# SGM90810

# 12-Bit, 8-Channel, Digital System Monitor with Temperature Sensor, Internal/External Reference, and I²C Interface

## GENERAL DESCRIPTION

The SGM90810 is an 8-channel system monitor especially designed for monitoring complicated system status. The power supply voltage range is from 3V to 5.5V. By configuring the internal registers, the signal input mode can be single-ended or pseudo-differential. The SGM90810 is equipped with a temperature sensor inside, built-in digital comparators and an interrupt output pin, which provides flexibility to monitor each channel and generate alarm signals when the input exceeds the thresholds. The SGM90810 also integrates an internal reference, which makes this device a complete single chip solution for system monitor.

The SGM90810 system monitor has a true 12-bit sigma-delta ADC internally with I²C interfaces. The interface supports the Standard Mode (100kbps) and the Fast Mode (400kbps). The analog filters on the I²C bus provide excellent noise resistance performance. The SDA and SCL of I²C have a timeout reset function to prevent I²C bus locking. The SGM90810 provides a flexible sequencer for controlling channel conversions. The data conversion results of each channel is stored in independent registers. And each channel can be independently shut down to save power.

The SGM90810 is available in a Green TSSOP-16 package. It operates over the operating temperature range of -40℃ to +125℃.

## FEATURES

- True 12-Bit Sigma-Delta ADC Core
- Power Supply Range: 3V to 5.5V
- Total Unadjusted Error: ±0.16%
- ±1 LSB INL and ±1 LSB DNL
- Operating Current: 0.25mA
- Deep Shutdown Current: 15μA
- Temperature Resolution: 0.5℃/LSB
- Temperature Accuracy:
  - -40℃ to +125℃: ±2℃ (MAX)
- Configurable Single-Ended and/or Pseudo-Diff. Inputs
- Selectable Internal 2.56V $V_{REF}$ or External $V_{REF}$
- Digital Comparators for Each Channel
- Interrupt Pin nINT for Generating Alarm Signal
- I²C Serial Bus Interface Compatibility with 9 Selectable Addresses
- Time-Out Reset Feature for I²C interface
- Separate Channel Shutdown and Whole Chip Deep Shutdown Mode to Minimize Power Consumption
- Available in a Green TSSOP-16 Package

## APPLICATIONS

Telecommunications
Server Systems
Industrial and Medical Systems
Instrumentation and Test Equipment
Voltage and Current Monitoring

## TYPICAL APPLICATION

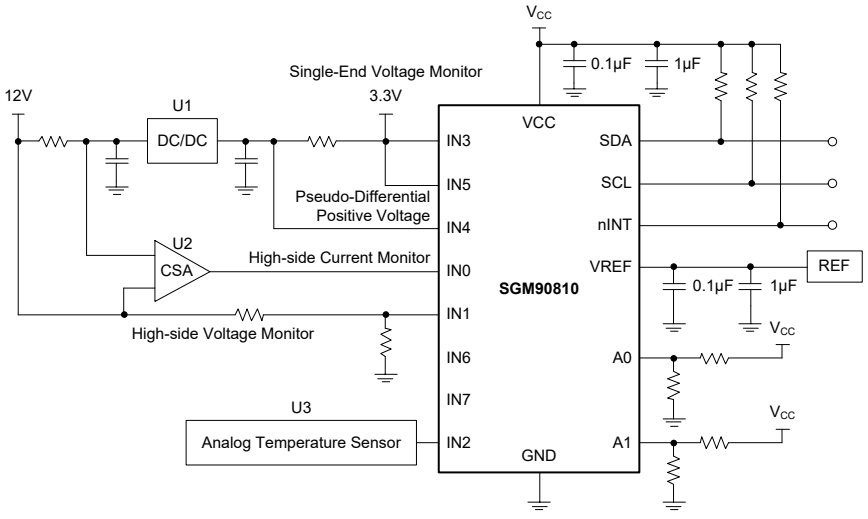


**Figure 1. Typical Application Circuit**

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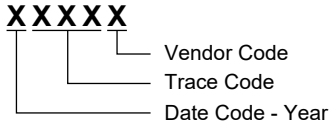
# PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---|---|---|---|---|---|
| SGM90810 | TSSOP-16 | -40℃ to +125℃ | SGM90810XTS16G/TR | SGM17J<br>XTS16<br>XXXXX | Tape and Reel, 4000 |

## MARKING INFORMATION

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




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, $V_{CC}$ ..... 6V
Voltage on SCL, SDA, A0, A1, nINT ..... -0.3V to 6V
Voltage on IN0 to IN7, $V_{REF}$ ..... -0.3V to $V_{CC}$ + 0.3V
Input Current at Any Pin ..... ±5mA
Package Input Current ..... ±30mA
Package Thermal Resistance
TSSOP-16, $\theta_{JA}$ ..... 99.3℃/W
TSSOP-16, $\theta_{JB}$ ..... 69.1℃/W
TSSOP-16, $\theta_{JC}$ ..... 38.7℃/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

Supply Voltage, $V_{CC}$ ..... 3V to 5.5V
Voltage on SCL, SDA, A0, A1, nINT ..... -0.05V to 5.5V
Voltage on IN0 to IN7, $V_{REF}$ ..... -0.05V to $V_{CC}$ + 0.05V
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

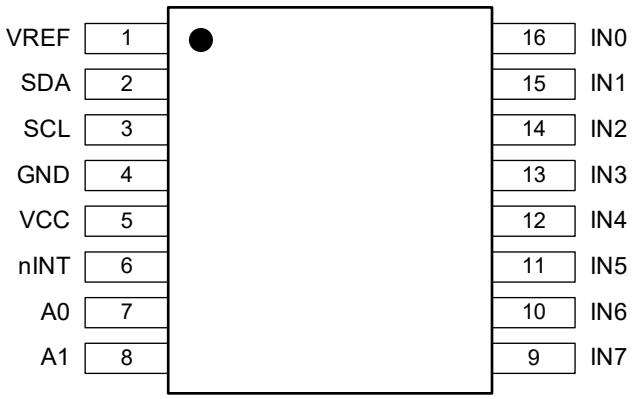
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

(TOP VIEW)




TSSOP-16

## PIN DESCRIPTION

| PIN | NAME | TYPE | FUNCTION |
|---|---|---|---|
| 1 | VREF | AI | External Reference Input. The external reference voltage ranges from 1.25V to $V_{CC}$. Bypass this pin with a ceramic 1μF parallel with 0.1μF capacitor is strongly recommended. Leave it disconnected if using internal 2.56V reference. Note that the SGM90810 enables internal reference by default. |
| 2 | SDA | DI/DO | Serial Bus Data Line, Open-Drain Input/Output. |
| 3 | SCL | DI | Serial Bus Clock Line, Open-Drain Input. |
| 4 | GND | G | Ground. |
| 5 | VCC | P | Power Supply Pin. Bypass this pin with a ceramic 1μF parallel with 0.1μF capacitor is strongly recommended. |
| 6 | nINT | DO | Active-Low Open-Drain Interrupt Alarm Pin. A pull-up resistor is needed to make it work properly. |
| 7 | A0 | Tri-Level Inputs | $I^2C$ Bus Device Address Select Pins. Support 9 addresses. |
| 8 | A1 | | |
| 9 | IN7 | AI | Eight input pins which can be configured to different input modes. The input mode can be configured as single ended mode or pseudo-differential mode through registers. |
| 10 | IN6 | | |
| 11 | IN5 | | |
| 12 | IN4 | | |
| 13 | IN3 | | |
| 14 | IN2 | | |
| 15 | IN1 | | |
| 16 | IN0 | | |

NOTE: AI: Analog Input, DI: Digital Input, DO: Digital Output, G: Ground, P: Power.

# ELECTRICAL CHARACTERISTICS

($V_{CC}$ = 3V to 5.5V, external $V_{REF}$ = 2.56V, $T_A$ = -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 | $V_{CC}$ | | 3 | 3.3 or 5 | 5.5 | V |
| External Reference Voltage | $V_{REF}$ | | 1.25 | 2.56 | $V_{CC}$ | V |
| Internal Reference Voltage | | | | 2.56 | | |
| | | | | 13 | | ppm/℃ |
| Supply Current | $I_{CC}$ | Interface inactive, $V_{CC}$ = 5.5V, Mode 2 | | | 0.28 | mA |
| | | Interface inactive, $V_{CC}$ = 3.6V, Mode 2 | | | 0.25 | |
| | | Shutdown mode, $V_{CC}$ = 5.5V | | | 0.14 | |
| | | Shutdown mode, $V_{CC}$ = 3.6V | | | 0.12 | |
| | | Deep shutdown mode | | | 15.0 | μA |
| **Temperature-to-Digital Converter** | | | | | | |
| Temperature Error | | | | | ±2 | ℃ |
| Resolution | | | | 0.5 | | ℃ |
| **Analog-to-Digital Converter** | | | | | | |
| Resolution | n | 12-bit with full-scale at $V_{REF}$ = 2.56V | | 0.625 | | mV |
| Integral Non-Linearity (1) | INL | External $V_{REF}$ = 1.25V | -1 | ±0.25 | 1 | LSB |
| | | External $V_{REF}$ = 2.56V | -1 | ±0.25 | 1 | |
| | | External $V_{REF}$ = 5V | -1 | ±0.25 | 1 | |
| Differential Non-Linearity (1) | DNL | | -1 | ±0.22 | 1 | LSB |
| Total Unadjusted Error (2) | TUE | Internal $V_{REF}$ | -0.42 | | 0.65 | % of FS |
| | | External $V_{REF}$ = 1.25V | -0.16 | | 0.16 | |
| | | External $V_{REF}$ = 2.56V | -0.16 | | 0.16 | |
| Gain Error | GE | Internal $V_{REF}$ | -0.41 | | 0.61 | % of FS |
| | | External $V_{REF}$ = 1.25V | -0.14 | | 0.14 | |
| | | External $V_{REF}$ = 2.56V | -0.14 | | 0.14 | |
| Offset Error | OE | Internal $V_{REF}$ | -0.1 | | 0.1 | % of FS |
| | | External $V_{REF}$ = 1.25V | -0.1 | | 0.1 | |
| | | External $V_{REF}$ = 2.56V | -0.1 | | 0.1 | |
| Continuous Conversion Mode | $t_C$ | Each enabled voltage channel | | 11.5 | 12.5 | ms |
| | | Internal temperature sensor | | 3.5 | 4 | |
| Low Power Conversion Mode | $t_C$ | Enabled voltage channel(s) and internal temperature sensor | | 713 | 770 | ms |
| **Multiplexer/ADC Input** | | | | | | |
| On-Resistance (3) | $R_{ON}$ | | | 3.3 | 10 | kΩ |
| Input Current (On Channel Leakage Current) | $I_{ON}$ | | | ±0.005 | | μA |
| Off Channel Leakage Current | $I_{OFF}$ | | | ±0.005 | | μA |

NOTES:

1. Limit is guaranteed by characterization.
2. TUE (Total Unadjusted Error) includes Offset, Gain and Linearity errors of the ADC.
3. Limit is guaranteed by design.

