LM109,LM309

LM109/LM309 5-Volt Regulator

Literature Number: SNVS752A

April 1998

National Semiconductor

LM109/LM309
5-Volt Regulator

General Description

The LM109 series are complete 5V regulators fabricated on a single silicon chip. They are designed for local regulation on digital logic cards, eliminating the distribution problems association with single-point regulation. The devices are available in two standard transistor packages. In the solid-kovar TO-5 header, it can deliver output currents in excess of 200 mA, if adequate heat sinking is provided. With the TO-3 power package, the available output current is greater than 1A.

The regulators are essentially blowout proof. Current limiting is included to limit the peak output current to a safe value. In addition, thermal shutdown is provided to keep the IC from overheating. If internal dissipation becomes too great, the regulator will shut down to prevent excessive heating.

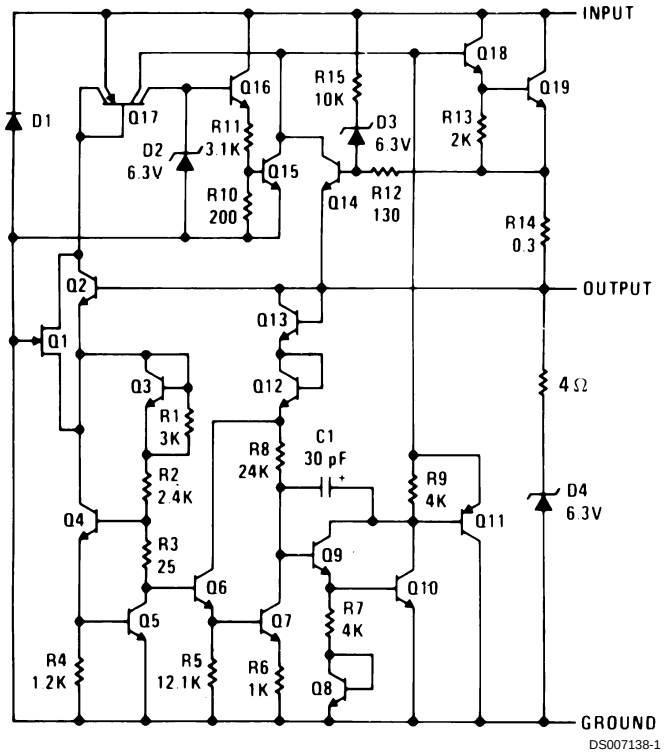
Considerable effort was expended to make these devices easy to use and to minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response somewhat. Input bypassing is needed, however, if the regulator is located very far from the filter capacitor of the power supply. Stability is also achieved by methods that provide very good rejection of load or line transients as are usually seen with TTL logic.

Although designed primarily as a fixed-voltage regulator, the output of the LM109 series can be set to voltages above 5V, as shown. It is also possible to use the circuits as the control element in precision regulators, taking advantage of the good current-handling capability and the thermal overload protection.

Features

- Specified to be compatible, worst case, with TTL and DTL
- Output current in excess of 1A
- Internal thermal overload protection
- No external components required

Schematic Diagram



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Absolute Maximum Ratings (Note 1)

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

Input Voltage	35V
Power Dissipation	Internally Limited
Operating Junction Temperature Range	
LM109	−55˚C to +150˚C
LM309	0˚C to +125˚C
Storage Temperature Range	−65˚C to +150˚C
Lead Temperature	
(Soldering, 10 sec.)	300˚C

Electrical Characteristics (Note 2)

Parameter	Conditions	LM109			LM309			Units
		Min	Typ	Max	Min	Typ	Max	
Output Voltage	T_j = 25˚C	4.7	5.05	5.3	4.8	5.05	5.2	V
Line Regulation	T_j = 25˚C 7.10V ≤ V_{IN} ≤ 25V		4.0	50		4.0	50	mV
Load Regulation	T_j = 25˚C							
TO-39 Package	5 mA ≤ I_{OUT} ≤ 0.5A		15	50		15	50	mV
TO-3 Package	5 mA ≤ I_{OUT} ≤ 1.5A		15	100		15	100	mV
Output Voltage	7.40V ≤ V_{IN} ≤ 25V, 5 mA ≤ I_{OUT} ≤ I_{MAX}, P < P_{MAX}	4.6		5.4	4.75		5.25	V
Quiescent Current	7.40V ≤ V_{IN} ≤ 25V		5.2	10		5.2	10	mA
Quiescent Current Change	7.40V ≤ V_{IN} ≤ 25V			0.5			0.5	mA
	5 mA ≤ I_{OUT} ≤ I_{MAX}			0.8			0.8	mA
Output Noise Voltage	T_A = 25˚C 10 Hz ≤ f ≤ 100 kHz		40			40		µV
Long Term Stability			10			20		mV
Ripple Rejection	T_j = 25˚C	50			50			dB
Thermal Resistance, Junction to Case	(Note 3)							
TO-39 Package			15			15		˚C/W
TO-3 Package			2.5			2.5		˚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.

