

Low Noise, Low Power Op Amp

Features

Low Noise: 5.4 nV/√Hz (typical)

• Low Quiescent Current: 520 µA (typical)

• Rail-to-Rail Output

Wide Supply Voltage Range: 2.2V to 5.5V
Gain Bandwidth Product: 3.5 MHz (typical)

Unity Gain Stable

• Extended Temperature Range: -40°C to +125°C

No Phase Reversal

· Small Package

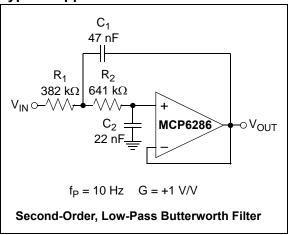
Applications

- · Noise Cancellation Headphones
- · Cellular Phones
- Analog Filters
- · Sensor Conditioning
- · Portable Instrumentation
- · Medical Instrumentation
- · Battery Powered Systems

Design Aids

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

Typical Application

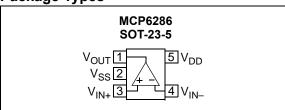


Description

The Microchip Technology Inc. MCP6286 operational amplifier (op amp) has low noise (5.4 nV/ $\sqrt{\text{Hz}}$, typical), low power (520 μA , typical) and rail-to-rail output operation. It is unity gain stable and has a gain bandwidth product of 3.5 MHz (typical). This device operates with a single supply voltage as low as 2.2V, while drawing low quiescent current. These features make the product well suited for single-supply, low noise, battery-powered applications.

The MCP6286 op amp is offered in a space saving SOT-23-5 package. It is designed with Microchip's advanced CMOS process and available in the extended temperature range, with a power supply range of 2.2V to 5.5V.

Package Types



1.0 ELECTRICAL CHARACTERISTICS

1.1 Absolute Maximum Ratings †

V _{DD} – V _{SS}
Current at Input Pins±2 mA
Analog Inputs (V _{IN} +, V _{IN} -)†† V_{SS} – 1.0V to V_{DD} + 1.0V
All Other Inputs and Outputs $\rm V_{SS} - 0.3V$ to $\rm V_{DD} + 0.3V$
Difference Input Voltage $ V_{DD} - V_{SS} $
Output Short-Circuit Currentcontinuous
Current at Output and Supply Pins±30 mA
Storage Temperature65°C to +150°C
Maximum Junction Temperature (T _J)+150°C
ESD protection on all pins (HBM; MM) ≥ 4 kV; 400V

† 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 4.1.2 "Input Voltage And Current Limits"

DC ELECTRICAL SPECIFICATIONS

Electrical Characteristics : Unless otherwise indicated, V_{DD} = +2.2V to +5.5V, V_{SS} = GND, T_A = +25°C, V_{CM} = $V_{DD}/3$, $V_{OUT} \approx V_{DD}/2$, V_L = $V_{DD}/2$ and R_L = 10 kΩ to V_L . (Refer to Figure 1-1).									
Parameters	Sym	Min	Тур	Max	Units	Conditions			
Input Offset									
Input Offset Voltage	Vos	-1.5	_	+1.5	mV				
Input Offset Drift with Temperature	$\Delta V_{OS}/\Delta T_{A}$	_	±1	_	μV/°C	T _A = -40°C to +125°C			
Power Supply Rejection Ratio	PSRR	80	100	_	dB				
Input Bias Current and Impedance	Input Bias Current and Impedance								
Input Bias Current	I _B	_	±1		рА				
		_	50	150	pА	$T_A = +85$ °C			
		_	1500	3000	pА	T _A = +125°C			
Input Offset Current	Ios	_	±1	_	pА				
Common Mode Input Impedance	Z _{CM}	_	10 ¹³ 20	_	ΩpF				
Differential Input Impedance	Z _{DIFF}	_	10 ¹³ 20	_	Ω pF				
Common Mode									
Common Mode Input Voltage Range	V _{CMR}	V _{SS} -0.3	_	V _{DD} -1.2	V	Note 1			
Common Mode Rejection Ratio	CMRR	76	95		dB	$V_{CM} = -0.3V \text{ to } 1.0V,$ $V_{DD} = 2.2V$			
		80	100	_	dB	$V_{CM} = -0.3V \text{ to } 4.3V,$ $V_{DD} = 5.5V$			
Open-Loop Gain									
DC Open-Loop Gain (Large Signal)	A _{OL}	100	120	_	dB	$0.2V < V_{OUT} < (V_{DD} - 0.2V)$			
Output									
Maximum Output Voltage Swing	V _{OL} , V _{OH}	V _{SS} +15	_	V _{DD} -15	mV	0.5V Input overdrive			
		V _{SS} +75	_	V _{DD} -75	mV	0.5V Input overdrive $R_L = 2 \text{ k}\Omega$			
Output Short-Circuit Current	I _{SC}		±20	_	mA				

Note 1: Figure 2-12 shows how V_{CMR} changes across temperature.

