Voltage Regulator Data Book

1984

Switching, Series Pass, Shunt, Precision

TEXAS INSTRUMENTS

Voltage Regulator Data Book

1984

TEXAS
INSTRUMENTS

IMPORTANT NOTICE

Texas Instruments reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Texas Instruments assumes no responsibility for infringement of patents or rights of others based on Texas Instruments applications assistance or product specifications, since TI does not possess full access to data concerning the use or applications of customer's products. TI also assumes no responsibility for customer product designs.

ISBN 0-904047-39-3

VOLTAGE REGULATOR DATA BOOK
1984

Voltage regulation is a basic function in the majority of today's electronic systems. In this data book, Texas Instruments is pleased to present important technical information on a broad line of voltage regulator and voltage controller circuits that will assist the designer in selecting components for the complete power system.

This data book includes series pass regulators (both fixed and adjustable), shunt regulators, switching voltage controllers (fixed on-time variable frequency, PWM, single-ended, and dual-ended), DC-to-DC converters, over voltage and under voltage protection circuits.

A functional index, selection guide and alternate source index are included to provide the designer with rapid access to the desired technical information.

While this data book offers design data and specifications only for voltage regulators and voltage regulator-related products, complete technical data on any Texas Instruments semiconductor component is available from your nearest TI field sales office or local TI distributor.

General Information

Alphanumeric Index
Selection Guide
Alternate Source Index
Glossary

1

1

FIXED OUTPUT VOLTAGE REGULATORS

positive output regulators

DEVICE SERIES	OUTPUT VOLTAGE TOLERANCE	MINIMUM DIFFERENTIAL VOLTAGE	OUTPUT CURRENT RATING	AVAILABLE VOLTAGE SELECTIONS	PACKAGES
LM2930-0	±10% †	0.6 V	150 mA	2 @ 5 V to 8 V	KC
LM330-0	± 4% ‡	0.6 V	150 mA	1 @ 5 V	KC
LM340-00	± 4% ‡	2.0 V	1.5 A	3 @ 5 V to 15 V	KC
TL780-00C	± 1% ‡	2.0 V	1.5 A	3 @ 5 V to 15 V	KC
uA7800C	± 4% ‡	2.0 V–3.0 V	1.5 A	9 @ 5 V to 24 V	KC
uA78L00AC	± 5% ‡	2.0 V	100 mA	8 @ 2.6 V to 15 V	LP
uA78L00C	±10% ‡	2.0 V–2.5 V	100 mA	8 @ 2.6 V to 15 V	LP
uA78M00C*	± 5% ‡	2.0 V–3.0 V	500 mA	8 @ 5 V to 24 V	KC

†Overrange −40°C to 25°C
‡@ 25°C

negative output regulators

DEVICE SERIES	OUTPUT VOLTAGE TOLERANCE	MINIMUM DIFFERENTIAL VOLTAGE	OUTPUT CURRENT RATING	AVAILABLE VOLTAGE SELECTIONS	PACKAGES
LM320-00	± 4%	2.0 V	1.5 A	3 @ 5 V to 15 V	KC
MC79L00AC	± 5%	1.7 V	100 mA	3 @ 5 V to 15 V	LP
MC79L00C	±10%	1.7 V	100 mA	3 @ 5 V to 15 V	LP
uA7900C	± 5%	2.0 V–3.0 V	1.5 A	8 @ 5 V to 24 V	KC
uA79M00C*	± 5%	2.0 V–3.0 V	1.5 A	7 @ 5 V to 24 V	KC

available output voltages for above regulator series

DEVICE SERIES	VOLTAGE SELECTIONS													
	2.6	5.0	5.2	6.0	6.2	8.0	8.5	9.0	10.0	12.0	15.0	18.0	20.0	24.0
LM2930-0		X				X								
LM320-00		X								X	X			
LM330-0		X												
LM340-00		X								X	X			
MC79L00AC		X								X	X			
MC79L00C		X								X	X			
TL780-00C		X								X	X			
uA7800C		X		X		X	X		X	X	X	X		X
uA78L00AC	X	X			X	X		X	X	X	X			
uA78L00C	X	X			X	X		X	X	X	X			
uA78M00C*		X		X		X			X	X	X		X	X
uA7900C		X	X	X		X				X	X	X		X
uA7900C*		X		X		X				X	X		X	X

*Also available in military temperature range (M Suffix)

1

1

VARIABLE OUTPUT VOLTAGE REGULATORS

positive output series regulators

DEVICE NUMBER	OUTPUT VOLTAGE MIN	OUTPUT VOLTAGE MAX	DIFFERENTIAL VOLTAGE MAX	OUTPUT CURRENT RATING	PACKAGES
LM217	1.2 V	37 V	V_I−1.2 V	1.5 A	KC
LM317	1.2 V	37 V	V_I−1.2 V	1.5 A	KC
LM350	1.2 V	33 V	V_I−1.2 V	3A	KC
TL317	1.2 V	32 V	V_I−1.2 V	100 mA	LP
TL783C	10 V	125 V	37 V	700 mA	KC
uA723C*	3 V	38 V	37 V	25 mA	J, N, U

negative output series regulators

DEVICE NUMBER	OUTPUT VOLTAGE MIN	OUTPUT VOLTAGE MAX	DIFFERENTIAL VOLTAGE MAX	OUTPUT CURRENT RATING	PACKAGES
LM237	1.2 V	37 V	V_I+1.2 V	1.5 A	KC
LM337	1.2 V	37 V	V_I+1.2 V	1.5 A	KC

positive shunt regulators

DEVICE NUMBER	SHUNT VOLTAGE MIN	SHUNT VOLTAGE MAX	SHUNT CURRENT MIN	SHUNT CURRENT MAX	TEMP COEFFICIENT MAX	PACKAGES
TL430C*	3 V	30 V	2 mA	100 mA	200 ppm/°C	LP
TL431C*	3 V	30 V	0.5 mA	100 mA	100 ppm/°C	LP, P
TL431I**	2.55 V	36 V	1 mA	100 mA	100 ppm/°C	LP, P

*Also available in Military Temperature Range (M Suffix)
**I—Suffix for Industrial Temperature Range

PROTECTION CIRCUITS

undervoltage protection circuits

DEVICE NUMBER	TEMP RANGE	PACKAGES	FEATURES
TL7702 TL7705 TL7712 TL7715	0°C to 70°C	P	Power-up and voltage drop reset generator specifically for microcomputer control supervision. These devices operate over a wide supply voltage range (3 V to 18 V) and have externally adjustable pulse width to ensure system reset.

overvoltage protection circuit

DEVICE NUMBER	TEMP RANGE	PACKAGES	FEATURES
MC3423	0° to 70°C	JG, P	Separate outputs for "crowbar" and logic circuitry, programmable time delay, TTL-level activation isolated from voltage-sensing inputs.

SWITCHING VOLTAGE REGULATOR/CONTROLLERS

FEATURES	BASE DEVICE NUMBERS						
	MC35060 MC34060	RC4193	SG3524 SG2524 SG1524	SG3525A SG2525A SG1525A	TL493	TL494	TL495
General Features							
General Purpose	X	X	X	X	X	X	X
Special Purpose	–	–	–	–	–	–	–
Dual Independent PWM Control	–	–	–	–	–	–	–
Fixed On Time	–	–	–	–	–	–	–
Fixed Frequency PWM	X	X	X	X	X	X	X
Adjustable Frequency PWM	–	–	–	–	–	–	–
Low Bias Current Requirements	–	135 μA	–	–	–	–	–
High Efficiency	–	80%	–	–	–	–	–
Expandable	X	–	X	X	X	X	X
Control Features							
On Chip Reference	X	X	X	X	X	X	X
Precision On Chip Reference	–	–	–	X	–	–	–
Dead Time Adjust	X	–	–	X	X	X	X
Current Sense Amplifier	–	–	–	–	1	–	–
Error Amplifier	2	–	2	1	1	2	2
Operates to 40 V	X	24 V	35 V	35 V	X	X	X
Operates above 40 V	–	–	–	–	–	–	X
Feed Forward Line Regulator	–	–	–	–	–	–	–
Protection Features							
On Chip Regulator	X	–	–	–	–	–	X
Internal Soft Start	–	–	X	X	–	–	–
Under Voltage Lockout	–	–	X	X	–	–	–
Inhibit Control	–	X	X	X	X	X	X
Double Pulse Protection	–	–	X	X	X	X	X
Output Features							
Single-ended Output	X	X	–	–	–	–	–
Double-ended Outputs	–	–	X	X	X	X	X
Totem-Pole Outputs	–	–	–	X	–	–	–
Parallelable Outputs	–	–	–	–	X	X	X
Adjustable Output (2.5 V to 24 V)	–	X	–	–	–	–	–
Output Current Capability (150 mA)	–	X	–	–	–	–	–
Isolated Power and Ground to Output	–	–	–	–	–	–	–
High Noise Immunity	–	–	–	–	–	–	–
External Output Trigger	–	–	–	–	–	–	X
Part Number Ordering Information							
Commercial Temp Range							
Plastic	MC34060N	RC4193P	SG3524N	SG3525AN	TL493CN	TL494CN	TL495CN
Ceramic	MC34060J	RC4193JG	SG3524J	SG3525AJ	TL493CJ	TL494CJ	
Industrial Temp Range							
Plastic			SG2524N	SG2525AN		TL494IN	
Ceramic			SG2524J	SG2525AJ		TL494IJ	
Military Temp Range							
Ceramic	MC35060J	RM4193JG	SG1524J	SG1525AJ	TL493MJ	TL494MJ	

1

SWITCHING VOLTAGE REGULATOR/CONTROLLERS

FEATURES	BASE DEVICE NUMBERS					
	TL496	TL497A	TL593	TL594	TL595	TL1451
General Features						
General Purpose	–	X	X	X	X	X
Special Purpose	9 V	–	–	–	–	–
Dual Independent PWM Control	–	–	–	–	–	–
Fixed On Time	X	X	–	–	–	–
Fixed Frequency PWM	–	–	X	X	X	X
Adjustable Frequency PWM	–	–	–	–	–	–
Low Bias Current Requirements	–	–	–	–	–	–
High Efficiency	–	–	–	–	–	–
Expandable	–	–	X	X	X	X
Control Features						
On Chip Reference	X	X	X	X	X	X
Precision On Chip Reference	–	–	X	X	X	–
Dead Time Adjust	X	–	X	X	X	X
Current Sense Amplifier	X	X	1	–	–	–
Error Amplifier	–	1	1	2	2	2
Operates to 40 V	–	–	X	X	X	X
Operates above 40 V	–	–	–	–	X	–
Feed Forward Line Regulator	–	–	–	–	–	–
Protection Features						
On Chip Regulator	X	–	–	–	X	–
Internal Soft Start	–	–	–	–	–	–
Under Voltage Lockout	–	–	X	X	X	–
Inhibit Control	–	X	X	X	X	–
Doublt Pulse Protection	–	–	X	X	X	–
Output Features						
Single-ended Output	X	X	–	–	–	2
Double-ended Outptus	–	–	X	X	X	–
Totem-pole Outputs	–	–	–	–	–	–
Parallelable Outputs	–	–	X	X	X	–
Adjustable Output (2.5 V to 24 V)	–	–	–	–	–	–
Output Current Capability (150 mA)	–	–	–	–	–	–
Isolated Power and Ground to Output	–	–	–	–	–	–
High Noise Immunity	–	–	–	–	–	–
External Output Trigger	–	–	–	–	X	–
Part Number Ordering Information						
Commercial Temp Range						
Plastic	TL496CP	TL497ACN	TL593CN	TL594CN	TL595CN	TL1451CN
Ceramic		TL497ACJ	TL593CJ	TL594CJ		TL1451CJ
Industrial Temp Range						
Plastic		TL497AIN		TL594IN		
Ceramic		TL497AIJ		TL594IJ		
Military Temp Range						
Ceramic		TL497AMJ	TL593MJ	TL594MJ		

AMD	TI
723C	uA723C

Exar	TI
XR2524	SG2524
XR3524	SG3524

Fairchild	TI
μA78L02AC	uA78L02AC
μA78L05AC	uA78L05AC
μA78L09AC	uA78L09AC
μA78L12AC	uA78L12AC
μA78L15AC	uA78L15AC
μA78L6.2AC	uA78L06AC
μA78M05C	uA78M05C
μA78M06C	uA78M06C
μA78M08C	uA78M08C
μA78M12C	uA78M12C
μA78M15C	uA78M15C
μA78M24C	uA78M24C
μA79M05C	uA79M05C
μA79M08C	uA79M08C
μA79M12C	uA79M12C
μA79M15C	uA79M15C
μA217	LM217
μA317	LM317
μA431	TL431C
μA494	TL494C
μA723C	uA723C
μA7805C	uA7805C
μA7806C	uA7806C
μA7808C	uA7808C
μA7812C	uA7812C
μA7815C	uA7815C
μA7818C	uA7818C
μA7824C	uA7824C
μA7885C	uA7885C
μA7905C	uA7905C
μA7908C	uA7908C
μA7912C	uA7912C
μA7915C	uA7915C

Fujitsu	TI
MB3759	TL494C

ITT	TI
TDD1605	uA78M05C
TDD1606	uA78M06C
TDD1608	uA78M08C
TDD1610	uA78M10C
TDD1612	uA78M12C
TDD1615	uA78M15C
TDD1624	uA78M24C

Lambda	TI
LAS1505	uA7805C
LAS1506	uA7806C
LAS1508	uA7808C
LAS1510	uA7810C
LAS1512	uA7812C
LAS1515	uA7815C
LAS1518	uA7818C
LAS1524	uA7824C
LAS1805	uA7905C
LAS1806	uA7906C
LAS1808	uA7908C
LAS1812	uA7912C
LAS1815	uA7915C
LAS1818	uA7918C
LAS1824	uA7924C
LAS18052	uA7952C

Motorola	TI
LM217	LM217
LM317L	TL317
LM317	LM317
LM340-5	LM340-5
LM340-12	LM340-12
LM340-15	LM340-15
MC78L05AC	uA78L05AC
MC78L05C	uA78L05C
MC78L08AC	uA78L08AC
MC78L08C	uA78L08C
MC78L12AC	uA78L12AC
MC78L12C	uA78L12C
MC78L15AC	uA78L15AC
MC78L15C	uA78L15C
MC78M05C	uA78M05C
MC78M06C	uA78M06C
MC78M08C	uA78M08C
MC78M12C	uA78M12C
MC78M15C	uA78M15C
MC78M20C	uA78M20C
MC78M24C	uA78M24C
MC79L05AC	MC79L05AC
MC79L05C	MC79L05C
MC79L12AC	MC79L12AC
MC79L12C	MC79L12C
MC79L15AC	MC79L15AC
MC79L15C	MC79L15C
MC1723C	uA723C
MC3423	MC3423
MC7805C	uA7805C
MC7806C	uA7806C
MC7808C	uA7808C
MC7812C	uA7812C
MC7815C	uA7815C

Motorola	TI
MC7818C	uA7818C
MC7824C	uA7824C
MC7905C	uA7905C
MC7906C	uA7906C
MC7908C	uA7908C
MC7912C	uA7912C
MC7915C	uA7915C
MC7918C	uA7918C
MC7924C	uA7924C
MC7905.2C	uA7952C
MC34060	MC34060
MC35060	MC35060
TL431C	TL431C
TL494C	TL494C

National	TI
LM78L05C	uA78L05C
LM78L12C	uA78L12C
LM78L15C	uA78L15C
LM78M05	uA78M05C
LM78M12	uA78M12C
LM78M15	uA78M15C
LM79L05A	LM79L05AC
LM79L05	MC79L05C
LM79L12A	MC79L12AC
LM79L12	MC79L12C
LM79L15A	MC79L15AC
LM79L15	MC79L15C
LM79M05	uA79M05C
LM79M12	uA79M12C
LM79M15	uA79M15C
LM217	LM217
LM237	LM237
LM317L	TL317
LM317	LM317
LM320	LM320
LM323	LM323
LM330-5.0	LM330
LM337	LM337
LM340A-5.0	TL780-05C
LM340A-12	TL780-12C
LM340A-15	TL780-15C
LM340-5.0	LM340-5
LM340-12	LM340-12
LM340-15	LM340-15
LM350	LM350
LM723C	uA723C
LM2524	SG2524
LM2930-5.0	LM2930-5
LM2930-8.0	LM2930-8
LM3524	SG3524
LM7805	uA7805C

VOLTAGE REGULATOR ALTERNATE SOURCE INDEX

National	TI
LM7812	uA7812C
LM7815	uA7815C
LM7905	uA7905C
LM7912	uA7912C
LM7915	uA7915C

NEC	TI
UPC78L05	uA78L05C
UPC78L08	uA78L08C
UPC78L12	uA78L12C
UPC78L15	uA78L15C
UPC78M05	uA78M05C
UPC78M08	uA78M08C
UPC78M12	uA78M12C
UPC78M15	uA78M15C
UPC494C	TL494C
UPC7805	uA7805C
UPC7808	uA7808C
UPC7812	uA7812C
UPC7818	uA7818C
UPC7824	uA7824C

RCA	TI
CA723	uA723C
CA2524	SG2524
CA3524	SG3524

Raytheon	TI
RC723	uA723C
RC4193	RC4193

Signetics	TI
SG2524	SG2524
SG3524	SG3524
SG3525A	SG3525A
SG3527A	SG3527A
μA723C	uA723C

Silicon General	TI
SG217	LM217
SG237	LM237
SG317	LM317
SG323	LM323
SG337	LM337
SG340-5	LM340-5
SG340-12	LM340-12
SG350	LM350
SG723C	uA723C
SG1525A	SG1525A
SG1527A	SG1527A
SG2524	SG2524
SG2525A	SG2525A

Silicon General	TI
SG2527A	SG2527A
SG3423	MC3423
SG3524	SG3524
SG3525A	SG3525A
SG3527A	SG3527A
SG7805C	uA7805C
SG7806C	uA7806C
SG7808C	uA7808C
SG7812C	uA7812C
SG320-05T	uA79M05C
SG320-08T	uA79M08C
SG320-20T	uA79M20C
SG7815C	uA7815C
SG7818C	uA7818C
SG7805CT	uA78M05C
SG7806CT	uA78M06C
SG7808CT	uA78M08C
SG7812CT	uA78M12C
SG7815CT	uA78M15C
SG7820CT	uA78M20C
SG7824CT	uA78M24C
SG7824C	uA7824C
SG7905.2C	uA7952C
SG7905C	uA7905C
SG7908C	uA7908C
SG7912C	uA7912C
SG7915C	uA7915C
SG7918C	uA7918C

Toshiba	TI
TA78L005A	uA78L05AC
TA78L005	uA78L05C
TA78L008A	uA78L08AC
TA78L008	uA78L08C
TA78L009A	uA78L09AC
TA78L009	uA78L09C
TA78L010A	uA78L10AC
TA78L010	uA78L10C
TA78L012A	uA78L12AC
TA78L012	uA78L12C
TA78L015A	uA78L15AC
TA78L015	uA78L15C
TA7316	uA78L02C

Unitrode	TI
UC217	LM217
UC237	LM237
UC317	LM317
UC337	LM337
UC350	LM350

Unitrode	TI
UC2524	SG2524
UC3524	SG3524
UC3525A	SG3525A
UC3527A	SG3527A
UC493AC	TL593C
UC494AC	TL594C
UC495AC	TL595C
UC7805AC	TL780-05C
UC7805C	uA7805C
7812AC	TL780-12C
UC7812C	uA7812C
UC7815AC	TL780-15C
UC7815C	uA7815C
UC7905C	uA7905C
UC7912C	uA7912C
UC7915C	uA7915C

SERIES REGULATORS

Input Regulation

The change in output voltage, often expressed as a percentage of output voltage, for a change in input voltage from one level to another level.

NOTE: Sometimes this characteristic is normalized with respect to the input voltage change.

Ripple Rejection

The ratio of the peak-to-peak input ripple voltage to the peak-to-peak output ripple voltage.

NOTE: This is the reciprocal of ripple sensitivity.

Ripple Sensitivity

The ratio of the peak-to-peak output ripple voltage, sometimes expressed as a percentage of output voltage, to the peak-to-peak input ripple voltage.

NOTE: This is the reciprocal of ripple rejection.

Output Regulation

The change in output voltage, often expressed as a percentage of output voltage, for a change in load current from one level to another level.

Output Resistance

The output resistance under small-signal conditions.

Temperature Coefficient of Output Voltage (α_{VO})

The ratio of the change in output voltage, usually expressed as a percentage of output voltage, to the change in temperature. This is the average value for the total temperature change.

$$\alpha_{VO} = \pm\left[\frac{V_O \text{ at } T_2 - V_O \text{ at } T_1}{V_O \text{ at } 25^\circ C}\right]\left[\frac{100\%}{T_2 - T_1}\right]$$

Output Voltage Change with Temperature

The percentage change in the output voltage for a change in temperature. This is the net change over the total temperature range.

Output Voltage Long-Term Drift

The change in output voltage over a long period of time.

Output Noise Voltage

The rms value of the ac component of the output voltage, sometimes expressed as a percentage of the dc output voltage, with constant load and no input ripple.

Current-Limit Sense Voltage

The current-sense voltage at which current limiting occurs.

Current-Sense Voltage

The voltage that is a function of the load current and is normally used for control of the current-limiting circuitry.

Dropout Voltage

The low input-to-output differential voltage at which the circuit ceases to regulate against further reductions in input voltage.

Feedback Sense Voltage
The voltage that is a function of the output voltage and is used for feedback control of the regulator.

Reference Voltage
The voltage that is compared with the feedback sense voltage to control the regulator.

Bias Current
The difference between input and output currents.
NOTE: This is sometimes referred to as quiescent current.

Standby Current
The input current drawn by the regulator with no output load and no reference voltage load.

Short-Circuit Output Current
The output current of the regulator with the output shorted to ground.

Peak Output Current
The maximum output current that can be obtained from the regulator due to limiting circuitry within the regulator.

Overvoltage Shutdown Voltage
The input voltage applied to a regulator having overvoltage shutdown protection that will cause the output voltage to go nearly to zero.

Junction Temperature, Virtual Junction Temperature
A temperature representing the temperature of the junction(s), field-effect transistor channel(s) or other internal point(s) of heat generation calculated on the basis of a simplified model of the thermal and electrical behavior of the semiconductor device.

SHUNT REGULATORS

NOTE: These terms and symbols are based on JEDEC and IEC standards for voltage regulator diodes.

Shunt Regulator
A device having a voltage-current characteristic similar to that of a voltage-regulator diode; normally biased to operate in a region of low differential resistance (corresponding to the breakdown region of a regulator diode) to develop across its terminals an essentially constant voltage throughout a specified current range.

Anode
The electrode to which the regulator current flows within the regulator when it is biased for regulation.

Cathode
The electrode from which the regulator current flows within the regulator when it is biased for regulation.

Reference Input Voltage (V_{ref}) (of an adjustable shunt regulator)
The voltage at the reference input terminal with respect to the anode terminal.

Temperature Coefficient of Reference Voltage ($\alpha_{V_{ref}}$)
The ratio of the change in reference voltage to the change in temperature. This is the average value for the total temperature change.
To obtain a value in ppm/°C:

$$\alpha_{V_{ref}} = \left[\frac{V_{ref} \text{ at } T_2 - V_{ref} \text{ at } T_1}{V_{ref} \text{ at } 25^\circ C}\right]\left[\frac{10^6}{T_2 - T_1}\right]$$

Regulator Voltage (V_Z)
The dc voltage across the regulator when it is biased for regulation.

Regulator Current (I_Z)
The dc current through the regulator when it is biased for regulation.

Regulator Current near Lower Knee of Regulation Range (I_{ZK})
The regulator current near the lower limit of the region within which regulation occurs; this corresponds to the breakdown knee of a regulator diode.

Regulator Current at Maximum Limit of Regulation Range (I_{ZM})
The regulator current above which the differential resistance of the regulator significantly increases.

Differential Regulator Resistance (r_z)
The quotient of a change in voltage across the regulator and the corresponding change in current through the regulator when it is biased for regulation.

Noise Voltage (V_{nz})
The rms value of the ac component of the voltage across the regulator with the regulator biased for regulation and with no input ripple.

1

Descriptive Information

2

2

TYPES LM217, LM317
3-TERMINAL ADJUSTABLE REGULATORS

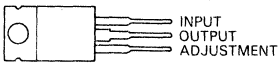
D2212, SEPTEMBER 1977 — REVISED DECEMBER 1982

- **Output Voltage Range Adjustable from 1.2 V to 37 V**
- **Guaranteed Output Current Capability of 1.5 A**
- **Input Regulation Typically 0.01% Per Input-Volt Change**
- **Output Regulation Typically 0.1%**
- **Peak Output Current Constant Over Temperature Range of Regulator**
- **Popular 3-Lead TO-220AB Package**
- **Ripple Rejection Typically 80 dB**
- **Direct Replacement for National LM217 and LM317**

terminal assignments

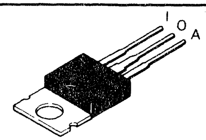
KC PACKAGE

(TOP VIEW)



THE OUTPUT TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



description

The LM217, and LM317 are adjustable 3-terminal positive-voltage regulators capable of supplying 1.5 amperes over a differential voltage range of 3 volts to 40 volts. They are exceptionally easy to use and require only two external resistors to set the output voltage. Both input and output regulation are better than standard fixed regulators. The devices are packaged in a standard transistor package that is easily mounted and handled.

In addition to higher performance than fixed regulators, these regulators offer full overload protection available only in integrated circuits. Included on the chip are current limit, thermal overload protection, and safe-area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected. Normally, no capacitors are needed unless the device is situated far from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection, which is difficult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators, these regulators are useful in a wide variety of other applications. The primary applications of each of these regulators is that of a programmable output regulator, but by connecting a fixed resistor between the adjustment terminal and the output terminal, each device can be used as a precision current regulator. Even though the regulator is floating and sees only the input-to-output differential voltage, use of these devices to regulate output voltages that would cause the maximum-rated differential voltage to be exceeded if the output became shorted to ground is not recommended. The TL783 or TL783A is recommended for output voltages exceeding 37 volts. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground, which programs the output to 1.2 volts where most loads draw little current.

The LM217 and LM317 are characterized for operation from −25 °C to 150 °C and from 0 °C to 125 °C, respectively.

electrical characteristics over recommended ranges of operating virtual junction temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		LM217 MIN	LM217 TYP	LM217 MAX	LM317 MIN	LM317 TYP	LM317 MAX	UNIT
Input regulation (See Note 2)	$V_I - V_O$ = 3 V to 40 V,	T_J = 25°C		0.01	0.02		0.01	0.04	%/V
	See Note 3	I_O = 10 mA to 1.5 A		0.02	0.05		0.02	0.07	%/V
Ripple rejection	V_O = 10 V,	f = 120 Hz		65			65		dB
	V_O = 10 V, 10-μF capacitor between ADJ and ground	f = 120 Hz	66	80		66	80		dB
Output regulation	I_O = 10 mA to 1.5 A, T_J = 25°C, See Note 3	$V_O \le 5$ V		5	15		5	25	mV
		$V_O > 5$ V		0.1	0.3		0.1	0.5	%
	I_O = 10 mA to 1.5 A, See Note 3	$V_O \le 5$ V		20	50		20	70	mV
		$V_O > 5$ V		0.3	1		0.3	1.5	%
Output voltage change with temperature	T_J = MIN to MAX			1			1		%
Output voltage long-term drift (see Note 4)	After 1000 h at T_J = MAX and $V_I - V_O$ = 40 V			0.3	1		0.3	1	%
Output noise voltage	f = 10 Hz to 10 kHz, T_J = 25°C			0.003			0.003		%
Minimum output current to maintain regulation	$V_I - V_O$ = 40 V			3.5	5		3.5	10	mA
Peak output current	$V_I - V_O \le 15$ V		1.5	2.2		1.5	2.2		A
	$V_I - V_O \le 40$ V			0.4			0.4		A
Adjustment-terminal current				50	100		50	100	μA
Change in adjustment-terminal current	$V_I - V_O$ = 2.5 V to 40 V, I_O = 10 mA to 1.5 A			0.2	5		0.2	5	μA
Reference voltage (output to ADJ)	$V_I - V_O$ = 3 V to 40 V, I_O = 10 mA to 1.5 A,	P ≤ 20 W	1.2	1.25	1.3	1.2	1.25	1.3	V

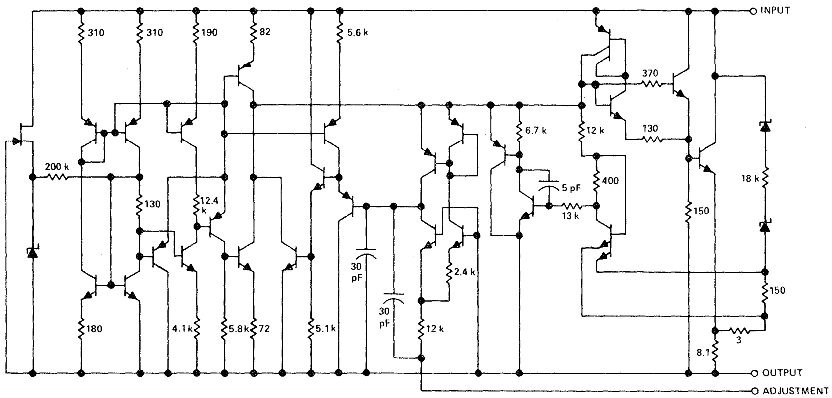
† Unless otherwise noted, these specifications apply for the following test conditions; $V_I - V_O$ = 5 V and I_O = 0.5 A. For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

NOTES: 2. Input regulation is expressed here as the percentage change in output voltage per 1-volt change at the input.

3. Input regulation and output regulation are measured using pulse techniques ($t_w \le 10$ μs, duty cycle ≤ 5%) to limit changes in average internal dissipation. Output voltage changes due to large changes in internal dissipation must be taken into account separately.

4. Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

schematic



All resistor values shown are nominal and in ohms.

absolute maximum ratings over operation temperature range (unless otherwise noted)

	LM217	LM317	UNIT
Input-to-output differential voltage, $V_I - V_O$	40	40	V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2000	2000	mW
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	20	20	W
Operating free-air, case, or virtual junction temperature range	−25 to 150	0 to 125	°C
Storage temperature range	−65 to 150	−65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260	260	°C

NOTE 1: For operation above 25° free-air or case temperature, refer to Figures 15 and 16, Page 2-8. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activitated at power levels slightly above or below the rated dissipation.

recommended operating conditions

	LM217		LM317		UNIT
	MIN	MAX	MIN	MAX	
Output current, I_O	5	1500	10	1500	mA
Operating virtual junction temperature, T_J	−25	150	0	125	°C

TYPICAL APPLICATION DATA

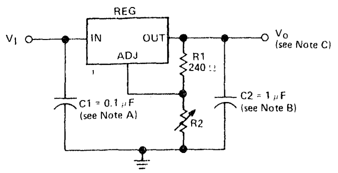


FIGURE 1–ADJUSTABLE VOLTAGE REGULATOR

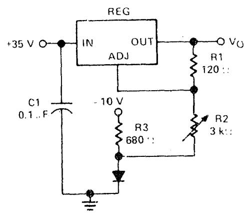
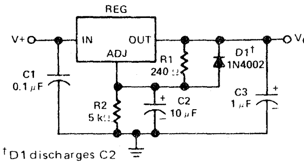


FIGURE 2–0-V to 30-V REGULATOR CIRCUIT



†D1 discharges C2 if output is shorted to ground.

FIGURE 3–ADJUSTABLE REGULATOR CIRCUIT WITH IMPROVED RIPPLE REJECTION

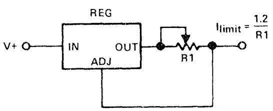


FIGURE 4–PRECISION CURRENT LIMITER CIRCUIT

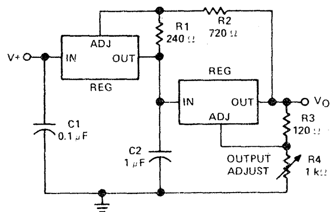


FIGURE 5–TRACKING PREREGULATOR CIRCUIT

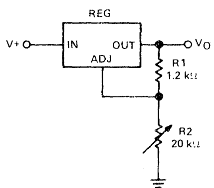
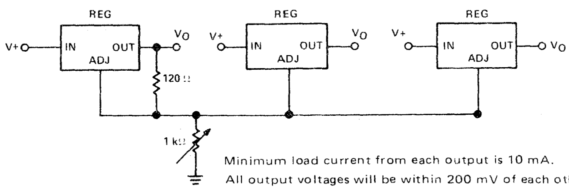


FIGURE 6–1.2 to 20-V REGULATOR CIRCUIT WITH MINIMUM PROGRAM CURRENT



Minimum load current from each output is 10 mA.
All output voltages will be within 200 mV of each other.

FIGURE 7–ADJUSTING MULTIPLE ON-CARD REGULATORS WITH A SINGLE CONTROL

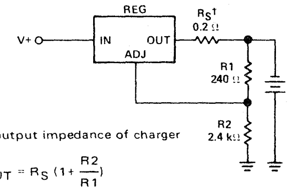
NOTES: A. Use of an input bypass capacitor is recommended if regulator is far from filter capacitors.

B. Use of an output capacitor improves transient response but is optional.

C. Output voltage is calculated from the equation: $V_O = V_{ref}\left(1 + \frac{R2}{R1}\right)$

V_{ref} equals the difference between the output and adjustment terminal voltages.

TYPICAL APPLICATIONS



†R_S controls output impedance of charger

$$Z_{OUT} = R_S \left(1 + \frac{R2}{R1}\right)$$

The use of R_S allows low charging rates with a fully charged battery.

FIGURE 8—BATTERY CHARGER CIRCUIT

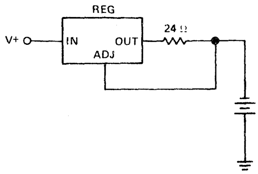


FIGURE 9—50-mA CONSTANT-CURRENT BATTERY CHARGER CIRCUIT

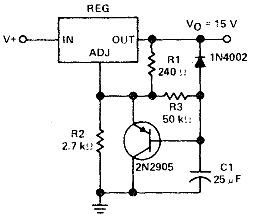


FIGURE 10—SLOW-TURN-ON 15-V REGULATOR CIRCUIT

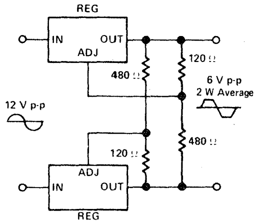
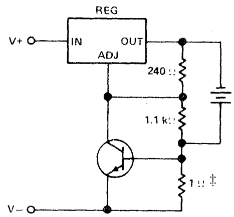


FIGURE 11—A-C VOLTAGE REGULATOR CIRCUIT



‡ This resistor sets peak current (0.6 A for 1 Ω).

FIGURE 12—CURRENT-LIMITED 6-V CHARGER

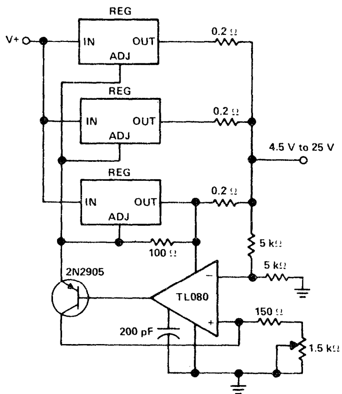
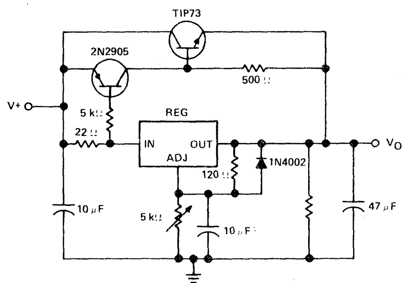


FIGURE 13—ADJUSTABLE 4-A REGULATOR



¶ Minimum load current is 30 mA.
§ Optional capacitor improves ripple rejection

FIGURE 14—HIGH-CURRENT ADJUSTABLE REGULATOR

THERMAL INFORMATION

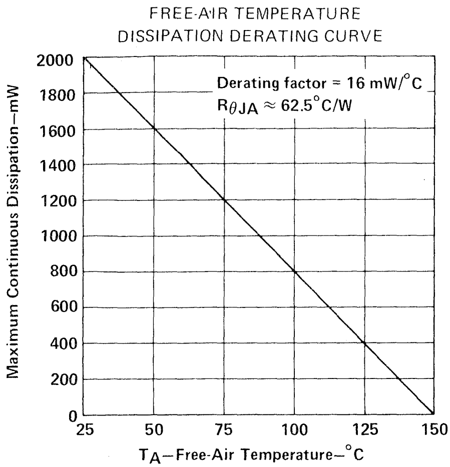


FIGURE 15

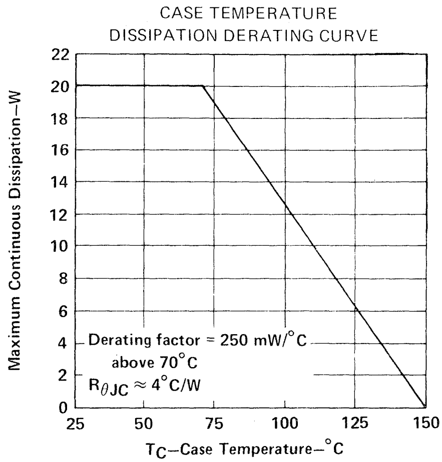


FIGURE 16

2

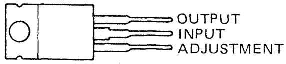
TYPES LM237, LM337
3-TERMINAL ADJUSTABLE REGULATORS

D2640, NOVEMBER 1981

- Output Voltage Range Adjustable from −1.2 V to −37 V
- Guaranteed I_O Capability of 1.5 A
- Input Regulation Typically 0.01% per Input-Volt Change
- Output Regulation Typically 0.3%
- Peak Output Current Constant Over Temperature Range of Regulator
- Ripple Rejection Typically 77 dB
- Direct Replacement for National Semiconductor LM237, LM337

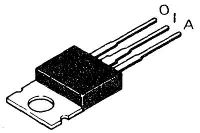
LM237, LM337 . . . KC PACKAGE

(TOP VIEW)



THE INPUT TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



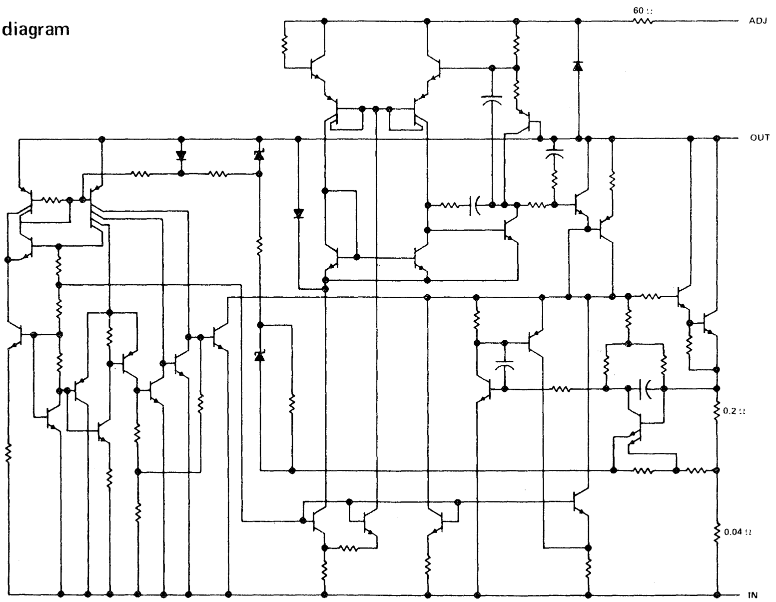
description

The LM237 and LM337 are adjustable 3-terminal negative-voltage regulators capable of supplying in excess of −1.5 A over an output voltage range of −1.2 V to −37 V. They are exceptionally easy to use, requiring only two external resistors to set the output voltage and one output capacitor for frequency compensation. The current design has been optimized for excellent regulation and low thermal transients. In addition the LM237 and LM337 feature internal current limiting, thermal shutdown, and safe-area compensation, making them virtually immune to blowout by overloads.

The LM237 and LM337 serve a wide variety of applications including local on-card regulation, programmable output voltage regulation, or precision current regulation. They are ideal complements to the LM217 and LM317 adjustable positive-voltage regulators.

2

schematic diagram



absolute maximum ratings over operating temperature range (unless otherwise noted)

Input-to-output differential voltage, $V_I - V_O$		−40 V
Continuous total dissipation at 25°C free-air temperature (see Note 1)		2 W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)		20 W
Operating free-air, case, or virtual junction temperature range:	LM237	−25°C to 150°C
	LM337	0°C to 125°C
Storage temperature range		−65°C to 150°C
Lead temperature 1/16 inch from case for 10 seconds		260°C

NOTE 1: For operation above 25° free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activitated at power levels slightly above or below the rated dissipation.

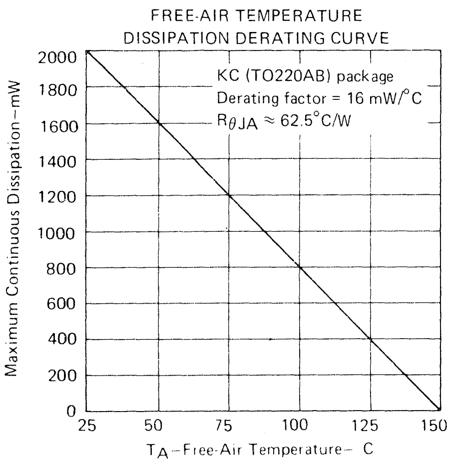


FIGURE 1

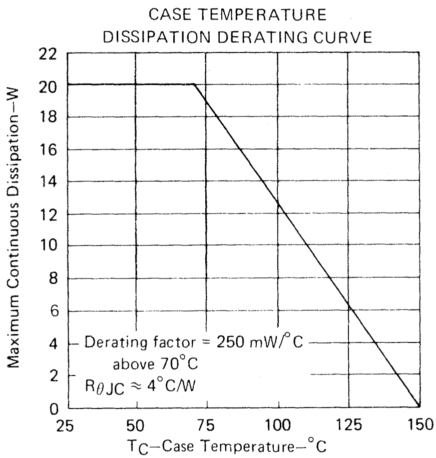


FIGURE 2

recommended operating conditions

		LM237		LM337		UNIT
		MIN	MAX	MIN	MAX	
Output current, I_O	$\lvert V_I - V_O \rvert \leq 40$ V, $P \leq 15$ W	10	1500	10	1500	mA
	$\lvert V_I - V_O \rvert \leq 10$ V, $P \leq 15$ W	6	1500	6	1500	
Operating virtual junction temperature, T_J		−25	150	0	125	°C

electrical characteristics over recommended ranges of operating virtual junction temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		LM237 MIN	LM237 TYP	LM237 MAX	LM337 MIN	LM337 TYP	LM337 MAX	UNIT
Input regulation‡	$V_I - V_O = -3$ V to −40 V, See Note 2	$T_J = 25°C$		0.01	0.02		0.01	0.04	%/V
		T_J = MIN to MAX		0.02	0.05		0.02	0.07	
Ripple rejection	$V_O = -10$ V,	f = 120 Hz		60			60		dB
	$V_O = -10$ V, $C_{ADJ} = 10\ \mu F$	f = 120 Hz	66	77		66	77		
Output regulation	I_O = 10 mA to 1.5 A, $T_J = 25°C$, See Note 2	$\lvert V_O \rvert \leq 5$ V			25			50	mV
		$\lvert V_O \rvert \geq 5$ V			0.5			1	%
	I_O = 10 mA to 1.5 A, See Note 2	$\lvert V_O \rvert \leq 5$ V			50			70	mV
		$\lvert V_O \rvert \geq 5$ V			1			1.5	%
Output voltage change with temperature	T_J = MIN to MAX			0.6			0.6		%
Output voltage long-term drift (see Note 3)	After 1000 h at T_J = MAX and $V_I - V_O = -40$ V			0.3	1		0.3	1	%
Output noise voltage	f = 10 Hz to 10 kHz,	$T_J = 25°C$		0.003			0.003		%
Minimum output current to maintain regulation	$\lvert V_I - V_O \rvert \leq 40$ V			2.5	5		2.5	10	mA
	$\lvert V_I - V_O \rvert \leq 10$ V			1.2	3		1.5	6	
Peak output current	$\lvert V_I - V_O \rvert \leq 15$ V		1.5	2.2		1.5	2.2		A
	$\lvert V_I - V_O \rvert \leq 40$ V,	$T_J = 25°C$	0.24	0.4		0.15	0.4		
Adjustment-terminal current				65	100		65	100	μA
Change in adjustment terminal current	$V_I - V_O = -2.5$ V to −40 V, I_O = 10 mA to MAX,	$T_J = 25°C$		2	5		2	5	μA
Reference voltage (output to ADJ)	$V_I - V_O = -3$ to −40 V, I_O = 10 mA to 1.5 A, $P \leq$ rated dissipation	$T_J = 25°C$	−1.225	−1.250	−1.275	−1.213	−1.25	−1.287	V
		T_J = MIN to MAX	−1.2	−1.25	−1.3	−1.2	−1.25	−1.3	
Thermal regulation	Initial $T_J = 25°C$,	10-ms pulse		0.002	0.02		0.003	0.04	%/W

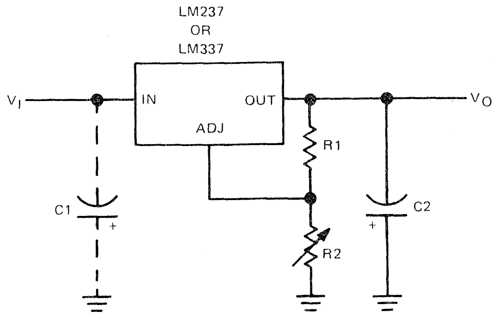
† Unless otherwise noted, these specifications apply for the following test conditions $\lvert V_I - V_O \rvert = 5$ V and $I_O = 0.5$ A. For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡ Input regulation is expressed here as the percentage change in output voltage per 1 volt change at the input.

NOTES: 2. Input regulation and output regulation are measured using pulse techniques ($t_w \leq 10\ \mu s$, duty cycle $\leq 5\%$) to limit changes in average internal dissipation. Output voltage changes due to large changes in internal dissipation must be taken into account separately.

3. Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPICAL APPLICATION DATA



R1 is typically 120 Ω.

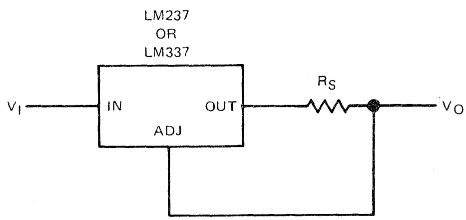
$$R2 = R1\left(\frac{-V_O}{-1.25} - 1\right)$$ where V_O is the output in volts.

C1 is a 1-μF solid tantalum required only if the regulator is more than 10 cm (4 in.) from the power supply filter capacitor.

C2 is a 1-μF solid tantalum or 10-μF aluminum electrolytic required for stability.

FIGURE 3 – ADJUSTABLE NEGATIVE-VOLTAGE REGULATOR

2



$$R_S = \frac{1.25\ V}{I_{LIMIT}}$$

FIGURE 4 – CURRENT-LIMITING CIRCUIT

TYPE SERIES LM320
3-TERMINAL NEGATIVE-VOLTAGE REGULATORS

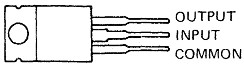
D2334, APRIL 1983

- 3-Terminal Regulators
- Internal Thermal Overload Protection
- Internal Short-Circuit Current Limiting
- Easily Adjustable to Higher Output Voltage
- Interchangeable with National Semiconductor LM320 Series

NOMINAL OUTPUT VOLTAGE	MAXIMUM OUTPUT CURRENT	REGULATOR
−5 V	1.5 A	LM320-5
−12 V	1 A	LM320-12
−15 V	1A	LM320-15

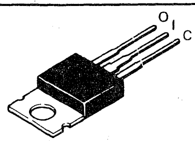
KC PACKAGE

(TOP VIEW)



THE INPUT TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



description

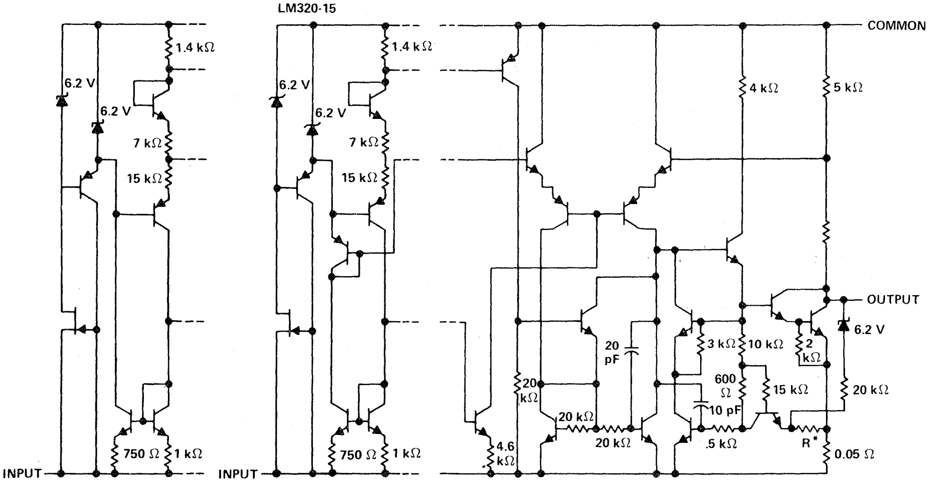
The LM320 series of three-terminal, fixed-negative-voltage monolithic integrated circuit voltage regulators are designed to provide a fixed output voltage of −5 volts, −12 volts, and −15 volts with up to 1.5 amperes of output current. Each is designed for a wide range of applications which includes on-card regulation for elimination of noise and distribution problems associated with single-point regulation.

The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. The LM320, when used as a fixed-voltage regulator, needs only one external component: a compensation capacitor at the output terminal. In addition, these devices can be used with external components to obtain adjustable output voltages and currents or as the power-pass element in precision regulators.

schematic diagram

LM320-5

LM320-12
LM320-15



For LM320-5, R* = 50 Ω. For LM320-12 and LM320-15, R* = 150 Ω
All component values are nominal.

absolute maximum ratings over operating temperature range (unless otherwise noted)

Input voltage: LM320-5	−25 V
LM320-12	−35 V
LM320-15	−35 V
Input-output voltage differential	25 V
Continuous total dissipation at 25 °C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 25 °C case temperature (see Note 1)	15 W
Operating free-air, case, or virtual junction temperature range	−55 °C to 150 °C
Storage temperature range	−65 °C to 150 °C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260 °C

NOTE 1: For operation above 25 °C free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activated at power levels slightly above or below the rated dissipation.

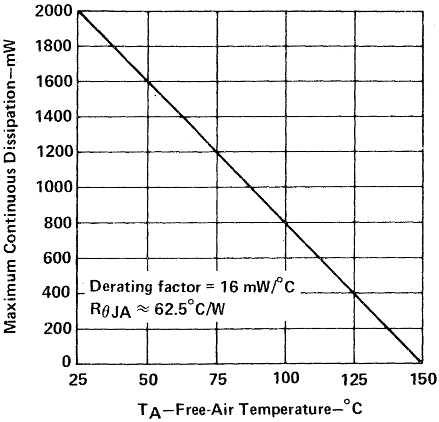


FIGURE 1

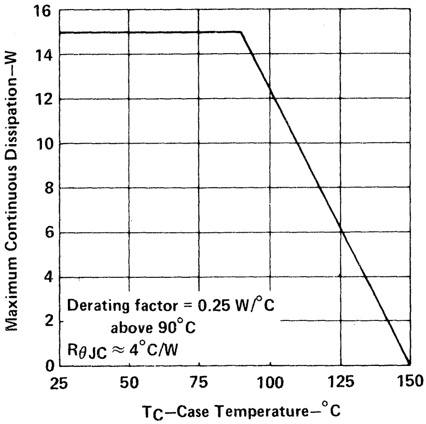


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	LM320-5	−7.5	−25	V
	LM320-12	−14.5	−32	
	LM320-15	−17.5	−35	
Output current, I_O	LM320-5		1.5	A
	LM320-12		1	
	LM320-15		1	
Operating virtual junction temperature, T_J		0	125	°C

LM320-5 electrical characteristics at specified virtual junction temperature, I_O = 5 mA, V_I = −10 V, (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage		T_J = 25°C	−4.8		−5.2	V
	V_I = −7.5 V to −25 V, P ≤ 15 W,	I_O = 5 mA to 1.5 A, T_J = 0°C to 125°C	−4.75		−5.25	
Input regulation	V_I = −7.5 V to −25 V,	T_J = 25°C		10	40	mV
Ripple rejection	f = 120 Hz,	T_J = 0°C to 125°C	54	64		dB
Output regulation	I_O = 5 mA to 1.5 A,	T_J = 25°C		50	100	mV
Output noise voltage	C_L = 1 μF, f = 10 Hz to 100 kHz,	T_J = 25°C		150		μV
Output voltage long-term drift (see Note 2)	After 1000 h at T_J = 125°,	T_J = 25°C		10		mV
Bias current	V_I = −7.5 V to −25 V,	T_J = 0°C to 125°C		1	2	mA
Bias current change	V_I = −7.5 V to −25 V	T_J = 25°C		0.1	0.4	mA
	I_O = 5 mA to 1.5 A			0.1	0.4	

LM320-12 electrical characteristics at specified virtual junction temperature, I_O = 5 mA, V_I = −17 V, (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage		T_J = 25°C	−11.6	−12	−12.4	V
	V_I = −14.5 V to −32 V, P ≤ 15 W,	I_O = 5 mA to 1 A, T_J = 0°C to 125°C	−11.4		−12.6	
Input regulation	V_I = −14.5 V to −32 V,	T_J = 25°C		4	20	mV
Ripple rejection	f = 120 Hz,	T_J = 0°C to 125°C	56	80		dB
Output regulation	I_O = 5 mA to 1 A,	T_J = 25°C		30	80	mV
Output noise voltage	C_L = 1 μF, f = 10 Hz to 100 kHz,	T_J = 25°C		400		μV
Output voltage long-term drift (see Note 2)	After 1000 h at T_J = 125°C,	T_J = 25°C		24		mV
Bias current	V_I = −14.5 V to −32 V,	T_J = 0°C to 125°C		2	4	mA
Bias current change	V_I = −14.5 V to −32 V	T_J = 25°C		0.1	0.4	mA
	I_O = 5 mA to 1 A			0.1	0.4	

2

LM320-15 electrical characteristics at specified virtual junction temperature, I_O = 5 mA, V_I = −20 V, (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage		T_J = 25°C	−14.5	−15	−15.5	V
	V_I = −17.5 V to −35 V, P ≤ 15 W,	I_O = 5 mA to 1 A, T_J = 0°C to 125°C	−14.3		−15.7	
Input regulation	V_I = −17.5 V to −35 V,	T_J = 25°C		5	20	mV
Ripple rejection	f = 120 Hz,	T_J = 0°C to 125°C	56	80		dB
Output regulation	I_O = 5 mA to 1 A	T_J = 25°C		30	80	mV
Output noise voltage	C_L = 1 μF, f = 10 Hz to 100 kHz,	T_J = 25°C		400		μV
Output voltage long-term drift (see Note 2)	After 1000 h at T_J = 125°C,	T_J = 25°C		30		mV
Bias current	V_I = −17.5 V to −35 V,	T_J = 0°C to 125°C		2	4	mA
Bias current change	V_I = −17.5 V to −35 V,	T_J = 25°C		0.1	0.4	mA
	I_O = 5 mA to 1 A			0.1	0.4	

†All characteristics are measured with a 1-μF capacitor across the input and a 2-μF solid-tantalum capacitor across the output. All characteristics except ripple rejection and output noise voltage are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

NOTE 2: Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPICAL CHARACTERISTICS

NORMALIZED OUTPUT VOLTAGE
vs
VIRTUAL JUNCTION TEMPERATURE

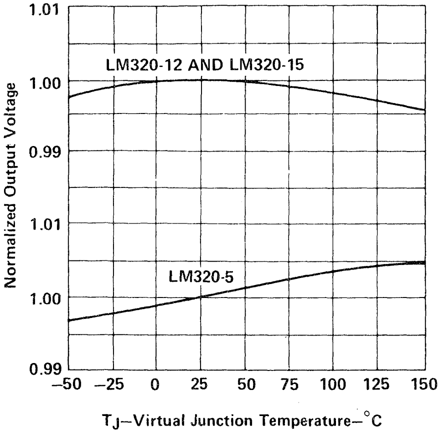


FIGURE 3

RIPPLE REJECTION
vs
FREQUENCY

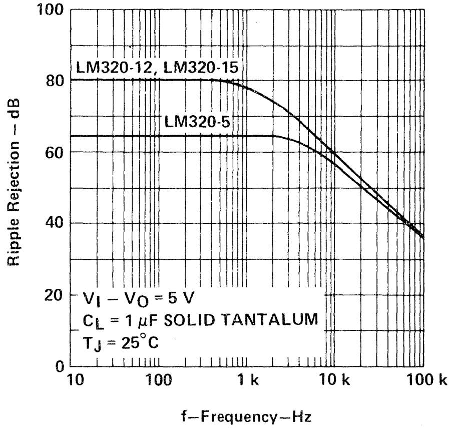


FIGURE 4

2

BIAS CURRENT
vs
INPUT VOLTAGE

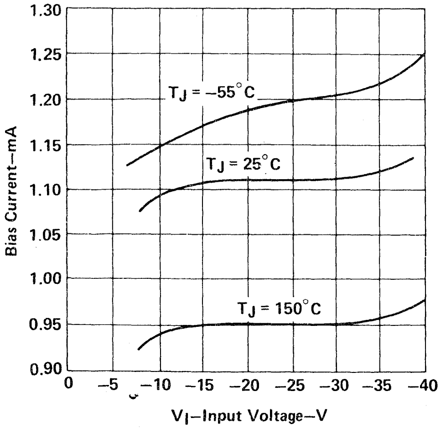


FIGURE 5

BIAS CURRENT
vs
OUTPUT CURRENT

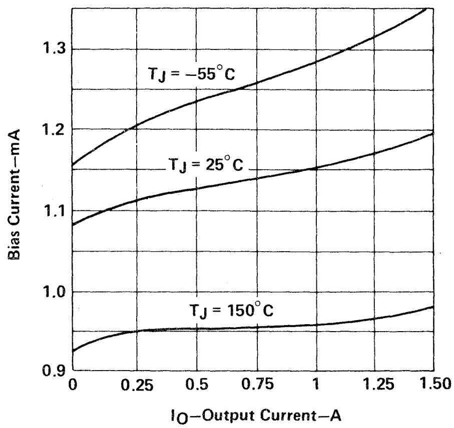


FIGURE 6

TYPICAL CHARACTERISTICS

SHORT-CIRCUIT OUTPUT CURRENT
vs
INPUT-OUTPUT VOLTAGE DIFFERENTIAL

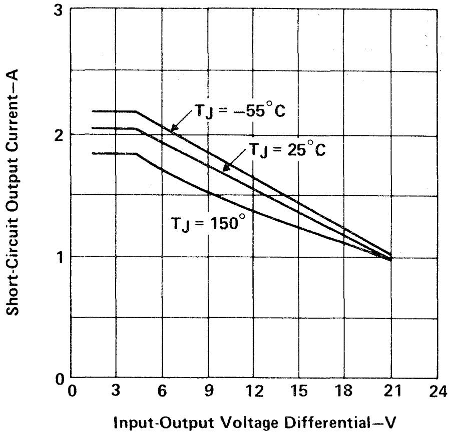


FIGURE 7

DROPOUT VOLTAGE
vs
OUTPUT CURRENT

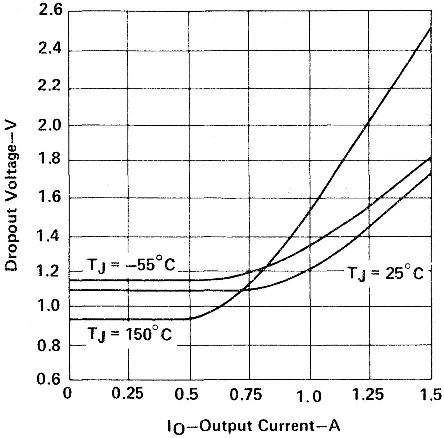


FIGURE 8

OUTPUT IMPEDANCE
vs
FREQUENCY

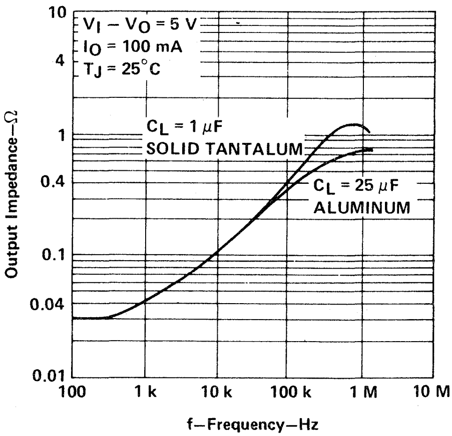


FIGURE 9

TYPICAL APPLICATION INFORMATION

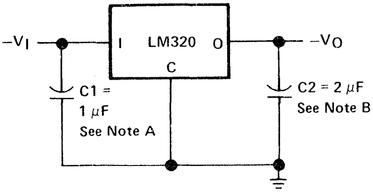
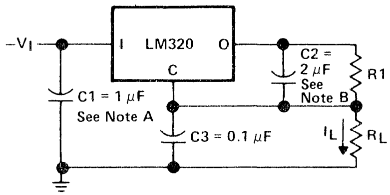


FIGURE 10 — FIXED-VOLTAGE REGULATOR



LM320-5

$I_L = 1\text{ mA} + \frac{5\text{ V}}{R1}$

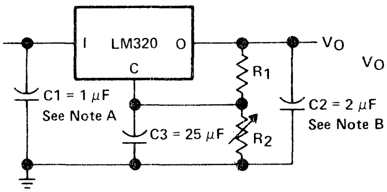
LM320-12KC

$I_L = 2\text{ mA} + \frac{12\text{ V}}{R1}$

LM320-15KC

$I_L = 2\text{ mA} + \frac{15\text{ V}}{R1}$

FIGURE 11 — CURRENT SOURCE REGULATOR



$V_O = V_{R2}\,\frac{R1 + R2}{R2}$

FIGURE 12 — ADJUSTABLE OUTPUT REGULATOR

2

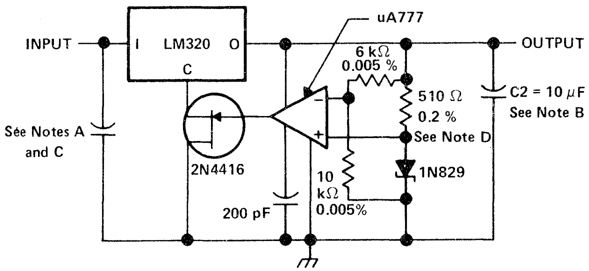


FIGURE 13 — HIGH-STABILITY REGULATOR

NOTES: A. Capacitor C1 is required if the regulator is not located within 75 mm (3 inches) of the power supply filter.

