SGM840J
-4V to 80V, Bidirectional, Ultra-Precision Current-Sense Amplifier with High PWM Rejection

GENERAL DESCRIPTION

The SGM840J device is a bidirectional, fixed gain, voltage-output, current-sense amplifier which features high PWM rejection and wide common-mode voltage range from -4V to 80V.

The high PWM rejection suppresses large common-mode transients (ΔV/Δt) on the output signal, which is particularly relevant for applications utilizing pulse width modulation (PWM), such as motor driver and solenoid control systems. The negative common-mode voltage capability allows the device to function even when the voltage is below ground, which is useful in typical applications like the flyback period of a solenoid.

These characteristics make accurate current measurement without large transients and related recovery disturbances on the output voltage.

The device is powered from a single 2.7V to 5.5V supply, and draws 1mA (TYP) supply current. The gain of SGM840J is 10V/V. The low offset in the zero-drift architecture enables highly accurate current sensing, even with very small voltage drops across the shunt as low as 10mV full-scale.

The SGM840J is available in Green MSOP-8 and SOIC-8 packages. It operates in the temperature range of -40℃ to +125℃.

FEATURES

- **High PWM Rejection**
- **Excellent CMRR:**
  - **130dB (TYP) DC CMRR**
  - **80dB (TYP) AC CMRR at 50kHz**
- **Wide Common-Mode Range: -4V to 80V**
- **Gain Error:**
  - **+25℃: ±0.35% (MAX)**
  - **-40℃ to +125℃: ±2% (MAX)**
- **Offset:**
  - **+25℃: ±100μV (MAX)**
  - **-40℃ to +125℃: ±250μV (MAX)**
- **Available Gain: 10V/V**
- **Available in Green MSOP-8 and SOIC-8 Packages**

APPLICATIONS

Motor Controls
Solenoid and Valve Controls
Power Management
Actuator Controls
Pressure Regulators
Telecom Equipment

TYPICAL APPLICATION

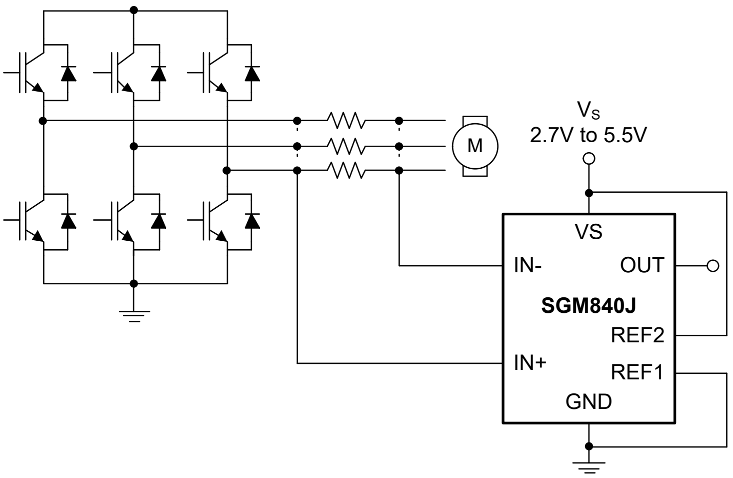


Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM840J	MSOP-8	-40℃ to +125℃	SGM840JXMS8G/TR	SGM840J XMS8 XXXXX	Tape and Reel, 4000
	SOIC-8	-40℃ to +125℃	SGM840JXS8G/TR	SGM 840JXS8 XXXXX	Tape and Reel, 4000

MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace Code and Vendor Code.

XXXXX
- Vendor Code
- Trace Code
- Date Code - Year

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_S 6V
Analog Inputs, V_{IN+}, V_{IN-}
Differential V_{IN+} - V_{IN-} .... -36V to 36V
Common-Mode .... -6V to 85V
REF1, REF2, NC Inputs .... GND - 0.3V to V_S + 0.3V
Output .... GND - 0.3V to V_S + 0.3V
Package Thermal Resistance
MSOP-8, θ_{JA} .... 131.2℃/W
MSOP-8, θ_{JB} .... 77.8℃/W
MSOP-8, θ_{JC} .... 46.3℃/W
SOIC-8, θ_{JA} .... 114.3℃/W
SOIC-8, θ_{JB} .... 63.9℃/W
SOIC-8, θ_{JC} .... 54.5℃/W
Junction Temperature .... +150℃
Storage Temperature Range .... -65℃ to +150℃
Lead Temperature (Soldering, 10s) .... +260℃
ESD Susceptibility [(1) (2)]
HBM .... ±8000V
CDM .... ±2000V

NOTES:

1. For human body model (HBM), all pins comply with ANSI/ESDA/JEDEC JS-001 specifications.
2. For charged device model (CDM), all pins comply with ANSI/ESDA/JEDEC JS-002 specifications.

RECOMMENDED OPERATING CONDITIONS

Input Common-Mode Voltage, V_{CM} .... -4V to 80V
Supply Voltage Range, V_S .... 2.7V to 5.5V
Operating Ambient Temperature Range .... -40℃ to +125℃
Operating Junction 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

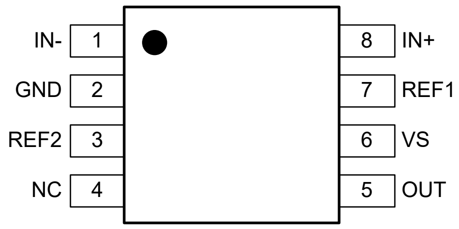
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

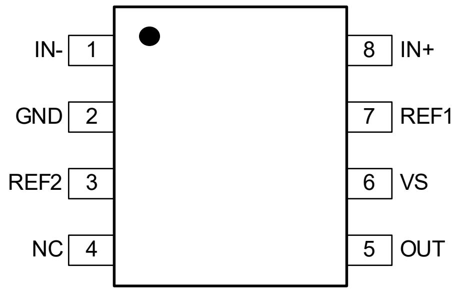
PIN CONFIGURATIONS

(TOP VIEW)



MSOP-8

(TOP VIEW)



SOIC-8

PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION
1	IN-	A/I	Connect it to load side of shunt resistor.
2	GND	G	Ground.
3	REF2	A/I	Voltage Reference 2. Connect it to any voltage source between GND and V_S.
4	NC	—	Connect it to GND or leave it floating.
5	OUT	A/O	Output Voltage.
6	VS	P	2.7V to 5.5V Power Supply.
7	REF1	A/I	Voltage Reference 1. Connect it to any voltage source between GND and V_S.
8	IN+	A/I	Connect it to supply side of shunt resistor.

NOTE: I = input, O = output, A = analog, P = power, G = ground.

