MICROCHIP

Programmable Gain Amplifiers (PGAs), Operational Amplifiers and Comparators Design Guide

High Performance Devices for a Variety of Precision and Embedded Systems Applications

Design ideas in this guide use the following devices. A complete device list and corresponding data sheets for these products can be found at www.microchip.com.

Programmable Gain Amplifiers	Operational Amplifiers			Comparators
MCP6S21/2/6/8	MCP601/2/3/4	MCP602X	MCP627X	MCP6541/2/3/4/5
MCP6S91/2/3	MCP606/7/8/9	MCP604X	MCP6275	MCP6546/7/8/9
	MCP61X	MCP605X	MCP628X	MCP6561/2/4
	MCP62X	MCP606X	MCP6285	MCP6566/7/9
	MCP63X	MCP607X	MCP6286	
	MCP65X	MCP614X	MCP629X	
	MCP66X	MCP623X	MCP6295	
	MCP600X	MCP624X	MCP6V0X	

www.microchip.com/analog

PGA, Op Amp and Comparators Overview

It is vital for designers of embedded control products to select the most suitable controller and companion devices. Embedded control products are found in all market segments: consumer, PC peripherals, telecommunications, automotive and industrial. Most embedded control products must meet special requirements: cost effectiveness, low-power, small-footprint and a high level of system integration.

Microchip has established itself as a leading supplier of embedded control solutions. The combination of high performance mixed-signal and linear analog products provide the basis for this leadership. Microchip's extensive family of Programmable Gain Amplifiers (PGAs), Operational Amplifiers and Comparators are an example of the innovation and improvement in design that Microchip is committed to deliver to our customers.

Programmable Gain Amplifiers

The **MCP6S21/2/6/8** and **MCP6S91/2/3** precision Programmable Gain Amplifiers (PGAs) are programmable over an SPI bus and thus add gain control and input channel selection to the embedded control system. These PGAs are optimized for high speed, low offset voltage and single-supply operation with rail-to-rail input and output capability.

Operational Amplifiers
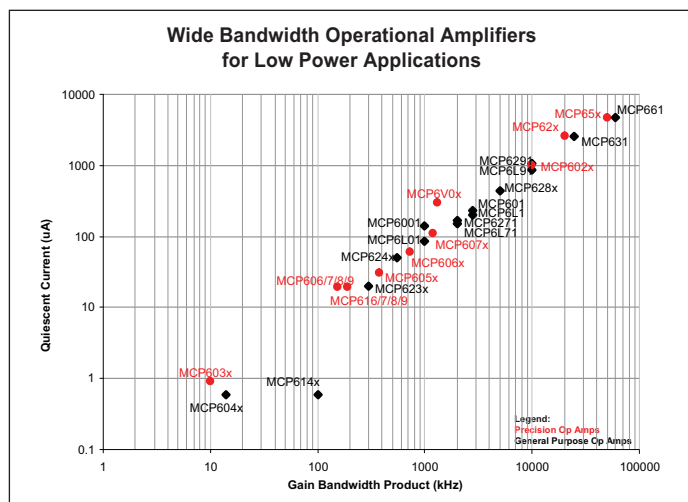
Microchip's family of operational amplifiers are suitable for low power, precision and general purpose applications.

The **MCP602X** family of op amps has a Total Harmonic Distortion plus Noise ratio of 0.00064% with 600Ω load at a gain of +1V/V. This device is ideal for single-supply audio applications.

The **MCP627X, MCP628X** and **MCP629X** families are also targeted for low-cost precision applications. These devices are characterized with a Extended Temperature range of -40°C to +125°C, which are ideal for automotive applications.

Microchip's **MCP601/2/3/4, MCP600X** and **MCP624X,** are low-cost op amps suitable for general purpose applications such us signal amplification, sensor buffer or driving an analog-to-digital converters.

The **MCP604X** and **MCP614X** families are 600 nA, rail-to-rail input and output op amps that are ideal for battery powered applications.

The **MCP606/7/8/9, MCP61X, MCP6051/2/4, MCP6061/2/4** and the **MCP6071/2/4** families also consume very low current and provide wide Gain Bandwidth Product. These op amps are targeted for low power precision applications with very low offset voltage

The **MCP6V0X** families of auto-zero operational amplifiers has input offset voltage correction for very low offset and offset drift. These devices are unity gain stable, have no 1/f noise, and have good PSRR and CMRR. These products are targeted for ultra high precision applications that require the highest level of performance.

The **MCP62X** and **MCP65X** families of operational amplifiers feature low offset via the mCal Technology. At power-up, these op amps are calibrated using mCal. Some package options also provide a calibration/chip select pin that supports a low power mode of operation, with offset calibration at the time normal operation is re-started. These amplifiers are optimized for high speed, low noise and distortion, single-supply operation with rail-to-rail output and an input that includes the negative rail.

Comparators

Several comparators are offered with low supply voltage (1.8V) and low supply current (1 µA). Examples include the **MCP6541/2/3/4, TC1038, TC1039** and the **MCP6546/7/8/9** family of push-pull and open-drain comparators, which are designed for very low power single-supply applications.
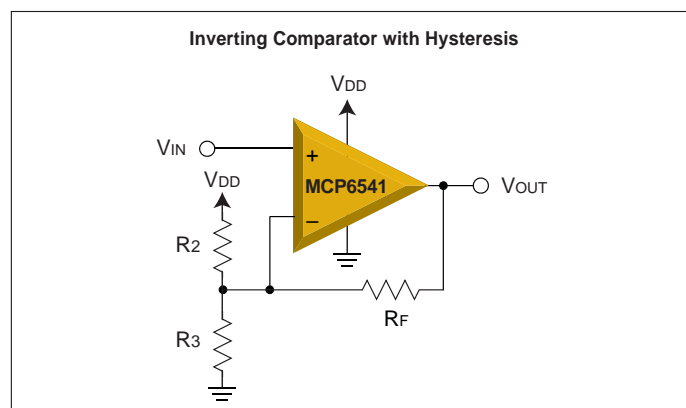
The **MCP6541/2/3/4** and **MCP6561/2/4** families of comparators have a push-pull output that interfaces with CMOS/TTL logic. The output limits supply current surges and dynamic power consumption while switching.

The **MCP6546/7/8/9** and **MCP6566/7/9** families of comparators have an open-drain output that can be used as a voltage level shifter.

