1MHZ CMOS Rail-to-Rail IO Opamp

1 Features

- Single-Supply Operation from +2.1V ~ +5.5V Rail-to-Rail Input / Output
- Gain-Bandwidth Product: 1MHz (Typ)
- Low Input Bias Current: 1pA (Typ)
- Low Offset Voltage: 3.5mV (Max)
- Quiescent Current: 40μA per Amplifier (Typ)
- Operating Temperature: -40°C ~ +125°C
- Embedded RF Anti-EMI Filter
- Small Package:
  – MCOA321 Available in SOT23-5 and SC70-5 Packages
  – MCOA358 Available in SOP-8, MSOP-8, DIP-8 and DFN-8 Packages
  – MCOA324 Available in SOP-14 and TSSOP-14 Packages

2 Applications

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

3 Description

The MCOA321/358/324 family have a high gain-bandwidth product of 1MHz, a slew rate of 0. 6V/μs, and a quiescent current of 40μA /amplifier at 5V. The MCOA321/358/324 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 MCOA321/358/324 family. They are specified over the extended industrial temperature range (-40 to +125). The operating range is from 2.1V to 5.5V. The MCOA321 single is available in Green SC70-5 and SOT-23-5 packages. The MCOA358 Dual is available in Green SOP-8, MSOP-8, DIP-8 and DFN-8 packages. The MCOA324 Quad is available in Green SOP-14 and TSSOP-14 packages.

4 Pin Configuration and Functions

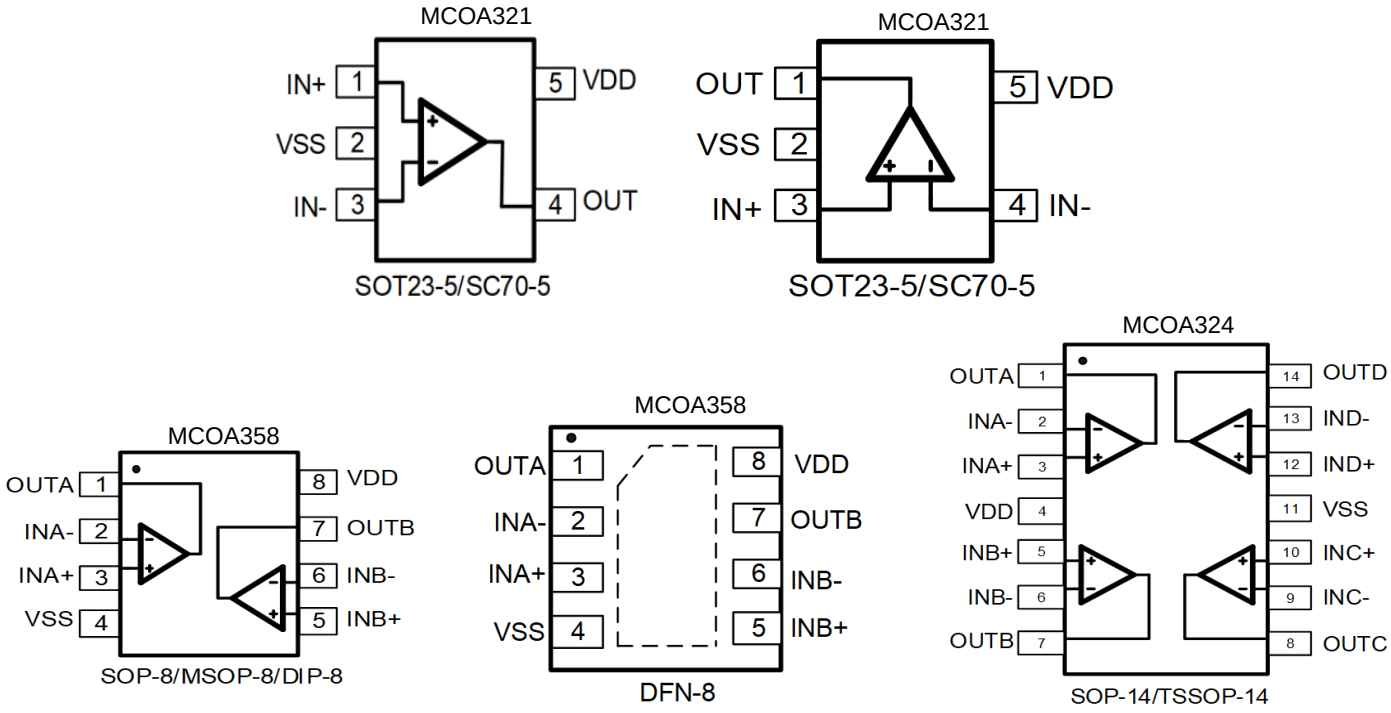


Figure 1. Pin Assignment Diagram

5 Specifications

5.1 Absolute Maximum Ratings

	MIN	TYP	MAX	UNIT
Power Supply voltage(V_{CC} to V_{SS})	-0.5		7.5	V
Analog Input Voltage(IN+ or IN-)	V_{DD}-0.5		V_{DD}+0.5	V
PDB Input voltage	V_{SS}-0.5		7	V
Operating Temperature Range	-40		125	°C
Junction Temperature		160		°C
Storage temperature range	–55		150	°C
Lead Temperature (soldering, 10sec)		260		°C

5.2 ESD Ratings

		MIN	MAX	UNIT
$V_{(ESD)}$ Electrostatic discharge	HBM	0	6000	V
	MM	0	300	

5.3 Package Thermal Resistance (TA=+25°C)

			UNIT
$R_{\theta JA}$ Junction-to-ambient thermal resistance	SOP-8	125	°C/W
	MSOP-8	216	
	SOT23-5	190	
	SC70-5	333	

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.

5.4 Electrical Characteristics

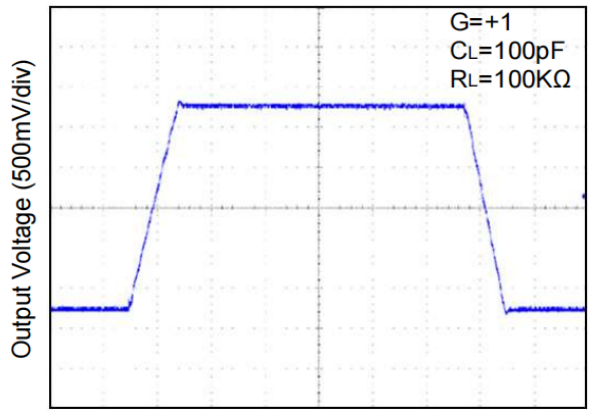
At Vs = +5V, R_L = 100kΩ connected to Vs/2, and V_{OUT} = Vs/2(unless otherwise noted.)

