LM723/LM723C Voltage Regulator

Check for Samples: LM723, LM723C

FEATURES

- **150 mA Output Current Without External Pass Transistor**
- **Output Currents in Excess of 10A Possible by Adding External Transistors**
- **Input Voltage 40V Max**
- **Output Voltage Adjustable from 2V to 37V**
- **Can be Used as Either a Linear or a Switching Regulator**

DESCRIPTION

The LM723/LM723C is a voltage regulator designed primarily for series regulator applications. By itself, it will supply output currents up to 150 mA; but external transistors can be added to provide any desired load current. The circuit features extremely low standby current drain, and provision is made for either linear or foldback current limiting.

The LM723/LM723C is also useful in a wide range of other applications such as a shunt regulator, a current regulator or a temperature controller.

The LM723C is identical to the LM723 except that the LM723C has its performance ensured over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

Connection Diagram

Figure 1. Top View
CDIP Package or PDIP Package
See Package J or NFF0014A

Note: Pin 5 connected to case.

Figure 2. Top View
TO-100
See Package LME

Figure 3. Top View
See Package NAJ0020A

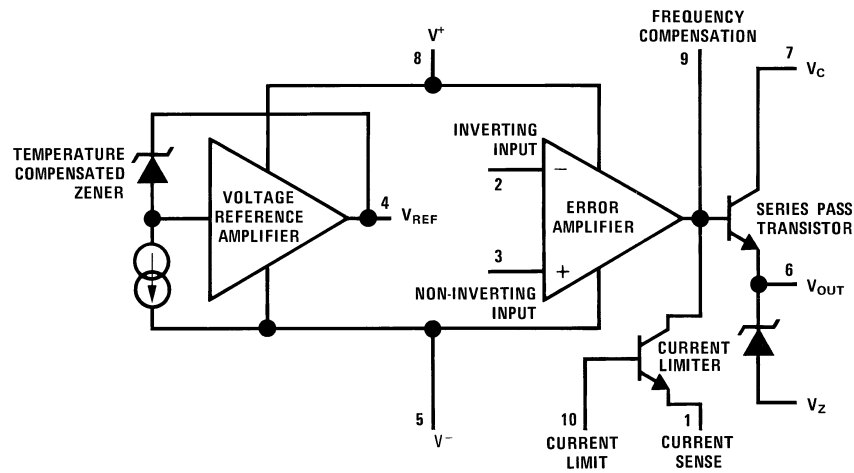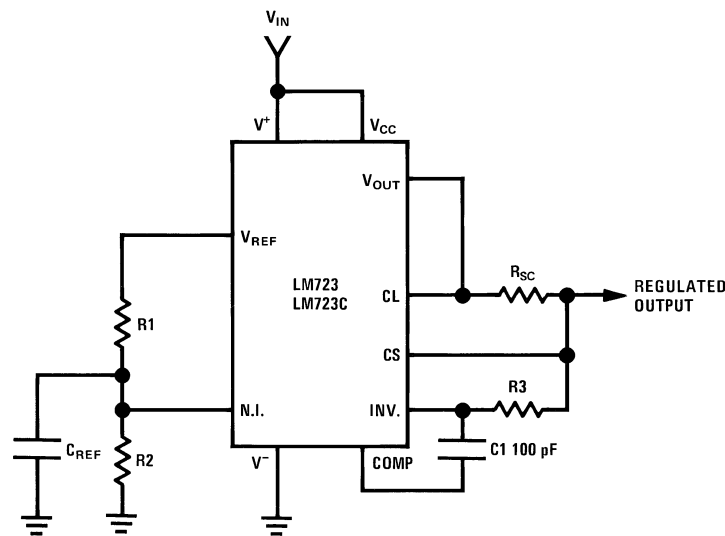## Equivalent Circuit*

*Pin numbers refer to metal can package.

Typical Application

Note: $R3 = \dfrac{R1\,R2}{R1 + R2}$

for minimum temperature drift.

Typical Performance

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

Figure 4. Basic Low Voltage Regulator ($V_{OUT} = 2$ to 7 Volts)

Product Folder Links: *LM723 LM723C*

⚠️ These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS[1][2]

Pulse Voltage from V^+ to V^- (50 ms)	50V
Continuous Voltage from V^+ to V^-	40V
Input-Output Voltage Differential	40V
Maximum Amplifier Input Voltage (Either Input)	8.5V
Maximum Amplifier Input Voltage (Differential)	5V
Current from V_Z	25 mA
Current from V_{REF}	15 mA
Internal Power Dissipation Metal Can [3]	800 mW
CDIP [3]	900 mW
PDIP [3]	660 mW
Operating Temperature Range	
LM723	−55°C to +150°C
LM723C	0°C to +70°C
Storage Temperature Range Metal Can	−65°C to +150°C
PDIP	−55°C to +150°C
Lead Temperature (Soldering, 4 sec. max.)	
Hermetic Package	300°C
Plastic Package	260°C
ESD Tolerance	1200V
(Human body model, 1.5 kΩ in series with 100 pF)	

(1) "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits.
(2) A military RETS specification is available on request. At the time of printing, the LM723 RETS specification complied with the Min and Max limits in this table. The LM723E, H, and J may also be procured as a Standard Military Drawing.
(3) See derating curves for maximum power rating above 25°C.

