LINEAR INTEGRATED CIRCUIT

SGS **L146**

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

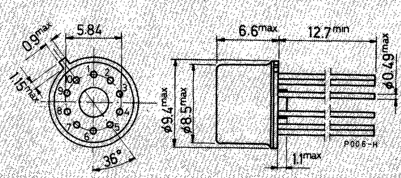
The L146 is a monolithic integrated programmable voltage regulator in 14-lead dual in-line plastic package and 10-lead Metal Can (TO-100 type). It is made with high voltage technology and provides internal current limiting and thermal shut down protection; when current exceeds 150 mA an external NPN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

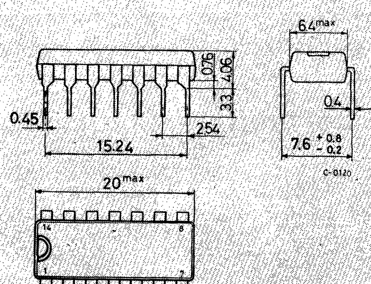
V_i	Input voltage		80	V
V_i-V_o	Voltage drop		78	V
I_o	Output current		150	mA
I_{ref}	Current from V_{ref}		8	mA
P_{tot}	Power dissipation (at T_{amb}= 70°C)	Plastic DIP	1	W
		TO-100	520	mW
T_{op}	Operating junction temperature	L146	-25 to + 85	°C
		L146C	0 to +70	°C
T_{stg}	Storage temperature		-65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

MECHANICAL DATA

Dimensions in mm

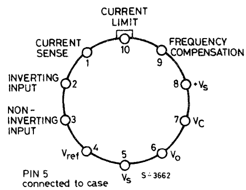


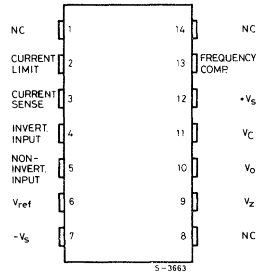
TO-100



DIP

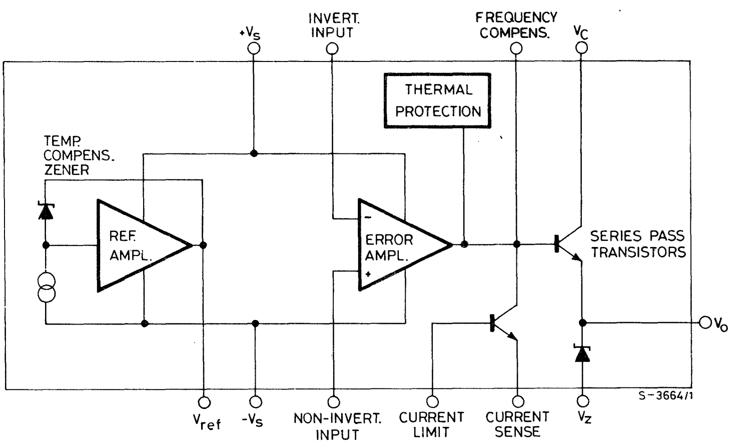
CONNECTION DIAGRAMS
(top view)