DC ELECTRICAL SPECIFICATIONS (CONTINUED)

Electrical Characteristics: Unless otherwise indicated, V_{DD} = +2.2V to +5.5V, V_{SS} = GND, T_A = +25°C, V_{CM} = V_{DD} /3, $V_{OUT} \approx V_{DD}$ /2, $V_L = V_{DD}$ /2 and R_L = 10 k Ω to V_L . (Refer to Figure 1-1).

Parameters	Sym	Min	Тур	Max	Units	Conditions		
Power Supply								
Supply Voltage	V_{DD}	2.2	_	5.5	V			
Quiescent Current per Amplifier	IQ	300	520	700	μA	$I_{O} = 0, V_{DD} = 2.2V$		
		320	540	720	μΑ	$I_{O} = 0, V_{DD} = 5.5V$		

Note 1: Figure 2-12 shows how V_{CMR} changes across temperature.

AC ELECTRICAL SPECIFICATIONS

 Electrical Characteristics: Unless otherwise indicated, $T_A = +25^{\circ}C$, $V_{DD} = +2.2$ to +5.5V, $V_{SS} = GND$, $V_{CM} = V_{DD}/3$, $V_{OUT} \approx V_{DD}/2$, $V_L = V_{DD}/2$, $V_L = 10$ kΩ to V_L and $C_L = 60$ pF. (Refer to Figure 1-1).

 Parameters
 Sym
 Min
 Typ
 Max
 Units
 Conditions

 AC Response

 Gain Bandwidth Product
 GBWP
 —
 3.5
 —
 MHz

	,		71				
AC Response							
Gain Bandwidth Product	GBWP	_	3.5	_	MHz		
Phase Margin	PM	_	60	_	٥	G = +1 V/V	
Slew Rate	SR	_	2	_	V/µs		
Noise							
Input Noise Voltage	E _{ni}	_	1.0	_	μV_{P-P}	f = 0.1 Hz to 10 Hz	
Input Noise Voltage Density	e _{ni}	_	22	_	nV/√Hz	f = 10 Hz	
		_	5.4	_	nV/√Hz	f = 10 kHz	
Input Noise Current Density	i _{ni}	_	0.6	_	fA/√Hz	f = 1 kHz	

TEMPERATURE SPECIFICATIONS

Electrical Characteristics: Unless otherwise indicated, $V_{DD} = +2.2V$ to +5.5V and $V_{SS} = GND$.							
Parameters	Sym	Min	Тур	Max	Units	Conditions	
Temperature Ranges							
Operating Temperature Range	T _A	-40	_	+125	°C	Note 1	
Storage Temperature Range	T _A	-65		+150	°C		
Thermal Package Resistances							
Thermal Resistance, 5L-SOT-23	θ_{JA}	_	256	_	°C/W		

Note 1: The internal junction temperature (T_J) must not exceed the absolute maximum specification of +150°C.

1.2 Test Circuits

The circuit used for most DC and AC tests is shown in Figure 1-1. It independently sets V_{CM} and V_{OUT} ; see Equation 1-1. The circuit's common mode voltage is $(V_P + V_M)/2, \ \text{not} \ V_{CM}. \ V_{OST}$ includes V_{OS} plus the effects of temperature, CMRR, PSRR and $A_{OL}.$

EQUATION 1-1:

$$\begin{split} G_{DM} &= R_F / R_G \\ G_N &= 1 + G_{DM} \\ V_{CM} &= V_P (1 - 1 / G_N) + V_{REF} (1 / G_N) \\ V_{OST} &= V_{IN-} - V_{IN+} \\ V_{OUT} &= V_{REF} + (V_P - V_M) G_{DM} + V_{OST} G_N \\ \text{Where:} \\ G_{DM} &= \text{Differential Mode Gain} \qquad (V/V) \\ G_N &= \text{Noise Gain} \qquad (V/V) \\ V_{CM} &= \text{Op Amp's Common Mode} \qquad (V/V) \\ Input Voltage \\ V_{OST} &= \text{Op Amp's Total Input Offset} \qquad (mV) \\ \text{Voltage} \end{split}$$

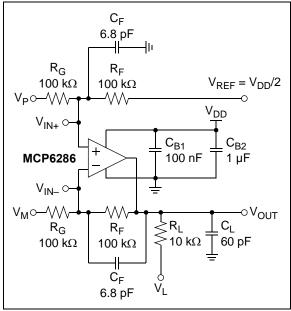


FIGURE 1-1: AC and DC Test Circuit for Most Specifications.

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.2V to +5.5V, V_{SS} = GND, V_{CM} = $V_{DD}/3$, $V_{OUT} \approx V_{DD}/2$, V_L = $V_{DD}/2$, R_L = 10 k Ω to V_L and C_L = 60 pF.

