



# MICROCHIP MCP6001/1R/1U/2/4

## 1 MHz, Low-Power Op Amp

### Features

- Available in SC-70-5 and SOT-23-5 packages
- Gain Bandwidth Product: 1 MHz (typical)
- Rail-to-Rail Input/Output
- Supply Voltage: 1.8V to 6.0V
- Supply Current:  $I_Q = 100 \mu\text{A}$  (typical)
- Phase Margin: 90° (typical)
- Temperature Range:
  - Industrial: -40°C to +85°C
  - Extended: -40°C to +125°C
- Available in Single, Dual and Quad Packages

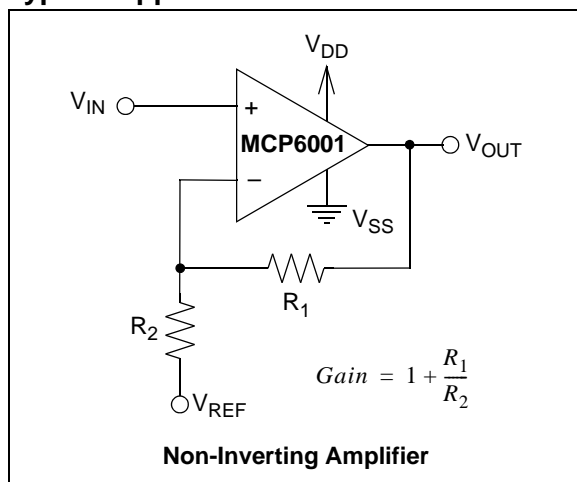
### Applications

- Automotive
- Portable Equipment
- Photodiode Amplifier
- Analog Filters
- Notebooks and PDAs
- Battery-Powered Systems

### Design Aids

- SPICE Macro Models
- FilterLab® Software
- Mindi™ Circuit Designer & Simulator
- Microchip Advanced Part Selector (MAPS)
- Analog Demonstration and Evaluation Boards
- Application Notes

### Typical Application

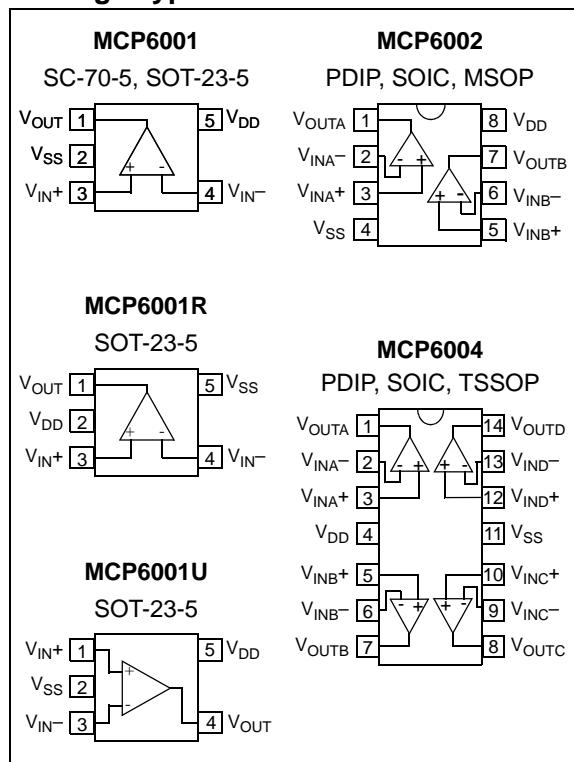


### Description

The Microchip Technology Inc. MCP6001/2/4 family of operational amplifiers (op amps) is specifically designed for general-purpose applications. This family has a 1 MHz Gain Bandwidth Product (GBWP) and 90° phase margin (typical). It also maintains 45° phase margin (typical) with a 500 pF capacitive load. This family operates from a single supply voltage as low as 1.8V, while drawing 100  $\mu\text{A}$  (typical) quiescent current. Additionally, the MCP6001/2/4 supports rail-to-rail input and output swing, with a common mode input voltage range of  $V_{DD} + 300 \text{ mV}$  to  $V_{SS} - 300 \text{ mV}$ . This family of op amps is designed with Microchip's advanced CMOS process.

The MCP6001/2/4 family is available in the industrial and extended temperature ranges, with a power supply range of 1.8V to 6.0V.