Programmable Gain Amplifiers (PGAs)

Microchip's industry first precision Programmable Gain Amplifiers (PGAs), the **MCP6S21/2/6/8** and **MCP6S91/2/3** come with Serial Peripheral Interface (SPI) and up to eight multiplexed input channels. These PGAs are configured in a non-inverting configuration with gains of 1, 2, 4, 5, 8, 10, 16 or 32V/V that can be digitally selected using a microcontroller. The input channels are also selected using the digital interface. These devices come with an internal register that allow the user to select gains, channels and shutdown the device.

These amplifiers were designed with the embedded control system in mind. The typical complexity of multiple sensor systems is reduced to one amplifier that the microcontroller can control. This reduces the demand on the microcontroller I/O and allows control over the level gain. One superior amplifier can be used to perform the functions of multiple amplifiers at a lower cost.
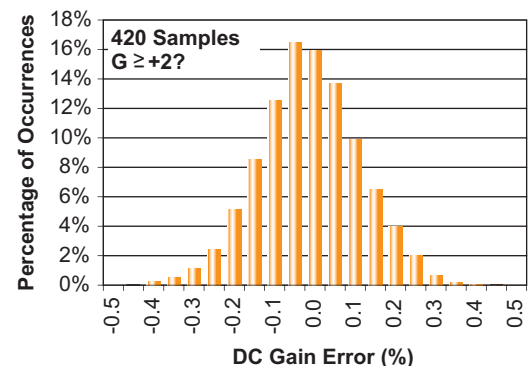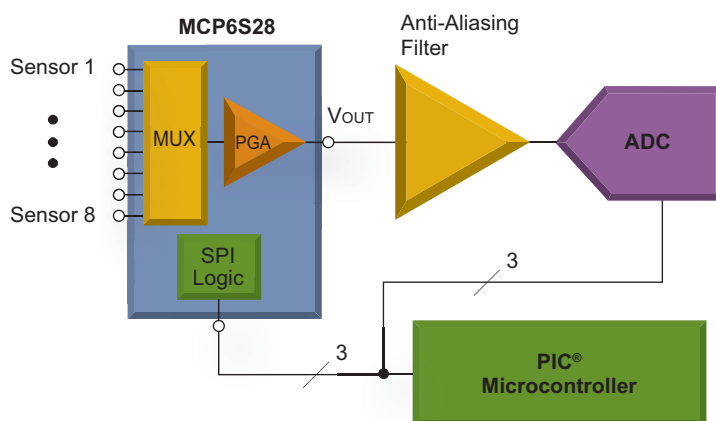
Programmable Gain Amplifiers Key Features
- Multiplexed Inputs:
  - MCP6S21/2/6/8: 1, 2, 6 or 8 channels
  - MCP6S91/2/3: 1 or 2 channels
- 8 gain selections: +1, +2, +4, +5, +8, +10, +16 or +32V/V
- Serial Peripheral Interface (SPI)
- Rail-to-Rail Input and Output
- Low Gain Error: ±1% (max.)
- Low Offset (MCP6S21/2/6/8): ±275 µV (max.)
- High Bandwidth: 2 to 12 MHz (typ.)
- Low Noise: 10 nV/√Hz at 10 kHz (typ.)
- Low Supply Current: 1.0 mA (typ.)
- Single Supply: 2.5V to 5.5V

Programmable Gain Amplifiers Applications
- A/D Converter Driver
- Multiplexed Analog Applications
- Data Acquisition
- Industrial Instrumentation
- Test Equipment
- Medical Instrumentation

MCP6S28 Circuit

Product Specifications: Programmable Gain Amplifiers

Device	Switching Channels	-3 dB Bandwidth (MHz)	Gain Steps (V/V)	Supply Current (mA Typ.)	Supply Voltage (V)	Vos (±µV) Max.	Noise (nV/√Hz Typ.)	Packages
MCP6S21	1	2 to 12	1, 2, 4, 5, 8, 10, 16, 32	1.0	2.5 to 5.5	275	10	PDIP, SOIC, MSOP
MCP6S22	2	2 to 12	1, 2, 4, 5, 8, 10, 16, 32	1.0	2.5 to 5.5	275	10	PDIP, SOIC, MSOP
MCP6S26	6	2 to 12	1, 2, 4, 5, 8, 10, 16, 32	1.0	2.5 to 5.5	275	10	PDIP, SOIC, TSSOP
MCP6S28	8	2 to 12	1, 2, 4, 5, 8, 10, 16, 32	1.0	2.5 to 5.5	275	10	PDIP, SOIC
MCP6S91	1	1 to 18	1, 2, 4, 5, 8, 10, 16, 32	1.0	2.5 to 5.5	4,000	10	PDIP, SOIC, MSOP
MCP6S92	2	1 to 18	1, 2, 4, 5, 8, 10, 16, 32	1.0	2.5 to 5.5	4,000	10	PDIP, SOIC, MSOP
MCP6S93	2	1 to 18	1, 2, 4, 5, 8, 10, 16, 32	1.0	2.5 to 5.5	4,000	10	MSOP

High Bandwidth Op Amps for Precision Applications

Microchip offers a variety of amplifiers for wide bandwidth, precision applications. The **MCP602X** family of op amps has a Total Harmonic Distortion (THD) plus Noise ratio of 0.00064% with 600Ω load at a gain of +1V/V. This device is ideal for single-supply audio applications. If more bandwidth is needed, the **MCP62X** and **MCP65X** families of operational amplifiers offer 20 MHz and 50 MHz of gain bandwidth respectively. These two families also offer mCal Technology, an on-board calibration circuit that enables low offset and minimizes drift over time and temperature.

The **MCP63X** and **MCP66X** families are targeted for lower cost applications that demand higher bandwidth. All of these amplifiers are characterized over the Extended Temperature range of -40°C to +125°C.

