MCP6271/1R/2/3/4/5

170 µA, 2 MHz Rail-to-Rail Operational Amplifier

Features

- Gain Bandwidth Product: 2 MHz (typical)
- Supply Current: I_Q = 170 µA (typical)
- Supply Voltage: 2.0V to 6.0V
- Rail-to-Rail Input/Output (I/O)
- Extended Temperature Range: -40°C to +125°C
- Available in Single, Dual and Quad Packages
- Parts with Chip Select ($\overline{CS}$):
  - Single Operational Amplifier (MCP6273)
  - Dual Operational Amplifier (MCP6275)

Applications

- Automotive
- Portable Equipment
- Photodiode Amplifier
- Analog Filters
- Notebooks and PDAs
- Battery Powered Systems

Available Tools

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

Description

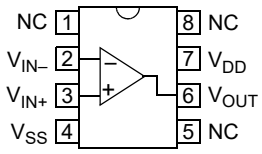
MCP6271/1R/2/3/4/5 is a family of operational amplifiers that provides a wide current bandwidth. This product family has a 2 MHz Gain Bandwidth Product (GBWP) and a 65° Phase Margin. The operational amplifiers operate from a single supply voltage as low as 2.0V, while drawing 170 µA (typical) quiescent current (I_Q). MCP6271/1R/2/3/4/5 supports rail-to-rail input and output swing and a Common mode input voltage (V_{CM}) range of V_{DD} + 300 mV to V_{SS} – 300 mV. Operational amplifiers in this family are designed with Microchip's advanced CMOS process.

MCP6275 has a Chip Select pin ($\overline{CS}$) for dual operational amplifiers in an 8-pin package, manufactured by cascading two operational amplifiers (the output of operational amplifier A connected to the non-inverting input of operational amplifier B). The $\overline{CS}$ pin puts the MCP6275 device in low power mode.

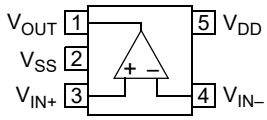
The MCP6271/1R/2/3/4/5 family operates over the Extended Temperature Range of -40°C to +125°C, with a power supply range of 2.0V to 6.0V.

Package Types

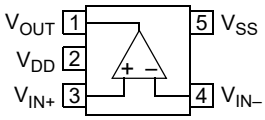
MCP6271
PDIP, SOIC, MSOP



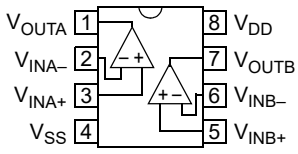
MCP6271
SOT-23-5



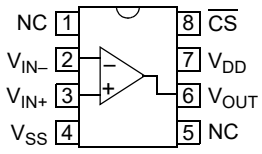
MCP6271R
SOT-23-5



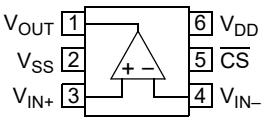
MCP6272
PDIP, SOIC, MSOP



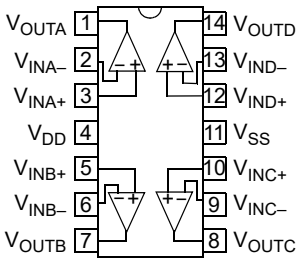
MCP6273
PDIP, SOIC, MSOP



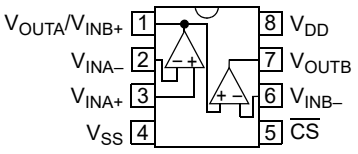
MCP6273
SOT-23-6



MCP6274
PDIP, SOIC, TSSOP



MCP6275
PDIP, SOIC, MSOP



NOTES:

1.0 ELECTRICAL CHARACTERISTICS

1.1 Absolute Maximum Ratings (†)

$V_{DD} - V_{SS}$ 7.0V
Current at Input Pins ..... ±2 mA
Analog Inputs (V_{IN+} and V_{IN-}) (1) ..... V_{SS} – 1.0V to V_{DD} + 1.0V
All other Inputs and Outputs ..... V_{SS} – 0.3V to V_{DD} + 0.3V
Difference Input Voltage ..... $|V_{DD} - V_{SS}|$
Output Short Circuit Current ..... Continuous
Current at Output and Supply Pins ..... ±30 mA
Storage Temperature ..... –65°C to +150°C
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 the functional operation of the device at these or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Note 1: See **Section 4.1.2 “Input Voltage and Current Limits”**.

1.2 DC Electrical Specifications

Electrical Characteristics: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.0V to +5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, $V_{OUT} \approx V_{DD}/2$, $V_L = V_{DD}/2$, R_L = 10 kΩ to V_L and $\overline{CS}$ is tied low. (Refer to Figure 1-2 and Figure 1-3).

Parameters	Symbol	Min	Typical	Max	Units	Conditions
Input Offset (Note 1)						
Input Offset Voltage	V_{OS}	-3.0	—	+3.0	mV	$V_{CM} = V_{SS}$
Input Offset Voltage (Extended Temperature)	V_{OS}	-5.0	—	+5.0	mV	T_A = -40°C to +125°C, $V_{CM} = V_{SS}$
Input Offset Temperature Drift	$\Delta V_{OS}/\Delta T_A$	—	±1.7	—	µV/°C	T_A = -40°C to +125°C, $V_{CM} = V_{SS}$
Power Supply Rejection Ratio	PSRR	70	90	—	dB	$V_{CM} = V_{SS}$
Input Bias Current and Impedance						
Input Bias Current	I_B	—	±1.0	—	pA	**Note 2**
at +85°C	I_B	—	50	200	pA	T_A= +85°C (**Note 2**)
at +125°C	I_B	—	2	5	nA	T_A= +125°C (**Note 2**)
Input Offset Current	I_{OS}	—	±1.0	—	pA	**Note 3**
Common Mode Input Impedance	Z_{CM}	—	10^{13}||6	—	Ω||pF	**Note 3**
Differential Input Impedance	Z_{DIFF}	—	10^{13}||3	—	Ω||pF	**Note 3**

Note 1: The MCP6275’s V_{CM} for operational amplifier B (pins V_{OUTA}/V_{INB+} and V_{INB-}) is V_{SS} + 100 mV.
2: The current at the MCP6275’s V_{INB-} pin is specified by I_B only.
3: This specification does not apply to the MCP6275’s V_{OUTA}/V_{INB+} pin.
4: The MCP6275’s V_{INB-} pin (operational amplifier B) has a Common mode input voltage range (V_{CMR}) of V_{SS} + 100 mV to V_{DD} – 100 mV. CMRR is not measured for operational amplifier B of the MCP6275. The MCP6275’s V_{OUTA}/V_{INB+} pin (operational amplifier B) has a voltage range specified by V_{OH} and V_{OL}.
5: Set by design and characterization.
6: Does not apply to the operational amplifier B of MCP6275.
7: All parts with date codes November 2007 and later are screened to ensure operation at V_{DD} = 6.0V. However, the other minimum and maximum specifications are measured at 2.0V and 5.5V.

1.2 DC Electrical Specifications (Continued)

Electrical Characteristics: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.0V to +5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2, V_L = V_{DD}/2, R_L = 10 kΩ to V_L and $\overline{CS}$ is tied low. (Refer to Figure 1-2 and Figure 1-3).

Parameters	Symbol	Min	Typical	Max	Units	Conditions
Common Mode (Note 4)						
Common Mode Input Voltage Range	V_{CMR}	V_{SS} – 0.15	—	V_{DD} + 0.15	V	V_{DD} = 2.0V **(Note 5)**
	V_{CMR}	V_{SS} – 0.30	—	V_{DD} + 0.30	V	V_{DD} = 5.5V **(Note 5)**
Common Mode Rejection Ratio	CMRR	70	85	—	dB	V_{CM} = -0.3V to 2.5V, V_{DD} = 5V (**Note 6**)
Common Mode Rejection Ratio	CMRR	65	80	—	dB	V_{CM} = -0.3V to 5.3V, V_{DD} = 5V (**Note 6**)
Open-Loop Gain						
DC Open-Loop Gain (Large Signal)	A_{OL}	90	110	—	dB	V_{OUT} = 0.2V to V_{DD} – 0.2V, V_{CM} = V_{SS} (**Note 1**)
Output						
Maximum Output Voltage Swing	V_{OL}, V_{OH}	V_{SS} + 15	—	V_{DD} – 15	mV	0.5V input overdrive (**Note 4**)
Output Short Circuit Current	I_{SC}	—	±25	—	mA	—
Power Supply						
Supply Voltage	V_{DD}	2.0	—	6.0	V	—
Quiescent Current per Amplifier	I_Q	100	170	240	µA	I_O = 0A

Note 1: The MCP6275's V_{CM} for operational amplifier B (pins V_{OUTA}/V_{INB+} and $V_{INB–}$) is V_{SS} + 100 mV.

2: The current at the MCP6275's $V_{INB–}$ pin is specified by I_B only.

3: This specification does not apply to the MCP6275's V_{OUTA}/V_{INB+} pin.

4: The MCP6275's $V_{INB–}$ pin (operational amplifier B) has a Common mode input voltage range (V_{CMR}) of V_{SS} + 100 mV to V_{DD} – 100 mV. CMRR is not measured for operational amplifier B of the MCP6275. The MCP6275's V_{OUTA}/V_{INB+} pin (operational amplifier B) has a voltage range specified by V_{OH} and V_{OL}.

5: Set by design and characterization.

6: Does not apply to the operational amplifier B of MCP6275.

7: All parts with date codes November 2007 and later are screened to ensure operation at V_{DD} = 6.0V. However, the other minimum and maximum specifications are measured at 2.0V and 5.5V.

1.3 AC Electrical Specifications

Electrical Characteristics: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.0V to +5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2, V_L = V_{DD}/2, R_L = 10 kΩ to V_L, C_L = 60 pF and $\overline{CS}$ is tied low. (Refer to Figure 1-2 and Figure 1-3).

Parameters	Symbol	Min	Typical	Max	Units	Conditions
AC Response						
Gain Bandwidth Product	GBWP	—	2.0	—	MHz	—
Phase Margin	PM	—	65	—	°	G = +1 V/V
Slew Rate	SR	—	0.9	—	V/µs	—
Noise						
Input Noise Voltage	E_{ni}	—	4.6	—	$µV_{P-P}$	f = 0.1 Hz to 10 Hz
Input Noise Voltage Density	e_{ni}	—	20	—	nV/√Hz	f = 1 kHz
Input Noise Current Density	i_{ni}	—	3	—	fA/√Hz	f = 1 kHz

1.4 Temperature Specifications

Electrical Characteristics: Unless otherwise indicated, V_{DD} = +2.0V to +5.5V and V_{SS} = GND.						
Parameters	**Symbol**	**Min**	**Typical**	**Max**	**Units**	**Conditions**
Temperature Ranges						
Specified Temperature Range	T_A	-40	—	+125	°C	—
Operating Temperature Range	T_A	-40	—	+125	°C	**Note**
Storage Temperature Range	T_A	-65	—	+150	°C	—
Thermal Package Resistances						
Thermal Resistance, 5L-SOT-23	θ_{JA}	—	256	—	°C/W	—
Thermal Resistance, 6L-SOT-23	θ_{JA}	—	230	—	°C/W	—
Thermal Resistance, 8L-PDIP	θ_{JA}	—	85	—	°C/W	—
Thermal Resistance, 8L-SOIC	θ_{JA}	—	163	—	°C/W	—
Thermal Resistance, 8L-MSOP	θ_{JA}	—	206	—	°C/W	—
Thermal Resistance, 14L-PDIP	θ_{JA}	—	70	—	°C/W	—
Thermal Resistance, 14L-SOIC	θ_{JA}	—	120	—	°C/W	—
Thermal Resistance, 14L-TSSOP	θ_{JA}	—	100	—	°C/W	—

Note: The Junction Temperature (T_J) must not exceed the Absolute Maximum specification of +150°C.

1.5 MCP6273/MCP6275 Chip Select Specifications

Electrical Characteristics: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.0V to +5.5V, V_{SS} = GND, $V_{CM} = V_{DD}/2$, $V_{OUT} \approx V_{DD}/2$, $V_L = V_{DD}/2$, R_L = 10 kΩ to $V_{DD}/2$, C_L = 60 pF and $\overline{CS}$ is tied low.						
Parameters	**Symbol**	**Min**	**Typical**	**Max**	**Units**	**Conditions**
$\overline{CS}$ Low Specifications						
$\overline{CS}$ Logic Threshold, Low	V_{IL}	V_{SS}	—	0.2 × V_{DD}	V	—
$\overline{CS}$ Input Current, Low	I_{CSL}	—	0.01	—	µA	$\overline{CS} = V_{SS}$
$\overline{CS}$ High Specifications						
$\overline{CS}$ Logic Threshold, High	V_{IH}	0.8 × V_{DD}	—	V_{DD}	V	—
$\overline{CS}$ Input Current, High	I_{CSH}	—	0.7	2	µA	$\overline{CS} = V_{DD}$
GND Current per Amplifier	I_{SS}	—	–0.7	—	µA	$\overline{CS} = V_{DD}$
Amplifier Output Leakage	—	—	0.01	—	µA	$\overline{CS} = V_{DD}$
Dynamic Specifications (Note 1)						
$\overline{CS}$ Low to Valid Amplifier Output, Turn on Time	t_{ON}	—	4	10	µs	$\overline{CS}$ Low ≤ 0.2 V_{DD}, G = +1 V/V, $V_{IN} = V_{DD}/2$, V_{OUT} = 0.9 $V_{DD}/2$, V_{DD} = 5.0V
$\overline{CS}$ High to Amplifier Output High-Z	t_{OFF}	—	0.01	—	µs	$\overline{CS}$ High ≥ 0.8 V_{DD}, G = +1 V/V, $V_{IN} = V_{DD}/2$, V_{OUT} = 0.1 $V_{DD}/2$
Hysteresis	V_{HYST}	—	0.6	—	V	V_{DD} = 5V

Note 1: The input condition (V_{IN}) specified applies to both operational amplifiers (A and B) of MCP6275. The dynamic specification is tested at the output of operational amplifier B (V_{OUTB}).

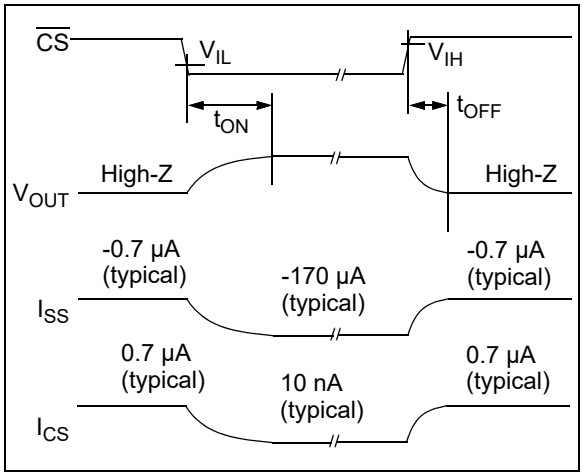


FIGURE 1-1: *Timing Diagram for the Chip Select ($\overline{CS}$) pin on MCP6273 and MCP6275.*

1.6 Test Circuits

The test circuits used for the DC and AC tests are shown in Figure 1-2 and Figure 1-3. The bypass capacitors are laid out according to the rules discussed in **Section 4.7 "Supply Bypass"**.

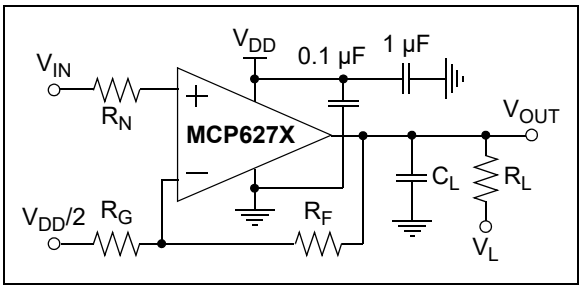


FIGURE 1-2: *AC and DC Test Circuit for Most Non-Inverting Gain Conditions.*

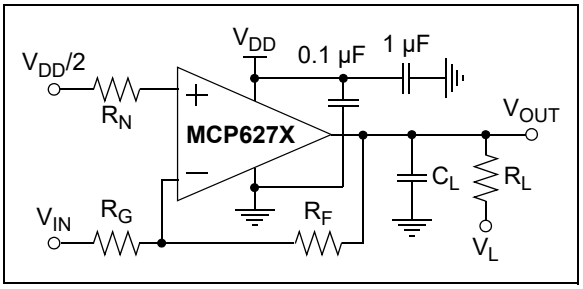


FIGURE 1-3: *AC and DC Test Circuit for Most Inverting Gain Conditions.*

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} = +2.0V to +5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2, V_L = V_{DD}/2, R_L = 10 kΩ to V_L, C_L = 60 pF and $\overline{CS}$ is tied low.

