



SGM722Q

Automotive, 11MHz, Rail-to-Rail I/O CMOS Operational Amplifier

GENERAL DESCRIPTION

The SGM722Q is a dual, low voltage, low noise and low power operational amplifier for automotive applications. This device can operate from 2.1V to 5.5V single supply, and consumes low quiescent current.

The SGM722Q features a $\pm 6.5\text{mV}$ maximum input offset voltage. The minimum input common mode voltage is within 0.1V below the negative rail, and the output swing is rail-to-rail with heavy loads. It exhibits a high gain-bandwidth product of 11MHz and a slew rate of $6\text{V}/\mu\text{s}$. These specifications make the operational amplifier appropriate for various applications.

The device is AEC-Q100 qualified (Automotive Electronics Council (AEC) standard Q100 Grade 1) and it is suitable for automotive applications.

The SGM722Q is available in Green SOIC-8 and MSOP-8 packages. It operates over an ambient temperature range of -40°C to $+125^{\circ}\text{C}$.

FEATURES

- AEC-Q100 Qualified for Automotive Applications
Device Temperature Grade 1
 $T_A = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
- Input Offset Voltage: $\pm 6.5\text{mV}$ (MAX)
- High Gain-Bandwidth Product: 11MHz
- High Slew Rate: $6\text{V}/\mu\text{s}$
- Settling Time to 0.1%: $0.4\mu\text{s}$
- Overload Recovery Time: $0.8\mu\text{s}$
- Low Noise: $8.5\text{nV}/\sqrt{\text{Hz}}$ at 10kHz
- Rail-to-Rail Input and Output
- Supply Voltage Range: 2.1V to 5.5V
- Input Voltage Range: -0.1V to 5.6V with $V_S = 5.5\text{V}$
- Low Quiescent Current: 1.2mA/Amplifier (TYP)
- Available in Green SOIC-8 and MSOP-8 Packages

APPLICATIONS

Automotive Applications
Sensors
Audio
Active Filters
A/D Converters
Communications
Test Equipment
Cellular and Cordless Phones
Laptops and PDAs
Photodiode Amplification
Battery-Powered Instrumentation

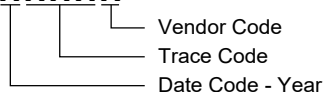
PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---------|---------------------|-----------------------------|-----------------|----------------------|---------------------|
| SGM722Q | SOIC-8 | -40°C to +125°C | SGM722QS8G/TR | 0GNS8 XXXXXX | Tape and Reel, 4000 |
| | MSOP-8 | -40°C to +125°C | SGM722QMS8G/TR | 0GO MS8 XXXXXX | Tape and Reel, 4000 |

MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace Code and Vendor Code.

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, $+V_S$ to $-V_S$ | 6V |
| Input Common Mode Voltage Range | |
| | $(-V_S) - 0.3V$ to $(+V_S) + 0.3V$ |
| Package Thermal Resistance | |
| SOIC-8, θ_{JA} | 168.5°C/W |
| MSOP-8, θ_{JA} | 159.4°C/W |
| Junction Temperature | +150°C |
| Storage Temperature Range | -65°C to +150°C |
| Lead Temperature (Soldering, 10s) | +260°C |
| ESD Susceptibility | |
| HBM | 8000V |
| CDM | 1000V |

RECOMMENDED OPERATING CONDITIONS

| | |
|-----------------------------|-----------------|
| 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.

