LM2940QML 1A Low Dropout Regulator

Check for Samples: LM2940QML

FEATURES

- **Available with radiation guarantee**
  - **ELDRS Free 100 krad(Si)**
- **Dropout voltage typically 0.5V @I_O = 1A**
- **Output current in excess of 1A**
- **Output voltage trimmed before assembly**
- **Reverse battery protection**
- **Internal short circuit current limit**
- **Mirror image insertion protection**

DESCRIPTION

The LM2940 positive voltage regulator features the ability to source 1A of output current with a dropout voltage of typically 0.5V and a maximum of 1V over the entire temperature range. Furthermore, a quiescent current reduction circuit has been included which reduces the ground current when the differential between the input voltage and the output voltage exceeds approximately 3V. The quiescent current with 1A of output current and an input-output differential of 5V is therefore only 30 mA. Higher quiescent currents only exist when the regulator is in the dropout mode ($V_{IN} - V_{OUT} \leq 3V$).

Designed also for vehicular applications, the LM2940 and all regulated circuitry are protected from reverse battery installations or 2-battery jumps. During line transients, such as load dump when the input voltage can momentarily exceed the specified maximum operating voltage, the regulator will automatically shut down to protect both the internal circuits and the load. The LM2940 cannot be harmed by temporary mirror-image insertion. Familiar regulator features such as short circuit and thermal overload protection are also provided.

CONNECTION DIAGRAMS

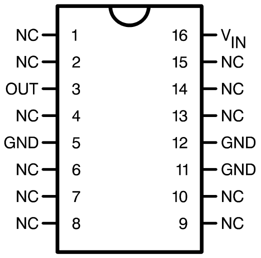
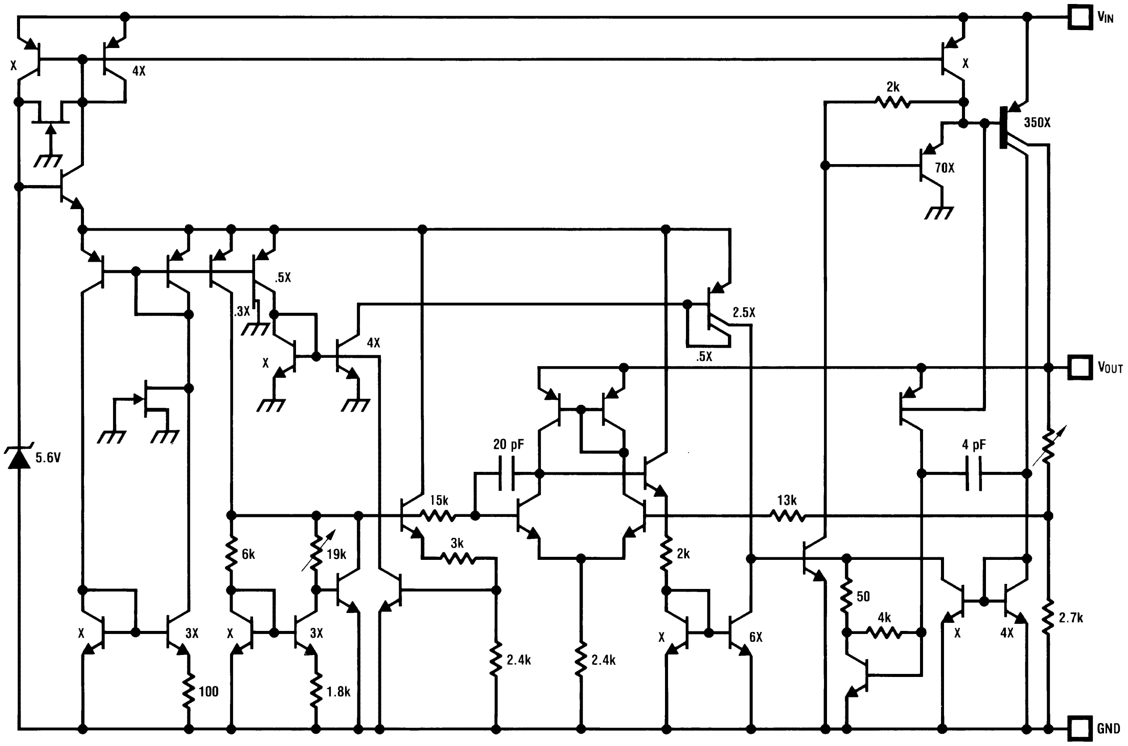


