

LM2991QML Negative Low Dropout Adjustable Regulator

Check for Samples: [LM2991QML](#)

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

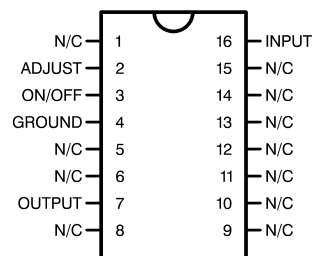
DESCRIPTION

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 ensured 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 ($V_O - V_I \leq 3V$).

The LM2991 is short-circuit proof, and thermal shutdown includes hysteresis to enhance the reliability of the device when inadvertently overloaded for extended periods.

CONNECTION DIAGRAMS



**Package Number NAC0016A (Top View)
16-Lead CLGA Package**



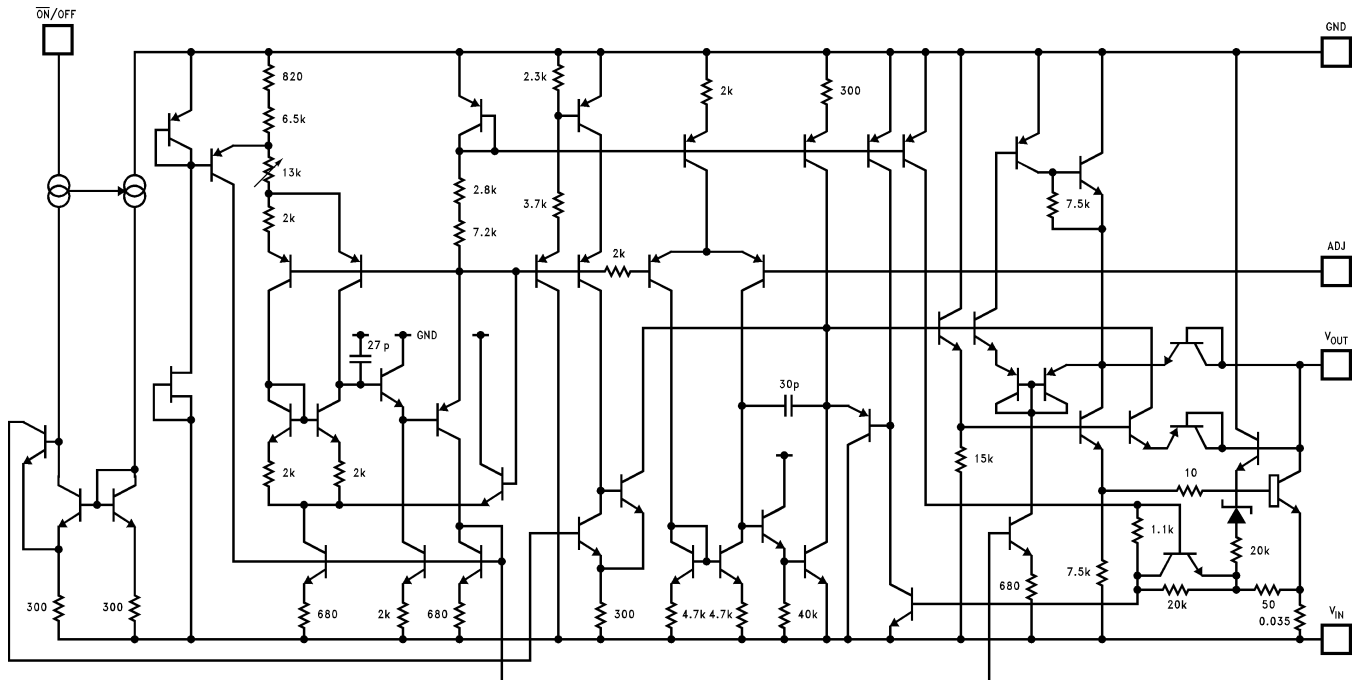
Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

