

## Series Low Dropout Regulators

### General Description

The LM2931 positive voltage regulator features a very low quiescent current of 1mA or less when supplying 10mA loads. This unique characteristic and the extremely low input-output differential required for proper regulation (0.2V for output currents of 10mA) make the LM2931 the ideal regulator for standby power systems. Applications include memory standby circuits, CMOS and other low power processor power supplies as well as systems demanding as much as 100mA of output current.

Designed originally for automotive applications, the LM2931 and all regulated circuitry are protected from reverse battery installations or 2 battery jumps. During line transients, such as a load dump (60V) when the input voltage to the regulator can momentarily exceed the specified maximum operating voltage, the regulator will automatically shut down to protect both internal circuits and the load. The LM2931 cannot be harmed by temporary mirror-image insertion. Familiar regulator features such as short circuit and thermal overload protection are also provided.

The LM2931 family includes a fixed 5V output ( $\pm 3.8\%$  tolerance for A grade) or an adjustable output with ON/OFF pin.

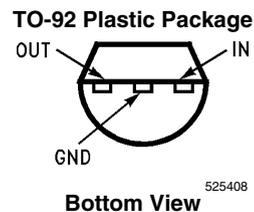
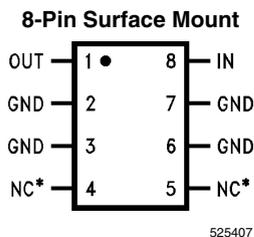
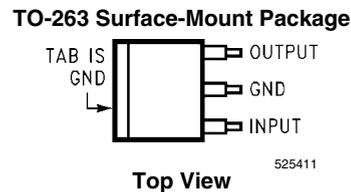
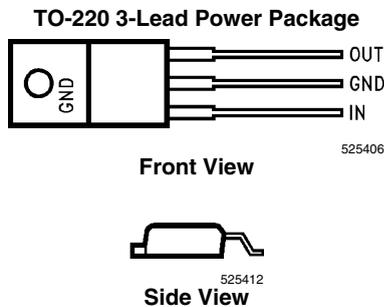
Both versions are available in a TO-220 power package, TO-263 surface mount package, and an 8-lead surface mount package. The fixed output version is also available in the TO-92 plastic package.

### Features

- Very low quiescent current
- Output current in excess of 100 mA
- Input-output differential less than 0.6V
- Reverse battery protection
- 60V load dump protection
- -50V reverse transient protection
- Short circuit protection
- Internal thermal overload protection
- Mirror-image insertion protection
- Available in TO-220, TO-92, TO-263, or SO-8 packages
- Available as adjustable with TTL compatible switch

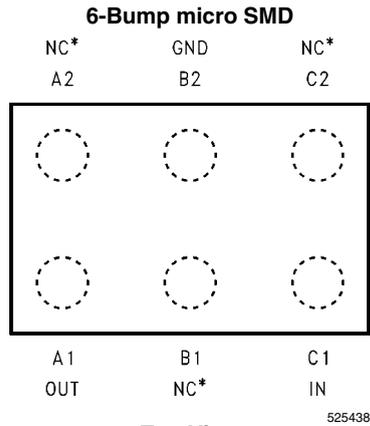
### Connection Diagrams

#### FIXED VOLTAGE OUTPUT

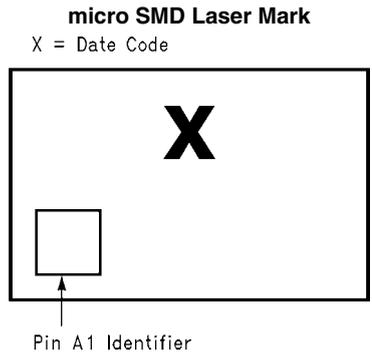


\*NC = Not internally connected. Must be electrically isolated from the rest of the circuit for the micro SMD package.

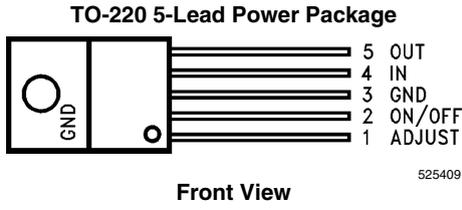
#### Top View



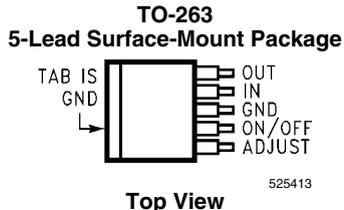
**Top View  
(Bump Side Down)**



**ADJUSTABLE OUTPUT VOLTAGE**



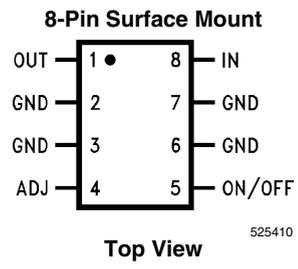
**Front View**



**Top View**



**Side View**

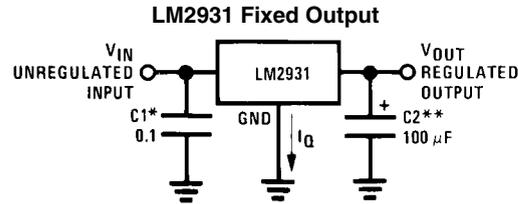


**Top View**

## Ordering Information

Output Voltage	Package Type	NSC Drawing	Order Number	Package Marking	Transport Media
5V	8-Pin SOIC Narrow	M08A	LM2931AM-5.0	2931AM-5.0	Rail of 95
			LM2931AMX-5.0	2931AM-5.0	Reel of 2500
			LM2931M-5.0	2931M-5.0	Rail of 95
			LM2931MX-5.0	2931M-5.0	Reel of 2500
	3-Pin TO-220	T03B	LM2931AT-5.0	LM2931AT5.0	Rail of 45
			LM2931T-5.0	LM2931T5.0	Rail of 45
	3-Pin TO-263	TS3B	LM2931AS-5.0	LM2931AS5.0	Rail of 45
			LM2931ASX-5.0	LM2931AS5.0	Reel of 500
			LM2931S-5.0	LM2931S5.0	Rail of 45
	3-Pin TO-92	Z03A	LM2931AZ-5.0	LM2931AZ-5	Box of 1800
LM2931Z-5.0			LM2931Z-5	Box of 1800	
Adjustable 3V to 24V	8-Pin SOIC Narrow	M08A	LM2931CM	LM2931CM	Rail of 95
			LM2931CMX	LM2931CM	Reel of 2500
	5-Pin TO-220	T05A	LM2931CT	LM2931CT	Rail of 45
	5-Pin TO-263	TS5B	LM2931CS	LM2931CS	Rail of 45

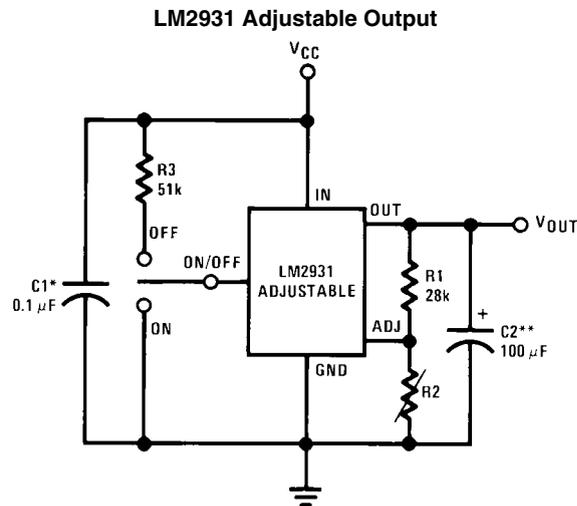
## Typical Applications



525404

\*Required if regulator is located far from power supply filter.

