

LM2991 Negative Low Dropout Adjustable Regulator

General Description

The LM2991 is a low dropout adjustable negative regulator with a output voltage range between $-2V$ to $-25V$. The LM2991 provides up to 1A of load current and features a \overline{ON}/OFF pin for remote shutdown capability.

The LM2991 uses new circuit design techniques to provide a low dropout voltage, low quiescent current and low temperature coefficient precision reference. The dropout voltage at 1A load current is typically 0.6V and a guaranteed worst-case maximum of 1V over the entire operating temperature range. The quiescent current is typically 1 mA with a 1A load current and an input-output voltage differential greater than 3V. A unique circuit design of the internal bias supply limits the quiescent current to only 9 mA (typical) when the regulator is in the dropout mode ($V_{OUT} - V_{IN} \leq 3V$).

The LM2991 is short-circuit proof, and thermal shutdown includes hysteresis to enhance the reliability of the device when inadvertently overloaded for extended periods. The LM2991 is available in a 5-lead TO-220, TO-263, and is rated for operation over the automotive temperature range of $-40^{\circ}C$ to $+125^{\circ}C$.

Features

- Output voltage adjustable from $-2V$ to $-25V$
- Output current in excess of 1A
- Dropout voltage typically 0.6V at 1A load
- Low quiescent current
- Internal short circuit current limit
- Internal thermal shutdown with hysteresis
- TTL, CMOS compatible \overline{ON}/OFF switch
- Functional complement to the LM2941 series

Applications

- Post switcher regulator
- Local, on-card, regulation
- Battery operated equipment

Connection Diagrams and Ordering Information

5-Lead TO-220
Straight Leads



TL/H/11260-9

Front View
Order Number LM2991T
See NS Package Number T05A

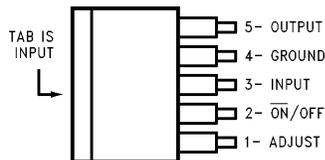
5-Lead TO-220
Bent, Staggered Leads



TL/H/11260-2

Front View
Order Number LM2991T Flow LB03
See NS Package Number T05D

TO263
5-Lead Surface-Mount Package



TL/H/11260-11

Top View



TL/H/11260-12

Side View
Order Number LM2991S
See NS Package Number TS5B

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	-26V to +0.3V
ESD Susceptibility (Note 2)	2 kV
Power Dissipation (Note 3)	Internally limited
Junction Temperature (T_{Jmax})	125°C

Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	230°C

Operating Ratings (Note 1)

Junction Temperature Range (T_J)	-40°C to +125°C
Maximum Input Voltage (Operational)	-26V

Electrical Characteristics $V_{IN} = -10V$, $V_O = -3V$, $I_O = 1A$, $C_O = 47 \mu F$, $R1 = 2.7k$, $T_J = 25^\circ C$, unless otherwise specified. **Boldface** limits apply over the entire operating junction temperature range.

Parameter	Conditions	Typical (Note 4)	Min	Max	Units
Reference Voltage	$5 \text{ mA} \leq I_O \leq 1 \text{ A}$	-1.210	-1.234	-1.186	V
	$5 \text{ mA} \leq I_O \leq 1 \text{ A}$, $V_O - 1V \geq V_{IN} \geq -26V$		-1.27	-1.15	V
Output Voltage Range		-2		-3	V
	$V_{IN} = -26V$	-25	-24		V
Line Regulation	$I_O = 5 \text{ mA}$, $V_O - 1V \geq V_{IN} \geq -26V$	0.004		0.04	%/V
Load Regulation	$50 \text{ mA} \leq I_O \leq 1 \text{ A}$	0.04		0.4	%
Dropout Voltage	$I_O = 0.1 \text{ A}$, $\Delta V_O \leq 100 \text{ mV}$	0.1		0.2 0.3	V
	$I_O = 1 \text{ A}$, $\Delta V_O \leq 100 \text{ mV}$	0.6		0.8 1	V
Quiescent Current	$I_O \leq 1 \text{ A}$	0.7		5	mA
Dropout Quiescent Current	$V_{IN} = V_O$, $I_O \leq 1 \text{ A}$	16		50	mA
Ripple Rejection	$V_{\text{ripple}} = 1 \text{ Vrms}$, $f_{\text{ripple}} = 1 \text{ kHz}$, $I_O = 5 \text{ mA}$	60	50		dB
Output Noise	10 Hz - 100 kHz, $I_O = 5 \text{ mA}$	200		450	μV
$\overline{\text{ON}}$ /OFF Input Voltage	(V_{OUT} : ON)	1.2		0.8	V
	(V_{OUT} : OFF)	1.3	2.4		
$\overline{\text{ON}}$ /OFF Input Current	$V_{\overline{\text{ON}}/\text{OFF}} = 0.8 \text{ V}$ (V_{OUT} : ON)	0.1		10	μA
	$V_{\overline{\text{ON}}/\text{OFF}} = 2.4 \text{ V}$ (V_{OUT} : OFF)	40		100	
Output Leakage Current	$V_{IN} = -26V$, $V_{\overline{\text{ON}}/\text{OFF}} = 2.4V$ $V_{OUT} = 0V$	60		250	μA
Current Limit	$V_{OUT} = 0V$	2	1.5		A

