June 2002

National Semiconductor

LM2936-3.3
Ultra-Low Quiescent Current 3.3V Regulator

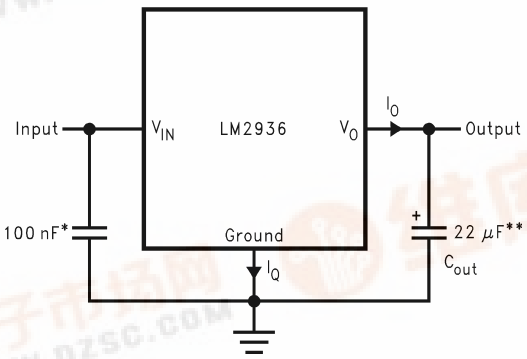
General Description

The LM2936-3.3 ultra-low quiescent current regulator features low dropout voltage and low current in the standby mode. With less than 20 µA quiescent current at a 100 µA load, the LM2936-3.3 is ideally suited for automotive and other battery operated systems. The LM2936-3.3 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 LM2936-3.3 has a 40V maximum operating voltage limit, a −40˚C to +125˚C operating temperature range, and ±3% output voltage tolerance over the entire output current, input voltage, and temperature range. The LM2936-3.3 is available in a TO-92 package, a SO-8 surface mount package, as well as SOT-223 and TO-252 surface mount power packages.

Features

- Ultra low quiescent current ($I_Q \leq 20$ µA for $I_O = 100$ µA)
- Fixed 3.3V, 50 mA output
- ±2% Initial output tolerance
- ±3% Output tolerance 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
- 60V operating voltage limit for LM2936HV
- Shutdown pin available with LM2936BM package

Typical Application



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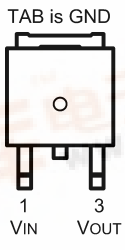
* Required if regulator is located more than 2" from power supply filter capacitor.

** Required for stability. Must be rated for 22 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-252



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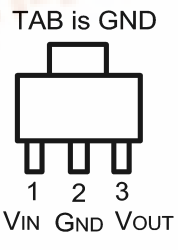
Top View
Order Number LM2936DT-3.3
See NS Package Number TD03B

SOT-223



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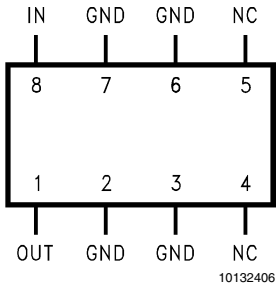
Top View
Order Number LM2936MP-3.3
See NS Package Number MA04A

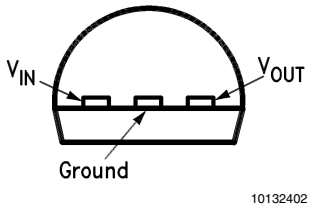
Connection Diagrams (Continued)

8-Pin SO (M)



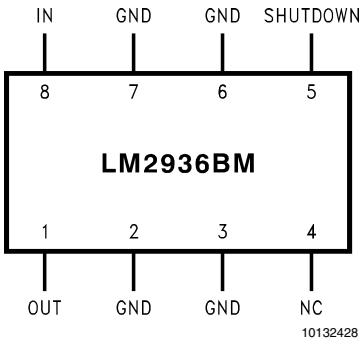
Top View
Order Number LM2936M-3.3
See NS Package Number M08A

TO-92



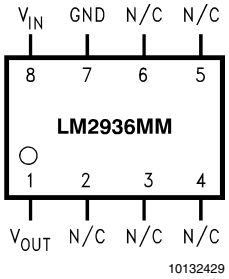
Bottom View
Order Number LM2936Z-3.3
See NS Package Number Z03A

8-Pin SO (M)



Top View
Order Number LM2936BM-3.3, LM2936HVBMA-3.3
See NS Package Number M08A

8-Pin Mini SOIC (MM)



