SGM450
Low Power, High Accuracy Analog Output Temperature Sensor

GENERAL DESCRIPTION

The SGM450 is a high-precision linear analog temperature sensor IC, providing an output voltage directly proportional to temperature, making it suitable for various analog temperature measuring and temperature monitoring applications. With a typical accuracy of ±0.5℃ over the 0℃ to +85℃ range, the SGM450 delivers higher accuracy than other pin-compatible devices currently on the market. The SGM450 generates a positive output slope of 10mV per degree Celsius across an extensive temperature ranging from -40℃ to +150℃, powered by a single supply voltage varying from 2.3V to 5.5V.

The SGM450 provides a low quiescent current of 7.5μA (TYP) and a power-on time of 420μs (TYP), making it ideal for battery-powered applications due to its energy-efficient consumption characteristics. The output stage of the SGM450 is structured as a Class-AB type with a maximum output driver capability of 500μA, capable of driving a capacitive load of 1000pF, which is more suitable for connecting with the input stage of analog-to-digital converter (ADC). The SGM450 analog output temperature sensor, with its high accuracy and robust linear output driver, presents a cost-effective solution compared to traditional devices (passive thermistors).

The SGM450 is available in Green SC70-5 and SOT-23 packages. It is specified over the extended industrial temperature range from -40℃ to +150℃.

FEATURES

- **Wide Temperature Measurement Range:**
  -40℃ to +150℃
- **Temperature Accuracy:**
  ±2°C (MAX): -40℃ to +150℃
- **Positive Slope Sensor Gain: 10mV/℃ (TYP)**
- **Output Voltage Offset: 500mV at 0℃ (TYP)**
- **Wide Power Supply Range: 2.3V to 5.5V**
- **Short-Circuit Protected Output**
- **Low Quiescent Current: 7.5μA (TYP)**
- **Class-AB Structure Output**
- **Able to Drive Capacitive Load up to 1000pF**
- **Available in Green SC70-5 and SOT-23 Packages**

APPLICATIONS

Wireless and Telecom Infrastructure
Test and Measurement
Factory Automation and Control
Automotive Infotainment

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM450	SC70-5	-40℃ to +150℃	SGM450A2XC5G/TR	QAXX	Tape and Reel, 3000
	SOT-23	-40℃ to +150℃	SGM450A2XN3LG/TR	Q9XX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XX = Date Code.

YY X X

- X — Date Code - Week
- X — Date Code - Year
- YY — Serial Number

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_{DD} 6V
Output Voltage Range, V_{OUT} .... -0.3V to V_{DD} + 0.3V
Output Current Range .... -30mA to 30mA
Latch-Up Current Range, Each Pin .... -200mA to 200mA
Package Thermal Resistance
SC70-5, θ_{JA} .... 218℃/W
SOT-23, θ_{JA} .... 260℃/W
Junction Temperature .... +150℃
Storage Temperature Range .... -65℃ to +150℃
Lead Temperature (Soldering, 10s) .... +260℃
ESD Susceptibility
HBM 4000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range, V_{DD} .... 2.3V to 5.5V
Operating Ambient Temperature Range .... -40℃ to +150℃

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

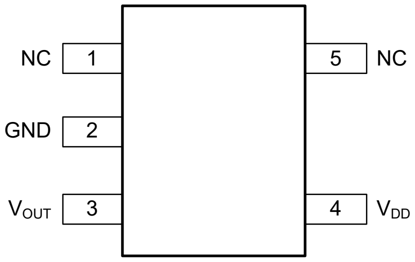
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

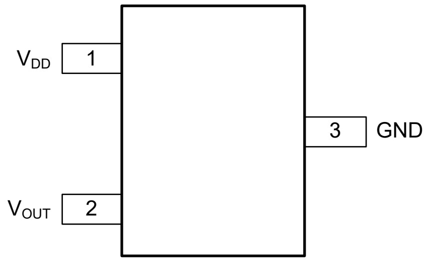
PIN CONFIGURATIONS

(TOP VIEW)



SC70-5

(TOP VIEW)



SOT-23

PIN DESCRIPTION

PIN		NAME	TYPE	FUNCTION
SC70-5	SOT-23			
1, 5	—	NC	—	No Internal Connection. Leave it floating or connect it to ground pin.
2	3	GND	G	Ground.
3	2	V_{OUT}	O	Temperature Sensor Output. The output voltage of the temperature sensor is designed to vary in direct proportion to the measured temperature.
4	1	V_{DD}	I	Positive Power Supply Voltage Pin.

