



# SGM8955/SGM8956

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

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### GENERAL DESCRIPTION

The single SGM8955 and dual SGM8956 are low power, high precision CMOS operational amplifiers. These devices can operate from 1.8V to 5.5V single supply or from  $\pm 0.9V$  to  $\pm 2.75V$  dual power supplies, and consume only 20 $\mu A$  quiescent current per amplifier. The SGM8955/6 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  $(-V_S) + 0.014V$  to  $(+V_S) - 0.014V$ .

The SGM8955/6 are designed to provide optimal performance in low voltage and low power systems. They have high impedance inputs and zero-drift 50 $\mu V$  (MAX) offset voltage. These specifications make SGM8955/6 appropriate for a wide range of applications requiring high precision, such as high linearity driver of high precision ADC.

The SGM8955 is available in Green SOT-23-5, SC70-5 and SOIC-8 packages. The SGM8956 is available in Green SOIC-8, MSOP-8 and TDFN-3 $\times$ 3-8L packages. They are specified over  $-40^{\circ}C$  to  $+125^{\circ}C$  temperature range.

### FEATURES

- **Low Input Offset Voltage: 50 $\mu V$  (MAX)**
- **Low Noise: 2 $\mu V_{p,p}$  at 0.1Hz to 10Hz**
- **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: 20 $\mu A$ /Amplifier (TYP)**
- **$-40^{\circ}C$  to  $+125^{\circ}C$  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 $\times$ 3-8L Packages**

### APPLICATIONS

Industrial Equipment  
Battery-Powered Equipment  
Sensor Signal Conditioning

**PACKAGE/ORDERING INFORMATION**

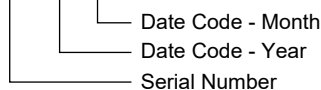
MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8955	SOT-23-5	-40°C to +125°C	SGM8955XN5G/TR	SVCXX	Tape and Reel, 3000
	SC70-5	-40°C to +125°C	SGM8955XC5G/TR	SUCXX	Tape and Reel, 3000
	SOIC-8	-40°C to +125°C	SGM8955XS8G/TR	SGM 8955XS8 XXXXX	Tape and Reel, 2500
SGM8956	SOIC-8	-40°C to +125°C	SGM8956XS8G/TR	SGM 8956XS8 XXXXX	Tape and Reel, 2500
	MSOP-8	-40°C to +125°C	SGM8956XMS8G/TR	SGM8956 XMS8 XXXXX	Tape and Reel, 4000
	TDFN-3x3-8L	-40°C to +125°C	SGM8956XTDB8G/TR	SGM 8956DB XXXXX	Tape and Reel, 4000

**MARKING INFORMATION**

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

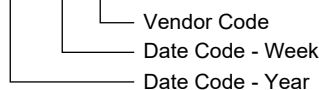
**SOT-23-5/SC70-5**

YYY X X



**SOIC-8/MSOP-8/TDFN-3x3-8L**

XXXXX



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<sub>S</sub>) - 0.3V to (+V<sub>S</sub>) + 0.3V
- Junction Temperature.....+150°C
- Storage Temperature Range .....-65°C to +150°C
- Lead Temperature (Soldering, 10s).....+260°C
- ESD Susceptibility
- HBM.....4000V
- 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.

