

## Low-Input Leakage, Rail-to-Rail Input/Output Op Amps

### Features

- Low Quiescent Current: 600 nA/Amplifier (typical)
- Rail-to-Rail Input/Output
- Gain Bandwidth Product: 10 kHz (typical)
- Wide Supply Voltage Range: 1.8V to 5.5V
- Unity Gain Stable
- Available in Single and Dual Configurations
- Temperature Ranges: -10°C to +60°C

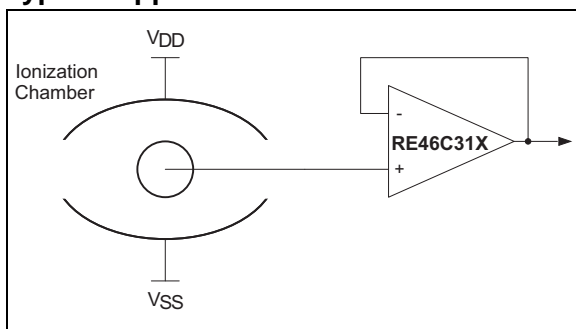
### Applications

- Ionization Smoke Detectors
- Low Leakage High-Impedance Input Circuits
- Battery-Powered Circuits

### Design Aids

- MAPS (Microchip Advanced Part Selector)
- Analog Demonstration and Evaluation Boards
- Application Notes

### Typical Application



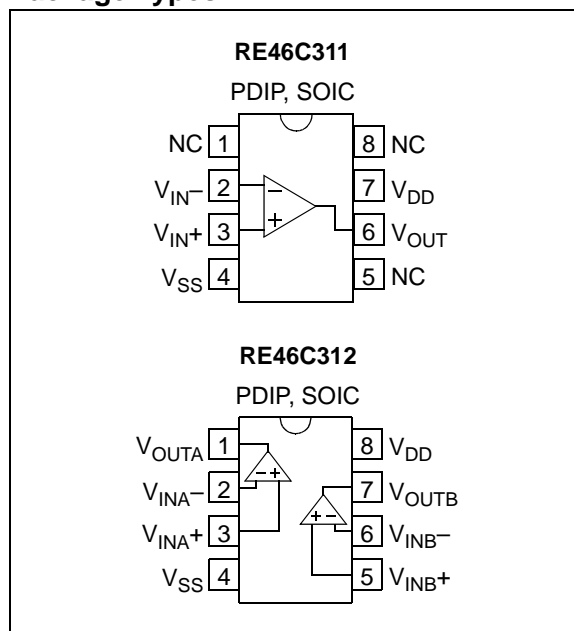
### Description

The RE46C311/2 family of operational amplifiers (op amps) from Microchip Technology Inc. operate with a single-supply voltage as low as 1.8V, while drawing less than 1  $\mu$ A (maximum) of quiescent current per amplifier. These devices are also designed to support rail-to-rail input and output operation. This combination of features supports battery-powered and portable applications.

The RE46C311/2 amplifiers have a gain-bandwidth product of 10 kHz (typical) and are unity gain stable. These specifications make these op amps appropriate for low-frequency applications, such as ionization smoke detectors and sensor conditioning.

The RE46C311/2 family operational amplifiers are offered in single (RE46C311), and dual (RE46C312) configurations.

### Package Types



# RE46C311/2

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

$V_{DD} - V_{SS}$ .....	6.0V
Current at Input Pins .....	$\pm 2$ mA
All Inputs and Outputs .....	$V_{SS} - 0.3V$ to $V_{DD} + 0.3V$
Difference Input voltage .....	$ V_{DD} - V_{SS} $
Output Short Circuit Current .....	continuous
Current at Output and Supply Pins .....	$\pm 30$ mA
Storage Temperature .....	$-65^{\circ}\text{C}$ to $+150^{\circ}\text{C}$
Junction Temperature .....	$+150^{\circ}\text{C}$
ESD protection on all pins (HBM; MM) .....	$\geq 4$ kV; 400V

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

†† See [Section 4.1, Rail-to-Rail Input](#).

### DC ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, $V_{DD} = +1.8V$ to $+5.5V$ , $V_{SS} = \text{GND}$ , $T_A = +25^{\circ}\text{C}$ , $V_{CM} = V_{DD}/2$ , $V_{OUT} \approx V_{DD}/2$ , $V_L = V_{DD}/2$ , and $R_L = 1 \text{ M}\Omega$ to $V_L$ (refer to <a href="#">Figure 1-1</a> and <a href="#">Figure 1-2</a> ).						
Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
<b>Input Offset</b>						
Input Offset Voltage	$V_{OS}$	-3	—	+3	mV	
Drift with Temperature	$\Delta V_{OS}/\Delta T_A$	—	$\pm 2$	—	$\mu\text{V}/^{\circ}\text{C}$	$T_A = -10^{\circ}\text{C}$ to $+60^{\circ}\text{C}$
Power Supply Rejection	PSRR	70	76	—	dB	$V_{CM} = V_{SS}$
<b>Input Leakage Current and Impedance</b>						
Input Leakage Current	$I_{L1}$	-0.75	—	0.75	pA	Non Inverting Input only, $V_{IN} = V_{DD}$ or $V_{SS}$ $T_A = +60^{\circ}\text{C}$
		—	3.5	6		
Input Leakage Current	$I_{L2}$	-100	—	100	nA	Inverting input only
Common Mode Input Impedance	$Z_{CM}$	—	$10^{13}  6$	—	$\Omega  \text{pF}$	
Differential Input Impedance	$Z_{DIFF}$	—	$10^{13}  6$	—	$\Omega  \text{pF}$	
<b>Common Mode</b>						
Common-Mode Input Range	$V_{CMR}$	$V_{SS}$	—	$V_{DD}$	V	
Common-Mode Rejection Ratio	CMRR	62	86	—	dB	$V_{DD} = 5V$ , $V_{CM} = 0V$ to $5.0V$
<b>Open-Loop Gain</b>						
DC Open-Loop Gain (large signal)	$A_{OL}$	85	115	—	dB	$R_L = 50 \text{ k}\Omega$ to $V_L$ , $V_{OUT} = 0.1V$ to $V_{DD}-0.1V$
<b>Output</b>						
Maximum Output Voltage Swing	$V_{OL}, V_{OH}$	$V_{SS} + 10$	—	$V_{DD} - 10$	mV	$R_L = 50 \text{ k}\Omega$ to $V_L$ , 0.5V input overdrive
Output Short Circuit Current	$I_{SC}$	—	5	—	mA	$V_{DD} = 1.8V$
		—	27	—	mA	$V_{DD} = 5.5V$
<b>Power Supply</b>						
Supply Voltage	$V_{DD}$	1.8	—	5.5	V	
Quiescent Current per Amplifier	$I_Q$	0.3	0.6	1.0	$\mu\text{A}$	$I_O = 0$

## AC ELECTRICAL CHARACTERISTICS

**Electrical Characteristics:** Unless otherwise indicated,  $V_{DD} = +1.8V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ ,  $V_{CM} = V_{DD}/2$ ,  $V_{OUT} \approx V_{DD}/2$ ,  $V_L = V_{DD}/2$ ,  $R_L = 1\text{ M}\Omega$  to  $V_L$ , and  $C_L = 60\text{ pF}$  (refer to [Figure 1-1](#) and [Figure 1-2](#)).

