National Semiconductor

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/µs 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

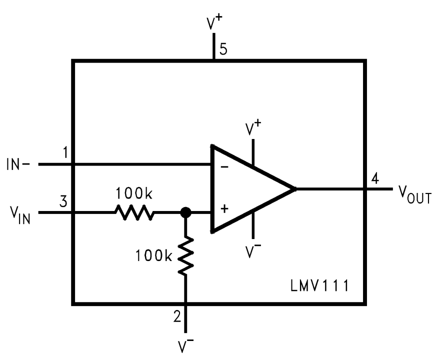
(For 5V Supply, Typical Unless Otherwise Noted)

- Resistor ratio matching 1% (typ)
- Space saving package SC70-5 & SOT23-5
- Industrial temp. range −40˚C to +85˚C
- Low supply current 130µA
- 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 Diagram



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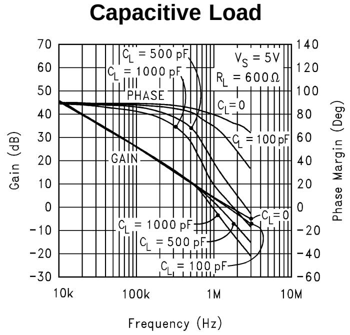
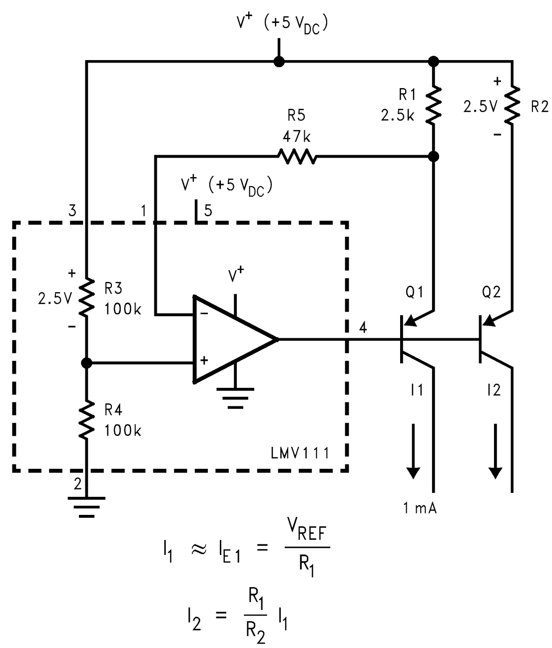
Gain and Phase vs. Capacitive Load



DS101262-9

Fixed Current Source



$$I_1 \approx I_{E1} = \frac{V_{REF}}{R_1}$$

$$I_2 = \frac{R_1}{R_2} I_1$$

DS101262-25

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	$-40˚C \le T_J \le 85˚C$
Thermal Resistance (θ_{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˚C, V^+ = 2.7V, V^- = 0V, V_O = $V^+/2$ and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Typ (Note 6)	Limit (Note 7)	Units
V_O	Output Swing	R_L = 10kΩ to 1.35V	V^+ −0.01	V^+ −0.1	V min
			0.06	0.18	V max
I_S	Supply Current		80	170	µA max
	Resistor Ratio Matching		1		%
GBWP	Gain-Bandwidth Product	C_L = 200pF	1		MHz
Φ_m	Phase Margin		60		Deg
G_m	Gain Margin		10		dB

5V Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25˚C, V^+ = 5V, V^- = 0V, V_O = $V^+/2$ and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Typ (Note 6)	Limit (Note 7)	Units
V_O	Output Swing	R_L = 2kΩ to 2.5V	V^+ −0.04	V^+ −0.3 **V^+ −0.4**	V min
			0.12	0.3 **0.4**	V max
		R_L = 10kΩ to 2.5V	V^+ −0.01	V^+ −0.1 **V^+ −0.2**	V min
			0.065	0.18 **0.28**	V max
I_O	Output Current	Sourcing, V_O = OV	60	5	mA min
		Sinking, V_O = 5V	160	10	mA min
I_S	Supply Current		130	250 **350**	µA max
	Resistor Ratio Matching		1		%
GBWP	Gain-Bandwidth Product	C_L = 200pF	1		MHz
ϕm	Phase Margin		60		Deg
G_m	Gain Margin		10		dB
SR	Slew Rate	(Note 8)	1		V/µs

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, 1.5kΩ in series with 100pF. Machine model, 0Ω 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 $T_{J(max)}$, θ_{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.

