

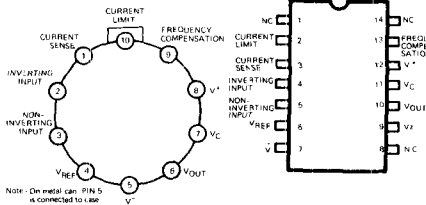
## precision voltage regulator

STANDARD TEMPERATURE RANGE, 0°C to +70°C

- Positive or negative supply operation
- Series, shunt, switching or floating operation
- .01% line and load regulation
- Output voltage adjustable from 2 to 37 volts
- Output current to 150 mA without external pass transistor

The L 123 is a monolithic voltage regulator constructed on a single silicon chip using the Planar epitaxial process. The device consists of a temperature compensated reference amplifier, error amplifier, power series pass transistor and current limit circuitry. Additional NPN or PNP pass elements may be used when output currents exceeding 150 mA are required. Provisions are made for adjustable current limiting and remote shutdown. In addition to the above, the device features low standby current drain, low temperature drift and high ripple rejection. The L 123 is intended for use with positive or negative supplies as a series, shunt, switching or floating regulator. Applications include laboratory power supplies, isolation regulators for low level data amplifiers, logic card regulators, small instrument power supplies, airborne systems and in other power supplies for digital and linear circuits.

CONNECTION DIAGRAM TOP VIEW



### ABSOLUTE MAXIMUM RATINGS (1)

(TA = 25°C unless otherwise noted)

Voltage from V+ to V-	40 V
Input-Output Voltage Differential	40 V
Maximum Output Current	150 mA
Current from VREF	25 mA
Internal Power Dissipation (1)	800 mW
Operating Temperature Range	0°C to +70°C
Storage Temperature Range (Metal Can)	-65°C to +150°C
Storage Temperature Range (DIP)	-55°C to +125°C
Lead Temperature (Soldering, 60 sec.)	300°C

NOTE ON PAGE 2

<p style="text-align: center;"><b>EQUIVALENT CIRCUIT</b></p>	<p style="text-align: center;"><b>PHYSICAL DIMENSIONS</b> 14-pin plastic DIP</p> <p style="text-align: center;">Note: all dimensions in mm.</p>	<p style="text-align: center;"><b>PHYSICAL DIMENSIONS</b> similar to Jedec TO 100 outline</p> <p style="text-align: center;">Notes: All dimensions in mm. Leads are gold-plated K over.</p>
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**ORDERING NUMBER**

- L123 B1 (for TO 116 package)
- L123 T1 (for TO 5 package)

**ELECTRICAL CHARACTERISTICS** (note 2)

PARAMETER (see definitions)	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Line Regulation	$V = 12\text{ V to } V = 15\text{ V}$		0.01	0.1	% $V_{OUT}$
	$V_{IN} = 12\text{ V to } V_{IN} = 40\text{ V}$		0.1	0.5	% $V_{OUT}$
	$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}, V_{IN} = 12\text{ V to } V_{IN} = 15\text{ V}$			0.3	% $V_{OUT}$
Load Regulation	$I_L = 1\text{ mA to } I_L = 50\text{ mA}$		0.03	0.2	% $V_{OUT}$
	$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}, I_L = 1\text{ mA to } I_L = 50\text{ mA}$			0.6	% $V_{OUT}$
Ripple Rejection	$f = 50\text{ Hz to } 10\text{ kHz}, C_{REF} = 0$		74		dB
	$f = 50\text{ Hz to } 10\text{ kHz}, C_{REF} = 5\text{ }\mu\text{F}$		86		dB
Average Temperature Coefficient of Output Voltage	$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$		0.003	0.015	%/ $^\circ\text{C}$
Short Circuit Current Limit	$R_{SC} = 10\text{ }\Omega, V_{OUT} = 0$		65		mA
Reference Voltage		6.80	7.15	7.50	V
Output Noise Voltage	$BW = 100\text{ Hz to } 10\text{ kHz}, C_{REF} = 0$		20		$\mu\text{V}_{rms}$
	$BW = 100\text{ Hz to } 10\text{ kHz}, C_{REF} = 5\text{ }\mu\text{F}$		2.5		$\mu\text{V}_{rms}$
Long Term Stability			0.1		%/1000 hrs
Standby Current Drain	$I_L = 0, V_{IN} = 30\text{ V}$		2.3	4	mA
Input Voltage Range		9.5		40	V
Output Voltage Range		2		37	V
Input-Output Voltage Differential		3		38	V

