ratings

Power Dissipation:	
Each Transistor	300 mW
Each Diode	100 mW
T.O. 5, 8, or 10 Lead Package	500 mW(1)
14 Lead Dual-in-line Plastic or Hermetic Package	750 mW(1)
Storage Temperature:	
Met. Can.8, or 10 Lead Package and D.I.L. Hermetic Package	−65°C to +150°C
D.I.L. Package	−65°C to +150°C
Operating Temperature:	
T.O. 5, 8, 10, or 12 Lead and D.I.L. Hermetic Package	−55°C to +125°C(1)
D.I.L. Plastic Package	0°C to +70°C(1)

Collector-to-emitter Voltage	45V
Collector-to-base Voltage	60V
Collector-diode Substrate Voltage	60V
Emitter-to-base Voltage	6.0V
Diode Peak Reverse Voltage	6.0V
Collector Current	30mA
Diode Forward Current	100mA

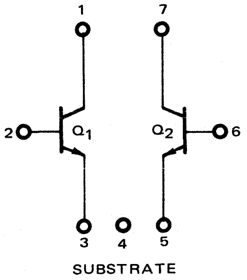
10

NOTES:

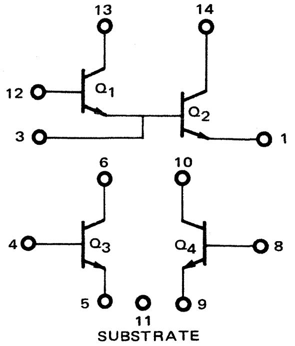
1. Rating applies for case temperatures up to respective maximum operating temperatures. For metal can 8 or 10 pin package, derate 6.8 mW/°C for operation at ambient temperatures above +75°C. For D.I.L. hermetic package, derate 8 mW/°C for operation at ambient temperatures above +75°C. For D.I.L. plastic package, derate 6.67 mW/°C for operation at ambient temperatures above +55°C.

schematic diagrams

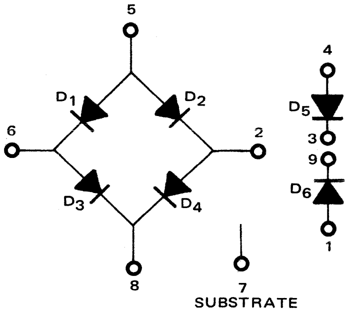
ML3100



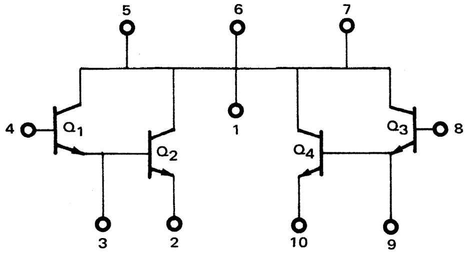
ML3118



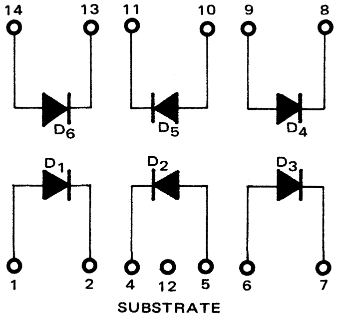
ML3119



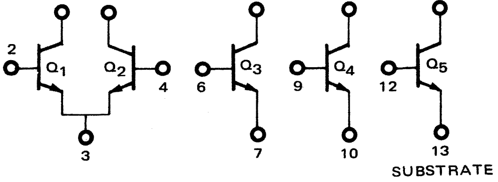
ML3136



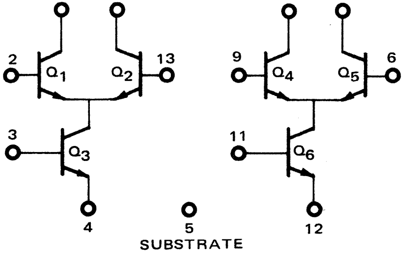
ML3139



ML3145

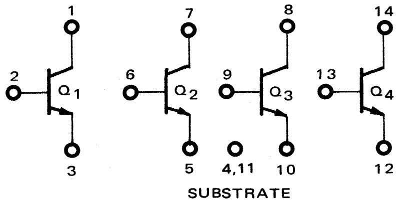


ML3154

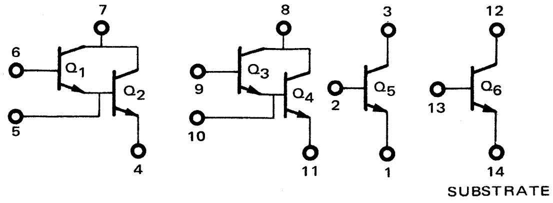


schematic diagrams (cont'd)

ML3484

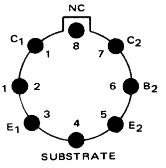


ML3923

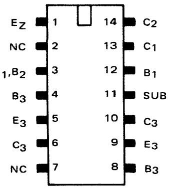


connection diagrams (Top View)

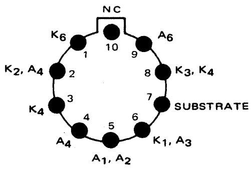
ML3100
Metal Can Package



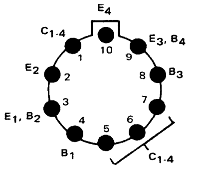
ML3118
Dual-in-line Package



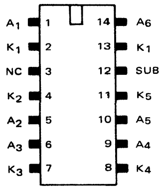
ML3119
T.O. Metal Can Package



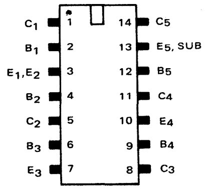
ML3136
Metal Can Package



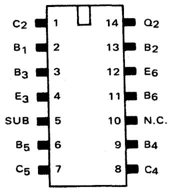
ML3139
Dual-in line Package



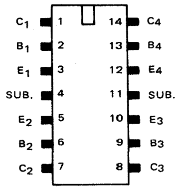
ML3145
Dual-in-line Package



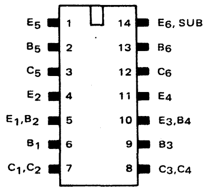
ML3154
Dual-in-line Package



ML3484
Dual-in-line Package



ML3923
Dual-in-line Package



NOTES:
1. The collector of each transistor and anode of each diode is isolated from the substrate by an integral diode. The substrate must be connected to a voltage more negative than any collector/anode voltage in order to maintain isolation between devices on the same substrate.

electrical characteristics

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C FOR EACH TRANSISTOR)

PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Collector-base Breakdown Voltage	$V_{(BR)CBO}$	$I_C=10\mu A, I_E=0$	60	90	–	V
Collector-emitter Breakdown Voltage	$V_{(BR)CEO}$	$I_C=1mA,\ I_B=0$	45	50	–	V
Collector-Substrate Breakdown Voltage	$V_{(BR)CSO}$	$I_{CS}=10\mu A, I_B=0$ $I_E=0$	60	100	–	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	$I_E=10\mu A, I_C=0$	6.0	7.5	–	V
Collector Cutoff Current	I_{CEO}	$V_{CE}=30V, I_B=0$	–	.35	100	nA
Collector Cutoff Current	I_{CBO}	$V_{CB}=40V, I_E=0$	–	.005	100	nA
Emitter Cutoff Current	I_{EBO}	$V_{EB}=5V, I_C=0$	–	.0004	100	nA
DC Forward Current Transfer Ratio	h_{FE}	$V_{CE}=5V, I_C=1mA$ $V_{CE}=5V, I_C=10\mu A$	150 150	350 350	– –	– –
Base-to-Emitter Voltage	V_{BE}	$V_{CE}=5V, I_C=1mA$	0.6	0.72	0.8	V
Collector-to-emitter Saturation Voltage	$V_{CE(SAT)}$	$I_C=10mA, I_B=1mA$	–	0.35	–	V

DYNAMIC ELECTRICAL CHARACTERISTICS (T_A = 25°C FOR EACH TRANSISTOR)

PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Low Frequency Noise Figure	NF	f=1KHZ, $V_{CE}=5V$ $1_C=1mA,\ R_S=1K\Omega$	–	1.0	–	dB
Forward Current Transfer Ratio	h_{FE}	f=1KHZ, $V_{CE}=5V$ $I_C=1mA$	–	350	–	–
Open circuit output Conductance	h_{OE}	f=1KHZ, $V_{CE}=5V$ $I_C=1mA$	–	1.2	–	μS
Emitter-base Capacitance	C_{EB}	$V_{EB}=5V$	–	0.4	–	pF
Collector-Base Capacitance	C_{CB}	$V_{CB}=5V$	–	0.2	–	pF
Collector-Substrate Capacitance	C_{CS}	$V_{CI}=5V$	–	1.3	–	pF
Magnitude of V_{BE} Temperature coefficient	$\frac{\Delta V_{BE}}{\Delta T}$	$V_{CE}=5V,\ I_E=1mA$	–	−1.9	–	mV/°C

electrical characteristics (cont'd)

MATCHED TRANSISTOR CHARACTERISTICS (T_A = 25°C FOR EACH TRANSISTOR)

PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Collector-Collector Breakdown Voltage	$V_{(BR)CC}$	I_{CC}=10μA	60	100	–	V
Collector-Collector Capacitance	C_{CC}	V_{CC}=5V	–	1.4	–	pF
Absolute Input Offset Voltage	V_{OS}	V_{CE}=5V, I_C=1mA	–	0.4	5	mV
Absolute Input Offset Current	I_{OS}	V_{CE}=5V, I_C=1mA	–	.08	2.5	μA
Magnitude of V_{OS} Temperature coefficient	$\frac{\Delta V_{OS}}{\Delta T}$	V_{CE}=5V $I_{C1} = I_{C2}$ = 1mA	–	1.5	–	μV/°C
Magnitude of I_{OS} Temperature coefficient	$\frac{\Delta I_{OS}}{\Delta T}$	V_{CE}=5V $I_{C1} = I_{C2}$ = 1mA	–	0.3	–	nA/°C

DARLINGTON CONNECTED TRANSISTOR CHARACTERISTICS (T_A = 25°C FOR EACH PAIR)

PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBOD}$	I_E=10μA	10	14.5	–	V
DC Forward Current Transfer Ratio	h_{FED}	$I_{C1} = I_{C2}$ = 1mA V_{CE2} = 5V	10^4	2.2 X 10^5	–	–

electrical characteristics (cont'd)

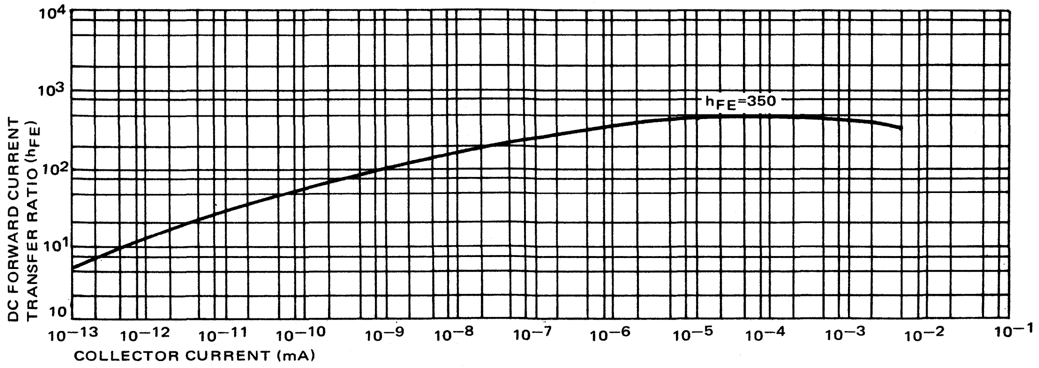
DIODE CONNECTED TRANSISTOR CHARACTERISTICS (T_A = 25°C FOR EACH DIODE)

PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Peak Inverse Voltage	P_{IV}	I_R=10µA	6	7.5	–	V
DC Forward Voltage Drop	V_F	I_F=1mA	–	0.72	0.8	V
DC Forward Voltage Change	ΔV_F	1pA≤I_F≤1mA	–	60	–	mV/ Decade
Diode-substrate Breakdown Voltage	$V_{(BR)DS}$	I_R=10µA	60	100	–	V
DC Forward Current	I_F	–	–	–	25	mA
Peak Forward Surge Current	I_F	–	–	–	100	mA
Diode Offset Voltage	$\|V_{FA}-V_{FB}\|$	$I_{FA} = I_{FB}$ = 1mA	-	0.45	5	mV
Temperature coefficient Forward Drop	$\frac{\Delta V_F}{\Delta T}$	I_F=1mA	–	1.9	–	mV/°C
Temperature coefficient of Diode Offset Voltage	$\frac{\Delta\|V_{FA}-V_{FB}\|}{\Delta T}$	I_F=1mA	–	1.5	–	µV/°C
Diode Leakage Current	I_R	V_R=5V	–	.0003	100	nA
Diode Capacitance	C_D	V_R=1V	–	0.3	–	pF
Diode-to-Subtrate Capacitance	C_{DS}	V_R = 5V	–	2.0	–	pF
Anode-Substrate DC Forward Voltage Drop	V_F	I_F=1mA	–	0.7	–	V

typical characteristic curves

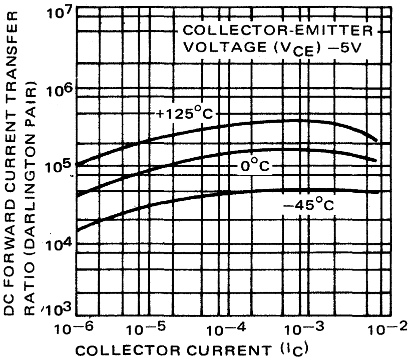
FOR EACH TRANSISTOR

DC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

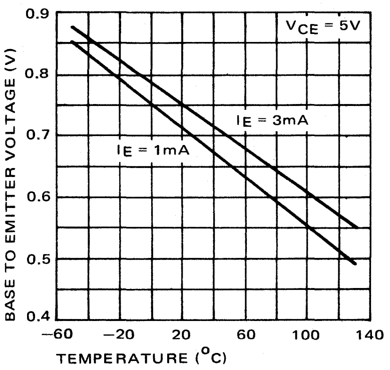


typical characteristic curves (cont'd)

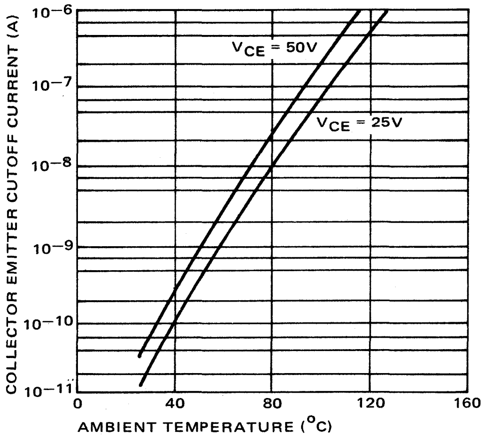
DC FORWARD CURRENT TRANSFER RATIO (DARLINGTON PAIR) vs COLLECTOR CURRENT



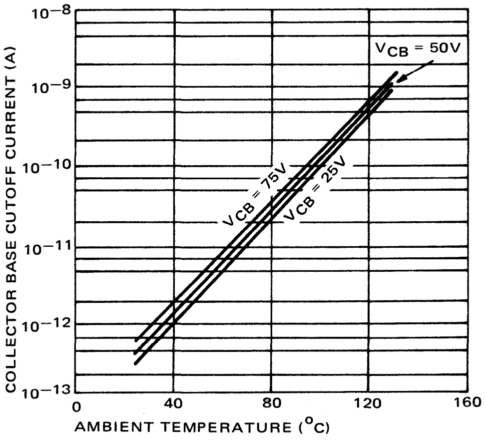
BASE TO EMITTER VOLTAGE vs TEMPERATURE



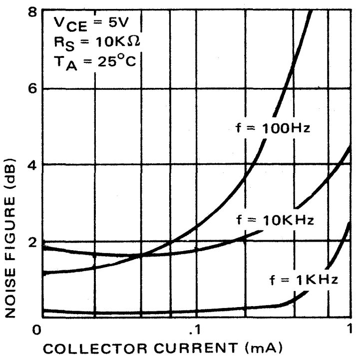
COLLECTOR BASE CUTOFF CURRENT vs AMBIENT TEMPERATURE



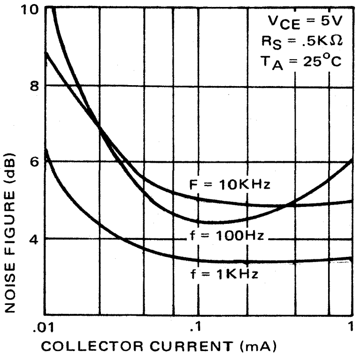
COLLECTOR EMITTER CUTOFF CURRENT vs AMBIENT TEMPERATURE



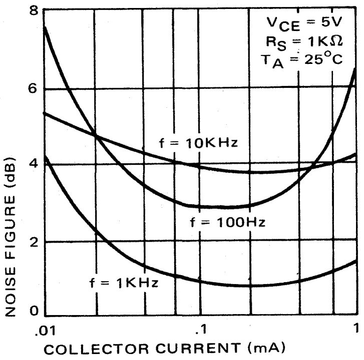
NOISE FIGURE vs COLLECTOR CURRENT



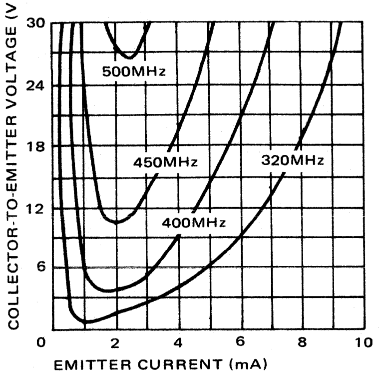
NOISE FIGURE vs COLLECTOR CURRENT



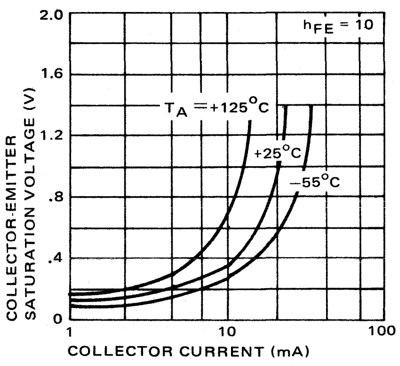
NOISE FIGURE vs COLLECTOR CURRENT



COLLECTOR-TO-EMITTER VOLTAGE vs EMITTER CURRENT

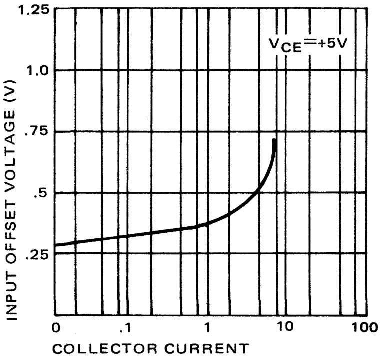


COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

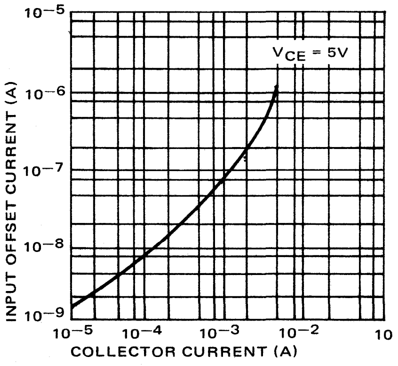


MATCHED TRANSISTORS CHARACTERISTICS

INPUT OFFSET VOLTAGE vs COLLECTOR CURRENT

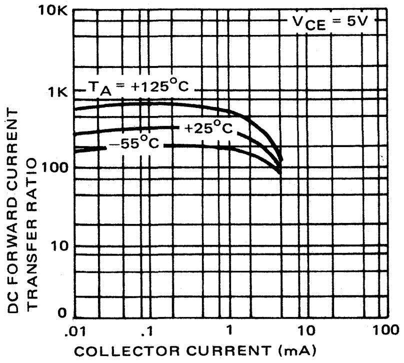


INPUT OFFSET CURRENT vs COLLECTOR CURRENT

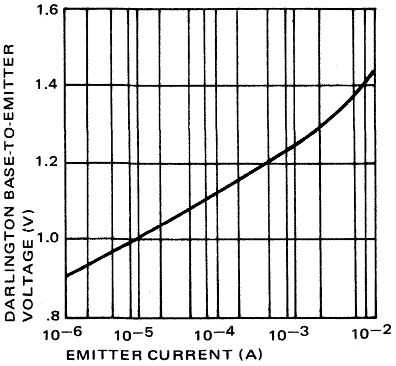


DARLINGTON CONNECTED TRANSISTOR CHARACTERISTICS

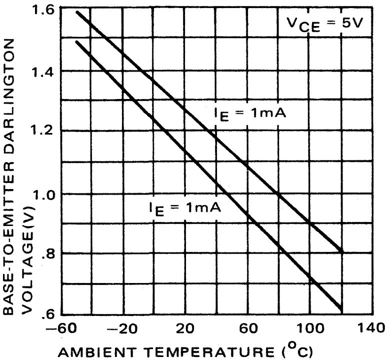
DC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT



