LM109QML

LM109QML 5-Volt Regulator

Literature Number: SNVS366

November 2005

National Semiconductor

LM109QML
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

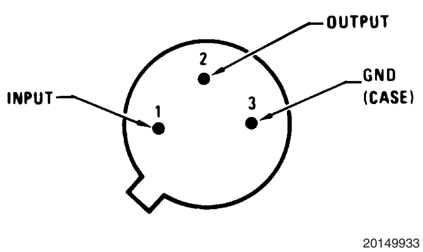
- Specified to be compatible, worst case, with TTL and DTL
- Output current in excess of 1A
- Internal thermal overload protection
- No external components required

Ordering Information

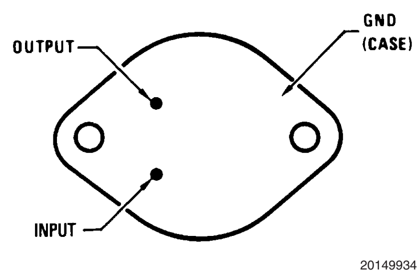
NS Part Number	SMD Part Number	NS Package Number	Package Description
LM109H/883		H03A	3LD TO-39 Metal Can
LM109K/883		K02C	2LD TO-3 Metal Can

Connection Diagrams

Metal Can Packages

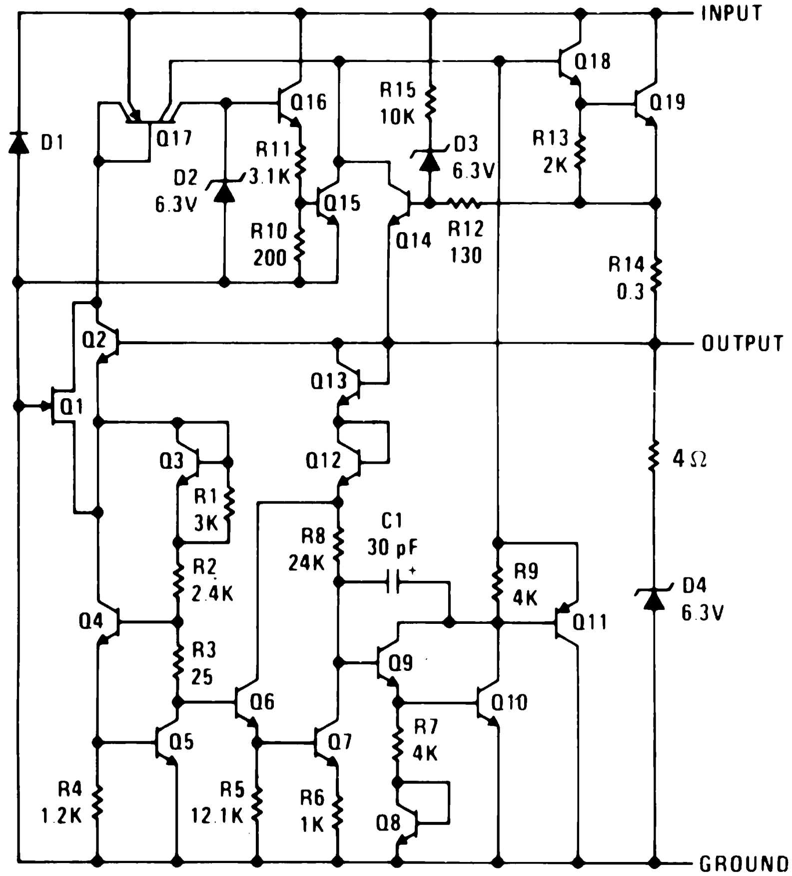


See NS Package Number H03A
Bottom View



See NS Package Number K02C
Bottom View

Schematic Diagram



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Absolute Maximum Ratings (Note 1)

Input Voltage	35V
Power Dissipation	Internally Limited
Operating Ambient Temperature Range	$-55^{\circ}C \leq T_A \leq +150^{\circ}C$
Storage Temperature Range	$-65^{\circ}C \leq T_A \leq +150^{\circ}C$
Maximum Junction Temperature	150˚C
Thermal Resistance	
θ_{JA}	
H-Pkg (Still Air)	190˚C/W
H-Pkg (500LF/Min Air flow)	69˚C/W
K-Pkg (Still Air)	39˚C/W
K-Pkg (500LF/Min Air flow)	TBD
θ_{JC}	
H-Pkg	25˚C/W
K-Pkg	3˚C/W
Lead Temperature (Soldering, 10 sec.)	300˚C
ESD Tolerance (Note 6)	4000V

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
12	Settling time at	25
13	Settling time at	125
14	Settling time at	-55

LM109H Electrical Characteristics

DC/AC Parameters

The following conditions apply to all the following parameters, unless otherwise specified.