\*\*C2 must be at least 100 μF to maintain stability. May be increased without bound to maintain regulation during transients. Locate as close as possible to the regulator. This capacitor must be rated over the same operating temperature range as the regulator. The equivalent series resistance (ESR) of this capacitor is critical; see curve.



525405

$$V_{OUT} = \text{Reference Voltage} \times \frac{R1 + R2}{R1}$$

**Note:** Using 27k for R1 will automatically compensate for errors in  $V_{OUT}$  due to the input bias current of the ADJ pin (approximately 1 μA).

## Absolute Maximum Ratings *(Note 1)*

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

Input Voltage	
Operating Range	26V
Overvoltage Protection	
LM2931A, LM2931C (Adjustable)	60V
LM2931	50V
Internal Power Dissipation	
<i>(Note 2, Note 4)</i>	Internally Limited
Operating Ambient Temperature	
Range	-40°C to +85°C
Maximum Junction Temperature	125°C
Storage Temperature Range	-65°C to +150°C
Lead Temp. (Soldering, 10 seconds)	230°C
ESD Tolerance <i>(Note 5)</i>	2000V

## Electrical Characteristics for Fixed 3.3V Version

$V_{IN} = 14V$ ,  $I_O = 10mA$ ,  $T_J = 25^\circ C$ ,  $C_2 = 100\mu F$  (unless otherwise specified) *(Note 2)*

Parameter	Conditions	LM2931-3.3		Units
		Typ	Limit <i>(Note 3)</i>	
Output Voltage		3.3	3.465 3.135	$V_{MAX}$ $V_{MIN}$
	$4V \leq V_{IN} \leq 26V$ , $I_O = 100mA$ $-40^\circ C \leq T_J \leq 125^\circ C$		<b>3.630</b> <b>2.970</b>	$V_{MAX}$ $V_{MIN}$
Line Regulation	$4V \leq V_{IN} \leq 26V$	4	33	$mV_{MAX}$
Load Regulation	$5mA \leq I_O \leq 100mA$	10	50	$mV_{MAX}$
Output Impedance	$100mA_{DC}$ and $10mA_{rms}$ , 100Hz - 10kHz	200		$m\Omega$
Quiescent Current	$I_O \leq 10mA$ , $4V \leq V_{IN} \leq 26V$ $-40^\circ C \leq T_J \leq 125^\circ C$	0.4	<b>1.0</b>	$mA_{MAX}$
	$I_O = 100mA$ , $V_{IN} = 14V$ , $T_J = 25^\circ C$	15		mA
Output Noise Voltage	10Hz -100kHz, $C_{OUT} = 100\mu F$	330		$\mu V_{rms}$
Long Term Stability		13		mV/1000 hr
Ripple Rejection	$f_O = 120Hz$	80		dB
Dropout Voltage	$I_O = 10mA$	0.05	0.2	$V_{MAX}$
	$I_O = 100mA$	0.30	0.6	
Maximum Operational Input Voltage		33	26	$V_{MIN}$
Maximum Line Transient	$R_L = 500\Omega$ , $V_O \leq 5.5V$ , $T = 1ms$ , $\tau \leq 100ms$	70	50	$V_{MIN}$
Reverse Polarity Input Voltage, DC	$V_O \geq -0.3V$ , $R_L = 500\Omega$	-30	-15	$V_{MIN}$
Reverse Polarity Input Voltage, Transient	$T = 1ms$ , $\tau \leq 100ms$ , $R_L = 500\Omega$	-80	-50	$V_{MIN}$

## Electrical Characteristics for Fixed 5V Version

$V_{IN} = 14V$ ,  $I_O = 10mA$ ,  $T_J = 25^\circ C$ ,  $C_2 = 100 \mu F$  (unless otherwise specified) (*Note 2*)

Parameter	Conditions	LM2931A-5.0		LM2931-5.0		Units
		Typ	Limit ( <i>Note 3</i> )	Typ	Limit ( <i>Note 3</i> )	
Output Voltage		5	5.19 4.81	5	5.25 4.75	$V_{MAX}$ $V_{MIN}$
	$6.0V \leq V_{IN} \leq 26V$ , $I_O = 100mA$ $-40^\circ C \leq T_J \leq 125^\circ C$		<b>5.25</b> <b>4.75</b>		<b>5.5</b> <b>4.5</b>	$V_{MAX}$ $V_{MIN}$
Line Regulation	$9V \leq V_{IN} \leq 16V$	2	10	2	10	$mV_{MAX}$
	$6V \leq V_{IN} \leq 26V$	4	30	4	30	
Load Regulation	$5 mA \leq I_O \leq 100mA$	14	50	14	50	$mV_{MAX}$
Output Impedance	$100mA_{DC}$ and $10mA_{rms}$ , $100Hz - 10kHz$	200		200		$m\Omega$
Quiescent Current	$I_O \leq 10mA$ , $6V \leq V_{IN} \leq 26V$ $-40^\circ C \leq T_J \leq 125^\circ C$	0.4	<b>1.0</b>	0.4	<b>1.0</b>	$mA_{MAX}$
	$I_O = 100mA$ , $V_{IN} = 14V$ , $T_J = 25^\circ C$	15	30	15		$mA_{MAX}$
Output Noise Voltage	$10Hz - 100kHz$ , $C_{OUT} = 100\mu F$	500		500		$\mu V_{rms}$
Long Term Stability		20		20		$mV/1000$ hr
Ripple Rejection	$f_O = 120 Hz$	80	<b>55</b>	80		$dB_{MIN}$
Dropout Voltage	$I_O = 10mA$	0.05	0.2	0.05	0.2	$V_{MAX}$
	$I_O = 100mA$	0.3	0.6	0.3	0.6	
Maximum Operational Input Voltage		33	26	33	26	$V_{MIN}$
Maximum Line Transient	$R_L = 500\Omega$ , $V_O \leq 5.5V$ , $T = 1ms$ , $\tau \leq 100ms$	70	60	70	50	$V_{MIN}$
Reverse Polarity Input Voltage, DC	$V_O \geq -0.3V$ , $R_L = 500\Omega$	-30	-15	-30	-15	$V_{MIN}$
Reverse Polarity Input Voltage, Transient	$T = 1ms$ , $\tau \leq 100ms$ , $R_L = 500\Omega$	-80	-50	-80	-50	$V_{MIN}$

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Electrical specifications do not apply when operating the device beyond its rated operating conditions.

**Note 2:** See circuit in Typical Applications. To ensure constant junction temperature, low duty cycle pulse testing is used.

**Note 3:** All limits are guaranteed for  $T_J = 25^\circ C$  (standard type face) or over the full operating junction temperature range of  $-40^\circ C$  to  $+125^\circ C$  (bold type face).

**Note 4:** The maximum power dissipation is a function of maximum junction temperature  $T_{Jmax}$ , total thermal resistance  $\theta_{JA}$ , and ambient temperature  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{Jmax} - T_A)/\theta_{JA}$ . If this dissipation is exceeded, the die temperature will rise above  $150^\circ C$  and the LM2931 will go into thermal shutdown. For the LM2931 in the TO-92 package,  $\theta_{JA}$  is  $195^\circ C/W$ ; in the SO-8 package,  $\theta_{JA}$  is  $160^\circ C/W$ , and in the TO-220 package,  $\theta_{JA}$  is  $50^\circ C/W$ ; in the TO-263 package,  $\theta_{JA}$  is  $73^\circ C/W$ ; and in the 6-Bump micro SMD package  $\theta_{JA}$  is  $290^\circ C/W$ . If the TO-220 package is used with a heat sink,  $\theta_{JA}$  is the sum of the package thermal resistance junction-to-case of  $3^\circ C/W$  and the thermal resistance added by the heat sink and thermal interface.