Top View
Order Number LM2936MM-3.3
See NS Package Number MUA08A

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 Susceptibility (Note 2)	2000V
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
Maximum Operating Input Voltage - LM2936	+40V
Maximum Operating Input Voltage - LM2936HV only	+60V
Maximum Shutdown Pin Voltage - LM2936BM only	0V to 40V

MSO-8 (MUA08A) θ_{JA}	200˚C/W
TO-92 (Z03A) θ_{JA}	195˚C/W
SO-8 (M08A) θ_{JA}	140˚C/W
SO-8 (M08A) θ_{JC}	45˚C/W
TO-252 (TD03B) θ_{JA}	126˚C/W
TO-252 (TD03B) θ_{JC}	6˚C/W
SOT-223 (MA04A) θ_{JA}	149˚C/W
SOT-223 (MA04A) θ_{JC}	36˚C/W

Operating Ratings

Operating Temperature Range	−40˚C to +125˚C

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	Min (Note 5)	Typical (Note 4)	Max (Note 5)	Units
LM2936HV Only					
Output Voltage	5.5V ≤ V_{IN} ≤ 48V, 100 µA ≤ I_O ≤ 50 mA (Note 6)	**3.201**	**3.300**	**3.399**	V
Line Regulation	6V ≤ V_{IN} ≤ 60V, I_O = 1mA		10	30	mV
All LM2936					
Output Voltage		3.234	3.300	3.366	V
	4.0V ≤ V_{IN} ≤ 26V, 100µA ≤ I_O ≤ 50mA (Note 6)	**3.201**	**3.30**	**3.399**	
Quiescent Current	I_O = 100 µA, 8V ≤ V_{IN} ≤ 24V		15	20	µA
	I_O = 10 mA, 8V ≤ V_{IN} ≤ 24V		0.20	0.50	mA
	I_O = 50 mA, 8V ≤ V_{IN} ≤ 24V		1.5	2.5	mA
Line Regulation	9V ≤ V_{IN} ≤ 16V		5	10	mV
	6V ≤ V_{IN} ≤ 40V, I_O = 1 mA		10	30	
Load Regulation	100 µA ≤ I_O ≤ 5 mA		10	30	mV
	5 mA ≤ I_O ≤ 50 mA		10	30	
Dropout Voltage	I_O = 100 µA		0.05	0.10	V
	I_O = 50 mA		0.20	0.40	V
Short Circuit Current	V_O = 0V	65	120	250	mA
Output Impedance	I_O = 30 mAdc and 10 mArms, f = 1000 Hz		450		mΩ
Output Noise Voltage	10 Hz–100 kHz		500		µV
Long Term Stability			20		mV/1000 Hr
Ripple Rejection	V_{ripple} = 1 V_{rms}, f_{ripple} = 120 Hz	−40	−60		dB
Reverse Polarity Transient Input Voltage	R_L = 500Ω, T = 1 ms	−50	−80		V
Output Voltage with Reverse Polarity Input	V_{IN} = −15V, R_L = 500Ω		0.00	−0.30	V
Maximum Line Transient	R_L = 500Ω, V_O ≤ 3.63V	60			30
Output Bypass Capacitance (C_{OUT}) ESR	C_{OUT} = 22µF 0.1mA ≤ I_{OUT} ≤ 50mA	0.3		8	Ω

Electrical Characteristics (Continued)

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

Parameter	Conditions	Min (Note 5)	Typical (Note 4)	Max (Note 5)	Units
Shutdown Input - LM2936BM Only					
Output Voltage, V_{OUT}	Output Off, V_{SD} = 2.4V		0	0.010	V
Shutdown High Threshold Voltage, V_{IH}	Output Off, R_{LOAD} = 500Ω	2.00	1.1		V
Shutdown Low Threshold Voltage, V_{IL}	Output On, R_{LOAD} = 500Ω		1.1	0.60	V
Shutdown High Current, I_{IH}	Output Off, V_{SD} = 2.4V, R_{LOAD} = 500Ω		12		µA
Quiescent Current	Output Off, V_{SD} = 2.4V, R_{LOAD} = 500Ω Includes I_{IH} Current		30		µA

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.