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
<b>AC Response</b>						
Gain Bandwidth Product	GBWP	—	10	—	kHz	
Slew Rate	SR	—	3.0	—	V/ms	
Phase Margin	PM	—	65	—	°	$G = +1\text{ V/V}$
<b>Noise</b>						
Input Voltage Noise	$E_{ni}$	—	5.0	—	$\mu V_{P-P}$	$f = 0.1\text{ Hz to }10\text{ Hz}$
Input Voltage Noise Density	$e_{ni}$	—	170	—	$nV/\sqrt{Hz}$	$f = 1\text{ kHz}$
Input Current Noise Density	$i_{ni}$	—	0.6	—	$fA/\sqrt{Hz}$	$f = 1\text{ kHz}$

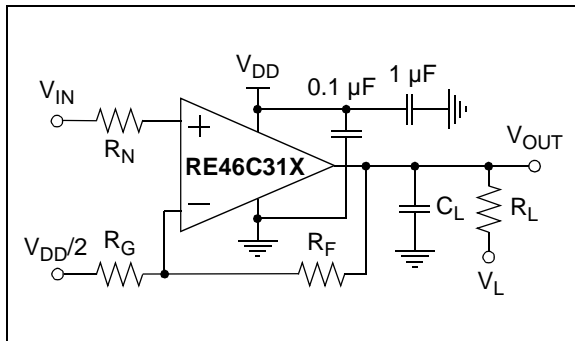
## TEMPERATURE CHARACTERISTICS

**Electrical Characteristics:** Unless otherwise indicated,  $V_{DD} = +1.8V$  to  $+5.5V$ ,  $V_{SS} = GND$ .

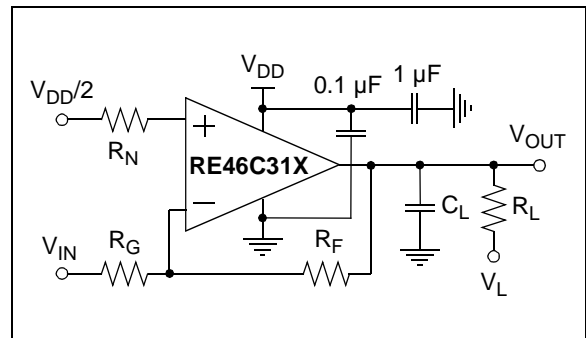
Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
<b>Temperature Ranges</b>						
Operating Temperature Range	$T_A$	-10	—	+60	°C	
Storage Temperature Range	$T_A$	-65	—	+150	°C	
<b>Thermal Package Resistances</b>						
Thermal Resistance, 8L-PDIP	$\theta_{JA}$	—	89.3	—	°C/W	
Thermal Resistance, 8L-SOIC	$\theta_{JA}$	—	149.5	—	°C/W	

### 1.1 Test Circuits

The test circuits used for the DC and AC tests are shown in [Figure 1-1](#) and [Figure 1-2](#). The bypass capacitors are laid out according to the rules discussed in [Section 4.5, Supply Bypass](#).



**FIGURE 1-1:** AC and DC Test Circuit for Most Non-Inverting Gain Conditions.



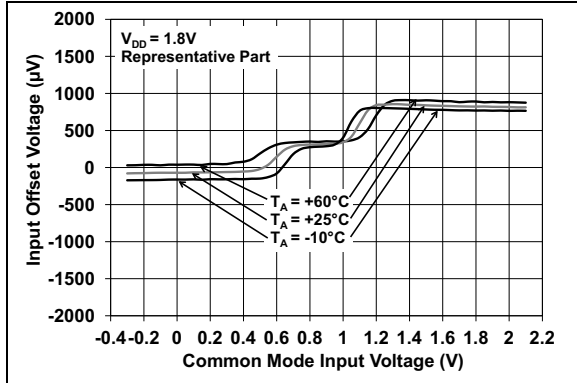
**FIGURE 1-2:** AC and DC Test Circuit for Most Inverting Gain Conditions.

# RE46C311/2

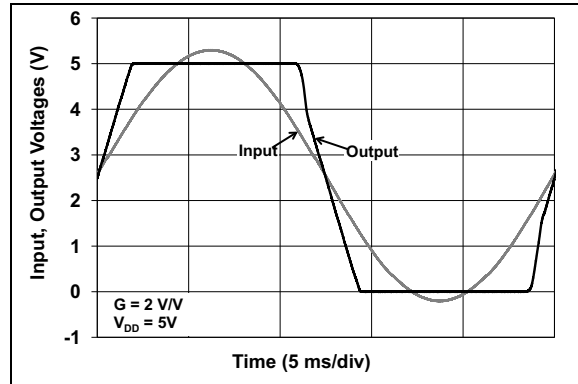
## 2.0 TYPICAL PERFORMANCE CURVES

**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

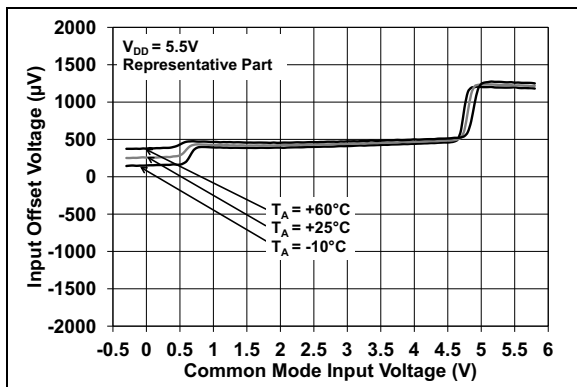
**Note:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = +1.8\text{V}$  to  $+5.5\text{V}$ ,  $V_{SS} = \text{GND}$ ,  $V_{CM} = V_{DD}/2$ ,  $V_{OUT} \approx V_{DD}/2$ ,  $V_L = V_{DD}/2$ ,  $R_L = 1\text{ M}\Omega$  to  $V_L$ , and  $C_L = 60\text{ pF}$ .



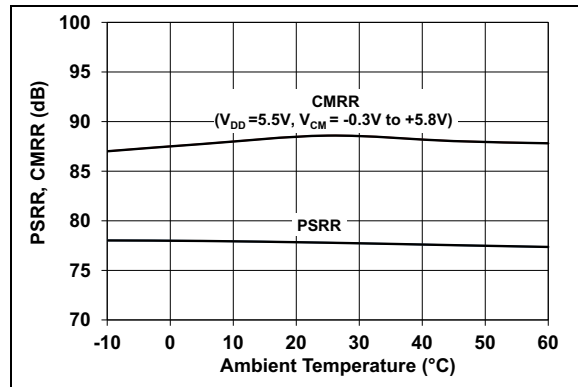
**FIGURE 2-1:** Input Offset Voltage vs. Common Mode Input Voltage with  $V_{DD} = 1.8\text{V}$ .



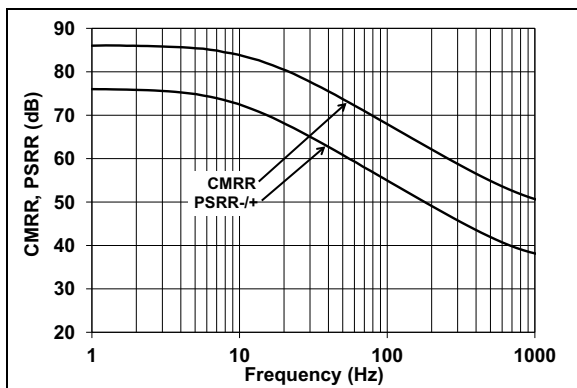
**FIGURE 2-4:** The RE46C311/2 Family Shows No Phase Reversal.



