# MIC860

## Teeny™ Ultra Low Power Op Amp

## General Description

The MIC860 is a rail-to-rail output, operational amplifier in *Teeny*™ SC70 packaging. The MIC860 provides 4MHz gain-bandwidth product while consuming an incredibly low 30µA 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
- 4MHz gain-bandwidth product
- 30µA supply current
- Rail-to-Rail output
- Ground sensing at input common mode to GND
- Common mode to GND
- Drive large capactive loads

## Applications

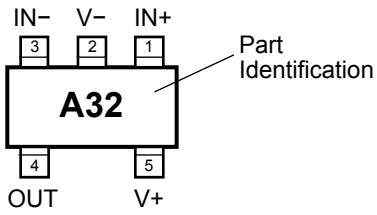
- Portable equipment
- PDAs
- Pagers
- Cordless Phones
- Consumer Electronics

## Ordering Information

| Part Number | | | | Ambient Temp. Range | Package |
|---|---|---|---|---|---|
| Standard | Marking | Pb-Free | Marking* | | |
| MIC860BC5 | A32 | MIC860YC5 | A32 | –40°C to +85°C | SC-70-5 |

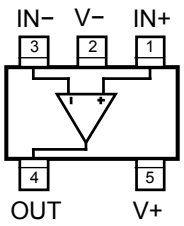
* Underbar marking may not be to scale.

## Pin Configuration




**SC-70**

## Functional Pinout

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## 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 | | –20 | –5 | 15 | mV |
| | | | –25 | | 20 | mV |
| | Input Offset Voltage Temp Coefficient | | | 20 | | µV/°C |
| $I_B$ | Input Bias Current | | | 20 | | pA |
| $I_{OS}$ | Input Offset Current | | | 10 | | pA |
| $V_{CM}$ | Input Voltage Range | CMRR > 60dB | **1** | 1.8 | | V |
| CMRR | Common-Mode Rejection Ratio | 0 < $V_{CM}$ < 1.35V | **38** | 76 | | dB |
| PSRR | Power Supply Rejection Ratio | Supply voltage change of 3V | **40** | 78 | | dB |
| $A_{VOL}$ | Large-Signal Voltage Gain | $R_L$ = 5k, $V_{OUT}$ 2V peak to peak | **50** | 66 | | dB |
| | | $R_L$ = 100k, $V_{OUT}$ 2V peak to peak | **66** | 81 | | dB |
| | | $R_L$ = 500k, $V_{OUT}$ 2V peak to peak | **76** | 91 | | dB |
| $V_{OUT}$ | Maximum Output Voltage Swing | $R_L$ = 5k | **V+–70mV** | V+–34mV | | V |
| | | $R_L$ = 500k | **V+–2mV** | V+–0.7mV | | V |
| $V_{OUT}$ | Minimum Output Voltage Swing | $R_L$ = 5k | | V–+11mV | **V–+ 50mV** | mV |
| | | $R_L$ = 500k | | V–+0.2mV | **V–+ 2mV** | mV |
| GBW | Gain-Bandwidth Product | | | 4 | | MHz |
| SR | Slew Rate | | | 3 | | V/µs |
| $I_{SC}$ | Short-Circuit Output Current | Source | **4.5** | 6 | | mA |
| | | Sink | **10** | 16 | | mA |
| $I_S$ | Supply Current | No Load | | 30 | 50 | 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 | | –20 | –5 | 20 | mV |
| | Input Offset Voltage Temp Coefficient | | | 20 | | µV/°C |
| $I_B$ | Input Bias Current | | | 20 | | pA |
| $I_{OS}$ | Input Offset Current | | | 10 | | pA |
| $V_{CM}$ | Input Voltage Range | CMRR > 60dB | **3.5** | 4.2 | | V |
| CMRR | Common-Mode Rejection Ratio | 0 < $V_{CM}$ < 3.5V | **44** | 77 | | dB |
| PSRR | Power Supply Rejection Ratio | Supply voltage change of 1V | **40** | 79 | | dB |
| $A_{VOL}$ | Large-Signal Voltage Gain | $R_L$ = 5k, $V_{OUT}$ 4.8V peak to peak | **52** | 66 | | dB |
| | | $R_L$ = 100k, $V_{OUT}$ 4.8V peak to peak | **67** | 80 | | dB |
| | | $R_L$ = 500k, $V_{OUT}$ 4.8V peak to peak | **75** | 90 | | dB |

