LM2941QML 1A Low Dropout Adjustable Regulator

Check for Samples: LM2941QML, LM2941QML-SP

FEATURES

- **Available with Radiation Ensure**
  - **ELDRS Free 100 krad(Si)**
- **Output Voltage Adjustable from 5V to 20V**
- **Dropout Voltage Typically 0.5V at I_O = 1A**
- **Output Current in Excess of 1A**
- **Trimmed Reference Voltage**
- **Reverse Battery Protection**
- **Internal Short Circuit Current Limit**
- **Mirror Image Insertion Protection**
- **TTL, CMOS Compatible ON/OFF Switch**

DESCRIPTION

The LM2941 positive voltage regulator features the ability to source 1A of output current with a typical dropout voltage of 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 pin 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 30mA. Higher quiescent currents only exist when the regulator is in the dropout mode ($V_I - V_O \leq 3V$).

Originally designed for vehicular applications, the LM2941 and all regulated circuitry are protected from reverse battery installations or two-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. Familiar regulator features such as short circuit and thermal overload protection are also provided.

Connection Diagram

Top View

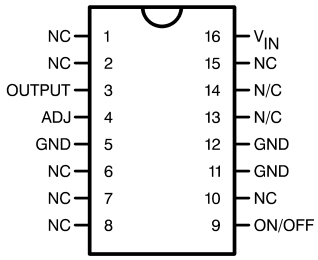

Figure 1. 16-Lead CFP Package

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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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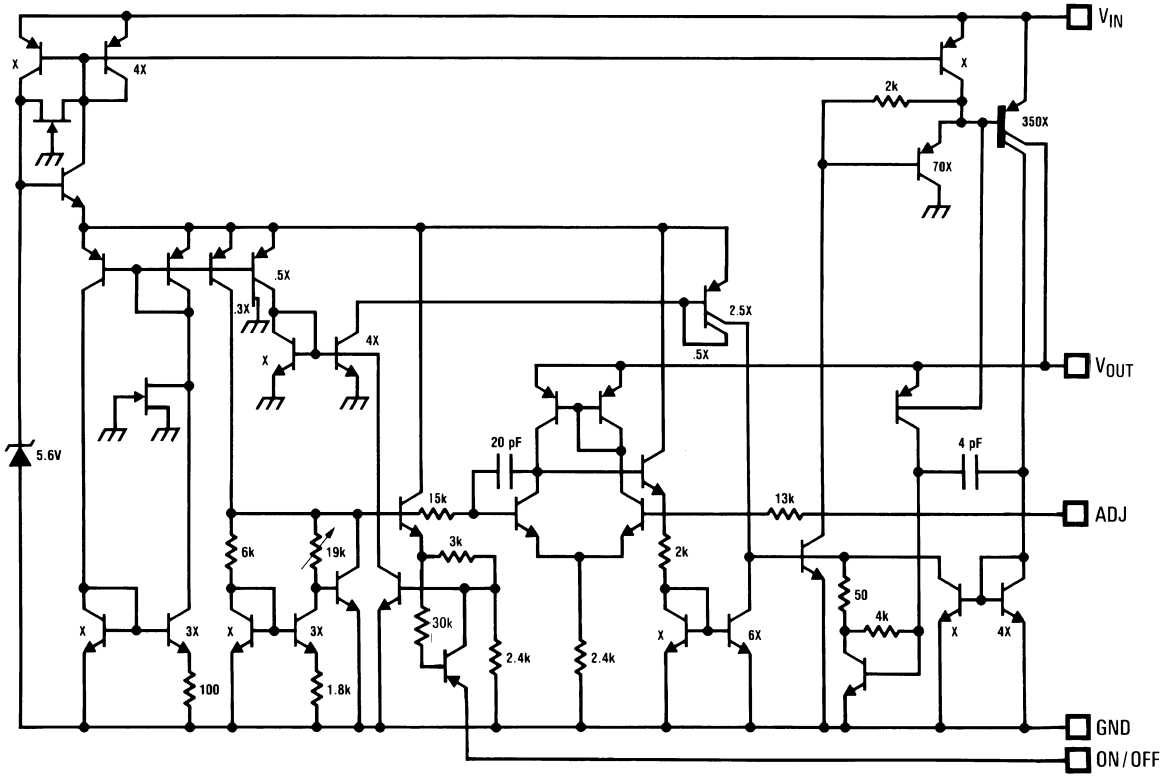
Equivalent Schematic Diagram



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.