NOTE: I = input, O = output, G = ground.

ELECTRICAL CHARACTERISTICS

(V_{DD} = 2.3V to 5.5V, T_A = -40℃ to +150℃, GND = Ground and no load, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Power Supply						
Operating Current	I_{DD}	T_A = +25℃, V_{DD} = 2.3V		7.5	10	μA
		T_A = +150℃		11	16	
Line Regulation	Δ℃/ΔV_{DD}		-0.2	0.04	0.2	℃/V
Sensor Accuracy						
Temperature Accuracy (1)	T_{ACC}	T_A = +25℃		±0.5		℃
		T_A = 0℃ to +85℃	-1.5	±0.5	1.5	
		T_A = -40℃ to +150℃	-2.0	±0.5	2.0	
Sensor Output						
Offset Output Voltage	V_{OFFS}	T_A = 0℃		500		mV
Temperature Coefficient (Sensor Gain)	T_C			10		mV/℃
Output Nonlinearity (1)	V_{ONL}	T_A = 0℃ to +85℃, no load		±0.5		℃
Output Current	I_{OUT}				500	μA
Output Impedance	Z_{OUT}	I_{OUT} = 100μA, f = 100Hz		3		Ω
		I_{OUT} = 100μA, f = 500Hz		4		
Output Load Regulation		T_A = 0℃ to +85℃, I_{OUT} = 100μA, $\Delta V_{OUT}/\Delta I_{OUT}$		0.1	0.6	Ω
Power-On Time	t_{ON}	Time to reach accuracy within ±0.5℃		420	1300	μs
Typical Load Capacitance	C_{LOAD}				1000	pF

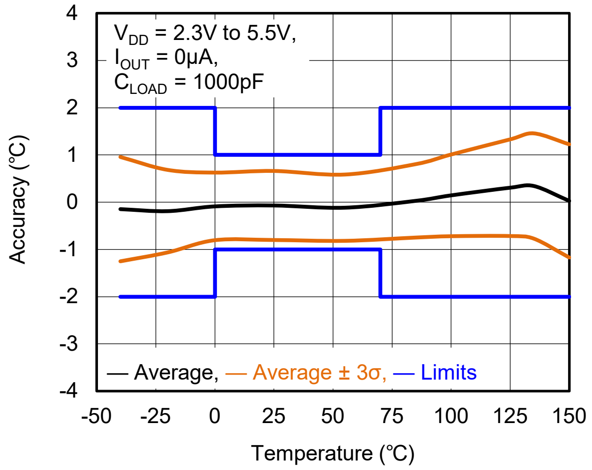
NOTE:

1. Accuracy is defined as the difference between the measured and reference output voltages, as listed in Table 2 under specified supply voltage and temperature conditions (in ℃). The accuracy limits take into account line regulation under these conditions but exclude load regulation, assuming the output is high impedance.

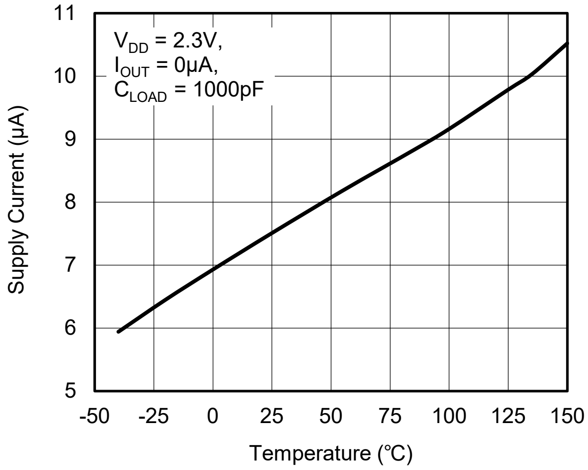
TYPICAL PERFORMANCE CHARACTERISTICS

T_A = +25℃, unless otherwise noted.