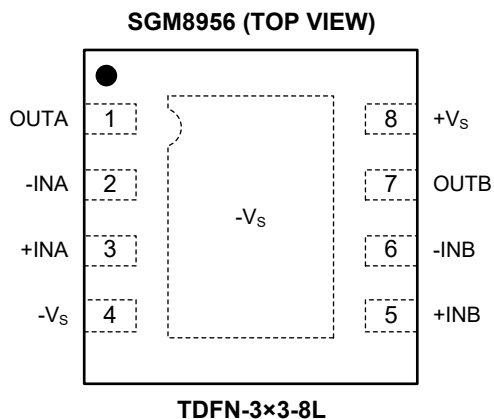
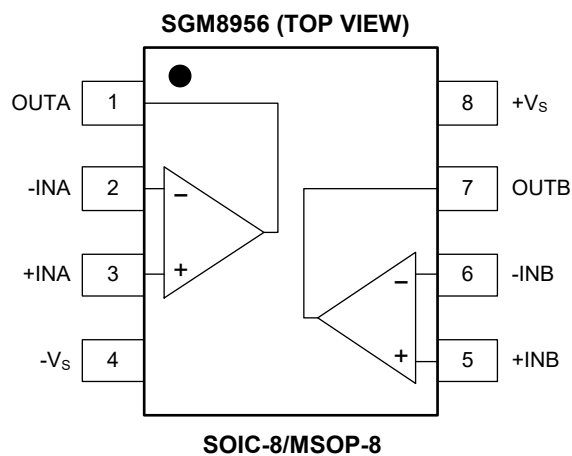
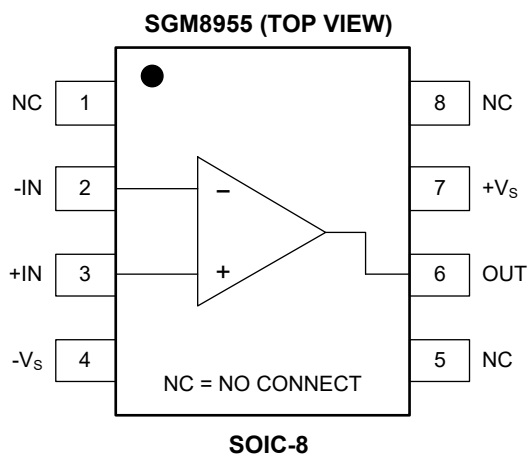
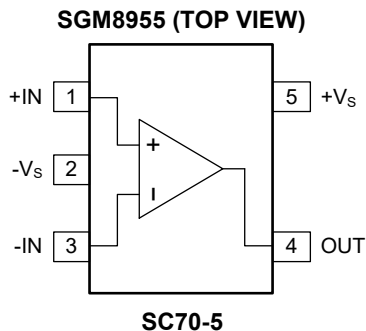
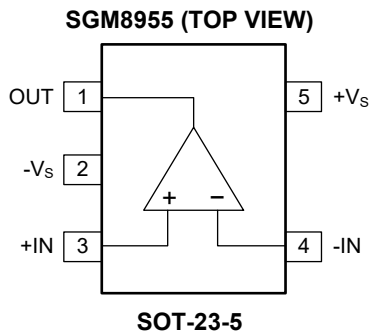
**ESD SENSITIVITY CAUTION**

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 TDFN-3x3-8L package, exposed pad can be connected to -Vs or left floating.

