SGM8955/SGM8956
1.8V, Micro-Power CMOS Zero-Drift Operational Amplifiers

GENERAL DESCRIPTION

The single SGM8955 and dual SGM8956 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 14mV of the rails. Single or dual supplies as low as 1.8V (±0.9V) and up to 5.5V (±2.75V) may be used. They are optimized for low voltage, single-supply operation.

The SGM8955/6 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 SGM8955 is available in Green SOT-23-5, SC70-5 and SOIC-8 packages. The dual SGM8956 is available in Green SOIC-8, MSOP-8 and TDFN-3×3-8L packages. They are specified over -40℃ to +125℃ temperature range.

FEATURES

- **Low Offset Voltage: 50μV (MAX)**
- **Low 0.1Hz to 10Hz Noise: 2μV_{P-P}**
- **Quiescent Current: 20μA/Amplifier (TYP)**
- **Integrated RFI Filter**
- **Single-Supply Operation**
- **Supply Voltage Range: 1.8V to 5.5V**
- **Rail-to-Rail Input and Output**
- **-40℃ to +125℃ Operating Temperature Range**
- **Small Packaging:**
  - **SGM8955 Available in Green SOT-23-5, SC70-5 and SOIC-8 Packages**
  - **SGM8956 Available in Green SOIC-8, MSOP-8 and TDFN-3×3-8L Packages**

APPLICATIONS

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

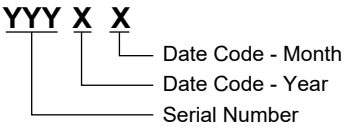
PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8955	SOT-23-5	-40℃ to +125℃	SGM8955XN5G/TR	SVCXX	Tape and Reel, 3000
	SC70-5	-40℃ to +125℃	SGM8955XC5G/TR	SUCXX	Tape and Reel, 3000
	SOIC-8	-40℃ to +125℃	SGM8955XS8G/TR	SGM 8955XS8 XXXXX	Tape and Reel, 2500
SGM8956	SOIC-8	-40℃ to +125℃	SGM8956XS8G/TR	SGM 8956XS8 XXXXX	Tape and Reel, 2500
	MSOP-8	-40℃ to +125℃	SGM8956XMS8G/TR	SGM8956 XMS8 XXXXX	Tape and Reel, 4000
	TDFN-3×3-8L	-40℃ to +125℃	SGM8956XTDB8G/TR	SGM 8956DB XXXXX	Tape and Reel, 4000

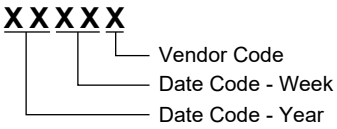
MARKING INFORMATION

NOTE: XX = Date Code. XXXXX = Date Code and Vendor Code.

SOT-23-5/SC70-5



SOIC-8/MSOP-8/TDFN-3×3-8L



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.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage.....6V
Input Common Mode Voltage Range
..... ($-V_S$) - 0.3V to ($+V_S$) + 0.3V
Junction Temperature.....+150℃
Storage Temperature Range.....-65℃ to +150℃
Lead Temperature (Soldering, 10s).....+260℃
ESD Susceptibility
HBM.....4000V
MM.....400V
CDM.....1000V

RECOMMENDED OPERATING CONDITIONS

Specified Voltage Range.....1.8V to 5.5V
Operating Temperature Range.....-40℃ to +125℃

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

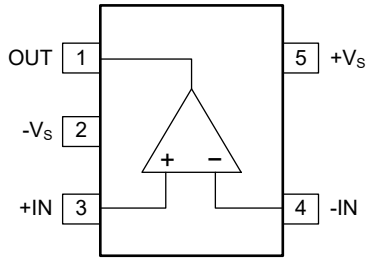
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

DISCLAIMER

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

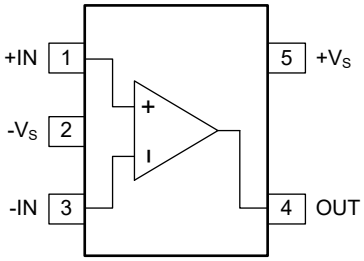
PIN CONFIGURATIONS

SGM8955 (TOP VIEW)



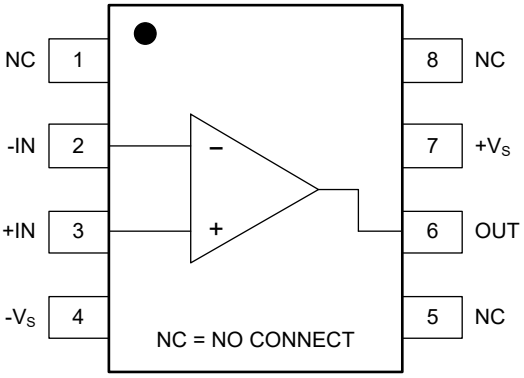
SOT-23-5

SGM8955 (TOP VIEW)



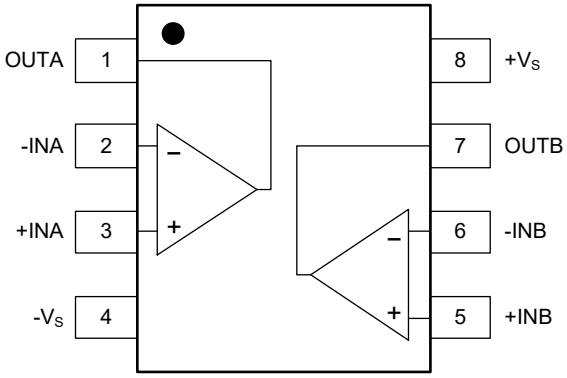
SC70-5

SGM8955 (TOP VIEW)



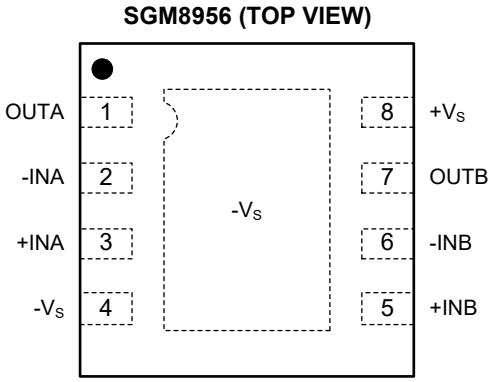
SOIC-8

SGM8956 (TOP VIEW)



SOIC-8/MSOP-8

SGM8956 (TOP VIEW)



TDFN-3×3-8L

NOTE: For TDFN-3×3-8L package, exposed pad can be connected to -VS or left floating.