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{OUT}$ | Maximum Output Voltage Swing | $R_L$ = 5k | **V+–75mV** | V+–37mV | | V |
| | | $R_L$ = 500k | **V+–35mV** | V+–4mV | | V |
| $V_{OUT}$ | Minimum Output Voltage Swing | $R_L$ = 5k | | V–+14mV | **V–+ 40mV** | mV |
| | | $R_L$ = 500k | | V–+0.4mV | **V–+ 5mV** | mV |
| GBW | Gain-Bandwidth Product | | | 4 | | MHz |
| SR | Slew Rate | | | 3 | | V/µs |
| $I_{SC}$ | Short-Circuit Output Current | Source | **15** | 23 | | mA |
| | | Sink | **30** | 47 | | mA |
| $I_S$ | Supply Current | No Load | | 33 | **55** | µA |

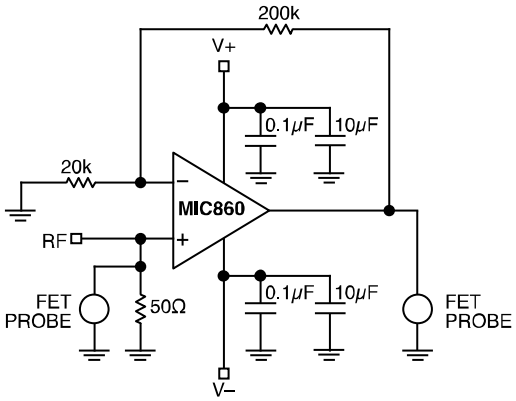
**Note 1**. Exceeding the absolute maximum rating may damage the device.

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

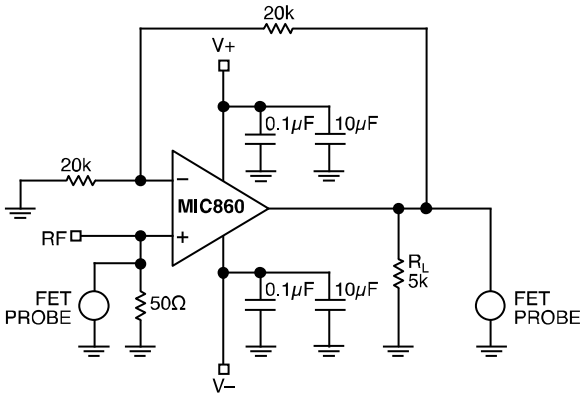
**Note 3.** Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k in series with 100pF. Pin 4 is ESD sensetive