If the TO-263 package is used, the thermal resistance can be reduced by increasing the P.C. board copper area thermally connected to the package: Using 0.5 square inches of copper area,  $\theta_{JA}$  is  $50^\circ C/W$ ; with 1 square inch of copper area,  $\theta_{JA}$  is  $37^\circ C/W$ ; and with 1.6 or more square inches of copper area,  $\theta_{JA}$  is  $32^\circ C/W$ .

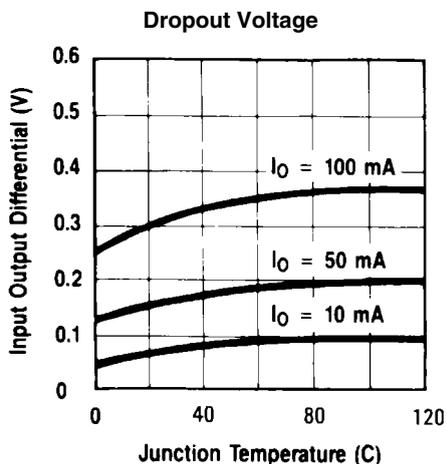
**Note 5:** Human body model, 100 pF discharged through 1.5 k $\Omega$ .

## Electrical Characteristics for Adjustable Version

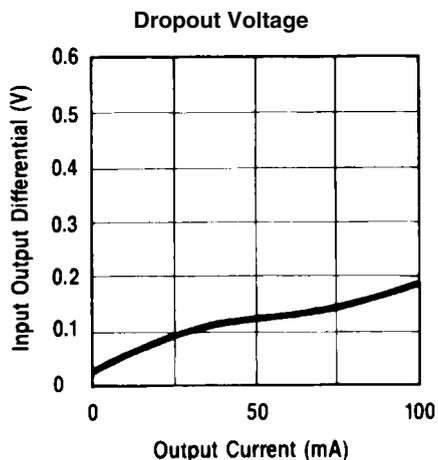
 $V_{IN} = 14V$ ,  $V_{OUT} = 3V$ ,  $I_O = 10\text{ mA}$ ,  $T_J = 25^\circ\text{C}$ ,  $R_1 = 27k$ ,  $C_2 = 100\ \mu\text{F}$  (unless otherwise specified) (*Note 2*)

Parameter	Conditions	Typ	Limit	Units Limit
Reference Voltage		1.20	1.26 1.14	$V_{MAX}$ $V_{MIN}$
	$I_O \leq 100\text{ mA}$ , $-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$ , $R_1 = 27k$ Measured from $V_{OUT}$ to Adjust Pin		<b>1.32</b> <b>1.08</b>	$V_{MAX}$ $V_{MIN}$
Output Voltage Range			24 3	$V_{MAX}$ $V_{MIN}$
Line Regulation	$V_{OUT} + 0.6V \leq V_{IN} \leq 26V$	0.2	1.5	$\text{mV}/V_{MAX}$
Load Regulation	$5\text{ mA} \leq I_O \leq 100\text{ mA}$	0.3	1	$\%_{MAX}$
Output Impedance	$100\text{ mA}_{DC}$ and $10\text{ mA}_{rms}$ , 100 Hz–10 kHz	40		$\text{m}\Omega/V$
Quiescent Current	$I_O = 10\text{ mA}$	0.4	1	$\text{mA}_{MAX}$
	$I_O = 100\text{ mA}$	15		mA
	During Shutdown $R_L = 500\Omega$	0.8	1	$\text{mA}_{MAX}$
Output Noise Voltage	10 Hz–100 kHz	100		$\mu\text{V}_{rms}/V$
Long Term Stability		0.4		$\%/1000\text{ hr}$
Ripple Rejection	$f_o = 120\text{ Hz}$	0.02		$\%/V$
Dropout Voltage	$I_O \leq 10\text{ mA}$	0.05	0.2	$V_{MAX}$
	$I_O = 100\text{ mA}$	0.3	0.6	$V_{MAX}$
Maximum Operational Input Voltage		33	26	$V_{MIN}$
Maximum Line Transient	$I_O = 10\text{ mA}$ , Reference Voltage $\leq 1.5V$ $T = 1\text{ ms}$ , $\tau \leq 100\text{ ms}$	70	60	$V_{MIN}$
Reverse Polarity Input Voltage, DC	$V_O \geq -0.3V$ , $R_L = 500\Omega$	-30	-15	$V_{MIN}$
Reverse Polarity Input Voltage, Transient	$T = 1\text{ ms}$ , $\tau \leq 100\text{ ms}$ , $R_L = 500\Omega$	-80	-50	$V_{MIN}$
On/Off Threshold Voltage	$V_O = 3V$	2.0	1.2	$V_{MAX}$
		2.2	3.25	$V_{MIN}$
On/Off Threshold Current		20	50	$\mu\text{A}_{MAX}$