B. Capacitor C2 is required for stability. For the value given, the capacitor must be solid tantalum but a 25-μF aluminum electrolytic may be substituted. Values given may be increased without limit.

C. In Figure 13 capacitor C1 is solid tantalum.

D. This resistor determines zener current. Adjust to minimize thermal drift.

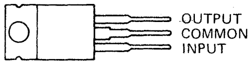
TYPE LM330
3-TERMINAL POSITIVE REGULATOR

D2700, APRIL 1983

- Input-Output Differential Less than 0.6 V
- Output Current of 150 mA
- Reverse Polarity Protection
- Line Transient Protection
- Internal Short-Circuit Current Limiting
- Internal Thermal Overload Protection
- Mirror-Image Insertion Protection
- Direct Replacement for National LM330T-5.0

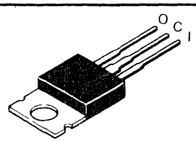
KC PACKAGE

(TOP VIEW)



THE COMMON TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



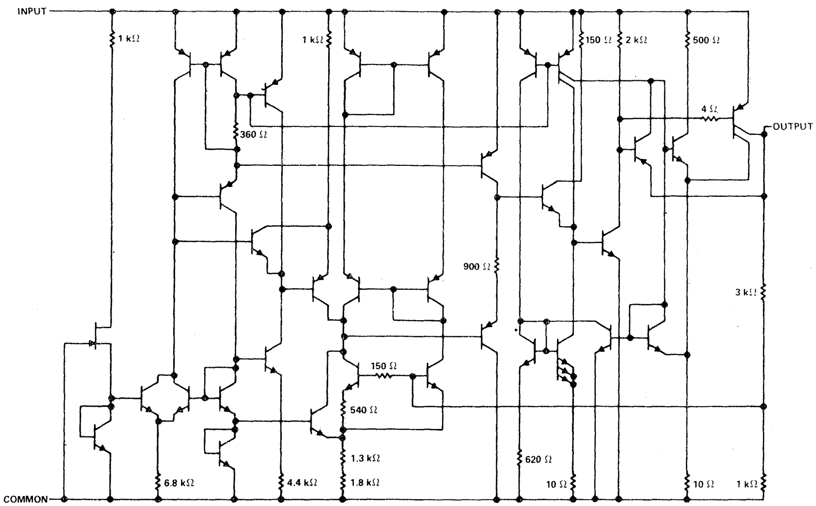
description

The LM330 3-terminal positive regulator features an ability to source 150 milliamperes of output current with an input-output differential of 0.6 volt or less. Familar regulator features such as current limit and thermal overload protection are also provided.

The LM330 has low dropout voltage making it useful for certain battery applications. For example, since the low dropout voltage allows a longer battery discharge before the output falls out of regulation, a battery supplying the regulator input voltage may discharge to 5.6 volts and still properly regulate the system and load voltage. The LM330 protects both itself and the regulated system from reverse installation of batteries.

Other protection features include line transient protection above 40 volts, where the output actually shuts down to avoid damaging internal and external circuits. The LM330 regulator cannot be harmed by temporary mirror-image insertion.

schematic diagram



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Continuous input voltage	26 V
Transient input voltage t = 1 s	50 V
t = 100 ms	60 V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) case temperature (see Note 1)	20 W
Operating free-air, case, or virtual junction temperature	−55°C to 150°C
Storage temperature	−65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activated at power levels slightly above or below the rated dissipation.

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

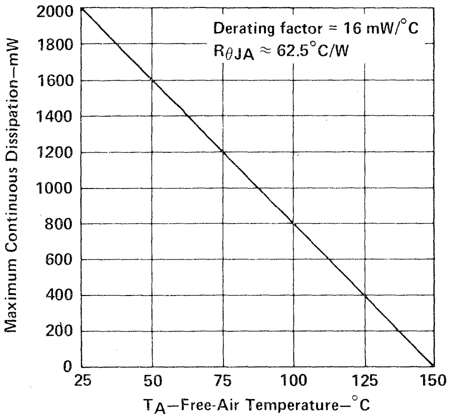


FIGURE 1

CASE TEMPERATURE
DISSIPATION DERATING CURVE

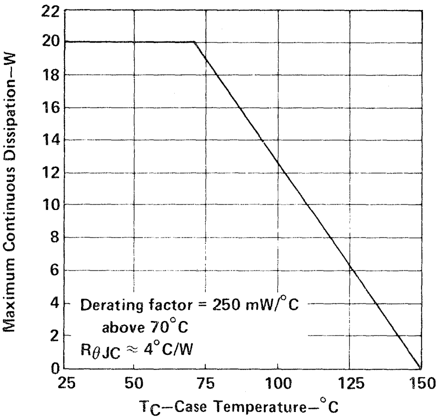


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
I_O	Output current	5	150	mA
T_A	Operating virtual junction temperature	0	100	°C

electrical characteristics at 25 °C virtual junction temperature, V_I = 14 V, I_O = 150 mA, (unless otherwise noted)

PARAMETERS	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	V_I = 6 V to 26 V,	I_O = 5 mA to 150 mA,	4.8	5	5.2	V
	T_J = 0 °C to 100 °C		4.75		5.25	
Input regulation	I_O = 5 mA	V_I = 9 V to 16 V		7	25	mV
		V_I = 6 V to 26 V		30	60	
Ripple rejection	f = 120 Hz			56		dB
Output regulation	I_O = 5 mA to 150 mA			14	50	mV
Output voltage long-term drift‡	After 1000 h at T_J = 100 °C			20		mV
Dropout voltage	I_O = 150 mA			0.32	0.6	V
Output noise voltage	f = 10 Hz to 100 kHz			50		μV
Output voltage with input polarity reversed	R_L = 100 Ω	V_I = −30 V, t = 100 ms		> −0.3		V
		V_I = −12 V, DC		> −0.3		
Output voltage with input transient	V_I = 60 V,	t = 100 ms		<5.5		V
	V_I = 50 V,	t = 1 s		<5.5		
Bias current with input transient	R_L = 100 Ω	V_I = 40 V, t = 1 s		14		mA
		V_I = −6 V, t = 1 s		−80		
Overvoltage shutdown voltage			26	45		V
Output impedance	I_O = 100 mA, I_o = 10 mA (rms), f = 100 Hz to 10 kHz			200		mΩ
Bias current	I_O = 10 mA			3.5	7	mA
	I_O = 50 mA			5	11	
	I_O = 150 mA			18	40	
Bias current change	V_I = 6 V to 26 V			10		%
Peak output current			150	420	700	mA

†Unless otherwise specified, all characteristics except ripple rejection and noise voltage measurements are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%) with a capacitor of 0.1 μF across the input and a capacitor of 10 μF across the output. Output voltage changes due to changes in internal temperature must be taken into account separately.

‡Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPICAL CHARACTERISTICS

OUTPUT VOLTAGE vs VIRTUAL JUNCTION TEMPERATURE

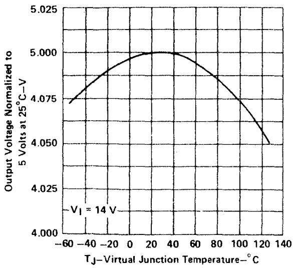


FIGURE 3

OUTPUT VOLTAGE vs INPUT VOLTAGE

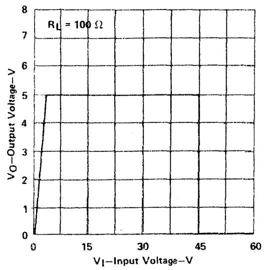


FIGURE 4

OUTPUT VOLTAGE vs INPUT VOLTAGE

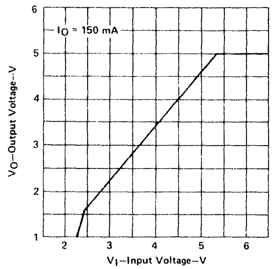


FIGURE 5

PEAK OUTPUT CURRENT vs INPUT VOLTAGE

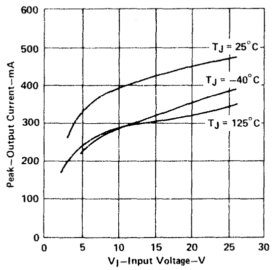


FIGURE 6

RIPPLE REJECTION vs FREQUENCY

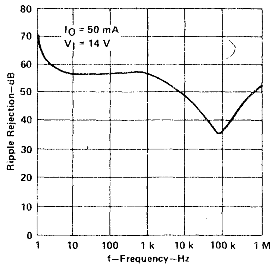


FIGURE 7

RIPPLE REJECTION vs OUTPUT CURRENT

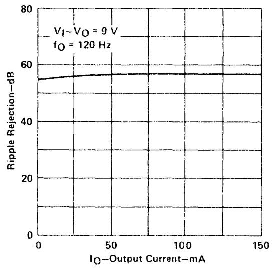


FIGURE 8

DROPOUT VOLTAGE vs VIRTUAL JUNCTION TEMPERATURE

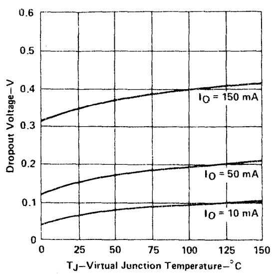


FIGURE 9

DROPOUT VOLTAGE vs OUTPUT CURRENT

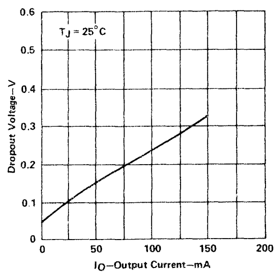


FIGURE 10

OUTPUT IMPEDANCE vs FREQUENCY

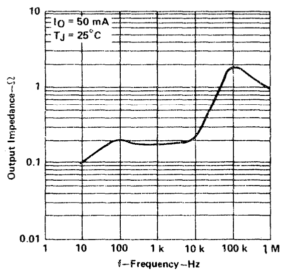


FIGURE 11

TYPICAL CHARACTERISTICS

INPUT CURRENT
vs
INPUT VOLTAGE

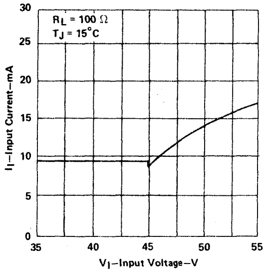


FIGURE 12

LINE TRANSIENT RESPONSE

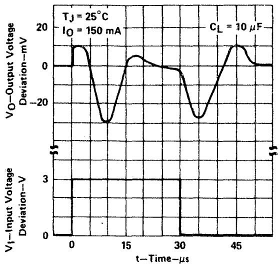


FIGURE 13

INPUT CURRENT
vs
REVERSE INPUT VOLTAGE

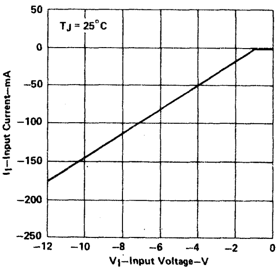


FIGURE 14

OUTPUT VOLTAGE
vs
REVERSE INPUT VOLTAGE

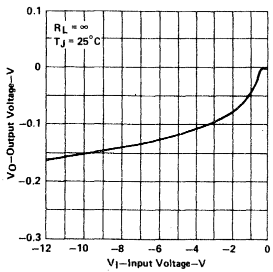


FIGURE 15

LOAD TRANSIENT RESPONSE

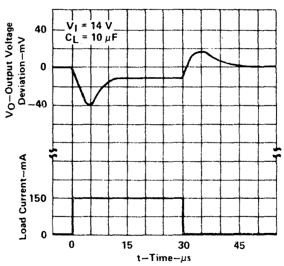


FIGURE 16

BIAS CURRENT
vs
OUTPUT CURRENT

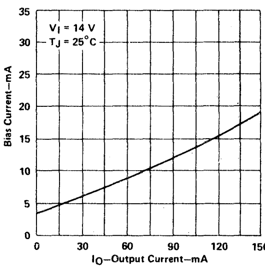


FIGURE 17

BIAS CURRENT
vs
VIRTUAL JUNCTION TEMPERATURE

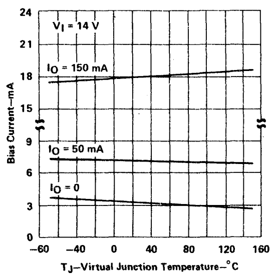


FIGURE 18

BIAS CURRENT
vs
INPUT VOLTAGE

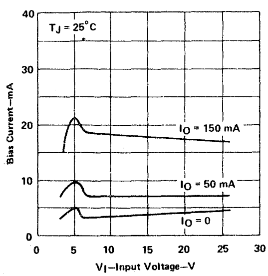
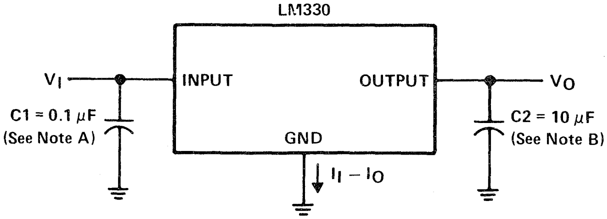


FIGURE 19

TYPICAL APPLICATION DATA



NOTES: A. Use of C1 is required if the regulator is not located in close proximity to the supply filter.

B. Capacitor C2 must be located as close as possible to the regulator and may be an aluminum or tantalum type capacitor. The minimum capacitance that will provide stability is 10 μF. The capacitor must be rated for operation at −40°C to guarantee stability to that extreme.

FIGURE 20

SERIES LM340
POSITIVE-VOLTAGE REGULATORS

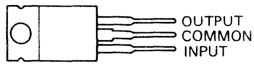
D2332, SEPTEMBER 1977—REVISED MARCH 1983

- 3-Terminal Regulators
- Output Current up to 1.5 A
- No External Components
- Internal Thermal Overload
- High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Output Load Regulation . . . 0.3% Typ
- Direct Replacements for National LM340 Series

NOMINAL OUTPUT VOLTAGE	REGULATOR
5 V	LM340-5
12 V	LM340-12
15 V	LM340-15

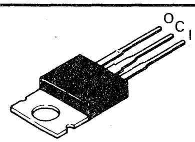
KC PACKAGE

(TOP VIEW)



THE COMMON TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

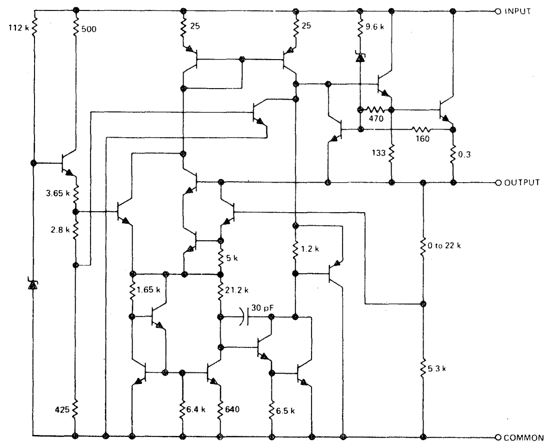
TO-220AB



description

This series of fixed-voltage monolithic integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Any of these regulators can deliver up to 1.5 amperes of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and also as the power-pass element in precision regulators.

schematic



Resistor values shown are nominal and in ohms.

absolute maximum ratings over operating temperature range (unless otherwise noted)

Input voltage	35 V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	15 W
Operating free-air, case, or virtual junction temperature range	−55°C to 150°C
Storage temperature range	−65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

NOTE 1: For operation above 25° free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activitated at power levels slightly above or below the rated dissipation.

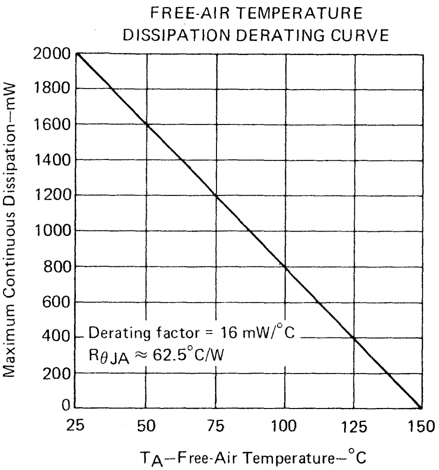


FIGURE 1

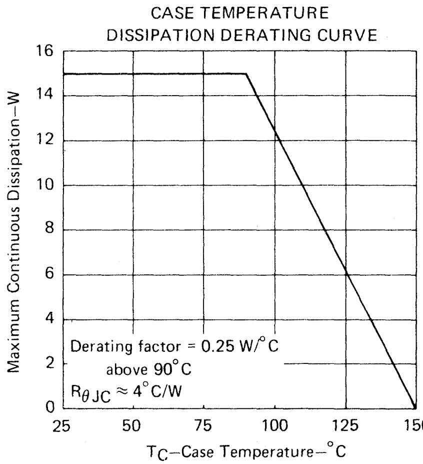


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	LM340-5	7	25	V
	LM340-12	14.5	30	
	LM340-15	17.5	30	
Output current, I_O			1.5	A
Operating virtual junction temperature, T_J		0	125	°C

2

LM340-5 electrical characteristics at specified virtual junction temperature, V_I = 10 V, I_O = 1 A (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			MIN	TYP	MAX	UNIT
Output voltage	I_O = 5 mA to 1 A		25°C	4.8	5	5.2	V
	V_I = 7 V to 20 V, P ≤ 15 W	I_O = 5 mA to 1 A,	0°C to 125°C	4.75		5.25	
Input regulation	I_O = 500 mA	V_I = 7 V to 25 V	25°C		3	50	mV
		V_I = 8 V to 20 V	0°C to 125°C			50	
	I_O = 1 A	V_I = 7.3 V to 20 V	25°C			50	
		V_I = 8 V to 12 V	0°C to 125°C			25	
Ripple rejection	V_I = 8 V to 18 V, f = 120 Hz	I_O ≤ 1 A	25°C	62	80		dB
		I_O ≤ 500 mA	0°C to 125°C	62			
Output regulation	I_O = 250 mA to 750 mA		25°C			25	mV
	I_O = 5 mA to 1.5 A				10	50	
	I_O = 5 mA to 1 A		0°C to 125°C			50	
Output noise voltage	f = 10 Hz to 100 kHz		25°C		40		μV
Dropout voltage	I_O = 1 A		25°C		2		V
Temperature coefficient of output voltage	I_O = 5 mA		0°C to 125°C		−0.6		mV/°C
Output impedance	f = 1 kHz		25°C		8		mΩ
Bias current	I_O ≤ 1 A		25°C			8	mA
			0°C to 125°C			8.5	
Bias current change	V_I = 7.5 V to 20 V,	I_O ≤ 1 A	25°C			1	mA
	V_I = 7 V to 25 V,	I_O ≤ 500 mA	0°C to 125°C			1	
	I_O = 5 mA to 1 A					0.5	
Peak output current			25°C		2.4		A
Short-circuit current			25°C		2.1		A

† All characteristics are measured with a capacitor across the input of 0.22 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

LM340-12 electrical characteristics at specified virtual junction temperature, V_I = 19 V, I_O = 1 A (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			MIN	TYP	MAX	UNIT
Output voltage	I_O = 5 mA to 1 A		25°C	11.5	12	12.5	V
	V_I = 14.5 V to 27 V, I_O = 5 mA to 1 A, P ≤ 15 W		0°C to 125°C	11.4		12.6	
Input regulation	I_O = 500 mA	V_I = 14.5 V to 30 V	25°C		4	120	mV
		V_I = 15 V to 27 V	0°C to 125°C			120	
	I_O = 1 A	V_I = 14.6 V to 27 V	25°C			120	
		V_I = 16 V to 22 V	0°C to 125°C			120	
Ripple rejection	V_I = 15 V to 25 V, f = 120 Hz	I_O ≤ 1 A	25°C	55	72		dB
		I_O ≤ 500 mA	0°C to 125°C	55			
Output regulation	I_O = 250 mA to 750 mA		25°C			60	mV
	I_O = 5 mA to 1.5 A				12	120	
	I_O = 5 mA to 1 A		0°C to 125°C			120	
Output noise voltage	f = 10 Hz to 100 kHz		25°C		75		μV
Dropout voltage	I_O = 1 A		25°C		2		V
Temperature coefficient of output voltage	I_O = 5 mA		0°C to 125°C		−1.5		mV/°C
Output impedance	f = 1 kHz		25°C		18		mΩ
Bias current	I_O ≤ 1 A		25°C			8	mA
			0°C to 125°C			8.5	
Bias current change	V_I = 14.8 V to 27 V, I_O ≤ 1 A		25°C			1	mA
	V_I = 14.5 V to 30 V, I_O ≤ 500 mA		0°C to 125°C			1	
	I_O = 5 mA to 1 A					0.5	
Peak output current			25°C		2.4		A
Short-circuit current			25°C		1.5		A

† All characteristics are measured with a capacitor across the input of 0.22 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

LM340-15 electrical characteristics at specified virtual junction temperature, V_I = 23 V, I_O = 1 A (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			MIN	TYP	MAX	UNIT
Output voltage	I_O = 5 mA to 1 A		25°C	14.4	15	15.6	V
	V_I = 17.5 V to 30 V, I_O = 5 mA to 1 A, P ≤ 15 W		0°C to 125°C	14.25		15.75	
Input regulation	I_O = 500 mA	V_I = 17.5 V to 30 V	25°C		4	150	mV
		V_I = 18.5 V to 30 V	0°C to 125°C			150	
	I_O = 1 A	V_I = 17.7 V to 30 V	25°C			150	
		V_I = 20 V to 26 V	0°C to 125°C			75	
Ripple rejection	V_I = 18.5 V to 28.5 V, f = 120 Hz	I_O ≤ 1 A	25°C	54	70		dB
		I_O ≤ 500 mA	0°C to 125°C	54			
Output regulation	I_O = 250 mA to 750 mA		25°C			75	mV
	I_O = 5 mA to 1.5 A		25°C		12	150	
	I_O = 5 mA to 1 A		0°C to 125°C			150	
Output noise voltage	f = 10 Hz to 100 kHz		25°C		90		μV
Dropout voltage	I_O = 1 A		25°C		2		V
Temperature coefficient of output voltage	I_O = 5 mA		0°C to 125°C		−1.8		mV/°C
Output impedance	f = 1 kHz		25°C		19		mΩ
Bias current	I_O ≤ 1 A		25°C			8	mA
			0°C to 125°C			8.5	
Bias current change	V_I = 17.9 V to 30 V, I_O ≤ 1 A		25°C			1	mA
	V_I = 17.5 V to 30 V, I_O ≤ 500 mA		0°C to 125°C			1	
	I_O = 5 mA to 1 A		0°C to 125°C			0.5	
Peak output current			25°C		2.4		A
Short-circuit current			25°C		1.2		A

† All characteristics are measured with a capacitor across the input of 0.22 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

TYPICAL CHARACTERISTICS

NORMALIZED OUTPUT VOLTAGE
vs
VIRTUAL JUNCTION TEMPERATURE

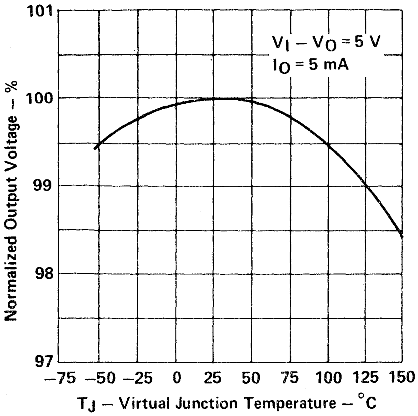


FIGURE 3

RIPPLE REJECTION
vs
FREQUENCY

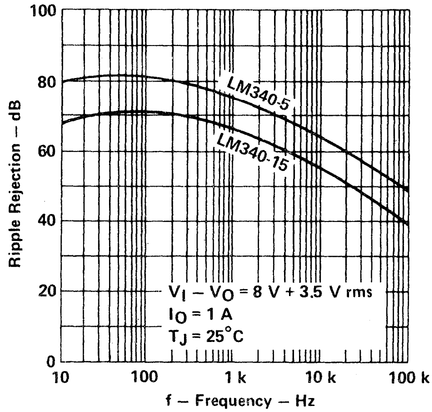


FIGURE 4

2

DROPOUT VOLTAGE
vs
VIRTUAL JUNCTION TEMPERATURE

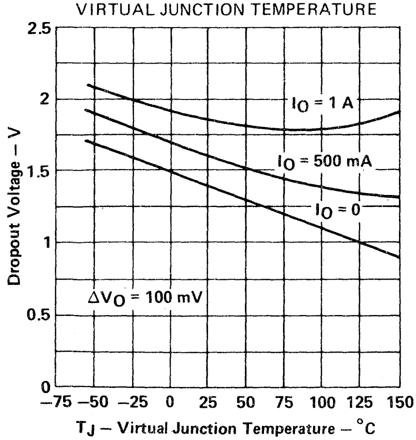


FIGURE 5

LM340-5
DROPOUT VOLTAGE
vs
INPUT VOLTAGE

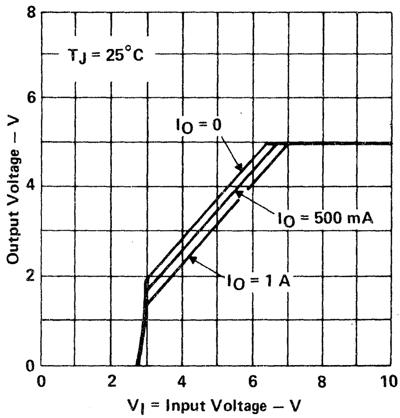


FIGURE 6

TYPICAL CHARACTERISTICS

LM340-5
BIAS CURRENT
vs
VIRTUAL JUNCTION TEMPERATURE

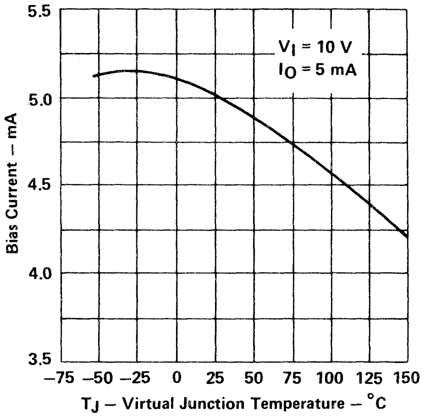


FIGURE 7

LM340-5
BIAS CURRENT
vs
INPUT VOLTAGE

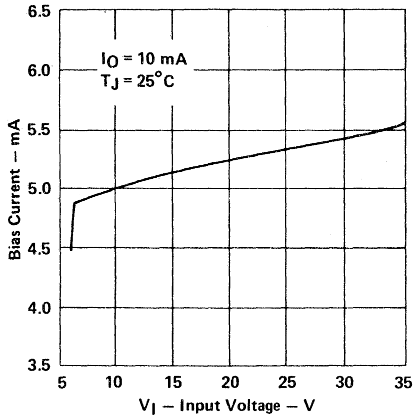


FIGURE 8

LM340-5
OUTPUT IMPEDANCE
vs
FREQUENCY

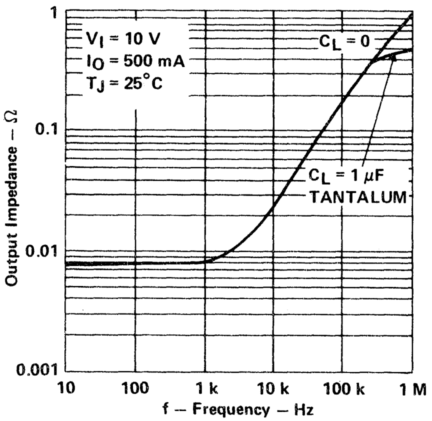


FIGURE 9

PEAK OUTPUT CURRENT
vs
INPUT-TO-OUTPUT VOLTAGE DIFFERENTIAL

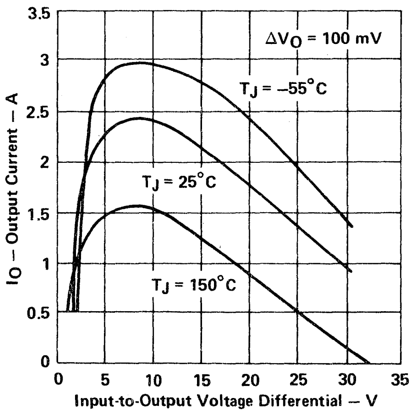


FIGURE 10

2

TYPICAL APPLICATION DATA

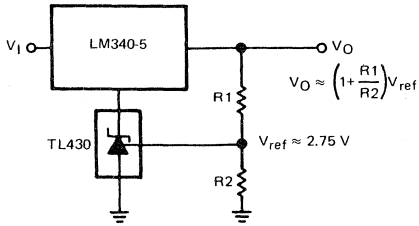
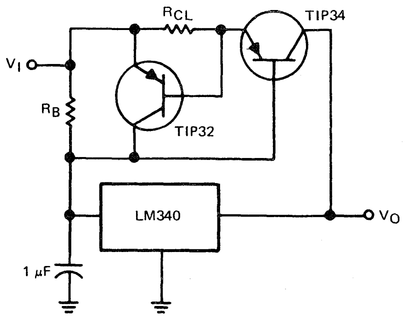


FIGURE 11—ADJUSTABLE SUPPLY WITH STABLE OUTPUT FROM 8 VOLTS TO 35 VOLTS



The boost circuit takes over at a level determined by R_B.

$$R_B \approx \frac{0.6\text{ V}}{I_B}$$

where I_B is the LM340 operating level.

Maximum current limit I_{CL} is determined by R_{CL}.

$$R_{CL} \approx \frac{0.6\text{ V}}{I_{CL}}$$

Example: If I_B is selected to be 0.5 A, then $R_B = 1.2\ \Omega$.
If I_{CL} is 3 A, then $R_{CL} = 0.2\ \Omega$.

FIGURE 12—OUTPUT CURRENT BOOST CIRCUIT

TYPE LM350
3-AMP ADJUSTABLE REGULATOR

D2716, MARCH 1983

- **Adjustable Output . . . 1.2 V to 33 V**
- **3-A Output Current Capability**
- **Line Regulation . . . 0.005 %/V Typ**
- **Load Regulation . . . 0.1% Typ**
- **Current Limit Constant with Temperature**
- **Guaranteed Thermal Regulation**
- **Direct Replacement for National Semiconductor LM350**

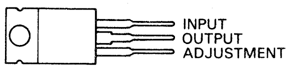
description

The LM350 is an adjustable 3-terminal positive-voltage regulator capable of supplying 3 amperes over an output voltage range of 1.2 volts to 33 volts. The device is easy to use and requires only two external resistors to set the output voltage. Both input and output regulation are better than standard fixed regulators.

In addition to higher performance than fixed regulators, the LM350 offers full overload protection available only in integrated circuits. Included on the chip are current limit, thermal overload protection, and safe-area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected. Normally, no capacitors are needed unless the device is situated far from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection, which is difficult to achieve with standard 3-terminal regulators.

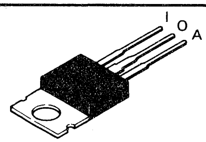
KC PACKAGE

(TOP VIEW)



THE OUTPUT TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



2

Besides replacing fixed regulators, the LM350 is useful in a wide variety of other applications. Even though the regulator is floating and sees only the input-to-output differential voltage, use of these devices to regulate voltages that would cause the maximum-rated differential voltage to be exceeded if the output became shorted to ground is not recommended. The TL783 is recommended for output voltages exceeding 33 volts. The primary application of the LM350 is that of a programmable output regulator, but by connecting a fixed resistor between the adjustment terminal and the output terminal, this device can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground, which programs the output to 1.2 volts where most loads draw little current.

The LM350 is characterized for operation from 0 °C to 125 °C.

ADVANCE INFORMATION

This document contains information on a new product. Specifications are subject to change without notice.

absolute maximum ratings over operating temperature range (unless otherwise noted)

Input-to-output voltage differential . . . . 35 V
Continuous total power dissipation at 25 °C free-air temperature (see Note 1):
KC package . . . . 2 W
Continuous total power dissipation at (or below) 25 °C case temperature (see Note 1) . . . . 30 W
Operating free-air, case, or virtual junction temperature range . . . . −55 °C to 150 °C
Storage temperature range . . . . −65 °C to 150 °C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds 260C

NOTE 1: For operation above 25° free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activitated at power levels slightly above or below the rated dissipation.

recommended operating conditions

	MIN	MAX	UNIT
Output current, I_O		3	A
Operating virtual junction temperature, T_J	0	125	°C

electrical characteristics over recommended ranges of operating virtual junction temperature, $V_I - V_O$ = 5 V, I_O = 1.5 A (unless otherwise noted)

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input regulation (see Note 2)	$V_I - V_O$ = 3 V to 35 V, See Note 3	T_J = 25 °C		0.005	0.03	%/V
		T_J = 0 °C to 125 °C		0.02	0.07	%/V
Ripple rejection	V_O = 10 V,	f = 120 Hz		65		dB
	V_O = 10 V, 10-µF capacitor between ADJ and ground	f = 120 Hz,	66			dB
Output regulation	I_O = 10 mA to 3 A, T_J = 25 °C, See Note 3	$V_O \le 5$ V		5	25	mV
		$V_O > 5$ V		0.1	0.5	%
	I_O = 10 mA to 3 A, See Note 3	$V_O \le 5$ V		20	70	mV
		$V_O > 5$ V		0.3	1.5	%
Output voltage change with temperature	T_J = 0 °C to 125 °C			1		%
Thermal regulation	t_w = 20 ms			0.002	0.03	%/W
Output voltage long-term drift (see Note 4)	After 1000 h at T_J = 125 °C			0.3	1	%
Output noise voltage	f = 10 Hz to 10 kHz,	T_J = 25 °C		0.003		%
Minimum output current to maintain regulation	$V_I - V_O$ = 35 V			3.5	10	mA
Peak output current	$V_I - V_O \le 10$ V		3	4.5		A
	$V_I - V_O$ = 30 V,	T_J = 25 °C	0.25	1		A
Adjustment-terminal current				50	100	µA
Change in adjustment-terminal current	$V_I - V_O$ = 3 V to 35 V, I_O = 10 mA to 3 A			0.2	5	µA
Reference voltage (output to ADJ)	$V_I - V_O$ = 3 V to 35 V, I_O = 10 mA to 3 A,	P ≤ 30 W	1.2	1.25	1.3	V

NOTES: 2. Input regulation is expressed as the percentage change in output voltage per 1-volt change at the input.
3. Input regulation and output regulation are measured using pulse techniques ($t_w \le 10$ µs, duty cycle ≤ 5%) to limit changes in average internal dissipation. Output voltage changes due to large changes in internal dissipation must be taken into account separately.
4. Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

THERMAL INFORMATION

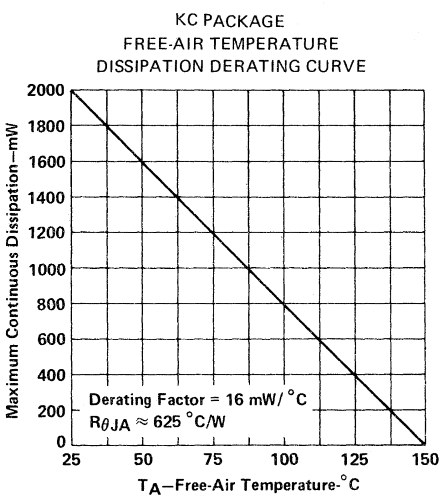


FIGURE 1

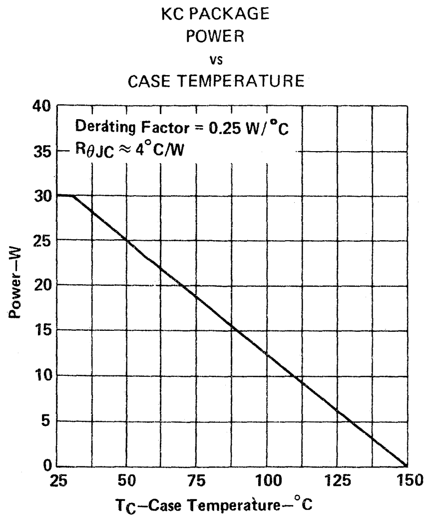


FIGURE 2

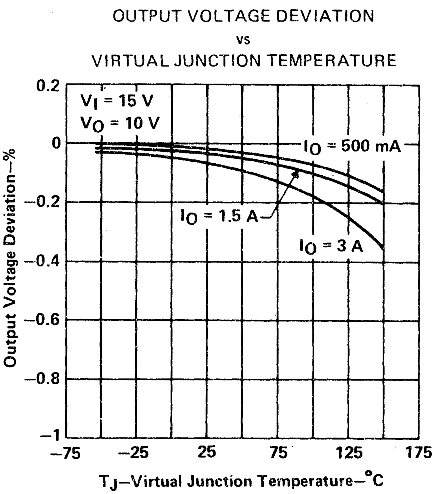


FIGURE 3

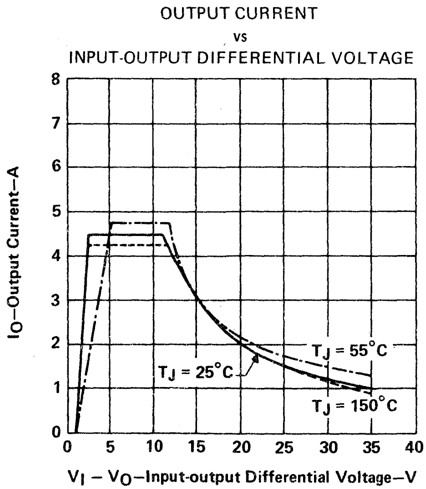


FIGURE 4

TYPICAL CHARACTERISTICS

ADJUSTMENT CURRENT
vs
VIRTUAL JUNCTION TEMPERATURE

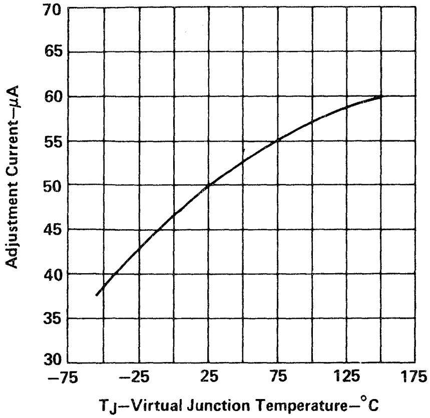


FIGURE 5

REFERENCE VOLTAGE
vs
VIRTUAL JUNCTION TEMPERATURE

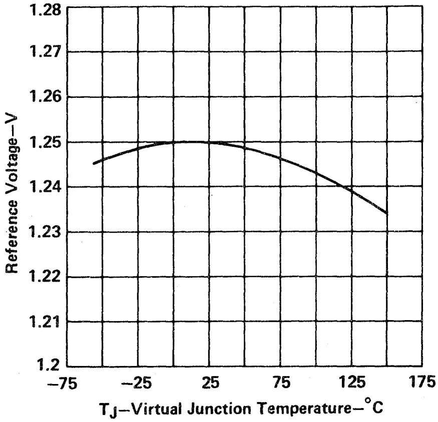
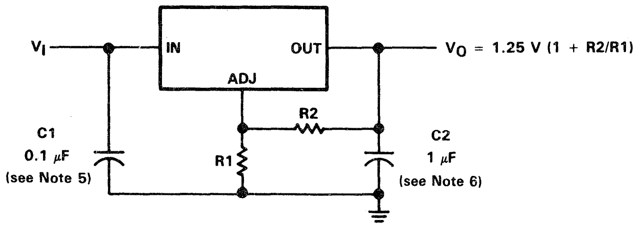


FIGURE 6

TYPICAL APPLICATION DATA



NOTES: 5. Capacitor C1 is required if regulator is not located in close proximity to the power supply amplifier.
6. Capacitor C2 may be used to improve transient response.

2

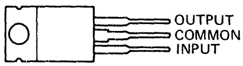
TYPES LM2930-5, LM2930-8
3-TERMINAL POSITIVE REGULATORS

D2733, APRIL 1983

- Input-Output Differential Less than 0.6 V
- Output Current of 150 mA
- Reverse Battery Protection
- Line Transient Protection
- 40-Volt Load-Dump Protection
- Internal Short-Circuit Current Limiting
- Internal Thermal Overload Protection
- Mirror-Image Insertion Protection
- Direct Replacement for National LM2930 Series

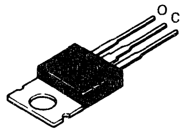
KC PACKAGE

(TOP VIEW)



THE COMMON TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



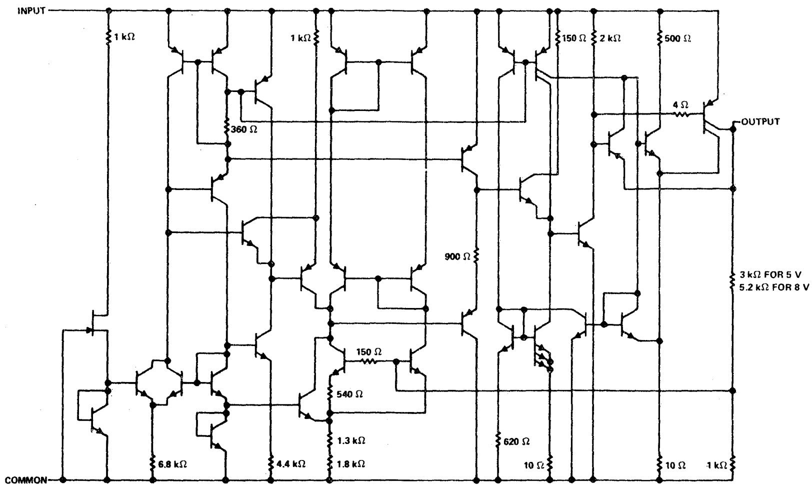
description

The LM2930-5 and LM2930-8 are 3-terminal positive regulators that provide fixed 5-volt and 8-volt regulated outputs. Each features the ability to source 150 milliamperes of output current with an input-output differential of 0.6 volt or less. Familiar regulator features such as current limit and thermal overload protection are also provided.

The LM2930 series has low voltage dropout making it useful for certain battery applications. For example, the low voltage dropout feature allows a longer battery discharge before the output falls out of regulation; the battery supplying the regulator input voltage may discharge to 5.6 volts and still properly regulate the system and load voltage. Supporting this feature, the LM2930 series protects both itself and the regulated system from reverse battery installation or two-battery jumps.

Other protection features include line transient protection for load-dump of up to 40 volts. In this case the regulator shuts down to avoid damaging internal and external circuits. The LM2930 series regulator cannot be harmed by temporary mirror-image insertion.

schematic diagram



All component values are nominal.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Continuous input voltage	26 V
Transient input voltage: t = 1 s	40 V
Continuous reverse input voltage	−6 V
Transient reverse input voltage: t = 100 ms	−12 V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 25°C case-temperature (see Note 1)	20 W
Operating free-air, case, or virtual junction temperature	−40°C to 150°C
Storage temperature range	−65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case to 10 seconds	260°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variation in individual device elecrical characteristics and thermal resistance, the bult-in thermal overload protection may be activated at power levels slightly above or below the rated dissipation.

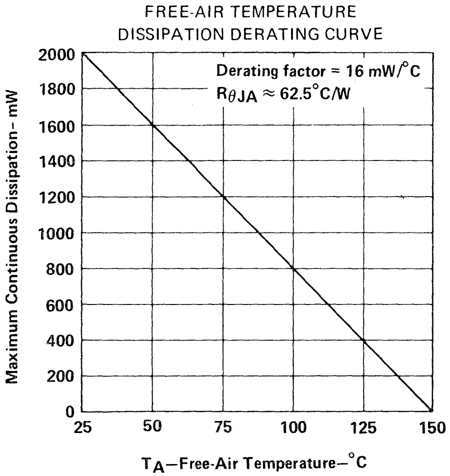


FIGURE 1

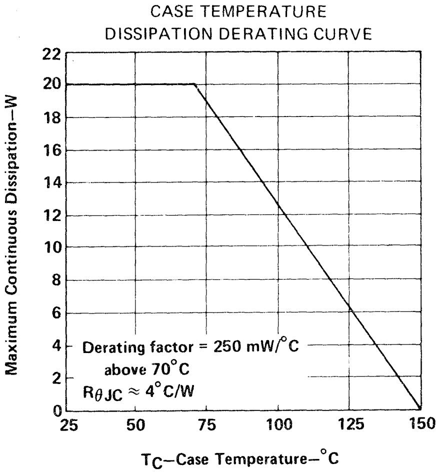


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
I_O	Output current		150	mA
T_J	Operating virtual junction temperature	−40	125	°C

LM2930-5 electrical characteristics at 25 °C virtual junction temperature, V_I = 14 V, I_O = 150 mA, (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	V_I = 6 V to 26 V, T_J = −40 °C to 125 °C	I_O = 5 mA to 150 mA,	4.5	5	5.5	V
Input regulation	I_O = 5 mA	V_I = 9 V to 16 V		7	25	mV
		V_I = 6 V to 26 V		30	80	
Ripple rejection	f = 120 Hz			56		dB
Output regulation	I_O = 5 mA to 150 mA			14	50	mV
Output voltage long-term drift‡	After 1000 h at T_J = 125 °C			20		mV
Dropout voltage	I_O = 150 mA			0.32	0.6	V
Output noise voltage	f = 10 Hz to 100 kHz			60		μV
Output voltage during line transients	V_I = −12 V to 40 V,	R_L = 100 Ω	−0.3		5.5	V
Output impedance	I_O = 100 mA, I_o = 10 mA (rms), f = 100 Hz to 10 kHz			200		mΩ
Bias current	I_O = 10 mA			4	7	mA
	I_O = 150 mA			18	40	
Peak output current			150	300	700	mA

LM2930-8 electrical characteristics at 25 °C virtual junction temperature, V_I = 14 V, I_O = 150 mA, (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	V_I = 9.4 V to 26 V, T_J = −40 °C to 125 °C	I_O = 5 mA to 150 mA,	7.2	8	8.8	V
Input regulation	I_O = 5 mA	V_I = 9.4 V to 16 V		12	50	V
		V_I = 9.4 V to 26 V		50	100	
Ripple rejection	f = 120 Hz			52		dB
Output regulation	I_O = 5 mA to 150 mA			25	50	mV
Output voltage long-term drift‡	After 1000 h at T_J = 125 °C			30		mV
Dropout voltage	I_O = 150 mA			0.32	0.6	V
Output noise voltage	f = 10 Hz to 100 kHz			90		μV
Output voltage during line transients	V_I = −12 V to 40 V,	R_L = 100 Ω	−0.3		8.8	V
Output impedance	I_O = 100 mA, I_o = 10 mA (rms), f = 100 Hz to 10 kHz			300		mΩ
Bias current	I_O = 10 mA			4	7	mA
	I_O = 150 mA			18	40	
Peak output current			150	300	700	mA

† Unless otherwise specified, all characteristics, except ripple rejection and noise voltage measurements, are measured using pulse techniques (t_W ≤ 10 ms, duty cycle ≤ 5%) with a capacitor of 0.1 μF across the input and a capacitor of 10 μF across the output. Output voltage changes due to changes in internal temperature must be taken into account separately.

‡ Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPICAL CHARACTERISTICS

NORMALIZED OUTPUT VOLTAGE
vs
VIRTUAL JUNCTION TEMPERATURE

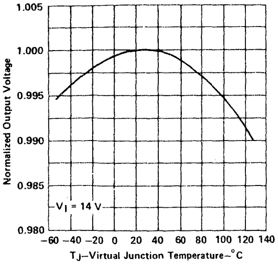


FIGURE 3

LM2930-5
OUTPUT VOLTAGE
vs
INPUT VOLTAGE

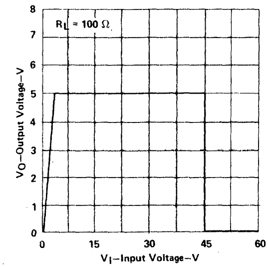


FIGURE 4

LM2930-5
OUTPUT VOLTAGE
vs
INPUT VOLTAGE

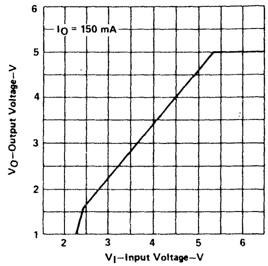


FIGURE 5

RIPPLE REJECTION
vs
FREQUENCY

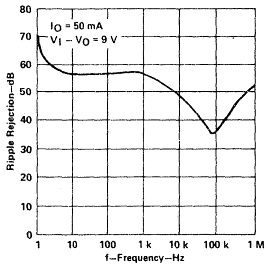


FIGURE 6

RIPPLE REJECTION
vs
OUTPUT CURRENT

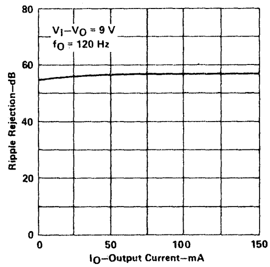


FIGURE 7

DROPOUT VOLTAGE
vs
VIRTUAL JUNCTION TEMPERATURE

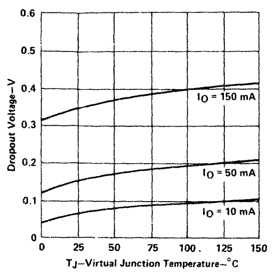


FIGURE 8

DROPOUT VOLTAGE
vs
OUTPUT CURRENT

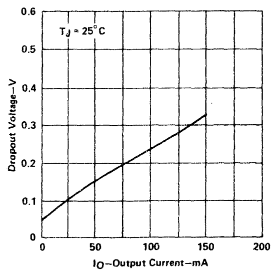


FIGURE 9

OUTPUT IMPEDANCE
vs
FREQUENCY

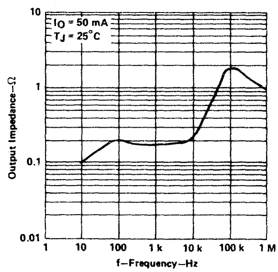


FIGURE 10

2

TYPICAL CHARACTERISTICS

INPUT CURRENT
vs
INPUT VOLTAGE

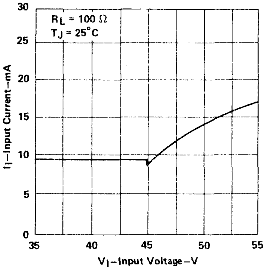


FIGURE 11

LINE TRANSIENT RESPONSE

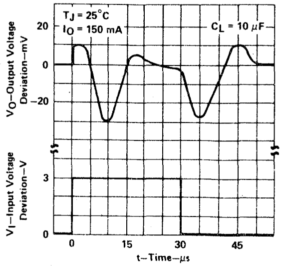


FIGURE 12

INPUT CURRENT
vs
REVERSE INPUT VOLTAGE

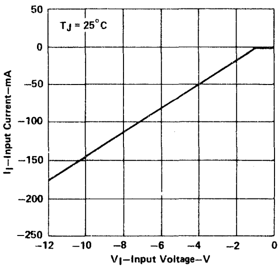


FIGURE 13

OUTPUT VOLTAGE
vs
REVERSE INPUT VOLTAGE

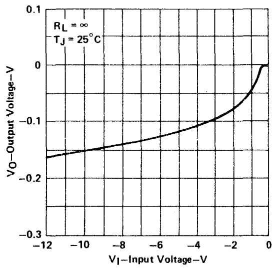


FIGURE 14

LOAD TRANSIENT RESPONSE

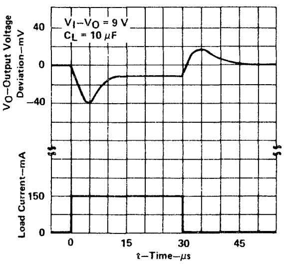


FIGURE 15

BIAS CURRENT
vs
OUTPUT CURRENT

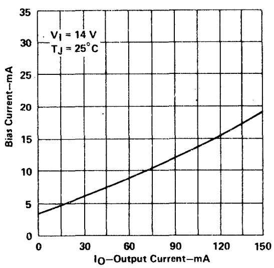


FIGURE 16

BIAS CURRENT
vs
VIRTUAL JUNCTION TEMPERATURE

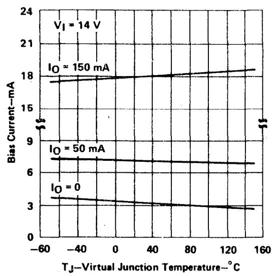


FIGURE 17

LM2905-5
BIAS CURRENT
vs
INPUT VOLTAGE

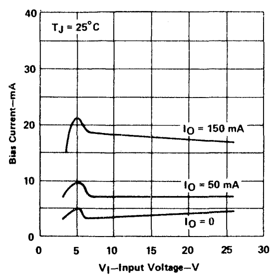
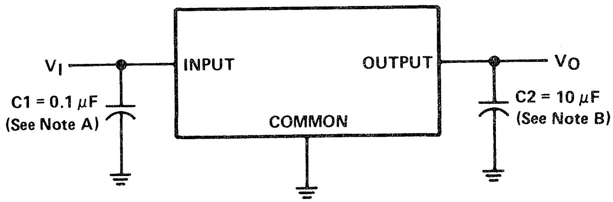


FIGURE 18

TYPICAL APPLICATION DATA



NOTES: A. Use of C1 is required if the regulator is not located in close proximity to the supply filter.