EQUIVALENT SCHEMATIC



ABSOLUTE MAXIMUM RATINGS ⁽¹⁾

Input Voltage		-26V to +0.3V
Power Dissipation ⁽²⁾		Internally limited
Junction Temperature (T_{Jmax})		150°C
Storage Temperature Range		-65°C ≤ T_A ≤ +150°C
Thermal Resistance ⁽³⁾	θ_{JA} CLGA (Still Air at 0.5°C/W) "GW"	130°C/W
	θ_{JA} CLGA (500LF/Min Air flow at 0.5°C/W) "GW"	80°C/W
	θ_{JC} CLGA "GW"	6°C/W
Package Weight "GW"		410mg
Lead Temperature (Soldering, 10 sec.)		260°C
ESD Susceptibility ⁽⁴⁾		1,500V

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
- (2) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{JA} (package junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is $P_{Dmax} = (T_{Jmax} - T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower.
- (3) The package material for these devices allows much improved heat transfer over our standard ceramic packages. In order to take full advantage of this improved heat transfer, heat sinking must be provided between the package base (directly beneath the die), and either metal traces on, or thermal vias through, the printed circuit board. Without this additional heat sinking, device power dissipation must be calculated using θ_{JA} , rather than θ_{JC} , thermal resistance. It must not be assumed that the device leads will provide substantial heat transfer out the package, since the thermal resistance of the leadframe material is very poor, relative to the material of the package base. The stated θ_{JC} thermal resistance is for the package material only, and does not account for the additional thermal resistance between the package base and the printed circuit board. The user must determine the value of the additional thermal resistance and must combine this with the stated value for the package, to calculate the total allowed power dissipation for the device. The user must determine the value of the additional thermal resistance and must combine this with the stated value for the package, to calculate the total allowed power dissipation for the device.
- (4) Human body model, 1.5 kΩ in series with 100 pF.

RECOMMENDED OPERATING CONDITIONS ⁽¹⁾

Operating Temperature Range (T_A)	$-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$
Maximum Input Voltage (Operational)	-26V

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

QUALITY CONFORMANCE INSPECTION

Mil-Std-883, Method 5005 - Group A		
Subgroup	Description	Temp °C
1	Static tests at	+25
2	Static tests at	+125
3	Static tests at	-55
4	Dynamic tests at	+25
5	Dynamic tests at	+125
6	Dynamic tests at	-55
7	Functional tests at	+25
8A	Functional tests at	+125
8B	Functional tests at	-55
9	Switching tests at	+25
10	Switching tests at	+125
11	Switching tests at	-55
12	Settling time at	+25
13	Settling time at	+125
14	Settling time at	-55

LM2991 ELECTRICAL CHARACTERISTICS DC PARAMETERS

The following conditions apply, unless otherwise specified.

