LM2941/LM2941C 1A Low Dropout Adjustable Regulator

Check for Samples: LM2941, LM2941C

FEATURES

- **WSON Space Saving Package**
- **Output Voltage Adjustable From 5V to 20V**
- **Dropout Voltage Typically 0.5V @ I_O = 1A**
- **Output Current in Excess of 1A**
- **Trimmed Reference Voltage**
- **Reverse Battery Protection**
- **Internal Short Circuit Current Limit**
- **Mirror Image Insertion Protection**
- **P^+ Product Enhancement Tested**
- **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 ($V_{IN} - V_{OUT} \leq 3V$).

Designed also 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 Diagrams

TO-220 Plastic Package

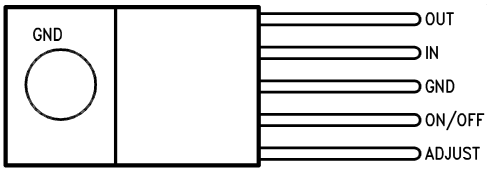


Figure 1. Top View
See Package Number KC

TO-263 Surface-Mount Package

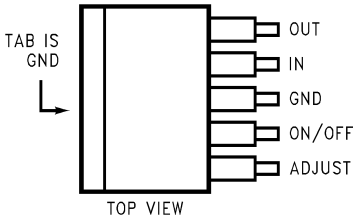


Figure 2. See Package Number KTT

8-Lead WSON Surface Mount Package

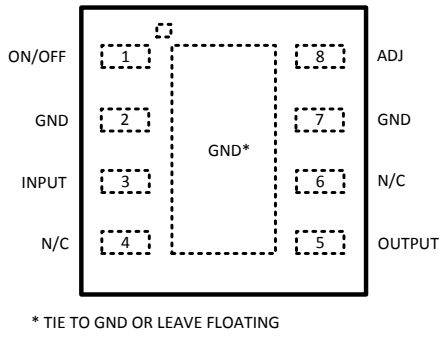


Figure 3. Top View
See Package Number NGN

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)(2)

Input Voltage (Survival Voltage, ≤ 100ms)	LM2941T, LM2941S, LM2941LD	60V
	LM2941CT, LM2941CS	45V
Internal Power Dissipation (3)		Internally Limited
Maximum Junction Temperature		150°C
Storage Temperature Range		−65°C ≤ T_J ≤ +150°C
Soldering Temperature(4)	TO-220 (T), Wave	260°C, 10s
	TO-263 (S)	235°C, 30s
	WSON-8 (LD)	235°C, 30s
ESD Rating (5)		±2 kV

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating ratings indicate conditions for which the device is intended to be functional, but device parameter specifications may not be ensured under these conditions. For ensured specifications and test conditions, see the Electrical Characteristics.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(3) The maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above 150°C and the LM2941 will go into thermal shutdown. If the TO-263 package is used, the thermal resistance can be reduced by increasing the P.C. board copper area thermally connected to the package: Using 0.5 square inches of copper area, θ_{JA} is 50°C/W; with 1 square inch of copper area, θ_{JA} is 37°C/W; and with 1.6 or more square inches of copper area, θ_{JA} is 32°C/W. Thermal performance for the WSON package was obtained using a JESD51-7 board with six vias, using no airflow and an ambient temperature of 22°C. The value θ_{JA} for the WSON package is specifically dependent on PCB trace area, trace material, and the number of layers and thermal vias. For improved thermal resistance and power dissipation for the WSON package, refer to Application Note AN-1187 (literature number SNOA401). It is recommended that 6 vias be placed under the center pad to improve thermal performance.
(4) Refer to JEDEC J-STD-020C for surface mount device (SMD) package reflow profiles and conditions. Unless otherwise stated, the temperature and time are for Sn-Pb (STD) only.
(5) The Human Body Model (HBM) is a 100 pF capacitor discharged through a 1.5kΩ resistor into each pin. Test method is per JESD22–A114.

Operating Ratings

Maximum Input Voltage		26V
Temperature Range	LM2941T	−40°C ≤ T_J ≤ 125°C
	LM2941CT	0°C ≤ T_J ≤ 125°C
	LM2941S	−40°C ≤ T_J ≤ 125°C
	LM2941CS	0°C ≤ T_J ≤ 125°C
	LM2941LD	−40°C ≤ T_J ≤ 125°C

Electrical Characteristics—LM2941T, LM2941S, LM2941LD

5V ≤ V_O ≤ 20V, V_{IN} = V_O + 5V, C_O = 22µF, unless otherwise specified. Specifications in standard typeface apply for T_J = 25°C, while those in **boldface type** apply over the full **Operating Temperature Range.**

