# SGM8543
# 1.1MHz, 48μA, Rail-to-Rail I/O, CMOS Operational Amplifier with Shutdown

## GENERAL DESCRIPTION

The SGM8543 (single with shutdown) is a low cost, voltage feedback amplifier. The device can operate from 2.1V to 5.5V single supply, while consuming only 48μA quiescent current. It provides rail-to-rail input with a wide input common mode voltage range and rail-to-rail output voltage swing. This feature makes SGM8543 appropriate for buffering ASIC.

The SGM8543 offers a gain-bandwidth product of 1.1MHz and an ultra-low input bias current of 0.5pA. It is well suited for piezoelectric sensors, integrators and photodiode amplifiers.

The SGM8543 is designed into a wide range of applications, such as battery-powered instrumentation, safety monitoring, portable systems, and transducer interface circuits in low power systems.

The SGM8543 is available in Green SOIC-8 and SOT-23-6 packages. It is specified over the extended -40℃ to +125℃ temperature range.

## FEATURES

- **Low Cost**
- **Input Offset Voltage: 3.5mV (MAX)**
- **Ultra-Low Input Bias Current: 0.5pA**
- **Unity-Gain Stable**
- **Gain-Bandwidth Product: 1.1MHz**
- **Rail-to-Rail Input and Output**
- **Supply Voltage Range: 2.1V to 5.5V**
- **Input Voltage Range:**
  **-0.1V to 5.6V with $V_S$ = 5.5V**
- **Low Supply Current: 48μA**
  **Supply Current is 10nA When Disabled**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in Green SOT-23-6 and SOIC-8 Packages**

## APPLICATIONS

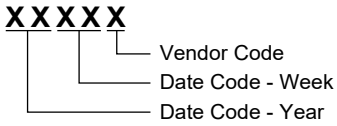
ASIC Input or Output Amplifiers
Piezoelectric Transducer Amplifiers
Battery-Powered Equipment
Portable Equipment
Sensor Interfaces
Medical Instrumentation
Mobile Communications
Audio Outputs
Smoke Detectors
Mobile Telephones
PCMCIA Cards

# PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---|---|---|---|---|---|
| SGM8543 | SOT-23-6 | -40℃ to +125℃ | SGM8543XN6/TR | 8543 | Tape and Reel, 3000 |
| | SOIC-8 | -40℃ to +125℃ | SGM8543XS/TR | SGM8543XS<br>XXXXX | Tape and Reel, 2500 |

## MARKING INFORMATION

NOTE: XXXXX = Date Code and Vendor Code.




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, $+V_S$ to $-V_S$ ..... 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 ..... 3000V
MM ..... 400V

## RECOMMENDED OPERATING CONDITIONS

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.

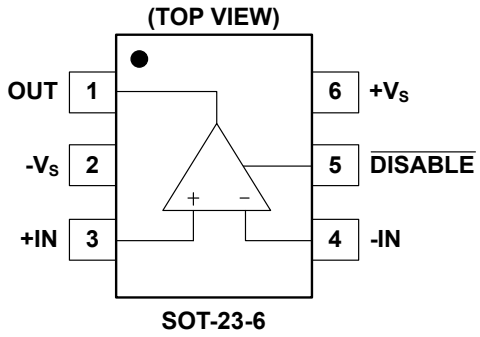
## ESD SENSITIVITY CAUTION

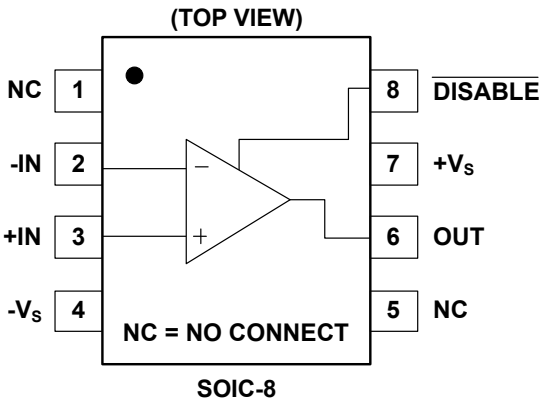
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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



