SGM8959-1/ SGM8959-2
Low V_{OS}, Low Noise, High Precision Zero-Drift Operational Amplifiers

GENERAL DESCRIPTION

The single SGM8959-1 and dual SGM8959-2 are low power, high precision CMOS operational amplifiers. These devices can operate from 1.8V to 5.5V single supply or from ±0.9V to ±2.75V dual power supplies, and consume only 380μA quiescent current per amplifier. The SGM8959-1/2 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 ($-V_S$) + 0.005V to ($+V_S$) - 0.005V.

The SGM8959-1/2 are designed to provide optimal performance in low voltage and low power systems. They have high impedance inputs and zero-drift 10μV (MAX) offset voltage. These specifications make SGM8959-1/2 appropriate for a wide range of applications requiring high precision, such as high linearity driver of high precision ADC.

The SGM8959-1 is available in Green SOT-23-5, SC70-5 and SOIC-8 packages. The SGM8959-2 is available in Green SOIC-8 and TDFN-3×3-8L packages. They are specified over -40℃ to +125℃ temperature range.

FEATURES

- **Low Input Offset Voltage: 10μV (MAX)**
- **Low Noise: 0.2μV_{P-P} at 0.1Hz to 10Hz**
- **Input Voltage Noise: 8nV/$\sqrt{Hz}$**
- **Gain-Bandwidth Product: 3.9MHz**
- **Slew Rate: 1.0V/μs**
- **Integrated EMI Filter**
- **Rail-to-Rail Input and Output**
- **Support Single or Dual Power Supplies: 1.8V to 5.5V or ±0.9V to ±2.75V**
- **Quiescent Current: 380μA/Amplifier (TYP)**
- **-40℃ to +125℃ Operating Temperature Range**
- **Small Packaging:**
  SGM8959-1 Available in Green SOT-23-5, SC70-5 and SOIC-8 Packages
  SGM8959-2 Available in Green SOIC-8 and TDFN-3×3-8L Packages

APPLICATIONS

Industrial Equipment
Battery-Powered Equipment
Sensor Signal Conditioning

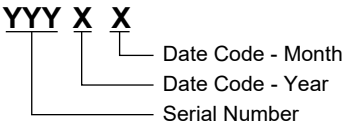
PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8959-1	SOT-23-5	-40℃ to +125℃	SGM8959-1XN5G/TR	GD4XX	Tape and Reel, 3000
	SC70-5	-40℃ to +125℃	SGM8959-1XC5G/TR	GCDXX	Tape and Reel, 3000
	SOIC-8	-40℃ to +125℃	SGM8959-1XS8G/TR	SGM 89591XS8 XXXXX	Tape and Reel, 2500
SGM8959-2	SOIC-8	-40℃ to +125℃	SGM8959-2XS8G/TR	SGM 89592XS8 XXXXX	Tape and Reel, 2500
	TDFN-3×3-8L	-40℃ to +125℃	SGM8959-2XTDB8G/TR	SGM GD5DB XXXXX	Tape and Reel, 4000

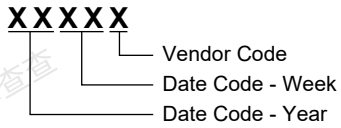
MARKING INFORMATION

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

SOT-23-5/SC70-5



SOIC-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
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

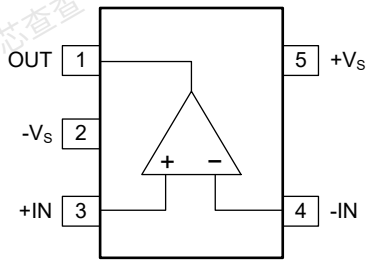
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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.

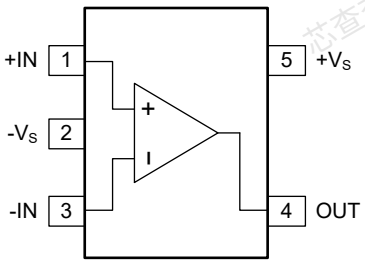
PIN CONFIGURATIONS

SGM8959-1 (TOP VIEW)



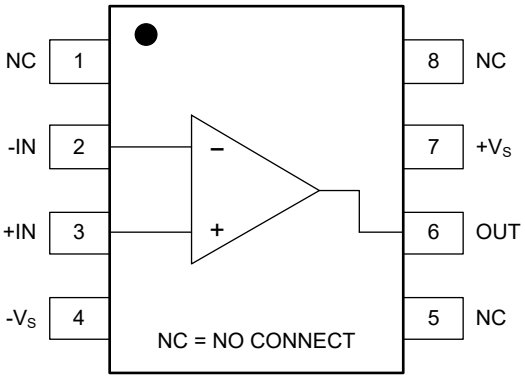
SOT-23-5

SGM8959-1 (TOP VIEW)



