



SGM875

-4V to 48V, 400kHz, Bidirectional, High-Precision Current Sense Amplifier with Enhanced PWM Rejection

GENERAL DESCRIPTION

The SGM875 device is a bidirectional, fixed gain, voltage-output, current-sense amplifier which features enhanced PWM rejection and wide common-mode voltage range from -4V to 48V. The device is powered by a single 2.7V to 5.5V supply, and draws supply current of 0.7mA (TYP). There are four fixed gain options: 20V/V, 50V/V, 100V/V and 200V/V, providing more flexibility to meet the gain requirements in various applications.

The enhanced PWM rejection suppresses large common-mode transients ($\Delta V/\Delta t$) on the output signal, which is particularly relevant for applications utilizing pulse width modulation (PWM), such as motor drivers. The negative common-mode voltage capability allows the device to operate normally 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 SGM875 is available in a Green SC70-6 package.

TYPICAL APPLICATION

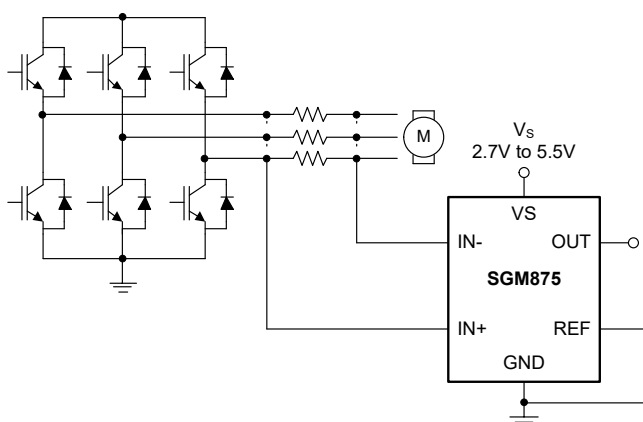


Figure 1. Typical Application Circuit

FEATURES

- Enhanced PWM Rejection
- Wide Common-Mode Voltage Range: -4V to 48V
- High Signal Bandwidth:
 - ♦ SGM875A/B/C: 400kHz
 - ♦ SGM875D: 340kHz
- Slew Rate: 4V/ μ s
- Gain Error Accuracy:
 - ♦ SGM875A/B/C: $\pm 0.4\%$ (MAX)
 - ♦ SGM875D: $\pm 0.55\%$ (MAX)
- Offset Voltage Accuracy:
 - ♦ +25°C: $\pm 130\mu$ V (MAX)
 - ♦ Offset Drift: 1 μ V/°C (MAX)
- Bidirectional Current-Sensing Capability
- Available Gains:
 - ♦ SGM875A: 20V/V
 - ♦ SGM875B: 50V/V
 - ♦ SGM875C: 100V/V
 - ♦ SGM875D: 200V/V
- Quiescent Current: 0.7mA (TYP)
- Available in a Green SC70-6 Package

APPLICATIONS

Motor Control
Power Management
Battery Monitors and Balancers
Lighting Control
Solar Inverters

-4V to 48V, 400kHz, Bidirectional, High-Precision SGM875 Current Sense Amplifier with Enhanced PWM Rejection

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE TOP MARKING	PACKING OPTION
SGM875A	SC70-6	-40°C to +125°C	SGM875AXC6G/TR	35VXX	Tape and Reel, 3000
SGM875B	SC70-6	-40°C to +125°C	SGM875BXC6G/TR	35WXX	Tape and Reel, 3000
SGM875C	SC70-6	-40°C to +125°C	SGM875CXC6G/TR	35XXX	Tape and Reel, 3000
SGM875D	SC70-6	-40°C to +125°C	SGM875DXC6G/TR	35YXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XX = Date Code.

YYY X X

_____ Date Code - Week

_____ Date Code - Year

_____ 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_S 6V

Analog Inputs, $IN+$, $IN-$

Differential $V_{IN+} - V_{IN-}$ -36V to 36V

Common Mode ⁽¹⁾ -6V to 50V

Common Mode (Less than 2s) -10V to 50V

Reference Voltage, V_{REF} GND - 0.3V to $V_S + 0.3V$

Output Voltage, V_{OUT} ⁽¹⁾ GND - 0.3V to $V_S + 0.3V$

Package Thermal Resistance

SC70-6, θ_{JA} 134.6°C/W

SC70-6, θ_{JB} 47°C/W

SC70-6, θ_{JC} 104.1°C/W

Junction Temperature +150°C

Storage Temperature Range -65°C to +150°C

Lead Temperature (Soldering, 10s) +260°C

ESD Susceptibility ^{(2) (3)}

HBM ±4000V

CDM ±2000V

NOTES:

1. Input voltage at any pin can exceed the voltage shown if the current at that pin is limited to 5mA.

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

3. For charged device model (CDM), all pins comply with ANSI/ESDA/JEDEC JS-002 specifications.

RECOMMENDED OPERATING CONDITIONS

Common-Mode Input Range, V_{CM} -4V to 48V (12V, TYP)

Operating Supply Voltage, V_S 2.7V to 5.5V (5V, TYP)

Operating Ambient Temperature Range, T_A -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

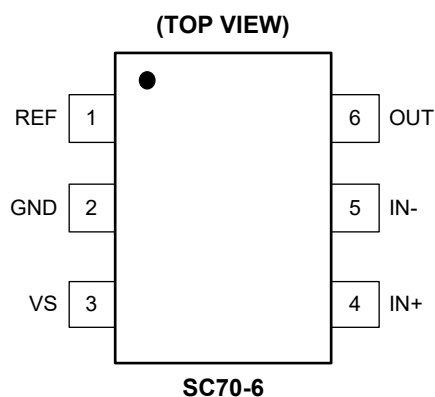
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

SGM875 -4V to 48V, 400kHz, Bidirectional, High-Precision Current Sense Amplifier with Enhanced PWM Rejection

PIN CONFIGURATION



PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION
1	REF	AI	Reference Input.
2	GND	G	Ground.
3	VS	P	2.7V to 5.5V Power Supply. Connect a 0.1 μ F capacitor from VCC to GND close to the device.
4	IN+	AI	Device Positive Input. For high-side sensing, connect it to the bus-voltage side of the sense resistor; for low-side sensing, connect it to the load side.
5	IN-	AI	Device Negative Input. For high-side sensing, connect it to the load side of the sense resistor; for low-side sensing, connect it to ground side.
6	OUT	AO	Output Voltage.

NOTE: AI = analog input, AO = analog output, P = power, G = ground.

-4V to 48V, 400kHz, Bidirectional, High-Precision SGM875 Current Sense Amplifier with Enhanced PWM Rejection

ELECTRICAL CHARACTERISTICS

($T_A = +25^\circ\text{C}$, $V_{\text{SENSE}} = V_{\text{IN}+} - V_{\text{IN}-}$, $V_S = 5\text{V}$, $V_{\text{REF}} = V_S/2$ and $V_{\text{IN}+} = 12\text{V}$, unless otherwise noted.)

