

GENERAL DESCRIPTION

The SGM458 is a low power, low supply voltage, CSP package, serial control interface and digital output temperature sensor with an accuracy of $\pm 1^{\circ}\text{C}$ (TYP) in the temperature range of -55°C to $+125^{\circ}\text{C}$. The serial two-wire interface supports traditional I²C bus or SMBus interface. Multiple device access instruction is used in this serial bus, so multiple SGM458 devices (up to three) can share one serial bus. The micro-controller will communicate with these devices on the bus without sending separate instructions which increases the efficiency of software. In multiple hot points monitoring systems such as computing platform, the design can be realized by connecting one serial bus with multiple temperature sensors. The SGM458 has a power supply voltage range of 1.6V to 5.5V, so the 1.8V I/O of the micro-controller can be used as the power supply of SGM458.

The SGM458 is available in a Green WLCSP-0.85×0.85-4B package and specified over a temperature range of -55°C to $+125^{\circ}\text{C}$.

FEATURES

- 1.6V to 5.5V Supply Voltage Range
- Two-Wire Interface Supports 1.8V, 2.8V, 3.3V and 5.0V Logic
- Temperature Accuracy:
 -55°C to $+125^{\circ}\text{C}$: $\pm 1^{\circ}\text{C}$ (TYP)
- Resolution: 12 Bits or 8 Bits
- Support Multiple Devices in One Serial Bus
- Serial Control Bus is Compatible with I²C and SMBus Interface
- Low Quiescent Current (I_Q): 2.9 μA at 0.25Hz
- Shutdown Mode Current: 0.7 μA (TYP)
- Available in a Green WLCSP-0.85×0.85-4B Package

APPLICATIONS

Smart Phone
Temperature Monitor in Computing Platform
Industrial Control
Temperature Monitor in Power System

TYPICAL APPLICATION

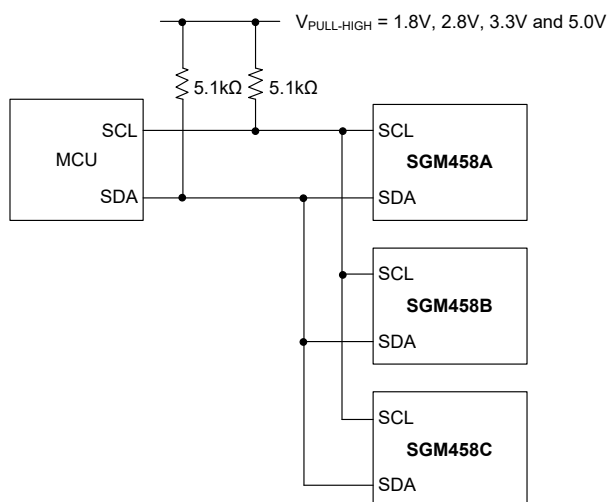


Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM458A	WLCSP-0.85×0.85-4B	-55°C to +125°C	SGM458ATG/TR	3J X	Tape and Reel, 3000
SGM458B	WLCSP-0.85×0.85-4B	-55°C to +125°C	SGM458BTG/TR	5T X	Tape and Reel, 3000
SGM458C	WLCSP-0.85×0.85-4B	-55°C to +125°C	SGM458CTG/TR	5U X	Tape and Reel, 3000

MARKING INFORMATION

NOTE: X = Date Code.

YY — Serial Number
 X
 — Date Code - Quarter

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} 6.5V
 Voltage at SCL and SDA -0.3V to ($V_{CC} + 0.3V$) and $\leq 6.5V$
 Package Thermal Resistance
 WLCSP-0.85×0.85-4B, θ_{JA} 270°C/W
 Junction Temperature +150°C
 Storage Temperature Range -65°C to +150°C
 Lead Temperature (Soldering, 10s) +260°C
 ESD Susceptibility
 HBM 4000V
 CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Supply Voltage Range 1.6V to 5.5V

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.

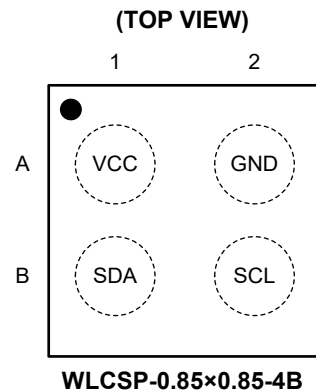
ESD SENSITIVITY CAUTION

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	I/O	FUNCTION
A1	VCC	I	Power Supply Pin.
A2	GND	—	Ground Pin.
B1	SDA	I/O	Data Input/Output Pin.
B2	SCL	I	Clock Input Pin.

NOTE: I: Input; O: Output.

FUNCTIONAL BLOCK DIAGRAM

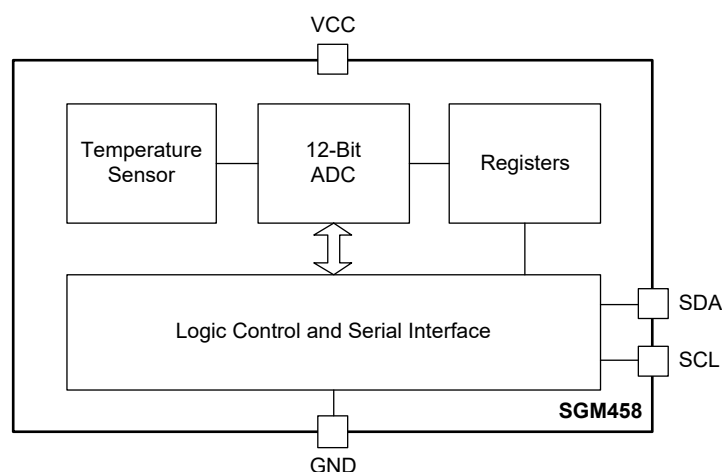


Figure 2. Block Diagram

ELECTRICAL CHARACTERISTICS(V_{CC} = 1.6V to 5.5V, T_A = -55°C to +125°C, typical values are at T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Temperature Input						
Range			-55		+125	°C
Accuracy (Temperature Error)		V _{CC} = 1.8V	-1.5	±1	1.5	°C
		vs. Supply		0.5		°C/V
Resolution				0.0625		°C
SCL and SDA Digital Input/Output						
High-Level Input Voltage	V _{IH}	V _{CC} is external open-drain pull-high power supply	0.7 × V _{CC}			V
Low-Level Input Voltage	V _{IL}	V _{CC} is external open-drain pull-high power supply			0.3 × V _{CC}	
Input Current	I _{IN}	0V < V _{IN} < V _{CC} + 0.3V		10	100	nA
Output Logic Levels	V _{OL}	SDA, V _{CC} > 2V, I _{OL} = 2mA	0	0.06	0.15	V
Resolution				12		Bits
Conversion Time				13	17	ms
Conversion Modes		CR1 = 0, CR0 = 0 (default)		0.25		Conv/s
		CR1 = 0, CR0 = 1		1		
		CR1 = 1, CR0 = 0		4		
		CR1 = 1, CR0 = 1		8		
Timeout Time				30	38	ms
Power Supply						
Operating Supply Range			1.6		5.5	V
Quiescent Current	I _Q	Serial bus inactive, CR1 = 0, CR0 = 0 (default), V _{CC} = 1.8V		2.9	3.9	μA
Shutdown Current	I _{SD}	Serial bus inactive, V _{CC} = 1.8V		0.7	2.5	μA
Temperature						
Specified Range			-55		+125	°C

