

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 ($V_{IN} - V_{OUT} \leq 3V$).

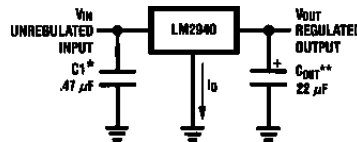
Designed also for vehicular applications, the LM2940/LM2940C and all regulated circuitry are protected from reverse battery installations or 2-battery jumps. During line transients, such as load dump when the input voltage can momentarily exceed the specified maximum operating volt-

age, 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



TL/H/8822-3

*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

Temperature Range	Output Voltage						Package
	5.0	8.0	9.0	10	12	15	
$0^{\circ}C \leq T_A \leq 125^{\circ}C$	LM2940CT-5.0 LM2940CS-5.0		LM2940CT-9.0 LM2940CS-9.0		LM2940CT-12 LM2940CS-12	LM2940CT-15 LM2940CS-15	TO-220 TO-263
$-40^{\circ}C \leq T_A \leq 125^{\circ}C$	LM2940T-5.0 LM2940S-5.0	LM2940T-8.0 LM2940S-8.0	LM2940T-9.0 LM2940S-9.0	LM2940T-10 LM2940S-10	LM2940T-12 LM2940S-12		TO-220 TO-263
$-55^{\circ}C \leq T_A \leq 125^{\circ}C$	LM2940K-5.0/883	LM2940K-8.0/883			LM2940K-12/883	LM2940K-15/883	TO-3

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications. (Note 2)

LM2940S, $T \leq 100$ ms	60V
LM2940T, $T \leq 100$ ms	60V
LM2940K/883, $T \leq 20$ ms	40V
LM2940CT, $T \leq 1$ ms	45V
LM2940CS, $T \leq 1$ ms	45V
Internal Power Dissipation (Note 3)	Internally Limited
Maximum Junction Temperature	150°C
Storage Temperature Range	$-65^{\circ}\text{C} \leq T_J \leq +150^{\circ}\text{C}$

Lead Temperature (Soldering, 10 seconds)

TO-3 (K) Package	300°C
TO-220 (T) Package	260°C
TO-263 (S) Package	260°C

ESD Susceptibility (Note 4)

2 kV

Operating Conditions (Note 1)

Input Voltage	26V
Temperature Range	
LM2940K/883	$-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$
LM2940T, LM2940S	$-40^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$
LM2940CT, LM2940CS	$0^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$

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 $T_A = T_J = 25^{\circ}\text{C}$

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)	
Output Voltage	$5 \text{ mA} \leq I_O \leq 1A$	$6.25V \leq V_{IN} \leq 26V$			$9.4V \leq V_{IN} \leq 26V$			V_{MIN} V_{MAX}
		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	
Line Regulation	$V_O + 2V \leq V_{IN} \leq 26V$, $I_O = 5 \text{ mA}$	20	50	40/ 50	20	80	50/ 80	mV _{MAX}
Load Regulation	$50 \text{ mA} \leq I_O \leq 1A$ LM2940, LM2940/883 LM2940C	35	50/ 80	50/ 100	55	80/ 130	80/ 130	mV _{MAX}
		35	50		55	80		
Output Impedance	100 mADC and 20 mArms, $f_O = 120 \text{ Hz}$	35		1000/ 1000	55		1000/ 1000	m Ω
Quiescent Current	$V_O + 2V \leq V_{IN} \leq 26V$, $I_O = 5 \text{ mA}$ 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	
Output Noise Voltage	10 Hz – 100 kHz, $I_O = 5 \text{ mA}$	150		700/ 700	240		1000/ 1000	μV_{rms}
Ripple Rejection	$f_O = 120 \text{ Hz}$, 1 V _{rms} , $I_O = 100 \text{ mA}$ LM2940 LM2940C	72 72	60/ 54 60		66 66	54/ 48 54		dB _{MIN}
	$f_O = 1 \text{ kHz}$, 1 V _{rms} , $I_O = 5 \text{ mA}$			60/ 50			54/ 48	
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}
	$I_O = 100 \text{ mA}$	110	150/ 200	150/ 200	110	150/ 200	150/ 200	mV _{MAX}

