# SGM4051
# Micro-Power Precision Shunt Voltage Reference

## GENERAL DESCRIPTION

The SGM4051 is a micro-power, precision shunt voltage reference which is easy to use in many applications. The device is available in a fixed output voltage of 1.225V and an adjustable version. It draws operating current up to 12mA. The device has no need for external capacitors and can keep stable with any capacitive load.

The SGM4051 features low temperature coefficient, low output noise, and low dynamic impedance. These characteristics enable the device to output stable voltage over a wide operating temperature and current range.

The SGM4051 offers high accuracy of 0.3% (MAX) for B grade and 0.5% (MAX) for C grade.

The SGM4051 is available in Green SOT-23 and SC70-5 packages. It operates over an ambient temperature range of -40℃ to +125℃.

## FEATURES

- **Fixed Output Voltage: 1.225V**
- **Adjustable Output Voltage: 1.206V to 10V**
- **Wide Operating Current Range: 45μA to 12mA (TYP)**
- **Output Voltage Accuracy:**
  - **SGM4051B: 0.3% (MAX)**
  - **SGM4051C: 0.5% (MAX)**
- **Low Temperature Coefficient: 20ppm/℃ (TYP)**
- **Low Output Noise: 16μ$V_{RMS}$ (TYP)**
- **Stable without External Capacitors**
- **Stable with Any Capacitive Load**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in Green SOT-23 and SC70-5 Packages**

## APPLICATIONS

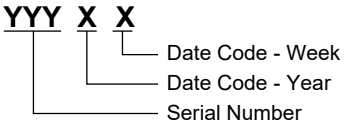
Precision Data-Acquisition Systems
Instrumentation and Test Equipment
Industrial Process Controls
Precision Audio Components
Power Management
Battery-Powered Equipment

# PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---|---|---|---|---|---|
| SGM4051C-1.2 | SC70-5 | -40℃ to +125℃ | SGM4051C-1.2XC5G/TR | R88XX | Tape and Reel, 3000 |
| SGM4051B-ADJ | SOT-23 | -40℃ to +125℃ | SGM4051B-ADJXN3LG/TR | 013XX | Tape and Reel, 3000 |
| | SC70-5 | -40℃ to +125℃ | SGM4051B-ADJXC5G/TR | 015XX | Tape and Reel, 3000 |
| SGM4051C-ADJ | SOT-23 | -40℃ to +125℃ | SGM4051C-ADJXN3LG/TR | 014XX | Tape and Reel, 3000 |
| | SC70-5 | -40℃ to +125℃ | SGM4051C-ADJXC5G/TR | 016XX | Tape and Reel, 3000 |

## MARKING INFORMATION

NOTE: XX = Date 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

Package Thermal Resistance
SC70-5, $\theta_{JA}$ ..... 237℃/W
Junction Temperature ..... +150℃
Storage Temperature Range..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM..... 5000V
CDM ..... 1000V

## 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

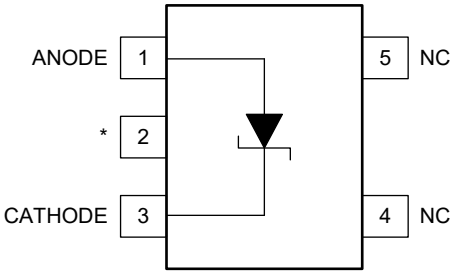
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

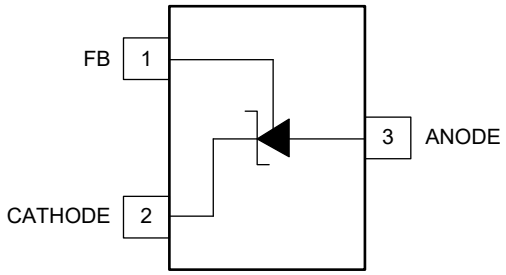
## PIN CONFIGURATIONS

SGM4051C-1.2 (TOP VIEW)



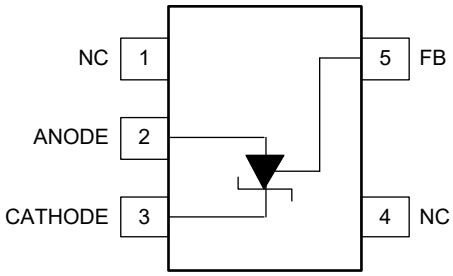

SC70-5

SGM4051B/C-ADJ (TOP VIEW)




SOT-23

SGM4051B/C-ADJ (TOP VIEW)




SC70-5

## PIN DESCRIPTION

| PIN | | | NAME | I/O | FUNCTION |
|---|---|---|---|---|---|
| SGM4051C-1.2 SC70-5 | SGM4051B/C-ADJ SOT-23 | SGM4051B/C-ADJ SC70-5 | | | |
| 1 | 3 | 2 | ANODE | O | Anode Pin. Connect to GND directly. |
| 2 | — | — | * | — | Must be connected to ANODE pin or left floating. |
| 3 | 2 | 3 | CATHODE | I/O | Cathode Pin. Shunt current and output voltage. |
| 4, 5 | — | 1, 4 | NC | — | Not Connected. |
| — | 1 | 5 | FB | I | Feedback Pin. Used for Adjusting Output Voltage. |

## SGM4051C-1.2 ELECTRICAL CHARACTERISTICS

(Full = -40℃ to +125℃, typical values are at $T_A$ = +25℃, unless otherwise noted.)

