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.

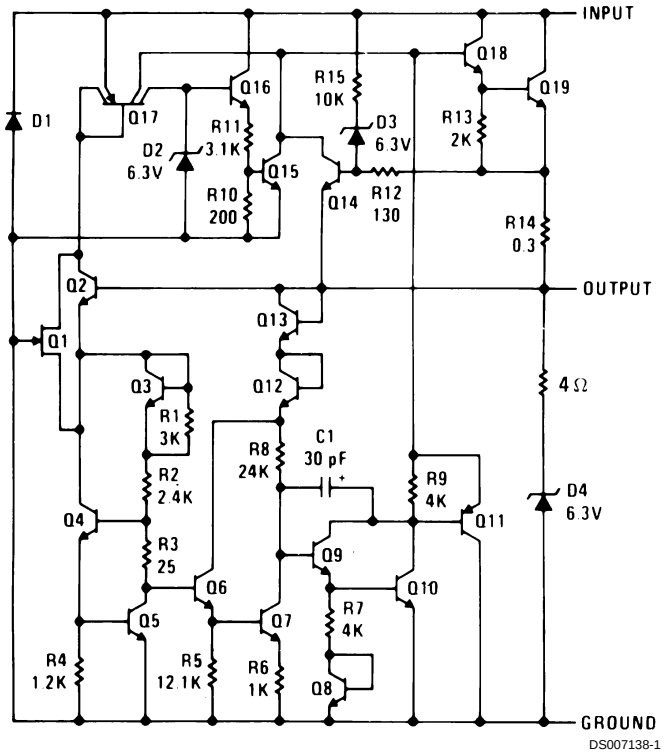
Considerable effort was expended to make these devices easy to use and to minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response somewhat. Input bypassing is needed, however, if the regulator is located very far from the filter 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



DS007138-1

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.

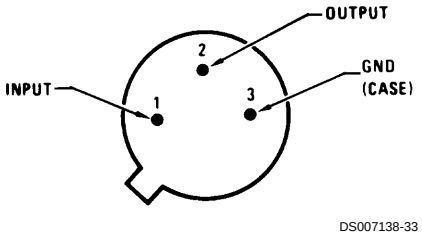
Note 2: Unless otherwise specified, these specifications apply −55˚C ≤ T_j ≤ +150˚C for the LM109 and 0˚C ≤ T_j ≤ +125˚C for the LM309; V_{IN} = 10V; and I_{OUT} = 0.1A for the TO-39 package or I_{OUT} = 0.5A for the TO-3 package. For the TO-39 package, I_{MAX} = 0.2A and P_{MAX} = 2.0W. For the TO-3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

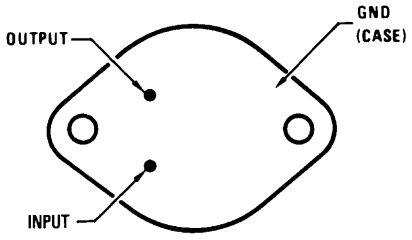
Connection Diagrams

Metal Can Packages



DS007138-33

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



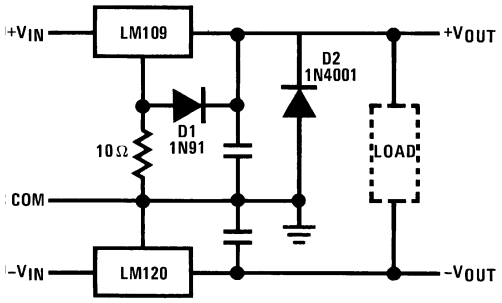
DS007138-34

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:

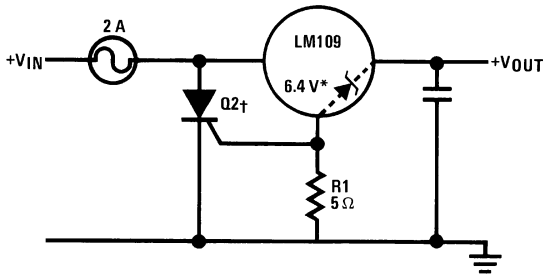
If the output of the LM109 is pulled negative by a high current supply so that the output pin is more than 0.5V negative with respect to the ground pin, the LM109 can latch off. This can be prevented by clamping the ground pin to the output pin with a germanium or Schottky diode as shown. A silicon diode (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.