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 $T_A = T_J = 25^\circ C$ (Continued)

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	$R_O = 100\Omega$ LM2940, $T \leq 100$ ms LM2940/883, $T \leq 20$ ms LM2940C, $T \leq 1$ ms	75	60/ 60	40/ 40	75	60/ 60	40/ 40	V_{MIN}
		55	45		55	45		
Reverse Polarity DC Input Voltage	$R_O = 100\Omega$ LM2940, LM2940/883 LM2940C	-30	-15/- 15	-15/- 15	-30	-15/- 15	-15/- 15	V_{MIN}
		-30	-15		-30	-15		
Reverse Polarity Transient Input Voltage	$R_O = 100\Omega$ LM2940, $T \leq 100$ ms LM2940/883, $T \leq 20$ ms LM2940C, $T \leq 1$ ms	-75	-50/- 50	-45/- 45	-75	-50/- 50	-45/- 45	V_{MIN}
		-55	-45/- 45					

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 $T_A = T_J = 25^\circ C$ (Continued)

Output Voltage (V _O)		9V		10V		Units
Parameter	Conditions	Typ	LM2940 Limit (Note 5)	Typ	LM2940 Limit (Note 5)	
Output Voltage	5 mA ≤ I _O ≤ 1A	10.5V ≤ V _{IN} ≤ 26V		11.5V ≤ V _{IN} ≤ 26V		
		9.00	8.73/ 8.55 9.27/ 9.45	10.00	9.70/ 9.50 10.30/ 10.50	V _{MIN} 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 LM2940 LM2940C	60 60	90/ 150 90	65	100/ 165	mV _{MAX}
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 LM2940 LM2940C	10 10	15/ 20 15	10	15/ 20	mA _{MAX}
	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 LM2940 LM2940C	64 64	52/ 46 52	63	51/ 45	dB _{MIN}
Long Term Stability		34		36		mV/ 1000 Hr
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 LM2940C	75 55	60/ 60 45	75	60/ 60	V _{MIN}
Reverse Polarity DC Input Voltage	R _O = 100Ω LM2940 LM2940C	−30 −30	−15/− 15 −15	−30	−15/− 15	V _{MIN}
Reverse Polarity Transient Input Voltage	R _O = 100Ω T ≤ 100 ms LM2940 LM2940C	−75 −55	−50/− 50 −45/− 45	−75	−50/− 50	V _{MIN}

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 $T_A = T_J = 25^\circ C$ (Continued)

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)	
Output Voltage	$5 mA \leq I_O \leq 1A$	$13.6V \leq V_{IN} \leq 26V$			$16.75V \leq V_{IN} \leq 26V$			V_{MIN} V_{MAX}
		12.00	11.64/ 11.40 12.36/ 12.60	11.64/ 11.40 12.36/ 12.60	15.00	14.55/ 14.25 15.45/ 15.75	14.55/ 14.25 15.45/ 15.75	
Line Regulation	$V_O + 2V \leq V_{IN} \leq 26V$, $I_O = 5 mA$	20	120	75/ 120	20	150	95/ 150	mV _{MAX}
Load Regulation	$50 mA \leq I_O \leq 1A$ LM2940, LM2940/883 LM2940C	55	120/ 200	120/ 190	70	150	150/ 240	mV _{MAX}
		55	120					
Output Impedance	100 mADC and 20 mArms, $f_O = 120 Hz$	80		1000/ 1000	100		1000/ 1000	m Ω
Quiescent Current	$V_O + 2V \leq V_{IN} \leq 26V$, $I_O = 5 mA$ LM2940, LM2940/883 LM2940C	10	15/ 20	15/ 20	10	15	15/ 20	mA _{MAX}
		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}
Ripple Rejection	$f_O = 120 Hz$, 1 V _{rms} , $I_O = 100 mA$ LM2940 LM2940C	66	54/ 48		64	52		dB _{MIN}
		66	54					
	$f_O = 1 kHz$, 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	$R_O = 100\Omega$ LM2940, $T \leq 100 ms$ LM2940/883, $T \leq 20 ms$ LM2940C, $T \leq 1 ms$	75	60/ 60	40/ 40	55	45	40/ 40	V _{MIN}
		55	45					
Reverse Polarity DC Input Voltage	$R_O = 100\Omega$ LM2940, LM2940/883 LM2940C	-30 -30	-15/ - 15 -15	-15/ - 15	-30	-15	-15/ - 15	V _{MIN}
Reverse Polarity Transient Input Voltage	$R_O = 100\Omega$ LM2940, $T \leq 100 ms$ LM2940/883, $T \leq 20 ms$ LM2940C, $T \leq 1 ms$	-75	-50/ - 50	-45/ - 45	-55	-45/ - 45	-45/ - 45	V _{MIN}
		-55	-45/ - 45					

