# SGM4022
# High Voltage, Low Noise, Low Drift, Precision Voltage Reference

## GENERAL DESCRIPTION

The SGM4022 is a high voltage, precision voltage reference with extreme low noise and drift. Also, this device has the ability to sink or source current at the output pin, and the load and line regulation of SGM4022 is good.

The temperature drift of SGM4022 is just 6ppm/℃ (MAX) and the initial accuracy of the output voltage is significant high (±0.05% MAX). The combination of the above two advantages and the low noise ability make excellent performance for SGM4022 in data acquisition systems.

The SGM4022 is available in a Green SOIC-8 package. It operates an operating temperature range of -40℃ to +125℃.

## FEATURES

- **Wide Power Supply Range: 2.8V to 18V**
- **Low Temperature Drift:**
  **2ppm/℃ (TYP), 6ppm/℃ (MAX)**
- **High Initial Accuracy: ±0.05% (MAX)**
- **Fixed Output Voltage:**
  **1.25V, 2.048V, 2.5V, 3.0V, 4.096V, 5.0V, 10V**
- **Reference Output Can Drive 2.2μF to 100μF Capacitive Load Directly**
- **Smooth $V_{OUT}$ Long with Power On**
- **Low 0.1Hz to 10Hz Noise: 2.5μ$V_{P-P}$/V**
- **High Output Current: ±10mA**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in a Green SOIC-8 Package**

## APPLICATIONS

Telecom Equipment
Instrumentation and Test Equipment
Industrial Equipment
Medical Equipment

## SIMPLIFIED SCHEMATIC

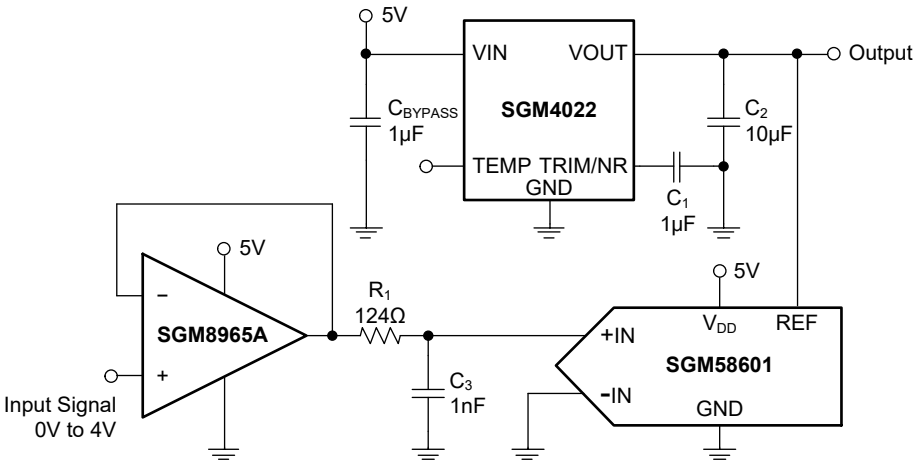


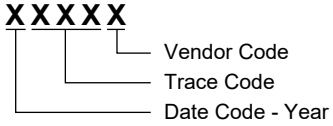

**Figure 1. Schematic of Data Acquisition System**

# PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---|---|---|---|---|---|
| SGM4022-1.25 | SOIC-8 | -40℃ to +125℃ | SGM4022-1.25XS8G/TR | SGM<br>3F2XS8<br>XXXXX | Tape and Reel, 4000 |
| SGM4022-2.048 | SOIC-8 | -40℃ to +125℃ | SGM4022-2.048XS8G/TR | SGM<br>3F3XS8<br>XXXXX | Tape and Reel, 4000 |
| SGM4022-2.5 | SOIC-8 | -40℃ to +125℃ | SGM4022-2.5XS8G/TR | SGM<br>402225XS8<br>XXXXX | Tape and Reel, 4000 |
| SGM4022-3.0 | SOIC-8 | -40℃ to +125℃ | SGM4022-3.0XS8G/TR | SGM<br>402230XS8<br>XXXXX | Tape and Reel, 4000 |
| SGM4022-4.096 | SOIC-8 | -40℃ to +125℃ | SGM4022-4.096XS8G/TR | SGM<br>3F4XS8<br>XXXXX | Tape and Reel, 4000 |
| SGM4022-5.0 | SOIC-8 | -40℃ to +125℃ | SGM4022-5.0XS8G/TR | SGM<br>402250XS8<br>XXXXX | Tape and Reel, 4000 |
| SGM4022-10.0 | SOIC-8 | -40℃ to +125℃ | SGM4022-10.0XS8G/TR | SGM<br>3F5XS8<br>XXXXX | Tape and Reel, 4000 |

## MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace 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

Input Voltage Range ..... -0.2V to 18V
Output Short-Circuit Current ..... 30mA
Package Thermal Resistance
SOIC-8, $\theta_{JA}$ ..... 111.9℃/W
SOIC-8, $\theta_{JB}$ ..... 58.8℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility (1) (2)
HBM ..... ±6000V
CDM ..... ±1000V

NOTES:

1. For human body model (HBM), all pins comply with ANSI/ESDA/JEDEC JS-001 specifications.

2. For charged device model (CDM), all pins comply with ANSI/ESDA/JEDEC JS-002 specifications.

## RECOMMENDED OPERATING CONDITIONS

Input Voltage Range ..... MAX($V_{OUT}$ + 0.7V, 2.8V) to 18V
Output Current Range ..... -10mA to 10mA

## 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.

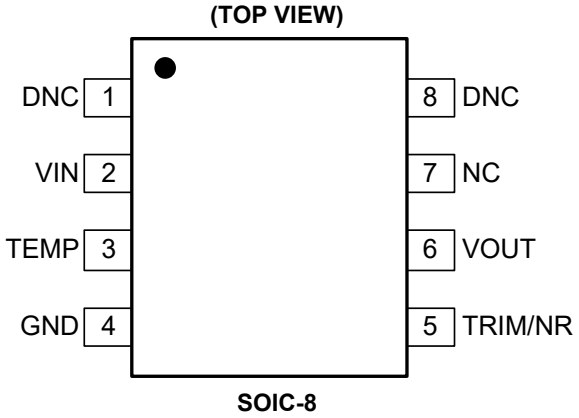
## ESD SENSITIVITY CAUTION

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




## PIN DESCRIPTION

| PIN | NAME | FUNCTION |
|---|---|---|
| 1, 8 | DNC | Do Not Connect. Don’t connect with any external device in application. |
| 2 | VIN | Power Supply. It is recommended to connect a capacitor of at least 1μF to the VIN pin for stability. |
| 3 | TEMP | Temperature Monitoring. Output voltage which is proportional to absolute temperature (PTAT). If unused, this pin can be left floating. |
| 4 | GND | Ground. |
| 5 | TRIM/NR | Adjust the Output Voltage and Reduce the Effect of Noise. If unused, this pin can be left floating. |
| 6 | VOUT | Output of the Voltage Reference. It can drive 2.2μF to 100μF capacitive load directly. |
| 7 | NC | There is no connection inside the device. |

