# 1MHz, 60uA, Rail-to-Rail I/O CMOS Operational Amplifiers

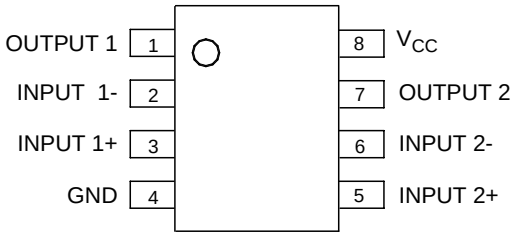
## DESCRIPTION

The FC358F(dual) are rail-to-rail input and output voltage feedback amplifiers offering low cost. They have a wide input common -mode voltage range and output voltages wing,and take the minimum operating supply voltage down to 2.1V and the maximum recommended supply voltage is 5.5V. temperature range.

The FC358F provide 1MHz bandwidth at a low current consumption of 60μA per amplifier. Very low input bias currents of 10p A enable FC358F to be used for integrators, photodiode amplifiers, and piezoelectric sensors. Rail - to - rail inputs and outputs are useful to designers buffering ASIC in single - supply systems. Applications for the series amplifiers include safety monitoring , portable equipment, battery and power supply control, and signal conditioning and interfacing for transducers in very low power systems.

The FC358F is available in SOP-8 and MSOP-8 packages.

**SOP-8 / MSOP-8**




## Features

- Low Cost
- Rail-to-Rail Input and Output 0.8mV Typical VOS
- Unity Gain Stable
- Gain Bandwidth Product: 1MHz
- Very Low Input Bias Currents:
- Operates on 2.1V to 5.5V Supplies
- Input Voltage Range: -0.1V to +5.6V with VS = 5.5V
- Low Supply Current: < 60μA/Amplifier
- Small Packaging: FC358F Available in SOP-8, MSOP-8

## Applications

- ASIC Input or Output Amplifier
- Sensor Interface
- Piezo Electric Transducer Amplifier
- Medical Instrumentation
- Mobile Communication
- Audio Output
- Portable Systems
- Smoke Detectors
- Notebook PC
- PCMCIA Cards
- Battery – Powered Equipment
- DSP Interface

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V+ to V-.....7.5V
Common-Mode Input Voltage..... ($-V_S$) - 0.5V to ($+V_S$) + 0.5V
Storage Temperature Range..... .....–65℃ to +150℃
Junction Temperature.....160℃
Operating Temperature Range..... ……0℃ to +70℃
Lead Temperature Range (Soldering 10 sec).....260℃

## ELECTRICAL CHARACTERISTICS

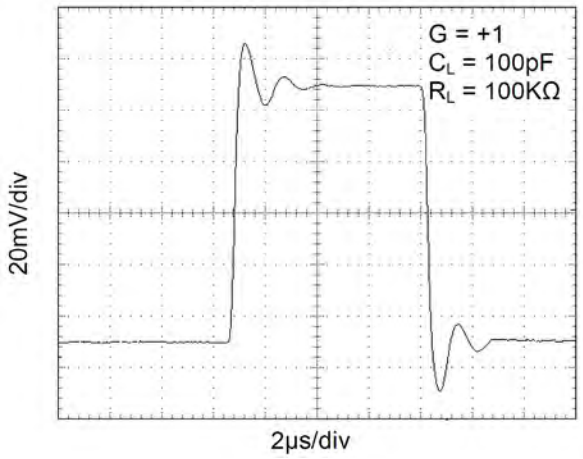
(At RL = 100KΩ connected to Vs/2, and VOUT = Vs/2, $V_S$=+5V,unless otherwise noted.)

