150KHz CMOS Rail-to-Rail IO Opamp with RF Filter

Features

- **Single-Supply Operation from +2.1V ~ +5.5V**
- **Rail-to-Rail Input / Output**
- **Gain-Bandwidth Product: 150KHz (Typ)**
- **Low Input Bias Current: 1pA (Typ)**
- **Low Offset Voltage: 3.5mV (Max)**
- **Quiescent Current: 5.5μA per Amplifier (Typ)**
- **Operating Temperature: -40°C ~ +125°C**
- **Embedded RF Anti-EMI Filter**
- **Small Package:**

MA8521 Available in SOT23-5 Package
MA8522 Available in SOP-8 and MSOP-8 Packages
MA8524 Available in SOP-14 and TSSOP-14 Packages

General Description

The MA852X family have a high gain-bandwidth product of 150KHz, a slew rate of 0.07V/μs, and a quiescent current of 5.5μA/amplifier at 5V. The MA852X family is designed to provide optimal performance in low voltage and low noise systems. They provide rail-to-rail output swing into heavy loads. The input common mode voltage range includes ground, and the maximum input offset voltage is 3.5mV for MA852X family. They are specified over the extended industrial temperature range (-40℃ to +125℃). The operating range is from 2.1V to 5.5V. The MA8521 single is available in Green SOT-23-5 packages The MA8522 Dual is available in Green SOP-8 and MSOP-8 packages. The MA8524 Quad is available in Green SOP-14 and TSSOP-14 packages.

Applications

- ASIC Input or Output Amplifier
- Sensor Interface
- Medical Communication
- Smoke Detectors
- Audio Output
- Piezoelectric Transducer Amplifier
- Medical Instrumentation
- Portable Systems

Pin Configuration

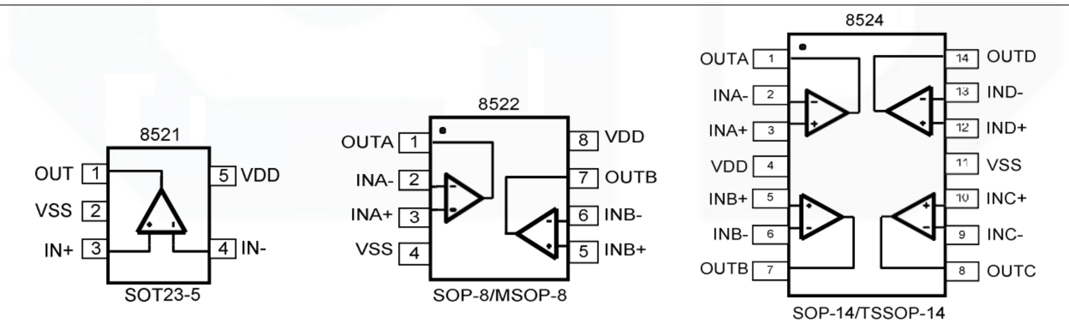


Figure 1. Pin Assignment Diagram

Absolute Maximum Ratings

Condition	Min	Max
Power Supply Voltage (V_{DD} to Vss)	-0.5V	+7.5V
Analog Input Voltage (IN+ or IN-)	Vss-0.5V	V_{DD}+0.5V
PDB Input Voltage	Vss-0.5V	+7V
Operating Temperature Range	-40°C	+125°C
Junction Temperature	+160°C	
Storage Temperature Range	-55°C	+150°C
Lead Temperature (soldering, 10sec)	+260°C	
Package Thermal Resistance (T_A=+25℃)		
SOP-8, θ_{JA}	125°C/W	
MSOP-8, θ_{JA}	216°C/W	
SOT23-5, θ_{JA}	190°C/W	
ESD Susceptibility		
HBM	6KV	
MM	300V	

Note: Stress greater than 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 these or any other conditions outside those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Package/Ordering Information

MODEL	CHANNEL	ORDER NUMBER	PACKAGE DESCRIPTION	PACKAGE OPTION	MARKING INFORMATION
MA8521	Single	MA8521-TR	SOT23-5	Tape and Reel,3000	8521
MA8522	Dual	MA8522-SR	SOP-8	Tape and Reel,4000	MA8522
		MA8522-MR	MSOP-8	Tape and Reel,3000	MA8522
MA8524	Quad	MA8524-TR	TSSOP-14	Tape and Reel,3000	MA8524
		MA8524-SR	SOP-14	Tape and Reel,2500	MA8524

