The Infinite Bandwidth Company™

# MIC921

## 45MHz Low-Power SC-70 Op Amp

## Final Information

## General Description

The MIC921 is a high-speed operational amplifier with a gain-bandwidth product of 45MHz. The part is unity gain stable. It has a very low 300µA supply current, and features the IttyBitty™ SC-70 and SOT-23-5 package.

Supply voltage range is from ±2.5V to ±9V, allowing the MIC921 to be used in low-voltage circuits or applications requiring large dynamic range.

The MIC921 is stable driving any capacitative load and achieves excellent PSRR and CMRR, making it much easier to use than most conventional high-speed devices. Low supply voltage, low power consumption, and small packing make the MIC921 ideal for portable equipment. The ability to drive capacitative loads also makes it possible to drive long coaxial cables.

## Features

- 45MHz gain bandwidth product
- 61MHz –3dB bandwidth
- 300µA supply current
- SC-70 or SOT-23-5 packages
- 3200V/µs slew rate
- Drives any capacitive load
- 112dB CMRR
- Unity gain stable

## Applications

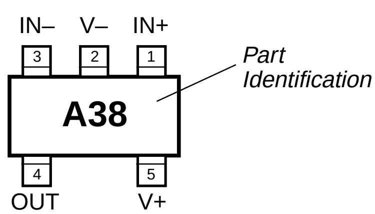
- Video
- Imaging
- Ultrasound
- Portable equipment
- Line drivers

## Ordering Information

| Part Number | Junction Temp. Range | Package |
|---|---|---|
| MIC921BM5 | –40°C to +85°C | SOT-23-5* |
| MIC921BC5 | –40°C to +85°C | SC-70 |

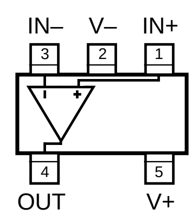
*Contact factory for availability of SOT-23-5 package.

## Pin Configuration




**SOT-23-5 or SC-70**

## Functional Pinout




**SOT-23-5 or SC-70**

## Pin Description

| Pin Number | Pin Name | Pin Function |
|---|---|---|
| 1 | IN+ | Noninverting Input |
| 2 | V– | Negative Supply (Input) |
| 3 | IN– | Inverting Input |
| 4 | OUT | Output: Amplifier Output |
| 5 | V+ | Positive Supply (Input) |

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## Absolute Maximum Ratings (Note 1)

Supply Voltage ($V_{V+} – V_{V–}$) .......................................... 20V
Differentail Input Voltage ($|V_{IN+} – V_{IN–}|$) .......... 4V, **Note 3**
Input Common-Mode Range ($V_{IN+}$, $V_{IN–}$) .......... $V_{V+}$ to $V_{V–}$
Lead Temperature (soldering, 5 sec.) ....................... 260°C
Storage Temperature ($T_S$) ....................................... 150°C
ESD Rating, **Note 4** .................................................. 1.5kV

## Operating Ratings (Note 2)

Supply Voltage ($V_S$) ...................................... ±2.5V to ±9V
Junction Temperature ($T_J$) ......................... –40°C to +85°C
Package Thermal Resistance
SC70-5 ............................................................. 450°C/W
SOT23-5 ........................................................... 260°C/W

## Electrical Characteristics (±5V)

V+ = +5V, V– = –5V, $V_{CM}$ = 0V, $R_L$ = 10MΩ; $T_J$ = 25°C, **bold** values indicate –40°C ≤ $T_J$ ≤ +85°C; unless noted.

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | | | 0.43 | **5** | mV |
| $V_{OS}$ | $V_{OS}$ Temperature Coefficient | | | 1 | | µV/°C |
| $I_B$ | Input Bias Current | | | 0.13 | **0.6** | µA |
| $I_{OS}$ | Input Offset Current | | | 0.06 | **0.3** | µA |
| $V_{CM}$ | Input Common-Mode Range | CMRR > 72dB | **–3.25** | | **+3.25** | V |
| CMRR | Common-Mode Rejection Ratio | –2.5V < $V_{CM}$ < +2.5V | **75** | 87 | | dB |
| PSRR | Power Supply Rejection Ratio | ±3.5V < $V_S$ < ±9V | **95** | 105 | | dB |
| $A_{VOL}$ | Large-Signal Voltage Gain | $R_L$ = 2k, $V_{OUT}$ = ±2V | **70** | 84 | | dB |
| | | $R_L$ = 100Ω, $V_{OUT}$ = ±1V | | 85 | | dB |
| $V_{OUT}$ | Maximum Output Voltage Swing | positive, $R_L$ = 2kΩ | **+3.0** | 3.7 | | V |
| | | negative, $R_L$ = 2kΩ | | –3.7 | **–3.0** | V |
| | | positive, $R_L$ = 200Ω | **+1.5** | 3.0 | | V |
| | | negative, $R_L$ = 200Ω, **Note 5** | | –2.5 | **–1.0** | V |
| GBW | Unity Gain-Bandwidth Product | $A_V$ = 1, $C_L$ = 1.7pF | | 37 | | MHz |
| PM | Phase Margin | | | 46 | | ° |
| BW | –3dB Bandwidth | $A_V$ = 1, $R_L$ = 1kΩ, $C_L$ = 1.7pF | | 53 | | MHz |
| SR | Slew Rate | C=1.7pF, Gain=1, $V_{OUT}$=5V, peak to peak, negative SR = 1300V/µs | | 1500 | | V/µs |
| $I_{SC}$ | Short-Circuit Output Current | source | **45** | 57 | | mA |
| | | sink | **20** | 40 | | mA |
| $I_S$ | Supply Current | No Load | | 0.30 | **0.50** | mA |
| | Input Voltage Noise | f = 10kHz | | 12 | | nV$\sqrt{Hz}$ |
| | Input Current Noise | f = 10kHz | | 0.7 | | pA$\sqrt{Hz}$ |