ELECTRICAL CHARACTERISTICS

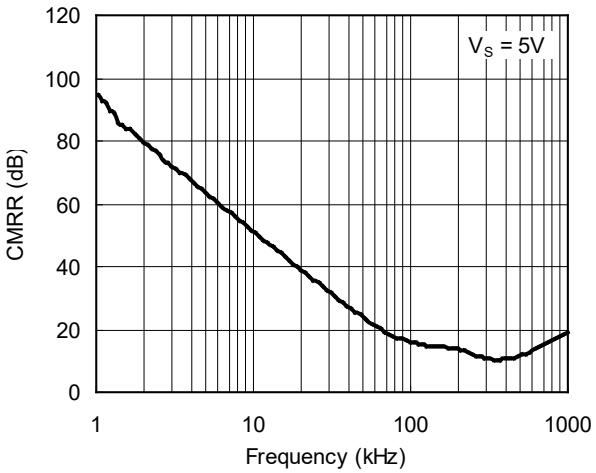
(At T_A = +25℃, V_S = 1.8V to 5.5V, V_{CM} = V_S/2, V_{OUT} = V_S/2, and R_L = 10kΩ to V_S/2, Full = -40℃ to +125℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Characteristics							
Input Offset Voltage	V_{OS}	V_S = 5V	+25℃		22	50	μV
			Full			83	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		Full		0.08		μV/℃
Input Bias Current	I_B		+25℃		130		pA
Input Common Mode Voltage Range	V_{CM}		+25℃	$(-V_S)$ - 0.1		$(+V_S)$ + 0.1	V
Common Mode Rejection Ratio	CMRR	$(-V_S)$ - 0.1V < V_{CM} < $(+V_S)$ + 0.1V	+25℃	89	100		dB
			Full	85			
Open-Loop Voltage Gain	A_{OL}	$(-V_S)$ + 0.1V < V_{OUT} < $(+V_S)$ - 0.1V, R_L = 10kΩ	+25℃	95	121		dB
			Full	94			
Input Impedance							
Differential			+25℃		10^9		Ω
Common Mode			+25℃		10^9		Ω
Output Characteristics							
Output Voltage Swing from Rail		R_L = 10kΩ	+25℃		14	25	mV
			Full			27	
Short-Circuit Current	I_{SC}	V_S = 1.8V	+25℃		6		mA
		V_S = 5V	+25℃		60		
Open-Loop Output Impedance		f = 350kHz, I_{OUT} = 0	+25℃		1		kΩ
Power Supply							
Specified Voltage Range	V_S		Full	1.8		5.5	V
Power Supply Rejection Ratio	PSRR	V_S = 1.8V to 5.5V	+25℃		4	20	μV/V
			Full			25	
Quiescent Current/Amplifier	I_Q	I_{OUT} = 0	+25℃		20	37	μA
			Full			48	
Turn-On Time		V_S = 5V	+25℃		220		μs
Dynamic Performance							
Gain-Bandwidth Product	GBP	C_L = 100pF	+25℃		350		kHz
Slew Rate	SR	G = +1	+25℃		0.18		V/μs
Noise							
Input Voltage Noise		f = 0.1Hz to 10Hz	+25℃		2		$μV_{P-P}$

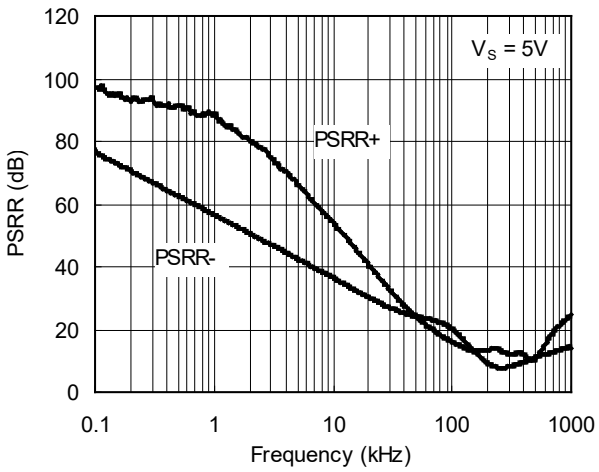
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_S = 5V and C_L = 0pF, unless otherwise noted.

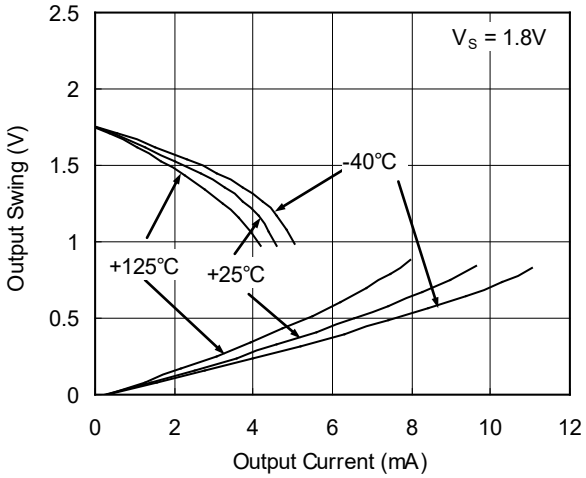
Common Mode Rejection Ratio vs. Frequency



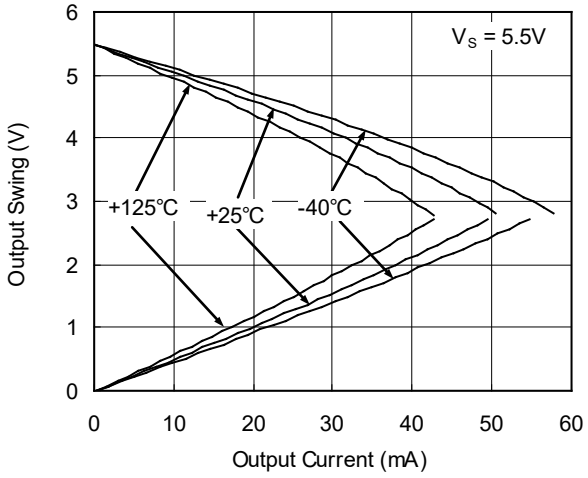
Power Supply Rejection Ratio vs. Frequency



