



## MIC861

### Teeny™ Ultra-Low-Power Op Amp

#### General Description

The MIC861 is a rail-to-rail output, input common-mode to ground, operational amplifier in Teeny™ SC70 packaging. The MIC861 provides a 400kHz gain-bandwidth product while consuming an incredibly low 4.6µA supply current.

The SC70 packaging achieves significant board space savings over devices packaged in SOT-23 or MSOP-8 packaging. The SC70 occupies approximately half the board area of a SOT-23 package.

Datasheets and support documentation are available on Micrel's website at: [www.micrel.com](http://www.micrel.com).

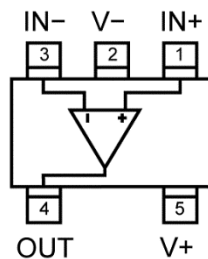
#### Features

- Teeny™ SC70 packaging
- 400kHz gain-bandwidth product
- 650kHz, -3dB bandwidth
- 4.6µA supply current
- Rail-to-rail output
- Ground sensing at input (common mode to GND)
- Drives large capacitive loads (1000pF)
- Unity gain stable

#### Applications

- Portable equipment
- PDAs
- Pagers
- Cordless phones
- Consumer electronics

#### Functional Pinout



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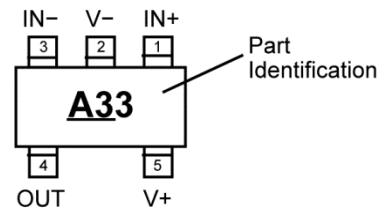
## Ordering Information

| Part Number | Marking <sup>(1)</sup> | Ambient Temperature Range | Package    |
|-------------|------------------------|---------------------------|------------|
| MIC861YC5   | A33                    | -40° to +85°C             | 5-Pin SC70 |

### Note:

- Underbar marking may not be to scale.

## Pin Configuration



5-Pin SC70 (C5)  
(Top View)

## Pin Description

| Pin Number | Pin Name | Pin Function   |
|------------|----------|--|
| 1          | IN+      | Non-inverting input.   |
| 2          | V-       | Negative power supply connection. Connect a 10 $\mu$ F and 0.1 $\mu$ F capacitor in parallel to this pin for power supply bypassing. |
| 3          | IN-      | Inverting input.   |
| 4          | OUT      | Output of operational amplifier.   |
| 5          | V+       | Positive power supply input. Connect a 10 $\mu$ F and 0.1 $\mu$ F capacitor in parallel to this pin for power supply bypassing.      |

### Absolute Maximum Ratings<sup>(2)</sup>

|  |                          |
|--|--------------------------|
| Supply Voltage ( $V_{V+} - V_{V-}$ ).....              | +6.0V                    |
| Differential Input Voltage $ V_{IN+} - V_{IN-} $ ..... | +6.0V                    |
| Input Voltage ( $V_{IN+} - V_{IN-}$ ).....             | $V_+ + 0.3V, V_- - 0.3V$ |
| Lead Temperature (soldering, 5s).....                  | 260°C                    |
| Output Short Circuit Current Duration.....             | Indefinite               |
| Storage Temperature ( $T_s$ ).....                     | 150°C                    |
| ESD Rating.....  | Note 4                   |

### Operating Ratings<sup>(3)</sup>

|  |                  |
|--|------------------|
| Supply Voltage ( $V_{V+} - V_{V-}$ ) ..... | +2.43V to +5.25V |
| Ambient Temperature ( $T_A$ ) .....        | -40°C to +85°C   |
| Junction Thermal Resistance                |                  |
| 5-Pin SC70 ( $\Theta_{JA}$ ) .....         | 450°C/W          |

### Electrical Characteristics<sup>(5)</sup>

$V_+ = +2.7V, V_- = 0V, V_{CM} = V_+/2; R_L = 500k\Omega$  to  $V_+/2; T_A = 25^\circ C$ , **bold** values indicate  $-40^\circ C \leq T_A \leq +85^\circ C$ , unless noted.

