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June 1999

National Semiconductor

LM723/LM723C Voltage Regulator

General 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.

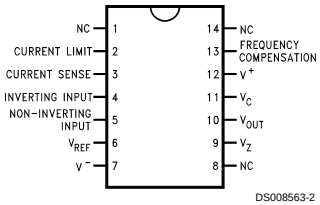
The LM723C is identical to the LM723 except that the LM723C has its performance guaranteed over a 0˚C to +70˚C temperature range, instead of −55˚C to +125˚C.

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

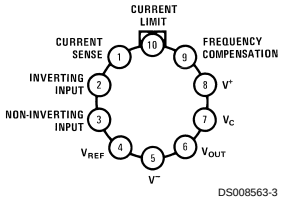
Connection Diagrams

Dual-In-Line Package



Top View
Order Number LM723J/883 or LM723CN
See NS Package J14A or N14A

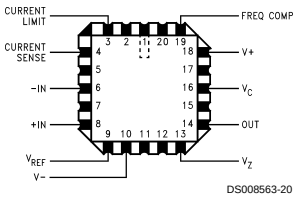
Metal Can Package



Note: Pin 5 connected to case.

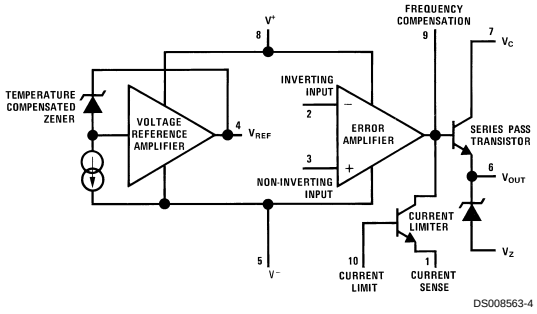
Top View
Order Number LM723H, LM723H/883 or LM723CH
See NS Package H10C

Connection Diagrams (Continued)



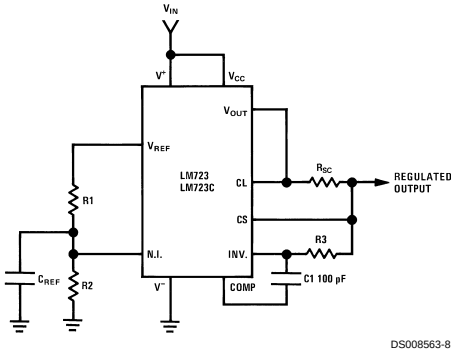
Top View
Order Number LM723E/883
See NS Package E20A

Equivalent Circuit*



*Pin numbers refer to metal can package.

Typical Application



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

for minimum temperature drift.

Typical Performance

Regulated Output Voltage	5V
Line Regulation (ΔV_{IN} = 3V)	0.5mV
Load Regulation (ΔI_L = 50 mA)	1.5mV

FIGURE 1. Basic Low Voltage Regulator (V_{OUT} = 2 to 7 Volts)

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

(Note 10)

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 (Note 2)	800 mW
Cavity DIP (Note 2)	900 mW
Molded DIP (Note 2)	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
Molded DIP	−55˚C to +150˚C
Lead Temperature (Soldering, 4 sec. max.)	
Hermetic Package	300˚C
Plastic Package	260˚C
ESD Tolerance (Human body model, 1.5 kΩ in series with 100 pF)	1200V

Electrical Characteristics (Note 3) (Note 10)

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
Average Temperature Coeffic-	−55˚C ≤ T_A ≤ +125˚C		0.002	0.015				%/˚C
ient of Output Voltage (Note 8)	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}	Molded DIP					105		˚C/W
θ_{JA}	Cavity DIP		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

Note 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 guarantee specific performance limits.

Note 2: See derating curves for maximum power rating above 25˚C.

Note 3: 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 1.* 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.

Note 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.

Note 5: Figures in parentheses may be used if R1/R2 divider is placed on opposite input of error amp.

Note 6: Replace R1/R2 in figures with divider shown in *Figure 13.*

Note 7: V^+ and V_{CC} must be connected to a +3V or greater supply.

Note 8: For metal can applications where V_Z is required, an external 6.2V zener diode should be connected in series with V_{OUT}.

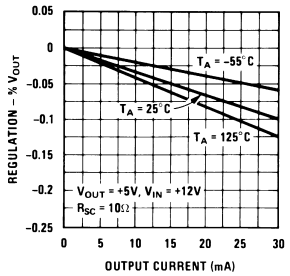
Electrical Characteristics (Note 3) (Note 10) (Continued)

Note 9: Guaranteed by correlation to other tests.

