National Semiconductor

February 2005

LM723QML
Voltage Regulator

General Description

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

Features

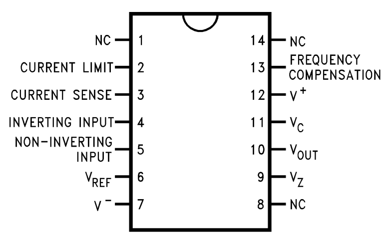
- 150 mA output current without external pass transistor
- Output currents in excess of 10A possible by adding external transistors
- Input voltage 40V max
- Output voltage adjustable from 2V to 37V
- Can be used as either a linear or a switching regulator

Ordering Information

NS PART NUMBER	SMD PART NUMBER	NS PACKAGE NUMBER	PACKAGE DISCRIPTION
LM723E/883		E20A	20LD LEADLESS CHIP CARRIER
LM723H/883		H10C	10LD T0–100, METAL CAN
LM723J/883		J14A	14LD CERDIP

Connection Diagrams

Dual-In-Line Package



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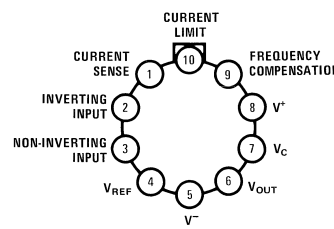
Top View
See NS Package J14A

Metal Can Package



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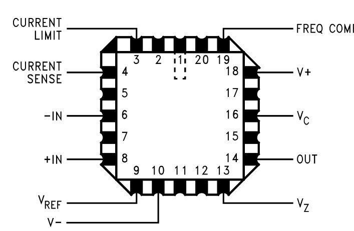
Note: Pin 5 connected to case.

Top View
See NS Package H10C



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Top View
See NS Package E20A

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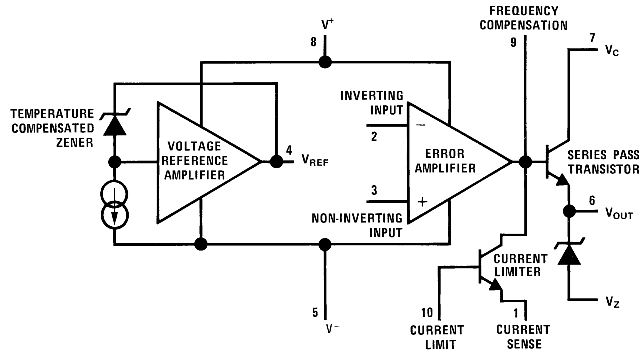
Equivalent Circuit*



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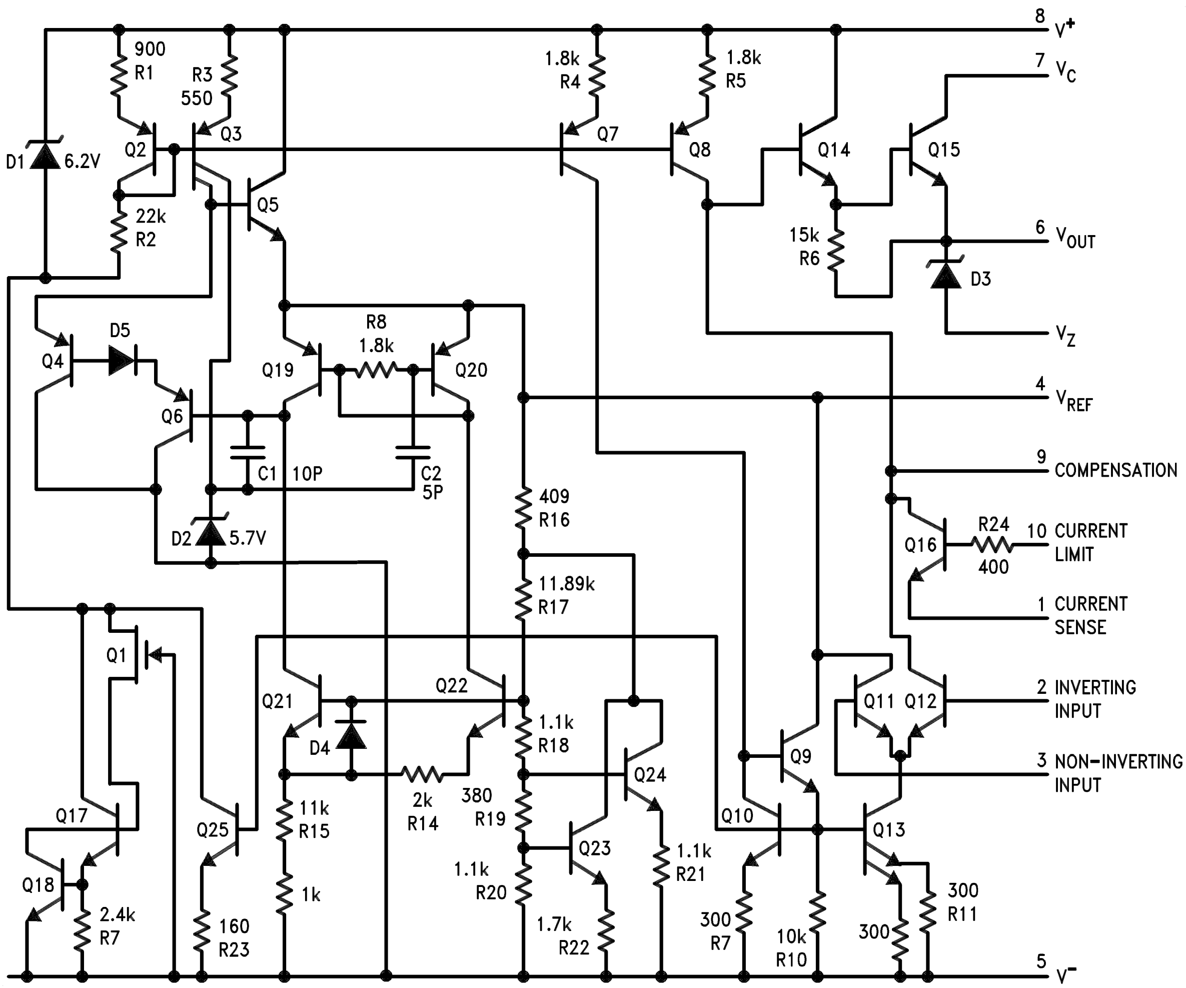
*Pin numbers refer to metal can package.

