



SGM8954-1/SGM8954-2

High Precision, Low Power, Rail-to-Rail I/O, CMOS Operational Amplifiers

GENERAL DESCRIPTION

The single SGM8954-1 and dual SGM8954-2 are low power, high precision CMOS operational amplifiers, which can operate from 1.8V to 5.5V single supply or from $\pm 0.9V$ to $\pm 2.75V$ dual power supplies, while consuming only 9 μA quiescent current per amplifier. The SGM8954-1/2 support rail-to-rail input and output operation. The input common mode voltage range is from $(-V_S) - 0.1V$ to $(+V_S) + 0.1V$, and the output range is from $(-V_S) + 0.0055V$ to $(+V_S) - 0.0055V$.

The SGM8954-1/2 are designed to provide optimal performance in low voltage and low power systems. They have high impedance inputs and zero-drift 35 μV (MAX) offset voltage. These specifications make SGM8954-1/2 appropriate for a wide range of applications requiring high precision, such as high linearity driver of high precision ADC.

The SGM8954-1 is available in Green SOT-23-5, SOIC-8 and UTDFN-1.6 \times 1.6-6L packages. The SGM8954-2 is available in Green SOIC-8, MSOP-8 and TDFN-2 \times 2-8L packages. They are specified over the extended industrial temperature range (-40°C to +125°C).

FEATURES

- **Low Input Offset Voltage:** 8 μV (TYP), 35 μV (MAX)
- **Low Noise:** 1 μV_{P-P} at 0.1Hz to 10Hz
- **Unity-Gain Stable**
- **Gain-Bandwidth Product:** 110kHz
- **Integrated RFI Filter**
- **Rail-to-Rail Input and Output**
- **Support Single or Dual Power Supplies:**
1.8V to 5.5V or $\pm 0.9V$ to $\pm 2.75V$
- **Quiescent Current:** 9 μA /Amplifier (TYP)
- **-40°C to +125°C Operating Temperature Range**
- **Small Packaging:**
SGM8954-1 Available in Green SOT-23-5, SOIC-8 and UTDFN-1.6 \times 1.6-6L Packages
SGM8954-2 Available in Green SOIC-8, MSOP-8 and TDFN-2 \times 2-8L Packages

APPLICATIONS

Industrial Equipment
Battery-Powered Equipment
Sensor Signal Conditioning

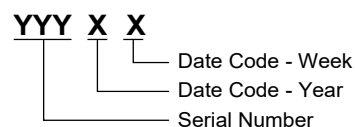
PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8954-1	SOT-23-5	-40°C to +125°C	SGM8954-1XN5G/TR	MBBXX	Tape and Reel, 3000
	SOIC-8	-40°C to +125°C	SGM8954-1XS8G/TR	SGM 89541XS8 XXXXX	Tape and Reel, 4000
	UTDFN-1.6×1.6-6L	-40°C to +125°C	SGM8954-1XUDN6G/TR	H6X	Tape and Reel, 3000
SGM8954-2	SOIC-8	-40°C to +125°C	SGM8954-2XS8G/TR	SGM 89542XS8 XXXXX	Tape and Reel, 4000
	MSOP-8	-40°C to +125°C	SGM8954-2XMS8G/TR	SGM89542 XMS8 XXXXX	Tape and Reel, 4000
	TDFN-2×2-8L	-40°C to +125°C	SGM8954-2XTDE8G/TR	MH8 XXXX	Tape and Reel, 3000

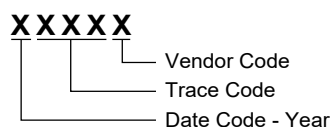
MARKING INFORMATION

NOTE: X = Date Code. XX = Date Code. XXXX = Date Code and Trace Code. XXXXX = Date Code, Trace Code and Vendor Code.

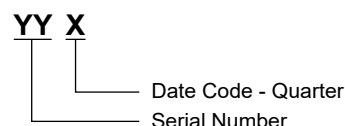
SOT-23-5



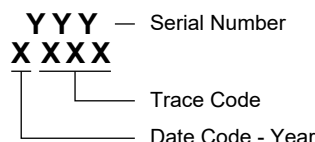
SOIC-8/MSOP-8



UTDFN-1.6×1.6-6L



TDFN-2×2-8L



Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

SGM8954-1 SGM8954-2

High Precision, Low Power, Rail-to-Rail I/O, CMOS Operational Amplifiers

ABSOLUTE MAXIMUM RATINGS

Supply Voltage.....	6V
Input Common Mode Voltage Range	$(-V_s) - 0.3V$ to $(+V_s) + 0.3V$
Junction Temperature	+150°C
Storage Temperature Range.....	-65°C to +150°C
Lead Temperature (Soldering, 10s).....	+260°C
ESD Susceptibility	
HBM.....	8000V
MM.....	400V
CDM	1000V

RECOMMENDED OPERATING CONDITIONS

Specified Voltage Range	1.8V to 5.5V
Operating Temperature Range	-40°C to +125°C

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to

absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

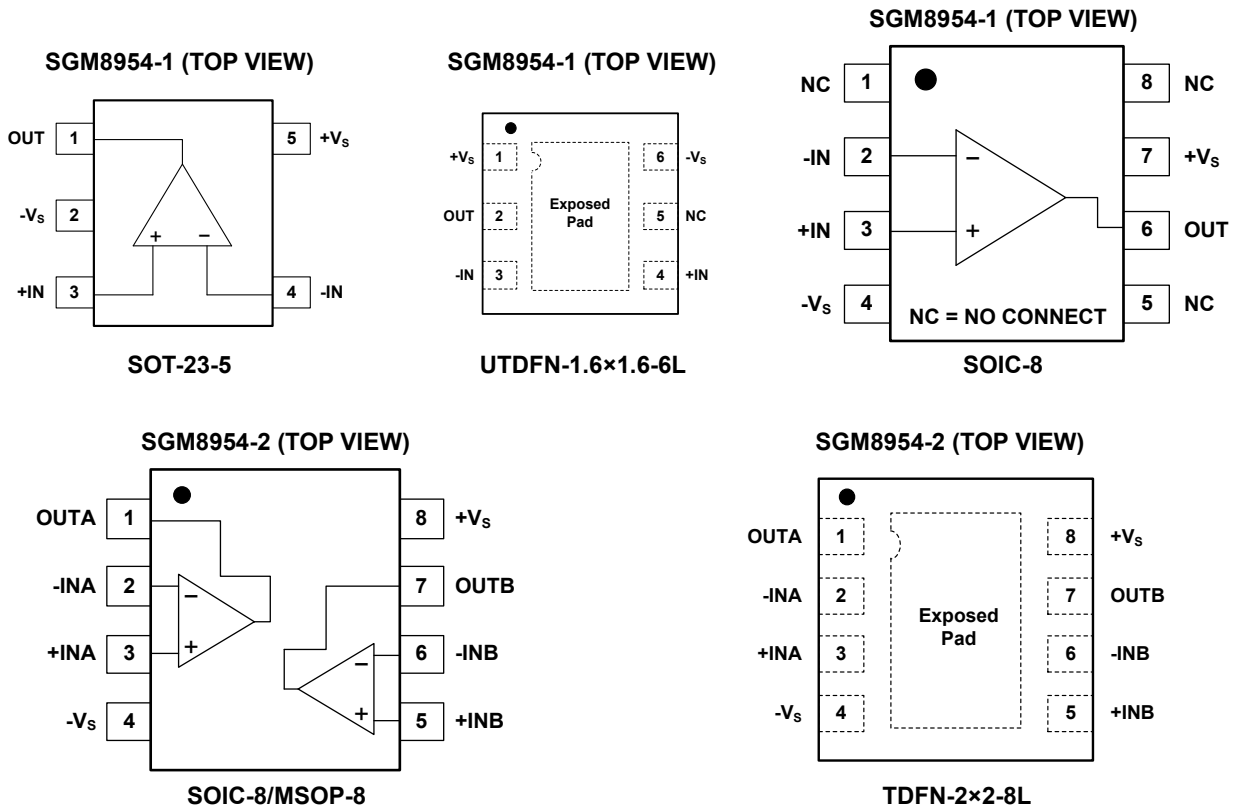
ESD SENSITIVITY CAUTION

This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

PIN CONFIGURATIONS



NOTE: For UTDFN-1.6x1.6-6L and TDFN-2x2-8L packages, exposed pad can be connected to $-V_s$ or left floating.

