# **MIC7111**



# 1.8V to 11V, 15µA, 25kHz GBW, Rail-to-Rail Input and Output Operational Amplifier

## **General Description**

The MIC7111 is a low-power operational amplifier with rail-to-rail inputs and outputs. The device operates from a 1.8V to 11V single supply or an  $\pm 0.9V$  to  $\pm 5.5V$  dual supply. The device consumes a low 15µA of current from a 1.8V supply and 25µA from a 10V supply. The device features a unity gain bandwidth of 25kHz and swings within 1mV of either the supply rail with a 100k $\Omega$  load. The device is capable of sinking and sourcing 25mA of current from a 1.8V supply and up to 200mA from a 10V supply. The device is available in the cost effective SOT23-5 package.

Datasheets and support documentation are available on Micrel's web site at: <a href="https://www.micrel.com">www.micrel.com</a>.

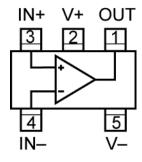
### **Features**

- 1.8V to 11V single supply operation
- ±0.9V to ±5.5V dual supply operation
- Low 15µA supply current at 1.8V
- 25kHz gain bandwidth
- 1mV input offset voltage (typical)
- 1pA input bias current (typical)
- 0.01pA input offset current (typical)
- Input-referred noise is 110nv/√Hz at 1kHz
- Output swing to within 1mV of rails with 1.8V supply and  $100k\Omega$  load
- Suitable for driving capacitive loads
- Cost effective SOT23-5 package

## **Applications**

- · Wireless and cellular communications
- · GaAs RF bias amplifier
- Current sensing for battery chargers
- Transducer linearization and interface
- · Portable computing

## **Functional Configuration**



SOT-23-5 (M5)

Micrel Inc. • 2180 Fortune Drive • San Jose, CA 95131 • USA • tel +1 (408) 944-0800 • fax + 1 (408) 474-1000 • <a href="http://www.micrel.com">http://www.micrel.com</a>

February 11, 2013 Revision 2.0

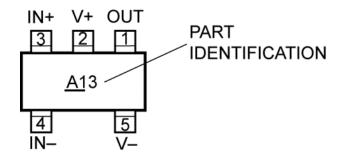
# **Ordering Information**

Part Number	lunction Tomporature Bongs	Package <sup>(1)</sup>
Pb-Free	Junction Temperature Range	Fackage
MIC7111YM5	−40°C to +85°C	SOT23-5

### Note:

1. Other packages are available. Contact Micrel for details.

# **Pin Configuration**



SOT23-5 (M5) (Top View)

# **Pin Description**

Pin Number	Pin Name	Pin Function
1	OUT	Amplifier Output.
2	V+	Positive Supply
3	IN+	Non-inverting Input.
4	IN-	Inverting Input
5	V–	Negative Supply.

# Absolute Maximum Ratings<sup>(1)</sup>

## 

# Operating Ratings<sup>(2)</sup>

Supply Voltage (V <sub>V+</sub> – V <sub>V-</sub> )	+1.8V to +11V
Junction Temperature (T <sub>J</sub> )	
Maximum Junction Temperature (T <sub>J(MAX)</sub> )	<sup>(4)</sup> +85°C
Package Thermal Resistance (θ <sub>JA</sub> ) <sup>(5)</sup>	+252°C/W
Maximum Power Dissipation	Note 4

### **DC Electrical Characteristics**

 $V_{V+} = +1.8V; V_{V-} = 0V; V_{CM} = V_{OUT} = V_{V+}/2; R_L = 1M; T_J = +25^{\circ}C,$  bold values indicate  $-40^{\circ}C \le T_J \le +85^{\circ}C,$  unless noted.