DARLINGTON BASE-TO-EMITTER VOLTAGE vs EMITTER CURRENT



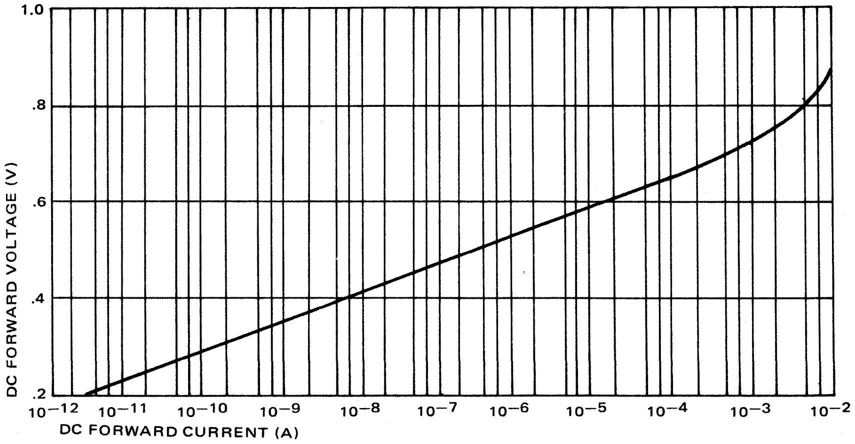
BASE-TO-EMITTER DARLINGTON vs AMBIENT TEMPERATURE



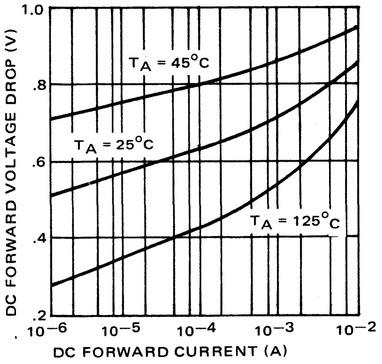
typical characteristic curves (cont'd)

DIODE CONNECTED TRANSISTOR CHARACTERISTICS

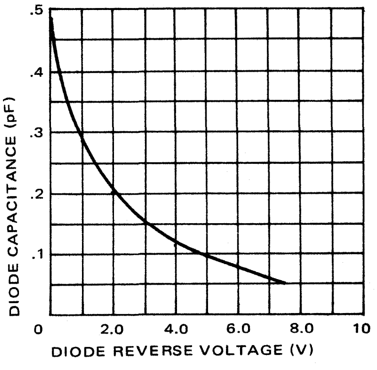
DC FORWARD VOLTAGE vs DC FORWARD CURRENT



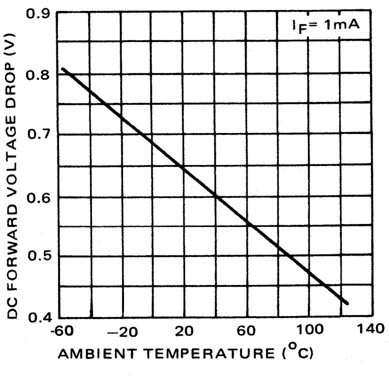
DC FORWARD VOLTAGE DROP vs DC FORWARD CURRENT



DIODE CAPACITANCE vs DIODE REVERSE VOLTAGE



DC FORWARD VOLTAGE DROP vs AMBIENT TEMPERATURE



microsystems international

SELECTED LINEAR I.C. CATALOGUE

Package Information

11

MICROSYSTEMS INTERNATIONAL LIMITED, BOX 3529 STATION C, OTTAWA, CANADA, K1Y 4J1

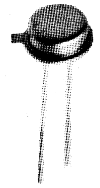
package availability

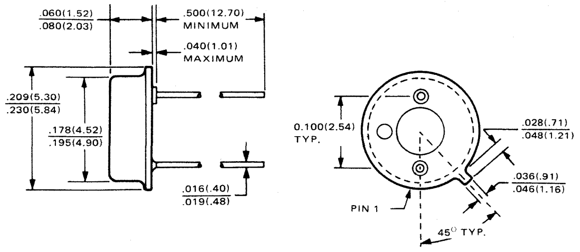
PRODUCT CODE	PACKAGE CODE						
	T Metal Can	D Hermetic D.I.L. Ceramic	P Molded D.I.L. Plastic	M Hermetic D.I.L. Metal	S Molded D.I.L. Plastic	F Flat Pack	K Chip
ML101A	●	●		●		●	●
ML102A	●	●		●		●	●
ML301A	●	●	●		●		●
ML101	●	●		●		●	●
ML201	●	●		●		●	●
ML301	●	●	●		●		●
ML107	●	●		●		●	●
ML207	●	●		●		●	●
ML307	●	●	●		●		●
ML709A	●	●		●		●	●
ML709	●	●		●		●	●
ML709C	●	●	●		●		●
ML741A	●	●		●		●	●
ML741	●	●		●		●	●
ML741C	●	●	●		●		●
ML748	●	●		●		●	●
ML748C	●	●	●		●		●
ML777	●	●		●		●	●
ML777C	●	●	●		●		●
ML1436	●						●
ML1536	●						●
ML108A	●			●		●	●
ML208A	●			●		●	●
ML308A	●			●			●
ML108	●			●		●	●
ML208	●			●		●	●
ML308	●		●	●	●		●
ML118	●	●		●		●	●
ML218	●	●		●		●	●
ML318	●	●		●	●		●
ML776	●	●		●			●
ML776C	●	●	●	●	●		●
ML4250	●	●					●
ML4250C	●	●			●		●
ML4251	●	●					●
ML4251C	●	●			●		●
ML747	●			●		●	●
ML747C	●	●	●				●
ML1537		●		●			●
ML1437		●	●				●
ML1558	●	●		●			●
ML1458	●	●	●		●		●
ML4136		●	●	●			●
ML4136C		●	●				●
ML4202C		●	●				●
ML111	●	●		●		●	●
ML211	●	●		●		●	●
ML311	●	●		●	●		●
ML723	●	●		●		●	●
ML723C	●	●	●	●			●
ML4270			●				●
ML4270–15			●				●
ML1488		●		●			●
ML1489		●		●			●
ML1489A		●		●			●
ML4102			●				
ML113	●						●
ML213	●						●
ML313	●						●
ML3045		●		●			●
ML3046			●				●
ML3083		●	●				●
ML3100	●				●		●
ML3118		●	●				●
ML3119	●						●
ML3136	●						●
ML3139		●	●				●
ML3145		●	●				●
ML3154		●	●				●
ML3183		●	●				●
ML3484		●	●				●
ML3923		●	●				●

PACKAGE INFORMATION

T PACKAGE

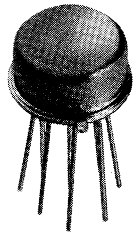
2 – LEAD METAL CAN
JEDEC(TO–46) OUTLINE

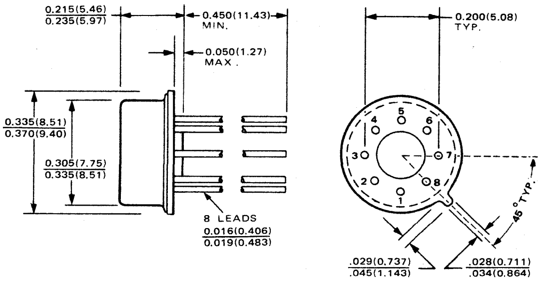




T PACKAGE

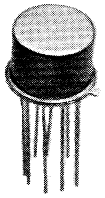
8 – LEAD METAL CAN
JEDEC(TO–99) OUTLINE

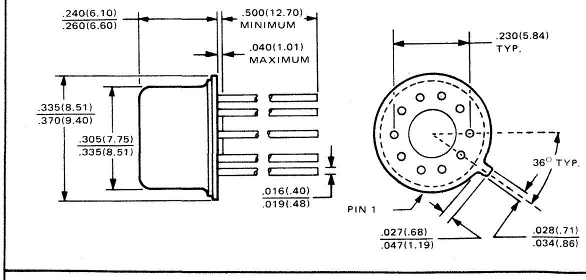




T PACKAGE

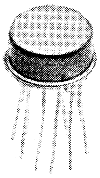
10 – LEAD METAL CAN
JEDEC(TO–96) OUTLINE

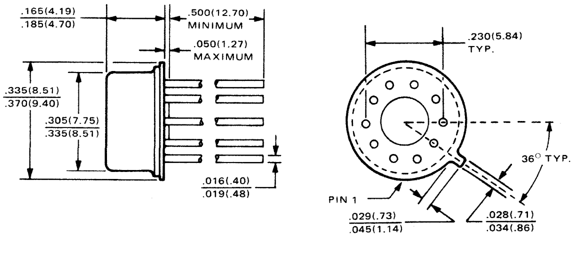




T PACKAGE

10 – LEAD METAL CAN
JEDEC(TO–100) OUTLINE





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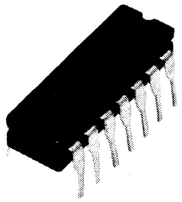
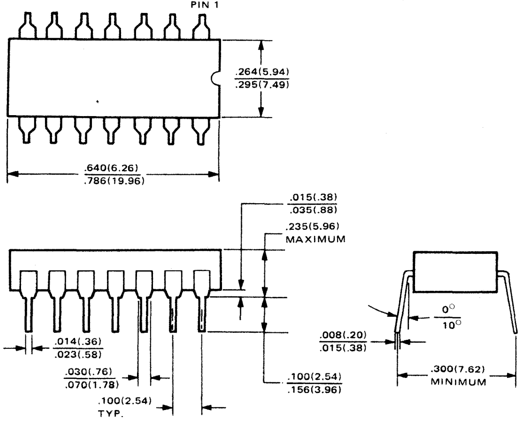
PACKAGE INFORMATION

D PACKAGE

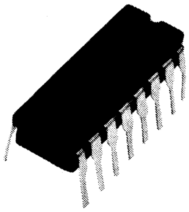
14 – LEAD HERMETIC
DUAL–IN–LINE CERAMIC

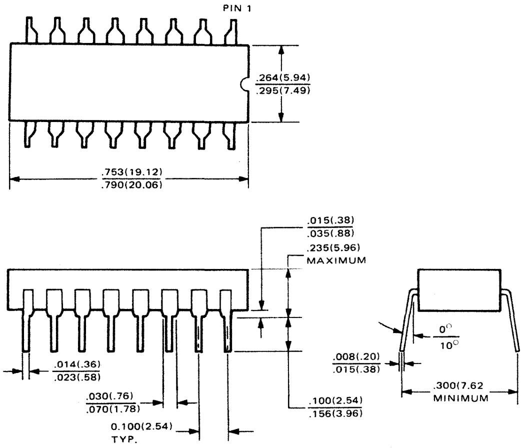




D PACKAGE

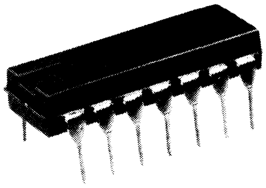
16 – LEAD HERMETIC
DUAL–IN–LINE CERAMIC

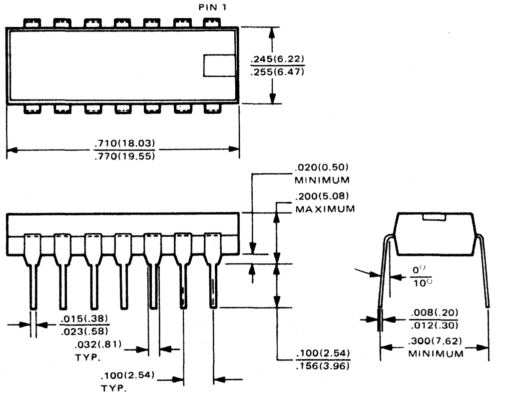




P PACKAGE

14 – LEAD MOLDED D.I.L.
JEDEC(TO–116) OUTLINE





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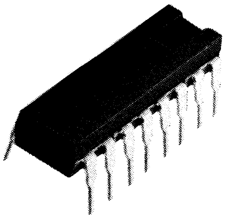

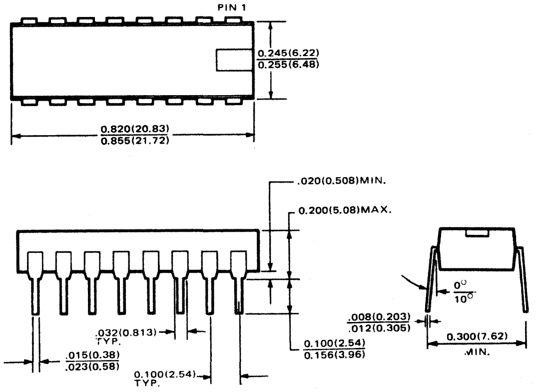

PACKAGE INFORMATION

M PACKAGE

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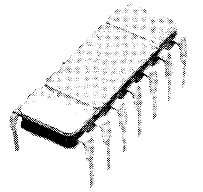
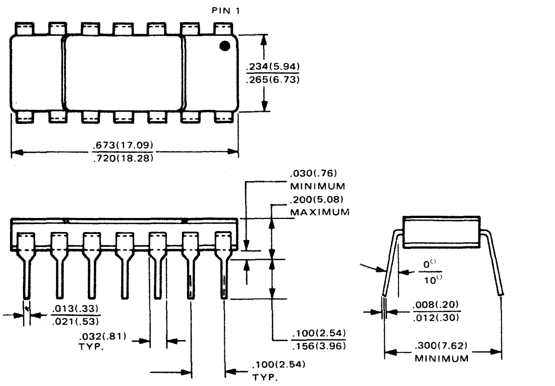
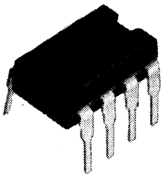
JEDEC(TO–116) OUTLINE



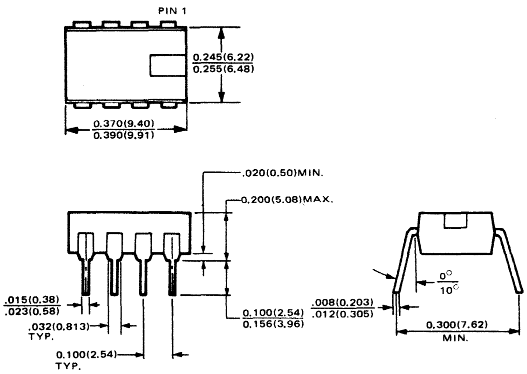


S PACKAGE

8 – LEAD MOLDED D.I.L.

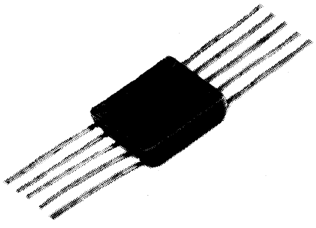


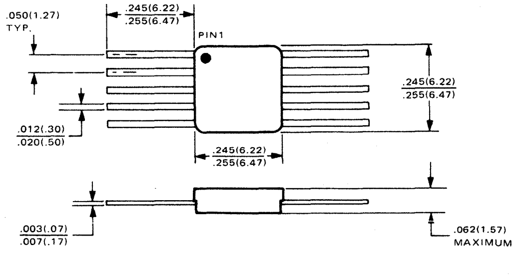
MEM S PACKAGE 8-LEAD



F PACKAGE

10 – LEAD FLAT PACK
JEDEC(TO–91) OUTLINE





F PACKAGE

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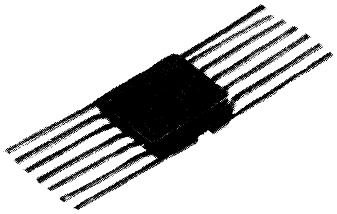
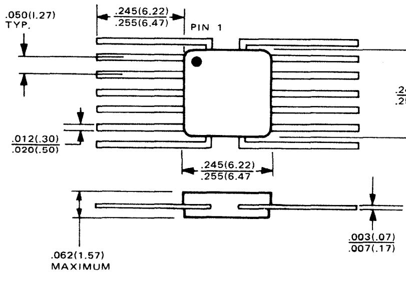
JEDEC(TO–86) OUTLINE





NOTES

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Application Bulletins

12

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contents

TITLE PAGE

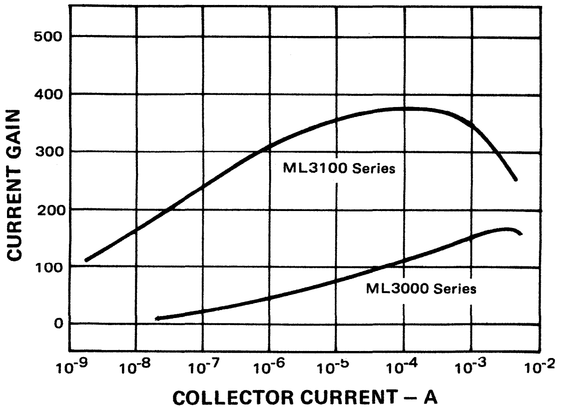
APPLICATIONS OF TRANSISTOR ARRAYS

With the advent of low cost high voltage transistor arrays, it is now possible to design many circuits that take advantage of the inherent matching characteristics of monolithic transistors. A cost advantage may also be realized in simple applications where discrete transistors are to be replaced. The savings in insertion costs alone can easily justify re-design in high labour content assemblies.

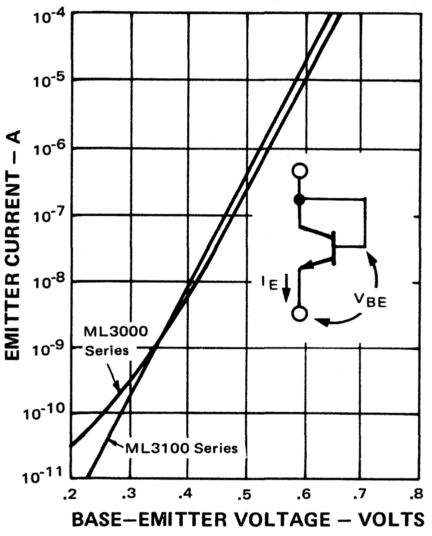
The following table and attached curves briefly summarize some important typical parameters for the ML3000 family of transistor arrays. The ML3000 family duplicates arrays which have been available for some time. The ML3100 family takes advantage of recent advances in linear processing technology and offers a higher voltage, higher gain, lower noise transistor than was previously available in array format.

PARAMETER	ML3000	ML3100	UNITS
LV_{CEO}	20	60	V
h_{FE} (10μA)	80	350	–
(1mA)	150	350	–
f_T	500	400	MHz
V_{CE} (SAT) (10mA)	0.3	0.4	V
BV_{EBO}	6.7	7.9	V

DC FORWARD TRANSFER RATIO VERSUS COLLECTOR CURRENT

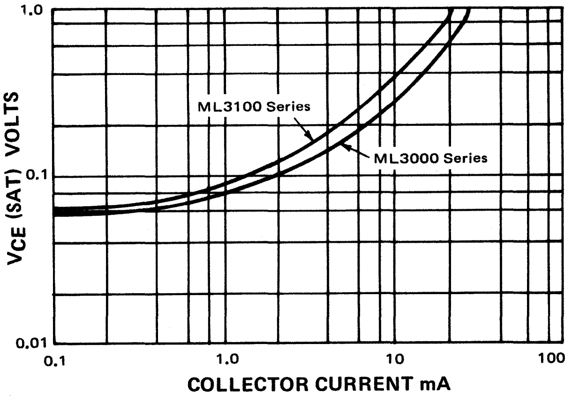


EMITTER CURRENT VERSUS BASE–EMITTER VOLTAGE

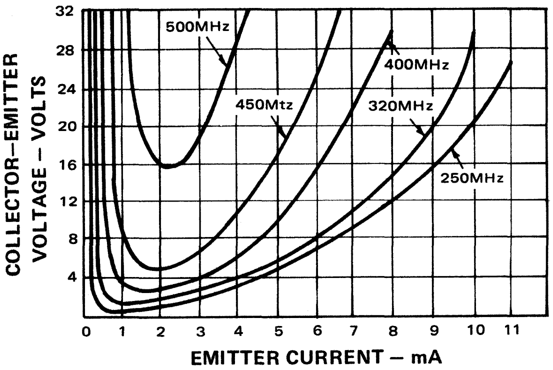


APPLICATIONS OF TRANSISTOR ARRAYS

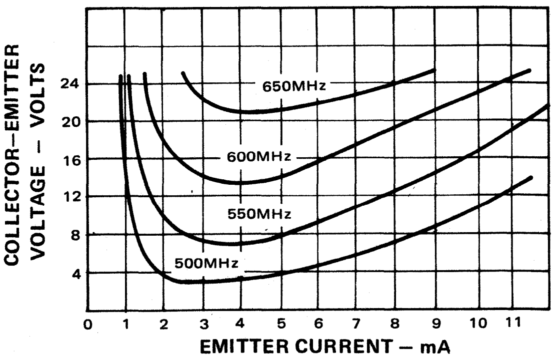
COLLECTOR–EMITTER SATURATION VOLTAGE VERSUS COLLECTOR CURRENT



CONTOURS OF CONSTANT GAIN – BANDWIDTH PRODUCT ML3100 SERIES



CONTOURS OF CONSTANT GAIN – BANDWIDTH ML3000 SERIES PRODUCT



The following circuits are presented for guidance in the application of arrays. Most cannot be built successfully with discrete transistors on a production basis. All will benefit from the thermal tracking inherent in a transistor array. In all cases the substrate terminal must be the most negatively biased point in the circuit.