Schematic Diagram



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Absolute Maximum Ratings (Note 1)

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
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
LCC (Note 2)	900 mW
Operating Temperature Range	$-55^\circ C \le T_A \le +125^\circ C$
Maximum T_J	+150˚C
Storage Temperature Range	$-65^\circ C \le T_A \le +150^\circ C$
Lead Temperature (Soldering, 4 sec. max.)	300˚C
Thermal Resistance	
θ_{JA}	
Cerdip (Still Air)	100˚C/W
Cerdip (500LF/ Min Air flow)	61˚C/W
Metal Can (Still Air)	156˚C/W
Metal Can (500LF/ Min Air flow)	89˚C/W
LCC (Still Air)	96˚C/W
LCC (500LF/ Min Air flow)	70˚C/W
θ_{JC}	
CERDIP	22˚C/W
Metal Can	37˚C/W
LCC	27˚C/W
ESD Tolerance (Note 3)	500V

Quality Conformance Inspection

MIL-STD-883, Method 5005 — Group A

Subgroup	Description	Temp (˚C)
1	Static tests at	+25
2	Static tests at	+125
3	Static tests at	-55
4	Dynamic tests at	+25
5	Dynamic tests at	+125
6	Dynamic tests at	-55
7	Functional tests at	+25
8A	Functional tests at	+125
8B	Functional tests at	-55
9	Switching tests at	+25
10	Switching tests at	+125
11	Switching tests at	-55

Electrical Characteristics

DC Parameters (Note 9)

Symbol	Parameter	Conditions	Notes	Min	Max	Units	Sub-groups
V_{rline}	Line Regulation	$12V \le V_{IN} \le 15V$, $V_{OUT} = 5V$, $I_L = 1mA$		–0.1	0.1	$\%V_{OUT}$	1
				–0.2	0.2	$\%V_{OUT}$	2
				–0.3	0.3	$\%V_{OUT}$	3
		$12V \le V_{IN} \le 40V$, $V_{OUT} = 2V$, $I_L = 1mA$		–0.2	0.2	$\%V_{OUT}$	1
		$9.5V \le V_{IN} \le 40V$, $V_{OUT} = 5V$, $I_L = 1mA$		–0.3	0.3	$\%V_{OUT}$	1
V_{rload}	Load Regulation	$1mA \le I_L \le 50mA$, $V_{IN} = 12V$, $V_{OUT} = 5V$		–0.15	0.15	$\%V_{OUT}$	1
				–0.4	0.4	$\%V_{OUT}$	2
				–0.6	0.6	$\%V_{OUT}$	3
		$1mA \le I_L \le 10mA$, $V_{IN} = 40V$, $V_{OUT} = 37V$		–0.5	0.5	$\%V_{OUT}$	1
		$6mA \le I_L \le 12mA$, $V_{IN} = 10V$, $V_{OUT} = 7.5V$		–0.2	0.2	$\%V_{OUT}$	1
V_{REF}	Voltage Reference	$I_{REF} = 1mA$, $V_{IN} = 12V$		6.95	7.35	V	1
				6.9	7.4	V	2, 3
I_{SCD}	Standby Current	$V_{IN} = 30V$, $I_L = I_{REF} = 0$, $V_{OUT} = V_{REF}$		0.5	3	mA	1
				0.5	2.4	mA	2
				0.5	3.5	mA	3
I_{OS}	Short Circuit Current	$V_{OUT} = 5V$, $V_{IN} = 12V$, $R_{SC} = 10\Omega$, $R_L = 0$		45	85	mA	1
V_Z	Zener Voltage	$V_{IN} = 40V$, $V_{OUT} = 7.15V$, $I_Z = 1mA$	(Note 8) (Note 10)	5.58	6.82	V	1
V_{OUT}	Output Voltage	$V_{IN} = 12V$, $V_{OUT} = 5V$, $I_L = 1mA$		4.5	5.5	V	1, 2, 3