Symbol	Parameter	Condition	Min.	Тур.	Max.	Units
V	lanut Offe at Valtage			0.9	7	mV
Vos	Input Offset Voltage				9	IIIV
TCVos	Input Offset Voltage Temperature Drift			2.0		μV/°C
	Innut Diga Current			1	10	<b>π</b> Λ
$I_{B}$	Input Bias Current				500	рA
	Input Offact Current			0.01	0.5	- Α
I <sub>OS</sub>	Input Offset Current				75	- pA
R <sub>IN</sub>	Input Resistance			>10		ΤΩ
+PSRR	Positive Power Supply Rejection Ratio	$1.8V \le V_{V+} \le 5V, V_{V-} = 0V,$ $V_{CM} = V_{OUT} = 0.9V$	60	85		dB
-PSRR	Negative Power Supply Rejection Ratio	$-1.8V \le V_V - \le -5V$ , $V_V + = 0V$ , $V_{CM} = V_{OUT} = -0.9V$	60	85		dB
CMRR	Common-Mode Rejection Ratio	$V_{CM} = -0.2V \text{ to } +2.0V$	50	70		dB
C <sub>IN</sub>	Common-Mode Input Capacitance			3		pF
		Output HIGH, R <sub>L</sub> = 100k,		0.14	1	
		Specified as V <sub>V+</sub> –V <sub>OUT</sub>			1	]
		Output LOW D. 400k		0.14	1	mV
.,	Output Vallage Output	Output LOW, R <sub>L</sub> = 100k			1	
V <sub>OUT</sub>	Output Voltage Swing	Output HIGH, R <sub>L</sub> = 2k,		6.8	23	
		Specified as V <sub>V+</sub> – V <sub>OUT</sub>			34	
		Output LOW B. Ok		6.8	23	
		Output LOW, R <sub>L</sub> = 2k			34	

### Notes:

- Absolute maximum ratings indicate limits beyond which damage to the component may occur. Electrical specifications do not apply when operating
  the device outside its recommended operating ratings.
- 2. The device is not guaranteed to function outside its operating ratings.
- 3. I/O pin voltage is any external voltage to which an input or output is referenced.
- 4. The maximum allowable power dissipation is a function of the maximum junction temperature, T<sub>J(MAX)</sub>; the junction-to-ambient thermal resistance, θ<sub>JA</sub>; and the ambient temperature, T<sub>A</sub>. The maximum allowable power dissipation at any ambient temperature is calculated using P<sub>D</sub> = (T<sub>J(MAX)</sub> TA) ÷ θ<sub>JA</sub>. Exceeding the maximum allowable power dissipation will result in excessive die temperature.
- 5. Thermal resistance,  $\theta_{JA}$ , applies to a part soldered on a printed-circuit board.
- Devices are ESD protected, however, handling precautions are recommended. All limits guaranteed by testing on statistical analysis. Human body model, 1.5kΩ in series with 100pF.

# **DC Electrical Characteristics (Continued)**

 $V_{V+} = +1.8V$ ;  $V_{V-} = 0V$ ;  $V_{CM} = V_{OUT} = V_{V+}/2$ ;  $R_L = 1M$ ;  $T_J = +25^{\circ}C$ , **bold** values indicate  $-40^{\circ}C \le T_J \le +85^{\circ}C$ , unless noted.

Symbol	Parameter	Condition	Min.	Тур.	Max.	Units
I <sub>SC</sub>	Output Short Circuit Current(7)	Sourcing, V <sub>OUT</sub> = 0V	15	25		m 1
	Output Short-Circuit Current <sup>(7)</sup>	Sinking, V <sub>OUT</sub> = 1.8V	15	25		mA
Δ.	Valtaga Cain	Sourcing		400		\//ma\/
A <sub>VOL</sub>	Voltage Gain	Sinking		400		V/mV
Is	Supply Current	$V_{V+} = 1.8V, V_{OUT} = V_{V+}/2$		15	35	μA

### **AC Electrical Characteristics**

 $V+=+1.8V;\ V-=0V;\ V_{CM}=V_{OUT}=V_{V+}/2;\ R_L=1M;\ T_J=+25^{\circ}C,\ \text{bold}\ values\ indicate}\ -40^{\circ}C\leq T_J\leq +85^{\circ}C,\ unless\ noted.$ 