Fig. 1 illustrates a configuration for a variable gain differential amplifier. The gain may be adjusted without effecting the dc balance or the dc bias voltage at the output terminals. R_B is added to further stabilize the current sources and improve output impedance at high currents. The drop on R_B should be of the order of 0.5V.

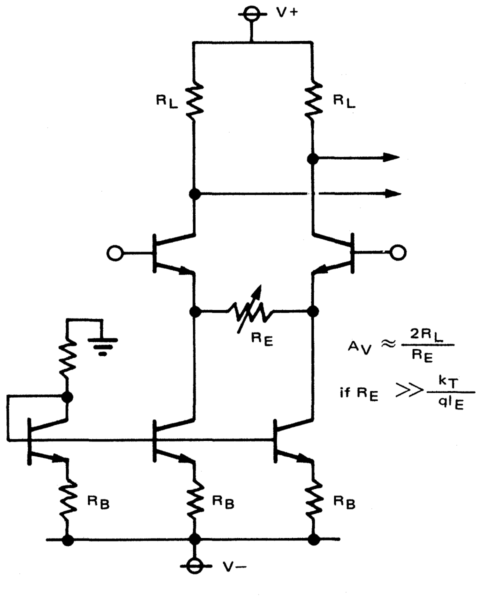


FIG. 1. A VARIABLE GAIN DIFFERENTIAL AMPLIFIER

The circuit shown in Fig. 2 is a low dissipation zero temperature coefficient voltage reference suitable for use in portable instruments requiring very low current drain. The Q_4, Q_5 combination will give reasonable regulation versus battery life, (in this case 9V down to 5V) while maintaining the reference stability versus temperature better than 1%.

Since the impedance levels are high, a low power buffer amplifier such as the ML4251 could be used to provide isolation, impedance transformation and level shifting.

APPLICATIONS OF TRANSISTOR ARRAYS

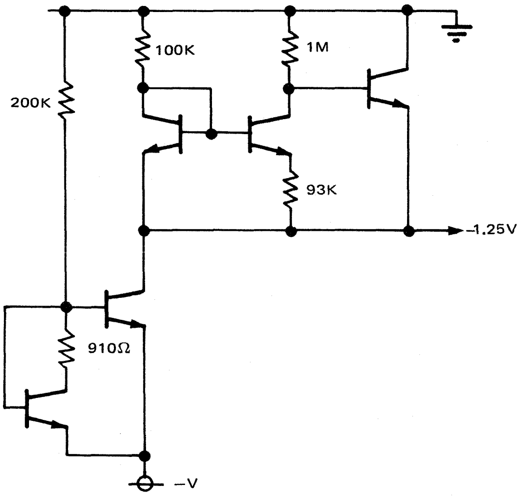


FIG. 2. A LOW DISSIPATION ZERO TEMPERATURE COEFFICIENT VOLTAGE REFERENCE

Fig. 3 shows three current sources. Type A has a linear input-output transfer characteristic. Type B is linear until the drop across R_E becomes significant in terms of the given expressions, where I_{out} will continue to increase with increasing I_{in} but will not be strongly dependant on I_{in} for $\frac{I_{in}}{I_{out}} > e$.

Type C is also linear until the drop across R_C becomes significant. In this case however, I_{out} will decrease for increasing I_{in} for $I_{out}/I_{in} < \frac{1}{e}$

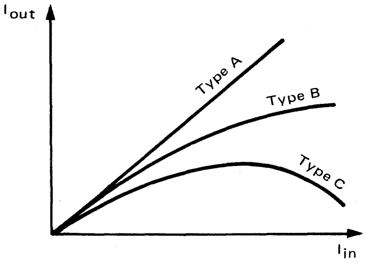


FIG. 3A. CURRENT SOURCE CHARACTERISTICS

Fig. 4 demonstrates a low noise amplifier configuration. The main advantage of the circuit is that it allows tailored noise performance using a low cost operational amplifier, which may be unsuitable for direct use in a particular low noise application.

The quiescent input current is set by R_5, the gain by the ratio of R_4 to R_3, and the input stage gain by $R_1 / \frac{kT}{qI}$. C_C can be 30pF for gains of 100 or higher but must be increased depending on the ratio of open loop to closed loop gain. The advantage of an ML3145 over a dual transistor is that the current source is included in the same package — at no extra cost.

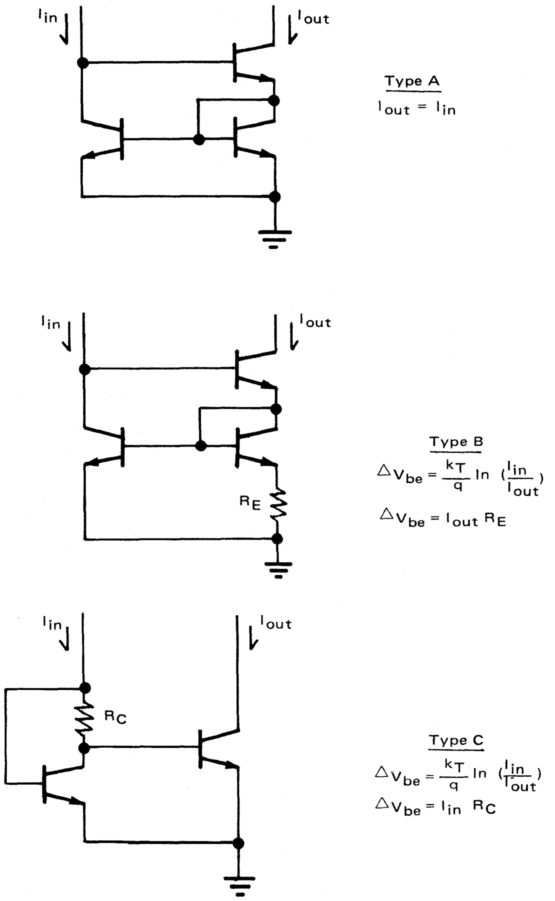


FIG. 3B. THREE CURRENT SOURCE CONFIGURATIONS

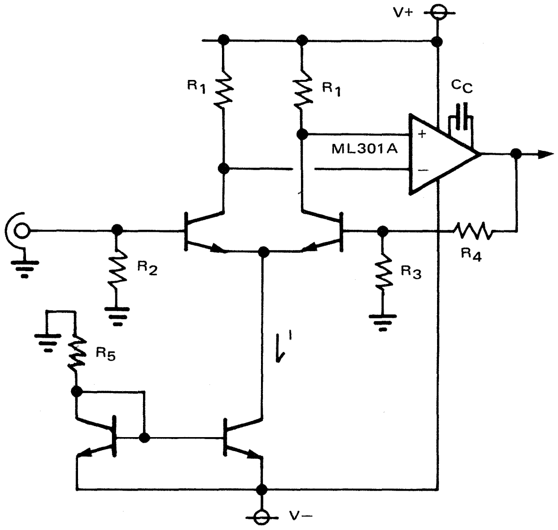


FIG. 4. A LOW NOISE AMPLIFIER

APPLICATIONS OF TRANSISTOR ARRAYS

Fig. 5 shows a low drift amplifier, which takes advantage of the inherently low offset voltage of matched transistors and gives an order of magnitude better drift performance than can be guaranteed by amplifiers such as the ML741C or ML301A. The addition of a low cost array will yield drift rates of < 3uV/°C on better than 90% of typical ML3100 array pairs.

If offset nulling is required the null terminals of the ML741 may be used with negligable effect on overall amplifier drift.

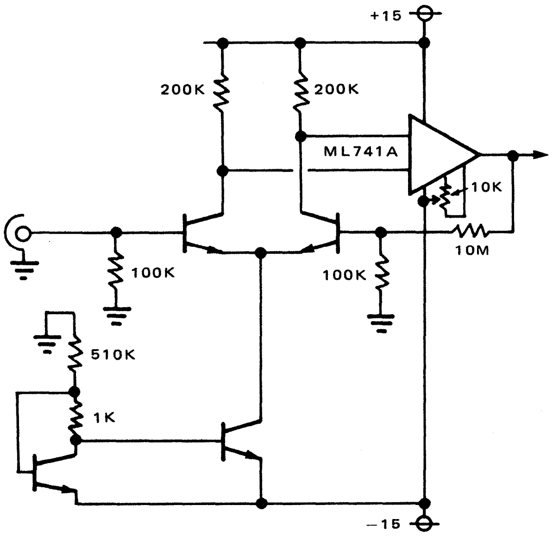


FIG. 5. A LOW DRIFT AMPLIFIER

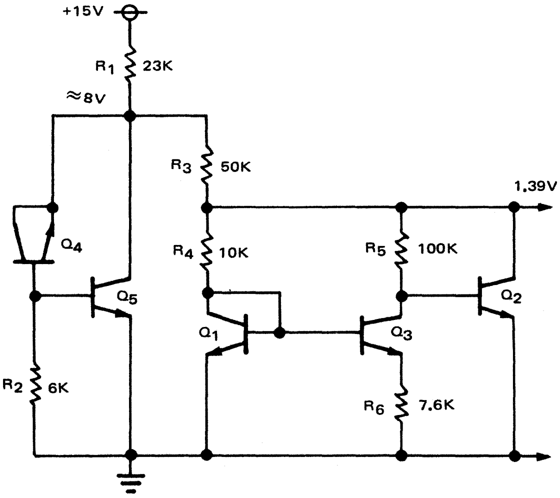
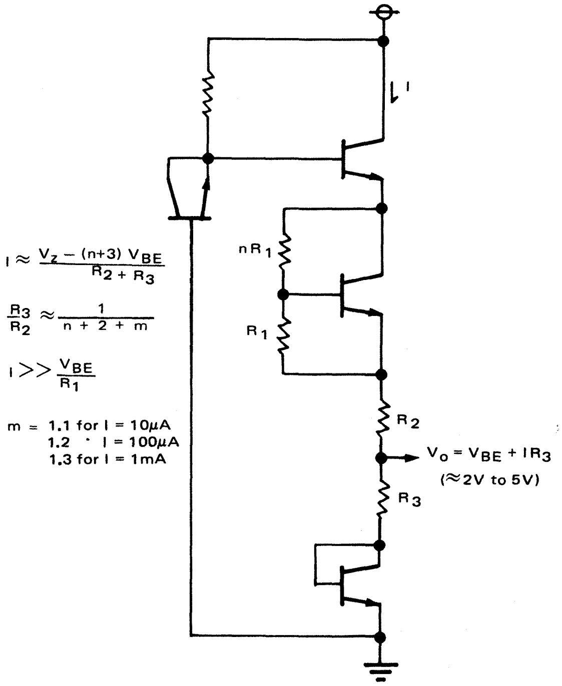


FIG. 6. A LOW VOLTAGE REFERENCE

Fig. 6 shows a low voltage reference with zero temperature coefficient. As in Fig. 2 the circuit cannot be loaded significantly without upsetting the temperature coefficient. R6 may be adjusted to vary temperature coefficient, tracking the absolute value of output voltage around the nominal value. If R3 and R6 are varied appropriately, the zero temperature coefficient output voltage may be adjusted between approximately 1.1V and 1.5 V.



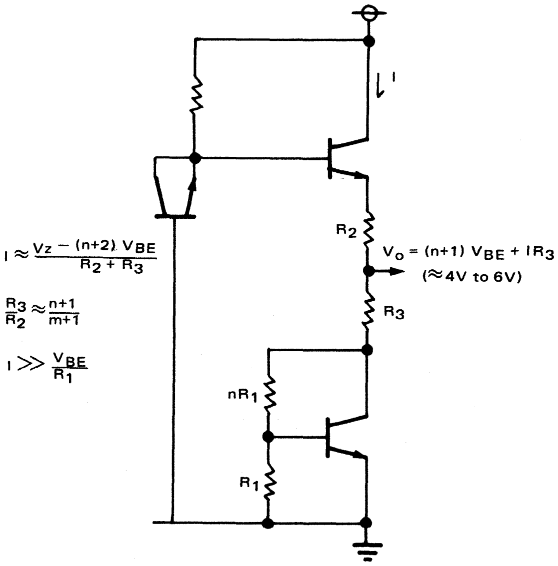


FIG. 7. A LOW TEMPERATURE COEFFICIENT VOLTAGE REFERENCE

Fig. 7 shows low temperature coefficient voltage references also. By appropriately varying the ratio of R_2 and R_3 and n, a zero temperature coefficient reference may be obtained for any voltage between approximately 2.0V and 6.0V. Once designed, excellent repeatability can be obtained from lot to lot. The circuit can be operated at total currents ranging from 20μA to 2mA, depending upon the output impedance wanted, or the dissipation requirement.

Fig. 8 shows an inductively coupled balanced modulator. Because of the excellent matching of the monolithic transistors, balance is maintained such that no significant direct offset current will flow in the transformers.

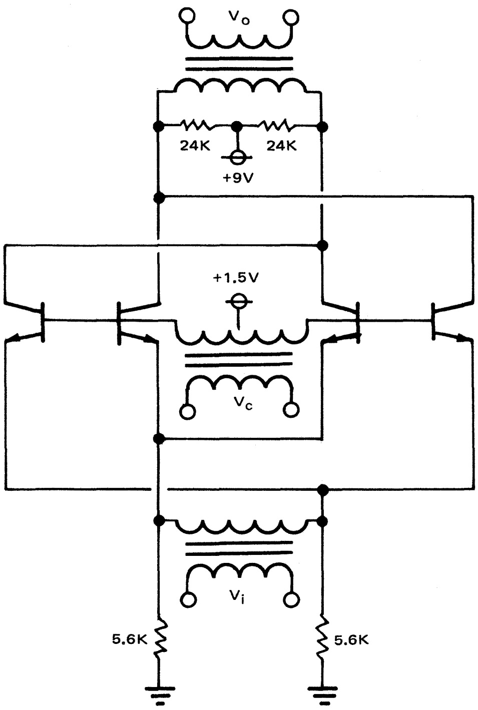


FIG. 8. AN INDUCTIVELY COUPLED BALANCED MODULATOR

Fig. 9 demonstrates a simple current-source bridge which may be used to match dc characteristics of discrete diodes, bipolar transistors, FETs or resistors. The null detector could be made with an operational amplifier such as the ML301A, or from a differential amplifier such as shown in Fig. 1.

In Fig. 10 an ML3045 is connected as a relaxation oscillator, suitable for use as an oscilloscope calibrator, clock generator, or time base. The frequency of oscillation is determined primarily by R_1, R_2, R_3 and C if R_1, $R_2 >> R7$, R_4, R_5 and R_6 determine base quiescent conditions of the circuit. Level shifting in the second stage is set so the external switch has sufficient off drive to give stable operation at high temperature.

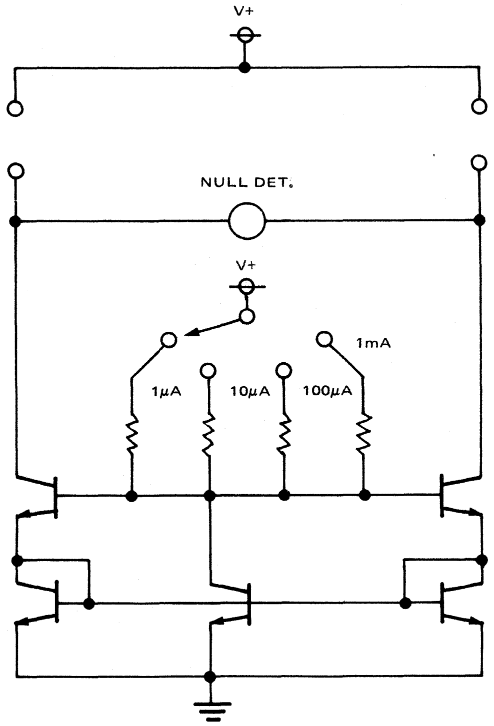


FIG. 9. A SIMPLE CURRENT-SOURCE BRIDGE

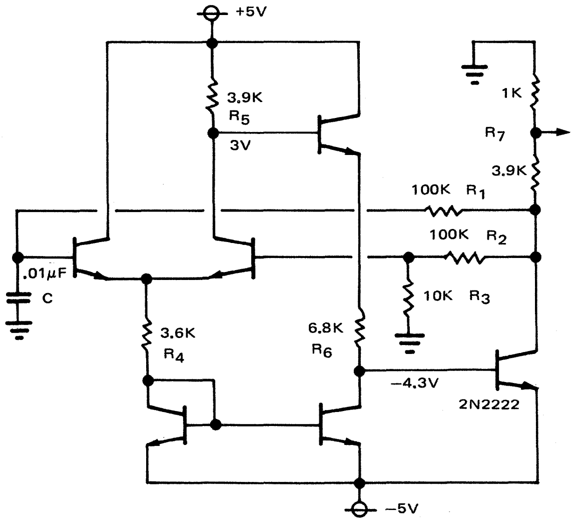


FIG. 10. AN ML3045 AS A RELAXATION OSCILLATOR

APPLICATIONS OF TRANSISTOR ARRAYS

Fig. 11 shows a simple voltage follower configuration suitable for impedance transformation of low level signals.

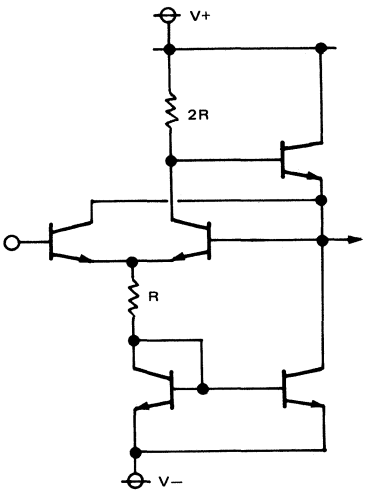


FIG. 11. A SIMPLE VOLTAGE FOLLOWER

Fig. 12 illustrates a two-terminal current source suitable for use in timing circuits, or as an active load. The nominal current is varied by changing R. For a high gain PNP transistor as shown $R \simeq 138/I_{out}$ (in mA) The current will vary ±20% around the nominal value for the given transistor and R±5%. The compliance of the circuit is limited to 1.2V minimum and approximately 90V maximum if an ML3145 is used. For operation at currents above 2mA the remaining transistors in the array should be connected as shown by the dotted lines. For that connection $R \simeq 102/I_{out}$ (in mA).

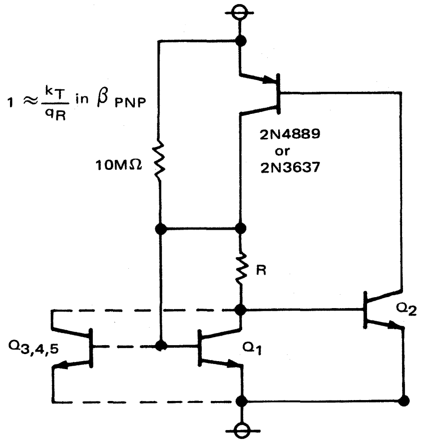


FIG. 12. A TWO-TERMINAL CURRENT SOURCE CONFIGURATION

A SIMPLE TRACKING REGULATOR

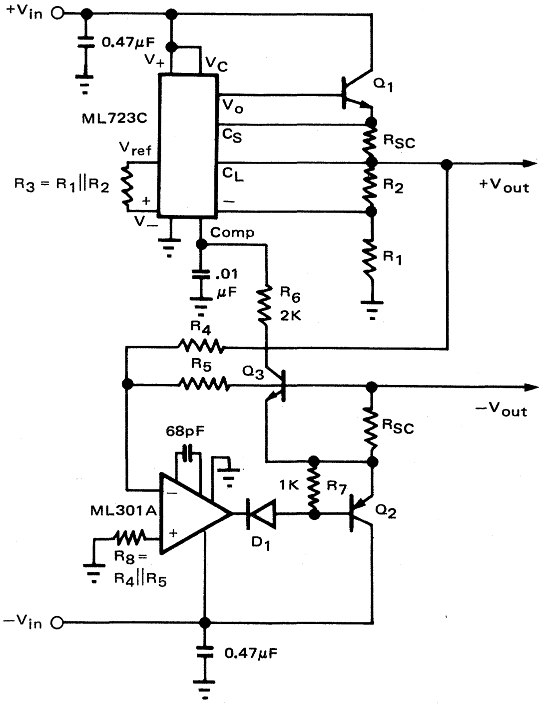
It is often desirable to maintain either symmetry or a fixed ratio between positive and negative power supplies used in analog circuitry. Although monolithic tracking regulators are available, many require several external components and in addition cannot track under load fault conditions. A more practical disadvantage of monolithic tracking regulators now available is their high cost. The following schematic illustrates a simple tracking regulator utilizing popular low cost integrated circuits from the ML723 and ML101A families. The technique presented here may be extended to multiple positive or negative supplies.

