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, which can operate from 1.8V to 5.5V single supply or from ±0.9V to ±2.75V dual power supplies, while consuming 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 100mV beyond the rails, and the output swings within 5mV of the rails.

The SGM8959-1/2 feature high impedance inputs, a 10µV maximum input offset voltage and zero-drift over time and temperature. These devices are designed to provide optimal performance in low voltage and low power systems. These specifications make the operational amplifiers appropriate for a wide range of applications requiring high precision, such as driving ADCs with high linearity.

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 Offset Voltage: 10µV (MAX)**
- **Low 0.1Hz to 10Hz Noise: 0.2µV$_{P-P}$**
- **Input Voltage Noise: 8nV/√Hz**
- **Integrated EMI Filter**
- **Gain-Bandwidth: 3.9MHz**
- **Slew Rate : 1.0V/µs**
- **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

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

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

<u>YYY</u> <u>X</u> <u>X</u>
   └── Date Code - Month
  └──── Date Code - Year
 └─────── Serial Number

SOIC-8/TDFN-3×3-8L

<u>X X X X X</u>
    └── Vendor Code
   └───── Date Code - Week
  └──────── Date Code - Year
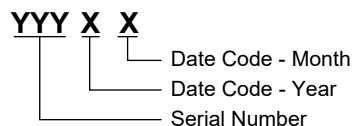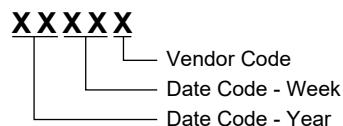
Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

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)

OUT `1`   `5` $+V_S$

$-V_S$ `2`

$+$ $-$

$+IN$ `3`   `4` $-IN$

SOT-23-5

SGM8959-1 (TOP VIEW)

$+IN$ `1`   `5` $+V_S$

$-V_S$ `2`

$+$
$-$

$-IN$ `3`   `4` OUT

SC70-5

SGM8959-1 (TOP VIEW)

NC `1`   `8` NC

$-IN$ `2` $-$ `7` $+V_S$

$+IN$ `3` $+$ `6` OUT

$-V_S$ `4`   `5` NC

NC = NO CONNECT

SOIC-8

SGM8959-2 (TOP VIEW)

OUTA `1`   `8` $+V_S$

$-INA$ `2` $-$ `7` OUTB

$+INA$ `3` $+$ `6` $-INB$

$-V_S$ `4` $-$ `5` $+INB$

$+$

SOIC-8

SGM8959-2 (TOP VIEW)