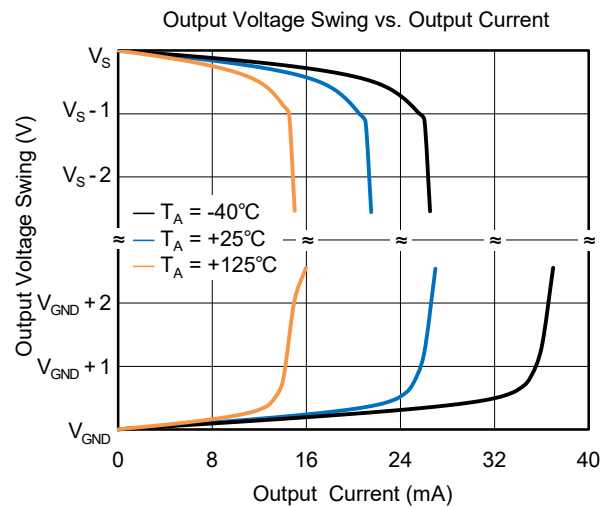
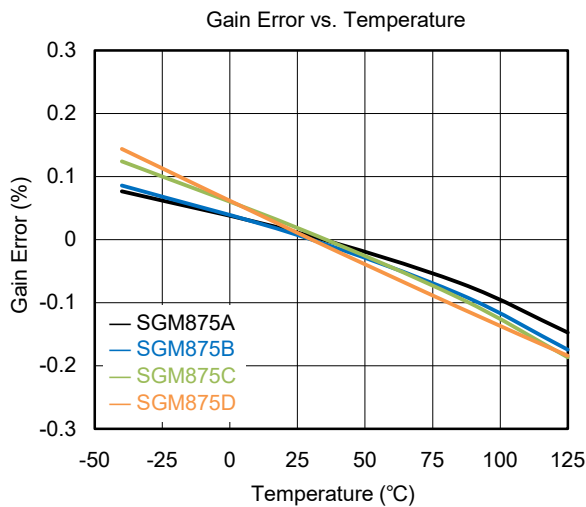
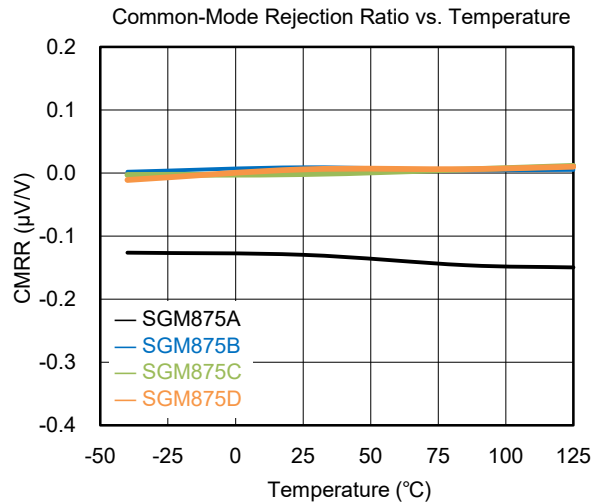
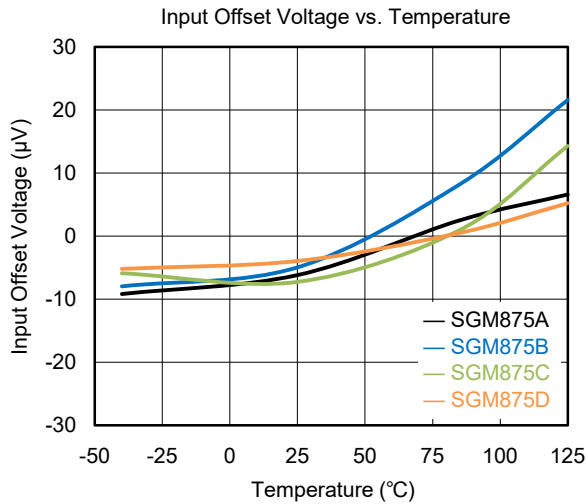
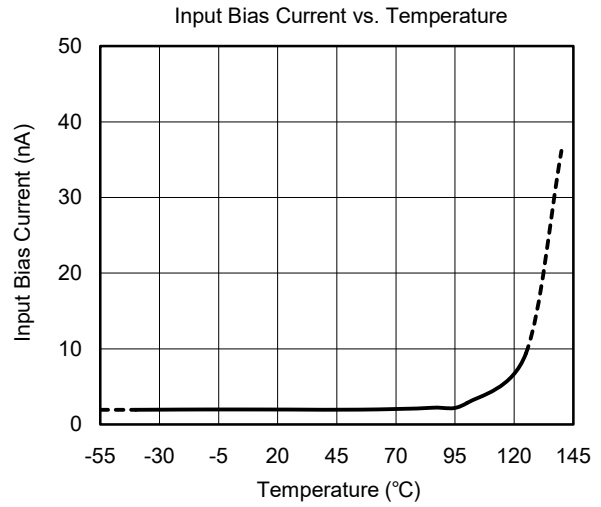
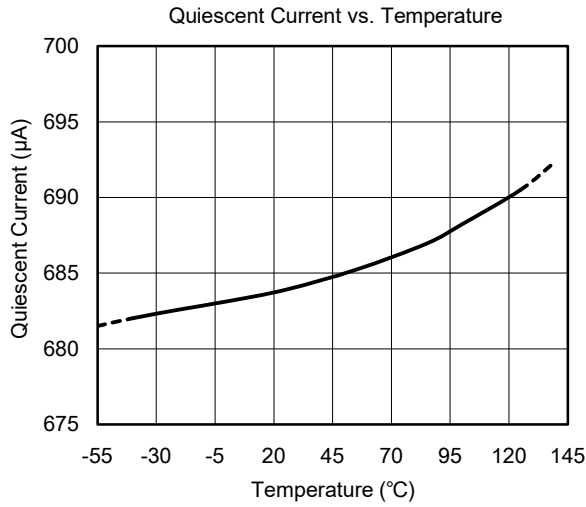
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input							
Common-Mode Rejection Ratio, RTI ⁽¹⁾	CMRR	V _{IN+} = -4V to 48V, V _{SENSE} = 0mV, T _A = -40°C to +125°C	SGM875A	115	135		dB
			SGM875B/C/D	120	145		
		f = 50kHz			100		
Offset Voltage, RTI	V _{OS}	V _{SENSE} = 0mV			±25	±130	μV
Offset Drift, RTI	dV _{OS} /dT	V _{SENSE} = 0mV, T _A = -40°C to +125°C			0.3	1	μV/°C
Power Supply Rejection Ratio, RTI	PSRR	V _S = 2.7V to 5.5V, V _{IN+} = 12V, V _{SENSE} = 0mV			±1	±15	μV/V
Input Bias Current	I _{IB}	V _{SENSE} = 0mV			10		nA
Input Offset Current	I _{IO}	V _{SENSE} = 0mV			10		nA
Output							
Gain	G	SGM875A			20		V/V
		SGM875B			50		
		SGM875C			100		
		SGM875D			200		
Gain Error	E _G	V _{OUT} = 0.5V to V _S - 0.5V, T _A = -40°C to +125°C	SGM875A/B/C		±0.04	±0.4	%
			SGM875D		±0.04	±0.55	
Gain Error Drift		T _A = -40°C to +125°C	SGM875A/B/C		15	25	ppm/°C
			SGM875D		25	40	
Nonlinearity Error		V _{OUT} = 0.5V to V _S - 0.5V			±0.01		%
Reference Voltage Rejection Ratio (Input-Referred)	RVRR	SGM875A			45		μV/V
		SGM875B			20		
		SGM875C/D			10		
Maximum Capacitive Load		No sustained oscillation			1		nF
Voltage Output							
Swing to V _S	V _{SP}	R _L = 10kΩ to GND, T _A = -40°C to +125°C			V _S - 0.020	V _S - 0.032	V
Swing to GND	V _{SN}	R _L = 10kΩ to GND, V _{IN+} - V _{IN-} = -10mV, T _A = -40°C to +125°C			V _{GND} + 0.003	V _{GND} + 0.010	V
Zero-Current Swing to GND	V _{SG}	R _L = open, V _{REF} = 0V, V _{IN+} - V _{IN-} = 0mV, T _A = -40°C to +125°C	SGM875A/B		V _{GND} + 0.003	V _{GND} + 0.011	V
			SGM875C		V _{GND} + 0.003	V _{GND} + 0.020	
			SGM875D		V _{GND} + 0.003	V _{GND} + 0.030	
Frequency Response							
Bandwidth	BW	C _{LOAD} = 10pF	SGM875A/B/C		400		kHz
			SGM875D		340		
Slew Rate	SR				4		V/μs
Noise, RTI ⁽¹⁾							
Voltage Noise Density					80		nV/√Hz
Power Supply							
Quiescent Current	I _Q	V _{SENSE} = 0mV			0.7	0.9	mA
		V _{SENSE} = 0mV, T _A = -40°C to +125°C				1	

NOTE: 1. RTI = referred-to-input.

SGM875 -4V to 48V, 400kHz, Bidirectional, High-Precision Current Sense Amplifier with Enhanced PWM Rejection

TYPICAL PERFORMANCE CHARACTERISTICS

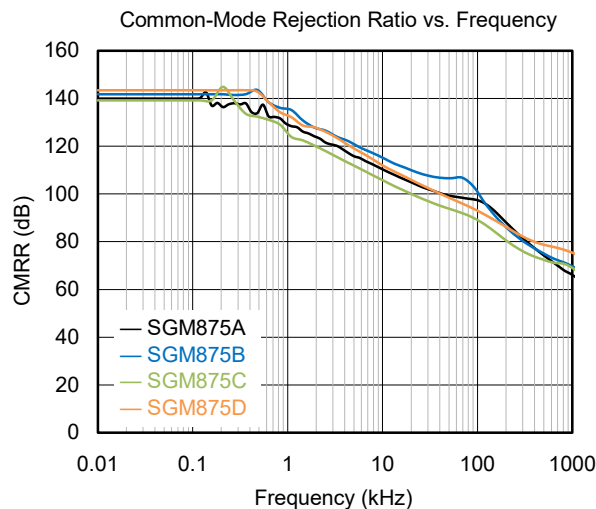
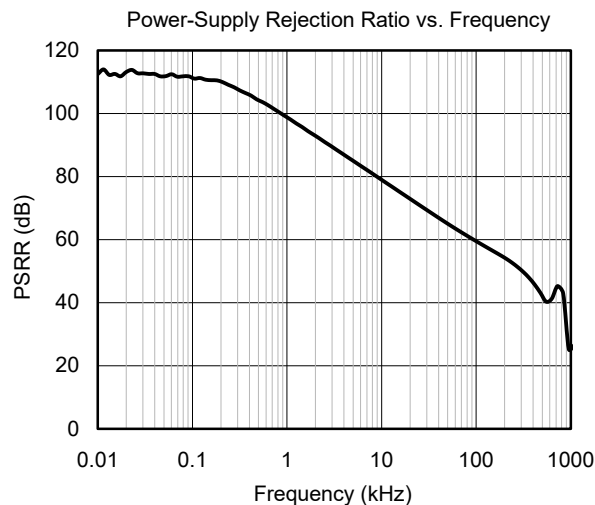
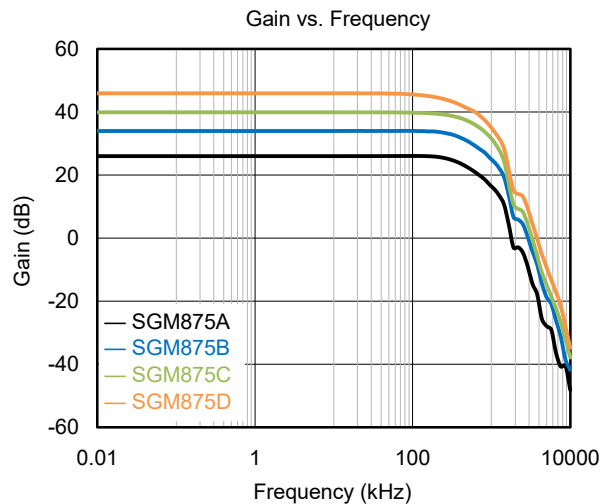
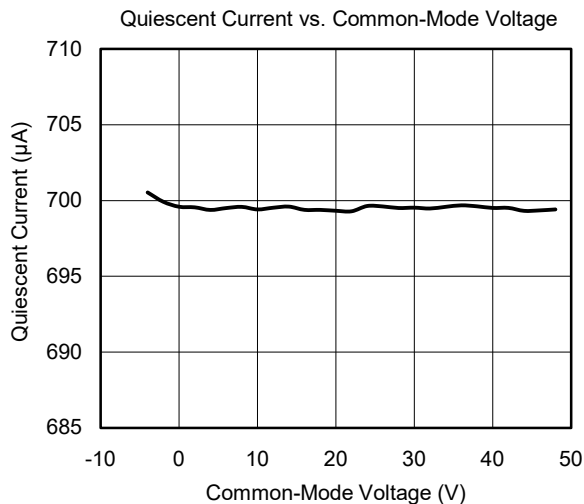
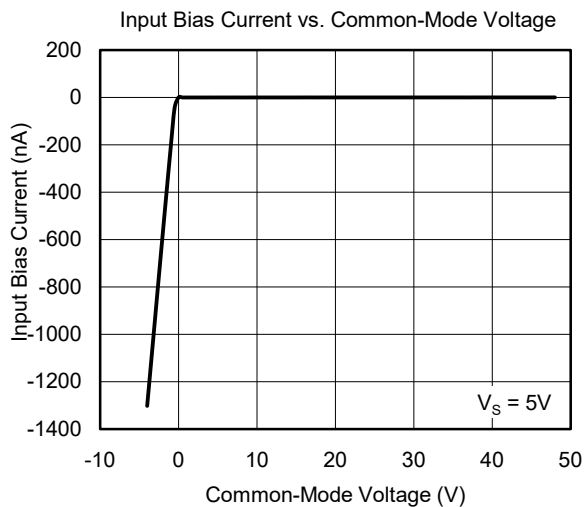
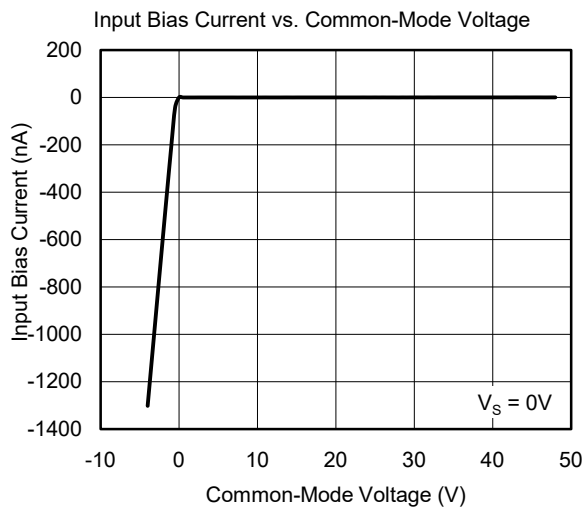
$T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{\text{REF}} = V_S/2$ and $V_{\text{IN}+} = 12\text{V}$, unless otherwise noted.



