

GENERAL DESCRIPTION

The SGM4029 is a precision voltage reference with extreme low noise and drift. Also, this device has the ability to sink or source current at the output pin, which means that the load and line regulation of SGM4029 is good.

The temperature drift of SGM4029 is just 10ppm/°C (MAX) and the initial accuracy of the output voltage is significant high (0.1% MAX), and these two advantages are achieved by the special internal structure. In addition, the combination of the above two advantages and the low noise ability make excellent performance for SGM4029 in data acquisition systems.

The SGM4029 is available in a Green SOIC-8 package. It operates an operating temperature range of -40°C to +125°C.

FEATURES

- **Low Temperature Drift:**
 - ◆ -40°C to +125°C: 5ppm/°C (TYP), 10ppm/°C (MAX)
 - ◆ 0°C to +85°C: 3ppm/°C (TYP)
- **High Initial Accuracy: ±0.05% (TYP), ±0.1% (MAX)**
- **Low Noise: 4.5µV_{P-P}/V**
- **High Output Current: ±10mA**
- **-40°C to +125°C Operating Temperature Range**
- **Available in a Green SOIC-8 Package**

APPLICATIONS

- Data-Acquisition Systems
- Instrumentation and Test Equipment
- Industrial Process Controls
- Medical Equipment
- Temperature and Pressure Transmitters
- Lab Instrumentation
- Field Instrumentation

SIMPLIFIED SCHEMATIC

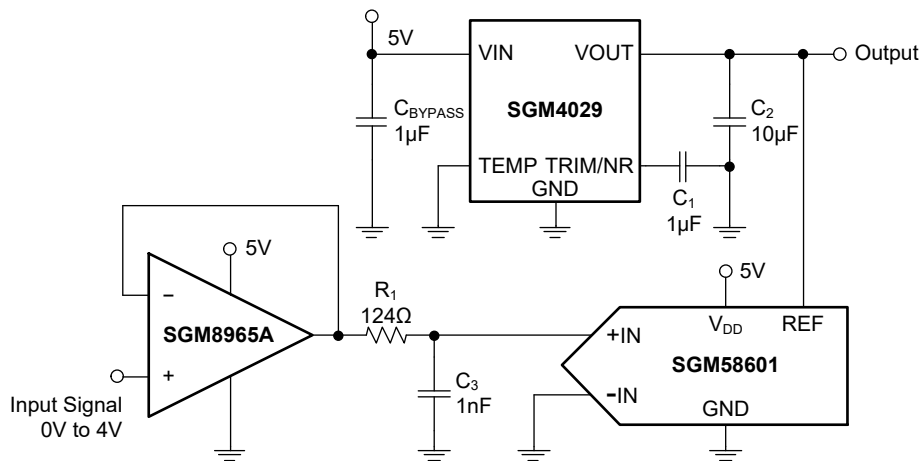


Figure 1. Schematic of Data Acquisition System

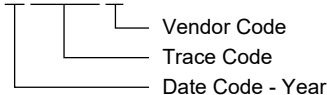
PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM4029-2.5	SOIC-8	-40°C to +125°C	SGM4029-2.5XS8G/TR	SGM S000XS8 XXXXX	Tape and Reel, 4000
SGM4029-3.0	SOIC-8	-40°C to +125°C	SGM4029-3.0XS8G/TR	SGM S00QXS8 XXXXX	Tape and Reel, 4000
SGM4029-4.096	SOIC-8	-40°C to +125°C	SGM4029-4.096XS8G/TR	SGM S00UXS8 XXXXX	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

Input Voltage Range -0.2V to 6V
 Output Short-Circuit Current Continuous
 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

Input Voltage Range (V_{OUT} + 0.7V) to 5.5V
 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.

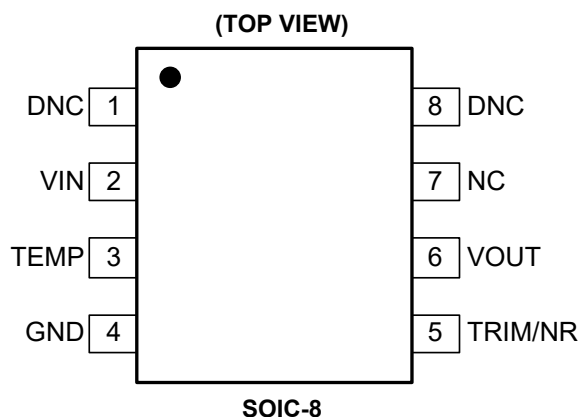
ESD SENSITIVITY CAUTION

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 CONFIGURATION



PIN DESCRIPTION

PIN	NAME	FUNCTION
1, 8	DNC	Do Not Connect. Don't connect with any external device in application.
2	VIN	Power Supply.
3	TEMP	Temperature Monitoring. Output voltage which is proportional to absolute temperature (PTAT), add a 0.1 μ F to 1 μ F capacitor to ground for best robustness to interference. If this pin is not used, short it to ground.
4	GND	Ground.
5	TRIM/NR	Adjust the Output Voltage and Reduce the Effect of Noise. Add a 0.1 μ F to 1 μ F capacitor to ground for best robustness to interference.
6	VOUT	Output of the Voltage Reference.
7	NC	There is no connection inside the device.

ELECTRICAL CHARACTERISTICS(V_{IN} = 5V, I_{LOAD} = 0mA, typical values are at T_A = +25°C, unless otherwise noted.)

