National Semiconductor

February 2005

LM723JAN
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

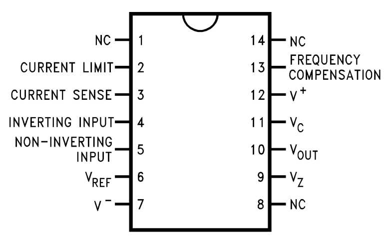
- 150 mA output current without external pass transistor
- Output currents in excess of 10A possible by adding external transistors
- Input voltage 40V max
- Output voltage adjustable from 2V to 37V
- Can be used as either a linear or a switching regulator

Ordering Information

NS PART NUMBER	SMD PART NUMBER	NS PACKAGE NUMBER	PACKAGE DISCRIPTION
JL723BIA	JM38510/10201BIA	H10C	10LD Metal Can
JL723SCA	JM38510/10201SCA	J14A	14LD CERDIP
JL723SIA	JM38510/10201SIA	H10C	10LD Metal Can

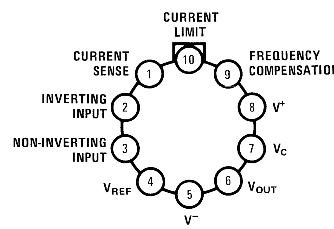
Connection Diagrams

Dual-In-Line Package



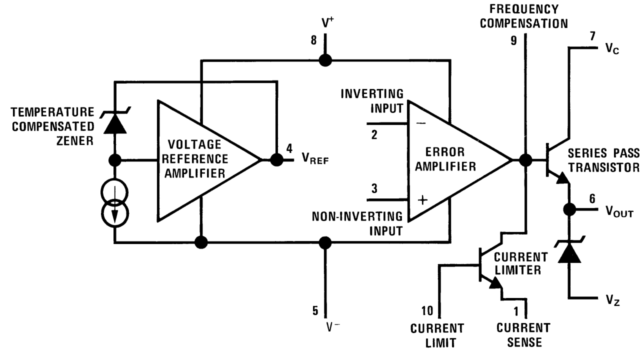
Top View
See NS Package J14A

Metal Can Package



Note: Pin 5 connected to case.
Top View
See NS Package H10C

Equivalent Circuit*



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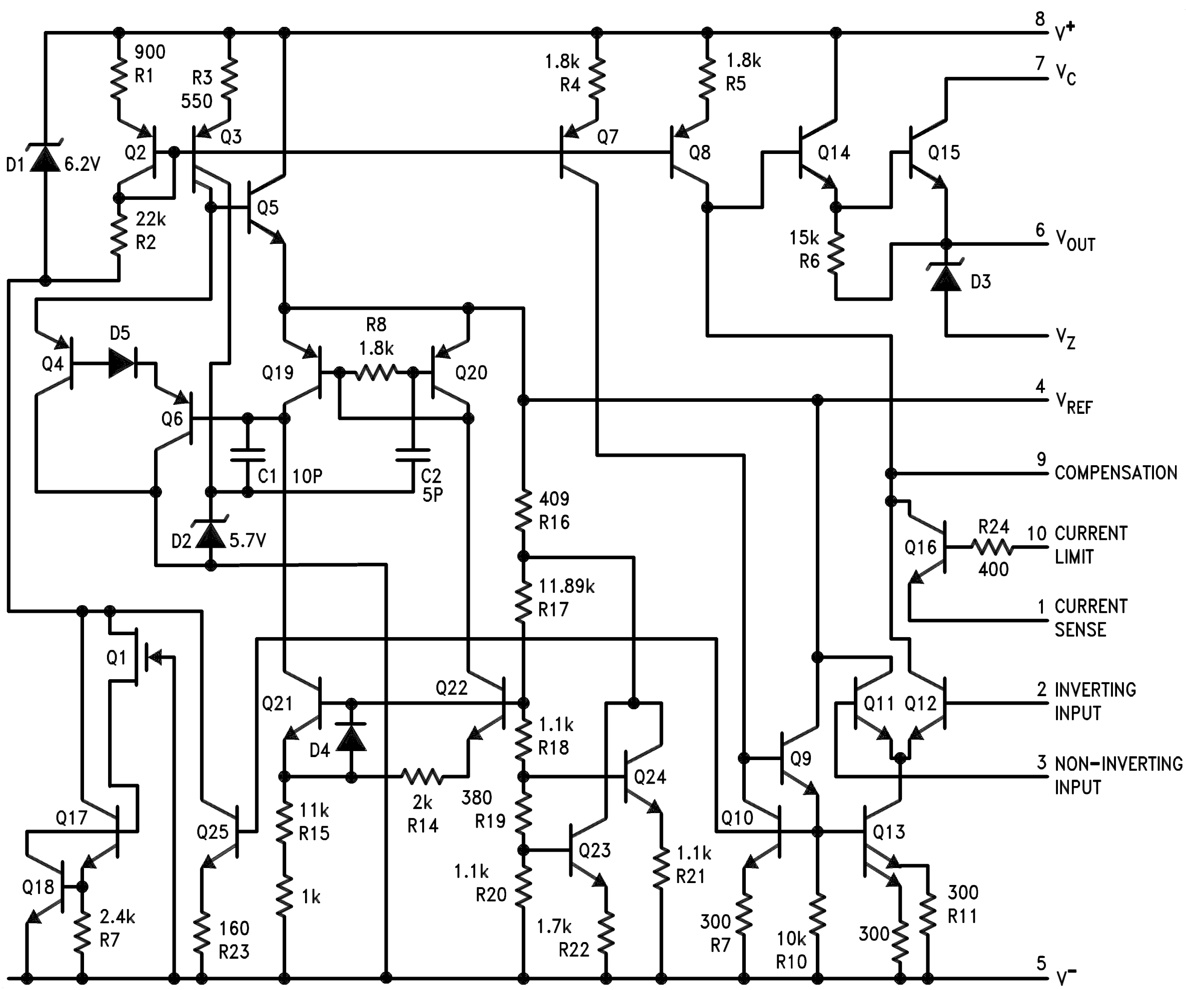
*Pin numbers refer to metal can package.

