National Semiconductor

April 1998

LM2936
Ultra-Low Quiescent Current 5V Regulator

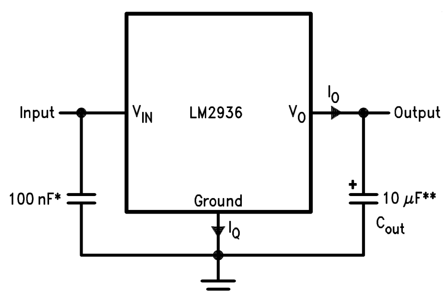
General Description

The LM2936 ultra-low quiescent current regulator features low dropout voltage and low current in the standby mode. With less than 15 µA quiescent current at a 100 µA load, the LM2936 is ideally suited for automotive and other battery operated systems. The LM2936 retains all of the features that are common to low dropout regulators including a low dropout PNP pass device, short circuit protection, reverse battery protection, and thermal shutdown. The LM2936 has a 40V operating voltage limit, −40˚C to +125˚C operating temperature range, and ±3% output voltage tolerance over the entire output current, input voltage, and temperature range. The LM2936 is available in both a TO-92 package and an 8-pin surface mount package with a fixed 5V output.

Features

- Ultra low quiescent current ($I_Q \leq 15$ µA for $I_O \leq 100$ µA)
- Fixed 5V, 50 mA output
- Output tolerance ±3% over line, load, and temperature
- Dropout voltage typically 200 mV @ I_O = 50 mA
- Reverse battery protection
- −50V reverse transient protection
- Internal short circuit current limit
- Internal thermal shutdown protection
- 40V operating voltage limit

Typical Application



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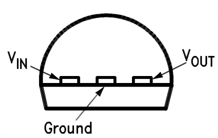
* Required if regulator is located more than 2" from power supply filter capacitor.

** Required for stability. Must be rated for 10 µF minimum over intended operating temperature range. Effective series resistance (ESR) is critical, see curve. Locate capacitor as close as possible to the regulator output and ground pins. Capacitance may be increased without bound.

Connection Diagrams

TO-92 Plastic Package (Z)



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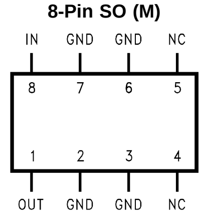
Bottom View
Order Number LM2936Z-5.0
See NS Package Number Z03A

8-Pin SO (M)



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Top View
Order Number LM2936M-5.0
See NS Package Number M08A

Absolute Maximum Ratings (Note 1)

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

Input Voltage (Survival)	+60V, −50V
ESD Susceptability (Note 2)	1900V
Power Dissipation (Note 3)	Internally limited
Junction Temperature (T_{Jmax})	150˚C
Storage Temperature Range	−65˚C to +150˚C
Lead Temperature (Soldering, 10 sec.)	260˚C

Operating Ratings

Operating Temperature Range	−40˚C to +125˚C
Maximum Input Voltage (Operational)	40V

Electrical Characteristics

V_{IN} = 14V, I_O = 10 mA, T_J = 25˚C, unless otherwise specified. **Boldface** limits apply over entire operating temperature range