OUTA `1`   `8` $+V_S$

$-INA$ `2`   `7` OUTB

$+INA$ `3` $-V_S$ `6` $-INB$

$-V_S$ `4`   `5` $+INB$

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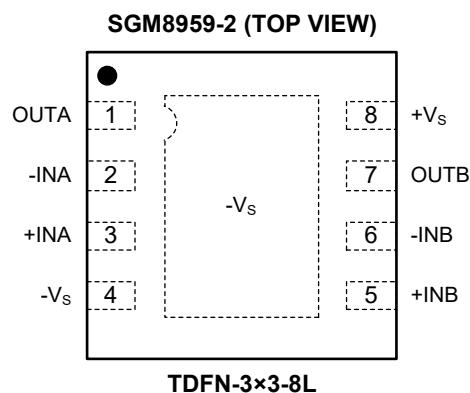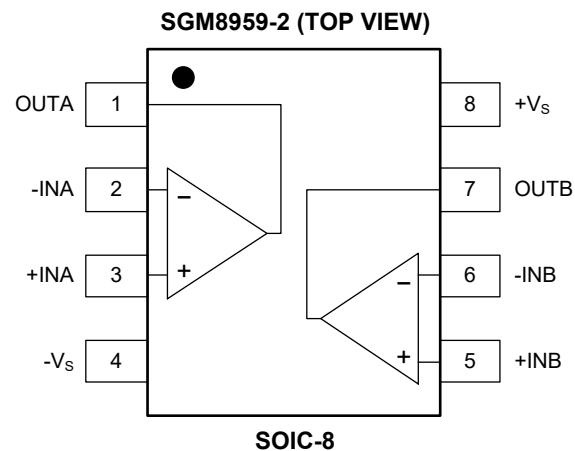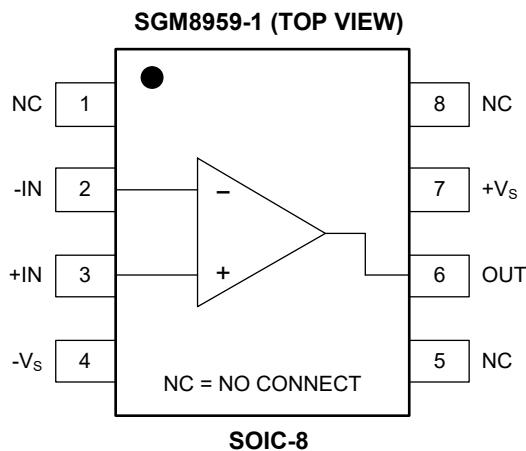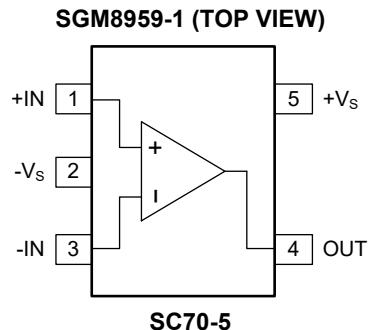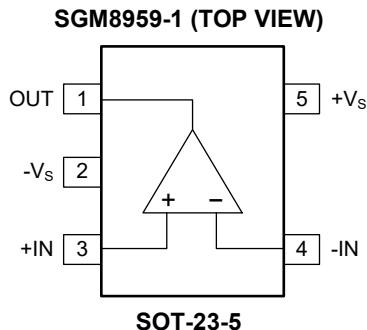
NOTE: For TDFN-3×3-8L package, exposed pad can be connected to $-V_S$ or left floating.

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} = 0	+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/$\sqrt{Hz}$

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	ΔV$_{OS}$/ΔT		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$_{OUT}$ = 0	+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/$\sqrt{Hz}$

TYPICAL PERFORMANCE CHARACTERISTICS

At T$_A$ = +25℃, unless otherwise noted.