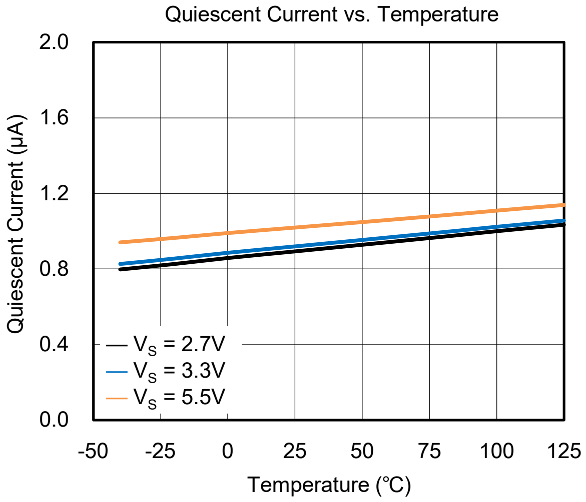
ELECTRICAL CHARACTERISTICS

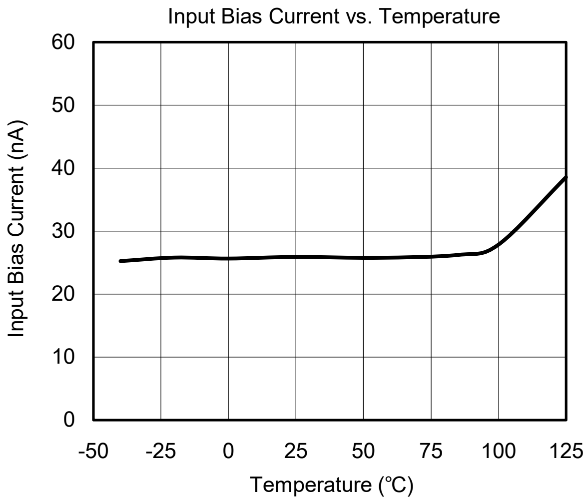
(V_S = 5V, V_{SENSE} = V_{IN+} - V_{IN-}, V_{CM} = 12V, V_{REF1} = V_{REF2} = V_S/2 and T_A = -40℃ to +125℃, typical values are measured at T_A = +25℃, unless otherwise noted.)

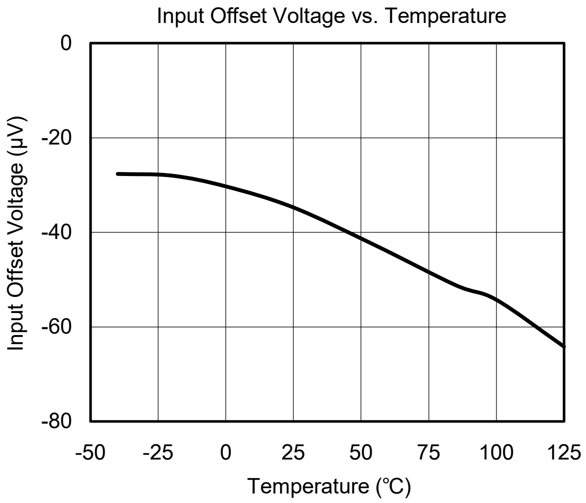
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input						
Full-Scale Sense Input Voltage	V_{SENSE}		-275		275	mV
Input Common-Mode Voltage	V_{CM}	V_{IN+} = -4V to 80V, V_{SENSE} = 0mV	-4		80	V
Common-Mode Rejection Ratio	CMRR	V_{IN+} = -4V to 80V, V_{SENSE} = 0mV	120	130		dB
		f = 50kHz		80		
Offset Voltage, Input-Referred	V_{OS}	V_{SENSE} = 0mV, T_A = +25℃		±5	±100	μV
		V_{SENSE} = 0mV, T_A = -40℃ to +125℃			±250	
Power Supply Rejection Ratio	PSRR	V_S = 2.7V to 5.5V, V_{SENSE} = 0mV		±1	±20	μV/V
Input Bias Current	I_B	I_{B+}, I_{B-}, V_{SENSE} = 0mV		0.05		μA
Reference Input Range			0		V_S	V
Output						
Gain	G			10		V/V
Gain Error		GND + 50mV ≤ V_{OUT} ≤ V_S - 200mV, T_A = +25℃		±0.05	±0.35	%
		T_A = -40℃ to +125℃			±2	
Nonlinearity Error		GND + 10mV ≤ V_{OUT} ≤ V_S - 200mV		±0.02		%
Reference Divider Accuracy		V_{OUT} = |(V_{REF1} - V_{REF2})|/2 at V_{SENSE} = 0mV		±0.02	±0.45	%
Reference Voltage Rejection Ratio (Input-Referred)	RVRR			80		μV/V
Maximum Capacitive Load		No sustained oscillation		1		nF
Voltage Output						
Swing to VS Power Supply Rail		R_L = 10kΩ to GND		V_S - 0.02	V_S - 0.05	V
Swing to GND		R_L = 10kΩ to GND, V_{SENSE} = 0mV, V_{REF1} = V_{REF2} = 0V		V_{GND} + 3	V_{GND} + 10	mV
Frequency Response						
Bandwidth	BW	All gains, -3dB bandwidth		450		kHz
		All gains, 1% THD+N		100		
Settling Time		Output settles to 0.5% of final value		6		μs
Slew Rate	SR			2.5		V/μs
Noise (Input-Referred)						
Voltage Noise Density				100		nV/$\sqrt{Hz}$
Power Supply						
Operating Voltage Range	V_S		2.7		5.5	V
Quiescent Current	I_Q	V_{SENSE} = 0mV, T_A = +25℃		1.0	1.5	mA
		vs. temperature, T_A = -40℃ to +125℃			1.7	