Parameter	Conditions	Typical (Note 4)	Tested Limit (Note 5)	Units
Output Voltage	5.5V ≤ V_{IN} ≤ 26V, I_O ≤ 50 mA (Note 6)		**4.85**	V_{min}
		5		V
			5.15	V_{max}
Line Regulation	9V ≤ V_{IN} ≤ 16V	5	10	mV_{max}
	6V ≤ V_{IN} ≤ 40V, I_O = 1 mA	10	30	
Load Regulation	100 µA ≤ I_O ≤ 5 mA	10	30	mV_{max}
	5 mA ≤ I_O ≤ 50 mA	10	30	
Output Impedance	I_O = 30 mAdc and 10 mArms, $_f$ = 1000 Hz	450		mΩ
Quiescent Current	I_O = 100 µA, 8V ≤ V_{IN} ≤ 24V	9	15	$µA_{max}$
	I_O = 10 mA, 8V ≤ V_{IN} ≤ 24V	0.20	0.50	mA_{max}
	I_O = 50 mA, 8V ≤ V_{IN} ≤ 24V	1.5	2.5	mA_{max}
Output Noise Voltage	10 Hz–100 kHz	500		$µV_{rms}$
Long Term Stability		20		mV/1000 Hr
Ripple Rejection	V_{ripple} = 1 V_{rms}, f_{ripple} = 120 Hz	60	40	dB_{min}
Dropout Voltage	I_O = 100 µA	0.05	0.10	V_{max}
	I_O = 50 mA	0.20	0.40	V_{max}
Reverse Polarity DC Input Voltage	R_L = 500Ω, V_O ≥ −0.3V		−15	V_{min}
Reverse Polarity Transient Input Voltage	R_L = 500Ω, T = 1 ms	−80	−50	V_{min}
Output Leakage with Reverse Polarity Input	V_{IN} = −15V, R_L = 500Ω	−0.1	−600	$µA_{max}$
Maximum Line Transient	R_L = 500Ω, V_O ≤ 5.5V, T = 40 ms		60	V_{min}
Short Circuit Current	V_O = 0V	120	250	mA_{max}
			65	mA_{min}

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its specified operating ratings.

Note 2: Human body model, 100 pF discharge through a 1.5 kΩ resistor.

Note 3: The maximum power dissipation is a function of T_{Jmax}, θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{Jmax} - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above 150˚C and the LM2936 will go into thermal shutdown. For the LM2936Z, the junction-to-ambient thermal resistance (θ_{JA}) is 195˚C/W. For the LM2936M, θja is 160˚C/W.

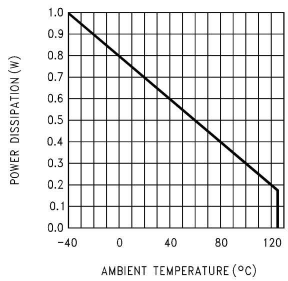
Note 4: Typicals are at 25˚C (unless otherwise specified) and represent the most likely parametric norm.

Note 5: Tested limits are guaranteed to National's AOQL (Average Outgoing Quality Level) and 100% tested.

Note 6: To ensure constant junction temperature, pulse testing is used.

Typical Performance Characteristics

Maximum Power Dissipation (TO-92)



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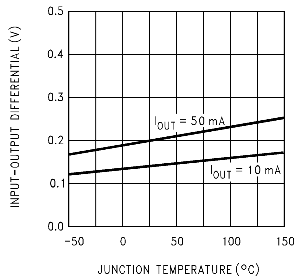
Dropout Voltage



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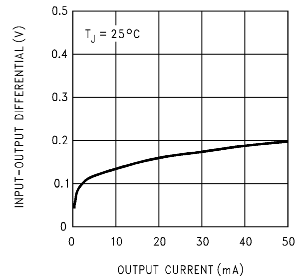
Dropout Voltage



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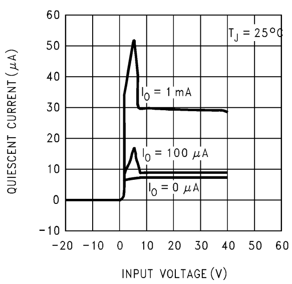
Quiescent Current



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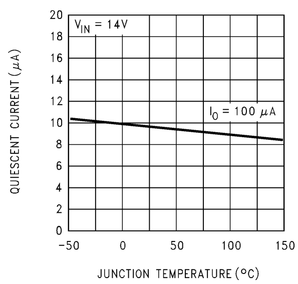
Quiescent Current



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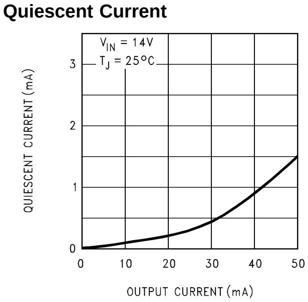
Quiescent Current



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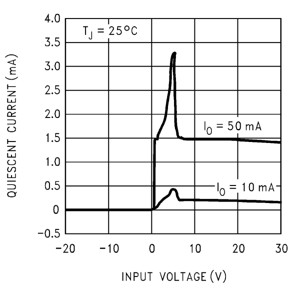
Quiescent Current



