

## LM2936

# Ultra-Low Quiescent Current LDO Voltage Regulator

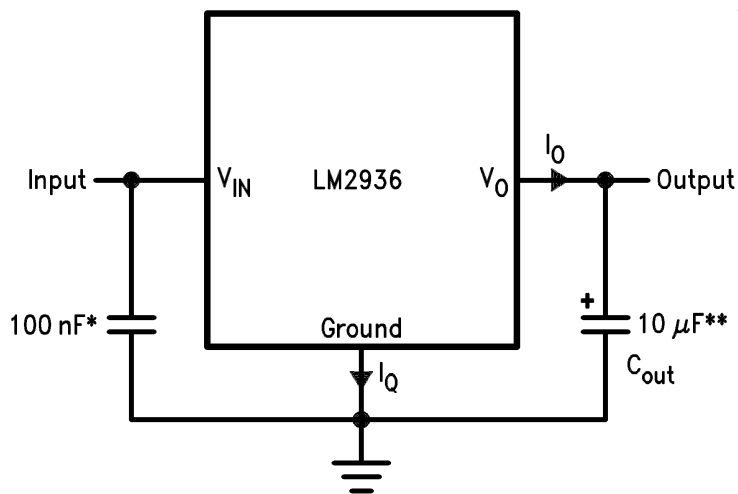
### General Description

The LM2936 ultra-low quiescent current regulator features low dropout voltage and low current in the standby mode. With less than 15  $\mu\text{A}$  quiescent current at a 100  $\mu\text{A}$  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 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 LM2936 is available in a TO-92 package, SO-8 and SOT-23 surface mount packages, and a TO-252 surface mount power package.

### Features

- 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 LM2936BM package

### Typical Application



00975901

\* 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.

## Ordering Information

Output Voltage	High Voltage	Shutdown Pin	Order	Package Type	Package Drawing	Transport Media
3.00V	-	Yes	LM2936BM-3.0	8-Lead SOIC	M08A	Rail
	-	Yes	LM2936BMX-3.0	8-Lead SOIC	M08A	Tape/Reel
	-	-	LM2936DT-3.0	TO-252	TD03B	Rail
	-	-	LM2936DTX-3.0	TO-252	TD03B	Tape/Reel
	Yes	Yes	LM2936HVBMA-3.0	8-Lead SOIC	M08A	Rail
	Yes	Yes	LM2936HVBMAX3.0	8-Lead SOIC	M08A	Tape/Reel
	-	-	LM2936M-3.0	8-Lead SOIC	M08A	Rail
	-	-	LM2936MX-3.0	8-Lead SOIC	M08A	Tape/Reel
	-	-	LM2936MP-3.0	SOT-223	MP04A	Tape/Reel
	-	-	LM2936MPX-3.0	SOT-223	MP04A	Tape/Reel
	-	-	LM2936MM-3.0	8-Lead Mini SOIC	MUA08A	Rail
	-	-	LM2936MMX-3.0	8-Lead Mini SOIC	MUA08A	Tape/Reel
-	-	LM2936Z-3.0	TO-92	Z03A	Box	
3.30V	-	Yes	LM2936BM-3.3	8-Lead SOIC	M08A	Rail
	-	Yes	LM2936BMX-3.3	8-Lead SOIC	M08A	Tape/Reel
	-	-	LM2936DT-3.3	TO-252	TD03B	Rail
	-	-	LM2936DTX-3.3	TO-252	TD03B	Tape/Reel
	Yes	Yes	LM2936HVBMA-3.3	8-Lead SOIC	M08A	Rail
	Yes	Yes	LM2936HVBMAX3.3	8-Lead SOIC	M08A	Tape/Reel
	-	-	LM2936M-3.3	8-Lead SOIC	M08A	Rail
	-	-	LM2936MX-3.3	8-Lead SOIC	M08A	Tape/Reel
	-	-	LM2936MP-3.3	SOT-223	MP04A	Tape/Reel
	-	-	LM2936MPX-3.3	SOT-223	MP04A	Tape/Reel
	-	-	LM2936MM-3.3	8-Lead Mini- SOIC	MUA08A	Rail
	-	-	LM2936MMX-3.3	8-Lead Mini- SOIC	MUA08A	Tape/Reel
-	-	LM2936Z-3.3	TO-92	Z03A	Box	
5.00V	-	Yes	LM2936BM-5.0	8-Lead SOIC	M08A	Rail
	-	Yes	LM2936BMX-5.0	8-Lead SOIC	M08A	Tape/Reel
	-	-	LM2936DT-5.0	TO-252	TD03B	Rail
	-	-	LM2936DTX-5.0	TO-252	TD03B	Tape/Reel
	Yes	Yes	LM2936HVBMA-5.0	8-Lead SOIC	M08A	Rail
	Yes	Yes	LM2936HVBMAX5.0	8-Lead SOIC	M08A	Tape/Reel
	Yes	-	LM2936HVMA-5.0	8-Lead SOIC	M08A	Rail
	Yes	-	LM2936HVMAX-5.0	8-Lead SOIC	M08A	Tape/Reel
	-	-	LM2936M-5.0	8-Lead SOIC	M08A	Rail
	-	-	LM2936MX-5.0	8-Lead SOIC	M08A	Tape/Reel
	-	-	LM2936MP-5.0	SOT-223	MP04A	Tape/Reel
	-	-	LM2936MPX-5.0	SOT-223	MP04A	Tape/Reel
	-	-	LM2936MM-5.0	8-Lead Mini-SOIC	MUA08A	Rail
	-	-	LM2936MMX-5.0	8-Lead Mini-SOIC	MUA08A	Tape/Reel
-	-	LM2936Z-5.0	TO-92	Z03A	Box	

