



# MICROCHIP MCP6541/1R/1U/2/3/4

## Push-Pull Output Sub-Microamp Comparators

### Features

- Low Quiescent Current: 600 nA/comparator (typ.)
- Rail-to-Rail Input:  $V_{SS} - 0.3V$  to  $V_{DD} + 0.3V$
- CMOS/TTL-Compatible Output
- Propagation Delay: 4  $\mu s$  (typ., 100 mV Overdrive)
- Wide Supply Voltage Range: 1.6V to 5.5V
- Available in Single, Dual and Quad
- Single available in SOT-23-5, SC-70-5 \* packages
- Chip Select ( $\overline{CS}$ ) with MCP6543
- Low Switching Current
- Internal Hysteresis: 3.3 mV (typ.)
- Temperature Ranges:
  - Industrial:  $-40^{\circ}C$  to  $+85^{\circ}C$
  - Extended:  $-40^{\circ}C$  to  $+125^{\circ}C$

### Typical Applications

- Laptop Computers
- Mobile Phones
- Metering Systems
- Hand-held Electronics
- RC Timers
- Alarm and Monitoring Circuits
- Windowed Comparators
- Multi-vibrators

### Related Devices

- Open-Drain Output: MCP6546/7/8/9

### Description

The Microchip Technology Inc. MCP6541/1R/1U/2/3/4 family of comparators is offered in single (MCP6541, MCP6541R, MCP6541U), single with Chip Select ( $\overline{CS}$ ) (MCP6543), dual (MCP6542) and quad (MCP6544) configurations. The outputs are push-pull (CMOS/TTL-compatible) and are capable of driving heavy DC or capacitive loads.

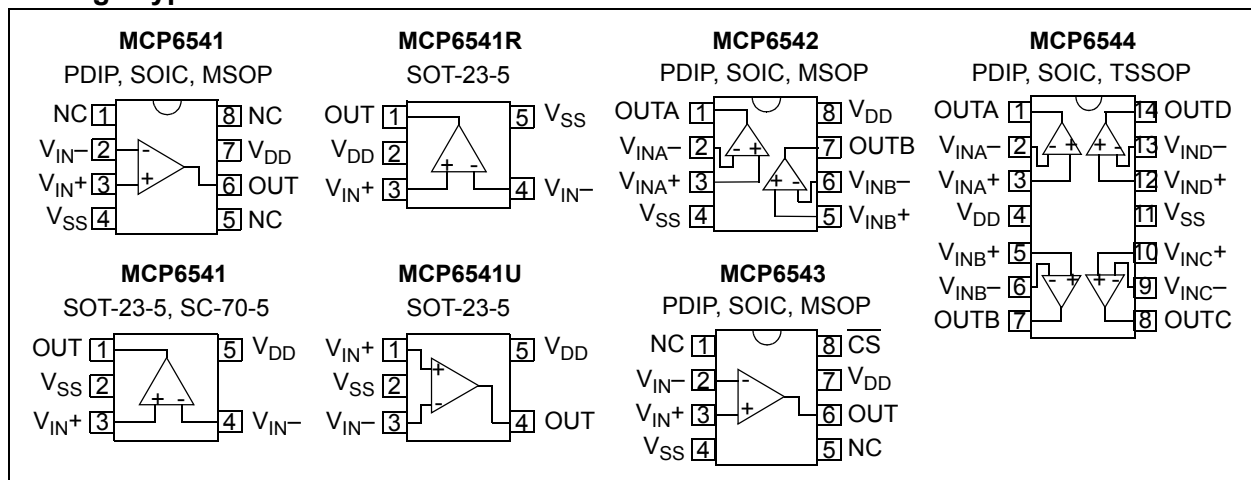
These comparators are optimized for low power, single-supply operation with greater than rail-to-rail input operation. The push-pull output of the MCP6541/1R/1U/2/3/4 family supports rail-to-rail output swing and interfaces with TTL/CMOS logic. The internal input hysteresis eliminates output switching due to internal input noise voltage, reducing current draw. The output limits supply current surges and dynamic power consumption while switching. This product family operates with a single-supply voltage as low as 1.6V and draws less than 1  $\mu A$ /comparator of quiescent current.