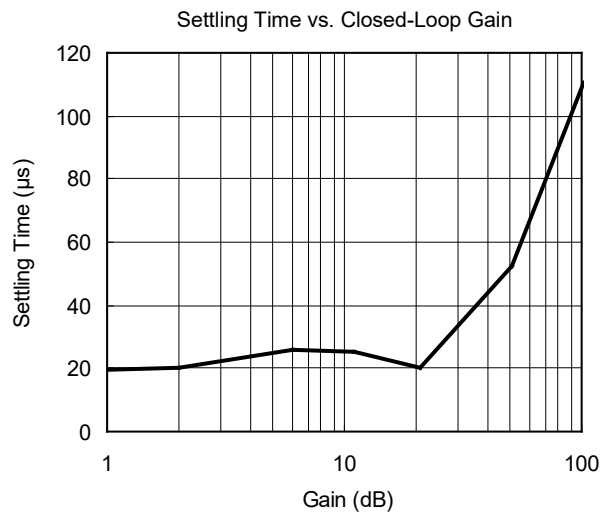
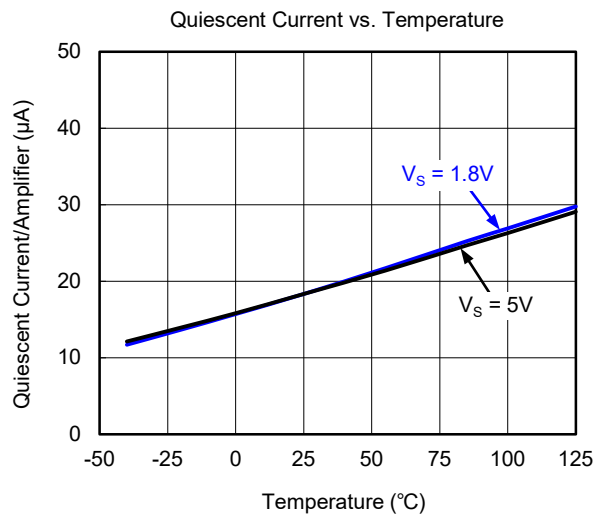
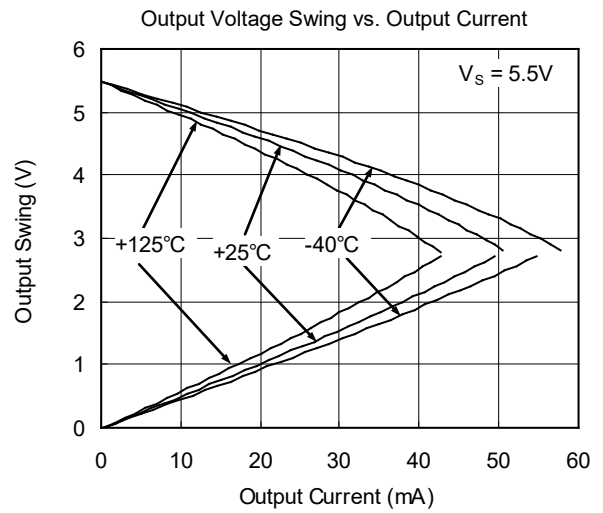
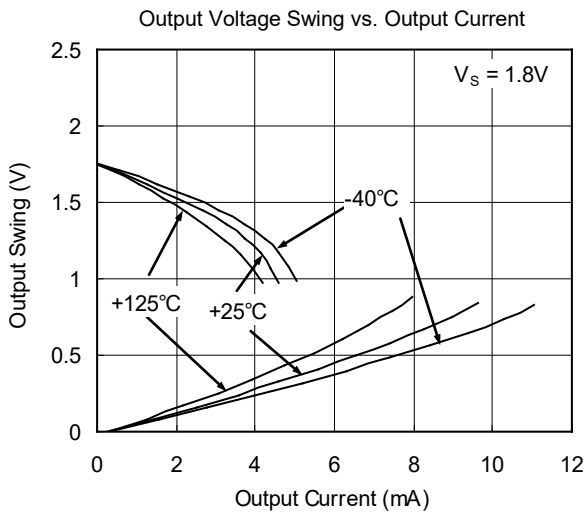
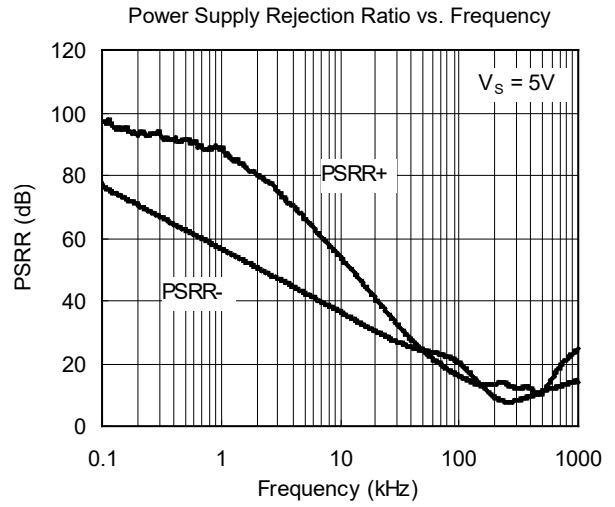
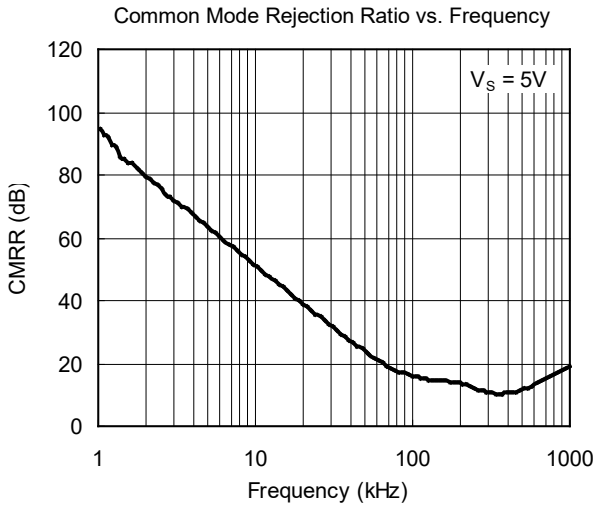
**ELECTRICAL CHARACTERISTICS**

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

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

**TYPICAL PERFORMANCE CHARACTERISTICS**

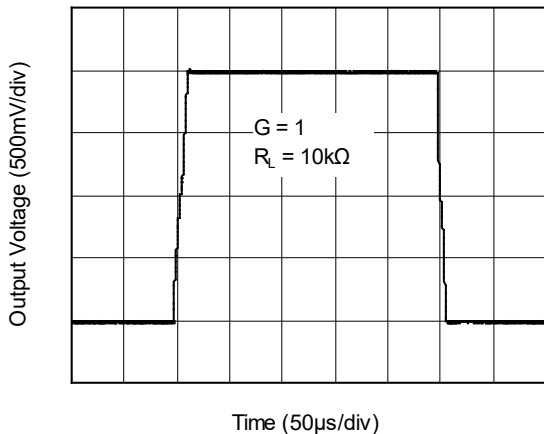
At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $C_L = 0\text{pF}$ , unless otherwise noted.