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Absolute Maximum Ratings[1]

Input Voltage (Survival Voltage, ≤ 100ms)			60V
Internal Power Dissipation[2]			Internally Limited
Maximum Junction Temperature			150°C
Storage Temperature Range			−65°C ≤ T_J ≤ +150°C
Lead Temperature (Soldering, 10 seconds)			300°C
Thermal Resistance	θ_{JA}	CFP "WG" (device 01, 02) (Still Air)	122°C/W
		CFP "WG" (device 01, 02) (500LF/Min Air Flow)	77°C/W
		CFP "GW" (device 03, 04) (Still Air)	136°C/W
		CFP "GW" (device 03, 04) (500LF/Min Air Flow)	87°C/W
	θ_{JC}	CFP "WG" (device 01, 02)[3]	5°C/W
		CFP "GW" (device 03, 04)	13°C/W
Package Weight (Typ)		CFP "WG" (device 01, 02)	360mg
		CFP "GW" (device 03, 04)	410mg
ESD susceptibility to be determined[4]			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 specified 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 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

Maximum Input Voltage	26V
Temperature Range	−55°C ≤ T_A ≤ 125°C

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Table 1. 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

LM2941 Electrical Characteristics DC Parameters

The following conditions apply, unless otherwise specified.
DC: 5V ≤ V_O ≤ 20V, V_{IN} = V_O+5V, C_O = 22µF

Parameter		Test Conditions	Notes	Min	Max	Unit	Sub-groups
V_{Ref}	Reference Voltage	5mA ≤ I_O ≤ 1A		1.237	1.313	V	1
				1.211	1.339	V	2, 3
V_{RLine}	Line Regulation	V_O + 2V ≤ V_{IN} ≤ 26V, I_O = 5mA	See (1)		10	mV/V	1, 2, 3
V_{RLoad}	Load Regulation	50mA ≤ I_O ≤ 1A, V_{IN} = 10V, V_{OUT} = 5V	See (1)		10	mV/V	1, 2, 3
		50mA ≤ I_O ≤ 1A, V_{IN} = 25V, V_{OUT} = 20V			10	mV/V	1, 2, 3
I_Q	Quiescent Current	V_O + 2V ≤ V_{IN} ≤ 26V, I_O = 5mA			15	mA	1
					20	mA	2, 3
		V_{IN} = V_O + 5V, I_O = 1A			45	mA	1
					60	mA	2, 3
V_{DO}	Dropout Voltage	I_O = 1A			0.8	V	1
					1.0	V	2, 3
		I_O = 100mA			200	mV	1
					300	mV	2, 3
I_{SC}	Short Circuit Current	$V_{IN\ Max}$ = 26V		1.6	3.5	A	1
				1.3	3.7	A	2, 3
	Maximum Operational Input Voltage		See (2)		26	V_{DC}	1, 2, 3
	Reverse Polarity DC Input Voltage	R_O = 100Ω, V_O ≥ -0.6V	See (3)	-15		V	1, 2, 3
$V_{TH\ On}$	ON/OFF Threshold Voltage ON	I_O ≤ 1A	See (3)		0.8	V	1, 2, 3
$V_{Th\ Off}$	ON/OFF Threshold Voltage OFF	I_O ≤ 1A	See (3)	2.00		V	1, 2, 3
	ON/OFF Threshold Current	$V_{ON/OFF}$ = 2.0V, I_O ≤ 1A			100	µA	1
					300	µA	2, 3

(1) Limit = mV per volt of V_O.
(2) Condition for V_{IN}
(3) Functional test go-no-go only.

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LM2941 Electrical Characteristics AC Parameters

The following conditions apply, unless otherwise specified.
AC: $5V \le V_O \le 20V$, $V_{IN} = V_O+5V$, $C_O = 22\mu F$

Parameter		Test Conditions	Notes	Min	Max	Unit	Sub-groups
	Maximum Line Transient	$V_{O\ Max}$ 1V above nominal V_O, $R_O = 100\Omega$, $t \le 100mS$		60		V	4, 5, 6
	Reverse Polarity Transient Input Voltage	$t \le 100mS$, $R_O = 100\Omega$		-50		V	4, 5, 6
RR	Ripple Rejection	f_O = 1KHz, 1 V_{RMS}, I_L = 100mA	See (1)		0.02	%/V	4
		f_O = 1KHz, 1 V_{RMS}, I_L = 100mA	See (1)		0.04	%/V	5, 6

(1) %/V = % of V_{IN} per Volt of V_O.