Figure 1. 16-Lead Ceramic Surface-Mount Package (WG) Top View

Equivalent Schematic Diagram



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 (Survival Voltage ≤ 100mS)	60V
Internal Power Dissipation with no heat sink (T_A = +25°C) (2)	1W
Maximum Junction Temperature	150°C
Storage Temperature Range	$-65°C \le T_A \le +150°C$
Lead Temperature (Soldering 10 seconds)	300°C
Thermal Resistance	
θ_{JA}	
16LD Ceramic SOIC (Still Air) 'WG'	122°C/W
16LD Ceramic SOIC (Still Air) 'GW'	136°C/W
16LD Ceramic SOIC (500LF/Min Air flow) 'WG'	77°C/W
16LD Ceramic SOIC (500LF/Min Air flow) 'GW'	87°C/W
θ_{JC}	
16LD Ceramic SOIC 'WG' (3)	5°C/W
16LD Ceramic SOIC 'GW'	13°C/W
Package Weight 'WG'	360 mg
Package Weight 'GW'	410 mg
ESD Susceptibility (4)	4KV

(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. With heat sinking, the maximum power is 5 Watts, but then this will depend upon the temperature of the heat sink, the efficiency of the heat sink, and the efficiency of the heat flow between the package body and the heat sink. We can not predict these values.

(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 of the package, since the thermal resistance of the lead frame 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.

(4) Human body model, 1.5 kΩ in series with 100 pF.

Recommended Operating Conditions (1)

Input Voltage	26V
Temperature Range	$-55°C \le T_A \le 125°C$

(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.

Table 1. Quality Conformance InspectionMil-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

Table 1. Quality Conformance InspectionMil-Std-883, Method 5005 - Group A (continued)

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

LM2940-5.0 Electrical Characteristics SMD: 5962R8958701 DC Parameters

The following conditions apply, unless otherwise specified.
DC: V_I = 10V, I_O = 1A, C_O = 22µF

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_O	Output Voltage	V_{IN} = 10V, I_{OUT} = 5mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 6V, I_{OUT} = 5mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 7V, I_{OUT} = 5mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 26V, I_{OUT} = 5mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 10V, I_{OUT} = 1A		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 6V, I_{OUT} = 1A		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 6V, I_{OUT} = 50mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 10V, I_{OUT} = 50mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
	Reverse Polarity Input Voltage DC	R_O = 100Ω	(1)	-15		V	1, 2, 3
I_Q	Quiescent Current	V_{IN} = 10V, I_{OUT} = 5mA		0.0	15	mA	1
				0.0	20	mA	2, 3
		V_{IN} = 7V, I_{OUT} = 5mA		0.0	15	mA	1
				0.0	20	mA	2, 3
		V_{IN} = 26V, I_{OUT} = 5mA		0.0	15	mA	1
				0.0	20	mA	2, 3
		V_{IN} = 10V, I_{OUT} = 1A		0.0	50	mA	1
				0.0	100	mA	2, 3
V_{RLine}	Line Regulation	7V ≤ V_{IN} ≤ 26V, I_{OUT} = 5mA		-40	40	mV	1
				-50	50	mV	2, 3
V_{RLoad}	Load Regulation	V_{IN} = 10V, 50mA ≤ I_{OUT} ≤ 1A		-50	50	mV	1
				-100	100	mV	2, 3
V_{DO}	Dropout Voltage	I_{OUT} = 1A		0.0	0.7	V	1
				0.0	1.0	V	2, 3
		I_{OUT} = 100mA		0.0	200	mV	1
				0.0	300	mV	2, 3
I_{SC}	Short Circuit Current	V_{IN} = 10V		1.5		A	1
				1.3		A	2, 3

(1) Functional test only.