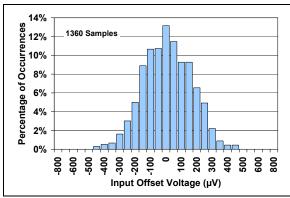


FIGURE 2-1: Input Offset Voltage.

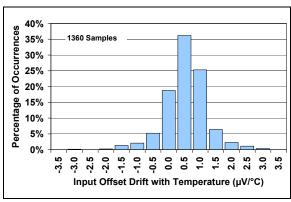


FIGURE 2-2: Input Offset Voltage Drift.

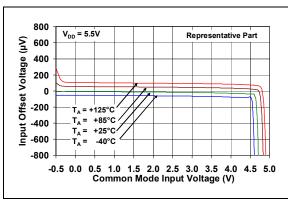


FIGURE 2-3: Input Offset Voltage vs. Common Mode Input Voltage with $V_{DD} = 5.5V$.

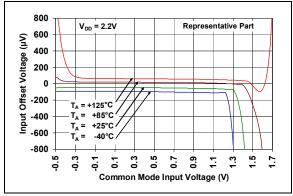


FIGURE 2-4: Input Offset Voltage vs. Common Mode Input Voltage with $V_{DD} = 2.2V$.

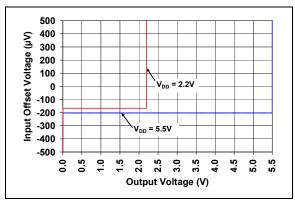


FIGURE 2-5: Input Offset Voltage vs. Output Voltage.

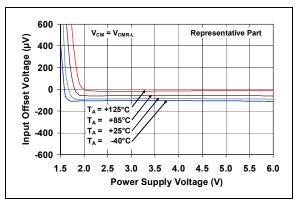


FIGURE 2-6: Input Offset Voltage vs. Power Supply Voltage with $V_{CM} = V_{CMR}$ L.

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.2V to +5.5V, V_{SS} = GND, V_{CM} = $V_{DD}/3$, $V_{OUT} \approx V_{DD}/2$, V_L = $V_{DD}/2$, R_L = 10 k Ω to V_L and C_L = 60 pF.

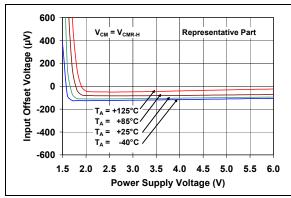


FIGURE 2-7: Input Offset Voltage vs. Power Supply Voltage with $V_{CM} = V_{CMR_H}$.

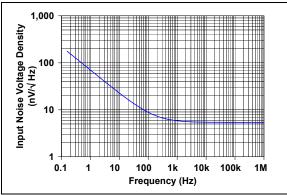


FIGURE 2-8: Input Noise Voltage Density vs. Frequency.

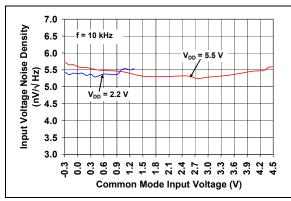


FIGURE 2-9: Input Noise Voltage Density vs. Common Mode Input Voltage.

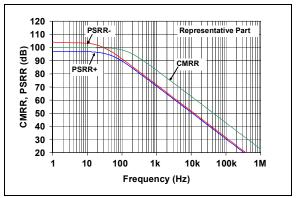


FIGURE 2-10: CMRR, PSRR vs. Frequency.

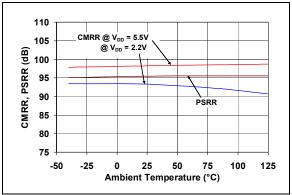


FIGURE 2-11: CMRR, PSRR vs. Ambient Temperature.

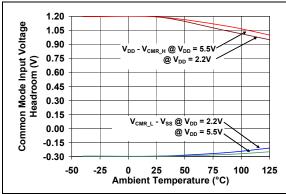


FIGURE 2-12: Common Mode Input
Voltage Headroom vs. Ambient Temperature.

Note: Unless otherwise indicated, $T_A = +25$ °C, $V_{DD} = +2.2$ V to +5.5V, $V_{SS} = GND$, $V_{CM} = V_{DD}/3$, $V_{OUT} \approx V_{DD}/2$, $V_L = V_{DD}/2$, $R_L = 10$ k Ω to V_L and $C_L = 60$ pF.

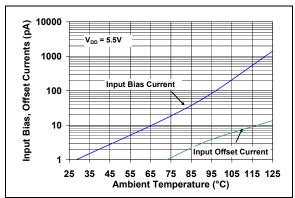


FIGURE 2-13: Input Bias, Offset Currents vs. Ambient Temperature.

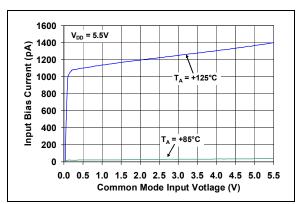


FIGURE 2-14: Input Bias Current vs. Common Mode Input Voltage.

