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

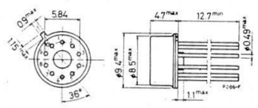
The L146 is a monolithic integrated programmable voltage regulator in 14 lead dual in-line plastic package and 10 lead Metal Can (TO-100 type). It is made with high voltage technology and provides internal current limiting and thermal shut down protection; when current exceeds 150 mA an external NPN 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

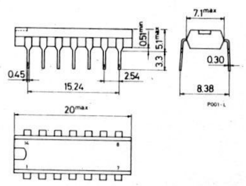
V_i	Input voltage	80	V
V_i-V_o	Voltage drop	78	V
I_o	Output current	150	mA
I_{ref}	Current from V_{ref}	8	mA
P_d	Power dissipation (at T_{amb} = 70°C) Plastic DIP	1	W
	TO-100	520	mW
T_{op}	Operating temperature L146	-25 to + 85	°C
	L146C	0 to +70	°C
T_{stg}	Storage temperature	-65 to +150	°C

MECHANICAL DATA

Dimensions in mm

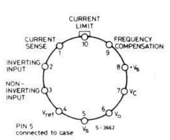


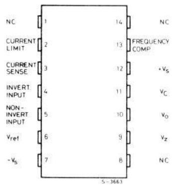
TO-100



DIP

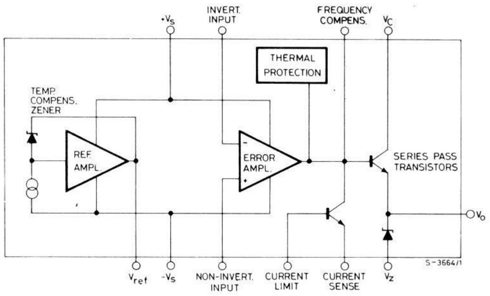
CONNECTION DIAGRAMS
(top view)





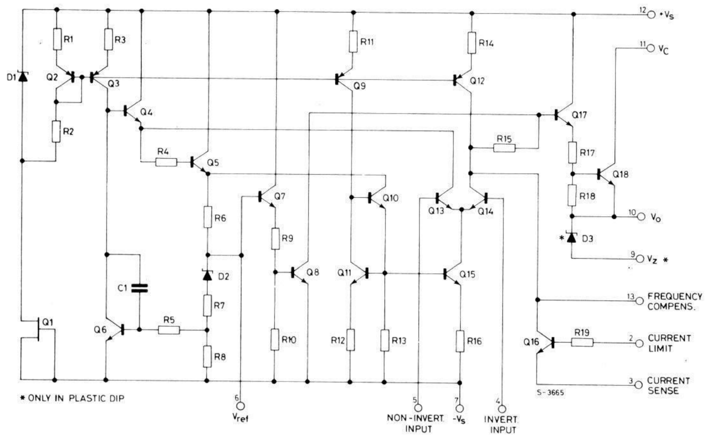
Type	TO-100	Plastic DIP
L146	L146 T	
L146 C	L146 CT	L146 CB

BLOCK DIAGRAM

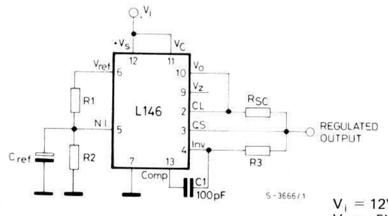


THERMAL DATA			TO-100	Plastic DIP
$R_{th\ j\text{-}amb}$	Thermal resistance junction-ambient	max	155°C/W	80°C/W

SCHEMATIC DIAGRAM (pin number relative to the plastic package)



TEST CIRCUIT



$V_i = 12V$
$V_o = 5V \quad I_o = 1\ mA$
$R_1 // R_2 \leqslant 10\ K\Omega$

ELECTRICAL CHARACTERISTICS (Refer to the test circuit, T_{amb} = 25°C unless otherwise specified)

	Parameter	Test conditions	L146 C Min.	L146 C Typ.	L146 C Max.	L146 Min.	L146 Typ.	L146 Max.	Unit
$\frac{\Delta V_o}{\Delta V_i}$	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 = 12V V_o = 5V I_o = 1 to 50 mA		0.03	0.2		0.03	0.15	%
		V_i = 40V V_o = 37V I_o = 1 to 10 mA		0.1	0.5		0.1	0.3	%
		V_i = 80V V_o = 77V I_o = 1 to 10 mA		0.12	0.8		0.12	0.5	%
V_{ref}	Reference voltage	I_{ref} = 160 μA	7.75	8.15	8.55	7.9	8.15	8.4	V
ΔV_{ref}		I_{ref} = 160 μA to 5 mA		4	14		4	14	mV
SVR	Ripple rejection	f = 100 Hz to 10 KHz C_{ref} = 0 C_{ref} = 5 μF		60 88			60 88		dB
$\frac{\Delta V_o}{\Delta T}$	Output voltage drift				150			150	ppM/°C
I_{sc}	Short circuit current limiting	R_{sc} = 10Ω 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_o = 0 V_o = 5V (including I_{ref} = 160 μA) V_i = 12V V_i = 40V V_i = 80V		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_o = 1 mA, V_o = 5V; V_i = 12 to 40V			2.2			1.6	mA
		I_o = 1 mA, V_o = 5V; V_i = 12 to 80V			2.6			2	mA
	Long term stability			0.1			0.1		%/1000 hrs
e_N	Output noise voltage	BW = 100 Hz to 10 KHz C_{ref} = 0 C_{ref} = 5 μF		300 30			300 30		μV
V_z	Output zener voltage (for plastic package only)	I_z = 1 mA	6.9		7.7				V