### Package Types



# MCP6001/1R/1U/2/4

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

$V_{DD} - V_{SS}$ .....	7.0V
Current at Analog Input Pins ( $V_{IN+}$ , $V_{IN-}$ ) .....	$\pm 2$ mA
Analog Inputs ( $V_{IN+}$ , $V_{IN-}$ ) †† .....	$V_{SS} - 1.0V$ to $V_{DD} + 1.0V$
All Other Inputs and Outputs .....	$V_{SS} - 0.3V$ to $V_{DD} + 0.3V$
Difference Input Voltage .....	$ V_{DD} - V_{SS} $
Output Short Circuit Current .....	Continuous
Current at Output and Supply Pins .....	$\pm 30$ mA
Storage Temperature .....	$-65^{\circ}C$ to $+150^{\circ}C$
Maximum Junction Temperature ( $T_J$ ) .....	$+150^{\circ}C$
ESD Protection On All Pins (HBM; MM) .....	$\geq 4$ kV; 200V

† **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 listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

†† See Section 4.1.2 “Input Voltage and Current Limits”.

### DC ELECTRICAL SPECIFICATIONS

**Electrical Characteristics:** Unless otherwise indicated,  $T_A = +25^{\circ}C$ ,  $V_{DD} = +1.8V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $V_{CM} = V_{DD}/2$ ,  $V_L = V_{DD}/2$ ,  $R_L = 10$  k $\Omega$  to  $V_L$ , and  $V_{OUT} \approx V_{DD}/2$  (refer to Figure 1-1 and Figure 1-2).

Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Input Offset</b>						
Input Offset Voltage	$V_{OS}$	-4.5	—	+4.5	mV	$V_{CM} = V_{SS}$ (Note 1)
Input Offset Drift with Temperature	$\Delta V_{OS}/\Delta T_A$	—	$\pm 2.0$	—	$\mu V/^{\circ}C$	$T_A = -40^{\circ}C$ to $+125^{\circ}C$ , $V_{CM} = V_{SS}$
Power Supply Rejection Ratio	PSRR	—	86	—	dB	$V_{CM} = V_{SS}$
<b>Input Bias Current and Impedance</b>						
Input Bias Current:	$I_B$	—	$\pm 1.0$	—	pA	
Industrial Temperature	$I_B$	—	19	—	pA	$T_A = +85^{\circ}C$
Extended Temperature	$I_B$	—	1100	—	pA	$T_A = +125^{\circ}C$
Input Offset Current	$I_{OS}$	—	$\pm 1.0$	—	pA	
Common Mode Input Impedance	$Z_{CM}$	—	$10^{13}  6$	—	$\Omega  pF$	
Differential Input Impedance	$Z_{DIFF}$	—	$10^{13}  3$	—	$\Omega  pF$	
<b>Common Mode</b>						
Common Mode Input Range	$V_{CMR}$	$V_{SS} - 0.3$	—	$V_{DD} + 0.3$	V	
Common Mode Rejection Ratio	CMRR	60	76	—	dB	$V_{CM} = -0.3V$ to $5.3V$ , $V_{DD} = 5V$
<b>Open-Loop Gain</b>						
DC Open-Loop Gain (Large Signal)	$A_{OL}$	88	112	—	dB	$V_{OUT} = 0.3V$ to $V_{DD} - 0.3V$ , $V_{CM} = V_{SS}$
<b>Output</b>						
Maximum Output Voltage Swing	$V_{OL}, V_{OH}$	$V_{SS} + 25$	—	$V_{DD} - 25$	mV	$V_{DD} = 5.5V$ , 0.5V Input Overdrive
Output Short Circuit Current	$I_{SC}$	—	$\pm 6$	—	mA	$V_{DD} = 1.8V$
		—	$\pm 23$	—	mA	$V_{DD} = 5.5V$
<b>Power Supply</b>						
Supply Voltage	$V_{DD}$	1.8	—	6.0	V	<b>Note 2</b>
Quiescent Current per Amplifier	$I_Q$	50	100	170	$\mu A$	$I_O = 0$ , $V_{DD} = 5.5V$ , $V_{CM} = 5V$

**Note 1:** MCP6001/1R/1U/2/4 parts with date codes prior to December 2004 (week code 49) were tested to  $\pm 7$  mV minimum/maximum limits.

**Note 2:** All parts with date codes November 2007 and later have been screened to ensure operation at  $V_{DD} = 6.0V$ . However, the other minimum and maximum specifications are measured at 1.8V and 5.5V.

## AC ELECTRICAL SPECIFICATIONS

Electrical Characteristics: Unless otherwise indicated,  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = +1.8$  to  $5.5\text{V}$ ,  $V_{SS} = \text{GND}$ ,  $V_{CM} = V_{DD}/2$ ,  $V_L = V_{DD}/2$ ,  $V_{OUT} \approx V_{DD}/2$ ,  $R_L = 10\text{ k}\Omega$  to  $V_L$ , and  $C_L = 60\text{ pF}$  (refer to [Figure 1-1](#) and [Figure 1-2](#)).

Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>AC Response</b>						
Gain Bandwidth Product	GBWP	—	1.0	—	MHz	
Phase Margin	PM	—	90	—	°	$G = +1\text{ V/V}$
Slew Rate	SR	—	0.6	—	$\text{V}/\mu\text{s}$	
<b>Noise</b>						
Input Noise Voltage	$E_{ni}$	—	6.1	—	$\mu\text{Vp-p}$	$f = 0.1\text{ Hz to }10\text{ Hz}$
Input Noise Voltage Density	$e_{ni}$	—	28	—	$\text{nV}/\sqrt{\text{Hz}}$	$f = 1\text{ kHz}$
Input Noise Current Density	$i_{ni}$	—	0.6	—	$\text{fA}/\sqrt{\text{Hz}}$	$f = 1\text{ kHz}$

## TEMPERATURE SPECIFICATIONS

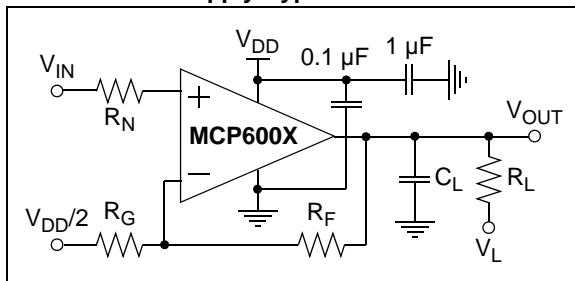
Electrical Characteristics: Unless otherwise indicated,  $V_{DD} = +1.8\text{V}$  to  $+5.5\text{V}$  and  $V_{SS} = \text{GND}$ .

Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Temperature Ranges</b>						
Industrial Temperature Range	$T_A$	-40	—	+85	°C	
Extended Temperature Range	$T_A$	-40	—	+125	°C	
Operating Temperature Range	$T_A$	-40	—	+125	°C	<b>Note</b>
Storage Temperature Range	$T_A$	-65	—	+150	°C	
<b>Thermal Package Resistances</b>						
Thermal Resistance, 5L-SC70	$\theta_{JA}$	—	331	—	°C/W	
Thermal Resistance, 5L-SOT-23	$\theta_{JA}$	—	256	—	°C/W	
Thermal Resistance, 8L-PDIP	$\theta_{JA}$	—	85	—	°C/W	
Thermal Resistance, 8L-SOIC (150 mil)	$\theta_{JA}$	—	163	—	°C/W	
Thermal Resistance, 8L-MSOP	$\theta_{JA}$	—	206	—	°C/W	
Thermal Resistance, 14L-PDIP	$\theta_{JA}$	—	70	—	°C/W	
Thermal Resistance, 14L-SOIC	$\theta_{JA}$	—	120	—	°C/W	
Thermal Resistance, 14L-TSSOP	$\theta_{JA}$	—	100	—	°C/W	

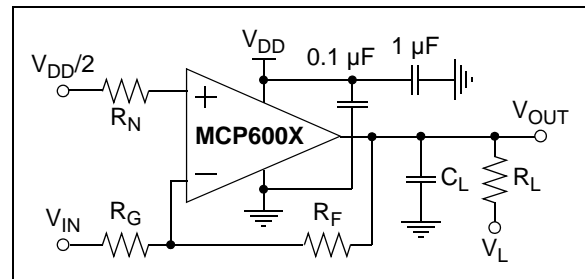
**Note:** The industrial temperature devices operate over this extended temperature range, but with reduced performance. In any case, the internal Junction Temperature ( $T_J$ ) must not exceed the Absolute Maximum specification of  $+150^\circ\text{C}$ .

### 1.1 Test Circuits

The test circuits used for the DC and AC tests are shown in [Figure 1-1](#) and [Figure 1-2](#). The bypass capacitors are laid out according to the rules discussed in [Section 4.4 "Supply Bypass"](#).



