MIC861

Ultra-Low Power Operational Amplifier

Features

- SC70 Packaging
- 400 kHz Gain-Bandwidth Product
- 650 kHz, –3dB Bandwidth
- 4.6 µA Supply Current
- Rail-to-Rail Output
- Ground Sensing at Input (Common Mode to GND)
- Drives Large Capacitive Loads (1000 pF)
- Unity Gain Stable

Applications

- Handheld Electronics
- Laptop Computers
- Tablets
- Mobile Phones
- Consumer Electronics

General Description

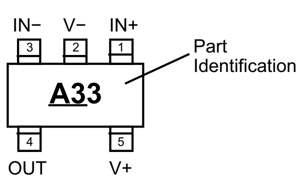
The MIC861 is a rail-to-rail output, input common-mode to ground, operational amplifier in SC70 packaging. The MIC861 provides a 400 kHz gain-bandwidth product while consuming an incredibly low 4.6 µA supply current.

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.

Package Type

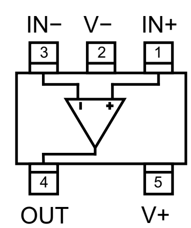
Pin Configuration

SC70–5 (C5)



Functional Configuration

SC70–5 (C5)



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{V+} to V_{V-}) .... +6.0V
Differential Input Voltage (V_{IN+} to V_{IN-}) .... +6.0V
Input Voltage (V_{IN+}, V_{IN-}) .... V_+ +0.3V to V_- –0.3V
Output Short-Circuit Current Duration .... Indefinite
ESD Rating........ (Note 1)

Operating Ratings ‡

Supply Voltage (V+ to V-) .... +2.43V to +5.25V

† 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 sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ Notice: The device is not guaranteed to function outside the operating ratings.

Note 1: Devices are ESD sensitive. Handling precautions are recommended. Human body model, 1.5 kΩ in series with 100 pF. Pin 4 is ESD sensitive.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: V+ = +2.7V, V– = 0V V_{CM} = V+/2; R_L = 500 kΩ to V+/2; T_A = 25°C, unless otherwise noted. (Note 2).

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Offset Voltage	V_{OS}	–10	2	10	mV	–40°C ≤ T_A ≤ +85°C (Note 1)
Input Offset Voltage Temperature Coefficient		—	15	—	µV/°C	—
Input Bias Current	I_B	—	20	—	pA	—
Input Offset Current	I_{OS}	—	10	—	pA	—
Input Voltage Range	V_{CM}	—	1.8	—	V	CMRR >60 dB
Common-Mode Rejection Ratio	CMRR	45	77	—	dB	0 < V_{CM} < 1.35V, –40°C ≤ T_A ≤ +85°C
Power Supply Rejection Ratio	PSRR	50	83	—	dB	Supply voltage change of 3V, –40°C ≤ T_A ≤ +85°C
Large-Signal Voltage Gain	A_{VOL}	60	74	—	dB	R_L = 100 kΩ, V_{OUT} = $2V_{PP}$, –40°C ≤ T_A ≤ +85°C
		73	83	—	dB	R_L = 500 kΩ, V_{OUT} = $2V_{PP}$, –40°C ≤ TA ≤ +85°C
Maximum Output Voltage Swing	V_{OUT}	V ±2 mV	V ±0.7 mV	—	V	R_L = 500 kΩ, –40°C ≤ T_A ≤ +85°
		—	V ±0.2 mV	V ±2 mV		
Gain-Bandwidth Product	GBWP	—	350	—	kHz	R_L = 200 kΩ, C_L = 2 pF, V_{OUT} = 0
–3 dB Bandwidth	B_W	—	500	—	kHz	A_V = 1, C_L = 2 pF, R_L = 1 MΩ
Slew Rate	S_R	—	0.12	—	V/µs	A_V = 1, C_L = 2 pF, R_L = 1 MΩ
Short-Circuit Output Current	I_{SC}	—	6	—	mA	Source
	—	—	5	—	mA	Sink
Supply Current	I_S	—	4.2	9	µA	No load, –40°C ≤ T_A ≤ +85°

ELECTRICAL CHARACTERISTICS (SINGLE SUPPLY)

Electrical Characteristics: V+ = +5V, V- = 0V, V_{CM} = V+/2; R_L = 500 kΩ to V+/2; T_A = 25°C, T_A= T_J; unless otherwise noted (Note 2).

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Offset Voltage	V_{OS}	–10	2	10	mV	–40°C ≤ T_A ≤ +85°C (Note 1)
Input Offset Voltage Temperature Coefficient	V_{OS}	—	15	—	µV/°C	—
Input Bias Current	I_B	—	20	—	pA	—
Input Offset Current	I_{OS}	—	10	—	pA	—
Input Voltage Range	V_{CM}	—	4.2	—	V	CMRR >60 dB
Common-Mode Rejection Ratio	CMRR	60	80	—	dB	0 < V_{CM} < 3.5V, –40°C ≤ T_A ≤ +85°C
Power Supply Rejection Ratio	PSRR	45	85	—	dB	Supply voltage change of 1V, –40°C ≤ T_A ≤ +85°C
Large-Signal Voltage Gain	A_{VOL}	60	76	—	dB	R_L = 100 kΩ, V_{OUT} = $4V_{PP}$, –40°C ≤ TA ≤ +85°C
		68	83	—	dB	R_L = 500 kΩ, V_{OUT} = $4V_{PP}$, –40°C ≤ TA ≤ +85°C
Maximum Output Voltage Swing	V_{OUT}	V ±2 mV	V ±0.7 mV	—	V	R_L = 500 kΩ, –40°C ≤ T_A ≤ +85°C
		—	V ±0.7 mV	V ±2 mV	V	
Gain-Bandwidth Product	GBWP	—	400	—	kHz	R_L = 200 kΩ, C_L = 2 pF, V_{OUT} = 0
–3 dB Bandwidth	B_W	—	650	—	kHz	A_V = 1, C_L = 2 pF, R_L = 1 MΩ
Slew Rate	S_R	—	0.12	—	V/µs	A_V = 1, C_L = 2 pF, R_L = 1 MΩ
Short-Circuit Output Current	I_{SC}	10	24	—	mA	Source, –40°C ≤ T_A ≤ +85°C
				—	mA	Sink, –40°C ≤ T_A ≤ +85°C
Supply Current	I_S	—	4.6	9	µA	No load, –40°C ≤ T_A ≤ +85°

Note 1: The offset voltage distribution is centered around 0V. The typical offset number shown is equal to the standard deviation of the voltage offset distribution.