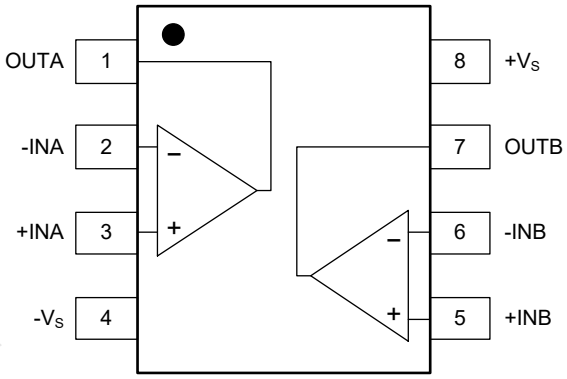
SC70-5

SGM8959-1 (TOP VIEW)



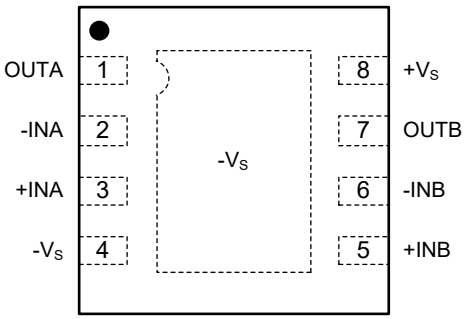
SOIC-8

SGM8959-2 (TOP VIEW)



SOIC-8

SGM8959-2 (TOP VIEW)



TDFN-3×3-8L

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

ELECTRICAL CHARACTERISTICS

(V_S = 5V, V_{CM} = V_S/2, V_{OUT} = V_S/2, and R_L = 10kΩ to V_S/2, Full = -40℃ to +125℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Characteristics							
Input Offset Voltage	V_{OS}	V_S = 5V	+25℃		2.5	10	μV
			Full			28	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		Full		0.032		μV/℃
Input Bias Current	I_B		+25℃		350		pA
Input Offset Current	I_{OS}		+25℃		700		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 < V_{CM} < V_S	+25℃	107	123		dB
			Full	105			
Open-Loop Voltage Gain	A_{OL}	(-V_S) + 0.1V < V_{OUT} < (+V_S) - 0.1V, R_L = 10kΩ	+25℃	110	127		dB
Output Characteristics							
Output Voltage Swing from Rail		R_L = 10kΩ	+25℃		5	10	mV
Short-Circuit Current	I_{SC}		+25℃	25	42		mA
Capacitive Load Drive			+25℃	See Typical Performance Characteristics			
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, V_{CM} = 0.2V	+25℃		1	4	μV/V
			Full			5	
Quiescent Current/Amplifier	I_Q	I_{OUT} = 0A	+25℃		380	560	μA
			Full			665	
Turn-On Time		G = +1, V_{IN} = 0.1V, R_L = 10kΩ, C_L = 30pF	+25℃		33		μs
Dynamic Performance							
Gain-Bandwidth Product	GBP	C_L = 30pF	+25℃		4		MHz
Slew Rate	SR	G = +1, V_{OUT} = $2V_{P-P}$, C_L = 30pF	+25℃		1		V/μs
Noise							
Input Voltage Noise		f = 0.1Hz to 10Hz	+25℃		0.2		μV_{P-P}
Input Voltage Noise Density	e_n	f = 1kHz	+25℃		8		$nV/\sqrt{Hz}$
Input Current Noise Density	i_n	f = 1kHz	+25℃		3		$pA/\sqrt{Hz}$

ELECTRICAL CHARACTERISTICS (continued)

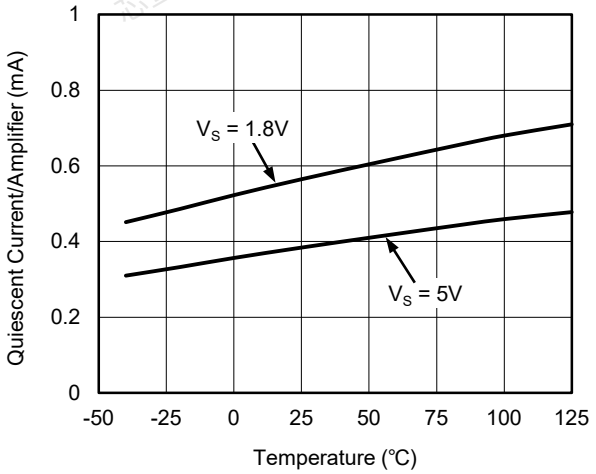
(V_S = 1.8V, V_{CM} = V_S/2, V_{OUT} = V_S/2, and R_L = 10kΩ to V_S/2, Full = -40℃ to +125℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Characteristics							
Input Offset Voltage	V_{OS}	V_S = 1.8V	+25℃		3.0	10	μV
			Full			29	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		Full		0.035		μV/℃
Input Bias Current	I_B		+25℃		350		pA
Input Offset Current	I_{OS}		+25℃		700		pA
Input Common Mode Voltage Range	V_{CM}		+25℃	$(-V_S)$ - 0.1		$(+V_S)$ + 0.1	V
Common Mode Rejection Ratio	CMRR	$-V_S < V_{CM} < V_S$	+25℃	104	122		dB
			Full	69			
Open-Loop Voltage Gain	A_{OL}	$(-V_S)$ + 0.1V < V_{OUT} < $(+V_S)$ - 0.1V, R_L = 10kΩ	+25℃	109	127		dB
Output Characteristics							
Output Voltage Swing from Rail		R_L = 10kΩ	+25℃		3	6	mV
Short-Circuit Current	I_{SC}		+25℃	7.5	12		mA
Capacitive Load Drive			+25℃	See Typical Performance Characteristics			
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, V_{CM} = 0.2V	+25℃		1	4	μV/V
			Full			5	
Quiescent Current/Amplifier	I_Q	I_{OUT} = 0A	+25℃		560	780	μA
			Full			950	
Turn-On Time		G = +1, V_{IN} = 0.1V, R_L = 10kΩ, C_L = 30pF	+25℃		63		μs
Dynamic Performance							
Gain-Bandwidth Product	GBP	C_L = 30pF	+25℃		3.5		MHz
Slew Rate	SR	G = +1, V_{OUT} = $1V_{P-P}$, C_L = 30pF	+25℃		0.6		V/μs
Noise							
Input Voltage Noise		f = 0.1Hz to 10Hz	+25℃		0.3		μV_{P-P}
Input Voltage Noise Density	e_n	f = 1kHz	+25℃		14		$nV/\sqrt{Hz}$
Input Current Noise Density	i_n	f = 1kHz	+25℃		2		$pA/\sqrt{Hz}$