The related MCP6546/7/8/9 family of comparators from Microchip has an open-drain output. Used with a pull-up resistor, these devices can be used as level-shifters for any desired voltage up to 10V and in wired-OR logic.

\* SC-70-5 E-Temp parts not available at this release of the data sheet.

MCP6541U SOT-23-5 is E-Temp only.

### Package Types



# MCP6541/1R/1U/2/3/4

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

$V_{DD} - V_{SS}$ .....	7.0V
Current at Analog Input Pin ( $V_{IN+}$ , $V_{IN-}$ ) .....	$\pm 2$ mA
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 .....	continuous
Current at Input Pins .....	$\pm 2$ mA
Current at Output and Supply Pins .....	$\pm 30$ mA
Storage temperature .....	$-65^{\circ}C$ to $+150^{\circ}C$
Maximum Junction Temperature ( $T_J$ ) .....	$+150^{\circ}C$
ESD protection on all pins (HBM;MM) .....	4 kV; 400V

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

†† See **Section 4.1.2 “Input Voltage and Current Limits”**

### DC CHARACTERISTICS

**Electrical Specifications:** Unless otherwise indicated,  $V_{DD} = +1.6V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $T_A = +25^{\circ}C$ ,  $V_{IN+} = V_{DD}/2$ ,  $V_{IN-} = V_{SS}$ , and  $R_L = 100$  k $\Omega$  to  $V_{DD}/2$  (Refer to [Figure 1-3](#)).

Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Power Supply</b>						
Supply Voltage	$V_{DD}$	1.6	—	5.5	V	
Quiescent Current per comparator	$I_Q$	0.3	0.6	1.0	$\mu A$	$I_{OUT} = 0$
<b>Input</b>						
Input Voltage Range	$V_{CMR}$	$V_{SS}-0.3$	—	$V_{DD}+0.3$	V	
Common Mode Rejection Ratio	CMRR	55	70	—	dB	$V_{DD} = 5V$ , $V_{CM} = -0.3V$ to $5.3V$
Common Mode Rejection Ratio	CMRR	50	65	—	dB	$V_{DD} = 5V$ , $V_{CM} = 2.5V$ to $5.3V$
Common Mode Rejection Ratio	CMRR	55	70	—	dB	$V_{DD} = 5V$ , $V_{CM} = -0.3V$ to $2.5V$
Power Supply Rejection Ratio	PSRR	63	80	—	dB	$V_{CM} = V_{SS}$
Input Offset Voltage	$V_{OS}$	-7.0	$\pm 1.5$	+7.0	mV	$V_{CM} = V_{SS}$ ( <b>Note 1</b> )
Drift with Temperature	$\Delta V_{OS}/\Delta T_A$	—	$\pm 3$	—	$\mu V/^{\circ}C$	$T_A = -40^{\circ}C$ to $+125^{\circ}C$ , $V_{CM} = V_{SS}$
Input Hysteresis Voltage	$V_{HYST}$	1.5	3.3	6.5	mV	$V_{CM} = V_{SS}$ ( <b>Note 1</b> )
Linear Temp. Co. ( <b>Note 2</b> )	$TC_1$	—	6.7	—	$\mu V/^{\circ}C$	$T_A = -40^{\circ}C$ to $+125^{\circ}C$ , $V_{CM} = V_{SS}$
Quadratic Temp. Co. ( <b>Note 2</b> )	$TC_2$	—	-0.035	—	$\mu V/^{\circ}C^2$	$T_A = -40^{\circ}C$ to $+125^{\circ}C$ , $V_{CM} = V_{SS}$
Input Bias Current	$I_B$	—	1	—	pA	$V_{CM} = V_{SS}$
At Temperature (I-Temp parts)	$I_B$	—	25	100	pA	$T_A = +85^{\circ}C$ , $V_{CM} = V_{SS}$ ( <b>Note 3</b> )
At Temperature (E-Temp parts)	$I_B$	—	1200	5000	pA	$T_A = +125^{\circ}C$ , $V_{CM} = V_{SS}$ ( <b>Note 3</b> )
Input Offset Current	$I_{OS}$	—	$\pm 1$	—	pA	$V_{CM} = V_{SS}$
Common Mode Input Impedance	$Z_{CM}$	—	$10^{13}  4$	—	$\Omega  pF$	
Differential Input Impedance	$Z_{DIFF}$	—	$10^{13}  2$	—	$\Omega  pF$	

