



## 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 an SOT-23 package.

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

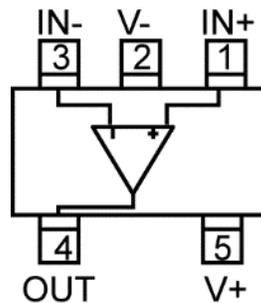
#### Features

- 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
- Drives large capacitive loads

#### Applications

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

#### Functional Pinout



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Revision 2.0

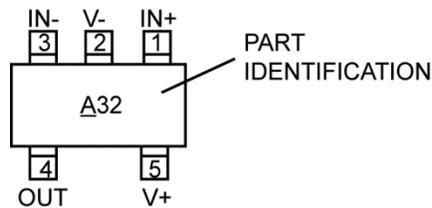
## Ordering Information

Part Number	Marking <sup>(1)</sup>	Junction Temp. Range	Package
MIC860YC5	<u>A32</u>	-40°C to +85°C	5-Pin SC-70

### Note:

- Underbar marking may not be to scale.

## Pin Configuration



5-pin SC-70 (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-} $ ) <sup>(5)</sup>	+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 <sup>(4)</sup>	ESD Sensitive

## 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
Packaging Thermal Resistance	
5-pin SC-70 ( $\theta_{JA}$ )	450°C/W

## Electrical Characteristics

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

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		$\mu V/^\circ C$
$I_B$	Input Bias Current			20		pA
$I_{OS}$	Input Offset Current			10		pA
$V_{CM}$	Input Voltage Range	CMRR > 60dB	<b>1</b>	1.8		V
CMRR	Common-Mode Rejection Ratio	$0 < V_{CM} < 1.35V$	<b>38</b>	76		dB
PSRR	Power Supply Rejection Ratio	Supply voltage change of 3V	<b>40</b>	78		dB
$A_{VOL}$	Large-Signal Voltage Gain	$R_L = 5k\Omega, V_{OUT} = 2V_{PP}$	<b>50</b>	66		dB
		$R_L = 100k\Omega, V_{OUT} = 2V_{PP}$	<b>66</b>	81		dB
		$R_L = 500k\Omega, V_{OUT} = 2V_{PP}$	<b>76</b>	91		dB
$V_{OUT}$	Maximum Output Voltage Swing	$R_L = 5k\Omega$	<b><math>V \pm 70mV</math></b>	$V \pm 34mV$		V
		$R_L = 500k\Omega$	<b><math>V \pm 2mV</math></b>	$V \pm 0.7mV$		V
$V_{OUT}$	Minimum Output Voltage Swing	$R_L = 5k\Omega$		$V \pm 11mV$	<b><math>V \pm 50mV</math></b>	mV
		$R_L = 500k\Omega$		$V \pm 0.2mV$	<b><math>V \pm 2mV</math></b>	mV
GBW	Gain-Bandwidth Product			4		MHz
SR	Slew Rate			3		V/ $\mu s$
$I_{SC}$	Short-Circuit Output Current	Source	<b>4.5</b>	6		mA
		Sink	<b>10</b>	16		mA
$I_S$	Supply Current	No Load		30	50	$\mu A$

### Notes:

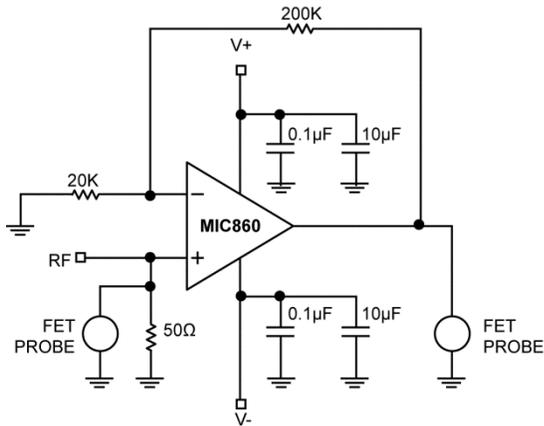
- Exceeding the absolute maximum ratings may damage the device.
- The device is not guaranteed to function outside its operating ratings.
- Devices are ESD sensitive. Handling precautions are recommended. Human body model, 1.5k $\Omega$  in series with 100pF. Pin 4 is ESD sensitive.
- Exceeding the maximum differential input voltage will damage the input stage and degrade performance (in particular, input bias current is likely to increase).

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

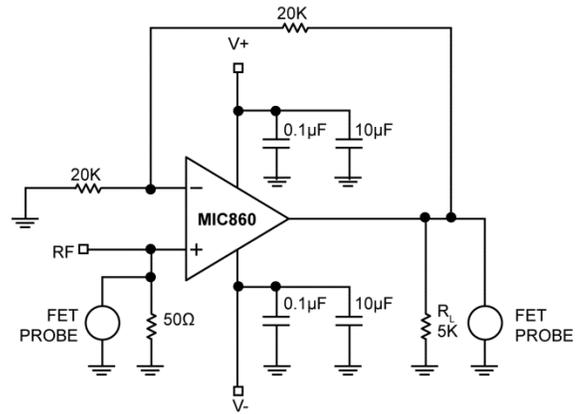
$V_{+} = +5V$ ,  $V_{-} = 0V$ ,  $V_{CM} = V_{+}/2$ ;  $R_L = 500k\Omega$  to  $V_{+}/2$ ;  $T_A = 25^{\circ}C$ , unless otherwise noted. **Bold** values indicate  $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ .

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
$V_{OS}$	Input Offset Voltage		-20	-5	20	mV
	Input Offset Voltage Temp Coefficient			20		$\mu V/^{\circ}C$
$I_B$	Input Bias Current			20		pA
$I_{OS}$	Input Offset Current			10		pA
$V_{CM}$	Input Voltage Range	CMRR > 60dB	<b>3.5</b>	4.2		V
CMRR	Common-Mode Rejection Ratio	$0 < V_{CM} < 3.5V$	<b>44</b>	77		dB
PSRR	Power Supply Rejection Ratio	Supply voltage change of 1V	<b>40</b>	79		dB
$A_{VOL}$	Large-Signal Voltage Gain	$R_L = 5k\Omega$ , $V_{OUT} 4.8V_{PP}$	<b>52</b>	66		dB
		$R_L = 100k\Omega$ , $V_{OUT} 4.8V_{PP}$	<b>67</b>	80		dB
		$R_L = 500k\Omega$ , $V_{OUT} 4.8V_{PP}$	<b>75</b>	90		dB
$V_{OUT}$	Maximum Output Voltage Swing	$R_L = 5k\Omega$	<b><math>V_{\pm 75mV}</math></b>	$V_{\pm 37mV}$		V
		$R_L = 500k\Omega$	<b><math>V_{\pm 35mV}</math></b>	$V_{\pm 4mV}$		V
$V_{OUT}$	Minimum Output Voltage Swing	$R_L = 5k\Omega$		$V_{\pm 14mV}$	<b><math>V_{\pm 40mV}</math></b>	mV
		$R_L = 500k\Omega$		$V_{\pm 0.4mV}$	<b><math>V_{\pm 5mV}</math></b>	mV
GBW	Gain-Bandwidth Product			4		MHz
SR	Slew Rate			3		V/ $\mu s$
$I_{SC}$	Short-Circuit Output Current	Source	<b>15</b>	23		mA
		Sink	<b>30</b>	47		mA
$I_S$	Supply Current	No Load		33	<b>55</b>	$\mu A$

