MIC860

Ultra-Low Power Op Amp

Features

- 5-Lead SC70 Packaging
- 4 MHz Gain-Bandwidth Product
- 30 µA 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
- Sensor Conditioning
- Analog Filters
- Mobile Phones
- Consumer Electronics

General Description

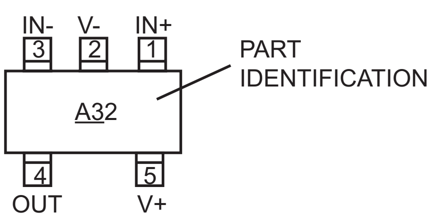
The MIC860 is a rail-to-rail output, operational amplifier in the SC70 package. The MIC860 provides 4 MHz gain-bandwidth product while consuming an incredibly low 30 µA supply current.

The SC70 packaging achieves significant board space savings over devices packaged in SOT-23 or MSOP-8 packaging.

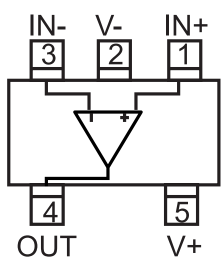
The SC70 occupies approximately half the board area of an SOT-23 package.

Package Type

MIC860
5-Lead SC70 (C5)
(Top View)



Functional Pinout



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{V+} – $V_{V–}$) .... +6.0V
Differential Input Voltage (|V_{IN+} – $V_{IN–}$|) (Note 1) .... +6.0V
Input Voltage (V_{IN+} – $V_{IN–}$) .... V_+ + 0.3V, $V_–$ – 0.3V
Output Short-Circuit Duration .... Indefinite
ESD Rating (Note 2) .... ESD Sensitive

Operating Ratings ‡

Supply Voltage (V_{V+} – $V_{V–}$) .... +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 its operating ratings. Final test on outgoing product is performed at T_A = +25°C.

Note 1: Exceeding the maximum differential input voltage will damage the input stage and degrade performance. In particular, input bias current is likely to increase.

2: 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 (2.7V)

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.

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Offset Voltage	V_{OS}	–20	–5	15	mV	—
		–25	—	20	mV	
Input Offset Voltage Temp. Coefficient		—	20	—	µV/°C	
Input Bias Current	I_B	—	20	—	pA	—
Input Offset Current	I_{OS}	—	10	—	pA	—
Input Voltage Range	V_{CM}	1	1.8	—	V	CMRR > 60 dB, –40°C ≤ T_A ≤ +85°C
Common Mode Rejection Ratio	CMRR	38	76	—	dB	0V < V_{CM} < 1.35V, –40°C ≤ T_A ≤ +85°C
Power Supply Rejection Ratio	PSRR	40	78	—	dB	Supply voltage change of 3V, –40°C ≤ T_A ≤ +85°C
Large-Signal Voltage Gain	A_{VOL}	50	66	—	dB	R_L = 5 kΩ, V_{OUT} = 2 V_{PP}, –40°C ≤ T_A ≤ +85°C
		66	81	—	dB	R_L = 100 kΩ, V_{OUT} = 2 V_{PP}, –40°C ≤ T_A ≤ +85°C
		76	91	—	dB	R_L = 500 kΩ, V_{OUT} = 2 V_{PP}, –40°C ≤ T_A ≤ +85°C
Maximum Output Voltage Swing	V_{OUT}	V±70mV	V±34mV	—	V	R_L = 5 kΩ, –40°C ≤ T_A ≤ +85°C
		V±2mV	V±0.7mV	—	V	R_L = 500 kΩ, –40°C ≤ T_A ≤ +85°C
Minimum Output Voltage Swing	V_{OUT}	—	V±11mV	V±50mV	mV	R_L = 5 kΩ, –40°C ≤ T_A ≤ +85°C
		—	V±0.2mV	V±2mV	mV	R_L = 500 kΩ, –40°C ≤ T_A ≤ +85°C
Gain Bandwidth Product	GBW	—	4	—	MHz	—
Slew Rate	SR	—	3	—	V/µs	—
Short-Circuit Output Current	I_{SC}	4.5	6	—	mA	Source, –40°C ≤ T_A ≤ +85°C
		10	16	—	mA	Sink, –40°C ≤ T_A ≤ +85°C
Supply Current	I_S	—	30	50	µA	No Load

ELECTRICAL CHARACTERISTICS (5.0V)

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

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Offset Voltage	V_{OS}	–20	–5	20	mV	—
Input Offset Voltage Temp Coefficient		—	20	—	µV/°C	—
Input Bias Current	I_B	—	20	—	pA	—
Input Offset Current	I_{OS}	—	10	—	pA	—
Input Voltage Range	V_{CM}	3.5	4.2	—	V	CMRR > 60 dB, –40°C ≤ T_A ≤ +85°C
Common Mode Rejection Ratio	CMRR	44	77	—	dB	0V < V_{CM} < 3.5V, –40°C ≤ T_A ≤ +85°C
Power Supply Rejection Ratio	PSRR	40	79	—	dB	Supply voltage change of 1V, –40°C ≤ T_A ≤ +85°C
Large Signal Voltage Gain	A_{VOL}	52	66	—	dB	R_L = 5 kΩ, V_{OUT} = 4.8 V_{PP}, –40°C ≤ T_A ≤ +85°C
		67	80	—	dB	R_L = 100 kΩ, V_{OUT} = 4.8 V_{PP}, –40°C ≤ T_A ≤ +85°C
		75	90	—	dB	R_L = 500 kΩ, V_{OUT} = 4.8 V_{PP}, –40°C ≤ T_A ≤ +85°C
Maximum Output Voltage Swing	V_{OUT}	V±75mV	V±37mV	—	V	R_L = 5 kΩ, –40°C ≤ T_A ≤ +85°C
		V±35mV	V±4mV	—	V	R_L = 500 kΩ, –40°C ≤ T_A ≤ +85°C
Minimum Output Voltage Swing	V_{OUT}	—	V±14mV	V±40mV	mV	R_L = 5 kΩ, –40°C ≤ T_A ≤ +85°C
		—	V±0.4mV	V±5mV	mV	R_L = 500 kΩ, –40°C ≤ T_A ≤ +85°C
Gain Bandwidth Product	GBW	—	4	—	MHz	—
Slew Rate	SR	—	3	—	V/µs	—
Short-Circuit Output Current	I_{SC}	15	23	—	mA	Source, –40°C ≤ T_A ≤ +85°C
		30	47	—	mA	Sink, –40°C ≤ T_A ≤ +85°C
Supply Current	I_S	—	33	55	µA	No Load, –40°C ≤ T_A ≤ +85°C