TIMING REQUIREMENTS

PARAMETER	SYMBOL	FAST MODE		HIGH-SPEED MODE		UNITS
		MIN	MAX	MIN	MAX	
SCL Operating Frequency, $V_{CC} > 1.8V$	f_{SCL}	0.001	0.4	0.001	3.4	MHz
SCL Operating Frequency, $V_{CC} < 1.8V$		0.001	0.4	0.001	2.75	
Bus Free Time between STOP and START Condition	t_{BUF}	600		160		ns
Hold Time after Repeated START Condition After This Period, The First Clock is Generated.	t_{HDSTA}	100		100		ns
Repeated START Condition Setup Time	t_{SUSTA}	100		100		ns
STOP Condition Setup Time	t_{SUSTO}	100		100		ns
Data Hold Time	t_{HDDAT}	20	400	10	125	ns
Data Setup Time	t_{SUDAT}	100		10		ns
SCL Clock Low Period, $V_{CC} > 1.8V$	t_{LOW}	1300		160		ns
SCL Clock Low Period, $V_{CC} < 1.8V$	t_{LOW}	1300		200		ns
SCL Clock High Period	t_{HIGH}	600		60		ns
Clock/Data Fall Time	t_F		300			ns
Clock/Data Rise Time	t_R		300		160	ns
Clock/Data Rise Time, $SCL \leq 100kHz$	t_R		1000			ns

NOTE:

1. The above values are measured with one time, which means that the maximum and minimum of the results are not provided.

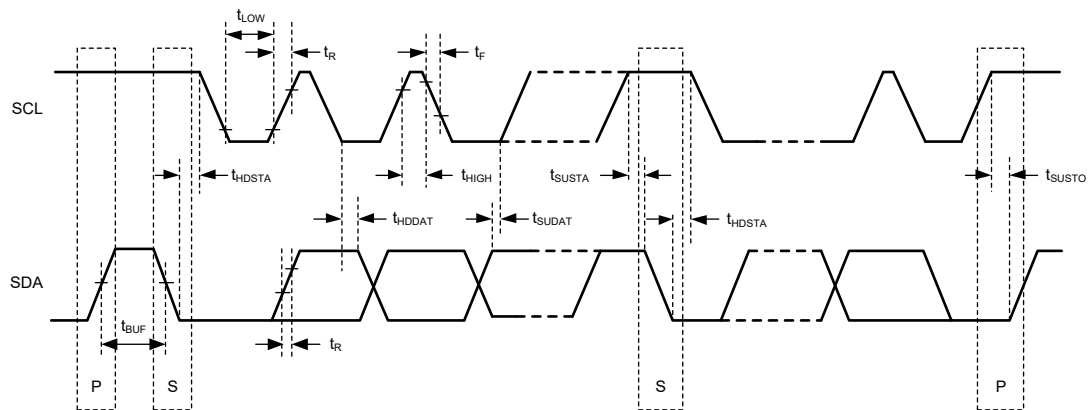


Figure 3. I²C Timing Diagram

Figure 3 to Figure 7 illustrate how the I²C works for the digital output of SGM458. The bus definition of Figure 3 is shown as below:

Bus Idle: SDA and SCL are in high position in this mode.

Start Data Transfer: When SCL remains in high position and SDA changes from high to low, a START condition occurs. The transmission should always be launched with a START condition.

Stop Data Transfer: When SCL remains in high position and SDA changes from low to high, a STOP condition occurs. The transmission should always be finished with a STOP condition.

Data Transfer: The data bytes transferred between START and STOP condition are determined by the master device.

Acknowledge: The acknowledge signal should be generated to guarantee that the receiving device is addressed. The SDA should be pulled low for the entire clock pulse of SCL during the acknowledge time. Both the data hold time and data setup time should also be considered. If the master is a receiving in this case, the receiver can also send a not-acknowledge pulse on the last byte.

SERIAL INTERFACE

Table 1. The First Byte after START (Address of Slave Device)

MSB							LSB
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1	1	1	0	A2	A1	A0	R/ \overline{W}

NOTES:

1. R: read, \overline{W} : write; ACK: acknowledge, NCK: not acknowledge.
2. All of SGM458 should acknowledge the transmission byte.
3. The acknowledge signal should be pulled low to issue a successful receiving for each read action.
4. The SGM458 version determines the values of A0, A1, and A2.

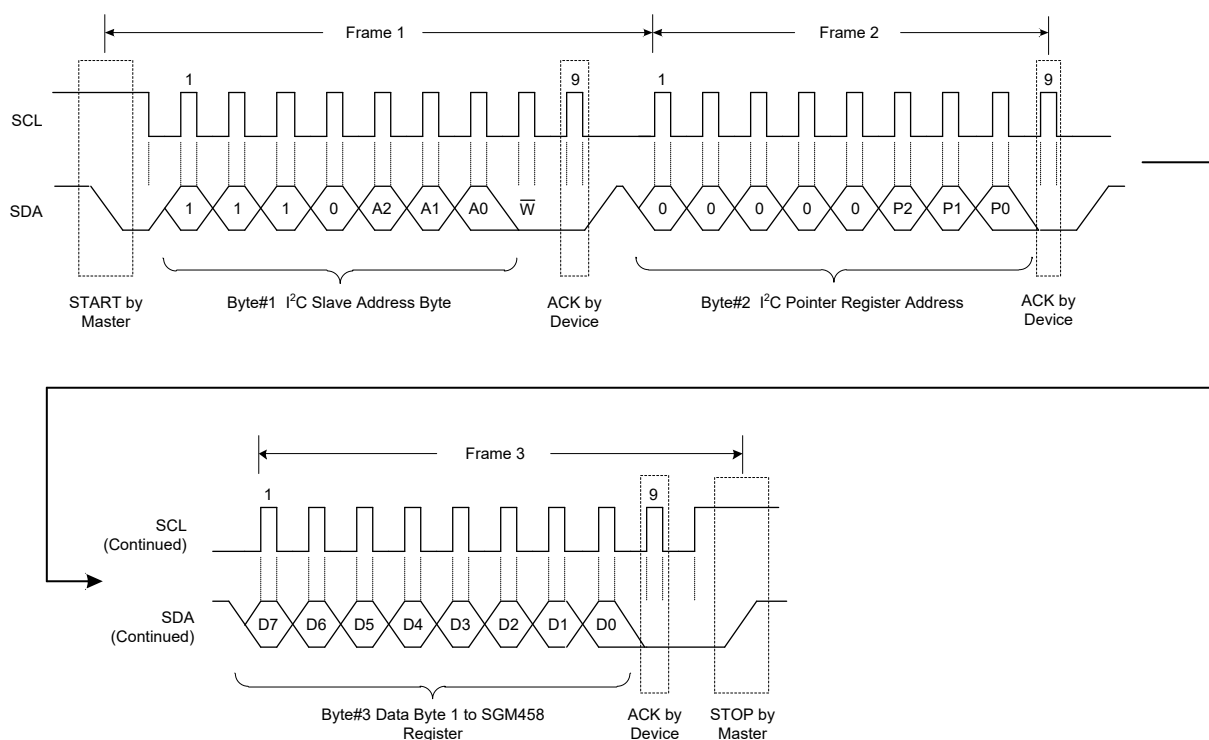


Figure 4. Register Write Byte Format

SERIAL INTERFACE (continued)

