MCP6L1/1R/2/4

2.8 MHz, 200 µA Op Amps

Features

- Supply Voltage: 2.7V to 6.0V
- Rail-to-Rail Output
- Input Range Includes Ground
- Available in SOT-23-5 Package
- Gain Bandwidth Product: 2.8 MHz (typical)
- Supply Current: I_Q = 200 µA/Amplifier (typical)
- Extended Temperature Range: -40°C to +125°C

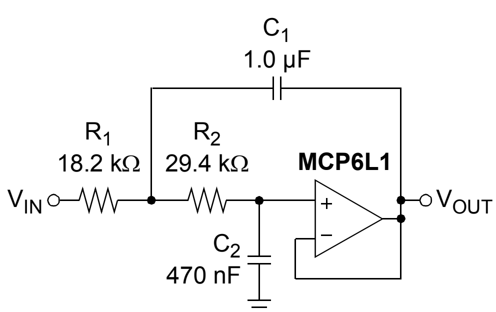
Typical Applications

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

Design Aids

- SPICE Macro Model
- FilterLab® Software
- Microchip Advanced Part Selector (MAPS)
- Analog Demonstration and Evaluation Boards
- Application Notes

Typical Application



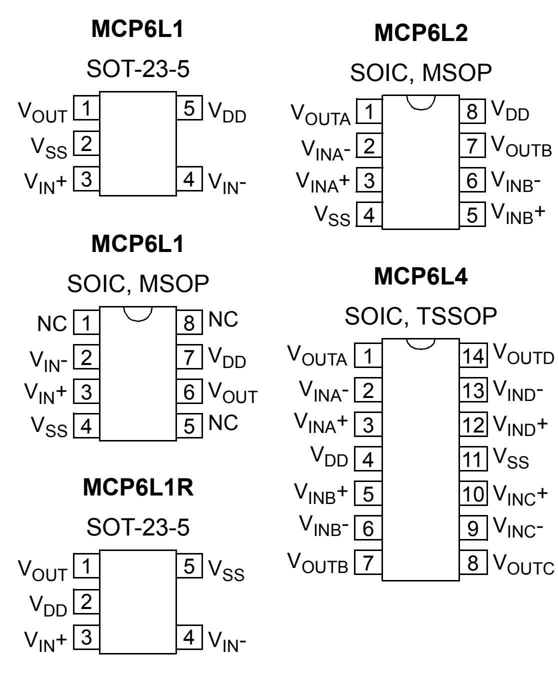
Low-Pass Filter

Description

The Microchip Technology Inc. MCP6L1/1R/2/4 family of operational amplifiers (op amps) supports general-purpose applications. Battery powered circuits benefit from their low quiescent current, A/D converters from their wide bandwidth and anti-aliasing filters from their low input bias current.

This family has a 2.8 MHz Gain Bandwidth Product (GBWP) with a low 200 µA per amplifier quiescent current. These op amps operate on supply voltages between 2.7V and 6.0V, with rail-to-rail output swing. They are available in the extended temperature range.

Package Types



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}+, V_{IN}-) †† .... V_{SS} – 1.0V to V_{DD} + 1.0V
All 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
Max. Junction Temperature ....+150°C
ESD Protection on All Pins (HBM, MM) ....≥ 3 kV, 200V

† 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”**.

1.2 Specifications

TABLE 1-1: DC ELECTRICAL SPECIFICATIONS

Electrical Characteristics: Unless otherwise indicated, T_A = +25°C, V_{DD} = 5.0V, V_{SS} = GND, $V_{CM} = V_{SS}$, $V_{OUT} \approx V_{DD}/2$, $V_L = V_{DD}/2$, and R_L = 10 kΩ to V_L (refer to Figure 1-1).

Parameters	Sym	Min (Note 1)	Typ	Max (Note 1)	Units	Conditions
Input Offset						
Input Offset Voltage	V_{OS}	-3	±1	+3	mV	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T_A$	—	±2.5	—	µV/°C	T_A= -40°C to+125°C
Power Supply Rejection Ratio	PSRR	—	90	—	dB	
Input Current and Impedance						
Input Bias Current	I_B	—	1	—	pA	
Across Temperature	I_B	—	20	—	pA	T_A= +85°C
Across Temperature	I_B	—	500	—	pA	T_A= +125°C
Input Offset Current	I_{OS}	—	±1	—	pA	
Common-Mode Input Impedance	Z_{CM}	—	10^{13}‖5	—	Ω‖pF	
Differential Input Impedance	Z_{DIFF}	—	10^{13}‖2	—	Ω‖pF	
Common-Mode						
Common-Mode Input Voltage Range	V_{CMR}	-0.3	—	3.7	V	
Common-Mode Rejection Ratio	CMRR	—	90	—	dB	V_{CM} = -0.3V to 3.7V
Open-Loop Gain						
DC Open-Loop Gain (large signal)	A_{OL}	—	105	—	dB	V_{OUT} = 0.2V to 4.8V
Output						
Maximum Output Voltage Swing	V_{OL}	—	—	0.030	V	G = +2, 0.5V Input Overdrive
	V_{OH}	4.960	—	—	V	G = +2, 0.5V Input Overdrive
Output Short Circuit Current	I_{SC}	—	±20	—	mA	
Power Supply						
Supply Voltage	V_{DD}	2.7	—	6.0	V	
Quiescent Current per Amplifier	I_Q	70	200	330	µA	I_O = 0

Note 1: For design guidance only; not tested.

TABLE 1-2: AC ELECTRICAL SPECIFICATIONS

Electrical Characteristics: Unless otherwise indicated, T_A = 25°C, V_{DD} = +5.0V, V_{SS} = GND, V_{CM} = V_{SS}, $V_{OUT} \approx V_{DD}/2$, $V_L = V_{DD}/2$, R_L = 10 kΩ to V_L and C_L = 60 pF (refer to Figure 1-1).						
Parameters	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
AC Response						
Gain Bandwidth Product	GBWP	—	2.8	—	MHz	
Phase Margin	PM	—	50	—	° (degree)	G = +1
Slew Rate	SR	—	2.3	—	V/µs	
Noise						
Input Noise Voltage	E_{ni}	—	7	—	μV_{P-P}	f = 0.1 Hz to 10 Hz
Input Noise Voltage Density	e_{ni}	—	21	—	nV/√Hz	f = 10 kHz
Input Noise Current Density	i_{ni}	—	0.6	—	fA/√Hz	f = 1 kHz

TABLE 1-3: TEMPERATURE SPECIFICATIONS

Electrical Characteristics: Unless otherwise indicated, all limits are specified for: V_{DD} = +2.7V to +6.0V, V_{SS} = GND.						
Parameters	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
Temperature Ranges						
Specified Temperature Range	T_A	-40	—	+125	°C	
Operating Temperature Range	T_A	-40	—	+125	°C	(Note 1)
Storage Temperature Range	T_A	-65	—	+150	°C	
Thermal Package Resistances						
Thermal Resistance, 5L-SOT-23	θ_{JA}	—	220.7	—	°C/W	
Thermal Resistance, 8L-MSOP	θ_{JA}	—	211	—	°C/W	
Thermal Resistance, 8L-SOIC (150 mil)	θ_{JA}	—	149.5	—	°C/W	
Thermal Resistance, 14L-SOIC	θ_{JA}	—	95.3	—	°C/W	
Thermal Resistance, 14L-TSSOP	θ_{JA}	—	100	—	°C/W	

Note 1: Operation must not cause T_J to exceed Maximum Junction Temperature specification (150°C).

1.3 Test Circuit

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

EQUATION 1-1:

$$G_{DM} = R_F/R_G$$
$$V_{CM} = (V_P + V_{DD}/2)/2$$
$$V_{OST} = V_{IN-} - V_{IN+}$$
$$V_{OUT} = (V_{DD}/2) + (V_P - V_M) + V_{OST}(1 + G_{DM})$$

Where:

G_{DM}	=	Differential-Mode Gain	(V/V)
V_{CM}	=	Op Amp's Common-Mode Input Voltage	(V)
V_{OST}	=	Op Amp's Total Input Offset Voltage	(mV)

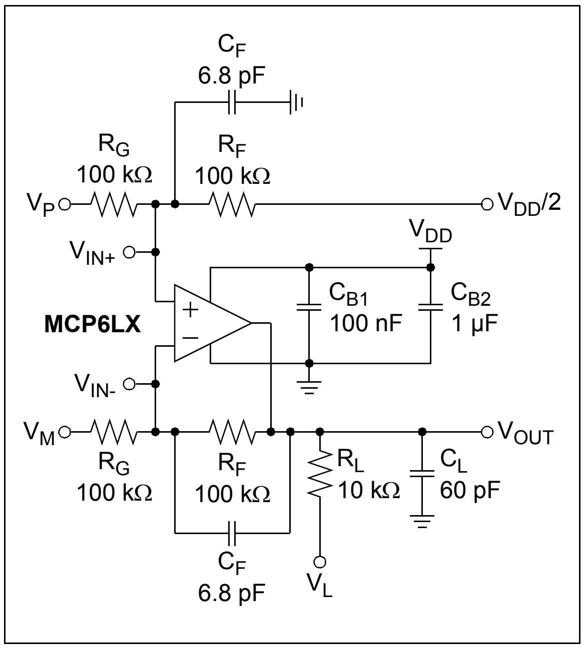


FIGURE 1-1: AC and DC Test Circuit for Most Specifications.

