

L 146

LINEAR INTEGRATED CIRCUIT

HIGH PRECISION HIGH VOLTAGE REGULATOR

- INPUT VOLTAGE UP TO 80V
- OUTPUT VOLTAGE ADJUSTABLE FROM 2 TO 77V
- POSITIVE OR NEGATIVE SUPPLY OPERATION
- SERIES, SHUNT, SWITCHING OR FLOATING OPERATION
- OUTPUT CURRENT UP TO 150 mA WITHOUT EXTERNAL PASS TRANSISTOR
- ADJUSTABLE CURRENT LIMITING
- THERMAL PROTECTION

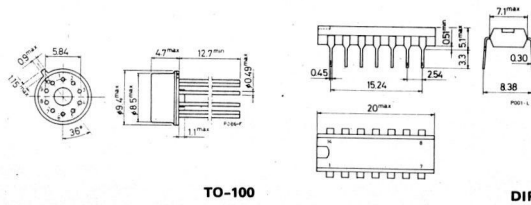
The L146 is a monolithic integrated programmable voltage regulator in 14 lead dual in-line plastic package and 10 lead Metal Can (TO-100 type). It is made with high voltage technology and provides internal current limiting and thermal shut down protection; when current exceeds 150 mA an external NPN or PNP pass element may be used. Provisions are made for adjustable current limiting and remote shut down. The L146 is intended to widen the application range of L123 up to 80V.

ABSOLUTE MAXIMUM RATINGS

V_i	Input voltage	80	V
$V_i - V_o$	Voltage drop	78	V
I_o	Output current	150	mA
I_{ref}	Current from V_{ref}	8	mA
P_d	Power dissipation (at $T_{amb} = 70^\circ\text{C}$) Plastic DIP	1	W
	TO-100	520	mW
T_{op}	Operating temperature L146	-25 to +85	$^\circ\text{C}$
	L146C	0 to +70	$^\circ\text{C}$
T_{stg}	Storage temperature	-65 to +150	$^\circ\text{C}$

MECHANICAL DATA

Dimensions in mm

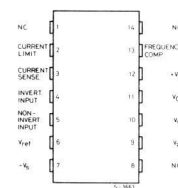
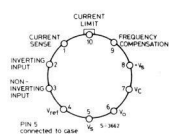


TO-100

DIP

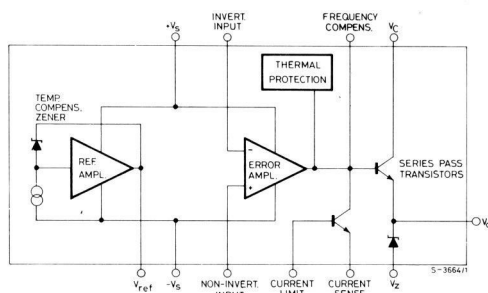
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CONNECTION DIAGRAMS (top view)



Type	TO-100	Plastic DIP
L 146	L 146 T	
L 146 C	L 146 CT	L 146 CB

BLOCK DIAGRAM



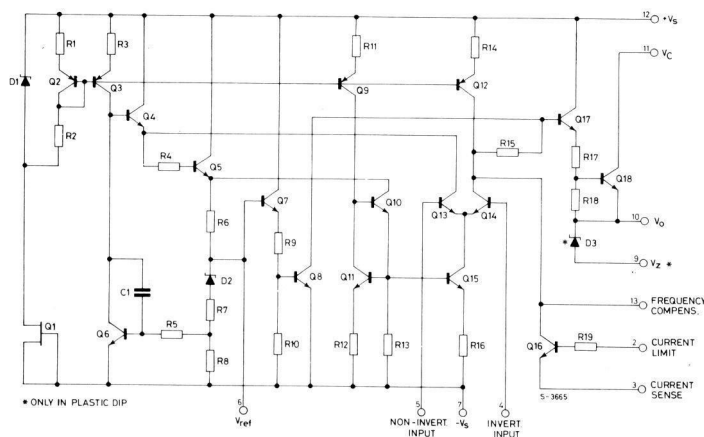
THERMAL DATA

	TO-100	Plastic DIP
$R_{th j-amb}$ Thermal resistance junction-ambient	max	155°C/W
		80°C/W

