

GENERAL DESCRIPTION

The SGM8198 series is a high-side, unipolar, current shunt monitor that operates from 2.7V to 36V single supply, consuming only 65µA quiescent current. The device also features a wide input common mode voltage range from 2.7V to 36V. Therefore, either side of the shunt current can be connected to the power supply, and the error is minimized.

The SGM8198 is designed to set any gain from 1 to 100 or more with one external resistor. Differential input voltage can be converted into output current, and the output current is converted back to voltage through load resistance. In addition to current shunt measurement, the device is also very suitable for measurement and level shifting.

The SGM8198 is available in a Green SOT-23-5 package. It is specified for the -40 °C to +125 °C temperature range.

FEATURES

- Unipolar High-side Current Measurement Circuit
- Wide Supply Voltage Range: 2.7V to 36V
- Wide Range of Common Mode Voltage: 2.7V to 36V
- Single Gain Set Resistor
- Low Quiescent Current: 65µA (TYP)
- -40°C to +125°C Operating Temperature Range
- Available in a Green SOT-23-5 Package

APPLICATIONS

- Current Measurement
- Portable Devices
- Battery-Powered Equipment
- Charging Systems
- Power Managements
- Mobile Phones
- Precision Current Sources

TYPICAL APPLICATION

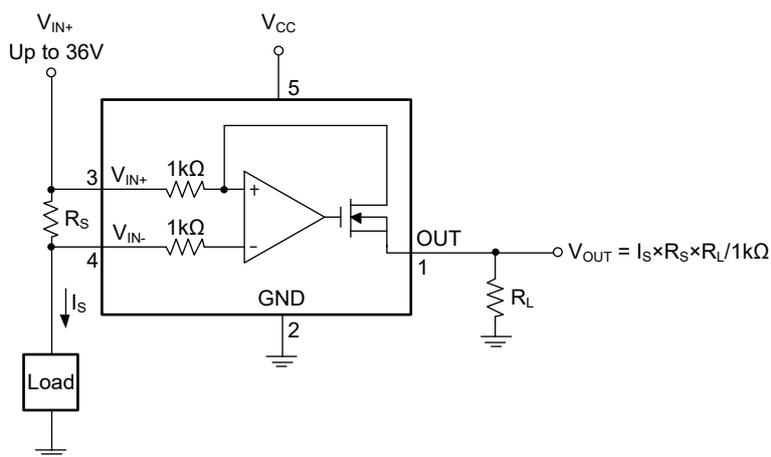


Figure 1. Typical Application Circuit

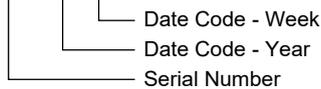
PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8198	SOT-23-5	-40°C to +125°C	SGM8198XN5G/TR	GMCXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XX = Date Code.

YYY X X



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 Range	-0.3V to 40V
Analog Inputs (V _{IN+} , V _{IN-}) Common Mode Voltage Range	-0.3V to 40V
Analog Output Voltage Range, V _{OUT}	-0.3V to 40V
Input Current into Any Pin	10mA
Package Thermal Resistance	
SOT-23-5, θ _{JA}	199°C/W
SOT-23-5, θ _{JB}	85°C/W
SOT-23-5, θ _{JC}	126°C/W
Junction Temperature	+150°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10s)	+260°C
ESD Susceptibility	
HBM	2000V
CDM	1000V

RECOMMENDED OPERATING CONDITIONS

Operating Voltage Range	2.7V to 36V
Operating Temperature Range	-40°C to +125°C

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

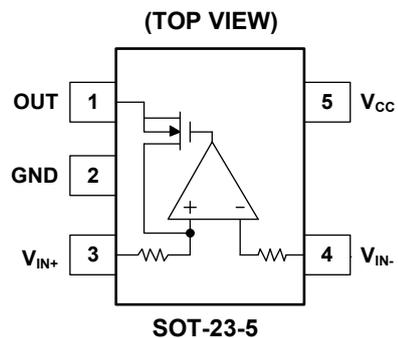
ESD SENSITIVITY CAUTION

This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

PIN CONFIGURATION



ELECTRICAL CHARACTERISTICS(At $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$, $V_{CC} = 5\text{V}$, $V_{IN+} = 12\text{V}$ and $R_L = 1\text{k}\Omega$, unless otherwise noted.)