Note 10: 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.

Typical Performance Characteristics

Load Regulation Characteristics with Current Limiting



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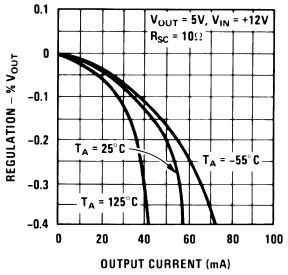
Load Regulation Characteristics with Current Limiting



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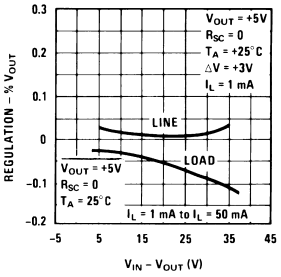
Load & Line Regulation vs Input-Output Voltage Differential



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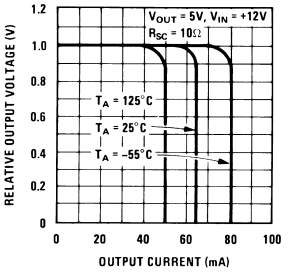
Current Limiting Characteristics



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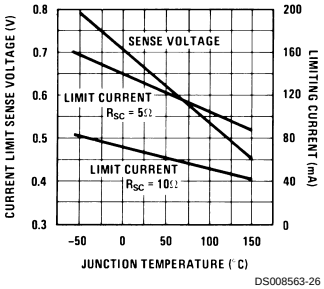
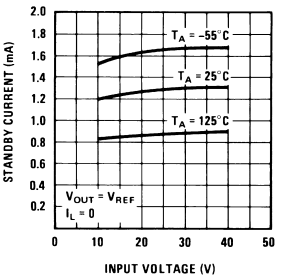
Current Limiting Characteristics vs Junction Temperature



DS008563-26

Standby Current Drain vs Input Voltage



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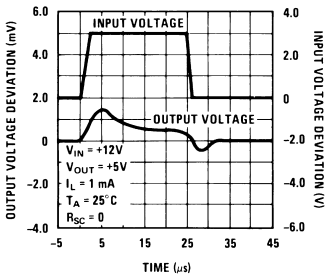
Line Transient Response



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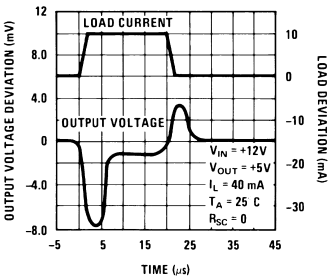
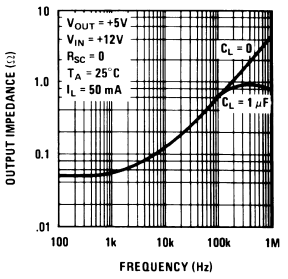
Load Transient Response



DS008563-29

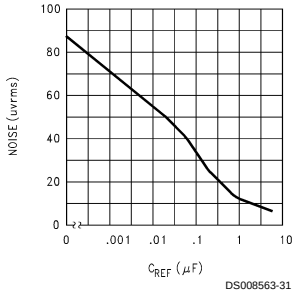
Output Impedence vs Frequency



DS008563-30

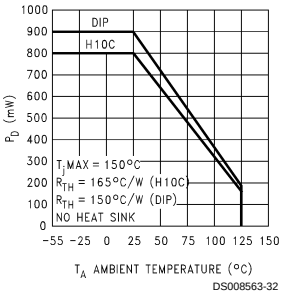
Maximum Power Ratings

Noise vs Filter Capacitor
(C_{REF} in Circuit of *Figure 1*)
(Bandwidth 100 Hz to 10 kHz)



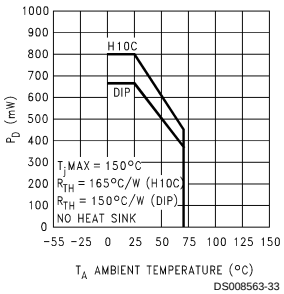
DS008563-31

LM723
Power Dissipation vs
Ambient Temperature



DS008563-32

LM723C
Power Dissipation vs
Ambient Temperature



DS008563-33

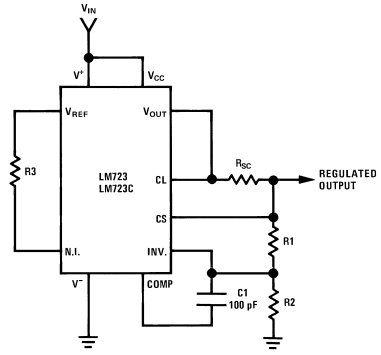
TABLE 1. Resistor Values (kΩ) for Standard Output Voltage