PARAMETER		CONDITIONS	MCOA321\MCOA358\MCOA324				
			TYP	MIN/MAX OVER TEMPERATURE			
			+25℃	+25℃	-40℃ to +85℃	UNITS	MIN/MAX
INPUT CHARACTERISTICS							
V_{OS}	Input Offset Voltage	$V_{CM} = V_S/2$	0.4	3.5	5.6	mV	MAX
I_B	Input Bias Current		1			pA	TYP
I_{OS}	Input Offset Current		1			pA	TYP
V_{CM}	Common-Mode Voltage Range	V_S = 5.5V	-0.1 to +5.6			V	TYP
CMRR	Common-Mode Rejection Ratio	V_S = 5.5V, V_{CM} = -0.1V to 4V	70	62	62	dB	MIN
		V_S = 5.5V, V_{CM} = -0.1V to 5.6V	68	56	55		
A_{OL}	Open-Loop Voltage Gain	R_L = 5kΩ, V_O = +0.1V to +4.9V	80	70	70	dB	MIN
		R_L = 10kΩ, V_O = +0.1V to +4.9V	100	94	85		
$\Delta V_{OS}/\Delta_T$	Input Offset Voltage Drift		2.7			μV/℃	TYP
OUTPUT CHARACTERISTICS							
V_{OH}	Output Voltage Swing from Rail	R_L = 100kΩ	4.997	4.99	4.98	V	MIN
V_{OL}		R_L = 100kΩ	3	10	20	mV	MAX
V_{OH}		R_L = 10kΩ	4.992	4.97	4.96	V	MIN
V_{OL}		R_L = 10kΩ	8	30	40	mV	MAX
I_{SOURCE}	Output Current	R_L = 10Ω to $V_S/2$	84	60	45	mA	MIN
I_{SINK}			75	60	45		
POWER SUPPLY							
	Operating Voltage Range			2.1	2.5	V	MIN
				5.5	5.5	V	MAX
PSRR	Power Supply Rejection Ratio	V_S = +2.5V to +5.5V, V_{CM} = +0.5V	82	60	58	dB	MIN
I_Q	Quiescent Current / Amplifier		40			μA	TYP
DYNAMIC PERFORMANCE (CL = 100pF)							
GBP	Gain-Bandwidth Product		1			MHz	TYP
SR	Slew Rate	G = +1, 2V Output Step	0.6			V/μs	TYP
t_S	Settling Time to 0.1%	G = +1, 2V Output Step	5			μs	TYP
	Overload Recovery Time	V_{IN} ·Gain = V_S	2.6			μs	TYP
NOISE PERFORMANCE							
e_n	Voltage Noise Density	f = 1kHz	27			nV/√ Hz	TYP
		f = 10kHz	20			nV/√ Hz	TYP

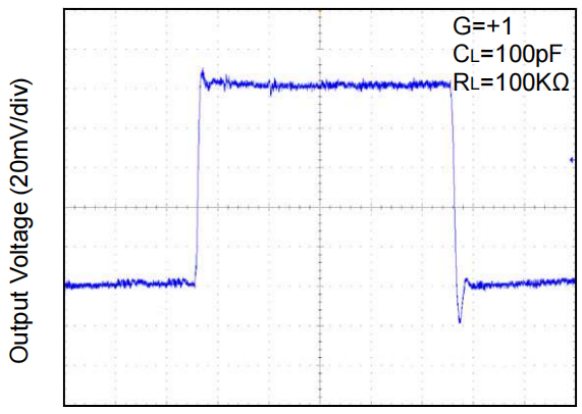
5.5 Typical Performance characteristics

At T_A=+25°C, V_S=+5V, and R_L=100KΩ connected to V_S/2, unless otherwise noted.

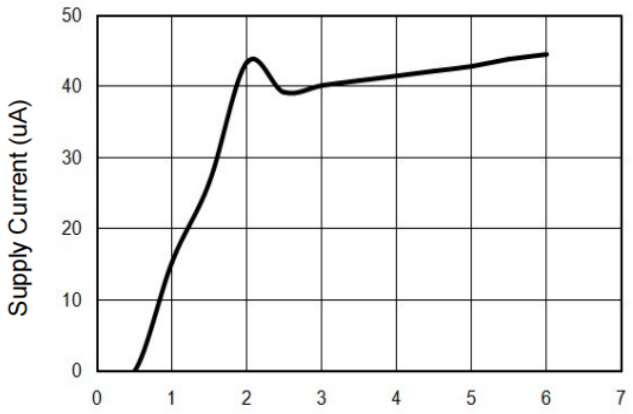
Large-Signal Step Response



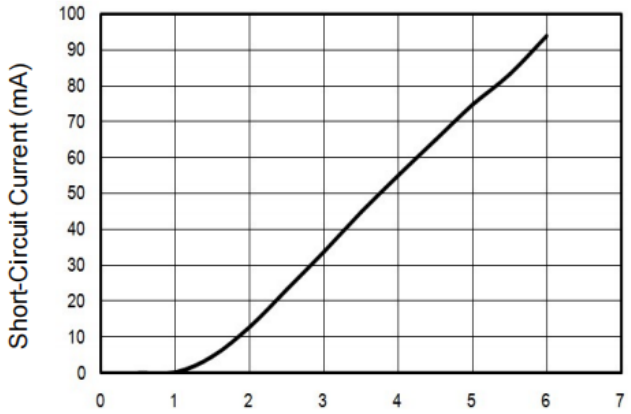
Small-Signal Step Response



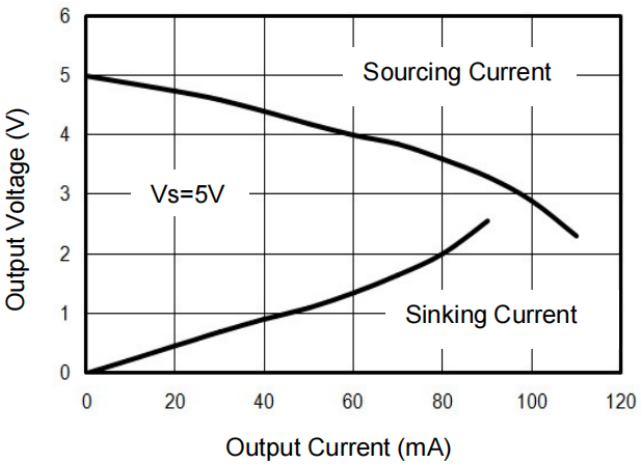
Supply Current vs. Supply Voltage



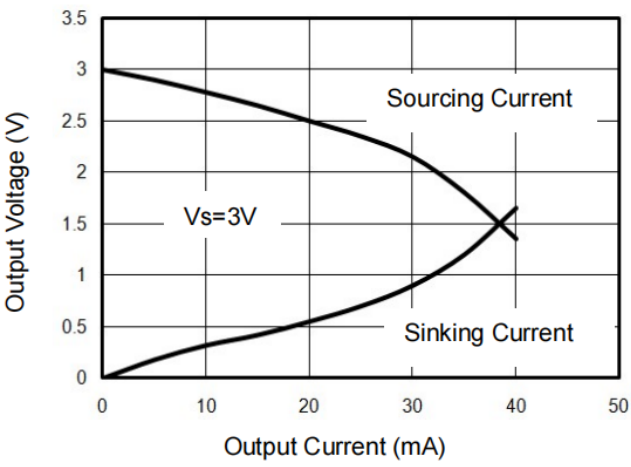
Short-Circuit Current vs. Supply Voltage