ELECTRICAL CHARACTERISTICS[1][2][3][4]

Parameter	Conditions	LM723			LM723C			Units
		Min	Typ	Max	Min	Typ	Max	
Line Regulation	V_{IN} = 12V to V_{IN} = 15V		0.01	0.1		0.01	0.1	% V_{OUT}
	−55°C ≤ T_A ≤ +125°C			0.3				% V_{OUT}
	0°C ≤ T_A ≤ +70°C						0.3	% V_{OUT}
	V_{IN} = 12V to V_{IN} = 40V		0.02	0.2		0.1	0.5	% V_{OUT}
Load Regulation	I_L = 1 mA to I_L = 50 mA		0.03	0.15		0.03	0.2	% V_{OUT}
	−55°C ≤ T_A ≤ +125°C			0.6				% V_{OUT}
	0°C ≤ T_A ≤ +70°C						0.6	% V_{OUT}
Ripple Rejection	f = 50 Hz to 10 kHz, C_{REF} = 0		74			74		dB
	f = 50 Hz to 10 kHz, C_{REF} = 5 μF		86			86		dB

(1) Unless otherwise specified, T_A = 25°C, V_{IN} = V^+ = V_C = 12V, V^- = 0, V_{OUT} = 5V, I_L = 1 mA, R_{SC} = 0, C_1 = 100 pF, C_{REF} = 0 and divider impedance as seen by error amplifier ≤ 10 kΩ connected as shown in Figure 4. Line and load regulation specifications are given for the condition of constant chip temperature. Temperature drifts must be taken into account separately for high dissipation conditions.
(2) A military RETS specification is available on request. At the time of printing, the LM723 RETS specification complied with the Min and Max limits in this table. The LM723E, H, and J may also be procured as a Standard Military Drawing.
(3) Specified by correlation to other tests.
(4) L_1 is 40 turns of No. 20 enameled copper wire wound on Ferroxcube P36/22-3B7 pot core or equivalent with 0.009 in. air gap.

LM723, LM723C

ELECTRICAL CHARACTERISTICS[(1)(2)(3)(4)] (continued)

Parameter	Conditions	LM723			LM723C			Units
		Min	Typ	Max	Min	Typ	Max	
Average Temperature Coefficient of Output Voltage ([(5)])	−55°C ≤ T_A ≤ +125°C		0.002	0.015				%/°C
	0°C ≤ T_A ≤ +70°C					0.003	0.015	%/°C
Short Circuit Current Limit	R_{SC} = 10Ω, V_{OUT} = 0		65			65		mA
Reference Voltage		6.95	7.15	7.35	6.80	7.15	7.50	V
Output Noise Voltage	BW = 100 Hz to 10 kHz, C_{REF} = 0		86			86		µVrms
	BW = 100 Hz to 10 kHz, C_{REF} = 5 µF		2.5			2.5		µVrms
Long Term Stability			0.05			0.05		%/1000 hrs
Standby Current Drain	I_L = 0, V_{IN} = 30V		1.7	3.5		1.7	4.0	mA
Input Voltage Range		9.5		40	9.5		40	V
Output Voltage Range		2.0		37	2.0		37	V
Input-Output Voltage Differential		3.0		38	3.0		38	V
$θ_{JA}$	PDIP					105		°C/W
$θ_{JA}$	CDIP		150					°C/W
$θ_{JA}$	H10C Board Mount in Still Air		165			165		°C/W
$θ_{JA}$	H10C Board Mount in 400 LF/Min Air Flow		66			66		°C/W
$θ_{JC}$			22			22		°C/W

(5) For metal can applications where V_Z is required, an external 6.2V zener diode should be connected in series with V_{OUT}.

Product Folder Links: *LM723 LM723C*

TYPICAL PERFORMANCE CHARACTERISTICS

Load Regulation Characteristics with Current Limiting
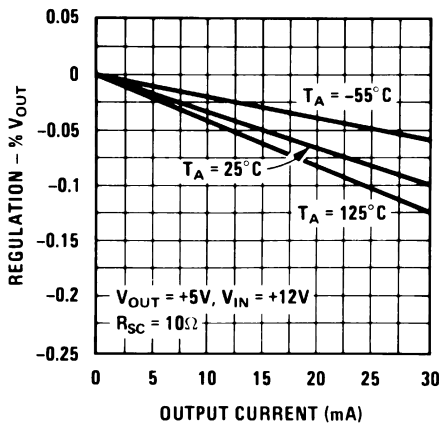
Figure 5.

Load Regulation Characteristics with Current Limiting
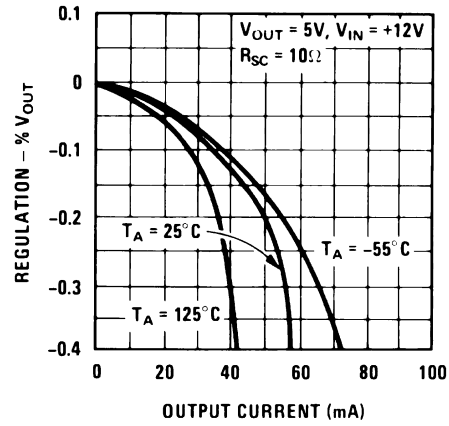
Figure 6.

Load & Line Regulation vs Input-Output Voltage Differential
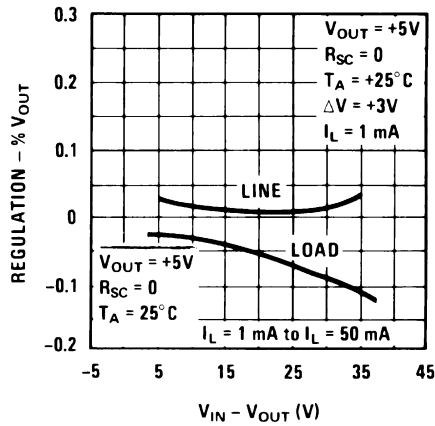
Figure 7.