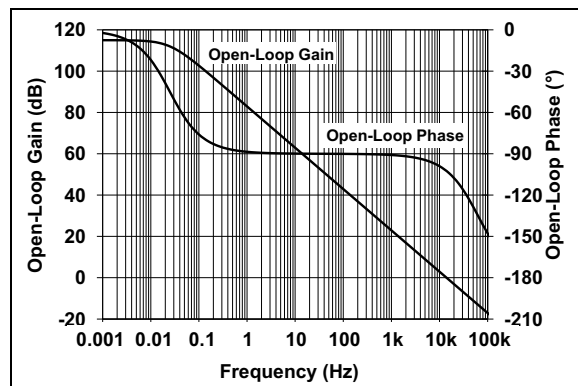
**FIGURE 2-2:** Input Offset Voltage vs. Common Mode Input Voltage with  $V_{DD} = 5.5\text{V}$ .



**FIGURE 2-5:** CMRR, PSRR vs. Ambient Temperature.

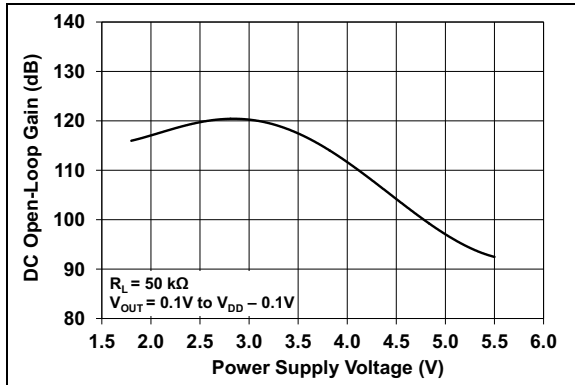


**FIGURE 2-3:** CMRR, PSRR vs. Frequency.

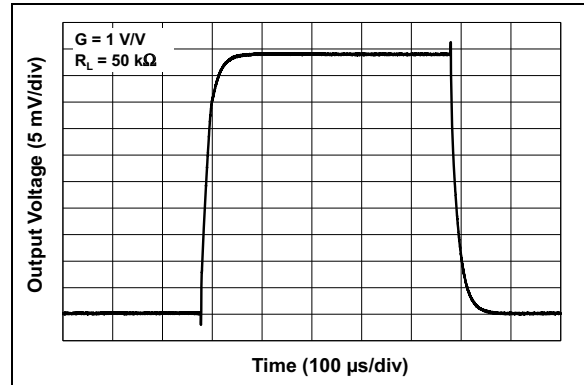


**FIGURE 2-6:** Open-Loop Gain, Phase vs. Frequency.

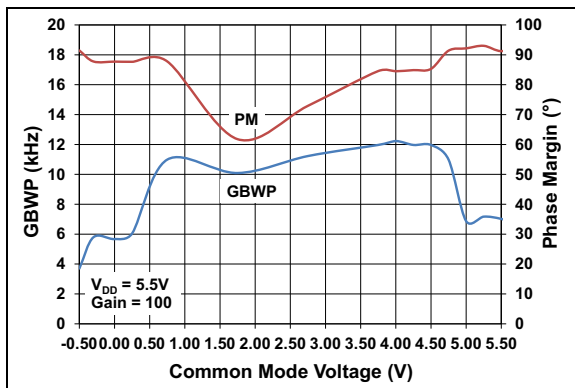
**Note:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = +1.8\text{V to } +5.5\text{V}$ ,  $V_{SS} = \text{GND}$ ,  $V_{CM} = V_{DD}/2$ ,  $V_{OUT} \approx V_{DD}/2$ ,  $V_L = V_{DD}/2$ ,  $R_L = 1\text{ M}\Omega$  to  $V_L$ , and  $C_L = 60\text{ pF}$ .



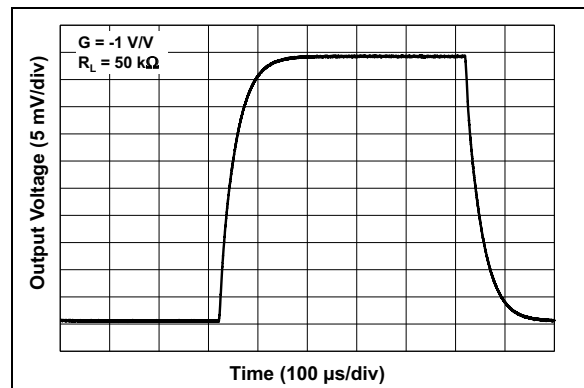
**FIGURE 2-7:** DC Open-Loop Gain vs. Power Supply Voltage.



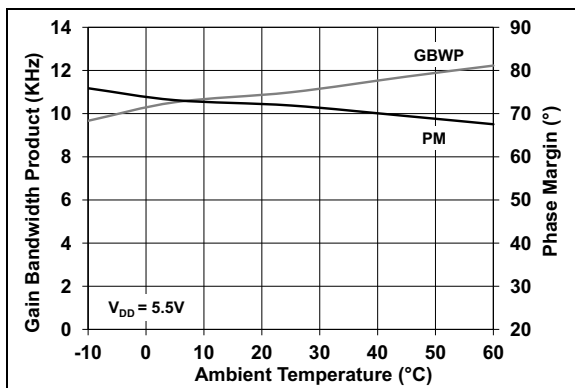
**FIGURE 2-10:** Small Signal Non-inverting Pulse Response.



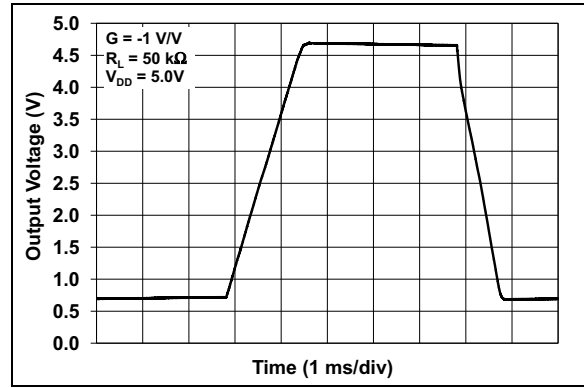
**FIGURE 2-8:** Gain Bandwidth Product, Phase Margin vs. Common Mode Input Voltage.



**FIGURE 2-11:** Small Signal Inverting Pulse Response.



**FIGURE 2-9:** Gain Bandwidth Product, Phase Margin vs. Ambient Temperature with  $V_{DD} = 5.5\text{V}$ .

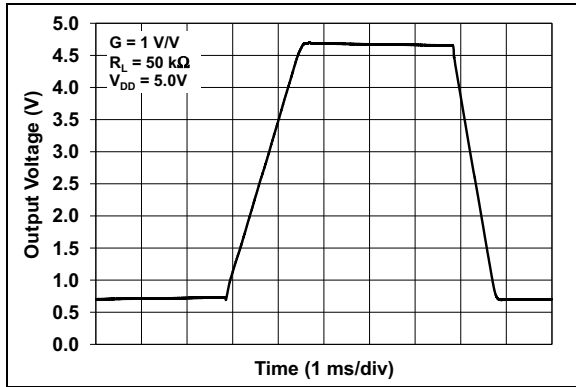


**FIGURE 2-12:** Large Signal Non-inverting Pulse Response.

# RE46C311/2

---

**Note:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = +1.8\text{V}$  to  $+5.5\text{V}$ ,  $V_{SS} = \text{GND}$ ,  $V_{CM} = V_{DD}/2$ ,  $V_{OUT} \approx V_{DD}/2$ ,  $V_L = V_{DD}/2$ ,  $R_L = 1\text{ M}\Omega$  to  $V_L$ , and  $C_L = 60\text{ pF}$ .



