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## 1.8V Low-Power Push-Pull Output Comparator

### Features

- Propagation Delay at 1.8V<sub>DD</sub>:
  - 56 ns (typical) High-to-Low
  - 49 ns (typical) Low-to-High
- Low Quiescent Current: 100 μA (typical)
- Input Offset Voltage: ±3 mV (typical)
- Rail-to-Rail Input: V<sub>SS</sub> - 0.3V to V<sub>DD</sub> + 0.3V
- CMOS/TTL-Compatible Output
- Wide Supply Voltage Range: 1.8V to 5.5V
- Available in Single, Dual, and Quad
- Packages: SC70-5, SOT-23-5, SOIC, MSOP, TSSOP

### Typical Applications

- Laptop Computers
- Mobile Phones
- Hand-held Electronics
- RC Timers
- Alarm and Monitoring Circuits
- Window Comparators
- Multivibrators

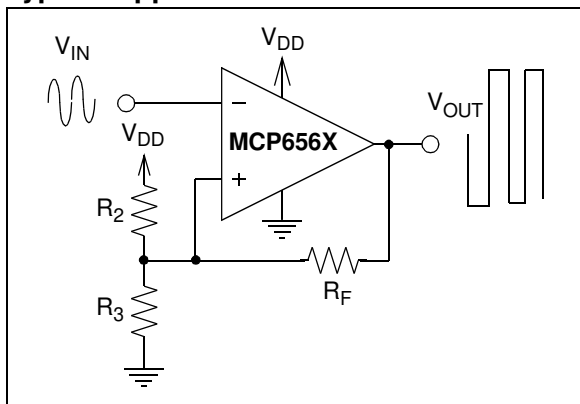
### Design Aids

- Microchip Advanced Part Selector (MAPS)
- Analog Demonstration and Evaluation Boards
- Application Notes

### Related Devices

- Open-Drain Output: MCP6566/6R/6U/7/9

### Typical Application



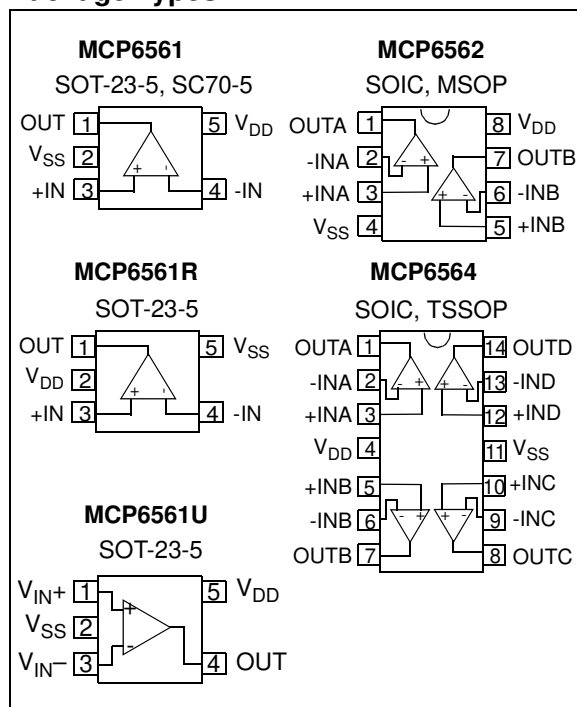
### Description

The Microchip Technology, Inc. MCP6561/1R/1U/2/4 families of CMOS/TTL compatible comparators are offered in single, dual, and quad configurations.

These comparators are optimized for low power 1.8V, single-supply applications with greater than rail-to-rail input operation. The internal input hysteresis eliminates output switching due to internal input noise voltage, reducing current draw. The push-pull output of the MCP6561/1R/1U/2/4 family supports rail-to-rail output swing, and interfaces with CMOS/TTL logic. The output toggle frequency can reach a typical of 4 MHz (typical) while limiting supply current surges and dynamic power consumption during switching.

This family operates with single supply voltage of 1.8V to 5.5V while drawing less than 100 μA/comparator of quiescent current (typical).

### Package Types



# MCP6561/1R/1U/2/4

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NOTES:

## 1.0 ELECTRICAL CHARACTERISTICS

### 1.1 Maximum Ratings †

$V_{DD} - V_{SS}$ .....	6.5V
Analog Input ( $V_{IN}$ ) †† .....	$V_{SS} - 1.0V$ to $V_{DD} + 1.0V$
All other inputs and outputs.....	$V_{SS} - 0.3V$ to $V_{DD} + 0.3V$
Difference Input voltage .....	$ V_{DD} - V_{SS} $
Output Short Circuit Current .....	$\pm 25$ mA
Current at Input Pins .....	$\pm 2$ mA
Current at Output and Supply Pins .....	$\pm 50$ mA
Storage temperature .....	$-65^{\circ}\text{C}$ to $+150^{\circ}\text{C}$
Ambient temp. with power applied.....	$-40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
Junction temp.....	$+150^{\circ}\text{C}$
ESD protection on all pins (HBM/MM).....	$\geq 4$ kV/300V

† **Notice:** Stresses above those listed under “Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

†† See [Section 4.1.2 “Input Voltage and Current Limits”](#)

## DC CHARACTERISTICS

**Electrical Characteristics:** Unless otherwise indicated:  $V_{DD} = +1.8V$  to  $+5.5V$ ,  $V_{SS} = \text{GND}$ ,  $T_A = +25^{\circ}\text{C}$ ,  $V_{IN+} = V_{DD}/2$ ,  $V_{IN-} = V_{SS}$ ,  $R_L = 10$  k $\Omega$  to  $V_{DD}/2$  (see [Figure 1-1](#)).

Parameters	Symbol	Min	Typ	Max	Units	Conditions
<b>Power Supply</b>						
Supply Voltage	$V_{DD}$	1.8	—	5.5	V	
Quiescent Current per comparator	$I_Q$	60	100	130	$\mu\text{A}$	$I_{OUT} = 0$
Power Supply Rejection Ratio	PSRR	63	70	—	dB	$V_{CM} = V_{SS}$
<b>Input</b>						
Input Offset Voltage	$V_{OS}$	-10	$\pm 3$	+10	mV	$V_{CM} = V_{SS}$ ( <a href="#">Note 1</a> )
Input Offset Drift	$\Delta V_{OS}/\Delta T$	—	$\pm 2$	—	$\mu\text{V}/^{\circ}\text{C}$	$V_{CM} = V_{SS}$
Input Offset Current	$I_{OS}$	—	$\pm 1$	—	pA	$V_{CM} = V_{SS}$
Input Bias Current	$I_B$	—	1	—	pA	$T_A = +25^{\circ}\text{C}$ , $V_{IN-} = V_{DD}/2$
		—	60	—	pA	$T_A = +85^{\circ}\text{C}$ , $V_{IN-} = V_{DD}/2$
		—	1500	5000	pA	$T_A = +125^{\circ}\text{C}$ , $V_{IN-} = V_{DD}/2$
Input Hysteresis Voltage	$V_{HYST}$	1.0	—	5.0	mV	$V_{CM} = V_{SS}$ ( <a href="#">Notes 1, 2</a> )
Input Hysteresis Linear Temp. Co.	$TC_1$	—	10	—	$\mu\text{V}/^{\circ}\text{C}$	
Input Hysteresis Quadratic Temp. Co.	$TC_2$	—	0.3	—	$\mu\text{V}/^{\circ}\text{C}^2$	
Common-mode Input Voltage Range	$V_{CMR}$	$V_{SS}-0.2$	—	$V_{DD}+0.2$	V	$V_{DD} = 1.8V$
		$V_{SS}-0.3$	—	$V_{DD}+0.3$	V	$V_{DD} = 5.5V$
Common-mode Rejection Ratio	CMRR	54	66	—	dB	$V_{CM} = -0.3V$ to $V_{DD}+0.3V$ , $V_{DD} = 5.5V$
		50	63	—	dB	$V_{CM} = V_{DD}/2$ to $V_{DD}+0.3V$ , $V_{DD} = 5.5V$
		54	65	—	dB	$V_{CM} = -0.3V$ to $V_{DD}/2$ , $V_{DD} = 5.5V$
Common-mode Input Impedance	$Z_{CM}$	—	$10^{13}  4$	—	$\Omega  \text{pF}$	
Differential Input Impedance	$Z_{DIFF}$	—	$10^{13}  2$	—	$\Omega  \text{pF}$	
<b>Push-Pull Output</b>						
High-Level Output Voltage	$V_{OH}$	$V_{DD}-0.7$	—	—	V	$I_{OUT} = -3$ mA/ $-8$ mA with $V_{DD} = 1.8V/5.5V$ ( <a href="#">Note 3</a> )
Low-Level Output Voltage	$V_{OL}$	—	—	0.6	V	$I_{OUT} = 3$ mA/ $8$ mA with $V_{DD} = 1.8V/5.5V$ ( <a href="#">Note 3</a> )
Short Circuit Current	$I_{SC}$	—	$\pm 30$	—	mA	<a href="#">Note 3</a>
Output Pin Capacitance	$C_{OUT}$	—	8	—	pF	

**Note 1:** The input offset voltage is the center of the input-referred trip points. The input hysteresis is the difference between the input-referred trip points.

**2:**  $V_{HYST}$  at different temperatures is estimated using  $V_{HYST}(T_A) = V_{HYST}@+25^{\circ}\text{C} + (T_A - 25^{\circ}\text{C})TC_1 + (T_A - 25^{\circ}\text{C})^2TC_2$ .