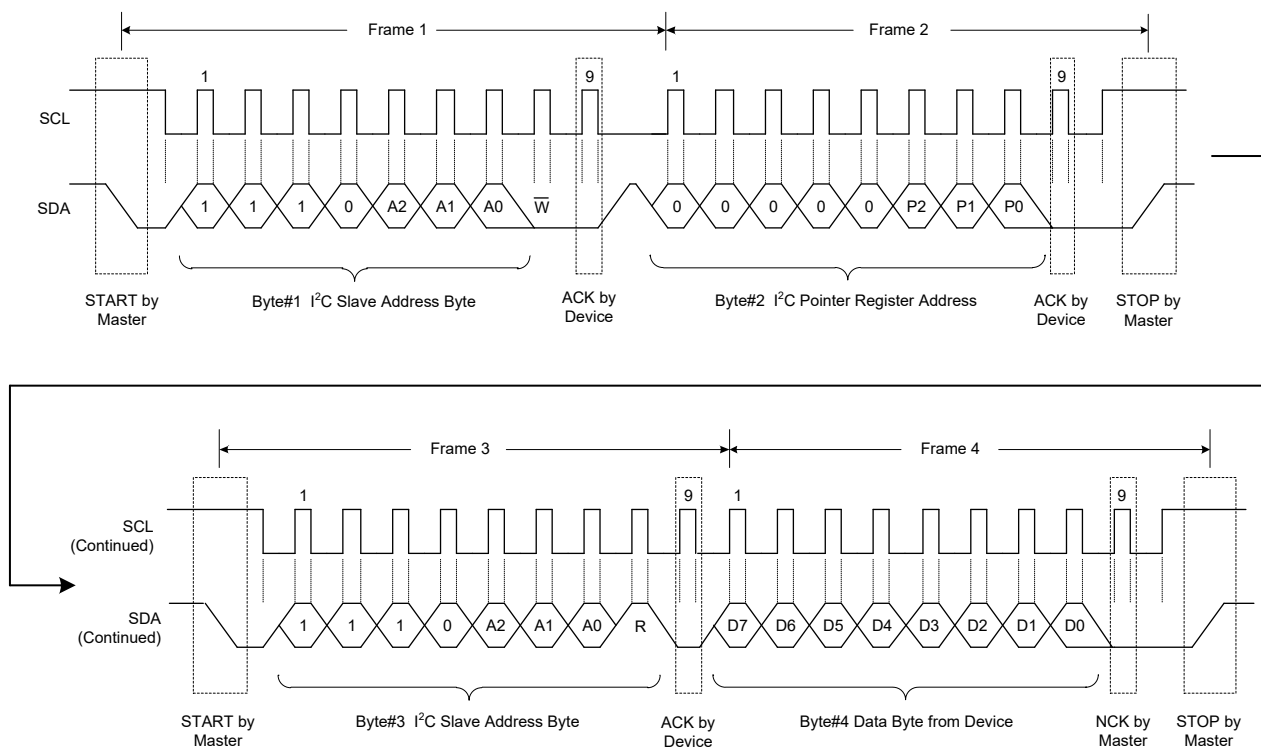


Figure 5. Register Read Byte Format

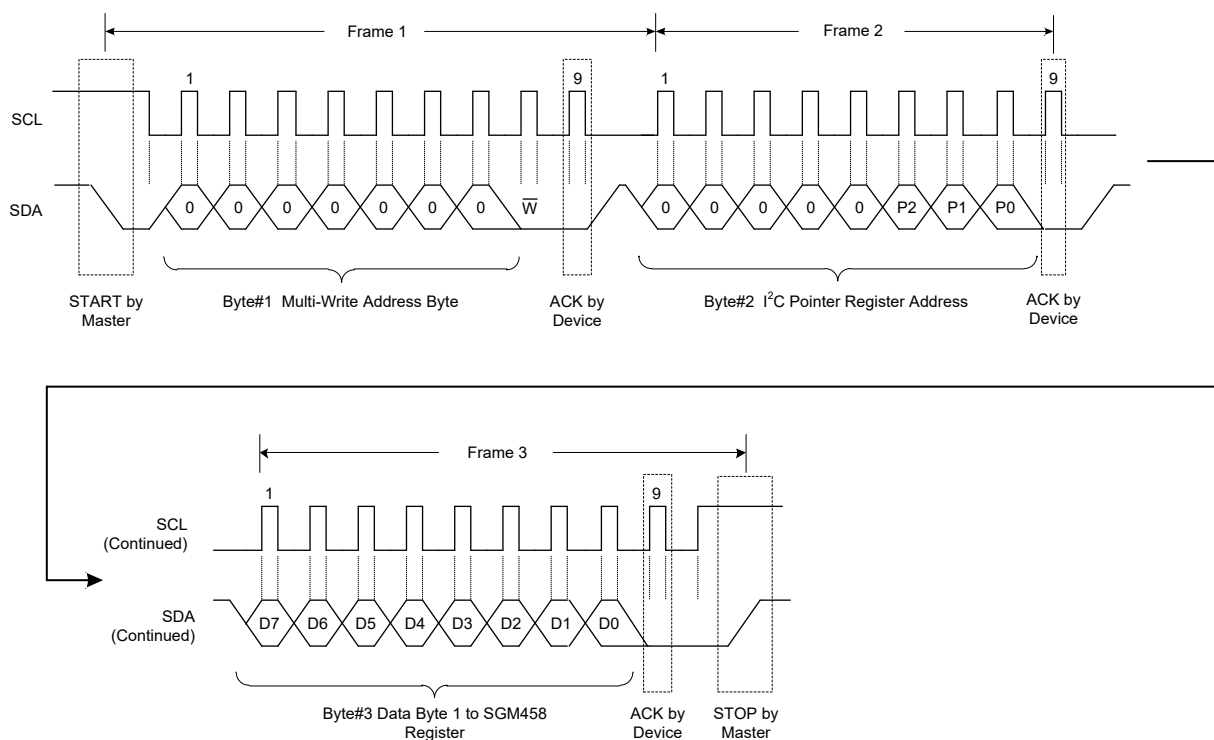


Figure 6. Register Multi-Write Format

SERIAL INTERFACE (continued)