DS007138-7

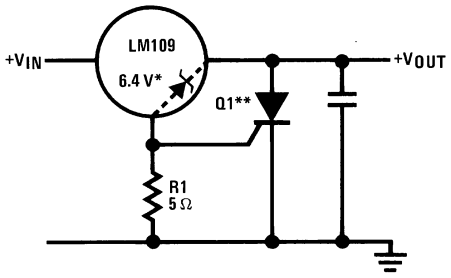
Crowbar Overvoltage Protection

Input Crowbar



DS007138-8

Output Crowbar



DS007138-9

*Zener is internal to LM109.

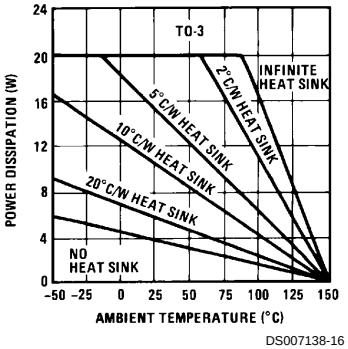
**Q1 must be able to withstand 7A continuous current if fusing is not used at regulator input. LM109 bond wires will fuse at currents above 7A.

†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.

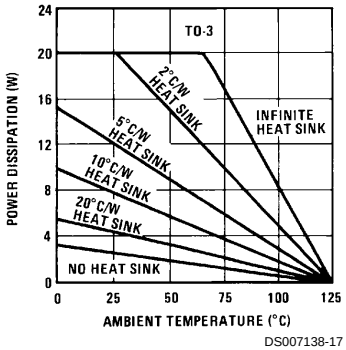
Typical Performance Characteristics

Maximum Average Power Dissipation (LM109K)



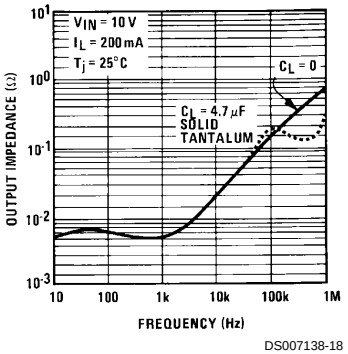
DS007138-16

Maximum Average Power Dissipation (LM309K)



DS007138-17

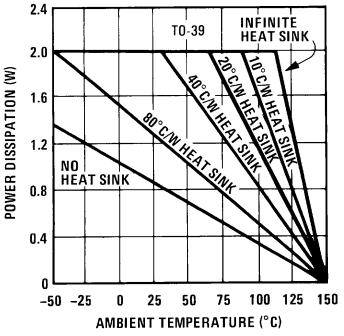
Output Impedance



DS007138-18

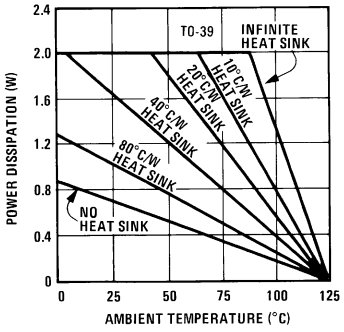
Typical Performance Characteristics (Continued)

Maximum Average Power Dissipation (LM109H)



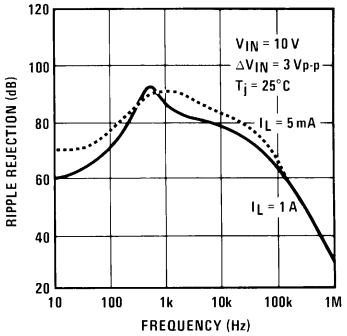
DS007138-19

Maximum Average Power Dissipation (LM309H)