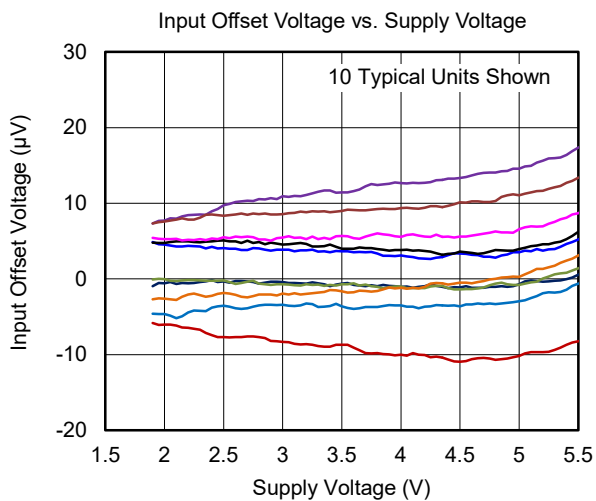
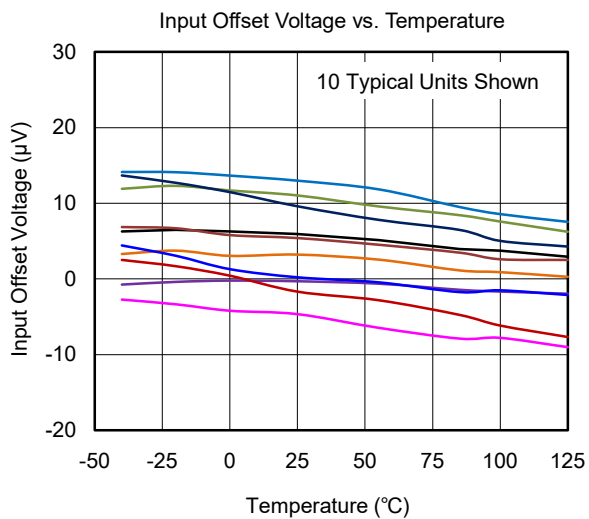
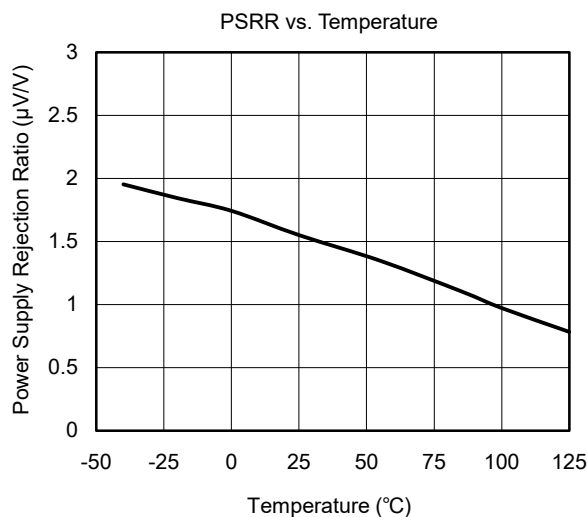
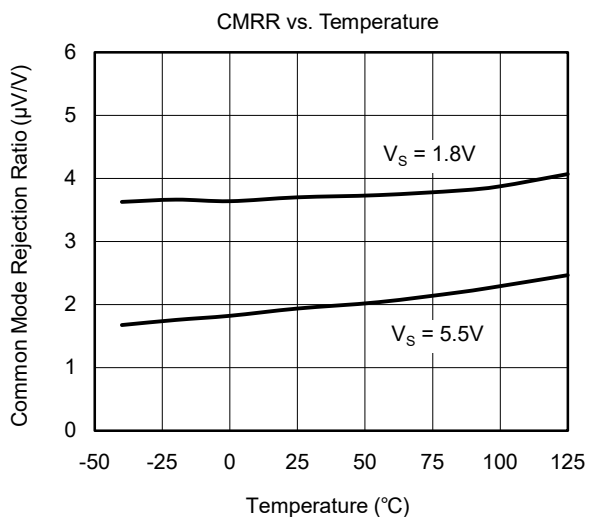
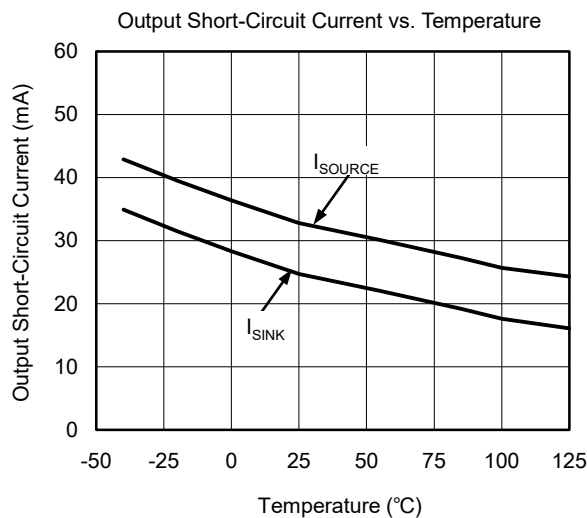
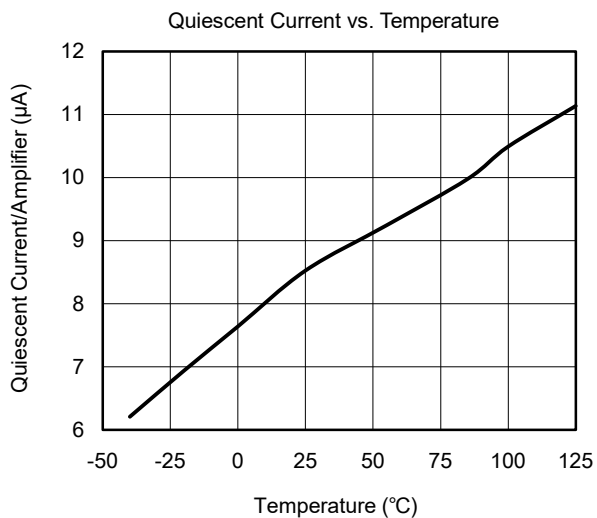
ELECTRICAL CHARACTERISTICS