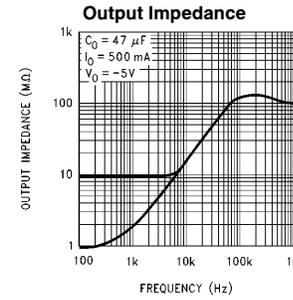
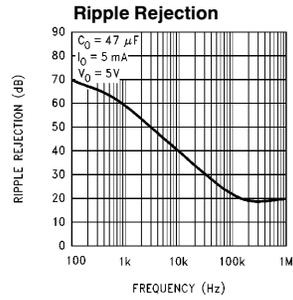
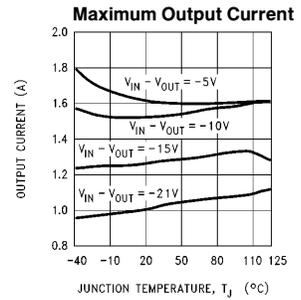
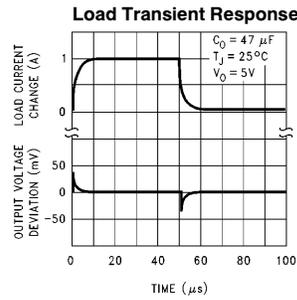
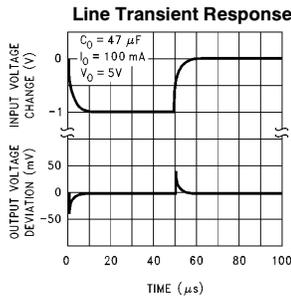
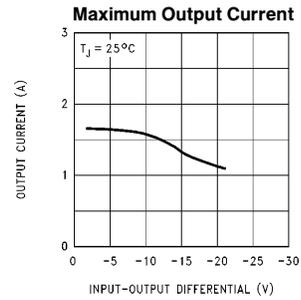
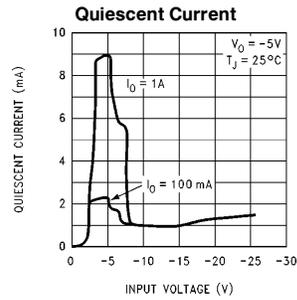
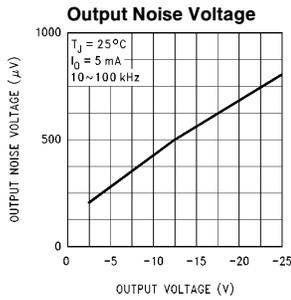
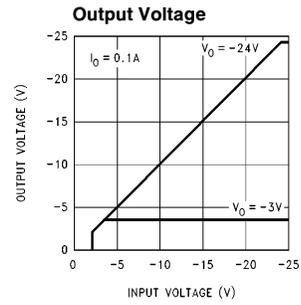
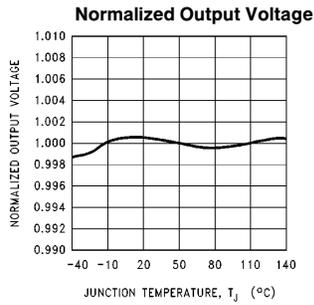
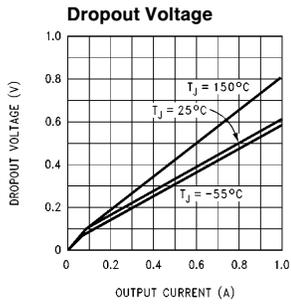
Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

Note 2: Human body model, 100 pF discharged through a 1.5 k Ω resistor.