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 3V to 5.5V, external $V_{REF}$ = 2.56V, $T_A$ = -40℃ to +125℃, typical values are measured at $T_A$ = +25℃, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **Digital Outputs: nINT** | | | | | | |
| Logical 0 Output Voltage | $V_{OUT(0)}$ | $I_{OUT}$ = 3mA at $V_{CC}$ = 3V | | | 0.3 | V |
| | | $I_{OUT}$ = 5.0mA at $V_{CC}$ = 4.5V | | | 0.42 | |
| **Open-Drain Serial Bus Output: SDA** | | | | | | |
| Logical 0 Output Voltage | $V_{OUT(0)}$ | $I_{OUT}$ = 3.0mA at $V_{CC}$ = 4.5V | | | 0.3 | V |
| High Level Output Current | $I_{OH}$ | $V_{OUT}$ = $V_{CC}$ | | | 1 | μA |
| **Digital Inputs: A0 and A1** | | | | | | |
| Logical 1 Input Voltage | $V_{IN(1)}$ | | 0.9 × $V_{CC}$ | | 5.5 | V |
| Logical Middle Input Voltage | $V_{IM}$ | | 0.43 × $V_{CC}$ | | 0.57 × $V_{CC}$ | V |
| Logical 0 Input Voltage | $V_{IN(0)}$ | | GND - 0.05 | | 0.1 × $V_{CC}$ | V |
| **Serial Bus Inputs: SCL and SDA** | | | | | | |
| Logical 1 Input Voltage | $V_{IN(1)}$ | | 0.7 × $V_{CC}$ | | 5.5 | V |
| Logical 0 Input Voltage | $V_{IN(0)}$ | | GND - 0.05 | | 0.3 × $V_{CC}$ | V |
| Hysteresis Voltage | $V_{HYST}$ | $V_{CC}$ = 3.3V | | 0.59 | | V |
| | | $V_{CC}$ = 5.5V | | 1.07 | | |
| **All Digital Inputs: SCL, SDA, A0, A1** | | | | | | |
| Logical 1 Input Current | $I_{IN(1)}$ | $V_{IN}$ = $V_{CC}$ | | | 1 | μA |
| Logical 0 Input Current | $I_{IN(0)}$ | $V_{IN}$ = 0V | | | 1 | μA |
| Digital Input Capacitance | $C_{IN}$ | | | 20 | | pF |

## TIMING REQUIREMENTS

($V_{CC}$ = 3V to 5.5V, external $V_{REF}$ = 2.56V, $T_A$ = -40℃ to +125℃, typical values are measured at $T_A$ = +25℃, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| SCL (Clock) Period | $t_1$ | | 2.5 | | 100 | μs |
| Data In Set-up Time to SCL High | $t_2$ | | 100 | | | ns |
| Data Out Stable After SCL Low | $t_3$ | | 0 | | 900 | ns |
| SDA Low Setup Time to SCL Low (start) | $t_4$ | | 600 | | | ns |
| SDA High Hold Time After SCL High (stop) | $t_5$ | | 600 | | | ns |
| SCL or SDA Time Low for I²C Bus Reset | $t_{TIME-OUT}$ | | 25 | | 35 | ms |

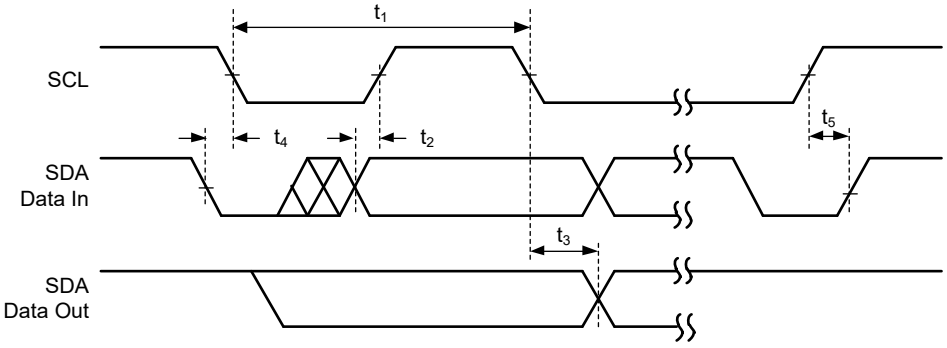
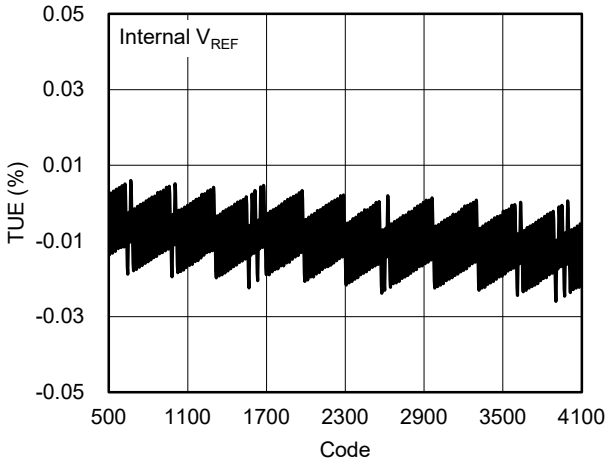



**Figure 2. Serial Bus Timing Diagram**

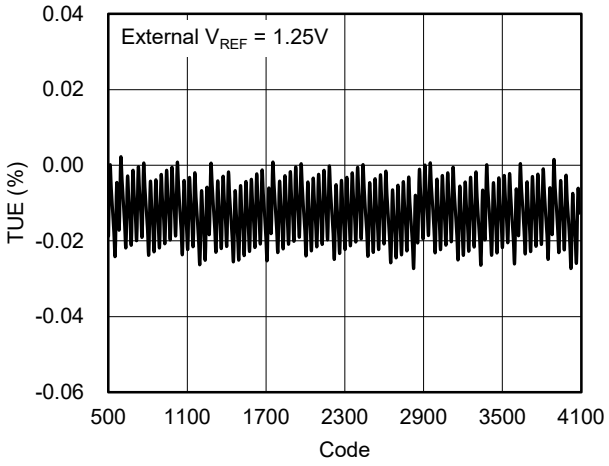
## TYPICAL PERFORMANCE CHARACTERISTICS

$V_{CC}$ = 3.3V, internal $V_{REF}$ = 2.56V, $T_A$ = +25℃, pseudo-differential connection, unless otherwise noted.

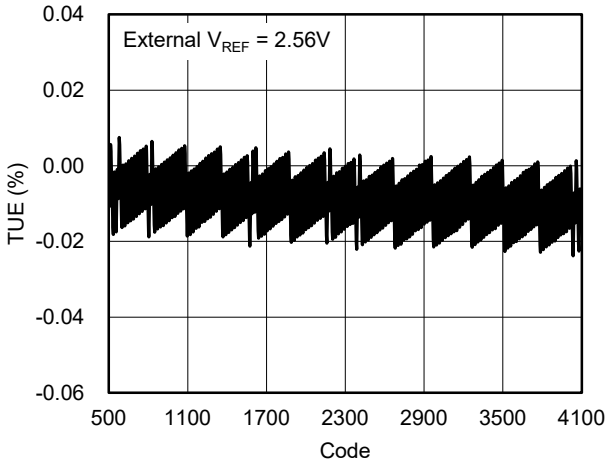
TUE vs. Code



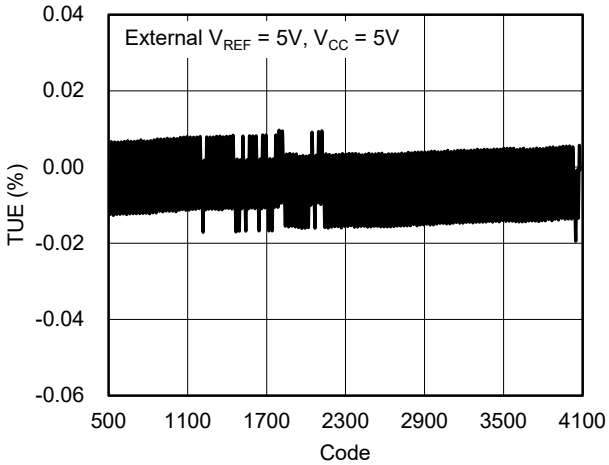

TUE vs. Code



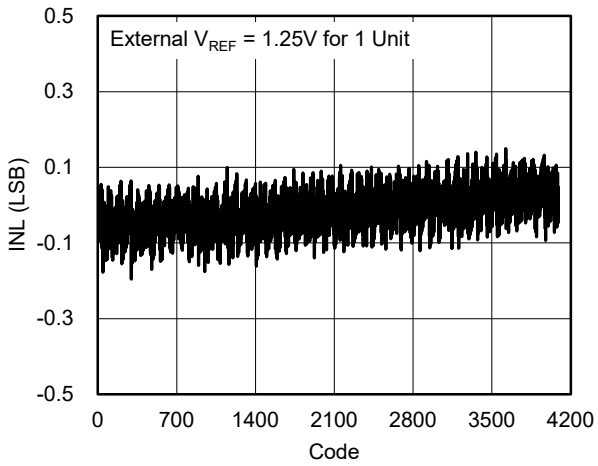

TUE vs. Code



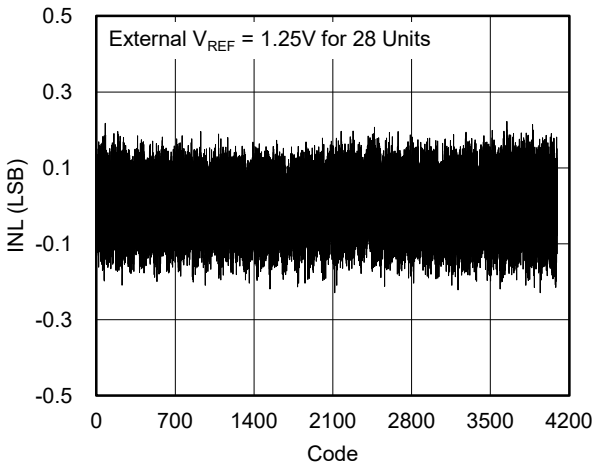

TUE vs. Code




INL vs. Code



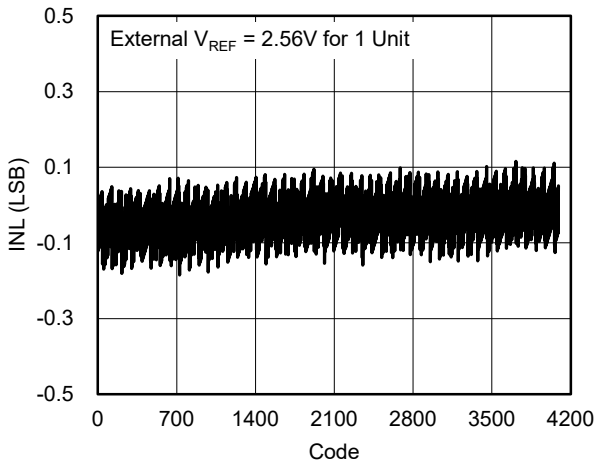

INL vs. Code



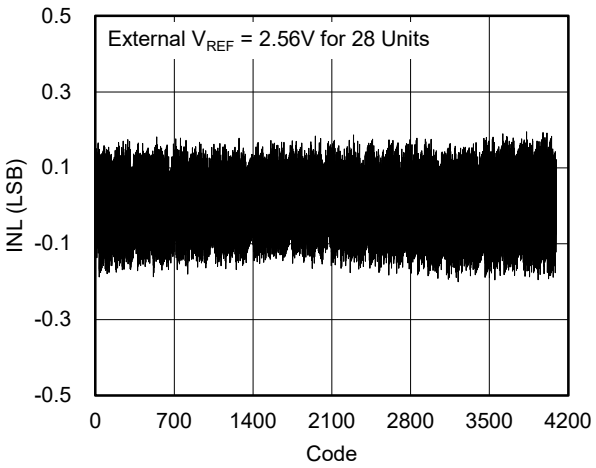
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{CC}$ = 3.3V, internal $V_{REF}$ = 2.56V, $T_A$ = +25℃, pseudo-differential connection, unless otherwise noted.