**FIGURE 2-13:** Large Signal Inverting Pulse Response.

## 3.0 PIN DESCRIPTIONS

Descriptions of the pins are listed in [Table 3-1](#).

**TABLE 3-1: PIN FUNCTION TABLE**

RE46C311	RE46C312	Symbol	Description
PDIP, SOIC	PDIP, SOIC,		
6	1	$V_{OUT}, V_{OUTA}$	Analog Output (op amp A)
2	2	$V_{IN-}, V_{INA-}$	Inverting Input (op amp A)
3	3	$V_{IN+}, V_{INA+}$	Non-inverting Input (op amp A)
7	8	$V_{DD}$	Positive Power Supply
—	5	$V_{INB+}$	Non-inverting Input (op amp B)
—	6	$V_{INB-}$	Inverting Input (op amp B)
—	7	$V_{OUTB}$	Analog Output (op amp B)
4	4	$V_{SS}$	Negative Power Supply
1, 5, 8	—	NC	No Internal Connection

### 3.1 Analog Outputs

The output pins are low-impedance voltage sources.

### 3.2 Analog Inputs

The non-inverting and inverting inputs are high-impedance CMOS inputs with low bias and leakage currents.

### 3.3 Power Supply Pins

The positive power supply pin ( $V_{DD}$ ) is 1.8V to 5.5V higher than the negative power supply pin ( $V_{SS}$ ). For normal operation, the other pins are at voltages between  $V_{SS}$  and  $V_{DD}$ .

Typically, these parts are used in a single (positive) supply configuration. In this case,  $V_{SS}$  is connected to ground and  $V_{DD}$  is connected to the supply.  $V_{DD}$  will need bypass capacitors.

# RE46C311/2

## 4.0 APPLICATIONS INFORMATION

The RE46C311/2 family of op amps is manufactured using a state of the art CMOS process. These op amps are unity gain stable and suitable for a wide range of general purpose, low-power applications.

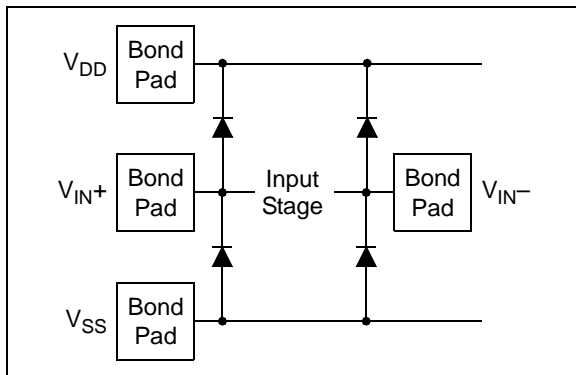
### 4.1 Rail-to-Rail Input

#### 4.1.1 PHASE REVERSAL

The RE46C311/2 op amps are designed to not exhibit phase inversion when the input pins exceed the supply voltages. Figure 2-4 shows an input voltage exceeding both supplies with no phase inversion.

#### 4.1.2 INPUT VOLTAGE AND CURRENT LIMITS

The ESD protection on the inputs can be depicted as shown in Figure 4-1. This structure was chosen to protect the input transistors and to minimize input bias current ( $I_B$ ). The input ESD diodes clamp the inputs when they try to go more than one diode drop below  $V_{SS}$  or one diode drop above  $V_{DD}$ .



**FIGURE 4-1:** Simplified Analog Input ESD Structures.

In order to prevent damage and/or improper operation of these amplifiers, the circuit must limit the currents (and voltages) at the input pins (see [Absolute Maximum Ratings †](#)).

A significant amount of current can flow out of the inputs (through the ESD diodes) when the common mode voltage ( $V_{CM}$ ) is below  $V_{SS}$  or above  $V_{DD}$ . Applications that are high-impedance may need to limit the usable voltage range.

#### 4.1.3 NORMAL OPERATION

The input stage of the RE46C311/2 op amps uses two differential input stages in parallel. One operates at a low common mode input voltage ( $V_{CM}$ ), while the other operates at a high  $V_{CM}$ . With this topology, the device operates with a  $V_{CM}$  up to  $V_{DD}$  and down to  $V_{SS}$ . The input offset voltage is measured at  $V_{CM} = V_{SS}$  and  $V_{DD}$  to ensure proper operation.

There are two transitions in input behavior as  $V_{CM}$  is changed. The first occurs when  $V_{CM}$  is near  $V_{SS} + 0.4V$ , and the second occurs when  $V_{CM}$  is near  $V_{DD} - 0.5V$  (see [Figure 2-1](#) and [Figure 2-2](#)). For the best distortion performance with non-inverting gains, avoid these regions of operation.

### 4.2 Rail-to-Rail Output

There are two specifications that describe the output swing capability of the RE46C311/2 family of op amps. The first specification (Maximum Output Voltage Swing) defines the absolute maximum swing that can be achieved under the specified load condition. Thus, the output voltage swings to within 10 mV of either supply rail with a 50 kΩ load to  $V_{DD}/2$ . Figure 2-4 shows how the output voltage is limited when the input goes beyond the linear region of operation.

The second specification that describes the output swing capability of these amplifiers is the Linear Output Voltage Range. This specification defines the maximum output swing that can be achieved while the amplifier still operates in its linear region. To verify linear operation in this range, the large signal DC Open-Loop Gain ( $A_{OL}$ ) is measured at points inside the supply rails. The measurement must meet the specified  $A_{OL}$  condition in the specification table.

### 4.3 Output Loads and Battery Life

The RE46C311/2 op amp family has outstanding quiescent current, which supports battery-powered applications.

Heavy resistive loads at the output can cause excessive battery drain. Driving a DC voltage of 2.5V across a 100 kΩ load resistor will cause the supply current to increase by 25 μA, depleting the battery 43 times as fast as  $I_Q$  (0.6 μA, typical) alone.

High frequency signals (fast edge rate) across capacitive loads will also significantly increase supply current. For instance, a 0.1 μF capacitor at the output presents an AC impedance of 15.9 kΩ ( $1/2\pi fC$ ) to a 100 Hz sine wave. It can be shown that the average power drawn from the battery by a 5.0  $V_{p-p}$  sine wave (1.77  $V_{rms}$ ), under these conditions, is:

#### EQUATION 4-1:

$$\begin{aligned}
 P_{Supply} &= (V_{DD} - V_{SS})(I_Q + V_{L(p-p)}fC_L) \\
 &= (5V)(0.6 \mu A + 5.0V_{p-p} \cdot 100Hz \cdot 0.1\mu F) \\
 &= 3.0 \mu W + 50 \mu W
 \end{aligned}$$

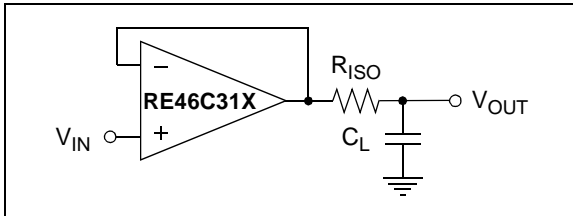
This will drain the battery 17 times as fast as  $I_Q$  alone.