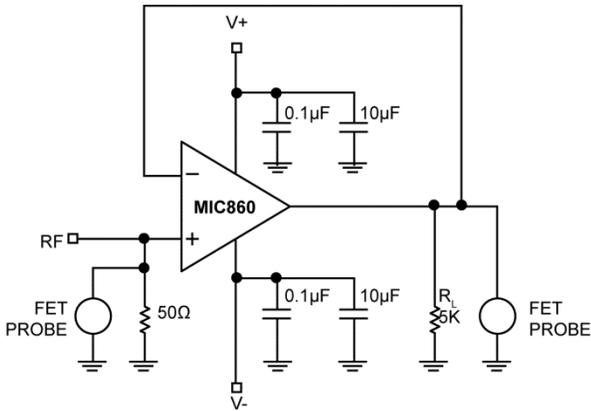
## Test Circuits



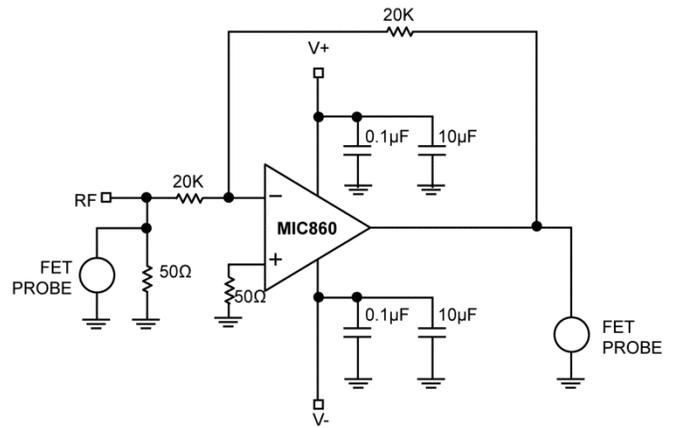
**Test Circuit 1.  $A_V = 10$**



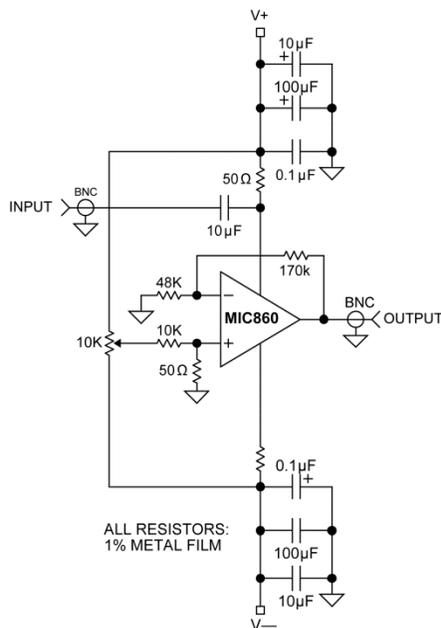
**Test Circuit 2.  $A_V = 2$**



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

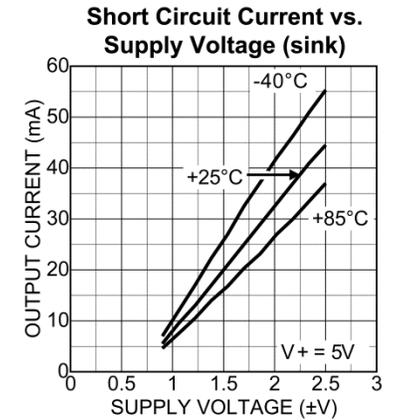
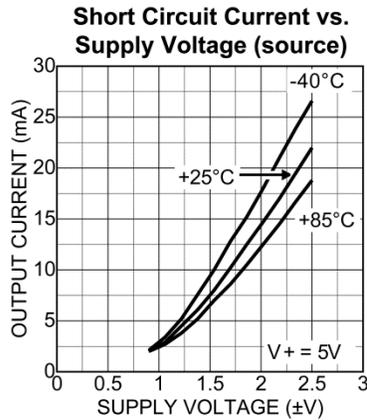
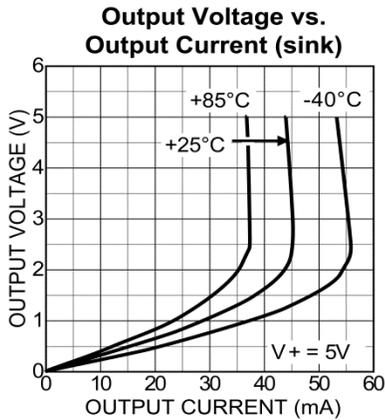
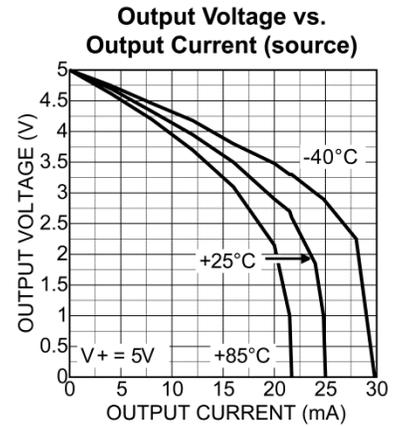
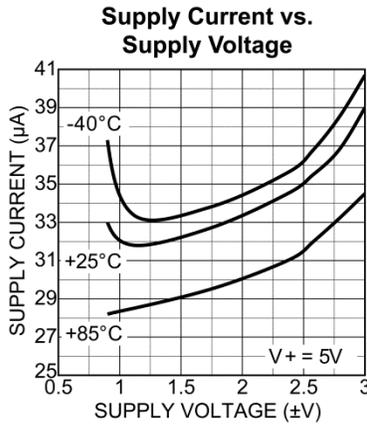
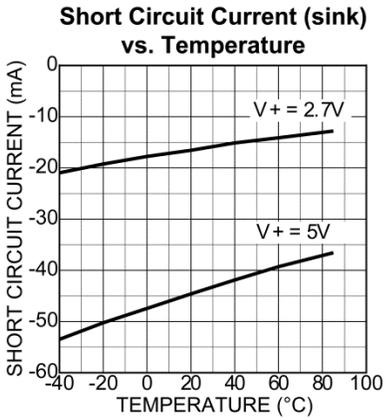
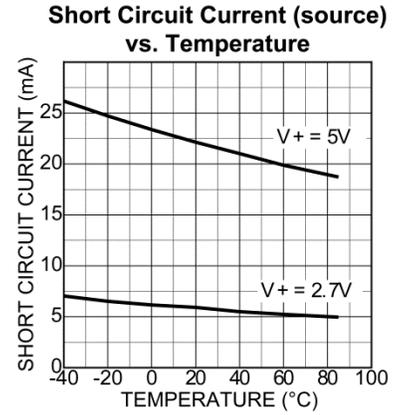
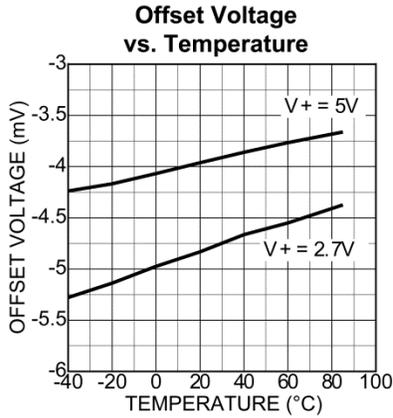
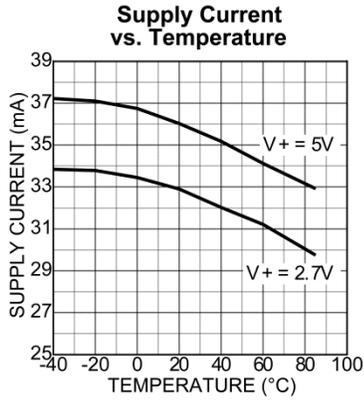