## ELECTRICAL CHARACTERISTICS

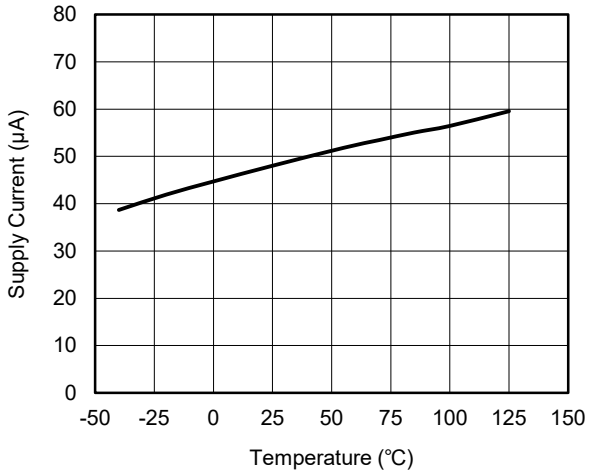
(At $V_S$ = 5V, $R_L$ = 100kΩ connected to $V_S$/2 and $V_{OUT}$ = $V_S$/2, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | TYP | MIN/MAX OVER TEMPERATURE | | | |
|---|---|---|---|---|---|---|---|
| | | | +25℃ | +25℃ | -40℃ to +125℃ | UNITS | MIN/MAX |
| **Input Characteristics** | | | | | | | |
| Input Offset Voltage | $V_{OS}$ | $V_{CM}$ = $V_S$/2 | 0.8 | 3.5 | 8.6 | mV | MAX |
| Input Bias Current | $I_B$ | | 0.5 | | | pA | TYP |
| Input Offset Current | $I_{OS}$ | | 0.5 | | | pA | TYP |
| Logic Low Voltage | $V_{IL}$ | | | 0.8 | | V | MAX |
| Logic High Voltage | $V_{IH}$ | | | 2 | | V | MIN |
| Input Common Mode Voltage Range | $V_{CM}$ | $V_S$ = 5.5V | -0.1 to 5.6 | | | V | TYP |
| Common Mode Rejection Ratio | CMRR | $V_S$ = 5.5V, $V_{CM}$ = -0.1V to 4V | 88 | 71 | 62 | dB | MIN |
| | | $V_S$ = 5.5V, $V_{CM}$ = -0.1V to 5.6V | 76 | 60 | 58 | | |
| Open-Loop Voltage Gain | $A_{OL}$ | $R_L$ = 5kΩ, $V_{OUT}$ = 0.1V to 4.9V | 100 | 80 | 75 | dB | MIN |
| | | $R_L$ = 100kΩ, $V_{OUT}$ = 0.035V to 4.965V | 105 | 85 | 76 | | |
| Input Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | | 2.7 | | | μV/℃ | TYP |
| **Output Characteristics** | | | | | | | |
| Output Voltage Swing | $V_{OH}$ | $R_L$ = 100kΩ | 4.997 | 4.980 | 4.970 | V | MIN |
| | $V_{OL}$ | $R_L$ = 100kΩ | 5 | 20 | 30 | mV | MAX |
| | $V_{OH}$ | $R_L$ = 10kΩ | 4.992 | 4.970 | 4.960 | V | MIN |
| | $V_{OL}$ | $R_L$ = 10kΩ | 8 | 30 | 40 | mV | MAX |
| Output Current | $I_{SOURCE}$ | $R_L$ = 10Ω to $V_S$/2 | 84 | 60 | 45 | mA | MIN |
| | $I_{SINK}$ | | 75 | 60 | 45 | | |
| **Power Supply** | | | | | | | |
| Operating Voltage Range | | | | 2.1 | 2.5 | V | MIN |
| | | | | 5.5 | 5.5 | V | MAX |
| Power Supply Rejection Ratio | PSRR | $V_S$ = 2.5V to 5.5V, $V_{CM}$ = 0.5V | 86 | 70 | 67 | dB | MIN |
| Quiescent Current | $I_Q$ | | 48 | 69 | 84 | μA | MAX |
| Supply Current when Disabled | $I_{SD}$ | $\overline{DISABLE}$ = $V_{IL}$ | 10 | 3000 | | nA | MAX |
| **Dynamic Performance** ($C_L$ = 100pF) | | | | | | | |
| Gain-Bandwidth Product | GBP | | 1.1 | | | MHz | TYP |
| Slew Rate | SR | G = +1, 2V Output Step | 0.52 | | | V/μs | TYP |
| Settling Time to 0.1% | $t_S$ | G = +1, 2V Output Step | 5.3 | | | μs | TYP |
| Overload Recovery Time | | $V_{IN}$ ·G = $V_S$ | 2.6 | | | μs | TYP |
| **Noise Performance** | | | | | | | |
| Input Voltage Noise Density | $e_n$ | f = 1kHz | 27 | | | nV/$\sqrt{Hz}$ | TYP |
| | | f = 10kHz | 20 | | | nV/$\sqrt{Hz}$ | TYP |

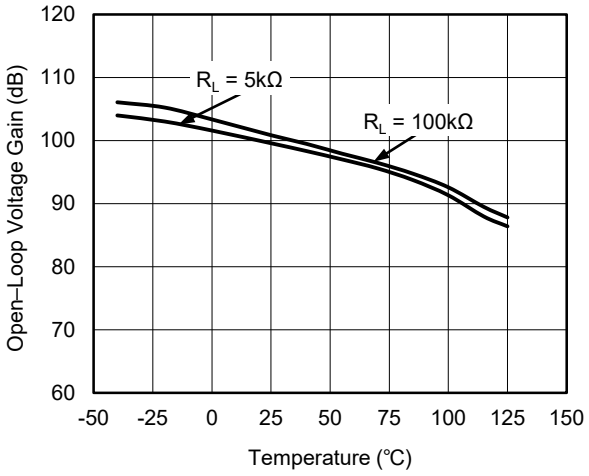
## TYPICAL PERFORMANCE CHARACTERISTICS

At $T_A$ = +25℃, $V_S$ = 5V, and $R_L$ = 100kΩ connected to $V_S$/2, unless otherwise noted.

