

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

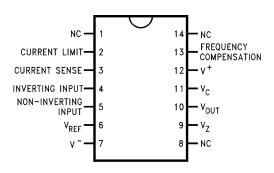


Figure 1. Top View CDIP Package or PDIP Package See Package J or NFF0014A

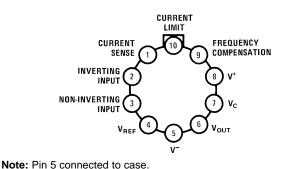
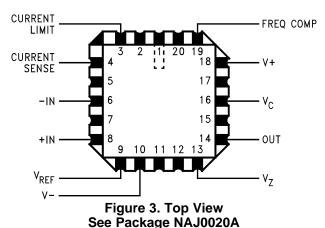


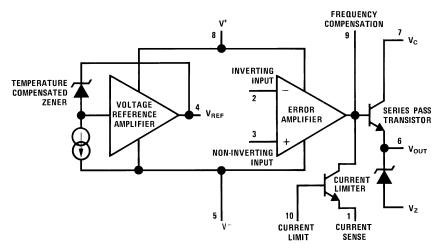
Figure 2. Top View TO-100 See Package LME



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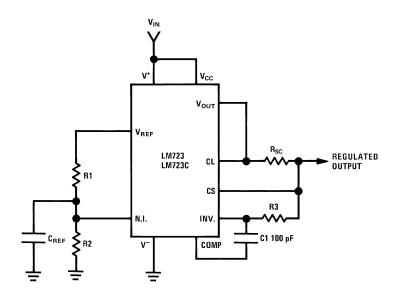


Equivalent Circuit*



^{*}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 ($\Delta V_{IN} = 3V$) 0.5mV Load Regulation ($\Delta I_{L} = 50$ mA) 1.5mV

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





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			Units		
		Min	Тур	Max	Min	Тур	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}
	$0^{\circ}\text{C} \le \text{T}_{\text{A}} \le +70^{\circ}\text{C}$						0.3	% V _{OUT}
	$V_{IN} = 12V$ to $V_{IN} = 40V$		0.02	0.2		0.1	0.5	% V _{OUT}
Load Regulation	$I_L = 1 \text{ mA to } I_L = 50 \text{ mA}$		0.03	0.15		0.03	0.2	% V _{OUT}
	-55°C ≤ T _A ≤ +125°C			0.6				% V _{OUT}
	$0^{\circ}\text{C} \le \text{T}_{\text{A}} \le +70^{\circ}\text{C}$						0.6	% V _{OUT}
Ripple Rejection	$f = 50 \text{ Hz to } 10 \text{ kHz}, C_{REF} = 0$		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, C₁ = 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.

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⁽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⁾ L₁ 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.



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

Parameter	Conditions		LM723	3		Units		
		Min	Тур	Max	Min	Тур	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	$R_{SC} = 10\Omega$, $V_{OUT} = 0$		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

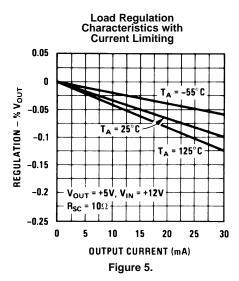
⁽⁵⁾ For metal can applications where V_Z is required, an external 6.2V zener diode should be connected in series with V_{OUT} .

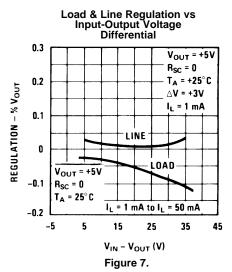
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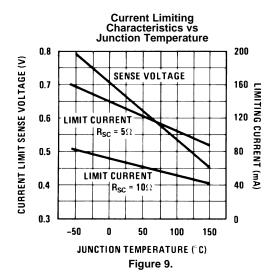
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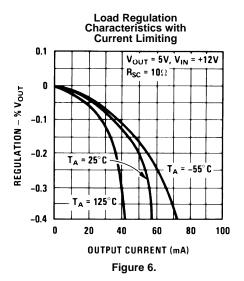


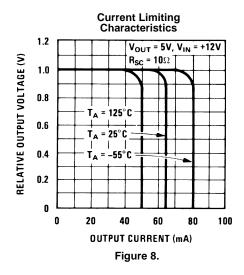
TYPICAL PERFORMANCE CHARACTERISTICS

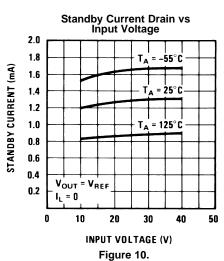












TYPICAL PERFORMANCE CHARACTERISTICS (continued) ine Transient Response Load Transient Response

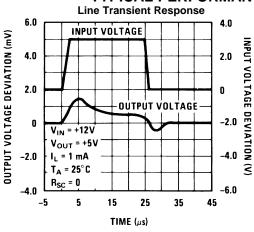
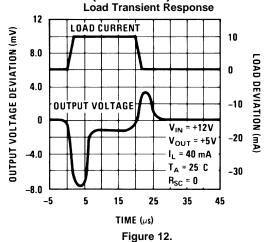


Figure 11.