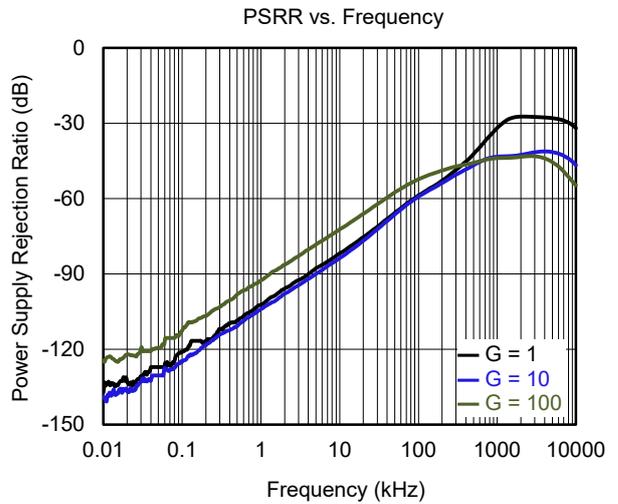
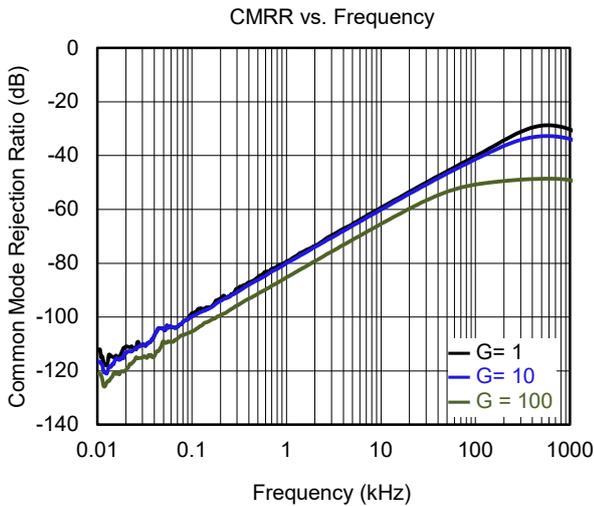
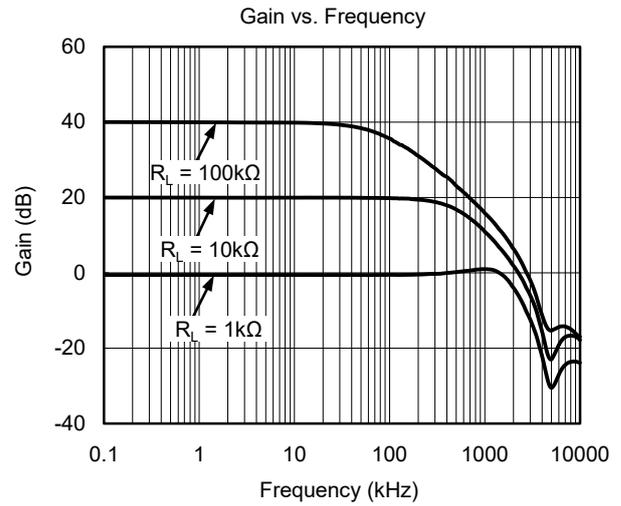
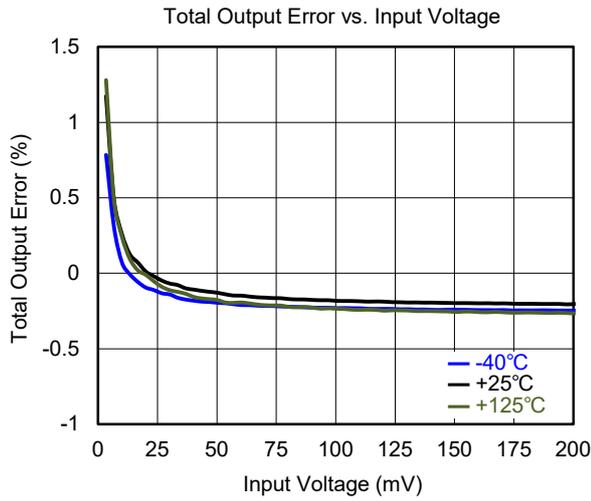
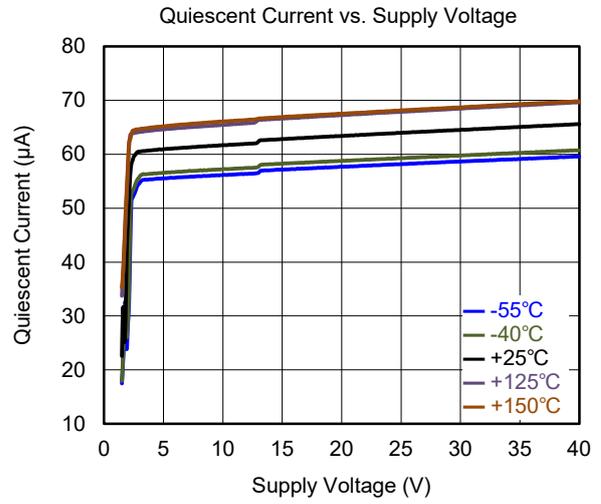
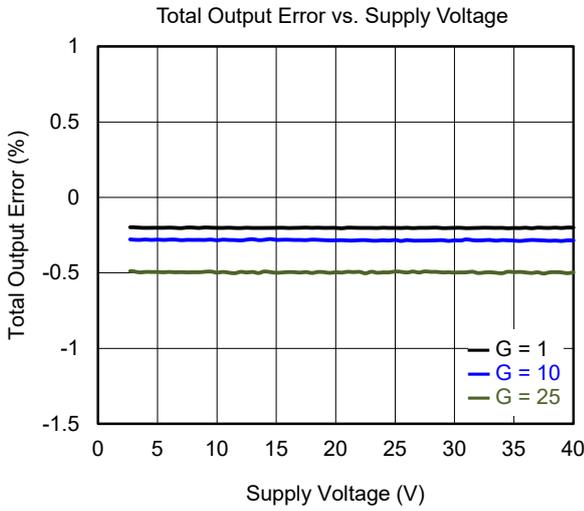
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics						
Full-Scale Sense Voltage		$V_{SENSE} = V_{IN+} - V_{IN-}$		100	500	mV
Input Offset Voltage ⁽¹⁾ RTI	V_{OS}	$V_{IN+} = 2.7\text{V}$ to 36V		± 30	± 550	μV
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$			1		$\mu\text{V}/^\circ\text{C}$
Input Bias Current	I_B			16		μA
Input Common Mode Voltage Range	V_{CM}		2.7		36	V
Common Mode Rejection Ratio	CMRR	$V_{IN+} = 2.7\text{V}$ to 36V , $V_{SENSE} = 50\text{mV}$	104	140		dB
Output Characteristics						
Transconductance	g_m	$V_{SENSE} = 10\text{mV}$ to 150mV	990	1000	1010	$\mu\text{A}/\text{V}$
Transconductance vs. Temperature	$\Delta g_m/\Delta T$	$V_{SENSE} = 10\text{mV}$ to 150mV		10		$\text{nA}/\text{V}/^\circ\text{C}$
Nonlinearity Error	INL	$V_{SENSE} = 10\text{mV}$ to 150mV		± 0.01	± 0.13	%
Total Output Error		$V_{SENSE} = 100\text{mV}$		± 0.25	± 1.8	%
Output Voltage		Swing to power supply, V_{CC}	$V_{CC} - 1.85$	$V_{CC} - 1.6$		V
		Swing to common mode, V_{CM}	$V_{CM} - 1.25$	$V_{CM} - 1$		
Power Supply						
Operating Voltage Range	V_{CC}		2.7		36	V
Quiescent Current	I_Q	$V_{SENSE} = 0\text{mV}$, $I_{OUT} = 0\text{A}$		65	90	μA
Power Supply Rejection Ratio	PSRR	$V_{CC} = 2.7\text{V}$ to 36V , $V_{SENSE} = 50\text{mV}$		0.1	5	$\mu\text{V}/\text{V}$
Frequency Response						
Bandwidth	BW	$R_L = 10\text{k}\Omega$		480		kHz
		$R_L = 20\text{k}\Omega$		270		
Settling Time to 0.1%		5V step, $R_L = 10\text{k}\Omega$		15		μs
		5V step, $R_L = 20\text{k}\Omega$		15		
Noise						
Total Output Current Noise		BW = 100kHz		6		nA_{RMS}
Output Current Noise Density				20		$\text{pA}/\sqrt{\text{Hz}}$

NOTE:

1. The definition of the V_{OS} is that the value of V_{SENSE} which can make the output voltage of the SGM8198 equal to 0mV.