| PARAMETER | CONDITIONS | TEMP | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Reverse Breakdown Voltage ($V_Z$) | $I_Z$ = 100μA | +25℃ | | 1.225 | | V |
| Reverse Breakdown Voltage Tolerance | $I_Z$ = 100μA | +25℃ | -6.1 | | 6.1 | mV |
| | | Full | -10.5 | | 10.5 | |
| Minimum Cathode Current ($I_{Z(MIN)}$) | | +25℃ | | 45 | 70 | μA |
| | | Full | | | 90 | |
| Average Temperature Coefficient of Reverse Breakdown Voltage ($\alpha V_Z$) | $I_Z$ = 10mA | Full | | 20 | | ppm/℃ |
| | $I_Z$ = 1mA | Full | | 20 | | |
| | $I_Z$ = 100μA | Full | | 15 | | |
| Reverse Breakdown Voltage Change with Cathode Current Change ($\Delta V_Z/\Delta I_Z$) | $I_{Z(MIN)} < I_Z < 1$mA | +25℃ | | 0.55 | 1.3 | mV |
| | | Full | | | 2.8 | |
| | 1mA < $I_Z$ < 12mA | +25℃ | | 1.5 | 3 | |
| | | Full | | | 4 | |
| Reverse Dynamic Impedance ($Z_Z$) | $I_Z$ = 1mA, $I_{AC} = 0.5I_Z$ | +25℃ | | 0.5 | 1.2 | Ω |
| | | Full | | | 1.5 | |
| Wideband Noise ($e_n$) | $I_Z$ = 100μA, 10Hz ≤ f ≤ 10kHz | +25℃ | | 16 | | $\mu V_{RMS}$ |
| Thermal Hysteresis (1) ($V_{HYST}$) | $\Delta T_A$ = -40℃ to +125℃ | | | 0.3 | | mV |

NOTE: 1. Thermal hysteresis is defined as the output voltage difference at the +25℃ after a temperature excursion to -40℃, then to +125℃, and back to +25℃.

## SGM4051B-ADJ ELECTRICAL CHARACTERISTICS

(Full = -40℃ to +125℃, typical values are at $T_A$ = +25℃, unless otherwise noted.)

| PARAMETER | CONDITIONS | TEMP | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Reverse Breakdown Voltage ($V_Z$) | $I_Z$ = 100μA, $V_{OUT}$ = 1.206V | +25℃ | | 1.206 | | V |
| Reverse Breakdown Voltage Tolerance | $I_Z$ = 100μA, $V_{OUT}$ = 1.206V | +25℃ | -3.62 | | 3.62 | mV |
| | | Full | -13.50 | | 13.50 | |
| Minimum Cathode Current ($I_{Z(MIN)}$) | $V_{OUT}$ = 1.206V | +25℃ | | 39 | 60 | μA |
| | | Full | | | 75 | |
| Average Temperature Coefficient of Reverse Breakdown Voltage ($\alpha V_Z$) | $I_Z$ = 12mA, $V_{OUT}$ = 1.206V | +25℃ | | 20 | | ppm/℃ |
| | $I_Z$ = 1mA, $V_{OUT}$ = 1.206V | +25℃ | | 20 | | |
| | $I_Z$ = 100μA, $V_{OUT}$ = 1.206V | +25℃ | | 20 | | |
| Reverse Breakdown Voltage Change with Cathode Current Change ($\Delta V_Z/\Delta I_Z$) | $I_{Z(MIN)}$ < $I_Z$ < 1mA, $V_{OUT}$ = 1.206V | +25℃ | | 0.6 | 1.5 | mV |
| | | Full | | | 2.8 | |
| | 1mA < $I_Z$ < 12mA, $V_{OUT}$ = 1.206V | +25℃ | | 0.45 | 1.2 | |
| | | Full | | | 2.4 | |
| Reference Voltage Change with Output Voltage Change ($\Delta V_{REF}/\Delta V_{KA}$) | $I_Z$ = 1mA, $V_{OUT}$ = 1.206V/10V | +25℃ | | 0.08 | 0.18 | mV/V |
| | | Full | | | 0.23 | |
| Reverse Dynamic Impedance ($Z_Z$) | $I_Z$ = 1mA, $I_{AC}$ = 0.5$I_Z$, $V_{OUT}$ = 1.206V | +25℃ | | 0.36 | 1.5 | Ω |
| | | Full | | | 2 | |
| Feedback Current ($I_{FB}$) | $I_Z$ = 100μA, $V_{OUT}$ = 1.206V/15V | +25℃ | | 200 | 300 | nA |
| | | Full | | | 350 | |
| Wideband Noise ($e_n$) | $I_Z$ = 100μA, 10Hz ≤ f ≤ 10kHz | +25℃ | | 16 | | $\mu V_{RMS}$ |
| Long-Term Stability of Reverse Breakdown Voltage | $I_Z$ = 100μA, t = 1000h, $T_A$ = 25℃ ± 0.1℃ | +25℃ | | 100 | | ppm |