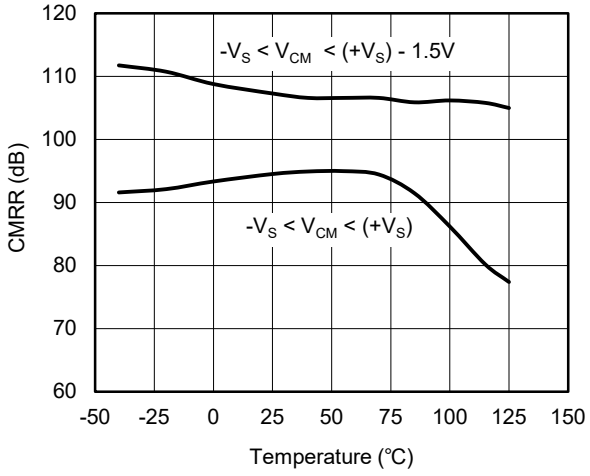
Supply Current vs. Temperature



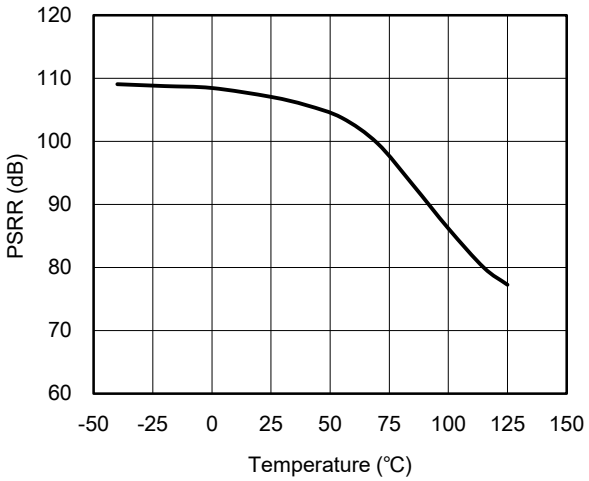

Open-Loop Voltage Gain vs. Temperature



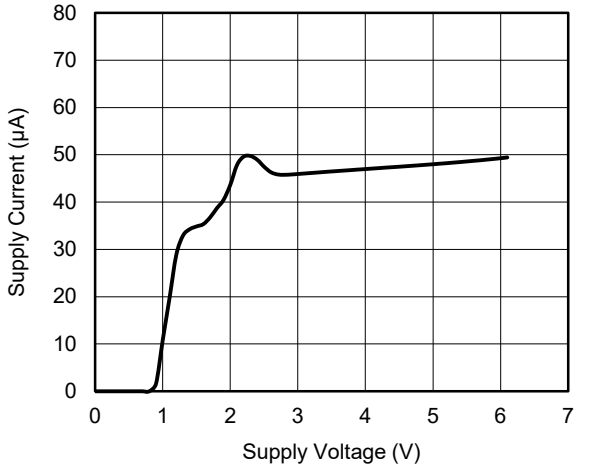

Common Mode Rejection Ratio vs. Temperature



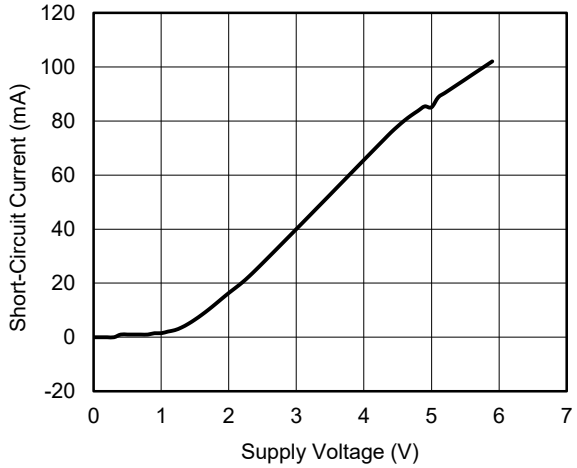

Power Supply Rejection Ratio vs. Temperature




Supply Current vs. Supply Voltage



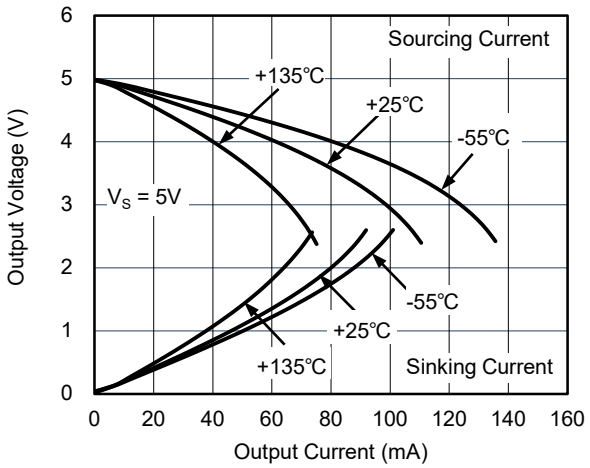

Short-Circuit Current vs. Supply Voltage



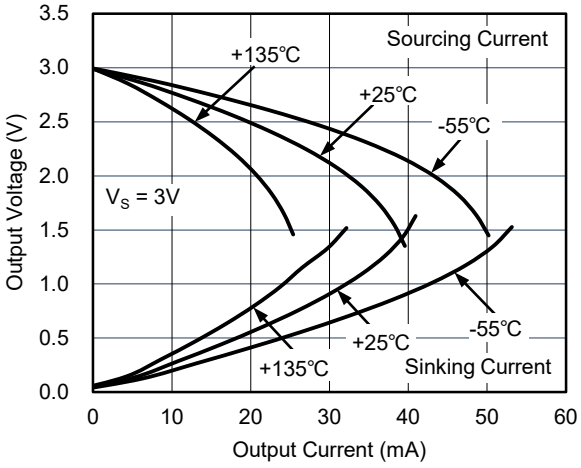
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A$ = +25℃, $V_S$ = 5V, and $R_L$ = 100kΩ connected to $V_S$/2, unless otherwise noted.