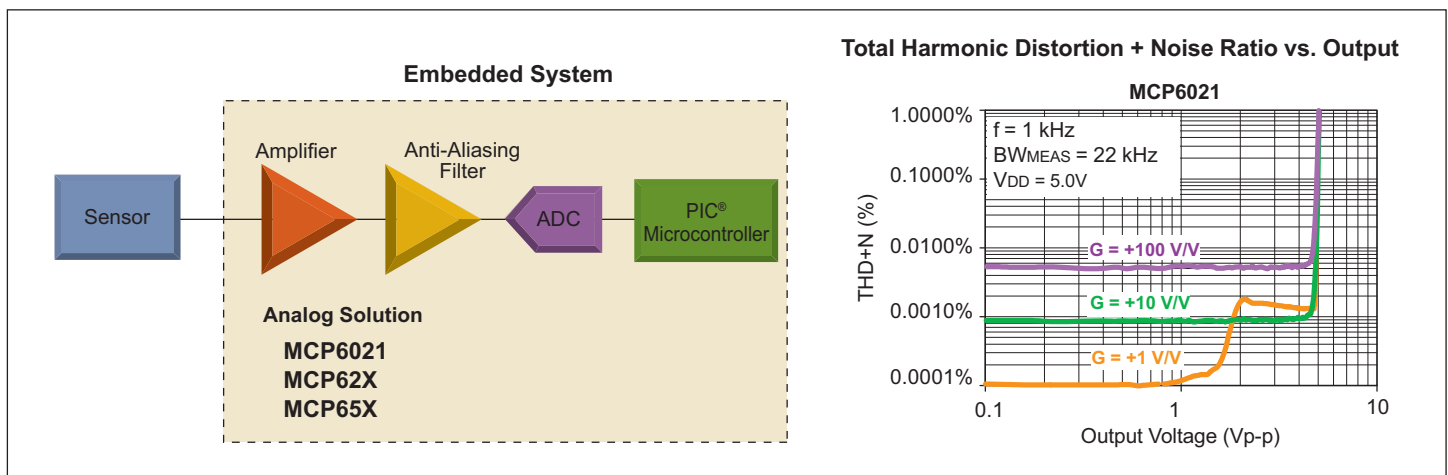**MCP602X Operational Amplifier Key Features**
- Rail-to-Rail Input/Output
- Gain Bandwidth Product: 10 MHz (typ.)
- Low Noise: 8.7 nV/Hz (typ.), at 10 kHz
- Low Offset Voltage:
  – Industrial Temperature: ±500 µV (max.)
  – Extended Temperature: ±250 µV (max.)
- Mid-Supply Reference Voltage (V_{REF})
- Low Supply Current: 1 mA (typ.)
- Total Harmonic Distortion: 0.00053% (typ. G = 1)

- Power Supply Range: 2.5V to 5.5V
- Temperature Range:
  – Industrial: -40°C to +85°C
  – Extended: -40°C to +125°C

Microchip provides an active filter design software known as FilterLab® free of charge. This software simplifies the high-pass, low-pass and band-pass filter design procedures. The Butterworth, Bessel and Chebychev filters can be implemented in Sallen Key and Multiple Feedback configurations using this software.

Operational Amplifiers Applications
- Automotive
- Driving A/D Converters
- Multi-Pole Active Filters
- Barcode Scanners
- Audio Processing
- Communications
- DAC Buffer
- Test Equipment
- Medical Instrumentation
- Portable Equipment
- Photodiode Pre-amps
- Analog Filters
- Notebooks and PDAs
- Battery-powered Systems

Embedded System

Sensor → Amplifier → Anti-Aliasing Filter → ADC → PIC® Microcontroller

Analog Solution
MCP6021
MCP62X
MCP65X

Total Harmonic Distortion + Noise Ratio vs. Output

MCP6021

f = 1 kHz
BW_{MEAS} = 22 kHz
V_{DD} = 5.0V

G = +100 V/V
G = +10 V/V
G = +1 V/V

THD+N (%) vs. Output Voltage (Vp-p)

Product Specifications: Operational Amplifiers

Device	Op Amp	Bandwidth (MHz Typ.)	Slew Rate (V/µs Typ.)	Current (mA Typ.)	Supply Voltage (V)	Offset Voltage (± µV max.)	Temp. Range (C°)	Packages
MCP602X	Single, Dual, Single w/Chip Select, Quad	10	7	1	2.5 to 5.5	500	-40 to +125	PDIP, SOIC, MSOP, TSSOP, SOT
MCP62X	Single, Dual w/mCal Technology	20	10	2.5	2.5 to 5.5	200	-40 to +125	DFN, SOIC, MSOP
MCP63X	Single, Dual w/Chip Select	24	10	2.5	2.5 to 5.5	8000	-40 to +125	DFN, SOIC, MSOP
MCP65X	Single, Dual w/mCal Technology	50	30	6	2.5 to 5.5	200	-40 to +125	DFN, SOIC, MSOP
MCP66X	Single, Dual w/Chip Select	60	30	6	2.5 to 5.5	8000	-40 to +125	DFN, SOIC, MSOP
MCP629X	Single, Dual, Single w/Chip Select, Quad	10	7	1	2.4 to 6.0	3000	-40 to +125	PDIP, SOIC, MSOP, TSSOP, SOT