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
Differential Input Voltage	±5V
Voltage between non-inverting input and V^-	+8V
Current from V_Z	25 mA
Current from V_{REF}	15 mA
Internal Power Dissipation (T_A = 125˚C)	
Metal Can (Note 2)	300 mW
Cavity DIP (Note 2)	400 mW
Maximum T_J	+175˚C
Storage Temperature Range	−65˚C ≤ T_A ≤ +150˚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
θ_{JC}	
CERDIP	22˚C/W
Metal Can	37˚C/W
ESD Tolerance (Note 3)	1200V

Recommended Operating Conditions

Input Voltage Range	9.5V to 40V $_{DC}$
Output Voltage Range	2V to 37V $_{DC}$
Input-Output Voltage Differential	2.5 V to 38V $_{DC}$
Ambient Operating Temperature Range	−55˚C ≤ T_A ≤ +125˚C

Quality Conformance Inspection

MIL-STD-883, Method 5004 and Method 5005

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
		$12V \le V_{IN} \le 15V$, $V_{OUT} = 5V$, $I_L = 1mA$		–10.0	+10.0	mV	1
				–20.0	+20.0	mV	2
				–30.0	+30.0	mV	3
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
		$1mA \le I_L \le 50mA$, $V_{IN} = 12V$, $V_{OUT} = 5V$		–15.0	+15.0	mV	1
				–40.0	+40.0	mV	2
				–60.0	+60.0	mV	3
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	$I_Z = 1mA$	(Notes 8, 10)	5.58	6.82	V	1
V_{OUT}	Output Voltage	$V_{IN} = 12V$, $V_{OUT} = 5V$, $I_L = 1mA$	(Note 11)	4.5	5.5	V	1, 2, 3
Delta V_{OUT} / Delta T	Average Temperature Coefficient of Output Voltage	$25°C \le T_A \le +125°C$, $V_{IN} = 12V$, $V_{OUT} = 5V$, $I_L = 1mA$	(Note 12)	–0.01	0.01	%/°C	8A
		$-55°C \le T_A \le +25°C$, $V_{IN} = 12V$, $V_{OUT} = 5V$, $I_L = 1mA$	(Note 12)	–0.015	0.015	%/°C	8B
Delta V_{OUT} / Delta V_{IN}	Ripple Rejection	f = 10KHz, $C_{REF} = 0F$, $V_{INS} = 2V_{RMS}$		64		dB	4
		f = 10KHz, $C_{REF} = 5\mu F$, $V_{INS} = 2V_{RMS}$		76		dB	4
N_O	Output Noise Voltage	$100Hz \le f \le 10KHz$, $V_{INS} = 0V_{RMS}$, $C_{REF} = 0\mu F$			120	μV_{RMS}	4
		$100Hz \le f \le 10KHz$, $V_{INS} = 0V_{RMS}$, $C_{REF} = 5\mu F$			7	μV_{RMS}	4
Delta V_{OUT} / Delta V_{IN}	Line Transient Response	$V_{IN} = 12V$, $V_{OUT} = 5V$, $I_L = 1mA$, $C_{REF} = 5\mu F$, $R_{SC} = 0\Omega$, Delta $V_{IN} = 3V$ for 25µsec		0	10	mV/V	4