LM2941 Electrical Characteristics DC Drift Parameters

The following conditions apply, unless otherwise specified.
DC: $5V \le V_O \le 20V$, $V_{IN} = V_O+5V$, $C_O = 22\mu F$
Delta calculations performed on QMLV devices at group B , subgroup 5.

Parameter		Test Conditions	Notes	Min	Max	Unit	Sub-groups
V_{Ref}	Reference Voltage	$5mA \le I_O \le 1A$		-25	+25	mV	1

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Typical Performance Characteristics

Dropout Voltage

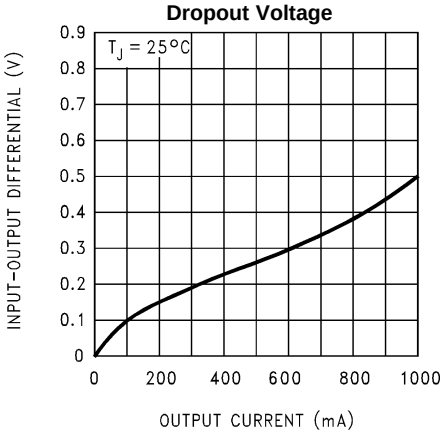

Figure 2.

Dropout Voltage vs. Temperature

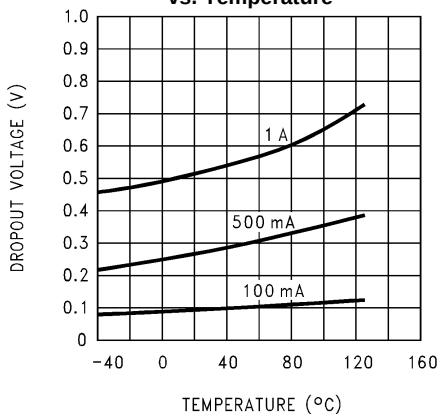

Figure 3.

Output Voltage

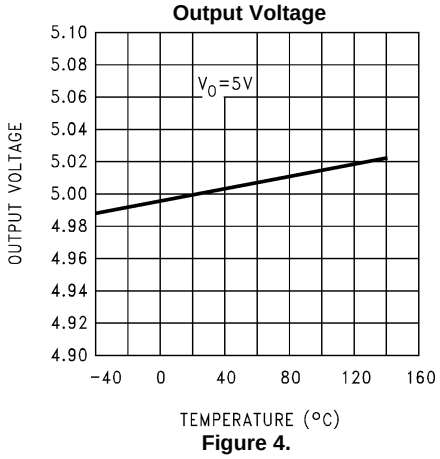

Figure 4.

Quiescent Current vs. Temperature

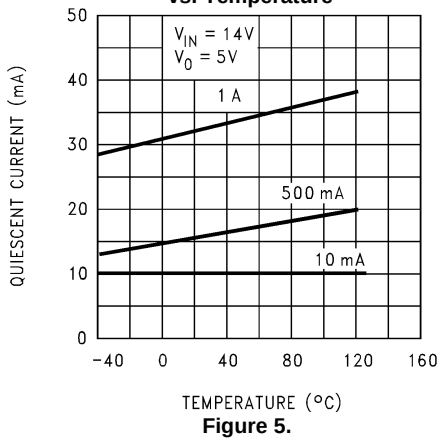

Figure 5.

Quiescent Current

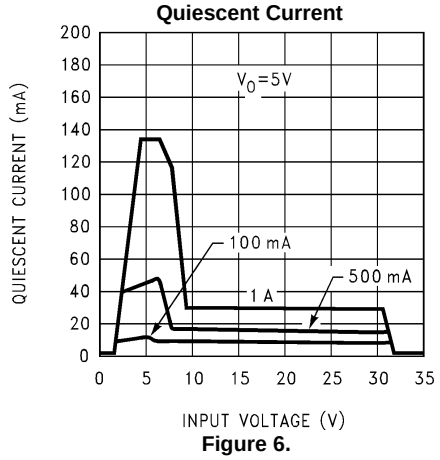

Figure 6.