TEMPERATURE SPECIFICATIONS

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 Soldering	—	—	—	+260	°C	Soldering, 5 sec.
Package Thermal Resistances						
5-Lead SC70	θ_{JA}	—	450	—	°C/W	—

2.0 TEST CIRCUITS

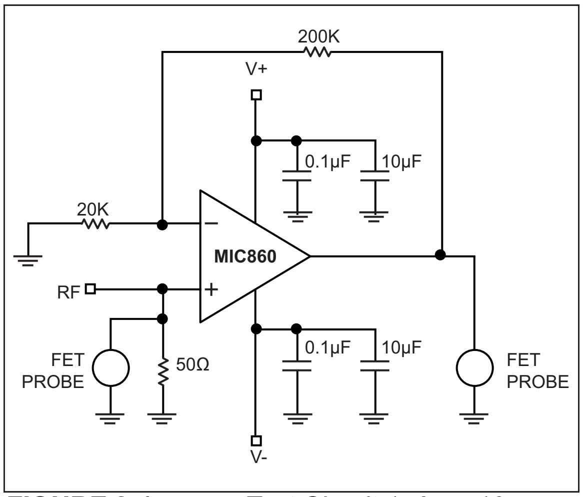


FIGURE 2-1: *Test Circuit 1, A_V = 10.*

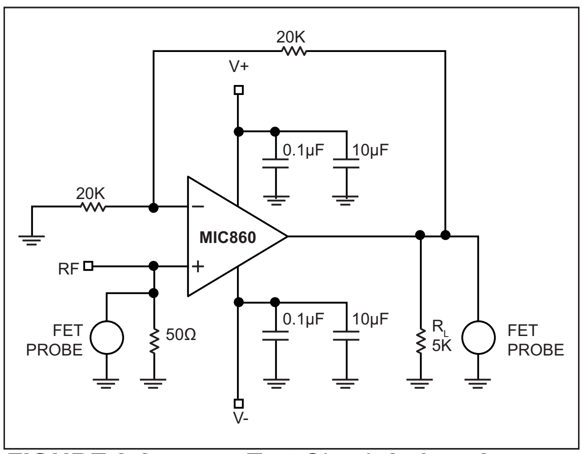


FIGURE 2-2: *Test Circuit 2, A_V = 2.*

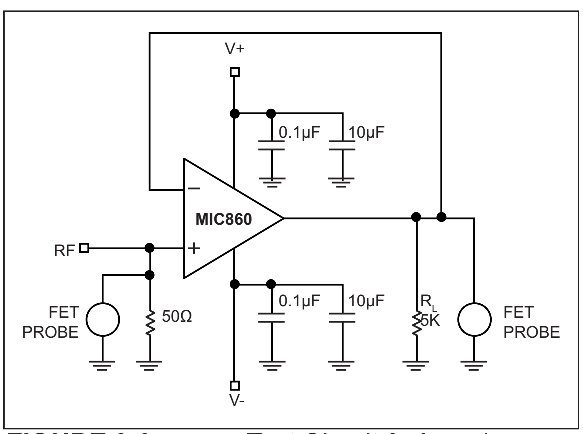


FIGURE 2-3: *Test Circuit 3, A_V = 1.*

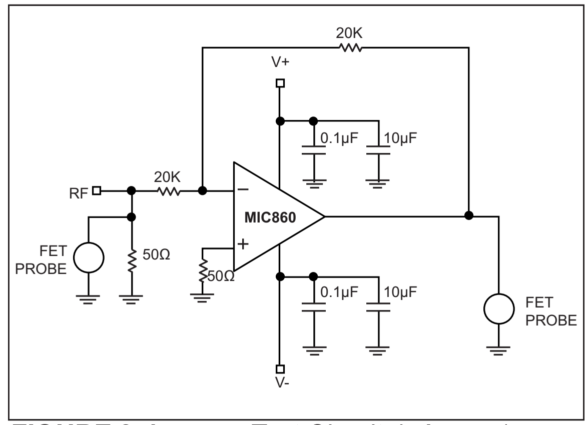


FIGURE 2-4: *Test Circuit 4, A_V = –1.*

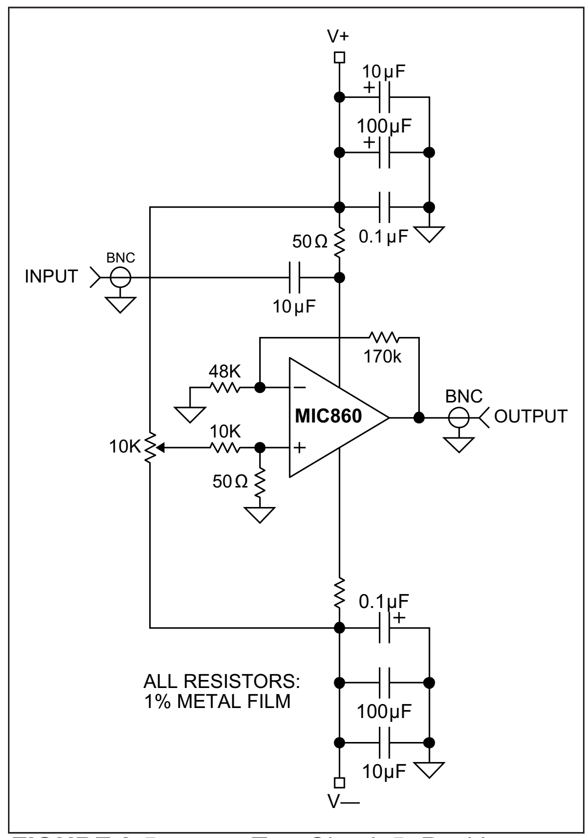


FIGURE 2-5: *Test Circuit 5, Positive Power Supply Rejection Ratio Measurement.*

3.0 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.