**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.

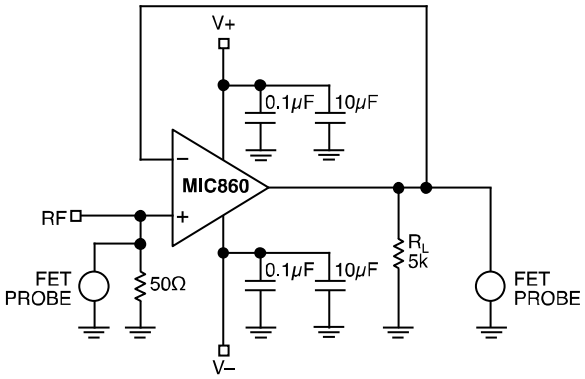
## Test Circuits



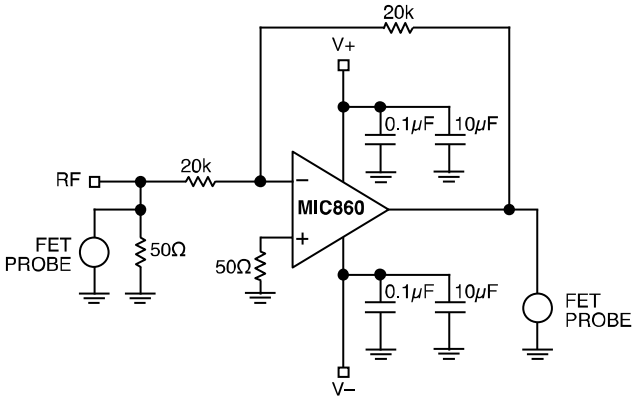

**Test Circuit 1. $A_V = 10$**



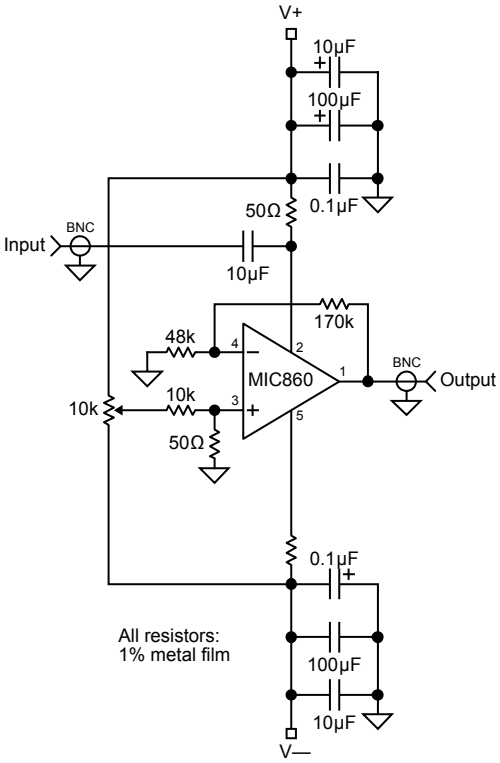

**Test Circuit 2. $A_V = 2$**




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



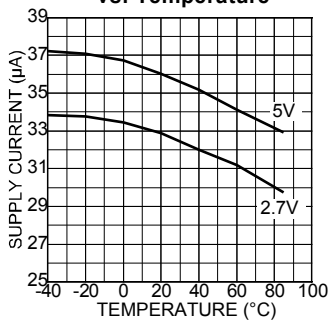

**Test Circuit 4. $A_V = -1$**



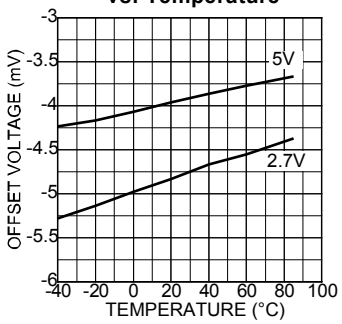

**Test Circuit 5. Positive Power Supply Rejection Ratio Measurement**

## Typical Characteristics

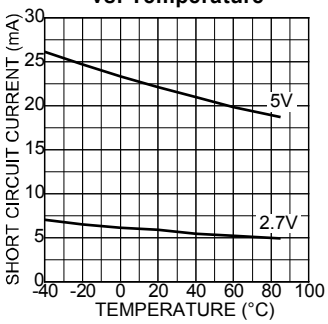
**Supply Current vs. Temperature**



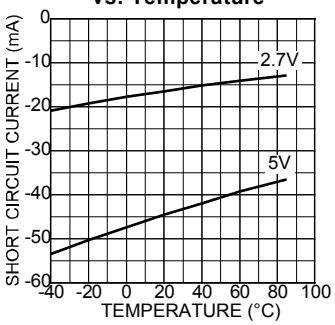

**Offset Voltage vs. Temperature**



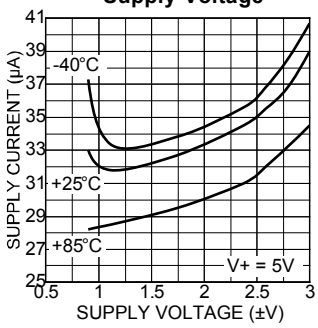

**Short Circuit Current (source) vs. Temperature**



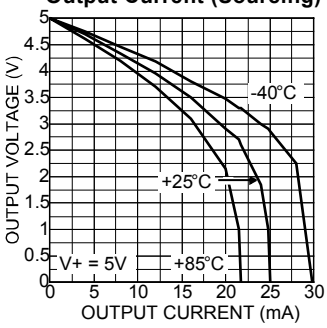

**Short Circuit Current (sink) vs. Temperature**



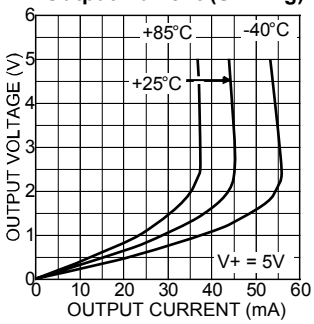