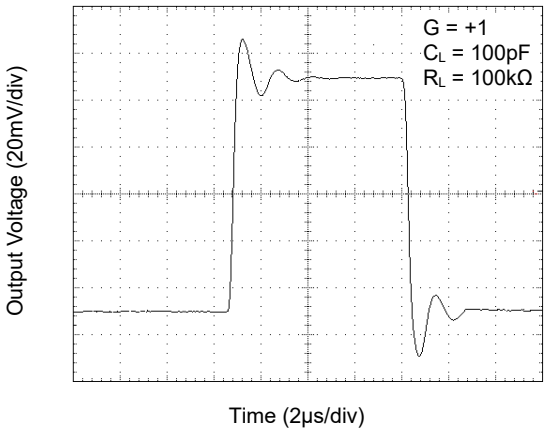
Output Voltage Swing vs. Output Current



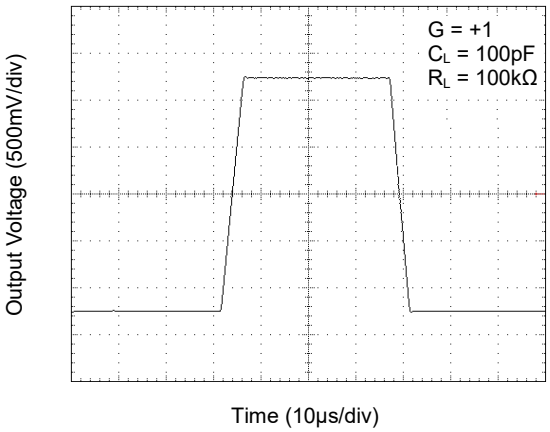

Output Voltage Swing vs. Output Current



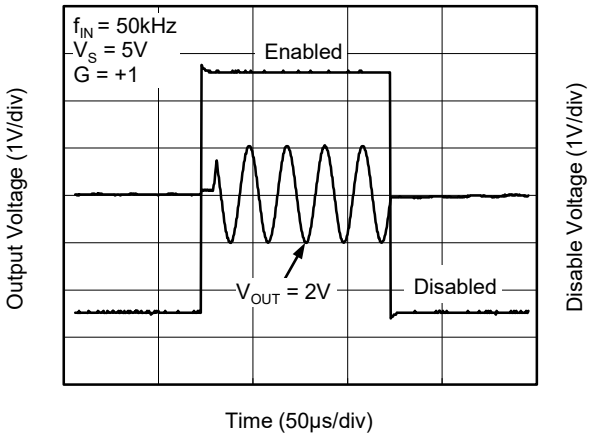

Small-Signal Step Response



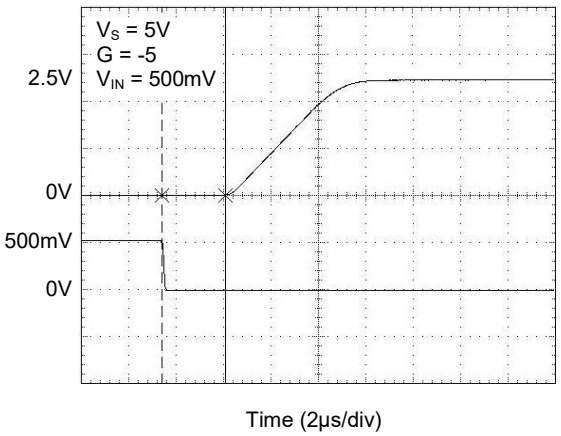

Large-Signal Step Response




Small-Signal Disable/Enable Response



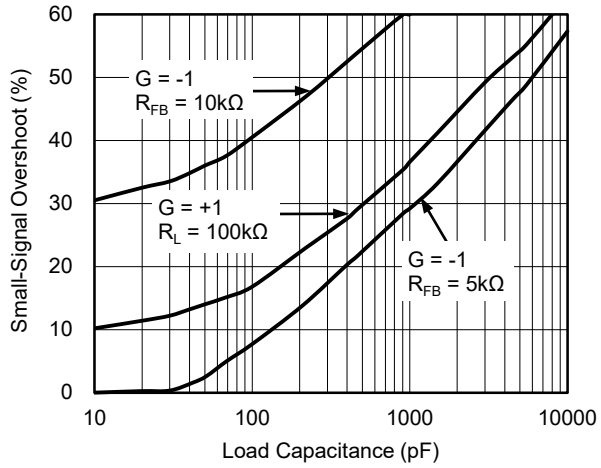

Overload Recovery Time



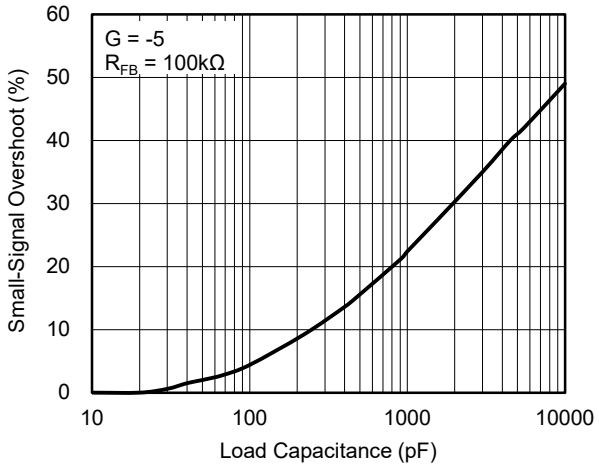
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A$ = +25℃, $V_S$ = 5V, and $R_L$ = 100kΩ connected to $V_S$/2, unless otherwise noted.

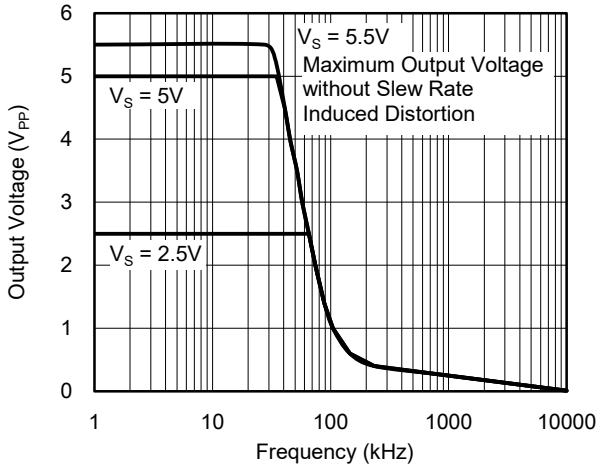
Small-Signal Overshoot vs. Load Capacitance