2.0 TYPICAL PERFORMANCE CURVES

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

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = 5.0V, V_{SS} = GND, $V_{CM} = V_{SS}$, $V_{OUT} = V_{DD}/2$, $V_L = V_{DD}/2$, R_L = 10 kΩ to V_L and C_L = 60 pF.

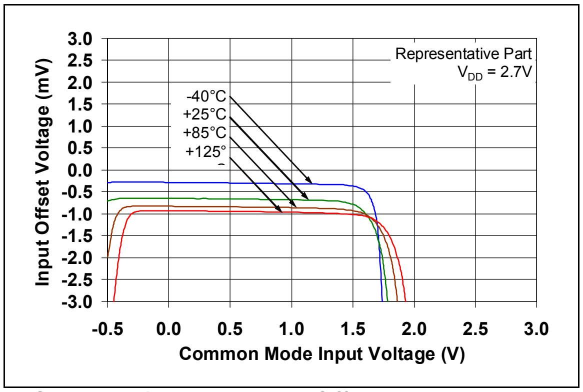


FIGURE 2-1: *Input Offset Voltage vs. Common-Mode Input Voltage at V_{DD} = 2.7V.*

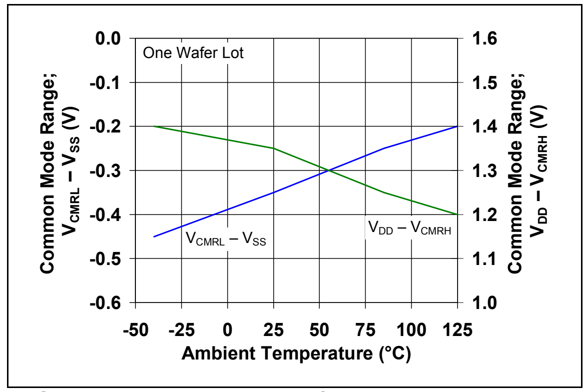


FIGURE 2-4: *Input Common-Mode Range Voltage vs. Ambient Temperature.*

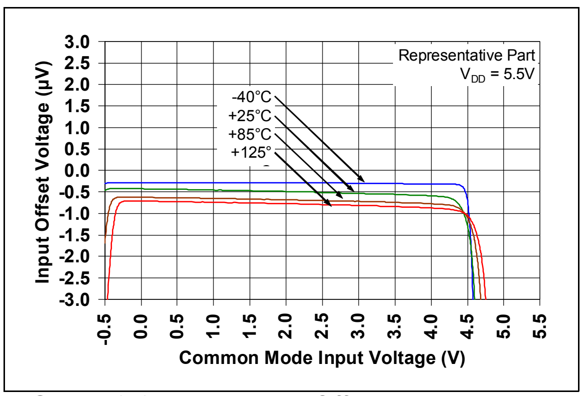


FIGURE 2-2: *Input Offset Voltage vs. Common-Mode Input Voltage at V_{DD} = 5.5V.*

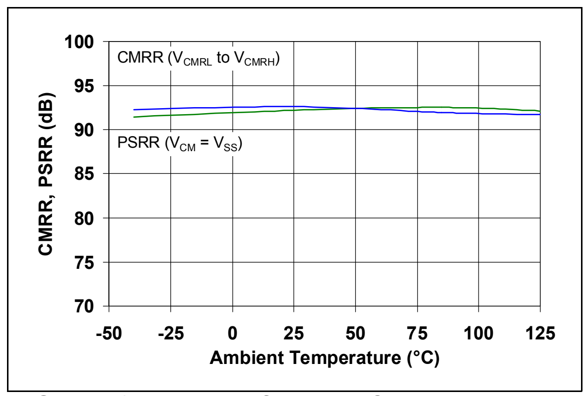


FIGURE 2-5: *CMRR, PSRR vs. Ambient Temperature.*

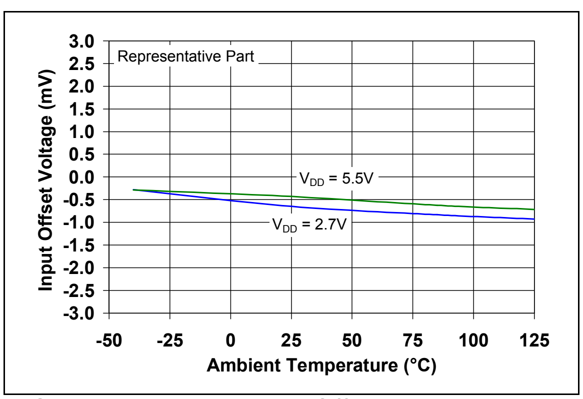


FIGURE 2-3: *Input Offset Voltage vs. Ambient Temperature.*

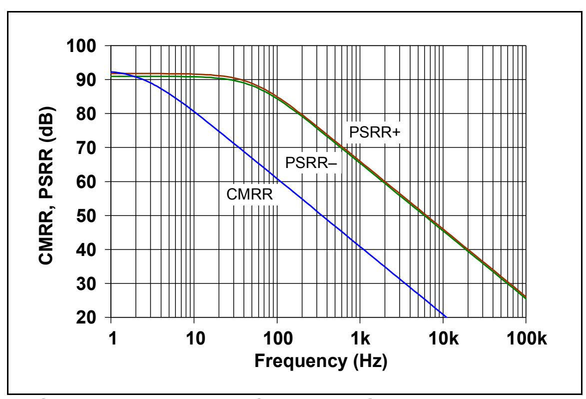


FIGURE 2-6: *CMRR, PSRR vs. Frequency.*

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = +5.0V, V_{SS} = GND, V_{CM} = V_{SS}, V_{OUT} = $V_{DD}/2$, V_L = $V_{DD}/2$, R_L = 10 kΩ to V_L and C_L = 60 pF.