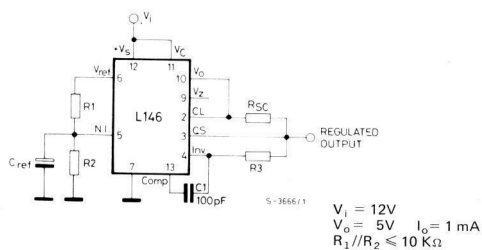
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SCHEMATIC DIAGRAM (pin number relative to the plastic package)



TEST CIRCUIT



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ELECTRICAL CHARACTERISTICS (Refer to the test circuit, $T_{amb} = 25^\circ\text{C}$ unless otherwise specified)

Parameter	Test conditions	L146 C			L146			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
$\frac{\Delta V_O}{\Delta V_I}$ Line regulation	$V_I = 12$ to 15V $V_I = 12$ to 40V $V_I = 40$ to 80V		0.05 0.1 0.1	0.15 0.5 0.5	0.05 0.1 0.1	0.15 0.2 0.2	%	
$\frac{\Delta V_O}{V_O}$ Load regulation	$V_I = 12\text{V}$ $V_O = 5\text{V}$ $I_O = 1$ to 50mA		0.03	0.2	0.03	0.15	%	
	$V_I = 40\text{V}$ $V_O = 37\text{V}$ $I_O = 1$ to 10mA		0.1	0.5	0.1	0.3	%	
	$V_I = 80\text{V}$ $V_O = 77\text{V}$ $I_O = 1$ to 10mA		0.12	0.8	0.12	0.5	%	
V_{ref} Reference voltage	$I_{ref} = 160\ \mu\text{A}$	7.75	8.15	8.55	7.9	8.15	8.4	V
ΔV_{ref}	$I_{ref} = 160\ \mu\text{A}$ to 5mA		4	14	4	14	mV	
SVR Ripple rejection	$f = 100\text{Hz}$ to 10KHz $C_{ref} = 0$ $C_{ref} = 5\ \mu\text{F}$		60 88		60 88		dB	
$\frac{\Delta V_O}{\Delta T}$ Output voltage drift				150		150	$\frac{\text{ppm}}{^\circ\text{C}}$	
I_{sc} Short circuit current limiting	$R_{SC} = 10\ \Omega$ $V_O = 0$	50	60	70	50	60	70	mA
V_I Input voltage range		10		80	10		80	V
V_O Output voltage range		2		77	2		77	V
$V_I - V_O$ Voltage drop		3		78	3		78	V
I_d Quiescent drain current	$I_D = 0$ $V_O = 5\text{V}$ (including $I_{ref} = 160\ \mu\text{A}$) $V_I = 12\text{V}$ $V_I = 40\text{V}$ $V_I = 80\text{V}$		4 5.6 6	5.5 7 7.5	4 5.6 6	5.5 7 7.5	mA	
ΔI_d Quiescent drain current change	$I_D = 1\text{mA}$ $V_O = 5\text{V}$	$V_I = 12$ to 40V		2.2		1.6	mA	
		$V_I = 12$ to 80V		2.6		2	mA	
Long term stability			0.1		0.1		$\frac{\%}{1000\text{hrs}}$	
e_N Output noise voltage	$\text{BW} = 100\text{Hz}$ to 10KHz $C_{ref} = 0$ $C_{ref} = 5\ \mu\text{F}$		300 30		300 30		μV	
V_Z Output zener voltage (for plastic package only)	$I_Z = 1\text{mA}$	6.9		7.7			V	

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Fig. 1 - Maximum output current vs. voltage drop

