# MIC861

## Teeny™ Ultra Low Power Op Amp

**Final Information**

## General Description

The MIC861 is a rail-to-rail output, input common-mode to ground, operational amplifier in *Teeny*™ SC70 packaging. The MIC861 provides 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.

## 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 capactive loads (1000pF)
- Unity gain stable

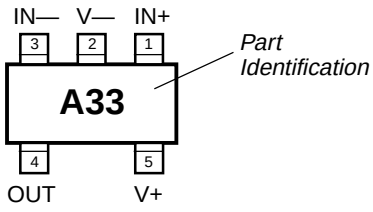
## Applications

- Portable equipment
- PDAs
- Pagers
- Cordless Phones
- Consumer Electronics

## Ordering Information

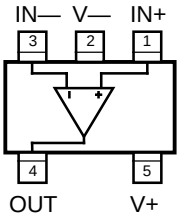
| Part Number | Marking | Ambient Temp. Range* | Package |
|---|---|---|---|
| MIC861BC5 | A33 | –40°C to +85°C | SC70-5 |

## Pin Configuration




**SC-70**

## Functional Pinout




*Teeny* is a trademark of Micrel, Inc.

## Absolute Maximum Ratings (Note 1)

Supply Voltage ($V_{V+}$ – V–) ..... +6.0V
Differentail Input Voltage ($|V_{IN+} – V_{IN–}|$), Note 4 ..... +6.0V
Input Voltage ($V_{IN+} – V_{IN–}$) ..... $V_+$ + 0.3V, $V_-$ –0.3V
Lead Temperature (soldering, 5 sec.) ..... 260°C
Output Short Circuit Current Duration ..... Indefinite
Storage Temperature ($T_S$) ..... 150°C
ESD Rating, **Note 3**

## Operating Ratings (Note 2)

Supply Voltage (V+ – V–) ..... +2.43V to +5.25V
Ambient Temperature Range ..... –40°C to +85°C
Package Thermal Resistance ..... 450°C/W

## Electrical Characteristics

V+ = +2.7V, V– = 0V, $V_{CM}$ = V+/2; $R_L$ = 500kΩ to V+/2; $T_A$ = 25°C, unless otherwise noted. **Bold** values indicate –40°C≤ $T_A$≤ +85°C.

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | **Note 5** | **–10** | 2 | **10** | mV |
| | Input Offset Voltage Temp Coefficient | | | 15 | | µV/°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 | **45** | 77 | | dB |
| PSRR | Power Supply Rejection Ratio | Supply voltage change of 3V | **50** | 83 | | dB |
| $A_{VOL}$ | Large-Signal Voltage Gain | $R_L$ = 100k, $V_{OUT}$ 2V peak to peak | **60** | 74 | | dB |
| | | $R_L$ = 500k, $V_{OUT}$ 2V peak to peak | **73** | 83 | | dB |
| $V_{OUT}$ | Maximum Output Voltage Swing | $R_L$ = 500k | **V+–2mV** | V+–0.7mV | | V |
| $V_{OUT}$ | Minimum Output Voltage Swing | $R_L$ = 500k | | V–+0.2mV | **V–+ 2mV** | V |
| GBW | Gain-Bandwidth Product | $R_L$ = 200kΩ, $C_L$ = 2pF, $V_{OUT}$ = 0 | | 350 | | kHz |
| BW | –3dB Bandwidth | $A_V$ = 1, $C_L$ = 2pF, $R_L$ = 1MΩ | | 500 | | kHz |
| SR | Slew Rate | $A_V$ = 1, $C_L$ = 2pF, $R_L$ = 1MΩ | | 0.12 | | V/µs |
| $I_{SC}$ | Short-Circuit Output Current | Source | | 6 | | mA |
| | | Sink | | 5 | | mA |
| $I_S$ | Supply Current | No Load | | 4.2 | **9** | µA |

V+= +5V, V–= 0V, $V_{CM}$= V+/2; $R_L$= 500kΩ to V+/2; $T_A$= 25°C, unless otherwise noted. **Bold** values indicate –40°C≤ $T_A$≤ +85°C.