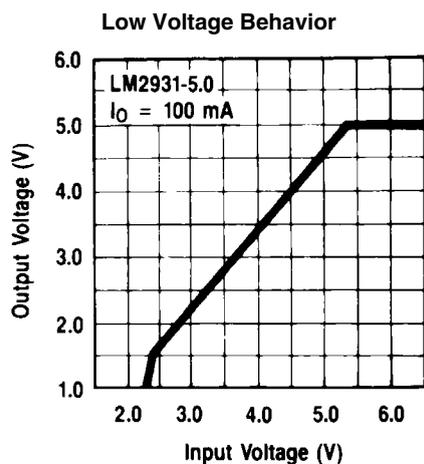
## Typical Performance Characteristics



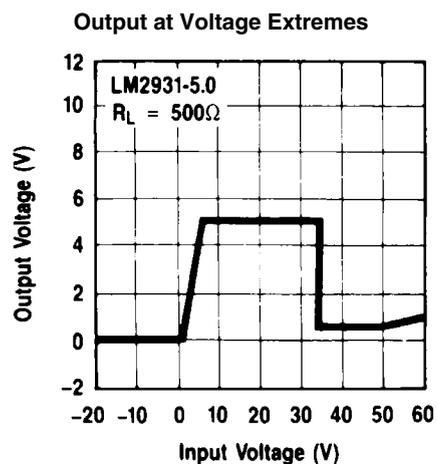
525416



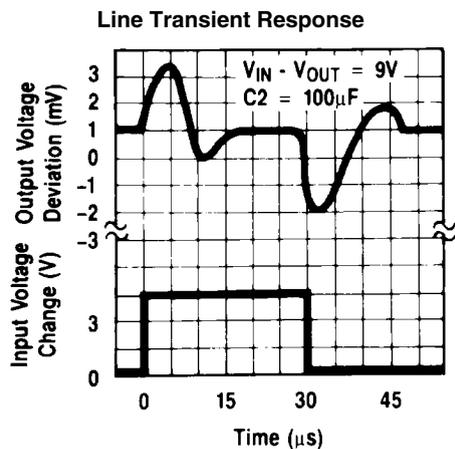
525417



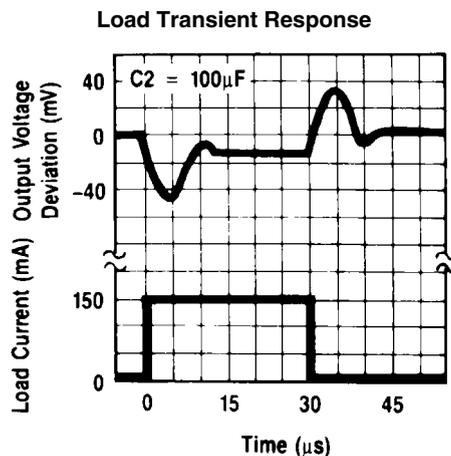
525418



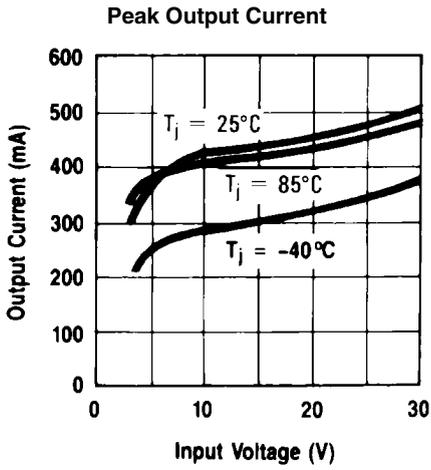
525419



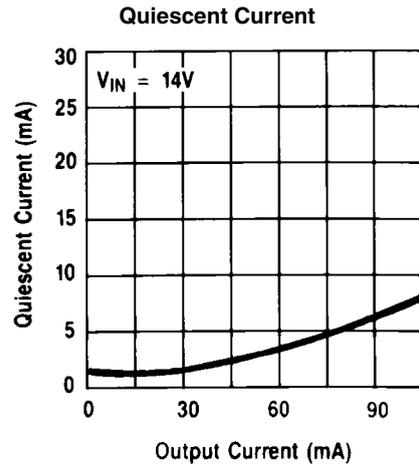
525420



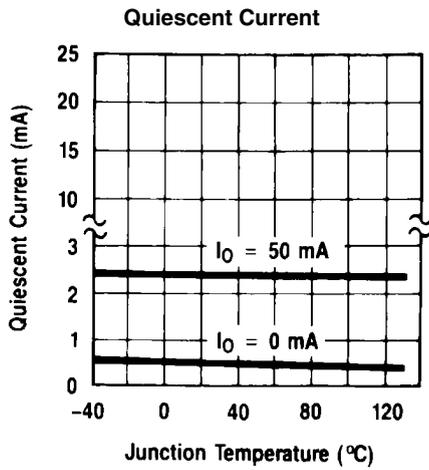
525421



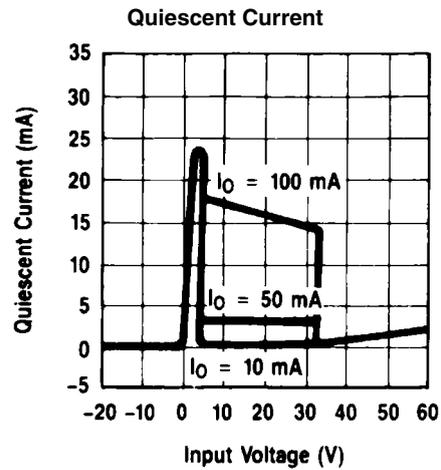
525422



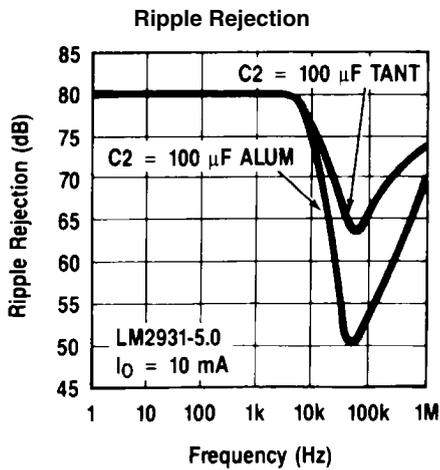
525423



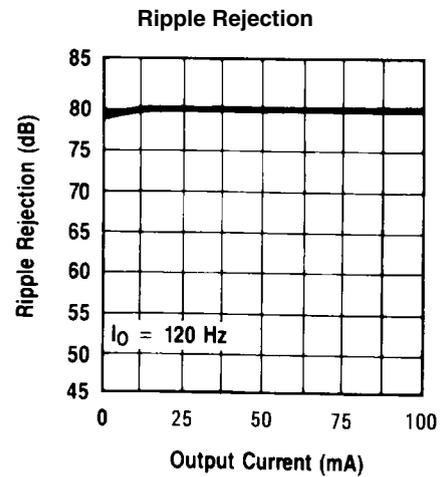
525424



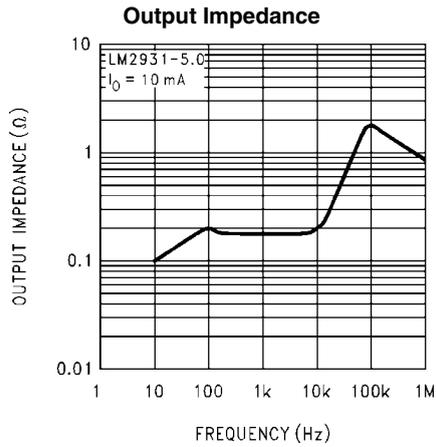
525425



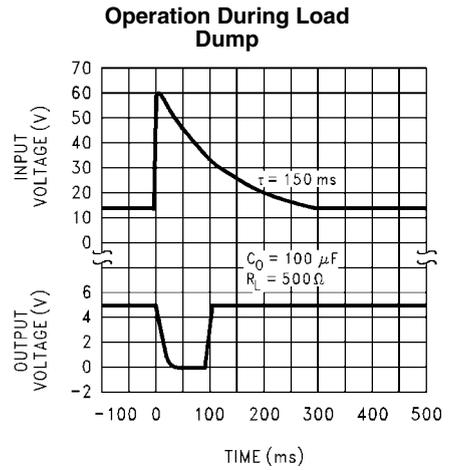
525426



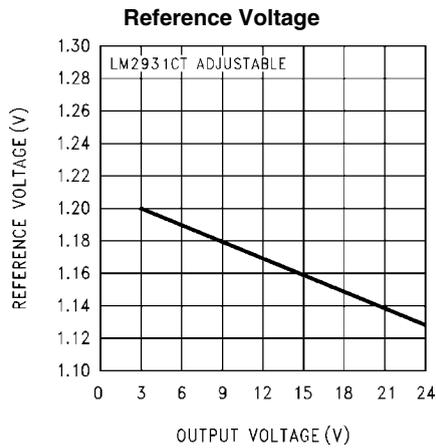
525427



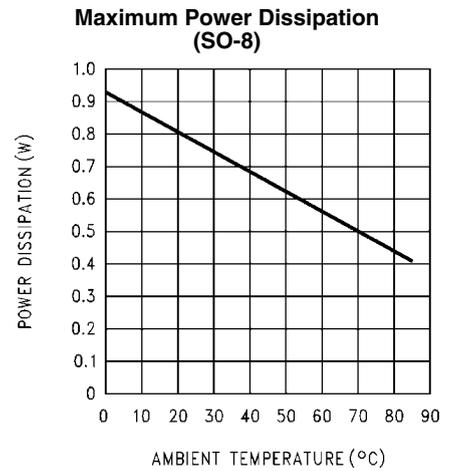
525428



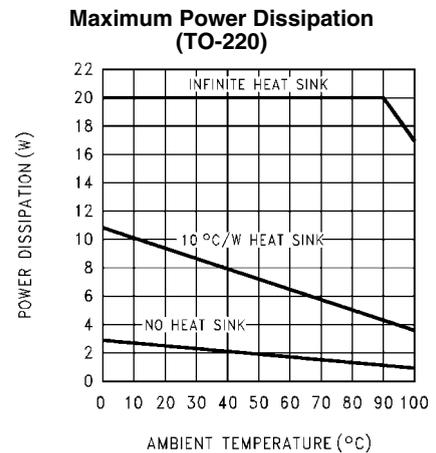
525429



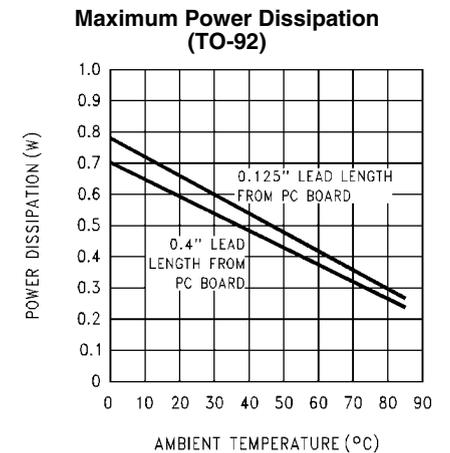
525430



525431

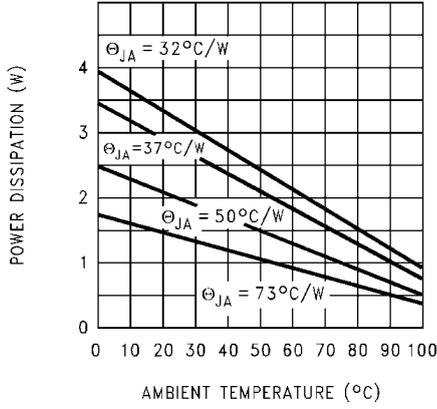


525432



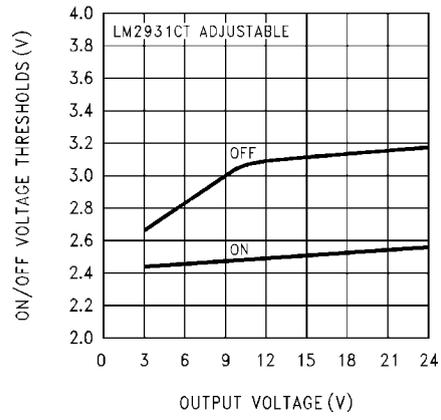
525433

**Maximum Power Dissipation  
(TO-263) (Note 4)**



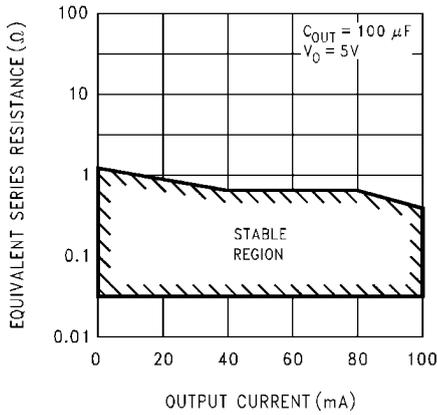
525434

**On/Off Threshold**



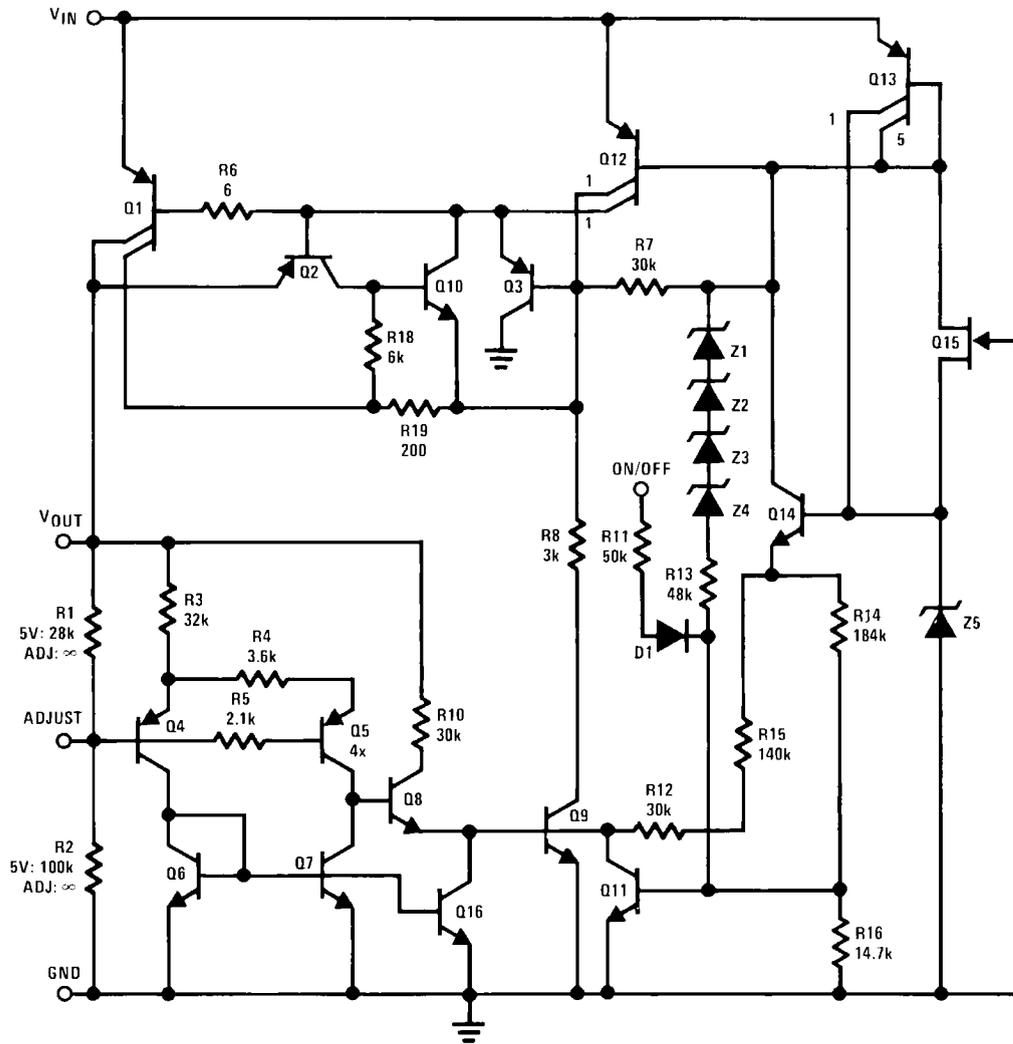
525435

**Output Capacitor ESR**



525436

### Schematic Diagram



525401

## Application Hints

One of the distinguishing factors of the LM2931 series regulators is the requirement of an output capacitor for device stability. The value required varies greatly depending upon the application circuit and other factors. Thus some comments on the characteristics of both capacitors and the regulator are in order.

High frequency characteristics of electrolytic capacitors depend greatly on the type and even the manufacturer. As a result, a value of capacitance that works well with the LM2931 for one brand or type may not necessary be sufficient with an electrolytic of different origin. Sometimes actual bench testing, as described later, will be the only means to determine the proper capacitor type and value. Experience has shown that, as a rule of thumb, the more expensive and higher quality electrolytics generally allow a smaller value for regulator stability. As an example, while a high-quality 100  $\mu\text{F}$  aluminum electrolytic covers all general application circuits, similar stability can be obtained with a tantalum electrolytic of only 47 $\mu\text{F}$ . This factor of two can generally be applied to any special application circuit also.

