Remote and Local Temperature Sensor with ±1°C, η-Factor and Offset Correction, Series-Resistance Cancellation, and Programmable Digital Filter

1 Features

- Temperature measurement range:
  - Local, remote channel: −55°C to 150°C
- Local measurement accuracy: ±1.0°C
- Remote measurement accuracy: ±2.0°C
- Local, remote resolution: 0.0625°C (12 Bits)
- Supply voltage: 1.7V to 5.5V
- Low quiescent current:
  - Normal operation: 27μA(0.0625Hz)
    165μA (16Hz)
  - Shutdown mode: 3μA
- Digital output: SMBus™, I2C compatibility
- Device function
  - Series-resistance cancellation
  - η-factor and offset correction
  - Programmable digital filter
  - Remote and local temperature sensor
- Package: 8-PIN WSON

2 Applications

- Processor and FPGA temperature monitoring
- Smart phones and tablets
- Servers, desktops and laptops
- Telecom equipment and SANs

3 Description

The GD30TS451N is a high-accuracy, low-power remote temperature sensor with a build-in local temperature measurement channel. The typical remote temperature sensors are NPN, PNP or diodes that are integrated in the microprocessor or FPGA to be measured. The temperature is represented as a 12-bit digital output for both local and remote sensors, giving a resolution of 0.0625°C.The GD30TS451N also features extended temperature measurement mode for −55°C to 150°C range. The GD30TS451N supports SMBus™ communication protocol.

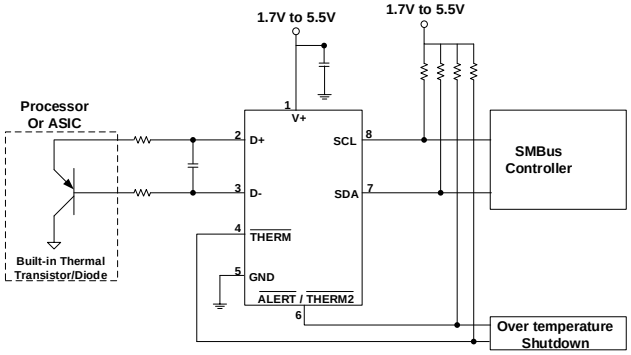
The GD30TS451N features series resistance cancellation, programmable nonideality factor (η-factor), temperature offset, programmable digital filter to provide a remote temperature monitoring solution with improved accuracy and noise immunity.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
GD30TS451N	WSON-8	2.00 mm × 2.00 mm

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

Simplified Application Schematic



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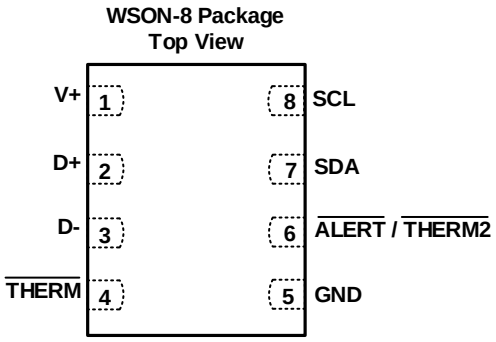
4 Device Overview

4.1 Pinout and Pin Assignment



4.2 Pin Description

PINS		PIN TYPE[1]	FUNCTION
NAME	NUM		
V+	1	P	Power supply voltage, 1.7V to 5.5V.
D+	2	I	Positive connection to remote temperature sensor.
D-	3	I	Negative connection to remote temperature sensor.
$\overline{\text{THERM}}$	4	O	Thermal shutdown or fan-control pin. Open-drain output, requires pullup resistor.
GND	5	G	Ground connection.
$\overline{\text{ALERT}}/\overline{\text{THERM2}}$	6	O	Interrupt or SMBus alert output. Can be configured as a second THERM output. Open-drain; requires pullup resistor.
SDA	7	IO	Serial data line. Open-drain output, requires pullup resistor.
SCL	8	I	Serial clock line. Open-drain output, requires pullup resistor.

1. P = power, G = Ground, I = input, 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_+	Power supply	−0.3	6	V
V_{IO}	$\overline{THERM}$、$\overline{ALERT}$/$\overline{THERM2}$、SCL、SDA Input voltage	−0.3	6	V
V_{D+}	D+ Input voltage	−0.3	V_+ + 0.3	V
V_{D-}	D- Input voltage	−0.3	0.3	V
I_{IN}	Input current		10	mA
T_J	Junction temperature		150	°C
T_A	Local channel operating range	−55	160	°C
T_D	Remote channel operating range	−55	160	°C
T_{stg}	Storage temperature	−60	150	°C

1. Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

5.2 Recommended Operation Conditions

SYMBOL[1,2]	PARAMETER	MIN	TYP	MAX	UNIT
V_+	Supply voltage	1.7	3.3	5.5	V
T_A	Local channel operating range	−40		125	°C
T_D	Remote channel operating range	−50		150	°C

5.3 Electrical Sensitivity

SYMBOL	CONDITIONS	VALUE	UNIT
$V_{ESD(HBM)}$	Human Body Mode (HBM), per ANSI/ESDA/JEDEC JS-001	±5000	V
$V_{ESD(MM)}$	Machine Mode (MM), per JEDEC-STD Classification	300	V

1. Unless otherwise stated, over operating free-air temperature range.

5.4 Electrical Characteristics

At T_A = −40 to 125°C and V+ = 3.3V, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
TE_{LOCAL}	Local temperature sensor	T_A = 25°C		±0.25	±1	°C
		T_A = −40°C to 125°C		±1	±2	°C
TE_{REMOTE}	Remote temperature sensor Remote temperature sensor versus supply	T_A = 25°C，T_D = –50°C to 150°C		±1	±2	°C
		T_A = −40°C to 125°C T_D = −50°C to 150°C		±2	±4	°C
		V+ = 1.7V to 5V		±0.1	±0.25	°C/V
T_{CON}	Conversion time	One-shot mode, local & remote		31	34	ms
Bits	Resolution	Local & remote channel		12		Bits
I_{REMOTE}	Remote sensor source current (High)	Series resistance⩽1kΩ		120		μA
	Remote sensor source current (Medium)			45		
	Remote sensor source current (Low)			7.5		
η_{FACTOR}	η remote BJT ideality factor			1.000		
F_{SMBus}	SMBus clock frequency		0.01		2.5	MHz
T_{TIME_OUT}	SMBus time-out		20	25	30	ms
V_+	V_+ voltage range		1.7	3.3	5.5	V
V_{+_UVLO}	V+ under voltage lockout			1.2	1.55	V
V_{IH}	Logic high-level input voltage		0.7 x V_+		5.5	V
V_{IL}	Logic low-level input voltage		GND		0.3 x V_+	V
I_{C_CON}	Average current during continuous conversion (serial bus inactive)	0.0625 conversions per second		27	40	μA
		16 conversions per second		165	250	
		32 conversions per second		300	450	
I_{SD}	Average current in shutdown mode	Serial bus inactive		3	8	μA
		Serial bus inactive, fs = 400KHz		90		
		Serial bus inactive, fs = 2.5MHz		350		