Electrical Characteristics

AC Parameters (Note 9)

Symbol	Parameter	Conditions	Not es	Min	Max	Units	Sub-groups
Delta V_{OUT} Delta V_{IN}	Ripple Rejection	$f = 120H_Z$, $C_{REF} = 0$, $V_{INS} = 2V_{RMS}$		55		dB	4
		$f = 120H_Z$, $C_{REF} = 5\mu F$, $V_{INS} = 2V_{RMS}$		67		dB	4

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. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Note 2: The maximum power dissipation for these devices must be derated at elevated temperatures and is dictated by T_{JMAX}, θ_{JA}, and the ambient temperature, T_A. The maximum available power dissipation at any temperature is $P_d = (T_{JMAX} - T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is less. See derating curves for maximum power rating above 25˚C.

Note 3: Human body model, 1.5 kΩ in series with 100 pF.

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.

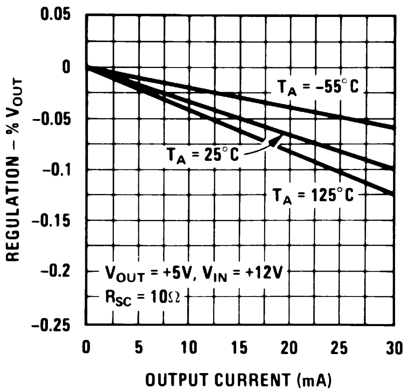
Note 8: For metal can applications where V_Z is required, an external 6.2V zener diode should be connected in series with V_{OUT}.

Note 9: 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 10: Tested for DIPS only.

Typical Performance Characteristics

Load Regulation Characteristics with Current Limiting



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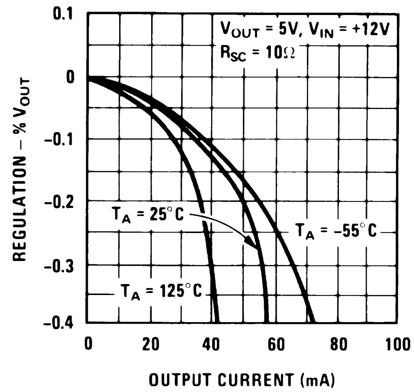
Load Regulation Characteristics with Current Limiting



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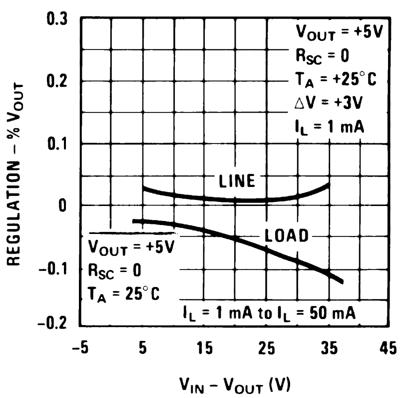
Load & Line Regulation vs Input-Output Voltage Differential



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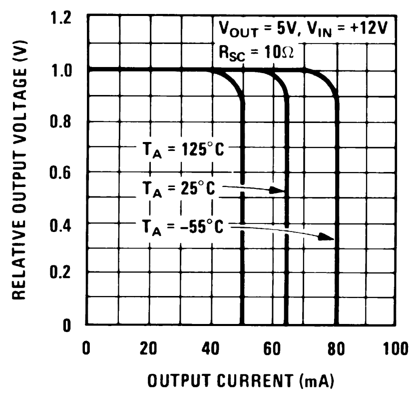
Current Limiting Characteristics