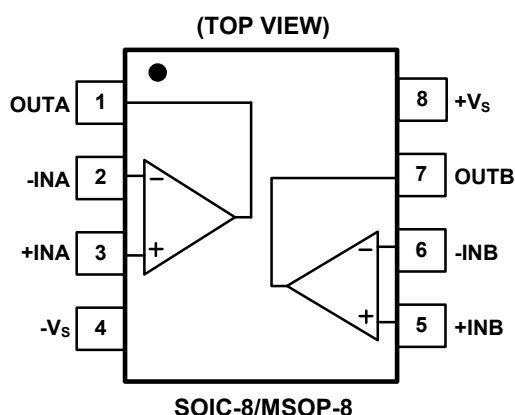
ESD SENSITIVITY CAUTION

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

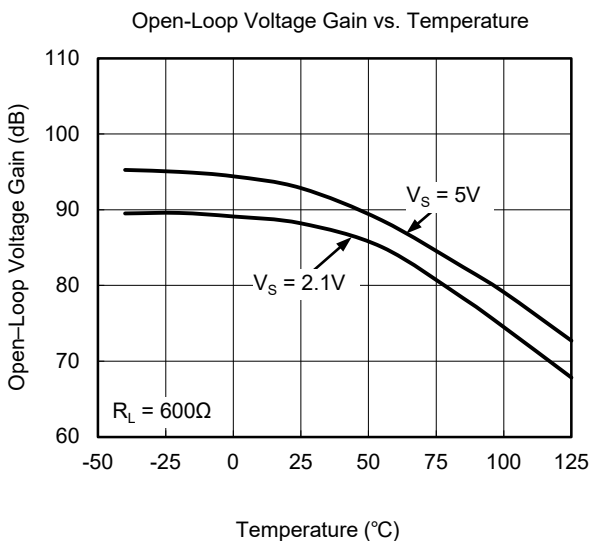
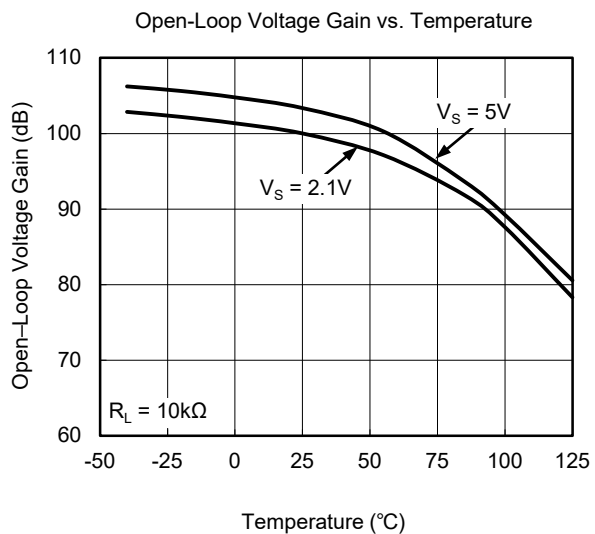
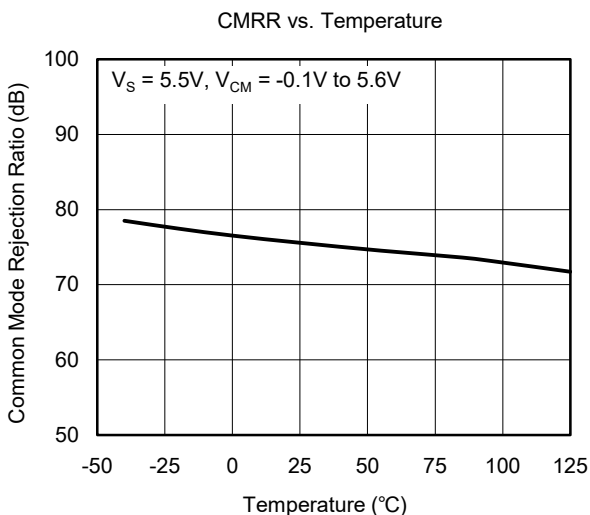
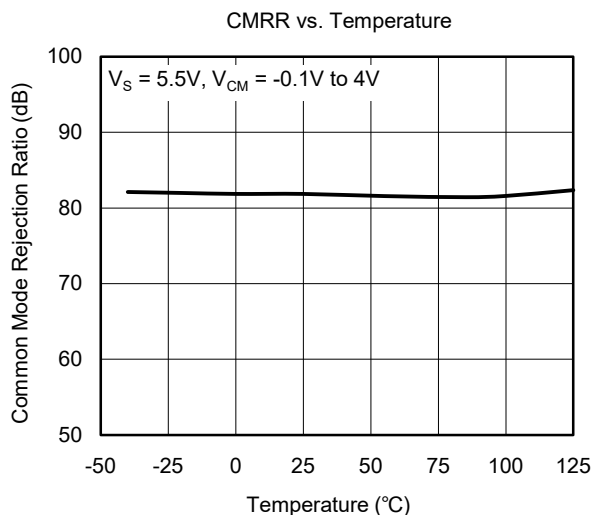
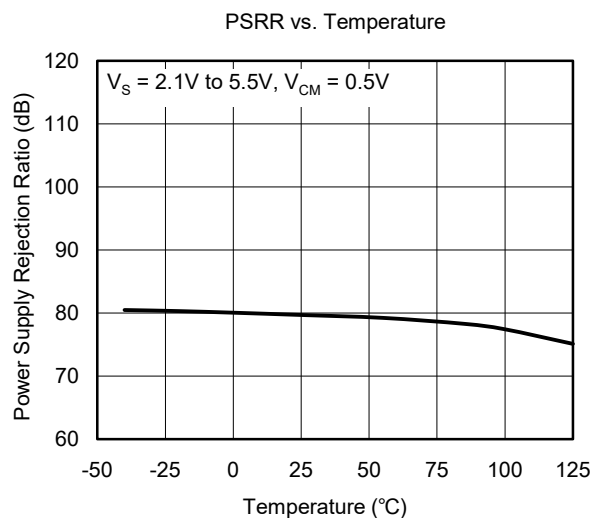
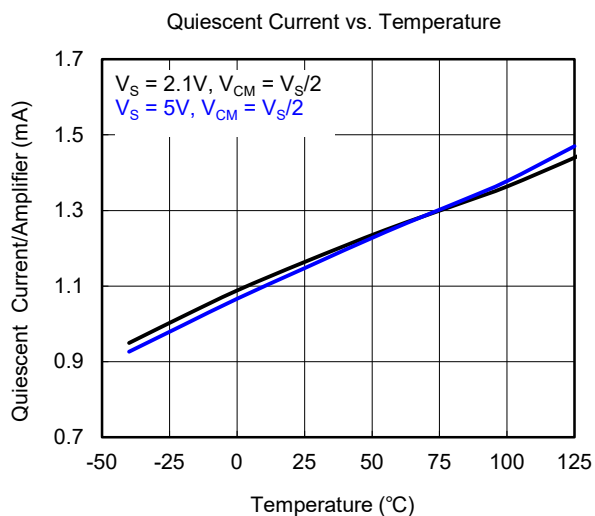


ELECTRICAL CHARACTERISTICS

(At $T_A = +25^\circ\text{C}$, $V_S = 2.1\text{V}$ to 5V , $V_{CM} = V_S/2$ and $R_L = 600\Omega$, unless otherwise noted.)