Electrical Characteristics

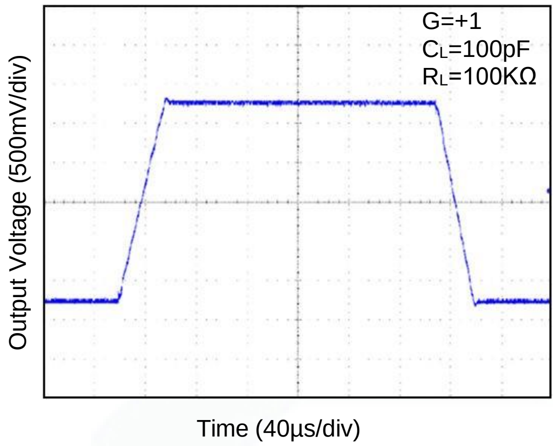
(At V_S = +5V, R_L = 500kΩ connected to $V_S/2$, and V_{OUT} = $V_S/2$, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TYP	MIN	MAX	UNITS
INPUT CHARACTERISTICS						
Input Offset Voltage	V_{OS}	V_{CM} = $V_S/2$	0.4		3.5	mV
Input Bias Current	I_B		1			pA
Input Offset Current	I_{OS}		1			pA
Common-Mode Voltage Range	V_{CM}	V_S = 5.5V	-0.1 to +5.6			V
Common-Mode Rejection Ratio	CMRR	V_S = 5.5V, V_{CM} = -0.1V to 4V	114	70		dB
		V_S = 5.5V, V_{CM} = -0.1V to 5.6V	87	60		
Open-Loop Voltage Gain	A_{OL}	R_L = 500kΩ, V_O = +0.1V to +4.9V	110	90		dB
		R_L = 100kΩ, V_O = +0.1V to +4.9V	108	88		
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta_T$		2			uV/ºC
OUTPUT CHARACTERISTICS						
Output Voltage Swing from Rail	V_{OH}	R_L = 500kΩ	4.997	4.990		V
	V_{OL}	R_L = 500kΩ	3	10		mV
Output Current	I_{SOURCE}	R_L = 10Ω to $V_S/2$	58	40		mA
	I_{SINK}		58	40		
POWER SUPPLY						
Operating Voltage Range				2.1	5.5	V
Power Supply Rejection Ratio	PSRR	V_S = +2.5V to +5.5V, V_{CM} = +0.5V	94	65		dB
Quiescent Current / Amplifier	I_Q		5.5			uA
DYNAMIC PERFORMANCE						
Gain-Bandwidth Product	GBP		150			kHz
Slew Rate	SR	G = +1, 2V Output Step	0.07			V/uS
Settling Time to 0.1%	t_S	G = +1, 2V Output Step	30			uS
NOISE PERFORMANCE						
Voltage Noise Density	e_n	f = 1kHz	85			$nV/\sqrt{Hz}$
		f = 10kHz	44			$nV/\sqrt{Hz}$

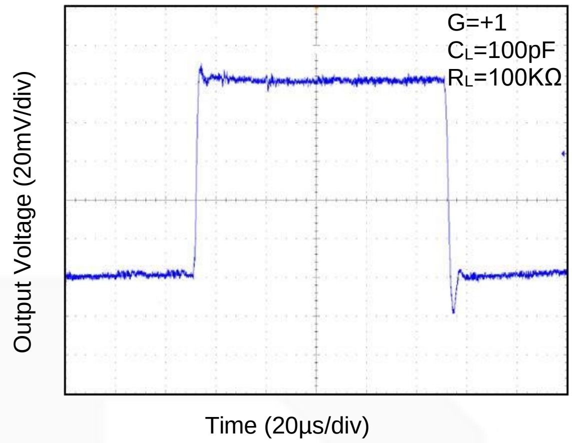
Typical Performance characteristics

At T_A=+25ºC, V_S=+5V, and R_L=500KΩ connected to V_S/2, unless otherwise noted.

