

# LM137,LM337

*LM137/LM337 3-Terminal Adjustable Negative Regulators*



Literature Number: SNVS778C

# LM137/LM337

## 3-Terminal Adjustable Negative Regulators

### General Description

The LM137/LM337 are adjustable 3-terminal negative voltage regulators capable of supplying in excess of  $-1.5A$  over an output voltage range of  $-1.2V$  to  $-37V$ . These regulators are exceptionally easy to apply, requiring only 2 external resistors to set the output voltage and 1 output capacitor for frequency compensation. The circuit design has been optimized for excellent regulation and low thermal transients. Further, the LM137 series features internal current limiting, thermal shutdown and safe-area compensation, making them virtually blowout-proof against overloads.

The LM137/LM337 serve a wide variety of applications including local on-card regulation, programmable-output voltage regulation or precision current regulation. The LM137/LM337 are ideal complements to the LM117/LM317 adjustable positive regulators.

### Features

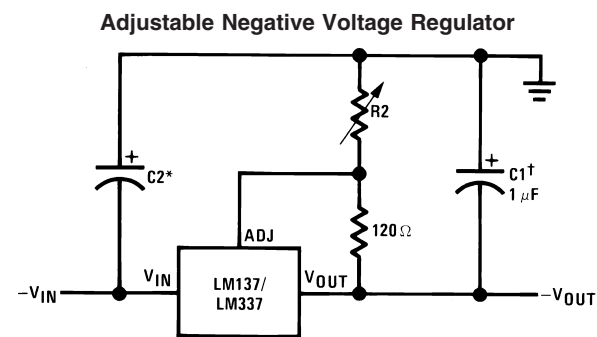
- Output voltage adjustable from  $-1.2V$  to  $-37V$
- $1.5A$  output current guaranteed,  $-55^{\circ}C$  to  $+150^{\circ}C$
- Line regulation typically  $0.01\%/V$
- Load regulation typically  $0.3\%$

- Excellent thermal regulation,  $0.002\%/W$
- $77$  dB ripple rejection
- Excellent rejection of thermal transients
- $50$  ppm/ $^{\circ}C$  temperature coefficient
- Temperature-independent current limit
- Internal thermal overload protection
- P+ Product Enhancement tested
- Standard 3-lead transistor package
- Output is short circuit protected

### LM137 Series Packages and Power Capability

Device	Package	Rated Power Dissipation	Design Load Current
LM137/337	TO-3 (K)	20W	1.5A
	TO-39 (H)	2W	0.5A
LM337	TO-220 (T)	15W	1.5A
LM337	SOT-223 (MP)	2W	1A

### Typical Applications



00906701

Full output current not available at high input-output voltages

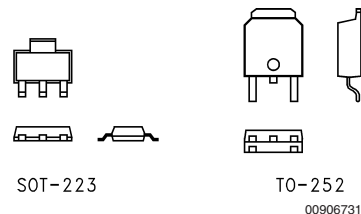
$$-V_{OUT} = -1.25V \left( 1 + \frac{R2}{120} \right) + (-I_{ADJ} \times R2)$$

†C1 =  $1 \mu F$  solid tantalum or  $10 \mu F$  aluminum electrolytic required for stability

\*C2 =  $1 \mu F$  solid tantalum is required only if regulator is more than 4" from power-supply filter capacitor

Output capacitors in the range of  $1 \mu F$  to  $1000 \mu F$  of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients

### Comparison between SOT-223 and D-Pak (TO-252) Packages



Scale 1:1

00906731

**Absolute Maximum Ratings** (Notes 1,

4)

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

Power Dissipation	Internally Limited
Input-Output Voltage Differential	40V
Operating Junction Temperature Range	
LM137	-55°C to +150°C

LM337	0°C to +125°C
LM337I	-40°C to +125°C
Storage Temperature	-65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	300°C
Plastic Package (Soldering, 4 sec.)	260°C
ESD Rating	2k Volts

**Electrical Characteristics** (Note 1)

Parameter	Conditions	LM137			LM337			Units
		Min	Typ	Max	Min	Typ	Max	
Line Regulation	$T_j = 25^\circ\text{C}$ , $3\text{V} \leq  V_{\text{IN}} - V_{\text{OUT}}  \leq 40\text{V}$ (Note 2) $I_L = 10\text{ mA}$		0.01	0.02		0.01	0.04	%/V
Load Regulation	$T_j = 25^\circ\text{C}$ , $10\text{ mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$		0.3	0.5		0.3	1.0	%
Thermal Regulation	$T_j = 25^\circ\text{C}$ , 10 ms Pulse		0.002	0.02		0.003	0.04	%/W
Adjustment Pin Current			65	100		65	100	$\mu\text{A}$
Adjustment Pin Current Charge	$10\text{ mA} \leq I_L \leq I_{\text{MAX}}$ $3.0\text{V} \leq  V_{\text{IN}} - V_{\text{OUT}}  \leq 40\text{V}$ , $T_A = 25^\circ\text{C}$		2	5		2	5	$\mu\text{A}$
Reference Voltage	$T_j = 25^\circ\text{C}$ (Note 3) $3\text{V} \leq  V_{\text{IN}} - V_{\text{OUT}}  \leq 40\text{V}$ , (Note 3) $10\text{ mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$ , $P \leq P_{\text{MAX}}$	-1.225	-1.250	-1.275	-1.213	-1.250	-1.287	V
		-1.200	-1.250	-1.300	-1.200	-1.250	-1.300	V
Line Regulation	$3\text{V} \leq  V_{\text{IN}} - V_{\text{OUT}}  \leq 40\text{V}$ , (Note 2)		0.02	0.05		0.02	0.07	%/V
Load Regulation	$10\text{ mA} \leq I_{\text{OUT}} \leq I_{\text{MAX}}$ , (Note 2)		0.3	1		0.3	1.5	%
Temperature Stability	$T_{\text{MIN}} \leq T_j \leq T_{\text{MAX}}$		0.6			0.6		%
Minimum Load Current	$ V_{\text{IN}} - V_{\text{OUT}}  \leq 40\text{V}$ $ V_{\text{IN}} - V_{\text{OUT}}  \leq 10\text{V}$		2.5	5		2.5	10	mA
			1.2	3		1.5	6	mA
Current Limit	$ V_{\text{IN}} - V_{\text{OUT}}  \leq 15\text{V}$ K, MP and T Package H Package $ V_{\text{IN}} - V_{\text{OUT}}  = 40\text{V}$ , $T_j = 25^\circ\text{C}$ K, MP and T Package H Package	1.5	2.2	3.5	1.5	2.2	3.7	A
		0.5	0.8	1.8	0.5	0.8	1.9	A
		0.24	0.4		0.15	0.4		A
		0.15	0.17		0.10	0.17		A
RMS Output Noise, % of $V_{\text{OUT}}$	$T_j = 25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 10\text{ kHz}$		0.003			0.003		%
Ripple Rejection Ratio	$V_{\text{OUT}} = -10\text{V}$ , $f = 120\text{ Hz}$ $C_{\text{ADJ}} = 10\text{ }\mu\text{F}$		60			60		dB
		66	77		66	77		dB
Long-Term Stability	$T_j = 125^\circ\text{C}$ , 1000 Hours		0.3	1		0.3	1	%
Thermal Resistance, Junction to Case	H Package		12	15		12	15	$^\circ\text{C/W}$
	K Package		2.3	3		2.3	3	$^\circ\text{C/W}$
	T Package					4		$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient (No Heat Sink)	H Package		140			140		$^\circ\text{C/W}$
	K Package		35			35		$^\circ\text{C/W}$
	T Package					50		$^\circ\text{C/W}$
	MP Package					170		$^\circ\text{C/W}$