2: 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).

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Storage Temperature	T_S	—	—	150	°C	—
Ambient Temperature Range	T_A	–40	—	+85	°C	—
Lead Temperature	—	—	—	260	°C	Soldering, 5s
Package Thermal Resistance						
Thermal Resistance SC70	θ_{JA}	—	450	—	°C/W	—

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +85°C rating. Sustained junction temperatures above +85°C can impact the device reliability.

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.

DC Typical Characteristics:

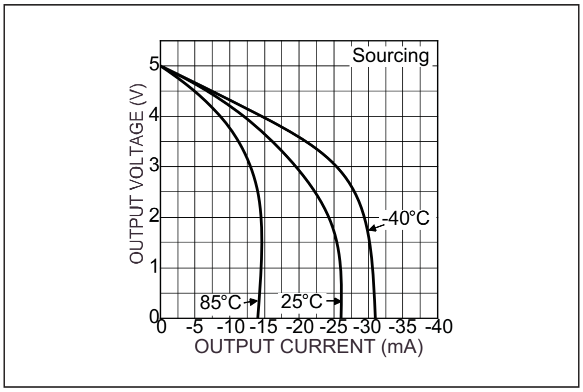


FIGURE 2-1: Output Voltage vs. Output Current.

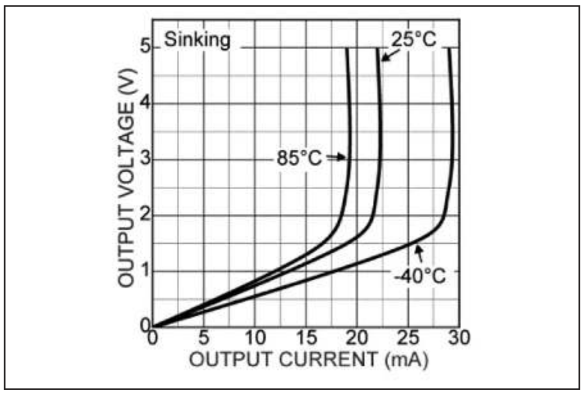


FIGURE 2-2: Output Voltage vs. Output Current.

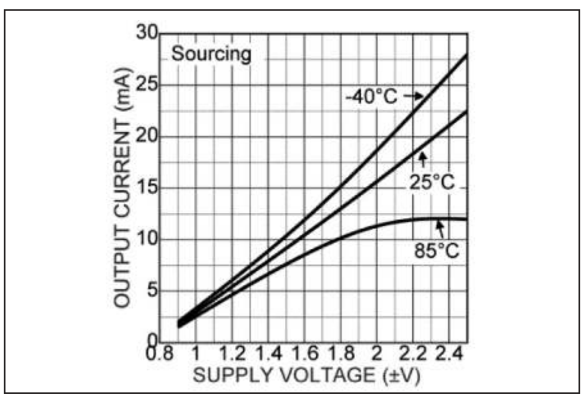


FIGURE 2-3: Short Circuit Current vs. Supply Voltage.

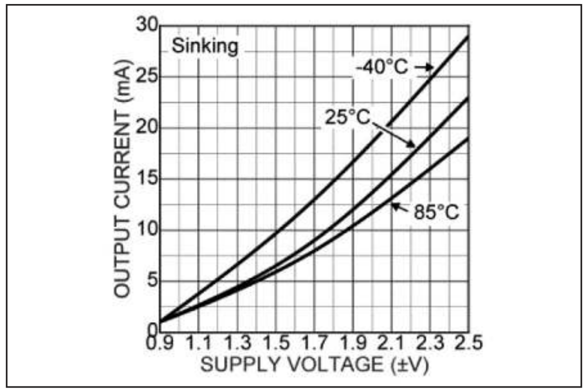


FIGURE 2-4: Short Circuit Current vs. Supply Voltage.

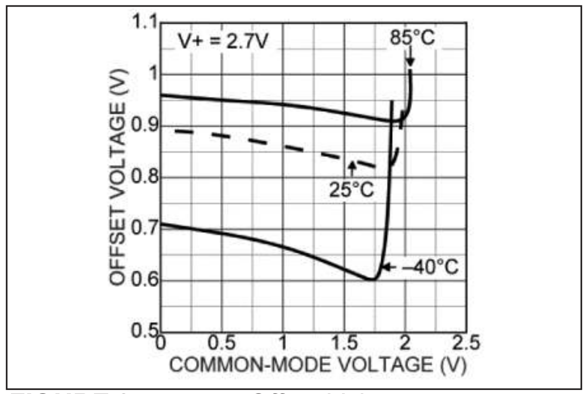


FIGURE 2-5: Offset Voltage vs. Common-Mode Voltage.

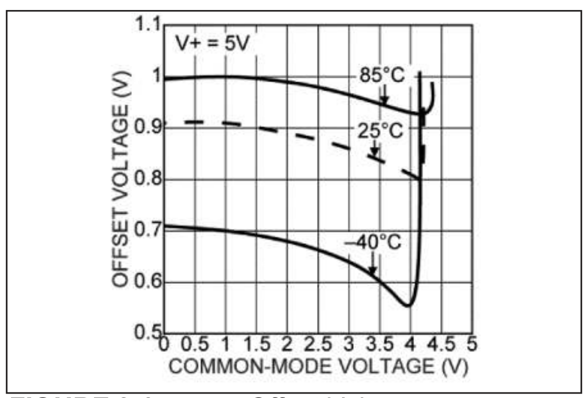


FIGURE 2-6: Offset Voltage vs. Common-Mode Voltage.