The positive regulator is a normal ML723 configuration. The output voltage is given by V_{ref} $[(R_1+R_2)/R_1)]$ and the short circuit current is given by V_{be}/R_{sc}. The short circuit current decreases with increasing temperature at approximately 0.3%/°C. Compensation to ground is used for added flexibility in the selection of R_2 and R_1. R_3 may be eliminated if temperature stability of output voltage is not of major concern.

The negative regulator is a simple inverter. The circuit takes advantage of the ML301A's ability to operate within specifications with its input connected to the positive supply terminal. This avoids an excessive voltage requirement for the negative error amplifier. The negative output voltage is given by R_5/R_4 times the positive output voltage. The short circuit current is again given by V_{be}/R_{sc}. The current sensing transistor is connected to take advantage of the ML723's ability to be shut-down via the compensation terminal. If the negative side of the regulator is forced into current limiting the positive supply is shut-down and the negative supply simply follows down to zero volts.

If the negative regulator is not to be operated at less than 2 volts output except under fault conditions then D1 and R_7 may be eliminated. Also, R_8 may be eliminated if the slightly increased temperature dependance of output voltage can be tolerated. R_6 ensures that the surge current associated with a fast turn-on of Q_3 will not damage either Q_2, Q_3 or the ML723.

In systems where the regulator is to supply a distributed load on a long line, problems can arise with oscillation as a result of small capacitive loading. To ensure stability under all loading conditions it is only necessary to add a large enough capacitor from each output to ground to ensure that the output time constant ($R_{sc}C_L$) is long with respect to the internal frequency compensation.



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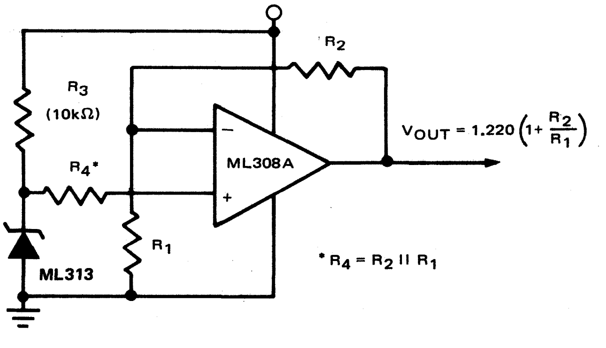
DESCRIPTION AND APPLICATION OF THE ML113 LOW-VOLTAGE REFERENCE DIODE

1 THE ML113 VERSUS OTHER DIODES

The ML113 family of diodes have unique advantages over other avalanche or zener diodes in reference circuitry. The relative merits of semiconductor reference diodes are listed in the following table for easy comparison.

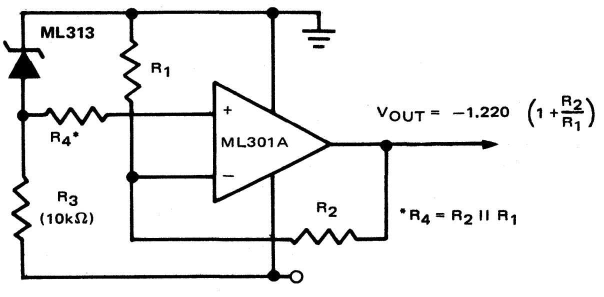
	ML113 Family	**Other Diodes**
Breakdown Voltage	1.220V	2.4V to 200V
Operating Current	0.5mA to 20mA	0.1μA to 20mA
Temp. Coeff.	0.01mV/°C	−2mV/°C to +200mV/°C
Noise Voltage	$1\mu V_{rms}$	$30\mu V_{peak}$ to $100\mu V_{peak}$
Long Term Drift	0.1mV	10mV to 40mV
Dynamic Impedance	0.05Ω	5Ω to 5000Ω
Leakage Current	20μA	5μA to 150μA



POSITIVE REFERENCE

2 BREAKDOWN VOLTAGE

The ML113 is supplied with tolerances of ±1%, ±2% or ±5% around the center value of 1.220V. The low voltage allows the ML113 to be used in applications where supply voltages prevent the use of conventional references. The addition of a low cost buffer operational amplifier as in the diagram, allows tailoring of the output voltage to any convenient value; however, the temperature coefficient of the amplifier must be accounted for in the calculation of the total drift of the output voltage. One advantage of a buffered reference circuit is its having the ability to both 'source' and 'sink' current without excessive reference current.



NEGATIVE REFERENCE

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3 OPERATING CURRENT AND DYNAMIC IMPEDANCE

The ML113 might, at a casual glance, appear to be inferior to a conventional zener diode because of its soft turn-on characteristic. This observation is misleading. Conventional zener diodes and temperature-compensated diodes must be operated in the 1 to 10mA range in order to ensure low noise, low dynamic impedance and acceptable long term drift. The ML113 has its dynamic impedance guaranteed at 0.75Ω – one order of magnitude lower than of conventional diodes. The typical value is 0.05Ω over the operating current range.

4 LONG TERM DRIFT AND NOISE VOLTAGE

Conventional voltage reference diodes exhibit long term drift characteristics of the order of 20mV to 50mV in the first 168 hours of operation at 125°C, when operated at low currents. At more moderate temperatures this drift is extended over several weeks.

To minimize long term drift, a one square mil zener diode must be operated in the 1mA to 3mA range. More recently developed monolithic regulators are using higher reference currents to achieve stability, even at the cost of the extra dissipation.

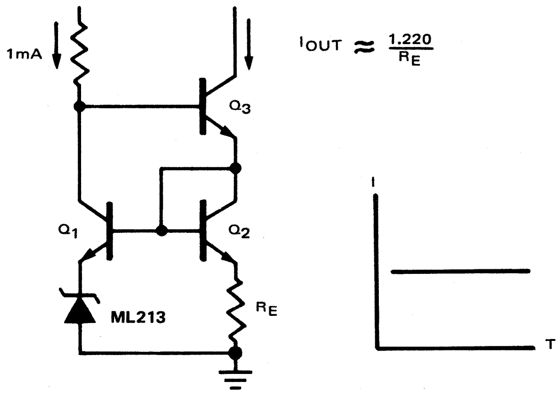
Conventional reference diodes also exhibit gross 1/f and popcorn noise near the "knee" of their operating region and 30μV to 200μV noise at higher current levels. This characteristic makes zener diodes unsuitable for use as bias references in low noise low frequency amplifiers.

The ML113 family of reference diodes has neither of the above limitations. Long term drift is better than 0.2mV per 1000 hours, and noise voltages are approximately 1μV$_{rms}$ with little evidence of 1/f noise even at low temperatures.

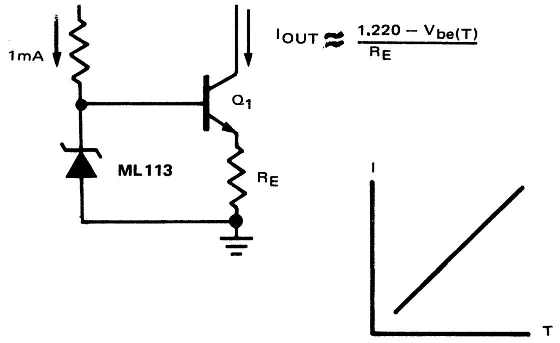
5 TEMPERATURE DRIFT

The ML113 family of diodes features exceptional temperature drift characteristics. Although better than 1% change is guaranteed over the operating temperature range, units with high yield, and exhibiting better than 0.2% drift over –25°C to +85°C can be selected. This makes the ML213 ideal for use as a reference in 6 and 8 bit D/A convertors specified over the telecommunications temperature range. Devices accurate to 10 bits may also be selected. Compensated reference diodes also exhibit low temperature drift. The drift rates however are very current-dependant. For optimum performance the operating current must be either kept constant or varied in a controlled manner. The ML113's temperature coefficient is monotonic and independant of operating current. The ML113 therefore eliminates the need for an accurate current source in order to maintain high stability.

6 APPLICATIONS



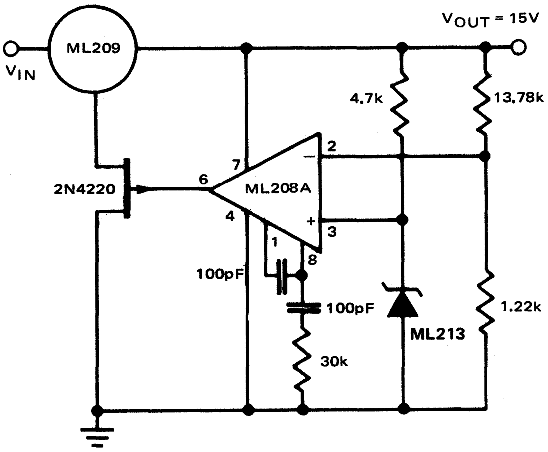
CURRENT SOURCE (Temperature Independent)



CURRENT SOURCE (Temperature Dependent)

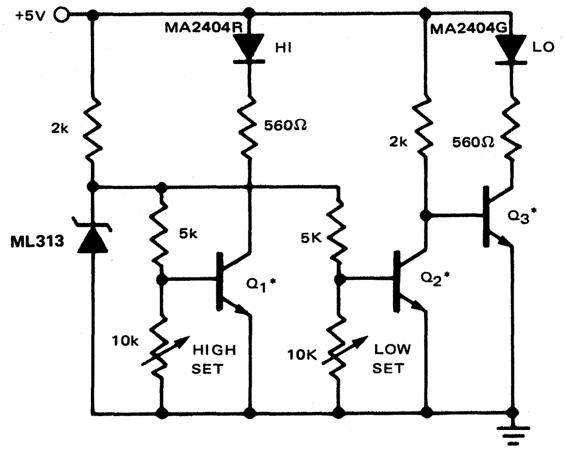
DESCRIPTION AND APPLICATION OF THE ML113 LOW-VOLTAGE REFERENCE DIODE

6 Continued . . .



CONDITION	OUTPUT STABILITY
$18V \leqslant \Delta V_{IN} \leqslant 35V$	$\Delta V_{OUT} \leqslant 1mV$
$0 \leqslant \Delta I_{LOAD} \leqslant 1.5A$	$\Delta V_{OUT} \leqslant 2mV$
$-25°C \leqslant T_A \leqslant +85°C$	$\Delta V_{OUT} \leqslant 1mV$

HIGH STABILITY REGULATOR



*Shows use of temp. characteristics of the transistors in ML3045 array — Q_1, Q_2 are the senors.

HIGH/LOW AMBIENT TEMPERATURE INDICATOR

A LOW COST REGULATED SUPPLY USING THE ML723

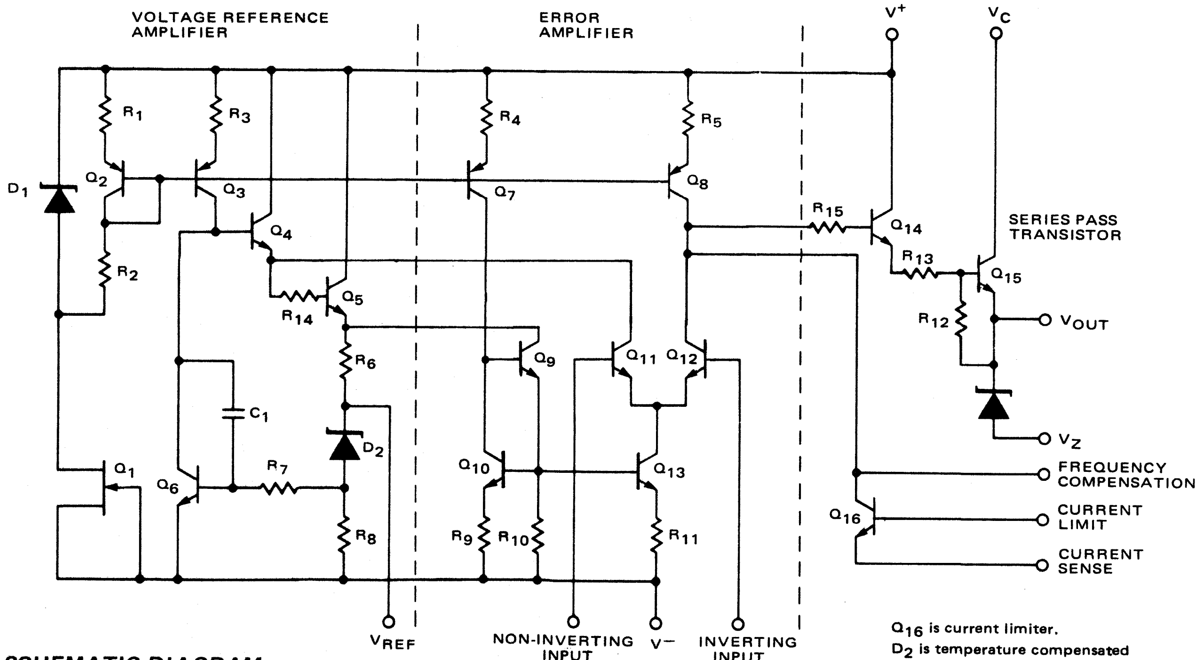
1 INTRODUCTION

The most widely used piece of lab equipment is certainly the regulated power supply. All such systems may be broken down into three component parts (disregarding the transformer rectifier combination) namely the reference generator, error amplifier and output element. The ML723 integrated circuit contains the first two items, only an external series pass transistor being required to accommodate the designed worst case dissipation required.

2 CIRCUIT DESCRIPTION

The complete circuit of the ML723 is shown in the schematic diagram with the basic sections named.

The operation is as follows: Q1 a junction FET provides a constant current supply, independent of V+ to the zener diode D1. The resultant constant voltage drives an array of constant current loads Q3, Q7, Q8, via the temperature compensated potentiometer R1, R2, Q2. The reference voltage is generated by D2 and Vbe (on) of Q6, the combination having the average temp. co-efficient of .002% per degree C. Q6, Q3 are the active devices and load of a simple feedback amplifier whose output is emitter-followed by Q4, Q5, C1 providing closed loop stabilization.



Q_{16} is current limiter.
D_2 is temperature compensated

SCHEMATIC DIAGRAM

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The error amplifier is the differential pair Q11, Q12, with Q8 acting as a constant current load. Q14, Q15 emitter-follow the differential output and allow output currents up to 150 mA to be drawn without external transistors. The collector of Q15 is available separately to enable resistive limiting to be used if required to reduce the ON chip dissipation where a large input/output differential exists. Current limiting is achieved by Q16 removing the base drive current to Q14 Q15 when a voltage developed across an external series resistor reaches the turn on potential of the base emitter junction. By adjustment of this value any preset limit may be achieved.

3 1A SUPPLY

As outlined previously the only addition required for a 1A supply is that of a higher dissipation series element. Since however the unit must be continuously variable over the range 2-20V, certain modifications from the single fixed voltage systems are required. Considering the block diagrams of Fig. 1, two modes of operation are usually employed; one for output voltages below V ref(a) and the second for outputs above V ref (b).

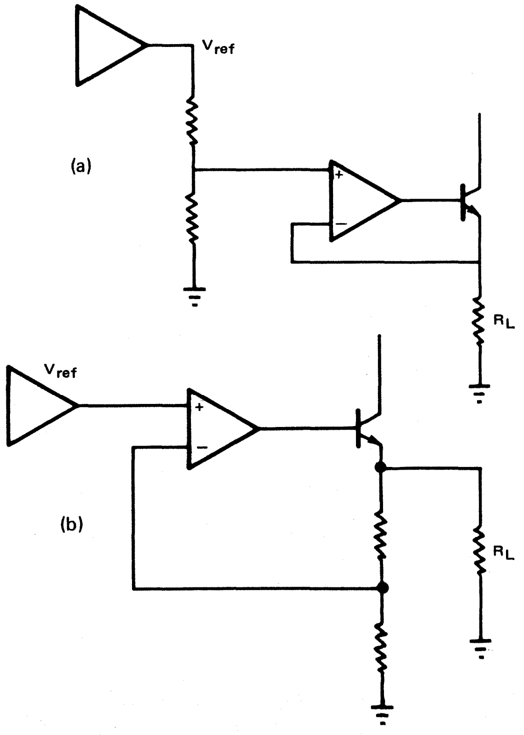

FIG. 1. SIMPLIFIED 1A SUPPLY BLOCK DIAGRAMS

The difference is that in (a) V ref is potted down to the required output and the error amplifier acts as a voltage follower, while in (b) the output is potted down until it equals V ref. For a continuously variable supply passing both sides of V ref, the circuit (c) enables switching of input output connectors to be removed and replaced by a single knob control.

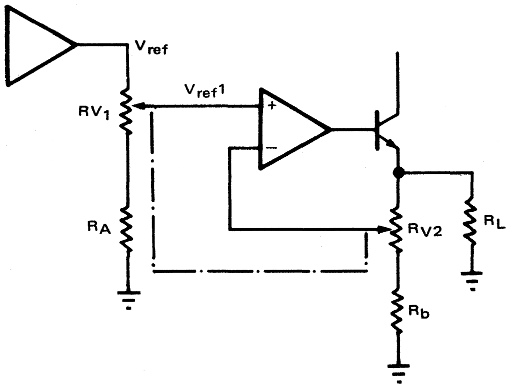

FIG. 2. SIMPLIFIED 1A SUPPLY WITH SINGLE KNOB CONTROL

With Fig. 2 arrangement, with RV1 at its lower end, V ref' = 2V while RV2 is at the top of its travel thus enabling the error amplifier to act as a simple voltage follower. At the opposite end V ref' = V ref and the output potential is V ref. $\frac{Rb + Rv2}{Rb}$

It is adequate to simply divide down the reference voltage to 2V for a low cost supply.

Normally the output capability of the ML723 is adequate to drive a 1A output stage; however, in a variable supply, the dissipation in the TO99 encapsulation would be excessive, hence the use of a Darlington output. The same transistor type as the output device is used as the Darlington input to simplify the best sinking arrangements, which apply at low output voltages.

If a fixed voltage supply were required, the excess dissipation in Q15 (ML723) is easily reduced by a series resistor between pin 8 (V+) and pin 7 (Vc). Such a solution is not however toleranceable in a wide range variable unit.

4 CURRENT LIMITING

A continuously variable current limit is provided by the addition of a variable resistor sensing the output current as shown in Fig. 3.

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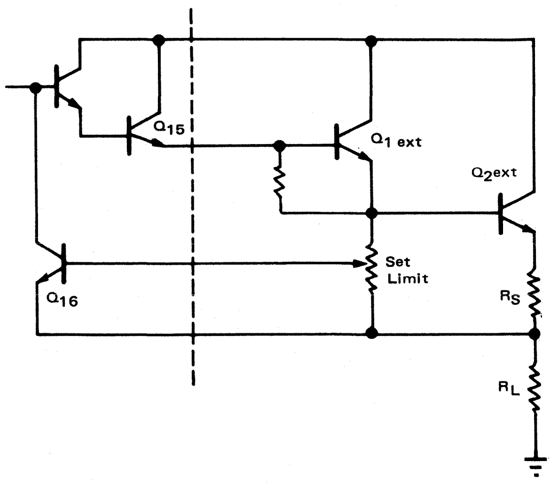

FIG. 3. SUPPLY WITH OUTPUT RESISTOR SENSING

The operation has been described previously. It should be noted that the sensing must be performed by a resistor in the true output lead, for high reliability.

This however entails a higher dissipation. The final circuit is chosen to allow limiting for values down to zero output current, this being possible because of the forward base-emitter voltage drop of Q_2 ext.

5 COMPENSATION

When used at currents up to the limit of the internal series pass transistor and on predominantly resistive loads, compensation to ensure closed loop stability may be obtained by a capacitor from the 'frequency compensation ' point to the INV. input. This operates with conventional single pole stabilization as used in the ML741 family of operational amplifiers. However when a large capacitive component exists in the load, a second pole is introduced in the open loop response. This can give rise to instability and, for the supply being discussed, large capacitive loads; e.g., distributed decoupling on TTL systems may occur. In this supply, compensation has been applied by the technique shown in Fig. 4 where Rs Cc provide the single pole for stabilization. Any additional external C then only decreases its frequency rather than creating a second pole, as shown in Fig.4.