Quiescent Current

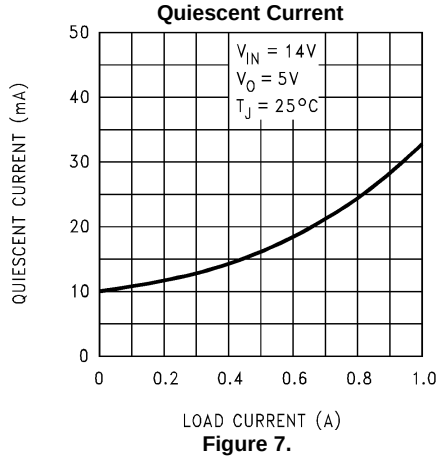

Figure 7.

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Typical Performance Characteristics (continued)

Line Transient Response

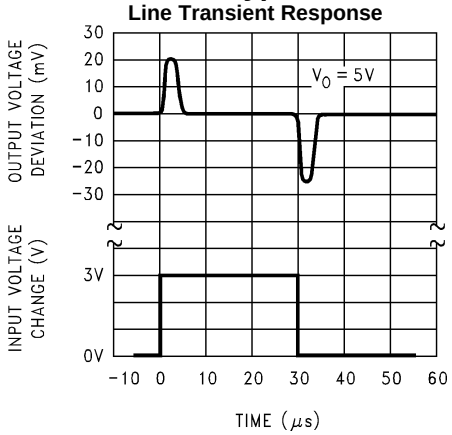

Figure 8.

Load Transient Response

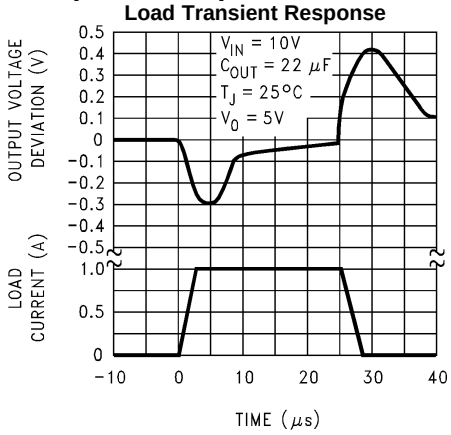

Figure 9.

Ripple Rejection

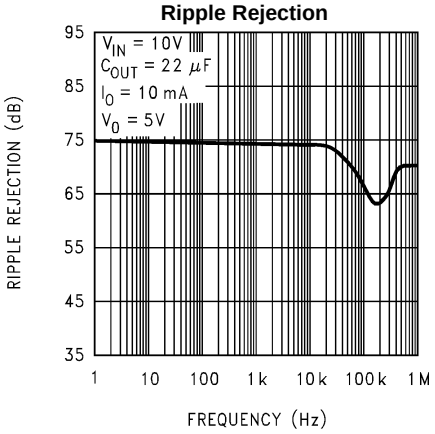

Figure 10.

Output Impedance

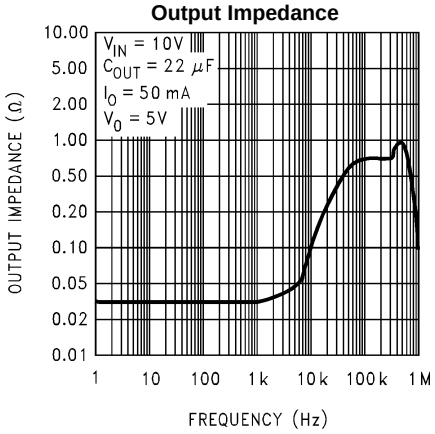

Figure 11.

Low Voltage Behavior

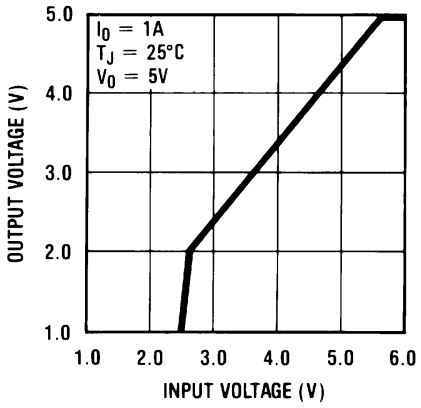

Figure 12.

