GX122 0.5°C Programmable Digital Temperature Sensor with SPI Interface

FEATURES

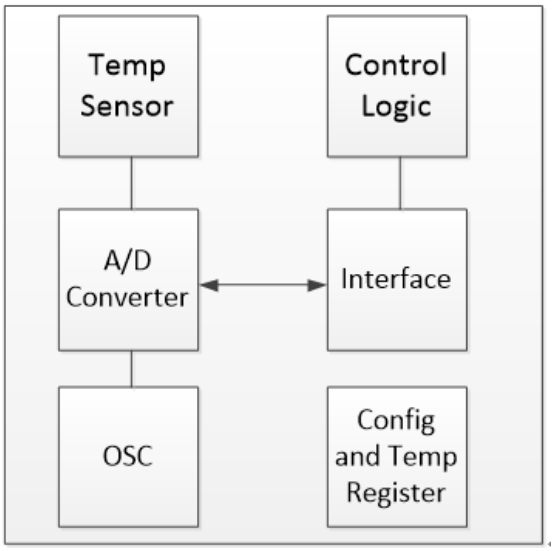
- Digital output: SPI compatible interface
- Programmable resolution: 9 to 12 bits + sign bit
- Accuracy：±0.3℃ -25℃～+85℃（typical）
  ±0.5℃ -40℃～+125℃（typical）
- Low quiescent current：50μA
- Wide range of power supply：2.7V to 5.5V
- Small SOT23-6 package
- Can operate at 150°C
- Programmable high/low setpoints

APPLICATION

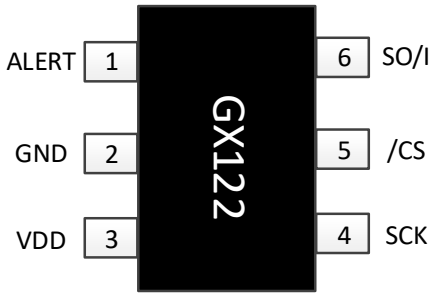
- Automotive pressure sensor
- Power supply temperature monitoring
- Computer Peripheral Thermal Protection
- laptop
- Phone
- Battery management
- Office machine
- Thermostat control
- Environmental Monitoring and HVAC
- Electromechanical equipment temperature

DESCRIPTION

The GX122 is an SPI compatible temperature sensor available in a SOT23-6 package. The GX122 temperature sensor only needs a pull-up resistor to achieve a typical temperature accuracy of 0.3°C in the temperature range of -25°C to +85°C，and the operating temperature is as high as 150°C. Programmable resolution, programmable set point and shutdown function provide versatility for any application. Low supply current and a power supply range from 2.7V to 5.5V make the GX122 an excellent candidate for low power applications. The GX122 is ideal for extended thermal measurement in a variety of communications, computer, consumeren, vironmental,industrial, and instrumentation applications.



PIN CONFIGURATIONS



Content

1 Electrical Properties

Parameter	Condition	GX122			Units
		Min	Typ	Max	
Temperature Range		-55		+150	˚C
Accuracy (temperature error)	–25˚C to +85˚C		±0.3	±0.5	˚C
	–40˚C to +125˚C		±0.5	±1.0	˚C
	–55˚C to +150˚C		±1.0		˚C
Varies with power supply		-0.3	0.1	+0.3	˚C/V
Resolution (1)	optional		±0.0625		˚C
Input logic V_{IH}		0.7（V+）			V
Input logic V_{IL}				0.3（V+）	V
Input Current SO/I SCK $\overline{CS}$	0V ≤ VIN ≤ V+			±1	μA
Output logic V_{OL} SO/I	ISINK = 3mA			0.4	V
Output logic V_{OH} SO/I	ISOURCE = 2mA	(V+)-0.4			V
Output logic V_{OL} ALERT	ISINK = 4mA			0.4	V
Leakage current ALERT	0V ≤ VIN ≤ 6V			±1	μA
Input capacitance SO/I SCK /$\overline{CS}$ /ALERT			2.5		pF
Resolution	optional		9 to12 + Sign		Bits
Conversion time	9-Bit + Sign		30	40	ms
	10-Bit + Sign		60	80	ms
	11-Bit + Sign		120	160	ms
	12-Bit + Sign		240	320	ms
Operating range		2.7		5.5	V
Operating Current	no communication		50	75	μA
Standby Current	no communication		20		μA
Shutdown current	no communication		0.1	1	μA
Specified range		-40		+125	˚C
Operating range		-55		+150	˚C
Storage range		-60		+150	˚C
Thermal resistance	SOT23-6 Surface-Mount		200		˚C/W

2 Application information

The GX122 digital temperature sensor is the best choice for thermal management and thermal protection applications. GX122 is compatible with SPI interface and the specified temperature range is -55℃～+150℃. The GX122 requires minimal external components to operate, requiring only a pull-up resistor on the ALERT pin and a bypass capacitor on the power supply. A 0.1μF bypass capacitor is recommended. Figure 1 shows typical connections for the GX122. To maintain accuracy in applications requiring air or surface temperature measurements, care should be taken to isolate the package and leads from the ambient air temperature.