| PARAMETER | CONDITIONS | TYP | MIN/MAX OVER TEMPERATURE | | | | |
|--|--|-------------|--------------------------|----------------|-----------------|--------|---------|
| | | +25°C | +25°C | -40°C to +85°C | -40°C to +125°C | UNITS | MIN/MAX |
| Input Characteristics | | | | | | | |
| Input Offset Voltage (V _{OS}) | | ±2 | ±5.5 | ±6 | ±6.5 | mV | MAX |
| Input Bias Current (I _B) | | 0.01 | | 1 | 6 | nA | MAX |
| Input Offset Current (I _{OS}) | | 0.01 | | 1 | 3 | nA | MAX |
| 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 = 2.1V, V _{CM} = -0.1V to 2.2V | 67 | 53 | 50 | 46 | dB | MIN |
| | V _S = 5.5V, V _{CM} = -0.1V to 4V | 81 | 66 | 63 | 61 | dB | MIN |
| | V _S = 5.5V, V _{CM} = -0.1V to 5.6V | 75 | 60 | 57 | 55 | dB | MIN |
| Open-Loop Voltage Gain (A _{OL}) | R _L = 600Ω, V _{OUT} = 0.15V to (+V _S) - 0.15V | 86 | 80 | 72 | 62 | dB | MIN |
| | R _L = 10kΩ, V _{OUT} = 0.05V to (+V _S) - 0.15V | 98 | 91 | 80 | 68 | dB | MIN |
| | | | | | | | |
| Input Offset Voltage Drift (ΔV _{OS} /ΔT) | | 5.5 | | | | μV/°C | TYP |
| Output Characteristics | | | | | | | |
| Output Voltage Swing from Rail | R _L = 600Ω | 76 | 100 | 110 | 120 | mV | MAX |
| | R _L = 10kΩ | 6 | 20 | 30 | 40 | mV | MAX |
| Output Current (I _{OUT}) | V _S = 2.1V | ±25 | ±19 | ±15 | ±13 | mA | MIN |
| | V _S = 5V | ±58 | ±48 | ±38 | ±34 | mA | MIN |
| Closed-Loop Output Impedance | f = 1MHz, G = +1 | 9.5 | | | | Ω | TYP |
| Power Supply | | | | | | | |
| Operating Voltage Range | | | | | 2.1 | V | MIN |
| | | | | | 5.5 | V | MAX |
| Power Supply Rejection Ratio (PSRR) | V _S = 2.1V to 5.5V, V _{CM} = (-V _S) + 0.5V | 79 | 67 | 64 | 62 | dB | MIN |
| Quiescent Current/Amplifier (I _Q) | I _{OUT} = 0A | 1.2 | 1.5 | 1.7 | 1.85 | mA | MAX |
| Dynamic Performance | | | | | | | |
| Gain-Bandwidth Product (GBP) | C _L = 50pF | 11 | | | | MHz | TYP |
| Phase Margin (φ _O) | C _L = 50pF | 60 | | | | ° | TYP |
| Full-Power Bandwidth (BW _P) | < 1% distortion, V _{OUT} = 1V _{P-P} | 200 | | | | kHz | TYP |
| Slew Rate (SR) | G = +1 | 6 | | | | V/μs | TYP |
| Settling Time to 0.1% (t _s) | G = +1 | 0.4 | | | | μs | TYP |
| Overload Recovery Time | V _{IN} × G = V _S | 0.8 | | | | μs | TYP |
| Noise Performance | | | | | | | |
| Input Voltage Noise Density (e _n) | f = 1kHz | 12.5 | | | | nV/√Hz | TYP |
| | f = 10kHz | 8.5 | | | | nV/√Hz | TYP |

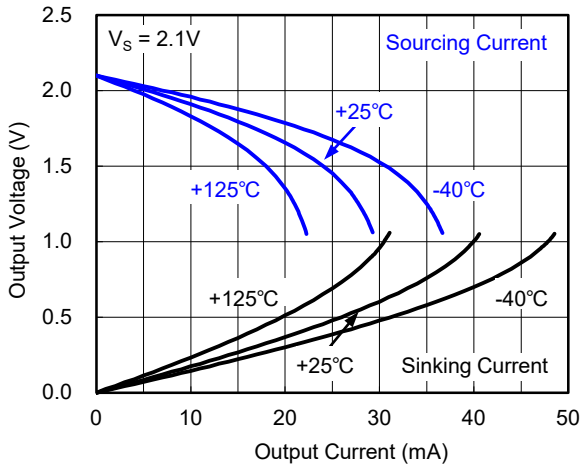
TYPICAL PERFORMANCE CHARACTERISTICS

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

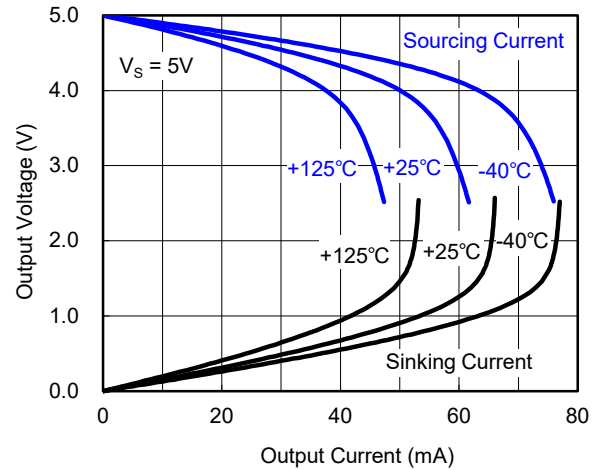
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