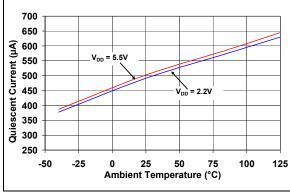


FIGURE 2-15: Quiescent Current vs Ambient Temperature.

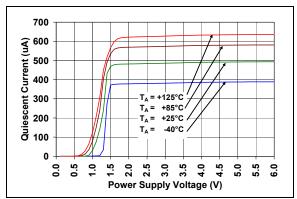


FIGURE 2-16: Quiescent Current vs. Power Supply Voltage.

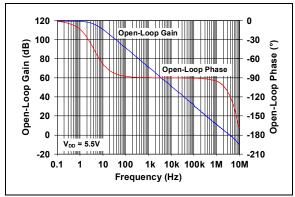


FIGURE 2-17: Open-Loop Gain, Phase vs. Frequency.

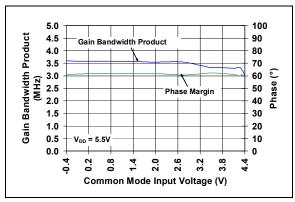


FIGURE 2-18: Gain Bandwidth Product, Phase Margin vs. Common Mode Input Voltage with $V_{DD} = 5.5V$.

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.2V to +5.5V, V_{SS} = GND, V_{CM} = $V_{DD}/3$, $V_{OUT} \approx V_{DD}/2$, V_L = $V_{DD}/2$, R_L = 10 k Ω to V_L and C_L = 60 pF

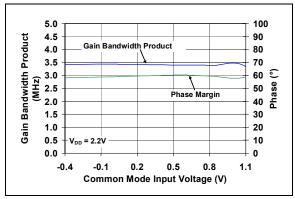


FIGURE 2-19: Gain Bandwidth Product, Phase Margin vs. Common Mode Input Voltage with $V_{DD} = 2.2V$.

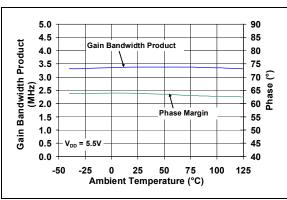


FIGURE 2-20: Gain Bandwidth Product, Phase Margin vs. Ambient Temperature with $V_{DD} = 5.5V$.

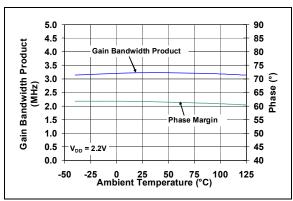


FIGURE 2-21: Gain Bandwidth Product, Phase Margin vs. Ambient Temperature with $V_{DD} = 2.2V$.

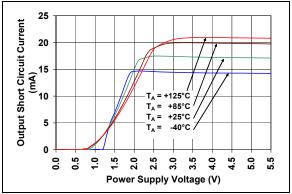


FIGURE 2-22: Ouput Short Circuit Current vs. Power Supply Voltage.

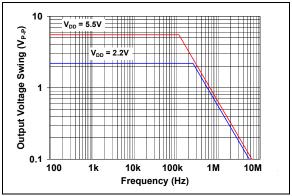


FIGURE 2-23: Output Voltage Swing vs. Frequency.

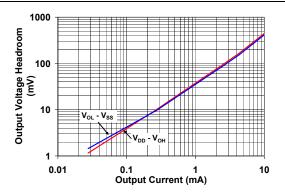


FIGURE 2-24: Output Voltage Headroom vs. Output Current.

Note: Unless otherwise indicated, $T_A = +25^{\circ}C$, $V_{DD} = +2.2V$ to +5.5V, $V_{SS} = GND$, $V_{CM} = V_{DD}/3$, $V_{OUT} \approx V_{DD}/2$, $V_L = V_{DD}/2$, $R_L = 10~k\Omega$ to V_L and $C_L = 60~pF$.

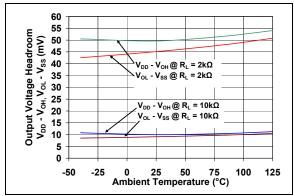


FIGURE 2-25: Output Voltage Headroom vs. Ambient Temperature.

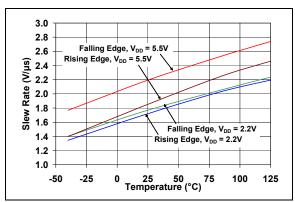


FIGURE 2-26: Slew Rate vs. Ambient Temperature.

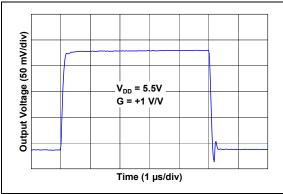


FIGURE 2-27: Small Signal Non-Inverting Pulse Response.

