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## MCP6002T-I/SN(MS)

Product specification

## GENERAL DESCRIPTION

The MCP6002T-I/SN(MS) is dual CMOS operational amplifier that uses the proprietary auto-calibration technique to simultaneously provides very lowoffset voltage, near-zero drift over time and temperature. These miniature, high-precision, low quiescent current amplifiers offer high-impedance inputs that have a common-mode range 200mV beyond the rails, and rail-to-rail output that swings within 50mV of the rails, single or dual supplies as low as 2.1V( $\pm 1.35$  V) and up to 5.5V( $\pm 2.75$ V) can be used. These devices are optimized for low voltage, single supply operation. The MCP6002T-I/SN(MS) offers excellent CMRR without the crossover associated with traditional complementary input stages. This design results in superior performance for driving analog-to-digital converters(ADC) without degradation of differential linearity. The MCP6002T-I/SN(MS) is available in the 8-pin VSSOP and TSSOP packages.

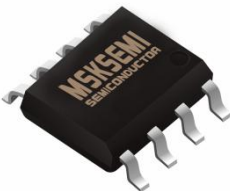
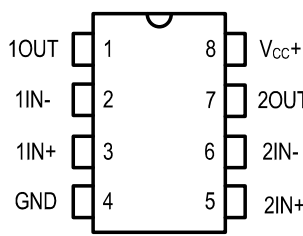

## FEATURES

- VDD range: 2.1V to 5.5V
- Low Offset Voltage: 0.5mV (Typical)
- Low Drift: 0.65 $\mu$ V/C (Typical)
- Low Noise
- Quiescent Current: 50 $\mu$ A (Total)
- Rail to Rail Input/Output
- MicroSize Packages: SOP-8

## APPLICATIONS

- Transducers
- Temperature Measurement
- Electronic Scales
- Medical instrumentation
- Handheld Test Equipment

## Reference News

PACKAGE OUTLINE	PIN CONFIGURATION	Marking
 <p>SOP-8</p>		

## PIN DESCRIPTION

Pin Name	Pin Number	Description
1OUT	1	Output 1
1IN-	2	Inverting input 1
1IN+	3	Noninverting input 1
GND	4	Negative (lowest) power supply
2IN+	5	Noninverting input 2
2IN-	6	Inverting input 2
2OUT	7	Output 2
Vcc+	8	Positive (highest) power supply

**SIMPLIFIED SCHEMATIC**

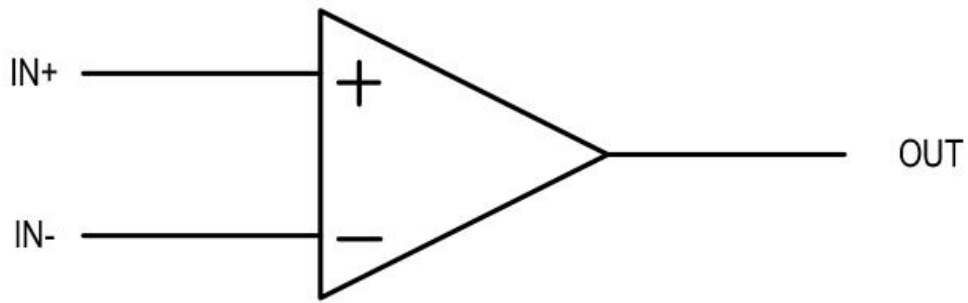


Figure 1.Simplified Schematic

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**ABSOLUTE MAXIMUM RATINGS**

Thermal Resistance $\theta_{Jc}$ .....	130°C/W
Supply Voltage.....	2.1 to 5.5V
Signal Input Terminals Voltage...-	0.1 to (V+)+0.1V
Operating Junction Temperature.....	150°C
Operating Temperature Range.....	-55°C to 125°C
Storage Temperature .....	-65°C to 150°C

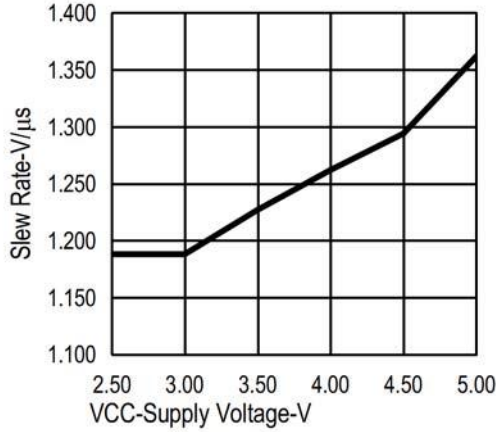
**ELECTRICAL CHARACTERISTICS**

 (At  $T_A=25^{\circ}\text{C}$ ,  $R_L=10\text{k}$  to  $V_S/2$ , and  $V_{out}=V_S/2$ , unless