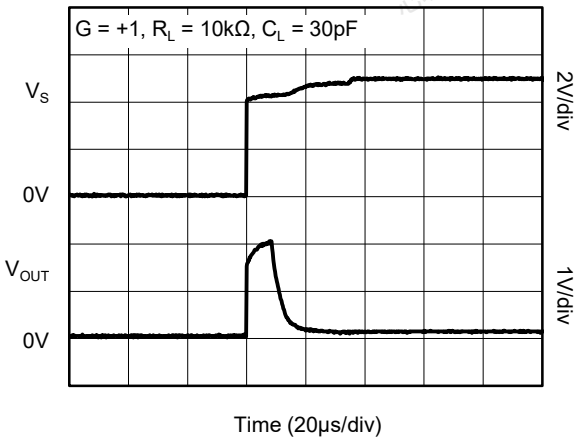
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, unless otherwise noted.

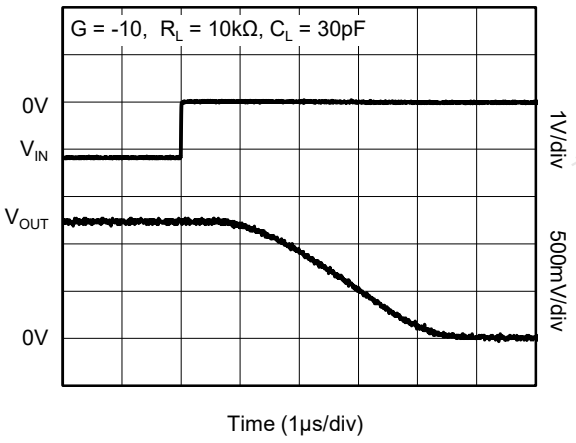
Quiescent Current vs. Temperature



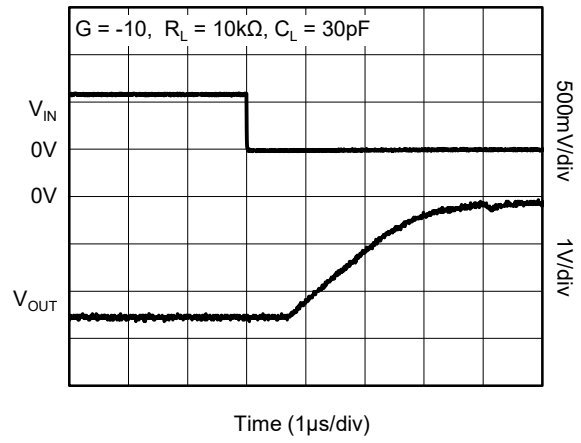
Turn-On Time



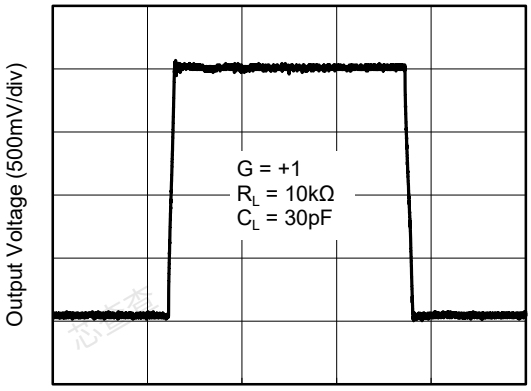
Positive Over-Voltage Recovery



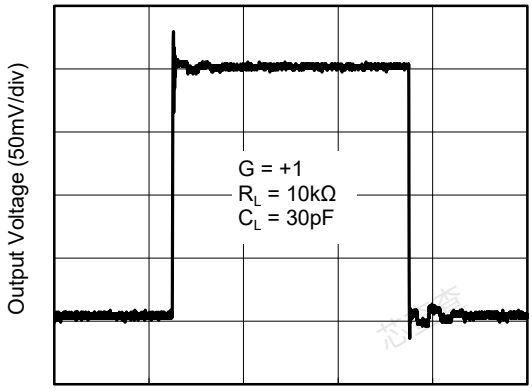
Negative Over-Voltage Recovery



Large-Signal Step Response