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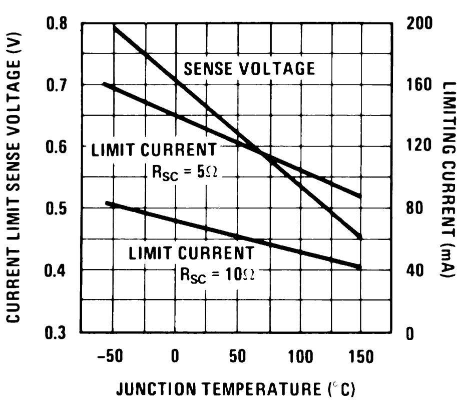
Current Limiting Characteristics vs Junction Temperature



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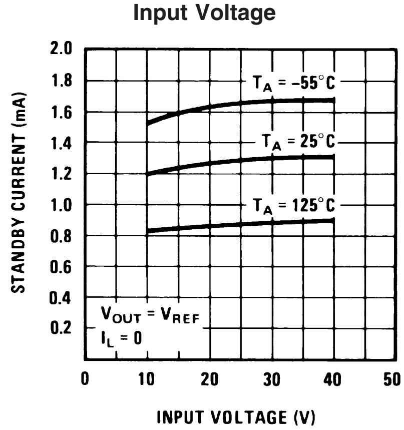
Standby Current Drain vs Input Voltage



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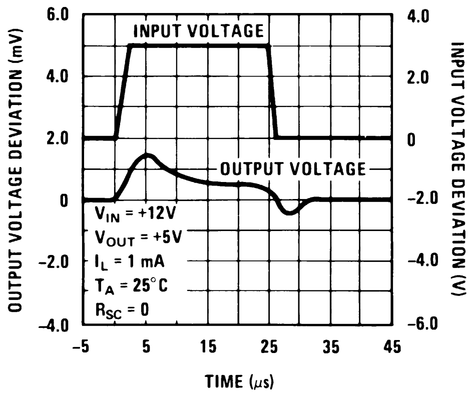
Typical Performance Characteristics (Continued)

Line Transient Response



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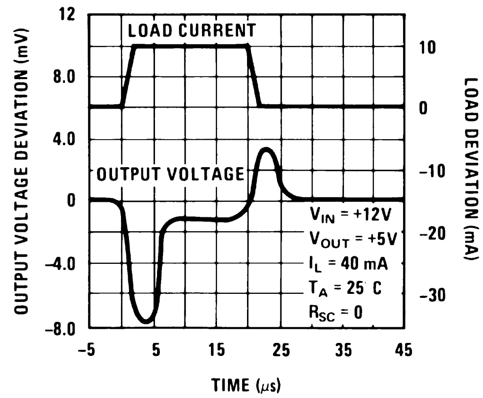
Load Transient Response



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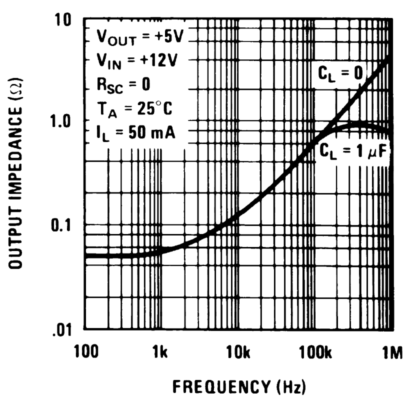
Output Impedence vs Frequency



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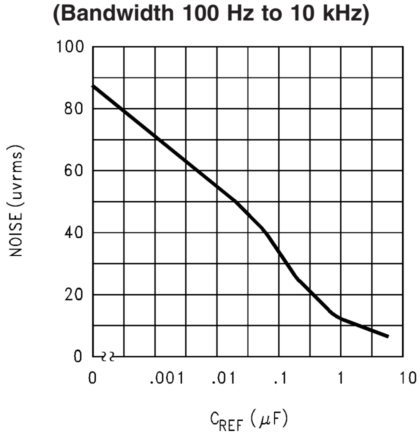
Maximum Power Ratings

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



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Power Dissipation vs Ambient Temperature

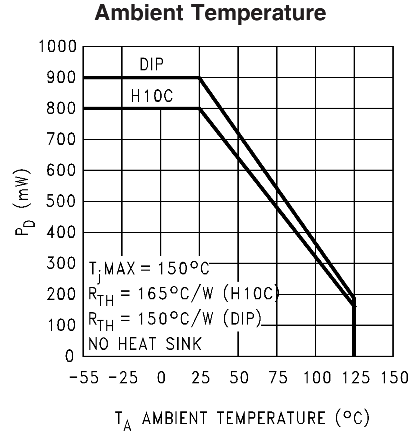

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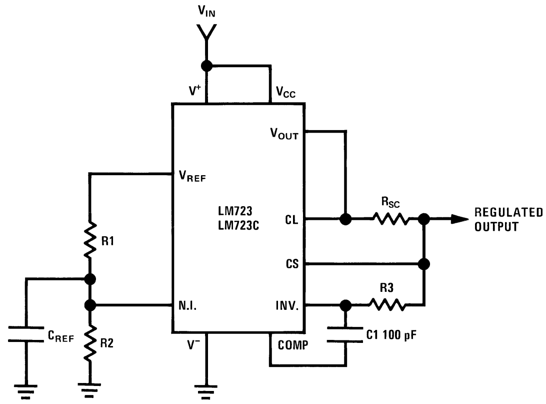
TABLE 1. Resistor Values (kΩ) for Standard Output Voltage