Current Limiting Characteristics
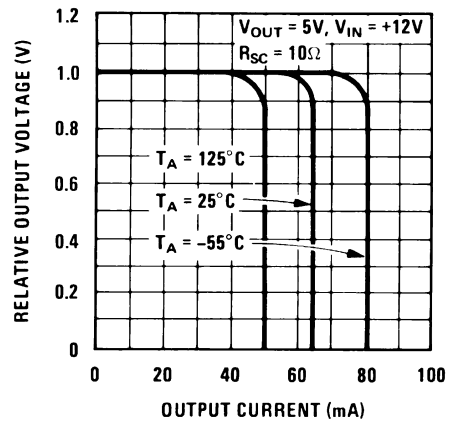
Figure 8.

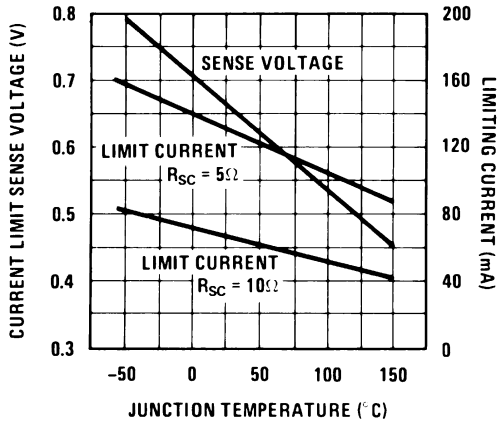**Current Limiting Characteristics vs Junction Temperature**

Figure 9.

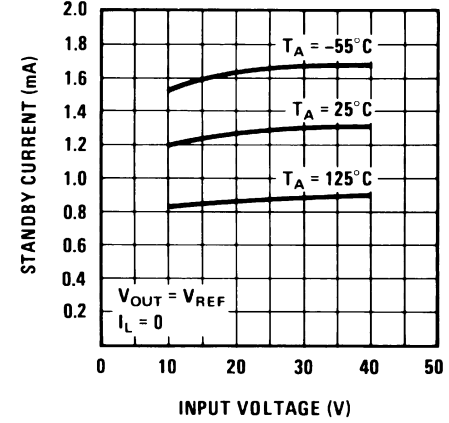**Standby Current Drain vs Input Voltage**
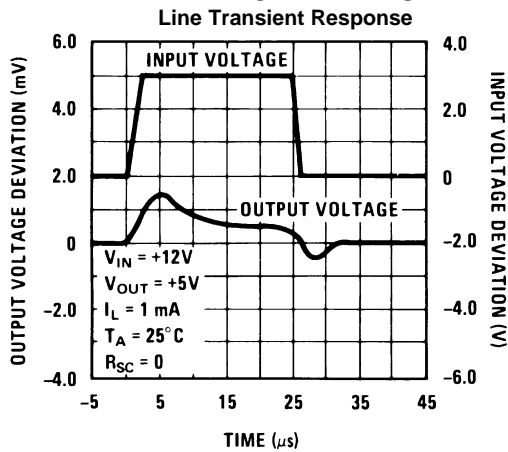

Figure 10.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Line Transient Response

Figure 11.

Load Transient Response

Figure 12.

Output Impedence vs Frequency

Figure 13.

Product Folder Links: *LM723 LM723C*

MAXIMUM POWER RATINGS

Noise vs Filter Capacitor
(C$_{REF}$ in Circuit of Figure 4)
(Bandwidth 100 Hz to 10 kHz)

Figure 14.

LM723 Power Dissipation vs Ambient Temperature

Figure 15.

LM723C Power Dissipation vs Ambient Temperature

Figure 16.