LM2940-5.0 Electrical Characteristics SMD: 5962R8958701 AC Parameters SMD: 5962R8958701

The following conditions apply, unless otherwise specified.

AC: V_I = 10V, I_O = 1A, C_O = 22µF

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
	Max Line Transient	V_O ≤ 6V, R_O = 100Ω, t = 20mS	(1)	40		V	1, 2, 3
	Reverse Polarity Input Voltage Transient	t = 20mS, R_O = 100Ω	(1)	-45		V	1, 2, 3
RR	Ripple Rejection	V_{IN} = 10V, 1V_{RMS}, ƒ = 1KHz, I_{OUT} = 5mA	(1)	60		dB	4
			(1)	50		dB	5, 6
N_O	Output Noise Voltage	V_{IN} = 10V, I_{OUT} = 5mA, 10Hz - 100KHz	(1)	0.0	700	µV_{RMS}	1, 2, 3
Z_O	Output Impedance	V_{IN} = 10V, ƒ$_O$ = 120Hz I_{OUT} = 100mA DC and 20mA AC	(1)		1.0	Ω	1, 2, 3

(1) Functional test only.

LM2940-5.0 Electrical Characteristics SMD: 5962R8958702 DC Parameters

The following conditions apply, unless otherwise specified.

DC: V_I = 10V, I_O = 1A, C_O = 22µF

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_O	Output Voltage	V_{IN} = 10V, I_{OUT} = 5mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 6V, I_{OUT} = 5mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 7V, I_{OUT} = 5mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 26V, I_{OUT} = 5mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 10V, I_{OUT} = 1A		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 6V, I_{OUT} = 1A		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 6V, I_{OUT} = 50mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
		V_{IN} = 10V, I_{OUT} = 50mA		4.85	5.15	V	1
				4.75	5.25	V	2, 3
	Reverse Polarity Input Voltage DC	R_O = 100Ω	(1)	-15		V	1, 2, 3
I_Q	Quiescent Current	V_{IN} = 10V, I_{OUT} = 5mA		0.0	15	mA	1
				0.0	20	mA	2, 3
		V_{IN} = 7V, I_{OUT} = 5mA		0.0	15	mA	1
				0.0	20	mA	2, 3
		V_{IN} = 26V, I_{OUT} = 5mA		0.0	15	mA	1
				0.0	20	mA	2, 3
		V_{IN} = 10V, I_{OUT} = 1A		0.0	50	mA	1
				0.0	100	mA	2, 3
V_{RLine}	Line Regulation	7V ≤ V_{IN} ≤ 26V, I_{OUT} = 5mA		-40	40	mV	1
				-50	50	mV	2, 3
V_{RLoad}	Load Regulation	V_{IN} = 10V, 50mA ≤ I_{OUT} ≤ 1A		-50	50	mV	1
				-100	100	mV	2, 3
V_{DO}	Dropout Voltage	I_{OUT} = 1A		0.0	0.7	V	1
				0.0	1.0	V	2, 3
		I_{OUT} = 100mA		0.0	200	mV	1
				0.0	300	mV	2, 3
I_{SC}	Short Circuit Current	V_{IN} = 10V		1.5		A	1
				1.3		A	2, 3

(1) Functional test only.

LM2940-5.0 Electrical Characteristics SMD: 5962R8958702 AC Parameters SMD: 5962R8958702

The following conditions apply, unless otherwise specified.
AC: V_I = 10V, I_O = 1A, C_O = 22µF

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
	Max Line Transient	V_O ≤ 6V, R_O = 100Ω, t = 20mS	(1)	40		V	1, 2, 3
	Reverse Polarity Input Voltage Transient	t = 20mS, R_O = 100Ω	(1)	-45		V	1, 2, 3
RR	Ripple Rejection	V_{IN} = 10V, $1V_{RMS}$, ƒ = 1KHz, I_{OUT} = 5mA	(1)	60		dB	4
			(1)	50		dB	5, 6
N_O	Output Noise Voltage	V_{IN} = 10V, I_{OUT} = 5mA, 10Hz - 100KHz	(1)	0.0	700	$µV_{RMS}$	1, 2, 3
Z_O	Output Impedance	V_{IN} = 10V, $ƒ_O$ = 120Hz I_{OUT} = 100mA DC and 20mA AC	(1)		1.0	Ω	1, 2, 3

(1) Functional test only.