**Note 1:** Unless otherwise specified, these specifications apply  $-55^\circ\text{C} \leq T_j \leq +150^\circ\text{C}$  for the LM137,  $0^\circ\text{C} \leq T_j \leq +125^\circ\text{C}$  for the LM337;  $V_{\text{IN}} - V_{\text{OUT}} = 5\text{V}$ ; and  $I_{\text{OUT}} = 0.1\text{A}$  for the TO-39 package and  $I_{\text{OUT}} = 0.5\text{A}$  for the TO-3, SOT-223 and TO-220 packages. Although power dissipation is internally limited, these specifications are applicable for power dissipations of 2W for the TO-39 and SOT-223 (see Application Hints), and 20W for the TO-3, and TO-220.  $I_{\text{MAX}}$  is 1.5A for the TO-3, SOT-223 and TO-220 packages, and 0.2A for the TO-39 package.

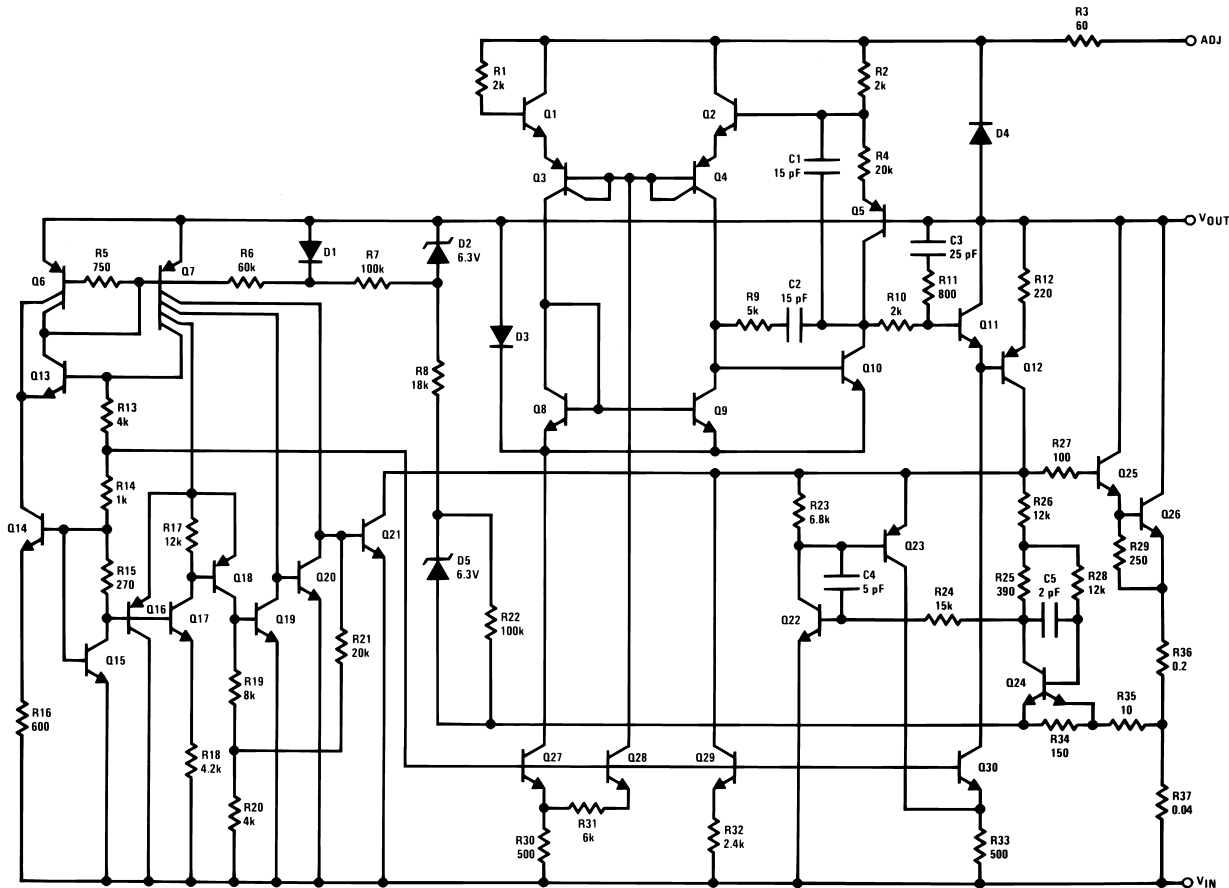
**Note 2:** Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation. Load regulation is measured on the output pin at a point  $\frac{1}{8}$ " below the base of the TO-3 and TO-39 packages.