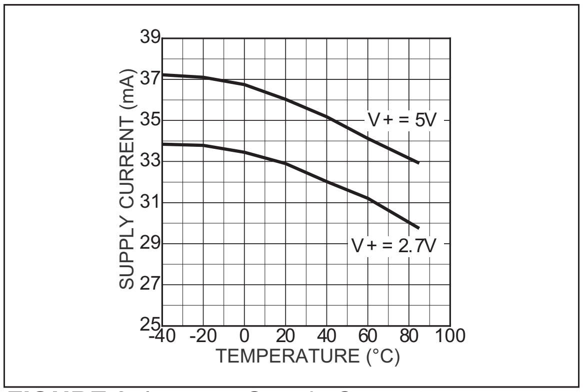


FIGURE 3-1: *Supply Current vs. Temperature.*

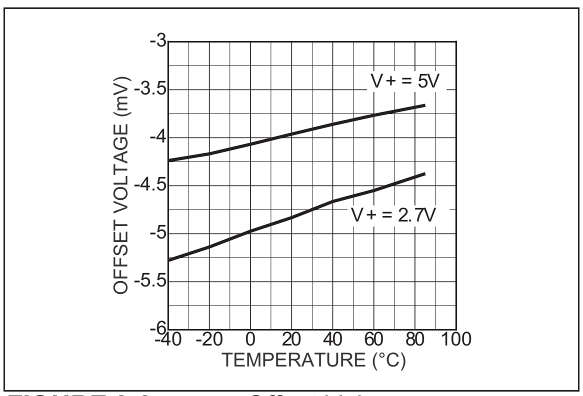


FIGURE 3-2: *Offset Voltage vs. Temperature.*

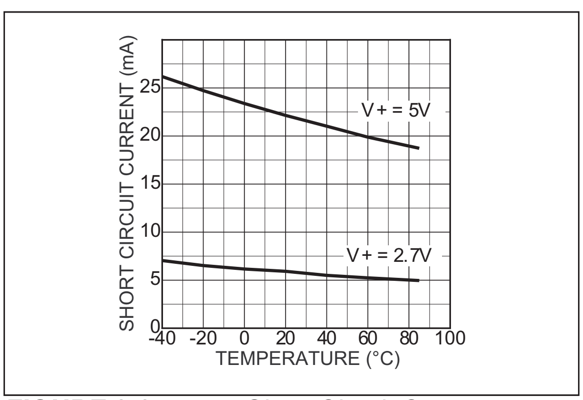


FIGURE 3-3: *Short-Circuit Current (Source) vs. Temperature.*

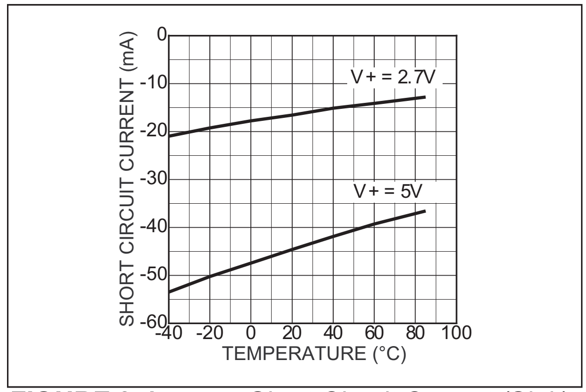


FIGURE 3-4: *Short-Circuit Current (Sink) vs. Temperature.*

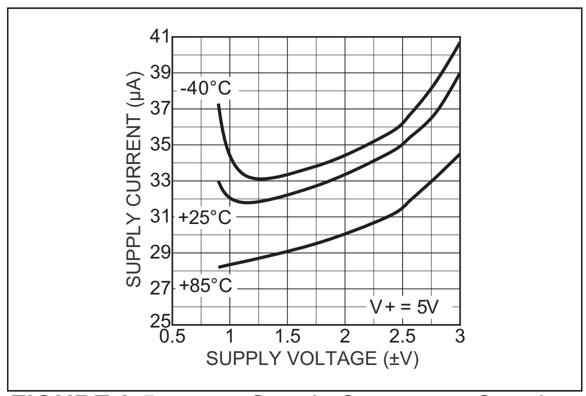


FIGURE 3-5: *Supply Current vs. Supply Voltage.*

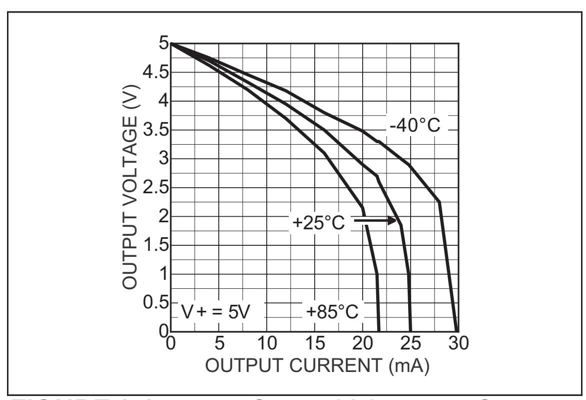


FIGURE 3-6: *Output Voltage vs. Output Current (Source).*

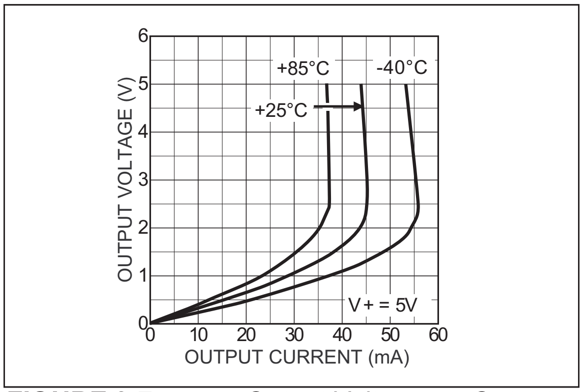


FIGURE 3-7: *Output Voltage vs. Output Current (Sink).*