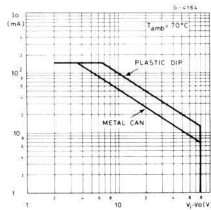


Fig. 2 - Load regulation vs. output current (with current limiting)

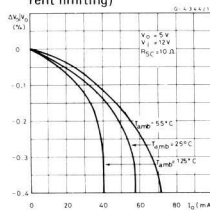


Fig. 3 - Load regulation vs. output current (with current limiting)

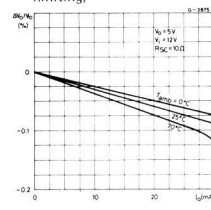


Fig. 4 - Load regulation vs. output current (without current limiting)

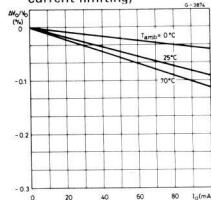


Fig. 5 - Current limiting characteristics

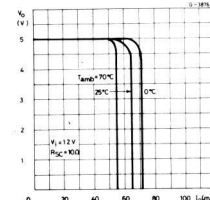


Fig. 6 - Current limiting characteristics vs. junction temperature

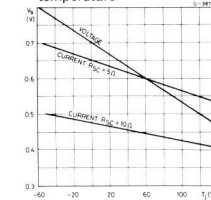


Fig. 7 - Line transient response

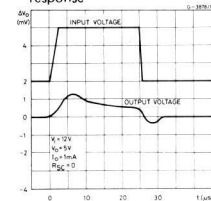


Fig. 8 - Load transient response

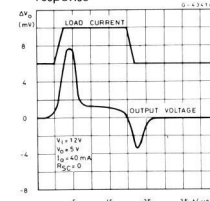
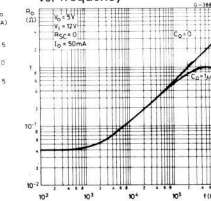


Fig. 9 - Output impedance vs. frequency



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Table I — Resistor values (K Ω) for standard output voltage

Positive output voltage	Applicable figures	Fixed output $\pm 5\%$		Negative output voltage	Applicable figures	Fixed output $\pm 5\%$	
		R ₁	R ₂			R ₁	R ₂
+6	10, 13, 14, 18, 20	2.4	6.8	-9	12	2.2	2.7
+12	11, 13, 14, 15, 18, 20	3.2	6.8	-12		1.5	3
+30		15	5.6	-30		4.7	30
+50		24	4.7	-50		2.7	30
+70		30	3.9	-100		2	4.7
+100	16	2.7	6.8	-250	2	120	
+250		4.7	120				

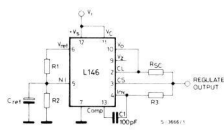
Table II — Formulae for intermediate output voltages

Outputs from +2 to +7 volts Fig. 10, 13, 14, 15, 18, 20 $V_{OUT} = [V_{REF} \times \frac{R_2}{R_1 + R_2}]$	Outputs from +4 to +250 volts Fig. 16 $V_{OUT} = [\frac{V_{REF}}{2} \times \frac{R_2 - R_1}{R_1}], R_3 = R_4$	Current Limiting $I_{LIMIT} = \frac{V_{SENSE}}{R_{sc}}$
Outputs from +7 to +77 volts Fig. 11, 13, 14, 15, 18, 20 $V_{OUT} = [V_{REF} \times \frac{R_1 + R_2}{R_2}]$	Output from -6 to -250 volts Fig. 12, 17 $V_{OUT} = [\frac{V_{REF}}{2} \times \frac{R_1 + R_2}{R_1}], R_3 = R_4$	Foldback Current Limiting $I_{KNEE} = [\frac{V_{OUT}}{R_{sc}} \times \frac{R_3}{R_4} + \frac{V_{SENSE}}{R_{sc}} (R_3 + R_4)]$ $I_{SHORT\ CKT} = [\frac{V_{SENSE}}{R_{sc}} \times \frac{R_3 + R_4}{R_4}]$

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APPLICATION CIRCUITS (continued)

Fig. 10 - Basic low voltage regulator ($V_{OUT} = 2$ to 7V)



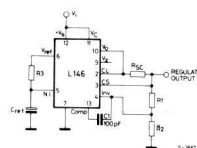
NOTE: $R_3 = \frac{R_1 \cdot R_2}{R_1 + R_2}$ for minimum temperature drift.

