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 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 ($V_O − V_I ≤ 3V$).

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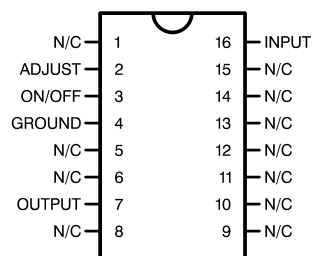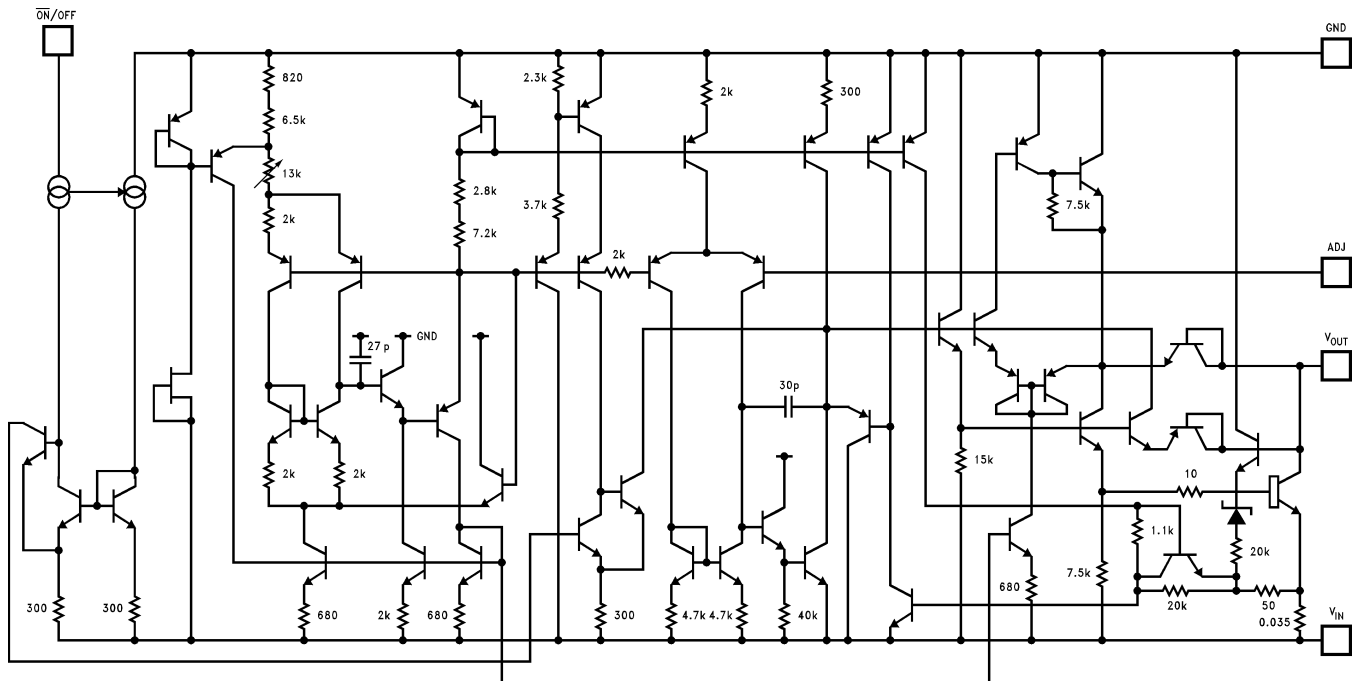
Connection Diagrams

Figure 1. Top View

Equivalent Schematic

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.

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	
θ_{JA}	
Ceramic SOIC (Still Air @ 0.5°C/W) "GW"	130°C/W
Ceramic SOIC (500LF/Min Air flow @ 0.5°C/W) "GW"	80°C/W
θ_{JC}	
Ceramic SOIC "GW"	6°C/W
Package Weight "GW"	410mg
Lead Temperature (Soldering, 10 sec.)	260°C
ESD Susceptibility [(3)]	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 guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed 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) Human body model, 1.5 kΩ in series with 100 pF.