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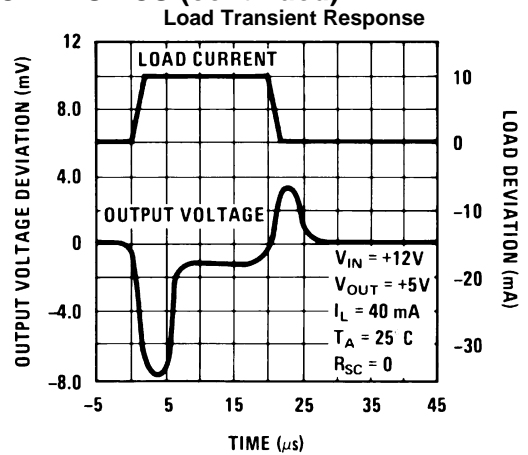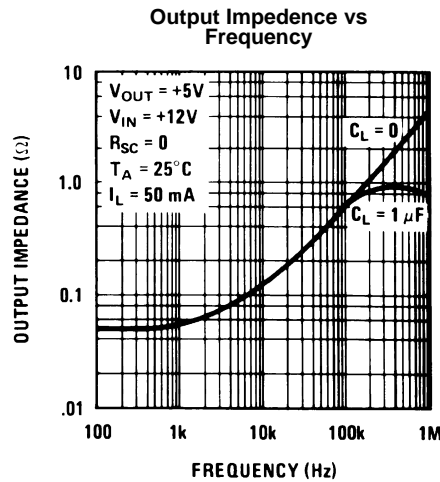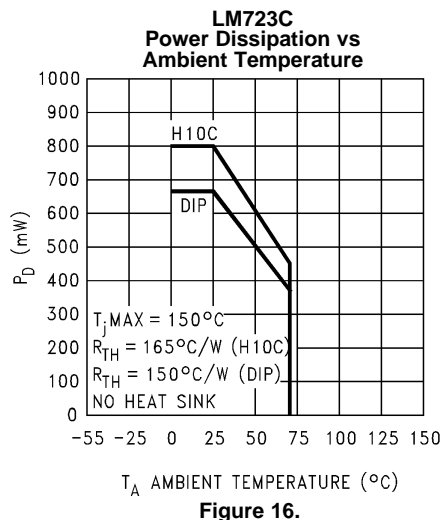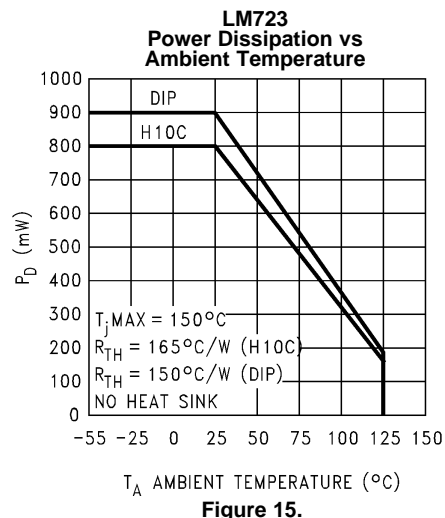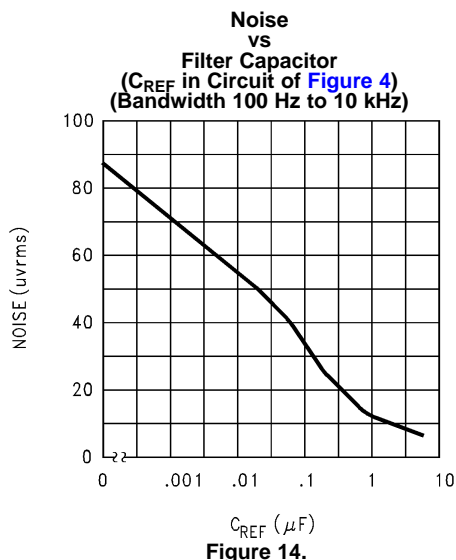
Table 1. Resistor Values (kΩ) for Standard Output Voltage

| Positive Output Voltage	Applicable Figures See[2]	Fixed Output ±5%		Output Adjustable ±10%[1]			Negative Output Voltage	Applicable Figures	Fixed Output ±5%		5% Output Adjustable ±10%		
		R1	R2	R1	P1	R2			R1	R2	R1	P1	R2
+3.0	Figure 4, Figure 19, Figure 21, Figure 24, Figure 27 (Figure 19)	4.12	3.01	1.8	0.5	1.2	+100	Figure 22	3.57	102	2.2	10	91
+3.6	Figure 4, Figure 19, Figure 21, Figure 24, Figure 27 (Figure 19)	3.57	3.65	1.5	0.5	1.5	+250	Figure 22	3.57	255	2.2	10	240
+5.0	Figure 4, Figure 19, Figure 21, Figure 24, Figure 27 (Figure 19)	2.15	4.99	0.75	0.5	2.2	−6[3]	Figure 18, (Figure 25)	3.57	2.43	1.2	0.5	0.75
+6.0	Figure 4, Figure 19, Figure 21, Figure 24, Figure 27 (Figure 19)	1.15	6.04	0.5	0.5	2.7	−9	Figure 18, Figure 25	3.48	5.36	1.2	0.5	2.0
+9.0	Figure 17, Figure 19, (Figure 19, Figure 21, Figure 24, Figure 27)	1.87	7.15	0.75	1.0	2.7	−12	Figure 18, Figure 25	3.57	8.45	1.2	0.5	3.3
+12	Figure 17, Figure 19, (Figure 19, Figure 21, Figure 24, Figure 27)	4.87	7.15	2.0	1.0	3.0	−15	Figure 18, Figure 25	3.65	11.5	1.2	0.5	4.3
+15	Figure 17, Figure 19, (Figure 19, Figure 21, Figure 24, Figure 27)	7.87	7.15	3.3	1.0	3.0	−28	Figure 18, Figure 25	3.57	24.3	1.2	0.5	10
+28	Figure 17, Figure 19, (Figure 19, Figure 21, Figure 24, Figure 27)	21.0	7.15	5.6	1.0	2.0	−45	Figure 23	3.57	41.2	2.2	10	33
+45	Figure 22	3.57	48.7	2.2	10	39	−100	Figure 23	3.57	97.6	2.2	10	91
+75	Figure 22	3.57	78.7	2.2	10	68	−250	Figure 23	3.57	249	2.2	10	240

(1) Replace R1/R2 in figures with divider shown in Figure 28.
(2) Figures in parentheses may be used if R1/R2 divider is placed on opposite input of error amp.
(3) V^+ and V_{CC} must be connected to a +3V or greater supply.

Table 2. Formulae for Intermediate Output Voltages

Outputs from +2 to +7 volts	Outputs from +4 to +250 volts	Current Limiting
(Figure 4 Figure 19 Figure 20 Figure 21 Figure 24 Figure 27) $$V_{OUT} = \left(V_{REF} \times \frac{R2}{R1 + R2} \right)$$	(Figure 22) $$V_{OUT} = \left(\frac{V_{REF}}{2} \times \frac{R2 - R1}{R1} \right); R3 = R4$$	$$I_{LIMIT} = \frac{V_{SENSE}}{R_{SC}}$$
Outputs from +7 to +37 volts	**Outputs from −6 to −250 volts**	**Foldback Current Limiting**
(Figure 17 Figure 19 Figure 20 Figure 21 Figure 24 Figure 27) $$V_{OUT} = \left(V_{REF} \times \frac{R1 + R2}{R2} \right)$$	(Figure 18 Figure 23 Figure 25) $$V_{OUT} = \left(\frac{V_{REF}}{2} \times \frac{R1 + R2}{R1} \right); R3 = R4$$	$$I_{KNEE} = \left(\frac{V_{OUT}}{R_{SC}} \frac{R3}{R4} + \frac{V_{SENSE} (R3 + R4)}{R_{SC} R4} \right)$$ $$I_{SHORT\ CKT} = \left(\frac{V_{SENSE}}{R_{SC}} \times \frac{R3 + R4}{R4} \right)$$