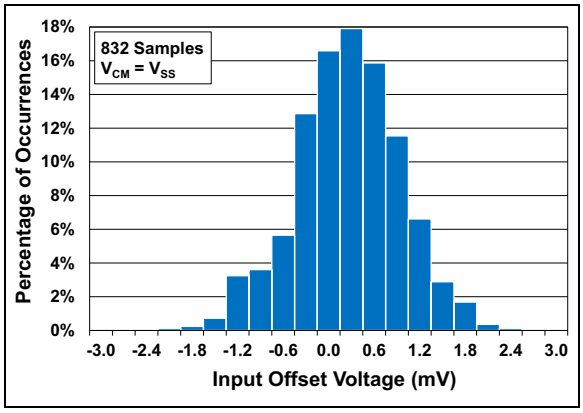


FIGURE 2-1: *Input Offset Voltage.*

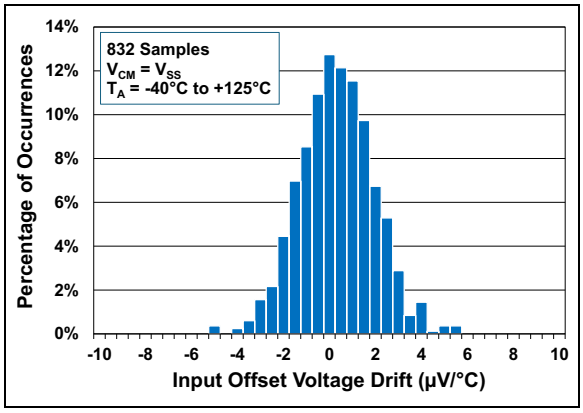


FIGURE 2-4: *Input Offset Voltage Drift.*

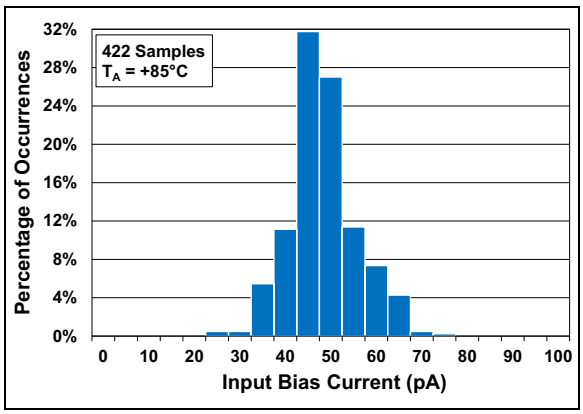


FIGURE 2-2: *Input Bias Current, T_A = +85°C.*

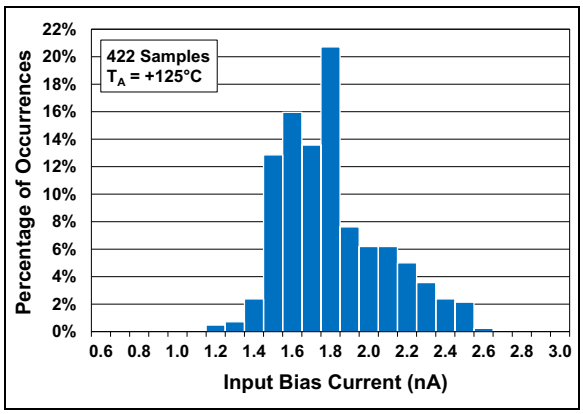


FIGURE 2-5: *Input Bias Current, T_A = +125°C.*

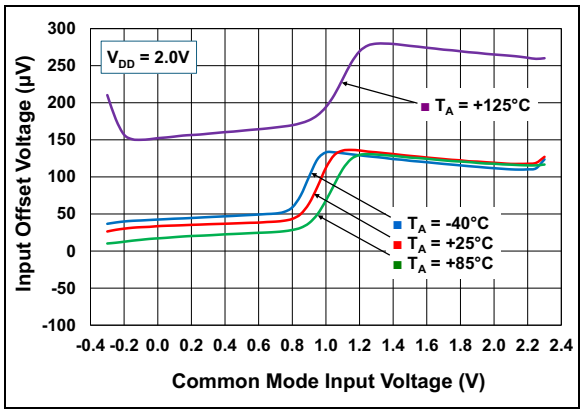


FIGURE 2-3: *Input Offset Voltage vs. Common Mode Input Voltage, V_{DD} = 2.0V.*

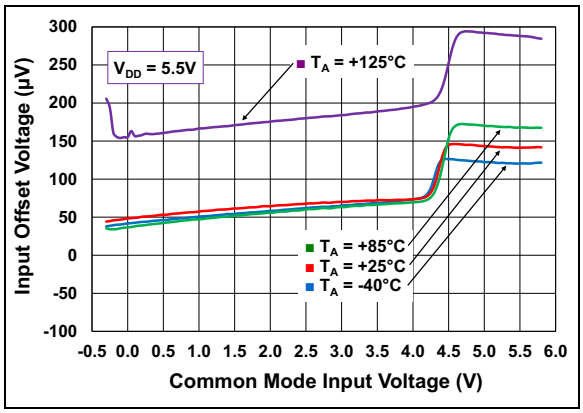


FIGURE 2-6: *Input Offset Voltage vs. Common-mode Input Voltage, V_{DD} = 5.5V.*

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.0V to +5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2, V_L = V_{DD}/2, R_L = 10 kΩ to V_L, C_L = 60 pF and $\overline{CS}$ is tied low.

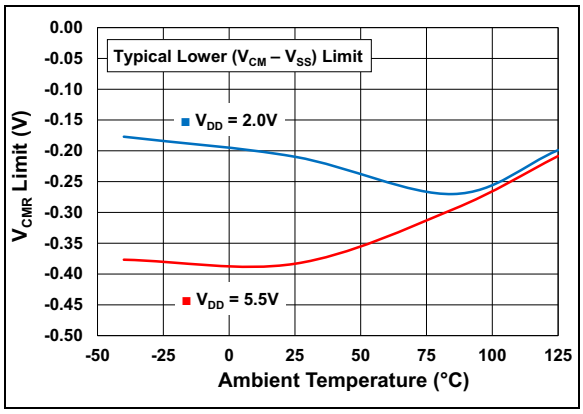


FIGURE 2-7: *Common Mode Input Voltage Range (V_{CMR}) Lower Limit vs. Temperature.*

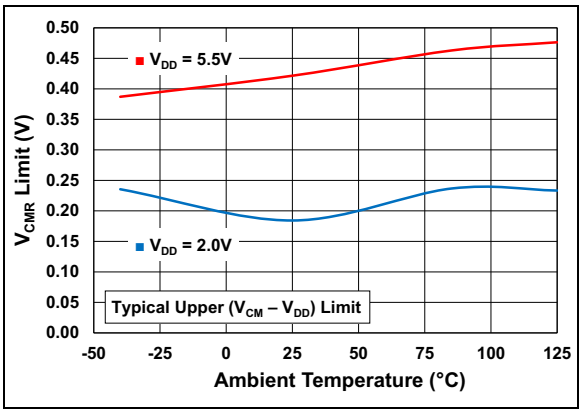


FIGURE 2-10: *Common Mode Input Voltage Range (V_{CMR}) Upper Limit vs. Temperature.*

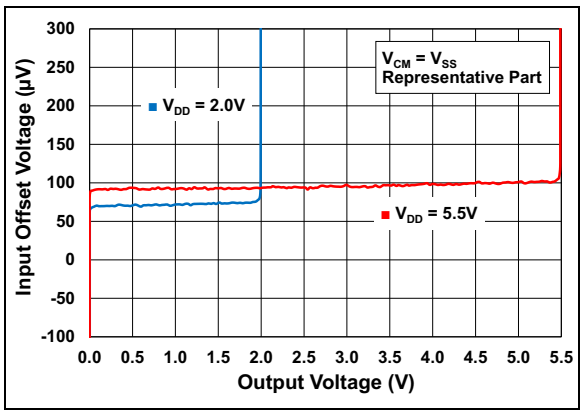


FIGURE 2-8: *Input Offset Voltage vs. Output Voltage.*

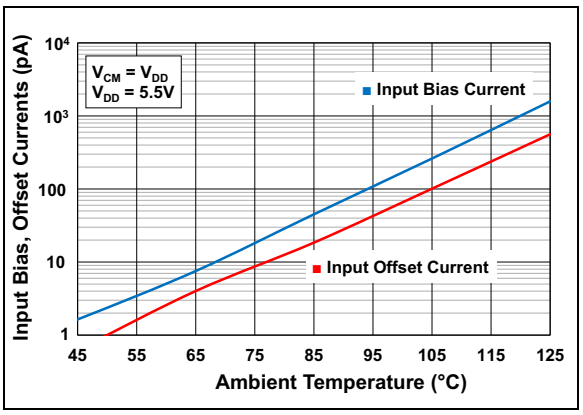


FIGURE 2-11: *Input Bias, Input Offset Currents vs. Temperature.*

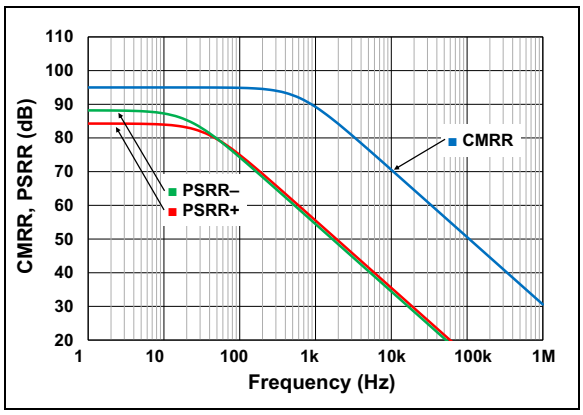


FIGURE 2-9: *CMRR, PSRR vs. Frequency.*

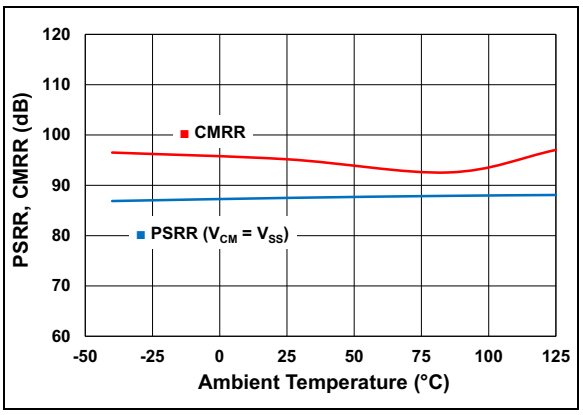


FIGURE 2-12: *CMRR, PSRR vs. Temperature.*

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.0V to +5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2, V_L = V_{DD}/2, R_L = 10 kΩ to V_L, C_L = 60 pF and $\overline{CS}$ is tied low.

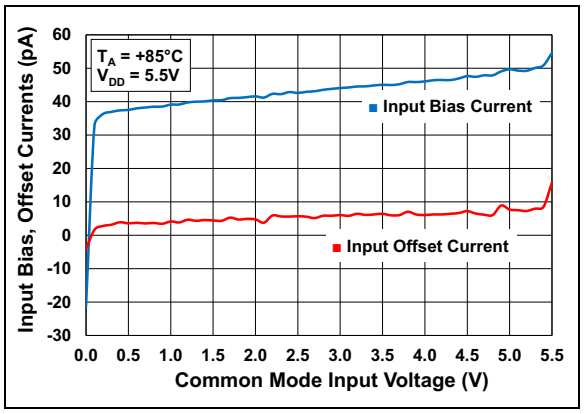


FIGURE 2-13: *Input Bias, Offset Currents vs. Common-mode Input Voltage, T_A = +85°C.*

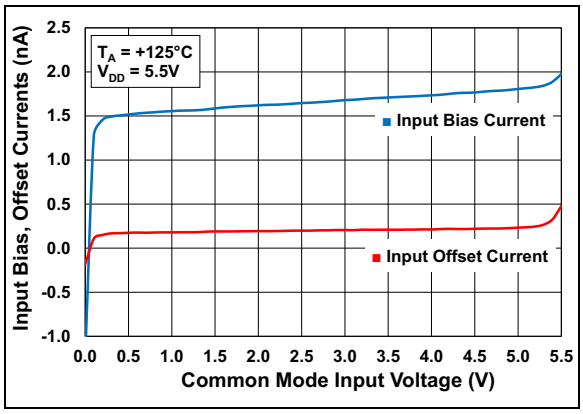


FIGURE 2-16: *Input Bias, Offset Currents vs. Common-mode Input Voltage, T_A = +125°C.*

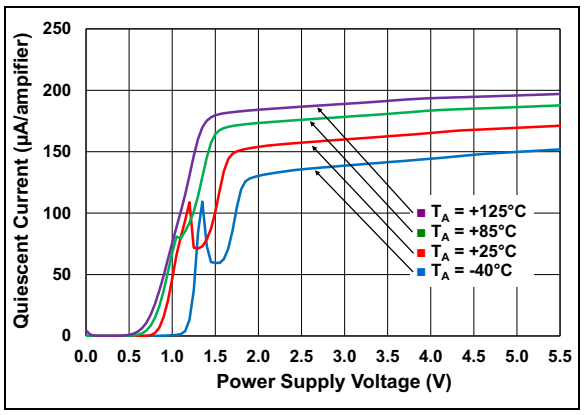


FIGURE 2-14: *Quiescent Current vs. Supply Voltage.*

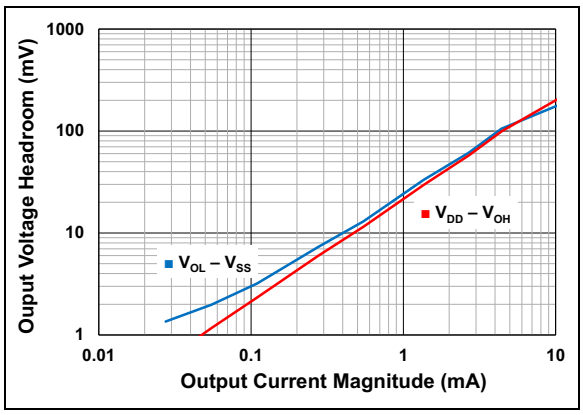


FIGURE 2-17: *Output Voltage Headroom vs. Output Current Magnitude.*

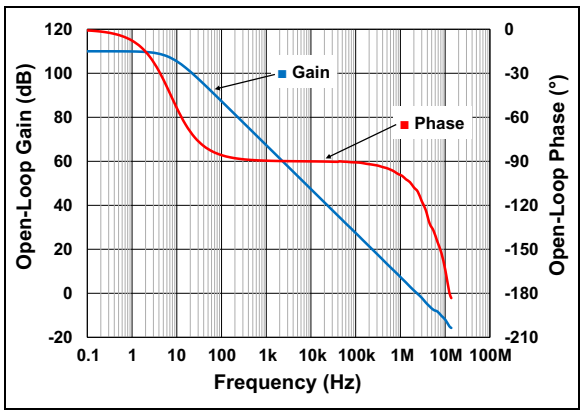


FIGURE 2-15: *Open-Loop Gain, Phase vs. Frequency.*

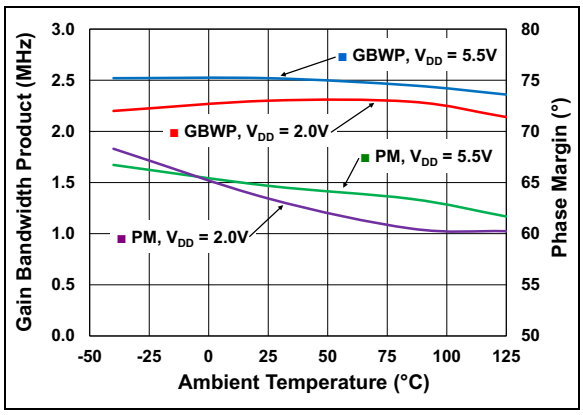


FIGURE 2-18: *Gain Bandwidth Product, Phase Margin vs. Temperature.*

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.0V to +5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2, V_L = V_{DD}/2, R_L = 10 kΩ to V_L, C_L = 60 pF and $\overline{CS}$ is tied low.

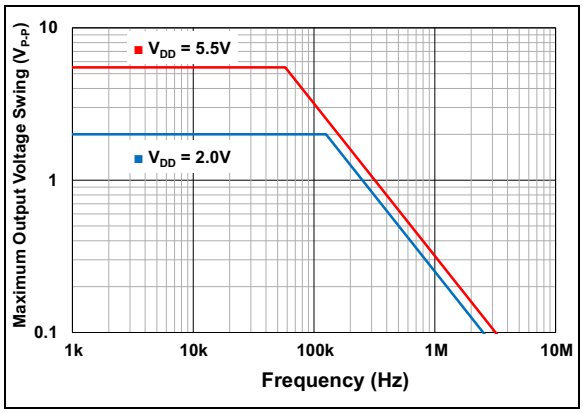


FIGURE 2-19: *Maximum Output Voltage Swing vs. Frequency.*

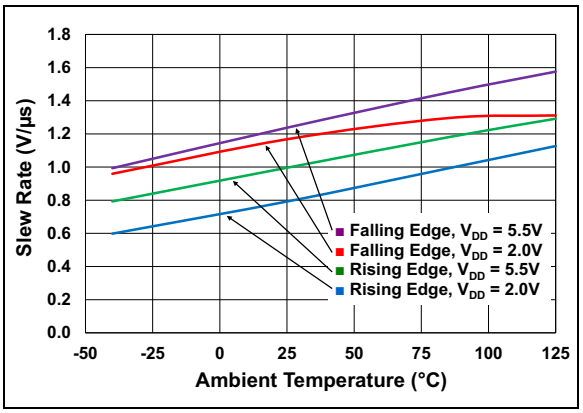


FIGURE 2-22: *Slew Rate vs. Temperature.*

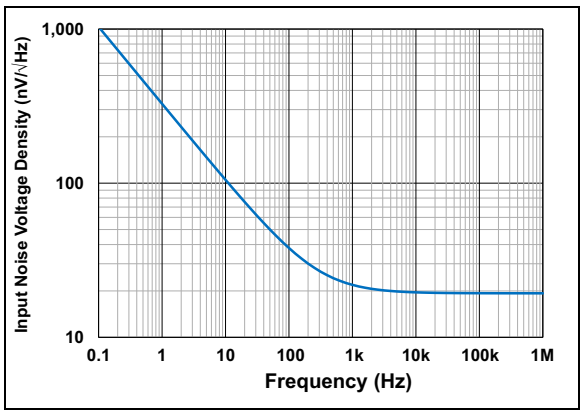


FIGURE 2-20: *Input Noise Voltage Density vs. Frequency.*

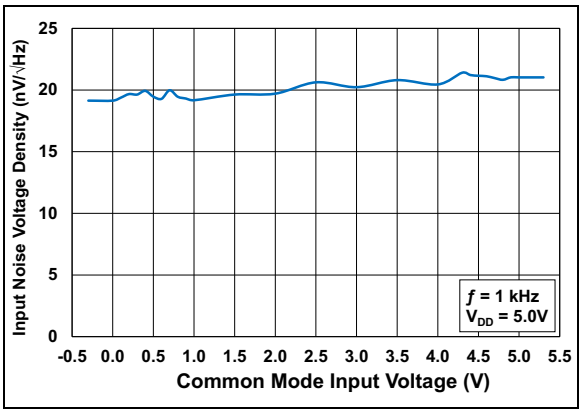


FIGURE 2-23: *Input Noise Voltage Density vs. Common-mode Input Voltage, ƒ = 1 kHz.*

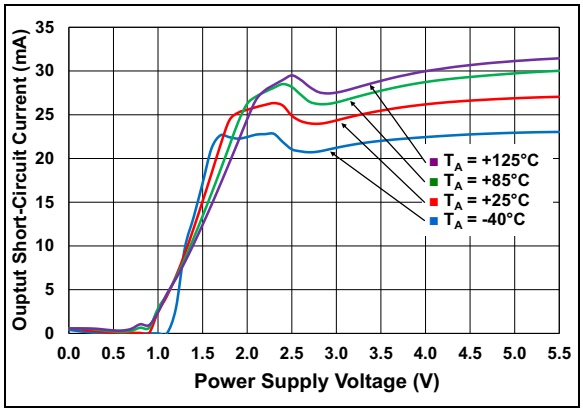


FIGURE 2-21: *Output Short Circuit Current vs. Supply Voltage.*

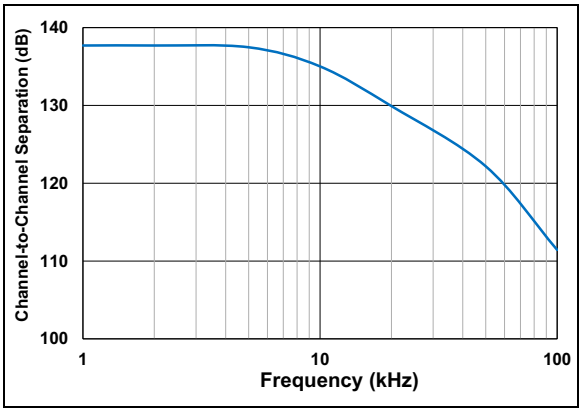


FIGURE 2-24: *Channel-to-Channel Separation vs. Frequency (MCP6272 and MCP6274 only).*

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.0V to +5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2, V_L = V_{DD}/2, R_L = 10 kΩ to V_L, C_L = 60 pF and $\overline{CS}$ is tied low.

