LM2991 Negative Low-Dropout Adjustable Regulator

1 Features

- Output Voltage Adjustable from −3 V to −24 V, Typically −2 V to −25 V
- Output Current in Excess of 1 A
- Dropout Voltage Typically 0.6 V at 1-A 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

2 Applications

- Post Switcher Regulator
- Local, On-Card, Regulation
- Battery Operated Equipment
- Industrial
- Instrumentation

3 Description

The LM2991 is a low dropout adjustable negative regulator with a output voltage range between −3 V to −24 V. The LM2991 provides up to 1 A 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 1-A load current is typically 0.6 V and an ensured worst-case maximum of 1 V over the entire operating temperature range. The quiescent current is typically 1 mA with a 1-A load current and an input-output voltage differential greater than 3 V. 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} ≤ 3 V).

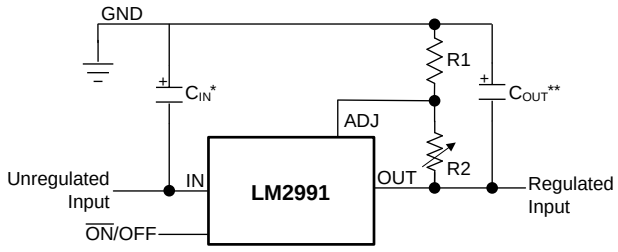
The LM2991 is short-circuit proof, and thermal shutdown includes hysteresis to enhance the reliability of the device when inadvertently overloaded for extended periods. The LM2991 is available in 5-lead TO-220 and DDPAK/TO-263 packages and is rated for operation over the automotive temperature range of −40°C to +125°C. Mil-Aero versions are also available.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM2991	DDPAK/TO-263 (5)	10.20 mm × 9.00 mm
	TO-220 (5)	14.99 mm × 10.16 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Typical Application



$V_{OUT} = V_{REF} (1 + R2/R1)$

* 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.

Table of Contents

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision H (June 2013) to Revision I — **Page**

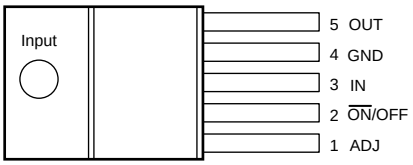
- Added *Device Information* and *ESD Rating* tables, *Feature Description*, *Device Functional Modes*, *Application and Implementation*, *Power Supply Recommendations*, *Layout*, *Device and Documentation Support*, and *Mechanical, Packaging, and Orderable Information* sections; moved some curves to *Application Curves* section ... 1
- Changed footnote 4 of *Abs Max* table and footnote 1 to *Typical Characteristics* to eliminate obsolete thermal values for thetaJA; updated values are in *Thermal Information* ... 4
- Changed Figure 14 as previous thermal values have been updated ... 8

Changes from Revision G (April 2013) to Revision H — **Page**

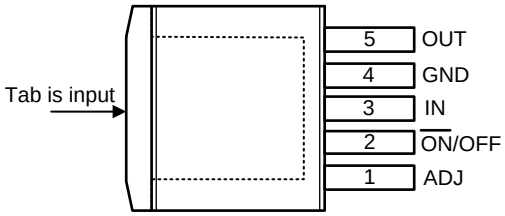
- Changed layout of National Semiconductor data sheet to TI format ... 1

5 Pin Configuration and Functions

KC and NDH Packages
5-Pin TO-220
Top View



KTT Package
5-Pin DDPAK/TO-263
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	ADJ	I	Feedback pin to the control loop for programming the output voltage.
2	ON/OFF	I	Logic high enable input
3	IN	I	Negative Input voltage. Internally connected directly to the thermal tab.
4	GND	—	Ground
5	OUT	O	Regulated output voltage
—	TAB	I	Negative Input voltage. Internally connected directly to the device pin 3. The thermal tab must be connected to a copper area on the PCB at the same potential as device pin 3 (IN) to assure thermal performance, or leave the thermal tab floating. Do NOT connect the thermal tab to any potential other than the same potential at device pin 3. Do NOT connect the thermal tab to ground.