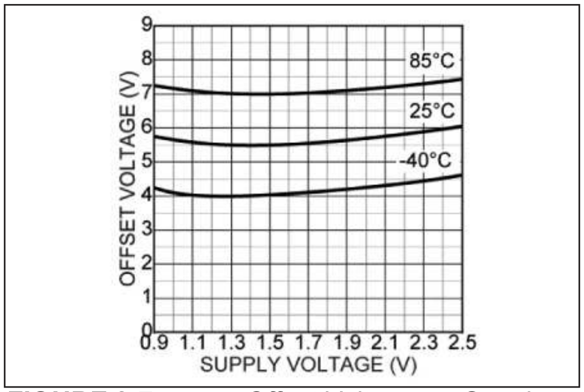


FIGURE 2-7: *Offset Voltage vs. Supply Voltage.*

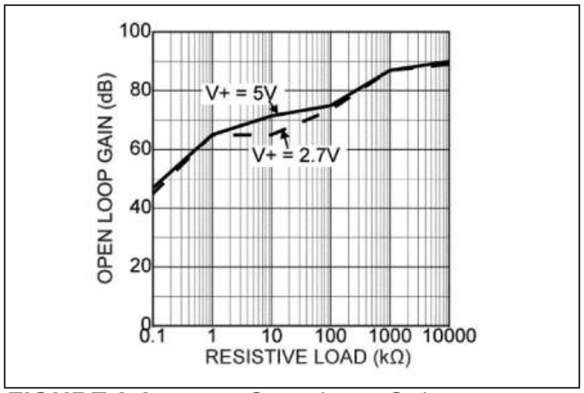


FIGURE 2-8: *Open Loop Gain vs. Resistive Load.*

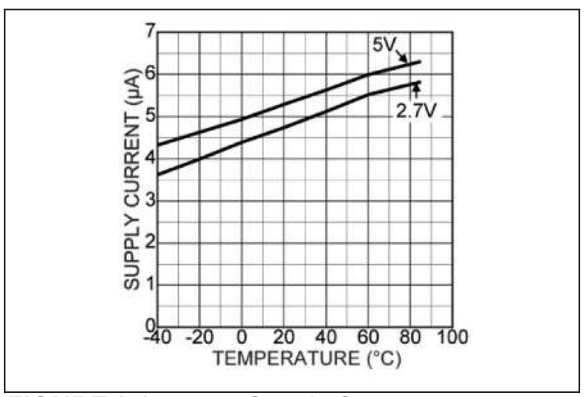


FIGURE 2-9: *Supply Current vs. Temperature.*

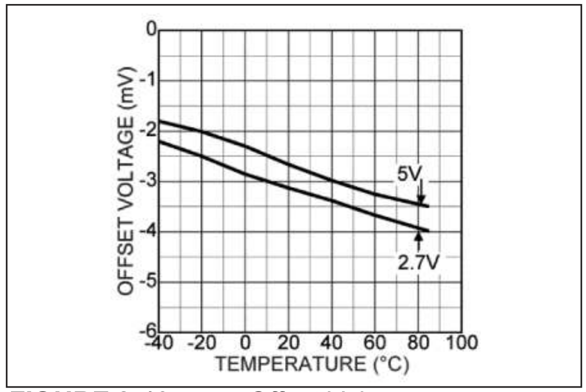


FIGURE 2-10: *Offset Voltage vs. Temperature.*

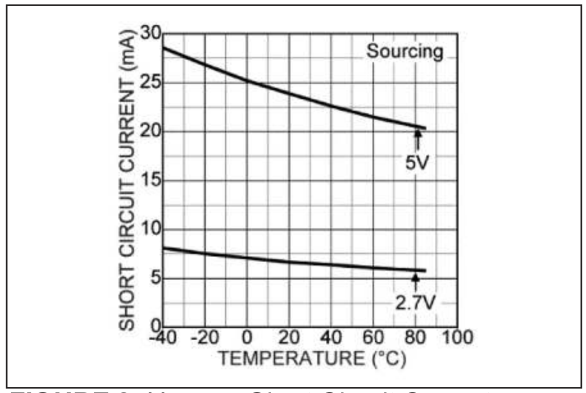


FIGURE 2-11: *Short Circuit Current vs. Temperature.*

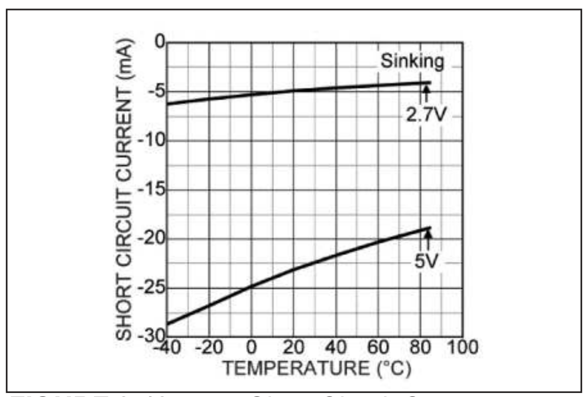


FIGURE 2-12: *Short Circuit Current vs. Temperature.*

AC Typical Characteristics:

