National Semiconductor

LM2940/LM2940C
1A Low Dropout Regulator

General Description

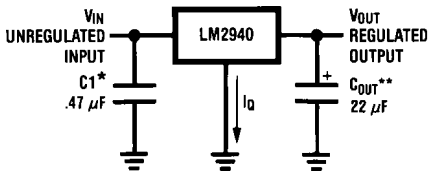
The LM2940/LM2940C positive voltage regulator features the ability to source 1A of output current with a dropout voltage of typically 0.5V and a maximum of 1V over the entire temperature range. Furthermore, a quiescent current reduction circuit has been included which reduces the ground current when 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/LM2940C 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/LM2940C cannot be harmed by temporary mirror-image insertion. Familiar regulator features such as short circuit and thermal overload protection are also provided.

Features

- 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
- P+ Product Enhancement tested

Typical Application



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*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.

Ordering Information

Temp Range	Output Voltage						Package
	5.0	8.0	9.0	10	12	15	
0°C ≤ T_J ≤ 125°C	LM2940CT-5.0	–	LM2940CT-9.0	–	LM2940CT-12	LM2940CT-15	TO-220
	LM2940CS-5.0	–	LM2940CS-9.0	–	LM2940CS-12	LM2940CS-15	TO-263
	LM2940CSX -5.0	–	LM2940CSX -9.0	–	LM2940CSX -12	LM2940CSX -15	
–40°C ≤ T_J ≤ 125°C	LM2940LD-5.0	LM2940LD-8.0	LM2940LD-9.0	LM2940LD-10	LM2940LD-12	LM2940LD-15	LLP 1k Units Tape and Reel
	LM2940LDX -5.0	LM2940LDX -8.0	LM2940LDX -9.0	LM2940LDX -10	LM2940LDX -12	LM2940LDX -15	LLP 4.5k Units Tape and Reel
–40°C ≤ T_J ≤ 125°C	LM2940T-5.0	LM2940T-8.0	LM2940T-9.0	LM2940T-10	LM2940T-12	–	TO-220
	LM2940S-5.0	LM2940S-8.0	LM2940S-9.0	LM2940S-10	LM2940S-12	–	TO-263
	LM2940SX-5.0	LM2940SX-8.0	LM2940SX-9.0	LM2940SX-10	LM2940SX-12	–	

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

LM2940S, J, WG, T, MP ≤ 100 ms	60V
LM2940CS, T ≤ 1 ms	45V
Internal Power Dissipation (Note 2)	Internally Limited
Maximum Junction Temperature	150°C
Storage Temperature Range	$-65°C \le T_J \le +150°C$
Soldering Temperature (Note 3)	
TO-220 (T), Wave	260°C, 10s
TO-263 (S)	235°C, 30s
SOT-223 (MP)	260°C, 30s
LLP-8 (LD)	235°C, 30s
ESD Susceptibility (Note 4)	2 kV

Operating Conditions (Note 1)

Input Voltage	26V
Temperature Range	
LM2940T, LM2940S	$-40°C \le T_J \le 125°C$
LM2940CT, LM2940CS	$0°C \le T_J \le 125°C$
LM2940IMP	$-40°C \le T_A \le 85°C$
LM2940J, LM2940WG	$-55°C \le T_J \le 125°C$
LM2940LD	$-40°C \le T_J \le 125°C$

Electrical Characteristics

$V_{IN} = V_O + 5V$, $I_O = 1A$, $C_O = 22\ \mu F$, unless otherwise specified. **Boldface limits apply over the entire operating temperature range of the indicated device.** All other specifications apply for $T_A = T_J = 25°C$.