R₃ may be eliminated for minimum component count.

Typical performance

Regulated Output Voltage 5V
Line Regulation ($\Delta V_I = 3V$) 0.5 mV
Load Regulation ($\Delta I_O = 50$ mA) 1.5 mV

Fig. 11 - Basic high voltage regulator ($V_{OUT} = 7$ to 77V)



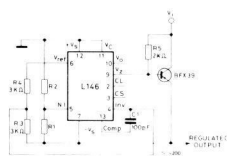
NOTE: $R_3 = \frac{R_1 \cdot R_2}{R_1 + R_2}$ for minimum temperature drift.

R₃ may be eliminated for minimum component count.

Typical performance

Regulated Output Voltage 15V
Line Regulation ($\Delta V_I = 3V$) 1.5 mV
Load Regulation ($\Delta I_O = 50$ mA) 4.5 mV

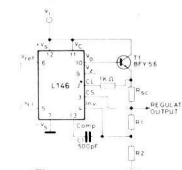
Fig. 12 - Negative voltage regulator



Typical performance

Regulated Output Voltage +15V
Line Regulation ($\Delta V_I = 3V$) 1.5 mV
Load Regulation ($\Delta I_O = 1$ A) 15 mV

Fig. 13 - Positive voltage regulator (External NPN Pass Transistor)



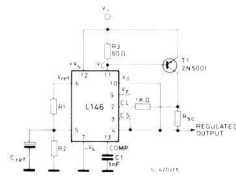
Typical performance

Regulated Output Voltage 15V
Line Regulation ($\Delta V_I = 3V$) 1 mV
Load Regulation ($\Delta I_O = 100$ mA) 2 mV

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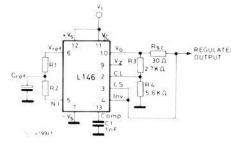
APPLICATION CIRCUITS (continued)

Fig. 14 - Positive voltage regulator (External PNP Pass Transistor)



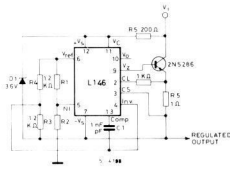
Typical performance
 Regulated Output Voltage +5V
 Line Regulation ($\Delta V_I = 3V$) 0.5 mV
 Load Regulation ($\Delta I_O = 1A$) 5 mV

Fig. 15 - Foldback current limiting



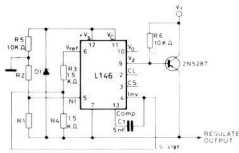
Typical performance
 Regulated Output Voltage +5V
 Line Regulation ($\Delta V_I = 3V$) 0.5 mV
 Load Regulation ($\Delta I_O = 10 mA$) 1 mV
 Current Limit Knee 20 mA

Fig. 16 - Positive floating regulator



Typical performance
 Regulated Output Voltage +100V
 Line Regulation ($\Delta V_I = 20V$) 15 mV
 Load Regulation ($\Delta I_O = 50 mA$) 20 mV

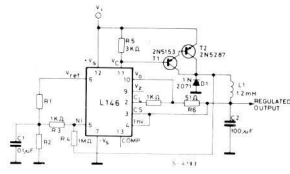
Fig. 17 - Negative floating regulator



Typical performance
 Regulated Output Voltage -100V
 Line Regulation ($\Delta V_I = 20V$) 30 mV
 Load Regulation ($\Delta I_O = 100 mA$) 20 mV

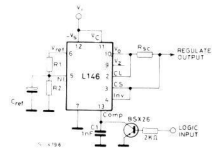
APPLICATION CIRCUITS (continued)