**DEFINITION OF TERMS**

**LINE REGULATION** – The percentage change in output voltage for a specified change in input voltage.

**LOAD REGULATION** – The percentage change in output voltage for a specified change in load current.

**RIPPLE REJECTION** – The ratio of the peak to peak input ripple voltage to the peak to peak output ripple voltage.

**AVERAGE TEMPERATURE COEFFICIENT OF OUTPUT VOLTAGE** – The percentage change in output voltage for a specified change in ambient temperature.

**SHORT CIRCUIT CURRENT LIMIT** – The output current of the regulator with the output shorted to the negative supply.

**REFERENCE VOLTAGE** – The output of the reference amplifier measured with respect to the negative supply.

**OUTPUT NOISE VOLTAGE** – The rms output noise voltage with constant load and no input ripple.

**STANDBY CURRENT DRAIN** – The supply current drawn by the regulator with no output load and no reference voltage load.

**INPUT VOLTAGE RANGE** – The range of supply voltage over which the regulator will operate.

**OUTPUT VOLTAGE RANGE** – The range of output voltage over which the regulator will operate.

**INPUT-OUTPUT VOLTAGE DIFFERENTIAL** – The range of voltage difference between the supply voltage and the regulated output voltage over which the regulator will operate.

**SENSE VOLTAGE** – The voltage between current sense and current limit terminals necessary to cause current limiting.

**TRANSIENT RESPONSE** – The closed-loop step function response of the regulator under small-signal conditions.

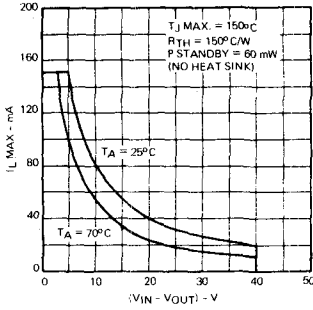
**NOTES:**

- (1) Derate metal can package at 6.4 mW/ $^\circ\text{C}$  and dual in-line package at 8 mW/ $^\circ\text{C}$  for operation at ambient temperatures above 25 $^\circ\text{C}$ .
- (2) Unless otherwise specified,  $T_A = 25^\circ\text{C}$ ,  $V_{IN} = V_+ = V_C = 12\text{ V}$ ,  $V_- = 0$ ,  $V_{OUT} = 5\text{ V}$ ,  $I_L = 1\text{ mA}$ ,  $R_{SC} = 0$ ,  $C_1 = 100\text{ pF}$  and divider impedance as seen by the error amplifier  $\leq 10\text{ K}\Omega$ .
- (3) For metal can applications where  $V_Z$  is required, an external 6.2 zener should be connected in series with  $V_{OUT}$ .
- (4) Figures in parentheses may be used if  $R_1/R_2$  divider is placed on opposite of error amp.
- (5) Replace  $R_1/R_2$  in figures with divider shown in figure 13.
- (6)  $V_+$  and  $V_C$  must be connected to a + 3 V or greater supply.
- (7)  $L_1$  is 40 turns of #20 enameled copper wire wound on Ferroxcube P36/22-3B7 pot core or equivalent with 0,23 mm. air gap.