Symbol	Parameter	Condition	Min.	Тур.	Max.	Units
SR	Slew Rate	Voltage follower, 1V step, R <sub>L</sub> = 100k @ 0.9V, V <sub>OUT</sub> = 1V <sub>P-P</sub>		0.015		V/µs
GBW	Gain Bandwidth Product	Sourcing		25		kHz

# **DC Electrical Characteristics (2.7V)**

 $V_{V+} = +2.7V$ ;  $V_{V-} = 0V$ ;  $V_{CM} = V_{OUT} = V_{V+}/2$ ;  $R_L = 1M$ ;  $T_J = +25^{\circ}C$ , **bold** values indicate  $-40^{\circ}C \le T_J \le +85^{\circ}C$ , unless noted.

Symbol	Parameter	Condition	Min.	Тур.	Max.	Units
M	Input Offact Valtage			0.9	7	m\/
Vos	Input Offset Voltage				9	mV
TCV <sub>OS</sub>	Input Offset Voltage Temperature Drift			2.0		μV/°C
1	Innut Bigg Current			1	10	n 1
I <sub>B</sub>	Input Bias Current				500	- pA
1	Input Offset Current			0.01	0.5	
I <sub>OS</sub>					75	pA
R <sub>IN</sub>	Input Resistance			>10		ТΩ
+PSRR	Positive Power Supply Rejection Ratio	$2.7V \le V_{V+} \le 5V, V_{V-} = 0V,$ $V_{CM} = V_{OUT} = 1.35V$	60	90		dB
-PSRR	Negative Power Supply Rejection Ratio	$-2.7V \le V_V - \le -5V$ , $V_V + = 0V$ , $V_{CM} = V_{OUT} = -1.35V$	60	90		dB
CMRR	Common-Mode Rejection Ratio	$V_{CM} = -0.2V \text{ to } +2.9V$	52	75		dB
C <sub>IN</sub>	Common-Mode Input Capacitance			3		pF

### Note:

<sup>7.</sup> Short circuit may cause the device to exceed maximum allowable power dissipation (see Note 3).

DC Electrical Characteristics (2.7V) (Continued)  $V_{V+} = +2.7V; \ V_{V-} = 0V; \ V_{CM} = V_{OUT} = V_{V+}/2; \ R_L = 1M; \ T_J = +25^{\circ}C, \ bold \ values \ indicate \ -40^{\circ}C \le T_J \le +85^{\circ}C, \ unless \ noted.$ 

Symbol	Parameter	Condition	Min.	Тур.	Max.	Units
		Output HIGH, R <sub>L</sub> = 100k,		0.2	1	
		Specified as V <sub>V+</sub> –V <sub>OUT</sub>			1	
		Output LOW B. 400k		0.2	1	
V	Output Voltage Swing	Output LOW, R <sub>L</sub> = 100k			1	mV
$V_{OUT}$	Output voltage Swing	Output HIGH, R <sub>L</sub> = 2k,		10	33	IIIV
		Specified as V <sub>V+</sub> – V <sub>OUT</sub>			50	
		Output LOW B. 3k		10	33	
		Output LOW, $R_L = 2k$			50	]
	Output Short-Circuit Current <sup>(7)</sup>	Sourcing, V <sub>OUT</sub> = 0V	30	50		
I <sub>SC</sub>	Output Short-Circuit Current	Sinking, V <sub>OUT</sub> = 2.7V	30	50		mA
۸	Valtage Cain	Sourcing		400		\//m\/
A <sub>VOL</sub>	Voltage Gain	Sinking		400		V/mV
Is	Supply Current	$V_{V+} = 2.7V, V_{OUT} = V_{V+}/2$		17	42	μA

# **AC Electrical Characteristics (2.7V)**

 $V+=+2.7V;\ V-=0V;\ V_{CM}=V_{OUT}=V_{V+}/2;\ R_L=1M;\ T_J=+25^{\circ}C,\ \text{bold}\ values\ indicate}\ -40^{\circ}C \leq T_J \leq +85^{\circ}C,\ unless\ noted.$ 