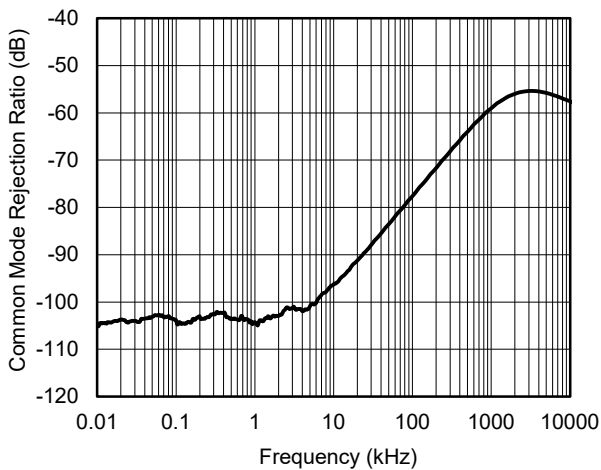
Output Voltage Swing vs. Output Current



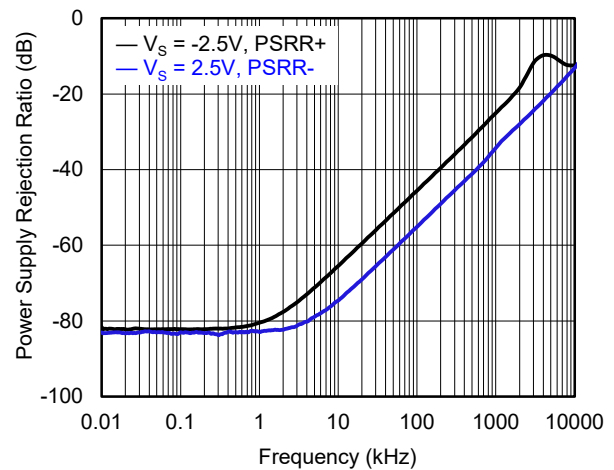
Output Voltage Swing vs. Output Current



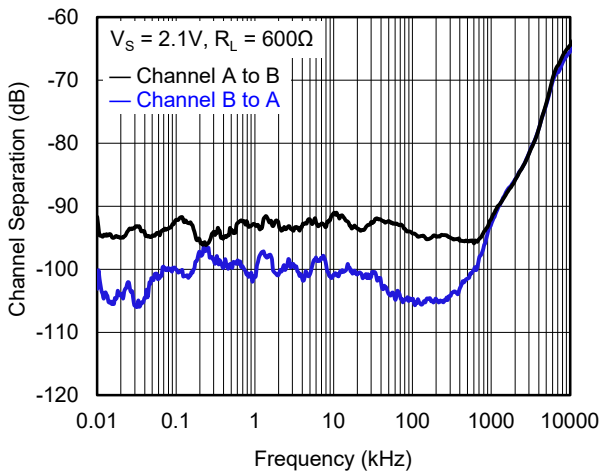
CMRR vs. Frequency



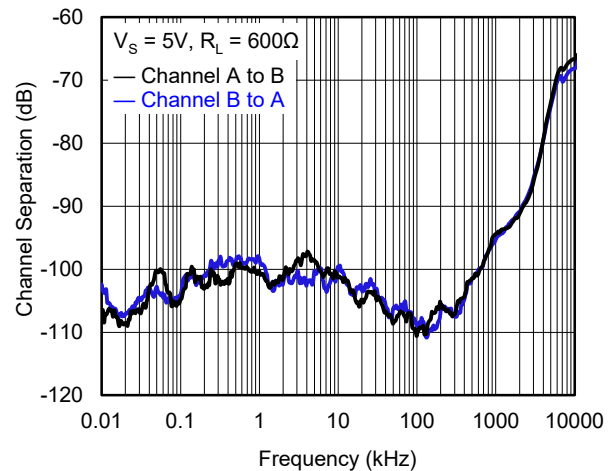
PSRR vs. Frequency



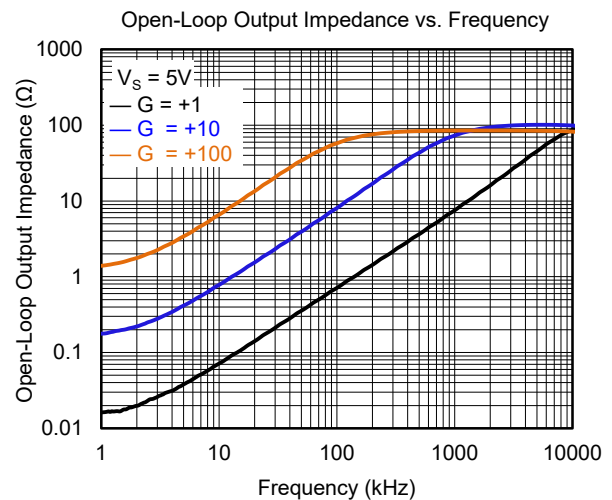
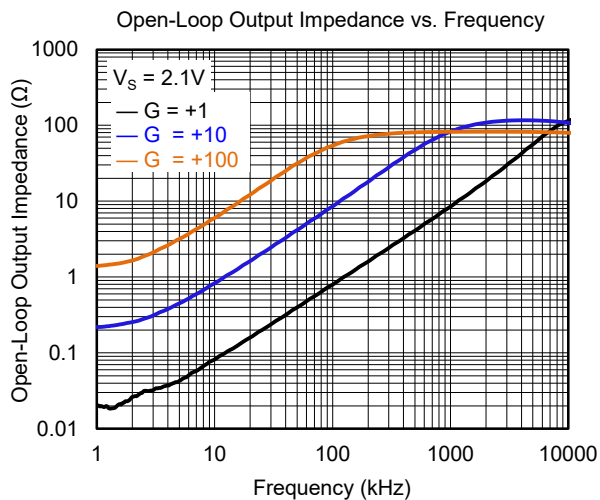
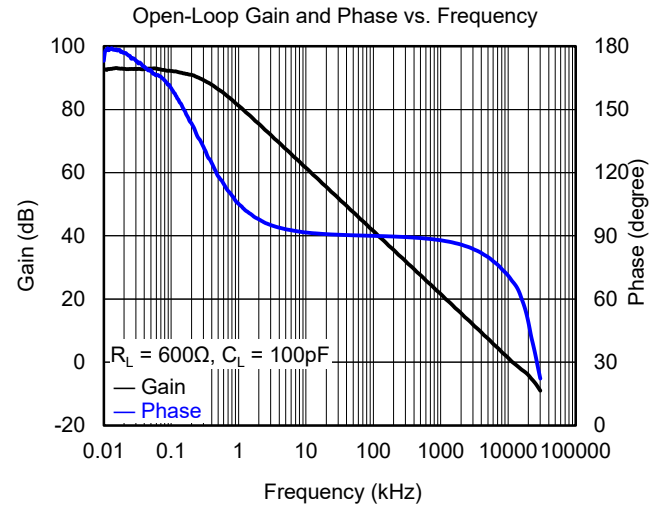
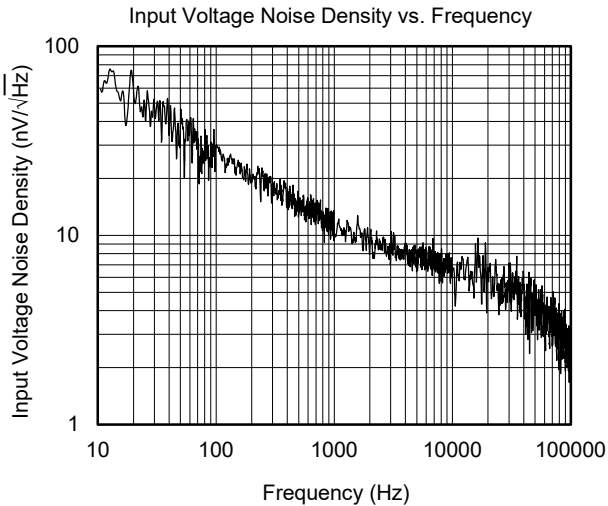
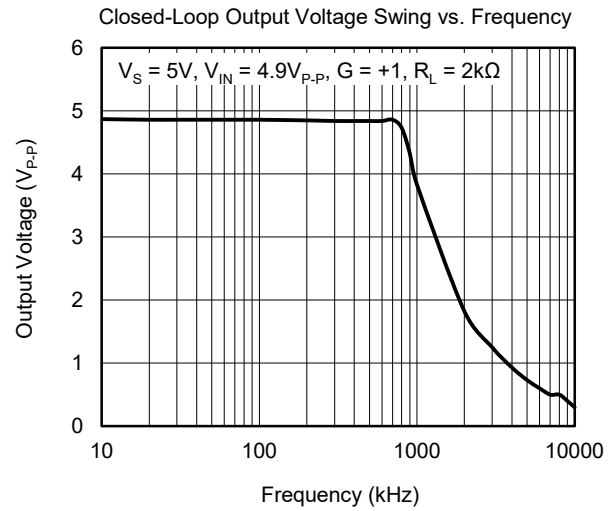
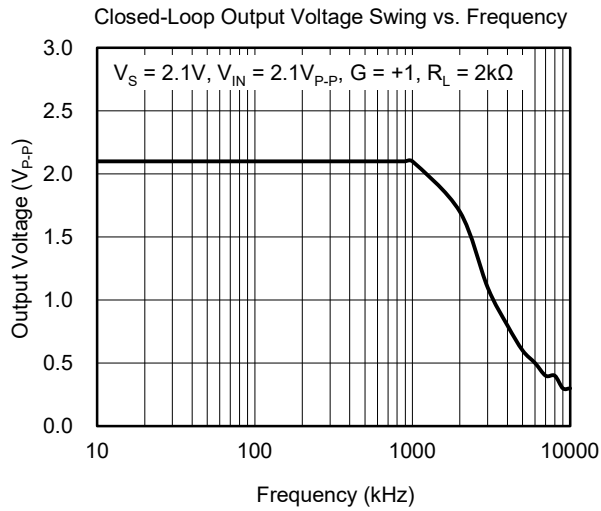
Channel Separation vs. Frequency



