High-Precision Digital Temperature Sensor Optimized for Human Body Temperature Measurement

1 Features

- Optimized for human body temperature measurement
- Accuracy: ± 0.1°C (+30°C to +45°C)
- Supply range: 1.6V to 5.5V
- Operating temperature: −40°C to +125°C
- Active current: 40μA
- Standby current: 0.5μA
- Resolution: 16bits (0.0078125°C)
- Interface: S-Bus

2 Applications

- Medical thermometer
- Wearable temperature monitoring
- High-precision temperature probe

3 Description

GD30TS110T is a high-precision digital temperature sensor optimized for human body temperature measurement. It can achieve 16-bit (0.0078125°C) temperature output without any external temperature sensing unit, and has a temperature measurement error of less than ±0.1°C in the range of 30°C to 45°C.

GD30TS110T supports four packaging forms: WLCSP-4、MCLGA-4、DFN-6 and TO-92S. The former is extremely small and suitable for applications with extremely limited space; the latter can conduct heat rapidly and is designed for measuring the surface temperature of human skin.

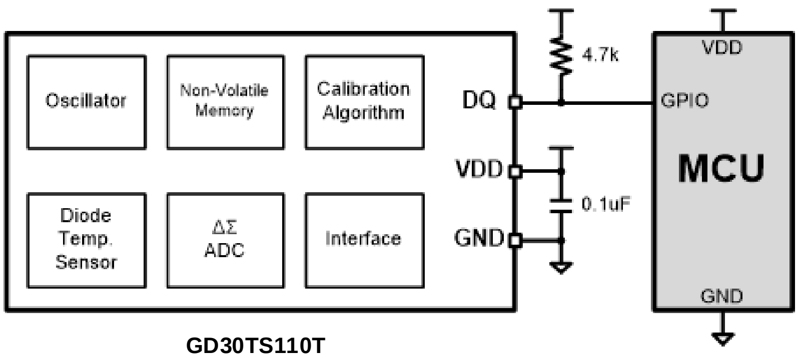
GD30TS110T supports single-line communication and can mount up to 16 slaves, requiring only a single signal line to obtain temperature output.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE(NOM)
GD30TS110T	WLCSP-4	0.73 mm × 0.73 mm
	MCLGA-4	3.00 mm × 3.00 mm
	DFN-6	2.00 mm × 2.00 mm
	TO-92S	4.00 mm × 3.15 mm

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

Typical Application Schematic

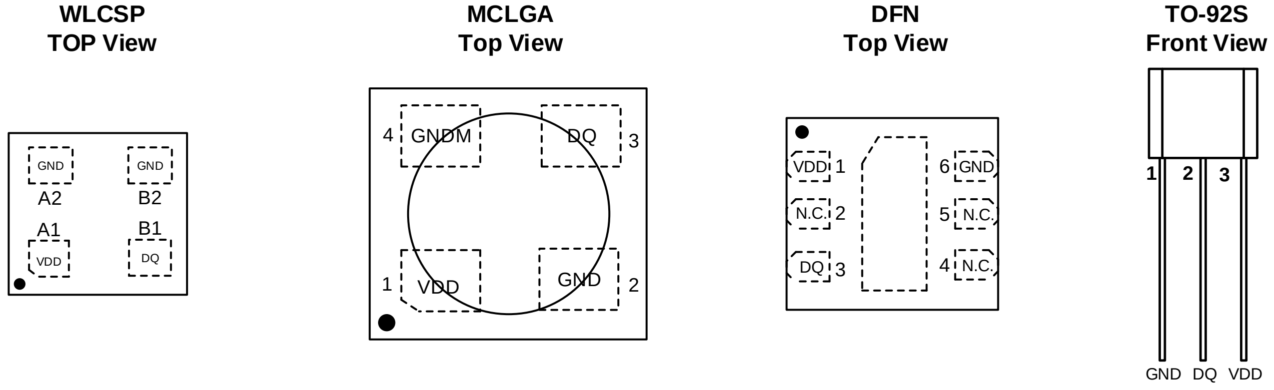


GD30TS110T

Table of Contents

4 Device Overview

4.1 Pinout and Pin Assignment



4.2 Pin Description

PINS					PIN TYPE[1]	FUNCTION[1]
NAME	WLCSP	MCLGA	DFN	TO-92S		
VDD	A1	1	1	3	P	For the power pin, it is recommended to add a 0.1μF to 10μF ground bypass capacitor.
GND	A2, B2	2	6	1	G	Ground.
DQ	B1	3	3	2	O	Communication pin, requires 4.7kΩ pull-up resistor.
GNDM		4			G	Metal cap ground pin. It is recommended to connect to GND.
N.C.			2, 4, 5			No connection.