## ELECTRICAL CHARACTERISTICS (SGM4022-2.5)

($V_{IN}$ = MAX($V_{OUT}$ + 0.7V, 2.8V) to 18V, $I_{LOAD}$ = 0mA, $C_L$ = 2.2μF, typical values are at $T_A$ = +25℃, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **SGM4022-2.5** | | | | | | | |
| Output Voltage | $V_{OUT}$ | | | | 2.5 | | V |
| Initial Accuracy | | | | -0.05 | | 0.05 | % |
| Output Voltage Noise | | f = 0.1Hz to 10Hz | | | 2.5 | | $\mu V_{P-P}/V$ |
| Line Regulation | $\Delta V_{OUT}/\Delta V_{IN}$ | $V_{OUT}$ + 0.7V ≤ $V_{IN}$ ≤ 18V | $T_A$ = +25℃ | | 0.1 | 2 | ppm/V |
| | | | $T_A$ = -40℃ to +85℃ | | | 10 | |
| | | | $T_A$ = -40℃ to +125℃ | | | 45 | |
| Load Regulation (1) | $\Delta V_{OUT}/\Delta I_{LOAD}$ | -10mA < $I_{LOAD}$ < 10mA | | | 1 | 10 | ppm/mA |
| **SGM4022** | | | | | | | |
| Output Voltage Temperature Drift (2) | $\Delta V_{OUT}/\Delta T$ | $T_A$ = -40℃ to +125℃ | | | 2 | 6 | ppm/℃ |
| Long-Term Stability (3) | | 0h to 1000h, $I_{OUT}$ = 0mA, $T_A$ = +30℃ | | | 80 | | ppm |
| | | 1000h to 2000h, $I_{OUT}$ = 0mA, $T_A$ = +30℃ | | | 20 | | |
| Thermal Hysteresis | dT | $T_A$ = +25℃ to +125℃ to -40℃ to +25℃ | | | 50 | | ppm |
| Dropout Voltage | $V_{IN}$ - $V_{OUT}$ | $I_{OUT}$ = 0mA | | | 20 | | mV |
| | | $I_{OUT}$ = 10mA | | | 280 | 700 | |
| Short-Circuit Current | $I_{SC}$ | | | | 30 | | mA |
| Turn-On Settling Time | $t_S$ | To 0.1% with $C_L$ = 2.2μF | | | 260 | | μs |
| **TEMP Pin** | | | | | | | |
| Voltage Output | | | | | 570 | | mV |
| Temperature Sensitivity | | $T_A$ = -40℃ to +125℃ | | | 2 | | mV/℃ |
| **Power Supply** | | | | | | | |
| Power Supply Range | $V_{IN}$ | | | MAX($V_{OUT}$ + 0.7, 2.8) | | 18 | V |
| Quiescent Current | $I_Q$ | | | | 0.9 | 2.5 | mA |
| | | $T_A$ = -40℃ to +125℃ | | | | 3 | |

NOTES:

1. Load regulation is Kelvin sensed at the package.

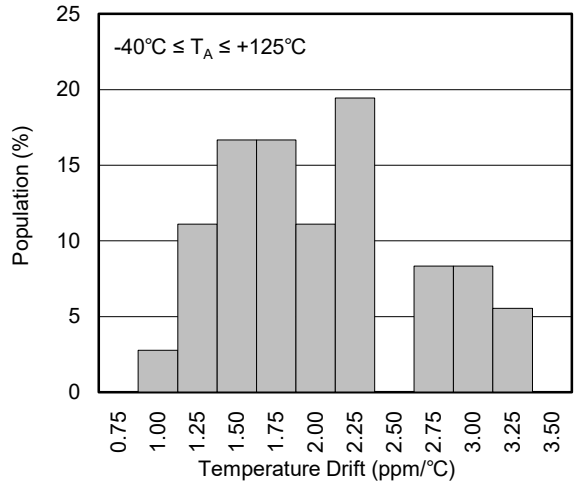
2. The way to determine temperature drift is using Box Method.

3. Typical values only for information.

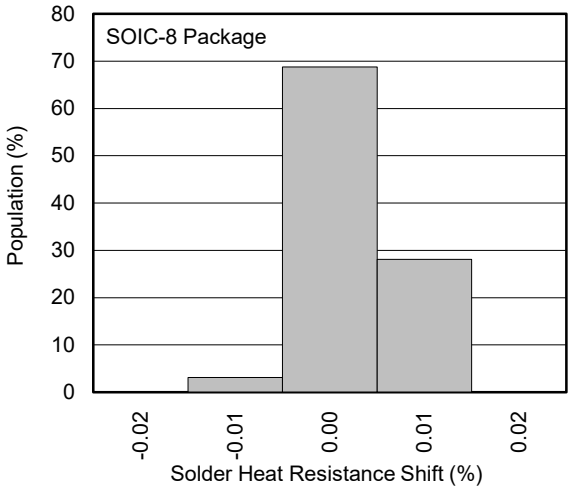
## TYPICAL PERFORMANCE CHARACTERISTICS

At $T_A$ = +25℃, $V_{OUT}$ = 2.5V, unless otherwise noted.

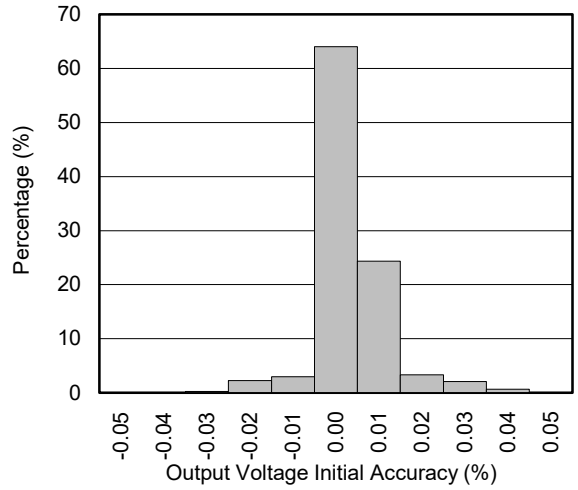
Temperature Drift Production Distribution



