±1°C, 3 Channel (2-Remote and 1-Local), High Accuracy Temperature Sensor

1 Features

- Temperature range：−55°C ~ +150°C
- Temperature accuracy: (−40°C ~ +125°C)
  - Local Channel: ±1°C
  - Remote Channel: ±1°C
- High resolution: 0.0625°C / 16bits
- Conversion time per channel: 16ms
- Digital output:
  - SMBus, I²C interface compatibility
- Supply voltage range: 2.7V ~ 5.5V
- Low quiescent current: (3.3V, 27°C)
- Average current: 16μA (0.0625Hz) / 45μA (1Hz) / 90μA (4Hz)
  - Local Channel: 180μA
  - Remote Channel: 380μA
  - Shutdown current: 0.4μA
- Series Resistance Cancellation, Automatic Beta Compensation, η-Factor Correction

2 Applications

- MCU, GPU, FPGA, DSP, CPU
- Servers, Desktops, and Notebooks
- Industrial and Medical Equipment

3 Description

GD30TS302T is a high-precision, low-power digital temperature sensor compatible with SMBus and I2C interfaces. Up to two remote diode-connected temperature zones can be monitored simultaneously in addition to the local temperature.

GD30TS302T features series resistance cancellation, pro-grammable η factor correction, β value detection and automatic compensation, and programmable tem-perature thresholds, providing a reliable temperature monitoring solution with high accuracy and low power consumption.

GD30TS302T is especially suitable for temperature measurement using remote transistors (NPN / PNP Type) in servers and processors integrated in advanced processes. GD30TS302T supports automatic compensation of transistor-connected PNP (0.09<β<21.36) to achieve high-precision temperature measurement.

The typical accuracy of GD30TS302T's local and remote channel is ±1°C. GD30TS302T provide a measurement resolution of 0.0625°C and a measurement range of -55°C~150°C. GD30TS302T are available in 3.0mm×3.0mm, 10 pin MSOP and 3mm × 3mm, 10 pin DFN packages

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
GD30TS302T	MSOP-10	3.00mm × 3.00mm
	DFN-10	3.00mm × 3.00mm

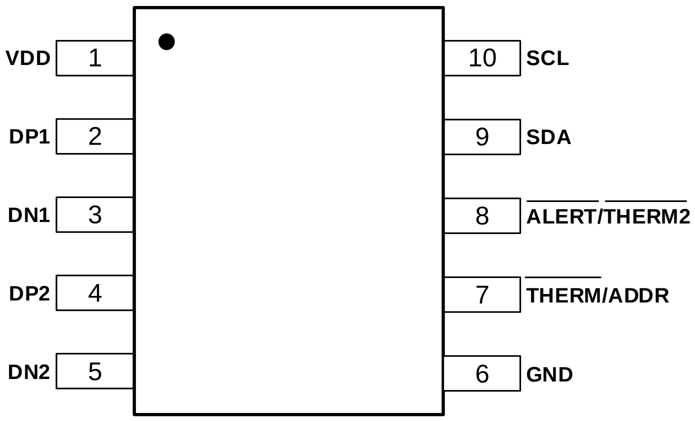
1. For packaging details, see *Package Information* section.

Table of Contents

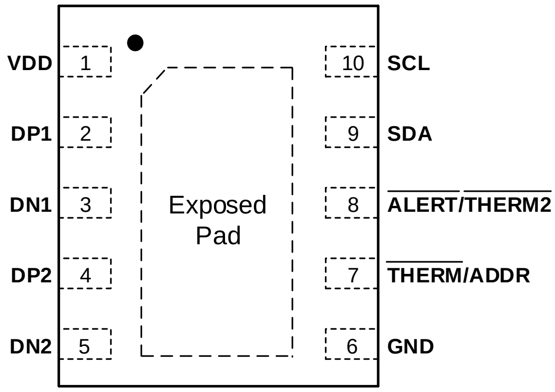
4 Device Overview

4.1 Pinout and Pin Assignment

MSOP Package
10-Pin Top View



DFN Package
10-Pin Top View



4.2 Pin Description

PINS		PIN TYPE[1]	FUNCTION
NAME	NUM		
VDD	1	P	Positive supply voltage, 2.7 V to 5.5 V.
DP1	2	AI	Positive connection of first Remote Channel.
DN1	3	AI	Negative connection of first Remote Channel.
DP2	4	AI	Positive connection of second Remote Channel.
DN2	5	AI	Negative connection of second Remote Channel.
GND	6	G	Supply ground connection.
$\overline{\text{THERM}}$/ ADDR	7	DI/DO	1) Thermal shutdown pin; Open-drain, requires pullup resistor to VDD. 2) Address select pin.
$\overline{\text{ALERT}}$ / $\overline{\text{THERM2}}$	8	DO	Thermal shutdown pin; Open-drain, requires pullup resistor to VDD.
SDA	9	DI/DO	Serial data line for SMBus. Open-drain, requires pullup resistor to VDD.
SCL	10	DI	Serial clock line for SMBus. Open-drain, requires pullup resistor to VDD.

1. P = power, G = Ground, DI = Digital input, AI = Analog input, DO = Digital Output, IO=input and output.

5 Parameter Information

5.1 Absolute Maximum Ratings

Exceeding the operating temperature range (unless otherwise noted)[1]

SYMBOL	PARAMETER	MIN	MAX	UNIT
V_{DD}	Power Supply Voltage VDD	−0.3	6	V
	DP1/DP2 Pin Input Voltage	−0.3	V_{DD} + 0.3	V
	DN1/DN2 Pin Input Voltage	−0.3	0.3	V
	$\overline{\text{THERM}}$ / ADDR , $\overline{\text{ALERT}}$ / $\overline{\text{THERM2}}$, SCL, SDA Pin Voltage	−0.3	6	V
I_{in}	Input current		10	mA
T_J	Junction Temperature		150	°C
T_A	Operating Range	−55	150	°C
T_{stg}	Storage temperature	−60	160	°C

1. Unless otherwise specified, the specifications in the above table apply within the atmospheric temperature range. Stresses beyond the range may cause permanent damage to the device.

5.2 Recommended Operation Conditions

SYMBOL[1]	PARAMETER	MIN	TYP	MAX	UNIT
V_{DD}	Power Supply Voltage	2.7	3.3	5.5	V
T_A	Operating Temperature	−50		150	°C

1. Unless otherwise specified, the specifications in the above table apply within the atmospheric temperature range.

5.3 Electrical Sensitivity

SYMBOL[1]	CONDITIONS	VALUE	UNIT
$V_{ESD(HBM)}$	Human-body mode (HBM), per ANSI/ESDA/JEDEC JS-001-2017	±8000	V
$V_{ESD(MM)}$	Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002-2022	±1000	V
LU	Latch-Up, per JESD 78, Class IA	±200	mA

1. Unless otherwise noted, the specifications in the above table apply within the atmospheric temperature range.

5.4 Electrical Characteristics

Unless otherwise specified, the following data are the characteristics of the chip at T_A = -40°C ~ 125°C and V_{DD} = 2.7V ~ 5.5V; where TYP condition is T_A = 27°C and V_{DD} = 3.3V.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
TEMPERATURE MEASUREMENT						
T_{Local}	Local Temperature Channel Accuracy	T_L = −5°C to +100°C		±0.5	±1	°C
		T_L = −40°C to +125°C		±0.5	±1.5	
T_{Remote}	Remote Temperature Channel Accuracy	T_L/T_R = −5°C to +100°C		±0.5	±1	°C
		T_L/T_R = −40°C to +125°C		±0.5	±1.5	
PSRR	PSRR of local channel	V_{DD} = 2.7 ~ 5.5V		±0.0625	±0.125	°C /V
	PSRR of remote channel	V_{DD} = 2.7 ~ 5.5V		±0.0625	±0.125	
	Resolution	All Channel		0.0625		°C
	Conversion Time	Local channel		16	17.5	ms
		Remote channel1 / 2		16	17.5	
	Remote sensor source current	High		120		μA
		Medium		45		
		Low		7.5		
	η of remote transistor			1.008		
SERIAL INTERFACE						
	High-level input voltage		0.7*V_{DD}			V
	Low-level input voltage				0.3*V_{DD}	V
	Hysteresis			0.22		V
	SDA output-low sink current		6			mA
	Low-level output voltage	I_O=6mA		0.15	0.4	V
	Input capacitance			3		pF
	Serial bus timeout			30		ms
$\overline{THERM}$ / ADDR、$\overline{ALERT}$ / $\overline{THERM2}$ Pin						
I_{sink}	Output-low sink current		6			mA
	Low-level output voltage	I_O=6mA		0.15	0.4	V
POWER SUPPLY						
V_{DD}	Supply voltage range		2.7	3.3	5.5	V
I_Q	Quiescent current	Average current (0.0625Hz)		16	30	μA
		Average current (1Hz)		45	90	
		Average current (4Hz, default)		90	145	
		Active conversion, local channel		180	300	
		Active conversion, remote channel		380	520	
		Shutdown Mode		0.4	4.2	

Electrical Characteristics (Continued)