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

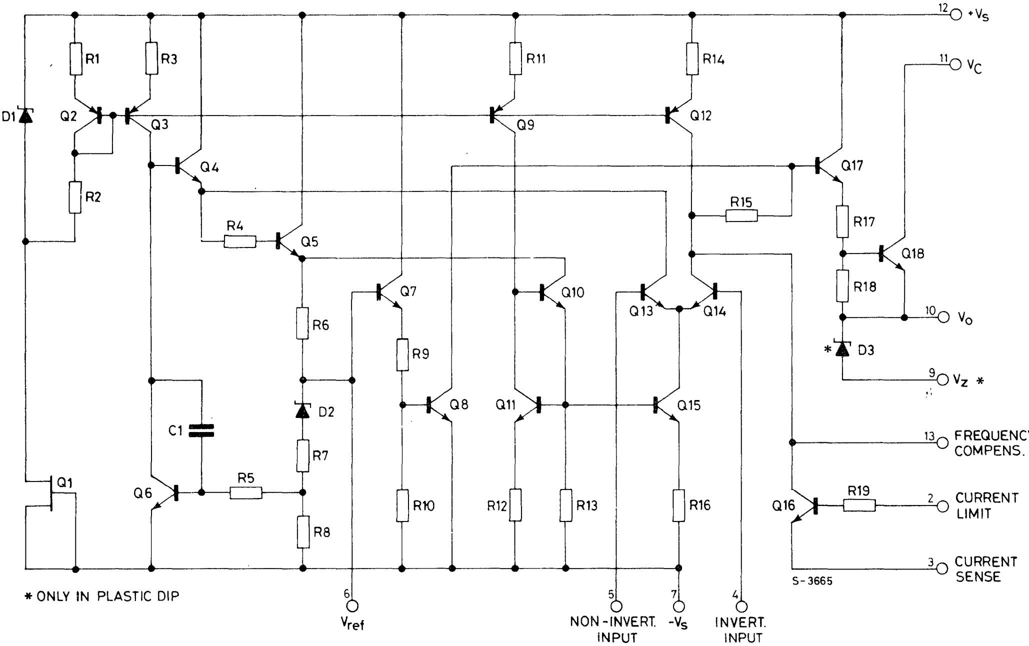
BLOCK DIAGRAM



THERMAL DATA

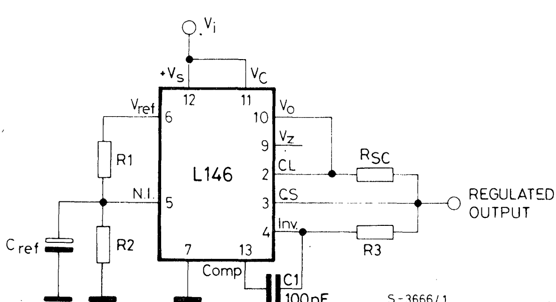
			TO-100	Plastic DIP
$R_{th\ j\text{-}amb}$	Thermal resistance junction-ambient	max	155°C/W	80°C/W

SCHEMATIC DIAGRAM (pin number relative to the plastic package)



* ONLY IN PLASTIC DIP

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)

Symbol	Parameter	Test conditions	L146 C Min.	L146 C Typ.	L146 C Max.	L146 Min.	L146 Typ.	L146 Max.	Unit
$\frac{\Delta V_o}{V_o}$	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	$\frac{ppM}{°C}$
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		$\frac{\%}{1000\ hrs}$
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

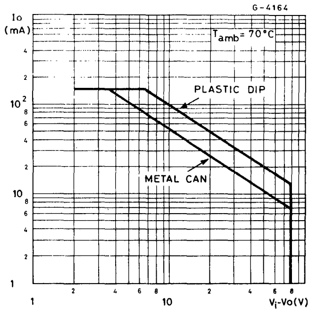


Fig. 2 - Load regulation vs. output current (with current limiting)

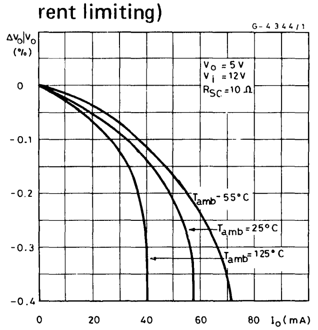


Fig. 3 - Load regulation vs. output current (with current limiting)

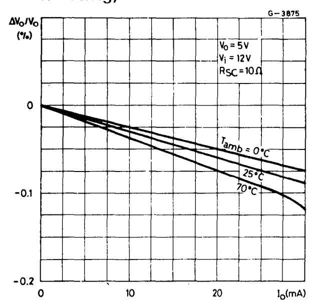


Fig. 4 - Load regulation vs. output current (without current limiting)