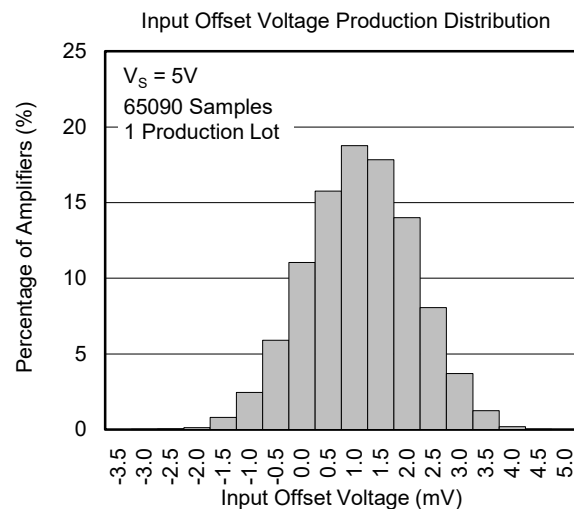
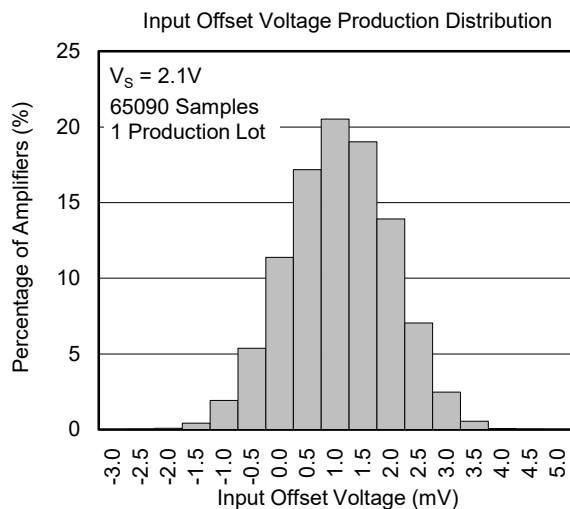
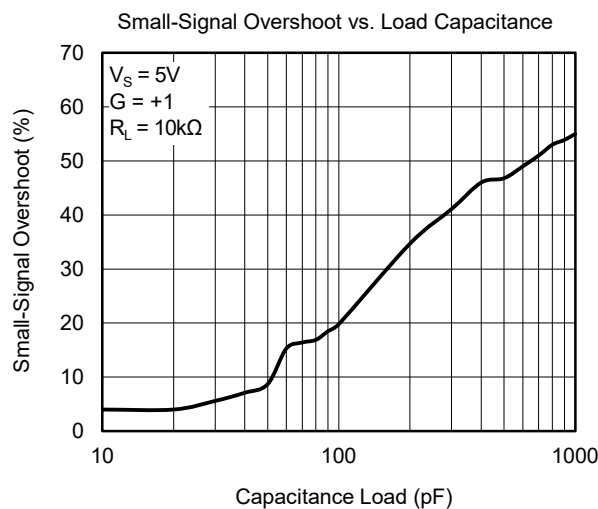
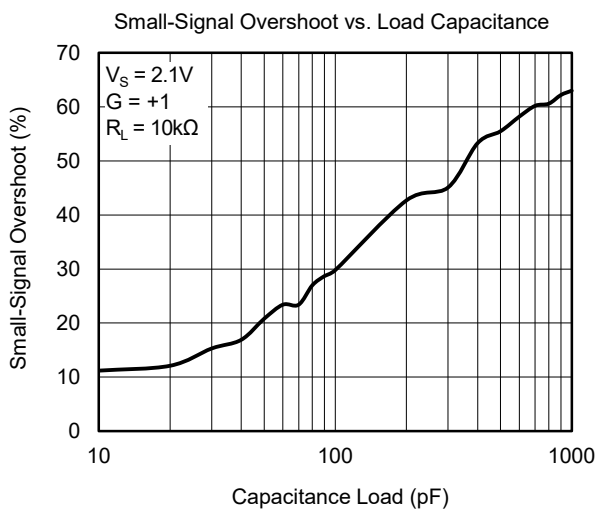
Channel Separation vs. Frequency