## 4.4 Capacitive Loads

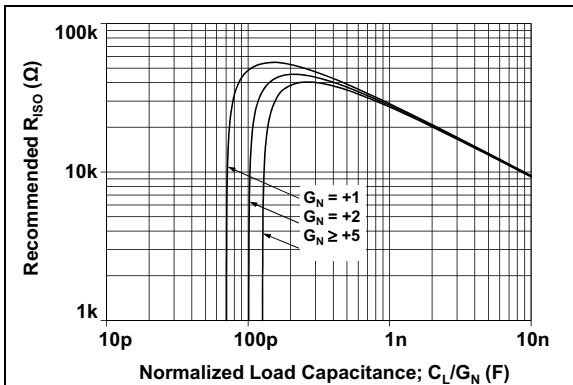
Driving large capacitive loads can cause stability problems for voltage feedback op amps. As the load capacitance increases, the feedback loop's phase margin decreases and the closed-loop bandwidth is reduced. This produces gain peaking in the frequency response, with overshoot and ringing in the step response. A unity gain buffer ( $G = +1$ ) is the most sensitive to capacitive loads, although all gains show the same general behavior.

When driving large capacitive loads with these op amps (e.g.,  $> 60$  pF when  $G = +1$ ), a small series resistor at the output ( $R_{ISO}$  in Figure 4-2) improves the feedback loop's phase margin (stability) by making the output load resistive at higher frequencies. The bandwidth will be generally lower than the bandwidth with no capacitive load.



**FIGURE 4-2:** Output Resistor,  $R_{ISO}$ , Stabilizes Large Capacitive Loads.

Figure 4-3 gives recommended  $R_{ISO}$  values for different capacitive loads and gains. The x-axis is the normalized load capacitance ( $C_L/G_N$ ), where  $G_N$  is the circuit's noise gain. For non-inverting gains,  $G_N$  and the Signal Gain are equal. For inverting gains,  $G_N$  is  $1 + |\text{Signal Gain}|$  (e.g.,  $-1$  V/V gives  $G_N = +2$  V/V).



**FIGURE 4-3:** Recommended  $R_{ISO}$  Values for Capacitive Loads.

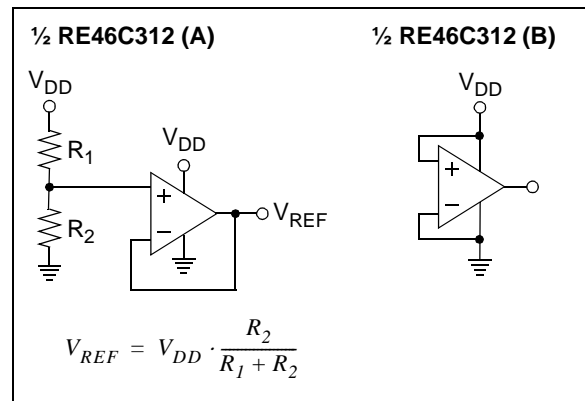
After selecting  $R_{ISO}$  for your circuit, double check the resulting frequency response peaking and step response overshoot. Modify  $R_{ISO}$ 's value until the response is reasonable.

## 4.5 Supply Bypass

With this family of operational amplifiers, the power supply pin ( $V_{DD}$  for single supply) should have a local bypass capacitor (i.e.,  $0.01$   $\mu\text{F}$  to  $0.1$   $\mu\text{F}$ ) within 2 mm for good high-frequency performance. It can use a bulk capacitor (i.e.,  $1$   $\mu\text{F}$  or larger) within 100 mm to provide large, slow currents. This bulk capacitor is not required for most applications and can be shared with nearby analog parts.

## 4.6 Unused Op Amps

An unused op amp in a dual package (RE46C312) should be configured as shown in Figure 4-4. These circuits prevent the output from toggling and causing crosstalk. Circuit A sets the op amp at its minimum noise gain. The resistor divider produces any desired reference voltage within the output voltage range of the op amp; the op amp buffers that reference voltage. Circuit B uses the minimum number of components and operates as a comparator, but it may draw more current.



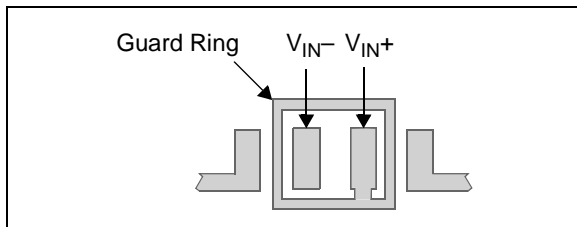
**FIGURE 4-4:** Unused Op Amps.

# RE46C311/2

## 4.7 PCB Surface Leakage

In applications where low input bias current is critical, printed circuit board (PCB) surface leakage effects need to be considered. Surface leakage is caused by humidity, dust or other contamination on the board. Under low humidity conditions, a typical resistance between nearby traces is  $10^{12}\Omega$ . A 5V difference would cause 5 pA of current to flow, which is greater than the RE46C311/2 family's leakage current at +25°C.

The easiest way to reduce surface leakage is to use a guard ring around sensitive pins (or traces). The guard ring is biased at the same voltage as the sensitive pin. [Figure 4-5](#) shows an example of this type of layout.



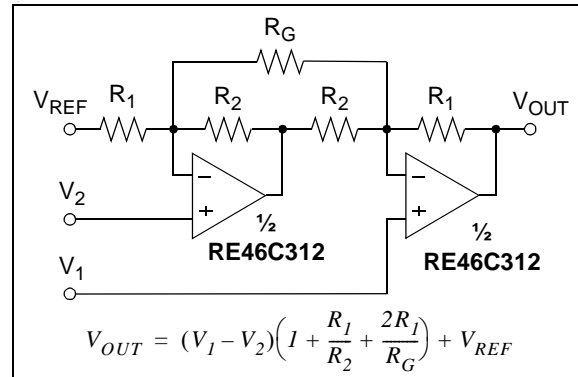
**FIGURE 4-5:** Example Guard Ring Layout for Inverting Gain.

1. Non-inverting Gain and Unity Gain Buffer:
  - a) Connect the non-inverting pin ( $V_{IN+}$ ) to the input with a wire that does not touch the PCB surface.
  - b) Connect the guard ring to the inverting input pin ( $V_{IN-}$ ). This biases the guard ring to the Common mode input voltage.
2. Inverting Gain and Transimpedance Gain (convert current to voltage, such as photo detectors) amplifiers:
  - a) Connect the guard ring to the non-inverting input pin ( $V_{IN+}$ ). This biases the guard ring to the same reference voltage as the op amp (e.g.,  $V_{DD}/2$  or ground).
  - b) Connect the inverting pin ( $V_{IN-}$ ) to the input with a wire that does not touch the PCB surface.

## 4.8 Application Circuits

### 4.8.1 INSTRUMENTATION AMPLIFIER

The RE46C311/2 op amp is well suited for conditioning sensor signals in battery-powered applications. [Figure 4-6](#) shows a two op amp instrumentation amplifier, using the RE46C312, that works well for applications requiring rejection of Common mode noise at higher gains. The reference voltage ( $V_{REF}$ ) is supplied by a low impedance source. In single supply applications,  $V_{REF}$  is typically  $V_{DD}/2$ .



**FIGURE 4-6:** Two Op Amp Instrumentation Amplifier.

## 5.0 DESIGN AIDS

Microchip provides the basic design tools needed for the RE46C311/2 family of op amps.