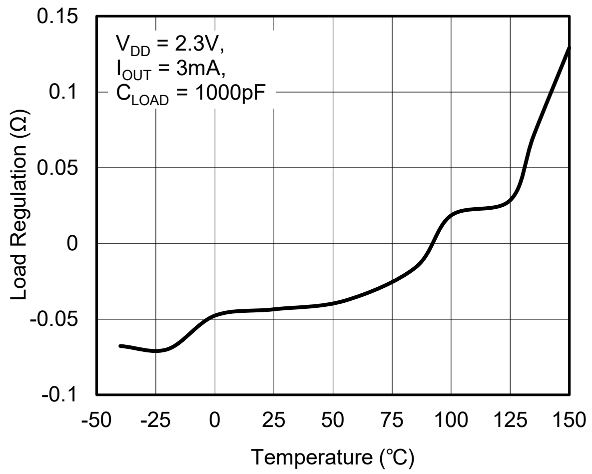
Accuracy vs. Temperature



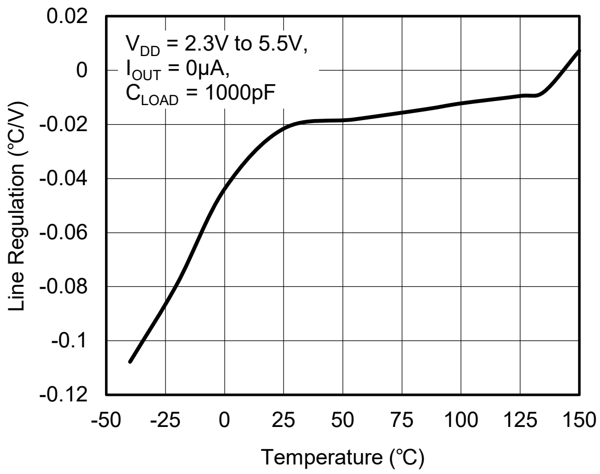
Supply Current vs. Temperature



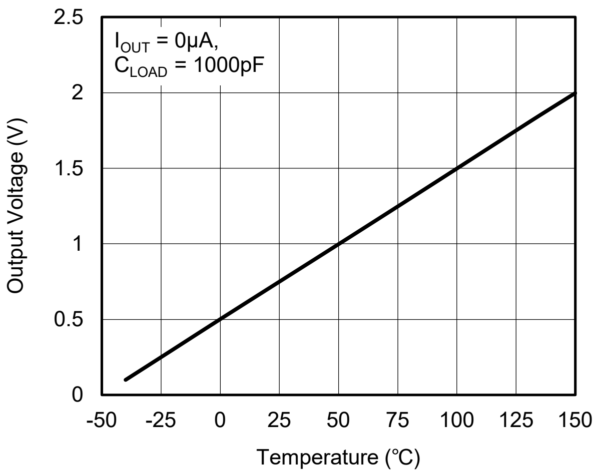
Load Regulation vs. Temperature



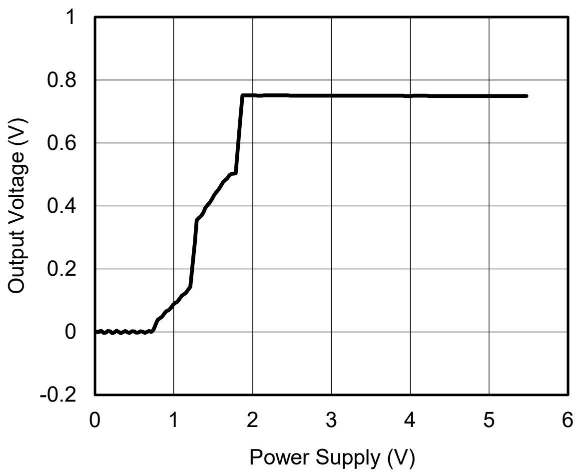
Line Regulation vs. Temperature



Output Voltage vs. Temperature

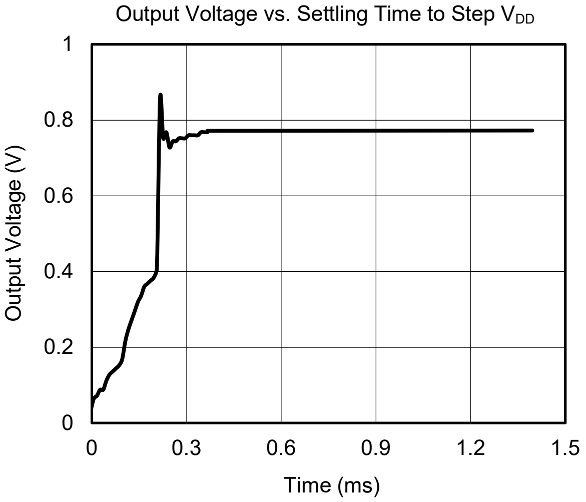


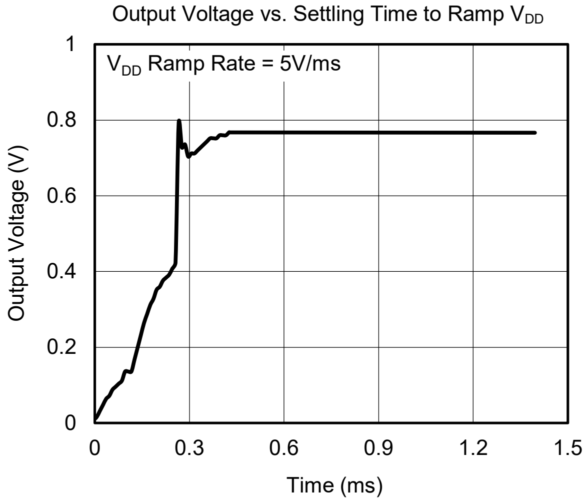
Output Voltage vs. Power Supply

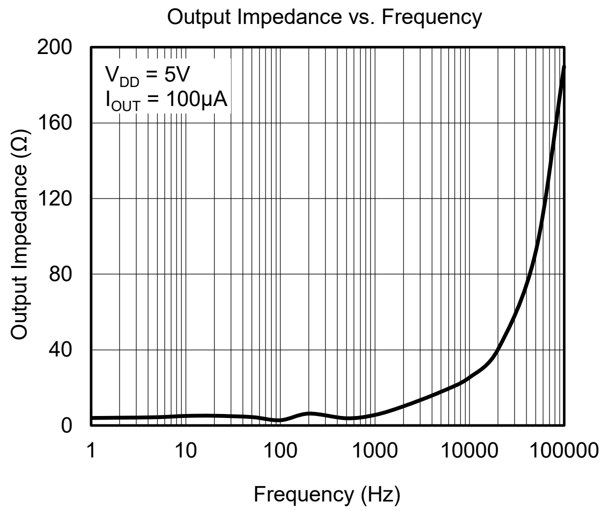


TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_A = +25°C, unless otherwise noted.







FUNCTIONAL BLOCK DIAGRAM

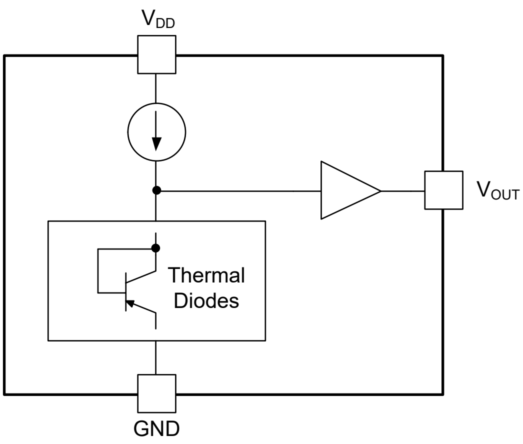


Figure 1. Block Diagram

DETAILED DESCRIPTION

The SGM450 is a precision linear analog temperature sensor that delivers an output voltage directly proportional to the sensed temperature. It offers a typical measurement accuracy of ±0.5℃ within the 0℃ to +85℃ range. The SGM450 delivers a positive output slope of 10mV/℃ across the entire temperature range from -40℃ to +150℃ and supports wide range power supply from 2.3V to 5.5V. A Class-AB output driver architecture is capable of delivering a maximum output current of 500μA, enabling it to effectively drive capacitive loads up to 1000pF.

Feature Description

As illustrated in Figure 3, the SGM450 exhibits linear behavior, though a slight V_{OUT} gain shift occurs at temperatures exceeding +100℃. When higher accuracy is expected, a piecewise linear function offers optimal solution and is therefore for defining the device's accuracy specifications.

The SGM450 provides a piecewise linear function that operates across three distinct temperature ranges, as specified in Table 1. To determine the temperature-to-voltage conversion (V_{OUT}) of the sensor, Equation 1 is utilized for the mathematical calculation.

$$V_{OUT} = (T_A - T_{INFL}) \times T_C + V_{OFFS} \quad (1)$$

where:

V_{OUT} represents the SGM450's temperature-to-voltage conversion output, which corresponds to a specific temperature input.