**Note 3:** Selected devices with tightened tolerance reference voltage available.

# Electrical Characteristics (Note 1) (Continued)

Note 4: Refer to RETS137H drawing for LM137H or RETS137K drawing for LM137K military specifications.

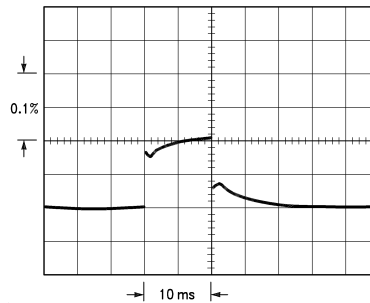
## Schematic Diagram



00906702

## Thermal Regulation

When power is dissipated in an IC, a temperature gradient occurs across the IC chip affecting the individual IC circuit components. With an IC regulator, this gradient can be especially severe since power dissipation is large. Thermal regulation is the effect of these temperature gradients on output voltage (in percentage output change) per Watt of power change in a specified time. Thermal regulation error is independent of electrical regulation or temperature coefficient, and occurs within 5 ms to 50 ms after a change in power dissipation. Thermal regulation depends on IC layout as well as electrical design. The thermal regulation of a voltage regulator is defined as the percentage change of  $V_{OUT}$ , per Watt, within the first 10 ms after a step of power is applied. The LM137's specification is 0.02%/W, max.



00906703

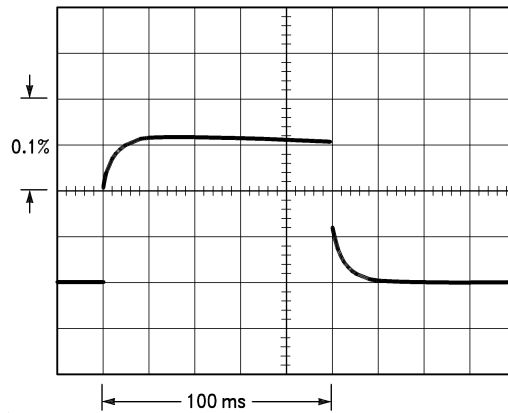
LM137,  $V_{OUT} = -10V$   
 $V_{IN} - V_{OUT} = -40V$   
 $I_L = 0A \rightarrow 0.25A \rightarrow 0A$   
 Vertical sensitivity, 5 mV/div

FIGURE 1.

## Thermal Regulation (Continued)

In *Figure 1*, a typical LM137's output drifts only 3 mV (or 0.03% of  $V_{OUT} = -10V$ ) when a 10W pulse is applied for 10 ms. This performance is thus well inside the specification limit of  $0.02\%/W \times 10W = 0.2\%$  max. When the 10W pulse is

ended, the thermal regulation again shows a 3 mV step at the LM137 chip cools off. Note that the load regulation error of about 8 mV (0.08%) is additional to the thermal regulation error. In *Figure 2*, when the 10W pulse is applied for 100 ms, the output drifts only slightly beyond the drift in the first 10 ms, and the thermal error stays well within 0.1% (10 mV).

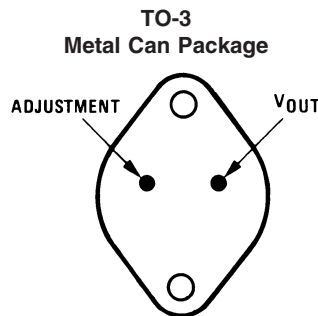


00906704

LM137,  $V_{OUT} = -10V$   
 $V_{IN} - V_{OUT} = -40V$   
 $I_L = 0A \rightarrow 0.25A \rightarrow 0A$   
 Horizontal sensitivity, 20 ms/div

FIGURE 2.

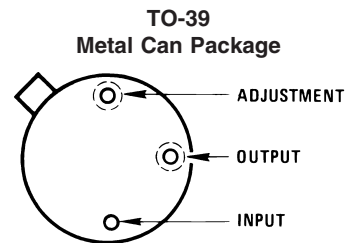
## Connection Diagrams



00906705

Case Is Input

**Bottom View**  
 Order Number LM137K/883  
 LM137KPQML and LM137KPQMLV(Note 5)  
 See NS Package Number K02C  
 Order Number LM337K STEEL  
 See NS Package Number K02A



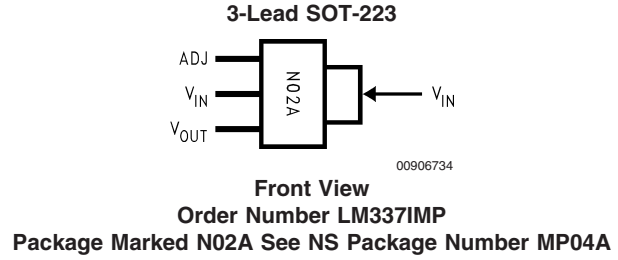
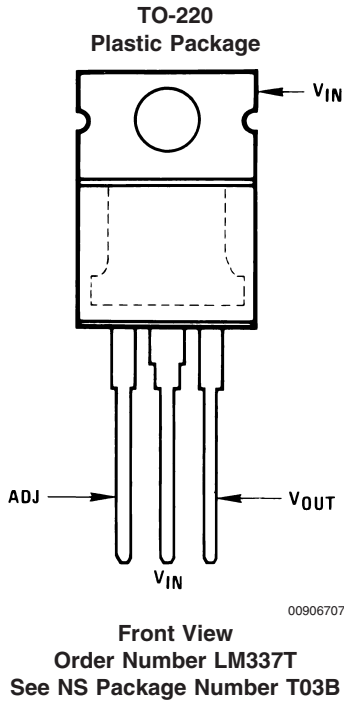
00906706

Case Is Input

**Note 5:** See STD Mil DWG 5962P99517 for Radiation Tolerant Devices

**Bottom View**  
 Order Number LM137H, LM137H/883 or LM337H  
 LM137HPQML and LM137HPQMLV(Note 5)  
 See NS Package Number H03A

Connection Diagrams (Continued)



Application Hints

When a value for  $\theta_{(H-A)}$  is found using the equation shown, a heatsink must be selected that has a value that is less than or equal to this number.

