

## 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 $V_L$ ,<br>$V_{OUT} = 0.1V$ to $V_{DD} - 0.1V$ |
|  | $A_{OL}$                   | 95             | 110          | —              | dB                | $R_L = 5$ k $\Omega$ to $V_L$ ,<br>$V_{OUT} = 0.1V$ 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

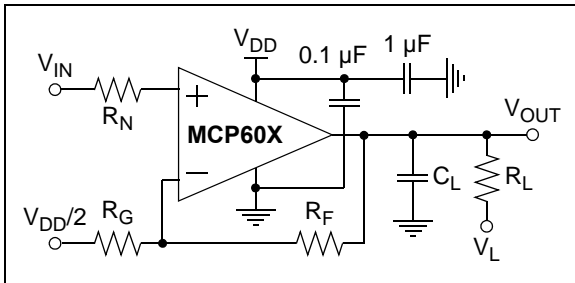
## TEMPERATURE CHARACTERISTICS

| 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  |                              |

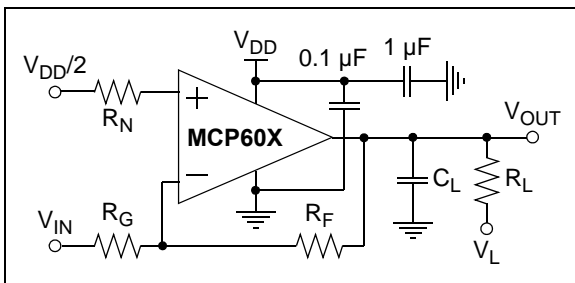
**Note:** The Industrial temperature parts operate over this extended range, but with reduced performance. The Extended temperature specs do not apply to Industrial temperature parts. In any case, the internal Junction temperature ( $T_J$ ) must not exceed the absolute maximum specification of 150°C.

### 1.1 Test Circuits

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

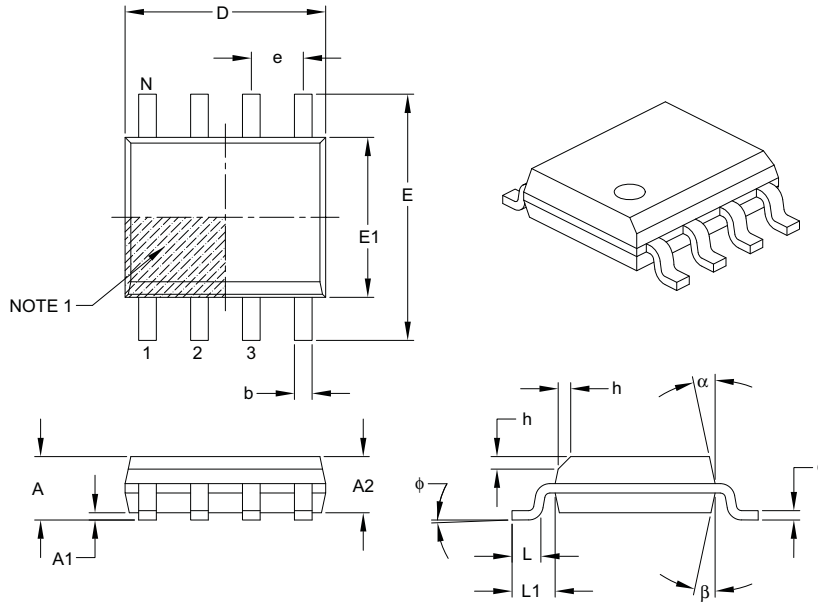


**FIGURE 1-2:** AC and DC Test Circuit for Most Non-Inverting Gain Conditions.



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

## 8-Lead Plastic Small Outline (SN) – Narrow, 3.90 mm Body [SOIC]



| Dimension Limits         | Units    | MILLIMETERS |     |      |
|--------------------------|----------|-------------|-----|------|
|                          |          | MIN         | NOM | MAX  |
| Number of Pins           | N        | 8           |     |      |
| Pitch                    | e        | 1.27 BSC    |     |      |
| Overall Height           | A        | –           | –   | 1.75 |
| Molded Package Thickness | A2       | 1.25        | –   | –    |
| Standoff §               | A1       | 0.10        | –   | 0.25 |
| Overall Width            | E        | 6.00 BSC    |     |      |
| Molded Package Width     | E1       | 3.90 BSC    |     |      |
| Overall Length           | D        | 4.90 BSC    |     |      |
| Chamfer (optional)       | h        | 0.25        | –   | 0.50 |
| Foot Length              | L        | 0.40        | –   | 1.27 |
| Footprint                | L1       | 1.04 REF    |     |      |
| Foot Angle               | $\phi$   | 0°          | –   | 8°   |
| Lead Thickness           | c        | 0.17        | –   | 0.25 |
| Lead Width               | b        | 0.31        | –   | 0.51 |
| Mold Draft Angle Top     | $\alpha$ | 5°          | –   | 15°  |
| Mold Draft Angle Bottom  | $\beta$  | 5°          | –   | 15°  |

### Notes:

- Pin 1 visual index feature may vary, but must be located within the hatched area.
- § Significant Characteristic.
- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.

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

REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-057B

## 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<br>(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<br>(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<br>(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<br>(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<br>(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                                    |  |