Output Voltage vs. Output Current



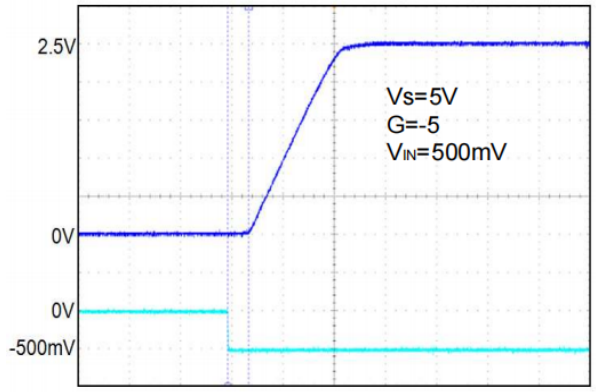
Output Voltage vs. Output Current



5.5 Typical Performance characteristics (continued)

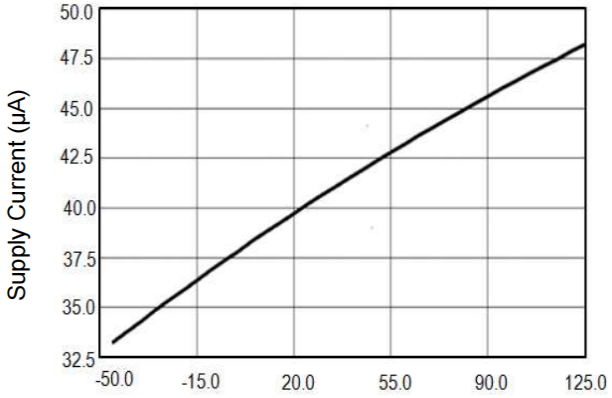
At T_A=+25°C, V_S=+5V, and R_L=100KΩ connected to V_S/2, unless otherwise noted.

Overload Recovery Time



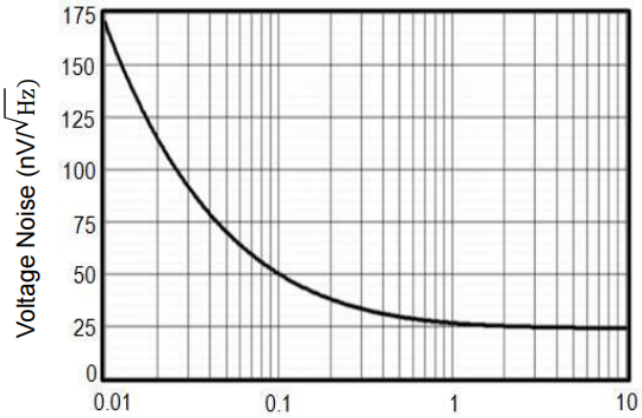
Time (2μs/div)

Supply Current vs. Temperature



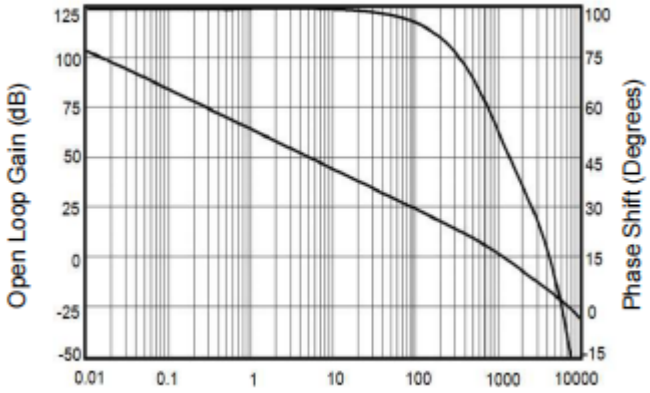
Temperature (℃)

Input Voltage Noise Spectral Density vs. Frequency



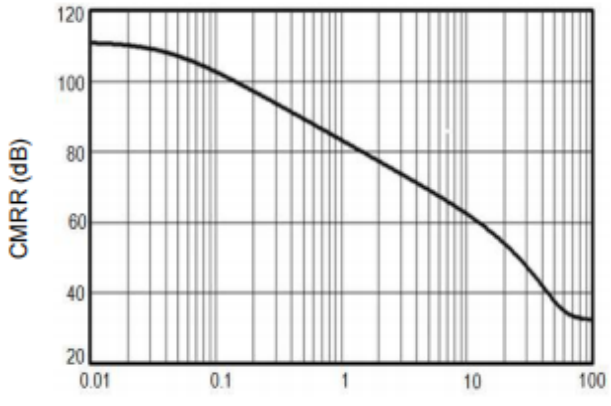
Frequency (kHz)

Open Loop Gain, Phase Shift vs. Frequency at +5V



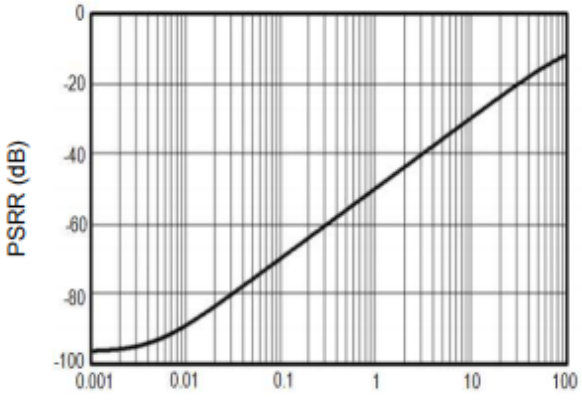
Frequency (kHz)

CMRR vs. Frequency



Frequency (kHz)

PSRR vs. Frequency



Frequency (kHz)

6 Application

Note

Size

MCOA321/358/324 family series op amps are unity-gain stable and suitable for a wide range of general -purpose applications. The small footprints of the MCOA321/358/324 family packages save spaceon printed circuit boards and enable the design of smaller electronic products.