HEATSINKING SOT-223 PACKAGE PARTS

The SOT-223 ("MP") packages use a copper plane on the PCB and the PCB itself as a heatsink. To optimize the heat sinking ability of the plane and PCB, solder the tab of the package to the plane.

Figures 3, 4 show the information for the SOT-223 package. Figure 4 assumes a  $\theta_{(J-A)}$  of 75°C/W for 1 ounce copper and 51°C/W for 2 ounce copper and a maximum junction temperature of 125°C.

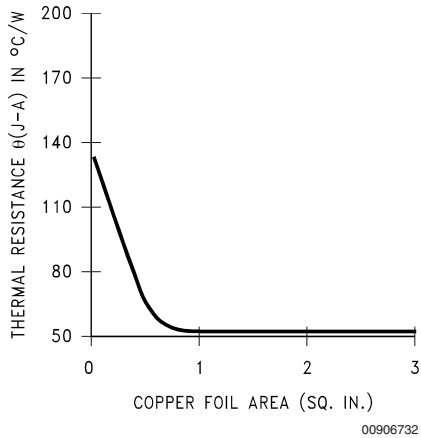


FIGURE 3.  $\theta_{(J-A)}$  vs Copper (2 ounce) Area for the SOT-223 Package

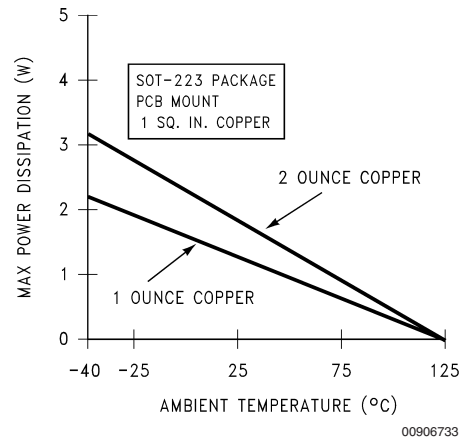
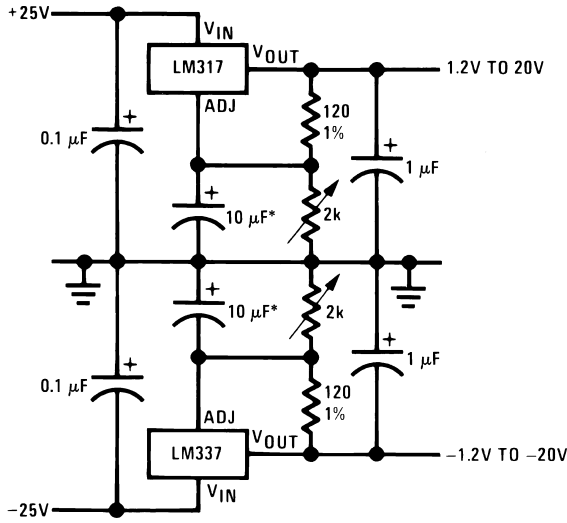


FIGURE 4. Maximum Power Dissipation vs.  $T_{AMB}$  for the SOT-223 Package

Please see AN1028 for power enhancement techniques to be used with the SOT-223 package.

# Typical Applications

### Adjustable Lab Voltage Regulator

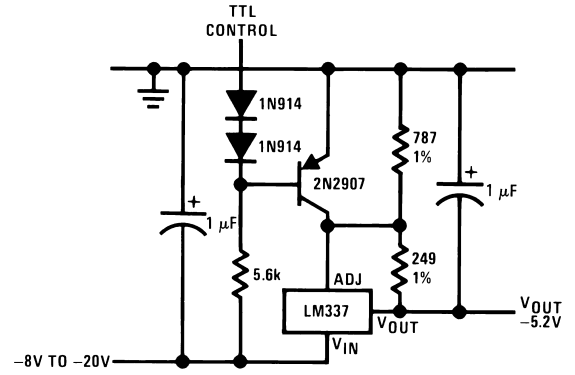


00906709

Full output current not available at high input-output voltages

\*The 10 μF capacitors are optional to improve ripple rejection

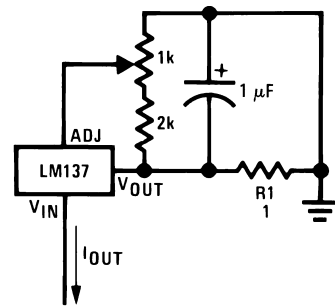
### -5.2V Regulator with Electronic Shutdown\*



00906710

\*Minimum output = -1.3V when control input is low

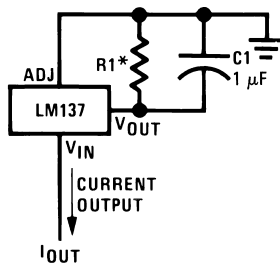
### Adjustable Current Regulator



00906712

$$I_{OUT} = \left( \frac{1.5V}{R1} \right) \pm 15\% \text{ adjustable}$$

### Current Regulator

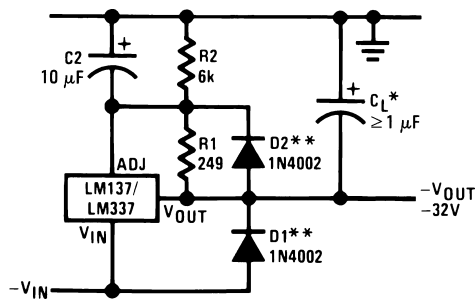


00906711

$$I_{OUT} = \frac{1.250V}{R1}$$

\*0.8Ω ≤ R1 ≤ 120Ω

### Negative Regulator with Protection Diodes

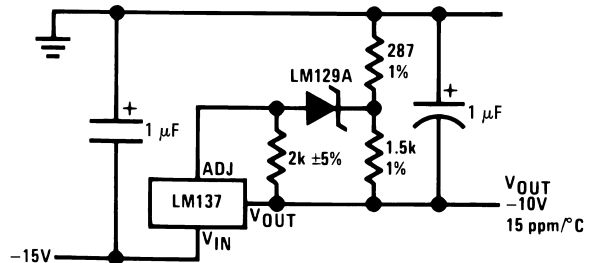


00906713

\*When C<sub>L</sub> is larger than 20 μF, D1 protects the LM137 in case the input supply is shorted