Electrical Characteristics (Continued)

DC Parameters (Note 9)

Symbol	Parameter	Conditions	Notes	Min	Max	Units	Sub-groups
Delta V_{OUT} / Delta I_L	Load Transient Response	V_{IN} = 12V, V_{OUT} = 5V, I_L = 40mA, C_{REF} = 5µF, R_{SC} = 0Ω, Delta I_L = 10mA for 25µsec		–1.5	0	mV/mA	4

DC Parameters: Drift Values

Delta calculations performed on JAN S and QMLV devices at Group B, Subgroup 5, only.

Symbol	Parameters	Conditions	Notes	Min	Max	Unit	Sub-groups
V_{Rline}	Line Regulation	12V ≤ V_{IN} ≤ 15V, V_{OUT} = 5V, I_L = 1mA, ±1mV, or ±15% (whichever is greater)		–1.0	1.0	mV	1
V_{Rload}	Load Regulation	1mA ≤ I_L ≤ 50mA, V_{IN} = 12V, V_{OUT} = 5V, ±1mV, or ±20% (whichever is greater)		–1.0	1.0	mV	1
V_{REF}	Reference Voltage	I_{REF} = 1mA, V_{IN} = 12V		–15	15	mV	1
I_{SCD}	Standby Current Drain	V_{IN} = 30V, I_L = I_{REF} =0, V_{OUT} = V_{REF}		–10	10	%	1

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.

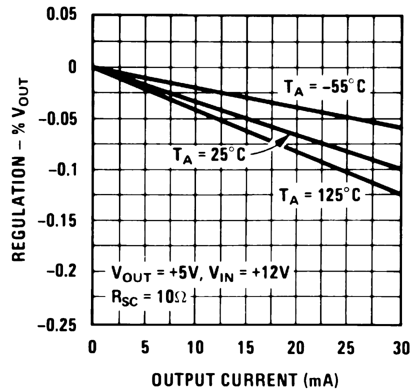
Note 10: Tested for 14 – lead DIP only.

Note 11: Setup test for Temp. Coeff.

Note 12: Calculated parameter

Typical Performance Characteristics

Load Regulation Characteristics with Current Limiting



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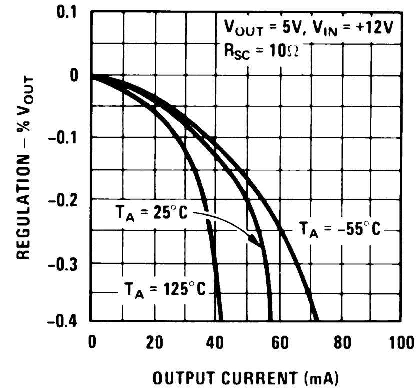
Load Regulation Characteristics with Current Limiting



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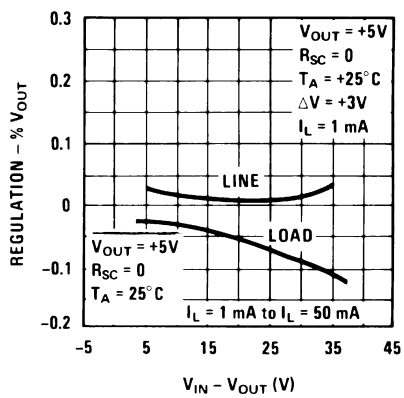
Load & Line Regulation vs Input-Output Voltage Differential



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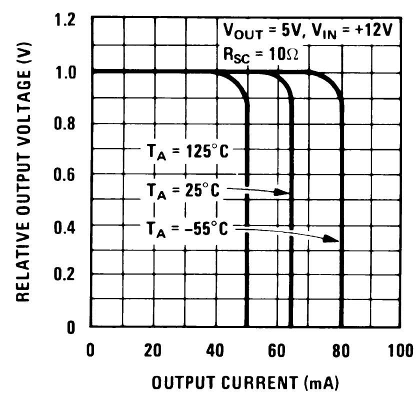
Current Limiting Characteristics