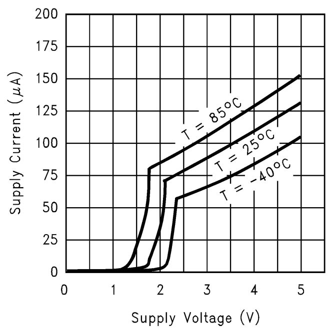
Note 6: Typical values represent the most likely parametric norm.

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°C.)

Supply Current vs. Supply Voltage



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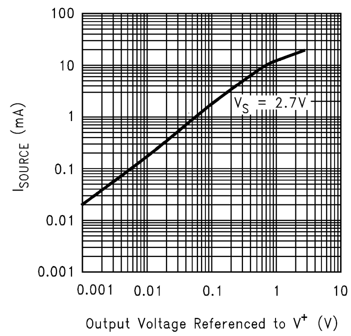
Sourcing Current vs. Output Voltage



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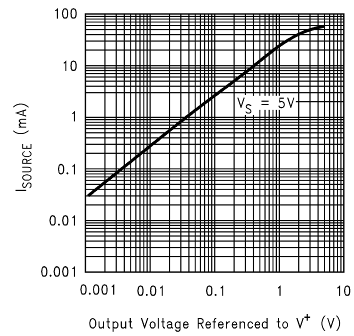
Sourcing Current vs. Output Voltage



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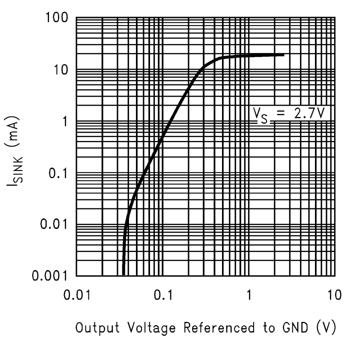
Sinking Current vs. Output Voltage



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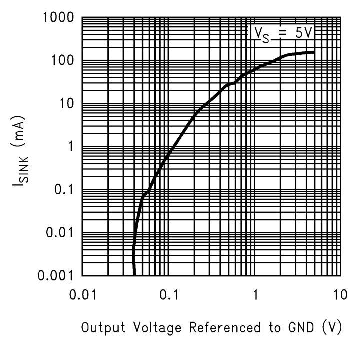
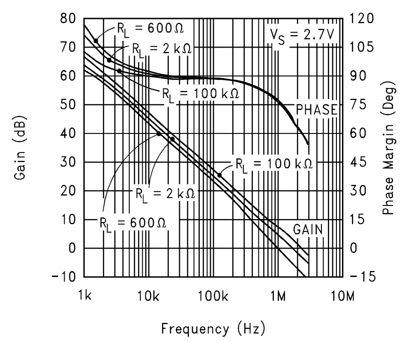
Sinking Current vs. Output Voltage



DS101262-5

Open Loop Frequency vs. Response



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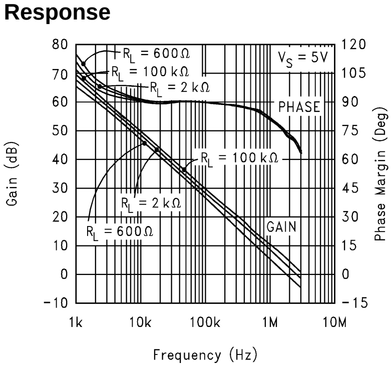
Open Loop Frequency vs. Response



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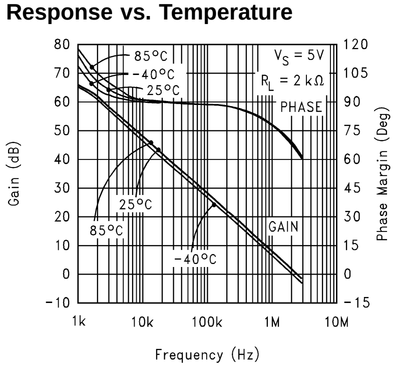
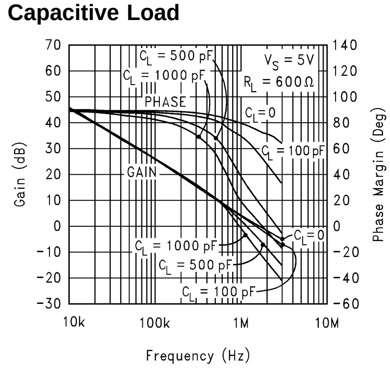
Open Loop Frequency Response vs. Temperature