6 Functional Description

6.1 Block Diagram

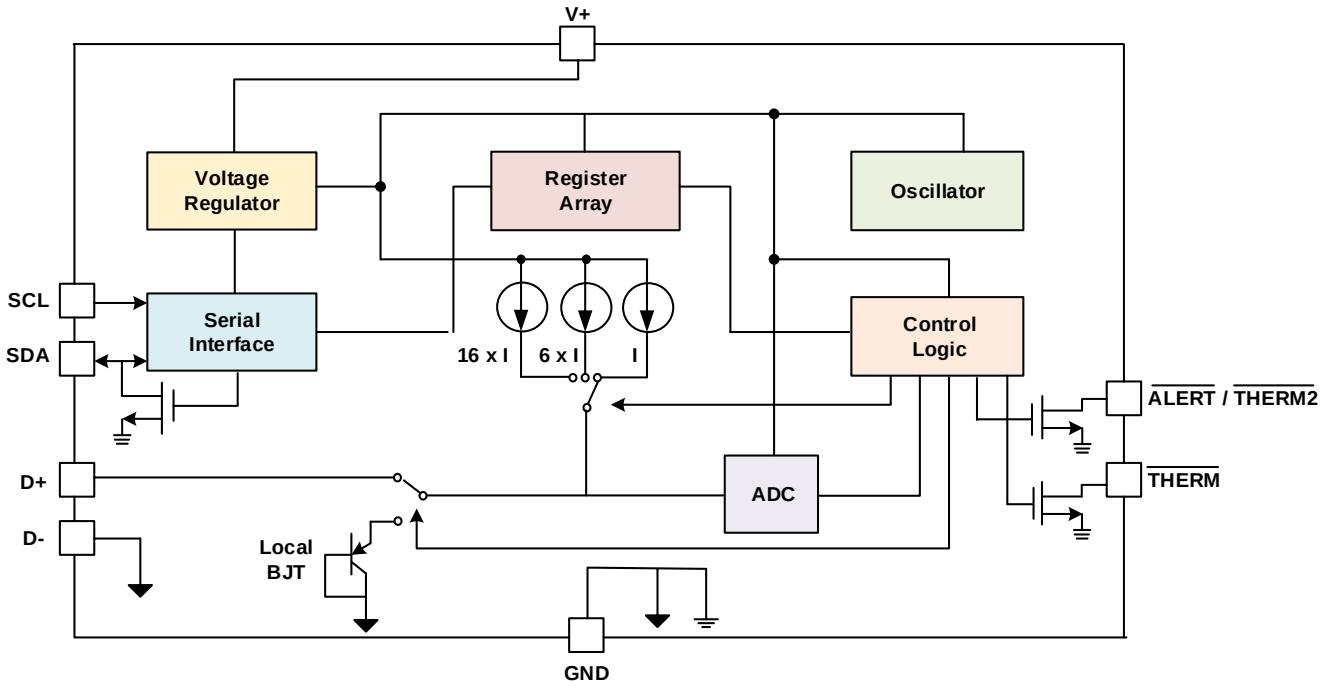


Figure 1. GD30TS451N Functional Block Diagram

6.2 Device Feature Description

6.2.1 Temperature Measurement Format

The local and remote temperature measurement resolutions of the GD30TS451N are both 12 bits (0.0625°C), and the temperature results are represented in binary form, as shown in Table 1 an Table 2. The GD30TS451N supports standard temperature measurement mode or extended temperature measurement mode. Any temperature below 0°C results in a data value of 00h, temperatures above 127°C result in a value of 7Fh. The device can be set to measure over an extended temperature range by writing the RANGE bit of configuration register to 1. The change in measurement range and data format from standard mode to extended mode occurs at the next temperature conversion. For data captured in the extended mode, an offset of 64 (40h) is added to the standard mode value, as shown in Table 1. In the extended mode, the measurement range of the GD30TS451N is increased to −64°C to 191°C. However, most diodes only measure with the range of −55°C to 150°C. Parameters in the “Absolute Maximum Ratings” and “Recommended Operating Conditions” must be observed. The local and remote temperature measurement results of GD30TS451N are represented by two bytes. The resolution of the high byte is 1°C, which is used to store the integer part of the temperature; the resolution of the low byte is 0.0625°C, which is used to store the fractional part of the temperature.

Table 1. Local and Remote Temperature High Bytes (1LSB = 1°C)

TEMPERATURE (°C)	STANDARD MODE[1]		EXTENDED MODE[2]	
	BINARY	HEX	BINARY	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
175	0111 1111	7F	1110 1111	EF
191	0111 1111	7F	1111 1111	FF

1. Resolution is 1°C/count. Negative values produce a read of 0°C.
2. Resolution is 1°C/count. All values are unsigned with a −64°C offset.

Table 2. Local and Remote Temperature Low Bytes（1LSB = 0.0625°C）

TEMPERATURE (°C)	BINARY	HEX
0	0000 0000	00
0.0625	0001 0000	10
0.1250	0010 0000	20
0.1875	0011 0000	30
0.2500	0100 0000	40
0.3125	0101 0000	50
0.3750	0110 0000	60
0.4375	0111 0000	70
0.5000	1000 0000	80
0.5625	1001 0000	90
0.6250	1010 0000	A0
0.6875	1011 0000	B0
0.7500	1100 0000	C0
0.8125	1101 0000	D0
0.8750	1110 0000	E0
0.9375	1111 0000	F0

6.2.2 Series Resistance Cancellation

The series resistance cancellation automatically eliminates the resistance on the wires connecting the D+, D- pins to the remote temperature probe, or the remote temperature errors due to the resistors used in external low-pass filters (as shown in Figure 1). A total up to 1kΩ of series resistance can be cancelled by the GD30TS451N.

6.2.3 Filtering

The GD30TS451N device has a built-in, 65KHz filter between D+ and D– to minimize the effects of external noise on temperature measurement. However, a capacitor placed (100pF to 1nF) between D+ and D– is recommended for better elimination of the irrelevant coupling signals between the two pins. Some specific applications attain better remote temperature measurement accuracy with additional series resistance (not greater than 1kΩ). The recommended filter capacitor and resistor values are 100pF and 50Ω, respectively, as shown in Figure 1 Appropriate resistor and capacitor values can be selected according to different application scenarios.

Additionally, a build-in programmable digital filter with two levels is available for filtering the remote temperature measurement results. Level 1 performs an average of the first four temperature measurement results (filter off) during remote temperature measurement; level 2 performs an average of the first eight temperature measurement results (filter off) during measurement. The value stored in the remote temperature register is the output of the digital filter. The schematic diagram of the filter is shown in Figure 2. The filter can be enabled or disabled by configuring the digital filter control register (pointer address 24h, see section 6.5.10). The digital filter is disabled by default and on POR.