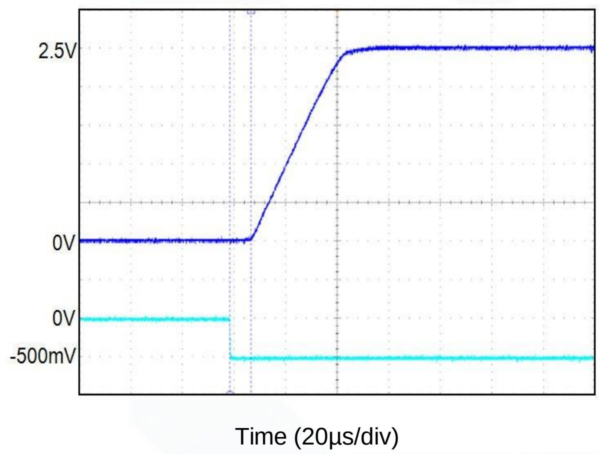
Large-Signal Step Response



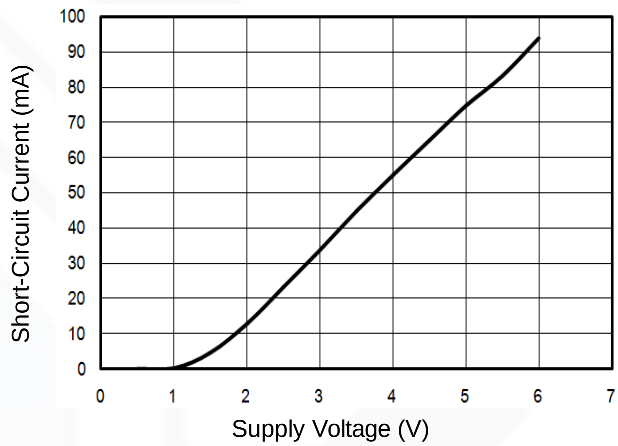
Small-Signal Step Response



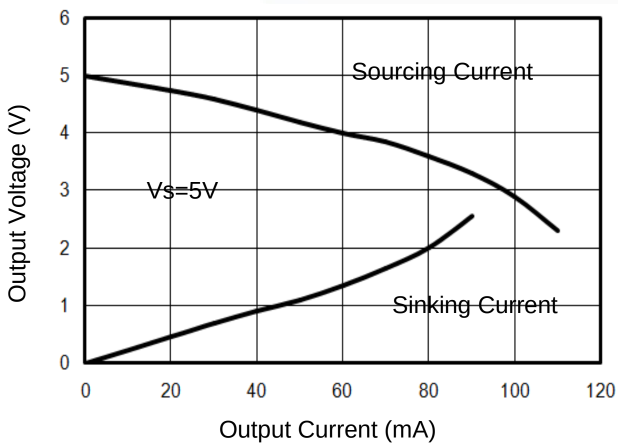
Overload Recovery Time



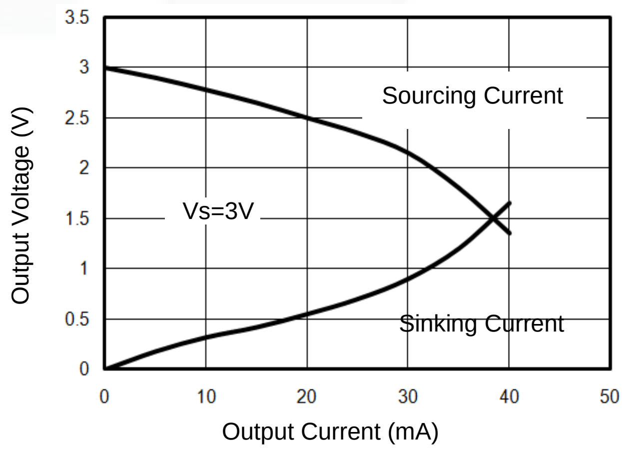
Short-Circuit Current vs. Supply Voltage



Output Voltage vs. Output Current



Output Voltage vs. Output Current



Application Note

Size

MA852X family series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the MA852X family packages save space on printed circuit boards and enable the design of smaller electronic products.

Power Supply Bypassing and Board Layout

MA852X family series operates from a single 2.1V to 5.5V supply or dual ±1.05V to ±2.75V supplies. For best performance, a 0.1µF ceramic capacitor should be placed close to the V_{DD} pin in single supply operation. For dual supply operation, both V_{DD} and V_{SS} supplies should be bypassed to ground with separate 0.1µF ceramic capacitors.

Low Supply Current

The low supply current (typical 5.5µA per channel) of MA852X family will help to maximize battery life. They are ideal for battery powered systems.

Operating Voltage

MA852X family operates under wide input supply voltage (2.1V to 5.5V). In addition, all temperature specifications apply from -40 ^{o}C to +125 ^{o}C. Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime.