DS101262-8

Gain and Phase vs. Capacitive Load



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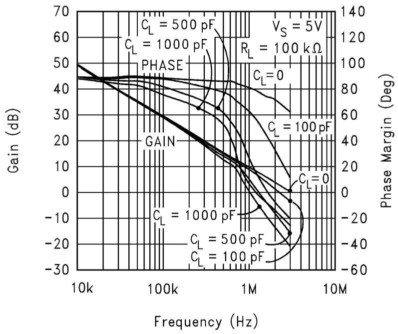
Typical Performance Characteristics (Unless otherwise specified, V_S = +5V, single supply, T_A = 25˚C.) (Continued)

Gain and Phase vs. Capacitive Load



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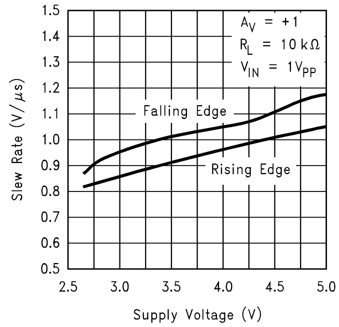
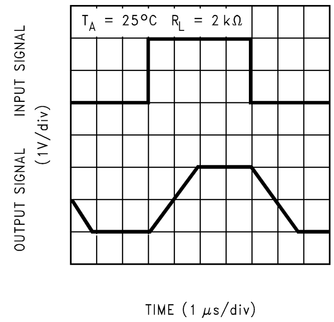
Slew Rate vs. Supply Voltage



DS101262-11

Non-Inverting Large Signal Pulse Response



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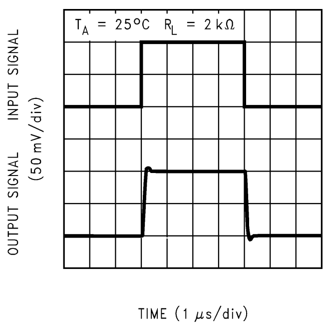
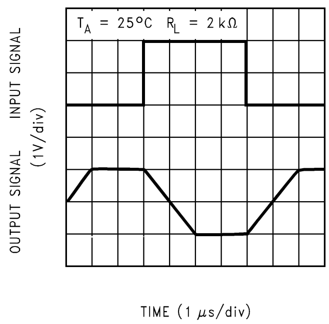
Non-Inverting Small Signal Pulse Response



DS101262-13

Inverting Large Signal Pulse Response



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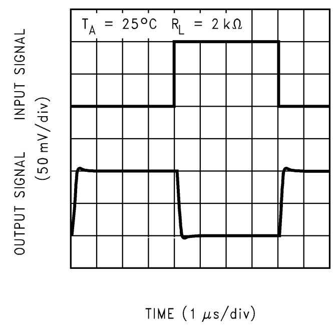
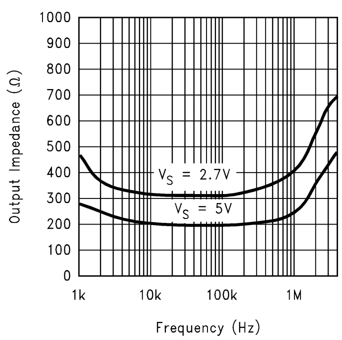
Inverting Small Signal Pulse Response



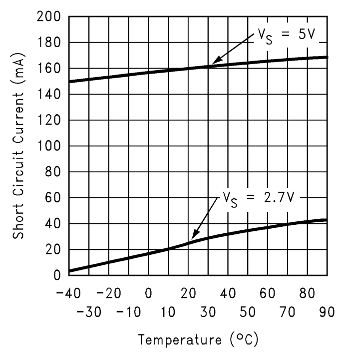
DS101262-15

Open Loop Output Impedance vs. Frequency



DS101262-16

Short Circuit Current vs. Temperature (Sinking)



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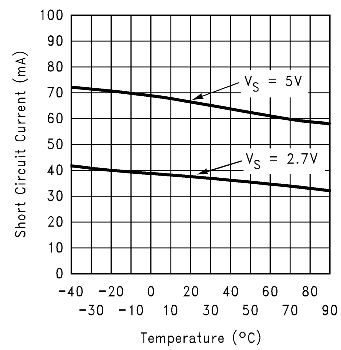
Short Circuit Current vs. Temperature (Sourcing)