(At $T_A = +25^\circ\text{C}$, $V_S = 1.8\text{V}$ to 5.5V , $V_{CM} = +V_S/2$, $V_{OUT} = +V_S/2$ and $R_L = 10\text{k}\Omega$ to $+V_S/2$, Full = -40°C to $+125^\circ\text{C}$, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Characteristics							
Input Offset Voltage	V_{OS}		+25°C		8	35	μV
			Full			40	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		Full		55		$\text{nV}/^\circ\text{C}$
Input Bias Current	I_B		+25°C		60	500	pA
Input Offset Current	I_{OS}		+25°C		110	700	pA
Input Common Mode Voltage Range	V_{CM}		Full	$(-V_S) - 0.1$		$(+V_S) + 0.1$	V
Common Mode Rejection Ratio	CMRR	$(-V_S) - 0.1\text{V} < V_{CM} < (+V_S) + 0.1\text{V}$	+25°C	93	108		dB
			Full	90			
Open-Loop Voltage Gain	A_{OL}	$(-V_S) + 0.1\text{V} < V_{OUT} < (+V_S) - 0.1\text{V}$, $R_L = 10\text{k}\Omega$	+25°C	106	125		dB
			Full	103			
Output Characteristics							
Output Voltage Swing from Rail		$R_L = 10\text{k}\Omega$	+25°C		5.5	10	mV
			Full			11	
Output Short-Circuit Current	I_{SC}	$V_S = 1.8\text{V}$	+25°C	5.5	8		mA
		$V_S = 5.5\text{V}$	+25°C	17	26		
Power Supply							
Specified Voltage Range	V_S		Full	1.8		5.5	V
Power Supply Rejection Ratio	PSRR	$V_S = 1.8\text{V}$ to 5.5V	+25°C		1.8	10	$\mu\text{V}/\text{V}$
			Full			14	
Quiescent Current/Amplifier	I_Q	$I_{OUT} = 0$	+25°C		9	13	μA
			Full			15.5	
Dynamic Performance							
Gain-Bandwidth Product	GBP	$C_L = 100\text{pF}$	+25°C		110		kHz
Phase Margin	ϕ_o	$C_L = 100\text{pF}$	+25°C		80		$^\circ$
Slew Rate	SR	$G = 1$	+25°C		0.04		$\text{V}/\mu\text{s}$
Overload Recovery Time		$G = -10$	+25°C		16		μs
Noise							
Input Voltage Noise		$f = 0.1\text{Hz}$ to 10Hz	+25°C		1		μV_{P-P}
Input Voltage Noise Density	e_n	$f = 1\text{kHz}$	+25°C		65		$\text{nV}/\sqrt{\text{Hz}}$
Input Current Noise Density	i_n	$f = 1\text{kHz}$	+25°C		360		$\text{fA}/\sqrt{\text{Hz}}$

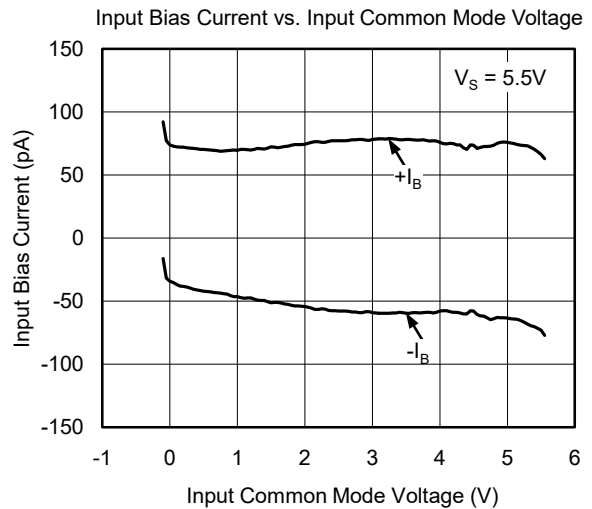
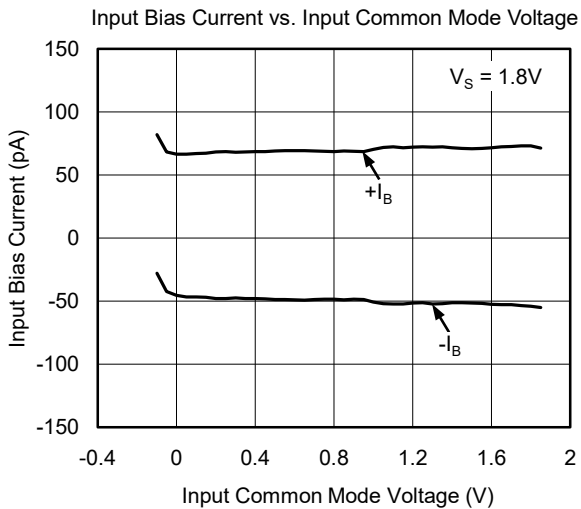
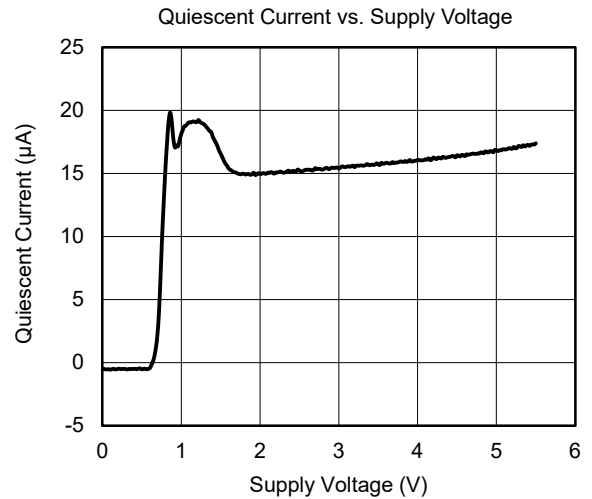
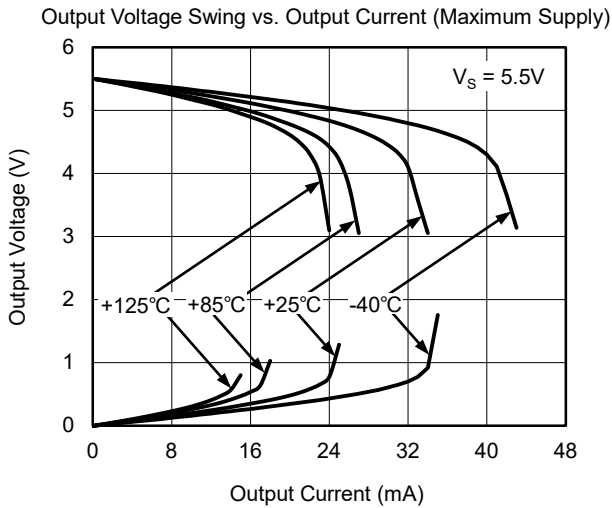
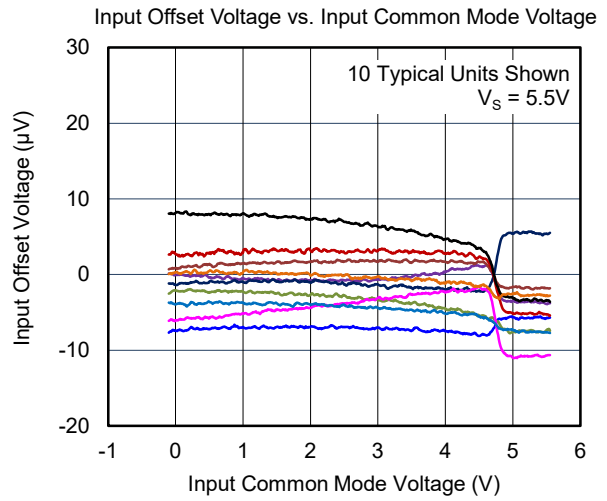
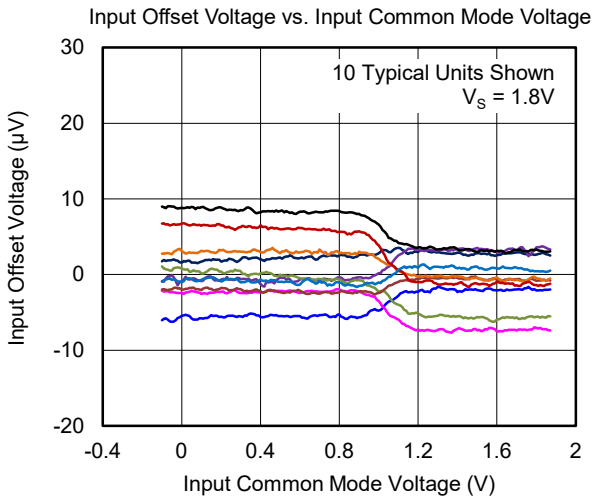
TYPICAL PERFORMANCE CHARACTERISTICS

At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $R_L = 10\text{k}\Omega$ and $C_L = 100\text{pF}$, unless otherwise noted.