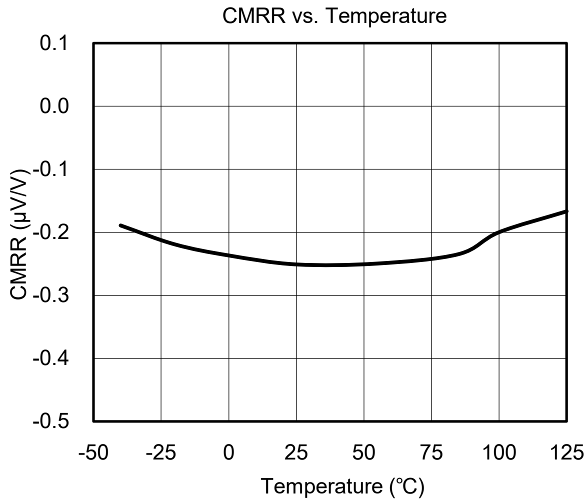
TYPICAL PERFORMANCE CHARACTERISTICS

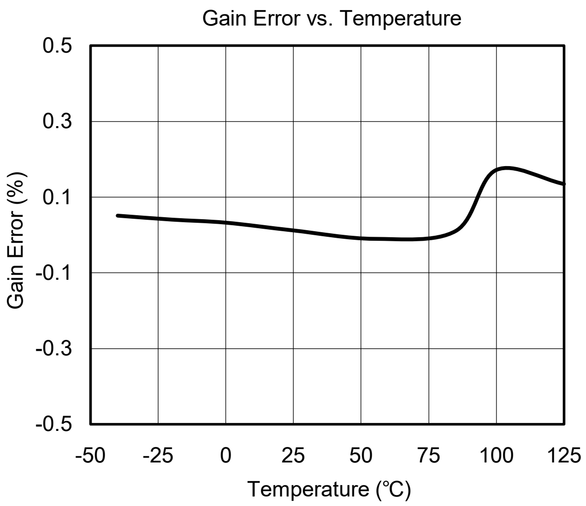
V_S = 5V, V_{CM} = 12V, V_{REF1} = V_{REF2} = V_S/2 and T_A = +25℃, unless otherwise noted.

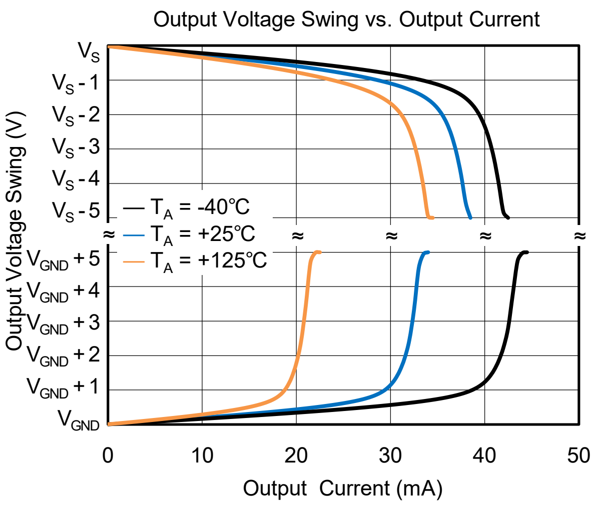








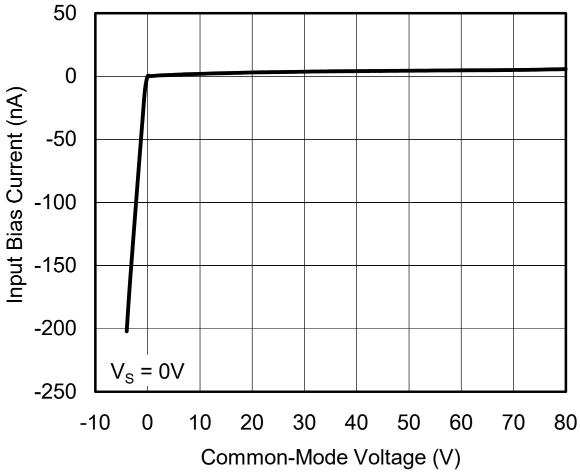




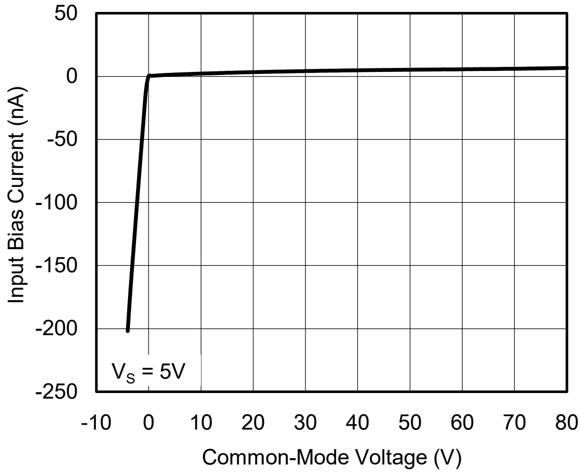
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

V_S = 5V, V_{CM} = 12V, V_{REF1} = V_{REF2} = V_S/2 and T_A = +25℃, unless otherwise noted.

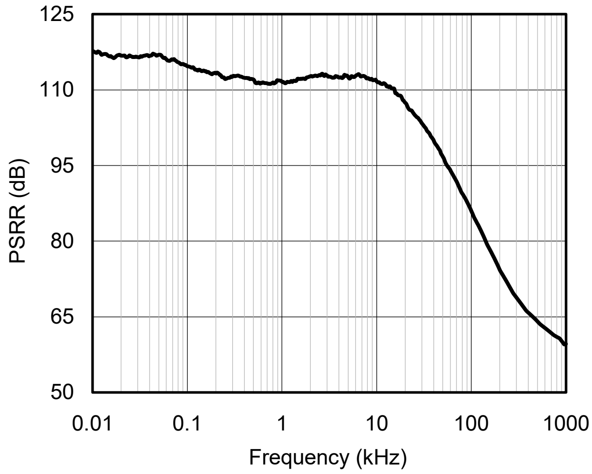
Input Bias Current vs. Common-Mode Voltage



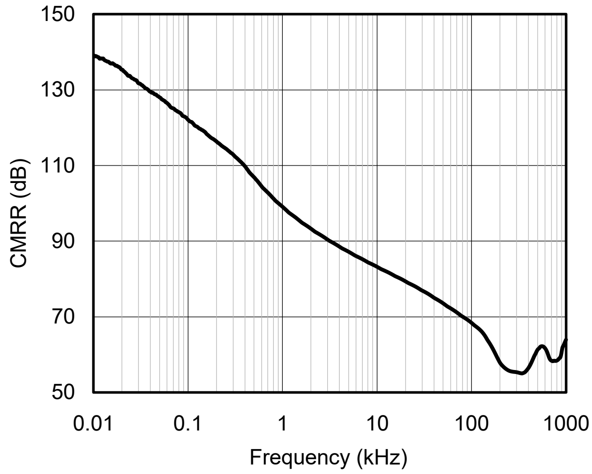
Input Bias Current vs. Common-Mode Voltage



