

## 2.7V to 6.0V Single Supply CMOS Op Amps

### Features

- Single-Supply: 2.7V to 6.0V
- Rail-to-Rail Output
- Input Range Includes Ground
- Gain Bandwidth Product: 2.8 MHz (typical)
- Unity-Gain Stable
- Low Quiescent Current: 230  $\mu$ A/amplifier (typical)
- Chip Select ( $\overline{CS}$ ): **MCP603 only**
- Temperature Ranges:
  - Industrial: -40°C to +85°C
  - Extended: -40°C to +125°C
- Available in Single, Dual, and Quad

### Typical Applications

- Portable Equipment
- A/D Converter Driver
- Photo Diode Pre-amp
- Analog Filters
- Data Acquisition
- Notebooks and PDAs
- Sensor Interface

### Available Tools

- SPICE Macro Models
- FilterLab<sup>®</sup> Software
- Mindi<sup>™</sup> Simulation Tool
- MAPS (Microchip Advanced Part Selector)
- Analog Demonstration and Evaluation Boards
- Application Notes

### Description

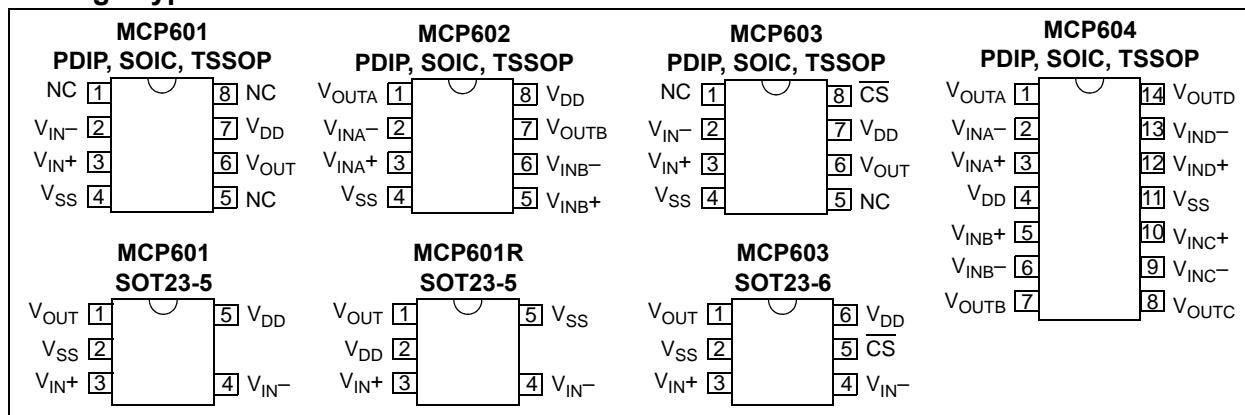
The Microchip Technology Inc. MCP601/1R/2/3/4 family of low-power operational amplifiers (op amps) are offered in single (MCP601), single with Chip Select ( $\overline{CS}$ ) (MCP603), dual (MCP602), and quad (MCP604) configurations. These op amps utilize an advanced CMOS technology that provides low bias current, high-speed operation, high open-loop gain, and rail-to-rail output swing. This product offering operates with a single supply voltage that can be as low as 2.7V, while drawing 230  $\mu$ A (typical) of quiescent current per amplifier. In addition, the common mode input voltage range goes 0.3V below ground, making these amplifiers ideal for single-supply operation.

These devices are appropriate for low power, battery operated circuits due to the low quiescent current, for A/D convert driver amplifiers because of their wide bandwidth or for anti-aliasing filters by virtue of their low input bias current.

The MCP601, MCP602, and MCP603 are available in standard 8-lead PDIP, SOIC, and TSSOP packages. The MCP601 and MCP601R are also available in a standard 5-lead SOT-23 package, while the MCP603 is available in a standard 6-lead SOT-23 package. The MCP604 is offered in standard 14-lead PDIP, SOIC, and TSSOP packages.