Low-cost General Purpose Op Amps

Microchip offers a number of low-cost op amps that are suitable for general purpose applications such as signal amplification, sensor buffer or driving an analog-to-digital converter. These op amps provide competitive bandwidth per given quiescent current. For example, **MCP600X** devices have a high phase margin which makes them ideal for capacitive load applications. The low supply voltage, low quiescent current and wide bandwidth makes the **MCP600X** family ideal for battery-powered applications.
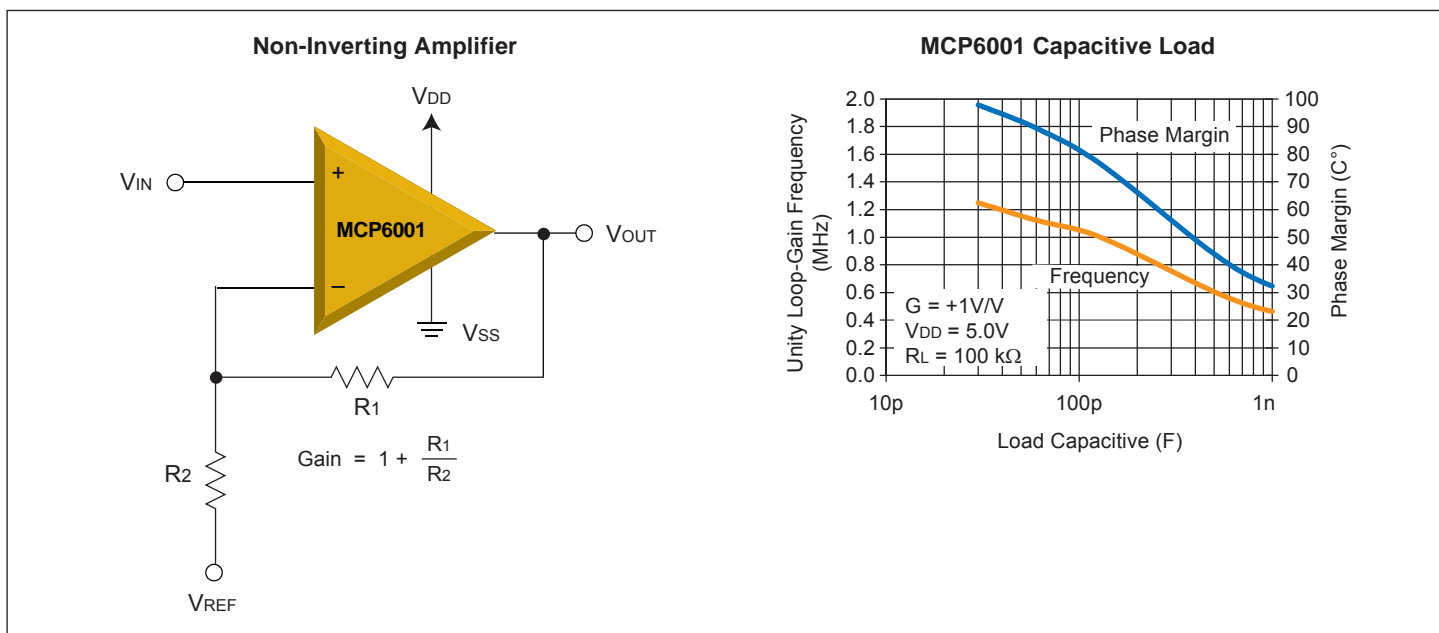
This device is offered in a SOT-23-5 package with three different pin outs. It's also available in a SC-70-5 package which is 50% smaller then SOT-23-5 package.

MCP600X Key Features
- Gain Bandwidth Product: 1 MHz (typ.)
- Rail-to-Rail Input/Output
- Supply Voltage: 1.8V to 6.0V
- Supply Current: I_Q = 100 µA (typ.)
- Phase Margin: 90° (typ.)
- Temperature Range:
    - Industrial: -40°C to +85°C
    - Extended: -40°C to +125°C
- Available in Single, Dual and Quad
- Available in SOT-23-5 and SC-70-5 packages

MCP600X Applications
- Automotive
- Portable Equipment
- Photodiode Pre-amps
- Analog Filters
- Notebooks and PDAs
- Battery-powered Systems

Non-Inverting Amplifier

$$\text{Gain} = 1 + \frac{R_1}{R_2}$$

MCP6001 Capacitive Load

G = +1V/V
V_{DD} = 5.0V
R_L = 100 kΩ

Product Specifications: Operational Amplifiers

Device	Op Amp	Bandwidth (kHz Typ.)	Slew Rate (V/µs Typ.)	Current (µA Typ.)	Supply Voltage (V)	Offset Voltage (±mV max.)	Temp. Range (C°)	Packages
MCP601/2/3/4	Single, Dual, Single w/Chip Select, Quad	2800	2.3	230	2.7 to 6.0	2	-40 to +125	PDIP, SOIC, TSSOP SOT-23-5
MCP600X	Single, Dual, Quad	1000	0.6	100	1.8 to 6.0	4.5	-40 to +125	PDIP, SOIC, MSOP, SC-70-5, SOT-23-5,
MCP627X	Single, Dual, Single w/Chip Select, Quad	2000	0.9	170	2.0 to 6.0	3	-40 to +125	PDIP, SOIC, MSOP, SOT-23-5
MCP624X	Single, Dual, Quad	550	0.3	50	1.8 to 6.0	5	-40 to +125	PDIP, SOIC, SC-70-5, SOT-23-5
MCP628X	Single, Dual, Single w/Chip Select, Quad	5000	2.5	450	2.2 to 6.0	3	-40 to +125	PDIP, SOIC, MSOP, TSSOP, SOT

Low Power Op Amps

Microchip's **MCP603X, MCP604X** and **MCP614X** rail-to-rail input and output op amps draw a maximum of 1 µA quiescent current. These devices provide 10 kHz, 14 kHz and 100 kHz Gain Bandwidth Product, respectively and are ideal for battery powered applications such as battery current sensing and wearable devices.

The **MCP605X, MCP606X** and **MCP607X** op amps feature quiescent currents ranging from 30 to 110 µA, offset voltages of just 150 µV, and a Gain Bandwidth Product (GBWP) ranging from 385 kHz to 1.2 MHz. The devices are well suited for applications requiring low power consumption, low-voltage operation and high precision, such as those in the industrial, medical, consumer and other markets.

The **MCP606** and **MCP61X** devices also draw very low current and provide wide bandwidth. These op amps are targeted for low power, precision applications with very low offset voltage.

The **MCP623X** and **MCP624X** families are rail-to-rail input and output op amps that provide high performance while drawing only 20 µA and 50 µA quiescent current, respectively.
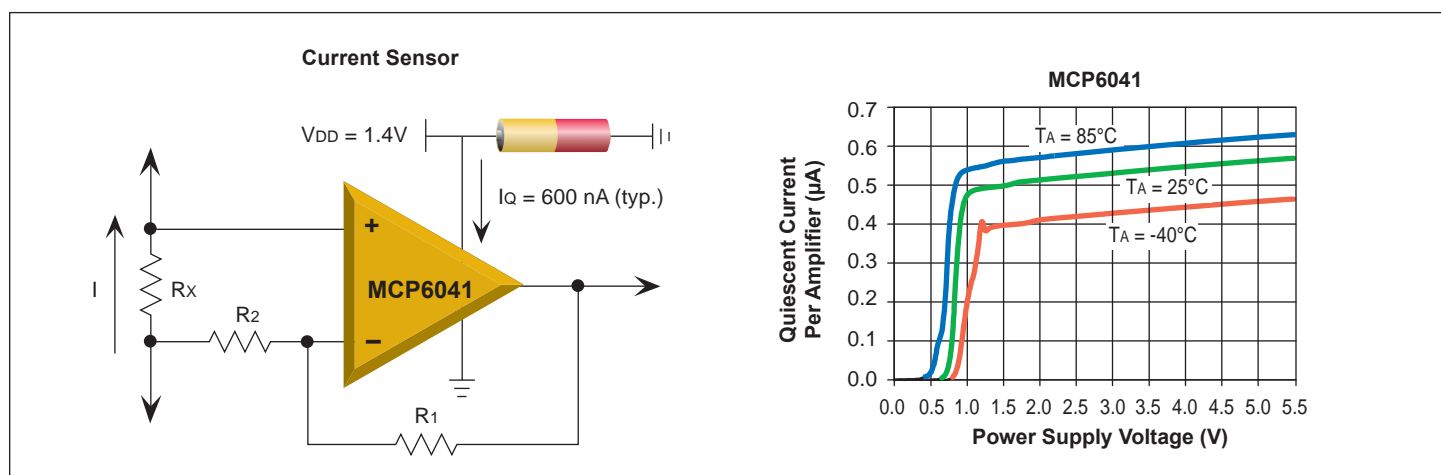
They provide wider bandwidth (300 kHz and 550 kHz) than the other op amps in this category. They work well in low low power applications that cannot compromise on bandwidth.