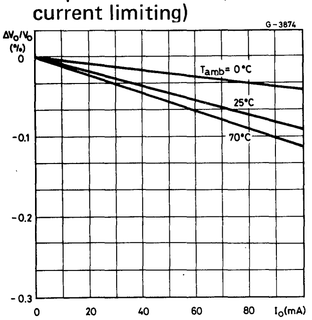


Fig. 5 - Current limiting characteristics

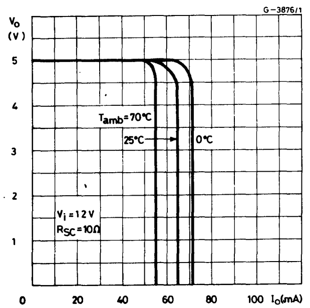


Fig. 6 - Current limiting characteristics vs. junction temperature

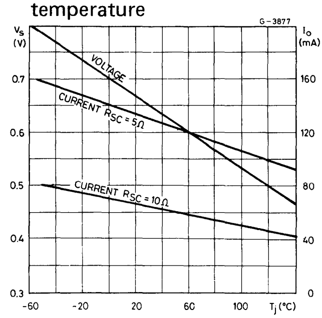


Fig. 7 - Line transient response

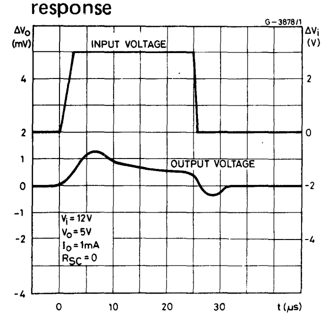


Fig. 8 - Load transient response

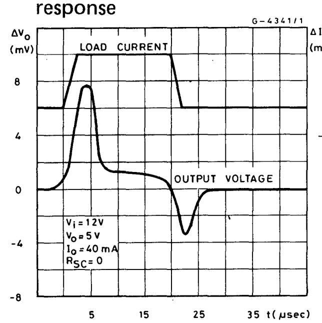


Fig. 9 - Output impedance vs. frequency

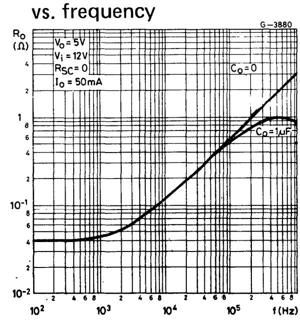


Table I — Resistor values (KΩ) for standard output voltage

Positive output voltage	Applicable figures	Fixed output ± 5%	
		R_1	R_2
+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

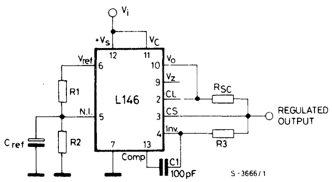
Negative output voltage	Applicable figures	Fixed output ± 5%	
		R_1	R_2
-9	12	2.2	2.7
-12		1.5	3
-30		4.7	30
-50		2.7	30
-100	17	2	47
-250		2	120

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)

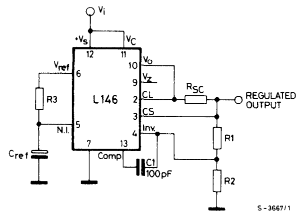


NOTE: $R3 = \frac{R1 \cdot R2}{R1 + R2}$ for minimum temperature drift.

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)

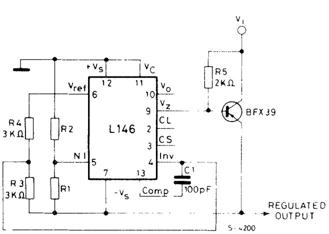


NOTE: $R3 = \frac{R1 \cdot R2}{R1 + R2}$ for minimum temperature drift.

R3 may be eliminated for minimum component count.