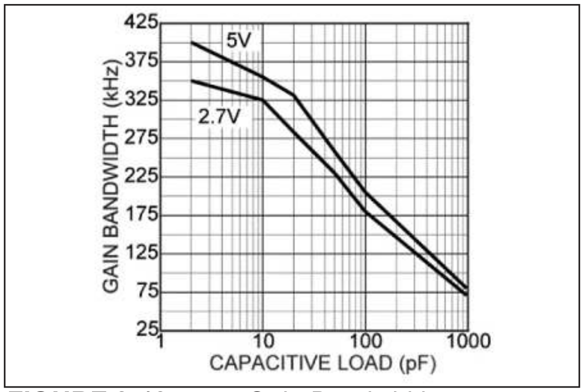


FIGURE 2-13: *Gain Bandwidth vs. Capacitive Load.*

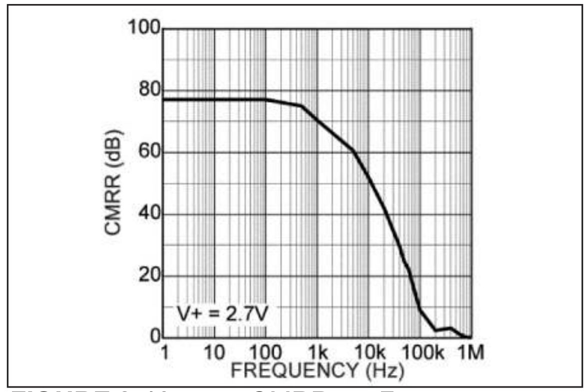


FIGURE 2-16: *CMRR vs. Frequency.*

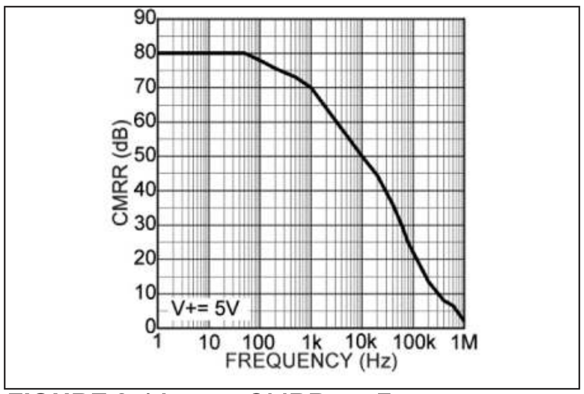


FIGURE 2-14: *CMRR vs. Frequency.*

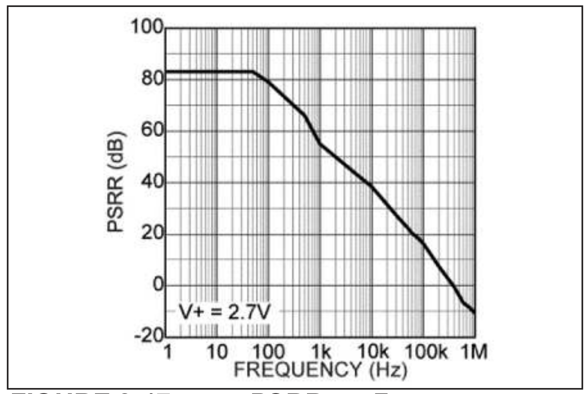


FIGURE 2-17: *PSRR vs. Frequency.*

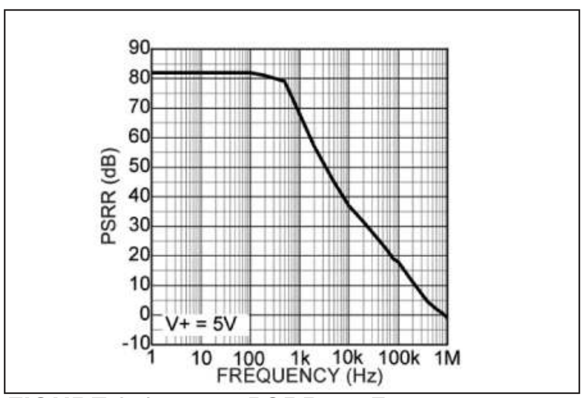


FIGURE 2-15: *PSRR vs. Frequency.*

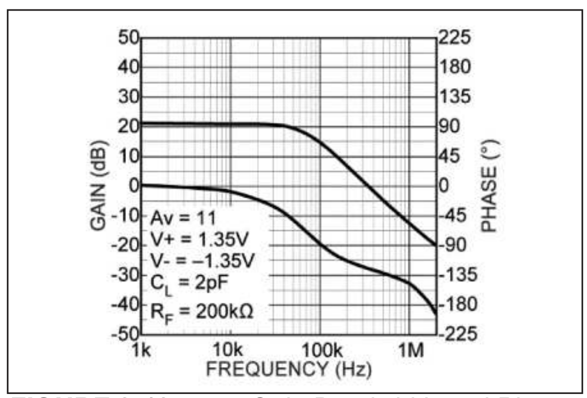


FIGURE 2-18: *Gain Bandwidth and Phase Margin.*

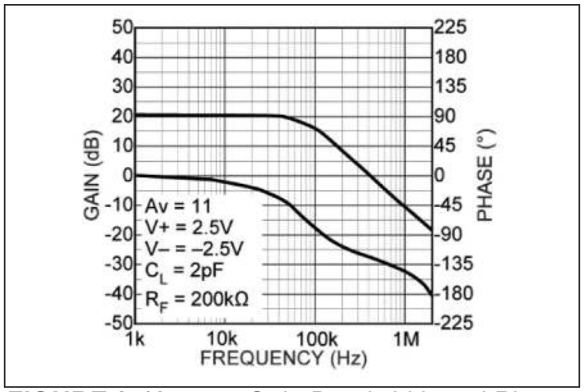


FIGURE 2-19: *Gain Bandwidth and Phase Margin.*

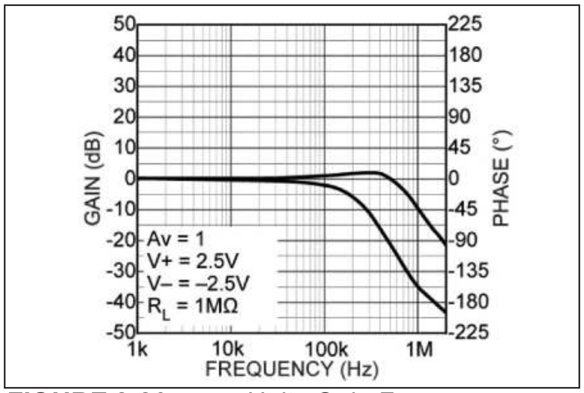


FIGURE 2-20: *Unity Gain Frequency Response.*