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

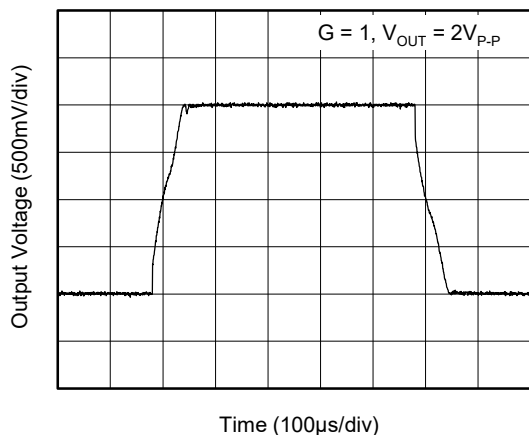
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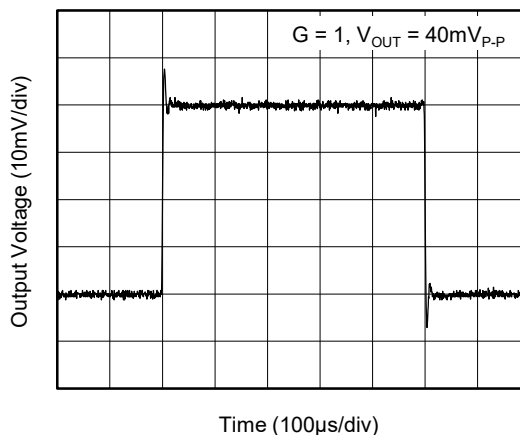
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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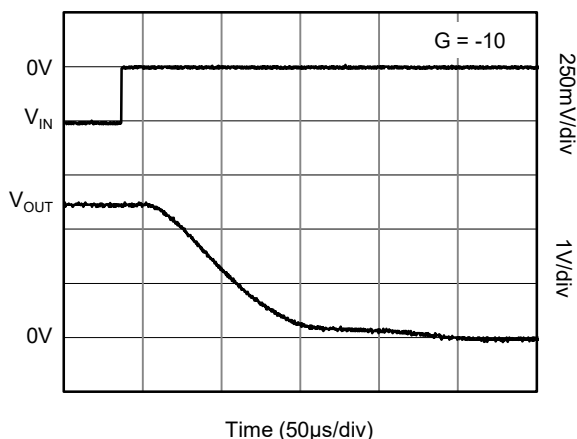
Large-Signal Step Response



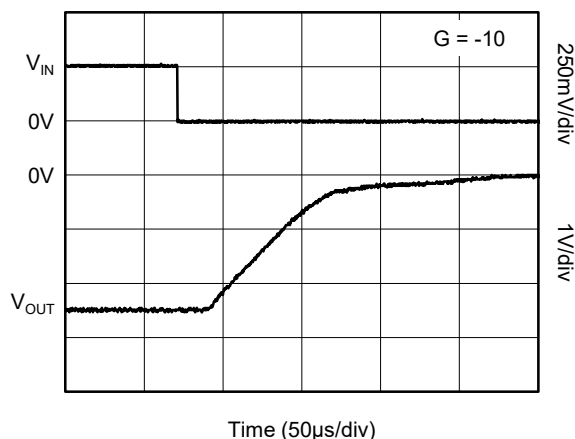
Small-Signal Step Response



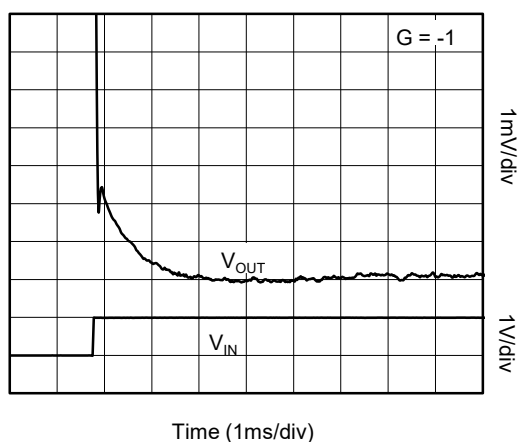
Positive Overload Recovery



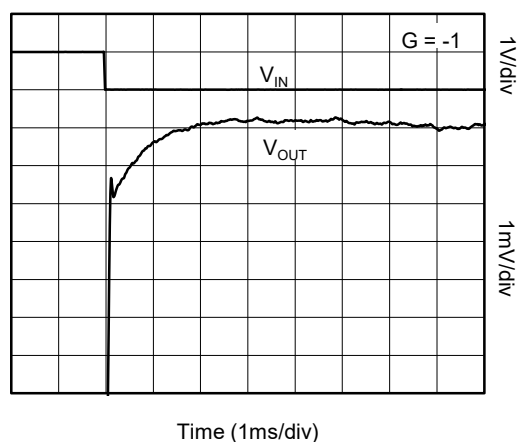
Negative Overload Recovery



Large-Signal Settling Time (Positive)