Output Voltage (V_O)		5V			8V			Units
Parameter	**Conditions**	**Typ**	**LM2940 Limit** (Note 5)	**LM2940/883 Limit** (Note 6)	**Typ**	**LM2940 Limit** (Note 5)	**LM2940/883 Limit** (Note 6)	
		$6.25V \le V_{IN} \le 26V$			**$9.4V \le V_{IN} \le 26V$**			
Output Voltage	$5\ mA \le I_O \le 1A$	5.00	4.85/**4.75** 5.15/**5.25**	4.85/**4.75** 5.15/**5.25**	8.00	7.76/**7.60** 8.24/**8.40**	7.76/**7.60** 8.24/**8.40**	V_{MIN} V_{MAX}
Line Regulation	$V_O + 2V \le V_{IN} \le 26V$, $I_O = 5\ mA$	20	50	40/**50**	20	80	50/**80**	mV_{MAX}
Load Regulation	$50\ mA \le I_O \le 1A$ LM2940, LM2940/883 LM2940C	 35 35	 50/**80** 50	 50/**100**	 55 55	 80/**130** 80	 80/**130**	 mV_{MAX}
Output Impedance	100 mADC and 20 mArms, $f_O = 120\ Hz$	35		1000/**1000**	55		1000/**1000**	mΩ
Quiescent Current	$V_O + 2V \le V_{IN} \le 26V$, $I_O = 5\ mA$ LM2940, LM2940/883 LM2940C	 10 10	 15/**20** 15	 15/**20**	 10	 15/**20**	 15/**20**	 mA_{MAX}
	$V_{IN} = V_O + 5V$, $I_O = 1A$	30	45/**60**	50/**60**	30	45/**60**	50/**60**	mA_{MAX}
Output Noise Voltage	10 Hz – 100 kHz, $I_O = 5\ mA$	150		700/**700**	240		1000/**1000**	μV_{rms}
Ripple Rejection	$f_O = 120\ Hz$, $1\ V_{rms}$, $I_O = 100\ mA$ LM2940 LM2940C	 72 72	 60/**54** 60		 66 66	 54/**48** 54		 dB_{MIN}
	$f_O = 1\ kHz$, $1\ V_{rms}$, $I_O = 5\ mA$			60/**50**			54/**48**	dB_{MIN}
Long Term Stability		20			32			mV/ 1000 Hr
Dropout Voltage	$I_O = 1A$	0.5	0.8/**1.0**	0.7/**1.0**	0.5	0.8/**1.0**	0.7/**1.0**	V_{MAX}
	$I_O = 100\ mA$	110	150/**200**	150/**200**	110	150/**200**	150/**200**	mV_{MAX}

Output Voltage (V_O)		5V			8V			Units
Parameter	**Conditions**	**Typ**	**LM2940 Limit** (Note 5)	**LM2940/883 Limit** (Note 6)	**Typ**	**LM2940 Limit** (Note 5)	**LM2940/883 Limit** (Note 6)	
Short Circuit Current	(Note 7)	1.9	1.6	1.5/**1.3**	1.9	1.6	1.6/**1.3**	A_{MIN}
Maximum Line Transient	R_O = 100Ω							V_{MIN}
	LM2940, T ≤ 100 ms	75	60/**60**		75	60/**60**		
	LM2940/883, T ≤ 20 ms			40/**40**			40/**40**	
	LM2940C, T ≤ 1 ms	55	45		55	45		
Reverse Polarity DC Input Voltage	R_O = 100Ω							V_{MIN}
	LM2940, LM2940/883	−30	−15/**−15**	−15/**−15**	−30	−15/**−15**	−15/**−15**	
	LM2940C	−30	−15		−30	−15		
Reverse Polarity Transient Input Voltage	R_O = 100Ω							V_{MIN}
	LM2940, T ≤ 100 ms	−75	−50/**−50**		−75	−50/**−50**		
	LM2940/883, T ≤ 20 ms			−45/**−45**			−45/**−45**	
	LM2940C, T ≤ 1 ms	−55	−45/**−45**					

Electrical Characteristics

$V_{IN} = V_O + 5V$, I_O = 1A, C_O = 22 µF, unless otherwise specified. **Boldface limits apply over the entire operating temperature range of the indicated device.** All other specifications apply for $T_A = T_J$ = 25°C.