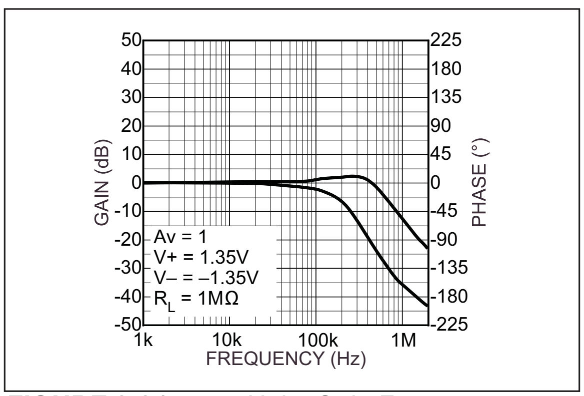


FIGURE 2-21: *Unity Gain Frequency Response.*

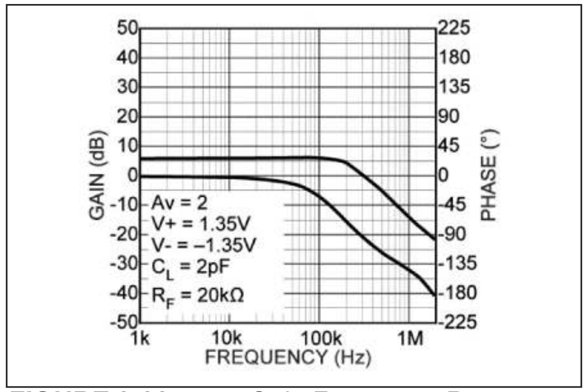


FIGURE 2-22: *Gain Frequency Response.*

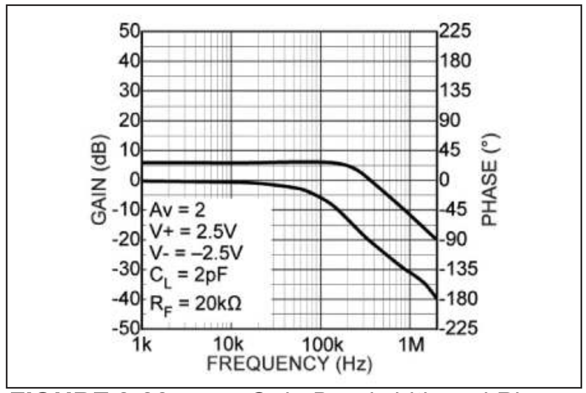


FIGURE 2-23: *Gain Bandwidth and Phase Margin.*

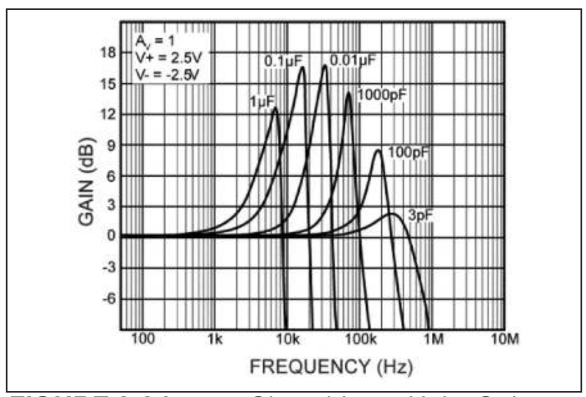


FIGURE 2-24: *Closed-Loop Unity Gain Frequency Response.*

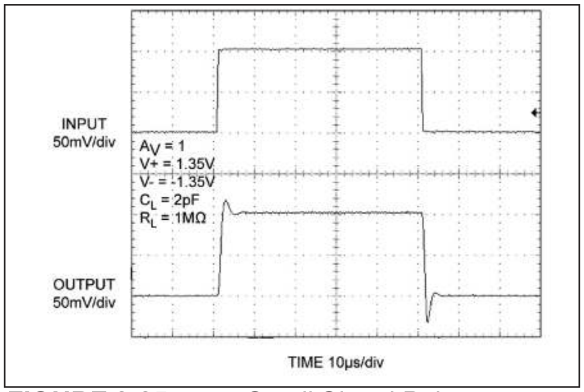


FIGURE 2-25: *Small Signal Pulse Response (See Figure 3-3).*

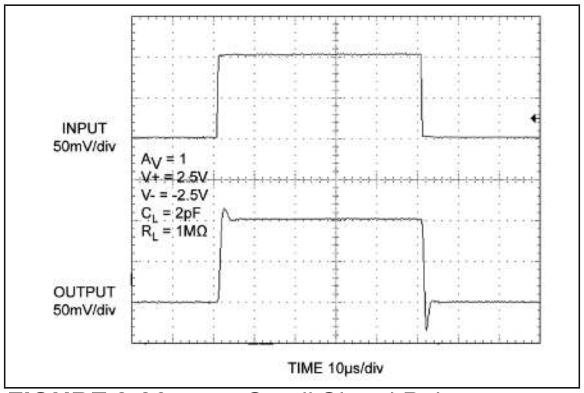


FIGURE 2-26: *Small Signal Pulse Response (See Figure 3-3).*

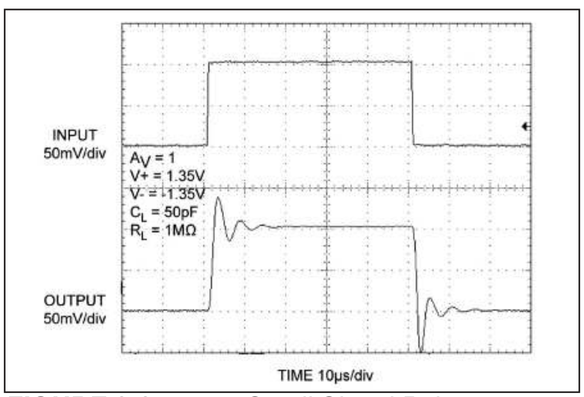


FIGURE 2-27: *Small Signal Pulse Response (See Figure 3-3).*