If however the supply is to be used with primarily resistive loads, the compensation may be performed by a 470pF capacitor between the 'compensation point' and the non-inverting input. In this condition, the output capacitors (C2 C3) may be removed, the output being taken from the emitter of Q_2 ext. The 4.7 ohm (R3) may be reduced to lower the dissipation in the sensing element.

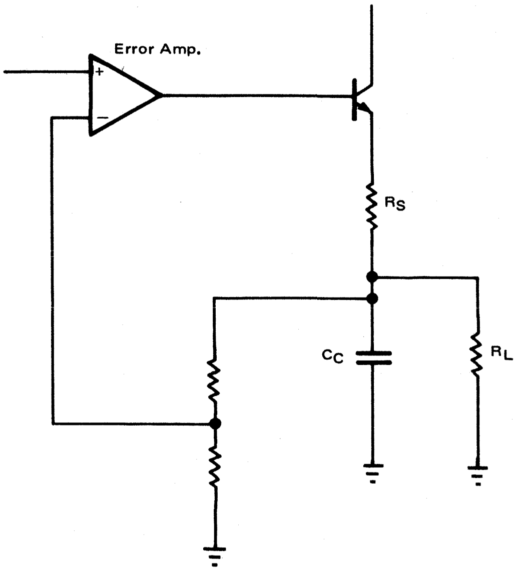

FIG. 4. SUPPLY WITH EXTERNAL STABILIZATION

Because of the wide frequency response of the current limiting loop via Q16, oscillation may be started by load transients or turn-on charging current in the output capacitor. To slow down the response of the current limiter without effecting overall stability, it is necessary to add the 1KΩ and 470pF capacitor as shown in Fig.5.

6 CONSTRUCTION

The complete circuit for the supply is shown in Fig. 5. Layout is not critical. The heat sink should be positioned in free air since in the worst case (Vo = 2v Io = 1 A) the dissipation in the series element is approximately 35w, hence a heat sink of adequate rating must be employed. In practice, for the transistors specified, this should be at least 40 square inches.

DIL-14

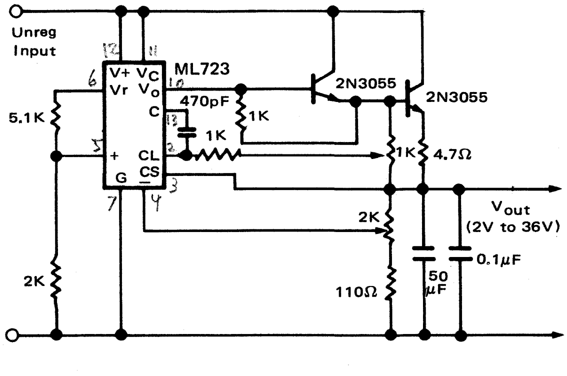

FIG. 5. THE COMPLETE 1A SUPPLY CIRCUIT

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7 TYPICAL PERFORMANCE

V out	2v – 36v
R out	0.02 Ω with current limit set at 1A
Noise	< 0.5mV R.M.S.
Ripple	< 0.5mV R.M.S. at $I_L = 1A$
Line rejection	0.02%

Transient performance (See Fig. 6)

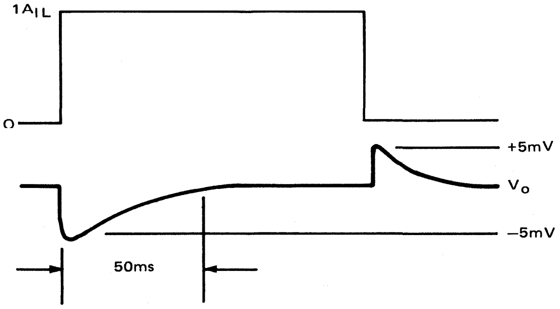


FIG. 6. TRANSIENT PERFORMANCE TIMING

DESCRIPTION AND APPLICATION OF THE ML4270, ML4270-15 DC-DC CONVERTER

1. INTRODUCTION

DC–DC converters are switching mode power supplies used to:

(1) upconvert an input voltage to a higher output voltage

(2) downconvert an input voltage to a lower output voltage with higher efficiency than with a standard series or shunt regulated supply.

(3) obtain an output voltage of opposite polarity to the input with respect to circuit ground.

DC–DC converters operate in general by chopping the input, amplifying or attenuating the resulting voltage waveform, then rectifying and filtering. A variety of specific design approaches are possible. These may use, for example, either a push-pull or single-ended power output stage and a transformer with a core that may or may not saturate. The output voltage may be either regulated or unregulated.

The ML4270 monolithic dc–dc converter produces a regulated output using a transformer with a core that does not saturate. The circuit includes a voltage reference, a comparator, a multivibrator, and a single-ended current output stage. The multivibrator mark-space ratio is varied through feedback such that the output voltage is regulated to a scaled multiple of the reference voltage.

The ML4270 operates over an input voltage range of 3 to 12V. Large output voltages consistent with power limitations can be obtained with an appropriate step-up transformer. Any combination of positive or negative input and output voltage polarity is available. Normal output power is in the 100–200 milliwatt range but can be increased with an external booster transistor.

External components required for normal operation include a pulse transformer, switching diode, timing capacitor and pair of resistors; also, an input charge reservoir capacitor, output filter capacitor, and a pair of output voltage setting resistors. The pulse transformer coupling between input and output makes possible multiple outputs from a single input and provides inherent output short-circuit protection.

An inductor can be used in place of the pulse transformer when the desired output voltage is positive. The ML4270–15 contains the output voltage setting resistors on the chip and gives a fixed 15V output.

Primary areas of application include electronic calculators and other battery powered field equipment. It can be used also as a standard component in light-load power supply systems for inverting the polarity of dc power.

This application note describes the on-chip circuitry of the ML4270, the required external components, and a number of typical complete working circuits.

2. ON CHIP CIRCUITRY

The on-chip circuitry shown in Fig. 1 includes a voltage reference, a comparator, a multivibrator, and an output current switch transistor. A fraction of the output voltage is compared to the reference voltage and the resulting error signal used to control the multivibrator mark-space ratio via fixed OFF time and variable ON time, such that the circuit output voltage is maintained equal to a controlled multiple of the reference voltage.

The multivibrator OFF time is set by external resistor R_{off} (pins 8–12) and capacitor C_T (pin 12-GND). The maximum ON time is set by external resistor R_{on} (pins 10–12). Referring to the chip schematic of Fig. 1 (B) the multivibrator is made up of R4–15, Q3–15, D2–3.

When supply voltage is applied, the base of Q5 is held momentarily at ground by capacitor C_T while the base of Q6 goes to $2/3V_{in}$ as determined by R6 and R7. Q6, 4, 14, 15 are ON. Capacitor C_T at the base of Q5 charges through Q15 and R_{on} until it reaches the upper trip point (UTP) of $2/3\ V_{in}$. At that time Q5 comes ON, turning on Q3, 7, 10–13. Positive feedback through Q10 snaps the base of Q6 to $1/3\ V_{in}$ as determined by R6 and the parallel combination of R5 and R7. The capacitor now discharges through R_{off} and Q13 until reaching the lower trip point (LTP) of $1/3\ V_{in}$ at which time Q5 snaps OFF and Q6 ON. The capacitor voltage continues to oscillate between the UTP of $2/3\ V_{in}$ and LTP of $1/3\ V_{in}$.

During the part of the oscillator period when Q4, 6, 14, 15 are ON, the output switch transistor Q18 is also ON. The maximum base current drive to Q18 is set at approximately 3.5mA by the V_{be} of Q16 across R16. The collector current of Q18 is limited to a maximum value of about 300mA by R17–19 and Q17. Q11, 12 provide active base charge pull-off for the fast turn-off of Q18, thus minimizing power loss during the turn-off transient.

DESCRIPTION AND APPLICATION OF THE ML4270, ML4270-15 DC-DC CONVERTER

The reference voltage is determined by zener diode D1 and the V_{be} of Q2. When the scaled output is higher than the reference voltage, relatively large currents flow in the collector of Q2 and therefore, of Q1 also. Collector current of Q1 flowing through D3 adds to the current through Q15 and R_{on} and charges the capacitor towards the UTP. The ON time of the switch transistor is thus shortened, decreasing the power transferred through the pulse transformer to the output filter and hence lowering the output voltage.

Q7 sinks the current from the right collector of Q1 during the OFF time. Diode D3 blocks any modulating current from the timing capacitor during the OFF time, ensuring that the fixed OFF time is determined solely by R_{off} and C_T. Diode D2 provides transient protection.

3. EXTERNAL COMPONENTS

The frequency of oscillation of the multivibrator is determined by an external capacitor and two external resistors as shown in the standard connection diagram of Fig. 2. The OFF, and maximum ON, times of the switch transistor are:

$$T_{off} = 0.69\ R_{off}\ C_T \qquad (1)$$

$$T_{on}\ \text{max} = 0.69\ R_{on}\ C_T \qquad (2)$$

The frequency of oscillation is desired sufficiently high so that a reasonably small pulse transformer and filter capacitor can be used, but not so high that too much power is lost in switching transients. Oscillation frequencies of tens of kilohertz are common.

The pulse transformer must have a suitable primary inductance and a core that does not saturate at maximum dc current. Transformers with large step-up turns ratios are not common as the voltage gain can only be achieved at the expense of rise-time. In fact, a 1:1 turns ratio gives the best coupling between windings and therefore is usually used.

The switching diode is chosen for adequately high reverse blocking voltage, low forward ohmic drop, and fast recovery time.

The input charge reservoir capacitor and output filter capacitor must be sufficiently large so that the associated ripples are acceptably small.

4. CIRCUIT PERFORMANCE

The average power consumed on the output side of the transformer in the standard connection of Fig. 2 is:

$$P_o = (V_o + V_d)\ (I_L + I_B) \qquad (3)$$

where V_o = output voltage

V_d = diode forward voltage drop

I_L = load current

I_B = bias current drawn by voltage reference part of converter circuit and output voltage setting resistors, about 1.5mA.

The output power must be transferred through the transformer. During the ON time of the switch transistor, the current in the transformer primary builds up linearly from zero to a maximum value of:

$$I_P\ \text{max} = (V_{in} - V_{ce\ sat})\ T_{on}/L_p \qquad (4)$$

where L_p = inductance of primary winding. The energy input to the transformer per cycle is therefore

$$E = 1/2\ LI^2 = (V_{in} - V_{ce\ sat})^2\ T_{on}^2/\ 2L_p \qquad (5)$$

If this energy is averaged over the total period $T_{on} = T_{off}$ the average power is:

$$P_{in}\ [(V_{in} - V_{ce}\ \text{sat.})^2 2L_p] \cdot [T_{on}\ (1 + T_{off}/T_{on})] \qquad (6)$$

For a lossless transformer the power expressions of equations (3) and (6) are equal.

The efficiency of the entire dc—dc converter is:
Efficiency = $(V_o I_L)/(V_{in} I_{in})$ (7)

Caution: It is easy to underestimate the peak value of dc current through the transformer primary. The ratio of load current to peak primary current, assuming an ideal switching diode and pulse transformer, is:

$$I_L = \frac{I_p\ \text{max}}{2} \cdot \frac{T_{on}}{T_{on} + T_{off}} \cdot \frac{V_{in}}{V_o} \qquad (8)$$

Typically, for instance:

I_L = $(I_p\ \text{max.}/2) \cdot (3/5) \cdot (1/3)$

or $I_{pmax} = 10\ I_L$.

If the transformer core is allowed to saturate because of high dc current the impedance of the primary becomes very small and the circuit ceases to function correctly.

4.1 Example 1: Positive in, Positive out

The supply shown in Fig. 4 will upconvert a battery voltage that can vary from 5-10 V, to a 15V output. The load can vary from open circuit to 2KΩ. These requirements could be encountered, for example, in the design of a small electronic calculator.

With R_{off} = 15KΩ, R_{on} = 30KΩ, C_T = 1000pF: T_{off} = 10μsec and T_{on} max = 20μsec. When $T_{on} = T_{off}$ the frequency of oscillation is 50kHz.

Maximum transistor ON time corresponds to V_{in} = 5V and R_L = 2KΩ.

Equating Eqns. (3) and (6), assuming $V_{ce\,sat}$ negligible, and using an estimated maximum ON time of 18µsec somewhat below the available max. ON time of 20µs gives:

$$L_p = \frac{V_{in}^2}{2(V_o + V_d)\;(I_L + I_B)} \cdot \frac{T_{on}}{1 + T_{off}/T_{on}} \quad (9)$$

$$= \frac{25V^2}{2(15.7V)\;(9mA)} \cdot \frac{18\mu sec}{1 + 10/18}$$

$$= 1mH.$$

Minimum ON time corresponds to V_{in} = 10V and I_L = 0. Calculating from (9) gives T_{on} min ≃ 3µsec. From Eqn. (4) I_p max ≃ 90mA. The transformer core must not saturate at this current level. The rectifying diode type as shown in Fig. 4 is IN914, with reverse recovery time less than 10nsec. Both the output filter capacitor and the input decoupling capacitor are chosen to give worst case ripples of about 20mV. The measured performance parameters of the converter circuit are shown in Figs. 4 and 5.

The switching waveforms for both sides of the pulse transformer are shown in Figs 6 and 7. The top waveforms are the connection between the primary of the transformer and the switch transistor collector. The lower waveforms are the connection between the transformer secondary and the diode. Fig. 6 corresponds to a minimum ON time with V_{in} = 10V and I_L = 0. Fig. 7 corresponds to maximum ON time with V_{in} = 5V and R_L = 2KΩ.

In Fig. 6, for example, when the switch transistor is turned ON the pulse transformer primary goes from +10V to ground. Because of the 1:1 turns ratio the secondary goes from ground to −10V.

When the switch transistor is subsequently turned OFF both the primary and secondary fly high. The secondary is clamped at $V_o + V_d$V, 15.8V in Fig. 6, as the diode conducts. Since the voltage excursion of the primary must be the same as that of the secondary, the primary is clamped at $V_{in} + V_o + V_d$ V or 24.8 V in Fig. 7.

NOTE: For a 1:1 transformer, the collector-emitter of the current switch transistor always senses the sum of the absolute values of input and output voltages.

The fixed OFF time should be regarded in two parts corresponding to two different physical events. During the first part, corresponding to the high flat part of the waveform, the energy stored in the transformer is transferred through the diode to the filter capacitor. This energy transfer takes place with a time constant of approximately L_s/R, where L_s = secondary inductance and R = total series resistance in the secondary circuit. During the second part of the OFF period, both the primary and the secondary are open-circuited and the transformer inductance rings with the stray capacitance present.

4.2 Example 2: Negative in, Positive out

An inductor can be used in place of the pulse transformer if the desired output voltage is positive (so that the waveform at the collector of the current switch transistor, pin 4, is in phase with the waveform at the switching diode). Fig. 8 shows a circuit similar to that of example 1 but with an inductor in place of the pulse transformer, the input negative, and using an ML4270—15 device.

4.3 Example 3: Positive in, Negative out

Fig. 9 shows a circuit connection suitable for realizing an output voltage smaller in magnitude than the input voltage. A probable application is a substrate bias supply for MOS circuitry.

4.4 Example 4: Negative in, Positive and Negative out

The circuit of Fig. 10 uses an external booster transistor and a transformer secondary with two windings. The booster transistor increases the possible load current to about 50mA. The output voltage from one secondary winding is regulated in the normal manner, while the output voltage from the other is determined by the regulated output voltage and the turns ratio of the two secondary windings. At full load current the efficiency of the circuit of Fig. 10 is about 60%.

DESCRIPTION AND APPLICATION OF THE ML4270, ML4270-15 DC-DC CONVERTER

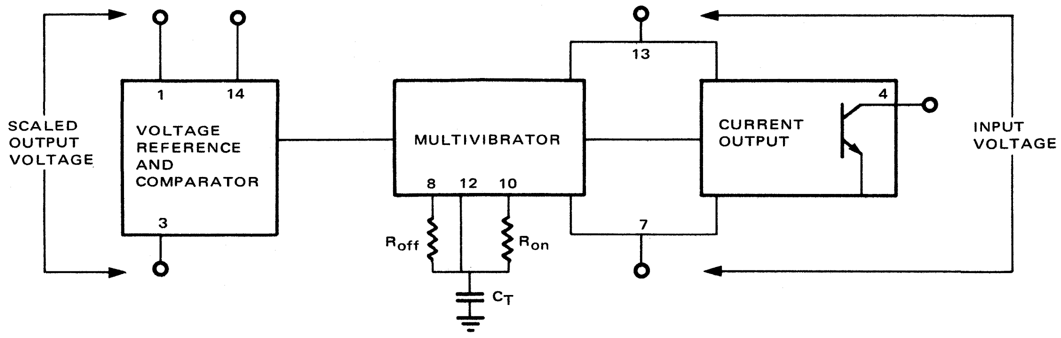


FIG. 1 (a) ML4270 DC—DC CONVERTER BLOCK DIAGRAM

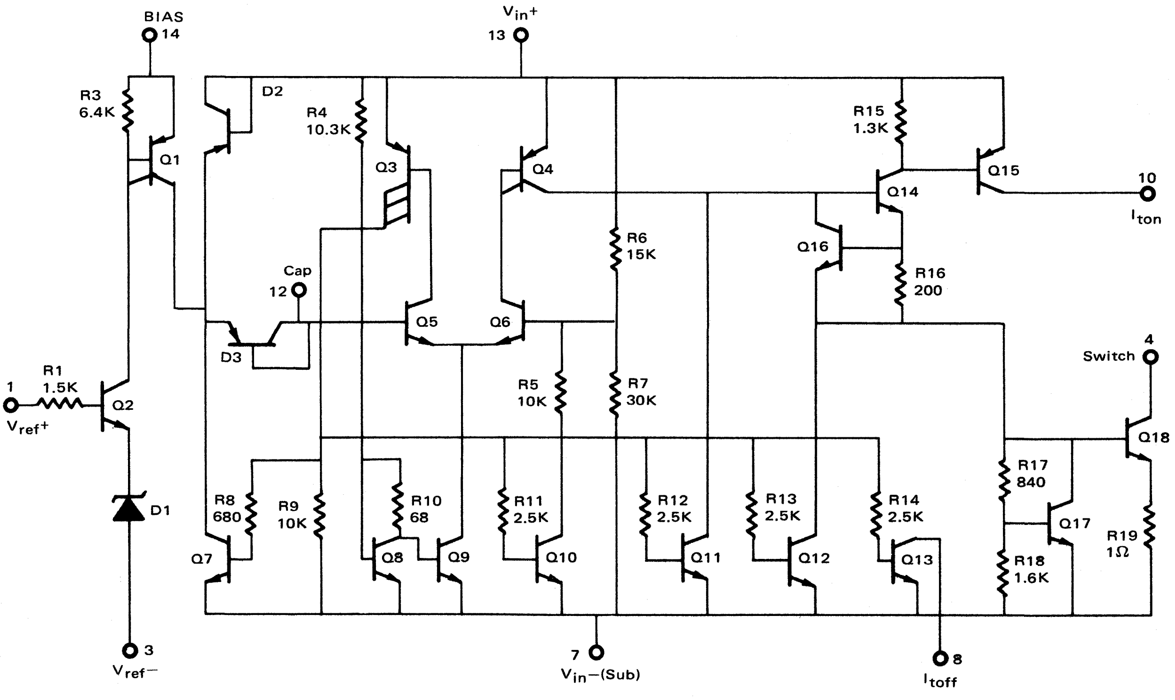


FIG. 1 (b) ML4270 CIRCUIT SCHEMATIC

DESCRIPTION AND APPLICATION OF THE ML4270, ML4270-15 DC-DC CONVERTER

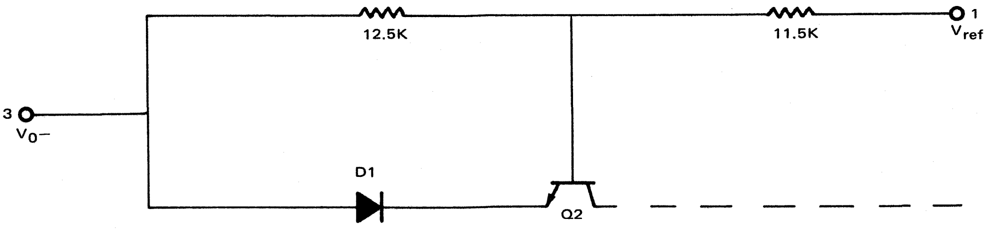


FIG. 1 (c) ML4270–15 VOLTAGE REFERENCE
(Otherwise Identical to ML4270)