Unless otherwise specified, the following data are the characteristics of the chip at T_A = -40°C ~ 125°C and V_{DD} = 2.7V ~ 5.5V; where TYP condition is T_A = 27°C and V_{DD} = 3.3V.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY						
	Power-on-reset threshold			1.6	2.3	V

5.5 Typical Characteristic

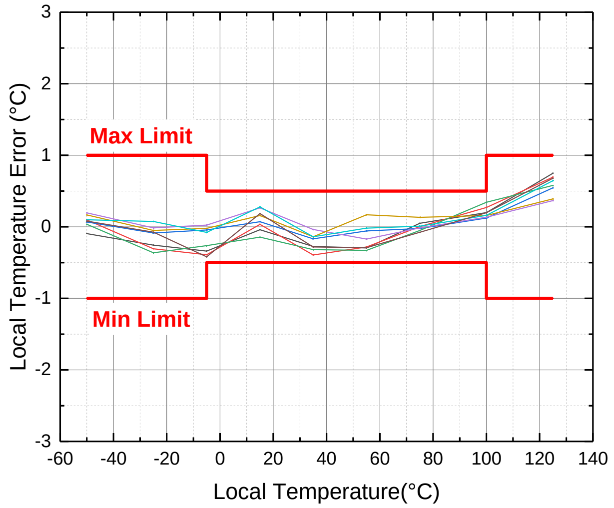


Figure 1. Local Temperature Error vs. Ambient Temperature at V_{DD}=3.3V

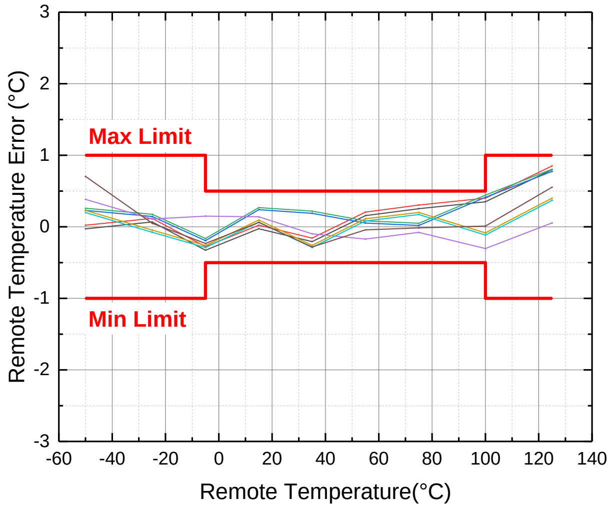


Figure 2. Remote Temperature Error vs. Device JunctionTemperature at V_{DD}=3.3V

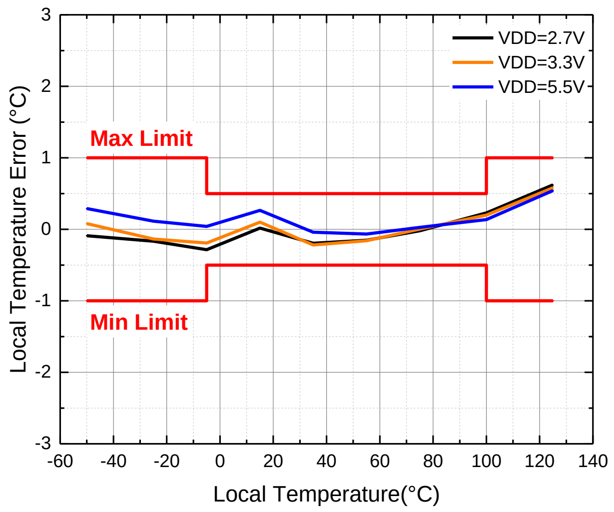


Figure 3. Local Temperature Error Power Supply Sensitivity vs. Ambient Temperature

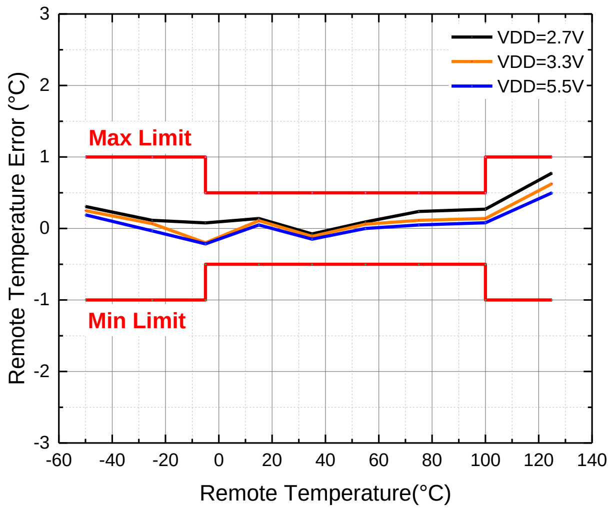


Figure 4. Remote Temperature Error Power Supply Sensitivity vs. Device Junction Temperature

Typical Characteristic (Continued)