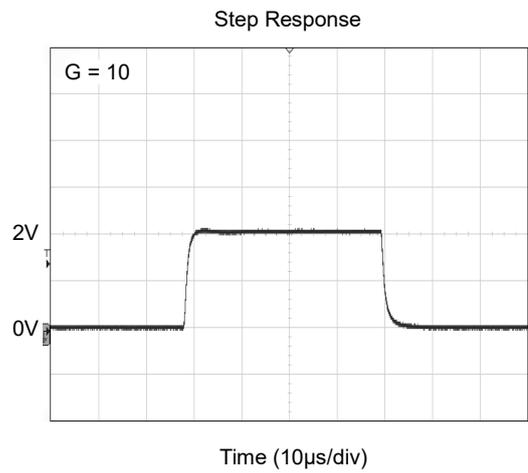
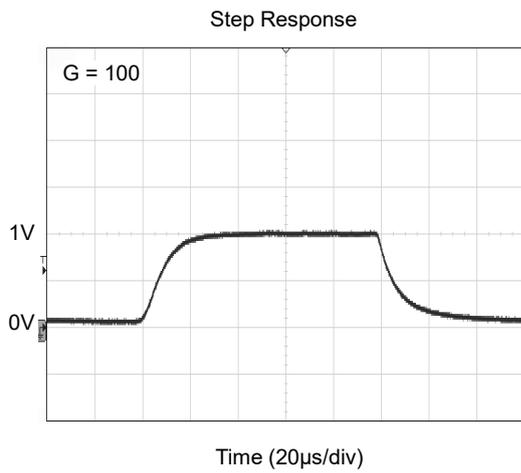
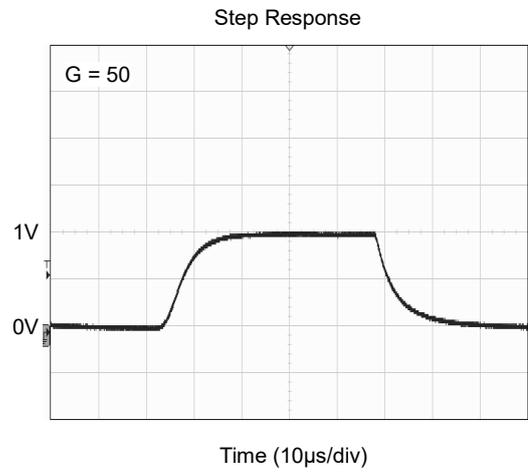
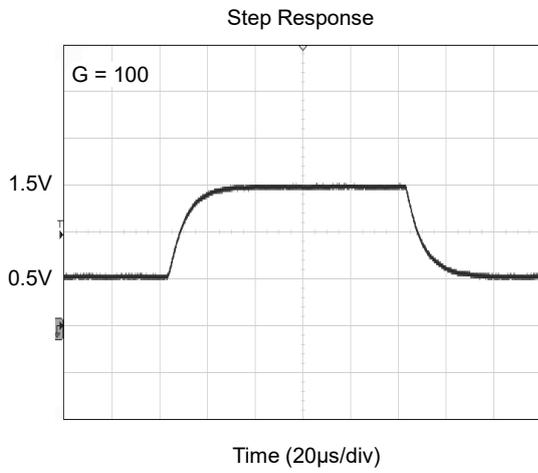
TYPICAL PERFORMANCE CHARACTERISTICS

At $T_A = +25^\circ\text{C}$, $V_{CC} = 5\text{V}$, $V_{IN+} = 12\text{V}$ and $R_L = 1\text{k}\Omega$, unless otherwise noted.



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A = +25^\circ\text{C}$, $V_{CC} = 5\text{V}$, $V_{IN+} = 12\text{V}$ and $R_L = 1\text{k}\Omega$, unless otherwise noted.



FUNCTIONAL BLOCK DIAGRAM

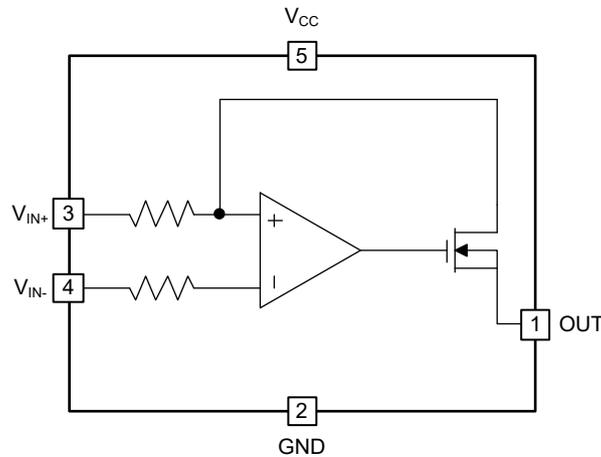


Figure 2. Functional Block Diagram

FEATURE DESCRIPTION

Overview

The features of the SGM8198 are high voltage, precision measurement, precision resistors trimmed for meeting the absolute tolerance and the ability of low noise. Also, the SGM8198 can be powered by a single power supply and the input voltage level can exceed the supply voltage level. In addition, the SGM8198 can measure the small sense voltage at a higher common mode voltage level. The Functional Block Diagram illustrates the internal structure of the SGM8198.