| Symbol    | Parameter                                    | Condition                                     | Min.                          | Typ.                  | Max.                          | Units            |
|-----------|--|---|-------------------------------|-----------------------|-------------------------------|------------------|
| $V_{OS}$  | Input Offset Voltage                         | Note 6  | <b>-10</b>                    | 2                     | <b>10</b>                     | mV               |
|           | Input Offset Voltage Temperature Coefficient |   |                               | 15                    |                               | $\mu V/^\circ C$ |
| $I_B$     | Input Bias Current                           |   |                               | 20                    |                               | pA               |
| $I_{OS}$  | Input Offset Current                         |   |                               | 10                    |                               | pA               |
| $V_{CM}$  | Input Voltage Range                          | CMRR >60dB                                    |                               | 1.8                   |                               | V                |
| CMRR      | Common Mode Rejection Ratio                  | $0 < V_{CM} < 1.35V$                          | <b>45</b>                     | 77                    |                               | dB               |
| PSRR      | Power Supply Rejection Ratio                 | Supply voltage change of 3V                   | <b>50</b>                     | 83                    |                               | dB               |
| $A_{VOL}$ | Large Signal Voltage Gain                    | $R_L = 100k\Omega, V_{OUT} = 2V$ peak-to-peak | <b>60</b>                     | 74                    |                               | dB               |
|           |  | $R_L = 500k\Omega, V_{OUT} = 2V$ peak-to-peak | <b>73</b>                     | 83                    |                               | dB               |
| $V_{OUT}$ | Maximum Output Voltage Swing                 | $R_L = 500k\Omega$                            | <b>V <math>\pm 2mV</math></b> | $\frac{V}{\pm 0.7mV}$ |                               | V                |
| $V_{OUT}$ | Minimum Output Voltage Swing                 | $R_L = 500k\Omega$                            |                               | $\frac{V}{\pm 0.2mV}$ | <b>V <math>\pm 2mV</math></b> | V                |
| GBW       | Gain-Bandwidth Product                       | $R_L = 200k\Omega, C_L = 2pF, V_{OUT} = 0$    |                               | 350                   |                               | kHz              |
| BW        | -3dB Bandwidth                               | $A_V = 1, C_L = 2pF, R_L = 1M\Omega$          |                               | 500                   |                               | kHz              |
| SR        | Slew Rate                                    | $A_V = 1, C_L = 2pF, R_L = 1M\Omega$          |                               | 0.12                  |                               | V/ $\mu s$       |
| $I_{SC}$  | Short-Circuit Output Current                 | Source  |                               | 6                     |                               | mA               |
|           |  | Sink  |                               | 5                     |                               | mA               |
| $I_S$     | Supply Current                               | No load                                       |                               | 4.2                   | <b>9</b>                      | $\mu A$          |

**Notes:**

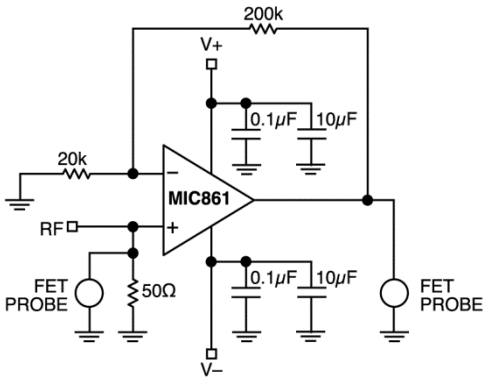
- Exceeding the absolute maximum ratings may damage the device.
- The device is not guaranteed to function outside its operating ratings.
- Devices are ESD sensitive. Handling precautions are recommended. Human body model, 1.5k $\Omega$  in series with 100pF. Pin 4 is ESD sensitive.
- Specification for packaged product only. Exceeding the maximum differential input voltage will damage the input stage and degrade performance (in particular, input bias will likely increase).
- The offset voltage distribution is centered around 0V. The typical offset number shown is equal to the standard deviation of the voltage offset distribution.

## Electrical Characteristics<sup>(5)</sup> (Continued)

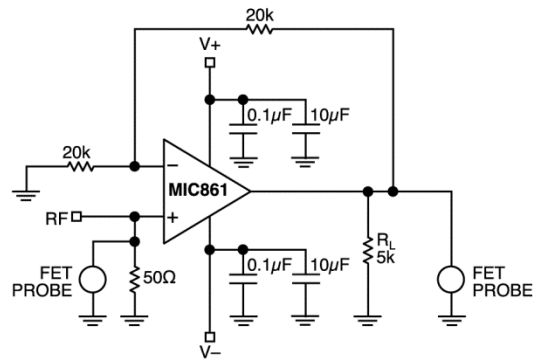
V<sub>+</sub> = +5V, V<sub>-</sub> = 0V, V<sub>CM</sub> = V<sub>+</sub>/2; R<sub>L</sub> = 500kΩ to V<sub>+</sub>/2; T<sub>A</sub> = 25°C, **bold** values indicate -40°C ≤ T<sub>A</sub> ≤ +85°C, unless noted.