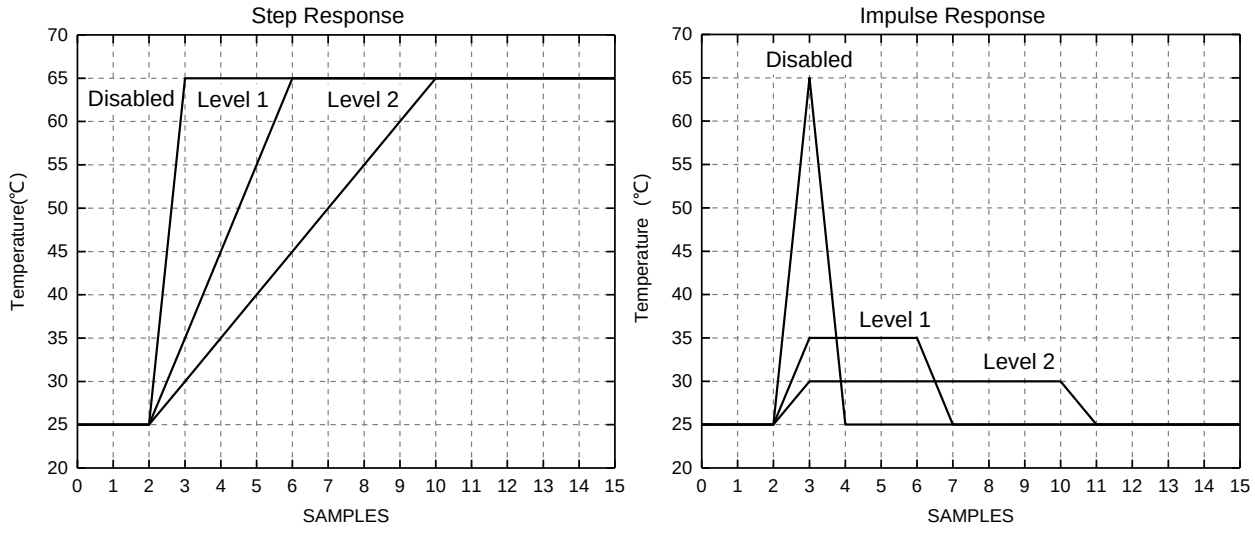


Figure 2. Schematic Diagram of Programmable Digital Filter in GD30TS451N

6.2.4 Sensor Misconnection Detection

The GD30TS451N detects misconnection of remote temperature probes. The detection standard is: the voltage of the D+ port exceeds V_{LDO} − 0.3V (V_{LDO} is the output voltage of the LDO inside the chip, V_{LDO} = 1.7V typically) when the remote temperature measurement channel is working. If the voltage of the D+ port exceeds V_{LDO} − 0.3V, the GD30TS451N determines that the remote temperature measurement probe is open, and the OPEN bit in the status register will be written to 1, and the remote temperature measurement result will be set to -64°C (00h).

If the D+ and D- ports of the GD30TS451N are short-circuited, the remote temperature measurement result of the GD30TS451N will also be set to −64°C (00h), but the OPEN bit in the status register will not be written to 1. When the GD30TS451N remote temperature measurement function is not used, the D+ and D- inputs must be connected together to prevent meaningless fault warnings in the OPEN bit.

6.3 Device Functional Modes

6.3.1 Shutdown Mode

The GD30TS451N shutdown mode enables the user to reduce power consumption by shutting down all circuits other than the serial interface, reducing device current to below 3μA (Typical). Shutdown mode is enabled when the SD bit of the configuration register is written from 0 to 1. The GD30TS451N shuts down after the current conversion is over. When the GD30TS451N is in shutdown mode, the device will re-enter the continuous temperature measurement mode when the SD bit is written from 1 to 0.

6.3.2 One-Shot Mode

When the GD30TS451N is in shutdown mode, a single conversion is started by writing any value to the one-shot start register (pointer address 0Fh). This operation starts one conversion on both the local and the remote channels. After conversion, the GD30TS451N returns to the shutdown mode. The value of the data sent in the write command is irrelevant and is not stored by the GD30TS451N.

6.3.3 ALERT and THERM Mode

GD30TS451N provides alarm and constant temperature monitoring modes. The output of pin 4 and pin 6 can be controlled according to the value of the status register. See section 6.5.3 for the detailed description of the status register. The LHIGH and LLOW bits are the flag bits of the local temperature measurement result being too high and too low, respectively. The RHIGH and RLOW bits are the flag bits of the remote temperature measurement result being too high and too low, respectively. The OPEN bit is the flag bit of the open circuit state of the remote temperature measuring diode. When the conditions that cause the above flag bits to be 1 no longer exist (eg, the corresponding temperature measurement results are within the temperature limits, or the remote temperature measurement diode is properly connected), reading the status register will clear the above five flag bits.

When pin 6 is configured as $\overline{\text{ALERT}}$ output, the five flag bits above will be used for OR operation together; if any of the five bits are high, the $\overline{\text{ALERT}}$ output will be low. Reading the status register will clear the pin, and if the temperature measurement result is within the temperature limit, the pin will remain in the cleared state; if the temperature limit is exceeded, the pin will be activated again after the specified number of consecutive registers.

When the temperature measurement result exceeds the $\overline{\text{THERM}}$ limit, the RTHRM and LTHRM bits will be set to 1 and the $\overline{\text{THERM}}$ output will be 0. The RTHRM and LTHRM bits will be set to 0 and the output will be 1 when the temperature measurement returns to within the limits. The $\overline{\text{THERM}}$ hysteresis register (pointer address 21h) allows hysteresis to be added to the $\overline{\text{THERM}}$ limit so that the temperature threshold becomes the $\overline{\text{THERM}}$ limit minus this hysteresis.

When pin 6 is configured as $\overline{\text{THERM2}}$, only the upper temperature limit will function. If the temperature exceeds the upper limit, the LHIGH and RHIGH bits will be set to 1 and the $\overline{\text{THERM2}}$ output will be 0. The LLOW and RLOW

bits have no effect on the behavior of the $\overline{\text{THERM2}}$ pin. At this time, the output behavior of this pin is consistent with $\overline{\text{THERM}}$. The above behavior is shown in Figure 3 and Figure 3.