Low Voltage Behavior

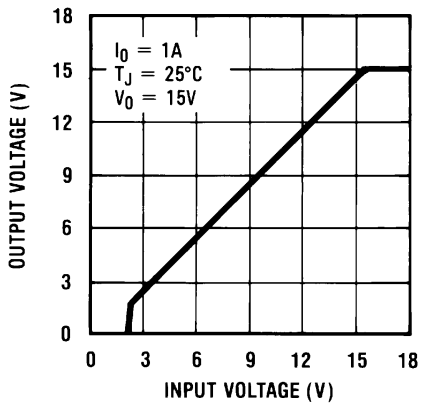

Figure 13.

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Typical Performance Characteristics (continued)

Output Capacitor ESR

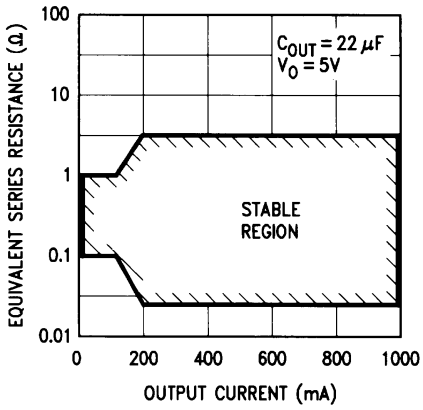

Figure 14.

Output at Voltage Extremes

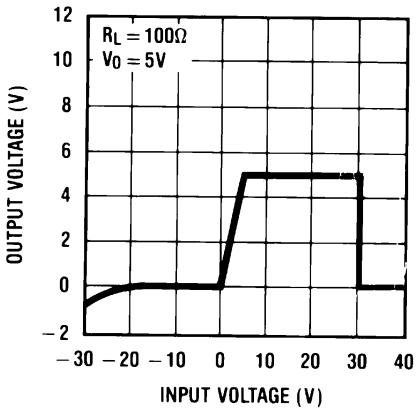

Figure 15.

Output at Voltage Extremes

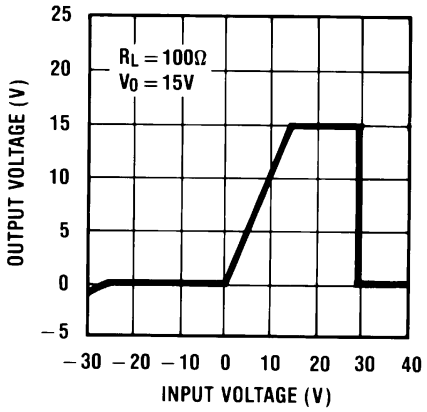

Figure 16.

Peak Output Current

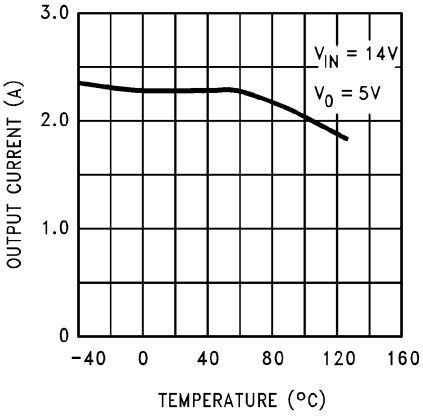

Figure 17.

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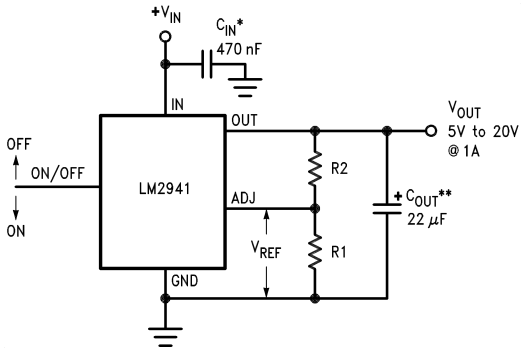
Typical Applications



$$V_{OUT} = \text{Reference voltage} \times \frac{R1 + R2}{R1} \text{ where } V_{REF} = 1.275 \text{ typical}$$