Another critical characteristic of electrolytics is their performance over temperature. While the LM2931 is designed to operate to  $-40^{\circ}\text{C}$ , the same is not always true with all electrolytics (hot is generally not a problem). The electrolyte in many aluminum types will freeze around  $-30^{\circ}\text{C}$ , reducing their effective value to zero. Since the capacitance is needed for regulator stability, the natural result is oscillation (and lots of it) at the regulator output. For all application circuits where cold operation is necessary, the output capacitor must be rated to operate at the minimum temperature. By coincidence, worst-case stability for the LM2931 also occurs at minimum temperatures. As a result, in applications where the regulator junction temperature will never be less than  $25^{\circ}\text{C}$ , the output capacitor can be reduced approximately by a factor of two over the value needed for the entire temperature range. To continue our example with the tantalum electrolytic, a value of only 22 $\mu\text{F}$  would probably thus suffice. For high-quality aluminum, 47 $\mu\text{F}$  would be adequate in such an application.

Another regulator characteristic that is noteworthy is that stability decreases with higher output currents. This sensible fact has important connotations. In many applications, the LM2931 is operated at only a few milliamps of output current or less. In such a circuit, the output capacitor can be further reduced in value. As a rough estimation, a circuit that is required to deliver a maximum of 10mA of output current from the regulator would need an output capacitor of only half the value compared to the same regulator required to deliver the full output current of 100mA. If the example of the tantalum capacitor in the circuit rated at  $25^{\circ}\text{C}$  junction temperature and above were continued to include a maximum of 10mA of output current, then the 22 $\mu\text{F}$  output capacitor could be reduced to only 10 $\mu\text{F}$ .

In the case of the LM2931CT adjustable regulator, the minimum value of output capacitance is a function of the output voltage. As a general rule, the value decreases with higher output voltages, since internal loop gain is reduced.

At this point, the procedure for bench testing the minimum value of an output capacitor in a special application circuit should be clear. Since worst-case occurs at minimum operating temperatures and maximum operating currents, the entire circuit, including the electrolytic, should be cooled to the minimum temperature. The input voltage to the regulator should be maintained at 0.6V above the output to keep internal power dissipation and die heating to a minimum. Worst-case occurs just after input power is applied and before the die has had a chance to heat up. Once the minimum value of capacitance has been found for the brand and type of electrolytic in question, the value should be doubled for actual use to account for production variations both in the capacitor and the regulator. (All the values in this section and the remainder of the data sheet were determined in this fashion.)

### LM2931 micro SMD Light Sensitivity

When the LM2931 micro SMD package is exposed to bright sunlight, normal office fluorescent light, and other LED's, it operates within the guaranteed limits specified in the electrical characteristic table.

## Definition of Terms

**Dropout Voltage:** The input-output voltage differential at which the circuit ceases to regulate against further reduction in input voltage. Measured when the output voltage has dropped 100 mV from the nominal value obtained at 14V input, dropout voltage is dependent upon load current and junction temperature.

**Input Voltage:** The DC voltage applied to the input terminals with respect to ground.

**Input-Output Differential:** The voltage difference between the unregulated input voltage and the regulated output voltage for which the regulator will operate.

**Line Regulation:** The change in output voltage for a change in the input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average chip temperature is not significantly affected.

**Load Regulation:** The change in output voltage for a change in load current at constant chip temperature.

**Long Term Stability:** Output voltage stability under accelerated life-test conditions after 1000 hours with maximum rated voltage and junction temperature.

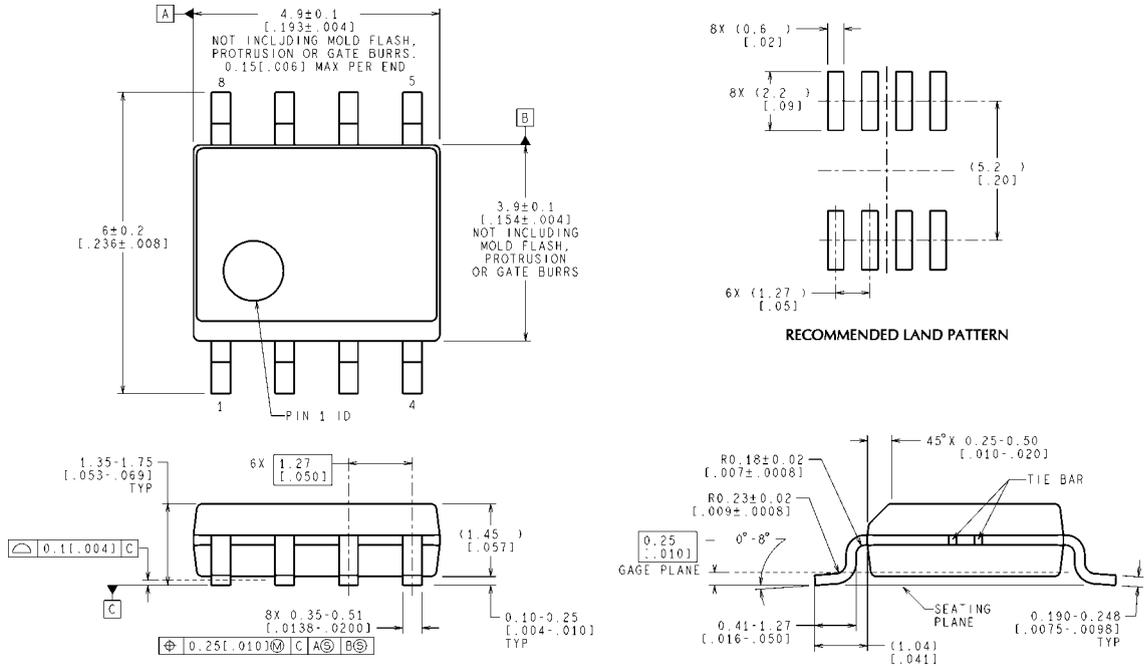
**Output Noise Voltage:** The rms AC voltage at the output, with constant load and no input ripple, measured over a specified frequency range.

**Quiescent Current:** That part of the positive input current that does not contribute to the positive load current. The regulator ground lead current.

**Ripple Rejection:** The ratio of the peak-to-peak input ripple voltage to the peak-to-peak output ripple voltage at a specified frequency.

**Temperature Stability of  $V_{\text{O}}$ :** The percentage change in output voltage for a thermal variation from room temperature to either temperature extreme.