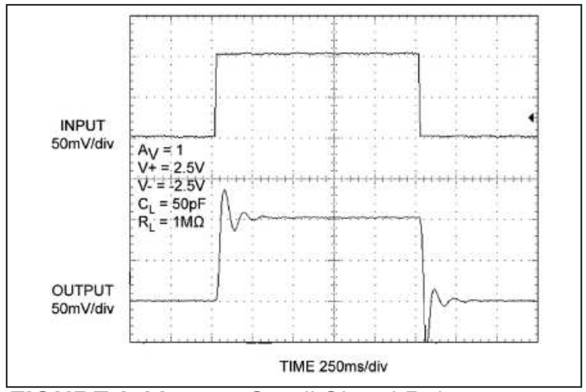


FIGURE 2-28: *Small Signal Pulse Response (See Figure 3-3).*

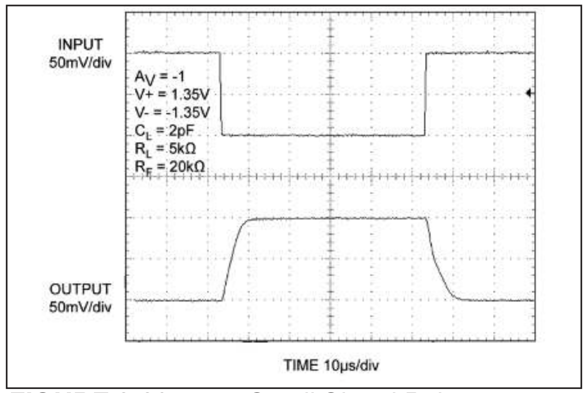


FIGURE 2-29: *Small Signal Pulse Response (See Figure 3-4).*

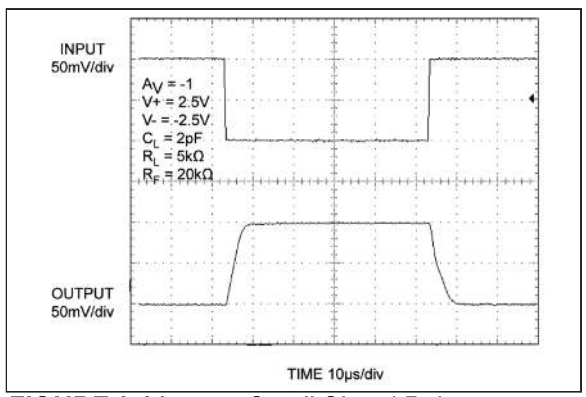


FIGURE 2-30: *Small Signal Pulse Response (See Figure 3-4).*

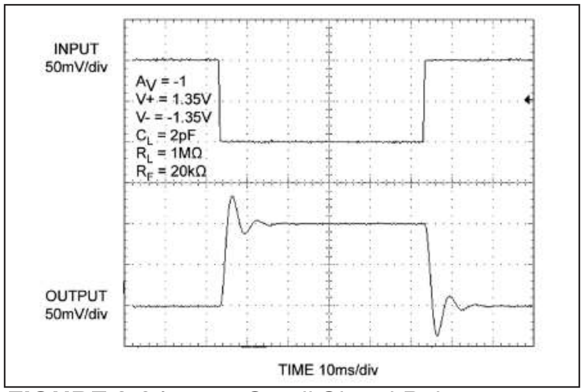


FIGURE 2-31: Small Signal Pulse Response (See Figure 3-4).

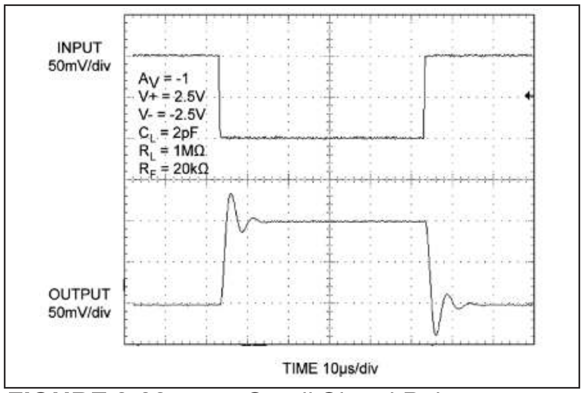


FIGURE 2-32: Small Signal Pulse Response (See Figure 3-4).

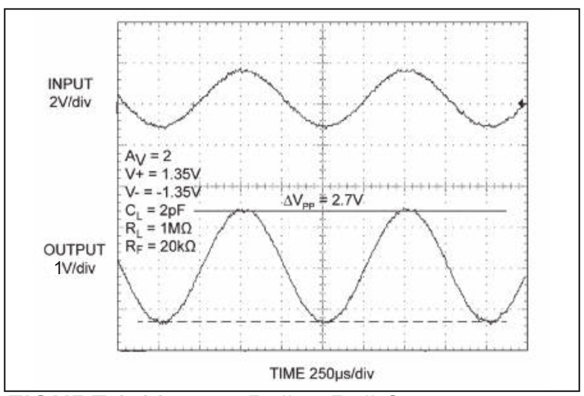


FIGURE 2-33: Rail to Rail Output Operation.

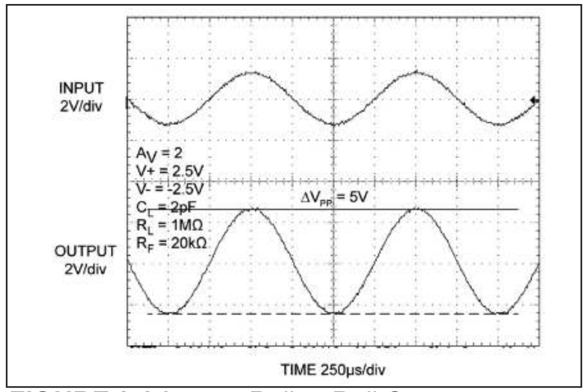


FIGURE 2-34: Rail to Rail Output Operation.

