



SGM8954-1/SGM8954-2 1.8V, 9 μ A Ultra-Low Power CMOS Zero-Drift Operational Amplifiers

GENERAL DESCRIPTION

The single SGM8954-1 and dual SGM8954-2 CMOS operational amplifiers provide very low offset voltage and zero-drift over time and temperature.

The miniature, high precision, low quiescent current amplifiers offer high-impedance inputs that have a wide input common mode range of 100mV beyond the rails and rail-to-rail output that swings within 5.5mV of the rails. Single or dual supplies as low as 1.8V ($\pm 0.9V$) and up to 5.5V ($\pm 2.75V$) may be used. They are optimized for low voltage, single or dual supply operation.

The SGM8954-1/2 offer 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.

The single SGM8954-1 is available in Green SOT-23-5, SOIC-8 and UTDFN-1.6 \times 1.6-6L packages. The dual 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 $^{\circ}$ C to +125 $^{\circ}$ C).

FEATURES

- **Quiescent Current:** 9 μ A/Amplifier (TYP)
- **Low Offset Voltage:** 8 μ V (TYP), 35 μ V (MAX)
- **Low 0.1Hz to 10Hz Noise:** 1 μ V_{P-P}
- **Gain-Bandwidth Product:** 110kHz
- **Unity-Gain Stable**
- **Integrated RFI Filter**
- **Single or Dual Supply Operation**
- **Supply Voltage Range:** 1.8V to 5.5V
- **Rail-to-Rail Input and Output**
- **-40 $^{\circ}$ C to +125 $^{\circ}$ 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

Transducer Applications
Temperature Measurements
Electronic Scales
Medical Instrumentation
Battery-Powered Instruments
Handheld Test Equipment

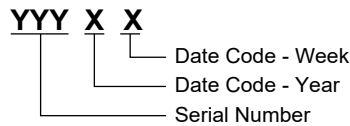
PACKAGE/ORDERING INFORMATION

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

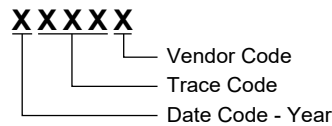
MARKING INFORMATION

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

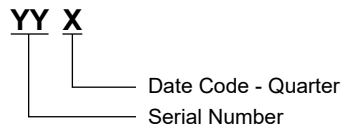
SOT-23-5



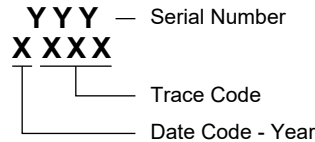
SOIC-8/MSOP-8



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

1.8V, 9µA Ultra-Low Power CMOS Zero-Drift 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.

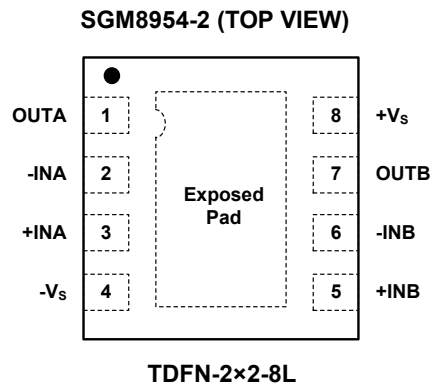
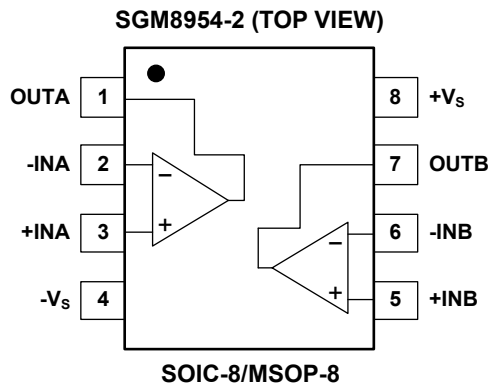
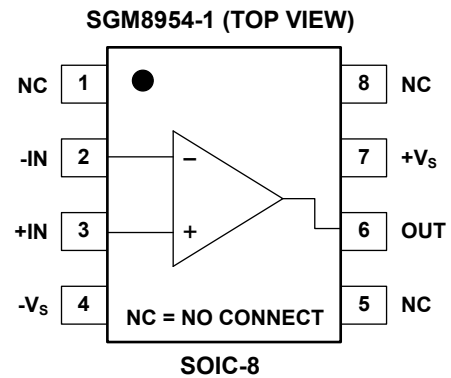
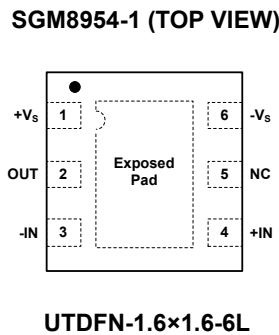
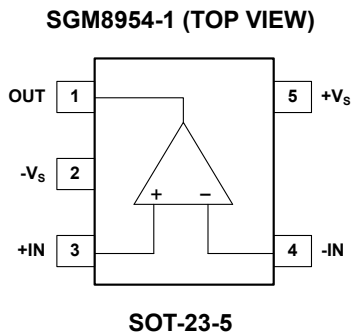
ESD SENSITIVITY CAUTION

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.