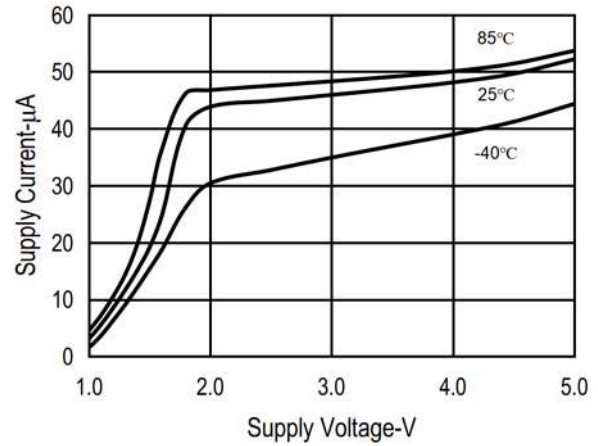
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Input Offset Voltage	$V_S=\pm 2.5\text{V}$	-2	0.5	2	mV
Input Offset Voltage Drift	$T_A=-55^{\circ}\text{C}$ to $125^{\circ}\text{C}$		0.65		$\mu\text{V}/^{\circ}\text{C}$
Power Supply Rejection Ratio	$V_S=2.1\text{V}$ to $5.5\text{V}$ $T_A=-55^{\circ}\text{C}$ to $125^{\circ}\text{C}$	80	90		dB
Input Bias Current	$T_A=25^{\circ}\text{C}$		2		pA
Input Offset Current			1		pA
Common-mode Voltage Range		(V-)-0.1		(V+)+0.1	V
Common-mode Rejection Ratio	$(V-)-0.1 < V_{cm} < (V+)+0.1$ $T_A=-55^{\circ}\text{C}$ to $125^{\circ}\text{C}$	80	95		dB
Open Loop Voltage Gain	$(V-)+100\text{mV} < V_o < (V+)-100\text{mV}$ $R_L=10\text{k}$ $T_A=-55^{\circ}\text{C}$ to $125^{\circ}\text{C}$	80	100		dB
Gain-bandwidth product	$C_L=120\text{pF}$		1.5		MHz
Slew Rate	$G=+1$		1.2		$\text{V}/\mu\text{s}$
Specified Voltage Range		2.1		5.5	V
Quiescent Current (Total)	$I_o=0\text{A}$		50		$\mu\text{A}$
Operating Temperature Range		-55		125	$^{\circ}\text{C}$
Storage Temperature Range		-65		150	$^{\circ}\text{C}$

**TYPICAL PERFORMANCE CHARACTERISTICS**

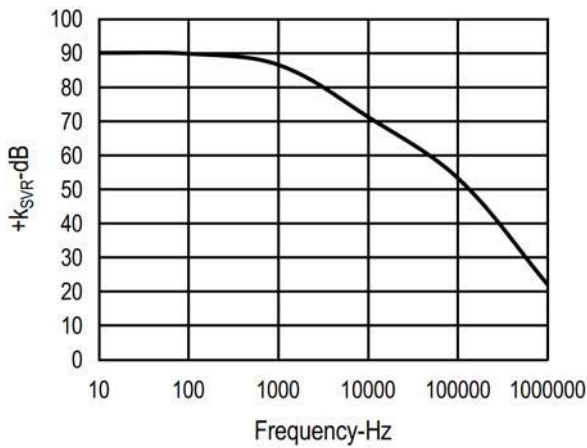
(At  $T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $C_L = 20\text{pF}$ , unless otherwise noted.)