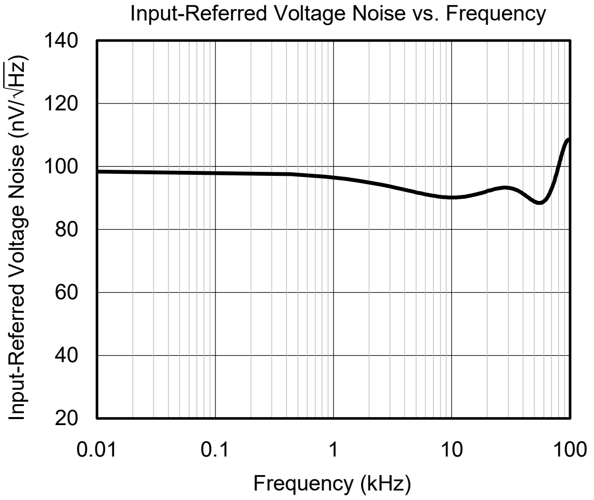
PSRR vs. Frequency



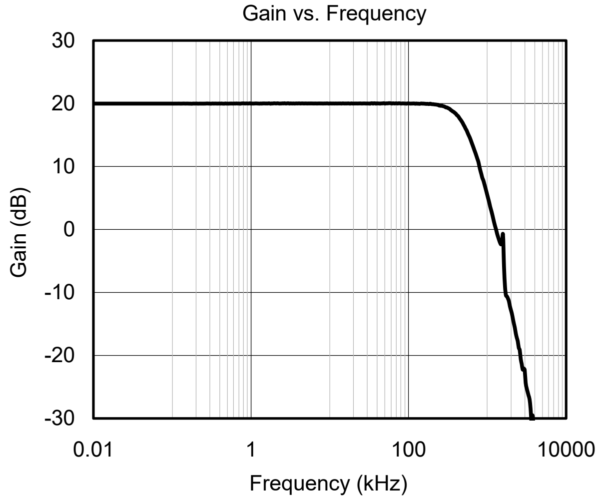
CMRR vs. Frequency



Input-Referred Voltage Noise vs. Frequency



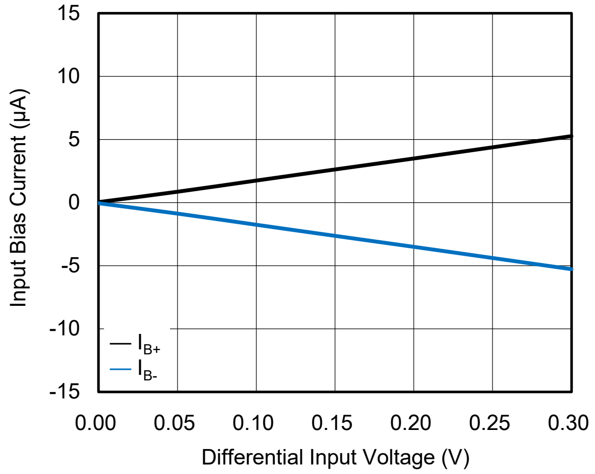
Gain vs. Frequency



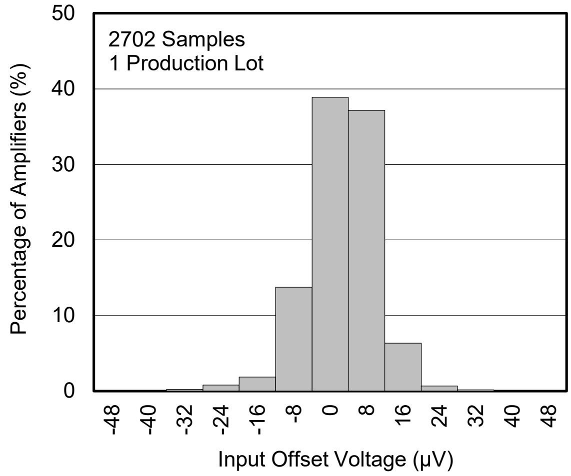
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

V_S = 5V, V_{CM} = 12V, V_{REF1} = V_{REF2} = V_S/2 and T_A = +25°C, unless otherwise noted.

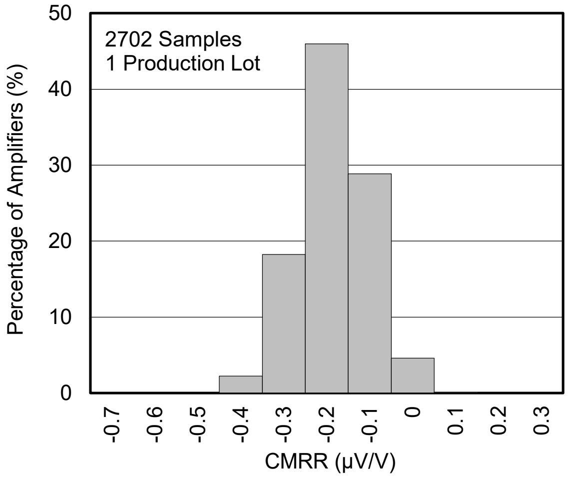
Input Bias Current vs. Differential Input Voltage



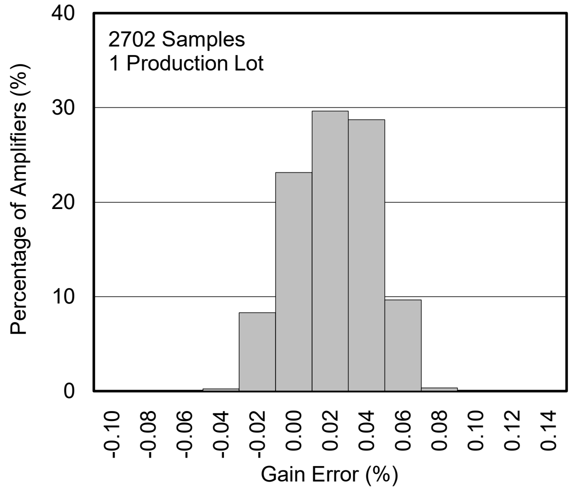
Input Offset Voltage Production Distribution