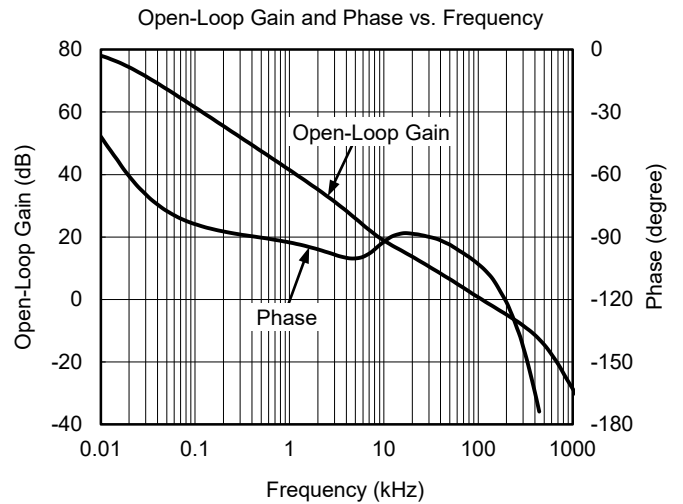
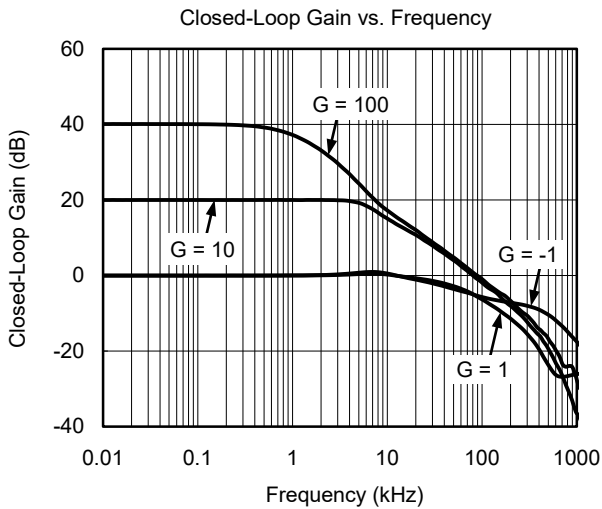
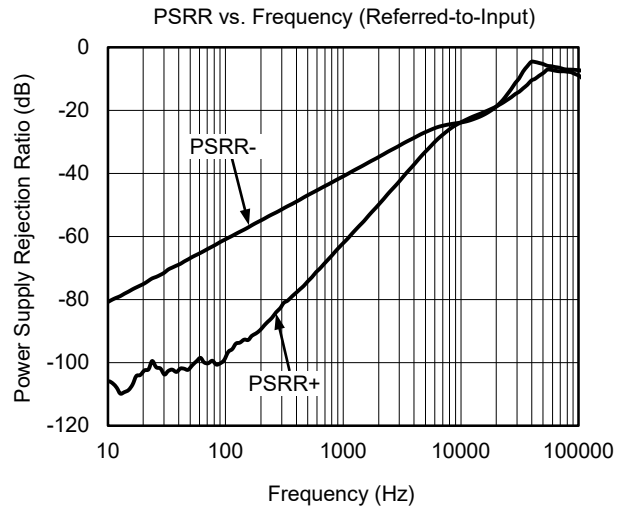
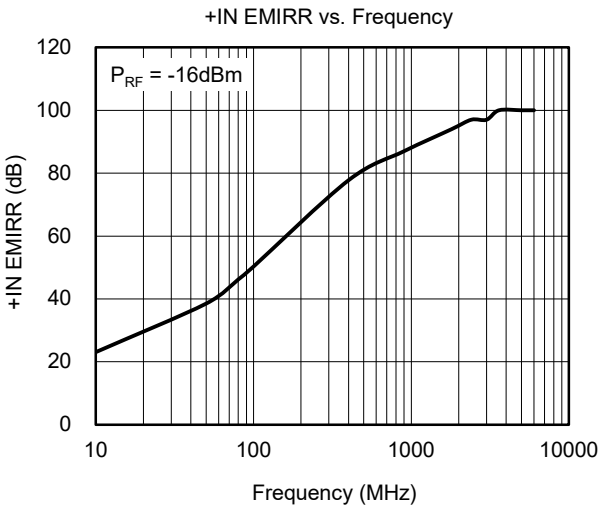
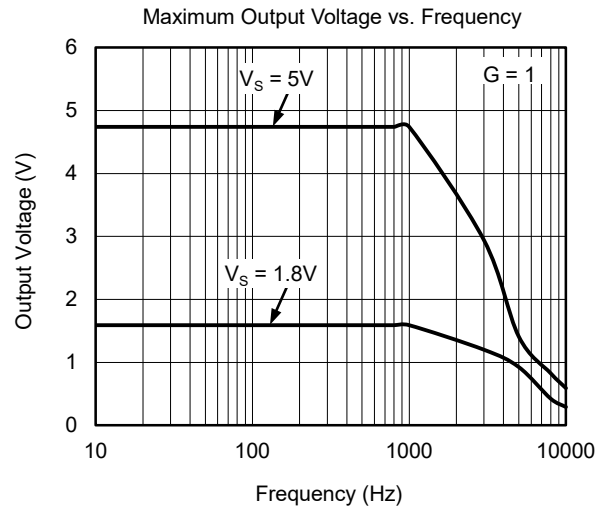
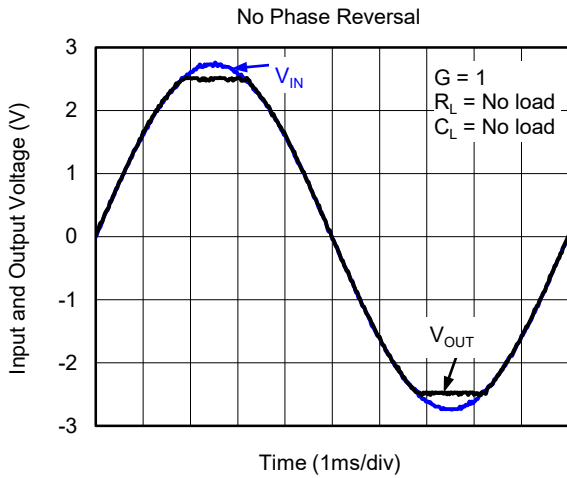


Large-Signal Settling Time (Negative)



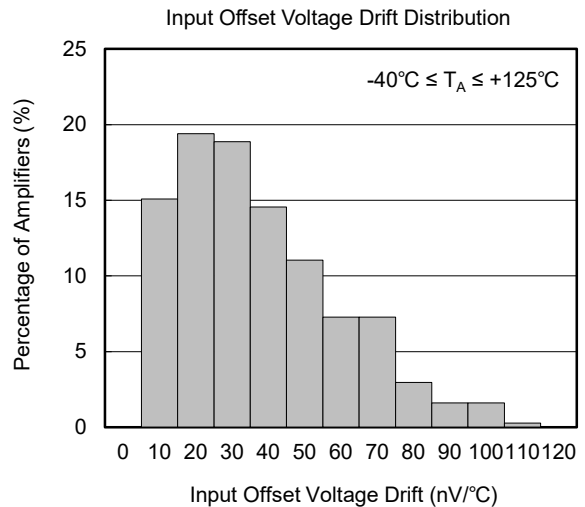
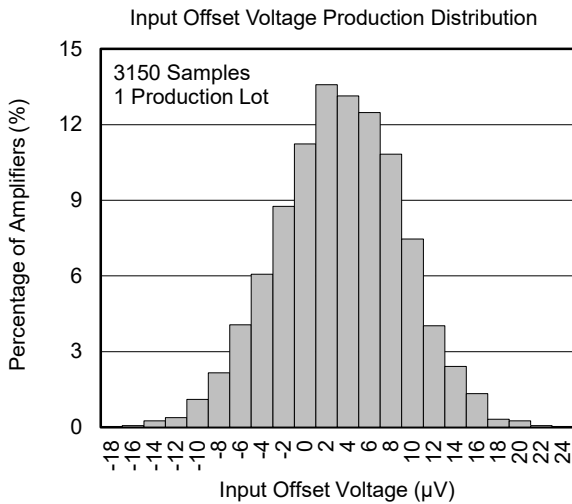
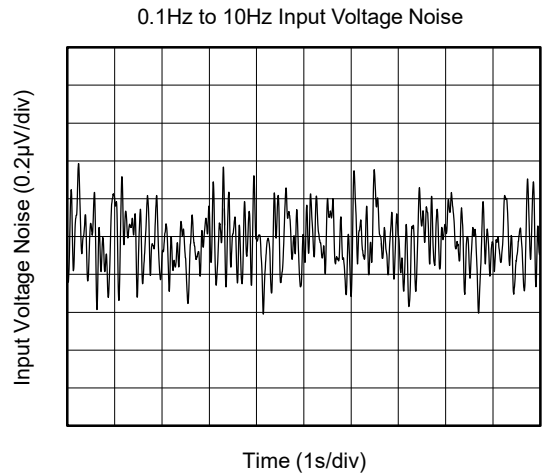
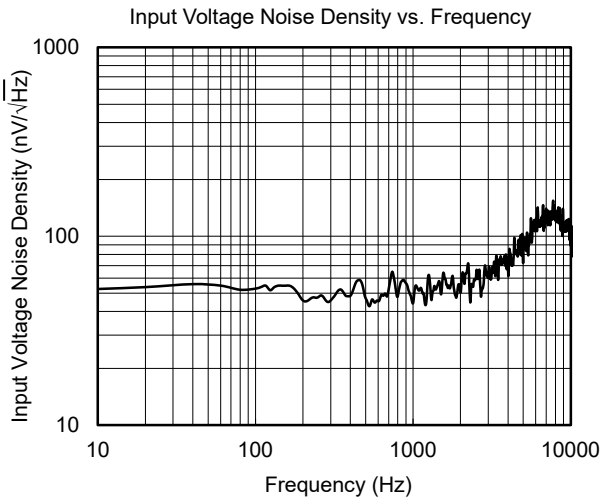
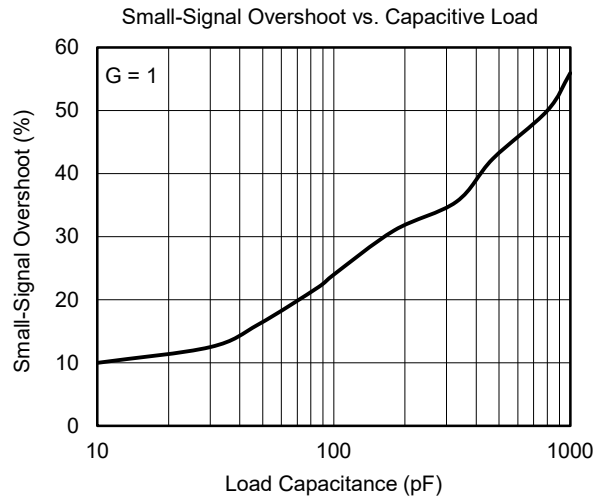
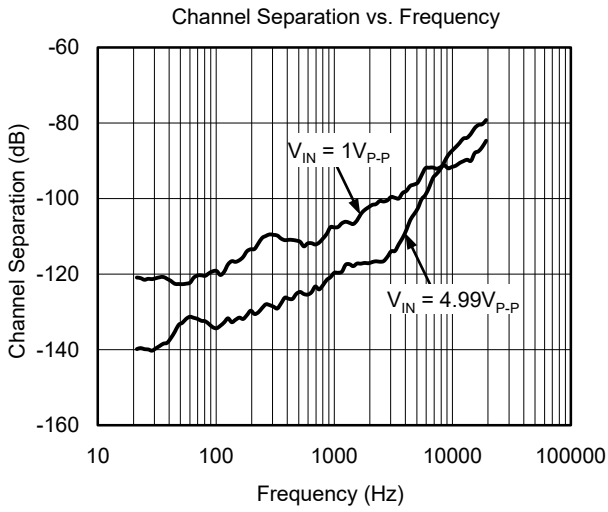
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $R_L = 10\text{k}\Omega$ and $C_L = 100\text{pF}$, unless otherwise noted.