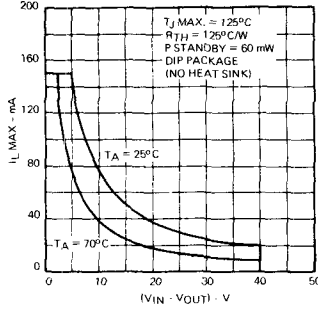
STANDARD TEMPERATURE RANGE

## TYPICAL ELECTRICAL CHARACTERISTICS (25°C free air temperature unless otherwise noted)

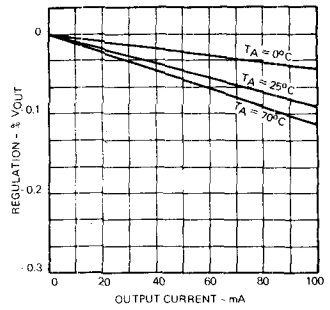
**MAXIMUM LOAD CURRENT AS A FUNCTION OF INPUT-OUTPUT VOLTAGE DIFFERENTIAL**



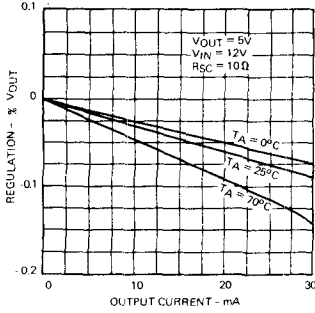
**MAXIMUM LOAD CURRENT AS A FUNCTION OF INPUT - OUTPUT VOLTAGE DIFFERENTIAL**



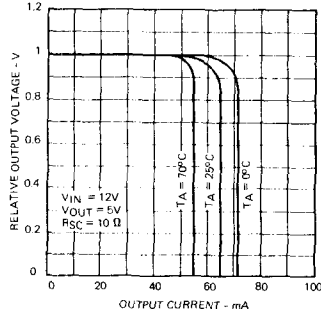
**LOAD REGULATION CHARACTERISTICS WITHOUT CURRENT LIMITING**



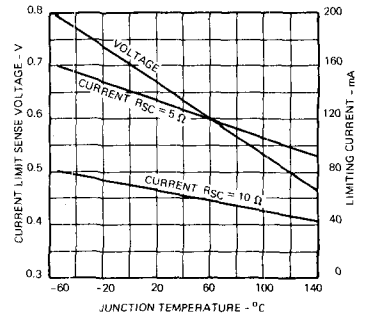
**LOAD REGULATION CHARACTERISTICS WITH CURRENT LIMITING**