The MCP601/1R/2/3/4 family is available in the Industrial and Extended temperature ranges and has a power supply range of 2.7V to 6.0V.

### Package Types



# MCP601/1R/2/3/4

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

$V_{DD} - V_{SS}$ .....	7.0V
Current at Input Pins .....	$\pm 2$ 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) .....	$\geq 3$ 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 CHARACTERISTICS

Electrical Specifications: Unless otherwise specified, $T_A = +25^{\circ}C$ , $V_{DD} = +2.7V$ to $+5.5V$ , $V_{SS} = GND$ , $V_{CM} = V_{DD}/2$ , $V_{OUT} \approx V_{DD}/2$ , $V_L = V_{DD}/2$ , and $R_L = 100$ k $\Omega$ to $V_L$ , and CS is tied low. (Refer to Figure 1-2 and Figure 1-3).						
Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Input Offset</b>						
Input Offset Voltage	$V_{OS}$	-2	$\pm 0.7$	+2	mV	
Industrial Temperature	$V_{OS}$	-3	$\pm 1$	+3	mV	$T_A = -40^{\circ}C$ to $+85^{\circ}C$ (Note 1)
Extended Temperature	$V_{OS}$	-4.5	$\pm 1$	+4.5	mV	$T_A = -40^{\circ}C$ to $+125^{\circ}C$ (Note 1)
Input Offset Temperature Drift	$\Delta V_{OS}/\Delta T_A$	—	$\pm 2.5$	—	$\mu V/^{\circ}C$	$T_A = -40^{\circ}C$ to $+125^{\circ}C$
Power Supply Rejection	PSRR	80	88	—	dB	$V_{DD} = 2.7V$ to $5.5V$
<b>Input Current and Impedance</b>						
Input Bias Current	$I_B$	—	1	—	pA	
Industrial Temperature	$I_B$	—	20	60	pA	$T_A = +85^{\circ}C$ (Note 1)
Extended Temperature	$I_B$	—	450	5000	pA	$T_A = +125^{\circ}C$ (Note 1)
Input Offset Current	$I_{OS}$	—	$\pm 1$	—	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	$V_{CMR}$	$V_{SS} - 0.3$	—	$V_{DD} - 1.2$	V	
Common Mode Rejection Ratio	CMRR	75	90	—	dB	$V_{DD} = 5.0V$ , $V_{CM} = -0.3V$ to $3.8V$
<b>Open-loop Gain</b>						
DC Open-loop Gain (large signal)	$A_{OL}$	100	115	—	dB	$R_L = 25$ k $\Omega$ to $V_L$ , $V_{OUT} = 0.1V$ to $V_{DD} - 0.1V$
	$A_{OL}$	95	110	—	dB	$R_L = 5$ k $\Omega$ to $V_L$ , $V_{OUT} = 0.1V$ to $V_{DD} - 0.1V$
<b>Output</b>						
Maximum Output Voltage Swing	$V_{OL}, V_{OH}$	$V_{SS} + 15$	—	$V_{DD} - 20$	mV	$R_L = 25$ k $\Omega$ to $V_L$ , Output overdrive = $0.5V$
	$V_{OL}, V_{OH}$	$V_{SS} + 45$	—	$V_{DD} - 60$	mV	$R_L = 5$ k $\Omega$ to $V_L$ , Output overdrive = $0.5V$
Linear Output Voltage Swing	$V_{OUT}$	$V_{SS} + 100$	—	$V_{DD} - 100$	mV	$R_L = 25$ k $\Omega$ to $V_L$ , $A_{OL} \geq 100$ dB
	$V_{OUT}$	$V_{SS} + 100$	—	$V_{DD} - 100$	mV	$R_L = 5$ k $\Omega$ to $V_L$ , $A_{OL} \geq 95$ dB
Output Short Circuit Current	$I_{SC}$	—	$\pm 22$	—	mA	$V_{DD} = 5.5V$
	$I_{SC}$	—	$\pm 12$	—	mA	$V_{DD} = 2.7V$
<b>Power Supply</b>						
Supply Voltage	$V_{DD}$	2.7	—	6.0	V	(Note 2)
Quiescent Current per Amplifier	$I_Q$	—	230	325	$\mu A$	$I_O = 0$

**Note 1:** These specifications are not tested in either the SOT-23 or TSSOP packages with date codes older than YYWW = 0408. In these cases, the minimum and maximum values are by design and characterization only.