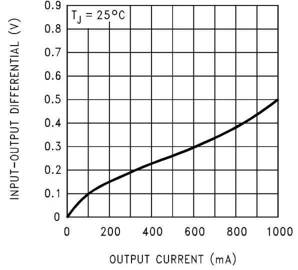
LM2940-5.0 Electrical Characteristics SMD: 5962R8958702 DC Drift Parameters

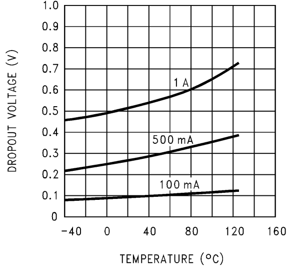
The following conditions apply, unless otherwise specified.

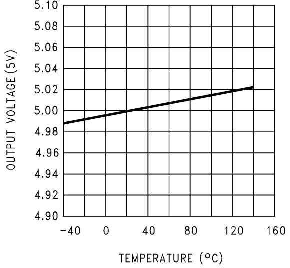
DC: V_I = 10V, I_O = 1A, C_O = 22µF, **“Delta calculations performed on QMLV devices at group B, subgroup 5 only”**

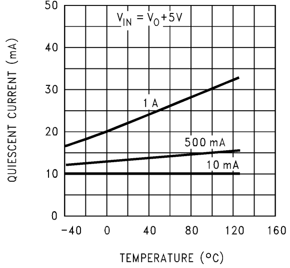
Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_O	Output Voltage	V_{IN} = 10V, I_{OUT} = 5mA		-30	30	mV	1
		V_{IN} = 6V, I_{OUT} = 5mA		-30	30	mV	1
		V_{IN} = 7V, I_{OUT} = 5mA		-30	30	mV	1
		V_{IN} = 26V, I_{OUT} = 5mA		-30	30	mV	1
		V_{IN} = 10V, I_{OUT} = 1A		-30	30	mV	1
		V_{IN} = 6V, I_{OUT} = 1A		-30	30	mV	1
		V_{IN} = 6V, I_{OUT} = 50mA		-30	30	mV	1
		V_{IN} = 10V, I_{OUT} = 50mA		-30	30	mV	1
V_{RLOAD}	Load Regulation	V_{IN} = 10V, 50mA ≤ I_{OUT} ≤ 1A		-20	20	mV	1