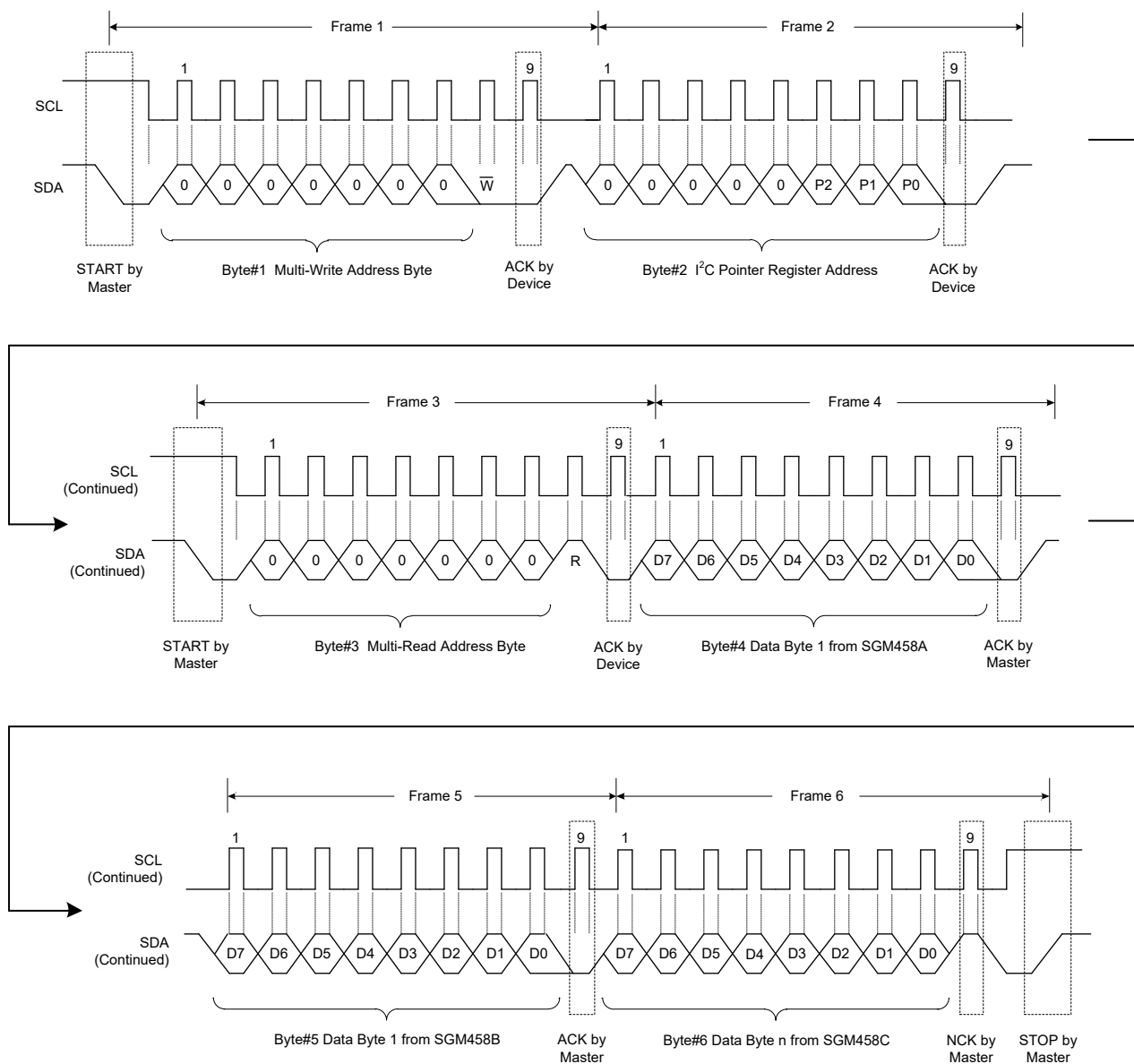
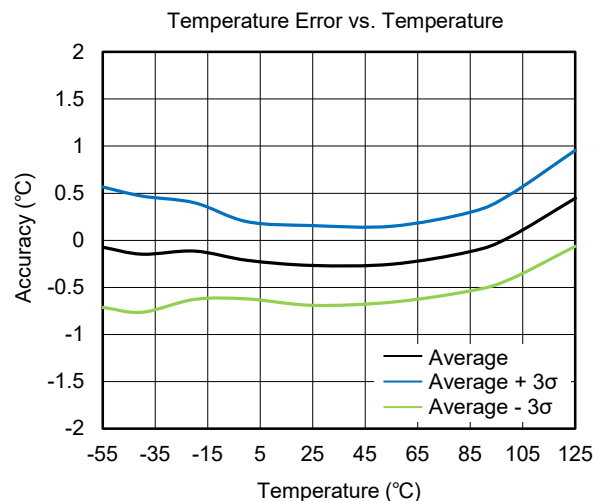
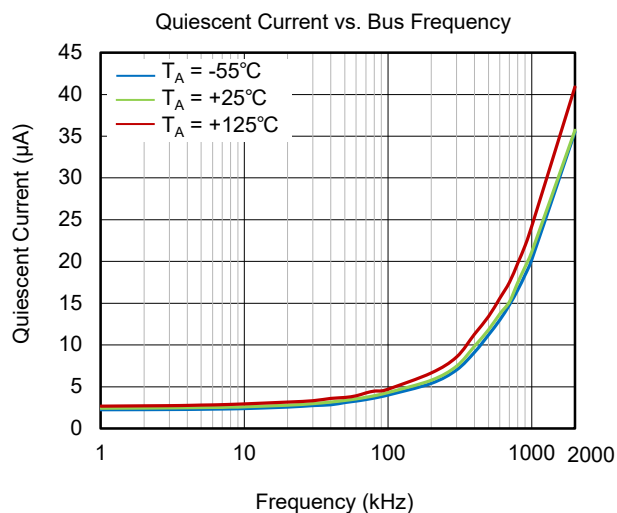
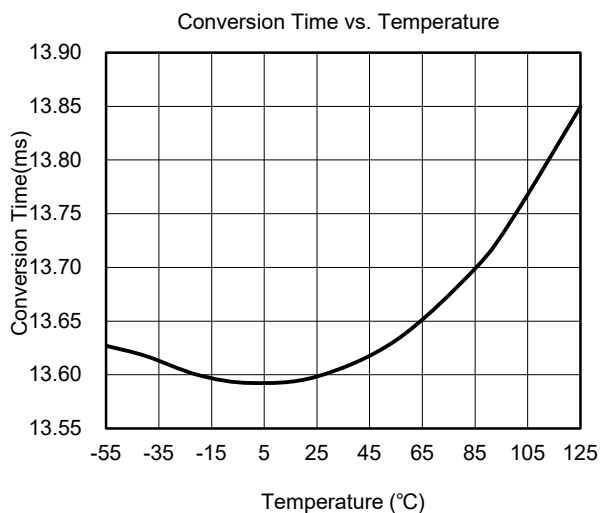
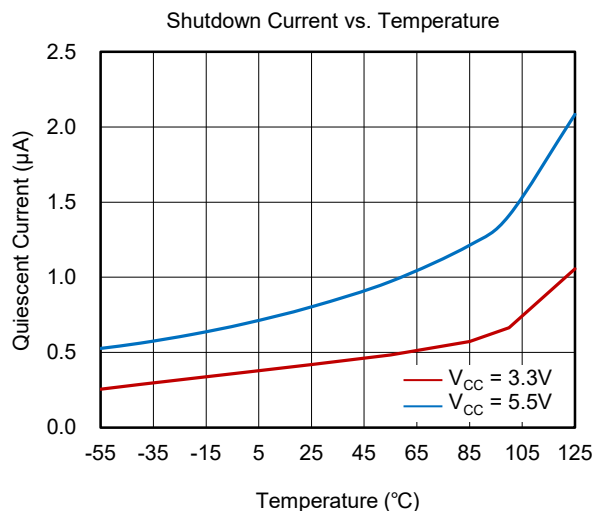
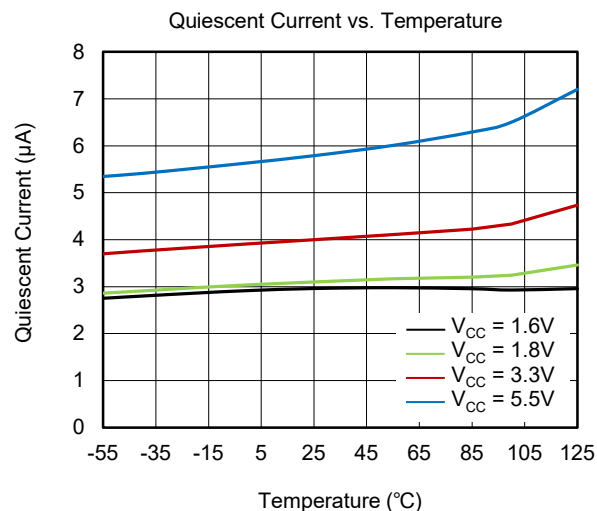


Figure 7. Register Multi-Read Format Using in Typical Application

TYPICAL PERFORMANCE CHARACTERISTICS

$V_{CC} = 1.8V$ and $T_A = +25^\circ C$, unless otherwise noted.