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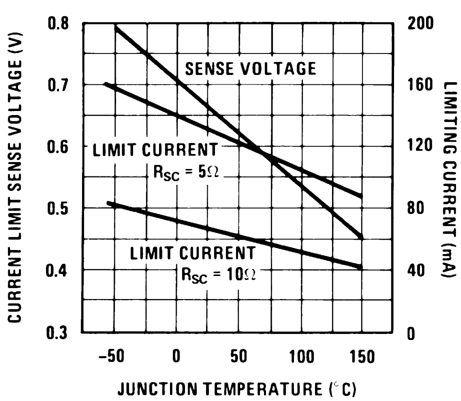
Current Limiting Characteristics vs Junction Temperature



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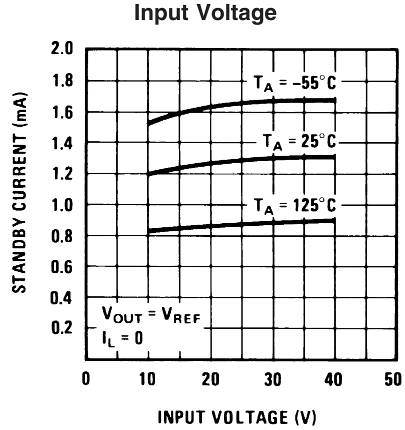
Standby Current Drain vs Input Voltage



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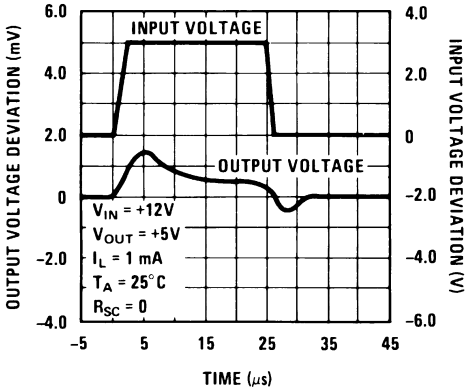
Typical Performance Characteristics (Continued)

Line Transient Response



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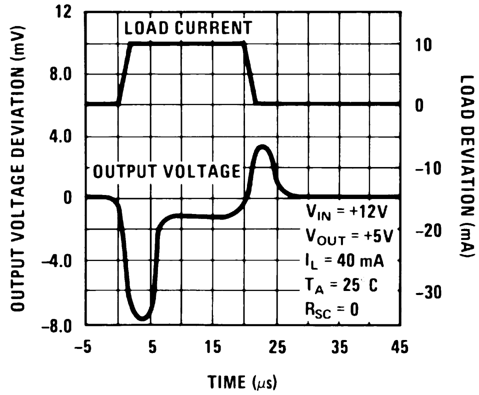
Load Transient Response



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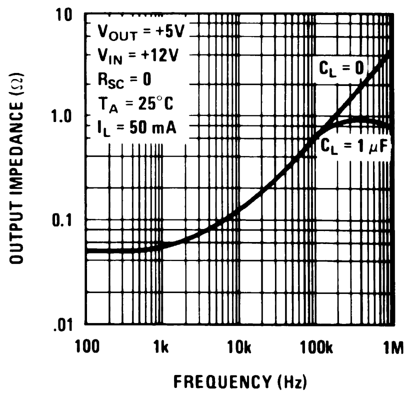
Output Impedence vs Frequency



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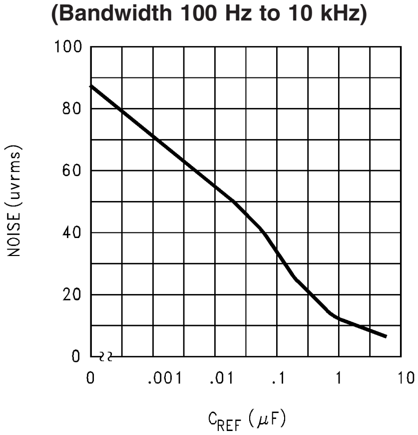
Maximum Power Ratings

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



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LM723 Power Dissipation vs Ambient Temperature