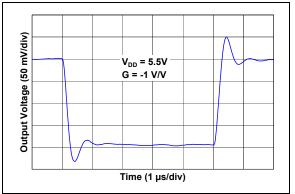


FIGURE 2-28: Small Signal Inverting Pulse Response.

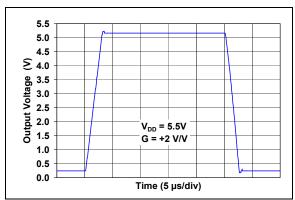


FIGURE 2-29: Large Signal Non-Inverting Pulse Response.

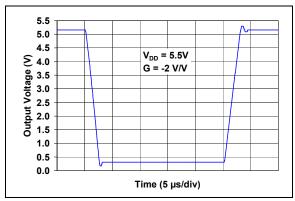


FIGURE 2-30: Large Signal Inverting Pulse Response.

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = +1.8V to +6.0V, V_{SS} = GND, V_{CM} = $V_{DD}/3$, $V_{OUT} \approx V_{DD}/2$, V_L = $V_{DD}/2$, R_L = 10 k Ω to V_L and C_L = 60 pF.

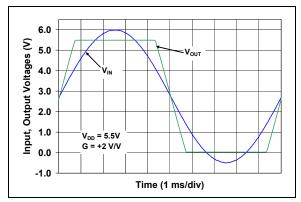


FIGURE 2-31: Phase Reversal.

The MCP6286 Shows No

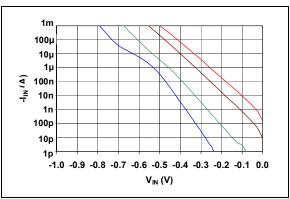


FIGURE 2-33: Measured Input Current vs. Input Voltage (below V_{SS}).

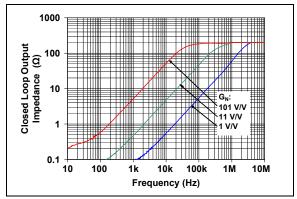


FIGURE 2-32:

Closed Loop Output

Impedance vs. Frequency.

3.0 PIN DESCRIPTIONS

Descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

MCP6286	Symbol	Description	
SOT-23-5	SOT-23-5 Symbol	Description	
1	V _{OUT}	Analog Output	
2	V _{SS}	Negative Power Supply	
3	V _{IN} +	Non-inverting Input	
4	V _{IN} -	Inverting Input	
5	V _{DD}	Positive Power Supply	

3.1 Analog Output

The output pin is low-impedance voltage source.

3.2 Analog Inputs

The non-inverting and inverting inputs are high-impedance CMOS inputs with low bias currents.

3.3 Power Supply Pins

The positive power supply (V_{DD}) is 2.2V to 5.5V higher than the negative power supply (V_{SS}). For normal operation, the other pins are at voltages between V_{SS} and V_{DD} .

Typically, these parts are used in a single (positive) supply configuration. In this case, V_{SS} is connected to ground and V_{DD} is connected to the supply. V_{DD} will need bypass capacitors.

4.0 APPLICATION INFORMATION

The MCP6286 op amp is manufactured using Microchip's state-of-the-art CMOS process and is specifically designed for low-power, low-noise applications.

4.1 Input

4.1.1 PHASE REVERSAL

The MCP6286 op amp is designed to prevent phase reversal when the input pins exceed the supply voltages. Figure 2-31 shows the input voltage exceeding the supply voltage without any phase reversal.

4.1.2 INPUT VOLTAGE AND CURRENT LIMITS

The ESD protection on the inputs can be depicted as shown in Figure 4-1. This structure was chosen to protect the input transistors and to minimize input bias current (I_B). The input ESD diodes clamp the inputs when they try to go more than one diode drop below V_{SS}. They also clamp any voltage that goes too far above V_{DD}; their breakdown voltage is high enough to allow normal operation and low enough to bypass ESD events within the specified limits.

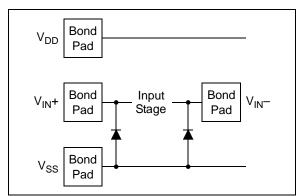


FIGURE 4-1: Simplified Analog Input ESD Structures.

In order to prevent damage and/or improper operation of these op amps, the circuit they are in must limit the voltages and currents at the $V_{\text{IN+}}$ and $V_{\text{IN-}}$ pins (see **Absolute Maximum Ratings** at the beginning of **Section 1.0 "Electrical Characteristics"**). Figure 4-2 shows the recommended approach to protecting these inputs. The internal ESD diodes prevent the input pins $(V_{\text{IN+}}$ and $V_{\text{IN-}})$ from going too far below ground, and the resistors R_1 and R_2 limit the possible current drawn out of the input pins. Diodes D_1 and D_2 prevent the input pins $(V_{\text{IN+}}$ and $V_{\text{IN-}})$ from going too far above V_{DD} . When implemented as shown, resistors R_1 and R_2 also limit the current through D_1 and D_2 .