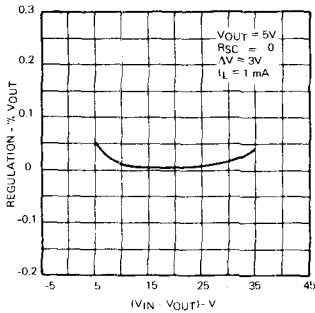
**CURRENT LIMITING CHARACTERISTICS**



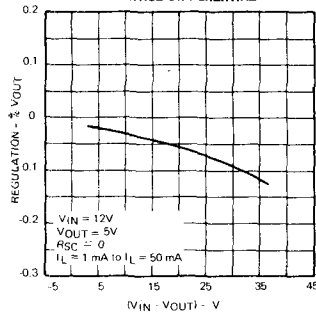
**CURRENT LIMITING CHARACTERISTICS AS A FUNCTION OF JUNCTION TEMPERATURE**



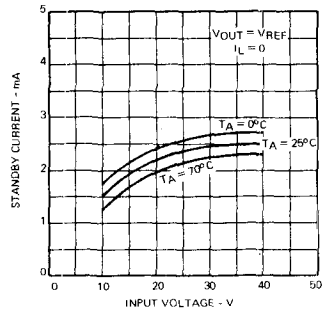
**LINE REGULATION AS A FUNCTION OF INPUT - OUTPUT VOLTAGE DIFFERENTIAL**

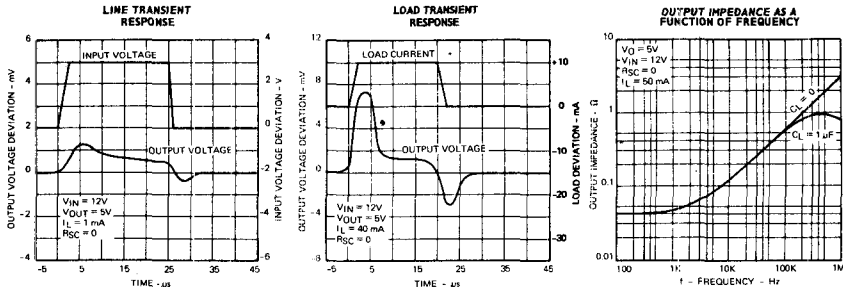


**LOAD REGULATION AS A FUNCTION OF INPUT-OUTPUT VOLTAGE DIFFERENTIAL**



**STANDBY CURRENT DRAIN AS A FUNCTION OF INPUT VOLTAGE**





**TABLE I**  
RESISTOR VALUES (KΩ) FOR STANDARD OUTPUT VOLTAGES

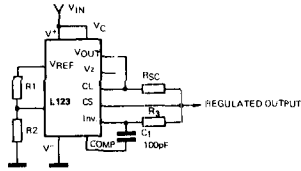
POSITIVE OUTPUT VOLTAGE	APPLICABLE FIGURES (Note 4)	FIXED OUTPUT ± 5 %		OUTPUT ADJUSTABLE ± 10% (Note 5)			NEGATIVE OUTPUT VOLTAGE	APPLICABLE FIGURES	FIXED OUTPUT ± 5 %		5 % OUTPUT ADJUSTABLE ± 10 %		
		R1	R2	R1	P1	R2			R1	R2	R1	P1	R2
+ 3	1, 5, 6, 9, 12 (4)	4.12	3.01	1.8	0.5	1.2	+100	7	3.57	102	2.2	10	91
+ 3.6	1, 5, 6, 9, 12 (4)	3.17	3.66	1.5	0.5	1.5	+250	7	3.57	256	2.2	10	240
+ 5	1, 5, 6, 9, 12 (4)	2.5	4.99	0.75	0.5	2.2	- 6 (note 6)	3, (10)	3.57	2.43	1.2	0.5	0.75
+ 6	1, 5, 6, 9, 12 (4)	1.5	6.04	0.5	0.5	2.7	- 9	3, 10	3.48	5.36	1.2	0.5	2
+ 9	2, 4, (5, 6, 12, 9)	1.17	7.15	0.75	1	2.7	- 12	3, 10	3.57	8.46	1.2	0.5	3.3
+ 12	2, 4, (5, 6, 9, 12)	4.17	7.15	2	1	3	- 15	3, 10	3.66	11.5	1.2	0.5	4.3
+ 15	2, 4, (5, 6, 9, 12)	7.17	7.15	3.3	1	3	- 28	3, 10	3.57	24.3	1.2	0.5	10
+28	2, 4, (5, 6, 9, 12)	21	7.15	5.6	1	2	- 45	8	3.57	41.2	2.2	10	33
+45	7	3.57	48.7	2.2	10	39	-100	8	3.57	97.6	2.2	10	91
+75	7	3.57	78.7	2.2	10	68	-250	8	3.57	249	2.2	10	240

**TABLE II**  
FORMULAE FOR INTERMEDIATE OUTPUT VOLTAGES

<p>Outputs from +2 to +7 volts [Figures 1, 5, 6, 9, 12, (4)]</p> $V_{OUT} = [V_{REF} \times \frac{R_2}{R_1 + R_2}]$	<p>Outputs from +4 to +250 volts [Figure 7]</p> $V_{OUT} = [ \frac{V_{REF}}{2} \times \frac{R_2 - R_1}{R_1} ]; R_3 = R_4$	<p>Current Limiting</p> $I_{LIMIT} = \frac{V_{SENSE}}{R_{SC}}$
<p>Outputs from +7 to +37 volts [Figures 2, 4, (5, 6, 9, 12)]</p> $V_{OUT} = [V_{REF} \times \frac{R_1 + R_2}{R_2}]$	<p>Outputs from -6 to -250 volts [Figures 3, 8, 10]</p> $V_{OUT} = [ \frac{V_{REF}}{2} \times \frac{R_1 + R_2}{R_1} ]; R_3 = R_4$	<p>Foldback Current Limiting</p> $I_{KNEE} = [ \frac{V_{OUT} R_3}{R_{IC} R_4} + \frac{V_{SENSE} (R_3 + R_4)}{R_{IC} R_4} ]$ $I_{SHORT\ Ckt} = [ \frac{V_{SENSE}}{R_{IC}} \times \frac{R_3 + R_4}{R_4} ]$