TYPICAL APPLICATIONS
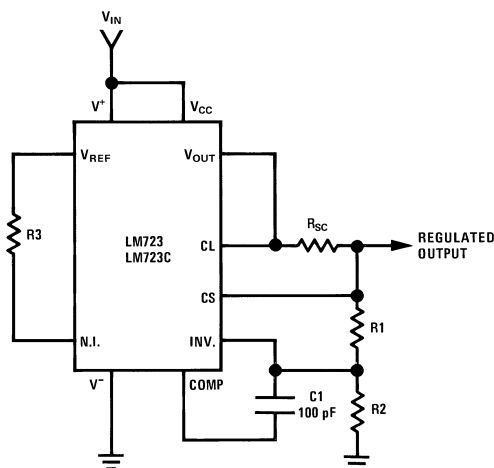
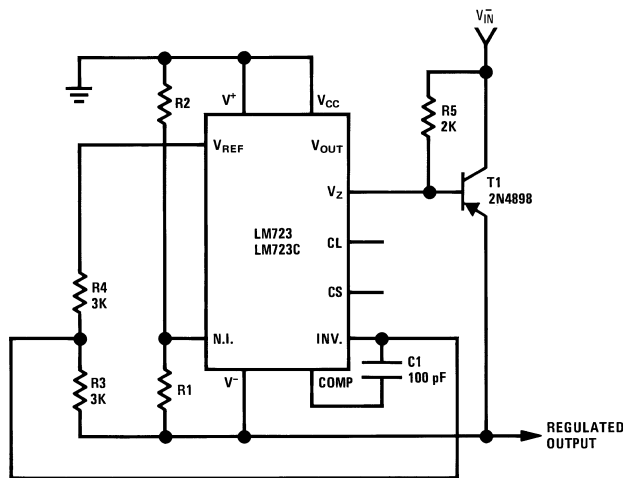Note: $R3 = \dfrac{R1\,R2}{R1 + R2}$

for minimum temperature drift.
R3 may be eliminated for minimum component count.

Typical Performance

Regulated Output Voltage	15V
Line Regulation (ΔV$_{IN}$ = 3V)	1.5 mV
Load Regulation (ΔI$_L$ = 50 mA)	4.5 mV

Figure 17. Basic High Voltage Regulator (V$_{OUT}$ = 7 to 37 Volts)

Typical Performance

Regulated Output Voltage	−15V
Line Regulation (ΔV$_{IN}$ = 3V)	1 mV
Load Regulation (ΔI$_L$ = 100 mA)	2 mV

Figure 18. Negative Voltage Regulator
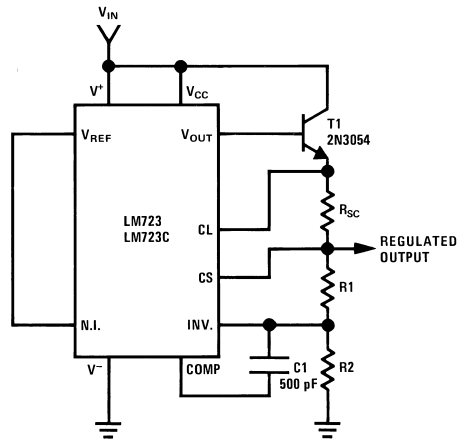
Product Folder Links: *LM723 LM723C*

Typical Performance

Regulated Output Voltage	+15V
Line Regulation (ΔV_{IN} = 3V)	1.5 mV
Load Regulation (ΔI_L = 1A)	15 mV

Figure 19. Positive Voltage Regulator (External NPN Pass Transistor)
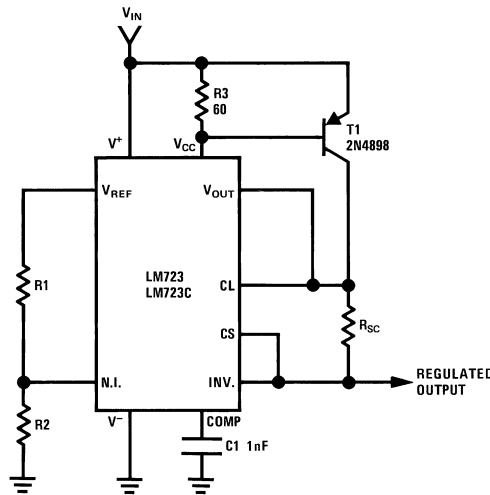
Typical Performance

Regulated Output Voltage	+5V
Line Regulation (ΔV_{IN} = 3V)	0.5 mV
Load Regulation (ΔI_L = 1A)	5 mV

Figure 20. Positive Voltage Regulator (External PNP Pass Transistor)
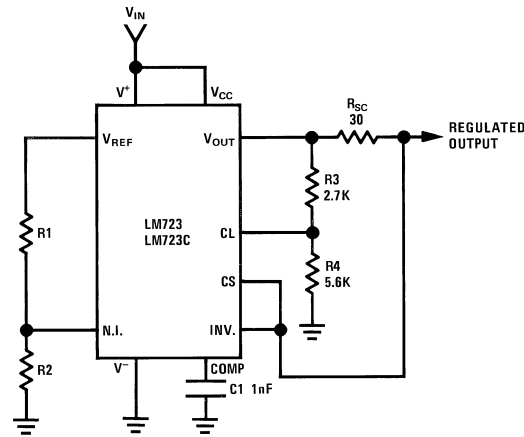
Product Folder Links: *LM723 LM723C*