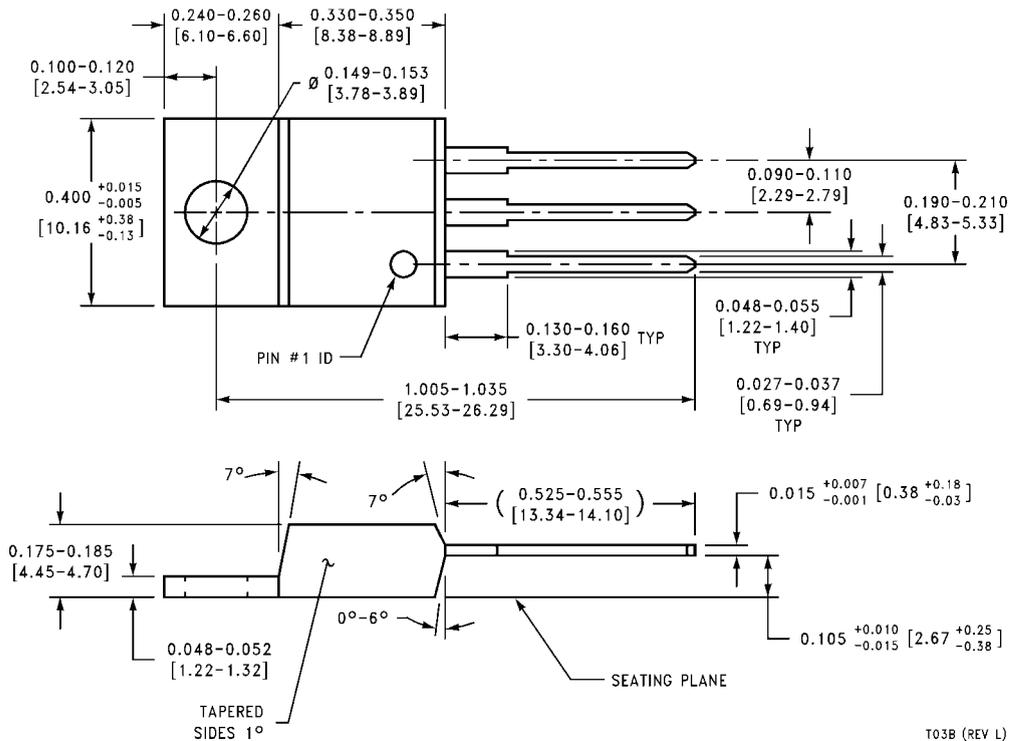
**Physical Dimensions** inches (millimeters) unless otherwise noted



CONTROLLING DIMENSION IS MILLIMETER  
 VALUES IN [ ] ARE INCHES  
 DIMENSIONS IN ( ) FOR REFERENCE ONLY

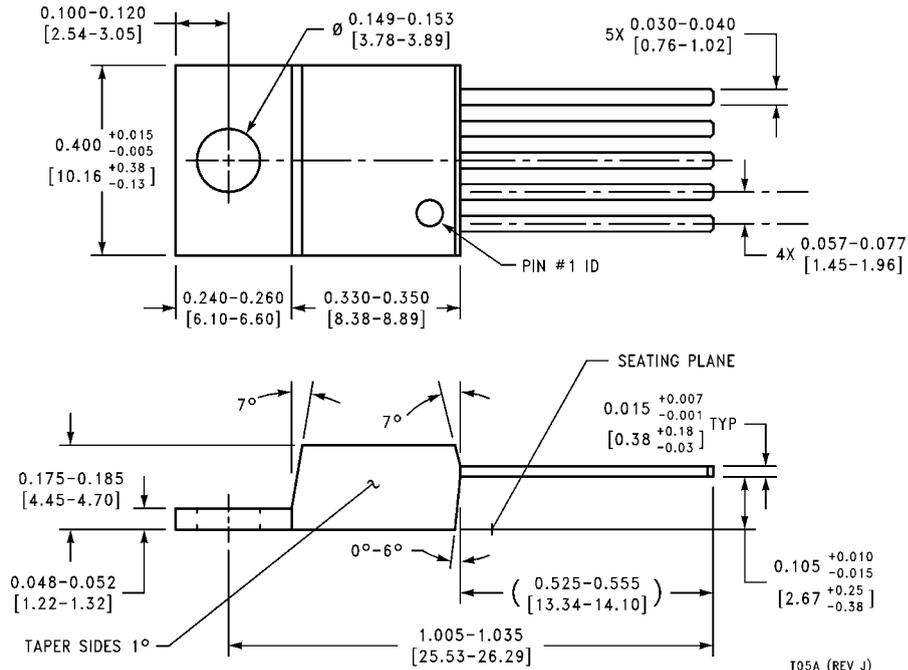
M08A (Rev M)

**8-Lead Surface Mount Package (M)**  
**NS Package Number M08A**



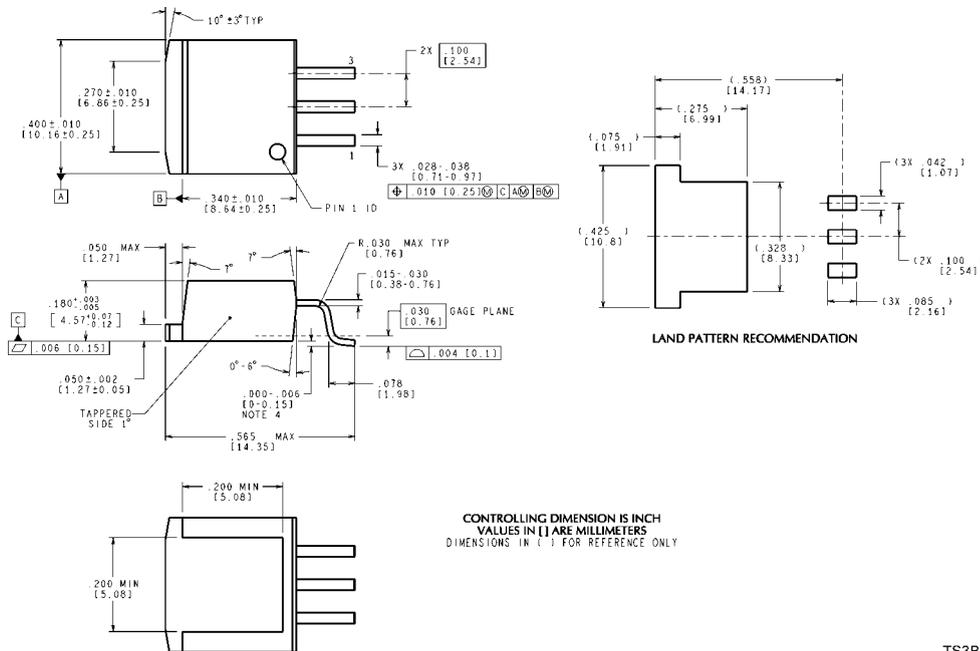
T03B (REV L)

**3-Lead TO-220 Plastic Package (T)**  
**NS Package Number T03B**



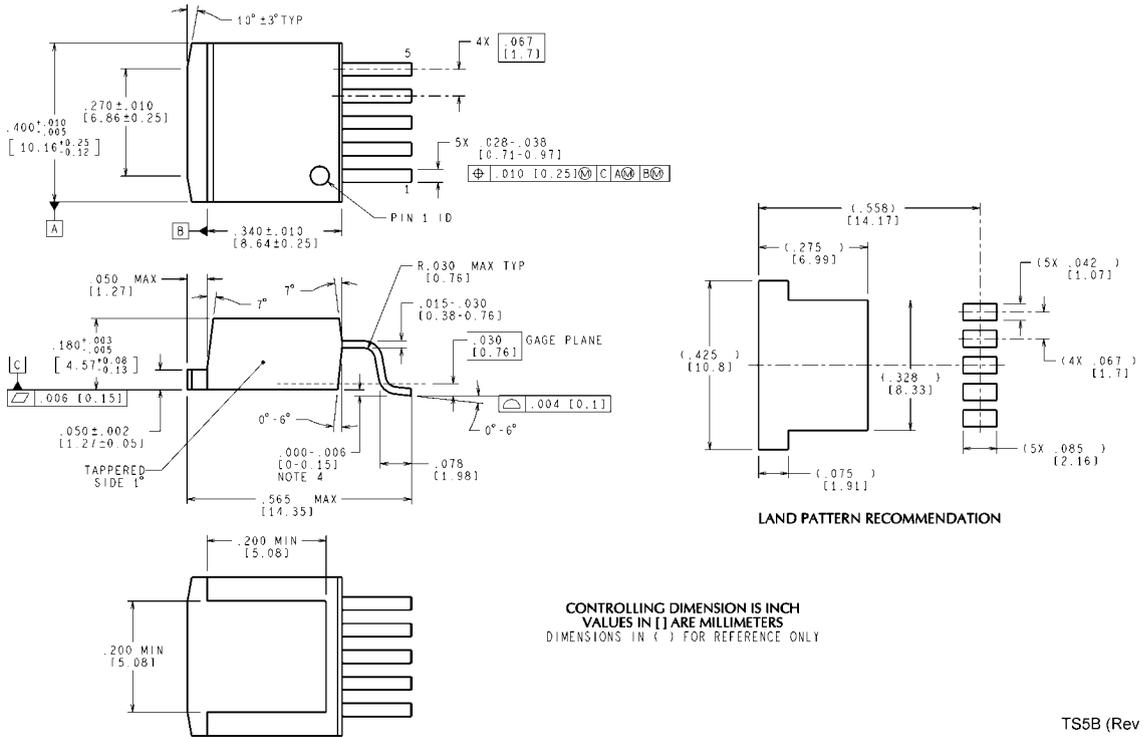
**5-Lead TO-220 Power Package (T)**  
NS Package Number T05A