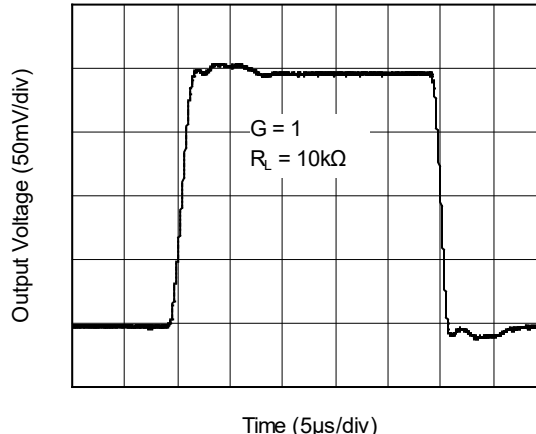
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $C_L = 0\text{pF}$ , unless otherwise noted.

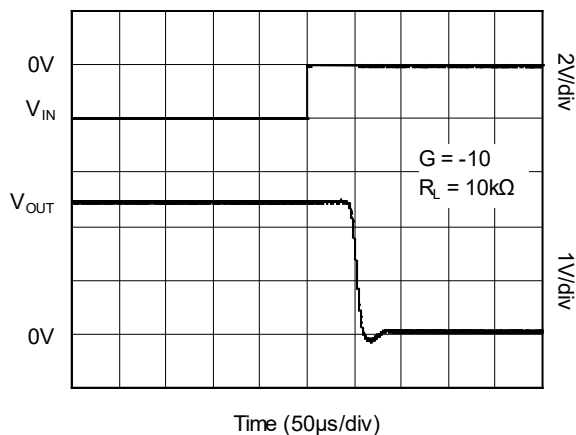
Large-Signal Step Response



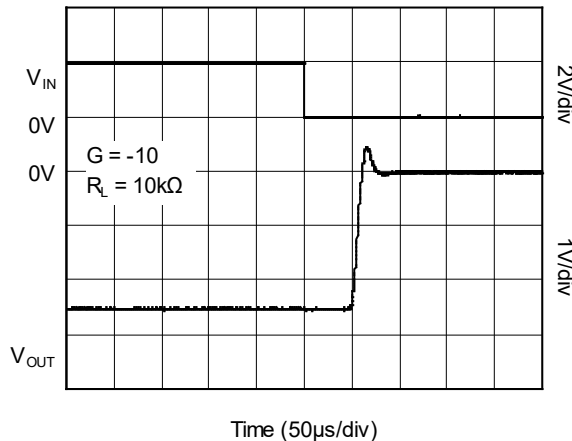
Small-Signal Step Response



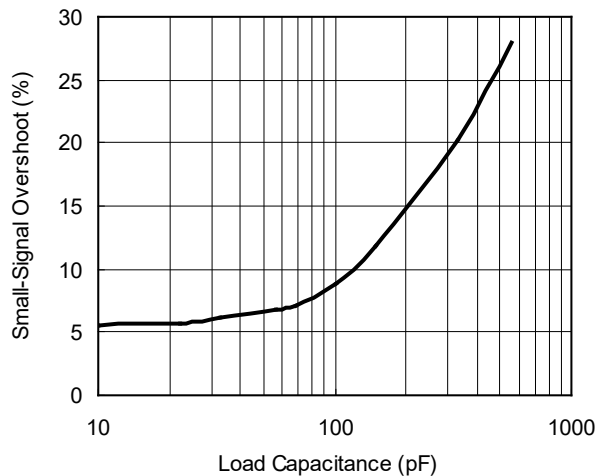
Positive Over-Voltage Recovery



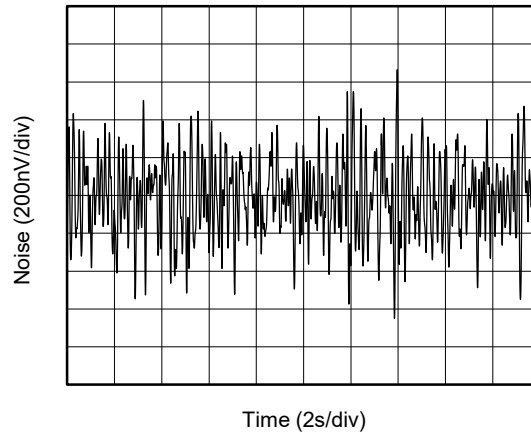
Negative Over-Voltage Recovery



Small-Signal Overshoot vs. Load Capacitance

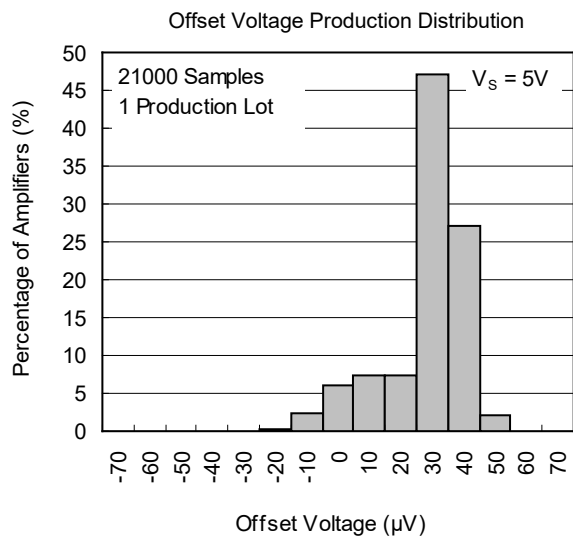
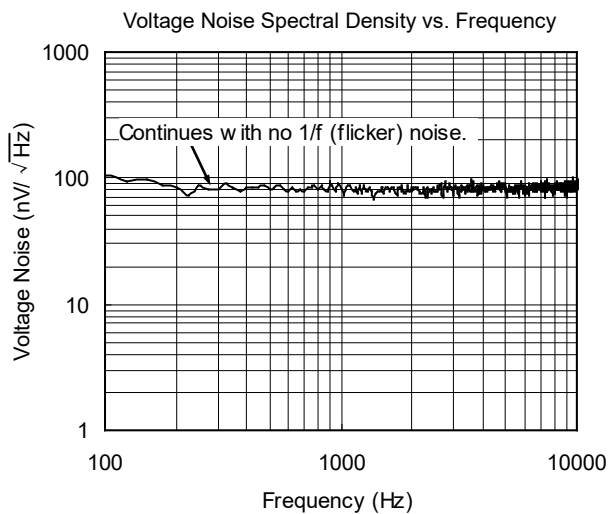


0.1Hz to 10Hz Noise



**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

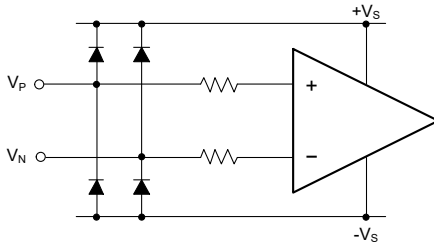
At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $C_L = 0\text{pF}$ , unless otherwise noted.



**APPLICATION INFORMATION**

**Rail-to-Rail Input**

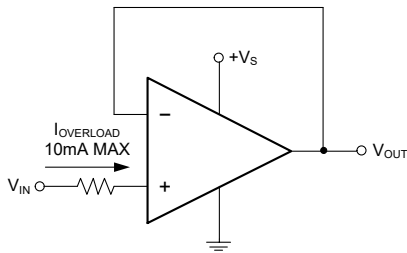