| | | | | | | |
|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | **Note 5** | **–10** | 2 | **10** | mV |
| | Input Offset Voltage Temp Coefficient | | | 15 | | µV/°C |
| $I_B$ | Input Bias Current | | | 20 | | pA |
| $I_{OS}$ | Input Offset Current | | | 10 | | pA |
| $V_{CM}$ | Input Voltage Range | CMRR > 60dB | | 4.2 | | V |
| CMRR | Common-Mode Rejection Ratio | 0 < $V_{CM}$ < 3.5V | **60** | 80 | | dB |
| PSRR | Power Supply Rejection Ratio | Supply voltage change of 1V | **45** | 85 | | dB |
| $A_{VOL}$ | Large-Signal Voltage Gain | $R_L$ = 100k, $V_{OUT}$ 4.0V peak to peak | **60** | 76 | | dB |
| | | $R_L$ = 500k, $V_{OUT}$ 4.0V peak to peak | **68** | 83 | | dB |
| $V_{OUT}$ | Maximum Output Voltage Swing | $R_L$ = 500k | **V+–2mV** | V+–0.7mV | | V |
| $V_{OUT}$ | Minimum Output Voltage Swing | $R_L$ = 500k | | V–+0.7mV | **V–+ 2mV** | V |
| GBW | Gain-Bandwidth Product | $R_L$ = 200kΩ, $C_L$ = 2pF, $V_{OUT}$ = 0 | | 400 | | kHz |
| BW | –3dB Bandwidth | $A_V$ = 1, $C_L$ = 2pF, $R_L$ = 1MΩ | | 650 | | kHz |

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| SR | Slew Rate | $A_V$ = 1, $C_L$ = 2pF, $R_L$ = 1MΩ | | 0.12 | | V/µs |
| $I_{SC}$ | Short-Circuit Output Current | Source | **10** | 24 | | mA |
| | | Sink | **10** | 24 | | mA |
| $I_S$ | Supply Current | No Load | | 4.6 | **9** | µA |

**Note 1**. Exceeding the absolute maximum rating may damage the device.

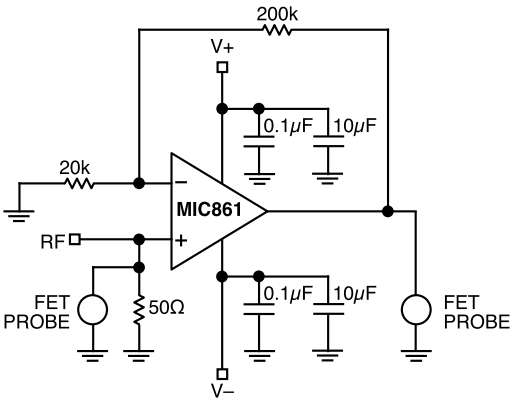
**Note 2.** The device is not guaranteed to function outside its operating rating.

**Note 3.** Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k in series with 100pF. Pin 4 is ESD sensetive

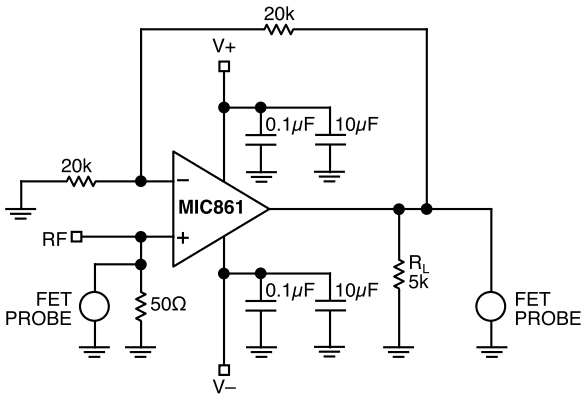
**Note 4.** Exceeding the maximum differential input voltage will damage the input stage and degrade performance (in particular, input bias current is likely to increase.

**Note 5.** The offset voltage distribution is centered around 0V. The typical offset number shown, is equal to the standard deviation of the voltage offset distribution.