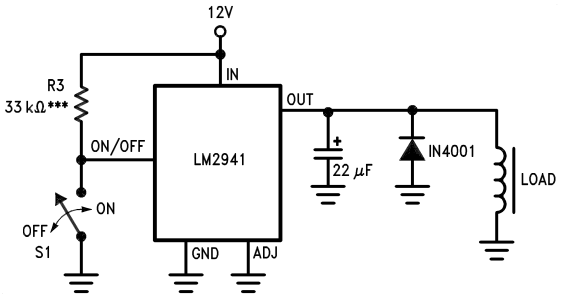
$$\text{Solving for R2: } R2 = R1 \left(\frac{V_O}{V_{REF}} - 1 \right)$$

Note: Using 1KΩ for R1 will ensure that the input bias current error of the adjust pin will be negligible. Do not bypass R1 or R2. This will lead to instabilities.

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

** C_O must be at least 22µF 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.

Figure 18. 5V to 20V Adjustable Regulator



*** To assure shutdown, select Resistor R3 to ensure at least 300µA of pull-up current when S1 is open. (Assume 2V at the ON/OFF pin.)

Figure 19. 1A Switch

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REVISION HISTORY SECTION

Released	Revision	Section	Changes
08/25/09	A	New Release, Corporate format	1 MDS data sheet converted into one Corp. data sheet format. Added Radiation products to ordering table. MNLM2941-X Rev 4A1 will be archived.
12–Oct-2011	B	Ordering Information, Absolute Max Ratings	Ordering Information — Added LM2941GW/883, LM2941GW-QMLV and LM2941GWRLQMLV. Absolute Max — Added Theta JA and Theta JC along with Package weight of 'GW' devices. RatingsLM2941QML Rev A will be archived.

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REVISION HISTORY

Changes from Revision A (April 2013) to Revision B	Page
• Changed layout of National Data Sheet to TI format	9

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PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
5962-9166703QYA	Active	Production	CFP (NAC) | 16	88 | TUBE	No	SNPB	Level-1-NA-UNLIM	-55 to 125	LM2941GW /883 Q 5962-91667 03QYA ACO 03QYA >T
5962-9166703VYA	Active	Production	CFP (NAC) | 16	88 | JEDEC TRAY (5+1)	No	SNPB	Level-1-NA-UNLIM	-55 to 125	LM2941GW-QMLV Q 5962-91667 03VYA ACO 03VYA >T
5962R9166702V9A	Active	Production	DIESALE (Y) | 0	34 | NOT REQUIRED	Yes	Call TI	Level-1-NA-UNLIM	-55 to 125	
5962R9166704VYA	Active	Production	CFP (NAC) | 16	88 | JEDEC TRAY (5+1)	No	SNPB	Level-1-NA-UNLIM	-55 to 125	LM2941GWRL QMLV Q 5962R91667 04VYA ACO 04VYA >T
LM2941 MDE	Active	Production	DIESALE (Y) | 0	34 | NOT REQUIRED	Yes	Call TI	Level-1-NA-UNLIM	-55 to 125	
LM2941-MD8	Active	Production	DIESALE (Y) | 0	221 | NOT REQUIRED	Yes	Call TI	Level-1-NA-UNLIM	-	
LM2941GW-QMLV	Active	Production	CFP (NAC) | 16	88 | JEDEC TRAY (5+1)	No	SNPB	Level-1-NA-UNLIM	-55 to 125	LM2941GW-QMLV Q 5962-91667 03VYA ACO 03VYA >T
LM2941GW/883	Active	Production	CFP (NAC) | 16	88 | TUBE	No	SNPB	Level-1-NA-UNLIM	-55 to 125	LM2941GW /883 Q 5962-91667 03QYA ACO 03QYA >T
LM2941GWRLQMLV	Active	Production	CFP (NAC) | 16	88 | JEDEC TRAY (5+1)	No	SNPB	Level-1-NA-UNLIM	-55 to 125	LM2941GWRL QMLV Q 5962R91667 04VYA ACO 04VYA >T

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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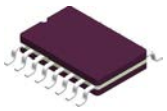
OTHER QUALIFIED VERSIONS OF LM2941QML, LM2941QML-SP :

- Military : LM2941QML
- Space : LM2941QML-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