Recommended Operating Conditions [(1)]

(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 guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Product Folder Links: *LM2991QML*

Recommended Operating Conditions [1] (continued)

Operating Temperature Range (T_A)	−55°C ≤ T_A ≤ +125°C
Maximum Input Voltage (Operational)	−26V

Quality Conformance Inspection

Table 1. 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

Product Folder Links: *LM2991QML*

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	$V\overline{ON}$/OFF = 0.6V (V_O : ON)			10	μA	1
					25	μA	2, 3
		$V\overline{ON}$/OFF = 2.4V (V_O : OFF)			100	μA	1
					150	μA	2, 3
I_L	Output Leakage Current	$V_I = -26V$, $V\overline{ON}$/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

Product Folder Links: *LM2991QML*

LM2991 Electrical Characteristics AC Parameters

The following conditions apply, unless otherwise specified.

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

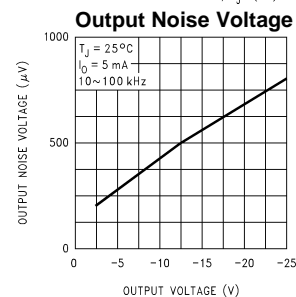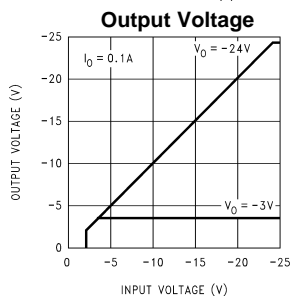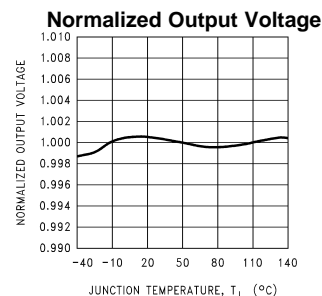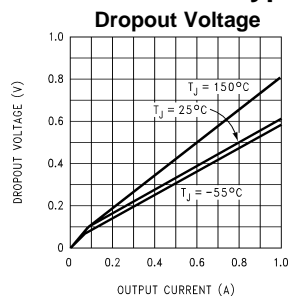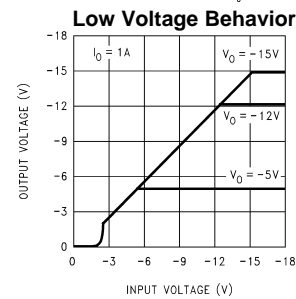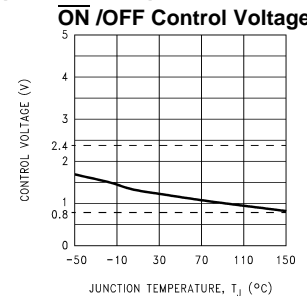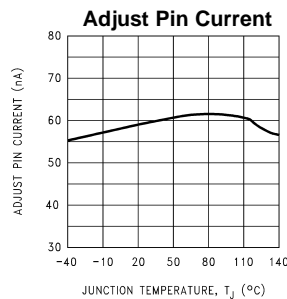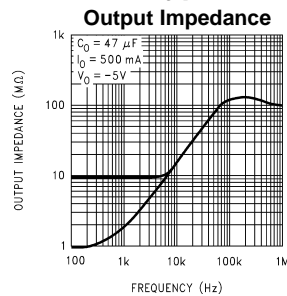| Symbol	Parameter	Conditions	Notes	Min	Max	Units	Sub-groups
RR	Ripple Rejection	$V_{Ripple} = 1V_{RMS}$, $F_{Ripple} = 1KHz$, $I_O = 5mA$		50		dB	1

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	$5mA \le I_O \le 1A$			±20	mV	1