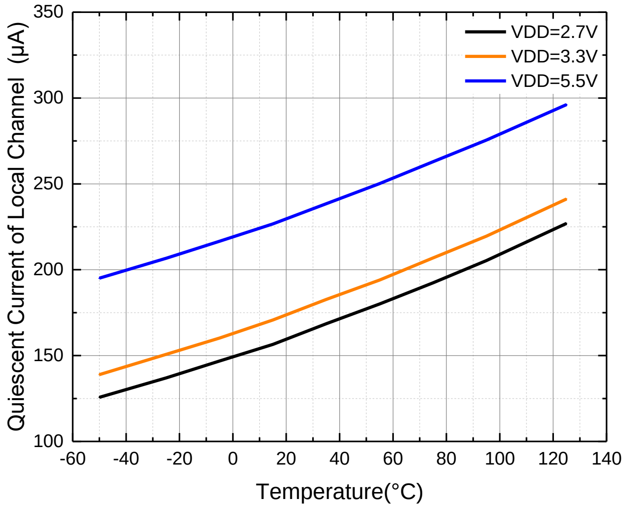


Figure 5. Quiescent Current in Local Channel vs. Ambient Temperature

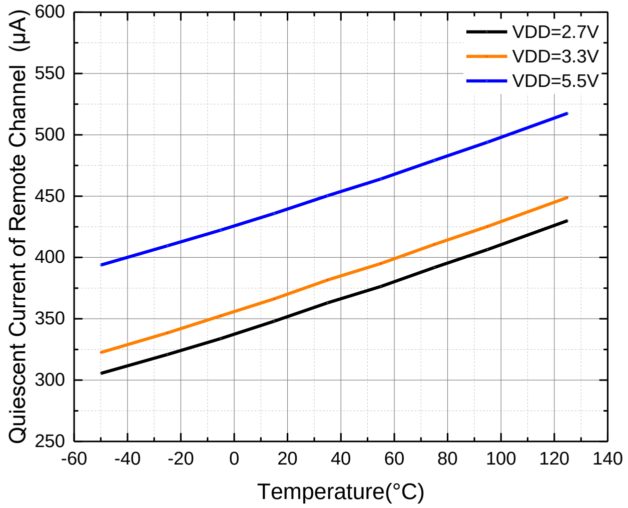


Figure 6. Quiescent Current in Remote Channel vs. Ambient Temperature

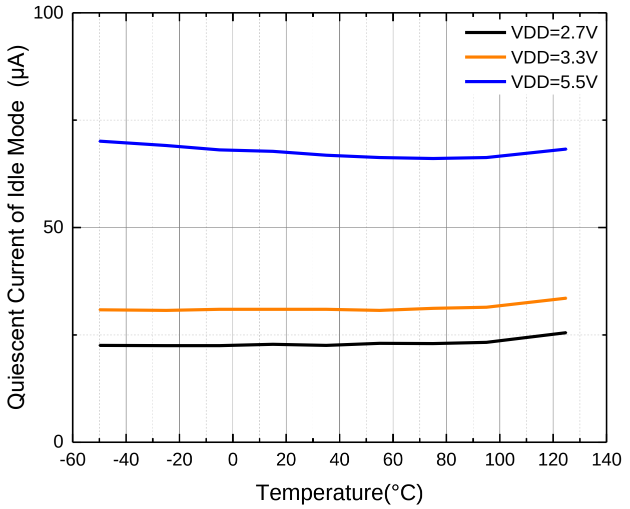


Figure 7. Quiescent Current in IDLE Mode vs. Ambient Temperature

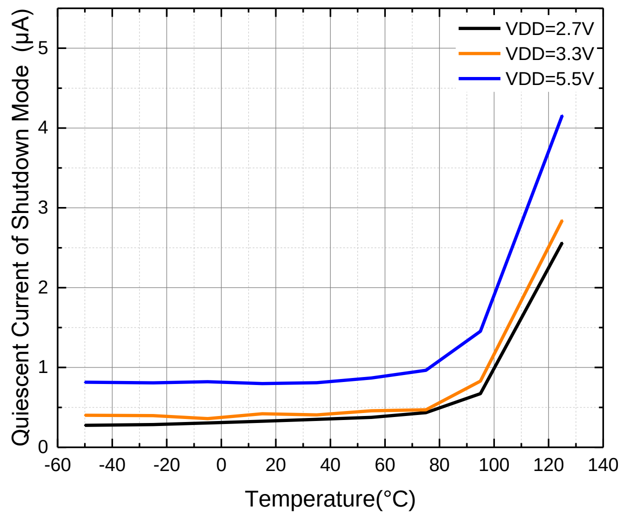
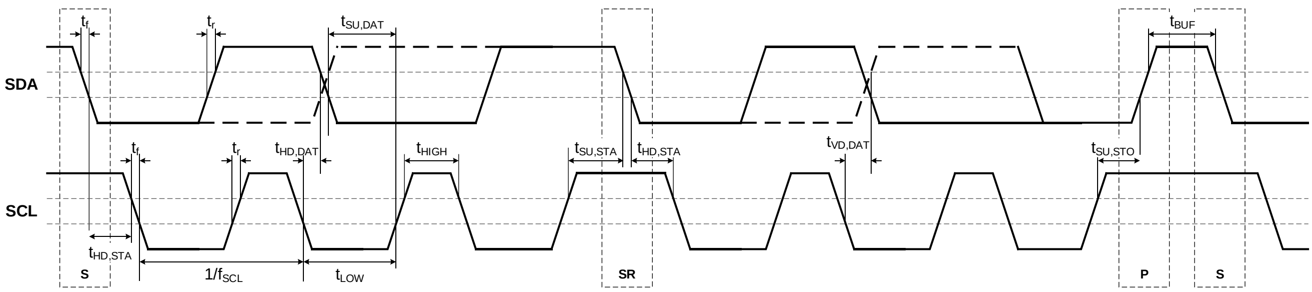


Figure 8. Quiescent Current in Shutdown Mode vs. Ambient Temperature

5.6 I²C Timing Requirements

Unless otherwise specified, the following data are the characteristics of the chip at T_A = -40°C ~ 125°C and V_{DD} = 2.7V ~ 5.5V.

SYMBOL	DESCRIPTION	Standard-Mode		Fast-Mode		High-Speed Mode		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
f_{SCL}	SCL operating frequency		100		400		2500	kHz
$t_{HD,STA}$	hold time after repeated start condition; After this period, the first clock is generated	4.0		0.6		0.16		μs
t_{LOW}	SCL clock low period	4.7		1.3		0.16		μs
t_{HIGH}	SCL clock high period	4.0		0.6		0.06		μs
$t_{SU,STA}$	repeated start condition setup time	4.7		0.6		0.16		μs
$t_{HD,DAT}$	data hold time	0		0		0	70	ns
$t_{SU,DAT}$	data setup time	250		100		10		ns
t_r	rise time of SCL		1000	20	300	10	40	ns
	rise time of SDA					10	80	
t_f	fall time of SCL		300	20*VCC /5.5	300	10	40	ns
	fall time of SDA					10	80	
$t_{SU,STO}$	stop condition setup time	4.0		0.6		0.16		μs
t_{BUF}	bus free time between stop and start condition	4.7		1.3				μs
$t_{VD,DAT}$	data valid time		3.45		0.9			μs
C_b	capacitive load for each bus line		400		400		100	pF



6 Functional Description

6.1 Chip Function Modes

6.1.1 Connections of Remote Channels

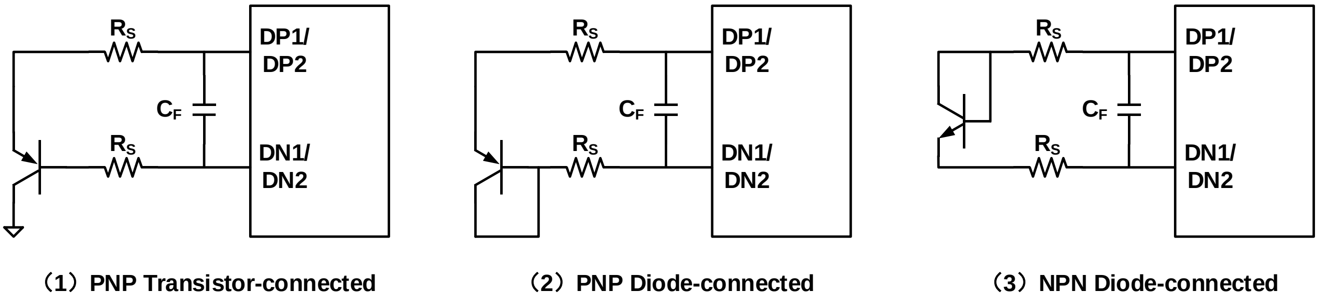


Figure 9. Remote BJT connections diagram

GD30TS302T supports three different remote temperature measurement connection methods: PNP transistor connection, PNP diode connection, and NPN diode connection, as shown in Figure 9.

6.1.2 Continuous Conversion Mode

The default mode of operation of the GD30TS302T is the continuous conversion mode. In this mode, the GD30TS302T will be converted sequentially in the order of local channel, remote 1 channel, and remote 2 channel. The LEN, REN1, and REN2 bit in Configuration Register 2 (41h) control the channels during continuous conversion. If some channels are not activated, they will be skipped. The R3:R0 bit in the Conversion Rate Register (0Ah) allows the GD30TS302T to be configured in conversion rates, as detailed in *Conversion Rate Register*.

All channels of the GD30TS302T can output 12bits temperature results with a resolution of 0.0625°C, and the results are stored in the Temperature Register of the corresponding channel using two bytes. In the Standard Mode, the temperature measurement range of all channels is 0 ~ 128°C, the results of negative temperature always output 0000h, and the results greater than or equal to 128°C always output 7FFFh.

GD30TS302T offers Extended Mode for a wider range of temperature measurements. Writing the RANGE bit in Configuration Register 1 (03h/09h) to 1 will enter the Extended Mode. GD30TS302T outputs the temperature measurement result in the Extended Mode after the next temperature conversion. In this mode, the final temperature measurement result is the sum of the actual temperature measurement result and 64°C (40h), and the temperature measurement range will be extended to -64 ~ 192°C. Table 1 and Table 2 show the high- and low-byte data formats of the Temperature Registers in Standard and Extended Mode.

The recommended temperature measurement range for all channels in GD30TS302T is -50°C ~ 150°C.

Table 1. Temperature Data Format (Local and Remote Temperature High Bytes)

Temperature (°C)	Local / Remote Temperature Register High Byte			
	Standard Mode		Extended Mode	
	BIN	HEX	BIN	HEX
-64	0000 0000	00	0000 0000	00
-50	0000 0000	00	0000 1110	0E
-25	0000 0000	00	0010 0111	27
0	0000 0000	00	0100 0000	40
1	0000 0001	01	0100 0001	41
5	0000 0101	05	0100 0101	45
10	0000 1010	0A	0100 1010	4A
25	0001 1001	19	0101 1001	59
50	0011 0010	32	0111 0010	72
75	0100 1011	4B	1000 1011	8B
100	0110 0100	64	1010 0100	A4
125	0111 1101	7D	1011 1101	BD
127	0111 1111	7F	1011 1111	BF
150	0111 1111	7F	1101 0110	D6
191	0111 1111	7F	1111 1111	FF

Table 2. Temperature Data Format (Local and Remote Temperature Low Bytes)

Temperature (°C)	Local / Remote Temperature Register Low Byte	
	BIN	HEX
0.0625	0001 0000	10
0.125	0010 0000	20
0.25	0100 0000	40
0.5	1000 0000	80
0.75	1100 0000	C0
0.9375	1111 0000	F0

6.1.3 Shutdown Mode

Shutdown mode reduces the power consumption of the chip by shutting down all circuitry except the serial interface, reducing the current of the GD30TS302T to 0.4μA (typical). Writing the SD bit in Configuration Register 1 (03h/09h) to 1 will enter into the shutdown mode. When such configured, the GD30TS302T will abort the current temperature conversion and shut down immediately. Write the SD bit to 0 will exit from shutdown mode and GD30TS302T will re-enter into continuous conversion mode.

In particular, writing the LEN, REN1, and REN2 bits in Configuration Register 2 to 0 at the same time will also enter into shutdown mode. In this case, writing any one or more of above bits as 1 will exit from shutdown mode.

6.1.4 One-Shot Mode

GD30TS302T can be configured in One-Shot mode. When the GD30TS302T is in shutdown mode (SD=1), writing any value to the One-Shot Register (0Fh) enables a single temperature conversion, and the value is not stored in the One-Shot Register. After this single temperature conversion, the GD30TS302T returns to the shutdown mode. When continuous temperature measurement is not required, this function can significantly reduce the power consumption of the chip.

6.1.5 β Detection and Compensation

GD30TS302T can detect the β value of the transistor-connected PNP (as shown in Figure 9) for remote temperature measurement, and compensate for different β values to avoid the error caused by β values. GD30TS302T provides two β compensation modes: automatic and manual. GD30TS302T enters the automatic β compensation mode by writing the BC3:BC0 bit of the β Compensation Register (25h/26h) to 1XXXb. In this mode, GD30TS302T will automatically detect the β value of the remote PNP before the remote temperature measurement, and automatically adjust the internal compensation circuit for this β value.