**Supply Current vs. Supply Voltage**



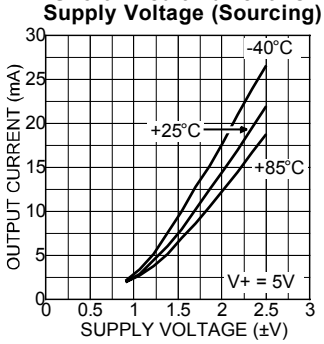

**Output Voltage vs. Output Current (Sourcing)**



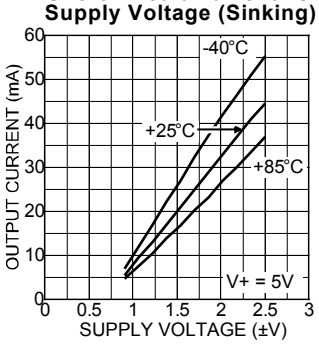

**Output Voltage vs. Output Current (Sinking)**



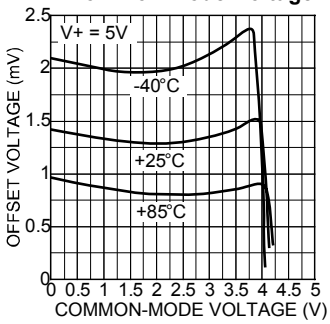

**Short Circuit Current vs. Supply Voltage (Sourcing)**



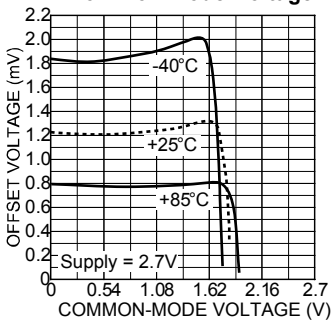

**Short Circuit Current vs. Supply Voltage (Sinking)**



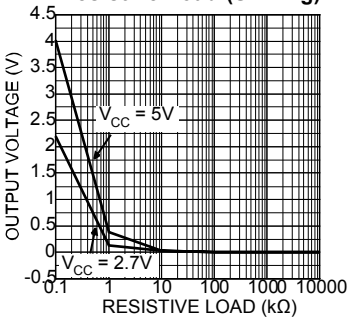

**Offset Voltage vs. Common-Mode Voltage**



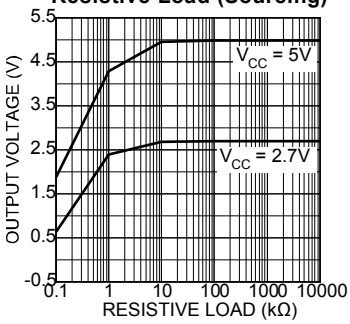

**Offset Voltage vs. Common-Mode Voltage**



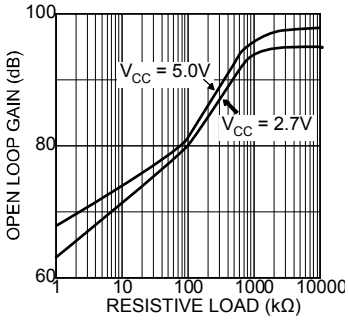

**Output Voltage Swing vs. Resistive Load (Sinking)**



**Output Voltage Swing vs. Resistive Load (Sourcing)**

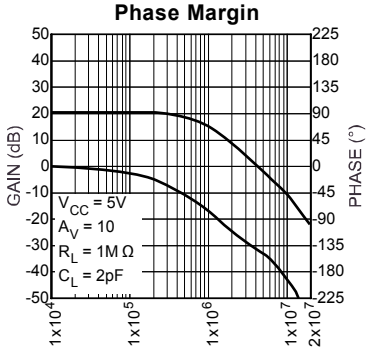



**Open Loop Gain vs. Resistive Load**

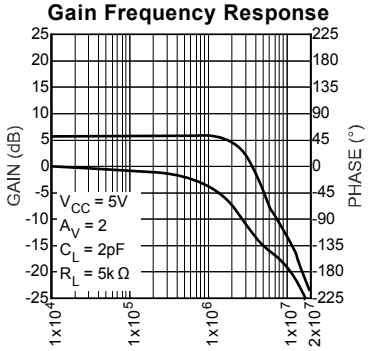


