

# LM2936Q

## Ultra-Low Quiescent Current LDO Voltage Regulator

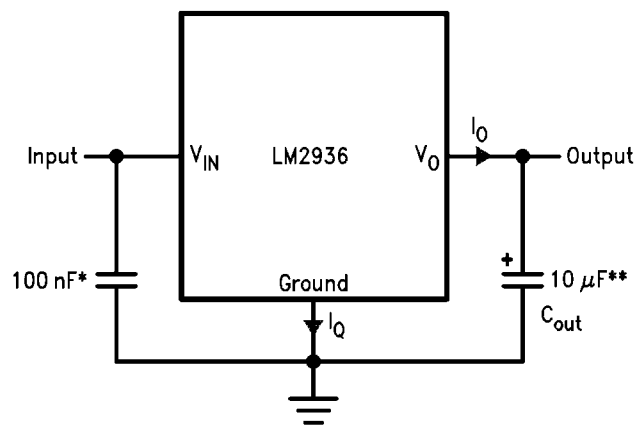
### General Description

The LM2936Q ultra-low quiescent current regulator features low dropout voltage and low current in the standby mode. With less than 15  $\mu\text{A}$  quiescent current at a 100  $\mu\text{A}$  load, the LM2936Q is ideally suited for automotive and other battery operated systems. The LM2936Q 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 LM2936Q has a 40V maximum operating voltage limit, a  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  operating temperature range, and  $\pm 3\%$  output voltage tolerance over the entire output current, input voltage, and temperature range. The LM2936Q is available in a SO-8 package, SOT-223 surface mount package and TO-252 surface mount package.

### Features

- AEC-Q100 Grade 1 Qualified ( $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ )
- Ultra low quiescent current ( $I_Q \leq 15 \mu\text{A}$  for  $I_O = 100 \mu\text{A}$ )
- Fixed 3.0V, 3.3V or 5.0V with 50 mA output
- $\pm 2\%$  Initial output tolerance
- $\pm 3\%$  Output tolerance over line, load, and temperature
- Dropout voltage typically 200 mV @  $I_O = 50 \text{ mA}$
- Reverse battery protection
- $-50\text{V}$  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 the LM2936BM package

### Typical Application

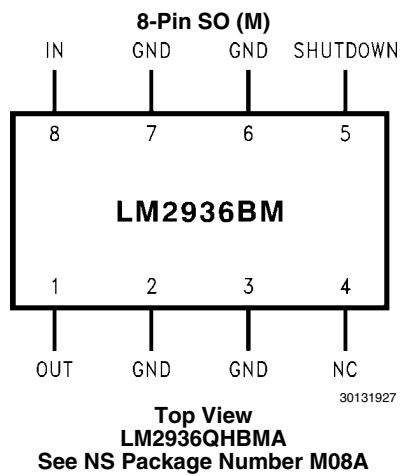
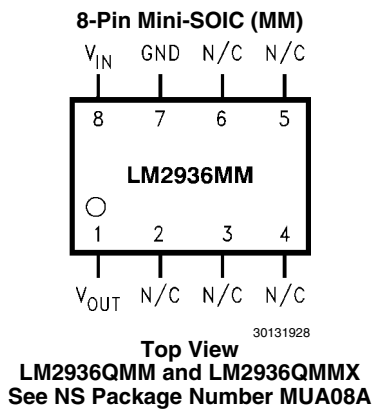
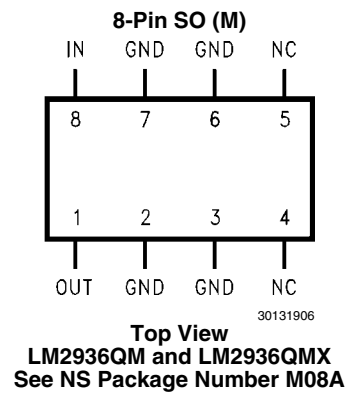
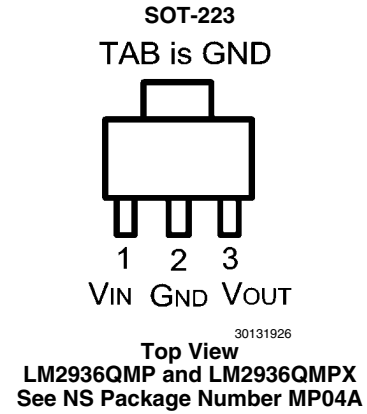
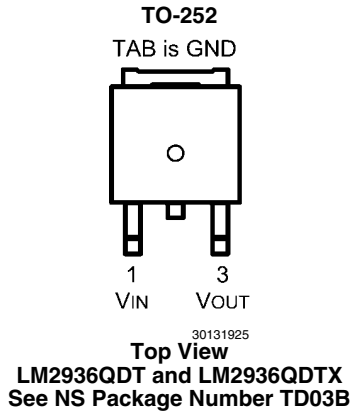


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\* Required if regulator is located more than 2" from power supply filter capacitor.