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: Military specifications complied with RETS/SMD at the time of printing. For current specifications refer to RETS LM2940K-5.0, LM2940K-8.0, LM2940K-12, and LM2940K-15. SMD numbers are 5962-8958701YA(5V), 5962-9083301YA(8V), 5962-9088401YA(12V), and 5962-9088501YA(15V).

Note 3: The maximum power dissipation is a function of the maximum junction temperature, $T_J = 150^\circ\text{C}$, the junction-to-ambient thermal resistance, θ_{JA} , and the ambient temperature, T_A . The maximum allowable power dissipation at any ambient temperature is $P_{D\text{MAX}} = (150 - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above 150°C and the LM2940 will go into thermal shutdown. For the LM2940T and LM2940CT, the junction-to-ambient thermal resistance (θ_{JA}) is 53°C/W . When using a heatsink, θ_{JA} is the sum of the 3°C/W junction-to-case thermal resistance (θ_{JC}) of the LM2940T or LM2940CT and the case-to-ambient thermal resistance of the heatsink. If the TO-263 package is used, the thermal resistance can be used 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 . For the LM2940K, θ_{JA} is 39°C/W and θ_{JC} is 4°C/W .

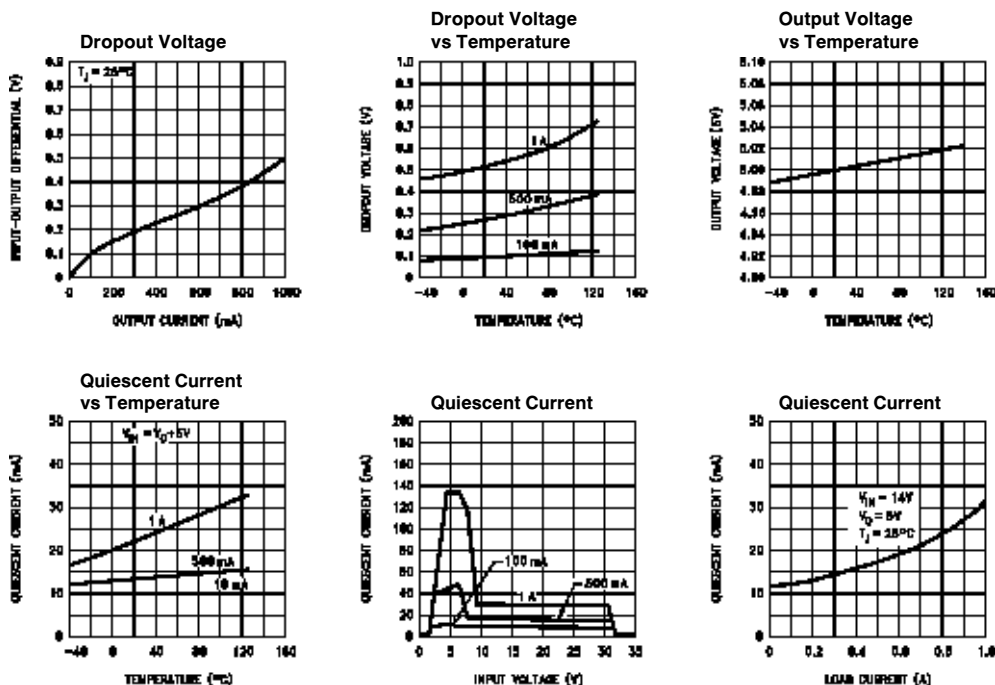
Note 4: ESD rating is based on the human body model, 100 pF discharged through 1.5 k Ω .