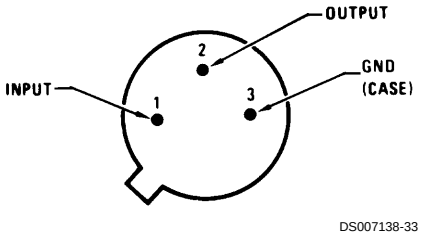
Note 2: Unless otherwise specified, these specifications apply −55˚C ≤ T_j ≤ +150˚C for the LM109 and 0˚C ≤ T_j ≤ +125˚C for the LM309; V_{IN} = 10V; and I_{OUT} = 0.1A for the TO-39 package or I_{OUT} = 0.5A for the TO-3 package. For the TO-39 package, I_{MAX} = 0.2A and P_{MAX} = 2.0W. For the TO-3 package, I_{MAX} = 1.0A and P_{MAX} = 20W.

Note 3: Without a heat sink, the thermal resistance of the TO-39 package is about 150˚C/W, while that of the TO-3 package is approximately 35˚C/W. With a heat sink, the effective thermal resistance can only approach the values specified, depending on the efficiency of the sink.

Note 4: Refer to RETS109H drawing for LM109H or RETS109K drawing for LM109K military specifications.

Connection Diagrams

Metal Can Packages



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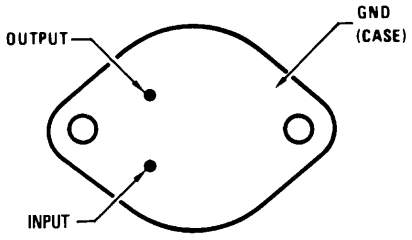
Order Number LM109H, LM109H/883 or LM309H
See NS Package Number H03A



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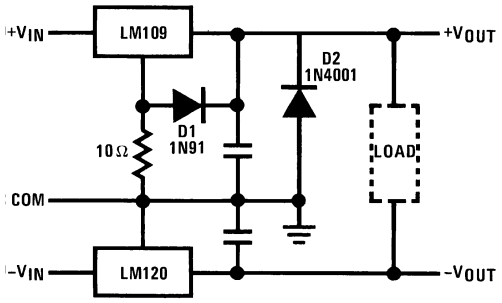
Order Number LM109K STEEL or LM309K STEEL
See NS Package Number K02A
Order Number LM109K/883
See NS Package Number K02C

Application Hints

1. **Bypass the input** of the LM109 to ground with ≥ 0.2 µF ceramic or solid tantalum capacitor if main filter capacitor is more than 4 inches away.
2. **Avoid insertion of regulator into "live" socket** if input voltage is greater than 10V. The output will rise to within 2V of the unregulated input if the ground pin does not make contact, possibly damaging the load. The LM109 may also be damaged if a large output capacitor is charged up, then discharged through the internal clamp zener when the ground pin makes contact.
3. **The output clamp zener** is designed to absorb transients only. It will not clamp the output effectively if a failure occurs in the internal power transistor structure. Zener dynamic impedance is ≈ 4Ω. Continuous RMS current into the zener should not exceed 0.5A.
4. **Paralleling of LM109s** for higher output current is not recommended. Current sharing will be almost nonexistent, leading to a current limit mode operation for devices with the highest initial output voltage. The current limit devices may also heat up to the thermal shutdown point (≈ 175˚C). Long term reliability cannot be guaranteed under these conditions.
5. **Preventing latchoff** for loads connected to negative voltage:

If the output of the LM109 is pulled negative by a high current supply so that the output pin is more than 0.5V negative with respect to the ground pin, the LM109 can latch off. This can be prevented by clamping the ground pin to the output pin with a germanium or Schottky diode as shown. A silicon diode (1N4001) at the output is also needed to keep the positive output from being pulled too far negative. The 10Ω resistor will raise $+V_{OUT}$ by ≈ 0.05V.