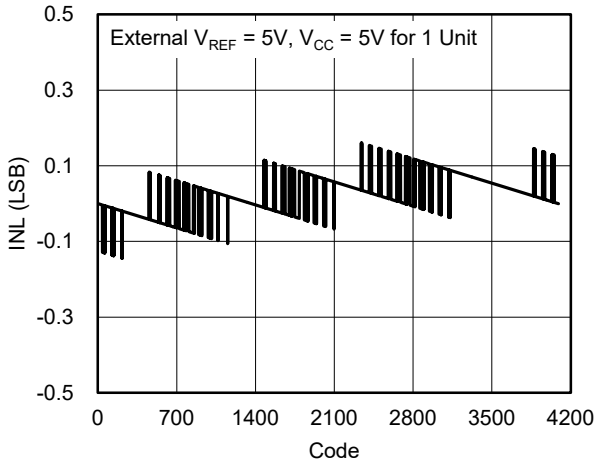
INL vs. Code



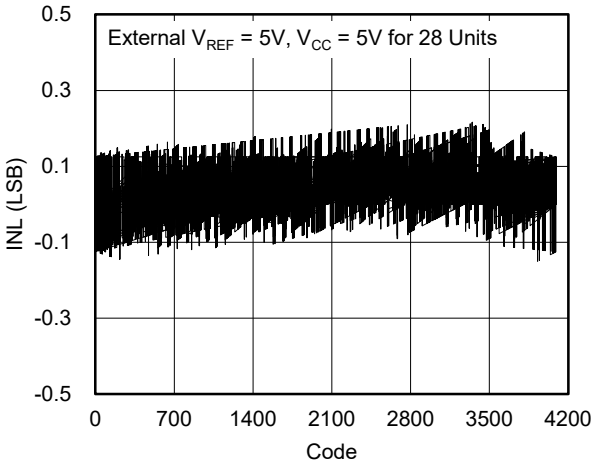

INL vs. Code



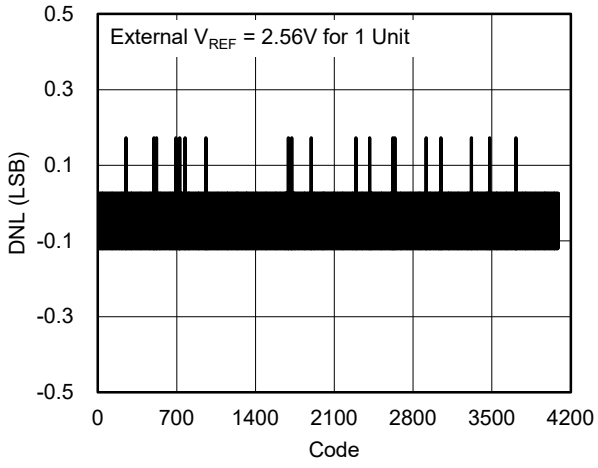

INL vs. Code



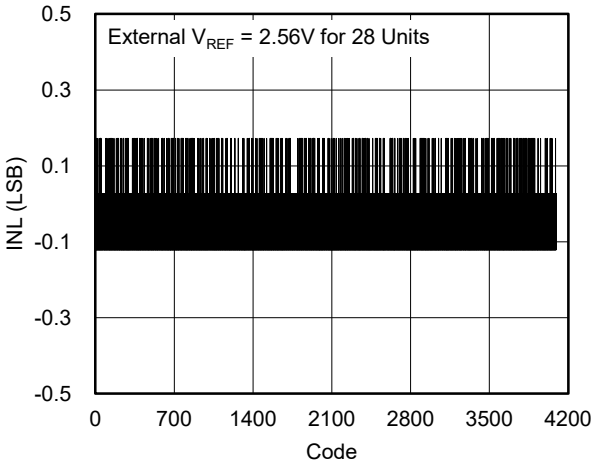

INL vs. Code




DNL vs. Code



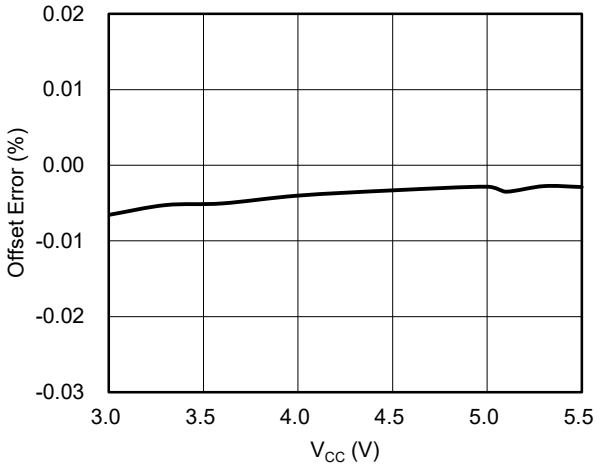

DNL vs. Code



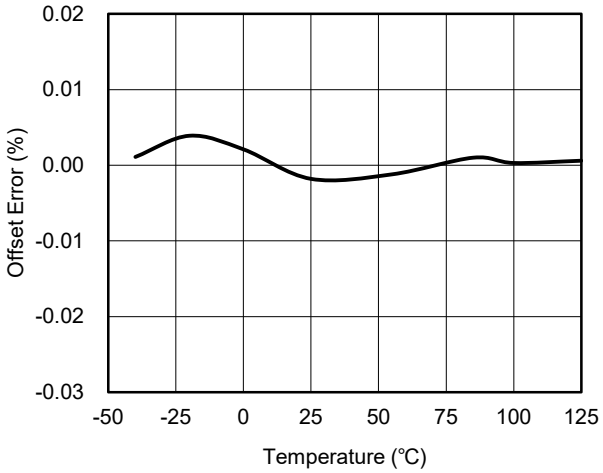
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{CC}$ = 3.3V, internal $V_{REF}$ = 2.56V, $T_A$ = +25℃, pseudo-differential connection, unless otherwise noted.

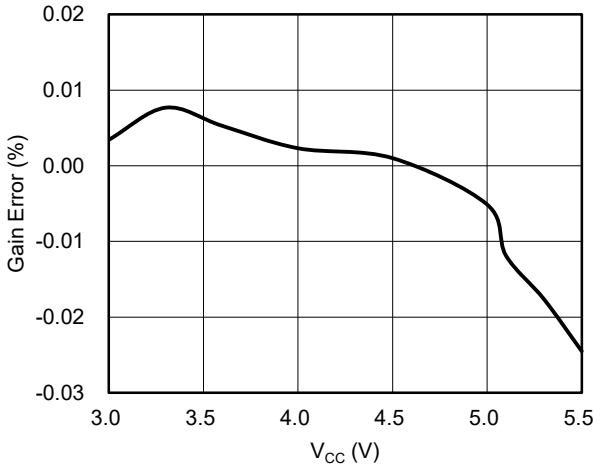
Offset Error vs. $V_{CC}$



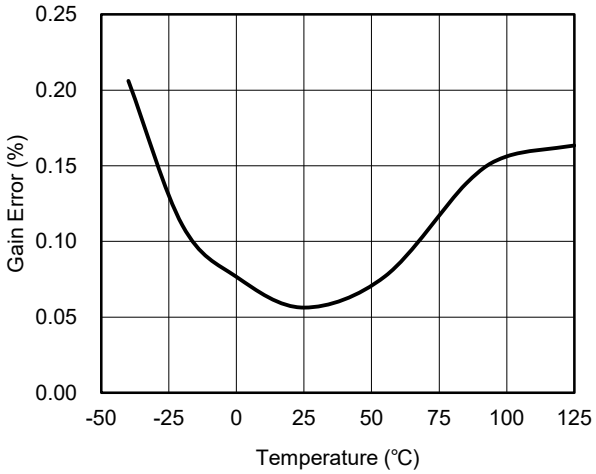

Offset Error vs. Temperature



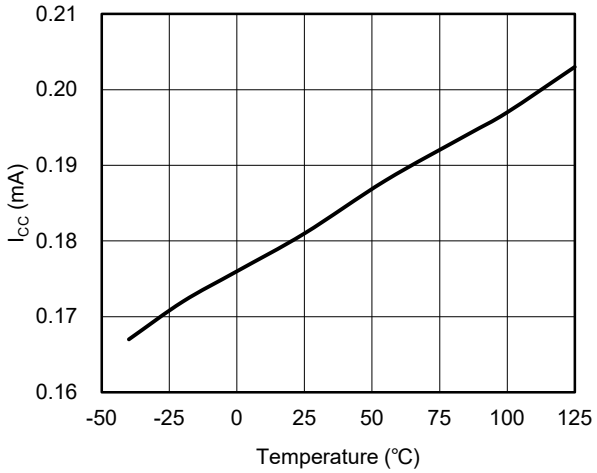

Gain Error vs. $V_{CC}$



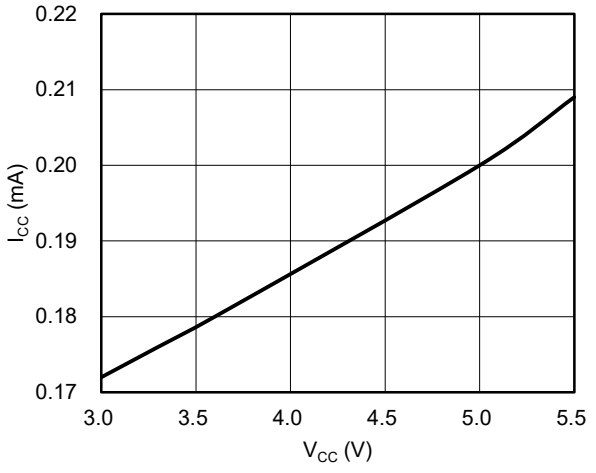

Gain Error vs. Temperature




$I_{CC}$ vs. Temperature for Voltage Conversion



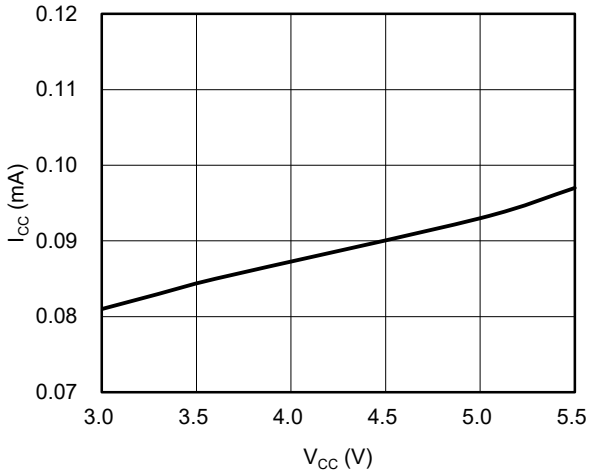

$I_{CC}$ vs. $V_{CC}$ for Voltage Conversion



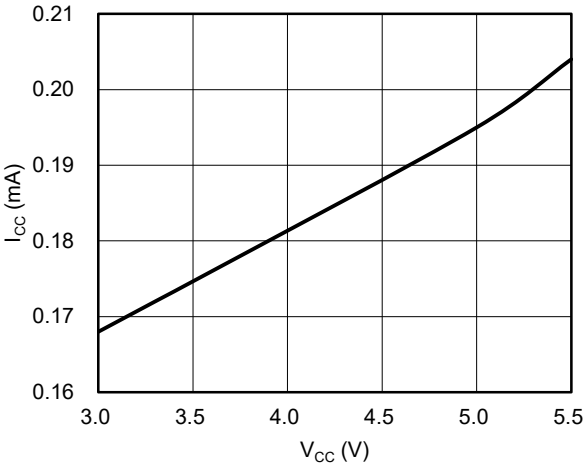
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{CC}$ = 3.3V, internal $V_{REF}$ = 2.56V, $T_A$ = +25℃, pseudo-differential connection, unless otherwise noted.