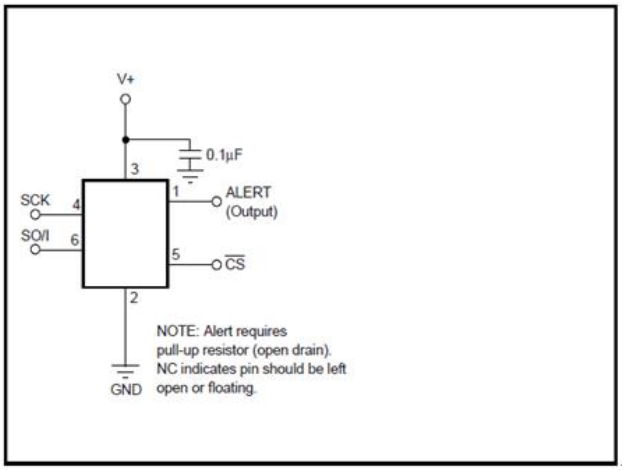


Figure 1. Typical connection of GX122

3 Communicating with GX122

The GX122 converts continuously. If CS falls during a conversion, the conversion process continues, but the last completed conversion is stored in the output register. GX122 starts by pulling CS low, and the first 16 clocks of data transmission will return temperature data from the temperature sensor. A 16-bit data word outputs the sign bit first, then the MSB. Any part of a 16-bit word can be read before CS is raised. If the user wants to continue to use CS low, the next 16 clocks will be transmitted in the form of read or write commands. See Table 1 and Table 2 for read and write commands.

Table 1. Read Command

Read Command	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Temperature	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Configuration register	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Low temperature threshold	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
High temperature threshold	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0

Table 2. Write Command

Write Command	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
configuration register	0	0	0	0	D1	D0	R1	R0	F1	F0	POL	TM1	TM0	0	1	0
low temperature threshold	T12	T11	T10	T9	T8	T7	T6	T5	T4	T3	T2	T1	T0	1	0	0
high temperature threshold	T12	T11	T10	T9	T8	T7	T6	T5	T4	T3	T2	T1	T0	1	1	0
shutdown command	X	X	X	X	X	X	X	X	1	1	1	1	1	1	1	1

The Read command contains an embedded address in bits D4 and D3 that identifies the register to be read. Bits D4 and D3 are registered internally and hold their value after a read command until the user completes the entire 16-bit read. The completion of the 16-bit read confirms that the read command has completed. If the read time of the next CS command is less than 16, the user will issue a command to read data from the next CS. Registered read addresses will remain valid until a full 16 clocks have been received. After completing the 16-bit read from the part, the read address is reset to return data from the temperature register. A write command to a register does not change the registered read address. See the Reading Address Register section for further discussion on reading the address register.

Multiple commands can be strung together, as shown in Figure 2. The GX122 accepts commands alternated with 16-bit response data. When CS is lowered, the part always reads the response from the address location indicated by the read address register. If the next command is a read command, the data is returned from the address specified by the read command, and the 16th clock resets the read address register to the default temperature register. GX122 requires a 16-bit command. If the command is a write command, 16 clocks after the command will return the temperature data again. Figures 3, 4, 5 and 6 illustrate the communication sequence in detail.