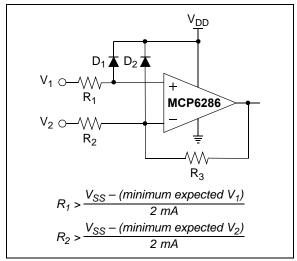


FIGURE 4-2: Protecting the Analog Inputs.

It is also possible to connect the diodes to the left of the resistors R_1 and $R_2.$ In this case, the currents through the diodes D_1 and D_2 need to be limited by some other mechanism. The resistors then serve as in-rush current limiters; the DC currents into the input pins (V $_{\rm IN+}$ and V $_{\rm IN-}$) should be very small. A significant amount of current can flow out of the inputs when the common mode voltage (V $_{\rm CM}$) is below ground (V $_{\rm SS}$). (See Figure 2-33).

4.1.3 NORMAL OPERATION

The input stage of the MCP6286 op amp uses a PMOS input stage. It operates at low common mode input voltage (V_{CM}), including ground. With this topology, the device operates with a V_{CM} up to V_{DD} - 1.2V and 0.3V below V_{SS} . (See Figure 2-12).The input offset voltage is measured at $V_{CM} = V_{SS} - 0.3V$ and V_{DD} - 1.2V to ensure proper operation.

For a unity gain buffer, since V_{OUT} is the same voltage as the inverting input, V_{OUT} must be maintained below V_{DD} -1.2V for correct operation.

4.2 Rail-to-Rail Output

The output voltage range of the MCP6286 op amp is V_{SS} + 15 mV (minimum) and V_{DD} – 15 mV (maximum) when R_L = 10 k Ω is connected to $V_{DD}/2$ and V_{DD} = 5.5V. Refer to Figure 2-24 and Figure 2-25 for more information.

4.3 Capacitive Loads

Driving large capacitive loads can cause stability problems for voltage feedback op amps. As the load capacitance increases, the feedback loop's phase margin decreases and the closed-loop bandwidth is reduced. This produces gain peaking in the frequency response, with overshoot and ringing in the step response. While a unity-gain buffer (G = +1 V/V) is the most sensitive to capacitive loads, all gains show the same general behavior.

When driving large capacitive loads with these op amps (e.g., > 100 pF when G = +1 V/V), a small series resistor at the output (R_{ISO} in Figure 4-3) improves the feedback loop's phase margin (stability) by making the output load resistive at higher frequencies. The bandwidth will be generally lower than the bandwidth with no capacitance load.

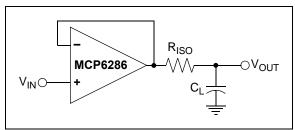


FIGURE 4-3: Output Resistor, R_{ISO} Stabilizes Large Capacitive Loads.

Figure 4-4 gives recommended R_{ISO} values for different capacitive loads and gains. The x-axis is the normalized load capacitance (C_L/G_N), where G_N is the circuit's noise gain. For non-inverting gains, G_N and the Signal Gain are equal. For inverting gains, G_N is 1+|Signal Gain| (e.g., -1 V/V gives G_N = +2 V/V).

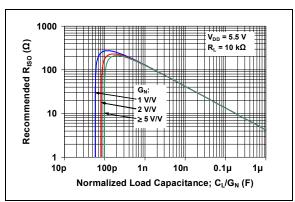


FIGURE 4-4: Recommended R_{ISO} Values for Capacitive Loads.

After selecting $R_{\rm ISO}$ for your circuit, double check the resulting frequency response peaking and step response overshoot. Modify $R_{\rm ISO}$'s value until the response is reasonable. Bench evaluation and simulations with the MCP6286 SPICE macro model are very helpful.

4.4 Supply Bypass

MCP6286 op amp's power supply pin (V_{DD} for single-supply) should have a local bypass capacitor (i.e., 0.01 μ F to 0.1 μ F) within 2 mm for good high frequency performance. It can use a bulk capacitor (i.e., 1 μ F or larger) within 100 mm to provide large, slow currents. This bulk capacitor can be shared with other analog parts.

4.5 PCB Surface Leakage

In applications where low input bias current is critical, Printed Circuit Board (PCB) surface leakage effects need to be considered. Surface leakage is caused by humidity, dust or other contamination on the board. Under low humidity conditions, a typical resistance between nearby traces is $10^{12}\Omega$. A 5V difference would cause 5 pA of current to flow; which is greater than the MCP6286 op amp's bias current at +25°C (±1 pA, typical).

The easiest way to reduce surface leakage is to use a guard ring around sensitive pins (or traces). The guard ring is biased at the same voltage as the sensitive pin. An example of this type of layout is shown in Figure 4-5.

