SGM845
-16V to 80V, 1.3MHz, High-Precision Current Sense Amplifier with Open-Drain Comparator and Reference

GENERAL DESCRIPTION

The SGM845 is a high-precision current sense amplifier with wide common-mode range from -16V to 80V to measure voltage drops across shunt resistors, irrespective of the supply voltage. The small gain error (±0.03%, TYP), low offset voltage (±100μV, TYP), and high DC CMRR (130dB, TYP) make it capable for high precision current measurements. The device has a high signal bandwidth of 1.3MHz, which is designed for high-voltage high-speed applications such as rapid over-current protection. The SGM845 includes an open-drain comparator and a 0.6V internal reference. The current trip point is adjustable via two external resistors. The comparator also features a latching function that can be overridden by grounding the nRESET pin or leaving it open.

Functioning from a single supply voltage between 2.7V and 20V, the SGM845 consumes low supply current of 1.5mA. It is offered in five different gain settings: 20V/V, 50V/V, 100V/V, 200V/V, and 500V/V. These gain options cater to a diverse range of current-sensing applications, covering a broad dynamic range.

The SGM845 is available in a Green MSOP-8 package and specified over an operating temperature range of −40°C to +125°C.

FEATURES

- **Wide Common-Mode Voltage Range:**
  - **Operational Voltage: -16V to 80V**
  - **Survival Voltage: -20V to 85V**
- **High Signal Bandwidth: 1.3MHz**
- **Slew Rate: 8V/μs**
- **Excellent CMRR: 130dB**
- **Gain Error Accuracy: ±0.03% (TYP), ±0.65% (MAX)**
- **Offset Voltage Accuracy:**
  ±100μV (TYP), ±600μV (MAX)
- **On-Board Open-Drain Comparator**
- **Internal Comparator Voltage Reference: 0.6V**
- **Propagation Delay Time: 1μs**
- **Comparator with Latching Function**
- **Available Gains:**
  - **SGM845A: 20V/V**
  - **SGM845B: 50V/V**
  - **SGM845C: 100V/V**
  - **SGM845D: 200V/V**
  - **SGM845E: 500V/V**
- **Available in a Green MSOP-8 Package**

APPLICATIONS

Test and Measurement Equipment
Macro Remote Radio Unit (RRU)
48V DC/DC Converter
48V Rack Server
48V Power Supply Unit (PSU) for Network and Server
48V Battery Management System (BMS)
Solenoid and Actuator Control Systems

SIMPLIFIED SCHEMATIC

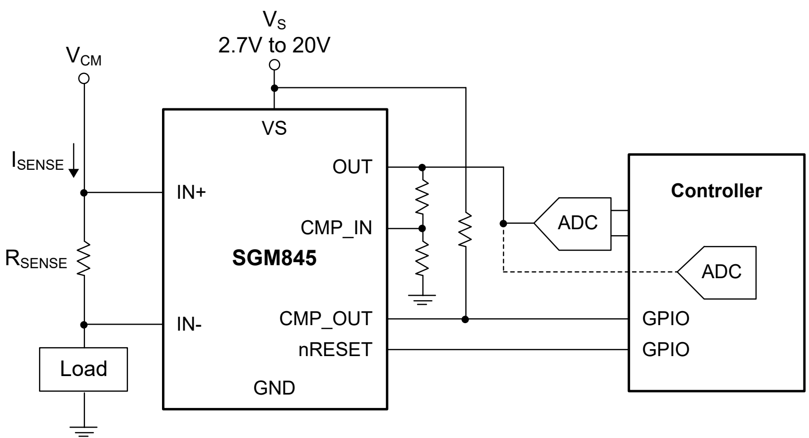


Figure 1. Simplified Schematic

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM845A	MSOP-8	-40℃ to +125℃	SGM845AXMS8G/TR	SGM845A XMS8 XXXXX	Tape and Reel, 4000
SGM845B	MSOP-8	-40℃ to +125℃	SGM845BXMS8G/TR	SGM845B XMS8 XXXXX	Tape and Reel, 4000
SGM845C	MSOP-8	-40℃ to +125℃	SGM845CXMS8G/TR	SGM845C XMS8 XXXXX	Tape and Reel, 4000
SGM845D	MSOP-8	-40℃ to +125℃	SGM845DXMS8G/TR	SGM845D XMS8 XXXXX	Tape and Reel, 4000
SGM845E	MSOP-8	-40℃ to +125℃	SGM845EXMS8G/TR	SGM845E XMS8 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 .... -0.3V to 22V
Analog Inputs
Differential V_{IN+} - V_{IN-} .... -60V to 60V
V_{IN+}, V_{IN-} (with respect to GND) .... -20V to 85V
Analog Output Voltage, V_{OUT} .... GND - 0.3V to V_S + 0.3V
Comparator Reset Pin Voltage .... GND - 0.3V to V_S + 0.3V
Comparator Analog Input Voltage ....
.... GND - 0.3V to MIN (5.5V, V_S)
Comparator Output Voltage .... GND - 0.3V to 22V
Input Current into Any Pin 5mA
Package Thermal Resistance
MSOP-8, θ_{JA} .... 136.5℃/W
MSOP-8, θ_{JB} .... 83.2℃/W
MSOP-8, θ_{JC} .... 49.9℃/W
Junction Temperature .... +150℃
Storage Temperature Range .... -65℃ to +150℃
Lead Temperature (Soldering, 10s) .... +260℃
ESD Susceptibility [1] [2]
HBM .... ±6000V
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

Common-Mode Input Range, V_{CM} .... -16V to 80V (48V, TYP)
Operating Supply Voltage, V_S .... 2.7V to 20V (5V, TYP)
Differential Sense Input Range, V_{SENSE} .... 0V to V_S/G
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.

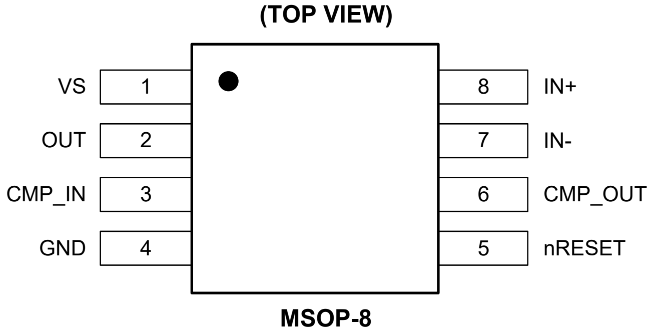
ESD SENSITIVITY CAUTION

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 CONFIGURATION



PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION
1	VS	P	2.7V to 20V Power Supply.
2	OUT	O	Output Voltage.
3	CMP_IN	I	Comparator Input.
4	GND	G	Ground.
5	nRESET	I	Active Low Comparator Reset Pin. Setting it low activates transparent mode, and setting it high activates latch mode.
6	CMP_OUT	O	Comparator Output. When nRESET is high, the comparator latches high.
7	IN-	I	Negative Sense Input Connection of Shunt Resistor. Connect it to the load side of sense resistor for high-side applications. Connect it to the ground side of sense resistor for low-side applications.
8	IN+	I	Positive Sense Input Connection of Shunt Resistor. Connect it to the bus-voltage side of sense resistor for high-side applications. Connect it to the load side of sense resistor for low-side applications.

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

ELECTRICAL CHARACTERISTICS

(V_S = 5.0V, V_{SENSE} = V_{IN+} - V_{IN-} = 0.5V/Gain, V_{CM} = V_{IN-} = 48V, and $R_{PULL\text{-}UP}$ = 5.1kΩ connected from CMP_OUT to VS, T_A = -40℃ to +125℃, typical values are measured at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supply							
Supply Voltage Range	V_S			2.7		20	V
Quiescent Current	I_Q	T_A = +25℃			1.5	2.0	mA
		T_A = -40℃ to +125℃				2.2	
Input							
Common-Mode Input Range	V_{CM}			-16		80	V
Common-Mode Rejection Ratio	CMRR	SGM845A, V_{IN+} = -16V to 80V, T_A = -40℃ to +125℃		108	130		dB
		SGM845B/C/D/E, V_{IN+} = -16V to 80V, T_A = -40℃ to +125℃		118	134		
		f = 50kHz			70		
Offset Voltage, RTI [1]	V_{OS}	SGM845A	T_A = +25℃		±100	±400	μV
			T_A = -40℃ to +125℃			±600	
		SGM845B	T_A = +25℃		±50	±300	
			T_A = -40℃ to +125℃			±400	
		SGM845C/D/E	T_A = +25℃		±50	±200	
			T_A = -40℃ to +125℃			±300	
Power-Supply Rejection Ratio, RTI	PSRR	SGM845A, V_S = 2.7V to 20V, T_A = -40℃ to +125℃			±3	±20	μV/V
		SGM845B/C/D/E, V_S = 2.7V to 20V, T_A = -40℃ to +125℃			±1	±10	
Input Bias Current	I_B	I_{B+}, I_{B-}, V_{SENSE} = 0mV	T_A = +25℃		±0.1	±0.5	μA
			T_A = -40℃ to +125℃			±2	
Output							
Gain	G	SGM845A			20		V/V
		SGM845B			50		
		SGM845C			100		
		SGM845D			200		
		SGM845E			500		
Gain Error	GERR	SGM845A/B/C/D, GND + 100mV ≤ V_{OUT} ≤ V_S - 200mV	T_A = +25℃		±0.03	±0.2	%
			T_A = -40℃ to +125℃			±0.4	
		SGM845E, GND + 100mV ≤ V_{OUT} ≤ V_S - 200mV	T_A = +25℃		±0.03	±0.3	
			T_A = -40℃ to +125℃			±0.65	
Nonlinearity Error	NL_{ERR}	GND + 100mV ≤ V_{OUT} ≤ V_S - 200mV			±0.01		%
Maximum Capacitive Load		No sustained oscillation, no isolation resistor			500		pF
Voltage Output							
Swing to VS (Power Supply Rail)	V_{SP}	R_{LOAD} = 10kΩ to GND			V_S - 50	V_S - 150	mV
Swing to GND	V_{SN}	R_{LOAD} = 10kΩ to GND, V_{SENSE} = 0mV			V_{GND} + 5	V_{GND} + 20	mV
Frequency Response							
Bandwidth	BW	SGM845A, C_{LOAD} = 5pF, V_{SENSE} = 200mV			1300		kHz
		SGM845B, C_{LOAD} = 5pF, V_{SENSE} = 80mV			1300		
		SGM845C, C_{LOAD} = 5pF, V_{SENSE} = 40mV			1000		
		SGM845D, C_{LOAD} = 5pF, V_{SENSE} = 20mV			400		
		SGM845E, C_{LOAD} = 5pF, V_{SENSE} = 8mV			400		

ELECTRICAL CHARACTERISTICS (continued)

(V_S = 5.0V, V_{SENSE} = V_{IN+} - V_{IN-} = 0.5V/Gain, V_{CM} = V_{IN-} = 48V, and $R_{PULL-UP}$ = 5.1kΩ connected from CMP_OUT to VS, T_A = -40℃ to +125℃, typical values are measured at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Slew Rate	SR	Rising edge			8		V/μs
Settling Time	t_S	V_{OUT} = 4V ± 0.1V step, output settles to 0.5%			6		μs
		V_{OUT} = 4V ± 0.1V step, output settles to 5%			1		μs
Noise							
Voltage Noise Density	V_{EN}				201		nV/√Hz
Comparator							
Alert Threshold	V_{TH}	T_A = +25℃		585	600	615	mV
		T_A = -40℃ to +125℃		580		620	
Hysteresis					8		mV
Small-Signal Propagation Delay	t_P	Comparator input overdrive = 20mV			1		μs
Slew-Rate-Limited Propagation Delay		V_{OUT} step = 0.5V to 4.5V, V_{LIMIT} (2) = 4V			1		μs
Input Bias Current, CMP_IN Pin	I_{BCMP_IN}	V_{CMP_IN} = 0.4V to 1.2V	T_A = +25℃		±5	±20	nA
			T_A = -40℃ to +125℃			250	
High-Level Leakage Current	I_{LKG}	V_{CMP_OUT} = V_S			0.01	1	μA
Low-Level Output Voltage	V_{OL}	I_{OL} = 2.35mA	T_A = +25℃		120	200	mV
			T_A = -40℃ to +125℃			350	
nRESET High-Level Input Voltage Threshold (3)	V_{IH}			1.3			V
nRESET Low-Level Input Voltage Threshold (3)	V_{IL}					0.4	V
Minimum nRESET Pulse Width					40		ns
nRESET Propagation Delay					40		ns

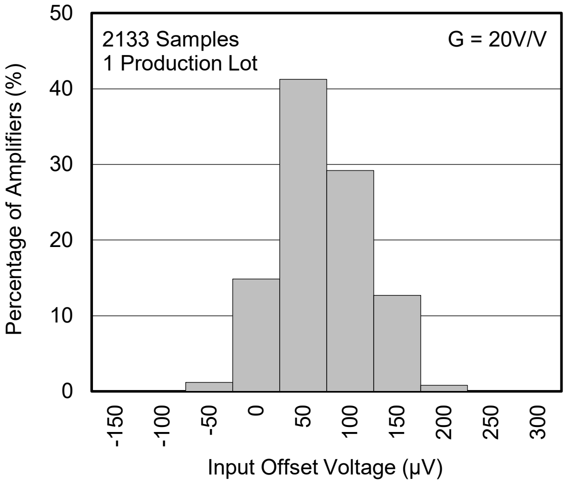
NOTES:

1. RTI = referred-to-input.
2. V_{LIMIT} represents V_{OUT} when the over-current threshold, determined by external resistors, is reached.
3. The nRESET features an internal 2MΩ pull-down resistor typically. Leaving nRESET open results in a low state and ensures transparent comparator operation.