| PARAMETER | CONDITIONS | FC358F | | | | |
|---|---|---|---|---|---|---|
| | | TYP | MIN/MAX OVER TEMPERATURE | | | |
| | | +25℃ | +25℃ | 0℃to 75℃ | UNITS | MIN/MAX |
| **INPUT HARACTERISTICS** | | | | | | |
| Input Offset Voltage ($V_{OS}$) | | ±0.8 | ±5 | ±6 | mV | MAX |
| Input Bias Current ($I_B$) | | 10 | | | pA | TYP |
| Input Offset Current ($I_{OS}$) | | 10 | | | pA | TYP |
| Common-Mode Voltage Range ($V_{CM}$) | VS=5.5V | -0.1to+5.6 | | | V | TYP |
| Common-Mode Rejection Ratio (CMRR) | VS=5.5V, VCM=-0.1V to 4V | 70 | 62 | 62 | dB | MIN |
| | VS= 5.5V, VCM=-0.1V to 5.6V | 68 | 56 | 55 | dB | MIN |
| Open-Loop Voltage Gain ( $A_{OL}$) | RL= 5KΩ ,Vo=0.1V to 4.9V | 80 | 70 | 70 | dB | MIN |
| | RL=100KΩ,Vo=0.035V to 4.965V | 84 | 80 | 80 | dB | MIN |
| **OUTPUT CHARACTERISTICS** | | | | | | |
| Output Voltage Swing from Rail | RL = 100KΩ | 0.008 | | | V | TYP |
| Output Current (IOUT) | RL = 10KΩ | 0.08 | | | V | TYP |
| | | 27 | 20 | 18.8 | mA | MIN |
| **POWER SUPPLY** | | | | | | |
| Operating Voltage Range | | | 2.1 | 2.5 | V | MIN |
| | | | 5.5 | 5.5 | V | MAX |
| Power Supply Rejection Ratio (PSRR) | Vs =+2.5V to + 5.5V<br>VCM= (-VS) + 0.5V | 82 | 60 | 58 | dB | MIN |
| Quiescent Current / Amplifier (IQ) | IOUT = 0 | 60 | 80 | 86 | µA | MAX |
| **DYNAMIC PERFORMANCE** | | | | | | |
| Gain-Bandwidth Product (GBP) | CL= 100pF | 1 | | | MHz | TYP |
| Slew Rate (SR) | G = +1, 2V Output Step | 0.52 | | | V/µs | TYP |
| Settling Time to 0.1% (tS) | G = +1, 2V Output Step | 5.3 | | | µs | TYP |
| Overload Recovery Time | VIN ·Gain = VS | 2.6 | | | µs | TYP |
| **NOISE PERFORMANCE** | | | | | | |
| Voltage Noise Density (en) | f = 1kHz | 27 | | | n$\sqrt{Hz}$ | TYP |
| | f = 10kHz | 20 | | | n$\sqrt{Hz}$ | TYP |

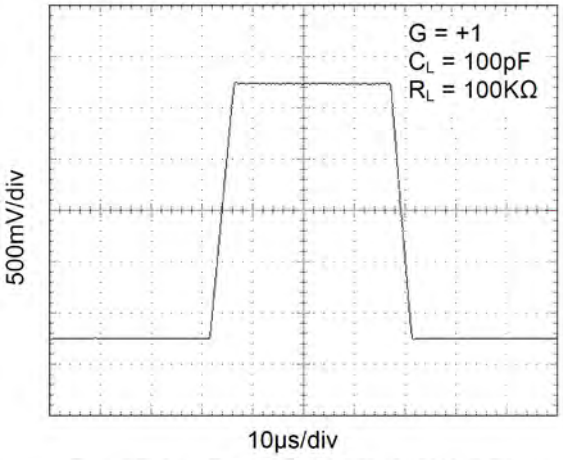
## TYPICAL PERFORMANCE CHARACTERISTICS

(At $T_A$ = +25℃, $V_S$ = +5V, and $R_L$ = 100KΩ connected to Vs/2, unless otherwise noted.)