-4V to 48V, 400kHz, Bidirectional, High-Precision SGM875 Current Sense Amplifier with Enhanced PWM Rejection

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

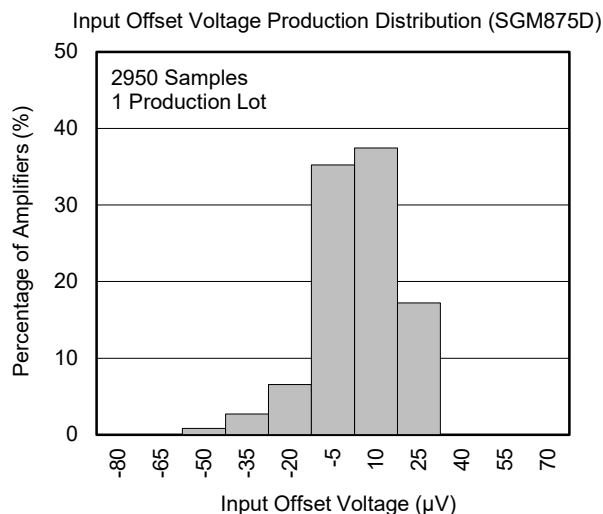
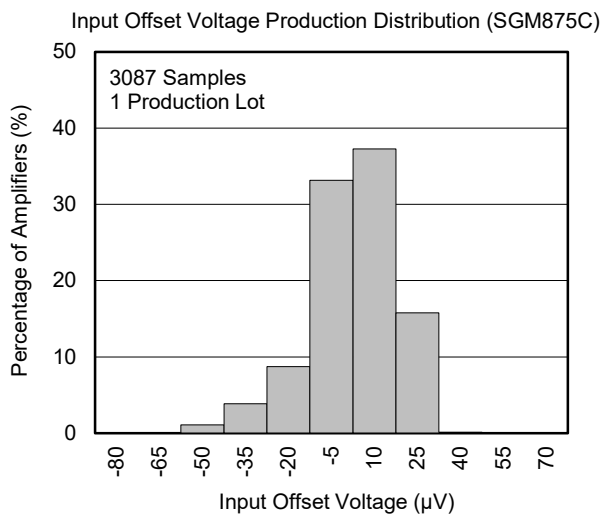
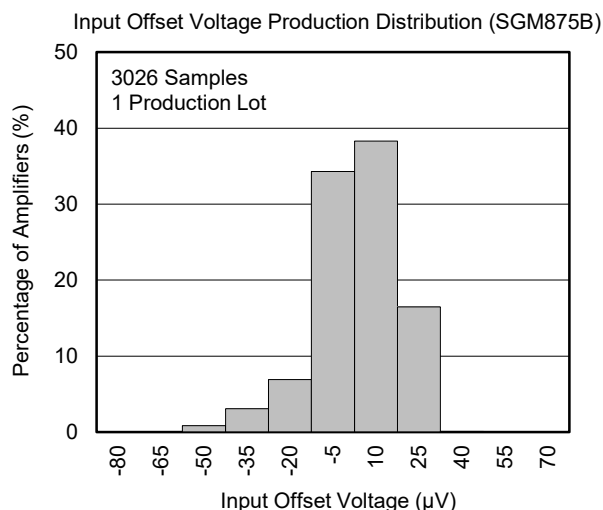
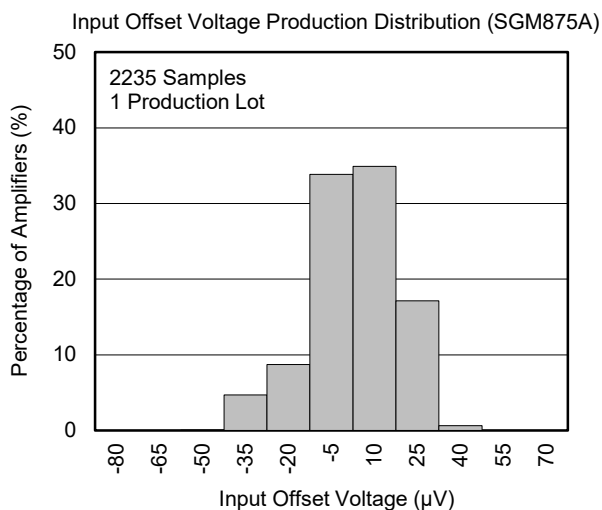
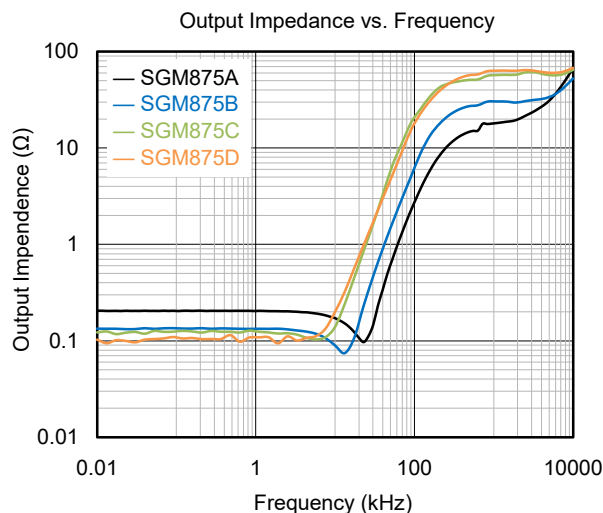
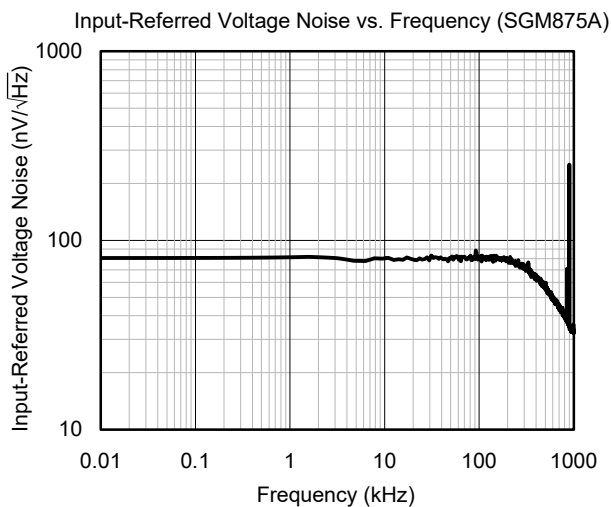
$T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{\text{REF}} = V_S/2$ and $V_{\text{IN}+} = 12\text{V}$, unless otherwise noted.



-4V to 48V, 400kHz, Bidirectional, High-Precision SGM875 Current Sense Amplifier with Enhanced PWM Rejection

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{REF} = V_S/2$ and $V_{IN+} = 12\text{V}$, unless otherwise noted.