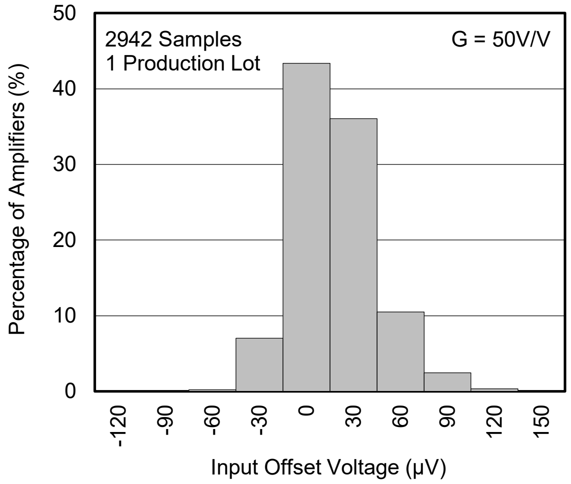
TYPICAL PERFORMANCE CHARACTERISTICS

T_A = +25℃, V_S = 5V, V_{SENSE} = V_{IN+} - V_{IN-} = 0.5V/Gain, V_{CM} = V_{IN-} = 48V, and $R_{PULL-UP}$ = 5.1kΩ, unless otherwise noted.

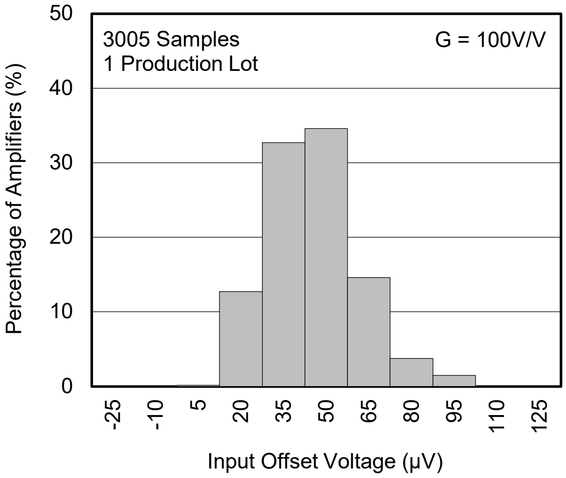
SGM845A Input Offset Production



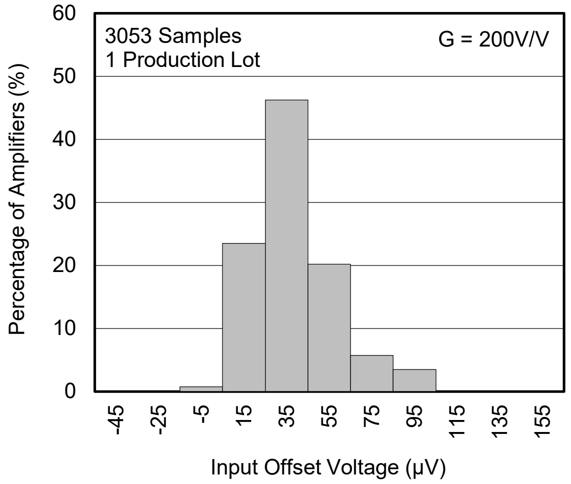
SGM845B Input Offset Production



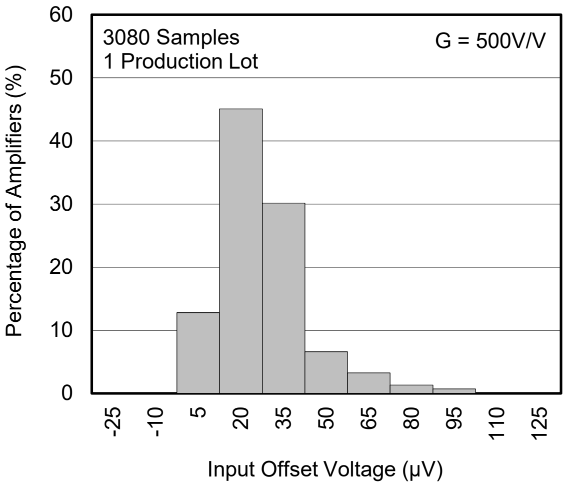
SGM845C Input Offset Production



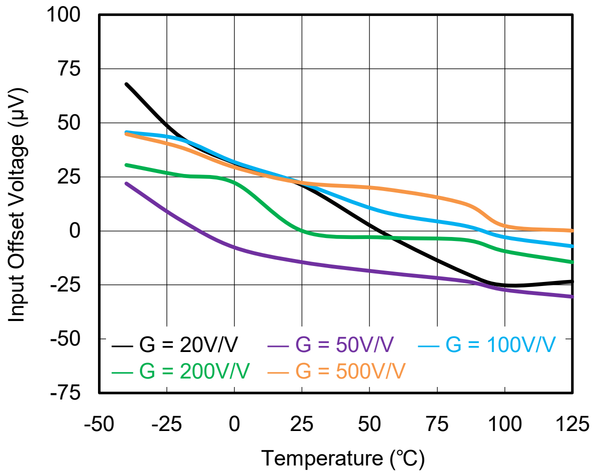
SGM845D Input Offset Production



SGM845E Input Offset Production

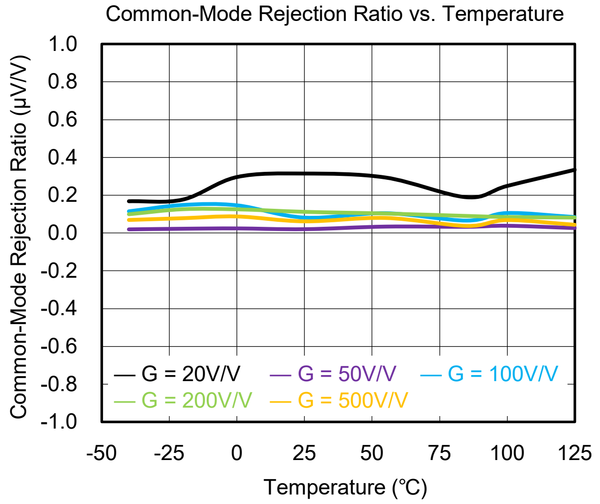


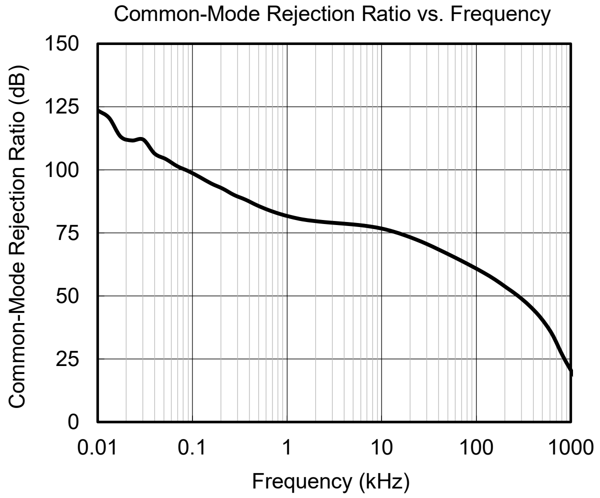
Input Offset Voltage vs. Temperature

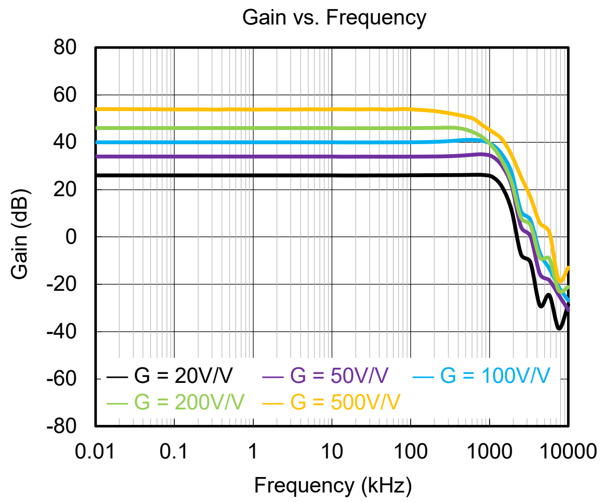


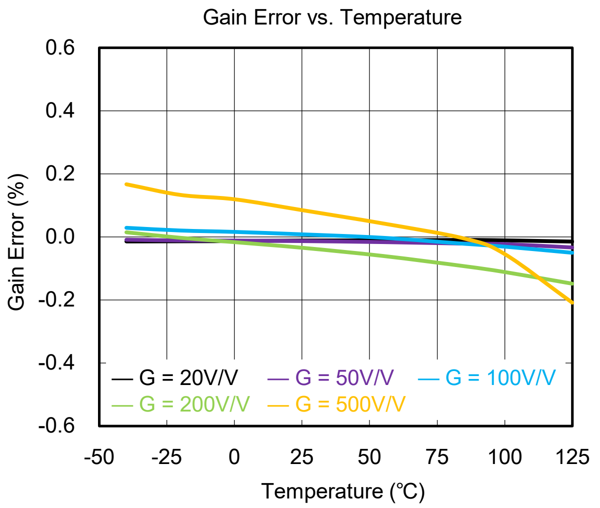
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

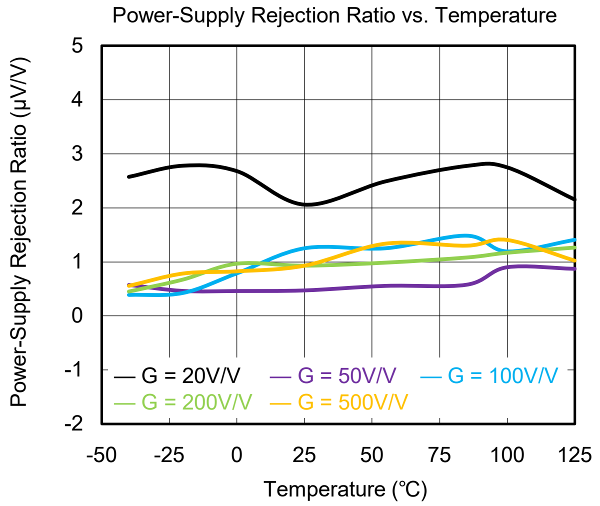
T_A = +25℃, V_S = 5V, V_{SENSE} = V_{IN+} - V_{IN-} = 0.5V/Gain, V_{CM} = V_{IN-} = 48V, and $R_{PULL-UP}$ = 5.1kΩ, unless otherwise noted.