T05A (REV J)



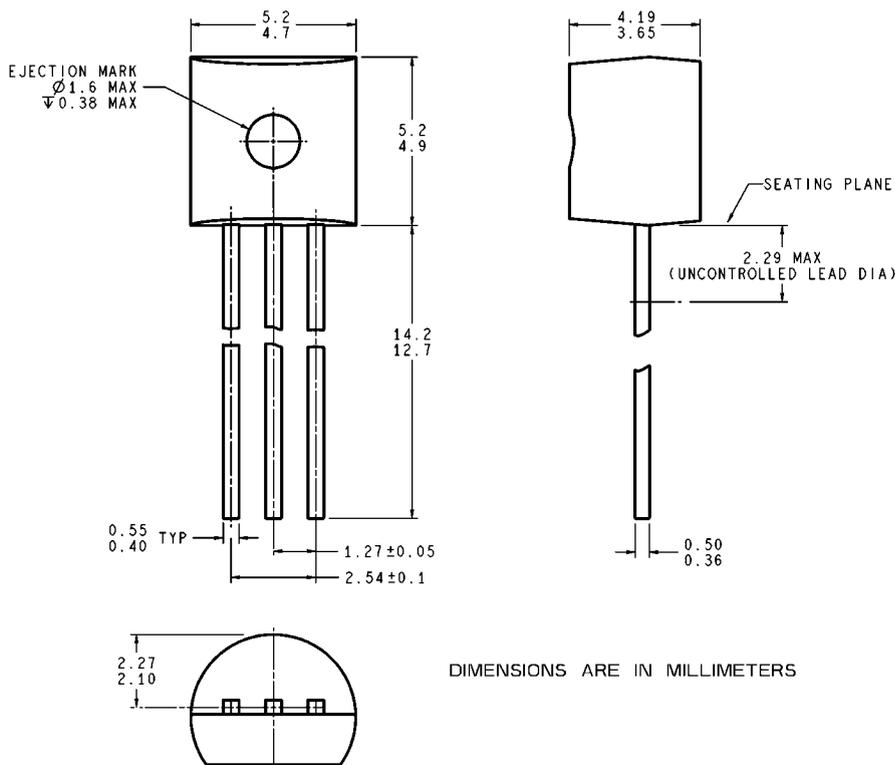
**3-Lead TO-263 Surface Mount Package**  
NS Package Number TS3B

TS3B (Rev F)



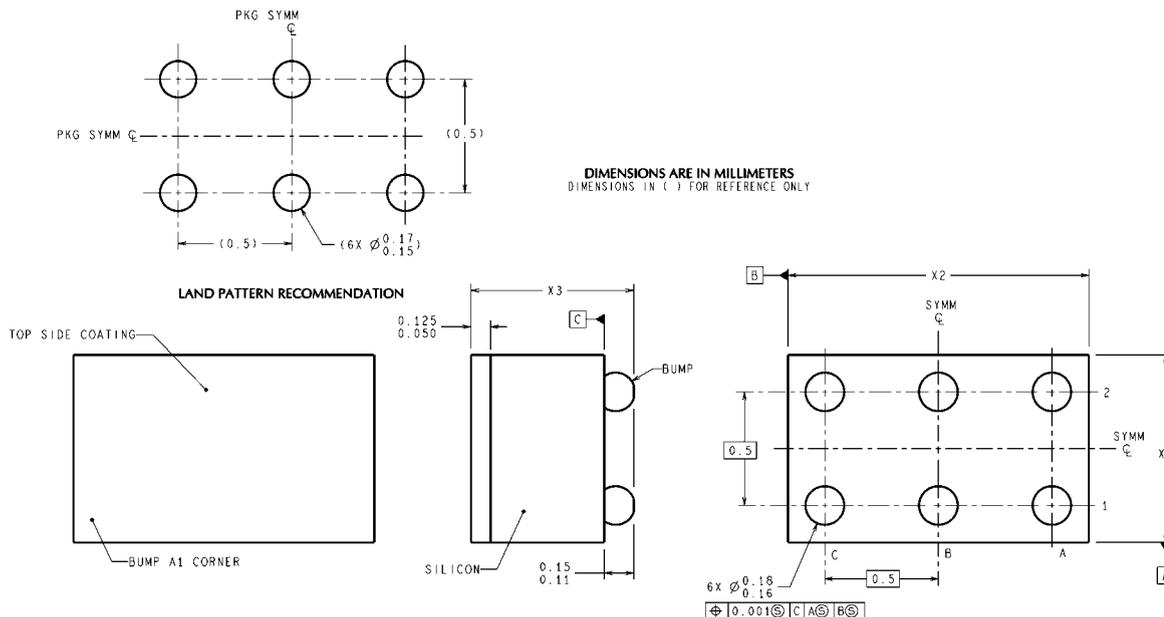
**5-Lead TO-263 Surface Mount Package**  
**NS Package Number TS5B**

TS5B (Rev D)



**3-Lead TO-92 Plastic Package (Z)**  
**NS Package Number Z03A**

Z03A (Rev G)



BPA06XXX (Rev D)

NOTE: UNLESS OTHERWISE SPECIFIED.

1. EPOXY COATING.
2. 63Sn/37Pb EUTECTIC BUMP.
3. RECOMMEND NON-SOLDER MASK DEFINED LANDING PAD.
4. PIN A1 IS ESTABLISHED BY LOWER LEFT CORNER WITH RESPECT TO TEST ORIENTATION PINS ARE NUMBERED COUNTERCLOCKWISE.
5. XXX IN DRAWING NUMBER REPRESENTS PACKAGE SIZE VARIATION WHERE X<sub>1</sub> IS PACKAGE WIDTH, X<sub>2</sub> IS PACKAGE LENGTH AND X<sub>3</sub> IS PACKAGE HEIGHT.
6. REFERENCE JEDEC REGISTRATION MO-211, VARIATION BC.

**6-Bump micro SMD**  
**NS Package Number BPA06HTB**  
**X<sub>1</sub> = 0.955 X<sub>2</sub> = 1.717 X<sub>3</sub> = 0.850**

# Notes

## 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

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
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>
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 © 2012, Texas Instruments Incorporated