MCP604X and MCP614X Key Features
- Low Quiescent Current: 600 nA Amplifier (typ.)
- Rail-to-Rail Input: -0.3V to V_{DD} +0.3V (max.)
- Rail-to-Rail Output: V_{SS} +10 mV to V_{DD} -10 mV (max.)
- Gain Bandwidth Product: 14 kHz (typ.), MCP6041 Gain Bandwidth Product: 100 kHz (typ.), MCP6141 (G ≥ 10)
- Wide Supply Voltage Range: 1.4V to 6.0V (max.)
- Available in Single, Dual and Quad
- Chip Select ($\overline{CS}$) with MCP6043 and MCP6143
- SOT-23-5 package

MCP604X and MCP614X Applications
- Booth Tags
- Wearable Products
- Temperature Measurement
- Battery-powered Systems

Current Sensor

$V_{DD} = 1.4V$

$I_Q = 600$ nA (typ.)

MCP6041

R_X, R_2, R_1

MCP6041

Quiescent Current Per Amplifier (µA) vs Power Supply Voltage (V)

T_A = 85°C, T_A = 25°C, T_A = -40°C

Product Specifications: Operational Amplifiers

Device	Op Amp	Bandwidth (kHz Typ.)	Slew Rate (V/ms Typ.)	Current (µA Typ.)	Supply Voltage (V)	Offset Voltage (±µV max.)	Temp. Range (C°)	Packages
MCP605X	Single, Dual, Quad	380	15	30	1.8 - 6.0	150	-40 to +125	SOIC, TDFN, TSSOP
MCP606X	Single, Dual, Quad	730	25	60	1.8 - 6.0	150	-40 to +125	SOIC, TDFN, TSSOP
MCP607X	Single, Dual, Quad	1200	50	110	1.8 - 6.0	150	-40 to +125	SOIC, TDFN, TSSOP
MCP606/7/8/9	Single, Dual, Single w/Chip Select, Quad	155	80	19	2.5 to 6.0	250	-40 to +85	PDIP, SOIC, TSSOP SOT-23-5
MCP61X	Single, Dual, Single w/Chip Select, Quad	190	80	19	2.3 to 5.5	150	-40 to +85	PDIP, SOIC, MSOP
MCP604X	Single, Dual, Single w/Chip Select, Quad	14	3	0.6	1.4 to 6.0	3000	-40 to +85	PDIP, SOIC, MSOP, TSSOP, SOT-23-5
MCP614X	Single, Dual, Single w/Chip Select, Quad	100	24	0.6	1.4 to 6.0	3000	-40 to +85	PDIP, SOIC, MSOP, TSSOP, SOT-23-5
MCP623X	Single, Dual, Quad	300	150	20	1.8 to 5.5	5000	-40 to +125	PDIP, SOIC, TSSOP, SOT-23-5, SC-70-5
MCP624X	Single, Dual, Quad	550	300	50	1.8 to 5.5	5000	-40 to +125	PDIP, SOIC, TSSOP, SOT-23-5, SC-70-5
MCP603X	Single, Dual, Single w/Chip Select, Quad	10	4	0.9	1.8 to 5.5	150	-40 to +125	DFN, SOIC, MSOP, SOT23

Cascaded Op Amps

Microchip has three new and innovative cascaded dual op amp families: **MCP6275** (2 MHz), **MCP6285** (5 MHz) and **MCP6295** (10 MHz).

MCP62X5 Key Features
- Chip Select ($\overline{CS}$) Pin for Both Amplifiers
- Small 8-pin Packages (PDIP-8, SOIC-8, MSOP-8)
- Pinout Similar to the Industry Standard for Duals

The two op amps are connected so that they will support many application circuits.

The output of op amp A is connected internally to the non-inverting input of op amp B (see Pinout Configuration). Combining these into one pin ($V_{OUTA}/V_{INB}+$ = pin # 1) makes it possible to add a $\overline{CS}$ input (pin # 5) to an 8-pin package. Both op amps function as normal op amps.

The $\overline{CS}$ input helps conserve power in many popular dual op amp applications. This pinout makes it relatively easy to modify many existing designs for these parts.

MCP62X5 Applications
The most common application circuit supported by these parts is cascaded amplifiers (see Cascaded Amplifiers). These parts allow for easy layout in this common application. Usually, most of the gain is produced by the first stage.

There are several interesting variations of the circuit in the Cascaded Amplifiers illustration that are supported by these parts. For instance, the input op amp (op amp A) can be configured as an inverting amplifier, as an inverting (Miller) integrator, or as a difference amplifier. The output amplifier can be set up as a unity gain buffer to isolate the load from op amp A. This results in an overall performance improvement when driving heavy loads (e.g., 1 kΩ).