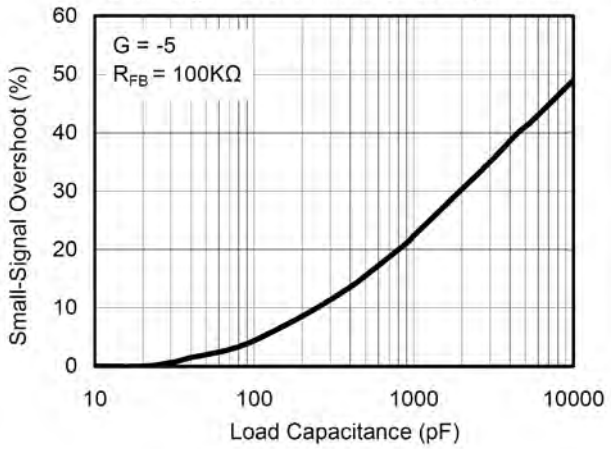
Small-Signal Step Response



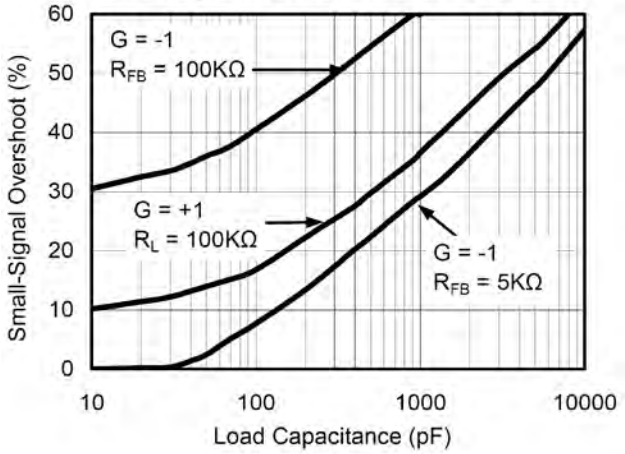

Large-Signal Step Response



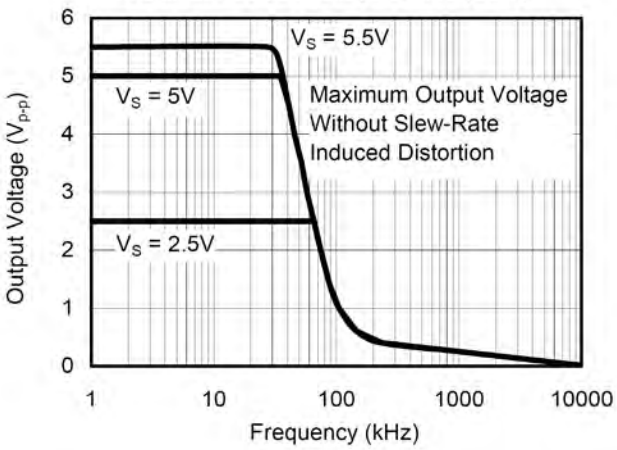

Small-Signal Overshoot vs. Load Capacitance



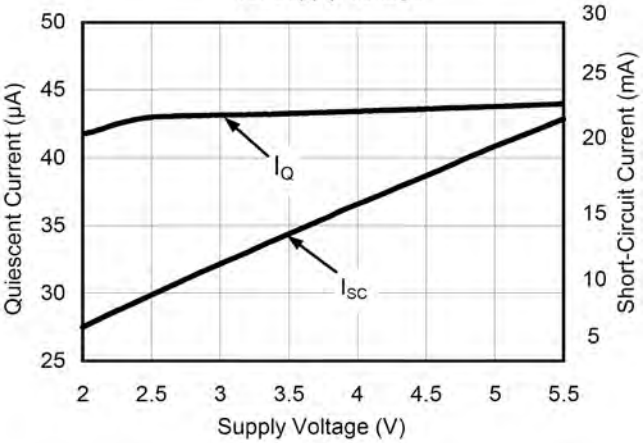

Small-Signal Overshoot vs. Load Capacitance




Maximum Output Voltage vs. Frequency

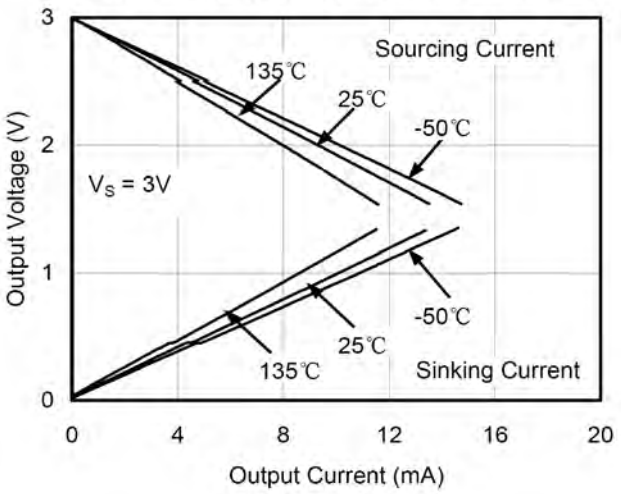



Quiescent and Short-Circuit Current vs. Supply Voltage

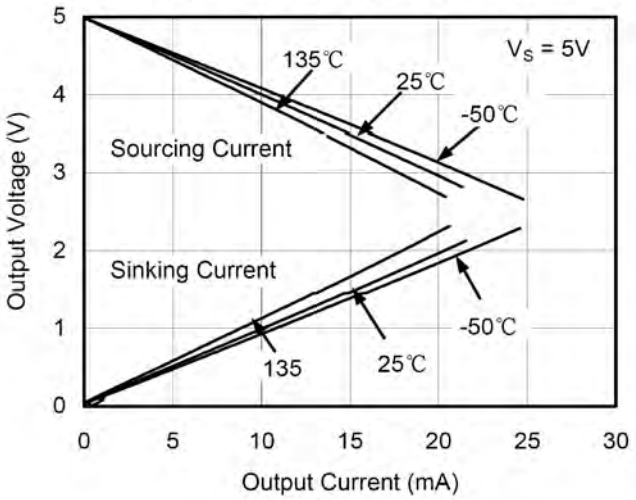


## TYPICAL PERFORMANCE CHARACTERISTICS(Con.)

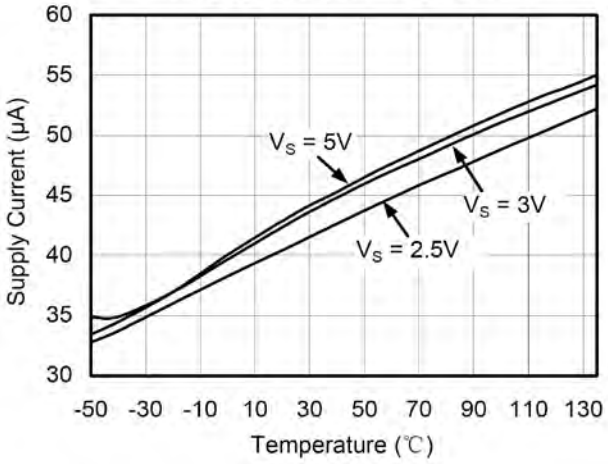
Output Voltage Swing vs. Output Current



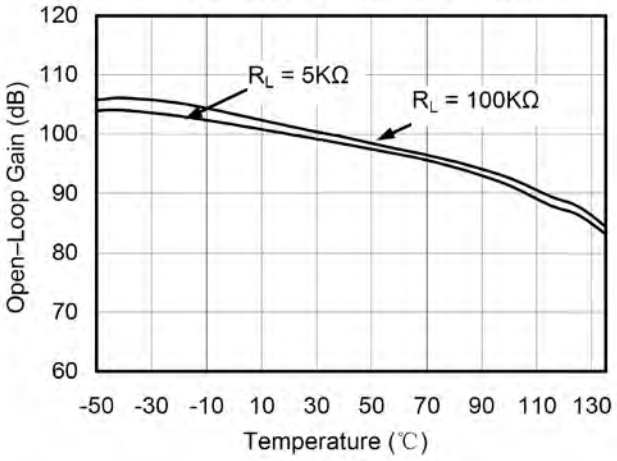

Output Voltage Swing vs. Output Current



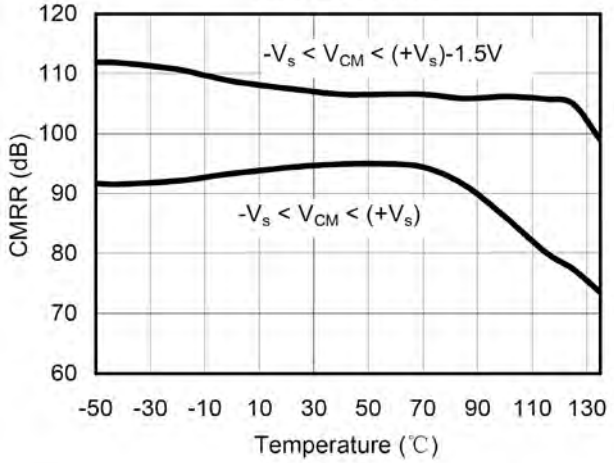

Supply Current vs. Temperature



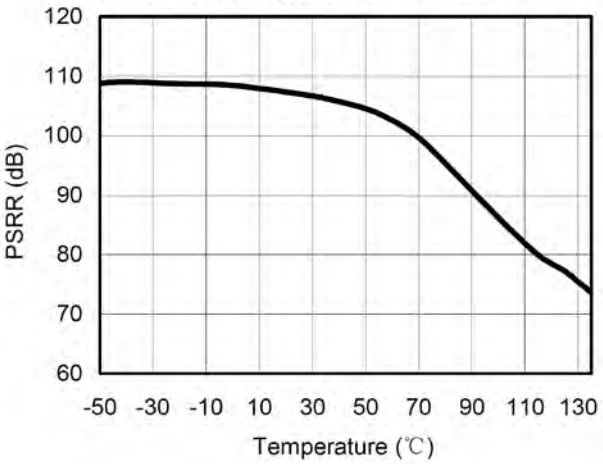

Open-Loop Gain vs. Temperature




Common-Mode Rejection Ratio vs. Temperature




Power-Supply Rejection Ratio vs. Temperature