Rail-to-Rail Input

The input common-mode range of MA852X family extends 100mV beyond the supply rails (V_{SS}-0.1V to V_{DD}+0.1V). This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

Rail-to-Rail Output

Rail-to-Rail output swing provides maximum possible dynamic range at the output. This is particularly important when operating in low supply voltages. The output voltage of MA852X family can typically swing to less than 10mV from supply rail in light resistive loads (>500kΩ), and 30mV of supply rail in moderate resistive loads (100kΩ).

Capacitive Load Tolerance

The MA852X family is optimized for bandwidth and speed, not for driving capacitive loads. Output capacitance will create a pole in the amplifier's feedback path, leading to excessive peaking and potential oscillation. If dealing with load capacitance is a requirement of the application, the two strategies to consider are (1) using a small resistor in series with the amplifier's output and the load capacitance and (2) reducing the bandwidth of the amplifier's feedback loop by increasing the overall noise gain. Figure 2. shows a unity gain follower using the series resistor strategy. The resistor isolates the output from the capacitance and, more importantly, creates a zero in the feedback path that compensates for the pole created by the output capacitance.

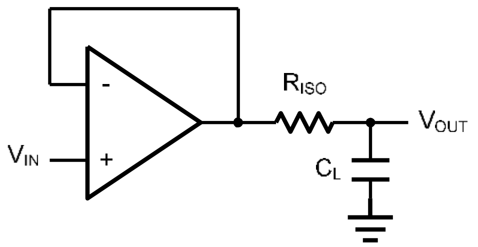


Figure 2. Indirectly Driving a Capacitive Load Using Isolation Resistor

The bigger the R_{ISO} resistor value, the more stable V_{OUT} will be. However, if there is a resistive load R_L in parallel with the capacitive load, a voltage divider (proportional to R_{ISO}/R_L) is formed, this will result in a gain error.

The circuit in Figure 3 is an improvement to the one in Figure 2. R_F provides the DC accuracy by feed-forward the V_{IN} to R_L. C_F and R_{ISO} serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving the phase margin in the overall feedback loop. Capacitive drive can be increased by increasing the value of C_F. This in turn will slow down the pulse response.

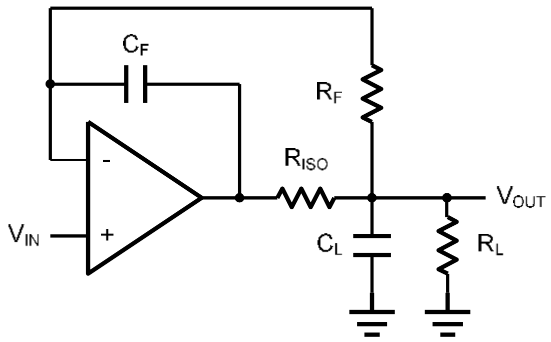


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

Typical Application Circuits

Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common the two inputs. It is useful as a computational amplifier in making a differential to single-end conversion or in rejecting a common mode signal. Figure 4. shown the differential amplifier using MA852X family.

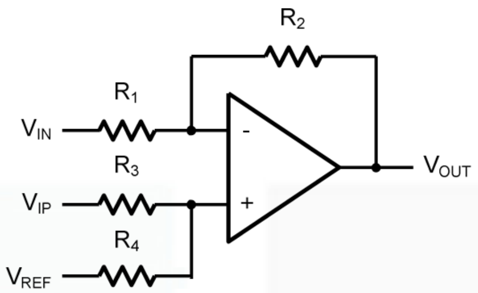


Figure 4. Differential Amplifier

$$V_{OUT} = \left(\frac{R_1+R_2}{R_3+R_4}\right)\frac{R_4}{R_1}V_{IN} - \frac{R2}{R1}V_{IP} + \left(\frac{R_1+R_2}{R_3+R_4}\right)\frac{R_3}{R_1}V_{REF}$$

If the resistor ratios are equal (i.e. R_1=R_3 and R_2=R_4), then

$$V_{OUT} = \frac{R2}{R1}(V_{IP} - V_{IN}) + V_{REF}$$

Low Pass Active Filter

The low pass active filter is shown in Figure 5. The DC gain is defined by $-R_2/R_1$. The filter has a -20dB/decade roll-off after its corner frequency $f_C=1/(2\pi R_3C_1)$.