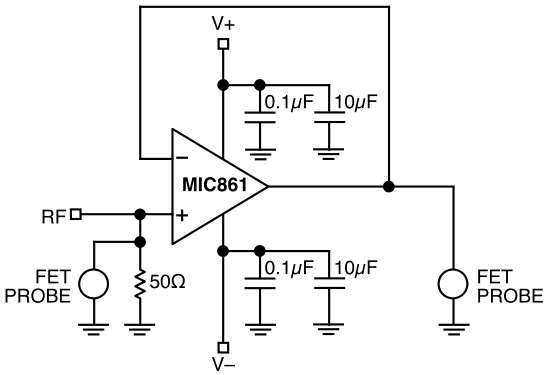
## Test Circuits



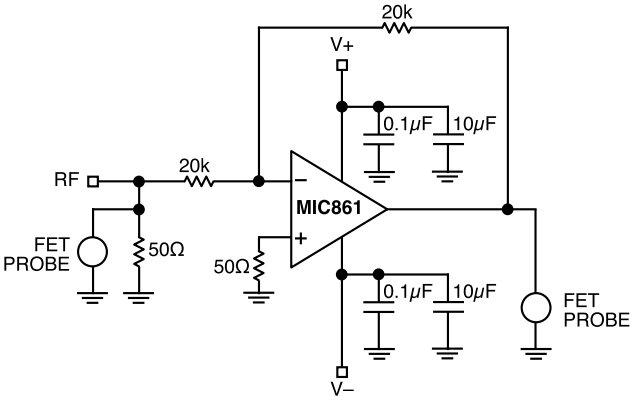

**Test Circuit 1. $A_V = 11$**



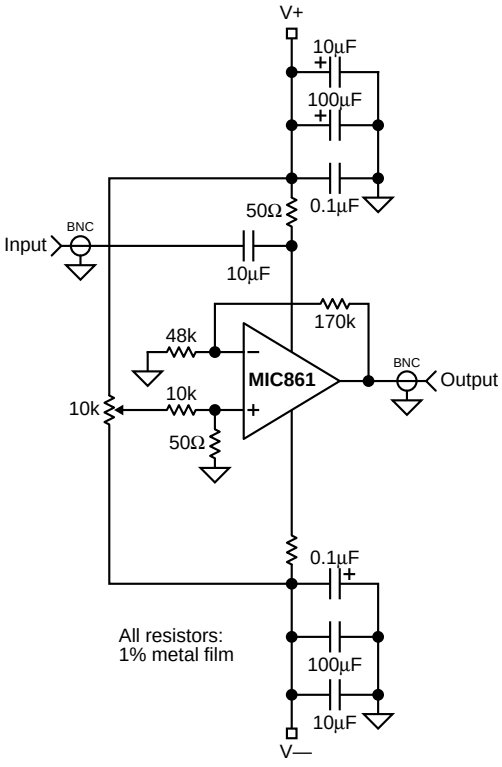

**Test Circuit 2:$A_V = 2$**




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



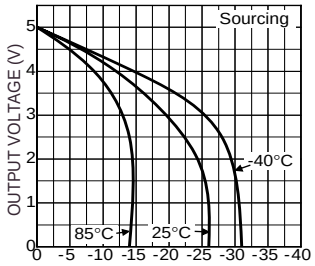

**Test Circuit 4. $A_V = –1$**



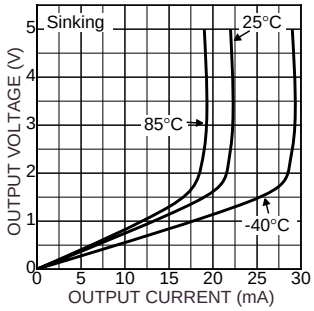

**Test Circuit 5. Positive Power Supply Rejection Ratio Measurement**

## DC Performance Characteristics

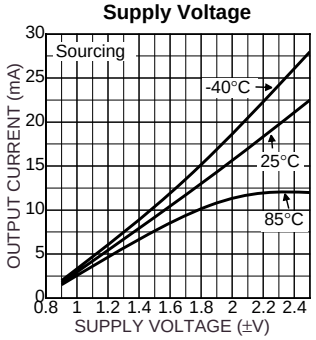
**Output Voltage vs. Output Current**



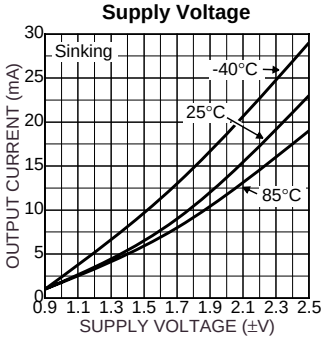

**Output Voltage vs. Output Current**



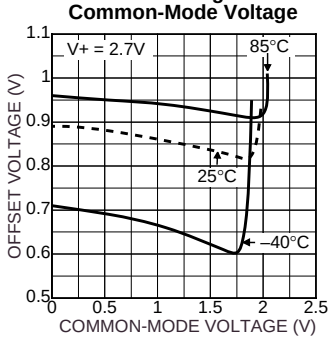

**Short Circuit Current vs. Supply Voltage**



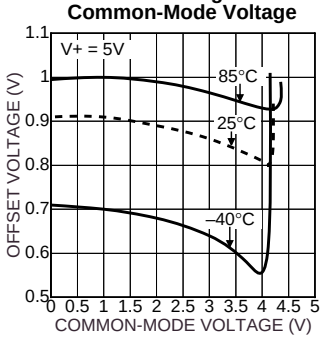