\*\* Required for stability. See Electrical Characteristics for required values. Must be rated 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



## Ordering Information

Output Voltage	High Voltage	Shutdown Pin	Order	Package Type	Package Drawing	Transport Media	Feature
3.00V	-	-	LM2936QMM-3.0	8-Lead Mini-SOIC	MUA08A	Rail	AEC-Q100 Grade 1 Qualified. Automotive Grade Production Flow. *
	-	-	LM2936QDT-3.0	TO-252	TD03B	Rail	
	-	-	LM2936QDTX-3.0	TO-252	TD03B	Tape/Reel	
3.30V	-	-	LM2936QMM-3.3	8-Lead Mini-SOIC	MUA08A	Rail	
	-	-	LM2936QMMX-3.3	8-Lead Mini-SOIC	MUA08A	Tape/Reel	
	-	-	LM2936QM-3.3	8-Lead SOIC	M08A	Rail	
	-	-	LM2936QMX-3.3	8-Lead SOIC	M08A	Tape/Reel	
	-	-	LM2936QDT-3.3	TO-252	TD03B	Rail	
	-	-	LM2936QDTX-3.3	TO-252	TD03B	Tape/Reel	
5.00V	-	-	LM2936QMM-5.0	8-Lead Mini-SOIC	MUA08A	Rail	
	-	-	LM2936QMMX-5.0	8-Lead Mini-SOIC	MUA08A	Tape/Reel	
	-	-	LM2936QM-5.0	8-Lead SOIC	M08A	Rail	
	-	-	LM2936QMX-5.0	8-Lead SOIC	M08A	Tape/Reel	
	Yes	Yes	LM2936QHBMA-5.0	8-Lead SOIC	M08A	Rail	
	Yes	Yes	LM2936QHBMAX-5.0	8-Lead SOIC	M08A	Tape/Reel	
	-	-	LM2936QDT-5.0	TO-252	TD03B	Rail	
	-	-	LM2936QDTX-5.0	TO-252	TD03B	Tape/Reel	
	-	-	LM2936QMP-5.0	SOT-223	MP04A	Tape/Reel	
-	-	LM2936QMPX-5.0	SOT-223	MP04A	Tape/Reel		

\* Automotive grade (Q) product incorporates enhanced manufacturing and support processes for the automotive market, including defect detection methodologies. Reliability qualification is compliant with the requirements

and temperature grades defined in the AEC-Q100 standard. Automotive grade products are identified with the letter Q. For more information go to <http://www.national.com/automotive>.

## Absolute Maximum Ratings *(Note 1)*

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

Input Voltage (Survival)	+60V, -50V
ESD Susceptibility <i>(Note 2)</i>	2000V
Power Dissipation <i>(Note 3)</i>	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 Operating Input Voltage - LM2936Q	+40V
Maximum Operating Input Voltage - LM2936QH Only	+60V
Maximum Shutdown Pin Voltage - LM2936QH Only	0V to +40V
SO-8 (M08A) $\theta_{JA}$	140°C/W
SO-8 (M08A) $\theta_{JC}$	45°C/W
MSO-8 (MUA08A) $\theta_{JA}$	200°C/W
TO-252 (TD03B) $\theta_{JA}$	136°C/W
TO-252 (TD03B) $\theta_{JC}$	6°C/W
SOT-223 (MP04A) $\theta_{JA}$	149°C/W
SOT-223 (MP04A) $\theta_{JC}$	36°C/W

## Electrical Characteristics for LM2936Q-3.0

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

Parameter	Conditions	Min <i>(Note 5)</i>	Typical <i>(Note 4)</i>	Max <i>(Note 5)</i>	Units
<b>All LM2936Q-3.0</b>					
Output Voltage		2.940	3.000	3.060	V
	$4.0V \leq V_{IN} \leq 26V$ , $100\ \mu\text{A} \leq I_O \leq 50\text{ mA}$ <i>(Note 6)</i>	<b>2.910</b>	<b>3.000</b>	<b>3.090</b>	
Quiescent Current	$I_O = 100\ \mu\text{A}$ , $8V \leq V_{IN} \leq 24V$		15	20	$\mu\text{A}$
	$I_O = 10\text{ mA}$ , $8V \leq V_{IN} \leq 24V$		0.20	0.50	mA
	$I_O = 50\text{ mA}$ , $8V \leq V_{IN} \leq 24V$		1.5	2.5	mA
Line Regulation	$9V \leq V_{IN} \leq 16V$		5	10	mV
	$6V \leq V_{IN} \leq 40V$ , $I_O = 1\text{ mA}$		10	30	
Load Regulation	$100\ \mu\text{A} \leq I_O \leq 5\text{ mA}$		10	30	mV
	$5\text{ mA} \leq I_O \leq 50\text{ mA}$		10	30	
Dropout Voltage	$I_O = 100\ \mu\text{A}$		0.05	0.10	V
	$I_O = 50\text{ mA}$		0.20	0.40	V
Short Circuit Current	$V_O = 0V$	65	120	250	mA
Output Impedance	$I_O = 30\text{ mAdc}$ and $10\text{ mArms}$ , $f = 1000\text{ Hz}$		450		$\text{m}\Omega$
Output Noise Voltage	10 Hz–100 kHz		500		$\mu\text{V}$
Long Term Stability			20		mV/1000 Hr
Ripple Rejection	$V_{\text{ripple}} = 1V_{\text{rms}}$ , $f_{\text{ripple}} = 120\text{ Hz}$	-40	-60		dB
Reverse Polarity	$R_L = 500\Omega$ , $T = 1\text{ ms}$	-50	-80		V
Transient Input Voltage					
Output Voltage with Reverse Polarity Input	$V_{IN} = -15V$ , $R_L = 500\Omega$		0.00	-0.30	V
Maximum Line Transient	$R_L = 500\Omega$ , $V_O \leq 3.30V$ , $T = 40\text{ms}$	60			V
Output Bypass Capacitance ( $C_{OUT}$ ) ESR	$C_{OUT} = 22\mu\text{F}$ $0.1\text{mA} \leq I_{OUT} \leq 50\text{mA}$	0.3		8	$\Omega$