| Symbol           | Parameter                                    | Condition  | Min.          | Typ.                  | Max.          | Units |
|------------------|--|--|---------------|-----------------------|---------------|-------|
| V <sub>OS</sub>  | Input Offset Voltage                         | Note 6   | <b>-10</b>    | 2                     | <b>10</b>     | mV    |
|                  | Input Offset Voltage Temperature Coefficient |  |               | 15                    |               | μV/°C |
| I <sub>B</sub>   | Input Bias Current                           |  |               | 20                    |               | pA    |
| I <sub>OS</sub>  | Input Offset Current                         |  |               | 10                    |               | pA    |
| V <sub>CM</sub>  | Input Voltage Range                          | CMRR >60dB   |               | 4.2                   |               | V     |
| CMRR             | Common Mode Rejection Ratio                  | 0 < V <sub>CM</sub> < 3.5V   | <b>60</b>     | 80                    |               | dB    |
| PSRR             | Power Supply Rejection Ratio                 | Supply voltage change of 1V  | <b>45</b>     | 85                    |               | dB    |
| A <sub>VOL</sub> | Large Signal Voltage Gain                    | R <sub>L</sub> = 100kΩ, V <sub>OUT</sub> = 4V peak-to-peak         | <b>60</b>     | 76                    |               | dB    |
|                  |  | R <sub>L</sub> = 500kΩ, V <sub>OUT</sub> = 4V peak-to-peak         | <b>68</b>     | 83                    |               | dB    |
| V <sub>OUT</sub> | Maximum Output Voltage Swing                 | R <sub>L</sub> = 500kΩ   | <b>V ±2mV</b> | $\frac{V}{\pm 0.7mV}$ |               | V     |
| V <sub>OUT</sub> | Minimum Output Voltage Swing                 | R <sub>L</sub> = 500kΩ   |               | $\frac{V}{\pm 0.7mV}$ | <b>V ±2mV</b> | V     |
| GBW              | Gain-Bandwidth Product                       | R <sub>L</sub> = 200kΩ, C <sub>L</sub> = 2pF, V <sub>OUT</sub> = 0 |               | 400                   |               | kHz   |
| BW               | -3dB Bandwidth                               | A <sub>V</sub> = 1, C <sub>L</sub> = 2pF, R <sub>L</sub> = 1MΩ     |               | 650                   |               | kHz   |
| SR               | Slew Rate                                    | A <sub>V</sub> = 1, C <sub>L</sub> = 2pF, R <sub>L</sub> = 1MΩ     |               | 0.12                  |               | V/μs  |
| I <sub>SC</sub>  | Short-Circuit Output Current                 | Source   | <b>10</b>     | 24                    |               | mA    |
|                  |  | Sink   | <b>10</b>     | 24                    |               | mA    |
| I <sub>S</sub>   | Supply Current                               | No load  |               | 4.6                   | <b>9</b>      | μA    |