## Functional Characteristics

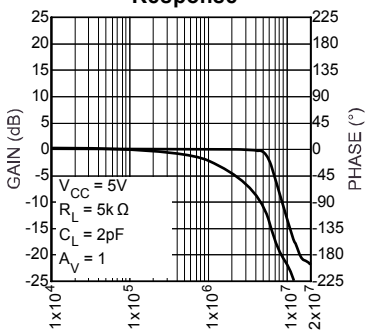
**Gain Bandwidth and Phase Margin**



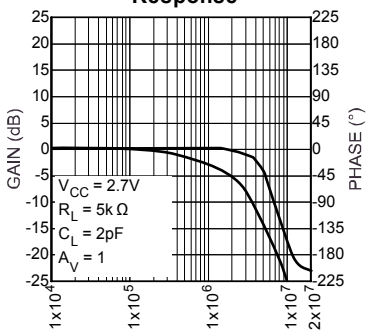

**Gain Frequency Response**



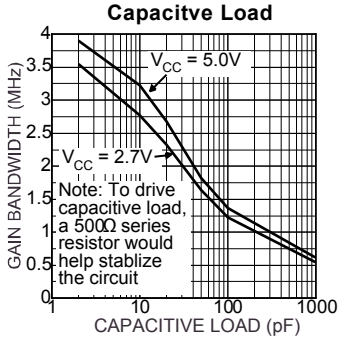

**Unity Gain Frequency Response**



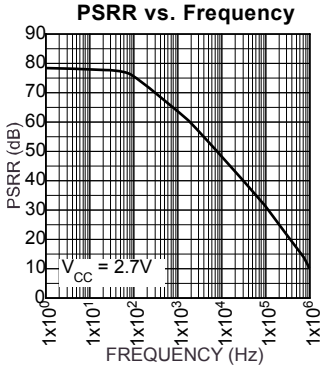

**Unity Gain Frequency Response**




**Gain Bandwidth vs. Capacitve Load**




**PSRR vs. Frequency**

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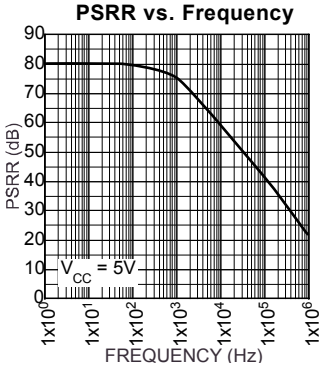
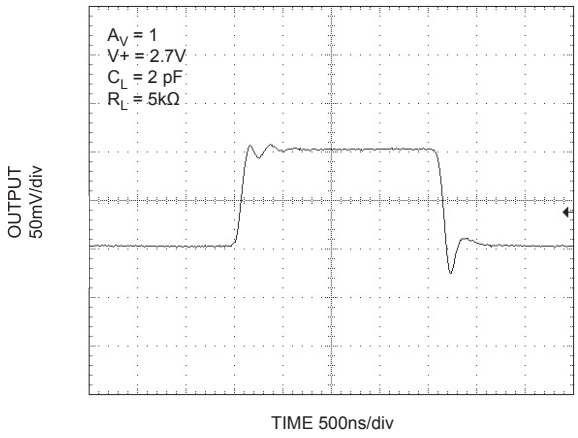


**Small Signal Response**
**Test Circuit 3: $A_V$ = 1**

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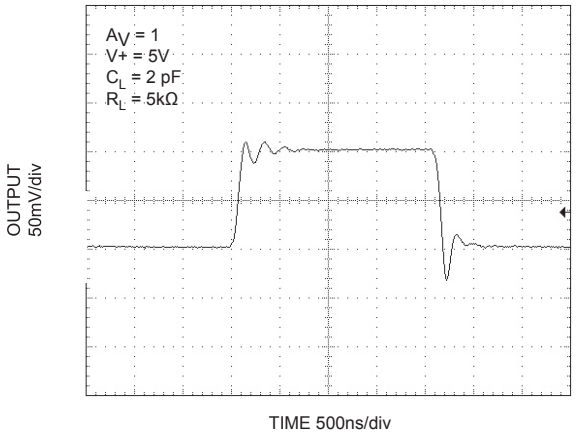


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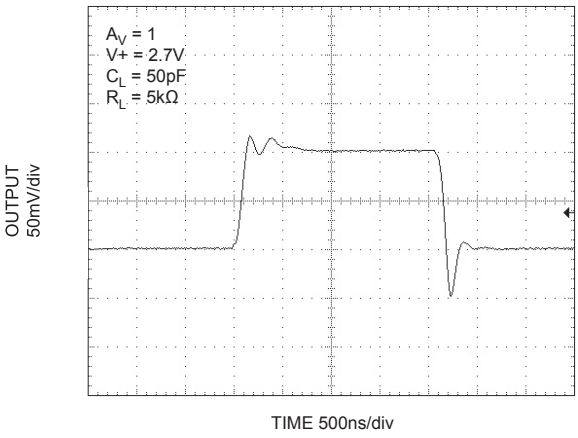


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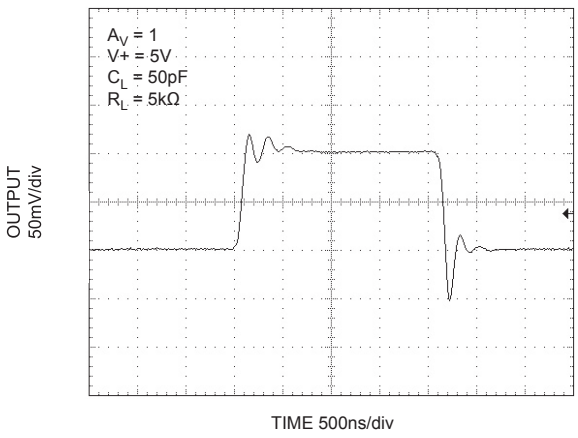