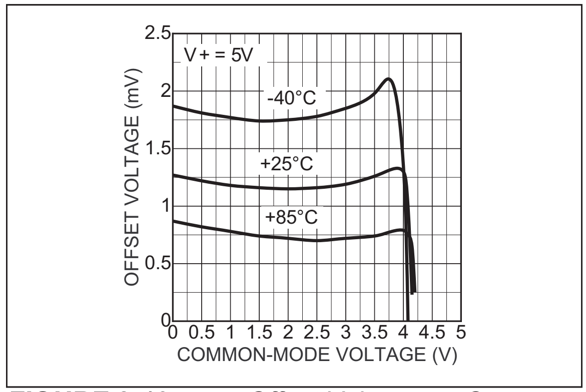


FIGURE 3-10: *Offset Voltage vs. Common Mode Voltage.*

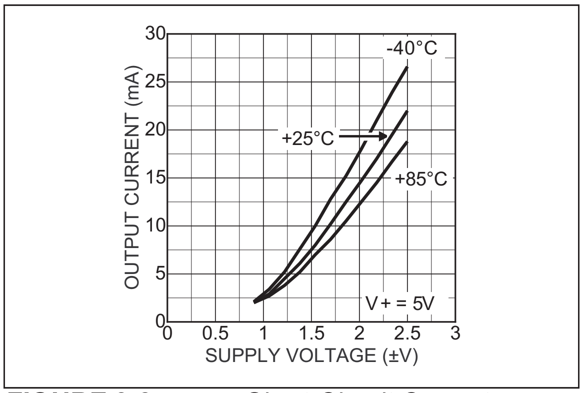


FIGURE 3-8: *Short-Circuit Current vs. Supply Voltage (Source).*

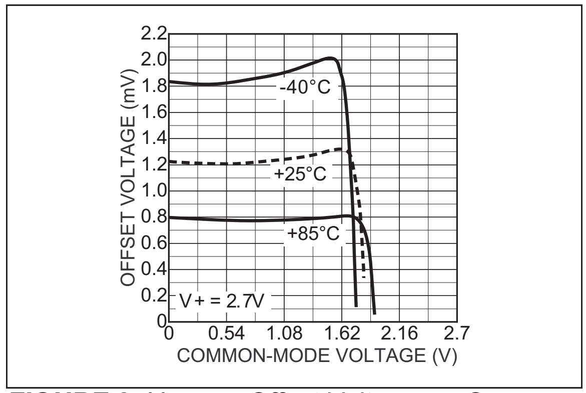


FIGURE 3-11: *Offset Voltage vs. Common Mode Voltage.*

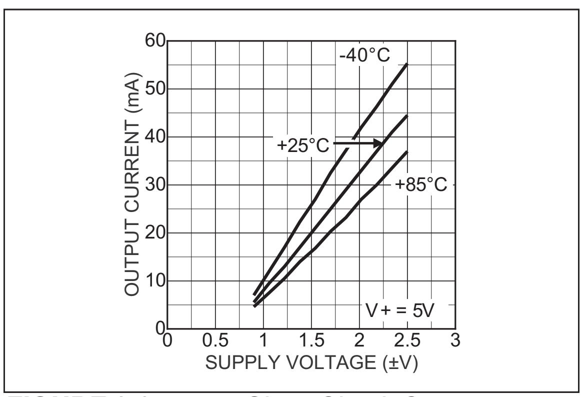


FIGURE 3-9: *Short-Circuit Current vs. Supply Voltage (Sink).*

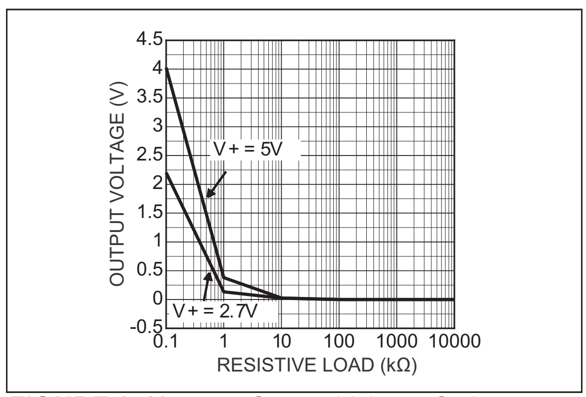


FIGURE 3-12: *Output Voltage Swing vs. Resistive Load (Sink).*

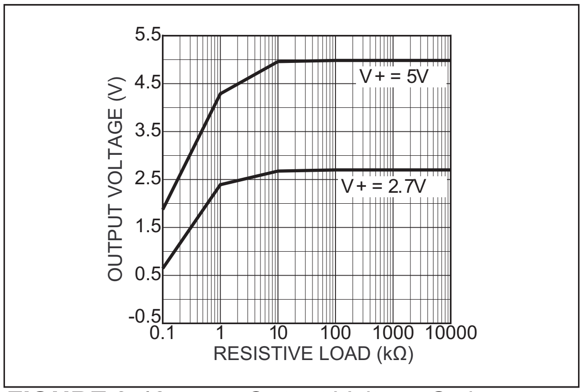


FIGURE 3-13: Output Voltage Swing vs. Resistive Load (Source).

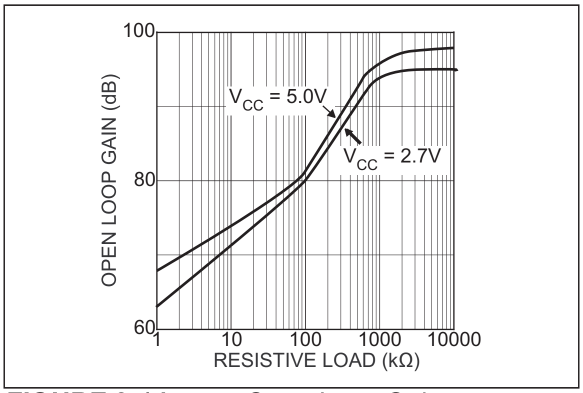


FIGURE 3-14: Open Loop Gain vs. Resistive Load.