DETAILED DESCRIPTION

Overview

For the management of thermal profiling and management, the SGM458 has a better performance with the digital output and WLCSP package. The digital output can also be used for I²C interface and SMBus interface. In addition, it supports up to three SGM458 connections, sharing one I²C interface to connect to the master device. The commands of MDA can decrease the communication time and the power dissipation which is caused by the multiple connection of SGM458. For normal operation, the temperature range of the SGM458 is from -55°C to +125°C.

The I²C interface supports a maximum of three SGM458 connections. There are three different addresses for SGM458, which indicates different address for the slave device. Also, the internal register can write or read a byte with the I²C interface. The function of MDA allows all connected slave devices to communicate without sending the corresponding address to each SGM458.

For Figure 8, the pull-up resistors are required for the communication of I²C interface, and a 0.01μF bypass capacitor is also required to reduce the interface from power supply noise.

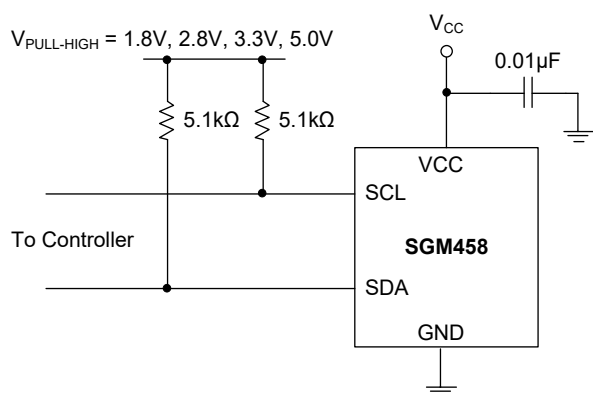


Figure 8. Typical Connections

The thermal paths of SGM458 are provided by the bumping of the internal thermal resistance. The accuracy of the measurement for surface or air environment would be enhanced by isolating the SGM458 from the ambient temperature.

Feature Description

The resolution of the SGM458 is just 0.0625°C and the two-wire digital structure can support MDA and I²C interfaces.

The mechanism of multiple device access (MDA) allows the slave to communicate at the same time, rather than sending the address for each slave device. Up to three SGM458 devices can be connected in parallel for easy reading, which means that the master device can simply read them with the I²C interface.

For power-sensitive and space-constrained applications, the SGM458 is a good choice and can be monitored by the master.

Programming

Temperature Watchdog Function

There is a watchdog function inside the SGM458 to check if the measured temperature is higher than the upper threshold or lower threshold of the device through T_{HIGH} and T_{LOW} registers. The flag-high bit (FH) is set to high if the measured temperature is higher than T_{HIGH}, and the flag-low bit (FL) is set to high if the measured temperature is lower than T_{LOW}. For the normal measurement case, if both FH and FL bit are set to low state, it means that the measured temperature is lower than T_{HIGH} and higher than T_{LOW}. The above three different cases are shown in Figure 9.

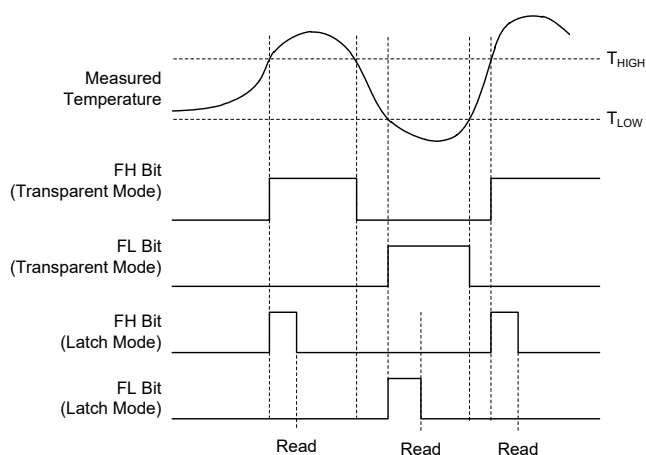


Figure 9. Temperature Flag Functional Diagram

DETAILED DESCRIPTION (continued)

The function of latch bit (LC) is used to pull the corresponding FH and FL bit high in latching mode and generate a pulse if the temperature is higher or lower than the limitation until the master completes read and sends a read command to the slave. If a read command is already received by SGM458 after a LC pulse or the measured temperature is within the limitations, the LC function will be low. For the default values when power-on, the LC, FH and FL are all in low state.

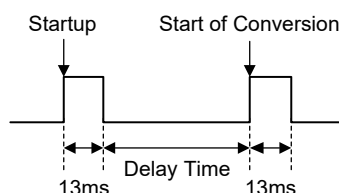
Conversion Rate

Users can set the value of CR1 and CR0 that are located in the corresponding register to adjust the conversion rates. Typically, the conversion time for SGM458 is 13ms. If the users desire to set a different conversion rate, the single conversion will be achieved first, and then the device will be powered down to wait the appropriate CR1 and CR0. The corresponding value of CR1 and CR0 is shown in Table 2.

Table 2. Conversion Rate Settings

CR1	CR0	Conversion Rate
0	0	0.25Hz (default)
0	1	1Hz
1	0	4Hz
1	1	8Hz

The startup conversion is taken placed immediately as the power-up or general-call reset. For the first result of the conversion, it should be after 13ms. For the active mode, the quiescent current for the conversion is 77 μ A (typical at +25°C, $V_{CC} = 1.8V$). For the delay mode, the quiescent current in this period is just 2.5 μ A (typical at +25°C, $V_{CC} = 1.8V$).



NOTE: 1. The delay time is set by CR1 and CR0.

Figure 10. Conversion Start**Shutdown Mode (M1 = 0, M0 = 0)**

When the shutdown mode operates, all of the circuitry inside SGM458 will be shutdown with the quiescent current of 0.7 μ A (TYP). If the values of M1 and M0 are equal to 0, the device will enter to shutdown mode after the conversion is completed.

One-Shot (M1 = 0, M0 = 1)

The one-shot mode can be supported by SGM458. For single conversion of the temperature measurement, simply writing 01 to M1 and M0 respectively when the device is in shutdown mode. The values of M1 and M0 are 01 in the conversion period. After finishing the conversion, the SGM458 will return to shutdown mode immediately and the values of M1 and M0 will convert to 00. For the applications that do not need to measure the temperature continuously, this feature can reduce the power consumption of the circuit.

The higher conversion rate can be achieved by SGM458 as well. A read command can be taken place in less than 20 μ s while a single conversion will take 13ms. When M1 and M0 are equal to 01 respectively (one-shot mode), the conversions can be greater than or equal to 30 times per second.

Continuous Conversion Mode (M1 = 1)

If the device is operated at continuous mode with M1 = 1, the conversion rate is determined by the bits of CR1 and CR0. For the process of the continuous conversion, it starts with a single conversion and then operates in shutdown mode until the master sends the values to CR1 and CR0 bits.

Bus Overview

The device which can send the command to the target register is called master and the device which can be controlled by the master is called slave. The master device can generate the clock signal to the slave in order to control it with SCL and SDA lines.

Send a specific address to start the slave, the SDA signal will be pulled from high to low while SCL is still in high state. For the slaves connected to the bus, at the CLK rising edge, the slaves start to be addressed by the master, and followed by a READ or WRITE bit. For the ninth bit of the transmission signal, if SDA is pulled low, the slave acknowledges the transmission, in which case the slave is being addressed.

DETAILED DESCRIPTION (continued)

In one word, for the data transfer process, the initial signal will indicate a start state, and then followed by eight clock pulsed and an acknowledge signal. However, the stability of SDA signal should be guaranteed when SCL is high, otherwise it will be mistaken for START or STOP mode. After the transmission completes, the signal of SDA will change from low to high when SCL is high.