T_A denotes the ambient temperature, measured in ℃.

T_{INFL} represents the temperature inflection point for a piecewise segment, measured in ℃.

T_C represents the temperature coefficient or gain.

V_{OFFS} represents the voltage offset inherent.

Hence, for a given V_{OUT} temperature-to-voltage output falling within a specific piecewise voltage range (V_{RANGE}), the corresponding T_A is determined by applying Equation 2. In applications where it is not necessary to improve accuracy beyond +100℃, it is advisable to refer to the first row of Table 1 for all voltage values.

$$T_A = (V_{OUT} - V_{OFFS})/T_C + T_{INFL} \quad (2)$$

Table 1. Piecewise Linear Function Summary

T_A (℃)	V_{RANGE} (mV)	T_{INFL} (℃)	T_C (mV/℃)	V_{OFFS} (mV)
-40 to +100	< 1500	0	10	500
+100 to +125	1500 to 1751.3	100	10.05	1500
+125 to +150	> 1751.3	125	9.876	1751.3

Table 2 provides a list of the typical temperature-to-voltage (V_{OUT}) conversions of the SGM450 across its entire operating temperature range. The ideal linear columns show the ideal V_{OUT} output response as a linear function of temperature, whereas the piecewise linear columns highlight the slight deviation in voltage output at higher temperatures.

Device Functional Mode

The SGM450 operates in a singular functional mode, generating an analog output that is directly proportional to the measured temperature.

Table 2. Transfer Table

Temperature (℃)	V_{OUT} (mV) Ideal Linear Values	V_{OUT} (mV) Piecewise Linear Values	Temperature (℃)	V_{OUT} (mV) Ideal Linear Values	V_{OUT} (mV) Piecewise Linear Values	Temperature (℃)	V_{OUT} (mV) Ideal Linear Values	V_{OUT} (mV) Piecewise Linear Values
-40	100	100	**25**	750	750	**90**	1400	1400
-35	150	150	**30**	800	800	**95**	1450	1450
-30	200	200	**35**	850	850	**100**	1500	1500
-25	250	250	**40**	900	900	**105**	1550	1550.3
-20	300	300	**45**	950	950	**110**	1600	1600.5
-15	350	350	**50**	1000	1000	**115**	1650	1650.8
-10	400	400	**55**	1050	1050	**120**	1700	1701
-5	450	450	**60**	1100	1100	**125**	1750	1751.3
0	500	500	**65**	1150	1150	**130**	1800	1800.7
5	550	550	**70**	1200	1200	**135**	1850	1850.1
10	600	600	**75**	1250	1250	**140**	1900	1899.4
15	650	650	**80**	1300	1300	**145**	1950	1948.8
20	700	700	**85**	1350	1350	**150**	2000	1998.2

APPLICATION INFORMATION

The SGM450 is suitable for a wide range of temperature-measuring applications. With the ability to operate on a power supply as low as 2.3V and a quiescent current of 7.5μA (TYP), the device is ideal for battery-powered applications. The device is packaged in SC70-5 and SOT-23 with surface-mount technology.