Fig. 18 - Positive switching regulator



Typical performance
 Regulated Output Voltage +5V
 Line Regulation ($\Delta V_i = 30V$) 10 mV
 Load Regulation ($\Delta I_o = 2A$) 80 mA

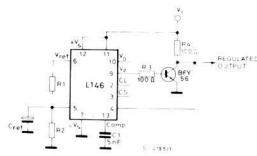
Fig. 19 - Remote shutdown regulator with current limiting



Typical performance
 Regulated Output Voltage5V
 Line Regulation ($\Delta V_i = 3V$) 0.5V
 Load Regulation ($\Delta I_o = 50 mA$) 1.5 mV

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

Fig. 20 - Shunt regulator



TYPICAL PERFORMANCE
 Regulated Output Voltage +5V
 Line Regulation ($\Delta V_i = 10V$) 2 mV
 Load Regulation ($\Delta I_o = 100 mA$) 5mV

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APPLICATION CIRCUITS (continued)

Fig. 21 - 50V voltage regulator with foldback characteristic

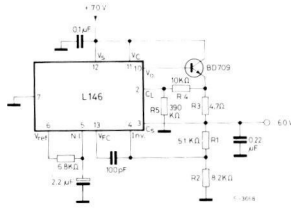
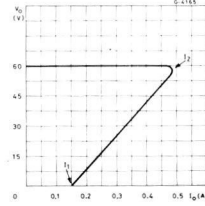
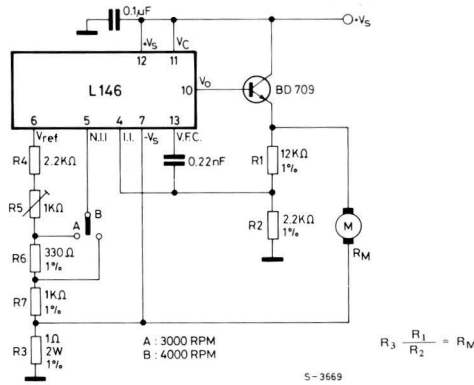


Fig. 22



$$I_2 = \frac{V_o \frac{R_4}{R_5} + V_{2-3}}{R_{SC}}; \quad I_1 = \frac{V_{2-3}}{R_{SC}} \left(1 + \frac{R_4}{R_5}\right); \quad V_{2-3} \cong 0.7V$$

Fig. 23 - Motor speed control

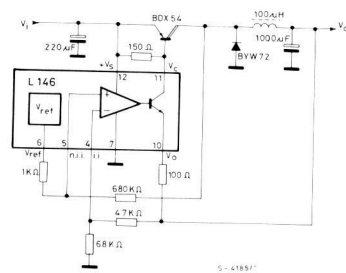


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APPLICATION CIRCUITS (continued)

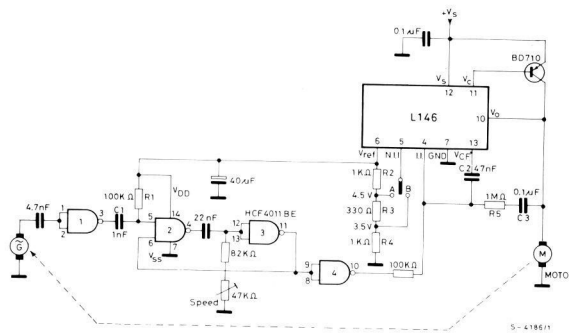
Fig. 24 - Switching regulator for 12V car radio



Performance:

Output voltage	13.5V
Max output current	3A
Input voltage range	20 to 30V
Line regulation	50 dB ($I_o = 2A$) $\Delta V_i = 10V$
Load regulation	0.1% ($\Delta I_o = 3A$)
Ripple	100 mVpp
Efficiency	75% ($I_o = 3A$)
Switching frequency	25 KHz

Fig. 25 - 30W motor speed regulator with tacho adjustment and speed change-over switch



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