GD30TS302T enters the manual β compensation mode by writing the BC3:BC0 bit of the β Compensation Register (25h/26h) to 0000b~0110b. In this mode, GD30TS302T no longer automatically detects the β value of the connected remote PNP, but instead works based on the value written into the β Compensation Register. Therefore, when using the manual β compensation mode, the β value of the remote PNP should be clarified in advance.

The β compensation circuit inside the chip can be manually turned off by writing the BC3:BC0 bit of the β Compensation Register as 0111b. In order to avoid excessive temperature measurement errors, it is necessary to ensure that the β value of the selected remote PNP is greater than 50 at this time.

The above discussion is based on the remote temperature measurement using the transistor-connected PNP. When using a diode-connected PNP/NPN, the chip will always automatically shut down the β compensation circuit, regardless of whether the chip is configured in automatic or manual compensation mode. Therefore, when selecting the diode-connected PNP/NPN, it should be ensured that the β value of the selected remote BJT is greater than 50.

The above configuration of the β Compensation Registers is described in *β Compensation Register*.

6.1.6 Series Resistance Cancellation and Filtering

When using GD30TS302T for remote temperature measurement, it is necessary to consider the influence of the remote series resistance R_S on the remote temperature measurement results. The parasitic resistance of the traces on the PCB is one of the main sources of RS. GD30TS302T automatically eliminates the effects of series resistance R_S up to 1kohm.

In addition, ambient noise can also reduce the accuracy of GD30TS302T temperature measurement. A 65kHz low-pass filter is integrated between the DPX and DNX pins of the GD30TS302T to suppress temperature measurement errors caused by the above-mentioned environmental noise. Nonetheless, it is recommended to connect a filter resistor R_S in series on the DPX and DNX pins of the GD30TS302T and a filter capacitor C_F across the two pins to form an off-chip low-pass filter that allows the chip to better filter out extraneous coupled signals between these pins, as shown in Figure 15.

The sum of the above filter resistors and PCB trace resistors should be less than 1kohm; the above filter capacitor C_F should be ⩽ 1nF. The recommended filter resistor and capacitor are R_S=50ohm, C_F=100pF. In some specific applications, the filter resistor and capacitor should be adjusted appropriately for better remote temperature measurement accuracy.

In addition, the GD30TS302T integrates a two-level programmable digital filter, which can be selected by configuring the Filter Control register (40h), as detailed in *Filter Control Register*. When Level 1 is selected, the final remote temperature measurement result is the average of the last four temperature measurement results. When Level 2 is selected, the final remote temperature measurement results is the average of the last eight temperature measurement results. A schematic diagram of the filter's operation is shown in Figure 10. The filter is disabled by default after POR.

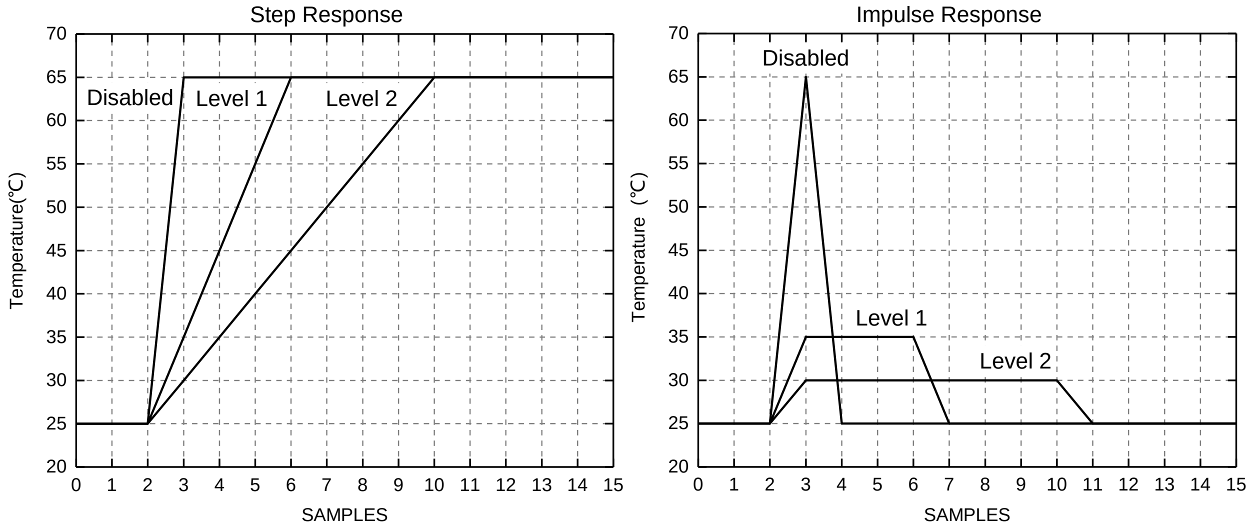


Figure 10. Filter Response to Impulse and Step Inputs

6.1.7 Sensor Fault

The GD30TS302T can sense a fault at the DPX input resulting from incorrect diode connection. When the voltage of the DPX pin is higher than (V_{DD} - 0.3V), the GD30TS302T will judge that the pin is open, the OPEN bit in the Status Register (02h) will be set to 1, and the temperature measurement result of the remote channel will return 0000h. If the chip is in ALERT mode, the ALERT pin will be activated (ALERT = 0).

GD30TS302T can also continuously detect the short circuit misconnection between the DPX pin and the DNX / GND pin. The temperature measurement result for this remote channel will also return 0000h, but the OPEN bit in the Status Register will not be activated. The behavior of the OPEN bit is shown in *Open bit (POR=0)*.

When not using the remote channels of the GD30TS302T, the DPX pin and DNX pin of the corresponding channel must be shorted to prevent meaningless misconnection detection.

6.1.8 Therm and Alert Function

GD30TS302T use $\overline{THERM}$ and $\overline{ALERT}/\overline{THERM2}$ pin to implement the Therm and Alert function.

6.1.8.1 THERM Mode

GD30TS302T compares the high byte of each channel results to the value in the Local/Remote THERM Limit Register (20h/19h/1Ah) after each conversion. If the result is higher than the value of the THERM Limit Register by the number of times defined by CTH2:CTH0 bits in the Consecutive Alert Register (22h), the LTHRM/R1THRM/R2THRM bit in the THERM Status Register (37h) will be set to 1. If any of the above three bits are set to 1, the THERM bit in the Status Register (02h) will be set to 1. If any of the above status bits are activated, the $\overline{\text{THERM}}$ pin will be activated at the same time ($\overline{\text{THERM}}$ = 0).

The above status bits will remain active, until the temperature measurement result is below the value of the THERM Limit Register minus the THERM Hysteresis Register (21h) by the number of times defined by CTH2:CTH0 bits in the Consecutive Alert Register (22h), after which the above status bit is reset to 0. The $\overline{\text{THERM}}$ pin will remain active until all of the above status bits are reset to 0, after which the $\overline{\text{THERM}}$ pin will be reset to 1.

6.1.8.2 THERM2 Mode

Writing the AL/TH bit in Configuration Register 1 to 1, and the $\overline{\text{ALERT}}$ / $\overline{\text{THERM2}}$ pin can be configured as a $\overline{\text{THERM2}}$ pin. If the temperature measurement result is higher than the High Limit Register of the channel (0Bh / 0Dh&13h / 15h&17h) by the number of times defined by CTH2:CTH0 bits in the Consecutive Alert Register (22h), the LHIGH/R1HIGH/R2HIGH bit in the High Limit Status Register (35h) will be set to 1. The HIGH bit in the Status Register will be set to 1 if any of the above three bits are set to 1. The $\overline{\text{THERM2}}$ pin will be activated at the same time ($\overline{\text{THERM2}}$ = 0).

The above status bits will remain active, until the temperature measurement result is below the value of the High Limit Register minus the THERM Hysteresis Register (21h) by the number of times defined by CTH2:CTH0 bits in the Consecutive Alert Register (22h), after which the above status bit is reset to 0. The $\overline{\text{THERM2}}$ pin will remain active until all of the above status bits are reset to 0, after which the $\overline{\text{THERM2}}$ pin will be reset to 1.

6.1.8.3 ALERT Mode

Writing the AL/TH bit in Configuration Register 1 to 0, and the $\overline{\text{ALERT}}$ / $\overline{\text{THERM2}}$ pin can be configured as a $\overline{\text{ALERT}}$ pin. If the temperature measurement result is higher than the High Limit Register of the channel (0Bh / 0Dh&13h / 15h&17h) or below the Low Limit Register of the channel (0Ch / 0Eh &14h / 16h &18h) by the number of times defined by CTH2:CTH0 bits in the Consecutive Alert Register (22h), the corresponding bits in the High Limit Status Register (35h) or Low Limit Status Register (36h) will be set to 1, and the HIGH bit or LOW bit in the Status Register will also be set to 1, as shown in *HIGH/LOW bit (POR=0)*. The above status bits will remain active until the Status Register (35h&36h) is read when the result is no longer in a overtemperature state, after which the above status bit will be reset to 0. When GD30TS302T successfully responding to an SMBus alert command, the corresponding status bit will also be reset immediately.