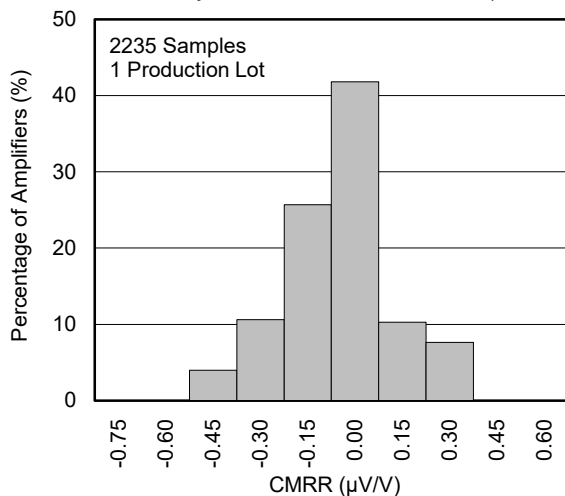


-4V to 48V, 400kHz, Bidirectional, High-Precision SGM875 Current Sense Amplifier with Enhanced PWM Rejection

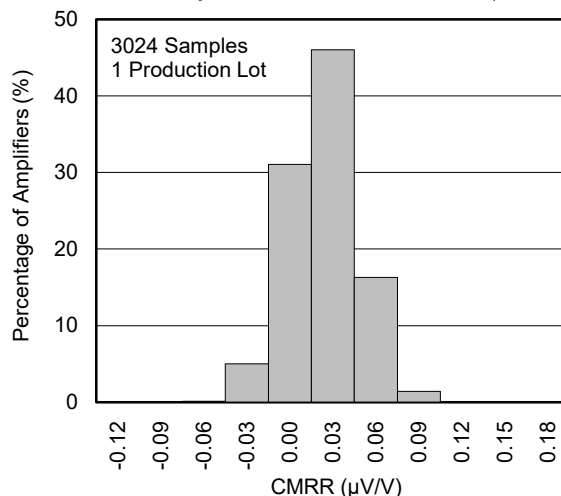
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{REF} = V_S/2$ and $V_{IN+} = 12\text{V}$, unless otherwise noted.

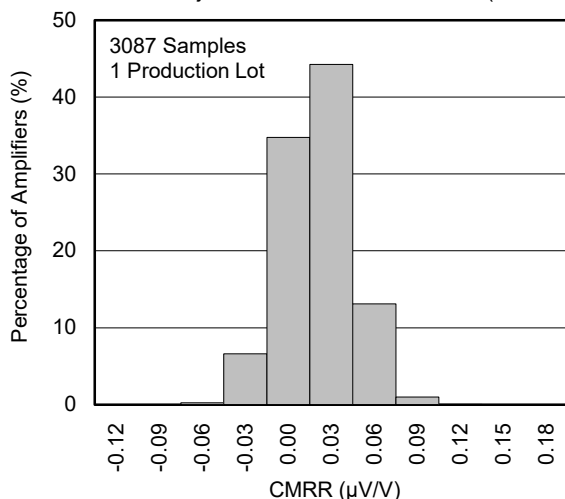
Common-Mode Rejection Production Distribution (SGM875A)



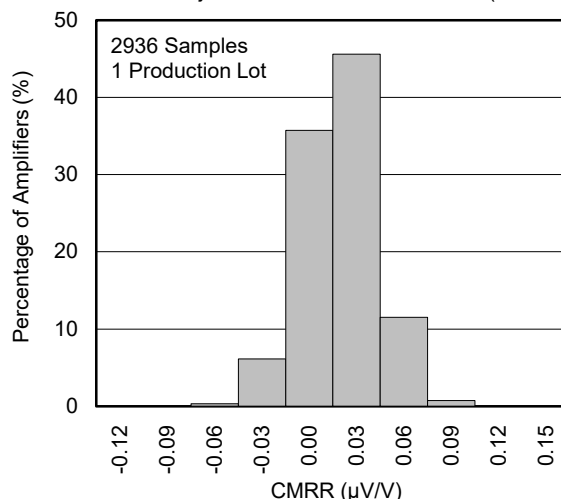
Common-Mode Rejection Production Distribution (SGM875B)



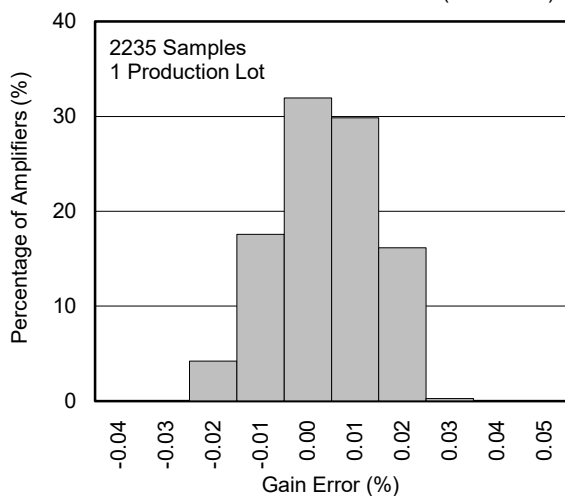
Common-Mode Rejection Production Distribution (SGM875C)



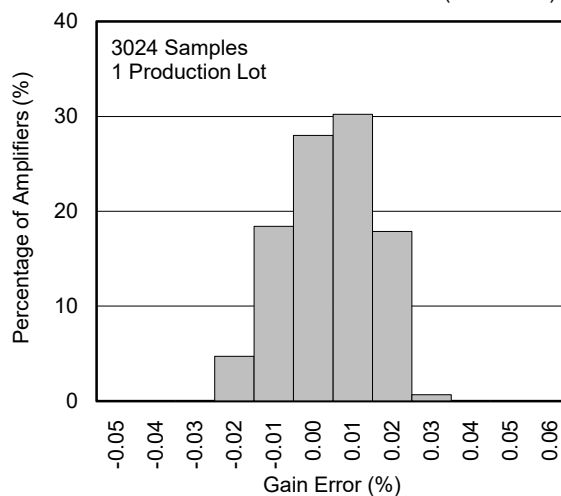
Common-Mode Rejection Production Distribution (SGM875D)



Gain Error Production Distribution (SGM875A)



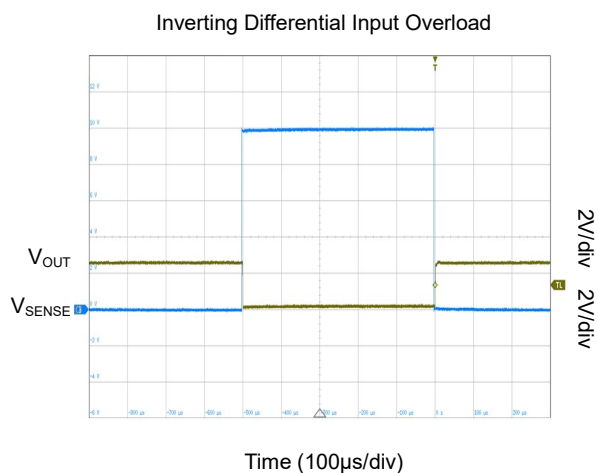
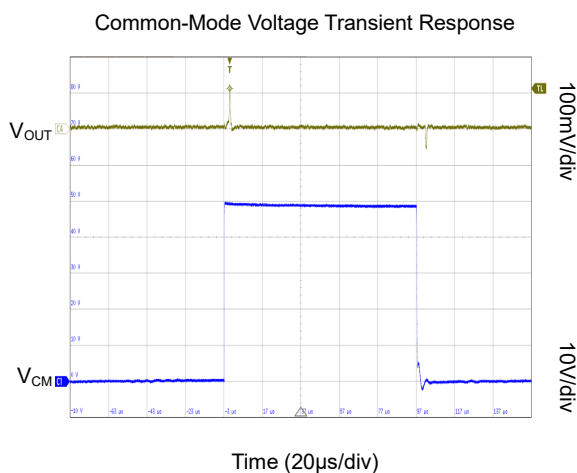
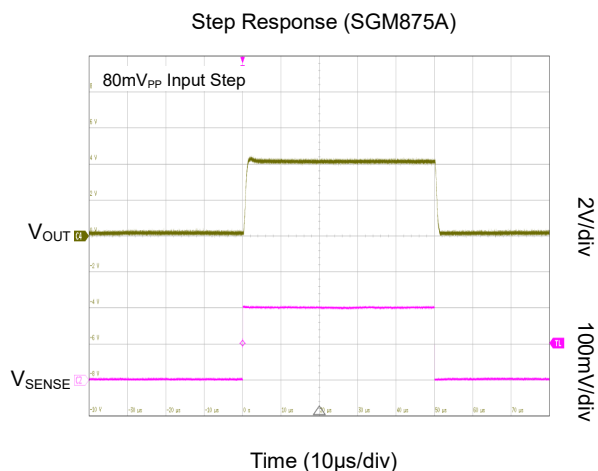
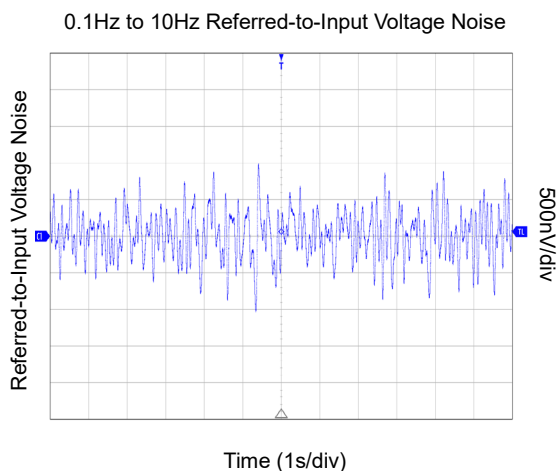
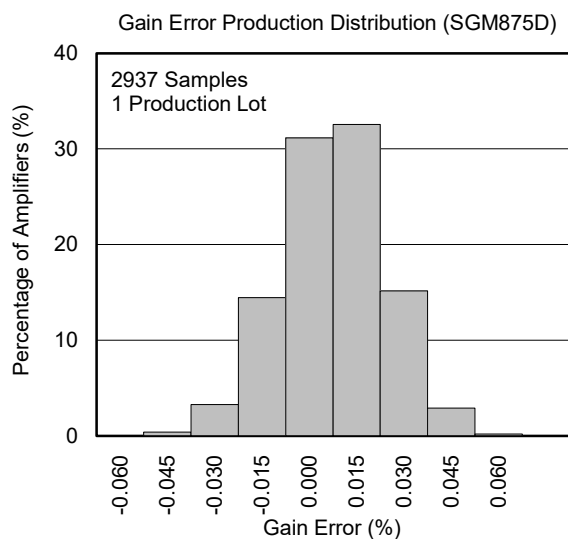
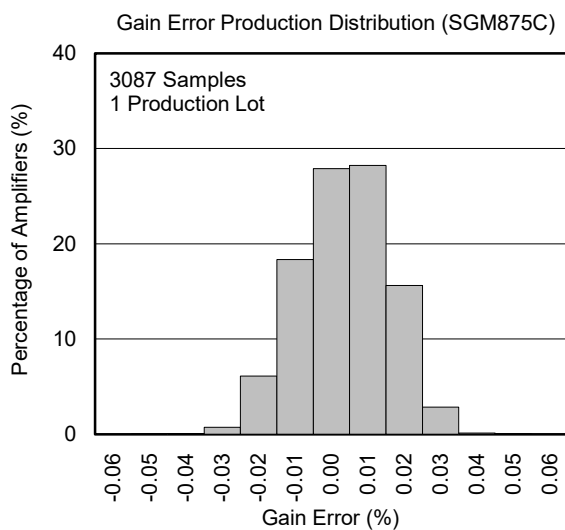
Gain Error Production Distribution (SGM875B)