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

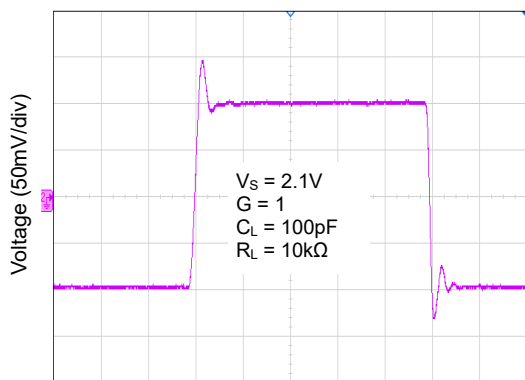
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

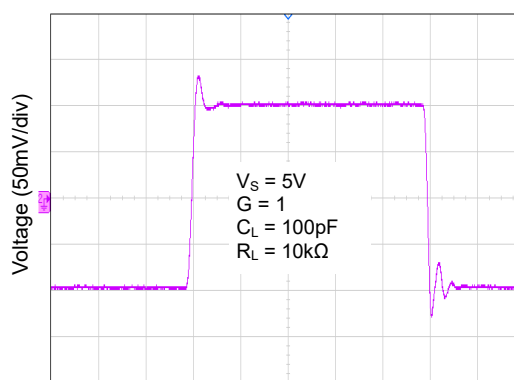
At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, unless otherwise noted.

Small-Signal Step Response



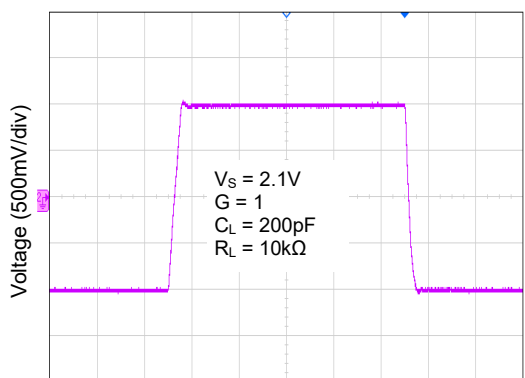
Time (200ns/div)

Small-Signal Step Response



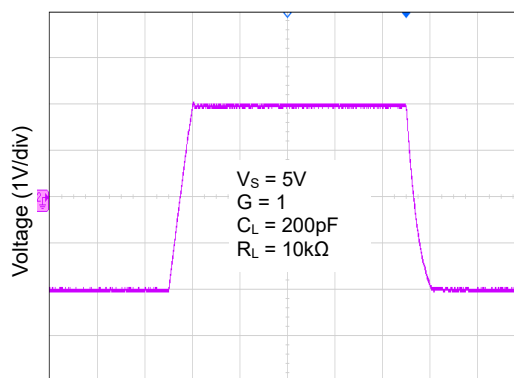
Time (200ns/div)

Large-Signal Step Response



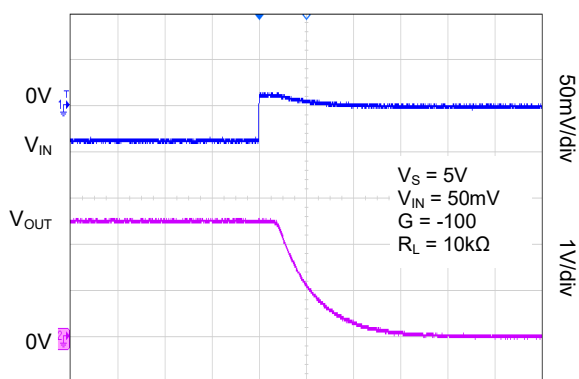
Time (1μs/div)

Large-Signal Step Response



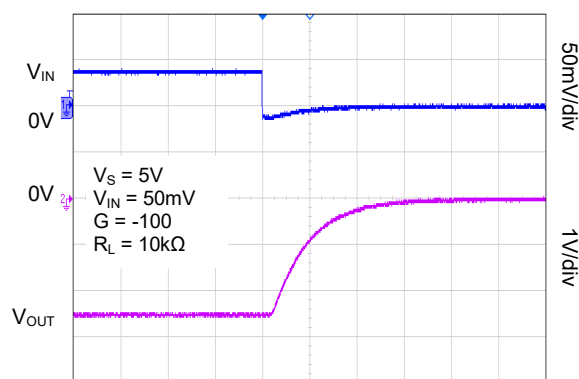
Time (1μs/div)

Positive Overload Recovery



Time (1μs/div)

Negative Overload Recovery



Time (1μs/div)

APPLICATION INFORMATION

Rail-to-Rail Input

When SGM722Q 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 so that it does not exceed the rails.

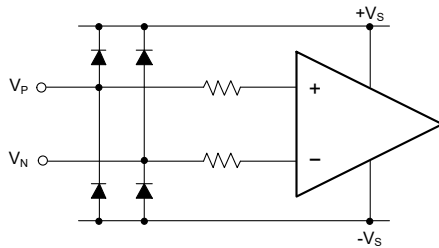


Figure 1. Input Equivalent Circuit

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.

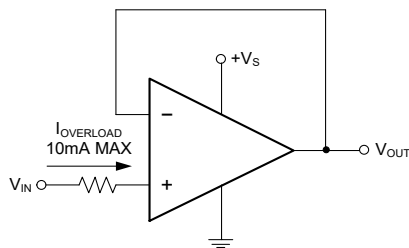


Figure 2. Input Current-Limit Protection

Rail-to-Rail Output

The SGM722Q supports 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 ground, the typical output swing range is from 0.006V to 4.994V.