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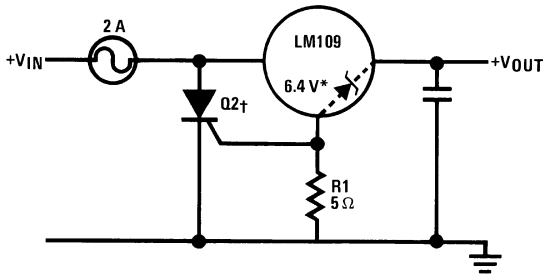
Crowbar Overvoltage Protection

Input Crowbar



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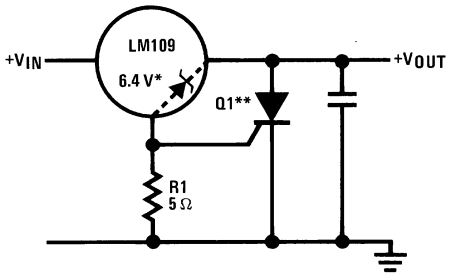
Output Crowbar



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*Zener is internal to LM109.

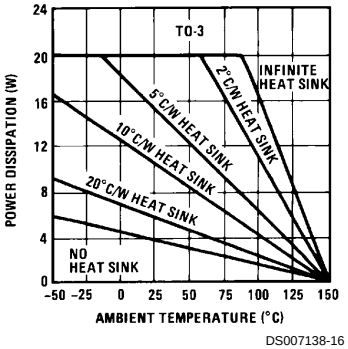
**Q1 must be able to withstand 7A continuous current if fusing is not used at regulator input. LM109 bond wires will fuse at currents above 7A.

†Q2 is selected for surge capability. Consideration must be given to filter capacitor size, transformer impedance, and fuse blowing time.

††Trip point is ≈ 7.5V.

Typical Performance Characteristics

Maximum Average Power Dissipation (LM109K)



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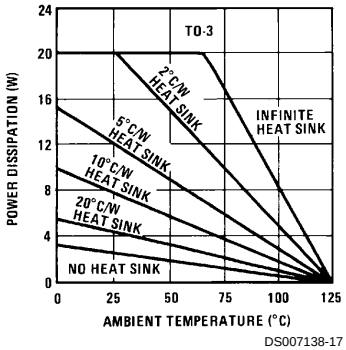
Maximum Average Power Dissipation (LM309K)



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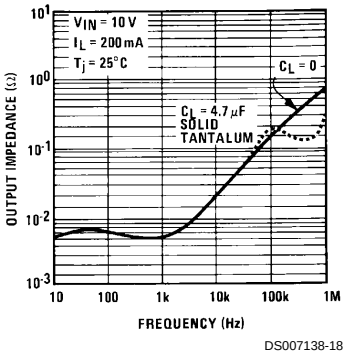
Output Impedance



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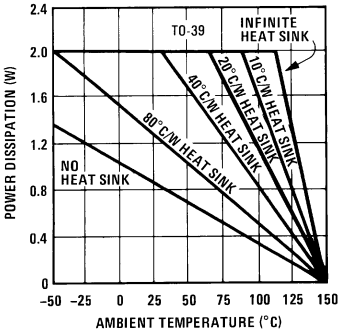
Typical Performance Characteristics (Continued)

Maximum Average Power Dissipation (LM109H)



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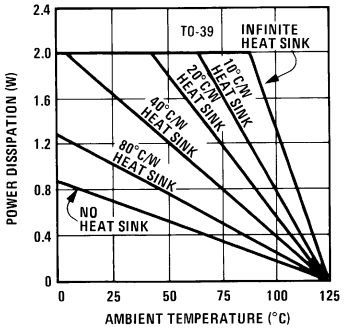
Maximum Average Power Dissipation (LM309H)



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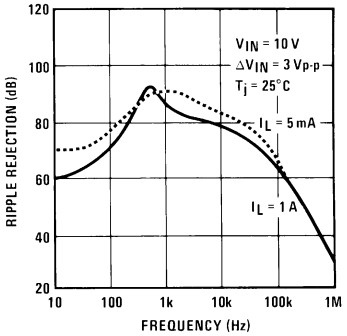
Ripple Rejection



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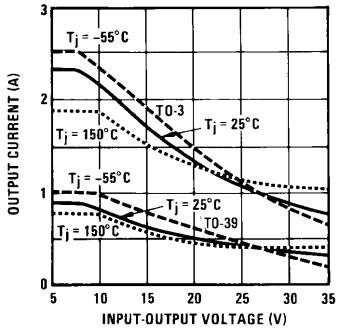
Current Limit Characteristics (Note 5)