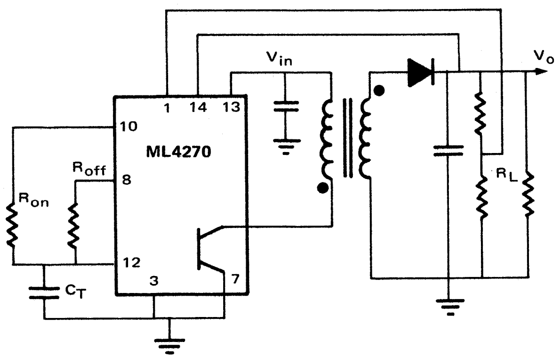
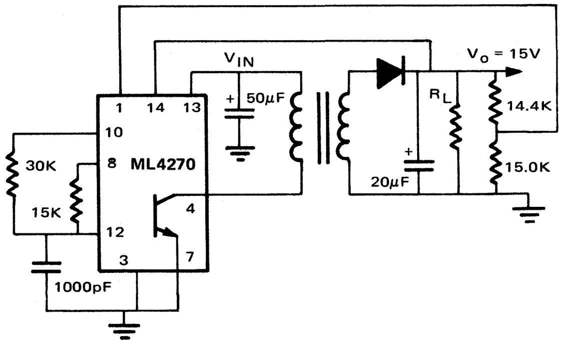


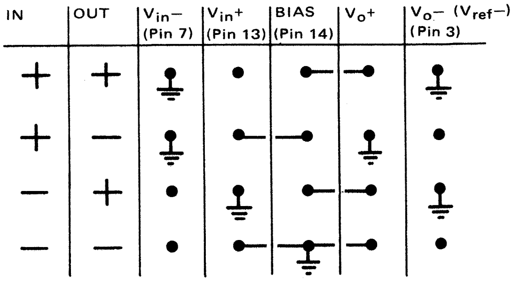
FIG. 2 STANDARD CONNECTION, INPUT AND OUTPUT VOLTAGES BOTH POSITIVE



NOTES:

1. Diode is silicon switching type IN914 or equivalent.
2. Pulse transformer is 1:1; L_P - 1mH (e.g. 63 turns of #36 wire on a 11mm diameter, 7mm thick, A_L = 250 ferrite pot core).
3. – Frequency of oscillation; V_{in} = 7.5V, R_L = 2KΩ:50kHz.
   – Line regulation; V_{in} = 5–10V:50mV/V.
   – Load regulation; I_L = 0–7.5mA:20mV/mA.
   – Average temp. coef. of V_{ref}; 0–70°C:+1mV/°C

FIG. 4 POSITIVE IN, POSITIVE OUT



IN	OUT	$V_{in}-$ (Pin 7)	$V_{in}+$ (Pin 13)	BIAS (Pin 14)	V_o+	V_o- ($V_{ref}-$) (Pin 3)
+	+	⏚	●	●—	—●	⏚
+	−	⏚	●—	—●	⏚	●
−	+	●	⏚	●—	—●	⏚
−	−	●	●—	—⏚—	—●	●

FIG. 3 CONNECTION MATRIX FOR POSITIVE AND NEGATIVE INPUT AND OUTPUT VOLTS

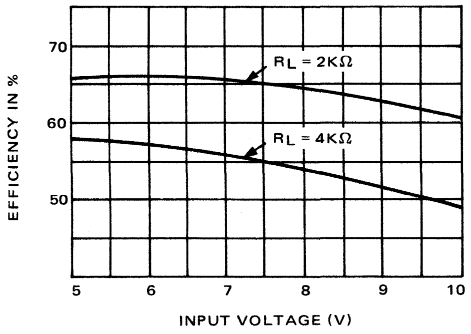
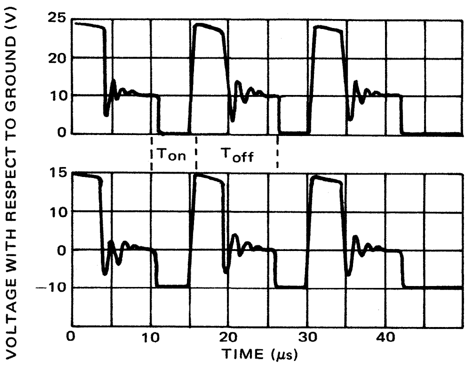


FIG. 5 EFFICIENCY OF CIRCUIT OF FIG. 4

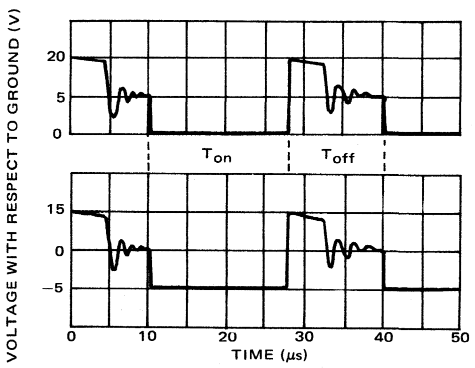
DESCRIPTION AND APPLICATION OF THE ML4270, ML4270-15 DC-DC CONVERTER



NOTES:

1. Waveform at collector of current switch transistor (pin 4).
2. Waveform at anode of switching diode.

FIG. 6 SWITCHING WAVEFORMS (minimum ON time)



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1. Waveform at collector of current switch transistor (pin 4).
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FIG. 7 SWITCHING WAVEFORMS (maximum ON time)

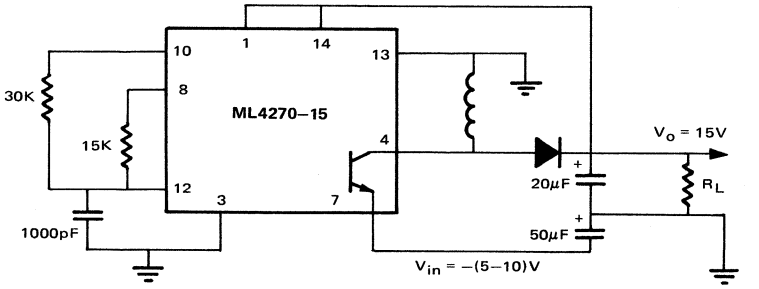

FIG. 8 NEGATIVE IN, POSITIVE OUT

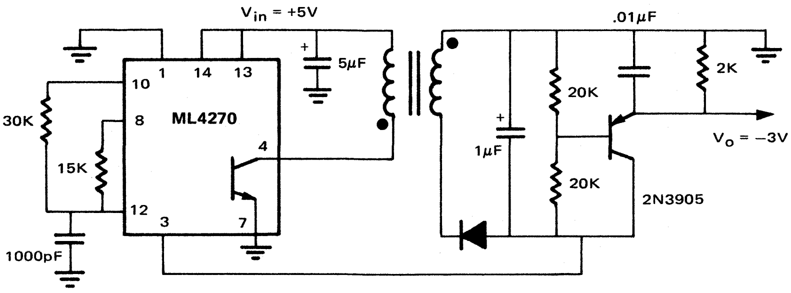

FIG. 9 POSITIVE IN, NEGATIVE OUT

DESCRIPTION AND APPLICATION OF THE ML4270, ML4270-15 DC-DC CONVERTER

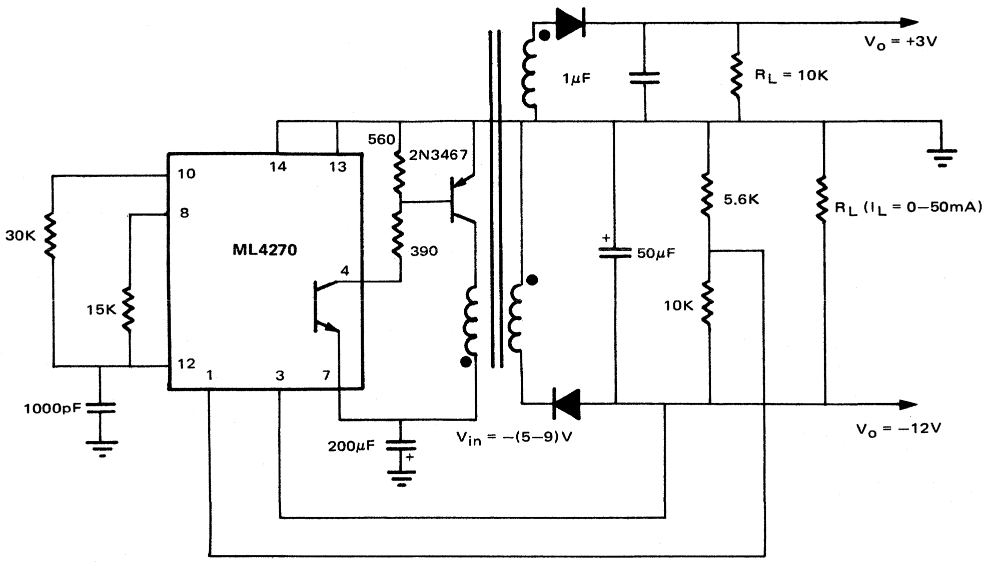

FIG. 10 NEGATIVE IN, POSITIVE AND NEGATIVE OUT

TESTING OPERATIONAL AMPLIFIERS EASILY AND ACCURATELY

1. INTRODUCTION

A problem often confronting the operational amplifier user is that of adequately testing the device for purposes of:

a) Incoming inspection
b) Verification of stability with life
c) Failure analysis
d) Selection to tightened limits

Many schemes are being used to test operational amplifiers. Many are grossly inadequate and incapable of completely testing even static parameters as specified by manufacturer's data sheets. Also, unfortunately, many small commercial operational amplifier testers are not well enough equipped for complete testing of modern monolithic operational amplifiers.

The test circuit recommended and described herein however, can be constructed for about $100; and it can be used manually or automatically to test all static parameters normally specified by the manufacturer's data sheets, and also those given in military specifications such as MIL-M-38510/101.

2. DEFINITION OF PARAMETERS

Direct measurement of operational amplifier input parameters is unrealistic because of the practical difficulties involved.

Shown in Table 1 are the definitions used by many manufacturers. Consideration of these definitions and their implications should prove evident that testing performed accordingly will allow complete prediction of an operational amplifier's dc performance over its operating range, including input common mode voltages, supply voltages and output loading.

The definitions related to input parameters have one common denominator — 'All parameters can be interpreted in terms of input offset voltage or a change in input offset voltage.' This implies that all static parameters can be verified if input offset voltage can be accurately measured. Input offset voltage is in fact easily measured with high speed and accuracy.

At this point it is advisable to note the significance of the definitions for "Input Voltage Range" and "Supply Voltage Range". These two imply a maximum error band without cumulative errors as allowed by some manufacturers. Consider the following specifications for the ML101A:

Supply Voltage Range	±5V to ±20V
Input Voltage Range	±15V at $\pm V_{SS}=\pm 20V$
Common Mode Rejection	80dB
Power Supply Rejection	80dB
Input Offset Voltage	±2.0mV ($R_S \leqslant 50K$)
Input Offset Current	±10nA
Input Bias Current	75nA

If a device were guaranteed to the above specification without applying the definitions for "Input Voltage Range" or "Supply Voltage Range" the net input error due to all sources could be:

$$\pm V_{io} + I_{io}\,R_S + PSRR\,\frac{(\Delta V_{io})}{(\Delta V_{SS})} + CMRR\,\frac{(\Delta V_{io})}{(\Delta V_{in})}$$

which equals

(±2.0mV) + (±0.75mV) + (±0.75mV)

or ±3.5mV

TESTING OPERATIONAL AMPLIFIERS EASILY AND ACCURATELY

TABLE 1. TEST PARAMETERS AND DEFINITIONS

PARAMETER	SYMBOL	DEFINITIONS
Input Offset Voltage	(V_{io})	The voltage which must be applied between the input terminals through two equal resistances to obtain zero output voltage.
Input Offset Current	(I_{io})	The difference in the current between the input terminals with zero output voltage.
Input Bias Current	(I_b)	The average of the two input currents.
Input Voltage Range	(V_{icm})	The range of voltages on the input terminals for which the amplifier operates within its input offset specifications.
Common Mode Rejection	(CMRR)	The ratio of input voltage range to the change in input offset voltage over the range.
Power Supply Range	(V_{SR})	The range of power supply voltages for which the amplifier operates within its input offset specifications.
Power Supply Rejection	(PSRR)	The ratio of supply voltage range to the change in input offset voltage over the range, with the supplies varied separately.
Large Signal Voltage Gain	(A_{VOL})	The ratio of output voltage swing to the change in input voltage required to drive the output from zero to that voltage.
Output Voltage Swing	(V_{out})	The peak output voltage swing, referred to zero, that can be obtained with the amplifier operating within its gain specification.
Supply Current	(I_S)	The current required from the power supply to operate the amplifier with no load and the output at zero volts.
Short Circuit Current	(I_{SC})	The current delivered by the output of the amplifier with the output connected to zero volts or either supply rail.

If the device is guaranteed over the input voltage range and power supply range, then the maximum error is ±2.0mV.

It would appear advantageous for the user to carefully examine data sheet fine print in order to determine how individual manufacturers test their product. A significant difference in error band can obviously exist depending upon test methods.

3. CIRCUIT DESCRIPTION (See Fig. 1)

The circuit is a simple two-amplifier gain stage. The buffer amplifier is connected as an integrator and as such provides a dominant pole for the loop. The loop gain is set at 1000 for convenience. This provides a 1V per 1mV sensitivity for input offset voltage readings. The source resistors in series with the inputs of the device under test (DUT) may be switched in the appropriate manner to perform input offset current and input bias current tests. Sensitivity is 20nA/V for R_S=50KΩ and 1nA/V for R_S= 1MΩ.

Gain tests are performed by varying the voltage at V_O equal to the required output voltage swing with the load resistor connected. The resulting change in input offset voltage of the DUT thus defines the gain error of the amplifier.

Power supply rejection is defined by the change in input offset voltage as a result of varying V_S+ and V_S- voltages separately.

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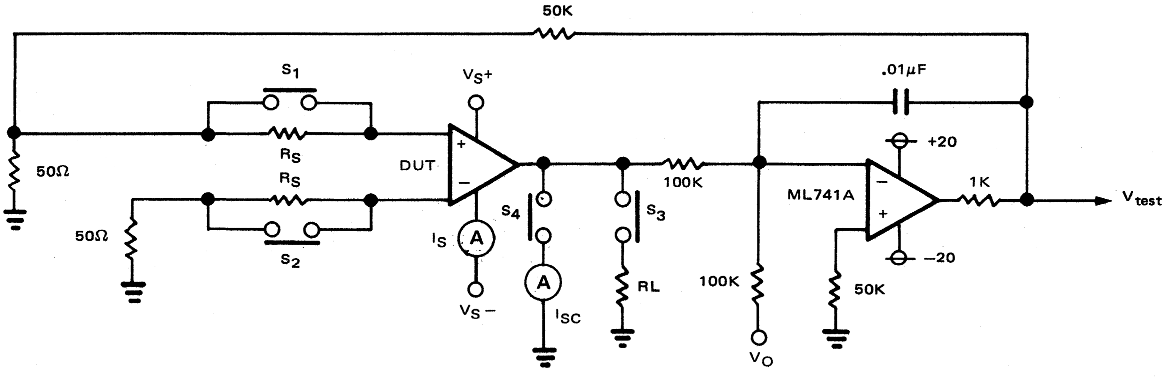

FIG. 1. TWO-AMPLIFIER GAIN STAGE

Common mode rejection is defined by the change in input offset voltage as a result of varying V_{S+}, V_S and V_O in a manner that effectively moves the inputs of the DUT between the common mode voltage extremes, with the output at zero volts relative.

Supply current and short-circuit current can be measured directly.

The following Table 2 lists some of the tests that can be performed with the test circuit.

Dual operational amplifiers may be tested in a dual version of the test circuit. If a dual circuit is used a channel separation test may be performed very simply. If the output of one amplifier is swung appropriately, the change in the input offset voltage of the second amplifier is a measure of channel separation and is given in dB by $20 \log_{10} \frac{\Delta V_{io}}{\Delta V_{out}}$

4. ACCURACIES, PRECAUTIONS AND ANOMALIES

Measurement accuracy of the circuit is a function of resistor tolerance. For setting loop gain, 0.1% resistors are adequate. The source resistors, however, should be matched to 0.01% to ensure negligible error in supply rejection, common mode rejection and input offset current measurements. Resistors also should have low internally generated thermocouple voltages.

The mechanical layout of the circuit is not critical. It is however, advisable to use a ground plane since 60Hz pickup can cause significant errors when high-value source resistors are switched into the circuit for input current measurements.

Care should be exercised in the selection of switches (S1 & S2). Significant errors can be introduced when measuring very low offset voltages because of the voltages generated within the switches by thermocouple action. Reed relays or mechanical switches can easily introduce between 20µV and 100µV errors. Ideally, low leakage, low resistance, matched FETS should be used for S1 & S2.

Offset and bias current tests can often be upset by the presence of a conductive path or of moisture on the package or socket of the DUT. Moisture from handling is the most common source of unwanted conductivity (7.5×10^9 Ω between pins 3 & 4 of an ML108 will cause the device to fail bias current).

The parameter likely to cause the most puzzling results is open loop gain. In amplifiers such as the ML741 thermal feedback effects can make the gain look infinite or even have the wrong sign. All that can be accomplished by measuring "gain" in this manner is to check the device's output swing capability while ensuring that a maximum gain error is not exceeded. The number measured is of little practical significance and is often so small that it is unsuitable as an indicator of proper device functioning, and should not be used as a reliability indicator.

5. POWER SUPPLY (See Fig. 2)

The following circuit is capable of supplying all voltages necessary to test all of the popular devices with the exception of the ML1536 and ML1436.

6. SAMPLE AND HOLD (See Fig. 3)

The following circuit when connected to the output of the test circuit of Fig. 1 will perform a different function for ΔV_{io} measurements. The "zero" switch is closed during the initial measurement and opened before the second measurement. The output is then the difference between measurements.

7. REFERENCES

1) Teradyne J-263 Reference Manual

2) MIL – M – 38510 / 101B

TESTING OPERATIONAL AMPLIFIERS EASILY AND ACCURATELY

TABLE 2. A SAMPLING OF TEST CIRCUIT CAPABILITY

PARAMETER	VOLTAGES			SWITCH POSITIONS				MEASUREMENT	UNITS	DEFINITION	UNITS
	V_{S+}	V_{S-}	V_o	S1	S2	S3	S4				
V_{io} ($-V_{CM}$)	+35	−5	−15	1	1	1	1	V_1	mV	$V_{io} = V_1/1000$	mV
V_{io} ($+V_{CM}$)	+5	−35	+15	1	1	1	1	V_2	mV	$V_{io} = V_2/1000$	mV
V_{io} (V_{SS} Max.)	+20	−20	0	1	1	1	1	V_3	mV	$V_{io} = V_3/1000$	mV
V_{io} (V_{SS} Min.)	+5	−5	0	1	1	1	1	V_4	mV	$V_{io} = V_4/1000$	mV
V_{io} ($-V_{CM}$)	+35	−5	−15	2	2	1	1	V_5	mV	$V_{io} = V_5/1000$	mV
V_{io} ($+V_{CM}$)	+5	−35	+15	2	2	1	1	V_6	mV	$V_{io} = V_6/1000$	mV
V_{io} (V_{SS} Max.)	+20	−20	0	2	2	1	1	V_7	mV	$V_{io} = V_7/1000$	mV
V_{io} (V_{SS} Min.)	+5	−5	0	2	2	1	1	V_8	mV	$V_{io} = V_8/1000$	mV
I_{io} ($-V_{CM}$)										$I_{io} = \frac{V_1 - V_5}{R_S \text{ in } \Omega \times 1000}$	nA
I_{io} ($+V_{CM}$)										$I_{io} = \frac{V_2 - V_6}{R_S \text{ in } \Omega \times 1000}$	nA
I_{io} (V_{SS} Max.)										$I_{io} = \frac{V_3 - V_7}{R_S \text{ in } \Omega \times 1000}$	nA
I_{io} (V_{SS} Min.)										$I_{io} = \frac{V_4 - V_8}{R_S \text{ in } \Omega \times 1000}$	nA
$+I_b$ (V_{SS} Max.)	+20	−20	0	2	1	1	1	V_9	mV	$I_b = \frac{V_9 - V_{10}}{R_S \text{ in } \Omega \times 1000}$	nA
$-I_b$ (V_{SS} Max.)	+20	−20	0	1	2	1	1	V_{10}	mV		
+PSRR	+20	−5	0	2	2	1	1	V_{11}	mV	$+\text{PSRR} = \frac{V_3 - V_{11}}{15 \times 1000}$	mV/V
−PSRR	+5	−20	0	2	2	1	1	V_{12}	mV	$-\text{PSRR} = \frac{V_4 - V_{12}}{15 \times 1000}$	mV/V
CMRR										$\text{CMRR} = \frac{V_5 - V_6}{30 \times 1000}$	mV/V
$I_{sc}+$	+20	−20	−15	1	1	1	2	I_1	mA	$I_1 = I_{sc}+$	mA
$I_{sc}-$	+20	−20	+15	1	1	1	2	I_2	mA	$I_2 = I_{sc}-$	mA
I_{ss}								I_3	mA	$I_3 = I_s$	mA
$A_{VOL}+$ RL = 2K	+20	−20	−15	1	1	2	1	V_{13}	mV	$A_{VOL}+ = \frac{15{,}000}{V_3 - V_{13}}$	V/mV
$A_{VOL}-$ RL = 2K	+20	−20	+15	1	1	2	1	V_{14}	mV	$A_{VOL}- = \frac{15{,}000}{V_3 - V_{13}}$	V/mV

