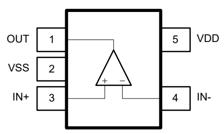
SNA8591Q/8592Q/8594Q
4.5MHZ Zero-Drift CMOS Rail-to-Rail IO Opamp with RF Filter

Features

- Single-Supply Operation from +1.8V ~ +5.5V
- Rail-to-Rail Input/Output
- Gain-Bandwidth Product: 4.5MHz(Typ@25°C)
- Low Input Bias Current: 20pA (Typ@25°C)
- Low Offset Voltage: 30μV (Max@25°C)
- Quiescent Current: 550μA per Amplifier (Typ)
- Operating Temperature: -45°C ~ +125°C
- Zero Drift: 0.01μV/°C (Typ)
- Embedded RF Anti-EMI Filter
- Small Package:
  - SNA8591Q available in SOT23-5 and SOP-8 Packages
  - SNA8592Q available in MSOP-8 and SOP-8 Packages
  - SNA8594Q available in SOP-14 and TSSOP-14 Packages
- AEC-Q100 qualified

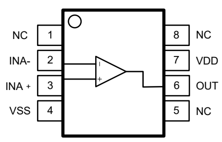
Pin Assignment

SNA8591Q



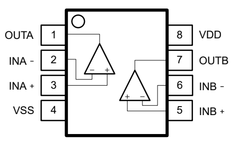
SOT-23-5

SNA8591Q



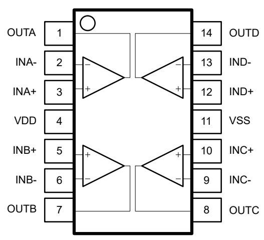
SOP-8

SNA8592Q



SOP-8/MSOP-8

SNA8594Q



SOP-14/TSSOP-14

General Description

The SNA859X amplifier is single/dual/quad supply, micro-power, zero-drift CMOS operational amplifiers, the amplifiers offer bandwidth of 4.5MHz, rail-to-rail inputs and outputs, and single-supply operation from 1.8V to 5.5V. SNA859X uses chopper stabilized technique to provide very low offset voltage (less than 30μV maximum) and near zero drift over temperature. Low quiescent supply current of 550μA per amplifier and very low input bias current of 20pA make the devices an ideal choice for low offset, low power consumption and high impedance applications.

The SNA859X offers excellent CMRR without the crossover associated with traditional complementary input stages. This design results in superior performance for driving analog-to-digital converters (ADCs) without degradation of differential linearity.

Applications

- Transducer Application
- Temperature Measurements
- Electronics Scales
- Handheld Test Equipment
- Battery-Powered Instrumentation

Contents

1 Specifications

1.1 Ordering Information

Model	Channel	Package	Ordering Number	Packing Option
SNA8591Q	Single	SOT23-5	SNA8591Q00CB5	Tape and Reel,3000
SNA8591Q	Single	SOP-8	SNA8591Q00CA8	Tape and Reel,4000
SNA8592Q	Dual	SOP-8	SNA8592Q01CA8	Tape and Reel,4000
SNA8592Q	Dual	MSOP-8	SNA8592Q00CM8	Tape and Reel,3000
SNA8594Q	Quad	TSSOP-14	SNA8594Q00CIF	Tape and Reel,3000
SNA8594Q	Quad	SOP-14	SNA8594Q00CAF	Tape and Reel,2500

1.2 Absolute Maximum Ratings

Parameter		Min	Max	Unit
Power Supply Voltage (V_{DD} to V_{SS})		-0.5	+7.5	V
Analog Input Voltage (IN+ or IN-)		V_{SS}-0.5	V_{DD}+0.5	V
PDB Input Voltage		V_{SS}-0.5	+7	V
Operating Temperature Range		-45	+125	°C
Junction Temperature		160		°C
Storage Temperature Range		-55	+150	°C
Lead Temperature (soldering, 10sec)		260		°C
Package Thermal Resistance, θ_{JA} (T_A=+25°C)	SOT-23-5	190		°C/W
	SOP-8	125		°C/W
	MSOP-8	216		°C/W
ESD	HBM	6000		V
	MM	400		V

Note: Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "Recommended Operating Conditions" is not implied. Exposure to "Absolute Maximum Ratings" for extended periods may affect device reliability.