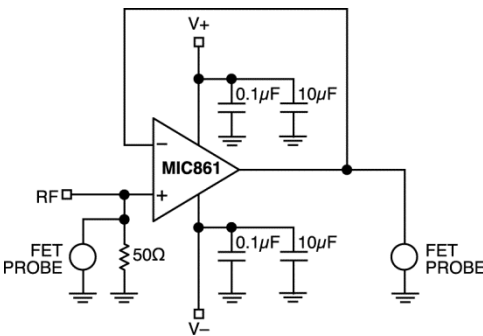
## Test Circuits



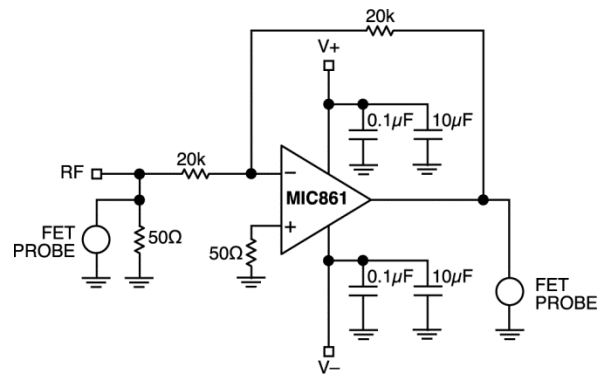
**Test Circuit 1.  $A_v = 11$**



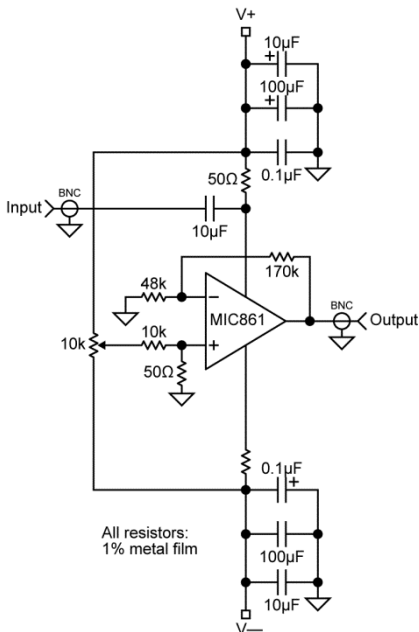
**Test Circuit 2.  $A_v = 2$**



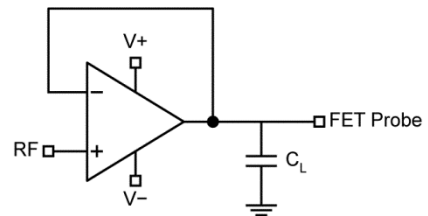
**Test Circuit 3.  $A_v = 1$**



**Test Circuit 4.  $A_v = -1$**

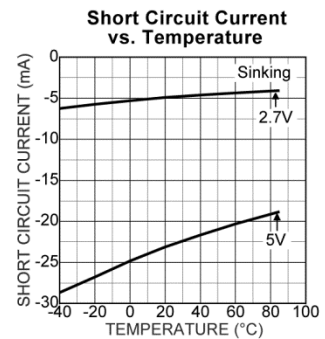
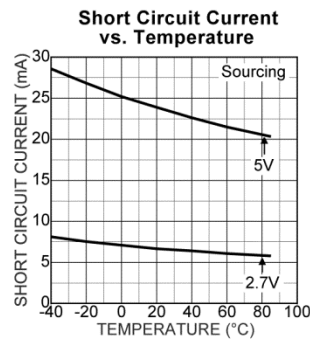
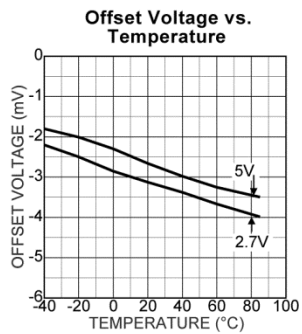
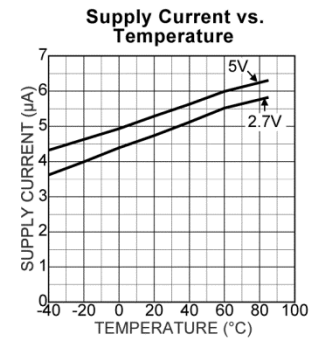
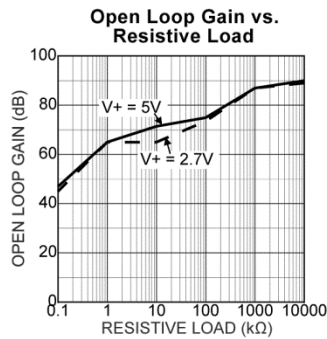
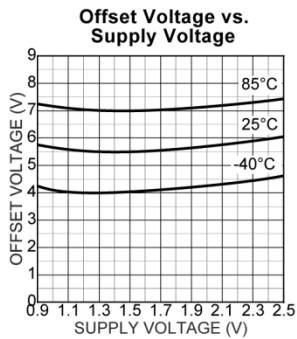
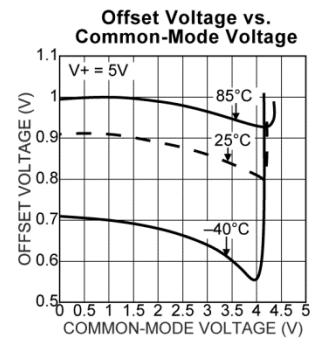
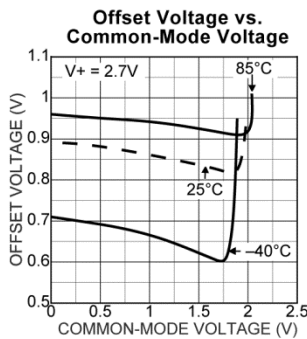
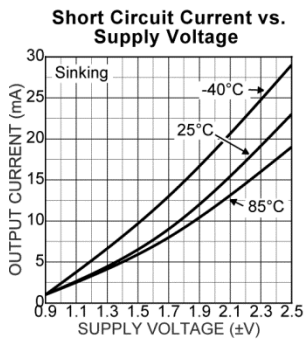
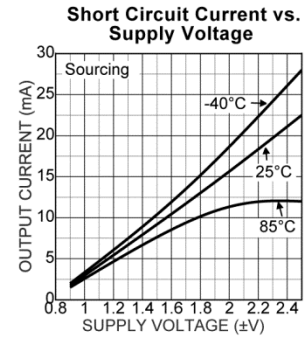
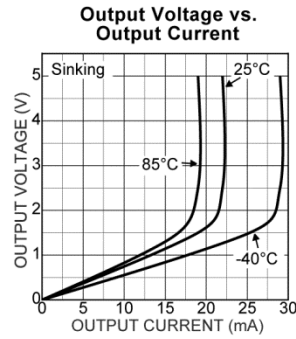
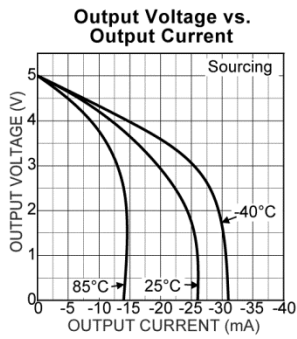