**Test Circuit 4.  $A_V = -1$**

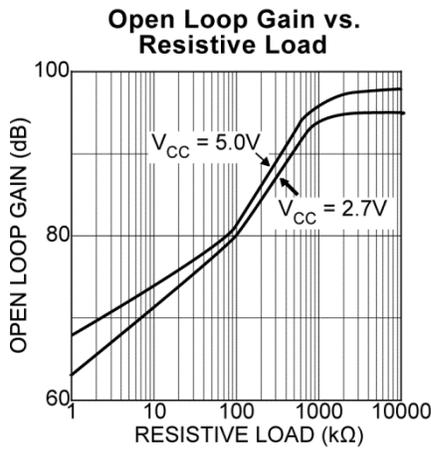
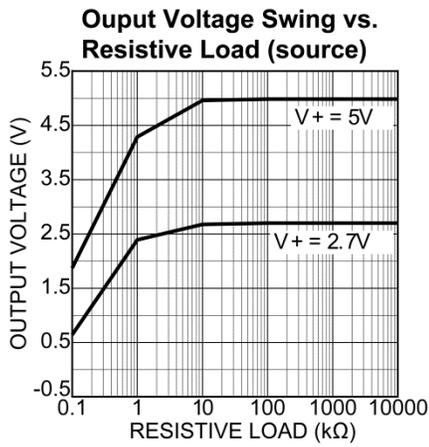
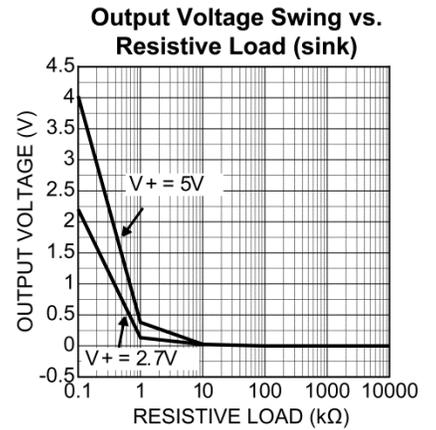
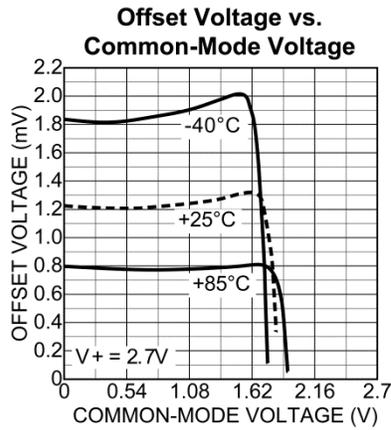
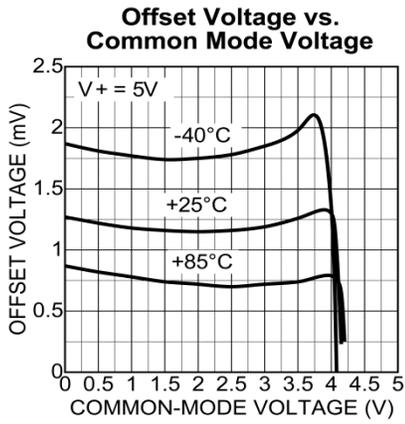


**Test Circuit 5. Positive Power Supply Rejection Ratio Measurement**

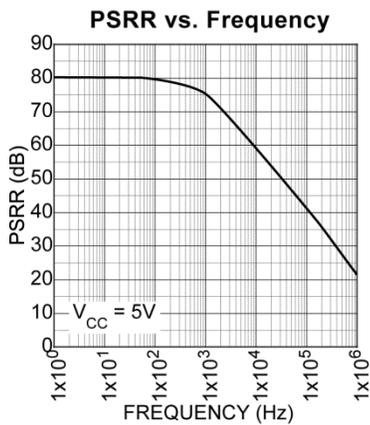
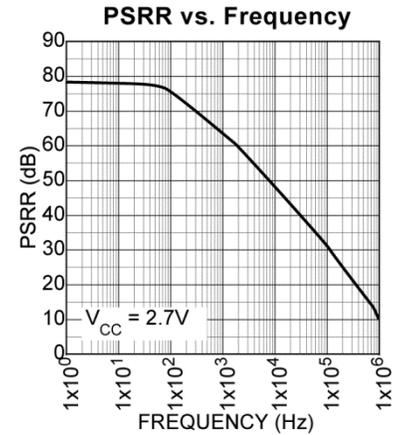
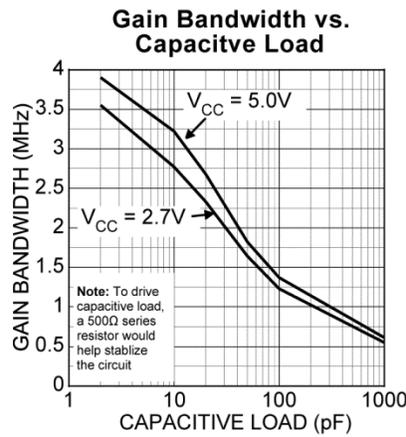
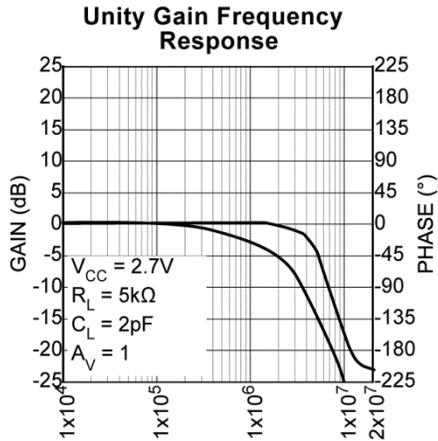
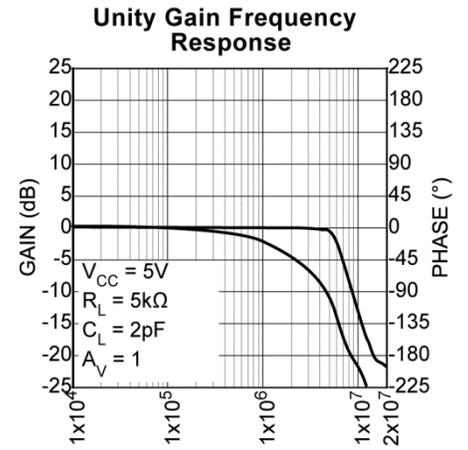
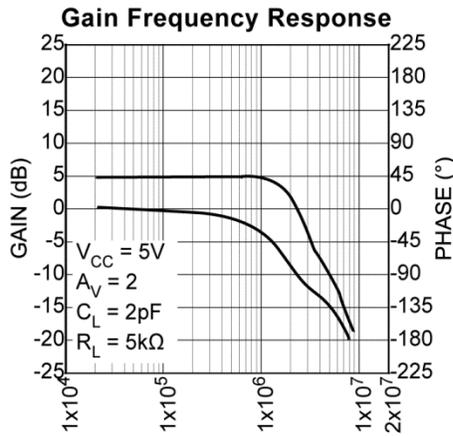
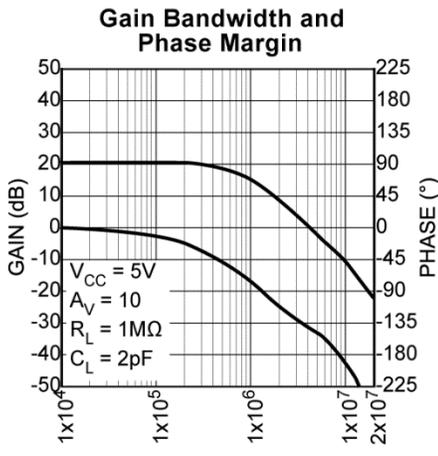
# Typical Characteristics