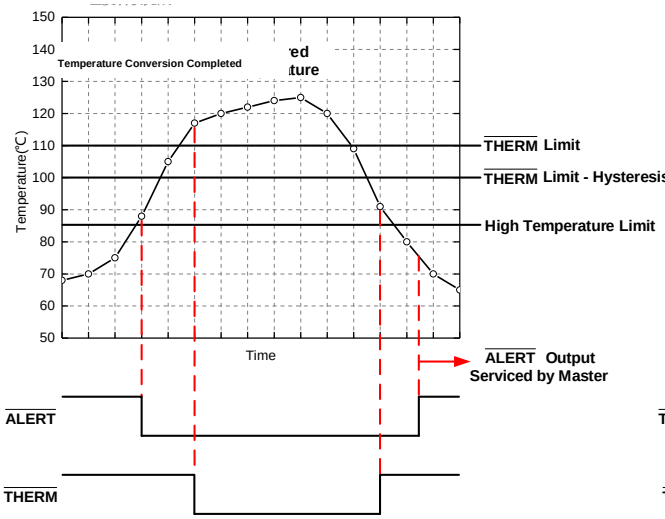


Figure 3. $\overline{\text{ALERT}}$ and $\overline{\text{THERM}}$ Pin Behavior

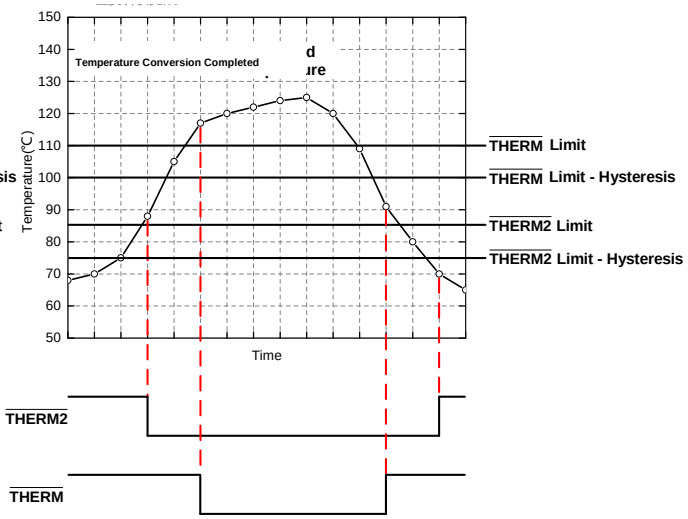


Figure 4. $\overline{\text{THERM2}}$ and $\overline{\text{THERM}}$ Pin Behavior

6.4 Serial Interface

6.4.1 Bus Overview

The GD30TS451N device is SMBus interface compatible. In 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 indicated by pulling the data line (SDA) from a high-to-low logic level while SCL is in high logic level. All slaves on the bus receive the slave address on the rising edge of the clock, with the last bit indicating whether a read or write operation is intended. During the ninth clock pulse, the slave being addressed responds to the master by generating an acknowledge bit and pulling SDA low. Data transfer is then initiated and sent over eight clock pulses followed by an acknowledge bit. During data transfer, SDA must remain stable while SCL is high, because any change in SDA while SCL is high is treated as a START or STOP signal. After all data have been transferred, the master generates a STOP signal indicated by pulling SDA from low to high while SCL is high.

6.4.2 Serial Bus Address

To communicate with the GD30TS451N device, the master must first address slave devices using a slave address byte. The slave address byte consists of seven address bits, and a direction bit indicating the intent of executing a read or write operation. The GD30TS451N device has a fixed address of 4Ch (1001 100b).

6.4.3 Read and Write Operations

When writing to the GD30TS451N, specific registers in the GD30TS451N can be accessed by writing the appropriate value to the pointer register. The value of the pointer register is the first byte transferred after the slave address byte when the R/$\overline{W}$ bit is low. Every write operation to the GD30TS451N requires a value for the pointer register (see Figure 5).

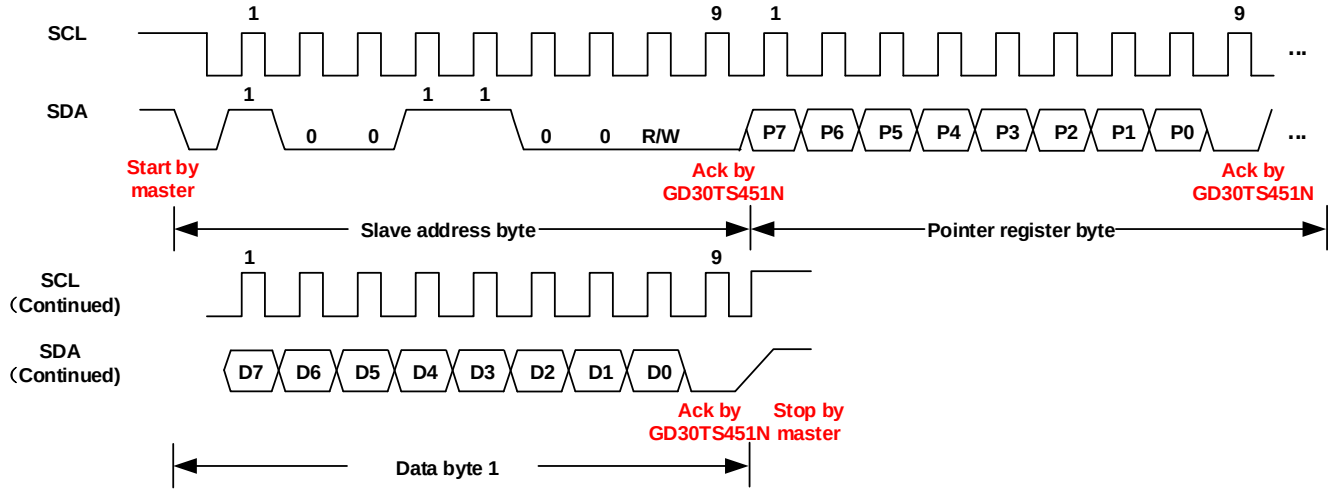


Figure 5. Two-Wire Timing Diagram for Write Command

When reading from the GD30TS451N, specify which register the read operation should read by writing the value to the pointer register. To change the register pointer for read operation, a new value must be written to the pointer register. This transaction is accomplished by issuing a slave address byte with the R/$\overline{W}$ bit low, followed by the pointer register byte. The master can then generate a START signal and send the slave address byte with the R/$\overline{W}$ bit high to initiate a read command. See Figure 6 for details on this step. To repeatedly read data from the same register, it is not necessary to send pointer register bytes continuously, the GD30TS451N will save the value of the pointer register in the last operation until it is changed by the next write operation. Read operations should be terminated by issuing a NACK command at the end of the last byte to be read.