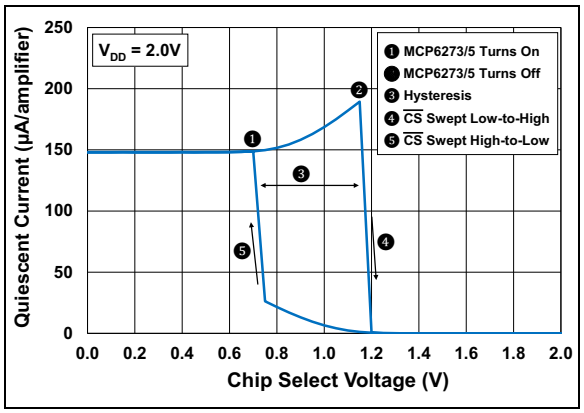


FIGURE 2-25: *Quiescent Current vs. Chip Select ($\overline{CS}$) Voltage, V_{DD} = 2.0V (MCP6273 and MCP6275 only).*

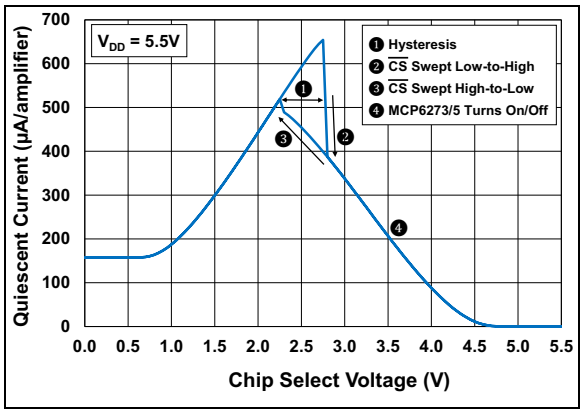


FIGURE 2-28: *Quiescent Current vs. Chip Select ($\overline{CS}$) Voltage, V_{DD} = 5.5V (MCP6273 and MCP6275 only).*

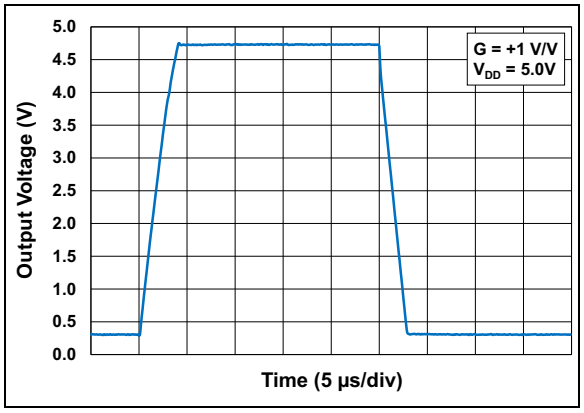


FIGURE 2-26: *Large Signal Non-inverting Pulse Response.*

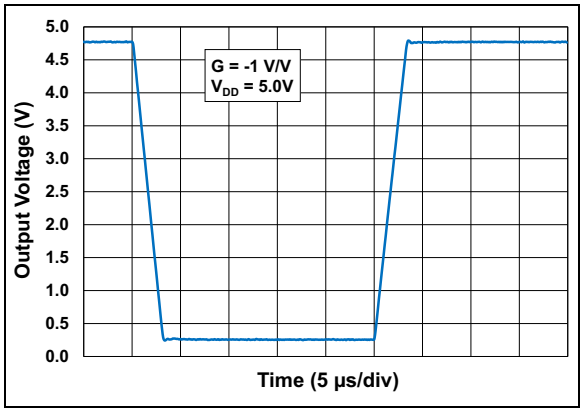


FIGURE 2-29: *Large Signal Inverting Pulse Response.*

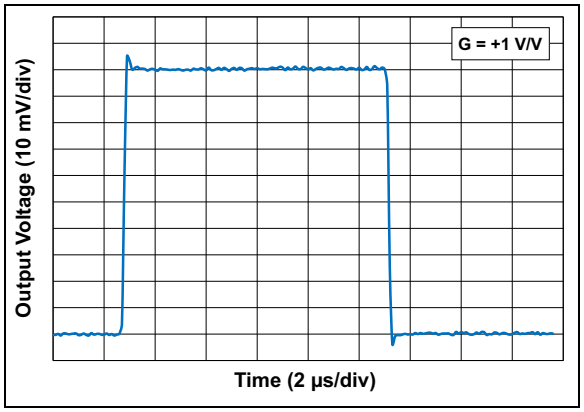


FIGURE 2-27: *Small Signal Non-inverting Pulse Response.*

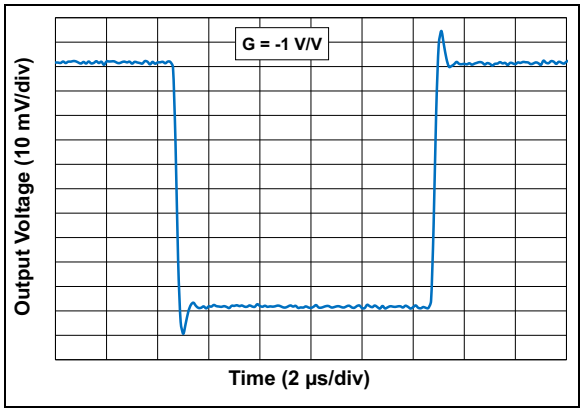


FIGURE 2-30: *Small Signal Inverting Pulse Response.*

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.0V to +5.5V, V_{SS} = GND, V_{CM} = $V_{DD}/2$, $V_{OUT} \approx V_{DD}/2$, $V_L = V_{DD}/2$, R_L = 10 kΩ to V_L, C_L = 60 pF and $\overline{CS}$ is tied low.

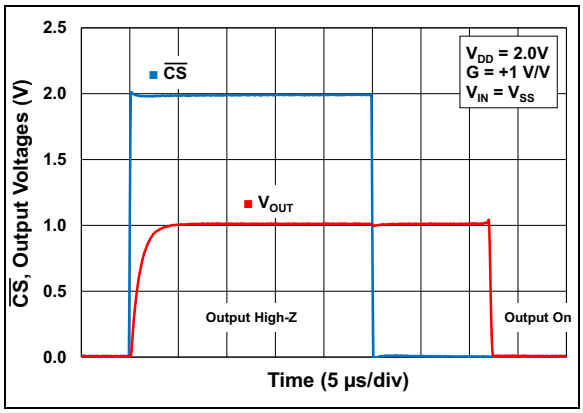


FIGURE 2-31: *Chip Select ($\overline{CS}$) to Amplifier Output Response Time, V_{DD} = 2.0V (MCP6273 and MCP6275 only).*

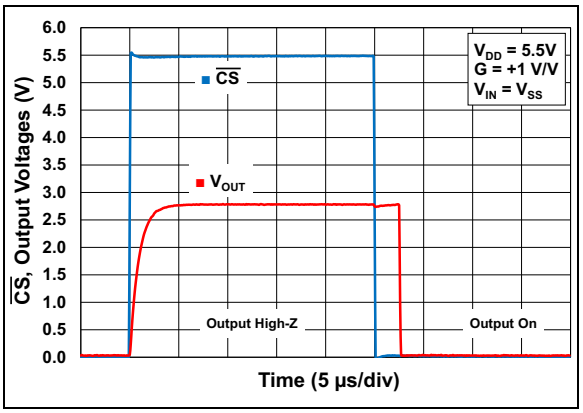


FIGURE 2-33: *Chip Select ($\overline{CS}$) to Amplifier Output Response Time, V_{DD} = 5.5V (MCP6273 and MCP6275 only).*

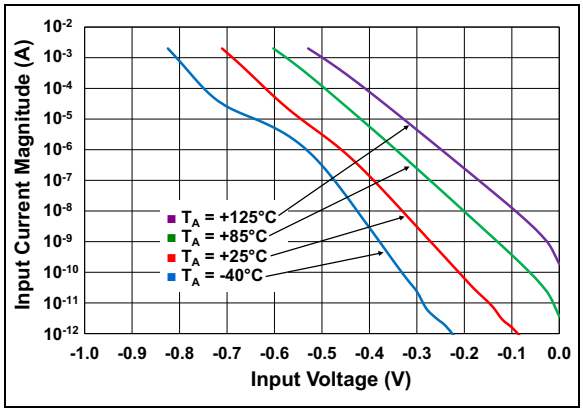


FIGURE 2-32: *Input Current vs. Input Voltage.*

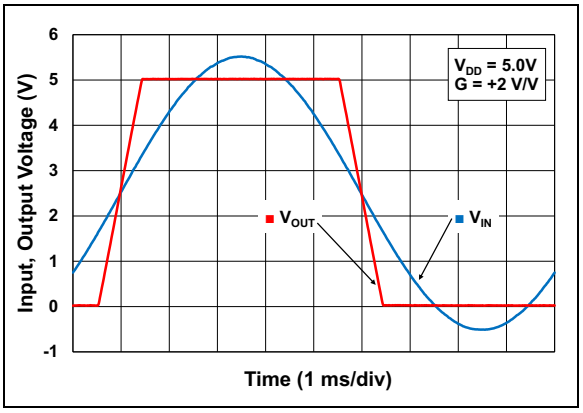


FIGURE 2-34: *MCP6271/1R/2/3/4/5 Shows No Phase Reversal.*

3.0 PIN DESCRIPTIONS

Pin descriptions for single operational amplifiers are listed in Table 3-1 and for dual and quad operational amplifiers in Table 3-2.

TABLE 3-1: PIN FUNCTION TABLE FOR SINGLE OPERATIONAL AMPLIFIERS

MCP6271		MCP6271R	MCP6273		Symbol	Description
PDIP, SOIC, MSOP	SOT-23-5	SOT-23-5	PDIP, SOIC, MSOP	SOT-23-6		
2	4	4	2	4	V_{IN-}	Inverting Input
3	3	3	3	3	V_{IN+}	Non-inverting Input
4	2	5	4	2	V_{SS}	Negative Power Supply
6	1	1	6	1	V_{OUT}	Analog Output
7	5	2	7	6	V_{DD}	Positive Power Supply
—	—	—	8	5	$\overline{CS}$	Chip Select
1,5,8	—	—	1,5	—	NC	No Internal Connection

TABLE 3-2: PIN FUNCTION TABLE FOR DUAL AND QUAD OPERATIONAL AMPLIFIERS

MCP6272	MCP6274	MCP6275	Symbol	Description
1	1	—	V_{OUTA}	Analog Output (operational amplifier A)
2	2	2	V_{INA-}	Inverting Input (operational amplifier A)
3	3	3	V_{INA+}	Non-inverting Input (operational amplifier A)
8	4	8	V_{DD}	Positive Power Supply
5	5	—	V_{INB+}	Non-inverting Input (operational amplifier B)
6	6	6	V_{INB-}	Inverting Input (operational amplifier B)
7	7	7	V_{OUTB}	Analog Output (operational amplifier B)
—	8	—	V_{OUTC}	Analog Output (operational amplifier C)
—	9	—	V_{INC-}	Inverting Input (operational amplifier C)
—	10	—	V_{INC+}	Non-inverting Input (operational amplifier C)
4	11	4	V_{SS}	Negative Power Supply
—	12	—	V_{IND+}	Non-inverting Input (operational amplifier D)
—	13	—	V_{IND-}	Inverting Input (operational amplifier D)
—	14	—	V_{OUTD}	Analog Output (operational amplifier D)
—	—	1	V_{OUTA} V_{INB+}	Analog Output (operational amplifier A)/ Non-inverting Input (operational amplifier B)
—	—	5	$\overline{CS}$	Chip Select

3.1 Analog Outputs

The output pins are low impedance voltage sources.

3.2 Analog Inputs

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

3.3 V_{OUTA}/V_{INB+} Pin for MCP6275

For MCP6275, the output of operational amplifier A is connected directly to the non-inverting input of operational amplifier B; this is the V_{OUTA}/V_{INB+} pin. This connection makes it possible to provide a $\overline{CS}$ pin for dual operational amplifiers in 8-pin packages.

3.4 Chip Select ($\overline{CS}$) Pin

This is a CMOS, Schmitt-triggered digital input that places the part into a low-power mode of operation.

3.5 Power Supply Pins

The positive power supply (V_{DD}) is 2.0V-to-6.0V 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} needs bypass capacitors.

NOTES:

4.0 APPLICATION INFORMATION

MCP6271/1R/2/3/4/5 operational amplifiers are manufactured using Microchip's state of the art CMOS process, specifically designed for low cost, low power and general purpose applications. The low supply voltage, low quiescent current and wide bandwidth makes MCP6271/1R/2/3/4/5 ideal for battery powered applications.

4.1 Rail-to-Rail Inputs

4.1.1 PHASE REVERSAL

The input devices are designed to not exhibit phase inversion when the input pins exceed supply voltages. Figure 2-34 shows an input voltage exceeding both supplies with no phase inversion.

4.1.2 INPUT VOLTAGE AND CURRENT LIMITS

The Electrostatic Discharge (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 voltages that go too far above V_{DD}; their breakdown voltage is high enough to allow normal operation and low enough to bypass quick ESD events within the specified limits.

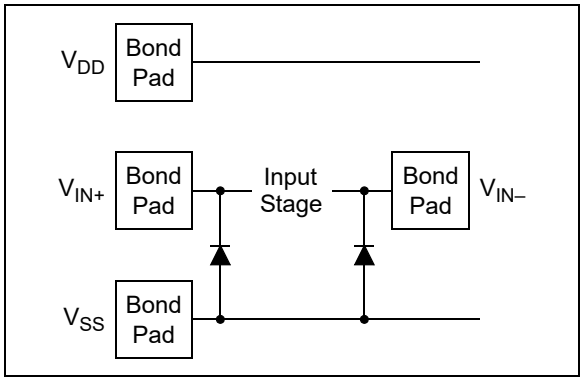


FIGURE 4-1: *Simplified Analog Input ESD Structures.*

To prevent damage and/or improper operation of these amplifiers, the circuit must limit the currents (and voltages) at the input pins (see Absolute Maximum Ratings (†)). Figure 4-2 shows the recommended approach to protecting these inputs. The internal ESD diodes prevent the input pins (V_{IN+} and V_{IN-}) from going too far below ground, and 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_{IN+} and V_{IN-}) from going too far above V_{DD} and dump any currents into V_{DD}. When implemented as in Figure 4-2, resistors R_1 and R_2 also limit the current through D_1 and D_2.

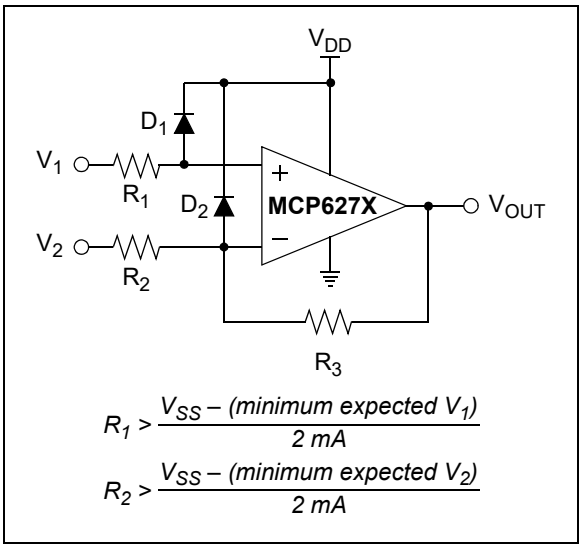


FIGURE 4-2: *Protecting the Analog Inputs.*

It is also possible to connect the diodes to the left of resistors R_1 and R_2. In this case, the currents through 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 current into the input pins (V_{IN+} and V_{IN-}) is very small.

A significant amount of current can flow out of the inputs (through the ESD diodes) when the Common mode voltage (V_{CM}) is below ground (V_{SS}); see Figure 2-32. Applications that are high impedance may need to limit the usable voltage range.