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

Typical Applications



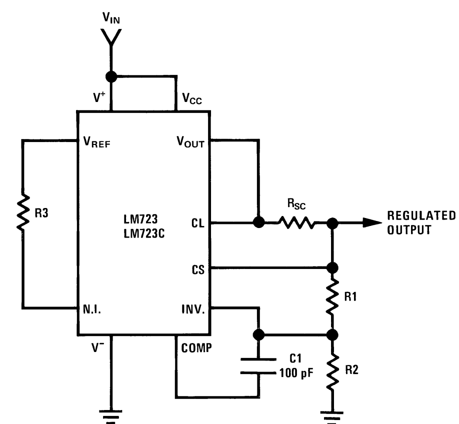
Note: $R3 = \frac{R1\,R2}{R1 + R2}$

for minimum temperature drift.

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)



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

for minimum temperature drift.

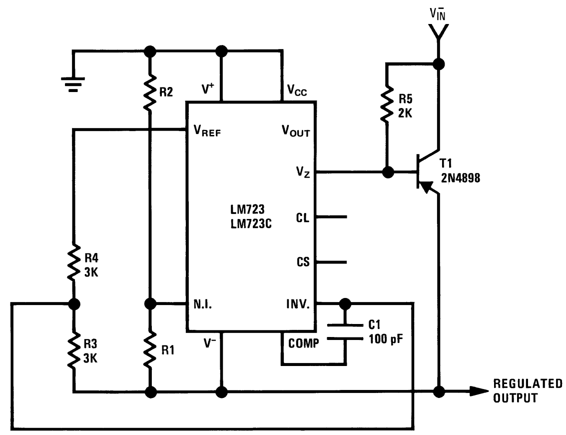
R3 may be eliminated for minimum component count.

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 Applications (Continued)



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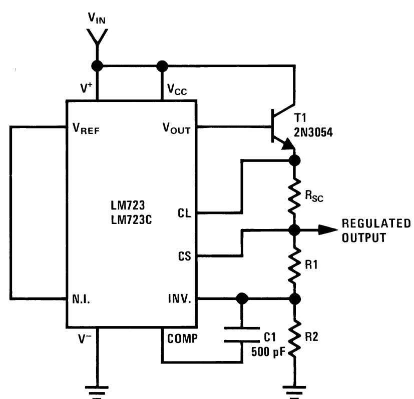
Typical Performance

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

FIGURE 3. Negative Voltage Regulator



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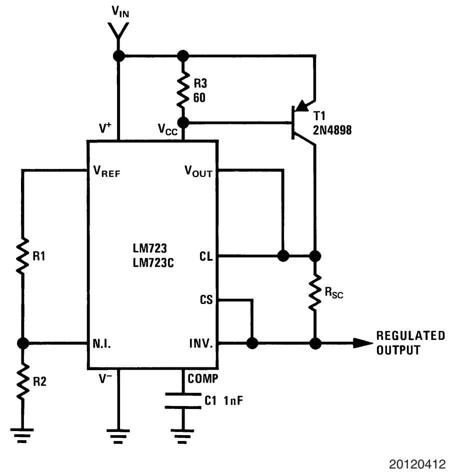
Typical Performance

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)

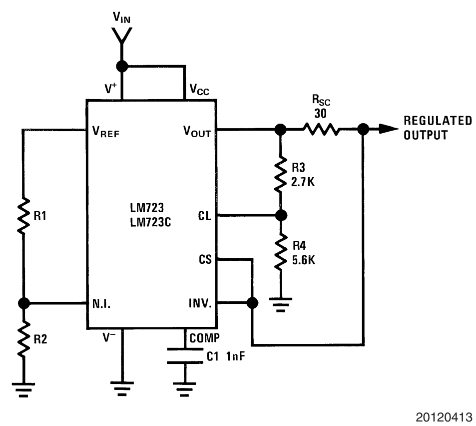
Typical Applications (Continued)



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)