-4V to 48V, 400kHz, Bidirectional, High-Precision SGM875 Current Sense Amplifier with Enhanced PWM Rejection

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

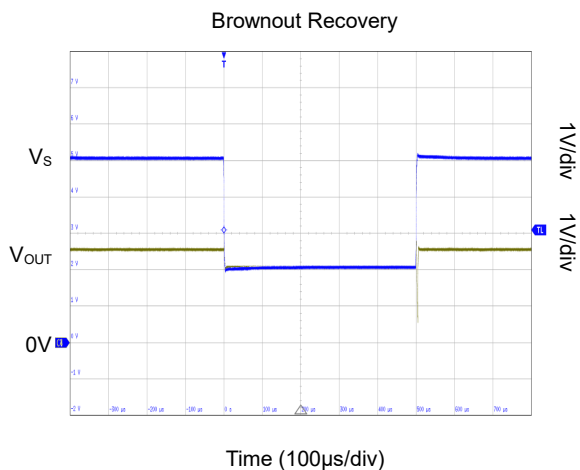
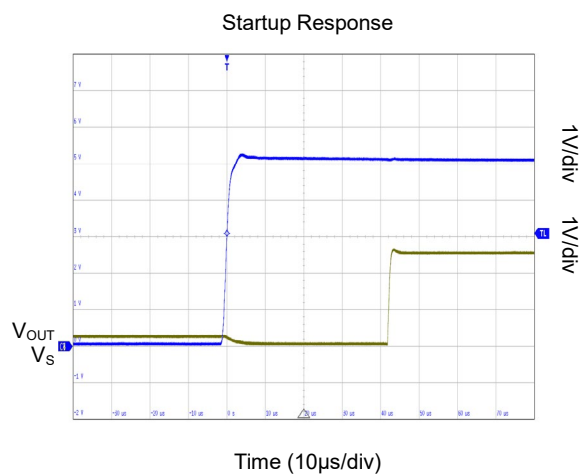
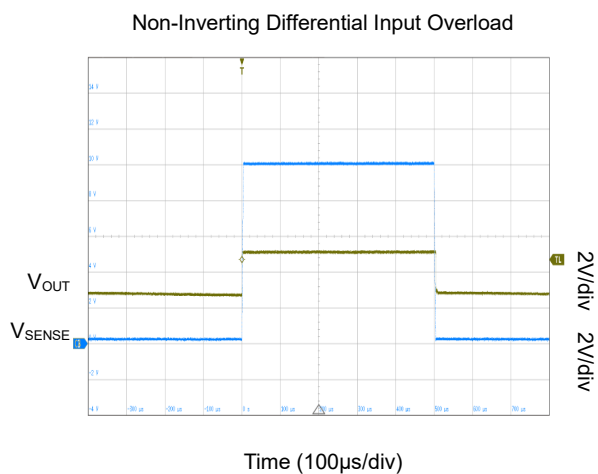
$T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{\text{REF}} = V_S/2$ and $V_{\text{IN}+} = 12\text{V}$, unless otherwise noted.



SGM875 -4V to 48V, 400kHz, Bidirectional, High-Precision Current Sense Amplifier with Enhanced PWM Rejection

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $V_{\text{REF}} = V_S/2$ and $V_{\text{IN}+} = 12\text{V}$, unless otherwise noted.



FUNCTIONAL BLOCK DIAGRAM

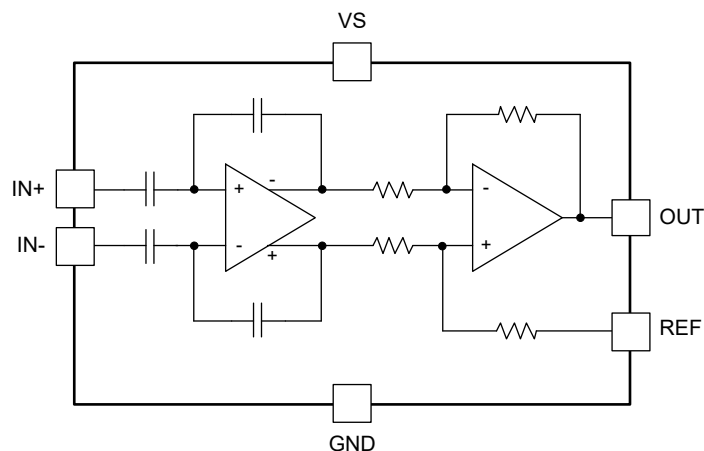


Figure 2. Block Diagram

SGM875 -4V to 48V, 400kHz, Bidirectional, High-Precision Current Sense Amplifier with Enhanced PWM Rejection

DETAILED DESCRIPTION

Overview

SGM875 is a current-sense amplifier supporting up to 48V common-mode voltage (V_{CM}), compatible with both high-side and low-side shunt resistor sampling schemes. Its proprietary internal topology enables precise voltage measurement across current shunts when the bus common-mode voltage far exceeds the supply rail of the chip. The component can accurately sample current on bus rails with potentials as high as 48V while operating from a minimal 2.7V supply input.

Feature Description

High Bandwidth and Slew Rate

The SGM875 delivers a maximum small-signal bandwidth of 400kHz for SGM875A/B/C, and 340kHz for SGM875D alongside a 4V/ μ s large-signal slew rate. This fast response capability allows real-time tracking of rapidly fluctuating load currents and rapid output voltage transitions, making it suitable for applications requiring ultra-fast signal capture. Low-side motor control is one major use case: rapid current tracking enables precise motor regulation across full operating ranges. The chip also serves fast fault detection circuits; paired with external comparators and reference voltages, it can instantly flag over-current and under-current fault conditions.

Bidirectional Current Monitoring

This amplifier tracks load current passing through the shunt resistor in both flow directions, implemented via adjustable voltage biasing on the REF pin. A positive differential voltage ($V_{IN+} > V_{IN-}$) pushes the output voltage above the reference potential set at REF; a negative differential input pulls V_{OUT} below V_{REF} . The mathematical formula to calculate output voltage is shown as Equation 1.

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

where:

- I_{LOAD} = monitored load current;
- R_{SENSE} = shunt sampling resistor resistance;
- G = fixed voltage gain of the selected SGM875 variant;
- V_{REF} = external voltage applied to the REF terminal.

Wide Input Common-Mode Voltage Range

The SGM875 supports input common-mode potentials spanning from -4V to 48V. Its unique internal circuit design decouples the common-mode operating limit from the chip supply rail (V_S), as long as V_S stays within the 2.7V to 5.5V operating window. The ability to process input voltages both above and below V_S enables flexible deployment in high-side and low-side current measurement topologies, illustrated in Figure 3.

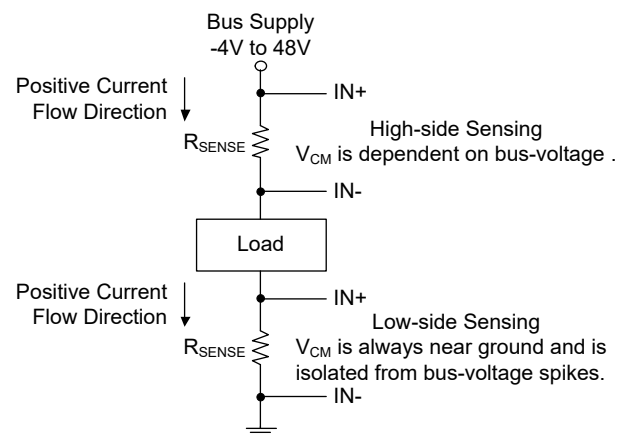


Figure 3. High-side and Low-side Sensing Connections

Precise Low-side Current Sensing

When configured for low-side current measurement, the SGM875 maintains tight input offset voltage tolerances below $\pm 130\mu V$ across all device variants. Low offset delivers two critical system benefits. Firstly, expanded dynamic measurement range: minimal offset error preserves reading precision for small low-magnitude currents. Secondly, lower-value shunt resistors can be deployed without sacrificing accuracy, reducing power dissipation across the sampling resistor and boosting overall system power efficiency. Gain error constitutes the dominant measurement error source when the shunt differential voltage far exceeds the offset voltage of the chip, with maximum gain error limited to $\pm 0.4\%$ for SGM875A/B/C, and $\pm 0.55\%$ for SGM875D.

Rail-to-Rail Output Swing

The output stage of SGM875 delivers linear signal operation with output potentials positioned extremely close to both the positive supply rail and circuit ground. The output only drops 32mV below V_S at maximum positive swing, and sits merely 10mV above GND for ground-proximity swing limits.

SGM875 -4V to 48V, 400kHz, Bidirectional, High-Precision Current Sense Amplifier with Enhanced PWM Rejection

DETAILED DESCRIPTION (continued)

Unlike standard operational amplifiers, current-sense amplifiers operate in closed-loop feedback architecture, so ground swing limits under unidirectional sampling (REF tied to GND, zero-load current) are constrained by the inherent offset voltage of the chip. Under zero-current conditions, the maximum output voltage near ground is capped at 11mV for SGM875A, 20mV for SGM875B, and 30mV for SGM875C/D.