4.1.3 NORMAL OPERATIONS

The input stage of MCP6271/1R/2/3/4/5 uses two differential CMOS input stages in parallel. One operates at low V_{CM} and the other at high V_{CM}. With this topology, the input operates with V_{CM} up to 0.3V past either supply rail (see Figure 2-7 and Figure 2-10). The input offset voltage (V_{OS}) is measured at $V_{CM} = V_{SS} - 0.3V$ and $V_{DD} + 0.3V$ to ensure proper operation.

The transition between the two input stages occurs when $V_{CM} \approx V_{DD} - 1.1V$ (see Figure 2-3 and Figure 2-6). For the best distortion and gain linearity with non-inverting gains, avoid this region of operation.

4.2 Rail-to-Rail Output

The output voltage range of MCP6271/1R/2/3/4/5 is $V_{DD} - 15$ mV (minimum) and $V_{SS} + 15$ mV (maximum), when $R_L = 10$ kΩ is connected to $V_{DD}/2$ and $V_{DD} = 5.5V$. See Figure 2-17 for more information.

4.3 Capacitive Loads

Driving large capacitive loads can cause stability problems for voltage feedback operational amplifiers. 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. A unity gain buffer (G = +1 V/V) is the most sensitive to capacitive loads, though all gains show the same general behavior.

When driving large capacitive loads with these operational amplifiers (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 is generally lower than the bandwidth with no capacitive load.

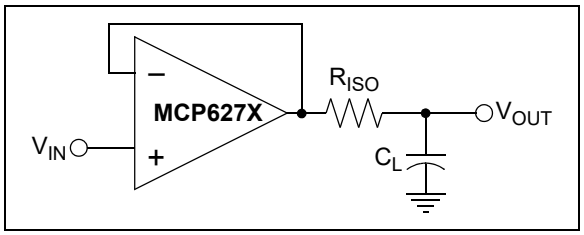


FIGURE 4-3: *Output Resistor, R_{ISO} stabilizes large capacitive loads.*

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, $G_N = Signal\ Gain$. For inverting gains, $G_N = 1 + |Signal\ Gain|$ (for example, -1 V/V gives G_N = +2 V/V).

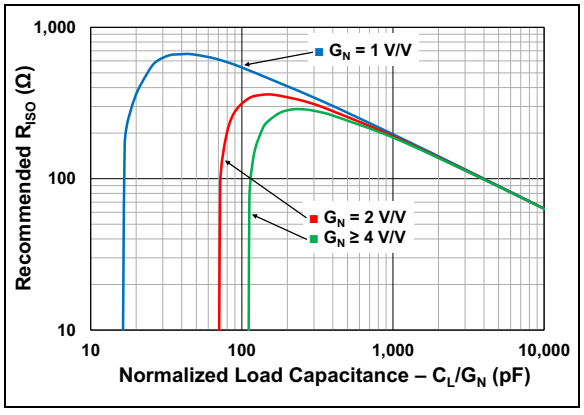


FIGURE 4-4: *Recommended R_{ISO} Values for Capacitive Loads.*

After selecting R_{ISO} for the circuit, double-check the resulting frequency response peaking and step response overshoot. Modify R_{ISO}'s value until the response is reasonable. Bench evaluation and simulations with the MCP6271/1R/2/3/4/5 SPICE macro model are helpful.

4.4 MCP6273/5 Chip Select

MCP6273 and MCP6275 are single and dual operational amplifiers with Chip Select ($\overline{CS}$), respectively. When $\overline{CS}$ is pulled high, the supply current drops to 0.7 µA (typical) and flows through the $\overline{CS}$ pin to V_{SS}. When this happens, the amplifier output is put into a high impedance state. By pulling $\overline{CS}$ low, the amplifier is enabled. The $\overline{CS}$ pin has an internal 5 MΩ (typical) pull-down resistor connected to V_{SS}, so it goes low if the $\overline{CS}$ pin is left floating. Figure 1-1 shows the output voltage and supply current response to a $\overline{CS}$ pulse.

4.5 Cascaded Dual Operational Amplifiers (MCP6275)

The MCP6275 is a dual operational amplifier with Chip Select ($\overline{CS}$). The $\overline{CS}$ input is available on what is the non-inverting input of a standard dual operational amplifier (pin 5). This pin is available because the output of operational amplifier A connects to the non-inverting input of operational amplifier B, as shown in Figure 4-5. The $\overline{CS}$ input, which can be connected to a microcontroller I/O line, puts the device in low power mode. Refer to **Section 4.4 "MCP6273/5 Chip Select"**.

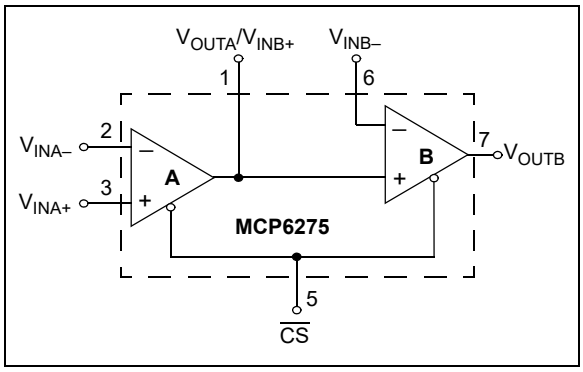


FIGURE 4-5: *Cascaded Gain Amplifier.*

The output of operational amplifier A is loaded by the input impedance of operational amplifier B, which is typically 10^{13}Ω||6 pF, as specified in the DC Electrical Specifications table. Refer to **Section 4.3 "Capacitive Loads"** for further details regarding capacitive loads.

The Common mode input voltage range (V_{CMR}) of these operational amplifiers is specified in the data sheet as V_{SS} – 300 mV to V_{DD} + 300 mV. However, the output of operational amplifier A is limited to V_{OL} and V_{OH} (20 mV from the rails with a 10 kΩ load); therefore, the non-inverting input range of operational amplifier B is limited to the V_{CMR} of V_{SS} + 20 mV to V_{DD} – 20 mV.

4.6 Unused Amplifiers

An unused operational amplifier in a quad package (MCP6274) must be configured as shown in Figure 4-6. These circuits prevent the output from toggling and causing crosstalk. In Circuit A, resistors R_1 and R_2 produce a voltage within its output voltage range (V_{OH}, V_{OL}). The operational amplifier buffers this voltage, which can be used elsewhere in the circuit. Circuit B uses the minimum number of components and operates as a comparator.

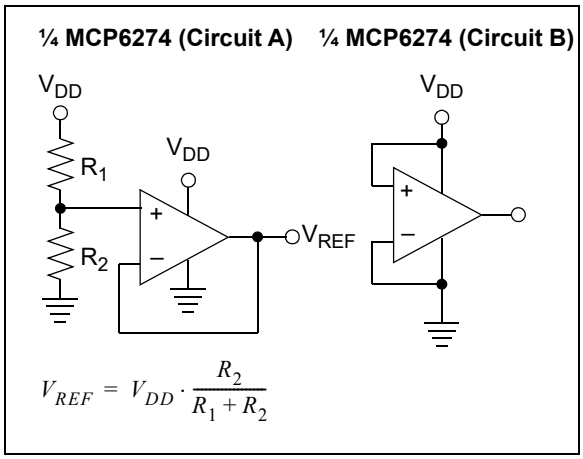


FIGURE 4-6: *Unused operational amplifiers.*

4.7 Supply Bypass

With this family of operational amplifiers, the power supply pin (V_{DD} for single supply) must have a local bypass capacitor (i.e., 0.01 µF to 0.1 µF) within 2 mm for good, high-frequency performance. It also needs a bulk capacitor (i.e., 1 µF or larger) within 100 mm to provide large, slow currents. This bulk capacitor can be shared with nearby analog parts.

4.8 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 can cause a current of 5 pA to flow. This is greater than the MCP6271/1R/2/3/4/5's bias current at +25°C of 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 illustrated in Figure 4-7.

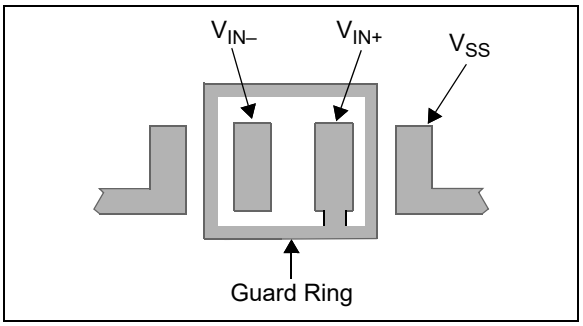


FIGURE 4-7: *Example Guard Ring Layout for Inverting Gain.*

1. For inverting gain and transimpedance 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 operational amplifier (e.g., $V_{DD}/2$ or ground).
   b) Connect the inverting pin (V_{IN-}) to the input with a wire that does not touch the PCB surface.
2. For non-inverting gain and unity gain buffer:
   a) Connect the non-inverting pin (V_{IN+}) to the input with a wire that does not touch the PCB surface.
   b) Connect the guard ring to the inverting input pin (V_{IN-}). This biases the guard ring to V_{CM}.

4.9 Application Circuits

4.9.1 ACTIVE FULL-WAVE RECTIFIER

MCP6271/1R/2/3/4/5 can be used in applications such as an Active Full-Wave Rectifier or an Absolute Value circuit, as shown in Figure 4-8. The amplifier and feedback loops in this active voltage rectifier circuit eliminate the diode drop problem that exists in a passive voltage rectifier. This circuit behaves as a follower (the output follows the input) as long as the input signal is more positive than the reference voltage. However, if the input signal is more negative than the reference voltage, the circuit behaves as an inverting amplifier. Therefore, the output voltage is always above the reference voltage, regardless of the input signal.

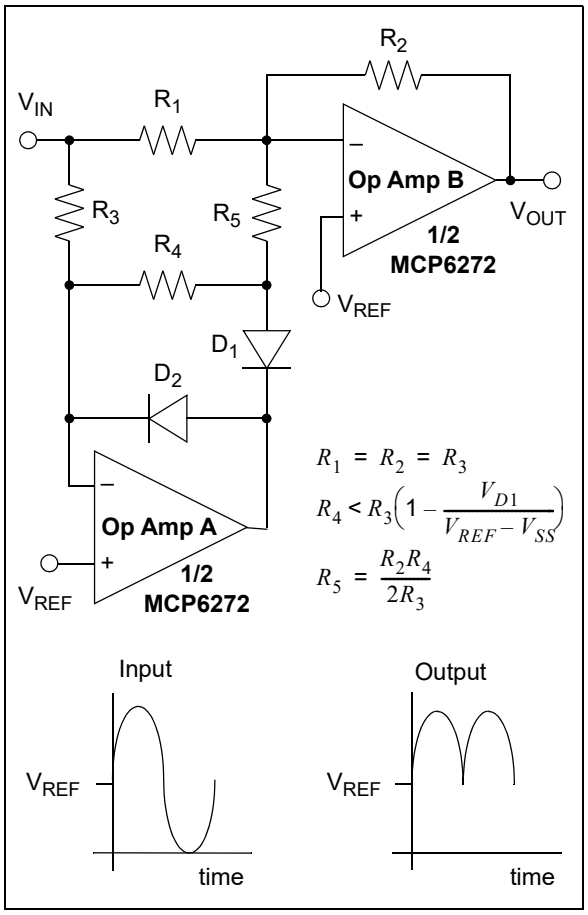


FIGURE 4-8: *Active Full-wave Rectifier.*

The design equations give a gain of ±1 V/V from V_{IN} to V_{OUT} and produce rail-to-rail outputs.

4.9.2 LOSSY NON-INVERTING INTEGRATOR

The non-inverting integrator shown in Figure 4-9 is easy to build. It saves one operational amplifier over the typical Miller integrator plus inverting amplifier configuration. The phase accuracy of this integrator depends on the matching of the input and feedback resistor-capacitor time constants. Resistor R_F makes this a lossy integrator (it has finite gain at DC) and stable by itself.

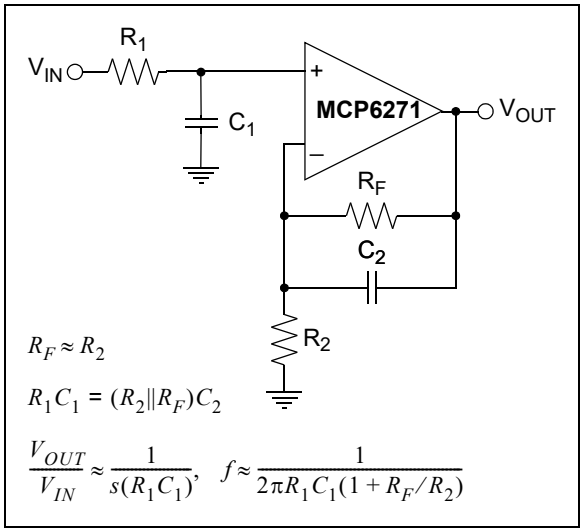


FIGURE 4-9: *Non-Inverting Integrator.*

4.9.3 CASCADED OPERATIONAL AMPLIFIER APPLICATIONS

MCP6275 provides the flexibility of Low-power mode for dual operational amplifiers in an 8-pin package. MCP6275 eliminates the added cost and space in a battery-powered application by using two single operational amplifiers with Chip Select ($\overline{CS}$) lines or a 10-pin device with one $\overline{CS}$ line for both operational amplifiers. The two operational amplifiers are internally cascaded; therefore, MCP6275 cannot be used in circuits that require active or passive elements between the two operational amplifiers. However, there are several applications where this operational amplifier configuration with a $\overline{CS}$ line becomes suitable. The following circuits show possible applications for this device.

4.9.3.1 Load Isolation

With the cascaded operational amplifier configuration, operational amplifier B can be used to isolate the load from operational amplifier A. In applications where operational amplifier A is driving capacitive or low-resistive loads in the feedback loop, such as an integrator or filter circuit, the operational amplifier can have insufficient source current to drive the load. In this case, operational amplifier B can be used as a buffer.

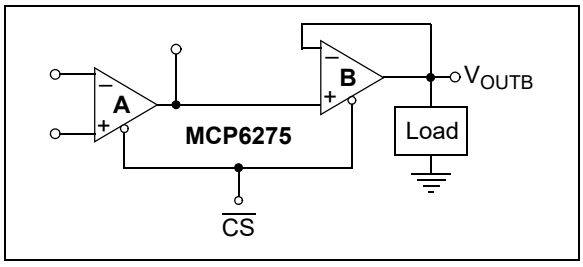


FIGURE 4-10: *Isolating the Load with a Buffer.*

4.9.3.2 Cascaded Gain

Figure 4-11 shows a cascaded gain circuit configuration with $\overline{CS}$. Operational amplifiers A and B are configured in a non-inverting amplifier configuration. In this configuration, the input offset voltage of operational amplifier A is amplified by the gain of operational amplifiers A and B, as shown in Equation 4-1.

EQUATION 4-1:

$$V_{OUT} = V_{IN}G_AG_B + V_{OSA}G_AG_B + V_{OSB}G_B$$

Where:

G_A = Operational Amplifier A Gain (V/V)

G_B = Operational Amplifier B Gain (V/V)

V_{OSA} = Operational Amplifier A Input Offset Voltage (V)

V_{OSB} = Operational Amplifier B Input Offset Voltage (V)

Therefore, Microchip recommends setting most of the gain with operational amplifier A and using operational amplifier B with a relatively small gain (for example, a unity gain buffer).

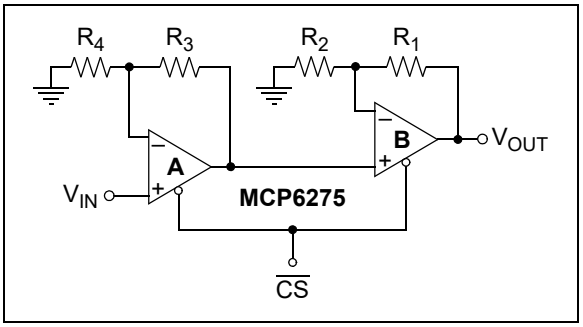


FIGURE 4-11: *Cascaded Gain Circuit Configuration.*

4.9.3.3 Difference Amplifier

Figure 4-12 shows operational amplifier A configured as a difference amplifier with $\overline{CS}$. In this configuration, Microchip recommends using well-matched resistors (for example, 0.1%) to increase the Common Mode Rejection Ratio (CMRR). Operational amplifier B can be used to provide additional gain and isolate the load from the difference amplifier.

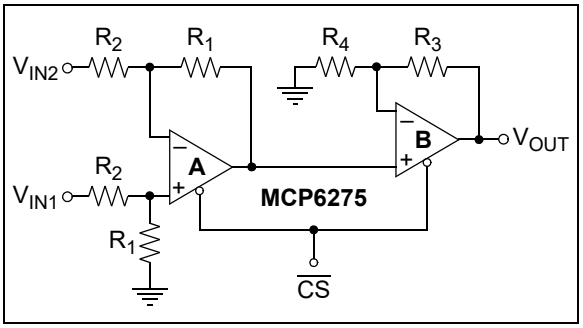


FIGURE 4-12: *Difference Amplifier Circuit.*

4.9.3.4 Inverting Integrator with Active Compensation and Chip Select

Figure 4-13 uses an active compensator (operational amplifier B) to compensate for the non-ideal operational amplifier characteristics introduced at higher frequencies. This circuit uses operational amplifier B as a unity gain buffer to isolate the integration capacitor C_1 from operational amplifier A and drives the capacitor with a low impedance source. Both operational amplifiers are matched very well; therefore, they provide a high quality integrator.

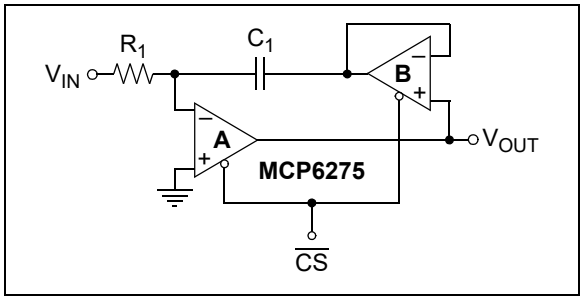


FIGURE 4-13: *Integrator Circuit with Active Compensation.*

4.9.3.5 Second Order MFB with an Extra Pole-Zero Pair

Figure 4-14 is a second order multiple feedback low-pass filter with Chip Select. Use FilterLab® from Microchip Technology Inc. to determine the resistance and capacitance values for operational amplifier A's second order filter. Operational amplifier B can be used to add a pole-zero pair using capacitor C_3 and resistors R_6 and R_7.

