

1. Description

MCP6001/2/4 family of operational amplifiers (op amps) is specifically designed for general-purpose applications. This family has a 1 MHz Gain Bandwidth Product (GBWP) and 90° phase margin (typical). It also maintains 45° phase margin (typical) with a 500 pF capacitive load. This family operates from a single supply voltage as low as 1.8V, while drawing 100 μ A (typical) quiescent current. Additionally, the MCP6001/2/4 supports rail-to-rail input and output swing, with a common mode input voltage range of $V_{DD} + 300$ mV to $V_{SS} - 300$ mV.

The MCP6001/2/4 family is available in the industrial and extended temperature ranges, with a power supply range of 1.8V to 6.0V.

3. Applications

- Portable Equipment
- Photodiode Amplifier
- Analog Filters

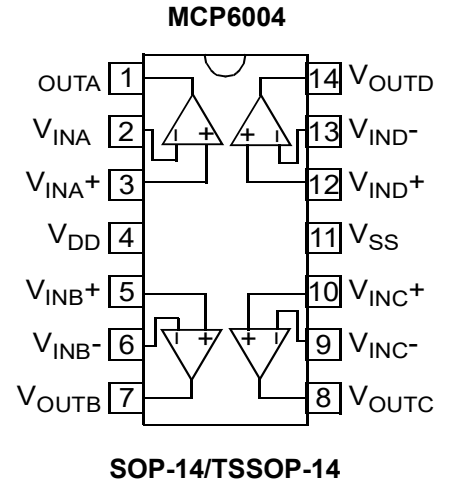
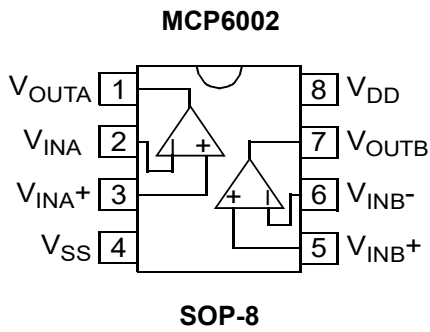
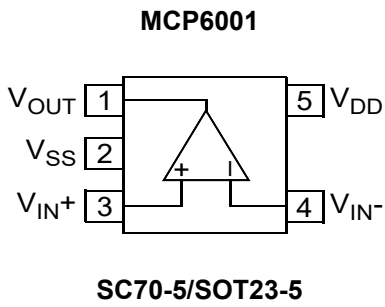
2. Features

- Gain Bandwidth Product: 1 MHz (typical)
- Rail-to-Rail Input/Output
- Supply Voltage: 1.8V to 6.0V
- Supply Current: $I_Q = 100$ μ A (typical)
- Phase Margin: 90° (typical)
- Temperature Range:
 - Industrial: -40°C to +85°C
 - Extended: -40°C to +125°C
- Available in Single, Dual and Quad Packages

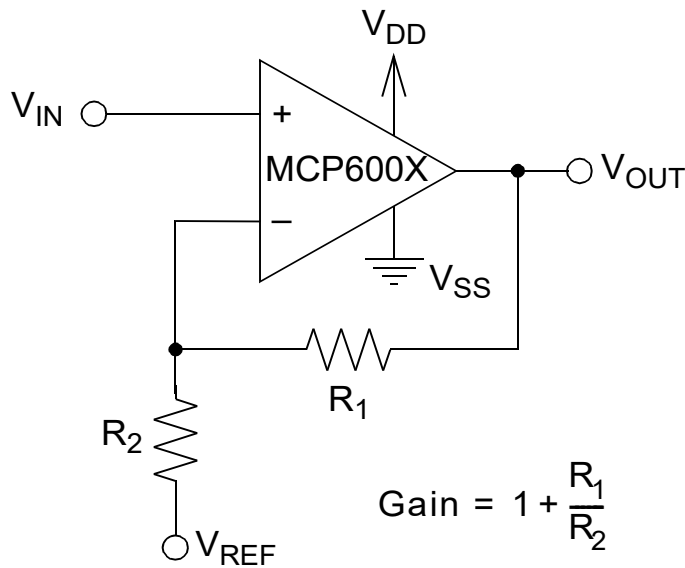
- Notebooks and PDAs
- Battery-Powered Systems