**Short Circuit Current vs. Supply Voltage**



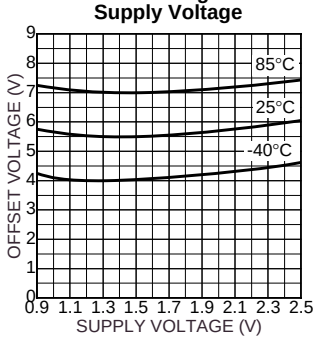

**Offset Voltage vs. Common-Mode Voltage**



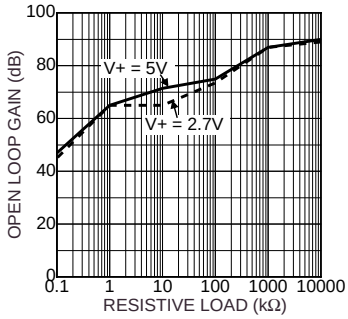

**Offset Voltage vs. Common-Mode Voltage**



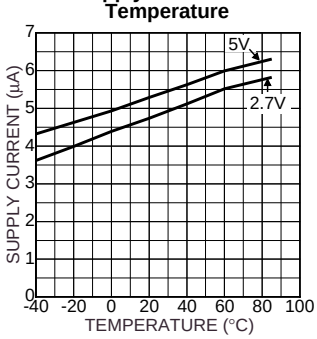

**Offset Voltage vs. Supply Voltage**



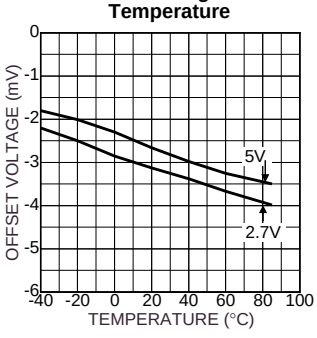

**Open Loop Gain vs. Resistive Load**



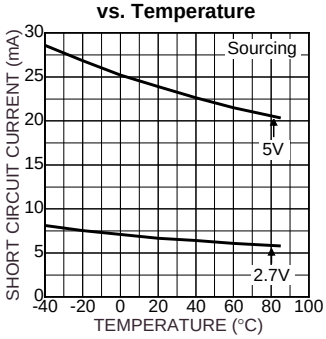

**Supply Current vs. Temperature**



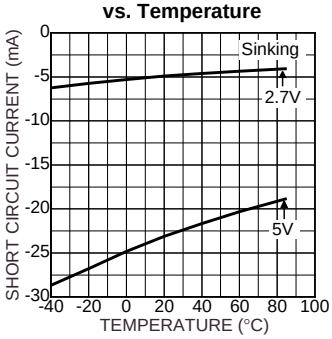

**Offset Voltage vs. Temperature**




**Short Circuit Current vs. Temperature**

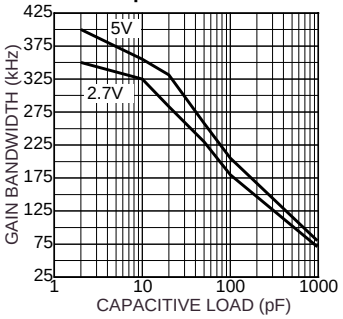



**Short Circuit Current vs. Temperature**

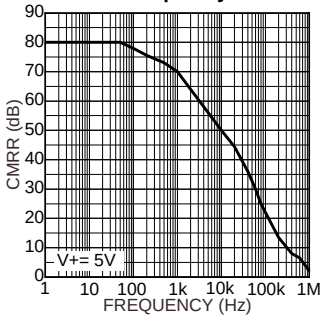


## AC Perfomance Characteristics

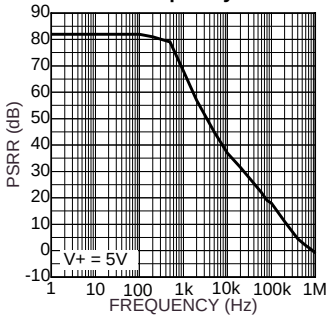
**Gain Bandwidth vs. Capacitive Load**



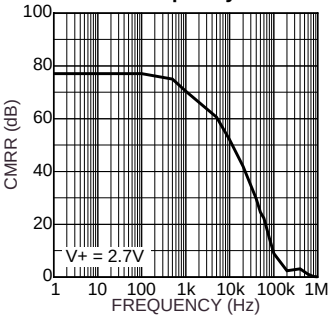