Range of Output Voltage

The load resistor R_L is used to convert the output current into voltage accurately. The maximum output swing of the SGM8198 is limited by the supply voltage, the common mode voltage, and the sense voltage.

Bandwidth

The value of the load resistor (R_L) has a significant effect on the measurement bandwidth. A narrower measurement bandwidth due to high gain is generated by the high R_L values. Therefore, the widest possible bandwidth can be obtained when the capacitive load on the output is kept to a minimum. For details of bandwidth reduction due to capacitive load, please refer to Typical Performance Characteristics.

As shown in Figure 5, adding a capacitor to the output can achieve the bandwidth limitation (filtering). And this operation will not cause system instability.

Device Functional Modes

The device specifications are shown in Electrical Characteristics. For proper operation, the following recommendations should be met for operating SGM8198:

- ◆ The device should be powered within the voltage range from 2.7V to 36V.
- ◆ The input common mode voltage range is from 2.7V to 36V.

APPLICATION INFORMATION

Operation

The basic structure of SGM8198 is shown in Figure 3. The measured load current is drawn from the supply voltage of the SGM8198. The internal amplifier forces the current to flow into the drain of the MOSFET (M1). The load resistor R_L is used to convert the output current into output voltage.

The calculation of I_{OUT} is shown in Equation 1:

$$I_{OUT} = g_m \times (V_{IN+} - V_{IN-}) \quad (1)$$

where $g_m = 1000\mu A/V$.

The value of $I_S \times R_S$ is equal to $(V_{IN+} - V_{IN-})$ and the output voltage is equal to $I_{OUT} \times R_L$. The transconductance,

g_m , is equal to $1000\mu A/V$. The relationship between I_S and V_{OUT} is shown in Equation 2:

$$V_{OUT} = I_S \times R_S \times (1000\mu A/V) \times R_L \quad (2)$$

For accuracy measurement, the maximum sense voltage is limited to 0.5V, which can produce 500 μA output current for the load. The maximum sense voltage that will not cause damage is 2V. For normal operation, the voltage applied to pin 3 should be greater than pin 4. If the applied voltage at pin 3 is smaller than that of pin 4, the SGM8198 will not be damaged and the output current is equal to 0 μA .

Voltage Gain	Exact R_L (Ω)	Nearest 1% R_L (Ω)
1	1k	1k
2	2k	2k
5	5k	4.99k
10	10k	10k
20	20k	20k
50	50k	49k
100	100k	100k

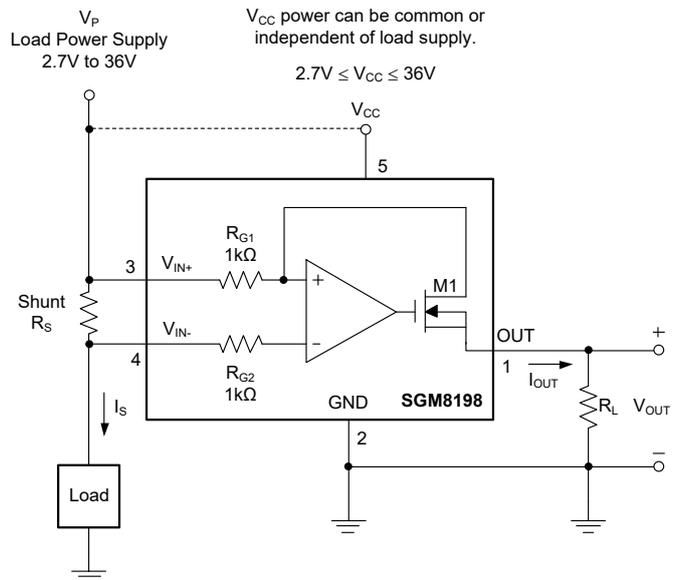


Figure 3. Basic Circuit Connections

TYPICAL APPLICATIONS

The SGM8198 is available for most applications. The examples are shown from Figure 7 to Figure 10.

Buffering Output to Drive an ADC

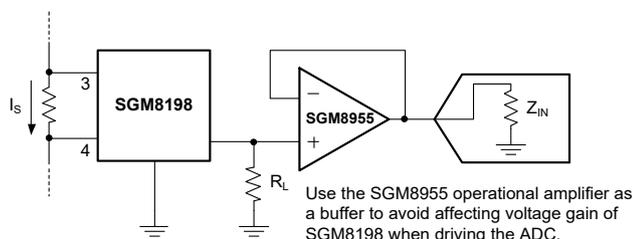


Figure 4. Buffering Output to Drive the A/D Converter

Design Requirements

Digitize the output of the SGM8198 device using a 1MSPS Analog-to-Digital converter (ADC).

Detailed Design Procedure

Selecting R_S and R_L

The choice of R_S is related to the accuracy of the small input signal and the maximum allowable voltage drop across R_S of the measured line. For measuring low current, a larger R_S can be taken into account to minimize the effect of the offset voltage and then enhance the accuracy. Lower R_S can reduce the voltage loss dramatically in supply line. The best performance of the SGM8198 for the sense voltage should be in the range of 50mV to 100mV, and the maximum allowable sense voltage for accurate measurement is 500mV, which can handle most of the applications.

The desired output voltage for the SGM8198 is determined by the value of R_L . Because of the high impedance structure of the SGM8198, the device allows the maximum resistance of R_L to be 100k Ω . For

enhancing the accuracy of the measurement, the input impedance of the external circuitry which is connected to the output of the SGM8198 should be much larger than 100k Ω .

The Analog-to-Digital converters (ADC) may have the input impedance that will affect the gain of the SGM8198 since it can be paralleled with R_L . Alternatively, the buffer should be placed between the ADC and SGM8198. The output impedance of the SGM8198 is significant larger as it is a current source. The load resistor R_L is used to convert the load current to the specific desired voltage. The ratio of the value of the load resistor to the internal resistor R_G determines the voltage gain of the device.

For most of the applications which need to digitize the output of the SGM8198, an ADC is required for completing this requirement. However, for the analog input stage of ADC, there is a dynamic input impedance which can be paralleled with R_L and affect the voltage gain of SGM8198. Also, the accuracy of the SGM8198 cannot be guaranteed for this situation. To avoid any external impedance which is paralleled with R_L , a buffer should be placed between the output of SGM8198 and the analog input of ADC. The SGM8955 is a good choice for the buffer.