Pinout Configuration

Cascaded Amplifiers
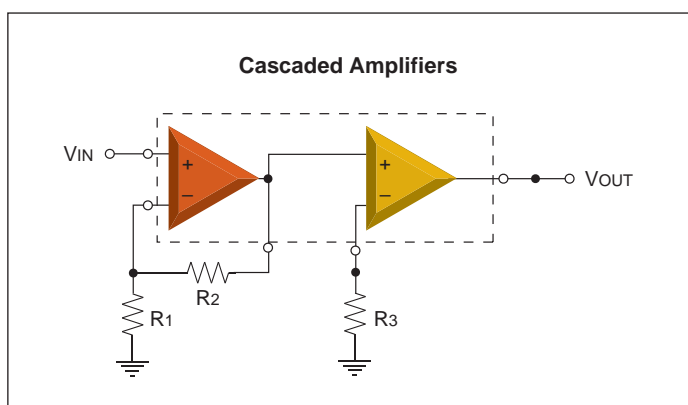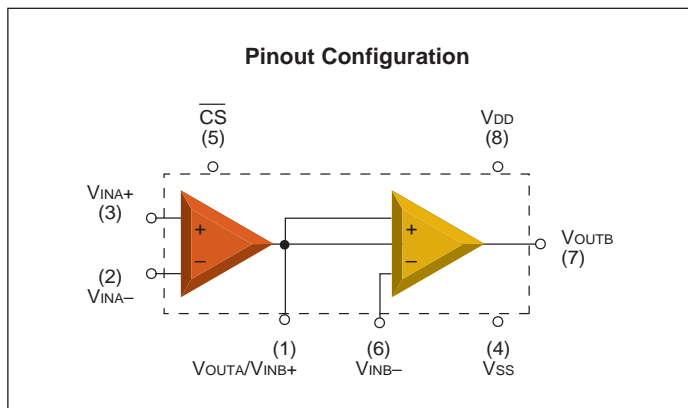
Product Specifications: Cascaded Dual Operational Amplifiers

Device	Op Amp	Bandwidth (MHz Typ.)	Slew Rate (V/µs Typ.)	Current (mA Typ.)	Supply Voltage (V)	Offset Voltage (±mV max.)	Temp. Range (C°)	Packages
MCP6275	Dual	2	0.9	0.17	2.0 to 5.5	3	-40 to +125	PDIP, SOIC, MSOP
MCP6285	Dual	5	2.5	0.45	2.2 to 5.5	3	-40 to +125	PDIP, SOIC, MSOP
MCP6295	Dual	10	7	1	2.4 to 5.5	3	-40 to +125	PDIP, SOIC, MSOP

# Low Power, Low Voltage Comparators in SOT-23-5 Packages

Microchip's families of both push-pull and open-drain comparators, the **MCP654X** and the **MCP656X**, are designed for low power, single supply applications. The **MCP654X** family fully operates with a supply voltage as low as 1.6V, while drawing 600 nA of current. The **MCP656X** family operates down to 1.8V and draws only 100 uA of current with a 47 ns propagation delay.

MCP654X Key Features
- Low Quiescent Current: 600 nA/Comparator (typ.)
- Rail-to-Rail Input: V_{SS} -0.3V to V_{DD} +0.3V
- CMOS/TTL-Compatible Output
- Push-pull and Open-drain Output
- Propagation Delay: 4 µs (typ.)
- Wide Supply Voltage Range: 1.6V to 5.5V
- Available in Single, Dual and Quad
- Chip Select ($\overline{CS}$) with MCP6543 and MCP6548
- Low Switching Current
- Internal Hysteresis: 3.3 mV (typ.)

MCP654X and MCP656X Applications
- Laptop Computers
- Mobile Phones
- Metering Systems
- Hand-held Electronics
- RC Timers
- Alarm and Monitoring Circuits
- Windowed Comparators
- Multi-vibrators
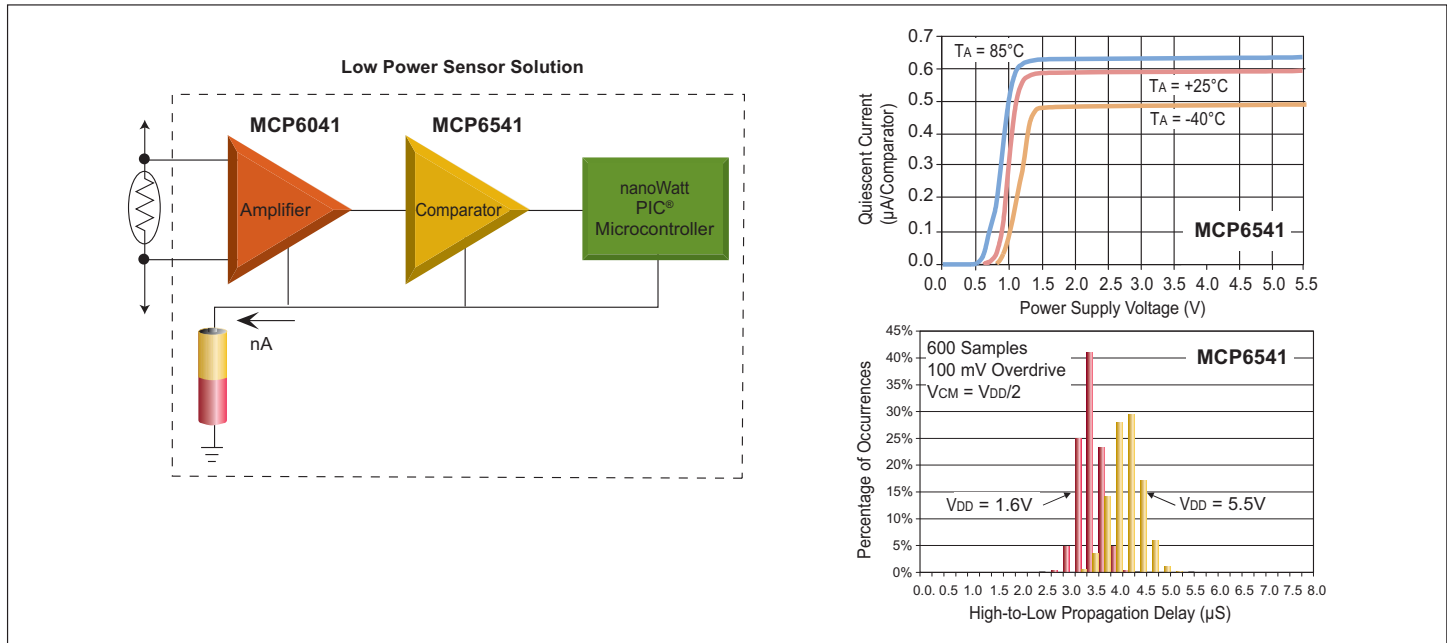
Product Specifications: Comparators