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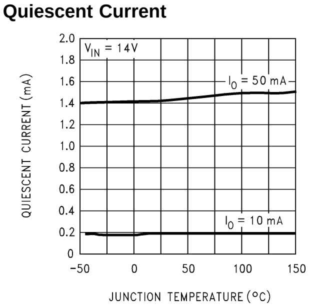
Quiescent Current



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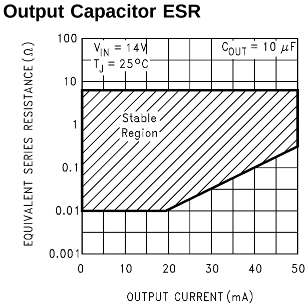
Output Capacitor ESR



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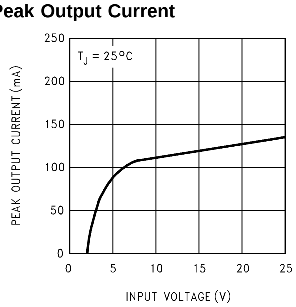
Peak Output Current



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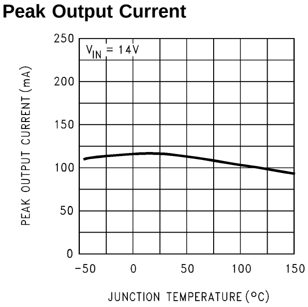
Peak Output Current



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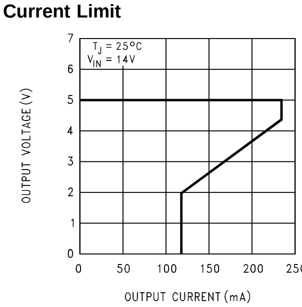
Current Limit



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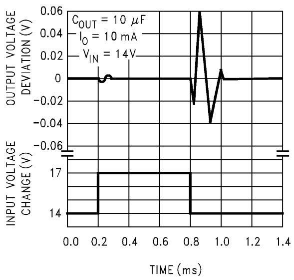
Typical Performance Characteristics (Continued)

Line Transient Response



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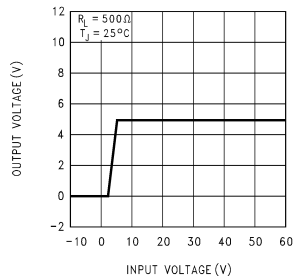
Output at Voltage Extremes



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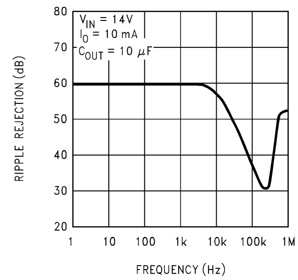
Ripple Rejection



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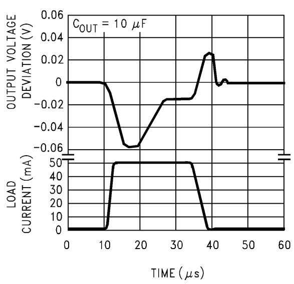
Load Transient Response



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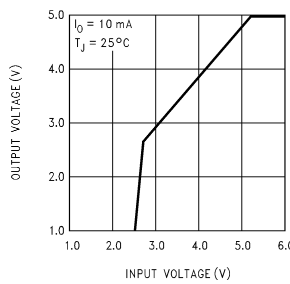
Low Voltage Behavior



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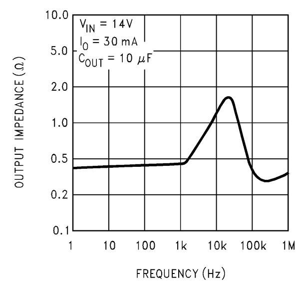
Output Impedance