Device Functional Modes

Normal Mode

The SGM875 enters standard linear measurement mode when all criteria below are satisfied.

- Supply voltage V_S falls between 2.7V and 5.5V.
- Input common-mode voltage V_{CM} remains within -4V to 48V.
- $G \times \text{maximum differential input voltage} + V_{REF} < V_S$ - positive rail swing margin.
- $G \times \text{minimum differential input voltage} + V_{REF} >$ ground swing margin (refer to Rail-to-Rail Output Swing section).
- In normal operation, the output terminal produces an amplified replica of the differential voltage across $IN+/IN-$, offset by the external reference voltage at the REF pin.

Unidirectional Mode

Single-direction current monitoring is achieved by hard-wiring the REF pin to ground potential, as shown in Figure 4. With zero-load current, OUT sits close to GND; current flowing from bus rail to load generates a positive differential shunt voltage, raising the output voltage proportionally.

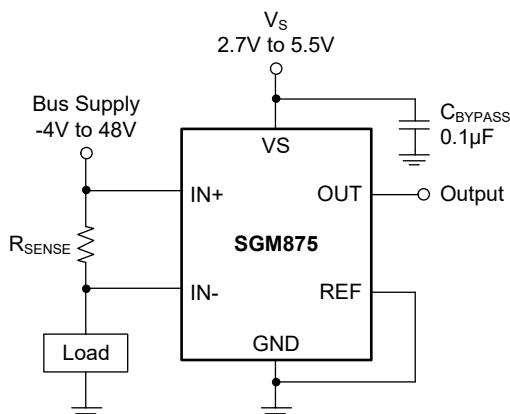


Figure 4. Unidirectional Application

The output linear operating range is constrained by how closely V_{OUT} can approach ground with zero input signal. For systems requiring precise low-current readings, engineers can bias the REF pin to a voltage above 50mV to shift the output into the optimal linear region of the device. A buffered reference voltage supply is recommended for the REF pin to minimize CMRR degradation.

An alternative biasing scheme connects the REF pin directly to V_S , which clamps the output 32mV below the supply rail with zero differential input signal. In this configuration, output voltage only responds to reverse-direction load currents that create negative $IN+/IN-$ differential potentials, with V_{OUT} falling as reverse current magnitude rises. The voltage fed to REF must never exceed the V_S supply rail.

Bidirectional Mode

This chip supports dual-direction current sampling for circuits with bidirectional current flow (such as battery charge/discharge loops and forward/reverse motor control). Figure 5 shows the standard bidirectional circuit topology.

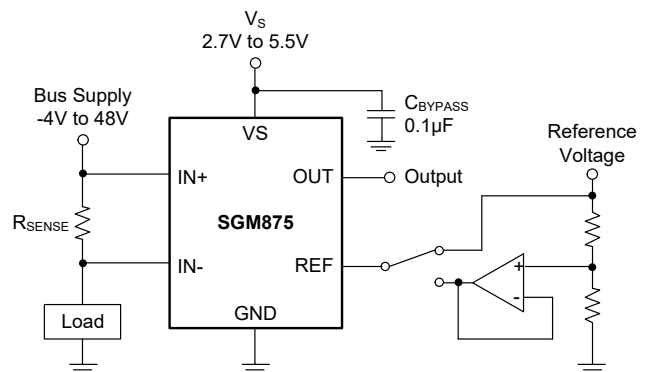


Figure 5. Bidirectional Application

Dual-range measurement is realized by feeding a fixed voltage to the REF pin, which sets the zero-current output baseline. Positive load currents generate $V_{IN+} > V_{IN-}$ differential voltages and push V_{OUT} higher than V_{REF} ; reverse currents create negative differential potentials and pull V_{OUT} below the reference level. V_{REF} can be programmed to any potential between 0V and V_S . For symmetric bidirectional current ranges, V_{REF} is typically set to $V_S/2$ to allocate equal linear swing range for forward and reverse currents. Asymmetric reference biasing is used when forward and reverse current operating ranges are mismatched.

DETAILED DESCRIPTION (continued)

Input Differential Overload

If the product of differential input voltage and device gain, summed with V_{REF} , exceeds the output swing boundaries of the chip, the output saturates at the nearest supply rail and stops delivering accurate current readings. To avoid this state during regular operation, designers can either reduce the shunt resistor resistance or select a lower-gain amplifier variant. If overload only occurs during transient fault events, the output automatically recovers valid readings approximately 5 μ s after the fault condition clears.

Shutdown Mode

No dedicated hardware shutdown pin is integrated on the SGM875. System-level power gating can be implemented by switching the VS supply rail via logic transistors or gate outputs to cut the quiescent current draw of the chip. Designers must evaluate leakage current flowing through the sampling shunt when the amplifier is fully powered down. Figure 6 presents a typical power gating circuit.

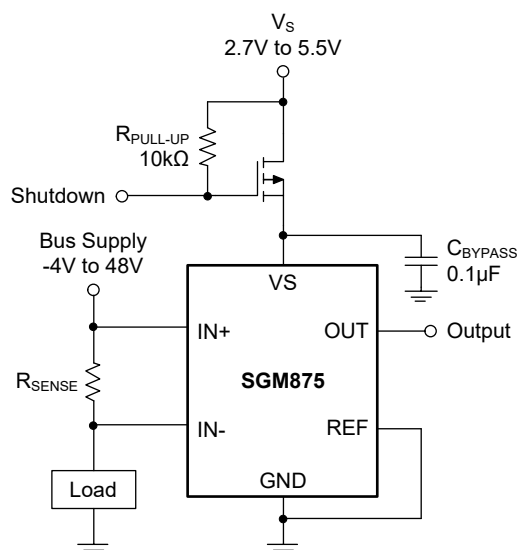


Figure 6. Basic Circuit to Shut Down the SGM875 with a Grounded Reference

As shown in Figure 2, by adding a capacitive coupled input bias stage at the input pins, when the amplifier is in a powered down state, the current at the input pins end is as low as the nA level. Especially when the common-mode voltage is greater than 0V, the current is approximately 10nA.

-4V to 48V, 400kHz, Bidirectional, High-Precision SGM875 Current Sense Amplifier with Enhanced PWM Rejection

APPLICATION INFORMATION

The SGM875 amplifies the tiny voltage drop generated across a series sampling shunt resistor when load current passes through the component. Adjustable biasing on the REF pin unlocks multiple circuit topologies for unidirectional and bidirectional sampling.

Basic Connections

Figure 7 displays the minimal peripheral circuit wiring for the amplifier. Traces linking the IN+ and IN- pins to the shunt resistor must be routed as short, matched-length Kelvin connections to eliminate series parasitic resistance measurement errors.

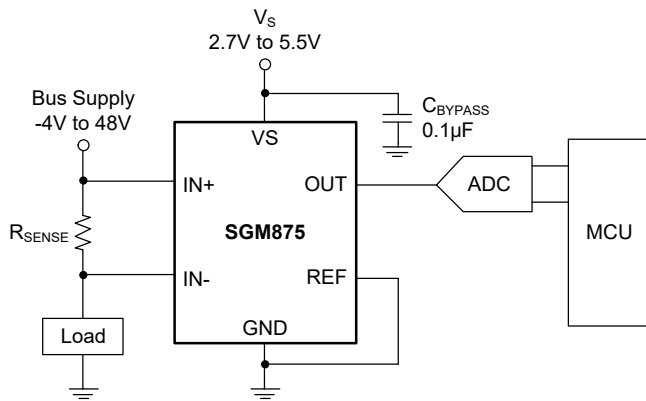


Figure 7. Basic Connections for the SGM875

A minimum-value 0.1µF decoupling capacitor must be mounted directly adjacent to the VS and GND pins for stable power delivery. Additional bulk decoupling capacitance can be added for noisy or high-impedance supply rails to suppress supply-borne interference.

R_{SENSE} and Device Gain Selection

Engineers should maximize shunt resistance as much as possible to boost differential input signal magnitude and reduce the relative contribution of offset voltage to total measurement error. However, practical hardware constraints limit maximum R_{SENSE} values. Input bias current mismatch error increases with larger shunt resistance, degrading CMRR performance; resistances above several ohms are discouraged for high-precision sampling systems. Maximum allowable power dissipation across the shunt resistor sets an upper resistance bound, calculated via Equation 2.

$$R_{SENSE} < \frac{PD_{MAX}}{I_{MAX}^2} \quad (2)$$

where:

- ♦ PD_{MAX} = maximum permitted power loss on the sampling resistor;
- ♦ I_{MAX} = peak load current magnitude.

Output swing limits defined by V_S and device rail proximity performance impose further gain/resistance tradeoffs. Equation 3 calculates the combined maximum gain and shunt resistance to avoid positive rail saturation.

$$I_{MAX} \times R_{SENSE} \times G < V_{SP} - V_{REF} \quad (3)$$

where:

- ♦ I_{MAX} is the maximum current that flows through R_{SENSE};
- ♦ G is the gain of the current sense-amplifier;
- ♦ V_{SP} is the positive output swing specified in the data sheet;
- ♦ V_{REF} is the externally applied voltage on the REF pin.

If the resistance value calculated from power dissipation constraints creates saturated output signals at peak load current, switch to a lower-gain SGM875 model. Equation 4 quantifies ground swing limitations to define minimum usable shunt resistance values.

$$I_{MIN} \times R_{SENSE} \times G > V_{SN} - V_{REF} \quad (4)$$

where:

- ♦ I_{MIN} is the minimum current that flows through R_{SENSE};
- ♦ G is the gain of the current sense amplifier;
- ♦ V_{SN} is the negative output swing of the device (see Rail-to-Rail Output Swing section);
- ♦ V_{REF} is the externally applied voltage on the REF pin.

