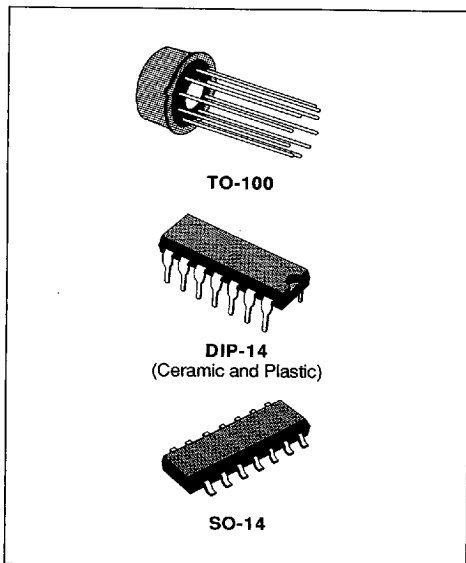


## HIGH PRECISION VOLTAGE REGULATOR

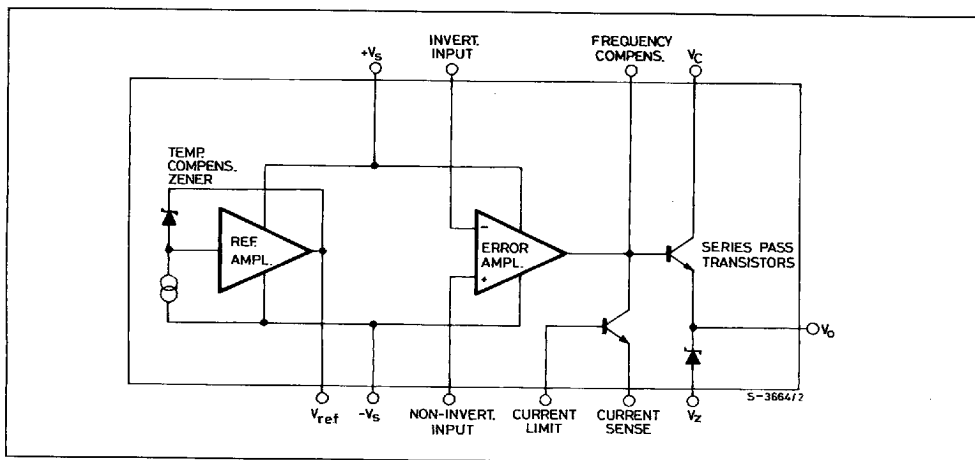
- INPUT VOLTAGE UP TO 40V
- OUTPUT VOLTAGE ADJUSTABLE FROM 2 TO 37V
- POSITIVE OR NEGATIVE SUPPLY OPERATION
- SERIES, SHUNT, SWITCHING OR FLOATING OPERATION
- OUTPUT CURRENT TO 150mA WITHOUT EXTERNAL PASS TRANSISTOR
- ADJUSTABLE CURRENT LIMITING

### DESCRIPTION

The LM723 is a monolithic integrated programmable voltage regulator, assembled in 14-lead dual in-line plastic and ceramic package, 10-lead Metal Can (TO-100 type) and SO-14 micropackage. The circuit provides internal current limiting. When the output current exceeds 150mA an external NPN or PNP pass element may be used. Provisions are made for adjustable current limiting and remote shut-down.



### BLOCK DIAGRAM



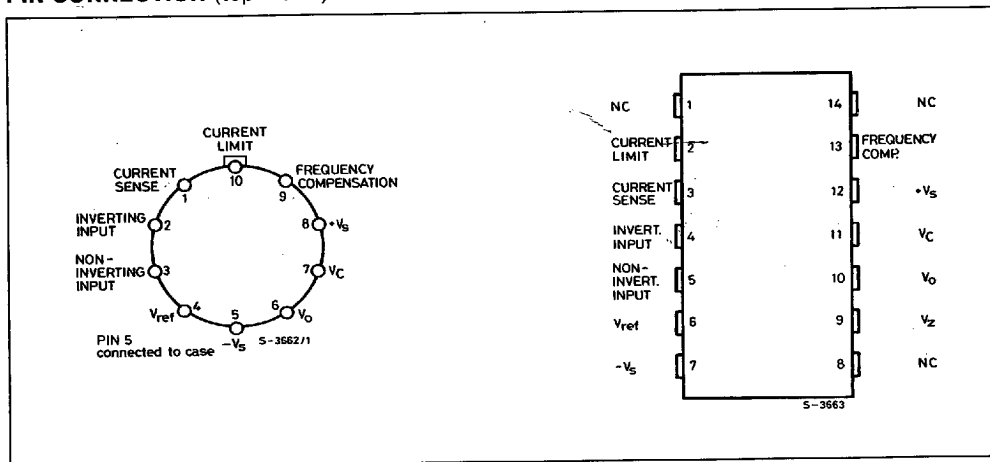
## ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	LM723	LM723C	Unit
$V_i$	Input Voltage	40	40	V
$\Delta V_{i-o}$	Dropout Voltage	40	40	V
$I_o$	Output Current	150	150	mA
$I_{ref}$	Current from $V_{ref}$	15	25	mA
$T_{op}$	Operating Temperature	-55 to 125	0 to 70	°C
$T_{sig}$	Storage Temperature	-65 to 150	-65 to 150	°C
$T_j$	Junction Temperature	150	125	°C