Typical Performance

Regulated Output Voltage	+5V
Line Regulation (ΔV_{IN} = 3V)	0.5 mV
Load Regulation (ΔI_L = 10 mA)	1 mV
Short Circuit Current	20 mA

Figure 21. Foldback Current Limiting
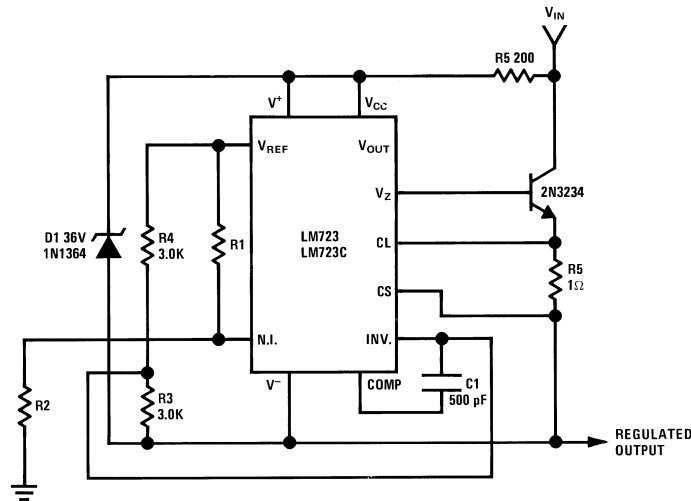
Typical Performance

Regulated Output Voltage	+50V
Line Regulation (ΔV_{IN} = 20V)	15 mV
Load Regulation (ΔI_L = 50 mA)	20 mV

Figure 22. Positive Floating Regulator

Product Folder Links: *LM723 LM723C*
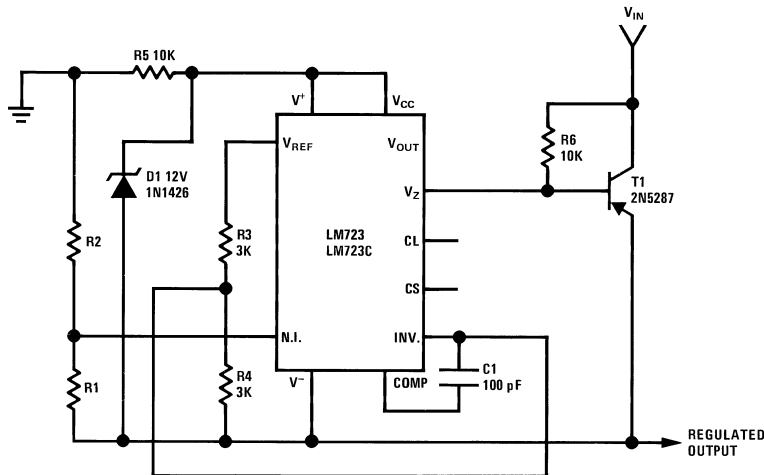
Typical Performance

Regulated Output Voltage	−100V
Line Regulation (ΔV_{IN} = 20V)	30 mV
Load Regulation (ΔI_L = 100 mA)	20 mV

Figure 23. Negative Floating Regulator
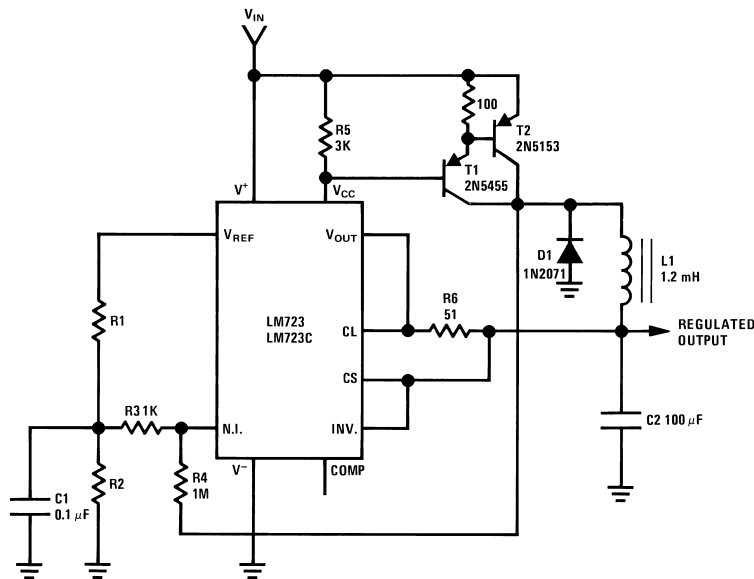
Typical Performance

Regulated Output Voltage	+5V
Line Regulation (ΔV_{IN} = 30V)	10 mV
Load Regulation (ΔI_L = 2A)	80 mV