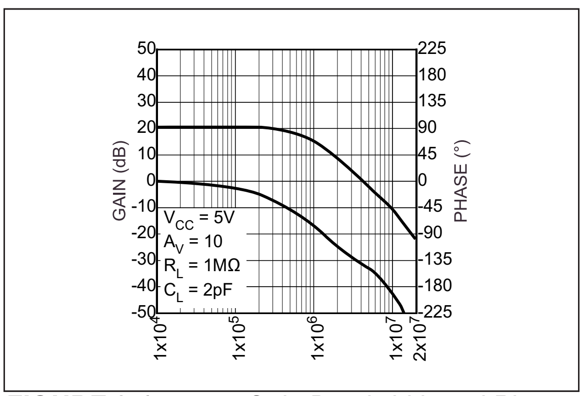


FIGURE 3-15: Gain Bandwidth and Phase Margin.

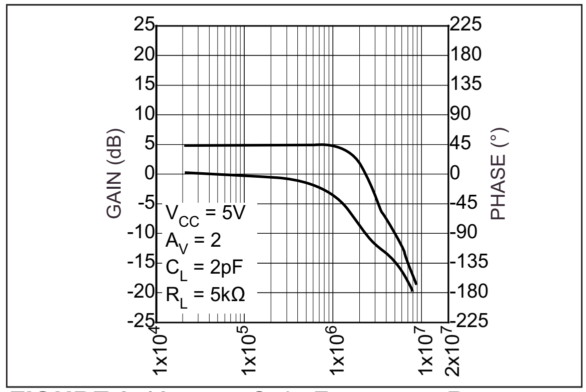


FIGURE 3-16: Gain Frequency Response.

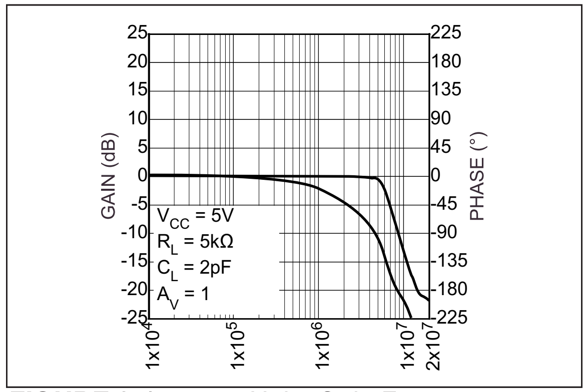


FIGURE 3-17: Unity Gain Frequency Response.

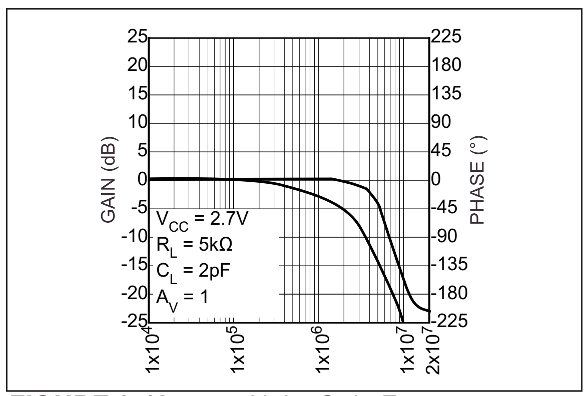


FIGURE 3-18: Unity Gain Frequency Response.