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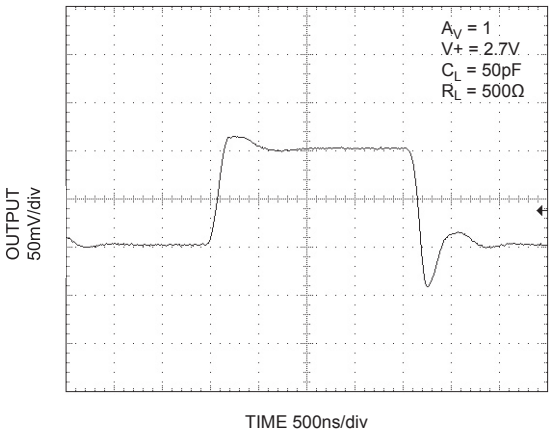
**Test Circuit 3: $A_V$ = 1**

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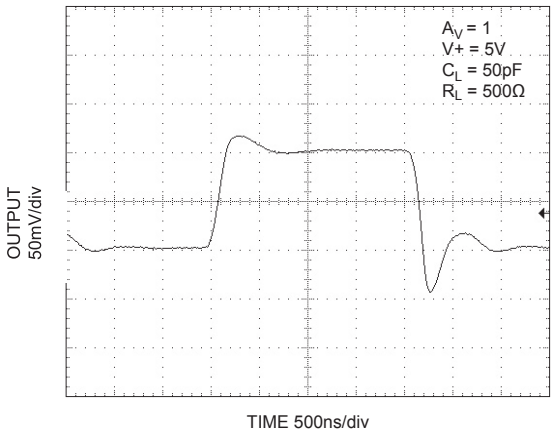

**Smal Signal Response**
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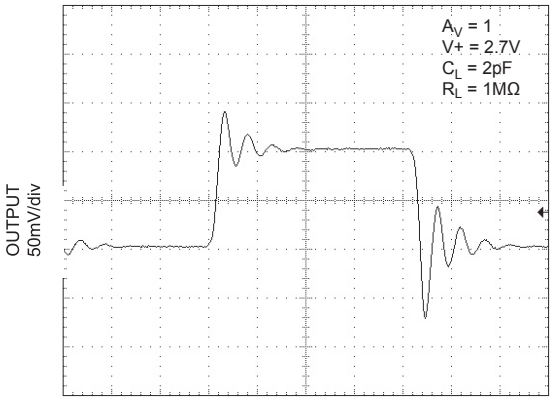
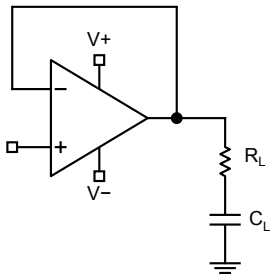
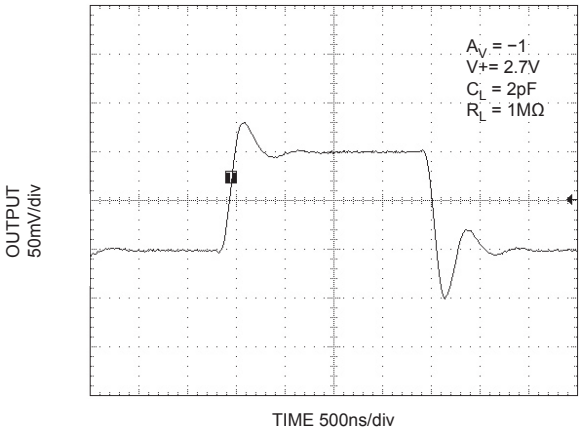
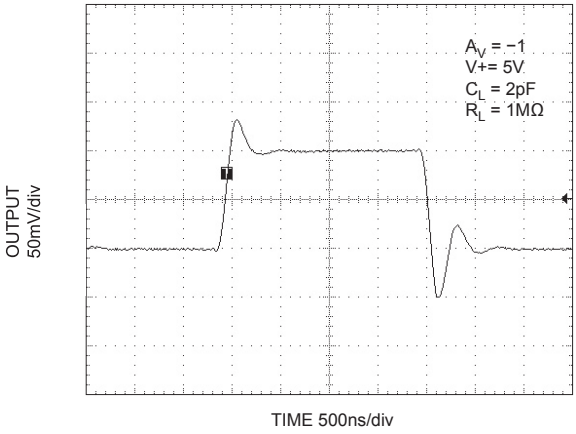