## Electrical Characteristics for LM2936Q–3.3

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

Parameter	Conditions	Min (Note 5)	Typical (Note 4)	Max (Note 5)	Units
<b>All LM2936Q–3.3</b>					
Output Voltage		3.234	3.300	3.366	V
	$4.0V \leq V_{IN} \leq 26V$ , $100\ \mu\text{A} \leq I_O \leq 50\text{ mA}$ (Note 6)	<b>3.201</b>	<b>3.300</b>	<b>3.399</b>	
Quiescent Current	$I_O = 100\ \mu\text{A}$ , $8V \leq V_{IN} \leq 24V$		15	20	$\mu\text{A}$
	$I_O = 10\text{ mA}$ , $8V \leq V_{IN} \leq 24V$		0.20	0.50	mA
	$I_O = 50\text{ mA}$ , $8V \leq V_{IN} \leq 24V$		1.5	2.5	mA
Line Regulation	$9V \leq V_{IN} \leq 16V$		5	10	mV
	$6V \leq V_{IN} \leq 40V$ , $I_O = 1\text{ mA}$		10	30	
Load Regulation	$100\ \mu\text{A} \leq I_O \leq 5\text{ mA}$		10	30	mV
	$5\text{ mA} \leq I_O \leq 50\text{ mA}$		10	30	
Dropout Voltage	$I_O = 100\ \mu\text{A}$		0.05	0.10	V
	$I_O = 50\text{ mA}$		0.20	0.40	V
Short Circuit Current	$V_O = 0V$	65	120	250	mA
Output Impedance	$I_O = 30\text{ mAdc}$ and $10\text{ mArms}$ , $f = 1000\text{ Hz}$		450		$\text{m}\Omega$
Output Noise Voltage	10 Hz–100 kHz		500		$\mu\text{V}$
Long Term Stability			20		mV/1000 Hr
Ripple Rejection	$V_{\text{ripple}} = 1V_{\text{rms}}$ , $f_{\text{ripple}} = 120\text{ Hz}$	-40	-60		dB
Reverse Polarity Transient Input Voltage	$R_L = 500\Omega$ , $T = 1\text{ ms}$	-50	-80		V
Output Voltage with Reverse Polarity Input	$V_{IN} = -15V$ , $R_L = 500\Omega$		0.00	-0.30	V
Maximum Line Transient	$R_L = 500\Omega$ , $V_O \leq 3.63V$ , $T = 40\text{ms}$	60			V
Output Bypass Capacitance ( $C_{OUT}$ ) ESR	$C_{OUT} = 22\mu\text{F}$ $0.1\text{ mA} \leq I_{OUT} \leq 50\text{ mA}$	0.3		8	$\Omega$

## Electrical Characteristics for LM2936Q–5.0

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

Parameter	Conditions	Min (Note 5)	Typical (Note 4)	Max (Note 5)	Units
<b>All LM2936QH–5.0 Only</b>					
Output Voltage	$5.5V \leq V_{IN} \leq 48V$ , $100\ \mu\text{A} \leq I_O \leq 50\text{ mA}$ (Note 6)	<b>4.85</b>	<b>5.00</b>	<b>5.15</b>	V
Line Regulation	$6V \leq V_{IN} \leq 60V$ , $I_O = 1\text{ mA}$		15	35	mV
<b>All LM2936Q–5.0</b>					
Output Voltage		4.90	5.00	5.10	V
	$5.5V \leq V_{IN} \leq 26V$ , $100\ \mu\text{A} \leq I_O \leq 50\text{ mA}$ (Note 6)	<b>4.85</b>	<b>5.00</b>	<b>5.15</b>	
Quiescent Current	$I_O = 100\ \mu\text{A}$ , $8V \leq V_{IN} \leq 24V$		9	15	$\mu\text{A}$
	$I_O = 10\text{ mA}$ , $8V \leq V_{IN} \leq 24V$		0.20	0.50	mA
	$I_O = 50\text{ mA}$ , $8V \leq V_{IN} \leq 24V$		1.5	2.5	mA

Parameter	Conditions	Min (Note 5)	Typical (Note 4)	Max (Note 5)	Units
Line Regulation	$9V \leq V_{IN} \leq 16V$		5	10	mV
	$6V \leq V_{IN} \leq 40V, I_O = 1 \text{ mA}$		10	30	
Load Regulation	$100 \mu\text{A} \leq I_O \leq 5 \text{ mA}$		10	30	mV
	$5 \text{ mA} \leq I_O \leq 50 \text{ mA}$		10	30	
Dropout Voltage	$I_O = 100 \mu\text{A}$		0.05	0.10	V
	$I_O = 50 \text{ mA}$		0.20	0.40	
Short Circuit Current	$V_O = 0V$	65	120	250	mA
Output Impedance	$I_O = 30 \text{ mAdc}$ and $10 \text{ mArms}$ , $f = 1000 \text{ Hz}$		450		m $\Omega$
Output Noise Voltage	10 Hz–100 kHz		500		$\mu\text{V}$
Long Term Stability			20		mV/1000 Hr
Ripple Rejection	$V_{\text{ripple}} = 1V_{\text{rms}}$ , $f_{\text{ripple}} = 120 \text{ Hz}$	-40	-60		dB
Reverse Polarity	$R_L = 500\Omega$ , $T = 1 \text{ ms}$	-50	-80		V
Transient Input Voltage					
Output Voltage with Reverse Polarity Input	$V_{IN} = -15V$ , $R_L = 500\Omega$		0.00	-0.30	V
Maximum Line Transient	$R_L = 500\Omega$ , $V_O \leq 5.5V$ , $T = 40\text{ms}$	60			V
Output Bypass Capacitance ( $C_{OUT}$ ) ESR	$C_{OUT} = 10\mu\text{F}$ $0.1\text{mA} \leq I_{OUT} \leq 50\text{mA}$	0.3		8	$\Omega$
<b>Shutdown Input LM2936QH-5.0</b>					
Output Voltage, $V_{OUT}$	Output Off, $V_{SD}=2.4V$ , $R_{LOAD}=500\Omega$		0	0.010	V
Shutdown High Threshold Voltage, $V_{IH}$	Output Off, $R_{LOAD}=500\Omega$	2.00	1.1		V
Shutdown Low Threshold Voltage, $V_{IL}$	Output On, $R_{LOAD}=500\Omega$		1.1	0.60	V
Shutdown High Current, $I_{IH}$	Output Off, $V_{SD}=2.4V$ , $R_{LOAD}=500\Omega$		12		$\mu\text{A}$
Quiescent Current	Output Off, $V_{SD}=2.4V$ , $R_{LOAD}=500\Omega$ Includes $I_{IH}$ Current		30		$\mu\text{A}$