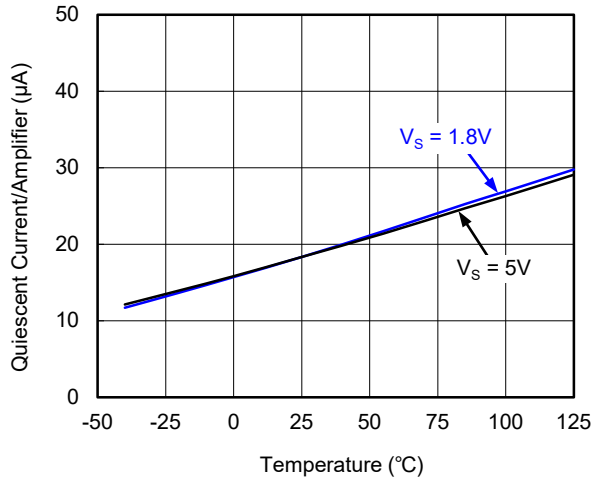
Output Voltage Swing vs. Output Current



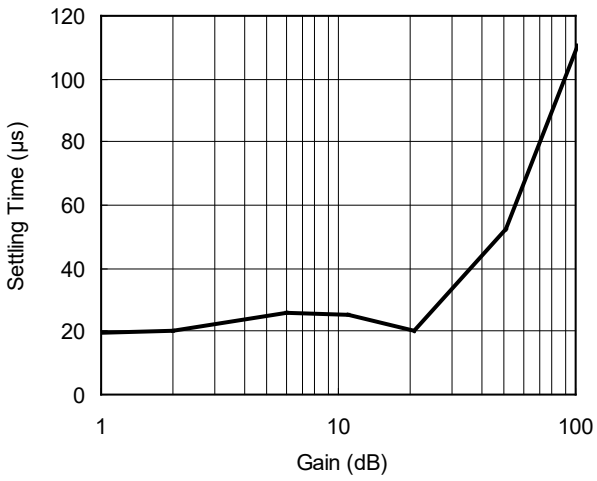
Output Voltage Swing vs. Output Current



Quiescent Current vs. Temperature



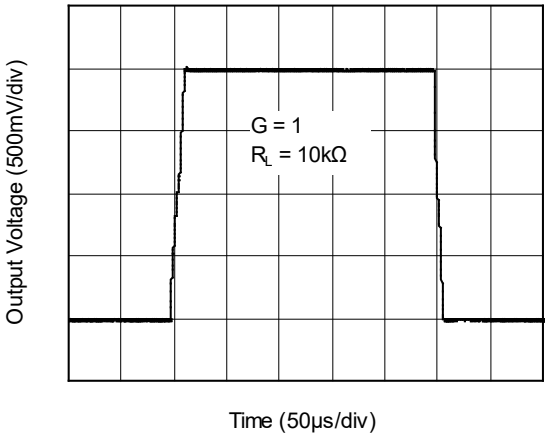
Settling Time vs. Closed-Loop Gain



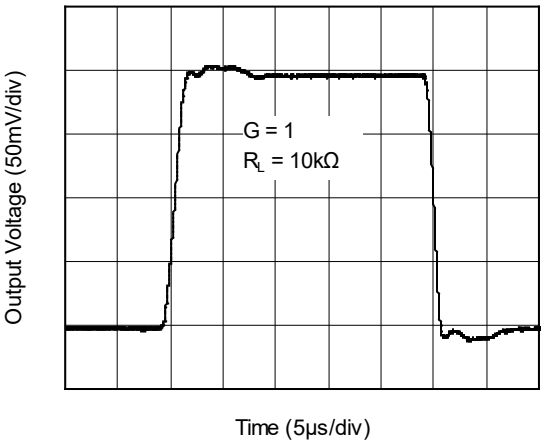
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 5V and C_L = 0pF, unless otherwise noted.