- Note 1:** The input offset voltage is the center (average) 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  $V_{HYST}(T_A) = V_{HYST} + (T_A - 25^{\circ}C) TC_1 + (T_A - 25^{\circ}C)^2 TC_2$ .
- 3:** Input bias current at temperature is not tested for SC-70-5 package.
- 4:** Limit the output current to Absolute Maximum Rating of 30 mA.

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## DC CHARACTERISTICS (CONTINUED)

**Electrical Specifications:** Unless otherwise indicated,  $V_{DD} = +1.6V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ ,  $V_{IN+} = V_{DD}/2$ ,  $V_{IN-} = V_{SS}$ , and  $R_L = 100\ k\Omega$  to  $V_{DD}/2$  (Refer to [Figure 1-3](#)).

Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Push-Pull Output</b>						
High-Level Output Voltage	$V_{OH}$	$V_{DD}-0.2$	—	—	V	$I_{OUT} = -2\ mA$ , $V_{DD} = 5V$
Low-Level Output Voltage	$V_{OL}$	—	—	$V_{SS}+0.2$	V	$I_{OUT} = 2\ mA$ , $V_{DD} = 5V$
Short-Circuit Current	$I_{SC}$	—	-2.5, +1.5	—	mA	$V_{DD} = 1.6V$ ( <b>Note 4</b> )
	$I_{SC}$	—	$\pm 30$	—	mA	$V_{DD} = 5.5V$ ( <b>Note 4</b> )

- Note 1:** The input offset voltage is the center (average) 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  $V_{HYST}(T_A) = V_{HYST} + (T_A - 25^\circ C) TC_1 + (T_A - 25^\circ C)^2 TC_2$ .
- 3:** Input bias current at temperature is not tested for SC-70-5 package.
- 4:** Limit the output current to Absolute Maximum Rating of 30 mA.

## AC CHARACTERISTICS

**Electrical Specifications:** Unless otherwise indicated,  $V_{DD} = +1.6V$  to  $+5.5V$ ,  $V_{SS} = GND$ ,  $T_A = +25^\circ C$ ,  $V_{IN+} = V_{DD}/2$ , Step = 200 mV, Overdrive = 100 mV, and  $C_L = 36\ pF$  (Refer to [Figure 1-2](#) and [Figure 1-3](#)).

Parameters	Sym	Min	Typ	Max	Units	Conditions
Rise Time	$t_R$	—	0.85	—	$\mu s$	
Fall Time	$t_F$	—	0.85	—	$\mu s$	
Propagation Delay (High-to-Low)	$t_{PHL}$	—	4	8	$\mu s$	
Propagation Delay (Low-to-High)	$t_{PLH}$	—	4	8	$\mu s$	
Propagation Delay Skew	$t_{PDS}$	—	$\pm 0.2$	—	$\mu s$	( <b>Note 1</b> )
Maximum Toggle Frequency	$f_{MAX}$	—	160	—	kHz	$V_{DD} = 1.6V$
	$f_{MAX}$	—	120	—	kHz	$V_{DD} = 5.5V$
Input Noise Voltage	$E_{ni}$	—	200	—	$\mu V_{P-P}$	10 Hz to 100 kHz