Power Supply Bypassing and Board Layout

MCOA321/358/324 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 VDD pin in single supply operation. For dual supply operation, both VDD and VSS supplies should be bypassed to ground with separate 0.1μF ceramic capacitors.

Low Supply Current

The low supply current (typical 40μA per channel) of MCOA321/358/324 family will help to maximize battery life. They are ideal for battery powered systems.

Operating Voltage

MCOA321/358/324 family operates under wide input supply voltage (2.1V to 5.5V). In addition, all temperature specifications apply from -40 ℃ to +125 ℃. 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 MCOA321/358/324 family extends 100mV beyond the supply rails (VSS-0.1V to VDD+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 MCOA321/358/324 family can typically swing to less than 5mV from supply rail in light resistive loads (>100kΩ), and 30mV of supply rail in moderate resistive loads (10kΩ).

Capacitive Load Tolerance

The MCOA321/358/324family is optimized for bandwidth and speed, not for driving capacitive loads. Output capacitance will create apole 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.

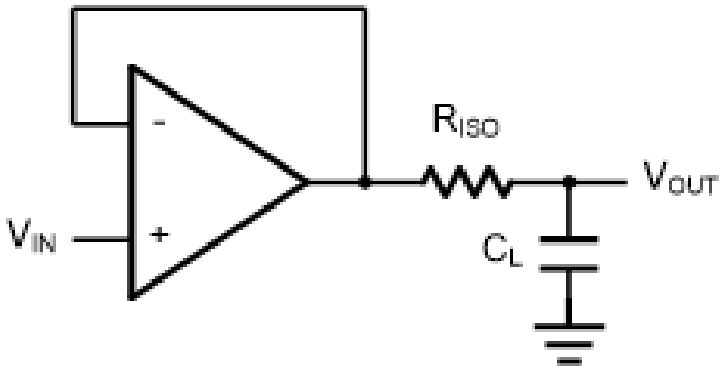


Figure 2. Indirectly Driving a Capacitive Load Using Isolation Resistor

The bigger the RISO resistor value, the more stable VOUT will be. However, if there is a resistive load RL in parallel with the capacitive load, a voltage divider (proportional to RISO/RL) is formed, this will result in a gain error.
The circuit in Figure 3 is an improvement to the one in Figure 2. RF provides the DC accuracy by feed-forward the VIN to RL. CF and RISO 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 CF. This in turn will slow down the pulse response.

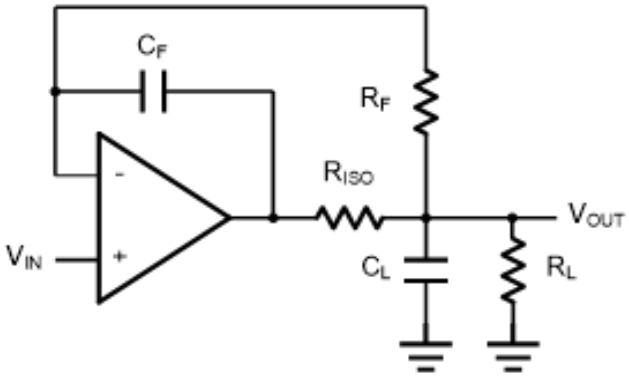


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

6.1 Typical Application Circuits

6.1.1 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 MCOA321/358/324 family.

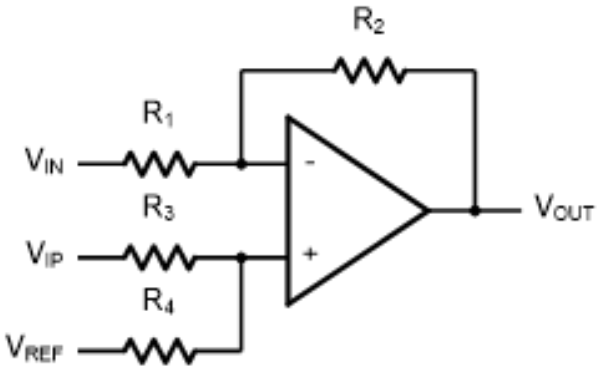


Figure 4. Differential Amplifier

$$V_{OUT}=\left(\frac{R1+R2}{R3+R4}\right)\frac{R4}{R1}V_{IN}-\frac{R2}{R1}V_{IP}+\left(\frac{R1+R2}{R3+R4}\right)\frac{R3}{R1}V_{REF}$$

If the resistor ratios are equal (i.e. R1=R3 and R2=R4), then

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

6.1.2 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 $f_C=1/(2\pi R_3 C_1)$.

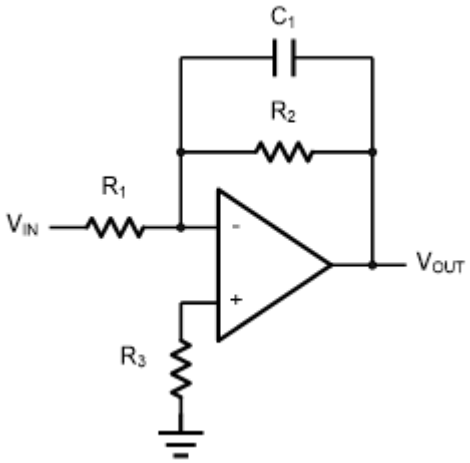


Figure 5. Low Pass Active Filter

6.1.3 Instrumentation Amplifier

The triple MCOA321/358/324 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.