Quiescent Current vs. Temperature

Small-Signal Overshoot vs. Load Capacitance

Common Mode Rejection Ratio vs. Frequency

Power Supply Rejection Ratio vs. Frequency

Channel Separation vs. Frequency

Open-Loop Gain and Phase Shift vs. Frequency
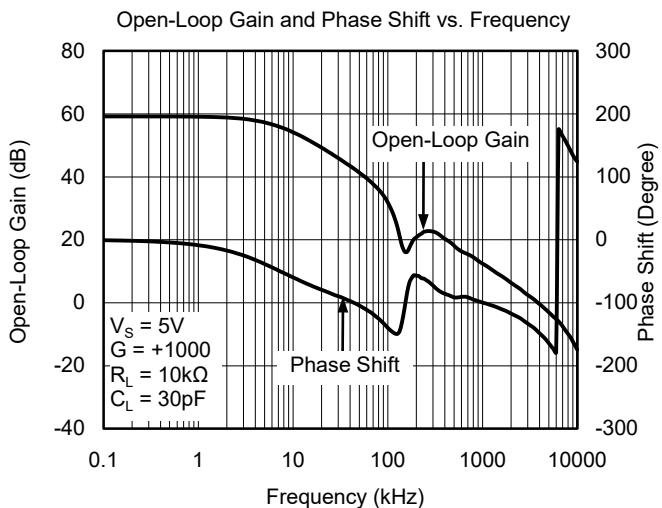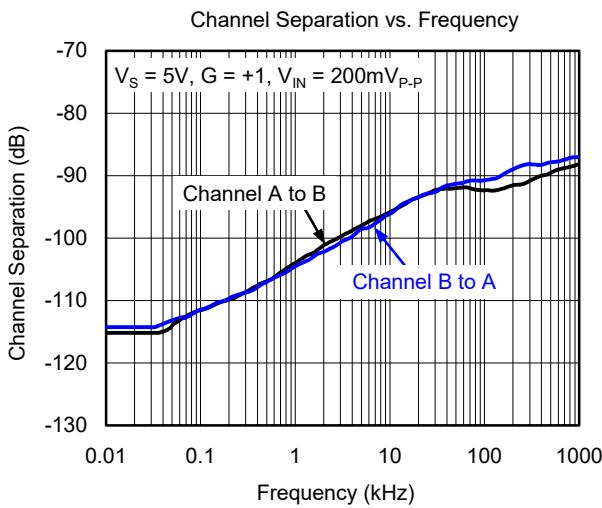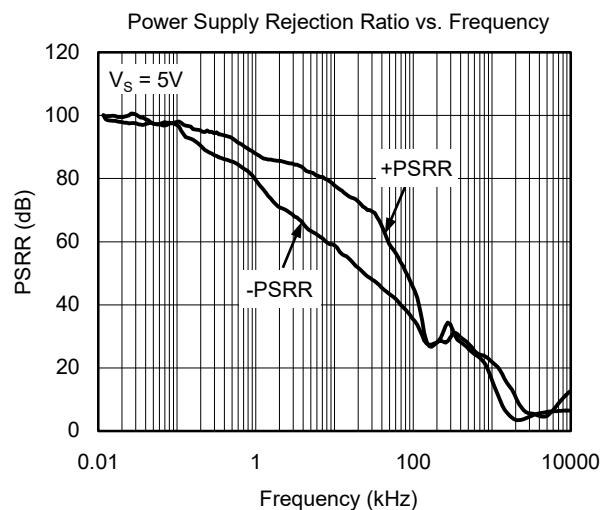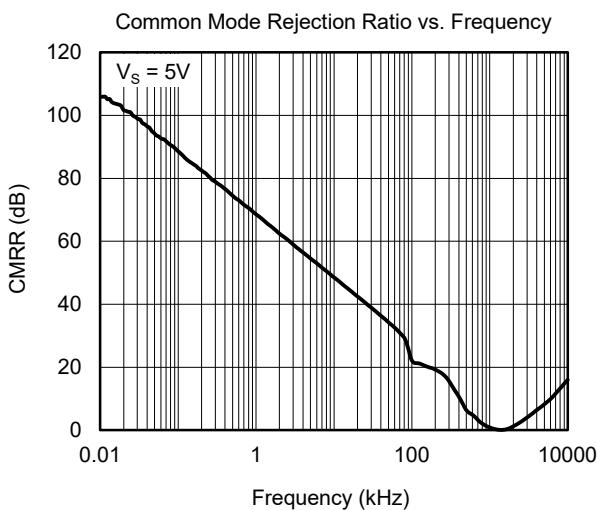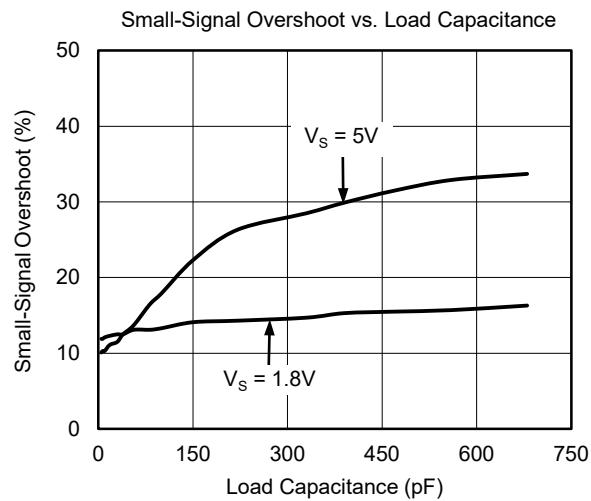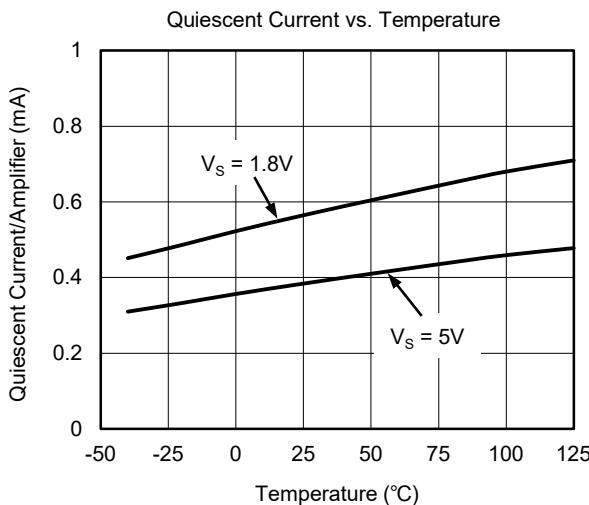
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T$_A$ = +25℃, unless otherwise noted.