B. Capacitor C2 must be located as close as possible to the regulator and may be an aluminum or tantalum type capacitor. The minimum value required for stability is 10 µF. The capacitor must be rated for operation at −40°C to guarantee stability to that extreme.

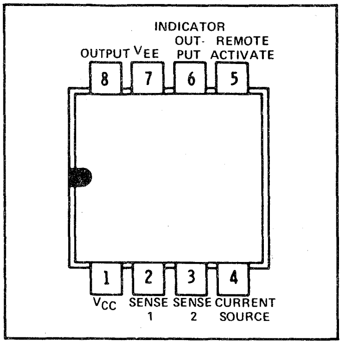
FIGURE 19

TYPE MC3423
OVERVOLTAGE-SENSING CIRCUIT

D2439, APRIL 1978—REVISED JANUARY 1983

- **Separate Outputs for "Crowbar" and Logic Circuitry**
- **Programmable Time Delay to Eliminate Noise Triggering**
- **TTL-Level Activation Isolated from Voltage-Sensing Inputs**
- **2.6-Volt Internal Voltage Reference with Temperature Coefficient Typically 0.08%/°C**

MC3423 . . . . . JG OR P
DUAL-IN-LINE PACKAGE
(TOP VIEW)

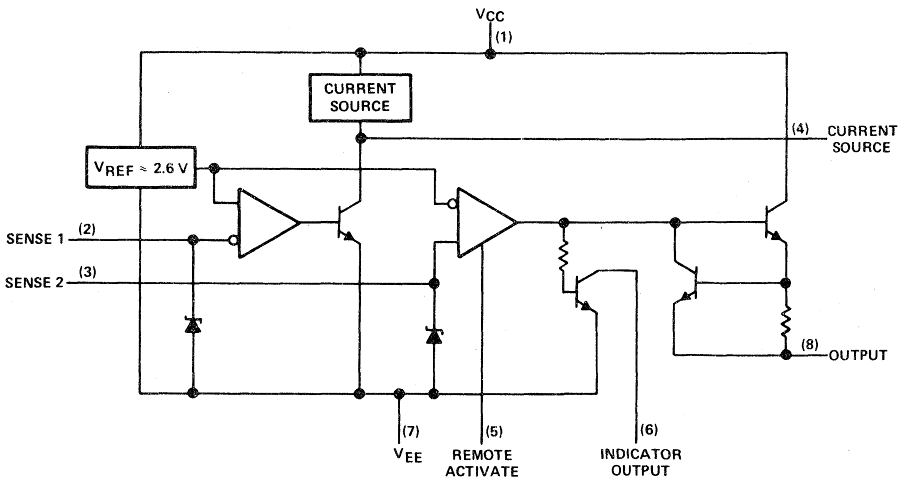


description

The MC3423 overvoltage-sensing circuit is designed to protect sensitive electronic circuitry by monitoring the supply rail and triggering an external "crowbar" SCR in the event of a voltage transient or loss of regulation. The protective mechanism may be activated by an overvoltage condition at the Sense 2 input or by application of a TTL high level to the Remote Activate terminal. Separate outputs are available to trigger the crowbar circuit and to provide a logic pulse to indicator or power supply control circuitry. The Sense 2 input provides a direct control of the output circuitry. The Sense 1 input controls an internal current source that may be utilized to implement a delayed trigger by connecting its output to an external capacitor and the Sense 2 input. This protects against false triggering due to noise at the Sense 1 input.

The MC3423 is characterized for operation from 0°C to 70°C.

functional block diagram



absolute maximum ratings

Supply voltage, V_{CC} (see Note 1) . . . . . 40 V
Sense 1 voltage . . . . . 6.5 V
Sense 2 voltage . . . . . 6.5 V
Remote activate input voltage . . . . . 7 V
Output current, I_O . . . . . 300 mA
Continuous dissipation at (or below) 25°C free-air temperature (see Note 2): JG package . . . . . 825 mW
P package . . . . . 1000 mW
Operating free-air temperature range . . . . . 0°C to 70°C
Storage temperature range . . . . . −65°C to 150°C

NOTES: 1. Voltage values are measured with respect to the V_{EE} terminal.
2. For operating above 25°C free-air temperature, refer to the Dissipation Derating Table. In the JG package, MC3423 chips are glass-mounted.

DISSIPATION DERATING TABLE

PACKAGE	POWER RATING	DERATING FACTOR	ABOVE T_A
JG (Glass-Mounted Chip)	825 mW	6.6 mW/°C	25°C
P	1000 mW	8 mW/°C	25°C

recommended operating conditions

2

	MIN	MAX	UNIT
Supply voltage, V_{CC}	4.5	40	V
High-level input voltage, remote activate input	2		V
Low-level input voltage, remote activate input		0.5	V

electrical characteristics over operating free-air temperature range, V_{CC} = 5 V to 36 V (unless otherwise noted)

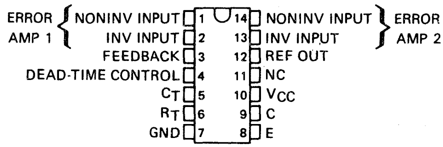
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output voltage	Remote Activate at 2 V, I_O = 100 mA	$V_{CC}-2.2$	$V_{CC}-1.8$		V
Indicator low-level output voltage	Remote Activate at 2 V, I_O = 1.6 mA		0.1	0.4	V
Threshold voltage of either sense input	T_A = 25°C	2.45	2.6	2.75	V
Temperature coefficient of input threshold voltage			0.06		%/°C
Source current (pin 4)	Sense 1 at 3 V, Pin 4 at 1.3 V	0.1	0.22	0.3	mA
High-level input current, Remote Activate input	V_{CC} = 5 V, V_I = 2 V		5	40	μA
Low-level input current, Remote Activate input	T_{CC} = 5 V, V_I = 0.8 V		−120	−180	μA
Supply current	Outputs open		6	10	mA
Propagation delay time, Remote Activate input to Output	T_A = 25°C		0.5		μs
Output current rate of rise	T_A = 25°C		400		mA/μs

TYPES MC35060, MC34060
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

D2726, MARCH 1983

- Complete PWM Power Control Circuitry
- Uncommitted Output for 200-mA Sink or Source Current
- Variable Dead-Time Provides Control Over Total Range
- Internal Regulator Provides a Stable 5-V Reference Supply
- Circuit Architecture Provides Easy Synchronization
- Direct Replacements for Motorola MC35060 and MC34060

J OR N
DUAL-IN-LINE PACKAGE
(TOP VIEW)



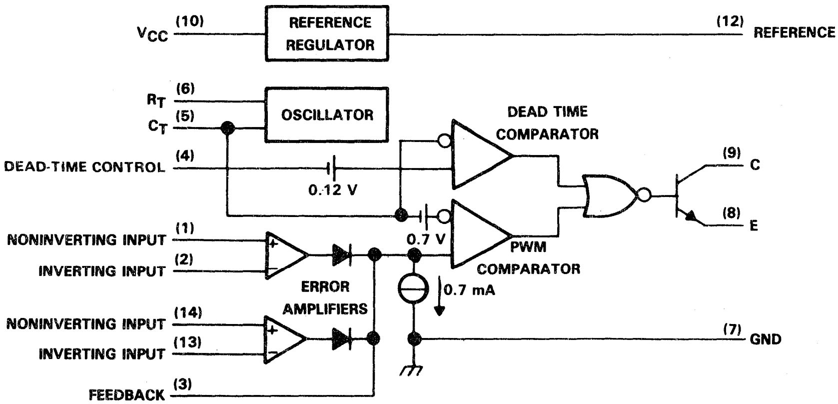
NC—No internal connections

description

The MC35060 and MC34060 incorporate on a single monolithic chip all the functions required in the construction of a pulse-width-modulation control circuit. Designed primarily for power supply control, each of the devices contains an on-chip 5-volt regulator, two error amplifiers, an adjustable oscillator, and a dead-time control comparator. The uncommitted output transistor provides either common-emitter or emitter-follower output capability. The internal amplifiers exhibit a common-mode voltage range from −0.3 volt to V_{CC} − 2 volts. The dead-time control comparator has a fixed offset that provides approximately 5% dead time unless externally altered. The on-chip oscillator may be bypassed by terminating R_T (pin 6) to the reference output and providing a sawtooth input to C_T (pin 5), or it may be used to drive the common MC35060 or MC34060 circuitry and provide a sawtooth input for associated control circuitry in multiple rail power supplies.

The MC35060 is characterized for operation over the full military temperature range of −55°C to 125°C. The MC34060 is characterized for operation from 0°C to 70°C.

functional block diagram



All voltage and current values shown are nominal.

absolute maximum ratings over operation temperature range (unless otherwise noted)

	MC35060	MC34060	UNIT
Supply voltage, V_{CC} (see Note 1)	42	42	V
Amplifier input voltages	$V_{CC}+0.3$	$V_{CC}+0.3$	V
Collector output voltage	42	42	V
Collector output current	250	250	mA
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 2)	1000	1000	mW
Operating free-air temperature range	−55 to 125	0 to 70	°C
Storage temperature range	−65 to 150	−65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package	300	300	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: N package		260	°C

NOTES: 1. All voltage values, except differential voltages, are with respect to the network ground terminal.
2. For operation above 25°C free-air temperature, refer to Dissipation Derating Table. In the J package, MC35060 chips are alloy-mounted and MC34060 chips are glass-mounted.

DISSIPATION DERATING TABLE

PACKAGE	POWER RATING	DERATING FACTOR	ABOVE T_A
J (Alloy-Mounted Chip)	1000 mW	11.0 mW/°C	59°C
J (Glass-Mounted Chip)	1000 mW	8.2 mW/°C	28°C
N	1000 mW	9.2 mW	41°C

2

recommended operating conditions

	MC35060		MC34060		UNIT
	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}	7	40	7	40	V
Amplifier input voltages, V_I	−0.3	$V_{CC}-2$	−0.3	$V_{CC}-2$	V
Collector output voltage, V_O		40		40	V
Collector output current (each transistor)		200		200	mA
Reference output current		10		10	mA
Current into feedback terminal		0.3		0.3	mA
Timing capacitor, C_T	0.47	10 000	0.47	10 000	nF
Timing resistor, R_T	1.8	500	1.8	500	kΩ
Oscillator frequency	1	200	1	200	kHz
Operating free-air temperature, T_A	−55	125	0	70	°C

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 15 V, f = 10 kHz (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS†	MC35060			MC34060			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Output voltage (V_{ref})	I_O = 1 mA	4.75	5	5.25	4.75	5	5.25	V
Input regulation	V_{CC} = 7 V to 40 V, T_A = 25°C		2	25		2	25	mV
Output regulation	I_{IO} = 1 to 10 mA, T_A = 25°C		1	15		1	15	mV
Output voltage change with temperature	ΔT_A = MIN to MAX		0.2	2		0.2	2.6	%
Short-circuit output current§	V_{ref} = 0	10	35	50		35		mA

oscillator section

PARAMETER	TEST CONDITIONS†	MC35060			MC34060			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Frequency	C_T = 0.001 μF, R_T = 47 kΩ		25			25		kHz
Standard deviation of frequency¶	C_T = 0.001 μF, R_T = 47 kΩ		3			3		%
Frequency change with voltage	V_{CC} = 7 V to 40 V, T_A = 25°C		0.1			0.1		%
Frequency change with temperature	C_T = 0.001 μF, R_T = 47 kΩ, ΔT_A = MIN to MAX			4			2	%

dead-time control-section (see figure 1)

PARAMETER	TEST CONDITIONS		MIN	TYP†	MAX	UNIT
Input bias current (pin 4)	V_I = 0 to 5.25 V			−2	−10	μA
Maximum duty cycle	$V_{I\ (pin\ 4)}$ = 0	C_T = 0.1 μF, R_T = 12 kΩ	90	96	100	%
		C_T = 0.1 μF, R_T = 47 kΩ		92	100	
Input threshold voltage (pin 4)	Zero duty cycle			3	3.3	V
	Maximum duty cycle		0			

error-amplifier sections

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
Input offset voltage	$V_{O\ (pin\ 3)}$ = 2.5 V		2	10	mV
Input offset current	$V_{O\ (pin\ 3)}$ = 2.5 V		25	250	nA
Input bias current	$V_{O\ (pin\ 3)}$ = 2.5 V		0.2	1	μA
Common-mode input voltage range	V_{CC} = 7 V to 40 V	−0.3 to $V_{CC}-2$			V
Open-loop voltage amplification	ΔV_O = 3 V, R_L = 2 kΩ, V_O = 0.5 V to 3.5 V	70	95		dB
Unit-gain bandwidth			800		kHz
Common-mode rejection ratio	V_{CC} = 40 V	65	80		dB
Output sink current (pin 3)	V_{ID} = −15 mV to −5 V, $V_{(pin\ 3)}$ = 0.5 V	0.3	0.7		mA
Output source current (pin 3)	V_{ID} = 15 mV to 5 V, $V_{(pin\ 3)}$ = 3.5 V	−2			mA

output section

PARAMETER		TEST CONDITIONS	MC35060			MC34060			UNIT
			MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Collector off-state current		V_{CE} = 40 V, V_{CC} = 40 V		2	100		2	100	μA
Emitter off-state current		V_{CC} = V_C = 40 V, V_E = 0			−150			−100	μA
Collector-emitter saturation voltage	Common-emitter	V_E = 0, I_C = 200 mA		1.1	1.5		1.1	1.3	V
	Emitter follower	V_C = 15 V, I_E = −200 mA		1.5	2.5		1.5	2.5	

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operation conditions.
‡All typical values except for temperature coefficients are at T_A = 25°C.
§Duration of the short-circuit should not exceed one second.
¶Standard deviation is a measure of the statistical distribution about the mean as derived from the formula $\sigma = \sqrt{\frac{\sum_{n=1}^{N} (x_n - \bar{x})^2}{N-1}}$

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 15 V, f = 10 kHz (unless otherwise noted)

pwm comparator section (see figure 1)

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Input threshold voltage (pin 3)	Zero duty cycle		4	4.5	V
Input sink current (pin 3)	$V_{(pin\ 3)}$ = 0.7 V	0.3	0.7		mA

total device

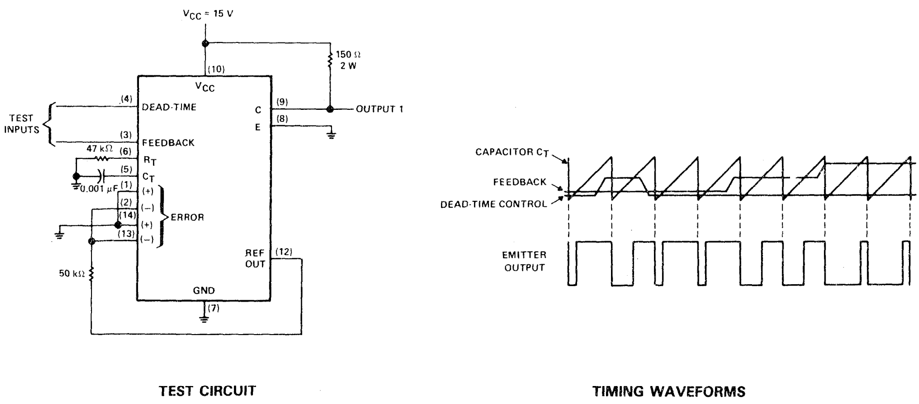
PARAMETER	TEST CONDITIONS		MIN	TYP‡	MAX	UNIT
Standby supply current	Pin 6 at V_{ref}, All other inputs and outputs open	V_{CC} = 15 V		6	10	mA
		V_{CC} = 40 V		9	15	
Average supply current	$V_{(pin\ 4)}$ = 2 V,	See Figure 1		7.5		mA

switching characteristics, T_A = 25°C

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Output voltage rise time	Common-emitter configuration,		100	200	ns
Output voltage fall time	See Figure 3		25	100	ns
Output voltage rise time	Emitter-follower configuration,		100	200	ns
Output voltage fall time	See Figure 4		40	100	ns

‡All typical values except for temperature coefficients are at T_A = 25°C.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

TIMING WAVEFORMS

FIGURE 1 — DEAD-TIME AND FEEDBACK CONTROL

PARAMETER MEASUREMENT INFORMATION

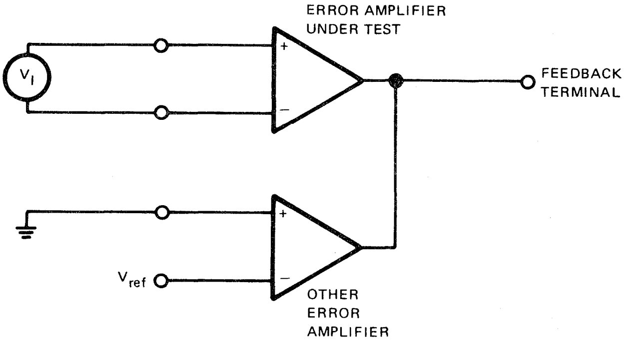
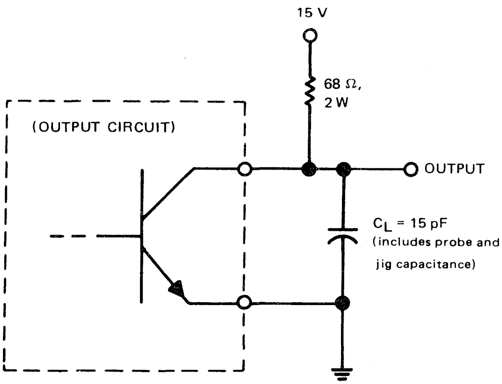
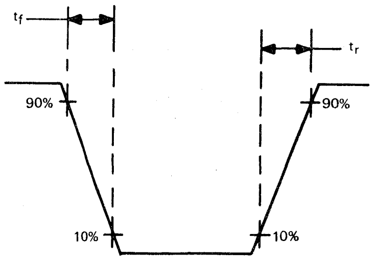


FIGURE 2 — ERROR-AMPLIFIER CHARACTERISTICS



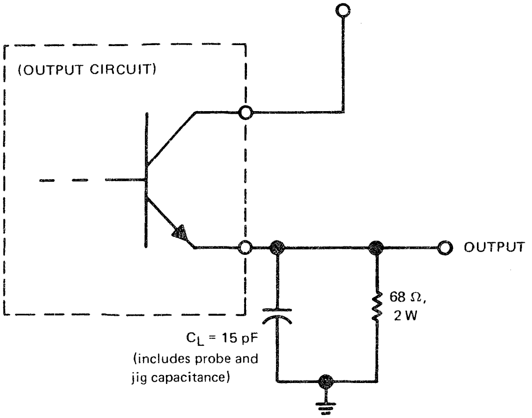
TEST CIRCUIT



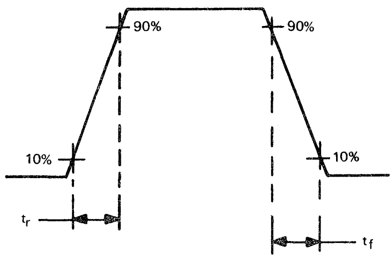
OUTPUT VOLTAGE WAVEFORM

FIGURE 3 — COMMON-EMITTER CONFIGURATION

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



OUTPUT VOLTAGE WAVEFORM

FIGURE 4 — EMITTER-FOLLOWER CONFIGURATION

2

TYPICAL CHARACTERISTICS

OSCILLATOR FREQUENCY and
FREQUENCY VARIATION† vs
TIMING RESISTANCE

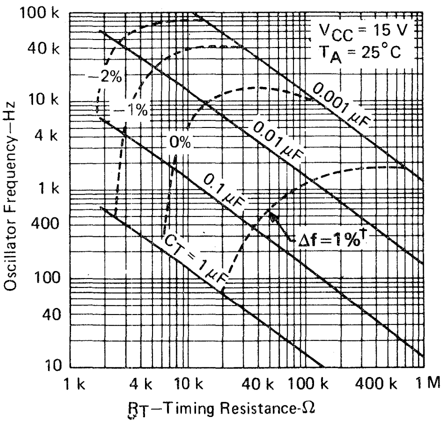


FIGURE 5

AMPLIFIER VOLTAGE AMPLIFICATION
vs
FREQUENCY

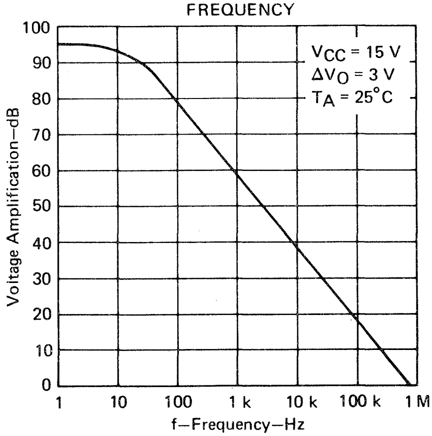


FIGURE 6

†Frequency variation (Δf) is the change in oscillator frequency that occurs over the full temperature range.

SERIES MC79L00
NEGATIVE-VOLTAGE REGULATORS

D2656, OCTOBER 1982

- 3-Terminal Regulators
- Output Current up to 100 mA
- No External Components Required
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting
- Direct Replacement for Motorola MC79L00 Series
- Available in 5% or 10% Selections

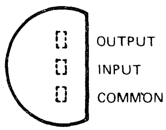
NOMINAL OUTPUT VOLTAGE	5% OUTPUT VOLTAGE TOLERANCE	10% OUTPUT VOLTAGE TOLERANCE
−5 V	MC79L05AC	MC79L05C
−12 V	MC79L12AC	MC79L12C
−15 V	MC79L15AC	MC79L15C

description

This series of fixed-voltage monolithic integrated-circuit voltage regulators is designed for a wide range of applications. These include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. In addition, they can be used to control series pass elements to make high-current voltage-regulator circuits. One of these regulators can deliver up to 100 mA of output current. The internal current-limiting and thermal-shutdown features make them essentially immune to overload. When used as a replacement for a Zener-diode and resistor combination, these devices can provide an effective improvement in output impedance of two orders of magnitude and lower bias current.

LP SILECT† PACKAGE

(TOP VIEW)

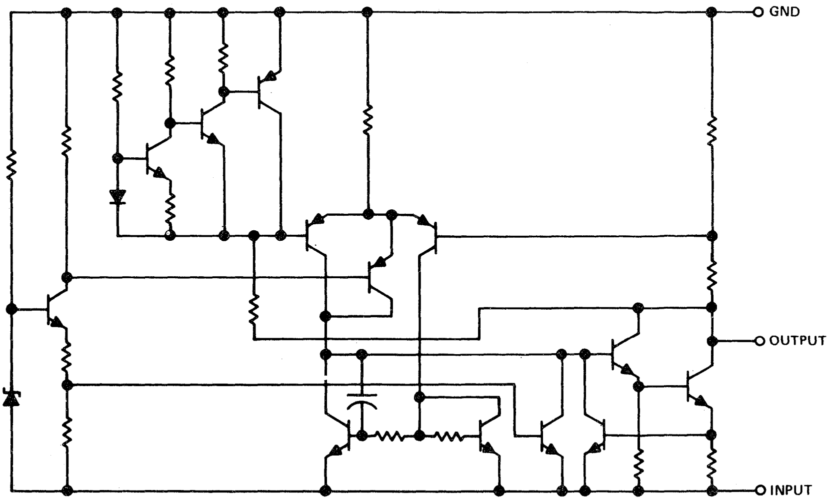


TO-226AA

CIO

2

schematic



†Trademark of Texas Instruments Incorporated.

absolute maximum ratings over operating temperature range (unless otherwise noted)

	MC79L05	MC79L12 MC79L15	UNIT
Input voltage	−30	−35	V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	775	775	mW
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	1600	1600	mW
Operating free-air, case, or virtual junction temperature range	0 to 150	0 to 150	°C
Storage temperature range	−65 to 150	−65 to 150	°C
Lead temperature 1/16 inch (1,6 mm) from case for 10 seconds	260	260	°C

NOTE 1: For operation above 25°C free-air temperature, refer to Dissipation Derating Curves, Figure 1 and Figure 2.

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

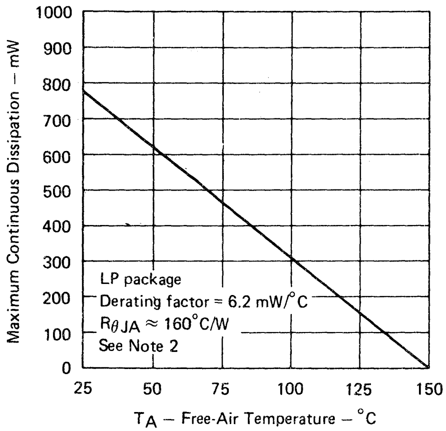


FIGURE 1

CASE TEMPERATURE
DISSIPATION DERATING CURVE

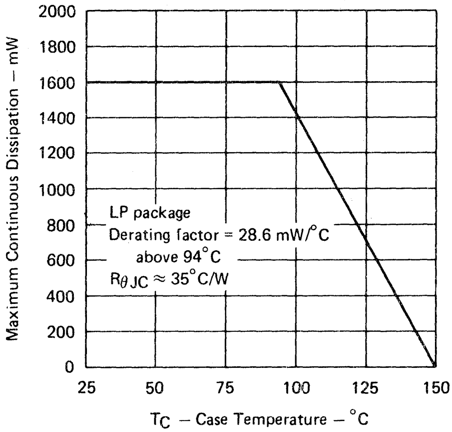


FIGURE 2

NOTE 2: This curve for the LP package is based on thermal resistance, $R_{\theta JA}$, measured in still air with the device mounted in an Augat socket. The bottom of the package was 3/8 inch above the socket.

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	MC79L05	−7	−20	V
	MC79L12	−14.5	−27	
	MC79L15	−17.5	−30	
Output current, I_O			100	mA
Operating virtual junction temperature, T_J		0	125	°C

MC79L05 electrical characteristics at specified virtual junction temperature, V_I = -10 V, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MC79L05C MIN	MC79L05C TYP	MC79L05C MAX	MC79L05AC MIN	MC79L05AC TYP	MC79L05AC MAX	UNIT
Output voltage		25°C	−4.6	−5	−5.4	−4.8	−5	−5.2	V
	V_I = −7 V to −20 V, I_O = 1 mA to 40 mA	0°C to 125°C	−4.5		−5.5	−4.75		−5.25	
	V_I = −10 V, I_O = 1 mA to 70 mA	0°C to 125°C	−4.5		−5.5	−4.75		−5.25	
Input regulation	V_I = −7 V to −20 V	25°C			200			150	mV
	V_I = −8 V to −20 V				150			100	
Ripple rejection	V_I = −8 V to −18 V, f = 120 Hz	25°C	40	49		41	49		dB
Output regulation	I_O = 1 mA to 100 mA	25°C			60			60	mV
	I_O = 1 mA to 40 mA				30			30	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		40			40		μV
Dropout voltage	I_O = 40 mA	25°C		1.7			1.7		V
Bias current		25°C			6			6	mA
		125°C			5.5			5.5	
Bias current change	V_I = −8 V to −20 V	0°C to 125°C			1.5			1.5	mA
	I_O = 1 mA to 40 mA				0.2			0.1	

MC79L12 electrical characteristics at specified virtual junction temperature, V_I = −19, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MC79L12C MIN	MC79L12C TYP	MC79L12C MAX	MC79L12AC MIN	MC79L12AC TYP	MC79L12AC MAX	UNIT
Output voltage		25°C	−11.1	−12	−12.9	−11.5	−12	−12.5	V
	V_I = −14.5 to −27 V, I_O = 1 mA to 40 mA	0°C to 125°C	−10.8		−13.2	−11.4		−12.6	
	V_I = −19 V, I_O = 1 mA to 70 mA	0°C to 125°C	−10.8		−13.2	−11.4		−12.6	
Input regulation	V_I = −14.5 to −27 V	25°C			250			250	mV
	V_I = −16 V to −27 V				200			200	
Ripple rejection	V_I = −15 V to −25 V, f = 120 Hz	25°C	36	42		37	42		dB
Output regulation	I_O = 1 mA to 100 mA	25°C			100			100	mV
	I_O = 1 mA to 40 mA				50			50	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		80			80		μV
Dropout voltage	I_O = 40 mA	25°C		1.7			1.7		V
Bias current		25°C			6.5			6.5	mA
		125°C			6			6	
Bias current change	V_I = −16 V to −27 V	0°C to 125°C			1.5			1.5	mA
	I_O = 1 mA to 40 mA				0.2			0.1	

†All characteristics are measured with a 0.33-μF capacitor across the input and a 0.1-μF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq$ 10 ms, duty cycle $\leq$ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

MC79L15 electrical characteristics at specified virtual junction temperature, V_I = −23 V, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MC79L15C			MC79L15AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage		25°C	−13.8	−15	−16.2	−14.4	−15	−15.6	V
	V_I = −17.5 V to −30 V, I_O = 1 mA to 40 mA	0°C to 125°C	−13.5		−16.5	−14.25		−15.75	
	V_I = −23 V, I_O = 1 mA to 70 mA	0°C to 125°C	−13.5		−16.5	−14.25		−15.75	
Input regulation	V_I = −17.5 V to −30 V	25°C			300			300	mV
	V_I = −20 V to −30 V				250			250	
Ripple rejection	V_I = −18.5 V to −28.5 V, f = 120 Hz	25°C	33	39		34	39		dB
Output regulation	I_O = 1 mA to 100 mA	25°C			150			150	mV
	I_O = 1 mA to 40 mA				75			75	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		90			90		μV
Dropout voltage	I_O = 40 mA	25°C		1.7			1.7		V
Bias current		25°C			6.5			6.5	mA
		125°C			6			6	
Bias current change	V_I = −20 V to −30 V	0°C to 125°C			1.5			1.5	mA
	I_O = 1 mA to 40 mA				0.2			0.1	

†All characteristics are measured with a 0.33-μF capacitor across the input and a 0.1-μF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leqslant$ 10 ms, duty cycle $\leqslant$ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

- **High Efficiency . . . 80% Typ**
- **Low Bias Current . . . 135 μA**
- **Adjustable Output . . . 2.5 V to 24 V**
- **Output Current . . . 150 mA**
- **Internal Reference . . . 1.3 V ±5%**
- **Remote Shutdown Capabilities**
- **Interchangeable with Raytheon RC4193**

RM4193 . . . JG
RC4193 . . JG OR P
DUAL-IN-LINE PACKAGE
(TOP VIEW)

LBR	1	8	LBD
CX	2	7	VFB
LX	3	6	IC
GND	4	5	V_{CC}

FUNCTION TABLE

PIN	FUNCTION	DESCRIPTION
1	LBR	Low battery resistor
2	CX	External capacitor
3	LX	External inductor
4	GND	Ground
5	V_{CC}	Supply voltage
6	IC	Reference set control
7	VFB	Feedback voltage
8	LBD	Low battery detector

description

The RC4193 is a monolithic micropower switching regulator designed to provide all the functions required to make a complete low-power switching regulator primarily for battery operated instruments. The RC4193 offers the system designer the flexibility of tailoring the circuit to the application. Typical applications include step-up switching regulation, step-down switching regulation, and inverting switch regulation. The RC4193 contains a 1.3-volt temperature-compensated band-gap reference, an adjustable free-running oscillator, voltage comparator, low battery detection circuitry, and a 150-milliampere output-switch transistor.

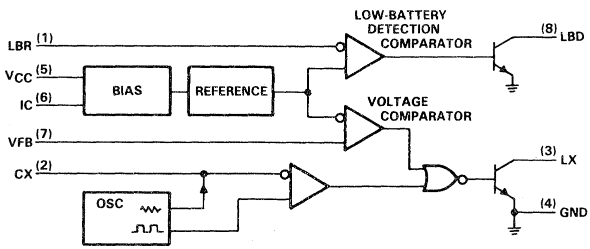
For most applications, the RC4193 can achieve up to 80% efficiency while operating over a wide supply voltage range from 2.4 volts to 24 volts at an ultra-low bias current drain of 135 microamperes. The RC4193 has an adjustable 100-hertz to 160-kilohertz free-running oscillator that provides the drive circuitry for the on-chip 150-milliampere output-switch transistor. An external capacitor on pin 2 determines the oscillator frequency.

The low-battery detection circuitry contains an open-collector output transistor that can be used to activate a liquid crystal display whenever the battery voltage drops below a programmed level. This programmed level is determined by the selection of external resistors connected to pin 1.

The RC4193 will shut off when pin 6 (IC) is below 0.5 volt. The shut-off feature is useful in battery-backup applications requiring operation only when the line power is removed. Another use of this feature is connecting a zener diode between pin 6 and the battery line to shut down the regulator whenever the battery voltage drops below a predetermined level.

The RM4193 is characterized for operation over the full military temperature range of −55°C to 125°C. The RC4193 is characterized for operation from 0°C to 70°C.

functional block diagram



2

PRODUCT PREVIEW

This document contains information on a product under development. Texas Instruments reserves the right to change or discontinue this product without notice.

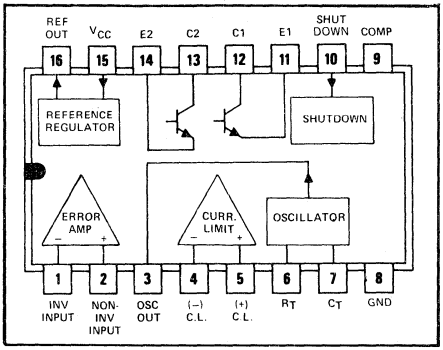
2

TYPES SG1524, SG2524, SG3524 REGULATING PULSE WIDTH MODULATORS

D2294, APRIL 1977 – REVISED DECEMBER 1982

- **Complete PWM Power Control Circuitry**
- **Uncommitted Outputs for Single-Ended or Push-Pull Applications**
- **Low Standby Current . . . 8 mA Typ**
- **Interchangeable With Silicon General SG1524, SG2524, and SG3524**

SG1524 . . . J
SG2524, SG3524 . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)



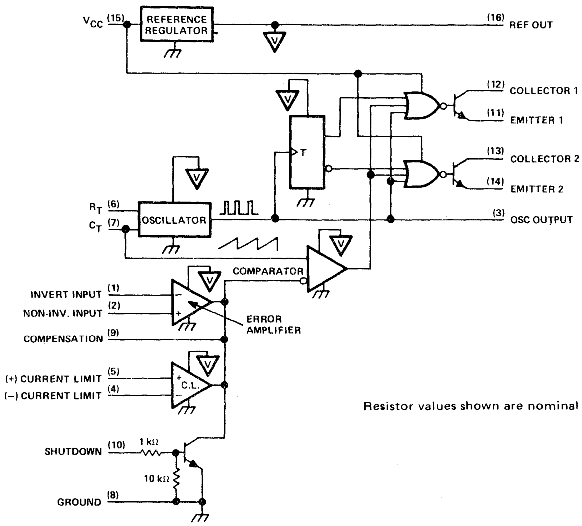
description

The SG1524, SG2524, and SG3524 incorporate on single monolithic chips all the functions required in the construction of a regulating power supply, inverter, or switching regulator. They can also be used as the control element for high-power-output applications. The SG1524 family was designed for switching regulators of either polarity, transformer-coupled dc-to-dc converters, transformerless voltage doublers, and polarity converter applications employing fixed-frequency, pulse-width-modulation techniques. The complementary output allows either single-ended or push-pull application. Each device includes an on-chip regulator, error amplifier, programmable oscillator, pulse-steering flip-flop, two uncommitted pass transistors, a high-gain comparator, and current-limiting and shut-down circuitry.

The SG1524 is characterized for operation over the full military temperature range of –55°C to 125°C The SG2524 is characterized for operation from –25°C to 85°C, and the SG3524 is characterized for operation from 0°C to 70°C.

2

functional block diagram



Resistor values shown are nominal

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply Voltage, V_{CC} (see Notes 1 and 2) .... 40 V
Collector Output Current .... 100 mA
Reference Output Current .... 50 mA
Current Through C_T Terminal .... −5 mA
Continuous Total Dissipation at (or below) 25°C Free-Air Temperature (See Note 3) .... 1000 mW
Operating Free-Air Temperature Range: SG1524 .... −55°C to 125°C
SG2524 .... −25°C to 85°C
SG3524 .... 0°C to 70°C
Storage Temperature Range .... −65°C to 150°C

NOTES: 1. All voltage values are with respect to network ground terminal.
2. The reference regulator may be bypassed for operation from a fixed 5-volt supply by connecting the V_{CC} and reference output pins both to the supply voltage. In this configuration the maximum supply voltage is 6 volts.
3. For operation at elevated temperature, refer to Figures 16 and 17. In the J package, SG1524 chips are alloy-mounted; SG2524 and SG3524 chips are glass-mounted.

recommended operating conditions

	SG1524		SG2524		SG3524		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}	8	40	8	40	8	40	V
Reference output current	0	50	0	50	0	50	mA
Current thru C_T terminal	−0.03	−2	−0.03	−2	−0.03	−2	mA
Timing resistor, R_T	1.8	100	1.8	100	1.8	100	kΩ
Timing capacitor, C_T	0.001	0.1	0.001	0.1	0.001	0.1	μF
Operating free-air temperature	−55	125	−25	85	0	70	°C

2

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 20 V, f = 20 kHz (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS†	SG1524			SG2524			SG3524			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Output voltage		4.8	5	5.2	4.8	5	5.2	4.6	5	5.4	V
Input regulation	V_{CC} = 8 to 40 V		10	20		10	20		10	30	mV
Ripple rejection	f = 120 Hz		66			66			66		dB
Output regulation	I_O = 0 to 20 mA		20	50		20	50		20	50	mV
Output voltage change with temperature	T_A = MIN to MAX		0.6	2		0.3	1		0.3	1	%
Short-circuit output current §	V_{ref} = 0		100			100			100		mA

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡All typical values except output voltage change with temperature are at T_A = 25°C.
§Duration of the short-circuit should not exceed one second.

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 20 V, f = 20 kHz (unless otherwise noted)

oscillator section

PARAMETER	TEST CONDITIONS†		MIN	TYP‡	MAX	UNIT
Frequency	C_T = 0.001 μF,	R_T = 2 kΩ		450		kHz
Standard deviation of frequency§	All values of voltage, temperature, resistance, and capacitance constant			5		%
Frequency change with voltage	V_{CC} = 8 to 40 V	T_A = 25°C			1	%
Frequency change with temperature	T_A = MIN to MAX				2	%
Output amplitude at pin 3				3.5		V
Output pulse width at pin 3	C_T = 0.01 μF			0.5		μs

error amplifier section

PARAMETER	TEST CONDITIONS	SG1524, SG2524			SG3524			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Input offset voltage	V_{IC} = 2.5 V		0.5	5		2	10	mV
Input bias current	V_{IC} = 2.5 V		2	10		2	10	μA
Open-loop voltage amplification		72	80		60	80		dB
Common-mode input voltage range	T_A = 25°C	1.8 to 3.4			1.8 to 3.4			V
Common-mode rejection ratio			70			70		dB
Unity-gain bandwidth			3			3		MHz
Output swing	T_A = 25°C	0.5		3.8	0.5		3.8	V

2

output section

PARAMETER	TEST CONDITIONS		MIN	TYP‡	MAX	UNIT
Collector-emitter breakdown voltage			40			V
Collector off-state current	V_{CE} = 40 V			0.01	50	μA
Collector-emitter saturation voltage	I_C = 50 mA			1	2	V
Emitter output voltage	V_C = 20 V,	I_E = −250 μA	17	18		V
Turn-off voltage rise time	R_C = 2 kΩ			0.2		μs
Turn-on voltage fall time	R_C = 2 kΩ			0.1		μs

comparator section

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Maximum duty cycle, each output		45			%
Input threshold voltage at pin 9	Zero duty cycle		1		V
	Maximum duty cycle		3.5		
Input bias current			−1		μA

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡All typical values except for temperature coefficients are at T_A = 25°C.

§Standard deviation is a measure of the statistical distribution about the mean as derived from the formula $\sigma = \sqrt{\dfrac{\sum_{n=1}^{N} (X_n - \overline{X})^2}{N-1}}$

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 20 V, f = 20 kHz (unless otherwise noted)

current limiting section

PARAMETER	TEST CONDITIONS	SG1524, SG2524			SG3524			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Input voltage range (either input)		−1 to +1			−1 to +1			V
Sense voltage at T_A = 25°C	$V_{(pin\ 2)} - V_{(pin\ 1)} \geq 50$ mV, $V_{(pin\ 9)}$ = 2 V	190	200	210	180	200	220	mV
Temperature coefficient of sense voltage			0.2			0.2		mV/°C

total device

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Standby current	V_{CC} = 40 V, Pin 2 at 2 V, Pins 1,4,7,8,9,11,14 grounded, All other inputs and outputs open		8	10	mA

‡All typical values except for temperature coefficients are at T_A = 25°C.

PARAMETER MEASUREMENT INFORMATION

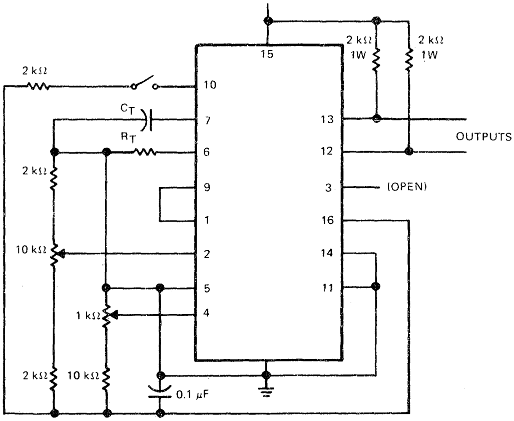
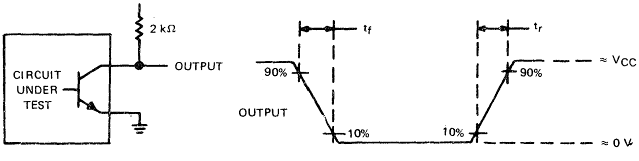


FIGURE 1—GENERAL TEST CIRCUIT



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 2—SWITCHING TIMES

TYPICAL CHARACTERISTICS

OPEN-LOOP VOLTAGE AMPLIFICATION OF ERROR AMPLIFIER vs FREQUENCY

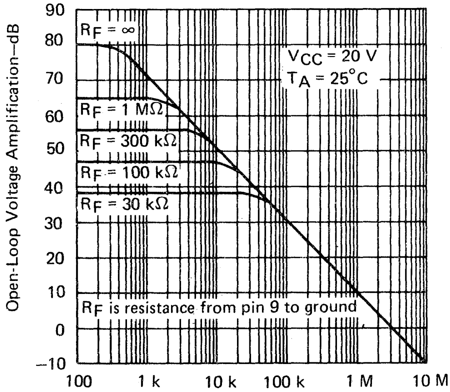


FIGURE 3

OSCILLATOR FREQUENCY vs TIMING RESISTANCE

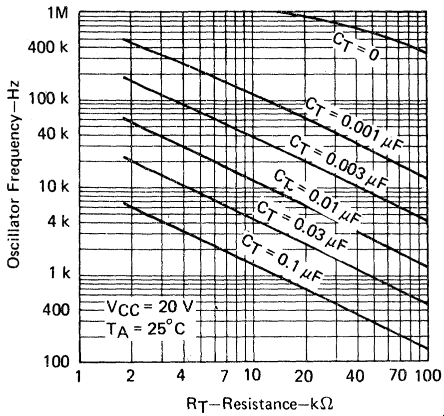


FIGURE 4

2

OUTPUT DEAD TIME vs TIMING CAPACITANCE VALUE

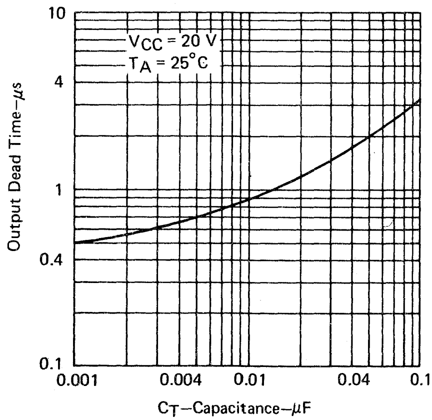


FIGURE 5

PRINCIPLES OF OPERATION

The SG1524† is a fixed-frequency pulse-width-modulation voltage-regulator control circuit. The regulator operates at a fixed frequency that is programmed by one timing resistor R_T and one timing capacitor C_T. R_T establishes a constant charging current for C_T This results in a linear voltage ramp at C_T, which is fed to the comparator providing linear control of the output pulse width by the error amplifier. The SG1524 contains an on-board 5-volt regulator that serves as a reference as well as supplying the SG1524's internal regulator control circuitry. The internal reference voltage is divided externally by a resistor ladder network to provide a reference within the common-mode range of the error amplifier as shown in Figure 6, or an external reference may be used. The output is sensed by a second resistor divider network and the error signal is amplified. This voltage is then compared to the linear voltage ramp at C_T. The resulting modulated pulse out of the high-gain comparator is then steered to the appropriate output pass transistor (Q1 or Q2) by the pulse-steering flip-flop, which is synchronously toggled by the oscillator output. The oscillator output pulse also serves as a blanking pulse to assure both outputs are never on simultaneously during the transition times. The width of the blanking pulse is controlled by the value of C_T. The outputs may be applied in a push-pull configuration in which their frequency is half that of the base oscillator, or paralleled for single-ended applications in which the frequency is equal to that of the oscillator. The output of the error amplifier shares a common input to the comparator with the current-limiting and shut-down circuitry and can be overridden by signals from either of these inputs. This common point is also available externally and may be employed to control the gain of, or to compensate, the error amplifier, or to provide additional control to the regulator.

TYPICAL APPLICATION DATA

oscillator

The oscillator controls the frequency of the SG1524 and is programmed by R_T and C_T as shown in Figure 4.

$$f \approx \frac{1.15}{R_T C_T}$$

2

where R_T is in kilohms
C_T is in microfarads
f is in kilohertz

Practical values of C_T fall between 0.001 and 0.1 microfarad. Practical values of R_T fall between 1.8 and 100 kilohms. This results in a frequency range typically from 140 hertz to 500 kilohertz.

blanking

The output pulse of the oscillator is used as a blanking pulse at the output. This pulse width is controlled by the value of C_T as shown in Figure 5. If small values of C_T are required, the oscillator output pulse width may still be maintained by applying a shunt capacitance from pin 3 to ground.

synchronous operation

When an external clock is desired, a clock pulse of approximately 3 volts can be applied directly to the oscillator output terminal. The impedance to ground at this point is approximately 2 kilohms. In this configuration R_T C_T must be selected for a clock period slightly greater than that of the external clock.

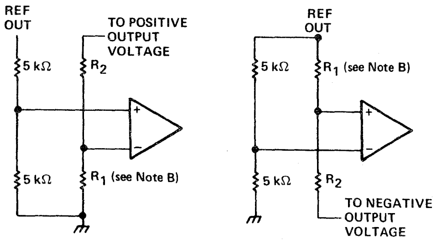
If two or more SG1524 regulators are to be operated synchronously, all oscillator output terminals should be tied together. The oscillator programmed for the minimum clock period will be the master from which all the other SG1524's operate. In this application, the C_T R_T values of the slaved regulators must be set for a period approximately 10% longer than that of the master regulator. In addition, C_T (master) = 2 C_T (slave) to ensure that the master output pulse, which occurs first, has a wider pulse width and will subsequently reset the slave regulators.

†Throughout these discussions, references to SG1524 apply also to SG2524 and SG3524.

TYPICAL APPLICATION DATA

voltage reference

The 5-volt internal reference may be employed by use of an external resistor divider network to establish a reference within the error amplifiers common-mode voltage range (1.8 to 3.4 volts) as shown in Figure 6, or an external reference may be applied directly to the error amplifier. For operation from a fixed 5-volt supply, the internal reference may be bypassed by applying the input voltage to both the V_{CC} and V_{REF} terminals. In this configuration, however, the input voltage is limited to a maximum of 6 volts.



$V_O = 2.5\ V \frac{R1 + R2}{R1}$ $\qquad$ $\frac{R1\ R2}{R1 + R2} = 2.5\ k\Omega$

FIGURE 6—ERROR AMPLIFIER BIAS CIRCUITS

2

error amplifier

The error amplifier is a differential-input transconductance amplifier. The output is available for dc gain control or ac phase compensation. The compensation node (pin 9) is a high-impedance node (R_L = 5 megohms). The gain of the amplifier is $A_V = (0.002\ \Omega^{-1})\ R_L$ and can easily be reduced from a nominal 10,000 by an external shunt resistance from pin 9 to ground. Refer to Figure 3 for data.

compensation

Pin 9, as discussed above, is made available for compensation. Since most output filters will introduce one or more additional poles at frequencies below 200 hertz, which is the pole of the uncompensated amplifier, introduction of a zero to cancel one of the output filter poles is desirable. This can best be accomplished with a series RC circuit from pin 9 to ground in the range of 50 kilohms and 0.001 microfarads. Other frequencies can be canceled by use of the formula $f \approx 1/RC$.

shut down circuitry

Pin 9 can also be employed to introduce external control of the SG1524. Any circuit that can sink 200 microamperes can pull the compensation terminal to ground and thus disable the SG1524.

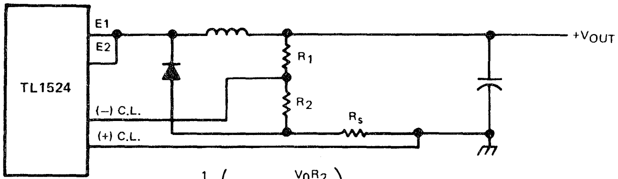
In addition to constant-current limiting, pins 4 and 5 may also be used in transformer-coupled circuits to sense primary current and shorten an output pulse should transformer saturation occur. Pin 5 may also be grounded to convert pin 4 into an additional shutdown terminal.

TYPICAL APPLICATION DATA

current limiting

A current-limiting sense amplifier is provided in the SG1524. The current-limiting sense amplifier exhibits a threshold of 200 millivolts and must be applied in the ground line since the voltage range of the inputs is limited to +1 volt to −1 volt. Caution should be taken to ensure the −1 volt limit is not exceeded by either input, otherwise damage to the device may result.

Fold-back current limiting can be provided with the network shown in Figure 7. The current-limit schematic is shown in Figure 8.



$$I_{O(max)} = \frac{1}{R_s}\left(V_{(sense)} + \frac{V_O R_2}{R_1 + R_2}\right)$$

$$I_{OS} = \frac{V_{(sense)}}{R_s} \qquad \text{where } V_{(sense)} = 20 \text{ mV}$$

FIGURE 7—FOLDBACK CURRENT LIMITING FOR SHORTED OUTPUT CONDITIONS

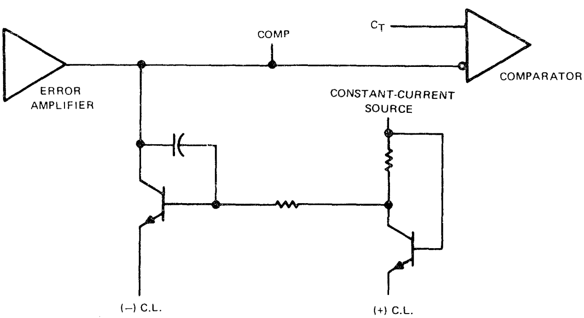


FIGURE 8—CURRENT-LIMIT SCHEMATIC

output circuitry

The SG1524 contains two identical n-p-n transistors the collectors and emitters of which are uncommitted. Each transistor has antisaturation circuitry that limits the current through that transistor to a maximum of 100 milliamperes for fast response.

TYPICAL APPLICATION DATA

general

There are a wide variety of output configurations possible when considering the application of the SG1524 as a voltage regulator control circuit. They can be segregated into three basic categories:

1. Capacitor-diode-coupled voltage multipliers
2. Inductor-capacitor-implemented single-ended circuits
3. Transformer-coupled circuits

Examples of these categories are shown in Figures 9, 10 and 11, respectively. Detailed diagrams of specific applications are shown in Figures 12 through 15.

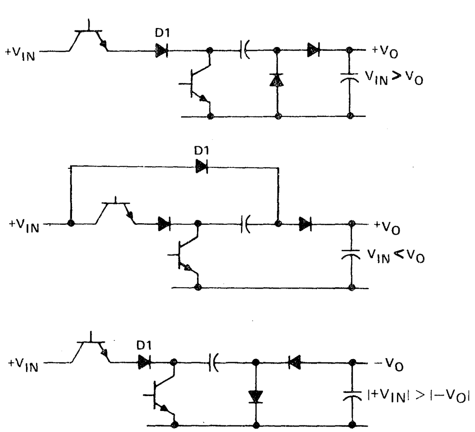


FIGURE 9—CAPACITOR-DIODE-COUPLED VOLTAGE-MULTIPLIER OUTPUT STAGES

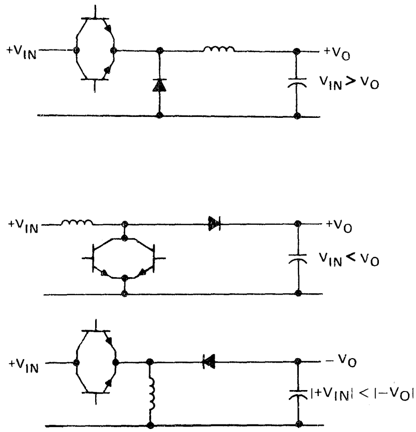
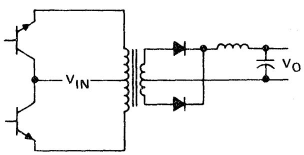
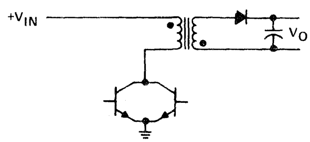


FIGURE 10—SINGLE-ENDED INDUCTOR CIRCUIT



PUSH PULL



FLYBACK

FIGURE 11—TRANSFORMER-COUPLED OUTPUTS

2

TYPICAL APPLICATION DATA

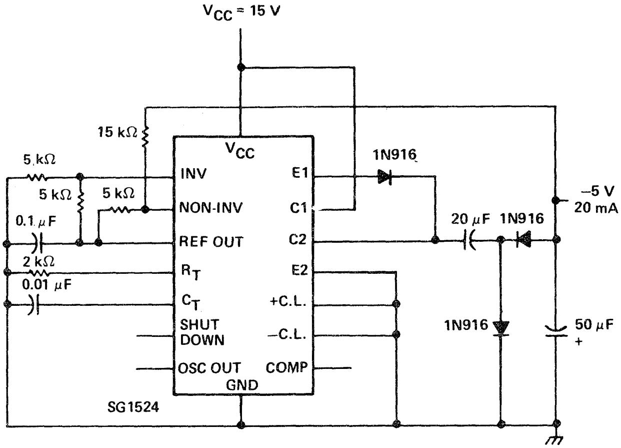


FIGURE 12—CAPACITOR-DIODE OUTPUT CIRCUIT

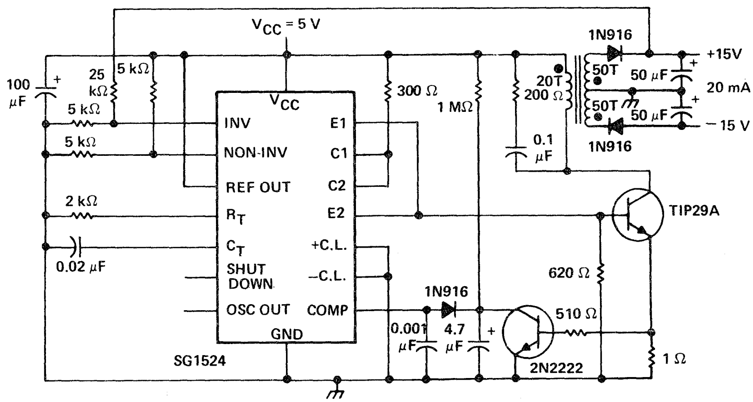


FIGURE 13 – FLYBACK CONVERTER CIRCUIT

TYPICAL APPLICATION DATA

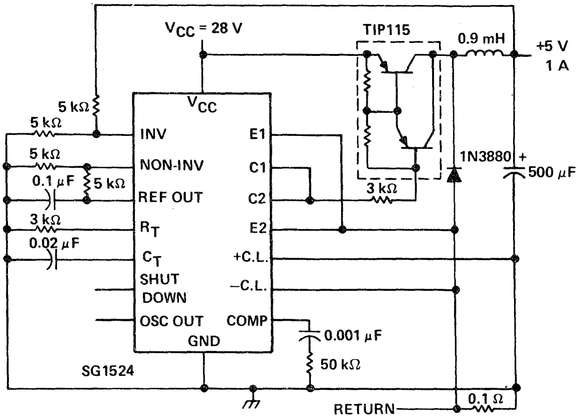


FIGURE 14–SINGLE-ENDED LC CIRCUIT

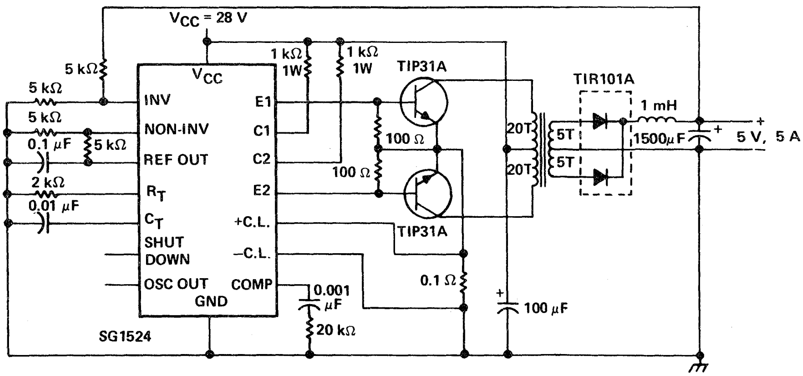


FIGURE 15–PUSH-PULL TRANSFORMER-COUPLED CIRCUIT

THERMAL INFORMATION

J PACKAGE FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

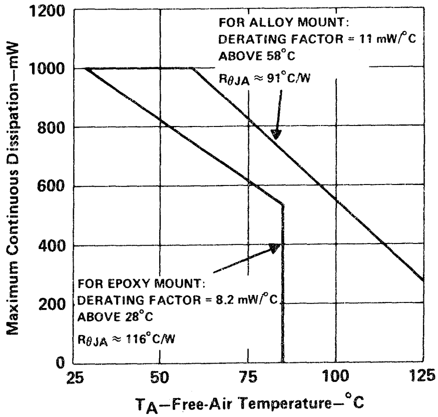


FIGURE 16

N PACKAGE FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

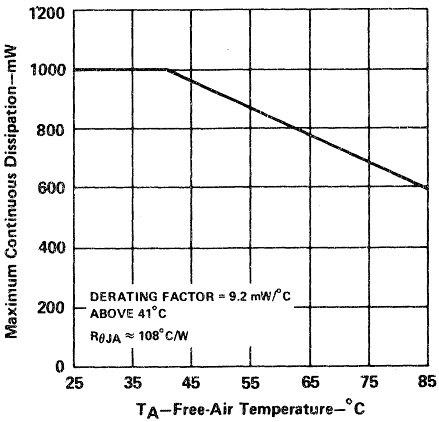


FIGURE 17

TYPES SG1525A, SG1527A, SG2525A, SG2527A, SG3525A, SG3527A PULSE-WIDTH MODULATION CONTROLLERS

D2724, APRIL 1983

- **Complete PWM Power Control Circuitry**
- **8-Volt to 35-Volt Operation**
- **5.1-Volt Reference Trimmed to ±1%**
- **Frequency Range . . . 100 Hz to 500 Hz**
- **Adjustable Deadtime Control**
- **Under-Voltage Lockout for Low V_{CC} Conditions**
- **Latched PWM Prevents Multiple Pulses**
- **Dual Sink or Source Output Drivers**
- **Direct Replacements for Silicon General SG1525/SG1527 Series**

SG1525A, SG1527A . . . J
SG2525A, SG2527A . . . J OR N
SG3525A, SG3527A . . . J OR N
DUAL-IN-LINE PACKAGE
(TOP VIEW)

INVERTING INPUT	1	16	REFERENCE
NONINVERTING INPUT	2	15	V_{CC} (V_I)
SYNC	3	14	OUTPUT B
OSCILLATOR OUT	4	13	V_C
C_T	5	12	GND
R_T	6	11	OUTPUT A
DISCHARGE	7	10	SHUTDOWN
SOFT-START	8	9	COMPENSATION

output logic

SG1525A, SG2525A, SG3525A . . . NOR
SG1527A, SG2527A, SG3527A . . . OR

description

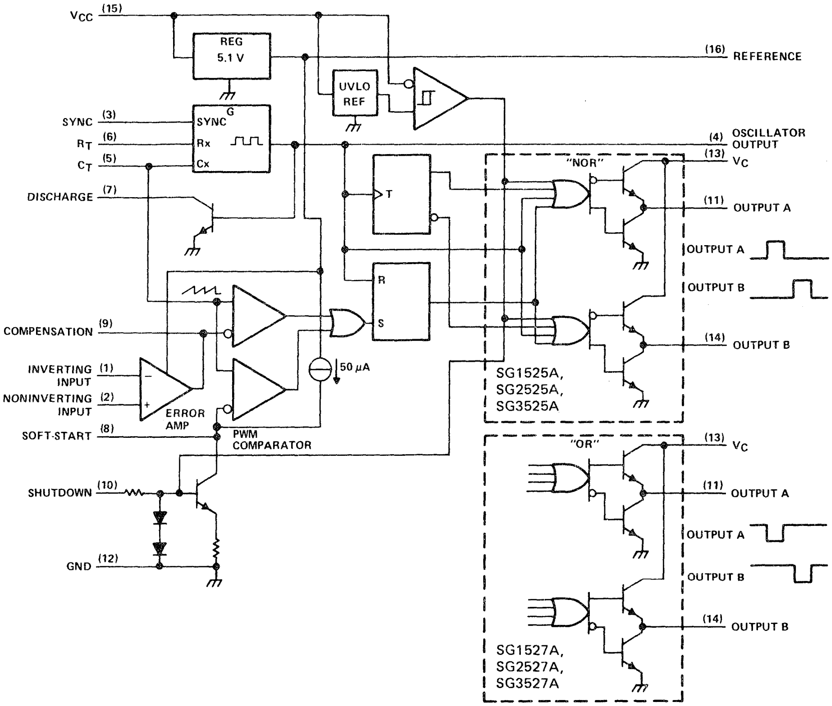
The SG1525A/SG1527A series of pulse-width modulation integrated circuits are designed to offer improved performance and lower external parts count when used to implement various types of switching power supplies. Each device includes an on-chip 5.1-volt reference, error amplifier, programmable oscillator, pulse-steering flip-flop, a latched comparator under-voltage lockout, shutdown circuitry, and complementary source or sink outputs. The on-chip 5.1-volt reference is trimmed to ± 1% initial accuracy that serves as a reference output as well as supplying the internal regulator control circuitry. The input common-mode range of the error amplifier includes the reference voltage, which eliminates the need for external divider resistors.

