

December 1999

## LMV111 Operational Amplifier with Bias Network

### General Description

The LMV111 integrates a rail-to-rail op amp with a  $V^+/2$  bias circuit into one ultra tiny package, SC70-5 or SOT23-5. The core op amp of the LMV111 is an LMV321, which provides rail-to-rail output swing, excellent speed-power ratio, 1MHz bandwidth, and  $1V/\mu s$  of slew rate with low supply current.

The LMV111 reduces external component count. It is a cost effective solution for applications where low voltage operation, low power consumption, space saving, and reliable performance are needed. It enables the design of small portable electronic devices, and allows the designer to place the device closer to the signal source to reduce noise pickup and increase signal integrity.

### Features

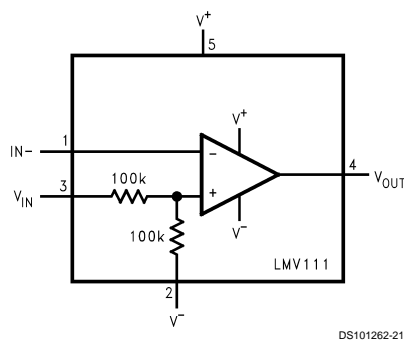
(For 5V Supply, Typical Unless Otherwise Noted)

- Resistor ratio matching 1% (typ)
- Space saving package SC70-5 & SOT23-5
- Industrial temp. range  $-40^{\circ}C$  to  $+85^{\circ}C$
- Low supply current 130 $\mu A$
- Gain-bandwidth product 1MHz
- Rail-to-Rail output swing
- Guaranteed 2.7V and 5V performance

### Applications

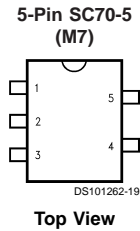
- General purpose portable devices
- Active filters
- Mobile communications
- Battery powered electronics
- Microphone preamplifiers

### Connection Diagrams

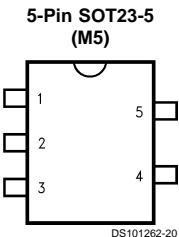


LMV111 Operational Amplifier with Bias Network

Connection Diagrams (Continued)



Top View



Top View

Ordering Information

Package	Part Number	Marking	Transport Media	NSC Drawing
SC70-5	LMV111M7	A42	1k Units Tape and Reel	MAA05A
	LMV111M7X		3k Units Tape and Reel	
SOT23-5	LMV111M5	A37A	1k Units Tape and Reel	MA05B
	LMV111M5X		3k Units Tape and Reel	

**Absolute Maximum Ratings** (Note 1)

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

## ESD Tolerance (Note 2)

Machine Model	200V
Human Body Model	1500V
Supply Voltage ( $V^+ - V^-$ )	5.5V
Output Short Circuit to $V^+$	(Note 3)
Output Short Circuit to $V^-$	(Note 4)
Storage Temp. Range	-65°C to 150°C

Junction Temp. ( $T_J$  max) (Note 5) 150°C

Mounting Temperature

Infrared or Convection (20 sec) 235°C

**Operating Ratings** (Note 1)

Supply Voltage	2.7V to 5.0V
Temperature Range	-40°C ≤ $T_J$ ≤ 85°C
Thermal Resistance ( $\theta_{JA}$ )	
5-pin SC70-5	478°C/W
5-pin SOT23-5	265°C/W

**2.7V Electrical Characteristics**

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ ,  $V^+ = 2.7\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_O = V^+/2$  and  $R_L > 1\text{ M}\Omega$ . **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Typ (Note 6)	Limit (Note 7)	Units
$V_O$	Output Swing	$R_L = 10\text{k}\Omega$ to 1.35V	$V^+ - 0.01$	$V^+ - 0.1$	V min
			0.06	0.18	V max
$I_S$	Supply Current		80	170	$\mu\text{A}$ max
	Resistor Ratio Matching		1		%
GBWP	Gain-Bandwidth Product	$C_L = 200\text{pF}$	1		MHz
$\Phi_m$	Phase Margin		60		Deg
$G_m$	Gain Margin		10		dB