Driving Capacitive Loads

The SGM722Q is designed for driving the 4700pF 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.

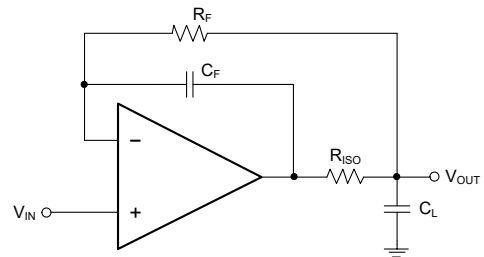


Figure 3. Circuit to Drive Heavy Capacitive Load

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

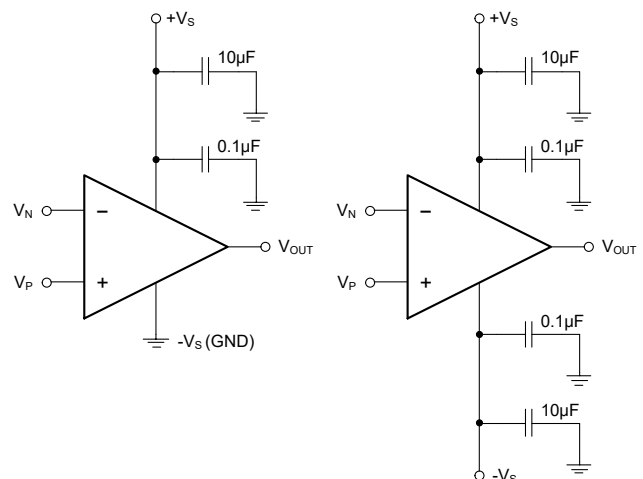


Figure 4. Amplifier Power Supply Bypassing

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

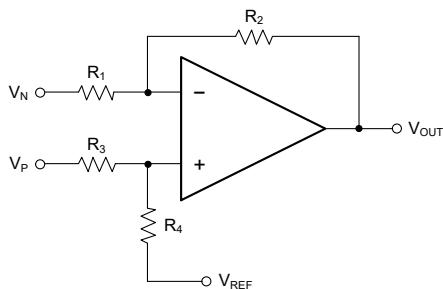


Figure 5. Difference Amplifier

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.

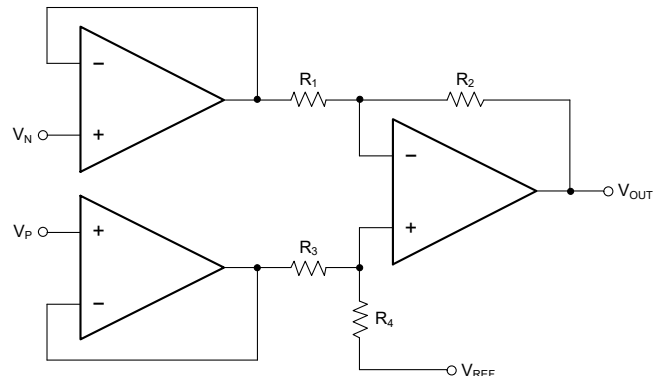


Figure 6. High Input Impedance Difference Amplifier

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, and the resistor values must be selected as low as possible to reduce ringing or oscillation generated by the parasitic parameters in PCB layout.

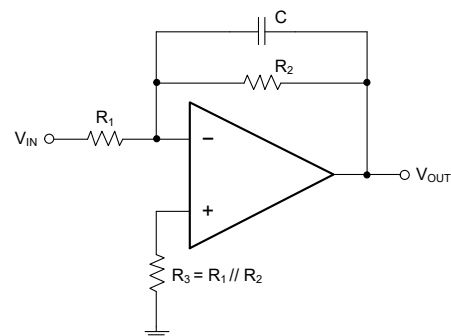


Figure 7. Active Low-Pass Filter

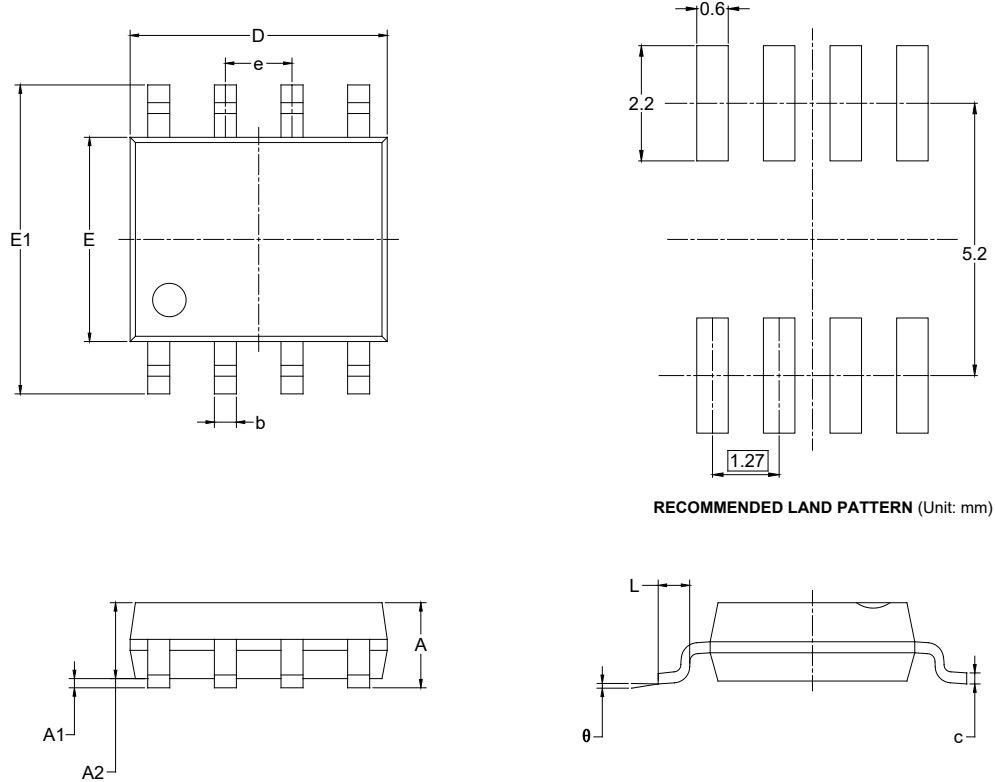
REVISION HISTORY

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

| JANUARY 2025 – REV.A to REV.A.1 | Page |
|--|-------------|
| Updated General Description section..... | 1 |
| Updated Features section..... | 1 |
| Changes from Original (APRIL 2024) to REV.A | Page |
| Changed from product preview to production data..... | All |