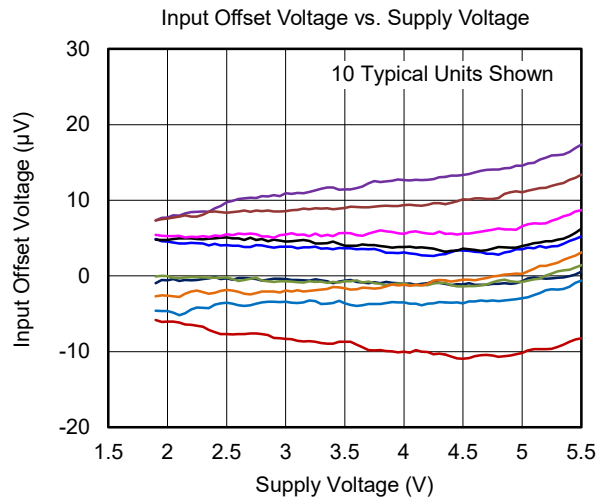
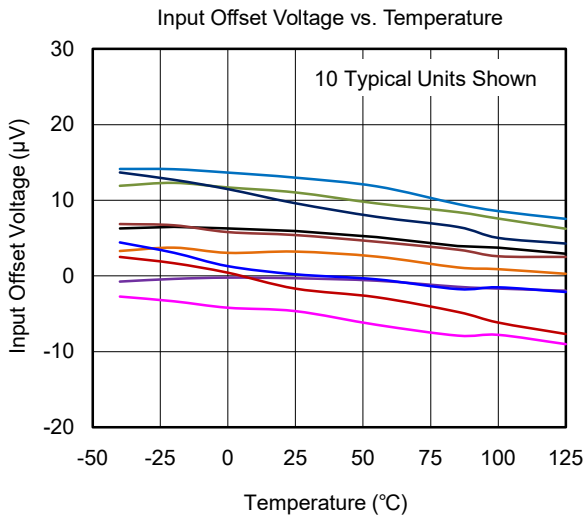
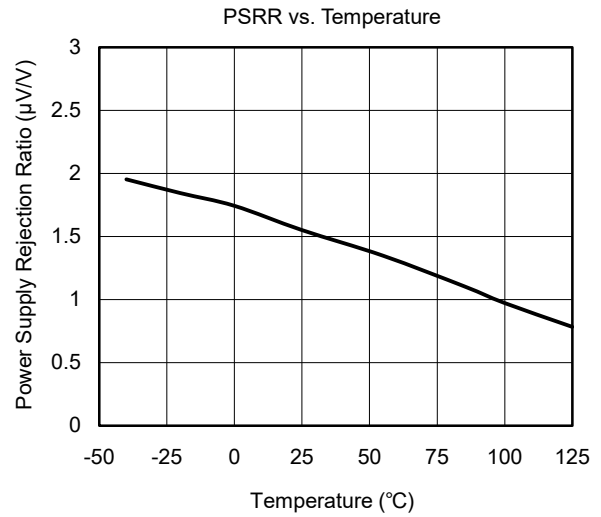
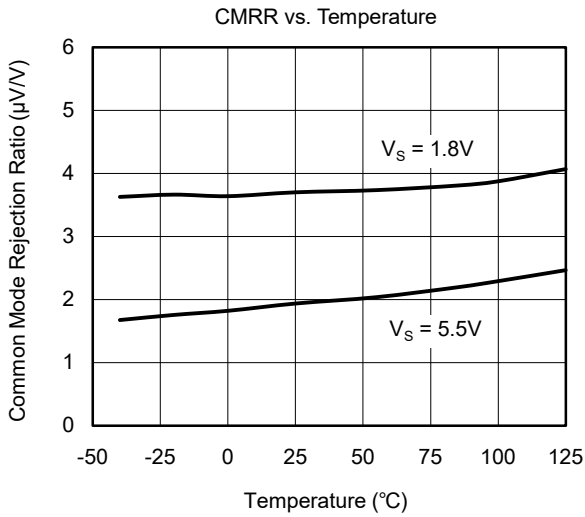
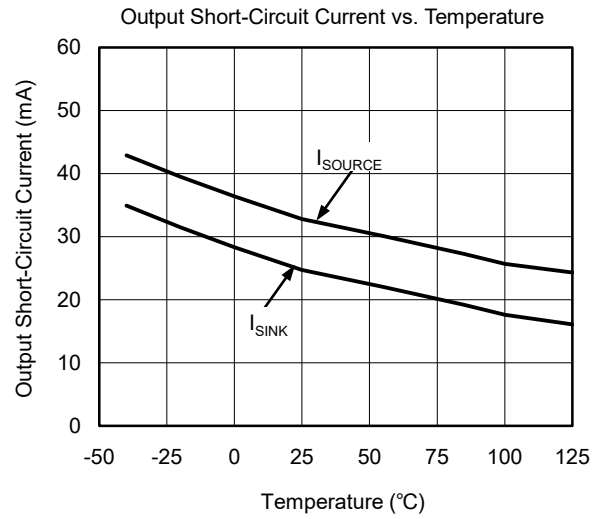
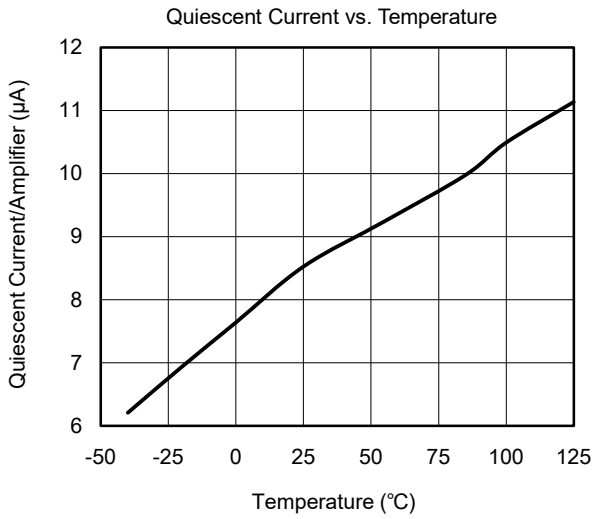
ELECTRICAL CHARACTERISTICS

(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		nV/°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	µV/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		°
Slew Rate	SR	$G = 1$	+25°C		0.04		V/µs
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		nV/ $\sqrt{\text{Hz}}$
Input Current Noise Density	i_n	$f = 1\text{kHz}$	+25°C		360		fA/ $\sqrt{\text{Hz}}$