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $R_L = 10\text{k}\Omega$ and $C_L = 100\text{pF}$, unless otherwise noted.



APPLICATION INFORMATION

Rail-to-Rail Input

When SGM8954-1/2 work at the power supply between 1.8V and 5.5V, the input common mode voltage range is from $(-V_S) - 0.1V$ to $(+V_S) + 0.1V$. In Figure 1, the ESD diodes between the inputs and the power supply rails will clamp the input voltage not to exceed the rails.

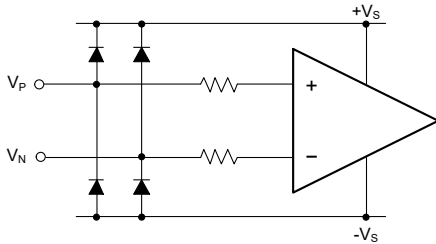


Figure 1. Input Equivalent Circuit

Input Current-Limit Protection

For ESD diode clamping protection, when the current flowing through ESD diode exceeds the maximum rating value, the ESD diode and amplifier will be damaged, so current-limit protection will be added in some applications. One resistor is selected to limit the current not to exceed the maximum rating value. In Figure 2, a series input resistor is used to limit the input current to less than 10mA, but the drawback of this current-limit resistor is that it contributes thermal noise at the amplifier input. If this resistor must be added, its value must be selected as small as possible.

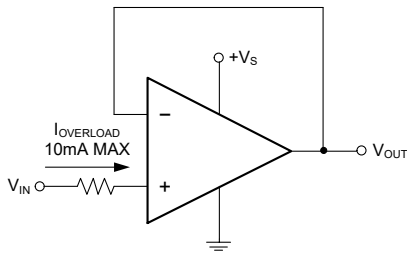


Figure 2. Input Current-Limit Protection

Rail-to-Rail Output

The SGM8954-1/2 support rail-to-rail output operation. In single power supply application, for example, when $+V_S = 5.5V$, $-V_S = GND$, 10kΩ load resistor is tied from OUT pin to $+V_S/2$, the typical output swing range is from 0.0055V to 5.4945V.

Driving Capacitive Loads

The SGM8954-1/2 are unity-gain stable with heavy capacitive load. If greater capacitive load must be driven in application, the circuit in Figure 3 can be used. In this circuit, the IR drop voltage generated by R_{ISO} is compensated by feedback loop.

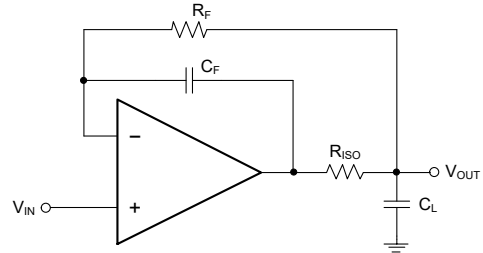


Figure 3. Circuit to Drive Heavy Capacitive Load

Power Supply Decoupling and Layout

A clean and low noise power supply is very important in amplifier circuit design, besides of input signal noise, the power supply is one of important source of noise to the amplifiers through $+V_S$ and $-V_S$ pins. Power supply bypassing is an effective method to clear up the noise at power supply, and the low impedance path to ground of decoupling capacitor will bypass the noise to GND. In application, 10μF ceramic capacitor paralleled with 0.1μF or 0.01μF ceramic capacitor is used in Figure 4. The ceramic capacitors should be placed as close as possible to $+V_S$ and $-V_S$ power supply pins.

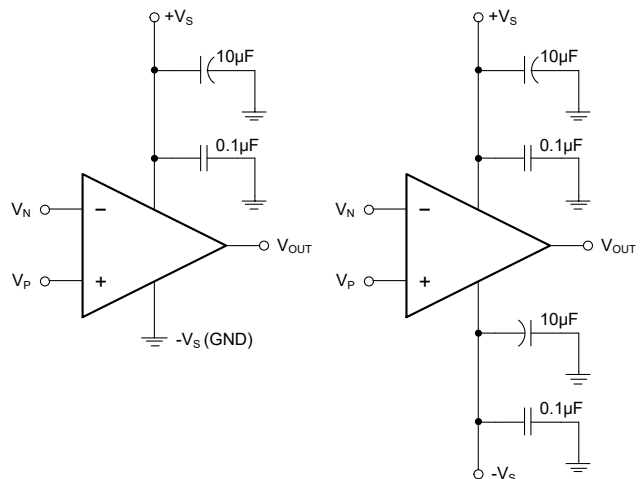


Figure 4. Amplifier Power Supply Bypassing

APPLICATION INFORMATION (continued)

Grounding

In low speed application, one node grounding technique is the simplest and most effective method to eliminate the noise generated by grounding. In high speed application, the general method to eliminate noise is to use a complete ground plane technique, and the whole ground plane will help distribute heat and reduce EMI noise pickup.

Reduce Input-to-Output Coupling

To reduce the input-to-output coupling, the input traces must be placed as far away from the power supply or output traces as possible. The sensitive trace must not be placed in parallel with the noisy trace in same layer. They must be placed perpendicularly in different layers to reduce the crosstalk. These PCB layout techniques will help to reduce unwanted positive feedback and noise.

Typical Application Circuits

Difference Amplifier

The circuit in Figure 5 is a design example of classical difference amplifier. If $R_4/R_3 = R_2/R_1$, then $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$.