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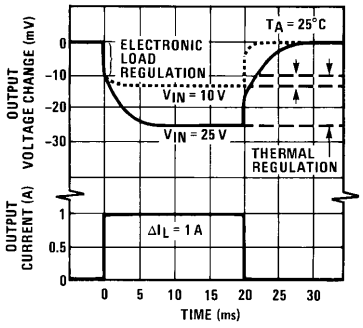
Thermally Induced Output Voltage Variation



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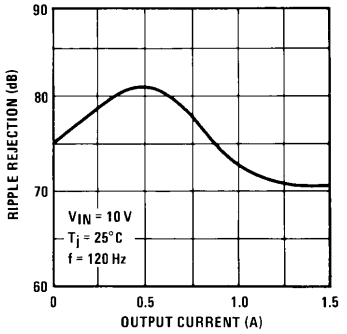
Ripple Rejection



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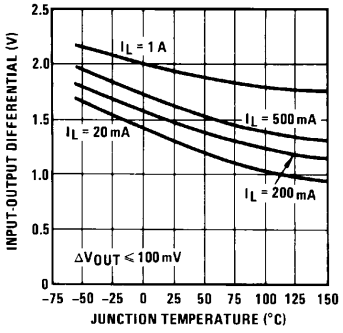
Note 5: Current limiting foldback characteristics are determined by input output differential, not by output voltage.

Input-Output Differential (V)



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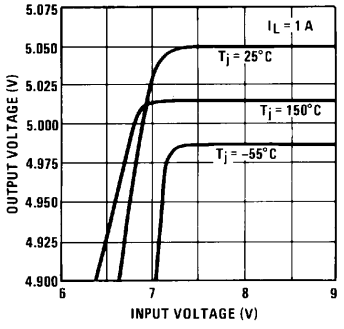
Output Voltage (V)



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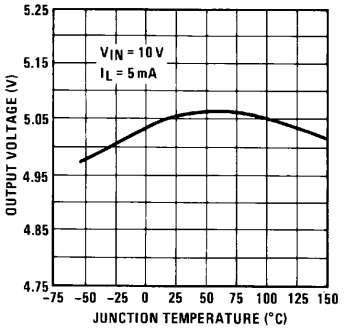
Output Voltage (V)



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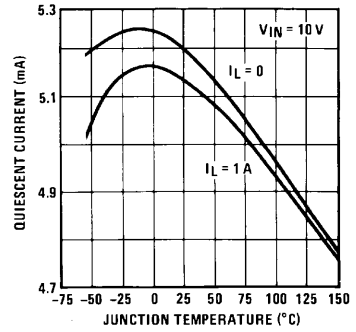
Typical Performance Characteristics (Continued)

Quiescent Current



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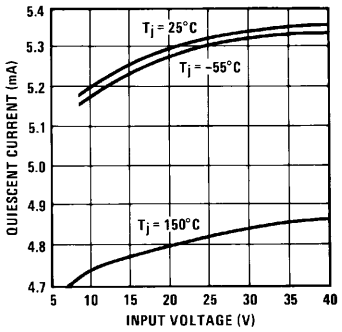
Quiescent Current



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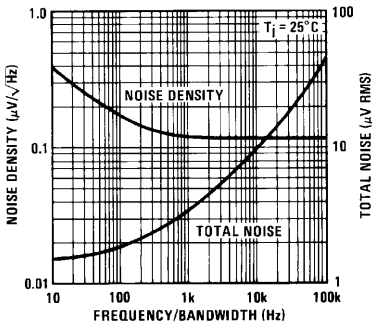
Output Voltage Noise



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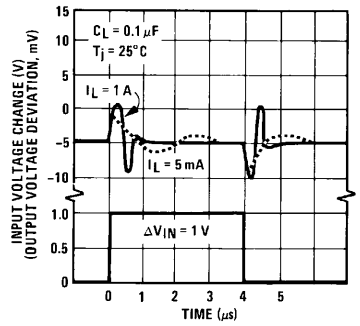
Line Transient Response



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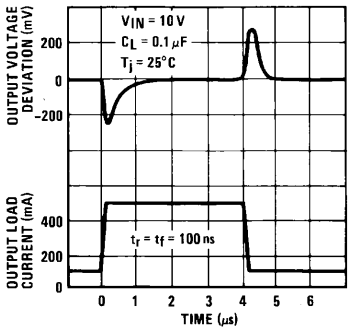
Load Transient Response