Symbol	Parameter	Condition	Min.	Тур.	Max.	Units
SR	Slew Rate	Voltage follower, 1V step, R <sub>L</sub> = 100k @ 1.35V , V <sub>OUT</sub> = 1V <sub>P-P</sub>		0.015		V/µs
GBW	Gain Bandwidth Product	Sourcing		25		kHz

# **DC Electrical Characteristics (5V)**

 $V_{V+} = +5V; \ V_{V-} = 0V; \ V_{CM} = V_{OUT} = V_{V+}/2; \ R_L = 1M; \ T_J = +25^{\circ}C, \ \textbf{bold} \ \ \text{values indicate} \ -40^{\circ}C \leq T_J \leq +85^{\circ}C, \ unless \ \text{noted}.$ 

Symbol	Parameter	Condition	Min.	Тур.	Max.	Units
V	Input Offact Valtage			0.9	7	mV
Vos	Input Offset Voltage				9	IIIV
TCVos	Input Offset Voltage Temperature Drift			2.0		μV/°C
1	Input Bigg Current			1	10	- Λ
I <sub>B</sub>	Input Bias Current				500	pA
Las	Input Offact Current			0.01	0.5	- Λ
IOS	·				75	pА
R <sub>IN</sub>	Input Resistance			>10		ΤΩ
+PSRR	Positive Power Supply Rejection Ratio	$5V \le V_{V+} \le 10V, V_{V-} = 0V,$ $V_{CM} = V_{OUT} = 2.5V$	65	95		dB
-PSRR	Negative Power Supply Rejection Ratio	$-5V \le V_V - \le -10V$ , $V_V + = 0V$ , $V_{CM} = V_{OUT} = -2.5V$	65	95		dB
CMRR	Common-Mode Rejection Ratio	$V_{CM} = -0.2V \text{ to } +5.2V$	57	80		dB
C <sub>IN</sub>	Common-Mode Input Capacitance			3		pF
		Output HIGH, $R_L = 100k$ , Specified as $V_{V+} - V_{OUT}$		0.3	1.5	
					1.5	-
		Output LOW, R <sub>L</sub> = 100k		0.3	1.5	
V	Output Voltage Swing				1.5	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		15	50	mV		
		Specified as V <sub>V+</sub> – V <sub>OUT</sub>			75	
		Output LOW P. – 2k		15	50	
		Output LOW, RE = 2K			75	<u></u>
L	Output Short Circuit Current <sup>(7)</sup>	Sourcing, V <sub>OUT</sub> = 0V	80	100		mΛ
ISC	Output Short-Circuit Current	Sinking, V <sub>OUT</sub> = 5V	80	100		mA
Δνω	Voltage Gain	Sourcing		500		\//m\/
A <sub>VOL</sub>	Voltage Gain	Sinking		500		V/mV
Is	Supply Current	$V_{V+} = 5V, V_{OUT} = V_{V+}/2$		20	50	μA

# **AC Electrical Characteristics (5V)**

 $V+=+5V;\ V-=0V;\ V_{CM}=V_{OUT}=V_{V+}/2;\ R_L=1M;\ T_J=+25^{\circ}C,\ \text{bold}\ values\ indicate}\ -40^{\circ}C\leq T_J\leq +85^{\circ}C,\ unless\ noted.$ 

Symbol	Parameter	Condition	Min.	Тур.	Max.	Units
SR	Slew Rate	Voltage follower, 1V step, R <sub>L</sub> = 100k @ 1.5V, V <sub>OUT</sub> = 1V <sub>P-P</sub>		0.02		V/µs
GBW	Gain Bandwidth Product	Sourcing		25		kHz

# **DC Electrical Characteristics (10V)**

 $V_{V+} = +10V; \ V_{V-} = 0V; \ V_{CM} = V_{OUT} = V_{V+}/2; \ R_L = 1M; \ T_J = +25^{\circ}C, \ \textbf{bold} \ values \ indicate} \ -40^{\circ}C \leq T_J \leq +85^{\circ}C, \ unless \ noted.$ 