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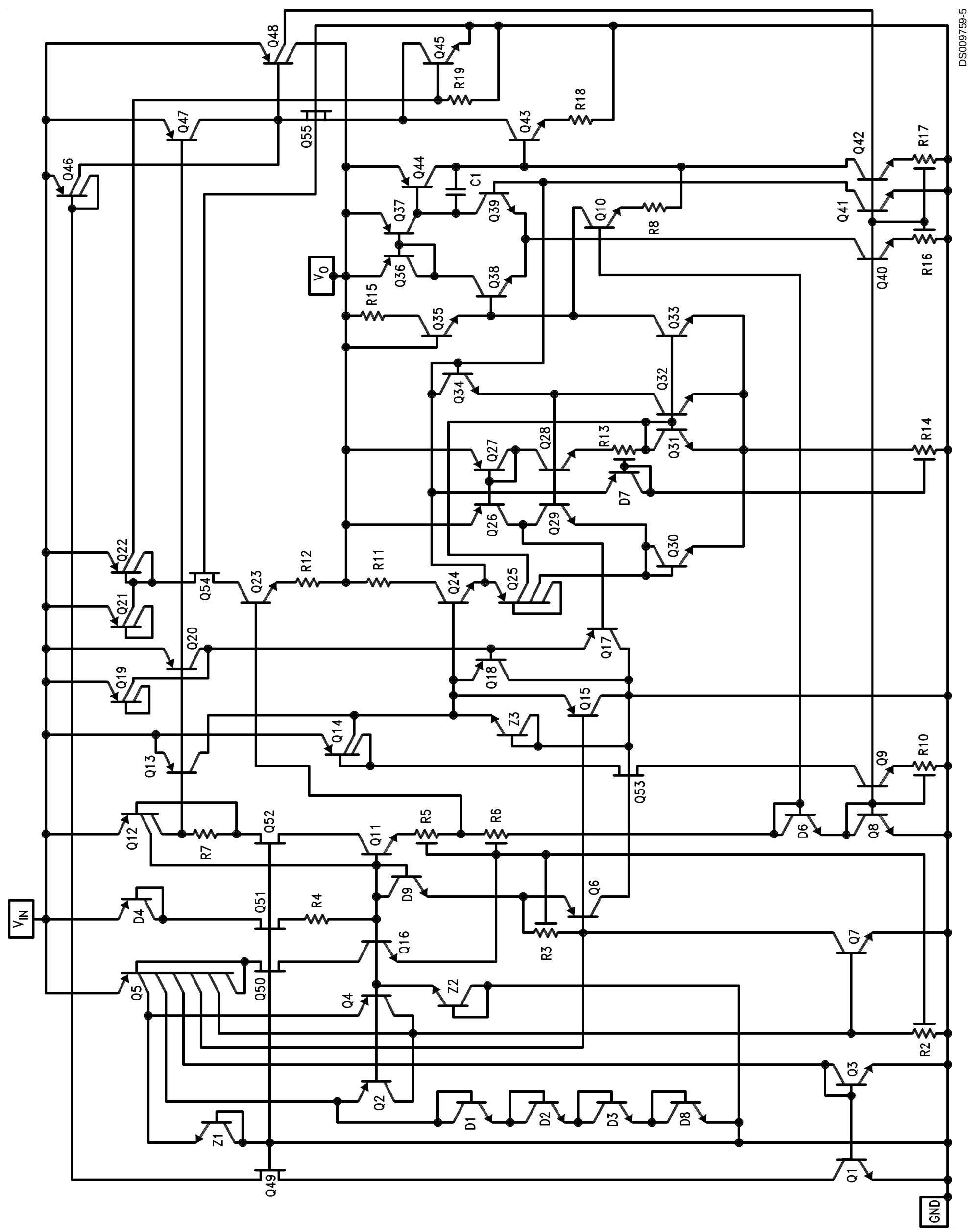
Applications Information

Unlike other PNP low dropout regulators, the LM2936 remains fully operational to 40V. Owing to power dissipation characteristics of the TO-92 package, full output current cannot be guaranteed for all combinations of ambient temperature and input voltage. As an example, consider an LM2936 operating at 25˚C ambient. Using the formula for maximum allowable power dissipation given in (Note 3) , we find that P_{Dmax} = 641 mW at 25˚C. Including the small contribution of the quiescent current to total power dissipation the maximum input voltage (while still delivering 50 mA output current) is 17.3V. The device will go into thermal shutdown if it attempts to deliver full output current with an input voltage of more than 17.3V. Similarly, at 40V input and 25˚C ambient the LM2936 can deliver 18 mA maximum.