**CMRR vs. Frequency**



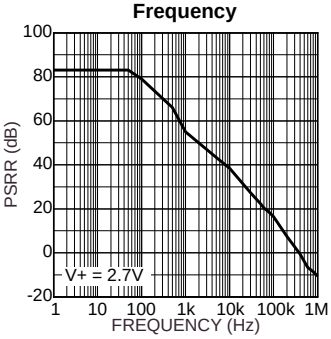

**PSRR vs. Frequency**



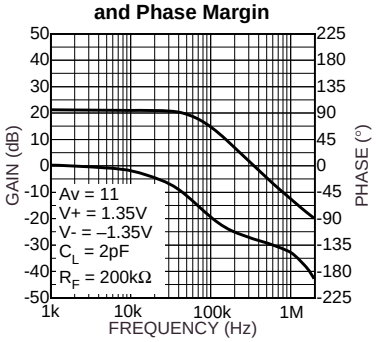

**CMRR vs. Frequency**




**PSRR vs. Frequency**




**Gain Bandwidth and Phase Margin**

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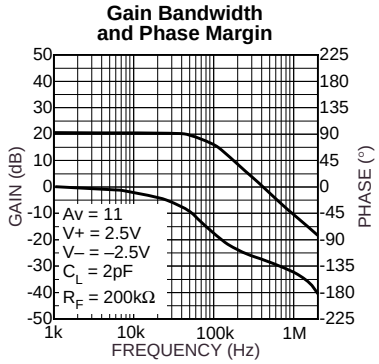
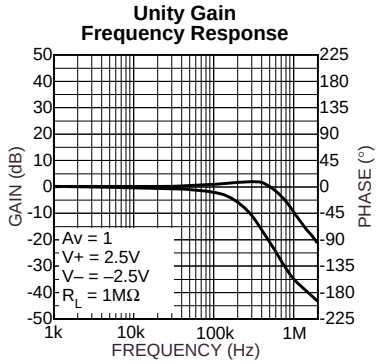
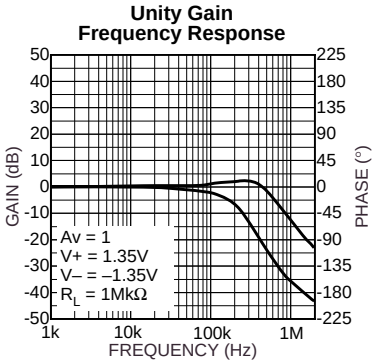


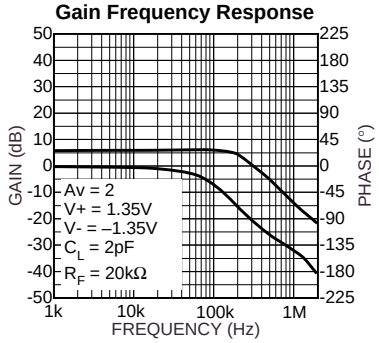

**Unity Gain Frequency Response**



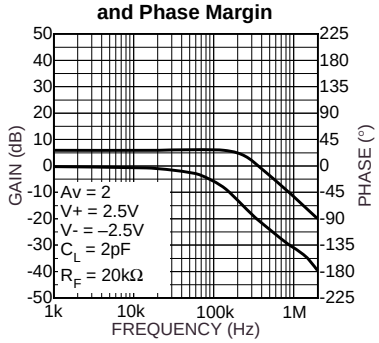

**Unity Gain Frequency Response**



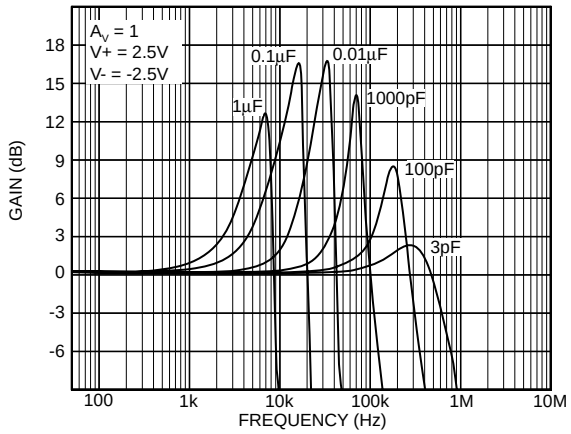

**Gain Frequency Response**

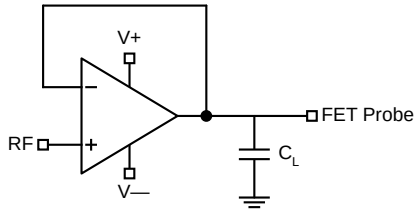



**Gain Bandwidth and Phase Margin**



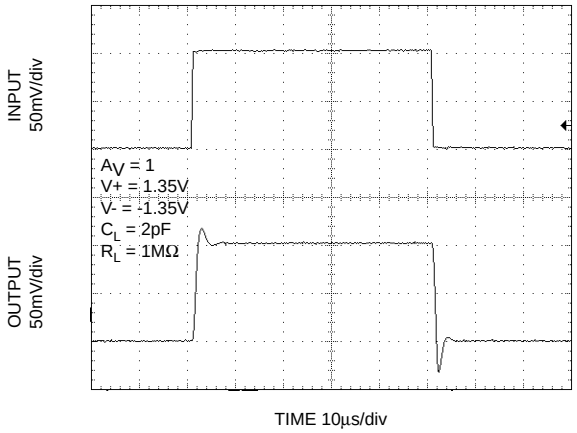
**Close-loop Unity Gain Frequency Response**