4. Pinning information



5. Typical Application



Noninverting Amplifier



6. Absolute Maximum Ratings ⁽¹⁾

Parameter	Value
$V_{DD} - V_{SS}$	7V
Current at Analog Input Pins (V_{IN+} , V_{IN-})	$\pm 2\text{mA}$
Analog Inputs (V_{IN+} , V_{IN-})	$V_{SS} - 1.0\text{V}$ to $V_{DD} + 1.0\text{V}$
All Other Inputs and Outputs	$V_{SS} - 0.3\text{V}$ to $V_{DD} + 0.3\text{V}$
Difference Input Voltage	$ V_{DD} - V_{SS} $
Output Short-Circuit Current	Continuous
Current at Output and Supply Pins	$\pm 30\text{mA}$
Storage Temperature	-65°C to $+150^{\circ}\text{C}$
Maximum Junction Temperature (T_J)	$+150^{\circ}\text{C}$
ESD Protection On All Pins (HBM; MM)	$\geq 4\text{kV}$; 200V

Notice:

(1) 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.



7.1 DC Electrical Characteristics

$T_A=+25^{\circ}\text{C}$, $V_{DD}=+1.8\text{V}$ to $+5.5\text{V}$, $V_{SS}=\text{GND}$, $V_{CM}=V_{DD}/2$, $V_L=V_{DD}/2$, $R_L=10\text{k}\Omega$ to V_L , and $V_{OUT}\approx V_{DD}/2$ (refer to Figure 1-1).

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input Offset						
Input Offset Voltage	V_{OS}	$V_{CM}=V_{SS}$ (Note 1)	-4.5		4.5	mV
Input Offset Drift with Temperature	$\Delta V_{OS}/\Delta T_A$	$T_A=-40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$, $V_{CM}=V_{SS}$		± 2		$\mu\text{V}/^{\circ}\text{C}$
Power Supply Rejection Ratio	PSRR	$V_{CM}=V_{SS}$		86		dB
Input Bias Current and Impedance						
Input Bias Current:	I_B			± 1		pA
Industrial Temperature		$T_A=+85^{\circ}\text{C}$		19		pA
Extended Temperature		$T_A=+125^{\circ}\text{C}$		1100		pA
Input Offset Current	I_{OS}			± 1		pA
Common Mode input impedance	Z_{CM}			$10^{13} 6$		ΩpF
Differential input Impedance	Z_{DIFF}			$10^{13} 3$		ΩpF
Common Mode						
Common Mode Input Range	V_{CMR}		$V_{SS}-0.3$		$V_{DD}+0.3$	V
Common Mode Rejection Ratio	CMRR	$V_{CM}=-0.3\text{V}$ to 5.3V , $V_{DD}=5\text{V}$	60	76		dB
Open-Loop Gain						
DC Open-Loop Gain (Large Signal)	A_{OL}	$V_{OUT}=0.3\text{V}$ to $V_{DD}-0.3\text{V}$, $V_{CM}=V_{SS}$	88	112		dB
Output						
Maximum Output Voltage Swing	V_{OL} , V_{OH}	$V_{DD}=5.5\text{V}$, 0.5V Input Overdrive	$V_{SS}+25$		$V_{DD}-25$	mV
Output Short Circuit Current	I_{SC}	$V_{DD}=1.8\text{V}$		± 6		mA
		$V_{DD}=5.5\text{V}$		± 23		mA
Power Supply						
Supply Voltage	V_{DD}	Note 2	1.8		6	V
Quiescent Current per Amplifier	I_Q	$I_O=0$, $V_{DD}=5.5\text{V}$, $V_{CM}=5\text{V}$	50	100	170	μA



7.2 AC Electrical Characteristics

$T_A=+25^{\circ}\text{C}$, $V_{DD}=+1.8\text{V}$ to $+5.5\text{V}$, $V_{SS}=\text{GND}$, $V_{CM}=V_{DD}/2$, $V_L=V_{DD}/2$, $V_{OUT}\approx V_{DD}/2$, $R_L=10\text{k}\Omega$ to V_L , and $C_L=60\text{pF}$ (refer to Figure 1-1).

Parameter	Symbol	Conditions	Min	Typ	Max	Units
AC Response						
Gain Bandwidth Product	GBWP			1		MHz
Phase Margin	PM	$G=+1\text{V/V}$		90		$^{\circ}\text{C}$
Slew Rate	SR			0.6		$\text{V}/\mu\text{s}$
Noise						
Input Noise Voltage	E_{ni}	$f=0.1\text{Hz}$ to 10Hz		6.1		μV_{p-p}
Input Noise Voltage Density	e_{ni}	$f=1\text{kHz}$		28		$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Current Density	i_{ni}	$f=1\text{kHz}$		0.6		$\text{fA}/\sqrt{\text{Hz}}$