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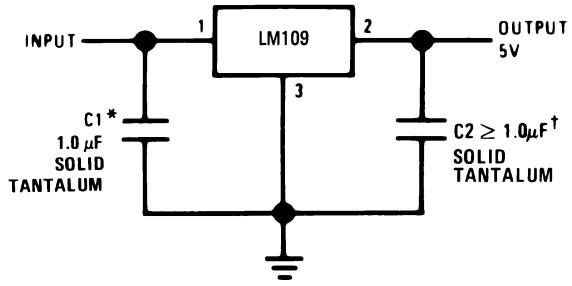
Typical Applications

Fixed 5V Regulator



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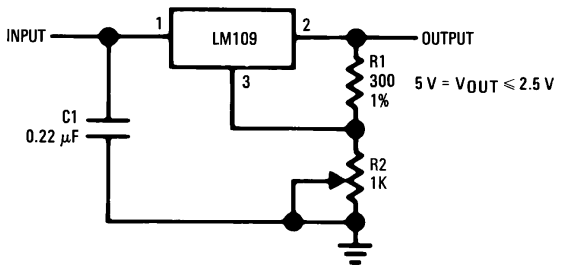
Adjustable Output Regulator



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*Required if regulator is located more than 4" from power supply filter capacitor.

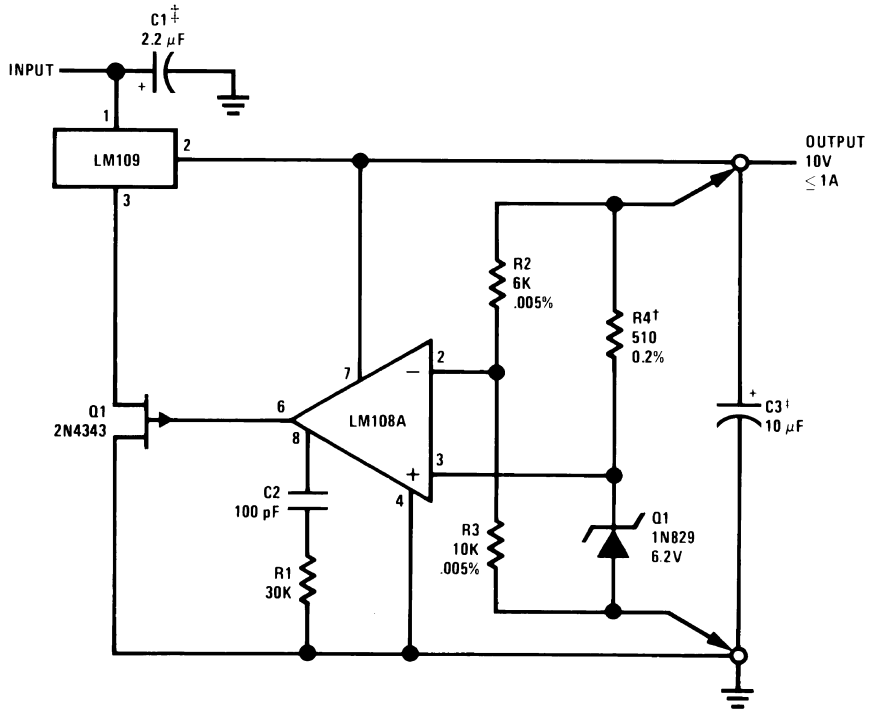
†Although no output capacitor is needed for stability, it does improve transient response.

C2 should be used whenever long wires are used to connect to the load, or when transient response is critical.

Note: Pin 3 electrically connected to case.

Typical Applications (Continued)

High Stability Regulator*



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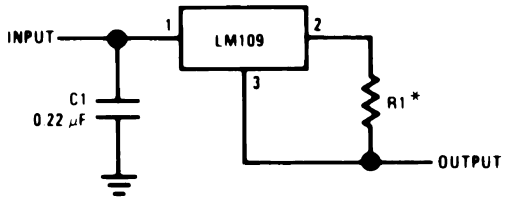
*Regulation better than 0.01%, load, line and temperature, can be obtained.
†Determines zener current. May be adjusted to minimize thermal drift.
‡Solid tantalum.