**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

**Operating Ratings**

Operating Temperature Range	-40°C to +125°C
Maximum Operating Input Voltage - LM2936	+40V
Maximum Operating Input Voltage - LM2936HV only	+60V
Maximum Shutdown Pin Voltage - LM2936BM only	0V to 40V
TO-92 (Z03A) $\theta_{JA}$	195°C/W
MSO-8 (MUA08A) $\theta_{JA}$	200°C/W
SO-8 (M08A) $\theta_{JA}$	140°C/W
SO-8 (M08A) $\theta_{JC}$	45°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 LM2936-3.0**

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

Parameter	Conditions	Min (Note 5)	Typical (Note 4)	Max (Note 5)	Units
<b>LM2936HV-3.0 Only</b>					
Output Voltage	$5.5V \leq V_{IN} \leq 48V$ , $100\ \mu A \leq I_O \leq 50\text{ mA}$ (Note 6)	<b>2.910</b>	<b>3.000</b>	<b>3.090</b>	V
Line Regulation	$6V \leq V_{IN} \leq 60V$ , $I_O = 1\text{ mA}$		10	30	mV
<b>All LM2936-3.0</b>					
Output Voltage	$4.0V \leq V_{IN} \leq 26V$ , $100\ \mu A \leq I_O \leq 50\text{ mA}$ (Note 6)	2.940	3.000	3.060	V
Quiescent Current	$I_O = 100\ \mu A$ , $8V \leq V_{IN} \leq 24V$		15	20	$\mu A$
	$I_O = 10\text{ mA}$ , $8V \leq V_{IN} \leq 24V$		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	mV
Load Regulation	$100\ \mu A \leq I_O \leq 5\text{ mA}$		10	30	mV
	$5\text{ mA} \leq I_O \leq 50\text{ mA}$		10	30	mV
Dropout Voltage	$I_O = 100\ \mu A$		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		$m\Omega$
Output Noise Voltage	10 Hz–100 kHz		500		$\mu V$
Long Term Stability			20		mV/1000 Hr
Ripple Rejection	$V_{ripple} = 1V_{rms}$ , $f_{ripple} = 120\text{ Hz}$	-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

**Electrical Characteristics for LM2936–3.3** (Continued) $V_{IN} = 14V$ ,  $I_O = 10\text{ mA}$ ,  $T_J = 25^\circ\text{C}$ , unless otherwise specified. **Boldface** limits apply over entire operating temperature range

Parameter	Conditions	Min (Note 5)	Typical (Note 4)	Max (Note 5)	Units
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	$\Omega$
<b>Shutdown Input – LM2936BM–3.3 Only</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		$\mu\text{A}$

**Electrical Characteristics for LM2936–5.0** $V_{IN} = 14V$ ,  $I_O = 10\text{ mA}$ ,  $T_J = 25^\circ\text{C}$ , unless otherwise specified. **Boldface** limits apply over entire operating temperature range

Parameter	Conditions	Min (Note 5)	Typical (Note 4)	Max (Note 5)	Units
<b>LM2936HV–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 LM2936–5.0</b>					
Output Voltage	$5.5V \leq V_{IN} \leq 26V$ , $100\mu\text{A} \leq I_O \leq 50\text{ mA}$ (Note 6)	<b>4.85</b>	<b>5.00</b>	<b>5.10</b>	V
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
Line Regulation	$9V \leq V_{IN} \leq 16V$		5	10	mV
	$6V \leq V_{IN} \leq 40V$ , $I_O = 1\text{ mA}$		10	30	mV
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	mV
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	$R_L = 500\Omega$ , $V_O \leq 5.5V$ , $T = 40\text{ms}$	60			V

## Electrical Characteristics for LM2936–5.0 (Continued)

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

Parameter	Conditions	Min (Note 5)	Typical (Note 4)	Max (Note 5)	Units
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 – LM2936BM–5.0 Only</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.