Fig. 1 - Maximum output current vs. voltage drop

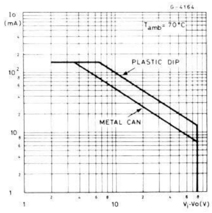


Fig. 2 - Load regulation vs. output current (with current limiting)

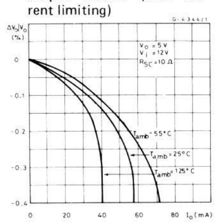


Fig. 3 - Load regulation vs. output current (with current limiting)

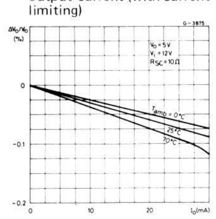


Fig. 4 - Load regulation vs. output current (without current limiting)

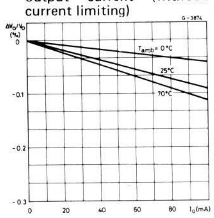


Fig. 5 - Current limiting characteristics

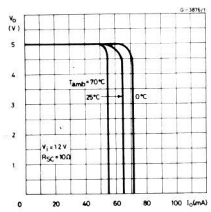


Fig. 6 - Current limiting characteristics vs. junction temperature

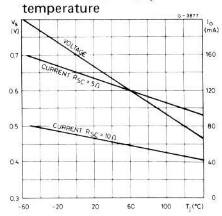


Fig. 7 - Line transient response

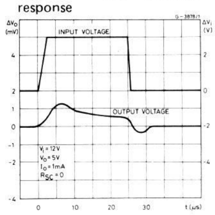


Fig. 8 - Load transient response

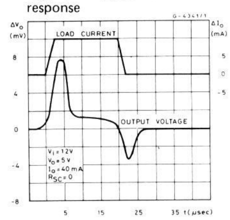


Fig. 9 - Output impedance vs. frequency

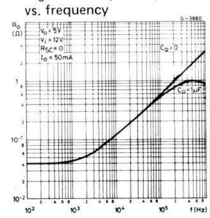


Table I – Resistor values (KΩ) for standard output voltage

Positive output voltage	Applicable figures	Fixed output ± 5% R1	Fixed output ± 5% R2
+6	10, 13, 14 18, 20	2.4	6.8
+12	11, 13, 14, 15, 18, 20	3.2	6.8
+30		15	5.6
+50		24	47
+70		30	39
+100	16	2.7	68
+250		4.7	120

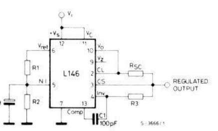
Negative output voltage	Applicable figures	Fixed output ± 5% R1	Fixed output ± 5% R2
-9	12	2.2	2.7
-12		1.5	3
-30		4.7	30
-50		2.7	30
-100	17	2	47
-250		2	120

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 $I_{KNEE} = [\frac{V_{OUT}\ R_3}{R_{sc}\ R_4} + \frac{V_{SENSE}\ (R_3 + R_4)}{R_{sc}\ R_4}]$ $I_{SHORT\ CKT} = [\frac{V_{SENSE}}{R_{sc}} \times \frac{R_3 + R_4}{R_4}]$

APPLICATION CIRCUITS (continued)

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

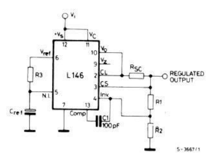


NOTE: $R3 = \frac{R1 \cdot R2}{R1 + R2}$ for minimum temperature drift.

R3 may be eliminated for minimum component count.

Typical performance
Regulated Output Voltage 5V
Line Regulation (ΔV_i = 3V) . . . . . . .0.5 mV
Load Regulation (ΔI_o = 50 mA) . . . .1.5 mV

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

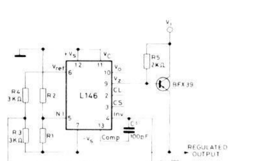


NOTE: $R3 = \frac{R1 \cdot R3}{R1 + R3}$ for minimum temperature drift.

R3 may be eliminated for minimum component count.