7.3 Electrical Characteristics

Unless otherwise indicated, $V_{DD}=+1.8V$ to $+5.5V$ and $V_{SS}=GND$.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Temperature Ranges						
Industrial Temperature Range	T_A		-40		85	°C
Extended Temperature Range	T_A		-40		125	°C
Operating Temperature Range	T_A	Note	-40		125	°C
Storage Temperature Range	T_A		-65		150	°C
Thermal Package Resistances						
Thermal Resistance, 5L-SC70	θ_{JA}			331		°C/W
Thermal Resistance, 5L-SOT-23	θ_{JA}			256		°C/W
Thermal Resistance, 8L-SOP(150 mil)	θ_{JA}			163		°C/W
Thermal Resistance, 14L-SOP	θ_{JA}			120		°C/W
Thermal Resistance, 14L-TSSOP	θ_{JA}			100		°C/W

Note: The industrial temperature devices operate over this extended temperature range, but with reduced performance. In any case, the internal Junction Temperature (T_J) must not exceed the Absolute Maximum specification of $+150^\circ\text{C}$.



8.1 Typical Characteristic

<p>Percentage of Occurrences</p> <p>Input Offset Voltage (mV)</p>	<p>Input Offset Voltage (μV)</p> <p>Common Mode Input Voltage (V)</p>
<p>Figure 1: Input Offset Voltage.</p>	<p>Figure 2: Input Offset Voltage vs. Common-Mode Input Voltage at $V_{DD} = 1.8\text{V}$.</p>
<p>Percentage of Occurrences</p> <p>Input Offset Voltage Drift; TC_1 ($\mu\text{V}/^\circ\text{C}$)</p>	<p>Input Offset Voltage (μV)</p> <p>Common Mode Input Voltage (V)</p>
<p>Figure 3: Input Offset Voltage Drift.</p>	<p>Figure 4: Input Offset Voltage vs. Common-Mode Input Voltage at $V_{DD} = 5.5\text{V}$.</p>
<p>Percentage of Occurrences</p> <p>Input Offset Quadratic Temp. Co.; TC_2 ($\mu\text{V}/^\circ\text{C}^2$)</p>	<p>Input Offset Voltage (μV)</p> <p>Output Voltage (V)</p>
<p>Figure 5: Input Offset Quadratic Temp. Co.</p>	<p>Figure 6: Input Offset Voltage vs. Output Voltage.</p>



8.2 Typical Characteristic

<p>Percentage of Occurrences</p> <p>14% 12% 10% 8% 6% 4% 2% 0%</p> <p>0 3 6 9 12 15 18 21 24 27 30</p> <p>Input Bias Current (pA)</p> <p>1230 Samples $V_{DD} = 5.5V$ $V_{CM} = V_{DD}$ $T_A = +85^\circ C$</p>	<p>PSRR, CMRR (dB)</p> <p>100 90 80 70 60 50 40 30 20</p> <p>10 100 1k 10k 100k</p> <p>Frequency (Hz)</p> <p>$V_{CM} = V_{SS}$</p> <p>PSRR- PSRR+ CMRR</p>
<p>Figure 7: Input Bias Current at +85°C.</p>	<p>Figure 8: PSRR, CMRR vs. Frequency.</p>
<p>Percentage of Occurrences</p> <p>55% 50% 45% 40% 35% 30% 25% 20% 15% 10% 5% 0%</p> <p>0 150 300 450 600 750 900 1050 1200 1350 1500</p> <p>Input Bias Current (pA)</p> <p>605 Samples $V_{DD} = 5.5V$ $V_{CM} = V_{DD}$ $T_A = +125^\circ C$</p>	<p>Open-Loop Gain (dB)</p> <p>120 100 80 60 40 20 0 -20</p> <p>0.1 1 10 100 1k 10k 100k 1M 10M</p> <p>Frequency (Hz)</p> <p>$V_{CM} = V_{SS}$</p> <p>Phase Gain</p> <p>Open-Loop Phase (°)</p> <p>0 -30 -60 -90 -120 -150 -180 -210</p>
<p>Figure 9: Input Bias Current at +125°C.</p>	<p>Figure 10: Open-Loop Gain, Phase vs. Frequency.</p>
<p>PSRR, CMRR (dB)</p> <p>100 95 90 85 80 75 70</p> <p>-50 -25 0 25 50 75 100 125</p> <p>Ambient Temperature (°C)</p> <p>$V_{DD} = 5.0V$</p> <p>PSRR ($V_{CM} = V_{SS}$) CMRR ($V_{CM} = -0.3V \text{ to } +5.3V$)</p>	<p>Input Noise Voltage Density (nV/√Hz)</p> <p>1,000 100 10</p> <p>0.1 1 10 100 1k 10k 100k</p> <p>Frequency (Hz)</p>
<p>Figure 11: CMRR, PSRR vs. Ambient Temperature.</p>	<p>Figure 12: Input Noise Voltage Density vs. Frequency.</p>