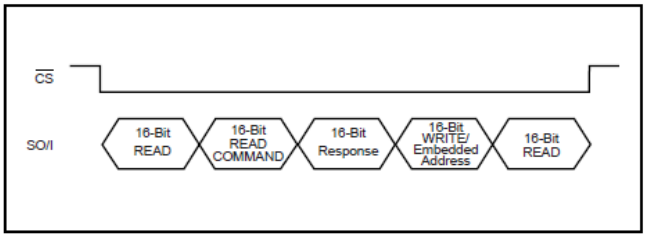
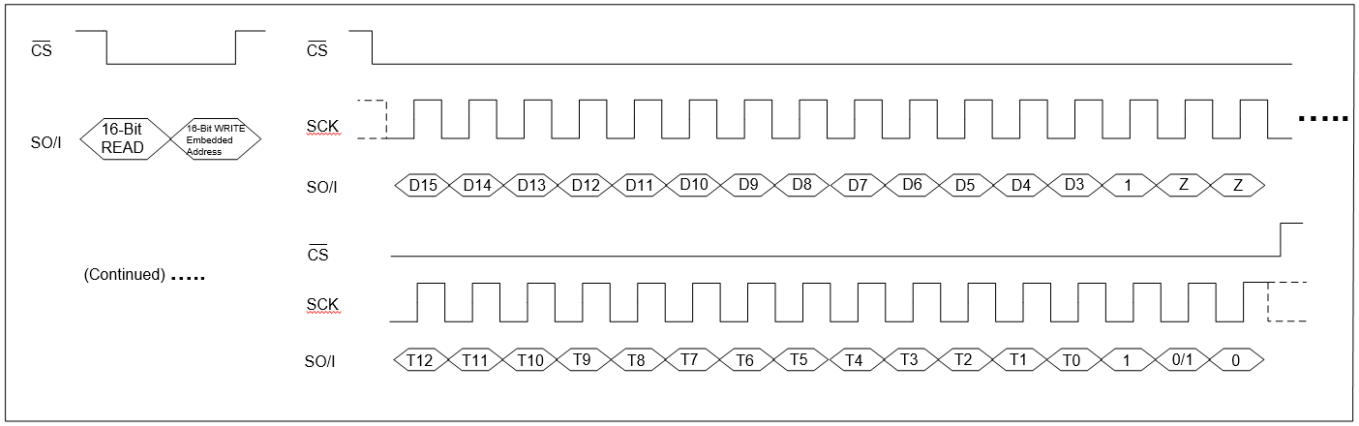


Figure2. Multiple Command Sequence



NOTE：（1）0 represents the T_{LOW} register

（2）1 represents T_{HIGH} register

Figure 3. Read and Write T_{LOW}/T_{HIGH} Register.