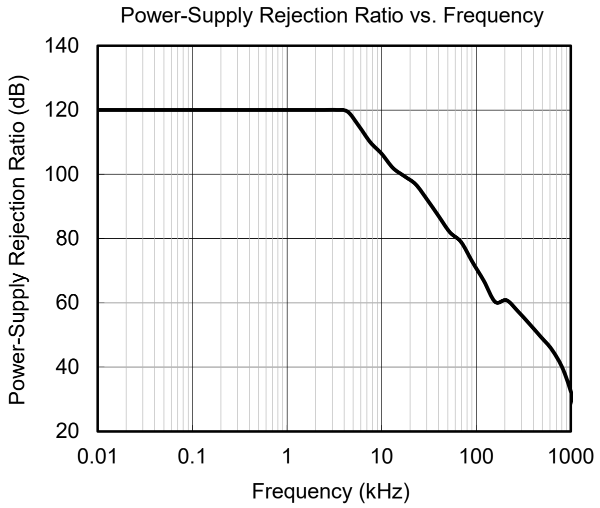






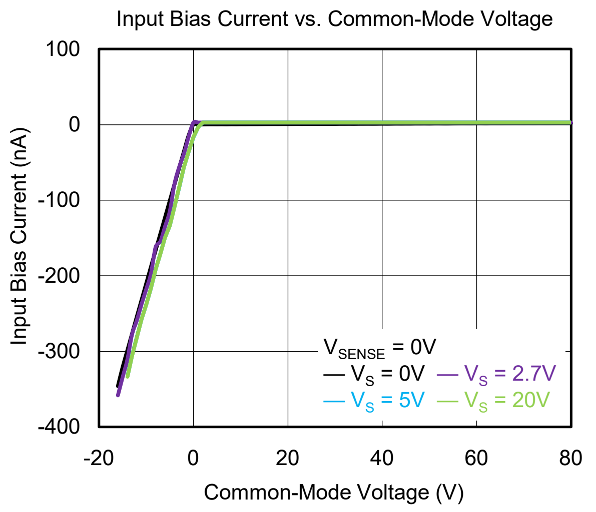


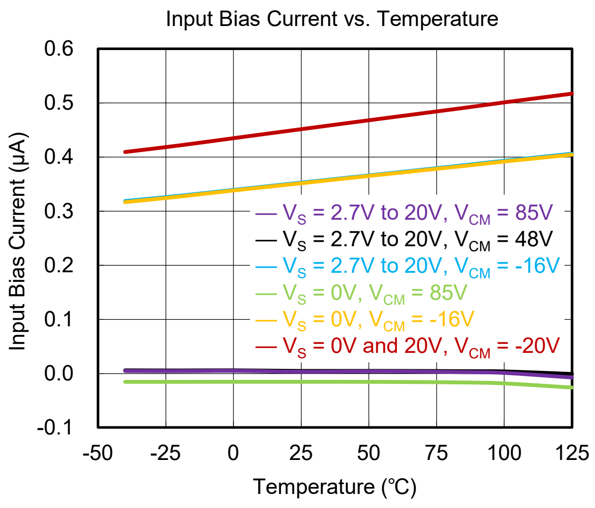


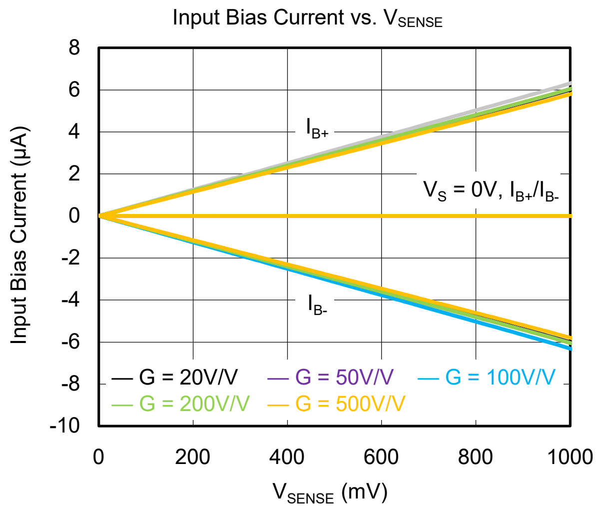


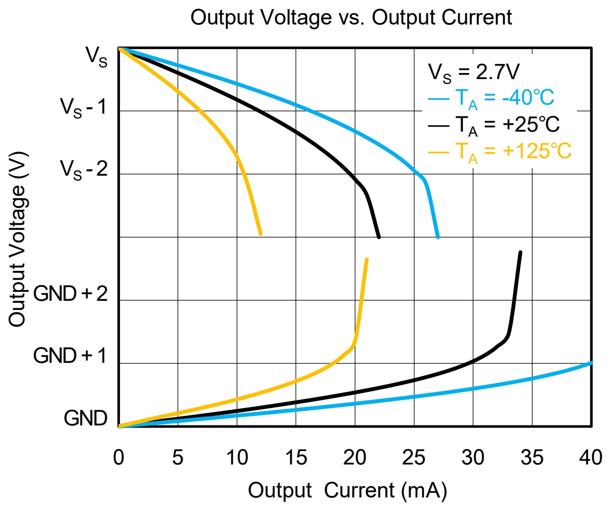
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

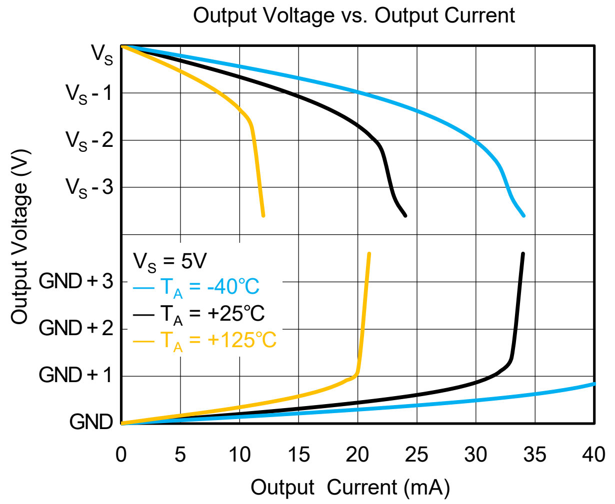
T_A = +25℃, V_S = 5V, V_{SENSE} = V_{IN+} - V_{IN-} = 0.5V/Gain, V_{CM} = V_{IN-} = 48V, and $R_{PULL-UP}$ = 5.1kΩ, unless otherwise noted.

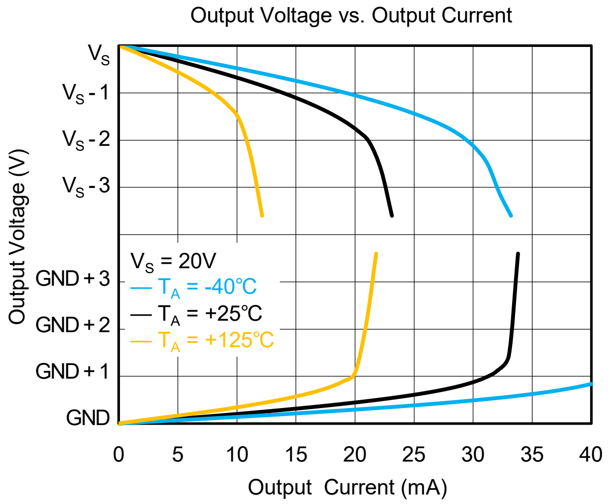








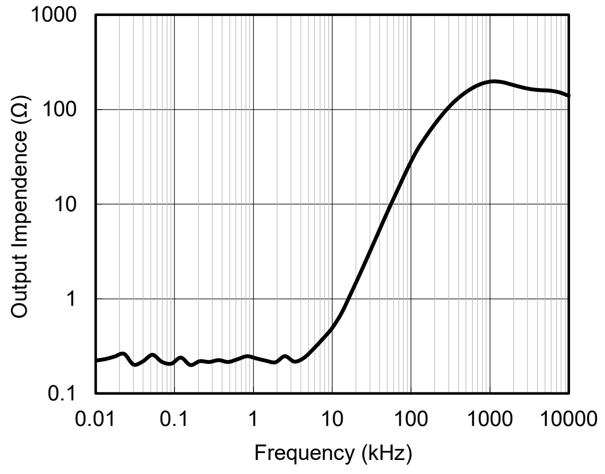




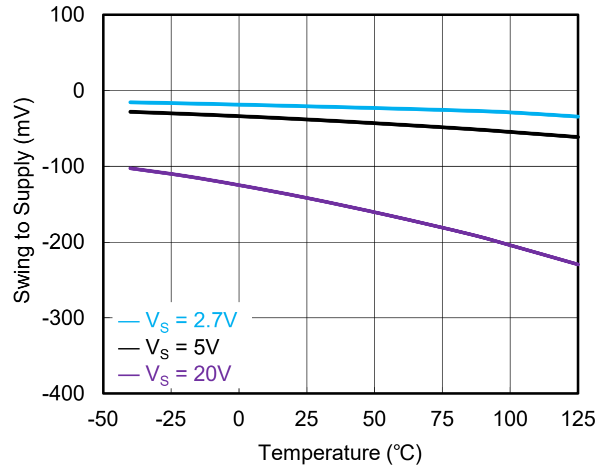
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_A = +25℃, V_S = 5V, V_{SENSE} = V_{IN+} - V_{IN-} = 0.5V/Gain, V_{CM} = V_{IN-} = 48V, and $R_{PULL-UP}$ = 5.1kΩ, unless otherwise noted.

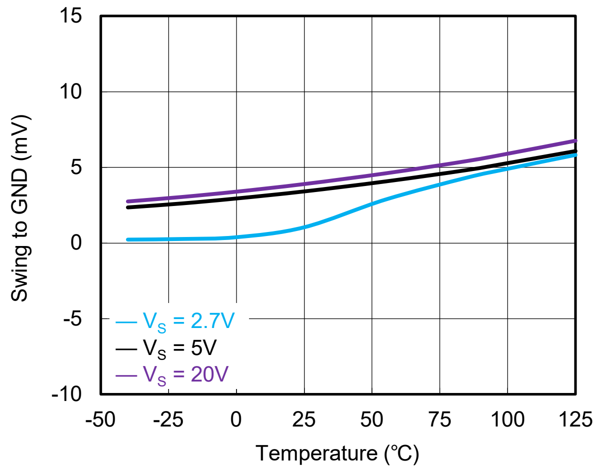
Output Impedance vs. Frequency



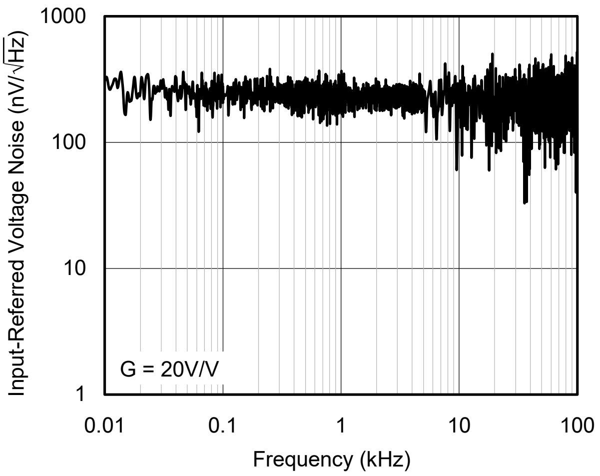
Swing to Supply vs. Temperature



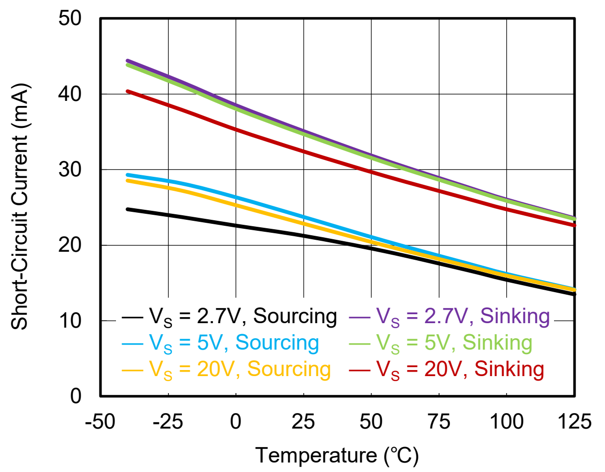
Swing to GND vs. Temperature



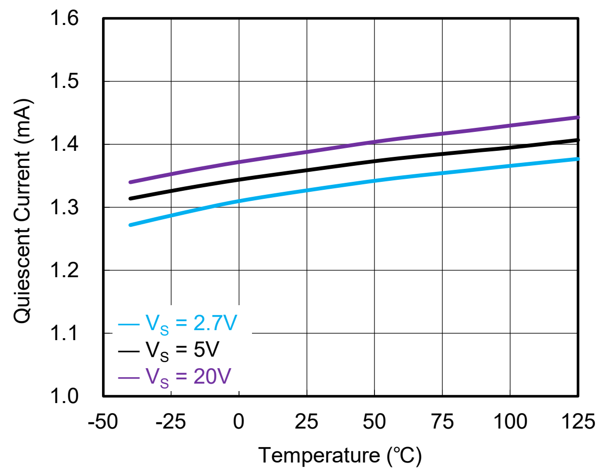
Input-Referred Voltage Noise vs. Frequency