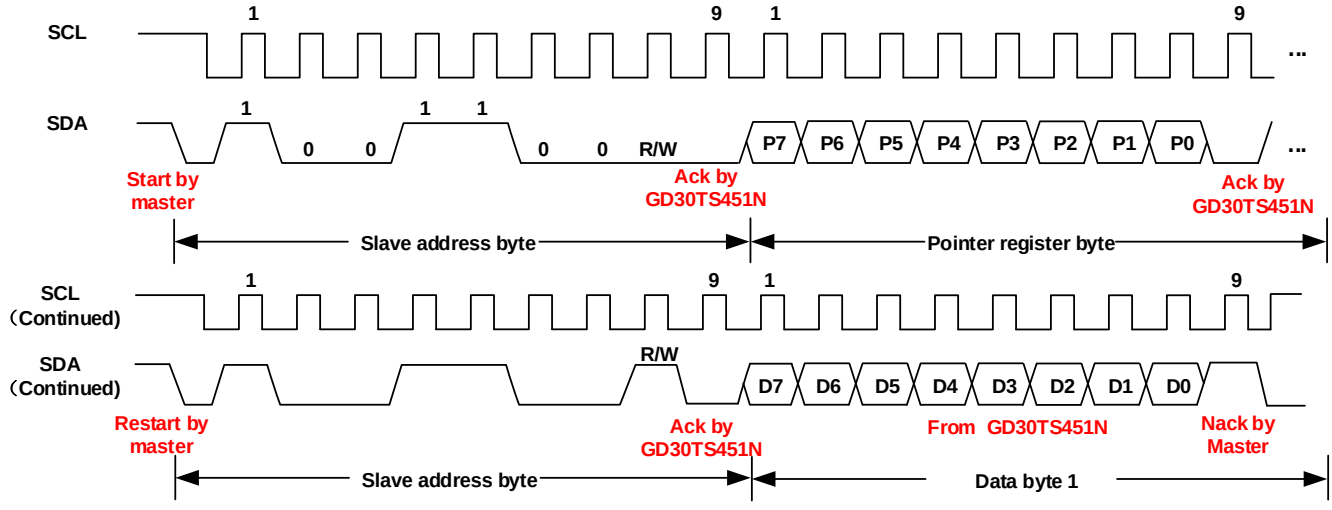


Figure 6. Two-Wire Timing Diagram for Read Command

6.4.4 Time-Out Mode

The GD30TS451N device resets the serial interface and releases the bus to wait for a START condition if either SCL or SDA are held low for 25ms (typical value) between a START and STOP condition. To avoid activating the time-out function, maintaining a communication speed of at least 1KHz for the SCL operating frequency is necessary. Setting the SMBTO bit to a value of 1 in the $\overline{\text{ALERT}}$ register enables the function.

6.4.5 High-Speed Mode

GD30TS451N supports two-wire bus operation at frequencies above 400KHz. The master device issues a high-speed mode code (0000 1xxx) after a START condition to switch the bus to high-speed operation. The GD30TS451N device does not acknowledge this byte, but switches the input filters on SDA and SCL and the output filter on SDA to operate in high-speed mode, allowing transfers data at up to 2.5MHz. After the high-speed mode code has been issued, the master transmits a two-wire slave address to initiate a data transfer operation. The bus continues to operate in high-speed mode until a STOP condition occurs on the bus. After receiving the STOP signal, the GD30TS451N will switch to the high-speed mode.

6.4.6 General Call Reset

The GD30TS451N responds to the two-wire general call reset command 00h (0000 0000b). The GD30TS451N will answer the command and continue to execute the command in the second byte. If the second byte is 06h (0000 0110b), the internal registers of the GD30TS451N will be reset to the power-on initial value, and the current temperature conversion will be aborted. If the second byte is other value, GD30TS451N will not respond.

6.5 Register Map

READ POINTER (HEX)	WRITE POINTER (HEX)	POWER-ON RESET (HEX)	BIT DESCRIPTION								TYPE	REGISTER DESCRIPTION
			7	6	5	4	3	2	1	0		
00	N/A	00	LT11	LT10	LT9	LT8	LT7	LT6	LT5	LT4	Read Only	Local temperature (high byte)
01	N/A	00	RT11	RT10	RT9	RT8	RT7	RT6	RT5	RT4	Read Only	Remote temperature (high byte)
02	N/A	N/A	BUSY	LHIGH	LLOW	RHIGH	RLOW	OPEN	RTHRM	LTHRM	Read Only	Status register
03	09	00	MASK1	SD	$\overline{\text{ALERT}}$ / $\overline{\text{THERM2}}$	0	0	RANGE	0	0	Read/Write	Configuration register
04	0A	08	0	0	0	0	CR3	CR2	CR1	CR0	Read/Write	Conversion rate register
05	0B	55	LTHL11	LTHL10	LTHL9	LTHL8	LTHL7	LTHL6	LTHL5	LTHL4	Read/Write	Local temperature high limit
06	0C	00	LTLL11	LTLL10	LTLL9	LTLL8	LTLL7	LTLL6	LTLL5	LTLL4	Read/Write	Local temperature low limit
07	0D	55	RTHL11	RTHL10	RTHL9	RTHL8	RTHL7	RTHL6	RTHL5	RTHL4	Read/Write	Remote temperature high limit (high byte)
08	0E	00	RTLL11	RTLL10	RTLL9	RTLL8	RTLL7	RTLL6	RTLL5	RTLL4	Read/Write	Remote temperature low limit (high byte)
N/A	0F	N/A	X	X	X	X	X	X	X	X	Write Only	One-shot start
10	N/A	00	RT3	RT2	RT1	RT0	0	0	0	0	Read Only	Remote temperature (low byte)
11	11	00	RTOS11	RTOS10	RTOS9	RTOS8	RTOS7	RTOS6	RTOS5	RTOS4	Read/Write	Remote temperature offset (high byte)
12	12	00	RTOS3	RTOS2	RTOS1	RTOS0	0	0	0	0	Read/Write	Remote temperature offset (low byte)
13	13	00	RTHL3	RTHL2	RTHL1	RTHL0	0	0	0	0	Read/Write	Remote temperature high limit (low byte)
14	14	00	RTLL3	RTLL2	RTLL1	RTLL0	0	0	0	0	Read/Write	Remote temperature low limit (low byte)
15	N/A	00	LT3	LT2	LT1	LT0	0	0	0	0	Read Only	Local temperature (low byte)
19	19	6C	RTH11	RTH10	RTH9	RTH8	RTH7	RTH6	RTH5	RTH4	Read/Write	Remote temperature $\overline{\text{THERM}}$ limit
20	20	55	LTH11	LTH10	LTH9	LTH8	LTH7	LTH6	LTH5	LTH4	Read/Write	Local temperature $\overline{\text{THERM}}$ limit
21	21	0A	HYS11	HYS10	HYS9	HYS8	HYS7	HYS6	HYS5	HYS4	Read/Write	$\overline{\text{THERM}}$ hysteresis
22	22	01	SMBTO	0	0	0	CONAL2	CONAL1	CONAL0	1	Read/Write	Consecutive $\overline{\text{ALERT}}$
23	23	00	NC7	NC6	NC5	NC4	NC3	NC2	NC1	NC0	Read/Write	η-factor correction
24	24	00	0	0	0	0	0	0	DF1	DF0	Read/Write	Digital filter control
FE	N/A	55	0	1	0	1	0	1	0	1	Read Only	Manufacturer ID

6.5.1 Pointer Register

The schematic diagram of the internal register structure of GD30TS451N is shown in Figure 7. The 8-bit pointer register is used to address a specific data register. The pointer register indicates which data register should respond to read and write commands on the bus. This register should be configured on every write command. Before executing a read command, the host must issue a write command to configure the pointer register. The power-on reset value of the pointer register is 00h (0000 0000b).