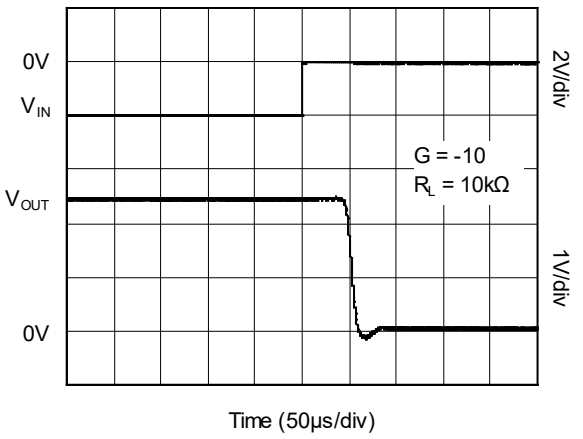
Large-Signal Step Response



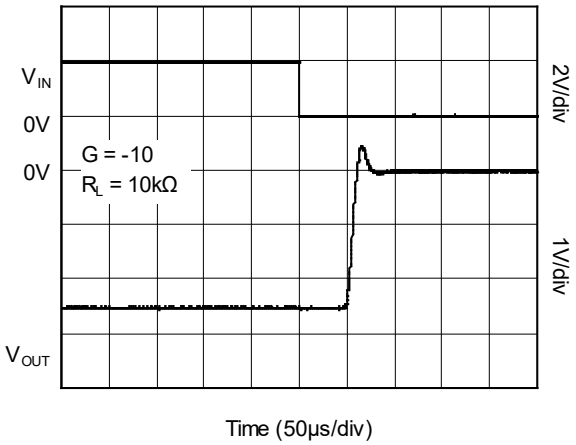
Small-Signal Step Response



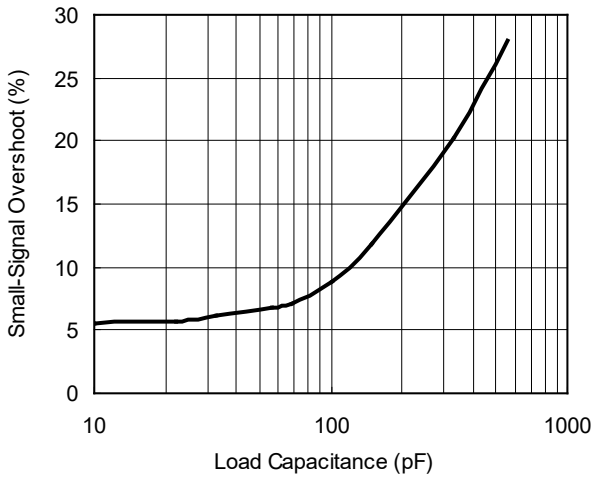
Positive Over-Voltage Recovery



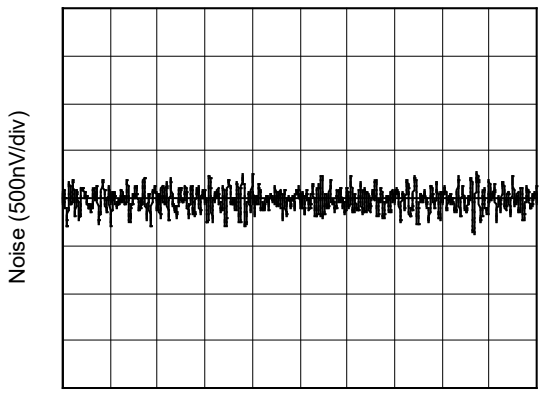
Negative Over-Voltage Recovery



Small-Signal Overshoot vs. Load Capacitance



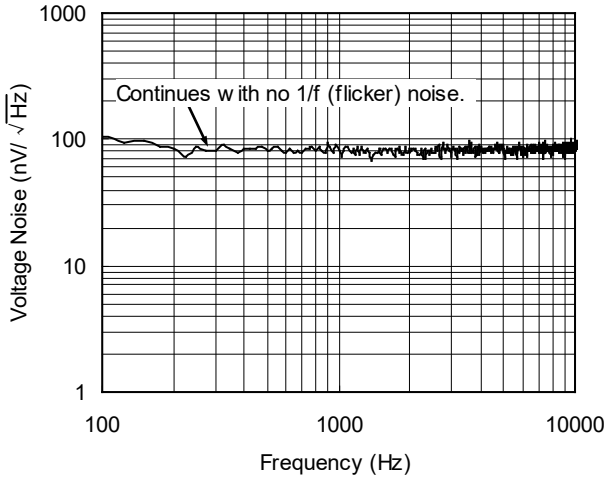
0.1Hz to 10Hz Noise



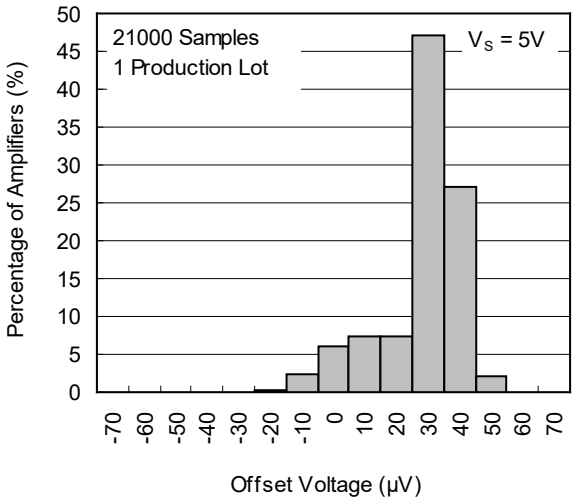
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 5V and C_L = 0pF, unless otherwise noted.

Voltage Noise Spectral Density vs. Frequency



Offset Voltage Production Distribution



APPLICATION INFORMATION

The SGM8955 and SGM8956 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, which can cause thermoelectric voltages of 0.08μV/℃ or higher, depending on materials used.

Operating Voltage

The SGM8955/6 operational amplifiers operate over a power supply range of 1.8V to 5.5V (±0.9V to ±2.75V). Supply voltages higher than 6V (absolute maximum) can permanently damage the device.

Input Voltage

The SGM8955/6 input common mode voltage range extends 0.1V beyond the supply rails. The SGM8955 is designed to cover the full range without the troublesome transition region found in some other rail-to-rail amplifiers.

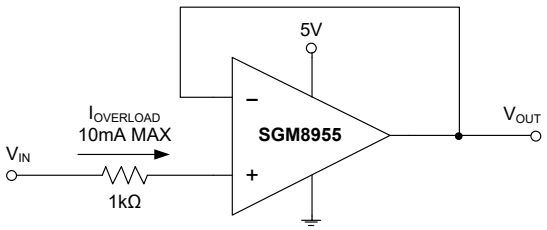
Normally, input bias current is about 130pA; however, input voltages exceeding the power supplies can cause excessive current flowing into or out of the input pins. Momentary voltages greater than the power supply can be tolerated if the input current is limited to 10mA. This limitation is easily accomplished with an input resistor, as shown in Figure 1.

Internal Offset Correction

The SGM8955/6 operational amplifiers use an auto-calibration technique with a time-continuous 350kHz operational amplifier in the signal path. Upon power-up, the amplifier requires approximately 220μs to achieve specified V_{OS} accuracy.

Achieving Output Swing to the Operational Amplifier Negative Rail

Some applications require output voltage swings from 0V to a positive full-scale voltage (such as 2.5V) with excellent accuracy. With most single-supply operational amplifiers, problems arise when the output signal approaches 0V, near the lower output swing limit of a single-supply operational amplifier. A good single-supply operational amplifier may swing close to single-supply ground, but will not reach ground. The output of the SGM8955/6 can be made to swing to ground, or slightly below, on a single-supply power source. To do so requires the use of another resistor and an additional, more negative, power supply than the operational amplifier negative supply. A pull-down resistor may be connected between the output and the additional negative supply to pull the output down below the value that the output would otherwise achieve, as shown in Figure 2.



NOTE: Current-limit resistor required if input voltage exceeds supply rails by ≥ 0.5V.

Figure 1. Input Current Protection

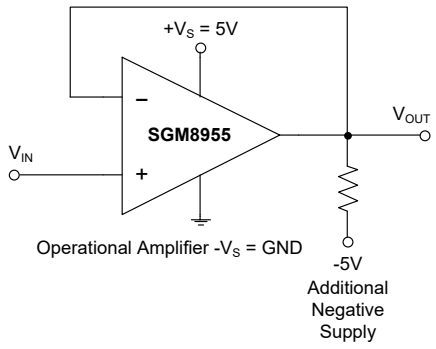


Figure 2. For V_{OUT} Range to Ground

APPLICATION INFORMATION (continued)