\*\*When C<sub>2</sub> is larger than 10 μF and -V<sub>OUT</sub> is larger than -25V, D2 protects the LM137 in case the output is shorted

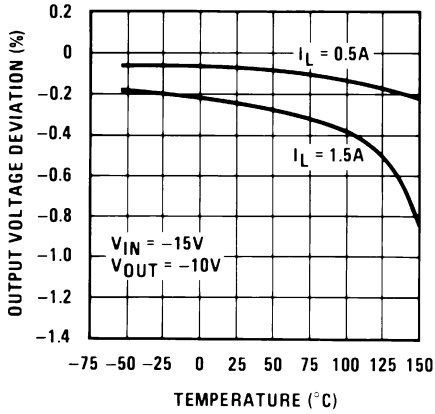
### High Stability -10V Regulator



00906714

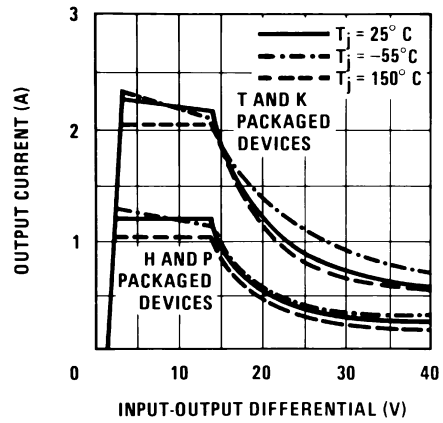
# Typical Performance Characteristics (K Steel and T Packages)

**Load Regulation**



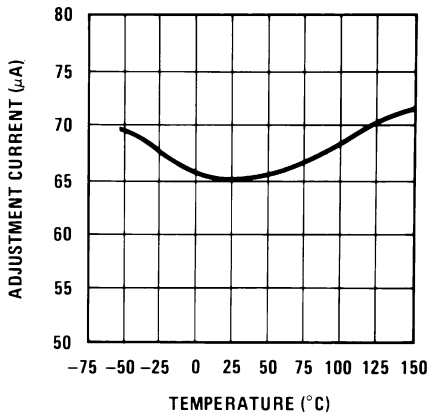
00906716

**Current Limit**



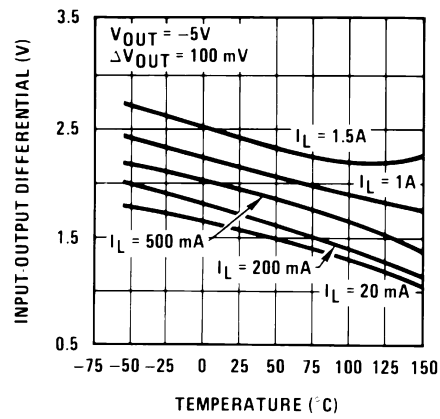
00906717

**Adjustment Current**



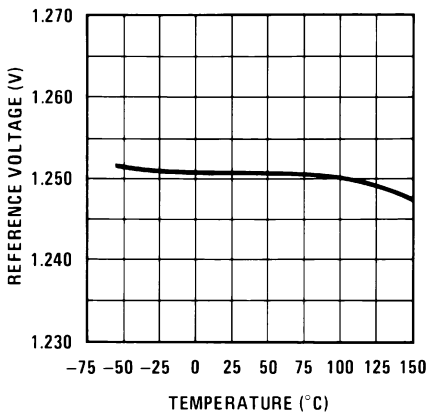
00906718

**Dropout Voltage**



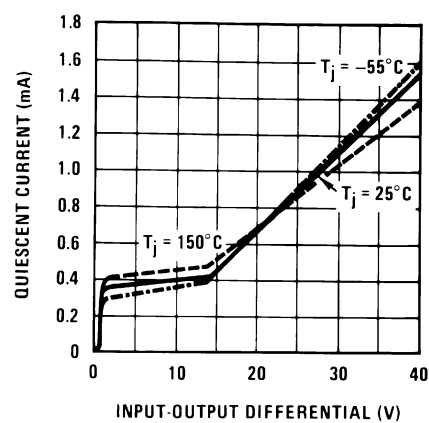
00906719

**Temperature Stability**



00906720

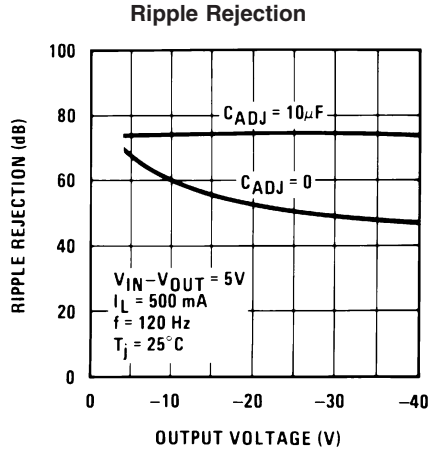
**Minimum Operating Current**



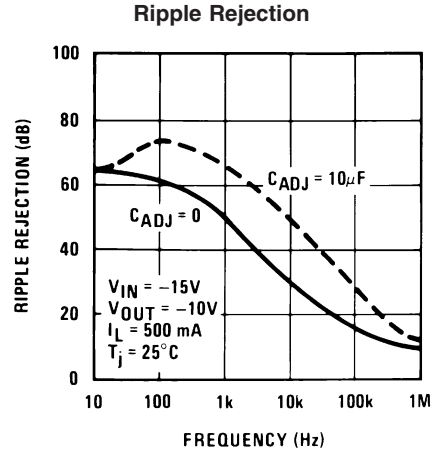
00906721



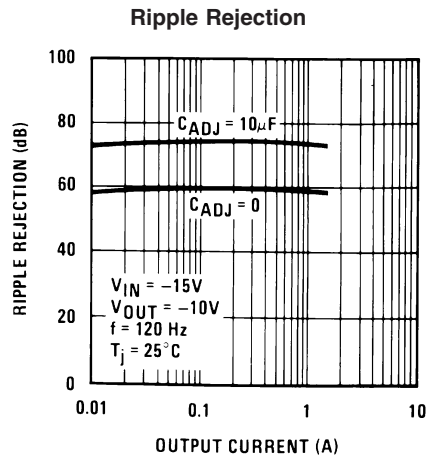
# Typical Performance Characteristics (K Steel and T Packages) (Continued)