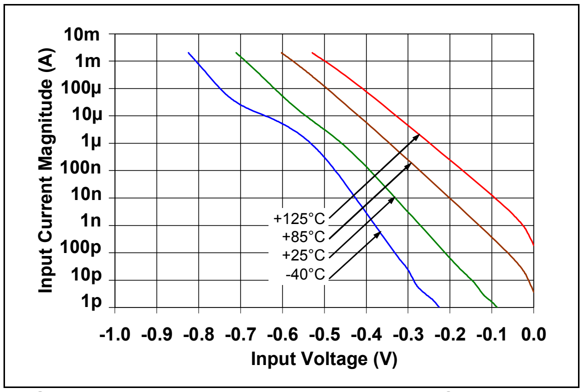


FIGURE 2-7: *Measured Input Current vs. Input Voltage (below V_{SS}).*

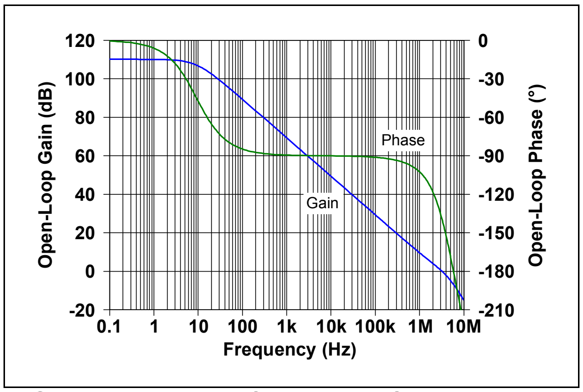


FIGURE 2-8: *Open-Loop Gain, Phase vs. Frequency.*

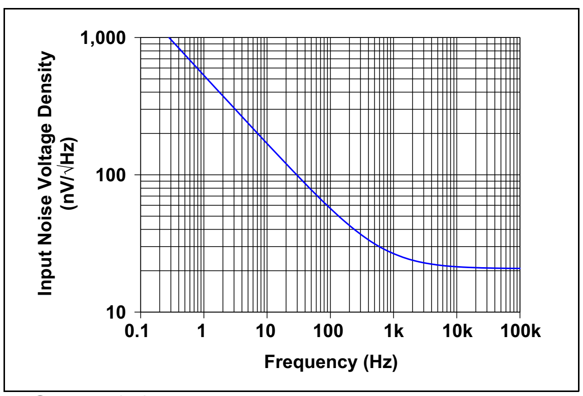


FIGURE 2-9: *Input Noise Voltage Density vs. Frequency.*

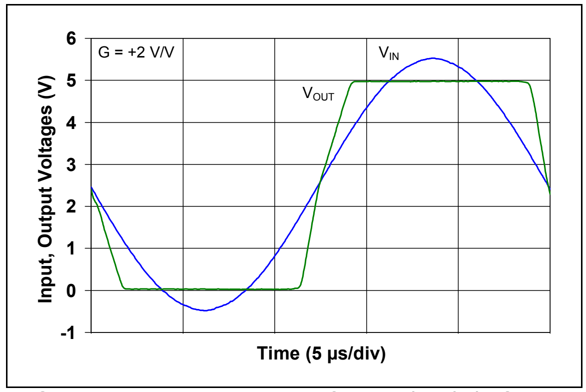


FIGURE 2-10: *The MCP6L1/1R/2/4 Show No Phase Reversal.*

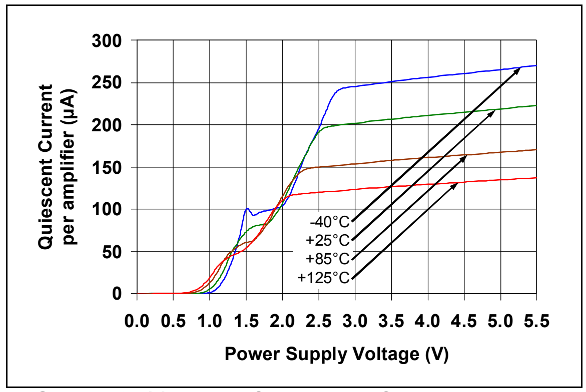


FIGURE 2-11: *Quiescent Current vs. Power Supply Voltage.*

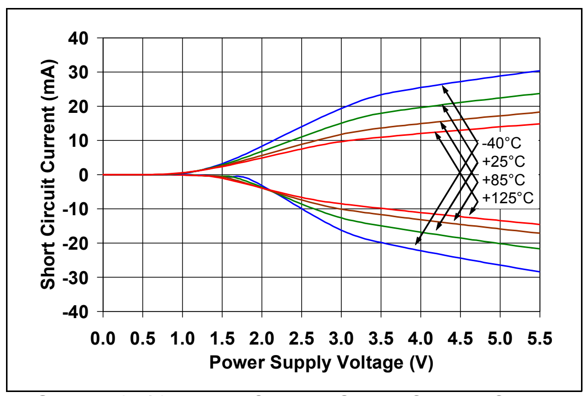


FIGURE 2-12: *Output Short Circuit Current vs. Power Supply Voltage.*

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = +5.0V, V_{SS} = GND, V_{CM} = V_{SS}, V_{OUT} = $V_{DD}/2$, V_L = $V_{DD}/2$, R_L = 10 kΩ to V_L and C_L = 60 pF.

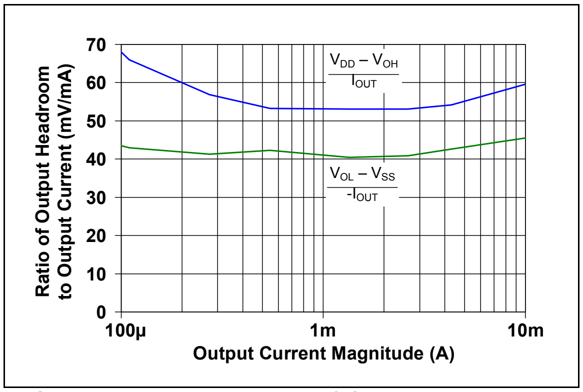


FIGURE 2-13: *Ratio of Output Voltage Headroom to Output Current vs. Output Current.*

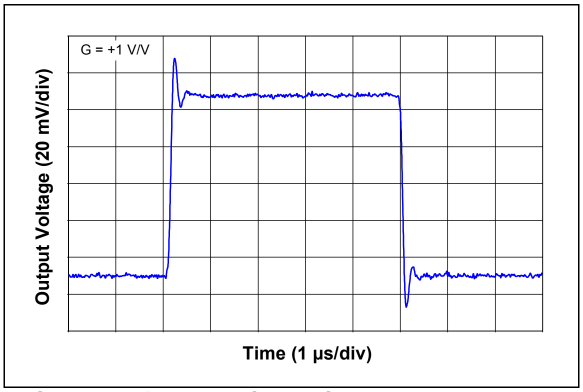


FIGURE 2-14: *Small Signal, Non-Inverting Pulse Response.*

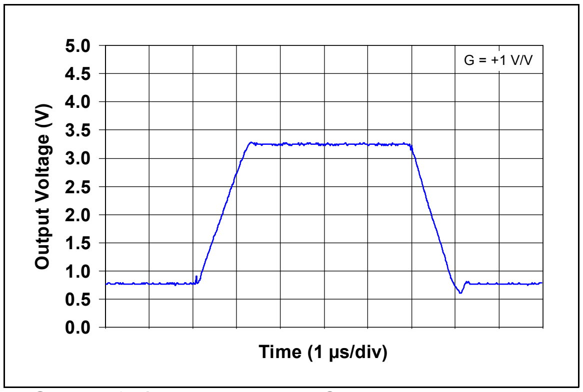


FIGURE 2-15: *Large Signal, Non-Inverting Pulse Response.*

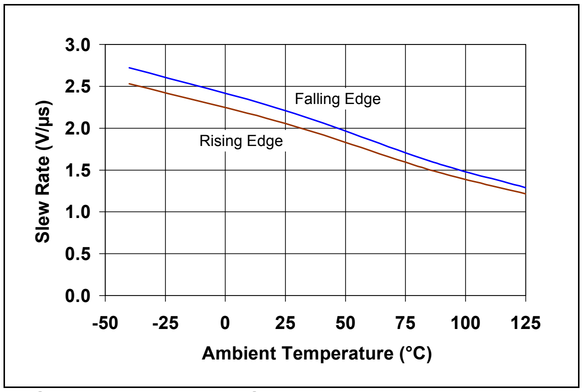


FIGURE 2-16: *Slew Rate vs. Ambient Temperature.*

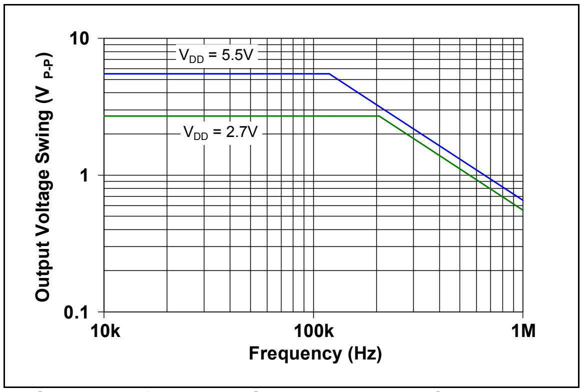


FIGURE 2-17: *Output Voltage Swing vs. Frequency.*

NOTES:

3.0 PIN DESCRIPTIONS

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

TABLE 3-1: PIN FUNCTION TABLE

MCP6L1		MCP6L1R	MCP6L2	MCP6L4	Symbol	Description
SOT-23-5	SOIC-8, MSOP-8	SOT-23-5	SOIC-8, MSOP-8	SOIC-14, TSSOP-14		
1	6	1	1	1	V_{OUT}, V_{OUTA}	Output (op amp A)
4	2	4	2	2	$V_{IN}-$, $V_{INA}-$	Inverting Input (op amp A)
3	3	3	3	3	$V_{IN}+$, $V_{INA}+$	Non-Inverting Input (op amp A)
5	7	2	8	4	V_{DD}	Positive Power Supply
—	—	—	5	5	$V_{INB}+$	Non-Inverting Input (op amp B)
—	—	—	6	6	$V_{INB}-$	Inverting Input (op amp B)
—	—	—	7	7	V_{OUTB}	Output (op amp B)
—	—	—	—	8	V_{OUTC}	Output (op amp C)
—	—	—	—	9	$V_{INC}-$	Inverting Input (op amp C)
—	—	—	—	10	$V_{INC}+$	Non-Inverting Input (op amp C)
2	4	5	4	11	V_{SS}	Negative Power Supply
—	—	—	—	12	$V_{IND}+$	Non-Inverting Input (op amp D)
—	—	—	—	13	$V_{IND}-$	Inverting Input (op amp D)
—	—	—	—	14	V_{OUTD}	Output (op amp D)
—	1, 5, 8	—	—	—	NC	No Internal Connection

3.1 Analog Outputs

The analog output pins (V_{OUT}) are low-impedance voltage sources.

3.2 Analog Inputs

The non-inverting and inverting inputs ($V_{IN}+$, $V_{IN}-$, …) are high-impedance CMOS inputs with low bias currents.

3.3 Power Supply Pins

The positive power supply (V_{DD}) is 2.7V to 6.0V higher than the negative power supply (V_{SS}). For normal operation, the other pins are between V_{SS} and V_{DD}.

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

NOTES:

4.0 APPLICATION INFORMATION

The MCP6L1/1R/2/4 family of op amps is manufactured using Microchip's state of the art CMOS process. They are unity gain stable and suitable for a wide range of general purpose applications.

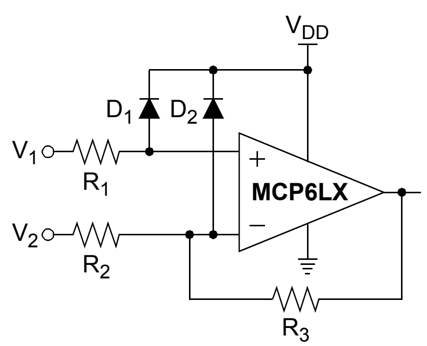
4.1 Inputs

4.1.1 PHASE REVERSAL

The MCP6L1/1R/2/4 op amps are designed to prevent phase inversion when the input pins exceed the supply voltages. Figure 2-10 shows an input voltage exceeding both supplies without any phase reversal.