Large-Signal Step Response
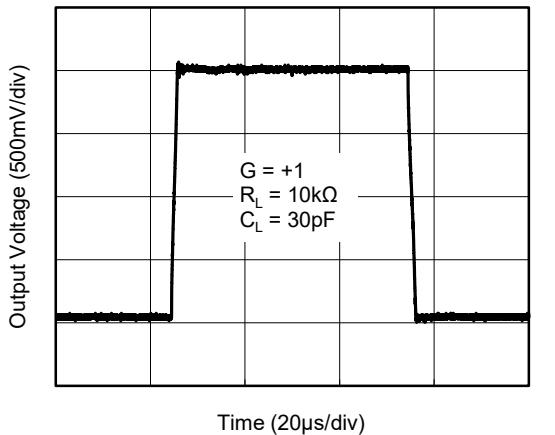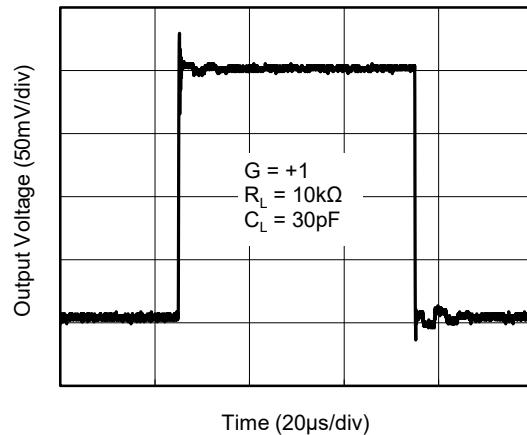
Output Voltage (500mV/div)

G = +1
R$_L$ = 10kΩ
C$_L$ = 30pF

Time (20µs/div)

Small-Signal Step Response

Output Voltage (50mV/div)

G = +1
R$_L$ = 10kΩ
C$_L$ = 30pF

Time (20µs/div)

Positive Over-Voltage Recovery

G = -10, R$_L$ = 10kΩ, C$_L$ = 30pF

0V
V$_{IN}$
V$_{OUT}$
0V

1V/div
500mV/div

Time (1µs/div)

Negative Over-Voltage Recovery

G = -10, R$_L$ = 10kΩ, C$_L$ = 30pF

V$_{IN}$
0V
0V
V$_{OUT}$

500mV/div
1V/div

Time (1µs/div)

Turn-On Time

G = +1, R$_L$ = 10kΩ, C$_L$ = 30pF

V$_S$
0V
V$_{OUT}$
0V

2V/div
1V/div

Time (20µs/div)
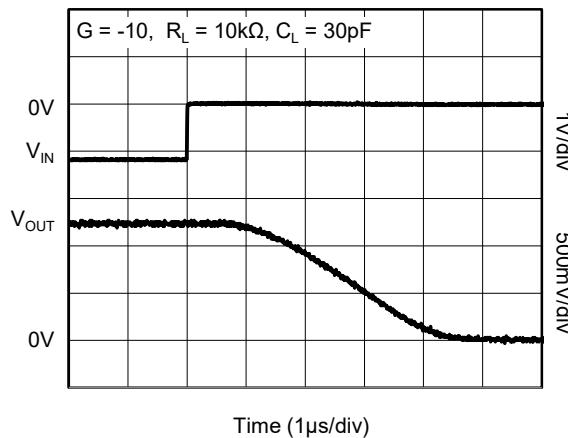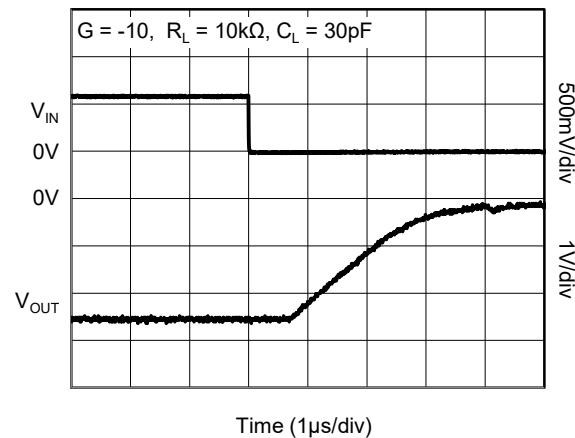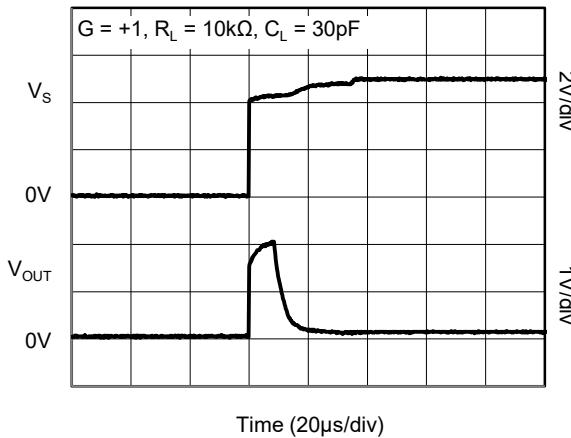
Settling Time vs. Closed-Loop Gain