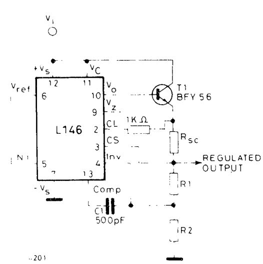
Typical performance
Regulated Output Voltage 15V
Line Regulation (ΔV_i = 3V) . . . . . . .1.5 mV
Load Regulation (ΔI_o = 50 mA) . . . .4.5 mV

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

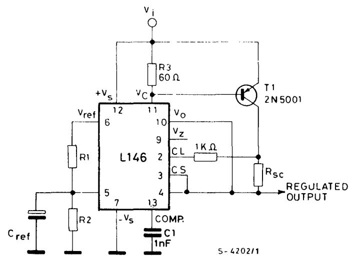
Fig. 13 - Positive voltage regulator (External NPN Pass Transistor)



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

APPLICATION CIRCUITS (continued)

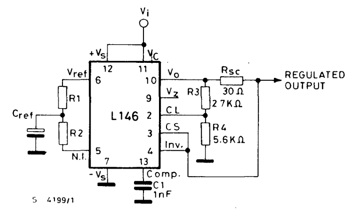
Fig. 14 - Positive voltage regulator (External PNP Pass Transistor)



Typical performance

Regulated Output Voltage . . . .+5V
Line Regulation ($\Delta V_i = 3V$) . . . . . . .0.5 mV
Load Regulation ($\Delta I_o = 1A$) . . . . .5 mV

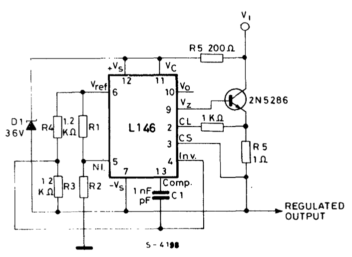
Fig. 15 - Foldback current limiting



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

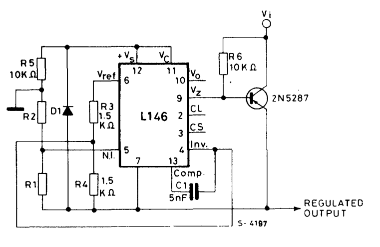
Fig. 16 - Positive floating regulator



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

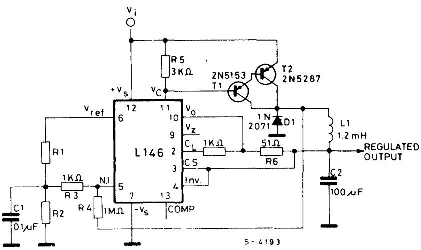


Typical performance

Regulated Output Voltage . . . . -100V
Line Regulation ($\Delta V_i = 20V$) . . . . . . 30 mV
Load Regulation ($\Delta I_o = 100$ mA) . . . 20 mV

APPLICATION CIRCUITS (continued)

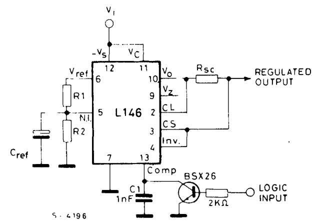
Fig. 18 - Positive switching regulator



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

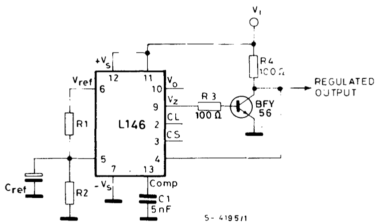


Typical performance

Regulated Output 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 ($\Delta I_o = 100$ mA) 5mV

APPLICATION CIRCUITS (continued)