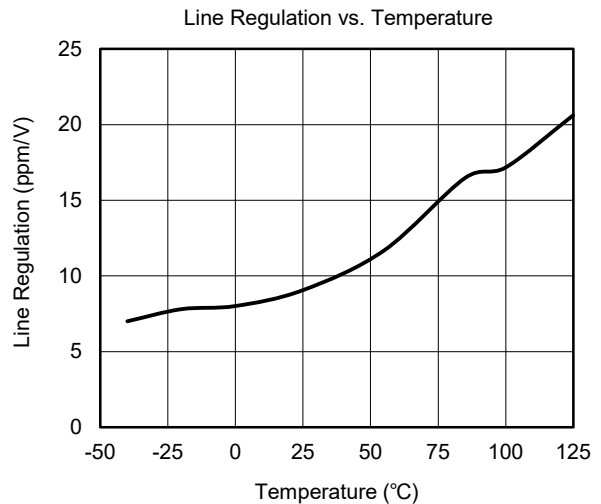
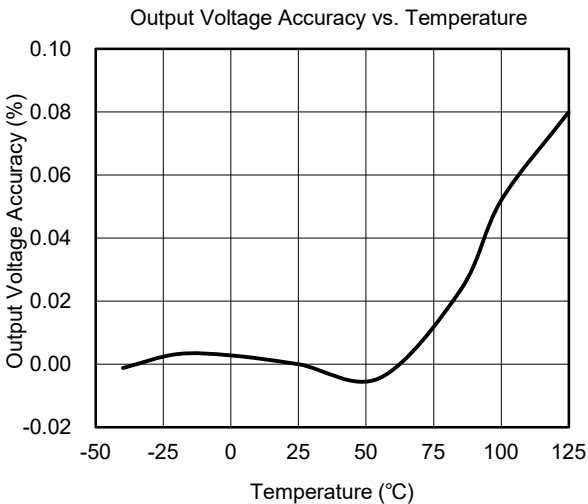
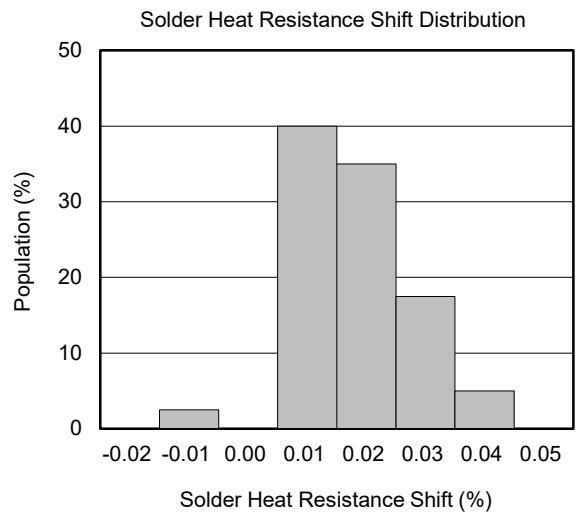
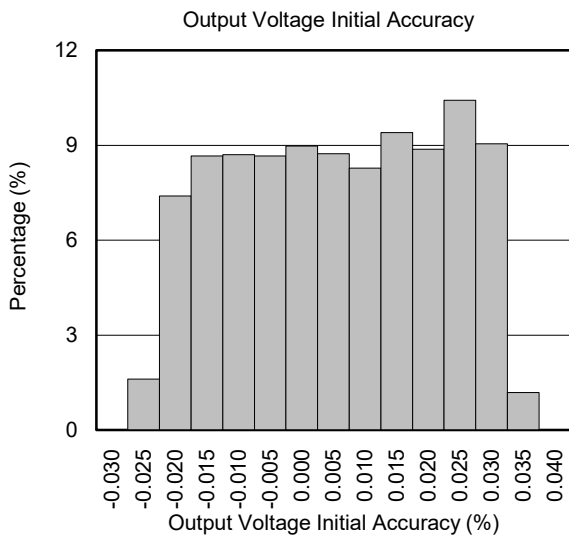
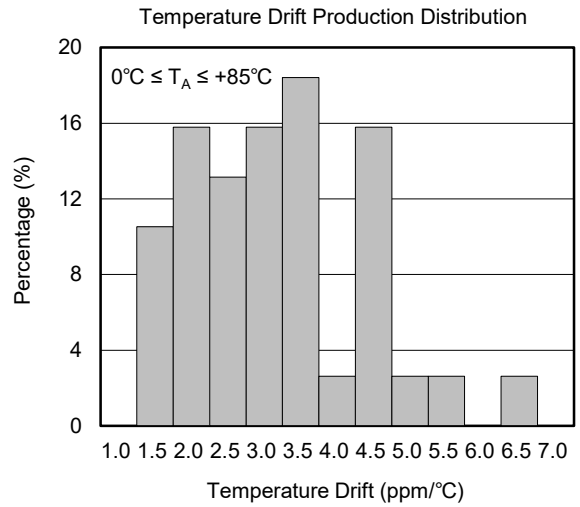
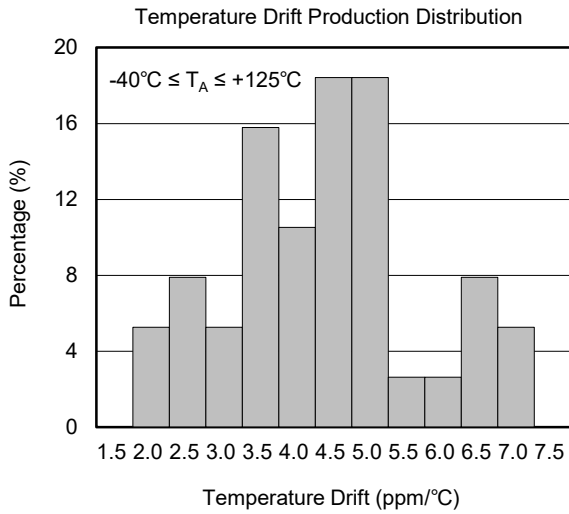
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SGM4029-2.5						
Output Voltage	V _{OUT}		2.4975	2.5	2.5025	V
Initial Accuracy			-0.1		+0.1	%
Output Voltage Noise		f = 0.1Hz to 10Hz		4.5		μV _{P-P} /V
Line Regulation		V _{REF} + 0.7V ≤ V _{IN} ≤ 5.5V		15		ppm/V
Load Regulation ⁽¹⁾	ΔV _{O(ΔIL)}	-10mA < I _{LOAD} < 10mA, V _{IN} = 5V		3		ppm/mA
SGM4029-3.0						
Output Voltage	V _{OUT}		2.997	3.0	3.003	V
Initial Accuracy			-0.1		+0.1	%
Output Voltage Noise		f = 0.1Hz to 10Hz		4.5		μV _{P-P} /V
Line Regulation		V _{REF} + 0.7V ≤ V _{IN} ≤ 5.5V		15		ppm/V
Load Regulation ⁽¹⁾	ΔV _{O(ΔIL)}	-10mA < I _{LOAD} < 10mA, V _{IN} = 5V		7		ppm/mA
SGM4029-4.096						
Output Voltage	V _{OUT}		4.092	4.096	4.100	V