The oscillator operates at a fixed frequency determined by one timing resistor R_T and one timing capacitor C_T. The timing resistor establishes the constant charging current for C_T, resulting in a linear voltage ramp at C_T, which is fed to the PWM comparator providing linear control of the output pulse duration by the error amplifier. A Sync input to the oscillator allows for external synchronization or for multiple units to be slaved together. A single external resistor between the C_T pin and the Discharge pin provides a wide range of dead-time adjustment. These devices also feature built-in soft-start circuitry that requires only an external timing capacitor. The Shutdown pin controls both the soft-start and the output drivers, and provides instantaneous turn-off with soft-start recycle for slow turn-on. The soft-start and output driver circuitry are also controlled by the under-voltage lockout circuit, which, during low-input supply voltage of less than that required for normal operation, keeps the soft-start capacitor discharged and the output drivers off.

Another unique feature is the S/R latch following the PWM comparator. This feature enables the output drivers to be turned off any time the PWM pulse is terminated; The latch is reset with each clock pulse. However, the PWM outputs will remain turned off for the duration of the period if the PWM comparator output is in a low-level state. The SG2525A, and SG3525A output stages feature NOR logic, which results in a low output for an off-state. The SG1527A. SG2527A, and SG3527A output stages feature OR logic, which results in a high-level output for an off-state. The output stages are totem-pole designs capable of sourcing or sinking 200 milliamperes of output current.

The SG1525A and SG1527A are characterized for operation over the full military temperature range of −55°C to 125°C. The SG2525A and SG2527A are characterized for operation from −25°C to 88°C. The SG3525A and SG3527A are characterized for operation for 0°C to 70°C.

functional block diagram (positive logic)



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1)	40 V
Collector voltage, V_C	40 V
Logic input voltage range sync and shutdown	−0.3 V to 5.5 V
Analog input voltage range error amplifier inputs	−0.3 V to V_{CC}
Output current, I_O	500 mA
Reference output current, I_{REF}	50 mA
Current through C_T terminal	−5 mA
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 2)	1000 mW
Operating free-air temperature range: SG1525A, SG1527A	−55°C to 125°C
SG2525A, SG2527A	−25°C to 85°C
SG3525A, SG3527A	0°C to 70°C
Operating virtual junction temperature range	0°C to 150°C
Storage temperature range	−65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J Package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: N Package	260°C

NOTES: 1. All voltage values are with respect to network ground terminal.
2. For operating above 25°C free-air temperature, see Dissipation Derating Curves, Figures 1 and 2. In the J package, SG1525A and SG1527A chips are alloy mounted; SG2525A, SG2527A, SG3525A, and SG3527A chips are epoxy mounted.

J PACKAGE FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

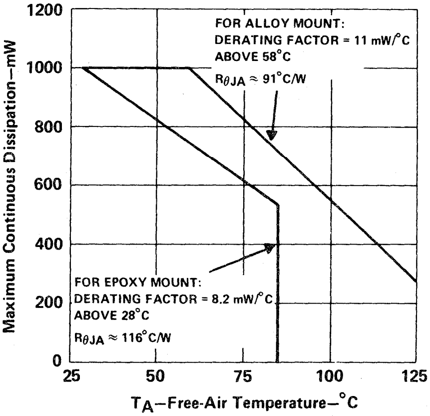


FIGURE 1

N PACKAGE FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

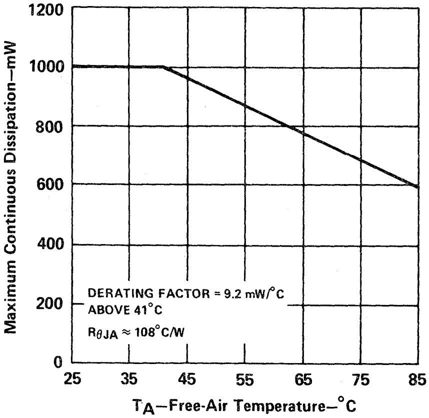


FIGURE 2

recommended operating conditions

PARAMETER		SG1525A, SG1527A		SG2525A, SG2527A		SG3525A, SG3527A		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}		8	35	8	35	8	35	V
Collector voltage, V_C		4.5	35	4.5	35	4.5	35	V
Output current, I_O	Steady state	0	±100	0	±100	0	±100	mA
	Peak	0	±400	0	±400	0	±400	mA
Reference output current, I_{REF}		0	20	0	20	0	20	mA
Oscillator frequency range		100	500	100	500	100	500	kHz
Timing resistor, R_T		2	150	2	150	2	150	kΩ
Timing capacitor, C_T		0.001	0.1	0.001	0.1	0.001	0.1	μF
Dead-time resistor, R_D		0	500	0	500	0	500	Ω
Operating free-air temperature range, T_A		−55	125	−25	85	0	70	°C

2

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 20 V (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS	SG1525A, SG1527A SG 2525A, SG2527A			SG3525A, SG3527A			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage	T_J = 25°C	5.05	5.1	5.15	5	5.1	5.2	V
	V_{CC} = 8 V to 35 V, I_O = 0 to 20 mA	5		5.2	4.95		5.25	
Input regulation	V_{CC} = 8 V to 35 V		14	20		14	20	mV
Output regulation	I_O = 0 to 20 mA		5	50		5	50	mV
Output voltage change with temperature			24	50		24	50	mV
Output voltage long-term drift (see Note 3)	After 1000 h at T_J = 125°C		25	50		25	50	mV
Output noise voltage (RMS)	f = 10 Hz to 10 kHz, T_J = 25°C		40	200		40	200	μV
Short-circuit output current	V_O = 0 V, T_J = 25°C		80	100		80	100	mA

oscillator section

PARAMETER	TEST CONDITIONS	SG1525A, SG1527A SG2525A, SG2527A			SG3525A, SG3527A			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
Maximum frequency	R_T = 2 kΩ, C_T = 1 nF	400			400			kHz
Minimum frequency	R_T = 150 kΩ, C_T = 0.1 μF			100			100	Hz
Initial frequency error	R_T = 3.6 kΩ, R_D = 0 Ω, C_T = 0.1 μF, f = 40 kHz, T_A = 25°C		±2%	±6%		±2%	±6%	
Frequency change with supply voltage	V_{CC} = 8 V to 35 V		±0.3%	±1%		±1%	±2%	
Frequency change with temperature	T_A = MIN to MAX		±3%	±6%		±3%	±6%	
Output amplitude at Pin 4	R_T = 3.6 kΩ, R_D = 0 Ω, C_T = 0.1 μF, f = 40 kHz	3	3.5		3	3.5		V
Output pulse duration at Pin 4	R_T = 3.5 kΩ, R_D = 0 Ω, C_T = 0.1 μF, f = 40 kHz, T_J = 25°C	0.3	0.5	1	0.3	0.6	1	μs
Input threshold voltage at Pin 3		1.2	2	2.8	1.2	2	2.8	V
Input current at Pin 3	$V_{I(Pin3)}$ = 3.5 V		1.6	2.5		1.6	2.5	mA
Current through Pin 5 due to internal current mirror	Current through Pin 6 = 6 mA	1.7	2	2.2	1.7	2	2.2	mA

NOTE 3: Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

2

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 20 V (unless otherwise noted)

error amplifier section

PARAMETER	TEST CONDITIONS	SG1525A, SG1527A SG2525A, SG2527A			SG3525A, SG3527A			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
High-level output voltage		3.8	5.6		3.8	5.6		V
Low-level output voltage			0.2	0.5		0.2	0.5	V
Input offset voltage			0.5	5		2	10	mV
Input bias current			1	10		1	10	μA
Input offset current				1			1	μA
Open-loop voltage amplification	$R_L \geq 10$ M	60	75		60	75		dB
Common-mode rejection ratio	V_{IC} = 1.5 V to 5.2 V	60	75		60	75		dB
Supply voltage rejection ratio	V_{CC} = 8 V to 35 V	50	60		50	60		dB
Gain-bandwidth product (see Note 3)	A_V = 0 dB, T_J = 25°C	1	2		1	2		MHz

comparator section

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input threshold voltage	R_T = 3.6 kΩ, R_D = 0 Ω, C_T = 10 nF, f = 40 kHz	Duty cycle = 0%	0.6	0.9		V
		Duty cycle = MAX		3.3	3.6	V
Input bias current				0.5	1	μA

2

soft-start section

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Soft-start voltage	V_I at Pin 10 = 2 V		0.4	0.6	V
Soft-start current	V_I at Pin 10 = 0 V	25	50	80	μA
Input current, Shutdown	V_I = Pin-10 = 2.5 V		0.4	1	mA

output section

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
High-level output voltage	I_{OH} = −20 mA	18	19		V
	I_{OH} = −100 mA	17	18		V
Low-level output voltage	I_{OL} = 20 mA		0.2	0.4	V
	I_{OL} = 100 mA		1	2	V
Under-voltage lockout voltage	V_I at Pins 8 and 9 high	6	7	8	V
Oscillator cutoff current (see Note 4)	V_C = 35 V, I_O = 100 mA			200	μA
Output pulse rise time	C_L = 1 nF, T_J = 25°C		100	600	ns
Output pulse fall time	C_L = 1 nF, T_J = 25°C		50	300	ns
Shutdown delay time	V_I at Pin 10 = 3 V, capacitance at pin 8 = 0, T_J = 25°C		0.2	0.5	μs

NOTE 4: Collector cutoff current specifications apply only for the SG1525A, SG2525A, and SG3625A devices.

total device

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Minimum duty cycle				0%	
Maximum duty cycle		45%	49%		
Standby current	V_{CC} = 35 V		14	20	mA

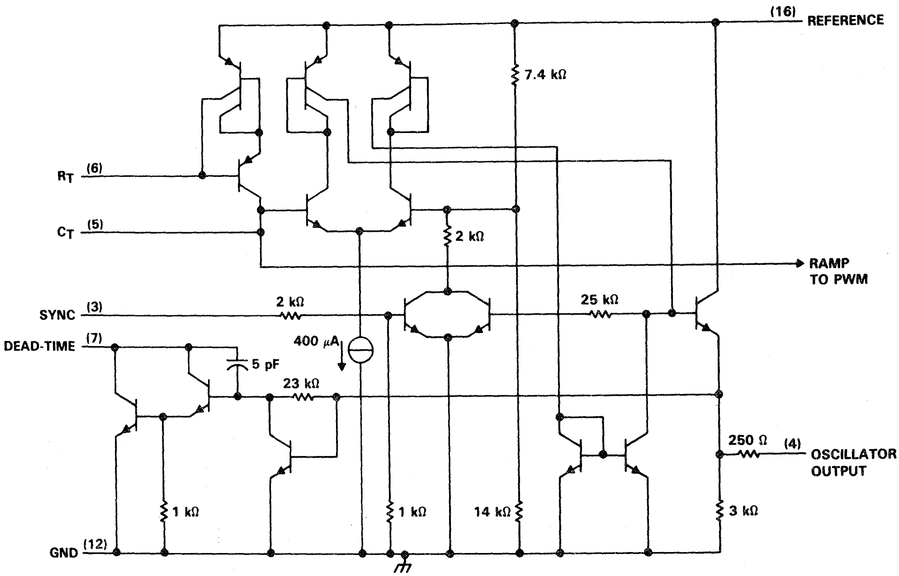


FIGURE 3 — OSCILLATOR SCHEMATIC DIAGRAM

TYPICAL CHARACTERISTICS

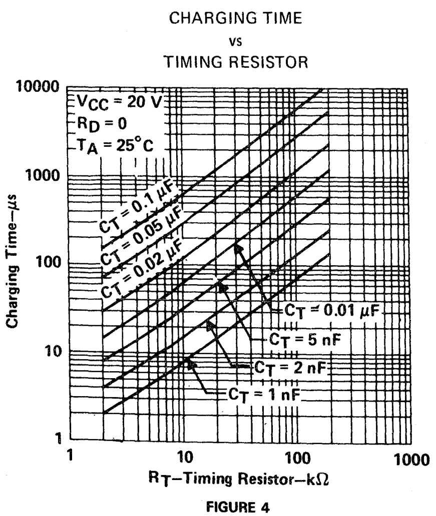


FIGURE 4

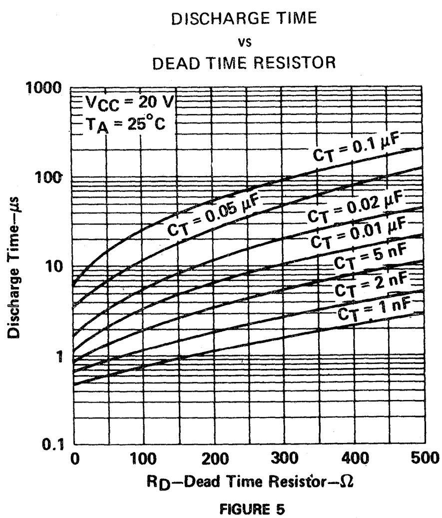


FIGURE 5

TYPICAL CHARACTERISTICS

ERROR AMPLIFIER OPEN-LOOP FREQUENCY RESPONSE

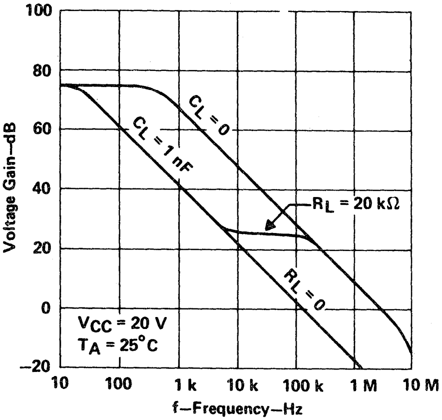


FIGURE 6

SG1525A OUTPUT SATURATION VOLTAGE vs OUTPUT CURRENT

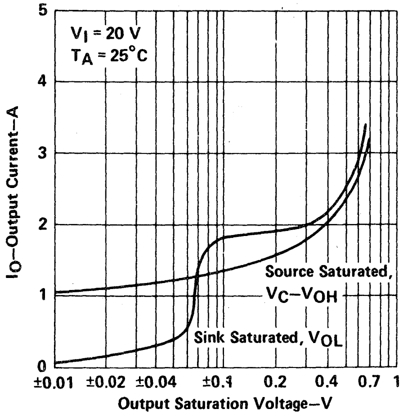


FIGURE 7

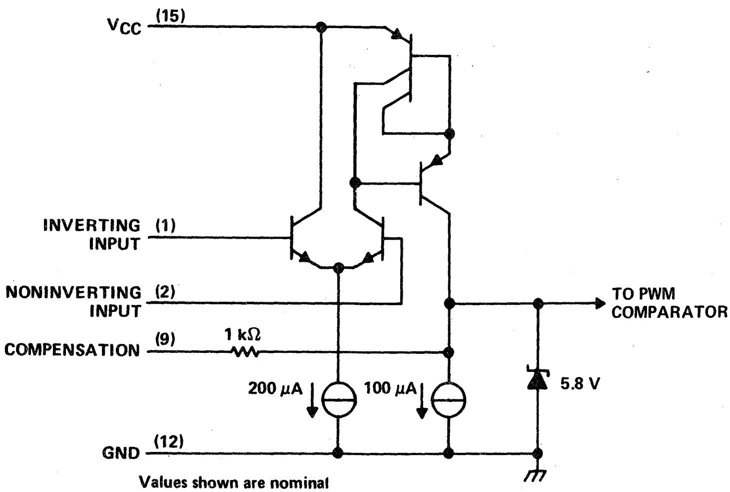


FIGURE 8 — ERROR AMPLIFIER SCHEMATIC DIAGRAM

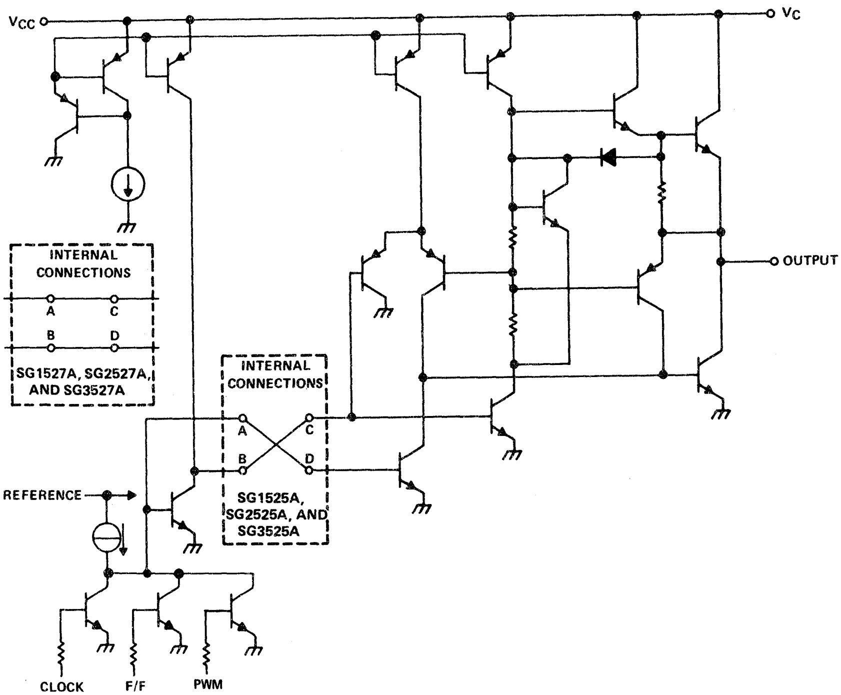


FIGURE 9 – OUTPUT CIRCUIT SCHEMATIC DIAGRAM

TYPICAL APPLICATION DATA

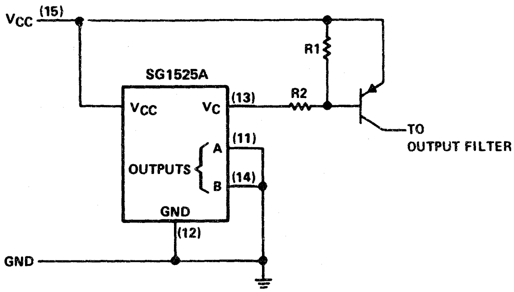
shutdown options

1. Use an external transistor or open-collector comparator to pull down on the Compensation terminal (Pin 9). This will set the PWM latch and turn off both driver outputs. If the shutdown signal is momentary, pulse-by-pulse protection will be accomplished as the PWM latch is reset with each clock pulse.

2. The same results may be accomplished by pulling down on the Soft-Start terminal (Pin 8) with the only difference being that on this pin shutdown will not affect the amplifier compensation network, but must discharge any soft-start capacitance.

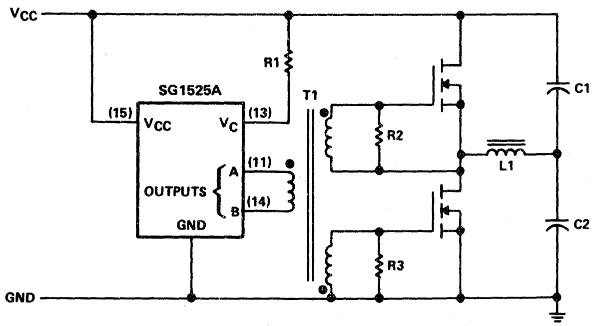
3. Application of a positive-going signal to the Shutdown terminal (Pin 10) will provide the most rapid shutdown of the driver outputs but will not immediately set the PWM latch if there is a capacitor at the Soft-Start terminal. The capacitor will discharge but at a current twice the charging current. The PWM latch can be set on a pulse-by-pulse basis by the shutdown terminal if there is no external capacitance on the Soft-start terminal (Pin 8). Slow turn-on may still be accomplished by connecting an external capacitor, blocking diode, and charging resistor to the Compensation terminal (Pin 9).

TYPICAL APPLICATION DATA



For single-ended supplies, the driver outputs are grounded. The V_C terminal is switched to ground by the totem-pole source transistors on the alternate oscillator cycles.

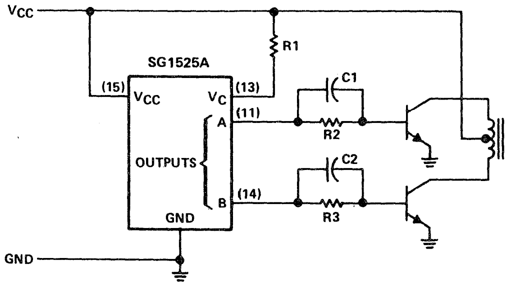
FIGURE 10 — SINGLE-ENDED CIRCUIT



Low-power transformers can be directly driven by the SG1525A. Automatic reset occurs during deadtime when both ends of the primary winding are switched to ground.

FIGURE 11 — TRANSFORMER-COUPLED CIRCUIT

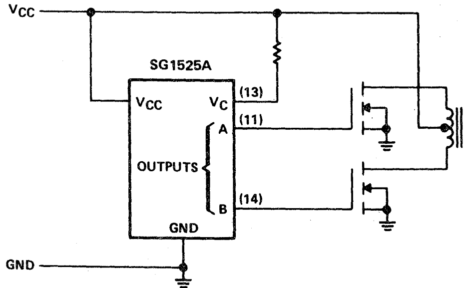
TYPICAL APPLICATION DATA



In conventional push-pull bipolar designs, forward base drive is controlled by $R_1 - R_3$. Rapid turn-off times for the power devices are achieved with speed-up capacitors C_1 and C_2.

FIGURE 12 — BIPOLAR PUSH-PULL CIRCUIT

2



The low source impedance of the output drivers provides rapid charging of power FET input capacitance while minimizing external components.

FIGURE 13 – LOW-IMPEDANCE BIPOLAR-DRIVE PUSH-PULL CIRCUIT

LINEAR INTEGRATED CIRCUITS

TYPE TL317M, TL317C 3-TERMINAL ADJUSTABLE REGULATOR

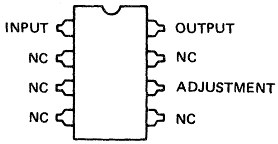
D2527, APRIL 1979–REVISED JANUARY 1983

- Output Voltage Range Adjustable from 1.2 V to 32 V
- Guaranteed Output Current Capability of 100 mA
- Input Regulation Typically 0.01% Per Input-Volt Change
- Output Regulation Typically 0.5%
- Ripple Rejection Typically 80 dB

terminal assignments

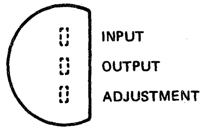
TL317M . . . JG PACKAGE

(TOP VIEW)



TL317C . . . LP SILECT PACKAGE

(TOP VIEW)



2

description

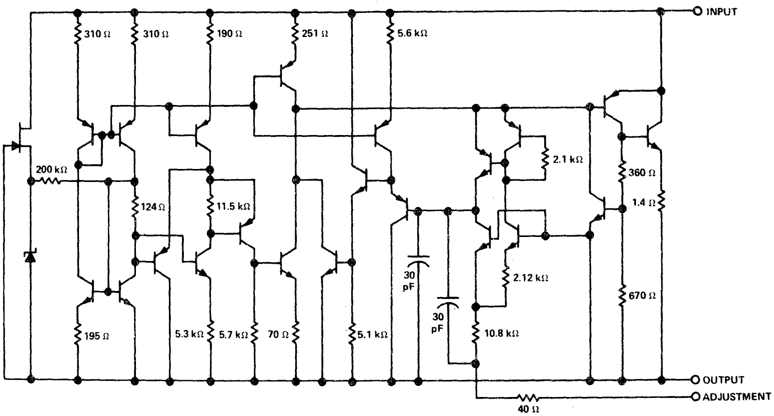
The TL317 is an adjustable 3-terminal positive-voltage regulator capable of supplying 100 milliamperes over an output-voltage range of 1.2 volts to 32 volts. It is exceptionally easy to use and requires only two external resistors to set the output voltage. Both input and output regulation are better than standard fixed regulators. The device is packaged in standard packages that are easily mounted and handled.

In addition to higher performance than fixed regulators, this regulator offers full overload protection available only in integrated circuits. Included on the chip are current limit and thermal overload protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected. Normally, no capacitors are needed unless the device is situated far from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection, which is difficult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators, the regulator is useful in a wide variety of other applications. Since the regulator is floating and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input-to-output differential is not exceeded. Its primary application is that of a programmable output regulator, but by connecting a fixed resistor between the adjustment terminal and the output terminal, this device can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground, which programs the output to 1.2 volts where most loads draw little current.

The TL317M is characterized for operation over the full military temperature range from −55°C to 125°C. The TL317C is characterized for operation from 0°C to 125°C.

schematic



All component values shown are nominal

absolute maximum ratings over operation temperature range (unless otherwise noted)

Input-to-output differential voltage, $V_I - V_O$	35 V
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 1): JG package	1050 mW
LP package	775 mW
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	1600 mW
Operating free-air, case, or virtual junction temperature range: TL317M	−55°C to 150°C
TL317C	0°C to 150°C
Storage temperature range	−65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds, JG package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds, LP package	260°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Table.

DISSIPATION DERATING TABLE

PACKAGE	REFERENCE POINT	POWER RATING	DERATING FACTOR	ABOVE (T_A OR T_C)
JG	Free-air	1050 mW	8.4 mW/°C	25°C
	Case	1600 mW	38.4 mW/°C	108°C
LP	Free-air	775 mW	6.2 mW/°C	25°C
	Case	1600 mW	28.6 mW/°C	94°C

recommended operating conditions

	TL317M		TL317C		UNIT
	MIN	MAX	MIN	MAX	
Output current, I_O	2.5	100	2.5	100	mA
Operating virtual junction temperature, T_J	−55	125	0	125	°C

electrical characteristics over recommended ranges of operating virtual junction temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Input regulation (see Note 2)	$V_I - V_O$ = 3 V to 35 V, See Note 3	T_J = 25°C		0.01	0.02	%/V
		I_O = 2.5 mA to 100 mA		0.02	0.05	
Ripple rejection	V_O = 10 V,	f = 120 Hz		65		dB
	V_O = 10 V, 10-µF capacitor between ADJ and ground	f = 120 Hz,	66	80		
Output regulation	I_O = 2.5 mA to 100 mA, T_J = 25°C, See Note 3	$V_O \leq 5$ V		25		mV
		$V_O \geq 5$ V		0.5		%
	I_O = 2.5 mA to 100 mA, See Note 3	$V_O \leq 5$ V		50		mV
		$V_O \geq 5$ V		1		%
Output voltage change with temperature	T_J = 0°C to 125°C			1		%
Output voltage long-term drift (see Note 4)	After 1000 h at T_J = 125°C and $V_I - V_O$ = 35 V			0.3	1	%
Output noise voltage	f = 10 Hz to 10 kHz,	T_J = 25°C		0.003		%
Minimum output current to maintain regulation	$V_I - V_O$ = 35 V			1.5	2.5	mA
Peak output current	$V_I - V_O \leq 35$ V		100	200		mA
Adjustment-terminal current				50	100	µA
Change in adjustment-terminal current	$V_I - V_O$ = 2.5 V to 35 V,	I_O = 2.5 mA to 100 mA		0.2	5	µA
Reference voltage (output to ADJ)	$V_I - V_O$ = 3 V to 35 V, P ≤ rated dissipation	I_O = 2.5 mA to 100 mA,	1.2	1.25	1.3	V

†Unless otherwise noted, these specifications apply for the following test conditions: $V_I - V_O$ = 5 V and I_O = 2.5 mA.

NOTES: 2. Input regulation is expressed here as the percentage change in output voltage per 1-volt change at the input.

3. Input regulation and output regulation are measured using pulse techniques ($t_w \leq 10$ µs, duty cycle ≤ 5%) to limit changes in average internal dissipation. Output voltage changes due to large changes in internal dissipation must be taken into account separately.

4. Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

2

TYPICAL APPLICATION DATA

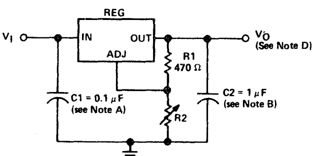


FIGURE 1—ADJUSTABLE VOLTAGE REGULATOR

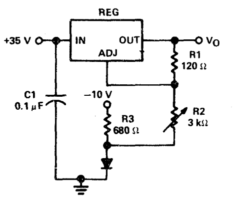
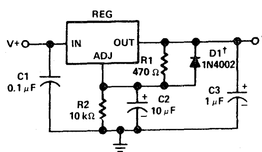


FIGURE 2—0-V to 30-V REGULATOR CIRCUIT



†D1 discharges C2 if output is shorted to ground.

FIGURE 3—ADJUSTABLE REGULATOR CIRCUIT WITH IMPROVED RIPPLE REJECTION

NOTES: A. Use of an input bypass capacitor is recommended if regulator is far from filter capacitors.

B. Use of an output capacitor improves transient response but is optional.

C. V_{ref} equals the difference between the output and adjustment terminal voltages.

D. Output voltage is calculated from the equation: $V_O = V_{ref}\left(1 + \frac{R2}{R1}\right)$

TYPICAL APPLICATION DATA

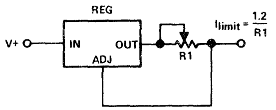


FIGURE 4—PRECISION CURRENT LIMITER CIRCUIT

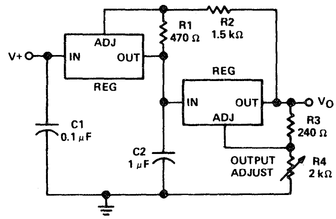


FIGURE 5—TRACKING PREREGULATOR CIRCUIT

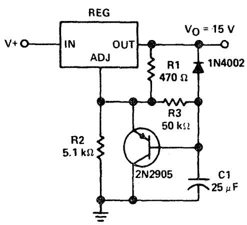


FIGURE 6—SLOW-TURN-ON 15-V REGULATOR CIRCUIT

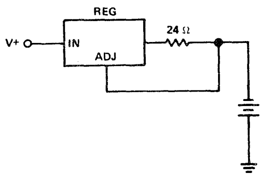
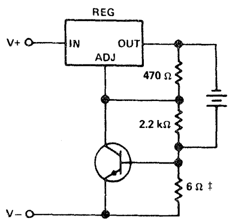
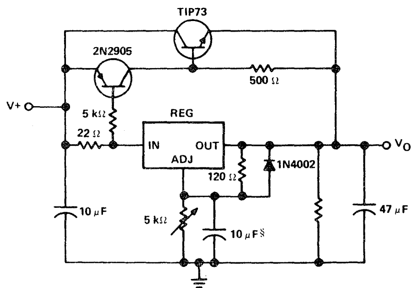


FIGURE 7—50-mA CONSTANT-CURRENT BATTERY CHARGER CIRCUIT



‡This resistor sets peak current (100 mA for 6 Ω).

FIGURE 8—CURRENT-LIMITED 6-V CHARGER



¶Minimum load current is 30 mA.
§Optional capacitor improves ripple rejection

FIGURE 9—HIGH-CURRENT ADJUSTABLE REGULATOR

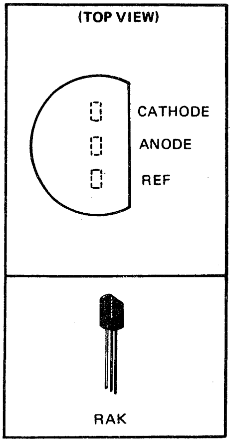
2

TYPES TL430I, TL430C ADJUSTABLE SHUNT REGULATORS

D2165, JUNE 1976—REVISED DECEMBER 1982

- **Temperature Compensated**
- **Programmable Output Voltage**
- **Low Output Resistance**
- **Low Output Noise**
- **Sink Capability to 100 mA**

LP
SILECT PACKAGE

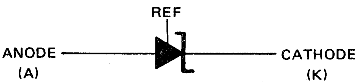


description

The TL430 is a three-terminal adjustable shunt regulator featuring excellent temperature stability, wide operating current range, and low output noise. The output voltage may be set by two external resistors to any desired value between 3 volts and 30 volts. The TL430 can replace zener diodes in many applications providing improved performance.

The TL430I is characterized for operation from −25 °C to 85 °C, and the TL430C is characterized for operating from 0 °C to 70 °C.

functional block diagram



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Regulator voltage (see Note 1)	30 V
Continuous regulator current	150 mA
Continuous dissipation at (or below) 25 °C free-air temperature (see Note 2)	775 mW
Operating free-air temperature range: TL430I	−40 °C to 85 °C
TL430C	0 °C to 70 °C
Storage temperature range	−65 °C to 150 °C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260 °C

recommended operating conditions

	MIN	MAX	UNIT
Regulator Voltage, V_Z	V_{ref}	30	V
Regulator current, I_Z	2	100	mA

NOTES: 1. All voltage values are with respect to the anode terminal.
2. For operation above 25 °C free-air temperature, refer to Dissipation Derating Curves, Figure 5.

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST FIGURE	TEST CONDITIONS	TL430I MIN	TL430I TYP	TL430I MAX	TL430C MIN	TL430C TYP	TL430C MAX	UNIT
V_{ref}	Reference input voltage	1	$V_Z = V_{ref}$, I_Z = 10 mA	2.6	2.75	2.9	2.5	2.75	3	V
α_{Vref}	Temperature coefficient of reference input voltage	1	$V_Z = V_{ref}$, I_Z = 10 mA, T_A = 0°C to 70°C		+120	+200		+120		ppm/°C
I_{ref}	Reference input current	2	I_Z = 10 mA, R1 = 10 kΩ, R2 = ∞		3	10		3	10	μA
I_{ZK}	Regulator current near lower knee of regulation range	1	$V_Z = V_{ref}$		0.5	2		0.5	2	mA
I_{ZM}	Regulator current at maximum limit of regulation range	1	$V_Z = V_{ref}$	50			50			mA
		2	V_Z = 5 V to 30 V, See Note 3	100			100			
r_z	Differential regulator resistance (see Note 4)	1	$V_Z = V_{ref}$, ΔI_Z = (52–2) mA		1.5	3		1.5	3	Ω
V_{nz}	Noise voltage	2	f = 0.1 Hz to 10 Hz, V_Z = 3 V		50			50		μV
			f = 0.1 Hz to 10 Hz, V_Z = 12 V		200			200		
			f = 0.1 Hz to 10 Hz, V_Z = 30 V		650			650		

NOTES: 3. The average power dissipation, $V_Z \cdot I_Z \cdot$ duty cycle, must not exceed the maximum continuous rating in any 10-ms interval.

4. The regulator resistance for $V_Z > V_{ref}$, r_z', is given by:

$$r_z' = r_z\left(1 + \frac{R1}{R2}\right)$$

PARAMETER MEASUREMENT INFORMATION

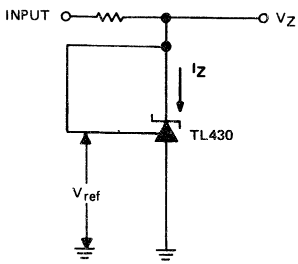
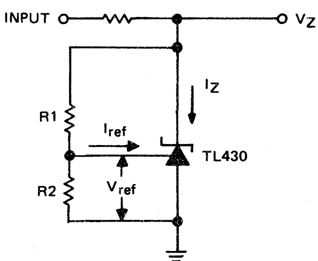


FIGURE 1—TEST CIRCUIT FOR $V_Z = V_{ref}$



$$V_Z = V_{ref}\left(1 + \frac{R1}{R2}\right) + I_{ref} \bullet R1$$

FIGURE 2—TEST CIRCUIT FOR $V_Z > V_{ref}$

TYPICAL CHARACTERISTICS

SMALL-SIGNAL REGULATOR IMPEDANCE
vs
FREQUENCY

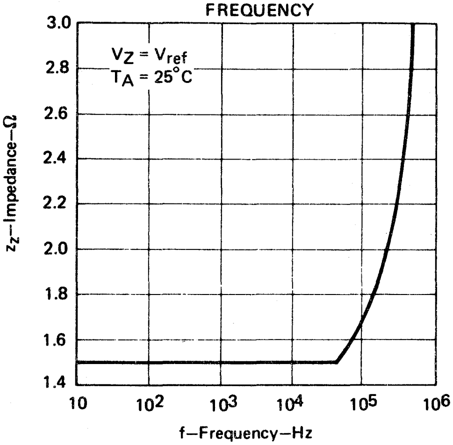


FIGURE 3

CURRENT
vs
VOLTAGE

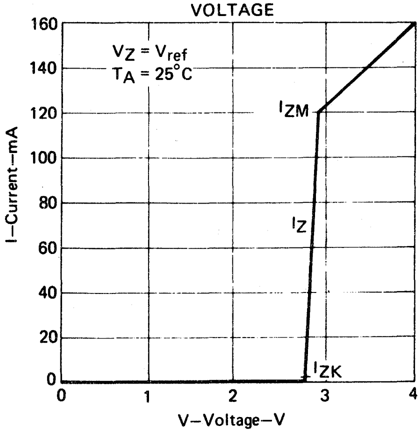


FIGURE 4

THERMAL INFORMATION

LP PACKAGE
DISSIPATION DERATING CURVE

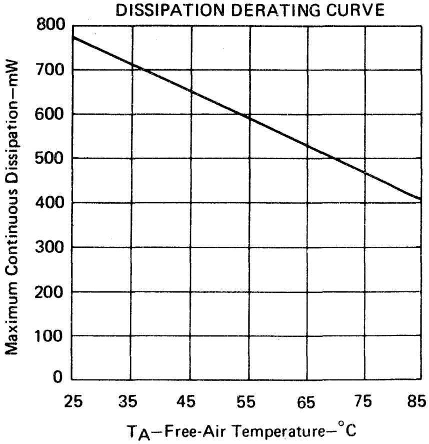
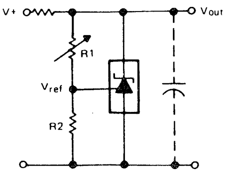


FIGURE 5

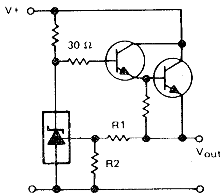
2

TYPICAL APPLICATION DATA



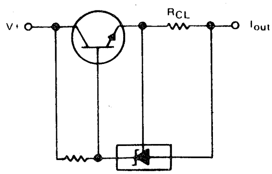
$V_{out} \approx (1 + \frac{R1}{R2})\, V_{ref}$

IGURE 6—SHUNT REGULATOR



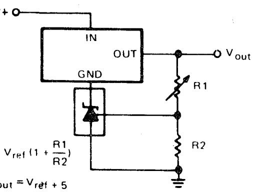
$V_{out} \approx (1 + \frac{R1}{R2})\, V_{ref}$

FIGURE 7—SERIES REGULATOR



$I_{out} = \frac{V_{ref}}{R_{CL}}$

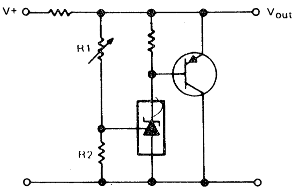
FIGURE 8—CURRENT LIMITER



$V_{out} = V_{ref}\,(1 + \frac{R1}{R2})$

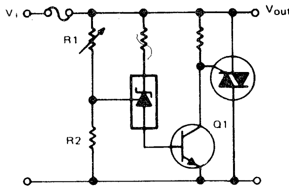
Min $V_{out} = V_{ref} + 5$

FIGURE 9—OUTPUT CONTROL OF A THREE-THERMAL FIXED REGULATOR



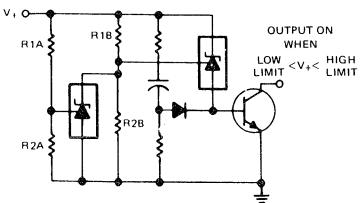
$V_{out} \approx (1 + \frac{R1}{R2})\, V_{ref}$

FIGURE 10—HIGHER-CURRENT APPLICATIONS



$\text{limit} \approx (1 + \frac{R1}{R2})(V_{ref} + V_{BE(Q1)})$

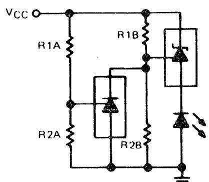
FIGURE 11—CROW BAR



Low limit $\approx V_{ref}\,(1 + \frac{R1B}{R2B}) + V_{BE}$

High limit $\approx V_{ref}\,(1 + \frac{R1A}{R2A})$

FIGURE 12—OVER-VOLTAGE/UNDER-VOLTAGE PROTECTION CIRCUIT



Low limit $\approx V_{ref}\,(1 + \frac{R1B}{R2B}) + V_{BE}$

High limit $\approx V_{ref}\,(1 + \frac{R1A}{R2A})$

FIGURE 13—V_{CC} MONITOR

2

TYPES TL431M, TL431I, TL431C
ADJUSTABLE PRECISION SHUNT REGULATORS

D2410, JULY 1978—REVISED DECEMBER 1982

- Equivalent Full-Range Temperature Coefficient . . . 30 ppm/°C Typ
- Temperature Compensated for Operation Over Full Rated Operating Temperature Range
- Adjustable Output Voltage
- Fast Turn-On Response
- Sink Current Capability . . . 1 mA to 100 mA
- Low (0.2-Ω Typ) Dynamic Output Impedance
- Low Output Noise Voltage

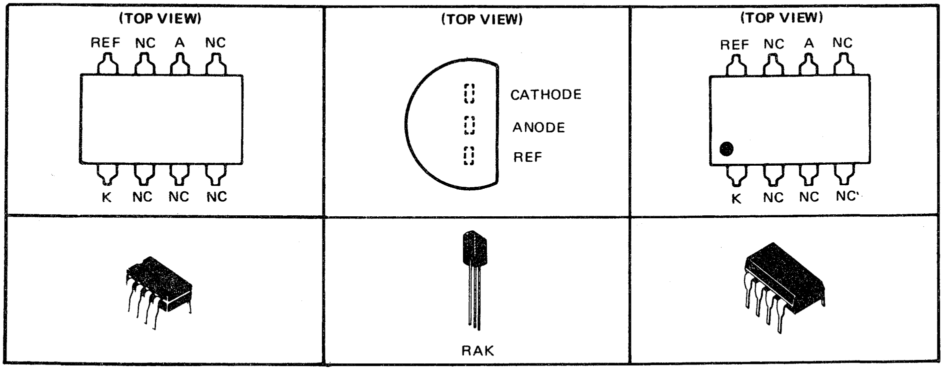
description

The TL431 is a three-terminal adjustable regulator series with guaranteed thermal stability over applicable temperature ranges. The output voltage may be set to any value between V_{ref} (approximately 2.5 volts) and 36 volts with two external resistors (see Figure 16). These devices have a typical dynamic output impedance of 0.2 Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacements for zener diodes in many applications.

The TL431M is characterized for operation over the full military temperature range of −55°C to 125°C. The TL431I is characterized for operation from −40°C to 85°C, and the TL431C from 0°C to 70°C.

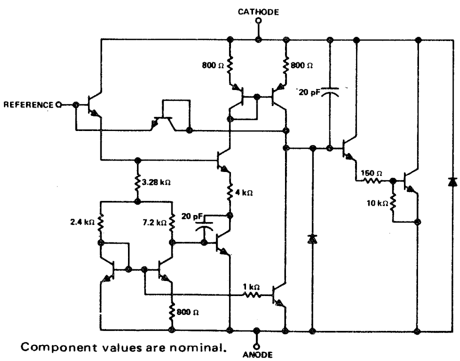
terminal assignments

TL431M . . JG DUAL-IN-LINE PACKAGE | TL431I, TL431C . . . LP SILECT PACKAGE | TL431I, TL431C . . . P DUAL-IN-LINE PACKAGE



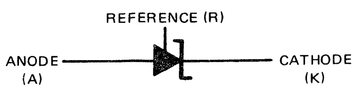
NC—No internal connection

schematic



Component values are nominal.

functional block diagram



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Cathode voltage (see Note 1)	37 V
Continuous cathode current range	−100 mA to 150 mA
Reference input current range	−50 μA to 10 mA
Continuous power dissipation at (or below) 25°C free-air temperature (see Note 2): JG package	1050 mW
LP package	775 mW
P package	1000 mW
Operating free-air temperature range: TL431C	0°C to 70°C
TL431I	−40°C to 85°C
TL431M	−55°C to 125°C
Storage temperature range	−65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: LP or P package	260°C

NOTES: 1. Voltage values are with respect to the anode terminal unless otherwise noted.
2. For operation above 25°C free-air temperature, refer to the Dissipation Derating Table.

DISSIPATION DERATING TABLE

PACKAGE	POWER RATING	DERATING FACTOR	ABOVE T_A
JG	1050 mW	8.4 mW/°C	25°C
LP	775 mW	6.2 mW/°C	25°C
P	1000 mW	8 0 mW/°C	25°C

recommended operating conditions

2

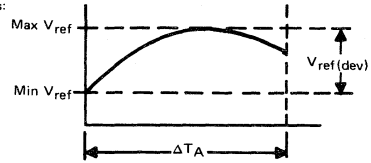
	MIN	MAX	UNIT
Cathode voltage, V_{KA}	V_{ref}	36	V
Cathode current, I_K, (for regulation)	1	100	mA

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CIRCUIT	TEST CONDITIONS		TL431M MIN	TL431M TYP	TL431M MAX	TL431I MIN	TL431I TYP	TL431I MAX	TL431C MIN	TL431C TYP	TL431C MAX	UNIT
V_{ref}	Reference input voltage	1	$V_{KA} = V_{ref}$, $I_K = 10$ mA		2440	2495	2550	2440	2495	2550	2440	2495	2550	mV
$V_{ref(dev)}$	Deviation of reference input voltage over full temperature range‡	1	$V_{KA} = V_{ref}$, $I_K = 10$ mA, T_A = full range†			22	44		15	30		8	17	mV
$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	Ratio of change in reference input voltage to the change in cathode voltage	2	$I_K = 10$ mA	$\Delta V_{KA} = 10\text{ V} - V_{ref}$		−1.4	−2.7		−1.4	−2.7		−1.4	−2.7	$\frac{mV}{V}$
				$\Delta V_{KA} = 36\text{ V} - 10\text{ V}$		−1	−2		−1	−2		−1	−2	
I_{ref}	Reference input current	2	$I_K = 10$ mA, R1 = 10 kΩ, R2 = ∞			2	4		2	4		2	4	μA
$I_{ref(dev)}$	Deviation of reference input current over full temperature range‡	2	$I_K = 10$ mA, R1 = 10 kΩ, R2 = ∞, T_A = full range†			1	3		0.8	2.5		0.4	1.2	μA
I_{min}	Minimum cathode current for regulation	1	$V_{KA} = V_{ref}$			0.4	1		0.4	1		0.4	1	mA
I_{off}	Off-state cathode current	3	$V_{KA} = 36$ V, $V_{ref} = 0$			0.1	1		0.1	1		0.1	1	μA
$\lvert z_{ka}\rvert$	Dynamic impedance§	1	$V_{KA} = V_{ref}$, $I_K = 1$ mA to 100 mA, $f \leq 1$ kHz			0.2	0.5		0.2	0.5		0.2	0.5	Ω

†Full temperature range is −55°C to 125°C for the TL431M, −40°C to 85°C for the TL431I, and 0°C to 70°C for the TL431C.

‡The deviation parameters $V_{ref(dev)}$ and $I_{ref(dev)}$ are defined as the differences between the maximum and minimum values obtained over the rated temperature range. The equivalent full-range temperature coefficient of the reference input voltage, αV_{ref}, is defined as:



$$\left|\alpha V_{ref}\right|\left(\frac{\text{ppm}}{°\text{C}}\right) = \frac{\left(\frac{V_{ref(dev)}}{V_{ref}\ @\ 25°\text{C}}\right) \times 10^6}{\Delta T_A}$$

where ΔT_A is the rated operating free-air temperature range of the device.

αV_{ref} can be positive or negative depending on whether minimum V_{ref} or maximum V_{ref}, respectively, occurs at the lower temperature (see Figure 8).

Example: Max V_{ref} = 2500 mV @ 30°C, Min V_{ref} = 2492 mV @ 0°C, V_{ref} = 2495 mV @ 25°C, ΔT_A = 70°C for TL431C

$$\left|\alpha V_{ref}\right| = \frac{\left(\frac{8\text{ mV}}{2495\text{ mV}}\right) \times 10^6}{70°\text{C}} = 46\text{ ppm}/°\text{C}$$

Because minimum V_{ref} occurs at the lower temperature, the coefficient is positive.

§The dynamic impedance is defined as:

$$\left|z_{ka}\right| = \frac{\Delta V_{KA}}{\Delta I_K}$$

When the device is operated with two external resistors (see Figure 2), the total dynamic impedance of the circuit is given by:

$$\left|z'\right| = \frac{\Delta V}{\Delta I} \approx \left|z_{ka}\right|\left(1 + \frac{R1}{R2}\right)$$

2

PARAMETER MEASUREMENT INFORMATION

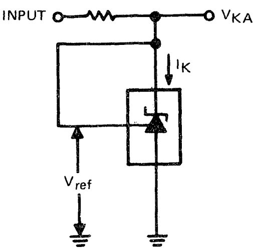


FIGURE 1—TEST CIRCUIT FOR $V_{KA} = V_{ref}$

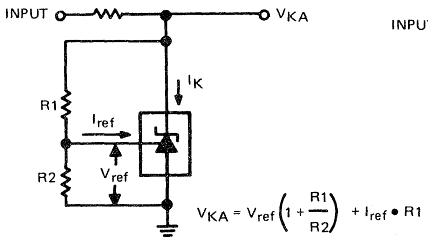


FIGURE 2—TEST CIRCUIT FOR $V_{KA} > V_{ref}$

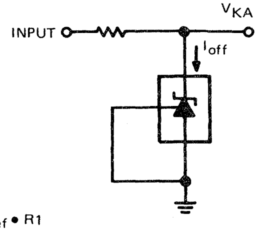


FIGURE 3—TEST CIRCUIT FOR I_{off}

TYPICAL CHARACTERISTICS

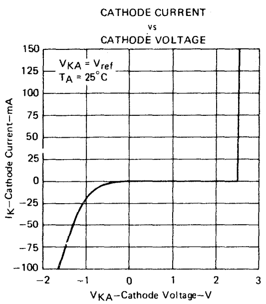


FIGURE 4

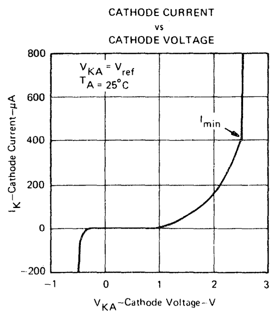


FIGURE 5

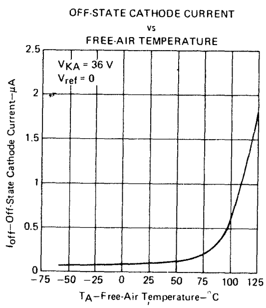


FIGURE 6

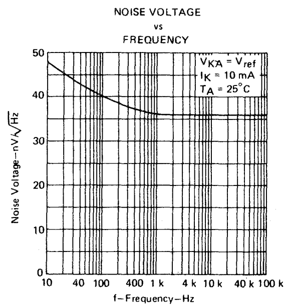


FIGURE 7

TYPICAL CHARACTERISTICS

REFERENCE INPUT VOLTAGE
vs
FREE-AIR TEMPERATURE

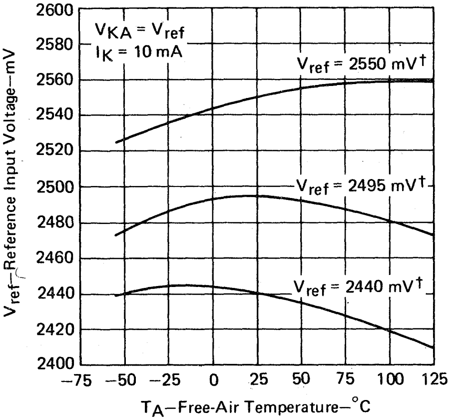


FIGURE 8

REFERENCE INPUT CURRENT
vs
FREE-AIR TEMPERATURE

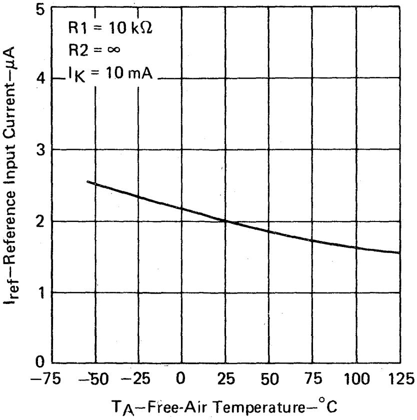


FIGURE 9

CHANGE IN REFERENCE INPUT VOLTAGE
vs
CATHODE VOLTAGE

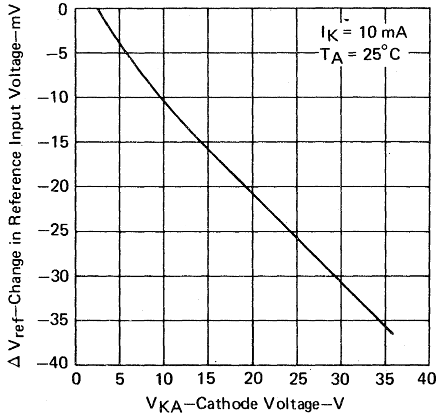


FIGURE 10

DYNAMIC IMPEDANCE
vs
FREE-AIR TEMPERATURE

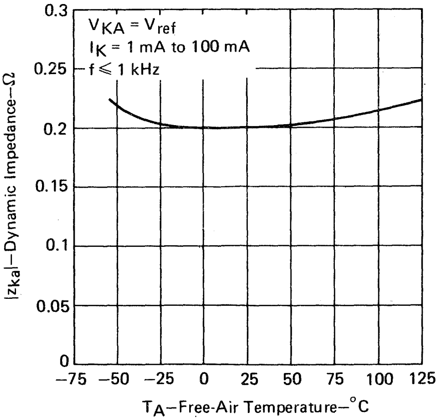


FIGURE 11

†Data is for devices having the indicated value of V_{ref} at I_K = 10 mA, T_A = 25°C.