Symbol	Parameter	Condition	Min.	Тур.	Max.	Units
\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	Input Offact Valtage			0.9	7	mV
Vos	Input Offset Voltage				9	IIIV
TCVos	Input Offset Voltage Temperature Drift			2.0		μV/°C
I <sub>B</sub>	Input Bias Current			1	10	pА
IВ	input bias current				500	PΑ
loo	Input Offset Current			0.01	0.5	pA
108	los Input Offset Current				75	PΛ
R <sub>IN</sub>	Input Resistance			>10		ΤΩ
+PSRR	Positive Power Supply Rejection Ratio	$5V \le V_{V+} \le 10V, V_{V-} = 0V,$ $V_{CM} = V_{OUT} = 2.5V$	65	95		dB
-PSRR	Negative Power Supply Rejection Ratio	$-5V \le V_{V^-} \le -10V$ , $V_{V^+} = 0V$ , $V_{CM} = V_{OUT} = -2.5V$	65	95		dB
CMRR	Common-Mode Rejection Ratio	$V_{CM} = -0.2V \text{ to } +10.2V$	60	85		dB
C <sub>IN</sub>	Common-Mode Input Capacitance			3		pF
		Output HIGH, R <sub>L</sub> = 100k,		0.45	2.5	
		Specified as V <sub>V+</sub> –V <sub>OUT</sub>			2.5	mV
		Output LOW, R <sub>L</sub> = 100k		0.45	2.5	
V <sub>OUT</sub>	Output Voltage Swing				2.5	
VOUT	Output Voltage Swiling	Output HIGH, R <sub>L</sub> = 2k,		9 2.0 1 10 500 0.01 0.5 75 >10 95 95 85 3 0.45 2.5 2.5 0.45 2.5 2.4 80 120 24 80	80	
		Specified as V <sub>V+</sub> – V <sub>OUT</sub>			120	
		Output LOW, R <sub>L</sub> = 2k		24	80	
		Output LOVV, NL = ZK			120	
I <sub>sc</sub>	Output Short-Circuit Current <sup>(7)</sup>	Sourcing, V <sub>OUT</sub> = 0V	100	200		mA
isc	Output Short-Sheart Outrent	Sinking, V <sub>OUT</sub> = 10V	100	200		IIIA
A <sub>VOL</sub>	Voltage Gain	Sourcing		500		V/mV
AVOL	vollage Gairi	Sinking		500		V/111 V
Is	Supply Current	$V_{V+} = 10V, V_{OUT} = V_{V+}/2$		25	65	μA

# **AC Electrical Characteristics (10V)**

 $V+=+10V;\ V-=0V;\ V_{CM}=V_{OUT}=V_{V+}/2;\ R_L=1M;\ T_J=+25^{\circ}C,\ \text{bold}\ values\ indicate}\ -40^{\circ}C\leq T_J\leq +85^{\circ}C,\ unless\ noted.$ 

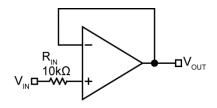
Symbol	Parameter	Condition	Min.	Тур.	Max.	Units
SR	Slew Rate	Voltage follower, 1V step, $R_L = 100k @ 1.35V$ $V_{OUT} = 1V_{P-P}$		0.02		V/µs
GBW	Gain Bandwidth Product			25		kHz
фм	Phase Margin			50		0
G <sub>M</sub>	Gain Margin			15		dB
e <sub>N</sub>	Input-Referred Voltage Noise	f = 1kHz, V <sub>CM</sub> = 1.0V		110		nV/√Hz
i <sub>N</sub>	Input-Referred Current Noise	f = 1kHz		0.03		pA/√Hz

### **Application Information**

### **Input Common Mode Voltage**

The MIC7111 tolerates input overdrive by at least 300mV beyond either rail without producing phase inversion.

If the absolute maximum input voltage is exceeded, the input current should be limited to  $\pm 5 \text{mA}$  maximum to prevent reducing reliability. A  $10 \text{k}\Omega$  series input resistor, used as a current limiter, will protect the input structure from voltages as large as 50V above the supply or below ground. See Figure 1.