Initial Accuracy			-0.1		+0.1	%
Output Voltage Noise		f = 0.1Hz to 10Hz		4.5		μV _{P-P} /V
Line Regulation		V _{REF} + 0.7V ≤ V _{IN} ≤ 5.5V		25		ppm/V
Load Regulation ⁽¹⁾	ΔV _{O(ΔIL)}	-10mA < I _{LOAD} < 10mA, V _{IN} = 5V		10		ppm/mA
SGM4029						
Output Voltage Temperature Drift ⁽²⁾	dV _{OUT} /dT	-40°C ≤ T _A ≤ +125°C		5	10	ppm/°C
Long-Term Stability ⁽³⁾		0h to 1000h, I _{OUT} = 0mA		50		ppm
		1000h to 2000h, I _{OUT} = 0mA		20		
Thermal Hysteresis	dT			150		ppm
Dropout Voltage	V _{IN} - V _{OUT}	I _{OUT} = 0mA, ΔV _{OUT} = 0.1%		110		mV
		I _{OUT} = 10mA, ΔV _{OUT} = 0.1%			700	
Short-Circuit Current	I _{SC}		21	28		mA
Turn-On Settling Time		To 0.1% with C _L = 1μF		800		μs
TEMP Pin						
Voltage Output				580		mV
Temperature Sensitivity		-40°C ≤ T _A ≤ +125°C		1.8		mV/°C
Power Supply						
Power Supply Range	V _{IN}		V _{OUT} + 0.7		5.5	V
Quiescent Current	I _Q			1450	2100	μA
		-40°C ≤ T _A ≤ +125°C			2550	