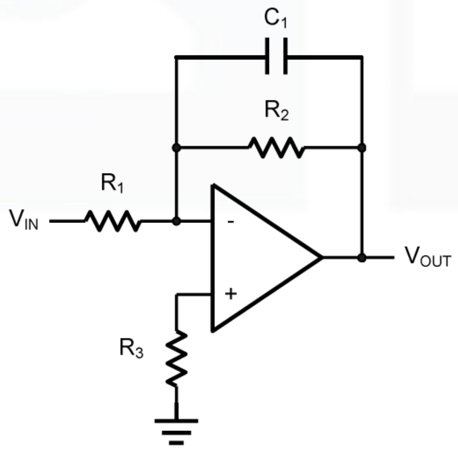


Figure 5. Low Pass Active Filter

Instrumentation Amplifier

The triple MA852X family can be used to build a three-op-amp instrumentation amplifier as shown in Figure 6. The amplifier in Figure 6 is a high input impedance differential amplifier with gain of R2/R1. The two differential voltage followers assure the high input impedance of the amplifier.

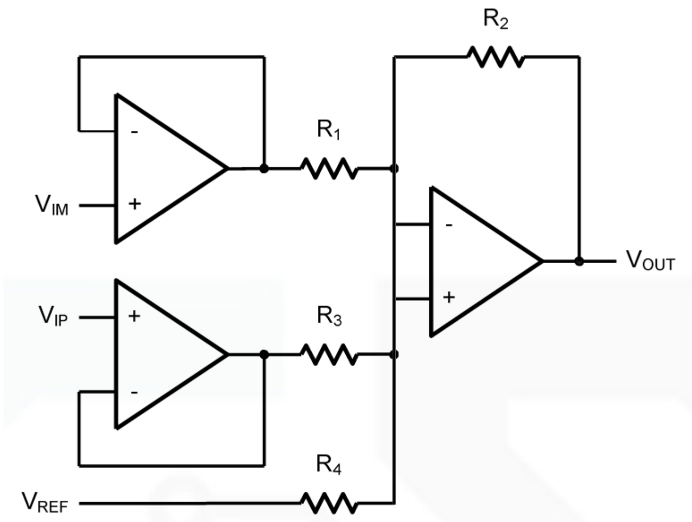
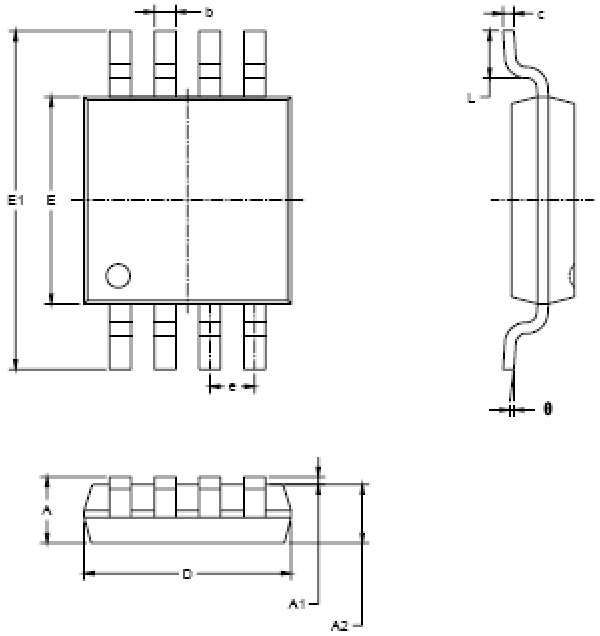