Figure 4 shows how to digitize the output of SGM8198 with an addition buffer. Between the output of the buffer and the input of the ADC, an RC filter can be added. The capacitor should provide any instantaneous current demand for the input stage of ADC. The resistor should be considered to isolate the buffer output from the load capacitor to enhance the stability. The values of the resistor and the capacitor for the filter should be varied for different selections of buffer and ADC.

TYPICAL APPLICATIONS (Continued)

Output Filter

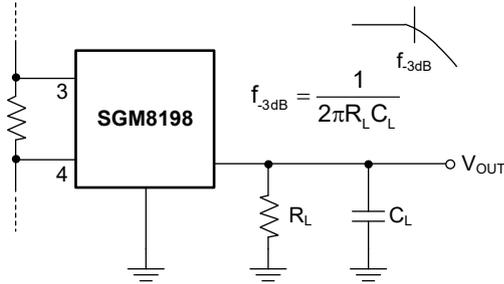


Figure 5. Output Filter

Design Requirements

Filter the output of the SGM8198 device.

Detailed Design Procedure

Placing a capacitor which is paralleled with the load resistor R_L can form an RC filter. First, select a suitable value of R_L to achieve the desired voltage gain. Second, select a suitable value of C_L to achieve the desired cutoff frequency with the equation shown in Figure 5. Figure 6 illustrates the frequency response for different gain settings with R_L .

Application Curve

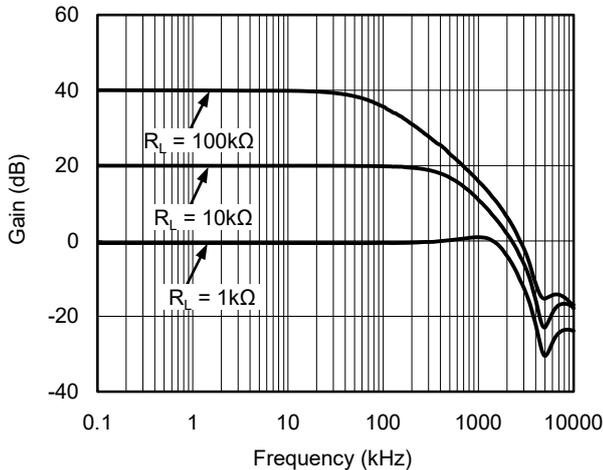
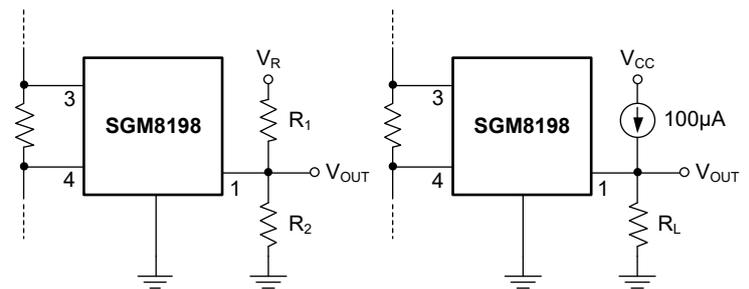


Figure 6. Gain vs. Frequency

Offsetting the Output Voltage

If the customers need to offset the output voltage away from GND when there is no load current flowing through R_S for single power supply, SGMICRO recommends the following two methods, as shown in Figure 7. The voltage divider method is shown in the left hand side. This method can locate the level of output voltage at the center of V_R when there is no current flowing through R_S . With this method, the gain of the SGM8198 is determined by the parallel combination of R_1 and R_2 and the offset level is determined by the voltage divider of them. If the customers need a fixed offset level which is not related with its supply voltage, a constant current source can be taken into account. With this method, the gain is determined by R_L and the offset voltage is determined by the multiplication product of constant current which is provided by the current source and the load resistor R_L .



Gain Set by $R_1 \parallel R_2$

$$\text{Output Offset} = \frac{(V_R) R_2}{R_1 + R_2}$$

a) Using resistor divider.

Gain Set by R_L

$$\text{Output Offset} = (100\mu\text{A}) (R_L)$$

(independent of V_{CC})

b) Using current source.

Figure 7. Offsetting the Output Voltage

TYPICAL APPLICATIONS (Continued)

Bipolar Current Measurement

The following circuitry can be taken into account for the applications which needs to measure positive and negative current flowing through the R_{SH} . The two inputs of each SGM8198 are connected at the two sides of R_{SH} together. The comparator can indicate if the current flowing is positive or negative. The magnitude of the output voltage is determined by the resistor which is located between the labeled output

and the GND. In this application, the 20V/V gain is generated by the 20k Ω resistor. The two 10k Ω resistors provide a voltage input for the SGM8740. In this example, there is only one SGM8198 can operate at a time as the two SGM8198 measures positive and negative current respectively, so two diodes should be placed at the output of them to prevent the current flowing into the output.