8.3 Typical Characteristic

<p>Short Circuit Current Magnitude (mA)</p> <p>Power Supply Voltage (V)</p>	<p>Output Voltage (20 mV/div)</p> <p>Time (1 μs/div)</p>
<p>Figure 13: Output Short-Circuit Current vs. Power Supply Voltage.</p>	<p>Figure 14: Small-Signal, Noninverting Pulse Response.</p>
<p>Output Voltage Headroom (mV)</p> <p>Output Current Magnitude (A)</p>	<p>Output Voltage (V)</p> <p>Time (10 μs/div)</p>
<p>Figure 15: Output Voltage Headroom vs. Output Current Magnitude.</p>	<p>Figure 16: Large-Signal, Noninverting Pulse Response.</p>
<p>Quiescent Current per amplifier (μA)</p> <p>Power Supply Voltage (V)</p>	<p>Slew Rate (V/μs)</p> <p>Ambient Temperature ($^{\circ}$C)</p>
<p>Figure 17: Quiescent Current vs. Power Supply Voltage.</p>	<p>Figure 18: Slew Rate vs. Ambient Temperature.</p>



8.4 Typical Characteristic

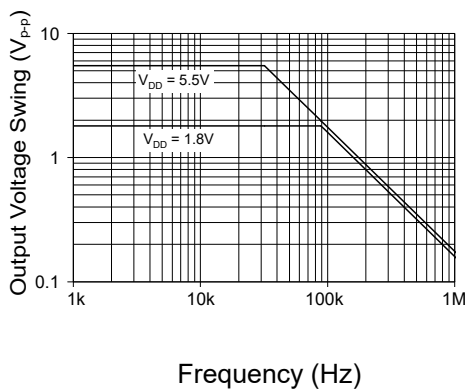


Figure 19: Output Voltage Swing vs. Frequency.

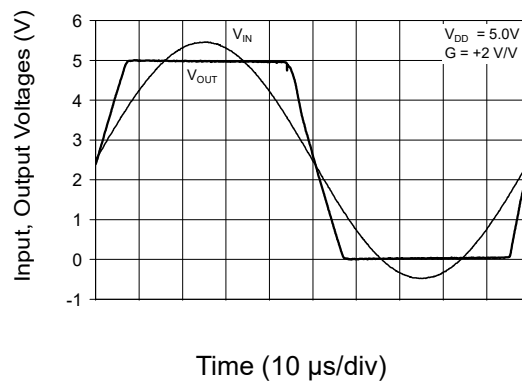


Figure 20: The MCP6001/2/4 Show No Phase Reversal.

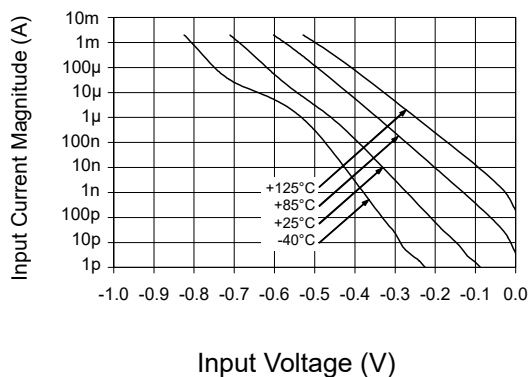
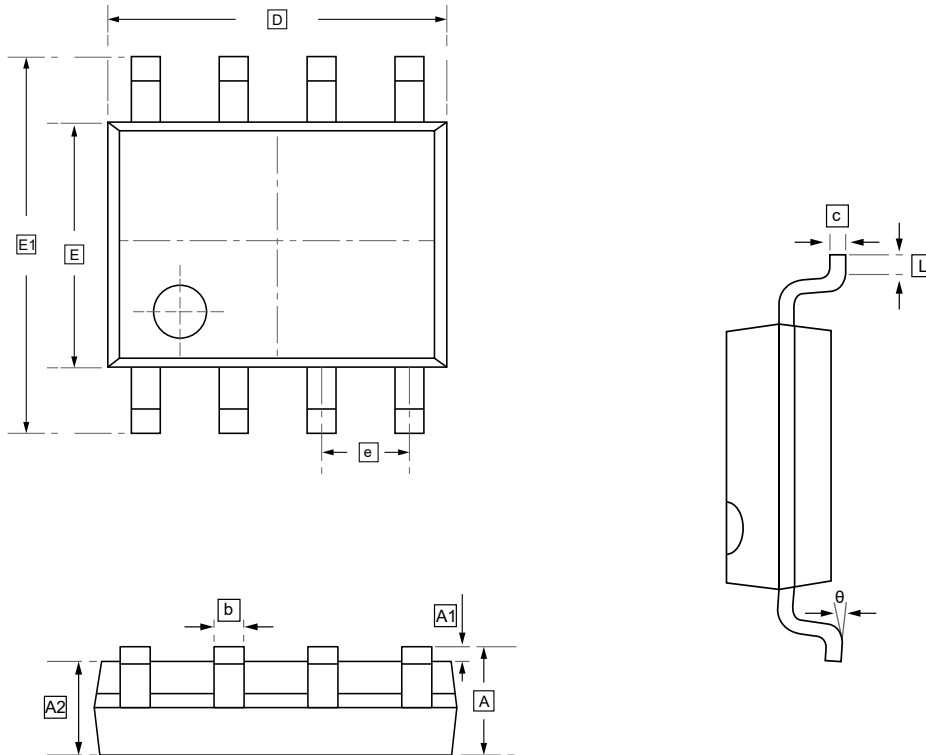