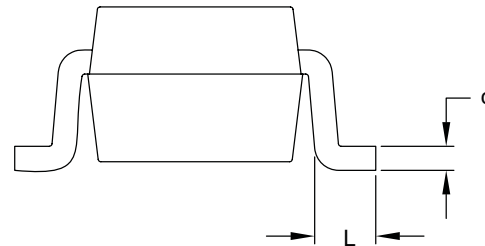
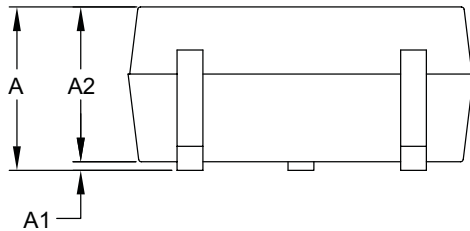
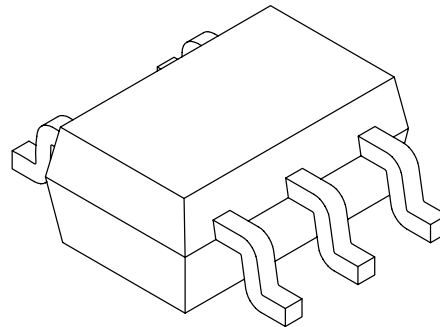
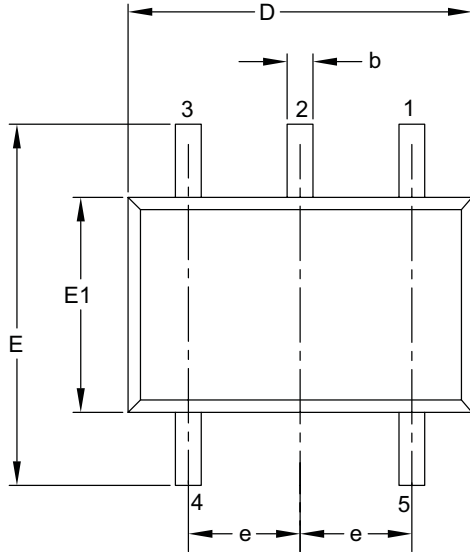
**FIGURE 1-1:** AC and DC Test Circuit for Most Non-Inverting Gain Conditions.



**FIGURE 1-2:** AC and DC Test Circuit for Most Inverting Gain Conditions.

# MCP6001/1R/1U/2/4

## 5-Lead Plastic Small Outline Transistor (LT) [SC70]



Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Number of Pins	N	5		
Pitch	e	0.65 BSC		
Overall Height	A	0.80	–	1.10
Molded Package Thickness	A2	0.80	–	1.00
Standoff	A1	0.00	–	0.10
Overall Width	E	1.80	2.10	2.40
Molded Package Width	E1	1.15	1.25	1.35
Overall Length	D	1.80	2.00	2.25
Foot Length	L	0.10	0.20	0.46
Lead Thickness	c	0.08	–	0.26
Lead Width	b	0.15	–	0.40

**Notes:**

- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-061B

## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<b>PART NO.</b>		<b>X</b>	<b>XX</b>
<b>Device</b>	<b>Temperature Range</b>		<b>Package</b>
Device:	MCP6001T:	Single Op Amp (Tape and Reel) (SC-70, SOT-23)	
	MCP6001RT:	Single Op Amp (Tape and Reel) (SOT-23)	
	MCP6001UT:	Single Op Amp (Tape and Reel) (SOT-23)	
	MCP6002:	Dual Op Amp	
	MCP6002T:	Dual Op Amp (Tape and Reel) (SOIC, MSOP)	
	MCP6004:	Quad Op Amp	
	MCP6004T:	Quad Op Amp (Tape and Reel) (SOIC, MSOP)	
Temperature Range:	I	= -40°C to +85°C	
	E	= -40°C to +125°C	
Package:	LT	= Plastic Package (SC-70), 5-lead (MCP6001 only)	
	OT	= Plastic Small Outline Transistor (SOT-23), 5-lead (MCP6001, MCP6001R, MCP6001U)	
	MS	= Plastic MSOP, 8-lead	
	P	= Plastic DIP (300 mil body), 8-lead, 14-lead	
	SN	= Plastic SOIC, (3.99 mm body), 8-lead	
	SL	= Plastic SOIC (3.99 mm body), 14-lead	
	ST	= Plastic TSSOP (4.4mm body), 14-lead	

<b>Examples:</b>	
a) MCP6001T-I/LT:	Tape and Reel, Industrial Temperature, 5LD SC-70 package
b) MCP6001T-I/OT:	Tape and Reel, Industrial Temperature, 5LD SOT-23 package.
c) MCP6001RT-I/OT:	Tape and Reel, Industrial Temperature, 5LD SOT-23 package.
d) MCP6001UT-E/OT:	Tape and Reel, Extended Temperature, 5LD SOT-23 package.
a) MCP6002-I/MS:	Industrial Temperature, 8LD MSOP package.
b) MCP6002-I/P:	Industrial Temperature, 8LD PDIP package.
c) MCP6002-E/P:	Extended Temperature, 8LD PDIP package.
d) MCP6002-I/SN:	Industrial Temperature, 8LD SOIC package.
e) MCP6002T-I/MS:	Tape and Reel, Industrial Temperature, 8LD MSOP package.
a) MCP6004-I/P:	Industrial Temperature, 14LD PDIP package.
b) MCP6004-I/SL:	Industrial Temperature, 14LD SOIC package.
c) MCP6004-E/SL:	Extended Temperature, 14LD SOIC package.
d) MCP6004-I/ST:	Industrial Temperature, 14LD TSSOP package.
e) MCP6004T-I/SL:	Tape and Reel, Industrial Temperature, 14LD SOIC package.
f) MCP6004T-I/ST:	Tape and Reel, Industrial Temperature, 14LD TSSOP package.