DC: $V_I = -10V$, $V_O = -3V$, $I_O = 1A$, $C_O = 47\mu F$, $R_L = 2.7k\Omega$

Symbol	Parameter	Conditions	Notes	Min	Max	Units	Sub-groups
V_{Ref}	Reference Voltage	$5mA \leq I_O \leq 1A$		-1.234	-1.186	V	1
		$5mA \leq I_O \leq 1A$, $V_O - 1V \geq V_I \geq -26V$		-1.27	-1.15	V	2, 3
V_O	Output Voltage Range				-3.0	V	1
		$V_I = -26V$		-24		V	1
				-25		V	2, 3
V_{RLine}	Line Regulation	$I_O = 5mA$, $V_O - 1V \geq V_I \geq -26V$		-26	+26	mV	1, 2, 3
V_{RLoad}	Load Regulation	$50mA \leq I_O \leq 1A$		-12	+12	mV	1
				-15	+15	mV	2, 3
V_{DO}	Dropout Voltage	$I_O = 0.1A$, $\Delta V_O \leq 100mV$			0.2	V	1
					0.3	V	2, 3
		$I_O = 1A$, $\Delta V_O \leq 100mV$			0.8	V	1
					1.0	V	2, 3
I_Q	Quiescent Current	$I_O \leq 1A$			5.0	mA	1, 2, 3
	Dropout Quiescent Current	$V_I = V_O$, $I_O \leq 1A$			50	mA	1, 2, 3
V_{ON}	Output Noise	10Hz - 100KHz, $I_O = 5mA$			450	μV	1
					500	μV	2, 3
	$\overline{ON/OFF}$ Input Voltage	$V_O : ON$			0.6	V	1, 2, 3
		$V_O : OFF$		2.4		V	1, 2, 3
	$\overline{ON/OFF}$ Input Current	$\overline{VON/OFF} = 0.6V$ ($V_O : ON$)			10	μA	1
					25	μA	2, 3
		$\overline{VON/OFF} = 2.4V$ ($V_O : OFF$)			100	μA	1
					150	μA	2, 3
I_L	Output Leakage Current	$V_I = -26V$, $\overline{VON/OFF} = 2.4V$, $V_O = 0V$			250	μA	1
					300	μA	2, 3
I_{Limit}	Current Limit	$V_O = 0V$		1.5	2.5	A	1
				1.0	4.0	A	2, 3

LM2991 ELECTRICAL CHARACTERISTICS AC PARAMETERS

The following conditions apply, unless otherwise specified.

AC: $V_I = -10V$, $V_O = -3V$, $I_O = 1A$, $C_O = 47\mu F$, $R_L = 2.7k\Omega$

Symbol	Parameter	Conditions	Notes	Min	Max	Units	Sub-groups
RR	Ripple Rejection	$V_{Ripple} = 1V_{RMS}$, $F_{Ripple} = 1KHz$, $I_O = 5mA$		50		dB	1

LM2991 ELECTRICAL CHARACTERISTICS DC DRIFT PARAMETERS

The following conditions apply, unless otherwise specified. DC: $V_I = -10V$, $V_O = -3V$, $I_O = 1A$, $C_O = 47\mu F$, $R_L = 2.7k\Omega$

Deltas not required on B-Level product. Deltas required for S-Level product ONLY.

Symbol	Parameter	Conditions	Notes	Min	Max	Units	Sub-groups
V_{Ref}	Reference Voltage	$5mA \leq I_O \leq 1A$			± 20	mV	1

TYPICAL PERFORMANCE CHARACTERISTICS

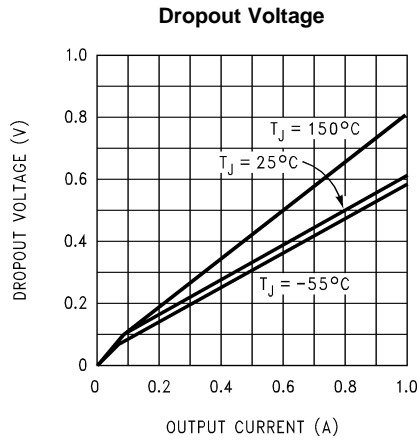


Figure 1.

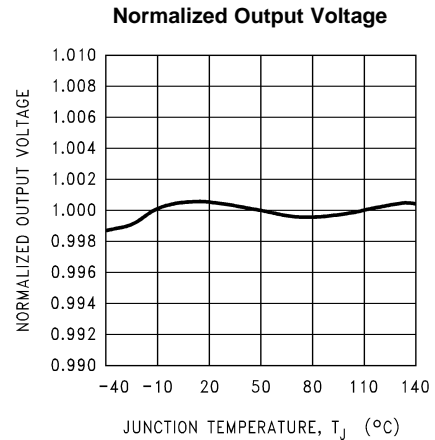


Figure 2.