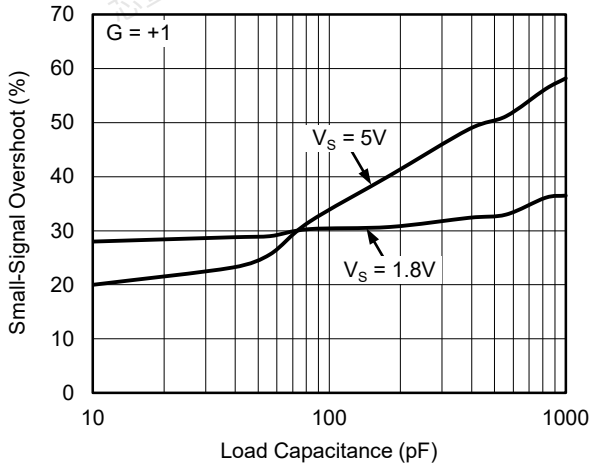
Small-Signal Step Response



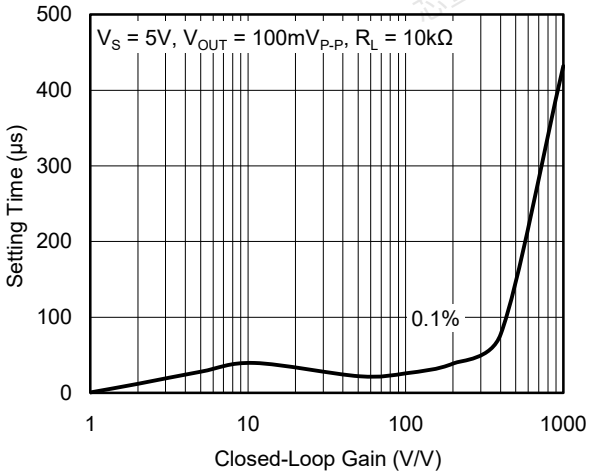
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, unless otherwise noted.

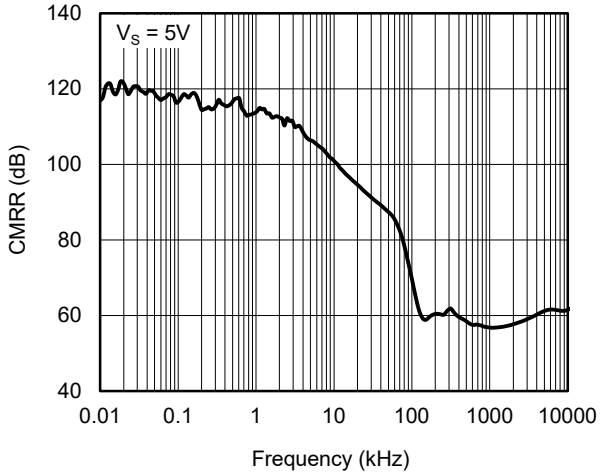
Small-Signal Overshoot vs. Load Capacitance



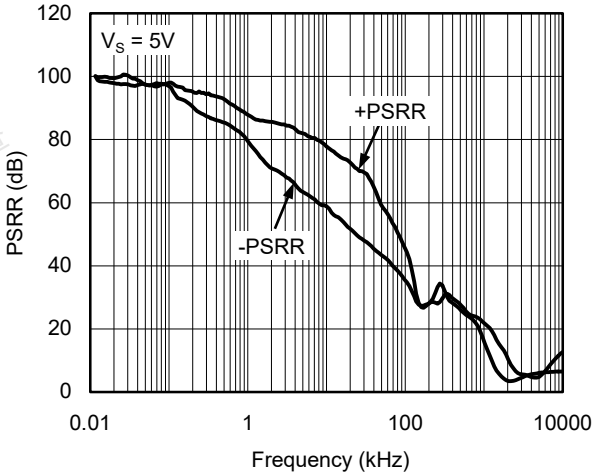
Settling Time vs. Closed-Loop Gain



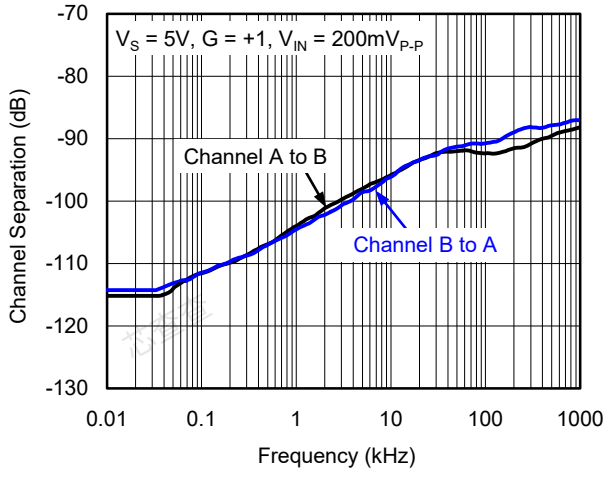
Common Mode Rejection Ratio vs. Frequency