**3:** Limit the output current to Absolute Maximum Rating of 50 mA.

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## AC CHARACTERISTICS

**Electrical Characteristics:** Unless otherwise indicated:  $V_{DD} = +1.8V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ ,  $V_{IN+} = V_{DD}/2$ ,  $V_{IN-} = V_{SS}$ ,  $R_L = 10\text{ k}\Omega$  to  $V_{DD}/2$ , and  $C_L = 25\text{ pF}$ . (see Figure 1-1).

Parameters	Symbol	Min	Typ	Max	Units	Conditions
<b>Propagation Delay</b>						
High-to-Low, 100 mV Overdrive	$t_{PHL}$	—	56	80	ns	$V_{CM} = V_{DD}/2$ , $V_{DD} = 1.8V$
		—	34	80	ns	$V_{CM} = V_{DD}/2$ , $V_{DD} = 5.5V$
Low-to-High, 100 mV Overdrive	$t_{PLH}$	—	49	80	ns	$V_{CM} = V_{DD}/2$ , $V_{DD} = 1.8V$
		—	47	80	ns	$V_{CM} = V_{DD}/2$ , $V_{DD} = 5.5V$
Skew <sup>1</sup>	$t_{PDS}$	—	$\pm 10$	—	ns	
<b>Output</b>						
Rise Time	$t_R$	—	20	—	ns	
Fall Time	$t_F$	—	20	—	ns	
Maximum Toggle Frequency	$f_{TG}$	—	4	—	MHz	$V_{DD} = 5.5V$
		—	2	—	MHz	$V_{DD} = 1.8V$
Input Voltage Noise <sup>2</sup>	$E_{NI}$	—	350	—	$\mu V_{P-P}$	10 Hz to 10 MHz

**Note 1:** Propagation Delay Skew is defined as:  $t_{PDS} = t_{PLH} - t_{PHL}$ .

**Note 2:** ENI is based on SPICE simulation.

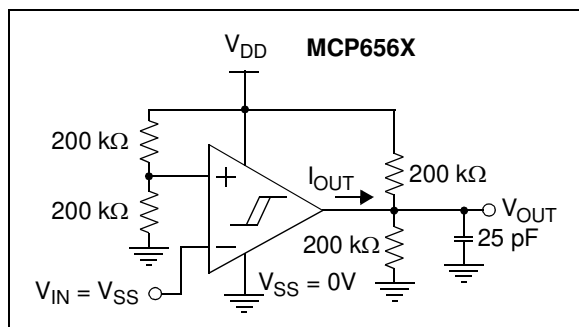
## TEMPERATURE SPECIFICATIONS

**Electrical Characteristics:** Unless otherwise indicated:  $V_{DD} = +1.8V$  to  $+5.5V$  and  $V_{SS} = GND$ .

Parameters	Symbol	Min	Typ	Max	Units	Conditions
<b>Temperature Ranges</b>						
Specified Temperature Range	$T_A$	-40	—	+125	$^\circ C$	
Operating Temperature Range	$T_A$	-40	—	+125	$^\circ C$	
Storage Temperature Range	$T_A$	-65	—	+150	$^\circ C$	
<b>Thermal Package Resistances</b>						
Thermal Resistance, SC70-5	$\theta_{JA}$	—	331	—	$^\circ C/W$	
Thermal Resistance, SOT-23-5	$\theta_{JA}$	—	220.7	—	$^\circ C/W$	
Thermal Resistance, 8L-SOIC	$\theta_{JA}$	—	149.5	—	$^\circ C/W$	
Thermal Resistance, 8L-MSOP	$\theta_{JA}$	—	211	—	$^\circ C/W$	
Thermal Resistance, 14L-SOIC	$\theta_{JA}$	—	95.3	—	$^\circ C/W$	
Thermal Resistance, 14L-TSSOP	$\theta_{JA}$	—	100	—	$^\circ C/W$	

### 1.2 Test Circuit Configuration

This test circuit configuration is used to determine the AC and DC specifications.

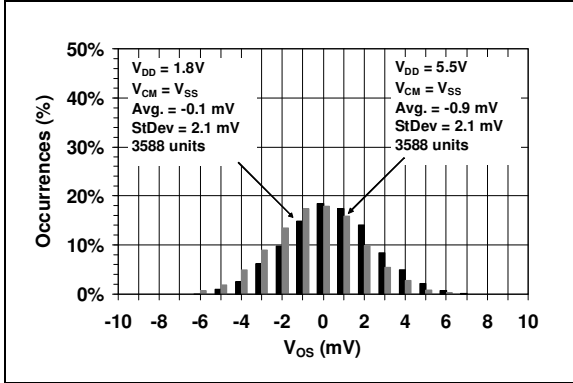


**FIGURE 1-1:** AC and DC Test Circuit for the Push-Pull Output Comparators.

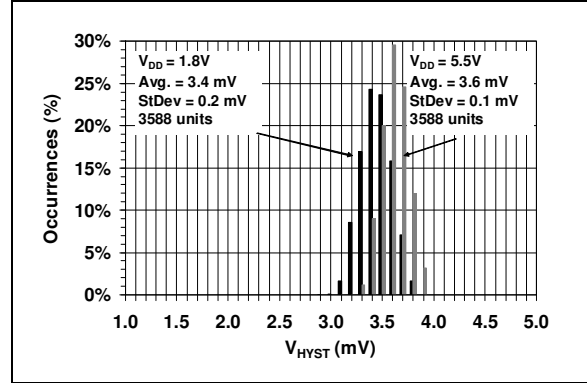
## 2.0 TYPICAL PERFORMANCE CURVES

**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.

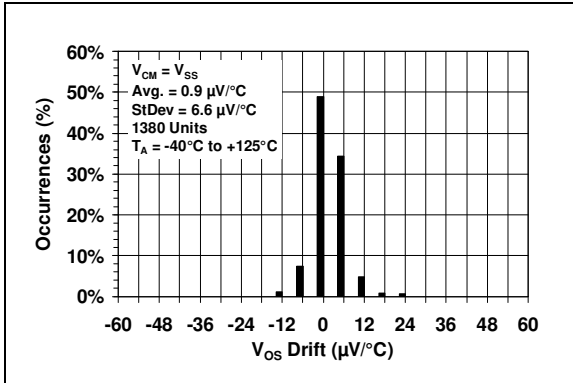
**Note:** Unless otherwise indicated,  $V_{DD} = +1.8V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ ,  $V_{IN+} = V_{DD}/2$ ,  $V_{IN-} = GND$ ,  $R_L = 10\text{ k}\Omega$  to  $V_{DD}/2$ , and  $C_L = 25\text{ pF}$ .



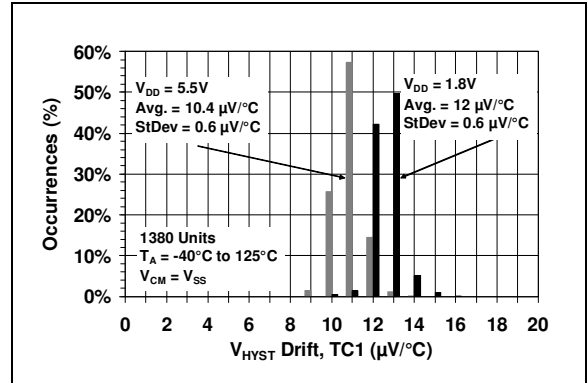
**FIGURE 2-1:** Input Offset Voltage.



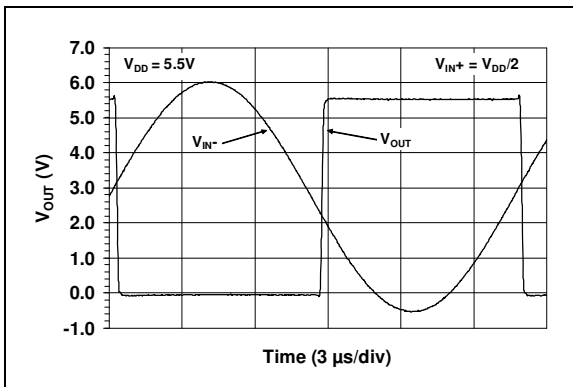
**FIGURE 2-4:** Input Hysteresis Voltage.



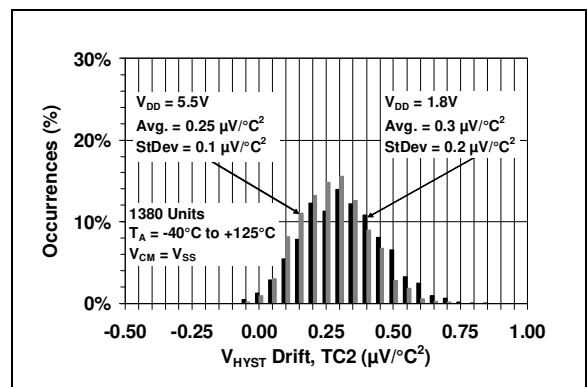
**FIGURE 2-2:** Input Offset Voltage Drift.



**FIGURE 2-5:** Input Hysteresis Voltage Drift - Linear Temp. Co. (TC1).



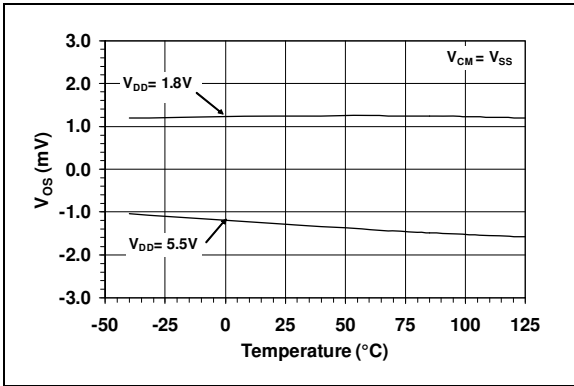
**FIGURE 2-3:** Input vs. Output Signal, No Phase Reversal.