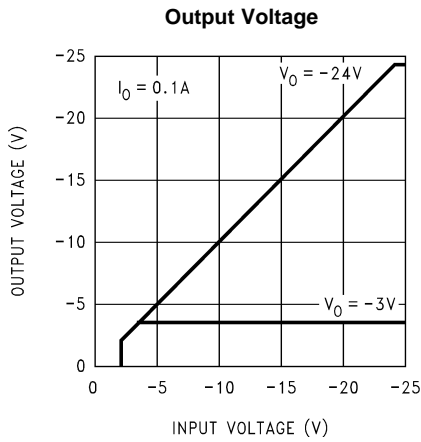


Figure 3.

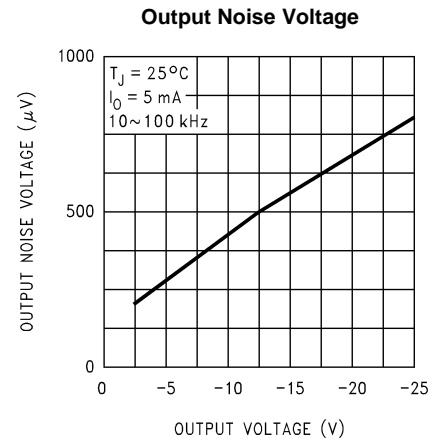


Figure 4.

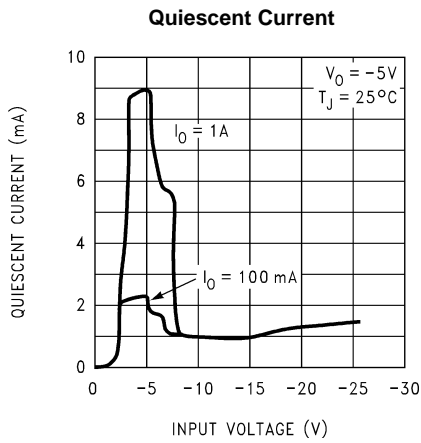


Figure 5.

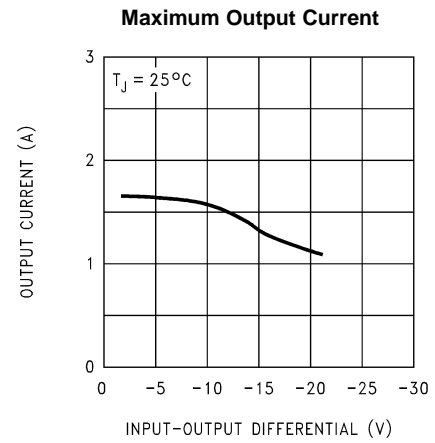


Figure 6.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Line Transient Response

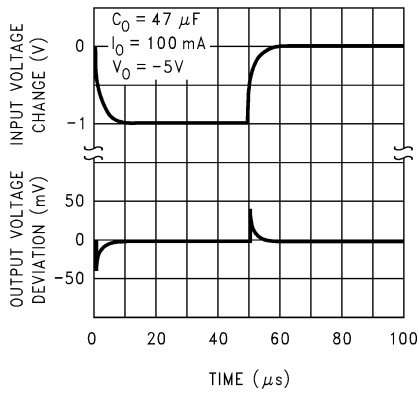


Figure 7.

Load Transient Response

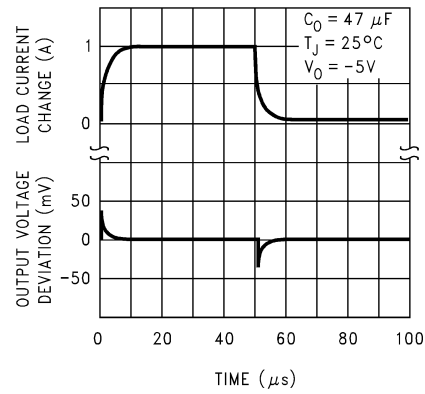


Figure 8.