Parameter	Conditions	Typ	LM2941T LM2941S LM2941LD Limit	Units (Limits)
Reference Voltage	5mA ≤ I_O ≤ 1A (1)	1.275	1.237/**1.211**	V(min)
			1.313/**1.339**	V(max)
Line Regulation	V_O + 2V ≤ V_{IN} ≤ 26V, I_O = 5mA	4	10/**10**	mV/V(max)
Load Regulation	50mA ≤ I_O ≤ 1A	7	10/**10**	mV/V(max)
Output Impedance	100 mADC and 20 mArms f_O = 120Hz	7		mΩ/V
Quiescent Current	V_O + 2V ≤ V_{IN} < 26V, I_O = 5mA	10	15/**20**	mA(max)
	V_{IN} = V_O + 5V, I_O = 1A	30	45/**60**	mA(max)

(1) The output voltage range is 5V to 20V and is determined by the two external resistors, R1 and R2. See Typical Application Circuit.

Electrical Characteristics—LM2941T, LM2941S, LM2941LD (continued)

5V ≤ V_O ≤ 20V, V_{IN} = V_O + 5V, C_O = 22µF, unless otherwise specified. Specifications in standard typeface apply for T_J = 25°C, while those in **boldface type** apply over the full **Operating Temperature Range.**

Parameter	Conditions	Typ	LM2941T LM2941S LM2941LD Limit	Units (Limits)
RMS Output Noise, % of V_{OUT}	10Hz–100kHz I_O = 5mA	0.003		%
Ripple Rejection	f_O = 120Hz, 1 Vrms, I_L = 100mA	0.005	0.02/**0.04**	%/V(max)
Long Term Stability		0.4		%/1000 Hr
Dropout Voltage	I_O = 1A	0.5	0.8/**1.0**	V(max)
	I_O = 100mA	110	200/**200**	mV(max)
Short Circuit Current	V_{IN} Max = 26V (2)	1.9	1.6	A(min)
Maximum Line Transient	V_O Max 1V Above Nominal V_O R_O = 100, t ≤ 100ms	75	60/**60**	V(min)
Maximum Operational Input Voltage		31	26/**26**	V_{DC}
Reverse Polarity DC Input Voltage	R_O = 100, V_O ≥ −0.6V	−30	−15/**−15**	V(min)
Reverse Polarity Transient Input Voltage	t ≤ 100ms, R_O = 100Ω	−75	−50/**−50**	V(min)
ON/OFF Threshold Voltage ON	I_O ≤ 1A	1.30	0.80/**0.80**	V(max)
ON/OFF Threshold Voltage OFF	I_O ≤ 1A	1.30	2.00/**2.00**	V(min)
ON/OFF Threshold Current	$V_{ON/OFF}$ = 2.0V, I_O ≤ 1A	50	100/**300**	µA(max)

(2) Output current capability will decrease with increasing temperature, but will not go below 1A at the maximum specified temperatures.

Electrical Characteristics—LM2941CT, LM2941CS

5V ≤ V_O ≤ 20V, V_{IN} = V_O + 5V, C_O = 22µF, unless otherwise specified. Specifications in standard typeface apply for T_J = 25°C, while those in **boldface type** apply over the full **Operating Temperature Range**.

Parameter	Conditions	Typ	Limit (1)	Units (Limits)
Reference Voltage	5mA ≤ I_O ≤ 1A (2)	1.275	1.237/**1.211**	V(min)
			1.313/**1.339**	V(max)
Line Regulation	V_O + 2V ≤ V_{IN} ≤ 26V, I_O = 5mA	4	10	mV/V(max)
Load Regulation	50mA ≤ I_O ≤ 1A	7	10	mV/V(max)
Output Impedance	100 mADC and 20 mArms f_O = 120Hz	7		mΩ/V
Quiescent Current	V_O + 2V ≤ V_{IN} < 26V, I_O = 5mA	10	15	mA(max)
	V_{IN} = V_O + 5V, I_O = 1A	30	45/**60**	mA(max)
RMS Output Noise, % of V_{OUT}	10Hz–100kHz I_O = 5mA	0.003		%
Ripple Rejection	f_O = 120Hz, 1 Vrms, I_L = 100mA	0.005	0.02	%/V(max)
Long Term Stability		0.4		%/1000 Hr
Dropout Voltage	I_O = 1A	0.5	0.8/**1.0**	V(max)
	I_O = 100mA	110	200/**200**	mV(max)
Short Circuit Current	V_{IN} Max = 26V (3)	1.9	1.6	A(min)

(1) All limits specified at room temperature (standard typeface) and at temperature extremes (boldface type). All room temperature limits are 100% production tested. All limits at temperature extremes are ensured via correlation using standard Statistical Quality Control (SQC) methods.
(2) The output voltage range is 5V to 20V and is determined by the two external resistors, R1 and R2. See Typical Application Circuit.
(3) Output current capability will decrease with increasing temperature, but will not go below 1A at the maximum specified temperatures.