AC / DC: I_L = 5mA

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_{Start}	Start Up Input Voltage	$V_O \geq 4.706V$, $R_L = 25\Omega$	(Note 2)		9.0	V	1
I_Q	Quiescent Current	$V_I = 7V$		-10		mA	1, 2, 3
		$V_I = 7.2V$, $I_L = 500mA$	(Note 4)	-10		mA	1, 2, 3
		$V_I = 25V$		-10		mA	1, 2, 3
		$V_I = 25V$, $I_L = 500mA$	(Note 4)	-10		mA	1, 2, 3
		$V_I = 35V$		-10		mA	1
Δ_{IQ}	Quiescent Current Change	$7V \leq V_I \leq 25$ V		-0.5	0.5	mA	1, 2, 3
		$V_I = 7.2V$, $5mA \leq I_L \leq 500mA$	(Note 4)	-0.8	0.8	mA	1, 2, 3
V_{RLine}	Line Regulation	$7V \leq V_I \leq 25V$		-50	50	mV	1
				-100	100	mV	2, 3
V_{RLoad}	Load Regulation	$V_I = 7.2V$, $5mA \leq I_L \leq 500mA$		-50	50	mV	1
			(Note 4)	-100	100	mV	2, 3
		$V_I = 10V$, $5mA \leq I_L \leq 500mA$		-50	50	mV	1
			(Note 4)	-100	100	mV	2, 3
		$V_I = 25V$, $20mA \leq I_L \leq 500mA$		-150	150	mV	1
		$V_I = 25V$, $t_{PW} \leq 10ms$, $500mA \geq I_L \geq 20mA$,	(Note 4)	-50	50	mV	1
V_O	Output Voltage	$V_I = 7V$, $P_1 \leq 2W$		4.6	5.4	V	1, 2, 3
		$V_I = 7.2V$, $I_L = 500mA$, $P \leq 2W$	(Note 4)	4.6	5.4	V	1, 2, 3
		$V_I = 10V$, $I_L = 100mA$, $P \leq 2W$		4.7	5.3	V	1
		$V_I = 25V$, $I_L = 20mA$, $P \leq 2W$		4.6	5.4	V	1
		$V_I = 25V$, $I_L = 500mA$, $P \leq 2W$, $t_{PW} \leq 10mS$	(Note 4)	4.6	5.4	V	1, 2, 3
		$V_I = 25V$, $P \leq 2W$		4.6	5.4	V	1, 2, 3
I_{OS}	Short Circuit Current	$V_I = 35V$			2.0	A	1
RR	Ripple Rejection f	$f \leq 120Hz$, $e_I = 1V_{RMS}$, $I_L = 125mA$		50		dB	4

LM109K Electrical Characteristics

DC/AC Parameters

The following conditions apply to all the following parameters, unless otherwise specified. AC / DC: I_L = 5mA (Note 6)