Maximum Output Current

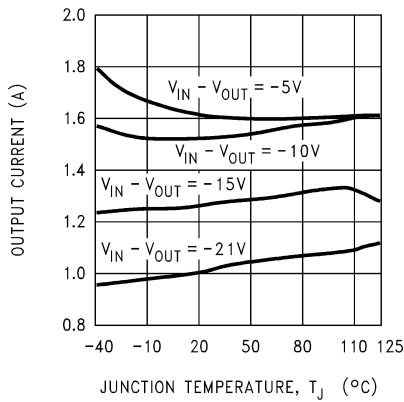


Figure 9.

Ripple Rejection

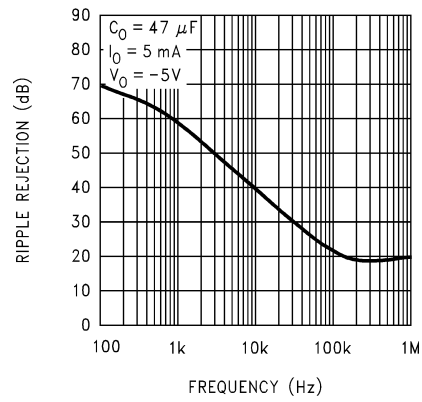


Figure 10.

Output Impedance

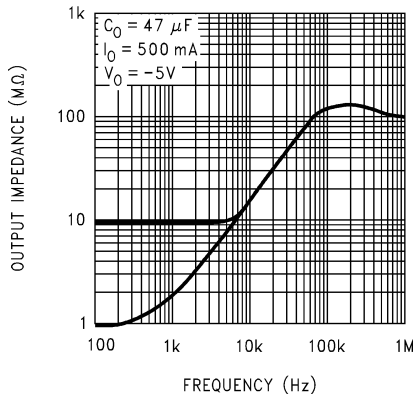


Figure 11.

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

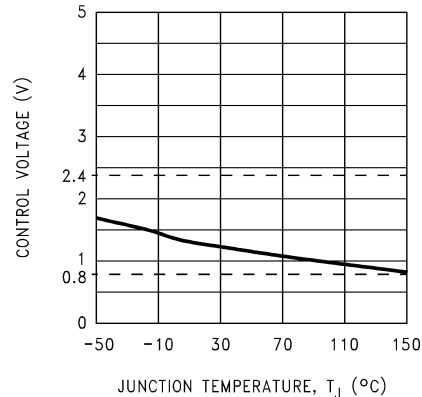


Figure 12.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Adjust Pin Current

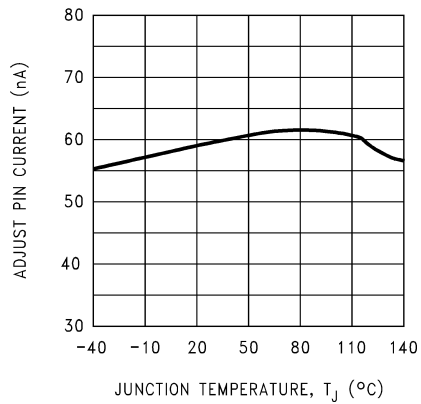


Figure 13.

Low Voltage Behavior

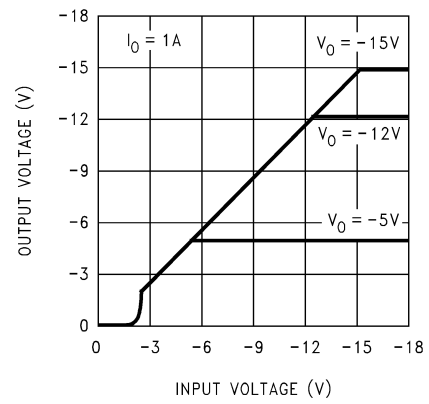


Figure 14.

APPLICATION HINTS

EXTERNAL CAPACITORS

Like any low-dropout regulator, external capacitors are required to stabilize the control loop. These capacitors must be correctly selected for proper performance.