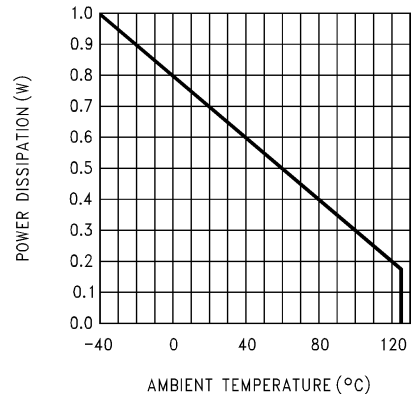
Note 4: Typicals are at 25˚C (unless otherwise specified) and represent the most likely parametric norm.

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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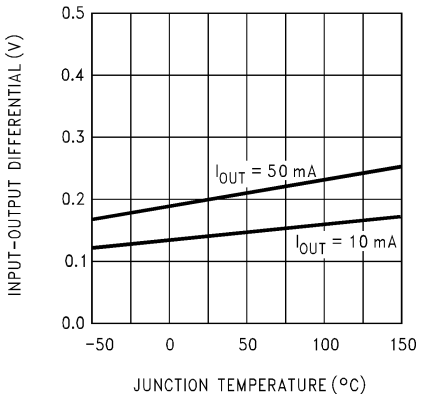
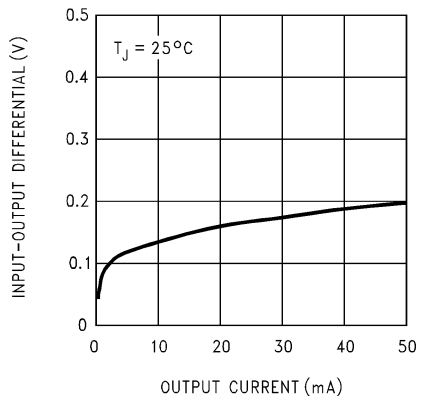
Dropout Voltage



10132408

Dropout Voltage



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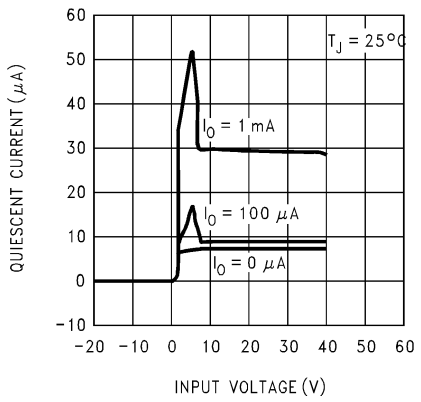
Quiescent Current



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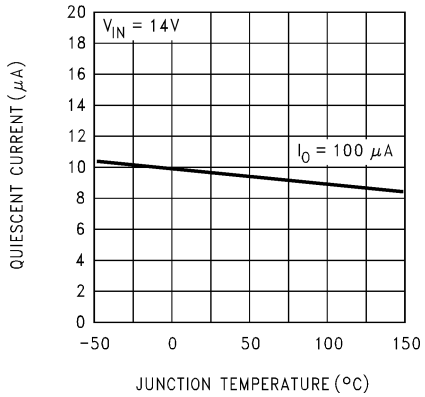
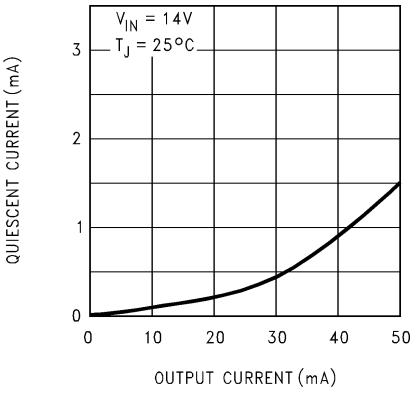
Typical Performance Characteristics (Continued)