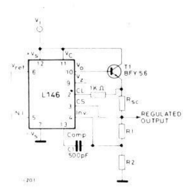
Typical performance
Regulated Output Voltage 15V
Line Regulation (ΔV_i = 3V) . . . . . . .1.5 mV
Load Regulation (ΔI_o = 50 mA) . . . .4.5 mV

Fig. 12 - Negative voltage regulator



Typical performance
Regulated Output Voltage . . . .+15V
Line Regulation (ΔV_i = 3V) . . . . . .1.5 mV
Load Regulation (ΔI_o = 1 A) . . . . . . 15 mV

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



Typical performance
Regulated Output Voltage 15V
Line Regulation (ΔV_i = 3V) . . . . .1 mV
Load Regulation (ΔI_o = 100 mA) . . . .2 mV

APPLICATION CIRCUITS (continued)

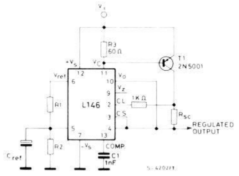


Fig. 14 - Positive voltage regulator (External PNP Pass Transistor)

Typical performance
Regulated Output Voltage . . . .+5V
Line Regulation (ΔV_i = 3V) . . . . . . .0.5 mV
Load Regulation (ΔI_o = 1A) . . . . .5 mV

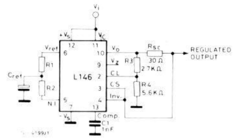


Fig. 15 - Foldback current limiting

Typical performance
Regulated Output Voltage . . . .+5V
Line Regulation (ΔV_i = 3V) . . . . . . .0.5 mV
Load Regulation (ΔI_o = 10 mA) . . . . .1 mV
Current Limit Knee . . . . .20 mA

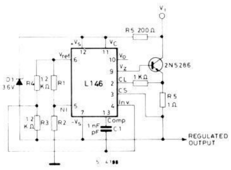


Fig. 16 - Positive floating regulator

Typical performance
Regulated Output Voltage . . . . +100V
Line Regulation (ΔV_i = 20V) . . . . . . 15 mV
Load Regulation (ΔI_o = 50 mA) . . . . 20 mV

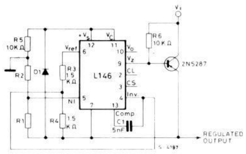
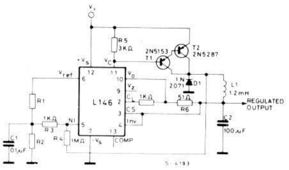


Fig. 17 - Negative floating regulator

Typical performance
Regulated Output Voltage . . . . -100V
Line Regulation (ΔV_i = 20V) . . . . . . 30 mV
Load Regulation (ΔI_o = 100 mA) . . . 20 mV

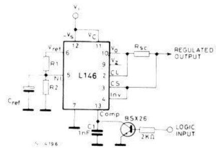
APPLICATION CIRCUITS (continued)

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

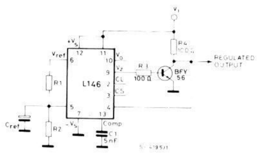
Fig. 19 – Remote shutdown regulator with current limiting



Typical performance
Regulated Output Voltage 5V
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 (ΔI_o =100 mA) 5mV

APPLICATION CIRCUITS (continued)

Fig. 21 - 50V voltage regulator with foldback characteristic

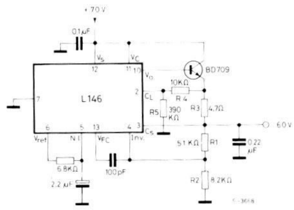
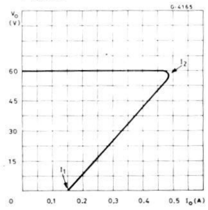
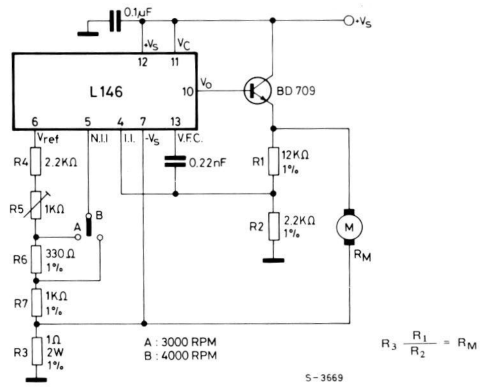


Fig. 22



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

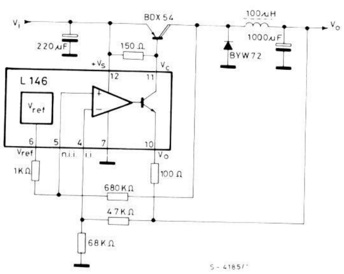
Fig. 23 - Motor speed control



$$R_3 \frac{R_1}{R_2} = R_M$$

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) ΔV_i = 10V
Load regulation . . . . 0.1% (ΔI_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