### Typical Characteristics (Continued)

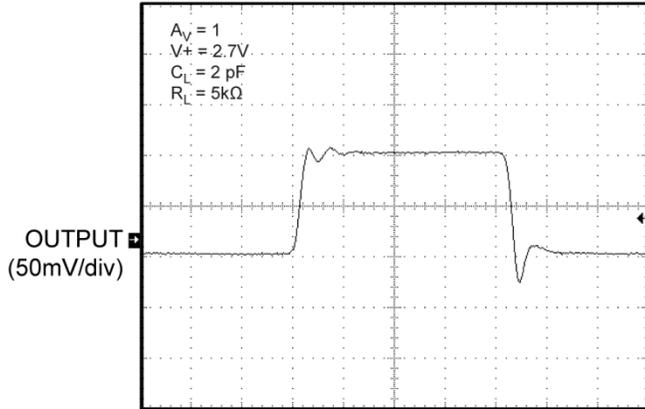


Typical Characteristics (Continued)



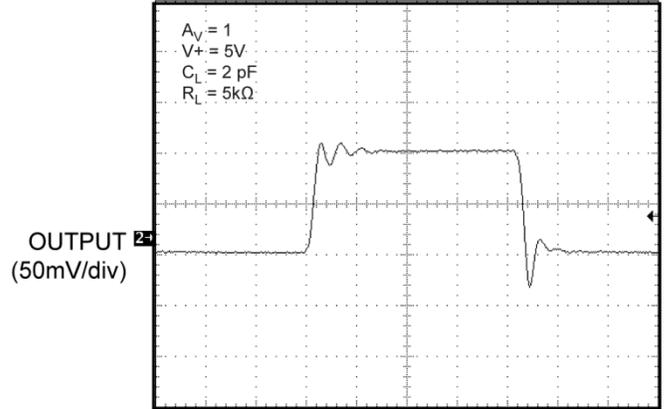
Functional Characteristics (Continued)

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



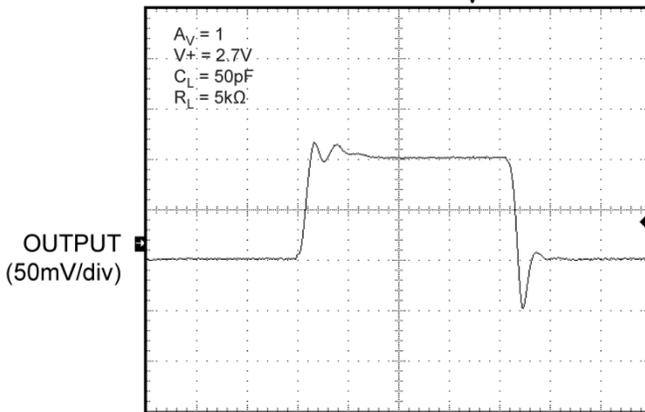
TIME (500ns/div)