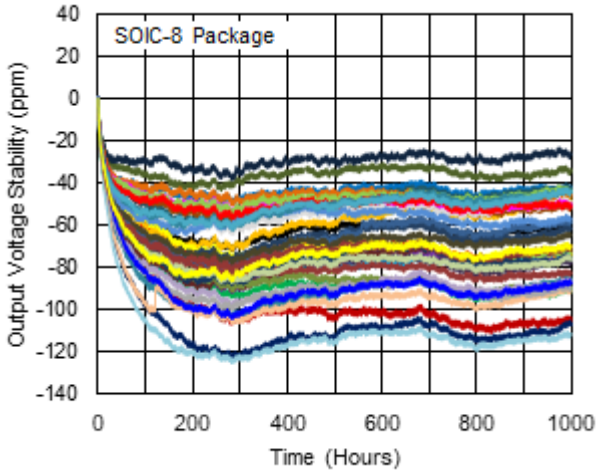

Solder Heat Resistance Shift



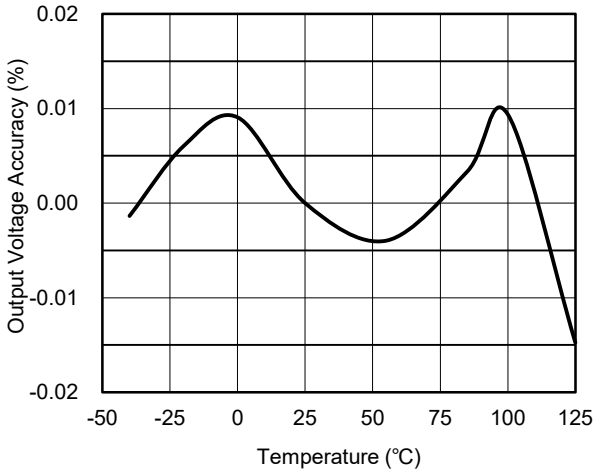

Output Voltage Initial Accuracy



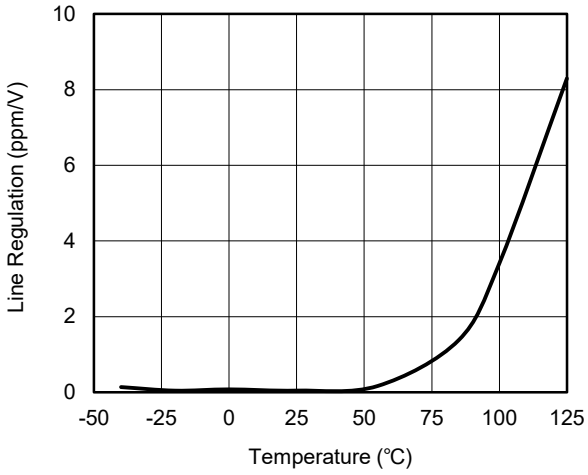

Long-Term Stability




Output Voltage Accuracy vs. Temperature



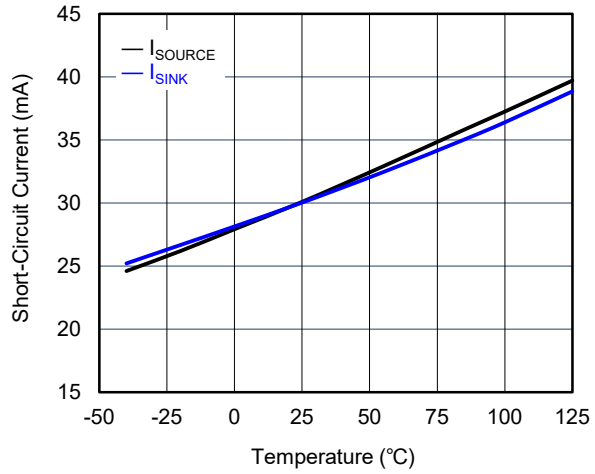

Line Regulation vs. Temperature



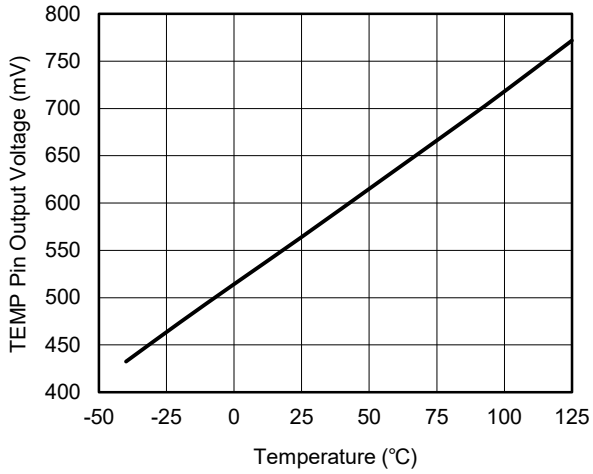
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A$ = +25℃, $V_{OUT}$ = 2.5V, unless otherwise noted.