1. P = power, G = Ground, O = Output.

5 Parameter Information

5.1 Absolute Maximum Ratings

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

SYMBOL	PARAMETER	MIN	MAX	UNIT
V_{IO}	Voltage at DQ and GNDM	−0.5	6	V
T_A	Temperature Range	−40	150	°C
T_J	Junction Temperature		150	°C
T_{stg}	Storage Temperature	−40	150	°C

1. Over operating free-air temperature range (unless otherwise noted). Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device.

5.2 Recommended Operation Conditions

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_+	Supply voltage	1.6	3.3	5.5	V
T_A	Operating Temperature	−40		125	°C

5.3 Electrical Sensitivity

SYMBOL[1]	CONDITIONS	VALUE	UNIT
$V_{ESD(HBM)}$	Human Body Mode (HBM), per ANSI/ESDA/JEDEC JS-001	±4000	V
Latch-up	Latch-Up, per JESD 78, Class IA	±200	mA

5.4 Electrical Characteristics

Unless otherwise specified, the following data are the characteristics of the chip at −40 °C to +125 °C and power supply voltage is in the range of 1.6 V to 5.5 V. (Typical operating conditions are + 25°C and 3.3V)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
V_+	Power Supply Voltage		1.6	3.3	5.5	V
T_A	Operating Temperature Range		−40		125	°C
T_{ERROR}	Accuracy (Temperature Error)	+30°C to +45°C, 3.3V		±0.03125	±0.1	°C
		+10°C to +60°C, 3.3V		±0.1	±0.3	°C
		−40°C to +125°C, 3.3V		±0.3	±0.5	°C
	DC Power Supply Sensitivity	−40°C to +125°C			0.1	°C/V
	Resolution			0.0078125		°C
				16		bits
t_{CON}	Conversion Time			120	150	ms
	Operating Current	Conversion period		40	80	μA
		Standby mode		0.5	3	μA
	Pull-up Resistor		0.5	4.7	10	kΩ

6 Functional Description

6.1 Interface Overview

After GD30TS110T is powered on, it takes about 3ms to stabilize, during which any communication operation is prohibited.

GD30TS110T uses a single-wire interface, which can realize communication between a single host and multiple slaves using only a single signal line, and can support up to 16 slaves. All slaves on the single line need to drive the signal line at an appropriate time, so they must be mounted on the single line in the form of open-drain output. The single-wire interface supports multiple device access operations (MDA), and the temperature output of all slaves can be read in one communication. The specific operation process is divided into the following two steps:

- Search process: reset the slaves and assign the sending order of each slave;
- Temperature reading process: start conversion mode and read the temperature output of each slave.

6.2 Signal Timing

Single-line data transmission uses a time slot as a basic unit, carrying only one bit of data once. Time slots all start when the host pulls down the single line. GD30TS110T can send data to the single line only when the host starts the time slot. The width of time slots is no shorter than 65μs, and an interval of no less than 1μs must be provided between adjacent time slots.

The time slot can be further divided into the following two signals according to the difference in transmitting 0 and 1:

- 1 time slot: starting from the falling edge of a single line, GD30TS110T directly releases the single line;
- 0 time slot: starting from the falling edge of the single line, GD30TS110T pulls down the single line and maintains for 15μs to 60μs.

In order to receive the data sent by GD30TS110T, the host must sample the single line within a specific window time, and the sampling result is one bit of data received. The shortest valid time of data is 15μs, so the maximum sampling window cannot exceed this time. In order to maximize the timing margin, it is recommended to release the single line time of the host as early as possible (take 1μs) and delay the host sampling time as late as possible (take 15μs). The specific timing is shown in Figure 1.