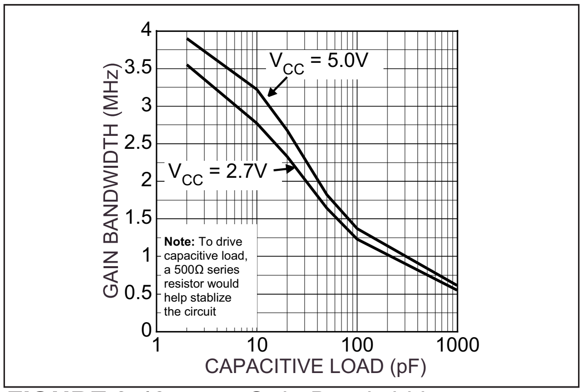


FIGURE 3-19: *Gain Bandwidth vs. Capacitive Load.*

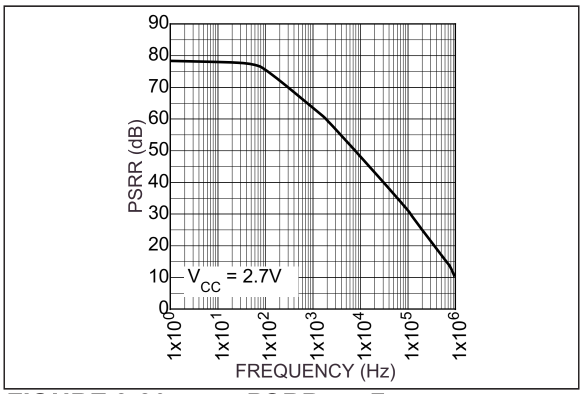


FIGURE 3-20: *PSRR vs. Frequency.*

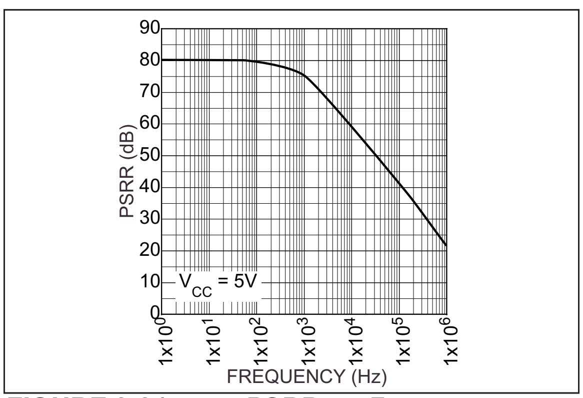


FIGURE 3-21: *PSRR vs. Frequency.*

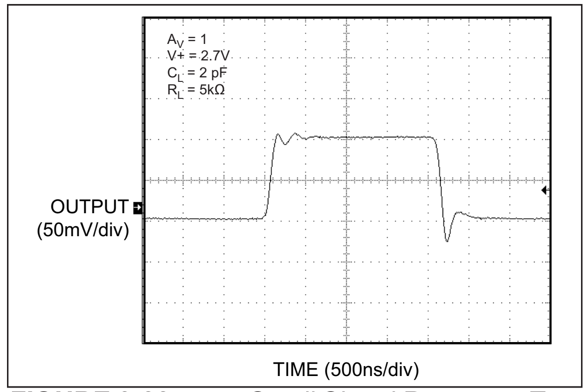


FIGURE 3-22: *Small Signal Response Test Circuit 3: A_V = 1.*

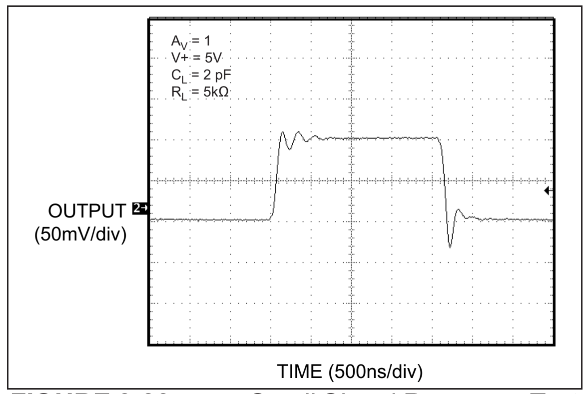


FIGURE 3-23: *Small Signal Response Test Circuit 3: A_V = 1.*

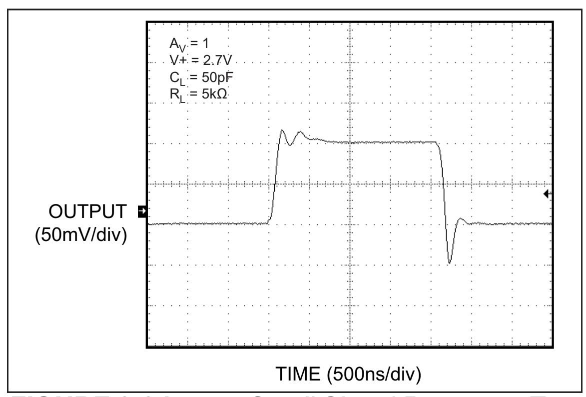


FIGURE 3-24: *Small Signal Response Test Circuit 3: A_V = 1.*

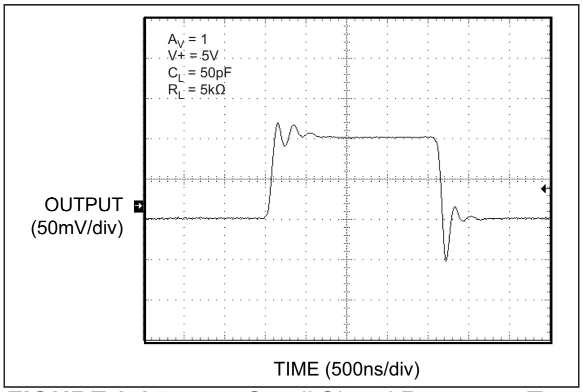


FIGURE 3-25: *Small Signal Response Test Circuit 3: $A_V = 1$.*

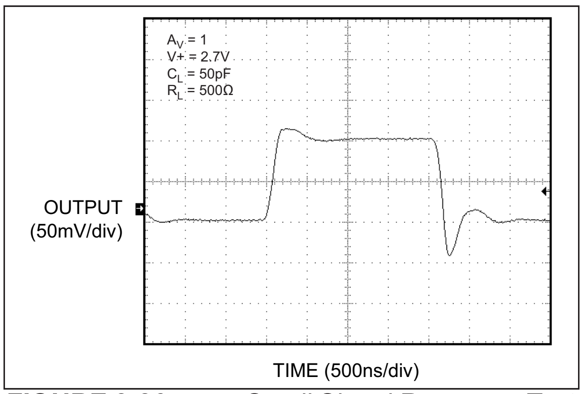


FIGURE 3-26: *Small Signal Response Test Circuit 3: $A_V = 1$.*

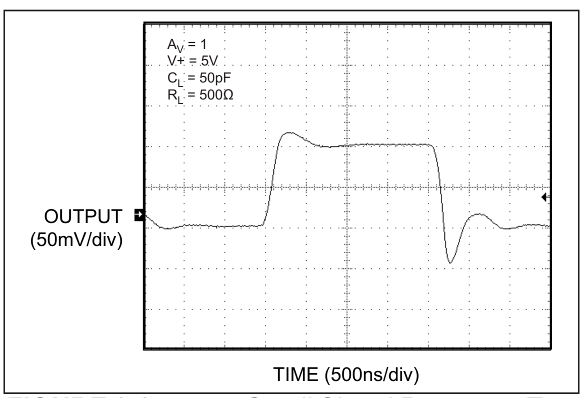


FIGURE 3-27: *Small Signal Response Test Circuit 3: $A_V = 1$.*

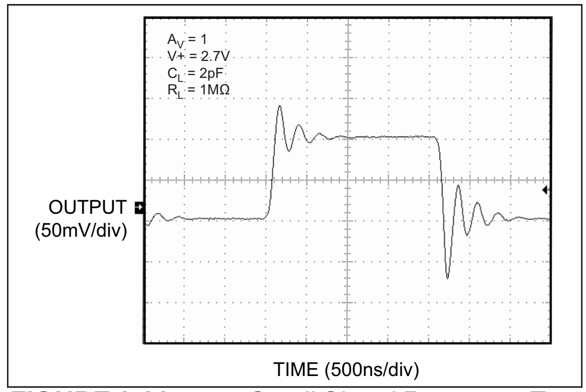


FIGURE 3-28: *Small Signal Response Test Circuit 3: $A_V = 1$.*

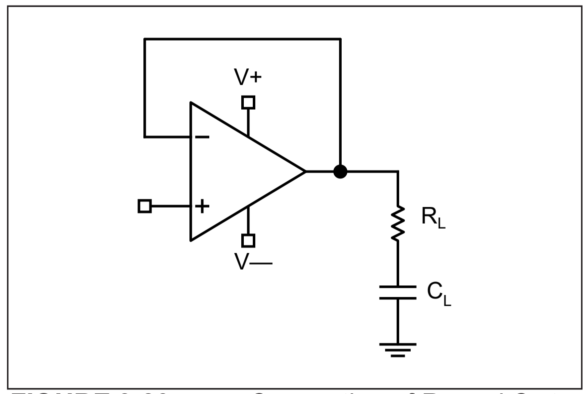


FIGURE 3-29: *Connection of R_L and C_L to the Output.*

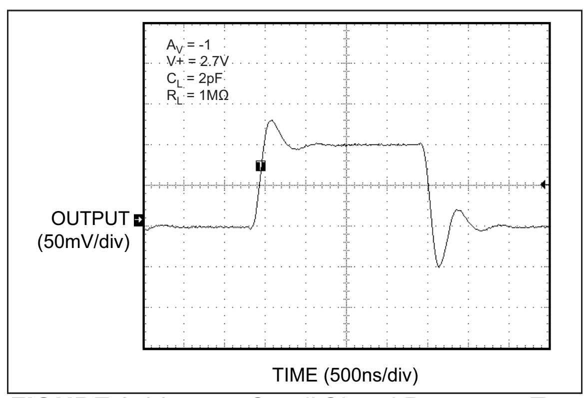


FIGURE 3-30: *Small Signal Response Test Circuit 4: $A_V = –1$.*

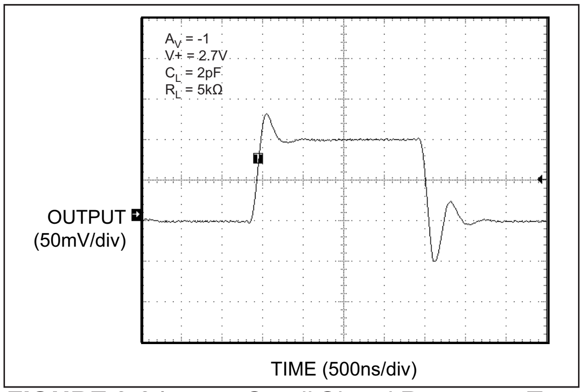


FIGURE 3-31: *Small Signal Response Test Circuit 4: A_V = –1.*

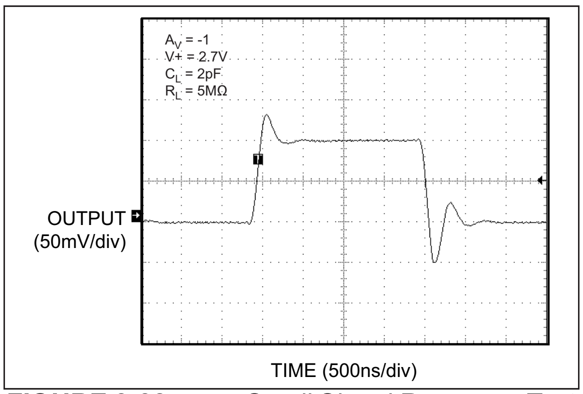