**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  $1.4V$  and/or  $5.5V$ .

## AC CHARACTERISTICS

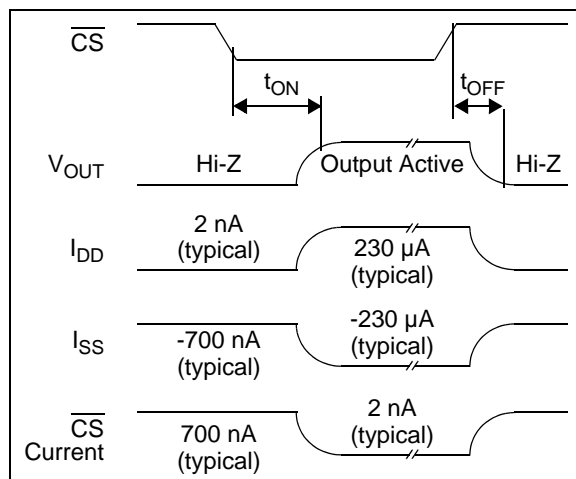
**Electrical Specifications:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = +2.7\text{V}$  to  $+5.5\text{V}$ ,  $V_{SS} = \text{GND}$ ,  $V_{CM} = V_{DD}/2$ ,  $V_{OUT} \approx V_{DD}/2$ ,  $V_L = V_{DD}/2$ , and  $R_L = 100\text{ k}\Omega$  to  $V_L$ ,  $C_L = 50\text{ pF}$ , and  $\overline{\text{CS}}$  is tied low. (Refer to [Figure 1-2](#) and [Figure 1-3](#)).

Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Frequency Response</b>						
Gain Bandwidth Product	GBWP	—	2.8	—	MHz	
Phase Margin	PM	—	50	—	°	$G = +1\text{ V/V}$
<b>Step Response</b>						
Slew Rate	SR	—	2.3	—	$\text{V}/\mu\text{s}$	$G = +1\text{ V/V}$
Settling Time (0.01%)	$t_{\text{settle}}$	—	4.5	—	$\mu\text{s}$	$G = +1\text{ V/V}$ , 3.8V step
<b>Noise</b>						
Input Noise Voltage	$E_{ni}$	—	7	—	$\mu\text{V}_{\text{P-P}}$	$f = 0.1\text{ Hz}$ to $10\text{ Hz}$
Input Noise Voltage Density	$e_{ni}$	—	29	—	$\text{nV}/\sqrt{\text{Hz}}$	$f = 1\text{ kHz}$
	$e_{ni}$	—	21	—	$\text{nV}/\sqrt{\text{Hz}}$	$f = 10\text{ kHz}$
Input Noise Current Density	$i_{ni}$	—	0.6	—	$\text{fA}/\sqrt{\text{Hz}}$	$f = 1\text{ kHz}$

## MCP603 CHIP SELECT ( $\overline{\text{CS}}$ ) CHARACTERISTICS

**Electrical Specifications:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = +2.7\text{V}$  to  $+5.5\text{V}$ ,  $V_{SS} = \text{GND}$ ,  $V_{CM} = V_{DD}/2$ ,  $V_{OUT} \approx V_{DD}/2$ ,  $V_L = V_{DD}/2$ , and  $R_L = 100\text{ k}\Omega$  to  $V_L$ ,  $C_L = 50\text{ pF}$ , and  $\overline{\text{CS}}$  is tied low. (Refer to [Figure 1-2](#) and [Figure 1-3](#)).