Note 5: All limits are guaranteed at $T_A = T_J = 25^\circ\text{C}$ only (standard typeface) or over the entire operating temperature range of the indicated device (**boldface type**). All limits at $T_A = T_J = 25^\circ\text{C}$ 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 $T_A = T_J = 25^\circ\text{C}$ 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.

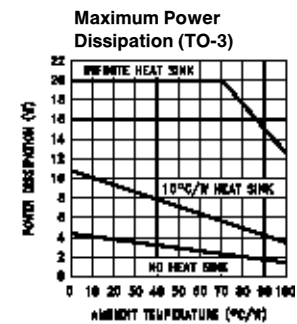
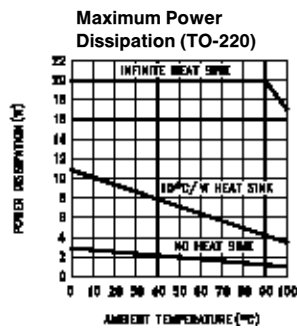
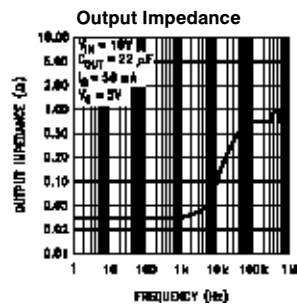
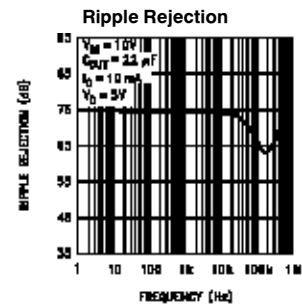
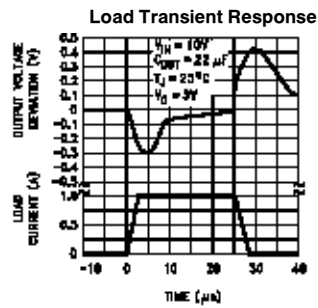
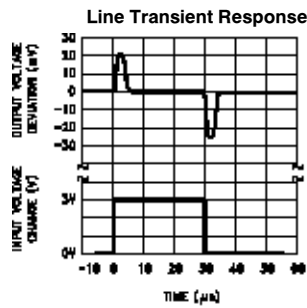
Note 7: Output current will decrease with increasing temperature but will not drop below 1A at the maximum specified temperature.

Typical Performance Characteristics

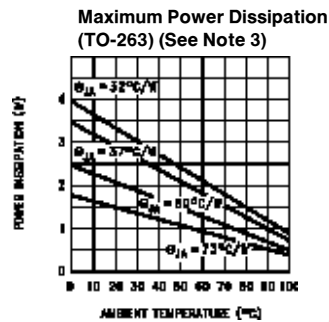


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Typical Performance Characteristics (Continued)