## THERMAL DATA

Symbol	Parameter	Plastic DIP-14	Ceramic DIP-14	TO-100	SO-14	Unit
$R_{th j-amb}$	Thermal Resistance Junction-ambient	Max 200	150	155	165	°C/W

## PIN CONNECTION (top views)



## ORDER CODES

Type	TO-100	Ceramic DIP-14	Plastic DIP-14	SO-14
LM723	LM723H	LM723J		
LM723C	LM723CH	LM723CJ	LM723CN	LM723CD

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

Symbol	Parameter	Test Conditions	LM723C			LM723			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
$\frac{\Delta V_o}{\Delta V_i}$	Line Regulation	$V_i = 12 \text{ to } 15\text{V}$		0.01	0.1		0.01	0.1	%
		$V_i = 12 \text{ to } 40\text{V}$		0.1	0.5		0.02	0.2	
		$V_i = 12 \text{ to } 15\text{V} ;$ $T_{\min} \leq T_{\text{amb}} \leq T_{\max}$			0.3			0.3	
$\frac{\Delta V_o}{V_o}$	Load Regulation	$I_o = 1 \text{ to } 50\text{mA}$		0.03	0.2		0.03	0.15	%
		$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$			0.6			0.6	
		$I_o = 1 \text{ to } 10\text{mA}$							
$V_{\text{REF}}$	Reference Voltage	$I_{\text{ref}} = 160\mu\text{A}$	6.8	7.15	7.5	6.95	7.15	7.35	V
SVR	Ripple Rejection	$f = 100\text{Hz to } 10\text{KHz}$ $C_{\text{ref}} = 0$ $C_{\text{ref}} = 5\mu\text{F}$		74 86			74 86		dB dB
$\frac{\Delta V_o}{\Delta T}$	Output Voltage Drift				150			150	$\frac{\text{ppm}}{^\circ\text{C}}$
$I_{\text{sc}}$	Short Circuit Current Limiting	$R_{\text{sc}} = 10\Omega \quad V_o = 0$		65			65		mA
$V_i$	Input Voltage Range		9.5		40	9.5		40	V
$V_o$	Output Voltage Range		2		37	2		37	V
$V_i - V_o$			3		38	3		38	V
$I_d$	Quiescent Drain Current	$I_o = 0$ $V_i = 30\text{V}$		2.3	4		2.3	5	mA
$K_{\text{VH}}$	Long Term Stability			0.1			0.1		$\frac{\%}{1000 \text{ hrs}}$
$\epsilon_N$	Output Noise Voltage	$\text{BW} = 100\text{Hz to } 10\text{KHz}$ $C_{\text{ref}} = 0$ $C_{\text{ref}} = 5\mu\text{F}$		20 2.5			20 2.5		$\mu\text{V}$ $\mu\text{V}$

**Note :**  $T_{min} = 0^{\circ}\text{C}$  (LM723C) ;  $-55^{\circ}\text{C}$  (LM723)  
 $T_{max} = 70^{\circ}\text{C}$  (LM723C) ;  $125^{\circ}\text{C}$  (LM723).

**TEST CIRCUIT** (pin configuration relative to the plastic package)

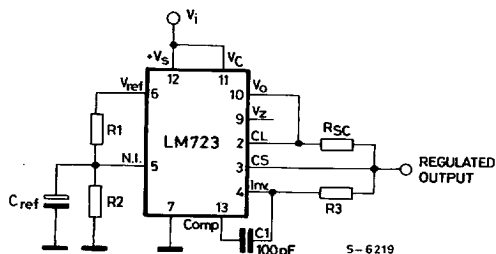

$$\begin{aligned} V_i &= 12V \\ V_o &= 5V \\ I_o &= 1mA \\ R_1/R_2 &\leq 10K\Omega \end{aligned}$$

Figure 1 : Maximum Output Current vs. Voltage Drop.

