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 µA (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

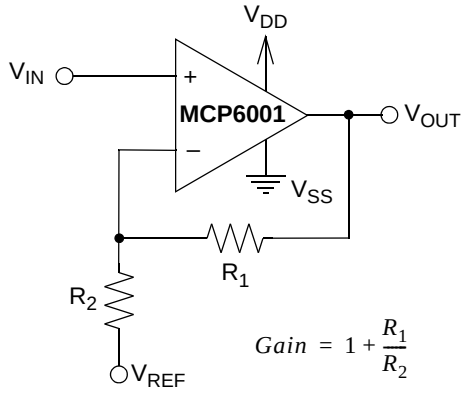
Applications

- 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



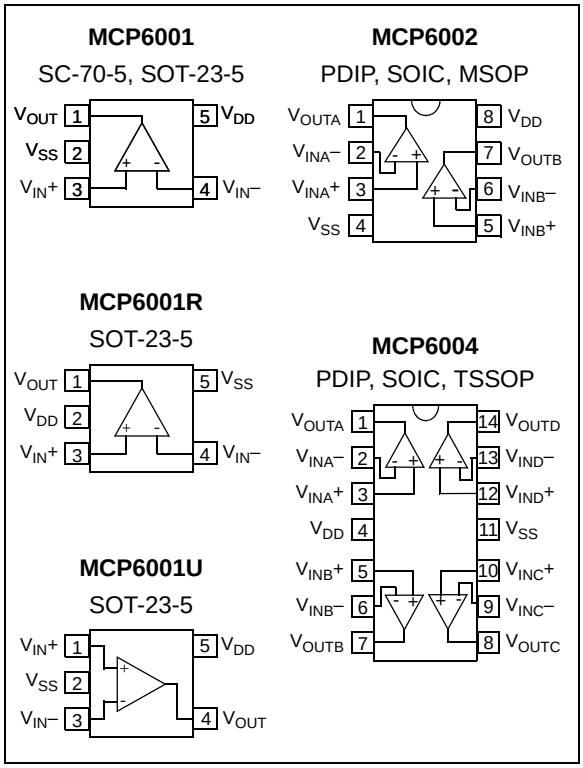
Non-Inverting Amplifier

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 µA (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 mV to V_{SS} – 300 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



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

$V_{DD} - V_{SS}$ 7.0V
Current at Analog Input Pins ($V_{IN}+$, $V_{IN}-$) .....±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 .....±30 mA
Storage Temperature.....–65°C to +150°C
Maximum Junction Temperature (T_J) .....+150°C
ESD Protection On All Pins (HBM; MM) ..... ≥ 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°C, V_{DD} = +1.8V to +5.5V, V_{SS} = GND, $V_{CM} = V_{DD}/2$, $V_L = V_{DD}/2$, R_L = 10 kΩ 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
Input Offset						
Input Offset Voltage	V_{OS}	-4.5	—	+4.5	mV	$V_{CM} = V_{SS}$ **(Note 1)**
Input Offset Drift with Temperature	$\Delta V_{OS}/\Delta T_A$	—	±2.0	—	µV/°C	T_A= -40°C to +125°C, $V_{CM} = V_{SS}$
Power Supply Rejection Ratio	PSRR	—	86	—	dB	$V_{CM} = V_{SS}$
Input Bias Current and Impedance						
Input Bias Current:	I_B	—	±1.0	—	pA	
Industrial Temperature	I_B	—	19	—	pA	T_A = +85°C
Extended Temperature	I_B	—	1100	—	pA	T_A = +125°C
Input Offset Current	I_{OS}	—	±1.0	—	pA	
Common Mode Input Impedance	Z_{CM}	—	10^{13}||6	—	Ω||pF	
Differential Input Impedance	Z_{DIFF}	—	10^{13}||3	—	Ω||pF	
Common Mode						
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
Open-Loop Gain						
DC Open-Loop Gain (Large Signal)	A_{OL}	88	112	—	dB	V_{OUT} = 0.3V to V_{DD} – 0.3V, $V_{CM} = V_{SS}$
Output						
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}	—	±6	—	mA	V_{DD} = 1.8V
		—	±23	—	mA	V_{DD} = 5.5V
Power Supply						
Supply Voltage	V_{DD}	1.8	—	6.0	V	**Note 2**
Quiescent Current per Amplifier	I_Q	50	100	170	µA	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 ±7 mV minimum/maximum limits.

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°C, V_{DD} = +1.8 to 5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, V_L = V_{DD}/2, V_{OUT} ≈ V_{DD}/2, R_L = 10 kΩ to V_L, and C_L = 60 pF (refer to Figure 1-1 and Figure 1-2).