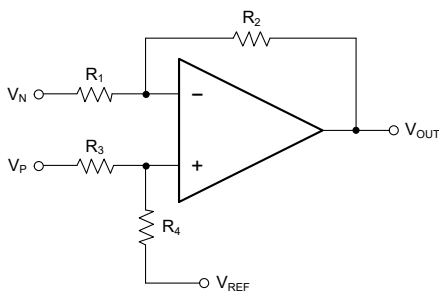


Figure 5. Difference Amplifier

High Input Impedance Difference Amplifier

The circuit in Figure 6 is a design example of high input impedance difference amplifier, the added amplifiers at

the input are used to increase the input impedance and eliminate drawback of low input impedance in Figure 5.

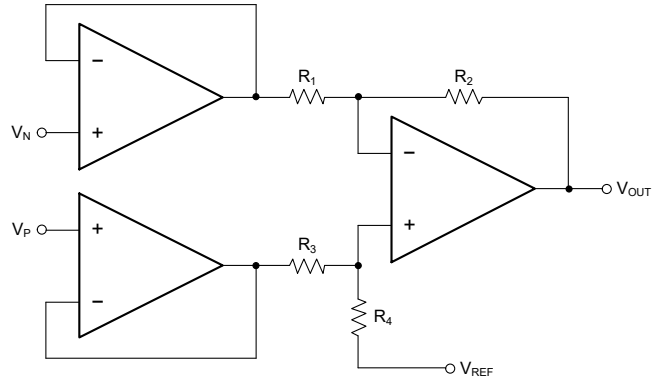


Figure 6. High Input Impedance Difference Amplifier

Active Low-Pass Filter

The circuit in Figure 7 is a design example of active low-pass filter, the DC gain is equal to $-R_2/R_1$ and the -3dB corner frequency is equal to $1/2\pi R_2 C$. In this design, the filter bandwidth must be less than the bandwidth of the amplifier, the resistor values must be selected as low as possible to reduce ringing or oscillation generated by the parasitic parameters in PCB layout.

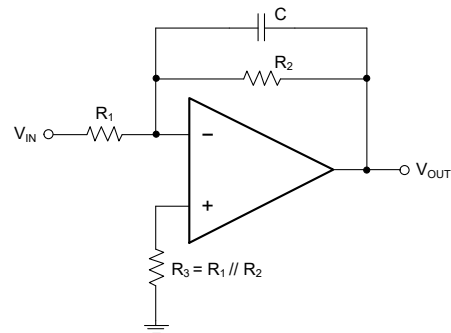


Figure 7. Active Low-Pass Filter

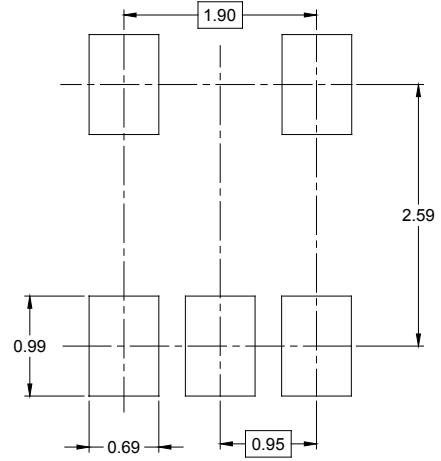
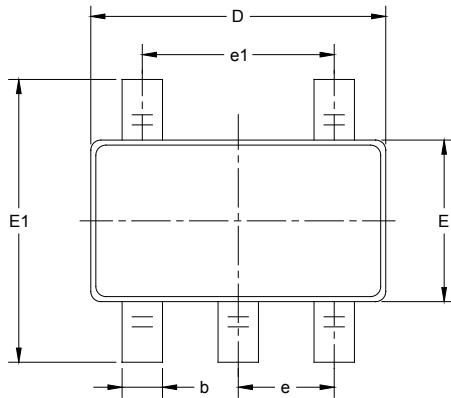
REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

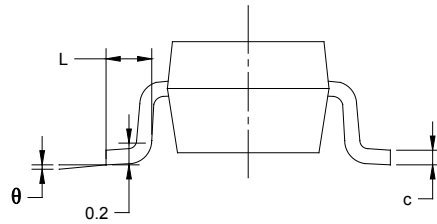
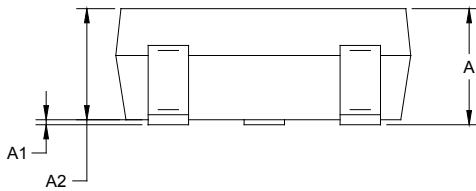
Changes from Original (DECEMBER 2018) to REV.A	Page
Changed from product preview to production data.....	All

PACKAGE OUTLINE DIMENSIONS

SOT-23-5



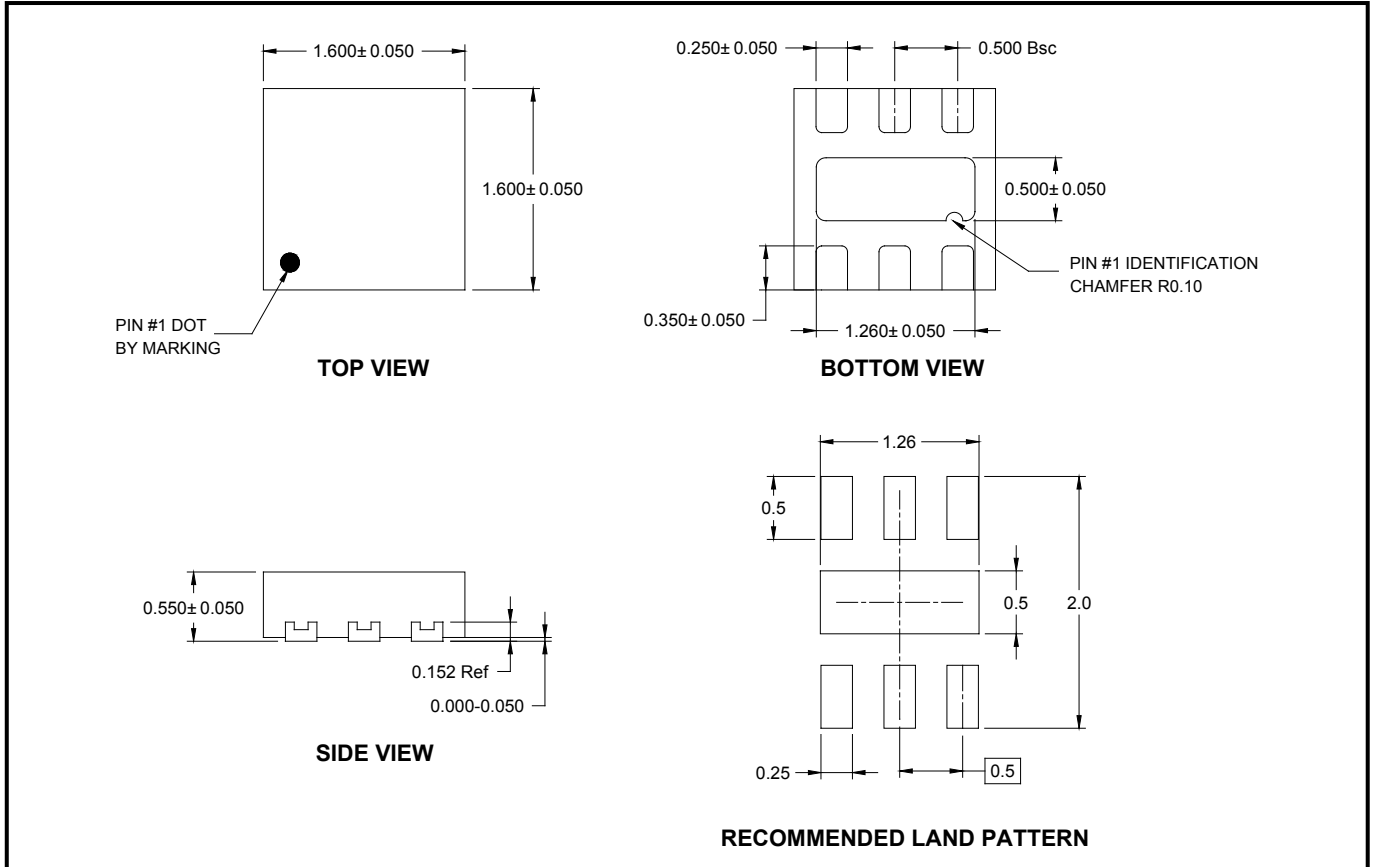
RECOMMENDED LAND PATTERN (Unit: mm)