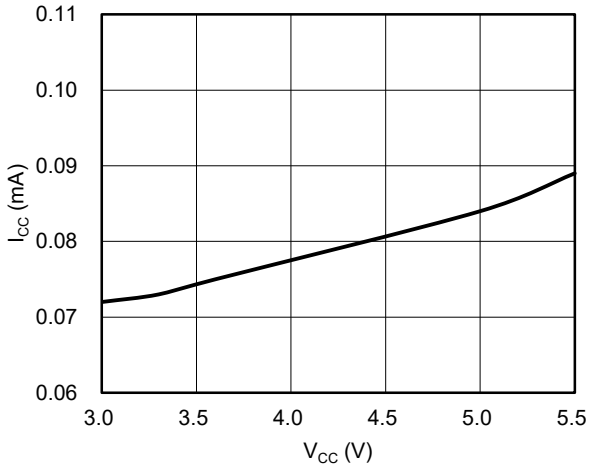
$I_{CC}$ vs. $V_{CC}$ Typical



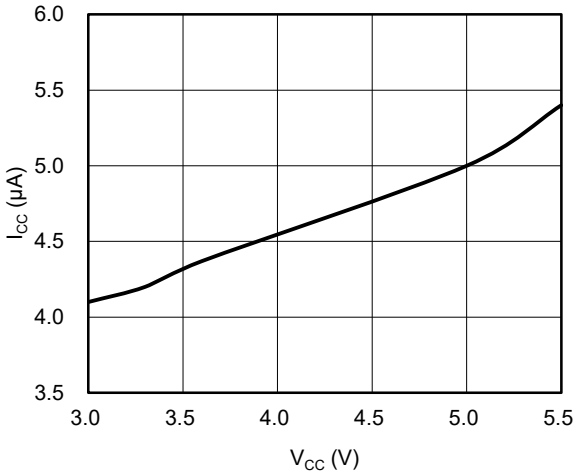

$I_{CC}$ vs. $V_{CC}$ for Temperature Conversion




$I_{CC}$ vs. $V_{CC}$ in Shutdown Mode




$I_{CC}$ vs. $V_{CC}$ in Deep Shutdown Mode



## FUNCTIONAL BLOCK DIAGRAM

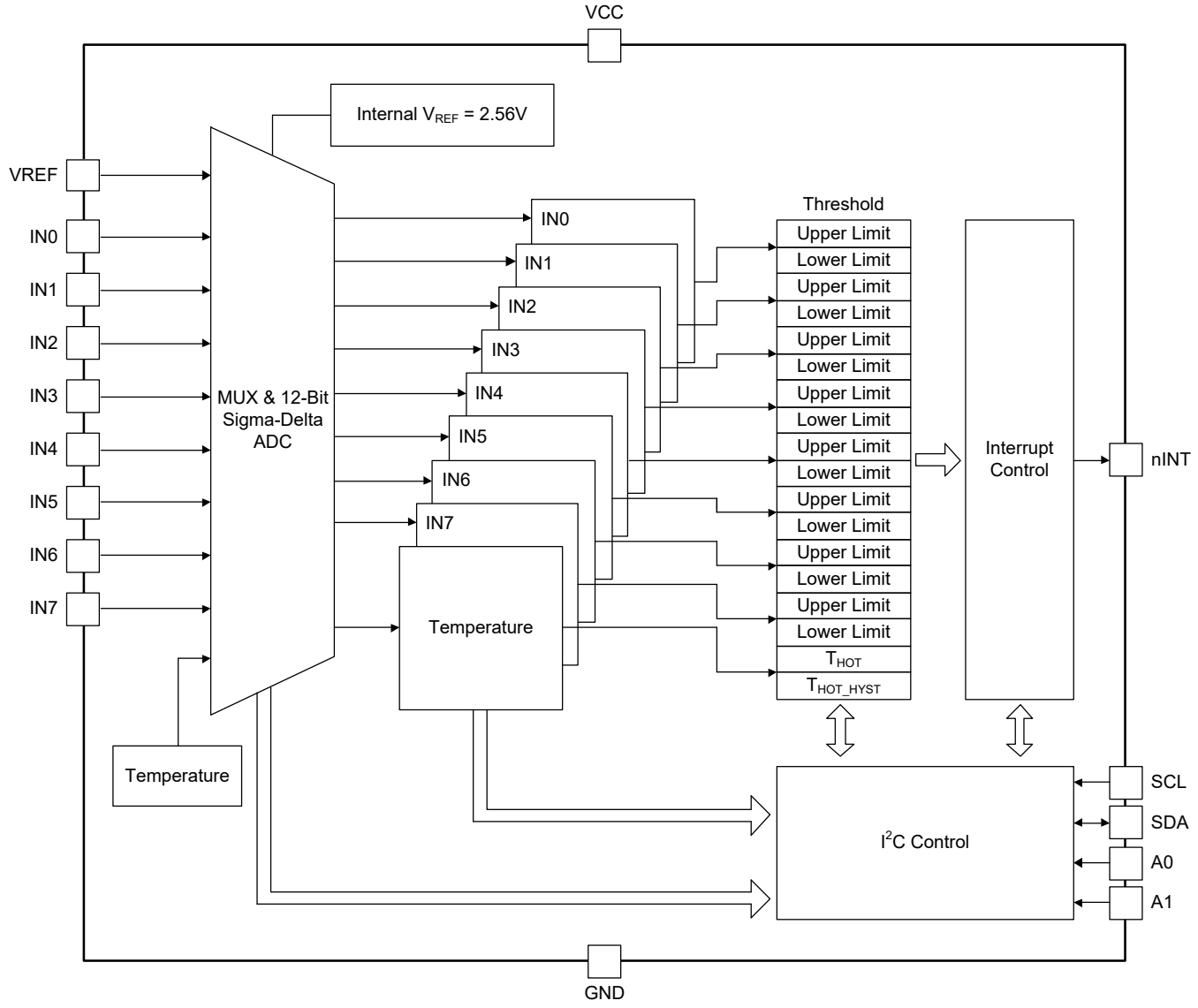



**Figure 3. Block Diagram**

# DETAILED DESCRIPTION

## Overview

The SGM90810 integrates a 12-bit sigma-delta ADC, a temperature sensor, an internal 2.56V $V_{REF}$, and a set of digital comparators internally. The device provides 8 analog input pins for analog signal monitoring. An $I^2C$ interface is provided for configurations and data transmission. The SGM90810 can work under a power supply range from 3V to 5.5V. Therefore, the SGM90810 provides a complete and flexible solution for voltage, current and temperature monitoring suitable for various systems.

When using internal $V_{REF}$, the LSB of SGM90810 is 0.625mV (the least significant bit). In addition to internal $V_{REF}$, SGM90810 can also use external reference (reference voltage range from 1.25V to $V_{CC}$). Eight analog input channels can be configured as single ended inputs or pseudo-differential inputs. The built-in temperature sensor converts the temperature to a 9-bit two's complement word with a resolution of 0.5℃ per LSB.

The SGM90810 adopts $I^2C$ interface and supports standard (Sm, 100kbps) and fast (Fm, 400kbps) modes. 9 different device addresses are available through configuring two address pins A0 and A1. The SDA and SCL of the SGM90810 have a time-out reset function. In addition, SGM90810 has an internal analog filter on $I^2C$, which makes the chip robust under noisy systems.

The SGM90810 starts cycling by setting the bit 0 of the Configuration Register (00h) to 1. The internal sequencer loops each channel in sequence according to the Conversion Rate Register (07h). Each conversion data will be compared to an upper limit threshold and a lower limit threshold set in the Limit Registers (2Ah – 39h). If the conversion data is out of the limit range, the SGM90810 reports an alarm event and the users can fetch the status through Interrupt Status Register (01h) as well as the nINT Pin.

## Voltage References (VREF)

The SGM90810 can select internal or external references through the Advanced Configuration Register (0Bh). When selecting an external reference, the voltage range covers from 1.25V to $V_{CC}$. $V_{REF}$ source must have low output impedance and needs to be bypassed with at least a 0.1μF capacitor. It would be better to use 1μF and 0.1μF capacitors in parallel as bypass capacitors. When the internal reference is selected, the SGM90810 provides a high-performance reference of 2.56V. SGM90810 defaults to internal reference when powered on.

The noise should be taken into consideration carefully when a power supply is used as the external reference source as the $V_{REF}$ cannot reject noise. Interference from external reference circuits will be reflected in the digital conversion results.

## Analog Inputs (IN0 - IN7)

The SGM90810 supports 8 single-ended inputs or 4 pseudo-differential inputs. The input combinations are organized in different modes of operations. Configure the Advanced Configuration Register (0Bh) to select the corresponding mode. The specific combination mode is described in the following text.

### Single-Ended Input

The SGM90810 allows a maximum of 8 single-ended inputs. When using single ended input, the source should be connected to INx (x = 0, 1…7) and grounded together with SGM90810 (Figure 4). The input voltage range of INx (x = 0, 1…7) is from 0V to ($V_{REF}$ - 1.5 LSB), where LSB equals $V_{REF}$/4096.

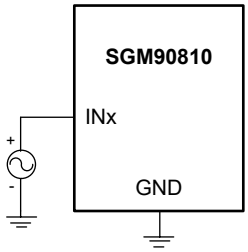



**Figure 4. Single-Ended Input Mode**

## DETAILED DESCRIPTION (continued)

### Pseudo-Differential Input

Figure 5 shows the connection method of pseudo-differential mode. The input that is digitized is ($\Delta V_{IN}$ = IN+ - IN-), where (IN+ - IN-) is (IN0 - IN1), (IN3 - IN2), (IN4 - IN5), or (IN7 - IN6). $\Delta V_{IN}$ can be of any value between 0V and ($V_{REF}$ - 1.5 LSB), where LSB = $V_{REF}$/4096.

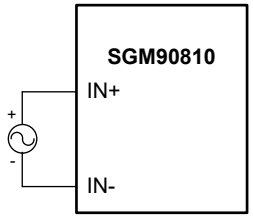



**Figure 5. Pseudo-Differential Input Mode**

### Modes of Operation

With the combinations among single-end input mode, pseudo-differential input mode and temperature measurement, the SGM90810 has total 4 modes of operation which are listed in the table below. Configuring the Advanced Configuration Register (0Bh) to select the corresponding operation mode.

**Table 1. Modes of Operation**

| CH. | Mode 0 | Mode 1 | Mode 2 | Mode 3 |
|---|---|---|---|---|
| 1 | IN0 | IN0 | IN0 (+) and IN1 (-) | IN0 |
| 2 | IN1 | IN1 | IN3 (+) and IN2 (-) | IN1 |
| 3 | IN2 | IN2 | IN4 (+) and IN5 (-) | IN2 |
| 4 | IN3 | IN3 | IN7 (+) and IN6 (-) | IN3 |
| 5 | IN4 | IN4 | | IN4 (+) and IN5 (-) |
| 6 | IN5 | IN5 | | IN7 (+) and IN6 (-) |
| 7 | IN6 | IN6 | | |
| 8 | | IN7 | | |
| Local Temp | Yes | No | Yes | Yes |

# PROGRAMMING

## Interface

The A0, A1 (serial bus address) pins, SCL (serial clock), and SDA (serial data) consists of the serial bus control line. The SGM90810 serves as a slave device. Figure 6 and Figure 7 show how to write to the SGM90810.

There are two cases for a “read”: when the register address is at the desired address, simply write the serial bus address to the slave device to read SGM90810 data. The specific process is detailed in Figure 8 and Figure 9.

Figure 10 and Figure 11 show a conventional serial bus data reading process. Firstly, the I²C device address is sent to trigger a “write” request, and then the register address is sent. Then repeat start, send the serial bus address again, initiate a "read" request, and followed by the register value read from the register.

### I²C Device Address

There are 9 different collocations for the SGM90810 I²C bus device address. Set the A0 and A1 pins to different voltage range can change the device address. The specific settings are as follows:

**Table 2. I²C Device Address Table**

| A1 | A0 | ADDRESS IN HEX [A6:A0] |
|---|---|---|
| Low | Low | 1Dh |
| Low | Mid | 1Eh |
| Low | High | 1Fh |
| Mid | Low | 2Dh |
| Mid | Mid | 2Eh |
| Mid | High | 2Fh |
| High | Low | 35h |
| High | Mid | 36h |
| High | High | 37h |

### Time-Out

If either SCL or SDA is tied low for more than 35ms, the SGM90810 will reset its I²C interface. Similarly, the SGM90810 will release SDA automatically after keeping it low for around 35ms. Note that the time-out feature does not work when the device is in the deep shutdown mode.