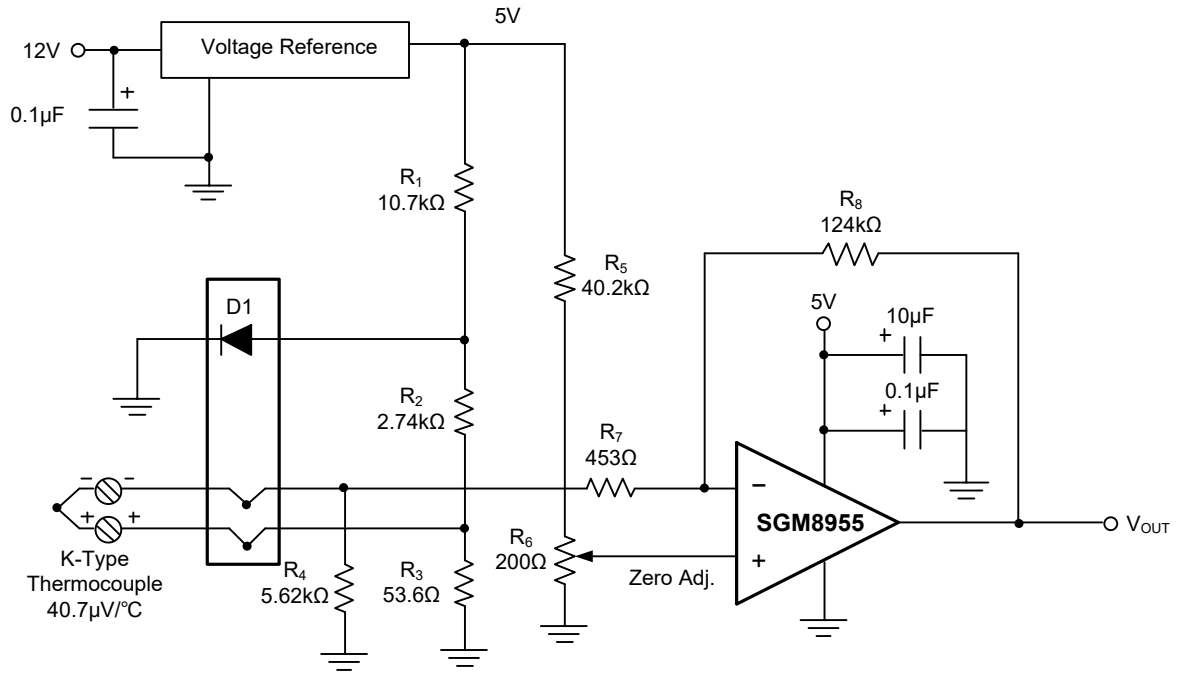


Figure 3. Temperature Measurement

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 SGM8955 has been specifically designed to minimize susceptibility to RFI and demonstrates remarkably low sensitivity. Strong RF fields may still cause varying offset levels.

Figure 4 shows the basic configuration for a bridge amplifier.

A low-side current shunt monitor is shown in Figure 5. R_N are operational resistors used to isolate the ADC from the noise of the digital I^2C bus. Since the ADC is a 16-bit converter, a precision reference is essential for maximum accuracy. Related application circuits are shown in Figure 6 ~ 8.

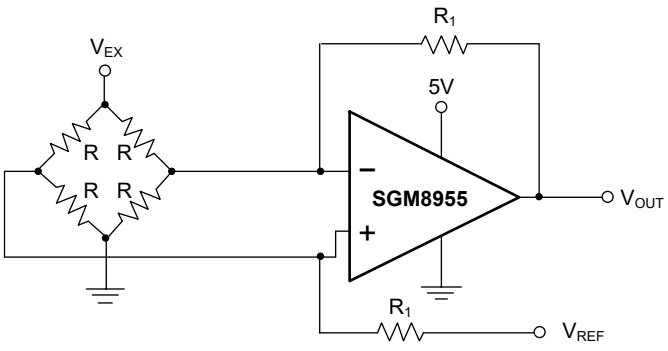


Figure 4. Bridge Amplifier Configuration

APPLICATION INFORMATION (continued)

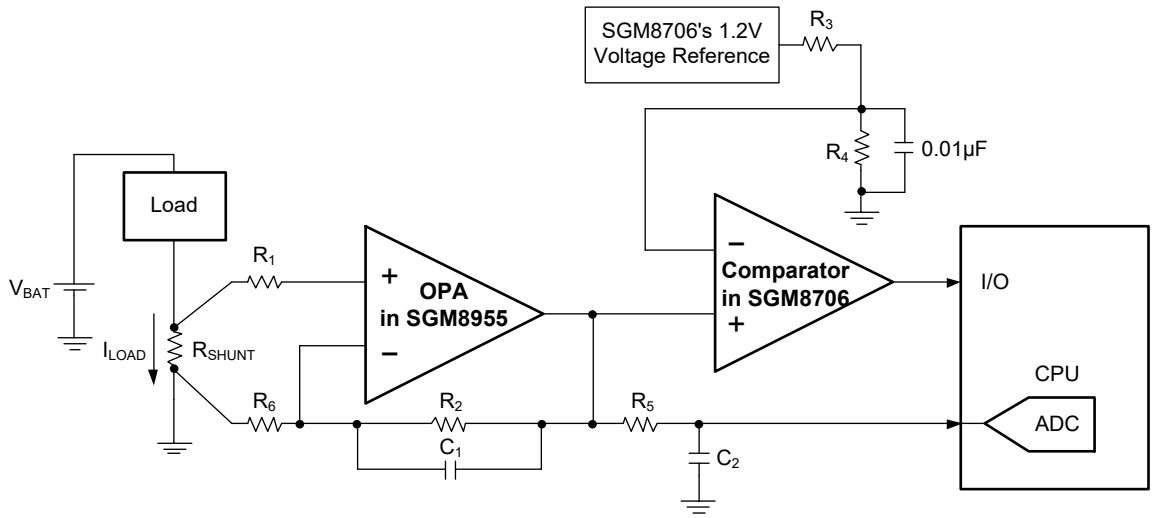
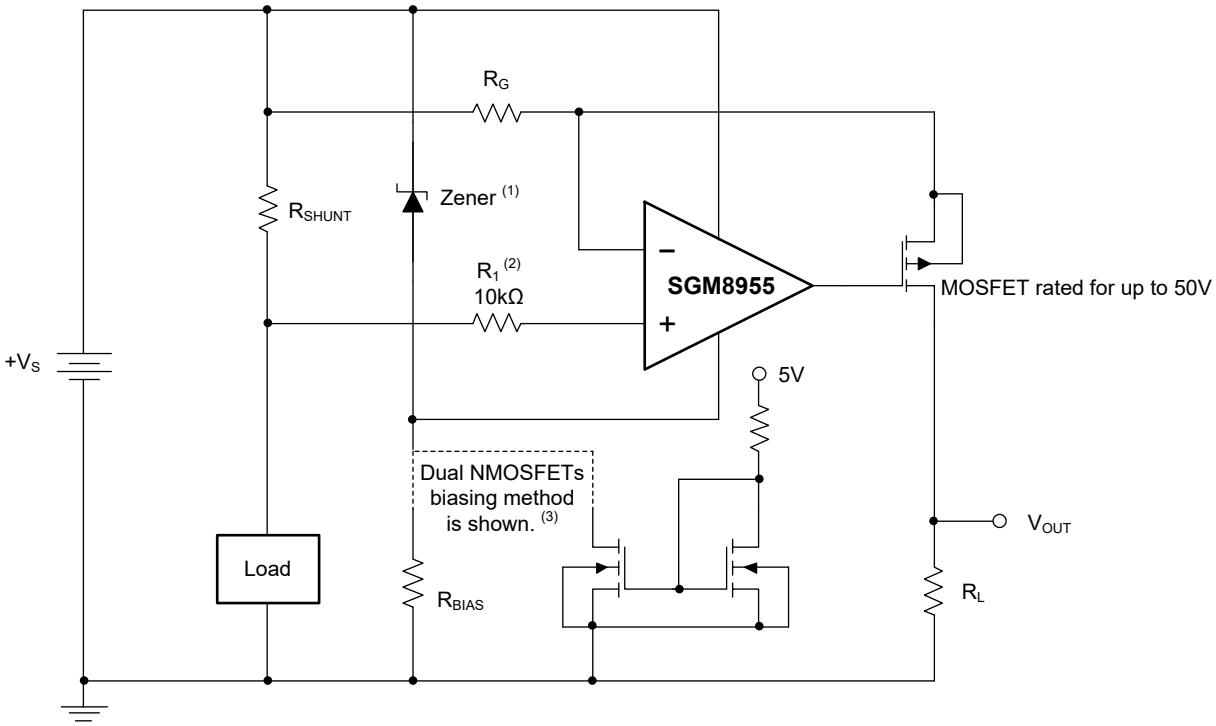