## SGM4051C-ADJ ELECTRICAL CHARACTERISTICS

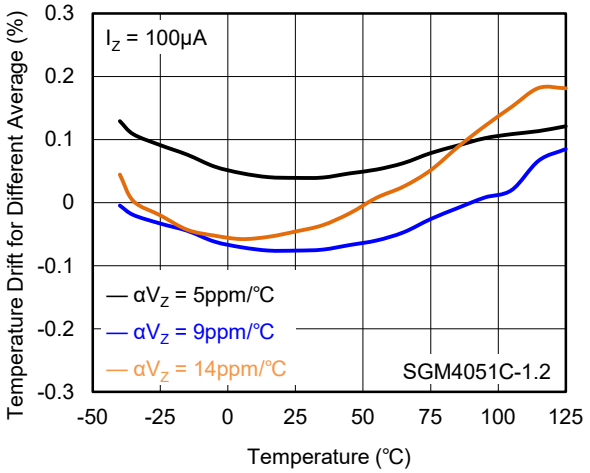
(Full = -40℃ to +125℃, typical values are at $T_A$ = +25℃, unless otherwise noted.)

| PARAMETER | CONDITIONS | TEMP | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Reverse Breakdown Voltage ($V_Z$) | $I_Z$ = 100μA, $V_{OUT}$ = 1.206V | +25℃ | | 1.206 | | V |
| Reverse Breakdown Voltage Tolerance | $I_Z$ = 100μA, $V_{OUT}$ = 1.206V | +25℃ | -6.03 | | 6.03 | mV |
| | | Full | -15.50 | | 15.50 | |
| Minimum Cathode Current ($I_{Z(MIN)}$) | $V_{OUT}$ = 1.206V | +25℃ | | 39 | 60 | μA |
| | | Full | | | 75 | |
| Average Temperature Coefficient of Reverse Breakdown Voltage ($\alpha V_Z$) | $I_Z$ = 12mA, $V_{OUT}$ = 1.206V | +25℃ | | 20 | | ppm/℃ |
| | $I_Z$ = 1mA, $V_{OUT}$ = 1.206V | +25℃ | | 20 | | |
| | $I_Z$ = 100μA, $V_{OUT}$ = 1.206V | +25℃ | | 20 | | |
| Reverse Breakdown Voltage Change with Cathode Current Change ($\Delta V_Z/\Delta I_Z$) | $I_{Z(MIN)}$ < $I_Z$ < 1mA, $V_{OUT}$ = 1.206V | +25℃ | | 0.6 | 1.5 | mV |
| | | Full | | | 2.8 | |
| | 1mA < $I_Z$ < 12mA, $V_{OUT}$ = 1.206V | +25℃ | | 0.45 | 1.2 | |
| | | Full | | | 2.4 | |
| Reference Voltage Change with Output Voltage Change ($\Delta V_{REF}/\Delta V_{KA}$) | $I_Z$ = 1mA, $V_{OUT}$ = 1.206V/10V | +25℃ | | 0.08 | 0.18 | mV/V |
| | | Full | | | 0.23 | |
| Reverse Dynamic Impedance ($Z_Z$) | $I_Z$ = 1mA, $I_{AC}$ = 0.5$I_Z$, $V_{OUT}$ = 1.206V | +25℃ | | 0.36 | 1.5 | Ω |
| | | Full | | | 2 | |
| Feedback Current ($I_{FB}$) | $I_Z$ = 100μA, $V_{OUT}$ = 1.206V/15V | +25℃ | | 200 | 300 | nA |
| | | Full | | | 350 | |
| Wideband Noise ($e_n$) | $I_Z$ = 100μA, 10Hz ≤ f ≤ 10kHz | +25℃ | | 16 | | $\mu V_{RMS}$ |
| Long-Term Stability of Reverse Breakdown Voltage | $I_Z$ = 100μA, t = 1000h, $T_A$ = 25℃ ± 0.1℃ | +25℃ | | 100 | | ppm |

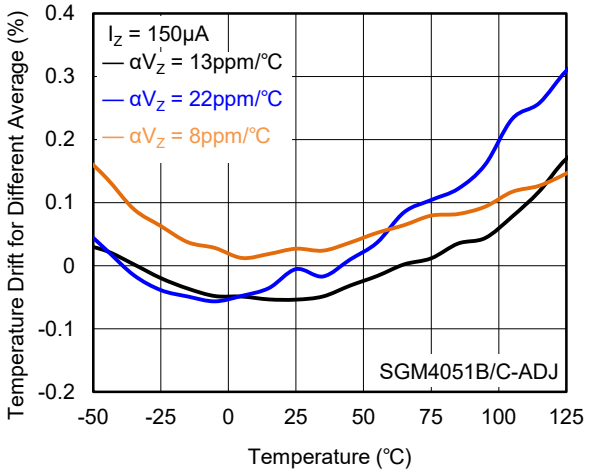
## TYPICAL PERFORMANCE CHARACTERISTICS

At $T_A$ = +25℃, unless otherwise noted.