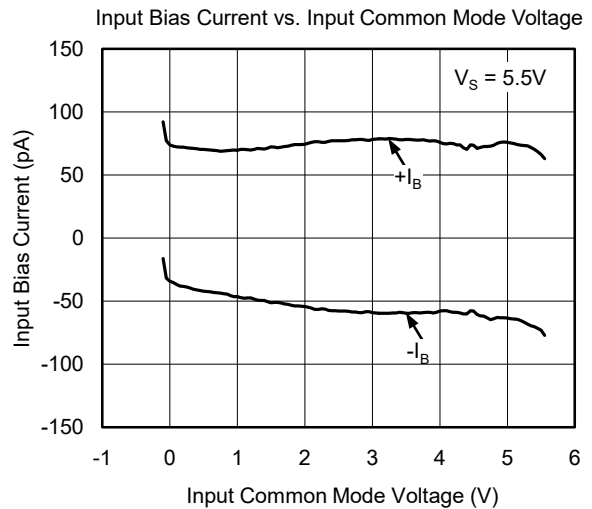
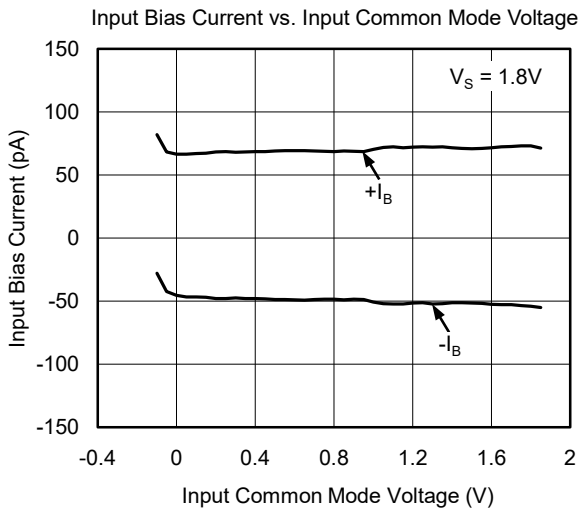
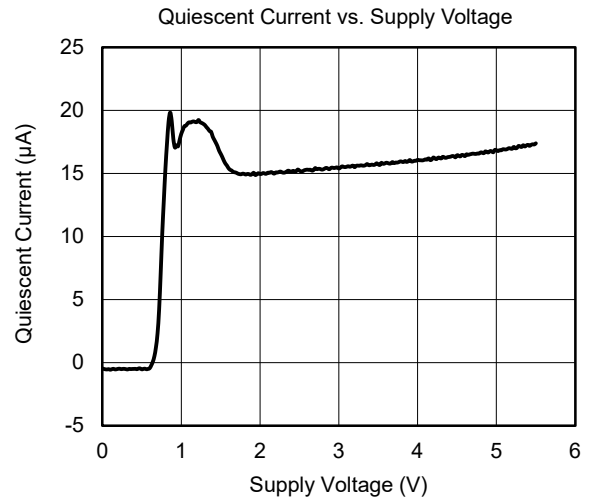
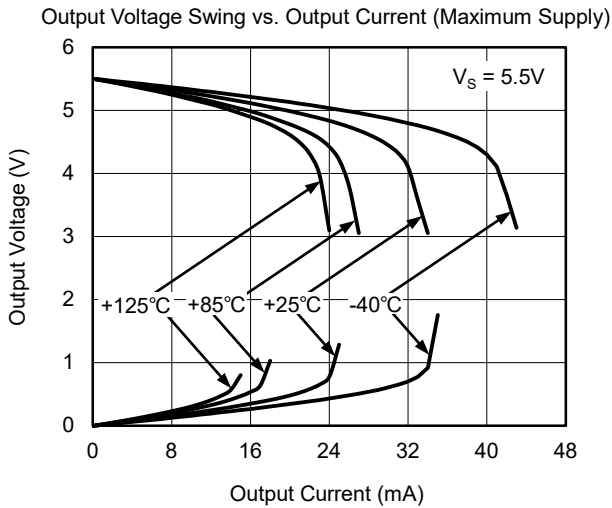
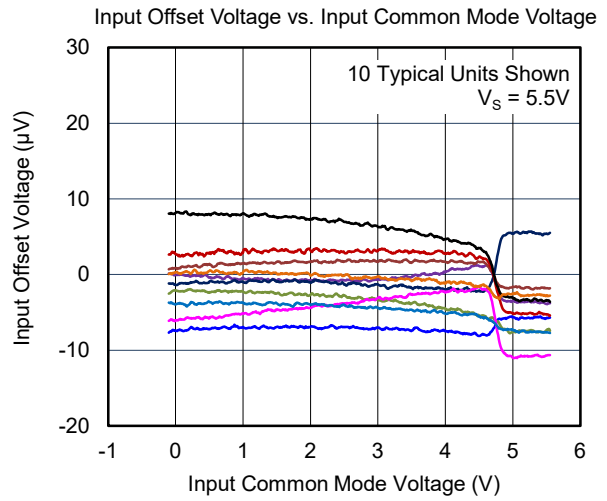
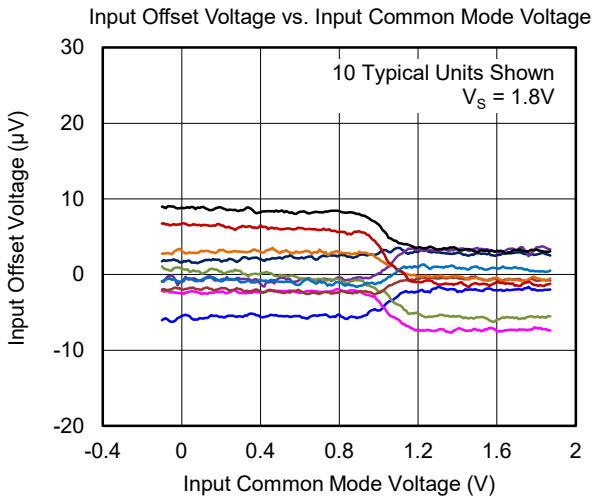
TYPICAL PERFORMANCE CHARACTERISTICS

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.