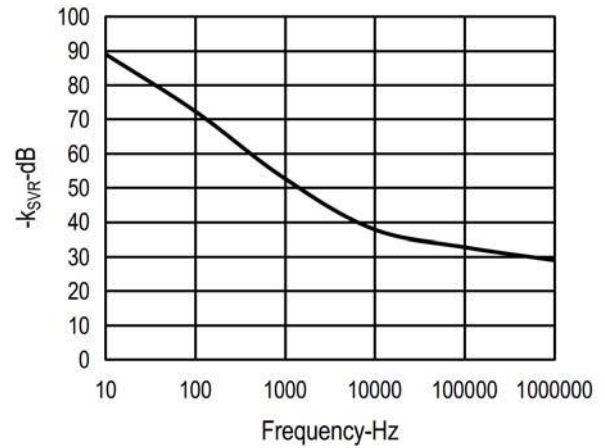
**Figure 2. Slew Rate vs Supply Voltage**



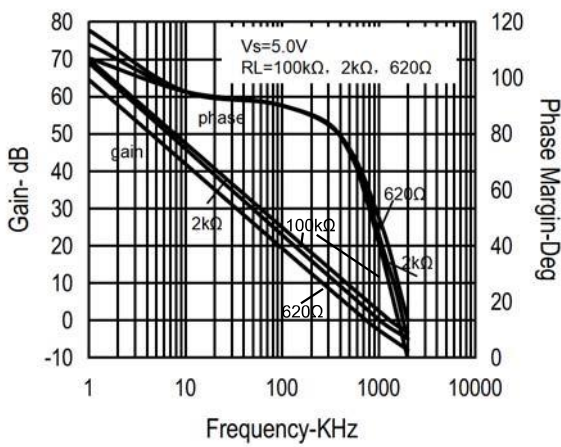
**Figure 3. Supply Current vs Supply Voltage**