4.1.2 INPUT VOLTAGE AND CURRENT LIMITS

In order to prevent damage and/or improper operation of these amplifiers, the circuit they are in must limit the currents (and voltages) at the input pins (see **Section 1.1 "Absolute Maximum Ratings †"**). Figure 4-1 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 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 onto V_{DD}.



$$R_1 > \frac{V_{SS} - (\text{minimum expected } V_1)}{2\text{ mA}}$$

$$R_2 > \frac{V_{SS} - (\text{minimum expected } V_2)}{2\text{ mA}}$$

FIGURE 4-1: *Protecting the Analog Inputs.*

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 2-7. Applications that are high-impedance may need to limit the usable voltage range.

4.1.3 NORMAL OPERATION

The Common-Mode Input Voltage Range (V_{CMR}) includes ground in single-supply systems (V_{SS}), but does not include V_{DD}. This means that the amplifier input behaves linearly as long as the Common-Mode Input Voltage (V_{CM}) is kept within the V_{CMR} limits (typically V_{SS} – 0.3V to V_{DD} – 1.3V at +25°C).

Figure 4-3 shows a unity gain buffer. Since V_{OUT} is the same voltage as the inverting input, V_{OUT} must be kept below V_{DD} – 1.2V (typically) for correct operation.

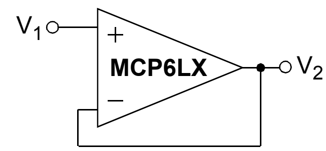


FIGURE 4-2: *Unity Gain Buffer has a Limited V_{OUT} Range.*

4.2 Rail-to-Rail Output

The output voltage range of the MCP6L1/1R/2/4 op amps is V_{DD} – 35 mV (minimum) and V_{SS} + 35 mV (maximum) when R_L = 10 kΩ is connected to V_{DD}/2 and V_{DD} = 5.0V. Refer to Figure 2-13 for more information.

4.3 Capacitive Loads

Driving large capacitive loads can cause stability problems for voltage feedback op amps. As the load capacitance increases, the feedback loop's phase margin decreases and the closed-loop bandwidth is reduced. This produces gain peaking in the frequency response, with overshoot and ringing in the step response.

When driving large capacitive loads with these op amps (e.g., > 100 pF when G = +1), a small series resistor at the output (R_{ISO} in Figure 4-3) improves the feedback loop's stability by making the output load resistive at higher frequencies; the bandwidth will usually be decreased.

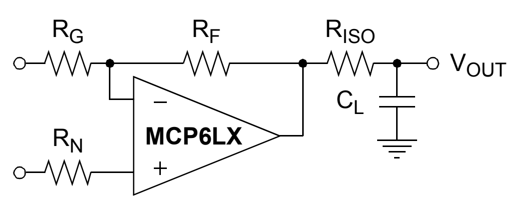


FIGURE 4-3: *Output Resistor, R_{ISO}, Stabilizes Large Capacitive Loads.*

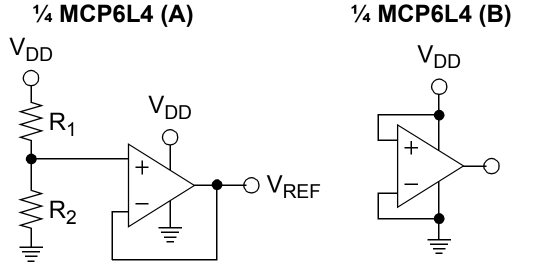
Bench measurements are helpful in choosing R_{ISO}. Adjust R_{ISO} so that a small signal step response (see Figure 2-14) has reasonable overshoot (e.g., 4%).

4.4 Supply Bypass

With this family of operational amplifiers, the power supply pin (V_{DD} for single supply) should 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 other nearby analog parts.

4.5 Unused Op Amps

An unused op amp in a quad package (e.g., MCP6L4) should be configured, as shown in Figure 4-4. These circuits prevent the output from toggling and causing crosstalk. Circuit A sets the op amp at its minimum noise gain. The resistor divider produces any desired reference voltage within the output voltage range of the op amp; the op amp buffers that reference voltage. Circuit B uses the minimum number of components and operates as a comparator, but it may draw more current.



$$V_{REF} = V_{DD} \cdot \frac{R_2}{R_1 + R_2}$$

FIGURE 4-4: *Unused Op Amps.*

4.6 PCB Surface Leakage

In applications where low input bias current is critical, the 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 this 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. Figure 4-5 shows an example of this type of layout.

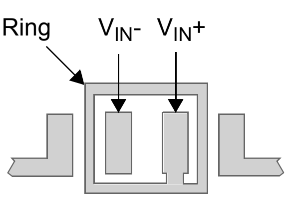


FIGURE 4-5: *Example Guard Ring Layout.*

1. Inverting Amplifiers (Figure 4-5) and Transimpedance Gain Amplifiers (convert current to voltage, such as photo detectors).
   a) Connect the guard ring to the non-inverting input pin (V_{IN}+); this biases the guard ring to the same reference voltage as the op amp's input (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. Non-Inverting Gain and Unity Gain Buffer.
   a) Connect the guard ring to the inverting input pin (V_{IN}-); this biases the guard ring to the common-mode input voltage.
   b) Connect the non-inverting pin (V_{IN}+) to the input with a wire that does not touch the PCB surface.

4.7 Application Circuits

4.7.1 ACTIVE LOW-PASS FILTER

Figure 4-6 shows a second-order Butterworth filter, with a 10 Hz cutoff frequency and a gain of +1 V/V, using a Sallen Key topology. Microchip's FilterLab® software designed the filter, then the capacitors were reduced in value (using the same program).

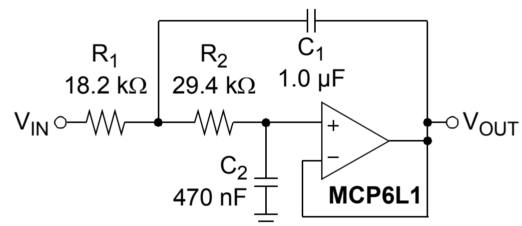


FIGURE 4-6: *Sallen Key Topology.*

Figure 4-7 shows a filter with the same requirements, except the gain is -1 V/V, in a Multiple Feedback Topology. It was designed in a similar fashion using FilterLab.

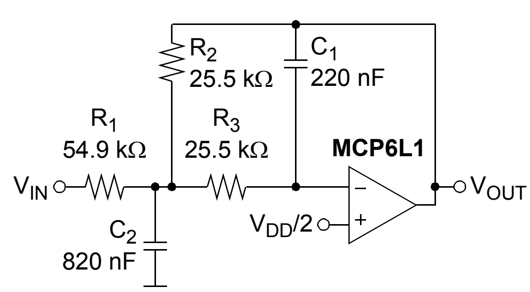


FIGURE 4-7: *Multiple Feedback Topology.*

5.0 DESIGN AIDS

Microchip provides the basic design aids needed for the MCP6L1/1R/2/4 family of op amps.

5.1 SPICE Macro Model

The latest SPICE macro model for the MCP6L1/1R/2/4 op amp is available on the Microchip web site at www.microchip.com. The model was written and tested in official Orcad (Cadence) owned PSPICE. For other simulators, translation may be required.

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

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

5.2 FilterLab® Software

Microchip's FilterLab software is an innovative software tool that simplifies analog active filter (using op amps) design. Available at no cost from the Microchip web site at www.microchip.com/filterlab, the Filter-Lab 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 Microchip Advanced Part Selector (MAPS)

MAPS is a software tool that helps efficiently identify Microchip devices that fit a particular design requirement. Available at no cost from the Microchip web site at www.microchip.com/maps, the MAPS is an overall selection tool for Microchip's product portfolio that includes Analog, Memory, MCUs and DSCs. Using this tool, a customer 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, purchasing and sampling of Microchip parts.

5.4 Analog Demonstration and Evaluation Boards

Microchip offers a broad spectrum of analog demonstration and evaluation boards that are designed to help customers 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/analog tools.

Some boards that are especially useful are:

- MCP6XXX Amplifier Evaluation Board 1
- MCP6XXX Amplifier Evaluation Board 2
- MCP6XXX Amplifier Evaluation Board 3
- MCP6XXX Amplifier Evaluation Board 4
- Active Filter Demo Board Kit
- P/N VSUPEV2: 5/6-Pin SOT-23 Evaluation Board
- P/N SOIC8EV: 8-Pin SOIC/MSOP/TSSOP/DIP Evaluation Board
- P/N SOIC14EV: 14-Pin SOIC/TSSOP/DIP Evaluation Board

5.5 Application Notes

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

ADN003: *"Select the Right Operational Amplifier for your Filtering Circuits"*, DS21821

AN722: *"Operational Amplifier Topologies and DC Specifications"*, DS00722

AN723: *"Operational Amplifier AC Specifications and Applications"*, DS00723

AN884: *"Driving Capacitive Loads With Op Amps"*, DS00884

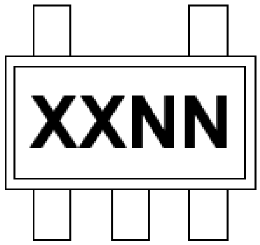
AN990: *"Analog Sensor Conditioning Circuits – An Overview"*, DS00990

NOTES:

6.0 PACKAGING INFORMATION

6.1 Package Marking Information

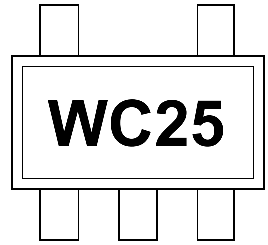
5-Lead SOT-23 (**MCP6L1, MCP6L1R**)



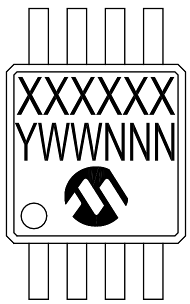
Device	Code
MCP6L1	WCNN
MCP6L1R	WDNN

Note: Applies to 5-Lead SOT-23.