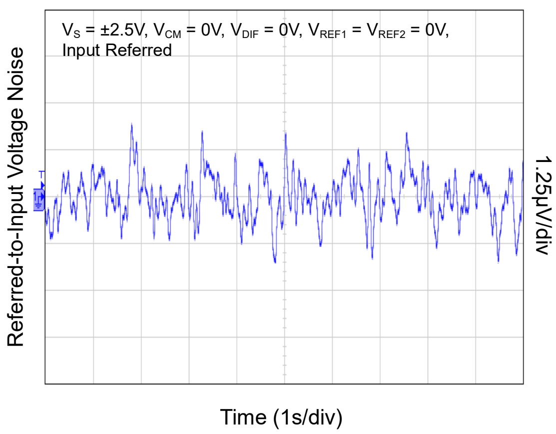
CMRR Production Distribution



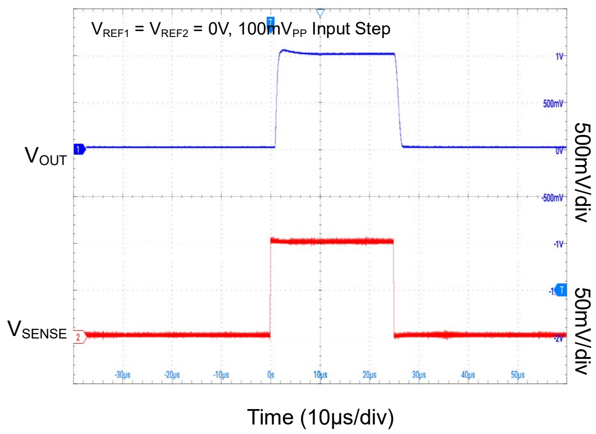
Gain Error Production Distribution



0.1Hz to 10Hz Voltage Noise



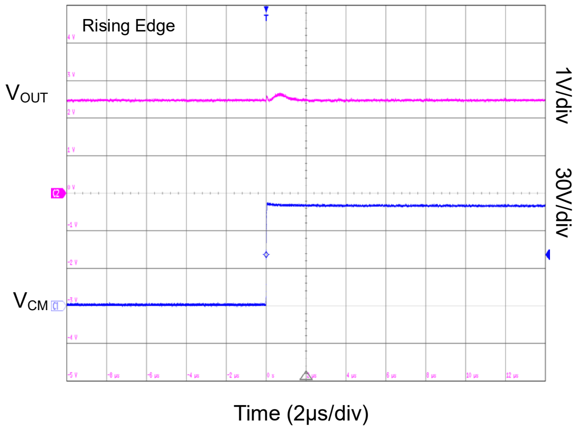
Step Response



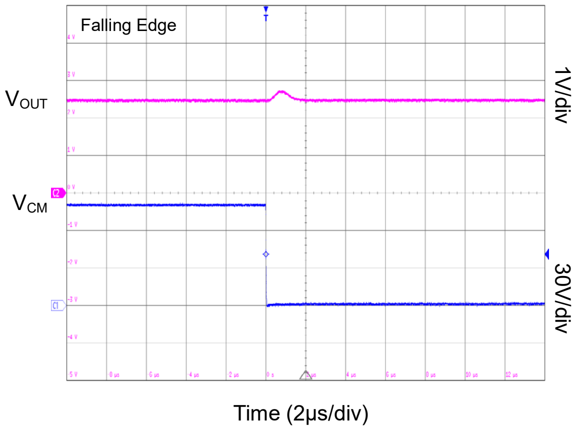
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

V_S = 5V, V_{CM} = 12V, V_{REF1} = V_{REF2} = V_S/2 and T_A = +25°C, unless otherwise noted.

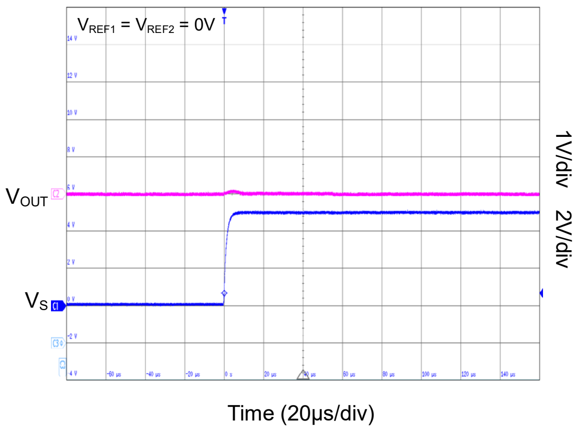
Common-Mode Voltage Transient Response



Common-Mode Voltage Transient Response



Startup Response



FUNCTIONAL BLOCK DIAGRAM

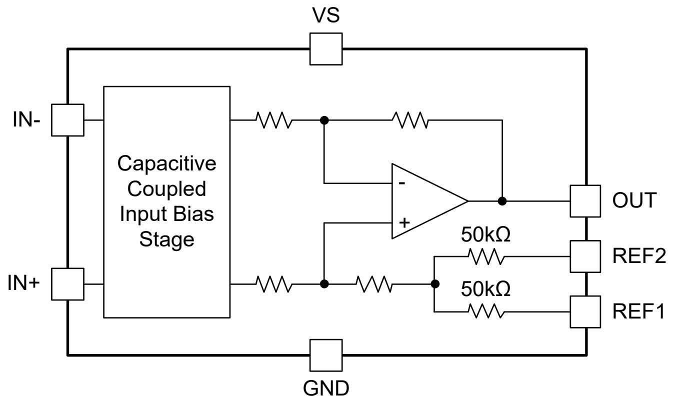


Figure 2. Block Diagram

DETAILED DESCRIPTION

Overview

The SGM840J is a bidirectional analog voltage output current-sense amplifier with a wide common-mode range, high accuracy, zero-drift topology, and high common-mode rejection. High common-mode rejection can suppress the effect of fast common-mode transients on the output. 10V/V gain version can be used to optimize the required full-scale output voltage according to the expected target current range in the application.

Feature Description

Precision Current Measurement

The SGM840J uses the zero-drift input architecture which provides the low offset voltage and low offset drift. The offset voltage is less than ±250μV from -40℃ to +125℃. The internal gain resistor has excellent temperature stability, ensuring that the gain error remains within ±2%. All of these features improve the accuracy, especially at smaller current-sense voltage, and allow for lower-value shunt resistor.

Large Input Common-Mode Voltages

The SGM840J uses a capacitive feedback amplifier on the input front end which makes the input common-mode voltage range no longer restricted by the power supply voltage (V_S). DC common-mode voltages are blocked from downstream circuits, resulting in very high common-mode rejection. The SGM840J can support wide common-mode voltages from -4V to 80V. This allows for the SGM840J to be used for both low-side and high-side current-sensing applications.

Low Input Bias Current

The SGM840J has low input bias current which draws a 0.05μA (TYP) at a common-mode voltage up to 80V. This feature achieves precision current sensing in applications where lower current leakage is required.

High Input-Signal Bandwidth

The SGM840J has 450kHz (TYP) input signal bandwidth and 2.5V/μs slew rate which provide the rapid throughput and response needed to quickly detect and handle over-current events. Without higher bandwidth, the protection circuit has not fast response time and may cause damage to the monitored application or circuit.

Bidirectional Current Monitoring

The SGM840J can sense current flow through a sense resistor in both directions. The output voltage (V_{OUT}) can be calculated according to the formula below.

$$V_{OUT} = (I_{SENSE} \times R_{SENSE} \times G) + V_{BIAS} \quad (1)$$

where:

I_{SENSE} is the load current that flows through a sense resistor.

R_{SENSE} is the current-sense resistor.

G is the available gain option of the selected device.

V_{BIAS} is the biased voltage of output set by REF1 and REF2 pins.

DETAILED DESCRIPTION (continued)

High PWM Rejection

The SGM840J uses a capacitive coupled amplifier which has high PWM rejection. The high PWM rejection allows the output to recover quickly after a rapid input PWM common-mode transient. The settling time after PWM common-mode transient events is about 2μs typically. This feature makes it possible to support higher PWM frequencies and lower duty cycles in applications like motor, solenoid control and switching power supplies.