The MASK bit in Configuration Register 1 controls the behavior of the $\overline{\text{ALERT}}$ pin only in ALERT Mode. When MASK=0, any of the above status bits are activated, and the $\overline{\text{ALERT}}$ pin will be activated at the same time ($\overline{\text{ALERT}}$ = 0). After all the above status bits are reset to 0, the $\overline{\text{ALERT}}$ pin will be reset to 1. When MASK=1, the $\overline{\text{ALERT}}$ pin will be masked and will never be activated, but the above status bit will not be affected by the MASK bit.

Each MASK bit in the Channel Mask Register (1Fh) acts the same as the MASK bit in configuration register 1 to corresponding channel.

The above function is shown in Figure 11.

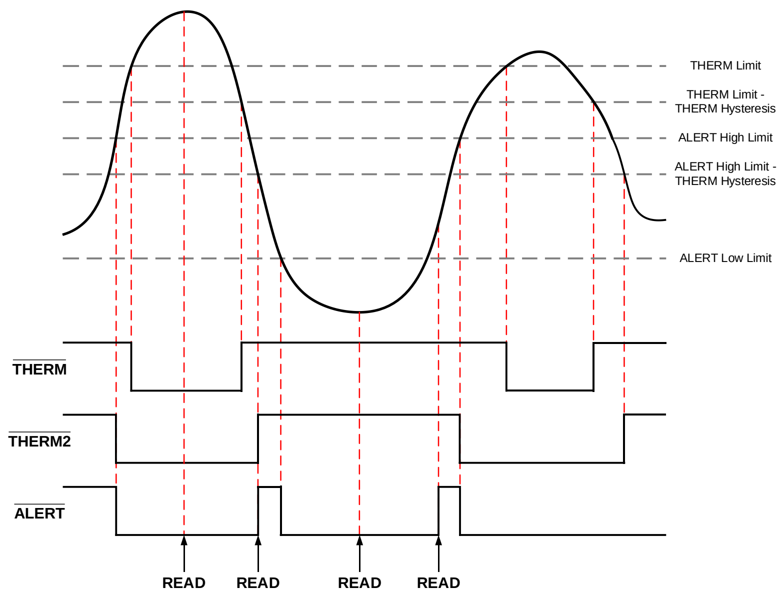


Figure 11. Therm and Alert Function Operation

6.2 Serial Interface

6.2.1 Bus Overview

The GD30TS302T is compatible with SMBus and I²C interfaces. In the SMBus protocol, the device that initiates the transfer is called a master, and the devices controlled by the master are slaves. The bus must be controlled by a master device that generates the serial clock (SCL), controls the bus access, and generates the START and STOP conditions. To address a specific device, a START condition is initiated, indicated by pulling the data line (SDA) from a high- to low-logic level when the SCL pin is high. All slaves on the bus receive the 8-bits slave address on the rising edge of the clock, and the last bit indicates whether a read or write operation is intended. During the ninth clock pulse, the addressed slave generates an acknowledge and pulls the SDA pin low to respond to the master. A data transfer is then initiated and sent over eight clock pulses followed by an acknowledge bit. When all data are transferred, the master generate a STOP signal to end the communication by pulling SDA from low to high when SCL is high.

During the data transfer, the SDA pin must remain stable when the SCL pin is high because any change in the SDA pin when the SCL pin is high is interpreted as a START or STOP signal.

6.2.2 Serial Bus Address

To communicate with GD30TS302T, the master must first address slave devices through an address byte. The address byte has seven address bits and a read-write (R/W) bit that indicates the intent of executing a read or write operation. Table 3 lists the slave addresses of different GD30TS302T series.

Table 3. Slave Address of GD30TS302T series

GD30TS302T Series	SMBus Address
GD30TS302TAMTR-I0A	Determined by the R_P on the $\overline{THERM}$/ ADDR Pin
GD30TS302TAMTR-I0B	1001 100
GD30TS302TAMTR-I0C	0011 000
GD30TS302TAETR-I0A	Determined by the R_P on the $\overline{THERM}$/ ADDR Pin

The slave address of the GD30TS302TA is determined by the pull-up resistor R_P of the pin, and the correspondence is shown in Table 4. Within 10ms after the GD30TS302TA is powered on, the chip automatically detects the pull-up resistor R_P of the pin and determines the corresponding slave address. During this time (10ms after POR), do not pull the pins low or communicate with the GD30TS302TA. In order to communicate with the GD30TS302TA properly, the error of the RP in Table 4 should be ≤ ±5%.

Table 4. Slave Address of GD30TS302TA

R_P on THERM/ADDR Pin	SMBus Address
4.7kohm	1111 100
6.8kohm	1011 100
10kohm	1001 100
15kohm	1101 100
22kohm	0011 100
33kohm	0111 100

6.2.3 Read and Write Operation

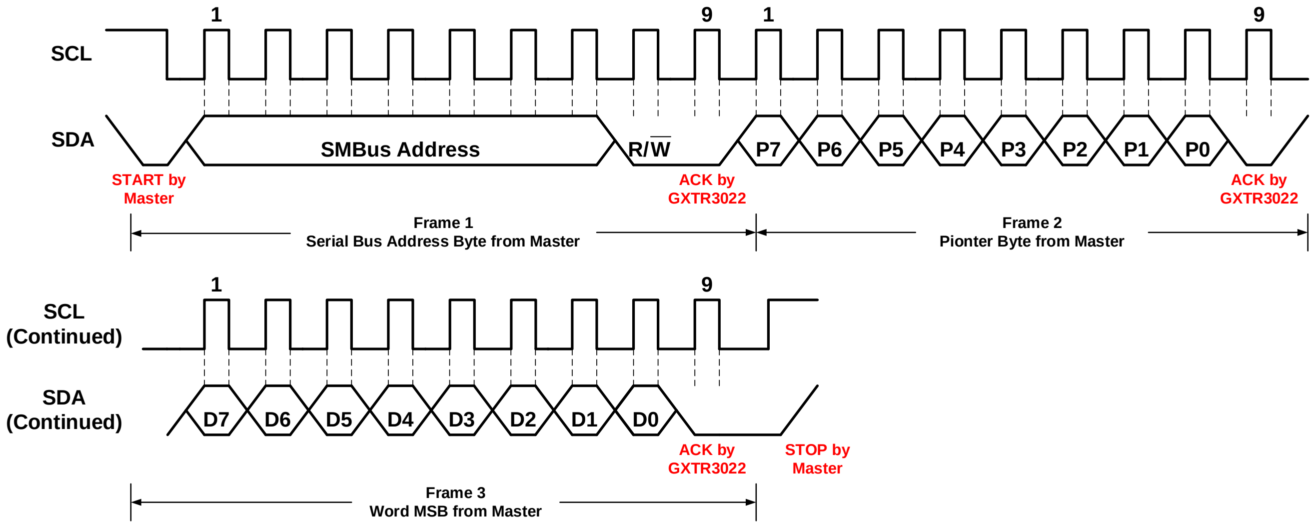


Figure 12. Two-wire Write Timing Diagram for Write Word Format

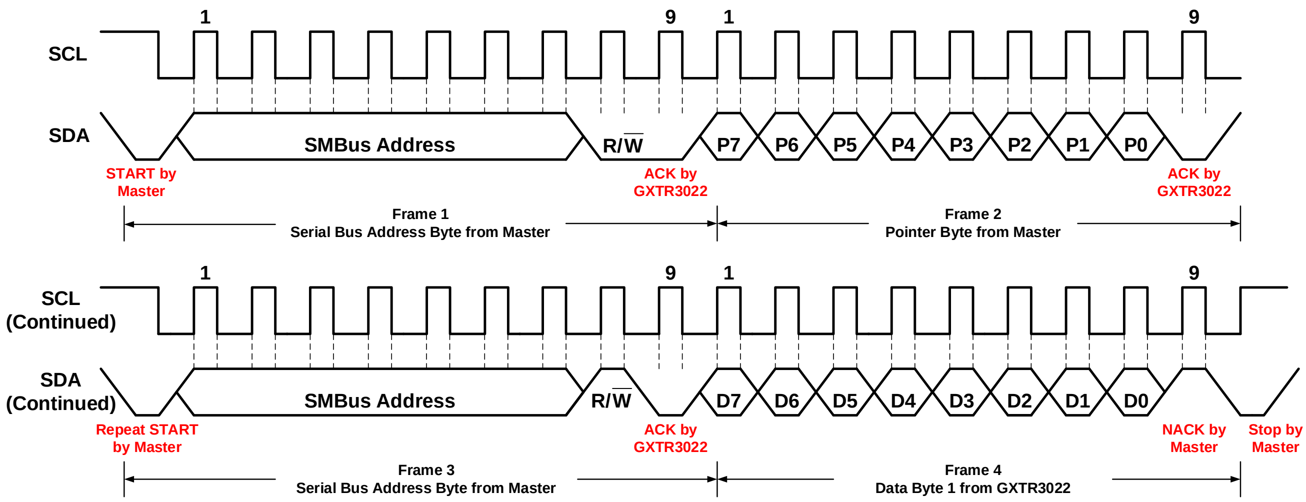


Figure 13. Two-wire Read Timing Diagram for Single-Byte Read Format

GD30TS302T allows the host to access specific internal registers by writing the target value to a pointer register.