Current Regulator



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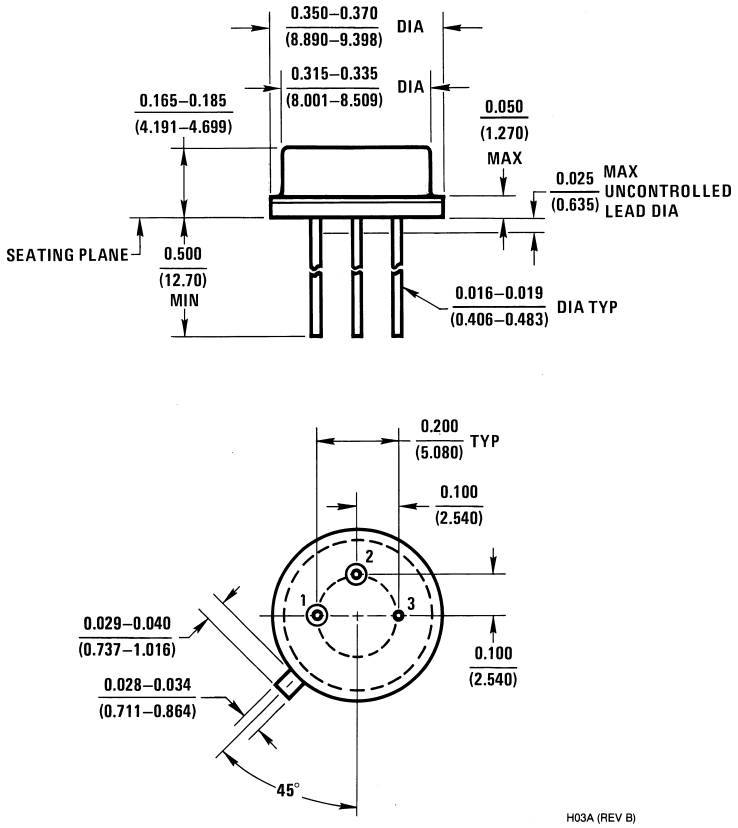
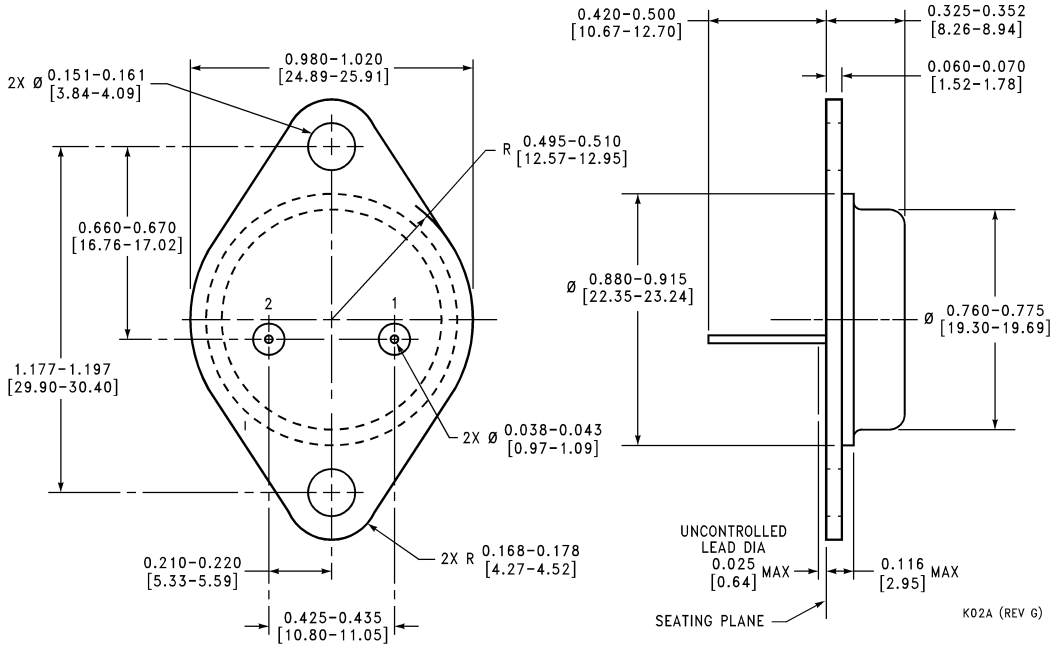
*Determines output current. If wirewound resistor is used, bypass with 0.1 μF.