V$_S$ = 5V, V$_{OUT}$ = 100mV$_{P-P}$, R$_L$ = 10kΩ

Setting Time (µs)

0.1%

Closed-Loop Gain
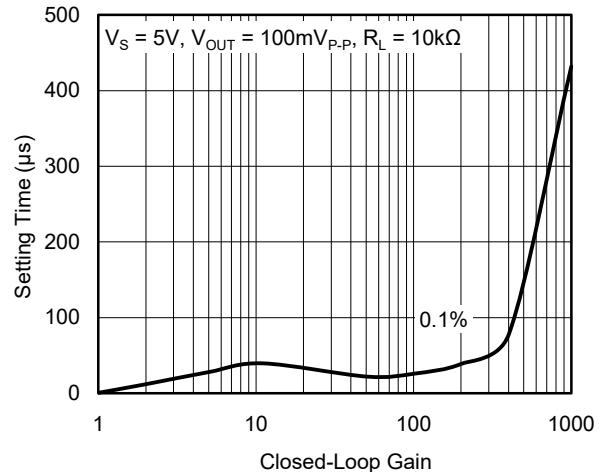
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, unless otherwise noted.

0.1Hz to 10Hz Noise
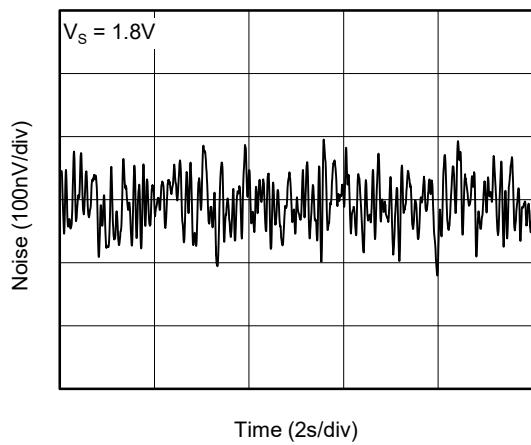
Offset Voltage Production Distribution
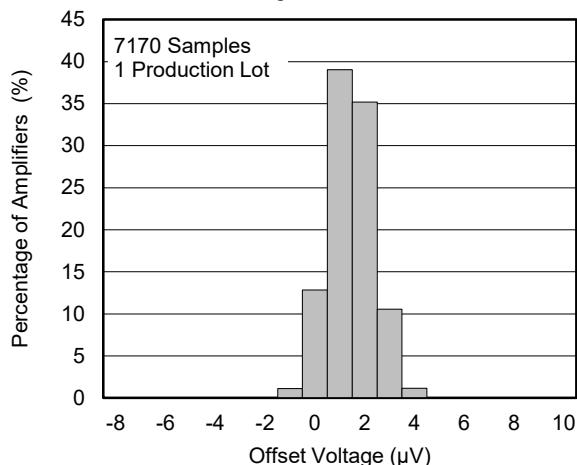
Input Voltage Noise Density vs. Frequency
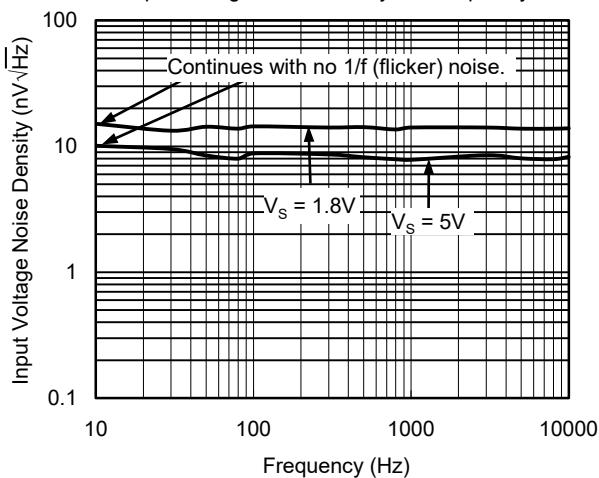
REVISION HISTORY