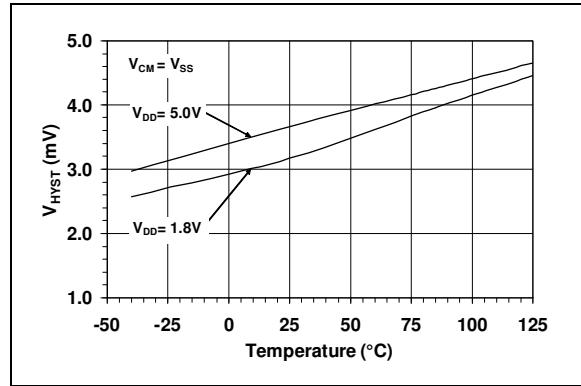
**FIGURE 2-6:** Input Hysteresis Voltage Drift - Quadratic Temp. Co. (TC2).

# MCP6561/1R/1U/2/4

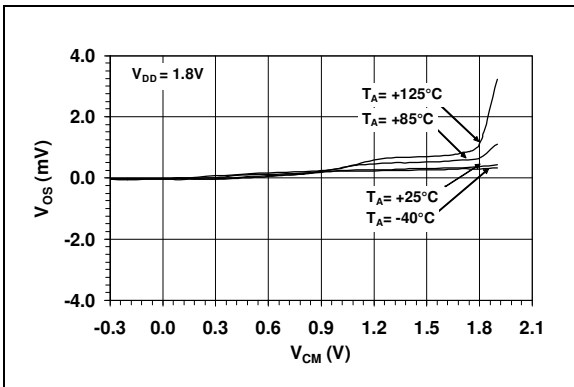
**Note:** Unless otherwise indicated,  $V_{DD} = +1.8V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ ,  $V_{IN+} = V_{DD}/2$ ,  $V_{IN-} = GND$ ,  $R_L = 10\text{ k}\Omega$  to  $V_{DD}/2$ , and  $C_L = 25\text{ pF}$ .



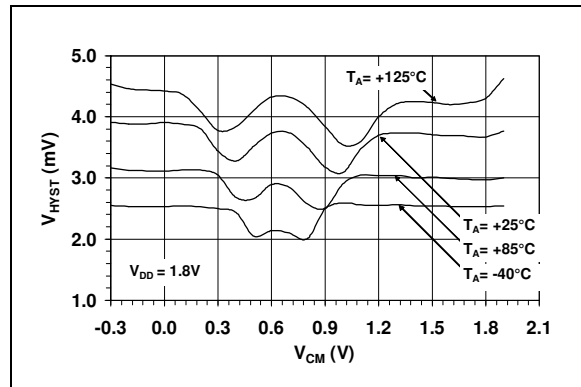
**FIGURE 2-7:** Input Offset Voltage vs. Temperature.



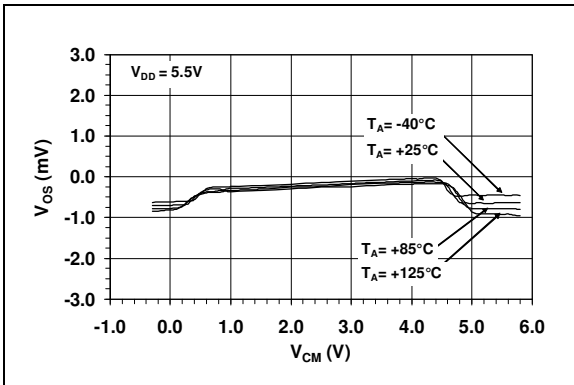
**FIGURE 2-10:** Input Hysteresis Voltage vs. Temperature.



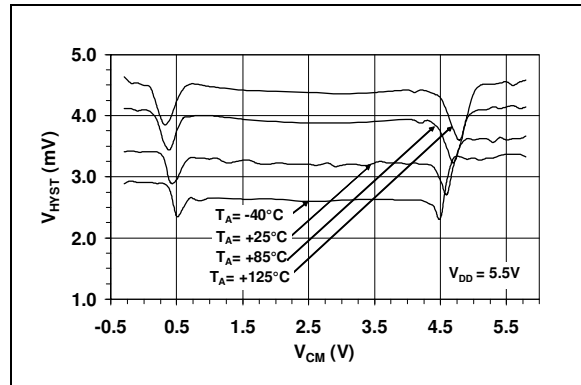
**FIGURE 2-8:** Input Offset Voltage vs. Common-mode Input Voltage.



**FIGURE 2-11:** Input Hysteresis Voltage vs. Common-mode Input Voltage.

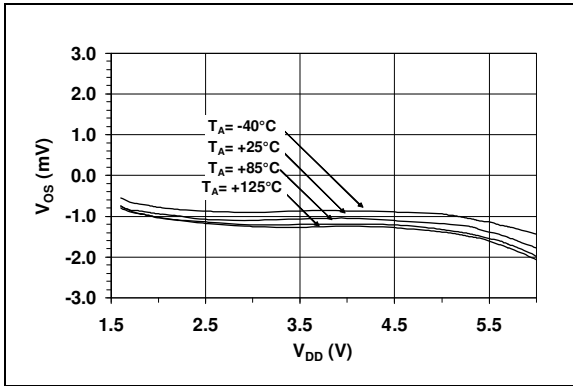


**FIGURE 2-9:** Input Offset Voltage vs. Common-mode Input Voltage.

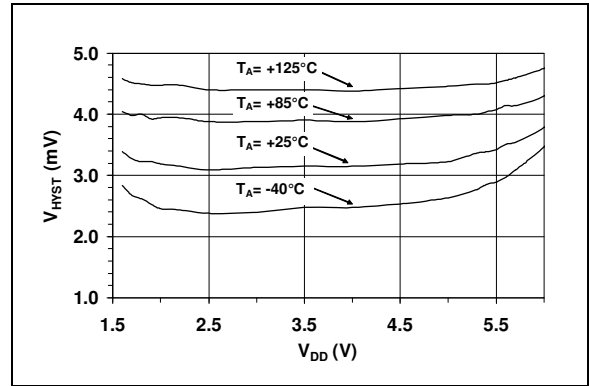


**FIGURE 2-12:** Input Hysteresis Voltage vs. Common-mode Input Voltage.

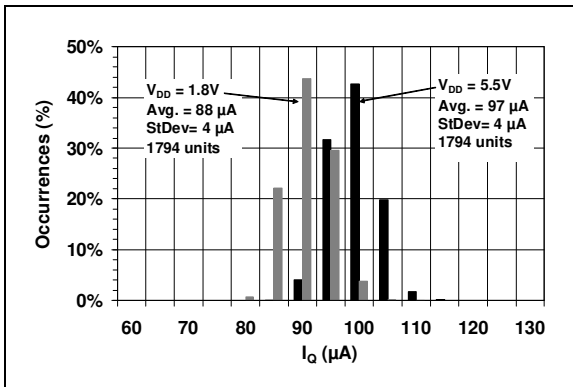
**Note:** Unless otherwise indicated,  $V_{DD} = +1.8V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ ,  $V_{IN+} = V_{DD}/2$ ,  $V_{IN-} = GND$ ,  $R_L = 10\text{ k}\Omega$  to  $V_{DD}/2$ , and  $C_L = 25\text{ pF}$ .



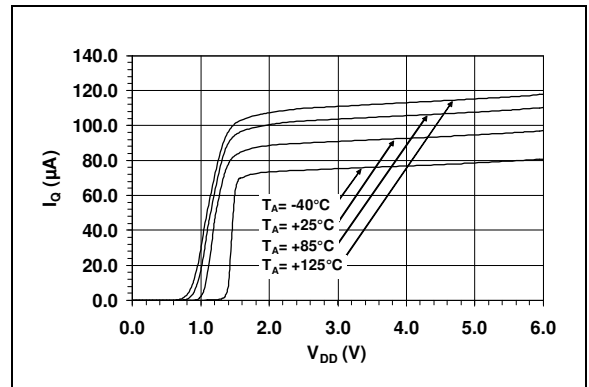
**FIGURE 2-13:** Input Offset Voltage vs. Supply Voltage vs. Temperature.



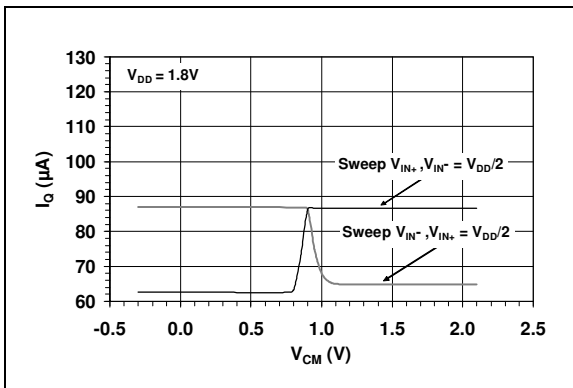
**FIGURE 2-16:** Input Hysteresis Voltage vs. Supply Voltage vs. Temperature.



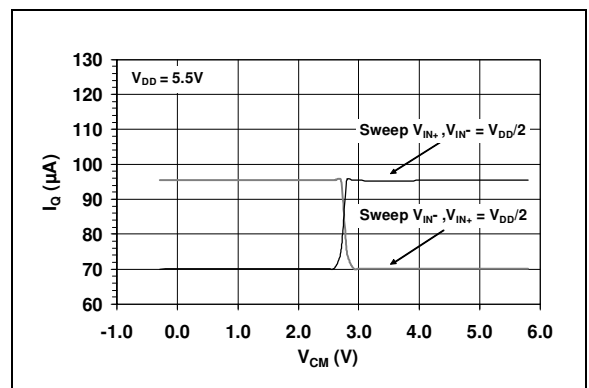
**FIGURE 2-14:** Quiescent Current.