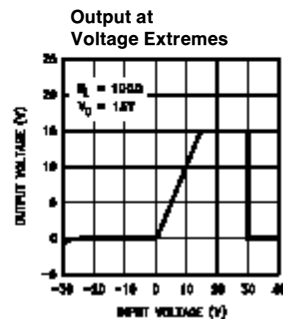
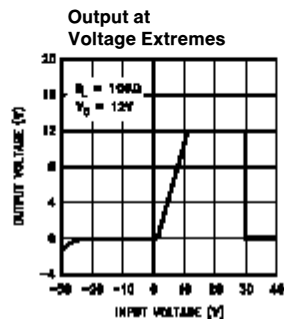
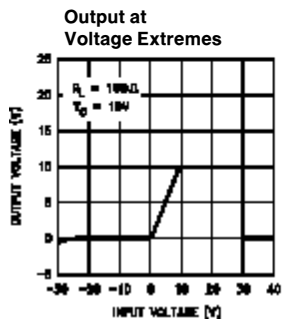
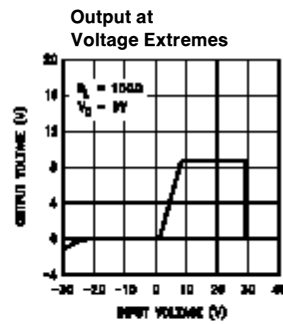
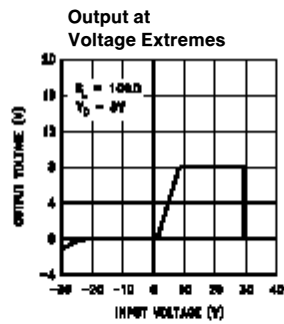
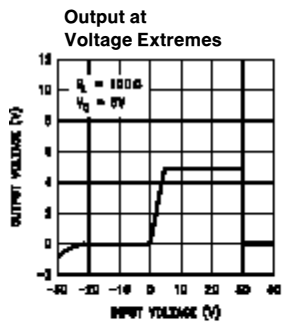
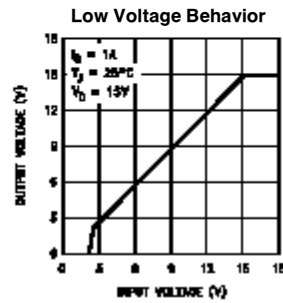
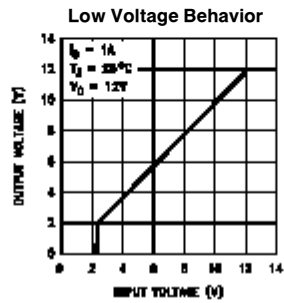
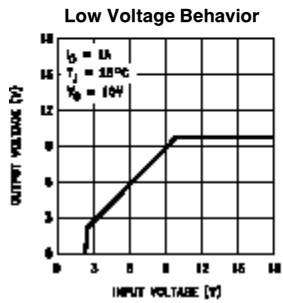
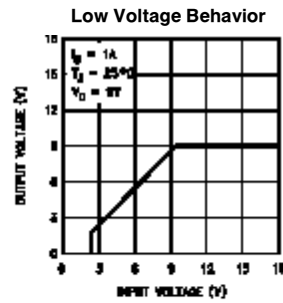
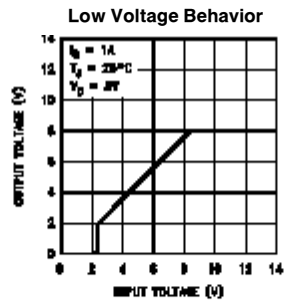
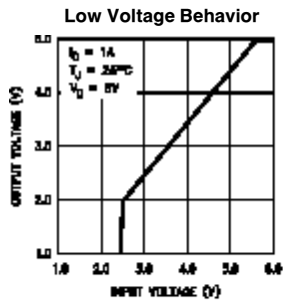


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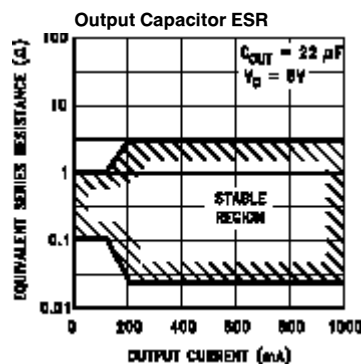
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Typical Performance Characteristics (Continued)