# Functional Characteristics

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

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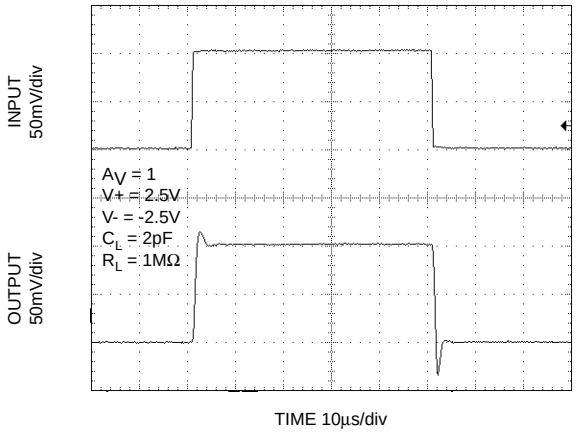


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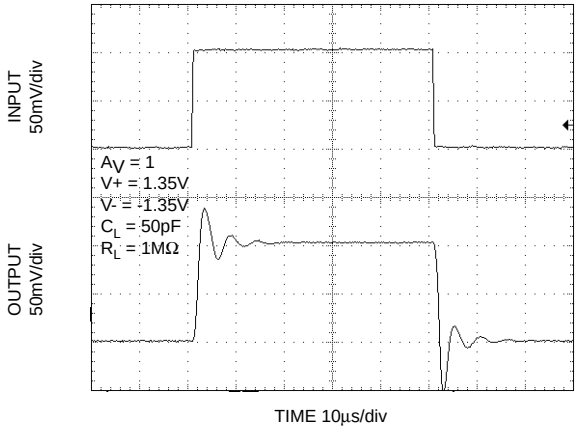


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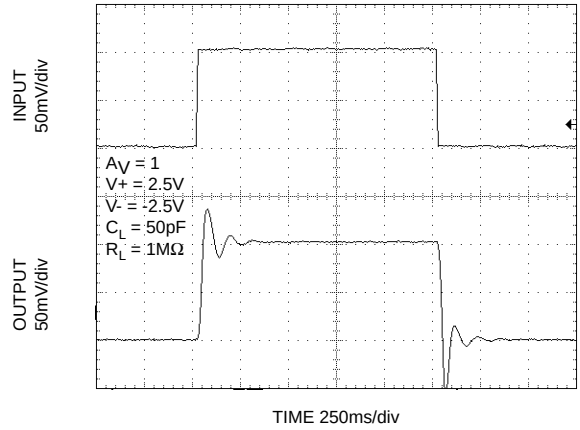
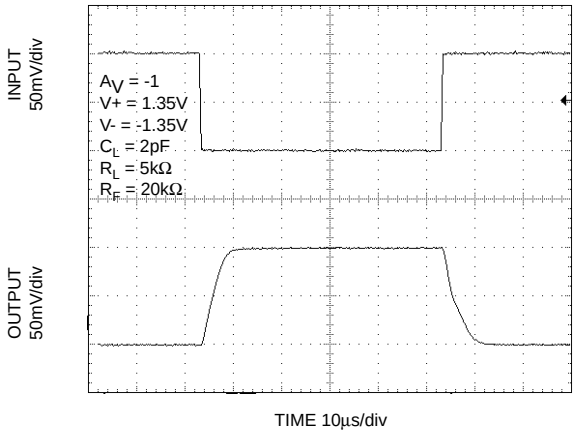
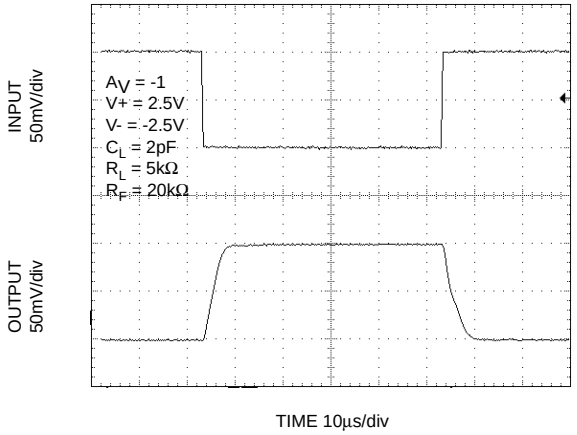