Quiescent Current



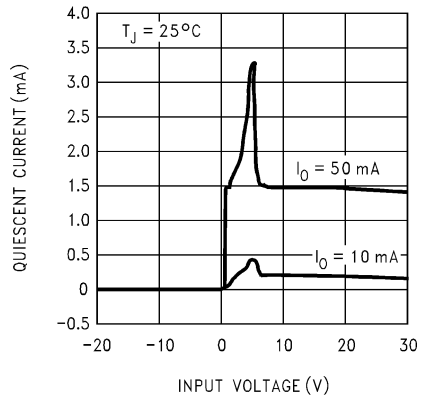
10132411

Quiescent Current



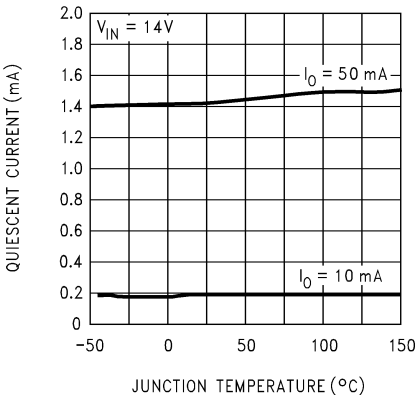
10132412

Quiescent Current



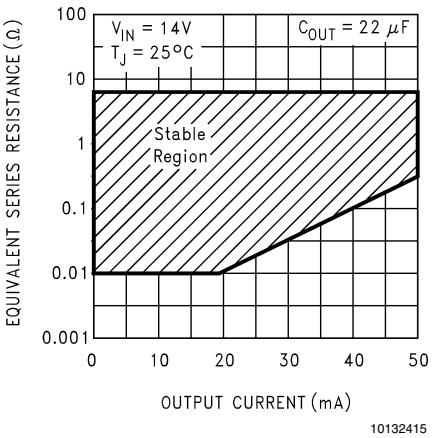
10132413

Quiescent Current



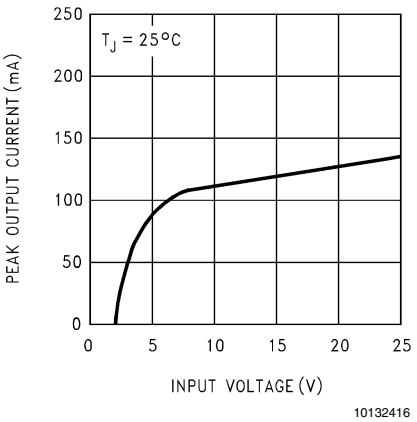
10132414

Output Capacitor ESR



10132415

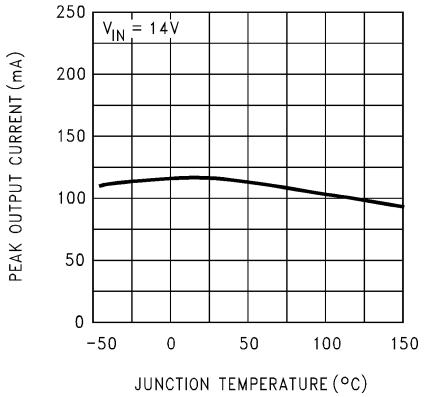
Peak Output Current



10132416

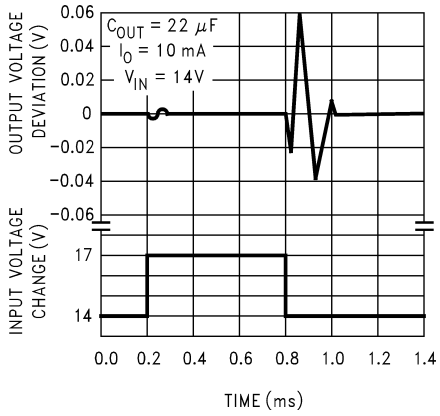
Typical Performance Characteristics (Continued)