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_{Start}	Start Up Input Voltage	$V_O \geq 4.706V$, $R_L = 5\Omega$	(Note 2)		9.0	V	1
I_Q	Quiescent Current	$V_I = 7V$		-10		mA	1, 2, 3
		$V_I = 7.2V$, $I_L = 1.5A$	(Note 3)	-10		mA	1, 2, 3
		$V_I = 25V$		-10		mA	1, 2, 3
		$V_I = 25V$, $I_L = 1.5A$ $t_{PW} \leq 10ms$	(Note 3)	-10		mA	1, 2, 3
		$V_I = 35V$		-10		mA	1
Δ_{IQ}	Quiescent Current Change	$7V \leq V_I \leq 25$ V		-0.5	0.5	mA	1, 2, 3
		$V_I = 7.2V$, $5mA \leq I_L \leq 1.5A$	(Note 3)	-0.8	0.8	mA	1, 2, 3
V_{RLine}	Line Regulation	$7V \leq V_I \leq 25V$		-50	50	mV	1
				-100	100	mV	2, 3
V_{RLoad}	Load Regulation	$V_I = 7.2V$, $5mA \leq I_L \leq 1.5A$		-100	100	mV	1
			(Note 3)	-200	200	mV	2, 3
		$V_I = 10V$, $1.5A \geq I_L \geq 5mA$		-100	100	mV	1
			(Note 3)	-200	200	mV	2, 3
		$V_I = 25V$, $t_{PW} < 10ms$, $1A \geq I_L \geq 20mA$,		-50	50	mV	1
V_O	Output Voltage	$V_I = 7V$, $P_1 \leq 20W$		4.6	5.4	V	1, 2, 3
		$V_I = 7.2V$, $I_L = 1.5A$, $P \leq 20W$	(Note 3)	4.6	5.4	V	1, 2, 3
		$V_I = 10V$, $I_L = 500mA$, $P \leq 20W$		4.7	5.3	V	1
		$V_I = 25V$, $I_L = 20mA$, $P \leq 20W$		4.6	5.4	V	1
		$V_I = 25V$, $I_L = 1A$, $P \leq 20W$, $t_{PW} \leq 10mS$		4.6	5.4	V	1, 2, 3
		$V_I = 25V$, $P \leq 20W$		4.6	5.4	V	1, 2, 3
I_{OS}	Short Circuit Current	$V_I = 35V$			2.8	A	1
RR	Ripple Rejection	$f \leq 120Hz$, $e_I = 1V_{RMS}$, $I_L = 500mA$		50		dB	4

DC Parameters

The following conditions apply to all the following parameters, unless otherwise specified. DC: I_L = 5mA(Note 6)

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_N	Output Noise Voltage	$10Hz \leq f \leq 100KHz$	(Note 5)		200	µV	7
$\Delta V_O / \Delta T$	Long Term Stability		(Note 5)		10	mV	8

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: This test is performed by shifting the input voltage in 50mV increments until output reaches 4.706V.

Note 3: At –55˚C & 125˚C, I_L = 1A rather than 1.5A.

Note 4: At –55˚C & 125˚C, I_L = 200mA rather than 500mA.

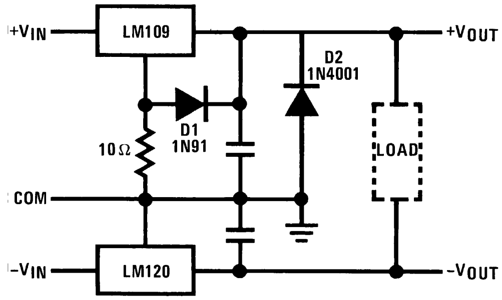
Note 5: Guaranteed parameter, not tested.

Note 6: Human body model, 1.5kΩ in series with 100pF.

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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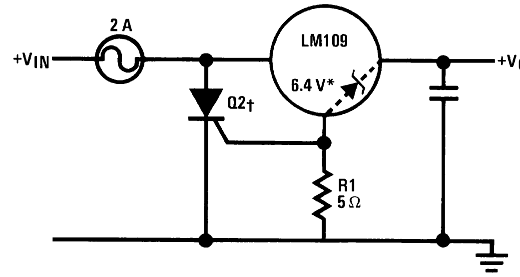
Crowbar Overvoltage Protection

Input Crowbar



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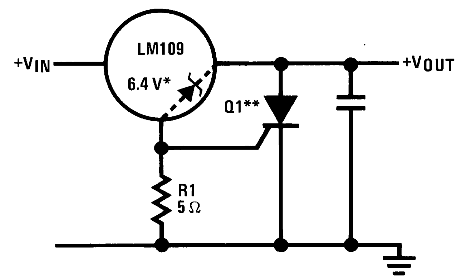
Output Crowbar



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*Zener is internal to LM109.

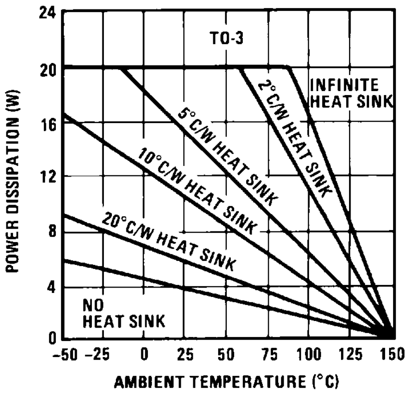
**Q1 must be able to withstand 7A continuous current if fusing is not used at regulator input. LM109 bond wires will fuse at currents above 7A.