When SGM8955/6 work at the power supply between 1.8V and 5.5V, the input common mode voltage range is from  $(-V_S) - 0.1V$  to  $(+V_S) + 0.1V$ . In Figure 1, the ESD diodes between the inputs and the power supply rails will clamp the input voltage not to exceed the rails.



**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.



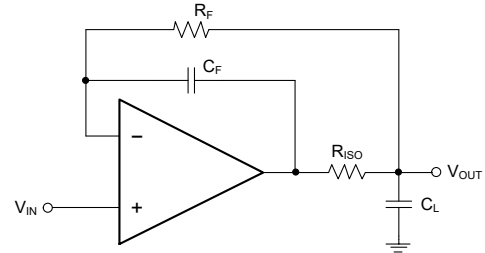
**Figure 2. Input Current-Limit Protection**

**Rail-to-Rail Output**

The SGM8955/6 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 0.014V to 5.486V.

**Driving Capacitive Loads**

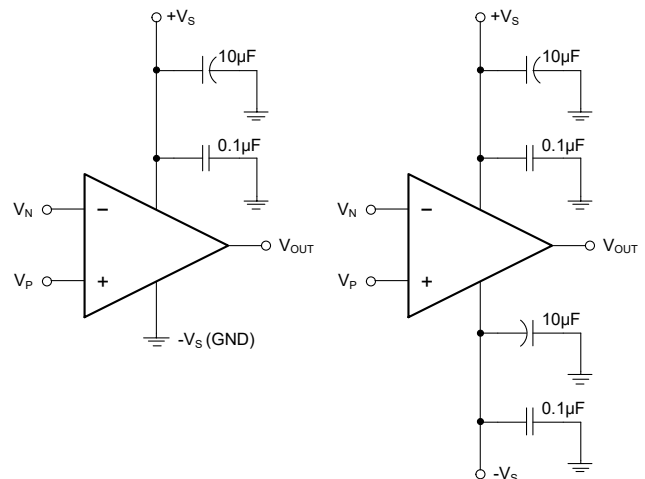
The SGM8955/6 are designed for driving capacitive load with unity-gain stable. If greater capacitive load must be driven in application, the circuit in Figure 3 can be used. In this circuit, the IR drop voltage generated by  $R_{ISO}$  is compensated by feedback loop.