Peak Output Current



10132417

Line Transient Response



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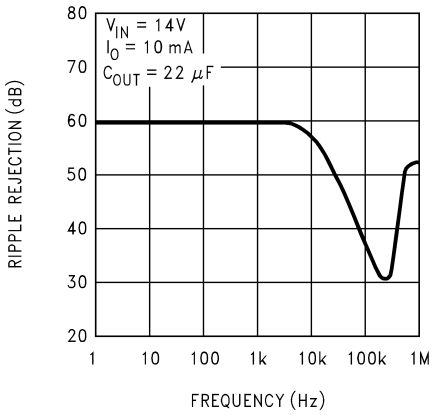
Ripple Rejection



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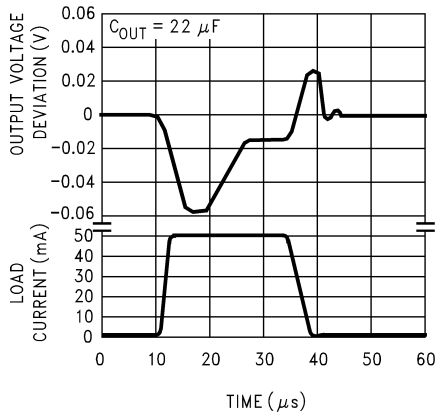
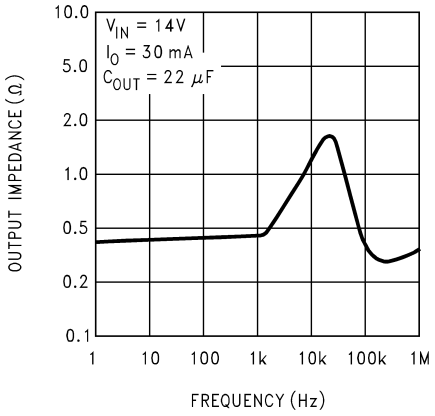
Load Transient Response



10132422

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 available packages, full output current cannot be guaranteed for all combinations of ambient temperature and input voltage. As an example, consider an LM2936Z-3.3 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 15.3V. The LM2936Z-3.3 will go into thermal shutdown if it attempts to deliver full output current with an input voltage of more than 15.3V. Similarly, at 40V input and 25˚C ambient the LM2936Z-3.3 can deliver 15 mA maximum.

Applications Information (Continued)

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 LM2936Z-3.3 can only dissipate 128 mW, limiting the input voltage to 5.6V for a 50 mA load, or 3.0 mA output current for a 40V input.

The junction to ambient thermal resistance θ_{JA} rating has two distinct components: the junction to case thermal resistance rating θ_{JC}; and the case to ambient thermal resistance rating θ_{CA}. The relationship is defined as: $\theta_{JA} = \theta_{JC} + \theta_{CA}$.

For the SO-8 and TO-252 surface mount packages the θ_{JA} rating can be improved by using the copper mounting pads on the printed circuit board as a thermal conductive path to extract heat from the package.

On the SO-8 package the four ground pins are thermally connected to the backside of the die. Adding approximately 0.04 square inches of 2 oz. copper pad area to these four pins will improve the θ_{JA} rating to approximately 110˚C/W. If this extra pad are is placed directly beneath the package there should not be any impact on board density.

On the TO-252 package the ground tab is thermally connected to the backside of the die. Adding 1 square inch of 2 oz. copper pad area directly under the ground tab will improve the θ_{JA} rating to approximately 50˚C/W.