Figure 21: Measured Input Current vs. Input Voltage (below V_{SS}).



9.1 SOP-8 Package Outline Dimensions

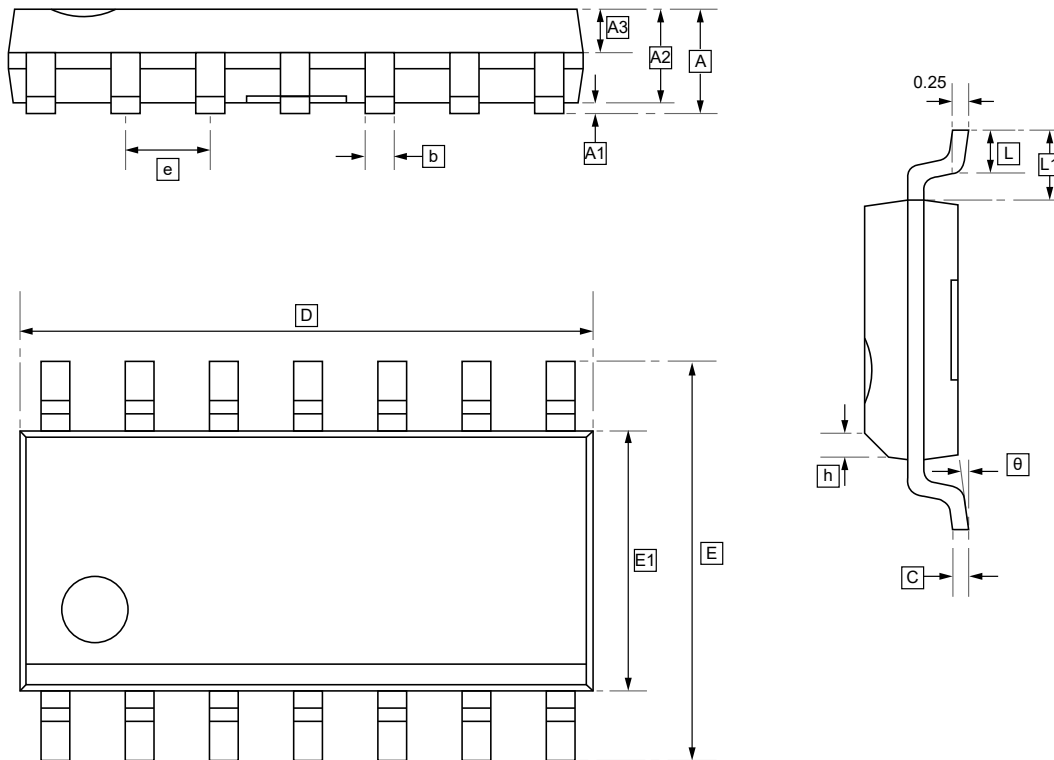


DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	b	c	D	E	E1	e	L	θ
Min	1.350	0.000	1.350	0.330	0.170	4.700	3.800	5.800	1.270	0.400	0°
Max	1.750	0.100	1.550	0.510	0.250	5.100	4.000	6.200	BSC	1.270	8°