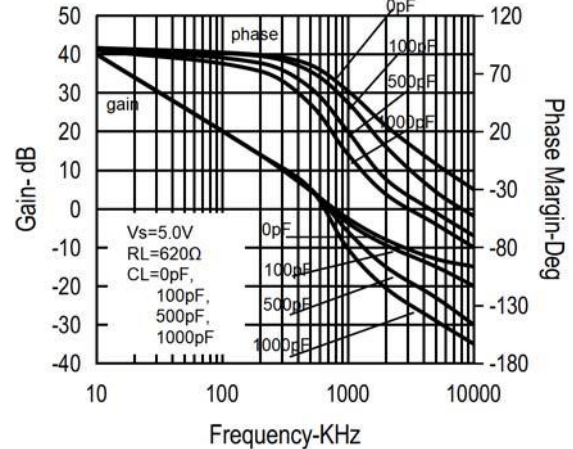
**Figure 4. +ksvR vs Frequency**



**Figure 5. -ksvR vs Frequency**



**Figure 6. Frequency Response vs Resistive Load**



**Figure 7. Frequency Response vs Capacitive Load**

**TYPICAL PERFORMANCE CHARACTERISTICS**

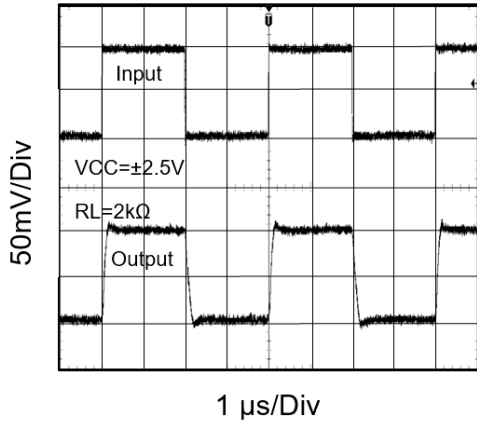


Figure 8. Noninverting Small-Signal Pulse Response

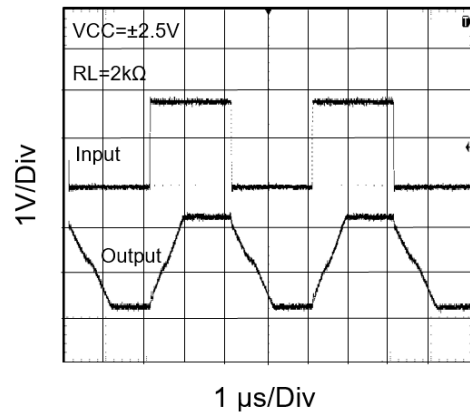


Figure 9. Noninverting Large-Signal Pulse Response

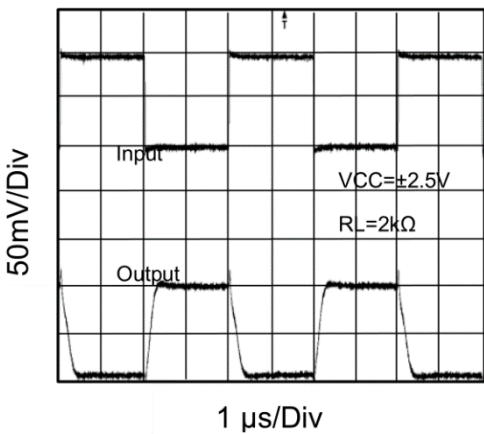


Figure 10. Inverting Small-Signal Pulse Response

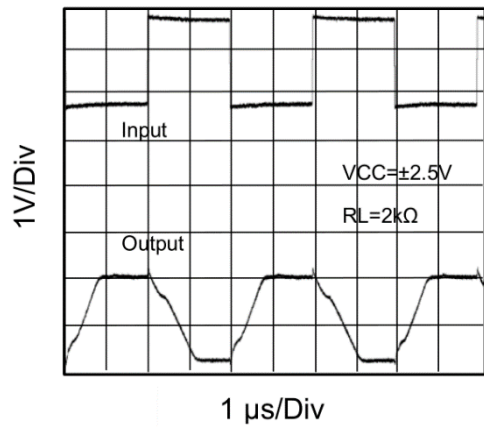


Figure 11. Inverting Large-Signal Pulse Response

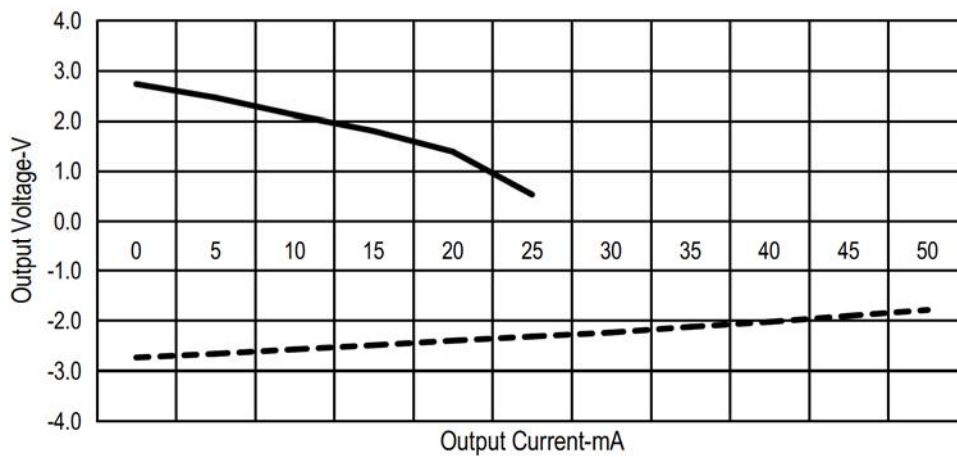


Figure 12. Output Voltage vs Output Current

## FUNCTIONAL DESCRIPTION

### Operating Voltage

The MCP6002T-I/SN(MS) device is fully specified and ensured for operation from 2.1V to 5.5V. In addition, many specifications apply from -55°C to 125°C. Parameters that vary significantly with operating voltages or temperature are shown in the Typical Characteristics graphs.

### Unity-Gain Bandwidth

The unity-gain bandwidth is the frequency up to which an amplifier with a unity gain may be operated without greatly distorting the signal. The MCP6002T-I/SN(MS) device has a 1.5-MHz unity-gain bandwidth.

### Slew Rate

The slew rate is the rate at which an operational amplifier can change its output when there is a change on the input. The MCP6002T-I/SN(MS) devices have a 1.2-V/ $\mu$ s slew rate. The MCP6002T-I/SN(MS) is characterized to perform with this technique; the recommended resistor value is approximately 20 k.

### Device Functional Modes

The MCP6002T-I/SN(MS) device has a single functional mode. The device is powered on as long as the power supply voltage is between 2.1V( $\pm$ 1.35V) and 5.5V( $\pm$ 2.75V).

## APPLICATIONS INFORMATION

The MCP6002T-I/SN(MS) is a unity-gain stable, precision operational amplifier with very low offset voltage drift; these devices are also free from output phase reversal. Applications with noisy or high-impedance power supplies require decoupling capacitors close to the device power-supply pins. In most cases, 0.1 $\mu$ F capacitors are adequate.

### Typical Application

Figure 13 shows a simple circuit to convert a single-ended input into differential output. The MCP6002T-I/SN(MS) could be used to build this circuit. The circuit is composed of two amplifiers. One amplifier acts as a buffer and creates a voltage,  $V_{out+}$ . The second amplifier inverts the input and adds a reference voltage to generate  $V_{out-}$ . Both  $V_{out+}$  and  $V_{out-}$  range from 0.5 to 2V. The difference,  $V_{DIFF}$ , is the difference between  $V_{out+}$  and  $V_{out-}$ .