Output Impedence vs Frequency

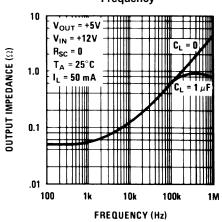
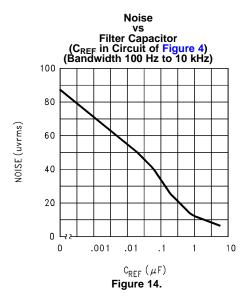


Figure 13.



MAXIMUM POWER RATINGS



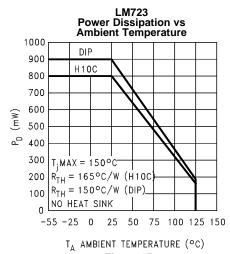
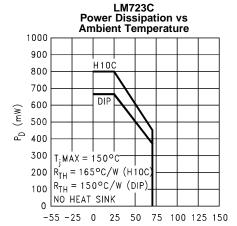


Figure 15.



TA AMBIENT TEMPERATURE (°C) Figure 16.

Product Folder Links: LM723 LM723C



Table 1. Resistor Values ($k\Omega$) for Standard Output Voltage

		•											
Positive Output Voltage	Applicable Figures	Fixed Output ±5%		Output Adjustable ±10% ⁽¹⁾			Negative Output Voltage	Applicable Figures	Fixed Output ±5%		5% Output Adjustable ±10%		
voitage	See ⁽²⁾	R1	R2	R1	P1	R2	voitage		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

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

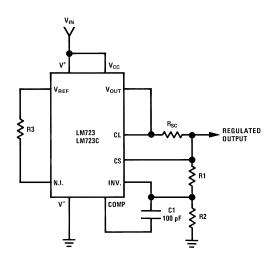
Table 2. Formulae for Intermediate Output Voltages

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

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TYPICAL APPLICATIONS



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

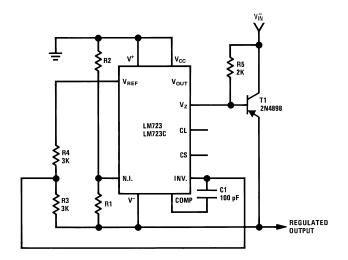
for minimum temperature drift.

R3 may be eliminated for minimum component count.

Typical Performance

Regulated Output Voltage 15V Line Regulation ($\Delta V_{IN} = 3V$) 1.5 mV Load Regulation ($\Delta I_{L} = 50$ mA) 4.5 mV

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

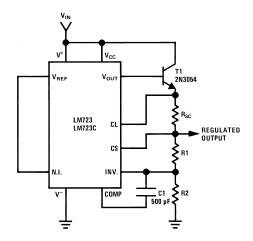


Typical Performance

Regulated Output Voltage -15V Line Regulation ($\Delta V_{IN} = 3V$) 1 mV Load Regulation ($\Delta I_L = 100 \text{ mA}$) 2 mV

Figure 18. Negative Voltage Regulator

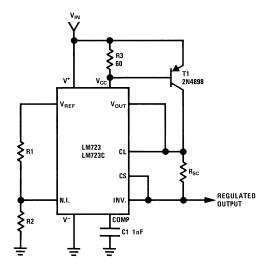




Typical Performance

Regulated Output Voltage Line Regulation ($\Delta V_{IN} = 3V$) Load Regulation ($\Delta I_{L} = 1A$) 15 mV

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

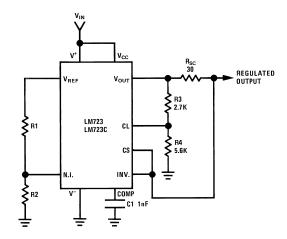


Typical Performance

Regulated Output Voltage +5V Line Regulation ($\Delta V_{IN} = 3V$) 0.5 mV Load Regulation ($\Delta I_L = 1A$) 5 mV