## APPLICATION NOTES

### Driving Capacitive Loads

The FC358F can directly drive 250pF in unity-gain without oscillation. The unity-gain follower (buffer) is the most sensitive configuration to capacitive loading. Direct capacitive loading reduces the phase margin of amplifiers and this results in ringing or even oscillation.Applications that require greater capacitive drive capability should use an isolation resistor between the output and the capacitive load like the circuit in Figure 1. Theisolation resistor RISO and the load capacitor CL form a zero to increase stability. The bigger the $R_{ISO}$ resistor value, the more stable VOUT will be. Note that this method results in a loss of gain accuracy because $R_{ISO}$ forms a voltage divider with the $R_{LOAD}$.

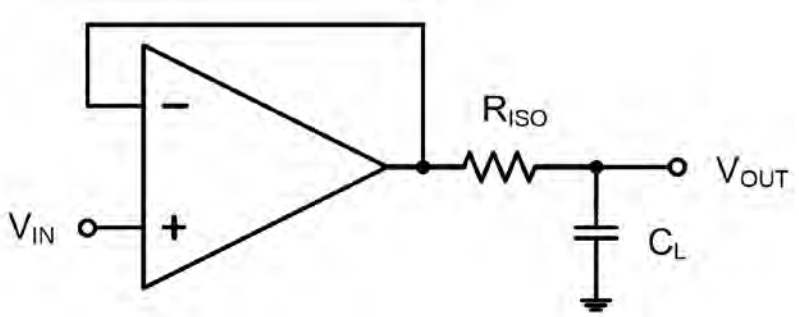



**Figure 1. Indirectly Driving Heavy Capacitive Load**

An improvement circuit is shown in Figure 2, It provides DC accuracy as well as AC stability. RF provides the DC accuracy by connecting the inverting signal with the output, CF and RIso serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving phase margin in the overall feedback loop.