When writing data to GD30TS302T, after sending a slave address byte with a low R/W bit, the corresponding pointer register byte is sent to write the data to a specific register in the GD30TS302T. Each writing to the GD30TS302T needs a pointer register byte.

When reading data from GD30TS302T, the slave address byte with the R/W bit is low is first sent, and then the corresponding pointer register byte is sent. The master then generates a Start signal again and sends the slave address byte with the high R/W bit to initiate the read command. There is no need to repeatedly send the pointer byte if reading data from the same register. GD30TS302T allow the host to automatically read data from the register specified by the previous pointer byte. When reading data is complete, the host needs to send a NACK bit at the end of the last byte to end the read operation. Figure 12 and Figure 13 show the read and write operations.

6.2.4 SMBus Alarm Function

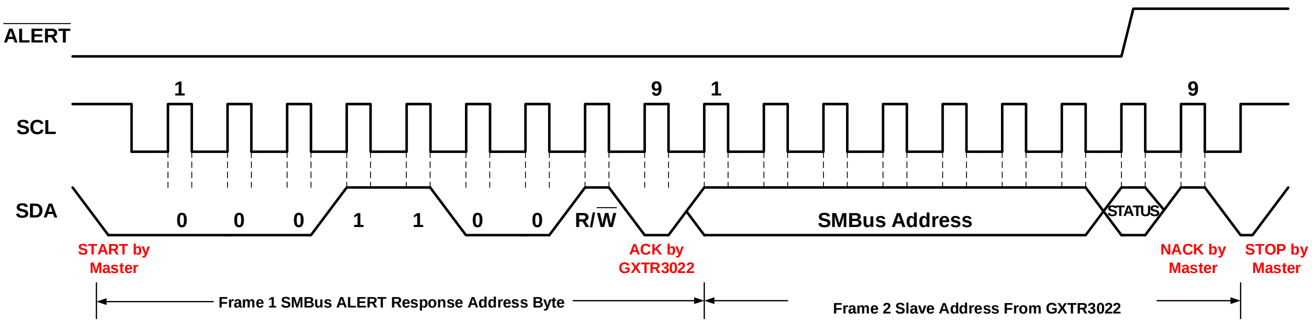


Figure 14. Timing Diagram for SMBus ALERT

GD30TS302T supports SMBus Alert function. When the GD30TS302T is in ALERT mode, the host can send the SMBus Alert command (19h) to the bus. If the ALERT pin of a GD30TS302T on the bus is active, the chip responds to the SMBus Alert command and returns its slave address. If the alert state is activated by result higher than the High Limit Register, the eighth bit of the slave address byte (LSB) will be set to 1; If the alert state is activated by result below the Low Limit Register, the eighth bit of the slave address byte (LSB) is set to 0.

If more than one GD30TS302T on the bus responds to a SMBus Alert command at the same time, the bus returns the smallest two wires address. Then the ALERT pin of this GD30TS302T will be cleared.
The above function is detailed in Figure 14.

6.2.5 General Call Reset

The GD30TS302T respond to the two-wire general call address 00h. The device acknowledges the general call address and responds to commands in the second byte. If the second byte is 06h, the GD30TS302T reset the internal registers to the power-up reset values, and aborts the current temperature conversion. If the second byte is other value, the GD30TS302T will not respond.

6.2.6 High-Speed Mode

For the two-wire bus to operate at frequencies above 400kHz, the master device must issue a high-speed mode (Hs-mode) master code (0000 1xxx) as the first byte after a START condition to switch the bus to high-speed operation. The GD30TS302T does not acknowledge this byte, but switches the input filters on SDA and SCL and the output filter on SDA to operate in Hs-mode, allowing transfers at up to 2.5MHz. After the Hs-mode master code has been issued, the master transmits a two-wire slave address to initiate a data transfer operation.

The bus continues to operate in Hs-mode until a STOP condition occurs on the bus. Upon receiving the STOP condition, the GD30TS302T switches the input and output filters back to fast mode operation.

6.2.7 Time-Out Function

GD30TS302T has the ability to detect serial bus timeouts. This function can be activated by writing the TO bit in the Consecutive Alert Register (22h) to 1. If the SDA and SCL remain low for 30ms (typical) between the START and STOP signals, the GD30TS302T will reset their serial interfaces, release the bus and wait for the START signal. To avoid activating the timeout function, the SCL operating frequency should be greater than 1kHz.

6.3 Register Descriptions

Table 5. GD30TS302T Register List

POINTER ADDRESS	TYPE	POR	BIT DESCRIPTIONS								REGISTER DESCRIPTIONS
			D7	D6	D5	D4	D3	D2	D1	D0	
00	R	00h	LT11	LT10	LT9	LT8	LT7	LT6	LT5	LT4	Local Temperature Register (High Byte)
01	R	00h	RT11	RT10	RT9	RT8	RT7	RT6	RT5	RT4	Remote Temperature 1 Register (High Byte)
02	R	00h	BUSY	0	0	HIGH	LOW	OPEN	THERM	0	Status Register
03/09	R/W	00h	MASK	SD	$\overline{AL}$/TH	0	0	RANGE	0	0	Configuration Register 1
04/0A	R/W	06h	0	0	0	0	R3	R2	R1	R0	Conversion rate Register
05/0B	R/W	55h	LTH11	LTH10	LTH9	LTH8	LTH7	LTH6	LTH5	LTH4	Local Temperature High Limit Register (High Byte)
06/0C	R/W	00h	LTL11	LTL10	LTL9	LTL8	LTL7	LTL6	LTL5	LTL4	Local Temperature Low Limit Register (High Byte)
07/0D	R/W	55h	RTH11	RTH10	RTH9	RTH8	RTH7	RTH6	RTH5	RTH4	Remote Temperature 1 High Limit Register (High Byte)
08/0E	R/W	00h	RTL11	RTL10	RTL9	RTL8	RTL7	RTL6	RTL5	RTL4	Remote Temperature 1 Low Limit Register (High Byte)
0F	W	00h	X	X	X	X	X	X	X	X	One-shot Register
10	R	00h	RT3	RT2	RT1	RT0	0	0	0	0	Remote Temperature 1 Register (Low Byte)
11	R/W	00h	X	X	X	X	X	X	X	X	User-defined
12	R/W	00h	X	X	X	X	X	X	X	X	User-defined
13	R/W	00h	RTH3	RTH2	RTH1	RTH0	0	0	0	0	Remote Temperature 1 High Limit Register (Low Byte)
14	R/W	00h	RTL3	RTL2	RTL1	RTL0	0	0	0	0	Remote Temperature 1 Low Limit Register (Low Byte)
15	R/W	55h	RTH11	RTH10	RTH9	RTH8	RTH7	RTH6	RTH5	RTH4	Remote Temperature 2 High Limit Register (High Byte)
16	R/W	00h	RTL11	RTL10	RTL9	RTL8	RTL7	RTL6	RTL5	RTL4	Remote Temperature 2 Low Limit Register (High Byte)
17	R/W	00h	RTH3	RTH2	RTH1	RTH0	0	0	0	0	Remote Temperature 2 High Limit Register (Low Byte)
18	R/W	00h	RTL3	RTL2	RTL1	RTL0	0	0	0	0	Remote Temperature 2 Low Limit Register (Low Byte)
19	R/W	55h	RTHL11	RTHL10	RTHL9	RTHL8	RTHL7	RTHL6	RTHL5	RTHL4	Remote 1 THERM Limit Register
1A	R/W	55h	RTHL11	RTHL10	RTHL9	RTHL8	RTHL7	RTHL6	RTHL5	RTHL4	Remote 2 THERM Limit Register

POINTER ADDRESS	TYPE	POR	BIT DESCRIPTIONS								REGISTER DESCRIPTIONS
			D7	D6	D5	D4	D3	D2	D1	D0	
1B	R	00h	0	0	0	0	0	R2OPEN	R1OPEN	0	Open Status Register
1F	R	00h	0	0	0	0	0	R2MASK	R1MASK	LMASK	Channel Mask Register
20	R/W	55h	LTHL11	LTHL10	LTHL9	LTHL8	LTHL7	LTHL6	LTHL5	LTHL4	Local THERM Limit Register
21	R/W	0Ah	TH11	TH10	TH9	TH8	TH7	TH6	TH5	TH4	THERM Hysteresis Register
22	R/W	70h	TO	CTH2	CTH1	CTH0	CALT2	CALT1	CALT0	0	Consecutive Alert Register
23	R	00h	RT11	RT10	RT9	RT8	RT7	RT6	RT5	RT4	Remote Temperature 2
24	R	00h	RT3	RT2	RT1	RT0	0	0	0	0	Remote Temperature 2
25	R/W	08h	0	0	0	0	BC3	BC2	BC1	BC0	Remote Channel 1
26	R/W	08h	0	0	0	0	BC3	BC2	BC1	BC0	Remote Channel 2
27	R/W	00h	NC7	NC6	NC5	NC4	NC3	NC2	NC1	NC0	Remote Channel 1
28	R/W	00h	NC7	NC6	NC5	NC4	NC3	NC2	NC1	NC0	Remote Channel 2
29	R	00h	LT3	LT2	LT1	LT0	0	0	0	0	Local Temperature
35	R	00h	0	0	0	0	0	R2HIGH	R1HIGH	LHIGH	High Limit Status Register
36	R	00h	0	0	0	0	0	R2LOW	R1LOW	LLOW	Low Limit Status Register
37	R	00h	0	0	0	0	0	R2THERM	R1THERM	LTHERM	THERM Status Register
40	R/W	00h	0	0	0	0	0	0	FIL1	FIL0	Filter Control Register
41	R/W	07h	0	0	0	0	0	REN2	REN1	LEN	Configuration Register 2
FD	R	21h	0	0	1	0	0	0	0	1	Device ID Register
FE	R	5Dh	0	1	0	1	1	1	0	1	Manufacturer ID Register
FF	R	03h	0	0	0	0	0	0	1	1	Revision Register

6.3.1 Status Register

6.3.1.1 BUSY bit (POR=0)

BUSY=1: The internal ADC is converting temperature.