Short-Circuit Current vs. Temperature

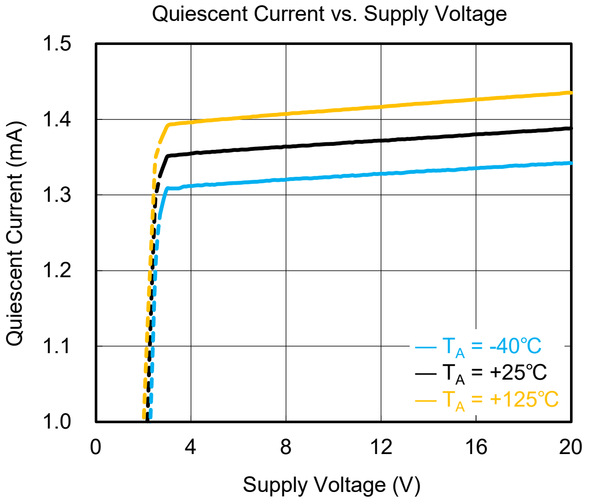


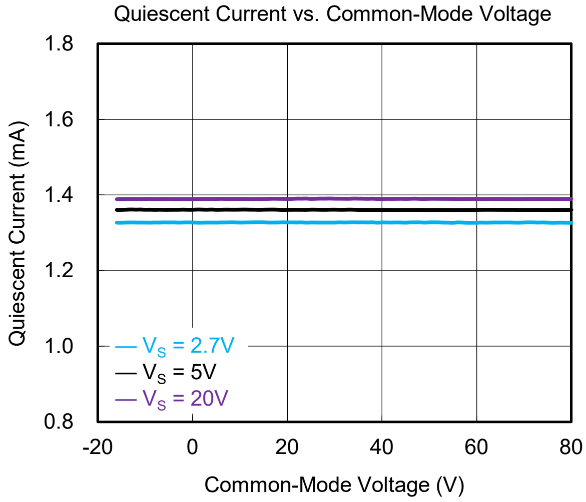
Quiescent Current vs. Temperature

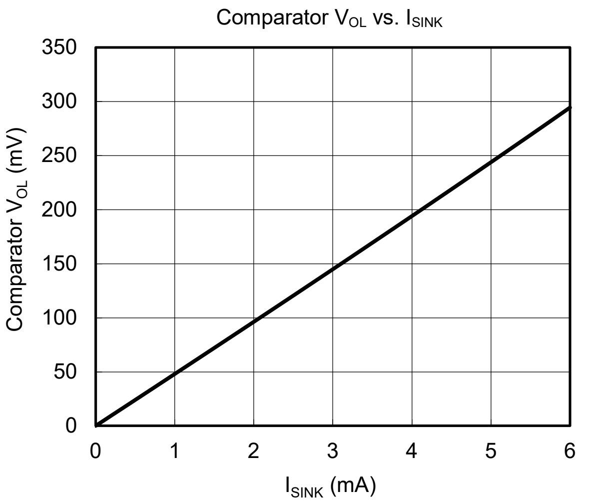


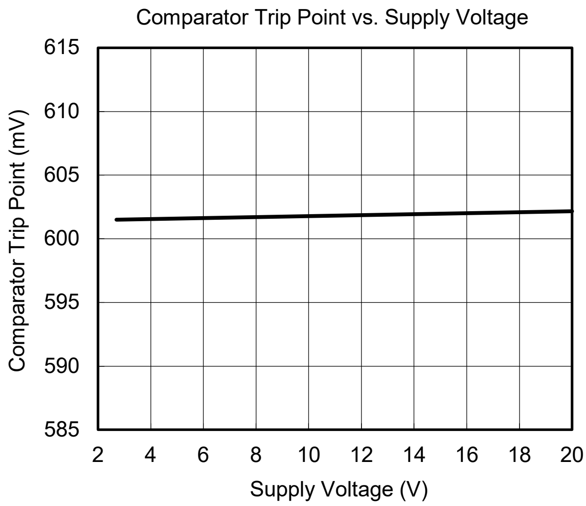
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

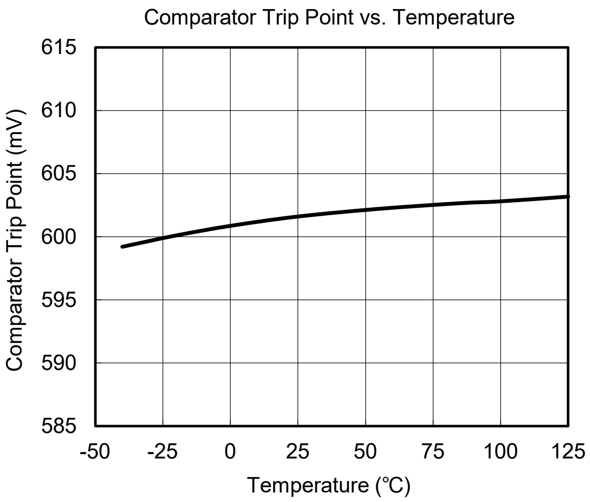
T_A = +25℃, V_S = 5V, V_{SENSE} = V_{IN+} - V_{IN-} = 0.5V/Gain, V_{CM} = V_{IN-} = 48V, and $R_{PULL-UP}$ = 5.1kΩ, unless otherwise noted.

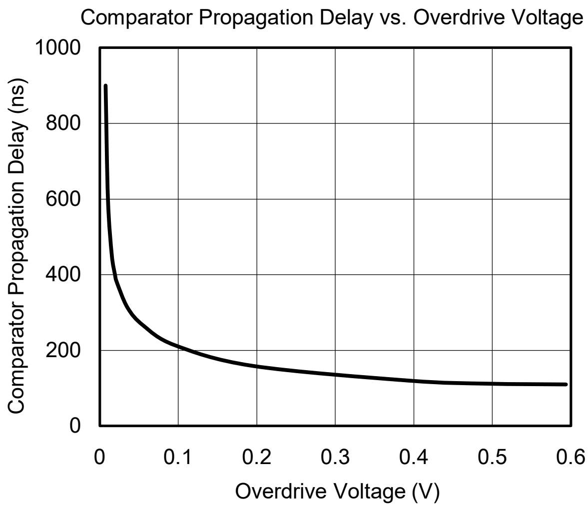








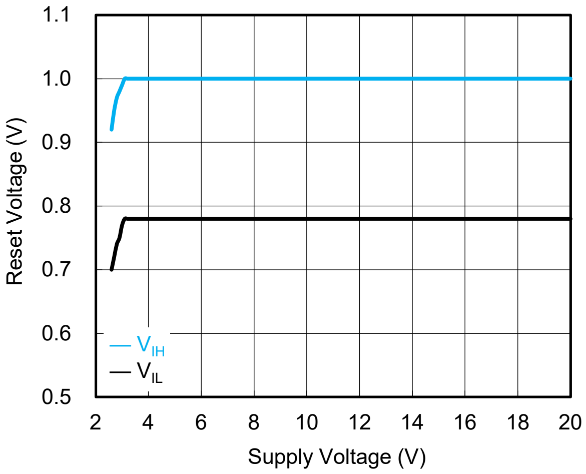




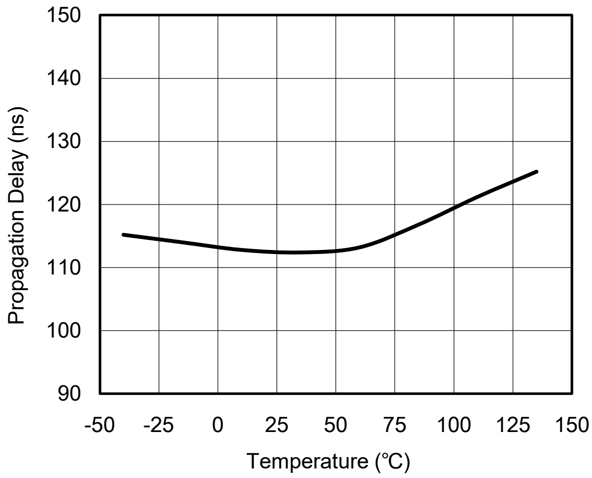
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_A = +25℃, V_S = 5V, V_{SENSE} = V_{IN+} - V_{IN-} = 0.5V/Gain, V_{CM} = V_{IN-} = 48V, and $R_{PULL-UP}$ = 5.1kΩ, unless otherwise noted.

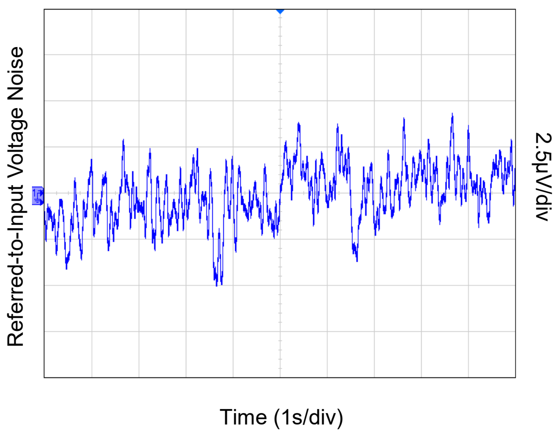
Comparator Reset Voltage vs. Supply Voltage



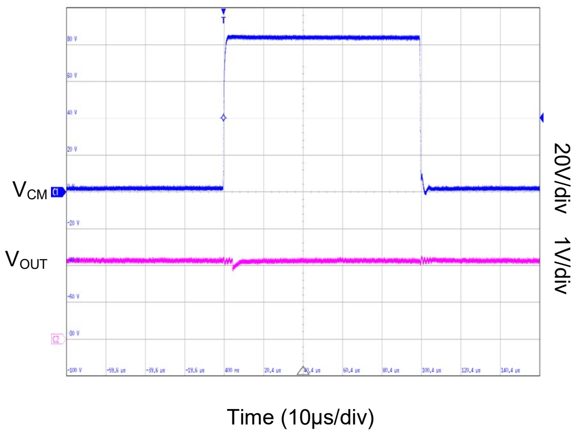
Comparator Propagation Delay vs. Temperature