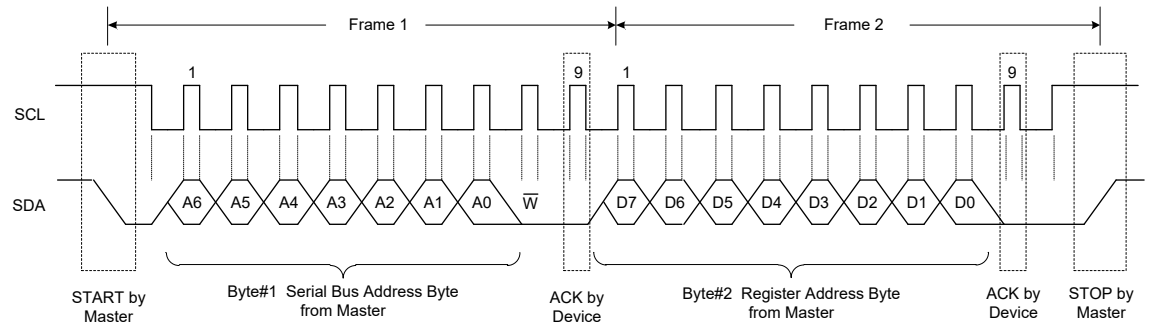



**Figure 6. Internal Address Register Set for Write Format**

## PROGRAMMING (continued)

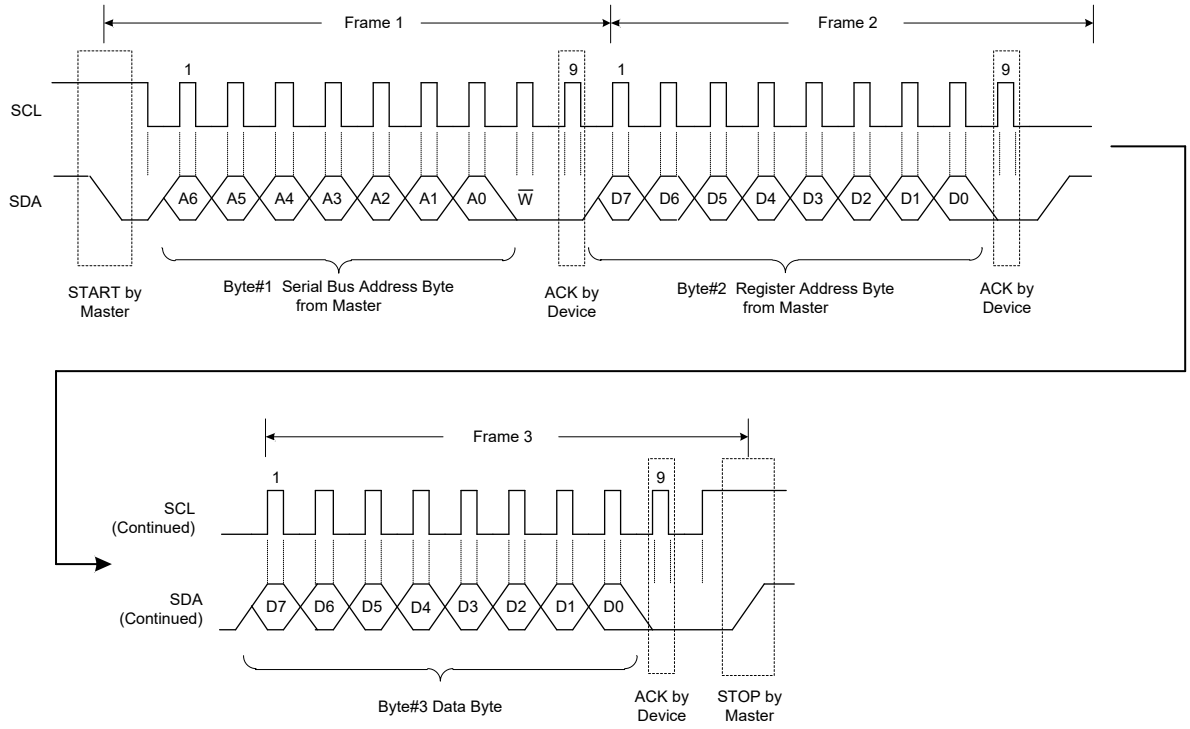



**Figure 7. Internal Address Register Set with Data Byte Write**

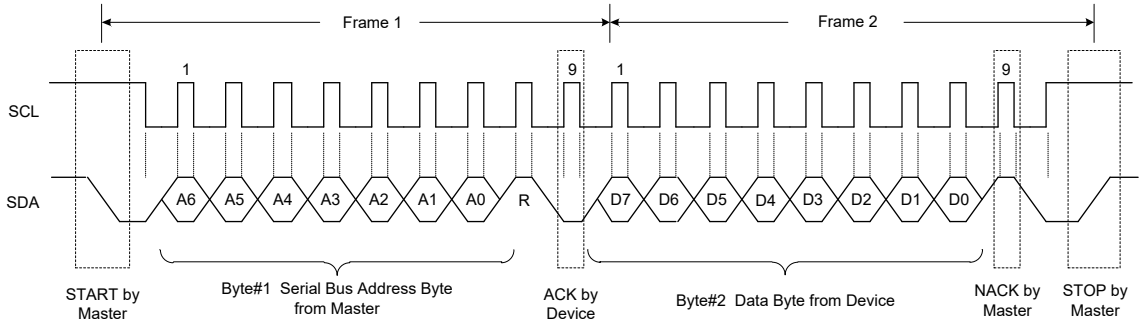



**Figure 8. Preset Internal Address Register Read Byte Format**

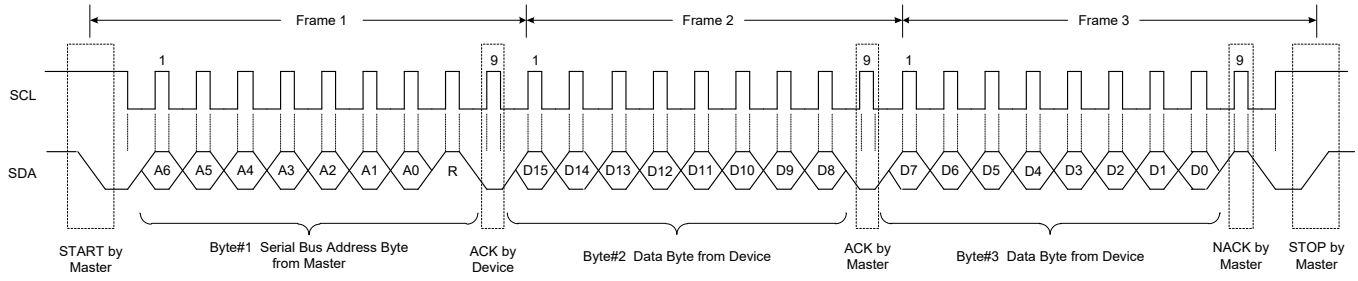



**Figure 9. Preset Internal Address Register Read Word Format**

## PROGRAMMING (continued)

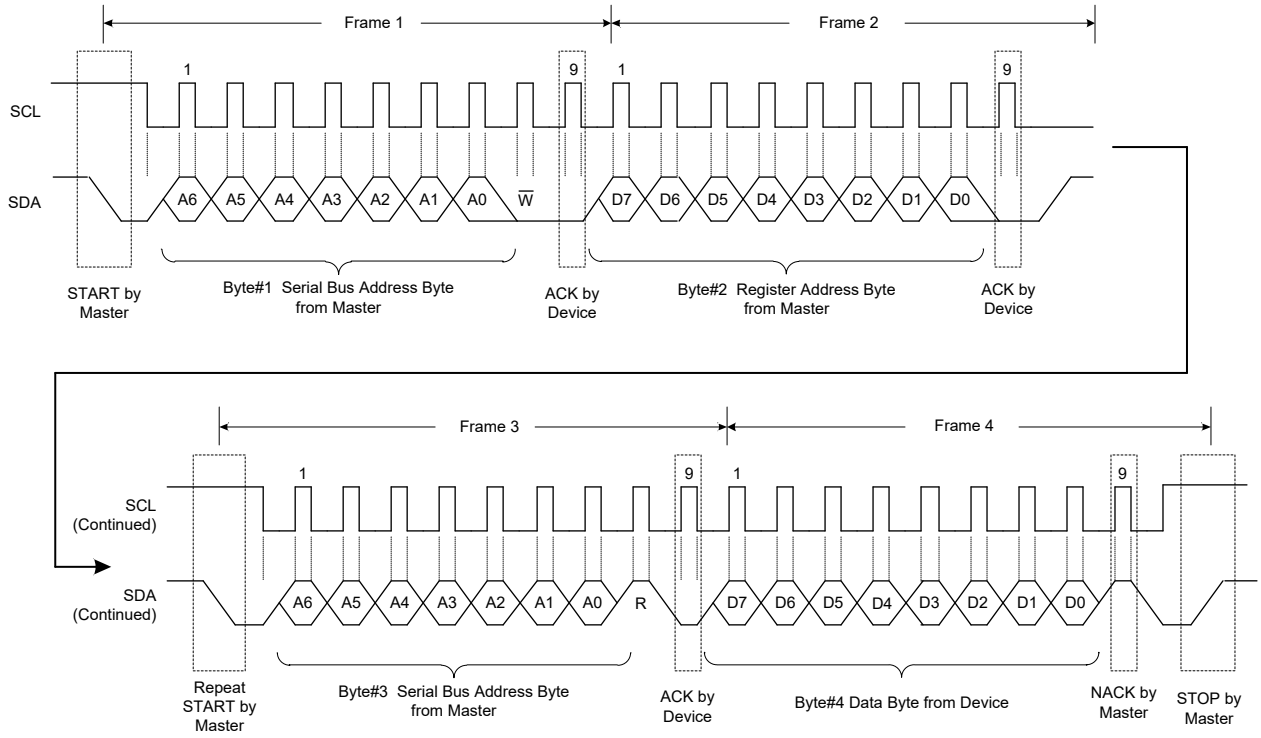



**Figure 10. Single Byte Read with Internal Address Set Using a Repeat Start**

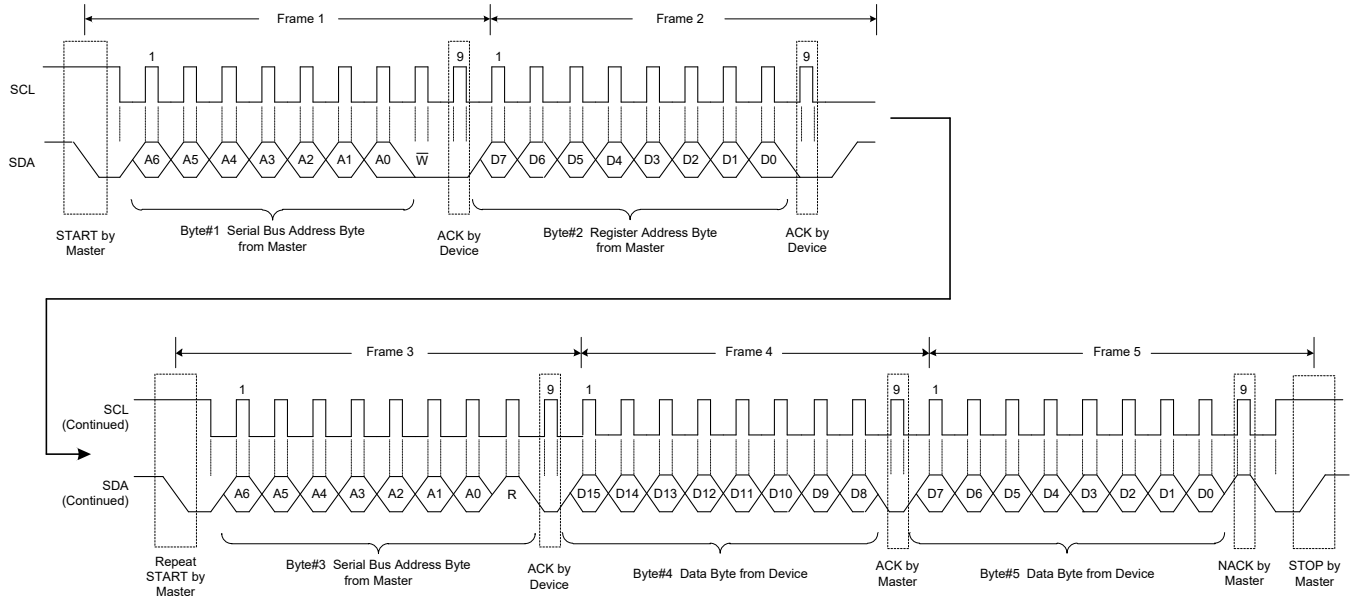



**Figure 11. Double Byte Read with Internal Address Set Using a Repeat Start**

# REGISTER MAPS

## Register Set Summary

| ADDRESS (HEX) | REGISTER NAME | FUNCTION | REGISTER FORMAT | DEFAULT VALUE [7:0] | TYPE |
|---|---|---|---|---|---|
| 00h | Configuration Register | Configuration for the SGM90810. | 8-bit | 00001000 | R/W |
| 01h | Interrupt Status Register | Interrupt status of each channel. | 8-bit | 00000000 | R |
| 03h | Interrupt Mask Register | Mask the interrupt status to the interrupt pin. | 8-bit | 00000000 | R/W |
| 07h | Conversion Rate Register | Select the conversion rate. | 8-bit | 00000000 | R/W |
| 08h | Channel Disable Register | Disable the selected channels. | 8-bit | 00000000 | R/W |
| 09h | One-Shot Register | Trigger a single conversion of all enabled channels. | 8-bit | 00000000 | W |
| 0Ah | Deep Shutdown Register | Enter deep shutdown mode. | 8-bit | 00000000 | R/W |
| 0Bh | Advanced Configuration Register | Select $V_{REF}$ source and operating mode. | 8-bit | 00000000 | R/W |
| 0Ch | Busy Status Register | SGM90810 Conversion statuses. | 8-bit | 00000010 | R |
| 20h - 27h | Channel Readings Registers | Reads the conversion results. | 16-bit | — | R |
| 2Ah - 39h | Limit Registers | Set the limit thresholds for all the channels. | 8-bit | — | R/W |
| 3Eh | Manufacturer ID Register | Manufacturer ID. | 8-bit | 01010011 | R |
| 3Fh | Revision ID Register | Revision ID. | 8-bit | 00001001 | R |

Bit Types:
R: Read only; R/W: Read/Write

## 00h: Configuration Register

### Configuration Register Details of All Modes

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | Initialization | 0 | R/W | 1 = Restore default values to all the registers except the Channel Readings Registers and the Limit Registers, This bit clears itself. |
| D[6:4] | Reserved | 000 | R | Reserved. |
| D[3] | nINT_Clear | 1 | R/W | 1 = Clear the interrupt pin without changing the Interrupt Status Registers. When this bit is set high, the device stops cycling. |
| D[2] | Reserved | 0 | R | Reserved. |
| D[1] | nINT_Enable | 0 | R/W | 1 = Interrupt pin enable |
| D[0] | START | 0 | R/W | Control the cycling of the monitoring loop. When the nINT pin is enabled, the nINT pin will not be cleared if this bit is set low after an interrupt event occurs.<br>0 = Stop cycling and enter shutdown mode<br>1 = Start cycling |

## 01h: Interrupt Status Register

This register clears on read. Each bit in this read-only register indicates whether the voltage reading is above the voltage high limit or is not higher than the voltage low limit, or the temperature reading is above the temperature high limit.