†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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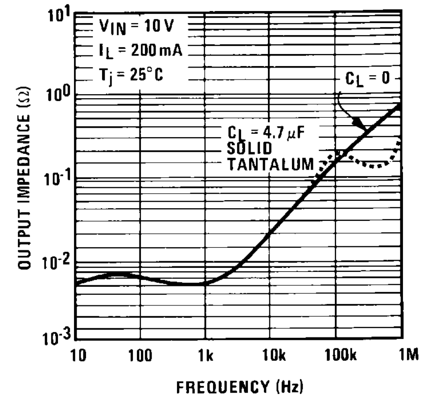
Output Impedance



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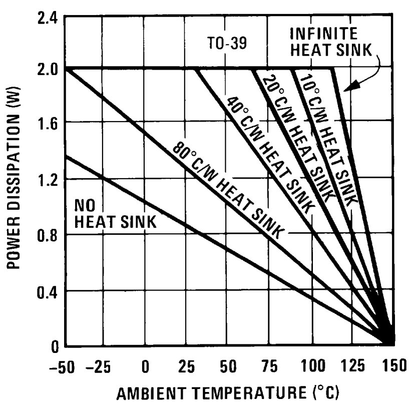
Maximum Average Power Dissipation (LM109H)



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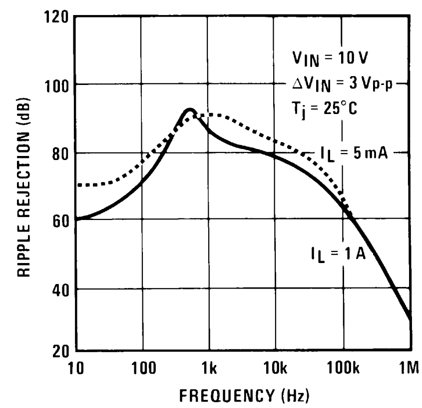
Ripple Rejection



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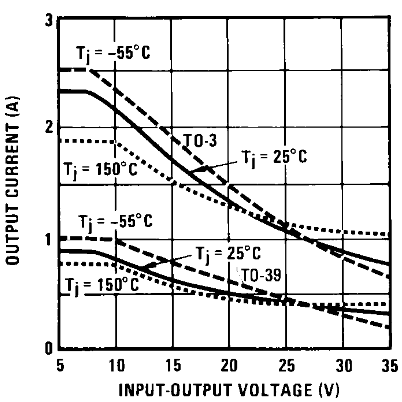
Current Limit Characteristics (Note 7)



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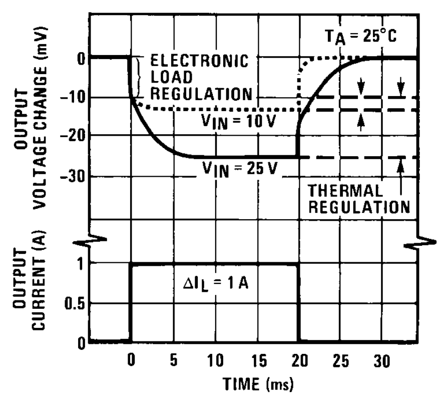
Thermally Induced Output Voltage Variation



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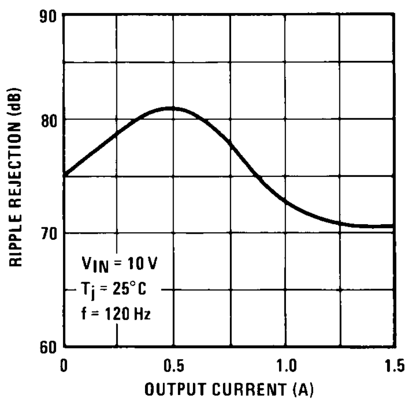
Typical Performance Characteristics (Continued)

Ripple Rejection



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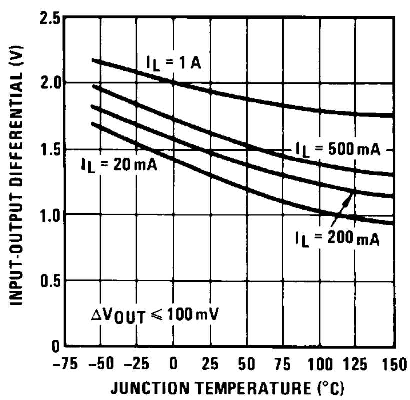
Note 7: Current limiting foldback characteristics are determined by input output differential, not by output voltage.