**FIGURE 2-17:** Quiescent Current vs. Supply Voltage vs. Temperature.



**FIGURE 2-15:** Quiescent Current vs. Common-mode Input Voltage.

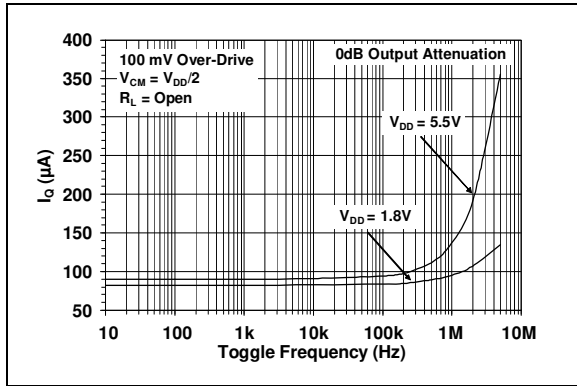


**FIGURE 2-18:** Quiescent Current vs. Common-mode Input Voltage.

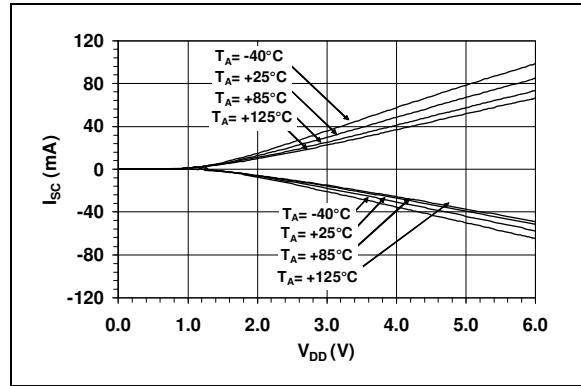


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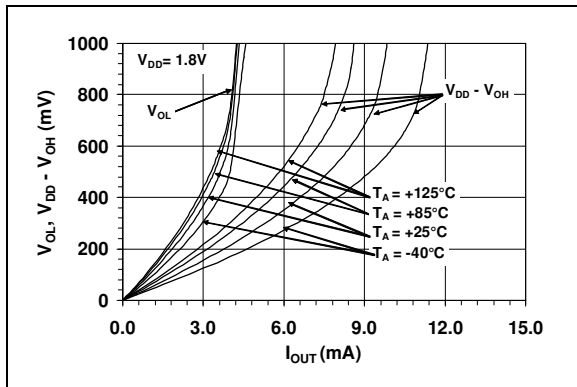
**Note:** Unless otherwise indicated,  $V_{DD} = +1.8V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ ,  $V_{IN+} = V_{DD}/2$ ,  $V_{IN-} = GND$ ,  $R_L = 10\ k\Omega$  to  $V_{DD}/2$ , and  $C_L = 25\ pF$ .



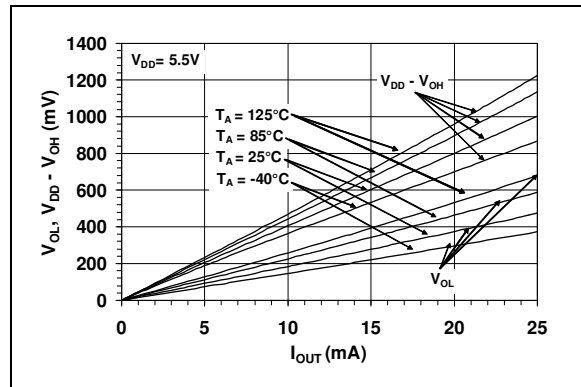
**FIGURE 2-19:** Quiescent Current vs. Toggle Frequency.



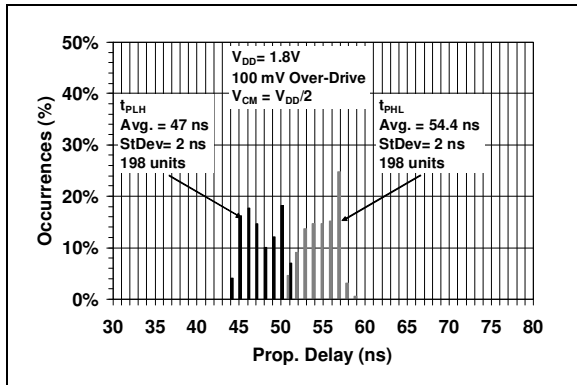
**FIGURE 2-22:** Short Circuit Current vs. Supply Voltage vs. Temperature.



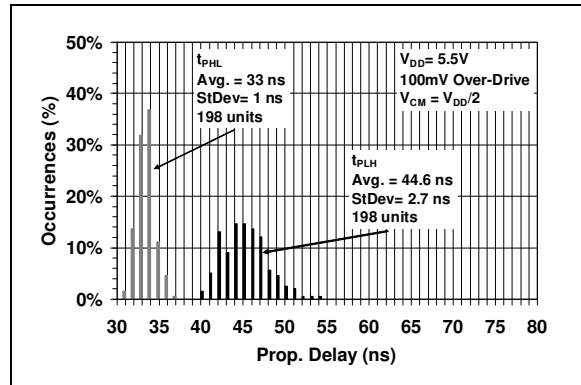
**FIGURE 2-20:** Output Headroom vs. Output Current.



**FIGURE 2-23:** Output Headroom vs. Output Current.



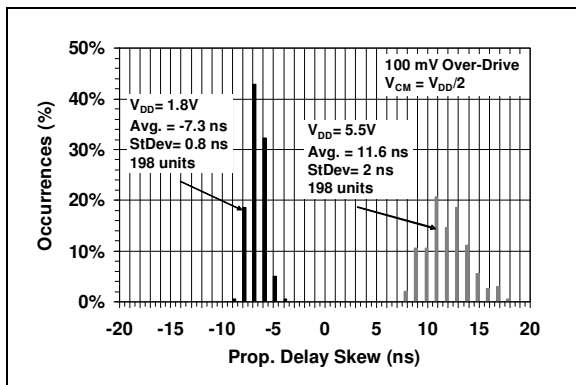
**FIGURE 2-21:** Low-to-High and High-to-Low Propagation Delays.



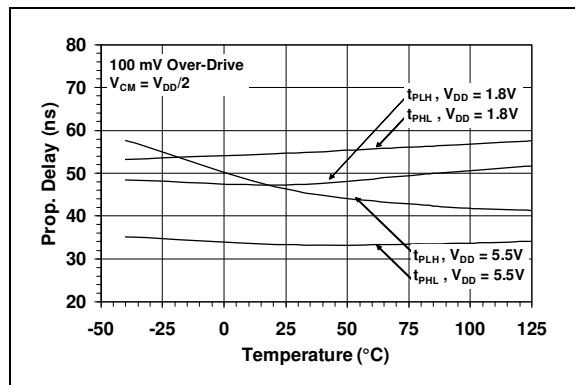
**FIGURE 2-24:** Low-to-High and High-to-Low Propagation Delays.

# MCP6561/1R/1U/2/4

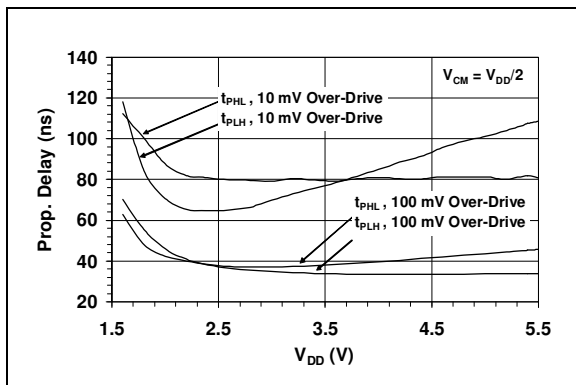
**Note:** Unless otherwise indicated,  $V_{DD} = +1.8V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ ,  $V_{IN+} = V_{DD}/2$ ,  $V_{IN-} = GND$ ,  $R_L = 10\text{ k}\Omega$  to  $V_{DD}/2$ , and  $C_L = 25\text{ pF}$ .



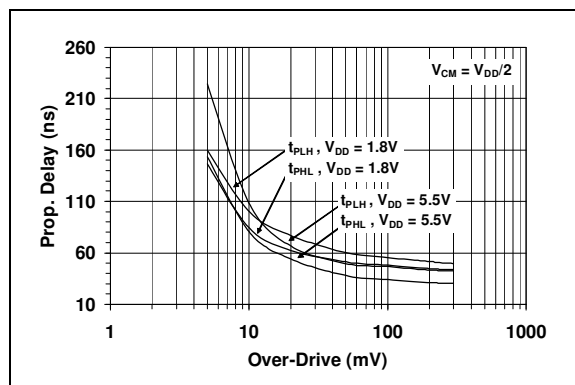
**FIGURE 2-25:** Propagation Delay Skew.



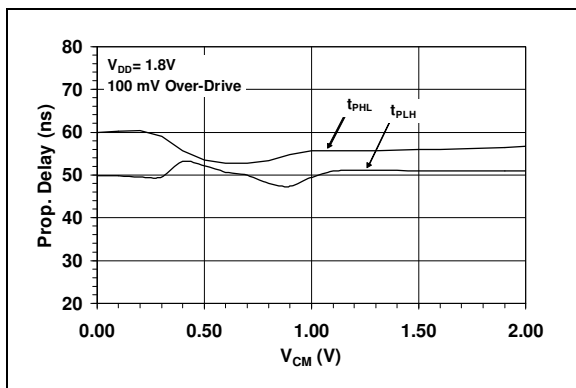
**FIGURE 2-28:** Propagation Delay vs. Temperature.