### Interrupt Status Register Details of Mode 0

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | Hot Temperature Error | 0 | R | 1 = An over-temperature event occurs |
| D[6] | IN6 Error | 0 | R | 1 = An over or below limit event occurs |
| D[5] | IN5 Error | 0 | R | 1 = An over or below limit event occurs |
| D[4] | IN4 Error | 0 | R | 1 = An over or below limit event occurs |
| D[3] | IN3 Error | 0 | R | 1 = An over or below limit event occurs |
| D[2] | IN2 Error | 0 | R | 1 = An over or below limit event occurs |
| D[1] | IN1 Error | 0 | R | 1 = An over or below limit event occurs |
| D[0] | IN0 Error | 0 | R | 1 = An over or below limit event occurs |

## REGISTER MAPS (continued)

**Interrupt Status Register Details of Mode 1**

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | IN7 Error | 0 | R | 1 = An over or below limit event occurs |
| D[6] | IN6 Error | 0 | R | 1 = An over or below limit event occurs |
| D[5] | IN5 Error | 0 | R | 1 = An over or below limit event occurs |
| D[4] | IN4 Error | 0 | R | 1 = An over or below limit event occurs |
| D[3] | IN3 Error | 0 | R | 1 = An over or below limit event occurs |
| D[2] | IN2 Error | 0 | R | 1 = An over or below limit event occurs |
| D[1] | IN1 Error | 0 | R | 1 = An over or below limit event occurs |
| D[0] | IN0 Error | 0 | R | 1 = An over or below limit event occurs |

**Interrupt Status Register Details of Mode 2**

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | Hot Temperature Error | 0 | R | 1 = An over-temperature event occurs |
| D[6:4] | Reserved | 000 | R | Reserved. |
| D[3] | IN7(+) and IN6(-) Error | 0 | R | 1 = An over or below limit event occurs |
| D[2] | IN4(+) and IN5(-) Error | 0 | R | 1 = An over or below limit event occurs |
| D[1] | IN3(+) and IN2(-) Error | 0 | R | 1 = An over or below limit event occurs |
| D[0] | IN0(+) and IN1(-) Error | 0 | R | 1 = An over or below limit event occurs |

**Interrupt Status Register Details of Mode 3**

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | Hot Temperature Error | 0 | R | 1 = An over-temperature event occurs |
| D[6] | Reserved | 0 | R | Reserved. |
| D[5] | IN7(+) and IN6(-) Error | 0 | R | 1 = An over or below limit event occurs |
| D[4] | IN4(+) and IN5(-) Error | 0 | R | 1 = An over or below limit event occurs |
| D[3] | IN3 Error | 0 | R | 1 = An over or below limit event occurs |
| D[2] | IN2 Error | 0 | R | 1 = An over or below limit event occurs |
| D[1] | IN1 Error | 0 | R | 1 = An over or below limit event occurs |
| D[0] | IN0 Error | 0 | R | 1 = An over or below limit event occurs |

### 03h: Interrupt Mask Register

This register maps the corresponding interrupt status to the nINT pin. For example, if IN0 Mask bit turns to 1, then the nINT pin will not be low even if an interrupt event occurs at IN0.

**Interrupt Mask Register Details of Mode 0**

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | Temperature Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[6] | IN6 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[5] | IN5 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[4] | IN4 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[3] | IN3 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[2] | IN2 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[1] | IN1 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[0] | IN0 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |

## REGISTER MAPS (continued)

**Interrupt Mask Register Details of Mode 1**

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | IN7 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[6] | IN6 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[5] | IN5 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[4] | IN4 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[3] | IN3 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[2] | IN2 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[1] | IN1 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[0] | IN0 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |

**Interrupt Mask Register Details of Mode 2**

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | Temperature Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[6:4] | Reserved | 000 | R | Reserved. |
| D[3] | IN7(+) and IN6(-) Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[2] | IN4(+) and IN5(-) Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[1] | IN3(+) and IN2(-) Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[0] | IN0(+) and IN1(-) Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |

**Interrupt Mask Register Details of Mode 3**

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | Temperature Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[6] | Reserved | 0 | R | Reserved. |
| D[5] | IN7(+) and IN6(-) Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[4] | IN4(+) and IN5(-) Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[3] | IN3 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[2] | IN2 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[1] | IN1 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |
| D[0] | IN0 Mask | 0 | R/W | 1 = Map the corresponding interrupt status to the interrupt pin, nINT |

### 07h: Conversion Rate Register

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7:1] | Reserved | 0000000 | R | Reserved. |
| D[0] | Conversion Rate | 0 | R/W | 0 = Low Power Conversion Mode<br>1 = Continuous Conversion Mode<br>Before configuring this bit, make sure the START bit of the Configuration Register (00h) is 0. |

# REGISTER MAPS (continued)

## 08h: Channel Disable Register

This register must only be configured when the SGM90810 is in the shutdown mode (the START bit of the Configuration Register (00h) is 0). Please note that programming this register will reset all values in both the Channel Reading Registers and the Interrupt Status Registers back to their default states.

**Channel Disable Register Details of Mode 0**

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | Temperature Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[6] | IN6 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[5] | IN5 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[4] | IN4 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[3] | IN3 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[2] | IN2 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[1] | IN1 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[0] | IN0 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |

**Channel Disable Register Details of Mode 1**

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | IN7 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[6] | IN6 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[5] | IN5 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[4] | IN4 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[3] | IN3 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[2] | IN2 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[1] | IN1 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[0] | IN0 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |

**Channel Disable Register Details of Mode 2**

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | Temperature Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[6:4] | Reserved | 000 | R | Reserved. |
| D[3] | IN7(+) and IN6(-) Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[2] | IN4(+) and IN5(-) Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[1] | IN3(+) and IN2(-) Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[0] | IN0(+) and IN1(-) Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |

# REGISTER MAPS (continued)

**Channel Disable Register Details of Mode 3**

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7] | Temperature Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[6] | Reserved | 0 | R | Reserved. |
| D[5] | IN7(+) and IN6(-) Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[4] | IN4(+) and IN5(-) Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[3] | IN3 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[2] | IN2 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[1] | IN1 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |
| D[0] | IN0 Disable | 0 | R/W | 1 = Channel disabled, the corresponding value in the Channel Readings Registers returns to 0 and interrupt events are suppressed. |

## 09h: One-Shot Register

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7:1] | Reserved | 0000000 | R | Reserved. |
| D[0] | One-Shot | 0 | W | Write operation to this bit triggers a single conversion and comparison cycle when the device is in the shutdown mode or the deep shutdown mode and will return to the original mode as long as the cycle is complete.<br>This bit is self-cleared, which means a zero will always be read from this register. |

## 0Ah: Deep Shutdown Register

Most of the internal modules are shut down to minimize the power consumption. Before entering the deep shutdown mode, make sure the START bit of the Configuration Register (00h) is 0.

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7:1] | Reserved | 0000000 | R | Reserved. |
| D[0] | Deep Shutdown Enable | 0 | R/W | 1 = Enter the deep shutdown mode. Make sure the START bit of the Configuration Register(00h) is 0. One-shot conversion could be triggered when the SGM90810 is in this mode.<br>0 = Exit the deep shutdown mode. |

## 0Bh: Advanced Configuration Register

Programming this register will reset all values in both the Channel Readings Registers and the Interrupt Status Register back to their default states. This register must only be programmed when the device is in shutdown mode, that is, when the START bit of the Configuration Register (00h) is 0.

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7:3] | Reserved | 00000 | R | Reserved. |
| D[2:1] | Mode Select[1:0] | 00 | R/W | Mode Select Bits [1:0]<br>00 = Mode 0<br>01 = Mode 1<br>10 = Mode 2<br>11 = Mode 3 |
| D[0] | External Reference Enable | 0 | R/W | 0 = Select the 2.56V internal $V_{REF}$.<br>1 = Select the external $V_{REF}$. |

## 0Ch: Busy Status Register

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7:2] | Reserved | 000000 | R | Reserved. |
| D[1] | Not Ready | 1 | R | 1 = Waiting for the power-up initialization to finish. |
| D[0] | Busy | 0 | R | 1 = SGM90810 is converting. |

# REGISTER MAPS (continued)

## 20h ~ 27h: Channel Readings Registers

These registers are the only 16-bit registers among all the registers. They are arranged to 12-bit voltage values and 9-bit temperature value. Conversion results will be updated to these registers and could be fetched at any time. The last conversion results are always available through these registers. Converting and I²C interface are working independently. When an I²C communication is started, the SGM90810 keeps converting but the results will not be updated to the Channel Reading Registers (20h to 27h) until the communication is complete.

**Channel Reading Register Details of Mode 0**

| ADDRESS | REGISTER NAME | TYPE | DESCRIPTION |
|---|---|---|---|
| 20h | IN0 Reading | R | Conversion result |
| 21h | IN1 Reading | R | Conversion result |
| 22h | IN2 Reading | R | Conversion result |
| 23h | IN3 Reading | R | Conversion result |
| 24h | IN4 Reading | R | Conversion result |
| 25h | IN5 Reading | R | Conversion result |
| 26h | IN6 Reading | R | Conversion result |
| 27h | Temperature Reading | R | Conversion result |

**Channel Reading Register Details of Mode 1**

| ADDRESS | REGISTER NAME | TYPE | DESCRIPTION |
|---|---|---|---|
| 20h | IN0 Reading | R | Conversion result |
| 21h | IN1 Reading | R | Conversion result |
| 22h | IN2 Reading | R | Conversion result |
| 23h | IN3 Reading | R | Conversion result |
| 24h | IN4 Reading | R | Conversion result |
| 25h | IN5 Reading | R | Conversion result |
| 26h | IN6 Reading | R | Conversion result |
| 27h | IN7 Reading | R | Conversion result |

**Channel Reading Register Details of Mode 2**

| ADDRESS | REGISTER NAME | TYPE | DESCRIPTION |
|---|---|---|---|
| 20h | IN0(+) and IN1(-) Reading | R | Conversion result |
| 21h | IN3(+) and IN2(-) Reading | R | Conversion result |
| 22h | IN4(+) and IN5(-) Reading | R | Conversion result |
| 23h | IN7(+) and IN6(-) Reading | R | Conversion result |
| 24h ~ 26h | Reserved | R | Reserved. |
| 27h | Temperature Reading | R | Conversion result |

# REGISTER MAPS (continued)

**Channel Reading Register Details of Mode 3**

| ADDRESS | REGISTER NAME | TYPE | DESCRIPTION |
|---|---|---|---|
| 20h | IN0 Reading | R | Conversion result |
| 21h | IN1 Reading | R | Conversion result |
| 22h | IN2 Reading | R | Conversion result |
| 23h | IN3 Reading | R | Conversion result |
| 24h | IN4(+) and IN5(-) Reading | R | Conversion result |
| 25h | IN7(+) and IN6(-) Reading | R | Conversion result |
| 26h | Reserved | R | Reserved. |
| 27h | Temperature Reading | R | Conversion result |

## 2Ah ~ 39h: Limit Registers

**Limit Registers Details of Mode 0**

| ADDRESS | REGISTER NAME | TYPE | REGISTER DESCRIPTION |
|---|---|---|---|
| 2Ah | IN0 High Limit | R/W | High Threshold |
| 2Bh | IN0 Low Limit | R/W | Low Threshold |
| 2Ch | IN1 High Limit | R/W | High Threshold |
| 2Dh | IN1 Low Limit | R/W | Low Threshold |
| 2Eh | IN2 High Limit | R/W | High Threshold |
| 2Fh | IN2 Low Limit | R/W | Low Threshold |
| 30h | IN3 High Limit | R/W | High Threshold |
| 31h | IN3 Low Limit | R/W | Low Threshold |
| 32h | IN4 High Limit | R/W | High Threshold |
| 33h | IN4 Low Limit | R/W | Low Threshold |
| 34h | IN5 High Limit | R/W | High Threshold |
| 35h | IN5 Low Limit | R/W | Low Threshold |
| 36h | IN6 High Limit | R/W | High Threshold |
| 37h | IN6 Low Limit | R/W | Low Threshold |
| 38h | Temperature High Limit | R/W | High Threshold |
| 39h | Temperature Hysteresis Limit | R/W | Hysteresis Limit |

## REGISTER MAPS (continued)

**Limit Registers Details of Mode 1**

| ADDRESS | REGISTER NAME | TYPE | REGISTER DESCRIPTION |
|---|---|---|---|
| 2Ah | IN0 High Limit | R/W | High Threshold |
| 2Bh | IN0 Low Limit | R/W | Low Threshold |
| 2Ch | IN1 High Limit | R/W | High Threshold |
| 2Dh | IN1 Low Limit | R/W | Low Threshold |
| 2Eh | IN2 High Limit | R/W | High Threshold |
| 2Fh | IN2 Low Limit | R/W | Low Threshold |
| 30h | IN3 High Limit | R/W | High Threshold |
| 31h | IN3 Low Limit | R/W | Low Threshold |
| 32h | IN4 High Limit | R/W | High Threshold |
| 33h | IN4 Low Limit | R/W | Low Threshold |
| 34h | IN5 High Limit | R/W | High Threshold |
| 35h | IN5 Low Limit | R/W | Low Threshold |
| 36h | IN6 High Limit | R/W | High Threshold |
| 37h | IN6 Low Limit | R/W | Low Threshold |
| 38h | IN7 High Limit | R/W | High Threshold |
| 39h | IN7 Low Limit | R/W | Low Threshold |