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.

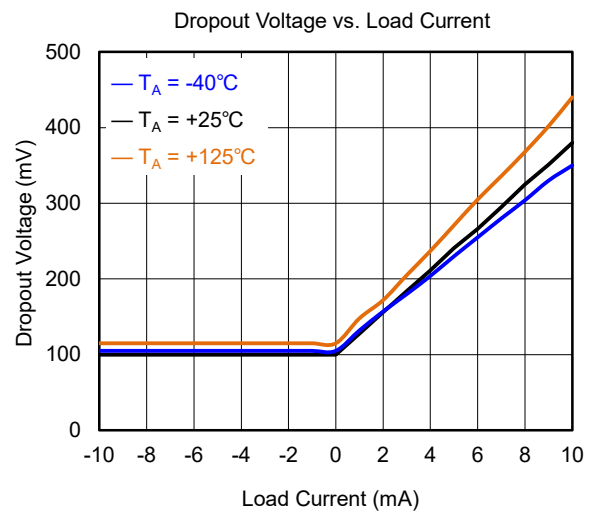
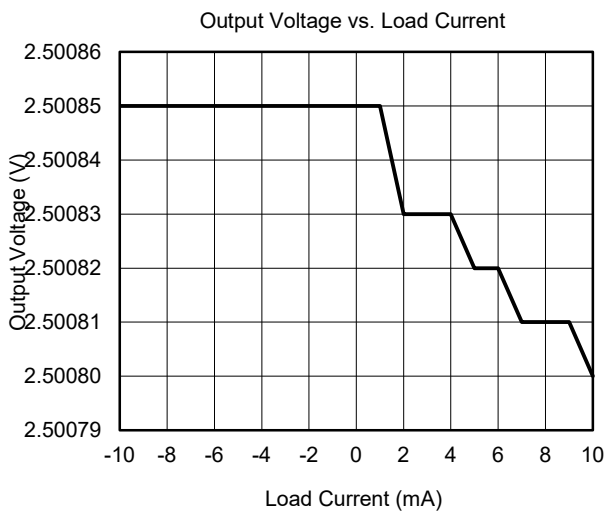
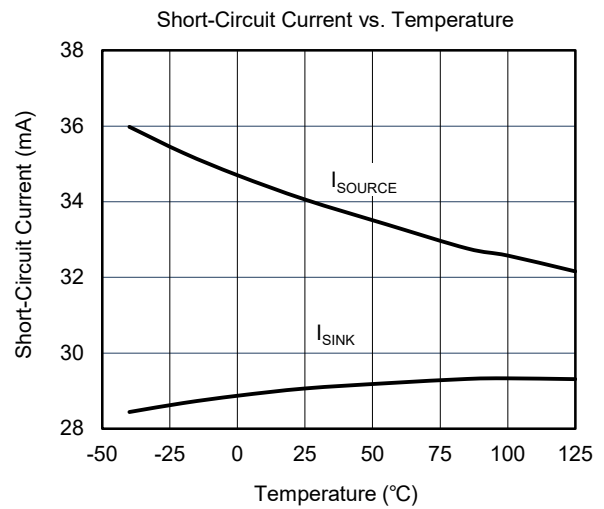
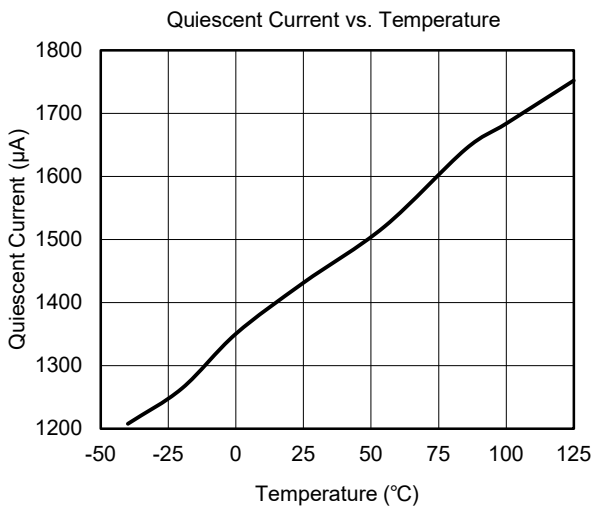
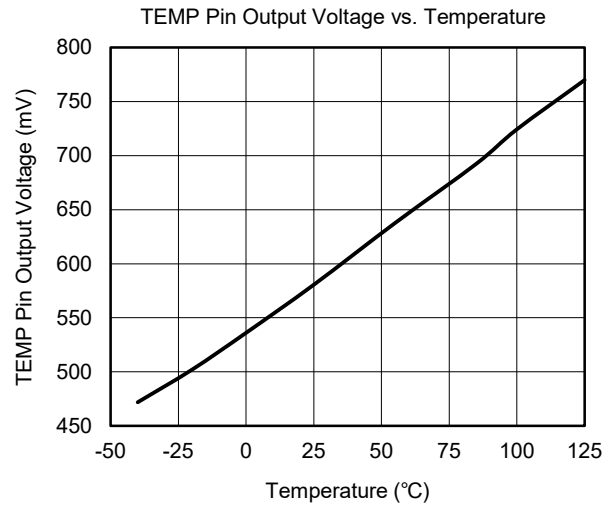
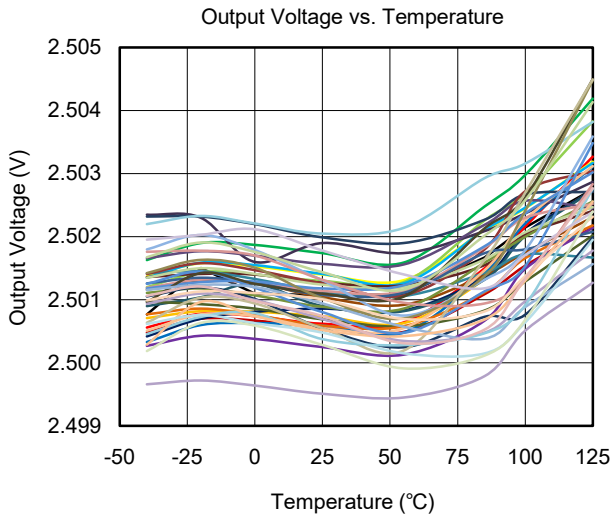
TYPICAL PERFORMANCE CHARACTERISTICS