1.3 Electrical Characteristics

At V_S = +5V, T_A = 25°C, V_O = 2.5V,unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Input Offset Voltage	V_{OS}			1	30	μV
Input Bias Current	I_B			20		pA
Input Offset Current	I_{OS}			10		pA
Common-Mode Rejection Ratio	CMRR	V_{CM} = 0V to 5V		110		dB
Large Signal Voltage Gain	A_{VO}	V_O = 0.3V to 4.7V		145		dB
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$			10	50	nV/°C
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	R_L = 100kΩ to $-V_S$		4.998		V
		R_L = 10kΩ to $-V_S$		4.994		V
Output Voltage Low	V_{OL}	R_L = 100kΩ to $+V_S$		2		mV
		R_L = 10kΩ to $+V_S$		5		mV
Short Circuit Limit	I_{SC}	R_L = 10Ω to $-V_S$		43		mA
Output Current	I_O			30		mA
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V_S = 2.5V to 5.5V		115		dB
Quiescent Current	I_Q	V_O = 0V,R_L = 0Ω		550		μA
DYNAMIC PERFORMANCE						
Gain-Bandwidth Product	GBP	G = +100		4.5		MHz
Slew Rate	SR	R_L = 10kΩ		2.5		V/μs
Overload Recovery Time				0.1		ms
NOISE PERFORMANCE						
Voltage Noise	$e_{n\ p\text{-}p}$	0Hz to 10Hz		0.2		$\mu V_{P\text{-}P}$
Voltage Noise Density	e_n	f = 1kHz		30		$nV/\sqrt{Hz}$

2 Typical Performance Characteristics

T_A = +25°C, V_S = 5V, R_L = 10kΩ connected to $V_S/2$ and V_{OUT} = $V_S/2$, unless otherwise noted.