Output Voltage (V_O)		9V		10V		Units
Parameter	**Conditions**	**Typ**	**LM2940 Limit** (Note 5)	**Typ**	**LM2940 Limit** (Note 5)	
		10.5V ≤ V_{IN} ≤ 26V		**11.5V ≤ V_{IN} ≤ 26V**		
Output Voltage	5 mA ≤ I_O ≤1A	9.00	8.73/**8.55**	10.00	9.70/**9.50**	V_{MIN}
			9.27/**9.45**		10.30/**10.50**	V_{MAX}
Line Regulation	V_O + 2V ≤ V_{IN} ≤ 26V, I_O = 5 mA	20	90	20	100	mV_{MAX}
Load Regulation	50 mA ≤ I_O ≤ 1A					mV_{MAX}
	LM2940	60	90/**150**	65	100/**165**	
	LM2940C	60	90			
Output Impedance	100 mADC and 20 mArms, f_O = 120 Hz	60		65		mΩ
Quiescent Current	V_O +2V ≤ V_{IN} < 26V, I_O = 5 mA					mA_{MAX}
	LM2940	10	15/**20**	10	15/**20**	
	LM2940C	10	15			
	$V_{IN} = V_O + 5V$, I_O = 1A	30	45/**60**	30	45/**60**	mA_{MAX}
Output Noise Voltage	10 Hz – 100 kHz, I_O = 5 mA	270		300		$µV_{rms}$
Ripple Rejection	f_O = 120 Hz, 1 V_{rms}, I_O = 100 mA					dB_{MIN}
	LM2940	64	52/**46**	63	51/**45**	
	LM2940C	64	52			
Long Term Stability		34		36		mV/ 1000 Hr

Output Voltage (V_O)		9V		10V		Units
Parameter	**Conditions**	**Typ**	**LM2940 Limit** (Note 5)	**Typ**	**LM2940 Limit** (Note 5)	
Dropout Voltage	I_O = 1A	0.5	0.8/**1.0**	0.5	0.8/**1.0**	V_{MAX}
	I_O = 100 mA	110	150/**200**	110	150/**200**	mV_{MAX}
Short Circuit Current	(Note 7)	1.9	1.6	1.9	1.6	A_{MIN}
Maximum Line Transient	R_O = 100Ω T ≤ 100 ms					
	LM2940	75	60/**60**	75	60/**60**	V_{MIN}
	LM2940C	55	45			
Reverse Polarity DC Input Voltage	R_O = 100Ω					
	LM2940	−30	−15/**−15**	−30	−15/**−15**	V_{MIN}
	LM2940C	−30	−15			
Reverse Polarity Transient Input Voltage	R_O = 100Ω T ≤ 100 ms					
	LM2940	−75	−50/**−50**	−75	−50/**−50**	V_{MIN}
	LM2940C	−55	−45/**−45**			

Electrical Characteristics

$V_{IN} = V_O + 5V$, I_O = 1A, C_O = 22 µF, unless otherwise specified. **Boldface limits apply over the entire operating temperature range of the indicated device.** All other specifications apply for $T_A = T_J$ = 25°C.

Output Voltage (V_O)		12V			15V			Units
Parameter	**Conditions**	**Typ**	**LM2940 Limit** (Note 5)	**LM2940/833 Limit** (Note 6)	**Typ**	**LM2940 Limit** (Note 5)	**LM2940/833 Limit** (Note 6)	
		13.6V ≤ V_{IN} ≤ 26V			**16.75V ≤ V_{IN} ≤ 26V**			
Output Voltage	5 mA ≤ I_O ≤1A	12.00	11.64/**11.40**	11.64/**11.40**	15.00	14.55/**14.25**	14.55/**14.25**	V_{MIN}
			12.36/**12.60**	12.36/**12.60**		15.45/**15.75**	15.45/**15.75**	V_{MAX}
Line Regulation	V_O + 2V ≤ V_{IN} ≤ 26V, I_O = 5 mA	20	120	75/**120**	20	150	95/**150**	mV_{MAX}
Load Regulation	50 mA ≤ I_O ≤ 1A							
	LM2940, LM2940/883	55	120/**200**	120/**190**			150/**240**	mV_{MAX}
	LM2940C	55	120		70	150		
Output Impedance	100 mADC and 20 mArms, f_O = 120 Hz	80		1000/**1000**	100		1000/**1000**	mΩ
Quiescent Current	V_O +2V ≤ V_{IN} ≤ 26V, I_O = 5 mA							
	LM2940, LM2940/883	10	15/**20**	15/**20**			15/**20**	mA_{MAX}
	LM2940C	10	15		10	15		
	$V_{IN} = V_O + 5V$, I_O = 1A	30	45/**60**	50/**60**	30	45/**60**	50/**60**	mA_{MAX}
Output Noise Voltage	10 Hz – 100 kHz, I_O = 5 mA	360		1000/**1000**	450		1000/**1000**	$µV_{rms}$