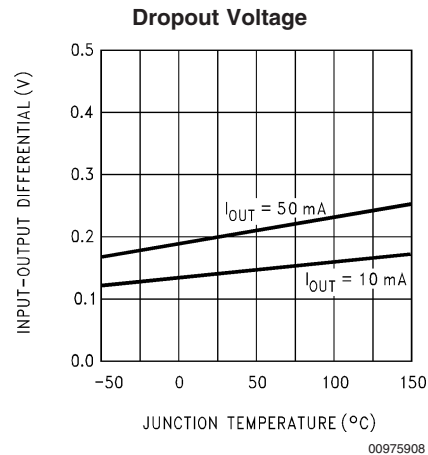
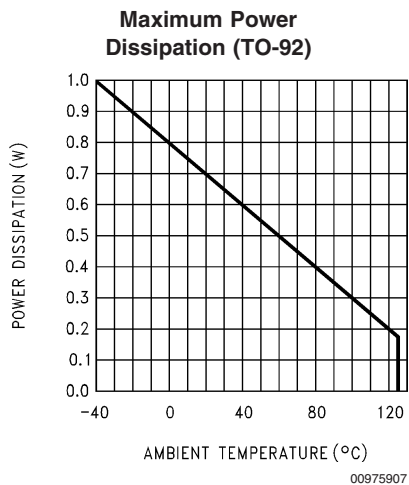
**Note 3:** The maximum power dissipation is a function of  $T_{Jmax}$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{Jmax} - T_A)/\theta_{JA}$ . If this dissipation is exceeded, the die temperature will rise above 150°C and the LM2936 will go into thermal shutdown.

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

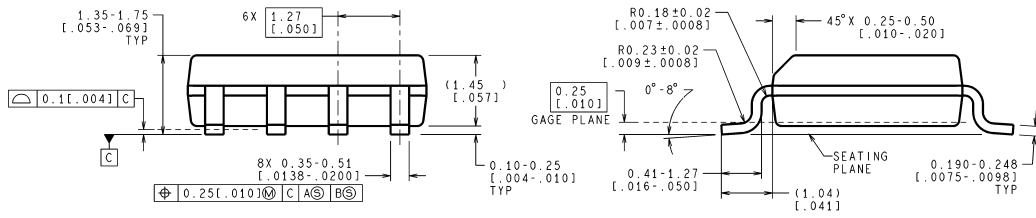
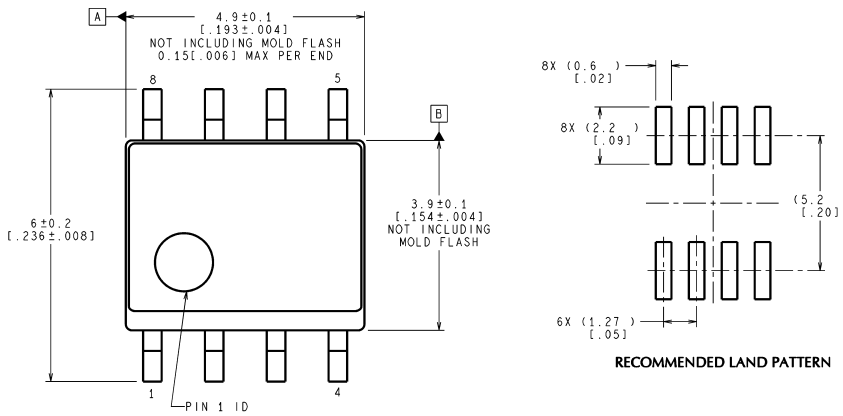
**Note 5:** Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

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

## Typical Performance Characteristics



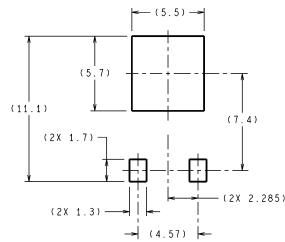
**Physical Dimensions** inches (millimeters) unless otherwise noted