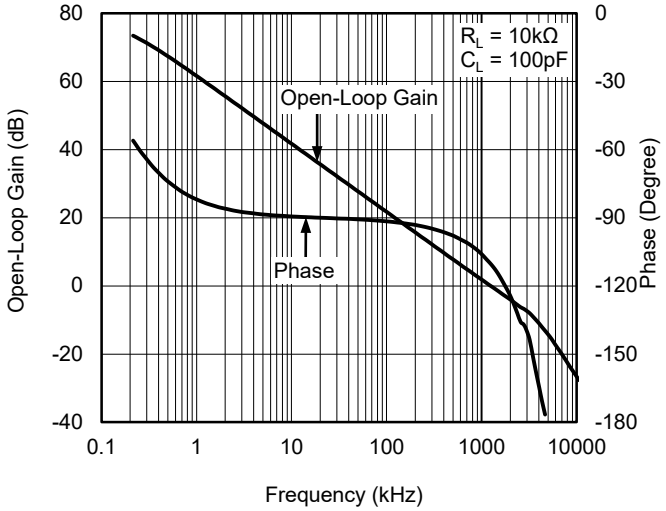

Small-Signal Overshoot vs. Load Capacitance



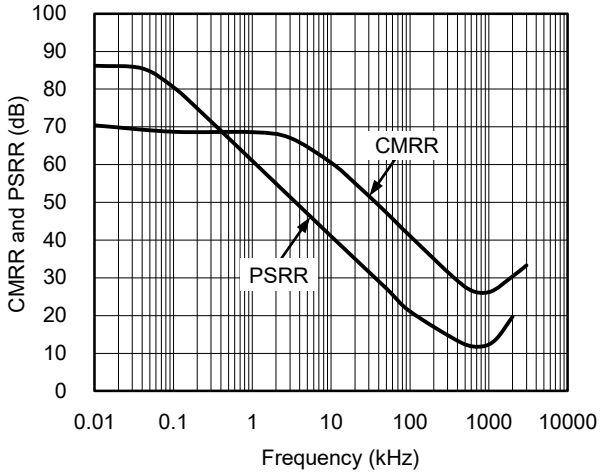

Maximum Output Voltage vs. Frequency



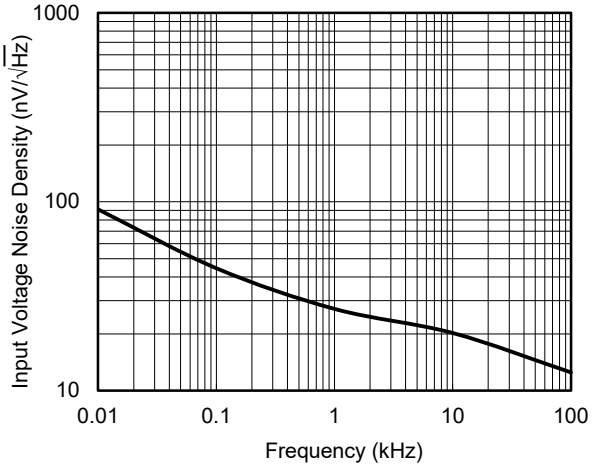

Open-Loop Gain and Phase vs. Frequency




CMRR and PSRR vs. Frequency

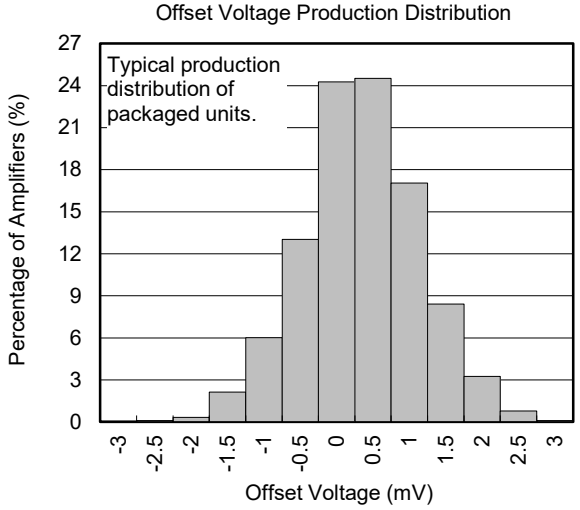



Input Voltage Noise Density vs. Frequency



## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A$ = +25℃, $V_S$ = 5V, and $R_L$ = 100kΩ connected to $V_S$/2, unless otherwise noted.



# APPLICATION INFORMATION

## Rail-to-Rail Input

When SGM8543 works at the power supply between 2.1V 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.

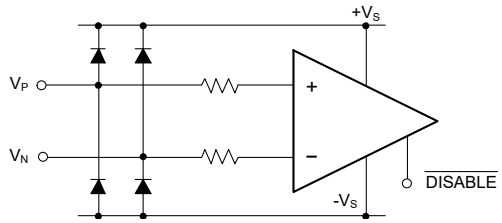



**Figure 1. Input Equivalent Circuit**

## Rail-to-Rail Output

The SGM8543 supports rail-to-rail output operation. In single power supply application, for example, when $+V_S$ = 5V, $-V_S$ = GND, 100kΩ load resistor is tied from OUT pin to $V_S$/2, the typical output swing range is from 0.005V to 4.997V.