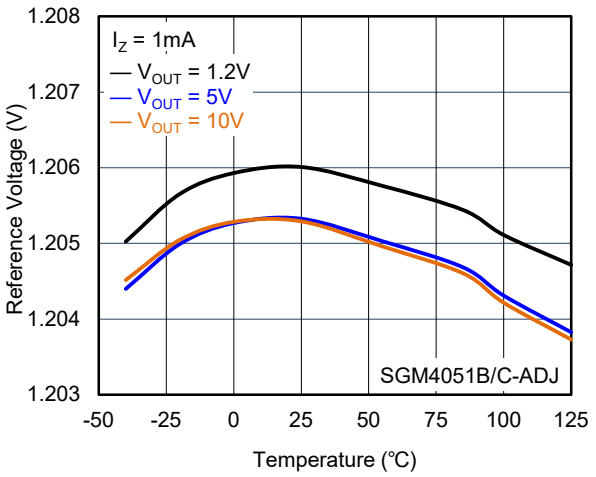
Temperature Drift for Different Average vs. Temperature



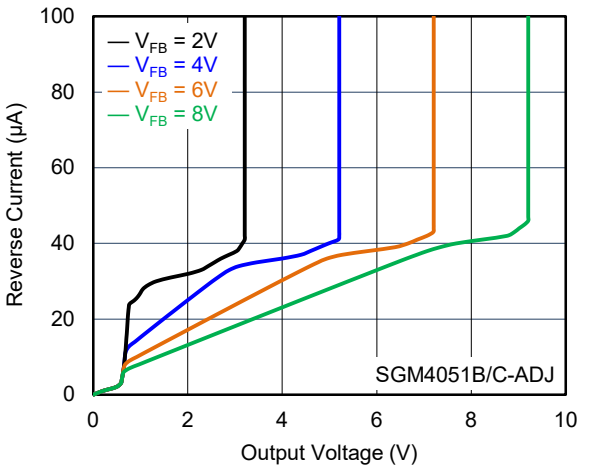

Temperature Drift for Different Average vs. Temperature



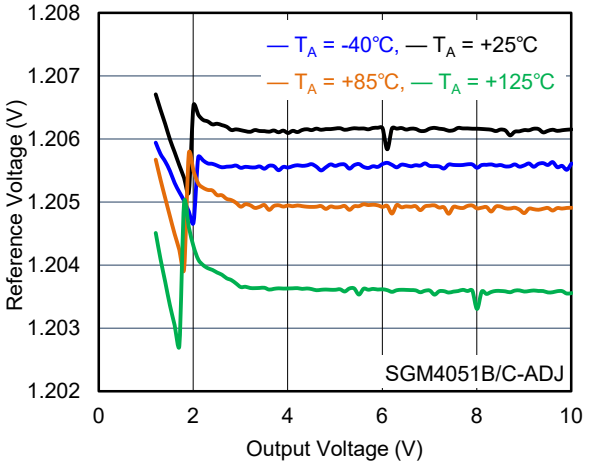

Reference Voltage vs. Temperature



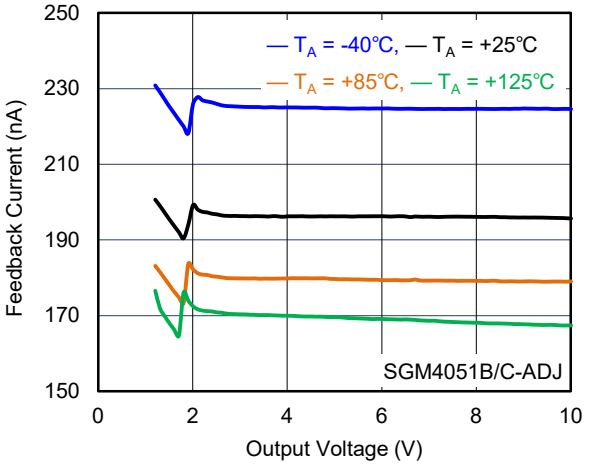

Reverse Current vs. Output Voltage




Reference Voltage vs. Output Voltage



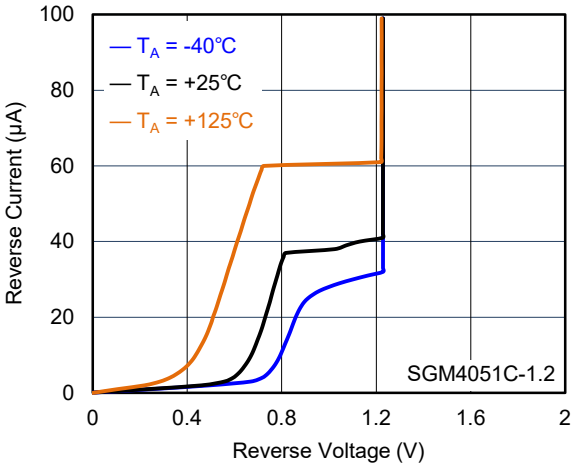

Feedback Current vs. Output Voltage



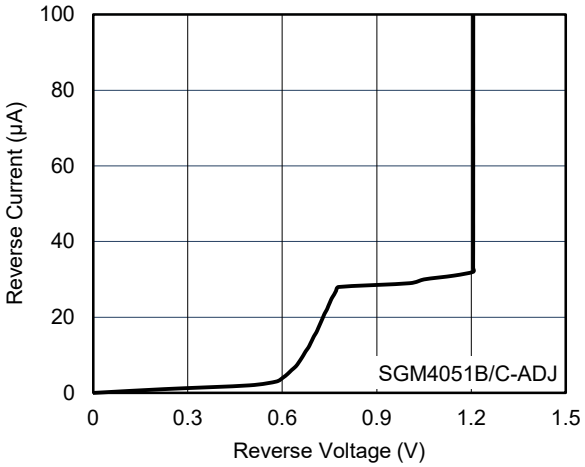
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A$ = +25℃, unless otherwise noted.