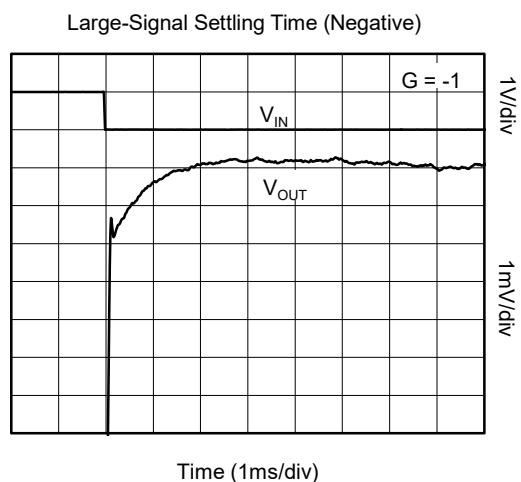
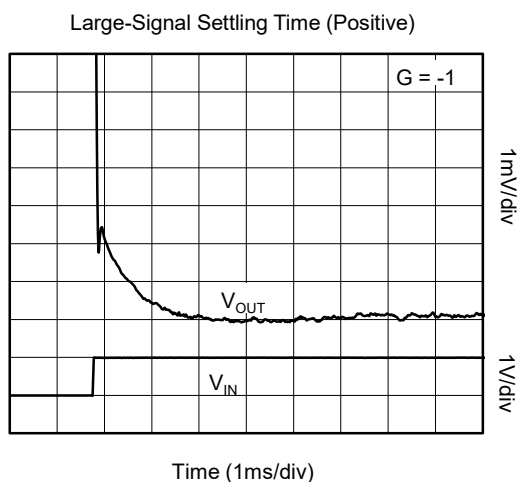
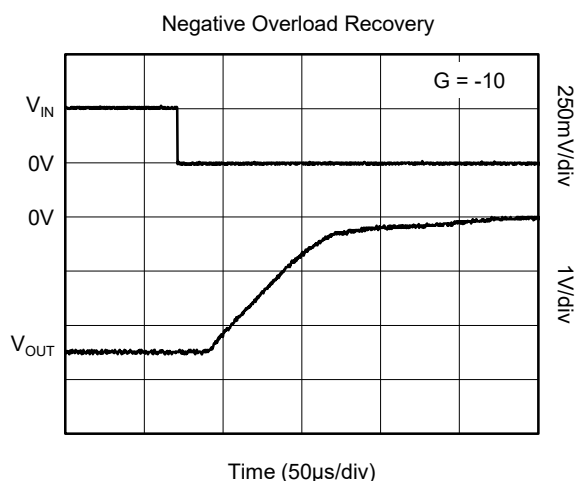
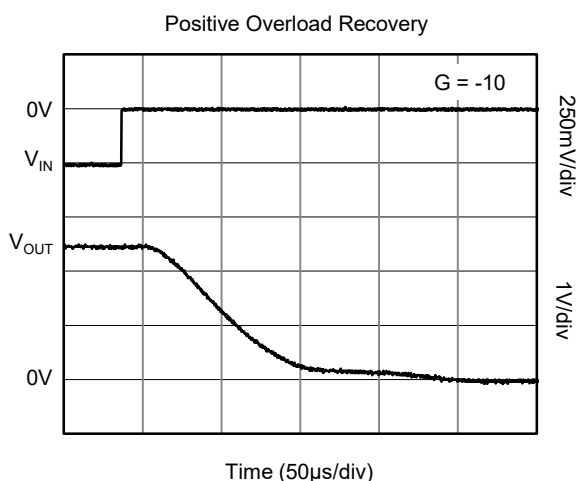
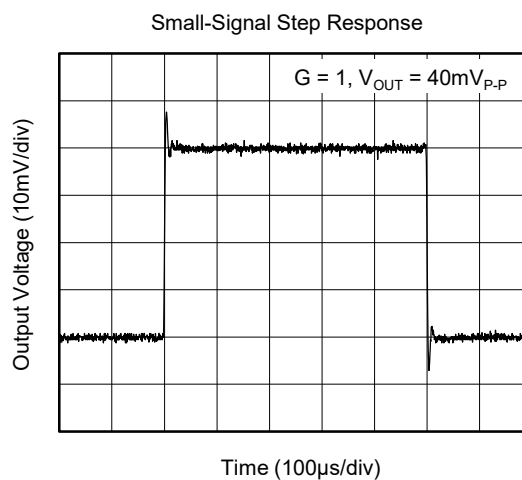
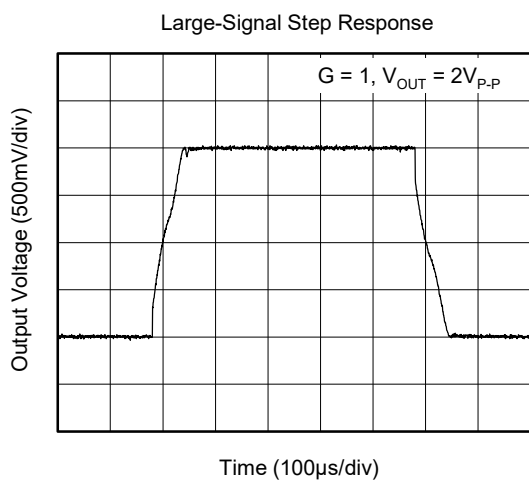
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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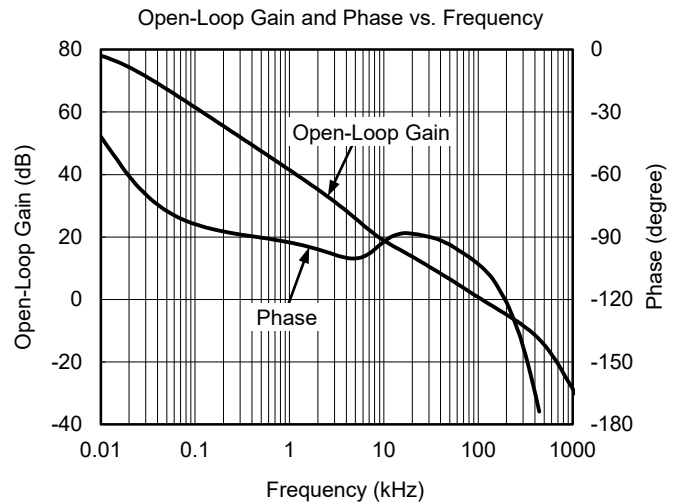
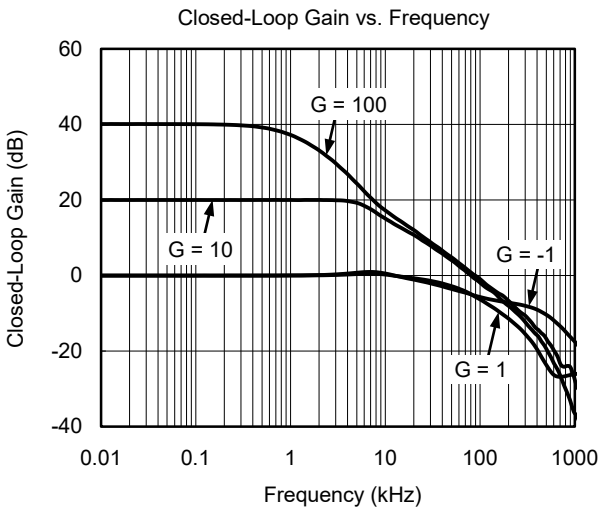
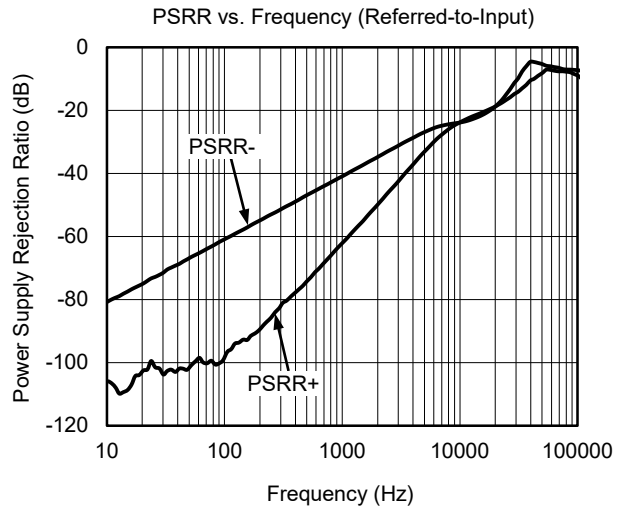
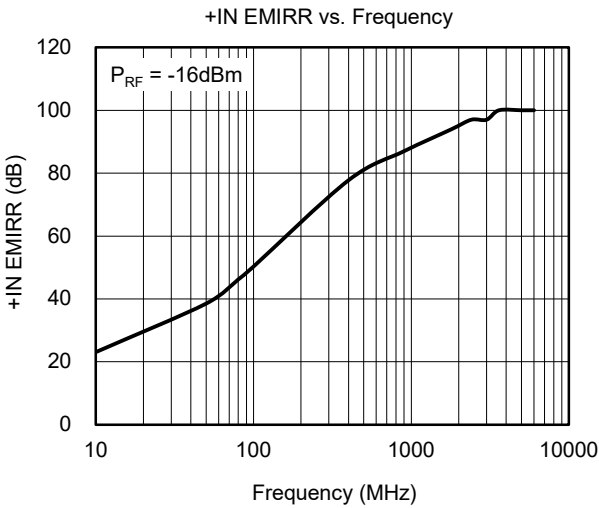