Positive Output Voltage	Applicable Figures	Fixed Output ±5%		Output Adjustable ±10% (Note 6)			Negative Output Voltage	Applicable Figures	Fixed Output ±5%		5% Output Adjustable ±10%		
	(Note 5)	R1	R2	R1	P1	R2			R1	R2	R1	P1	R2
+3.0	1, 5, 6, 9, 12 (4)	4.12	3.01	1.8	0.5	1.2	+100	7	3.57	102	2.2	10	91
+3.6	1, 5, 6, 9, 12 (4)	3.57	3.65	1.5	0.5	1.5	+250	7	3.57	255	2.2	10	240
+5.0	1, 5, 6, 9, 12 (4)	2.15	4.99	0.75	0.5	2.2	−6 (Note 7)	3, (10)	3.57	2.43	1.2	0.5	0.75
+6.0	1, 5, 6, 9, 12 (4)	1.15	6.04	0.5	0.5	2.7	−9	3, 10	3.48	5.36	1.2	0.5	2.0
+9.0	2, 4, (5, 6, 9, 12)	1.87	7.15	0.75	1.0	2.7	−12	3, 10	3.57	8.45	1.2	0.5	3.3
+12	2, 4, (5, 6, 9, 12)	4.87	7.15	2.0	1.0	3.0	−15	3, 10	3.65	11.5	1.2	0.5	4.3
+15	2, 4, (5, 6, 9, 12)	7.87	7.15	3.3	1.0	3.0	−28	3, 10	3.57	24.3	1.2	0.5	10
+28	2, 4, (5, 6, 9, 12)	21.0	7.15	5.6	1.0	2.0	−45	8	3.57	41.2	2.2	10	33
+45	7	3.57	48.7	2.2	10	39	−100	8	3.57	97.6	2.2	10	91
+75	7	3.57	78.7	2.2	10	68	−250	8	3.57	249	2.2	10	240

TABLE 2. Formulae for Intermediate Output Voltages

Outputs from +2 to +7 volts (*Figures 1, 4, 5, 6, 9, 12* $V_{OUT} = \left(V_{REF} \times \frac{R2}{R1 + R2}\right)$	**Outputs from +4 to +250 volts** (*Figure 7*) $V_{OUT} = \left(\frac{V_{REF}}{2} \times \frac{R2 - R1}{R1}\right)$; R3 = R4	**Current Limiting** $I_{LIMIT} = \frac{V_{SENSE}}{R_{SC}}$
Outputs from +7 to +37 volts (*Figures 2, 4, 5, 6, 9, 12*) $V_{OUT} = \left(V_{REF} \times \frac{R1 + R2}{R2}\right)$	**Outputs from −6 to −250 volts** (*Figures 3, 8, 10*) $V_{OUT} = \left(\frac{V_{REF}}{2} \times \frac{R1 + R2}{R1}\right)$; R3 = R4	**Foldback Current Limiting** $I_{KNEE} = \left(\frac{V_{OUT}\,R3}{R_{SC}\,R4} + \frac{V_{SENSE}\,(R3 + R4)}{R_{SC}\,R4}\right)$ $I_{SHORT\ CKT} = \left(\frac{V_{SENSE}}{R_{SC}} \times \frac{R3 + R4}{R4}\right)$

Typical Applications



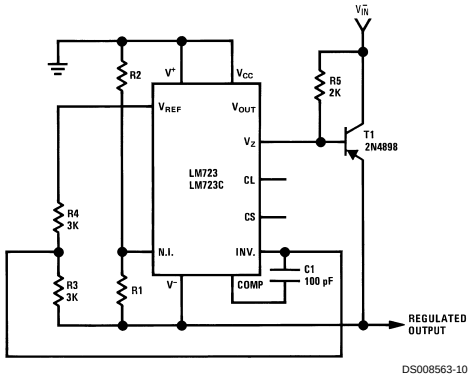
Note: $R3 = \frac{R1\,R2}{R1 + R2}$

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

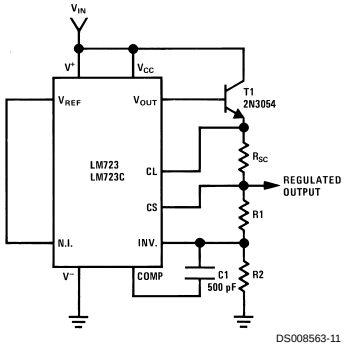
FIGURE 2. Basic High Voltage Regulator (V_{OUT} = 7 to 37 Volts)