**Limit Registers Details of Mode 2**

| ADDRESS | REGISTER NAME | TYPE | REGISTER DESCRIPTION |
|---|---|---|---|
| 2Ah | IN0(+) and IN1(-) High Limit | R/W | High Threshold |
| 2Bh | IN0(+) and IN1(-) Low Limit | R/W | Low Threshold |
| 2Ch | IN3(+) and IN2(-) High Limit | R/W | High Threshold |
| 2Dh | IN3(+) and IN2(-) Low Limit | R/W | Low Threshold |
| 2Eh | IN4(+) and IN5(-) High Limit | R/W | High Threshold |
| 2Fh | IN4(+) and IN5(-) Low Limit | R/W | Low Threshold |
| 30h | IN7(+) and IN6(-) High Limit | R/W | High Threshold |
| 31h | IN7(+) and IN6(-) Low Limit | R/W | Low Threshold |
| 32h - 37h | Reserved | R | Reserved. |
| 38h | Temperature High Limit | R/W | High Threshold |
| 39h | Temperature Hysteresis Limit | R/W | Hysteresis Limit |

# REGISTER MAPS (continued)

**Limit Registers Details of Mode 3**

| ADDRESS | REGISTER NAME | TYPE | REGISTER DESCRIPTION |
|---|---|---|---|
| 2Ah | IN0 High Limit | R/W | High Threshold |
| 2Bh | IN0 Low Limit | R/W | Low Threshold |
| 2Ch | IN1 High Limit | R/W | High Threshold |
| 2Dh | IN1 Low Limit | R/W | Low Threshold |
| 2Eh | IN2 High Limit | R/W | High Threshold |
| 2Fh | IN2 Low Limit | R/W | Low Threshold |
| 30h | IN3 High Limit | R/W | High Threshold |
| 31h | IN3 Low Limit | R/W | Low Threshold |
| 32h | IN4(+) and IN5(-) High Limit | R/W | High Threshold |
| 33h | IN4(+) and IN5(-) Low Limit | R/W | Low Threshold |
| 34h | IN7(+) and IN6(-) High Limit | R/W | High Threshold |
| 35h | IN7(+) and IN6(-) Low Limit | R/W | Low Threshold |
| 36h - 37h | Reserved | R | Reserved. |
| 38h | Temperature High Limit | R/W | High Threshold |
| 39h | Temperature Hysteresis Limit | R/W | Hysteresis Limit |

## 3Eh: Manufacturer ID Register

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7:0] | Manufacturer ID | 01010011 | R | Manufacturer's ID = 01010011. |

## 3Fh: Revision ID Register

| BITS | BIT NAME | DEFAULT | TYPE | DESCRIPTION |
|---|---|---|---|---|
| D[7:0] | Revision ID | 00001001 | R | Revision's ID = 00001001. |

# APPLICATION INFORMATION

## Digital Output ($D_{OUT}$)

Output code of SGM90810 can be calculated as:

$$D_{OUT} = (\Delta V_{IN}/V_{REF}) \times 4096 \quad (1)$$

The range of $\Delta V_{IN}$ is between 0 and ($V_{REF}$ - 1.5LSB), theoretically. When $\Delta V_{IN}$ exceeds this range, the output of SGM90810 is 0 or 4095. The specific relationship between $D_{OUT}$ and $\Delta V_{IN}$ can be referred to Figure 12.

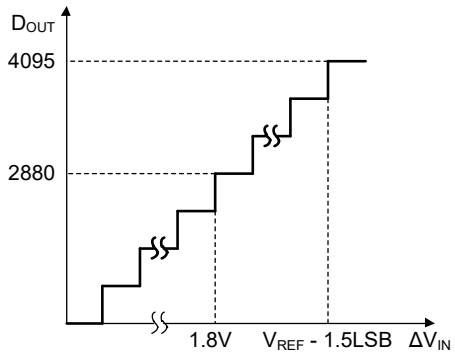



**Figure 12. $D_{OUT}$ vs. $\Delta V_{IN}$ for a 12-Bit ADC Assuming $V_{REF}$ = 2.56V**

## Temperature Measurement System

The SGM90810 has a built-in temperature sensor. In Mode 0, Mode 2 and Mode 3, SGM90810 stores the temperature value in the 0x27 register. This is a 16-bit register, sufficient to store 9-bit temperature values. Please refer to Figure 13 and Table 3 for details.

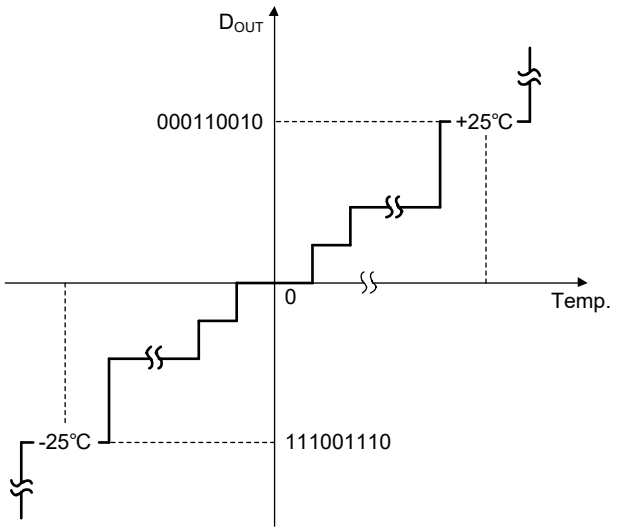



**Figure 13. 9-Bit Temperature-to-Digital Transfer Function**

For 9-bit temperature data, the highest bit is the sign bit, and the following formula can be used to convert temperature values.

If $D_{OUT}$[MSB] = 0:

$$\text{Temperature (℃)} = D_{OUT}\text{(DEC)}/2 \quad (2)$$

If $D_{OUT}$[MSB] = 1:

$$\text{Temperature (℃)} = [D_{OUT}\text{(DEC)} - 512]/2 \quad (3)$$

**Table 3. Temperature Registers Sample Temperatures**

| Temp. | Digital Output ($D_{OUT}$) | | |
|---|---|---|---|
| | Binary [MSB...LSB] | Decimal | Hex |
| +125℃ | 011111010 | 250 | 0FA |
| +25℃ | 000110010 | 50 | 032 |
| +0.5℃ | 000000001 | 1 | 001 |
| 0℃ | 000000000 | 0 | 000 |
| -0.5℃ | 111111111 | 511 | 1FF |
| -25℃ | 111001110 | 462 | 1CE |
| -40℃ | 110110000 | 432 | 1B0 |

### Temperature Limits

By setting the Temperature High Limit Register (38h) and the Temperature Hysteresis Limit Register (39h), SGM90810 can achieve temperature monitoring. When the temperature reading exceeds the set value in the Temperature High Limit Register, SGM90810 will generate an interrupt signal.

Both these two registers are 8-bit registers. The least significant bit of these registers is 1℃. The following formulas and Table 4 describe how the register values map to actual temperature.

If TempLimit (℃) ≥ 0:

$$D_{OUT}\text{(DEC)} = \text{TempLimit (℃)} \quad (4)$$

If TempLimit (℃) < 0:

$$D_{OUT}\text{(DEC)} = 256 - |\text{TempLimit (℃)}| \quad (5)$$

**Table 4. SGM90810 Internal Registers (continued)**

| Temp. | Digital Output ($D_{OUT}$) | | |
|---|---|---|---|
| | Binary [MSB...LSB] | Decimal | Hex |
| +125℃ | 01111101 | 125 | 7D |
| +25℃ | 00011001 | 25 | 19 |
| +1.0℃ | 00000001 | 1 | 01 |
| 0℃ | 00000000 | 0 | 00 |
| -1.0℃ | 11111111 | 255 | FF |
| -25℃ | 11101111 | 231 | E7 |
| -40℃ | 11011000 | 216 | D8 |

# APPLICATION INFORMATION (continued)

## Interrupt Structure

Figure 14 is the block diagram of the SGM90810's interrupt structure.

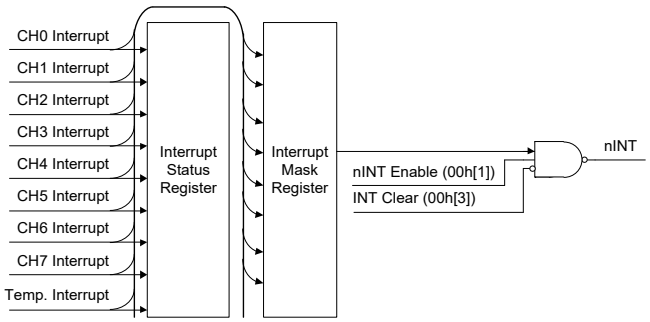



**Figure 14. Interrupt Structure**

### Interrupt Output (nINT)

The SGM90810 generates an interrupt event based on the comparison of the conversion results as well as the limit thresholds. The interrupt events could also be mapped to the output nINT pin. In order to trigger this pin, make sure that the nINT_Enable bit in the Configuration Register (00h[1]) is 1 and the nINT_Clear bit (00h[3]) in the same register is 0. Then, whenever a conversion result is out of the limit range or the temperature conversion result exceeds the corresponding threshold, the nINT pin will be triggered to low.

### Interrupt Clearing

The interrupt status results could be fetched from the Interrupt Status Register (01h). This register clears on read. If the nINT pin is enabled, it will also return to high when the Interrupt Status Register (01h) is read.

Setting the nINT_Clear bit of the Configuration Register (00h[3]) to 1 could also clear the nINT pin. However, this operation will cause the SGM90810 to stop cycling.

### Temperature Interrupt

The temperature interrupt structure is shown in Figure 15. It is based on the Temperature High Limit Register (38h) and the Temperature Hysteresis Limit Register (39h). When the temperature conversion result exceeds the value in the Temperature High Limit Register (38h) for the first time, an interrupt event occurs. The interrupt status will not be cleared until the Interrupt Status Register (01h) is read. Once the temperature interrupt is triggered, the trigger source will be switched from the value in the Temperature High Limit Register (38h) to the value in the Temperature Hysteresis Limit Register (39h) until the temperature conversion result goes below the Temperature Hysteresis Limit Register (39h). That means as long as the temperature conversion result is beyond the value in the Temperature Hysteresis Limit Register (39h), the temperature interrupt event will continue to occur. When the temperature conversion result is lower than the value in the Temperature Hysteresis Limit Register (39h) for the first time, the trigger source will return to the value in the Temperature High Limit Register (38h).

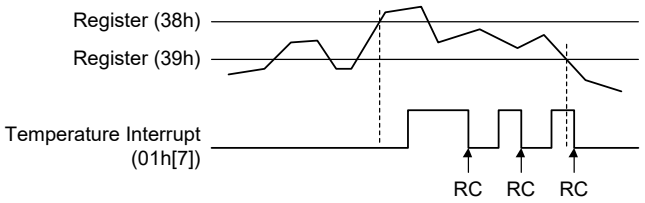



**Figure 15. Temperature Interrupt Structure**

## Detailed Design Procedure

### Conversion Rates and Power Consumptions

The SGM90810 provides three types of conversion rates: continuous conversion mode, low power conversion mode, and one-shot mode. Different conversion modes consume different supply current, which provides the flexibility to balance the conversion rates and power consumptions.

In the continuous conversion mode, the SGM90810 converts all the enabled channels round by round and never enters the shutdown mode until the device is set to stop. It takes about 11.5ms to finish a voltage conversion and about 3.5ms to complete a temperature conversion.

In the low power conversion mode, the device converts all the enabled channels and then enters shutdown mode. It takes about 713ms to finish one round.

The one-shot mode could only be triggered when the SGM90810 is in the shutdown mode or the deep shutdown mode. Moreover, when the one-shot mode is triggered, the SGM90810 will return to the original mode as long as the conversion cycle is completed.

## APPLICATION INFORMATION (continued)

To estimate the average supply current of the SGM90810, the current for conversion ($I_{CC\_VOLTAGE}$), the current for temperature conversion ($I_{CC\_TEMP}$) and the current for the shutdown mode ($I_{CC\_SHUTDOWN}$) shown in the datasheet could help. Besides, the conversion period of one channel is 11.5ms and one round period for the Low Power Conversion Mode is 713ms. With the time and current provided, the user could easily estimate the average current of the SGM90810 during a certain period of time.