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

Changes from Original (DECEMBER 2016) to REV.A   **Page**

Changed from product preview to production data ....All

PACKAGE OUTLINE DIMENSIONS

SOT-23-5
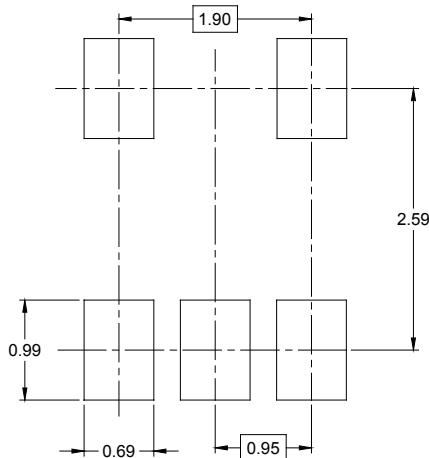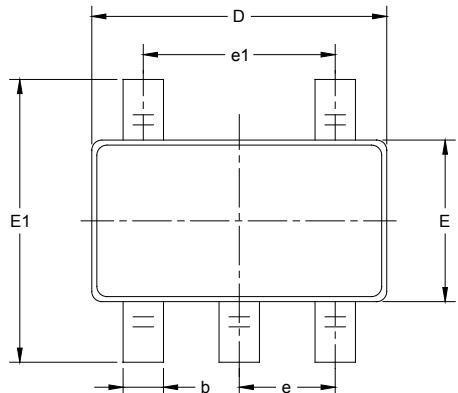
RECOMMENDED LAND PATTERN (Unit: mm)
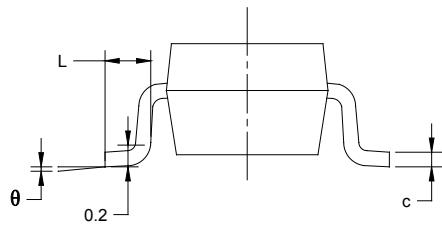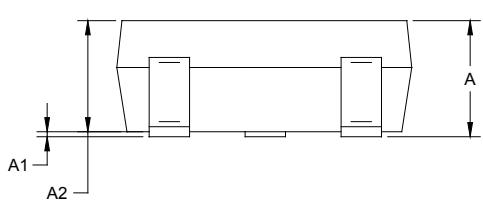
| Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	**MAX**	**MIN**	**MAX**
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 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°