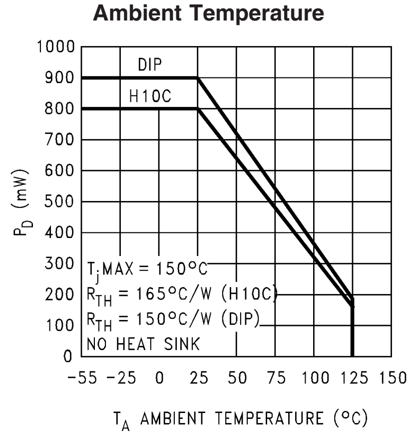

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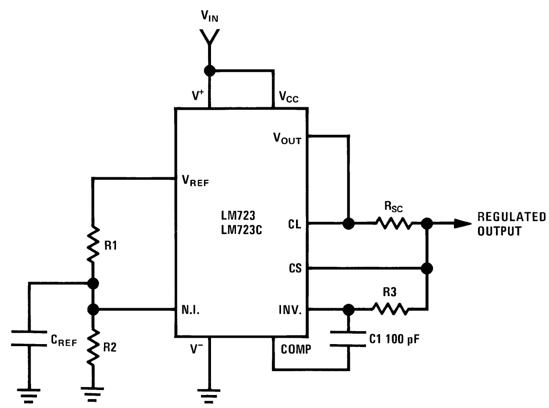
TABLE 1. Resistor Values (kΩ) for Standard Output Voltage

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 (*Figures 1, 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



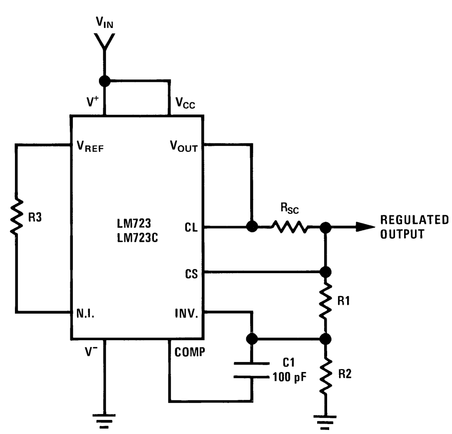
Note: $R3 = \frac{R1\,R2}{R1 + R2}$

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.

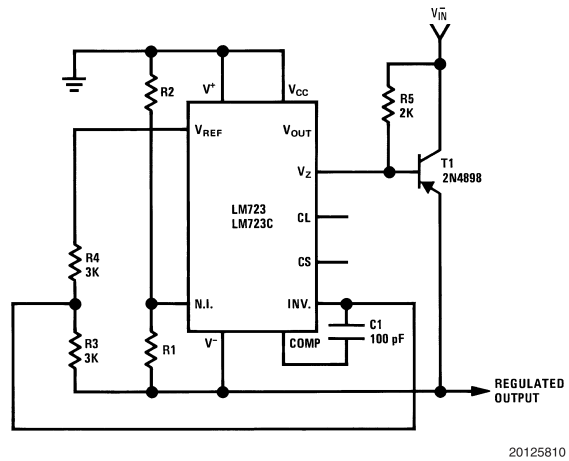
R3 may be eliminated for minimum component count.

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)

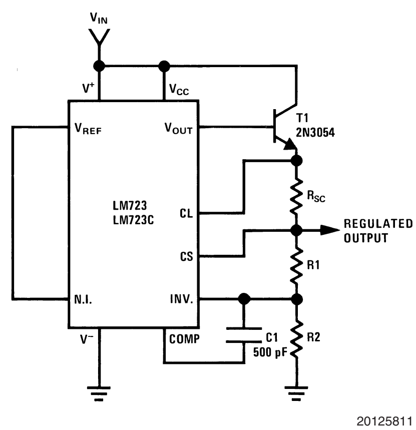
Typical Applications (Continued)



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

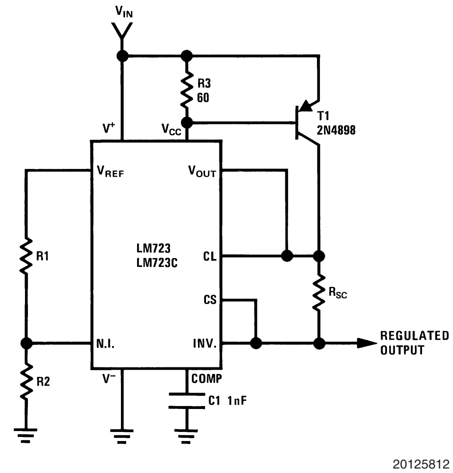


Typical Performance

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)