**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 k $\Omega$  resistor.

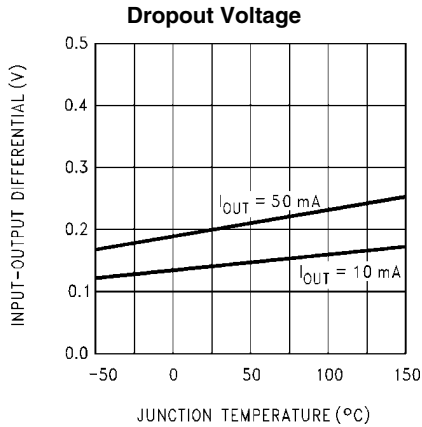
**Note 3:** The maximum power dissipation is a function of  $T_{Jmax}$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{Jmax} - T_A)/\theta_{JA}$ . If this dissipation is exceeded, the die temperature will rise above 150°C and the LM2936Q will go into thermal shutdown.

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

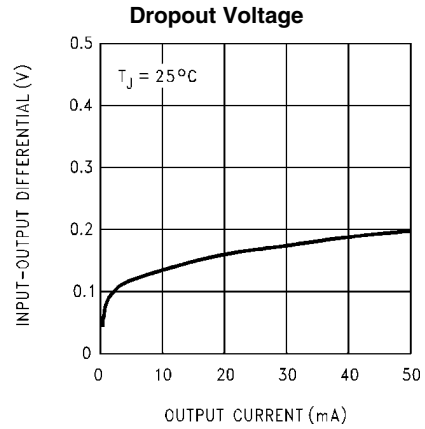
**Note 5:** Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