Low THD+Noise Output

Figure 3 displays the performance across different frequencies of the device. The SGM840J has less harmonic distortion which is beneficial for use in the audio.

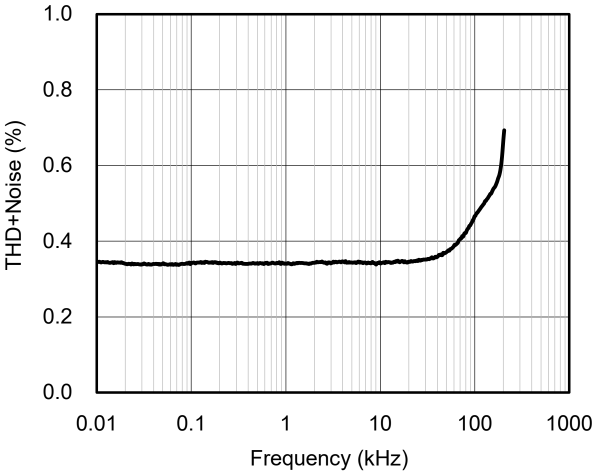


Figure 3. Performance over Frequency

Device Functional Modes

Adjusting the Output Midpoint with REFx Pins

Figure 4 shows a reference test circuit for the accuracy of the internal resistor divider. The SGM840J output can be configured to allow unidirectional or bidirectional operation.

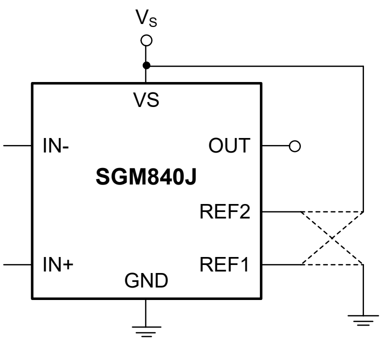


Figure 4. Test Circuit for Reference Divider Accuracy

Note that the input voltage of the REF1 pin or the REF2 pin must be between VS or GND.

The REF1 and REF2 are connected to the internal gain resistor divider network inside the chip. The output biased voltage can be set by connecting REF1 and REF2 to different voltage source such as VS, GND, or a low-impedance reference voltage.

Unidirectional Current Measurements with REFx Pins

Unidirectional operation allows the SGM840J to measure the current through a resistive shunt in a single direction. There is ground referenced output or VS referenced output. The following sections describe the two different configurations.

GND Referenced Output

Connect both reference pins of SGM840J together to GND. The current direction in this configuration is from IN+ to IN-.

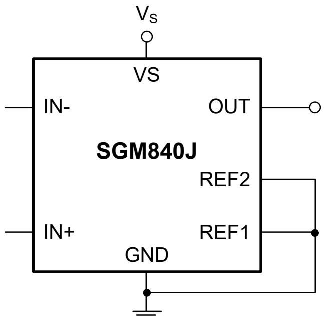


Figure 5. GND Referenced Output

VS Referenced Output

Connect both reference pins of SGM840J together to VS. The current direction is from IN- to IN+. This configuration is suitable for applications that require a stable power supply to the amplifier output and other control circuits before there is a current flowing through the current-sense resistor.

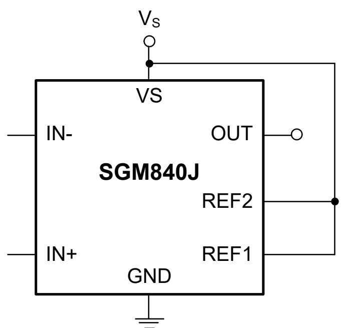


Figure 6. VS Referenced Output

DETAILED DESCRIPTION (continued)

Bidirectional Current Measurements with the Reference Pins

Bidirectional operation allows the SGM840J to measure the current through the resistor shunt in both directions. The common configuration is to set the reference input at half of the output full-scale which allows for an equal range in both directions. In asymmetrical bidirectional current sense application, the reference input can be set to others according to the application.

Setting Output to External Reference Voltage

Connect both reference pins together to an external reference voltage. The output biased voltage is equal to the reference voltage in this configuration. This is the most accurate method to bias the output to the reference voltage.

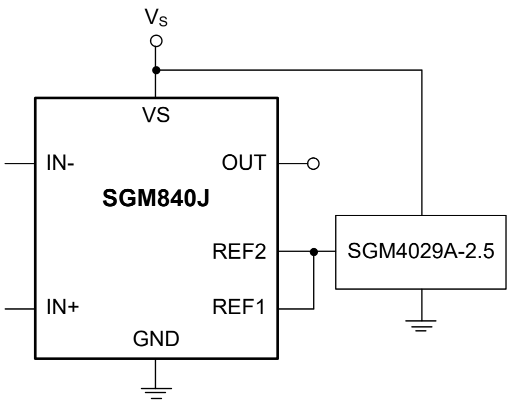


Figure 7. External Reference Output

Setting Output to a Half of V_S

Connect one reference pin to VS and the other reference pin to GND. The output biased voltage is equal to a half of V_S in this configuration. The output bias voltage keeps at a half if V_S varies.

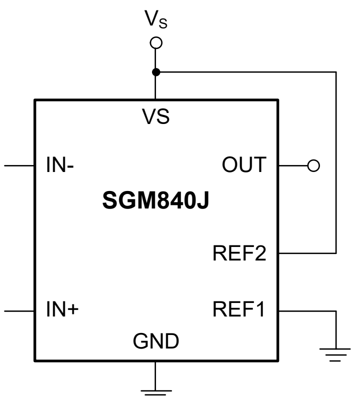


Figure 8. A Half of VS Output

Setting Output to a Half of External Reference

Connect one REF pin to an external reference and the other REF to the GND. The output biased voltage is equal to a half of external reference in this configuration. The output bias voltage keeps at a half of external reference if the external reference varies.

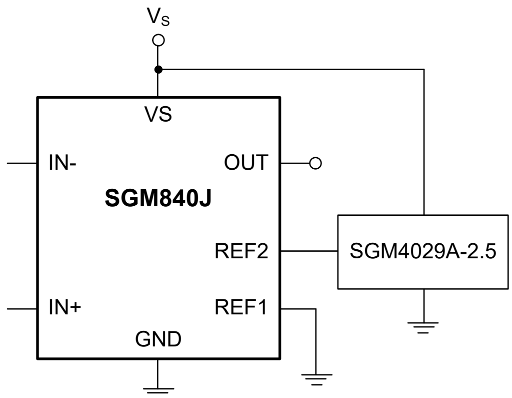


Figure 9. A Half of External Reference Output

Setting a Differential Output

As described above, the reference pins are usually configured to connect to supply, ground, or a low-impedance reference voltage. However, in some application, a differential output voltage is needed. Connecting the two reference pins together can get a differential output voltage between the reference and OUT pins. Figure 10 shows the configuration circuit.