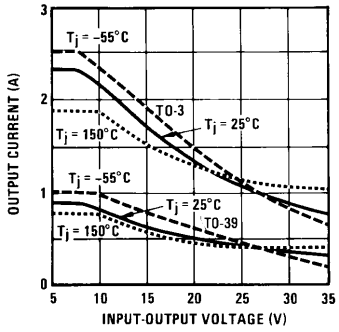
DS007138-20

Ripple Rejection



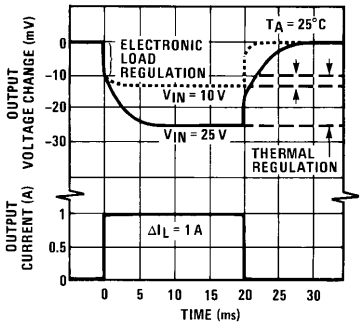
DS007138-21

Current Limit Characteristics (Note 5)



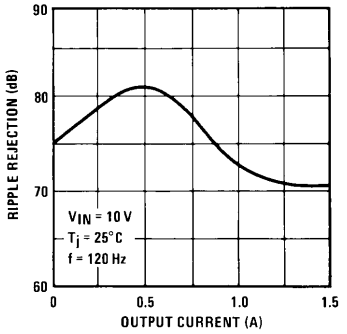
DS007138-22

Thermally Induced Output Voltage Variation



DS007138-23

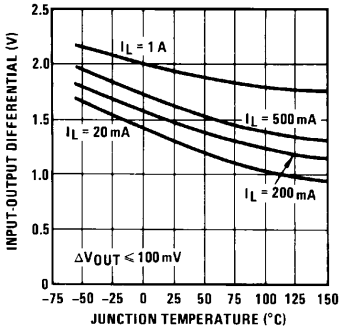
Ripple Rejection



DS007138-24

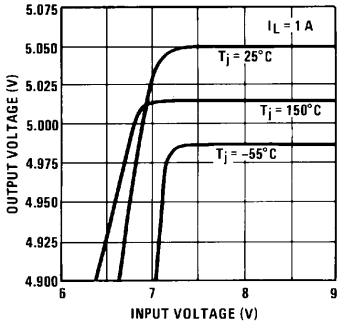
Note 5: Current limiting foldback characteristics are determined by input output differential, not by output voltage.

Input-Output Differential (V)



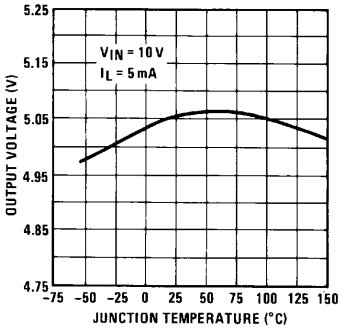
DS007138-25

Output Voltage (V)



DS007138-26

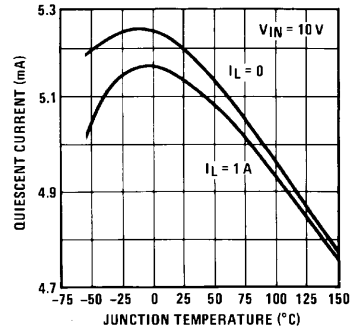
Output Voltage (V)



DS007138-27

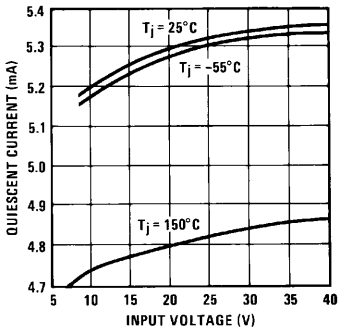
Typical Performance Characteristics (Continued)