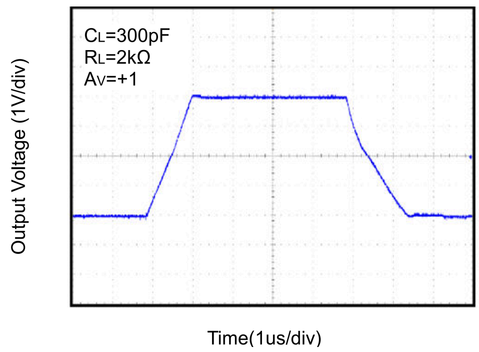


Figure 2-1 Large Signal Transient Response at +5V

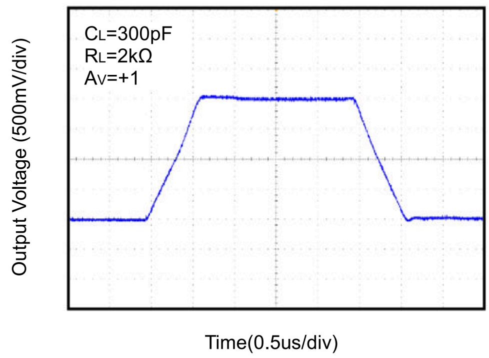


Figure 2-2 Large Signal Transient Response at +2.5V

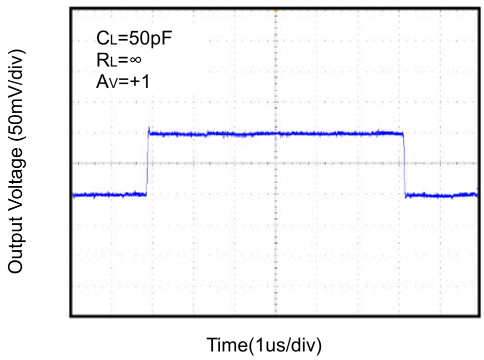


Figure 2-3 Small Signal Transient Response at +5V

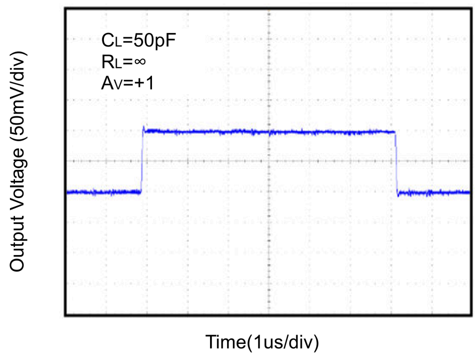


Figure 2-4 Small Signal Transient Response at +2.5V

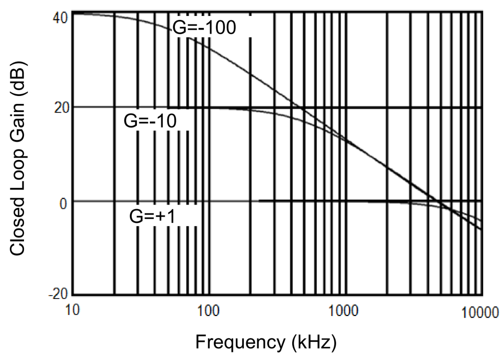


Figure 2-5 Closed Loop Gain vs. Frequency at +5V

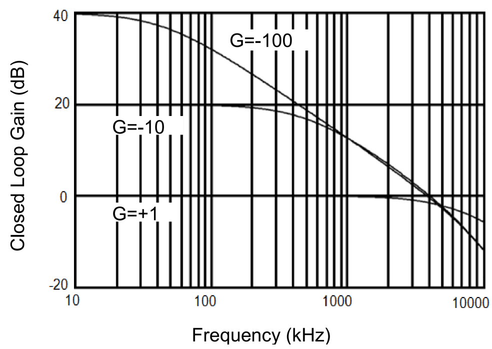


Figure 2-6 Closed Loop Gain vs. Frequency at +2.5V

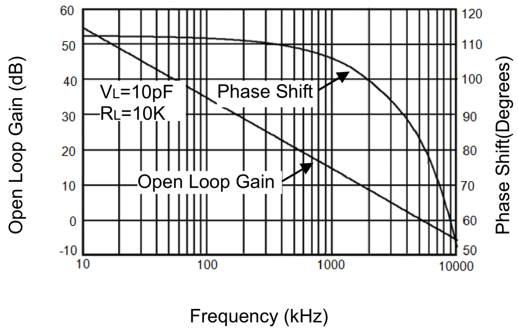


Figure 2-7 Open Loop Gain, Phase Shift vs. Frequency at +5V

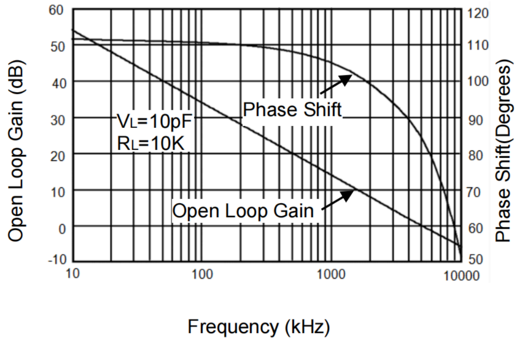


Figure 2-8 Open Loop Gain, Phase Shift vs. Frequency at +2.5V

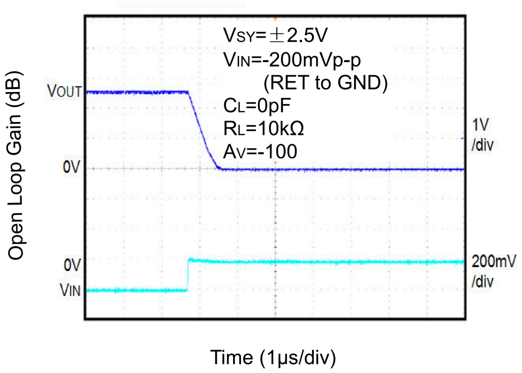


Figure 2-9 Positive Overvoltage Recovery

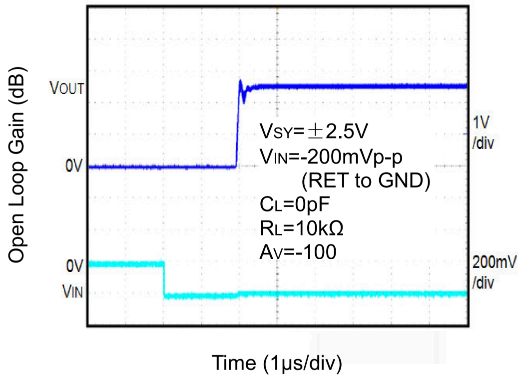


Figure 2-10 Negative Overvoltage Recovery

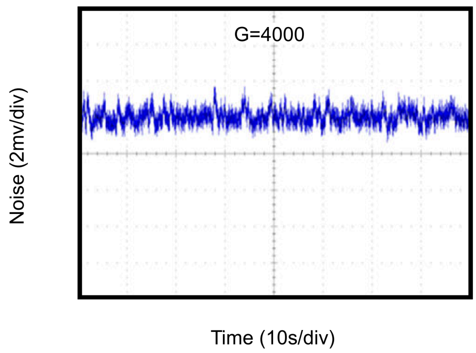


Figure 2-11 0.1Hz to 10Hz Noise at +5V

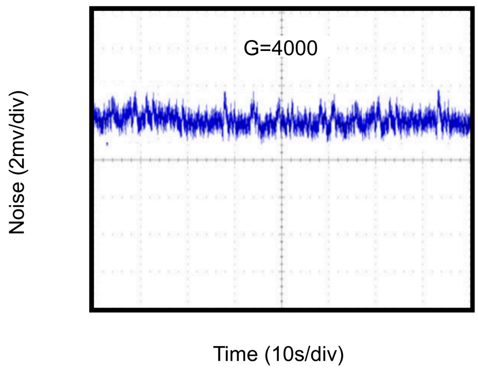


Figure 2-12 0.1Hz to 10Hz Noise at +2.5V

3 Application Note

3.1 Size

SNA859X series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the SNA859X series packages save space on printed circuit boards and enable the design of smaller electronic products.

3.2 Power Supply Bypassing and Board Layout

SNA859X series operates from a single 1.8V to 5.5V supply or dual ±0.9V 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.