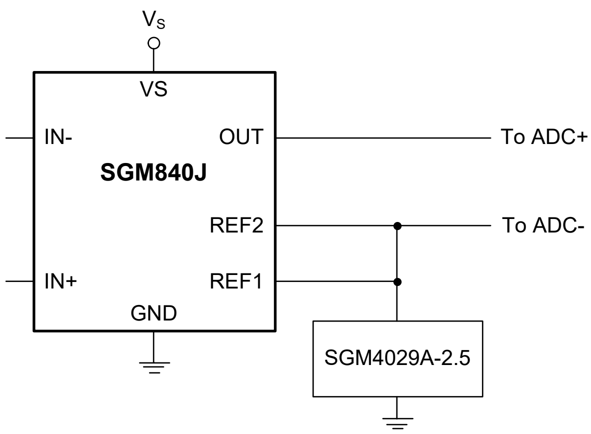


Figure 10. Reference Different Output

APPLICATION INFORMATION

The SGM840J can operate in unidirectional or bidirectional current-sensing operation by the different reference pins connection. In the in-line motor current sense applications, SGM840J is usually configured to bidirectional mode operation.

Input Filtering

When measuring current in noisy environments, filters are required for accurate measurements. The SGM840J features low input bias current that makes it possible to add a filter at the input end without sacrificing the current-sense accuracy. The filter at the input position can attenuate differential noise before the input signal is amplified. Figure 11 shows the filter at the input pins.

The series resistance of filter results in additional gain error. The gain error introduced can be calculated by the Equation 2.

$$\text{Gain Error}(\%) = 1 - \frac{R_{DIFF}}{R_{SENSE} + 2 \times R_F + R_{DIFF}} \quad (2)$$

where:

R_{DIFF} is the differential input impedance about 55kΩ.

R_F is the added value of the series filter resistance.

The high input impedance and low bias current of the SGM840J make the design of input filters easy and flexible without impacting the accuracy of current measurement. External series resistance adds to the measurement error, so limit the value of these series resistors to 22Ω or less. For example, set R_F = 22Ω and C_F = 2.2nF to achieve a low-pass filter corner frequency of 1.64MHz without severely impacting the current-sensing bandwidth or precision. Table 1 illustrates the gain error introduced by R_F where R_{SENSE} has been neglected.

Table 1. Gain Error Introduced by the External Filter Resistance at Input Pins

External Filter Resistance R_F (Ω)	Gain Error (%)
4.7	0.012
10	0.025
22	0.055

Special Precautions

For high-precision measurement, the following items need to be check first.

1. Choose a precision current-sense resistor.
2. Provide a precision reference voltage for REF1 and REF2.
3. Optimize the layout and routing between the input pins and the sensing resistor.
4. Place adequate decoupling capacitor between VS and GND pin.

Power Supply Recommendations

The SGM840J series can accurately measure signals over a wide range of common-mode voltages, from -4V to 80V, independent of the power supply voltage (VS). For instance, even if the SGM840J is powered by a 5V supply, it can handle common-mode voltages as low as -4V and as high as 80V. The output voltage range is subjected to the power supply.

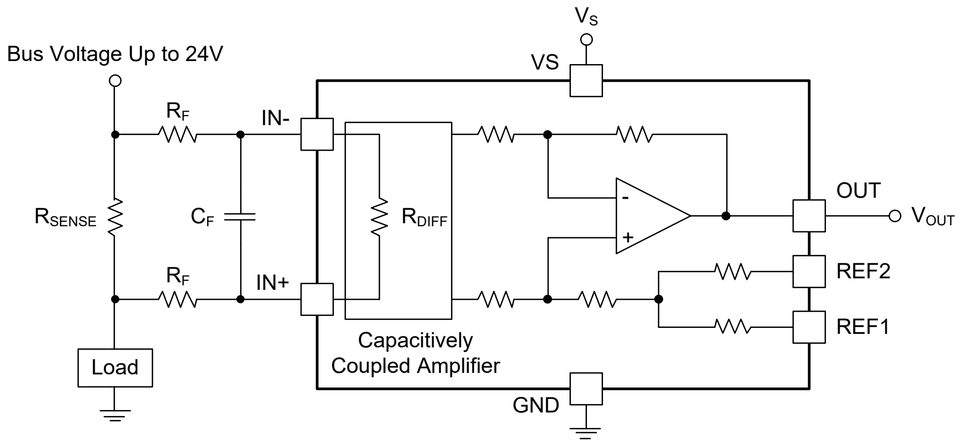


Figure 11. Filter at Input Pins

LAYOUT

Layout Guidelines

Current sense connections must be made using Kelvin or 4-wire connection between the input pins and the sensing resistor. This connection method eliminates the extra induced impedance, ensuring that only the current-sensing resistor impedance can be detected between the input pins. Figure 12 shows the good and bad connections.

Place a decoupling capacitor as close as possible to the VS and GND pins. A 0.1μF bypass capacitor for this supply is recommended.

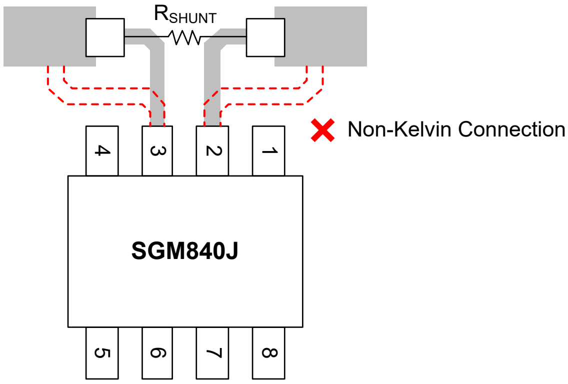


Figure 12. Shunt Connections to the SGM840J

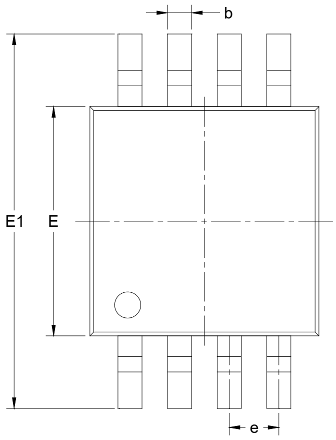
REVISION HISTORY

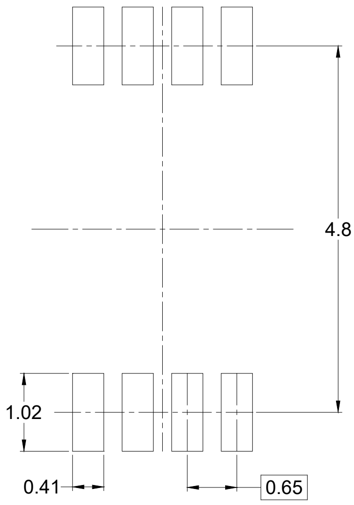
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (MARCH 2025) to REV.A	Page
Changed from product preview to production data	All