**Test Circuit 5. Positive Power Supply Rejection Ratio Measurement**

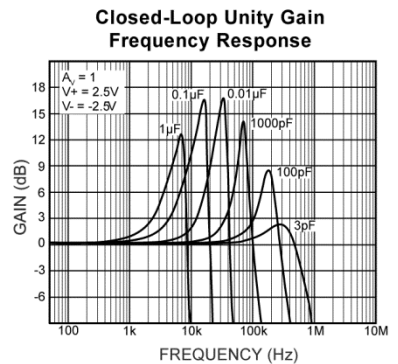
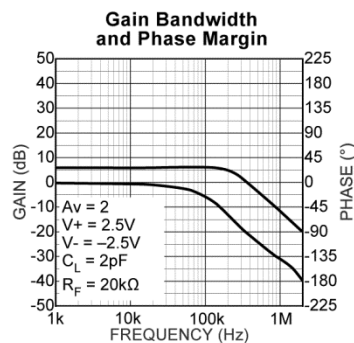
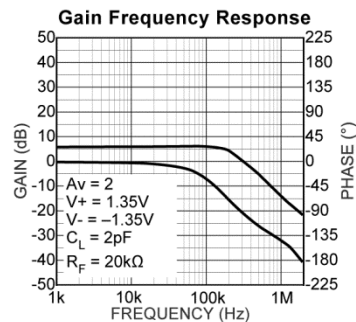
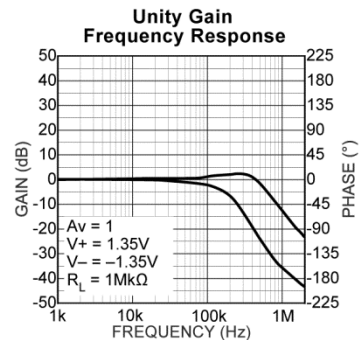
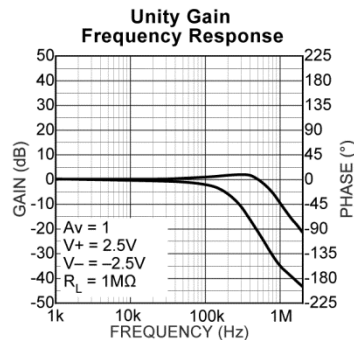
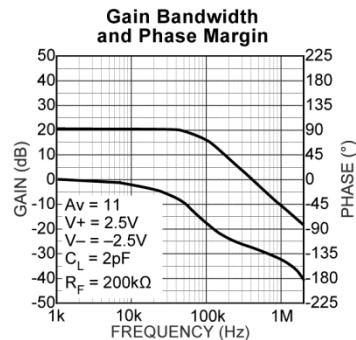
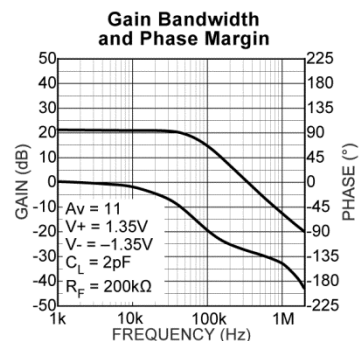
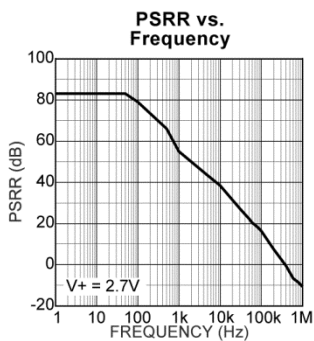
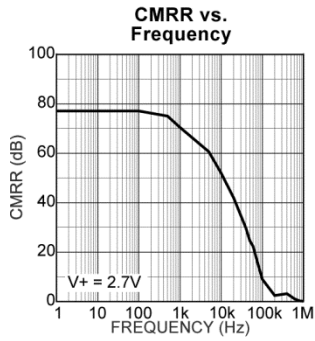
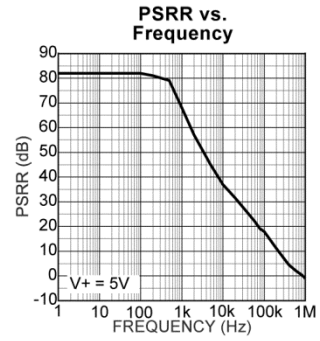
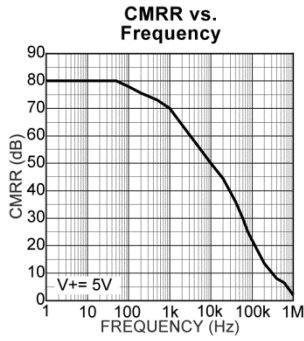
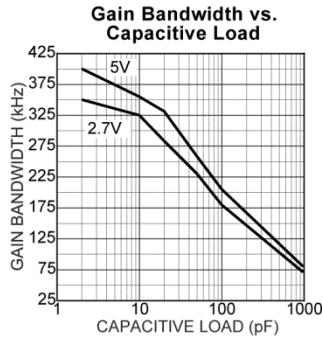