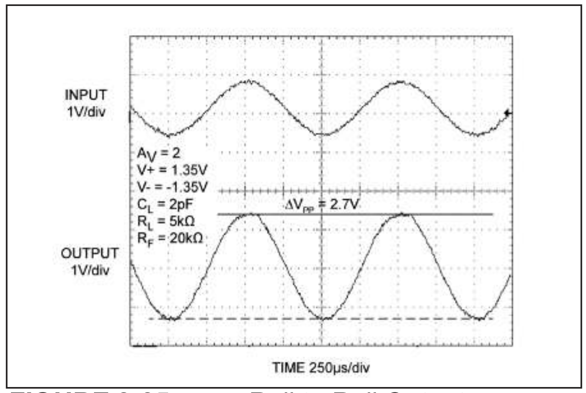


FIGURE 2-35: Rail to Rail Output Operation.

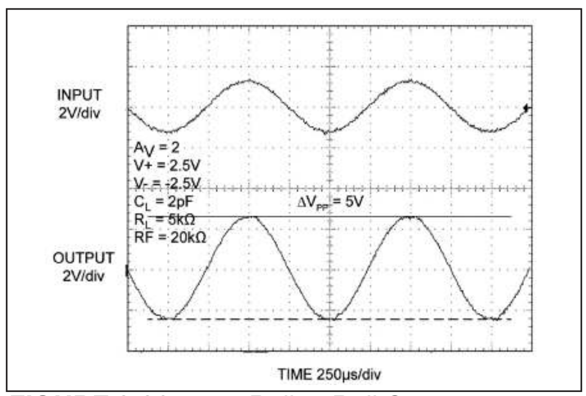


FIGURE 2-36: Rail to Rail Output Operation.