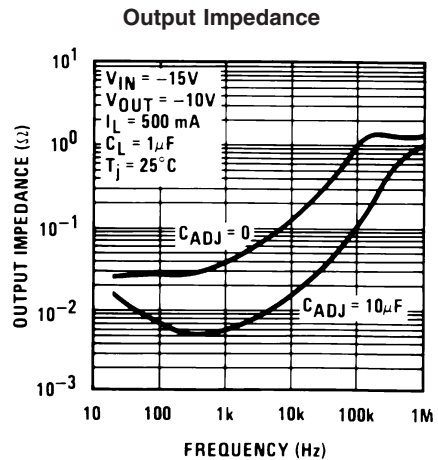
00906722



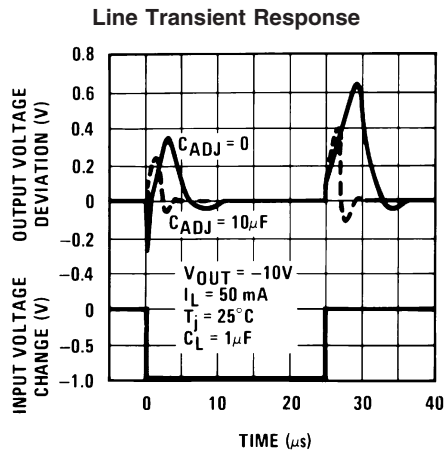
00906723



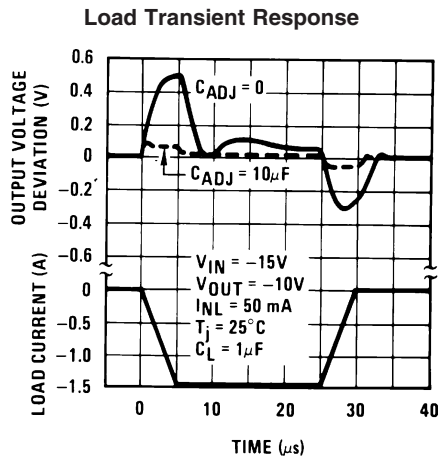
00906724



00906725



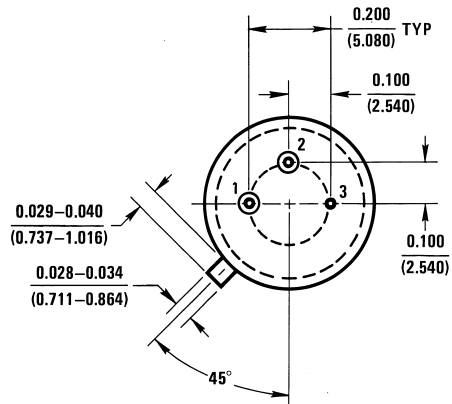
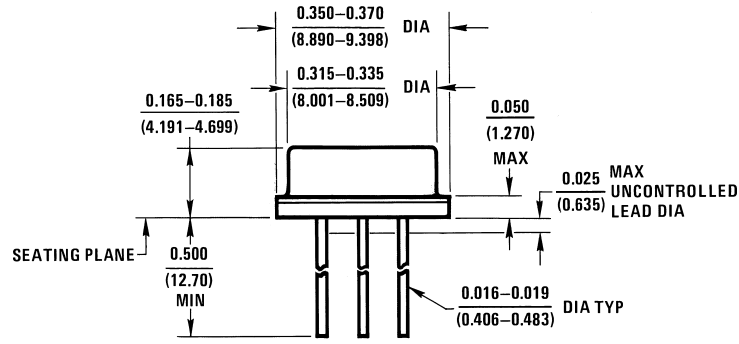
00906726