TYPICAL CHARACTERISTICS

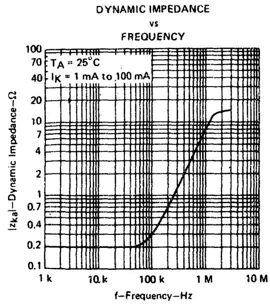
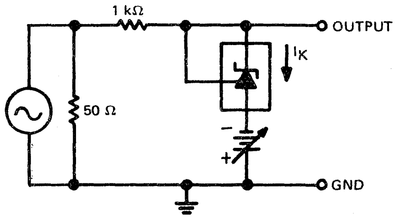


FIGURE 12



TEST CIRCUIT FOR DYNAMIC IMPEDANCE

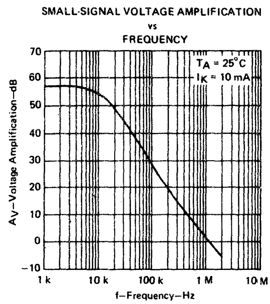
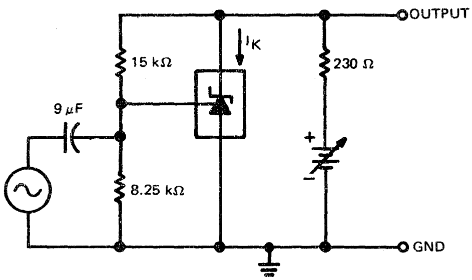


FIGURE 13



TEST CIRCUIT FOR VOLTAGE AMPLIFICATION

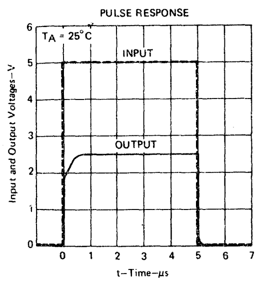
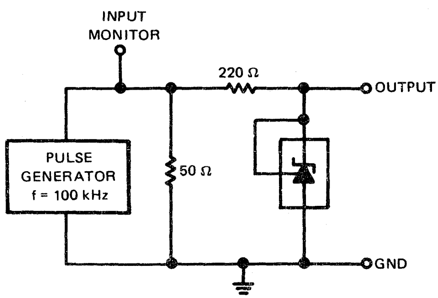
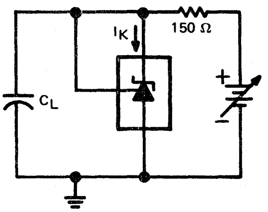


FIGURE 14

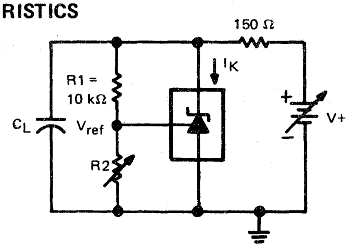


TEST CIRCUIT FOR PULSE RESPONSE

TYPICAL CHARACTERISTICS



TEST CIRCUIT FOR CURVE A BELOW



TEST CIRCUIT FOR CURVES B, C, AND D BELOW

STABILITY BOUNDARY CONDITIONS

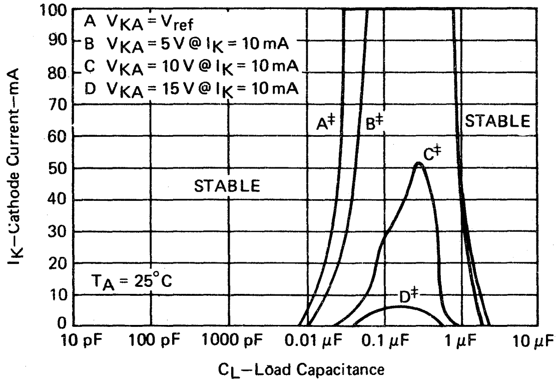


FIGURE 15

‡The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D, R2 and V+ were adjusted to establish the initial V_{KA} and I_K conditions with C_L = 0. V+ and C_L were then adjusted to determine the ranges of stability.

TYPICAL APPLICATIONS

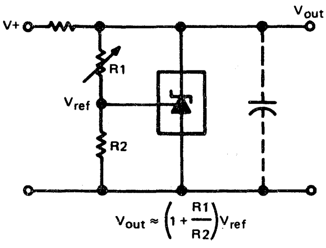


FIGURE 16—SHUNT REGULATOR

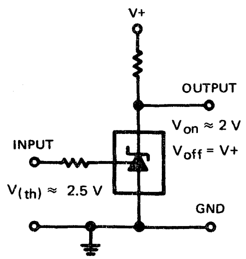


FIGURE 17—SINGLE-SUPPLY COMPARATOR WITH TEMPERATURE-COMPENSATED THRESHOLD

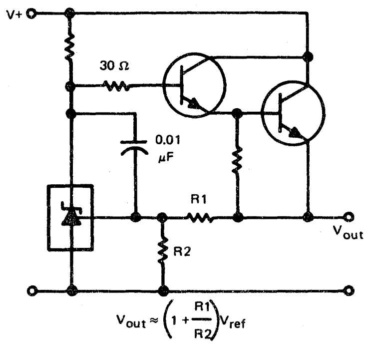
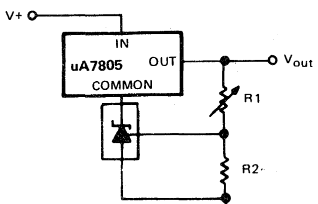


FIGURE 18—SERIES REGULATOR

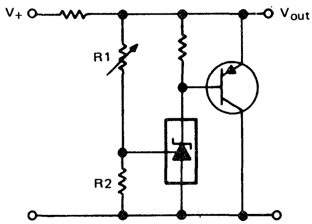
TYPICAL APPLICATIONS



$V_{out} = V_{ref}\left(1 + \frac{R1}{R2}\right)$

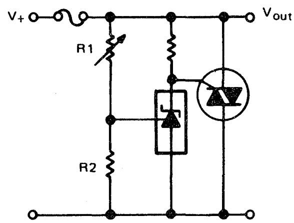
Min $V_{out} = V_{ref} + 5$ V

FIGURE 19– OUTPUT CONTROL OF A THREE-TERMINAL FIXED REGULATOR



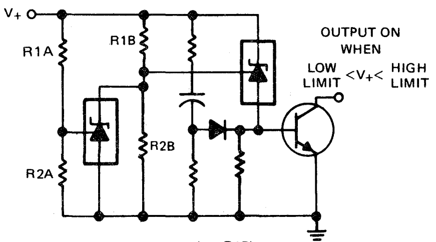
$V_{out} = \left(1 + \frac{R1}{R2}\right)V_{ref}$

FIGURE 20—HIGHER-CURRENT SHUNT REGULATOR



$V_{limit} \approx \left(1 + \frac{R1}{R2}\right) V_{ref}$

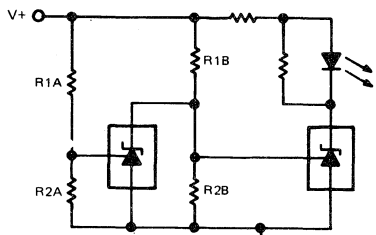
FIGURE 21—CROW BAR



Low limit $\approx V_{ref}\left(1 + \frac{R1B}{R2B}\right) + V_{BE}$

High limit $\approx V_{ref}\left(1 + \frac{R1A}{R2A}\right)$

FIGURE 22—OVER-VOLTAGE/UNDER-VOLTAGE PROTECTION CIRCUIT

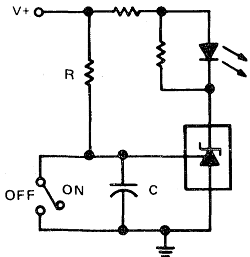


Low limit $\approx V_{ref}\left(1 + \frac{R1B}{R2B}\right)$

High limit $\approx V_{ref}\left(1 + \frac{R1A}{R2A}\right)$

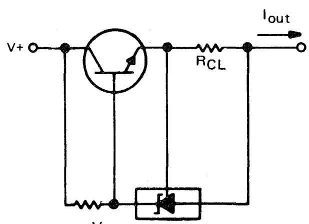
LED ON WHEN LOW LIMIT < V+ < HIGH LIMIT

FIGURE 23—VOLTAGE MONITOR



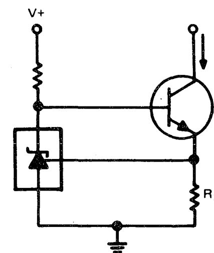
$\text{Delay} = R \cdot C \cdot \ln \frac{V+}{(V+) - V_{ref}}$

FIGURE 24—DELAY TIMER



$I_{out} = \frac{V_{ref}}{R_{CL}}$

FIGURE 25—CURRENT LIMITER OR CURRENT SOURCE



$I_{out} = \frac{V_{ref}}{R_S}$

FIGURE 26—CONSTANT-CURRENT SINK

2

TYPES TL493, TL494, TL495 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

D2535, JANUARY 1983

- **Complete PWM Power Control Circuitry**
- **Uncommitted Outputs for 200-mA Sink or Source Current**
- **Output Control Selects Single-Ended or Push-Pull Operation**
- **Internal Circuitry Prohibits Double Pulse at Either Output**
- **Variable Dead-Time Provides Control Over Total Range**
- **Internal Regulator Provides a Stable 5-V Reference Supply Trimmed to 1%**
- **Circuit Architecture Allows Easy Synchronization**
- **TL493 Has Output Current-Limit Sensing**
- **TL495 Has On-Chip 39-V Zener and External Control of Output Steering**

TL493C . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)

ERROR AMP 1	NONINV INPUT	1	16	NONINV INPUT	CURRENT LIMIT AMP
ERROR AMP 1	INV INPUT	2	15	INV INPUT	CURRENT LIMIT AMP
	FEEDBACK	3	14	REF OUT	
	DEAD-TIME CONTROL	4	13	OUTPUT CONTROL	
	C_T	5	12	V_{CC}	
	R_T	6	11	C2	
	GND	7	10	E2	
	C1	8	9	E1	

TL494M . . . J
TL494I, TL494C . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)

ERROR AMP 1	NONINV INPUT	1	16	NONINV INPUT	ERROR AMP 2
ERROR AMP 1	INV INPUT	2	15	INV INPUT	ERROR AMP 2
	FEEDBACK	3	14	REF OUT	
	DEAD-TIME CONTROL	4	13	OUTPUT CONTROL	
	C_T	5	12	V_{CC}	
	R_T	6	11	C2	
	GND	7	10	E2	
	C1	8	9	E1	

TL495I, TL495C . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)

ERROR AMP 1	NONINV INPUT	1	18	NONINV INPUT	ERROR AMP 2
ERROR AMP 1	INV INPUT	2	17	INV INPUT	ERROR AMP 2
	FEEDBACK	3	16	REF OUT	
	DEAD-TIME CONTROL	4	15	V_Z	
	C_T	5	14	OUTPUT CONTROL	
	R_T	6	13	STEERING INPUT	
	GND	7	12	V_{CC}	
	C1	8	11	C2	
	E1	9	10	E2	

2

description

The TL493, TL494, and TL495 each incorporate on a single monolithic chip all the functions required in the construction of a pulse-width-modulation control circuit. Designed primarily for power supply control, these devices offer the systems engineer the flexibility to tailor the power supply control circuitry to his application.

The TL493 contains an error amplifier, current-limiting amplifier, an on-chip adjustable oscillator, a dead-time control comparator, pulse-steering control flip-flop, a 5-volt, 1%-precision regulator, and output-control circuits.

The error amplifier exhibits a common-mode voltage range from −0.3 volts to V_{CC} − 2 volts. The current-limit amplifier exhibits a common-mode voltage range from −0.3 volts to 3 volts with an offset voltage of approximately 80 millivolts in series with the inverting input to ease circuit design requirements. The dead-time control comparator has a fixed offset that provides approximately 5% dead time when externally altered. The on-chip oscillator may be bypassed by terminating R_T (pin 6) to the reference output and providing a sawtooth input to C_T (pin 5), or it may be used to drive the common circuits in synchronous multiple-rail power supplies.

DEVICE TYPES, SUFFIX VERSIONS, AND PACKAGES

	TL493	TL494	TL495
TL49–M	*	J	*
TL49–I	*	J,N	J,N
TL49–C	J,N	J,N	J,N

*These combinations are not defined by this data sheet.

FUNCTION TABLE

INPUTS: OUTPUT CONTROL	INPUTS: STEERING INPUT (TL495 only)	OUTPUT FUNCTION
$V_I \le 0.4$ V	Open	Single-ended or parallel output
$V_I \ge 2.4$ V	Open	Normal push-pull operation
$V_I \ge 2.4$ V	$V_I \le 0.4$ V	PWM Output at Q1
$V_I \ge 2.4$ V	$V_I \ge 2.4$ V	PWM Output at Q2

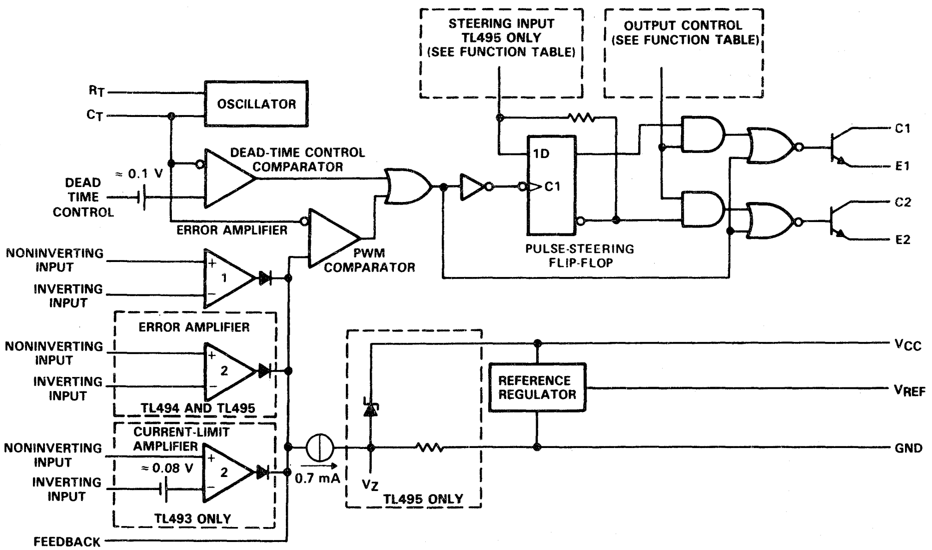
description (continued)

The uncommitted output transistors provide either common-emitter or emitter-follower output capability. Each device provides for push-pull or single-ended output operation, which may be selected through the output-control function. The architecture of these devices prohibits the possibility of either output being pulsed twice during push-pull operation.

The TL493 and TL494 are similar except that an additional error amplifier is included in the TL494 instead of a current-limiting amplifier. The TL495 provides the identical functions found in the TL494. In addition, it contains an on-chip 39-volt zener diode for high-voltage applications where V_{CC} is greater than 40 volts, and an output-steering control that overrides the internal control of the pulse-steering flip-flop.

The TL494M is characterized for operation over the full military temperature range from − 55 °C to 125 °C. The TL494I and TL495I are characterized for operation from − 25 °C to 85 °C. The TL493C, TL494C, and TL495C are characterized for operation from 0 °C to 70 °C.

functional block diagram



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

	TL494M	TL494I TL495I	TL493C TL494C TL495C	UNIT
Supply voltage, V_{CC} (see Note 1)	41	41	41	V
Amplifier input voltages	$V_{CC}+0.3$	$V_{CC}+0.3$	$V_{CC}+0.3$	V
Collector output voltage	41	41	41	V
Collector output current	250	250	250	mA
Continuous total dissipation at (or below) 25 °C free-air temperature (see Note 2)	1000	1000	1000	mW
Operating free-air temperature range	−55 to 125	−25 to 85	0 to 70	°C
Storage temperature range	−65 to 150	−65 to 150	−65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package	300	300	300	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: N package		260	260	°C

NOTES: 1. All voltage values, except differential voltages, are with respect to the network ground terminal.
2. For operation above 25 °C free-air temperature, refer to Dissipation Derating Table. In the J package, TL494M chips are alloy-mounted; TL493C, TL494I, TL494C, TL495I, and TL495I chips are glass mounted.

DISSIPATION DERATING TABLE

PACKAGE	POWER RATING	DERATING FACTOR	ABOVE T_A
J (Alloy-Mounted Chip)	1000 mW	11.0 mW/°C	59 °C
J (Glass-Mounted Chip)	1000 mW	8.2 mW/°C	28 °C
N	1000 mW	9.2 mW	41 °C

2

recommended operating conditions

	TL494M		TL494I TL495I		TL493C TL494C TL495C		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}	7	40	7	40	7	40	V
Amplifier input voltages, V_I	−0.3	$V_{CC}-2$	−0.3	$V_{CC}-2$	−0.3	$V_{CC}-2$	V
Collector output voltage, V_O		40		40		40	V
Collector output current (each transistor)		200		200		200	mA
Current into feedback terminal		0.3		0.3		0.3	mA
Timing capacitor, C_T	0.47	10 000	0.47	10 000	0.47	10 000	nF
Timing resistor, R_T	1.8	500	1.8	500	1.8	500	kΩ
Oscillator frequency	1	300	1	300	1	300	kHz
Operating free-air temperature, T_A	−55	125	−25	85	0	70	°C

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 15 V, f = 10 kHz (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS†	TL494M			TL493C TL494I, TL494C TL495I, TL495C			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Output voltage (V_{ref})	I_O = 1 mA	4.75	5	5.25	4.75	5	5.25	V
Input regulation	V_{CC} = 7 V to 40 V		2	25		2	25	mV
Output regulation	I_O = 1 to 10 mA		1	15		1	15	mV
Output voltage change with temperature	ΔT_A = MIN to MAX		0.2	1		0.2	1	%
Short-circuit output current§	V_{ref} = 0	10	35	50		35		mA

oscillator section

PARAMETER	TEST CONDITIONS†	TL494M			TL493C TL494I, TL494C TL495I, TL495C			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Frequency	C_T = 0.01 μF, R_T = 12 kΩ		10			10		kHz
Standard deviation of frequency¶	All values of V_{CC}, C_T, R_T, T_A constant		10			10		%
Frequency change with voltage	V_{CC} = 7 V to 40 V, T_A = 25°C		0.1			0.1		%
Frequency change with temperature	C_T = 0.01 μF, R_T = 12 kΩ, ΔT_A = MIN to MAX			4			2	%

amplifier sections (see figure 1)

PARAMETER		TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Input offset voltage	Error	V_O (pin 3) = 2.5 V		2	10	mV
	current-limit (TL493 only)			80		
Input offset current		V_O (pin 3) = 2.5 V		25	250	nA
Input bias current		V_O (pin 3) = 2.5 V		0.2	1	μA
Common-mode input voltage range	Error	V_{CC} = 7 V to 40 V	−0.3 to $V_{CC}-2$			V
	Current-limit (TL493 only)		−0.3 to 3			
Open-loop voltage amplification	Error	ΔV_O = 3 V, V_O = 0.5 V to 3.5 V	70	95		dB
	Current-limit (TL493 only)			90		
Unity-gain bandwidth				800		kHz
Common-mode rejection ratio	Error	V_{CC} = 40 V, T_A = 25°C	65	80		dB
	Current-limit (TL493 only)			70		
Output sink current (pin 3)		V_{ID} = −15 mV to −5 V, $V_{(pin\ 3)}$ = 0.5 V	0.3	0.7		mA
Output source current (pin 3)		V_{ID} = 15 mV to 5 V, $V_{(pin\ 3)}$ = 3.5 V	−2			mA

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡All typical values except for parameter changes with temperature are at T_A = 25°C.
§Duration of the short-circuit should not exceed one second.
¶Standard deviation is a measure of the statistical distribution about the mean as derived from the formula $\sigma = \sqrt{\dfrac{\sum_{n=1}^{N} (x_n - \bar{x})^2}{N-1}}$

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 15 V, f = 10 kHz (unless otherwise noted)

output section

PARAMETER		TEST CONDITIONS		TL494M			TL493C TL494I, TL494C TL495I, TL495C			UNIT
				MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Collector off-state current		V_{CE} = 40 V,	V_{CC} = 40 V		2	100		2	100	μA
Emitter off-state current		V_{CC} = V_C = 40 V, V_E = 0				−150			−100	μA
Collector-emitter saturation voltage	Common-emitter	V_E = 0,	I_C = 200 mA		1.1	1.5		1.1	1.3	V
	Emitter-follower	V_C = 15 V,	I_E = −200 mA		1.5	2.5		1.5	2.5	V
Output control input current		V_I = V_{ref}				3.5			3.5	mA

dead-time control-section (see figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Input bias current (pin 4)	V_I = 0 to 5.25 V		−2	−10	μA
Maximum duty cycle, each output	V_I (pin 4) = 0	45			%
Input threshold voltage (pin 4)	Zero duty cycle		3	3.3	V
	Maximum duty cycle	0			V

pwm comparator section (see figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Input threshold voltage (pin 3)	Zero duty cycle		4	4.5	V
Input sink current (pin 3)	$V_{(pin\ 3)}$ = 0.7 V	0.3	0.7		mA

steering control (TL495 only)

PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
Input current	V_I = 0.4 V		−200	μA
	V_I = 2.4 V		200	μA

zener-diode circuit (TL495 only)

PARAMETER	TEST CONDITIONS		MIN	TYP‡	MAX	UNIT
Breakdown voltage	V_{CC} = 41 V,	I_Z = 2 mA		39		V
Sink current	$V_{I(pin\ 15)}$ = 1 V			0.3		mA

total device

PARAMETER	TEST CONDITIONS		MIN	TYP‡	MAX	UNIT
Standby supply current	Pin 6 at V_{ref}, All other inputs and outputs open	V_{CC} = 15 V		6	10	mA
		V_{CC} = 40 V		9	15	mA
Average supply current	$V_{(pin\ 4)}$ = 2 V,	See Figures 1		7.5		mA

switching characteristics, T_A = 25°C

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Output voltage rise time	Common-emitter configuration,		100	200	ns
Output voltage fall time	See Figure 3		25	100	ns
Output voltage rise time	Emitter-follower configuration,		100	200	ns
Output voltage fall time	See Figure 4		40	100	ns

‡All typical values except for temperature coefficients are at T_A = 25°C.

2

PARAMETER MEASUREMENT INFORMATION

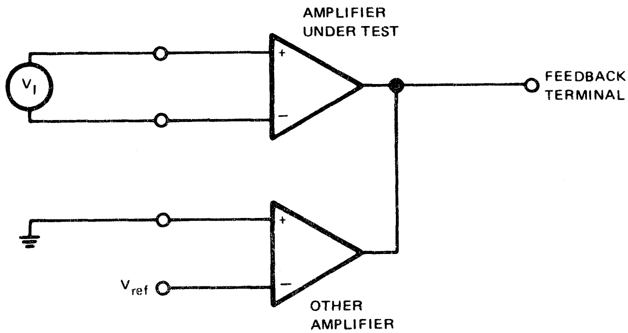
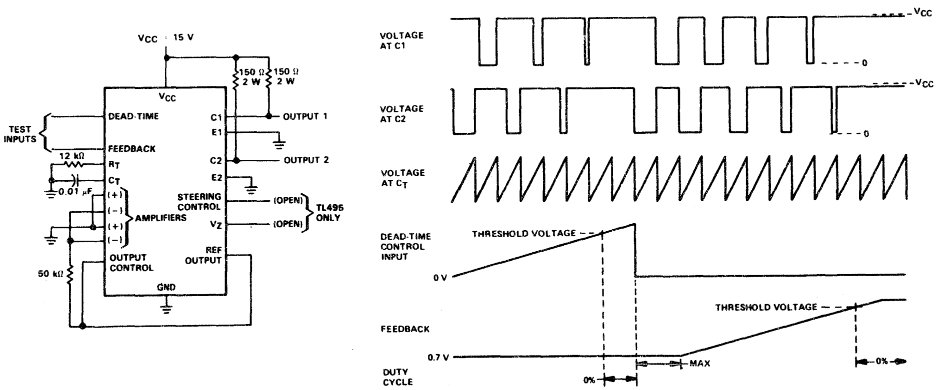


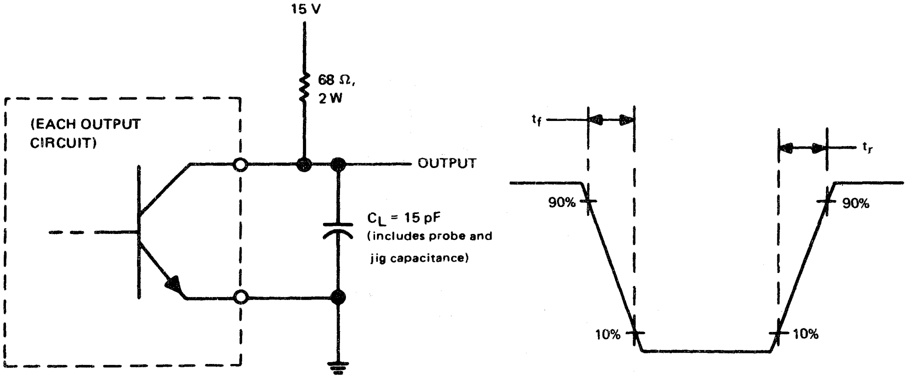
FIGURE 1 — AMPLIFIER CHARACTERISTICS



TEST CIRCUIT **VOLTAGE WAVEFORMS**

FIGURE 2 — DEAD-TIME AND FEEDBACK CONTROL

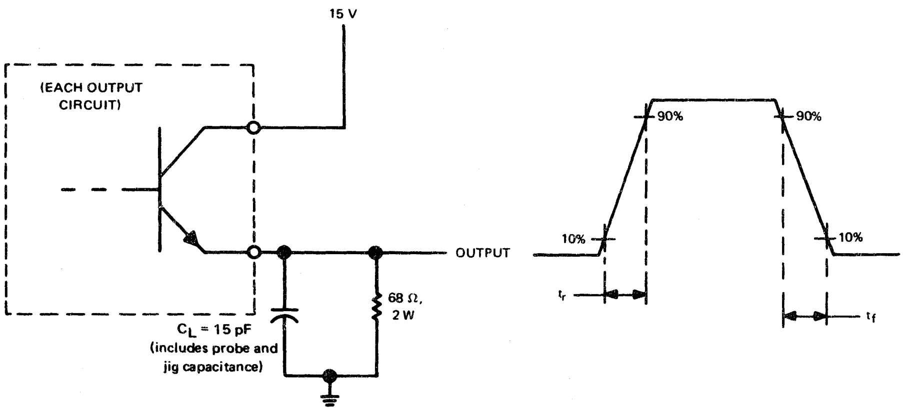
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

OUTPUT VOLTAGE WAVEFORM

FIGURE 3—COMMON-EMITTER CONFIGURATION



TEST CIRCUIT

OUTPUT VOLTAGE WAVEFORM

FIGURE 4—EMITTER-FOLLOWER CONFIGURATION

TYPICAL CHARACTERISTICS

OSCILLATOR FREQUENCY and
FREQUENCY VARIATION† vs
TIMING RESISTANCE

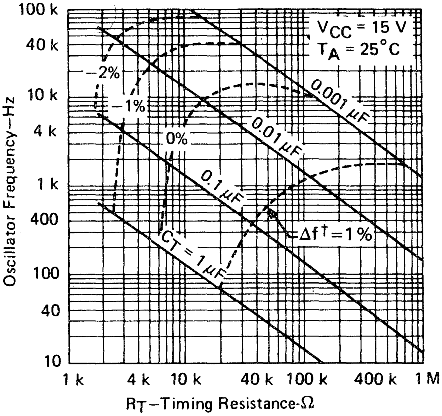


FIGURE 5

AMPLIFIER VOLTAGE AMPLIFICATION
vs
FREQUENCY

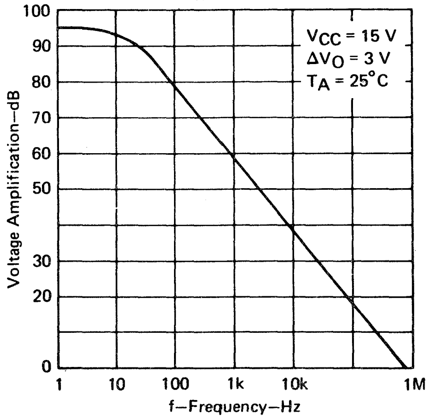


FIGURE 6

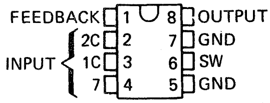
†Frequency variation (Δf) is the change in oscillator frequency that occurs over the full temperature range.

TYPE TL496C
9-VOLT POWER-SUPPLY CONTROLLER

D2486, AUGUST 1978—REVISED DECEMBER 1982

- Internal Step-Up Switching Regulator
- Fixed 9-Volt Output
- Charges Battery Source During Transformer-Coupled-Input Operation
- Minimum External Components Required (1 Inductor, 1 Capacitor, 1 Diode)
- 1- or 2-Cell-Input Operation

JG OR P
DUAL-IN-LINE PACKAGE
(TOP VIEW)



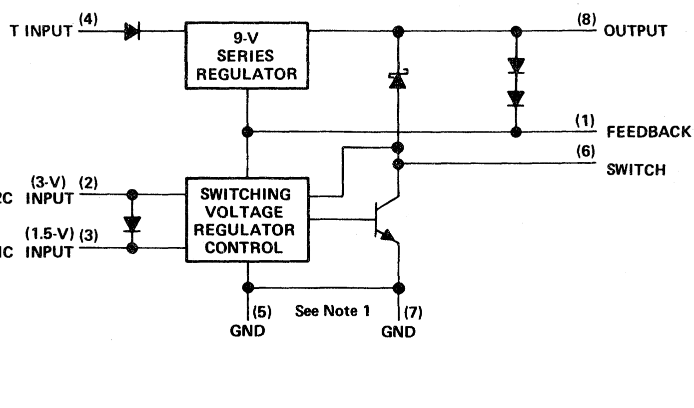
Pins 5 and 7 are connected together internally.

description

The TL496 power supply control circuit is designed to provide a 9-volt regulated supply from a variety of input sources. Operable from a 1- or 2-cell-battery input, the TL496 performs as a switching regulator with the addition of a single inductor and filter capacitor. When ac coupled with a step-down transformer, the TL496 operates as a series regulator to maintain the regulated output voltage and, with the addition of a single catch diode, time shares to recharge the input batteries.

The design of the TL496 allows minimal supply current drain during stand-by operation (125 μA typical). With most battery sources this allows a constant bias to be maintained on the power supply. This makes power instantly available to the system thus eliminating power-up sequencing problems.

functional block diagram



NOTE 1: Pins 5 and 7, though connected together internally, must both be terminated to ground to ensure proper circuit operation.

absolute maximum ratings

Input voltage:
- Pin 2 . . . 3.5 V
- Pin 3 . . . 2.5 V
- Pin 4 . . . 20 V

Output voltage (Pin 6) . . . 12 V
Diode reverse voltage (Pin 8) . . . 12 V
Switch current (Pin 6) . . . 1.2 A
Diode current (Pin 8) . . . 1.2 A
Operating free-air temperature range . . . 0°C to 70°C
Storage temperature range . . . −65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . 260°C

electrical characteristics at 25°C free-air temperature

series regulator section (input is pin 4)

PARAMETER	TEST CONDITIONS			MIN	TYP	MAX	UNIT
Dropout voltage	V_I = 5 V,	I_O = −50 mA			1.5	2	V
Regulated output voltage	V_I = 20 V		I_O = −50 μA	9.5	10.1	11.2	V
			I_O = −80 mA	9.0	10.0	11.0	
	V_I = 20 V, Pin 1 shorted to pin 8		I_O = −50 μA	8.5	9.0	9.7	
			I_O = −80 mA	6.7	8.6	9.5	
Standby current (pin 4)	V_I = 20 V,	Pin 8 at 12 V				400	μA
Reverse current thru pin 4	V_I = −1.5 V,	1 mA into Pin 8				−25	μA

output switch

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$V_{CE(sat)}$	Collector-emitter saturation voltage	800 mA into Pin 6,	Pin 2 at 2.25 V		0.35	0.6	V

diode (pin 6 to pin 8)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_F	Forward voltage	I_F = 1.5 A			1.6	2.5	V
I_R	Reverse current thru pin 6	Pin 6 at 0 V,	1 mA into Pin 8			−20	μA

control section

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
On-state current (pin 2)	Pins 1 and 8 at 0 V,	Pin 2 at 3 V		60	100	mA
Standby current (pin 1)	Pin 1 at 8.65 V,	Pins 2 and 6 at 3 V			40	μA
Standby current (pin 2 and 6)	Pin 1 at 8.65 V,	Pins 2 and 6 at 3 V			400	μA
Start-up current (current into pin 6 to initiate cycle)	Pins 1, 2, 6 and 8 at 2.25 V		16			mA

TYPICAL APPLICATION DATA

CIRCUIT COMPONENT INFORMATION

D1: 1N4001

C_F: 330 to 470 μF, 10 V, electrolytic

L: 40 to 50 μH, Q ≈ 3, R < 0.15 Ω

T1: V_{sec} = 6.8 V RMS typ., R_{sec} = 11 Ω typ.

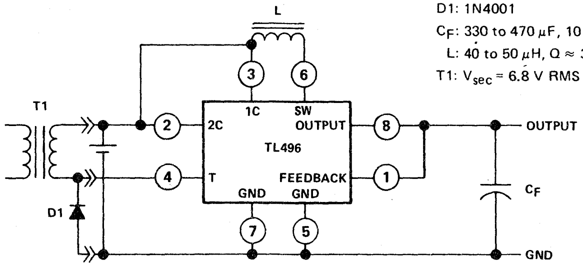


FIGURE 1—ONE-CELL OPERATION

CIRCUIT COMPONENT INFORMATION

D1: 1N4001

C_F: 330 to 470 μF, 10 V electrolytic

L: 40 to 50 μH, Q ≈ 3, R < 0.15 Ω

T1: V_{sec} = 6.8 V RMS typ., R_{sec} = 11 Ω typ.

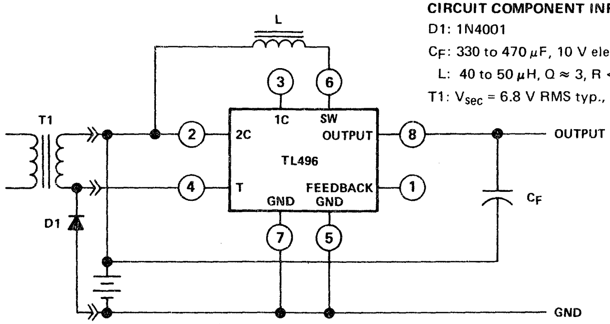


FIGURE 2—TWO-CELL OPERATION

2

recommended operating conditions

	MIN	MAX	UNIT
Input voltage, one-cell operation (pins 2 and 3 to ground)	1.1	1.5	V
Input voltage, two-cell operation (pin 2 to ground)	2.3	3	V
Input voltage, one-cell or two-cell operation (pin 4 to ground)	V_O+2	20	V

typical electrical characteristics for circuits above

PARAMETER		ONE-CELL OPERATION (FIGURE 1)	TWO-CELL OPERATION (FIGURE 2)
Input current	No load	125 uA	125 uA
	R_L = 120 Ω	525 mA	405 mA
Output voltage	Without T1	7.2 V	8.6 V
	With T1	8.6 V	10 V
Output current capability		40 mA	80 mA
Efficiency		66%	66%
Battery life (AA NiCad) no load		60 days	166 days

functional description

The TL496 is designed to operate from either a single-cell or two-cell source. To operate the device from a single cell (1.1 V to 1.5 V) the source must be connected to both inputs 1C and 2C as shown in Figure 1. For two-cell operation (2.3 V to 3.0 V), the input is applied to the 2C input only and the 1C input is left open (see Figure 2).

battery operation

The TL496 operates as a switching regulator from a battery input. The cycle is initiated when a low voltage condition is sensed by the internal feedback (the thresholds at pin 1 and pin 8 are approximately 7.2 and 8.6 volts respectively). An internal latch is set and the output transistor is turned "on." This causes the current in the external inductor (L) to increase linearly until it reaches a peak value of approximately 1 ampere. When the peak current is sensed the internal latch is reset and the output transistor is turned "off." The energy developed in the inductor is then delivered to the output storage capacitor through the blocking diode. The latch remains in the off state until the feedback signal indicates the output voltage is again deficient.

transformer-coupled operation

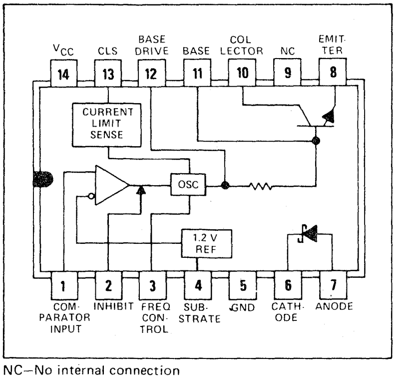
The TL496 operates on alternate half cycles of the ac input during transformer-coupled operation to, first, sustain the output voltage and, second, recharge the batteries. The TL496 performs like a series regulator to supply charge to the output filter/storage capacitor during the first half cycle. The output voltage of the series regulator is slightly higher voltage than that created by the switching circuit; this maintains the feedback voltage above the switching regulator control circuit threshold. This effectively inhibits the switching control circuitry. During the second half cycle an external diode (1N4001) is used to clamp the negative going end of the transformer secondary to ground thus allowing the positive-going end (end connected to V+ side of battery) to pump charge into the stand-by batteries.

TYPES TL497AM, TL497AI, TL497AC SWITCHING VOLTAGE REGULATORS

D2225, JUNE 1976—REVISED JANUARY 1983

- All Monolithic
- High Efficiency . . . 60% or Greater
- Output Current . . . 500 mA
- Input Current Limit Protection
- TTL Compatible Inhibit
- Adjustable Output Voltage
- Input Regulation . . . 0.2% Typ
- Output Regulation . . . 0.4% Typ
- Soft Start-up Capability

TL497AM . . . . J
TL497AI, TL497AC . . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)



NC—No internal connection

description

The TL497A incorporates on a single monolithic chip all the active functions required in the construction of a switching voltage regulator. It can also be used as the control element to drive external components for high-power-output applications. The TL497A was designed for ease of use in step-up, step-down, or voltage inversion applications requiring high efficiency.

A block diagram of the TL497A is shown in the above pinout. The TL497A is a fixed-on-time variable-frequency switching voltage regulator control circuit. The on time is programmed by a single external capacitor connected between the frequency control pin and ground. This capacitor, C_T, is charged by an internal constant-current generator to a predetermined threshold. The charging current and the threshold vary proportionally with V_{CC}, thus the on time remains constant over the specified range of input voltage (5 to 12 volts). Typical on times for various values of C_T are as follows:

TIMING CAPACITOR, C_T (pF)	200	250	350	400	500	750	1000	1500	2000
ON-TIME (μs)	19	22	26	32	44	56	80	120	180

The output voltage is controlled by an external resistor ladder network (R1 and R2 in Figures 1, 2, and 3) that provides a feedback voltage to the comparator input. This feedback voltage is compared to the reference voltage of 1.2 volts (relative to the substrate pin) by the high-gain comparator. When the output voltage decays below the value required to maintain 1.2 V at the comparator input, the comparator enables the oscillator circuit, which charges and discharges C_T as described above. The internal pass transistor is driven on during the charging of C_T. The internal transistor may be used directly for switching currents up to 500 milliamperes. Its collector and emitter are uncommitted and it is current driven to allow operation from the positive supply voltage or ground. An internal Schottky diode matched to the current characteristics of the internal transistor is also available for blocking or commutating purposes. The TL497A also has on-chip current-limit circuitry that senses the peak currents in the switching regulator and protects the inductor against saturation and the pass transistor against overstress. The current limit is adjustable and is programmed by a single sense resistor, R_{CL}, connected between pin 14 and pin 13. The current-limit circuitry is activated when 0.7 volt is developed across R_{CL}. External gating is provided by the inhibit input. When the inhibit input is high, the output is turned off.

Simplicity of design is a primary feature of the TL497A. With only six external components (three resistors, two capacitors, and one inductor), the TL497A will operate in numerous voltage conversion applications (step-up, step-down, invert) with as much as 85% of the source power delivered to the load. The TL497A replaces the TL497 in all applications.

The TL497AM is characterized for operation over the full military temperature range of −55°C to 125°C, the TL497AI is characterized for operation from −25°C to 85°C, and the TL497AC from 0°C to 70°C.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Input voltage, V_{CC} (see Note 1)	15 V
Output voltage	35 V
Comparator input voltage	5 V
Inhibit input voltage	5 V
Diode reverse voltage	35 V
Power switch current	750 mA
Diode forward current	750 mA
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 2)	1000 mW
Operating free-air temperature range: TL497AM	−55°C to 125°C
TL497AI	−25°C to 85°C
TL497AC	0°C to 70°C
Storage temperature range	−65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: N package	260°C

NOTES: 1. All voltage values except diode voltages are with respect to network ground terminal.
2. Above 28°C free-air temperature, derate the N package at the rate of 9.2 mW/°C. Above 41°C free-air temperature, derate the J glass-mounted package at the rate of 8.2 mW/°C. Above 59°C free-air temperature, derate the J alloy-mounted package at the rate of 11.0 mW/°C. In the J package, TL497AM chips are alloy-mounted; TL497AC chips are glass-mounted.

recommended operating conditions

	MIN	MAX	UNIT
Input voltage, V_I	4.5	12	V
Output voltage: step-up configuration (see Figure 1)	$V_I + 2$	30	V
step-down configuration (see Figure 2)	V_{ref}	$V_I - 1$	V
inverting regulator (see Figure 3)	$-V_{ref}$	−25	V
Power switch current		500	mA
Diode forward current		500	mA

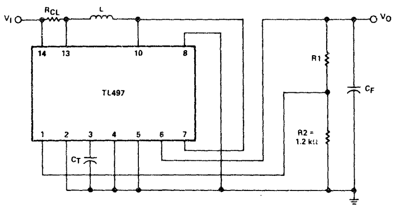
2

electrical characteristics at specified free-air temperature, V_I = 6 V (unless otherwise noted)

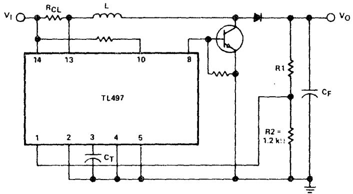
PARAMETER	TEST CONDITIONS†		TL497AM, TL497AI			TL497AC			UNIT
			MIN	TYP‡	MAX	MIN	TYP‡	MAX	
High-level inhibit input voltage		25°C	2.5			2.5			V
Low-level inhibit input voltage		25°C			0.8			0.8	V
High-level inhibit input current	$V_{I(I)}$ = 5 V	Full range		0.8	1.5		0.8	1.5	mA
Low-level inhibit input current	$V_{I(I)}$ = 0 V	Full range		5	20		5	10	µA
Comparator reference voltage	V_I = 4.5 V to 6 V	Full range	1.14	1.20	1.26	1.08	1.20	1.32	V
Comparator input bias current	V_I = 6 V	Full range		40	100		40	100	µA
Switch on-state voltage	V_I = 4.5 V, I_O = 100 mA	25°C		0.13	0.2		0.13	0.2	V
	V_I = 4.5 V, I_O = 500 mA	Full range			1			0.85	
Switch off-state current	V_I = 4.5 V, V_O = 30 V	25°C		10	50		10	50	µA
		Full range			500			200	
Current-limit sense voltage	V_I = 6 V	25°C	0.45		1	0.45		1	V
Diode forward voltage	I_O = 10 mA	Full range		0.75	0.95		0.75	0.85	V
	I_O = 100 mA	Full range		0.9	1.1		0.9	1	
	I_O = 500 mA	Full range		1.33	1.75		1.33	1.55	
Diode reverse voltage	I_O = 500 µA	Full range	30						V
	I_O = 200 µA	Full range				30			
On-state supply current		25°C		11	14		11	14	mA
		Full range			16			15	
Off-state supply current		25°C		6	9		6	9	mA
		Full range			11			10	

† Full range for TL497AM is −55°C to 125°C, for TL497AI is −25°C to 85°C, and for TL497AC is 0°C to 70°C.
‡ All typical values are at T_A = 25°C.

TYPICAL APPLICATION DATA



BASIC CONFIGURATION
(I_{PK} < 500 mA)



EXTENDED POWER CONFIGURATION
(USING EXTERNAL TRANSISTOR)

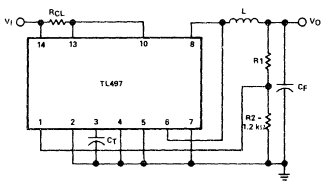
DESIGN EQUATIONS

- $I_{PK} = 2\, I_O \max \left[\frac{V_O}{V_I}\right]$
- $L\,(\mu H) = \frac{V_I}{I_{PK}}\, t_{on}(\mu s)$

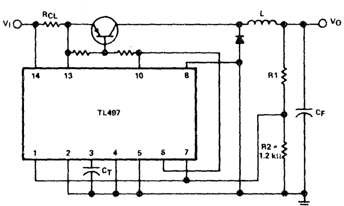
Choose L (50 to 500 μH), calculate t_{on} (25 to 150 μs)

- $C_T(pF) \approx 12\, t_{on}(\mu s)$
- $R1 = (V_O - 1.2)\ k\Omega$
- $R_{CL} = \frac{0.5\ V}{I_{PK}}$
- $C_F\,(\mu F) \approx t_{on} \frac{\left[\frac{V_I}{V_O} I_{PK} + I_O\right]}{V_{ripple\,(PK)}}$

FIGURE 1—POSITIVE REGULATOR, STEP-UP CONFIGURATIONS



BASIC CONFIGURATION
I_{PK} < 500 mA)



EXTENDED POWER CONFIGURATION
(USING EXTERNAL TRANSISTOR)

DESIGN EQUATIONS

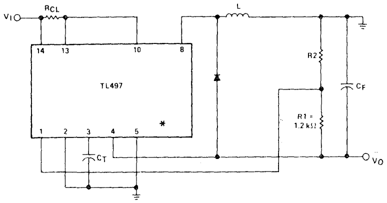
- $I_{PK} = 2\, I_O \max$
- $L\,(\mu H) = \frac{V_I - V_O}{I_{PK}}\, t_{on}(\mu s)$

Choose L (50 to 500 μH), calculate t_{on} (10 to 150 μs)

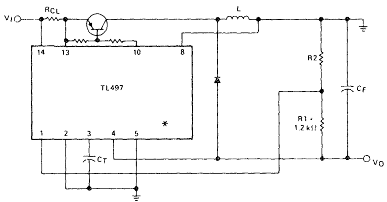
- $C_T(pF) \approx 12\, t_{on}(\mu s)$
- $R1 = (V_O - 1.2)\ k\Omega$
- $R_{CL} = \frac{0.5\ V}{I_{PK}}$
- $C_F\,(\mu F) \approx t_{on} \frac{\left[\frac{V_I}{V_O} I_{PK} + I_O\right]}{V_{ripple\,(PK)}}$

FIGURE 2—POSITIVE REGULATOR, STEP-DOWN CONFIGURATIONS

TYPICAL APPLICATION DATA



BASIC CONFIGURATION
($I_{PK} < 500$ mA)



EXTENDED POWER CONFIGURATION
(USING EXTERNAL TRANSISTOR)

- $I_{PK} = 2\, I_O \max \left[1 + \frac{|V_O|}{V_I}\right]$
- $L\ (\mu H) = \frac{V_I}{I_{PK}}\, t_{on}(\mu s)$

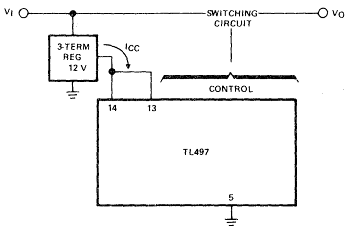
Choose L (50 to 500 μH), calculate t_{on} (25 to 150 μs)

- $C_T(\text{pF}) \approx 12\ t_{on}(\mu s)$
- $R2 = (V_O - 1.2)\ k\Omega$
- $R_{CL} = \frac{0.5\ V}{I_{PK}}$
- $C_F\ (\mu F) \approx \frac{\left[\frac{V_I}{V_O}\ I_{PK} + I_O\right]}{V_{ripple\ (PK)}}$

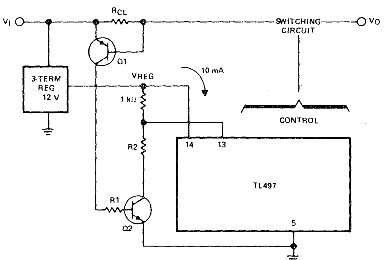
*Use external catch-diode, e.g., 1N4001, when building an inverting supply with the TL497A.

FIGURE 3–INVERTING APPLICATIONS

2



EXTENDED INPUT CONFIGURATION WITHOUT CURRENT LIMIT



DESIGN EQUATIONS

$$R_{CL} = \frac{V_{BE(Q1)}}{I_{limit\ (PK)}}$$

$$R1 = \frac{V_I}{I_{B(Q2)}}$$

$$R2 = (V_{reg} - 1)\ 10\ k\Omega$$

CURRENT LIMIT FOR EXTENDED INPUT CONFIGURATION

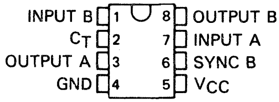
FIGURE 4–EXTENDED INPUT VOLTAGE RANGE ($V_I > 15$ V)

TYPES TL580C
MICROPOWER DUAL SWITCHING REGULATOR

D2723, MARCH 1983

- **High Efficiency . . . 80% Typ**
- **Low Bias Current . . . 140 μA**
- **Two Channels, Each with Output Voltage Adjustment**
  Channel A: Output Voltage 2.5 V to 24 V
  Output Current 100 mA
  Channel B: Output Voltage 2.5 V to 24 V
  Output Current 1.8 mA
- **Special Multifunctional Operation-Select Pin**

JG OR P
DUAL-IN-LINE PACKAGE
(TOP VIEW)



description

The TL580 is a monolithic, micropower, dual-switching regulator designed for use in battery applications. The output voltage of each channel is adjustable. Floating the special pin, SYNC B, causes Channel B to be synchronized to the oscillator in the same manner as Channel A. Shorting SYNC B to ground blocks the oscillator from Channel B, then Channel B becomes a single-input comparator for low-battery indicator detection.

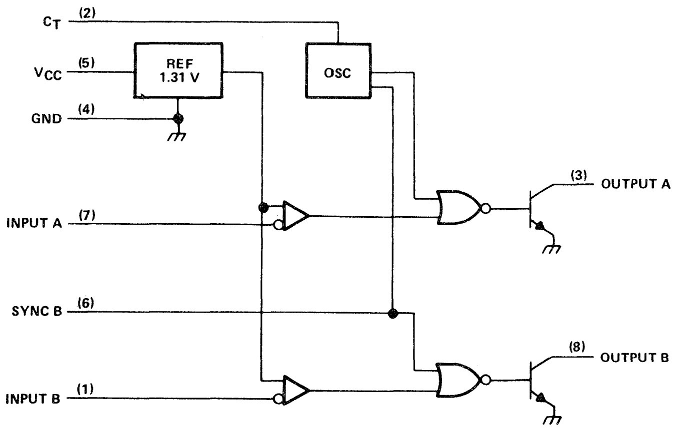
Both Channel A and Channel B are referenced to a band-gap generator. An external capacitor on the C_T input (Pin 2) sets the oscillator frequency between 100 hertz and 160 kilohertz.

The TL580C can attain up to 80-percent efficiency while operating over a supply voltage range of 2.4 volts to 30 volts at an ultralow bias current of 140 microamperes.

The TL580C is characterized for operation from 0°C to 70°C.

2

functional block diagram (positive logic)



TEXAS INSTRUMENTS

2

TYPES TL593, TL594, TL595
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

D2712, APRIL 1983

- Complete PWM Power Control Circuitry
- Uncommitted Outputs for 200-mA Sink or Source Current
- Output Control Selects Single-Ended or Push-Pull Operation
- Internal Circuitry Prohibits Double Pulse at Either Output
- Variable Dead-Time Provides Control Over Total Range
- Internal Regulator Provides a Stable 5-V Reference Supply Trimmed to 1%
- Circuit Architecture allows Easy Synchronization
- Under-Voltage Lockout for Low V_{CC} Conditions
- TL593 has Output Current-Limit Sensing
- TL595 has On-Chip 39-V Zener and External Control of Output Steering
- Improved Direct Replacements for TL493, TL494, and TL495

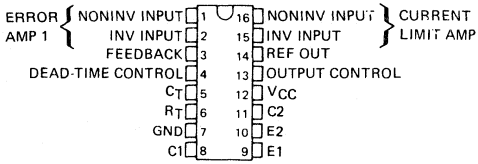
description

The TL593, TL594, and TL595 devices, each incorporate on a single monolithic chip all the functions required in the construction of a pulse-width-modulation control circuit. Designed primarily for power supply control, these devices offer the systems engineer the flexibility to tailor the power supply control circuitry to his application. The TL593, TL594, and TL595 are improved direct replacements for the TL493, TL494, and TL495.

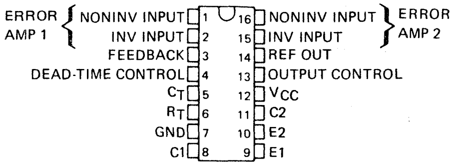
The TL593 contains an error amplifier, current-limiting amplifier, an on-chip adjustable oscillator, a dead-time control comparator, pulse-steering control flip-flop, 5-volt regulator with a precision of 1%, an under-voltage lockout control circuit, and output control circuitry.

The error amplifier exhibits a common-mode voltage range from −0.3 volts to V_{CC} −2 volts. The current-limit amplifier exhibits a common-mode voltage range from −0.3 volts to V_{CC} −6 volts with an offset voltage of approximately 80 millivolts in series with the inverting input to ease circuit design requirements. The dead-time control comparator has a fixed offset that provides approximately 5% dead time when externally altered. The on-chip oscillator may be bypassed by terminating R_T (pin 6) to the reference output and providing a sawtooth input to C_T (pin 5), or it may be used to drive the common circuitry in synchronous multiple-rail power supplies.

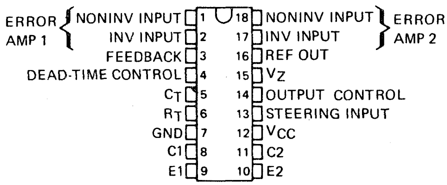
TL593M . . . J
TL593I, TL593C . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)



TL594M . . . J
TL594I, TL594C . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)



TL595I, TL595C . . . J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)



DEVICE TYPES, SUFFIX VERSIONS, AND PACKAGES

	TL593	TL594	TL595
TL59—M	J	J	*
TL59—I	J,N	J,N	J,N
TL59—C	J,N	J,N	J,N

*These combinations are not defined by this data sheet.

FUNCTION TABLE

INPUTS		OUTPUT FUNCTION
OUTPUT CONTROL	STEERING INPUT (TL595 only)	
V_I < 0.4 V	Open	Single ended or parallel output
V_I > 2.4 V	Open	Normal push-pull operation
V_I > 2.4 V	V_I < 0.4 V	PWM Output at Q1
V_I > 2.4 V	V_I < 2.4 V	PWM Output at Q2

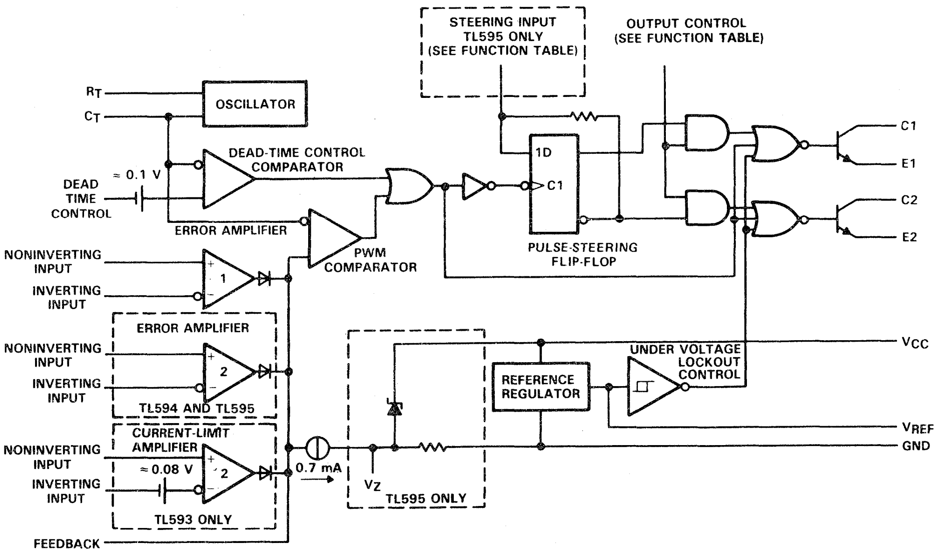
description (continued)

The uncommitted output transistors provide either common-emitter or emitter-follower output capability. Each device provides for push-pull or single-ended output operation with selection by means of the output-control function. The architecture of these devices prohibits the possibility of either output being pulsed twice during push-pull operation. The under-voltage lockout control circuit locks the outputs off until the internal circuitry is operational.