Product Folder Links: *LM2991QML*

Typical Performance Characteristics

Dropout Voltage

Normalized Output Voltage

Output Voltage

Output Noise Voltage

Quiescent Current

Maximum Output Current

Line Transient Response

Load Transient Response

Maximum Output Current

Ripple Rejection

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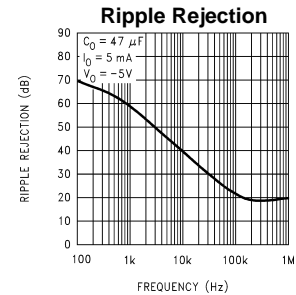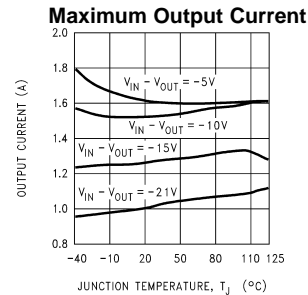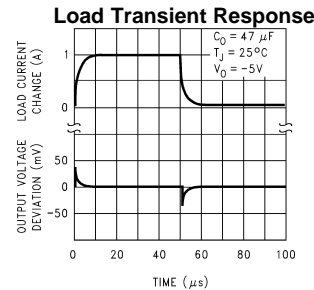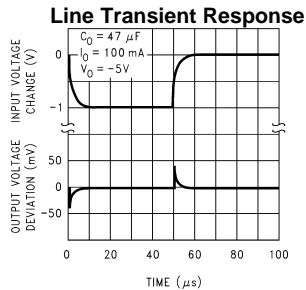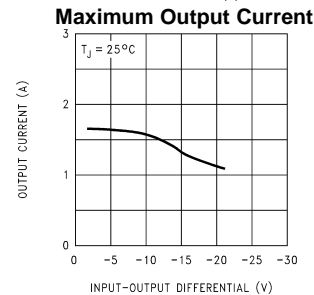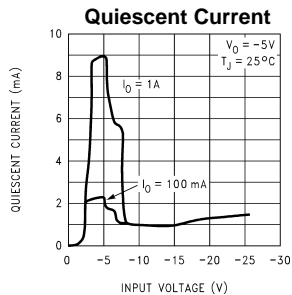
Typical Performance Characteristics (continued)

Output Impedance

ON /OFF Control Voltage

Adjust Pin Current

Low Voltage Behavior

Application Hints

EXTERNAL CAPACITORS

Like any low-dropout regulator, external capacitors are reqired 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 (≥ 10 µF) 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 mΩ and 10Ω.

A solid Tantalum (value ≥ 1 µF) is the best choice for the output capacitor. An aluminum electrolytic (≥ 10 µF) 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 mΩ means that ceramic capacitors can not be used directly on the output of an LDO. A ceramic (≥ 2.2 µF) can be used on the output if some external resistance is placed in series with it (1Ω recommended). Dielectric types X7R or X5R must be used if the temperature range of the application varies more than ± 25°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.

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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 2. Output Capacitor ESR Range
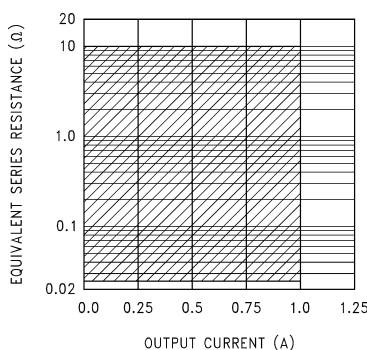
MINIMUM LOAD

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 using the following equation:

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

where V_{REF} = −1.21V. The output voltage can be programmed within the range of −3V to −24V, typically an even greater 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%.

$\overline{\text{ON/OFF}}$ PIN

The LM2991 regulator can be turned off by applying a TTL or CMOS level high signal to the $\overline{\text{ON/OFF}}$ 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
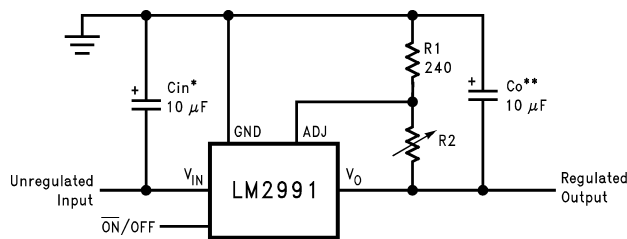
$V_O = V_{Ref} (1 + R2/R1)$
*Required if the regulator is located further than 6 inches from the power supply filter capacitors. A 1 µF solid tantalum or a 10 µF aluminum electrolytic capacitor is recommended.
**Required for stability. Must be at least a 10 µF aluminum electrolytic or a 1 µF solid tantalum 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.