## Electrical Characteristics

V+ = +9V, V– = –9V, $V_{CM}$ = 0V, $R_L$ = 10MΩ; $T_J$ = 25°C, **bold** values indicate –40°C ≤ $T_J$ ≤ +85°C; unless noted

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | | | 0.4 | **5** | mV |
| $V_{OS}$ | Input Offset Voltage Temperature Coefficient | | | 1 | | µV/°C |
| $I_B$ | Input Bias Current | | | 0.13 | **0.6** | µA |
| $I_{OS}$ | Input Offset Current | | | 0.06 | **0.3** | µA |
| $V_{CM}$ | Input Common-Mode Range | CMRR > 75dB | **–7.25** | | **+7.25** | V |
| CMRR | Common-Mode Rejection Ratio | –2.5V < $V_{CM}$ < +2.5V | **75** | 87 | | dB |

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| PSRR | Power Supply Rejection Ratio | ±3.5V < $V_S$ < ±9V | **95** | 105 | | dB |
| $A_{VOL}$ | Large-Signal Voltage Gain | $R_L$ = 2k, $V_{OUT}$ = ±3V | **75** | 86 | | dB |
| | | $R_L$ = 100Ω, $V_{OUT}$ = ±1V | | 92 | | dB |
| $V_{OUT}$ | Maximum Output Voltage Swing | positive, $R_L$ = 2kΩ | **+6.5** | 7.6 | | V |
| | | negative, $R_L$ = 2kΩ | | –7.6 | **–6.2** | V |
| GBW | Unity Gain-Bandwidth Product | $A_V$ = 1, $C_L$ = 1.7pF | | 45 | | MHz |
| PM | Phase Margin | | | 40 | | ° |
| BW | –3dB Bandwidth | $A_V$ = 1, $R_L$ = 1kΩ, $C_L$ = 1.7pF | | 61 | | MHz |
| SR | Slew Rate | C=1.7pF, Gain=1, $V_{OUT}$=5V, peak to peak, negative SR = 2500V/µs | | 3200 | | V/µs |
| $I_{SC}$ | Short-Circuit Output Current | source | **40** | 59 | | mA |
| | | sink | **25** | 45 | | mA |
| $I_S$ | Supply Current | No Load | | 0.36 | **0.6** | mA |
| | Input Voltage Noise | f = 10kHz | | 12 | | nV√Hz |
| | Input Current Noise | f = 10kHz | | 0.7 | | pA√Hz |

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

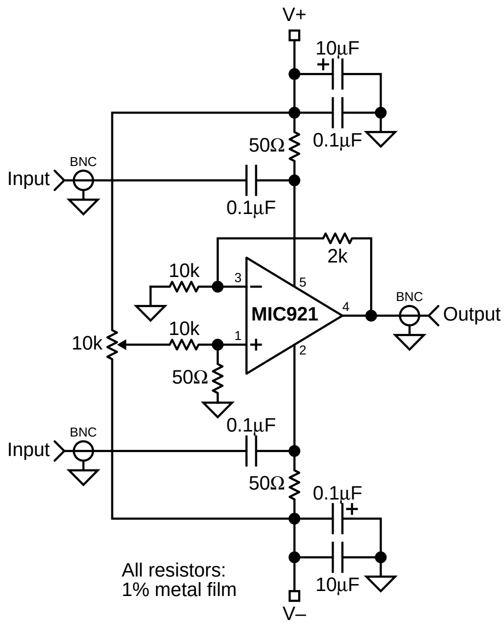
**Note 2.** The device is not guaranteed to function outside its operating rating.

**Note 3.** Exceeding the maximum differential input voltage will damage the input stage and degrade performance (in particular, input bias current is likely to change).

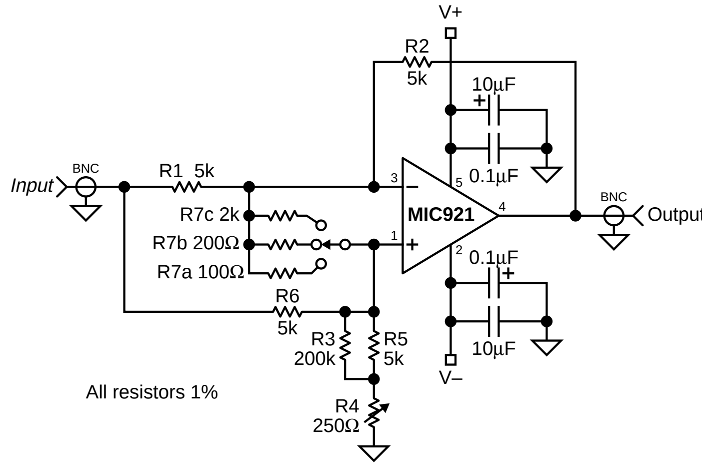
**Note 4.** Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k in series with 100pF.

**Note 5.** Output swing limited by the maximum output sink capability, refer to the short-circuit current vs. temperature graph in “Typical Characteristics.”