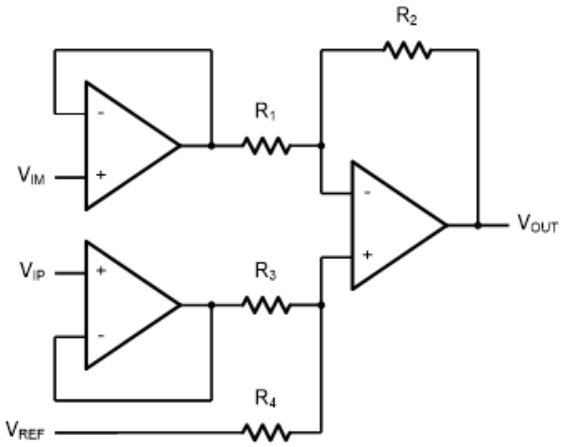
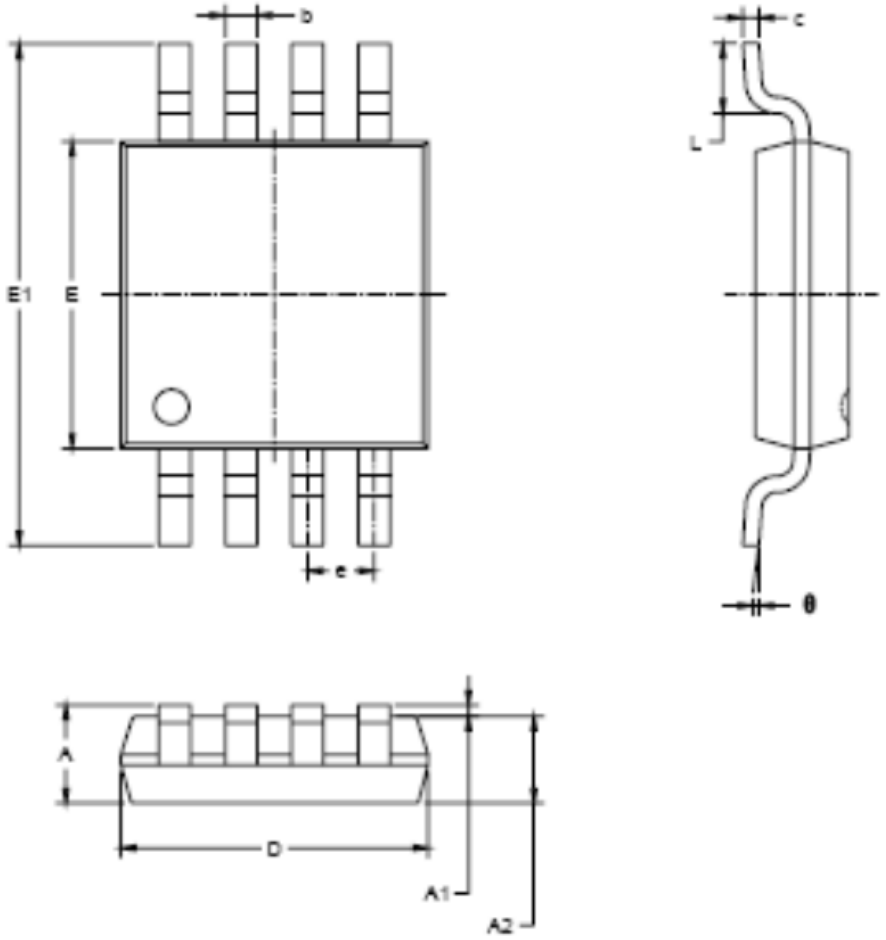