At $T_A = +25^\circ\text{C}$, $V_{OUT} = 2.5\text{V}$, unless otherwise noted.



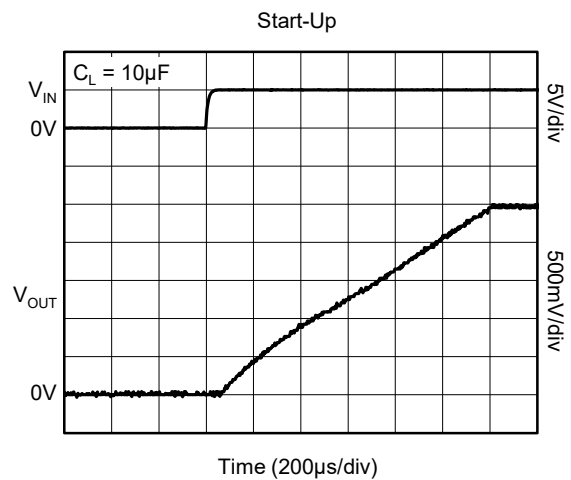
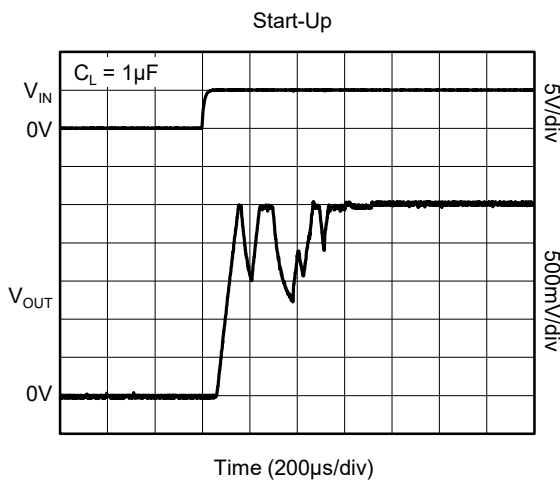
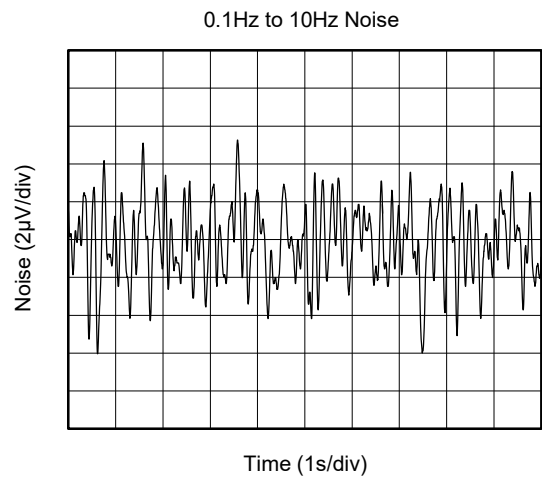
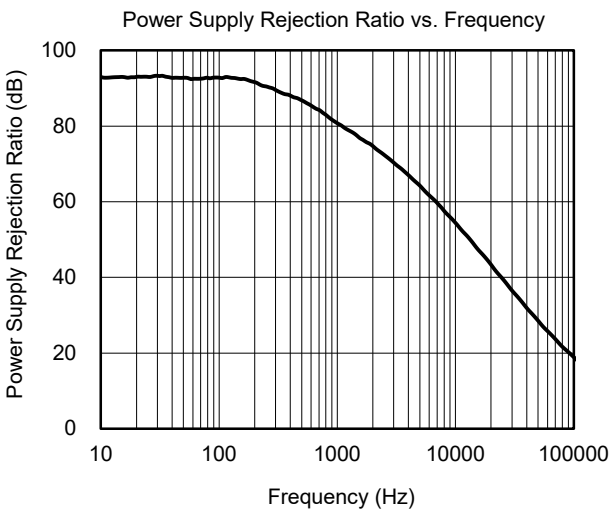
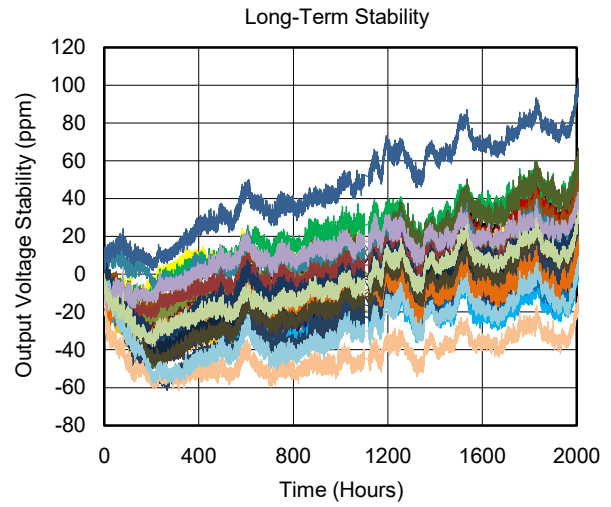
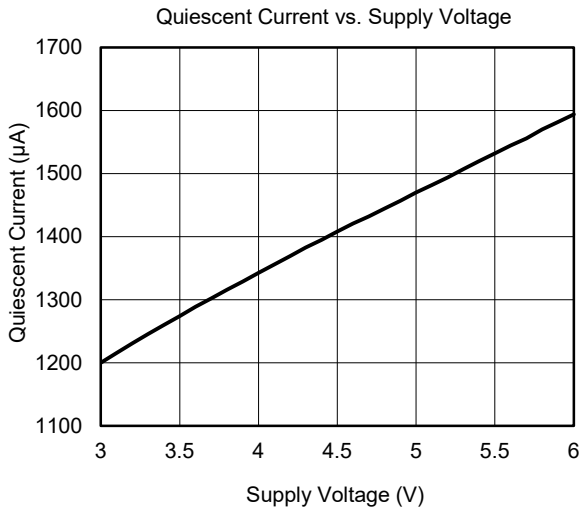
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A = +25^\circ\text{C}$, $V_{\text{OUT}} = 2.5\text{V}$, unless otherwise noted.