# Test Circuits

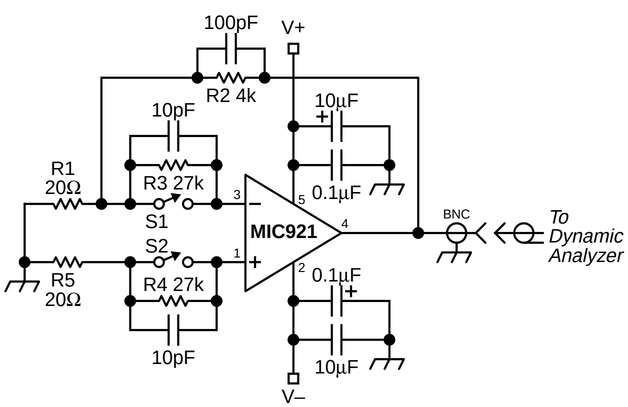



**PSRR vs. Frequency**

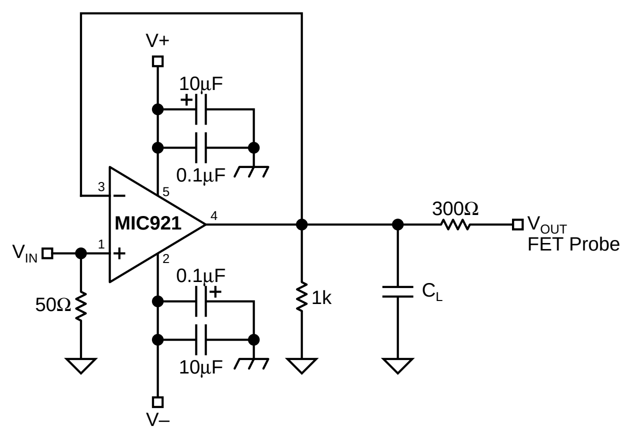



$$V_{OUT} = V_{ERROR}\left(1 + \frac{R2}{R1} + \frac{R2 + R5 + R4}{R7}\right)$$

**CMRR vs. Frequency**



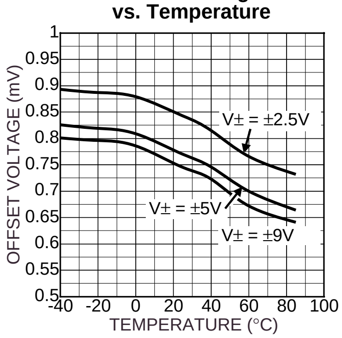

**Noise Measurement**



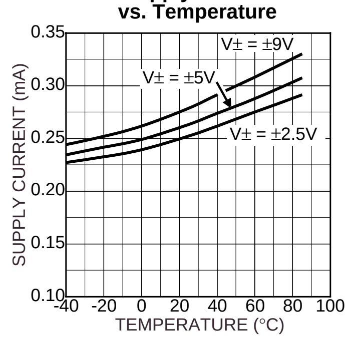

**Closed Loop Frequency Response Measurement**

# Typical Characteristics

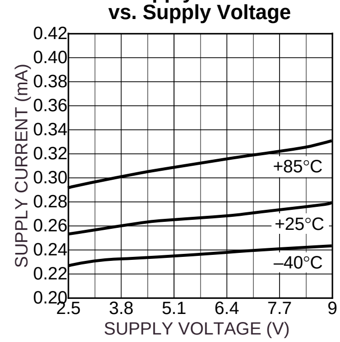
**Offset Voltage vs. Temperature**



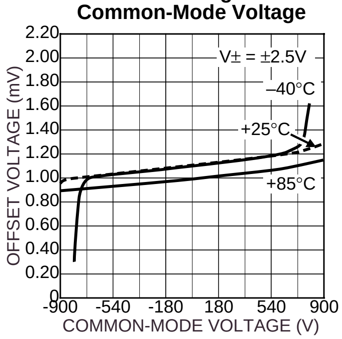

**Supply Current vs. Temperature**



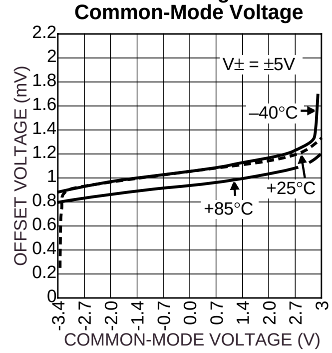

**Supply Current vs. Supply Voltage**



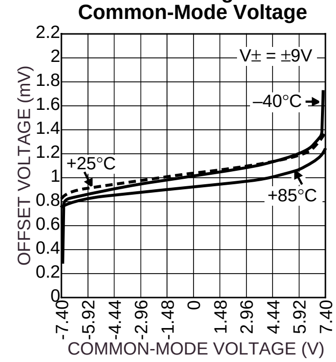

**Offset Voltage vs. Common-Mode Voltage**



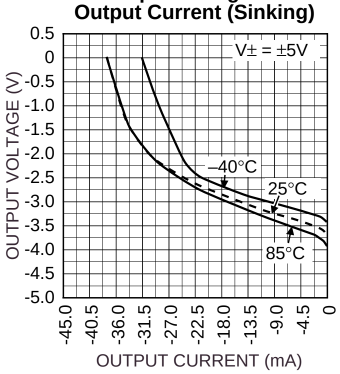

**Offset Voltage vs. Common-Mode Voltage**



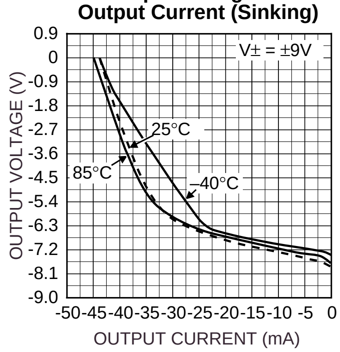