## Driving Capacitive Loads

The SGM8543 is designed for unity-gain stable for capacitive load up to 250pF. If greater capacitive load must be driven in application, the circuit in Figure 2 can be used. In this circuit, the IR drop voltage generated by $R_{ISO}$ is compensated by feedback loop.

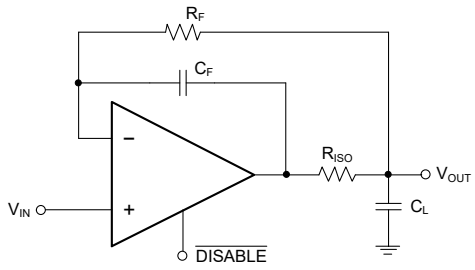



**Figure 2. Circuit to Drive Heavy Capacitive Load**

## 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 amplifier 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 3. The ceramic capacitors should be placed as close as possible to $+V_S$ and $-V_S$ power supply pins.

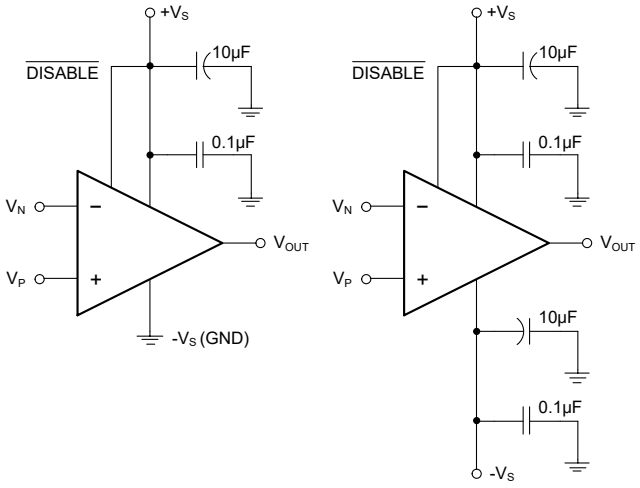



**Figure 3. Amplifier Power Supply Bypassing**

# APPLICATION INFORMATION (continued)

## Typical Application Circuits

### Difference Amplifier

The circuit in Figure 4 is a design example of classical difference amplifier. If $R_4/R_3 = R_2/R_1$, then $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$.