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

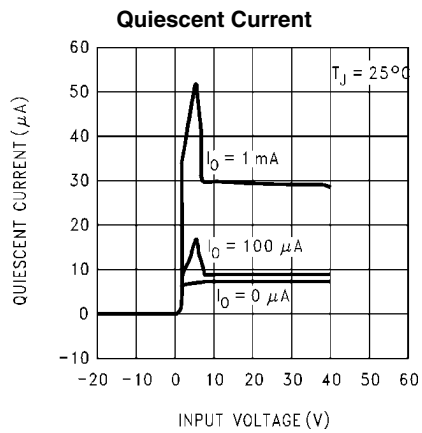
# Typical Performance Characteristics



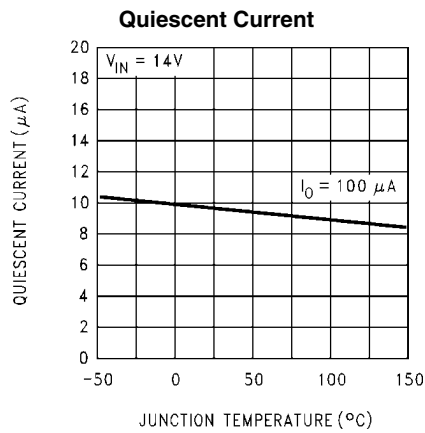
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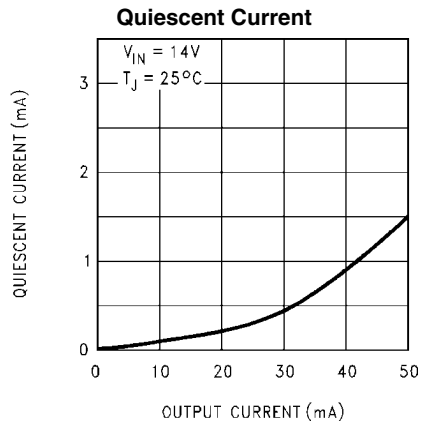
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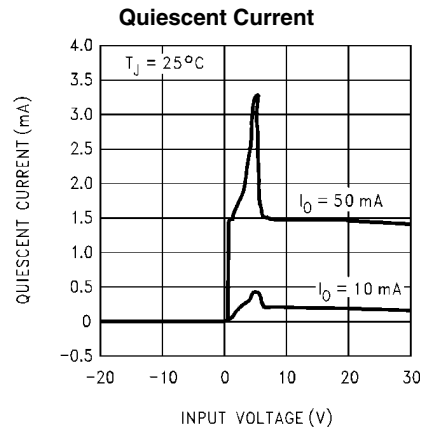
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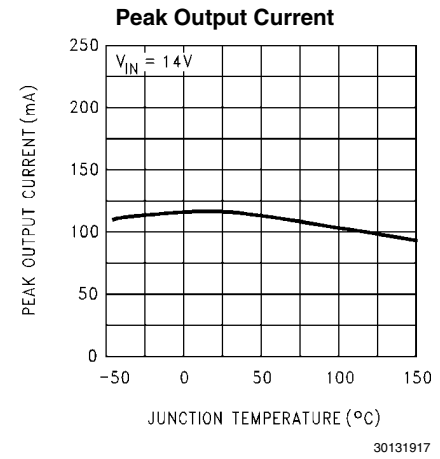
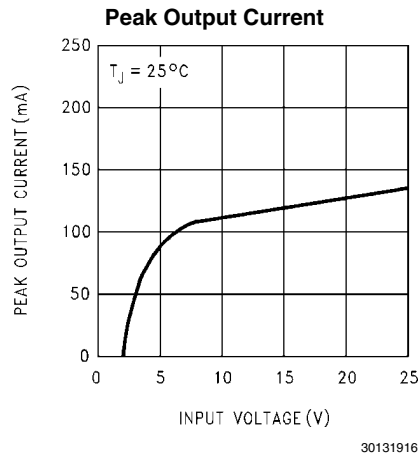
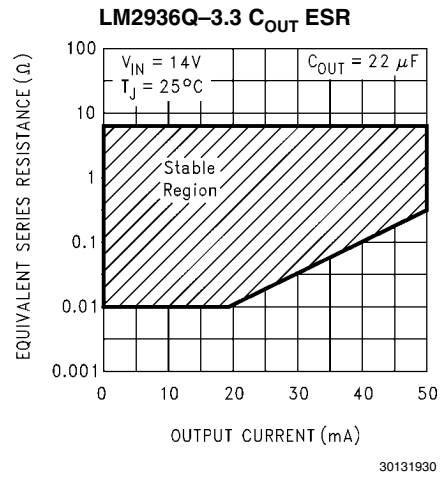
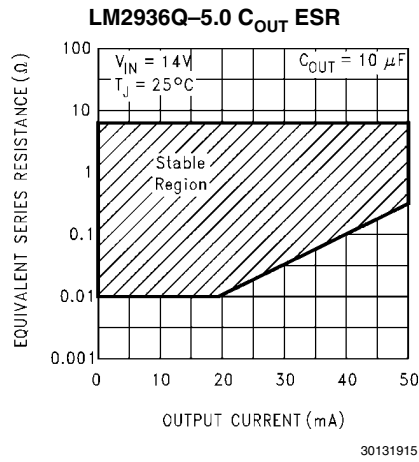
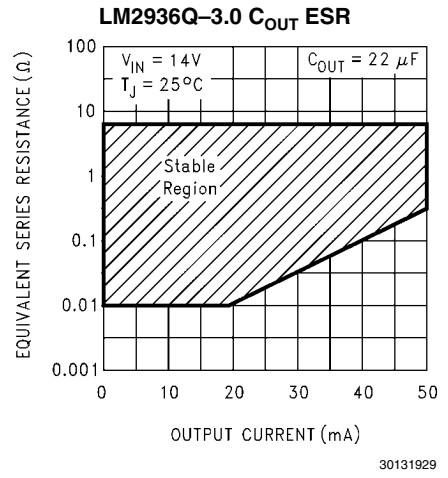
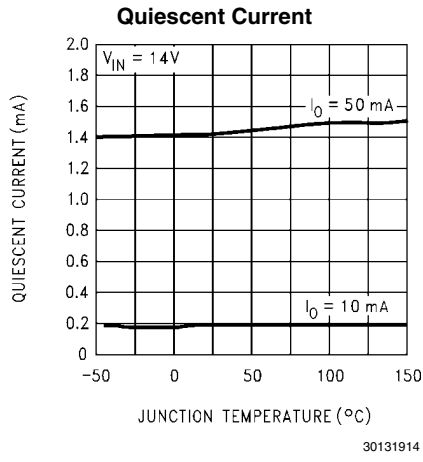
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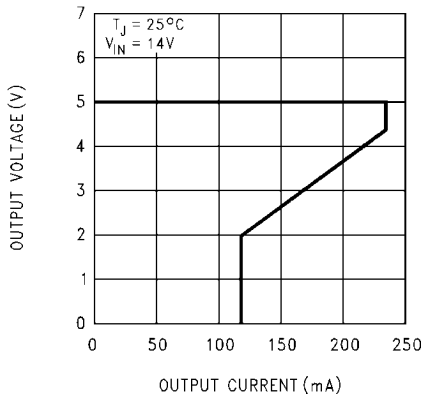


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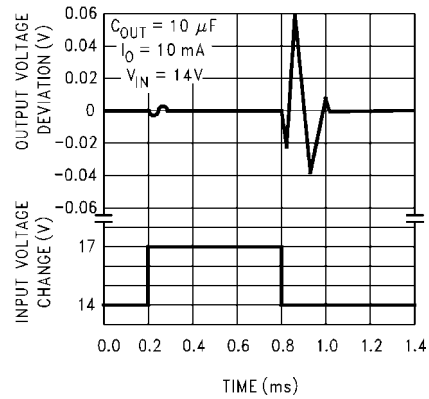


**LM2936Q-5.0 Current Limit**



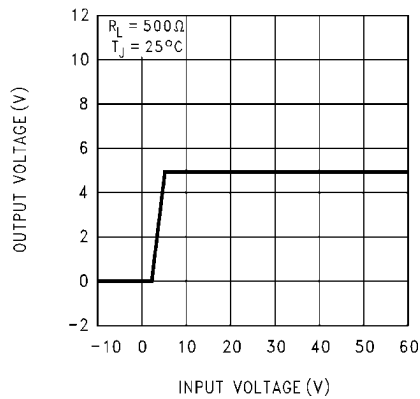
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**LM2936Q-5.0 Line Transient Response**