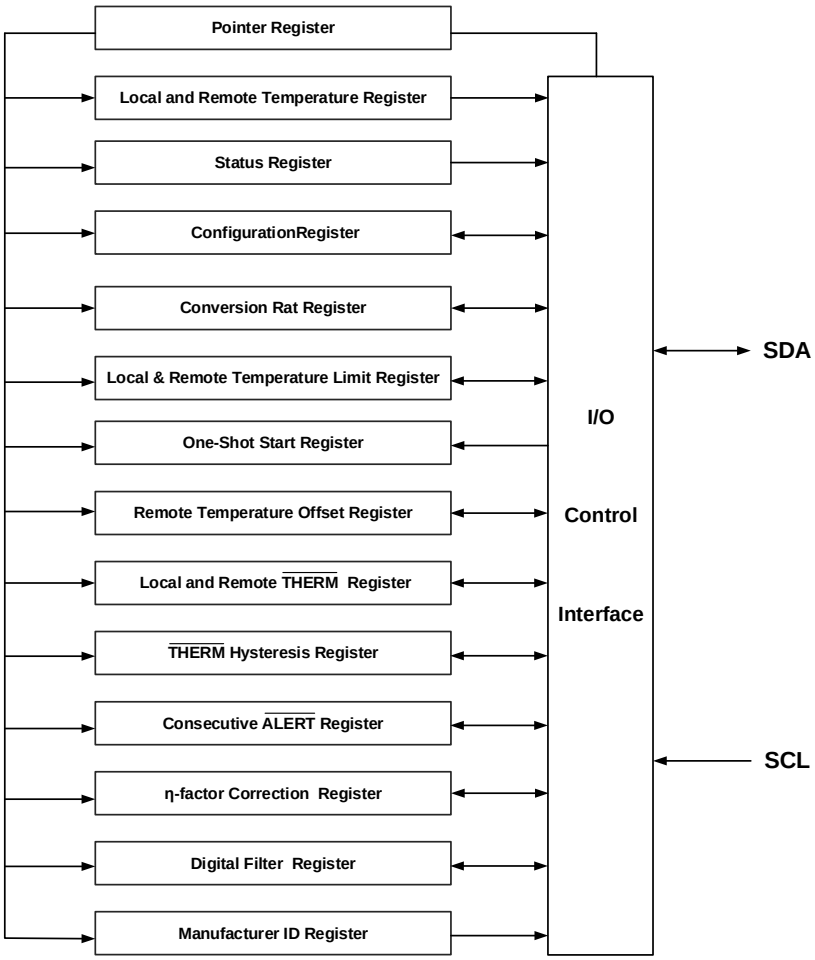


Figure 7. GD30TS451N Internal Register Structure

6.5.2 Temperature Register

The GD30TS451N has multiple 8-bit registers to save the temperature measurement results. The eight most significant bits (MSBs) of the local temperature measurement result are stored in register 00h, and the four least significant bits (LSBs) are stored in the four MSBs of register 15h. The eight MSBs of the remote temperature measurement result are stored in register 01h, and the four LSBs are stored in the four MSBs of register 10h. The four LSBs of both the local and remote sensors indicate the temperature value after the decimal point. These registers are read-only and are updated by the internal ADC each time a temperature measurement.

When the full temperature data is needed, reading the high temperature byte first will lock the low temperature byte (the ADC will not update it) until the low byte is read. The same is true for reading the low byte first (the high byte will be locked until read). This read mechanism ensures that the two adjacent high and low bytes read from

the same temperature conversion. To ensure the accuracy of the read data, the high byte of the temperature result should be read first. If the low byte data is not required, the low byte register may not be read. The power-on reset value of all temperature registers is 00h.

See Section 6.2.1 for specific temperature data information..

6.5.3 Status Register

The status register is used to indicate the temperature measurement status of GD30TS451N, and control the output of pin 4 and pin 6, see Section 6.3.3 for details.

Table 3. Status Register Descriptions

Bit	Field	Description
7	BUSY	ADC status indicator： 1=ADC is converting 0=ADC is not converting
6	LHIGH	Local temperature high limit status indicator[1] 1= Local temperature value exceeds the Local Temperature High Limit Register value. 0= = Local temperature value does not exceed the Local Temperature High Limit Register value.
5	LLOW	Local temperature low limit status indicator[1] 1= Local temperature value is below the Local Temperature Low Limit Register value. 0= Local temperature value is not below the Local Temperature Low Limit Register value.
4	RHIGH	Remote temperature high limit status indicator[1] 1= Remote temperature value exceeds the Remote Temperature High Limit Register value. 0= Remote temperature value does not exceed the Remote Temperature High Limit Register value.
3	RLOW	Remote temperature low limit status indicator[1] 1= Remote temperature value is below the Remote Temperature Low Limit Register value. 0= Remote temperature value is not below the Remote Temperature Low Limit Register value.
2	OPEN	Remote diode connection detection[1] 1= The remote diode is an open circuit。 0= The remote junction is not an open circuit.
1	RTHRM	Remote $\overline{\text{THERM}}$ limit status indicator 1= Remote temperature exceeds $\overline{\text{THERM}}$ limit. 0=Remote temperature does not exceed $\overline{\text{THERM}}$ limit.
0	LTHRM	Local $\overline{\text{THERM}}$ limit status indicator 1= Local temperature exceeds $\overline{\text{THERM}}$ limit. 0= Local temperature does not exceed $\overline{\text{THERM}}$ limit.

1 The above indicator bits remain high until the status register is read or a power-on reset occurs.

6.5.4 Configuration Register

MASK1 of the configuration register masks the $\overline{\text{ALERT}}$ output. This configuration applies only if the value of $\overline{\text{ALERT}}$ / $\overline{\text{THERM2}}$ bit is 0 (that is, pin 6 is configured as the $\overline{\text{ALERT}}$ output). If pin 6 is configured as the $\overline{\text{THERM2}}$ output, the value of the MASK1 bit has no effect. The remaining bits (bit4~3, bit1~0) in the configuration register must always be set to 0.

Table 4 Configuration Register Description

Bit	Field	Description
7	MASK1	$\overline{\text{ALERT}}$ output mask selection bits 1= $\overline{\text{ALERT}}$ is disabled. 0= $\overline{\text{ALERT}}$ is enabled.
6	SD	Device shutdown control 1= The device is in shutdown mode. 0= The device is in continuous conversion mode.
5	$\overline{\text{ALERT}}$ / $\overline{\text{THERM2}}$	$\overline{\text{ALERT}}$ or $\overline{\text{THERM2}}$ mode select 1= $\overline{\text{THERM2}}$ mode. 0= $\overline{\text{ALERT}}$ mode.
2	RANGE	Temperature measurement range selection bit 1= –64°C to 191°C 0= 0°C to 127°C。

6.5.5 Conversion Rate Register

The conversion rate register controls the rate at which the GD30TS451N measures temperature. This register adjusts the idle time between adjacent conversions, but not the conversion time itself. Table 5 lists the conversion rate and the time interval between the start of two consecutive conversions.

Table 5. Conversion Rate Description

REG VALUE	CONVERSIONS PER SECOND	TIME INTERVAL (s)
00h	0.0625	16
01h	0.125	8
02h	0.25	4
03h	0.5	2
04h	1	1
05h	2	0.5
06h	4	0.25
07h	8	0.125
08h	16(Default)	0.0625(Default)
09h	32	0.03125

6.5.6 Remote Temperature Offset Register

The remote temperature offset register of GD30TS451N is a 16bits read-write register, and the data format of this register is the same as that of the remote temperature register. The value in the remote temperature offset register is added to the temperature measurement result of the ADC, and the final result is stored in the remote temperature register. This register is used when calibration is required, allowing the GD30TS451N to compensate for system temperature offsets.

6.5.7 Consecutive $\overline{\text{ALERT}}$ Register

Table 6. Consecutive $\overline{\text{ALERT}}$ Register Description

BIT	FIELD	DESCRIPTION
7	SMBTO	SMBus time-out function selection bit 1= Enable SMBus time-out function. 0= Disable SMBus time-out function.
3-1	CONAL2-CONAL0	Consecutive $\overline{\text{ALERT}}$ times selection bit See Table 7 for details.