**Test Circuit 6. Closed-Loop Unity Gain Frequency Response Measurement**

# DC Typical Characteristics

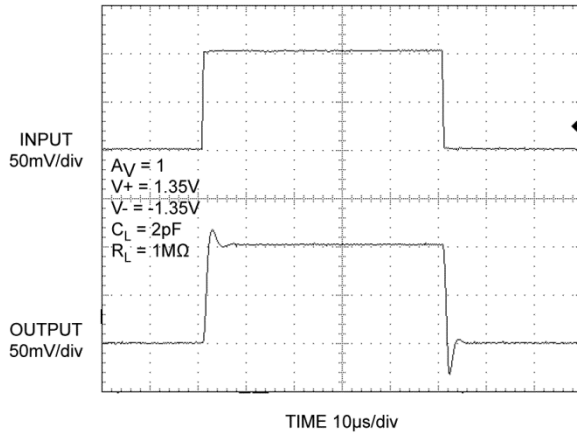


# AC Typical Characteristics

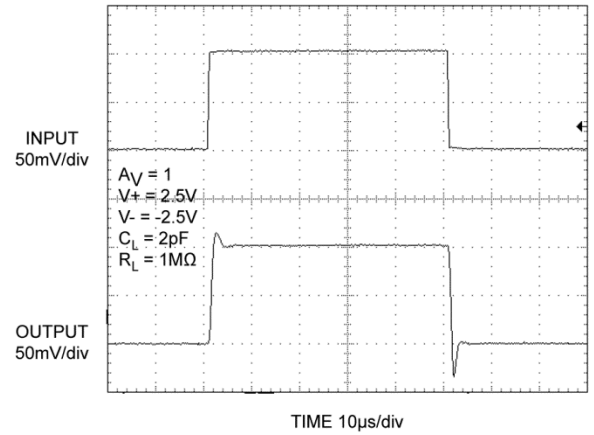


## Functional Characteristics

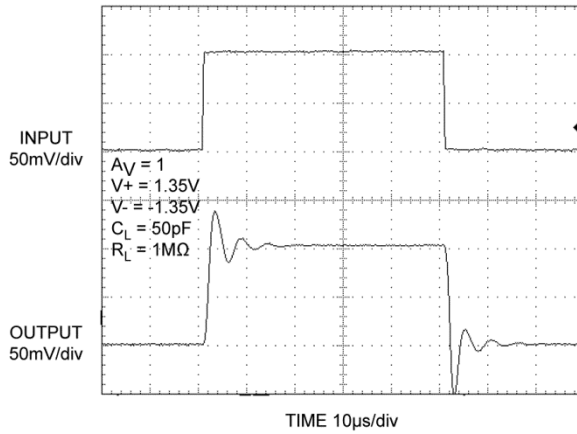
**Small Signal Pulse Response**  
Test Circuit 3:  $A_V = 1$



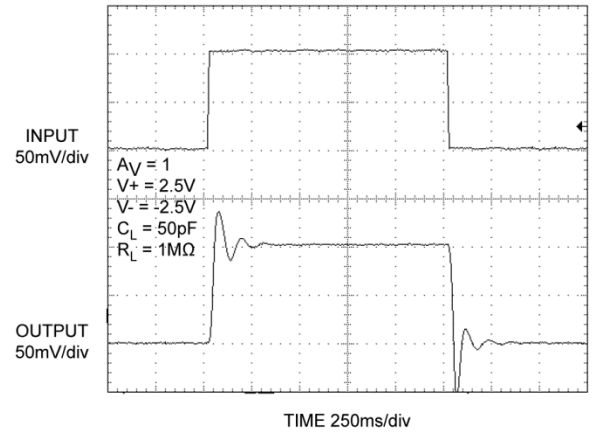
**Small Signal Pulse Response**  
Test Circuit 3:  $A_V = 1$



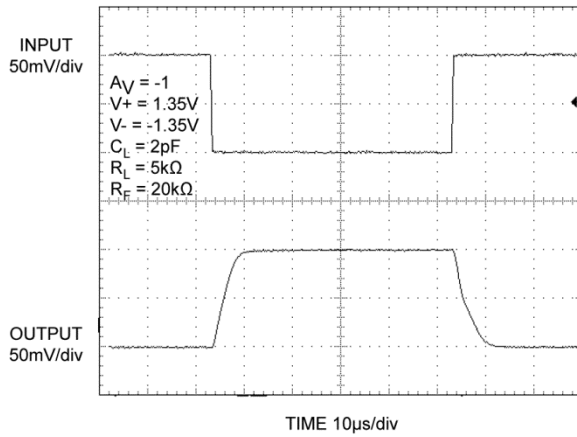
**Small Signal Pulse Response**  
Test Circuit 3:  $A_V = 1$



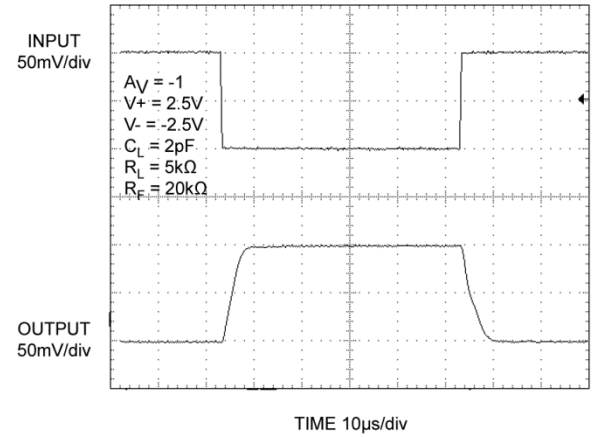
**Small Signal Pulse Response**  
Test Circuit 3:  $A_V = 1$