Figure 20. Positive Voltage Regulator (External PNP Pass Transistor)

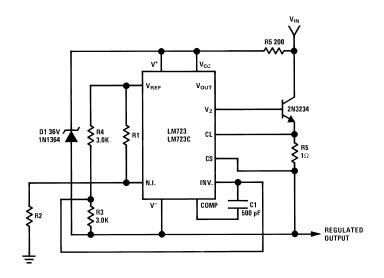




Typical Performance

Regulated Output Voltage Line Regulation ($\Delta V_{IN} = 3V$) Load Regulation ($\Delta I_{L} = 10 \text{ mA}$) Short Circuit Current 20 mA

Figure 21. Foldback Current Limiting

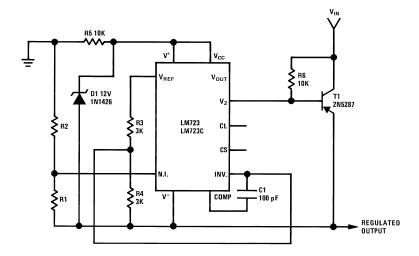


Typical Performance

Regulated Output Voltage +50VLine Regulation ($\Delta V_{IN} = 20V$) 15 mVLoad Regulation ($\Delta I_L = 50 \text{ mA}$) 20 mV

Figure 22. Positive Floating Regulator

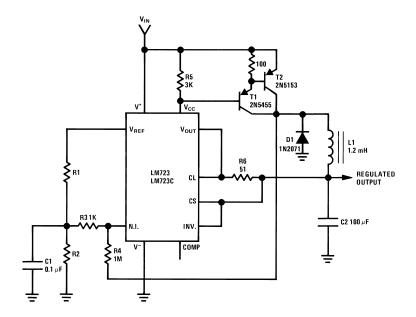




Typical Performance

Regulated Output Voltage -100V Line Regulation ($\Delta V_{IN} = 20V$) 30 mV Load Regulation ($\Delta I_L = 100 \text{ mA}$) 20 mV

Figure 23. Negative Floating Regulator

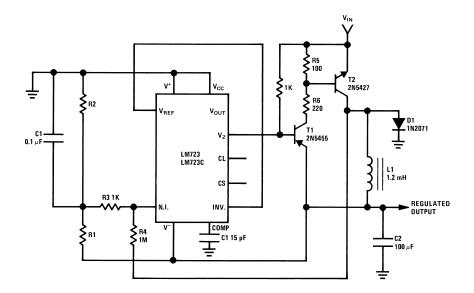


Typical Performance

Regulated Output Voltage Line Regulation ($\Delta V_{IN} = 30V$) Load Regulation ($\Delta I_{L} = 2A$) 80 mV

Figure 24. Positive Switching Regulator

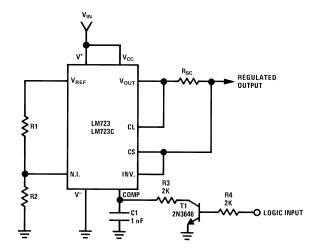




Typical Performance

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



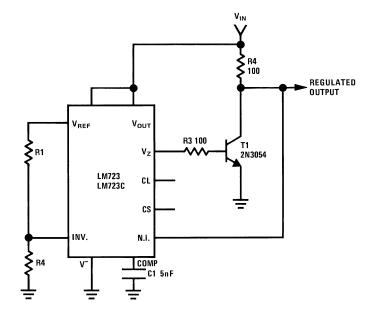
Note: Current limit transistor may be used for shutdown if current limiting is not required.

Typical Performance

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

Figure 26. Remote Shutdown Regulator with Current Limiting





Regulated Output Voltage Line Regulation ($\Delta V_{IN} = 10V$) Load Regulation ($\Delta I_L = 100$ mA) +5V