Note 3: The maximum power dissipation is a function of T_{Jmax} , θ_{JA} and 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 125°C and the LM2991 will go into thermal shutdown. For the LM2991, the junction-to-ambient thermal resistance is 53°C/W for the TO-220, 73°C/W for the TO-263, and junction-to-case thermal resistance is 3°C. If the TO-263 package is used, the thermal resistance can be reduced by increasing the PC board copper area thermally connected to the package. Using 0.5 square inches of copper area, θ_{JA} is 50°C/W; with 1 square inch of copper area, θ_{JA} is 37°C/W; and with 1.6 or more square inches of copper area, θ_{JA} is 32°C/W.

Note 4: Typicals are at $T_J = 25^\circ C$ and represent the most likely parametric norm.

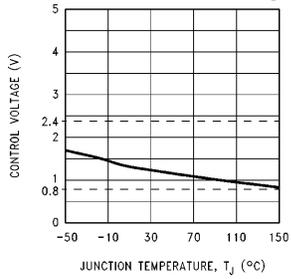
Typical Performance Characteristics



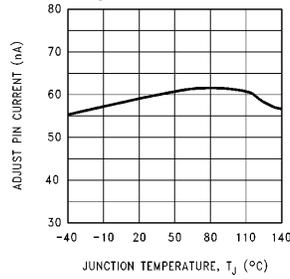
TL/H/11260-3

Typical Performance Characteristics (Continued)

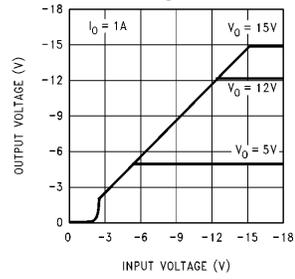
$\overline{\text{ON}}/\text{OFF}$ Control Voltage



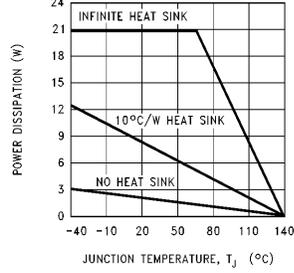
Adjust Pin Current



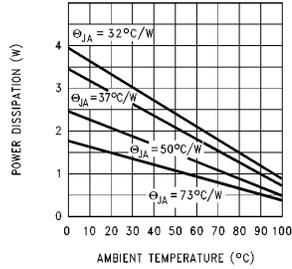
Low Voltage Behavior



Maximum Power Dissipation (TO-220)

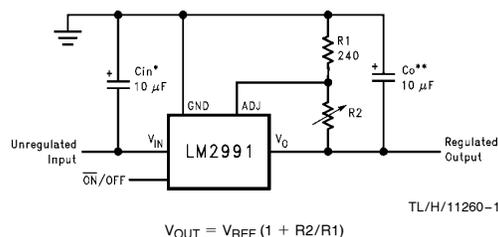


Maximum Power Dissipation (TO-263) (See Note 3)



TL/H/11260-4

Typical Applications



$$V_{OUT} = V_{REF} (1 + R_2/R_1)$$

Application Hints

EXTERNAL CAPACITORS

The LM2991 regulator requires an output capacitor to maintain stability. The capacitor must be at least 10 µF aluminum electrolytic or 1 µF solid tantalum. The output capacitor's ESR must be less than 10Ω, or the zero added to the regulator frequency response by the ESR could reduce the phase margin, creating oscillations. The shaded area in the Output Capacitor ESR graph indicates the recommended ESR range. An input capacitor, of at least 1 µF solid tantalum or 10 µF aluminum electrolytic, is also needed if the regulator is situated more than 6 inches from the input power supply filter.