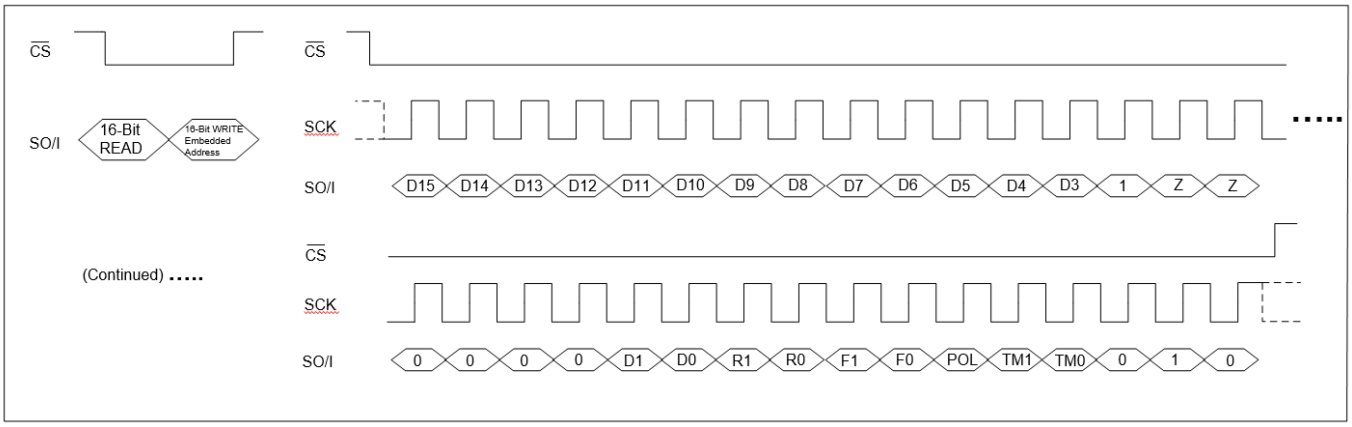


Figure 4. Read and write control registers

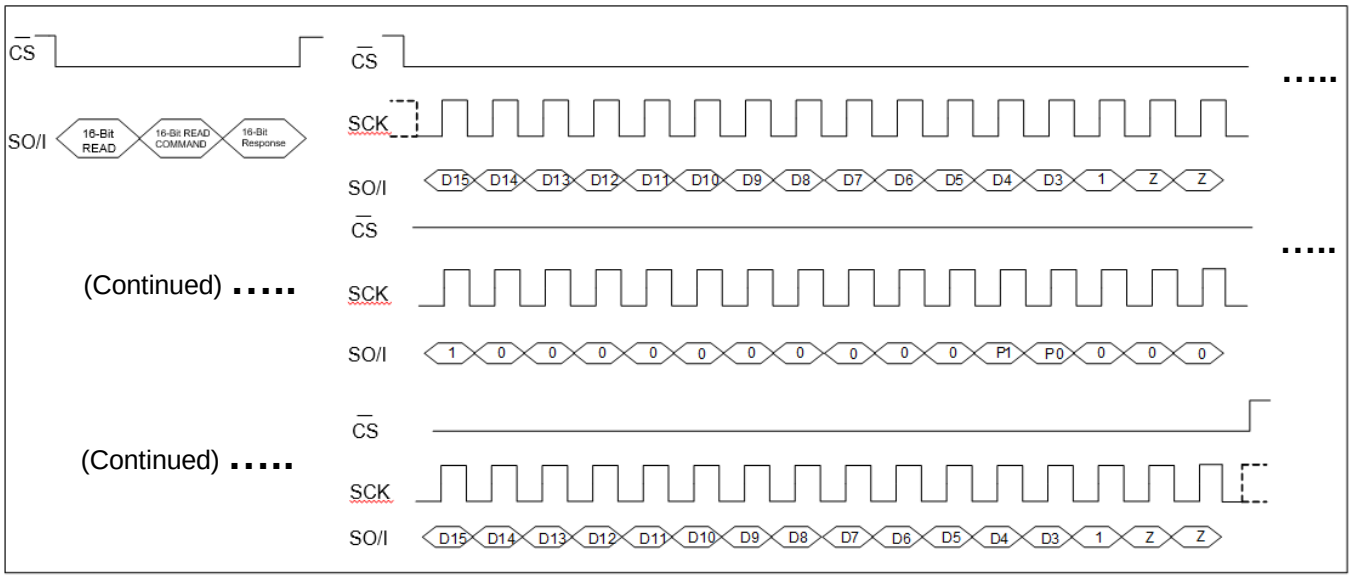


Figure 5. Read and then send the read command and read the result.

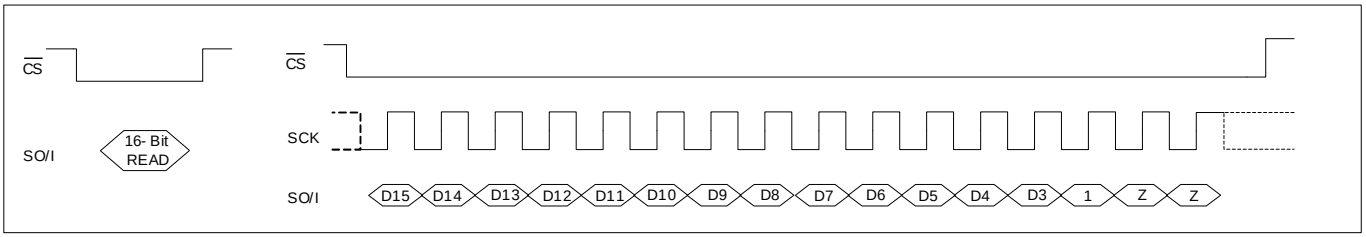


Figure 6. Read data

4 Read Address Register

Figure 8 shows the internal register structure of GX122. Table 3 describes the addresses of the available registers. The read address register uses these two bits to identify which data register should respond to a read command. After the 16-bit read is complete, the read address register is reset to the default power-up state with P1/P0 equal to 0/0.

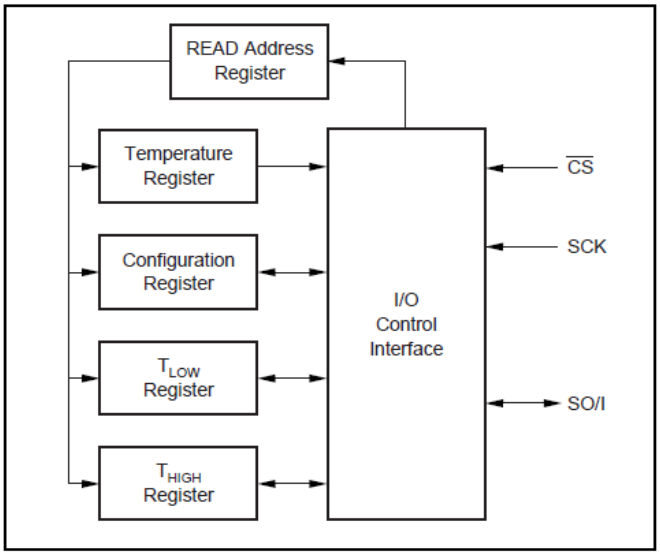


Figure 7. Internal register structure of .GX122

Table 3. Addresses of GX122 Registers

P1	P2	Registers
0	0	Temperature Register (Read Only)
0	1	Configuration Registers (Read/Write)
1	0	T_{LOW} Register (Read/Write)
1	1	T_{HIGH} Register (Read/Write)