Connection with ADC

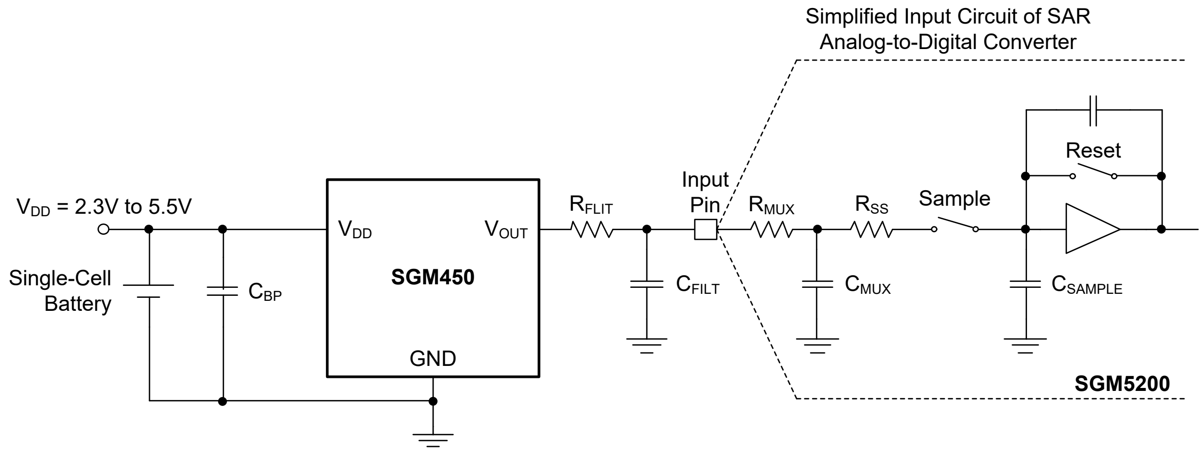


Figure 2. Recommended Connections to an ADC Input Stage

Design Requirements

Refer to Figure 2 for recommended connections to an ADC input stage. Most CMOS-based ADCs feature a sampling capacitor input structure. During the ADC's sampling process, where it charges the sampling capacitor (C_{SAMPLE}), an instantaneous charge transfer from the analog source temperature sensor's output is necessary. Consequently, the temperature sensor's output impedance can potentially influence the ADC's operational performance. In most situations, incorporating an external capacitor (C_{FILT}) will help with the design. The SGM450 can drive capacitive loads (C_{LOAD}) up to 1000pF, and C_{LOAD} is the sum of C_{FILT}, C_{MUX} and C_{SAMPLE}. To optimize performance, maximize the value of C_{FILT} while accounting for the maximum specified ADC input capacitance (C_{MUX} + C_{SAMPLE}) to keep the total C_{LOAD} below 1000pF. The recommended value of C_{FILT} is 680pF, which offers an appropriate margin for the ADC's input capacitance, effectively minimizing sampling errors and mitigating noise coupling. To further enhance noise rejection at the system level, an optional series resistor (R_{FILT}) in conjunction with C_{FILT} can be employed to create additional low-pass filtering. For optimal performance, it is advisable to locate R_{FILT} and C_{FILT} in close proximity to the ADC input.

Detailed Design Procedure

Considering the ADC input characteristics, an external filter (C_{FILT}) is needed. Its selection is based on balancing the capacitance of the sampling capacitor (C_{SAMPLE}), the chosen sampling rate, and ensuring the total capacitance load (C_{LOAD}) stays below the maximum allowable limit of 1000pF. Capacitor requirements may differ due to variations in ADC input stages. Figure 2 illustrates a general example of ADC application for reference purposes only.

Application Curve

The SGM450 generates a positive output slope of 10mV per degree Celsius across an extensive temperature ranging from -40℃ to +150℃.

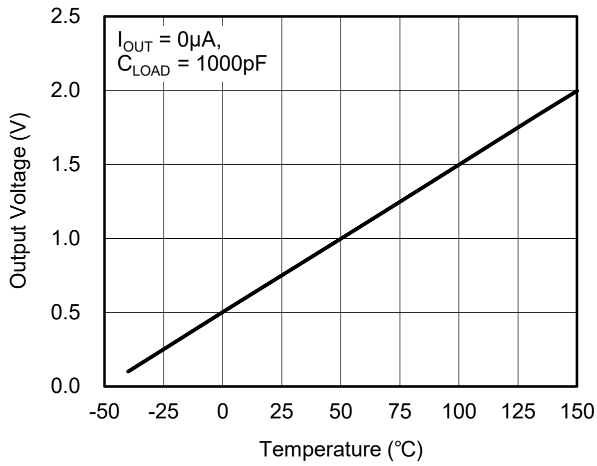


Figure 3. Output Voltage vs. Temperature

APPLICATION INFORMATION (continued)

Power Supply Recommendations

The SGM450's capability of operating with a low supply current and wide supply voltage range makes it compatible with a multitude of power sources.

Power supply bypassing is crucial for minimizing power supply noise. In environments with significant interference, incorporating a 0.1μF capacitor between V_{DD} and GND is highly recommended to bypass the power supply voltage. Depending on the level of noise present, larger capacitance values may be necessary.

Layout

The layout for the SGM450 is simple. To reduce noise, a power supply bypass capacitor should be used and positioned as close to the V_{DD} pin as possible.