**Offset Voltage vs. Common-Mode Voltage**



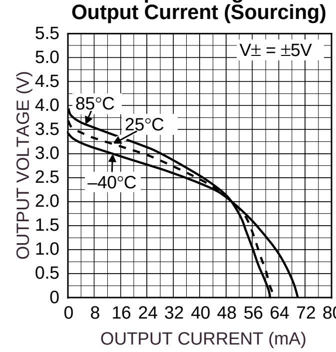

**Output Voltage vs. Output Current (Sinking)**



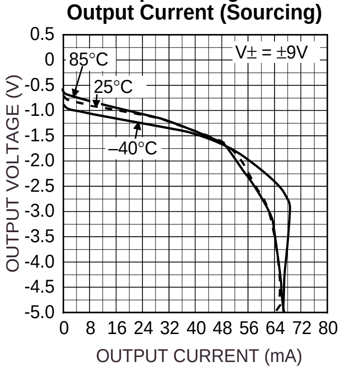

**Output Voltage vs. Output Current (Sinking)**



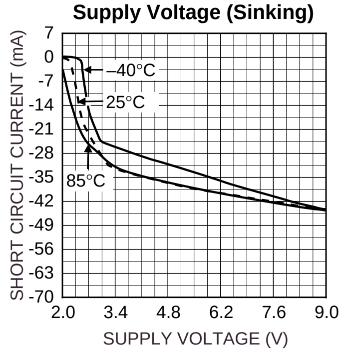

**Output Voltage vs. Output Current (Sourcing)**



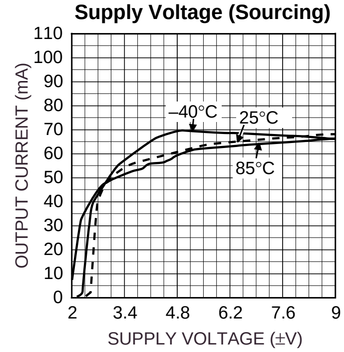

**Output Voltage vs. Output Current (Sourcing)**



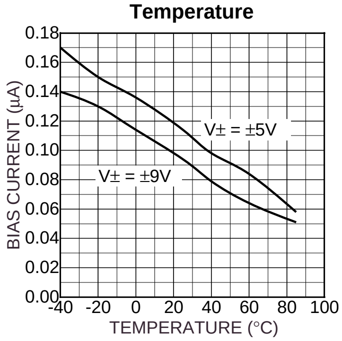

**Short Circuit Current vs. Supply Voltage (Sinking)**



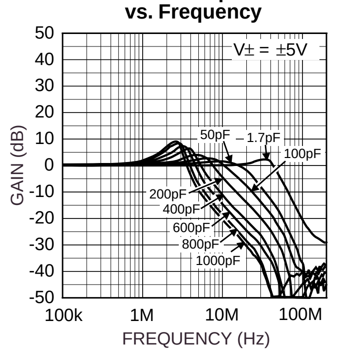

**Short-Circuit Current vs. Supply Voltage (Sourcing)**



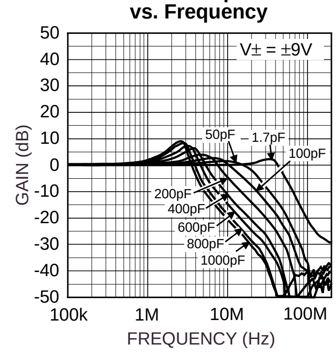
**Bias Current vs. Temperature**



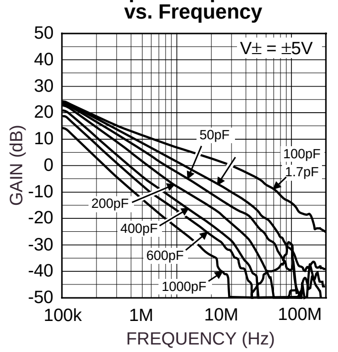

**Closed-Loop Gain vs. Frequency**



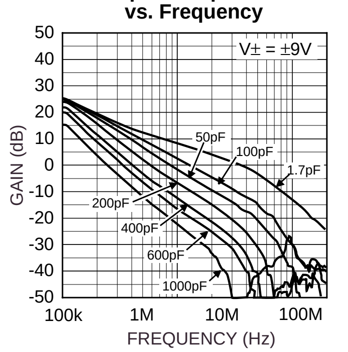