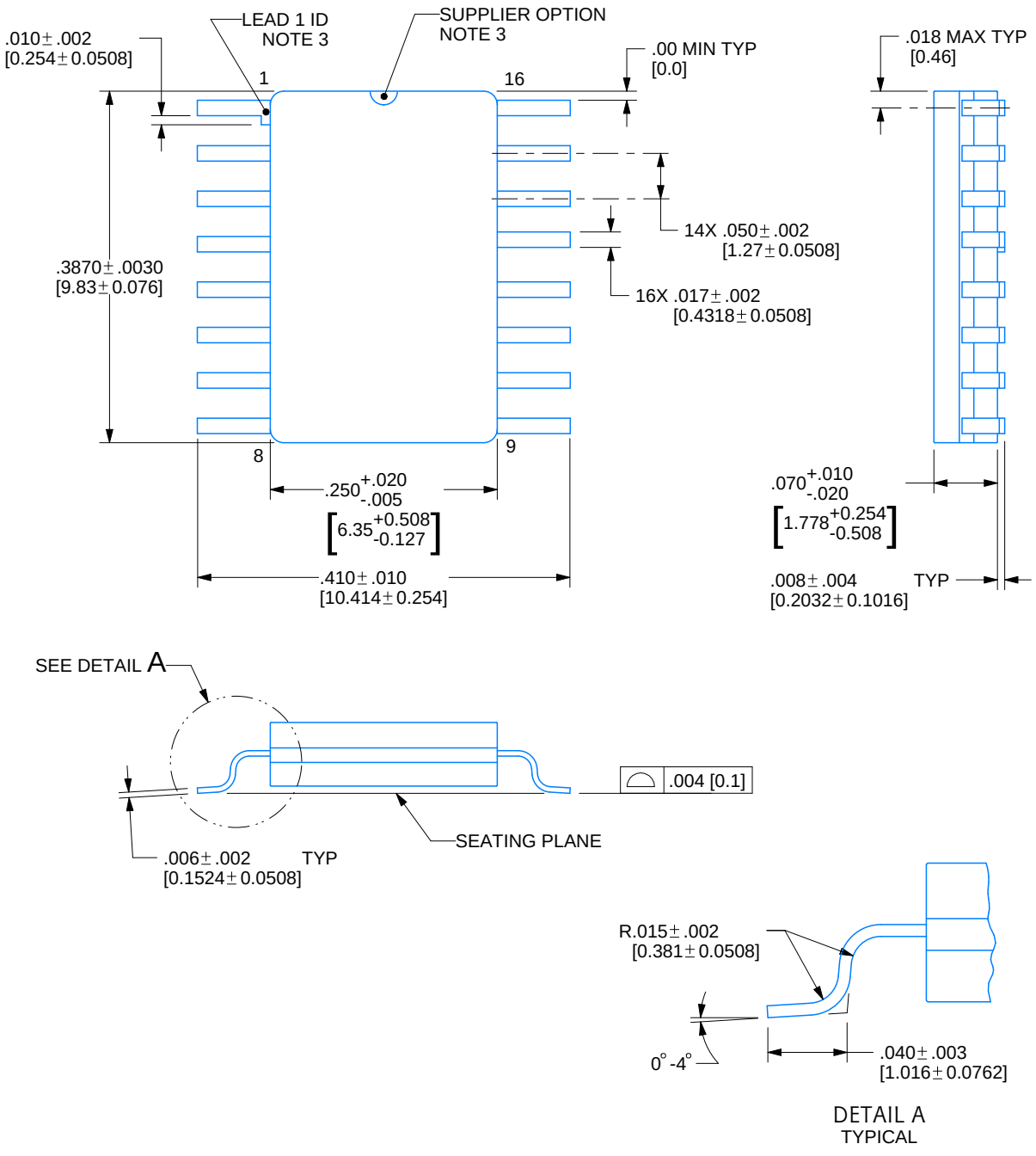


PACKAGE OUTLINE

NAC0016A

CFP - 2.33mm max height

CERAMIC FLATPACK



4215198/C 08/2022

NOTES:

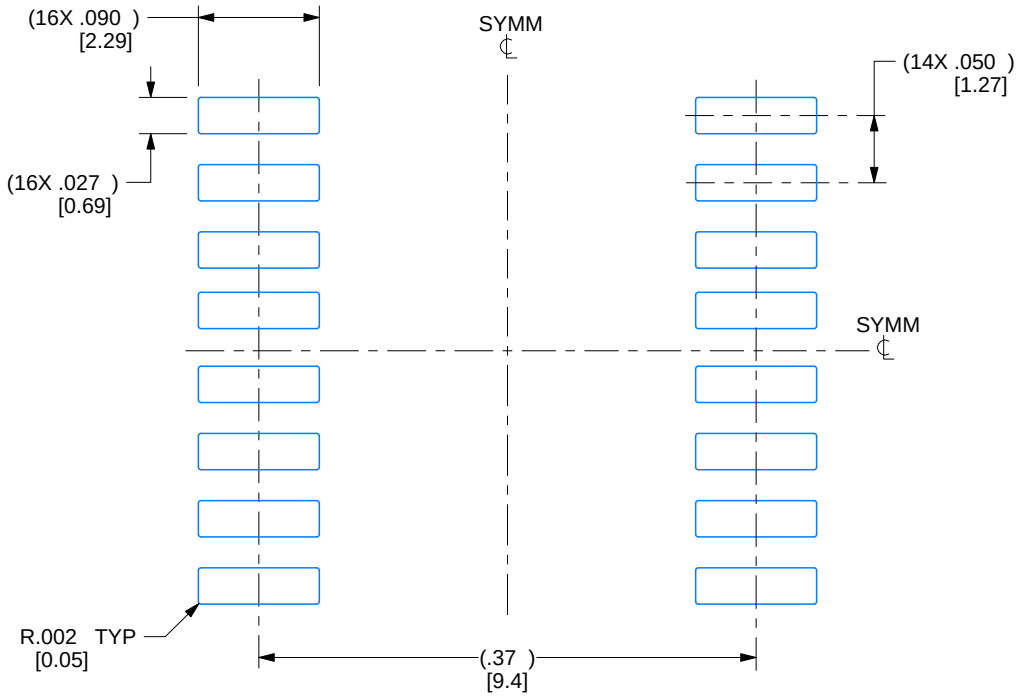
1. Controlling dimension is Inch. Values in [ ] are milimeters. Dimensions in ( ) for reference only.
2. For solder thickness and composition, see the "Lead Finish Composition/Thickness" link in the packaging section of the Texas Instruments website
3. Lead 1 identification shall be:
   a) A notch or other mark within this area
   b) A tab on lead 1, either side
4. No JEDEC registration as of December 2021

EXAMPLE BOARD LAYOUT

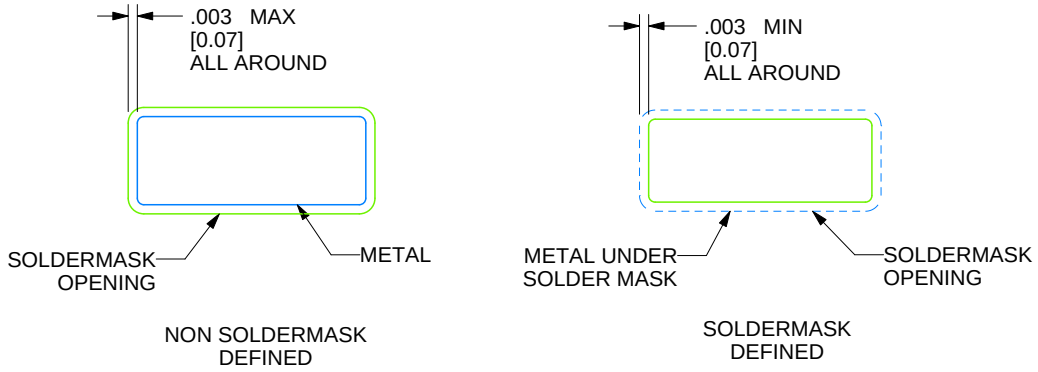
NAC0016A

CFP - 2.33mm max height

CERAMIC FLATPACK



RECOMMENDED LAND PATTERN



4215198/C 08/2022

REVISIONS

REV	DESCRIPTION	E.C.N.	DATE	BY/APP'D
A	RELEASE TO DOCUMENT CONTROL	2197879	12/30/2021	TINA TRAN / ANIS FAUZI
B	NO CHANGE TO DRAWING; REVISION FOR YODA RELEASE;	2198832	02/15/2022	K. SINCERBOX
C	.387± .003 WAS .39000± .00012;	2200917	08/08/2022	D. CHIN / K. SINCERBOX

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