Fig. 21 - 60V voltage regulator with foldback characteristic

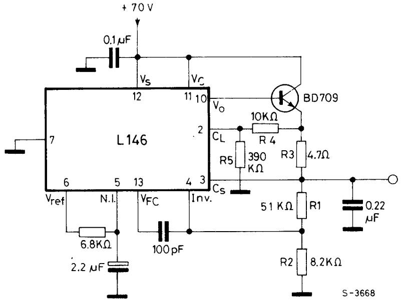
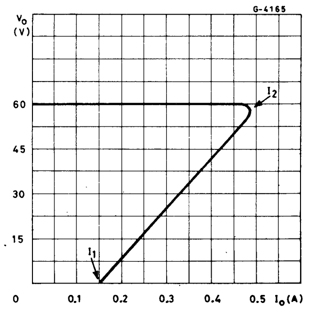
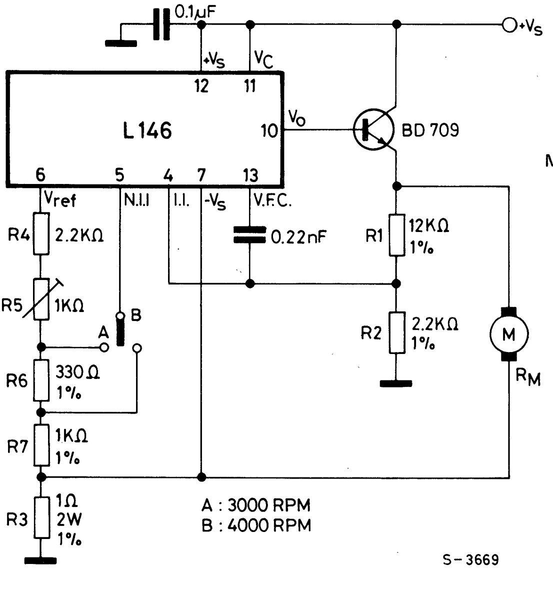


Fig. 22



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

Fig. 23 - Motor speed control

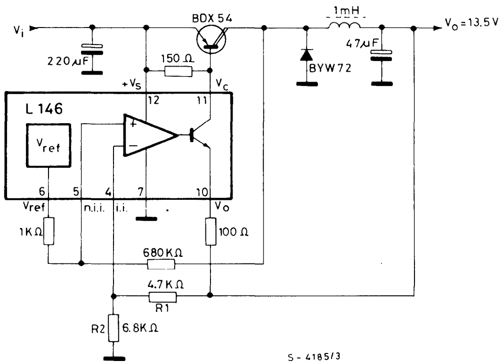


M = BK 6901.36 LENCO

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

APPLICATION CIRCUITS (continued)

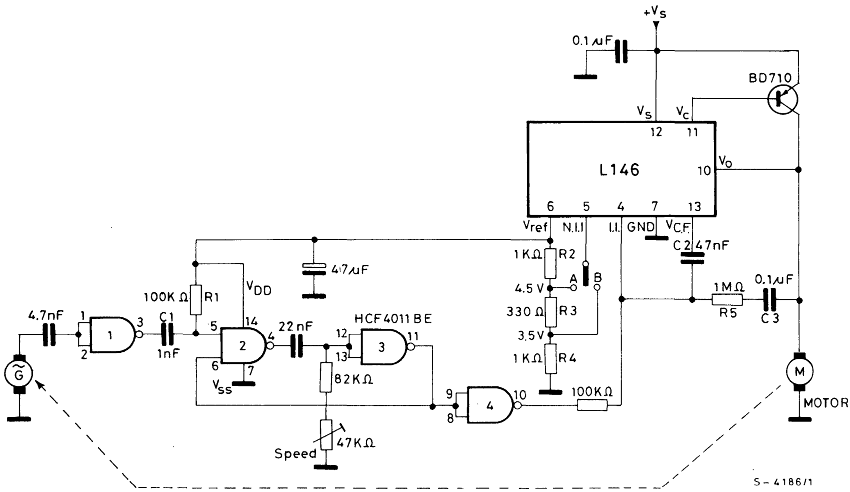
Fig. 24 - Step-down switching regulator for 12V car radio



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



NOTE - For a more detailed description of the L146 and its applications, refer to SGS-TECHNICAL NOTE TN.150.