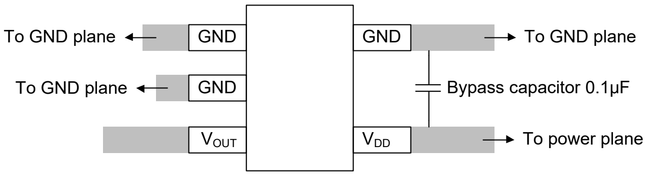


Figure 4. Recommended Layout of SC70-5 Package

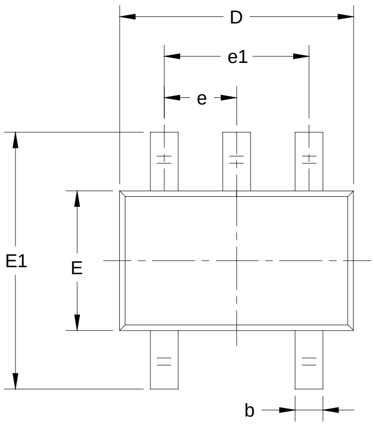
REVISION HISTORY

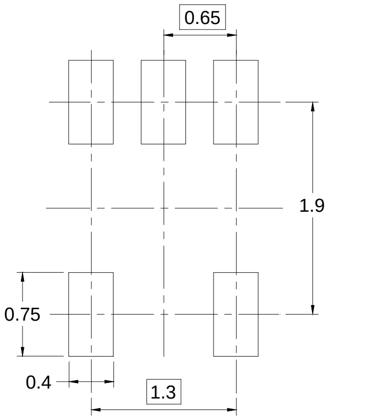
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (JUNE 2021) to REV.A	Page
Changed from product preview to production data	All

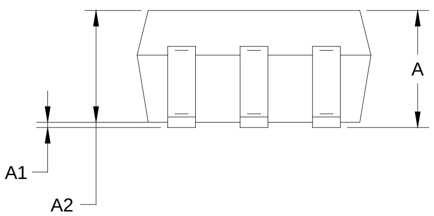
PACKAGE OUTLINE DIMENSIONS

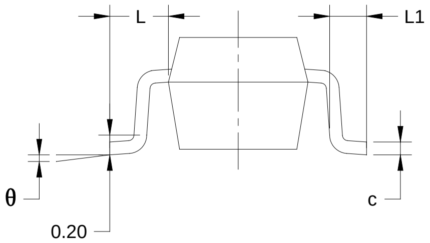
SC70-5





RECOMMENDED LAND PATTERN (Unit: mm)

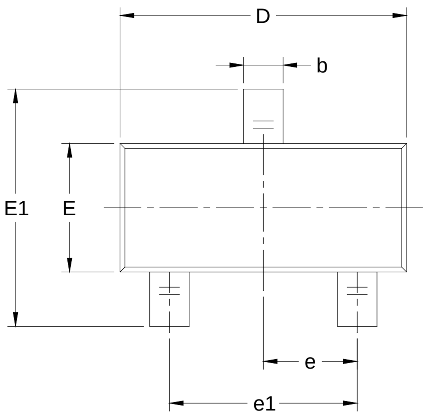


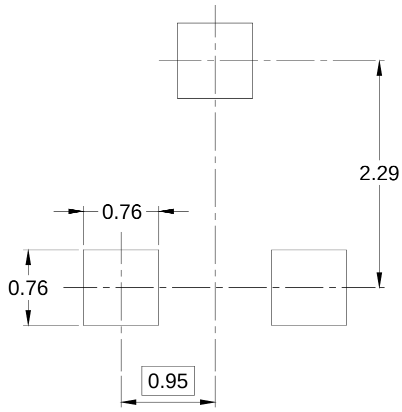


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.000	0.100	0.000	0.004
A2	0.800	1.000	0.031	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.220	0.003	0.009
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026 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°

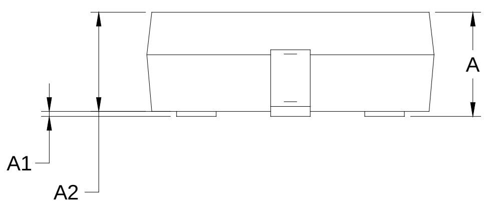
PACKAGE OUTLINE DIMENSIONS

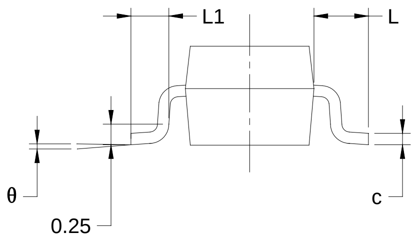
SOT-23





RECOMMENDED LAND PATTERN (Unit: mm)