Device	Comparator	Current (µA Typ.)	Supply Voltage (V)	Offset Voltage (±mV max.)	Temperature Range (°C)	Output	Package
MCP6541/2/3/4	Single, Dual, Single w/Chip Select, Quad	0.6	1.6 to 5.5	7	-40 to +125	Push-Pull	PDIP, SOIC, MSOP, TSSOP, SOT-23-5, SC-70-5
MCP6546/7/8/9	Single, Dual, Single w/Chip Select, Quad	0.6	1.6 to 5.5	7	-40 to +125	Open-Drain	PDIP, SOIC, MSOP, TSSOP, SOT-23-5, SC-70-5
MCP6561/2/4	Single, Dual, Quad	100	1.8 to 5.5	10	-40 to +125	Push-Pull	SOIC, MSOP, TSSOP, SOT-23-5, SC-70-5
MCP6566/7/9	Single, Dual, Quad	100	1.8 to 5.5	10	-40 to +125	Open-Drain	SOIC, MSOP, TSSOP, SOT-23-5, SC-70-5

FilterLab® 2.0 Active Filter Software Design Tool

FilterLab® 2.0 is an innovative software tool that simplifies active (op amp) filter design. Available at no cost from Microchip's web site (www.microchip.com), the FilterLab 2.0 active filter software design tool provides full schematic diagrams of the filter circuit with component values and displays the frequency response.

FilterLab 2.0 allows the design of low-pass filters up to an 8th order filter with Chebychev, Bessel or Butterworth responses from frequencies of 0.1 Hz to 10 MHz. FilterLab 2.0 also can be used to design band-pass and high-pass filters with Chebychev and Butterworth responses. The circuit topologies supported by FilterLab 2.0 are the Sallen Key and Multiple Feedback (MFB). The low-pass filters can use either the Sallen Key or MFB, the band-pass is available with the MFB and the high-pass uses the Sallen Key.

Users can select a flat passband or sharp transition from passband to stopband. Options, such as minimum ripple factor, sharp transition and linear phase delay are available. Once the filter response has been identified, FilterLab 2.0 generates the frequency response and the circuit. For maximum design flexibility, changes in capacitor values can be implemented to fit the demands of the application. FilterLab 2.0 will recalculate all values to meet the desired response, allowing real-world values to be substituted or changed as part of the design process.

FilterLab also generates a SPICE model of the designed filter. Extraction of this model will allow time domain analysis in SPICE simulations, streaming the design process.

Further consideration is given to designs used in conjunction with an analog-to-digital converter (ADC). A suggested filter can be generated by simply inputting the bit resolution and sample rate via the Anti-Aliasing Wizard. This eliminates erroneous signals folded back into the digital data due to the aliasing effect.

FilterLab 2.0 Key Features
- A Variety of Active Filter Types
  – Low-pass, Band-pass or High-pass
  – Bessel, Butterworth or Chebyshev
  – Sallen Key and Multiple Feedback Topologies
- A Wide Range of Selectable Parameters
  – Gain: 1 and 10 V/V
  – Order: 1 to 8
  – Passband Ripple: 0.01 dB to 3.0 dB
  – Stopband Attenuation: 10 dB to 100 dB
  – Cut-off Frequency: 0.1 Hz to 1 MHz
  – Stop-band Frequency: 0.1 Hz to 1 MHz
  – Bandpass Q: 0.5 to 5.0
  – Bandpass Fractional Bandwidth: 20% to 200%

FilterLab® 2.0 Active Filter Software
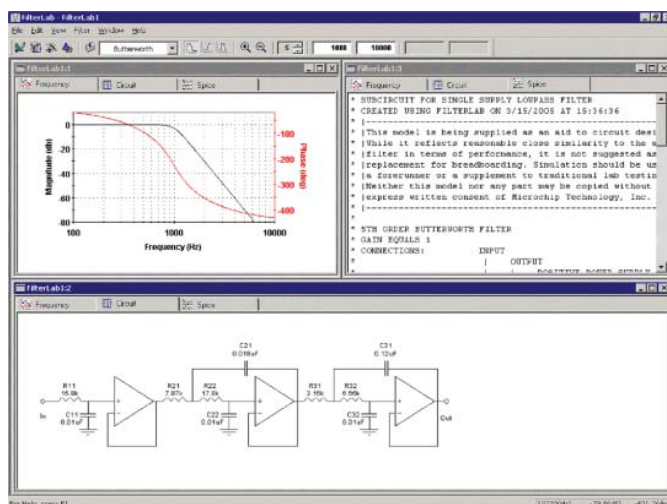
FilterLab 2.0 Key Features (Continued)
- Easy-to-Use Design Windows for Filter
  – Frequency Response
  – Circuit Diagram
  – SPICE Listing
- Design Aids
  – Toolbar
  – Filter Design Wizard
  – Filter Selection Wizard
  – Anti-Aliasing Wizard (for ADCs)
- Component Value Generation
  – Automatic Calculation of Components
  – Either Exact or 1% Resistor Values
  – Can Manually Input Capacitors
- User's Guide (Help Menu)
  – How to Use Chapters
  – Technical Background Appendices (SPICE Interface, Filter Templates, Group Delay, Bessel Filter Response, Op Amp Selection and Selected References)

Related Support Material

Application Notes

The following literature is available on the Microchip web site: www.microchip.com.

AN248: Interfacing MCP6S2X PGAs to PIC® Microcontroller

The MCP6S21/2/6/8 family of one, two, six or eight channel Programmable Gain Amplifiers (PGAs) communicate using a standard 3-wire Serial Peripheral Interface (SPI) protocol. This application note shows how to program the six channel MCP6S26 PGA gains, channels and shutdown registers using the PIC16C505 microcontroller.

AN251: Bridge-Sensing with the MCP6S2X PGAs

Resistive sensors configured as Wheatstone bridges are primarily used to sense pressure, temperature or loads. An external A/D converter (ADC) and a digitally Programmable Gain Amplifier (PGA) can easily be used to convert the difference in voltage from these resistor bridge sensors to usable digital words for manipulation by the microcontroller.

AN865: Sensing Light with a Programmable Gain Amplifier

Photo sensors bridge the gap between light and electronics. Microchip's Programmable Gain Amplifiers (PGAs) are not well suited for precision applications (such as CT scanners), but they can be effectively used in position photo sensing applications minus the headaches of amplifier stability.

AN867: Designing Operational Amplifier Oscillator Circuits for Sensor Applications

Operational amplifier (op amp) oscillators can be used to accurately measure resistive and capacitive sensors. Oscillator design can be simplified by using the procedure discussed in this application note. The derivation of the design equations provides a method to select the passive components and determine the influence of each component on the frequency of oscillation. The procedure will be demonstrated by analyzing two state-variable RC op amp oscillator circuits.