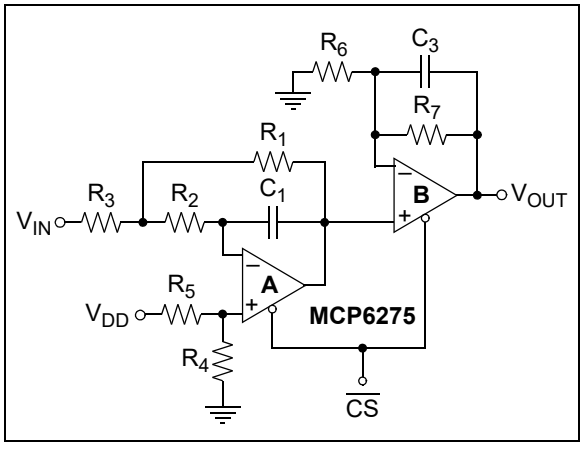


FIGURE 4-14: *Second Order Multiple Feedback Low-Pass Filter with an Extra Pole-Zero Pair.*

4.9.3.6 Second Order Sallen-Key with an Extra Pole-Zero Pair

Figure 4-15 is a second order Sallen-Key low-pass filter with CS. Use Filterlab from Microchip Technology Inc. to determine the resistance and capacitance values for operational amplifier A's second-order filter. Operational amplifier B can be used to add a pole-zero pair using capacitor C_3 and resistors R_5 and R_6.

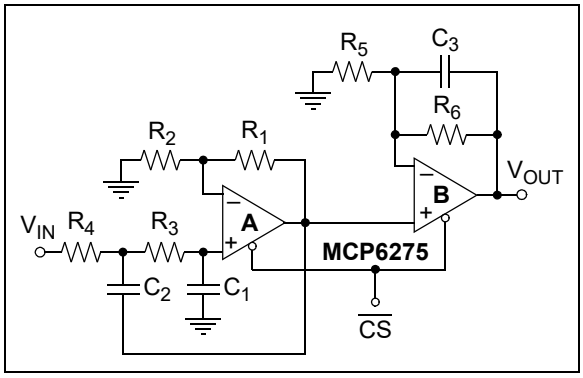


FIGURE 4-15: *Second Order Sallen-Key Low-Pass Filter with an Extra Pole-Zero Pair and Chip Select.*

4.9.3.7 Capacitorless Second Order Low-Pass Filter with Chip Select

The low-pass filter shown in Figure 4-16 does not require external capacitors and uses only three external resistors; the operational amplifier's GBWP sets the corner frequency. Resistors R_1 and R_2 are used to set the circuit gain. Resistor R_3 is used to set the quality factor (Q). To avoid gain peaking in the frequency response, Q needs to be low (lower values need to be selected for R_3). The amplifier bandwidth varies greatly over temperature and process. However, this configuration provides a low-cost solution for applications with high bandwidth requirements.

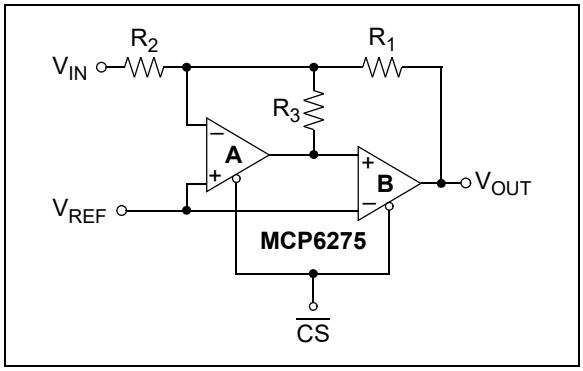


FIGURE 4-16: *Capacitorless Second Order Low-Pass Filter with Chip Select.*

5.0 DESIGN TOOLS

Microchip provides the basic design tools needed for the MCP6271/1R/2/3/4/5 family of operational amplifiers.

5.1 SPICE Macro Model

The latest SPICE macro model for MCP6271/1R/2/3/4/5 is available at microchip.com. This model is intended to be an initial design tool that works well in the operational amplifier's linear region of operation over the temperature range. See the model file for information on its capabilities.

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 tool that simplifies the analog active filter (using operational amplifiers) design. Available at no cost at 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 the active filter, amplifier and power-management applications. It is a free online circuit designer & simulator available at microchip.com/mindi. This interactive circuit designer & simulator enables designers to quickly generate circuit diagrams and simulate circuits. Circuits developed using the Mindi Circuit Designer & Simulator can be downloaded to a personal computer or workstation.

5.4 MAPS (Microchip Advanced Part Selector)

MAPS is a software tool that helps semiconductor professionals efficiently identify Microchip devices that fit a particular design requirement. Available at no cost at microchip.com/maps, the MAPS is an overall selection tool for Microchip's product portfolio that includes Analog, Memory, MCUs and DSCs. Use this tool to 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 data sheets and purchasing 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 microchipdirect.com.

Two of our boards that are especially useful are:

- **P/N SOIC8EV:** *8-pin SOIC/MSOP/TSSOP/DIP Evaluation Board*
- **P/N SOIC14EV:** *14-pin SOIC/TSSOP/DIP Evaluation Board*

5.6 Application Notes

The following Microchip Application Notes are available at 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 operational amplifiers,"* DS00884

AN990: *"Analog Sensor Conditioning Circuits – An Overview,"* DS00990

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

"Signal Chain Design Guide," DS21825

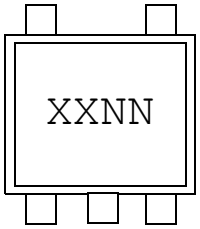
NOTES:

6.0 PACKAGING INFORMATION

6.1 Package Marking Information

5-Lead SOT-23 (**MCP6271 and MCP6271R**)

Example:

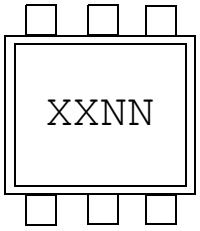


Device	Code
MCP6271	CGNN
MCP6271R	ETNN

Note: Applies to 5-Lead SOT-23

6-Lead SOT-23 (**MCP6273**)

Example:

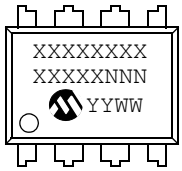


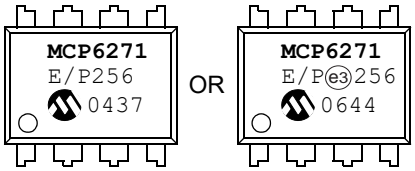
8-Lead MSOP

Example:

8-Lead PDIP (300 mil)

Example:

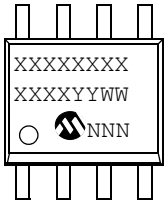




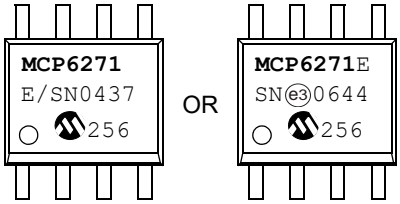
Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free 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.	

Package Marking Information (Continued)

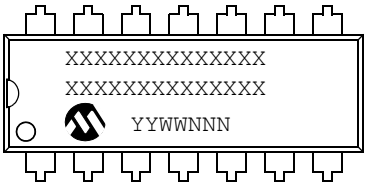
8-Lead SOIC (150 mil)



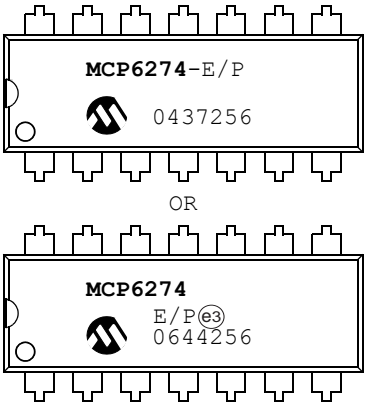
Example:



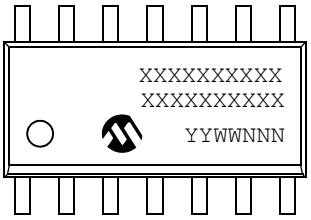
14-Lead PDIP (300 mil) **(MCP6274)**



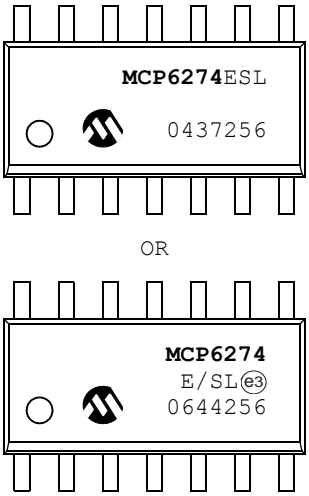
Example:



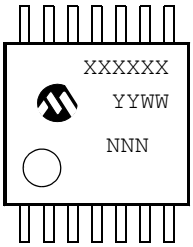
14-Lead SOIC (150 mil) **(MCP6274)**



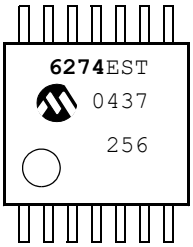
Example:



14-Lead TSSOP **(MCP6274)**



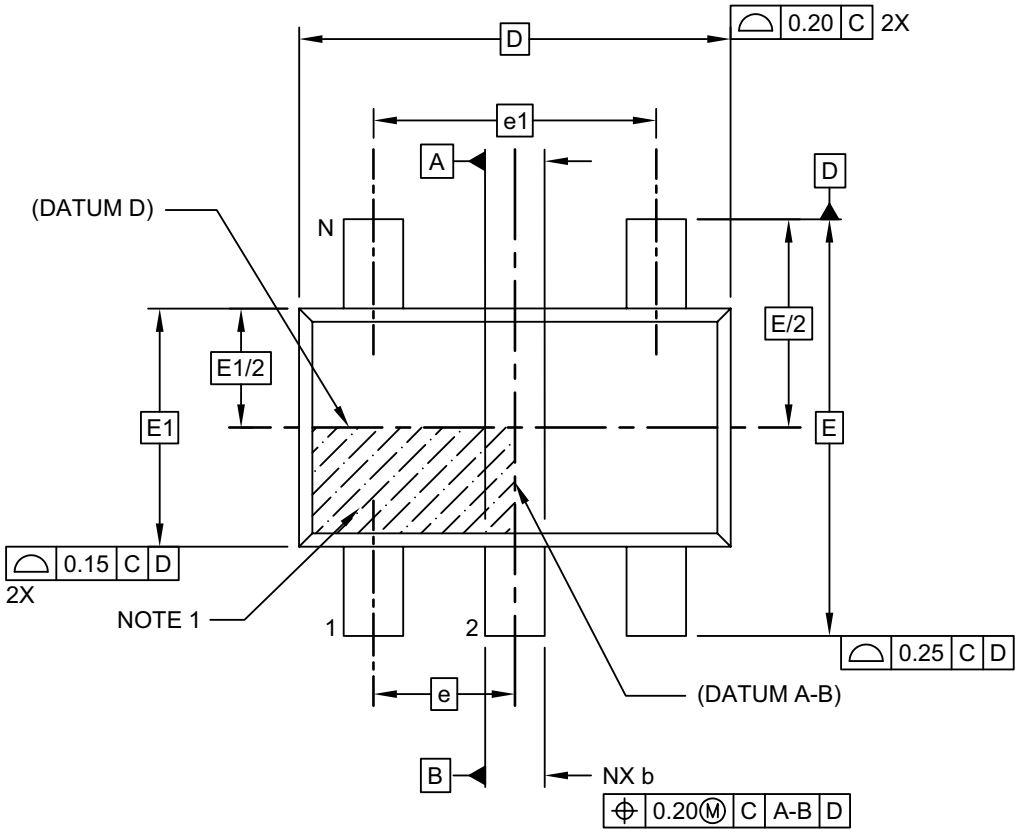
Example:



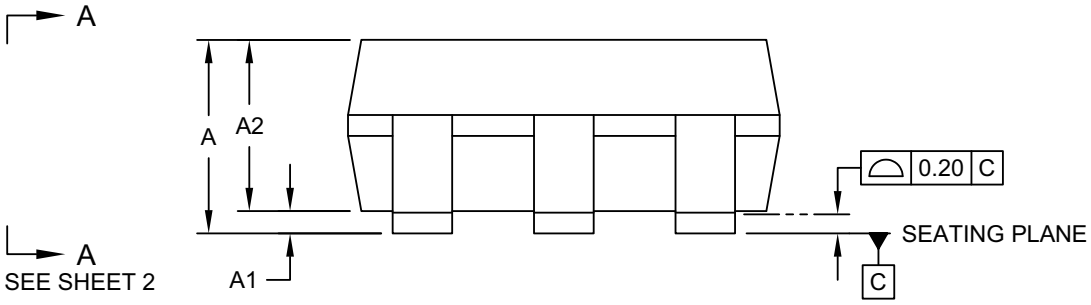
6.2 Package Drawings

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



TOP VIEW

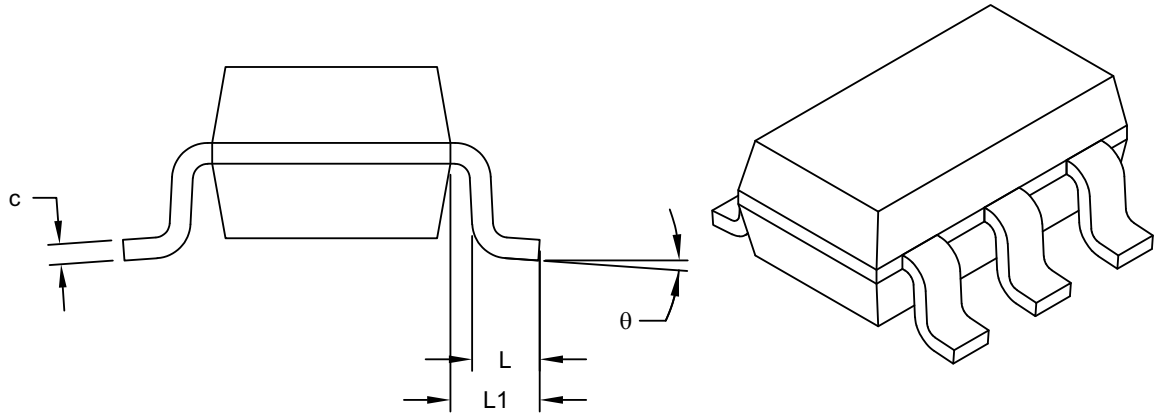


SIDE VIEW

Microchip Technology Drawing C04-091-OT Rev H Sheet 1 of 2

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



VIEW A-A
SHEET 1

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		5	
Pitch	e		0.95 BSC	
Outside lead pitch	e1		1.90 BSC	
Overall Height	A	0.90	-	1.45
Molded Package Thickness	A2	0.89	-	1.30
Standoff	A1	-	-	0.15
Overall Width	E		2.80 BSC	
Molded Package Width	E1		1.60 BSC	
Overall Length	D		2.90 BSC	
Foot Length	L	0.30	-	0.60
Footprint	L1		0.60 REF	
Foot Angle	θ	0°	-	10°
Lead Thickness	c	0.08	-	0.26
Lead Width	b	0.20	-	0.51

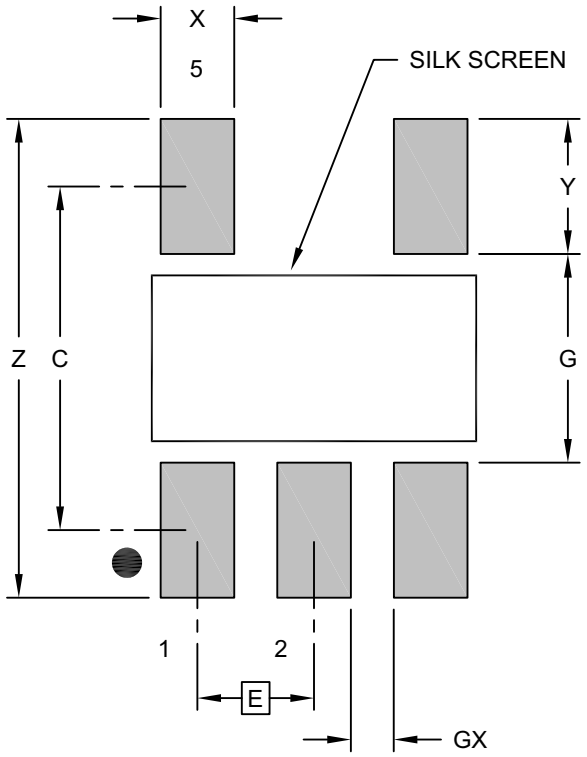
Notes:

1. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.25mm per side.
2. 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 C04-091-OT Rev H Sheet 2 of 2

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	0.95 BSC		
Contact Pad Spacing	C		2.80	
Contact Pad Width (X5)	X			0.60
Contact Pad Length (X5)	Y			1.10
Distance Between Pads	G	1.70		
Distance Between Pads	GX	0.35		
Overall Width	Z			3.90

Notes:

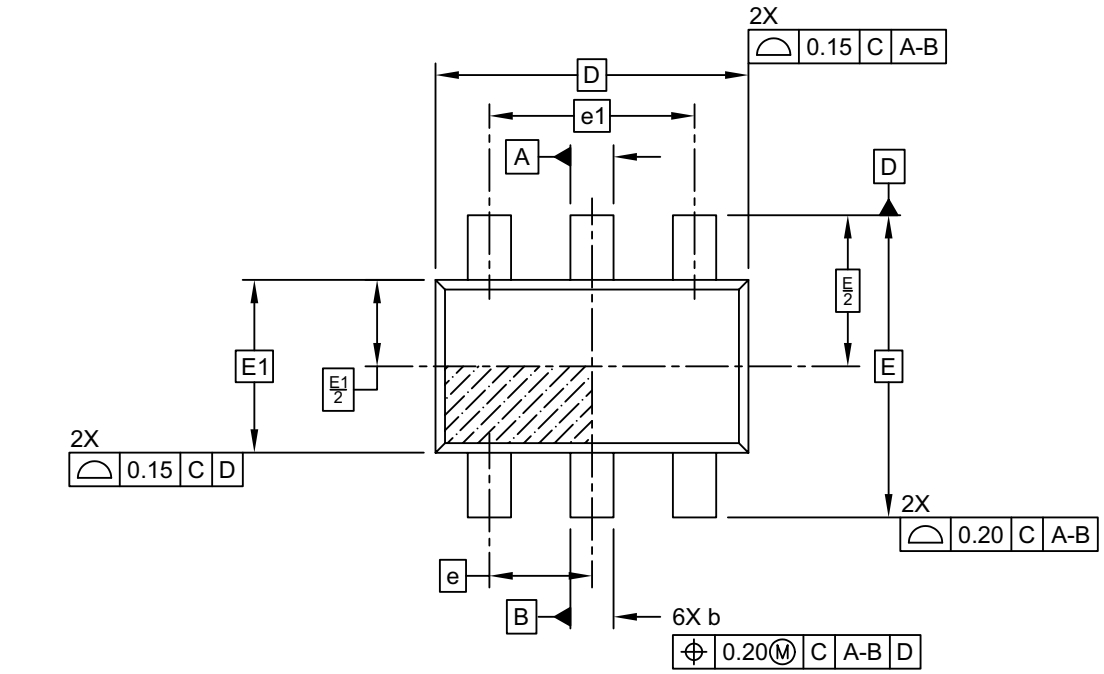
1. Dimensioning and tolerancing per ASME Y14.5M

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

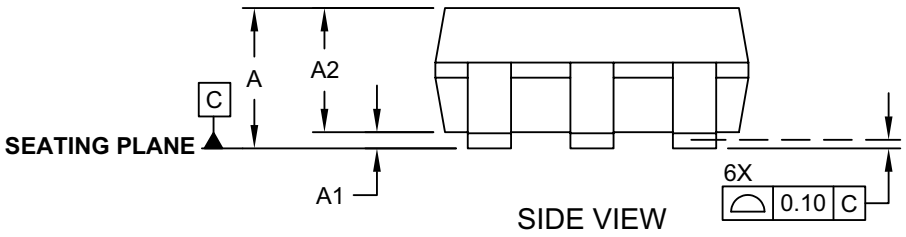
Microchip Technology Drawing No. C04-2091-OT Rev H

6-Lead Plastic Small Outline Transistor (CH) [SOT-23]

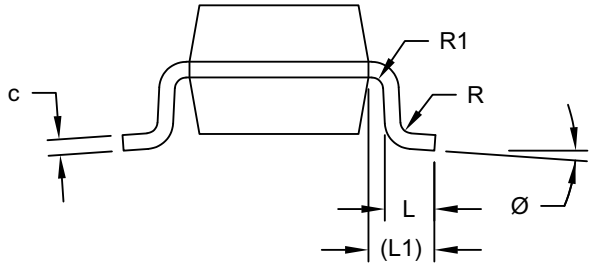
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



TOP VIEW



SIDE VIEW

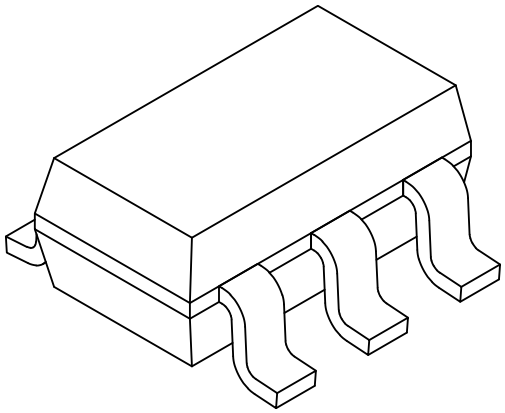


END VIEW

Microchip Technology Drawing C04-028-CH Rev. F Sheet 1 of 2

6-Lead Plastic Small Outline Transistor (CH) [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 Limits		MIN	NOM	MAX
Number of Leads	N		6	
Pitch	e		0.95 BSC	
Outside lead pitch	e1		1.90 BSC	
Overall Height	A	0.90	-	1.45
Molded Package Thickness	A2	0.89	1.15	1.30
Standoff	A1	0.00	-	0.15
Overall Width	E		2.80 BSC	
Molded Package Width	E1		1.60 BSC	
Overall Length	D		2.90 BSC	
Foot Length	L	0.30	0.45	0.60
Footprint	L1		0.60 REF	
Foot Angle	Ø	0°	-	10°
Lead Thickness	c	0.08	-	0.26
Lead Width	b	0.20	-	0.51

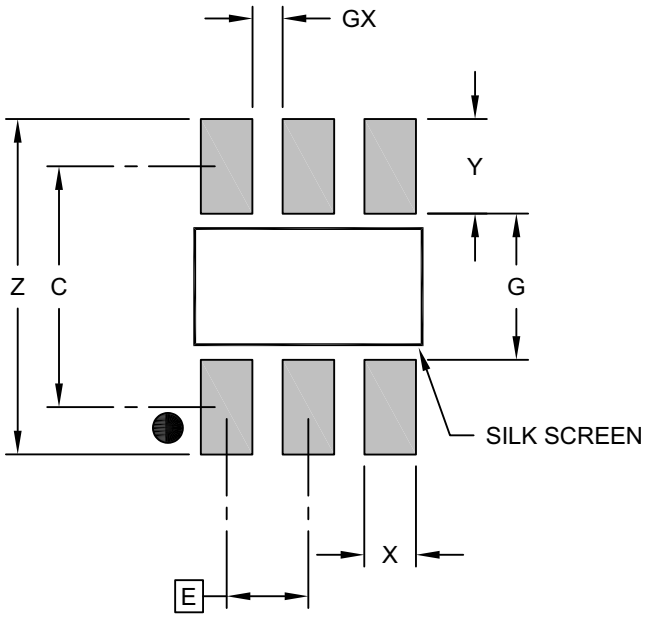
Notes:

1. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.25mm per side.
2. 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 C04-028-CH Rev.F Sheet 2 of 2

6-Lead Plastic Small Outline Transistor (CH) [SOT-23]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		0.95 BSC	
Contact Pad Spacing	C		2.80	
Contact Pad Width (X6)	X			0.60
Contact Pad Length (X6)	Y			1.10
Distance Between Pads	G	1.70		
Distance Between Pads	GX	0.35		
Overall Width	Z			3.90

Notes:

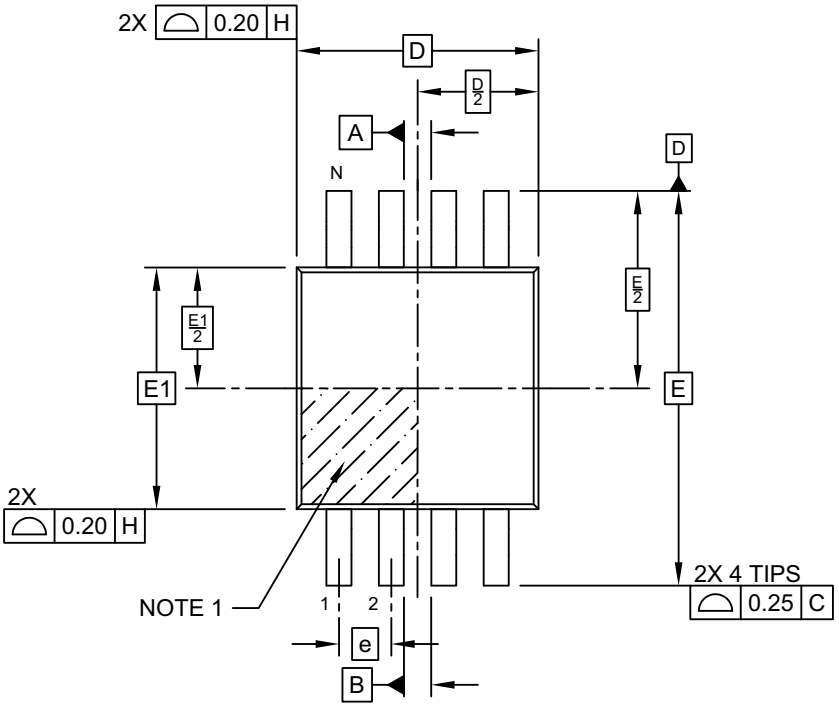
1. Dimensioning and tolerancing per ASME Y14.5M

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

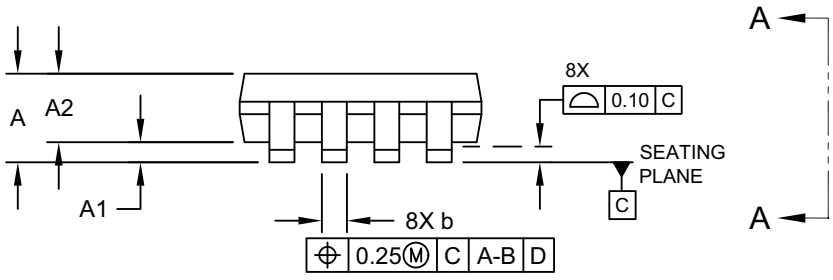
Microchip Technology Drawing No. C04-2028-CH Rev.F

8-Lead Plastic Micro Small Outline Package (MS) - 3x3 mm Body [MSOP]

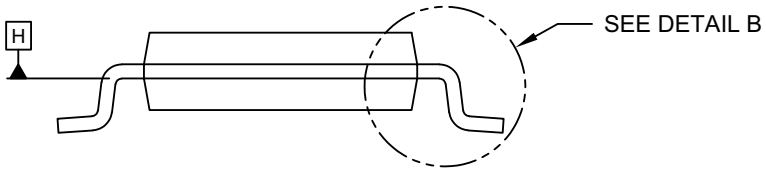
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



TOP VIEW



SIDE VIEW

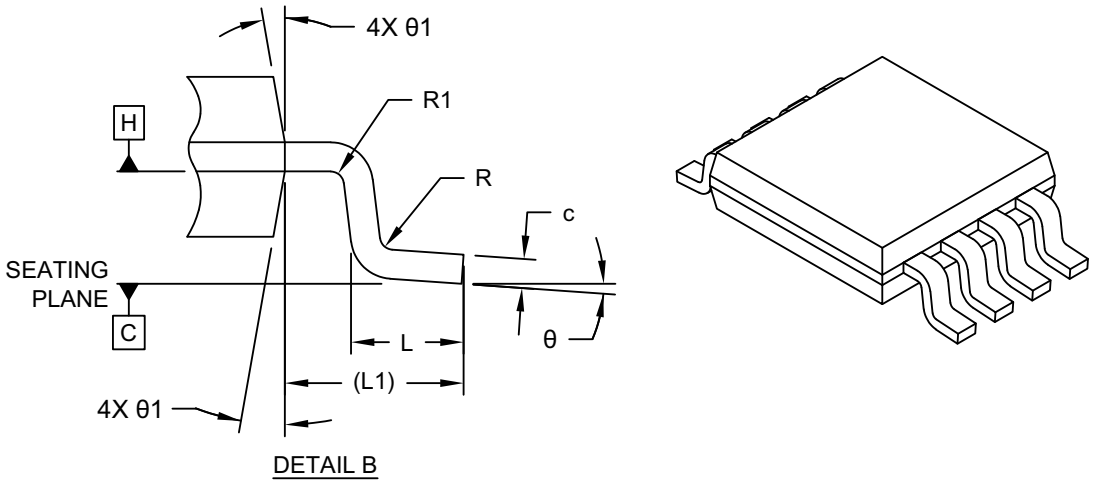


VIEW A–A

Microchip Technology Drawing C04-111-MS Rev F Sheet 1 of 2

8-Lead Plastic Micro Small Outline Package (MS) - 3x3 mm Body [MSOP]

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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N		8	
Pitch	e		0.65 BSC	
Overall Height	A	–	–	1.10
Standoff	A1	0.00	–	0.15
Molded Package Thickness	A2	0.75	0.85	0.95
Overall Length	D		3.00 BSC	
Overall Width	E		4.90 BSC	
Molded Package Width	E1		3.00 BSC	
Terminal Width	b	0.22	–	0.40
Terminal Thickness	c	0.08	–	0.23
Terminal Length	L	0.40	0.60	0.80
Footprint	L1		0.95 REF	
Lead Bend Radius	R	0.07	–	–
Lead Bend Radius	R1	0.07	–	–
Foot Angle	θ	0°	–	8°
Mold Draft Angle	θ1	5°	–	15°

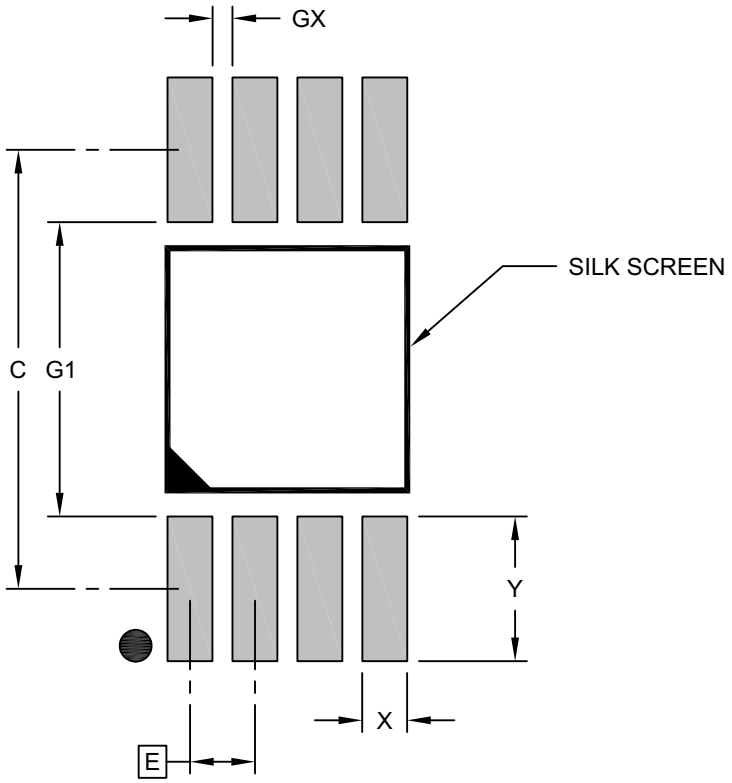
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
3. 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 C04-111-MS Rev F Sheet 2 of 2

8-Lead Plastic Micro Small Outline Package (MS) - 3x3 mm Body [MSOP]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	0.65 BSC		
Contact Pad Spacing	C		4.40	
Contact Pad Width (X8)	X			0.45
Contact Pad Length (X8)	Y			1.45
Contact Pad to Contact Pad (X4)	G1	2.95		
Contact Pad to Contact Pad (X6)	GX	0.20		

Notes:

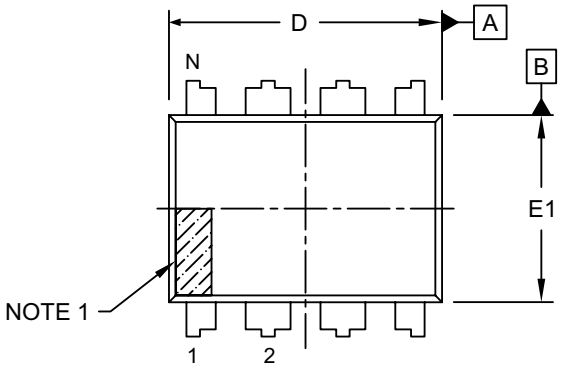
1. Dimensioning and tolerancing per ASME Y14.5M

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

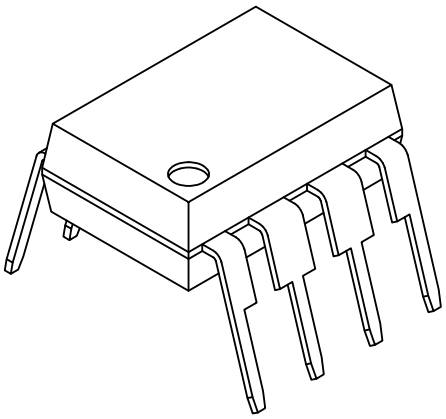
Microchip Technology Drawing C04-2111-MS Rev F

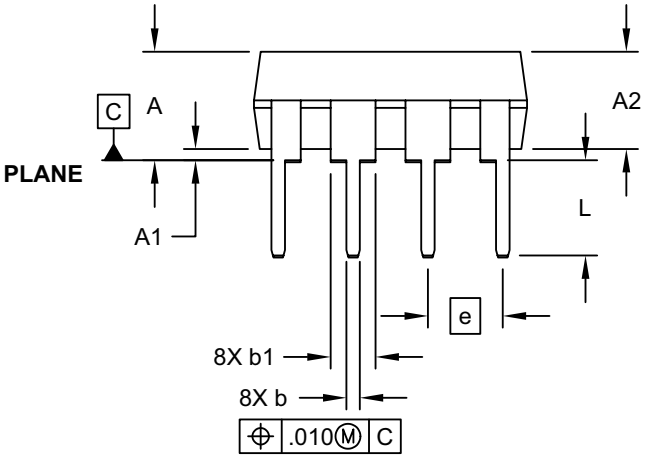
8-Lead Plastic Dual In-Line (P) - 300 mil Body [PDIP]