### 5.1 Microchip Advanced Part Selector (MAPS)

MAPS is a software tool that helps semiconductor professionals efficiently identify Microchip devices that fit a particular design requirement. Available at no cost from the Microchip website at [www.microchip.com/maps](http://www.microchip.com/maps), the MAPS is an overall selection tool for Microchip's product portfolio that includes Analog, Memory, MCUs and DSCs.

Using this tool you can define a filter to sort features for a parametric search of devices and export side-by-side technical comparison reports. Helpful links are also provided for data sheets, purchase, and sampling of Microchip parts.

### 5.2 Analog Demonstration and Evaluation Boards

Microchip offers a broad spectrum of Analog Demonstration and Evaluation Boards that are designed to help you achieve faster time to market. For a complete listing of these boards and their corresponding user's guides and technical information, visit the Microchip web site at [www.microchip.com/analogtools](http://www.microchip.com/analogtools).

Three of our boards that are especially useful are:

- **P/N SOIC8EV:** *8-Pin SOIC/MSOP/TSSOP/DIP Evaluation Board*
- **P/N SOIC14EV:** *14-Pin SOIC/TSSOP/DIP Evaluation Board*
- **P/N MCP651EV-VOS:** *MCP651 Input Offset Evaluation Board*

## 5.3 Application Notes

The following Microchip Application Notes are available on the Microchip web site at [www.microchip.com/appnotes](http://www.microchip.com/appnotes) and are recommended as supplemental reference resources.

**ADN003:** *"Select the Right Operational Amplifier for your Filtering Circuits"*, DS21821

**AN722:** *"Operational Amplifier Topologies and DC Specifications"*, DS00722

**AN723:** *"Operational Amplifier AC Specifications and Applications"*, DS00723

**AN884:** *"Driving Capacitive Loads With Op Amps"*, DS00884

**AN990:** *"Analog Sensor Conditioning Circuits – An Overview"*, DS00990

These application notes and others are listed in the design guide:

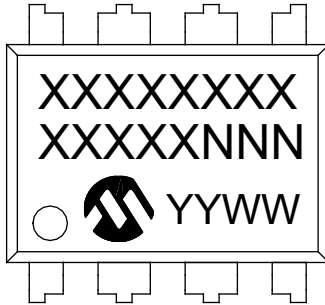
*"Signal Chain Design Guide"*, DS21825

# RE46C311/2

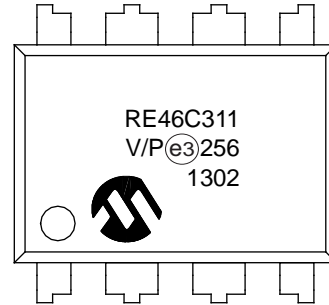
## 6.0 PACKAGING INFORMATION

### 6.1 Package Marking Information

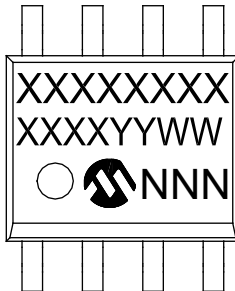
8-Lead PDIP (300 mil)



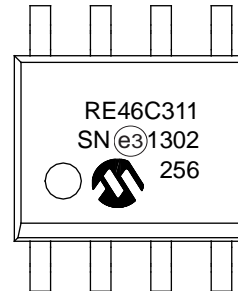
Example



8-Lead SOIC (3.90 mm)



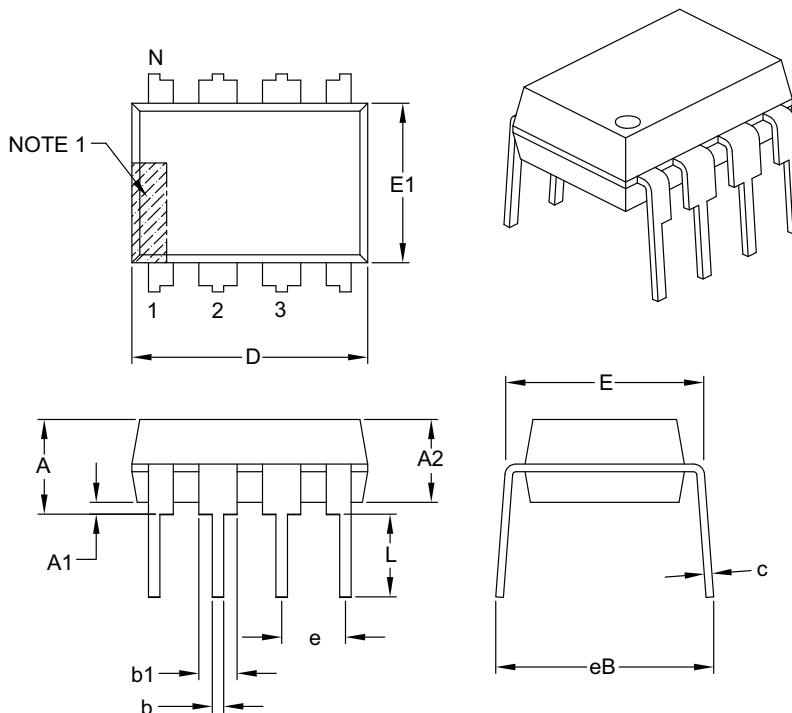
Example



<b>Legend:</b>	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	(e3)	Alphanumeric traceability code
	*	Pb-free JEDEC designator for Matte Tin (Sn)
		This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.
<b>Note:</b>	In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.	

## 8-Lead Plastic Dual In-Line (P) – 300 mil Body [PDIP]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Dimension Limits	Units	INCHES		
		MIN	NOM	MAX
Number of Pins	N	8		
Pitch	e	.100 BSC		
Top to Seating Plane	A	–	–	.210
Molded Package Thickness	A2	.115	.130	.195
Base to Seating Plane	A1	.015	–	–
Shoulder to Shoulder Width	E	.290	.310	.325
Molded Package Width	E1	.240	.250	.280
Overall Length	D	.348	.365	.400
Tip to Seating Plane	L	.115	.130	.150
Lead Thickness	c	.008	.010	.015
Upper Lead Width	b1	.040	.060	.070
Lower Lead Width	b	.014	.018	.022
Overall Row Spacing §	eB	–	–	.430

**Notes:**

- Pin 1 visual index feature may vary, but must be located with the hatched area.
- § Significant Characteristic.
- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
- Dimensioning and tolerancing per ASME Y14.5M.