**Initialization Sequence**

1. Power on the device, then wait for 3ms.

2. Keep reading the Not Ready bit of the Busy Status Register (0Ch) until it becomes 0.

3. Configure the mode of operation and the reference source by setting the Advanced Configuration Register (0Bh).

4. Choose the conversion rate in the Conversion Rate Register (07h).

5. Disable unused channel by program the Channel Disable Register (08h) if necessary.

6. Program the Interrupt Mask Register (03h) to select which alarm event could map to the nINT pin.

7. Set the alarm threshold of each enabled channel via the Limit Registers (2Ah – 39h).

8. Set the START bit of the Configuration Register (00h) to 1 to start cycling. Set the INT_Enable bit of the Configuration Register (00h) to 1 to enable the nINT pin function. Otherwise, the nINT pin will not work even if the Interrupt Mask Register (03h) is correctly set. Besides, the nINT_Clear bit of the same register should be set to 0 otherwise the cycling would be blocked even if the START bit is 1.

**Power-on-Reset (POR)**

The SGM90810 features a power-on-reset (POR) function, which restores all the registers to the default values shown in the datasheet. Note that some registers, which have indeterminate default values, are not shown in the datasheet.

**Power Supply Recommendations**

The SGM90810 works under a wide power supply range from 3V to 5.5V. Bypass the VCC pin with at least a 1μF ceramic capacitor along with a 0.1μF ceramic capacitor. Similarly, bypass the VREF pin with at least a 1μF ceramic capacitor along with a 0.1μF ceramic capacitor is strongly recommended. $V_{REF}$ decides the input range for conversions. The SGM90810 supports internal $V_{REF}$ and external $V_{REF}$ source. The internal $V_{REF}$ source is fixed at 2.56V while the external $V_{REF}$ source supports a range from 1.25V to $V_{CC}$. The noise should be taken into consideration carefully when a power supply is used as the external reference source as the $V_{REF}$ cannot reject noise. Interference from external reference circuits will be reflected in the digital conversion results.

### System Examples

A typical application for SGM90810 is system monitoring. In Figure 16, the voltage, current and temperature are monitored. U1 is a DC/DC converter which is widely used in different applications. U2 is a current sensing amplifier (CSA) which supports high common voltage current sensing. The output of the CSA is a single-ended voltage signal which represents the input current of the U1. This current signal is monitored by the IN0 of the SGM90810. The IN1 monitors the 12V power source via a two-resistor voltage divider. Thus, the system input voltage and current are monitored. In practical, keep each of the two resistors of the voltage divider less than 100kΩ is recommended. The IN2 monitors an external analog temperature sensor U3. This sensor is recommended to be placed far away from the SGM90810 as the SGM90810 integrates a temperature sensor which represents the local temperature. (The SGM90810 is a low power consumption chip so it does not heat up. Thus, the die temperature is similar to the local environment temperature.) The IN4 and IN5 measure the positive pseudo-differential voltage which represents the output current of U1. The IN3 monitors the output voltage 3.3V.

The SCL, SDA and the nINT pins are all open-drain pins. In order to work properly, they must be pulled up. 1kΩ to 10kΩ is usually recommended to be the pull-up resistor value. The voltage on the A0 and A1 pins decides the I²C device address of the SGM90810. According to the datasheet, there are 9 different addresses. In the above diagram, the voltage on the A0 and A1 pin is set by a two-resistor voltage divider each. However, these two pins could also be connected to general purpose input/output (GPIO) pins of the host controller or a digital-to-analog converter (DAC).

## APPLICATION INFORMATION (continued)

**Typical Application Diagram**

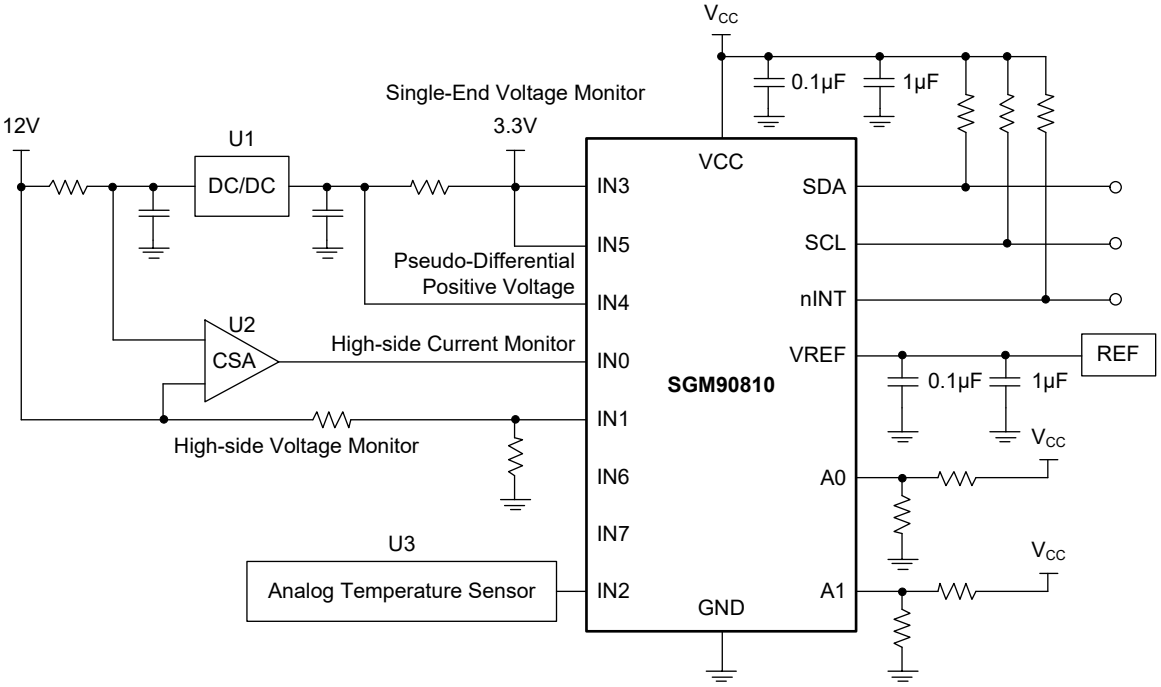



**Figure 16. Typical System Monitor Application**

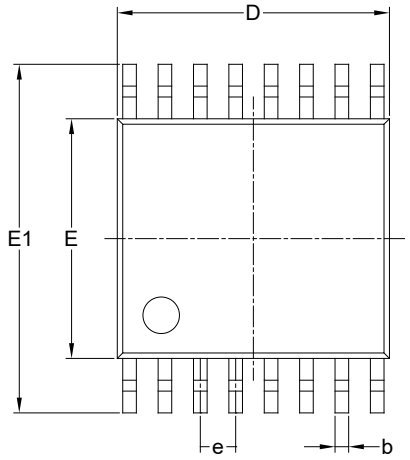
## REVISION HISTORY

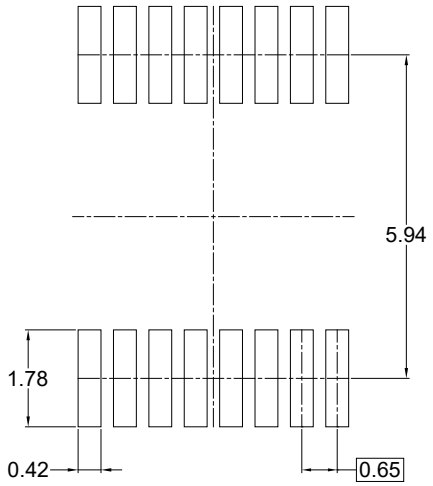
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Original (DECEMBER 2024) to REV.A | Page |
|---|---|
| Changed from product preview to production data | All |

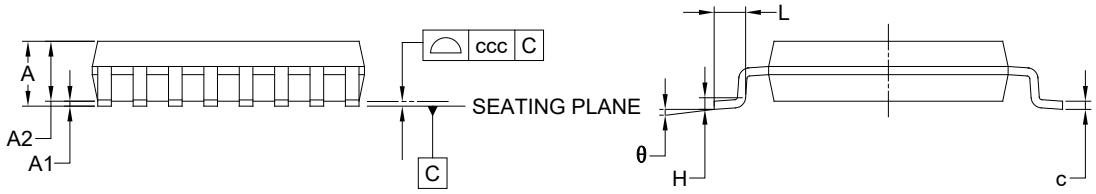
# PACKAGE OUTLINE DIMENSIONS

## TSSOP-16




**RECOMMENDED LAND PATTERN** (Unit: mm)

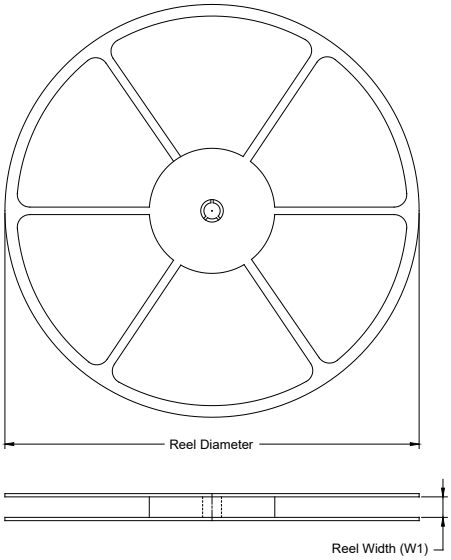



| Symbol | Dimensions In Millimeters | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| A | - | - | 1.200 |
| A1 | 0.050 | - | 0.150 |
| A2 | 0.800 | - | 1.050 |
| b | 0.190 | - | 0.300 |
| c | 0.090 | - | 0.200 |
| D | 4.860 | - | 5.100 |
| E | 4.300 | - | 4.500 |
| E1 | 6.200 | - | 6.600 |
| e | 0.650 BSC | | |
| L | 0.450 | - | 0.750 |
| H | 0.250 TYP | | |
| θ | 0° | - | 8° |
| ccc | 0.100 | | |

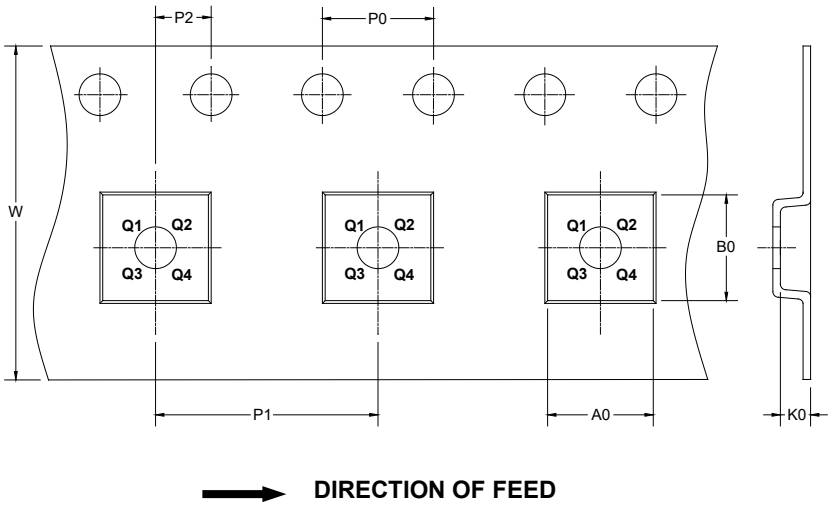
NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MO-153.

# TAPE AND REEL INFORMATION

### REEL DIMENSIONS




### TAPE DIMENSIONS



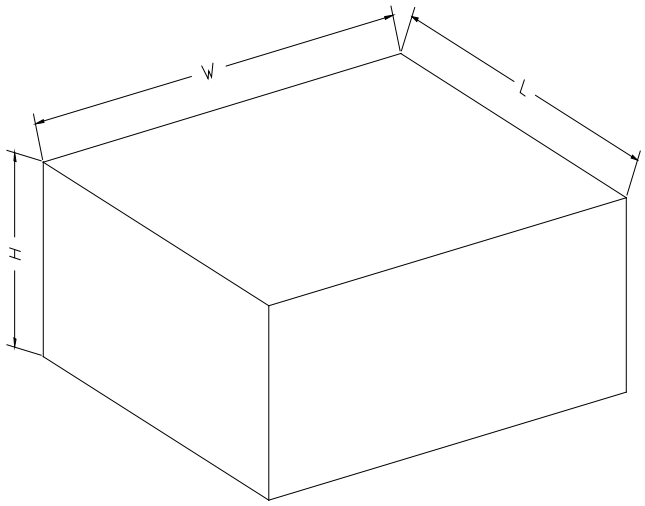

NOTE: The picture is only for reference. Please make the object as the standard.

## 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| TSSOP-16 | 13" | 12.4 | 6.80 | 5.40 | 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