Figure 5. Low-side Current Shunt Monitor



NOTES: (1) Zener rated for operational amplifier supply capability (that is, 5.1V for SGM8955 and SGM8956).
(2) Current-limit resistor.
(3) Choose Zener biasing resistor or dual NMOSFETs.

Figure 6. High-side Current Shunt Monitor

APPLICATION INFORMATION (continued)

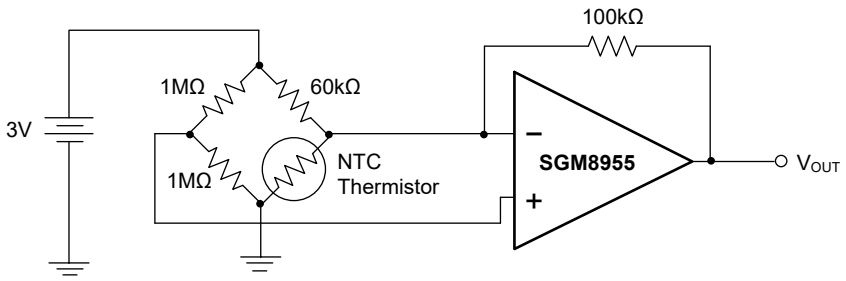


Figure 7. Thermistor Measurement

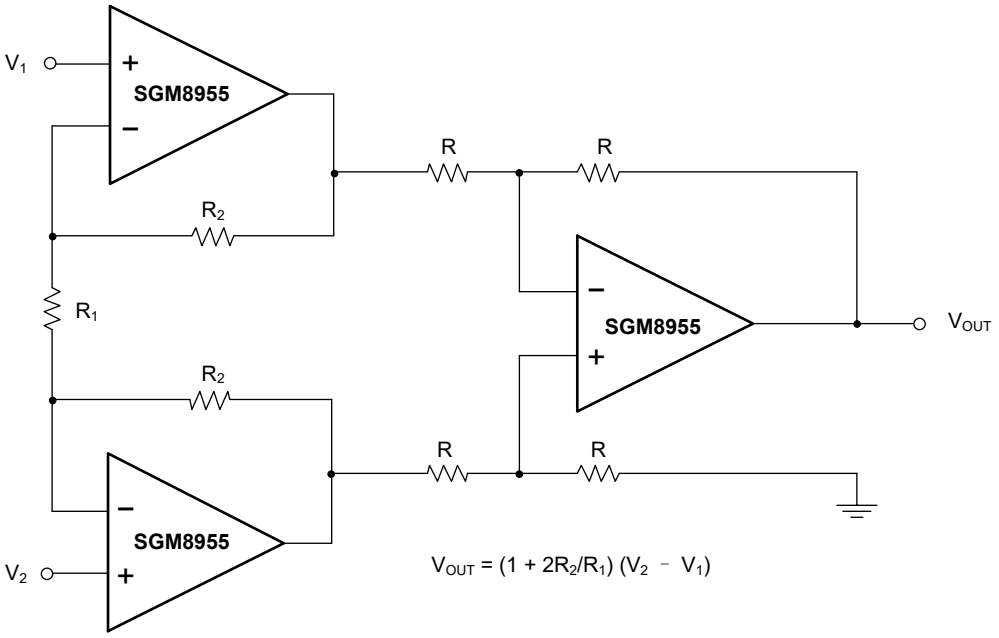


Figure 8. Precision Instrumentation Amplifier Configuration

REVISION HISTORY

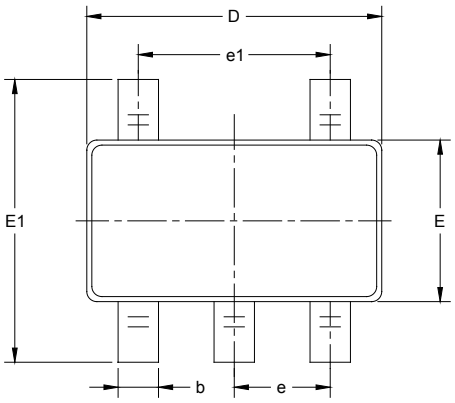
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