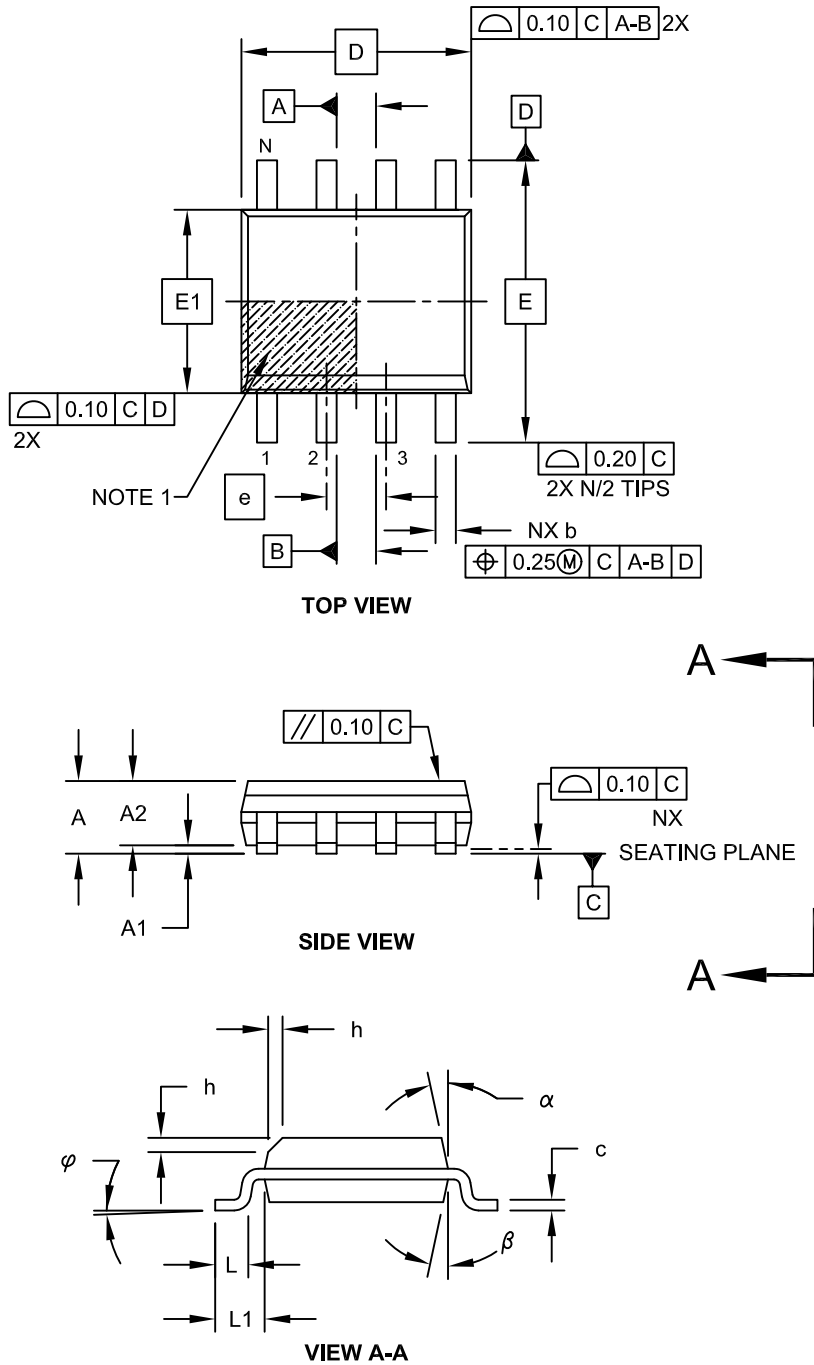
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-018B

# RE46C311/2

## 8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm Body [SOIC]

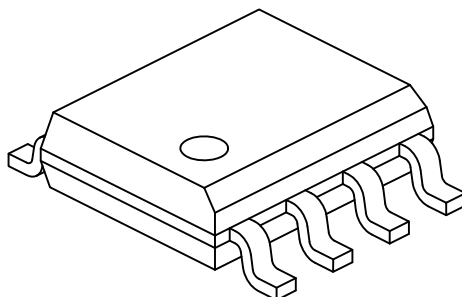
**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing No. C04-057C Sheet 1 of 2

## 8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm Body [SOIC]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Number of Pins	N	8		
Pitch	e	1.27 BSC		
Overall Height	A	-	-	1.75
Molded Package Thickness	A2	1.25	-	-
Standoff §	A1	0.10	-	0.25
Overall Width	E	6.00 BSC		
Molded Package Width	E1	3.90 BSC		
Overall Length	D	4.90 BSC		
Chamfer (Optional)	h	0.25	-	0.50
Foot Length	L	0.40	-	1.27
Footprint	L1	1.04 REF		
Foot Angle	φ	0°	-	8°
Lead Thickness	c	0.17	-	0.25
Lead Width	b	0.31	-	0.51
Mold Draft Angle Top	α	5°	-	15°
Mold Draft Angle Bottom	β	5°	-	15°

**Notes:**

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
4. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

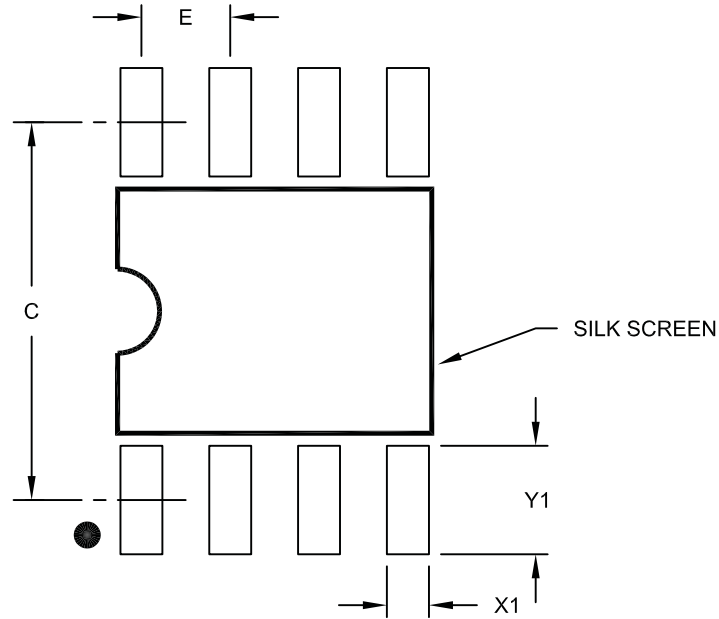
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing No. C04-057C Sheet 2 of 2

# RE46C311/2

## 8-Lead Plastic Small Outline (SN) – Narrow, 3.90 mm Body [SOIC]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packages>



RECOMMENDED LAND PATTERN

		Units	MILLIMETERS		
Dimension Limits			MIN	NOM	MAX
Contact Pitch	E		1.27 BSC		
Contact Pad Spacing	C			5.40	
Contact Pad Width (X8)	X1				0.60
Contact Pad Length (X8)	Y1				1.55

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2057A



## APPENDIX A: REVISION HISTORY

### Revision A (May 2013)

- Original Release of this Document.

# RE46C311/2

---

NOTES:

## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	X	X	X												
Device	Package	Number of Pins	Lead Free/ Tape and Reel												
<table border="1" style="width: 100%;"> <tr> <td style="width: 15%;"><b>Device:</b></td> <td>RE46C311:</td> <td>Single Low-Input Leakage Op Amp</td> </tr> <tr> <td></td> <td>RE46C312:</td> <td>Dual Low-Input Leakage Op Amp</td> </tr> <tr> <td><b>Package:</b></td> <td>E</td> <td>= Plastic Dual In-Line (300 mil Body), 8-lead (PDIP)</td> </tr> <tr> <td></td> <td>S</td> <td>= Small Plastic Outline - Narrow, 3.90 mm Body, 8-Lead (SOIC)</td> </tr> </table>				<b>Device:</b>	RE46C311:	Single Low-Input Leakage Op Amp		RE46C312:	Dual Low-Input Leakage Op Amp	<b>Package:</b>	E	= Plastic Dual In-Line (300 mil Body), 8-lead (PDIP)		S	= Small Plastic Outline - Narrow, 3.90 mm Body, 8-Lead (SOIC)
<b>Device:</b>	RE46C311:	Single Low-Input Leakage Op Amp													
	RE46C312:	Dual Low-Input Leakage Op Amp													
<b>Package:</b>	E	= Plastic Dual In-Line (300 mil Body), 8-lead (PDIP)													
	S	= Small Plastic Outline - Narrow, 3.90 mm Body, 8-Lead (SOIC)													
<b>Examples:</b>															
a)	RE46C311E8F:	8LD PDIP package, RoHS Compliant													
b)	RE46C311S8F:	8LD SOIC package, RoHS Compliant													
c)	RE46C311S8TF:	8LD SOIC package, Tape and Reel													
a)	RE46C312E8F:	8LD PDIP package, RoHS Compliant													
b)	RE46C312S8F:	8LD SOIC package, RoHS Compliant													
c)	RE46C312S8TF:	8LD SOIC package, Tape and Reel													