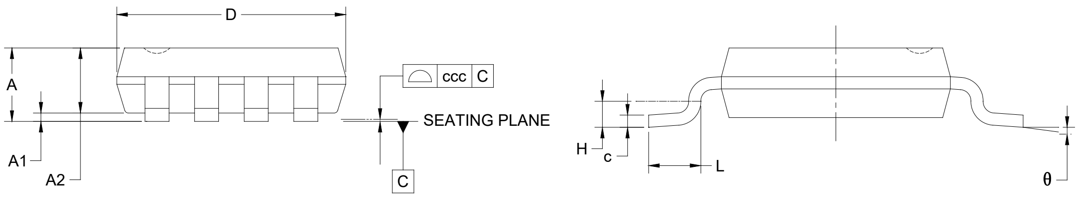
PACKAGE OUTLINE DIMENSIONS

MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)

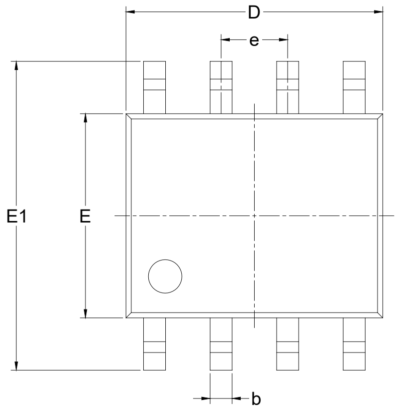


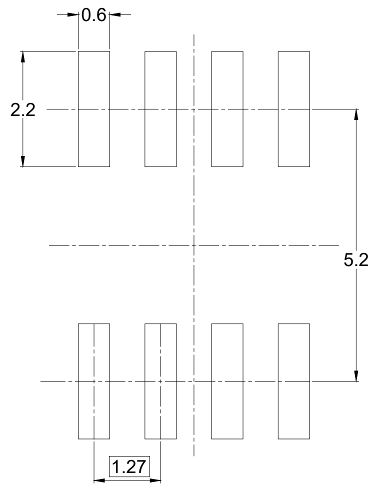
Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	-	-	1.100
A1	0.000	-	0.150
A2	0.750	-	0.950
b	0.220	-	0.380
c	0.080	-	0.230
D	2.800	-	3.200
E	2.800	-	3.200
E1	4.650	-	5.150
e	0.650 BSC		
L	0.400	-	0.800
H	0.250 TYP		
θ	0°	-	8°
ccc	0.100		

NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MO-187.

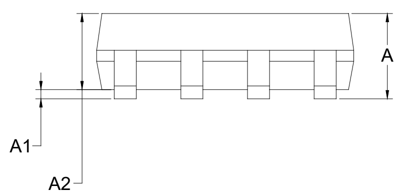
PACKAGE OUTLINE DIMENSIONS

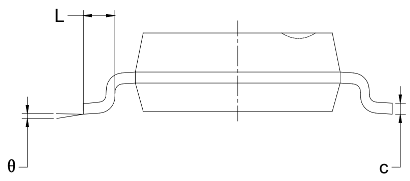
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)



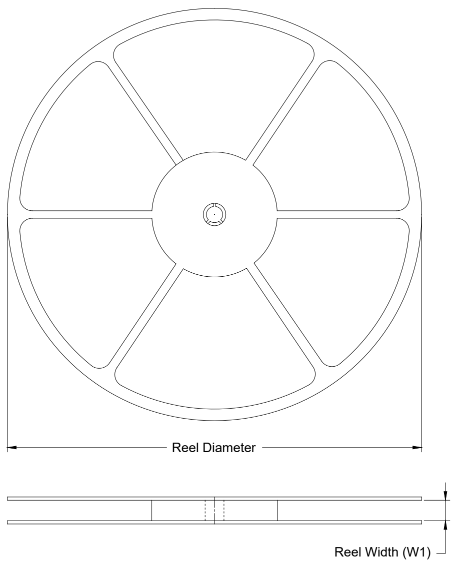


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

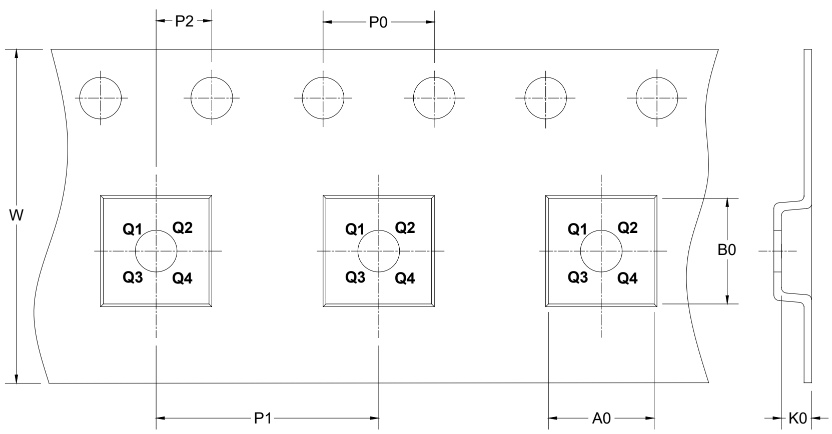
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

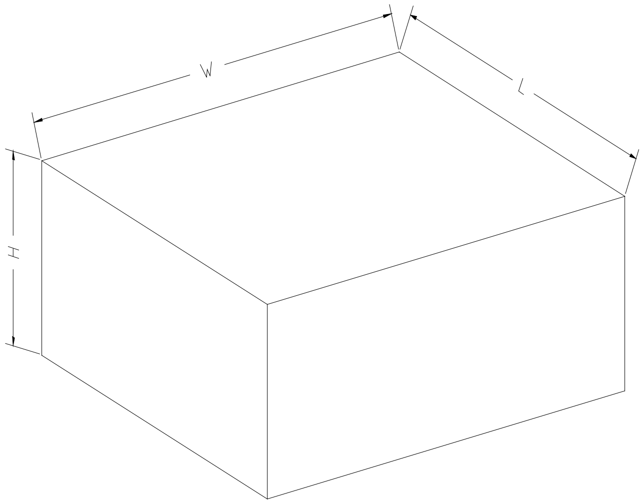
NOTE: The picture is only for reference. Please make the object as the standard.

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
MSOP-8	13"	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1
SOIC-8	13"	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1

DD0001

CARTON BOX DIMENSIONS



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

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
13″	386	280	370	5

DD0002