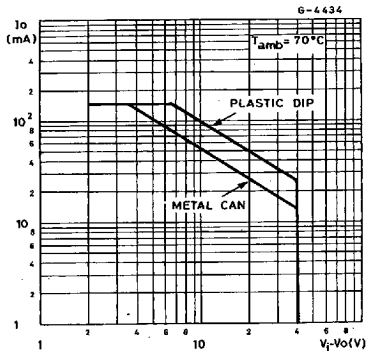


Figure 3 : Current Limiting Characteristics vs. Junction Temperature.

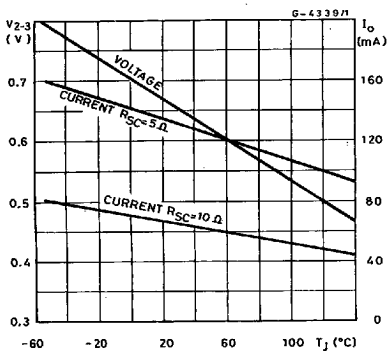


Figure 5 : Load Regulation Characteristics with Current Limiting.

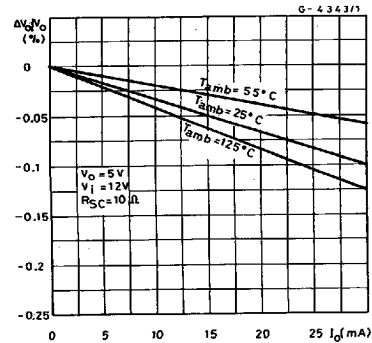


Figure 2 : Current Limiting Characteristics.

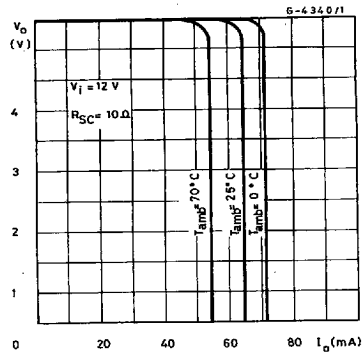


Figure 4 : Load Regulation Characteristics without Current Limiting.

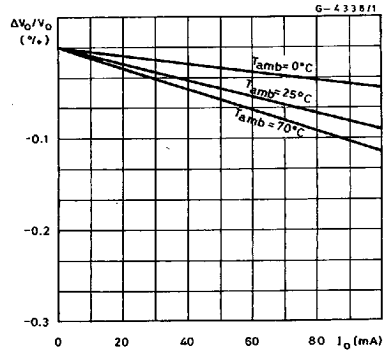


Figure 6 : Load Regulation Characteristics with Current Limiting

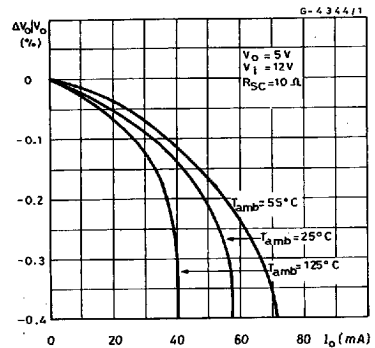


Figure 7 : Line Regulation vs. Voltage Drop.

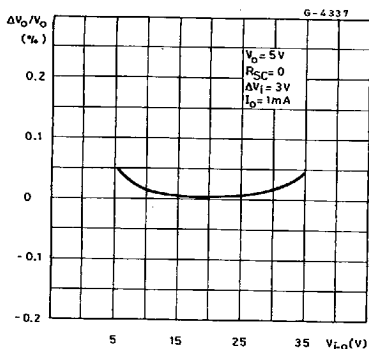


Figure 8 : Load Regulation vs. Voltage Drop.

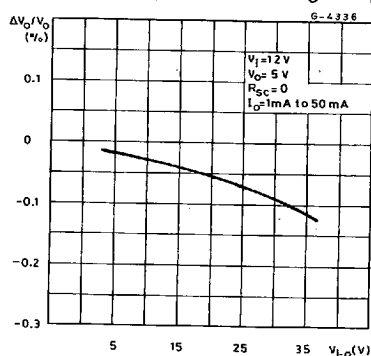


Figure 9 : Quiescent Drain Current vs. Input Voltage.