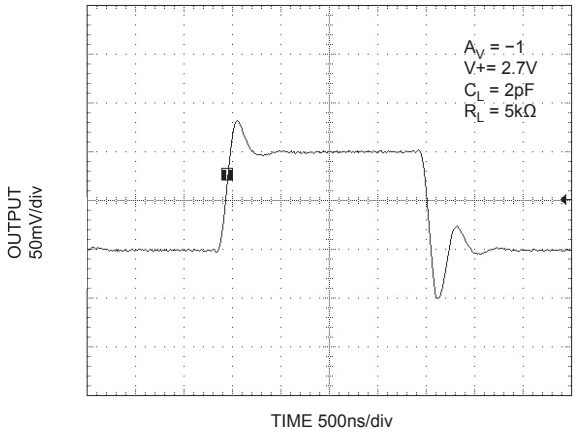

**Small Signal Response**
**Test Circuit 4: $A_V = -1$**



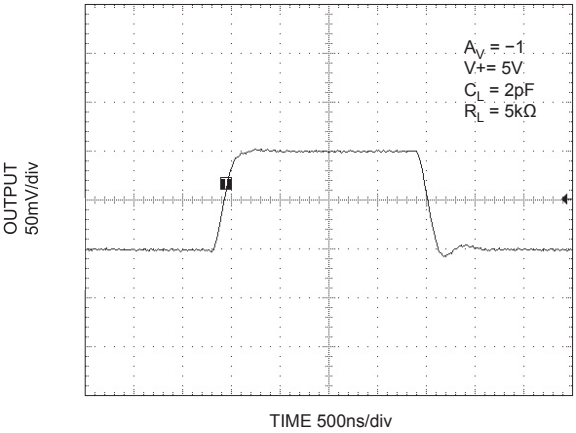

**Small Signal Response**
**Test Circuit 4: $A_V = -1$**



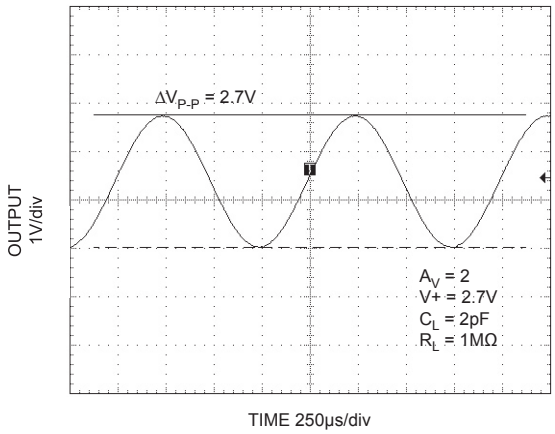

**Small Signal Response**
**Test Circuit 4: $A_V = -1$**



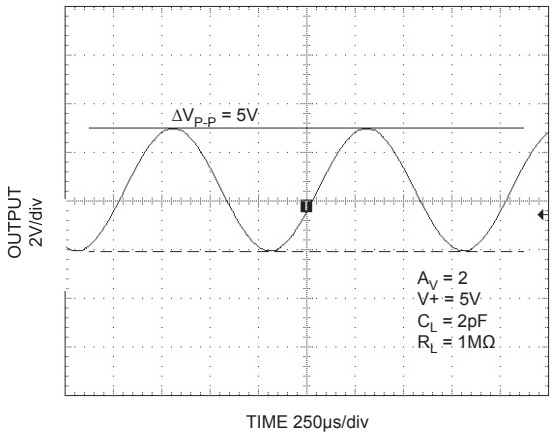

**Small Signal Response**
**Test Circuit 4: $A_V = -1$**



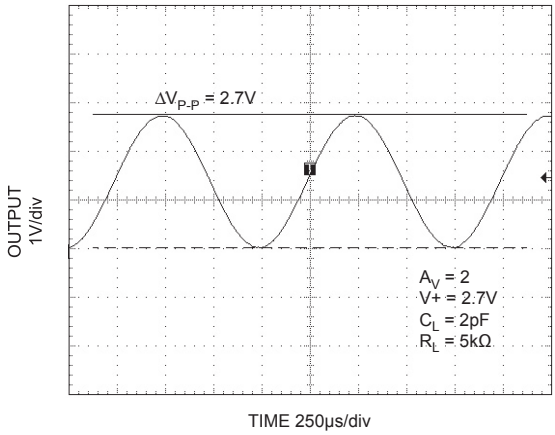
**Rail to Rail Output Operation**
**Test Circuit 2: $A_V = 2$**