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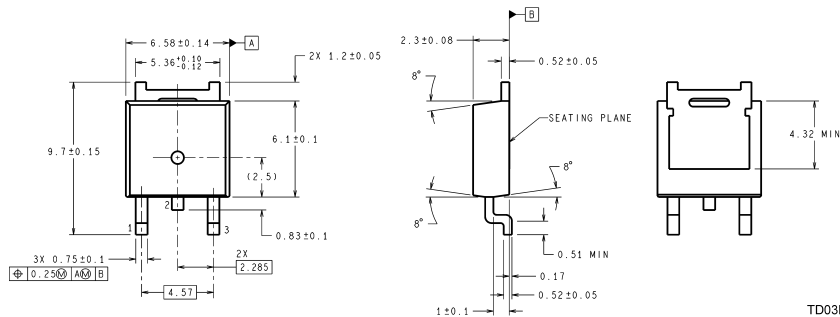
M08A (Rev L)

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



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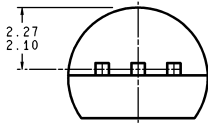
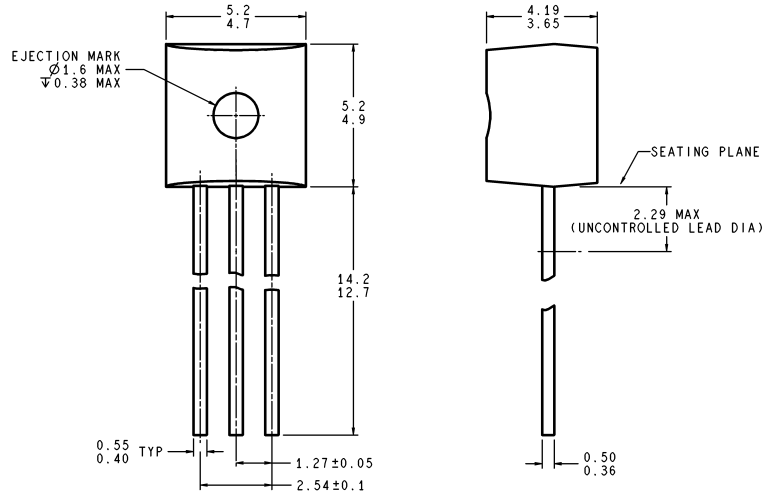
LAND PATTERN RECOMMENDATION



TD03B (Rev C)

**TO-252 Package (DT)  
 NS Package Number TD03B**

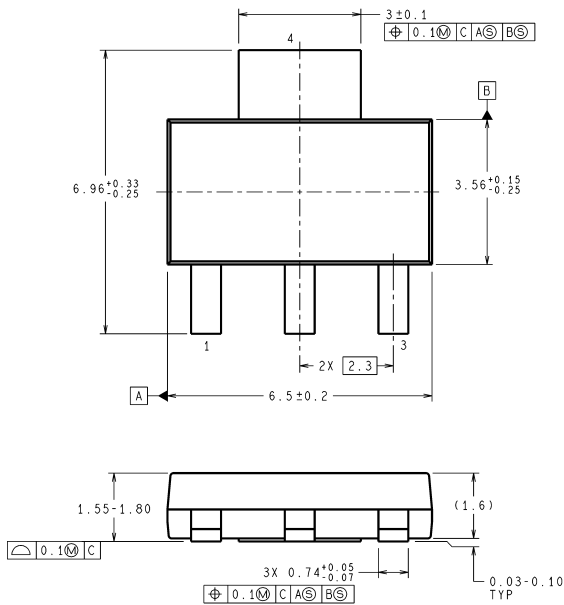
**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)



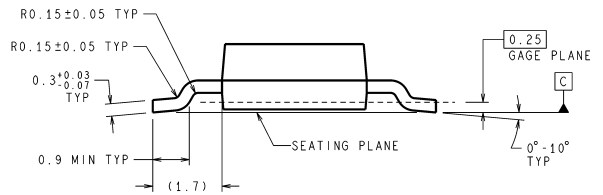
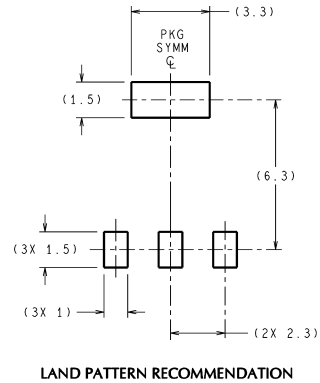
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Z03A (Rev 6)

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



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MP04A (Rev B)

**SOT-223 Package (MP)  
NS Package Number MP04A**