**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.

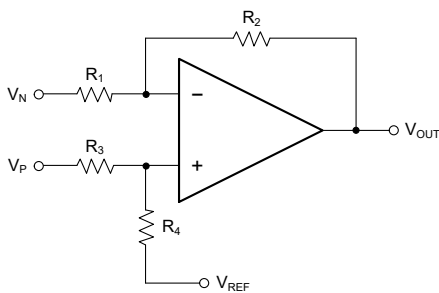
**Reduce Input-to-Output Coupling**

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

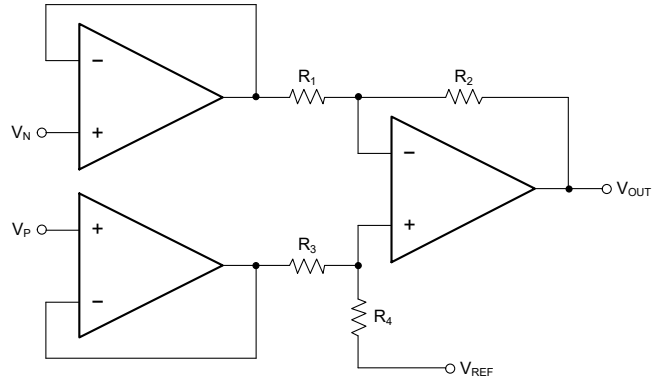


**Figure 5. Difference Amplifier**

**High Input Impedance Difference Amplifier**

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

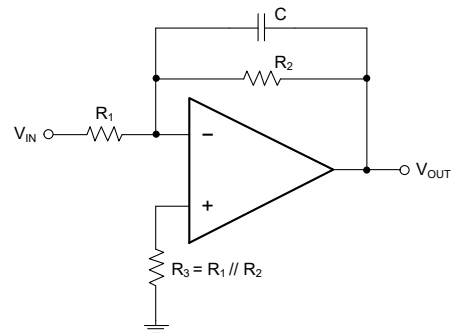
the input are used to increase the input impedance and eliminate drawback of low input impedance in Figure 5.



**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  $1/2\pi R_2 C$ . 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**

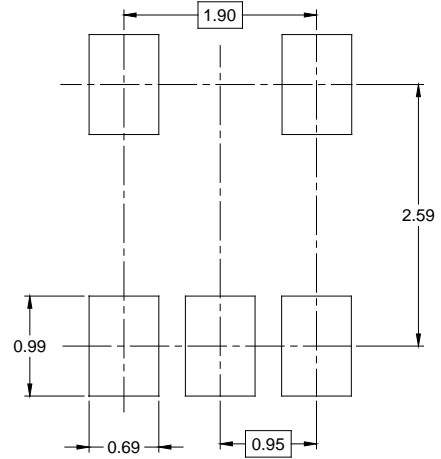
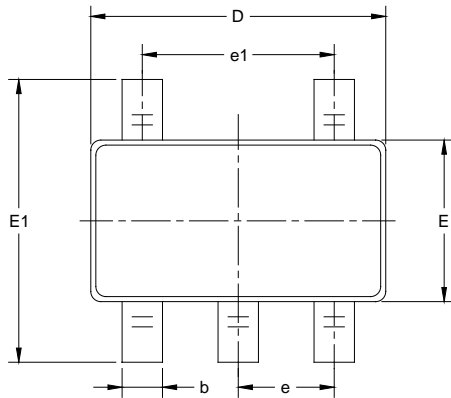
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>JULY 2023 – REV.A.2 to REV.A.3</b>	<b>Page</b>
Updated Package Outline Dimensions section .....	12
<hr/>	
<b>OCTOBER 2020 – REV.A.1 to REV.A.2</b>	<b>Page</b>
Updated Typical Performance Characteristics section .....	6
<hr/>	
<b>OCTOBER 2016 – REV.A to REV.A.1</b>	<b>Page</b>
Changed Typical Performance Characteristics section .....	5
<hr/>	
<b>Changes from Original (SEPTEMBER 2015) to REV.A</b>	<b>Page</b>
Changed from product preview to production data.....	All