Input-Output Differential (V)



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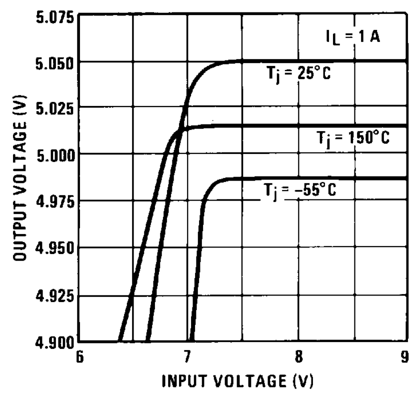
Output Voltage (V)



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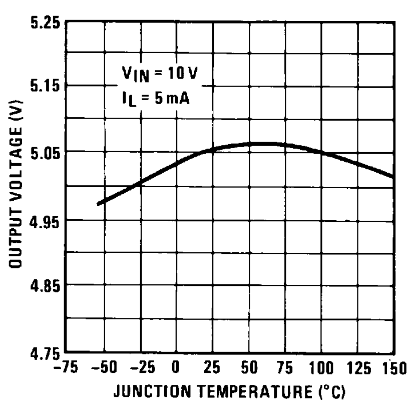
Output Voltage (V)



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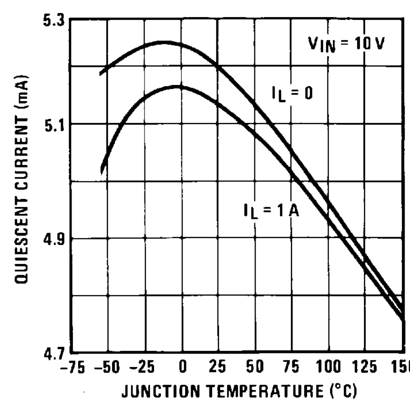
Quiescent Current



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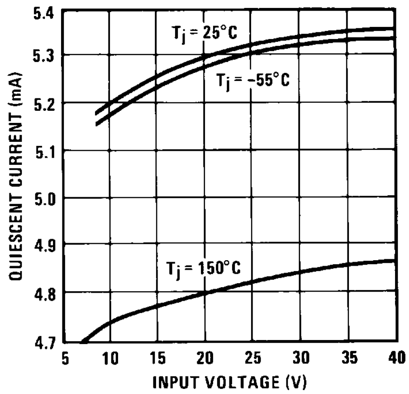
Typical Performance Characteristics (Continued)

Quiescent Current



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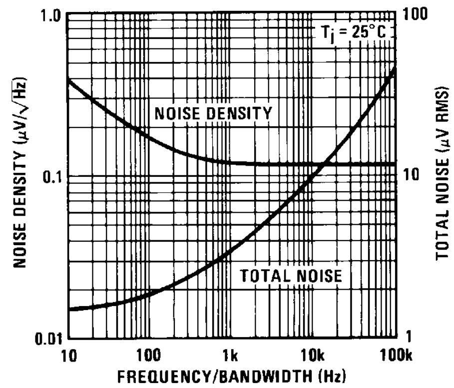
Output Voltage Noise



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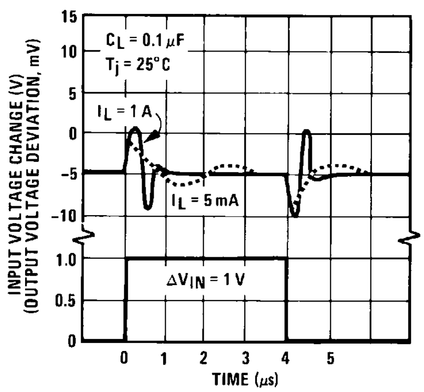
Line Transient Response



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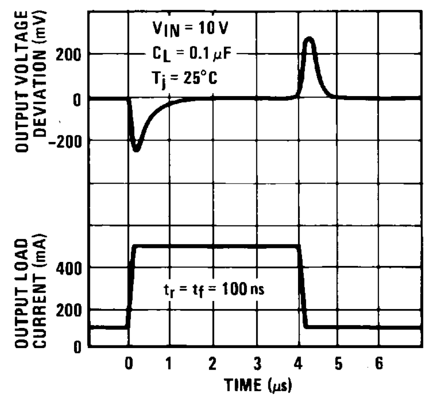
Load Transient Response