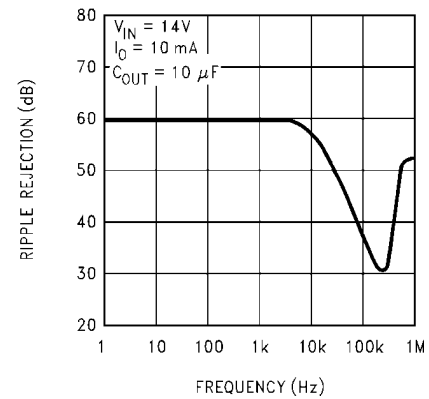
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**LM2936Q-5.0 Output at Voltage Extremes**



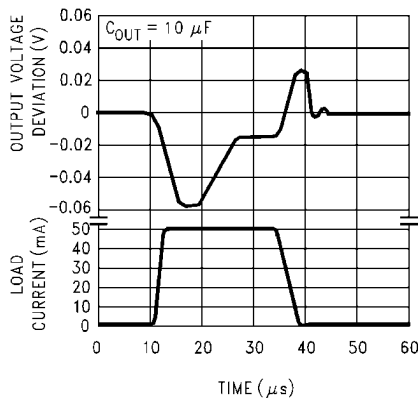
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**LM2936Q-5.0 Ripple Rejection**



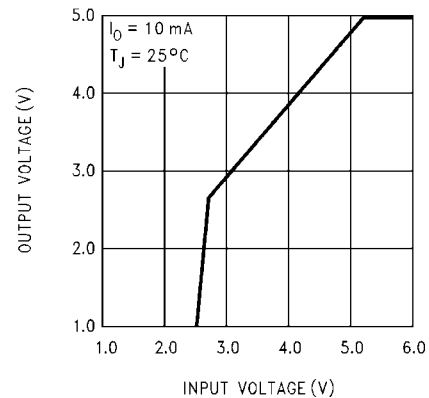
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**LM2936Q-5.0 Load Transient Response**



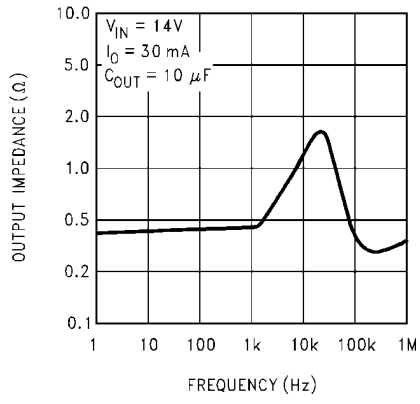
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**LM2936Q-5.0 Low Voltage Behavior**



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### LM2936Q-5.0 Output Impedance



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## Applications Information

Unlike other PNP low dropout regulators, the LM2936Q 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.

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

For the SO-8 and TO-252 surface mount packages the  $\theta_{JA}$  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  $\theta_{JA}$  rating to approximately 110°C/W. If this extra pad area 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  $\theta_{JA}$  rating to approximately 50°C/W.

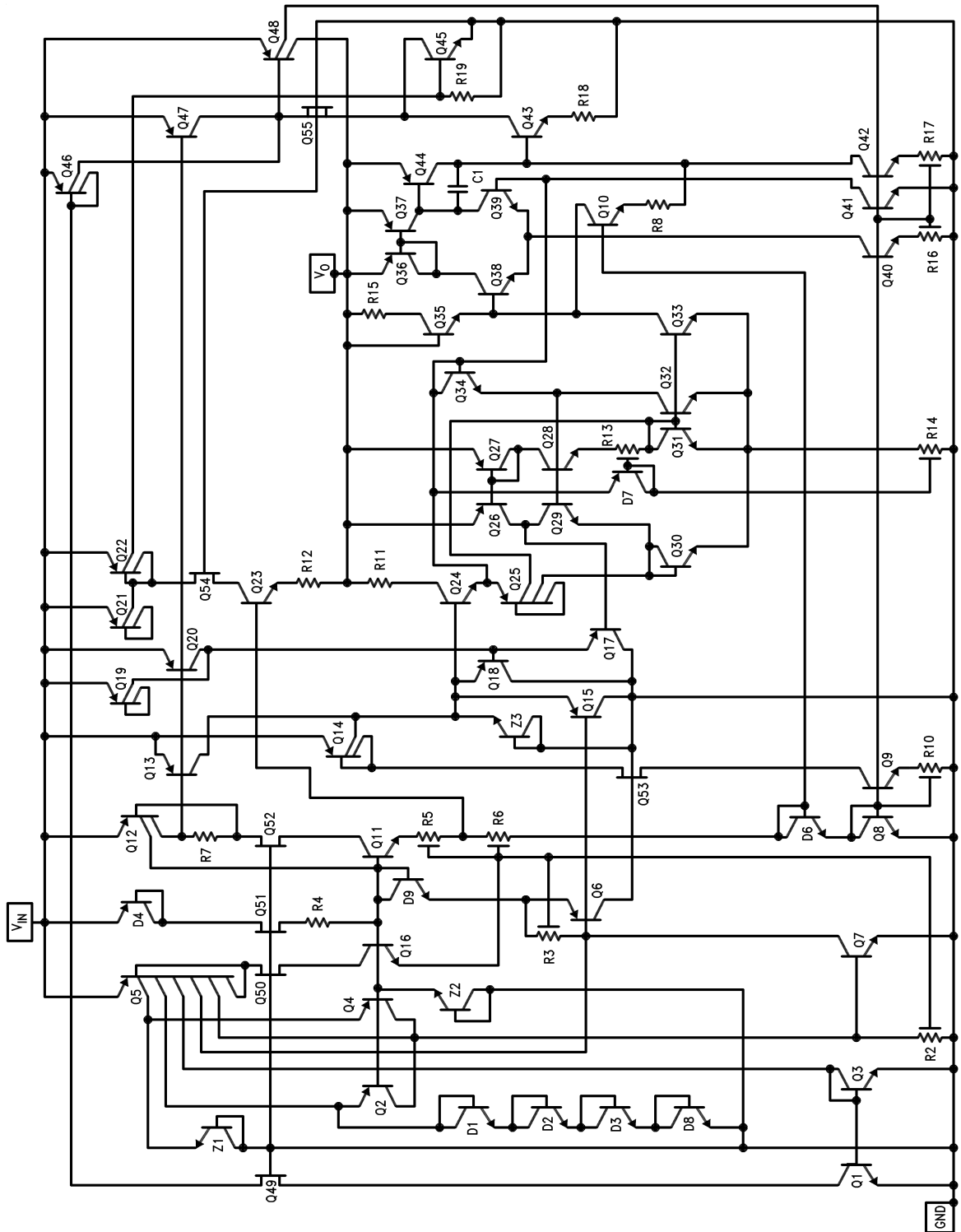
While the LM2936Q has an internally set thermal shutdown point of typically 160°C, this is intended as a safety feature only. Continuous operation near the thermal shutdown temperature should be avoided as it may have a negative affect on the life of the device.