INPUT CAPACITOR

An input capacitor is required if the regulator is located more than 6" from the input power supply filter capacitor (or if no other input capacitor is present).

A solid Tantalum or ceramic capacitor whose value is at least 1 μF is recommended, but an aluminum electrolytic ($\geq 10 \mu\text{F}$) may be used. However, aluminum electrolytics should not be used in applications where the ambient temperature can drop below 0°C because their internal impedance increases significantly at cold temperatures.

OUTPUT CAPACITOR

The output capacitor must meet the ESR limits shown in the graph, which means it must have an ESR between about 25 m Ω and 10 Ω .

A solid Tantalum (value $\geq 1 \mu\text{F}$) is the best choice for the output capacitor. An aluminum electrolytic ($\geq 10 \mu\text{F}$) may be used if the ESR is in the stable range.

It should be noted that the ESR of a typical aluminum electrolytic will increase by as much as 50X as the temperature is reduced from 25°C down to -40°C , while a Tantalum will exhibit an ESR increase of about 2X over the same range. For this and other reasons, aluminum electrolytics should not be used in applications where low operating temperatures occur.

The lower stable ESR limit of 25 m Ω means that ceramic capacitors can not be used directly on the output of an LDO. A ceramic ($\geq 2.2 \mu\text{F}$) can be used on the output if some external resistance is placed in series with it (1 Ω recommended). Dielectric types X7R or X5R must be used if the temperature range of the application varies more than $\pm 25^{\circ}\text{C}$ from ambient to assure the amount of capacitance is sufficient.

CERAMIC BYPASS CAPACITORS

Many designers place distributed ceramic capacitors whose value is in the range of 1000 pF to 0.1 μF at the power input pins of the IC's across a circuit board. These can cause reduced phase margin or oscillations in LDO regulators.

The advent of multi-layer boards with dedicated power and ground planes has removed the trace inductance that (previously) provided the necessary "decoupling" to shield the output of the LDO from the effects of bypass capacitors.

These capacitors should be avoided if possible, and kept as far away from the LDO output as is practical.

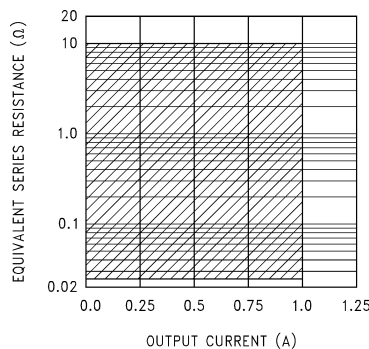


Figure 15. Output Capacitor ESR Range

MINIMUM LOAD

A minimum load current of 500 μ A 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 k Ω .

SETTING THE OUTPUT VOLTAGE

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

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

where $V_{REF} = -1.21$ V. The output voltage can be programmed within the range of -3 V to -24 V, typically an even greater range of -2 V to -25 V. The adjust pin current is about 60 nA, causing a slight error in the output voltage. However, using resistors lower than 100 k Ω makes the adjust pin current negligible. For example, neglecting the adjust pin current, and setting R_2 to 100 k Ω and V_{OUT} to -5 V, results in an output voltage error of only 0.16%.

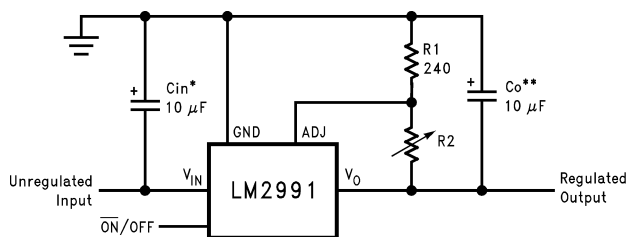
ON/OFF PIN

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

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



$$V_O = V_{Ref} (1 + R_2/R_1)$$

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

**Required for stability. Must be at least a 10 μ F aluminum electrolytic or a 1 μ F 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 10 Ω over the same operating temperature range as the regulator.