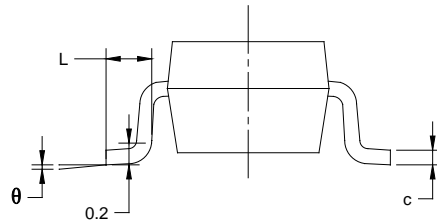
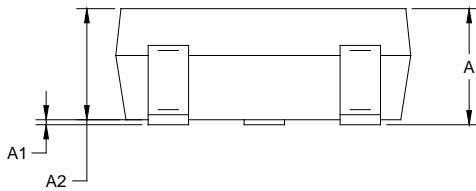
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PACKAGE OUTLINE DIMENSIONS

SOT-23-5



RECOMMENDED LAND PATTERN (Unit: mm)



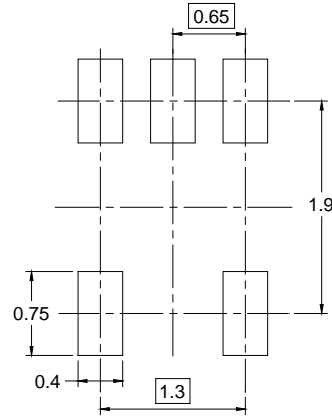
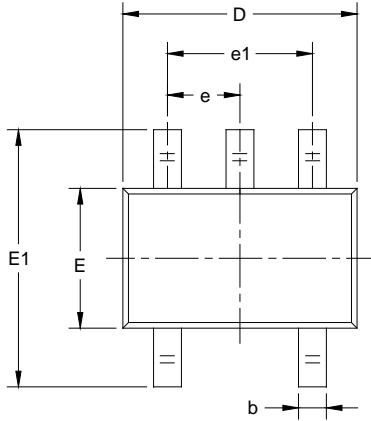
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

NOTES:

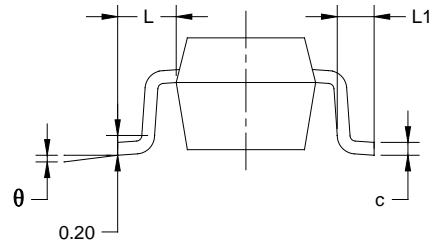
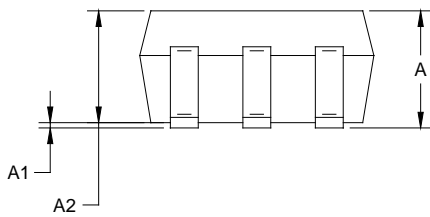
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

SC70-5



RECOMMENDED LAND PATTERN (Unit: mm)



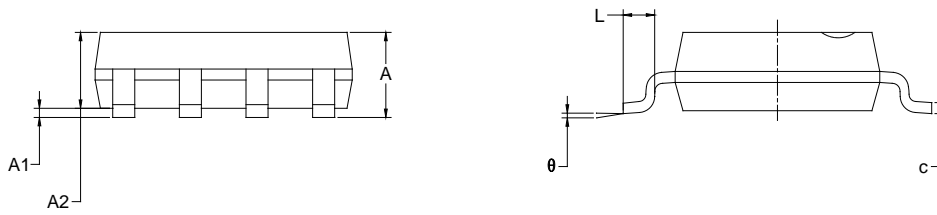
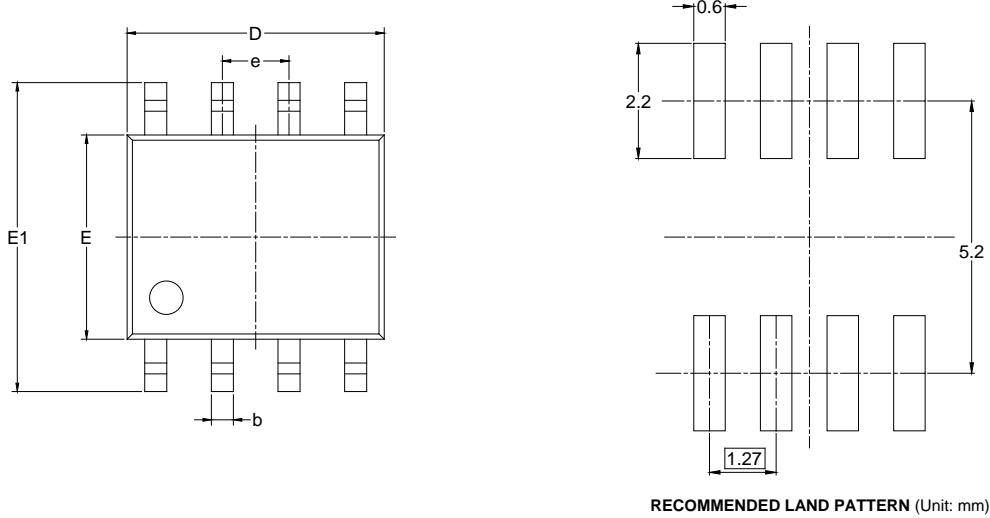
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.000	0.100	0.000	0.004
A2	0.800	1.000	0.031	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.220	0.003	0.009
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026 TYP	
e1	1.300 BSC		0.051 BSC	
L	0.525 REF		0.021 REF	
L1	0.260	0.460	0.010	0.018
$\theta$	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