**Closed-Loop Gain vs. Frequency**



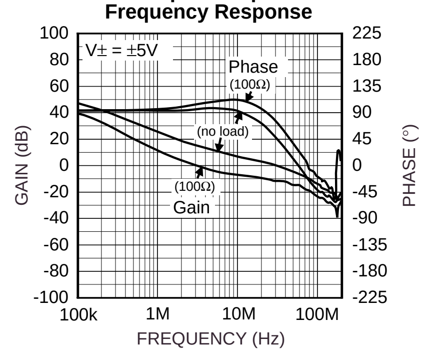

**Open-Loop Gain vs. Frequency**



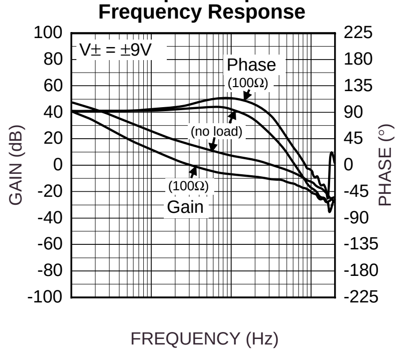

**Open-Loop Gain vs. Frequency**



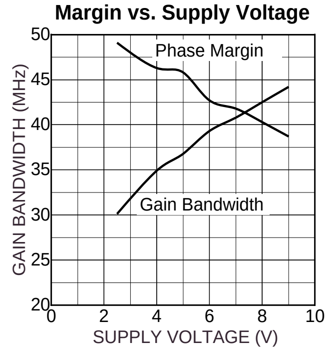

**Open-Loop Frequency Response**



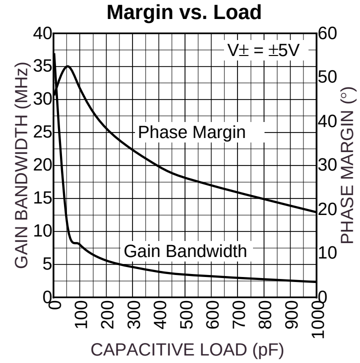

**Open-Loop Frequency Response**



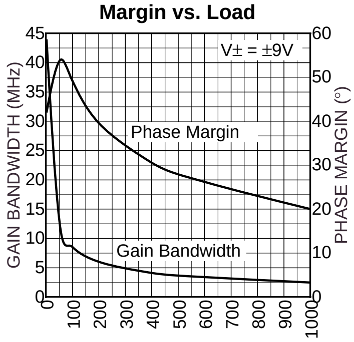

**Gain Bandwidth and Phase Margin vs. Supply Voltage**



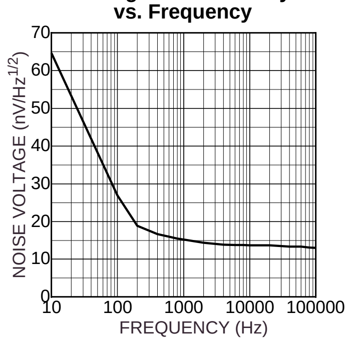

**Gain Bandwidth and Phase Margin vs. Load**



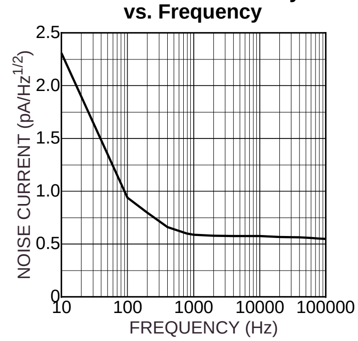

**Gain Bandwidth and Phase Margin vs. Load**



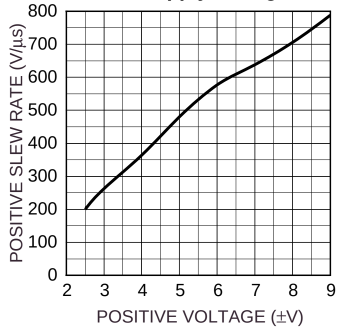

**Voltage Noise Density vs. Frequency**



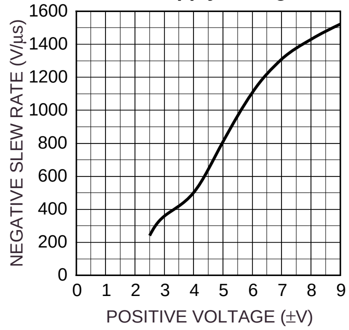

**Current Noise Density vs. Frequency**



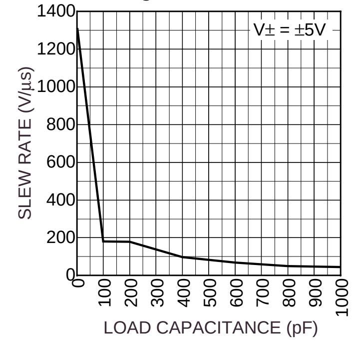
**Positive Slew Rate vs. Supply Voltage**