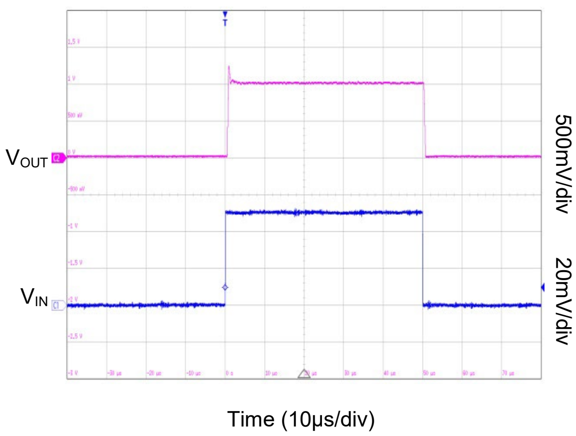
Input Referred Noise



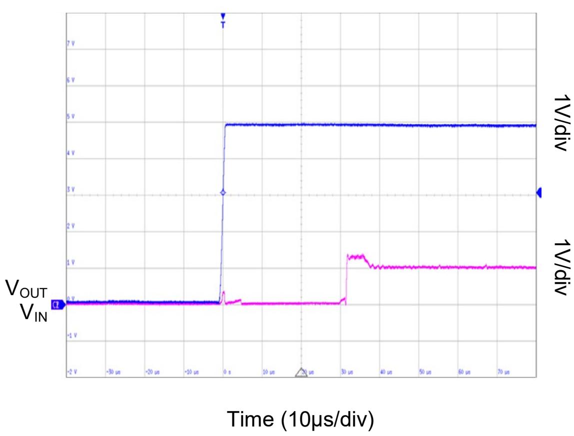
Common-Mode Voltage Fast Transient Pulse



SGM845A Step Response



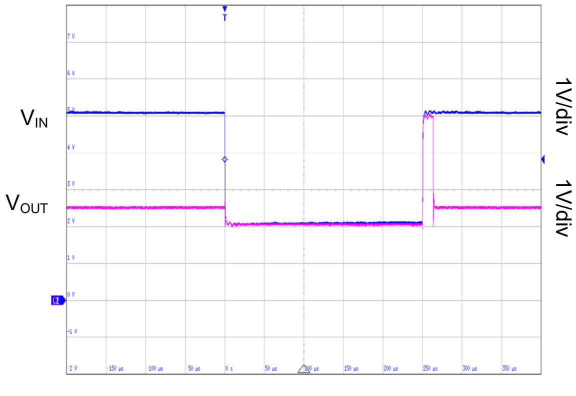
Startup Response



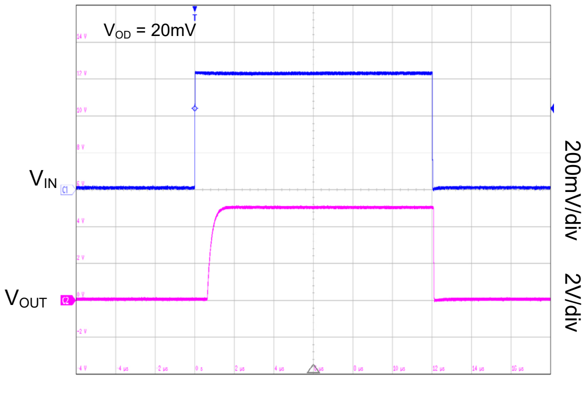
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_A = +25℃, V_S = 5V, V_{SENSE} = V_{IN+} - V_{IN-} = 0.5V/Gain, V_{CM} = V_{IN-} = 48V, and $R_{PULL-UP}$ = 5.1kΩ, unless otherwise noted.

Supply Transient Response



Comparator Propagation Delay



FUNCTIONAL BLOCK DIAGRAM

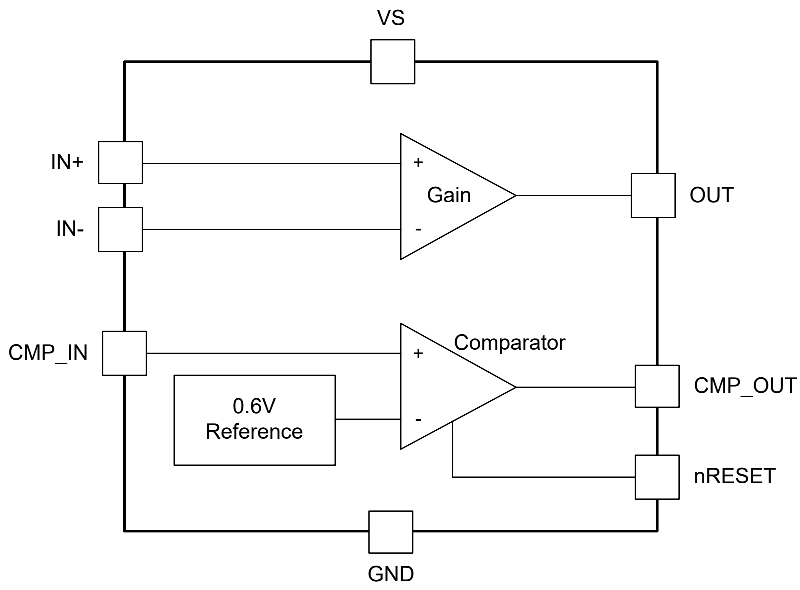


Figure 2. Block Diagram

DETAILED DESCRIPTION

Overview

The SGM845 is a high-speed, high-precision current-sense amplifier designed for demanding applications operating in noisy, high-voltage environments. It combines a wide common-mode range of -16V to 80V with a precision zero-drift topology, delivering exceptional accuracy. Its architecture is specifically engineered for superior PWM rejection, effectively mitigating output disturbances caused by rapid common-mode transients common in motor control and switched-mode power supplies. With a high signal bandwidth of 1.3MHz and a fast slew rate, the SGM845 is ideal for both precise DC current measurement and critical over-current protection events. The device integrates a versatile open-drain comparator with a 0.6V reference, providing a complete solution for current monitoring and fault detection.

Feature Description

High PWM Rejection for Noisy Environments

A key feature of the SGM845 is its excellent rejection of large, high-frequency common-mode voltage swings (dV/dt), often referred to as PWM rejection. In applications such as H-bridge motor drivers or solenoid controls, the common-mode voltage across the shunt resistor can transition rapidly. The SGM845's high bandwidth (1.3MHz) and high slew rate (8V/μs) allow its internal circuitry to settle quickly, preventing these common-mode transients from being rectified and appearing as unwanted disturbances or errors on the output signal. This results in a cleaner, more accurate representation of the actual load current, simplifying system design and improving control loop stability.

High Signal Bandwidth for Fast Response

The SGM845 offers a high signal bandwidth of 1.3MHz, which is crucial for applications requiring rapid detection of current events. This high bandwidth, combined with the integrated fast comparator, enables a very short propagation delay from the input sense resistor to the comparator's output. This makes the SGM845 an excellent choice for implementing fast-acting over-current protection (OCP) circuits, helping to protect power stages and loads from damaging fault conditions. The unique multi-stage design ensures that high bandwidth is maintained across different gain options, providing consistent performance for a wide range of currents.

Wide Common-Mode Range Operation

The SGM845 employs an advanced input stage topology that decouples the input common-mode voltage range from the device's power supply voltage (V_S). This allows the SGM845 to accurately sense currents on rails from -16V to 80V, regardless of whether it is powered by a 3.3V, 5V, or up to a 20V supply. This feature provides immense flexibility, enabling the device to be used in high-side, low-side, or even in-line current sensing configurations that extend well beyond its own supply rails.

Precision Zero-Drift Front-End

At the core of the SGM845 is a zero-drift input architecture, which delivers exceptional precision with a typical offset voltage of just ±100μV and near-zero offset drift over temperature. This high level of accuracy enables the use of smaller shunt resistors to minimize power loss without sacrificing measurement resolution, a critical advantage in power-sensitive applications. The internal gain is set by a highly matched, low-drift resistor network, ensuring a stable and predictable gain error across the entire operating temperature range from -40°C to +125°C.

Low Input Bias Current

A significant advantage of the SGM845's architecture is its low and remarkably stable input bias current across the entire -16V to 80V common-mode range. Unlike traditional topologies where bias current can increase significantly with common-mode voltage, the SGM845 maintains a consistent input characteristic. This behavior minimizes measurement errors that would otherwise be introduced by varying source impedances, ensuring high accuracy even in systems with fluctuating bus voltages. This predictable performance simplifies error budgeting and enhances overall system reliability.

Low V_{SENSE} Operation

The SGM845 excels at accurately measuring very small differential voltages (V_{SENSE}), thanks to its precision zero-drift front-end. The architecture inherently provides ultra-low offset voltage and near-zero drift, enabling the device to resolve microvolt-level signals across its full operating temperature range. This capability is particularly valuable in high-current applications, as it allows designers to specify shunt resistors with very low ohmic values.

DETAILED DESCRIPTION (continued)

Using smaller shunts directly translates to significant reductions in power dissipation (I^2R loss) and thermal stress, leading to a more efficient and reliable system design. The minimum measurable V_{SENSE} is primarily determined by the device's output swing-to-ground capability (V_{SN}) and the selected gain.

Wide Fixed Gain Output

To accommodate a wide variety of current sensing applications, the SGM845 is offered in five fixed-gain options: 20V/V, 50V/V, 100V/V, 200V/V, and 500V/V. Each version is factory-calibrated to achieve an exceptionally low typical gain error of just ±0.03%. Furthermore, the gain is remarkably stable over temperature, with a typical drift of only 10ppm/℃. This high level of precision and thermal stability ensures reliable and repeatable current measurements across the full operating range of -40℃ to +125℃, making the SGM845 an ideal choice for high-performance systems. Designers can select the optimal gain to maximize the signal-to-noise ratio and best utilize the input range of their ADC.

The gain of the SGM845 is set by a precision, low-drift internal resistor network. While the ratio of these internal resistors is excellently matched and stable over temperature to guarantee gain accuracy, their absolute values can have a wider manufacturing tolerance. Therefore, SGMICRO strongly advises against adding external resistors in an attempt to modify the gain, as this would introduce significant and unpredictable errors. The device should be used with its intended fixed gain.

Wide Supply Range

The SGM845 operates over a wide supply voltage range from 2.7V to 20V, making it compatible with a variety of standard logic and analog rails. A key architectural benefit is that the device's input common-mode voltage capability is completely independent of its supply voltage. However, the output voltage swing is inherently limited by the supply rails. The output can swing to within a few millivolts of ground (see V_{SN} in the Electrical Characteristics table) and typically up to 200mV below the positive supply rail (V_S), providing a wide dynamic range for the amplified current sense signal.

Integrated Comparator

The SGM845 incorporates a flexible open-drain comparator, which features a precise, internal 0.6V voltage reference for threshold detection. The comparator's input, CMP_IN, is designed to accommodate signals from 0V up to 5.5V or V_S, whichever is lower. To ensure stable and reliable switching in noisy industrial environments, a built-in 8mV (TYP) hysteresis is included. This feature prevents output chattering when the input signal is around the trip point, as illustrated in Figure 3. The comparator's open-drain output offers significant system design flexibility, as it can be pulled up to any voltage rail from 0V to 20V via an external resistor, independent of the SGM845's own supply voltage.

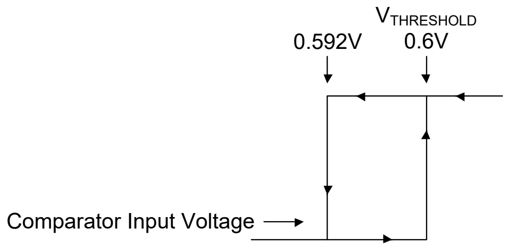


Figure 3. The Comparator Threshold and Hysteresis

nRESET Function

The nRESET pin provides powerful control over the comparator's operational mode, allowing designers to select between transparent and latching behavior to best suit their application's logic, as shown in Figure 4. Specifically, when the nRESET pin is held low or left floating, the comparator functions are in a transparent mode, with its output dynamically following the input signal relative to the 0.6V threshold. For applications requiring event capture, pulling the nRESET pin high activates the latching mode. Once triggered by an input exceeding the threshold, the comparator's output latches high and remains in that state irrespective of subsequent input changes. This mode is particularly useful for capturing transient fault events without requiring continuous monitoring by a microcontroller. Releasing the latch is simple: the nRESET pin must be returned to a low or floating state to restore transparent operation.