9.2 SOP-14 Package Outline Dimensions



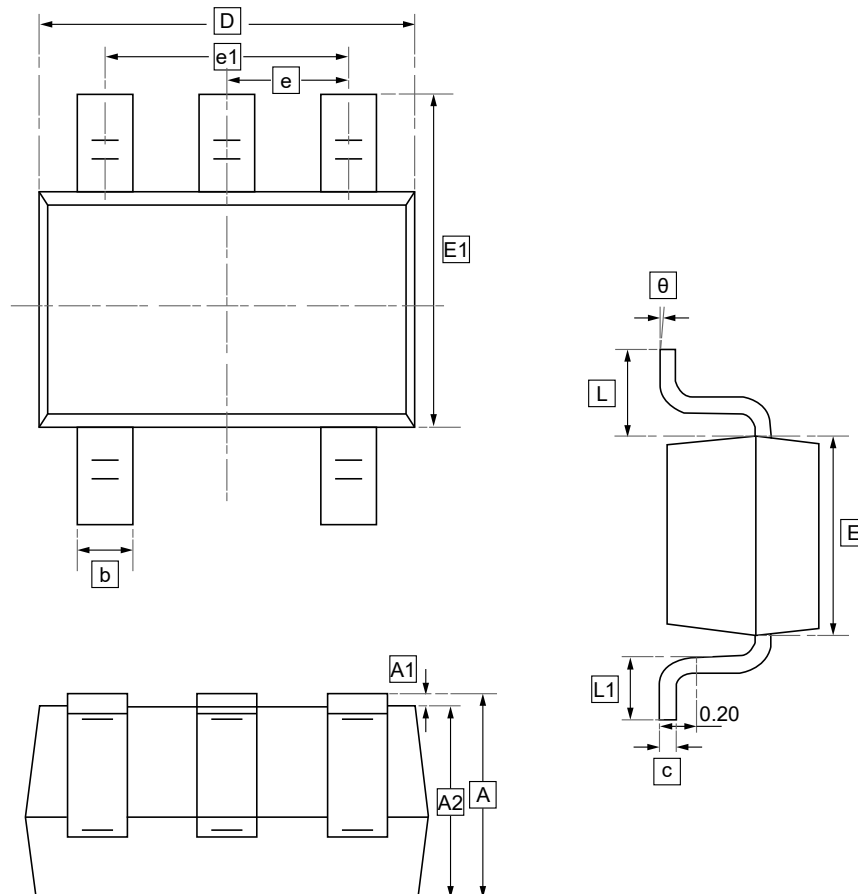
DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	A3	b	C	D	E	E1	e	h	L
Min	-	0.05	1.35	0.65	0.203	0.17	8.45	5.80	3.80	1.24	0.25	0.40
Max	1.75	0.25	1.55	0.75	0.305	0.25	8.85	6.20	4.00	1.30	0.50	0.80