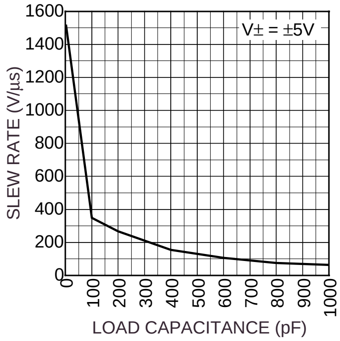

**Negative Slew Rate vs. Supply Voltage**



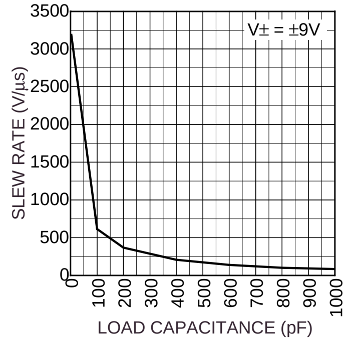

**Negative Slew Rate**



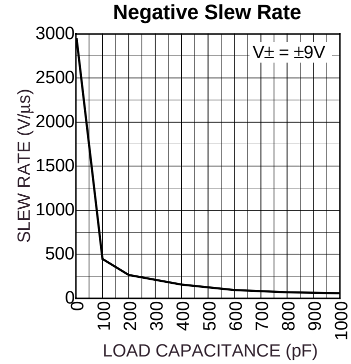

**Positive Slew Rate**



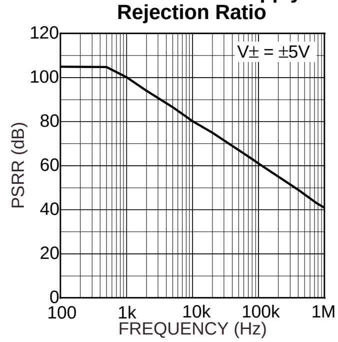

**Positive Slew Rate**



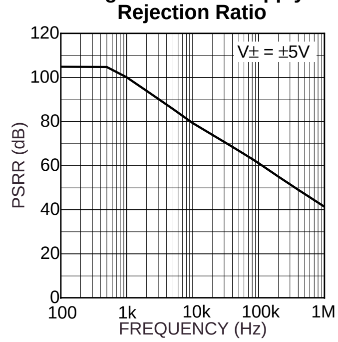

**Negative Slew Rate**



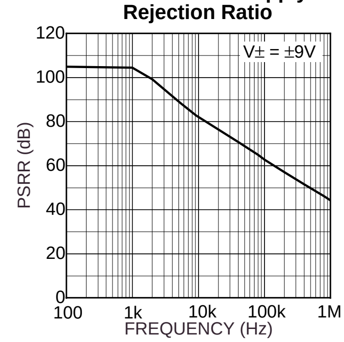

**Positive Power Supply Rejection Ratio**



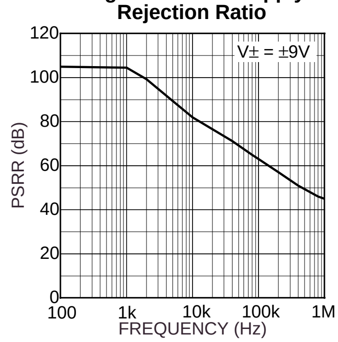

**Negative Power Supply Rejection Ratio**



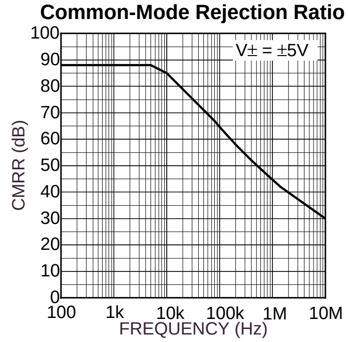

**Positive Power Supply Rejection Ratio**



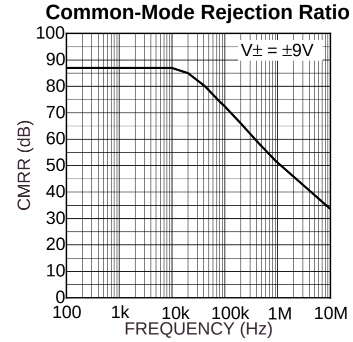

**Negative Power Supply Rejection Ratio**




**Common-Mode Rejection Ratio**

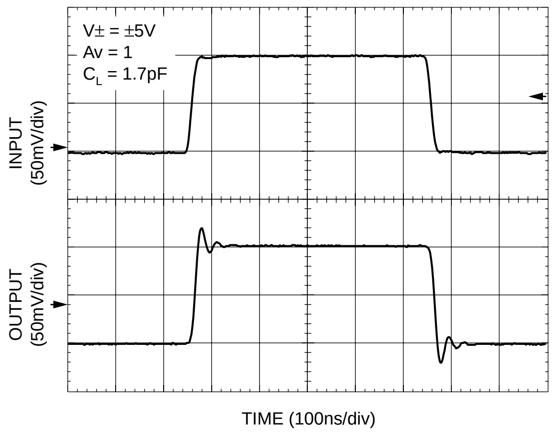



**Common-Mode Rejection Ratio**



# Functional Characteristics

**Small Signal Reponse**

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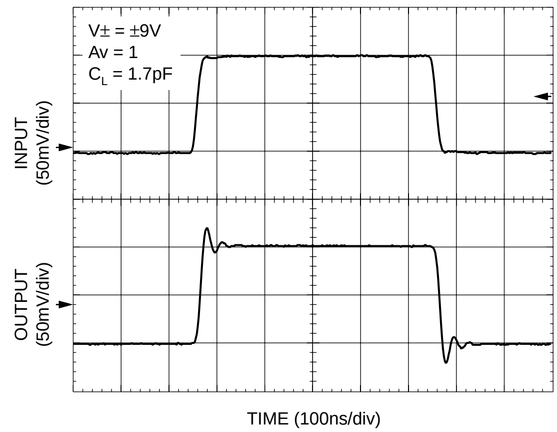
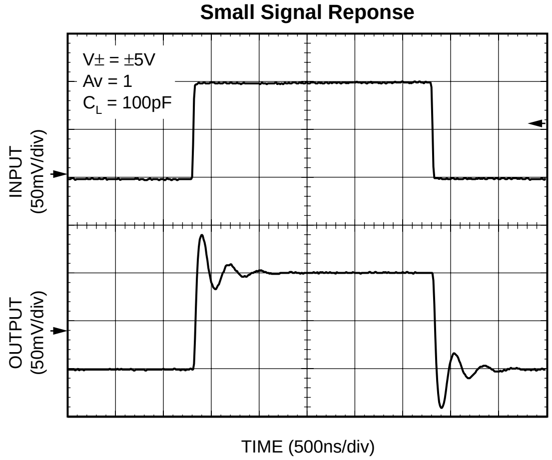
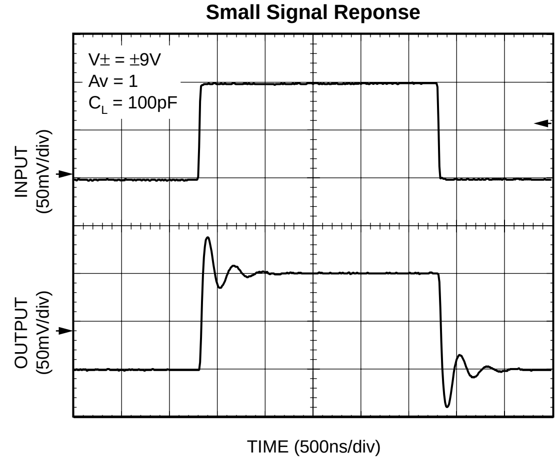