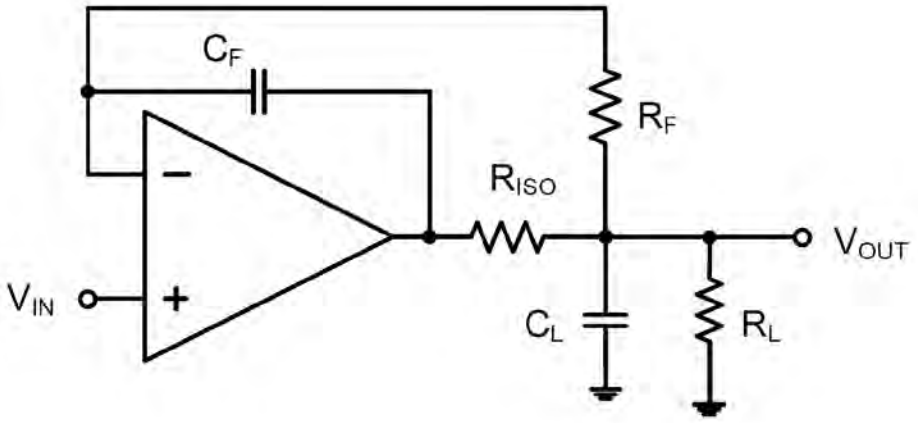



**Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy**

For no-buffer configuration, there are two others ways to increase the phase margin: (a) by increasing the amplifier's gain or (b) by placing a capacitor in parallel with the feedback resistor to counteract the parasitic capacitance associated with inverting node.

## APPLICATION NOTES(Con.)

### Power-Supply Bypassing and Layout

The FC358F family operates from either a single +2.5V to +5.5V supply or dual ±1.25V to ±2.75V supplies. For single-supply operation, bypass the power supply VDD with a 0.1µF ceramic capacitor which should be placed close to the VDD pin. For dual-supply operation, both the VDD and the VSS supplies should be bypassed to ground with separate 0.1µF ceramic capacitors. 2.2µF tantalum capacitor can be added for better performance.