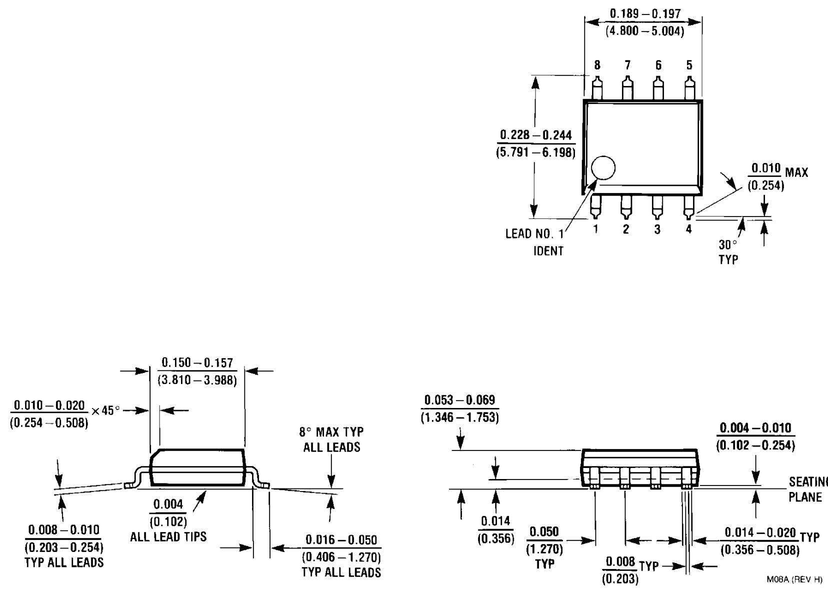
Under conditions of higher ambient temperatures, the voltage and current calculated in the previous examples will drop. For instance, at the maximum ambient of 125˚C the LM2936 can only dissipate 128 mW, limiting the input voltage to 7.34V for a 50 mA load, or 3.5 mA output current for a 40V input.

While the LM2936 maintains regulation to 60V, it will not withstand a short circuit above 40V because of safe operating area limitations in the internal PNP pass device. Above 60V the LM2936 will break down with catastrophic effects on the regulator and possibly the load as well. Do not use this device in a design where the input operating voltage may exceed 40V, or where transients are likely to exceed 60V.

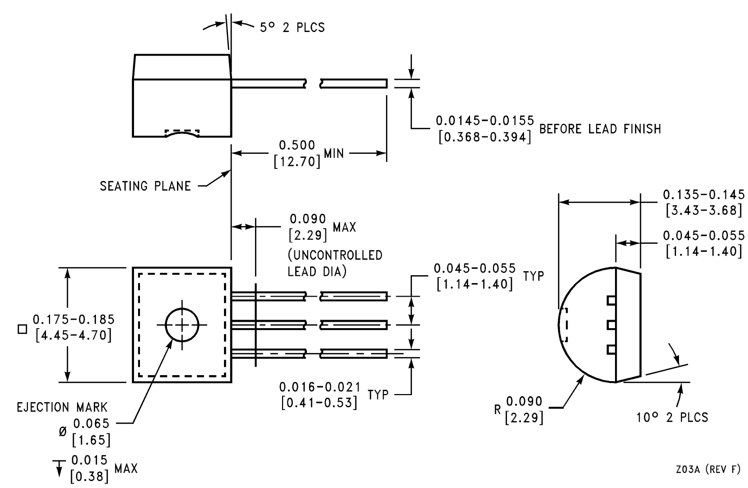
Equivalent Schematic Diagram



Physical Dimensions inches (millimeters) unless otherwise noted



8-Lead Small Outline Molded Package (M)
NS Package Number M08A



3-Lead TO-92 Plastic Package (Z)
NS Package Number Z03A

Notes

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