0.5 mV

1.5 mV

Figure 27. Shunt Regulator

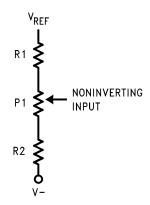
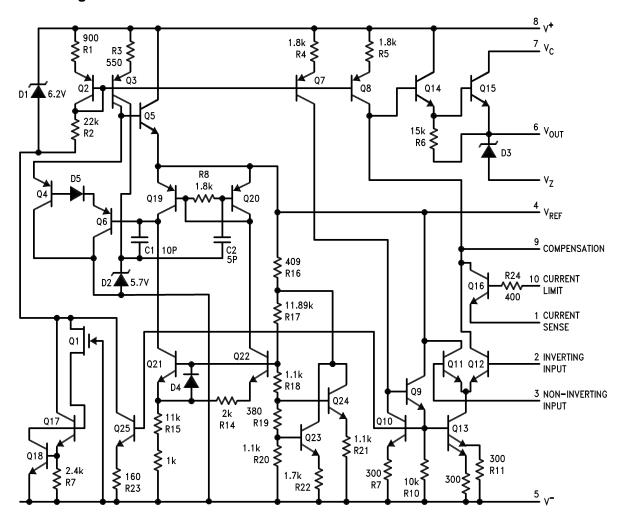


Figure 28. Output Voltage Adjust (1)

(1) Replace R1/R2 in figures with divider shown in Figure 28.



Schematic Diagram





REVISION HISTORY

Cł	nanges from Revision B (April 2013) to Revision C	Page
•	Changed layout of National Data Sheet to TI format	. 15





1-Nov-2013

PACKAGING INFORMATION

Orderable Device	Status	Package Type	_		Package	Eco Plan	Lead/Ball Finish	MSL Peak Temp	Op Temp (°C)	Device Marking	Samples
	(1)		Drawing		Qty	(2)	(6)	(3)		(4/5)	
LM723CH	ACTIVE	TO-100	LME	10	500	TBD	Call TI	Call TI	0 to 70	LM723CH	Samples
LM723CH/NOPB	ACTIVE	TO-100	LME	10	500	Green (RoHS & no Sb/Br)	POST-PLATE	Level-1-NA-UNLIM	0 to 70	LM723CH	Samples
LM723CN	NRND	PDIP	NFF	14	25	TBD	Call TI	Call TI	0 to 70	LM723CN	
LM723CN/NOPB	ACTIVE	PDIP	NFF	14	25	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 70	LM723CN	Samples
LM723H	ACTIVE	TO-100	LME	10	500	TBD	Call TI	Call TI	-55 to 150	LM723H	Samples
LM723H/NOPB	ACTIVE	TO-100	LME	10	500	Green (RoHS & no Sb/Br)	POST-PLATE	Level-1-NA-UNLIM	-55 to 150	LM723H	Samples
U5R7723312	ACTIVE	TO-100	LME	10	500	TBD	Call TI	Call TI	-55 to 150	LM723H	Samples
U5R7723393	ACTIVE	TO-100	LME	10	500	TBD	Call TI	Call TI	0 to 70	LM723CH	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

⁽³⁾ MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

⁽⁴⁾ There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.



PACKAGE OPTION ADDENDUM

1-Nov-2013

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

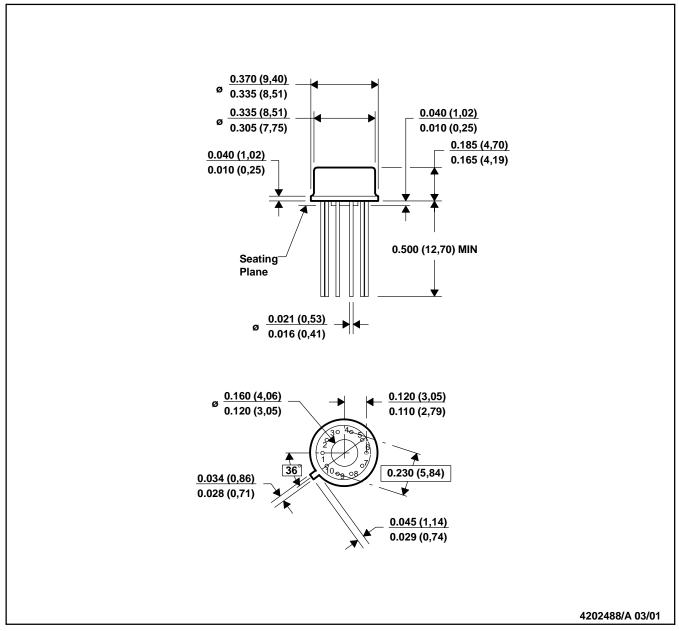
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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LME (O-MBCY-W10)

METAL CYLINDRICAL PACKAGE



NOTES: A. All linear dimensions are in inches (millimeters).

- B. This drawing is subject to change without notice.
- C. Leads in true position within 0.010 (0,25) R @ MMC at seating plane.
- D. Pin numbers shown for reference only. Numbers may not be marked on package.
- E. Falls within JEDEC MO-006/TO-100.



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