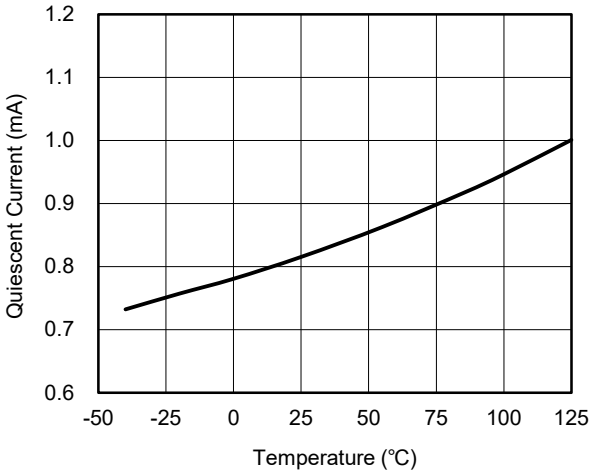
Short-Circuit Current vs. Temperature



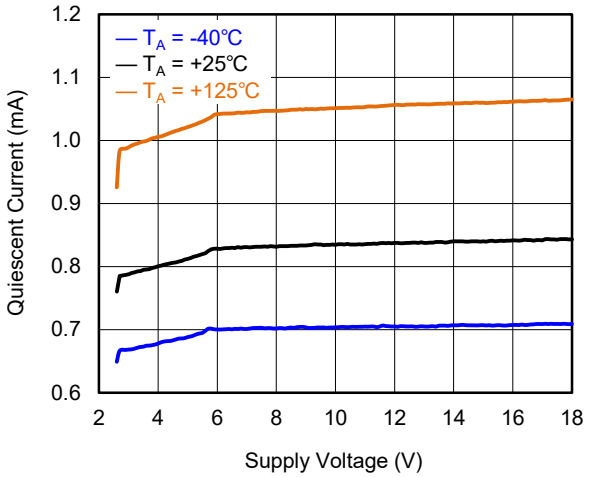

TEMP Pin Output Voltage vs. Temperature



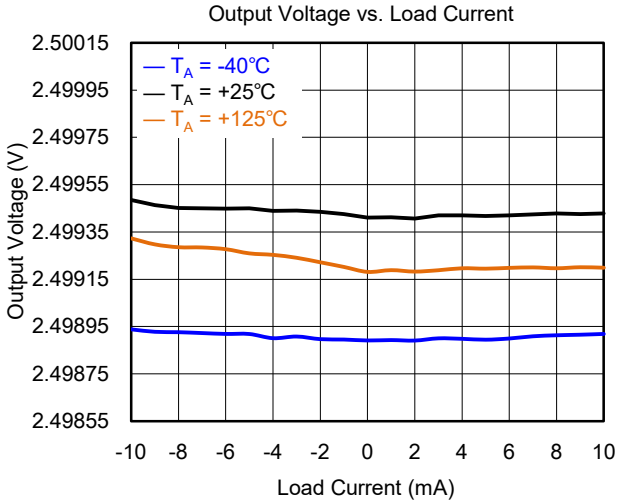

Quiescent Current vs. Temperature



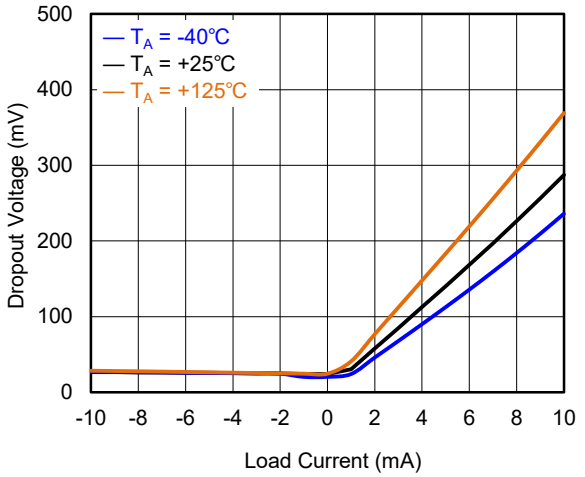

Quiescent Current vs. Supply Voltage




Output Voltage vs. Load Current



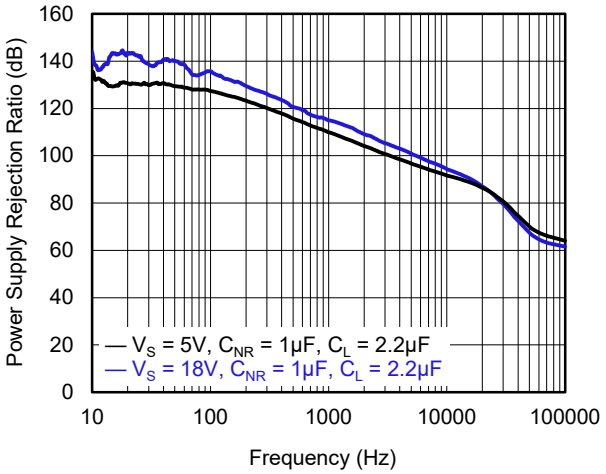

Dropout Voltage vs. Load Current



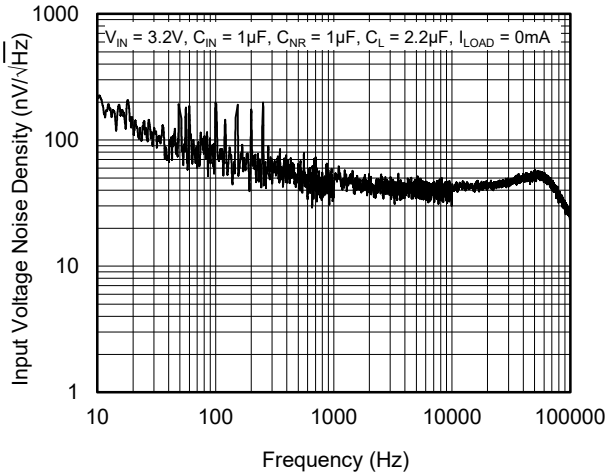
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A$ = +25℃, $V_{OUT}$ = 2.5V, unless otherwise noted.

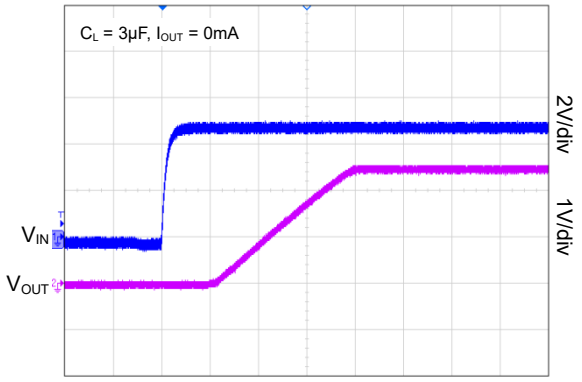
Power Supply Rejection Ratio vs. Frequency