Figure 6. Instrument Amplifier

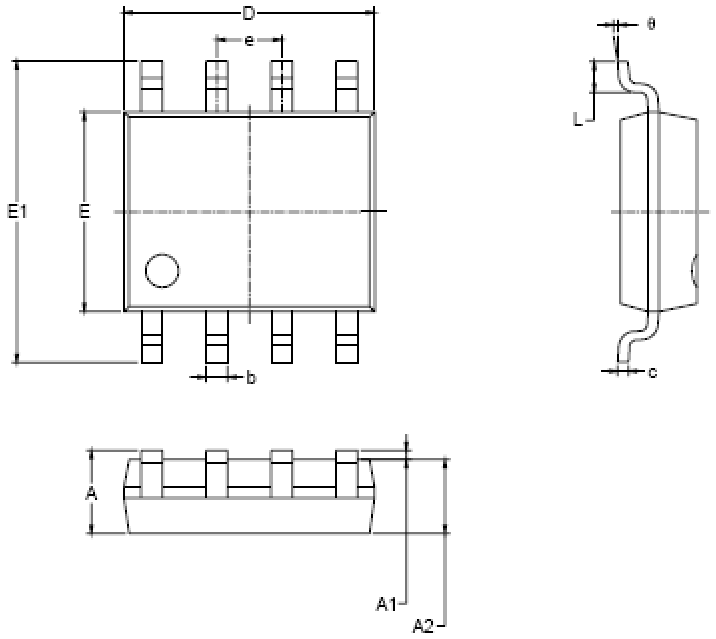
Package Information

MSOP-8



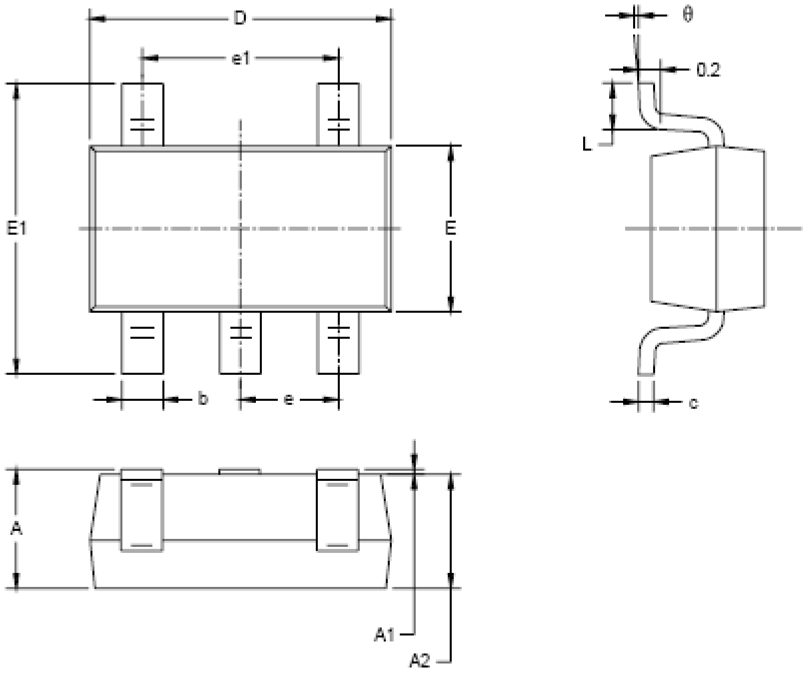
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

SOP-8



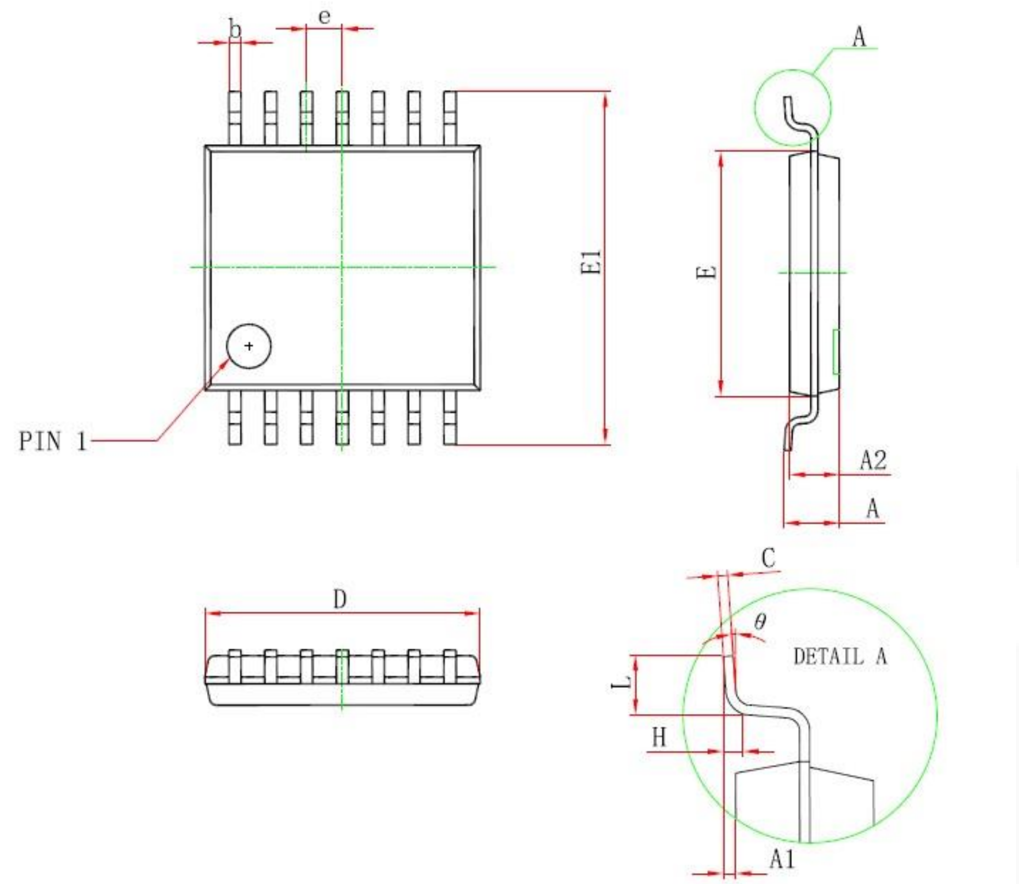
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