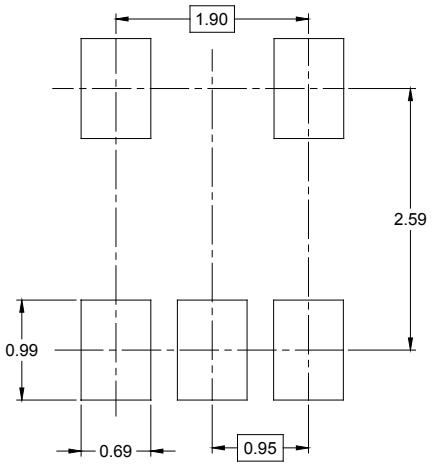
OCTOBER 2016 – REV.A to REV.A.1	**Page**
Changed Typical Performance Characteristics section	5

Changes from Original (SEPTEMBER 2015) to REV.A	**Page**
Changed from product preview to production data	All

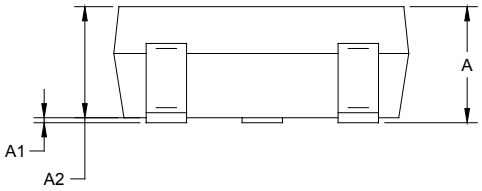
PACKAGE OUTLINE DIMENSIONS

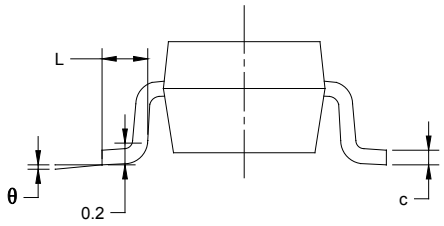
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)

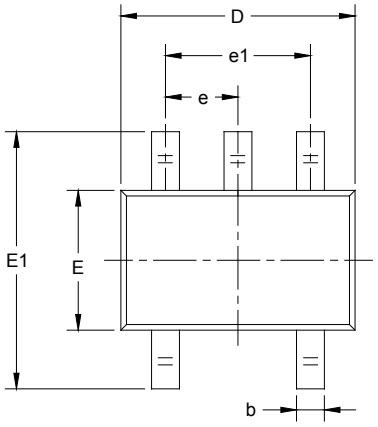


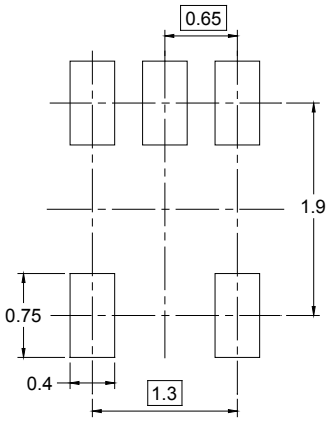


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

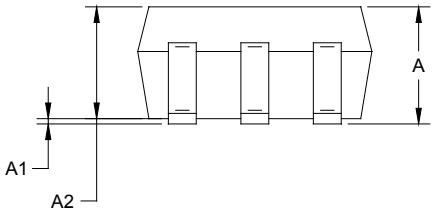
PACKAGE OUTLINE DIMENSIONS

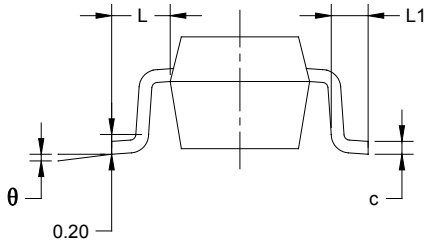
SC70-5





RECOMMENDED LAND PATTERN (Unit: mm)

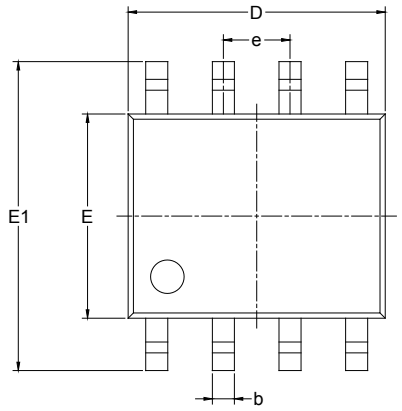


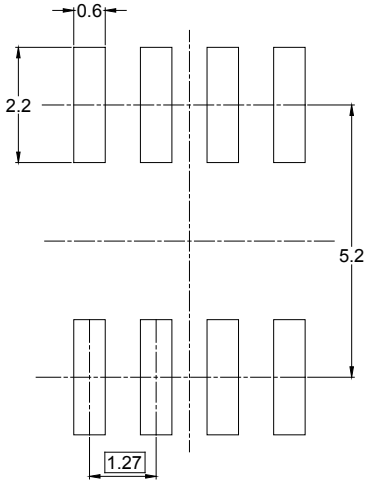


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026 TYP	
e1	1.300 BSC		0.051 BSC	
L	0.525 REF		0.021 REF	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°

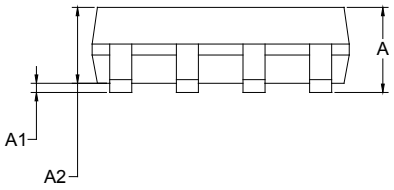
PACKAGE OUTLINE DIMENSIONS

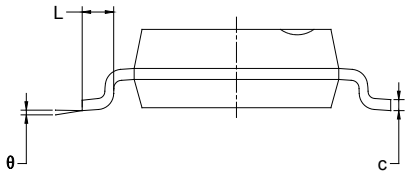
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)

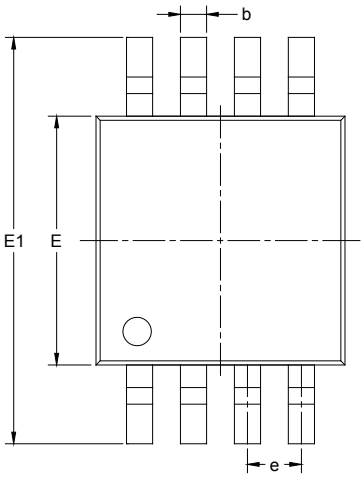


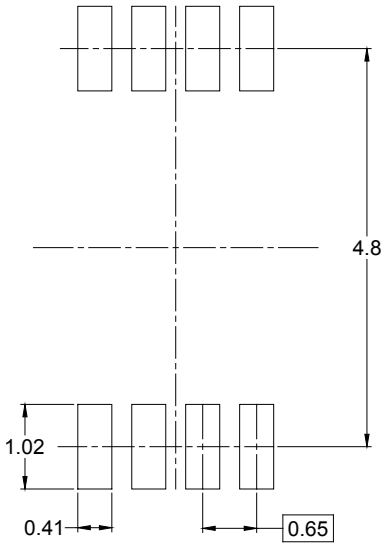


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

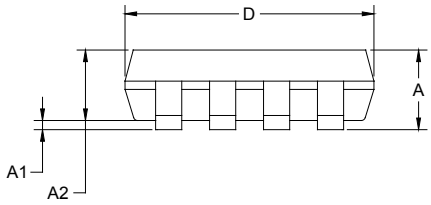
PACKAGE OUTLINE DIMENSIONS

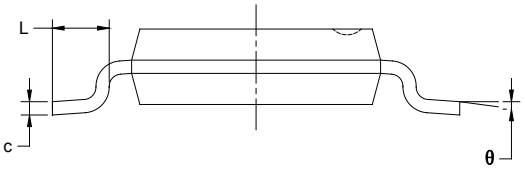
MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)