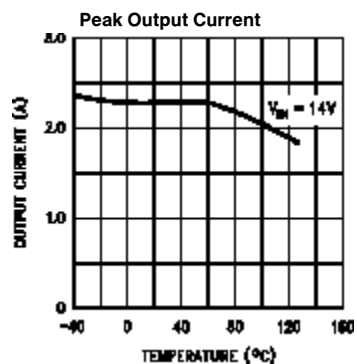


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Typical Performance Characteristics (Continued)

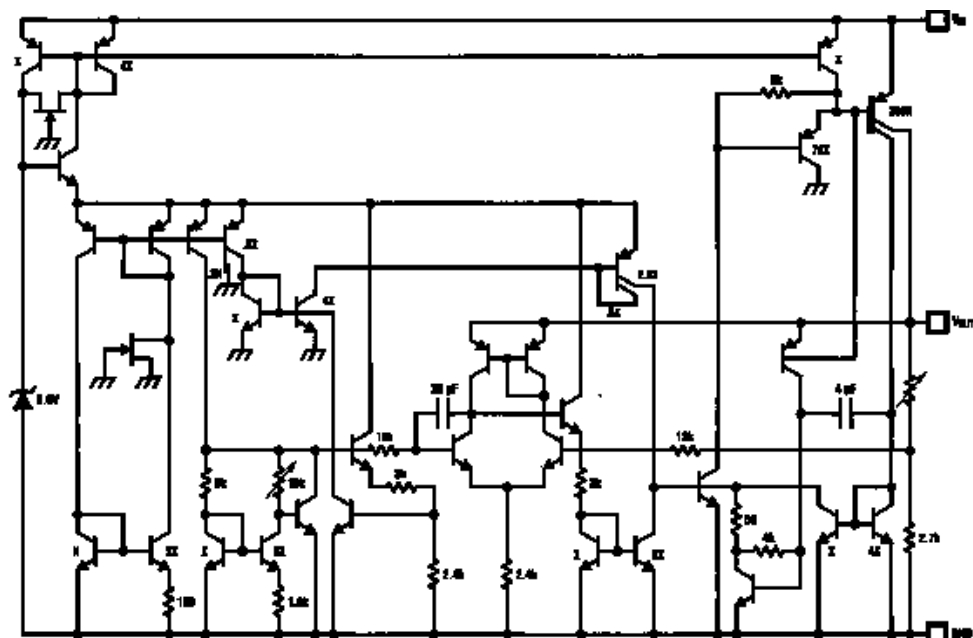


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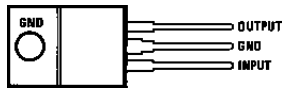
Equivalent Schematic Diagram



TL/H/8822-1

Connection Diagrams

(TO-220) Plastic Package

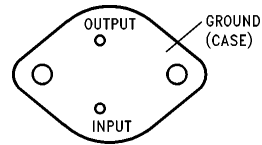


Front View

TL/H/8822-2

Order Number LM2940CT-5.0, LM2940CT-9.0,
LM2940CT-12, LM2940CT-15, LM2940T-5.0,
LM2940T-8.0, LM2940T-9.0,
LM2940T-10 or LM2940T-12
See NS Package Number TO3B

TO-3 Metal Can Package (K)

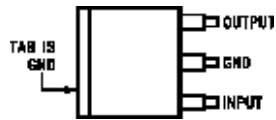


Bottom View

TL/H/8822-7

Order Number LM2940K-5.0/883,
LM2940K-8.0/883, LM2940K-12/883, LM2940K-15/883
See NS Package Number K02A