Physical Dimensions inches (millimeters) unless otherwise noted

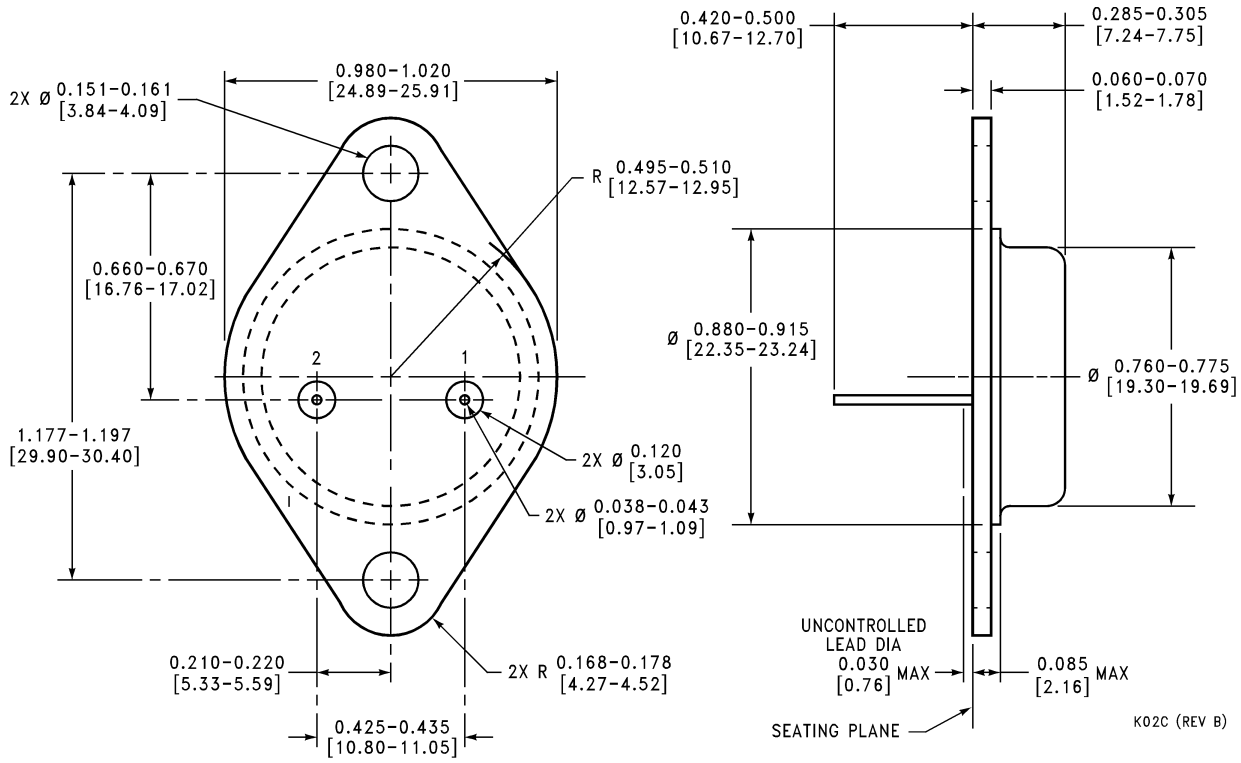


Metal Can Package (H)
Order Number LM109H, LM109H/883 or LM309H
NS Package Number H03A



Metal Can Package (K)
Order Number LM109K STEEL, LM309K STEEL
NS Package Number K02A

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



Metal Can Package (K)
Mil-Aero Product
Order Number LM109K/883
NS Package Number K02C

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

National Semiconductor Corporation
Americas
Email: support@nsc.com

www.national.com

National Semiconductor Europe
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor Asia Pacific Customer Response Group
Tel: 65-2544466
Fax: 65-2504466
Email: ap.support@nsc.com