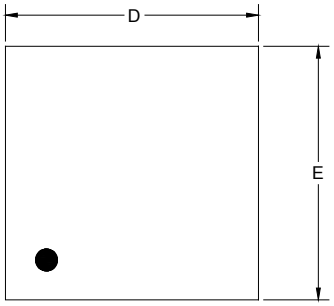




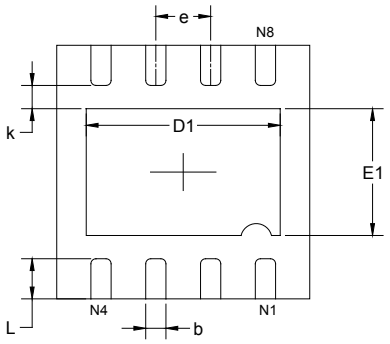
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

PACKAGE OUTLINE DIMENSIONS

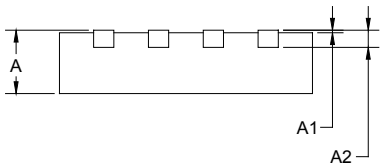
TDFN-3×3-8L



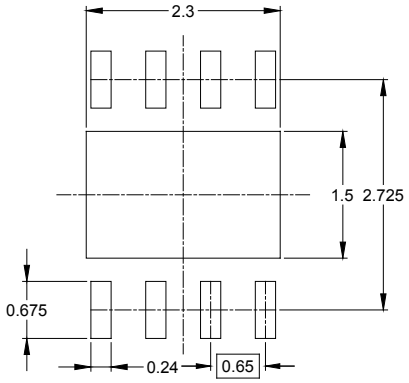
TOP VIEW



BOTTOM VIEW



SIDE VIEW

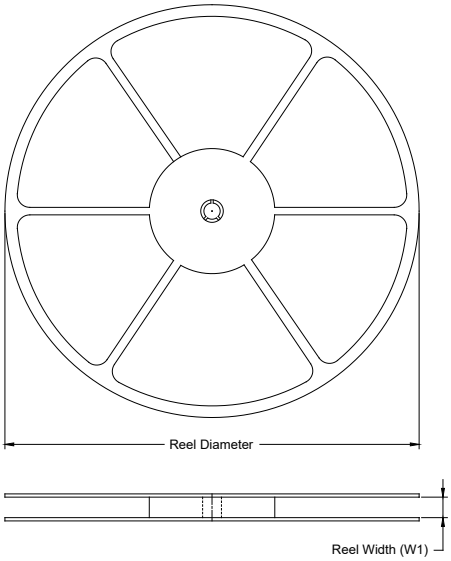


RECOMMENDED LAND PATTERN (Unit: mm)

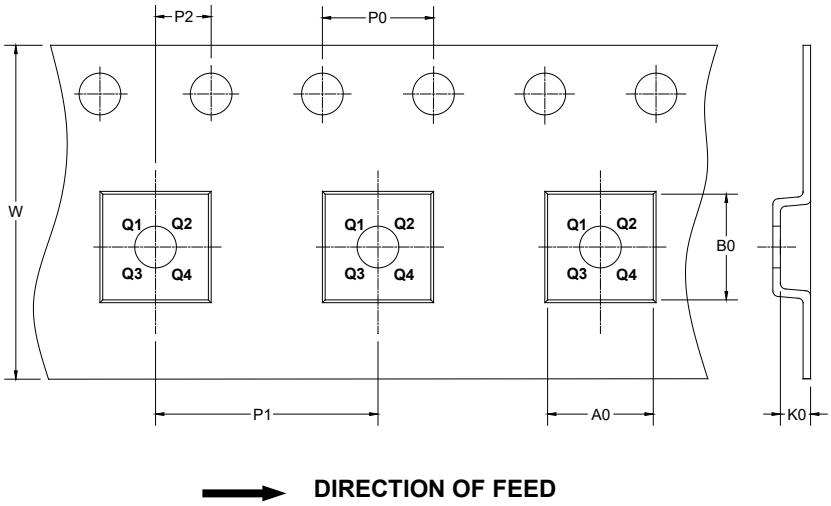
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	2.200	2.400	0.087	0.094
E	2.900	3.100	0.114	0.122
E1	1.400	1.600	0.055	0.063
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.650 TYP		0.026 TYP	
L	0.375	0.575	0.015	0.023

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



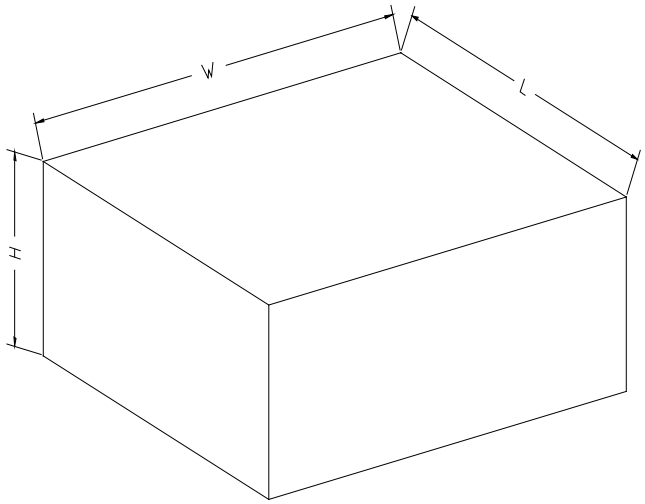
NOTE: The picture is only for reference. Please make the object as the standard.

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
SC70-5	7″	9.5	2.25	2.55	1.20	4.0	4.0	2.0	8.0	Q3
SOIC-8	13″	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1
MSOP-8	13″	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1
TDFN-3×3-8L	13″	12.4	3.35	3.35	1.13	4.0	8.0	2.0	12.0	Q1

DD0001

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