MINIMUM LOAD

A minimum load current of 500 µA is required for proper operation. The external resistor divider can provide the minimum load, with the resistor from the adjust pin to ground set to 2.4 kΩ.

SETTING THE OUTPUT VOLTAGE

The output voltage of the LM2991 is set externally by a resistor divider and the adjust pin current using the following equation:

$$V_{OUT} = V_{REF} * (1 + R_2/R_1) - I_{ADJ} * R_2$$

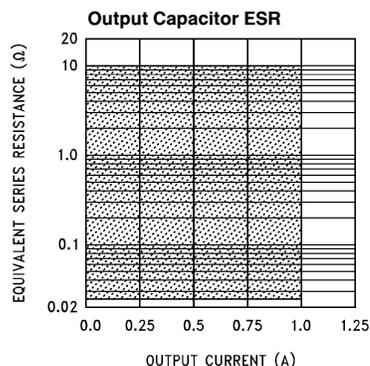
where $V_{REF} = -1.21V$. The output voltage can be programmed within the range of -2V to -25V. The adjust pin current is about 60 nA, causing a slight error in the output voltage. However, using resistors lower than 100 kΩ makes the adjust pin current negligible. For example, neglecting the adjust pin current, and setting R2 to 100 kΩ and V_{OUT} to -5V, results in an output voltage error of only 0.16%.

ON/OFF PIN

The LM2991 regulator can be turned off by applying a TTL or CMOS level high signal to the ON/OFF pin (see Current Sink Application).

*Required if the regulator is located further than 6 inches from the power supply filter capacitors. A 1 µF solid tantalum or a 10 µF aluminum electrolytic capacitor is recommended.

**Required for stability. Must be at least a 10 µF aluminum electrolytic or a 1 µF solid tantalum to maintain stability. May be increased without bound to maintain regulation during transients. Locate the capacitor as close as possible to the regulator. The equivalent series resistance (ESR) is critical, and should be less than 10Ω over the same operating temperature range as the regulator.