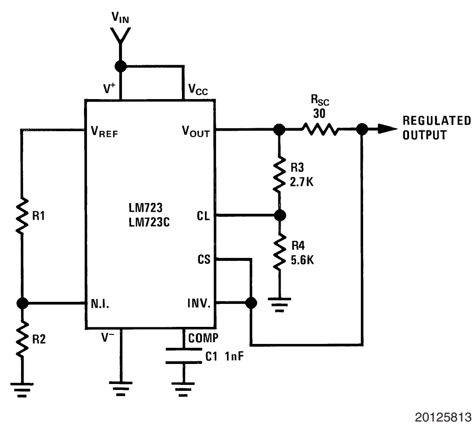
Typical Applications (Continued)



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)

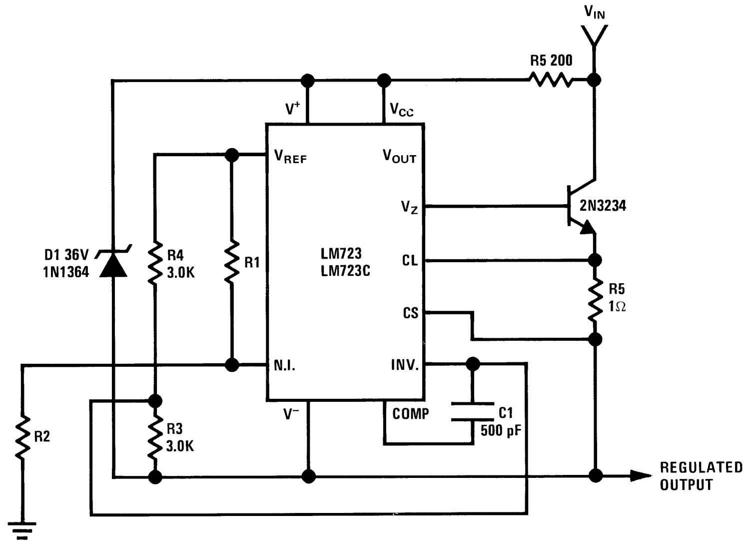


Typical Performance

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)



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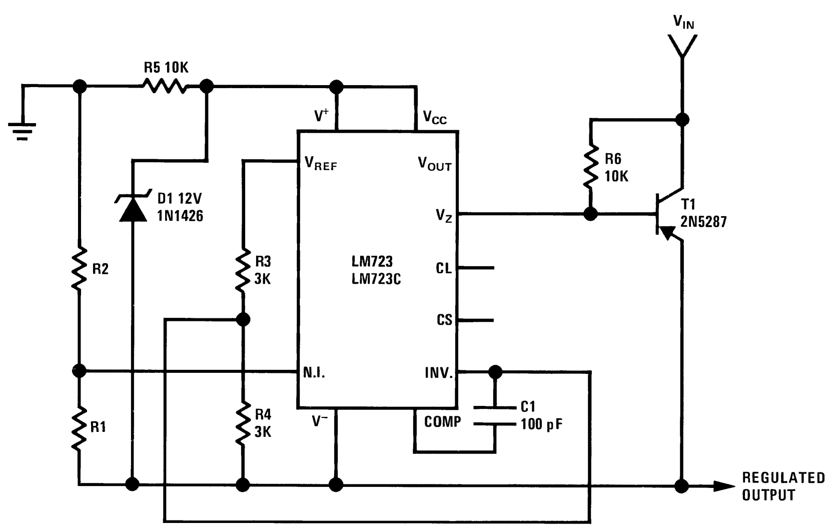
Typical Performance