Figure 3. Fully Isolated Post-Switcher Regulator
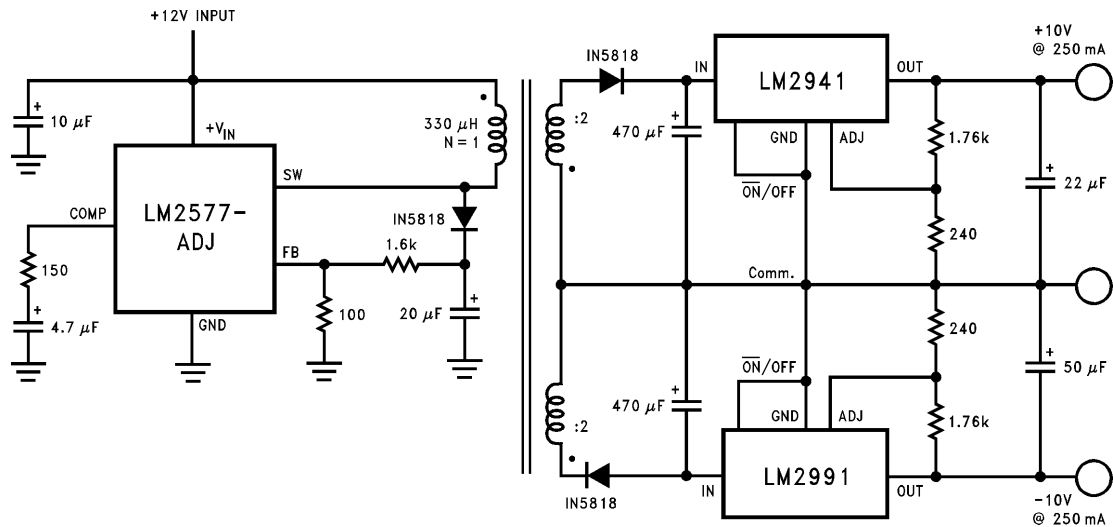
Figure 4. Adjustable Current Sink
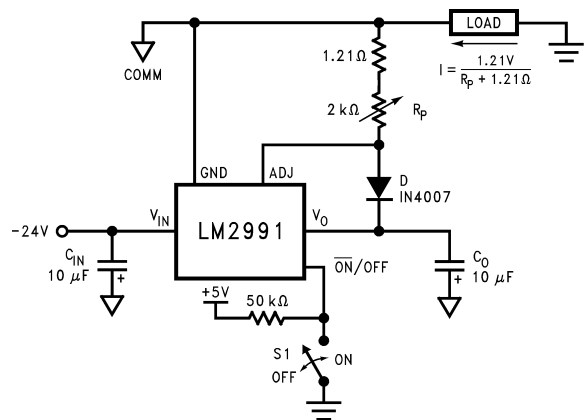
Table 2. Revision History

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.

Product Folder Links: *LM2991QML*

Table 2. Revision History (continued)

Released	Revision	Section	Changes
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)	Samples (Requires Login)
5962-9650502QXA	ACTIVE	CLGA	NAC	16	42	TBD	CU SNPB	Level-1-NA-UNLIM	
LM2991GW-QML	ACTIVE	CLGA	NAC	16	42	TBD	CU SNPB	Level-1-NA-UNLIM	

(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.