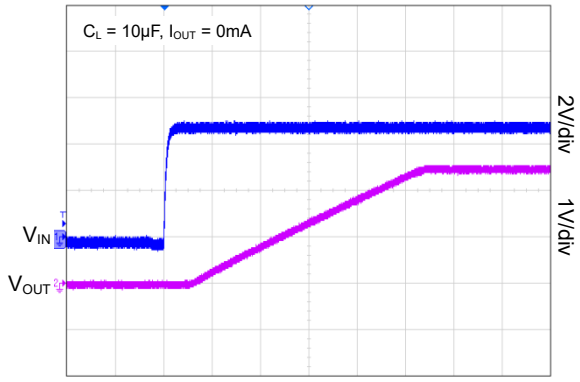

Input Voltage Noise Density vs. Frequency



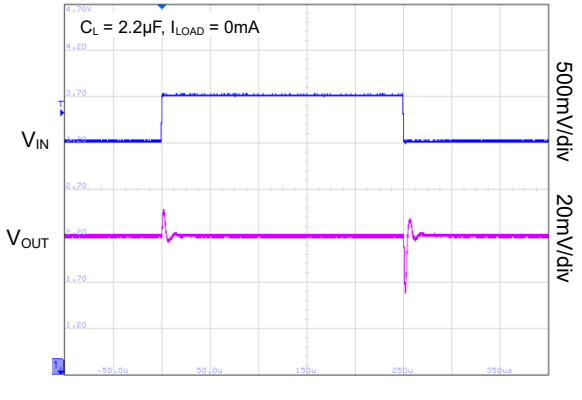

Start-Up



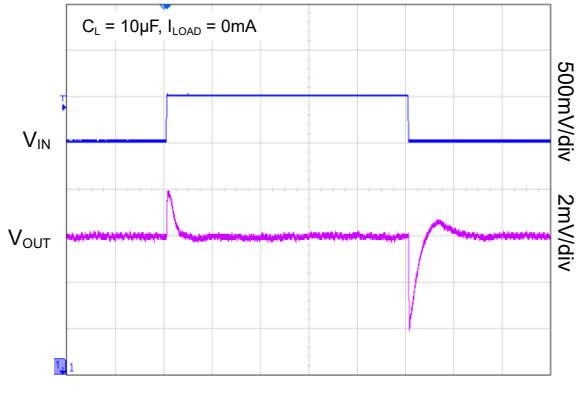

Start-Up




Line Transient



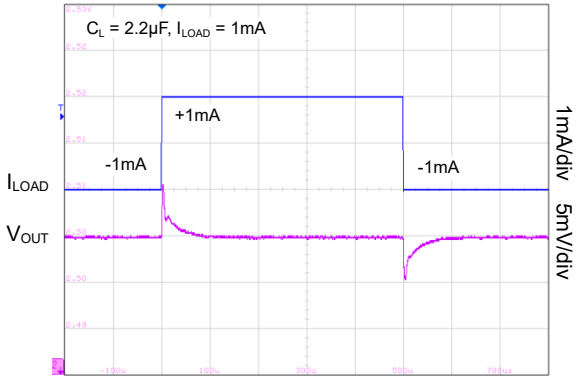

Line Transient



## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

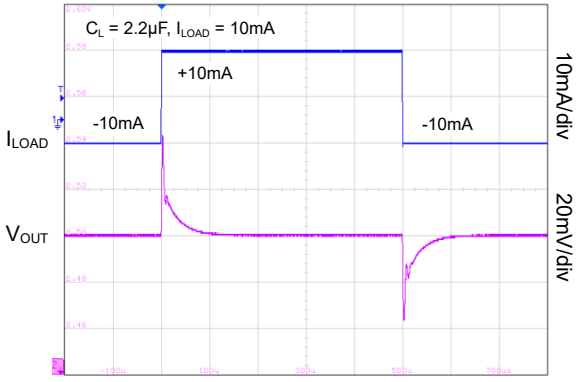
At $T_A$ = +25℃, $V_{OUT}$ = 2.5V, unless otherwise noted.

Load Transient



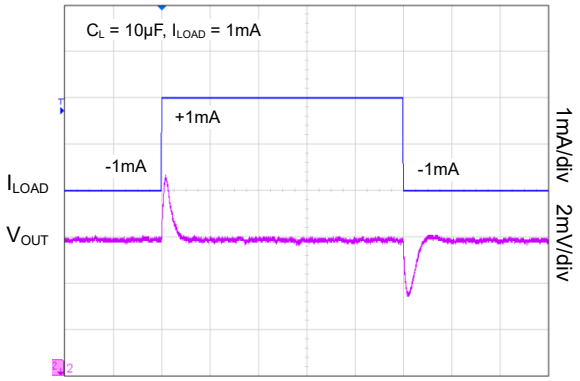

Time (100μs/div)

Load Transient



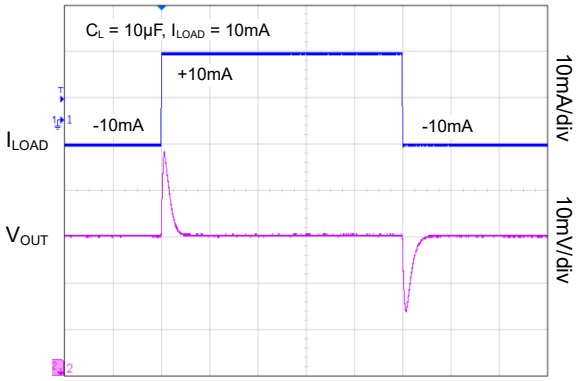

Time (100μs/div)

Load Transient



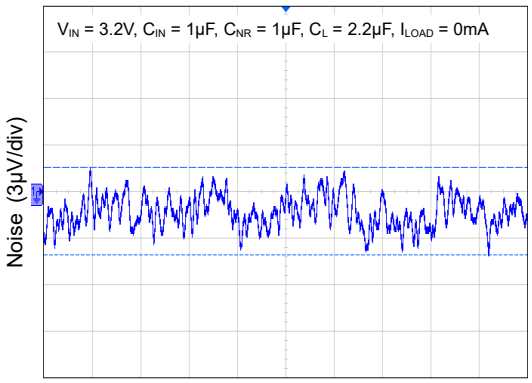

Time (200μs/div)

Load Transient




Time (200μs/div)

0.1Hz to 10Hz Noise

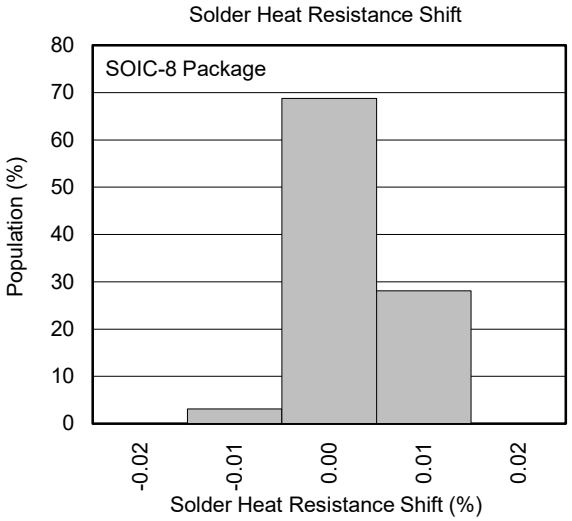



Time (1s/div)

# PARAMETER MEASUREMENT INFORMATION

## Solder Heat Shift

The internal structure of SGM4022 is made by different materials and different materials have different temperature coefficient, and the heat can cause stress of the die. Also, the output accuracy will be affected by the stress of temperature and pressure. Commonly, this kind of error is caused by reflow soldering.



## FUNCTIONAL BLOCK DIAGRAM

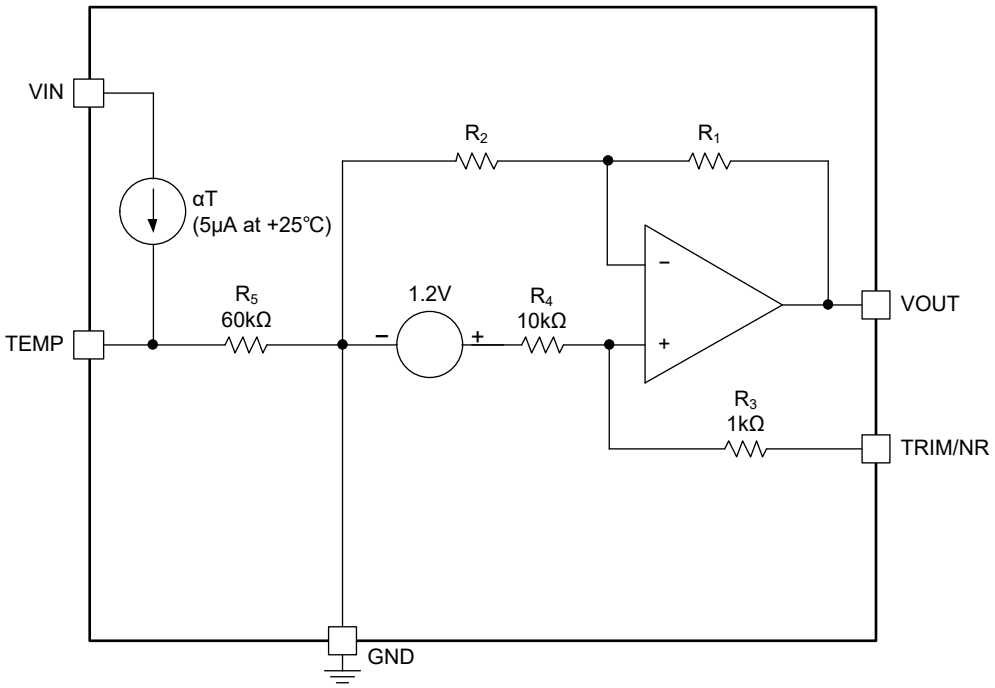



**Figure 2. Block Diagram**

# DETAILED DESCRIPTION

The SGM4022 is a precision bandgap voltage reference with extreme low noise and drift. The internal structure of SGM4022 is shown in the section of Functional Block Diagram.