**BASIC LOW VOLTAGE REGULATOR**  
( $V_{OUT} = 2$  to  $7$  V)

FIG. 1

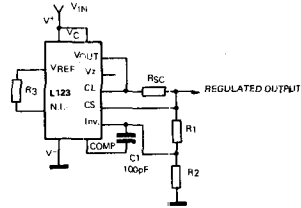


NOTE: R3 = R1/R2 for minimum temperature drift.  
R3 may be eliminated for minimum component count.

**TYPICAL PERFORMANCE**  
Regulated Output Voltage 5 V  
Line Regulation ( $\Delta V_{IN} = 3$  V) 0.5mV  
Load Regulation ( $\Delta I_L = 50$  mA) 1.5mV

**BASIC HIGH VOLTAGE REGULATOR**  
( $V_{OUT} = 7$  to  $37$  V)

FIG. 2

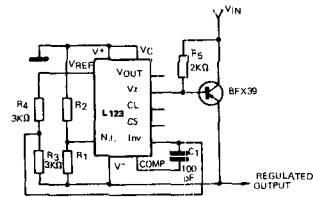


NOTE: R3 = R1/R2 for minimum temperature drift.  
R3 may be eliminated for minimum component count.

**TYPICAL PERFORMANCE**  
Regulated Output Voltage 15 V  
Line Regulation ( $\Delta V_{IN} = 3$  V) 1.5mV  
Load Regulation ( $\Delta I_L = 50$  mA) 4.5mV

**NEGATIVE VOLTAGE REGULATOR**

FIG. 3

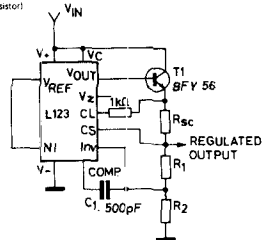


NOTE 3

**TYPICAL PERFORMANCE**  
Regulated Output Voltage -15 V  
Line Regulation ( $\Delta V_{IN} = 3$  V) 1mV  
Load Regulation ( $\Delta I_L = 100$  mA) 2mV

**POSITIVE VOLTAGE REGULATOR**  
(External NPN Pass Transistor)

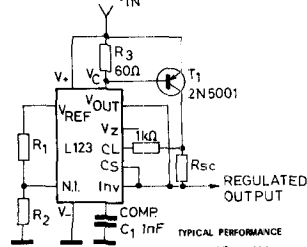
FIG. 4



**TYPICAL PERFORMANCE**  
Regulated Output Voltage +15 V  
Line Regulation ( $\Delta V_{IN} = 3$  V) 1.5mV  
Load Regulation ( $\Delta I_L = 1$  A) 15mV

**POSITIVE VOLTAGE REGULATOR**  
(External PNP Pass Transistor)

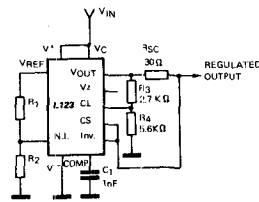
FIG. 5



**TYPICAL PERFORMANCE**  
Regulated Output Voltage +5 V  
Line Regulation ( $\Delta V_{IN} = 3$  V) 0.5mV  
Load Regulation ( $\Delta I_L = 1$  A) 5mV

**FOLDBACK CURRENT LIMITING**

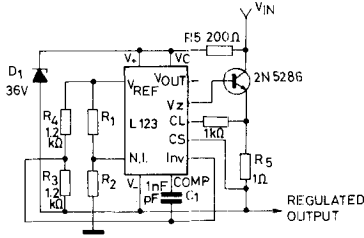
FIG. 6



**TYPICAL PERFORMANCE**  
Regulated Output Voltage +5 V  
Line Regulation ( $\Delta V_{IN} = 3$  V) 0.5mV  
Load Regulation ( $\Delta I_L = 10$  mA) 1mV  
Current Limit I<sub>osc</sub> 20 mA