**Small Signal Pulse Response**  
Test Circuit 4:  $A_V = -1$

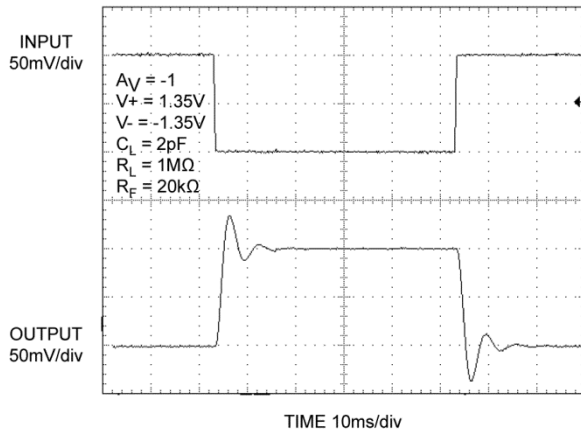


**Small Signal Pulse Response**  
Test Circuit 4:  $A_V = -1$

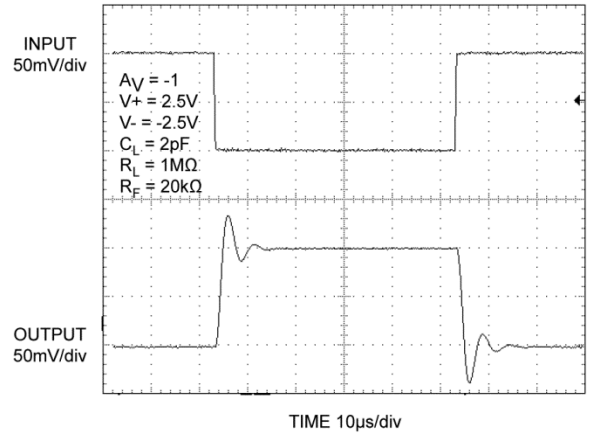


## Functional Characteristics (Continued)

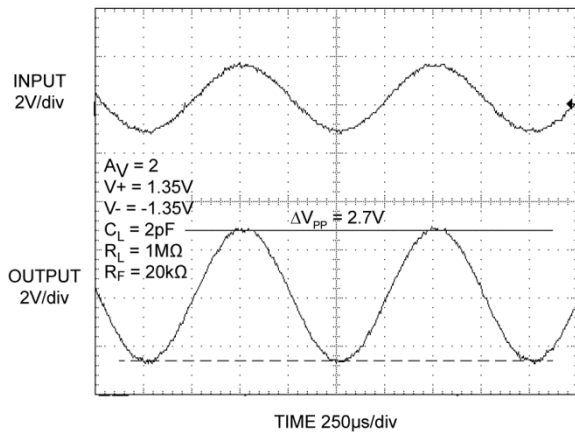
**Small Signal Pulse Response**  
Test Circuit 4:  $A_V = -1$



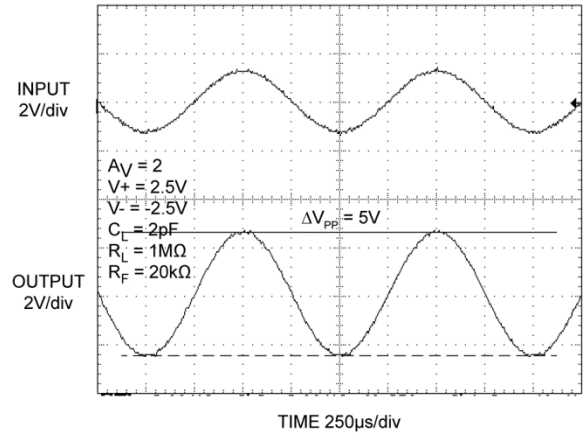
**Small Signal Pulse Response**  
Test Circuit 4:  $A_V = -1$