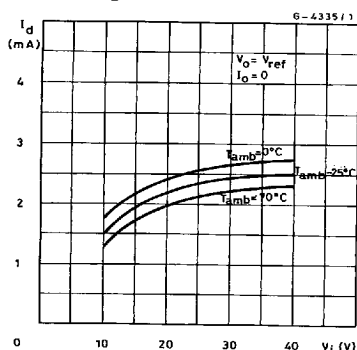


Figure 10 : Line Transient Response.

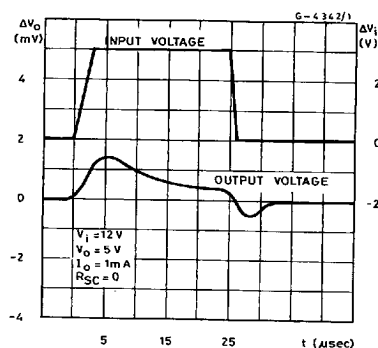


Figure 11 : Load Transient Response.

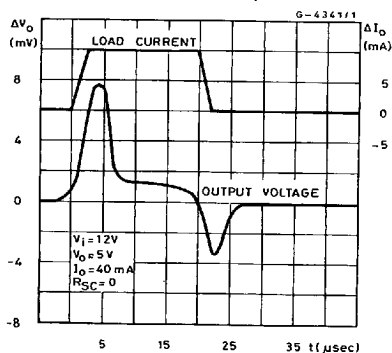


Figure 12 : Output Impedance vs. Frequency.

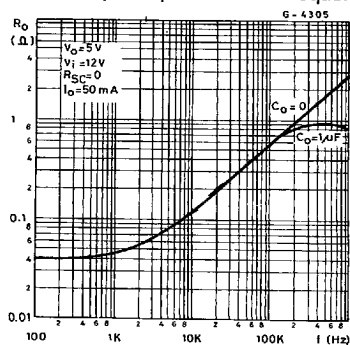


Table 1 : Resistor Values (K $\Omega$ ) for Standard Output Voltages.

Output Voltage	Applicable Figures	Fixed Output $\pm 5\%$		Output Adjustable $\pm 10\%$ (*)			Output Voltage	Applicable Figures	Fixed Output $\pm 5\%$		Output Adjustable $\pm 10\%$ (*)		
		R <sub>1</sub>	R <sub>2</sub>	R <sub>1</sub>	P <sub>1</sub>	R <sub>2</sub>			R <sub>1</sub>	R <sub>2</sub>	R <sub>1</sub>	P <sub>1</sub>	R <sub>2</sub>
+ 3	13, 16	4.12	3.01	1.8	0.5	1.2	+ 100						
+ 5	13, 16	2.15	4.99	0.75	0.5	2.2	+ 250						
+ 6	13, 16	1.15	6.04	0.5	0.5	2.7	- 6(°°)	15	3.57	2.43	1.2	0.5	0.75
+ 9	14, 16	1.87	7.15	0.75	1	2.7	- 9	15	3.48	5.36	1.2	0.5	2
+ 12	14, 16	4.87	7.15	2	1	3	- 12	15	3.57	8.45	1.2	0.5	3.3
+ 15	14, 16	7.87	7.15	3.3	1	3	- 15	15	3.65	11.5	1.2	0.5	4.3
+ 28	14, 16	21	7.15	5.6	1	2	- 28	15	3.57	24.3	1.2	0.5	10

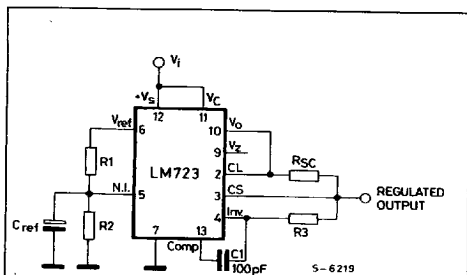
Note : (\*) Replace R<sub>1</sub>/R<sub>2</sub> divider with the circuit of fig. 24.  
 (°°) V\* must be connected to a + 3V or greater supply.

Table 2 : Formulae for Intermediate Output Voltages.