5 Temperature register

The GX122's temperature register is a 16-bit, signed read-only register that stores the most recent converted output. The GX122 has a temperature range of -55°C to +150°C and an operating range of -55°C to +150°C. Up to 16 bits can be read for data as described in Table 4. The first 13 bits are used to indicate the temperature, among which bit D2 is 1, and D1 and D0 are in high impedance state. Table 5 summarizes the temperature data format. After power-on or reset, the temperature register will read 0°C until the first conversion is complete.

Table 4. Temperature Register

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
T12	T11	T10	T9	T8	T7	T6	T5	T4	T3	T2	T1	T0	1	Z	Z

Table 5. Temperature Data Format

Temperature (°C)	Digital output (Binary)	Digital output (Hexadecimal)
150	0100 1011 0000 0111	4B07
125	0011 1110 1000 0111	3E87
25	0000 1100 1000 0111	0C87
0.0625	0000 0000 0000 1111	000F
0	0000 0000 0000 0111	0007
-0.0625	1111 1111 1111 1111	FFFF
-25	1111 0011 1000 0111	F387
-25	1110 0100 1000 0111	E487

The user can obtain 9-bit, 10-bit, 11 or 12-bit resolution by addressing the configuration register and setting the resolution bits accordingly. For 9-bit, 10-bit, or 11-bit resolutions, the most significant bit in the temperature register is used with the unused LSB set to zero.

6 Configuration Register

The configuration register is a 16-bit read/write register that stores bits that control the operating mode of the temperature sensor. Read/write operations are performed MSB first. The format of the configuration register of GX122 is shown in Table 6, followed by the decomposition of the register bits. The power-on/reset value of configuration register bits R1/R0 is equal to 1/1, all other bits are zero.

Table 6. Control Registers

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	D1	D0	R1	R0	F1	F0	POL	TM1	TM0	0	1	0

7 Shutdown Mode (SD)

The shutdown mode of the GX122 can be used to shut down all device circuits except the serial interface. When the last 8 bits of the write command are equal to 1, shutdown mode occurs and reduces current consumption to less than 1μA when the current conversion is complete. To bring the part out of shutdown, send any 16-bit read command or mode, the last 8 bits not equal to 1, power-on defaults to active mode.

8 Thermostat Mode (TM1/TM0)

The GX122's thermostat mode bit indicates to the device whether it is operating in comparator mode, interrupt mode, or

interrupt comparator mode. See Text High and Low Limit Registers for more information on comparator and interrupt modes. The bit assignments for thermostat mode are described in Table 7. The power-on default is comparator mode.

Table 7. GX122 Mode Settings

TM1	TM0	Operating Mode
0	0	Comparator mode
0	1	Interrupt mode
1	0	Interrupt Comparator Mode
1	1	---

9 Polarity (POL)

The polarity bit of GX122 adjusts the polarity of the alarm pin output. By default, POL=0, the ALERT pin will be active low, as shown in Figure 8. For POL=1, the ALERT pin will be active HIGH and the state of the ALERT pin is inverted.

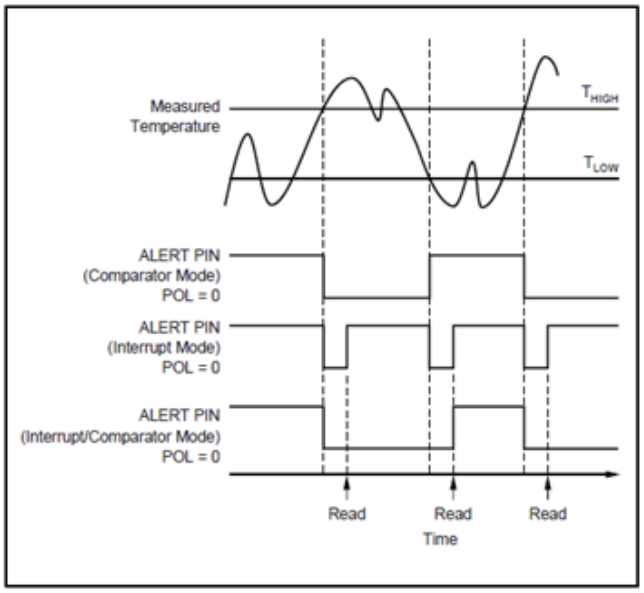


Figure 8. .ALERT Output Transfer Equation

10 Fault Queue (F1/F0)

A fault occurs when the measured temperature exceeds the limits set in the THIGH and TLOW registers. The fault queue is provided to prevent false alarms due to ambient noise, and continuous fault measurements are required to trigger the GX122's alarm function. Table 8 defines the number of consecutive failures required to trigger a consecutive alarm condition. The power-on default value of F1/F0 is 0/0.