Figure 24. Positive Switching Regulator

Product Folder Links: *LM723 LM723C*
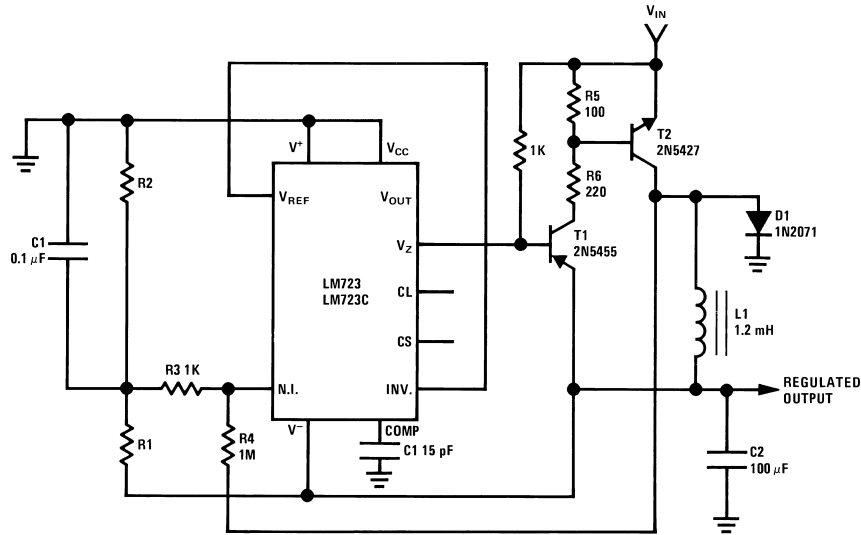
Typical Performance

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

Figure 25. Negative Switching Regulator
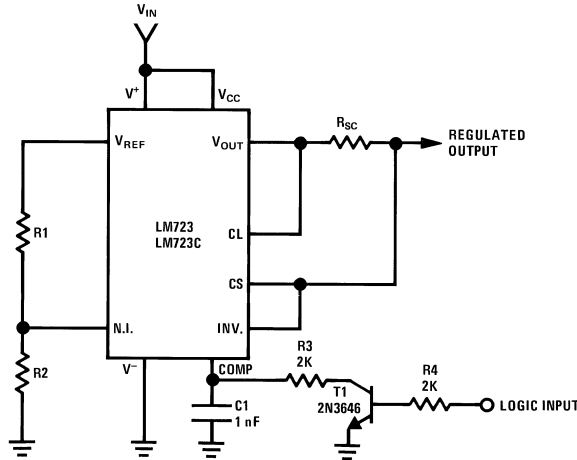
Note: Current limit transistor may be used for shutdown if current limiting is not required.

Typical Performance

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

Figure 26. Remote Shutdown Regulator with Current Limiting
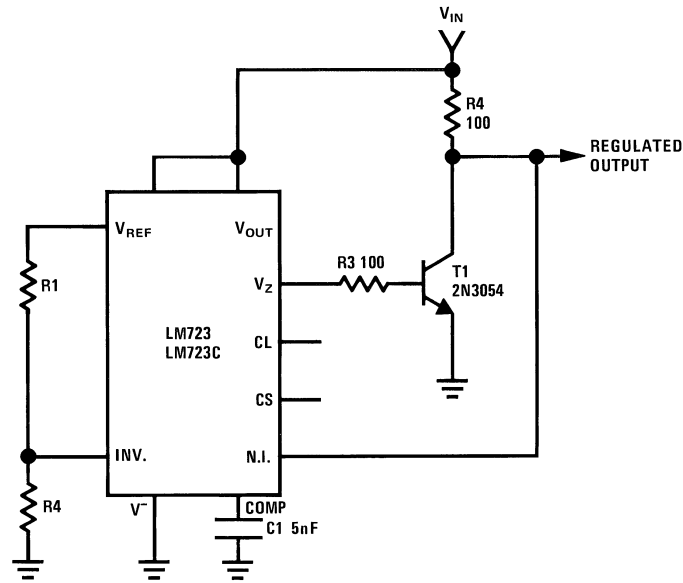
Regulated Output Voltage	+5V
Line Regulation (ΔV_{IN} = 10V)	0.5 mV
Load Regulation (ΔI_L = 100 mA)	1.5 mV

Figure 27. Shunt Regulator
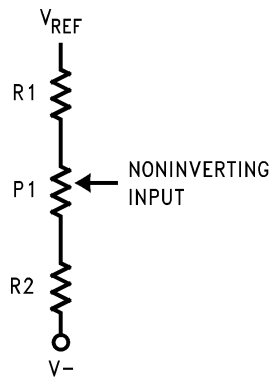
Figure 28. Output Voltage Adjust [1]