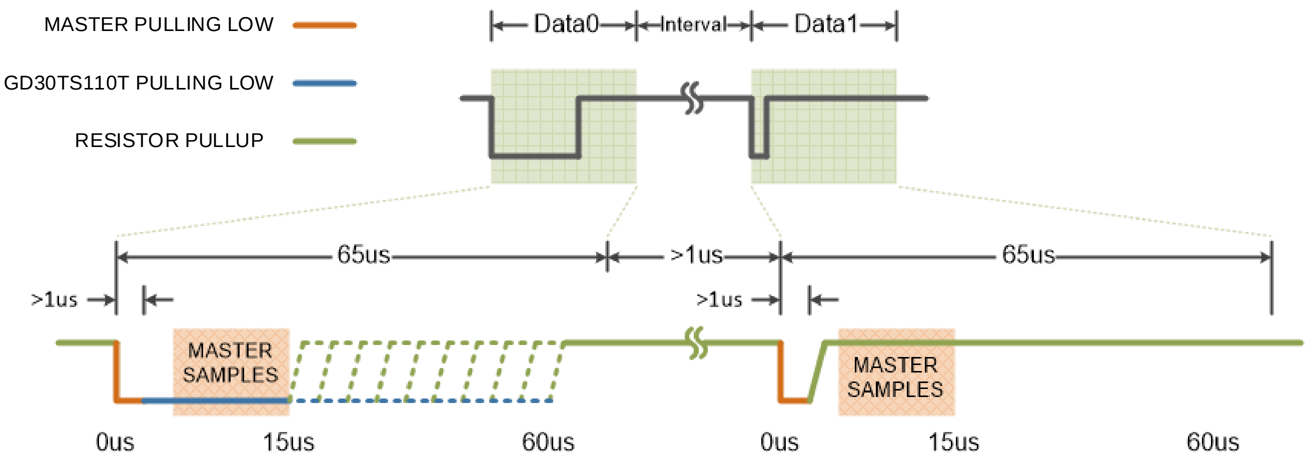


Figure 1. Signal Timing Diagram of Time Slot

6.3 Search Process

When multiple GD30TS110TBN with different addresses are mounted on a single line, the host should perform a search process after power-on to assign a corresponding sending timing to each slave on the single line, so as to avoid data conflicts during the temperature reading process. When only one GD30TS110T is mounted on a single line, there is no need to perform a search process.

Based on the open-drain structure's characteristic of "wired AND" (i.e., any slave outputting 0 will cause the single line to output 0, and the single line will output 1 only when all slaves output 1), GD30TS110T stipulates a single-line arbitration mechanism to avoid data conflicts in the search process, as shown in Figure 2 below. In the search process, all slaves on the single line will simultaneously send their own address values to the single line in sequence from high to low, and then sample the single line data to obtain the arbitration result:

- Send 1, receive 1: no data conflict occurs in this bit, and the slave will continue to send;
- Send 1, receive 0: data conflict occurs in this bit, and the slave loses single-line control, and will exit subsequent transmission and wait for the end of this round of allocation;
- Send 0, receive 0: There is no data conflict in this bit, or a data conflict occurs and the slave wins single-line control, and will continue to send subsequent messages;
- Send 0, receive 1: Circuit connection failure, this state should not appear.