BUSY=0: The internal ADC is not converting temperature.

6.3.1.2 HIGH/LOW bit (POR=0)

The above bits are controlled by the corresponding bits in the High Limit Status Register (35h) or the Low Limit Status Register (36h) and satisfies the following conditions: HIGH = LHIGH **OR** R1HIGH **OR** R2HIGH; LOW = LLOW **OR** R1LOW **OR** R2LOW, where the LHIGH/R1HIGH/R2HIGH bits are controlled by the $\overline{AL/TH}$ bit in Configuration Register 1 Register, and the LLOW/R1LOW/R2LOW bits are only valid when $\overline{AL/TH}$ =0.

When $\overline{AL/TH}$ =1 in Configuration Register 1, the chip is in THERM2 Mode, and the LHIGH/R1HIGH/R2HIGH bits act as follows:

LHIGH/R1HIGH/R2HIGH=1: The local/remote channel result is higher than the value of the Local/Remote High Limit Register, and remains higher than the value of the Local/Remote High Limit Register minus the THERM Hysteresis Register of the corresponding channel.

LHIGH/R1HIGH/R2HIGH=0: The local/remote channel result is lower than the value of the Local/Remote High Limit Register minus the THERM Hysteresis Register of the corresponding channel.

When $\overline{AL/TH}$ =0 in Configuration Register 1, the chip is in ALERT Mode, and the LHIGH/R1HIGH/R2HIGH /LLOW/R1LOW/R2LOW bits act as follows:

LHIGH/R1HIGH/R2HIGH=1: The temperature result of the local/remote channel is higher than the value of the Local/Remote High Limit Register of the corresponding channel since the latest reset of above bits;

LHIGH/R1HIGH/R2HIGH=0: Reads the High Limit Status Register when the local/remote channel result is lower than the value of the Local/Remote High Limit Register of the corresponding channel; or the chip successfully corresponds to the SMBus alert command; or the chip successfully corresponds to General Call Reset.

LLOW/R1LOW/R2LOW=1: The temperature result of the Local/Remote channel is lower than the value of the Local/Remote Low Limit Register of the corresponding channel since the latest reset of above bits;

LLOW/R1LOW/R2LOW=0: Reads the Low Limit Status Register when the local/remote channel result is higher than the value of the Local/Remote Low Limit Register of the corresponding channel; or the chip successfully corresponds to the SMBus alert command; or the chip successfully corresponds to General Call Reset.

6.3.1.3 Open bit (POR=0)

GD30TS302T detects the OPEN status of the remote channel only when the remote channel is opened.

OPEN=1: Since the latest reset of OPEN bit, the remote BJT of any remote channel is open, and the bit in the Open Status Register (1Bh) is set to 1; OPEN = R1OPEN **OR** R2OPEN.

OPEN=0: When remote BJTs of all remote channel are not open and reading the Open Status Register will set R1OPEN/R2OPEN to 0; OPEN = R1OPEN **OR** R2OPEN.

6.3.1.4 THERM bit (POR=0)

This bit is controlled by the LTHERM/R1THERM/R2THERM bits in the THERM Status Register (37h) and satisfies the THERM = LTHERM **OR** R1THERM **OR** R2THERM.

LTHERM/R1THERM/R2THERM=1: The local/remote channel result is higher than the value of the Local/Remote THERM Limit Register of the corresponding channel, and remains higher than the value of the Local/Remote THERM Limit Register minus the THERM Hysteresis Register of the corresponding channel.

LTHERM/R1THERM/R2THERM=0: The local/remote channel result is lower than the value of the Local/Remote THERM Limit Register minus the THERM Hysteresis Register of the corresponding channel.

6.3.2 Configuration Register

The Configuration Register 1 of the GD30TS302T controls the conversion mode of the chip. Any write to this register immediately terminates the current temperature conversion, after which the chip restarts a new conversion or enters into Shutdown Mode (SD=1) based on the value written to the register. Table 8 shows the functions of Configuration Register 1.

Table 6. Configuration Register 1 Description

BIT	Field	Default	Description
D7	MASK	0	**1**= $\overline{\text{ALERT}}$ pin is masked **0**= $\overline{\text{ALERT}}$ is activated (only effective when $\overline{\text{AL}}$/TH=0)
D6	SD	0	**1**=Chip enters into Shutdown Mode **0**= Chip enters into Continuous Conversion Mode
D5	$\overline{\text{AL}}$/TH	0	**1**=Chip enters into THERM2 Mode **0**= Chip enters into ALERT Mode
D2	RANGE	0	**1**= Chip enters into Extended Mode **0**= Chip enters into Standard Mode
Others	Reserved	0	/

The Configuration Register 2 of the GD30TS302T controls the enabling of the temperature measurement channel of the chip. Any write to this register immediately terminates the current temperature conversion, after which the chip restarts a new conversion or enters shutdown mode (LEN=REN1=REN2=0) based on the value written to the register. $\eta_{eff} = \frac{1.008 \times 2150}{2150 + N}$, $N = \frac{1.008 \times 2150}{\eta_{eff}} - 2150$

(1)

Table 9 shows the functions of Configuration Register 2.

Table 7. Configuration Register 2 Description

BIT	Field	Default	Description
D2	REN2	1	**1**=Remote channel 2 is enabled **0**=Remote channel 2 is shutdown
D1	REN1	1	**1**=Remote channel 1 is enabled **0**=Remote channel 1 is shutdown
D0	LEN	1	**1**=Local channel is enabled **0**=Local channel is shutdown
Others	Reserved	0	/

6.3.3 β Compensation Register

GD30TS302T can automatically detect the β value of the transistor-connected PNP and compensate for different β values, see *β Detection and Compensation* for details. The range of automatic compensation for β values is 0.09 < β < 21.36. Table 8 shows the register configuration for β compensation.

If the remote BJT is diode-connected, it is recommended to use the BJT with β>50 and configure the β Compensation Register to 0111.

Table 8. β Compensation Register Description

BCx3 ~ BCx0	β Range Description
1000	Automatic: 0.09＜β＜0.20
1001	Automatic: 0.18＜β＜0.26
1010	Automatic: 0.24＜β＜0.38
1011	Automatic:.35＜β＜0.72
1100	Automatic: 0.64＜β＜1.68
1101	Automatic: 1.47＜β＜10.03
1110	Automatic: 6.83＜β＜61.90
1111	Automatic:β＞21.36
1111	Automatic detect the diode-connected BJT
0000	Manual: 0.09＜β＜0.20
0001	Manual: 0.18＜β＜0.26
0010	Manual: 0.24＜β＜0.38
0011	Manual: 0.35＜β＜0.72
0100	Manual: 0.64＜β＜1.68
0101	Manual: 1.47＜β＜10.03
0110	Manual: 6.83＜β＜61.90
0111	Manually turn off β compensation function

6.3.4 η-factor Correction Register

GD30TS302T supports remote BJT with different η factors. In the actual using process, the η-factor Correction Register should be correctly configured to avoid unnecessary temperature measurement errors.

The configuration of the η-factor Correction Register is shown in $\eta_{eff} = \frac{1.008 \times 2150}{2150 + N}, \ N = \frac{1.008 \times 2150}{\eta_{eff}} - 2150$

(1)

Table 9; where η_{eff} is the value of the η factor of the remote BJT, N is the value of the η-factor Correction Register (negative value is expressed in the form of binary complement) and the trimming range is -128 ~ +127. When the default value of the η-factor is $\eta_{default}$ = 1.008, the correspondence is shown in the following formula:

$$\eta_{eff} = \frac{1.008 \times 2150}{2150 + N}, \ N = \frac{1.008 \times 2150}{\eta_{eff}} - 2150 \qquad (1)$$

Table 9. η-factor Correction Register Description

N			η
Binary	**HEX**	**Decimal**	
0111 1111	7F	127	0.951779
0000 1010	0A	10	1.003333
0000 1000	08	8	1.004263
0000 0110	06	6	1.005195
0000 0100	04	4	1.006128
0000 0010	02	2	1.007063
0000 0001	01	1	1.007531
0000 0000	00	0	1.008（default）
1111 1111	FF	-1	1.008469
1111 1110	FE	-2	1.008939
1111 1100	FC	-4	1.009879
1111 1010	FA	-6	1.010821
1111 1000	F8	-8	1.011765
1111 0110	F6	-10	1.012710
1000 0000	80	-128	1.071810

6.3.5 Conversion Rate Register

The Conversion Rate Register controls the time of the Idle State between two conversions, but not the conversion time itself. Table 10 shows the configuration of the Conversion Rate Register. In particular, if the conversion time is longer than the time shown in the table, there is no more idle time between two conversions.