Electrical Characteristics—LM2941CT, LM2941CS (continued)

5V ≤ V_O ≤ 20V, V_{IN} = V_O + 5V, C_O = 22µF, unless otherwise specified. Specifications in standard typeface apply for T_J = 25°C, while those in **boldface type** apply over the full **Operating Temperature Range**.

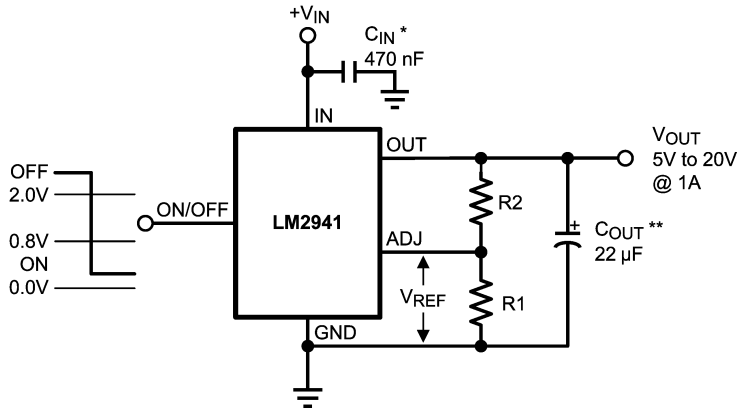
Parameter	Conditions	Typ	Limit (1)	Units (Limits)
Maximum Line Transient	V_O Max 1V Above Nominal V_O R_O = 100Ω, T ≤ 100ms	55	45	V(min)
Maximum Operational Input Voltage		31	26	V_{DC}
Reverse Polarity DC Input Voltage	R_O = 100Ω, V_O ≥ −0.6V	−30	−15	V(min)
Reverse Polarity Transient Input Voltage	T ≤ 100ms, R_O = 100Ω	−55	−45	V(min)
ON/OFF Threshold Voltage ON	I_O ≤ 1A	1.30	0.80	V(max)
ON/OFF Threshold Voltage OFF	I_O ≤ 1A	1.30	2.00	V(min)
ON/OFF Threshold Current	$V_{ON/OFF}$ = 2.0V, I_O ≤ 1A	50	100	µA(max)

Thermal Performance

Thermal Resistance Junction-to-Case, θ_{JC}	5-Lead TO-220	1		°C/W
	5-Lead TO-263	1		°C/W
	8-Lead WSON	5.3		°C/W
Thermal Resistance Junction-to-Ambient, θ_{JA} (1)	5-Lead TO-220	53		°C/W
	5-Lead TO-263 (See TO-263 Mounting)	73		°C/W
	8-Lead WSON (See WSON Mounting)	35		°C/W

(1) The maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above 150°C and the LM2941 will go into thermal shutdown. If the TO-263 package is used, the thermal resistance can be reduced by increasing the P.C. board copper area thermally connected to the package: Using 0.5 square inches of copper area, θ_{JA} is 50°C/W; with 1 square inch of copper area, θ_{JA} is 37°C/W; and with 1.6 or more square inches of copper area, θ_{JA} is 32°C/W. Thermal performance for the WSON package was obtained using a JESD51-7 board with six vias, using no airflow and an ambient temperature of 22°C. The value θ_{JA} for the WSON package is specifically dependent on PCB trace area, trace material, and the number of layers and thermal vias. For improved thermal resistance and power dissipation for the WSON package, refer to Application Note AN-1187 (literature number SNOA401). It is recommended that 6 vias be placed under the center pad to improve thermal performance.

Typical Applications



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

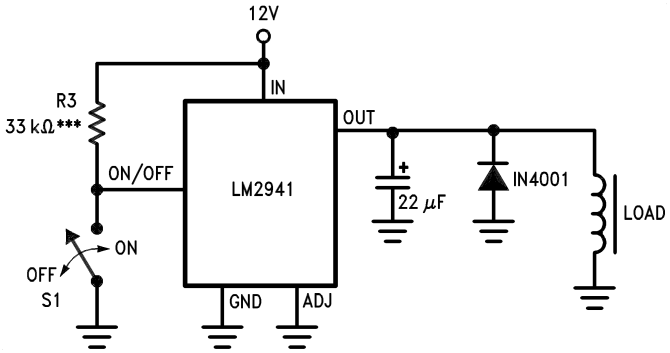
Solving for R2: $R2 = R1 \left(\frac{V_O}{V_{REF}} - 1\right)$

Note: Using 1k for R1 will ensure that the bias current error from 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_{OUT} 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.