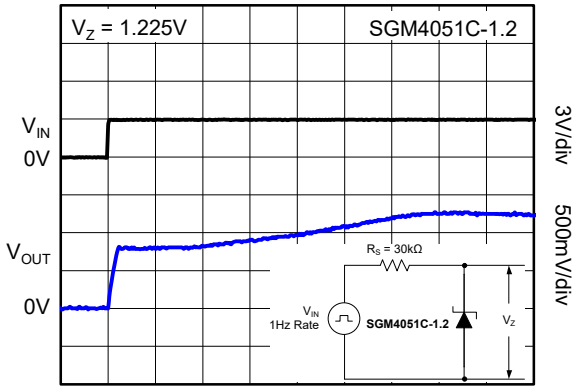
Reverse Current vs. Reverse Voltage



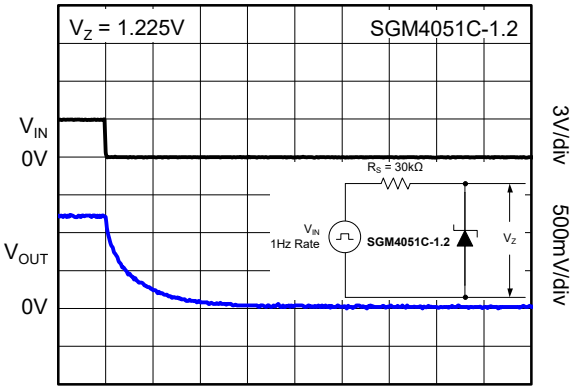

Reverse Current vs. Reverse Voltage



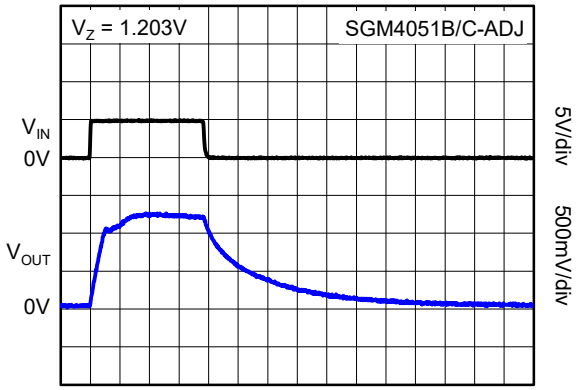

Start-Up Response



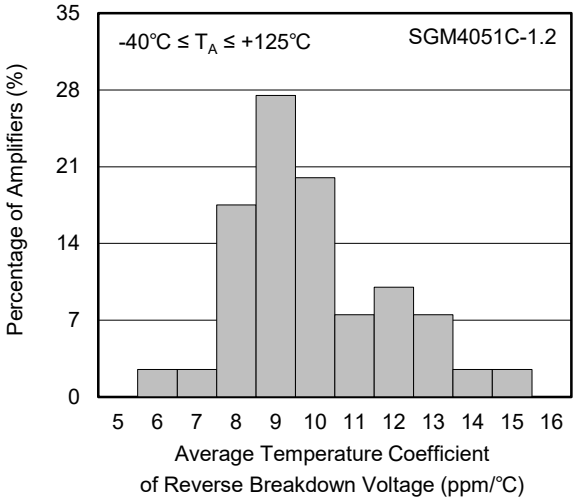

Power-Down Response




Start-Up Response



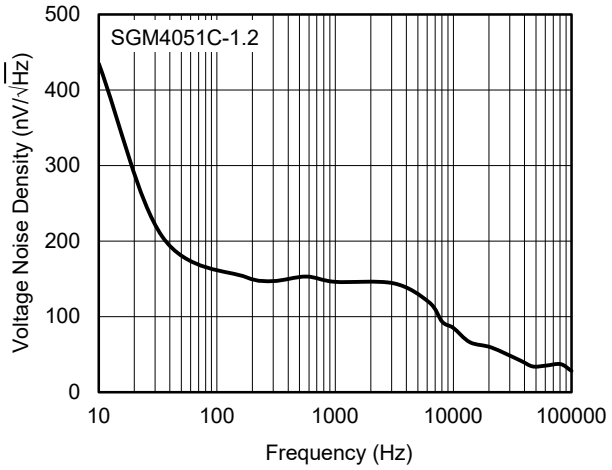

Average Temperature Coefficient Distribution



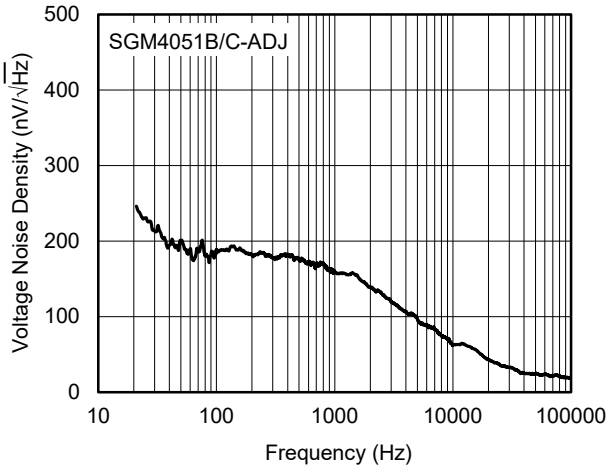
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A$ = +25℃, unless otherwise noted.