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)(2)

	MIN	MAX	UNIT
Input voltage	–26	0.3	V
Power dissipation(3)	Internally limited		
Storage temperature, T_{stg}	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) If Military/Aerospace specified devices are required, contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(3) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A)/R_{\theta JA}$. If this dissipation is exceeded, the die temperature will rise above 125°C, and the LM2991 will eventually go into thermal shutdown at a T_J of approximately 160°C. Refer to *Thermal Shutdown* for more details.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2000	V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)(1)

	MIN	NOM	MAX	UNIT
Junction temperature, T_J	–40		125	°C
$\overline{ON}$/OFF pin	0		5	V
Maximum input voltage (operational)	–26			V

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.4 Thermal Information

THERMAL METRIC(1)		LM2991			UNIT
		TO-263 (KTT)	TO-220 (NDH)(2)	TO-220 (KC)(2)	
		5 PINS	5 PINS	5 PINS	
$R_{\theta JA}$(3)	Junction-to-ambient thermal resistance, High-K	27.8	54.4	56.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	41.4	30.1	40.0	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	10.9	33.2	38.6	°C/W
ψ_{JT}	Junction-to-top characterization parameter	6.0	11.6	12.8	°C/W
ψ_{JB}	Junction-to-board characterization parameter	10.6	36.2	35.3	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	0.7	0.5	0.6	°C/W

(1) For more information about traditional and new thermal metrics, see *Semiconductor and IC Package Thermal Metrics*.
(2) The TO-220 package is vertically mounted in center of a JEDEC High-K test board (JESD 51-7) with no additional heat sink attached. This is a through-hole package; this is NOT a surface-mount package.
(3) Thermal resistance value $R_{\theta JA}$ is based on the EIA/JEDEC High-K printed circuit board defined by JESD51-7 - *High Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages*.

6.5 Electrical Characteristics

V_{IN} = −10 V, V_{OUT} = −3 V, I_{OUT} = 1 A, C_{OUT} = 47 µF, R1 = 2.7 kΩ, T_J = 25°C, unless otherwise specified.

PARAMETER	TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
Reference voltage	5 mA ≤ I_{OUT} ≤ 1 A	–1.234	–1.210	–1.186	V
	5 mA ≤ I_{OUT} ≤ 1 A, V_{OUT} – 1 V ≥ V_{IN} > −26 V −40°C ≤ T_J ≤ 125°C	–1.27		–1.15	V
Output voltage (V_{OUT})			–2	–3	V
	V_{IN} = −26 V	–24	–25		V
Line regulation	I_{OUT} = 5 mA, V_{OUT} −1 V > V_{IN} > −26 V		0.004	0.04	%/V
Load regulation	50 mA ≤ I_{OUT} ≤ 1 A		0.04%	0.4%	
Dropout voltage	I_{OUT} = 0.1 A, ΔV_{OUT} ≤ 100 mV		0.1	0.2	V
	I_{OUT} = 0.1 A, ΔV_{OUT} ≤ 100 mV −40°C ≤ T_J ≤ 125°C			0.3	
	I_{OUT} = 1 A, ΔV_{OUT} ≤ 100 mV		0.6	0.8	V
	I_{OUT} = 1 A, ΔV_{OUT} ≤ 100 mV −40°C ≤ T_J ≤ 125°C			1	
Quiescent current	I_{OUT} ≤ 1 A		0.7		mA
	I_{OUT} = 1 A, −40°C ≤ T_J ≤ 125°C			5	
Dropout quiescent current	V_{IN} = V_{OUT}, I_{OUT} ≤ 1 A		16	50	mA
Ripple rejection	V_{ripple} = 1 V_{RMS}, f_{ripple} = 1 kHz, I_{OUT} = 5 mA	50	60		dB
Output noise	10 Hz to 100 kHz, I_{OUT} = 5 mA		200	450	µV
$\overline{ON}$/OFF input voltage	V_{OUT}: ON		1.2		V
	V_{OUT}: ON −40°C ≤ T_J ≤ 125°C			0.8	
	V_{OUT}: OFF		1.3		V
	V_{OUT}: OFF, −40°C ≤ T_J ≤ 125°C	2.4			
$\overline{ON}$/OFF input current	$V_{\overline{ON}/OFF}$ = 0.8 V, V_{OUT}: ON		0.1	10	µA
	$V_{\overline{ON}/OFF}$ = 2.4 V, V_{OUT}: OFF		40	100	
Output leakage current	V_{IN} = −26 V, $V_{\overline{ON}/OFF}$ = 2.4 V, V_{OUT} = 0 V		60	250	µA
Current limit	V_{OUT} = 0 V	1.5	2		A

(1) Typicals are at T_J = 25°C and represent the most likely parametric norm.