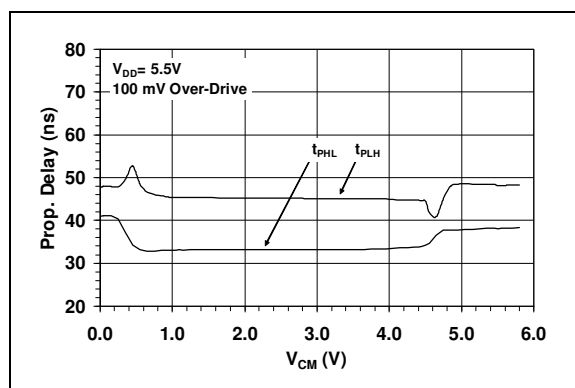
**FIGURE 2-26:** Propagation Delay vs. Supply Voltage.



**FIGURE 2-29:** Propagation Delay vs. Input Over-Drive.



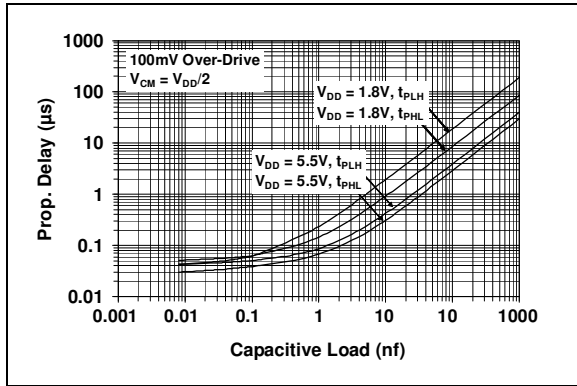
**FIGURE 2-27:** Propagation Delay vs. Common-mode Input Voltage.



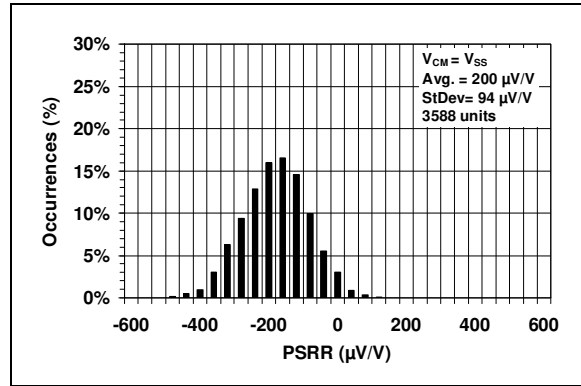
**FIGURE 2-30:** Propagation Delay vs. Common-mode Input Voltage.

# MCP6561/1R/1U/2/4

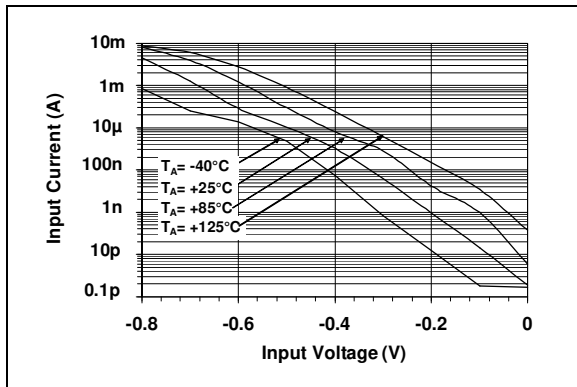
**Note:** Unless otherwise indicated,  $V_{DD} = +1.8\text{V}$  to  $+5.5\text{V}$ ,  $V_{SS} = \text{GND}$ ,  $T_A = +25^\circ\text{C}$ ,  $V_{IN+} = V_{DD}/2$ ,  $V_{IN-} = \text{GND}$ ,  $R_L = 10\text{ k}\Omega$  to  $V_{DD}/2$ , and  $C_L = 25\text{ pF}$ .



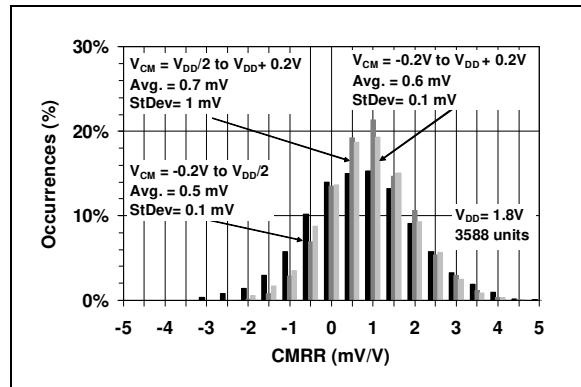
**FIGURE 2-31:** Propagation Delay vs. Capacitive Load.



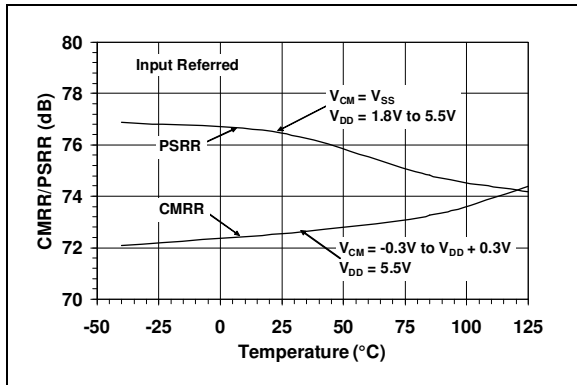
**FIGURE 2-34:** Power Supply Rejection Ratio (PSRR).



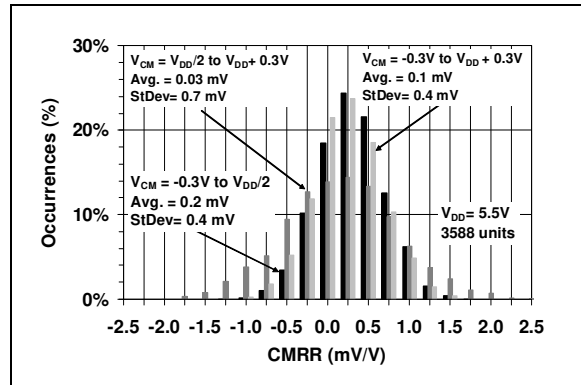
**FIGURE 2-32:** Input Bias Current vs. Input Voltage vs Temperature.



**FIGURE 2-35:** Common-mode Rejection Ratio (CMRR).

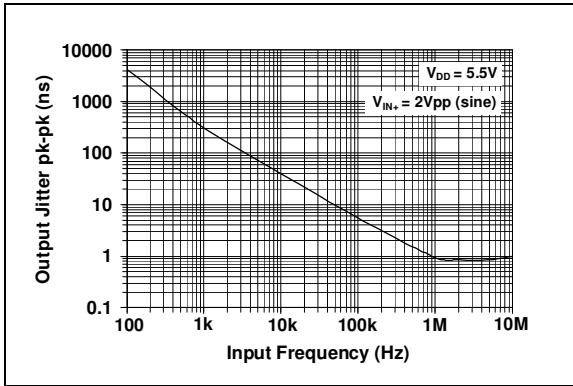


**FIGURE 2-33:** Common-mode Rejection Ratio and Power Supply Rejection Ratio vs. Temperature.

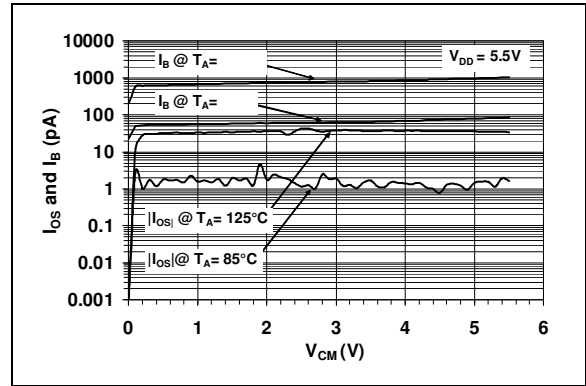


**FIGURE 2-36:** Common-mode Rejection Ratio (CMRR).

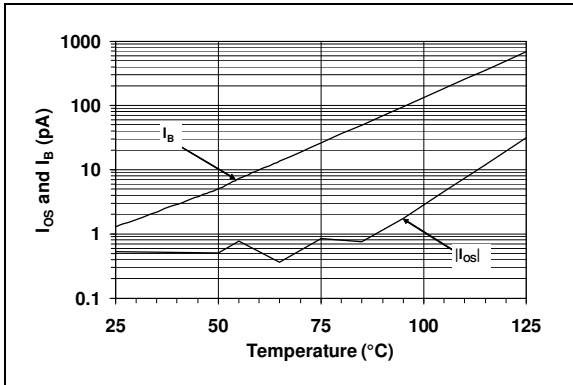
**Note:** Unless otherwise indicated,  $V_{DD} = +1.8V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ ,  $V_{IN+} = V_{DD}/2$ ,  $V_{IN-} = GND$ ,  $R_L = 10\text{ k}\Omega$  to  $V_{DD}/2$ , and  $C_L = 25\text{ pF}$ .



**FIGURE 2-37:** Output Jitter vs. Input Frequency.



**FIGURE 2-39:** Input Offset Current and Input Bias Current vs. Common-mode Input Voltage vs. Temperature.



**FIGURE 2-38:** Input Offset Current and Input Bias Current vs. Temperature.

# MCP6561/1R/1U/2/4

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NOTES:

## 3.0 PIN DESCRIPTIONS

Descriptions of the pins are listed in [Table 3-1](#).