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

## TEMPERATURE CHARACTERISTICS

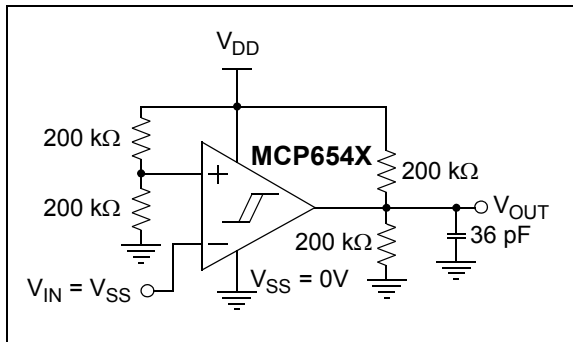
**Electrical Specifications:** Unless otherwise indicated,  $V_{DD} = +1.6V$  to  $+5.5V$  and  $V_{SS} = GND$ .

Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Temperature Ranges</b>						
Specified Temperature Range	$T_A$	-40	—	+85	°C	
Operating Temperature Range	$T_A$	-40	—	+125	°C	<b>Note</b>
Storage Temperature Range	$T_A$	-65	—	+150	°C	
<b>Thermal Package Resistances</b>						
Thermal Resistance, 5L-SC-70	$\theta_{JA}$	—	331	—	°C/W	
Thermal Resistance, 5L-SOT-23	$\theta_{JA}$	—	256	—	°C/W	
Thermal Resistance, 8L-PDIP	$\theta_{JA}$	—	85	—	°C/W	
Thermal Resistance, 8L-SOIC	$\theta_{JA}$	—	163	—	°C/W	
Thermal Resistance, 8L-MSOP	$\theta_{JA}$	—	206	—	°C/W	
Thermal Resistance, 14L-PDIP	$\theta_{JA}$	—	70	—	°C/W	
Thermal Resistance, 14L-SOIC	$\theta_{JA}$	—	120	—	°C/W	
Thermal Resistance, 14L-TSSOP	$\theta_{JA}$	—	100	—	°C/W	

**Note:** The MCP6541/1R/1U/2/3/4 I-Temp parts operate over this extended temperature range, but with reduced performance. In any case, the Junction Temperature ( $T_J$ ) must not exceed the Absolute Maximum specification of  $+150^\circ\text{C}$ .

### 1.1 Test Circuit Configuration

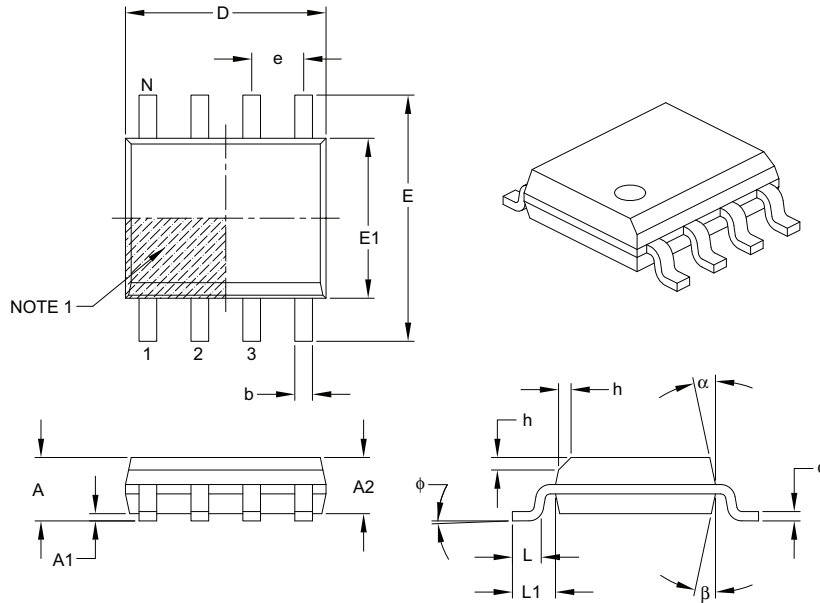
This test circuit configuration is used to determine the AC and DC specifications.