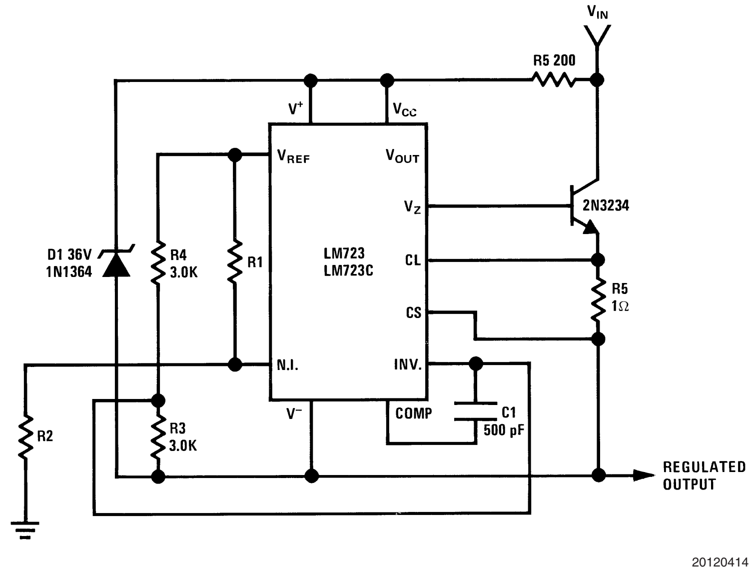


Typical Performance

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

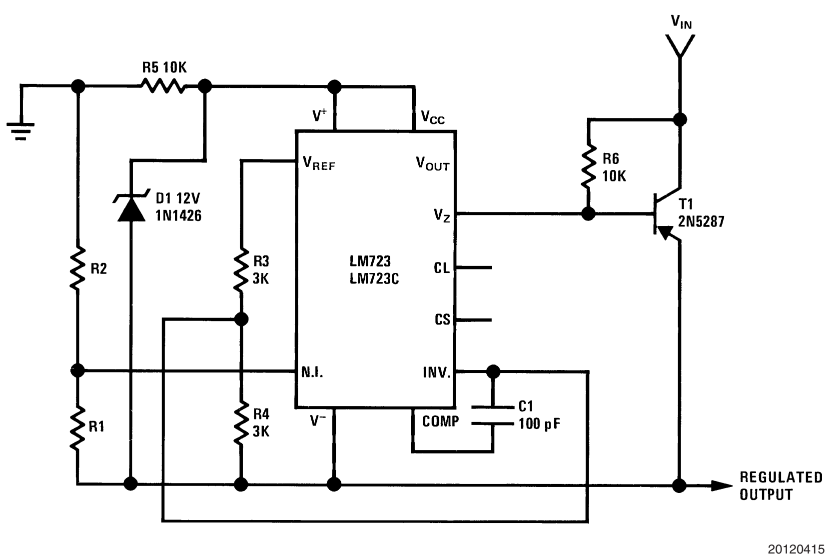
Typical Applications (Continued)



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

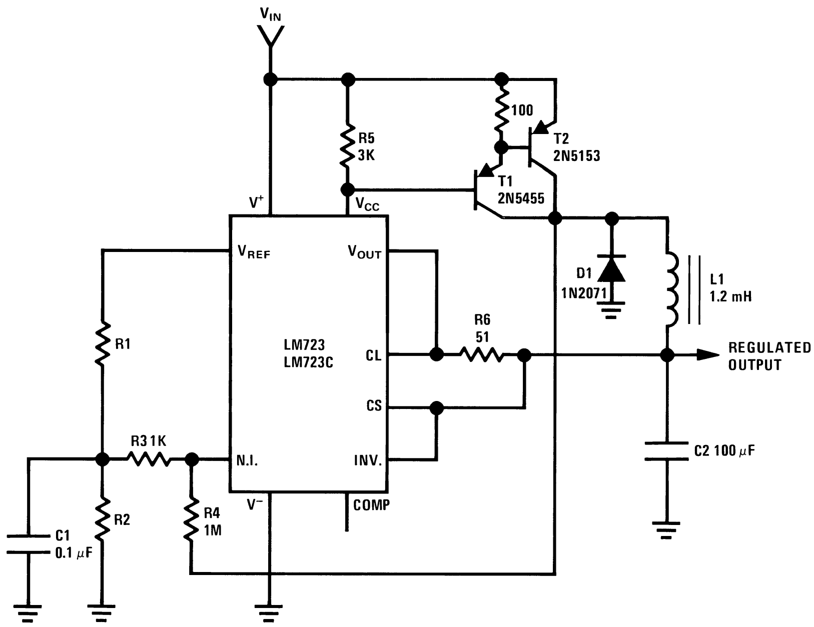


Typical Performance

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)