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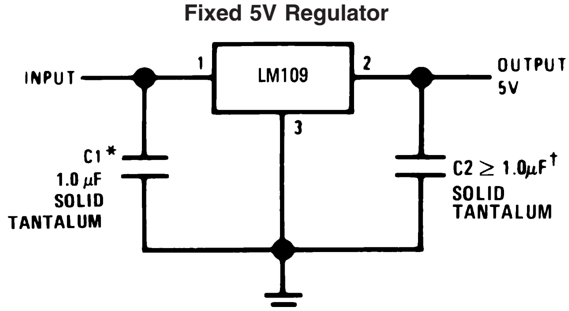
Typical Applications

Fixed 5V Regulator



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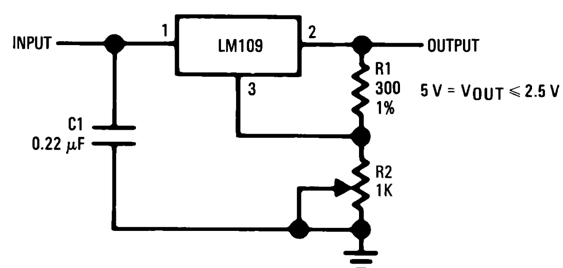
*Required if regulator is located more than 4" from power supply filter capacitor.

†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.

Adjustable Output Regulator



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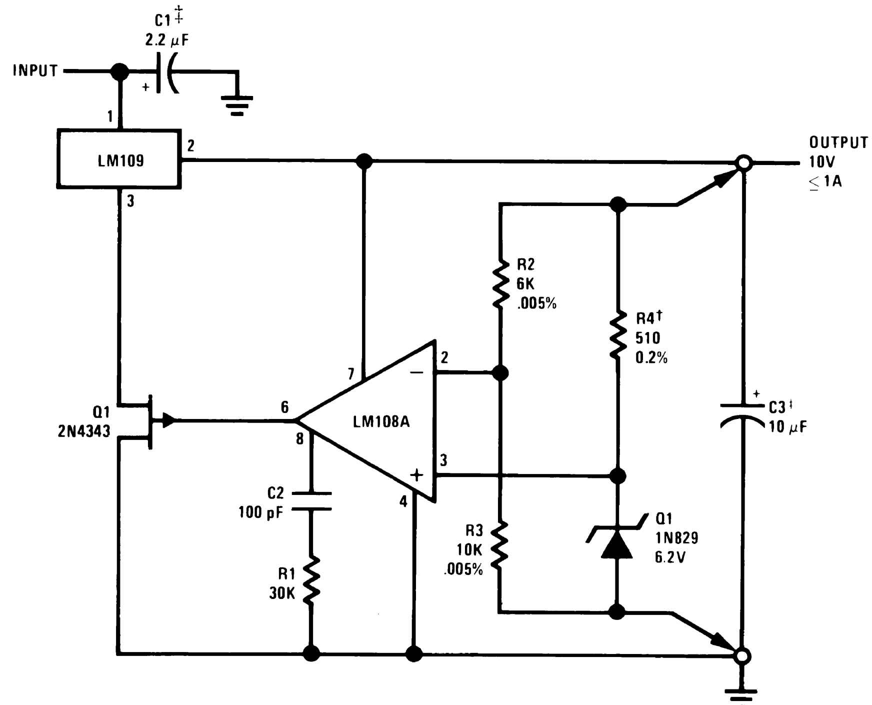
Typical Applications (Continued)

High Stability Regulator*



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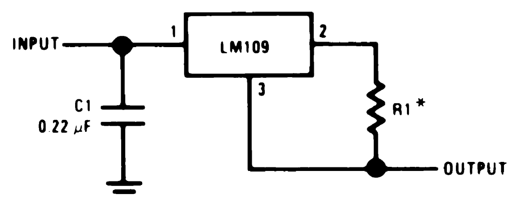
*Regulation better than 0.01%, load, line and temperature, can be obtained.

†Determines zener current. May be adjusted to minimize thermal drift.

‡Solid tantalum.