3.3 Low Supply Current

The low supply current (typical 550μA per channel) of SNA859X series will help to maximize battery life. They are ideal for battery powered systems.

3.4 Operating Voltage

SNA859X series operate under wide input supply voltage (1.8V to 5.5V). In addition, all temperature specifications apply from -40°C to +125°C. Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime.

3.5 Rail-to-Rail Input

The input common-mode range of SNA859X 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.

3.6 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 SNA859X series can typically swing to less than 5mV from supply rail in light resistive loads (>100kΩ), and 60mV of supply rail in moderate resistive loads (10kΩ).

3.7 Capacitive Load Tolerance

The SNA859X 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 3-1 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.

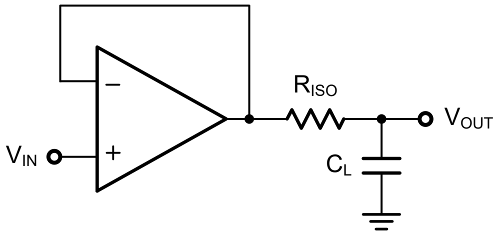


Figure 3-1 Indirectly Driving a Capacitive Load Using Isolation Resistor

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 3-2 is an improvement to the one in Figure 3-1. 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.

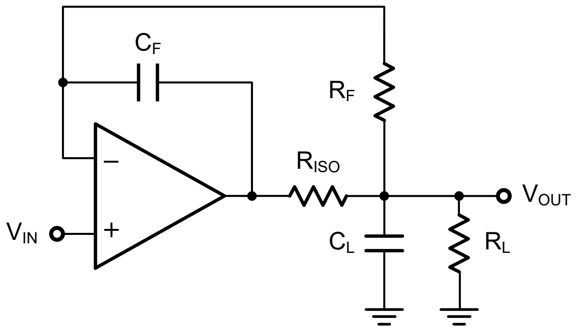


Figure 3-2 Indirectly Driving a Capacitive Load with DC Accuracy

4 Typical Application Circuits

4.1 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 4-1 shown the differential amplifier using SNA859X.