Outputs from + 2 to + 7 Volts Fig. 13, 16 $V_O = [V_{ref} \times \frac{R_2}{R_1 + R_2}]$		Current Limiting $I_{LIMIT} = \frac{V_{SENSE}}{R_{sc}}$
Outputs from + 7 to + 37 Volts Fig. 14, 16, $V_O = [V_{ref} \times \frac{R_1 + R_2}{R_2}]$	Output from - 6 to - 250 Volts Fig. 15, 20 $V_O = [\frac{V_{ref}}{2} \times \frac{R_1 + R_2}{R_1}]; R_3 = R_4$	Foldback Current Limiting $I_{KNEE} = [\frac{V_O R_3}{R_{sc} R_4} + \frac{V_{SENSE} (R_3 + R_4)}{R_{sc} R_4}]$ $I_{SHORT\ CKT} = [\frac{V_{SENSE}}{R_{sc}} \times \frac{R_3 + R_4}{R_4}]$

# APPLICATION INFORMATION (pin numbers relative to the plastic package).

**Figure 13 : Basic Low Voltage Regulator**  
( $V_o = 2$  to  $7V$ ).

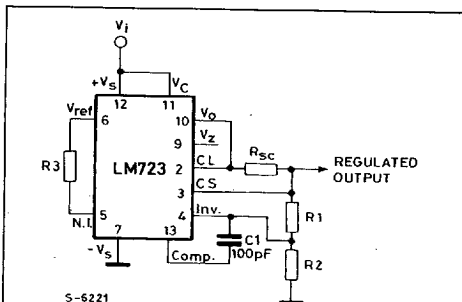


**Note:**  $R_3 = \frac{R_1 \times R_2}{R_1 + R_2}$  for minimum temperature drift.  
R3 may be eliminated for minimum component count.

## Typical performance

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

**Figure 14 : Basic High Voltage Regulator**  
( $V_o = 7$  to  $37V$ ).

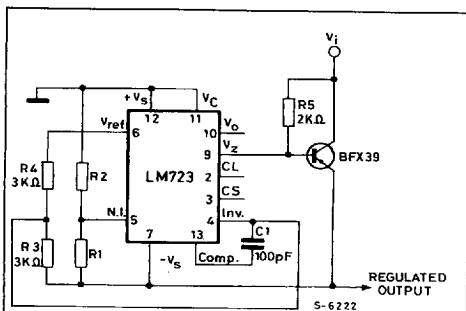


**Note:**  $R_3 = \frac{R_1 \times R_2}{R_1 + R_2}$  for minimum temperature drift.  
R3 may be eliminated for minimum component count.

## Typical performance

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

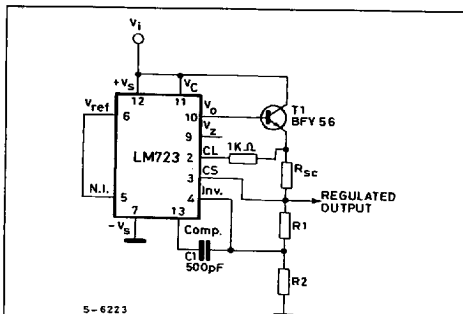
**Figure 15 : Negative Voltage Regulator.**



## Typical performance

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

**Figure 16 : Positive Voltage Regulator (external NPN Pass Transistor).**

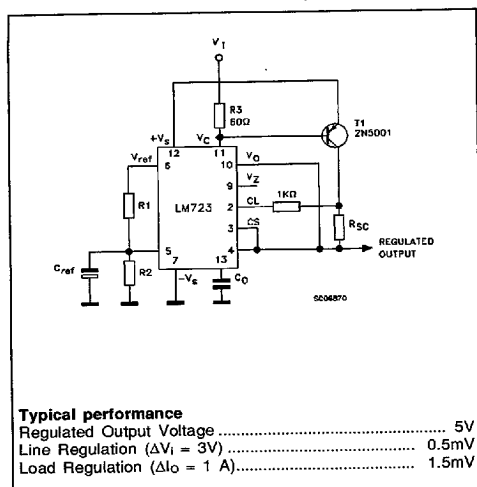


## Typical performance

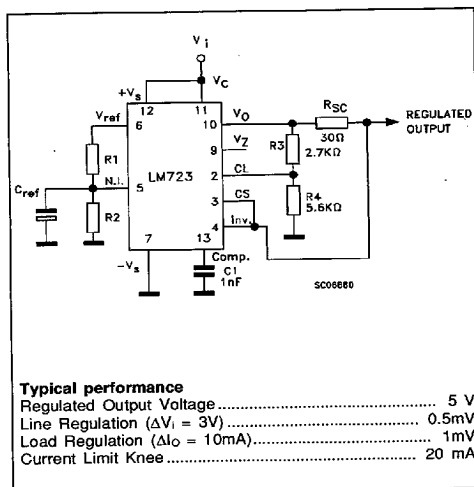
Regulated Output Voltage .....	+ 15V
Line Regulation ( $\Delta V_i = 3V$ ) .....	1.5mV
Load Regulation ( $\Delta I_o = 1A$ ) .....	15mV