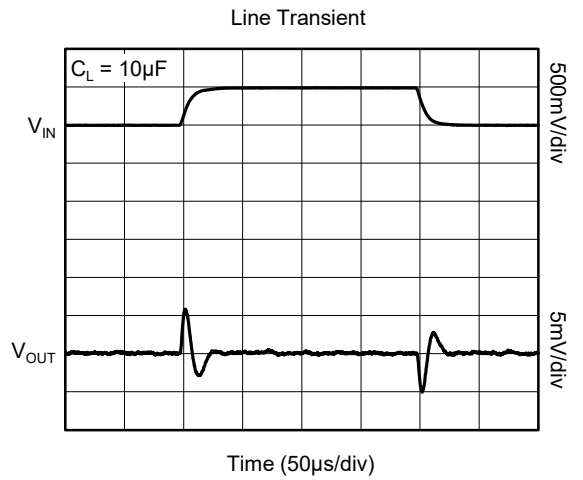
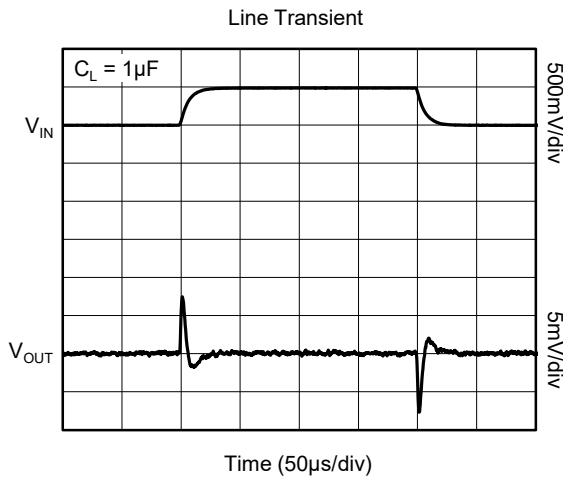
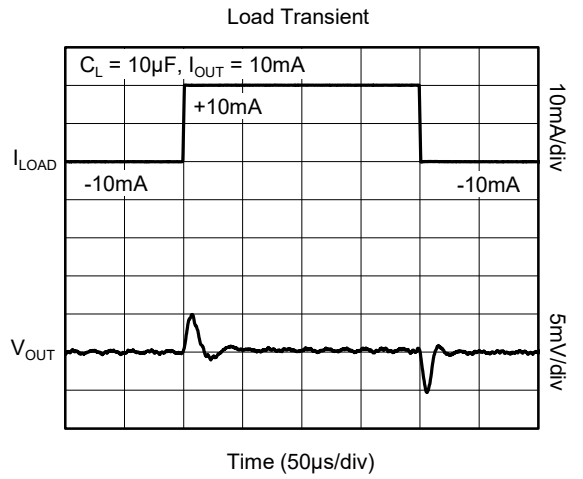
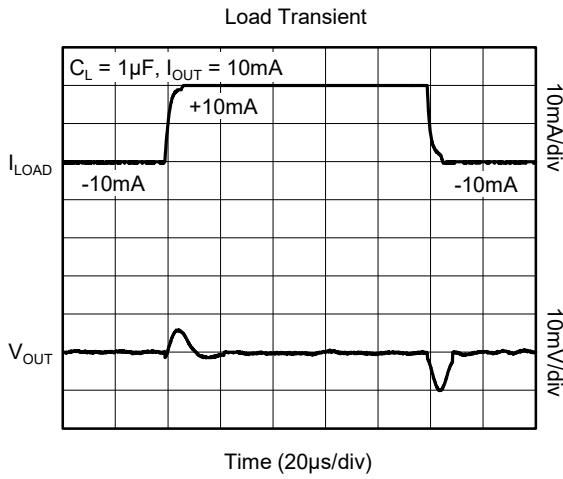
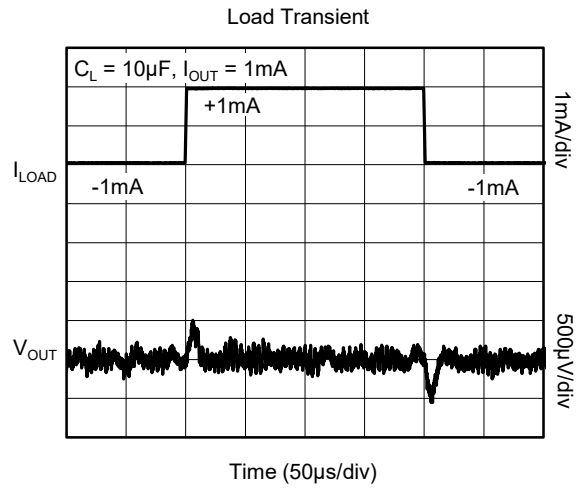
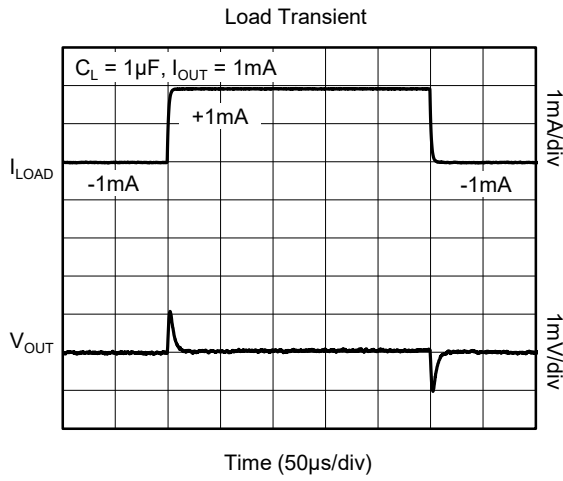
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A = +25^\circ\text{C}$, $V_{OUT} = 2.5\text{V}$, unless otherwise noted.



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A = +25^\circ\text{C}$, $V_{OUT} = 2.5\text{V}$, unless otherwise noted.



FUNCTIONAL BLOCK DIAGRAM

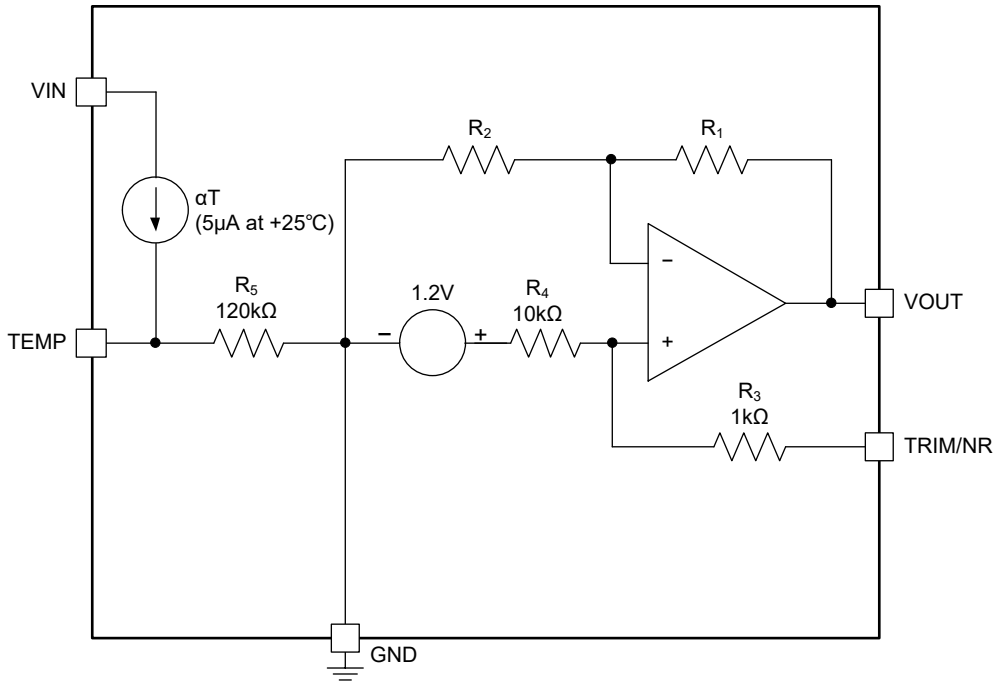


Figure 2. Block Diagram

PARAMETER MEASUREMENT INFORMATION

Solder Heat Shift

The internal structure of SGM4029 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.