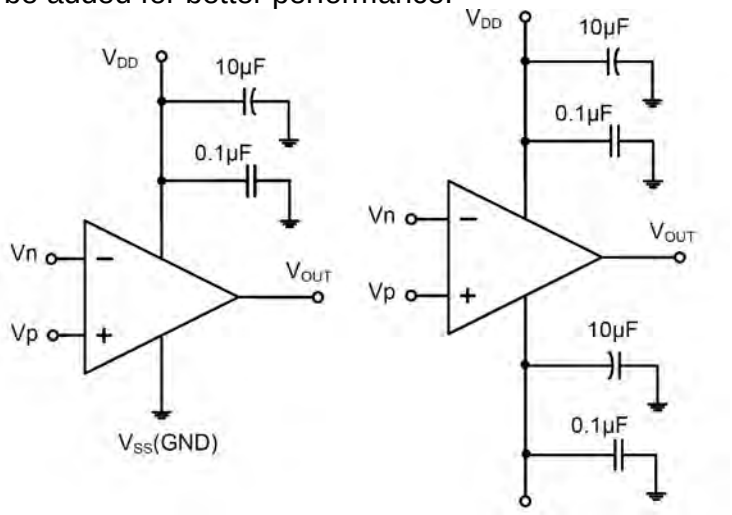



**Figure 3. Amplifier with Bypass Capacitors**

## TYPICAL APPLICATION CIRCUITS

### Differential Amplifier

The circuit shown in Figure 4 performs the difference function. If the resistors ratios are equal (R4 / R3 = R2 / R1), then VOUT = (Vp – Vn) × R2 / R1 + VREF.

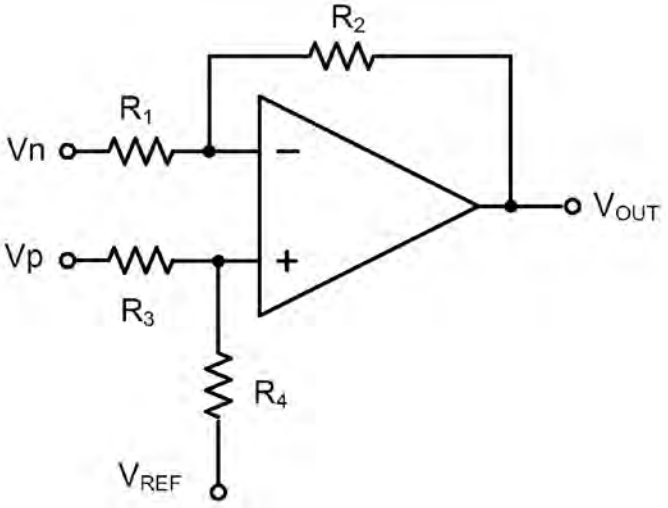



**Figure 4. Differential Amplifier**

## TYPICAL APPLICATION CIRCUITS(Con.)

### Instrumentation Amplifier

The circuit in Figure 5 performs the same function as that in Figure 4 but with the high input impedance.

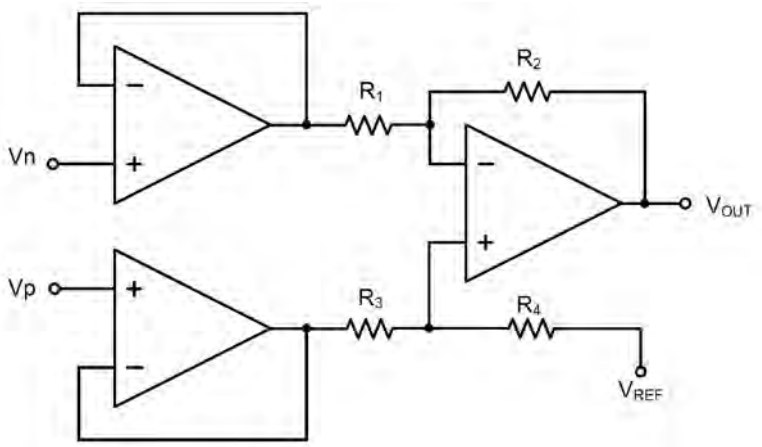



**Figure 5. Instrumentation Amplifier**

### Low Pass Active Filter

The low pass filter shown in Figure 6 has a DC gain of (-R2 / R1) and the –3dB corner frequency is 1/2πR2C. Make sure the filter is within the bandwidth of the amplifier. The Large values of feedback resistors can couple with parasitic capacitance and cause undesired effects such as ringing or oscillation in high-speed amplifiers. Keep resistors value as low as possible and consistent with output loading consideration.