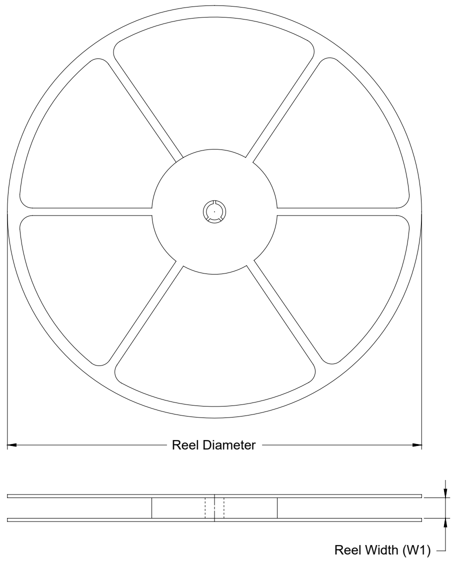




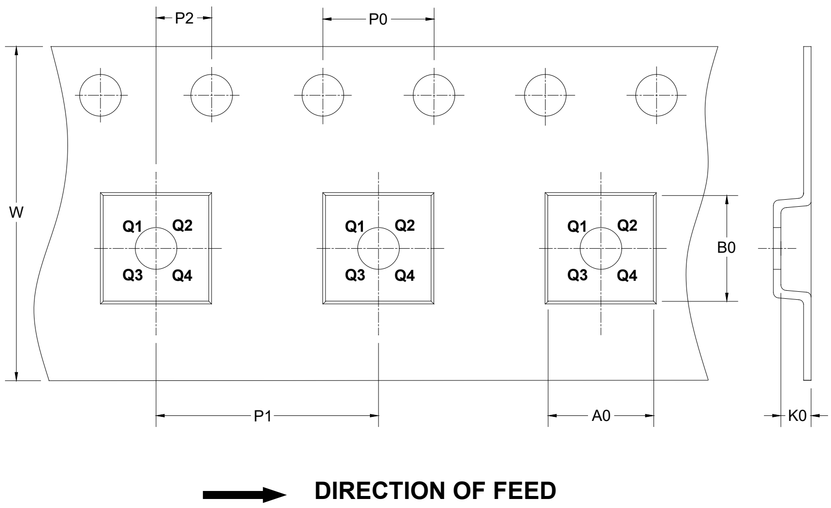
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.89	1.12	0.035	0.044
A1	0.01	0.10	0.000	0.004
A2	0.88	1.02	0.035	0.040
b	0.30	0.50	0.012	0.020
c	0.08	0.20	0.003	0.008
D	2.80	3.04	0.110	0.120
E	1.20	1.40	0.047	0.055
E1	2.10	2.64	0.083	0.104
e	0.95 BSC		0.037 BSC	
e1	1.90 BSC		0.075 BSC	
L	0.54 REF		0.021 REF	
L1	0.40	0.60	0.016	0.024
θ	0°	8°	0°	8°

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



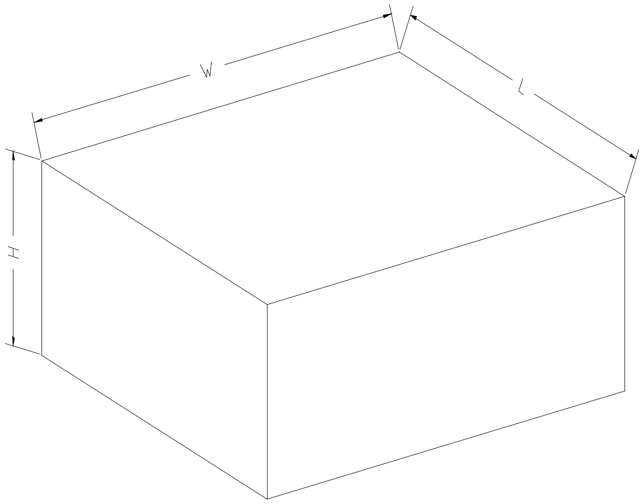
NOTE: The picture is only for reference. Please make the object as the standard.

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
SC70-5	7″	9.5	2.25	2.55	1.20	4.0	4.0	2.0	8.0	Q3
SOT-23	7″	9.5	3.15	2.77	1.22	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