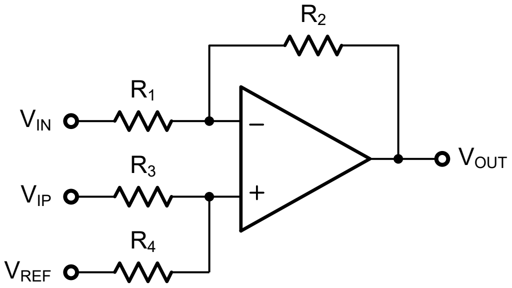


Figure 4-1 Differential Amplifier

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

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

$$V_{OUT} = \frac{R_2}{R_1}(V_{IP} - V_{IN}) + V_{REF}$$

4.2 Low Pass Active Filter

The low pass active filter is shown in Figure 4-2. The DC gain is defined by $-R_2/R_1$. The filter has a -20dB/decade roll-off after its corner frequency $f_C=1/(2\pi R_3C_1)$.

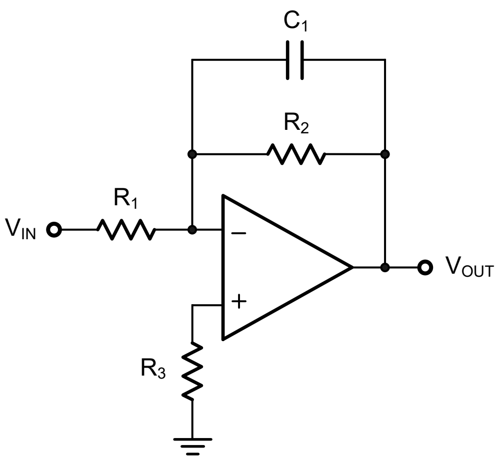


Figure 4-2 Low Pass Active Filter

4.3 Instrumentation Amplifier

The triple SNA859X can be used to build a three-op-amp instrumentation amplifier as shown in Figure 4-3. The amplifier in Figure 4-3 is a high input impedance differential amplifier with gain of R_2/R_1. The two differential voltage followers assure the high input impedance of the amplifier.

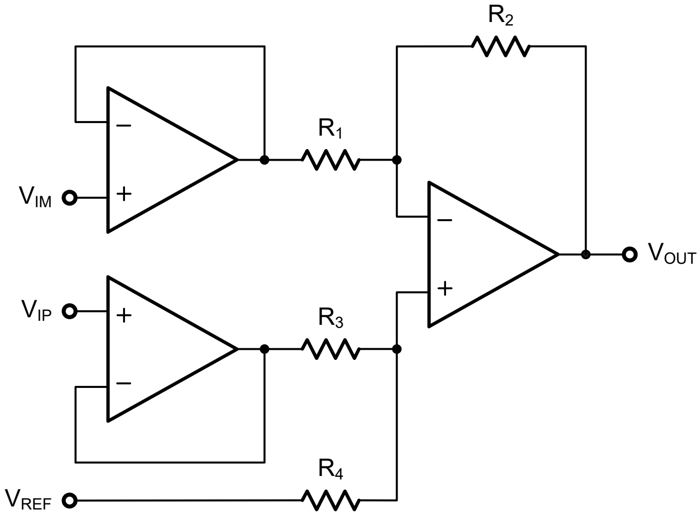
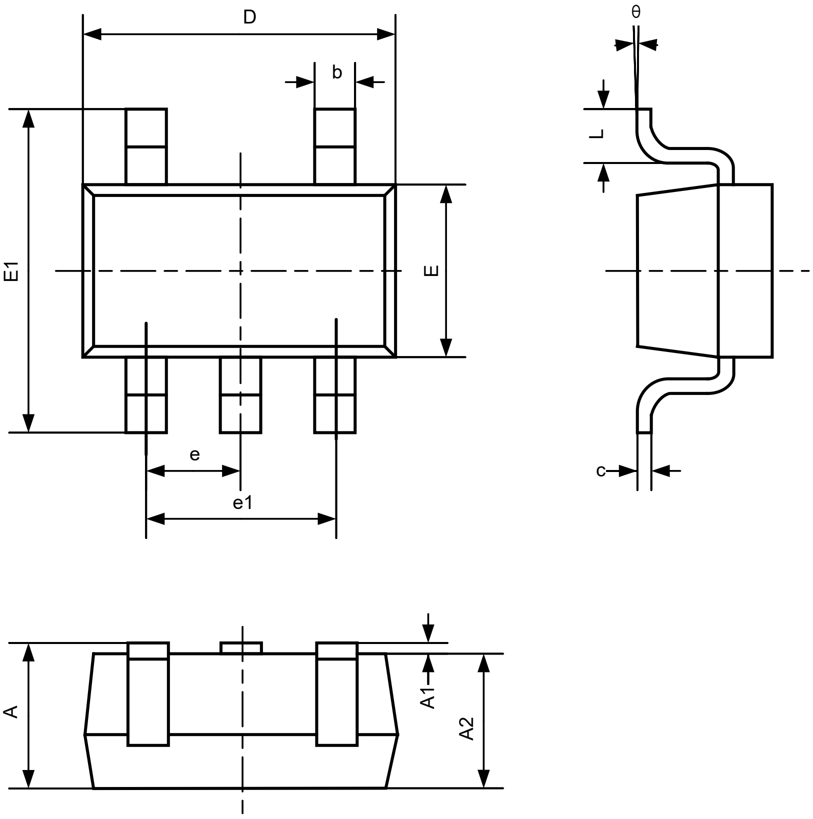