**TABLE 3-1: PIN FUNCTION TABLE**

MCP6561	MCP6561R	MCP6561U	MCP6562	MCP6564	Symbol	Description
SC70-5, SOT-23-5	SOT-23-5	SOT-23-5	MSOP, SOIC	SOIC, TSSOP		
1	1	4	1	1	OUT, OUTA	Digital Output (comparator A)
4	4	3	2	2	$V_{IN-}$ , $V_{INA-}$	Inverting Input (comparator A)
3	3	1	3	3	$V_{IN+}$ , $V_{INA+}$	Non-inverting Input (comparator A)
5	2	5	8	4	$V_{DD}$	Positive Power Supply
—	—	—	5	5	$V_{INB+}$	Non-inverting Input (comparator B)
—	—	—	6	6	$V_{INB-}$	Inverting Input (comparator B)
—	—	—	7	7	OUTB	Digital Output (comparator B)
—	—	—	—	8	OUTC	Digital Output (comparator C)
—	—	—	—	9	$V_{INC-}$	Inverting Input (comparator C)
—	—	—	—	10	$V_{INC+}$	Non-inverting Input (comparator C)
2	5	2	4	11	$V_{SS}$	Negative Power Supply
—	—	—	—	12	$V_{IND+}$	Non-inverting Input (comparator D)
—	—	—	—	13	$V_{IND-}$	Inverting Input (comparator D)
—	—	—	—	14	OUTD	Digital Output (comparator D)

### 3.1 Analog Inputs

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

### 3.2 Digital Outputs

The comparator outputs are CMOS, push-pull digital outputs. They are designed to be compatible with CMOS and TTL logic and are capable of driving heavy DC or capacitive loads.

### 3.3 Power Supply ( $V_{SS}$ and $V_{DD}$ )

The positive power supply pin ( $V_{DD}$ ) is 1.8V to 5.5V higher than the negative power supply pin ( $V_{SS}$ ). 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 a local bypass capacitor (typically 0.01  $\mu$ F to 0.1  $\mu$ F) within 2 mm of the  $V_{DD}$  pin. These can share a bulk capacitor with nearby analog parts (within 100 mm), but it is not required.

# MCP6561/1R/1U/2/4

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NOTES:

## 4.0 APPLICATIONS INFORMATION

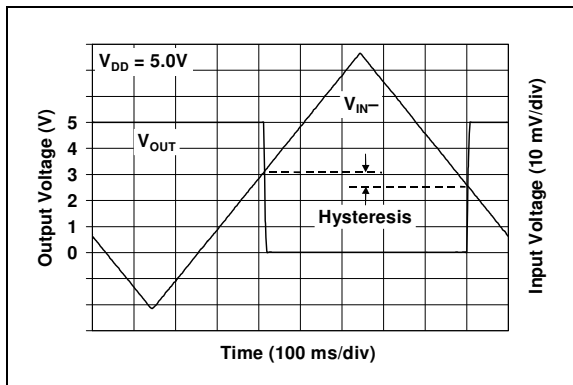
The MCP6561/1R/1U/2/4 family of push-pull output comparators are fabricated on Microchip's state-of-the-art CMOS process. They are suitable for a wide range of high speed applications requiring low power consumption.

### 4.1 Comparator Inputs

#### 4.1.1 NORMAL OPERATION

The input stage of this family of devices uses three differential input stages in parallel: one operates at low-input voltages, one at high-input voltages, and one at mid-input voltage. With this topology, the input voltage range is 0.3V above  $V_{DD}$  and 0.3V below  $V_{SS}$ , while providing low offset voltage through out the Common-mode range. The input offset voltage is measured at both  $V_{SS} - 0.3V$  and  $V_{DD} + 0.3V$  to ensure proper operation.

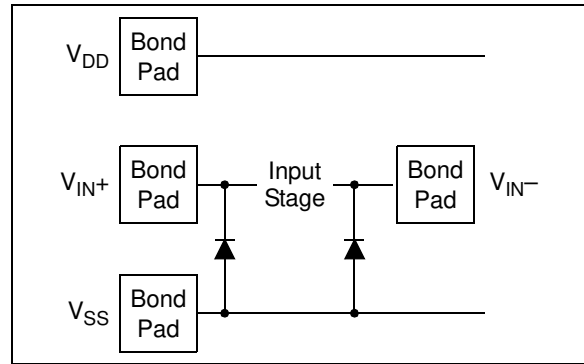
The MCP6561/1R/1U/2/4 family has internally-set hysteresis  $V_{HYST}$  that is small enough to maintain input offset accuracy and large enough to eliminate output chattering caused by the comparator's own input noise voltage  $E_{NI}$ . Figure 4-1 depicts this behavior. Input offset voltage ( $V_{OS}$ ) is the center (average) of the (input-referred) low-high and high-low trip points. Input hysteresis voltage ( $V_{HYST}$ ) is the difference between the same trip points.



**FIGURE 4-1:** The MCP6561/1R/1U/2/4 Comparators' Internal Hysteresis Eliminates Output Chatter Caused by Input Noise Voltage.

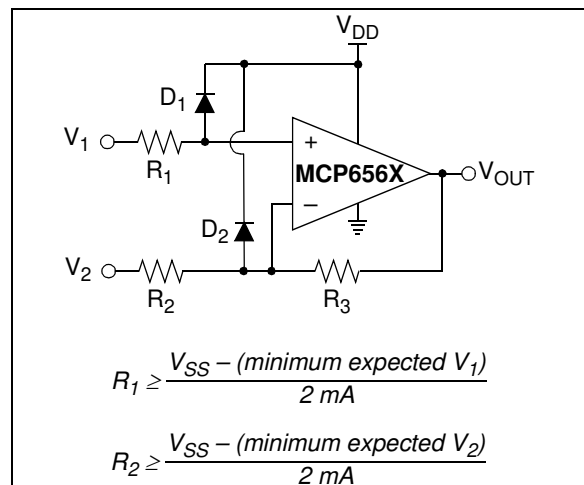
#### 4.1.2 INPUT VOLTAGE AND CURRENT LIMITS

The ESD protection on the inputs can be depicted as shown in Figure 4-2. 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 ESD events within the specified limits.



**FIGURE 4-2:** Simplified Analog Input ESD Structures.

In order to prevent damage and/or improper operation of these amplifiers, the circuits they are in must limit the currents (and voltages) at the  $V_{IN+}$  and  $V_{IN-}$  pins (see [Maximum Ratings](#) † at the beginning of [Section 1.0 "Electrical Characteristics"](#)). Figure 4-3 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 the resistors  $R_1$  and  $R_2$  limit the possible current drawn out of the input pin. Diodes  $D_1$  and  $D_2$  prevent the input pin ( $V_{IN+}$  and  $V_{IN-}$ ) 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 4-3:** 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 resistor then serves as in-rush current limiter; the DC current into the input pins ( $V_{IN+}$  and  $V_{IN-}$ ) should be very small.



# MCP6561/1R/1U/2/4

A significant amount of current can flow out of the inputs 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 PHASE REVERSAL

The MCP6561/1R/1U/2/4 comparator family uses CMOS transistors at the input. They are designed to prevent phase inversion when the input pins exceed the supply voltages. Figure 2-3 shows an input voltage exceeding both supplies with no resulting phase inversion.

## 4.2 Push-Pull Output

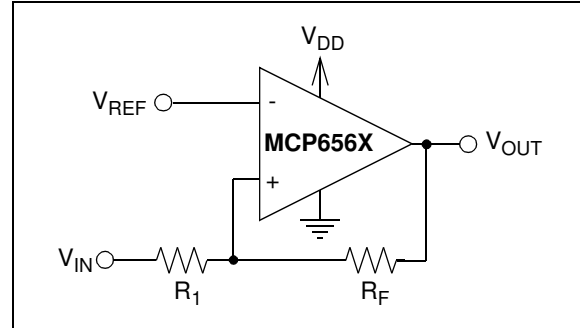
The push-pull output is designed to be compatible with CMOS and TTL logic, while the output transistors are configured to give rail-to-rail output performance. They are driven with circuitry that minimizes any switching current (shoot-through current from supply-to-supply) when the output is transitioned from high-to-low, or from low-to-high (see Figure 2-15 and Figure 2-18 for more information).

## 4.3 Externally Set Hysteresis

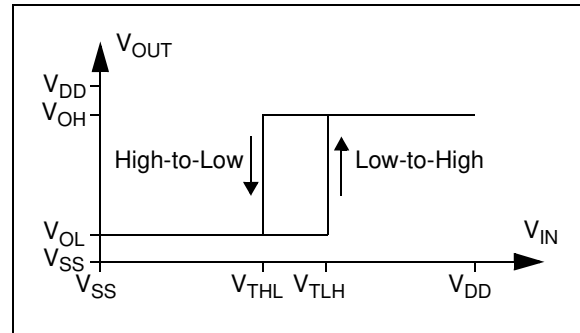
Greater flexibility in selecting hysteresis (or input trip points) is achieved by using external resistors. Hysteresis reduces output chattering when one input is slowly moving past the other. It also helps in systems where it is best not to cycle between high and low states too frequently (e.g., air conditioner thermostatic control). Output chatter also increases the dynamic supply current.

### 4.3.1 NON-INVERTING CIRCUIT

Figure 4-4 shows a non-inverting circuit for single-supply applications using just two resistors. The resulting hysteresis diagram is shown in Figure 4-5.