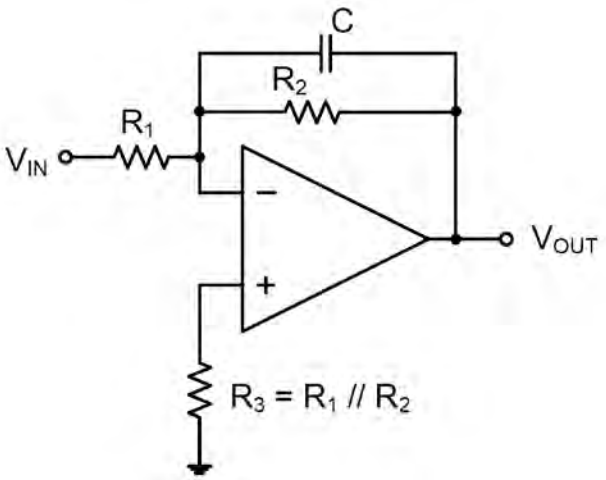
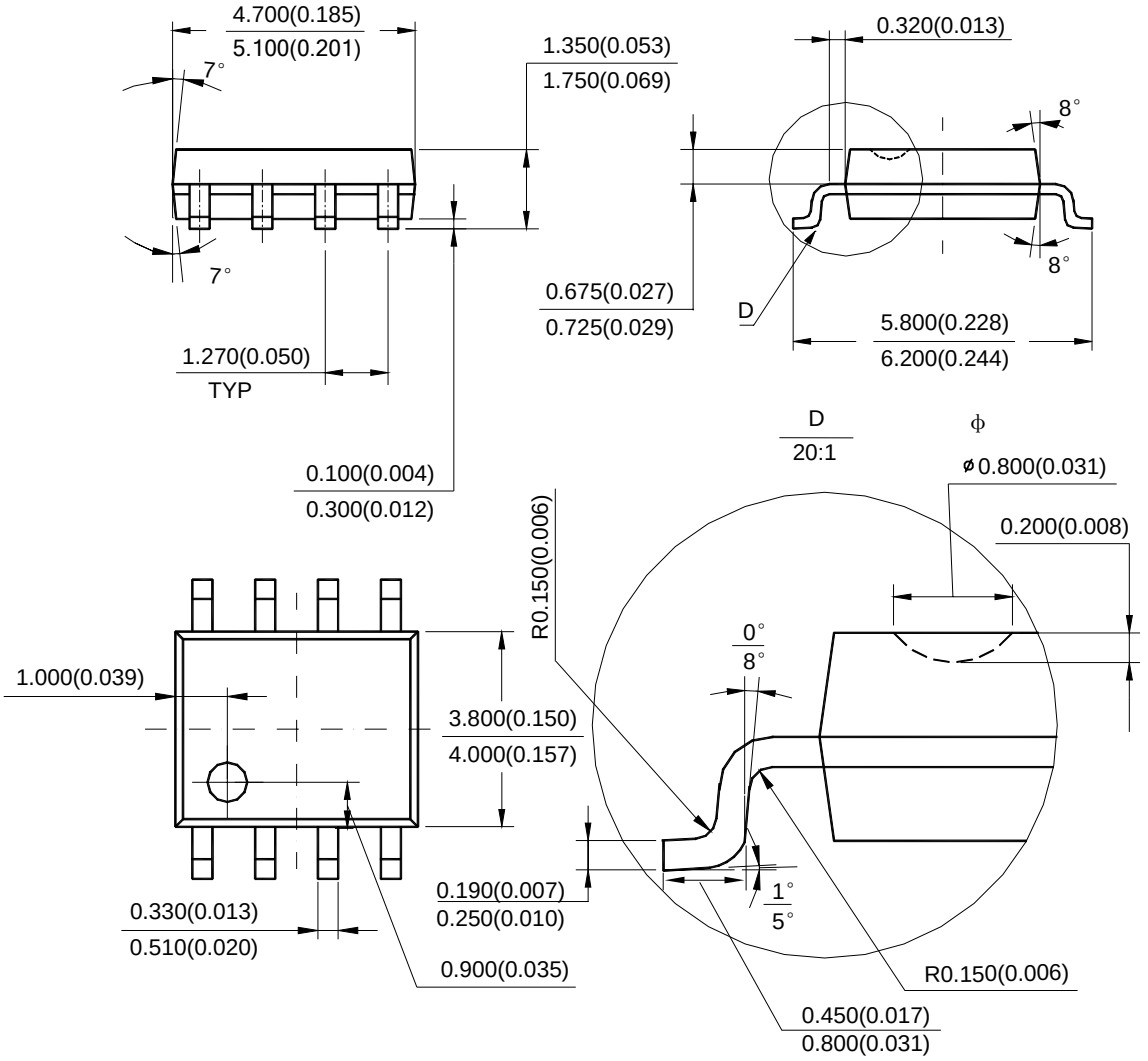