Quiescent Current



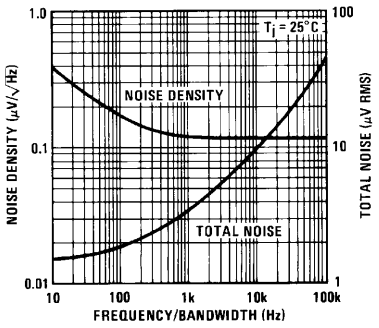
DS007138-28

Quiescent Current



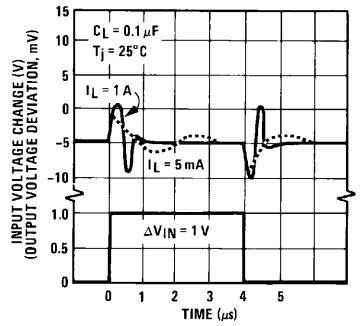
DS007138-29

Output Voltage Noise



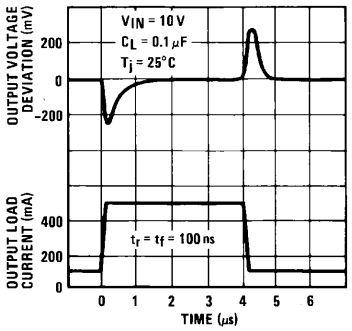
DS007138-30

Line Transient Response



DS007138-31

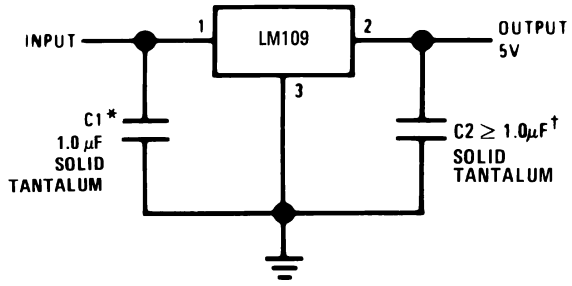
Load Transient Response



DS007138-32

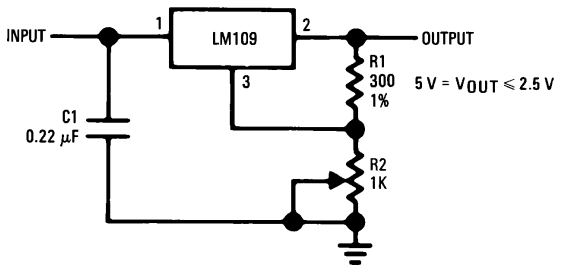
Typical Applications

Fixed 5V Regulator



DS007138-2

Adjustable Output Regulator



DS007138-4

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

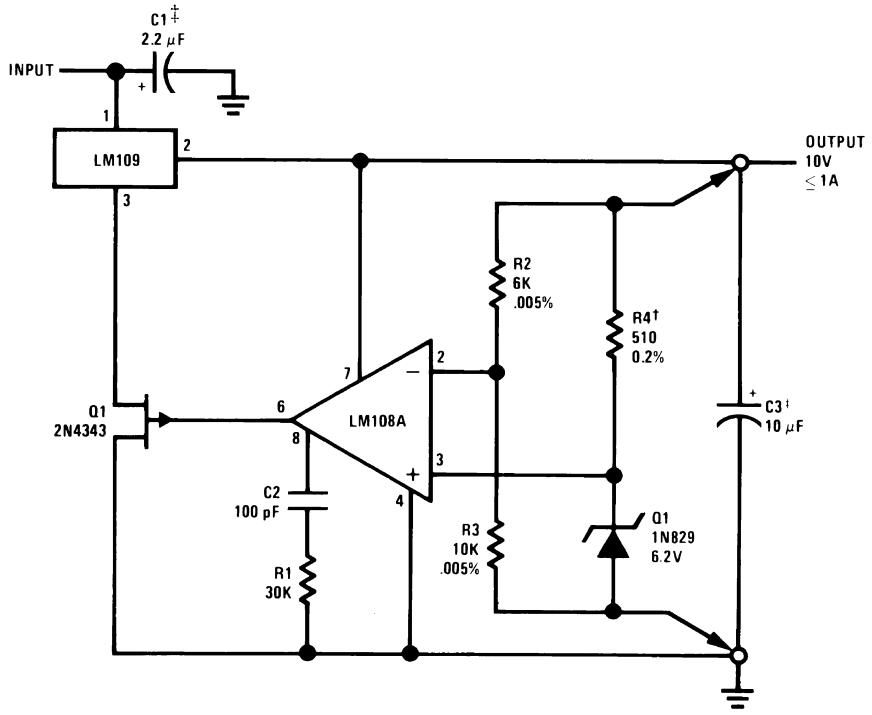
†Although no output capacitor is needed for stability, it does improve transient response.