AN866: Temperature Sensing with a Programmable Gain Amplifier

Although it is simple to measure temperature in a stand-alone system without the help of Microchip's Programmable Gain Amplifiers, a variety of problems can be eliminated by implementing temperature sensing capability in multiplexed applications with a PGA.

Technical Briefs

TB023: Serialized Quick Turn Programming^SM (SQTP^SM)

TB065: Linear Circuit Devices for Applications in Battery Powered Wireless Systems

Design Tools

SPICE Macro Model
FilterLab® Analog Filtering Design Software
Mindi™ Active Filter Designer

Stand-Alone Analog and Interface Products

Thermal Management	Power Management	Linear	Mixed-Signal	Interface
Temperature Sensors	LDO & Switching Regulators	Op Amps	A/D Converter Families	CAN Peripherals
Fan Speed Controllers/ Fan Fault Detectors	Charge Pump DC/DC Converters	Programmable Gain Amplifiers	Digital Potentiometers	Infrared Peripherals
	Power MOSFET Drivers	Comparators	D/A Converters	LIN Transceivers
	PWM Controllers		V/F and F/V Converters	Serial Peripherals
	System Supervisors	**Safety & Security**	Energy Measurement ICs	Ethernet Controllers
	Voltage Detectors	Photoelectric Smoke Detectors		
	Voltage References	Ionization Smoke Detectors		
	Li-Ion/Li-Polymer Battery Chargers	Ionization Smoke Detector Front End		
		Piezoelectric Horn Drivers		

Recommended Development Tools

Linear Products

Humidity Sensor PICtail™ Demonstration Board
Part Number: PIC16F690DM-PCTLHS

This board supports the capacitive humidity sensor application note AN1016. It measures the capacitance of a relative humidity sensor plugged into the board. The on-board microcontroller sends the measured and calculated relative humidity (RH) to a PC for display. The board can also measure small capacitors in different ranges of values using a dual slope integration method. The board can be modified, if desired, to achieve better measurement resolution.

Active Filter Demonstration Board Kit
Part Number: MCP6271DM-FLTR

This kit supports all of Microchip's single op amps that operate on single supply of V_{DD} = 5.5V and under (MCP601, MCP606, …, MCP6291). Board modifications may be required for the rest of Microchip's single op amps. This kit supports active filters designed by FilterLab® V2.0. These filters are all pole and are built by cascading first and second order sections. The Active Filter Demo Board Kit is comprised of three sub-assemblies:

V_{DD}/2 Filter Section – One PCB designed to provide mid-supply biasing to the other Printed Circuit Boards (PCB); it provides test points for connecting a lab power supply and a lab signal generator.

Active Filter Sections – Four PCBs that support active filter designs with filter order between n = 1 and 8; each board supports a first or second order filter section, and provides an output test point for lab equipment.

Accessory Bag – Contains op amps and zero ohm jumpers that can be used to help build filters; it also contains resistors and capacitors needed to build a 5th order, Bessel low-pass filter.

MCP6S22 PGA PICtail™ Demonstration Board
Part Number: MCP6S22DM-PICTL

This board evaluates/demonstrates Microchip's MCP6S21/2/6/8 Programmable Gain Amplifier (PGA) family. Interface this board with the PICkit™ 1 Flash Starter Kit to demonstrate firmware integration between the PIC® microcontroller and PGA devices, while allowing modification and development of firmware for specific requirements.

MCP6S2X PGA Evaluation Board
Part Number: MCP6S2XEV

Provides a versatile selection of input channels and gains to evaluate device performance. Board supports multiple input signal sources. Two devices can be cascaded to produce gain to 1024 V/V.

MCP6SX2 PGA Photodiode PICtail™ Demonstration Board
Part Number: MCP6SX2DM-PCTLPD

Opens possibilities to process other sensor signals. Increases the number of PIC® microcontroller I/O pins available for other purposes. Features a PNZ334 photo-diode, MCP6001U op amp, and MCP6S22 and MCP6S92 Programmable Gain Amplifiers (PGA).

MCP6SX2 PGA Thermistor PICtail™ Demonstration Board
Part Number: MCP6SX2DM-PCTLTH

Features MCP6S22 and MCP6S92 PGAs. Helps overcome non-linear response of the on-board NTC thermistor. Opens possibilities of temperature-correcting another sensor, and increasing the number of PIC® microcontroller I/O pins available for other purposes.

MCP6V01 Thermocouple Auto-Zero Reference Design
Part Number: MCP6V01RD-TCPL

The MCP6V01 Thermocouple Auto-Zeroed Reference Design demonstrates how to use a difference amplifier system to measure electromotive force (EMF) voltage at the cold junction of thermocouple in order to accurately measure temperature at the hot junction. This can be done by using the MCP6V01 auto-zeroed op amp because of its ultra low offset voltage (V_{OS}) and high common mode rejection ratio (CMRR).

MCP651 Input Offset Evaluation Board
Part Number: MCP651EV-VOS

The MCP651 Input Offset Evaluation Board is intended to provide a simple means to measure the MCP651 Input Offset Evaluation Board op amp's input offset voltage under a variety of operating conditions. The measured input offset voltage (V_{OST}) includes the input offset voltage specified in the data sheet (V_{OS}) plus changes due to: power supply voltage (PSRR), common mode voltage (CMRR), output voltage (AOL), input offset voltage drift over temperature ($\Delta V_{OS}/\Delta T_A$) and 1/f noise.

MCP6V01 Input Offset Demo Board
Part Number: MCP6V01DM-VOS

The MCP6V01 Input Offset Demo Board is intended to provide a simple means to measure the MCP6V01/2/3 op amps input offset voltage (V_{OS}) under a variety of bias conditions. This V_{OS} includes the specified input offset voltage value found in the data sheet plus changes due to power supply voltage (PSRR), common mode voltage (CMRR), output voltage (AOL) and temperature (IVOS/ITA).

Support

Microchip is committed to supporting its customers in developing products faster and more efficiently. We maintain a worldwide network of field applications engineers and technical support ready to provide product and system assistance. In addition, the following service areas are available at www.microchip.com:

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Microchip Technology Inc.
2355 W. Chandler Blvd.
Chandler, AZ 85224-6199