Example:

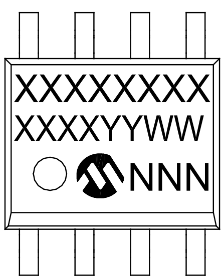


8-Lead MSOP (**MCP6L1, MCP6L2**)

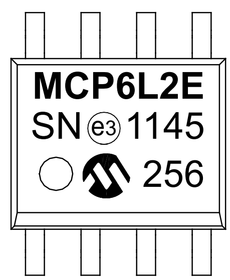


Example:

8-Lead SOIC (150 mil)(**MCP6L1, MCP6L2**)



Example:

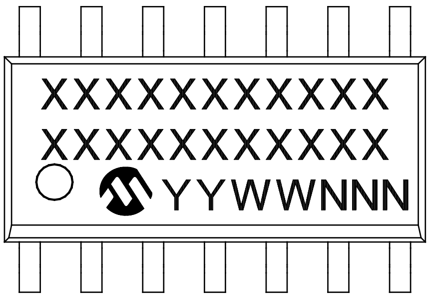


Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free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

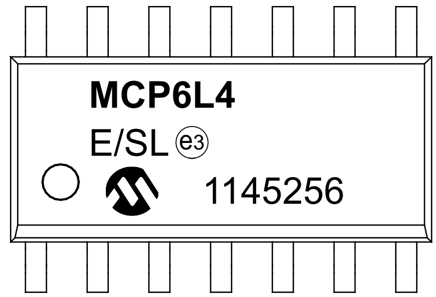
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

Package Marking Information (Continued)

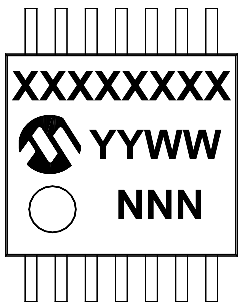
14-Lead SOIC (150 mil) (**MCP6L4**)



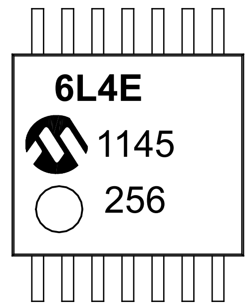
Example:



14-Lead TSSOP (**MCP6L4**)



Example:

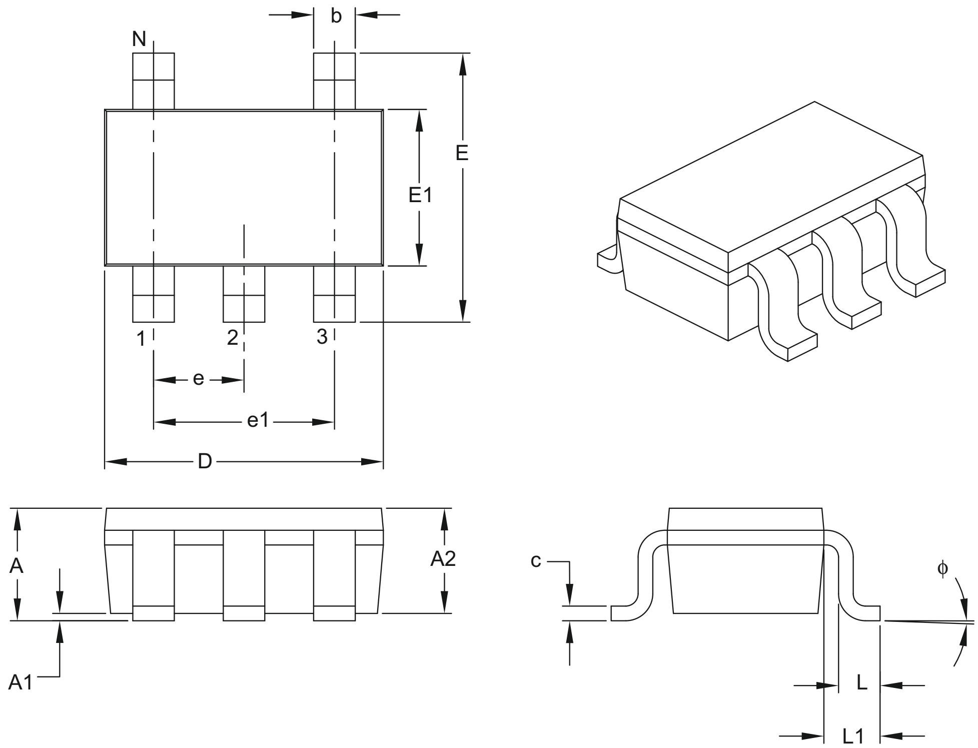


Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free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

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

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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N	5		
Lead 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	0.00	–	0.15
Overall Width	E	2.20	–	3.20
Molded Package Width	E1	1.30	–	1.80
Overall Length	D	2.70	–	3.10
Foot Length	L	0.10	–	0.60
Footprint	L1	0.35	–	0.80
Foot Angle	ϕ	0°	–	30°
Lead Thickness	c	0.08	–	0.26
Lead Width	b	0.20	–	0.51

Notes:

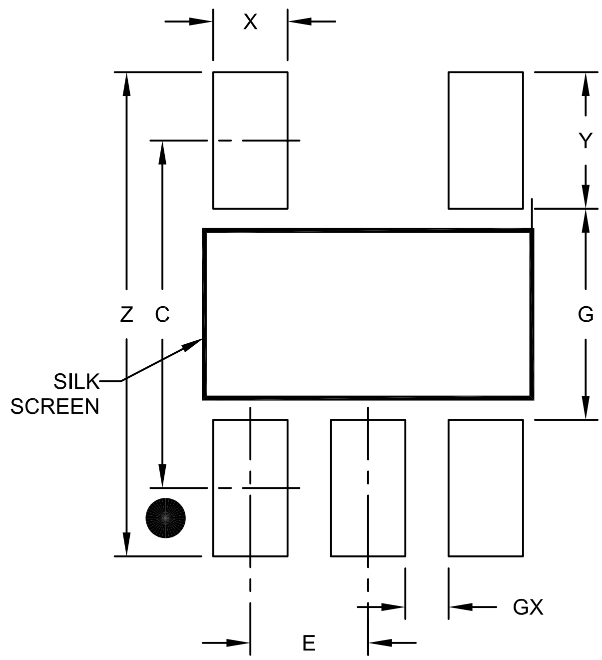
1. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M.

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

Microchip Technology Drawing C04-091B

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:

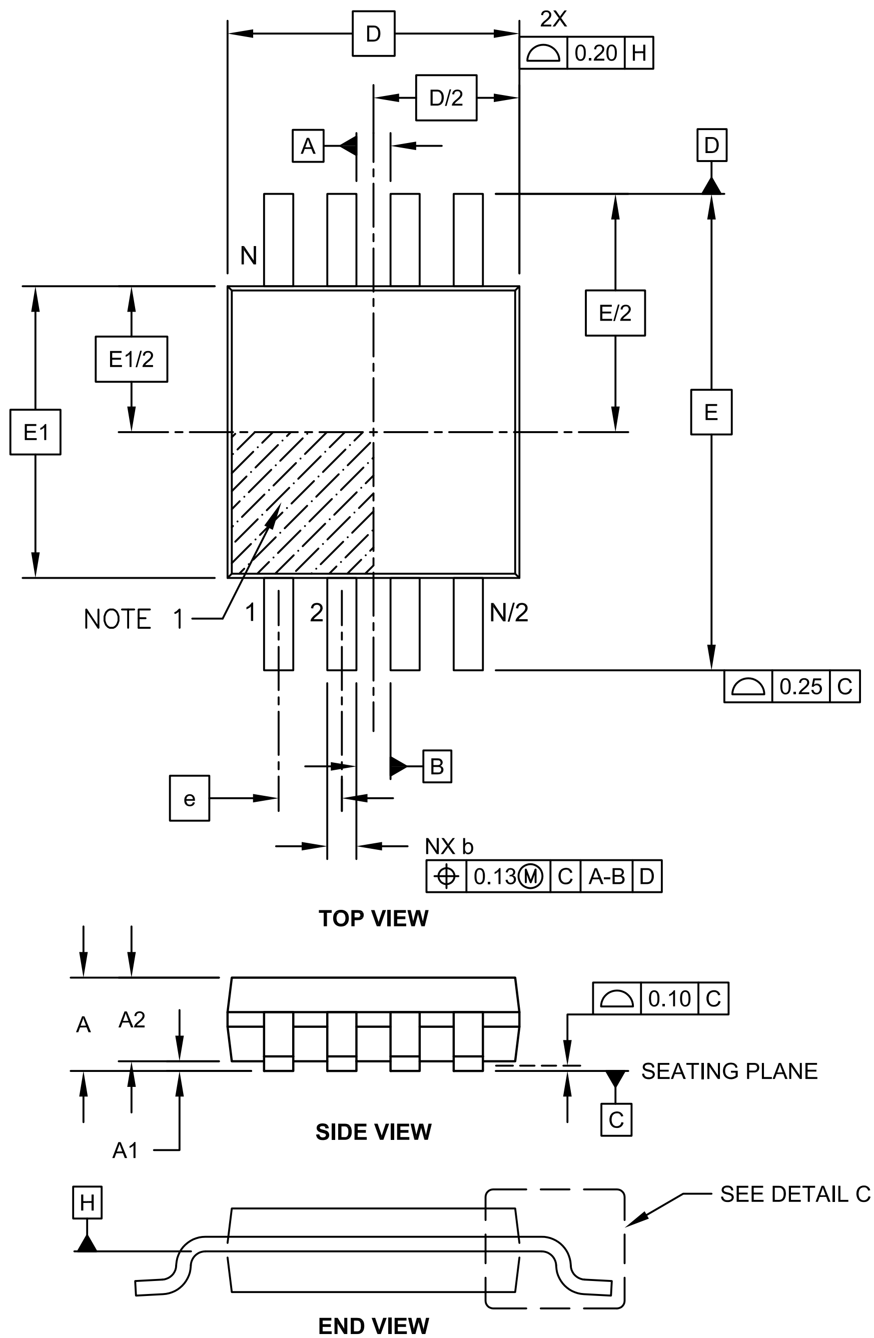
1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2091A