Current Regulator



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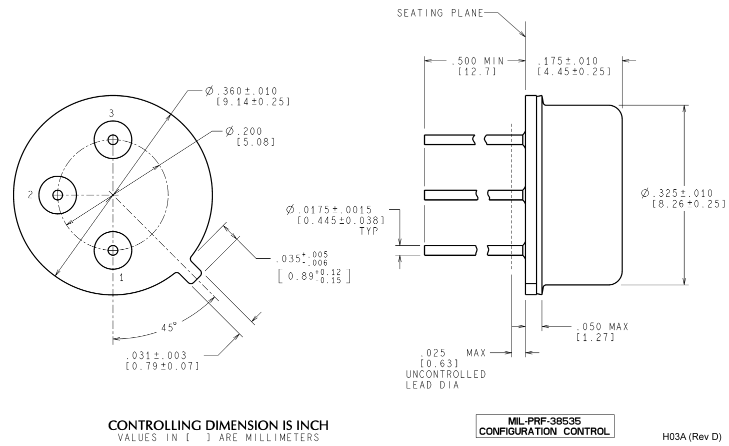
*Determines output current. If wirewound resistor is used, bypass with 0.1 μF.

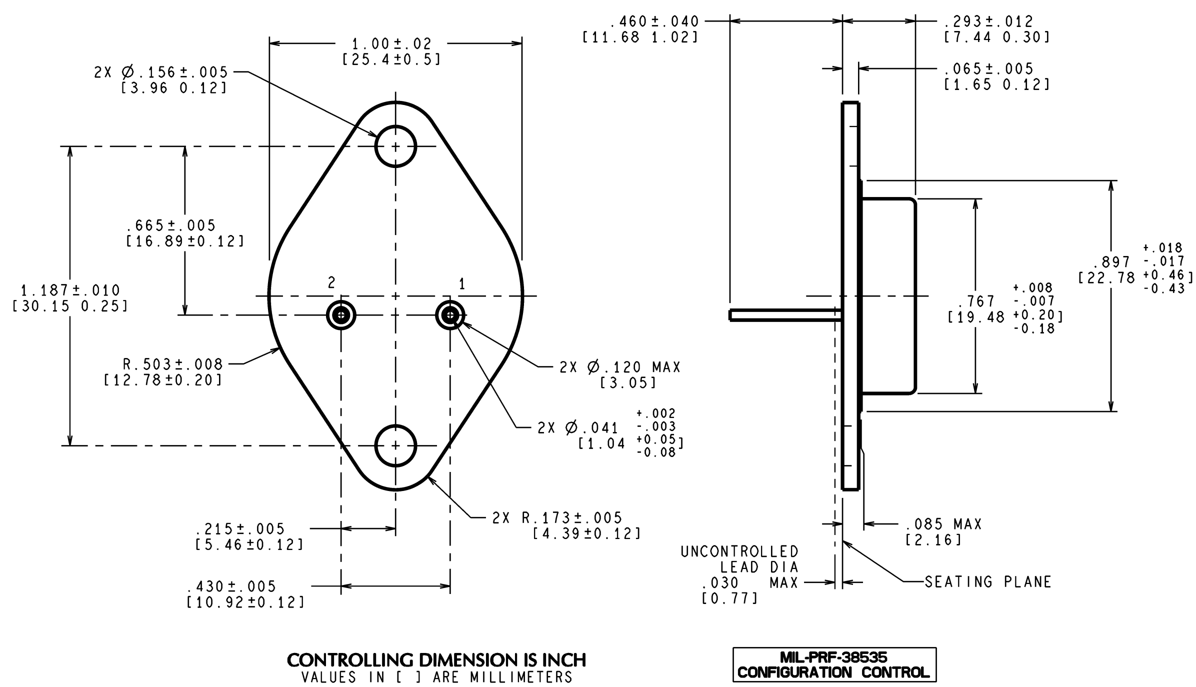
Revision History

Date Released	Revision	Section	Originator	Changes
11/08/05	A	New release to corporate format	L. Lytle	2 MDS datasheets converted into one datasheet in the corporate format. Deleted note 5 & corrected V_{RLoad} of LM109K to ≥ . MNLM109-K Rev 0AL & MNLM109-H Rev 0AL will be archived.

Physical Dimensions inches (millimeters) unless otherwise noted



Metal Can Package (H)
NS Package Number H03A



K02C (Rev E)

Metal Can Package (K)
NS Package Number K02C

Notes

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