Table 8. Fault Settings for GX122

F1	F0	Continuous Failure
0	0	1
0	1	2
1	0	4
1	1	6

11 High and low limit register

In comparator mode (TM1/TM0=0/0), when the temperature equals or exceeds the THIGH temperature value, the alarm pin of GX122 is activated and generates consecutive fault numbers according to the fault bits F1 and F0. For the same number of faults, the ALERT pin will remain active until the temperature drops below the indicated TLOW value.

In interrupt mode (TM1/TM0=0/1), when the temperature equals or exceeds THIGH several times consecutively, the ALERT pin is activated. The ALERT pin remains active until any register read operation occurs. The alert pin will also be cleared if the device is in shutdown mode. It will activate again when the temperature is lower than TLOW. When the temperature drops below TLOW, the ALERT pin activates and remains active until cleared by a read of any register. Once the ALERT pin is cleared, the above cycle will repeat and the ALERT pin becomes active when the temperature equals or exceeds THIGH temperature.

In Interrupt/Comparator mode (TM1/TM0=1/0), when the temperature equals or exceeds the value of THIGH, the ALERT pin of GX122 activates and generates consecutive fault numbers based on fault bits F1 and F0. The ALERT pin will remain active until the same number of faults the temperature is below the indicated TLOW value, and after that point it will communicate with the device.

The mode of operation is shown in Figure 8. Tables 9 and 10 describe the format of the THIGH and TLOW registers. The power-on reset values for THIGH and TLOW are: THIGH=80°C and TLOW=75°C. The data format of THIGH and TLOW is the same as the temperature register.

All 13 bits of the temperature register, THIGH register, and TLOW register are used for compare alert functions for all converter resolutions. The three LSBs in THIGH and TLOW affect the ALERT output even if the converter is configured for 9-bit resolution.

Table 9. THIGH Register

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
H12	H11	H10	H9	H8	H7	H6	H5	H4	H3	H2	H1	H0	1	1	0

Table 10. TLOW Register

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
L12	L11	L10	L9	L8	L7	L6	L5	L4	L3	L2	L1	L0	1	0	0

12 Conversion resolution (R1/R0)

The Converter Resolution bits control the resolution of the internal analog-to-digital (A/D) converter. This allows users to program higher resolutions or faster conversion times to maximize efficiency. Table 11 identifies the resolution bits and the relationship between resolution and conversion time. The default resolution of GX122 is 12 bit.

Table 11. Resolutions of GX122

R1	R0	Resolutions	Conversion Time (Typical)
0	0	9 Bit (0.5°C)+sign	30ms
0	1	10 Bit (0.25°C)+sign	60ms
1	0	11 Bit (0.125°C)+sign	120ms
1	1	12 Bit (0.0625°C)+sign	240ms

13 Delay Time

The delay bits control the amount of time delay between each conversion. This feature allows the user to maximize power savings by eliminating unnecessary transitions and minimizing current consumption. During active conversions, the GX122 typically draws 50 μA, the conversion time is about 0.25s, and the idle time between conversions requires about 20 μA. The delay settings are identified in Table 12 as conversion time and period, as shown in Figure 9. Default power-up is D1/D0 equal to 0/0. Conversion time and conversion period scale with resolution. The conversion period represents the time between conversion starts.

Table 12. Conversion Latency at 12-Bit Resolution

D1	D0	Conversion Time	Conversion Cycle
0	0	0.25s	0.25s
0	1	0.25s	0.5s
1	0	0.25s	1s
1	1	0.25s	8s