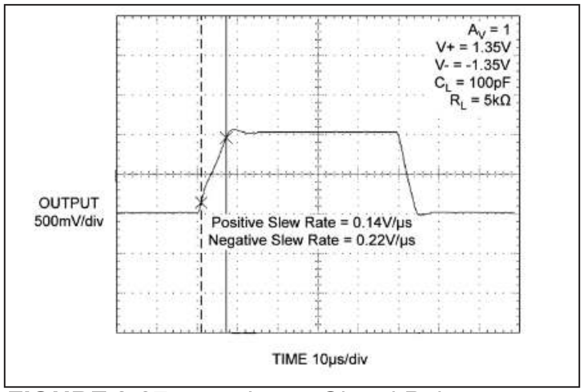


FIGURE 2-37: *Large Signal Pulse Response (See Figure 3-3).*

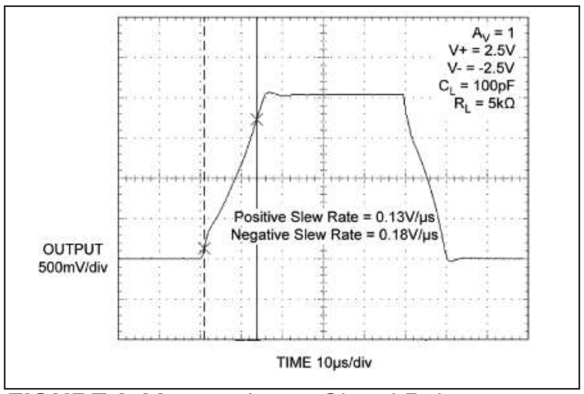


FIGURE 2-38: *Large Signal Pulse Response (See Figure 3-3).*

3.0 TEST CIRCUITS

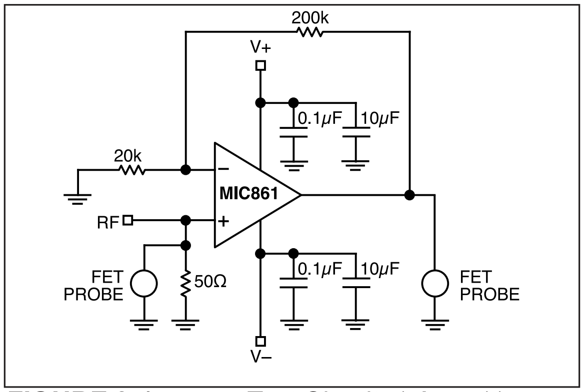


FIGURE 3-1: *Test Circuit: 1 A_V = 11.*

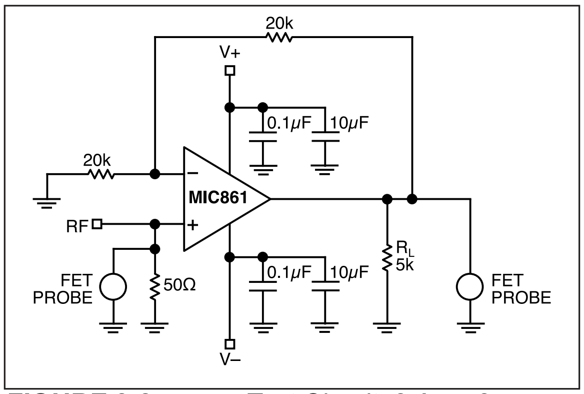


FIGURE 3-2: *Test Circuit: 2 A_V = 2.*

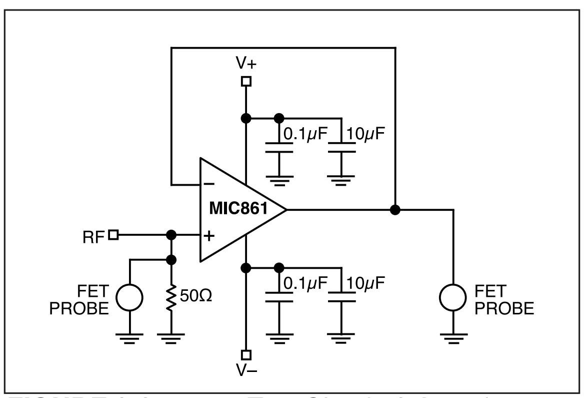


FIGURE 3-3: *Test Circuit: 3 A_V = 1.*

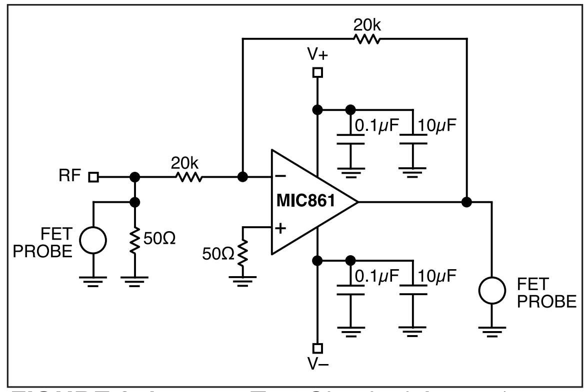


FIGURE 3-4: *Test Circuit: 4 A_V = –1.*

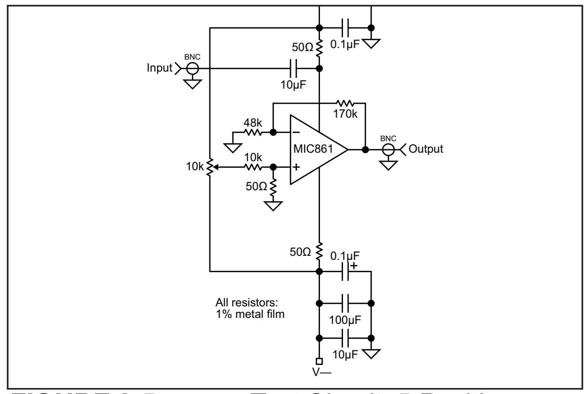


FIGURE 3-5: *Test Circuit: 5 Positive Power Supply Rejection Ratio Measurement.*

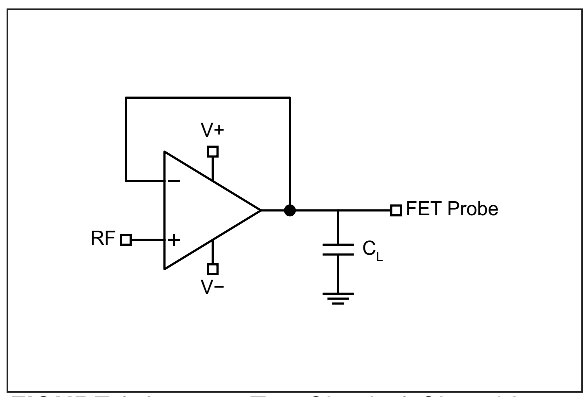


FIGURE 3-6: *Test Circuit: 6 Closed-Loop Unity Gain Frequency Response Measurement.*

4.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 4-1.

TABLE 4-1: PIN FUNCTION TABLE

Pin Number	Symbol	Description
1	IN+	Non-inverting input.
2	V–	Negative power supply connection. Connect a 10 µF and 0.1 µF 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 µF and 0.1 µF capacitor in parallel to this pin for power supply bypassing.

5.0 APPLICATION INFORMATION

Regular supply bypassing techniques are recommended. A 10 μF capacitor in parallel with a 0.1 μF 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.

6.0 PACKAGING INFORMATION

6.1 Package Marking Information

5-Lead SC70* (Front)	Example
XXX	A33

5-Lead SC70* (Back)	Example
NNN	415

Legend:	XX...X	Product code or 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')
	NNN	Alphanumeric traceability code
	(e3)	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.
	●, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).

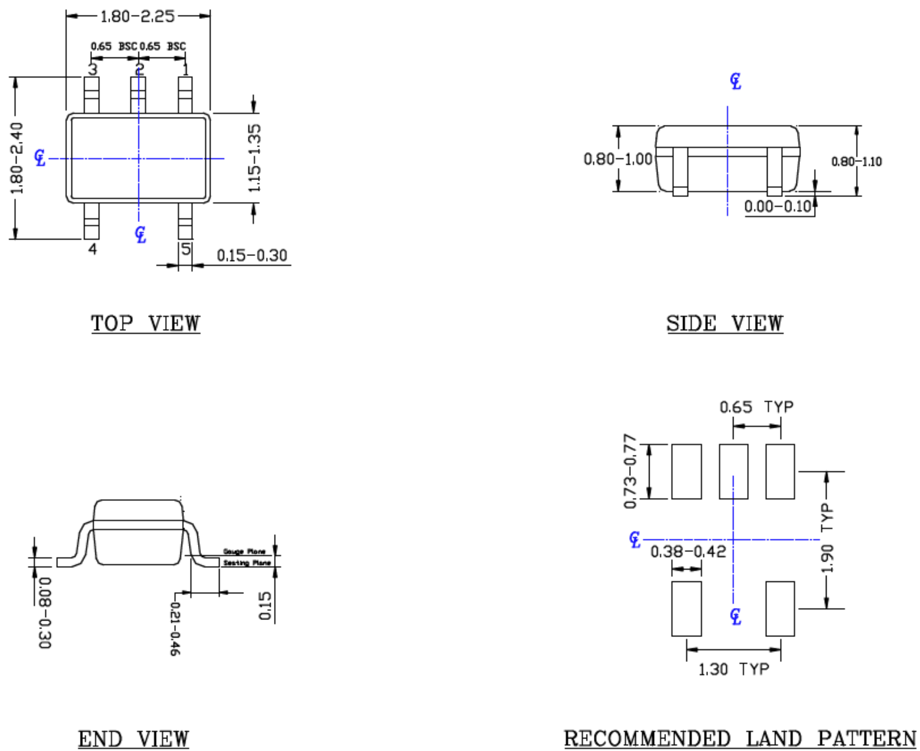
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

Underbar (_) and/or Overbar (‾) symbol may not be to scale.

5-Lead SC70 Package Outline and Recommended Land Pattern

TITLE
5 LEAD SC70 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	SC70-5LD-PL-2	UNIT	MM



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

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

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (July 2020)

- Converted Micrel document MIC861 to Microchip data sheet template DS20006347A.
- Minor text changes throughout.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART NO.	X	XX	-XX
Device	Temperature	Package	Media Type

Device:	MIC861:		Ultra-Low Power Operational Amplifier
Temperature:	Y	=	–40°C to +85°C
Package:	C5	=	5-Lead SC70
Media Type:	TR	=	3,000/Reel

Examples:

a) MIC861YC5-TR: Op Amp, –40°C to +85°C Junction Temperature Range, 5-Lead SC70 Package, 3,000/Reel

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

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.
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- 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."

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