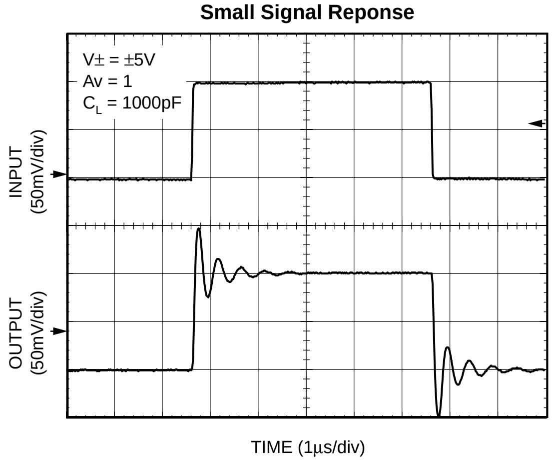

**Small Signal Reponse**



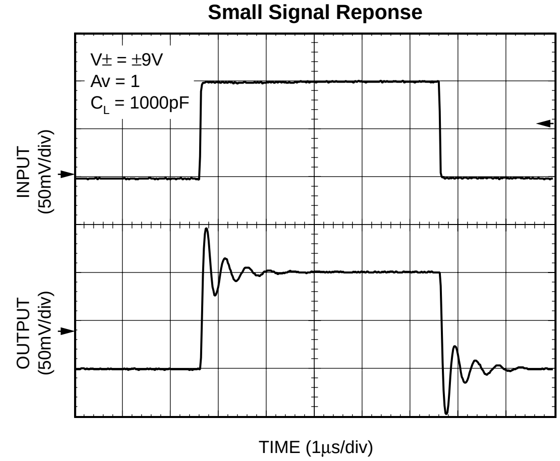

**Small Signal Reponse**




**Small Signal Reponse**




**Small Signal Reponse**



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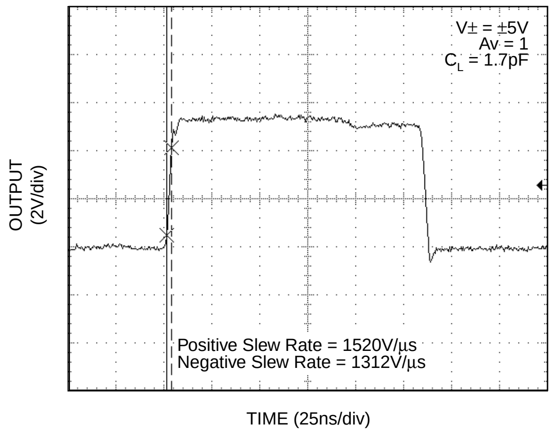


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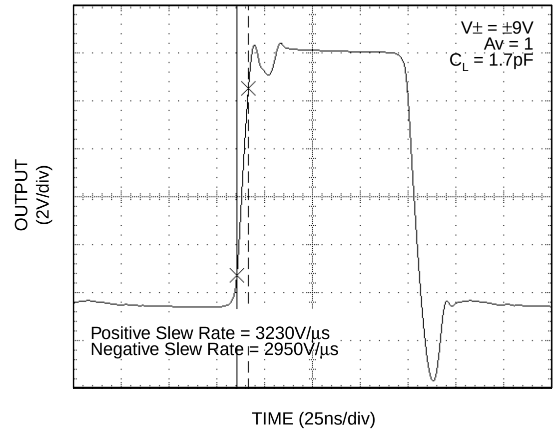


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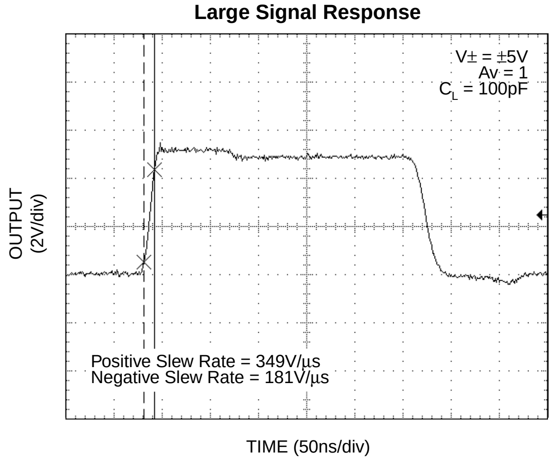
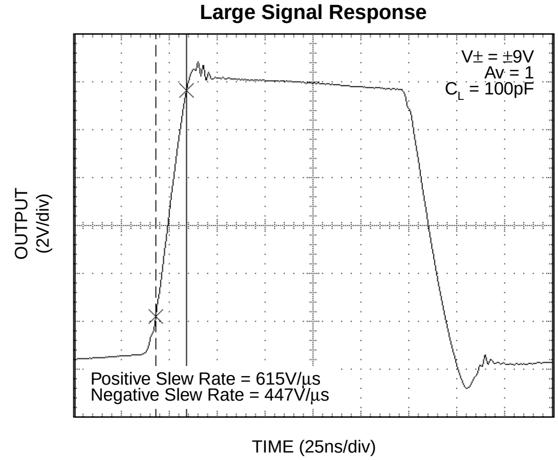



**Large Signal Response**

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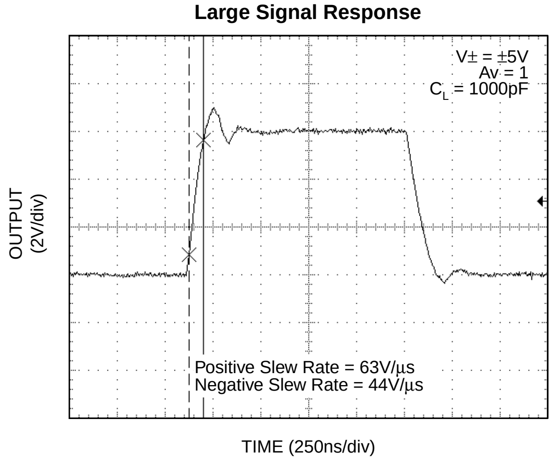
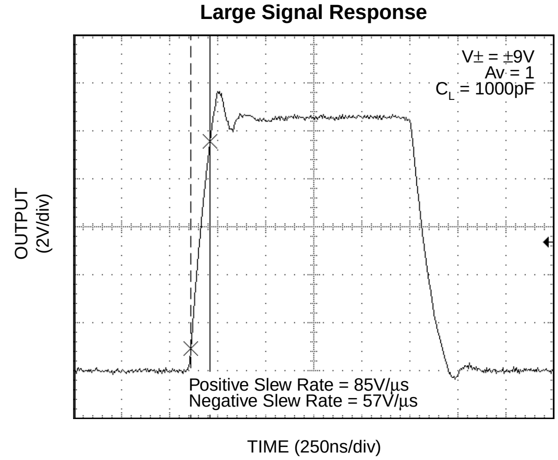



**Large Signal Response**



## Applications Information

The MIC921 is a high-speed, voltage-feedback operational amplifier featuring very low supply current and excellent stability. This device is unity gain stable, capable of driving high capacitance loads.