The TL593 and TL594 are similar except that an additional error amplifier is included in the TL594 instead of a current-limiting amplifier. The TL595 provides the identical functions found in the TL594. In addition, the TL595 also contains an on-chip 39-volt zener diode for high-voltage applications where V_{CC} is greater than 40 volts, and an output steering control that overrides the internal control of the pulse-steering flip-flop.

The TL593M and TL594M are characterized for operation over the full military temperature range from −55 °C to 125 °C. The TL593I, TL594I, and TL595I are characterized for operation from −25 °C to 85 °C. The TL593C, TL594C, and TL595C are characterized for operation from 0 °C to 70 °C.

functional block diagram



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

	TL593M TL594M	TL593I TL594I TL595I	TL593C TL594C TL595C	UNIT
Supply voltage, V_{CC} (see Note 10	41	41	41	V
Amplifier input voltages	$V_{CC}+0.3$	$V_{CC}+0.3$	$V_{CC}+0.3$	V
Collector output voltage	41	41	41	V
Collector output current	250	250	250	mA
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 2)	1000	1000	1000	mW
Operating free-air temperature range	−55 to 125	−25 to 85	0 to 70	°C
Storage temperature range	−65 to 150	−65 to 150	−65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package	300	300	300	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: N package		260	260	°C

NOTES: 1. All voltage values, except differential voltages, are with respect to the network ground terminal.
2. For operation above 25°C free-air temperature, refer to Dissipation Derating Table. In the J package, the TL593M and TL594M chips are alloy-mounted; TL593I, TL593C, TL594I, TL594C, TL595I, and TL595C chips are glass mounted.

DISSIPATION DERATING TABLE

PACKAGE	POWER RATING	DERATING FACTOR	ABOVE T_A
J (Alloy-Mounted Chip)	1000 mW	11.0 mW/°C	59°C
J (Glass-Mounted Chip)	1000 mW	8.2 mW/°C	28°C
N	1000 mW	9.2 mW	41°C

2

recommended operating conditions

	TL593M TL594M		TL593I TL594I TL595I		TL593C TL594C TL595C		UNIT
	MIN	MAX	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}	7	40	7	40	7	40	V
Amplifier input voltages, V_I	−0.3	$V_{CC}-2$	−0.3	$V_{CC}-2$	−0.3	$V_{CC}-2$	V
Collector output voltage, V_O		40		40		40	V
Collector output current (each transistor)		200		200		200	mA
Current into feedback terminal		0.3		0.3		0.3	mA
Timing capacitor, C_T	0.47	10 000	0.47	10 000	0.47	10 000	nF
Timing resistor, R_T	1.8	500	1.8	500	1.8	500	kΩ
Oscillator frequency	1	300	1	300	1	300	kHz
Operating free-air temperature, T_A	−55	125	−25	85	0	70	°C

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 15 V, f = 10 kHz (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS†	TL593M TL594M			TL593I, TL593C TL594I, TL594C TL595I, TL595C			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Output voltage (V_{ref})	I_O = 1 mA, T_A = 25°C	4.95	5	5.05	4.95	5	5.05	V
Input regulation	V_{CC} = 7 V to 40 V, T_A = 25°C		2	25		2	25	mV
Output regulation	I_O = 1 to 10 mA, T_A = 25°C		14	35		14	35	mV
Output voltage change with temperature	ΔT_A = MIN to MAX		0.2	1		0.2	1	%
Short-circuit output current§	V_{ref} = 0	10	35	60	10	35	50	mA

oscillator section, C_T = 0.01 μF, R_T = 12 kΩ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	TL593M TL594M			TL593I, TL593C TL594I, TL594C TL595I, TL595C			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Frequency			10			10		kHz
Standard deviation of frequency¶	All values of V_{CC}, C_T, R_T, T_A constant		10			10		%
Frequency change with voltage	V_{CC} = 7 V to 40 V, T_A = 25°C		0.1			0.1		%
Frequency change with temperature	ΔT_A = MIN to MAX			4			2	%

amplifier sections (see figure 1)

PARAMETER		TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Input offset voltage	Error	Feedback pin at 2.5 V		2	10	mV
	current-limit (TL593 only)			80		
Input offset current		Feedback control at 2.5 V		25	250	nA
Input bias current		Feedback control at 2.5 V		0.2	1	μA
Common-mode input voltage range	Error	V_{CC} = 7 V to 40 V	−0.3 to $V_{CC}-2$			V
	Current-limit (TL593 only)		−0.3 to $V_{CC}-6$			
Open-loop voltage amplification	Error	ΔV_O = 3 V, V_O = 0.5 V to 3.5 V	70	95		dB
	Current-limit (TL593 only)			90		
Unity-gain bandwidth				800		kHz
Common-mode rejection ratio	Error	V_{CC} = 40 V, T_A = 25°C	65	80		dB
	Current-limit (TL593 only)			70		
Output sink current (pin 3)		V_{ID} = −15 mV to −5 V, Feedback control at 0.5 V	0.3	0.7		mA
Output source current (pin 3)		V_{ID} = 15 mV to 5 V, Feedback at 3.5 V	−2			mA

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡All typical values except for parameter changes with temperature are at T_A = 25°C.
§Duration of the short-circuit should not exceed one second.
¶Standard deviation is a measure of the statistical distribution about the mean as derived from the formula $\sigma = \sqrt{\frac{\sum_{n=1}^{N} (x_n - \bar{X})^2}{N - 1}}$

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 15 V, f = 10 kHz (unless otherwise noted)

dead-time control section (see figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Input bias current (pin 4)	V_I = 0 to 5.25 V		−2	−10	μA
Maximum duty cycle, each output	Dead-time control at 0 V	45			%
Input threshold voltage (pin 4)	Zero duty cycle		3	3.3	V
	Maximum duty cycle	0			

output section

PARAMETER		TEST CONDITIONS	TL593M TL594M			TL593I, TL593C TL594I, TL594C TL595I, TL595C			UNIT
			MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Collector off-state current		V_{CE} = 40 V, V_{CC} = 40 V		2	100		2	100	μA
		V_C = 15 V, V_E = 0 V, V_{CC} = 1 to 3 V, Dead-time and output control pins at 0 V		4	200		4	200	
Emitter off-state current		V_{CC} = V_C = 40 V, V_E = 0			−150			−100	μA
Collector-emitter saturation voltage	Common-emitter	V_E = 0, I_C = 200 mA		1.1	1.5		1.1	1.3	V
	Emitter-follower	V_C = 15 V, I_E = −200 mA		1.5	2.5		1.5	2.5	
Output control input current		V_I = V_{ref}			3.5			3.5	mA

pwm comparator section (see figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Input threshold voltage (pin 3)	Zero duty cycle		4	4.5	V
Input sink current (pin 3)	$V_{(pin\ 3)}$ = 0.5 V	0.3	0.7		mA

2

under-voltage lockout section

PARAMETER	TEST CONDITIONS†	TL593M TL594M			TL593I, TL593C TL594I, TL594C TL595I, TL595C			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
Threshold voltage	T_A = 25°C			6			6	V
	ΔT_A = MIN to MAX	3		6.9	3.5		6.9	
Hysteresis§		30			100			mV

total device

PARAMETER	TEST CONDITIONS		MIN	TYP‡	MAX	UNIT
Standby supply current	Pin 6 at V_{ref}, All other inputs and outputs open	V_{CC} = 15 V		9	15	mA
		V_{CC} = 40 V		11	18	
Average supply current	Dead-time Control at 2 V, See Figure 2			12.4		mA

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡All typical values except for parameter changes with temperature are at T_A = 25°C.
§Hysteresis is the difference between the posditive-going input threshold voltage and the negative-going input threshold voltage.

switching characteristics, $T_A = 25°C$

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Output voltage rise time	Common-emitter configuration,		100	200	ns
Output voltage fall time	See Figure 3		30	100	
Output voltage rise time	Emitter-follower configuration,		200	400	ns
Output voltage fall time	See Figure 4		45	100	

‡All typical values are at $T_A = 25°C$.

PARAMETER MEASUREMENT INFORMATION

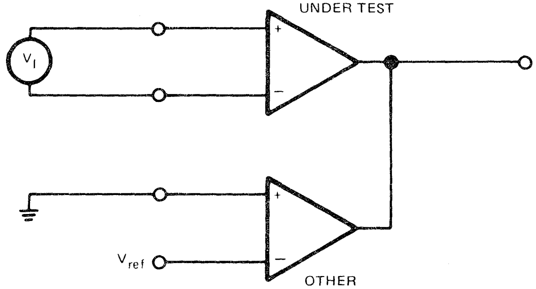
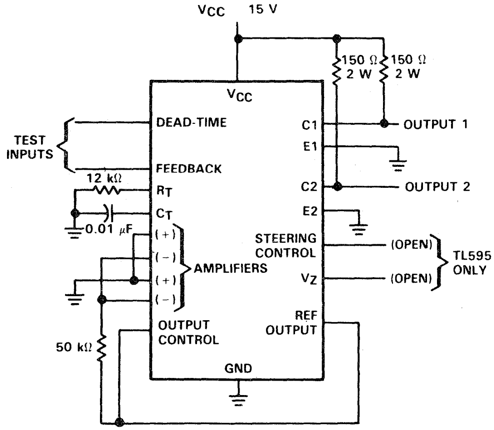


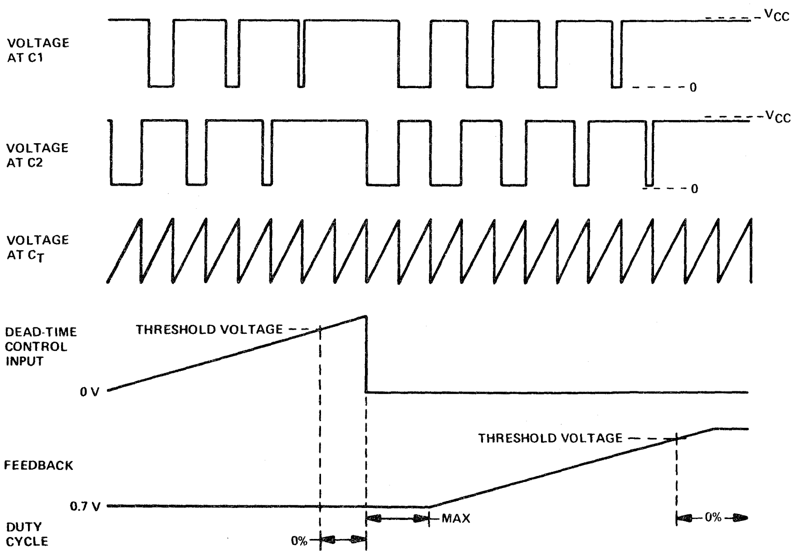
FIGURE 1 — AMPLIFIER CHARACTERISTICS

2

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

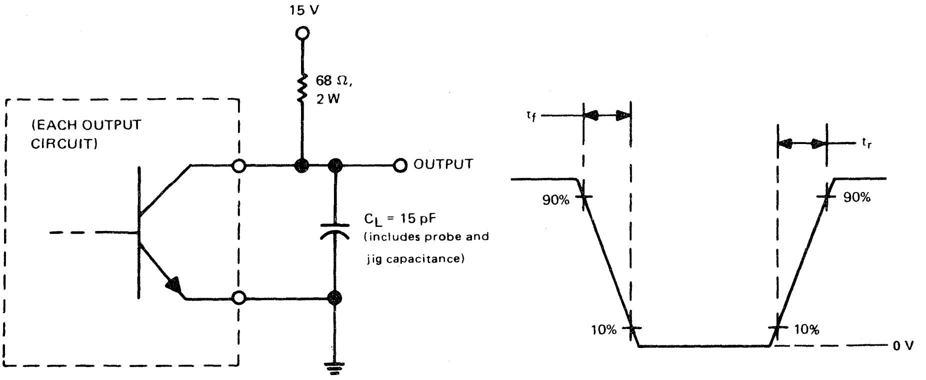


VOLTAGE WAVEFORMS

FIGURE 2 — DEAD-TIME AND FEEDBACK CONTROL

2

PARAMETER MEASUREMENT INFORMATION

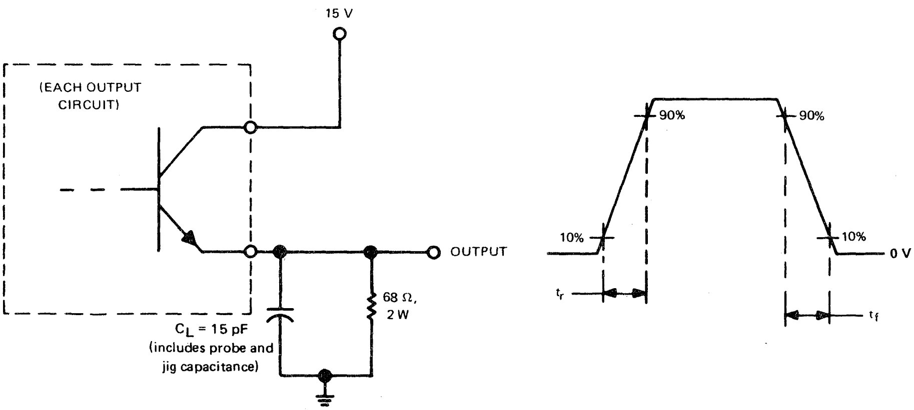


TEST CIRCUIT

OUTPUT VOLTAGE WAVEFORM

FIGURE 3—COMMON-EMITTER CONFIGURATION

2



TEST CIRCUIT

OUTPUT VOLTAGE WAVEFORM

FIGURE 4—EMITTER-FOLLOWER CONFIGURATION

TYPICAL CHARACTERISTICS

OSCILLATOR FREQUENCY and FREQUENCY VARIATION† vs TIMING RESISTANCE

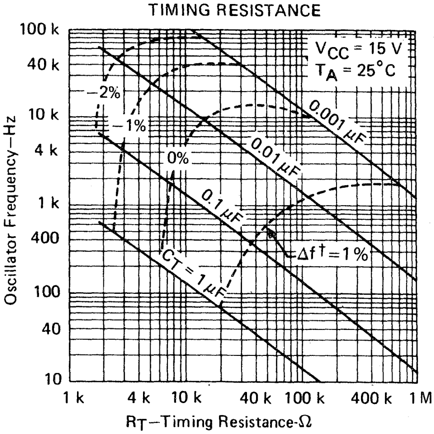


FIGURE 5

AMPLIFIER VOLTAGE AMPLIFICATION vs FREQUENCY

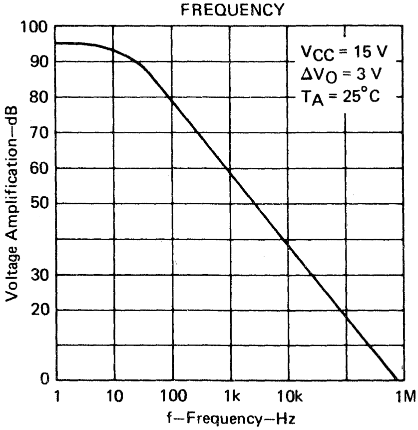


FIGURE 6

†Frequency variation (Δf) is the change in oscillator frequency that occurs over the full temperature range.

2

SERIES TL780
POSITIVE VOLTAGE REGULATORS

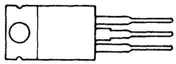
D2643, APRIL 1981

- ±1% Output tolerance at 25°C
- ±2% Output Tolerance Over Full Operating Range
- Thermal Shutdown
- Internal Short-Circuit Current Limiting
- Pinout Identical to uA7800 Series

NOMINAL OUTPUT VOLTAGE	REGULATOR
5 V	TL780-05C
12 V	TL780-12C
15 V	TL780-15C

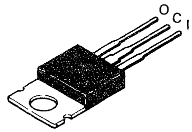
KC PACKAGE

(TOP VIEW)



THE COMMON TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

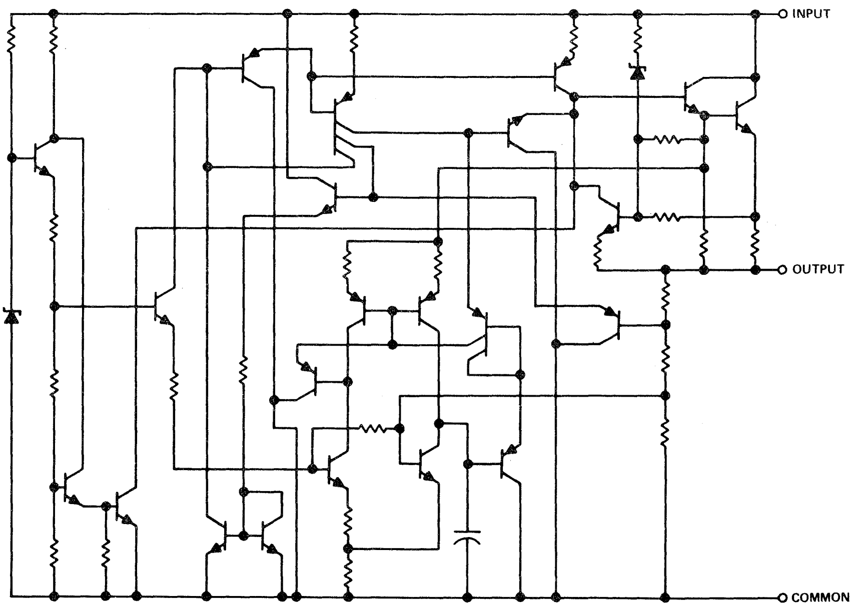
TO-220AB



description

Each fixed-voltage precision regulator in this series is capable of supplying 1.5 amperes of load current. A unique temperature-compensation technique coupled with an internally trimmed bandgap reference has resulted in improved accuracy when compared to other three-terminal regulators. Advanced layout techniques provide excellent line, load, and thermal regulation. The internal current limiting and thermal shutdown features make the devices essentially immune to overload.

schematic



2

absolute maximum ratings over operating temperature range (unless otherwise noted)

Input voltage	35 V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	15 W
Operating free-air, case, or virtual junction temperature range	0 to 150°C
Storage temperature range	−65 to 150°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds	260°C

NOTE 1: For operation above 25° free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activitated at power levels slightly above or below the rated dissipation.

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

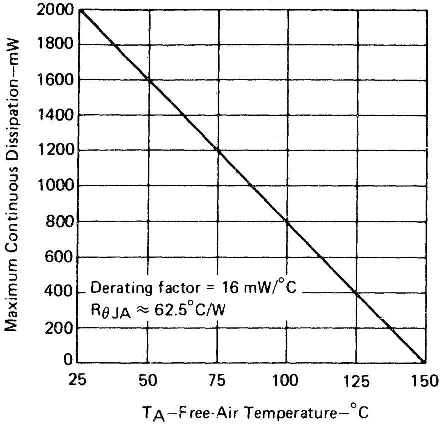


FIGURE 1

CASE TEMPERATURE
DISSIPATION DERATING CURVE

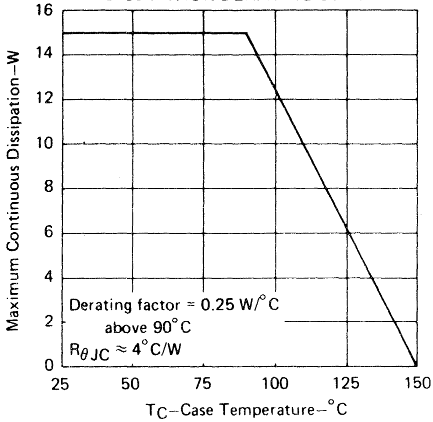


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	TL780-05C	7	25	V
	TL780-12C	14.5	30	
	TL780-15C	17.5	30	
Output current, I_O			1.5	A
Operating virtual junction temperature, T_J		0	125	°C

TL780-05C electrical characteristics at specified virtual junction temperature, V_I = 10 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	I_O = 5 mA to 1 A, P ≤ 15 W V_I = 7 V to 20 V	25°C	4.95	5	5.05	V
		0°C to 125°C	4.9		5.1	
Input regulation	V_I = 7 V to 25 V	25°C		0.5	5	mV
	V_I = 8 V to 12 V			0.5	5	
Ripple rejection	V_I = 8 V to 18 V, f = 120 Hz	0°C to 125°C	70	85		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		4	25	mV
	I_O = 250 mA to 750 mA			1.5	15	
Output resistance	f = 1 kHz	0°C to 125°C		0.0035		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		0.25		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		75		μV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		5	8	mA
Bias current change	V_I = 7 V to 25 V	0°C to 125°C		0.7	1.3	mA
	I_O = 5 mA to 1 A			0.03	0.5	
Short-circuit output current	V_I = 35 V	25°C		750		mA
Peak output current		25°C		2.2		A

TL780-12C electrical characteristics at specified virtual junction temperature, V_I = 19 V, I_O = 500 mA (unless otherwise noted)

2

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	I_O = 5 mA to 1 A, P ≤ 15 W V_I = 14.5 V to 27 V	25°C	11.88	12	12.12	V
		0°C to 125°C	11.76		12.24	
Input regulation	V_I = 14.5 V to 30 V	25°C		1.2	12	mV
	V_I = 16 V to 22 V			1.2	12	
Ripple rejection	V_I = 15 V to 25 V f = 120 Hz	0°C to 125°C	65	80		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		6.5	60	mV
	I_O = 250 mA to 750 mA			2.5	36	
Output resistance	f = 1 kHz	0°C to 125°C		0.0035		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		0.6		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		180		μV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		5.5	8	mA
Bias current change	V_I = 14.5 V to 30 V	0°C to 125°C		0.4	1.3	mA
	I_O = 5 mA to 1 A			0.03	0.5	
Short-circuit output current	V_I = 35 V	25°C		350		mA
Peak output current		25°C		2.2		A

† All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.22 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_W ≤ 10 ms, duty cycles ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

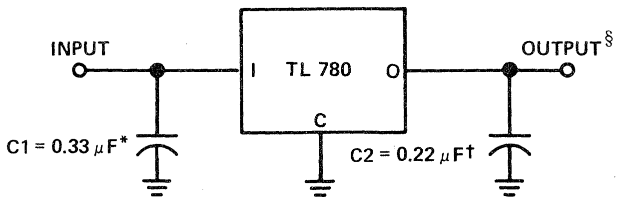
TL780-15C electrical characteristics at specified virtual junction temperature, V_I = 23 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage	I_O = 5 mA to 1 A, P ≤ 15 W, V_I = 17.5 V to 30 V	25°C	14.85	15	15.15	V
		0°C to 125°C	14.7		15.3	
Input regulation	V_I = 17.5 V to 30 V	25°C		1.5	15	mV
	V_I = 20 V to 26 V			1.5	15	
Ripple rejection	V_I = 18.5 V to 28.5 V, f = 120 Hz	0°C to 125°C	60	75		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		7	75	mV
	I_O = 250 mA to 750 mA			2.5	45	
Output resistance	f = 1 kHz	0°C to 125°C		0.0035		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		0.62		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		225		μV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		5.5	8	mA
Bias current change	V_I = 17.5 V to 30 V	0°C to 125°C		0.4	1.3	mA
	I_O = 5 mA to 1 A			0.02	0.5	
Short-circuit output current	V_I = 35 V	25°C		230		mA
Peak output current		25°C		2.2		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.22 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

TYPICAL APPLICATION DATA



*C1 required if regulator is far from power supply filter.
†C2 not required for stability, however transient response is improved
§Permanent damage can occur if output is pulled below ground.

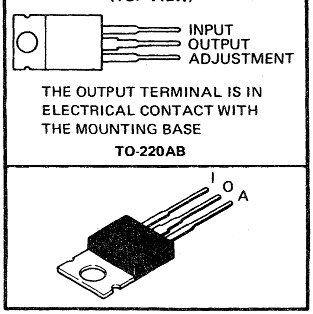
TYPE TL783C
HIGH-VOLTAGE ADJUSTABLE REGULATOR

D2659, SEPTEMBER 1981—REVISED JANUARY 1983

- Output Adjustable From 1.25 V To 125-Volt
- 700 mA Output Current
- Full Short-Circuit, Safe-Operating-Area, and Thermal Shutdown Protection
- 0.001 %/V Typical Input Regulation
- 0.15% Typical Output Regulation
- 76 dB Typical Ripple Rejection
- Standard TO-220AB Package

KC PACKAGE

(TOP VIEW)



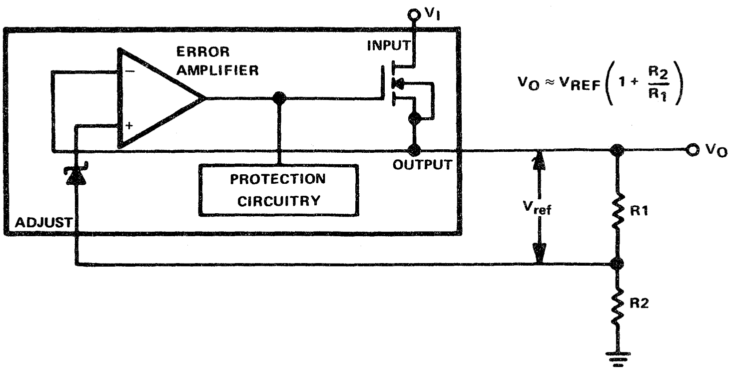
description

The TL783 is an adjustable 3-terminal positive-voltage regulator with an output range of 1.25 volts to 125 volts and a DMOS output transistor capable of sourcing more than 700 milliamperes. It is designed for use in high-voltage applications where standard bipolar regulators cannot be used. Excellent performance specifications . . . superior to those of most bipolar regulators . . . are achieved through circuit design and advanced layout techniques.

As a state-of-the-art regulator, the TL783 combines standard bipolar circuitry with high-voltage double-diffused MOS transistors on one chip to yield a device capable of withstanding voltages far higher than standard bipolar integrated circuits. Because of its lack of secondary breakdown and thermal runaway characteristics usually associated with bipolar outputs, the TL783 maintains full overload protection while operating at up to 125 volts from input to output. Other features of the device include current limiting, safe-operating-area (SOA) protection, and thermal shutdown. Even if the adjustment pin is inadvertently disconnected, the protection circuitry remains functional.

Only two external resistors are required to program the output voltage. An input bypass capacitor is necessary only when the regulator is situated far from the input filter. An output capacitor, although not required, will improve transient response and protection from instantaneous output short-circuits. Excellent ripple rejection can be achieved without a bypass capacitor at the adjustment terminal.

functional block diagram



absolute maximum ratings over operating temperature range (unless otherwise noted)

Input-to-output differential voltage, $V_I - V_O$	125 V
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	20 W
Operating free-air, case, or virtual junction temperature range	0°C to 150°C
Lead temperature 1/16 inch (1,6 mm) from case for 10 seconds	260°C

NOTE 1: For operation above 25° free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activitated at power levels slightly above or below the rated dissipation.

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

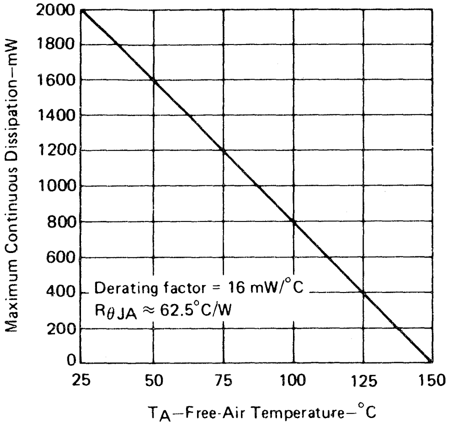


FIGURE 1

CASE TEMPERATURE
DISSIPATION DERATING CURVES

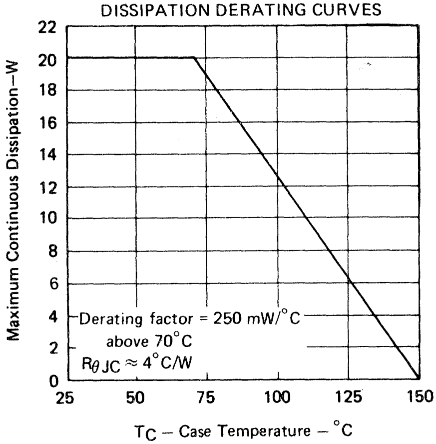


FIGURE 2

recommended operating conditions

	MIN	MAX	UNIT
Input-to-output voltage differential, $V_I - V_O$		125	V
Output current, I_O	15	700	mA
Operating virtual junction temperature, T_J	0	125	°C

electrical characteristics at $V_I - V_O = 25$ V, $I_O = 0.5$ A, $T_J = 0°C$ to $125°C$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			MIN	TYP	MAX	UNIT
Input regulation‡	$V_I - V_O = 20$ V to 125 V		$T_J = 25°C$		0.001	0.01	%/V
			$T_J = 0°C$ to $125°C$		0.004	0.02	
Ripple rejection	$\Delta V_{I(p-p)} = 10$ V,	$V_O = 10$ V,	f = 120 Hz	66	76		dB
Output regulation	$I_O = 15$ mA to 700 mA,	$T_J = 25°C$	$V_O \leq 5$ V		7.5	25	mV
			$V_O \geq 5$ V		0.15	0.5	%
	$I_O = 15$ mA to 700 mA		$V_O \leq 5$ V		20	70	mV
			$V_O \geq 5$ V		0.3	1.5	%
Output voltage change with temperature					0.4		%
Output voltage long-term drift	1000 h at $T_J = 125°C$, See Note 2	$V_I - V_O = 125$ V,			0.2		%
Output noise voltage	f = 10 Hz to 10 kHz,	$T_J = 25°C$			0.003		%
Minimum output current to maintain regulation	$V_I - V_O = 125$ V					15	mA
Peak output current	$V_I - V_O = 25$ V,	t = 1 ms			1100		mA
	$V_I - V_O = 15$ V,	t = 30 ms			715		
	$V_I - V_O = 25$ V,	t = 30 ms		700	900		
	$V_I - V_O = 125$ V,	t = 30 ms		100	250		
Adjustment-terminal current					83	110	μA
Change in adjustment-terminal current	$V_I - V_O = 15$ V to 125 V,	$I_O = 15$ mA to 700 mA,	P ≤ rated dissipation		0.5	5	μA
Reference voltage (output to ADJ)	$V_I - V_O = 10$ V to 125 V,	$I_O = 15$ mA to 700 mA,	P ≤ rated dissipation	1.2	1.27	1.3	V

†All characteristics except noise voltage and ripple rejection are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle ≤ 5%) to limit changes in average internal dissipation. Output voltage changes due to large changes in internal dissipation must be taken into account separately.

‡Input regulation is expressed here as the percentage change in output voltage per 1-volt change at the input.

NOTE 2: Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

TYPICAL CHARACTERISTICS

OUTPUT CURRENT LIMIT
vs
INPUT-TO-OUTPUT VOLTAGE DIFFERENTIAL

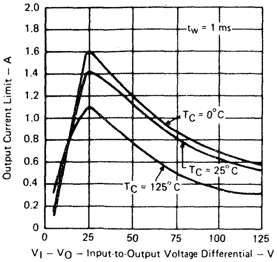


FIGURE 3

OUTPUT CURRENT LIMIT
vs
INPUT-TO-OUTPUT VOLTAGE DIFFERENTIAL

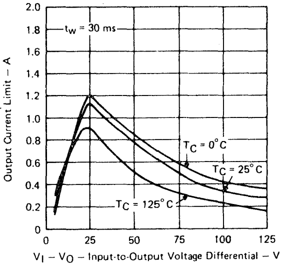


FIGURE 4

OUTPUT CURRENT LIMIT
vs
TIME

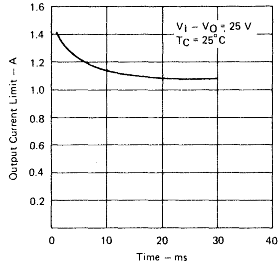


FIGURE 5

RIPPLE REJECTION
vs
OUTPUT VOLTAGE

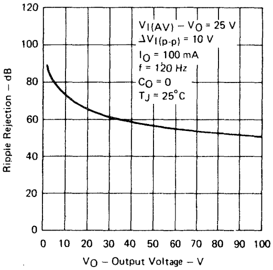


FIGURE 6

RIPPLE REJECTION
vs
OUTPUT CURRENT

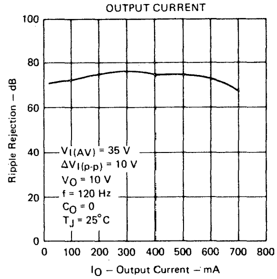


FIGURE 7

RIPPLE REJECTION
vs
FREQUENCY

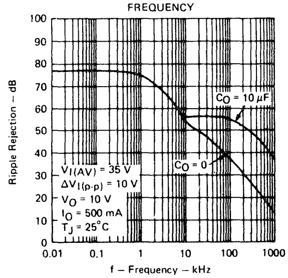


FIGURE 8

OUTPUT IMPEDANCE
vs
FREQUENCY

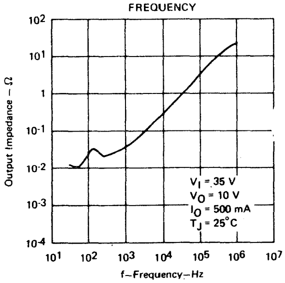


FIGURE 9

TYPICAL CHARACTERISTICS

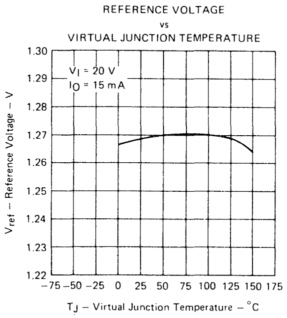


FIGURE 10

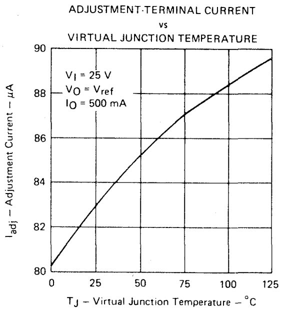


FIGURE 11

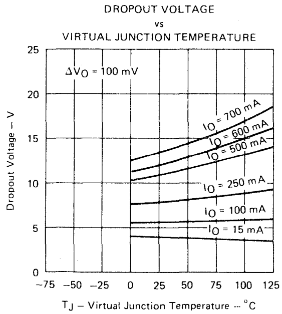


FIGURE 12

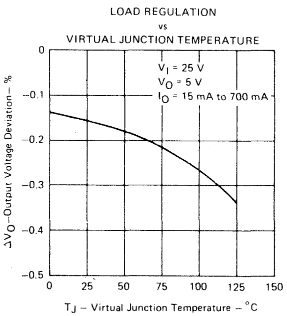


FIGURE 13

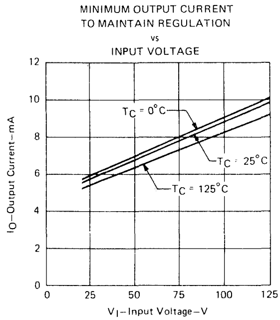


FIGURE 14

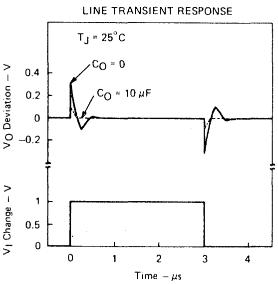


FIGURE 15

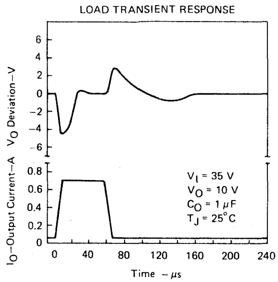


FIGURE 16

2

DESIGN CONSIDERATIONS

The internal reference (see functional block diagram) is used to generate 1.25 volts nominal (V_{ref}) between the output and adjustment terminals. This voltage is developed across R1 and causes a constant current to flow through R1 and the programming resistor R2, giving an output voltage of:

$$V_O = V_{ref.} (1 + R2/R1) + I_{adj} (R2)$$

or

$$V_O \approx V_{ref} (1 + R2/R1).$$

The TL783 was designed to minimize I_{adj} and maintain consistency over line and load variations, thereby minimizing the I_{adj} (R2) error term.

To maintain I_{adj} at a low level, all quiescent operating current is returned to the output terminal. This quiescent current must be sunk by the external load and is the minimum load current necessary to prevent the output from rising. The recommended R1 value of 82 ohms will provide a minimum load current of 15 milliamperes. Larger values may be used if the input-to-output differential voltage is less than 125 volts (see minimum operating current curve) or if the load will sink some portion of the minimum current.

Bypass capacitors

The TL783 regulator is stable without bypass capacitors; however, any regulator will become unstable with certain values of output capacitance if an input capacitor is not used. Therefore, the use of input bypassing is recommended, whenever the regulator is located more than four inches from the power-supply filter capacitor. A 1-microfarad tantalum or electrolytic capacitor is usually sufficient.

Adjustment-terminal capacitors are not recommended for use on the TL783 because they can seriously degrade load transient response as well as create a need for extra protection circuitry. Excellent ripple rejection is presently achieved without this added capacitor.

Due to the relatively low gain of the MOS output stage, output voltage drop-out may occur under large load transient conditions. Addition of an output bypass capacitor will greatly enhance load transient response as well as prevent drop-out. For most applications it is recommended that an output bypass capacitor be used with a minimum value of:

$$C_O (\mu f) = 15/V_O$$

Larger values will provide proportionally better transient response characteristics.

Protection circuitry

The TL783 regulator includes built-in protection circuitry capable of guarding the device against most overload conditions encountered in normal operation. These protective features are current limiting, safe-operating-area protection, and thermal shutdown. These circuits are meant to protect the device under occasional fault conditions only. Continuous operation in the current limit or thermal shutdown mode is not recommended.

The internal protection circuits of the TL783 will protect the device up to maximum rated V_I as long as certain precautions are taken. If V_I is instantaneously switched on, transients exceeding maximum input ratings may occur, which can destroy the regulator. These are usually caused by lead inductance and bypass capacitors causing a ringing voltage on the input. In addition, if rise times in excess of 10 V/ns are applied to the input, a parasitic n-p-n transistor in parallel with the DMOS output can be turned on causing the device to fail. If the device is operated over 50 volts and the input is switched on rather than ramped on, a low-Q capacitor, such as a tantalum or electrolytic should be used rather than ceramic, paper, or plastic bypass capacitors. A dissipation factor of 0.015 or greater will usually provide adequate damping to suppress ringing. Normally, no problems will occur if the input voltage is allowed to ramp upward through the action of an ac line rectifier and filter network.

Similarly, if an instantaneous short circuit is applied to the outputs, both ringing and excessive fall times can result. A tantalum or electrolytic bypass capacitor is recommended to eliminate this problem. However, if a large output capacitor is used and the input is shorted, addition of a protection diode may be necessary to prevent capacitor discharge through the regulator. The amount of discharge current delivered is dependent on output voltage, size of capacitor, and fall time of V_I. A protective diode (see Figure 17) is required only for capacitance values greater than

$$C_O\ (\mu f) = 3 \times 10^4/(V_O)^2.$$

Care should always be taken to prevent insertion of regulators into a socket with power on. Power should be turned off before removing or inserting regulators.

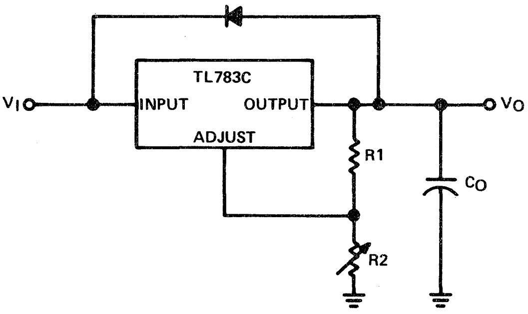


FIGURE 17– REGULATOR WITH PROTECTIVE DIODE

2

Load regulation

The current set resistor (R1) should be located close to the regulator output terminal rather than near the load. This eliminates long line drops from being amplified through the action of R1 and R2 to degrade load regulation. To provide remote ground sensing, R2 should be near the load ground.

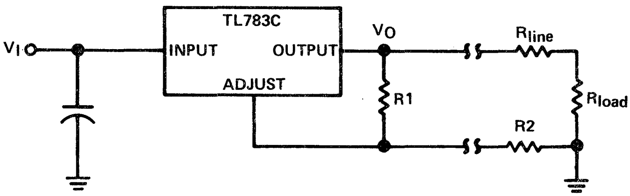
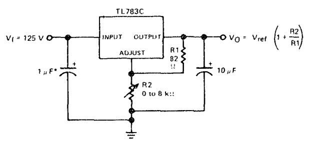


FIGURE 18–REGULATOR WITH CURRENT-SET RESISTOR

TYPICAL APPLICATION DATA



*NEEDED IF DEVICE IS MORE THAN 4 INCHES FROM FILTER CAPACITOR

FIGURE 19– 1.25-V TO 115-V ADJUSTABLE REGULATOR

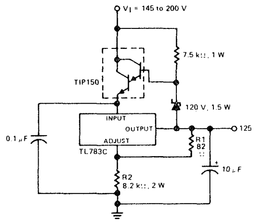


FIGURE 20–125-V SHORT-CIRCUIT-PROTECTED OFF-LINE REGULATOR

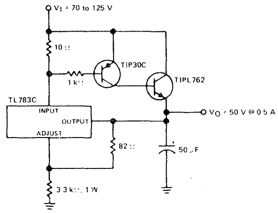


FIGURE 21–50-V REGULATOR WITH CURRENT BOOST

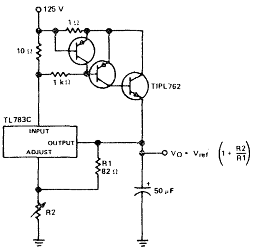


FIGURE 22–ADJUSTABLE REGULATOR WITH CURRENT BOOST AND CURRENT LIMIT

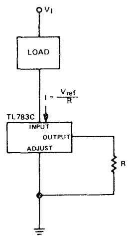


FIGURE 23 – CURRENT-SINKING REGULATOR

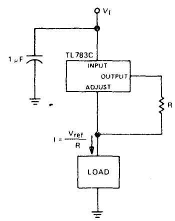


FIGURE 24 – CURRENT-SOURCING REGULATOR

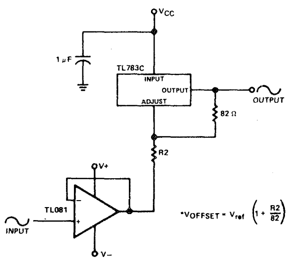


FIGURE 25–HIGH-VOLTAGE UNITY-GAIN OFFSET AMPLIFIER

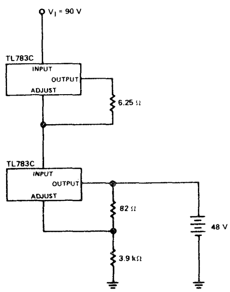


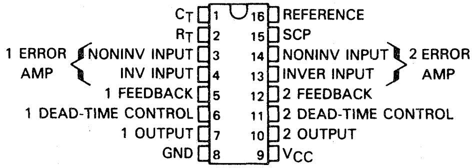
FIGURE 26–48-V, 200-mA FLOAT CHARGER

TYPE TL1451C
DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUIT

D2730, FEBRUARY 1983

- **Complete PWM Power Control Circuitry**
- **Completely Synchronized Operation**
- **Internal Under-Voltage Lockout Protection**
- **Wide Supply Voltage Range**
- **Internal Short-Circuit Protection**
- **Oscillator Frequency . . . 500 kHz Max**
- **Variable Dead Time Provides Control Over Total Range**
- **Internal Regulator Provides A Stable 2.5-V Reference Supply**

J OR N
DUAL IN-LINE PACKAGE (TOP VIEW)



description

The TL1451 incorporates on a single monolithic chip all the functions required in the construction of two pulse-width-modulation control circuits. Designed primarily for power supply control, the TL1451 contains an on-chip 2.5-volt regulator, two error amplifiers, an adjustable oscillator, two dead-time comparators, under-voltage lockout circuitry, and dual common-emitter output transistor circuits.

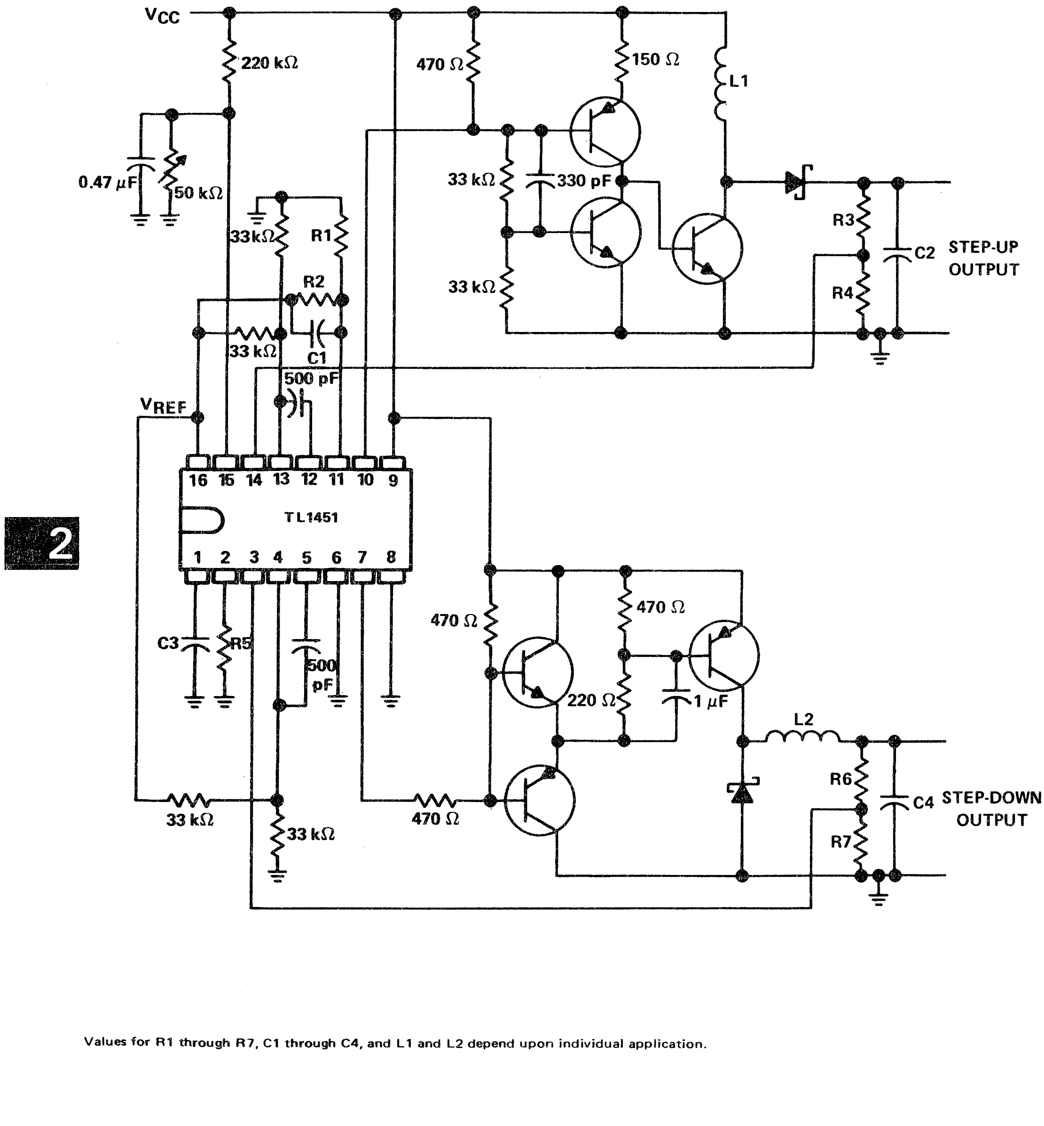
The uncommitted output transistors provide common-emitter output capability for each controller. The internal amplifiers exhibit a common-mode voltage range from 0.4 volts to 1.5 volts. The dead-time control comparator has no offset unless externally altered and may be used to provide 0% to 100% dead time. The on-chip oscillator may be operated by terminating R_T (pin 2) and C_T (pin 1). During low V_{CC} conditions, the under-voltage lockout control circuit feature locks the outputs off until the internal circuitry is operational.

The TL1451 is characterized for operation from −20°C to 85°C.

recommended operating conditions

	MIN	NOM	MAX	UNIT
Supply voltage, V_{CC}	3.6		40	V
High-level output voltage, V_{OH}			40	V
High-level output current, I_{OH}			20	mA
Error amplifier common-mode input voltage, V_{IC}	0.4		1.5	V
Input voltage range at dead-time terminal	1.4		2.05	V
Input current at feedback terminal			−50	μA
Timing capacitor, C_T	0.15		15	μF
Timing resistor, R_T	5		50	kΩ
Oscillator frequency, f_{osc}	1		500	kHz
Operating free-air temperature, T_A	−20		85	°C

TYPICAL APPLICATION DATA



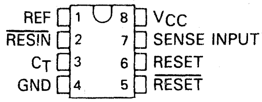
Values for R1 through R7, C1 through C4, and L1 and L2 depend upon individual application.

TYPES TL7702, TL7705, TL7712, TL7715 SUPPLY VOLTAGE SUPERVISORS

D2722, APRIL 1983

- Power On Reset Generator
- Automatic Reset Generation After Voltage Drop
- Wide Supply Voltage Range . . . 3 V to 18 V
- Precision Voltage Sensor
- Temperature-Compensated Voltage Reference
- True and Complement Reset Outputs
- Externally Adjustable Pulse Width

P DUAL-IN-LINE PACKAGE
(TOP VIEW)



description

The TL7702 series are monolithic integrated circuit supply voltage supervisors specifically designed for use as reset controllers in microcomputer and microprocessor systems. During power-up the device tests the supply voltage and keeps the reset outputs active as long as the supply voltage has not reached its nominal voltage value. Taking $\overline{\text{RESIN}}$ low has the same effect. To ensure that the microcomputer system has reset, the TL7702 then initiates an internal time delay that delays the return of the reset outputs to their inactive states. Since the time delay for most microcomputers and microprocessors is in the order of several machine cycles, the device internal time delay is determined by an external capacitor connected to the C_T input (pin 3).

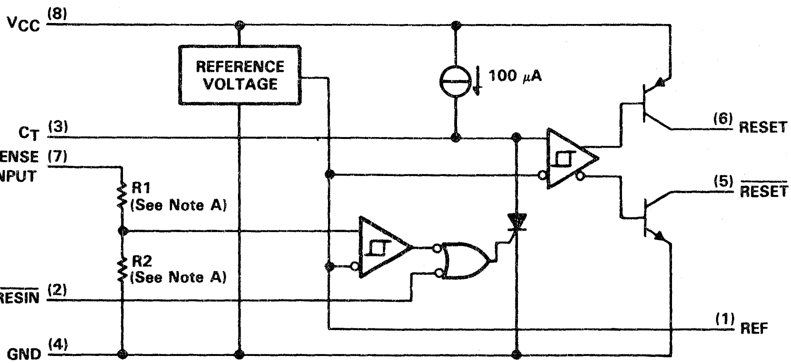
$$t_d = 1.3 \times 10^4 \times C_T$$

Where: C_T is in farads (F)
t_d is in seconds (s)

In addition, when the supply voltage drops below the nominal value, the outputs become active and stay in this state until the supply voltage returns to the nominal value. An external capacitor (typically 0.1 μF) must be connected to the REF output (pin 1) to reduce the influence of fast transients in the supply voltage.

The TL7702 series is characterized for operation from 0°C to 70°C.

functional block diagram



All resistor and current values shown are nominal.

NOTE A: TL7702: R1 = 0 Ω, R2 = open
TL7705: R1 = 9 kΩ, R2 = 10 kΩ
TL7709: R1 = 20.4 kΩ, R2 = 10 kΩ
TL7712: R1 = 36.6 kΩ, R2 = 10 kΩ
TL7715: R1 = 46.8 kΩ, R2 = 10 kΩ

ADVANCE INFORMATION

This document contains information on a new product. Specifications are subject to change without notice.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1)	20 V
Input voltage range at $\overline{RESIN}$	−0.3 V to 20 V
Input voltage range at SENSE: TL7702	−0.3 V to 6 V
TL7705, TL7709, TL7712, and TL7715	−0.3 V to 20 V
Operating free-air temperature range	0°C to 70°C
Storage temperature range	−65°C to 150°C

NOTE 1: All voltage values are with respect to the network ground terminal.

recommended operating conditions

	MIN	NOM	MAX	UNIT
Supply voltage	3		18	V
High-level input voltage at $\overline{RESIN}$, V_{IH}	2			V
Low-level input voltage at $\overline{RESIN}$, V_{IL}			0.7	V
High-level output current at RESET, I_{OH}			−1	mA
Low-level output current at $\overline{RESET}$, I_{OL}			16	mA
Operating free-air temperature range, T_A	0		70	°C

electrical characteristics over recommended ranges of supply voltage, input voltage, output current, and free-air temperature (unless otherwise noted)

2

PARAMETER			TEST CONDITIONS†	MIN	TYP	MAX	UNIT
V_{OH}	High-level output voltage at RESET		I_{OH} = −1 mA	$V_{CC}-1$			V
V_{OL}	Low-level output voltage at $\overline{RESET}$		I_{OH} = 16 mA			0.4	V
V_{ref}	Reference voltage				2.5		V
V_S	Sense voltage	TL7702	V_{CC} = 3.5 V to 18 V		V_{ref}		V
		TL7705		4.7	4.75	4.8	
		TL7709		7.5	7.6	7.7	
		TL7712		11.2	11.4	11.6	
		TL7715		14	14.2	14.4	
I_{IH}	High-level input current at $\overline{RESIN}$		V_I = 2.4 V to V_{CC}			20	μA
I_{IL}	Low-level input current at $\overline{RESIN}$		V_I = 0.4 V			−100	μA
I_{CC}	Supply current		All inputs and outputs open		1.8	3	mA

switching characteristics over recommended ranges of supply voltage, input voltage, output current, and free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	MIN	TYP	MAX	UNIT
t_{wS}	Minimum pulse duration at SENSE input to switch outputs	V_{IH} = V_S typical + 200 mV, V_{IL} = V_S typical − 200 mV			0.5	μs
t_w	Pulse duration at RESET and $\overline{RESET}$ outputs		0.65	1.3	2.6	ms
t_{pd}	Propagation delay time from $\overline{RESIN}$ to $\overline{RESET}$	V_{CC} = 5 V		9		μs
t_r	Rise time at RESET and $\overline{RESET}$	V_{CC} = 5 V, see Note 2			1	μs
t_f	Fall time at RESET and $\overline{RESET}$	V_{CC} = 5 V, see Note 2			1	μs

†All characteristics are measured with 0.1-μF capacitors connected at pins 1 and 2 to ground.
NOTE 2: The rise and fall times are measured with a 4.7-kΩ load resistor at $\overline{RESET}$ (pin 5) and RESET (pin 6).

PARAMETER MEASUREMENT INFORMATION

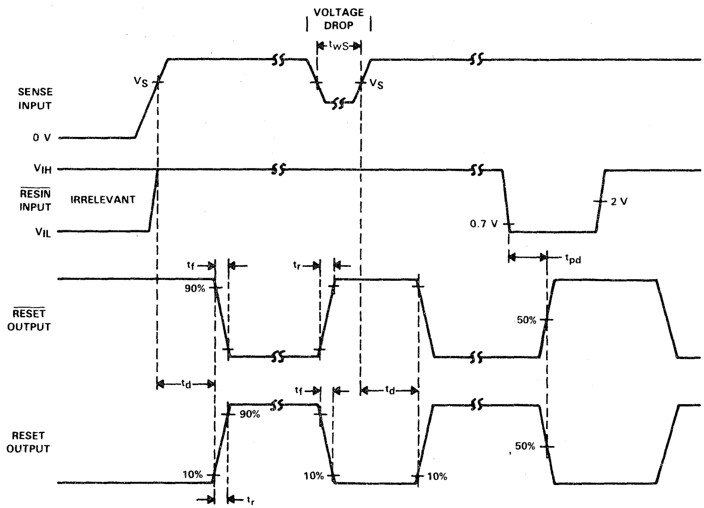


FIGURE 1 — SWITCHING DIAGRAM

TYPICAL CHARACTERISTICS

TIME DELAY
vs
TIMING CAPACITOR

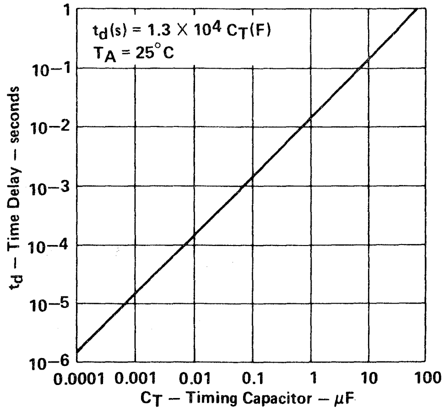


FIGURE 2

TYPICAL APPLICATION DATA

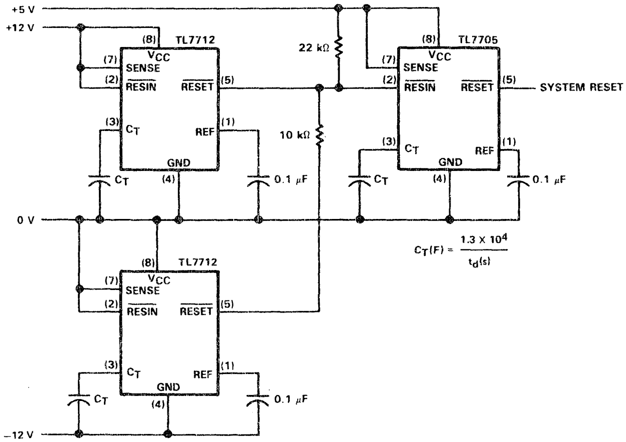


FIGURE 3 — MULTIPLE POWER SUPPLY SYSTEM RESET GENERATION

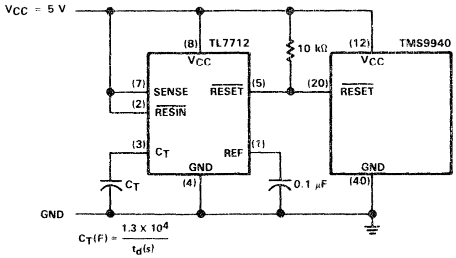


FIGURE 4 — RESET CONTROLLER FOR TMS9940 SYSTEM

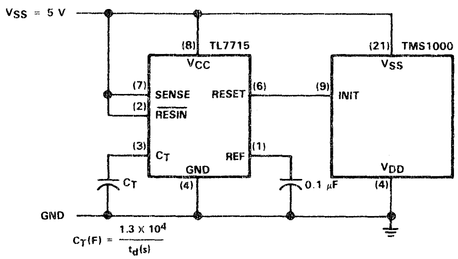


FIGURE 5 — RESET CONTROLLER FOR TMS1000

2

TYPES uA723M, uA723C PRECISION VOLTAGE REGULATORS

D1063, AUGUST 1972—REVISED DECEMBER 1982

- 150-mA Load Current without External Power Transistor
- Typically 0.02% Input Regulation and 0.03% Load Regulation (uA723M)
- Adjustable Current Limiting Capability
- Input Voltages to 40 Volts
- Output Adjustable from 2 to 37 Volts
- Direct Replacement for Fairchild μA723M and μA723C

description

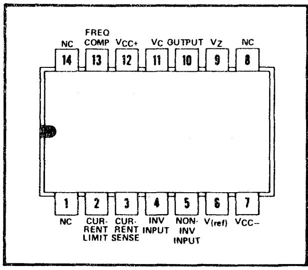
The uA723M and uA723C are monolithic integrated circuit voltage regulators featuring high ripple rejection, excellent input and load regulation, excellent temperature stability, and low standby current. The circuit consists of a temperature-compensated reference voltage amplifier, an error amplifier, a 150-milliampere output transistor, and an adjustable output current limiter.