(TO-263) Surface-Mount Package



Top View

TL/H/8822-11

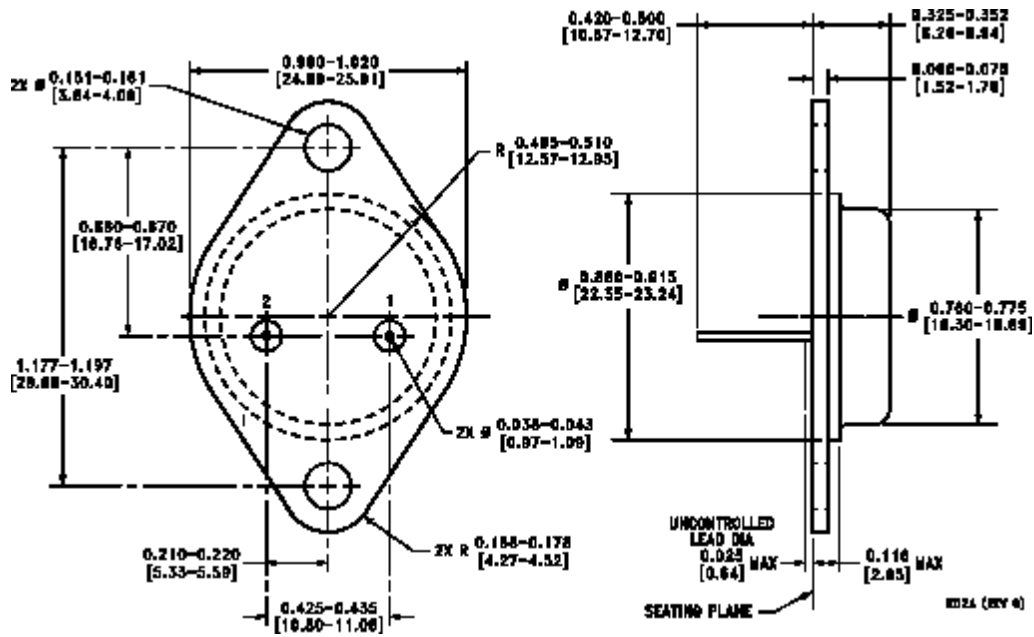


Side View

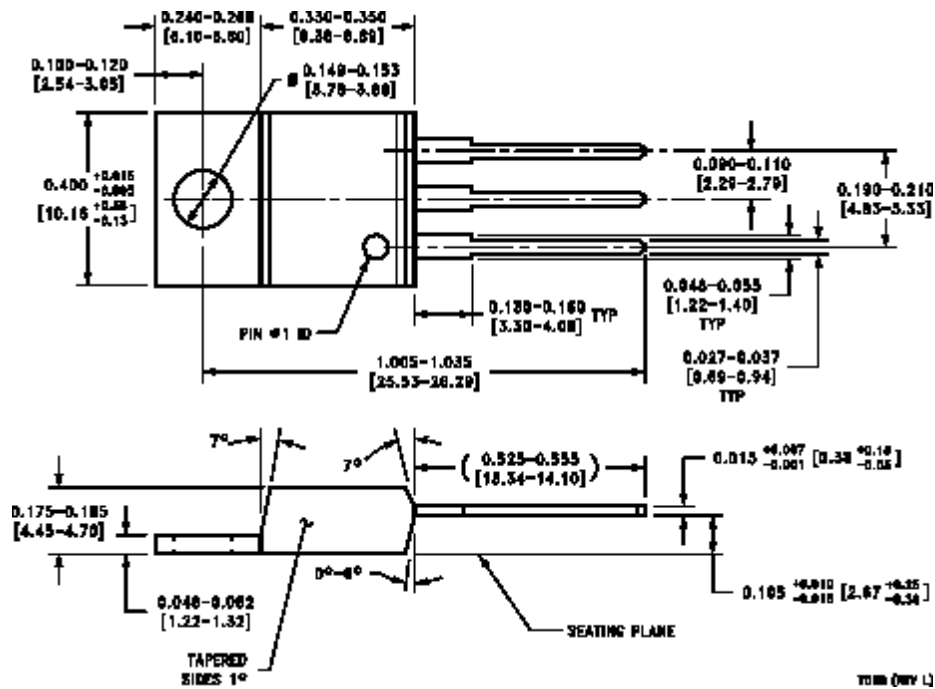
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Order Number LM2940CS-5.0, LM2940CS-9.0, LM2940CS-12,
LM2940CS-15, LM2940S-5.0, LM2940S-8.0,
LM2940S-9.0, LM2940S-10 or LM2940S-12
See NS Package Number TS3B