**Rail to Rail Output Operation**
**Test Circuit 2: $A_V = 2$**




**Rail to Rail Output Operation**
**Test Circuit 2: $A_V = 2$**




**Rail to Rail Output Operation**
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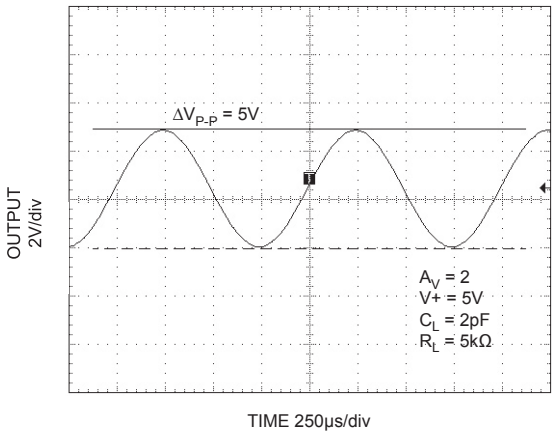
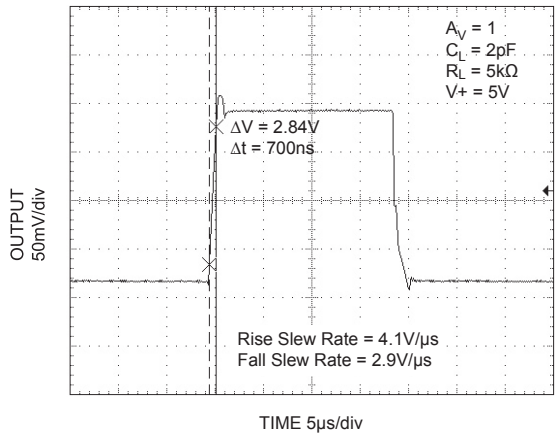
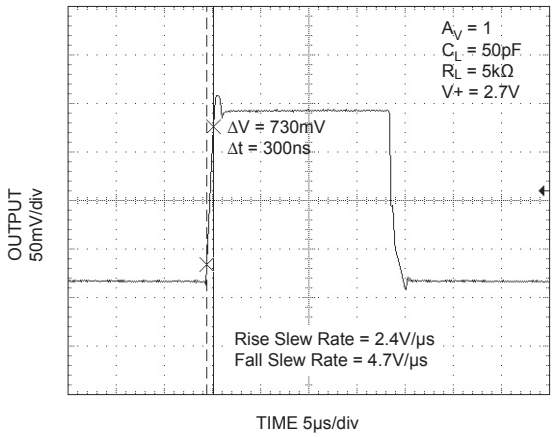



**Large Signal Pulse Response**
**Test Circuit 3: $A_V = 1$**




**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.

### Supply and Loading Considerations

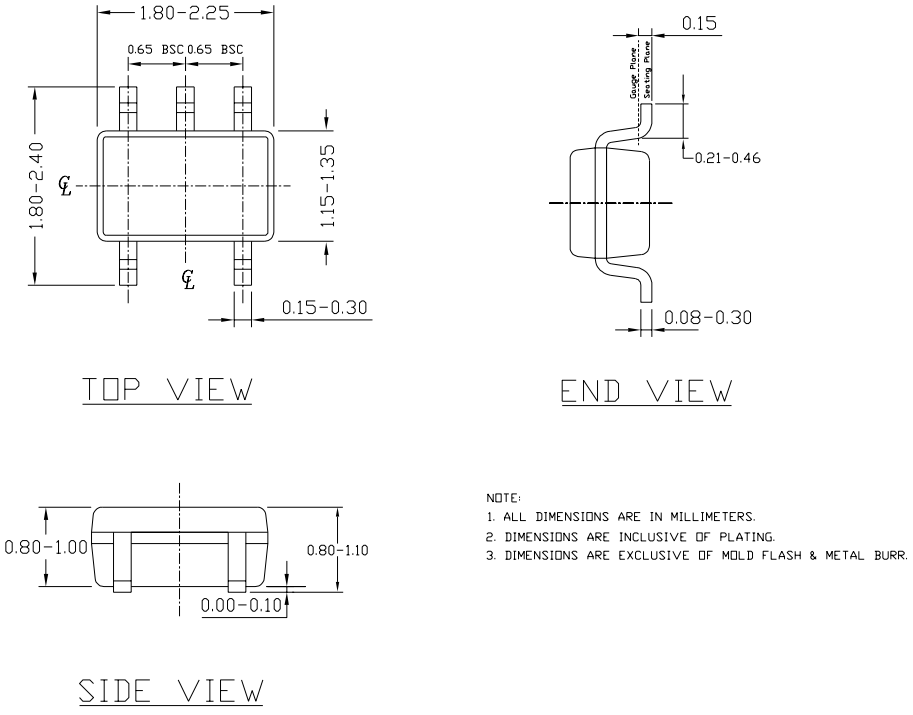
The MIC860 is intended for single supply applications configured with a grounded load. It is not advisable to operate the MIC860 with either:

1). A grounded load and split supplies (+/-V) or

2). A single supply where the load is terminated above ground.

Under the above conditions, if the load is less than 20kOhm and the output swing is greater than 1V(peak), there may be some instability when the output is sinking current.

## Package Information




**SC70-5**

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