In addition to adjusting the offset and gain, the voltage applied to the REF pin can be slightly increased to avoid negative swing limitations.

APPLICATION INFORMATION (continued)

Signal Filtering

If the downstream receiving circuit presents high input impedance, the optimal noise filtering position is an RC low-pass network wired between the OUT pin and system ground. Output-side filtering attenuates high-frequency interference originating from common-mode voltage transients, differential shunt signal noise, and supply rail fluctuations. If input-side filtering is mandatory or differential signal-only noise suppression is required, install RC filter networks on the IN+ and IN- pins as illustrated in Figure 8.

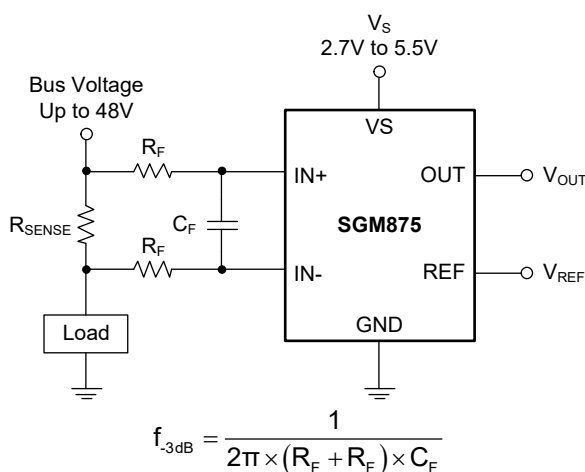


Figure 8. Filter at Input Pins

External series filter resistors introduce additional measurement errors, so their resistance value must be restricted below 10Ω to limit accuracy degradation. Internal input bias networks create minor input bias current mismatch; adding external series resistors generates differential voltage errors across the filter resistors, which offset the true shunt voltage drop captured by the amplifier inputs. Equation 5 quantifies the signal attenuation factor caused by external filter resistors.

$$\text{Gain Error Factor} = \frac{R_{\text{DIFF}}}{R_{\text{SENSE}} + 2 \times R_F + R_{\text{DIFF}}} \quad (5)$$

where:

- R_{DIFF} is the differential input impedance about 110kΩ;
- R_F is the added value of the series filter resistance.

The gain error that can be expected from the addition of the external series resistors can then be calculated based on Equation 6.

$$\text{Gain Error (\%)} = 100 - (100 \times \text{Gain Error Factor}) \quad (6)$$

Table 1 simplifies the attenuation factor formula for each model to calculate added gain error from external filter resistors via Equation 6. For example, fitting 10Ω series filter resistors to SGM875 produces an attenuation factor of 0.9998, translating to an extra 0.018% total gain error originating solely from the filter resistors. 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	0.009
10	0.018
22	0.04

Typical Application

Dual-direction current monitoring represents a primary target application for the SGM875, including battery charge/discharge monitoring and bidirectional motor current tracking. Figure 9 shows the complete bidirectional sampling circuit. Setting the REF pin to a stable voltage near $V_S/2$ allocates equal linear output swing for forward and reverse current flow; tying REF directly to GND reconfigures the circuit for single-direction measurement.

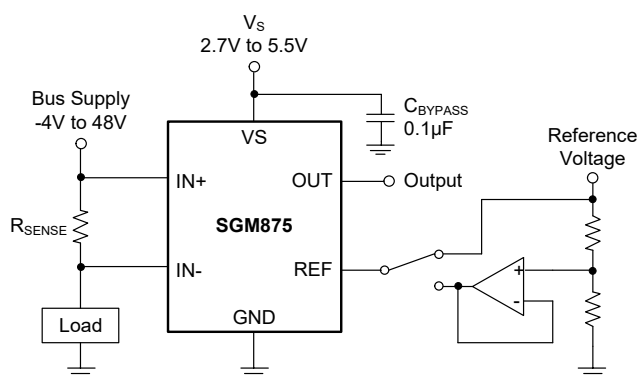


Figure 9. Measuring Bidirectional Current

-4V to 48V, 400kHz, Bidirectional, High-Precision SGM875 Current Sense Amplifier with Enhanced PWM Rejection

APPLICATION INFORMATION (continued)

Design Requirements

The design requirements for the circuit shown in Figure 9 are listed in Table 2.

Table 2. Design Parameters

DESIGN PARAMETER	SYMBOL	EXAMPLE VALUE
Power-Supply Voltage	V_S	5V
Bus Supply Rail	V_{CM}	12V
R_{SENSE} Power Loss		< 450mW
Maximum Sense Current	I_{MAX}	$\pm 20A$
Current Sensing Error		Less than 1% at maximum current, $T_J = +25^\circ C$
Small-Signal Bandwidth		> 100kHz

Detailed Design Procedure

First, calculate maximum allowable shunt resistance via power loss constraints by applying Equation 2: $PD_{MAX} = 450mW$, $I_{MAX} = 20A$ yields $R_{SENSE_MAX} = 1.125m\Omega$. Select the closest standard industry resistor value of $1m\Omega$ to meet thermal power limits.

Select matching amplifier gain for bidirectional symmetric $\pm 20A$ current range. Since this design targets bidirectional current measurement, the REF pin needs an input voltage within the $0V$ to V_S range. The bidirectional currents monitored are symmetric around $0A$ (that is, $\pm 20A$); therefore, the ideal voltage to apply to V_{REF} is $V_S/2$ or $2.5V$. Using Equation 3, and given that $I_{MAX} = 20A$, $R_{SENSE} = 1m\Omega$, and $V_{REF} = 2.5V$, positive swing limit calculation returns maximum allowable gain of $122.5V/V$. Likewise, using Equation 4 for negative swing constraints yields a maximum gain of $124.75V/V$. The $100V/V$ gain of SGM875C is selected to maximize output swing headroom without rail saturation. If calculated maximum allowable gain falls below $100V/V$, reduce shunt resistance to expand linear signal range.

Two error components, gain error and offset error, will be analyzed to assess accuracy under peak current conditions. The SGM875C features a maximum gain error of 0.4% . Under the conditions of $V_{CM} = 12V$ and $V_S = 5V$, offset-originated error is a fixed value with an upper limit of $130\mu V$. Given total offset error = $130\mu V$,

$R_{SENSE} = 1m\Omega$ and $I_{SENSE} = 20A$, Equation 7 produces an offset-voltage-related percentage error contribution of 0.65% .

$$\text{Total Offset Error(\%)} = \frac{\text{Total Offset Error(V)}}{I_{SENSE} \times R_{SENSE}} \times 100\% \quad (7)$$

Statistically accurate total error is computed via root-sum-square (R_{SS}) summation of uncorrelated gain and offset error components (Equation 8), delivering a total measurement error of 0.76% at peak current, which satisfies the $< 1\%$ design target.

$$\text{Total Error(\%)} = \sqrt{\text{Total Gain Error(\%)}^2 + \text{Total Offset Error(\%)}^2} \quad (8)$$

Equation 8 gives an overall current-sensing error of 0.76% at full-scale current, which meets the example design specification requiring error below 1% .

SGM875C provides $400kHz$ small-signal bandwidth, exceeding the $100kHz$ minimum specification.

Application Curve

Figure 10 plots the typical output voltage transfer curve for a bidirectional sampling circuit with V_{REF} set to $2.5V$; output rises above $2.5V$ for forward load currents and falls below $2.5V$ for reverse current flow.

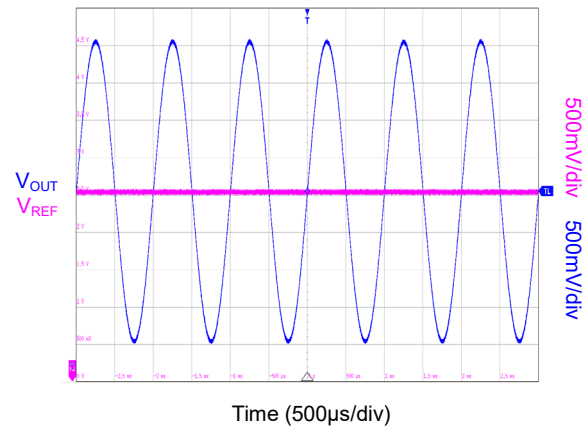


Figure 10. Bidirectional Application Output Response

SGM875 -4V to 48V, 400kHz, Bidirectional, High-Precision Current Sense Amplifier with Enhanced PWM Rejection

APPLICATION INFORMATION (continued)

Power Supply Recommendations

The front-end input topology of SGM875 enables accurate current sampling at bus voltages far exceeding the VS supply rail (e.g., 12V bus with 5V amplifier supply). However, the linear voltage operating window of OUT pin remains strictly bounded by the VS and GND supply potentials. The IN+ and IN- input pins also tolerate the full $\pm 36\text{V}$ differential voltage range even when the VS supply rail is unpowered.

Common-Mode Transients Greater than 48V

Automotive wiring harnesses frequently generate voltage transients exceeding native 48V common-mode operating limit of the chip, which can be mitigated with minimal external protection components. Zener diodes or TVS transorbs are mandatory for fast transient clamping (alternative surge suppression devices introduce excessive response delay). The standard protection circuit adds low-value series resistors ($< 10\Omega$) to form a current-limiting impedance for the clamping diodes, shown in Figure 11. Larger series resistors are usable but introduce measurable gain error as outlined in the signal filtering section. Low-power Zener diodes in SOD-523/SOT-523 miniature package deliver compact board-area protection for short-duration transients.