**Figure 6. Low Pass Active Filter**

## SOP-8 Package Outline Dimensions

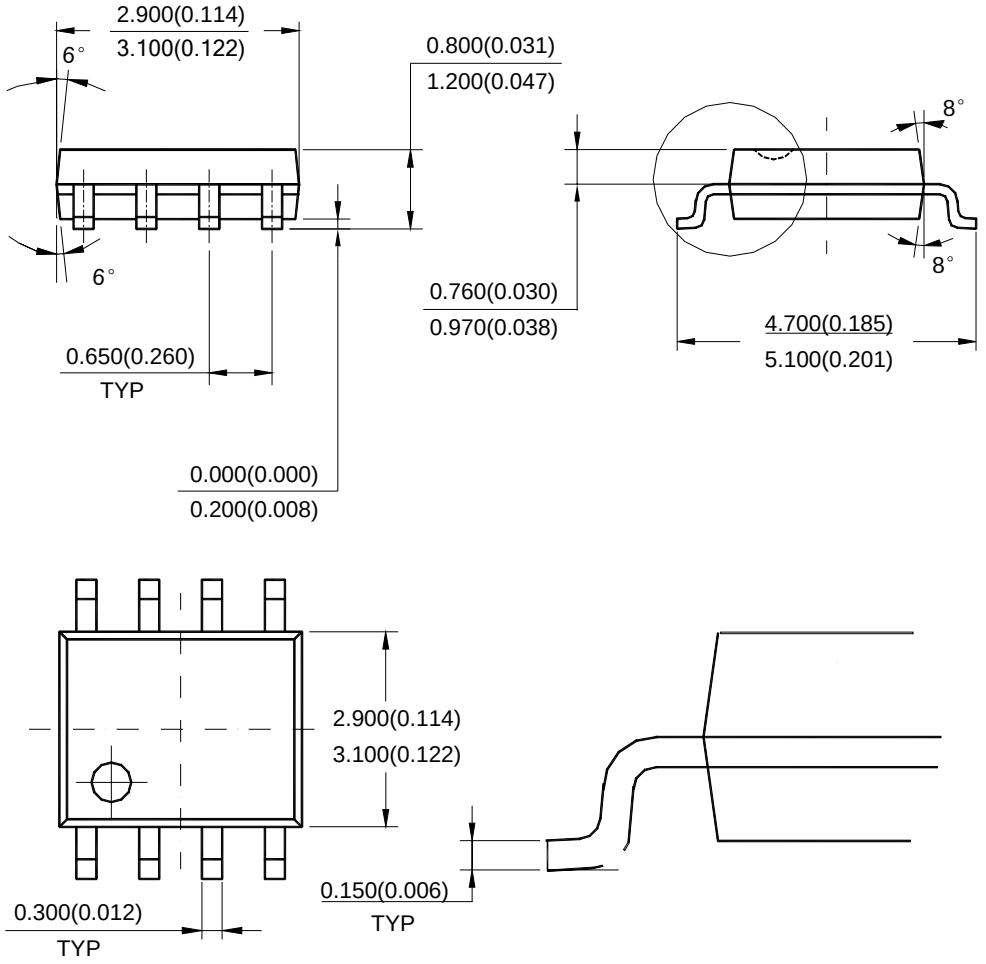
**Unit: mm(inch)**




Note: Eject hole, oriented hole and mold mark is optional.

## MSOP-8 Package Outline Dimensions

**Unit: mm(inch)**




Note: Eject hole, oriented hole and mold mark is optional.