Figure 4-3 Instrument Amplifier

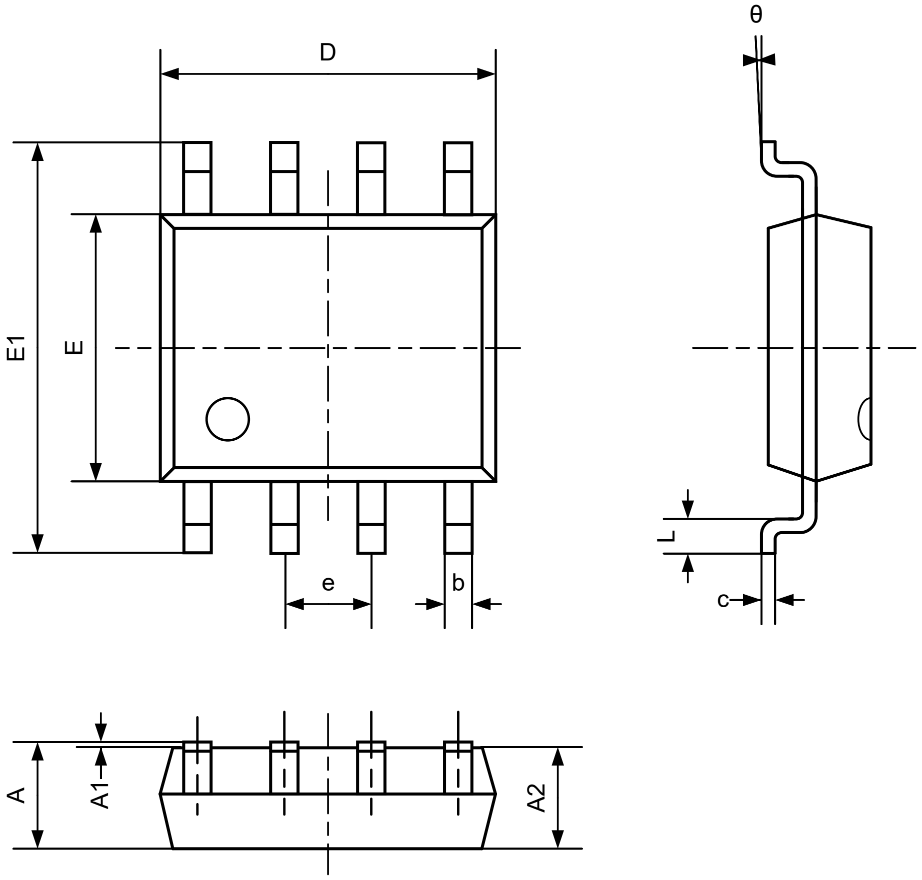
5 Package Information

5.1 SOT-23-5



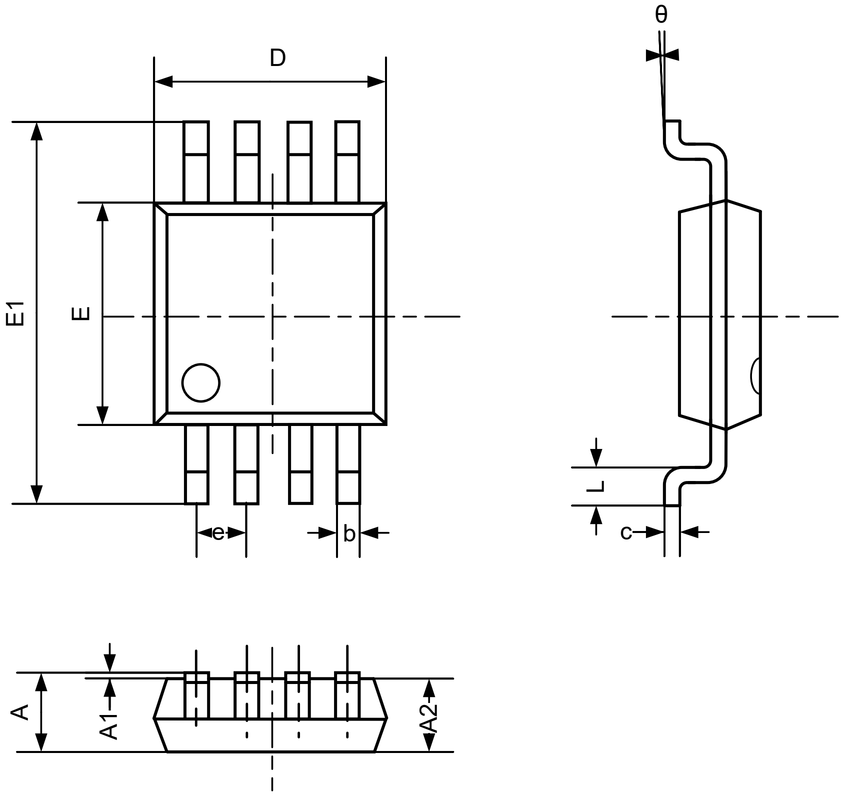
Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