PACKAGE OUTLINE DIMENSIONS

SOIC-8



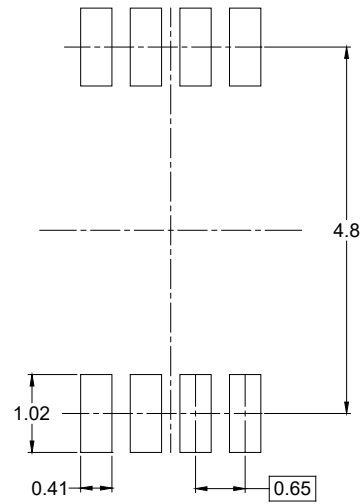
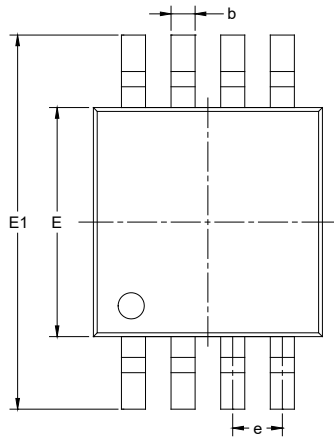
| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|--------|------------------------------|-------|-------------------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 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:

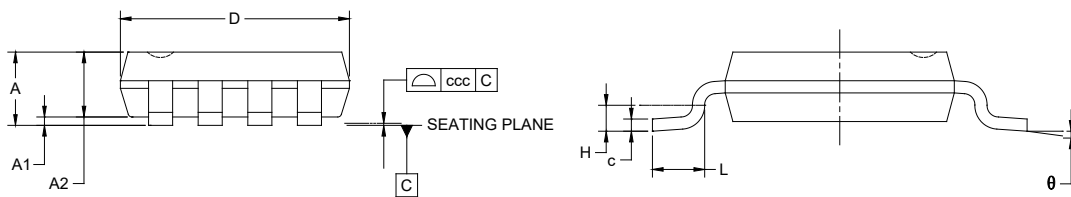
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

MSOP-8



RECOMMENDED LAND PATTERN (Unit: mm)



| Symbol | Dimensions In Millimeters | | |
|--------|---------------------------|-----|-------|
| | MIN | NOM | MAX |
| A | - | - | 1.100 |
| A1 | 0.000 | - | 0.150 |
| A2 | 0.750 | - | 0.950 |
| b | 0.220 | - | 0.380 |
| c | 0.080 | - | 0.230 |
| D | 2.800 | - | 3.200 |
| E | 2.800 | - | 3.200 |
| E1 | 4.650 | - | 5.150 |
| e | 0.650 BSC | | |
| L | 0.400 | - | 0.800 |
| H | 0.250 TYP | | |
| θ | 0° | - | 8° |
| ccc | 0.100 | | |

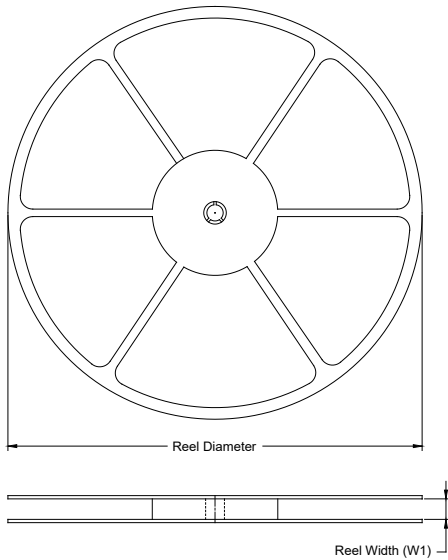
NOTES:

1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MO-187.

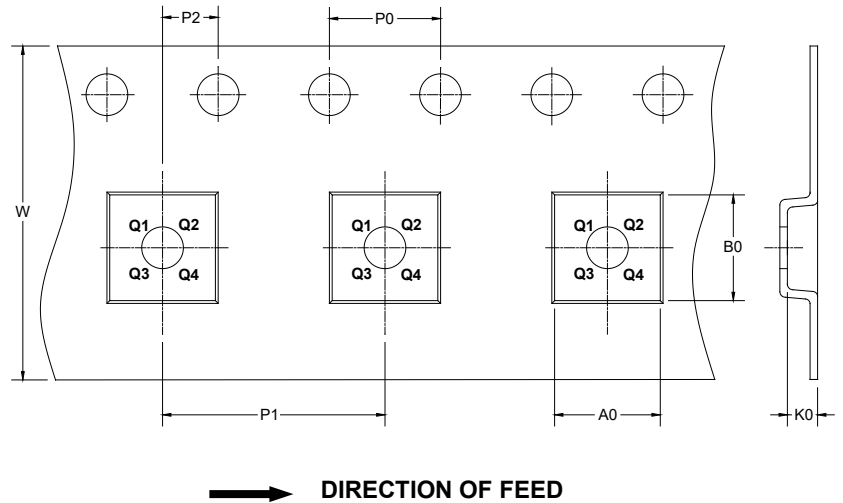
PACKAGE INFORMATION

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 |
|--------------|---------------|--------------------|---------|---------|---------|---------|---------|---------|--------|---------------|
| 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 |

DD00001

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 |
|-----------|----------------|---------------|----------------|--------------|
| 13" | 386 | 280 | 370 | 5 |

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