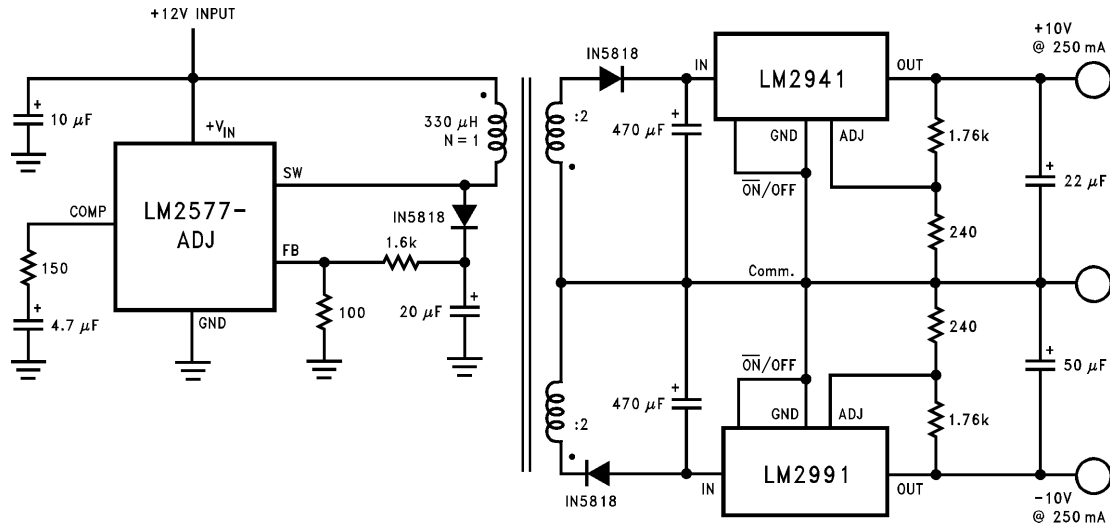


Figure 16. Fully Isolated Post-Switcher Regulator

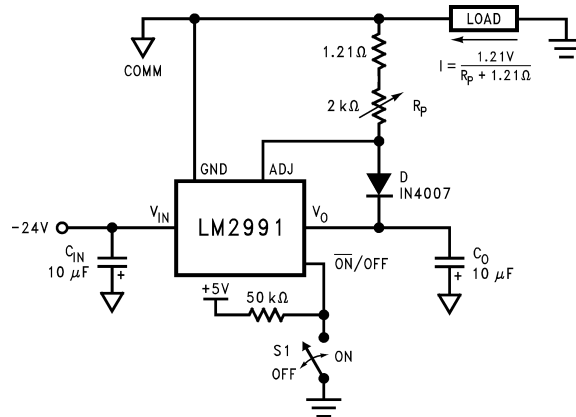




Figure 17. Adjustable Current Sink

REVISION HISTORY

Released	Revision	Section	Changes
03/10/06	A	New Release, Corporate format	1 MDS data sheet converted into one Corp. data sheet format. MNLM2991-X Rev 1A1 will be archived.
05-Oct-2011	B	Ordering Information, Absolute Maximum Ratings	Added new 'GW' NSID and —02 SMD part number. Added Theta JA & Theta JC as well as the weight for the 'GW' device. LM2991QML Rev A will be archived.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
5962-9650502QXA	ACTIVE	CFP	NAC	16	42	TBD	Call TI	Call TI	-55 to 125	LM2991GW-QML Q 5962-96505 02QXA ACO 02QXA >T	
LM2991GW-QML	ACTIVE	CFP	NAC	16	42	TBD	Call TI	Call TI	-55 to 125	LM2991GW-QML Q 5962-96505 02QXA ACO 02QXA >T	