8-Lead Plastic Micro Small Outline Package (MS) [MSOP]

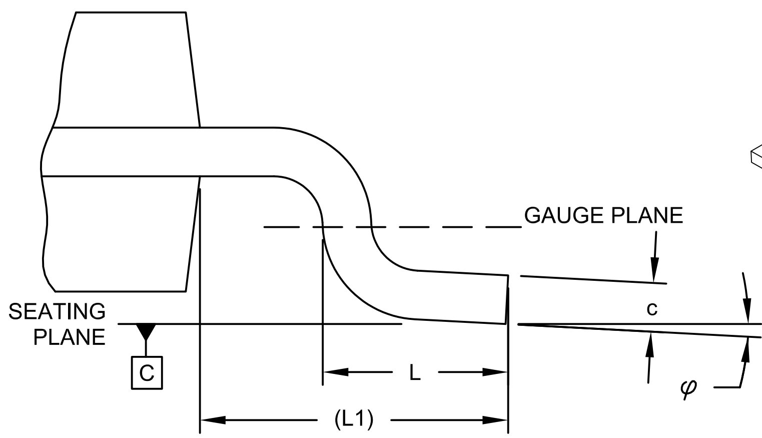
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



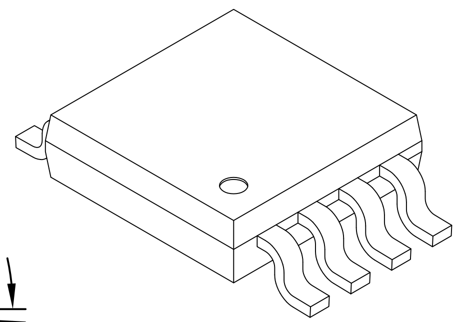
Microchip Technology Drawing C04-111C Sheet 1 of 2

8-Lead Plastic Micro Small Outline Package (MS) [MSOP]

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



DETAIL C



		Units	MILLIMETERS	
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		8	
Pitch	e		0.65 BSC	
Overall Height	A	-	-	1.10
Molded Package Thickness	A2	0.75	0.85	0.95
Standoff	A1	0.00	-	0.15
Overall Width	E		4.90 BSC	
Molded Package Width	E1		3.00 BSC	
Overall Length	D		3.00 BSC	
Foot Length	L	0.40	0.60	0.80
Footprint	L1		0.95 REF	
Foot Angle	φ	0°	-	8°
Lead Thickness	c	0.08	-	0.23
Lead Width	b	0.22	-	0.40

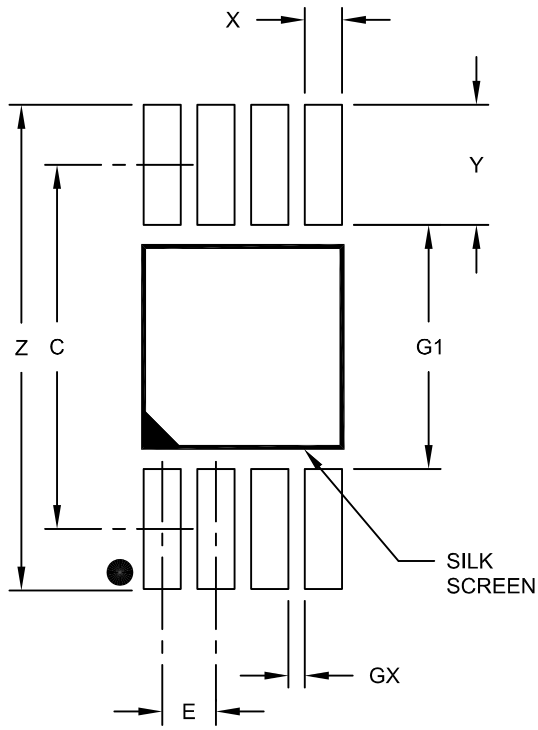
Notes:

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 C04-111C Sheet 2 of 2

8-Lead Plastic Micro Small Outline Package (MS) [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	
Overall Width	Z			5.85
Contact Pad Width (X8)	X1			0.45
Contact Pad Length (X8)	Y1			1.45
Distance Between Pads	G1	2.95		
Distance Between Pads	GX	0.20		

Notes:

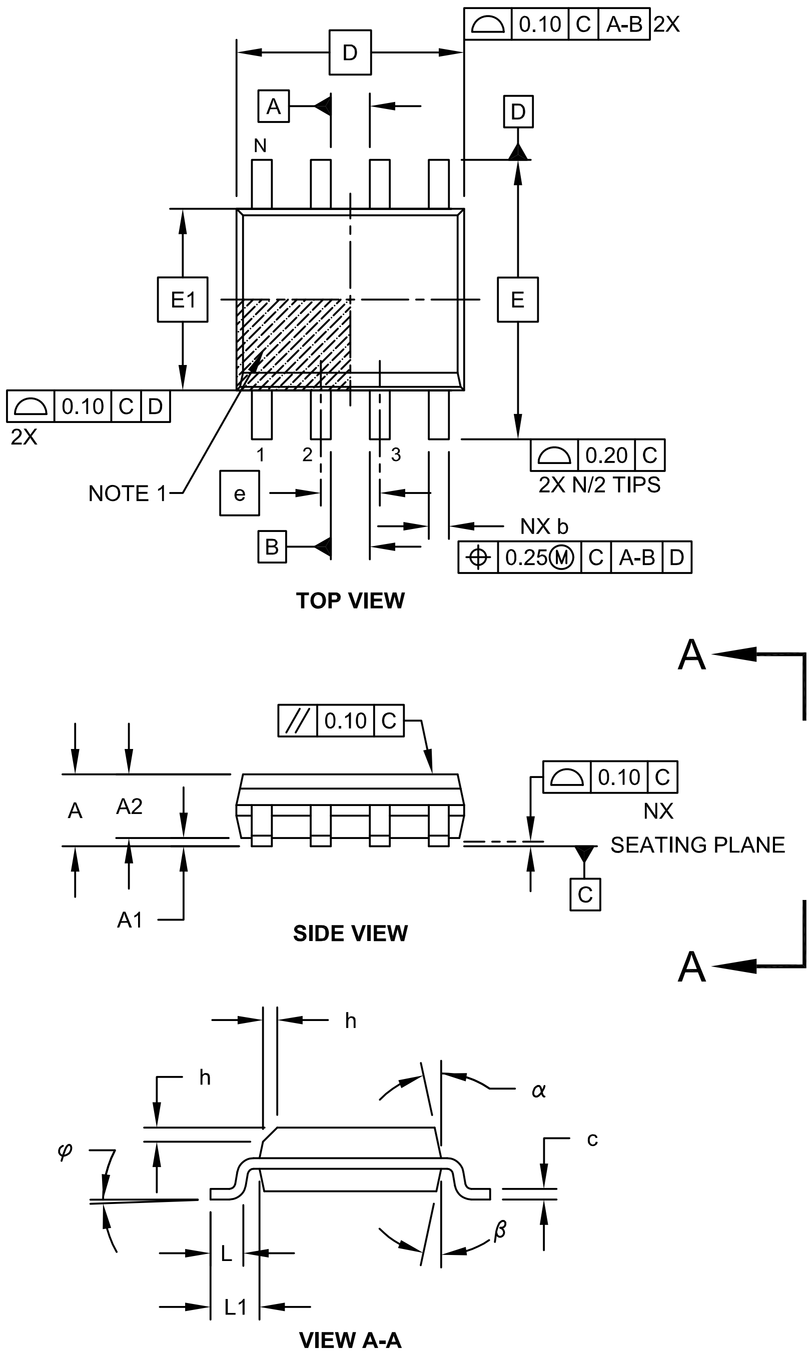
1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2111A