Typical Performance

Regulated Output Voltage	−15V
Line Regulation (ΔV_{IN} = 3V)	1 mV
Load Regulation (ΔI_L = 100 mA)	2 mV

FIGURE 3. Negative Voltage Regulator

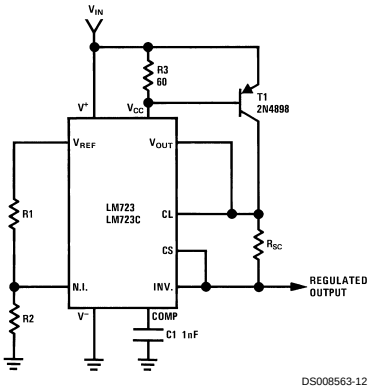


Typical Performance

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

FIGURE 4. Positive Voltage Regulator (External NPN Pass Transistor)

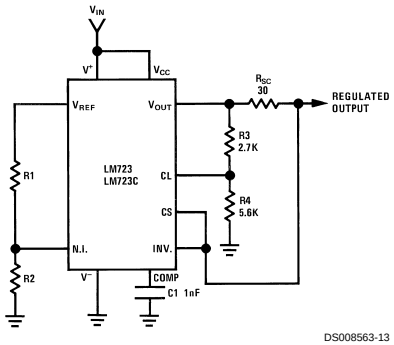
Typical Applications (Continued)



Typical Performance

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

FIGURE 5. Positive Voltage Regulator (External PNP Pass Transistor)

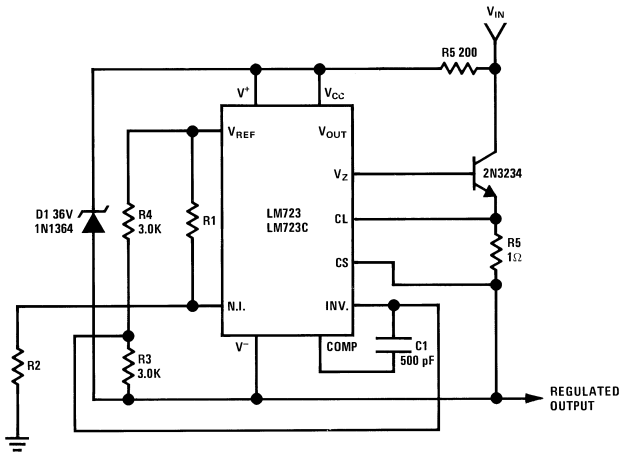


Typical Performance

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 6. Foldback Current Limiting

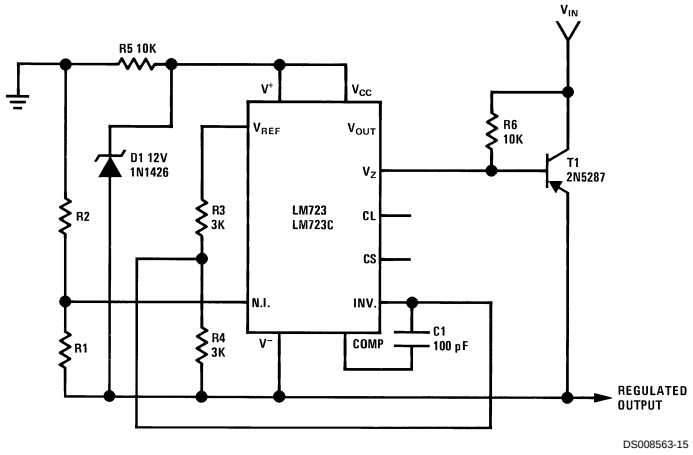
Typical Applications (Continued)