Symbol	L1	θ
Min	1.00	0°
Max	1.10	8°



9.3 SC70-5 Package Outline Dimensions

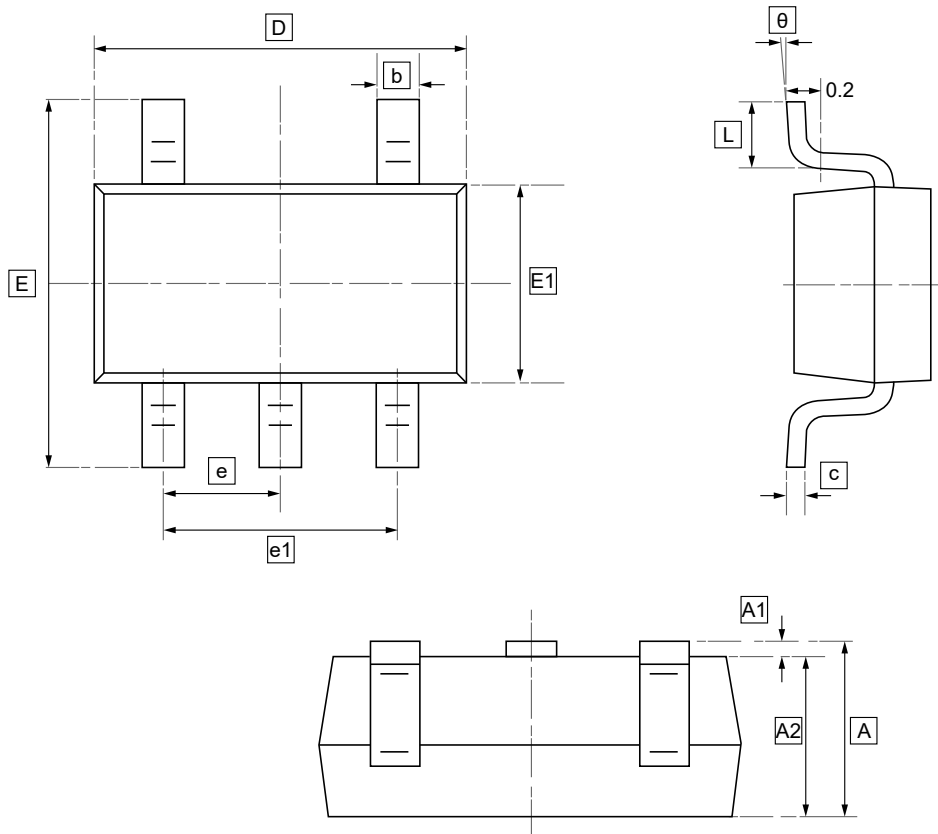


DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	b	c	D	E	E1	e	e1	L	θ
Min	0.90	0.00	0.90	0.15	0.08	2.05	1.15	2.15	0.65	1.20	0.26	7°
Max	1.10	0.10	1.00	0.35	0.15	2.25	1.35	2.45	TYP	1.40	0.46	REF.



9.4 SOT23-5 Package Outline Dimensions

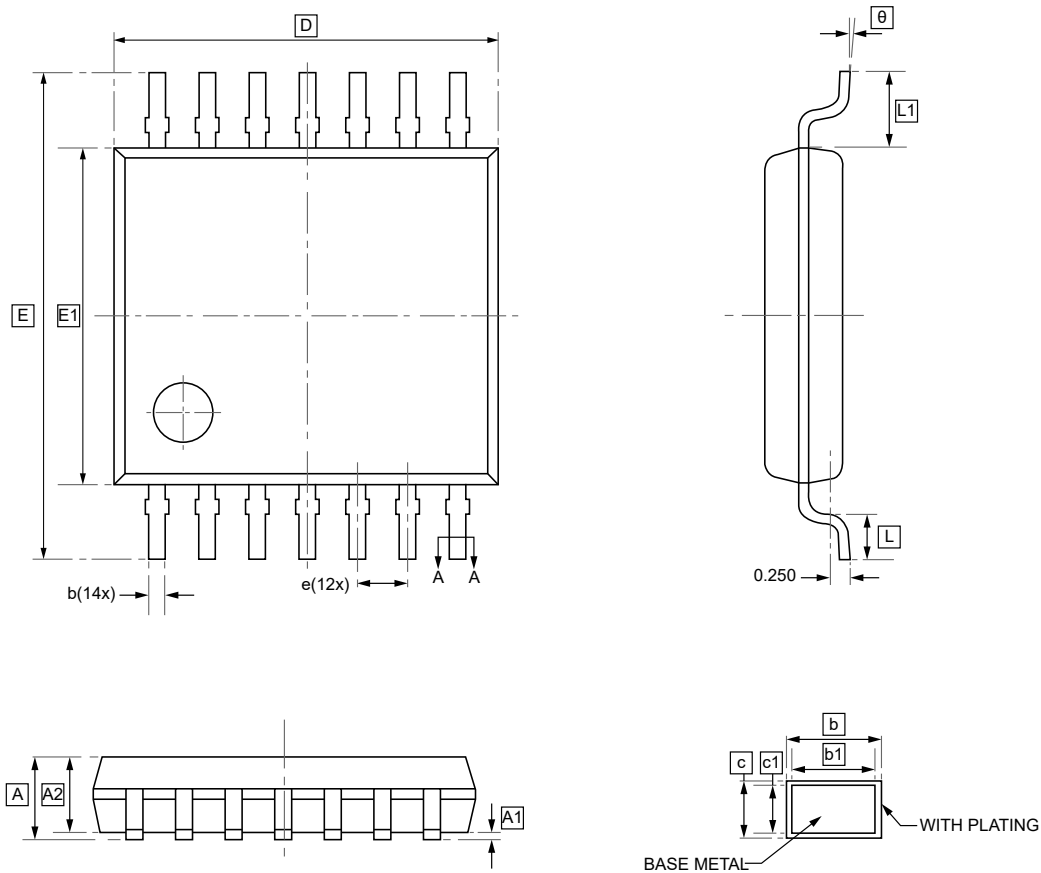


DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	b	c	D	E1	E	e	e1	L	θ
Min	1.050	0.000	1.050	0.300	0.100	2.820	1.500	2.650	0.950	1.800	0.300	0°
Max	1.250	0.100	1.150	0.500	0.200	3.020	1.700	2.950	BSC	2.000	0.600	8°