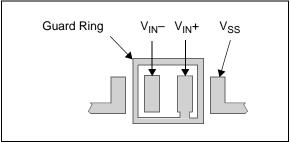


FIGURE 4-5: Example Guard Ring Layout for Inverting Gain.

- 1. Non-inverting Gain and Unity-Gain Buffer:
 - Connect the non-inverting pin (V_{IN}+) to the input with a wire that does not touch the PCB surface.
 - Connect the guard ring to the inverting input pin (V_{IN}-). This biases the guard ring to the common mode input voltage.
- Inverting Gain and Transimpedance Gain Amplifiers (convert current to voltage, such as photo detectors):
 - a. Connect the guard ring to the non-inverting input pin (V_{IN}+). This biases the guard ring to the same reference voltage as the op amp (e.g., V_{DD}/2 or ground).
 - Connect the inverting pin (V_{IN}-) to the input with a wire that does not touch the PCB surface.

4.6 Application Circuits

4.6.1 ACTIVE LOW-PASS FILTER

The MCP6286 op amp's low input bias current makes it possible for the designer to use larger resistors and smaller capacitors for active low-pass filter applications. However, as the resistance increases, the noise generated also increases. Parasitic capacitances and the large value resistors could also modify the frequency response. These trade-offs need to be considered when selecting circuit elements.

Figure 4-6 and Figure 4-7 show low-pass, second-order, Butterworth filters with a cut-off frequency of 10 Hz. The filter in Figure 4-6 has a non-inverting gain of +1 V/V, and the filter in Figure 4-7 has an inverting gain of -1 V/V.

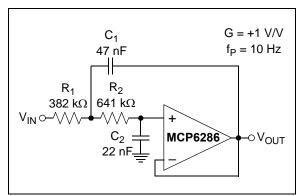


FIGURE 4-6: Second-Order, Low-Pass Butterworth Filter with Sallen-Key Topology.

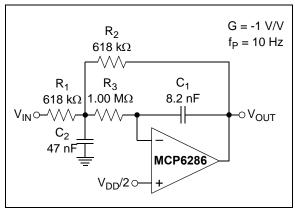


FIGURE 4-7: Second-Order, Low-Pass Butterwork Filter with Multiple-Feedback Topology.

4.6.2 PHOTO DETECTION

The MCP6286 op amps can be used to easily convert the signal from a sensor that produces an output current (such as a photo diode) into a voltage (a transimpedance amplifier). This is implemented with a single resistor (R_2) in the feedback loop of the amplifiers shown in Figure 4-8 and Figure 4-9. The optional capacitor (C_2) sometimes provides stability for these circuits.

A photodiode configured in the Photovoltaic mode has zero voltage potential placed across it (Figure 4-8). In this mode, the light sensitivity and linearity is maximized, making it best suited for precision applications. The key amplifier specifications for this application are: low input bias current, low noise, common mode input voltage range (including ground), and rail-to-rail output.

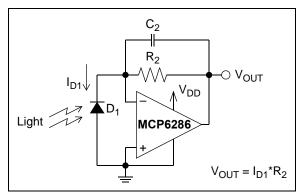


FIGURE 4-8: Photovoltaic Mode Detector.

In contrast, a photodiode that is configured in the Photoconductive mode has a reverse bias voltage across the photo-sensing element (Figure 4-9). This decreases the diode capacitance, which facilitates high-speed operation (e.g., high-speed digital communications). The design trade-off is increased diode leakage current and linearity errors. The op amp needs to have a wide Gain Bandwidth Product (GBWP).

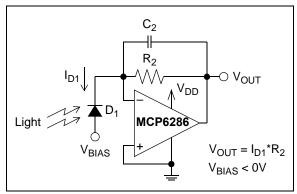


FIGURE 4-9: Detector.

Photoconductive Mode

5.0 DESIGN AIDS

Microchip provides the basic design tools needed for the MCP6286 op amp.

5.1 SPICE Macro Model

The latest SPICE macro model for the MCP6286 op amp is available on the Microchip web site at www.microchip.com. The model was written and tested in official Orcad (Cadence) owned PSPICE. For the other simulators, it may require translation.

The model covers a wide aspect of the op amp's electrical specifications. Not only does the model cover voltage, current, and resistance of the op amp, but it also covers the temperature and noise effects on the behavior of the op amp. The model has not been verified outside of the specification range listed in the op amp data sheet. The model behaviors under these conditions can not be guaranteed that it will match the actual op amp performance.

Moreover, the model is intended to be an initial design tool. Bench testing is a very important part of any design and cannot be replaced with simulations. Also, simulation results using this macro model need to be validated by comparing them to the data sheet specifications and characteristic curves.

5.2 FilterLab[®] Software

Microchip's FilterLab[®] software is an innovative software tool that simplifies analog active filter (using op amps) design. Available at no cost from the Microchip web site at www.microchip.com/filterlab, the FilterLab design tool provides full schematic diagrams of the filter circuit with component values. It also outputs the filter circuit in SPICE format, which can be used with the macro model to simulate actual filter performance.