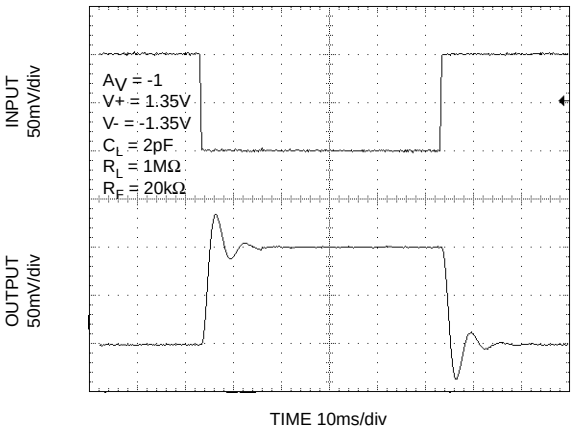

**Small Signal Pulse Response**
**Test Circuit 4: $A_V$ = -1**




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

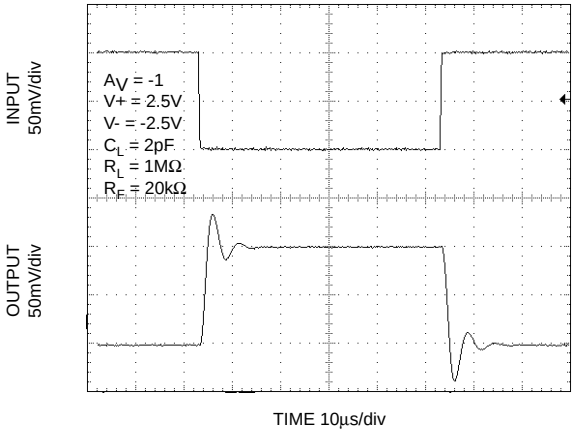


**Small Signal Pulse Response**
**Test Circuit 4: $A_V$ = -1**



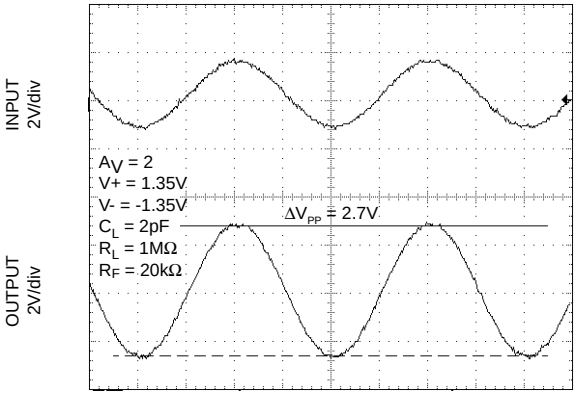

TIME 10ms/div

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



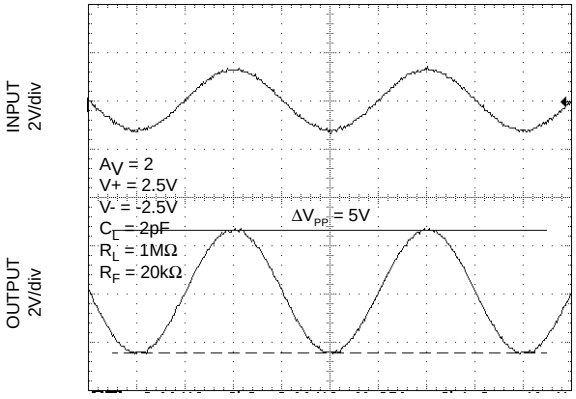

TIME 10µs/div

**Rail to Rail Output Operation**



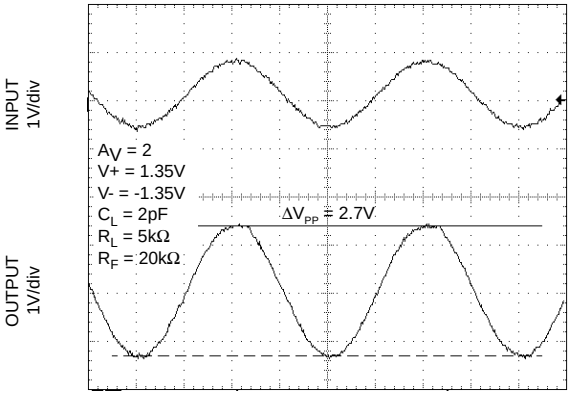

TIME 250µs/div

**Rail to Rail Output Operation**



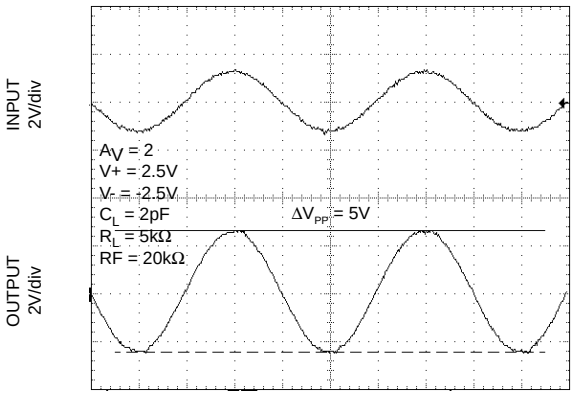

TIME 250µs/div

**Rail to Rail Output Operation**



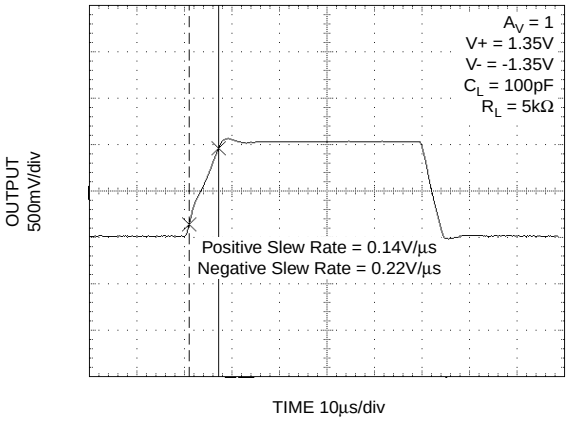

TIME 250µs/div