5.2 SOP-8



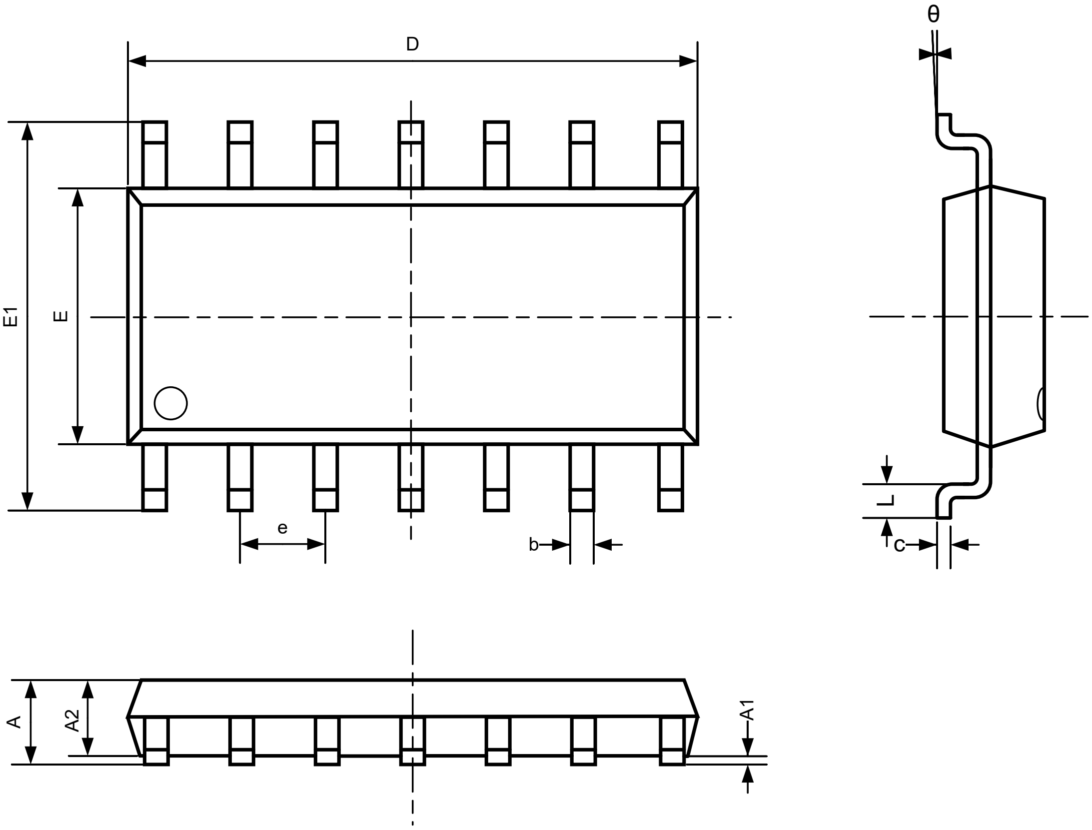
Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 BSC		0.050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