DETAILED DESCRIPTION

The SGM4029 is a precision bandgap voltage reference with extreme low noise and drift. The internal structure of SGM4029 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 120kΩ. The following equation indicates the relationship between the voltage of TEMP pin and the temperature.

$$V_{TEMP} = 534\text{mV} + 1.8\text{mV}/^{\circ}\text{C} \times T(^{\circ}\text{C}) \quad (1)$$

The TEMP pin can reflect the temperature of the chip, with the accuracy of $\pm 15^{\circ}\text{C}$. 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 54mV output change of TEMP pin can illustrate 30°C 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.

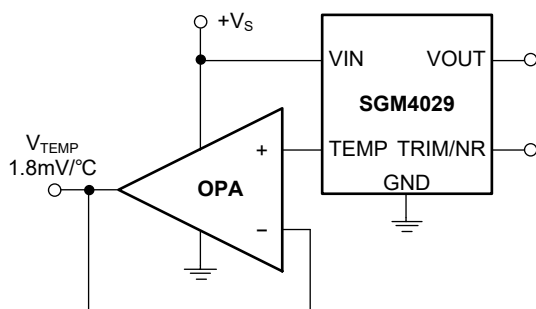


Figure 3. Buffering the TEMP Pin Output

Temperature Drift

The drift error for SGM4029 is significant small, and the change of output voltage illustrates the drift of error. The Box Method is used to evaluate the temperature drift as shown in Equation 2.

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

The temperature drift of SGM4029 is just 10ppm/ $^{\circ}\text{C}$.

Thermal Hysteresis

To measure the thermal hysteresis, the V_{OUT} of the device should be measured at the temperature of $+25^{\circ}\text{C}$. After finishing this, the SGM4029 will be cycled to the other temperatures, and then remove it back to $+25^{\circ}\text{C}$ and measure the V_{OUT} again. In conclusion, this voltage difference is the hysteresis of temperature.

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

where:

V_{HYST} is the thermal hysteresis.

V_{PRE} is the output voltage measured at $+25^{\circ}\text{C}$ before the device is removed to the temperature range of -40°C to $+125^{\circ}\text{C}$.

V_{POST} is the output voltage measured at $+25^{\circ}\text{C}$ after the device is removed to the temperature range of -40°C to $+125^{\circ}\text{C}$.

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

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 can improve the noise level of SGM4029; however, please make sure that the output impedance of the device is not affected. To reduce the noise, it is recommended that using a $1\mu\text{F}$ capacitor is enough for improving the noise.

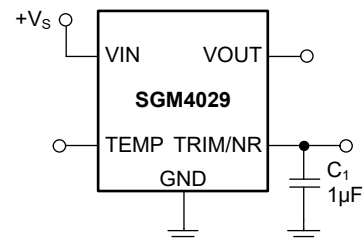


Figure 4. Reducing the Noise with TRIM/NR Pin

DETAILED DESCRIPTION (continued)

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.

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

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.

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 $\pm 15mV$.

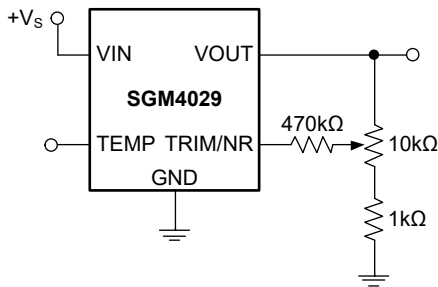


Figure 5. Adjusting Output with TRIM/NR Pin

With the ability of TRIM/NR pin, the users can access the internal bandgap of SGM4029. In Figure 4, an RC low-pass filter is created by placing a $1\mu F$ capacitor at the TRIM/NR pin, and the corner frequency of the low-pass filter is from 10Hz to 20Hz. Also, this filter can reduce half of the overall noise at the VOUT pin. The higher the value of capacitor is, the lower the corner frequency is. With the effect of this capacitor, the start-up time will be increased.

Basic Connections

For typical connection shown in Figure 6, it is recommended that a capacitor from $1\mu F$ to $100\mu F$ should be connected at the VOUT pin. Also, a $0.47\mu F$ capacitor should be connected to the VIN pin for stability. 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 1Ω and 1.5Ω equivalent resistance is suitable for reducing the effect of noise.

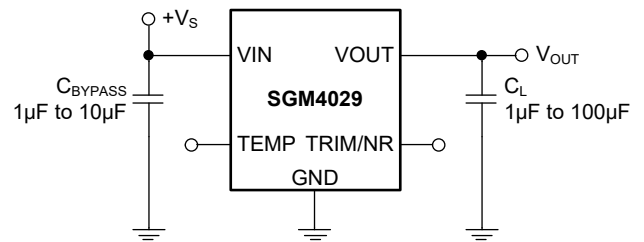


Figure 6. Basic Connections

Supply Voltage

For normal operation, the minimum supply voltage should be 700mV larger than the output voltage.

Negative Reference Voltage

If users desire to use SGM4029 to guarantee positive and negative voltage, SGM4029 and SGM8263 should be taken into account. In Figure 7, the output of SGM8263 is equal to the negative value of SGM4029. The following circuit can also guarantee the accuracy as the offset voltage and drift of SGM8263 is also extreme low. In addition, the temperature coefficient of two resistors should be taken into account.