SOT23-5



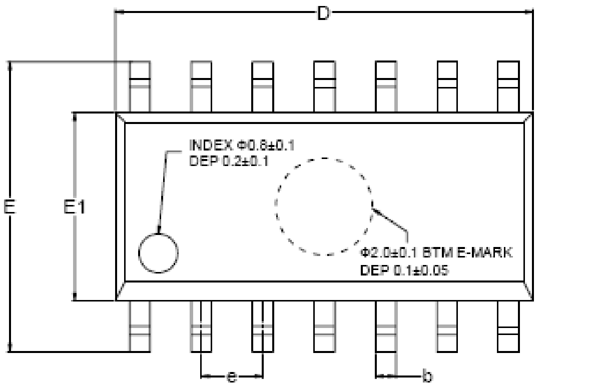
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

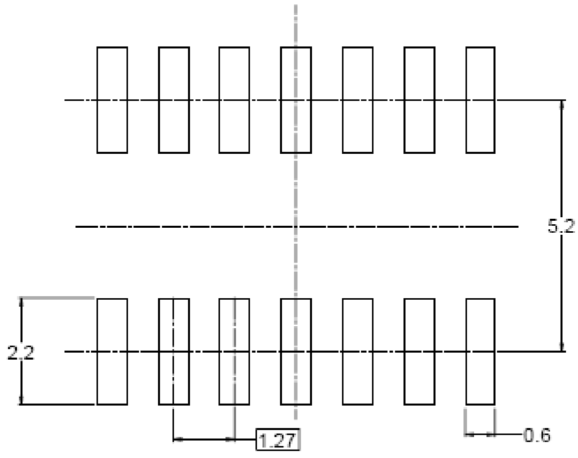
TSSOP-14



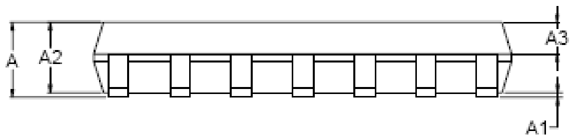
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
D	4.900	5.100	0.193	0.201
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A		1.200		0.047
A2	0.800	1.000	0.031	0.039
A1	0.050	0.150	0.002	0.006
e	0.65 (BSC)		0.026 (BSC)	
L	0.500	0.700	0.020	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°

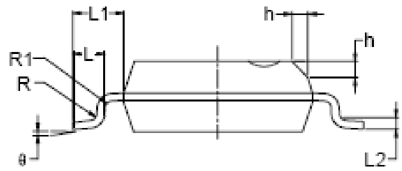
SOP-14





RECOMMENDED LAND PATTERN (Unit: mm)





Symbol	Dimensions In Millimeters			Dimensions In Inches		
	MIN	MOD	MAX	MIN	MOD	MAX
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.004		0.010
A2	1.25		1.65	0.049		0.065
A3	0.55		0.75	0.022		0.030
b	0.36		0.49	0.014		0.019
D	8.53		8.73	0.336		0.344
E	5.80		6.20	0.228		0.244
E1	3.80		4.00	0.150		0.157
e	1.27 BSC			0.050 BSC		
L	0.45		0.80	0.018		0.032
L1	1.04 REF			0.040 REF		
L2	0.25 BSC			0.01 BSC		
R	0.07			0.003		
R1	0.07			0.003		
h	0.30		0.50	0.012		0.020
θ	0°		8°	0°		8°

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