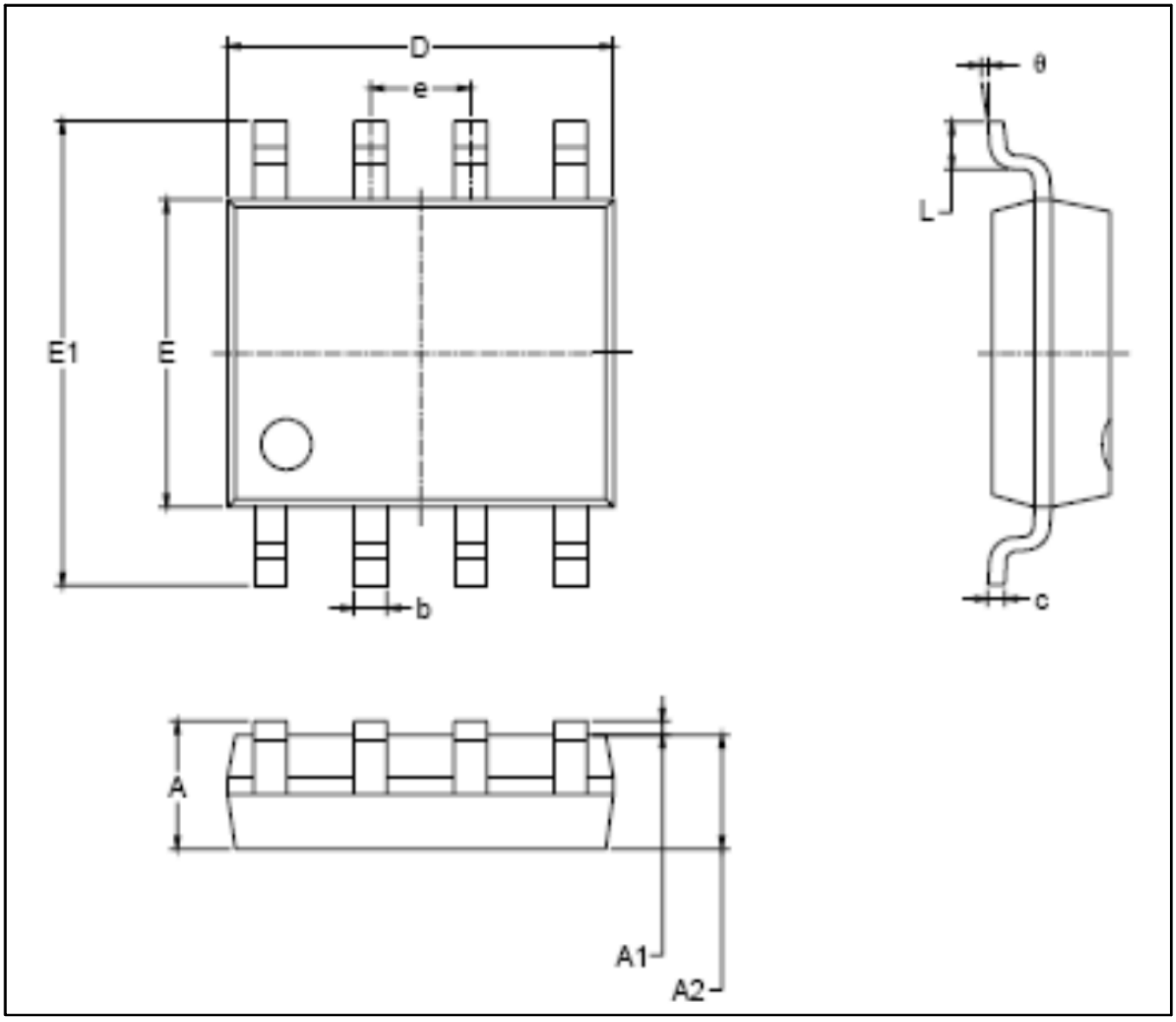
Figure 6. Instrument Amplifier

PACKAGE/ORDERING INFORMATION

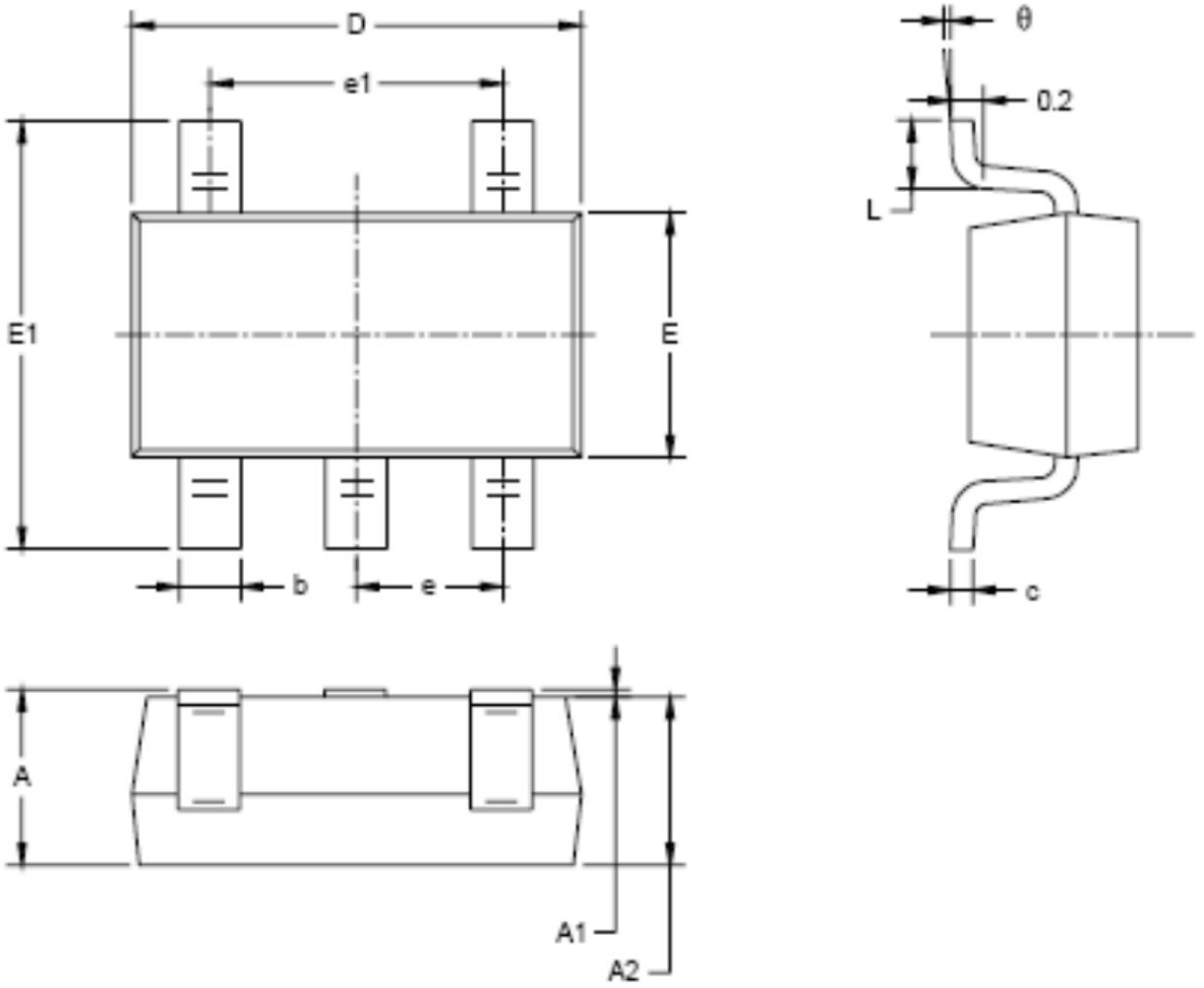
MODEL	CHANNEL	ORDER NUMBER	PACKAGE DESCRIPTION	PACKAGE OPTION	MARKING INFORMATION
MCOA321	Single	MCOA321-CR	SC70-5	Tape and Reel,3000	321
		MCOA321-TR	SOT23-5	Tape and Reel,3000	321
		MCOA321Y-CR	SC70-5	Tape and Reel,3000	321Y
		MCOA321Y-TR	SOT23-5	Tape and Reel,3000	321Y
MCOA358	Dual	MCOA358-SR	SOP-8	Tape and Reel,3000	MCOA358
		MCOA358-MR	MSOP-8	Tape and Reel,3000	MCOA358
		MCOA358-DR	DIP-8	20Tube(1000pcs)	MCOA358
		MCOA358-FR	DFN-8	Tape and Reel,3000	MCOA358
MCOA324	Quad	MCOA324-TR	TSSIP-14	Tape and Reel,3000	MCOA324
		MCOA324-SR	SOP-14	Tape and Reel,3000	MCOA324



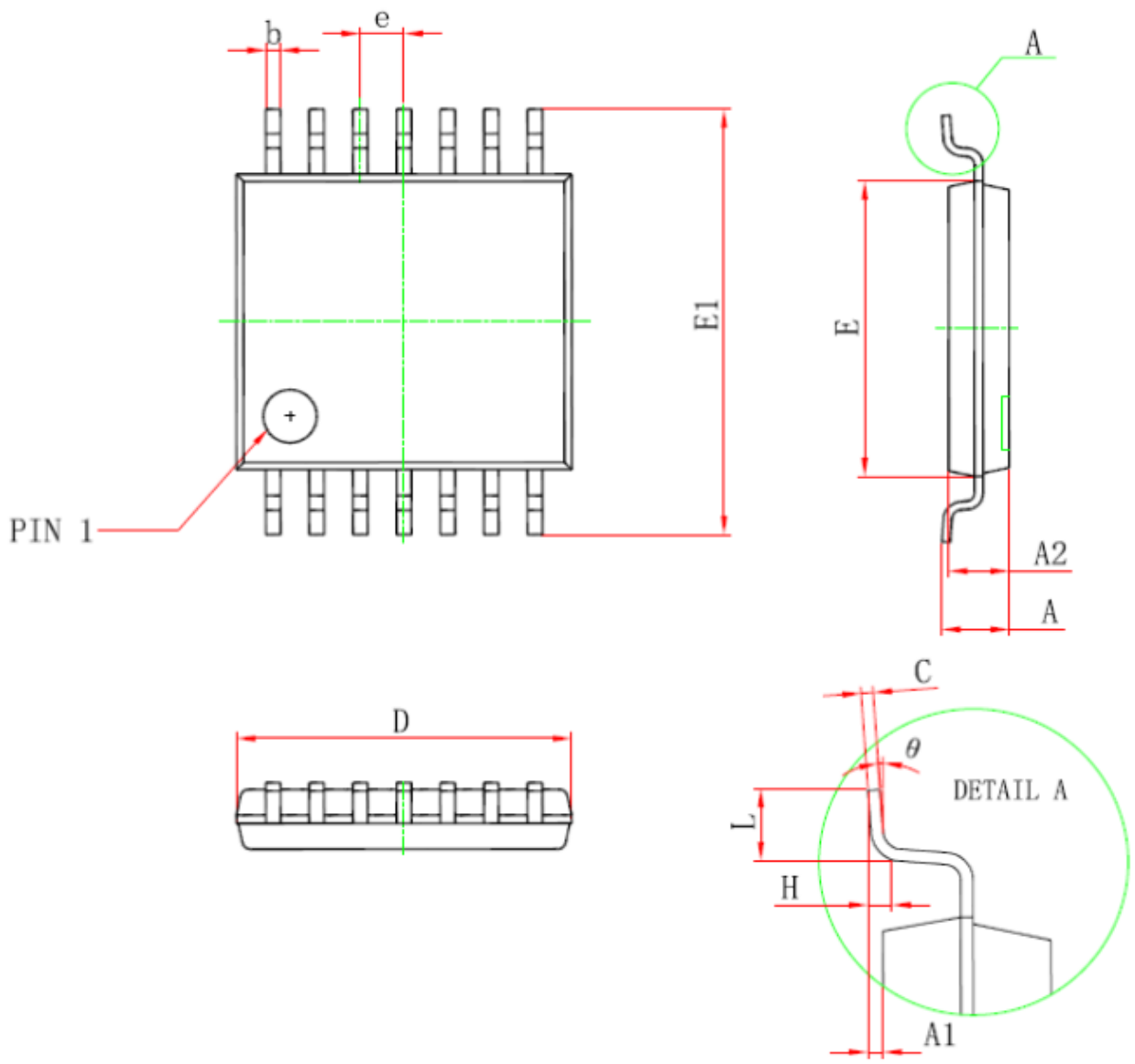
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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