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

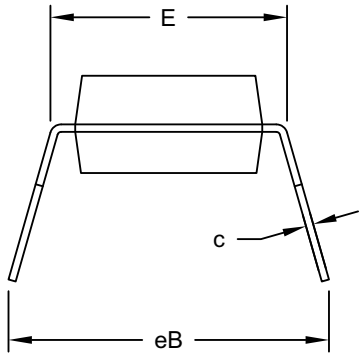


TOP VIEW





SIDE VIEW

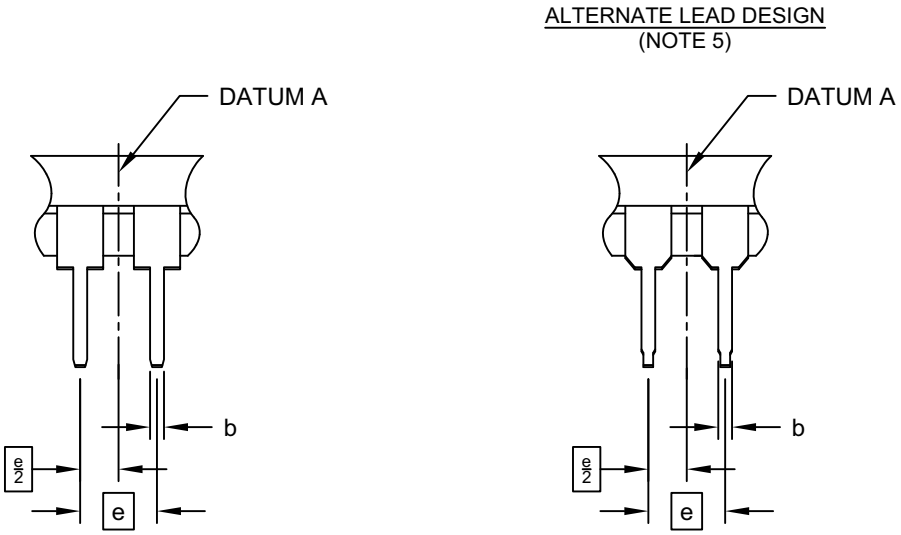


END VIEW

Microchip Technology Drawing No. C04-018-P Rev G Sheet 1 of 2

8-Lead Plastic Dual In-Line (P) - 300 mil Body [PDIP]

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



Units		INCHES		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		8	
Pitch	e		.100 BSC	
Top to Seating Plane	A	-	-	.210
Molded Package Thickness	A2	.115	.130	.195
Base to Seating Plane	A1	.015	-	-
Shoulder to Shoulder Width	E	.290	.310	.325
Molded Package Width	E1	.240	.250	.280
Overall Length	D	.348	.365	.400
Tip to Seating Plane	L	.115	.130	.150
Lead Thickness	c	.008	.010	.015
Upper Lead Width	b1	.040	.060	.070
Lower Lead Width	b	.014	.018	.022
Overall Row Spacing §	eB	-	-	.430

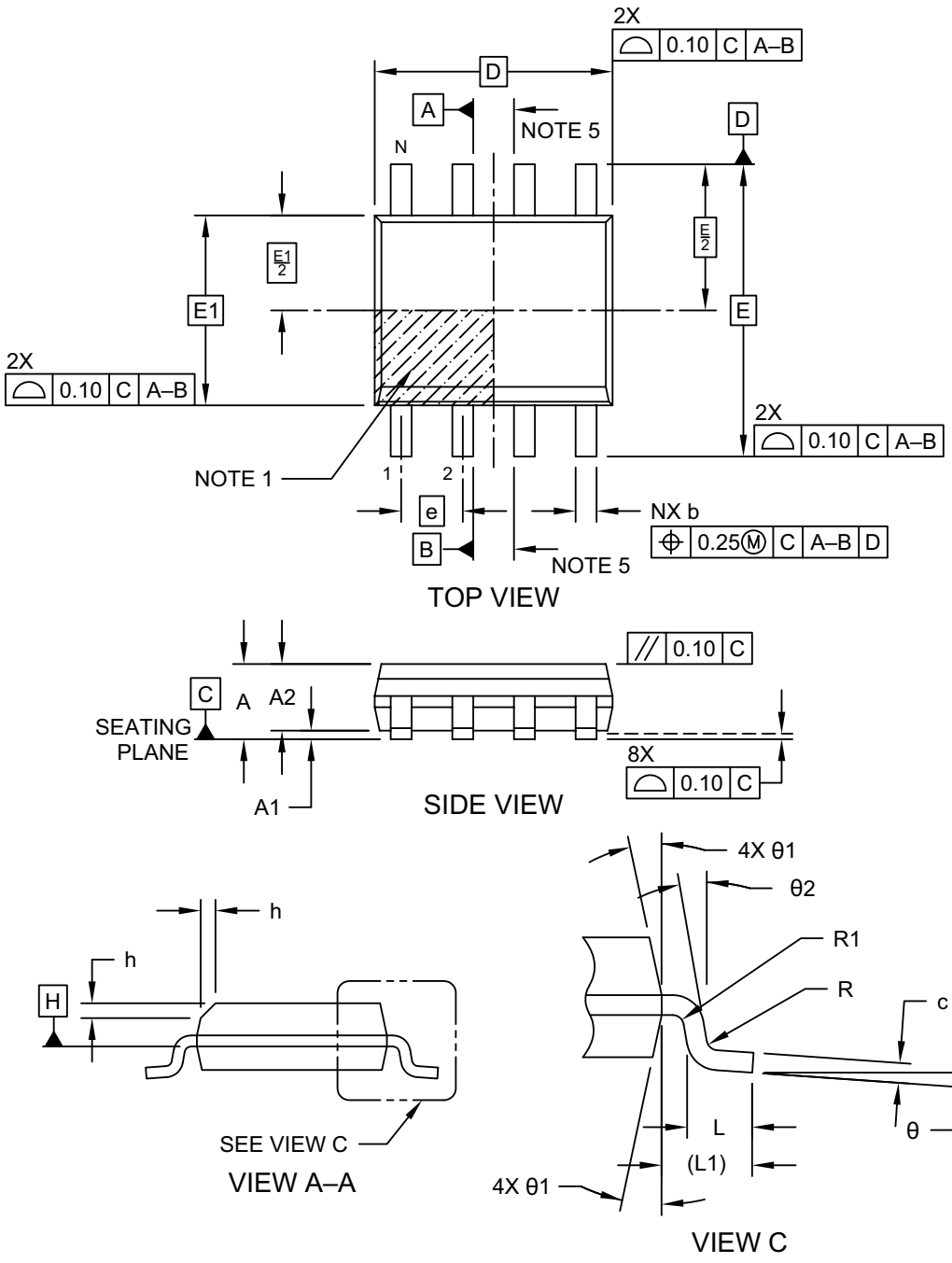
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
4. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
5. Lead design above seating plane may vary, based on assembly vendor.

Microchip Technology Drawing No. C04-018-P Rev E Sheet 2 of 2

8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm (.150 In.) Body [SOIC]

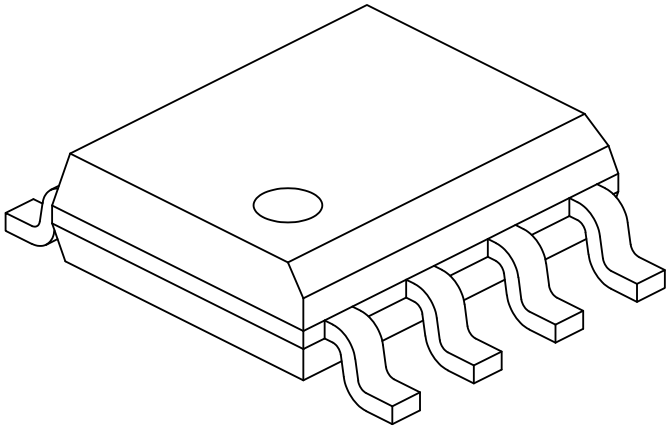
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing No. C04-057-SN Rev K Sheet 1 of 2

8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm (.150 In.) Body [SOIC]

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



Units		MILLIMETERS		
Dimension Limits		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	
Lead Thickness	c	0.17	–	0.25
Lead Width	b	0.31	–	0.51
Lead Bend Radius	R	0.07	–	–
Lead Bend Radius	R1	0.07	–	–
Foot Angle	θ	0°	–	8°
Mold Draft Angle	θ1	5°	–	15°
Lead Angle	θ2	0°	–	–

Notes:

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

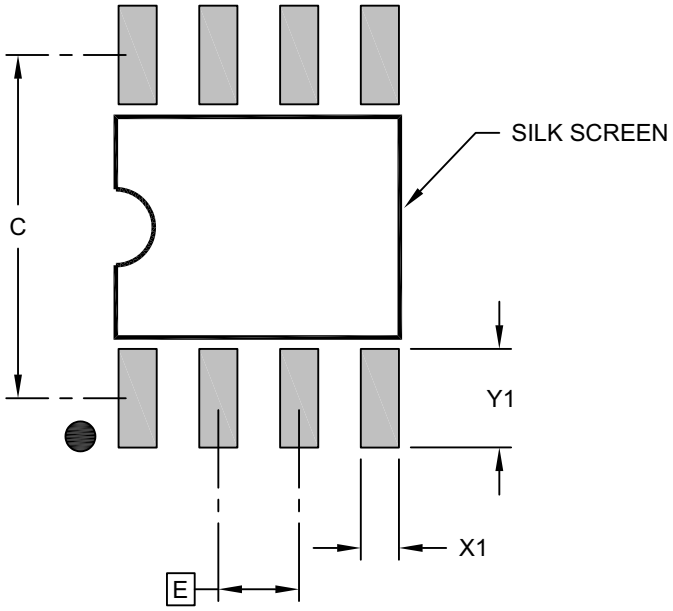
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.
5. Datums A & B to be determined at Datum H.

Microchip Technology Drawing No. C04-057-SN Rev K Sheet 2 of 2

8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm (.150 In.) Body [SOIC]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		1.27 BSC	
Contact Pad Spacing	C		5.40	
Contact Pad Width (X8)	X1			0.60
Contact Pad Length (X8)	Y1			1.55

Notes:

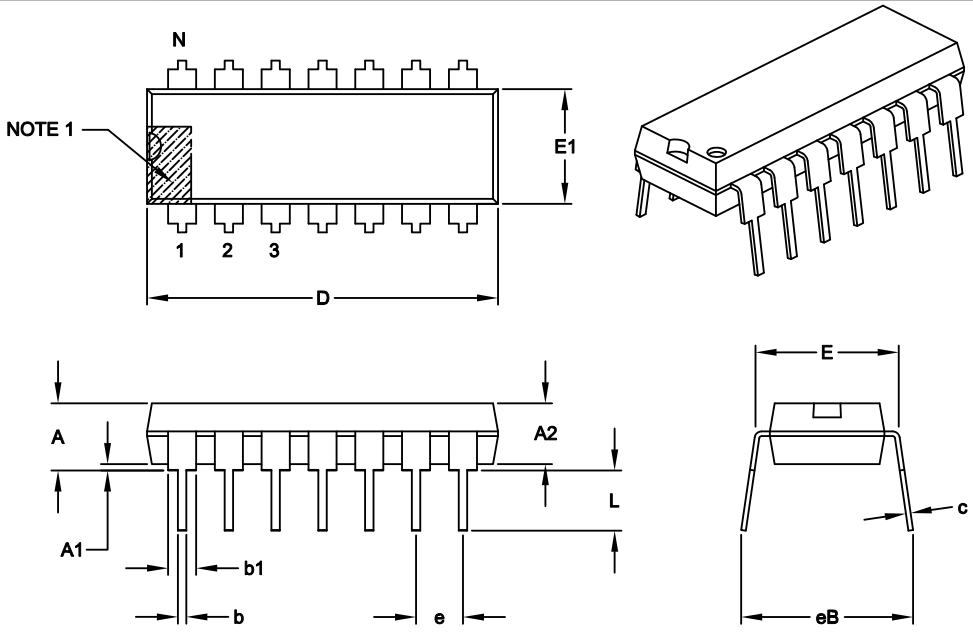
1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing C04-2057-SN Rev K

14-Lead Plastic Dual In-Line (P) - .300 In. Body [PDIP]

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



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

Notes:

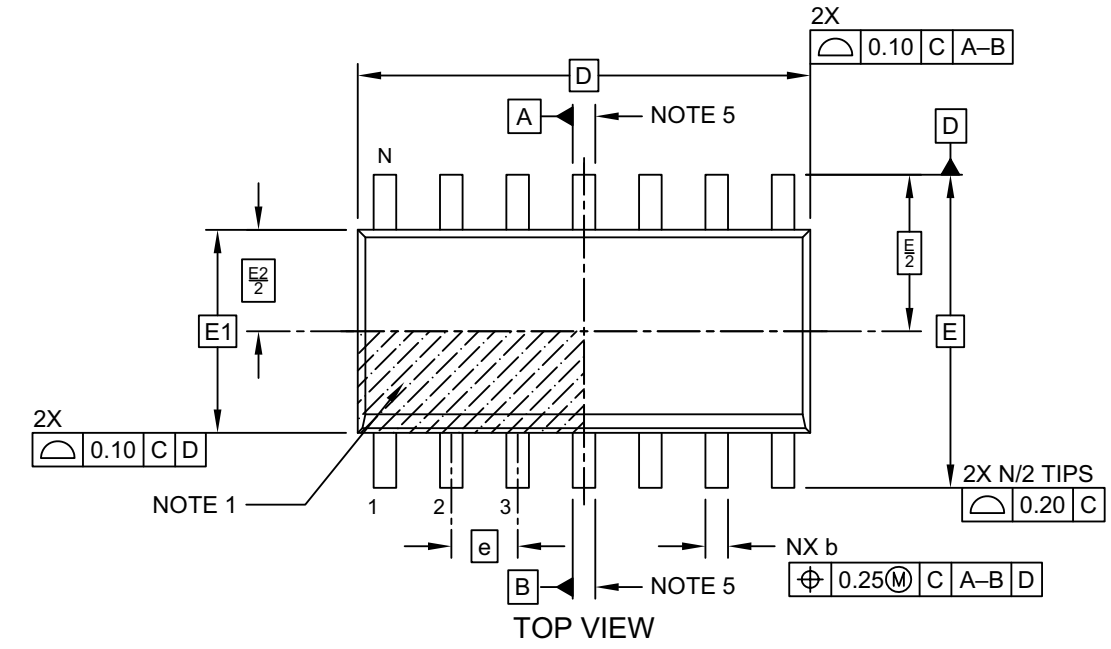
1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
4. Dimensioning and tolerancing per ASME Y14.5M

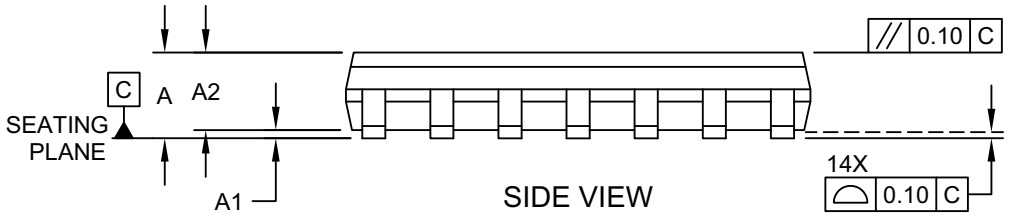
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

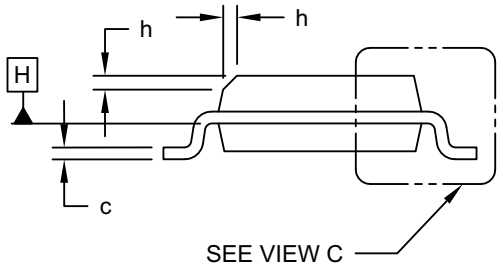
Microchip Technology Drawing No. C04-005B

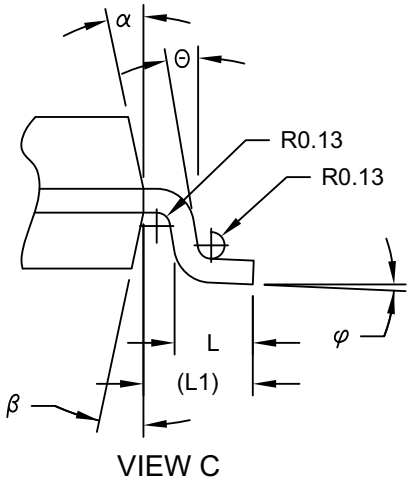
14-Lead Plastic Small Outline (SL) - Narrow, 3.90 mm Body [SOIC]

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





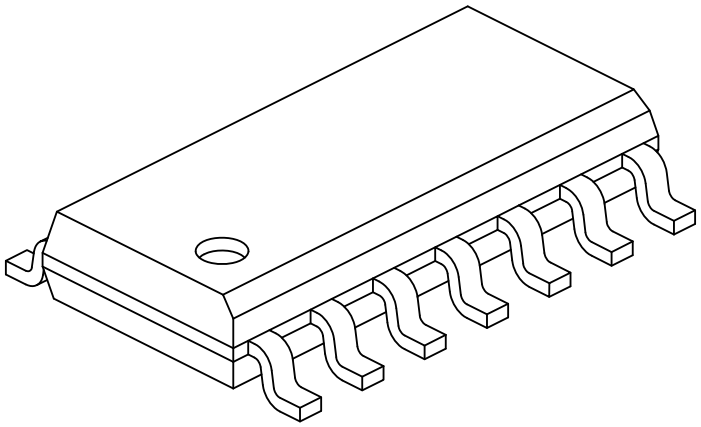




Microchip Technology Drawing No. C04-065-SL Rev D Sheet 1 of 2

14-Lead Plastic Small Outline (SL) - Narrow, 3.90 mm Body [SOIC]

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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		14	
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		8.65 BSC	
Chamfer (Optional)	h	0.25	-	0.50
Foot Length	L	0.40	-	1.27
Footprint	L1		1.04 REF	
Lead Angle	Θ	0°	-	-
Foot Angle	φ	0°	-	8°
Lead Thickness	c	0.10	-	0.25
Lead Width	b	0.31	-	0.51
Mold Draft Angle Top	α	5°	-	15°
Mold Draft Angle Bottom	β	5°	-	15°

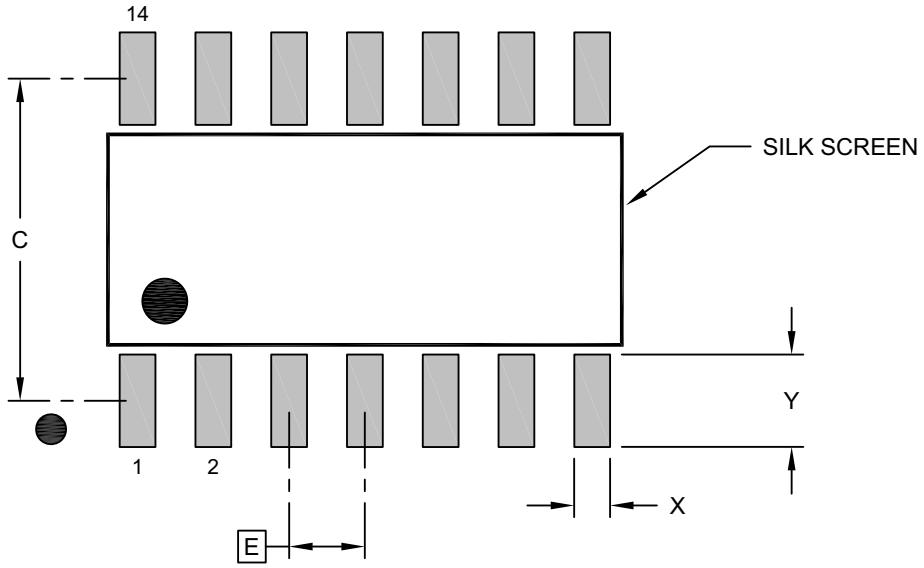
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimension D does not include mold flash, protrusions or gate burrs, which shall not exceed 0.15 mm per end. Dimension E1 does not include interlead flash or protrusion, which shall not exceed 0.25 mm per side.
4. 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.
5. Datums A & B to be determined at Datum H.