Serial Interface

On the two-wire bus or SMBus, the SGM458 can be operated as a slave device, which is controlled by the master. When connecting to the bus, both SDA and SCL pins are connected through the topology of open-drain. In addition, in order to improve the performance of slave devices under the condition of input peak value and noise bus, filter and Schmitt flip-flop are adopted. There are two modes of transmission protocol: fast mode (1kHz to 400kHz) and high-speed mode (1kHz to 3.4MHz). MSB is the first bit to be transferred when transmitting a byte.

Serial Bus Address

For the definition of I²C communication, before sending data, the master device should address the specified slave device. There are seven bits for the address of the slave device and another one bit is for the command of reading or writing.

The SGM458 has three different slave addresses as shown in Table 3. For the function of the address, it can use to indicate the location or designator of temperature for three different connected slave SGM458s.

Table 3. Different Slave Addresses of SGM458

Product	Slave Address						
					A2	A1	A0
SGM458A	1	1	1	0	0	0	0
SGM458B	1	1	1	0	0	0	1
SGM458C	1	1	1	0	0	1	0

Writing and Reading Operation

In order to access the specified pointer register of SGM458, it is necessary to send the values of the

desired pointer register after addressing the slave device. As already illustrates in Figure 3, the values of pointer register are required after each write command.

If the master device desires to read the information of the specified register, a write command must be send by the master at first to indicate which pointer register is needed. First, the slave address should be sent with the low state of R/ \bar{W} , followed by the address of the pointer address. Second, the START command should be sent by the master, the slave address of the specified SGM458, and then followed with the high state of R/ \bar{W} to indicate a read command (Figure 4). For the condition of repeated reading, it is not required for sending the bytes of pointer register again, unless the device is reset or the address of pointer register is altered by the write command.

Slave Receiver Mode and Slave Transmitter Mode

The SGM458 can also transmit or receive the information under read or write condition. The device cannot drive the SCL signal when used as a slave device.

When the slave is desired to receive the data, the master will firstly send a slave address to the slave, followed by R/ \bar{W} is low. After transmitting the slave address, the slave (SGM458) will pull SDA low to indicate an acknowledgement. Then, the address of pointer register is sent by the master and an acknowledgement signal is also required for the slave device. In addition, the data is written to the addressing pointer register, followed by the acknowledgement signal from the slave device. If the master wants to stop the transmission, a START or STOP command is required.

The R/ \bar{W} is pulled high after the slave address is transmitted by the master device, followed by an acknowledgement of the slave. Then, the data is transmitted by the specified pointer register of the slave device, followed by the acknowledgement of the master. In addition, if the master wants to stop the transmission, it can generate a not-acknowledge command or generate a START or STOP command to terminate the transmission.

DETAILED DESCRIPTION (continued)**General Call**

The SGM458 also supports a general call address (0000000) when the eighth bit is low. After receiving an acknowledgement signal from the slave device, the master prepares to send a second byte to the device. In this case, if the second byte is 00000110, the slave device (SGM458) will go into power-up mode and reset all registers. However, the SGM458 cannot acquire an address for general call from the master device.

High-Speed (Hs) Mode

If the transmission frequency is greater than 400kHz, in order for SGM458 to work in high-speed mode, the byte that is 00001xxx must be transmitted after the START condition by the master. 00001xxx command can be sent up to 1MHz (see Table 4 below) even when the SGM458 is in default mode (which is fast mode).

Table 4. Master Timing Requirements for Switching to I²C Hs-Mode

Symbol	Min	Max	Recommend Values	Unit
f _{SCL}	0	1000		kHz
t _{LOW}	500			ns
t _{HIGH}	260			ns
t _{HDSTA}	260			ns
t _{SUSTA}	260			ns
t _{HDDAT}	0			ns
t _{SUDAT}	75		250	ns
t _{BUF}	500			ns
t _{SUSTA}	260			ns
t _{R/tF}		120	40	ns

However, the SGM458 does not need to generate an acknowledge byte, but the input and output filters can be adjusted accordingly (up to 3.4MHz) to make SGM458 operate in high-speed mode. After the high-speed byte is transmitted, the master will transmit a START command, followed by the slave address to the SGM458. In addition, the high-speed mode will stop once the STOP command is transmitted from the master, and the input and output filters of SGM458 will be switched to the default mode.

Timeout Function

If the SCL line is pulled low by 30ms, it means that the SGM458 will perform reset mode. Under this condition,

the bus is released by SGM458 and then another START function is required for operation. To prevent the device goes into the timeout function, the operation frequency of the SCL should be greater than or equal to 1kHz.

Multiple Device Access (MDA)

The function of MDA can allow the master to communicate with up to three SGM458 devices on the same bus. There are two commands included in the MDA command, they are the address of MDA read (00000001) and MDA write (00000000). In addition, the SGM458 will send an acknowledge signal to the master after receiving a MDA command. If the users desire to use MDA function, the slave address of the SGM458 must be different.

Multiple Device Access Write:

At first, the MDA write command should be sent by the master device, and followed by the address of the specified pointer register (Table 6). After that, the slave devices connected to the same bus waits to be communicated by the master. After transmitting the data byte to the SGM458 devices, the information will be saved inside the pointer register and an acknowledge signal will be sent. In addition, the same information will be saved by the connected devices of SGM458 within only one transaction (Figure 6).

Multiple Device Access Read:

As mentioned before, if the master reads the information from the connected slave devices in MDA mode, it must first send a write command to the pointer register. Then, a read command can be transmitted to the pointer register of the slave devices. For instance, there are two slave devices (SGM458A and SGM458B) connected on the same bus. After the master device sends the MDA read command, the two bytes from SGM458A and SGM458B should be sent and followed by two acknowledge signals respectively from the master device. For each bytes from the slave devices, the master must send an acknowledge signal respectively to ensure that it already reads the data bytes from the slaves (Figure 7). However, if there is no acknowledge signal sent from the master device for each byte, the slave device will stop transmitting data to the master for reading.

DETAILED DESCRIPTION (continued)

The maximum slave devices that can be connected to the same bus is three, see Table 3. However, if the sequence of connected SGM458 devices is incomplete, the master should send the bytes to the dummy one as well to ensure that the system can operate normally. For instance, if SGM458A, SGM458B and SGM458D are connected on the same bus, after the MDA command is being transmitted, the four bytes and four ACKs must be followed in order to finish the MDA transaction.

Noise

Because of the low power property of SGM458, the level of noise generated by the SGM458 is low. However, in order to further reduce the noise problem of SGM458 and ensure that it does not affect other

devices connected on the same power supply, an RC filter can be taken in account. The resistance value should be lower than $5k\Omega$ and the capacitance value should be greater than $10nF$.