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



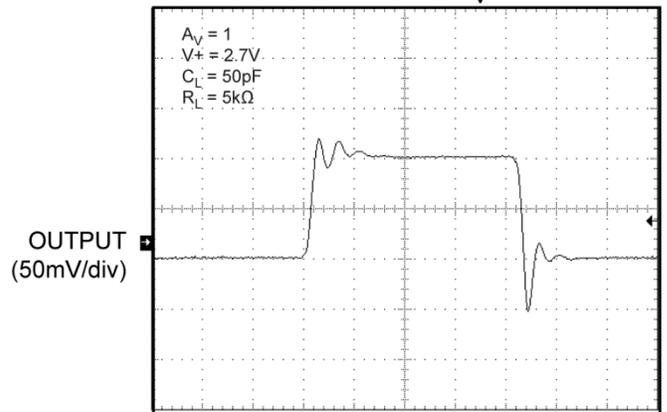
TIME (500ns/div)

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



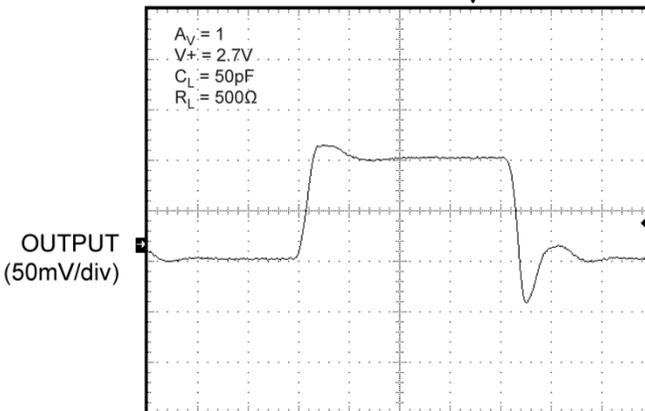
TIME (500ns/div)

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



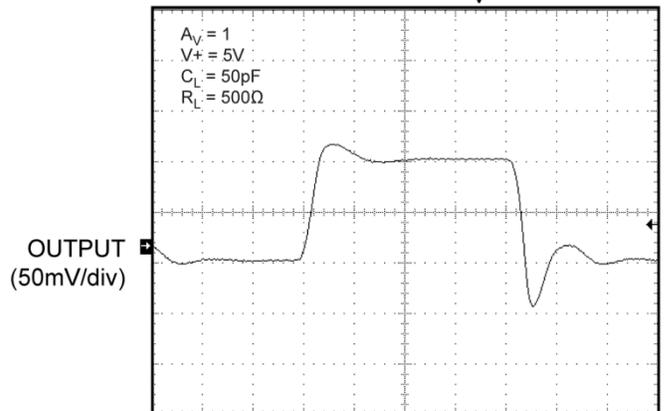
TIME (500ns/div)

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



TIME (500ns/div)

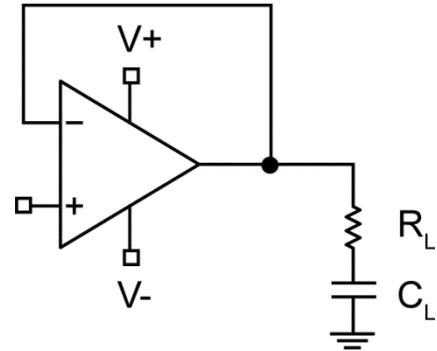
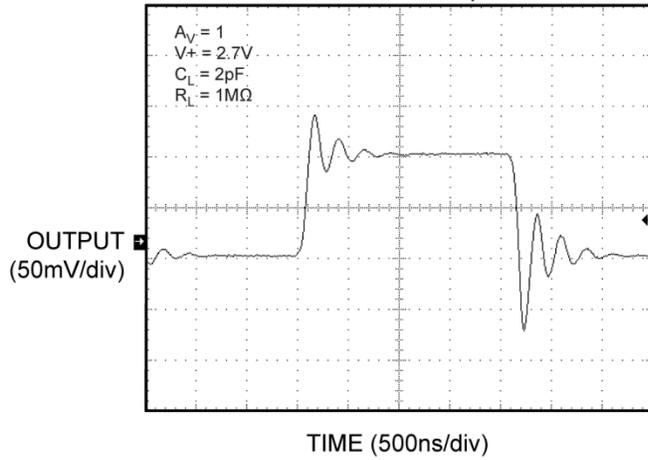
Small Signal Response  
Test Circuit 3:  $A_V = 1$



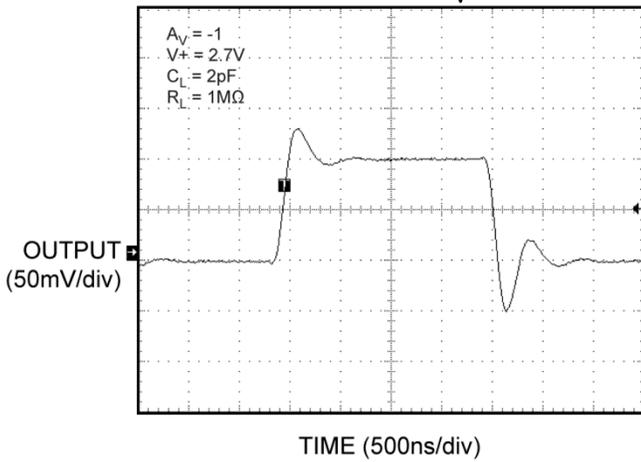
TIME (500ns/div)

Functional Characteristics (Continued)