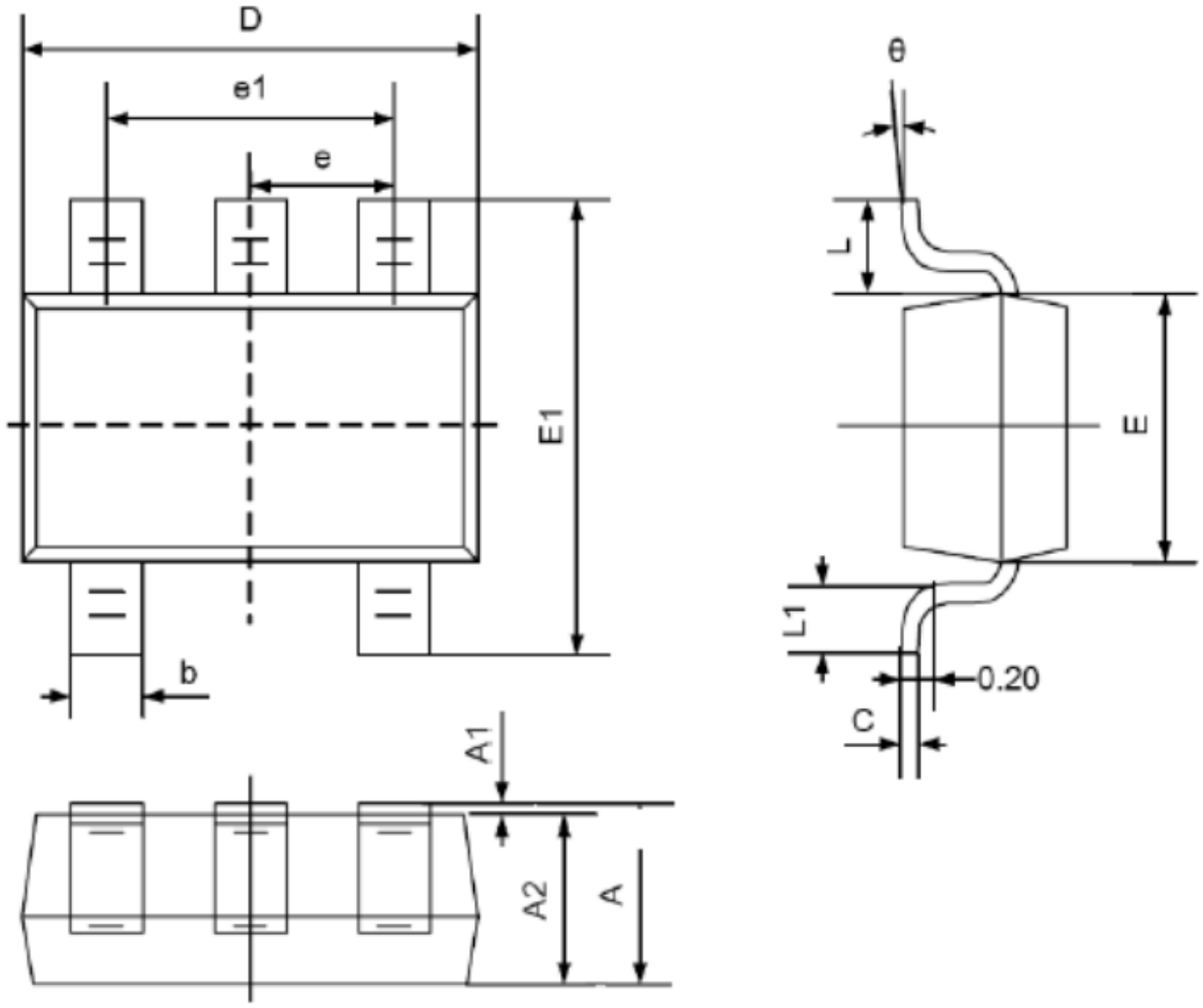
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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



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	0.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°



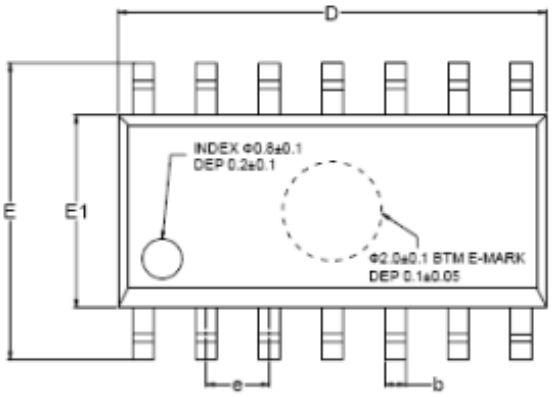
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
D	4.900	5.100	0.193	0.201
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A		1.200		0.047
A2	0.800	1.000	0.031	0.039
A1	0.050	0.150	0.002	0.006
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.020	0.028
H	0.250 TYP		0.010 TYP	
θ	1°	7°	1°	7°