**Figure 1. Input Current-Limit Protection** 

### **Output Voltage Swing**

Sink and source output resistances of the MIC7111 are equal. Maximum output voltage swing is determined by the load and the approximate output resistance. The output resistance is presented in Equation 1:

$$R_{OUT} = \frac{V_{DROP}}{I_{LOAD}}$$
 Eq. 1

 $V_{DROP}$  is the voltage dropped within the amplifier output stage.  $V_{DROP}$  and  $I_{LOAD}$  can be determined from the  $V_O$  (output swing) portion of the appropriate electrical characteristics table.  $I_{LOAD}$  is equal to the typical output high voltage minus V+/2 and divided by  $R_{LOAD}.$  For example, using the DC Electrical Characteristics (5V) table, the typical output voltage drop using a  $2k\Omega$  load (connected to V+/2) is 0.015V, which produces an  $I_{LOAD}$  of:

$$\frac{2.5V - 0.015V}{2k\Omega} = 1.243mA$$
 Eq. 2

Then,

$$R_{OUT} = \frac{15mV}{1.243mA} = 12.1 = 12\Omega$$
 Eq. 3

### **Driving Capacitive Loads**

Driving a capacitive load introduces phase-lag into the output signal, and this in turn reduces op-amp system phase margin. The application that is least forgiving of reduced phase margin is a unity gain amplifier. The MIC7111 can typically drive a 500pF capacitive load connected directly to the output when configured as a unity-gain amplifier.

### **Using Large-Value Feedback Resistors**

A large-value feedback resistor (>  $500k\Omega$ ) can reduce the phase margin of a system. This occurs when the feedback resistor acts in conjunction with input capacitance to create phase lag in the feedback signal. Input capacitance is usually a combination of input circuit components and other parasitic capacitance, such as amplifier input capacitance and stray printed circuit board capacitance.

Figure 2 illustrates a method of compensating phase lag caused by using a large-value feedback resistor. Feedback capacitor  $C_{FB}$  introduces sufficient phase lead to overcome the phase lag caused by feedback resistor  $R_{FB}$  and input capacitance  $C_{IN}$ . The value of  $C_{FB}$  is determined by first estimating  $C_{IN}$  and then applying the following formula:

$$R_{IN} \times C_{IN} \le R_{FB} \times C_{FB}$$
 Eq. 4

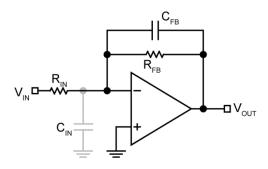


Figure 2. Cancelling Feedback Phase Lag

Since a significant percentage of  $C_{\text{IN}}$  may be caused by board layout, it is important to note that the correct value of  $C_{\text{FB}}$  may change when changing from a breadboard to the final circuit layout.

### **Typical Circuits**

Some single-supply, rail-to-rail applications – for which the MIC7111 is well suited – are shown in the circuit diagrams of Figures 3 through 8.