**5V Electrical Characteristics**

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ ,  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_O = V^+/2$  and  $R_L > 1\text{ M}\Omega$ . **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Typ (Note 6)	Limit (Note 7)	Units
$V_O$	Output Swing	$R_L = 2\text{k}\Omega$ to 2.5V	$V^+ - 0.04$	$V^+ - 0.3$ <b><math>V^+ - 0.4</math></b>	V min
			0.12	0.3 <b>0.4</b>	V max
		$R_L = 10\text{k}\Omega$ to 2.5V	$V^+ - 0.01$	$V^+ - 0.1$ <b><math>V^+ - 0.2</math></b>	V min
			0.065	0.18 <b>0.28</b>	V max
$I_O$	Output Current	Sourcing, $V_O = 0\text{V}$	60	5	mA min
		Sinking, $V_O = 5\text{V}$	160	10	mA min
$I_S$	Supply Current		130	250 <b>350</b>	$\mu\text{A}$ max
	Resistor Ratio Matching		1		%
GBWP	Gain-Bandwidth Product	$C_L = 200\text{pF}$	1		MHz
$\phi_m$	Phase Margin		60		Deg
$G_m$	Gain Margin		10		dB
SR	Slew Rate	(Note 8)	1		V/ $\mu\text{s}$

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.

**Note 2:** Human body model, 1.5k $\Omega$  in series with 100pF. Machine model, 0 $\Omega$  in series with 100pF.

## 5V Electrical Characteristics (Continued)

**Note 3:** Shorting circuit output to  $V^+$  will adversely affect reliability.

**Note 4:** Shorting circuit output to  $V^-$  will adversely affect reliability.

**Note 5:** The maximum power dissipation is a function of  $T_{J(max)}$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{J(max)} - T_A)/\theta_{JA}$ . All numbers apply for packages soldered directly into a PC board.

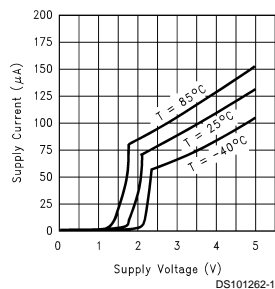
**Note 6:** Typical values represent the most likely parametric norm.

**Note 7:** All limits are guaranteed by testing or statistical analysis.

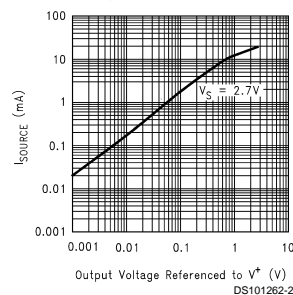
**Note 8:** Connected as voltage follower with 3V step input. Number specified is the slower of the positive and negative slew rates.