While the LM2936Q 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 LM2936EP 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

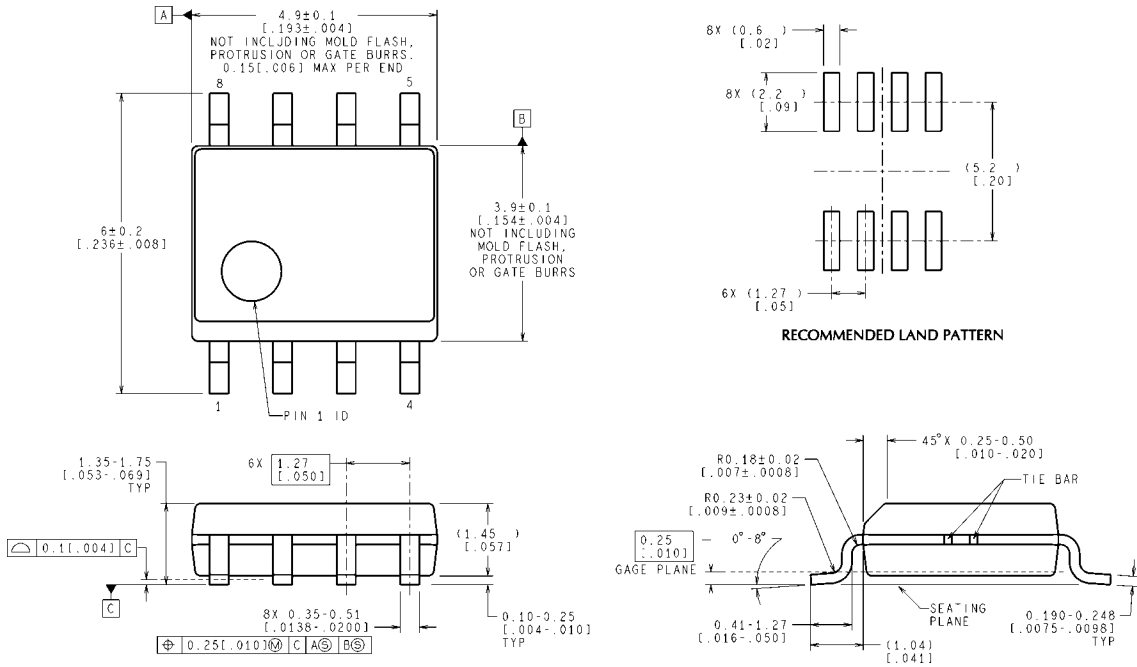
The LM2936QHBMA-5.0 has a pin for shutting down the regulator output. Applying a Logic Level High (>2.0V) to the Shutdown pin will cause the output to turn off. Leaving the Shutdown pin open, connecting it to Ground, or applying a Logic Level Low (<0.6V) will allow the regulator output to turn on.

# Equivalent Schematic Diagram



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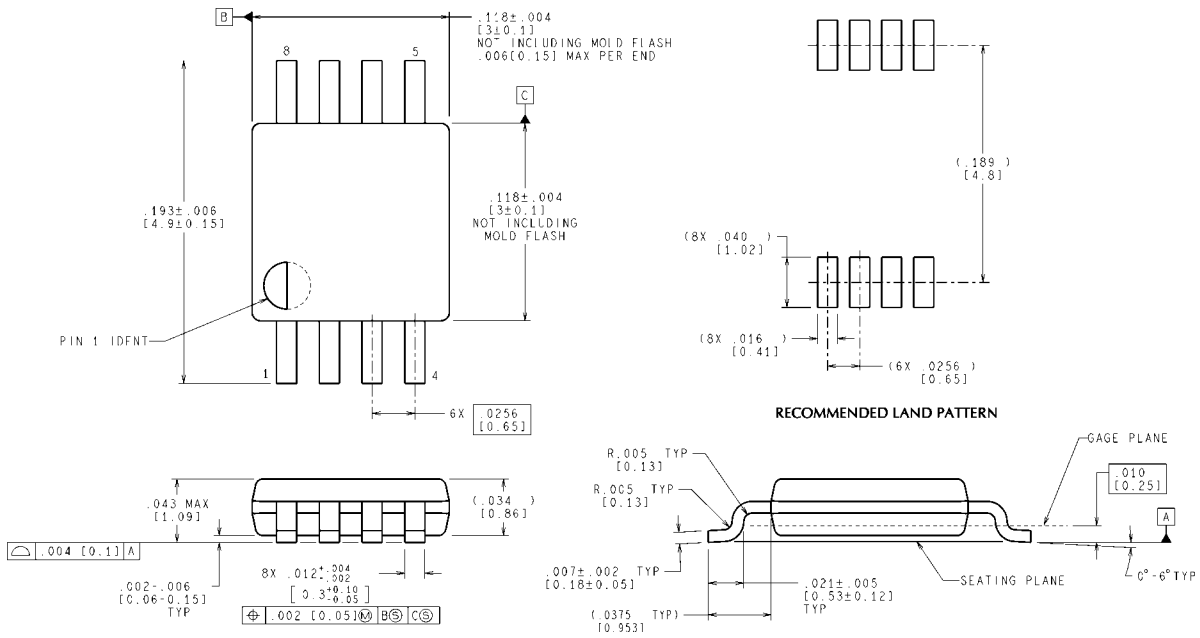
**Physical Dimensions** inches (millimeters) unless otherwise noted