### Detailed Design Procedure

Linearity over the input range is key for good dc accuracy. The common mode input range and the output swing limitations determine the linearity. In general, an amplifier with rail-to-rail input and output swing is required. Bandwidth is a key concern for this design. Because MCP6002T-I/SN(MS) has a bandwidth of 1 MHz, this circuit will only be able to process signals with frequencies of less than 1 MHz.

Because the transfer function of  $V_{out-}$  is heavily reliant on resistors ( $R_1$ ,  $R_2$ ,  $R_3$ , and  $R_4$ ), use resistors with low tolerances to maximize performance and minimize error. This design used resistors with resistance values of 36 k with tolerances measured to be within 2%. If the noise of the system is a key parameter, the user can select smaller resistance values (6 k or lower) to keep the overall system noise low. This ensures that the noise from the resistors is lower than the amplifier noise.

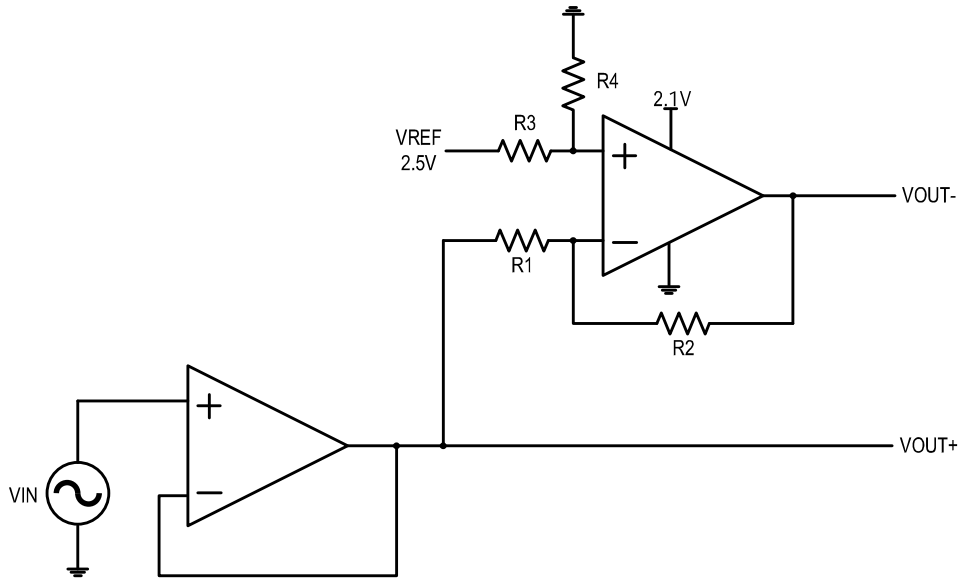
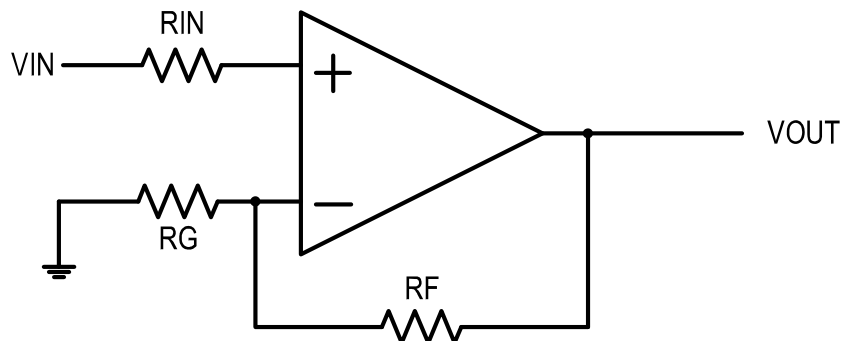


Figure 13. Schematic for Single-Ended Input to Differential Output Conversion

## LAYOUT

Use good PCB layout practices for best operational performance of the device, including:

- Keep the length of input traces as short as possible.
- Run the input traces as far away from the supply lines as possible to reduce parasitic coupling.
- Place components close to device and to each other to reduce parasitic capacitance and parasitic errors.
- Use low-ESR, ceramic bypass capacitors to reduce the coupled noise by providing low impedance power sources local to the analog circuitry.
- Grounding for analog and digital portions of circuitry separately to suppress the noise.