5.3 MSOP-8



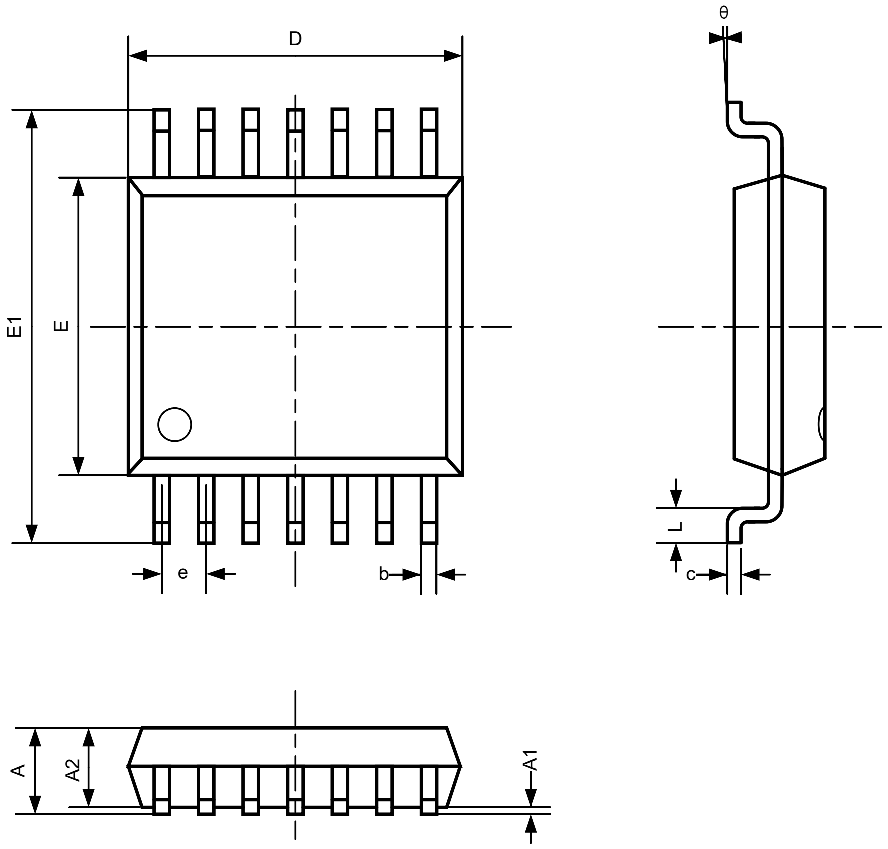
Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

5.4 SOP-14



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	1.250	1.650	0.049	0.065
b	0.360	0.490	0.014	0.019
c	0.130	0.250	0.005	0.010
D	8.530	8.730	0.336	0.344
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 BSC		0.050 BSC	
L	0.450	0.800	0.018	0.032
θ	0°	8°	0°	8°

5.5 TSSOP-14



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

6 Revision History

Version	Date	Description
0.1	2022/02/25	Initial release

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