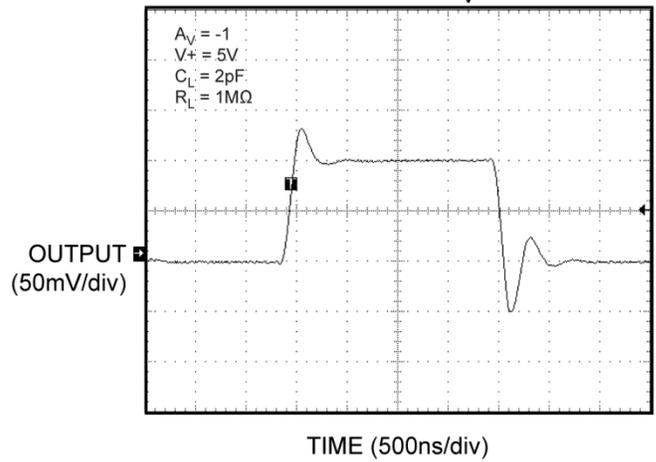
Small Signal Response  
Test Circuit 3:  $A_V = 1$



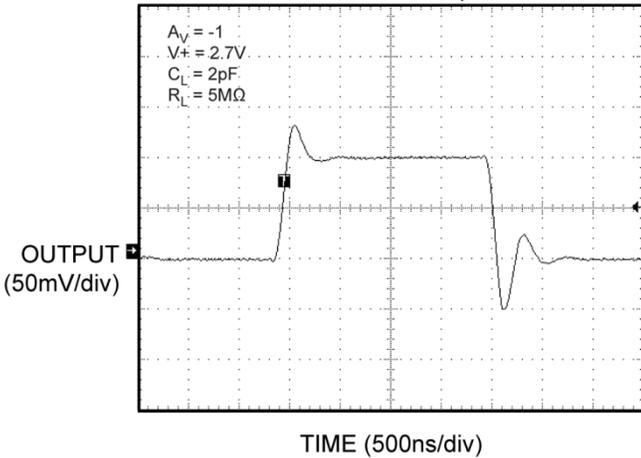
Small Signal Response  
Test Circuit 4:  $A_V = -1$



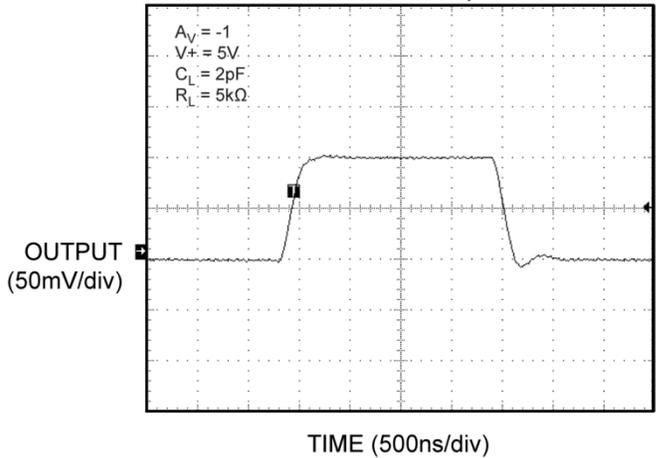
Small Signal Response  
Test Circuit 4:  $A_V = -1$



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

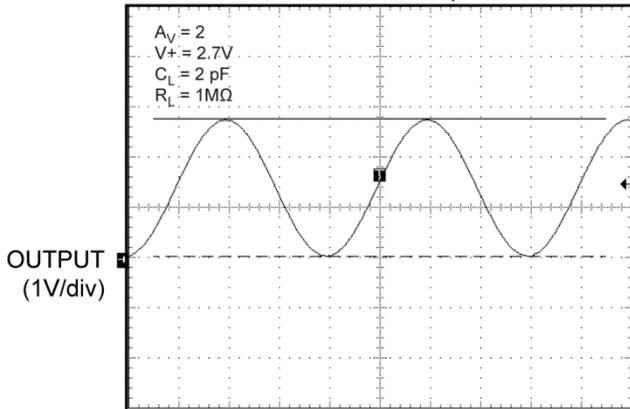


Small Signal Response  
Test Circuit 4:  $A_V = -1$



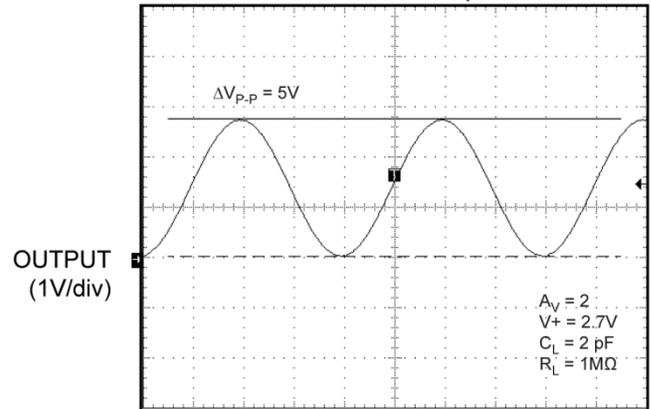
Functional Characteristics (Continued)