9.5 TSSOP-14 Package Outline Dimensions



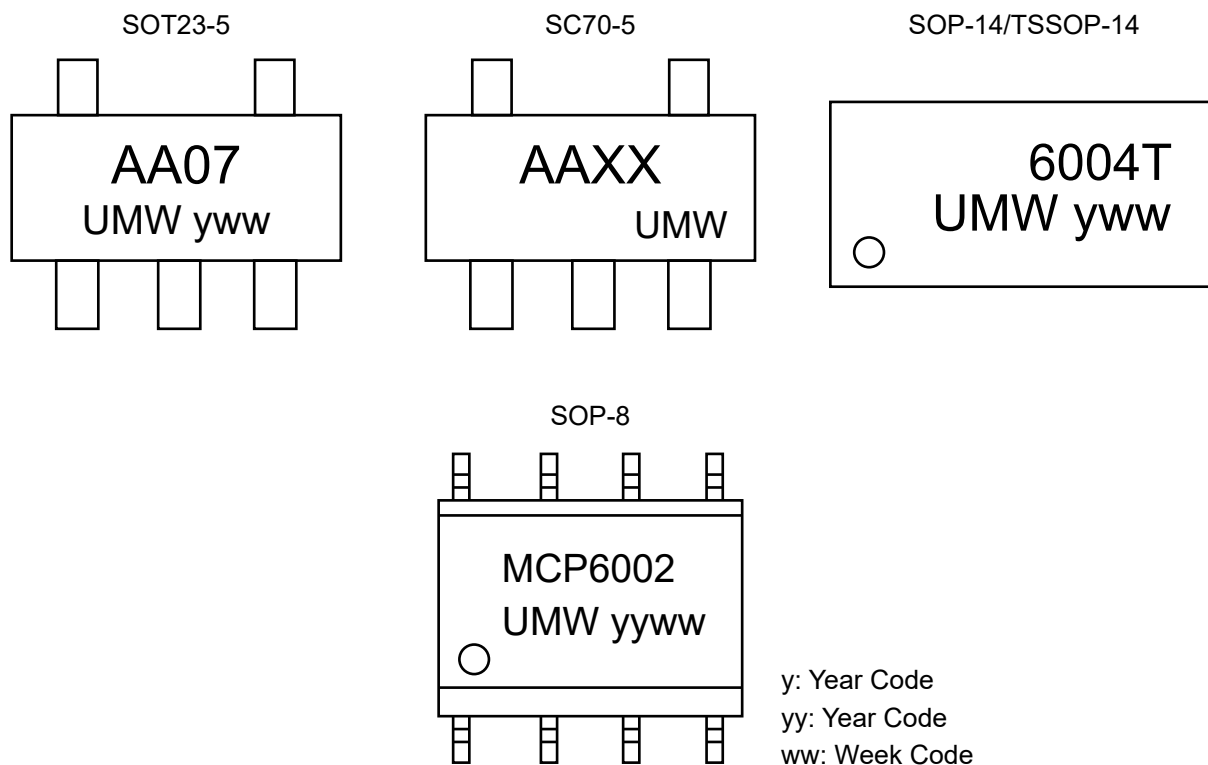
DIMENSIONS (mm are the original dimensions)

Symbol	A	A1	A2	b	b1	c	c1	D	E	E1	e	L1
Min	-	0.05	0.90	0.20	0.19	0.13	0.120	4.90	6.20	4.30	0.65	0.85
Max	1.20	0.15	1.05	0.28	0.25	0.17	0.14	5.10	6.60	4.50	BSC	1.15

Symbol	L	θ
Min	0.45	0°
Max	0.75	8°



10. Ordering information



Order Code	Marking	Package	Base QTY	Delivery Mode
UMW MCP6001T-I/OT	AA07	SOT23-5	3000	Tape and reel
UMW MCP6001T-E/OT	CDXX	SOT23-5	3000	Tape and reel
UMW MCP6001T-I/LT	AAXX	SC70-5	3000	Tape and reel
UMW MCP6002T-I/SN	MCP6002	SOP-8	2500	Tape and reel
UMW MCP6002T-E/SN	MCP6002	SOP-8	2500	Tape and reel
UMW MCP6004T-I/SL	MCP6004	SOP-14	2500	Tape and reel
UMW MCP6004T-E/SL	MCP6004	SOP-14	2500	Tape and reel
UMW MCP6004T-/ST	6004T	TSSOP-14	4000	Tape and reel
UMW MCP6004T-E/ST	6004T	TSSOP-14	4000	Tape and reel



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