Parameters	Sym	Min	Typ	Max	Units	Conditions
<b><math>\overline{\text{CS}}</math> Low Specifications</b>						
$\overline{\text{CS}}$ Logic Threshold, Low	$V_{IL}$	$V_{SS}$	—	$0.2 V_{DD}$	V	
$\overline{\text{CS}}$ Input Current, Low	$I_{CSL}$	-1.0	—	—	$\mu\text{A}$	$\overline{\text{CS}} = 0.2V_{DD}$
<b><math>\overline{\text{CS}}</math> High Specifications</b>						
$\overline{\text{CS}}$ Logic Threshold, High	$V_{IH}$	$0.8 V_{DD}$	—	$V_{DD}$	V	
$\overline{\text{CS}}$ Input Current, High	$I_{CSH}$	—	0.7	2.0	$\mu\text{A}$	$\overline{\text{CS}} = V_{DD}$
Shutdown $V_{SS}$ current	$I_{Q\_SHDN}$	-2.0	-0.7	—	$\mu\text{A}$	$\overline{\text{CS}} = V_{DD}$
Amplifier Output Leakage in Shutdown	$I_{O\_SHDN}$	—	1	—	nA	
<b>Timing</b>						
$\overline{\text{CS}}$ Low to Amplifier Output Turn-on Time	$t_{ON}$	—	3.1	10	$\mu\text{s}$	$\overline{\text{CS}} \leq 0.2V_{DD}$ , $G = +1\text{ V/V}$
$\overline{\text{CS}}$ High to Amplifier Output High-Z Time	$t_{OFF}$	—	100	—	ns	$\overline{\text{CS}} \geq 0.8V_{DD}$ , $G = +1\text{ V/V}$ , No load.
Hysteresis	$V_{HYST}$	—	0.4	—	V	$V_{DD} = 5.0\text{V}$



**FIGURE 1-1:** MCP603 Chip Select ( $\overline{\text{CS}}$ ) Timing Diagram.

# MCP601/1R/2/3/4

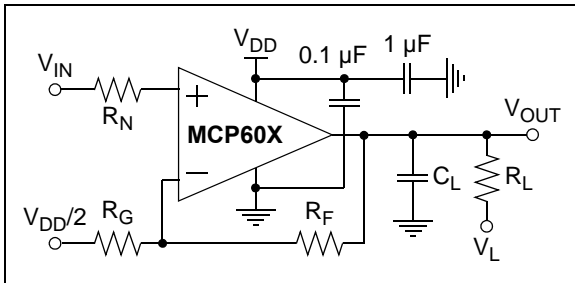
## TEMPERATURE CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, $V_{DD} = +2.7V$ to $+5.5V$ and $V_{SS} = GND$ .						
Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Temperature Ranges</b>						
Specified Temperature Range	$T_A$	-40	—	+85	°C	Industrial temperature parts
	$T_A$	-40	—	+125	°C	Extended temperature parts
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-SOT23	$\theta_{JA}$	—	256	—	°C/W	
Thermal Resistance, 6L-SOT23	$\theta_{JA}$	—	230	—	°C/W	
Thermal Resistance, 8L-PDIP	$\theta_{JA}$	—	85	—	°C/W	
Thermal Resistance, 8L-SOIC	$\theta_{JA}$	—	163	—	°C/W	
Thermal Resistance, 8L-TSSOP	$\theta_{JA}$	—	124	—	°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	

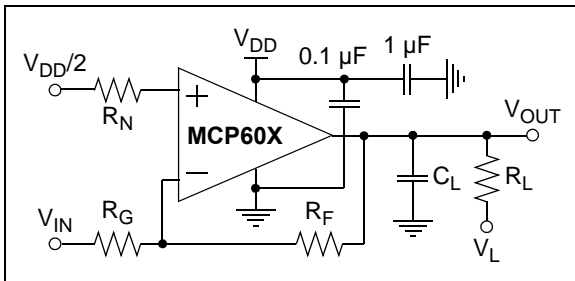
**Note:** The Industrial temperature parts operate over this extended range, but with reduced performance. The Extended temperature specs do not apply to Industrial temperature parts. In any case, the internal Junction temperature ( $T_J$ ) must not exceed the absolute maximum specification of 150°C.