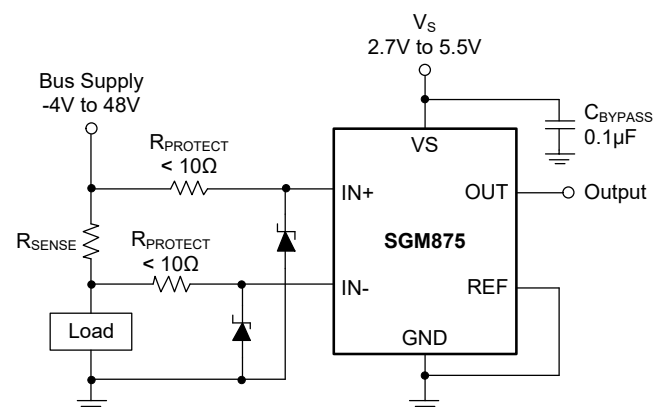


Figure 11. Transient Protection Using Dual Zener Diodes

For high-energy surge environments requiring stronger clamping capability, replace dual Zener diodes with a single unidirectional transorb paired with back-to-back signal diodes between IN+ and IN- pins, as shown in Figure 12. Dual series diodes integrated within single SOT/SOD miniature package minimize PCB footprint. With all protection peripherals populated, the total circuit footprint remains smaller than a standard SOIC-8 package and marginally larger than MSOP-8

footprint dimensions. Reference design documents covering high-transient shunt monitoring circuits contain additional protection topology details.

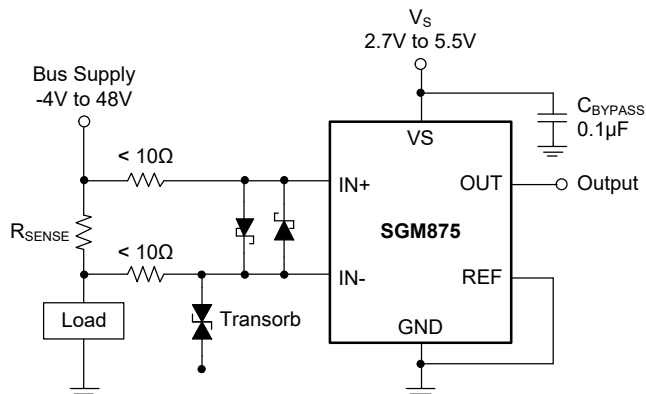


Figure 12. Transient Protection Using a Single Transorb and Input Clamps

Layout Guidelines

Implement Kelvin 4-wire routing between the shunt resistor and IN+/IN- pins to eliminate parasitic trace resistance from measurement readings; mismatched high-current trace resistance introduces severe full-scale errors due to the milliohm-scale shunt resistance values used in high-current systems.

Mount the $0.1\mu\text{F}$ decoupling capacitor between VS and GND in direct physical proximity to power and ground pins of the amplifier. Add supplementary bulk decoupling capacitance for noisy, high-impedance power delivery rails.

Route traces connecting the shunt resistor to the amplifier input pins with identical length and matched impedance to eliminate differential signal mismatch errors.

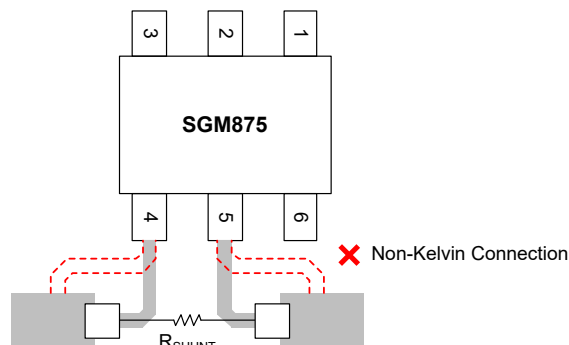


Figure 13. Shunt Connections to the SGM875

SGM875

**-4V to 48V, 400kHz, Bidirectional, High-Precision
Current Sense Amplifier with Enhanced PWM Rejection**

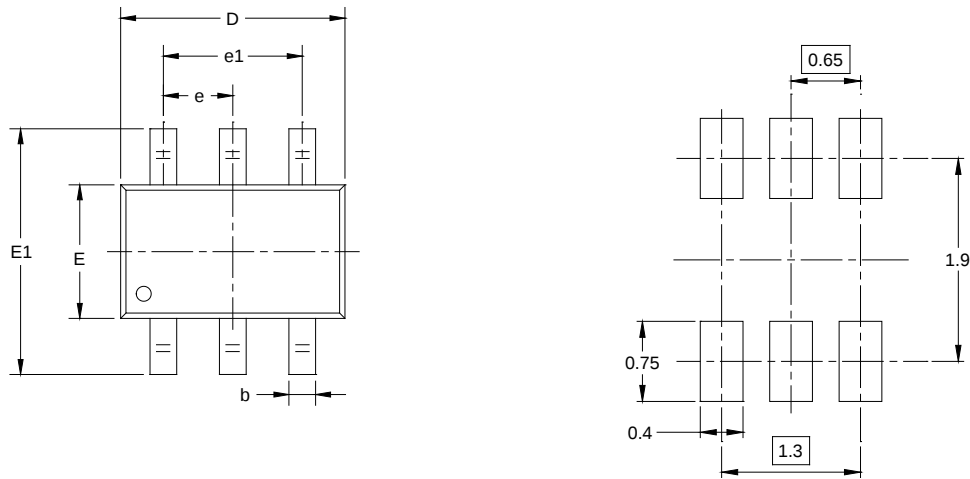
REVISION HISTORY

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

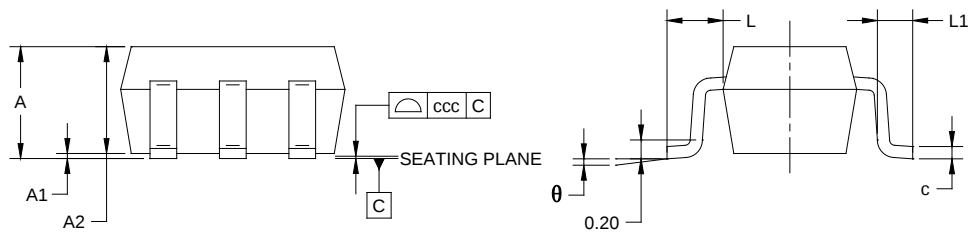
Changes from Original to REV.A (SEPTEMBER 2026)	Page
Changed from product preview to production data.....	All

PACKAGE OUTLINE DIMENSIONS

SC70-6



RECOMMENDED LAND PATTERN (Unit: mm)



Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	0.800	-	1.100
A1	0.000	-	0.100
A2	0.800	-	1.000
b	0.150	-	0.350
c	0.080	-	0.220
D	2.000	-	2.200
E	1.150	-	1.350
E1	2.150	-	2.450
e	0.600	0.650	0.700
e1	1.200	1.300	1.400
L	0.525 REF		
L1	0.260	-	0.460
ccc	0.100		
θ	0°	-	8°

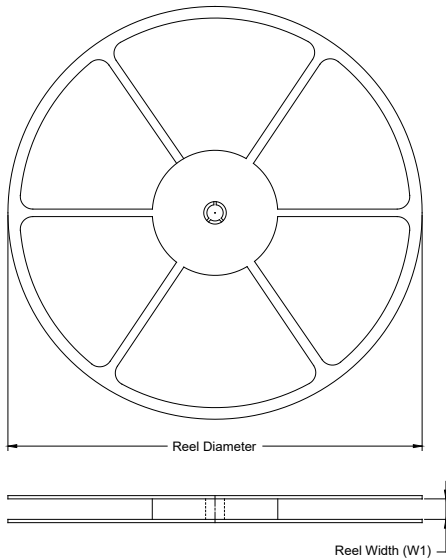
NOTES:

1. This drawing is subject to change without notice.
2. This dimension does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.2mm per side.
3. Reference JEDEC MO-203.

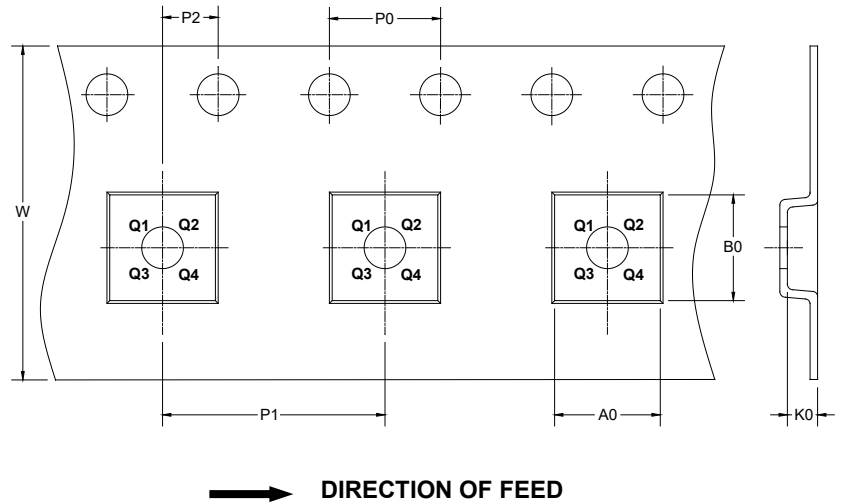
PACKAGE INFORMATION

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



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

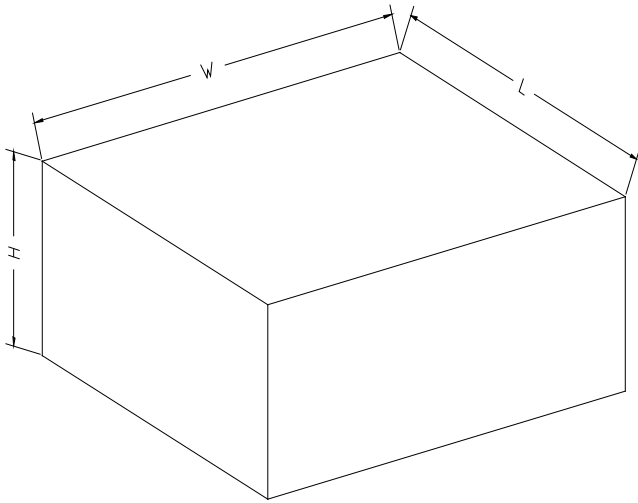
KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SC70-6	7"	9.5	2.40	2.50	1.20	4.0	4.0	2.0	8.0	Q3

DD00001

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

DD0002