Typical Performance

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

FIGURE 7. Positive Floating Regulator

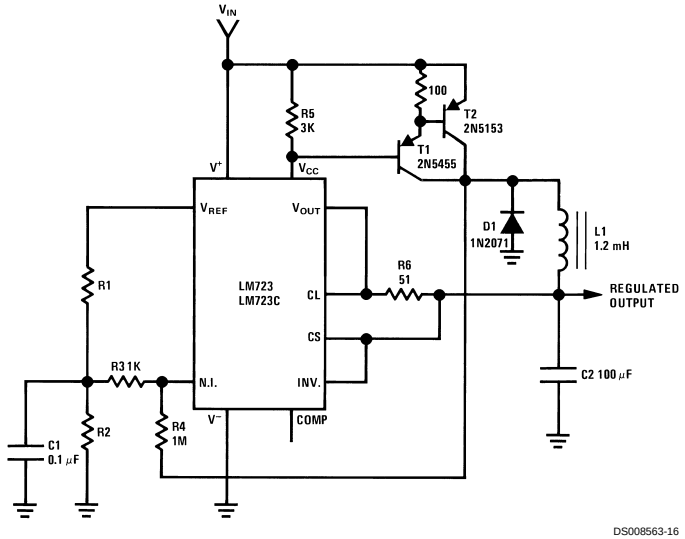


Typical Performance

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

FIGURE 8. Negative Floating Regulator

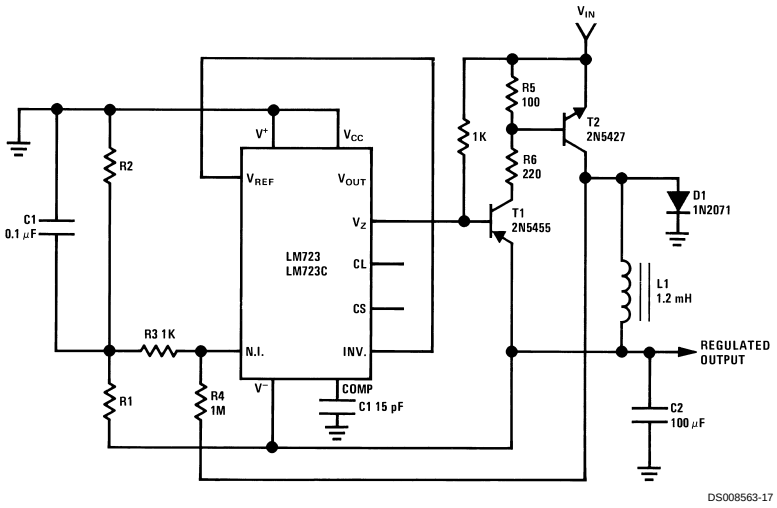
Typical Applications (Continued)



Typical Performance

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

FIGURE 9. Positive Switching Regulator

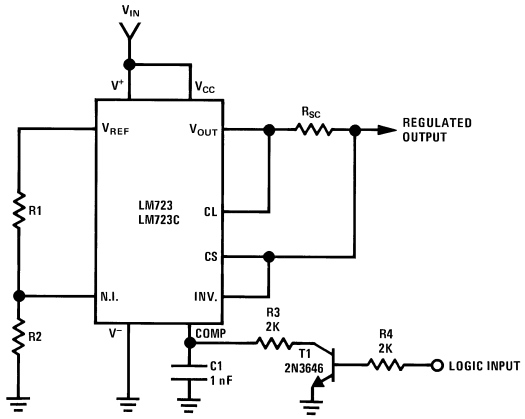


Typical Performance

Regulated Output Voltage	−15V
Line Regulation (ΔV_{IN} = 20V)	8 mV
Load Regulation (ΔI_L = 2A)	6 mV

FIGURE 10. Negative Switching Regulator

Typical Applications (Continued)

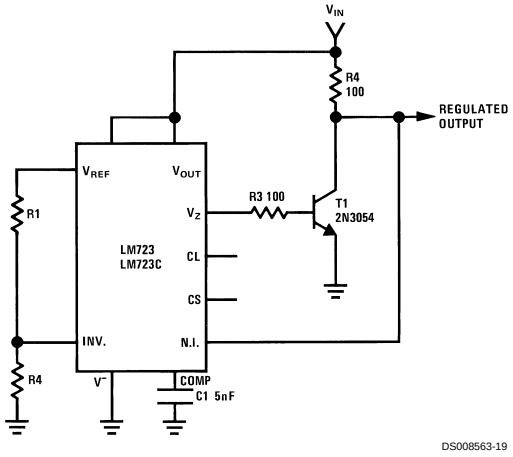


Note: Current limit transistor may be used for shutdown if current limiting is not required.