Output Voltage (V_O)		12V			15V			Units
Parameter	**Conditions**	**Typ**	**LM2940 Limit** (Note 5)	**LM2940/833 Limit** (Note 6)	**Typ**	**LM2940 Limit** (Note 5)	**LM2940/833 Limit** (Note 6)	
Ripple Rejection	f_O = 120 Hz, 1 V_{rms}, I_O = 100 mA							
	LM2940	66	54/**48**					dB_{MIN}
	LM2940C	66	54		64	52		
	f_O = 1 kHz, 1 V_{rms}, I_O = 5 mA			52/**46**			48/**42**	dB_{MIN}
Long Term Stability		48			60			mV/ 1000 Hr
Dropout Voltage	I_O = 1A	0.5	0.8/**1.0**	0.7/**1.0**	0.5	0.8/**1.0**	0.7/**1.0**	V_{MAX}
	I_O = 100 mA	110	150/**200**	150/**200**	110	150/**200**	150/**200**	mV_{MAX}
Short Circuit Current	(Note 7)	1.9	1.6	1.6/**1.3**	1.9	1.6	1.6/**1.3**	A_{MIN}
Maximum Line Transient	R_O = 100Ω							
	LM2940, T ≤ 100 ms	75	60/**60**					
	LM2940/883, T ≤ 20 ms			40/**40**			40/**40**	V_{MIN}
	LM2940C, T ≤ 1 ms	55	45		55	45		
Reverse Polarity DC Input Voltage	R_O = 100Ω							
	LM2940, LM2940/883	−30	−15/**−15**	−15/**−15**			−15/**−15**	V_{MIN}
	LM2940C	−30	−15		−30	−15		
Reverse Polarity Transient Input Voltage	R_O = 100Ω							
	LM2940, T ≤ 100 ms	−75	−50/**−50**					
	LM2940/883, T ≤ 20 ms			−45/**−45**			−45/**−45**	V_{MIN}
	LM2940C, T ≤ 1 ms	−55	−45/**−45**		−55	−45/**−45**		

Thermal Performance

Thermal Resistance Junction-to-Case, $\theta_{(JC)}$	3-Lead TO-220	4		°C/W
	3-Lead TO-263	4		
Thermal Resistance Junction-to-Ambient, $\theta_{(JA)}$	3-Lead TO-220 (Note 2)	60		°C/W
	3-Lead TO-263 (Note 2)	80		
	SOT-223(Note 2)	174		
	8-Lead LLP (Note 2)	35		

Note 1: Absolute Maximum Ratings are limits beyond which damage to the device may occur. Operating Conditions are conditions under which the device functions but the specifications might not be guaranteed. For guaranteed specifications and test conditions see the Electrical Characteristics.

Note 2: The maximum allowable power dissipation is a function of the maximum junction temperature, T_J, the junction-to-ambient thermal resistance, θ_{JA}, and the ambient temperature, T_A. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. The value of θ_{JA} (for devices in still air with no heatsink) is 60°C/W for the TO-220 package, 80°C/W for the TO-263 package, and 174°C/W for the SOT-223 package. The effective value of θ_{JA} can be reduced by using a heatsink (see Application Hints for specific information on heatsinking). The value of θ_{JA} for the LLP 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 LLP package, refer to Application Note AN-1187. It is recommended that 6 vias be placed under the center pad to improve thermal performance.