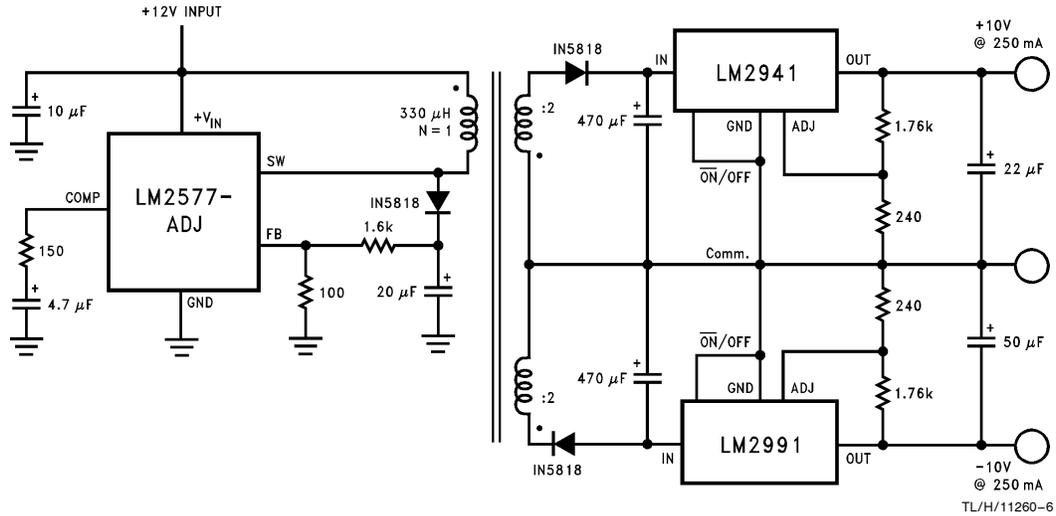
TL/H/11260-5

FORCING THE OUTPUT POSITIVE

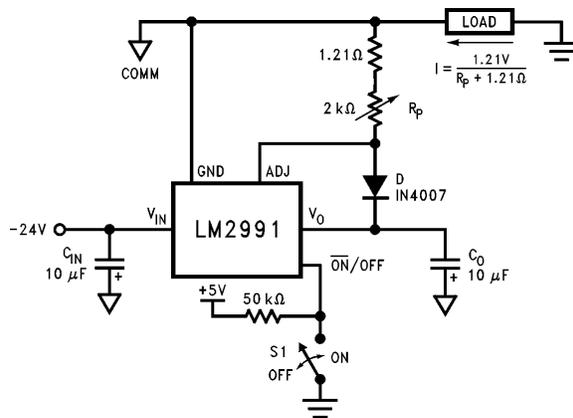
Due to an internal clamp circuit, the LM2991 can withstand positive voltages on its output. If the voltage source pulling the output positive is DC, the current must be limited to 1.5A. A current over 1.5A fed back into the LM2991 could damage the device. The LM2991 output can also withstand fast positive voltage transients up to 26V, without any current limiting of the source. However, if the transients have a duration of over 1 ms, the output should be clamped with a Schottky diode to ground.

Typical Applications (Continued)