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

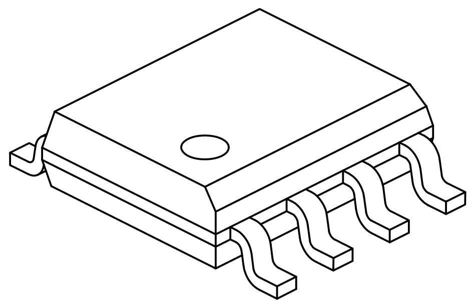
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing No. C04-057C Sheet 1 of 2

8-Lead Plastic Small Outline (SN) - 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		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:

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

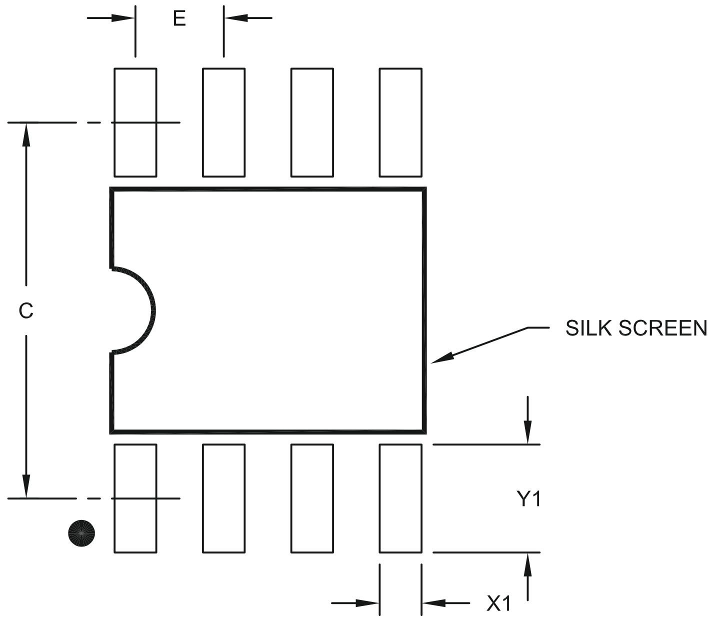
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

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

Microchip Technology Drawing No. C04-057C Sheet 2 of 2

8-Lead Plastic Small Outline (SN) – 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 (X8)	X1			0.60
Contact Pad Length (X8)	Y1			1.55

Notes:

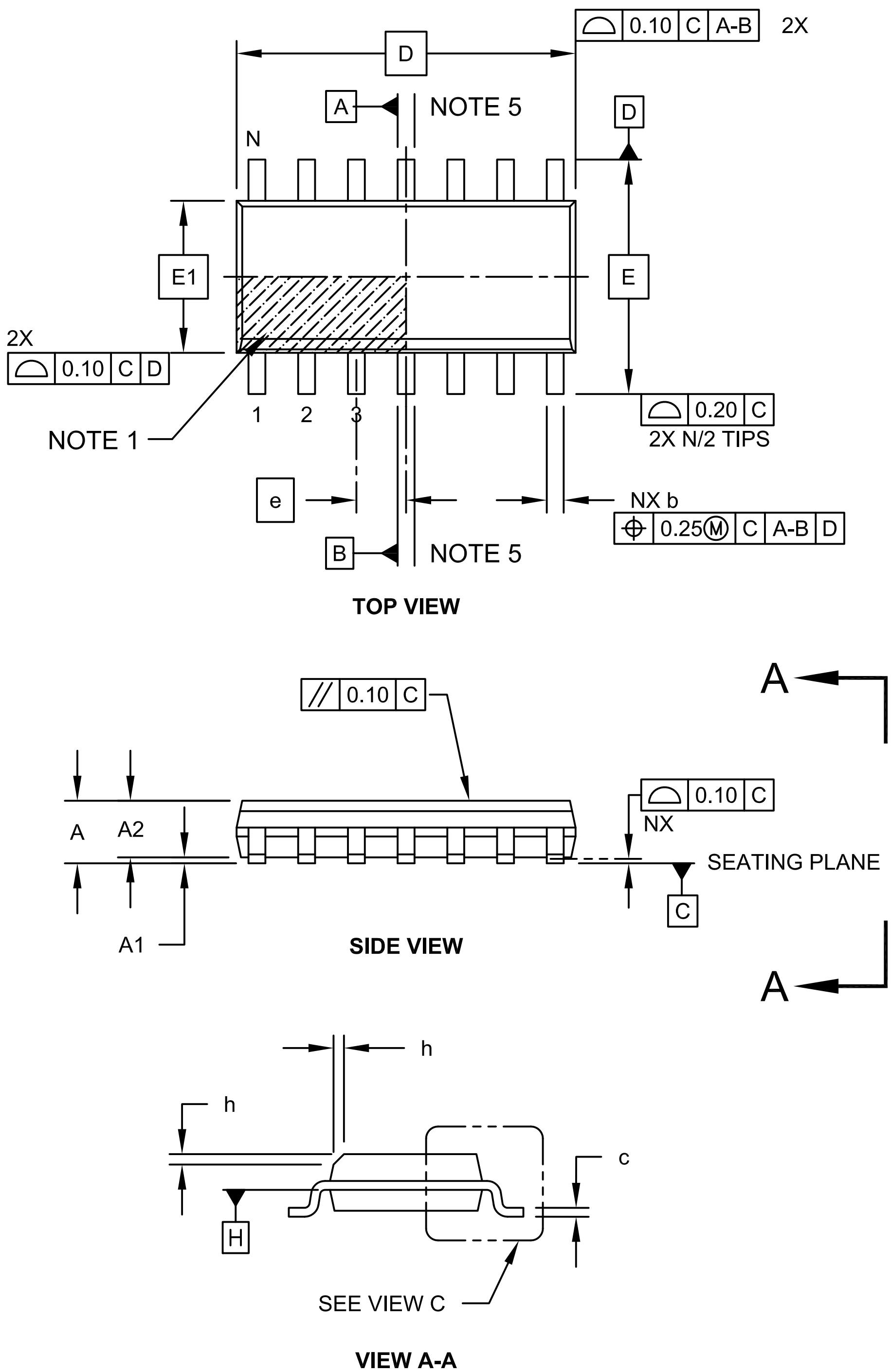
1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2057A

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

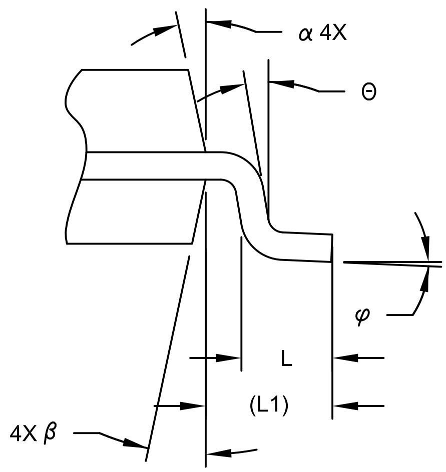
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



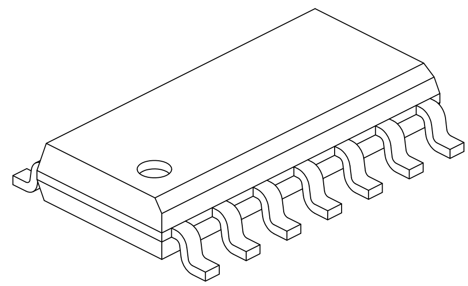
Microchip Technology Drawing No. C04-065C Sheet 1 of 2

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



VIEW C



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°

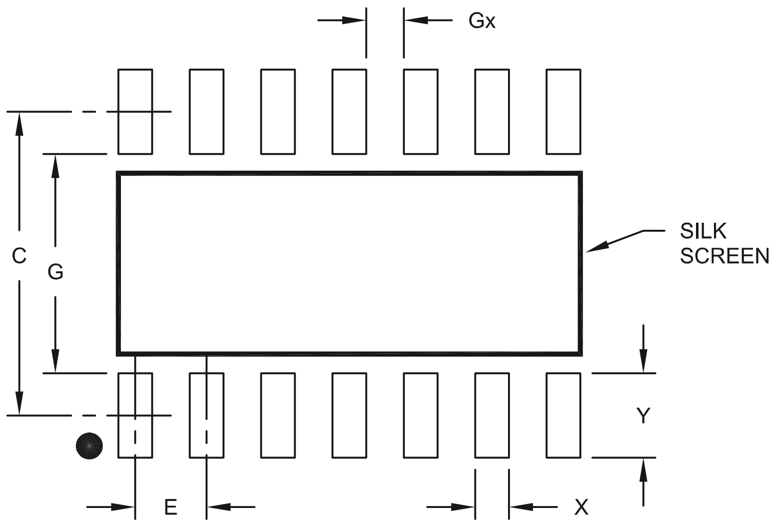
Notes:

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. C04-065C 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	X			0.60
Contact Pad Length	Y			1.50
Distance Between Pads	Gx	0.67		
Distance Between Pads	G	3.90		

Notes:

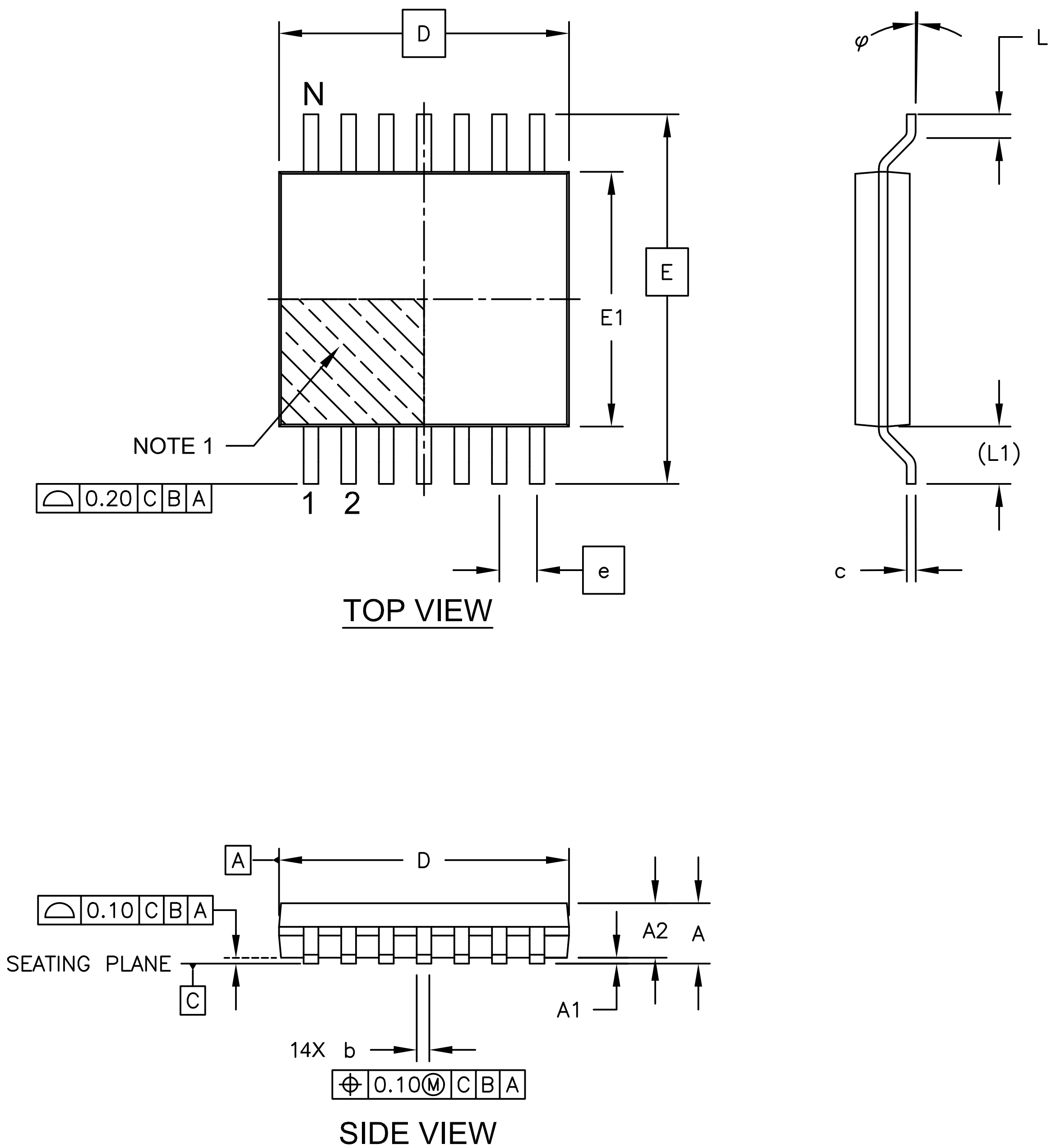
1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2065A

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

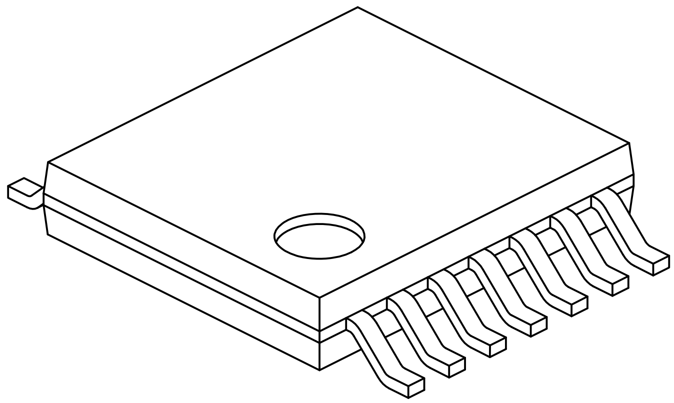
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-087C Sheet 1 of 2

14-Lead Plastic Thin Shrink Small Outline (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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N	14		
Pitch	e	0.65 BSC		
Overall Height	A	-	-	1.20
Molded Package Thickness	A2	0.80	1.00	1.05
Standoff	A1	0.05	-	0.15
Overall Width	E	6.40 BSC		
Molded Package Width	E1	4.30	4.40	4.50
Molded Package Length	D	4.90	5.00	5.10
Foot Length	L	0.45	0.60	0.75
Footprint	(L1)	1.00 REF		
Foot Angle	φ	0°	-	8°
Lead Thickness	c	0.09	-	0.20
Lead Width	b	0.19	-	0.30

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

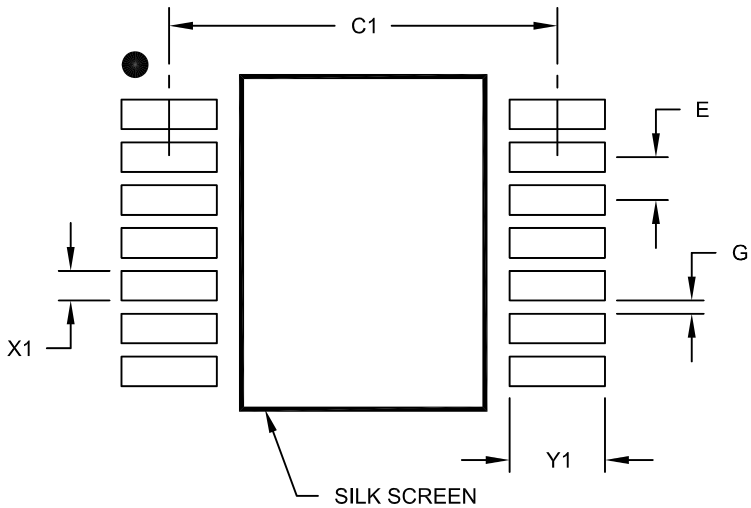
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

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

Microchip Technology Drawing No. C04-087C Sheet 2 of 2

14-Lead Plastic Thin Shrink Small Outline (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	C1		5.90	
Contact Pad Width (X14)	X1			0.45
Contact Pad Length (X14)	Y1			1.45
Distance Between Pads	G	0.20		

Notes:

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

Microchip Technology Drawing No. C04-2087A

APPENDIX A: REVISION HISTORY

Revision C (January 2012)

The following is the list of modifications:

1. Corrected CMRR value condition in Table 1-1.
2. Updated packages temperature values in Table 1-3.
3. Corrected values in first paragraph of **Section 4.1.3 "Normal Operation"**.

Revision B (September 2011)

The following is the list of modifications:

1. Updated **Section 3.0 "Pin Descriptions"**.
2. Updated the value for the Current at Output and Supply Pins parameter in **Section 1.1 "Absolute Maximum Ratings †"**.
3. Added **Section 5.1 "SPICE Macro Model"**.

Revision A (March 2009)

- Original Release of this Document.

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	/XX
Device	Temperature Range	Package

Device:	MCP6L1T:	Single Op Amp (Tape and Reel) (SOT-23, MSOP, SOIC)
	MCP6L1RT:	Single Op Amp (Tape and Reel) (SOT-23)
	MCP6L2T:	Dual Op Amp (Tape and Reel) (SOIC, MSOP)
	MCP6L4T:	Quad Op Amp (Tape and Reel) (SOIC, TSSOP)
Temperature Range:	E	= -40°C to +125°C
Package:	OT	= Plastic Small Outline Transistor (SOT-23), 5-lead
	MS	= Plastic MSOP, 8-lead
	SN	= Plastic SOIC, (3.99 mm body), 8-lead
	SL	= Plastic SOIC (3.99 mm body), 14-lead
	ST	= Plastic TSSOP (4.4mm body), 14-lead

Examples:

a) MCP6L1T-E/OT: Tape and Reel, Extended Temperature, 5LD SOT-23 package

b) MCP6L1T-E/MS: Tape and Reel, Extended Temperature, 8LD MSOP package.

c) MCP6L1T-E/SN: Tape and Reel, Extended Temperature, 8LD SOIC package.

a) MCP6L1RT-E/OT: Tape and Reel, Extended Temperature, 5LD SOT-23 package.

a) MCP6L2T-E/MS: Tape and Reel, Extended Temperature, 8LD MSOP package.

b) MCP6L2T-E/SN: Tape and Reel, Extended Temperature, 8LD SOIC package.

a) MCP6L4T-E/SL: Tape and Reel, Extended Temperature, 14LD SOIC package.

b) MCP6L4T-E/ST: Tape and Reel, Extended Temperature, 14LD TSSOP package.

NOTES:

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