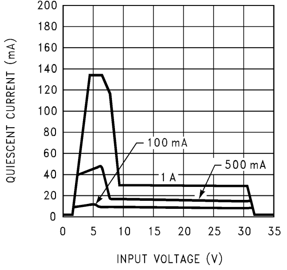
Typical Performance Characteristics

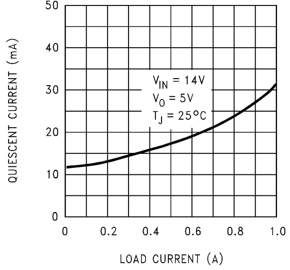

Dropout Voltage

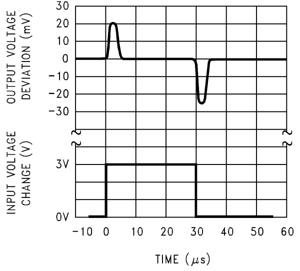

Dropout Voltage vs. Temperature

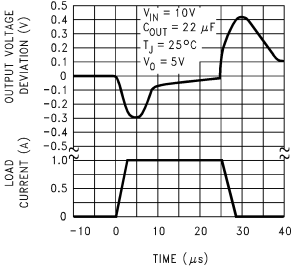

Output Voltage vs. Temperature

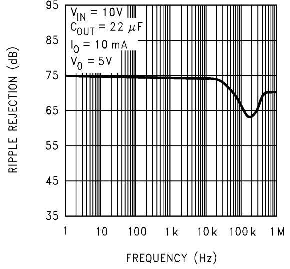

Quiescent Current vs. Temperature

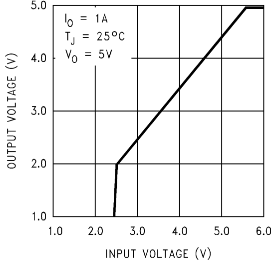

Quiescent Current


Quiescent Current


Line Transient Response

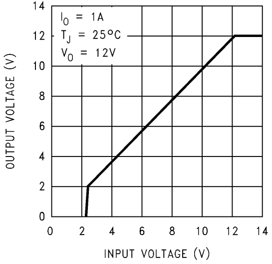

Load Transient Response


Ripple Rejection

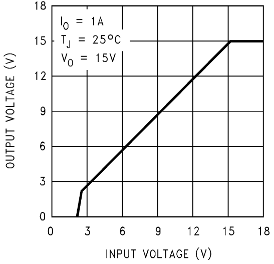

Low Voltage Behavior

Typical Performance Characteristics (continued)

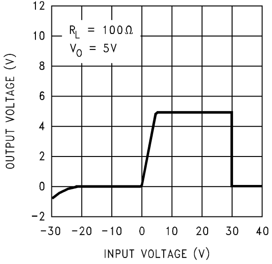
Low Voltage Behavior



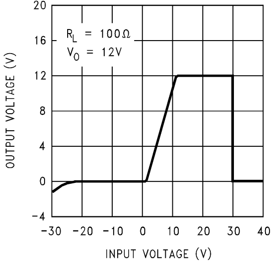
Low Voltage Behavior



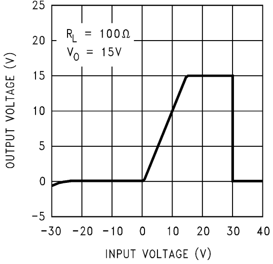
Output at Voltage Extremes



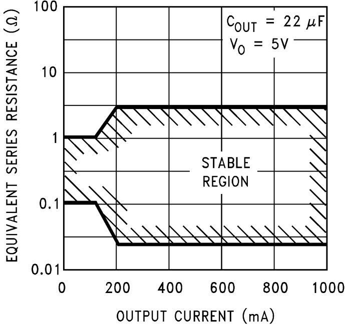
Output at Voltage Extremes



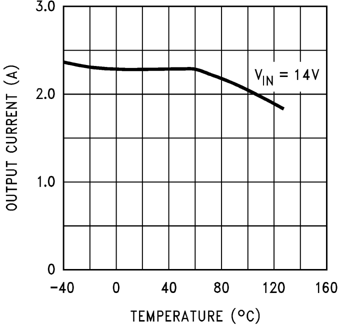
Output at Voltage Extremes



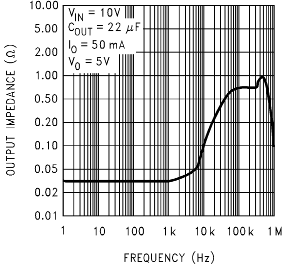
Output Capacitor ESR



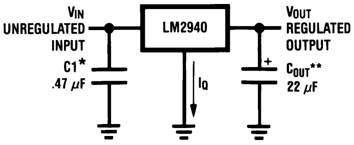
Peak Output Current



Output Impedance



Typical Application



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

**C_{OUT} must be at least 22 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 and the ESR is critical; see curve.

Application Hints

EXTERNAL CAPACITORS

The output capacitor is critical to maintaining regulator stability, and must meet the required conditions for both ESR (Equivalent Series Resistance) and minimum amount of capacitance.

MINIMUM CAPACITANCE:

The minimum output capacitance required to maintain stability is 22 µF (this value may be increased without limit). Larger values of output capacitance will give improved transient response.

ESR LIMITS:

The ESR of the output capacitor will cause loop instability if it is too high or too low. The acceptable range of ESR plotted versus load current is shown in the graph below. ***It is essential that the output capacitor meet these requirements, or oscillations can result.***

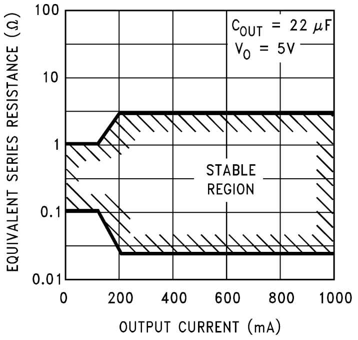


Figure 2. Output Capacitor ESR Limits

It is important to note that for most capacitors, ESR is specified only at room temperature. However, the designer must ensure that the ESR will stay inside the limits shown over the entire operating temperature range for the design.