Typical Performance

Regulated Output Voltage	+5V
Line Regulation (ΔV_{IN} = 3V)	0.5 mV
Load Regulation (ΔI_L = 50 mA)	1.5 mV

FIGURE 11. 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 12. Shunt Regulator

Typical Applications (Continued)

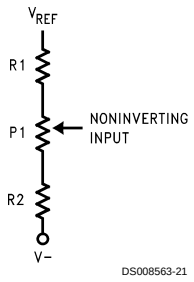
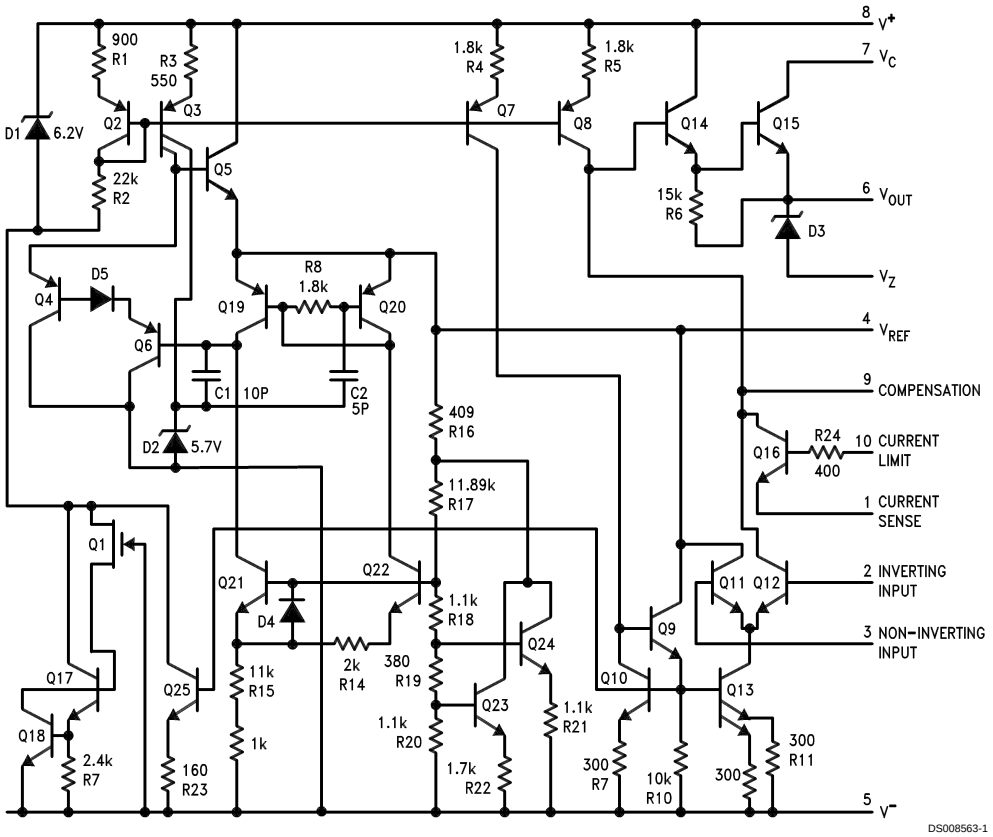
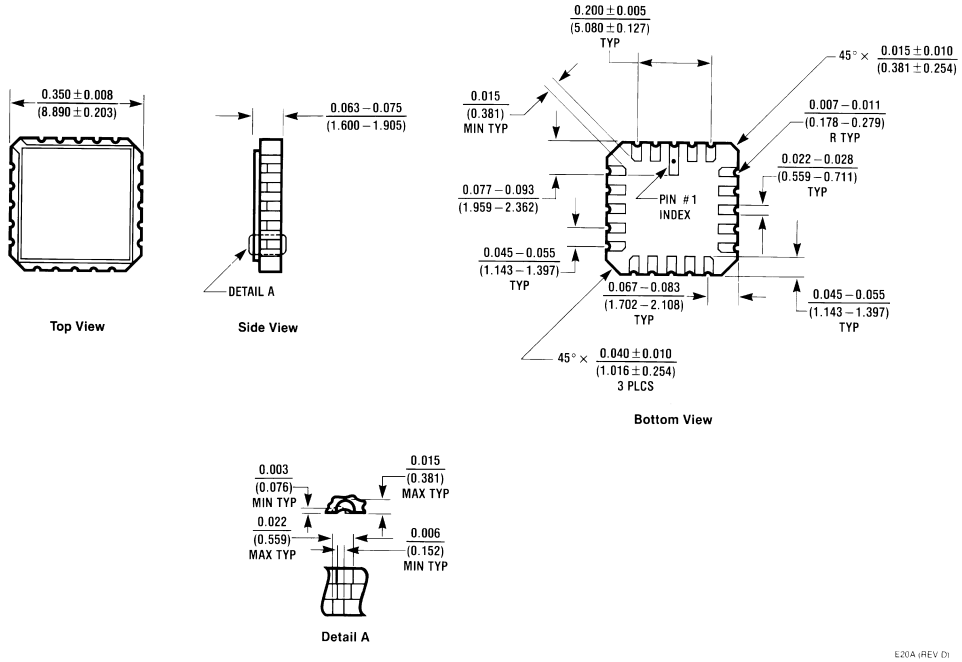