## Temperature Monitoring

The output of TEMP pin is related to the temperature, and the source impedance of this pin is 60kΩ. The following equation indicates the relationship between the voltage of TEMP pin and the temperature.

$$V_{TEMP} = 520mV + 2mV/℃ \times T(℃) \quad (1)$$

The TEMP pin can reflect the temperature of the chip, with the accuracy of ±15℃. Although this temperature range is not accurate enough, the TEMP pin can also reflect the temperature change of the chip or compensate the analog part of the circuit. From Equation 1, it can be seen that 60mV output change of TEMP pin can illustrate 30℃ of the temperature.

The output impedance of TEMP pin is high, which is indicated in the section of Functional Block Diagram. Also, this pin should not be connected with a low-impedance analog circuit as the error of $V_{TEMP}$ is increased; however, there is no relationship between the accuracy of output voltage and $V_{TEMP}$.

If the low-impedance analog circuit is necessary to be connected with TEMP pin, then please use a buffer between them, as shown in Figure 3.

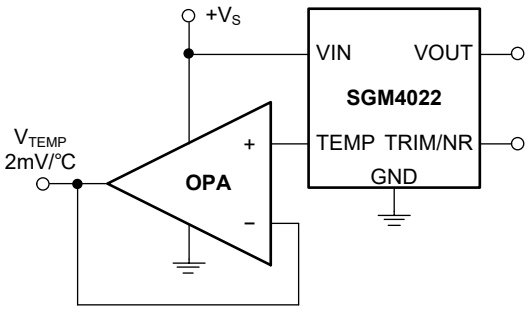



**Figure 3. Buffering the TEMP Pin Output**

## Temperature Drift

The drift error for SGM4022 is significantly small, and the change of output voltage with temperature illustrates the drift of error. The Box Method is used to evaluate the temperature drift as shown in Equation 2.

$$Drift = \left( \frac{V_{OUTMAX} - V_{OUTMIN}}{V_{OUTNOM} \times Temp\ Range} \right) \times 10^6 (ppm) \quad (2)$$

where:

$V_{OUTMAX}$ is the maximum output voltage over a specified temperature range.

$V_{OUTMIN}$ is the minimum output voltage over a specified temperature range.

$V_{OUTNOM}$ is the nominal output voltage at +25℃.

The temperature drift of SGM4022 is just 6ppm/℃ (MAX).

## Thermal Hysteresis

To measure the thermal hysteresis, the $V_{OUT}$ of the device should be measured at the temperature of +25℃. After finishing this, the SGM4022 will be cycled to the other temperatures, and then remove it back to +25℃ and measure the $V_{OUT}$ again. In conclusion, this voltage difference is the hysteresis of temperature.

$$V_{HYST} = \frac{|V_{PRE} - V_{POST}|}{V_{NOM}} \times 10^6 (ppm) \quad (3)$$

where:

$V_{HYST}$ is the thermal hysteresis.

$V_{PRE}$ is the output voltage measured at +25℃ before the device is removed to the temperature range of -40℃ to +125℃.

$V_{POST}$ is the output voltage measured at +25℃ after the device is removed to the temperature range of -40℃ to +125℃.

$V_{NOM}$ is the output voltage which is specified.

# DETAILED DESCRIPTION (continued)

## Noise Performance

The noise level for the frequency from 0.1Hz to 10Hz is shown in the table of Electrical Characteristics, and it will be increased for high output voltage or temperature. Using an RC filter connected to the VOUT pin can improve the noise level of SGM4022; however, please make sure that the output impedance of the device is not affected.

Furthermore, adding a capacitor to the TRIM/NR pin can effectively optimize noise performance. With the capability of TRIM/NR pin, users can access the internal bandgap of SGM4022. In Figure 4, an RC low-pass filter is created by placing a 1μF capacitor at the TRIM/NR pin, and the corner frequency of the low-pass filter ranges from 10Hz to 20Hz. Also, this filter can reduce half of the overall noise at the VOUT pin. The higher the value of the capacitor is, the lower the corner frequency is. With the effect of this capacitor, the start-up time will be increased.

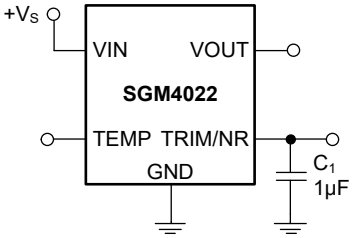



**Figure 4. Reducing the Noise with TRIM/NR Pin**

## Long-Term Stability

All of the devices are suffered from aging and thermal conditions as the die is changed over a long time. Also, these undesirable changes can affect the precision of voltage reference output. In addition, this value is mentioned in datasheet and the following equation shows how to calculate the long-term stability (LTD). In details, if the output drift is larger than the typical value over the specific period, the LTD will be positive. On the contrary, if the output drift is smaller over the specific period, the LTD will be negative.

$$LTD(ppm)|_{t=n} = \left( \frac{V_{OUT}|_{t=0} - V_{OUT}|_{t=n}}{V_{OUT}|_{t=0}} \right) \times 10^6 \qquad (4)$$

where:

$LTD(ppm)|_{t=n}$ is long-term stability (in units of ppm).

$V_{OUT}|_{t=0}$ is the measured output voltage at the start of time period.

$V_{OUT}|_{t=n}$ is the measured output voltage at the end of time period.

The long-term drift (LTD) of the SGM4022 is 80ppm from 0 to 1000 hours and 20ppm from 1000 to 2000 hours.

## Adjusting Output with TRIM/NR Pin

Using TRIM/NR pin can adjust the output voltage. With the circuit shown in Figure 5, the adjustment of the output voltage is ±15mV.