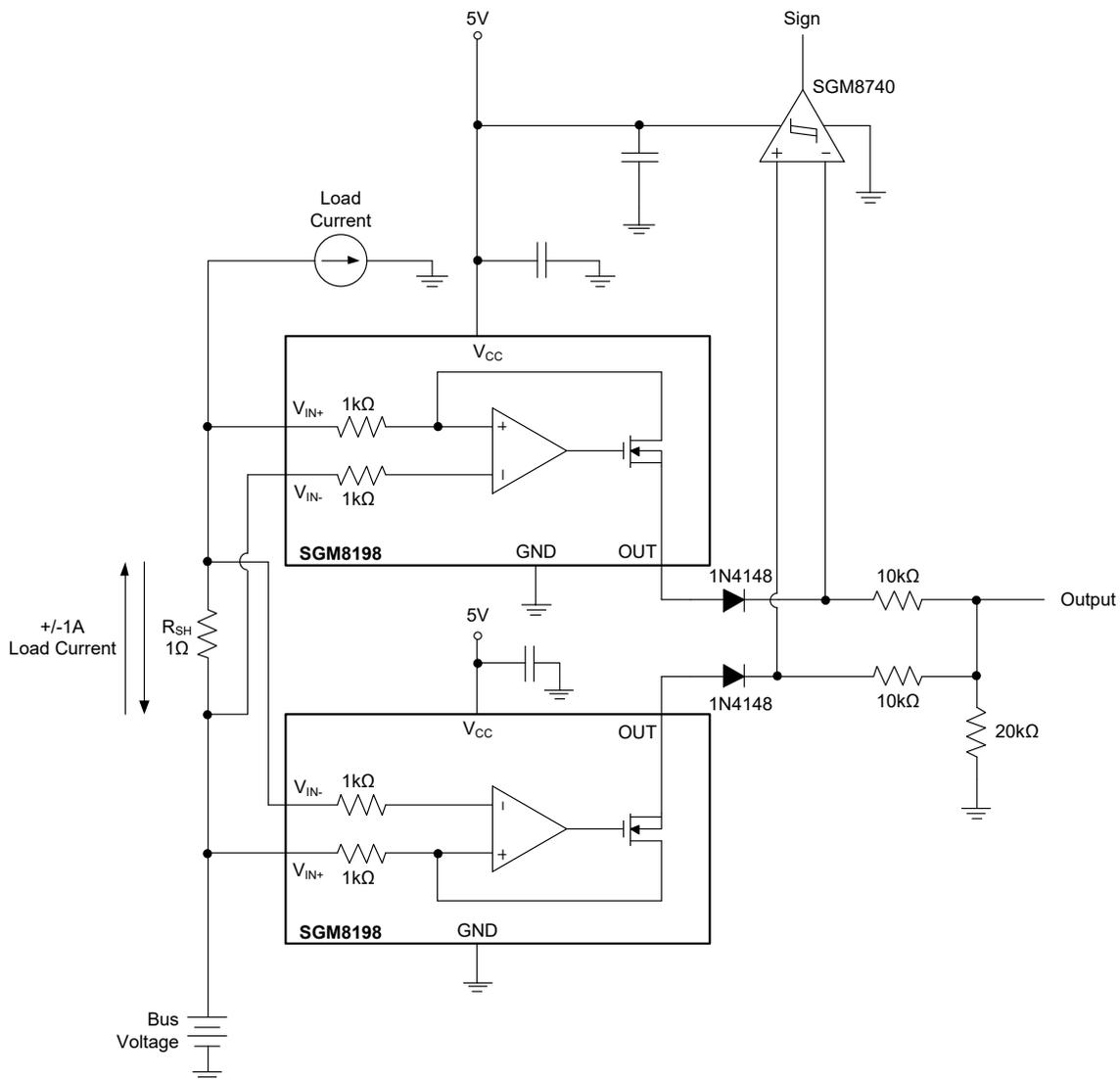


Figure 8. Bipolar Current Measurement

TYPICAL APPLICATIONS (Continued)

Bipolar Current Measurement Using a Differential Input of the A/D Converter

The SGM8198 can be used with a programmable ADC and the input of the ADC is differential. The application is used to measure the positive and negative current flowing from V_{CC} . The output voltage depends on the polarity of the measured current flowing, one of the outputs of SGM8198 must have a corresponding value and the other one is 0V. In this method, the ADC can illustrate the polarity of the current without addition circuitry.

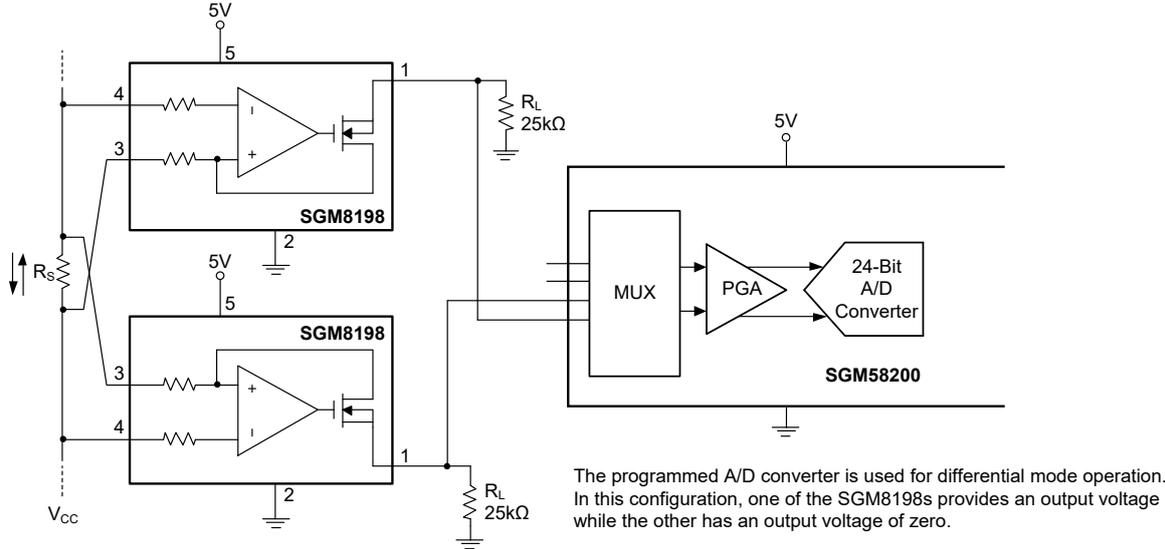


Figure 9. Bipolar Current Measurement Using a Differential Input of the A/D Converter

TYPICAL APPLICATIONS (Continued)

Multiplexed Measurement Using Logic Signal for Power

The following application is used to measure the multiples loads. The V_{CC} pin of each SGM8198 is powered by the I/O pins of SGM58200, so as to control on or off for multiplexing.