Table 10. Conversion Rate Register Description

R3	R2	R1	R0	CONV per Sec	Average Current (TYP)
0	0	0	0	0.0625	16μA
0	0	0	1	0.125	18μA
0	0	1	0	0.25	20μA
0	0	1	1	0.5	25μA
0	1	0	0	1	45μA
0	1	0	1	2	60μA
0	1	1	0	4(default)	90μA
0	1	1	1	8	140μA
1	0	0	0	16	250μA
1	0	0	1	32	315μA
1	0	1	0	64	315μA
Others				1	45μA

6.3.6 Consecutive Alert Register

This register controls the times of over-temperature required for GD30TS302T to activate the $\overline{\text{THERM}}$ and $\overline{\text{ALERT}}/\overline{\text{THERM2}}$ pin. This function helps to avoid jitter around the alert limit, which may cause the chip to repeatedly activate the alert pin. Table 11 shows the configuration of this register.

Table 11. Consecutive Alert Register Description

CALT2/CTH2	CALT1/CTH1	CALT0/CTH0	Times
0	0	0	1 (default for CALT2:0)
0	0	1	2
0	1	1	3
1	1	1	4 (default for CTH2:0)

6.3.7 Filter Control Register

Table 12. Filter Control Register Description

FIL1	FIL0	CALT0/CTH0
0	0	Disabled(default)
0	0	Level 1
0	1	Level 1
1	1	Level 2

7 Application Information

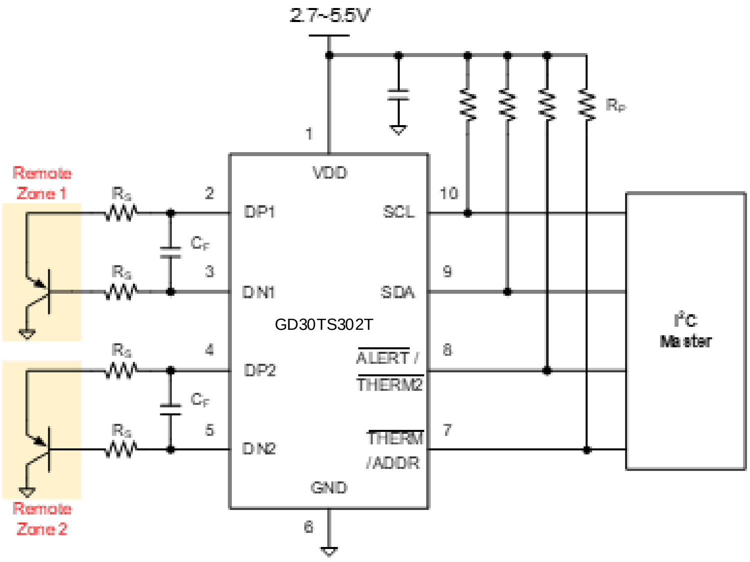


Figure 15. Typical Application Schematics

GD30TS302T provides β value detection and automatic compensation function to obtain accurate remote temperature measurement results when using transistor-connected PNP. The range of compensation for transistor-connected PNP is 0.09 < β < 21.36. When using a diode-connected PNP / NPN, GD30TS302T automatically detects this diode-connection and shuts down the internal β compensation circuitry, regardless of the β Compensation Register configuration.

Therefore, if it is necessary to use a diode-connected PNP / NPN for remote temperature measurement, or to manually configure the β compensation register to 0111, the BJT used should be correctly selected, and the selection criteria are as follows:

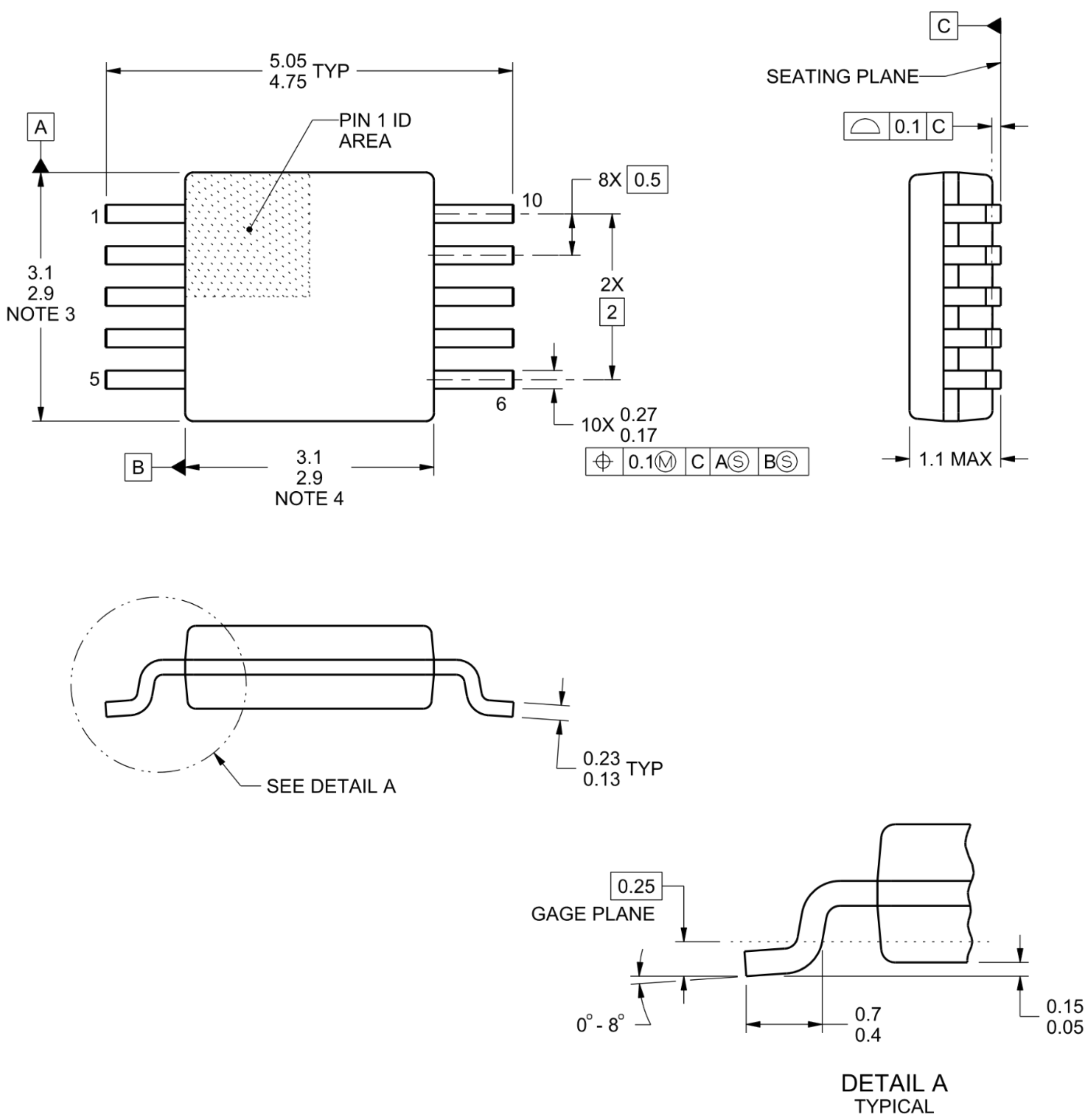
- V_{BE} > 0.25V at the maximum measured temperature and bias current of 7.5μA;
- V_{BE} < 0.95V at the lowest measured temperature and bias current of 120μA;
- Base resistance< 100ohm;
- The range of β value variation is as small as possible (50~150);

Based on the above criteria, the recommended remote temperature BJT is MMBT3904 (NPN) or MMBT3906 (PNP).

8 Package Information

8.1 Outline Dimensions

MSOP-10 Package Outline



NOTES: (continued)

1. All dimensions are in millimeters.
2. Package dimensions does not include mold flash, protrusions, or gate burrs.

9 Ordering Information

Ordering Code	Package Type	ECO Plan	Packing Type	MOQ	OP Temp(°C)
GD30TS302TAMTR-I0A	MSOP-10	Green	Tape & Reel	3000	−40°C to +125°C
GD30TS302TAMTR-I0B	MSOP-10	Green	Tape & Reel	3000	−40°C to +125°C
GD30TS302TAMTR-I0C	MSOP-10	Green	Tape & Reel	3000	−40°C to +125°C
GD30TS302TAETR-I0A	DFN-10	Green	Tape & Reel	3000	−40°C to +125°C

10 Revision History

REVISION NUMBER	DESCRIPTION	DATE
1.0	Initial release and device details	2024

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