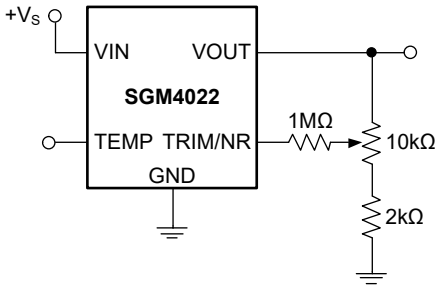



**Figure 5. Adjusting Output with TRIM/NR Pin**

## Basic Connections

For typical connection shown in Figure 6, it is recommended that a capacitor of at least 1μF should be connected to the VIN pin for stability. Also, a capacitor from 2.2μF to 100μF should be connected to the VOUT pin. To guarantee the stability of the output, the equivalent resistance of the output capacitor should be smaller than or equal to 1.5Ω. It is recommended that an equivalent resistance of 1Ω to 1.5Ω is suitable for reducing the effect of noise.

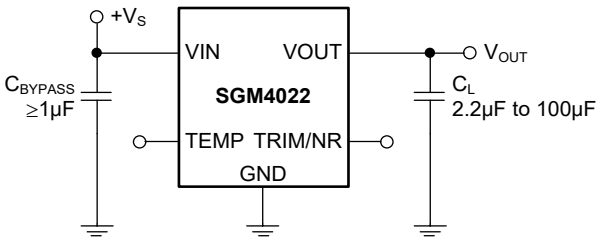



**Figure 6. Basic Connections**

## DETAILED DESCRIPTION (continued)

### Supply Voltage

For normal operation, the minimum supply voltage should be MAX($V_{OUT}$ + 0.7V, 2.8V). And, the maximum supply voltage is up to 18V.

### Negative Reference Voltage

If users desire to use SGM4022 to guarantee positive and negative voltage, SGM4022 and SGM8263 can be taken into account. In Figure 7, the output of SGM8263 is equal to the negative value of SGM4022. The following circuit can also guarantee the accuracy, as the offset voltage and drift of SGM8263 are extremely low. In addition, the temperature coefficient of two resistors should be taken into account.

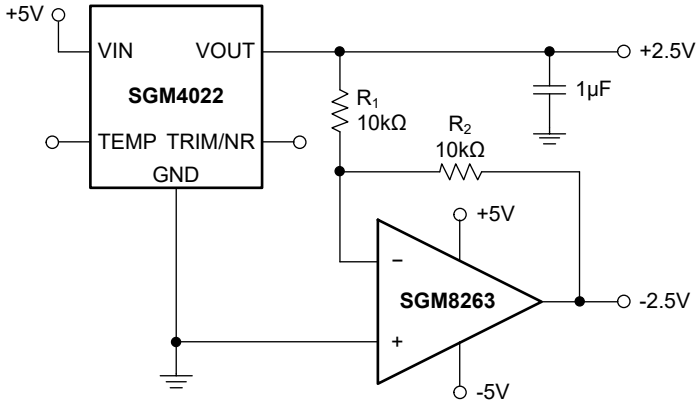



**Figure 7. Positive and Negative Voltage Reference**

# APPLICATION INFORMATION

The advantage of accuracy and stability is beneficial for SGM4022 to be used as a voltage reference for analog-to-digital converters (ADC). Figure 8 shows a data acquisition system with SGM4022.

## 24-Bit, 32KSPS Data Acquisition System

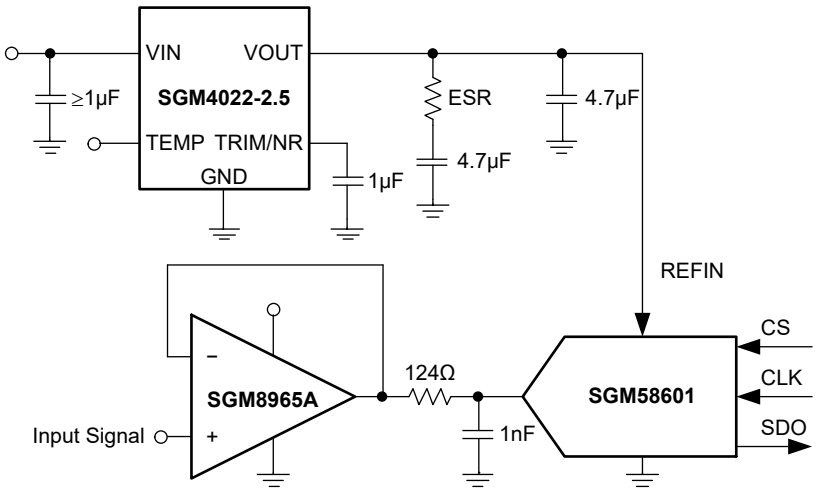



**Figure 8. Data Acquisition System with SGM4022**

### Design Requirements

If the output capacitor is not proper, it will provide a gain-peaking so that the noise of the system will be increased. Also, the output capacitor should guarantee a desired filtering performance for SGM4022. For enhance the stability, a bypass capacitor must be added at the input pin of SGM4022. In addition, a buffer and an RC filter should also be added at the input pin of the analog-to-digital converter to provide high driven performance and filter the noise from the input signal.

### Detailed Design Procedure

The bandwidth of RC filter which is at the output of the buffer should be at least 4 times less than the bandwidth of SGM8965A and it can filter out the switch noise, which is provided by ADC when sampling, so the output voltage at 1nF capacitor will be settled to 24-bit accuracy within the corresponding acquisition time. In addition, to provide a voltage reference for SGM58601, SGM4022-2.5 should be taken into account so that the full-scale input voltage for SGM58601 is 5V ($V_{FS}$ = $2V_{REF}$).

If the equivalent series resistance is low, it can provide a gain-peaking so that the noise level will be amplified at the corner frequency. To solve this problem, it is recommended that placing a resistor which is series with the output capacitor is an excellent choice. In addition, a 1μF capacitor should be added at the NR pin to reduce the noise.

## APPLICATION INFORMATION (continued)

### Layout

The bypass capacitor ≥1μF should be closed enough to the VIN pin and GND pin. If the power supply is noisy, then adding another bypass decoupling capacitor will be a good choice.

1μF capacitor can be added at the NR pin to reduce the noise.

A capacitor with 2.2μF to 100μF should be added to the output pin of the voltage reference. Although the equivalent series resistor is optional for the operation of SGM4022, it is recommended that a resistor from 1Ω to 1.5Ω should be series with the output capacitor to reduce the effect of noise.

For filtering high-frequency components of the noise, an additional 1μF capacitor can be connected in parallel with $C_L$. Also, the 1μF capacitor can also improve the performance of voltage reference if the load is switching.

### Power Dissipation

Within the specification of the supply voltage range, the load current of SGM4022 is specified to ±10mA. The following equation illustrates how the temperature changes with the increasing of temperature.

$$T_J = T_A + P_D \times \theta_{JA} \quad (5)$$

where:

$T_J$ is the junction temperature (℃).

$T_A$ is the ambient temperature (℃).

$P_D$ is the power dissipated (W).

$\theta_{JA}$ is the junction-to-ambient thermal resistance (℃/W).