The uA723M and uA723C are designed for use in positive or negative power supplies as a series, shunt, switching, or floating regulator. For output currents exceeding 150 mA, additional pass elements may be connected as shown in Figures 4 and 5.

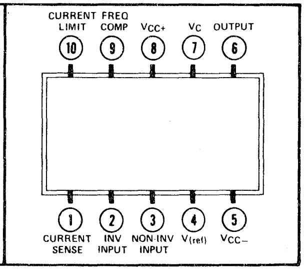
The uA723M is characterized for operation over the full military temperature range of −55°C to 125°C; the uA723C is characterized for operation from 0°C to 70°C.

terminal assignments

uA723M . . . J PACKAGE
uA723C . . . J OR N PACKAGE
(TOP VIEW)

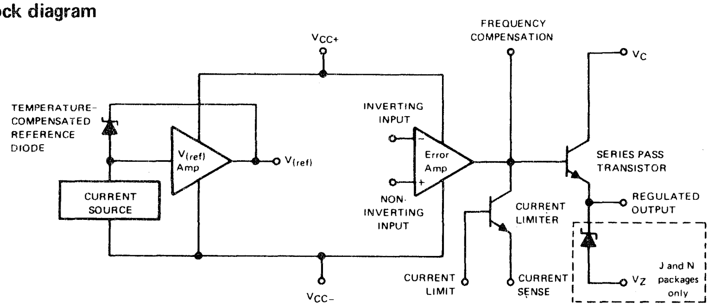


uA723M . . . U PACKAGE
(TOP VIEW)



NC—No internal connection

functional block diagram



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Peak voltage from V_{CC+} to V_{CC-} ($t_w \leqslant 50$ ms)	50 V
Continuous voltage from V_{CC+} to V_{CC-}	40 V
Input-to-output voltage differential	40 V
Differential input voltage to error amplifier	±5 V
Voltage between noninverting input and V_{CC-}	8 V
Current from V_Z	25 mA
Current from $V_{(ref)}$	15 mA
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 1):	
J or N package	1000 mW
U package	675 mW
Operating free-air temperature range: uA723M Circuits	−55°C to 125°C
uA723C Circuits	0°C to 70°C
Storage temperature range	−65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds, J or U package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds, N package	260°C

NOTE 1: Power dissipation = $[I_{(standby)} + I_{(ref)}] V_{CC} + [V_C - V_{OL}] I_O$. For operation at elevated temperature, refer to Dissipation Derating Table. In the J package, uA723M chips are alloy-mounted; uA723C chips are glass-mounted.

recommended operating conditions

	MIN	MAX	UNIT
Input voltage, V_I	9.5	40	V
Output voltage, V_O	2	37	V
Input-to-output voltage differential, $V_C - V_O$	3	38	V
Output current, I_O		150	mA

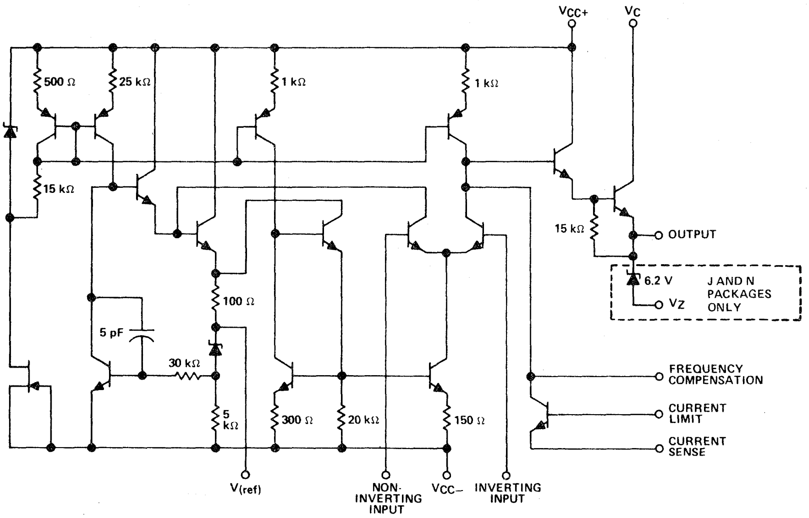
electrical characteristics at specified free-air temperature (see note 2)

PARAMETER	TEST CONDITIONS†		uA723M			uA723C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Input regulation	V_I = 12 V to V_I = 15 V	25°C		0.01%	0.1%		0.01%	0.1%	
	V_I = 12 V to V_I = 40 V	25°C		0.02%	0.2%		0.1%	0.5%	
	V_I = 12 V to V_I = 15 V	Full range			0.3%			0.3%	
Ripple rejection	f = 50 Hz to 10 kHz, $C_{(ref)}$ = 0	25°C		74			74		dB
	f = 50 Hz to 10 kHz, $C_{(ref)}$ = 5 μF	25°C		86			86		
Output regulation	I_O = 1 mA to I_O = 50 mA	25°C		−0.03%	−0.15%		−0.03%	−0.2%	
		Full range			−0.6%			−0.6%	
Reference voltage, $V_{(ref)}$		25°C	6.95	7.15	7.35	6.8	7.15	7.5	V
Standby current	V_I = 30 V, I_O = 0	25°C		2.3	3.5		2.3	4	mA
Temperature coefficient of output voltage		Full range		0.002	0.015		0.003	0.015	%/°C
Short-circuit output current	R_{SC} = 10 Ω, V_O = 0	25°C		65			65		mA
Output noise voltage	BW = 100 Hz to 10 kHz, $C_{(ref)}$ = 0	25°C		20			20		μV
	BW = 100 Hz to 10 kHz, $C_{(ref)}$ = 5 μF	25°C		2.5			2.5		

†Full range for uA723M is −55°C to 125°C and for uA723C is 0°C to 70°C.

NOTE 2: For all values in this table the device is connected as shown in Figure 1 with the divider resistance as seen by the error amplifie $\leqslant$ 10 kΩ. Unless otherwise specified, $V_I = V_{CC+} = V_C = 12$ V, $V_{CC-} = 0$, $V_O = 5$ V, $I_O = 1$ mA, $R_{SC} = 0$, and $C_{(ref)} = 0$.

schematic



RESISTOR AND CAPACITOR VALUES SHOWN ARE NOMINAL.

DISSIPATION DERATING TABLE

POWER	POWER RATING	DERATING FACTOR	ABOVE T_A
J (Alloy-Mounted Chip)	1000 mW	11.0 mW/°C	59°C
J (Glass-Mounted Chip)	1000 mW	8.2 mW/°C	28°C
N	1000 mW	9.2 mW/°C	41°C
U	675 mW	5.4 mW/°C	25°C

TYPICAL APPLICATION DATA

TABLE I
RESISTOR VALUES (kΩ) FOR STANDARD OUTPUT VOLTAGES

OUTPUT VOLTAGE (V)	APPLICABLE FIGURES (SEE NOTE 4)	FIXED OUTPUT ± 5% R1 (kΩ)	FIXED OUTPUT ± 5% R2 (kΩ)	OUTPUT ADJUSTABLE ± 10% (SEE NOTE 5) R1 (kΩ)	OUTPUT ADJUSTABLE ± 10% (SEE NOTE 5) P1 (kΩ)	OUTPUT ADJUSTABLE ± 10% (SEE NOTE 5) R2 (kΩ)	OUTPUT VOLTAGE (V)	APPLICABLE FIGURES (SEE NOTE 4)	FIXED OUTPUT ± 5% R1 (kΩ)	FIXED OUTPUT ± 5% R2 (kΩ)	OUTPUT ADJUSTABLE ± 10% (SEE NOTE 5) R1 (kΩ)	OUTPUT ADJUSTABLE ± 10% (SEE NOTE 5) P1 (kΩ)	OUTPUT ADJUSTABLE ± 10% (SEE NOTE 5) R2 (kΩ)
+3.0	1, 5, 6, 9, 11, 12 (4)	4.12	3.01	1.8	0.5	1.2	+100	7	3.57	105	2.2	10	91
+3.6	1, 5, 6, 9, 11, 12 (4)	3.57	3.65	1.5	0.5	1.5	+250	7	3.57	255	2.2	10	240
+5.0	1, 5, 6, 9, 11, 12 (4)	2.15	4.99	0.75	0.5	2.2	−6 (Note 6)	3, (10)	3.57	2.43	1.2	0.5	0.75
+6.0	1, 5, 6, 9, 11, 12 (4)	1.15	6.04	0.5	0.5	2.7	−9	3, 10	3.48	5.36	1.2	0.5	2.0
+9.0	2, 4, (5, 6, 9, 12)	1.87	7.15	0.75	1.0	2.7	−12	3, 10	3.57	8.45	1.2	0.5	3.3
+12	2, 4, (5, 6, 9, 12)	4.87	7.15	2.0	1.0	3.0	−15	3, 10	3.57	11.5	1.2	0.5	4.3
+15	2, 4, (5, 6, 9, 12)	7.87	7.15	3.3	1.0	3.0	−28	3, 10	3.57	24.3	1.2	0.5	10
+28	2, 4, (5, 6, 9, 12)	21.0	7.15	5.6	1.0	2.0	−45	8	3.57	41.2	2.2	10	33
+45	7	3.57	48.7	2.2	10	39	−100	8	3.57	95.3	2.2	10	91
+75	7	3.57	78.7	2.2	10	68	−250	8	3.57	249	2.2	10	240

TABLE II
FORMULAS FOR INTERMEDIATE OUTPUT VOLTAGES

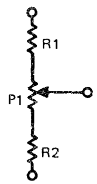
Outputs from +2 to +7 volts [Figures 1, 5, 6, 9, 11, 12, (4)] $V_O = V_{(ref)} \times \frac{R2}{R1 + R2}$	Outputs from +4 to +250 volts [Figure 7] $V_O = \frac{V_{(ref)}}{2} \times \frac{R2 - R1}{R1}$; $R3 = R4$	Current Limiting $I_{(limit)} \approx \frac{0.65\ V}{R_{sc}}$
Outputs from +7 to +37 volts [Figures 2, 4, (5, 6, 9, 11, 12)] $V_O = V_{(ref)} \times \frac{R1 + R2}{R2}$	Outputs from −6 to −250 volts [Figures 3, 8, 10] $V_O = -\frac{V_{(ref)}}{2} \times \frac{R1 + R2}{R1}$; $R3 = R4$	Foldback Current Limiting [Figure 6] $I_{(knee)} \approx \frac{V_O R3 + (R3 + R4)\ 0.65\ V}{R_{sc} R4}$; $I_{OS} \approx \frac{0.65\ V}{R_{sc}} \times \frac{R3 + R4}{R4}$

NOTES: 3. Figures 1 through 12 show the R1/R2 divider across either V_O or $V_{(ref)}$. Figure numbers in parentheses may be used if the R1/R2 divider is placed across the other voltage ($V_{(ref)}$ or V_O) that it was not placed across in the figures without parentheses.

4. To make the voltage adjustable, the R1/R2 divider shown in the figures must be replaced by the divider shown at the right.

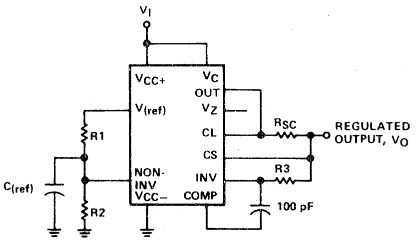
5. For negative output voltages less than 9 V, V_{CC+} and V_C must be connected to a positive supply such that the voltage between V_{CC+} and V_{CC-} is greater than 9 V.

6. When 10-lead uA723 devices are used in applications requiring V_Z, an external 6.2-V regulator diode must be connected in series with the V_O terminal.



ADJUSTABLE OUTPUT CIRCUITS

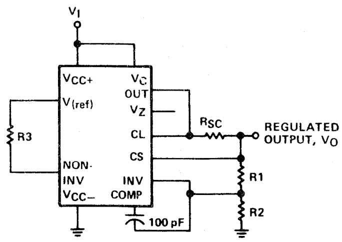
TYPICAL APPLICATION DATA



NOTES: A. $R3 = \frac{R1 \cdot R2}{R1 + R2}$ for minimum α_{VO}.

B. R3 may be eliminated for minimum component count. Use direct connection (i.e., $R_3 = 0$).

FIGURE 1—BASIC LOW-VOLTAGE REGULATOR (V_O = 2 TO 7 VOLTS)



NOTES: A. $R3 = \frac{R1 \cdot R2}{R1 + R2}$ for minimum α_{VO}.

B. R3 may be eliminated for minimum component count. Use direct connection (i.e., $R_3 = 0$).

FIGURE 2—BASIC HIGH-VOLTAGE REGULATOR (V_O = 7 TO 37 VOLTS)

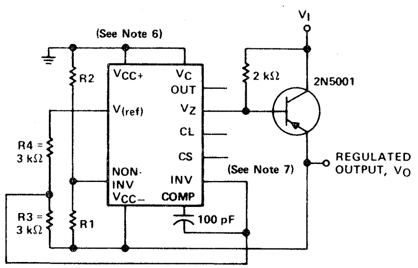


FIGURE 3—NEGATIVE-VOLTAGE REGULATOR

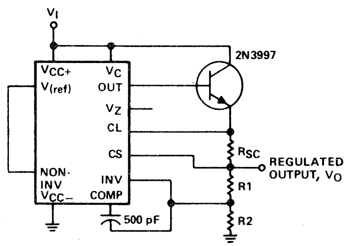


FIGURE 4—POSITIVE-VOLTAGE REGULATOR (EXTERNAL N-P-N-PASS TRANSISTOR)

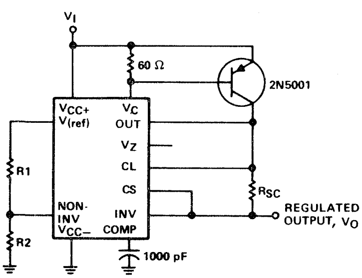


FIGURE 5—POSITIVE-VOLTAGE REGULATOR (EXTERNAL P-N-P PASS TRANSISTOR)

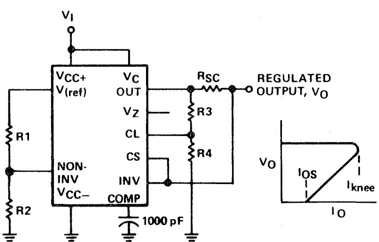


FIGURE 6—FOLDBACK CURRENT LIMITING

TYPICAL APPLICATION DATA

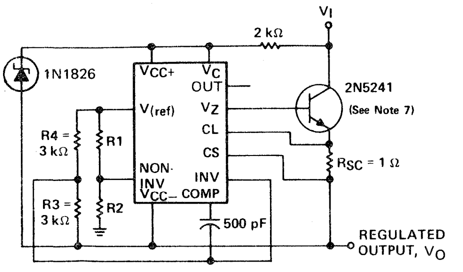


FIGURE 7–POSITIVE FLOATING REGULATOR

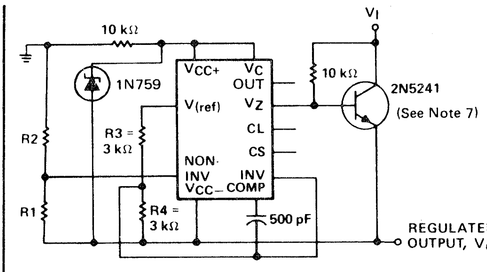


FIGURE 8–NEGATIVE FLOATING REGULATOR

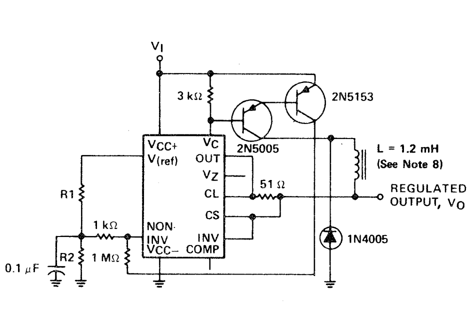


FIGURE 9–POSITIVE SWITCHING REGULATOR

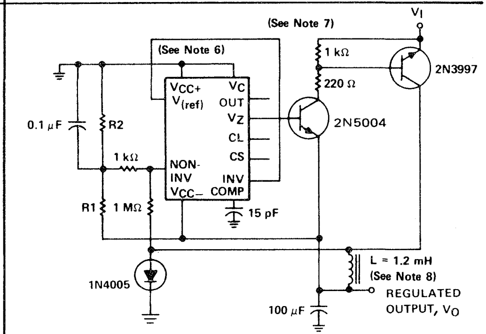
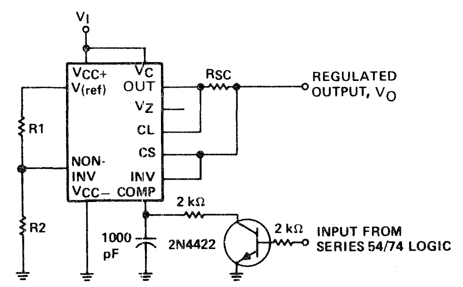


FIGURE 10–NEGATIVE SWITCHING REGULATOR



NOTE A: Current limit transistor may be used for shutdown if current limiting is not required.

FIGURE 11–REMOTE SHUTDOWN REGULATOR WITH CURRENT LIMITING

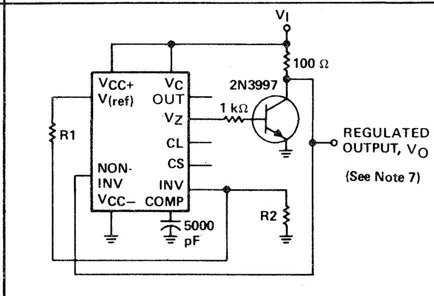


FIGURE 12–SHUNT REGULATOR

NOTES:
6. For negative output voltages less than 9 V, V_{CC+} and V_C must be connected to a positive supply such that the voltage betweer V_{CC+} and V_{CC-} is greater than 9 V.
7. When 10-lead uA723 devices are used in applications requiring V_Z, an external 6.2-V regulator diode must be connected in serie with the V_O terminal.
8. L is 40 turns of No. 20 enameled copper wire wound on Ferroxcube P36/22-3B7 potted core, or equivalent, with 0.009-inch ai gap.

SERIES uA7800
POSITIVE-VOLTAGE REGULATORS

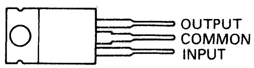
D2154, MAY 1976–REVISED DECEMBER 1982

- 3-Terminal Regulators
- Output Current up to 1.5 A
- No External Components
- Internal Thermal Overload Protection
- High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Direct replacements for Fairchild μA7800 Series

NOMINAL OUTPUT VOLTAGE	REGULATOR
5 V	uA7805C
6 V	uA7806C
8 V	uA7808C
8.5 V	uA7885C
10 V	uA7810C
12 V	uA7812C
15 V	uA7815C
18 V	uA7818C
24 V	uA7824C

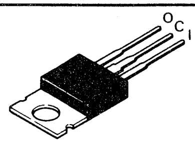
KC PACKAGE

(TOP VIEW)



THE COMMON TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

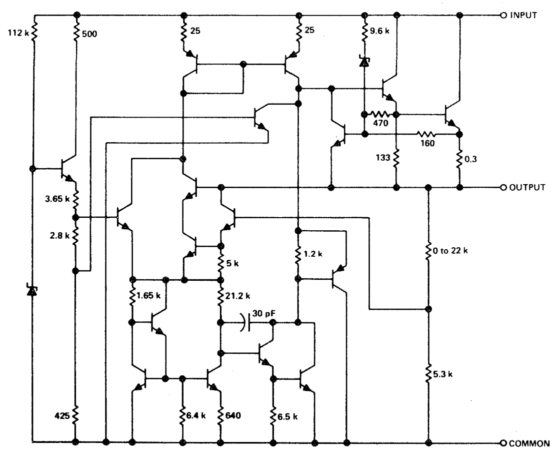
TO-220AB



description

This series of fixed-voltage monolithic integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 amperes of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and also as the power-pass element in precision regulators.

schematic



Resistor values shown are nominal and in ohms.

absolute maximum ratings over operating temperature range (unless otherwise noted)

		uA78__C	UNIT
Input voltage	uA7824C	40	V
	All others	35	
Continuous total dissipation at 25°C free-air temperature (see Note 1)		2	W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)		15	W
Operating free-air, case, or virtual junction temperature range		0 to 150	°C
Storage temperature range		−65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds		260	°C

NOTE 1: For operation above 25° free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activitated at power levels slightly above or below the rated dissipation.

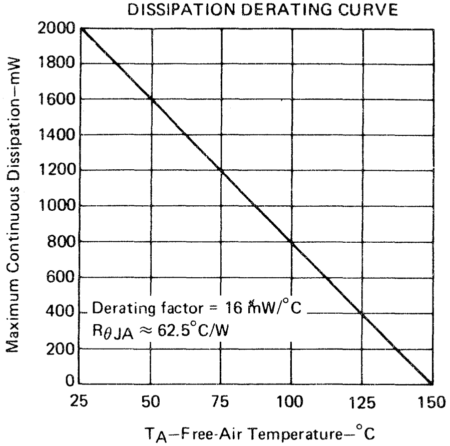


FIGURE 1

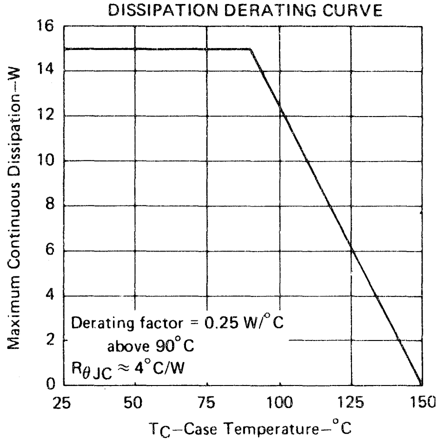


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	uA7805C	7	25	V
	uA7806C	8	25	
	uA7808C	10.5	25	
	uA7885C	10.5	25	
	uA7810C	12.5	28	
	uA7812C	14.5	30	
	uA7815C	17.5	30	
	uA7818C	21	33	
	uA7824C	27	38	
Output current, I_O			1.5	A
Operating virtual junction temperature, T_J		0	125	°C

uA7805C electrical characteristics at specified virtual junction temperature, V_I = 10 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage		25°C	4.8	5	5.2	V
	I_O = 5 mA to 1 A, V_I = 7 V to 20 V, P ≤ 15 W	0°C to 125°C	4.75		5.25	
Input regulation	V_I = 7 V to 25 V	25°C		3	100	mV
	V_I = 8 V to 12 V			1	50	
Ripple rejection	V_I = 8 V to 18 V, f = 120 Hz	0°C to 125°C	62	78		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		15	100	mV
	I_O = 250 mA to 750 mA			5	50	
Output resistance	f = 1 kHz	0°C to 125°C		0.017		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−1.1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		40		μV
Dropout voltage	I_O = 1 A	25°C		2.0		V
Bias current		25°C		4.2	8	mA
Bias current change	V_I = 7 V to 25 V	0°C to 125°C			1.3	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		750		mA
Peak output current		25°C		2.2		A

uA7806C electrical characteristics at specified virtual junction temperature, V_I = 11 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Output voltage		25°C	5.75	6	6.25	V
	I_O = 5 mA to 1 A, V_I = 8 V to 21 V, P ≤ 15 W	0°C to 125°C	5.7		6.3	
Input regulation	V_I = 8 V to 25 V	25°C		5	120	mV
	V_I = 9 V to 13 V			1.5	60	
Ripple rejection	V_I = 9 V to 19 V, f = 120 Hz	0°C to 125°C	59	75		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		14	120	mV
	I_O = 250 mA to 750 mA			4	60	
Output resistance	f = 1 kHz	0°C to 125°C		0.019		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−0.8		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		45		μV
Dropout voltage	I_O = 1 A	25°C		2.0		V
Bias current		25°C		4.3	8	mA
Bias current change	V_I = 8 V to 25 V	0°C to 125°C			1.3	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		550		mA
Peak output current		25°C		2.2		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA7808C electrical characteristics at specified virtual junction temperature, V_I = 14 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7808C MIN	TYP	MAX	UNIT
Output voltage		25°C	7.7	8	8.3	V
	I_O = 5 mA to 1 A, V_I = 10.5 V to 23 V, P ≤ 15 W	0°C to 125°C	7.6		8.4	
Input regulation	V_I = 10.5 V to 25 V	25°C		6	160	mV
	V_I = 11 V to 17 V			2	80	
Ripple rejection	V_I = 11.5 V to 21.5 V, f = 120 Hz	0°C to 125°C	56	72		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		12	160	mV
	I_O = 250 mA to 750 mA			4	80	
Output resistance	f = 1 kHz	0°C to 125°C		0.016		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−0.8		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		52		μV
Dropout voltage	I_O = 1 A	25°C		2.0		V
Bias current		25°C		4.3	8	mA
Bias current change	V_I = 10.5 V to 25 V	0°C to 125°C			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		450		mA
Peak output current		25°C		2.2		A

2

uA7885C electrical characteristics at specified virtual junction temperature, V_I = 15 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7885C MIN	TYP	MAX	UNIT
Output voltage		25°C	8.15	8.5	8.85	V
	I_O = 5 mA to 1 A, V_I = 11 V to 23.5 V, P ≤ 15 W	0°C to 125°C	8.1		8.9	
Input regulation	V_I = 10.5 V to 25 V	25°C		6	170	mV
	V_I = 11 V to 17 V			2	85	
Ripple rejection	V_I = 11.5 V to 21.5 V, f = 120 Hz	0°C to 125°C	54	70		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		12	170	mV
	I_O = 250 mA to 750 mA			4	85	
Output resistance	f = 1 kHz	0°C to 125°C		0.016		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−0.8		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		55		μV
Dropout voltage	I_O = 1 A	25°C		2.0		V
Bias current		25°C		4.3	8	mA
Bias current change	V_I = 10.5 V to 25 V	0°C to 125°C			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		450		mA
Peak output current		25°C		2.2		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA7810C electrical characteristics at specified virtual junction temperature, V_I = 17 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7810C MIN	uA7810C TYP	uA7810C MAX	UNIT
Output voltage		25°C	9.6	10	10.4	V
	I_O = 5 mA to 1 A, V_I = 12.5 V to 25 V, P ≤ 15 W	0°C to 125°C	9.5	10	10.5	
Input regulation	V_I = 12.5 V to 28 V	25°C		7	200	mV
	V_I = 14 V to 20 V			2	100	
Ripple rejection	V_I = 13 V to 23 V, f = 120 Hz	0°C to 125°C	55	71		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		12	200	mV
	I_O = 250 mA to 750 mA			4	100	
Output resistance	f = 1 kHz	0°C to 125°C		0.018		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−1.0		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		70		μV
Dropout voltage	I_O = 1 A	25°C		2.0		V
Bias current		25°C		4.3	8	mA
Bias current change	V_I = 12.5 V to 28 V	0°C to 125°C			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		400		mA
Peak output current		25°C		2.2		A

uA7812C electrical characteristics at specified virtual junction temperature, V_I = 19 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7812C MIN	uA7812C TYP	uA7812C MAX	UNIT
Output voltage		25°C	11.5	12	12.5	V
	I_O = 5 mA to 1 A, V_I = 14.5 V to 27 V, P ≤ 15 W	0°C to 125°C	11.4		12.6	
Input regulation	V_I = 14.5 V to 30 V	25°C		10	240	mV
	V_I = 16 V to 22 V			3	120	
Ripple rejection	V_I = 15 V to 25 V, f = 120 Hz	0°C to 125°C	55	71		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		12	240	mV
	I_O = 250 mA to 750 mA			4	120	
Output resistance	f = 1 kHz	0°C to 125°C		0.018		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−1.0		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		75		μV
Dropout voltage	I_O = 1 A	25°C		2.0		V
Bias current		25°C		4.3	8	mA
Bias current change	V_I = 14.5 V to 30 V	0°C to 125°C			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		350		mA
Peak output current		25°C		2.2		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA7815C electrical characteristics at specified virtual junction temperature, V_I = 23 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7815C MIN	uA7815C TYP	uA7815C MAX	UNIT
Output voltage		25°C	14.4	15	15.6	V
	I_O = 5 mA to 1 A, V_I = 17.5 V to 30 V, P ≤ 15 W	0°C to 125°C	14.25		15.75	
Input regulation	V_I = 17.5 V to 30 V	25°C		11	300	mV
	V_I = 20 V to 26 V			3	150	
Ripple rejection	V_I = 18.5 V to 28.5 V, f = 120 Hz	0°C to 125°C	54	70		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		12	300	mV
	I_O = 250 mA to 750 mA			4	150	
Output resistance	f = 1 kHz	0°C to 125°C		0.019		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−1.0		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		90		μV
Dropout voltage	I_O = 1 A	25°C		2.0		V
Bias current		25°C		4.4	8	mA
Bias current change	V_I = 17.5 V to 30 V	0°C to 125°C			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		230		mA
Peak output current		25°C		2.1		A

uA7818C electrical characteristics at specified virtual junction temperature, V_I = 27 V, I_O = 500 mA (unless otherwise noted)

2

PARAMETER	TEST CONDITIONS†		uA7818C MIN	uA7818C TYP	uA7818C MAX	UNIT
Output voltage		25°C	17.3	18	18.7	V
	I_O = 5 mA to 1 A, V_I = 21 V to 33 V, P ≤ 15 W	0°C to 125°C	17.1		18.9	
Input regulation	V_I = 21 V to 33 V	25°C		15	360	mV
	V_I = 24 V to 30 V			5	180	
Ripple rejection	V_I = 22 V to 32 V, f = 120 Hz	0°C to 125°C	53	69		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		12	360	mV
	I_O = 250 mA to 750 mA			4	180	
Output resistance	f = 1 kHz	0°C to 125°C		0.022		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−1.0		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		110		μV
Dropout voltage	I_O = 1 A	25°C		2.0		V
Bias current		25°C		4.5	8	mA
Bias current change	V_I = 21 V to 33 V	0°C to 125°C			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		200		mA
Peak output current		25°C		2.1		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA7824C electrical characteristics at specified virtual junction temperature, V_I = 33 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7824C MIN	uA7824C TYP	uA7824C MAX	UNIT
Output voltage		25°C	23	24	25	V
	I_O = 5 mA to 1 A, V_I = 27 V to 38 V, P ⩽ 15 W	0°C to 125°C	22.8		25.2	
Input regulation	V_I = 27 V to 38 V	25°C		18	480	mV
	V_I = 30 V to 36 V			6	240	
Ripple rejection	V_I = 28 V to 38 V, f = 120 Hz	0°C to 125°C	50	66		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		12	480	mV
	I_O = 250 mA to 750 mA			4	240	
Output resistance	f = 1 kHz	0°C to 125°C		0.028		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−1.5		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		170		μV
Dropout voltage	I_O = 1 A	25°C		2.0		V
Bias current		25°C		4.6	8	mA
Bias current change	V_I = 27 V to 38 V	0°C to 125°C			1	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		150		mA
Peak output current		25°C		2.1		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ⩽ 10 ms, duty cycle ⩽ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

2

SERIES uA78L00 POSITIVE-VOLTAGE REGULATORS

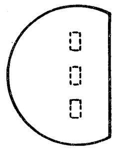
D2203, JANUARY 1976–REVISED APRIL 1977

- 3-Terminal Regulators
- Output Current up to 100 mA
- No External Components
- Internal Thermal Overload Protection
- Unusually High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Direct Replacement for Fairchild uA78L00 Series

NOMINAL OUTPUT VOLTAGE	5% OUTPUT VOLTAGE TOLERANCE	10% OUTPUT VOLTAGE TOLERANCE
2.6 V	uA78L02AC	uA78L02C
5 V	uA78L05AC	uA78L05C
6.2 V	uA78L06AC	uA78L06C
8 V	uA78L08AC	uA78L08C
9 V	uA78L09AC	uA78L09C
10 V	uA78L10AC	uA78L10C
12 V	uA78L12AC	uA78L12C
15 V	uA78L15AC	uA78L15C

LP
SILECT PACKAGE

(TOP VIEW)



TO-226AA

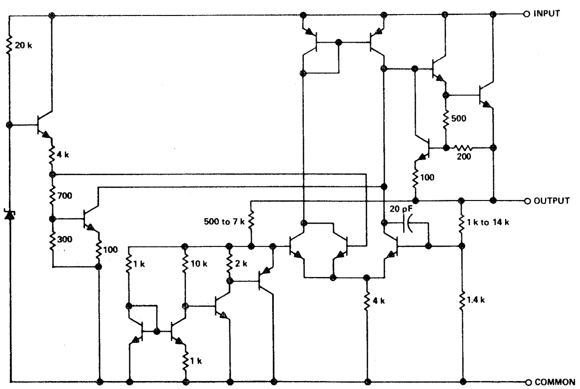
OCI

2

description

This series of fixed-voltage monolithic integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. In addition, they can be used with power-pass elements to make high-current voltage regulators. One of these regulators can deliver up to 100 mA of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. When used as a replacement for a Zener-diode–resistor combination, an effective improvement in output impedance of typically two orders of magnitude can be obtained together with lower bias current.

schematic



Resistor values shown are nominal and in ohms.

absolute maximum ratings over operating temperature range (unless otherwise noted)

		uA78L02AC, uA78L02C THRU uA78L10AC, uA78L10C	uA78L12AC, uA78L12C uA78L15AC, uA78L15C	UNIT
Input voltage		30	35	V
Continuous total dissipation at 25°C free-air temperature (see Note 1)	JG package	825	825	mW
	LP package	775	775	
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)		1600	1600	mW
Operating free-air, case, or virtual junction temperature range		0 to 150	0 to 150	°C
Storage temperature range		−65 to 150	−65 to 150	°C
Lead temperature 1/16 inch from case for 10 seconds		260	260	°C

NOTE 1: For operation above 25°C free-air or case temperature, refer to Dissipation Derating Curves, Figure 1 and Figure 2.

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

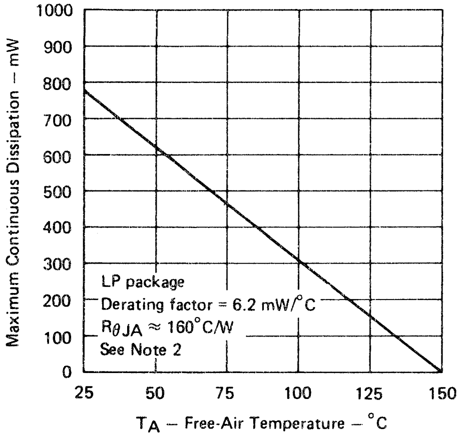


FIGURE 1

CASE TEMPERATURE
DISSIPATION DERATING CURVE

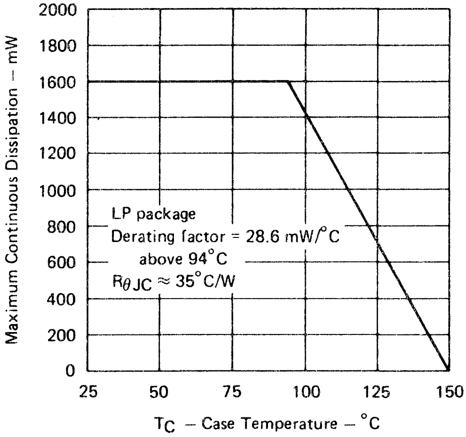


FIGURE 2

NOTE 2: This curve for the LP package is based on thermal resistance, $R_{\theta JA}$, measured in still air with the device mounted in an Augat socket. The bottom of the package was 3/8 inch above the socket.

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	uA78L02C, uA78L02AC	4.75	20	V
	uA78L05C, uA78L05AC	7	20	
	uA78L06C, uA78L06AC	8.5	20	
	uA78L08C, uA78L08AC	10.5	23	
	uA78L09C, uA78L09AC	11.5	24	
	uA78L10C, uA78L10AC	12.5	25	
	uA78L12C, uA78L12AC	14.5	27	
	uA78L15C, uA78L15AC	17.5	30	
Output current, I_O			100	mA
Operating virtual junction temperature, T_J		0	125	°C

uA78L02AC, uA78L02C electrical characteristics at specified virtual junction temperature, V_I = 9 V, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA78L02AC			uA78L02C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage		25°C	2.5	2.6	2.7	2.4	2.6	2.8	V
	V_I = 4.75 V to 20 V, I_O = 1 mA to 40 mA	0°C to 125°C	2.45		2.75	2.35		2.85	
	I_O = 1 mA to 70 mA		2.45		2.75	2.35		2.85	
Input regulation	V_I = 4.75 V to 20 V	25°C		20	100		20	125	mV
	V_I = 5 V to 20 V			16	75		16	100	
Ripple rejection	V_I = 6 V to 16 V, f = 120 Hz	25°C	43	51		42	51		dB
Output regulation	I_O = 1 mA to 100 mA	25°C		12	50		12	50	mV
	I_O = 1 mA to 40 mA			6	25		6	25	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		30			30		μV
Dropout voltage		25°C		1.7			1.7		V
Bias current		25°C		3.6	6		3.6	6	mA
		125°C			5.5			5.5	
Bias current change	V_I = 5 V to 20 V	0°C to 125°C			2.5			2.5	mA
	I_O = 1 mA to 40 mA				0.1			0.2	

uA78L05AC, uA78L05C electrical characteristics at specified virtual junction temperature, V_I = 10 V, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA78L05AC			uA78L05C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage		25°C	4.8	5	5.2	4.6	5	5.4	V
	V_I = 7 V to 20 V, I_O = 1 mA to 40 mA	0°C to 125°C	4.75		5.25	4.5		5.5	
	I_O = 1 mA to 70 mA		4.75		5.25	4.5		5.5	
Input regulation	V_I = 7 V to 20 V	25°C		32	150		32	200	mV
	V_I = 8 V to 20 V			26	100		26	150	
Ripple rejection	V_I = 8 V to 18 V, f = 120 Hz	25°C	41	49		40	49		dB
Output regulation	I_O = 1 mA to 100 mA	25°C		15	60		15	60	mV
	I_O = 1 mA to 40 mA			8	30		8	30	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		42			42		μV
Dropout voltage		25°C		1.7			1.7		V
Bias current		25°C		3.8	6		3.8	6	mA
		125°C			5.5			5.5	
Bias current change	V_I = 8 V to 20 V	0°C to 125°C			1.5			1.5	mA
	I_O = 1 mA to 40 mA				0.1			0.2	

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq$ 10 ms, duty cycle $\leq$ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA78L06AC, uA78L06C electrical characteristics at specified virtual junction temperature, V_I = 12 V, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA78L06AC MIN	uA78L06AC TYP	uA78L06AC MAX	uA78L06C MIN	uA78L06C TYP	uA78L06C MAX	UNIT
Output voltage		25°C	5.95	6.2	6.45	5.7	6.2	6.7	V
	V_I = 8.5 V to 20 V, I_O = 1 mA to 40 mA	0°C to 125°C	5.9		6.5	5.6		6.8	
	I_O = 1 mA to 70 mA		5.9		6.5	5.6		6.8	
Input regulation	V_I = 8.5 V to 20 V	25°C		35	175		35	200	mV
	V_I = 9 V to 20 V			29	125		29	150	
Ripple rejection	V_I = 10 V to 20 V, f = 120 Hz	25°C	40	48		39	48		dB
Output regulation	I_O = 1 mA to 100 mA	25°C		16	80		16	80	mV
	I_O = 1 mA to 40 mA			9	40		9	40	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		46			46		μV
Dropout voltage		25°C		1.7			1.7		V
Bias current		25°C		3.9	6		3.9	6	mA
		125°C			5.5			5.5	
Bias current change	V_I = 9 V to 20 V	0°C to 125°C			1.5			1.5	mA
	I_O = 1 mA to 40 mA				0.1			0.2	

uA78L08AC, uA78L08C electrical characteristics at specified virtual junction temperature, V_I = 14 V, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA78L08AC MIN	uA78L08AC TYP	uA78L08AC MAX	uA78L08C MIN	uA78L08C TYP	uA78L08C MAX	UNIT
Output voltage		25°C	7.7	8	8.3	7.36	8	8.64	V
	V_I = 10.5 V to 23 V, I_O = 1 mA to 40 mA	0°C to 125°C	7.6		8.4	7.2		8.8	
	I_O = 1 mA to 70 mA		7.6		8.4	7.2		8.8	
Input regulation	V_I = 10.5 V to 23 V	25°C		42	175		42	200	mV
	V_I = 11 V to 23 V			36	125		36	150	
Ripple rejection	V_I = 13 V to 23 V, f = 120 Hz	25°C	37	46		36	46		dB
Output regulation	I_O = 1 mA to 100 mA	25°C		18	80		18	80	mV
	I_O = 1 mA to 40 mA			10	40		10	40	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		54			54		μV
Dropout voltage		25°C		1.7			1.7		V
Bias current		25°C		4	6		4	6	mA
		125°C			5.5			5.5	
Bias current change	V_I = 11 V to 23 V	0°C to 125°C			1.5			1.5	mA
	I_O = 1 mA to 40 mA				0.1			0.2	

2

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq$ 10 ms, duty cycle $\leq$ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA78L09AC, uA78L09C electrical characteristics at specified virtual junction temperature, V_I = 16 V, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA78L09AC MIN	uA78L09AC TYP	uA78L09AC MAX	uA78L09C MIN	uA78L09C TYP	uA78L09C MAX	UNIT
Output voltage		25°C	8.6	9	9.4	8.3	9	9.7	V
	V_I = 12 V to 24 V, I_O = 1 mA to 40 mA	0°C to 125°C	8.55		9.45	8.1		9.9	
	I_O = 1 mA to 70 mA	0°C to 125°C	8.55		9.45	8.1		9.9	
Input regulation	V_I = 12 V to 24 V	25°C		45	175		45	225	mV
	V_I = 13 V to 24 V	25°C		40	125		40	175	
Ripple rejection	V_I = 13 V to 24 V, f = 120 Hz	25°C	37	45		36	45		dB
Output regulation	I_O = 1 mA to 100 mA	25°C		19	90		19	90	mV
	I_O = 1 mA to 40 mA	25°C		11	40		11	40	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		58			58		μV
Dropout voltage		25°C		1.7			1.7		V
Bias current		25°C		4.1	6		4.1	6	mA
		125°C			5.5			5.5	
Bias current change	V_I = 13 V to 24 V	0°C to 125°C			1.5			1.5	mA
	I_O = 1 mA to 40 mA	0°C to 125°C			0.1			0.2	

uA78L10AC, uA78L10C electrical characteristics at specified virtual junction temperature, V_I = 17 V, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA78L10AC MIN	uA78L10AC TYP	uA78L10AC MAX	uA78L10C MIN	uA78L10C TYP	uA78L10C MAX	UNIT
Output voltage		25°C	9.6	10	10.4	9.2	10	10.8	V
	V_I = 13 V to 25 V, I_O = 1 mA to 40 mA	0°C to 125°C	9.5		10.5	9		10	
	I_O = 1 mA to 70 mA	0°C to 125°C	9.5		10.5	9		10	
Input regulation	V_I = 13 V to 25 V	25°C		51	175		51	225	mV
	V_I = 14 V to 25 V	25°C		42	125		42	175	
Ripple rejection	V_I = 14 V to 25 V, f = 120 Hz	25°C	37	44		36	44		dB
Output regulation	I_O = 1 mA to 100 mA	25°C		20	90		20	90	mV
	I_O = 1 mA to 40 mA	25°C		11	40		11	40	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		62			62		μV
Dropout voltage		25°C		1.7			1.7		V
Bias current		25°C		4.2	6		4.2	6	mA
		125°C			5.5			5.5	
Bias current change	V_I = 14 V to 25 V	0°C to 125°C			1.5			1.5	mA
	I_O = 1 mA to 40 mA	0°C to 125°C			0.1			0.2	

2

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq$ 10 ms, duty cycle $\leq$ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA78L12AC, uA78L12C electrical characteristics at specified virtual junction temperature, V_I = 19 V, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA78L12AC MIN	uA78L12AC TYP	uA78L12AC MAX	uA78L12C MIN	uA78L12C TYP	uA78L12C MAX	UNIT
Output voltage		25°C	11.5	12	12.5	11.1	12	12.9	V
	V_I = 14.5 V to 27 V, I_O = 1 mA to 40 mA	0°C to 125°C	11.4		12.6	10.8		13.2	
	I_O = 1 mA to 70 mA	0°C to 125°C	11.4		12.6	10.8		13.2	
Input regulation	V_I = 14.5 V to 27 V	25°C		55	250		55	250	mV
	V_I = 16 V to 27 V	25°C		49	200		49	200	
Ripple rejection	V_I = 15 V to 25 V, f = 120 Hz	25°C	37	42		36	42		dB
Output regulation	I_O = 1 mA to 100 mA	25°C		22	100		22	100	mV
	I_O = 1 mA to 40 mA	25°C		13	50		13	50	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		70			70		μV
Dropout voltage		25°C		1.7			1.7		V
Bias current		25°C		4.3	6.5		4.3	6.5	mA
		125°C			6			6	
Bias current change	V_I = 16 V to 27 V	0°C to 125°C			1.5			1.5	mA
	I_O = 1 mA to 40 mA	0°C to 125°C			0.1			0.2	

uA78L15AC, uA78L15C electrical characteristics at specified virtual junction temperature, V_I = 23 V, I_O = 40 mA (unless otherwise noted)

2

PARAMETER	TEST CONDITIONS†		uA78L15AC MIN	uA78L15AC TYP	uA78L15AC MAX	uA78L15C MIN	uA78L15C TYP	uA78L15C MAX	UNIT
Output voltage		25°C	14.4	15	15.6	13.8	15	16.2	V
	V_I = 17.5 V to 30 V, I_O = 1 mA to 40 mA	0°C to 125°C	14.25		15.75	13.5		16.5	
	I_O = 1 mA to 70 mA	0°C to 125°C	14.25		15.75	13.5		16.5	
Input regulation	V_I = 17.5 V to 30 V	25°C		65	300		65	300	mV
	V_I = 20 V to 30 V	25°C		58	250		58	250	
Ripple rejection	V_I = 18.5 V to 28.5 V, f = 120 Hz	25°C	34	39		33	39		dB
Output regulation	I_O = 1 mA to 100 mA	25°C		25	150		25	150	mV
	I_O = 1 mA to 40 mA	25°C		15	75		15	75	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		82			82		μV
Dropout voltage		25°C		1.7			1.7		V
Bias current		25°C		4.6	6.5		4.6	6.5	mA
		125°C			6			6	
Bias current change	V_I = 20 V to 30 V	0°C to 125°C			1.5			1.5	mA
	I_O = 1 mA to 40 mA	0°C to 125°C			0.1			0.2	

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq$ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

SERIES uA78M00
POSITIVE-VOLTAGE REGULATORS

D2214, JUNE 1976—REVISED MARCH 1983

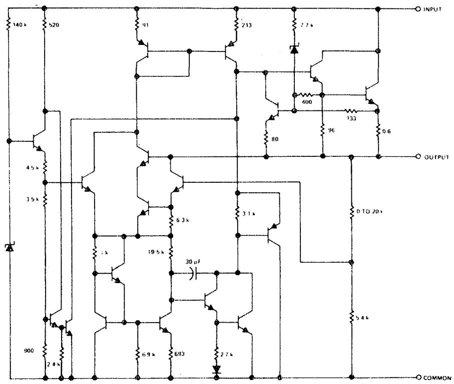
- 3-Terminal Regulators
- Output Current up to 500 mA
- No External Components
- Internal Thermal Overload Protection
- High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Direct Replacements for Fairchild μA78M00 Series and National LM78MXX and LM341 Series

NOMINAL OUTPUT VOLTAGE	−55°C to 150°C OPERATING TEMPERATURE RANGE	0°C to 125°C OPERATING TEMPERATURE RANGE
5 V	uA78M05M	uA78M05C
6 V	uA78M06M	uA78M06C
8V	uA78M08M	uA78M08C
10 V	uA78M10M	uA78M10C
12 V	uA78M12M	uA78M12C
15 V	uA78M15M	uA78M15C
20 V	uA78M20M	uA78M20C
24 V		uA78M24C
PACKAGES	JG	KC

description

This series of fixed-voltage monolithic integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 500 milliamperes of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and also as the power pass element in precision regulators.

schematic

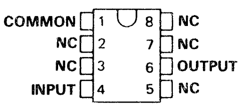


Resistor values shown are nominal and in ohms

terminal assignments

uA78M_M . . . JG PACKAGE

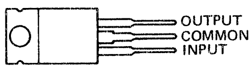
(TOP VIEW)



NC — No internal connection.

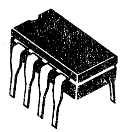
uA78M_C . . . KC PACKAGE

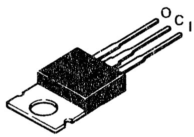
(TOP VIEW)



THE COMMON TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB





absolute maximum ratings over operating temperature range (unless otherwise noted)

		uA78M05M THRU uA78M24M	uA78M05C THRU uA78M24C	UNIT
Input voltage	uA78M20 thru uA78M24	40	40	V
	All others	35	35	
Continuous total dissipation at 25 °C free-air temperature (see Note 1)	JG package	1.05		W
	KC (TO-220AB) package		2	
Continuous total dissipation at (or below) 25 °C case temperature (see Note 1)	KC package		7.5	W
Operating free-air, case, or virtual junction temperature range		−55 to 150	0 to 150	°C
Storage temperature range		−65 to 150	−65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	JG package	300		°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	KC package		260	°C

NOTE 1: For operation above 25° free-air or case temperature, refer to Figures 1 to 3. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activitated at power levels slightly above or below the rated dissipation.