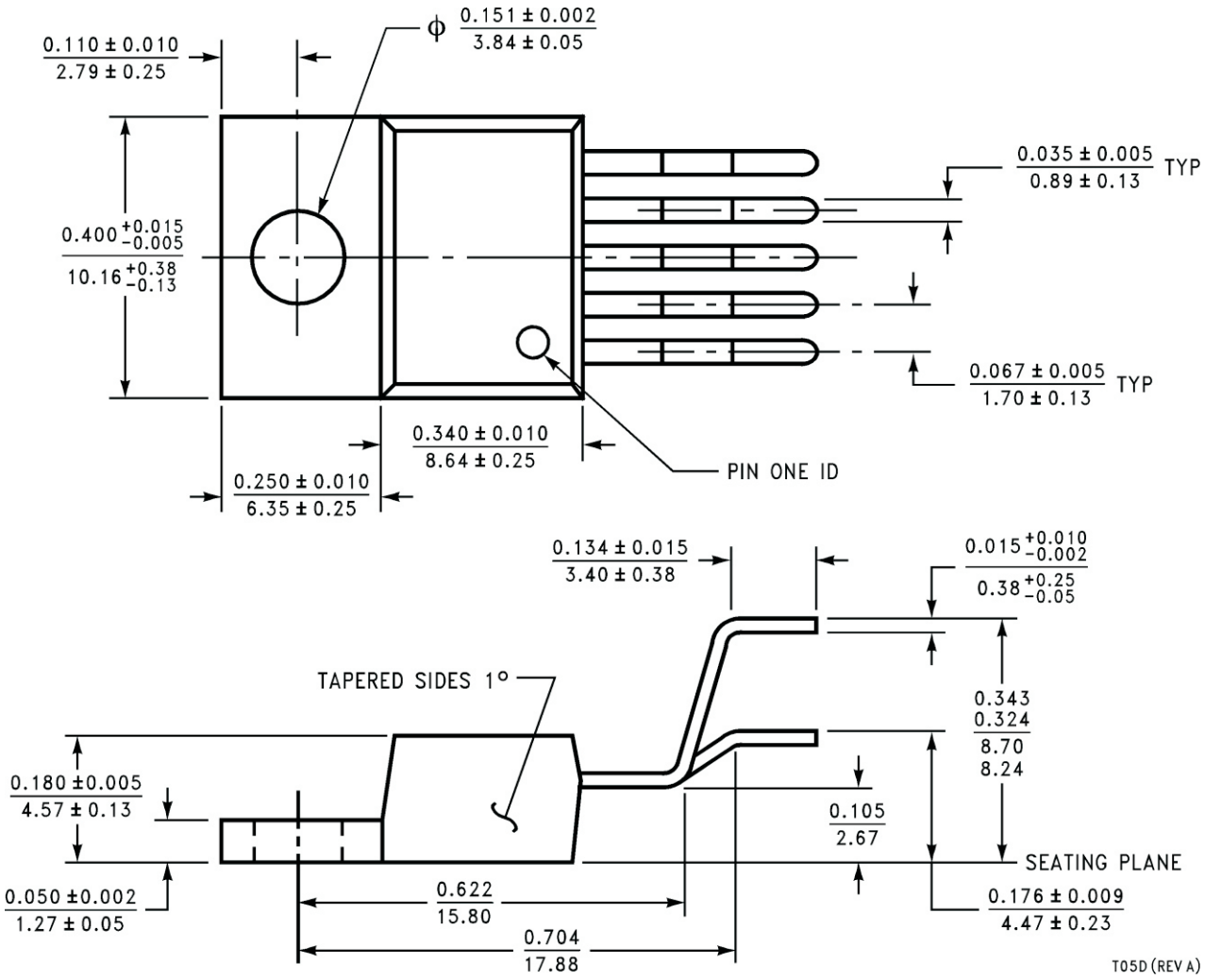
Figure 23. 5V to 20V Adjustable Regulator



******* 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 24. 1A Switch

NDH0005D


0.110 ± 0.010
2.79 ± 0.25
ϕ 0.151 ± 0.002
3.84 ± 0.05
0.035 ± 0.005
0.89 ± 0.13
TYP
0.400 +0.015 −0.005
10.16 +0.38 −0.13
0.067 ± 0.005
1.70 ± 0.13
TYP
0.340 ± 0.010
8.64 ± 0.25
PIN ONE ID
0.250 ± 0.010
6.35 ± 0.25
0.134 ± 0.015
3.40 ± 0.38
0.015 +0.010 −0.002
0.38 +0.25 −0.05
TAPERED SIDES 1°
0.343
0.324
8.70
8.24
0.180 ±0.005
4.57 ± 0.13
0.105
2.67
SEATING PLANE
0.050 ±0.002
1.27 ± 0.05
0.622
15.80
0.176 ± 0.009
4.47 ± 0.23
0.704
17.88
T05D (REV A)