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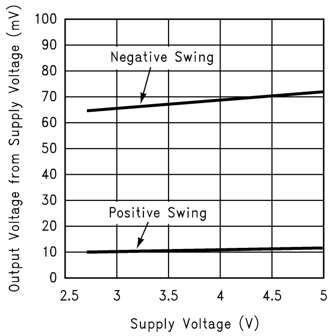
Typical Performance Characteristics (Unless otherwise specified, V_S = +5V, single supply, T_A = 25˚C.) (Continued)

Output Voltage Swing vs. Supply Voltage



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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 (0.1µF) or solid tantalum (1µF) 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 10µF (or larger) capacitor is used to absorb low frequency variations and a smaller 0.1µF 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˚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*.

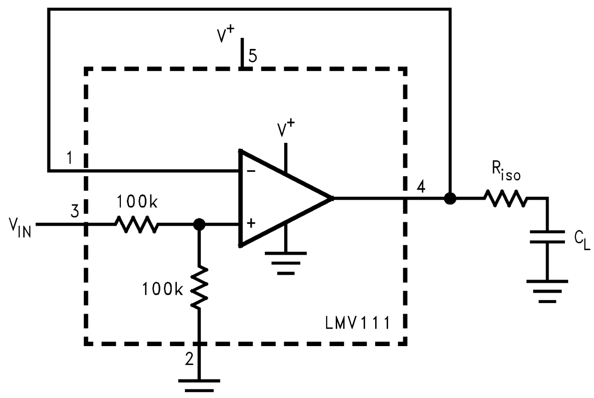

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FIGURE 1. Resistive Isolation of a Heavy Capacitive Load

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 50Ω to 100Ω 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 0.1µF 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.

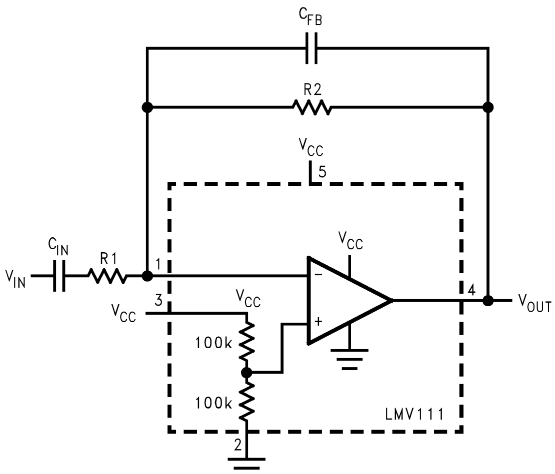

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FIGURE 2. Phase Inverting AC Amplifier

5.0 Fixed Current Source

A multiple fixed current source is show 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.

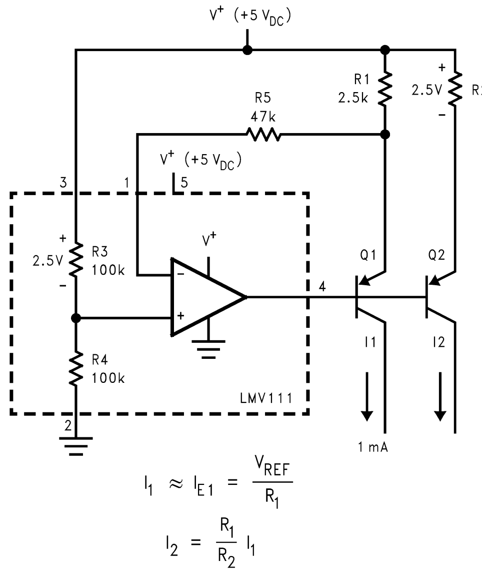

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FIGURE 3. Fixed Current Source

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.