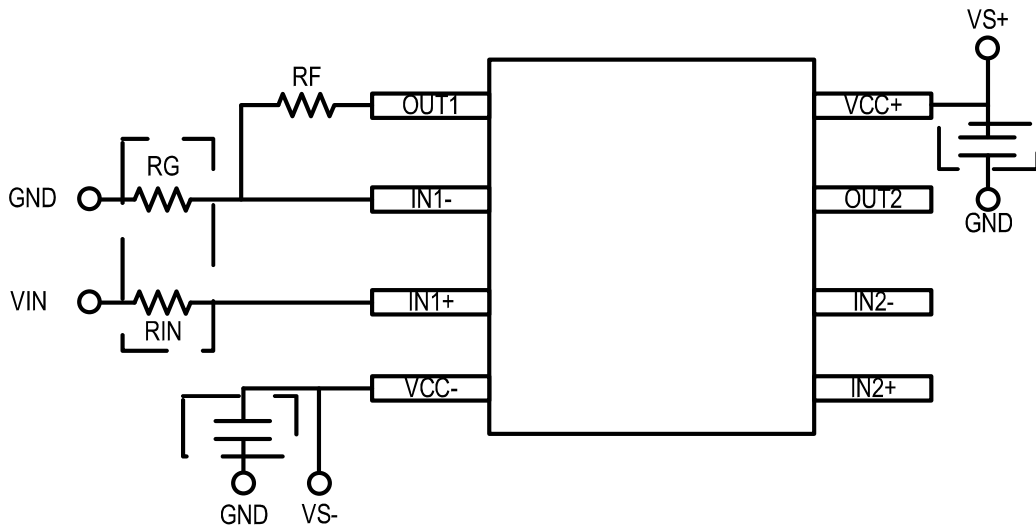
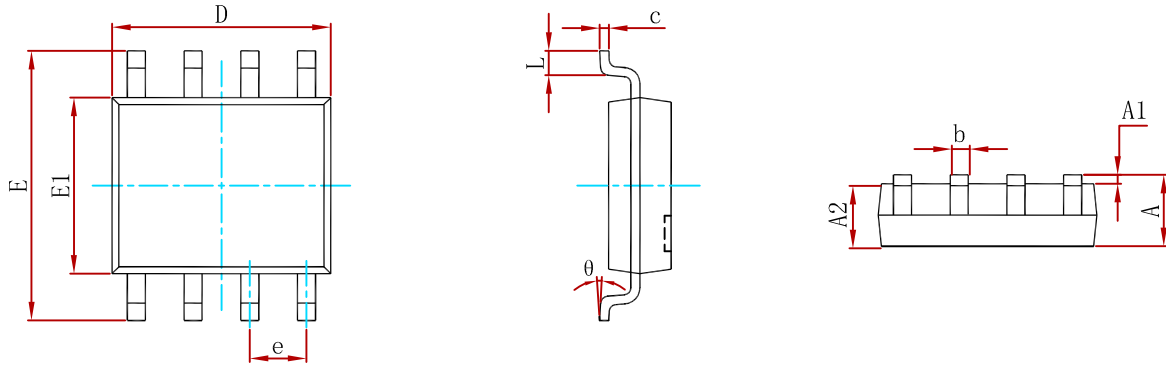


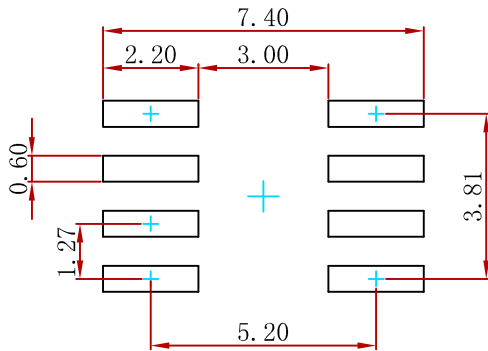
Figure 14. Operational Amplifier Schematic and Board Layout for Noninverting Configuration

**PACKAGE MECHANICAL DATA**



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.800	5.000	0.189	0.197
e	1.270 (BSC)		0.050 (BSC)	
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

**Suggested Pad Layout**



Note:  
 1. Controlling dimension: in millimeters.  
 2. General tolerance: ±0.05mm.  
 3. The pad layout is for reference purposes only.

**REEL SPECIFICATION**

P/N	PKG	QTY
MCP6002T-I/SN(MS)	SOP-8	2500PCS

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