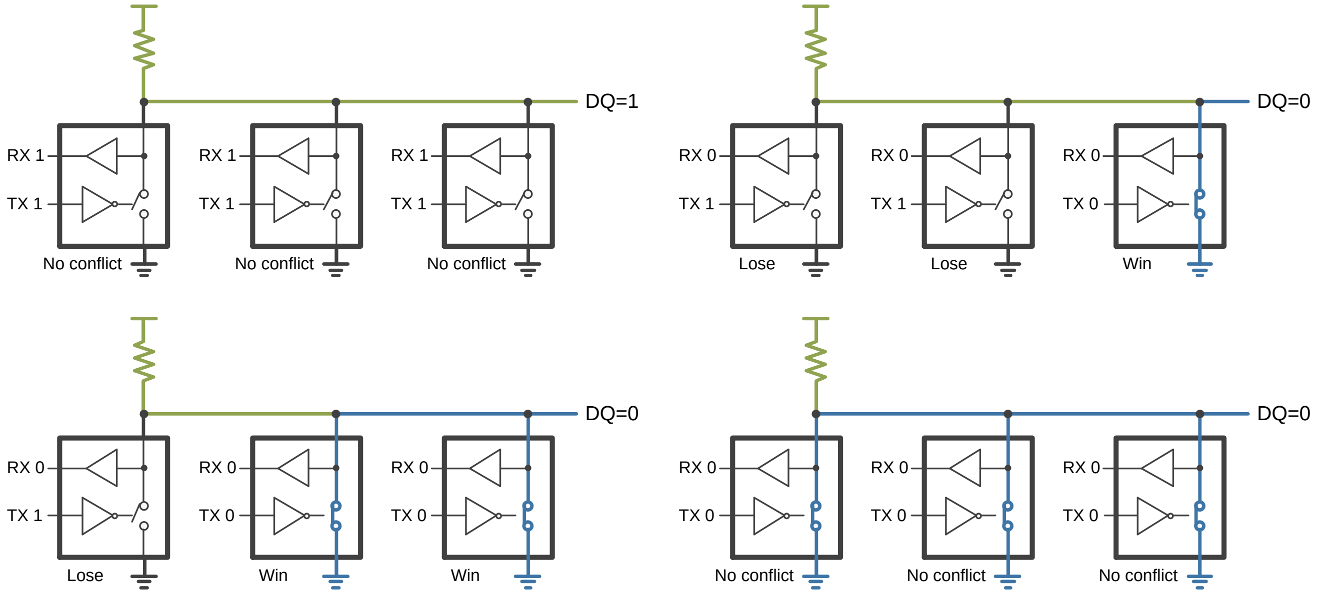


Figure 2. Diagram of the Single-wire Interface Arbitration Mechanism

By starting a series of time slots through the host, all slaves on a single line will automatically confirm each other's transmission order based on the basic principle that "the smaller the address, the earlier the sending order". The flowchart of the search process is shown in Figure 3 (left), and the specific execution steps are as follows:

- Step-0: The host sends a reset pulse (pull down the single line and maintain for 2ms to 3ms), resets all slaves on the single line, and starts the search process;
- Step-1: The host starts a one-bit time slot. If there are still unassigned slaves on the single line, the data is 0 (Ack), otherwise it is 1 (NAck);
- Step-2: The host starts a four-bit time slot and reads the address value of the slave that has not been assigned on the single line. The arbitration mechanism ensures that no data conflict occurs;
- Step-3: Go back to Step-1 and repeat multiple rounds until Step-1 reads NAck. At this time, the sending order of all slaves on the single line has been determined.