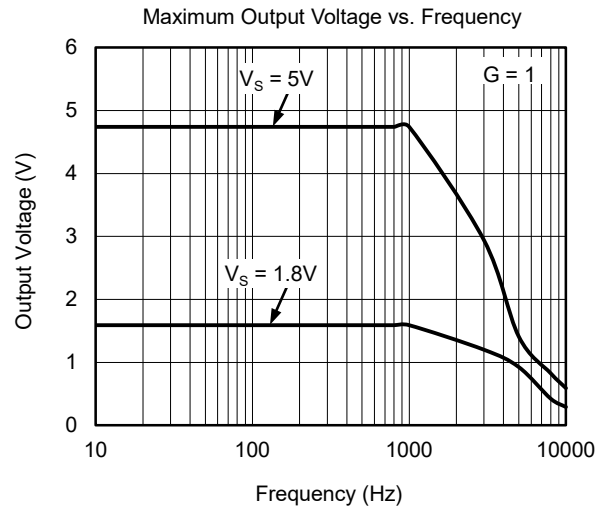
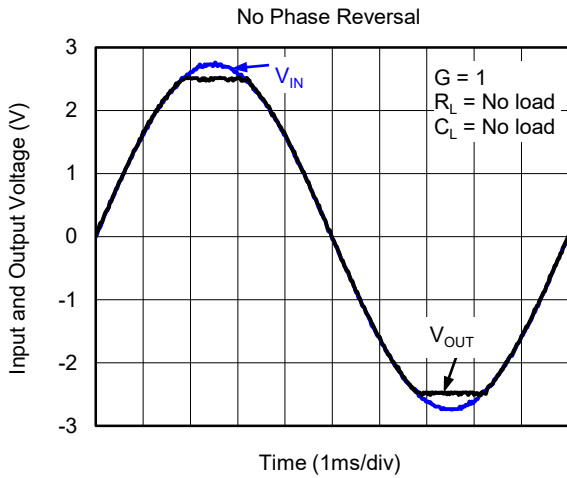
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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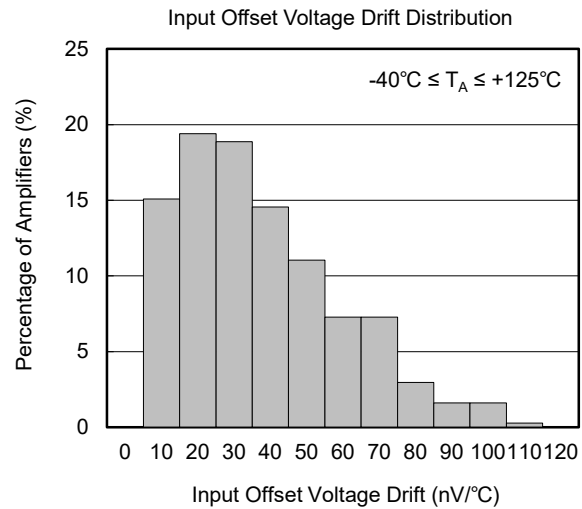
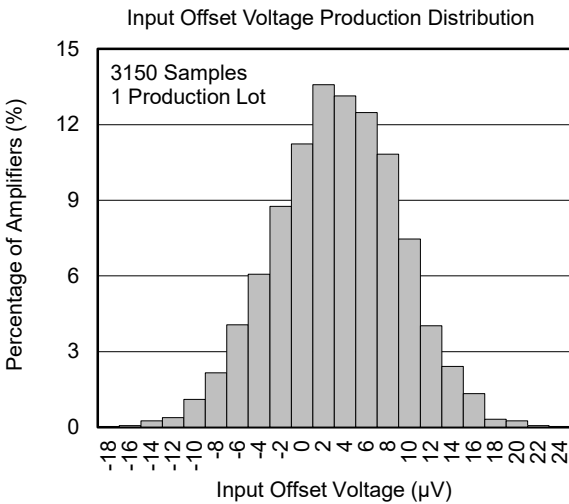
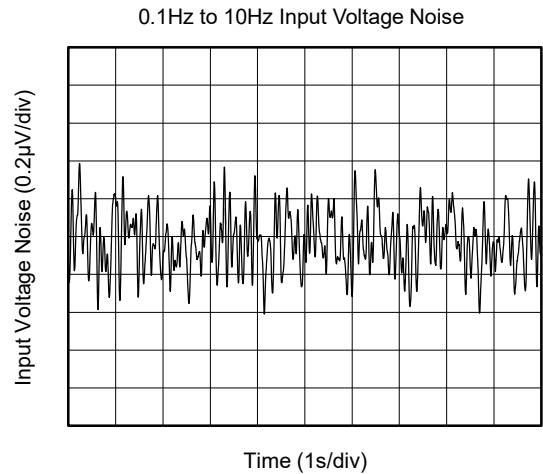
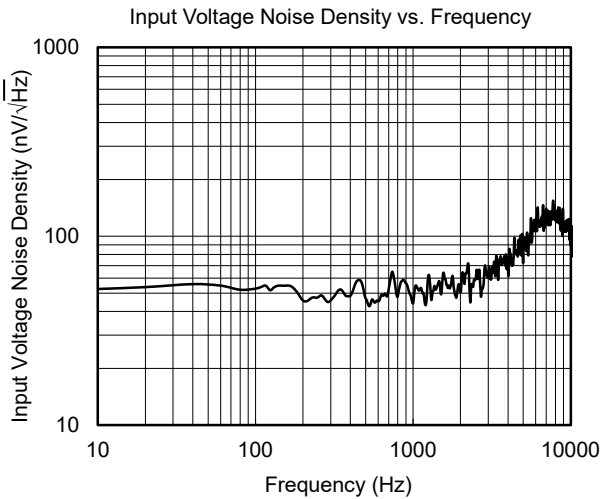
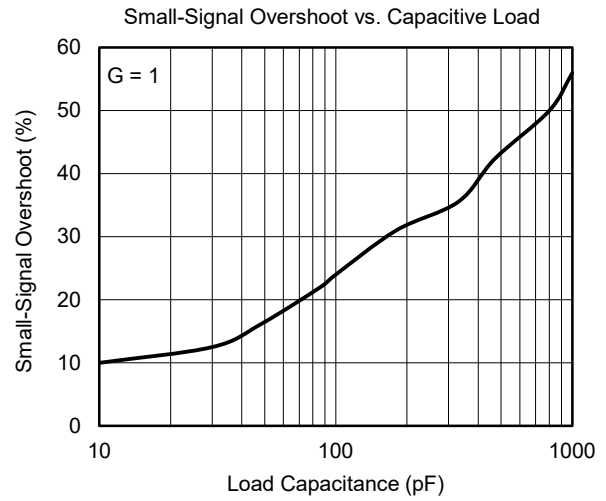
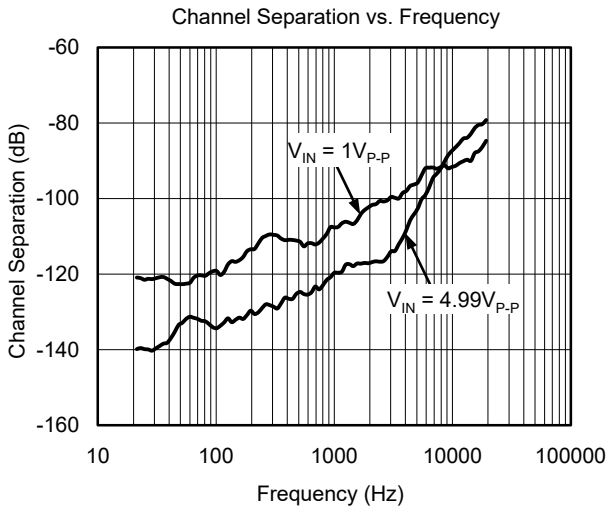
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TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