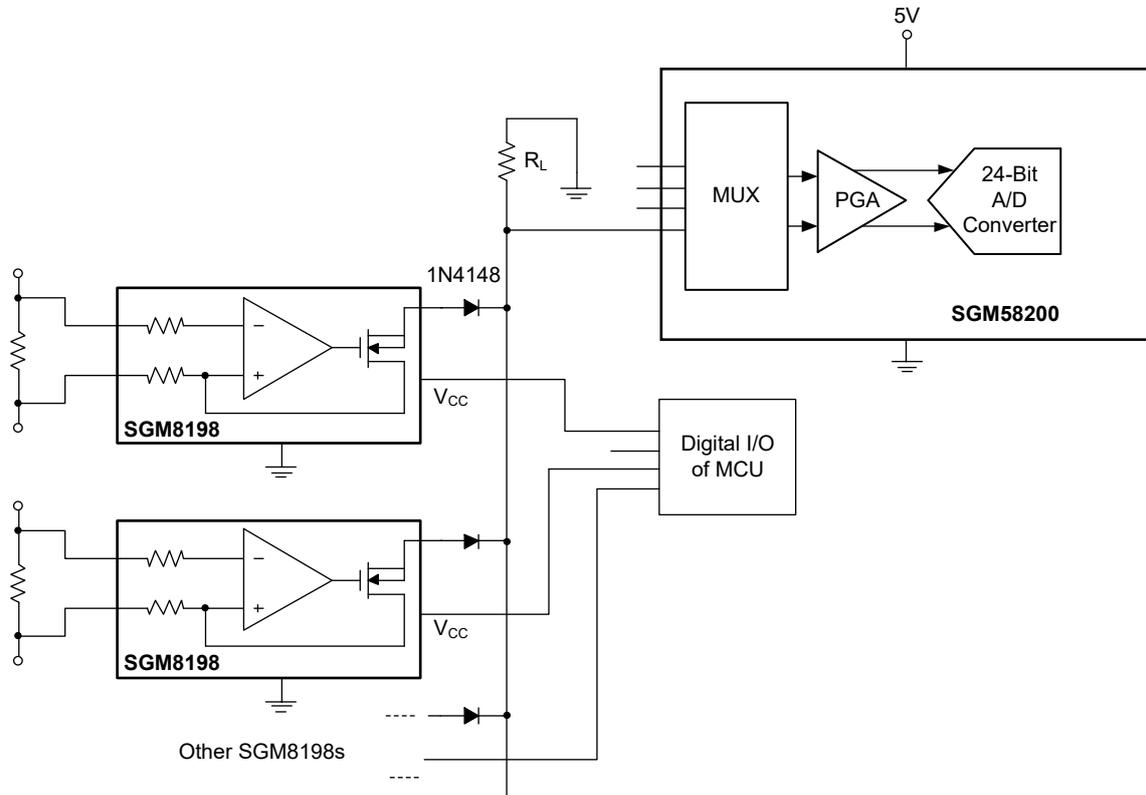


Figure 10. Multiplexed Measurement Using Logic Signal for Power

Power Supply Recommendations

The two input pins can measure the differential voltage accurately though their input common mode voltage which is higher than the supply voltage of the SGM8198. For instance, the two input pins can measure the current from a 36V system with 5V power supply voltage. A 0.1µF bypass capacitor should be placed as close as possible to the supply pin. For noisy power supply applications, an additional capacitor will be required.

TYPICAL APPLICATIONS (Continued)

Layout

Layout Guidelines

The recommendation of PCB layout for SGM8198 is shown in Figure 11. The input pins of SGM8198 should be placed closely to the measured load current to minimize the resistance which is in series with the shunt resistor R_S . The output resistor R_L is connected between OUT and GND pins. For enhancing the accuracy of the measurement, the operator should measure the voltage at the R_L directly. In some

high-current systems, the high-current can flow into the ground connections, which may cause inaccuracy.

The SGM8198 does not need any bypass capacitors for its stability. However, for noisy power supply, the capacitors are needed and should be placed as close as possible to the power supply pin for rejecting any noise from the power supply.