**APPLICATION INFORMATION** (continued).

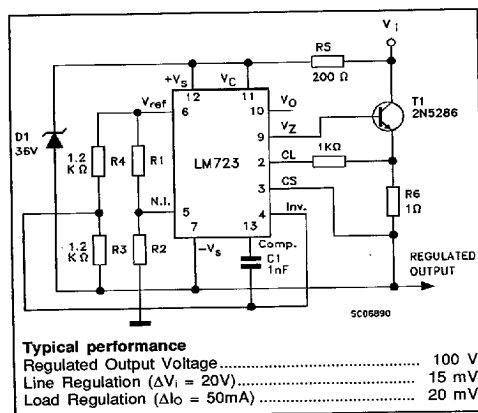
**Figure 17 : Positive Voltage Regulator (External PNP Pass Transistor)**



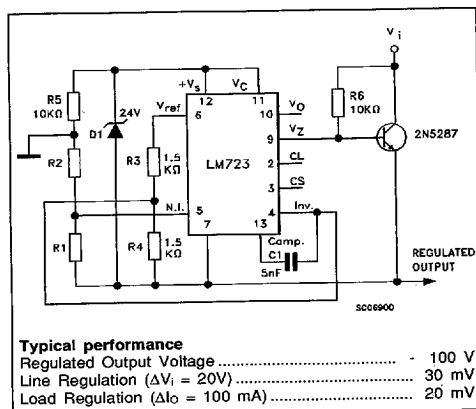
**Figure 18 : Foldback current limiting**



**Figure 19 : Positive Floating Regulator**



**Figure 20 : Negative Floating Regulator**





## APPLICATION INFORMATION (continued).

Figure 21 : Positive Switching Regulator

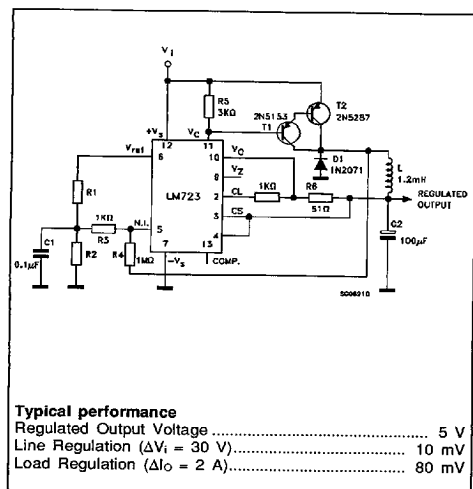


Figure 23 : Shunt Regulator.

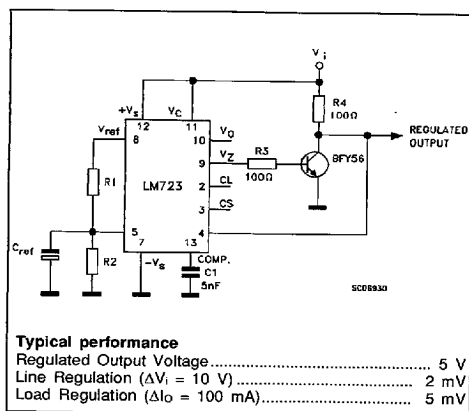
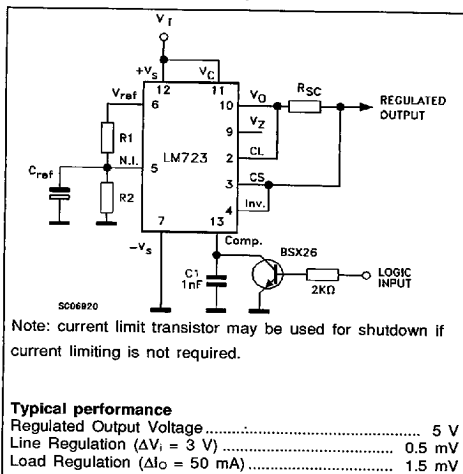


Figure 22 : Remote Shutdown Regulator With Current Limiting



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

Figure 24 : Output Voltage Adjust