For aluminum electrolytic capacitors, ESR will increase by about 30X as the temperature is reduced from 25°C to −40°C. This type of capacitor is not well-suited for low temperature operation.

Solid tantalum capacitors have a more stable ESR over temperature, but are more expensive than aluminum electrolytics. A cost-effective approach sometimes used is to parallel an aluminum electrolytic with a solid Tantalum, with the total capacitance split about 75/25% with the Aluminum being the larger value.

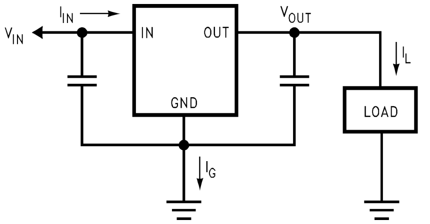
If two capacitors are paralleled, the effective ESR is the parallel of the two individual values. The “flatter” ESR of the Tantalum will keep the effective ESR from rising as quickly at low temperatures.

HEATSINKING

A heatsink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. Under all possible operating conditions, the junction temperature must be within the range specified under Absolute Maximum Ratings.

To determine if a heatsink is required, the power dissipated by the regulator, P_D, must be calculated.

The figure below shows the voltages and currents which are present in the circuit, as well as the formula for calculating the power dissipated in the regulator:



$I_{IN} = I_L \div I_G$
$P_D = (V_{IN} - V_{OUT})\ I_L + (V_{IN})\ I_G$

Figure 3. Power Dissipation Diagram

The next parameter which must be calculated is the maximum allowable temperature rise, T_R (max). This is calculated by using the formula:

$$T_R\ (\text{max}) = T_J(\text{max}) - T_A\ (\text{max}) \quad (1)$$

where: T_J (max) is the maximum allowable junction temperature.

T_A (max) is the maximum ambient temperature which will be encountered in the application.

Using the calculated values for T_R(max) and P_D, the maximum allowable value for the junction-to-ambient thermal resistance, $\theta_{(JA)}$, can now be found:

$$\theta_{(JA)} = T_R\ (\text{max})/P_D \quad (2)$$

Table 2. Revision History

Released	Revision	Section	Changes
05/10/2010	A	New Release, Corporate format	1 MDS data sheets converted into one Corp. data sheet format added reference to New ELDRS device. Change AC subgroups from 4, 5, 6, 7, 8A, 8B to 1, 2, 3 for parameters Max Line Transient, Reverse Polarity Input Voltage Transient, Output Noise Voltage, Output Impedance. To bring it into agreement with the SMD. MNLM2940-5.0-X Rev 1A1 will be archived.
12–Oct-2010	B	Ordering Information, Absolute Max Ratings	Ordering Information — Added LM2940GW5.0/883, LM2940GW5.0RLQV. Absolute Max Ratings — Added Theta JA and Theta JC along with Package Weight for 'GW' devices. LM2940QML 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)
5962-8958703XA	ACTIVE	CLGA	NAC	16	42	TBD	CU SNPB	Level-1-NA-UNLIM	
5962R8958704VXA	ACTIVE	CLGA	NAC	16	42	TBD	CU SNPB	Level-1-NA-UNLIM	
LM2940GW5.0/883	ACTIVE	CLGA	NAC	16	42	TBD	CU SNPB	Level-1-NA-UNLIM	
LM2940GW5.0RLQV	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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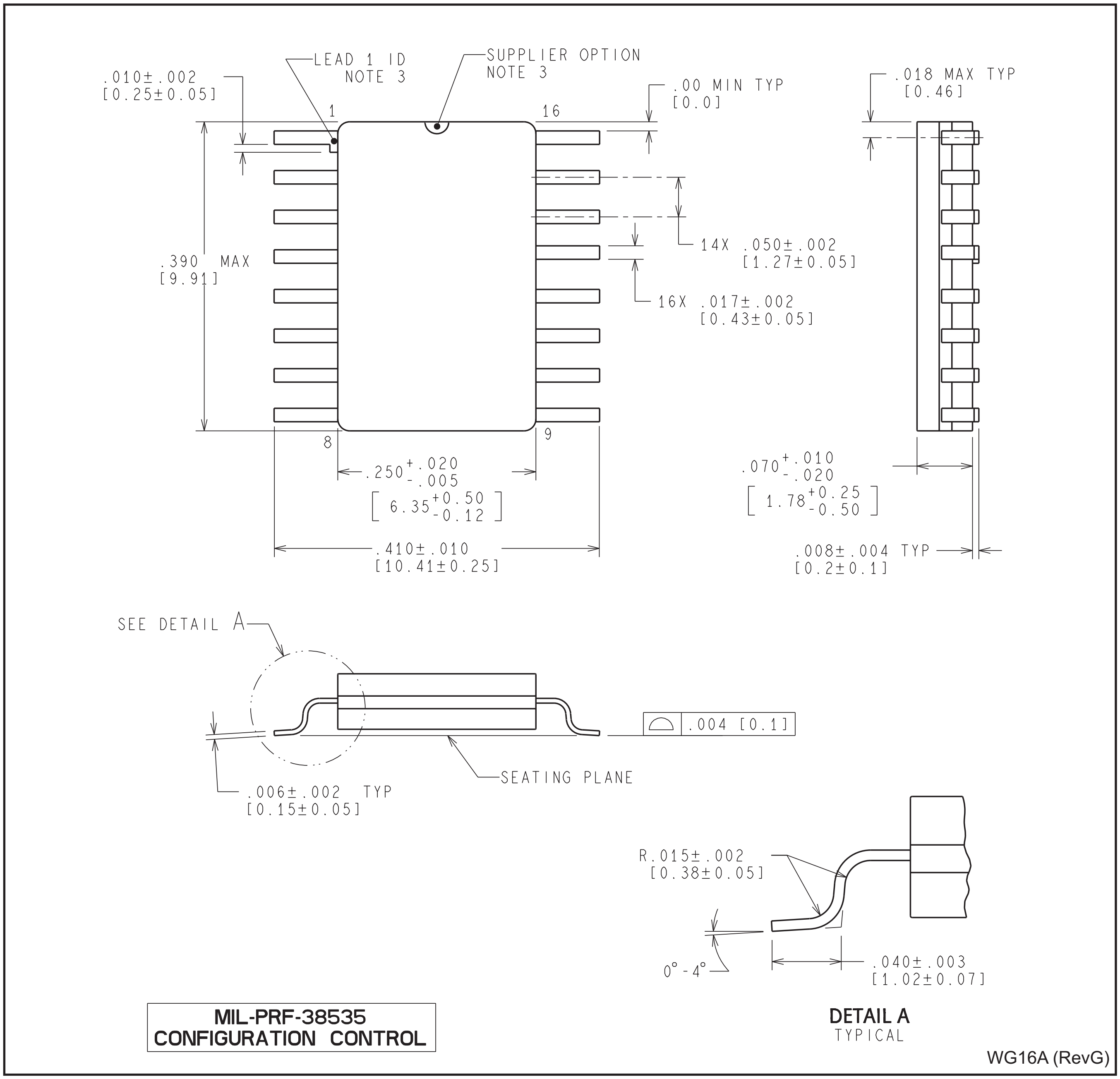
OTHER QUALIFIED VERSIONS OF LM2940QML, LM2940QML-SP :

- Military: LM2940QML
- Space: LM2940QML-SP

NOTE: Qualified Version Definitions:

- Military - QML certified for Military and Defense Applications
- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

NAC0016A


LEAD 1 ID
NOTE 3
SUPPLIER OPTION
NOTE 3
.010±.002
[0.25±0.05]
1
16
.00 MIN TYP
[0.0]
.018 MAX TYP
[0.46]
14X .050±.002
[1.27±0.05]
.390 MAX
[9.91]
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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