**FIGURE 1-3:** AC and DC Test Circuit for the Push-Pull Output Comparators.

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



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

### Notes:

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

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

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

Microchip Technology Drawing C04-057B

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## PRODUCT IDENTIFICATION SYSTEM

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

<u>PART NO.</u>	<u>-X</u>	<u>/XX</u>	<b>Examples:</b>
Device	Temperature Range	Package	
Device:	MCP6541: Single Comparator MCP6541T: Single Comparator (Tape and Reel) (SC-70, SOT-23, SOIC, MSOP)	Single Comparator	a) MCP6541T-I/LT: Tape and Reel, Industrial Temperature, 5LD SC-70.
	MCP6541RT: Single Comparator (Rotated - Tape and Reel) (SOT-23 only)	Single Comparator (Rotated - Tape and Reel) (SOT-23 only)	b) MCP6541T-I/OT: Tape and Reel, Industrial Temperature, 5LD SOT-23.
	MCP6541UT: Single Comparator (Tape and Reel) ( <b>SOT-23-5 is E-Temp only</b> )	Single Comparator (Tape and Reel) ( <b>SOT-23-5 is E-Temp only</b> )	c) MCP6541-E/P: Extended Temperature, 8LD PDIP.
	MCP6542: Dual Comparator MCP6542T: Dual Comparator (Tape and Reel for SOIC and MSOP)	Dual Comparator	d) MCP6541RT-I/OT: Tape and Reel, Industrial Temperature, 5LD SOT23.
	MCP6543: Single Comparator with $\overline{CS}$ MCP6543T: Single Comparator with $\overline{CS}$ (Tape and Reel for SOIC and MSOP)	Single Comparator with $\overline{CS}$	e) MCP6541-E/SN: Extended Temperature, 8LD SOIC.
	MCP6544: Quad Comparator MCP6544T: Quad Comparator (Tape and Reel for SOIC and TSSOP)	Quad Comparator	f) MCP6541UT-E/OT: Tape and Reel, Extended Temperature, 5LD SOT23.
Temperature Range:	I = -40°C to +85°C E* = -40°C to +125°C * SC-70-5 E-Temp parts not available at this release of the data sheet.		a) MCP6542-I/MS: Industrial Temperature, 8LD MSOP.
Package:	LT = Plastic Package (SC-70), 5-lead OT = Plastic Small Outline Transistor (SOT-23), 5-lead MS = Plastic MSOP, 8-lead P = Plastic DIP (300 mil Body), 8-lead, 14-lead SN = Plastic SOIC (150 mil Body), 8-lead SL = Plastic SOIC (150 mil Body), 14-lead (MCP6544) ST = Plastic TSSOP (4.4mm Body), 14-lead (MCP6544)		b) MCP6542T-I/MS: Tape and Reel, Industrial Temperature, 8LD MSOP.
			c) MCP6542-I/P: Industrial Temperature, 8LD PDIP.
			d) MCP6542-E/SN: Extended Temperature, 8LD SOIC.
			a) MCP6543-I/SN: Industrial Temperature, 8LD SOIC.
			b) MCP6543T-I/SN: Tape and Reel, Industrial Temperature, 8LD SOIC.
			c) MCP6543-I/P: Industrial Temperature, 8LD PDIP.
			d) MCP6543-E/SN: Extended Temperature, 8LD SOIC.
			a) MCP6544T-I/SL: Tape and Reel, Industrial Temperature, 14LD SOIC.
			b) MCP6544T-E/SL: Tape and Reel, Extended Temperature, 14LD SOIC.
			c) MCP6544-I/P: Industrial Temperature, 14LD PDIP.
			d) MCP6544T-E/ST: Tape and Reel, Extended Temperature, 14LD TSSOP.