FIGURE 13. Output Voltage Adjust
(Note 6)

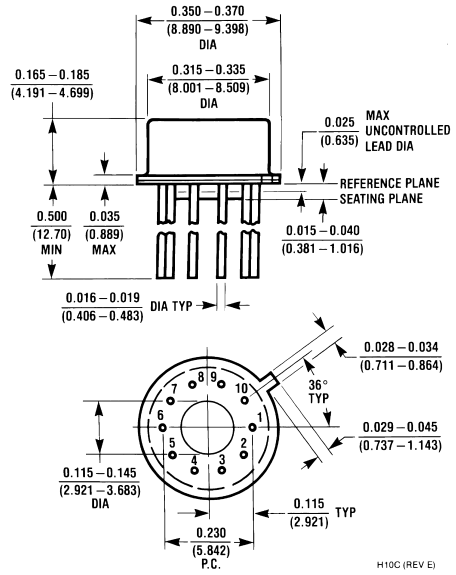
Schematic Diagram



Physical Dimensions inches (millimeters) unless otherwise noted

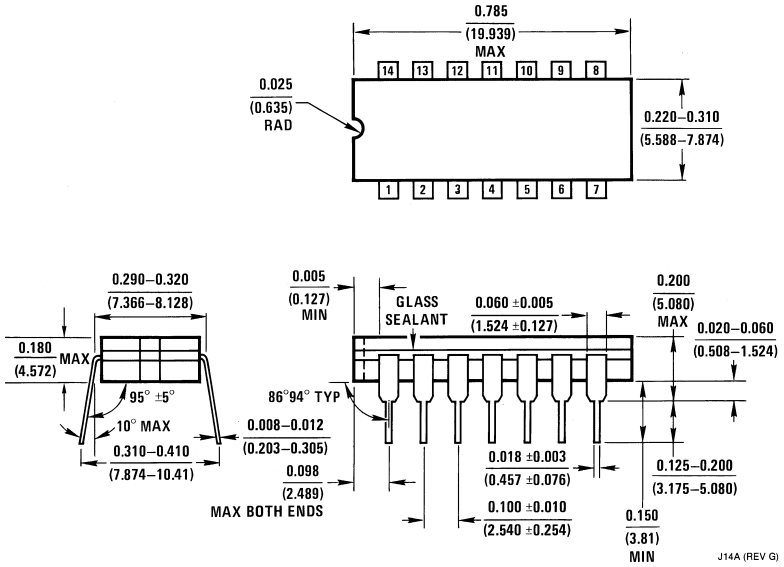


Leadless Chip Carrier Package (E)
Order Number LM723E/883
NS Package E20A



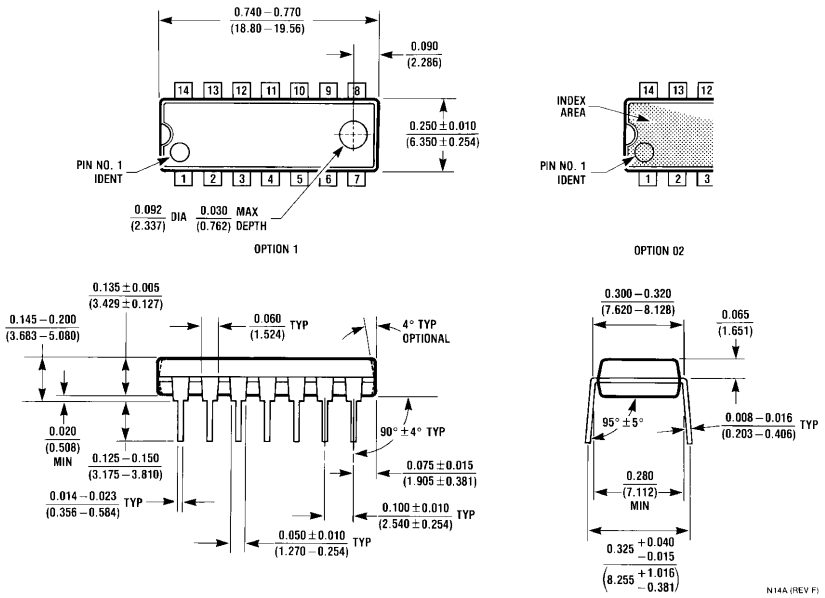
Metal Can Package (H)
Order Number LM723H, LM723H/883 or LM723CH
NS Package H10C