5.3 Mindi™ Circuit Designer & Simulator

Microchip's Mindi™ Circuit Designer & Simulator aids in the design of various circuits useful for active filter, amplifier and power-management applications. It is a free online circuit designer & simulator available from the Microchip web site at www.microchip.com/mindi. This interactive circuit designer & simulator enables designers to quickly generate circuit diagrams, simulate circuits. Circuits developed using the Mindi Circuit Designer & Simulator can be downloaded to a personal computer or workstation.

5.4 Microchip Advanced Part Selector (MAPS)

MAPS is a software tool that helps semiconductor professionals efficiently identify Microchip devices that fit a particular design requirement. Available at no cost from the Microchip website at www.microchip.com/maps, the MAPS is an overall selection tool for Microchip's product portfolio that includes Analog, Memory, MCUs and DSCs. Using this tool you can define a filter to sort features for a parametric search of devices and export side-by-side technical comparison reports. Helpful links are also provided for Datasheets, Purchase, and Sampling of Microchip parts.

5.5 Analog Demonstration and Evaluation Boards

Microchip offers a broad spectrum of Analog Demonstration and Evaluation Boards that are designed to help you achieve faster time to market. For a complete listing of these boards and their corresponding user's guides and technical information, visit the Microchip web site at www.microchip.com/analogtools.

Some boards that are especially useful are:

- MCP6XXX Amplifier Evaluation Board 1
- MCP6XXX Amplifier Evaluation Board 2
- MCP6XXX Amplifier Evaluation Board 3
- MCP6XXX Amplifier Evaluation Board 4
- · Active Filter Demo Board Kit
- 5/6-Pin SOT-23 Evaluation Board, P/N VSUPEV2

5.6 Application Notes

The following Microchip Analog Design Note and Application Notes are available on the Microchip web site at www.microchip.com/appnotes and are recommended as supplemental reference resources.

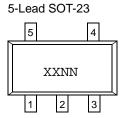
- ADN003: "Select the Right Operational Amplifier for your Filtering Circuits", DS21821
- AN722: "Operational Amplifier Topologies and DC Specifications", DS00722
- AN723: "Operational Amplifier AC Specifications and Applications", DS00723
- AN884: "Driving Capacitive Loads With Op Amps", DS00884
- AN990: "Analog Sensor Conditioning Circuits An Overview", DS00990
- AN1177: "Op Amp Precision Design: DC Errors", DS01177
- AN1228: "Op Amp Precision Design: Random Noise", DS01228

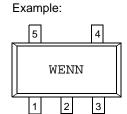
These application notes and others are listed in the design guide:

"Signal Chain Design Guide", DS21825

6.0 PACKAGING INFORMATION

6.1 Package Marking Information





Legend: XX...X Customer-specific information Year code (last digit of calendar year)

YY Year code (last digit of calendar year)
YY Year code (last 2 digits of calendar year)
WW Week code (week of January 1 is week '01')

NNN Alphanumeric traceability code

(e3) Pb-free JEDEC designator for Matte Tin (Sn)

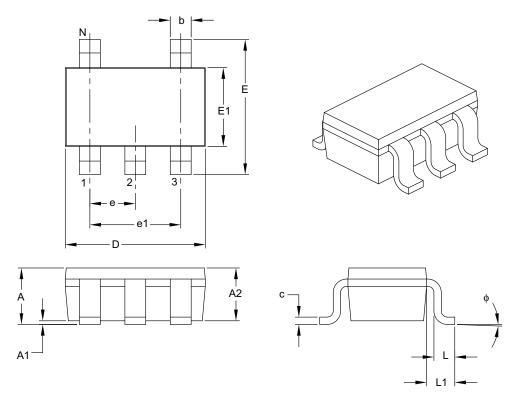
This package is Pb-free. The Pb-free JEDEC designator (e3)

can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

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

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



	Units			MILLIMETERS			
Dimension	on Limits	MIN	NOM	MAX			
Number of Pins	N	5					
Lead Pitch	е		0.95 BSC				
Outside Lead Pitch	e1		1.90 BSC				
Overall Height	Α	0.90	_	1.45			
Molded Package Thickness	A2	0.89	_	1.30			
Standoff	A1	0.00	_	0.15			
Overall Width	Е	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	ф	0°	-	30°			
Lead Thickness	С	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

APPENDIX A: REVISION HISTORY

Revision A (August 2009)

• Original Release of this Document.

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.	<u>x</u> /xx	Exa	Examples:			
-	erature Package nge	a)	MCP6286T-E/OT:	Tape and Reel, 5-LD SOT-23 package		
Device:	MCP6286T: Single Op Amp (Tape and Reel)					
Temperature Range:	E = -40°C to +125°C					
Package:	OT = Plastic Small Outline Transistor, 5-lead					

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