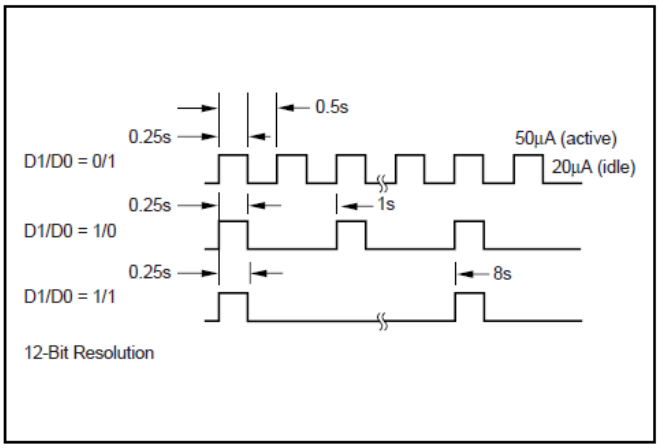


Figure 9. Interpretation of Conversion Time and Period

14 Timing Diagram

GX122 is SPI compatible. Figure 10 to Figure 12 describe various timing parameters of GX122, and its timing definition is shown in Table 13.

Table 13. Timing Description

Parameter	Min	Max	Units
SCK Cycle	100		ns
Data input rising edge SCK setup time	20		ns
SCK falling edge to output data delay		30	ns
SCK rising edge to input data hold time	20		ns
$\overline{CS}$ to rising edge SCK setup time	40		ns
$\overline{CS}$ to output data delay		30	ns
$\overline{CS}$ Rising edge output high impedance		30	ns

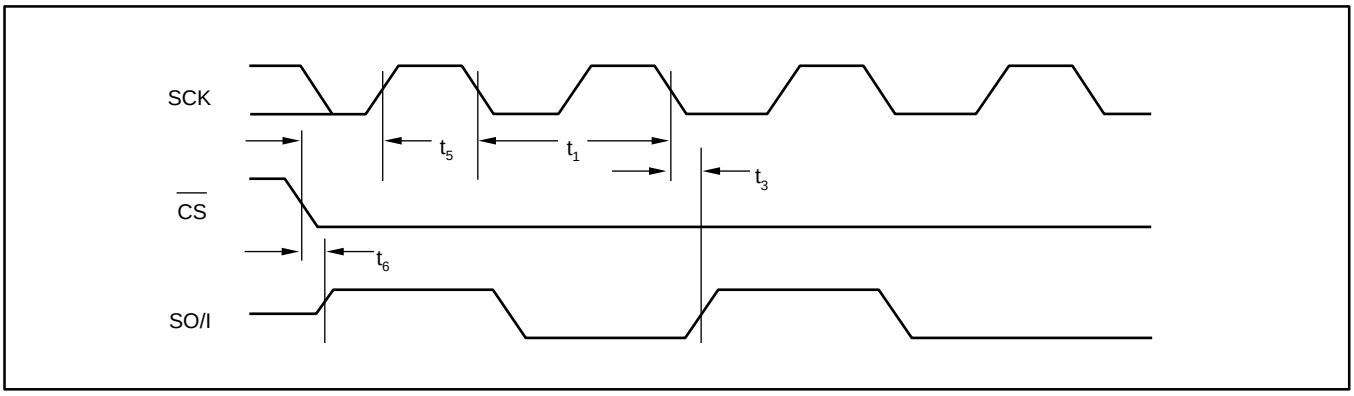


Figure 10. Output data timing diagram.