(1) Replace R1/R2 in figures with divider shown in Figure 28.
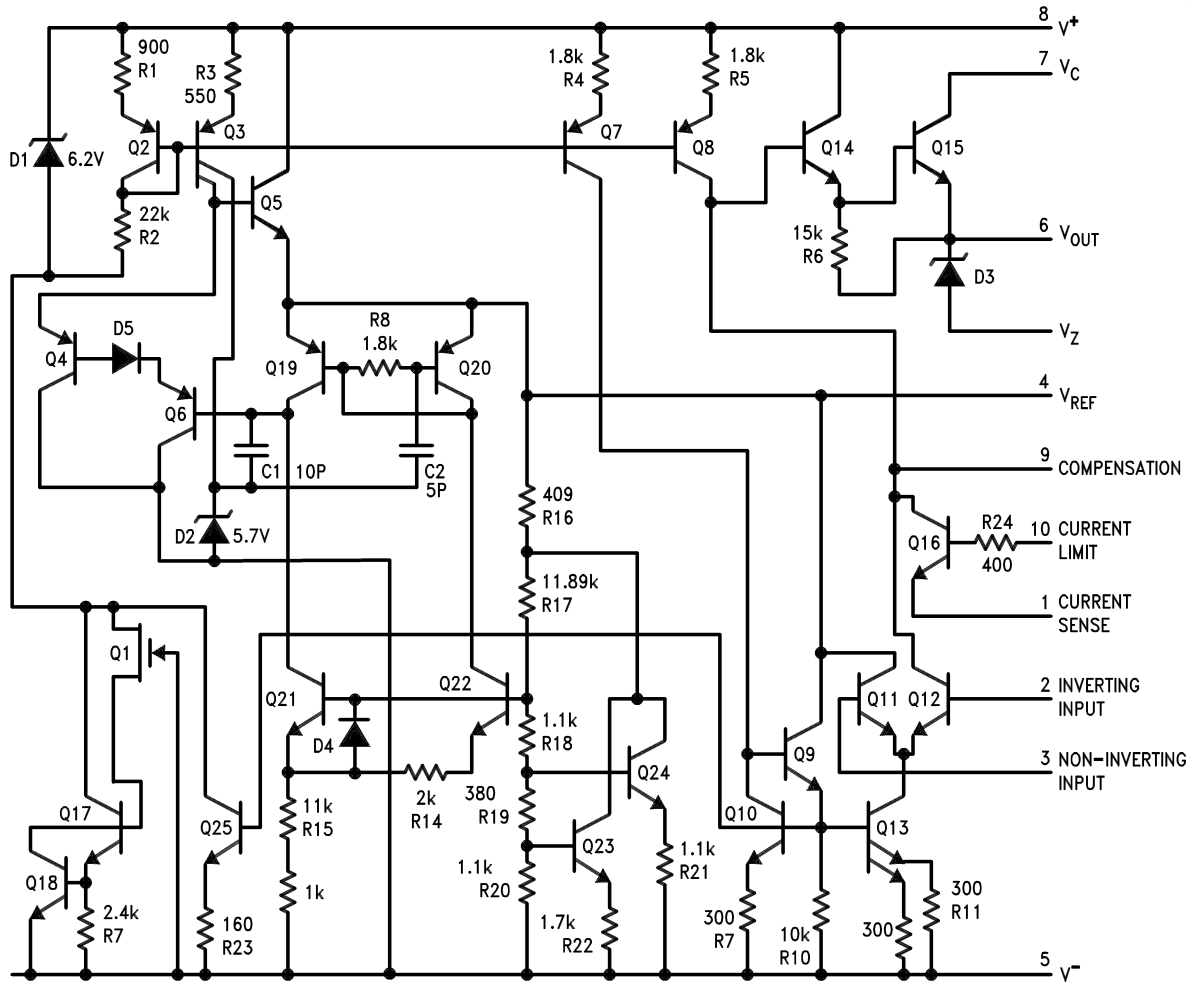
Product Folder Links: *LM723 LM723C*

Schematic Diagram

REVISION HISTORY

Product Folder Links: *LM723 LM723C*

PACKAGE OPTION ADDENDUM

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM723CH	Active	Production	TO-100 (LME) | 10	500 | BULK	No	Call TI	Level-1-NA-UNLIM	0 to 70	(LM723CH, LM723CH)
LM723CH.Z	Active	Production	TO-100 (LME) | 10	500 | BULK	No	Call TI	Level-1-NA-UNLIM	0 to 70	(LM723CH, LM723CH)
LM723CH/NOPB	Active	Production	TO-100 (LME) | 10	500 | BULK	Yes	Call TI	Level-1-NA-UNLIM	0 to 70	(LM723CH, LM723CH)
LM723CH/NOPB.Z	Active	Production	TO-100 (LME) | 10	500 | BULK	Yes	Call TI	Level-1-NA-UNLIM	0 to 70	(LM723CH, LM723CH)
LM723H	Active	Production	TO-100 (LME) | 10	500 | BULK	No	Call TI	Level-1-NA-UNLIM	-55 to 150	(LM723H, LM723H)
LM723H.Z	Active	Production	TO-100 (LME) | 10	500 | BULK	No	Call TI	Level-1-NA-UNLIM	-55 to 150	(LM723H, LM723H)
LM723H/NOPB	Active	Production	TO-100 (LME) | 10	500 | BULK	Yes	Call TI	Level-1-NA-UNLIM	-55 to 150	(LM723H, LM723H)
LM723H/NOPB.Z	Active	Production	TO-100 (LME) | 10	500 | BULK	Yes	Call TI	Level-1-NA-UNLIM	-55 to 150	(LM723H, LM723H)

(1) Status: For more details on status, see our product life cycle.

(2) Material type: When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) RoHS values: Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) Lead finish/Ball material: Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) MSL rating/Peak reflow: The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) Part marking: There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

∅ 8.51 / 7.75

1.02 MAX

4.70 / 4.19

5.72 MAX

C

1.02 / 0.25 STAND-OFF

SEATING PLANE

UNCONTROLLED
LEAD DIA
1.397 MAX

10X 12.7 MIN

10X 0.53 / 0.41

⊕ | 0.25 Ⓜ | C | A

(∅ 3.56)
STAND-OFF

2.92

∅ 5.84

∅ 9.40 / 8.51

A

1.14 / 0.74

0.86 / 0.71

36° TYP

4220604/B   09/2024

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration MO-006/TO-100.

SOLDER MASK
OPENING

(□ 1.4)

0.07 MAX
ALL AROUND

METAL

1

10

9

2

9X (∅ 1.4)
METAL

10X (∅ 0.8)
VIA

8

(R0.05)
TYP

9X SOLDER MASK
OPENING

3

7

9X 0.07 MAX
ALL AROUND

4

5

6

(∅ 5.84)

(36°) TYP

LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE: 12X

4220604/B   09/2024

IMPORTANT NOTICE AND DISCLAIMER