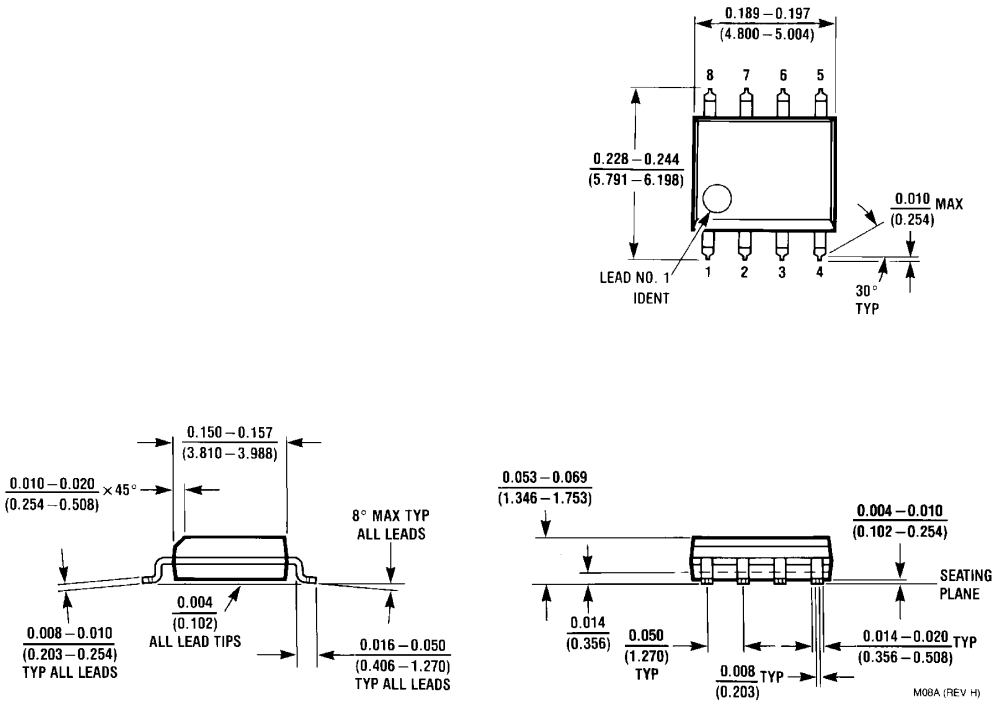
While the LM2936 has an internally set thermal shutdown point of typically 150˚C, this is intended as a safety feature only. Continuous operation near the thermal shutdown temperature should be avoided as it may have a negative affect on the life of the device.

While the LM2936-3.3 will survive input transients to +60V, output regulation is not guaranteed for input voltages greater than 40V. The LM2936 will not withstand a output short circuit with the input above 40V because of safe operating area limitations in the internal PNP pass device. With input voltages 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.

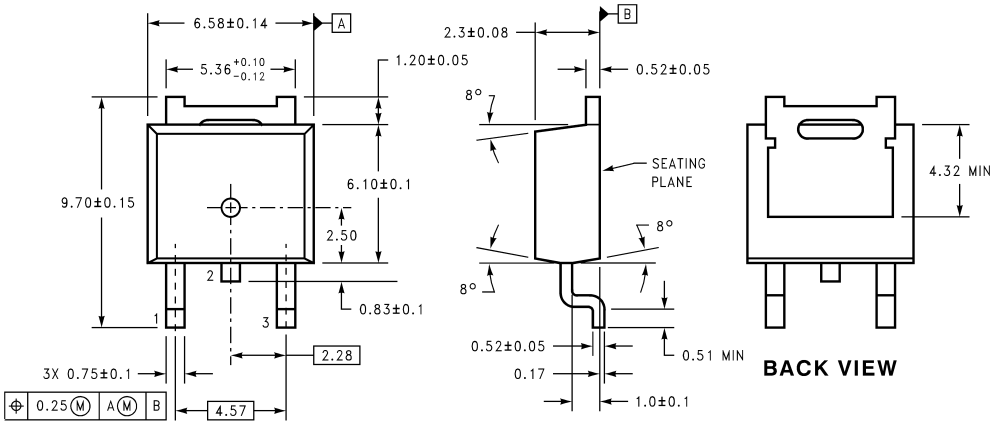
Shutdown Pin

The LM2936BM has a pin for shutting down the regulator output. Applying a Logic Level High (>2.0V) to the Shutdown pin will cause the output to turn off. Leaving the Shutdown pin open, connecting it to Ground, or applying a Logic Level Low (<0.6V) will allow the regulator output to turn on.