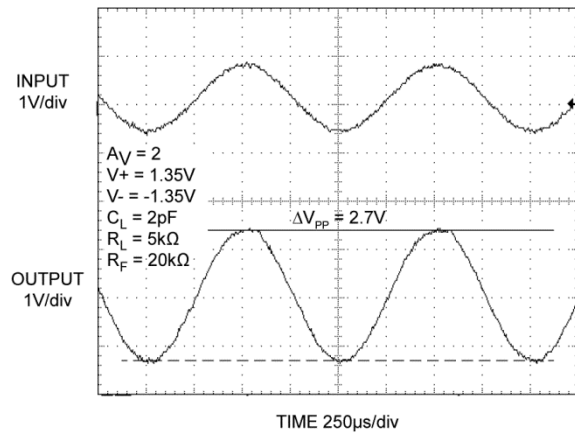
**Rail to Rail Output Operation**



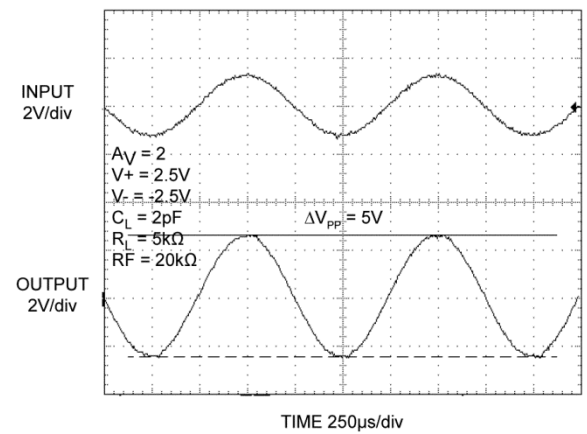
**Rail to Rail Output Operation**



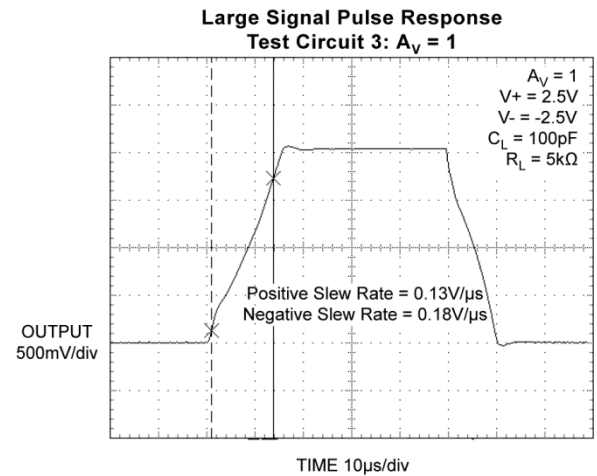
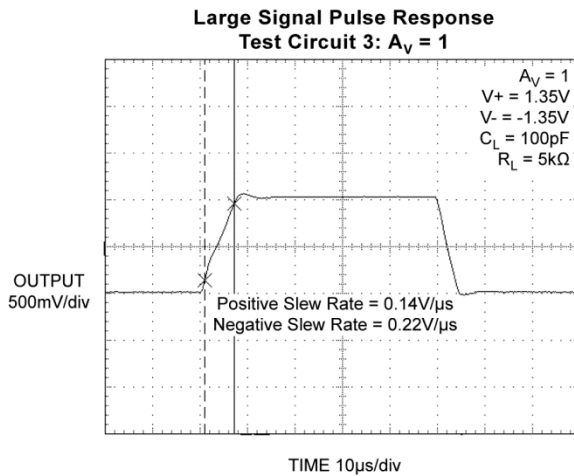
**Rail to Rail Output Operation**



**Rail to Rail Output Operation**



## Functional Characteristics (Continued)

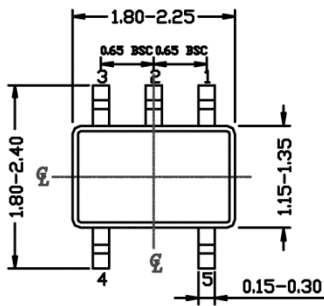


## Applications Information

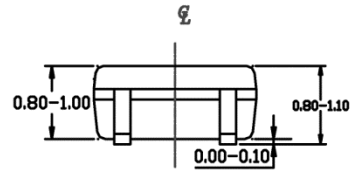
Regular supply bypassing techniques are recommended. A  $10\mu F$  capacitor in parallel with a  $0.1\mu F$  capacitor on both the positive and negative supplies is ideal. For best performance, all bypassing capacitors should be located

as close to the op amp as possible and all capacitors should be low equivalent series inductance (ESL) and equivalent series resistance (ESR). Surface-mount ceramic capacitors are ideal.

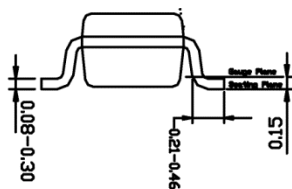
**Package Information<sup>(7)</sup>**



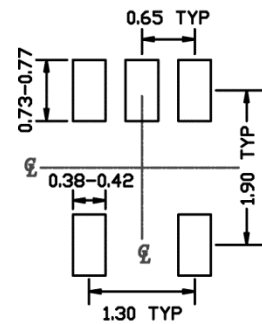
**TOP VIEW**



**SIDE VIEW**



**END VIEW**



**RECOMMENDED LAND PATTERN**

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS ARE INCLUSIVE OF PLATING.
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR.

**5-Pin SC70 (C5)**

**Note:**

7. Package information is correct as of the publication date. For updates and most current information, go to [www.micrel.com](http://www.micrel.com).

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