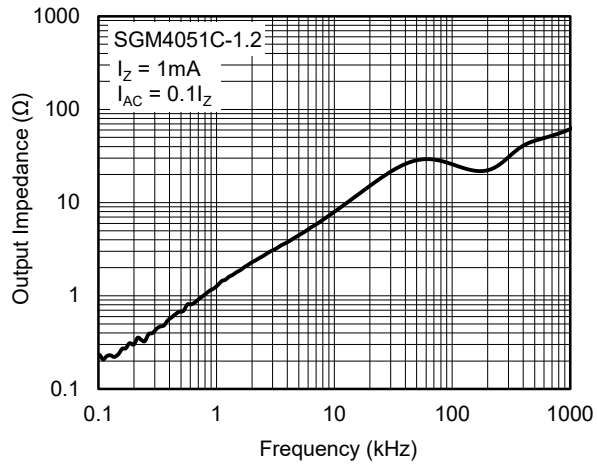
Voltage Noise Density vs. Frequency



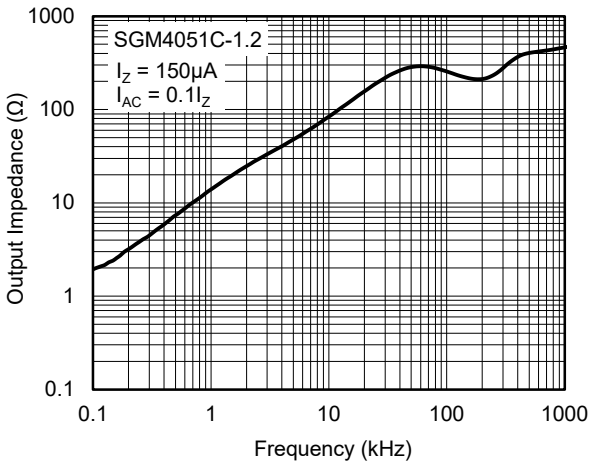

Voltage Noise Density vs. Frequency



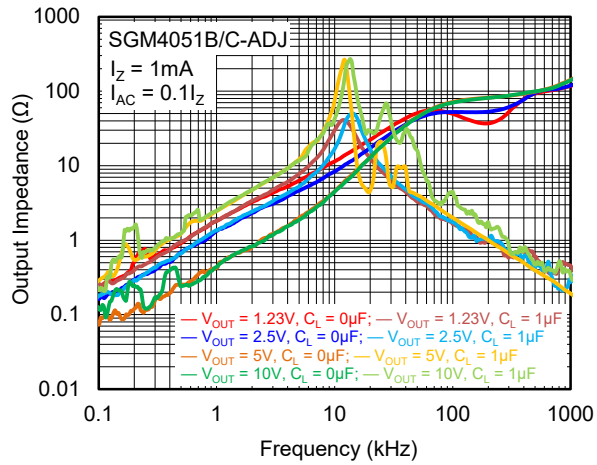

Output Impedance vs. Frequency



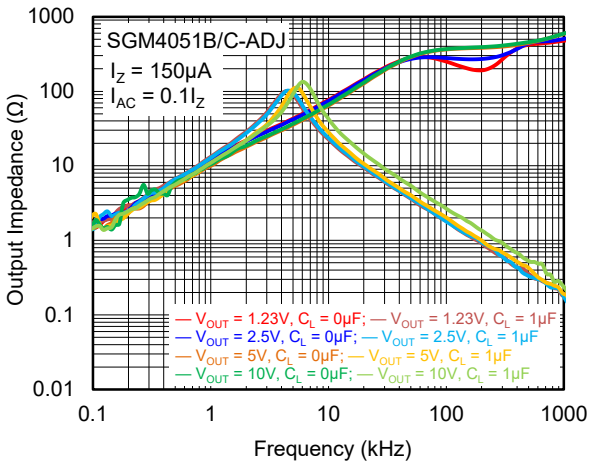

Output Impedance vs. Frequency




Output Impedance vs. Frequency




Output Impedance vs. Frequency



# APPLICATION INFORMATION

## Output Capacitor

Because of the excellent stability of the shunt voltage reference, the capacitors are not required to be connected between CATHODE and ANODE pins. However, if a bypass capacitor is required, the stability of SGM4051 will not be reduced.

## Adjustable Version

The advantage of this version is that the users can adjust the output voltage by simply changing the resistance of the voltage divider $R_1$ and $R_2$. Also, the relationship between $V_{REF}$ and $V_Z$ is shown as below:

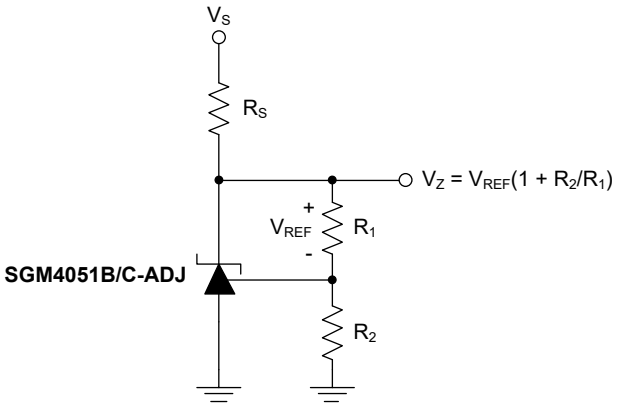



**Figure 1. Adjustable Shunt Regulator**

## Load Current and Cathode

For the shunt regulator shown in Figure 2, $R_S$ is required to be connected between $V_S$ and the cathode of SGM4051. The value of $R_S$ is significant for this shunt regulator because it determines how much current can be flowed to the voltage reference itself ($I_Z$) and the load ($I_L$), and the user needs to make sure that the cathode current ($I_Z$) is operated within the design specification. However, for one extreme case, if the supply voltage and load is varied (the load current $I_L$ is maximum and the $V_S$ is minimum), it is recommended that the resistance of $R_S$ should be selected low enough to guarantee normal operation of the shunt regulator. For the other extreme, $I_L$ is minimum and $V_S$ is maximum, the resistance of $R_S$ should be large enough to guarantee that the operating current $I_Z$ is less than 12mA.