### Driving High Capacitance

The MIC921 is stable when driving high capacitance, making it ideal for driving long coaxial cables or other high-capacitance loads. Most high-speed op amps are only able to drive limited capacitance.

> Note: increasing load capacitance does reduce the speed of the device. In applications where the load capacitance reduces the speed of the op amp to an unacceptable level, the effect of the load capacitance can be reduced by adding a small resistor (<100Ω) in series with the output.

### Feedback Resistor Selection

Conventional op amp gain configurations and resistor selection apply, the MIC921 is NOT a current feedback device.

Also, for minimum peaking, the feedback resistor should have low parasitic capacitance, usually 470Ω is ideal. To use the part as a follower, the output should be connected to input via a short wire.

### Layout Considerations

All high speed devices require careful PCB layout. The following guidelines should be observed: Capacitance, particularly on the two inputs pins will degrade performance; avoid large copper traces to the inputs. Keep the output signal away from the inputs and use a ground plane.

It is important to ensure adequate supply bypassing capacitors are located close to the device.

### 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.

### Thermal Considerations

The SC70-5 package, like all small packages, has a high thermal resistance. It is important to ensure the IC does not exceed the maximum operating junction (die) temperature of 85°C. The part can be operated up to the absolute maximum temperature rating of 125°C, but between 85°C and 125°C performance will degrade, in particular CMRR will reduce.

An MIC921 with no load, dissipates power equal to the quiescent supply current * supply voltage

$$P_{D(no\ load)} = \left(V_{V+} - V_{V-}\right) I_S$$

When a load is added, the additional power is dissipated in the output stage of the op amp. The power dissipated in the device is a function of supply voltage, output voltage and output current.

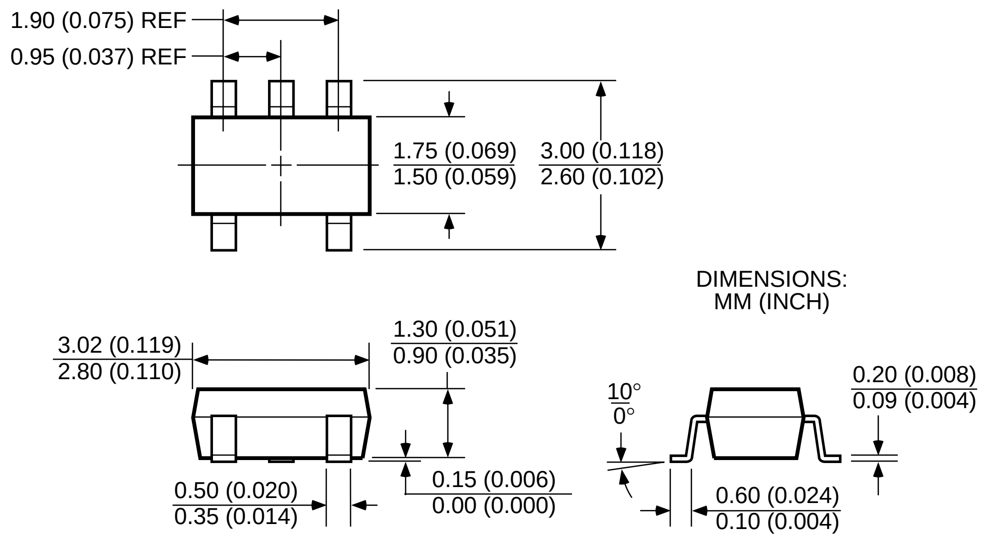
$$P_{D(output\ stage)} = \left(V_{V+} - V_{OUT}\right) I_{OUT}$$

$$Total\ Power\ Dissipation = P_{D(no\ load)} + P_{D(output\ stage)}$$

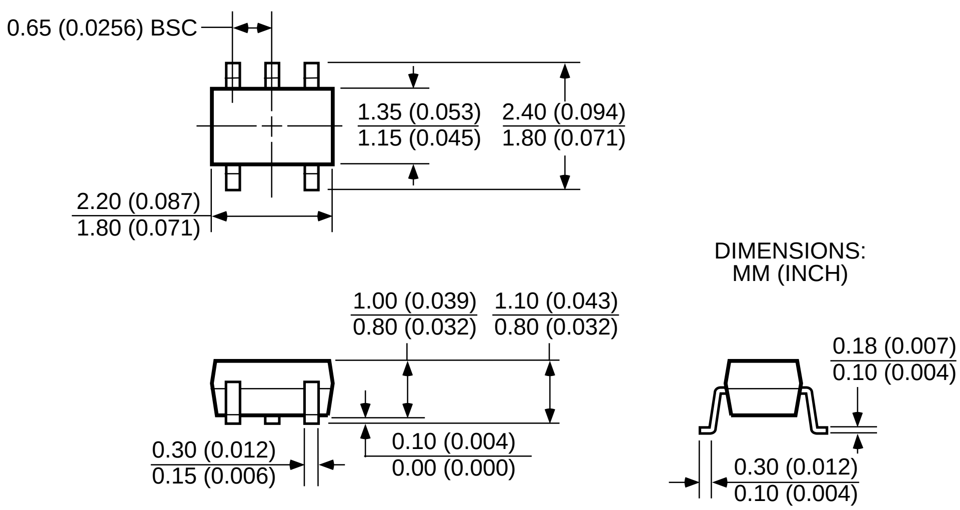
Ensure the total power dissipated in the device is no greater than the thermal capacity of the package. The SC70-5 package has a thermal resistance of 450°C/W.

$$\text{Max. Allowable Power Dissipation} = \frac{T_{J(max)} - T_{A(max)}}{450°C / W}$$

## Package Information




**SOT-23-5 (M5)**




**SC-70 (C5)**

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