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NAC0016A

.010±.002
[0.25±0.05]

LEAD 1 ID
NOTE 3

SUPPLIER OPTION
NOTE 3

.00 MIN TYP
[0.0]

.018 MAX TYP
[0.46]

1

16

.390 MAX
[9.91]

14X .050±.002
[1.27±0.05]

16X .017±.002
[0.43±0.05]

8

9

.250 +.020 -.005
[6.35 +0.50 -0.12]

.070 +.010 -.020
[1.78 +0.25 -0.50]

.410±.010
[10.41±0.25]

.008±.004 TYP
[0.2±0.1]

SEE DETAIL A

.004 [0.1]

SEATING PLANE

.006±.002 TYP
[0.15±0.05]

R.015±.002
[0.38±0.05]

0° - 4°

.040±.003
[1.02±0.07]
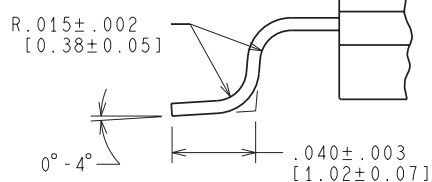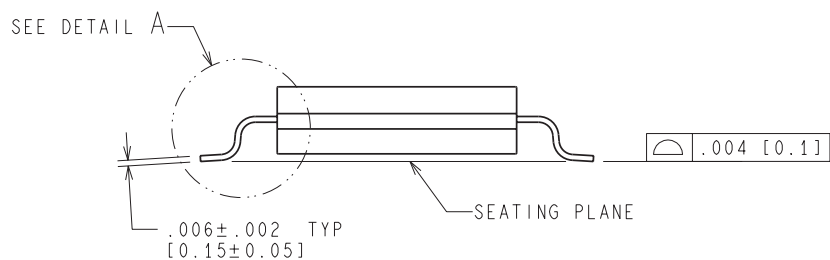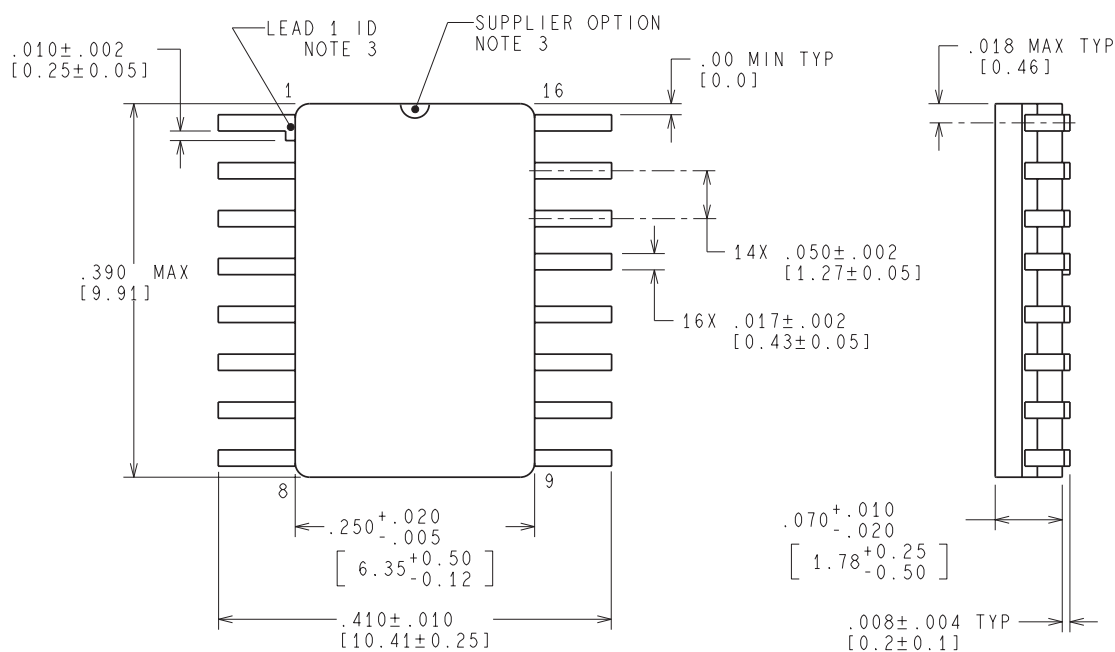
MIL-PRF-38535
CONFIGURATION CONTROL

DETAIL A
TYPICAL

WG16A (RevG)

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