NOTE: SWITCH POSITIONS

1 = OPEN
2 = CLOSED

TESTING OPERATIONAL AMPLIFIERS EASILY AND ACCURATELY

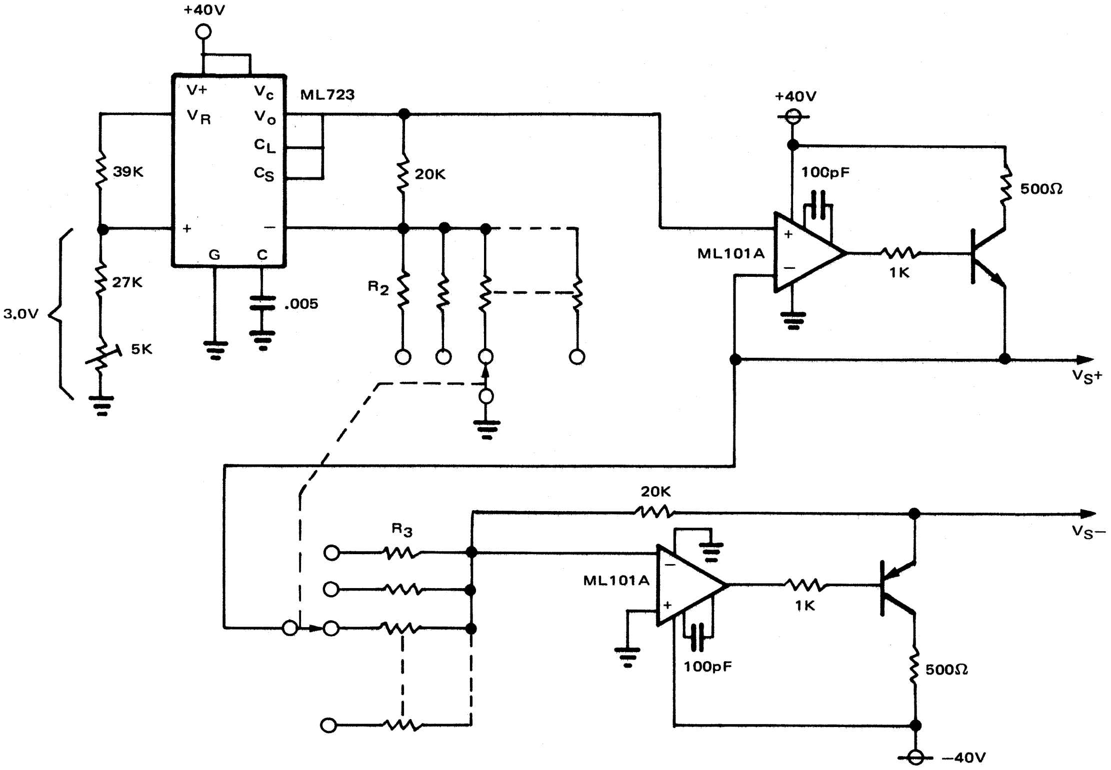

FIG. 2A. POWER SUPPLY CCT

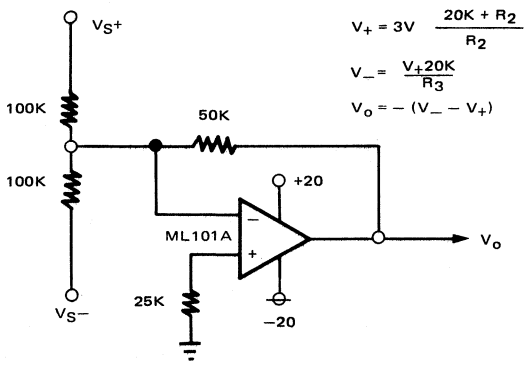

FIG. 2B. V_O POWER SUPPLY CCT

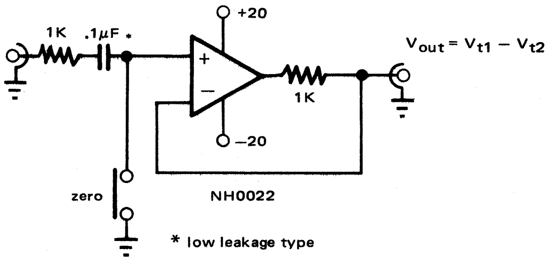

FIG. 3. SAMPLE AND HOLD CCT

THE OPERATIONAL AMPLIFIER AS A RELAXATION OSCILLATOR

1. INTRODUCTION

Due to the high large signal voltage gain, differential inputs and low input currents, the operational amplifier is ideally suited to a wide variety of relaxation oscillator designs. With the range of ICs available, superior stability of both frequency and mark-space can be obtained compared with discrete component designs.

2. BASIC CIRCUIT

The circuit from which a family of various functions can be derived is shown in Fig. 1.

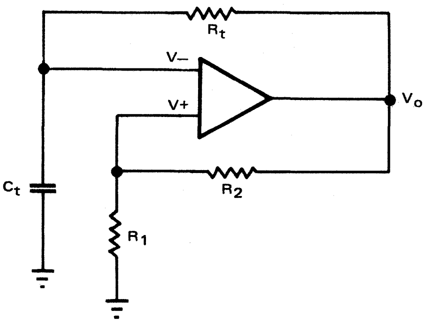

FIG. 1. BASIC RELAXATION OSCILLATOR

Operation is best considered by examination of the timing diagram shown in Fig. 2. It is assumed that the following conditions will always be met:

a) $A_{VO} > R_1 / R_1 + R_2$
b) $Vo/R_t > I_{bias}$

In practice these conditions are easily met.

Consider the operation from the point where Vo has just gone positive: it can be seen that the V- will start to charge positively, when it reaches Vo+ (R1/R1 + R2) the inverting action will cause the output to fall negatively. This action will be instantaneous (or governed only, by the slew rate of the operational amplifier) due to the positive feedback via R1 and R2. The circuit may be loaded externally with practically no effect on frequency due to the bridge arrangement, which virtually eliminates first order voltage sensitivity. Fig. 3 shows the bridge concept of Fig. 1.

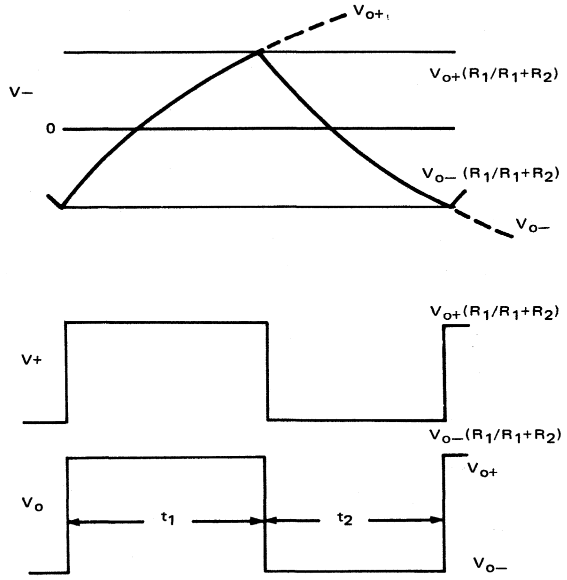

FIG. 2. TIMING DIAGRAM

The point at which the circuit changes state is of course governed by the time V- takes to reach V+. The values of V+ and V- are equal to within a few millivolts, being the offset voltage of the amplifier. Furthermore, the stability of this aiming point with temperature is excellent, at worst being 30μV/°C, and may be chosen to be better than this in the newer types of operational amplifiers.

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THE OPERATIONAL AMPLIFIER AS A RELAXATION OSCILLATOR

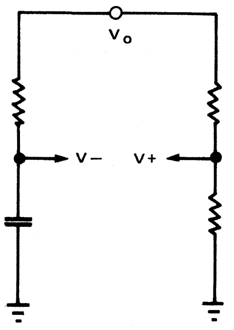

FIG. 3. BRIDGE CONCEPT

3. FREQUENCY OSCILLATION

From the timing diagram of Fig. 2 it can be seen that the point at which switching occurs is at 2/3 Vo; i.e., 66.6% up the charging curve.

Thus for the specific circuit of Fig. 1
$t_1 = t_2 = 1.04\ C_t R_t$ where R1 = R2.

In practice, a more convenient expression for the half cycle t_1 or t_2 (Fig. 2) may be given by

$$t = 2C_t R_t \cdot \frac{R1}{R1 + R2}$$

With the circuit shown, a square wave of unity mark-space ratio will result. The substitution of different values of R_t for positive and negative cycles will yield a mark-space of $R_{t}1$: $R_{t}2$ in the circuit of Fig. 4.

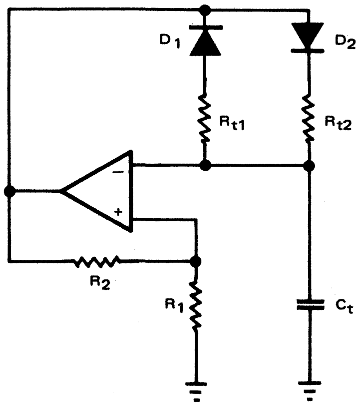

FIG. 4. VARIABLE MARK–SPACE GENERATOR

Isolation of the two timing cycles is achieved by the two diodes D1 D2. The expressions for t can be combined to yield:

$$f_{osc} = \frac{1}{2\,C_t\,(R_{t}1 + R_{t}2) - R1/(R1+R2)}$$

Where an equal mark-space ratio is required, as in the circuit of Fig. 1.

$$f_{osc} = \frac{1}{4\,C_t\,R_t \cdot R1/(R1 + R2)}$$

It can be seen from this expression, that the frequency may be varied by the term $R1/R1 + R2$. In practice, a range of three decades is easily obtained from this type of oscillator, the upper limit being imposed by the slew rate of the operational amplifier used.

4. CHOICE OF AMPLIFIER

Since the circuit never operates in its linear mode, no compensation is required; in fact, fully compensated devices, such as the ML741 family, have the disadvantage of lower slew rates thus limiting f_{osc} max, and therefore uncompensated types such as ML101,709, 748 are to be preferred. The choice within this group depends mainly upon the network R1 R2, because a differential input voltage approximately equal to half the value of V_o pk-pk exists at the instant of switching (to in Fig. 2). With a limit of 5V for the ML709 family, a maximum limit of the ratio R1/R2 is imposed such that breakdown cannot occur with the chosen supply voltage.

With the ML101,741 or 748 a differential input voltage approaching the supply voltage is permissable, thus any value of R1/R2 may be chosen. A practical limit of R1=R2 is however desirable, since the slope of the timing waveform decreases after the time t = CR resulting in a progressively less defined switching point.

5. FREQUENCY STABILITY

As has been shown, in Fig. 3, the oscillator is basically a bridge, thus the voltage sensivity is very low. A figure of 0.5% frequency variation is easily achieved for a 50% supply voltage variation.

The other main variable is the effect of bias current flowing through Rt as shown in Fig. 5.

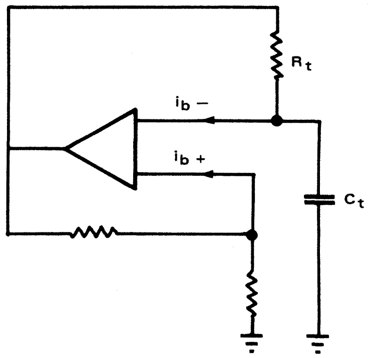

FIG. 5. EFFECT OF BIAS CURRENT

This has the effect of reducing the aiming potential of the timing waveform of Fig. 1 from V_{O-} to $V_{O-}(I_b - R_t)$.

In practice this term does not cause serious difficulty since the input bias currents of operational amplifiers are typically in the sub-microamp region. It does however impose a maximum value on Rt since I_b will vary with V supply and with temperature.

Values of R1/R2 present no difficulty since only the ratio is critical in the expression for f_{osc}, and they can always be designed to have a negligible effect at the typical values of I_{b+}.

6. WIDE RANGE PULSE GENERATOR

From the two variables discussed in the frequency expression

$$f_{osc} \quad \frac{1}{2\,C_t\,(R_t1 + R_t2)\cdot R1/(R1 + R2)}$$

It can be seen that to create a simple wide range pulse generator is possible, with independent frequency and pulse width controls as shown in Fig. 6.

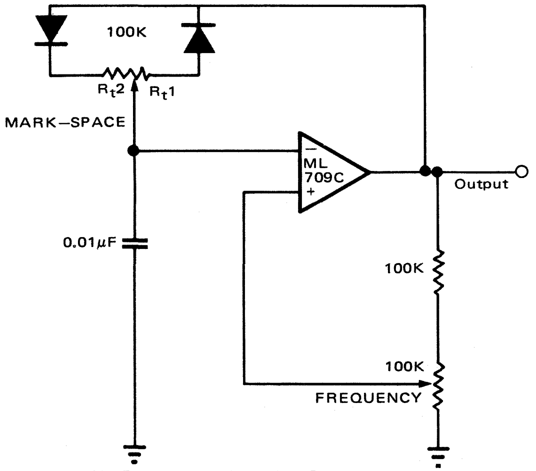

FIG. 6. WIDE–RANGE PULSE GENERATOR

Variation of mark-space, since the term (R_t1 + R_t2) remains constant, does not affect the frequency. Similarly, adjustment of frequency (R1/R1 + R2) does not affect mark-space. This circuit is capable of mark-space = 50:1 to 1:50 and a frequency range of 1KHz to 1MHz (at the upper frequency, slew rate prevents the full variation of mark-space ratio).

One interesting practical application of this circuit is for a simple twin-channel telemetry system. The two inputs being converted to frequency and mark-space independantly. To decode this information, a simple pulse counter will decode the frequency channel while a simple integrator will decode mark-space and remain independent of frequency. An isolation of 40dB can be obtained between channels of such a system as shown in Fig. 7.

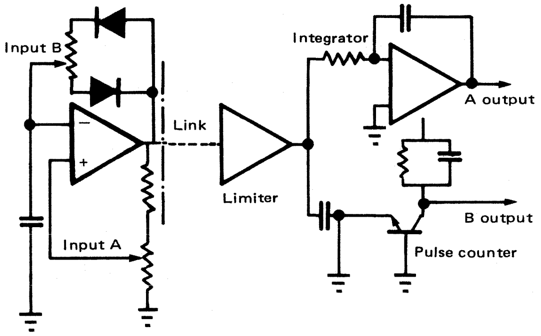

FIG. 7. INTEGRATOR–DECODER

7. VOLTAGE CONTROLLED OSCILLATORS

7.1 Voltage: frequency

A simple modification to the basic oscillator readily coverts it to a voltage controlled oscillator. The circuit form is shown in Fig. 8.

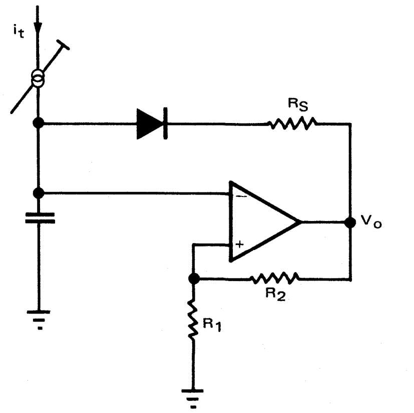

FIG. 8. VOLTAGE CONTROLLED OSCILLATOR

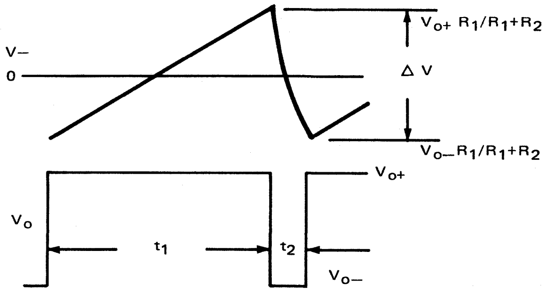

FIG. 9. TIMING DIAGRAM

The frequency of oscillation can be shown to be

$$f_{osc} = \frac{i_t}{\triangle V - Ct}$$

THE OPERATIONAL AMPLIFIER AS A RELAXATION OSCILLATOR

Where $\triangle V$ depends upon the ratio of R1/R2 and is governed by the maximum input differential voltage of the amplifier as discussed previously. This neglects the time t_2, which is negligible compared with t_1, except at high frequencies. The value of R_s must limit the peak discharge current to approximately 20mA. It should be noted that this is not required on devices such as ML101,741,748 since these have inbuilt current limiting.

The current drive is derived from the controlling voltage by a simple voltage to current convertor as shown in Fig. 10.

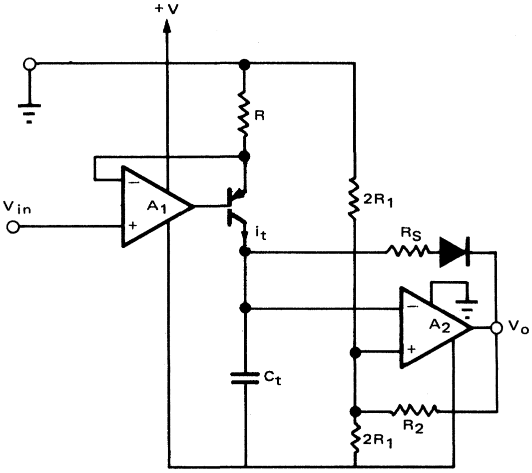

FIG. 10. SIMPLE VOLTAGE TO CURRENT CONVERTOR

The amplifier A1 must be a compensated type capable of operating with 100% feedback. The 741 is ideally suited, also possessing the offset null facility to set up the condition $i_t = 0$ when Vin $= 0$. In this arrangement $i_t = \text{Vin}/R$ from which the value of R can be chosen to suit the required frequency range and input voltage.

Since the voltage current converter must be at a more positive potential, the circuit of Fig. 10 shows the necessary grounding points. Of interest is the re-arrangement of the positive feedback network. In the basic circuit of Fig. 1 a centre tapped supply is used. If this is not available, as in Fig. 10, it may be generated by a voltage divider (note the value of each resistor is 2R1).

For operation, for Vin positive with respect to ground the circuit may be re-arranged as Fig. 11, the same design procedure applying.

7.2 Voltage: Mark-space

For functions requiring a varying mark-space output, such as pulsed servo drives etc, a comparator may be used in conjunction with the basic circuit as shown in Fig. 12.

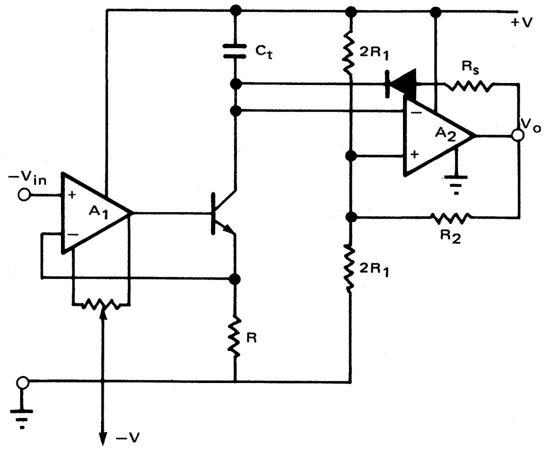

FIG. 11. REARRANGEMENT OF FIG. 10

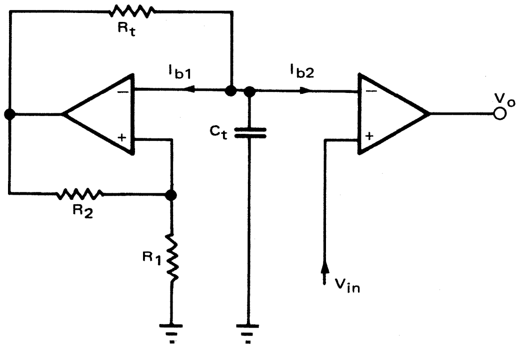

FIG. 12. COMPARATOR

The comparator need not be compensated since no feedback is involved. It should be noted that the design of the oscillator section is as described previously with the exception that two bias currents, I_{b1} and I_{b2} must be supplied through R_t, thus marginally reducing the maximum permissable value of R_t for a given stability.

The waveforms for the circuit are shown in Fig. 13.