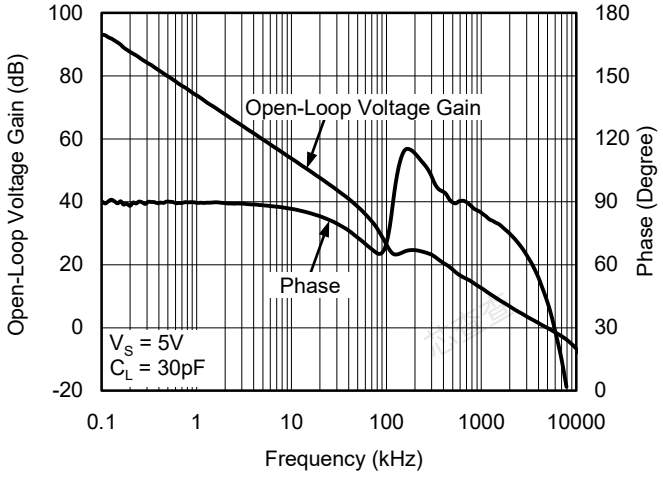
Power Supply Rejection Ratio vs. Frequency



Channel Separation vs. Frequency



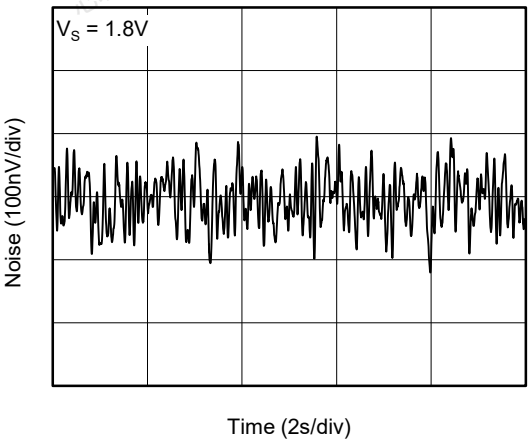
Open-Loop Voltage Gain and Phase vs. Frequency



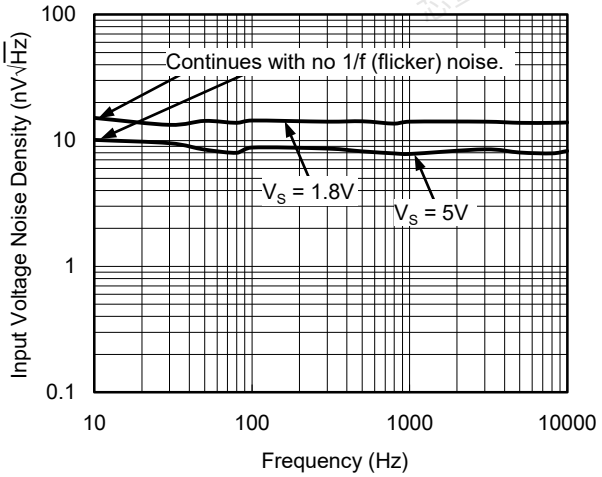
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, unless otherwise noted.

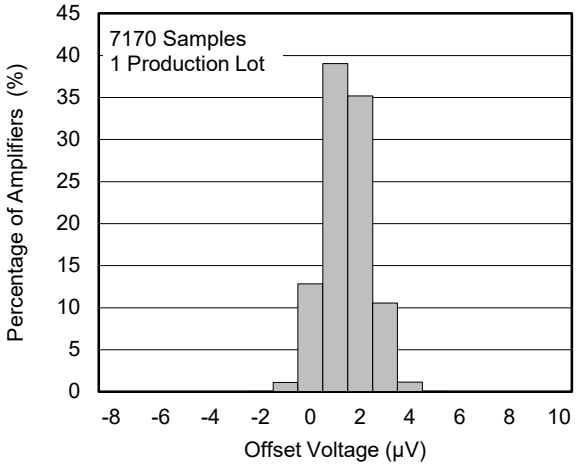
0.1Hz to 10Hz Noise



Input Voltage Noise Density vs. Frequency



Offset Voltage Production Distribution



APPLICATION INFORMATION

Rail-to-Rail Input

When SGM8959-1/2 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.

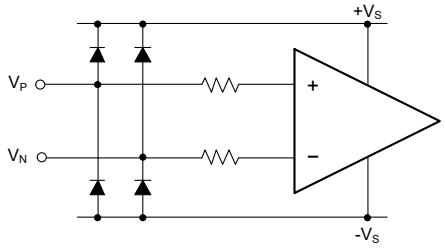


Figure 1. Input Equivalent Circuit

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.

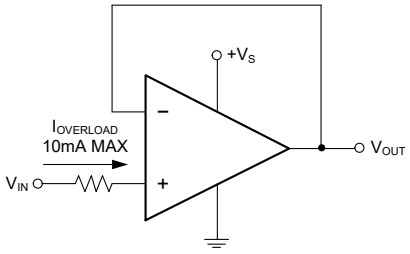


Figure 2. Input Current-Limit Protection

Rail-to-Rail Output

The SGM8959-1/2 support rail-to-rail output operation. In single power supply application, for example, when $+V_S$ = 5V, $-V_S$ = GND, 10kΩ load resistor is tied from OUT pin to V_S/2, the typical output swing range is from 0.005V to 4.995V.