**Rail to Rail Output Operation**

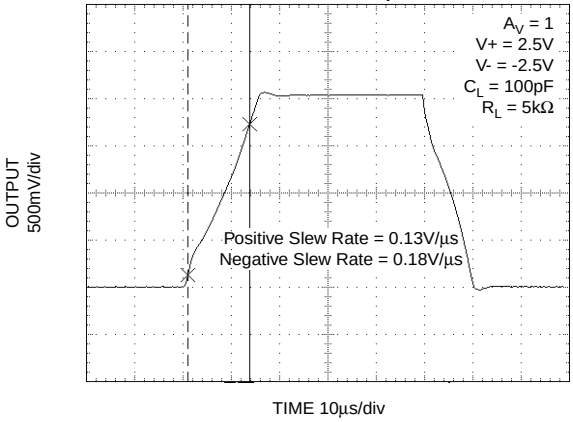



TIME 250µs/div

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




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

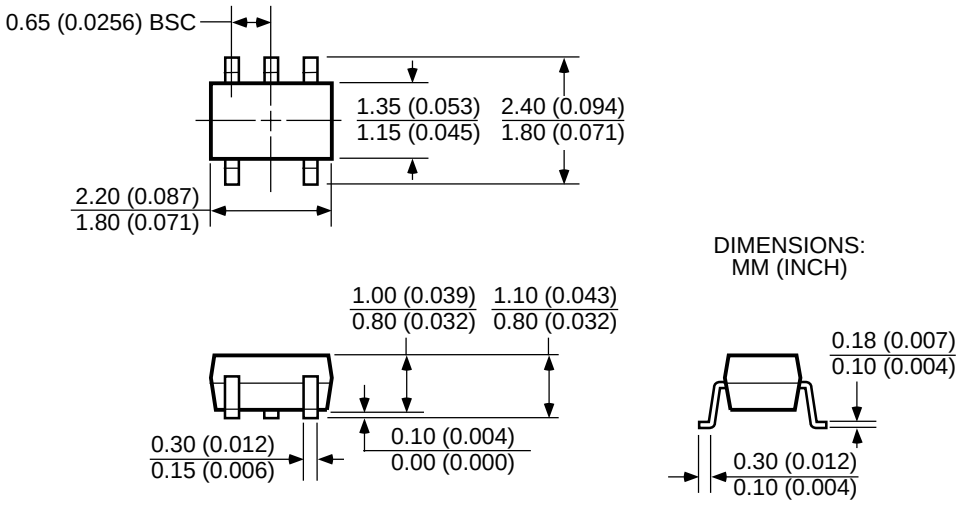


## Applications Information

### Power Supply Bypassing

Regular supply bypassing techniques are recommended. A 10µF capacitor in parallel with a 0.1µF capacitor on both the positive and negative supplies are ideal. For best performance all bypassing capacitors should be located as close to the op amp as possible and all capacitors should be low ESL (equivalent series inductance), ESR (equivalent series resistance). Surface-mount ceramic capacitors are ideal.

## Package Information




**SC70-5**

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