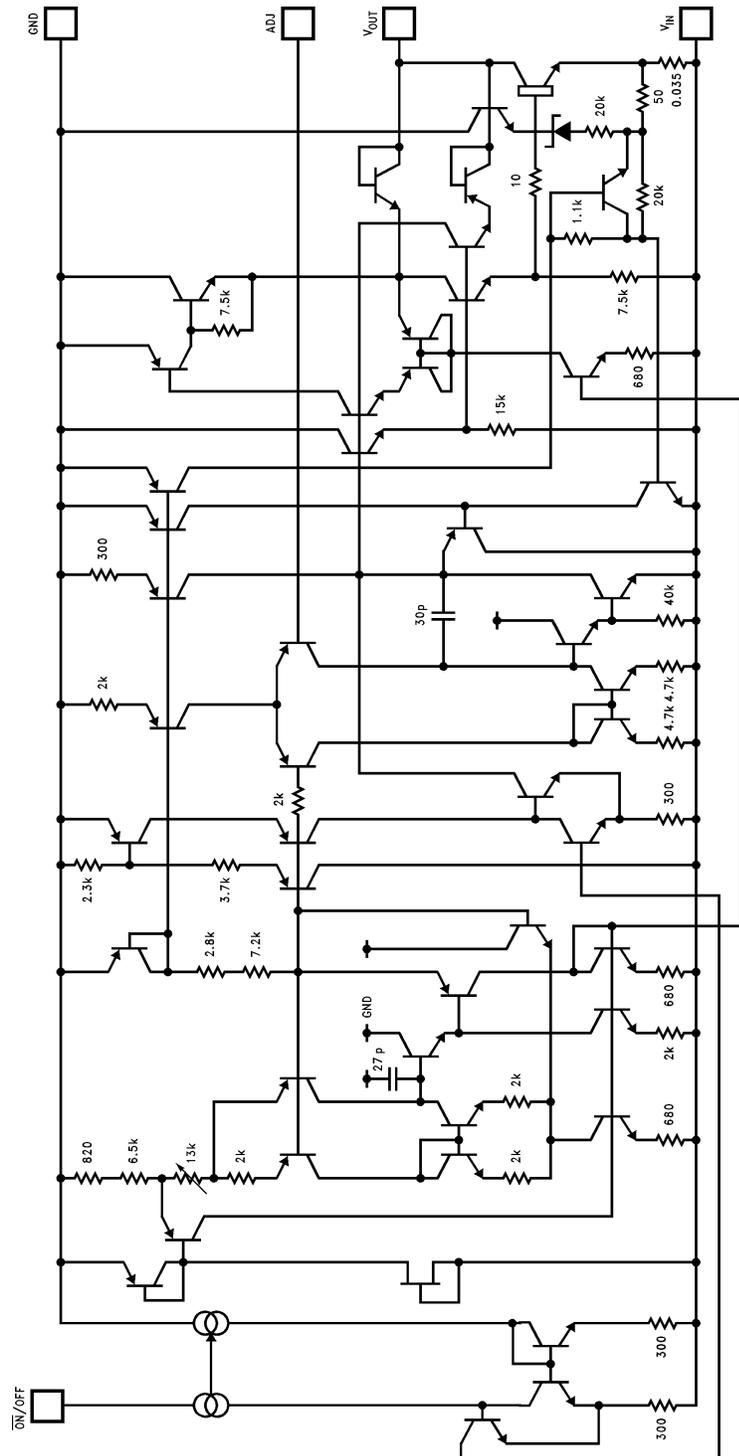
Fully Isolated Post-Switcher Regulator



Adjustable Current Sink

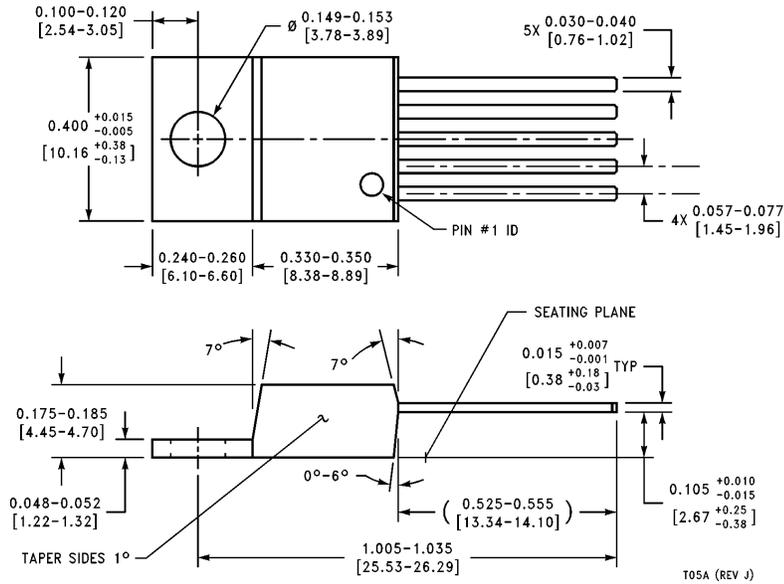


Equivalent Schematic

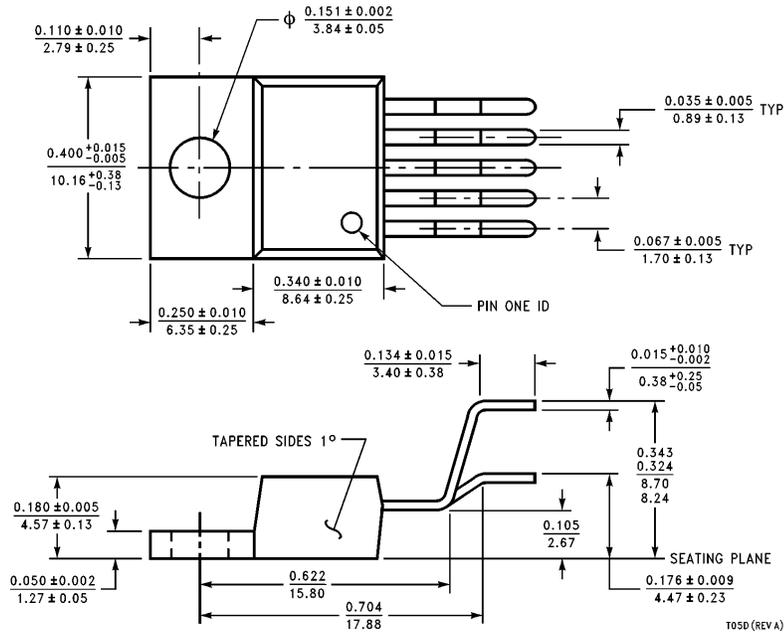




Physical Dimensions inches (millimeters)