00906727

**Physical Dimensions** inches (millimeters)

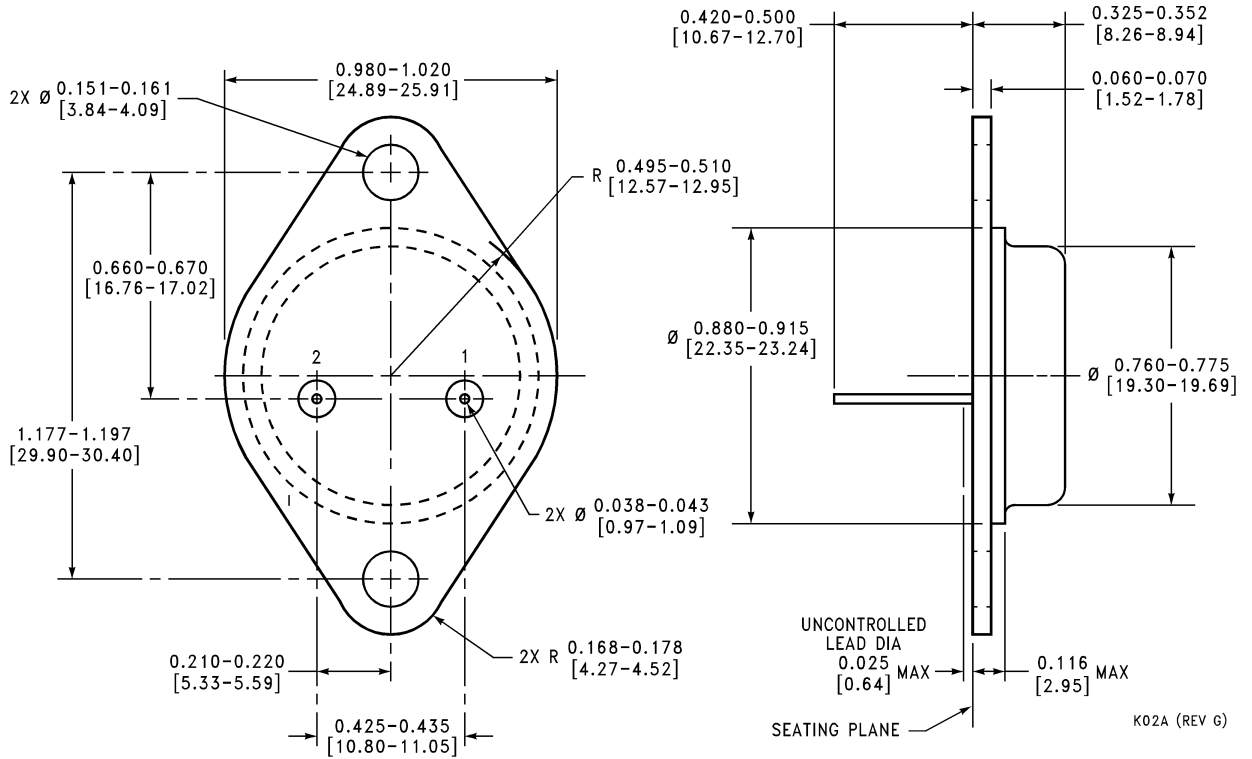
unless otherwise noted



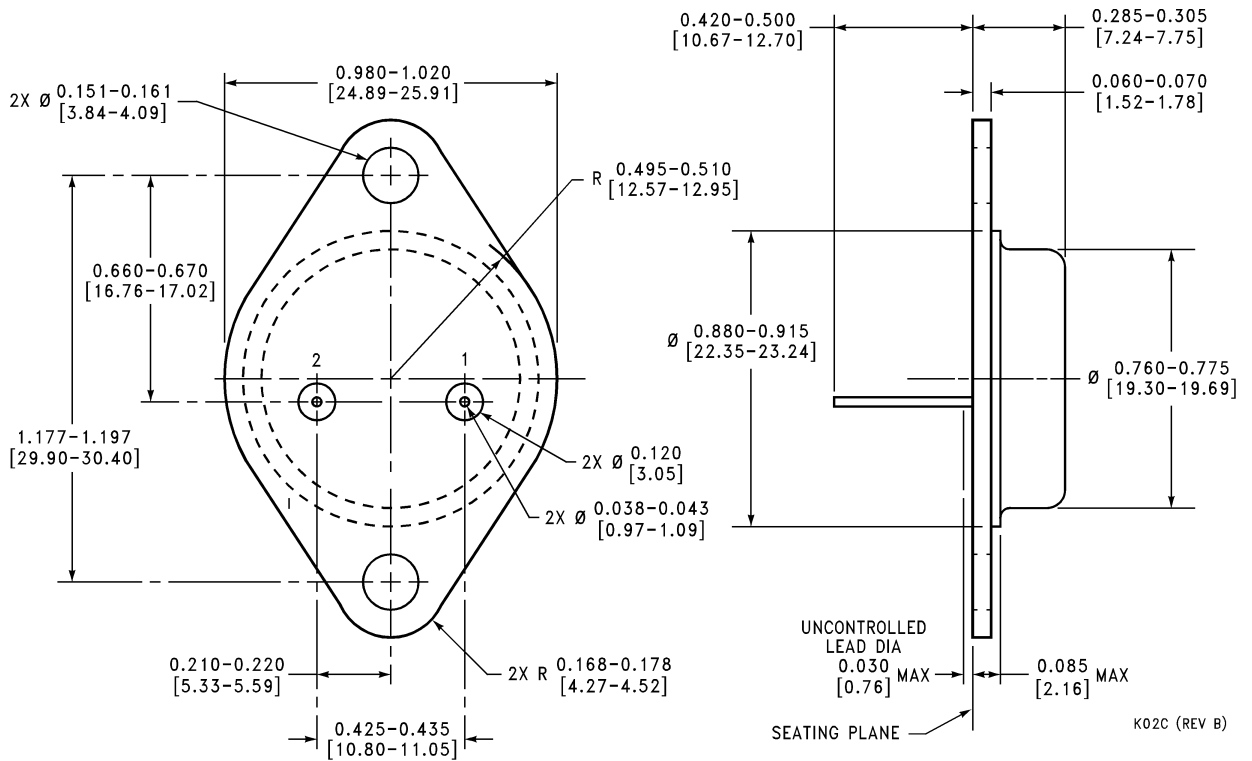
H03A (REV B)