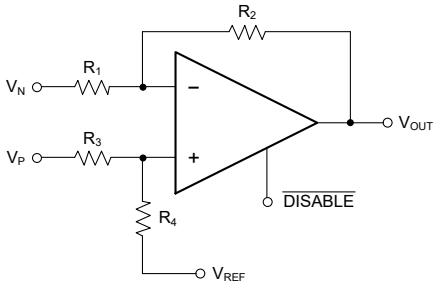



**Figure 4. Difference Amplifier**

### High Input Impedance Difference Amplifier

The circuit in Figure 5 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 4.

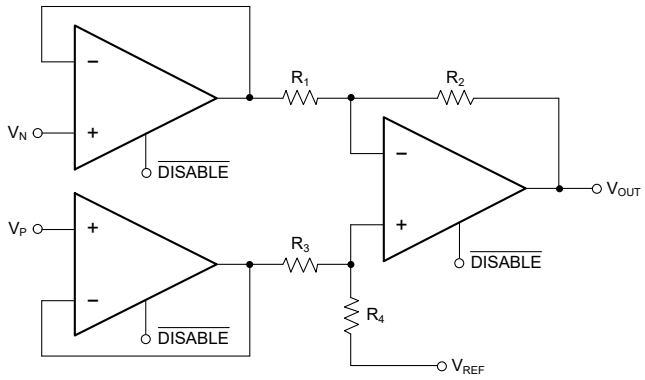



**Figure 5. High Input Impedance Difference Amplifier**

### Active Low-Pass Filter

The circuit in Figure 6 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.

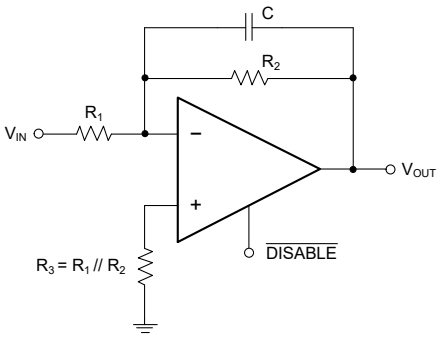



**Figure 6. Active Low-Pass Filter**

# REVISION HISTORY

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

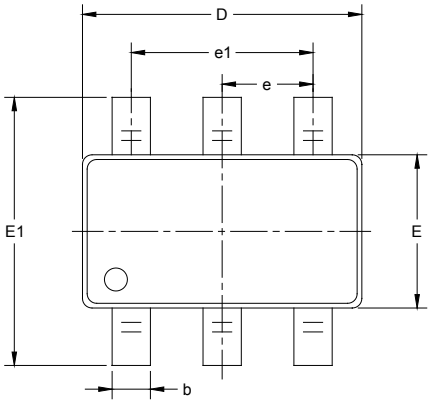
| NOVEMBER 2018 – REV.A.1 to REV.A.2 | Page |
|---|---|
| Added Open-Loop Gain and Phase vs. Frequency | 7 |

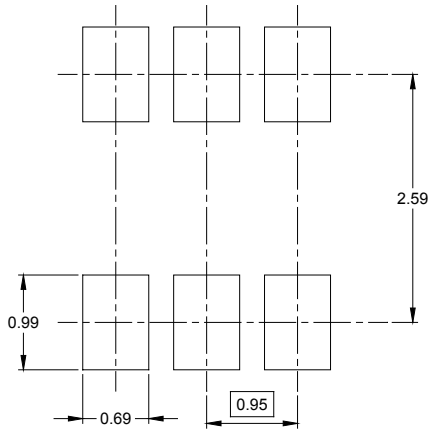
| JANUARY 2013 – REV.A to REV.A.1 | Page |
|---|---|
| Added Tape and Reel Information | 11, 12 |

| Changes from Original (NOVEMBER 2011) to REV.A | Page |
|---|---|
| Changed from product preview to production data | All |

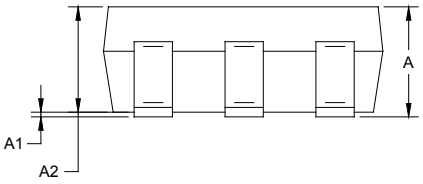
# PACKAGE OUTLINE DIMENSIONS

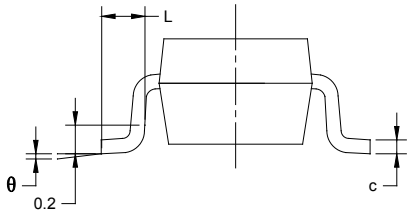
## SOT-23-6




**RECOMMENDED LAND PATTERN** (Unit: mm)

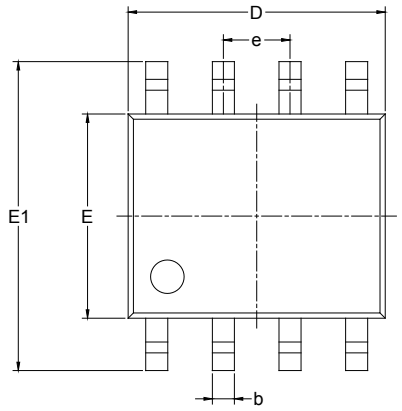


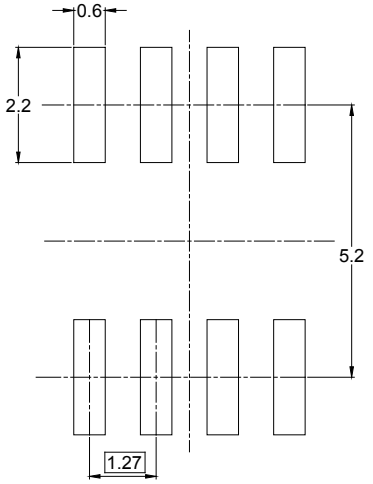




| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| 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° |