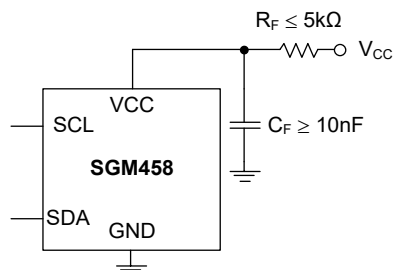


Figure 11. Noise Reduction

REGISTER DESCRIPTION

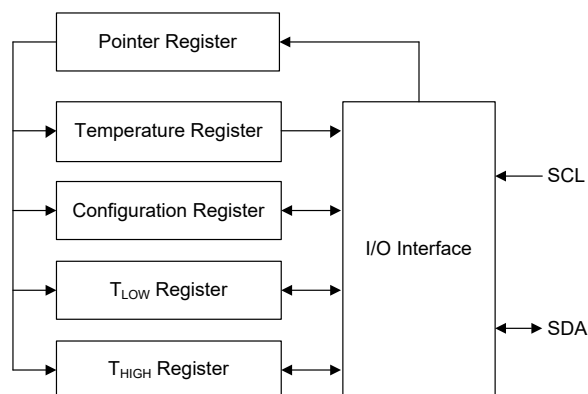


Figure 12. Internal Register Structure

Pointer Register

The registers of the SGM458 is shown in Figure 12. There is a pointer register followed by the I/O pins, which can give address for the following four registers. The three LSBs of the pointer register indicate which register the master wants to communicate with. The byte detail information is shown in Table 6. If the master wants to send a write command to the pointer register, P[7:3] must be set to 0. Table 7 indicates the address of the internal registers. If P[2:0] is 000, it also means that the device will be in the power-on reset mode, which means that SGM458 can also read the temperature when it is on power-up.

Temperature Register

The resolution of SGM458 is 12 bits, and the device can only support the function of reading. However, for the READ command, the two bytes should be transmitted by SGM458. That is, the MSB is for byte 1 and LSB is for byte 2. For the code of temperature, the first 12 bits represent the temperature converted by the internal ADC. If the customer application does not require information about TD[3:0], this part of the least significant bit is useless.

Negative numbers are represented in binary two's complement format. Following power-up or reset, the Temperature Register reads 0 until the first conversion completes.

The following equations illustrate how to transfer digital format to analog format or how to transfer analog format to digital format.

For converting the positive temperature to the corresponding digital signal:

1. The result of the temperature should be divided by the LSB of the temperature.

2. After calculation, convert the decimal value to binary value and then the digital signal is obtained.

Example: $(50^{\circ}\text{C}) / (0.0625^{\circ}\text{C}/\text{LSB}) = 800 = 320\text{h} = 001100100000$

For converting the digital signal to the corresponding temperature:

1. Firstly, convert the 12-bit digital signal to the corresponding decimal value, and MSB = 0 means that the corresponding temperature is a positive value.

2. The result of decimal value should be multiplied by the LSB to get the corresponding temperature.

Example: $001100100000 = 320\text{h} = 800 \times (0.0625^{\circ}\text{C}/\text{LSB}) = 50^{\circ}\text{C}$

For converting the positive temperature to the corresponding digital signal:

1. The result of the absolute temperature should be divided by the LSB of the temperature.

2. The value of two's complement format can be obtained by obtaining the complementary of the result digital signal and adding 1.

Example: $(|-25^{\circ}\text{C}|) / (0.0625^{\circ}\text{C}/\text{LSB}) = 400 = 190\text{h} = 000110010000$

Two's complement format: $111001101111 + 1 = 111001110000$

Table 5. 12-Bit Temperature Data Format

The resolution for the temp ADC in internal temperature mode is $0.0625^{\circ}\text{C}/\text{count}$.

Temperature ($^{\circ}\text{C}$)	Digital Output (Binary)	Hex
+128	011111111111	7FF
+127.9375	011111111111	7FF
+100	011001000000	640
+80	010100000000	500
+75	010010110000	4B0
+50	001100100000	320
+25	000110010000	190
0.25	000000001100	004
0	000000000000	000
-0.25	111111111100	FFC
-25	111001110000	E70
-55	110010010000	C90

REGISTER DESCRIPTION (continued)

Configuration Register

Configuration Register

The operation mode is defined in the configuration register. MSB code indicates the state of read (R) or write (\bar{W}). Table 10 illustrates the structure of the configuration register. All registers will be updated at the end of the bytes.

Temperature Limit Registers

The thresholds that are T_{HIGH} and T_{LOW} indicate the two temperature limits for the function of watchdog. After

measuring the temperature, the device will compare the result value with two thresholds to check if it exceeds the limitation. FH bit will be set to high state if the measured temperature is greater than T_{HIGH} . FL bit will be set to high state if the measured temperature is greater than T_{LOW} (Figure 12).

Table 13 and Table 14 illustrate the corresponding byte to set the T_{HIGH} and T_{LOW} thresholds. At the instant of power-on reset, the default values of T_{HIGH} and T_{LOW} are +60°C and -10°C respectively.

REGISTER MAPS

Table 6. Pointer Register

MSB					LSB		
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	0	0	0	0	P2	P1	P0
					Pointer Select Bits		

Table 7. Register Pointers Selection:

POINTER VALUE	P2	P1	P0	DESCRIPTION	TYPE
0x00	0	0	0	MSB Temperature Register (Byte-1)	R
0x01	0	0	1	Configuration Register	R/W
0x02	0	1	0	T_{LOW} Register (Low-Side Threshold of Temperature limit)	R/W
0x03	0	1	1	T_{HIGH} Register (High-Side Threshold of Temperature limit)	R/W
0x04	1	0	0	LSB Temperature Register (Byte-2)	R

Table 8. MSB Temperature Register (Byte-1)

MSB				Temperature MSB			
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TD11 (Sign)	TD10 (TMSB)	TD9	TD7	TD7	TD6	TD5	TD4

Table 9. LSB Temperature Register (Byte-2)

Temperature LSB						LSB	
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TD3	TD2	TD1	TD0 (TLSB)	0	0	0	0

Table 10. Configuration Register

MSB					LSB		
ID	Conversion Rate		Flag of Temperature comparing			Working Mode	
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
ID	CR1	CR0	FH	FL	LC	M1	M0
0 (Default)	0(Default)	0(Default)	0(Default)	0(Default)	0(Default)	1(Default)	0(Default)

REGISTER DESCRIPTION (continued)

Table 11. Conversion Rate Setting:

CR1	CR0	Conversion Rate (Hz)
0	0	0.25
0	1	1
1	0	4
1	1	8

Table 12. Working Mode setting:

M1	M0	Mode
0	0	Shutdown
0	1	One-Shot Conversion
1	X	Continuous Conversion

Working Mode Setting:

- (1) Shutdown Mode: Except the serial interface is active, other circuit is in shutdown status in this mode.
- (2) One-shot Conversion: In shutdown mode, when receiving M1 = 0, M0 = 1, SGM458 will execute one time conversion. After finishing the conversion, SGM458 will enter into shutdown mode again.

- (3) Continuous Conversion Mode: SGM458 will execute conversion continuously according to the conversion rate setting in configuration register.

The Flag of Temperature Comparing:

The Default value after power-on is FH = 0, FL = 0, LC = 0;

- (1) When the conversion result in MSB Temperature Register (Byte-1) > T_{HIGH} , then FH = 1;
- (2) When the conversion result in MSB Temperature Register (Byte-1) < T_{LOW} , then FL = 1;
- (3) When the conversion result in MSB Temperature Register (Byte-1) is between T_{HIGH} and T_{HIGH} , then FH = 0, FL = 0;
- (4) LC = 0, FH and FL are in Transparent mode, FH and FL will change according to the conversion result in MSB Temperature Register (Byte-1). LC = 1, FH and FL are in Latch mode, FH and FL will latch its flag until the host finishes a read command to configuration register. After a read command, both FH and FL change to 0.