Driving Capacitive Loads

The SGM8959-1/2 are designed for driving the 1nF capacitive load with unity-gain stable. 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.

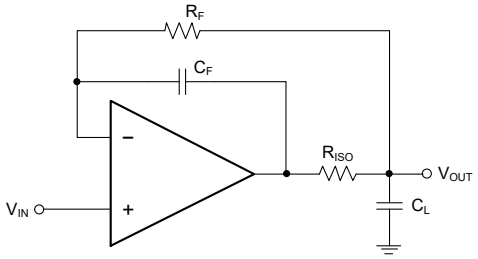


Figure 3. Circuit to Drive Heavy Capacitive Load

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.

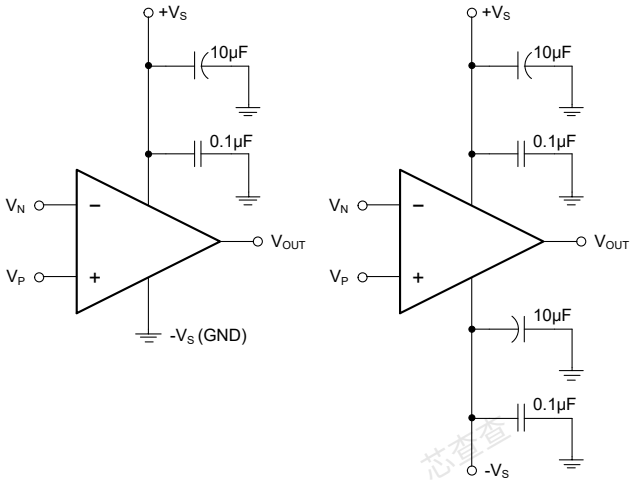


Figure 4. Amplifier Power Supply Bypassing

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 $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$.

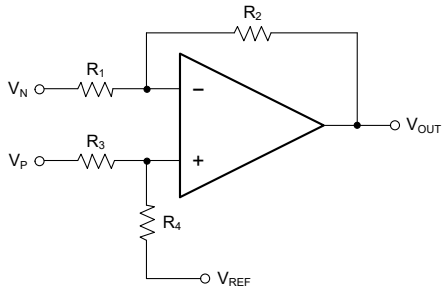


Figure 5. Difference Amplifier

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.

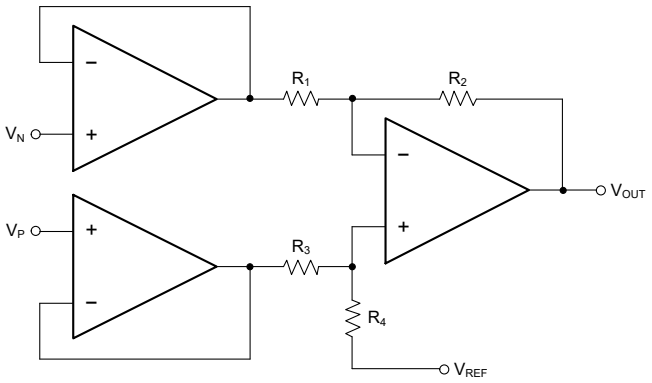


Figure 6. High Input Impedance Difference Amplifier

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 $1/2\pi R_2C$. 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.

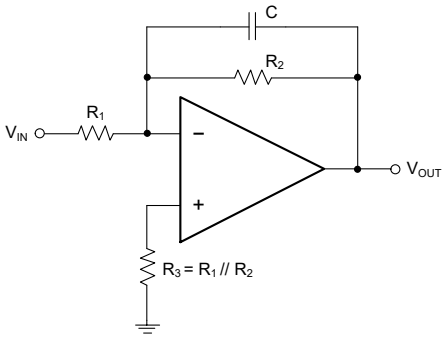


Figure 7. Active Low-Pass Filter

REVISION HISTORY

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

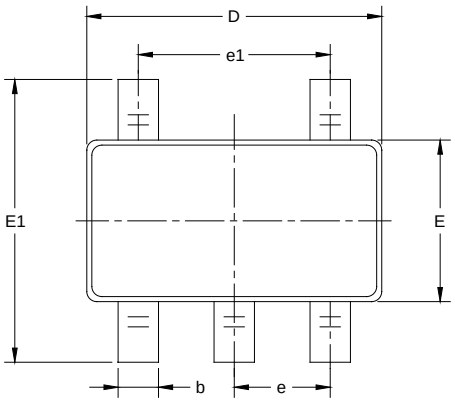
JULY 2023 – REV.A.1 to REV.A.2	Page
Updated Electrical Characteristics section	4, 5
Updated Typical Performance Characteristics section	7
Updated Package Outline Dimensions section	13

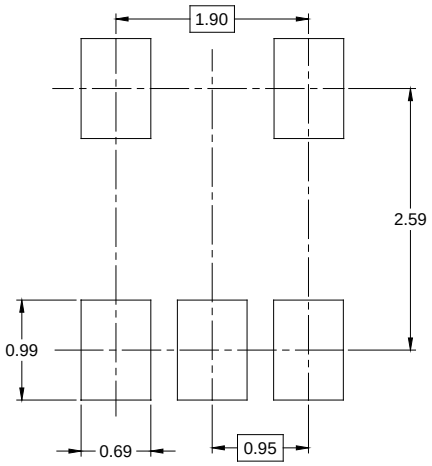
MARCH 2022 – REV.A to REV.A.1	Page
Updated Typical Performance Characteristics section	7