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

TEMPERATURE SPECIFICATIONS

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

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

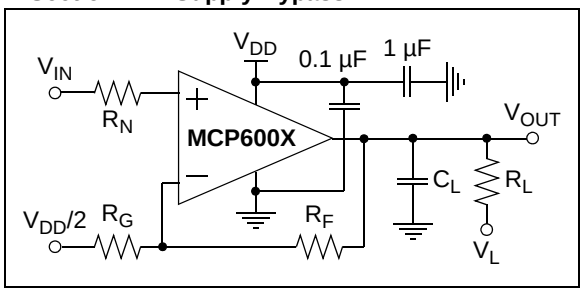


FIGURE 1-1: *AC and DC Test Circuit for Most Non-Inverting Gain Conditions.*

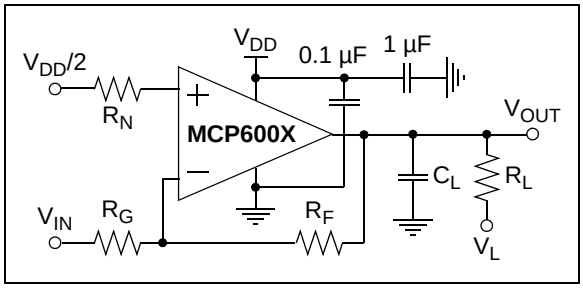
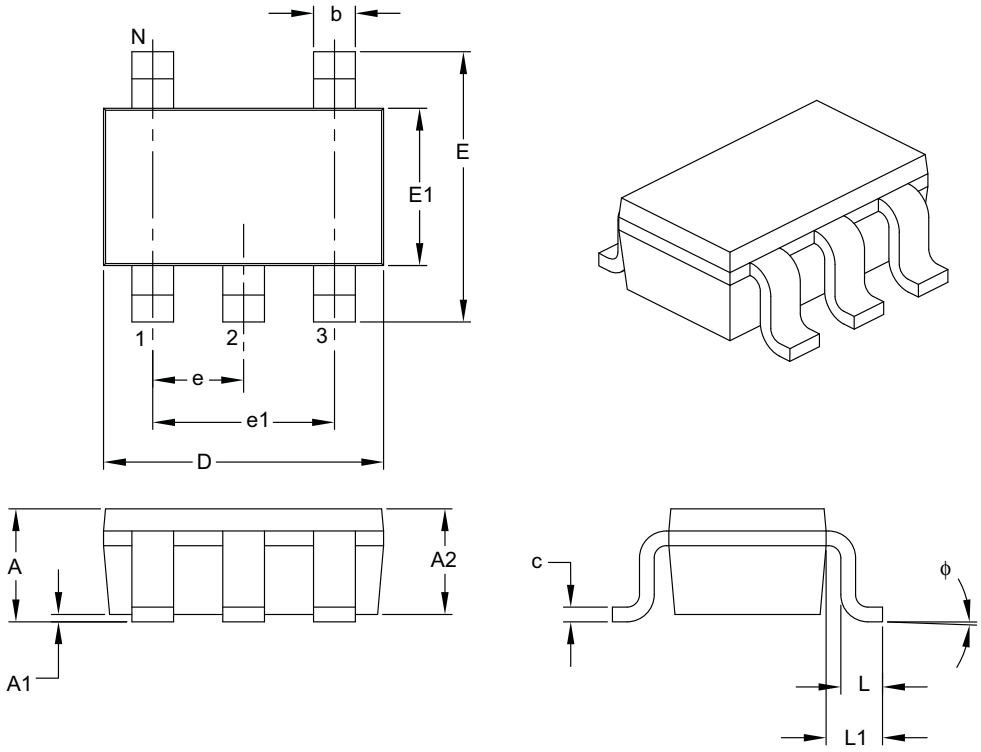


FIGURE 1-2: *AC and DC Test Circuit for Most Inverting Gain Conditions.*

5-Lead Plastic Small Outline Transistor (OT) [SOT-23]



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		5	
Lead Pitch	e		0.95 BSC	
Outside Lead Pitch	e1		1.90 BSC	
Overall Height	A	0.90	–	1.45
Molded Package Thickness	A2	0.89	–	1.30
Standoff	A1	0.00	–	0.15
Overall Width	E	2.20	–	3.20
Molded Package Width	E1	1.30	–	1.80
Overall Length	D	2.70	–	3.10
Foot Length	L	0.10	–	0.60
Footprint	L1	0.35	–	0.80
Foot Angle	ϕ	0°	–	30°
Lead Thickness	c	0.08	–	0.26
Lead Width	b	0.20	–	0.51

Notes:

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

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

Microchip Technology Drawing C04-091B

PRODUCT IDENTIFICATION SYSTEM

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

PART NO.	X	/XX
Device	Temperature Range	Package

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 body), 14-lead
	ST =	Plastic TSSOP (4.4mm body), 14-lead

Examples:

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.