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

FIGURE 7. Positive Floating Regulator



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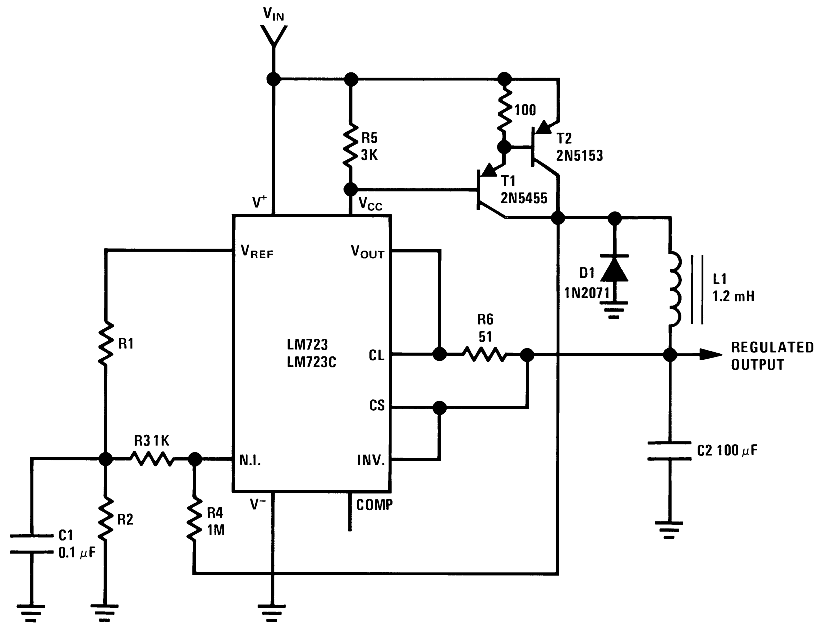
Typical Performance

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)

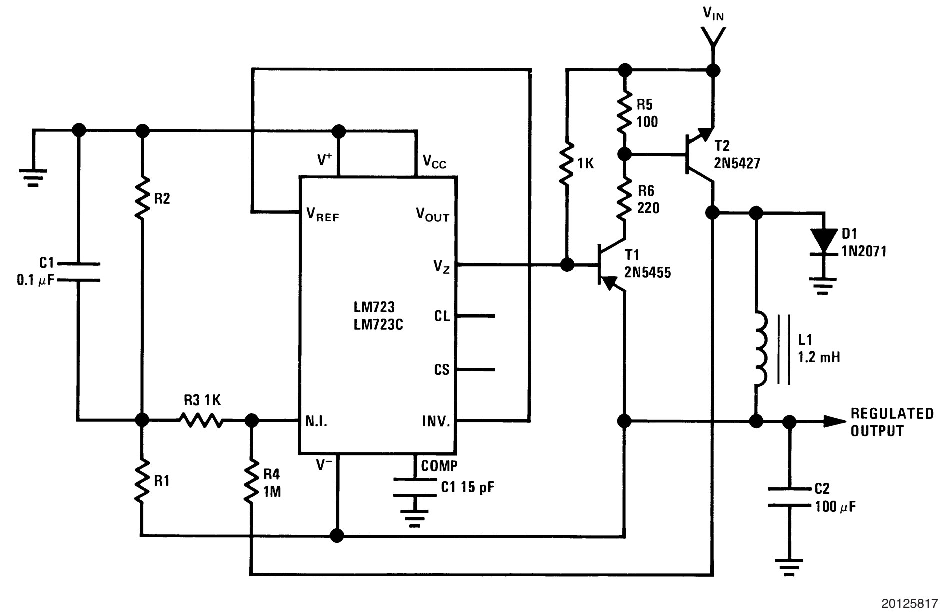


Typical Performance

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)

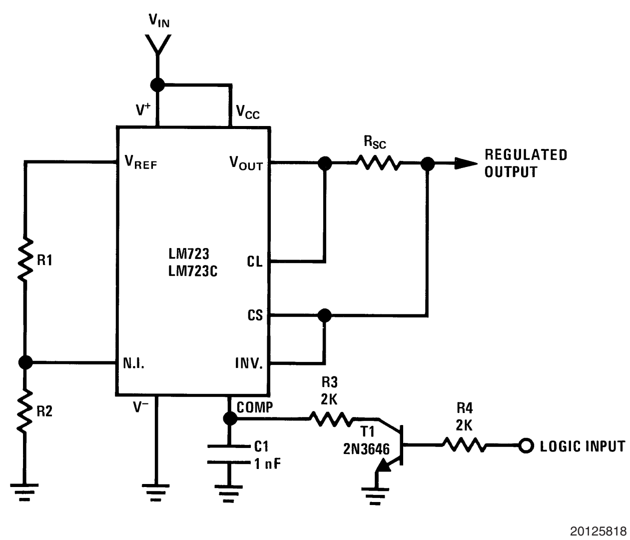
Typical Applications (Continued)



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)