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)

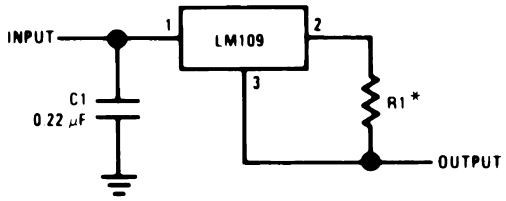
High Stability Regulator*



DS007138-5

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

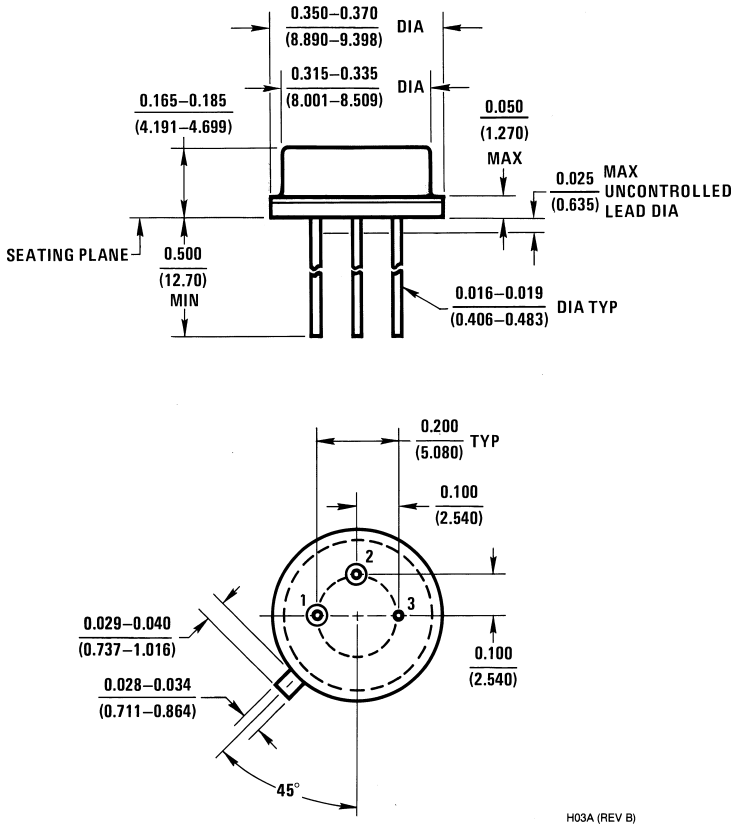
Current Regulator



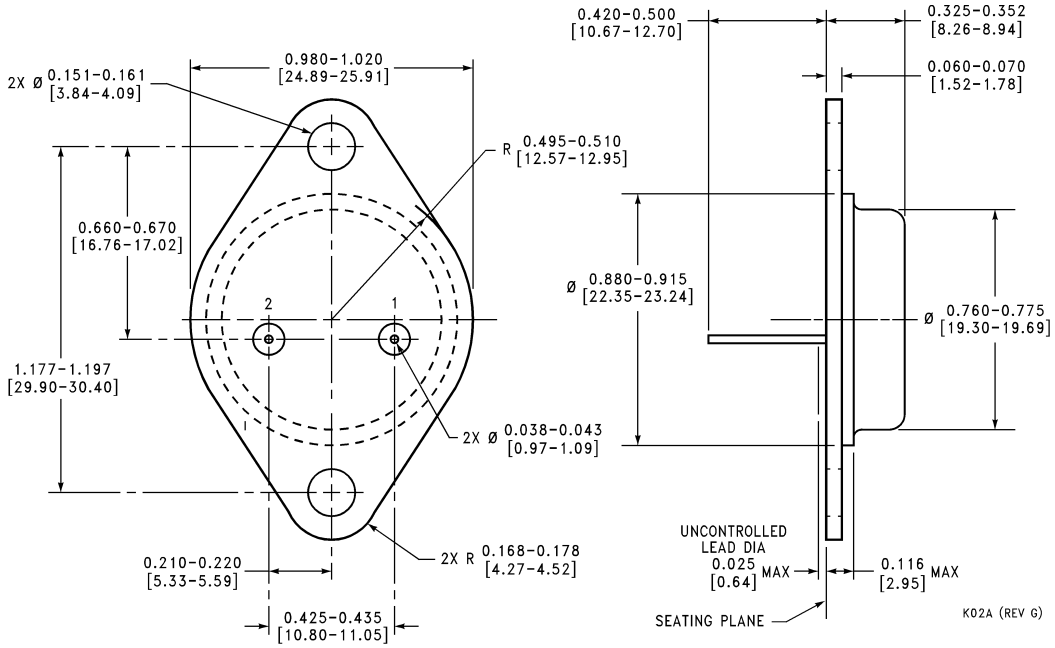
DS007138-6

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

Physical Dimensions inches (millimeters) unless otherwise noted

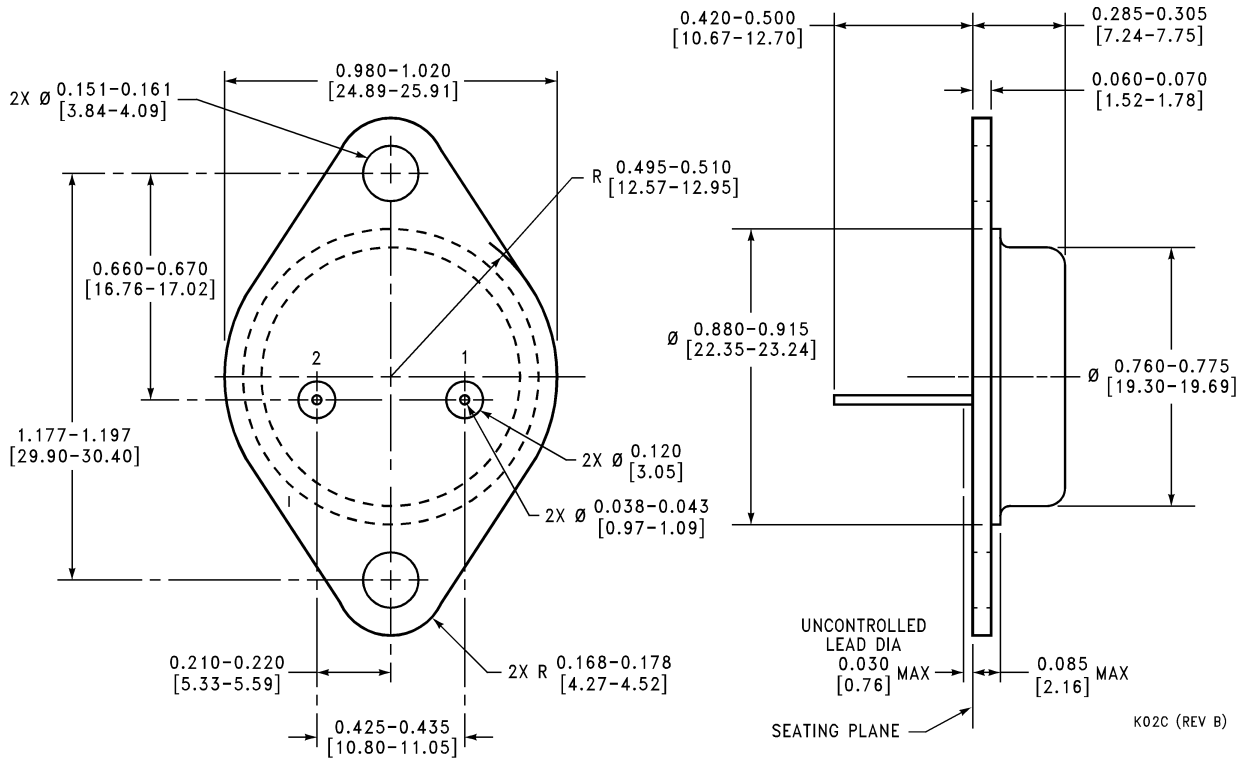


Metal Can Package (H)
Order Number LM109H, LM109H/883 or LM309H
NS Package Number H03A



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

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
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

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Audio	www.ti.com/audio	Communications and Telecom	www.ti.com/communications
Amplifiers	amplifier.ti.com	Computers and Peripherals	www.ti.com/computers
Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Mobile Processors	www.ti.com/omap		
Wireless Connectivity	www.ti.com/wirelessconnectivity		
	TI E2E Community Home Page		e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265