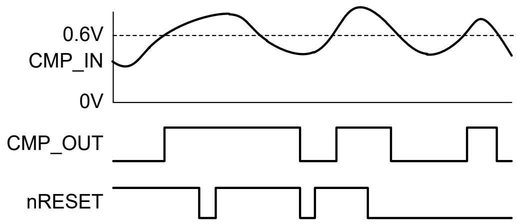


Figure 4. The Comparator nRESET Function

DETAILED DESCRIPTION (continued)

Short Propagation Delay

The SGM845 is engineered for speed. The synergistic combination of its high-speed current sense amplifier and the fast internal comparator results in a remarkably short total propagation delay of just 1μs. This delay is measured from the moment the differential sense voltage across the shunt resistor exceeds the configured over-current threshold, to the point where the comparator's output flags the event. The signal path — from sense resistor, through the amplifier, the external V_{OUT} divider network, and finally the comparator — is optimized for minimal latency. This rapid, end-to-end response makes the SGM845 exceptionally well-suited for implementing robust and fast-acting OCP in systems where component protection is paramount.

Comparator Input Bias Current

The comparator input of the SGM845 employs a high-impedance design, ensuring that the comparator's input bias current (I_{BCMP_IN}) remains at the nA level across the entire input voltage (V_{CMP_IN}) range. As depicted in Figure 5, this results in a linear relationship between the bias current and the input voltage. Critically, for input voltages near the 0.6V comparator threshold, the bias current remains about 18nA at room temperature. This characteristic ensures that the bias current does not significantly compromise the accuracy of the alert threshold (V_{TH}). To further optimize V_{TH} precision, it is advisable to avoid high-value resistors for the external voltage divider. As a guideline, the total resistance of this network (shown in the Figure 6) should be kept under 100kΩ.

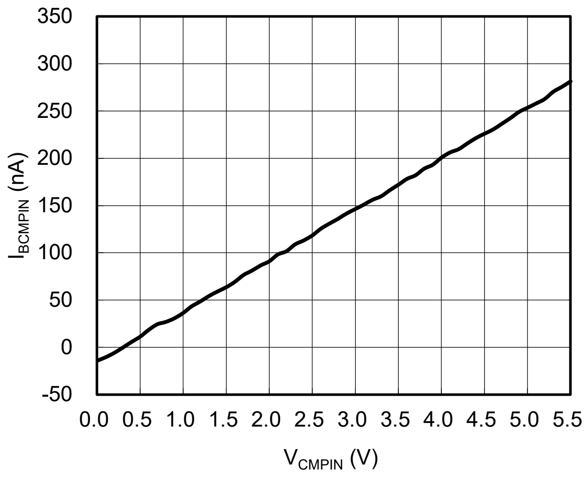


Figure 5. Comparator I_{BCMP_IN} vs. V_{CMP_IN}

Device Functional Modes

Basic Connections

A fundamental circuit configuration for the SGM845 is illustrated in Figure 6. The device is versatile enough to be configured for unidirectional current sensing in either high-side or low-side arrangements. For optimal accuracy, the input pins (IN+ and IN-) should be connected to the shunt resistor using Kelvin (4-wire) connections. This technique minimizes the impact of any parasitic resistance in series with the shunt element.

Stable operation requires a power-supply bypass capacitor. In systems with noisy or high-impedance power sources, additional decoupling may be necessary to filter out supply-line noise. Bypass capacitors should be placed in close proximity to the device's VS and GND pins. A value of 0.01μF is typically recommended.

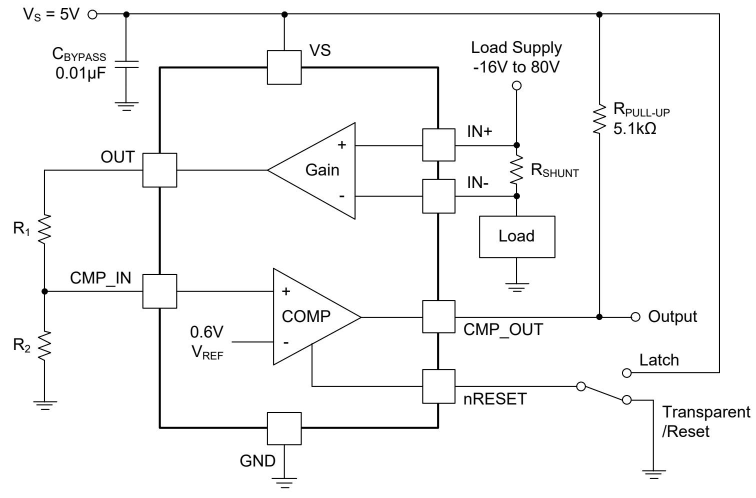


Figure 6. Basic Connections

DETAILED DESCRIPTION (continued)

Over-Current Threshold Connection

As shown in Figure 6, the SGM845's internal comparator can be configured to generate an over-current alert. The trip point is determined by comparing a divided-down version of the amplifier's output voltage (V_{OUT}) against the internal 0.6V reference. The external resistors, R_1 and R_2, form this voltage divider. Equation 1 defines the mathematical relationship between the over-current threshold and the values of the gain, R_{SHUNT}, R_1 and R_2.

$$I_{SENSE\_ALERT\_THRESHOLD} = \frac{0.6 \times (R_1 + R_2)}{R_2 \times G \times R_{SHUNT}} \quad (1)$$

Since R_1 and R_2 present a load to the OUT pin, SGMICRO suggests their sum be greater than 10kΩ to preserve the output swing range and reduce overall supply current. However, as noted in the Comparator Input Bias Current section, excessively high resistor values can affect the threshold accuracy (V_{TH}). The Application Information section provides examples for selecting appropriate resistor values.

High-side Switch Over-Current Shutdown

The SGM845 measures the differential voltage produced by current flowing through a shunt resistor. Figure 7 presents an application circuit where the SGM845 is used to control a high-side switch during an over-current event. When the monitored current surpasses the user-defined threshold, the comparator's output (CMP_OUT) goes high. This signal, in turn, drives an external transistor (Q_1) to turn off the main high-side switch. The transistor Q_1 serves to isolate the low-voltage CMP_OUT pin from the high-voltage supply rail.

For unidirectional current measurement, the shunt resistor can be placed in several locations. Options 1 and 2 represent high-side sensing, while option 3 is low-side sensing. Although both are high-side methods, option 1 measures the total current including that drawn by Q_1, whereas option 2 does not. High-side sensing offers the advantages of being immune to ground disturbances and capable of detecting load shorts. It requires a current sense amplifier with high CMRR and a wide common-mode range, as the inputs are near the supply potential. Low-side sensing does not necessitate a high-voltage amplifier but can introduce ground noise and is unable to detect direct shorts to ground at the load.

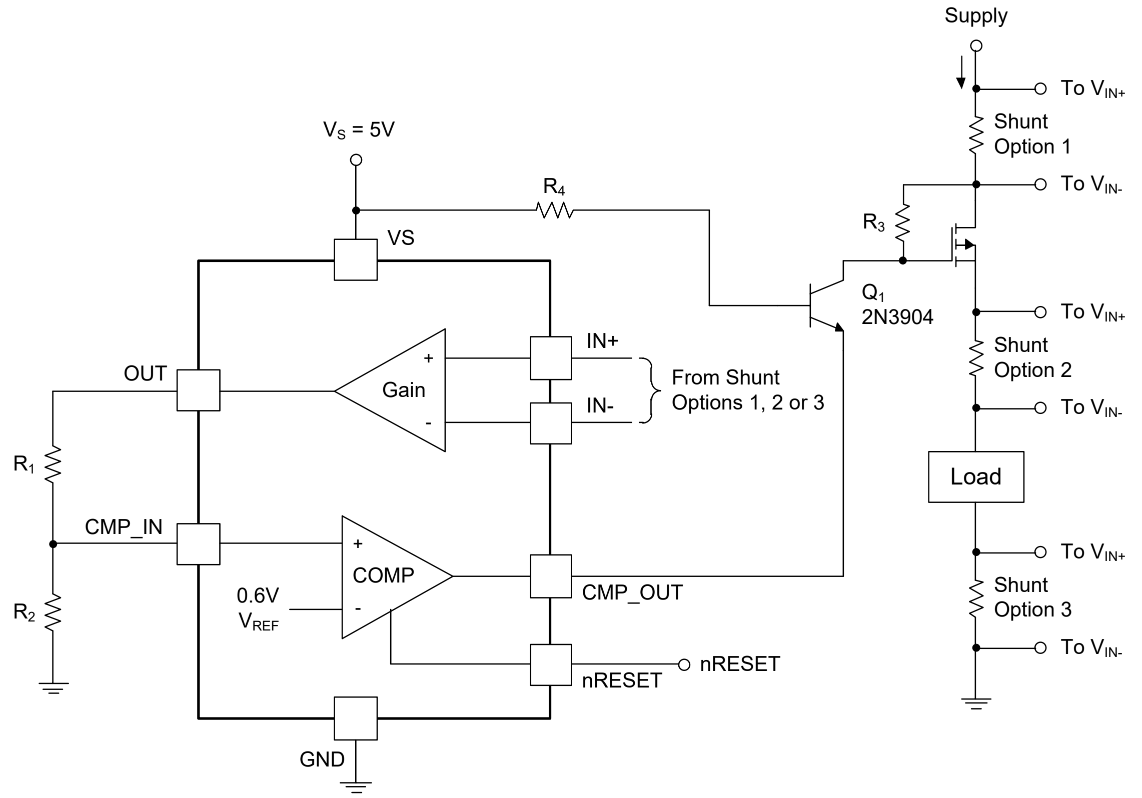


Figure 7. High-side Switch for Over-Current Shutdown

DETAILED DESCRIPTION (continued)

Bidirectional Over-current Comparator

While the SGM845 is designed for unidirectional operation, two devices can be configured to monitor bidirectional currents, as shown in Figure 8. In this arrangement, each SGM845 is responsible for one direction of current flow, as the polarity of the differential voltage across the shunt resistor will be opposite for each. Together, they provide a comprehensive bidirectional over-current monitoring solution.