## Typical Performance Characteristics (Unless otherwise specified, $V_S = +5V$ , single supply, $T_A = 25^\circ C$ .)

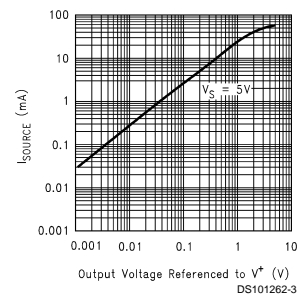
**Supply Current vs. Supply Voltage**



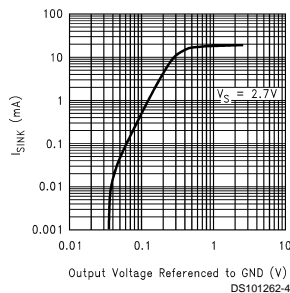
**Sourcing Current vs. Output Voltage**



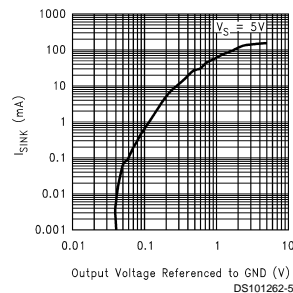
**Sourcing Current vs. Output Voltage**



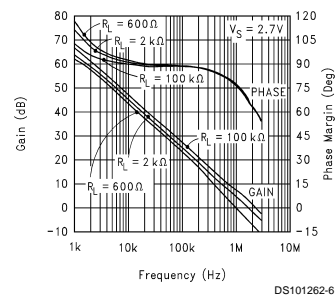
**Sinking Current vs. Output Voltage**



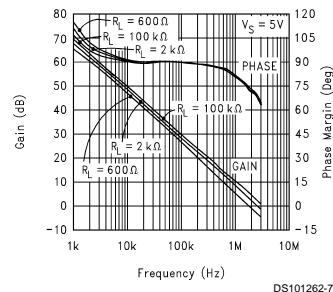
**Sinking Current vs. Output Voltage**



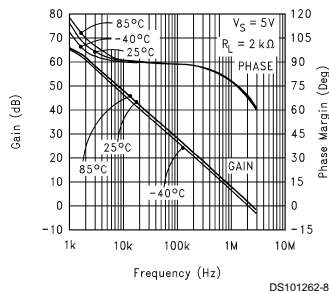
**Open Loop Frequency vs. Response**



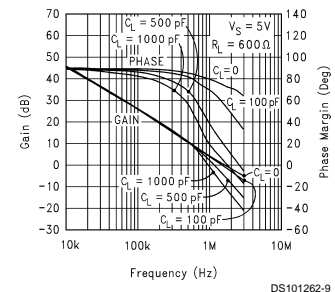
**Open Loop Frequency vs. Response**



**Open Loop Frequency Response vs. Temperature**



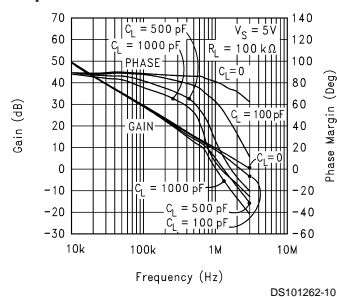
**Gain and Phase vs. Capacitive Load**



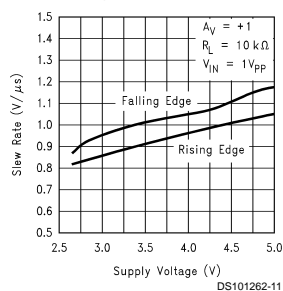
## Typical Performance Characteristics

(Unless otherwise specified,  $V_S = +5V$ , single supply,  $T_A = 25^\circ C$ .) (Continued)

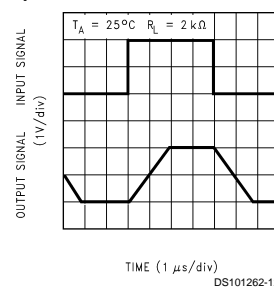
### Gain and Phase vs. Capacitive Load



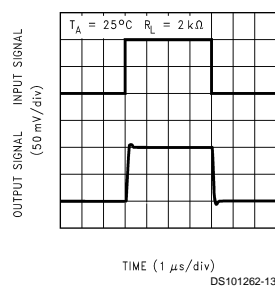
### Slew Rate vs. Supply Voltage



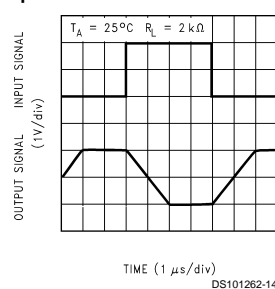
### Non-Inverting Large Signal Pulse Response



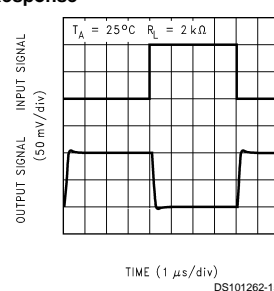
### Non-Inverting Small Signal Pulse Response



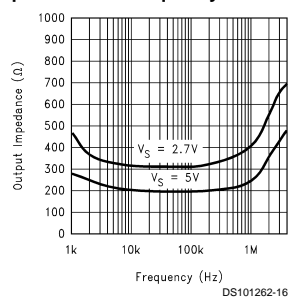
### Inverting Large Signal Pulse Response



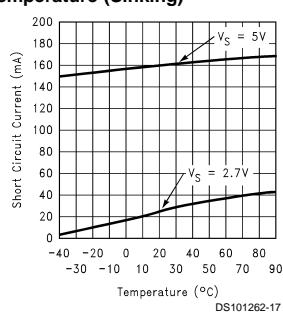
### Inverting Small Signal Pulse Response



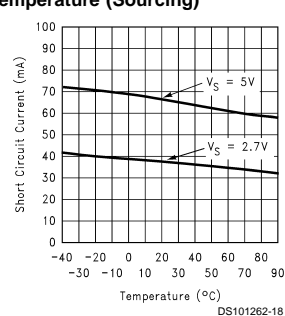
### Open Loop Output Impedance vs. Frequency