**FIGURE 4-4:** Non-inverting Circuit with Hysteresis for Single-Supply.



**FIGURE 4-5:** Hysteresis Diagram for the Non-inverting Circuit.

The trip points for Figure 4-4 and Figure 4-5 are:

#### EQUATION 4-1:

$$V_{TLH} = V_{REF} \left( 1 + \frac{R_1}{R_F} \right) - V_{OL} \left( \frac{R_1}{R_F} \right)$$

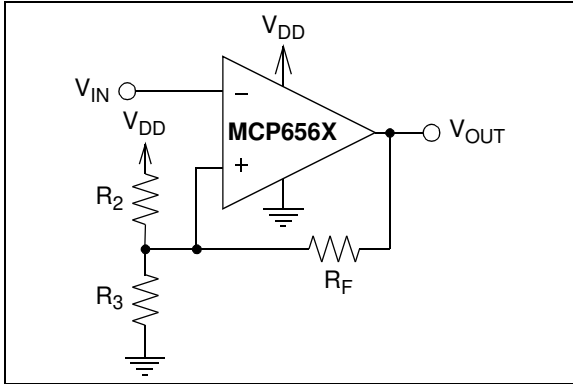
$$V_{THL} = V_{REF} \left( 1 + \frac{R_1}{R_F} \right) - V_{OH} \left( \frac{R_1}{R_F} \right)$$

Where:

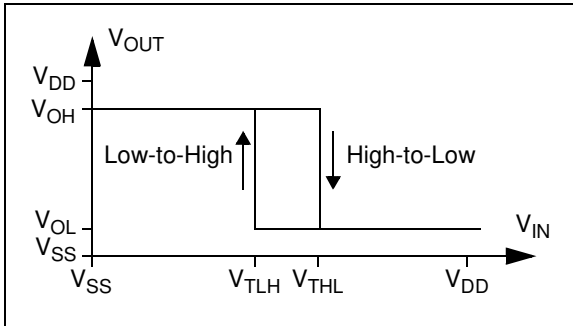
- $V_{TLH}$  = trip voltage from low-to-high
- $V_{THL}$  = trip voltage from high-to-low

## 4.3.2 INVERTING CIRCUIT

Figure 4-6 shows an inverting circuit for single-supply using three resistors. The resulting hysteresis diagram is shown in Figure 4-7.

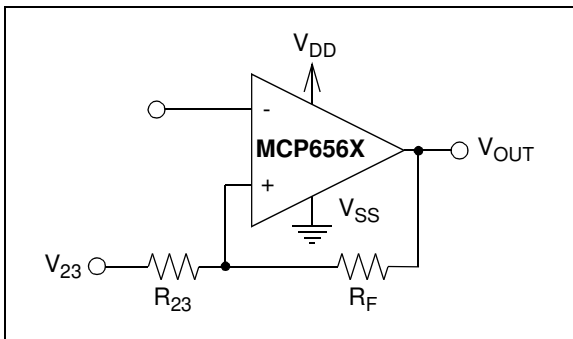


**FIGURE 4-6:** Inverting Circuit With Hysteresis.



**FIGURE 4-7:** Hysteresis Diagram for the Inverting Circuit.

In order to determine the trip voltages ( $V_{THL}$  and  $V_{TLH}$ ) for the circuit shown in Figure 4-6,  $R_2$  and  $R_3$  can be simplified to the Thevenin equivalent circuit with respect to  $V_{DD}$ , as shown in Figure 4-8.



**FIGURE 4-8:** Thevenin Equivalent Circuit.

Where:

$$R_{23} = \frac{R_2 R_3}{R_2 + R_3}$$

$$V_{23} = \frac{R_3}{R_2 + R_3} \times V_{DD}$$

Using this simplified circuit, the trip voltage can be calculated using the following equation:

### EQUATION 4-2:

$$V_{THL} = V_{OH} \left( \frac{R_{23}}{R_{23} + R_F} \right) + V_{23} \left( \frac{R_F}{R_{23} + R_F} \right)$$

$$V_{TLH} = V_{OL} \left( \frac{R_{23}}{R_{23} + R_F} \right) + V_{23} \left( \frac{R_F}{R_{23} + R_F} \right)$$

Where:

$V_{TLH}$  = trip voltage from low-to-high

$V_{THL}$  = trip voltage from high-to-low

Figure 2-20, and Figure 2-23 can be used to determine typical values for  $V_{OH}$  and  $V_{OL}$ .

## 4.4 Bypass Capacitors

With this family of comparators, the power supply pin ( $V_{DD}$  for single supply) should have a local bypass capacitor (i.e., 0.01  $\mu\text{F}$  to 0.1  $\mu\text{F}$ ) within 2 mm for good edge rate performance.

## 4.5 Capacitive Loads

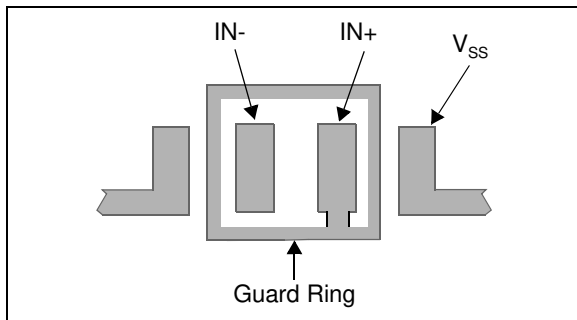
Reasonable capacitive loads (e.g., logic gates) have little impact on propagation delay (see Figure 2-31). The supply current increases with increasing toggle frequency (Figure 2-19), especially with higher capacitive loads. The output slew rate and propagation delay performance will be reduced with higher capacitive loads.

# MCP6561/1R/1U/2/4

## 4.6 PCB Surface Leakage

In applications where low input bias current is critical, PCB (Printed Circuit Board) 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. This is greater than the MCP6561/1R/1U/2/4 family'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 4-9.

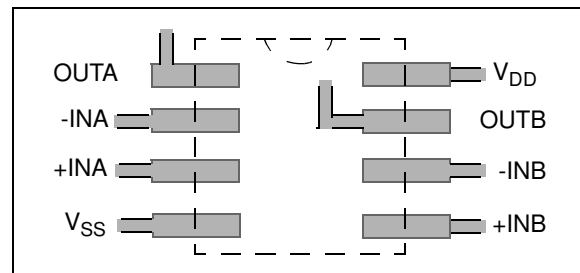


**FIGURE 4-9:** Example Guard Ring Layout for Inverting Circuit.

1. Inverting Configuration (Figures 4-6 and 4-9):
  - 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 comparator (e.g.,  $V_{DD}/2$  or ground).
  - b) Connect the inverting pin ( $V_{IN-}$ ) to the input pad without touching the guard ring.
2. Non-inverting Configuration (Figure 4-4):
  - a) Connect the non-inverting pin ( $V_{IN+}$ ) to the input pad without touching the guard ring.
  - b) Connect the guard ring to the inverting input pin ( $V_{IN-}$ ).

## 4.7 PCB Layout Technique

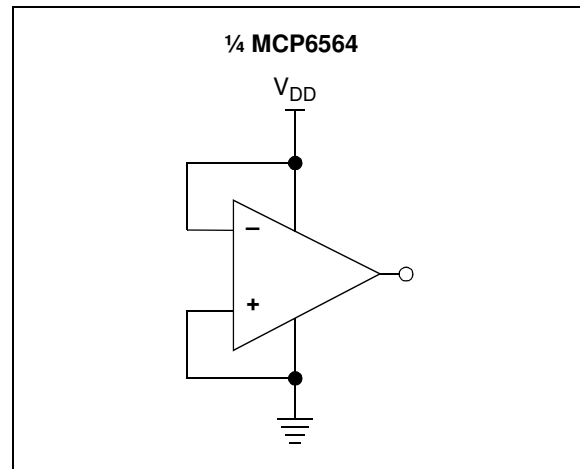
When designing the PCB layout, it is critical to note that analog and digital signal traces are adequately separated to prevent signal coupling. If the comparator output trace is at close proximity to the input traces, then large output voltage changes from  $V_{SS}$  to  $V_{DD}$ , or visa versa, may couple to the inputs and cause the device output to oscillate. To prevent such oscillation, the output traces must be routed away from the input pins. The SC70-5 and SOT-23-5 are relatively immune because the output pin OUT (pin 1) is separated by the power pin  $V_{DD}/V_{SS}$  (pin 2) from the input pin +IN (as long as the analog and digital traces remain separated throughout the PCB). However, the pinouts for the dual and quad packages (SOIC, MSOP, TSSOP) have OUT and -IN pins (pin 1 and 2) close to each other. The recommended layout for these packages is shown in Figure 4-10.



**FIGURE 4-10:** Recommended Layout.

## 4.8 Unused Comparators

An unused amplifier in a quad package (MCP6564) should be configured as shown in Figure 4-11. This circuit prevents the output from toggling and causing crosstalk. It uses the minimum number of components and draws minimal current (see Figure 2-15 and Figure 2-18).

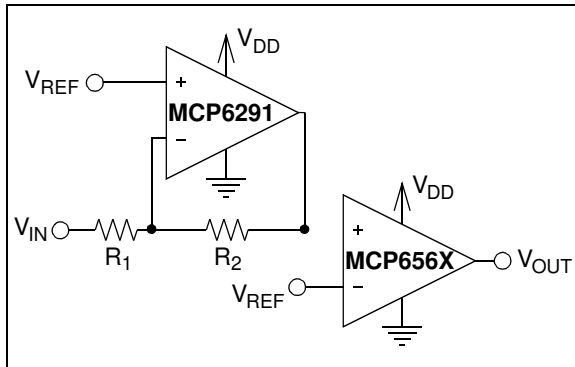


**FIGURE 4-11:** Unused Comparators.

## 4.9 Typical Applications

### 4.9.1 PRECISE COMPARATOR

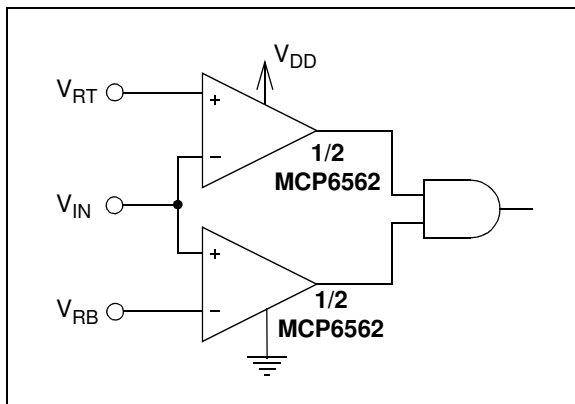
Some applications require higher DC precision. An easy way to solve this problem is to use an amplifier (such as the MCP6291) to gain-up the input signal before it reaches the comparator. [Figure 4-12](#) shows an example of this approach.