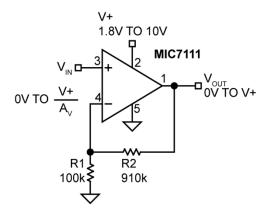


Figure 3. Noninverting Amplifier

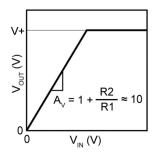


Figure 4. Noninverting Amplifier Behavior

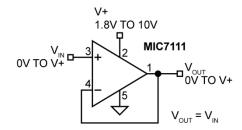


Figure 5. Voltage Follower/Buffer

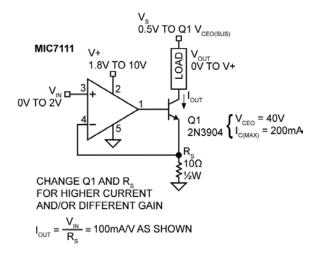


Figure 6. Voltage-Controlled Current Sink

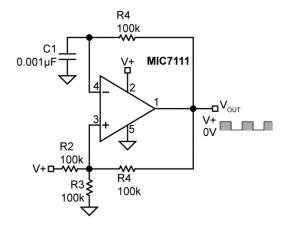


Figure 7. Square Wave Oscillator

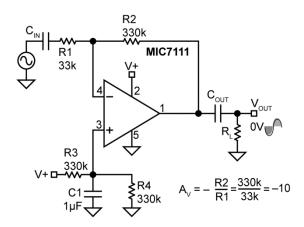
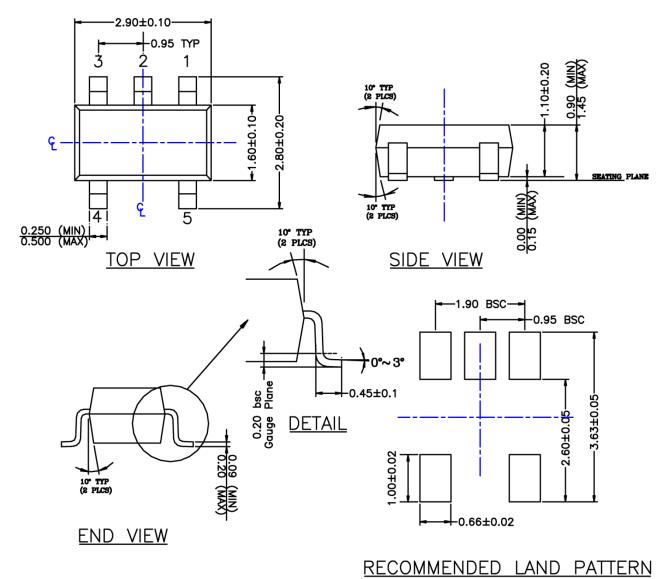


Figure 8. AC-Coupled Inverting Amplifier

# Package Information<sup>(1)</sup> and Recommended Landing Pattern



### NOTE:

- 1. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & BURR.
  2. PACKAGE OUTLINE INCLUSIVE OF SOLER PLATING.
  3. DIMENSION AND TOLERANCE PER ANSI Y14.5M, 1982.
  4. FOOT LENGTH MEASUREMENT BASED ON GAUGE PLANE METHOD.
- 5. DIE FACES UP FOR MOLD, AND FACES DOWN FOR TRIM/FORM.
- 6. ALL DIMENSIONS ARE IN MILLIMETERS.

### SOT23-5 (M5)

### Note:

1. Package information is correct as of the publication date. For updates and most current information, go to <a href="www.micrel.com">www.micrel.com</a>.

### MICREL, INC. 2180 FORTUNE DRIVE SAN JOSE, CA 95131 USA

TEL +1 (408) 944-0800 FAX +1 (408) 474-1000 WEB http://www.micrel.com

Micrel makes no representations or warranties with respect to the accuracy or completeness of the information furnished in this data sheet. This information is not intended as a warranty and Micrel does not assume responsibility for its use. Micrel reserves the right to change circuitry, specifications and descriptions at any time without notice. No license, whether express, implied, arising by estoppel or otherwise, to any intellectual property rights is granted by this document. Except as provided in Micrel's terms and conditions of sale for such products, Micrel assumes no liability whatsoever, and Micrel disclaims any express or implied warranty relating to the sale and/or use of Micrel products including liability or warranties relating to fitness for a particular purpose, merchantability, or infringement of any patent, copyright or other intellectual property right.

Micrel Products are not designed or authorized for use as components in life support appliances, devices or systems where malfunction of a product can reasonably be expected to result in personal injury. Life support devices or systems are devices or systems that (a) are intended for surgical implant into the body or (b) support or sustain life, and whose failure to perform can be reasonably expected to result in a significant injury to the user. A Purchaser's use or sale of Micrel Products for use in life support appliances, devices or systems is a Purchaser's own risk and Purchaser agrees to fully indemnify Micrel for any damages resulting from such use or sale.

© 2005 Micrel, Incorporated.