PACKAGE OUTLINE DIMENSIONS

SC70-5
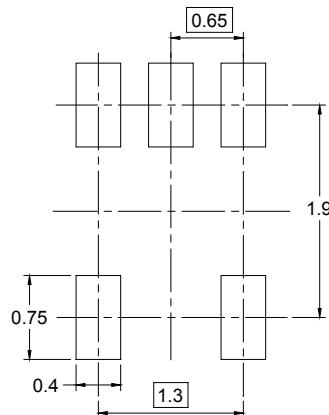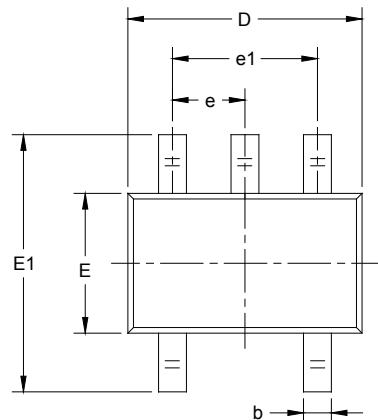
RECOMMENDED LAND PATTERN (Unit: mm)
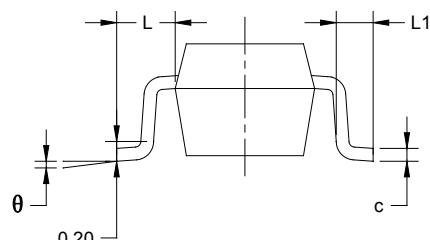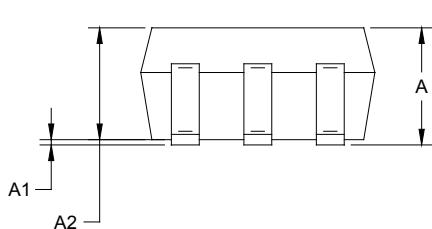
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026 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)
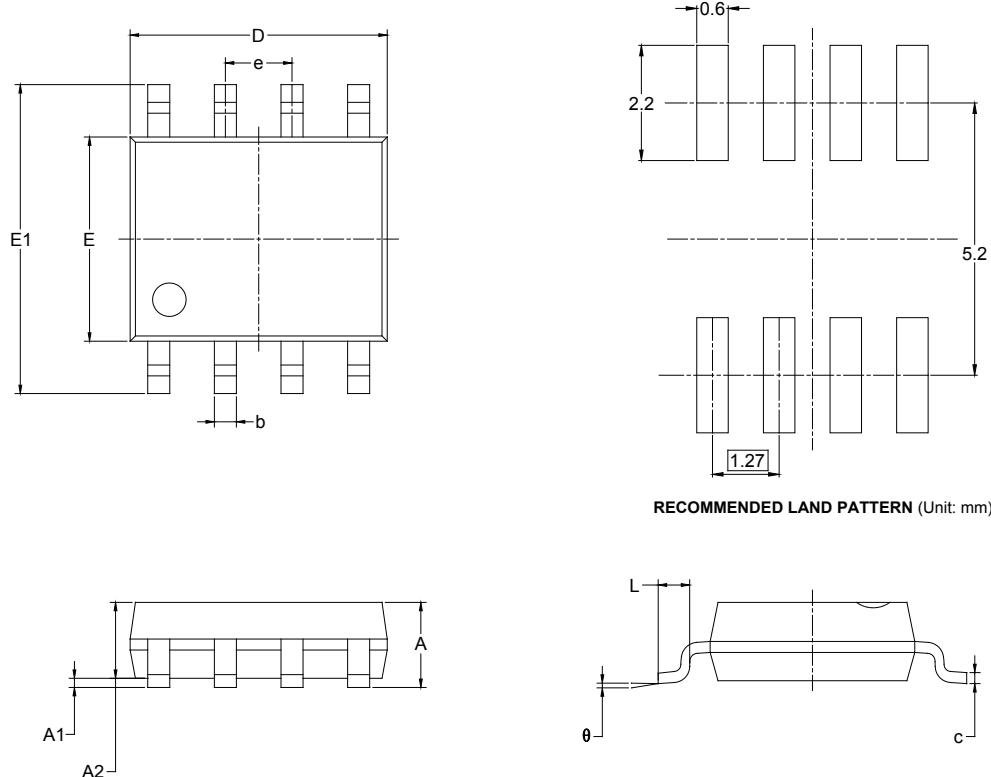
| Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