Table 7. Consecutive $\overline{\text{ALERT}}$ Number Description

REGISTER VALUE	CONSECUTIVE $\overline{\text{ALERT}}$ TIME
0h	1(Default)
1h	2
3h	3
7h	4

The CONAL2~CONAL0 bits define the number of times the temperature measurement result continuously exceeds the corresponding temperature limit value for the $\overline{\text{ALERT}}$ pin to be activated, and the power-on reset value is 1 time.

6.5.8 η− Factor Correction Register

The GD30TS451N allows for remote temperature measuring diodes (or BJTs) with different η-factors as remote temperature measuring probes. The remote channel uses different current to bias BJT for voltage ΔV_{BE}. Equation(1) shows the voltage ΔV_{BE} and temperature.

$$\Delta V_{BE} = \Delta V_{BE2} - \Delta V_{BE1} = \frac{\eta * kT}{q} \ln\left(\frac{I_2}{I_1}\right) \quad (1)$$

$$\eta = \frac{2048}{2048 + N} \quad (2)$$

$$N = \frac{2048}{\eta} - 2048 \quad (3)$$

The value η in Equations(1) is determined by the BJT characteristics applied in the actual temperature measurement. The default value of the BJT recommended by GD30TS451N (that is, the power-on reset value of the η-factor correction register) is η=1.008. When the η of the BJT used in the actual temperature measurement is other values, the η-factor correction register can be configured according to the corresponding relationship in equations (2) and (3) to realize the correction of the remote temperature measurement results. Among them, N is the 8-bit signed number represented by the η-factor correction register, the valid data range generated is −128 to +127, and the corresponding η-factor range is 0.941609~1.066667, see Table 8 for details.

Table 8. η-Factor Correction Value

N			η
BINARY	HEX	DECIMAL	
0111 1111	7F	127	0.941609
0001 0000	0A	16	0.992248
0000 1000	08	8	0.996109
0000 0100	04	4	0.998051
0000 0000	00	0	1.008000(Default)
1111 1100	FC	–4	1.001957
1111 1000	F8	–8	1.003922
1111 0000	F0	–16	1.007874
1000 0000	80	–128	1.066667

6.5.9 Digital Filter Control Register

This register is used to configure the remote temperature measurement result filter. When the filter is turned on, the remote temperature measurement result output is the average of the previous temperature measurement results. See Table 9 for details.

Table 9. Digital Filter Configuration

REGISTER VALUE	NUMBER OF REMOTE TEMPERATURE MEASUREMENTS AVERAGED
0h	0(Default, Filter Off)
1h	4
2h	8

6.5.10 Manufacturer ID Register

GD30TS451N allows the slave to query its production number through the bus. The manufacturer ID is obtained by reading from the pointer address FEh. The power-on reset value of the GD30TS451N production number is 55h.

7 Application Information

The following contents are the precautions for GD30TS451N recommended by GigaDevice in practical applications. When customers use GD30TS451N with reference to the following content, they should evaluate in advance whether the relevant components used are suitable for the intended use according to their requirements and application scenarios, and verify the correctness of the built temperature measurement system to avoid losses.

7.1 Remote Temperature Probe Selection

When GD30TS451N performs remote temperature measurement, a remote temperature measurement probe needs to be connected between D+ and D- pins. As mentioned above, the temperature probe can be NPN, PNP or diode. According to the principle of remote temperature measurement, no matter using NPN or PNP transistors, as long as the base-emitter junction of BJT is used for remote temperature sensing. It should be noted that if the NPN transistor is used as the remote temperature measuring probe, the NPN transistor must be diode-connected; if the PNP transistor is used, it can be diode-connected or transistor-connected, as shown in Figure 8.

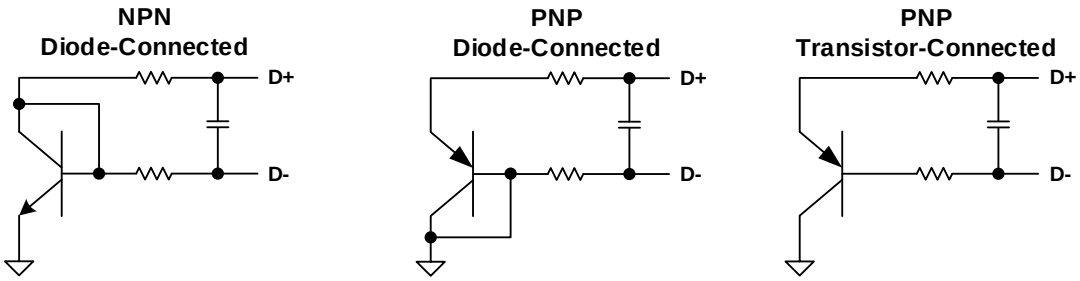


Figure 8. GD30TS451N Remote Temperature Probe Connection Method

When a PNP transistor is used as a remote temperature measuring probe, the method of the PNP transistor can be selected according to the actual use requirements. Diode-connected PNPs can provide faster settling times, while transistor-connected PNPs can achieve better series resistance cancellation.

The error generated by the GD30TS451N in remote temperature measurement is usually caused by the current biasing the remote BJT and the non-ideal factor η of the remote BJT. The current used by the GD30TS451N to bias the remote temperature measurement BJT is divided into three levels, from high to low, 120μA, 45μA and 7.5μA. The non-ideal factor η = 1.000 of the BJT recommended by GD30TS451N, and supports BJTs with different η values as remote temperature probes, see Section 6.5.8 for details. If the customer uses a BJT with η≠1.000 as a remote temperature measurement probe, the resulting remote temperature measurement error can be represented by the following formula, where T is the actual temperature in degrees Celsius:

$$T_{ERROR} = (\eta - 1.000) * (273.15 + T) \quad (4)$$

1. According to the above analysis, the selection of remote temperature measuring probes can be based on the following criteria:
2. When the current biasing the BJT is 7.5μA, at the highest detection temperature, VBE>0.25V;
3. When the current biasing the BJT is 120μA, at the lowest detection temperature, VBE<0.95V;
4. Base resistance<100Ω;
5. The characteristics of VBE are tightly controlled by hFE.

Based on the above criteria, the two recommended remote temperature measurement BJT models are 2N3904 (NPN) or 2N3906 (PNP).