### Short Circuit Current vs. Temperature (Sinking)



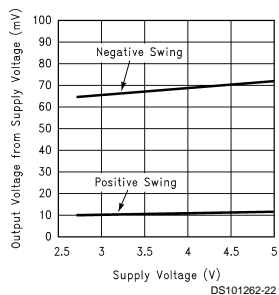
### Short Circuit Current vs. Temperature (Sourcing)



## Typical Performance Characteristics

(Unless otherwise specified,  $V_S = +5V$ , single supply,  $T_A = 25^\circ C$ .) (Continued)

### Output Voltage Swing vs. Supply Voltage



## Application Section

The LMV111 integrates a rail-to-rail op amp and a  $V^+/2$  bias circuit into one ultra tiny package. With its small footprint and reduced component count for bias network, it enables the design of smaller portable electronic products, such as cellular phones, pagers, PDAs, PCMCIA cards, etc. In addition, the integration solution minimizes printed circuit board stray capacitance, and reduces the complexity of circuit design.

The core op amp of this family is National's LMV321.

### 1.0 Supply Bypassing

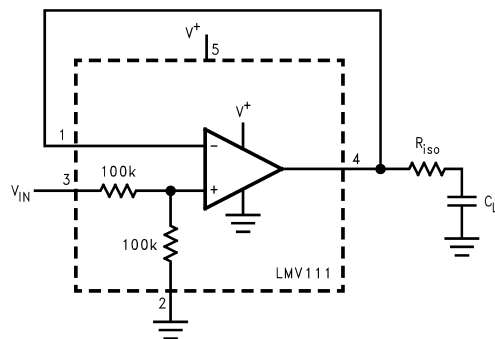
The application circuits in this datasheet do not show the power supply connections and the associated bypass capacitors for simplification. When the circuits are built, it is always required to have bypass capacitors. Ceramic disc capacitors (0.1 $\mu F$ ) or solid tantalum (1 $\mu F$ ) with short leads, and located close to the IC are usually necessary to prevent interstage coupling through the power supply internal impedance. Inadequate bypassing will manifest itself by a low frequency oscillation or by high frequency instabilities. Sometimes, a 10 $\mu F$  (or larger) capacitor is used to absorb low frequency variations and a smaller 0.1 $\mu F$  disc is paralleled across it to prevent any high frequency feedback through the power supply lines.

### 2.0 Input Voltage Range

The input voltage should be within the supply rails. The ESD protection circuitry at the input of the device includes a diode between the input pin and the negative supply pin. Driving the input more than 0.6V (at  $25^\circ C$ ) beyond the negative supply will turn on the diode and cause signal distortions.

### 3.0 Capacitive Load Tolerance

The LMV111 can directly drive 200pF capacitive load with unity gain without oscillation. The unity-gain follower is the most sensitive configuration to capacitive loading. Direct capacitive loading reduces the phase margin of amplifiers. The combination of the amplifier's output impedance and the capacitive load induces phase lag. This results in either an underdamped pulse or oscillation. To drive a heavier capacitive load, a resistive isolation can be used as shown in Figure 1.



**FIGURE 1. Resistive Isolation of a Heavy Capacitive Load**

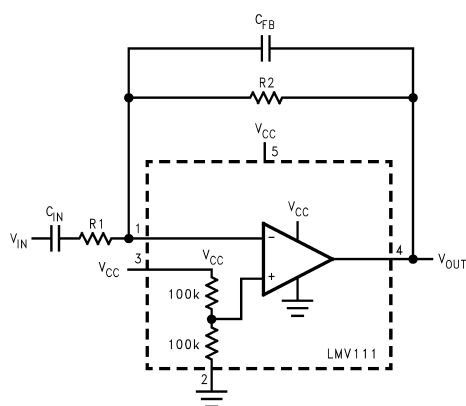
The isolation resistor  $R_{iso}$  and the  $C_L$  form a pole to increase stability by adding more phase margin to the overall system. The desired performance depends on the value of  $R_{iso}$ . A 50 $\Omega$  to 100 $\Omega$  isolation resistor is recommended for initial evaluation. The bigger the  $R_{iso}$  resistor value, the more stable  $V_{OUT}$  will be.