PACKAGE OUTLINE DIMENSIONS

TDFN-3×3-8L

TOP VIEW

BOTTOM VIEW

SIDE VIEW

RECOMMENDED LAND PATTERN (Unit: mm)
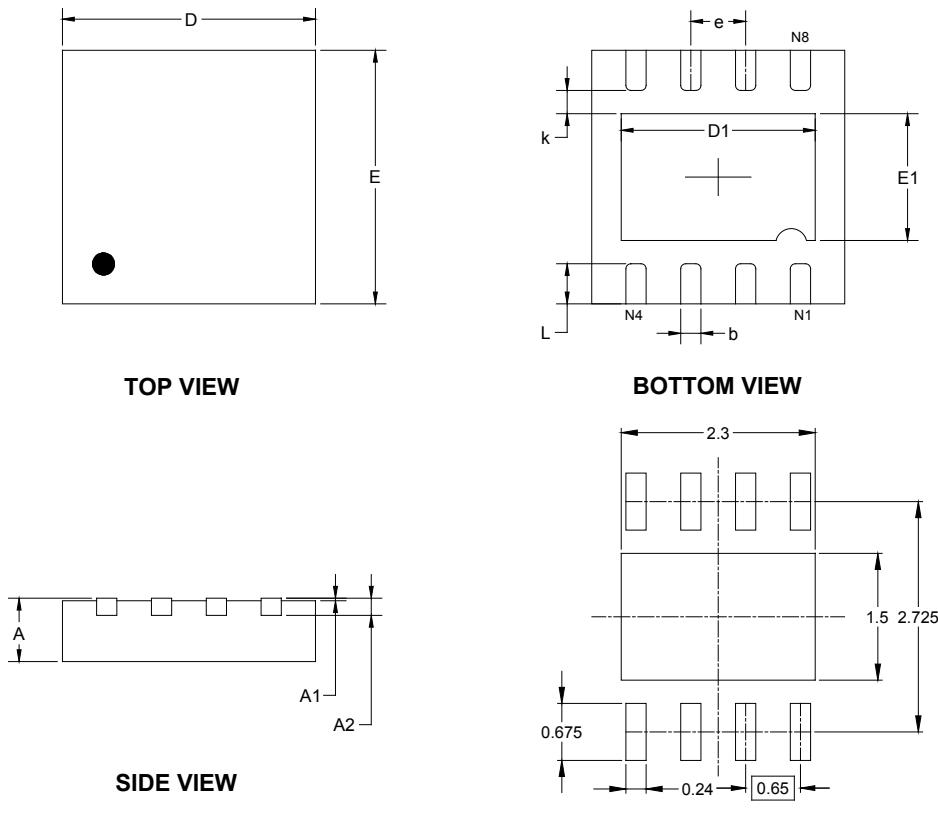
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	2.200	2.400	0.087	0.094
E	2.900	3.100	0.114	0.122
E1	1.400	1.600	0.055	0.063
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	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
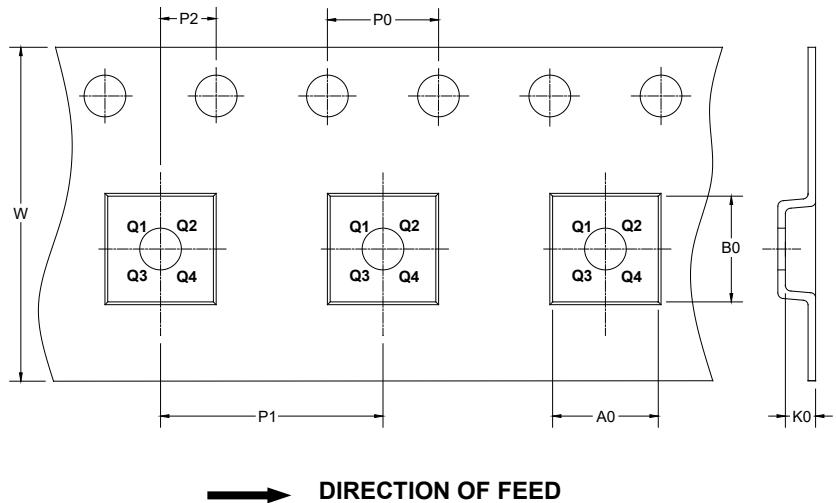
DIRECTION OF FEED

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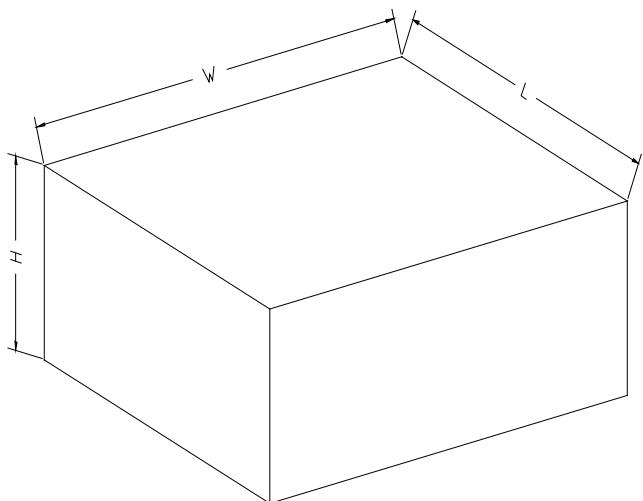
NOTE: The picture is only for reference. Please make the object as the standard.

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