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	uA78M05M, uA78M05C	7	25	V
	uA78M06M, uA78M06C	8	25	
	uA78M08M, uA78M08C	10.5	25	
	uA78M10M, uA78M10C	12.5	28	
	uA78M12M, uA78M12C	14.5	30	
	uA78M15M, uA78M15C	17.5	30	
	uA78M20C	23	35	
	uA78M24C	27	38	
Output current, I_O	All devices		500	mA
Operating virtual junction temperature, T_J	uA78M05M thru uA78M15M	−55	150	°C
	uA78M05C thru uA78M24C	0	125	

2

uA78M05M, uA78M05C electrical characteristics at specified virtual junction temperature, V_I = 10 V, I_O = 350 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA78M05M MIN	uA78M05M TYP	uA78M05M MAX	uA78M05C MIN	uA78M05C TYP	uA78M05C MAX	UNIT
Output voltage			25°C	4.8	5	5.2	4.8	5	5.2	V
	I_O = 5 mA to 350 mA	V_I = 8 V to 20 V	−55°C to 150°C	4.7		5.3				
		V_I = 7 V to 20 V	0°C to 125°C				4.75		5.25	
Input regulation	I_O = 200 mA	V_I = 7 V to 25 V	25°C		3	50		3	100	mV
		V_I = 8 V to 20 V			1	25				
		V_I = 8 V to 25 V						1	50	
Ripple rejection	V_I = 8 V to 18 V, f = 120 Hz	I_O = 100 mA	−55°C to 150°C	62						dB
			0°C to 125°C				62			
		I_O = 300 mA	25°C	62	80		62	80		
Output regulation	I_O = 5 mA to 500 mA		25°C		20	50		20	100	mV
	I_O = 5 mA to 200 mA				10	25		10	50	
Temperature coefficient of output voltage	I_O = 5 mA		−55°C to 25°C			−2				mV/°C
			25°C to 150°C			−1.5				
			0°C to 125°C					−1		
Output noise voltage	f = 10 Hz to 100 kHz		25°C		40	200		40	200	μV
Dropout voltage			25°C		2	2.5		2	2.5	V
Bias current			25°C		4.5	7		4.5	6	mA
Bias current change	I_O = 200 mA, V_I = 8 V to 25 V		−55°C to 150°C			0.8				mA
			0°C to 125°C						0.8	
	I_O = 5 mA to 350 mA		−55°C to 150°C			0.5				
			0°C to 125°C						0.5	
Short-circuit output current	V_I = 35 V		25°C		300	600		300		mA
Peak output current			25°C	0.5	0.7	1.4		0.7		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq$ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

uA78M06M, uA78M06C electrical characteristics at specified virtual junction temperature, V_I = 11 V, I_O = 350 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA78M06M MIN	uA78M06M TYP	uA78M06M MAX	uA78M06C MIN	uA78M06C TYP	uA78M06C MAX	UNIT
Output voltage			25°C	5.75	6	6.25	5.75	6	6.25	V
	I_O = 5 mA to 350 mA	V_I = 9 V to 21 V	−55°C to 150°C	5.7		6.3				
		V_I = 8 V to 21 V	0°C to 125°C				5.7		6.3	
Input regulation	I_O = 200 mA	V_I = 8 V to 25 V	25°C		5	60		5	100	mV
		V_I = 9 V to 20 V			1.5	30				
		V_I = 9 V to 25 V						1.5	50	
Ripple rejection	V_I = 9 V to 19 V, f = 120 Hz	I_O = 100 mA	−55°C to 150°C	59						dB
			0°C to 125°C				59			
		I_O = 300 mA	25°C	59	80		59	80		
Output regulation	I_O = 5 mA to 500 mA		25°C		20	60		20	120	mV
	I_O = 5 mA to 200 mA				10	30		10	60	
Temperature coefficient of output voltage	I_O = 5 mA		−55°C to 25°C			−2.4				mV/°C
			25°C to 150°C			−1.8				
			0°C to 125°C					−1		
Output noise voltage	f = 10 Hz to 100 kHz		25°C		45	240		45		µV
Dropout voltage			25°C		2	2.5		2		V
Bias current			25°C		4.5	7		4.5	6	mA
Bias current change	I_O = 200 mA, V_I = 9 V to 25 V		−55°C to 150°C			0.8				mA
			0°C to 125°C						0.8	
	I_O = 5 mA to 350 mA		−55°C to 150°C			0.5				
			0°C to 125°C						0.5	
Short-circuit output current	V_I = 35 V		25°C		270	600		270		mA
Peak output current			25°C	0.5	0.7	1.4		0.7		A

†All characteristics are measured with a capacitor across the input of 0.33 µF and a capacitor across the output of 0.1 µF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA78M08M, uA78M08C electrical characteristics at specified virtual junction temperature, V_I = 14 V, I_O = 350 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA78M08M MIN	uA78M08M TYP	uA78M08M MAX	uA78M08C MIN	uA78M08C TYP	uA78M08C MAX	UNIT
Output voltage		25°C	7.7	8	8.3	7.7	8	8.3	V
	I_O = 5 mA to 350 mA, V_I = 11.5 V to 23 V	−55°C to 150°C	7.6		8.4				
	I_O = 5 mA to 350 mA, V_I = 10.5 V to 23 V	0°C to 125°C				7.6		8.4	
Input regulation	I_O = 200 mA, V_I = 10.5 V to 25 V	25°C		6	60		6	100	mV
	I_O = 200 mA, V_I = 11 V to 20 V	25°C		2	30				
	I_O = 200 mA, V_I = 11 V to 25 V	25°C					2	50	
Ripple rejection	V_I = 11.5 V to 21.5 V, f = 120 Hz, I_O = 100 mA	−55°C to 150°C	56						dB
	V_I = 11.5 V to 21.5 V, f = 120 Hz, I_O = 100 mA	0°C to 125°C				56			
	V_I = 11.5 V to 21.5 V, f = 120 Hz, I_O = 300 mA	25°C	56	80		56	80		
Output regulation	I_O = 5 mA to 500 mA	25°C		25	80		25	160	mV
	I_O = 5 mA to 200 mA	25°C		10	40		10	80	
Temperature coefficient of output voltage	I_O = 5 mA	−55°C to 25°C			−3.2				mV/°C
	I_O = 5 mA	25°C to 150°C			−2.4				
	I_O = 5 mA	0°C to 125°C					−1		
Output noise voltage	f = 10 Hz to 100 kHz	25°C		52	320		52		μV
Dropout voltage		25°C		2	2.5		2		V
Bias current		25°C		4.6	7		4.6	6	mA
Bias current change	I_O = 200 mA, V_I = 11.5 V to 25 V	−55°C to 150°C			0.8				mA
	I_O = 200 mA, V_I = 10.5 V to 25 V	0°C to 125°C						0.8	
	I_O = 5 mA to 350 mA	−55°C to 150°C			0.5				
	I_O = 5 mA to 350 mA	0°C to 125°C						0.5	
Short-circuit output current	V_I = 35 V	25°C		250	600		250		mA
Peak output current		25°C	0.5	0.7	1.4		0.7		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

2

uA78M10M, uA78M10C electrical characteristics at specified virtual junction temperature, V_I = 17 V, I_O = 350 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA78M10M MIN	uA78M10M TYP	uA78M10M MAX	uA78M10C MIN	uA78M10C TYP	uA78M10C MAX	UNIT
Output voltage			25°C	9.6	10	10.4	9.6	10	10.4	V
	I_O = 5 mA to 350 mA	V_I = 13.5 V to 25 V	−55°C to 150°C	9.5		10.5				
		V_I = 12.5 V to 25 V	0°C to 125°C				9.5		10.5	
Input regulation	I_O = 200 mA	V_I = 12.5 V to 28 V	25°C		7	60		7	100	mV
		V_I = 14 V to 20 V			2	30				
		V_I = 14 V to 28 V						2	50	
Ripple rejection	V_I = 15 V to 25 V, f = 120 Hz	I_O = 100 mA	−55°C to 150°C	55						dB
			0°C to 125°C				55			
		I_O = 300 mA	25°C	55	80		55	80		
Output regulation	I_O = 5 mA to 500 mA		25°C		25	100		25	200	mV
	I_O = 5 mA to 200 mA				10	50		10	100	
Temperature coefficient of output voltage	I_O = 5 mA		−55°C to 25°C			−4				mV/°C
			25°C to 150°C			−3				
			0°C to 125°C					−1		
Output noise voltage	f = 10 Hz to 100 kHz		25°C		64			64		μV
Dropout voltage			25°C		2	2.5		2		V
Bias current			25°C		4.7	6		4.7	6	mA
Bias current change	I_O = 200 mA,	V_I = 13.5 V to 28 V	−55°C to 150°C			0.8				mA
		V_I = 12.5 V to 28 V	0°C to 125°C						0.8	
	I_O = 5 mA to 350 mA		−55°C to 150°C			0.5				
			0°C to 125°C						0.5	
Short-circuit output current	V_I = 35 V		25°C		245	600		245		mA
Peak output current			25°C	0.5	0.7	1.4		0.7		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq$ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA78M12M, uA78M12C electrical characteristics at specified virtual junction temperature, V_I = 19 V, I_O = 350 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA78M12M			uA78M12C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage			25°C	11.5	12	12.5	11.5	12	12.5	V
	I_O = 5 mA to 350 mA	V_I = 15.5 V to 27 V	−55°C to 150°C	11.4		12.6				
		V_I = 14.5 V to 27 V	0°C to 125°C				11.4		12.6	
Input regulation	I_O = 200 mA	V_I = 14.5 V to 30 V	25°C		8	60		8	100	mV
		V_I = 16 V to 25 V			2	30				
		V_I = 16 V to 30 V						2	50	
Ripple rejection	V_I = 15 V to 25 V, f = 120 Hz	I_O = 100 mA	−55°C to 150°C	55						dB
			0°C to 125°C				55			
		I_O = 300 mA	25°C	55	80		55	80		
Output regulation	I_O = 5 mA to 500 mA		25°C		25	120		25	240	mV
	I_O = 5 mA to 200 mA				10	60		10	120	
Temperature coefficient of output voltage	I_O = 5 mA		−55°C to 25°C			−4.8				mV/°C
			25°C to 150°C			−3.6				
			0°C to 125°C					−1		
Output noise voltage	f = 10 Hz to 100 kHz		25°C		75	480		75		μV
Dropout voltage			25°C		2	2.5		2		V
Bias current			25°C		4.8	7		4.8	6	mA
Bias current change	I_O = 200 mA,	V_I = 15 V to 30 V	−55°C to 150°C			0.8				mA
		V_I = 14.5 V to 30 V	0°C to 125°C						0.8	
	I_O = 5 mA to 350 mA		−55°C to 150°C			0.5				
			0°C to 125°C						0.5	
Short-circuit output current	V_I = 35 V		25°C		240	600		240		mA
Peak output current			25°C	0.5	0.7	1.4		0.7		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

2

uA78M15M, uA78M15C electrical characteristics at specified virtual junction temperature, V_I = 23 V, I_O = 350 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA78M15M MIN	uA78M15M TYP	uA78M15M MAX	uA78M15C MIN	uA78M15C TYP	uA78M15C MAX	UNIT
Output voltage			25°C	14.4	15	15.6	14.4	15	15.6	V
	I_O = 5 mA to 350 mA	V_I = 18.5 V to 30 V	−55°C to 150°C	14.25		15.75				
		V_I = 17.5 V to 30 V	0°C to 125°C				14.25		15.75	
Input regulation	I_O = 200 mA	V_I = 17.5 V to 30 V	25°C		10	60		10	100	mV
		V_I = 20 V to 30 V			3	30		3	50	
Ripple rejection	V_I = 18.5 V to 28.5 V, f = 120 Hz	I_O = 100 mA	−55°C to 150°C	54						dB
			0°C to 125°C				54			
		I_O = 300 mA	25°C	54	70		54	70		
Output regulation	I_O = 5 mA to 500 mA		25°C		25	150		25	300	mV
	I_O = 5 mA to 200 mA				10	75		10	150	
Temperature coefficient of output voltage	I_O = 5 mA		−55°C to 25°C			−6				mV/°C
			25°C to 150°C			−4.5				
			0°C to 125°C					−1		
Output noise voltage	f = 10 Hz to 100 kHz		25°C		90	600		90		μV
Dropout voltage			25°C		2	2.5		2		V
Bias current			25°C		4.8	7		4.8	6	mA
Bias current change	I_O = 200 mA,	V_I = 18.5 V to 30 V	−55°C to 150°C			0.8				mA
		V_I = 17.5 V to 30 V	0°C to 125°C						0.8	
	I_O = 5 mA to 350 mA		−55°C to 150°C			0.5				
			0°C to 125°C						0.5	
Short-circuit output current	V_I = 35 V		25°C		240	600		240		mA
Peak output current			25°C	0.5	0.7	1.4		0.7		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA78M20C electrical characteristics at specified virtual junction temperature, V_I = 29 V, I_O = 350 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA78M20C MIN	uA78M20C TYP	uA78M20C MAX	UNIT
Output voltage	I_O = 5 mA to 350 mA,	V_I = 23 V to 35 V	25°C	19.2	20	20.8	V
			0°C to 125°C	19		21	
Input regulation	I_O = 200 mA	V_I = 23 V to 35 V	25°C		10	100	mV
		V_I = 24 V to 35 V			5	50	
Ripple rejection	V_I = 24 V to 34 V, f = 120 Hz	I_O = 100 mA	0°C to 125°C	53			dB
		I_O = 300 mA	25°C	53	70		
Output regulation	I_O = 5 mA to 500 mA		25°C		30	400	mV
	I_O = 5 mA to 200 mA				10	200	
Temperature coefficient of output voltage	I_O = 5 mA		0°C to 125°C		−1.1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		25°C		110		μV
Dropout voltage			25°C		2		V
Bias current			25°C		4.9	6	mA
Bias current change	I_O = 200 mA,	V_I = 23 V to 35 V	0°C to 125°C			0.8	mA
	I_O = 5 mA to 350 mA		0°C to 125°C			0.5	
Short-circuit output current	V_I = 35 V		25°C		240		mA
Peak output current			25°C		0.7		A

†All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

2

uA78M24C electrical characteristics at specified virtual junction temperature, V_I = 33 V, I_O = 350 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS[†]			uA78M24C			UNIT
				MIN	TYP	MAX	
Output voltage			25°C	23	24	25	V
	I_O = 5 mA to 350 mA,	V_I = 27 V to 38 V	0°C to 125°C	22.8		25.2	
Input regulation	I_O = 200 mA	V_I = 27 V to 38 V			10	100	mV
		V_I = 28 V to 38 V			5	50	
Ripple rejection	V_I = 28 V to 38 V, f = 120 Hz	I_O = 100 mA	−55°C to 150°C				dB
			0°C to 125°C	50			
		I_O = 300 mA	25°C	50	70		
Output regulation	I_O = 5 mA to 500 mA		25°C		30	480	mV
	I_O = 5 mA to 200 mA				10	240	
Temperature coefficient of output voltage	I_O = 5 mA		0°C to 125°C		−1.2		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		25°C		170		μV
Dropout voltage			25°C		2		V
Bias current			25°C		5	6	mA
Bias current change	I_O = 200 mA,	V_I = 27 V to 38 V	0°C to 125°C			0.8	mA
	I_O = 5 mA to 350 mA		0°C to 125°C			0.5	
Short-circuit output current	V_I = 35 V		25°C		240		mA
Peak output current			25°C		0.7		A

[†] All characteristics are measured with a capacitor across the input of 0.33 μF and a capacitor across the output of 0.1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq$ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

THERMAL INFORMATION

KC PACKAGE
FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

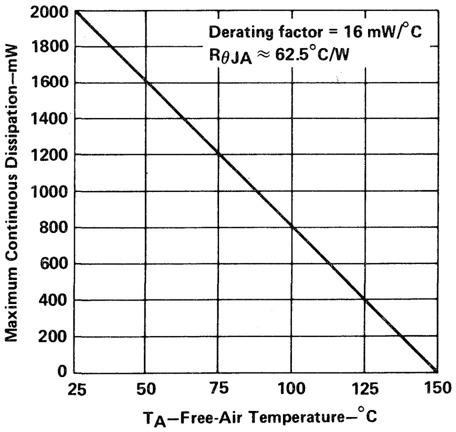


FIGURE 1

KC PACKAGE
CASE TEMPERATURE
DISSIPATION DERATING CURVE

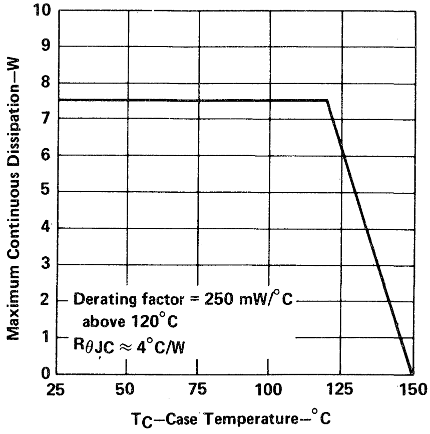


FIGURE 2

JG PACKAGE
CASE TEMPERATURE
DISSIPATION DERATING CURVE

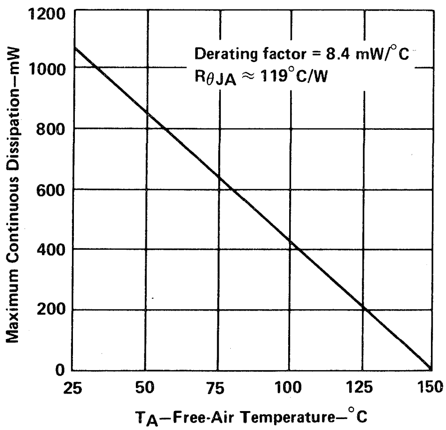


FIGURE 3

2

SERIES uA7900 NEGATIVE-VOLTAGE REGULATORS

D2215, JUNE 1976—REVISED JANUARY 1983

- 3-Terminal Regulators
- Output Current up to 1.5 A
- No External Components
- Internal Thermal Overload Protection
- High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Essentially Equivalent to National LM320 Series
- Direct Replacements for Fairchild μA7900 Series and National LM79XX Series

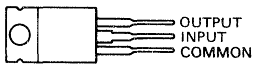
NOMINAL OUTPUT VOLTAGE	REGULATOR
−5 V	uA7905C
−5.2 V	uA7952C
−6 V	uA7906C
−8 V	uA7908C
−12 V	uA7912C
−15 V	uA7915C
−18 V	uA7918C
−24 V	uA7924C

description

This series of fixed-negative-voltage monolithic integrated-circuit voltage regulators is designed to complement Series uA7800 in a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 amperes of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and also as the power pass element in precision regulators.

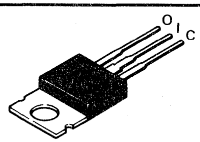
KC PACKAGE

(TOP VIEW)

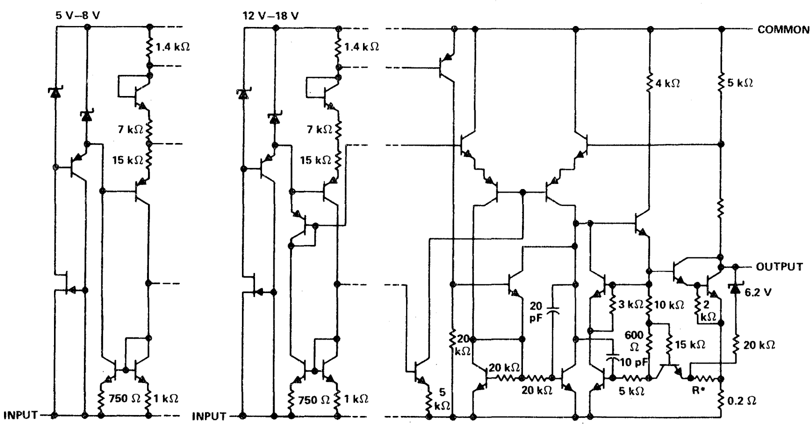


THE INPUT TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



schematic



12 V–18 V; R* = 50 Ω
5 V–8 V; R* = 150 Ω
All component values are nominal.

absolute maximum ratings over operating temperature range (unless otherwise noted)

		uA7905C THRU uA7924C	UNIT
Input voltage	uA7924C	−40	V
	All others	−35	
Continuous total dissipation at 25°C free-air temperature (see Note 1)		2	W
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)		15	W
Operating free-air, case, or virtual junction temperature range		0 to 150	°C
Storage temperature range		−65 to 150	°C
Lead temperature 3,2 mm (1/8 inch) from case for 10 seconds		260	°C

NOTE 1: For operation above 25° free-air or case temperature, refer to Figures 1 and 2. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activitated at power levels slightly above or below the rated dissipation.

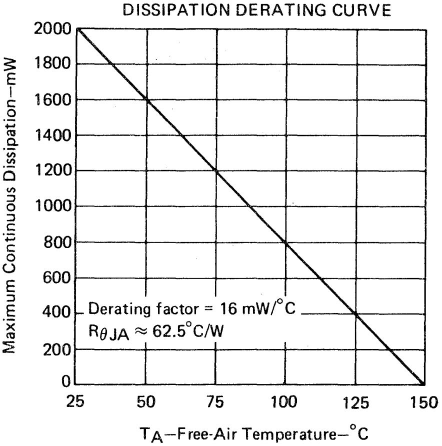


FIGURE 1

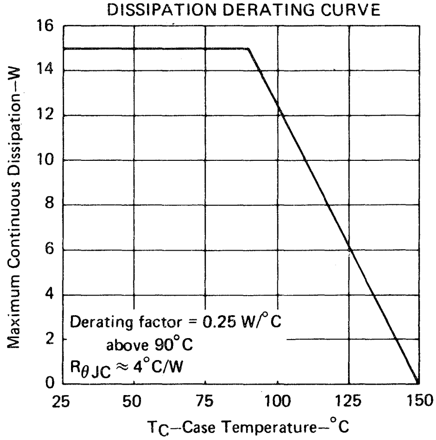


FIGURE 2

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	uA7905C	−7	−25	V
	uA7952C	−7.2	−25	
	uA7906C	−8	−25	
	uA7908C	−10.5	−25	
	uA7912C	−14.5	−30	
	uA7915C	−17.5	−30	
	uA7918C	−21	−33	
	uA7924C	−27	−38	
Output current, I_O			1.5	A
Operating virtual junction temperature, T_J		0	125	°C

uA7905C electrical characteristics at specified virtual junction temperature, $V_I = -10$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7905C MIN	TYP	MAX	UNIT
Output voltage		25°C	−4.8	−5	−5.2	V
	I_O = 5 mA to 1 A, V_I = −7 V to −20 V, P ≤ 15 W	0°C to 125°C	−4.75		−5.25	
Input regulation	V_I = −7 V to −25 V	25°C		12.5	50	mV
	V_I = −8 V to −12 V			4	15	
Ripple rejection	V_I = −8 V to −18 V, f = 120 Hz	0°C to 125°C	54	60		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		15	100	mV
	I_O = 250 mA to 750 mA			5	50	
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−0.4		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		125		μV
Dropout voltage	I_O = 1 A	25°C		1.1		V
Bias current		25°C		1.5	2	mA
Bias current change	V_I = −7 V to −25 V	0°C to 125°C		0.15	0.5	mA
	I_O = 5 mA to 1 A			0.08	0.5	
Peak output current		25°C		2.1		A

uA7952C electrical characteristics at specified virtual junction temperature, $V_I = -10$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7952C MIN	TYP	MAX	UNIT
Output voltage		25°C	−5	−5.2	−5.4	V
	I_O = 5 mA to 1 A, V_I = −7.2 V to −20 V, P ≤ 15 W	0°C to 125°C	−4.95		−5.45	
Input regulation	V_I = −7.2 V to −25 V	25°C		12.5	100	mV
	V_I = −8.2 V to −12 V			4	50	
Ripple rejection	V_I = −8.2 V to −18 V, f = 120 Hz	0°C to 125°C	54	60		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		15	100	mV
	I_O = 250 mA to 750 mA			5	50	
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−0.4		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		125		μV
Dropout voltage	I_O = 1 A	25°C		1.1		V
Bias current		25°C		1.5	2	mA
Bias current change	V_I = −7.2 V to −25 V	0°C to 125°C		0.15	1.3	mA
	I_O = 5 mA to 1 A			0.08	0.5	
Peak output current		25°C		2.1		A

†All characteristics are measured with a solid-tantalum capacitor across the input of 2 μF and a solid-tantalum capacitor across the output of 1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA7906C electrical characteristics at specified virtual junction temperature, $V_I = -11$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7906C MIN	TYP	MAX	UNIT
Output voltage		25°C	−5.75	−6	−6.25	V
	I_O = 5 mA to 1 A, V_I = −8 V to −21 V, P ≤ 15 W	0°C to 125°C	−5.7		−6.3	
Input regulation	V_I = −8 V to −25 V	25°C		12.5	120	mV
	V_I = −9 V to −13 V			4	60	
Ripple rejection	V_I = −9 V to −19 V, f = 120 Hz	0°C to 125°C	54	60		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		15	120	mV
	I_O = 250 mA to 750 mA			5	60	
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−0.4		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		150		μV
Dropout voltage	I_O = 1 A	25°C		1.1		V
Bias current		25°C		1.5	2	mA
Bias current change	V_I = −8 V to −25 V	0°C to 125°C		0.15	1.3	mA
	I_O = 5 mA to 1 A			0.08	0.5	
Peak output current		25°C		2.1		A

uA7908C electrical characteristics at specified virtual junction temperature, $V_I = -14$ V, $I_O = 500$ mA (unless otherwise noted)

2

PARAMETER	TEST CONDITIONS†		uA7908C MIN	TYP	MAX	UNIT
Output voltage		25°C	−7.7	−8	−8.3	V
	I_O = 5 mA to 1 A, V_I = −10.5 V to −23 V, P ≤ 15 W	0°C to 125°C	−7.6		−8.4	
Input regulation	V_I = −10.5 V to −25 V	25°C		12.5	160	mV
	V_I = −11 V to −17 V			4	80	
Ripple rejection	V_I = −11.5 V to −21.5 V, f = 120Hz	0°C to 125°C	54	60		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		15	160	mV
	I_O = 250 mA to 750 mA			5	80	
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−0.6		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		200		μV
Dropout voltage	I_O = 1 A	25°C		1.1		V
Bias current		25°C		1.5	2	mA
Bias current change	V_I = −10.5 V to −25 V	0°C to 125°C		0.15	1	mA
	I_O = 5 mA to 1 A			0.08	0.5	
Peak output current		25°C		2.1		A

†All characteristics are measured with a solid-tantalum capacitor across the input of 2 μF and a solid-tantalum capacitor across the output of 1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t_w ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA7912C electrical characteristics at specified virtual junction temperature, $V_I = -19$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7912C MIN	uA7912C TYP	uA7912C MAX	UNIT
Output voltage		25°C	−11.5	−12	−12.5	V
	I_O = 5 mA to 1 A, V_I = −14.5 V to −27 V, P ≤ 15 W	0°C to 125°C	−11.4		−12.6	
Input regulation	V_I = −14.5 V to −30 V	25°C		5	80	mV
	V_I = −16 V to −22 V			3	30	
Ripple rejection	V_I = −15 V to −25 V, f = 120 Hz	0°C to 125°C	54	60		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		15	200	mV
	I_O = 250 mA to 750 mA			5	75	
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−0.8		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		300		μV
Dropout voltage	I_O = 1 A	25°C		1.1		V
Bias current		25°C		2	3	mA
Bias current change	V_I = −14.5 V to −30 V	0°C to 125°C		0.04	0.5	mA
	I_O = 5 mA to 1 A			0.06	0.5	
Peak output current		25°C		2.1		A

uA7915C electrical characteristics at specified virtual junction temperature, $V_I = -23$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		uA7915C MIN	uA7915C TYP	uA7915C MAX	UNIT
Output voltage		25°C	−14.4	−15	−15.6	V
	I_O = 5 mA to 1 A, V_I = −17.5 V to −30 V, P ≤ 15 W	0°C to 125°C	−14.25		−15.75	
Input regulation	V_I = −17.5 V to −30 V	25°C		5	100	mV
	V_I = −20 V to −26 V			3	50	
Ripple rejection	V_I = −18.5 V to −28.5 V, f = 120 Hz	0°C to 125°C	54	60		dB
Output regulation	I_O = 5 mA to 1.5 A	25°C		15	200	mV
	I_O = 250 mA to 750 mA			5	75	
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		−1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		375		μV
Dropout voltage	I_O = 1 A	25°C		1.1		V
Bias current		25°C		2	3	mA
Bias current change	V_I = −17.5 V to −30 V	0°C to 125°C		0.04	0.5	mA
	I_O = 5 mA to 1 A			0.06	0.5	
Peak output current		25°C		2.1		A

†All characteristics are measured with a solid-tantalum capacitor across the input of 2 μF and a solid-tantalum capacitor across the output of 1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA7918C electrical characteristics at specified virtual junction temperature, $V_I = -27$ V, $I_O = 500$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA7918C MIN	uA7918C TYP	uA7918C MAX	UNIT
Output voltage			25°C	−17.3	−18	−18.7	V
	I_O = 5 mA to 1 A, P ≤ 15 W	V_I = −21 V to −33 V,	0°C to 125°C	−17.1		−18.9	
Input regulation	V_I = −21 V to −33 V		25°C		5	360	mV
	V_I = −24 V to −30 V				3	180	
Ripple rejection	V_I = −22 V to −32 V,	f = 120 Hz	0°C to 125°C	54	60		dB
Output regulation	I_O = 5 mA to 1.5 A		25°C		30	360	mV
	I_O = 250 mA to 750 mA				10	180	
Temperature coefficient of output voltage	I_O = 5 mA		0°C to 125°C		−1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		25°C		450		μV
Dropout voltage	I_O = 1 A		25°C		1.1		V
Bias current			25°C		2	3	mA
Bias current change	V_I = −21 V to −33 V		0°C to 125°C		0.04	1	mA
	I_O = 5 mA to 1 A				0.06	0.5	
Peak output current			25°C		2.1		A

uA7924C electrical characteristics at specified virtual junction temperature, $V_I = -33$ V, $I_O = 500$ mA (unless otherwise noted)

2

PARAMETER	TEST CONDITIONS†			uA7924C MIN	uA7924C TYP	uA7924C MAX	UNIT
Output voltage			25°C	−23	−24	−25	V
	I_O = 5 mA to 1 A, P ≤ 15 W	V_I = −27 V to −38 V,	0°C to 125°C	−22.8		−25.2	
Input regulation	V_I = −27 V to −38 V		25°C		5	480	mV
	V_I = −30 V to −36 V				3	240	
Ripple rejection	V_I = −28 V to −38 V,	f = 120 Hz	0°C to 125°C	54	60		dB
Output regulation	I_O = 5 mA to 1.5 A		25°C		85	480	mV
	I_O = 250 mA to 750 mA				25	240	
Temperature coefficient of output voltage	I_O = 5 mA		0°C to 125°C		−1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		25°C		600		μV
Dropout voltage	I_O = 1 A		25°C		1.1		V
Bias current			25°C		2	3	mA
Bias current change	V_I = −27 V to −38 V		0°C to 125°C		0.04	1	mA
	I_O = 5 mA to 1 A				0.06	0.5	
Peak output current			25°C		2.1		A

†All characteristics are measured with a solid-tantalum capacitor across the input of 2 μF and a solid-tantalum capacitor across the output of 1 μF. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

SERIES uA79M00
NEGATIVE-VOLTAGE REGULATORS

D2216, JUNE 1976—REVISED DECEMBER 1982

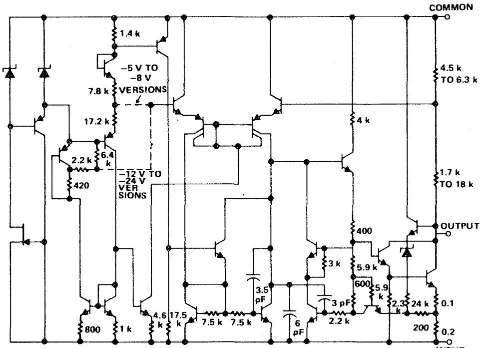
- 3-Terminal Regulators
- Output Current up to 500 mA
- No External Components
- High Power Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Direct Replacements for Fairchild μA79M00 Series

NOMINAL OUTPUT VOLTAGE	−55°C TO 150°C OPERATING TEMPERATURE RANGE	0°C TO 125°C OPERATING TEMPERATURE RANGE
−5 V	uA79M05M	uA79M05C
−6 V	uA79M06M	uA79M06C
−8 V	uA79M08M	uA79M08C
−12 V	uA79M12M	uA79M12C
−15 V	uA79M15M	uA79M15C
−20 V		uA79M20C
−24 V		uA79M24C
PACKAGE	JG	KC

description

This series of fixed-negative-voltage monolithic integrated-circuit voltage regulators is designed to complement Series uA78M00 in a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 500 milliamperes of output current. The internal current limiting and thermal shutdown features of these regulators make them essentially immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents and also as the power pass element in precision regulators.

schematic



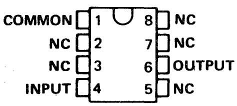
Resistor values shown are nominal and in ohms.

2

terminal assignments

uA79M_M. . .JG PACKAGE

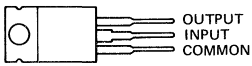
(TOP VIEW)



NC—No internal connection

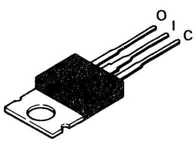
uA79M_C. . .KC PACKAGE

(TOP VIEW)



THE INPUT TERMINAL IS IN ELECTRICAL CONTACT WITH THE MOUNTING BASE

TO-220AB



absolute maximum ratings over operating temperature range (unless otherwise noted)

		uA79M05M THRU uA79M15M	uA79M05C THRU uA79M24C	UNIT
Input voltage	uA79M20, uA79M24		−40	V
	All others	−35	−35	
Continuous total dissipation at 25°C free-air temperature (see Note 1)	JG package	1.05		W
	KC (TO-220AB) package		2	
Continuous total dissipation at (or below) 25°C case temperature (see Note 1)	KC package		7.5	W
Operating free-air, case or virtual junction temperature range		−55 to 150	0 to 150	°C
Storage temperature range		−65 to 150	−65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	JG package	300		°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	KC package		260	°C

NOTE 1: For operation above 25° free-air or case temperature, refer to Figures 1 to 3. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activitated at power levels slightly above or below the rated dissipation.

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I	uA79M05M, uA79M05C	−7	−25	V
	uA79M06M, uA79M06C	−8	−25	
	uA79M08M, uA79M08C	−10.5	−25	
	uA79M12M, uA79M12C	−14.5	−30	
	uA79M15M, uA79M15C	−17.5	−30	
	uA79M20C	−23	−35	
	uA79M24C	−27	−38	
Output current, I_O			500	mA
Operating virtual junction temperature, T_J	uA79M05M thru uA79M15M	−55	150	°C
	uA79M05C thru uA79M24C	0	125	

2

uA79M05M, uA79M05C electrical characteristics at specified virtual junction temperature, $V_I = -10$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA79M05M MIN	uA79M05M TYP	uA79M05M MAX	uA79M05C MIN	uA79M05C TYP	uA79M05C MAX	UNIT
Output voltage			25°C	–4.8	–5	–5.2	–4.8	–5	–5.2	V
	I_O = 5 mA to 350 mA, V_I = –7 V to –25 V		–55°C to 150°C	–4.75		–5.25				
			0°C to 125°C				–4.75		–5.25	
Input regulation	V_I = –7 V to –25 V		25°C		7	50		7	50	mV
	V_I = –8 V to –18 V				3	30		3	30	
Ripple rejection	V_I = –8 V to –18 V, f = 120 Hz	I_O = 100 mA	–55°C to 150°C	50						dB
			0°C to 125°C				50			
		I_O = 300 mA	25°C	54	60		54	60		
Output regulation	I_O = 5 mA to 500 mA		25°C		75	100		75	100	mV
	I_O = 5 mA to 350 mA				50			50		
Temperature coefficient of output voltage	I_O = 5 mA		–55°C to 150°C			–1.5				mV/°C
			0°C to 125°C					–0.4		
Output noise voltage	f = 10 Hz to 100 kHz		25°C		125	400		125		µV
Dropout voltage			25°C		1.1	2.3		1.1		V
Bias current			25°C		1	2		1	2	mA
Bias current change	V_I = –8 V to –25 V		–55°C to 150°C			0.4				mA
			0°C to 125°C						0.4	
	I_O = 5 mA to 350 mA		–55°C to 150°C			0.4				
			0°C to 125°C						0.4	
Short-circuit output current	V_I = –30 V		25°C			600		140		mA
Peak output current			25°C	0.5	0.65	1.4		0.65		A

†All characteristics are measured with a 2-µF capacitor across the input and a 1-µF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA79M06M, uA79M06C electrical characteristics at specified virtual junction temperature, $V_I = -11$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA79M06M			uA79M06C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage			25°C	−5.75	−6	−6.25	−5.75	−6	−6.25	V
	I_O = 5 mA to 350 mA, V_I = −8 V to −25 V		−55°C to 150°C	−5.7		−6.3				
			0°C to 125°C				−5.7		−6.3	
Input regulation	V_I = −8 V to −25 V		25°C		7	60		7	60	mV
	V_I = −9 V to −19 V				3	40		3	40	
Ripple rejection	V_I = −9 V to −19 V, f = 120 Hz	I_O = 100 mA	−55°C to 150°C	50						dB
			0°C to 125°C				50			
		I_O = 300 mA	25°C	54	60		54	60		
Output regulation	I_O = 5 mA to 500 mA		25°C		80	120		80	120	mV
	I_O = 5 mA to 350 mA				55			55		
Temperature coefficient of output voltage	I_O = 5 mA		−55°C to 150°C			−1.5				mV/°C
			0°C to 125°C					−0.4		
Output noise voltage	f = 10 Hz to 100 kHz		25°C		150	480		150		μV
Dropout voltage			25°C		1.1	2.3		1.1		V
Bias current			25°C		1	2		1	2	mA
Bias current change	V_I = −9 V to −25 V		−55°C to 150°C			0.4				mA
			0°C to 125°C						0.4	
	I_O = 5 mA to 350 mA		−55°C to 150°C			0.4				
			0°C to 125°C						0.4	
Short-circuit output current	V_I = −30 V		25°C			600		140		mA
Peak output current			25°C	0.5	0.65	1.4		0.65		A

†All characteristics are measured with a 2-μF capacitor across the input and a 1-μF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA79M08M, uA79M08C electrical characteristics at specified virtual junction temperature, $V_I = -19$ V, $I_O = 350$ mA (unless noted)

PARAMETER	TEST CONDITIONS†			uA79M08M MIN	uA79M08M TYP	uA79M08M MAX	uA79M08C MIN	uA79M08C TYP	uA79M08C MAX	UNIT
Output voltage			25°C	−7.7	−8	−8.3	−7.7	−8	−8.3	V
	I_O = 5 mA to 350 mA, V_I = −10.5 V to −25 V		−55°C to 150°C	−7.6		−8.4				
			0°C to 125°C				−7.6		−8.4	
Input regulation	V_I = −10.5 V to −25 V		25°C		8	80		8	80	mV
	V_I = −11 V to −21 V				4	50		4	50	
Ripple rejection	V_I = −11.5 V to −21.5 V, f = 120 Hz	I_O = 100 mA	−55°C to 150°C	50						dB
			0°C to 125°C				50			
		I_O = 300 mA	25°C	54	59		54	59		
Output regulation	I_O = 5 mA to 500 mA		25°C		90	160		90	160	mV
	I_O = 5 mA to 350 mA				60			60		
Temperature coefficient of output voltage	I_O = 5 mA		−55°C to 150°C			−2.4				mV/°C
			0°C to 125°C					−0.6		
Output noise voltage	f = 10 Hz to 100 kHz		25°C		200	640		200		µV
Dropout voltage			25°C		1.1	2.3		1.1		V
Bias current			25°C		1	2		1	2	mA
Bias current change	V_I = −10.5 V to −25 V		−55°C to 150°C			0.4				mA
			0°C to 125°C						0.4	
	I_O = 5 mA to 350 mA		−55°C to 150°C			0.4				
			0°C to 125°C						0.4	
Short-circuit output current	V_I = −30 V		25°C			600		140		mA
Peak output current			25°C	0.5	0.65	1.4		0.65		A

†All characteristics are measured with a 2-µF capacitor across the input and a 1-µF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leqslant 10$ ms, duty cycle $\leqslant 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

uA79M12M, uA79M12C electrical characteristics at specified virtual junction temperature, $V_I = -19$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA79M12M			uA79M12C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
Output voltage			25°C	−11.5	−12	−12.5	−11.5	−12	−12.5	V
	I_O = 5 mA to 350 mA, V_I = −14.5 V to −30 V		−55°C to 150°C	−11.4		−12.6				
			0°C to 125°C				−11.4		−12.6	
Input regulation	V_I = −14.5 V to −30 V		25°C		9	80		9	80	mV
	V_I = −15 V to −25 V				5	50		5	50	
Ripple rejection	V_I = −15 V to −25 V, f = 120 Hz	I_O = 100 mA	−55°C to 150°C	50						dB
			0°C to 125°C				50			
		I_O = 300 mA	25°C	54	60		54	60		
Output regulation	I_O = 5 mA to 500 mA		25°C		65	240		65	240	mV
	I_O = 5 mA to 350 mA				45			45		
Temperature coefficient of output voltage	I_O = 5 mA		−55°C to 150°C			−3.6				mV/°C
			0°C to 125°C					−0.8		
Output noise voltage	f = 10 Hz to 100 kHz		25°C		300	960		300		µV
Dropout voltage			25°C		1.1	2.3		1.1		V
Bias current			25°C		1.5	3		1.5	3	mA
Bias current change	V_I = −14.5 V to −30 V		−55°C to 150°C			0.4				mA
			0°C to 125°C						0.4	
	I_O = 5 mA to 350 mA		−55°C to 150°C			0.4				
			0°C to 125°C						0.4	
Short-circuit output current	V_I = −30 V		25°C			600		140		mA
Peak output current			25°C	0.5	0.65	1.4		0.65		A

†All characteristics are measured with a 2-µF capacitor across the input and a 1-µF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle $\leq 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

uA79M15M, uA79M15C electrical characteristics at specified virtual junction temperature, $V_I = -23$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA79M15M MIN	uA79M15M TYP	uA79M15M MAX	uA79M15C MIN	uA79M15C TYP	uA79M15C MAX	UNIT
Output voltage			25°C	−14.4	−15	−15.6	−14.4	−15	−15.6	V
	I_O = 5 mA to 350 mA, V_I = −17.5 V to −30 V		−55°C to 150°C	−14.25		−15.75				
			0°C to 125°C				−14.25		−15.75	
Input regulation	V_I = −17.5 V to −30 V		25°C		9	80		9	80	mV
	V_I = −18 V to −28 V				7	50		7	50	
Ripple rejection	V_I = −18.5 V to −28.5 V, f = 120 Hz	I_O = 100 mA	−55°C to 150°C	50						dB
			0°C to 125°C				50			
		I_O = 300 mA	25°C	54	59		54	59		
Output regulation	I_O = 5 mA to 500 mA		25°C		65	240		65	240	mV
	I_O = 5 mA to 350 mA				45			45		
Temperature coefficient of output voltage	I_O = 5 mA		−55°C to 150°C			−4.5				mV/°C
			0°C to 125°C					−1		
Output noise voltage	f = 10 Hz to 100 kHz		25°C		375	1200		375		µV
Dropout voltage			25°C		1.1	2.3		1.1		V
Bias current			25°C		1.5	3		1.5	3	mA
Bias current change	V_I = −17.5 V to −30 V		−55°C to 150°C			0.4				mA
			0°C to 125°C						0.4	
	I_O = 5 mA to 350 mA		−55°C to 150°C			0.4				
			0°C to 125°C						0.4	
Short-circuit output current	V_I = −30 V		25°C			600		140		mA
Peak output current			25°C	0.5	0.65			0.65		A

†All characteristics are measured with a 2-µF capacitor across the input and a 1-µF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leqslant 10$ ms, duty cycle $\leqslant 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

uA79M20C electrical characteristics at specified virtual junction temperature $V_I = -29$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA79M20C MIN	TYP	MAX	UNIT
Output voltage	I_O = 5 mA to 350 mA, V_I = −23 V to −35 V		25°C	−19.2	−20	−20.8	V
			0°C to 125°C	−19		−21	
Input regulation	V_I = −23 V to −35 V		25°C		12	80	mV
	V_I = −24 V to −34 V				10	70	
Ripple rejection	V_I = −24 V to −34 V, f = 120 Hz	I_O = 100 mA	0°C to 125°C	50			dB
		I_O = 300 mA	25°C	54	58		
Output regulation	I_O = 5 mA to 500 mA		25°C		75	300	mV
	I_O = 5 mA to 350 mA				50		
Temperature coefficient of output voltage	I_O = 5 mA		0°C to 125°C		−1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		25°C		500		μV
Dropout voltage			25°C		1.1		V
Bias current			25°C		1.5	3.5	mA
Bias current change	V_I = −23 V to −35 V		0°C to 125°C			0.4	mA
	I_O = 5 mA to 350 mA					0.4	
Short-circuit output current	V_I = −30 V		25°C		140		mA
Peak output current			25°C		650		A

†All characteristics are measured with a 2-μF capacitor across the input and a 1-μF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

2

uA79M24C electrical characteristics at specified virtual junction temperature, $V_I = -33$ V, $I_O = 350$ mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			uA79M24C MIN	TYP	MAX	UNIT
Output voltage	I_O = 5 mA to 350 mA, V_I = −27 V to −38 V		25°C	−23	−24	−25	V
			0°C to 125°C	−22.8		−25.2	
Input regulation	V_I = −27 V to −38 V		25°C		12	80	mV
	V_I = −28 V to −38 V				12	70	
Ripple rejection	V_I = −28 V to −38 V, f = 120 Hz	I_O = 100 mA	0°C to 125°C	50			dB
		I_O = 300 mA	25°C	54	58		
Output regulation	I_O = 5 mA to 500 mA		25°C		75	300	mV
	I_O = 5 mA to 350 mA				50		
Temperature coefficient of output voltage	I_O = 5 mA		0°C to 125°C		−1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz		25°C		600		μV
Dropout voltage			25°C		1.1		V
Bias current			25°C		1.5	3.5	mA
Bias current change	V_I = −27 V to −38 V		0°C to 125°C			0.4	mA
	I_O = 5 mA to 350 mA					0.4	
Short-circuit output current	V_I = −30 V		25°C		140		mA
Peak output current			25°C		650		A

†All characteristics are measured with a 2-μF capacitor across the input and a 1-μF capacitor across the output. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \leq 10$ ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

THERMAL INFORMATION

KC PACKAGE
FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

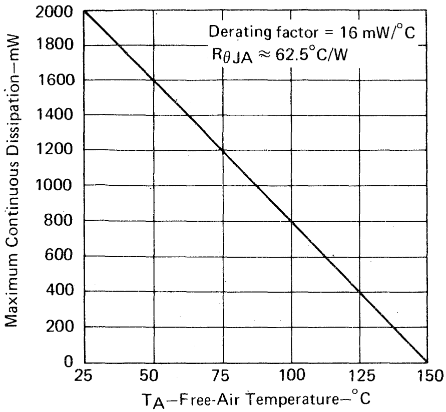


FIGURE 1

KC PACKAGE
CASE TEMPERATURE
DISSIPATION DERATING CURVE

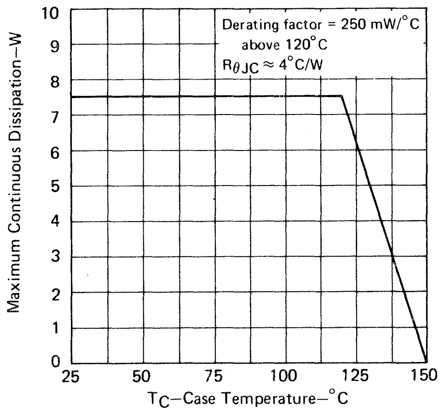


FIGURE 2

2

JG PACKAGE
FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

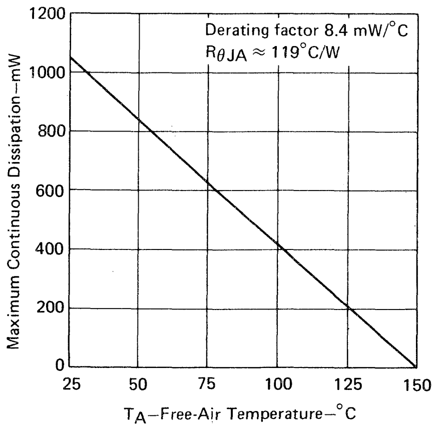


FIGURE 3

Appendix

Ordering Instructions
Mechanical Data

3

ORDERING INSTRUCTIONS

Electrical characteristics presented in this data book, unless otherwise noted, apply for the circuit type(s) listed in the page heading regardless of package. The availability of a circuit function in a particular package is denoted by an alphabetical reference above the pin-connection diagram(s). These alphabetical references refer to mechanical outline drawings shown in this section.

Factory orders for circuits described in this data book should include a four-part type number as explained in the following example.

EXAMPLE: TL 497AM JG /883B

1. Prefix (TL)

MUST CONTAIN TWO OR THREE LETTERS

TL	TI Linear Products (Excluding Interface)
TLC	TI Linear Silicon-Gate CMOS Products (Excluding Interface)
LM	Second Source for National
MC	Second Source for Motorola
RC	Second Source for Raytheon
SG	Second Source for Silicon General
uA	Second Source for Fairchild

2. Unique Circuit Designator Including Temperature Range (497AM)

MUST CONTAIN THREE TO SEVEN CHARACTERS

(From Individual Data Sheets)

Examples: 5941, 1524, 4193M, 78L05AC

3. Package (JG)

MUST CONTAIN ONE OR TWO LETTERS

J, JG, KC, LP, N, P, or U
(From Pin-Connection Diagram on individual Data Sheet)

4. MIL-STD-883B Method 5004, Class B (/883B)

OMIT /883B WHEN NOT APPLICABLE

Circuits are shipped in one of the carriers below. Unless a specific method of shipment is specified by the customer (with possible additional costs), circuits will be shipped on the most practical carrier.

Flat (U)
- Barnes Carrier
- Milton Ross Carrier

Dual-In-Line (J, JG, N, P)
- Slide Magazines
- A-Channel Plastic Tubing
- Barnes Carrier
- Sectioned Cardboard Box
- Individual Plastic Box

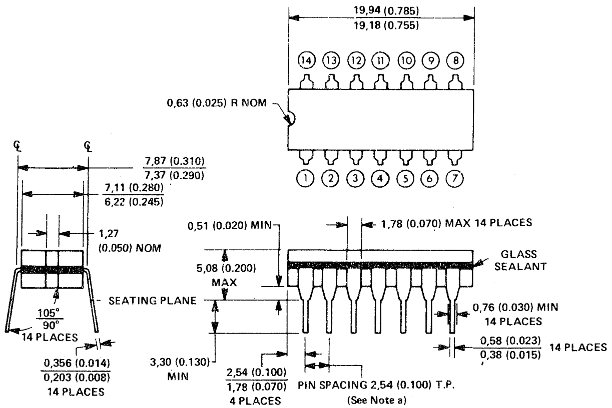
TO-220AB (KC)
- Bulk Pack
- Sleeves

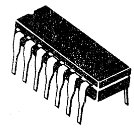
Plug-In (LP)
- Barnes Carrier
- Sectional Cardboard Box
- Individual Cardboard Box

J ceramic dual-in-line packages

These hermetically sealed dual-in-line packages consist of a ceramic base, ceramic cap, and a 14- or 16-lead frame. Hermetic sealing is accomplished with glass. The packages are intended for insertion in mounting-hole rows on 7,62 (0.300) centers (see Note a). Once the leads are compressed and inserted, sufficient tension is provided to secure the package in the board during soldering.

14-PIN J CERAMIC

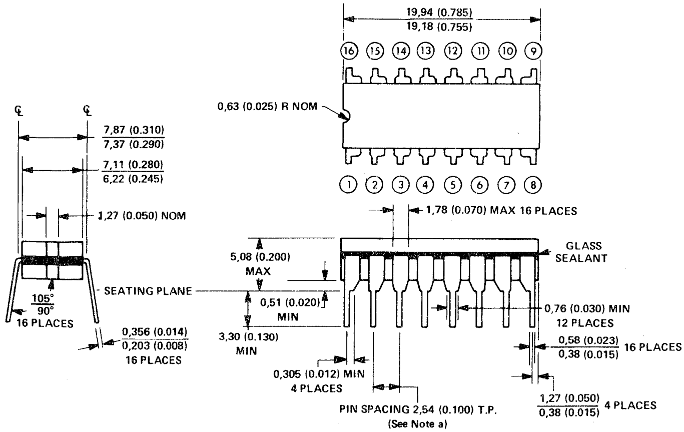


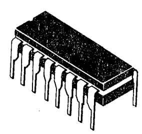


Falls Within JEDEC TO-116 and MO-001AA Dimensions

ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

16-PIN J CERAMIC





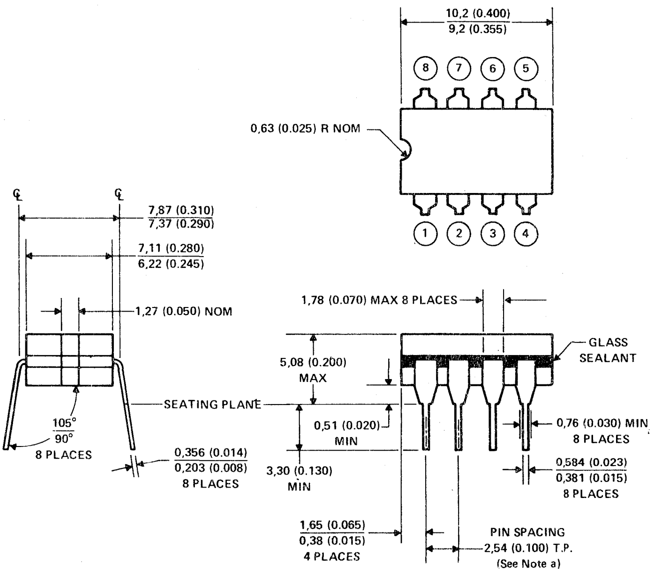
ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

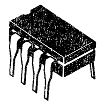
NOTE a: Each pin centerline is located within 0,25 (0.010) of its true longitudinal position.

JG ceramic dual-in-line package

This hermetically sealed dual-in-line package consists of a ceramic base, ceramic cap, and 8-lead frame. The package is intended for insertion in mounting-hole rows 7,62 (0.300) centers (see Note a). Once the leads are compressed and inserted, sufficient tension is provided to secure the package in the board during soldering.

8-PIN JG CERAMIC





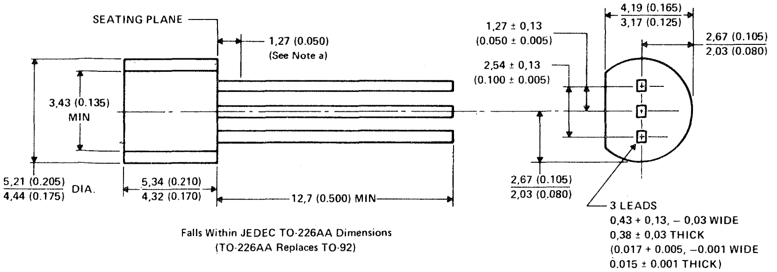
ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

3

NOTE a. Each pin centerline is located within 0,25 (0.010) of its true longitudinal position.

LP plastic package

This package is an encapsulation in a plastic compound specifically designed for this purposes. The package will withstand withstand soldering temperatures without deformation. The package exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B.

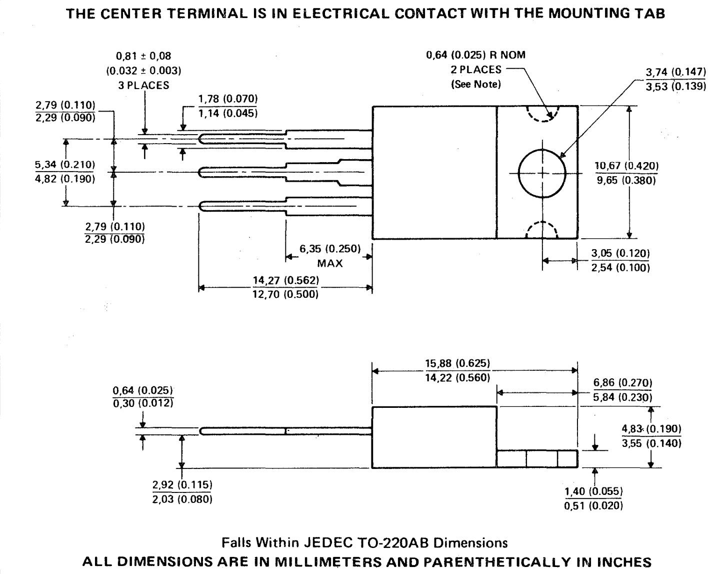


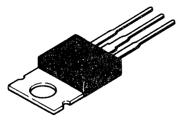
Falls Within JEDEC TO-226AA Dimensions
(TO-226AA Replaces TO-92)

ALL DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

NOTE a: Lead dimensions are not controlled in this area.

KC (TO-220AB) package



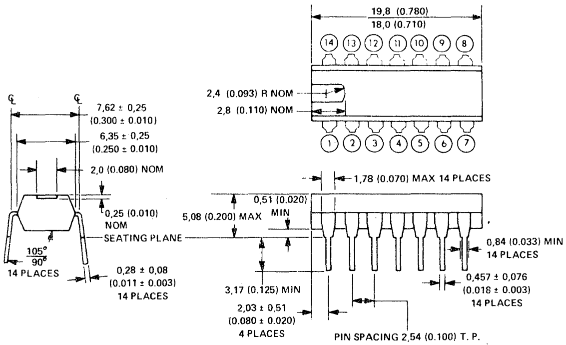


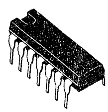
NOTE: Notches may or may not be present.

N plastic dual-in-line packages

These dual-in-line packages consist of a circuit mounted on a 14- or 16-lead frame and encapsulated within an electrically nonconductive plastic compound. The compound will withstand soldering temperature with no deformation and circuit performance characteristics remain stable when operated in high-humidity conditions. The packages are intended for insertion in mounting-hole rows on 7,62 (0.300) centers (see Note a). Once the leads are compressed and inserted, sufficient tension is provided to secure the package in the board during soldering.

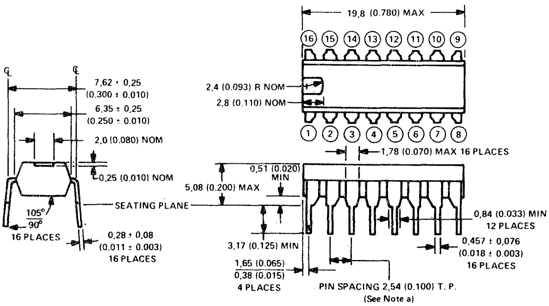
14-PIN N PLASTIC

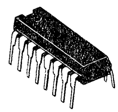




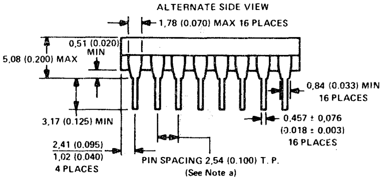
Falls Within JEDEC TO-116 and MO-001AA Dimensions
ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

16-PIN N PLASTIC





ALTERNATE SIDE VIEW



Parts may be supplied in accordance with the alternate side view at the option of TI plants located in Europe. In this case, the overall length of the package is 22,1 (0.870) max.

ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

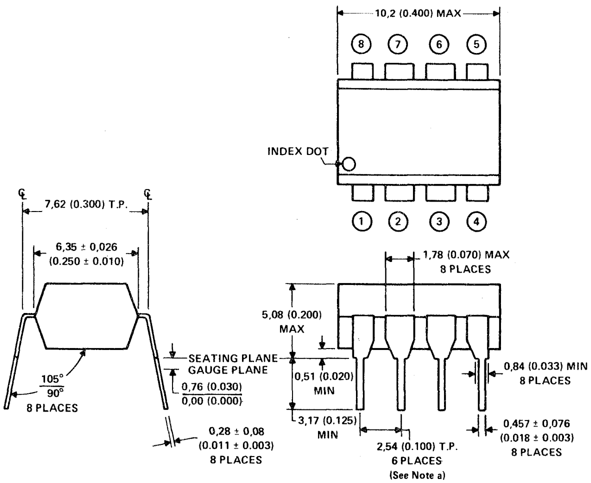
NOTE a: Each pin centerline is located within 0,25 (0.010) of its true longitudinal position.

3

P dual-in-line plastic package

This dual-in-line package consists of a circuit mounted on an 8-lead frame and encapsulated in an electrically nonconductive plastic compound. The compound will withstand soldering temperature with no deformation and circuit performance characteristics remain stable when operated under high-humidity conditions. This package is intended for insertion in mounting hole rows on 7,62 (0.300) centers. Once the leads are compressed and inserted, sufficient tension is provided to secure the package in the board during soldering.

8-PIN P PLASTIC



ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

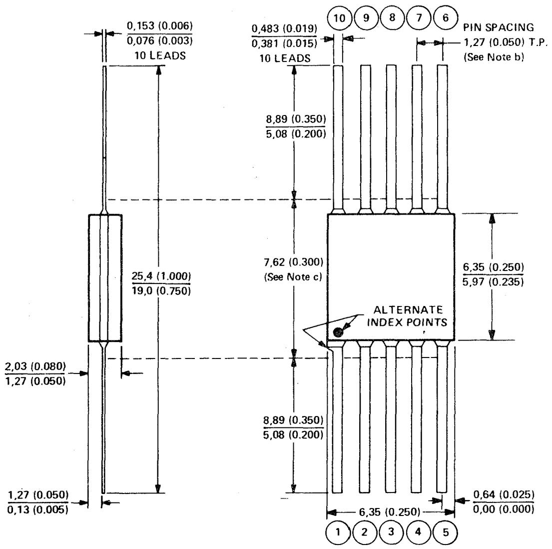
NOTE A: Each pin centerline is within 0,13 (0.005) radius of true position at the gauge plane with maximum material condition and unit installed.

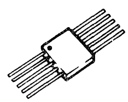
3

U ceramic flat packages

This flat package consists of a ceramic base, ceramic cap, and 10-lead frame. Circuit bars are alloy-mounted. Hermetic sealing is accomplished with glass. Tin-plated leads require no additional cleaning or processing when used in soldered assembly.

10-PIN U





Falls Within JEDEC MO-004AE Dimensions

ALL DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

NTOES: a. Leads are within 0.13 (0.005) radius of true position (TP) at maximum material condition.

b. This dimension determines a zone within which all body and lead irregularities lie.

3

Texas Instruments

AUSTRIA
Texas Instruments Ges.m.b.H.
Industriestraße B/16
A-2345 Brunn am Gebirge
Tel. 02236/84621-0

BELGIUM
Texas Instruments Belgium N.V.
Mercure Centre
Raketstraat 100, Rue de la Fusee
1130 Brussels
Tel. 02/7208000

DENMARK
Texas Instruments A/S
Marielundvej 46 E
2730 Herlev
Tel. 02/917400

ENGLAND
Texas Instruments Ltd.
Manton Lane
Bedford, MK 41 7 PA
Tel. 0234/67466
Technical Enquiry Service:
Tel. 0234/223000

FINLAND
Texas Instruments Finland OY
P.O. Box 56
Elimaenkatu 14 D
00511 Helsinki 51
Tel. 90/7013133

ESPANA
Texas Instruments Espana S.A.
C/Jose Lazaro Galdiano No. 6
16 Madrid
Telephone: (34) 1-4581458

FRANCE
Texas Instruments France
Boite Postale 5
06270 Villeneuve-Loubet
Tel. 093/200101

GERMANY
Texas Instruments Deutschland GmbH
Haggertystraße 1
8050 Freising
Tel. 08161/80-0

ITALIA
Texas Instruments
Semiconduttori Italia S.P.A.
Divisione Semiconduttori
Vialle delle Scienze 1
02015 Cittaducale (Rieti)
Telephone: (0746) 6941
Telex: 611003

NEDERLAND
Texas Instruments Holland BV.
Hogehilweg 19
(Bullewijk)
1101 CB Amsterdam Zuid-Oost
Tel. 020-5602911

NORWAY
Texas Instruments Norway A/S
Kr. Augustsgt. 13
Oslo 1
Tel. 02/206040

PORTUGAL
Texas Instruments Equipamento
Eletronico (Portugal) LDA
Rua Eng. Frederico, Ulrich 2650
4470 Maia
Tel. 948-1003

SWEDEN
Texas Instruments International
– Trade Corporation
(Sverigefilialen)
Box 39103
10054 Stockholm
Tel. 08/235480

TEXAS INSTRUMENTS

Creating useful products
and services for you.

Printed in U.K.

99889