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

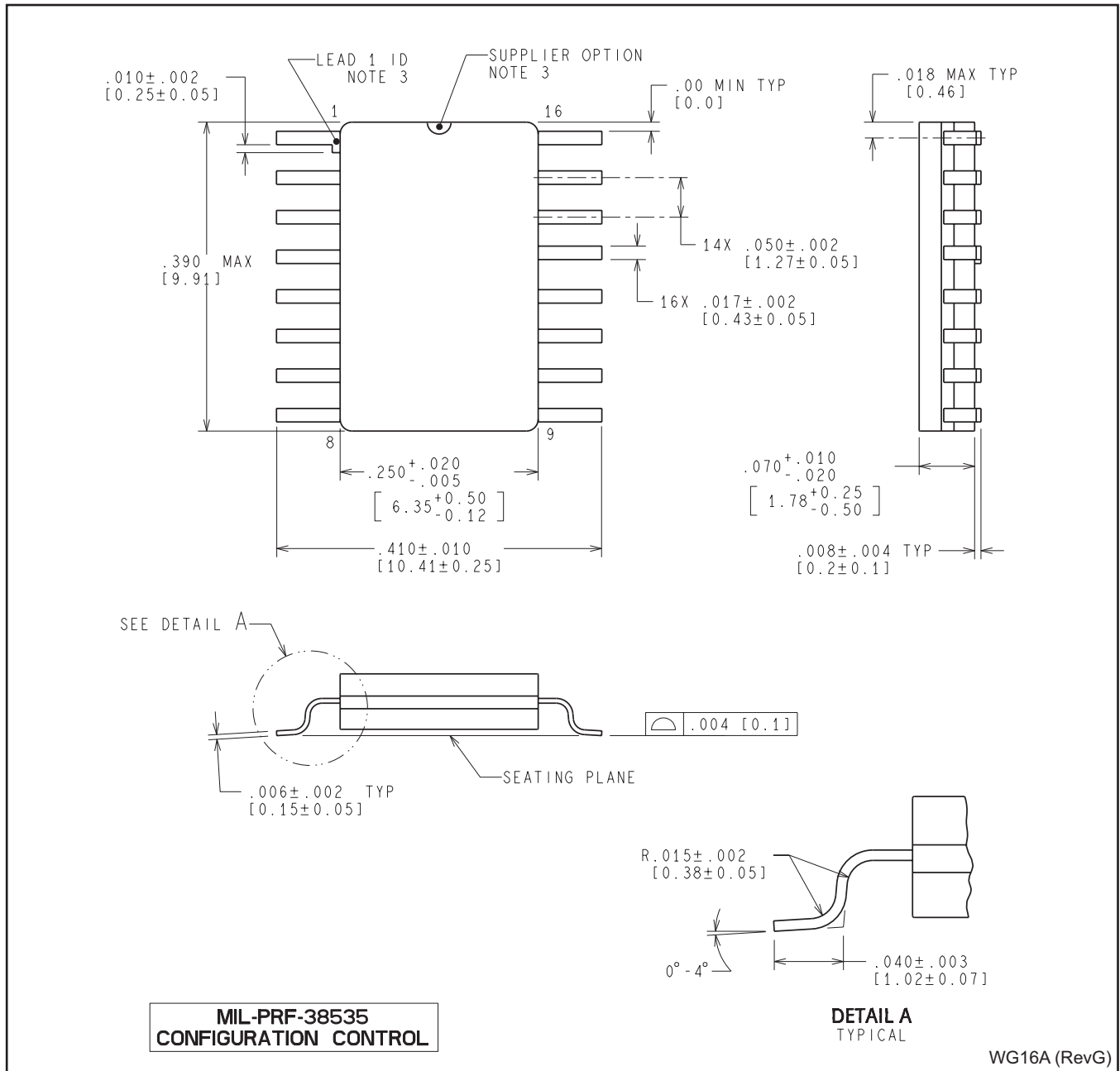
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

NAC0016A



IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

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

Applications

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

TI E2E Community

e2e.ti.com