 T_{HIGH} RegisterTable 13. T_{HIGH} Register

SMB							LSB
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TD7	TD6	TD5	TD4	TD3	TD2	TD1	TD0

 T_{LOW} RegistersTable 14. T_{LOW} Register

SMB							LSB
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TD7	TD6	TD5	TD4	TD3	TD2	TD1	TD0

APPLICATION INFORMATION

Typical Application Circuit

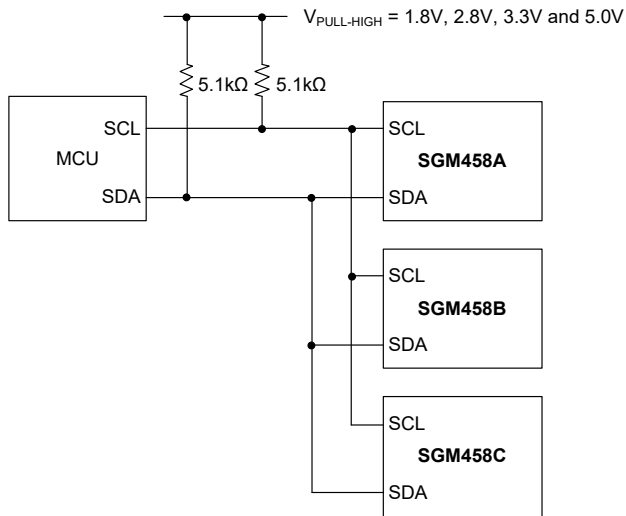


Figure 13. Typical Application Circuit

Design Requirements

The pull-up resistors on the SCL and SDA pins of SGM458 are necessary. The selection of the pull-up resistors is important because it will affect the sinking capability of the I/O pins of the SGM458. Also, the 0.01μF bypass capacitor needs to be placed as close to the power supply pin of the device as possible.

Detailed Design Procedure

When measuring the heat source, the SGM458 must be placed as close to the measured source as possible, and a good layout is also required for the coupling of heat. Furthermore, this kind of placement

can make sure that changes in the measured temperature can be detected as quickly as possible. In addition, the accuracy of the measurement for surface or air environment will be enhanced by isolating the SGM458 from the ambient temperature. Due to the low power consumption characteristics of SGM458, the noise level generated by the SGM458 is low. To further reduce the noise issue from SGM458 and ensure that it does not affect other devices connected to the same power supply, an RC filter can be taken into account, and the value of resistor should be lower than 5kΩ and the value of capacitor should be greater than 10nF.

Power Supply Recommendations

The supported power supply range of the SGM458 is from 1.6V to 5.5V. For the optimized power supplies of the SGM458, they are 1.8V, 2.8V, 3.3V and 5.0V respectively. However, the measured accuracy can be guaranteed by the whole power supply range.

Layout Guidelines

A 0.01μF bypass capacitor should be placed as close to the power supply pin as possible. And for the noisy power supply case, another capacitor should be added to reject the noise of the power supply. Two 5kΩ resistors are also required for SDA and SCL pins for their open-drain topology.

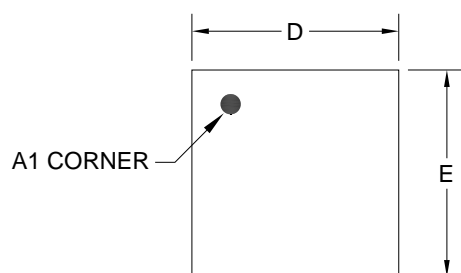
REVISION HISTORY

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

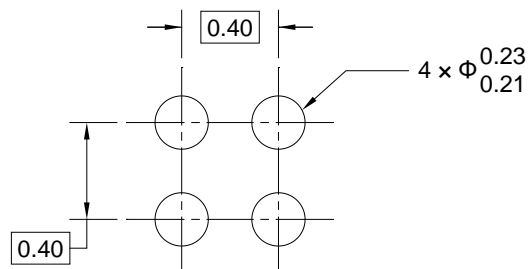
DECEMBER 2023 – REV.A.4 to REV.B	Page
Changed Detailed Description section	13
NOVEMBER 2023 – REV.A.3 to REV.A.4	Page
Changed Electrical Characteristics section	4
OCTOBER 2023 – REV.A.2 to REV.A.3	Page
Changed Electrical Characteristics section	4
MARCH 2023 – REV.A.1 to REV.A.2	Page
Update Package/Ordering Information section.....	2
AUGUST 2022 – REV.A to REV.A.1	Page
Update Package/Ordering Information section.....	2
Update Tape and Reel Information section	20
Changes from Original (JUNE 2022) to REV.A	Page
Changed from product preview to production data.....	All

PACKAGE OUTLINE DIMENSIONS

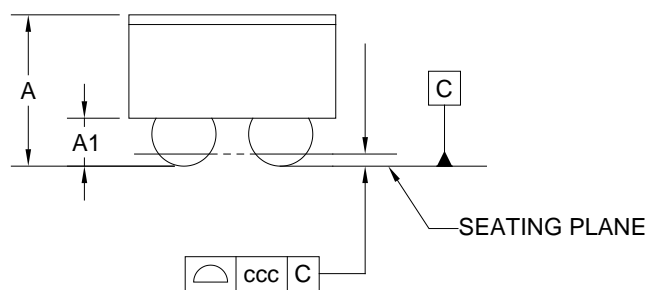
WLCSP-0.85x0.85-4B



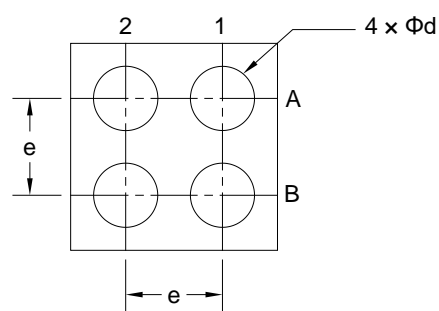
TOP VIEW



RECOMMENDED LAND PATTERN (Unit: mm)



SIDE VIEW



BOTTOM VIEW

Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	0.587	0.625	0.663
A1	0.178	0.198	0.218
D	0.825	0.855	0.885
E	0.825	0.855	0.885
d	0.235	0.265	0.295
e	0.400 BSC		
ccc	-	0.050	-

NOTE: This drawing is subject to change without notice.

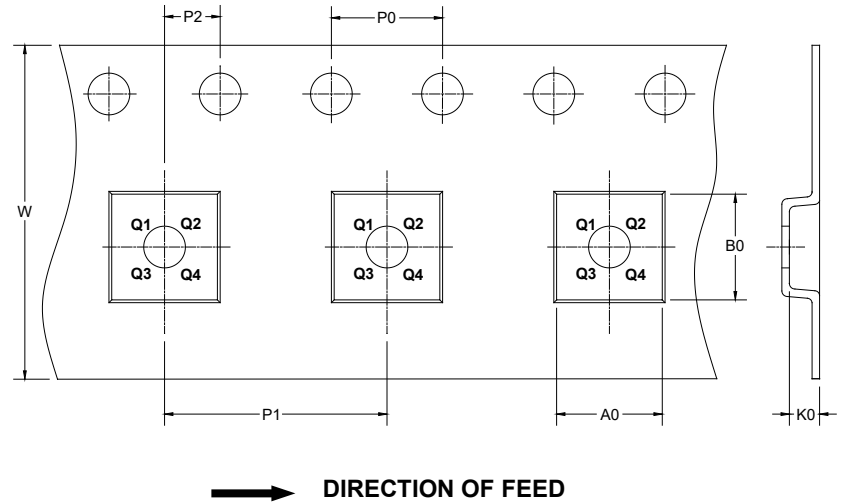
PACKAGE INFORMATION

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



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

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
WLCSP-0.85×0.85-4B	7"	9.5	0.94	0.94	0.71	4.0	4.0	2.0	8.0	Q1

DD00001

PACKAGE INFORMATION

CARTON BOX DIMENSIONS



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

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7" (Option)	368	227	224	8
7"	442	410	224	18

DD0002