7.2 Typical Applications

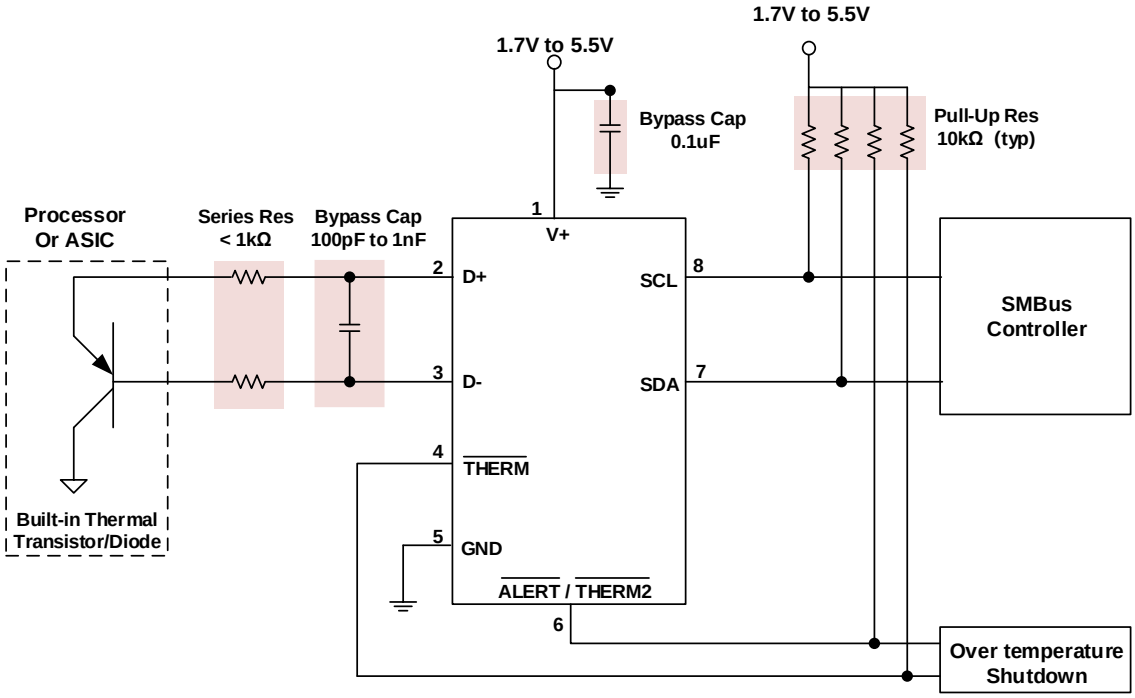


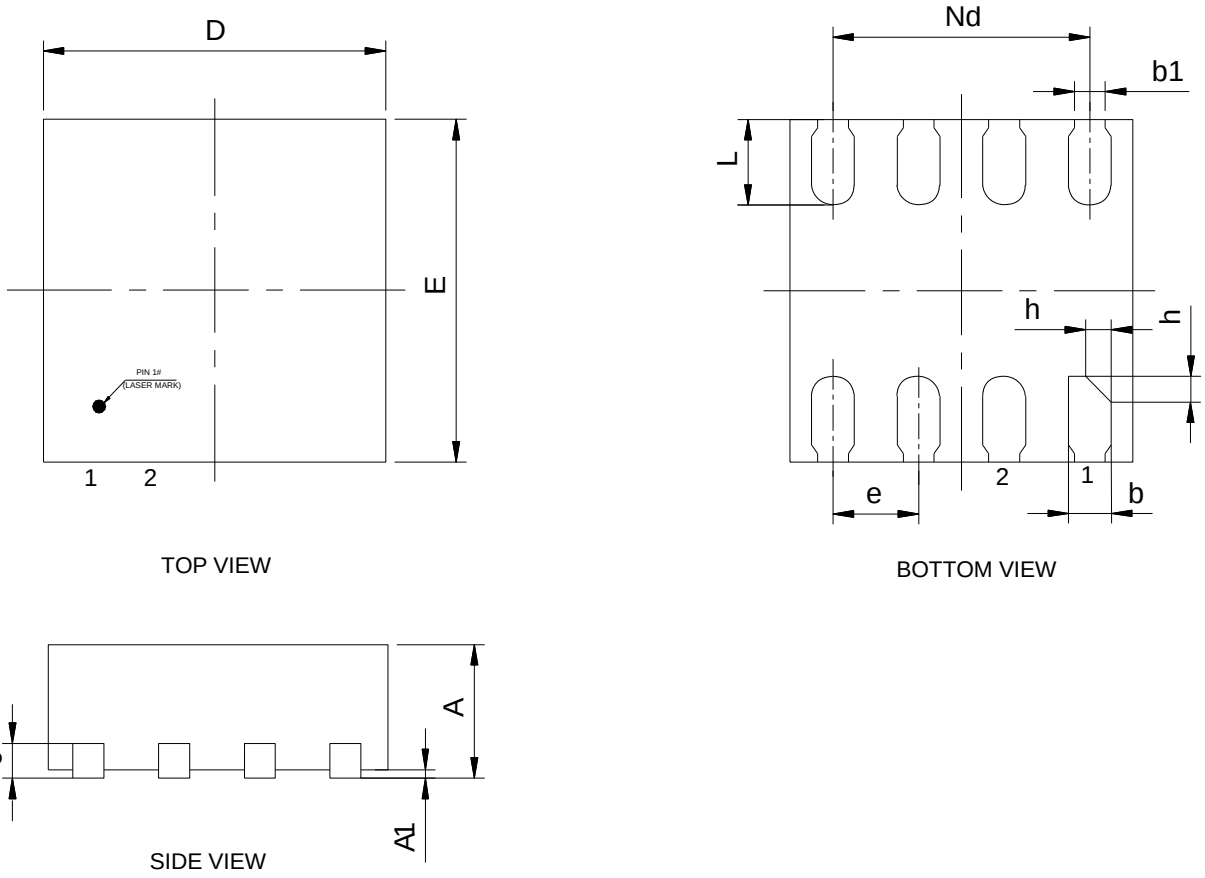
Figure 9. GD30TS451N Typical Application Connection Diagram

As shown in Figure 9, in practical applications of GD30TS451N, pins 4, 6, 7, and 8 all require pull-up resistors, with a typical value of 10kΩ; at the power supply pin V+, it is recommended to use a power supply bypass capacitor to suppress power supply noise. To improve the temperature measurement accuracy of the chip, the typical value of this capacitor is 0.1μF. For D+ and D- pins, according to the actual use requirements, the purpose of filtering can be achieved by connecting resistors and capacitors across them in series, see Section 6.2.3 for details. The value of the series resistance on the D+ and D- pins should be less than 1kΩ, the typical value is 50Ω; the value of the jumping capacitor should be between 100pF to 1nF, the typical value is 100pF.

8 Package Information

8.1 Outline Dimensions

WSON-8 Package Outline



NOTES:

1. All dimensions are in millimeters.
2. Package dimensions does not include mold flash, protrusions, or gate burrs.
3. Refer to the Table 10. *WSON-8 dimensions(mm)*.

Table 10. WSON-8 dimensions(mm)

SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0	0.02	0.05
b	0.18	0.25	0.30
b1	0.18 REF		
c	0.203 REF		
D	1.90	2.00	2.10
e	0.50 BSC		
Nd	1.50 BSC		
E	1.90	2.00	2.10
L	0.45	0.50	0.55
h	0.10	0.15	0.20

9 Ordering Information

Ordering Code	Package Type	ECO Plan	Packing Type	MOQ	OP Temp(°C)
GD30TS451NWJTR-I	WSON-8	Green	Tape & Reel	4000	−55°C to +150°C

10 Revision History

REVISION NUMBER	DESCRIPTION	DATE
1.0	Initial release and device details	2024

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