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



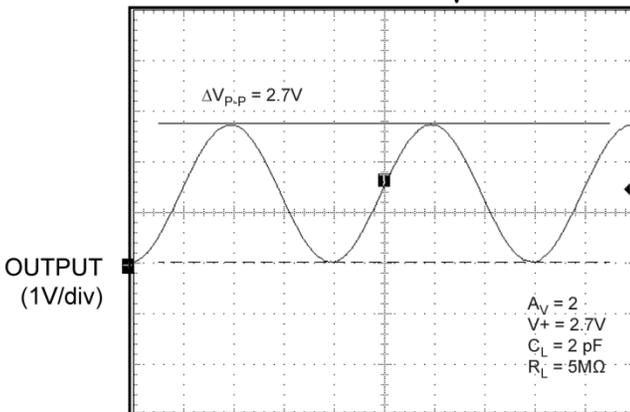
TIME (250μs/div)

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



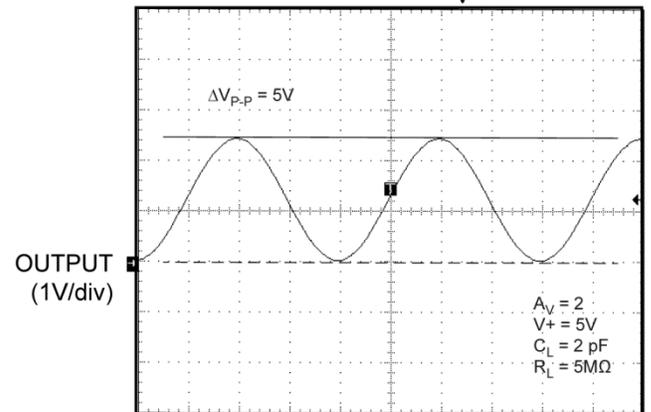
TIME (250μs/div)

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



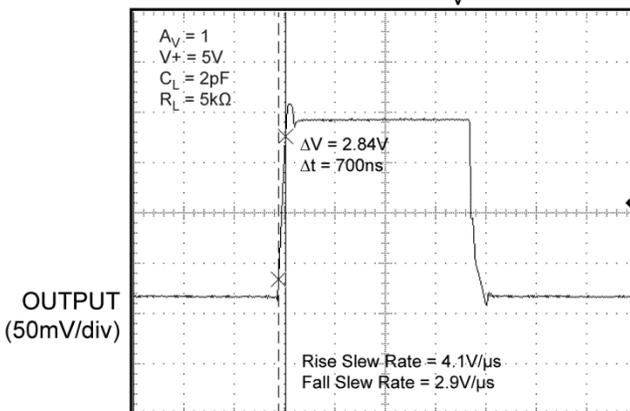
TIME (250μs/div)

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



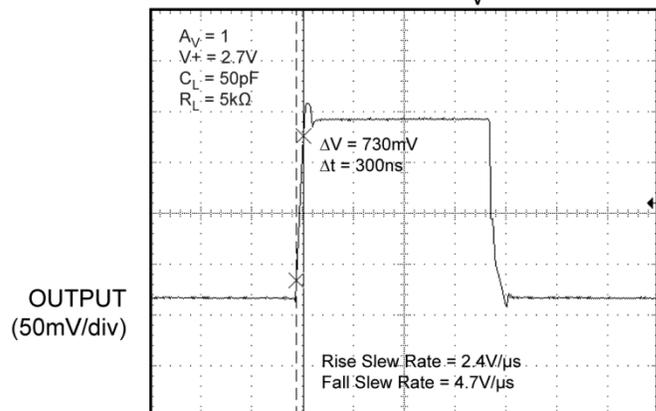
TIME (250μs/div)

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



TIME (5μs/div)

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



TIME (5μs/div)

## Application Information

### Power Supply Bypassing

Regular supply bypassing techniques are recommended. A  $10\mu\text{F}$  capacitor in parallel with a  $0.1\mu\text{F}$  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.

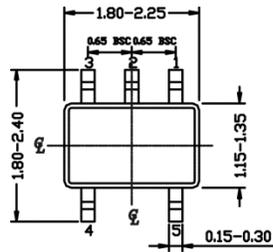
### Supply and Loading Considerations

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

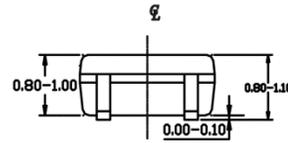
- 1). A grounded load and split supplies ( $\pm V$ ) or
- 2). A single supply where the load is terminated above ground.

Under the above conditions, if the load is less than  $20\text{k}\Omega$  and the output swing is greater than  $1\text{V}(\text{peak})$ , there may be some instability when the output is sinking current.

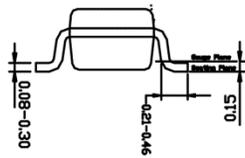
## Package Information and Recommended Land Pattern<sup>(6)</sup>



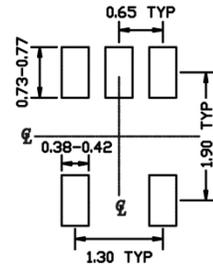
**TOP VIEW**



**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:**

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

**MICREL, INC. 2180 FORTUNE DRIVE SAN JOSE, CA 95131 USA**  
 TEL +1 (408) 944-0800 FAX +1 (408) 474-1000 WEB <http://www.micrel.com>

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