**FIGURE 4-12:** *Precise Inverting Comparator.*

### 4.9.2 WINDOWED COMPARATOR

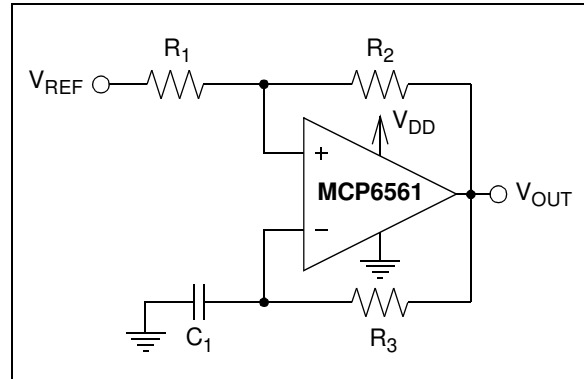
[Figure 4-13](#) shows one approach to designing a windowed comparator. The AND gate produces a logic '1' when the input voltage is between  $V_{RB}$  and  $V_{RT}$  (where  $V_{RT} > V_{RB}$ ).



**FIGURE 4-13:** *Windowed Comparator.*

### 4.9.3 BISTABLE MULTIVIBRATOR

A simple bistable multivibrator design is shown in [Figure 4-14](#).  $V_{REF}$  needs to be between the power supplies ( $V_{SS} = GND$  and  $V_{DD}$ ) to achieve oscillation. The output duty cycle changes with  $V_{REF}$ .



**FIGURE 4-14:** *Bistable Multivibrator.*

# MCP6561/1R/1U/2/4

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NOTES:

## 5.0 DESIGN AIDS

### 5.1 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 web site at [www.microchip.com/maps](http://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 data sheets, purchase, and sampling of Microchip parts.

### 5.2 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](http://www.microchip.com/analogtools). Three of our boards that are especially useful are:

- 8-Pin SOIC/MSOP/TSSOP/DIP Evaluation Board, P/N SOIC8EV
- 14-Pin SOIC/TSSOP/DIP Evaluation Board, P/N SOIC14EV
- 5/6-Pin SOT23 Evaluation Board, P/N VSUPEV2

## 5.3 Application Notes

The following Microchip Application Note is available on the Microchip web site at [www.microchip.com](http://www.microchip.com) and is recommended as a supplemental reference resource:

- **AN895**, "Oscillator Circuits For RTD Temperature Sensors", DS00895

# MCP6561/1R/1U/2/4

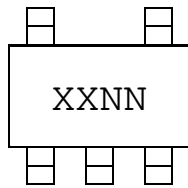
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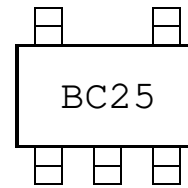
## 6.0 PACKAGING INFORMATION

### 6.1 Package Marking Information

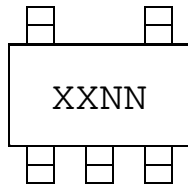
5-Lead SC-70 (MCP6561)



Example:



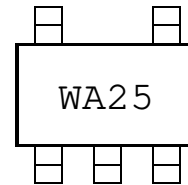
5-Lead SOT-23 (MCP6561, MCP6561R, MCP6561U)



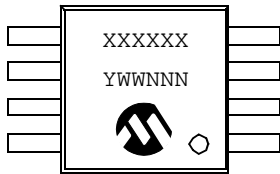
Device	Code
MCP6561T	WBNN
MCP6561RT	WANN
MCP6561UT	WKNN

**Note:** Applies to 5-Lead SOT-23.

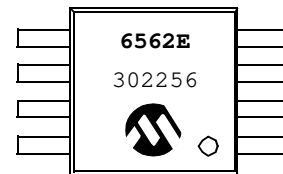
Example:



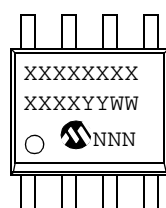
8-Lead MSOP (MCP6562)



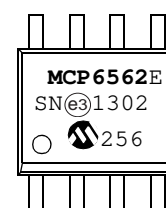
Example:



8-Lead SOIC (150 mil) (MCP6562)



Example:



<b>Legend:</b>	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.

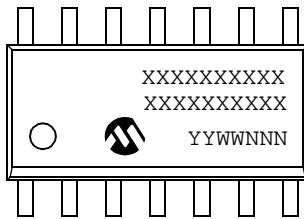


# MCP6561/1R/1U/2/4

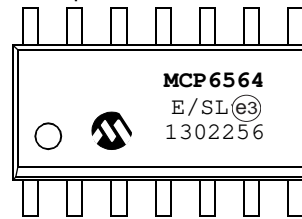
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## Package Marking Information (Continued)

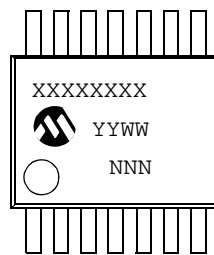
14-Lead SOIC (150 mil) (MCP6564)



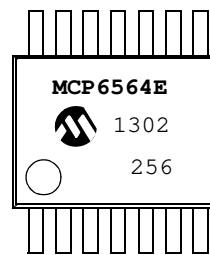
Example:



14-Lead TSSOP (MCP6564)

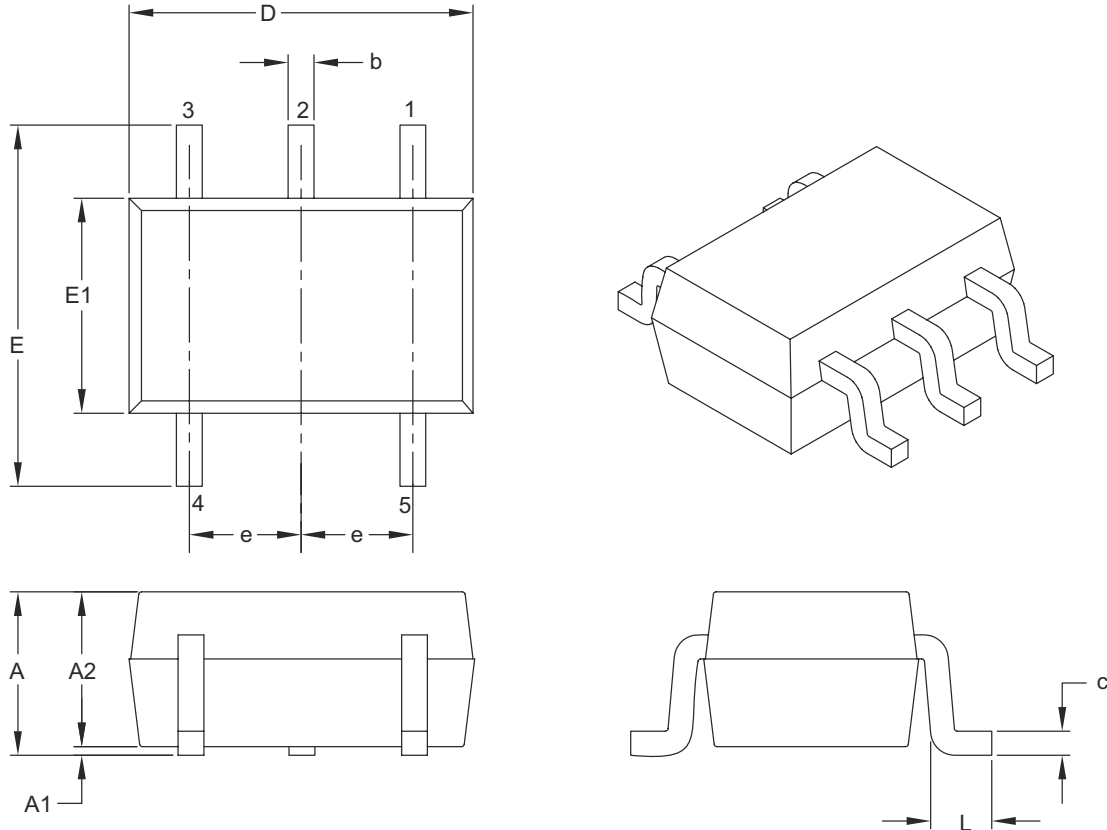


Example:



## 5-Lead Plastic Small Outline Transistor (LT) [SC70]

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



Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Number of Pins	N	5		
Pitch	e	0.65 BSC		
Overall Height	A	0.80	–	1.10
Molded Package Thickness	A2	0.80	–	1.00
Standoff	A1	0.00	–	0.10
Overall Width	E	1.80	2.10	2.40
Molded Package Width	E1	1.15	1.25	1.35
Overall Length	D	1.80	2.00	2.25
Foot Length	L	0.10	0.20	0.46
Lead Thickness	c	0.08	–	0.26
Lead Width	b	0.15	–	0.40

**Notes:**

- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.

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

Microchip Technology Drawing C04-061B