The equation 1 shows the calculation of $R_S$.

$$R_S = \frac{V_S - V_Z}{I_L + I_Z} \quad (1)$$

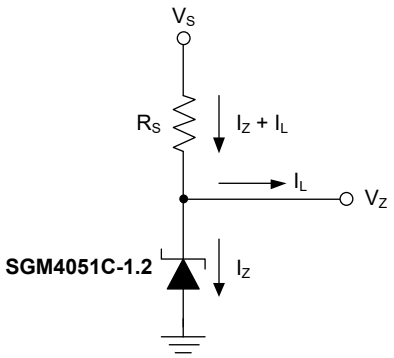



**Figure 2. Shunt Regulator**

# REVISION HISTORY

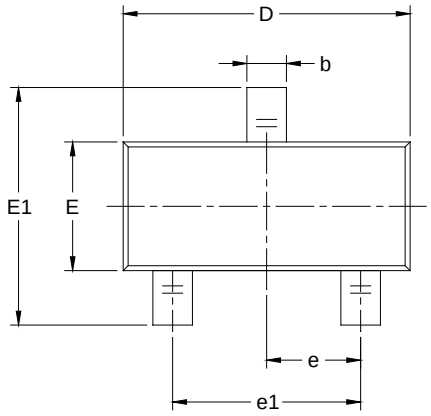
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

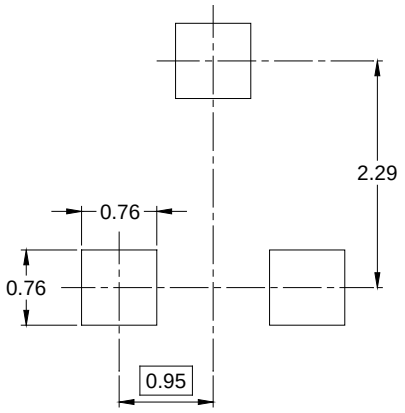
| MARCH 2022 – REV.A to REV.A.1 | Page |
|---|---|
| Added SGM4051B/C-ADJ version | All |

| Changes from Original (DECEMBER 2020) to REV.A | Page |
|---|---|
| Changed from product preview to production data | All |

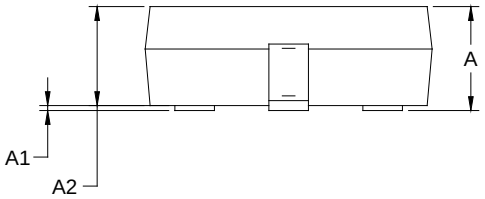
# PACKAGE OUTLINE DIMENSIONS

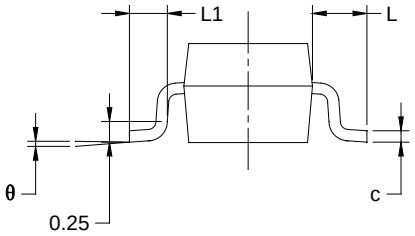
## SOT-23




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



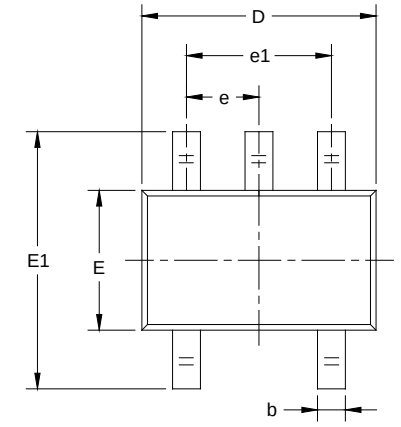



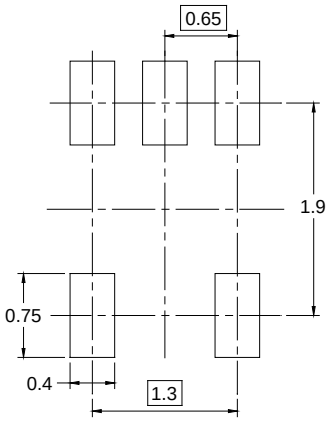

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.89 | 1.12 | 0.035 | 0.044 |
| A1 | 0.01 | 0.10 | 0.000 | 0.004 |
| A2 | 0.88 | 1.02 | 0.035 | 0.040 |
| b | 0.30 | 0.50 | 0.012 | 0.020 |
| c | 0.08 | 0.20 | 0.003 | 0.008 |
| D | 2.80 | 3.04 | 0.110 | 0.120 |
| E | 1.20 | 1.40 | 0.047 | 0.055 |
| E1 | 2.10 | 2.64 | 0.083 | 0.104 |
| e | 0.95 BSC | | 0.037 BSC | |
| e1 | 1.90 BSC | | 0.075 BSC | |
| L | 0.54 REF | | 0.021 REF | |
| L1 | 0.40 | 0.60 | 0.016 | 0.024 |
| 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.