**Metal Can Package (H)**  
**Order Number LM137H, LM137H/883 or LM337H**  
**NS Package Number H03A**

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

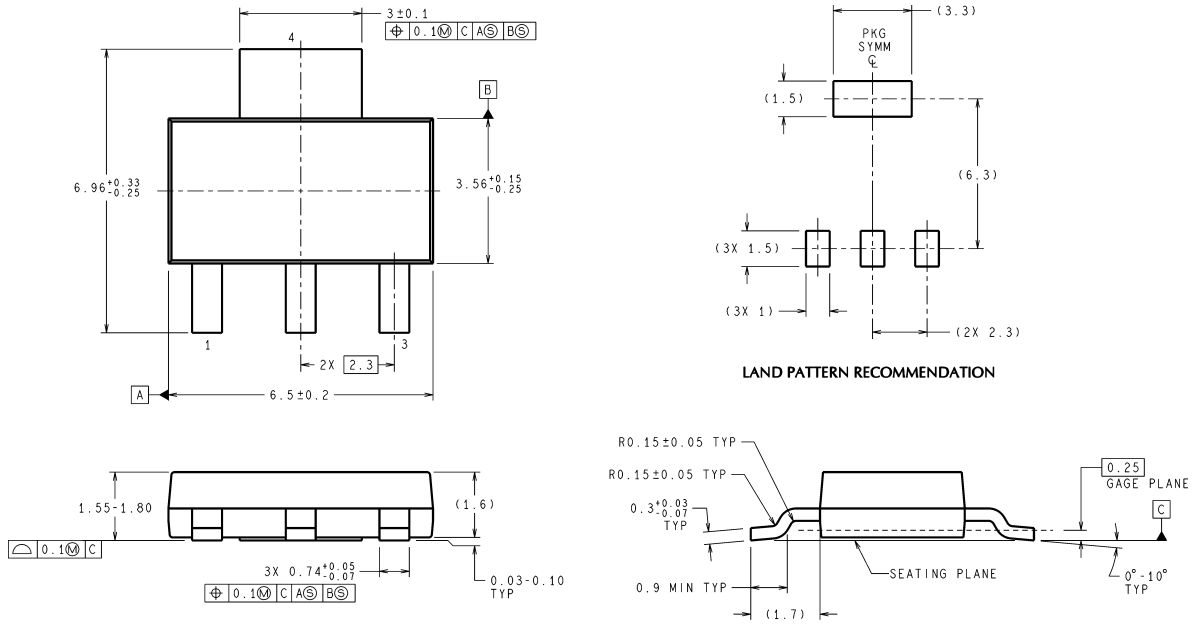


**Metal Can Package (K)**  
**Order Number LM337K STEEL**  
**NS Package Number K02A**



**Mil-Aero Metal Can Package (K)**  
**Order Number LM137K/883**  
**NS Package Number K02C**

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

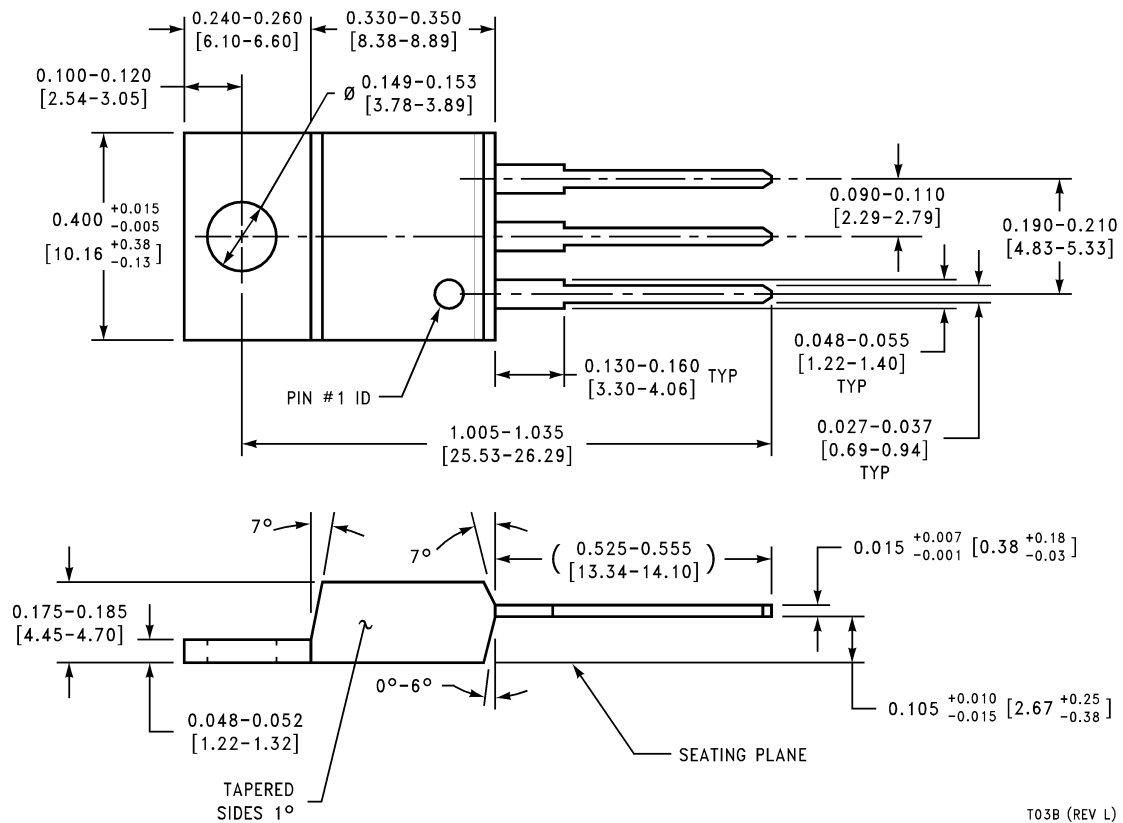


DIMENSIONS ARE IN MILLIMETERS

MP04A (Rev B)

**3-Lead SOT-223 Package  
Order Number LM337IMP  
NS Package Number MP04A**

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



**TO-220 Plastic Package (T)**  
**Order Number LM337T**  
**NS Package Number T03B**

T03B (REV L)

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

For the most current product information visit us at [www.national.com](http://www.national.com).


**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.

**BANNED SUBSTANCE COMPLIANCE**

National Semiconductor certifies that the products and packing materials meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.

 **National Semiconductor**  
**Americas Customer Support Center**  
 Email: [new.feedback@nsc.com](mailto:new.feedback@nsc.com)  
 Tel: 1-800-272-9959

**National Semiconductor**  
**Europe Customer Support Center**  
 Fax: +49 (0) 180-530 85 86  
 Email: [europe.support@nsc.com](mailto: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 Support Center**  
 Email: [ap.support@nsc.com](mailto:ap.support@nsc.com)

**National Semiconductor**  
**Japan Customer Support Center**  
 Fax: 81-3-5639-7507  
 Email: [jpn.feedback@nsc.com](mailto:jpn.feedback@nsc.com)  
 Tel: 81-3-5639-7560

## 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

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Mobile Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Transportation and Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2011, Texas Instruments Incorporated