### 1.1 Test Circuits

The test circuits used for the DC and AC tests are shown in Figure 1-2 and Figure 1-3. The bypass capacitors are laid out according to the rules discussed in Section 4.5 “Supply Bypass”.

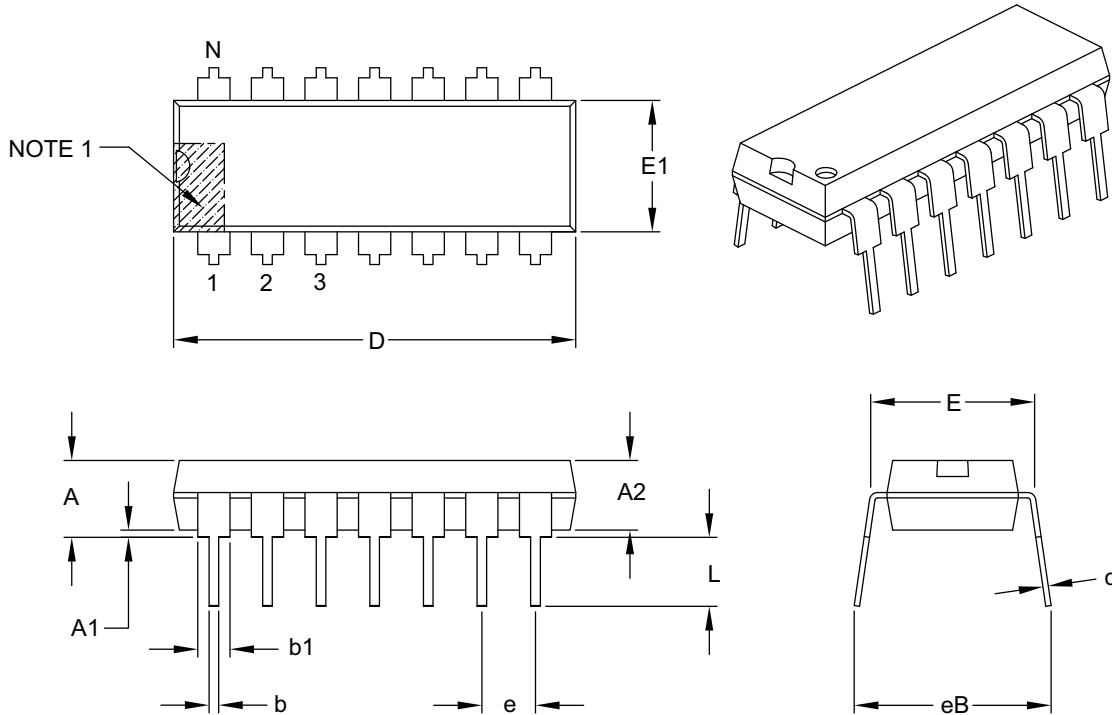


**FIGURE 1-2:** AC and DC Test Circuit for Most Non-Inverting Gain Conditions.



**FIGURE 1-3:** AC and DC Test Circuit for Most Inverting Gain Conditions.

## 14-Lead Plastic Dual In-Line (P) – 300 mil Body [PDIP]



Dimension Limits	Units	INCHES		
		MIN	NOM	MAX
Number of Pins	N	14		
Pitch	e	.100 BSC		
Top to Seating Plane	A	–	–	.210
Molded Package Thickness	A2	.115	.130	.195
Base to Seating Plane	A1	.015	–	–
Shoulder to Shoulder Width	E	.290	.310	.325
Molded Package Width	E1	.240	.250	.280
Overall Length	D	.735	.750	.775
Tip to Seating Plane	L	.115	.130	.150
Lead Thickness	c	.008	.010	.015
Upper Lead Width	b1	.045	.060	.070
Lower Lead Width	b	.014	.018	.022
Overall Row Spacing §	eB	–	–	.430