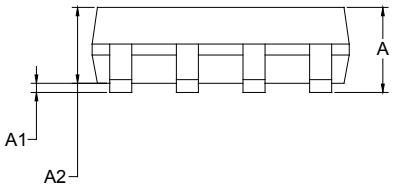
# PACKAGE OUTLINE DIMENSIONS

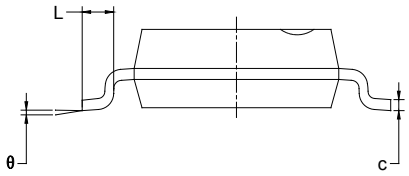
## SOIC-8




**RECOMMENDED LAND PATTERN** (Unit: mm)

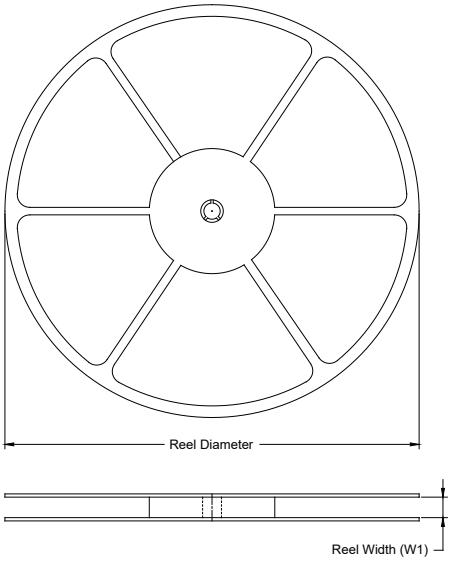


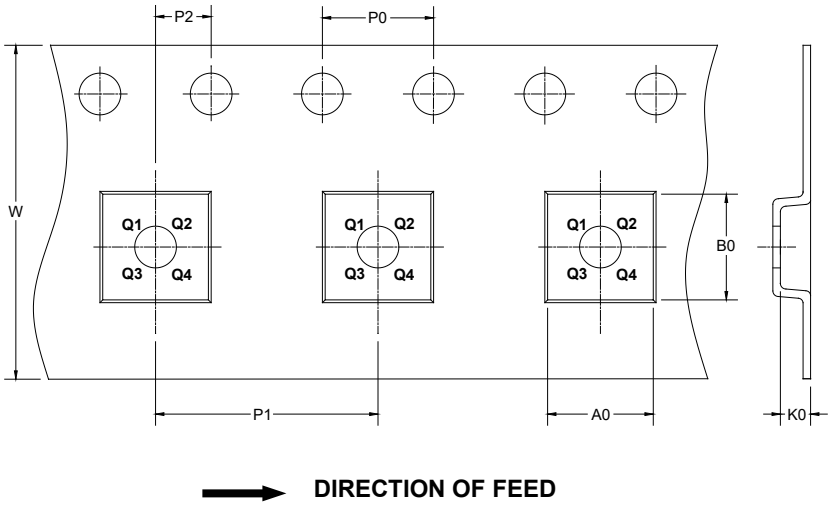

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.006 | 0.010 |
| 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° |

# 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-23-6 | 7″ | 9.5 | 3.17 | 3.23 | 1.37 | 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 |

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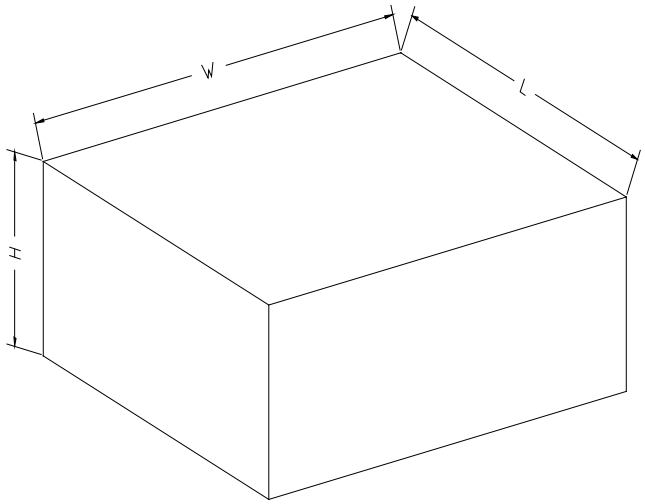
## CARTON BOX DIMENSIONS




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 |

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