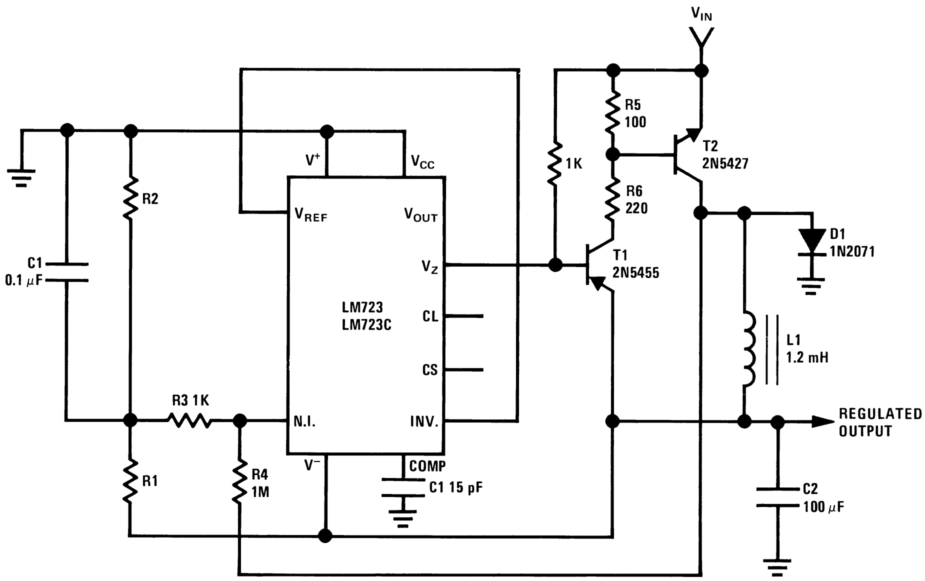


Typical Performance

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

FIGURE 9. Positive Switching Regulator(Note 4)

Typical Applications (Continued)



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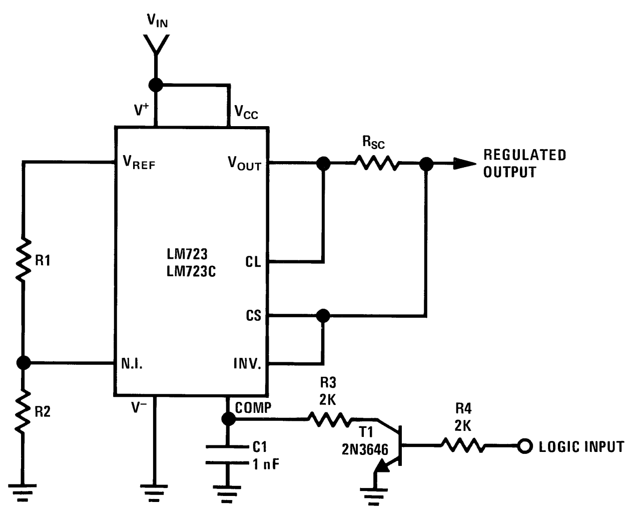
Typical Performance

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

FIGURE 10. Negative Switching Regulator(Note 4)



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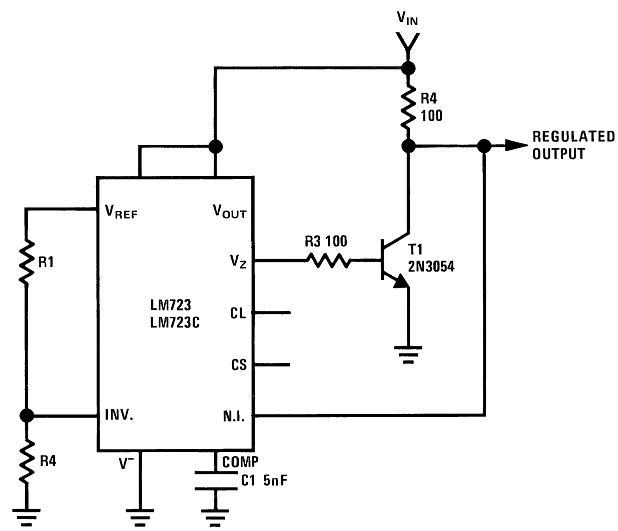
Note: Current limit transistor may be used for shutdown if current limiting is not required.