**POSITIVE FLOATING REGULATOR**

**FIG. 7**

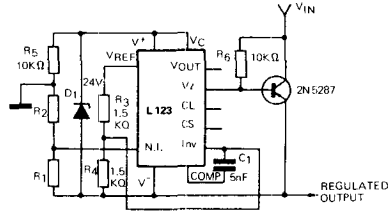


**TYPICAL PERFORMANCE**  
 Regulated Output Voltage +100 V  
 Line Regulation ( $\Delta V_{IN} = 20V$ ) 15 mV  
 Load Regulation ( $\Delta I_L = 50mA$ ) 20 mV

NOTE 3

**NEGATIVE FLOATING REGULATOR**

**FIG. 8**

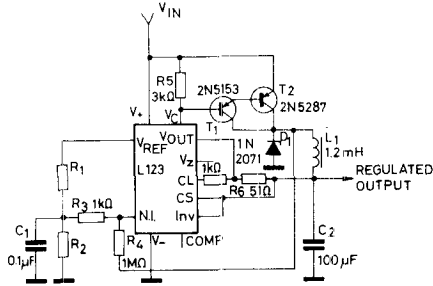


**TYPICAL PERFORMANCE**  
 Regulated Output Voltage -100 V  
 Line Regulation ( $\Delta V_{IN} = 20V$ ) 30 mV  
 Load Regulation ( $\Delta I_L = 100mA$ ) 20 mV

NOTE 3

**POSITIVE SWITCHING REGULATOR**

**FIG. 9**

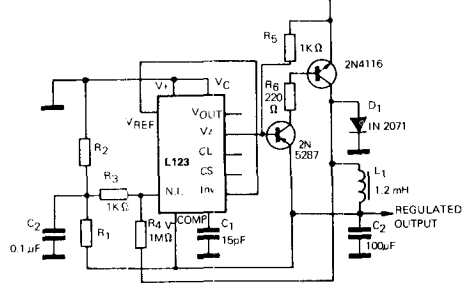


**TYPICAL PERFORMANCE**  
 Regulated Output Voltage +5 V  
 Line Regulation ( $\Delta V_{IN} = 30V$ ) 10 mV  
 Load Regulation ( $\Delta I_L = 2A$ ) 80 mV

NOTE 7

**NEGATIVE SWITCHING REGULATOR**

**FIG. 10**



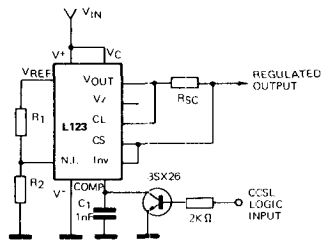
**TYPICAL PERFORMANCE**  
 Regulated Output Voltage -15 V  
 Line Regulation ( $\Delta V_{IN} = 20V$ ) 8 mV  
 Load Regulation ( $\Delta I_L = 2A$ ) 6 mV

NOTE 3

NOTE 7

**REMOTE SHUTDOWN REGULATOR WITH CURRENT LIMITING**

**FIG. 11**

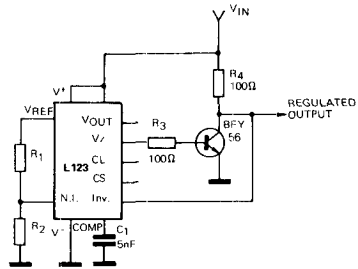


**TYPICAL PERFORMANCE**  
 Regulated Output Voltage 5 V  
 Line Regulation ( $\Delta V_{IN} = 3V$ ) 0.5 mV  
 Load Regulation ( $\Delta I_L = 50mA$ ) 1.5 mV

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

**SHUNT REGULATOR**

**FIG. 12**



**TYPICAL PERFORMANCE**  
 Regulated Output Voltage +5 V  
 Line Regulation ( $\Delta V_{IN} = 10V$ ) 2 mV  
 Load Regulation ( $\Delta I_L = 100mA$ ) 5 mV

NOTE 3

**OUTPUT VOLTAGE ADJUST**

**FIG. 13**