The SGM8954-1 and SGM8954-2 are unity-gain stable and free from unexpected output phase reversal. They provide low offset voltage and very low drift over time and temperature. For lowest offset voltage and precision performance, circuit layout and mechanical conditions should be optimized. Avoid temperature gradients that create thermoelectric (Seebeck) effects in the thermocouple junctions formed from connecting dissimilar conductors. These thermally-generated potentials can be made to cancel by ensuring they are equal on both input terminals. Other layout and design considerations include:

- Use low thermoelectric-coefficient conditions (avoid dissimilar metals).
- Thermally isolate components from power supplies or other heat sources.
- Shield operational amplifier and input circuitry from air currents, such as cooling fans.

Following these guidelines will reduce the likelihood of junctions at different temperatures.

Operating Voltage

The SGM8954-1/2 operational amplifiers operate over a power supply range of 1.8V to 5.5V ($\pm 0.9V$ to $\pm 2.75V$). Supply voltages higher than 6V (absolute maximum) can permanently damage the device.

Input Voltage

The SGM8954-1/2 input common mode voltage range extends 0.1V beyond the supply rails. The SGM8954-1/2 are designed to cover the full range without the troublesome transition region found in some other rail-to-rail amplifiers.

Normally, input bias current is about 60pA; however, input voltages exceeding the power supplies can cause excessive current flowing into or out of the input pins.

Internal Offset Correction

The SGM8954-1/2 operational amplifiers use an auto-calibration technique to reduce internal offset. Upon power-up, the amplifier requires approximately 1.5ms to achieve specified V_{OS} accuracy.

General Layout Guidelines

Attention to good layout practices is always recommended. Keep traces short and, when possible, use a printed circuit board (PCB) ground plane with surface-mount components placed as close to the device pins as possible. Place a 0.1µF capacitor closely across the supply pins. These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the EMI (electromagnetic interference) susceptibility. Operational amplifiers vary in their susceptibility to radio frequency interference (RFI). RFI can generally be identified as a variation in offset voltage or DC signal levels with changes in the interfering RF signal. The SGM8954-1/2 have been specifically designed to minimize susceptibility to RFI and demonstrate remarkably low sensitivity. Strong RF fields may still cause varying offset levels.

Figure 1 shows the basic configuration for a bridge amplifier.

A low-side current shunt monitor is shown in Figure 2. R_N are operational resistors used to isolate the ADC from the noise of the digital I²C bus. Since the ADC is a 16-bit converter, a precision reference is essential for maximum accuracy. Related application circuits are shown in Figure 3 ~ 5.

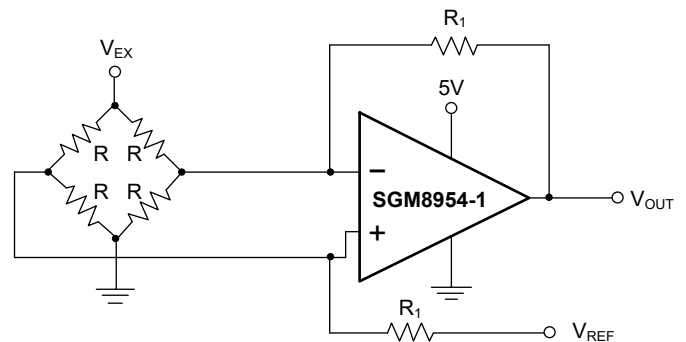


Figure 1. Bridge Amplifier Configuration

APPLICATION INFORMATION (continued)

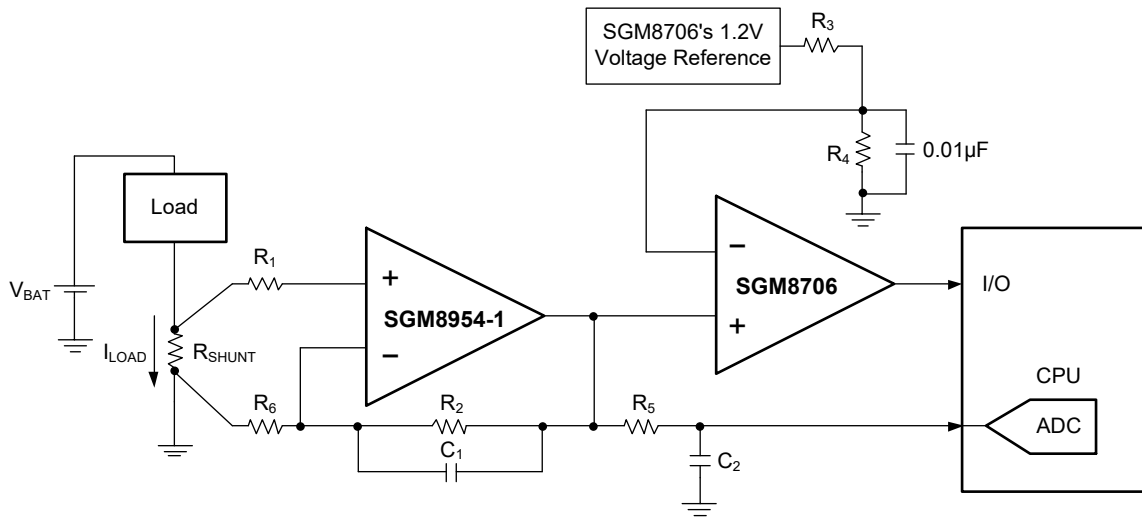
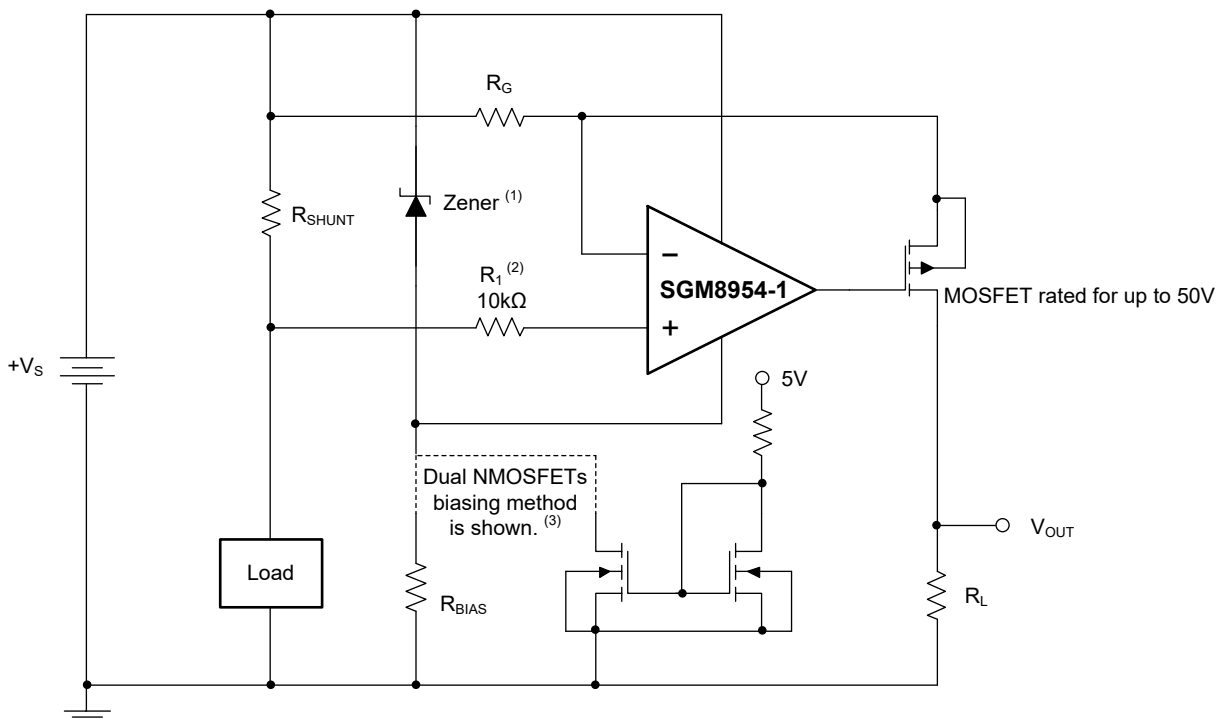


Figure 2. Low-side Current Shunt Monitor



- NOTES: (1) Zener rated for operational amplifier supply capability (that is, 5.1V for SGM8954-1 and SGM8954-2).
(2) Current-limiting resistor.
(3) Choose Zener biasing resistor or dual NMOSFETs.