Physical Dimensions inches (millimeters) unless otherwise noted

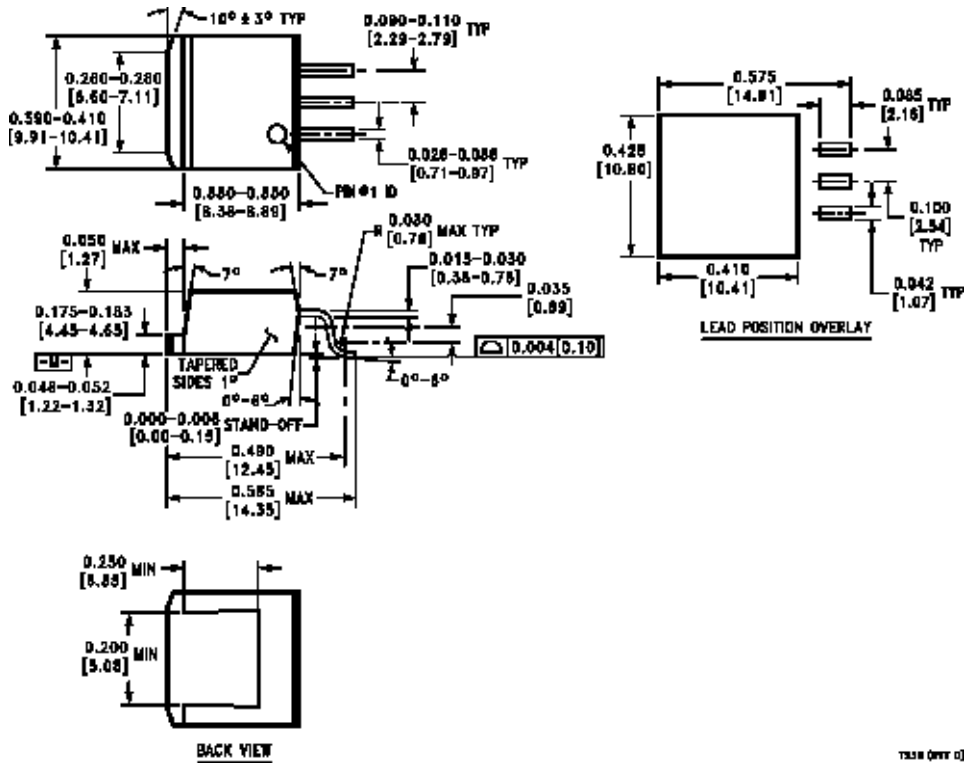


2 Lead TO-3 Metal Can Package (K)
 Order Number LM2940K-5.0/883,
 LM2940K-8.0/883, LM2940K-12/883, LM2940K-15/883
 NS Package Number K02A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

3-Lead TO-220 Plastic Package (T)
Order Number LM2940T-5.0, LM2940T-8.0,
LM2940T-9.0, LM2940T-10, LM2940T-12, LM2940CT-5.0,
LM2940CT-12 or LM2940CT-15
NS Package Number TO3B

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



3-Lead TO-263 Surface Mount Package
 Order Number LM2940S-5.0, LM2940S-8.0,
 LM2940S-9.0, LM2940S-10, LM2940S-12,
 LM2940CS-5.0, LM2940CS-12 or LM2940CS-15
 NS Package Number TS3B

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



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