CONTROLLING DIMENSION IS MILLIMETER  
VALUES IN [ ] ARE INCHES  
DIMENSIONS IN ( ) FOR REFERENCE ONLY

M08A (Rev M)

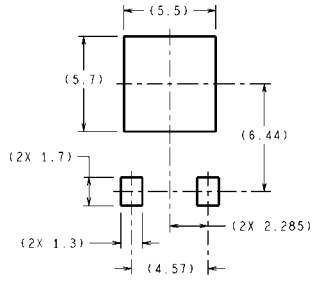
**8-Lead Small Outline Molded Package (M)**  
**NS Package Number M08A**



CONTROLLING DIMENSION IS INCH  
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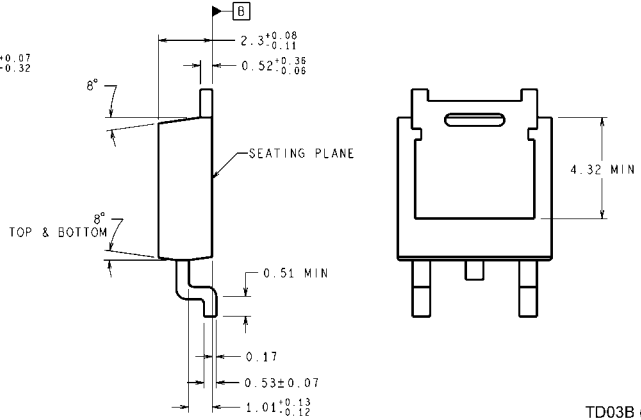
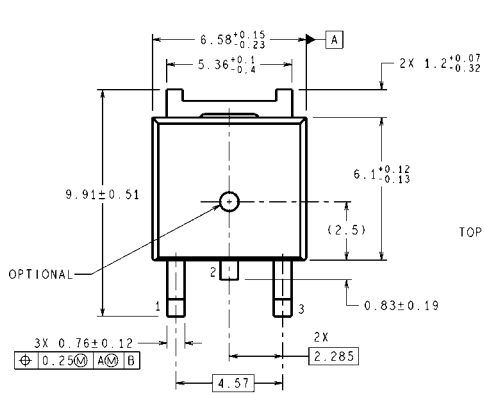
MUA08A (Rev F)

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



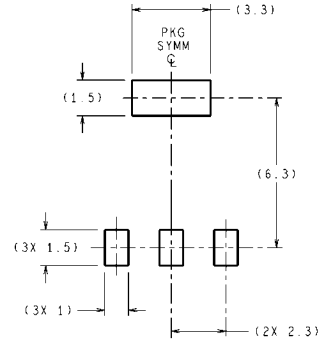
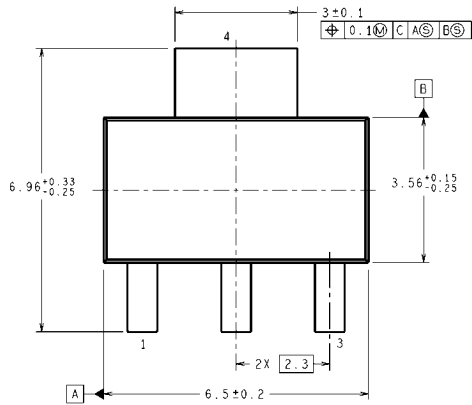
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DIMENSIONS IN ( ) FOR REFERENCE ONLY

LAND PATTERN RECOMMENDATION

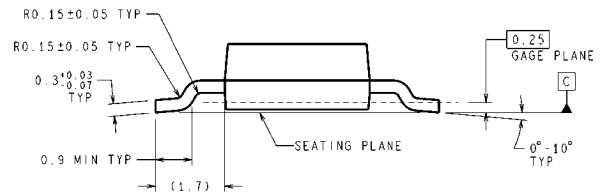
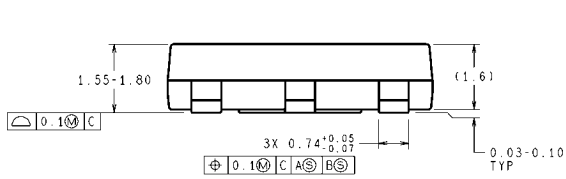


TD03B (Rev F)

TO-252 Package (DT)  
NS Package Number TD03B



LAND PATTERN RECOMMENDATION



DIMENSIONS ARE IN MILLIMETERS

MP04A (Rev B)

SOT-223 Package (MP)  
NS Package Number MP04A

# Notes

**Notes**



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