Figure 3. High-side Current Shunt Monitor

APPLICATION INFORMATION (continued)

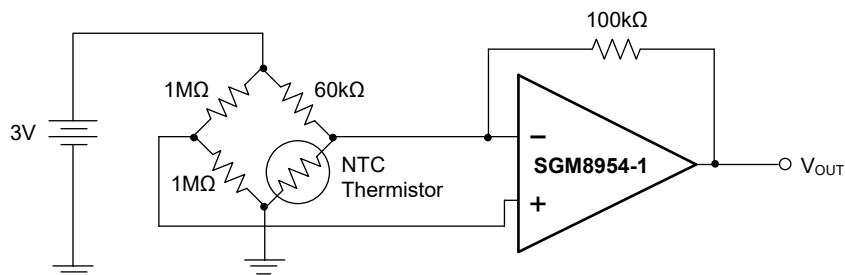


Figure 4. Thermistor Measurement

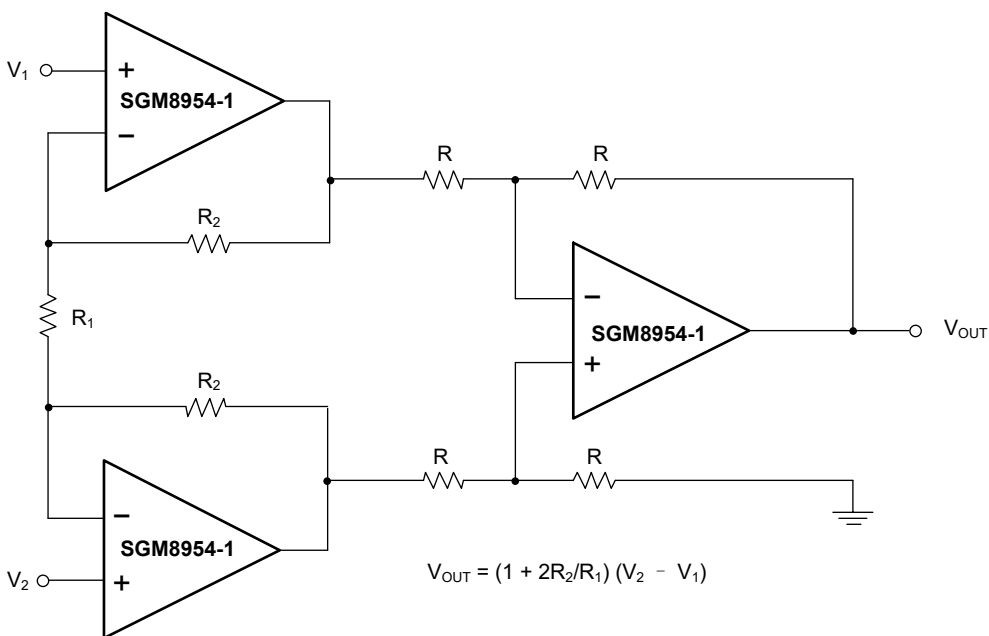


Figure 5. Precision Instrumentation Amplifier Configuration

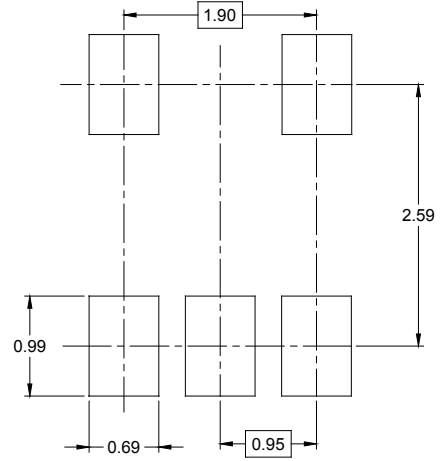
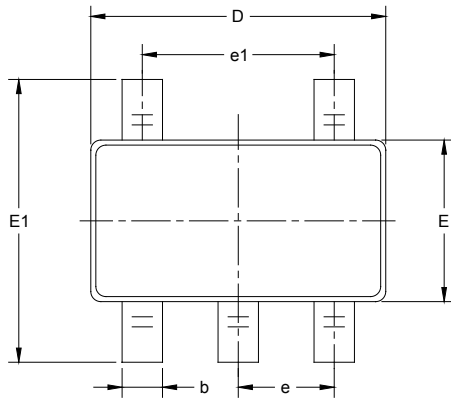
REVISION HISTORY

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

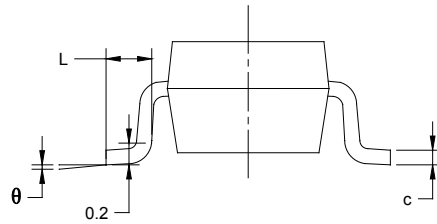
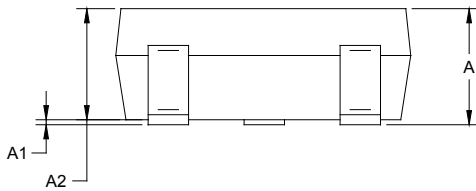
Changes from Original (DECEMBER 2018) to REV.A	Page
Changed from product preview to production data.....	All

PACKAGE OUTLINE DIMENSIONS

SOT-23-5



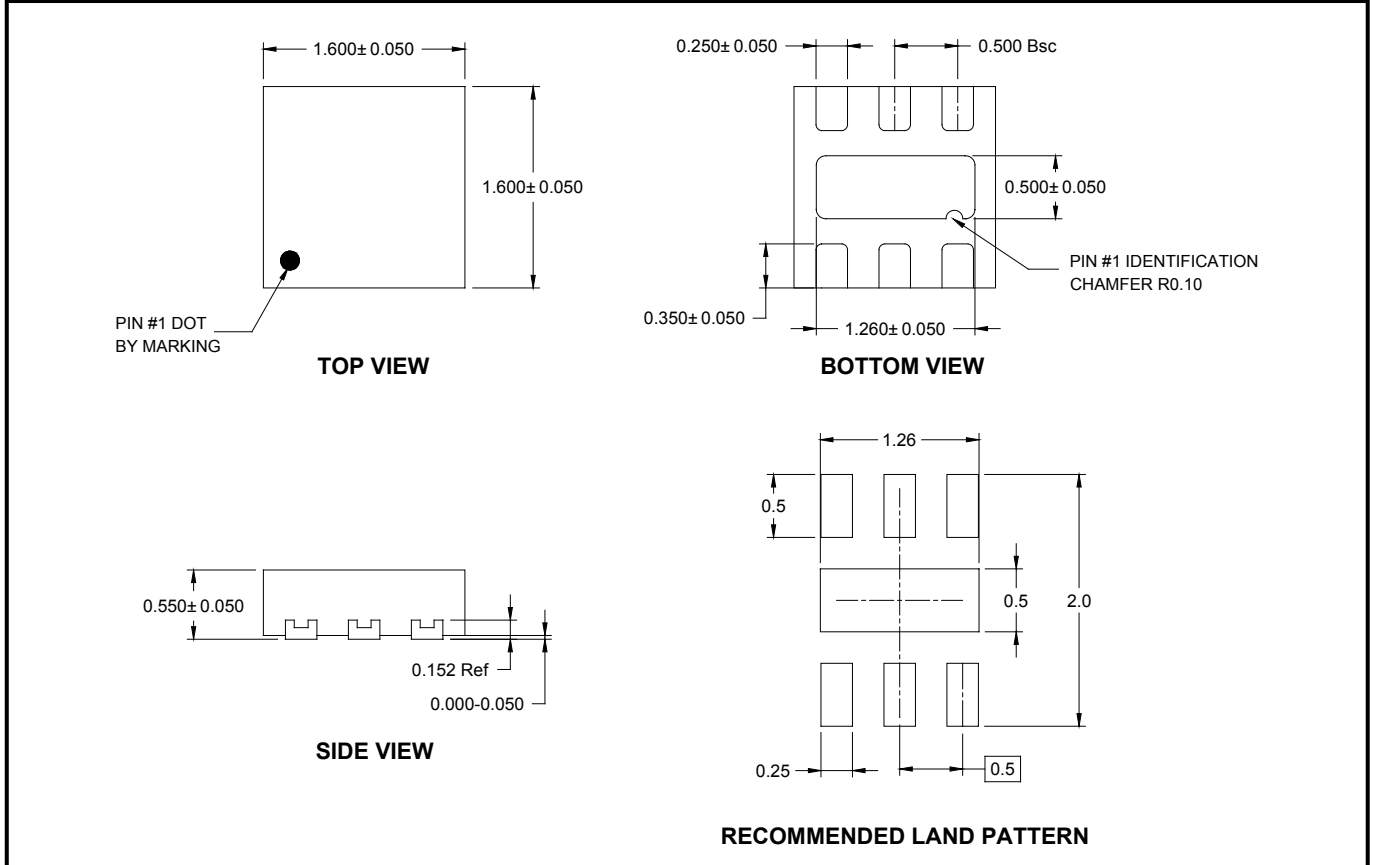
RECOMMENDED LAND PATTERN (Unit: mm)