The junction temperature of SGM4022 must be lower than +150 ℃, which is the maximum acceptable temperature of this voltage reference.

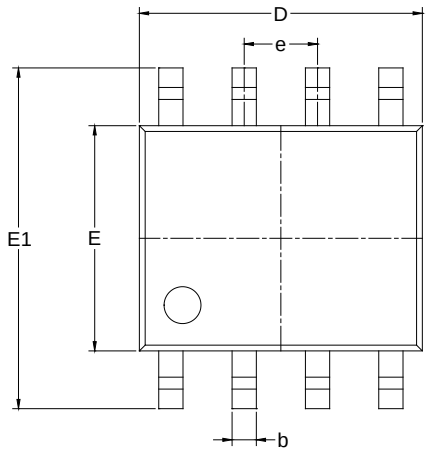
# REVISION HISTORY

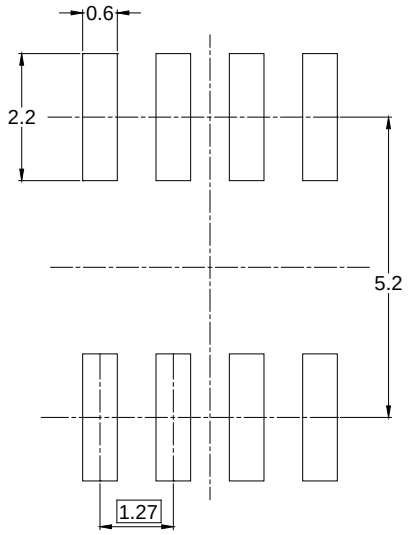
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Original to REV.A (NOVEMBER 2026) | Page |
|---|---|
| Changed from product preview to production data | All |

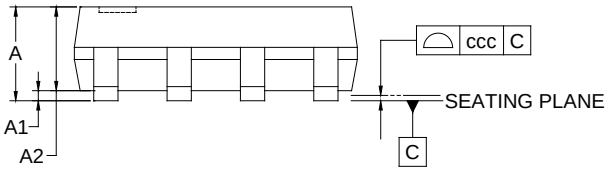
# PACKAGE OUTLINE DIMENSIONS

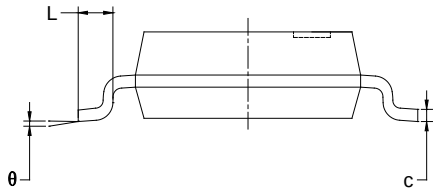
## SOIC-8




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



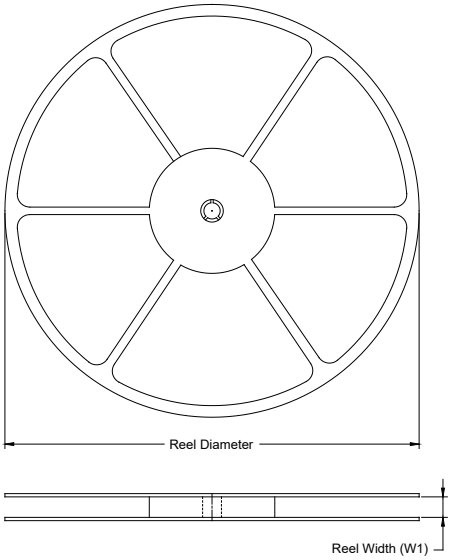




| Symbol | Dimensions In Millimeters | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| A | 1.350 | - | 1.750 |
| A1 | 0.100 | - | 0.250 |
| A2 | 1.350 | - | 1.550 |
| b | 0.330 | - | 0.510 |
| c | 0.170 | - | 0.250 |
| D | 4.700 | - | 5.100 |
| E | 3.800 | - | 4.000 |
| E1 | 5.800 | - | 6.200 |
| e | 1.270 BSC | | |
| L | 0.400 | - | 1.270 |
| θ | 0° | - | 8° |
| ccc | 0.100 | | |

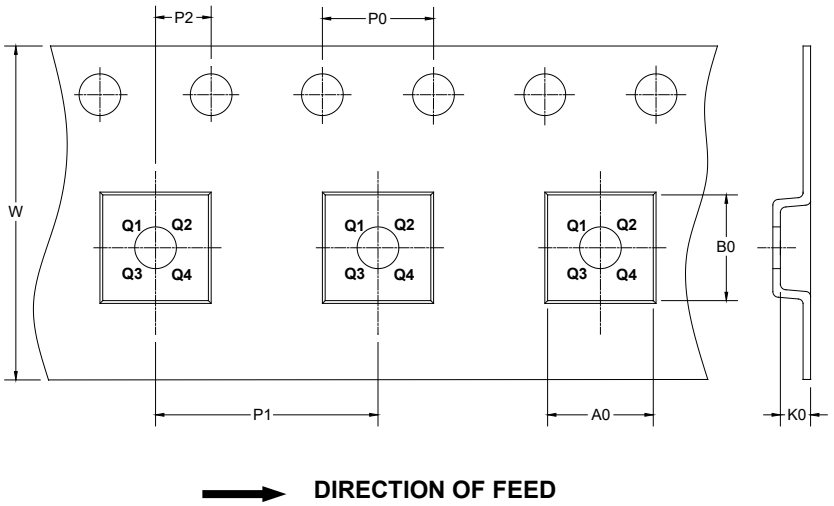
NOTES:
1. This drawing is subject to change without notice.
2. This dimension does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15mm per side.
3. Reference JEDEC MS-012.

# TAPE AND REEL INFORMATION

### REEL DIMENSIONS




### TAPE DIMENSIONS



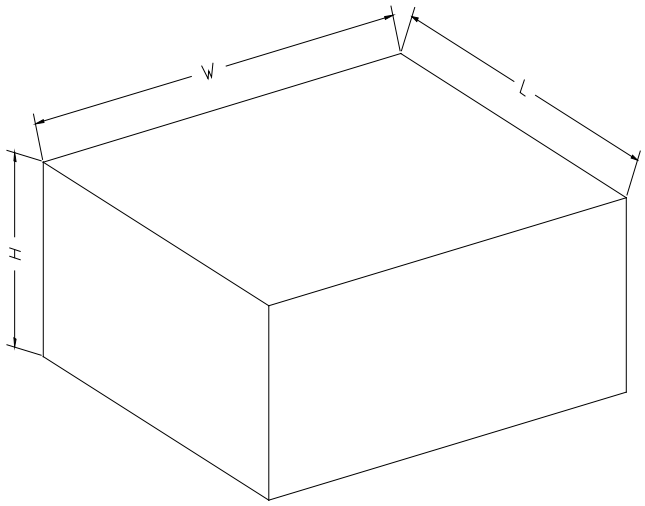

NOTE: The picture is only for reference. Please make the object as the standard.

## 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 |

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 |
|---|---|---|---|---|
| 13″ | 386 | 280 | 370 | 5 |

DD0002