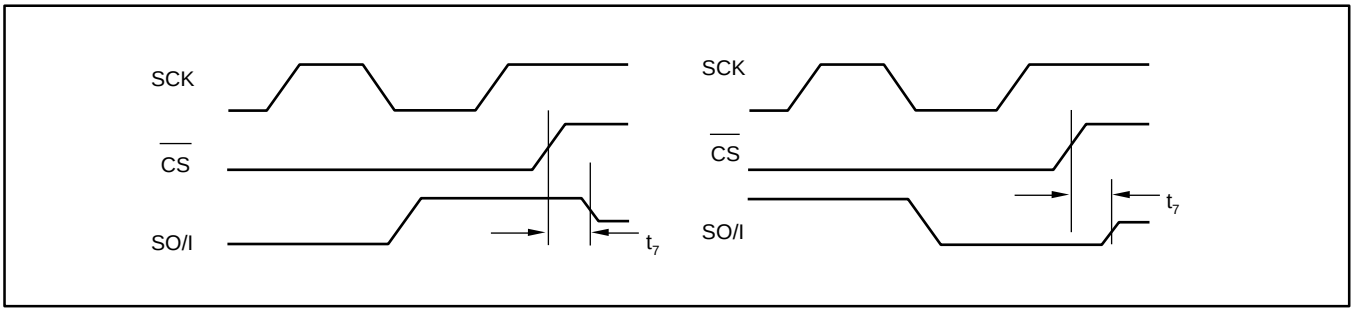


Figure 11. High-impedance output timing diagram

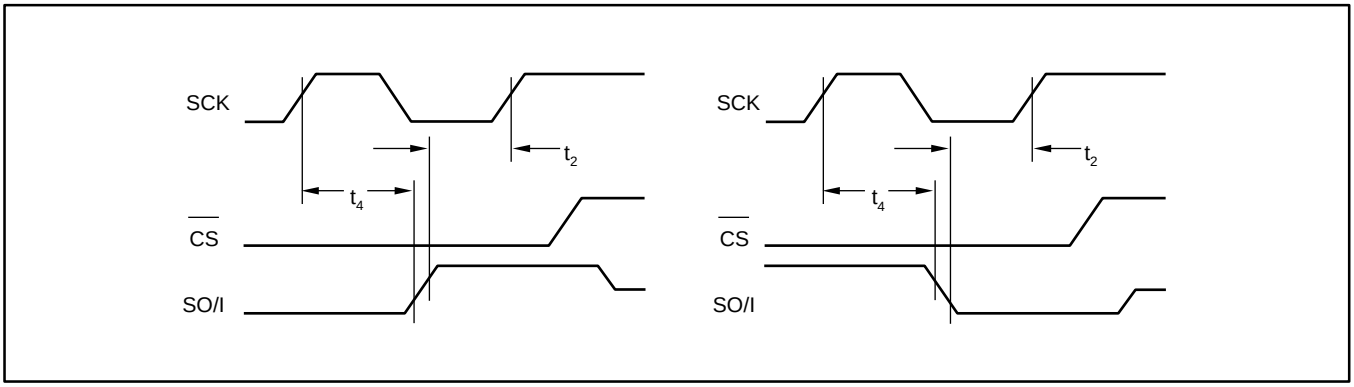
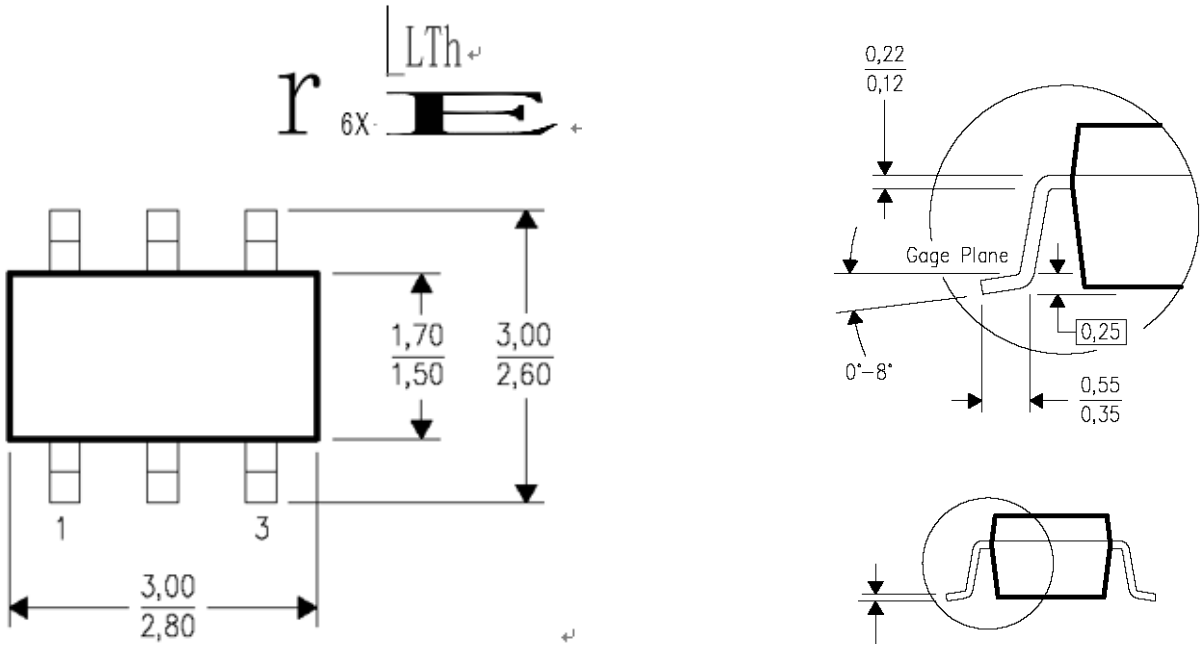


Figure 12. Input Data Timing Diagram

15 Package (SOT23-6)



16 Ordering Information

Purchase Number	Device	PIN-Package	SPQ	Remarks
GX122S-T&R	GX122S	SOT23-6	3000	Tape and reel