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

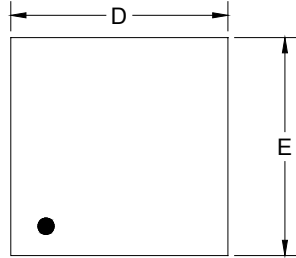
UTDFN-1.6×1.6-6L



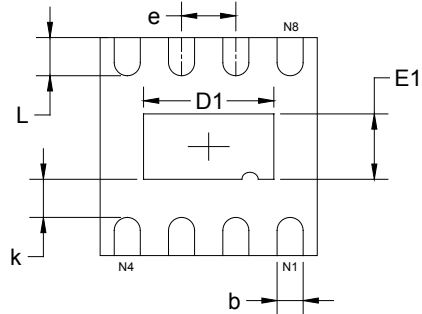
NOTE: All linear dimensions are in millimeters.

PACKAGE OUTLINE DIMENSIONS

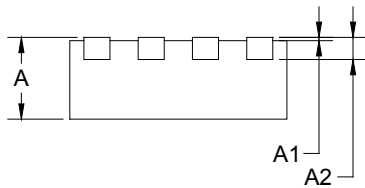
TDFN-2x2-8L



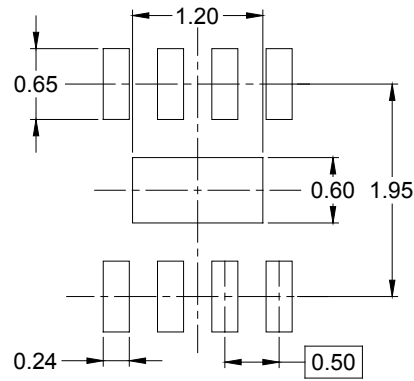
TOP VIEW



BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN (Unit: mm)

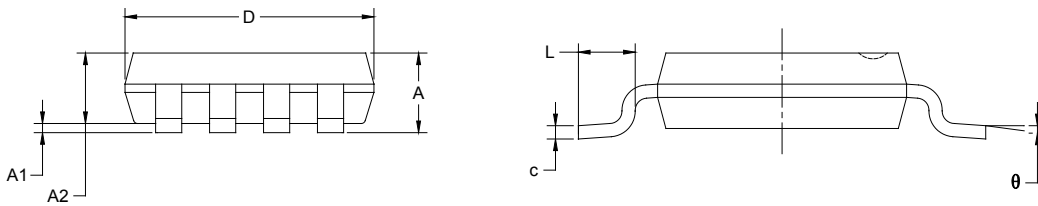
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.900	2.100	0.075	0.083
D1	1.100	1.300	0.043	0.051
E	1.900	2.100	0.075	0.083
E1	0.500	0.700	0.020	0.028
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007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

PACKAGE OUTLINE DIMENSIONS

MSOP-8



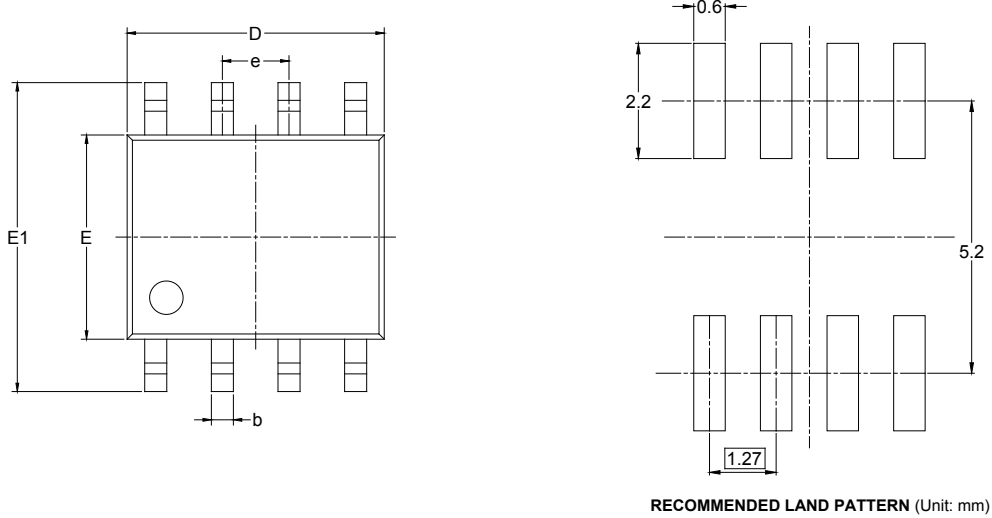
RECOMMENDED LAND PATTERN (Unit: mm)



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

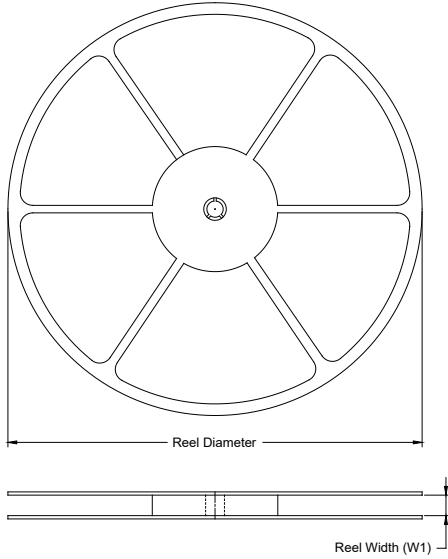


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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