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

Typical Applications (Continued)



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

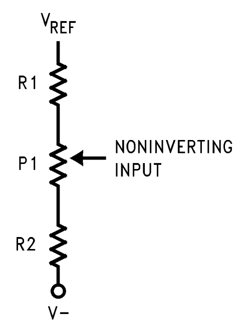
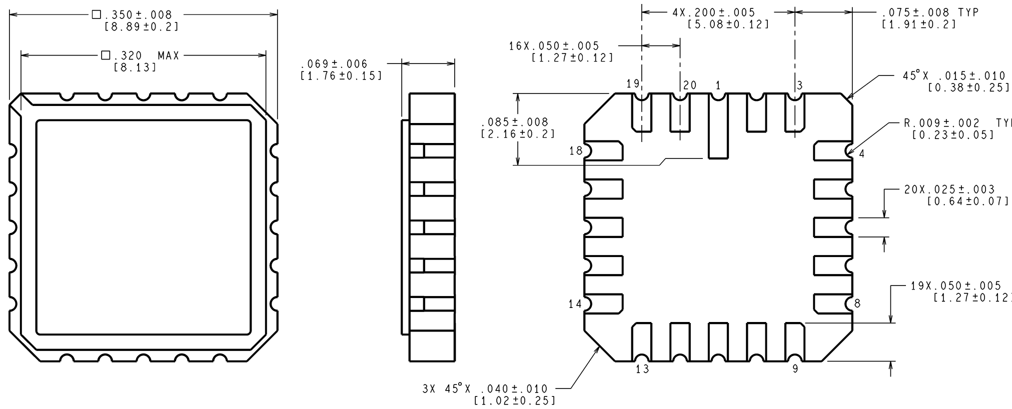


FIGURE 13. Output Voltage Adjust
(Note 6)

Revision History Section

Date Released	Revision	Section	Originator	Changes
02/15/05	A	New Release, Corporate format	L. Lytle	1 MDS data sheet converted into one Corp. data sheet format. MNLM723-X, Rev. 1A0. MDS data sheet will be archived. AC and Drift parameters removed from specifcation because they only applied to the JAN B/S devices, covered in a separate datasheet.

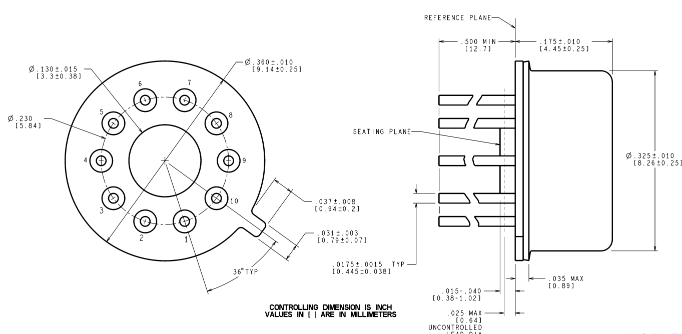
Physical Dimensions inches (millimeters) unless otherwise noted



CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS

E20A (Rev F)

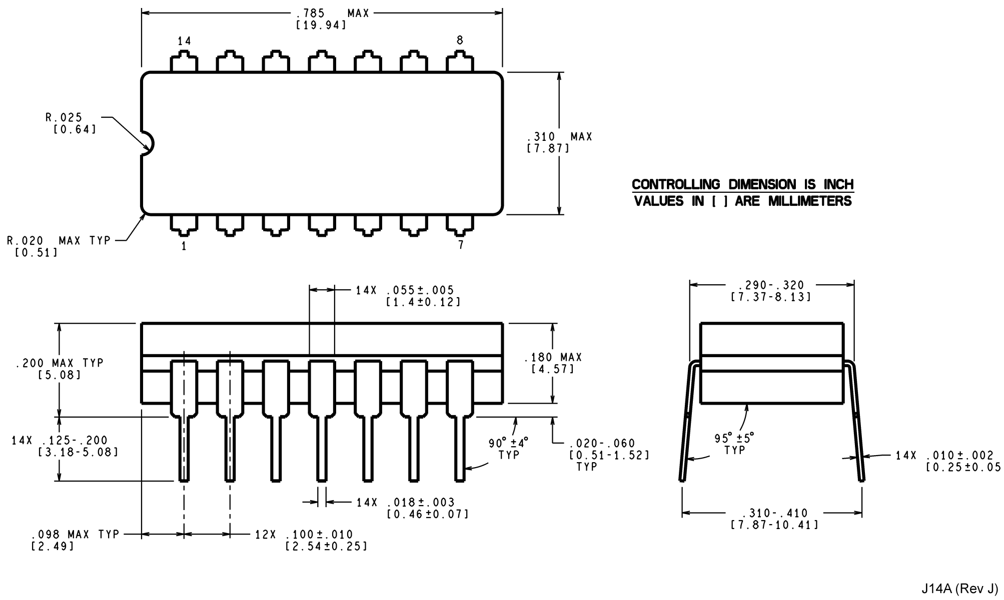
Leadless Chip Carrier Package (E)
NS Package E20A



H10C (Rev F)

Metal Can Package (H)
NS Package H10C

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



Ceramic Dual-In-Line Package (J)
NS Package J14A

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