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



Ceramic Dual-In-Line Package (J)
Order Number LM723J/883
NS Package J14A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



Molded Dual-In-Line Package (N)
Order Number LM723CN
NS Package N14A

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Product Folder

LM723 Voltage Regulator

See Also: LM117 - supports higher output currents

Contents

Parametric Table	
Multiple Output Capability	No
On/Off Pin	No
Input Voltage, min (Volt)	9.50
Input Voltage, max (Volt)	40
Output Current, max	150 mA
Output Voltage, min (Volt)	2
Output Voltage, max (Volt)	37

General 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 guaranteed over a 0°C to +70°C temperature range, instead of -55°C to +125°C.

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

Datasheet

Title	Size (in Kbytes)	Date	View Online	Download	Receive via Email
LM723/LM723C Voltage Regulator	470 Kbytes	23-Jun-99	View Online	Download	Receive via Email
LM723 Mil-Aero (JAN) Datasheet MJLM723-X	14 Kbytes		View Online	Download	Receive via Email
LM723 Mil-Aero Datasheet MNLM723-X	280 Kbytes		View Online	Download	Receive via Email

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Package Availability, Models, Samples & Pricing

Part Number	Package		Status	Models		Samples & Electronic Orders	Budgetary Pricing		Std Pack Size	Package Marking
	Type	# pins		SPICE	IBIS		Quantity	$US each		
LM723CN	MDIP(MCM)	14	Full production	N/A	N/A	Buy Now	1K+	$0.3100	tube of 25	[logo]¢U¢Z¢3¢T¢P LM723CN
LM723H	TO-5	10	Full production	N/A	N/A	Buy Now	1K+	$2.0000	box of 500	[logo]¢Z¢2¢T LM723H
LM723E/883	LCC	20	Full production	N/A	N/A	Buy Now	50+	$14.1000	tube of 50	[logo]¢Z¢S¢4¢A LM723E/883 Q¢M $E
LM723H/883	TO-5	10	Full production	N/A	N/A	Buy Now	50+	$2.5000	tray of 20	[logo]¢Z¢S¢4¢A$E LM723H/883Q
LM723J/883	CERDIP	16	Full production	N/A	N/A	Buy Now	50+	$2.5600	tube of 25	[logo]¢Z¢S¢4¢A$E LM723J/883Q¢M
JM38510/10201BI	TO-5	10	Full production	N/A	N/A		50+	$7.4000	tray of 20	[logo] ¢Z¢S¢4¢A 27014 QS JM38510/10201BIA $E
JM38510/10201SI	TO-5	10	Full production	N/A	N/A		50+	$195.0000	tray of 20	[logo] ¢Z¢S¢4¢A$E 27014 Q JM38510/10201SIA
JM38510/10201SC	CERDIP	16	Full production	N/A	N/A		50+	$189.0000	tube of 25	[logo] ¢Z¢S¢4¢A$E JM38510/10201SCA 27014 Q
LM723 MD8	Die		Full production	N/A	N/A				tray of N/A	-
LM723 MW8	Wafer		Full production	N/A	N/A				N/A	-

Application Notes

Title	Size (in Kbytes)	Date	View Online	Download	Receive via Email
AN-173: IC Zener Eases Reference Design	77 Kbytes	4-Nov-95	View Online	Download	Receive via Email

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[Information as of 10-Sep-2001]

Product Folder

LM723C Voltage Regulator

Contents

Parametric Table	
Multiple Output Capability	No
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Datasheet

Title	Size (in Kbytes)	Date	View Online	Download	Receive via Email
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Package Availability, Models, Samples & Pricing

Part Number	Package		Status	Models		Samples & Electronic Orders	Budgetary Pricing		Std Pack Size	Package Marking
	Type	# pins		SPICE	IBIS		Quantity	$US each		
LM723CH	TO-5	10	Full production	N/A	N/A	Buy Now	1K+	$0.8800	box of 500	[logo]¢Z¢2¢T LM723CH
LM723 MDA	Die		Full production	N/A	N/A				tray of N/A	-
LM723 MWA	Wafer		Full production	N/A	N/A				N/A	-

[Information as of 2-Oct-2001]