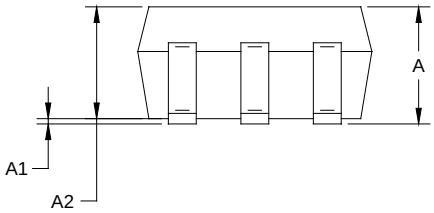
# PACKAGE OUTLINE DIMENSIONS

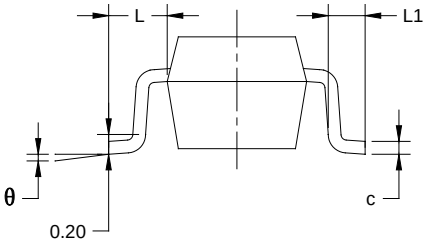
## SC70-5




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



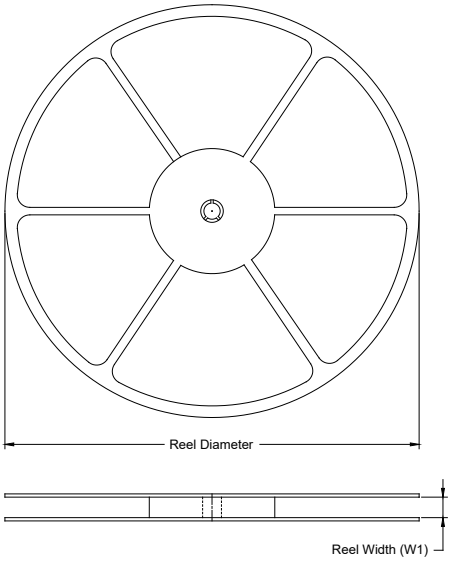




| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.800 | 1.100 | 0.031 | 0.043 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 0.800 | 1.000 | 0.031 | 0.039 |
| b | 0.150 | 0.350 | 0.006 | 0.014 |
| c | 0.080 | 0.220 | 0.003 | 0.009 |
| D | 2.000 | 2.200 | 0.079 | 0.087 |
| E | 1.150 | 1.350 | 0.045 | 0.053 |
| E1 | 2.150 | 2.450 | 0.085 | 0.096 |
| e | 0.65 TYP | | 0.026 TYP | |
| e1 | 1.300 BSC | | 0.051 BSC | |
| L | 0.525 REF | | 0.021 REF | |
| L1 | 0.260 | 0.460 | 0.010 | 0.018 |
| θ | 0° | 8° | 0° | 8° |

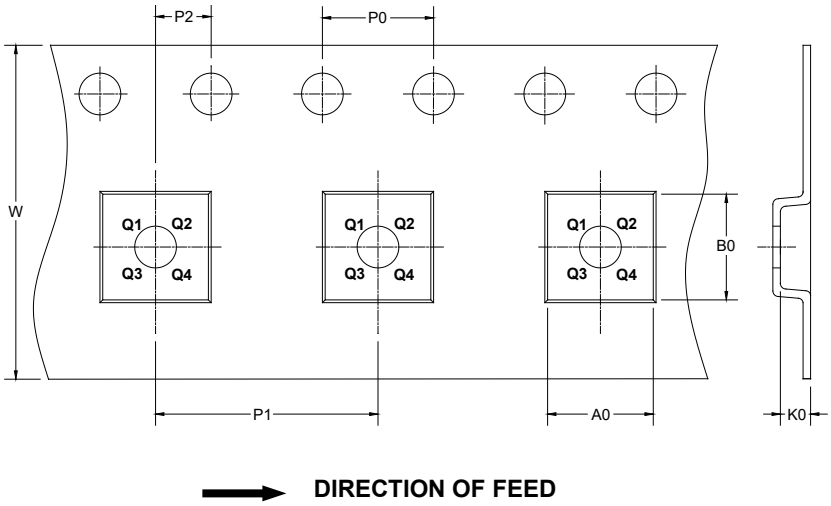
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

# TAPE AND REEL INFORMATION

### REEL DIMENSIONS




### TAPE DIMENSIONS



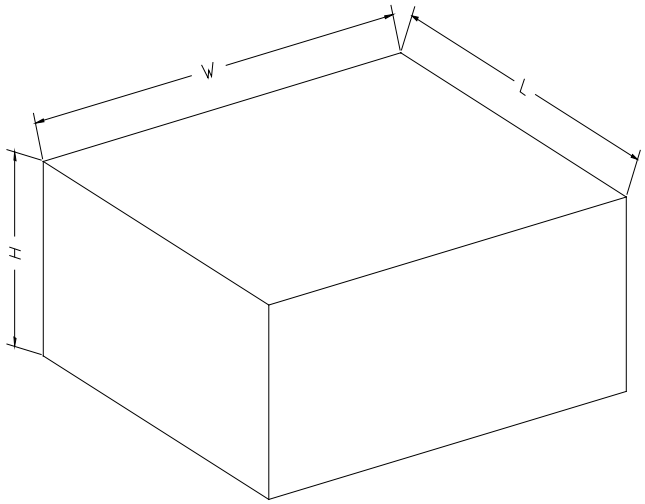

NOTE: The picture is only for reference. Please make the object as the standard.

## 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 | 7″ | 9.5 | 3.15 | 2.77 | 1.22 | 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 |

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 |

DD0002