# RE46C311/2

---

NOTES:

---

**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

---

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

#### **Trademarks**

The Microchip name and logo, the Microchip logo, dsPIC, FlashFlex, KEELOQ, KEELOQ logo, MPLAB, PIC, PICmicro, PICSTART, PIC<sup>32</sup> logo, rPIC, SST, SST Logo, SuperFlash and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MTP, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

Analog-for-the-Digital Age, Application Maestro, BodyCom, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniscent Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICkit, PICtail, REAL ICE, rLAB, Select Mode, SQI, Serial Quad I/O, Total Endurance, TSHARC, UniWinDriver, WiperLock, ZENA and Z-Scale are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

GestIC and ULPP are registered trademarks of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2013, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.

ISBN: 978-1-62077-236-2

*Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC<sup>®</sup> MCUs and dsPIC<sup>®</sup> DSCs, KEELOQ<sup>®</sup> code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.*

---

**QUALITY MANAGEMENT SYSTEM**  
**CERTIFIED BY DNV**  
**== ISO/TS 16949 ==**



# MICROCHIP

## Worldwide Sales and Service

### AMERICAS

**Corporate Office**  
2355 West Chandler Blvd.  
Chandler, AZ 85224-6199  
Tel: 480-792-7200  
Fax: 480-792-7277  
Technical Support:  
<http://www.microchip.com/support>  
Web Address:  
[www.microchip.com](http://www.microchip.com)

**Atlanta**  
Duluth, GA  
Tel: 678-957-9614  
Fax: 678-957-1455

**Boston**  
Westborough, MA  
Tel: 774-760-0087  
Fax: 774-760-0088

**Chicago**  
Itasca, IL  
Tel: 630-285-0071  
Fax: 630-285-0075

**Cleveland**  
Independence, OH  
Tel: 216-447-0464  
Fax: 216-447-0643

**Dallas**  
Addison, TX  
Tel: 972-818-7423  
Fax: 972-818-2924

**Detroit**  
Farmington Hills, MI  
Tel: 248-538-2250  
Fax: 248-538-2260

**Indianapolis**  
Noblesville, IN  
Tel: 317-773-8323  
Fax: 317-773-5453

**Los Angeles**  
Mission Viejo, CA  
Tel: 949-462-9523  
Fax: 949-462-9608

**Santa Clara**  
Santa Clara, CA  
Tel: 408-961-6444  
Fax: 408-961-6445

**Toronto**  
Mississauga, Ontario,  
Canada  
Tel: 905-673-0699  
Fax: 905-673-6509

### ASIA/PACIFIC

**Asia Pacific Office**  
Suites 3707-14, 37th Floor  
Tower 6, The Gateway  
Harbour City, Kowloon  
Hong Kong  
Tel: 852-2401-1200  
Fax: 852-2401-3431

**Australia - Sydney**  
Tel: 61-2-9868-6733  
Fax: 61-2-9868-6755

**China - Beijing**  
Tel: 86-10-8569-7000  
Fax: 86-10-8528-2104

**China - Chengdu**  
Tel: 86-28-8665-5511  
Fax: 86-28-8665-7889

**China - Chongqing**  
Tel: 86-23-8980-9588  
Fax: 86-23-8980-9500

**China - Hangzhou**  
Tel: 86-571-2819-3187  
Fax: 86-571-2819-3189

**China - Hong Kong SAR**  
Tel: 852-2943-5100  
Fax: 852-2401-3431

**China - Nanjing**  
Tel: 86-25-8473-2460  
Fax: 86-25-8473-2470

**China - Qingdao**  
Tel: 86-532-8502-7355  
Fax: 86-532-8502-7205

**China - Shanghai**  
Tel: 86-21-5407-5533  
Fax: 86-21-5407-5066

**China - Shenyang**  
Tel: 86-24-2334-2829  
Fax: 86-24-2334-2393

**China - Shenzhen**  
Tel: 86-755-8864-2200  
Fax: 86-755-8203-1760

**China - Wuhan**  
Tel: 86-27-5980-5300  
Fax: 86-27-5980-5118

**China - Xian**  
Tel: 86-29-8833-7252  
Fax: 86-29-8833-7256

**China - Xiamen**  
Tel: 86-592-2388138  
Fax: 86-592-2388130

**China - Zhuhai**  
Tel: 86-756-3210040  
Fax: 86-756-3210049

### ASIA/PACIFIC

**India - Bangalore**  
Tel: 91-80-3090-4444  
Fax: 91-80-3090-4123

**India - New Delhi**  
Tel: 91-11-4160-8631  
Fax: 91-11-4160-8632

**India - Pune**  
Tel: 91-20-2566-1512  
Fax: 91-20-2566-1513

**Japan - Osaka**  
Tel: 81-6-6152-7160  
Fax: 81-6-6152-9310

**Japan - Tokyo**  
Tel: 81-3-6880-3770  
Fax: 81-3-6880-3771

**Korea - Daegu**  
Tel: 82-53-744-4301  
Fax: 82-53-744-4302

**Korea - Seoul**  
Tel: 82-2-554-7200  
Fax: 82-2-558-5932 or  
82-2-558-5934

**Malaysia - Kuala Lumpur**  
Tel: 60-3-6201-9857  
Fax: 60-3-6201-9859

**Malaysia - Penang**  
Tel: 60-4-227-8870  
Fax: 60-4-227-4068

**Philippines - Manila**  
Tel: 63-2-634-9065  
Fax: 63-2-634-9069

**Singapore**  
Tel: 65-6334-8870  
Fax: 65-6334-8850

**Taiwan - Hsin Chu**  
Tel: 886-3-5778-366  
Fax: 886-3-5770-955

**Taiwan - Kaohsiung**  
Tel: 886-7-213-7828  
Fax: 886-7-330-9305

**Taiwan - Taipei**  
Tel: 886-2-2508-8600  
Fax: 886-2-2508-0102

**Thailand - Bangkok**  
Tel: 66-2-694-1351  
Fax: 66-2-694-1350

### EUROPE

**Austria - Wels**  
Tel: 43-7242-2244-39  
Fax: 43-7242-2244-393

**Denmark - Copenhagen**  
Tel: 45-4450-2828  
Fax: 45-4485-2829

**France - Paris**  
Tel: 33-1-69-53-63-20  
Fax: 33-1-69-30-90-79

**Germany - Munich**  
Tel: 49-89-627-144-0  
Fax: 49-89-627-144-44

**Italy - Milan**  
Tel: 39-0331-742611  
Fax: 39-0331-466781

**Netherlands - Drunen**  
Tel: 31-416-690399  
Fax: 31-416-690340

**Spain - Madrid**  
Tel: 34-91-708-08-90  
Fax: 34-91-708-08-91

**UK - Wokingham**  
Tel: 44-118-921-5869  
Fax: 44-118-921-5820

11/29/12