Layout Example

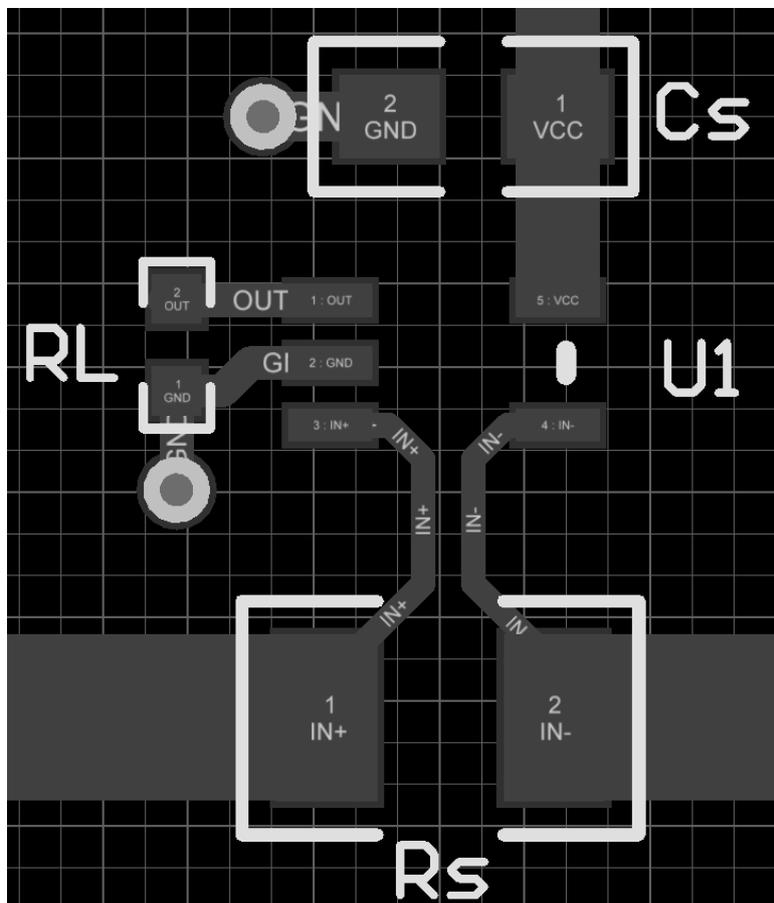


Figure 11. Typical Layout Example

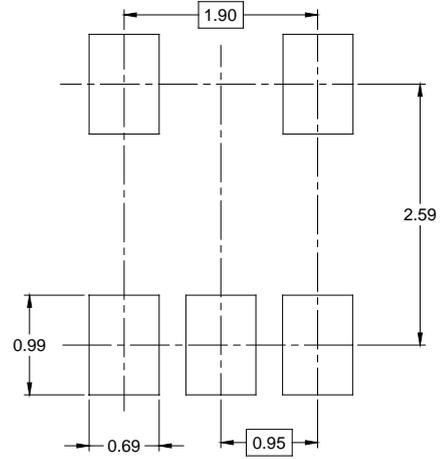
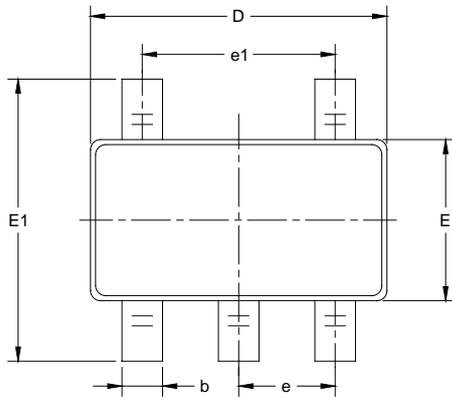
REVISION HISTORY

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

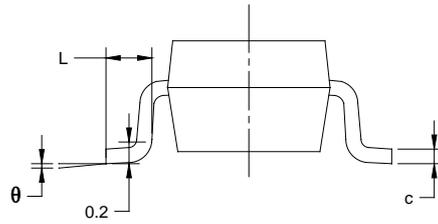
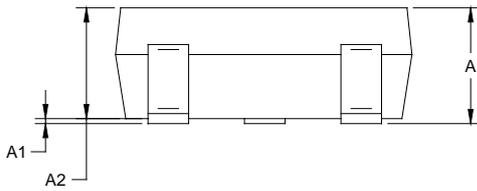
AUGUST 2022 – REV.A.2 to REV.A.3	Page
Updated Absolute Maximum Ratings section.....	2
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JANUARY 2021 – REV.A.1 to REV.A.2	Page
Updated Absolute Maximum Ratings section.....	2
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AUGUST 2019 – REV.A to REV.A.1	Page
Updated Electrical Characteristics section.....	3
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Changes from Original (DECEMBER 2018) to REV.A	Page
Changed from product preview to production data.....	All

PACKAGE OUTLINE DIMENSIONS

SOT-23-5



RECOMMENDED LAND PATTERN (Unit: mm)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

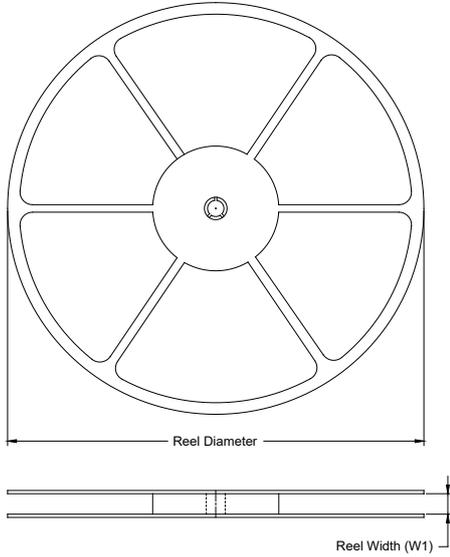
NOTES:

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

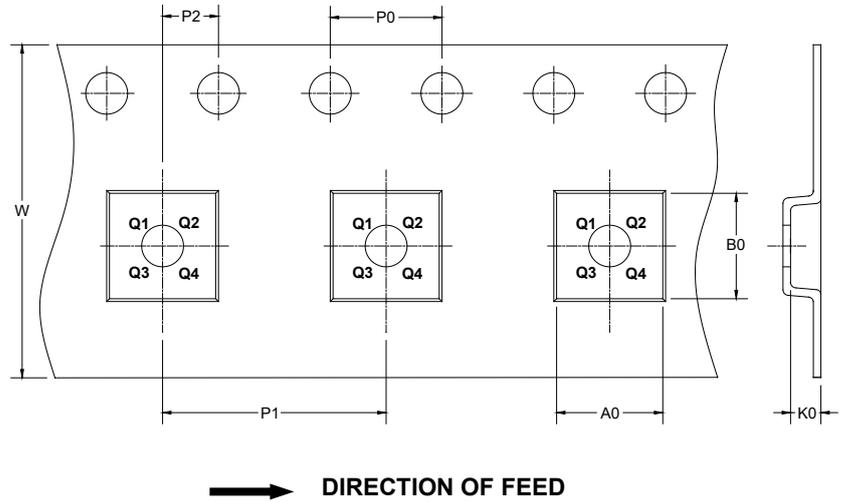
PACKAGE INFORMATION

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



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

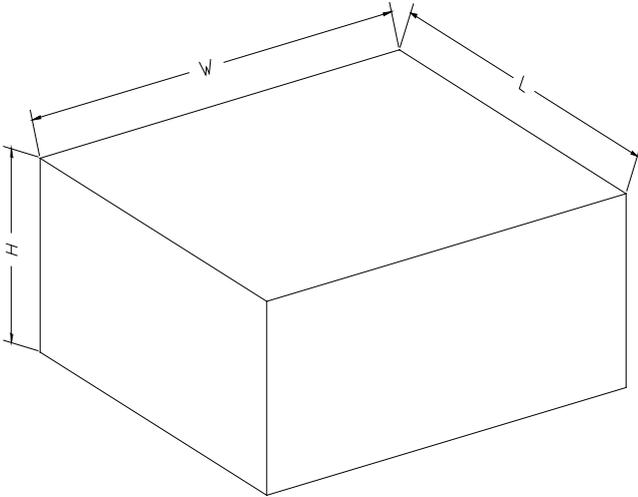
KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT-23-5	7"	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3

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
7" (Option)	368	227	224	8
7"	442	410	224	18

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