Microchip Technology Drawing No. C04-065-SL Rev D Sheet 2 of 2

14-Lead Plastic Small Outline (SL) - Narrow, 3.90 mm Body [SOIC]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		1.27 BSC	
Contact Pad Spacing	C		5.40	
Contact Pad Width (X14)	X			0.60
Contact Pad Length (X14)	Y			1.55

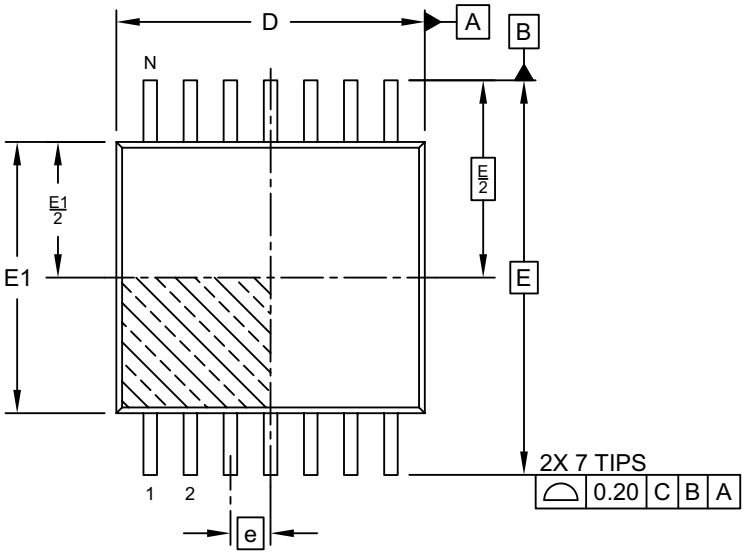
Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

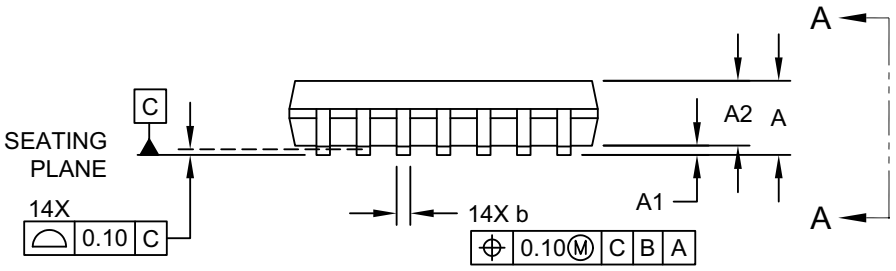
Microchip Technology Drawing No. C04-2065-SL Rev D

14-Lead Plastic Thin Shrink Small Outline Package [ST] - 4.4 mm Body [TSSOP]

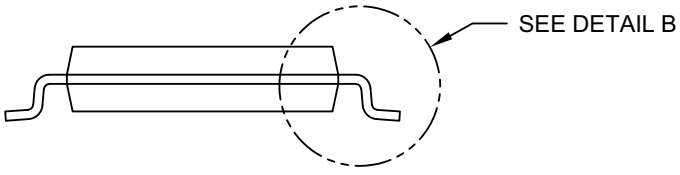
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



TOP VIEW



SIDE VIEW

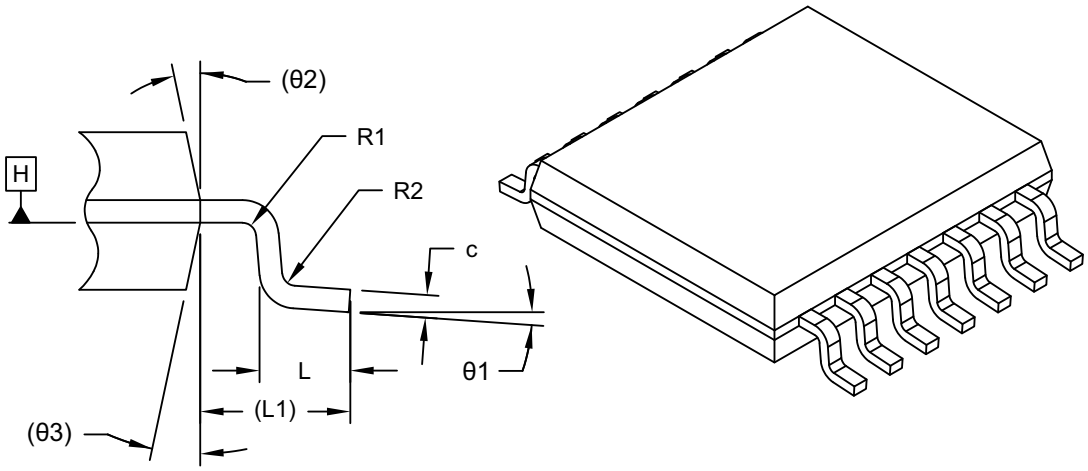


VIEW A–A

Microchip Technology Drawing C04-087-ST Rev F Sheet 1 of 2

14-Lead Plastic Thin Shrink Small Outline Package [ST] - 4.4 mm Body [TSSOP]

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



DETAIL B

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N		14	
Pitch	e		0.65 BSC	
Overall Height	A	–	–	1.20
Standoff	A1	0.05	–	0.15
Molded Package Thickness	A2	0.80	1.00	1.05
Overall Length	D	4.90	5.00	5.10
Overall Width	E		6.40 BSC	
Molded Package Width	E1	4.30	4.40	4.50
Terminal Width	b	0.19	–	0.30
Terminal Thickness	c	0.09	–	0.20
Terminal Length	L	0.45	0.60	0.75
Footprint	L1		1.00 REF	
Lead Bend Radius	R1	0.09	–	–
Lead Bend Radius	R2	0.09	–	–
Foot Angle	θ1	0°	–	8°
Mold Draft Angle	θ2	–	12° REF	–
Mold Draft Angle	θ3	–	12° REF	–

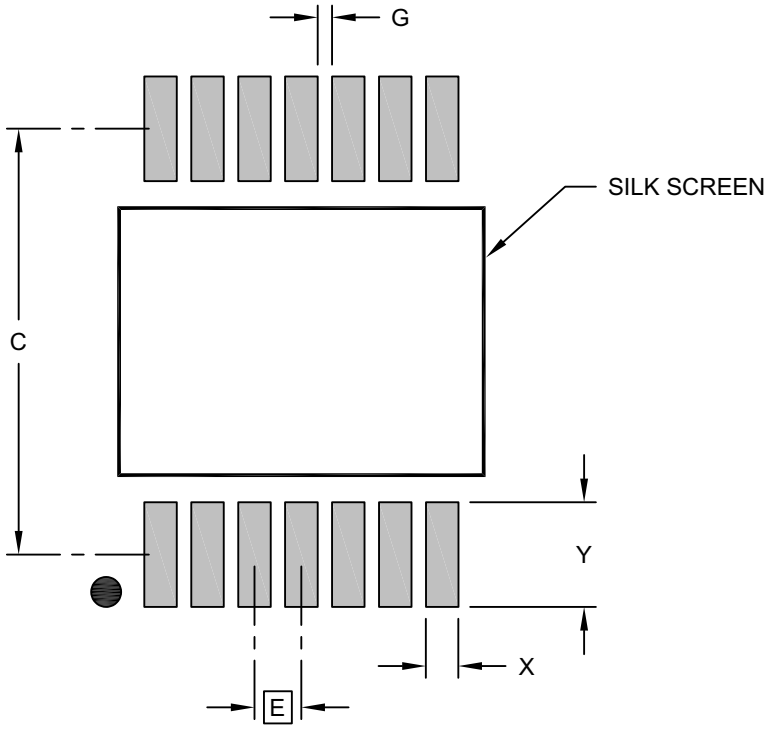
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. 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 C04-087-ST Rev F Sheet 2 of 2

14-Lead Plastic Thin Shrink Small Outline Package [ST] – 4.4 mm Body [TSSOP]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	0.65 BSC		
Contact Pad Spacing	C		5.90	
Contact Pad Width (X14)	X			0.45
Contact Pad Length (X14)	Y			1.45
Contact Pad to Contact Pad (X12)	G	0.20		

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-2087-ST Rev F

NOTES:

APPENDIX A: REVISION HISTORY

Revision H (July 2024)

The following is the list of modifications:

1. Updated **"Package Types"**.
2. Updated **Section 2.0 "Typical Performance Curves"**.
3. Updated Figure 4-4.
4. Updated **Section 6.2 "Package Drawings"**.
5. Updated **"Product Identification System"**.
6. Added **"Product Identification System (Automotive)"**.

Revision G (December 2019)

The following is the list of modifications:

1. Updated **Section 6.0 "Packaging Information"**.

Revision F (March 2008)

The following is the list of modifications:

1. Increased maximum operating V_{DD}.
2. Updated **Section 5.0 "Design Tools"**.
3. Various cleanups throughout document.
4. Updated package outline drawings in **Section 6.0 "Packaging Information"**.

Revision E (December 2006)

The following is the list of modifications:

1. Updated specifications (**Section 1.0 "Electrical Characteristics"**):
   a) Clarified Absolute Maximum Analog Input Voltage and Current specifications.
   b) Clarified V_{CMR}, V_{OL}, V_{OH} and PM specifications.
   c) Corrected the typical E_{ni}.
2. Added plots on Common Mode Input Range behavior vs. temperature and supply voltage (**Section 1.0 "Electrical Characteristics"**).
3. Added applications writeup on unused operational amplifiers and corrected description of floating $\overline{CS}$ pin behavior (**Section 4.0 "Application Information"**).
4. Updated package information (**Section 6.0 "Packaging Information"**):
   a) Corrected package markings.
   b) Added disclaimer to package outline drawings.

Revision D (December 2004)

The following is the list of modifications:

1. Added SOT-23-5 packages for the MCP6271 and MCP6271R single operational amplifiers.
2. Added SOT-23-6 packages for the MCP6273 single operational amplifier.
3. Added **Section 3.0 "Pin Descriptions"**.
4. Corrected application circuits (**Section 4.9 "Application Circuits"**).
5. Added SOT-23-5 and SOT-23-6 packages and corrected package marking information (**Section 6.0 "Packaging Information"**).
6. Added Appendix A: Revision History.

Revision C (June 2004)

- Undocumented Changes

Revision B (October 2003)

- Undocumented Changes

Revision A (June 2003)

- Original data sheet release.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

PART NO.	[X](1)	-X	/XX	XXX(2)
Device	Tape and Reel Option	Temperature Range	Package	Class

Device:	MCP6271:	Single Operational Amplifier	
	MCP6271R:	Single Operational Amplifier	
	MCP6272:	Dual Operational Amplifier	
	MCP6273:	Single Operational Amplifier with Chip Select ($\overline{CS}$)	
	MCP6274:	Quad Operational Amplifier	
	MCP6275:	Dual Operational Amplifier with Chip Select ($\overline{CS}$)	
Tape and Reel:	Blank	=	Standard packaging (tube or tray)
	T	=	Tape and Reel (1)
Temperature Range:	E	=	-40°C to +125°C (Extended)
Package:	OT	=	Plastic Small Outline Transistor (SOT-23), 5-Lead
	CH	=	Plastic Small Outline Transistor (SOT-23), 6-Lead
	MS	=	Plastic Micro Small Outline Package (MSOP), 3 x 3 mm, 8-Lead
	P	=	Plastic Dual In-Line (PDIP), 300 mil, 8-Lead or 14-Lead
	SN	=	Plastic Small Outline (SOIC), 150 mil, 8-Lead
	SL	=	Plastic Small Outline (SOIC), 150 mil, 14-Lead
	ST	=	Plastic Thin Shrink Small Outline Package (TSSOP), 4.4 mm, 14-Lead
Class:	Blank	=	Non-automotive
	VAO	=	Automotive (2) (MCP6271, MCP6272 and MCP6274 only)

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

2: Automotive parts are AEC-Q100 qualified. Grade 1.

Examples:

a)	MCP6271-E/MS:	Single Operational Amplifier, Extended Temperature, 8-Lead MSOP Package
b)	MCP6271-E/P:	Single Operational Amplifier, Extended Temperature, 8-Lead PDIP Package
c)	MCP6271T-E/SN:	Single Operational Amplifier, Tape and Reel, Extended Temperature, 8-Lead SOIC Package
d)	MCP6271T-E/OT:	Single Operational Amplifier, Tape and Reel, Extended Temperature, 5-Lead SOT-23 Package
a)	MCP6271RT-E/OT:	Single Operational Amplifier, Tape and Reel, Extended Temperature, 5-Lead SOT-23 Package
a)	MCP6272-E/MS:	Dual Operational Amplifier, Extended Temperature, 8-Lead MSOP Package
b)	MCP6272-E/P:	Dual Operational Amplifier, Extended Temperature, 8-Lead PDIP Package
c)	MCP6272T-E/SN:	Dual Operational Amplifier, Tape and Reel, Extended Temperature, 8-Lead SOIC Package
a)	MCP6273-E/MS:	Single Operational Amplifier $\overline{CS}$, Extended Temperature, 8-Lead MSOP Package
b)	MCP6273-E/P:	Single Operational Amplifier $\overline{CS}$, Extended Temperature, 8-Lead PDIP Package
c)	MCP6273T-E/CH:	Single Operational Amplifier $\overline{CS}$, Tape and Reel, Extended Temperature, 6-Lead SOT-23 Package
d)	MCP6273T-E/SN:	Single Operational Amplifier $\overline{CS}$, Tape and Reel, Extended Temperature, 8-Lead SOIC Package
a)	MCP6274-E/P:	Quad Operational Amplifier, Extended Temperature, 14-Lead PDIP Package
b)	MCP6274-E/SL:	Quad Operational Amplifier, Extended Temperature, 14-Lead SOIC Package
c)	MCP6274T-E/ST:	Quad Operational Amplifier, Tape and Reel, Extended Temperature, 14-Lead SOIC Package
a)	MCP6275-E/MS:	Dual Operational Amplifier $\overline{CS}$, Extended Temperature, 8-Lead MSOP Package
b)	MCP6275-E/P:	Dual Operational Amplifier $\overline{CS}$, Extended Temperature, 8-Lead PDIP Package
c)	MCP6275T-E/SN:	Dual Operational Amplifier $\overline{CS}$, Tape and Reel, Extended Temperature, 8-Lead SOIC Package

PRODUCT IDENTIFICATION SYSTEM (AUTOMOTIVE)

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

PART NO.	[X](1)	-X	/XX	XXX(2)
Device	Tape and Reel Option	Temperature Range	Package	Class

Device:	MCP6271:	Single Operational Amplifier	
	MCP6271R:	Single Operational Amplifier	
	MCP6272:	Dual Operational Amplifier	
	MCP6273:	Single Operational Amplifier with Chip Select ($\overline{CS}$)	
	MCP6274:	Quad Operational Amplifier	
	MCP6275:	Dual Operational Amplifier with Chip Select ($\overline{CS}$)	
Tape and Reel:	Blank	=	Standard packaging (tube or tray)
	T	=	Tape and Reel (1)
Temperature Range:	E	=	-40°C to +125°C (Extended)
Package:	OT	=	Plastic Small Outline Transistor (SOT-23), 5-Lead
	CH	=	Plastic Small Outline Transistor (SOT-23), 6-Lead
	MS	=	Plastic Micro Small Outline Package (MSOP), 3 x 3 mm, 8-Lead
	P	=	Plastic Dual In-Line (PDIP), 300 mil, 8-Lead or 14-Lead
	SN	=	Plastic Small Outline (SOIC), 150 mil, 8-Lead
	SL	=	Plastic Small Outline (SOIC), 150 mil, 14-Lead
	ST	=	Plastic Thin Shrink Small Outline Package (TSSOP), 4.4 mm, 14-Lead
Class:	Blank	=	Non-automotive
	VAO	=	Automotive (2) (MCP6271, MCP6272 and MCP6274 only)

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

2: Automotive parts are AEC-Q100 qualified. Grade 1.

Examples:

a) MCP6271T-E/OTVAO: Single Operational Amplifier, Tape and Reel, Extended Temperature, 5-Lead SOT-23 Package, Automotive

a) MCP6272-E/SNVAO: Dual Operational Amplifier, Extended Temperature, 8-Lead SOIC Package, Automotive

b) MCP6272T-E/MSVAO: Dual Operational Amplifier, Tape and Reel, Extended Temperature, 8-Lead MSOP Package, Automotive

c) MCP6272T-E/SNVAO: Dual Operational Amplifier, Tape and Reel, Extended Temperature, 8-Lead SOIC Package, Automotive

a) MCP6274T-E/STVAO: Quad Operational Amplifier, Tape and Reel, Extended Temperature, 14-Lead SOIC Package, Automotive

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