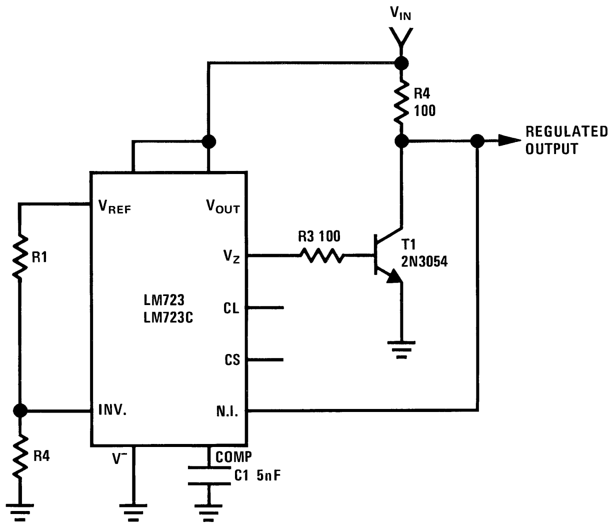
Note: Current limit transistor may be used for shutdown if current limiting is not required.

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

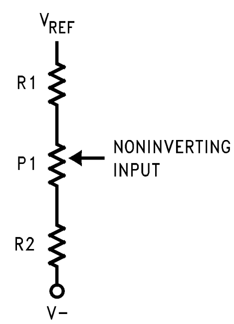
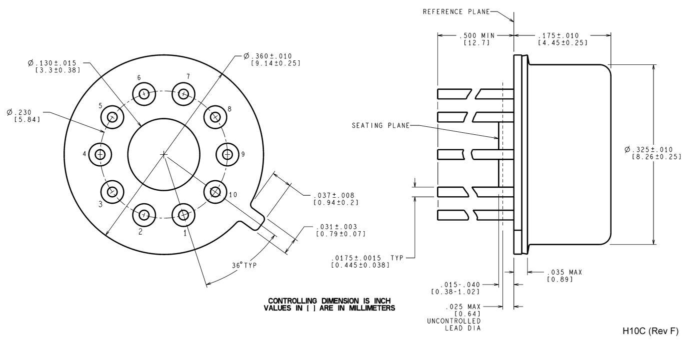


FIGURE 13. Output Voltage Adjust
(Note 6)

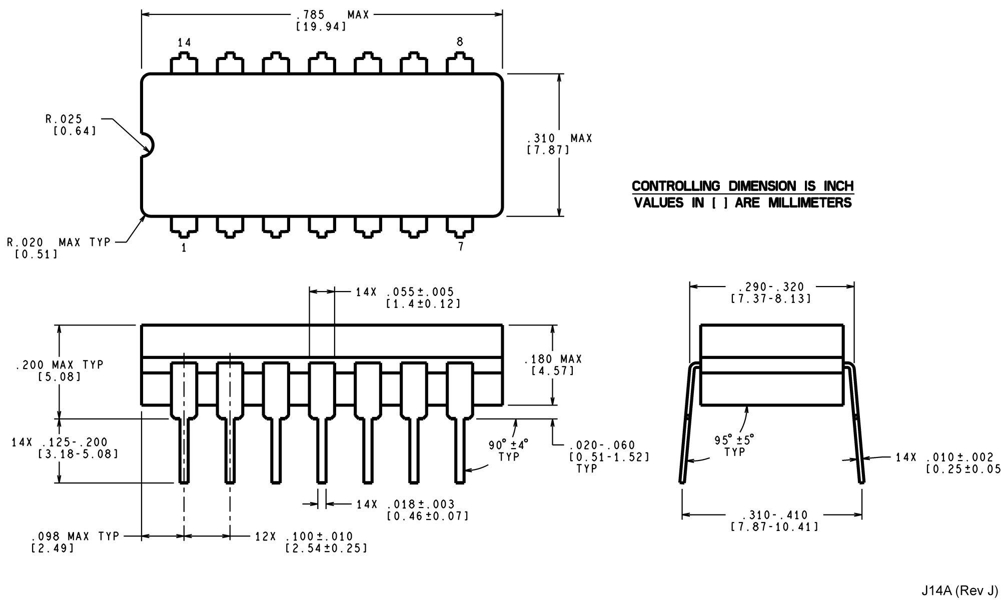
Revision History Section

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. MJLM723-X, Rev. 1A0. MDS data sheet will be archived.

Physical Dimensions inches (millimeters) unless otherwise noted



Metal Can Package (H)
NS Package H10C



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

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