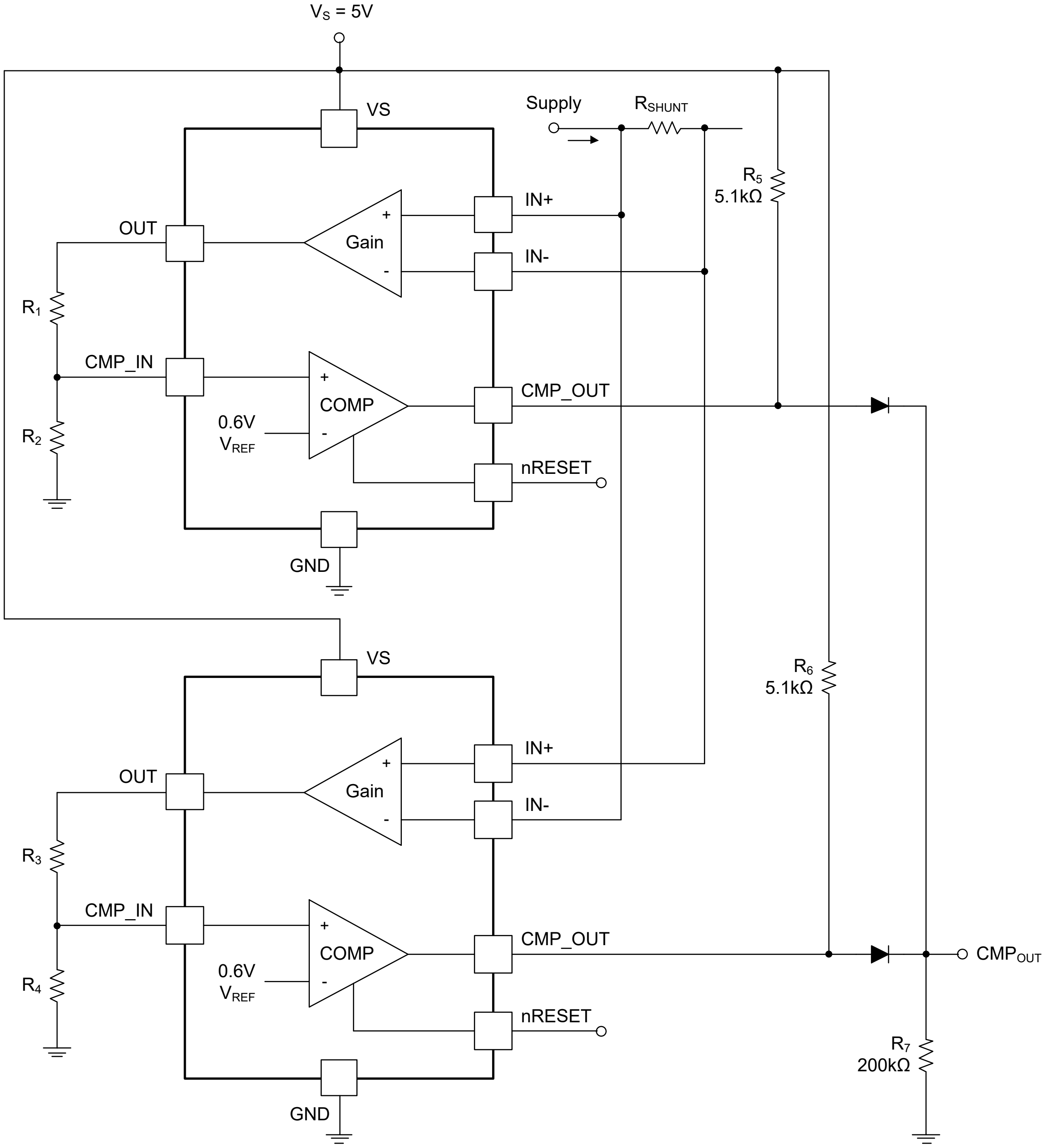


Figure 8. Ground Referenced Output

APPLICATION INFORMATION

The primary function of the SGM845 is to amplify the small differential voltage generated across a current-shunt resistor (R_{SENSE}) as current is delivered to a load. Due to its wide input common-mode voltage range and high common-mode rejection ratio (CMRR), the SGM845 can be deployed across a diverse array of voltage rails while consistently delivering accurate current measurements.

R_{SENSE} and Device Gain Selection

Selecting the appropriate sense resistor (R_{SENSE}) and amplifier gain is critical for optimizing the performance of any current sensing system. For maximum accuracy, it is generally advisable to choose the largest possible R_{SENSE} value. A larger resistance produces a stronger differential input signal for a given current, which effectively minimizes the relative error contribution from the amplifier's input offset voltage.

However, the selection of R_{SENSE} is constrained by practical considerations, including the resistor's physical size, its packaging, and most importantly, its power dissipation limit. The maximum allowable value for the sense resistor, based on a power dissipation budget, can be calculated using Equation 2.

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

where:

PD_{MAX} represents the maximum permissible power dissipation in the R_{SENSE} component.

I_{MAX} is the peak current expected to flow through R_{SENSE}.

Maximize the accuracy of a current sense amplifier, SGMICRO recommends to choose the largest current sense resistor value possible in an application. A larger value sense resistor maximizes the differential input signal for a given amount of current flow and reduces the error contribution of the offset voltage. However, there are practical limits as to how large the current-sense resistor value can be in a given application because of the physical dimensions of the resistor, package construction and maximum power dissipation. Equation 2 gives the maximum value for the current-sense resistor for a given power dissipation budget. Further constraints on the choice of R_{SENSE} and gain (G) are imposed by the amplifier's power supply voltage (V_S) and its output swing-to-rail limitations. The amplified signal must fit within the output dynamic range. Equation 3 establishes the condition to prevent the output from clipping at the positive supply rail:

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

where:

I_{MAX} is the maximum current through R_{SENSE}.

G is the selected gain of the amplifier.

V_{SP} is the positive output swing limit, as specified in the Electrical Characteristics table.

When designing, a trade-off between the R_{SENSE} value and the amplifier gain must be managed to avoid positive output saturation. If an R_{SENSE} value chosen for optimal power dissipation results in a calculated output voltage that exceeds V_{SP}, a lower-gain version of the SGM845 should be selected.

Similarly, the negative output swing limitation dictates the minimum practical value for the sense resistor in a given application. To ensure the output signal is not clipped near ground, the condition in Equation 4 must be met:

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

where:

I_{MIN} is the minimum current that will flow through R_{SENSE}.

G is the gain of the current-sense amplifier.

V_{SN} is the negative output swing of the device.

Table 1 provides a practical example, illustrating the outcomes of using the five different gain variants of the SGM845. The data highlights that higher-gain options enable the use of smaller shunt resistors, which in turn reduces the overall power dissipated in the sensing element. Note that the design example presented assumes a full-scale current of 10A, with the system configured for a maximum output voltage of 5V.

Table 1. R_{SENSE} Selection and Power Dissipation

Parameter		Equation	Results at V_S = 5 V				
			SGM845A	SGM845B	SGM845C	SGM845D	SGM845E
G	Gain		20V/V	50V/V	100V/V	200V/V	500V/V
V_{DIFF}	Ideal differential input voltage	$V_{DIFF} = V_{OUT}/G$	250mV	100mV	50mV	25mV	10mV
R_{SENSE}	Current sense resistor value	$R_{SENSE} = V_{DIFF}/I_{MAX}$	25mΩ	10mΩ	5mΩ	2.5mΩ	1mΩ
P_{SENSE}	Current-sense resistor power dissipation	$R_{SENSE} \times I_{MAX}^2$	2.5W	1W	0.5W	0.25W	0.1W

APPLICATION INFORMATION (continued)

Typical Application

The SGM845 is engineered as a unidirectional current sense amplifier. Its primary function is to accurately measure current flowing through a shunt resistor across a wide common-mode voltage range, from -16V up to 80V, making it suitable for a diverse set of applications.

Current Sensing in a Solenoid Application

Design Requirements

For this specific application example, the system operates with a common-mode voltage that varies between 0V and 24V. The SGM845 is powered by a 5V supply. The design objective is to monitor a maximum sense current of 1.5A, while triggering an alert if the current surpasses a threshold of 1.9A.

Adhering to the principles outlined in the R_{SENSE} and Device Gain Selection section, a shunt resistor (R_{SENSE}) of 50mΩ and an amplifier gain of 50V/V are chosen. This combination provides an optimal output dynamic range for the specified current levels. The complete design parameters for this application are summarized in Table 2.

Table 2. Design Parameters

Design Parameters	Example Value
Power Supply Voltage	5V
Common-Mode Voltage Range	0V to 24V
Maximum Sense Current	1.5A
R_{SENSE} Resistor	50mΩ
Gain Option	50V/V
Over-Current Threshold	1.9A
R_1	69.15kΩ
R_2	10kΩ

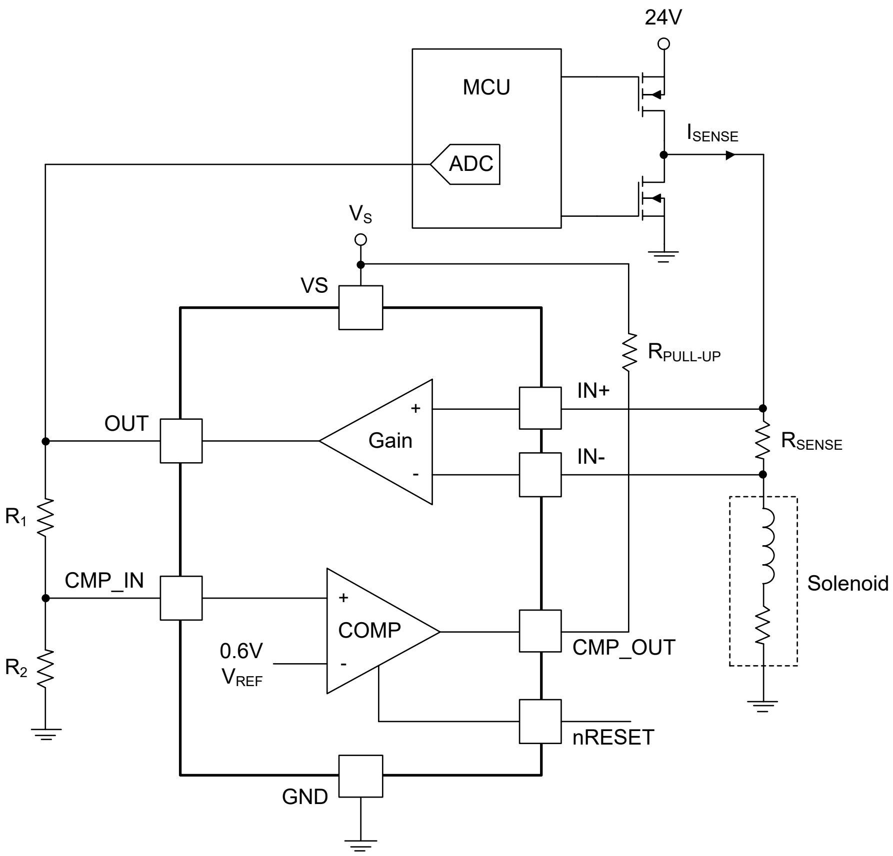


Figure 9. Current Sensing in a Solenoid Application

APPLICATION INFORMATION (continued)

Detailed Design Procedure

In a typical solenoid drive application, the SGM845 is employed to monitor the load current. This is achieved by measuring the voltage drop across a 50mΩ shunt resistor, which is strategically placed at the half-bridge output. The SGM845 senses the differential voltage across this shunt and applies an internal gain of 50V/V. The resulting amplified analog signal at the OUT pin is then fed into an analog-to-digital converter (ADC), typically within a microcontroller (MCU), for digital processing and monitoring. For the over-current detection circuit, the resistor R_2 is set to a fixed value of 10kΩ. This value is chosen to minimize the loading effect on the amplifier's output (OUT), as recommended in the Basic Connections section. Subsequently, using Equation 1, the value for R_1 is calculated to be 69.15kΩ.

$$1.9\text{A} = \frac{0.6\text{V} \times \left(\text{R}_1 + 10\text{k}\Omega\right)}{10\text{k}\Omega \times 50 \times 50\text{m}\Omega}$$

Together, the R_1 (69.15kΩ) and R_2 (10kΩ) resistors form a voltage divider that scales the output signal before it is fed to the internal comparator. This divider network effectively establishes the over-current alert threshold at 1.9A.

Solenoid loads, being highly inductive in nature, are susceptible to various failure modes. They are commonly found in systems requiring precise control, such as positioners, fluid regulators, and valves. Continuous, real-time current monitoring can provide early indications of a deteriorating solenoid, preventing failures that could compromise the entire control loop. Furthermore, high-side current sensing with the SGM845 can detect potentially damaging ground faults in the solenoid or the driving FETs. The SGM845's high bandwidth and fast slew rate are key attributes that enable the rapid detection of such over-current events, thereby protecting the solenoid from short-to-ground fault damage.

It is important to note that the SGM845 is a unidirectional amplifier, designed for operation with a positive differential input voltage (V_{SENSE}). Applying a negative V_{SENSE} will drive the device into an overload or saturated state. The amplifier will require a specific recovery time to return to linear operation once V_{SENSE} becomes positive again. The duration of this overload recovery time is proportional to the magnitude and duration of the negative V_{SENSE} applied.