Physical Dimensions inches (millimeters) unless otherwise noted

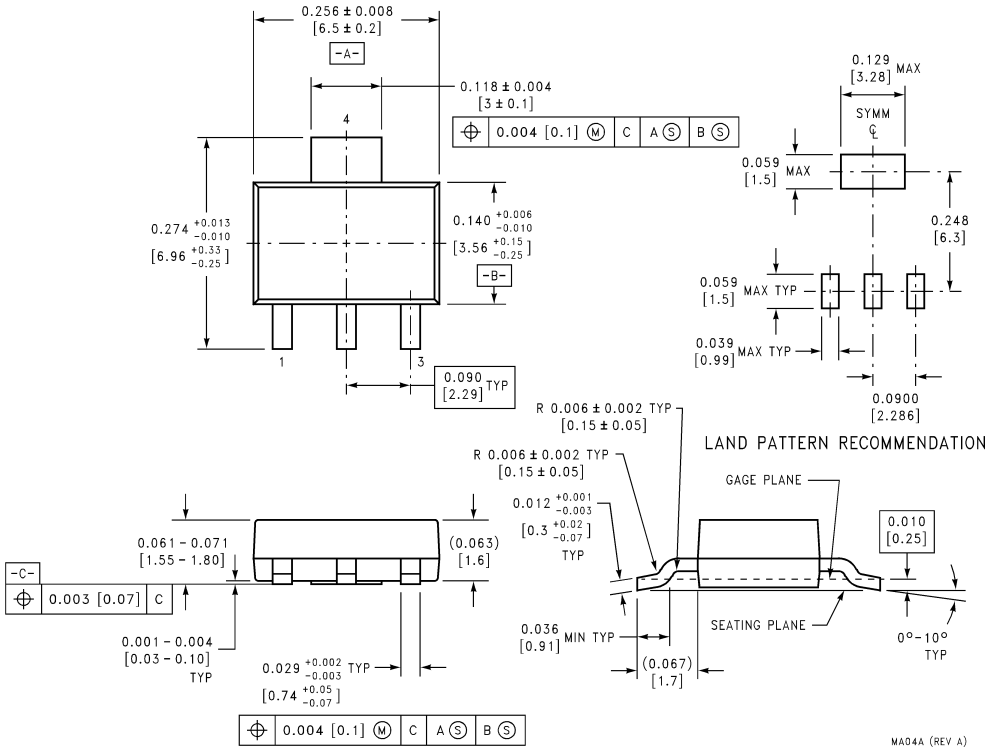


8-Lead Small Outline Molded Package (M)
NS Package Number M08A

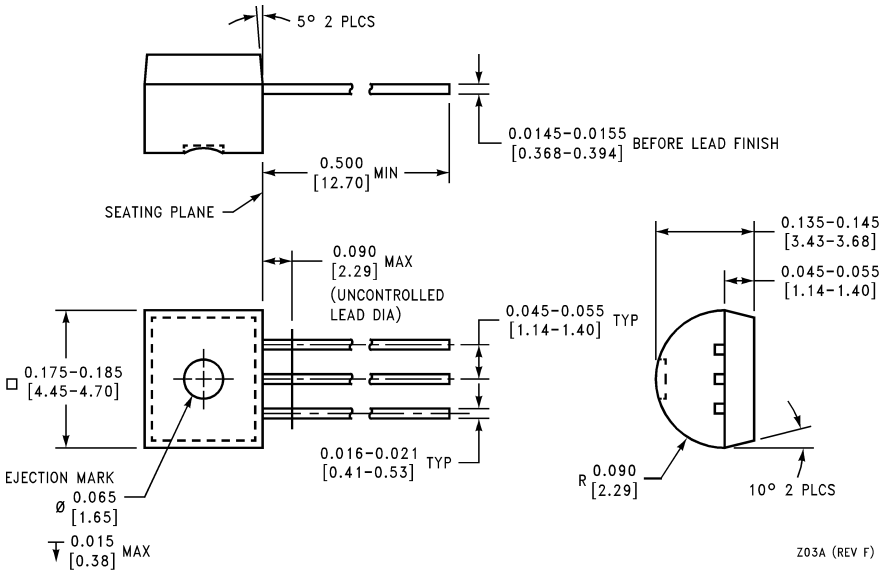


TO-252 Package (DT)
NS Package Number TD03B

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

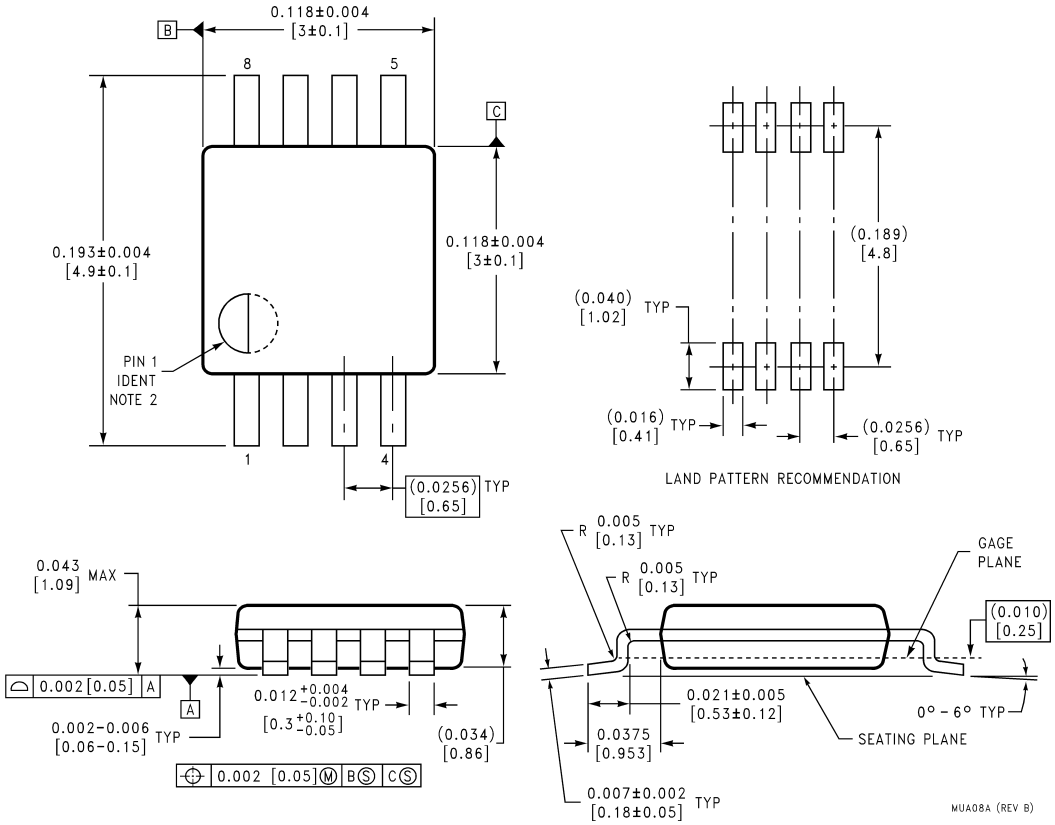


SOT-223 Package (MP)
NS Package Number MA04A



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

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



8-Lead Mini SOIC package (MM)
NS Package Number MUA08A

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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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