Changes from Original (DECEMBER 2016) to REV.A	Page
Changed from product preview to production data	All

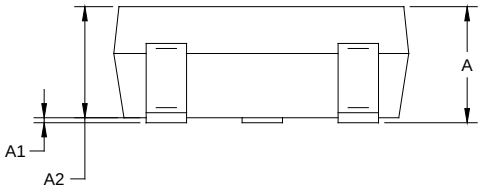
PACKAGE OUTLINE DIMENSIONS

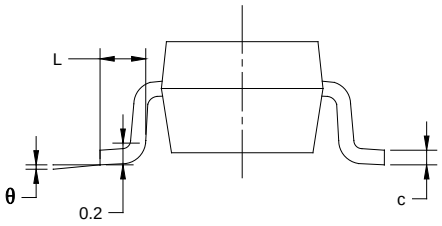
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)



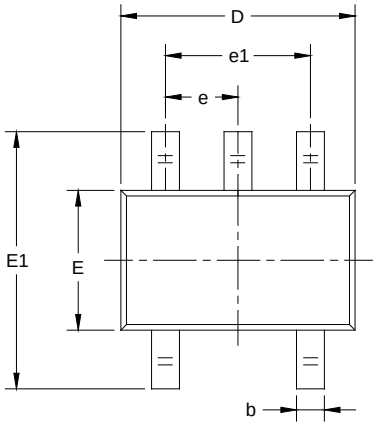


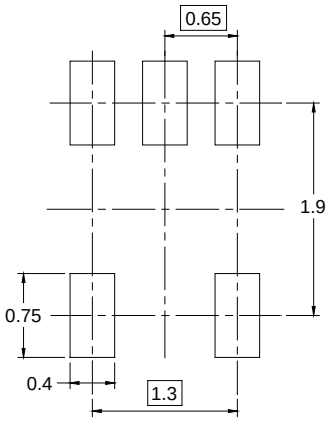
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

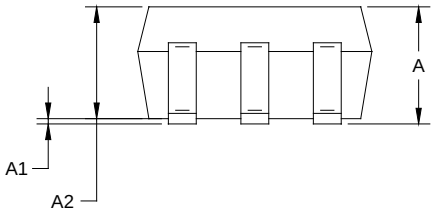
PACKAGE OUTLINE DIMENSIONS

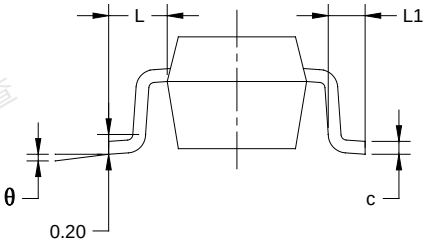
SC70-5





RECOMMENDED LAND PATTERN (Unit: mm)



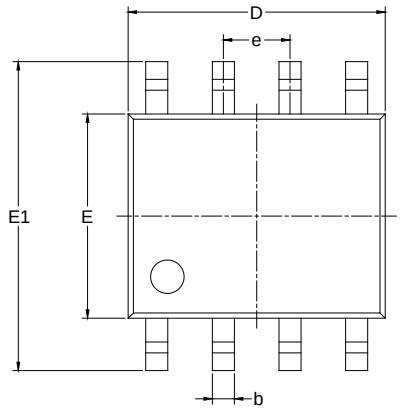


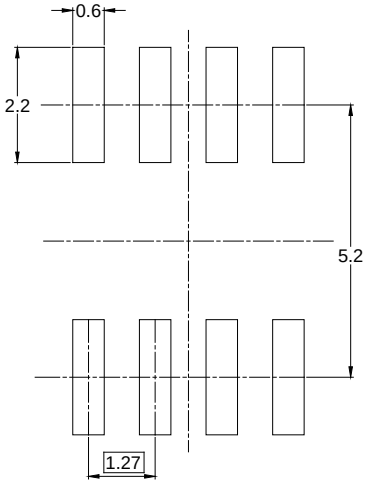
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.000	0.100	0.000	0.004
A2	0.800	1.000	0.031	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.220	0.003	0.009
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026 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°

NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

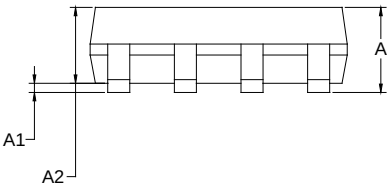
PACKAGE OUTLINE DIMENSIONS

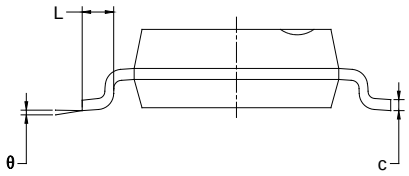
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)