## Application Section (Continued)

### 4.0 Phase Inverting AC Amplifier

A single supply phase inverting AC amplifier is shown in Figure 2. The output voltage is biased at mid-supply, and AC input signal is amplified by  $(R_2/R_1)$ . Capacitor  $C_{IN}$  acts as an input AC coupling capacitor to block DC potentials. A capacitor of 0.1  $\mu$ F or larger can be used. The output of the LMV111 can swing rail-to-rail. To avoid output distortion, the peak-to-peak amplitude of the input AC signal should be less than  $V_{CC}(R_1/R_2)$ .

It is recommended that a small-valued capacitor is used across the feedback resistor  $R_2$  to eliminate stability problems, prevent peaking of the response, and limit the bandwidth of the circuit. This can also help to reduce high frequency noise and some other interference.

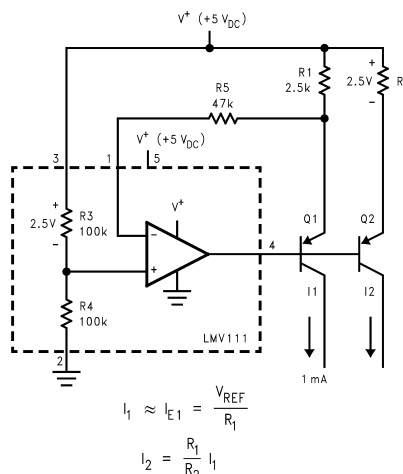


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FIGURE 2. Phase Inverting AC Amplifier

### 5.0 Fixed Current Source

A multiple fixed current source is shown in Figure 3. A reference voltage ( $V_{REF} = 2.5V$ ) is established across resistor  $R_3$  by the voltage divider ( $R_3$  and  $R_4$ ). Negative feedback is used to cause the voltage drop across  $R_1$  to be equal to  $V_{REF}$ . This controls the emitter current of transistor Q1 and if we neglect the base current of Q1 and Q2, essentially this same current is available out of the collector of Q1. A Darlington connection can be used to reduce errors due to the bias current of Q1.

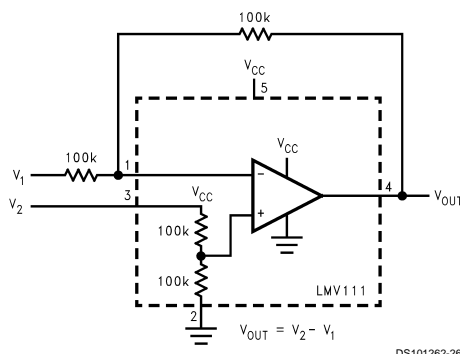


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FIGURE 3. Fixed Current Source

### 6.0 Difference Amplifier

The difference amplifier allows the subtraction of two voltages or, as a special case, the cancellation of a signal common to two inputs. It is useful as a computational amplifier, in making a differential to single-ended conversion or in rejecting a common mode signal.