### Notes:

1. Pin 1 visual index feature may vary, but must be located with the hatched area.
2. § Significant Characteristic.
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
4. Dimensioning and tolerancing per ASME Y14.5M.

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

Microchip Technology Drawing C04-005B

## PRODUCT IDENTIFICATION SYSTEM

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

<u>PART NO.</u>	<u>-X</u>	<u>/XX</u>	<b>Examples:</b>
Device	Temperature Range	Package	
Device	MCP601	Single Op Amp	a) MCP601-I/P: Single Op Amp, Industrial Temperature, 8 lead PDIP package.
	MCP601T	Single Op Amp (Tape and Reel for SOT-23, SOIC and TSSOP)	b) MCP601-E/SN: Single Op Amp, Extended Temperature, 8 lead SOIC package.
	MCP601RT	Single Op Amp (Tape and Reel for SOT-23-5)	c) MCP601T-E/ST: Tape and Reel, Extended Temperature, Single Op Amp, 8 lead TSSOP package
	MCP602	Dual Op Amp	d) MCP601RT-I/OT: Tape and Reel, Industrial Temperature, Single Op Amp, Rotated 5 lead SOT-23 package.
	MCP602T	Dual Op Amp (Tape and Reel for SOIC and TSSOP)	e) MCP601RT-E/OT: Tape and Reel, Extended Temperature, Single Op Amp, Rotated, 5 lead SOT-23 package.
	MCP603	Single Op Amp with Chip Select	a) MCP602-I/SN: Dual Op Amp, Industrial Temperature, 8 lead SOIC package.
	MCP603T	Single Op Amp with Chip Select (Tape and Reel for SOT-23, SOIC and TSSOP)	b) MCP602-E/P: Dual Op Amp, Extended Temperature, 8 lead PDIP package.
	MCP604	Quad Op Amp	c) MCP602T-E/ST: Tape and Reel, Extended Temperature, Dual Op Amp, 8 lead TSSOP package.
	MCP604T	Quad Op Amp (Tape and Reel for SOIC and TSSOP)	a) MCP603-I/SN: Industrial Temperature, Single Op Amp with Chip Select, 8 lead SOIC package.
Temperature Range	I	= -40° C to +85° C	b) MCP603-E/P: Extended Temperature, Single Op Amp with Chip Select, 8 lead PDIP package.
	E	= -40° C to +125° C	c) MCP603T-E/ST: Tape and Reel, Extended Temperature, Single Op Amp with Chip Select 8 lead TSSOP package.
Package	OT	= Plastic SOT-23, 5-lead ( <b>MCP601 only</b> )	d) MCP603T-I/SN: Tape and Reel, Industrial Temperature, Single Op Amp with Chip Select, 8 lead SOIC package.
	CH	= Plastic SOT-23, 6-lead ( <b>MCP603 only</b> )	a) MCP604-I/P: Industrial Temperature, Quad Op Amp, 14 lead PDIP package.
	P	= Plastic DIP (300 mil body), 8, 14 lead	b) MCP604-E/SL: Extended Temperature, Quad Op Amp, 14 lead SOIC package.
	SN	= Plastic SOIC (3.90 mm body), 8 lead	c) MCP604T-E/ST: Tape and Reel, Extended Temperature, Quad Op Amp, 14 lead TSSOP package.
	SL	= Plastic SOIC (3.90 mm body), 14 lead	
	ST	= Plastic TSSOP (4.4 mm body), 8, 14 lead	