National Semiconductor Japan Ltd.
Tel: 81-3-5639-7560
Fax: 81-3-5639-7507

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)
LM109H	Active	Production	TO (NDT) | 3	500 | BULK	Yes	AU	Level-1-NA-UNLIM	-55 to 150	(LM109HP+, LM109H P+)
LM109H/NOPB	Active	Production	TO (NDT) | 3	500 | BULK	Yes	AU	Level-1-NA-UNLIM	-55 to 150	(LM109HP+, LM109H P+)
LM109K	Active	Production	TO-3 (NDS) | 2	50 | TRAY NON-STD	No	Call TI	Call TI	-55 to 150	LM109K STEELP+
LM109K STEEL	Active	Production	TO-3 (NDS) | 2	50 | TRAY NON-STD	No	Call TI	Call TI	-55 to 150	LM109K STEELP+
LM109K STEEL/NOPB	Active	Production	TO-3 (NDS) | 2	50 | TRAY NON-STD	Yes	Call TI	Level-1-NA-UNLIM	-55 to 150	LM109K STEELP+
LM309H	Active	Production	TO (NDT) | 3	500 | BULK	Yes	AU	Level-1-NA-UNLIM	0 to 125	(LM309HP+, LM309H P+)
LM309H/NOPB	Active	Production	TO (NDT) | 3	500 | BULK	Yes	AU	Level-1-NA-UNLIM	0 to 125	(LM309HP+, LM309H P+)
LM309K STEEL	Active	Production	TO-3 (NDS) | 2	50 | TRAY NON-STD	No	Call TI	Call TI	0 to 125	LM309K STEELP+
LM309K STEEL/NOPB	Active	Production	TO-3 (NDS) | 2	50 | TRAY NON-STD	Yes	Call TI	Level-1-NA-UNLIM	0 to 125	LM309K STEELP+

(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.

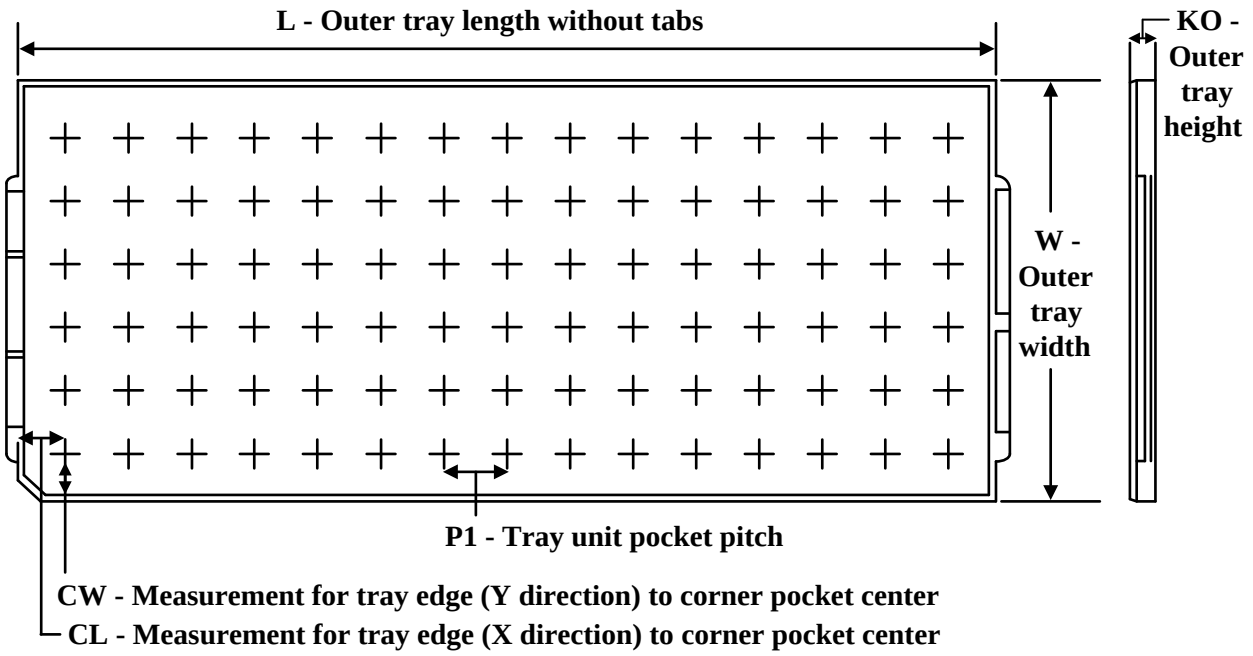
(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(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.

TRAY



Chamfer on Tray corner indicates Pin 1 orientation of packed units.

*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	Unit array matrix	Max temperature (°C)	L (mm)	W (mm)	K0 (µm)	P1 (mm)	CL (mm)	CW (mm)
LM109K	NDS	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4
LM109K STEEL	NDS	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4
LM109K STEEL/NOPB	NDS	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4
LM309K STEEL	NDS	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4
LM309K STEEL/NOPB	NDS	TO-CAN	2	50	9 X 6	NA	292.1	215.9	25654	3.87	22.3	25.4

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