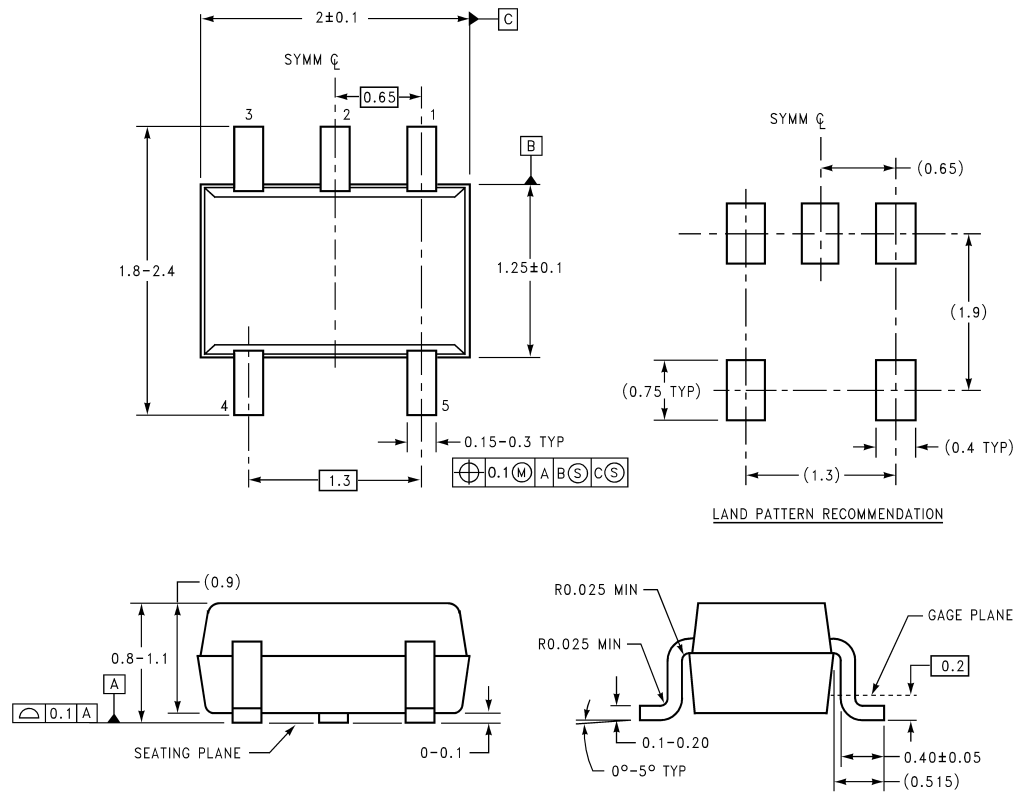


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FIGURE 4. Difference Amplifier

# Physical Dimensions

inches (millimeters) unless otherwise noted



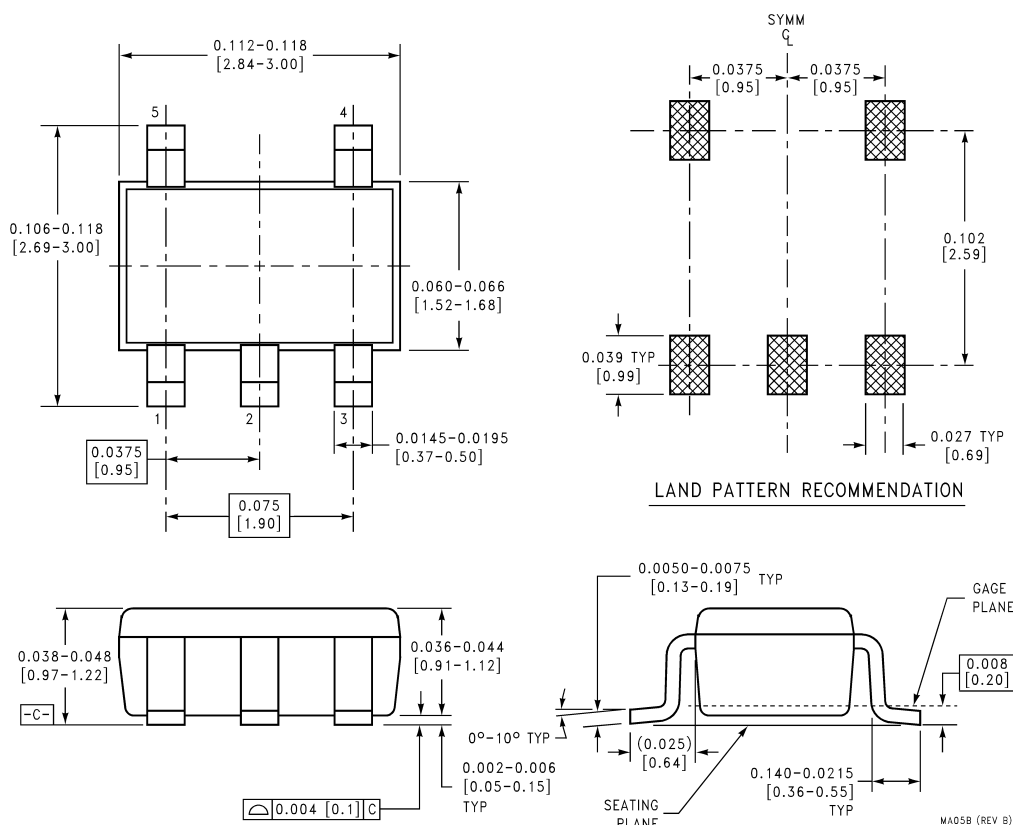
DIMENSIONS ARE IN MILLIMETERS

MAA05A (REV B)

**5-Pin SC70-5 Tape and Reel**  
**Order Numbers LMV111M7 and LMV111M7X**  
**NS Package Number MAA05A**



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



5-Pin SOT23-5 Tape and Reel  
Order Numbers LMV111M5 and LMV111M5X  
NS Package Number MA05B

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