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°

PACKAGE OUTLINE DIMENSIONS

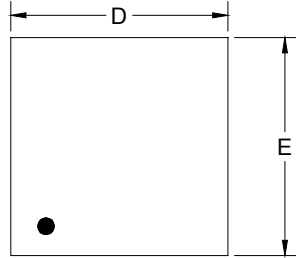
UTDFN-1.6×1.6-6L



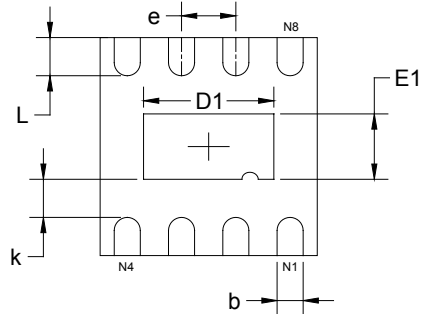
NOTE: All linear dimensions are in millimeters.

PACKAGE OUTLINE DIMENSIONS

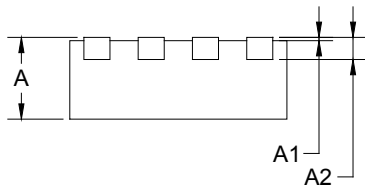
TDFN-2x2-8L



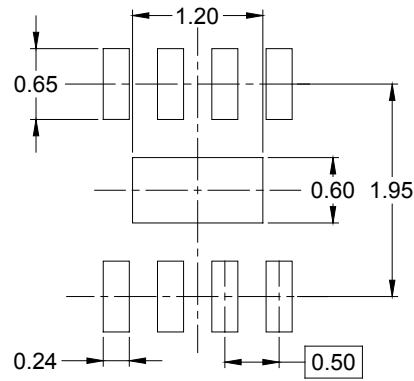
TOP VIEW



BOTTOM VIEW



SIDE VIEW

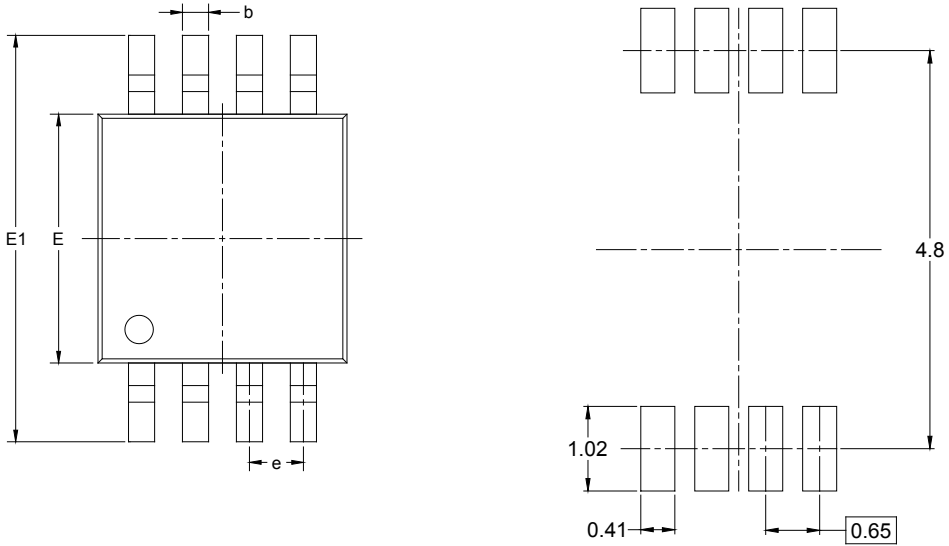


RECOMMENDED LAND PATTERN (Unit: mm)

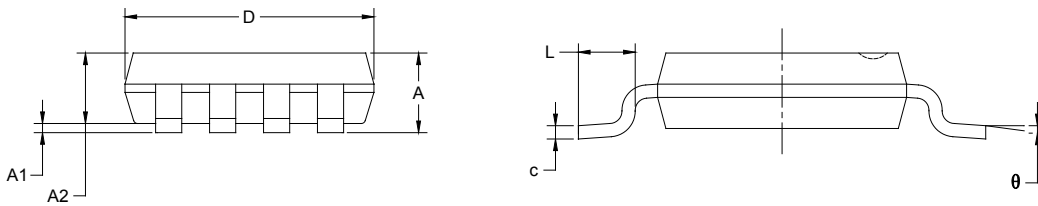
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.900	2.100	0.075	0.083
D1	1.100	1.300	0.043	0.051
E	1.900	2.100	0.075	0.083
E1	0.500	0.700	0.020	0.028
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.250	0.450	0.010	0.018

PACKAGE OUTLINE DIMENSIONS

MSOP-8



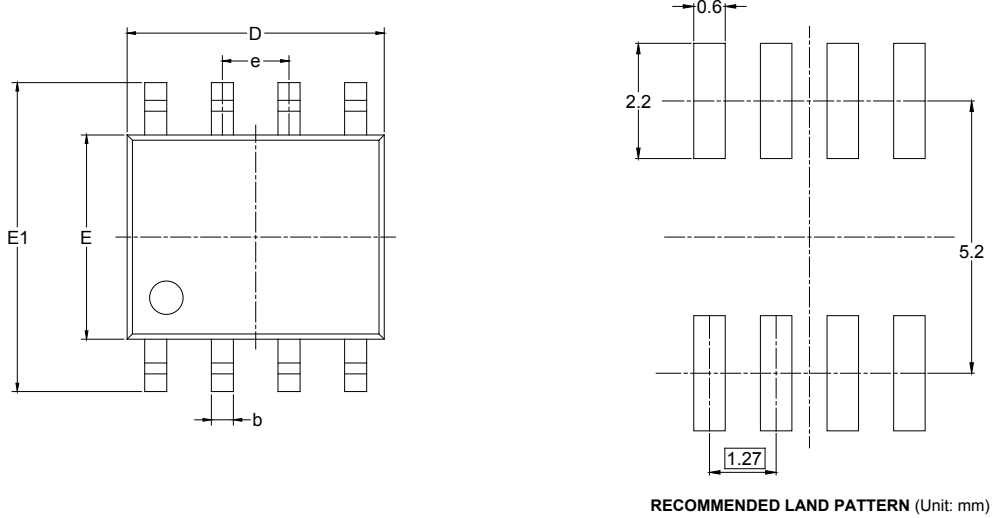
RECOMMENDED LAND PATTERN (Unit: mm)



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°

PACKAGE OUTLINE DIMENSIONS

SOIC-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°

PACKAGE INFORMATION

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT-23-5	7"	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
UTDFN-1.6×1.6-6L	7"	9.0	1.78	1.78	0.69	4.0	4.0	2.0	8.0	Q1
TDFN-2×2-8L	7"	9.5	2.30	2.30	1.10	4.0	4.0	2.0	8.0	Q1
MSOP-8	13"	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1
SOIC-8	13"	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1

D20001

PACKAGE INFORMATION

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7" (Option)	368	227	224	8
7"	442	410	224	18
13"	386	280	370	5

DD0002