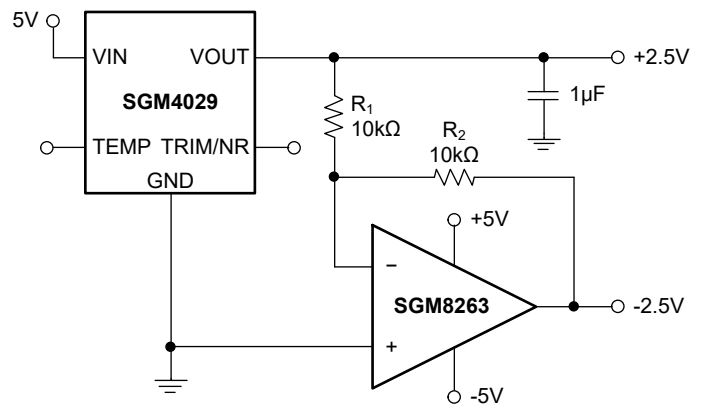


Figure 7. Positive and Negative Voltage Reference

APPLICATION INFORMATION

The advantage of accuracy and stability is beneficial for SGM4029 to be used as a voltage reference for analog-to-digital converters (ADC). Figure 8 shows a data acquisition system with SGM4029.

24-Bit, 32KSPS Data Acquisition System

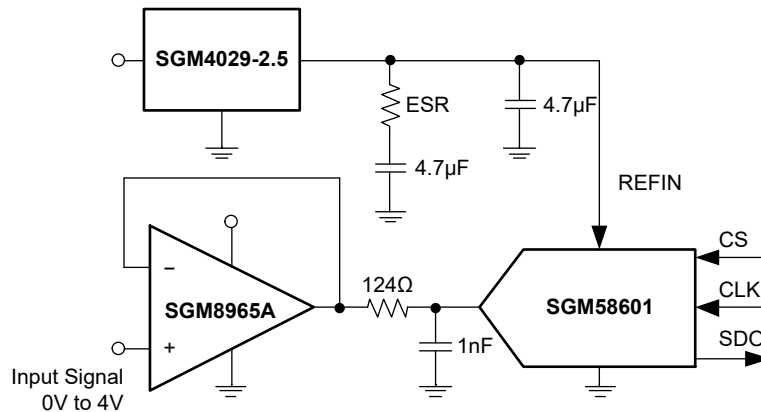


Figure 8. Data Acquisition System with SGM4029

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 SGM4029. For enhance the stability, a bypass capacitor must be added at the input pin of SGM4029. 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, SGM4029-2.5 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)**Power Supply Recommendations**

The dropout voltage of SGM4029 is extreme low. The lowest power supply voltage is equal to 3.2V and it must be 700mV greater than the output voltage of the voltage reference. It is recommended that a capacitor with 1μF to 10μF is required to add at the VIN pin to enhance the stability.

Layout

The bypass capacitor with 1μF to 10μF 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 1μF to 100μF should be added to the output pin of the voltage reference. Although the equivalent series resistor is optional for the operation of SGM4029, 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 component of the noise, a 1μF capacitor should be connected to the output pin. 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 SGM4029 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 (°C).

T_A is the ambient temperature (°C).

P_D is the power dissipated (W).

θ_{JA} is the junction-to-ambient thermal resistance (°C/W).

The junction temperature of SGM4029 must be lower than +150 °C, which is the maximum acceptable temperature of this voltage reference.

REVISION HISTORY

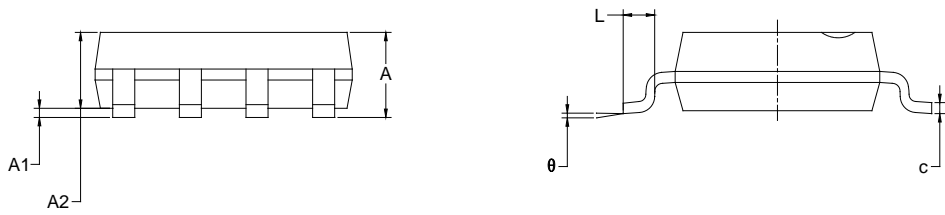
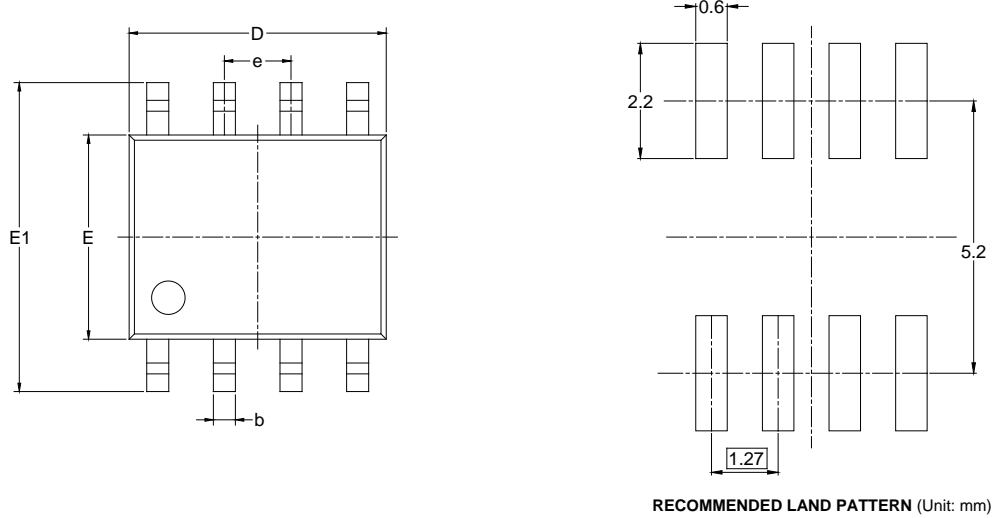
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

AUGUST 2023 – REV.A to REV.A.1	Page
Updated Electrical Characteristics section	4
Updated Typical Performance Characteristics section	7
Updated Application Information section.....	11, 13

Changes from Original (SEPTEMBER 2022) 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 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

DD0001

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

DD0002