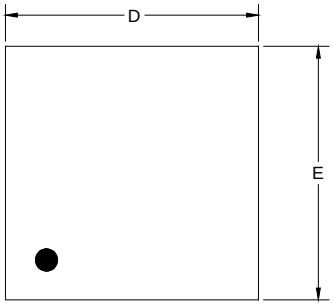


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

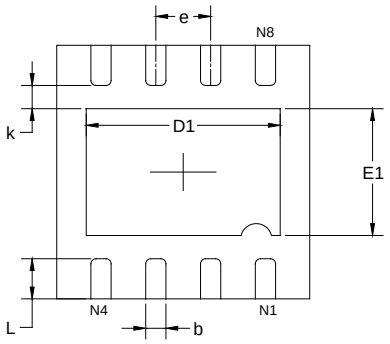
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

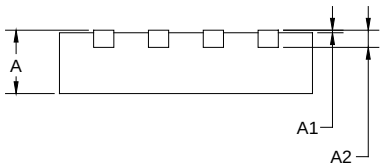
TDFN-3×3-8L



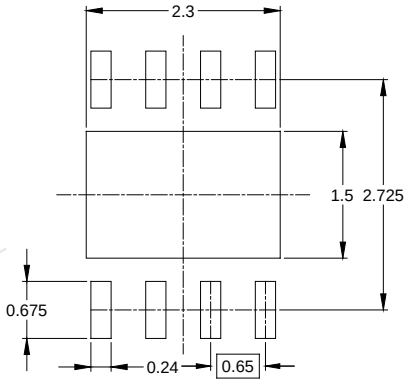
TOP VIEW



BOTTOM VIEW



SIDE VIEW



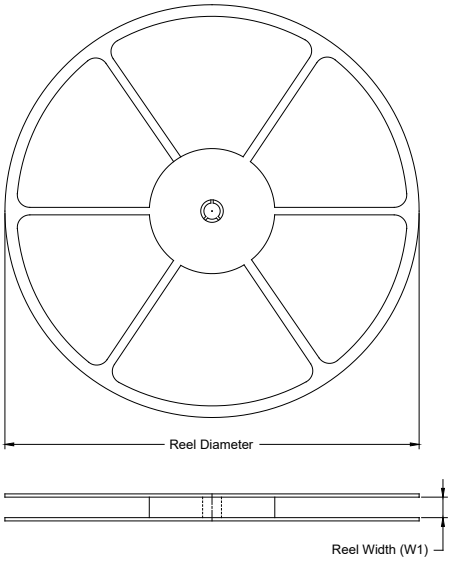
RECOMMENDED LAND PATTERN (Unit: mm)

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

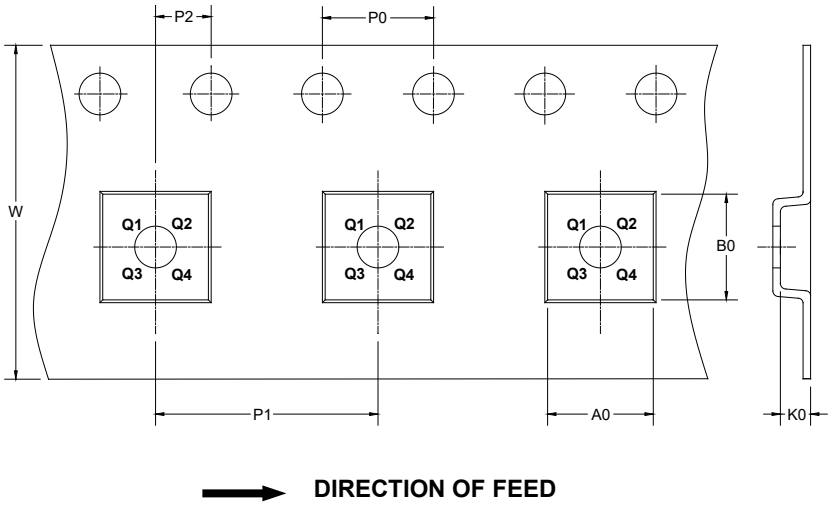
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



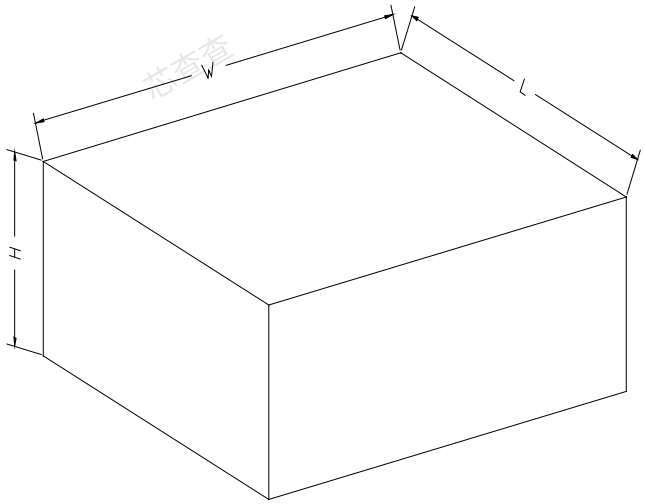
NOTE: The picture is only for reference. Please make the object as the standard.

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	2.40	2.50	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
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