FIGURE 3-32: *Small Signal Response Test Circuit 4: A_V = –1.*

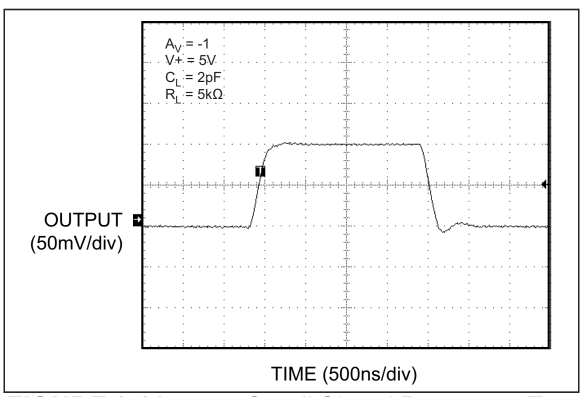


FIGURE 3-33: *Small Signal Response Test Circuit 4: A_V = –1.*

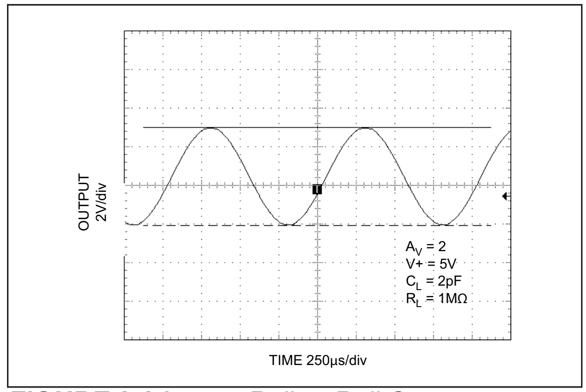


FIGURE 3-34: *Rail-to-Rail Output Operation Test Circuit 2: A_V = 2.*

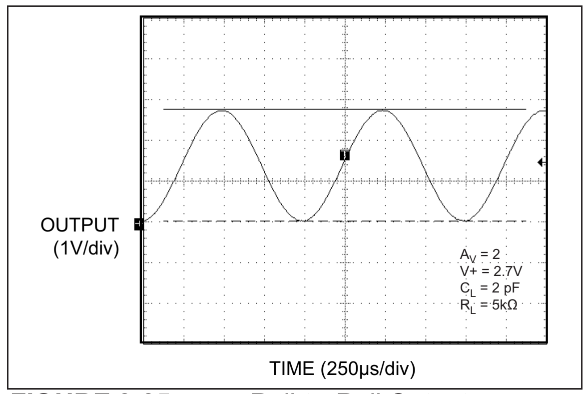


FIGURE 3-35: *Rail-to-Rail Output Operation Test Circuit 2: A_V = 2.*

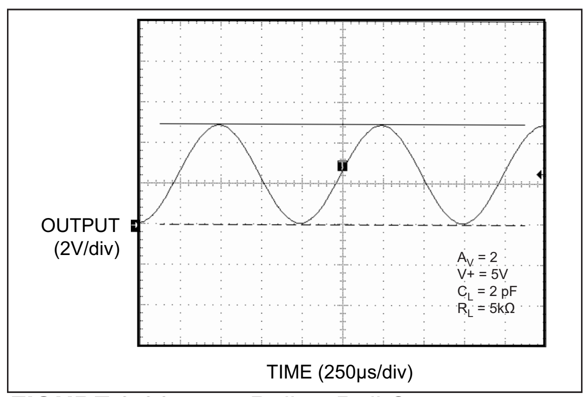


FIGURE 3-36: *Rail-to-Rail Output Operation Test Circuit 2: A_V = 2.*

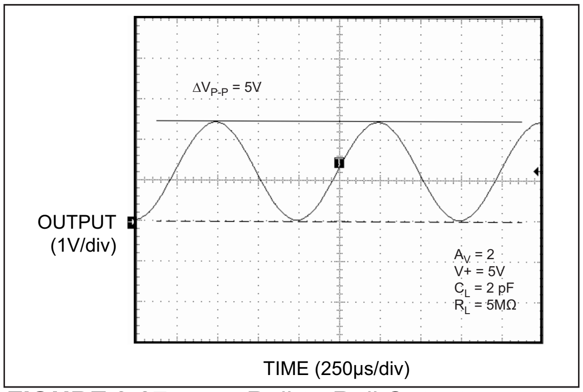


FIGURE 3-37: *Rail-to-Rail Output Operation Test Circuit 2: A_V = 2.*

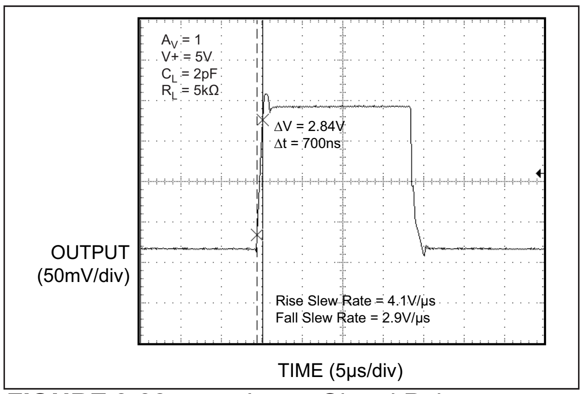


FIGURE 3-38: *Large Signal Pulse Response Test Circuit 3: A_V = 1.*

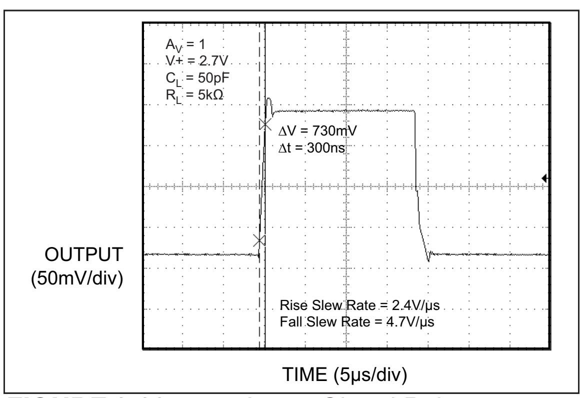


FIGURE 3-39: *Large Signal Pulse Response Test Circuit 3: A_V = 1.*

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

5.1 Power Supply Bypassing

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 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 ESI (equivalent series inductance), ESR (equivalent series resistance). Surface-mount ceramic capacitors are ideal.

5.2 Supply and Loading Considerations

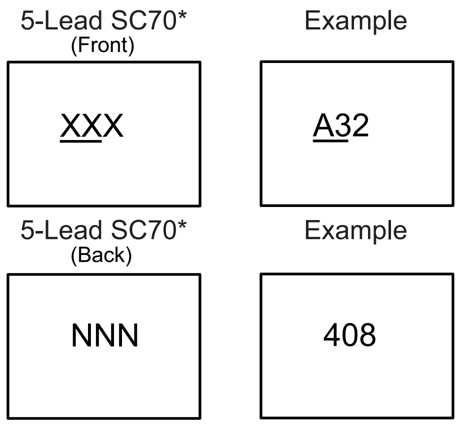
The MIC860 is intended for single supply applications configured with a grounded load. It is not advisable to operate the MIC860 with either:

- A grounded load and split supplies (±V) or
- A single supply where the load is terminated above ground.

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

6.0 PACKAGING INFORMATION

6.1 Package Marking Information



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).

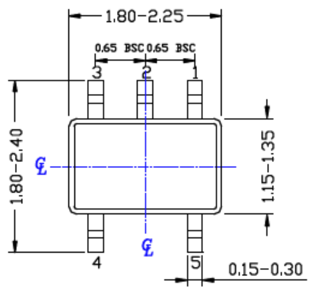
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

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

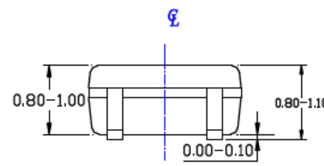
5-Lead SC70 Package Outline and Recommended Land Pattern

TITLE
5 LEAD SC70 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

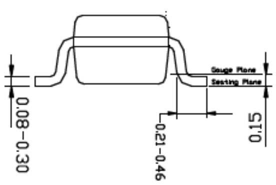
DRAWING #	SC70-5LD-PL-2	**UNIT**	MM



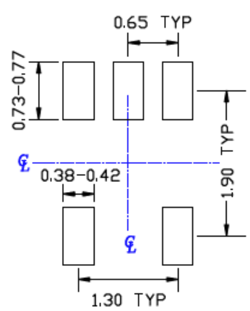
TOP VIEW



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.

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

APPENDIX A: REVISION HISTORY

Revision A (April 2020)

- Converted Micrel data sheet MIC860 to Microchip data sheet DS20006338A.
- Minor grammatical corrections 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	Temp.	Package	Media Type

Device:	MIC860:	Ultra-Low Power Op Amp
Temperature:	Y =	–40°C to +85°C
Package:	C5 =	5-Lead SC70
Media Type	TR =	3,000/Reel

Examples:

a) MIC860YC5-TR: Ultra-Low Power Op Amp
–40°C to +85°C 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:

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