Low-Side Switch Over-current Shutdown

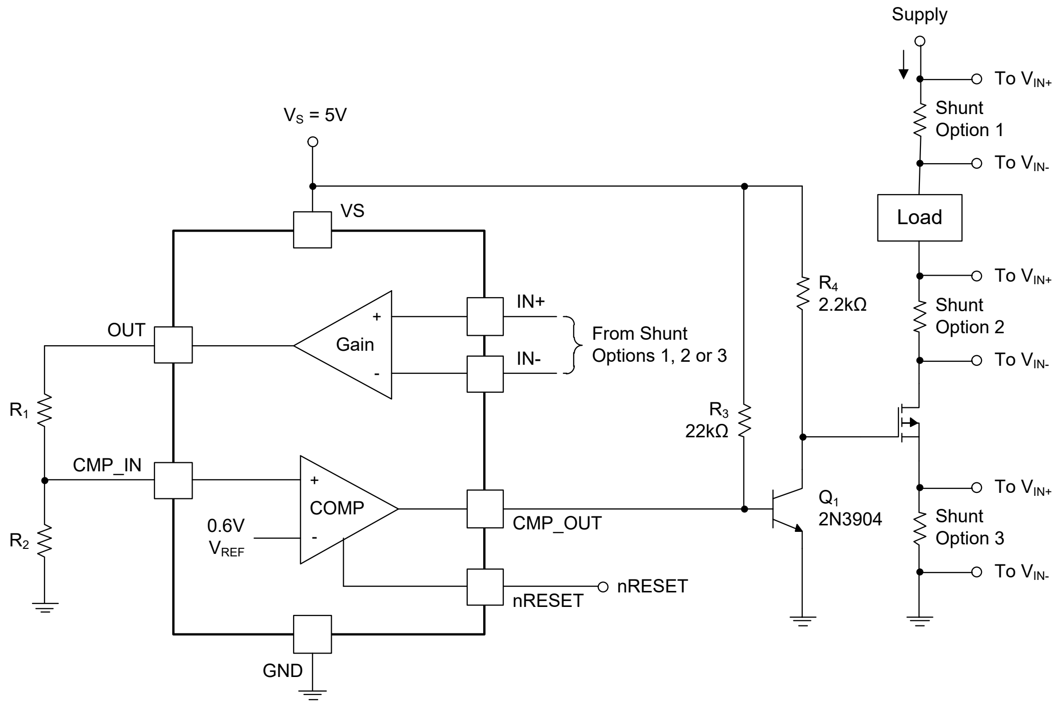


Figure 10. Low-side Switch Over-Current Shutdown

APPLICATION INFORMATION (continued)

Design Requirements

This application demonstrates how the SGM845 can be used for over-current protection. The device monitors a unidirectional current flowing through a shunt resistor. An over-current event is detected when the resulting differential input voltage surpasses a predefined threshold. Upon reaching the trip point set by the R_1/R_2 divider, the comparator's output (CMP_OUT) transitions to a high state. This signal then activates an external transistor (Q_1), which in turn pulls the gate of the main pass-FET low, effectively interrupting the current flow.

For this particular design example, the common-mode voltage is fixed at 5V, and the SGM845 is also powered by a 5V supply. The system is designed to handle a maximum sense current of 1A and must trigger a shutdown if the current exceeds 1.2A.

Following the selection methodology outlined in the R_{SENSE} and Device Gain Selection section, a shunt resistor (R_{SHUNT}) of 100mΩ is paired with the 20V/V gain version of the SGM845. This combination ensures an adequate output dynamic range for the application. All relevant design parameters are consolidated in Table 3.

Table 3. Design Parameters

Design Parameters	Example Value
Power Supply Voltage	5V
Common-Mode Voltage Range	5V
Maximum Sense Current	1A
R_{SENSE} Resistor	100mΩ
Gain Option	20V/V
Over-Current Threshold	1.2A
R_1	10.2kΩ
R_2	3.4kΩ

Detailed Design Procedure

Figure 10 illustrates the fundamental connections for this SGM845 application. It is crucial that the input terminals (IN+ and IN-) are connected to the current sense resistor with minimal trace length to avoid introducing parasitic series resistance. In this circuit, the SGM845 monitors the current across a 100mΩ shunt placed in series with the load. The device measures the differential voltage developed across this shunt and applies a fixed internal gain of 20V/V to the signal.

To establish the over-current threshold, R_1 is set to a fixed value of 10.2kΩ, a choice made to prevent significant loading of the OUT pin as suggested in the Basic Connections guidelines. Using Equation 1, the corresponding value for R_2 is then calculated to be 3.4kΩ. This resistive divider, formed by R_1 (10.2kΩ) and R_2 (3.4kΩ), scales the amplifier's output voltage down to create the input for the comparator, thereby setting the over-current alert threshold to 1.2A.

Power Supply Recommendations

The SGM845 is capable of making accurate measurements on voltage rails that extend far beyond V_S. This is possible because its inputs (IN+ and IN-) can operate over a wide common-mode range, from -16V to 80V, independent of the V_S potential. As a practical example, even when the SGM845 is powered by a 5V supply, it can accurately monitor current on a shunt with a common-mode voltage as high as 80V.

Power Supply Decoupling

For stable operation, a bypass capacitor should be placed as close as possible to VS and GND pins. SGMICRO recommends a bypass capacitor of at least 0.1μF. For systems with particularly noisy or high-impedance power supplies, additional or larger decoupling capacitors may be beneficial.

LAYOUT

Layout Guidelines

Attention to good layout practices is always recommended.

The input pins should be connected to the sense resistor pads using a Kelvin (4-wire) connection. This technique ensures that the measurement is sensitive only to the voltage drop across the current-sensing element itself, excluding any voltage drops across the high-current traces. Improper routing can easily introduce parasitic trace resistance between the input pins, which, given the low resistance of the shunt, can lead to significant measurement inaccuracies.

As mentioned previously, the power-supply bypass capacitor (typically 0.1μF) must be positioned in immediate proximity to the VS and GND pins of the device. This placement minimizes the inductance of the connection loop, ensuring effective filtering of high-frequency noise from the power supply.

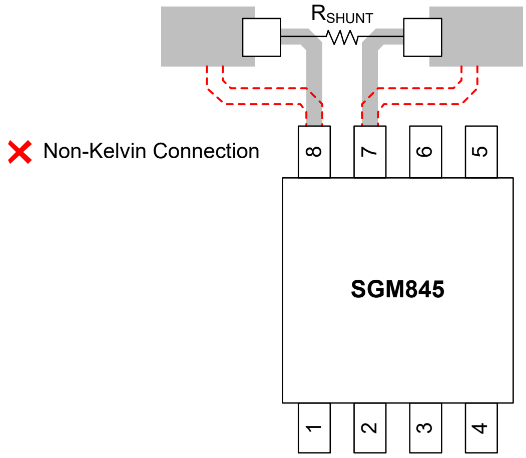


Figure 11. Shunt Connections to the SGM845

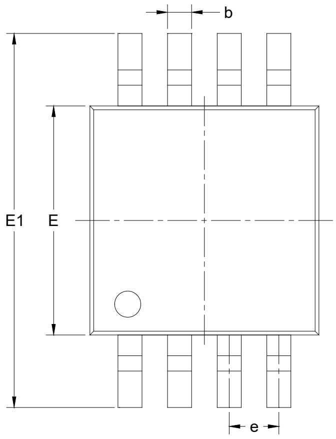
REVISION HISTORY

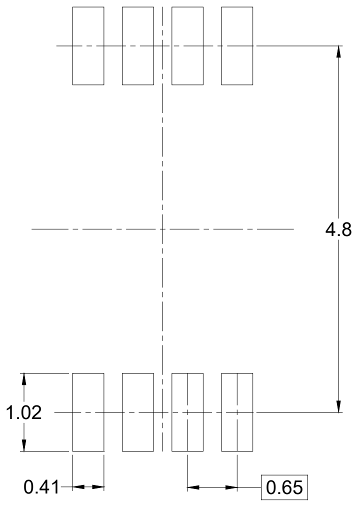
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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

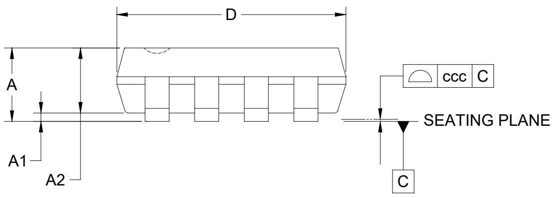
PACKAGE OUTLINE DIMENSIONS

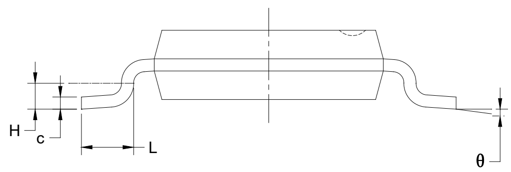
MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)



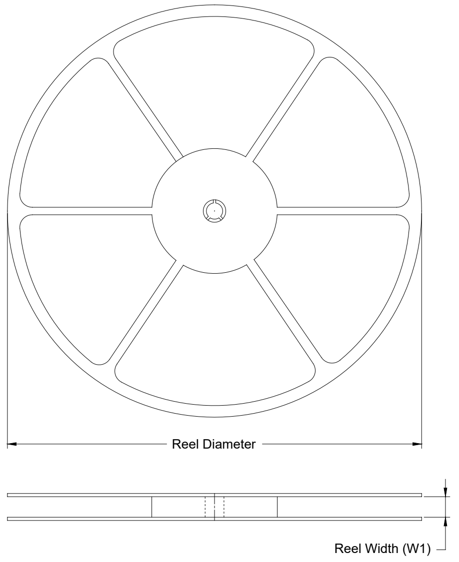


Symbol	Dimensions In Millimeters		
	MIN	**NOM**	**MAX**
A	-	-	1.100
A1	0.000	-	0.150
A2	0.750	-	0.950
b	0.220	-	0.380
c	0.080	-	0.230
D	2.800	-	3.200
E	2.800	-	3.200
E1	4.650	-	5.150
e	0.650 BSC		
L	0.400	-	0.800
H	0.250 TYP		
θ	0°	-	8°
ccc	0.100		

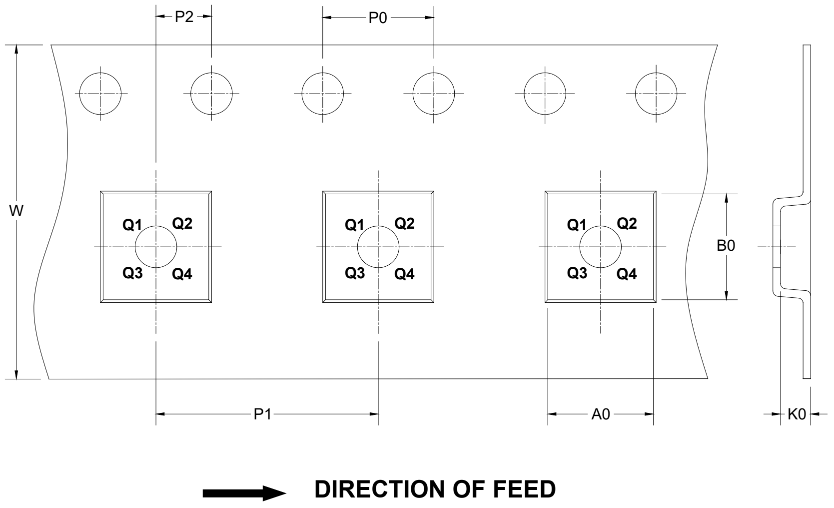
NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MO-187.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



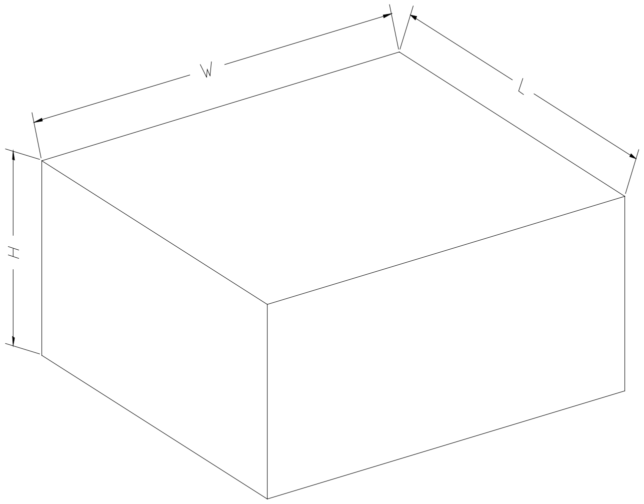
NOTE: The picture is only for reference. Please make the object as the standard.

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
MSOP-8	13"	12.4	5.30	3.20	1.50	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