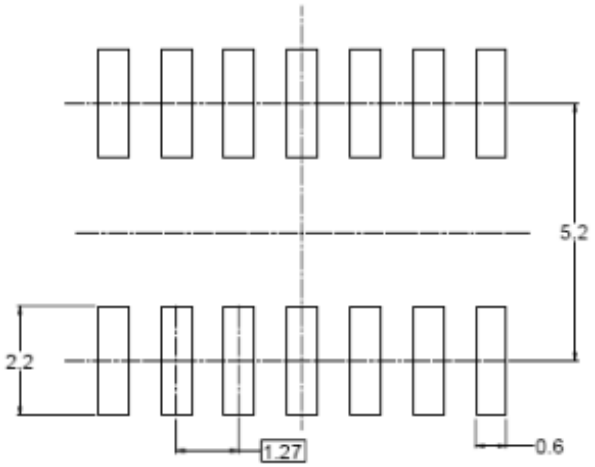


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650 TYP		0.026 TYP	
e1	1.200	1.400	0.047	0.055
L	0.525 REF		0.021 REF	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°

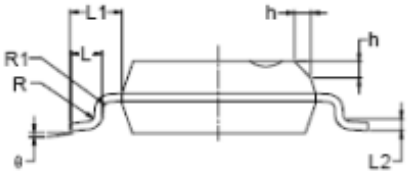
EXAMPLE STENCIL DESIGN

SOP-14

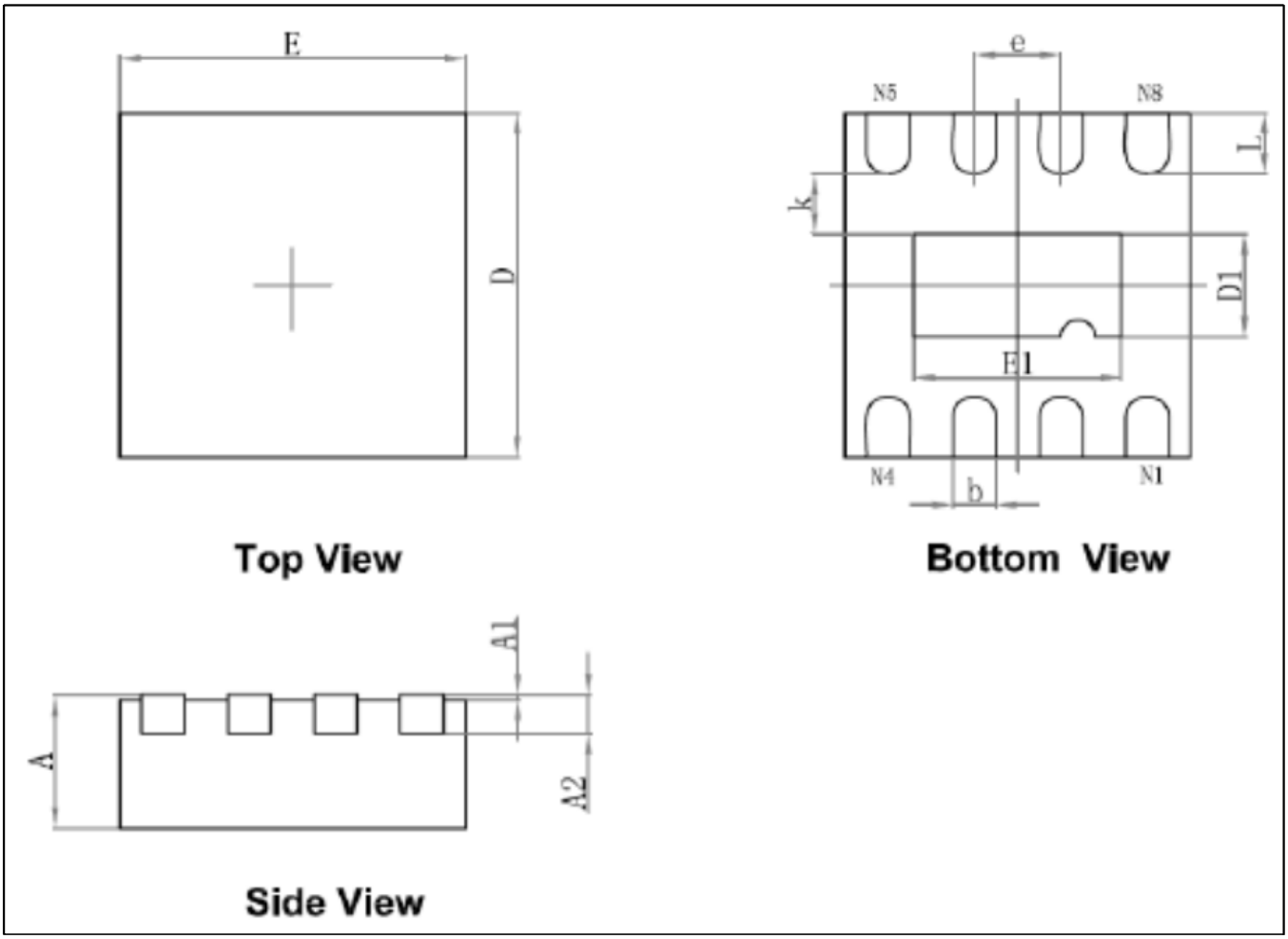




RECOMMENDED LAND PATTERN (Unit: mm)



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	MIN	MOD	MAX	MIN	MOD	MAX
A	1.350		1.750	0.053		0.069
A1	0.100		0.250	0.004		0.010
A2	1.250		1.650	0.049		0.065
A3	0.550		0.750	0.022		0.030
b	0.360		0.490	0.014		0.019
D	8.530		8.730	0.336		0.344
E	5.800		6.200	0.228		0.244
E1	3.800		4.000	0.150		0.157
e		1.270 BSC			0.050 TYP	
L	0.450		0.800	0.018		0.032
L1		1.040 REF			0.040 REF	
L2		0.250 BSC			0.010 BSC	
R	0.070			0.003		
R1	0.070			0.003		
h	0.300		0.500	0.012		0.020
θ	0°		8°	0°		8°



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	MIN	MOD	MAX	MIN	MOD	MAX
A	0.800	0.850	0.900	0.031	0.033	0.035
A1	0.000	0.020	0.050	0.000	0.001	0.002
A2	1.153	0.203	0.253	0.006	0.008	0.010
b	0.180	0.240	0.300	0.007	0.009	0.012
D	1.900	2.000	2.100	0.075	0.079	0.083
E	1.900	2.000	2.100	0.075	0.079	0.083
D1	0.500	0.600	0.700	0.020	0.024	0.028
E1	1.100	1.200	1.300	0.043	0.047	0.051
e		0.500			0.200	
k	0.200			0.008		
L	0.250	0.350	0.450	0.010	0.014	0.018