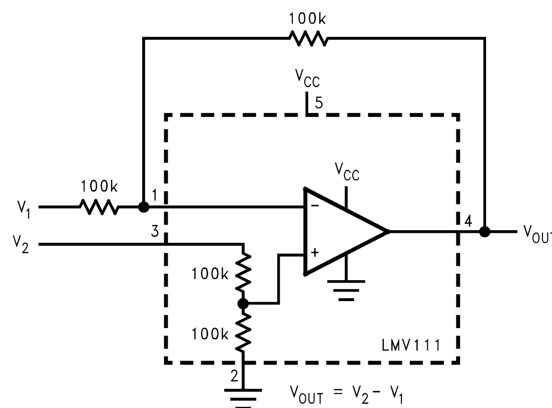

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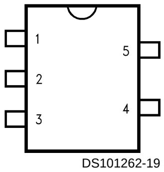
FIGURE 4. Difference Amplifier

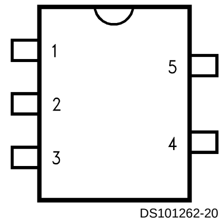
Connection Diagrams

5-Pin SC70-5 (M7)



Top View

5-Pin SOT23-5 (M5)

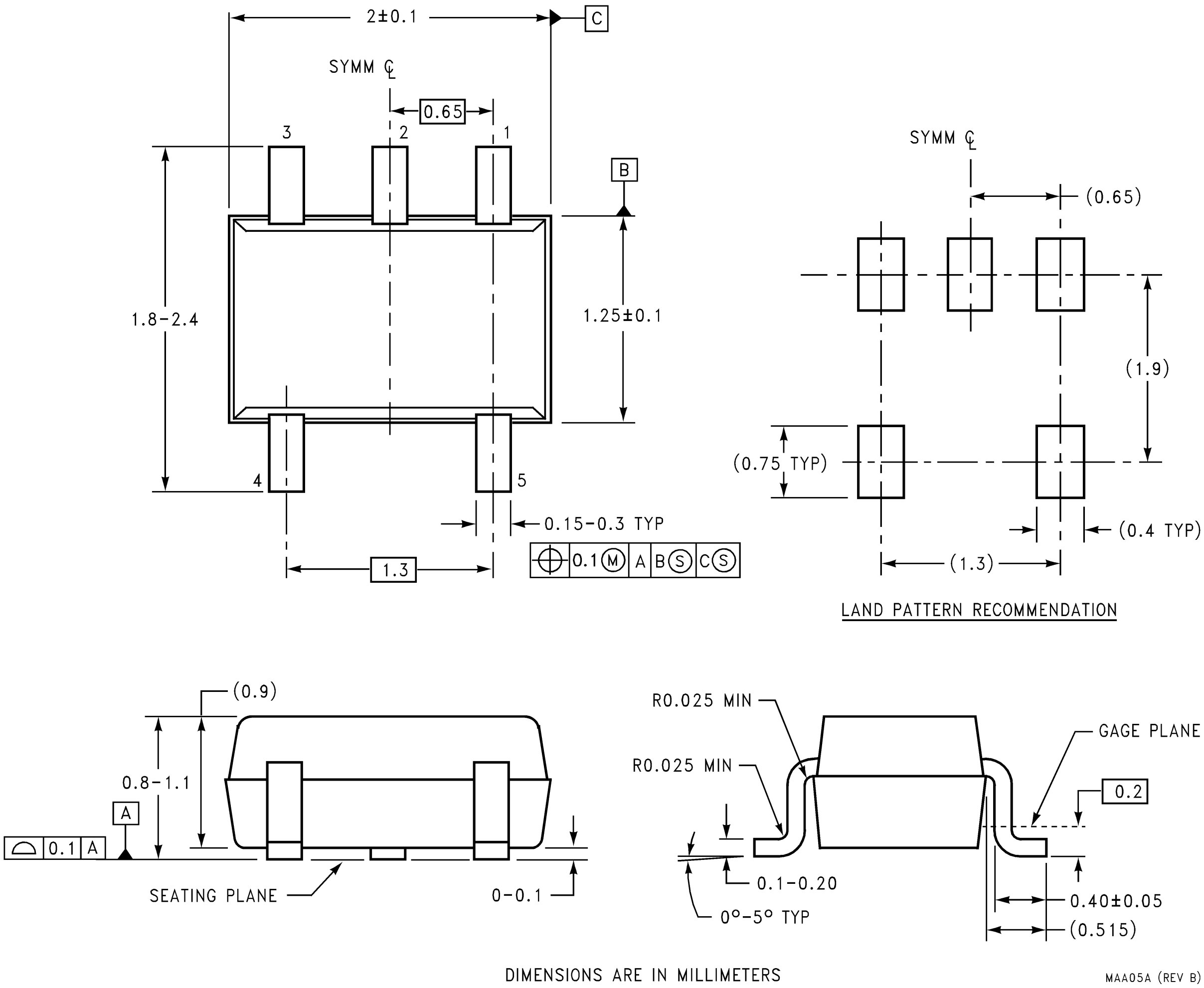


Top View

Ordering Information

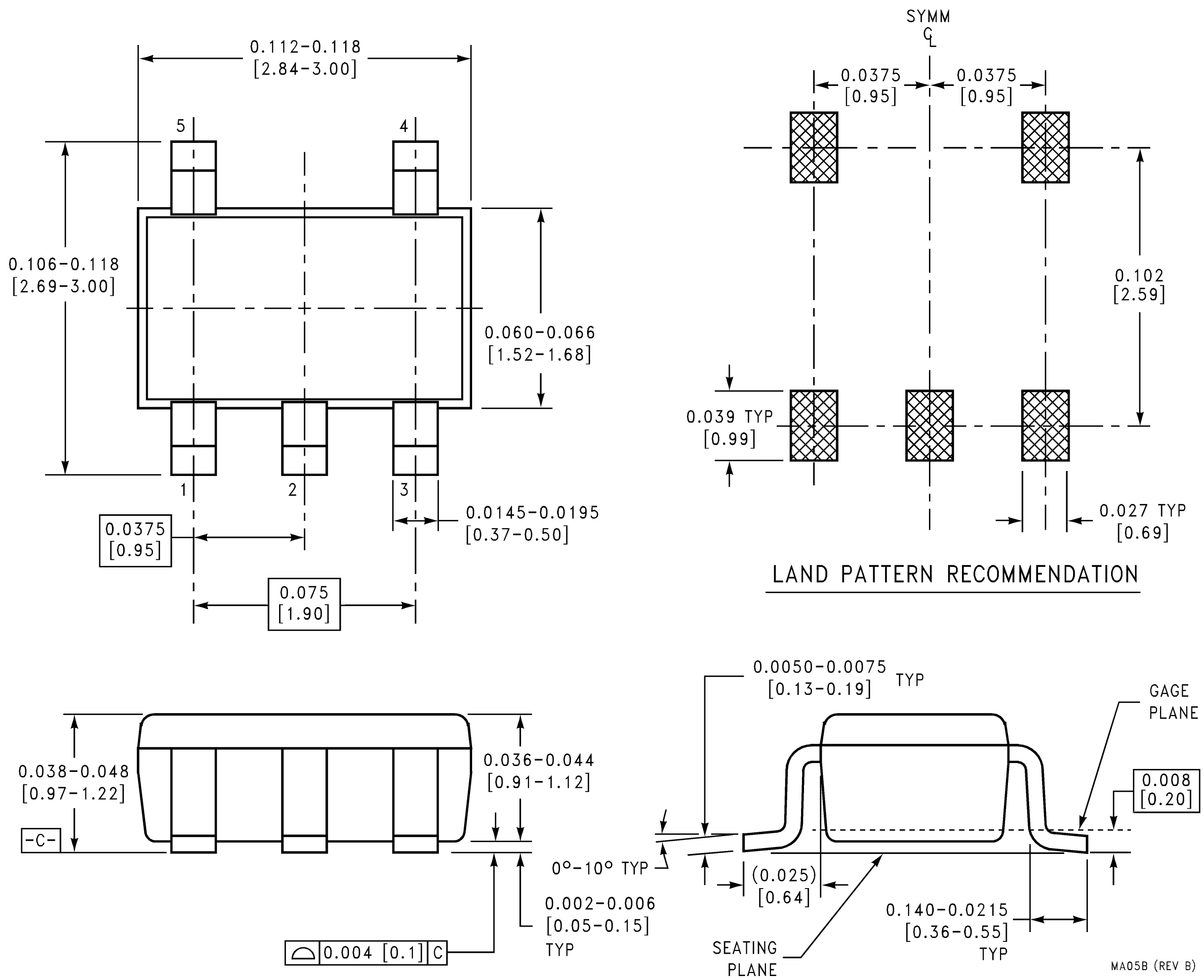
Package	Part Number	Marking	Transport Media	NSC Drawing
SC70-5	LMV111M7	A42	1k Units Tape and Reel	MAA05A
	LMV111M7X		3k Units Tape and Reel	
SOT23-5	LMV111M5	A37A	1k Units Tape and Reel	MA05B
	LMV111M5X		3k Units Tape and Reel	

Physical Dimensions inches (millimeters) unless otherwise noted



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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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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