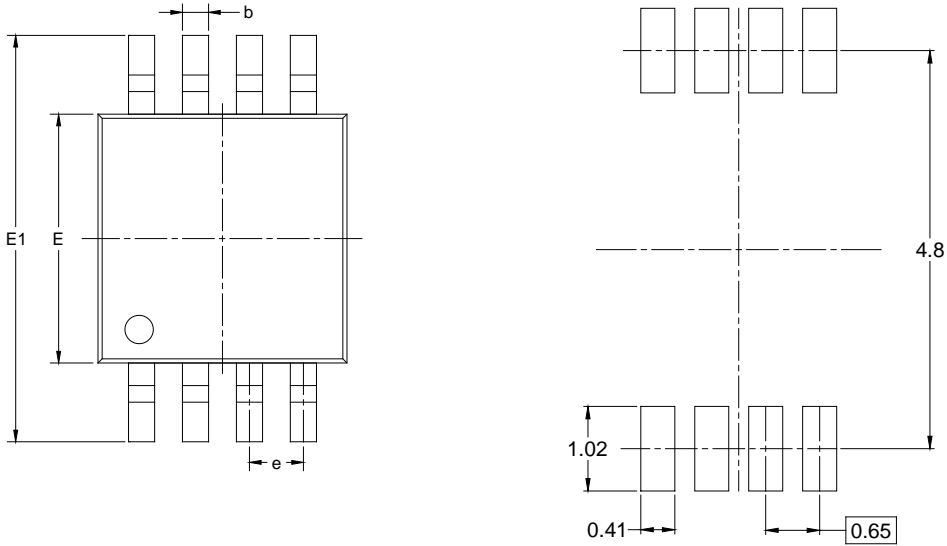


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

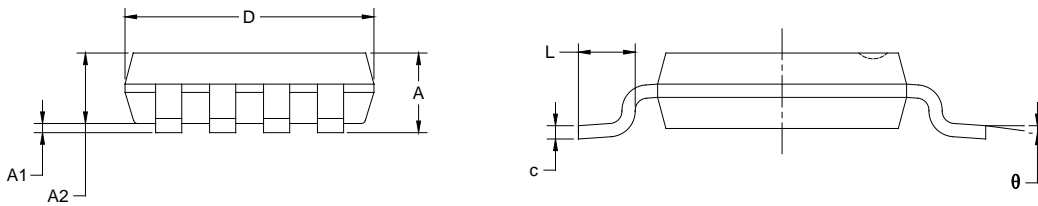
NOTES:  
 1. Body dimensions do not include mode flash or protrusion.  
 2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

MSOP-8



RECOMMENDED LAND PATTERN (Unit: mm)



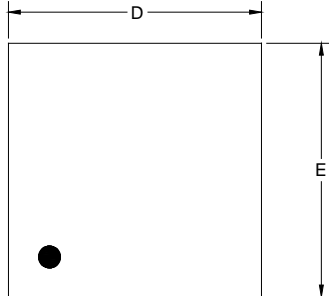
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

NOTES:

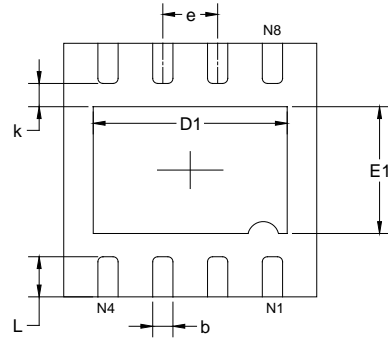
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

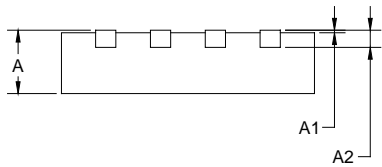
TDFN-3x3-8L



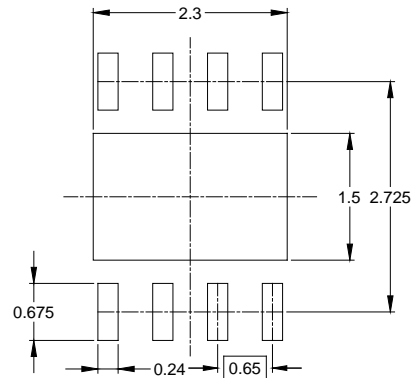
TOP VIEW



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.

# 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
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
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

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