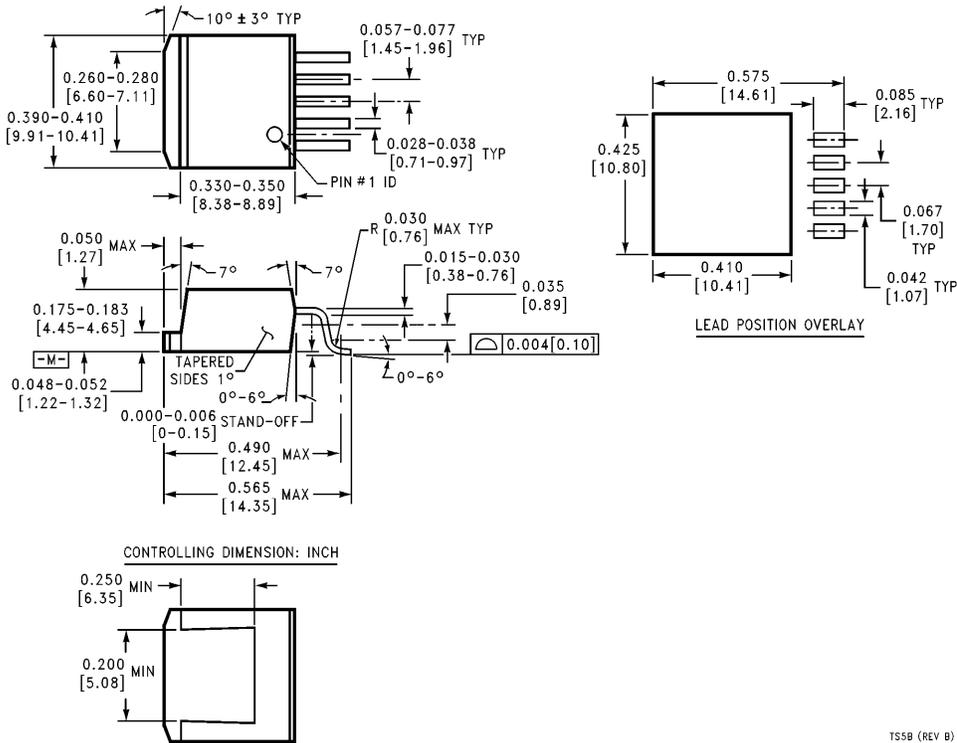
5-Lead T0-220, Straight Leads (T)
Order Number LM2991T
NS Package Number T05A



5-Lead T0-220, Bent, Staggered Leads (T)
Order Number LM2991T Flow LBO3
NS Package Number T05D

Physical Dimensions inches (millimeters) (Continued)

Lit. # 108041



TS5B (REV B)

TO-263 5-Lead Plastic Surface Mount Package
Ordering Number LM2991S
NS Package Number TS5B

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 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
 2900 Semiconductor Drive
 P.O. Box 58090
 Santa Clara, CA 95052-8090
 Tel: (800) 272-9959
 TWX: (910) 339-9240

National Semiconductor GmbH
 Livny-Gargan-Str. 10
 D-82256 Fürstenfeldbruck
 Germany
 Tel: (81-41) 35-0
 Telex: 527849
 Fax: (81-41) 35-1

National Semiconductor Japan Ltd.
 Sumitomo Chemical
 Engineering Center
 Bldg. 7F
 1-7-1, Nakase, Mihama-Ku
 Chiba-City,
 Chiba Prefecture 261
 Tel: (043) 299-2300
 Fax: (043) 299-2500

National Semiconductor Hong Kong Ltd.
 13th Floor, Straight Block,
 Ocean Centre, 5 Canton Rd.
 Tsimshatsui, Kowloon
 Hong Kong
 Tel: (852) 2737-1600
 Fax: (852) 2736-9960

National Semicondutores Do Brazil Ltda.
 Rue Deputado Lacorda Franco
 120-3A
 Sao Paulo-SP
 Brazil 05418-000
 Tel: (55-11) 212-5066
 Telex: 391-1131931 NSBR BR
 Fax: (55-11) 212-1181

National Semiconductor (Australia) Pty. Ltd.
 Building 16
 Business Park Drive
 Monash Business Park
 Nottingham, Melbourne
 Victoria 3168 Australia
 Tel: (3) 558-9999
 Fax: (3) 558-9998

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.