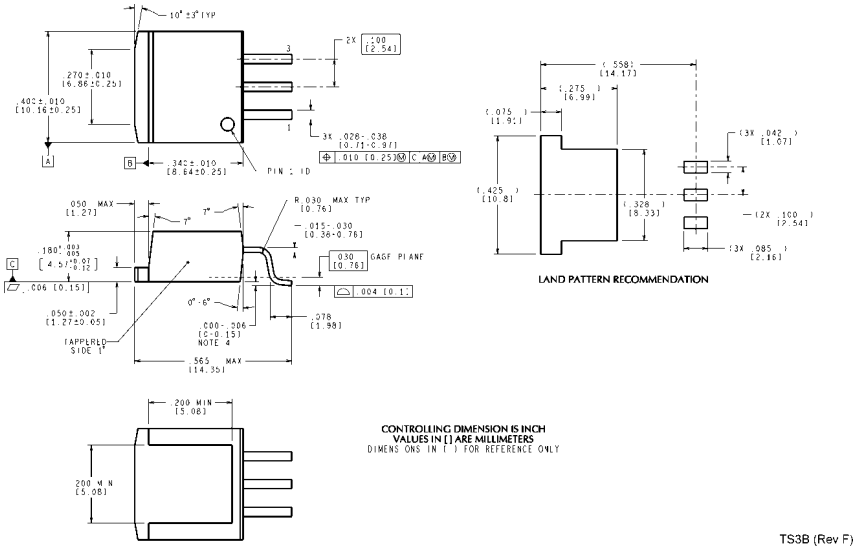
Note 3: Refer to JEDEC J-STD-020C for surface mount device (SMD) package reflow profiles and conditions. Unless otherwise stated, the temperature and time are for Sn-Pb (STD) only.

Note 4: ESD rating is based on the human body model, 100 pF discharged through 1.5 kΩ.

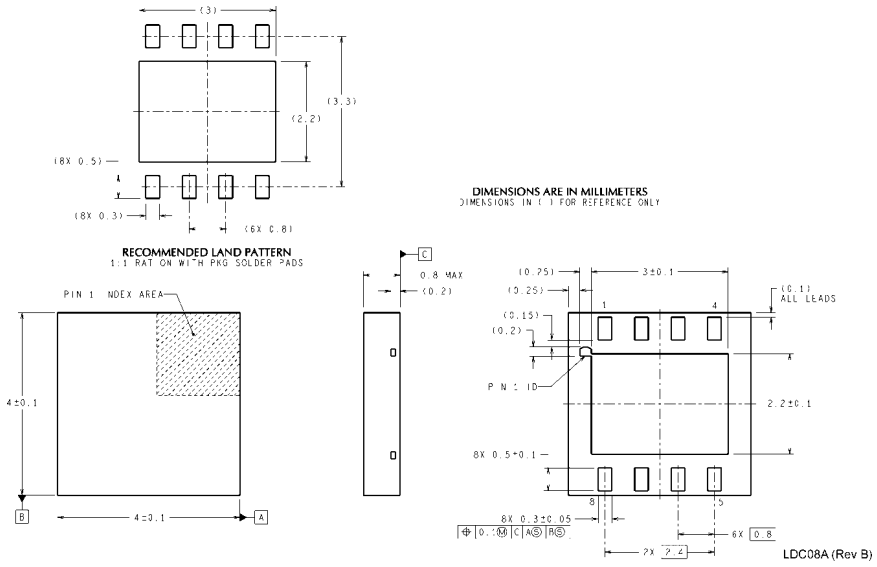
Note 5: All limits are guaranteed at $T_A = T_J = 25°C$ only (standard typeface) or over the entire operating temperature range of the indicated device (boldface type). All limits at $T_A = T_J = 25°C$ are 100% production tested. All limits at temperature extremes are guaranteed via correlation using standard Statistical Quality Control methods.

Note 6: All limits are guaranteed at $T_A = T_J = 25°C$ only (standard typeface) or over the entire operating temperature range of the indicated device (boldface type). All limits are 100% production tested and are used to calculate Outgoing Quality Levels.

Note 7: Output current will decrease with increasing temperature but will not drop below 1A at the maximum specified temperature.



3-Lead TO-263 Surface Mount Package (MP)
NS Package Number TS3B



8-Lead LLP
Order Number LM2940LD-5.0, LM2940LD-8.0,
LM2940LD-9.0, LM2940LD-10,
LM2940LD-12 or LM2940LD-15
NS Package Number LDC08A