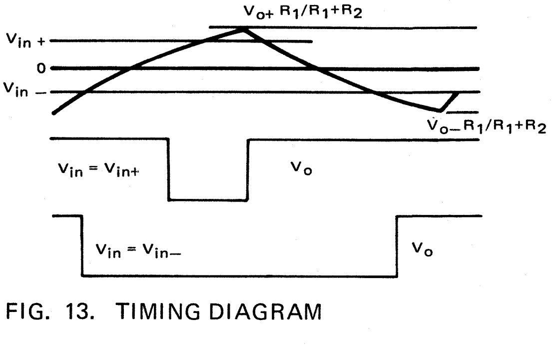

FIG. 13. TIMING DIAGRAM

ACTIVE FILTER DESIGN USING QUAD OPERATIONAL AMPLIFIERS

1. INTRODUCTION

Variations of the "Two Integrator loop" have long been known [1,2] as low sensitivity, high Q active filter designs. Their chief drawback is they use up to four op-amps to realize a biquadratic function. The advent of the Quad Op-amp, an array of four op-amps in a single package, competitive in both power dissipation and price to single op-amps, removes this drawback.

The general biquadratic function is given by:

$$H(S) = \frac{G\left(\frac{S^2}{W_Z^2} + \frac{S}{Q_Z W_Z} + 1\right)}{\frac{S^2}{W_P^2} + \frac{S}{Q_P W_P} + 1} \qquad (1)$$

Where: G = Gain Constant
Q_Z = Quality factor of zeros.
Q_P = Quality factor of poles.
W_Z = Natural frequency of zeros.
W_P = Natural frequency of poles.

Any high order function may be synthesized by cascading second order functions such as equation (1) along with simple first order functions.

The transfer function of equation (1) may be considered as the weighted sum of three fundamental functions, these being "Low Pass", "High Pass" and "Band Pass" functions. All three of these transfer functions are obtained simultaneously from the basic "Two Integrator Loop". The "State Variable" version of this filter, to be described in the next section, requires three amplifiers to achieve these basic functions. If one of these functions is desired, the fourth amplifier of the Quad Op-amp may be used as an input or output buffer, or to provide additional gain, or as a cascaded low Q filter section such as a Sallen & Key section [3]. If a more general biquadratic function is required (e.g., a "Band Reject" filter).The fourth amplifier must be used as a summing amplifier. The three basic functions are:

a) Low Pass: $$H_1(S) = \frac{G}{\frac{S^2}{W_P^2} + \frac{S}{Q_P W_P} + 1} \qquad (2)$$

b) Band Pass: $$H_2(S) = \frac{\frac{G}{Q_Z W_Z} S}{\frac{S^2}{W_P^2} + \frac{S}{Q_P W_P} + 1} \qquad (3)$$

c) High Pass: $$H_3(S) = \frac{\frac{G}{W_Z^2} S^2}{\frac{S^2}{W_P^2} + \frac{S}{Q_P W_P} + 1} \qquad (4)$$

The properties of these functions are summarized in Table 1.

2. A "STATE VARIABLE" SECOND ORDER FILTER

Excluding the effects of finite gain and bandwidth and compensation methods, Fig. 1 illustrates a general version of the "State Variable, Two Integrator Loop". The auxillary outputs V_a, V_b, and V_c yield High Pass, Band Pass and Low Pass transfer functions respectively. Amplifier No. 4 is used as a summing amplifier (weighting resistors R_a, R_b, and R_c). The transfer function to output V_o is:

$$\frac{V_o}{V_{in}} = \frac{\frac{R_4}{R_S}\,\frac{R_8}{R_C}\left[\frac{R_C}{R_a} t_1 t_2 S^2 - \frac{R_C}{R_b} t_2 S + 1\right]}{t_1 t_2 S^2 + \frac{R_5}{(R_Q + R_5)}\left(1 + \frac{R_4}{R_x}\right) t_2 S + 1} \qquad (4)$$

Where:

$$R_x = R_3 \| R_S = \frac{R_3 \; R_S}{R_3 + R_S} \qquad (5)$$

$$t_1 = R_1 \; C_1 \qquad (6)$$

$$t_2 = R_2 \; C_2 \qquad (7)$$

Comparing equation (4) with equation (1) and solving for the filter parameters:

$$G = \frac{R_4 \; R_8}{R_S \; R_C} \qquad (8)$$

$$W_Z = \sqrt{\frac{R_a}{R_C}} \cdot \frac{1}{\sqrt{t_1 \, t_2}} \qquad (9)$$

ACTIVE FILTER DESIGN USING QUAD OPERATIONAL AMPLIFIERS

$$W_P = \frac{1}{\sqrt{t_1 t_2}} \qquad (10)$$

$$Q_Z = \frac{-R_b}{\sqrt{R_c R_a}} \sqrt{\frac{t_1}{t_2}} \qquad (11)$$

$$Q_P = (1 + \frac{R_Q}{R_5}) (\frac{R_x}{R_x + R_4}) \sqrt{\frac{t_1}{t_2}} \qquad (12)$$

Notice that Q_Z is negative, and therefore the complex zeros are in the Right side of the 5-plane (a desirable condition for all-pass functions). If Left zeros are required, the weighting resistor R_b may be connected to the non-inverting input of amplifier No. 4 instead of the inverting input, and the weighting function re-calculated.

For the modified circuit

$$Q_Z = \frac{R_y}{R_a\ R_c} \sqrt{\frac{t_1}{t_2}} \ \frac{(1 + \frac{R_b}{R_9})}{(1 + \frac{R_y}{R_8})} \qquad (13)$$

Where:

$$R_y = R_a \| R_c = \frac{R_a\ R_c}{R_a + R_c} \qquad (14)$$

None of the other filter parameters are affected.

In the circuit of Fig. 1, resistors R_6, R_7 and R_9 have no direct effect on the filter performance, but are included only to minimize the effect of input bias current on the filter d.c. off-set. For minimum off-set, those resistors should be chosen such that.

$$R_6 \approx R_1 \qquad (15)$$

$$R_7 \approx R_2 \qquad (16)$$

$$R_9 \approx R_8 \| R_a \| R_b \| R_c \qquad (17)$$

In most cases, they may all be set equal to zero without loss in filter performance.

3. THE EFFECT OF FINITE GAIN AND BANDWIDTH

Although both the ML4136 and ML4202 Quad Op-amps have very high gains and bandwidths, they are not infinite. This results in deviations from the ideal filter characteristics of section 2, which become worse with increasing Q and resonant frequency. The finite amplifier bandwidth produces an excess phase shift in each of the integrators, resulting in the phenomenon known as "Q Enhancement"; that is, the observed value of Q_p may differ from the calculated value Q_{po}. It may be shown that:

$$Q_p = \frac{Q_{po}}{1 + \frac{G}{\mu_o} + \frac{2\ Q_{po}}{\mu_o}\ [1 - \frac{Z\,W_p}{W_a}]} \qquad (18)$$

Where:

G = Band Pass gain from equation (8)
μ_o = Amplifier open loop gain
W_a = Amplifier bandwidth

If the filter gain is kept reasonable low, (less than 10), the second term in the denominator may be neglected ($\mu_o > 5000$ for the ML4202 and $\mu_o > 50{,}000$ for the ML4136). Provided that the resonant frequency is much greater than the break frequency of the amplifier ($f_a \leqslant 400$Hz for the ML4202 and $f_a \approx 10$Hz for the ML4136), then equation (18) may be approximated by:

$$Q_p = \frac{Q_{po}}{1 - \frac{4\ Q_{po} W_p}{W_1}} \qquad (19)$$

Where: W_1 = Gain Bandwidth product=$\mu_o W_a$

Therefore, if $W_p > 4\ \frac{W_1}{Q_{po}}$, the actual Q is negative (i.e., poles located in the Right half plane) and the filter oscillates.

The same excess phase shift which causes Q enhancement (equation (19) also causes similar deviations in Q_Z. For example, when R_b of Fig. 1 is set to infinity, Q_Z is ideally infinite (i.e., a Band Reject filter with an infinite notch depth). However, the excess phase shift results in finite values of Q_Z and therefore, finite notch depths.

Fortunately, the excess phase shift may be effectively eliminated by introducing a small amount of phase lead into the loop. This may be accomplished by by-passing R_1, R_2, or R_3 with a small compensating capacitor C_c having a value (in farads) of:

$$C_c = \frac{4}{R_j\ W_1} \qquad (20)$$

Where:

W_1 = Gain Bandwidth Product (in rad/sec.)
R_j = Resistor by-passed by C_c (in ohms).

ACTIVE FILTER DESIGN USING QUAD OPERATIONAL AMPLIFIERS

4. FILTER ADJUSTMENT

A major advantage of the "Two-Integrator Loop" is that there exists a non-interactive tuning procedure. That is, the transfer function parameters may be adjusted or trimmed to value without upsetting any previously adjusted parameters. All adjustments are done on resistors, since it is assumed that precision resistors are more economical than precision capacitors. The circuit is initially set up using component values determined by equations (8) to (12).

1) Set W_p by applying a signal of frequency W_p at the input and adjusting R_1 and/or R_2 until a phase shift of 0° is obtained at the output V_b.

2) Set Q_p by applying a signal of frequency W_p at the input and adjusting R_Q and/or R_5 until the output at V_b is $G\ Q_p\ W_p/Q_Z\ W_Z$ times the input voltage.

3) The position of the zeros (W_Z) with respect to the resonant frequency is determined by the ratio of resistors R_a/R_c.

$$W_Z = \sqrt{\frac{R_a}{R_c}}\ W_p.$$

With an input signal of frequency W_Z, adjust the ratio of R_a:R_c until V_o is a minimum.

4) With an input signal of frequency W_Z, set Q_Z by adjusting R_b until the output V_o is:

$$G\ [\ 1 + W_Z{}^4/W_p{}^4 + (\ 1/Q_p{}^2 - 2)W_Z{}^2/W_p{}^2]^{-1/2}/Q_Z$$

times the input.

5) With an input signal frequency well below W_p, set gain G by adjusting R_8 until V_o/V_{in} =G.

5. A DESIGN EXAMPLE:

Required:

A Band Reject filter having the following parameters:

Input Impedance Z_{in}	= 10 KΩ
Notch freauency 8f	= 1000 HZ.
Rejection Bandwidth △f about f_z)	= 100 HZ. (symmetric
Band Pass Gain G	= 1
Notch Depth	> 60 db.

This filter is represented by the circuit of Fig 1 with $R_b = \infty$.

The input impedance is R_s and thus

$$R_s = 10K$$

For convenience, set R_3=R_4=R_5=R_s= 10K.

Symmetry about f_z requires W_Z=W_P.

Therefore $W_Z = 2\pi f_z = 6.28 \times 10^3$ r/sec.

$$Q_{po} = \frac{f_p}{\Delta f} = 10$$

$$G = 1$$

Again for convenience, let $C_1 = C_2$ and $R_1 = R_2$. Arbitrarily chosing $C_1 = C_2 = 15$ nf, then

$$R_1 = R_2 = \frac{t}{C_1} = \frac{1}{W_Z C_1} = 10.6\ K\Omega$$

$$R_x = \frac{R_3 R_s}{R_3 + R_s} = 5\ K\Omega$$

From equation (12), with the above values substituted:

$$R_Q = (3\ Q_{po} - 1)\ R_s = 290 K\Omega$$

Substituting Q_{po} = 10, f_1 = Z x 10^6HZ and fp = 6.28 x 10^3HZ, into equation (19) yields an enhanced Q_p of

$$Q_p = 10.4.$$

Since this is only 4% from the desired value, it is tempting to ignore the compensation capacitor C_c. However, for a notch depth of 60 dB.

$$\frac{H\ (0)}{H\ (W_p)} = \frac{Q_z}{Q_p} \cdot \frac{W_Z}{W_p} \geqslant 10^3$$

Therefore $Q_Z \geqslant 10^4$

To achieve such a high zero Q_Z, compensation is required.

$$C_c = \frac{4}{R_3 W_1}$$

Using ML4136 Quad Op-Amps, W_1(Typ) =12.6 x 10^6 r/sec. and R_3 = 10KΩ, therefore

$$C_c = 32\ pF$$

ACTIVE FILTER DESIGN USING QUAD OPERATIONAL AMPLIFIERS

For an overall gain of unity, $(G = 1)$, resistor R_8 is set to

$$R_8 = \frac{GR_sR_c}{R_4}.$$

Now $R_c = R_a$ for $W_z = W_p$. Convenient values are 10K.

$$R_8 = R_c = R_a = R_s = 10K$$

Fig. 2 illustrates the final circuit. Notch depths in excess of 70 dB may be achieved by trimming the value of C_c.

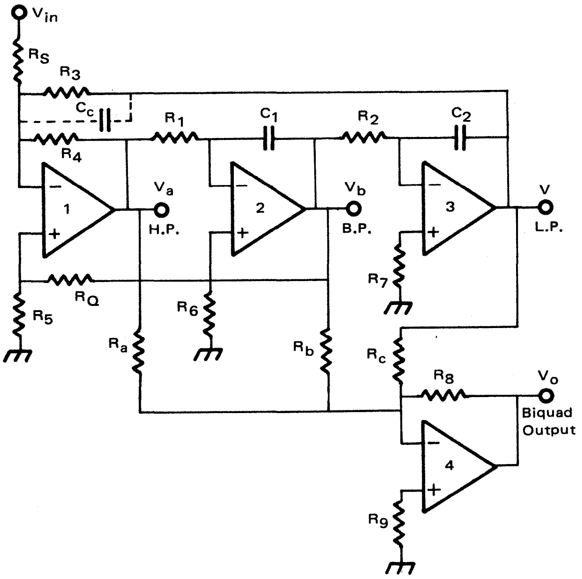

FIG. 1 A STATE VARIABLE BIQUAD FILTER USING A QUAD OP. AMP.

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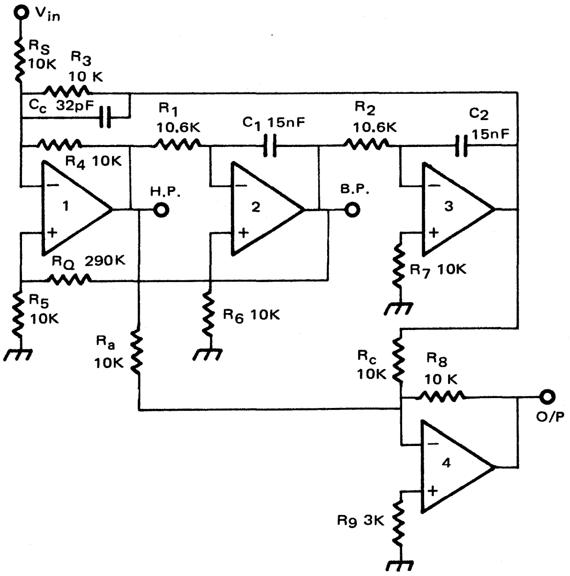

FIG. 2 A 1KHz BAND REJECT FILTER SECTION

ACTIVE FILTER DESIGN USING QUAD OPERATIONAL AMPLIFIERS

TABLE 1 SECOND ORDER FILTER PROPERTIES.

PARAMETER	LOW PASS(1)	BAND PASS	HIGH PASS(1)
	$H_1(S) = \frac{G}{(\frac{S^2}{W_p^2} + \frac{S}{Q_pW_p} + 1)}$	$H_2(S) = \frac{\frac{GS}{Q_ZW_Z}}{(\frac{S^2}{W_p^2} + \frac{S}{Q_pW_p} + 1)}$	$H_3(S) = \frac{\frac{GS^2}{W_Z^2}}{(\frac{S^2}{W_p^2} + \frac{S}{Q_pW_p} + 1)}$
Resonant Frequency	$W_p\ (1 - \frac{1}{2Q_p})^{1/2}$	W_p	$\frac{W_p}{(1 - \frac{1}{2Q_p^2})^{1/2}}$
Gain at Resonance	$\frac{Q_pG}{(1 - \frac{1}{4Q_p^2})^{1/2}}$	$G\ \frac{Q_pW_p}{Q_Z W_Z}$	$\frac{G\,Q_p\,(\frac{W_p}{W_Z})^2}{(1 - \frac{1}{4\,Q_p^2})^{1/2}}$
Phase Shift at Resonance	$\text{ton}^{-1}\left[2Q_p\ (1 - \frac{1}{2Q_p^2})^{1/2}\right]$	0	$\text{ton}^{-1}\left[2Q_p(1 - \frac{1}{2Q_p^2})^{1/2}\right] - \frac{\pi}{2}$
Low Frequency Gain ($W \ll W_p$)	G	$\frac{G\,S}{Q_Z\,W_Z}$	$\frac{G\ S^2}{W_Z^2}$
High Frequency Gain ($W \gg W_p$)	$\frac{G\,W_p^2}{S^2}$	$\frac{G\,W_p^2}{Q_ZW_ZS}$	$G\ (\frac{W_p}{W_Z})^2$
Cut-off Frequency (3dB down)(2)	$W_p\ (y + \sqrt{1 + Y^2})^{1/2}$	$W_p\ (X \pm \sqrt{x^2 - 1})^{1/2}$	$W_p\ (-y + \sqrt{1 + y^2})^{1/2}$

NOTES:

1. If $Q_p \leqslant \frac{1}{\sqrt{2}}$ there is no resonant peaking.
2. $Y = 1 - \frac{1}{2Q_p^2}$; $X = 1 + \frac{1}{2Q_p^2}$

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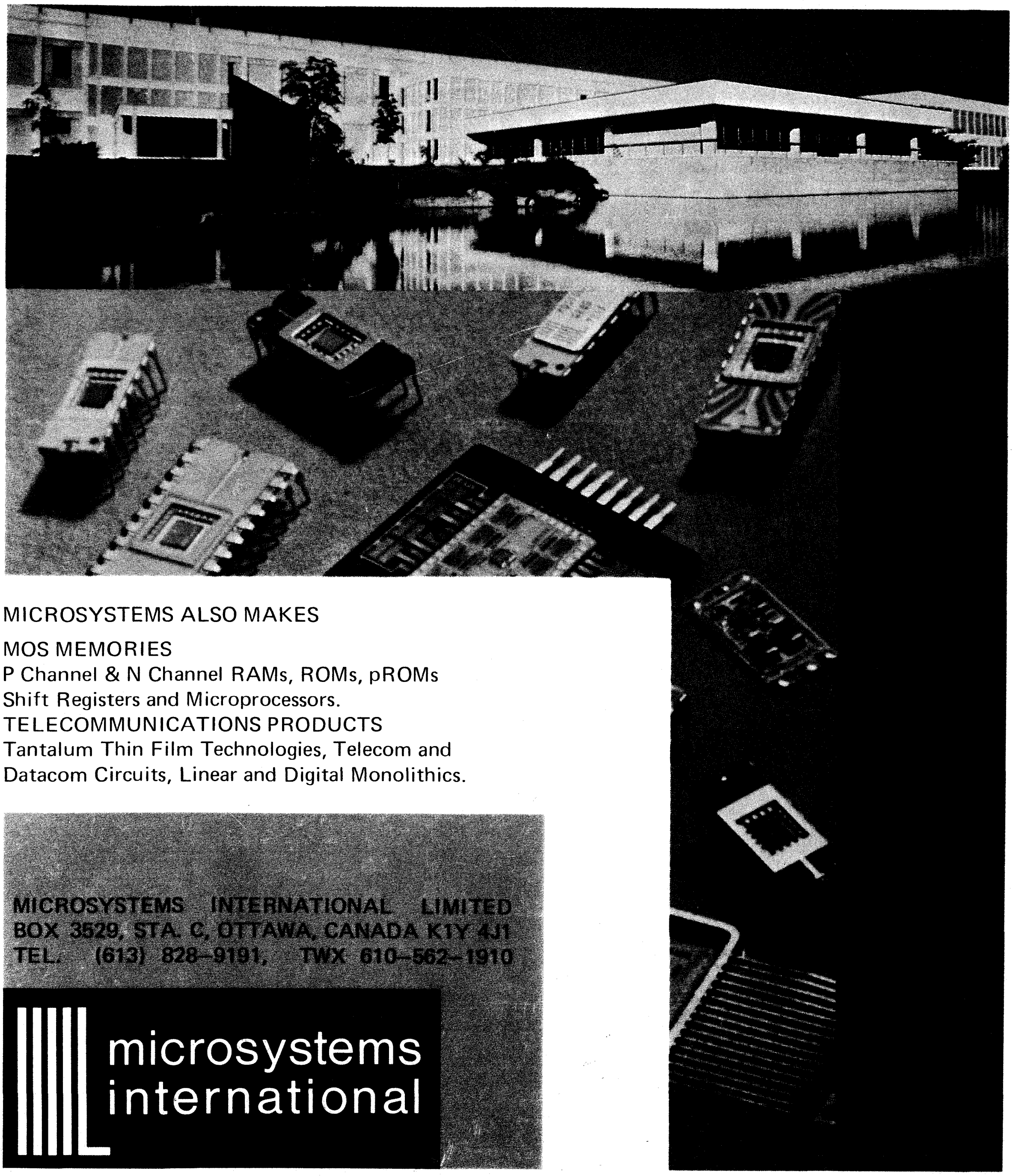

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