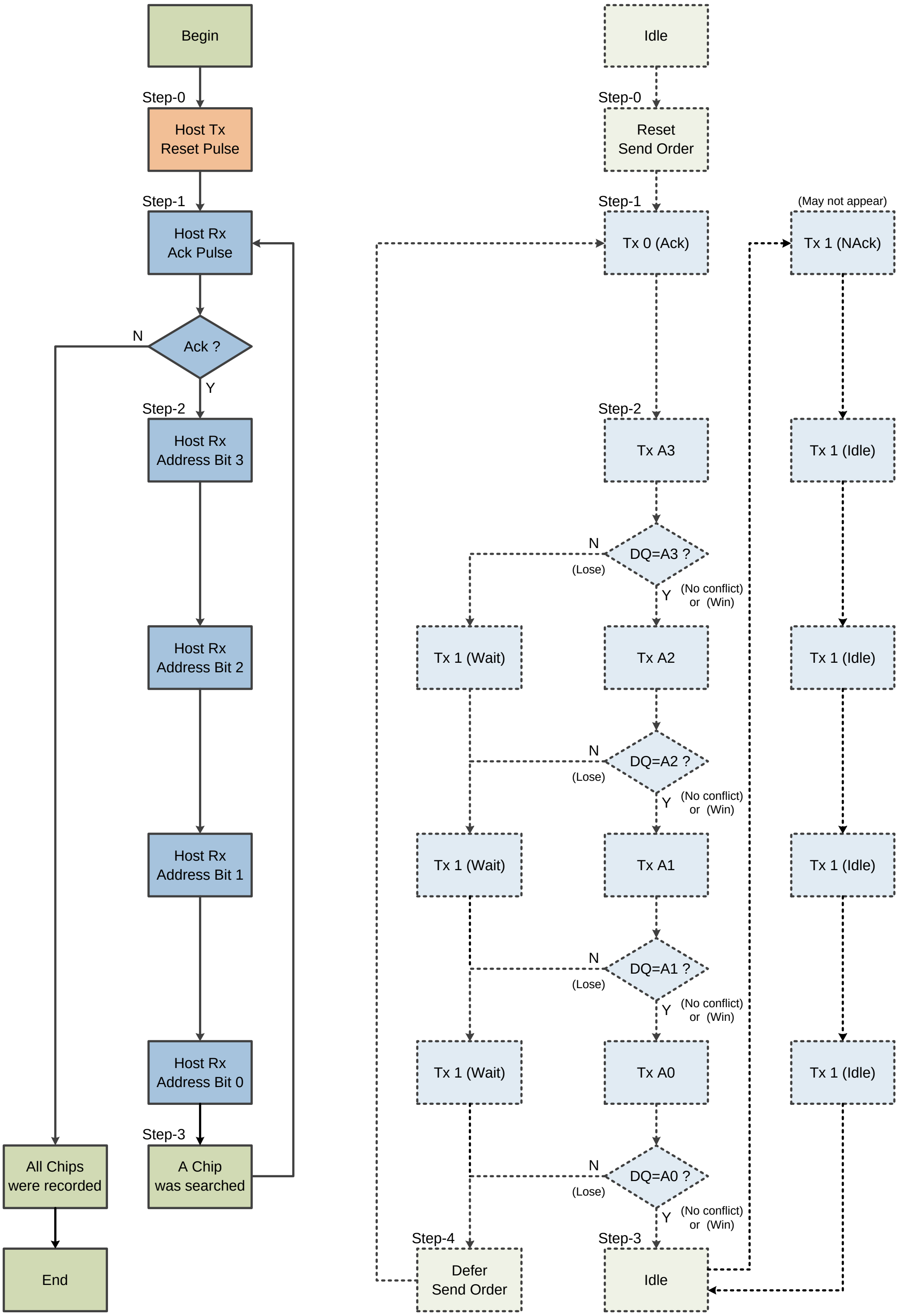


Figure 3. Flowchart of the Search Process (left: master; right: slave)

The processing logic of GD30TS110T in the search process is shown in Figure 3 (right), which corresponds to the host process in Figure 3 (left). The specific execution steps are as follows:

- Step-0: After GD30TS110T detects the reset pulse, it resets its own temperature reading process, send order to 1 and enters the state of waiting to be allocated;

- Step-1: GD30TS110T sends data 0 (Ack) to inform the host that there are still unassigned slaves on the single line;
- Step-2: GD30TS110T sends its own address A3/A2/A1/A0. If the arbitration is lost at any position, wait until the end of this round and jump to Step-4;
- Step-3: GD30TS110T saves the current sending order and enters the idle state. It will no longer drive the signal line, that is, send data 1 (NAck / Idle);
- Step-4: GD30TS110T postpones the current sending order (+1) and returns to Step-1. GD30TS110T may participate in multiple rounds until it exits from Step-3.

The above processing logic, including the judgment and execution of the arbitration mechanism, is automatically completed by GD30TS110T. The host does not need any additional algorithm. It directly uses five-bit time slots as one round and repeats n rounds to read out the addresses of n slaves on a single line in order from small to large address values. The reading order is the sending order of the slave.

Take the case of three GD30TS110TBN mounted on a single line (addresses are 0100b, 0001b and 1100b respectively), the signal timing of the search process is shown in Figure 5. After sending the reset pulse, the host needs to start at least 15 time slots. In chronological order, the serial data read out is 00001b / 00100b / 01100b. This string of binary numbers (divided into three sections) represents that there is a total of three GD30TS110TBN mounted on the single line, among which the slave 0001b is ranked first in the temperature reading process, the second is 0100b, and the third is ranked 1100b, regardless of their positions on the PCB. If the number of slaves mounted on the single line is known, the 16th time slot can be omitted because it must be data 1 (NAck); if the number is unknown, the 16th time slot (=5*n+1) is needed to know whether all slaves on the single line have been searched and recorded.

6.4 Temperature Reading Process

Based on the open-drain structure’s characteristic of “wired AND” (i.e., any slave outputting 0 will cause the single line to output 0, and the single line will output 1 only when all slaves output 1), GD30TS110T features a single-line polling mechanism to ensure that the read data are the latest results. After starting the temperature conversion, the host can start the time slot at any time to query the conversion situation of all slaves on the single line. If the data is 0 (Run), it means that at least one slave has not completed the conversion; if the data is 1 (End), it means that all slaves have completed the conversion. In order to improve the anti-interference ability of the polling mechanism, GD30TS110T stipulates that the temperature conversion stage is considered to be over only when the data 1 (End) is queued twice in a row. Each slave starts to queue up according to the sending order assigned in the search process and outputs its own temperature results in turn.

The flowchart of the entire temperature reading process is shown in Figure 4 (left), and the specific execution steps are as follows:

- Step-0: The host sends a start pulse (pull down the single line and maintain for 480μs to 640μs) to control all slaves on the single line to start temperature conversion;
- Step-1: The host starts a time slot. If there is still a slave that has not completed the conversion on the single line, the data is 0 (Run), otherwise it is 1 (End);

Note: During the conversion period, the host can start the time slot for multiple times to poll the conversion status; or it can choose not to poll and wait for a enough long time (>150ms). However, no matter which method is adopted, the host must complete two consecutive polls with the result of 1 before entering Step-2.

- Step-2: The host starts the 16-bit time slot and reads out the temperature result of the slave corresponding to the current sending order;
- Step-3: Go back to Step-2 and repeat for multiple rounds until all slaves on a single line are traversed.

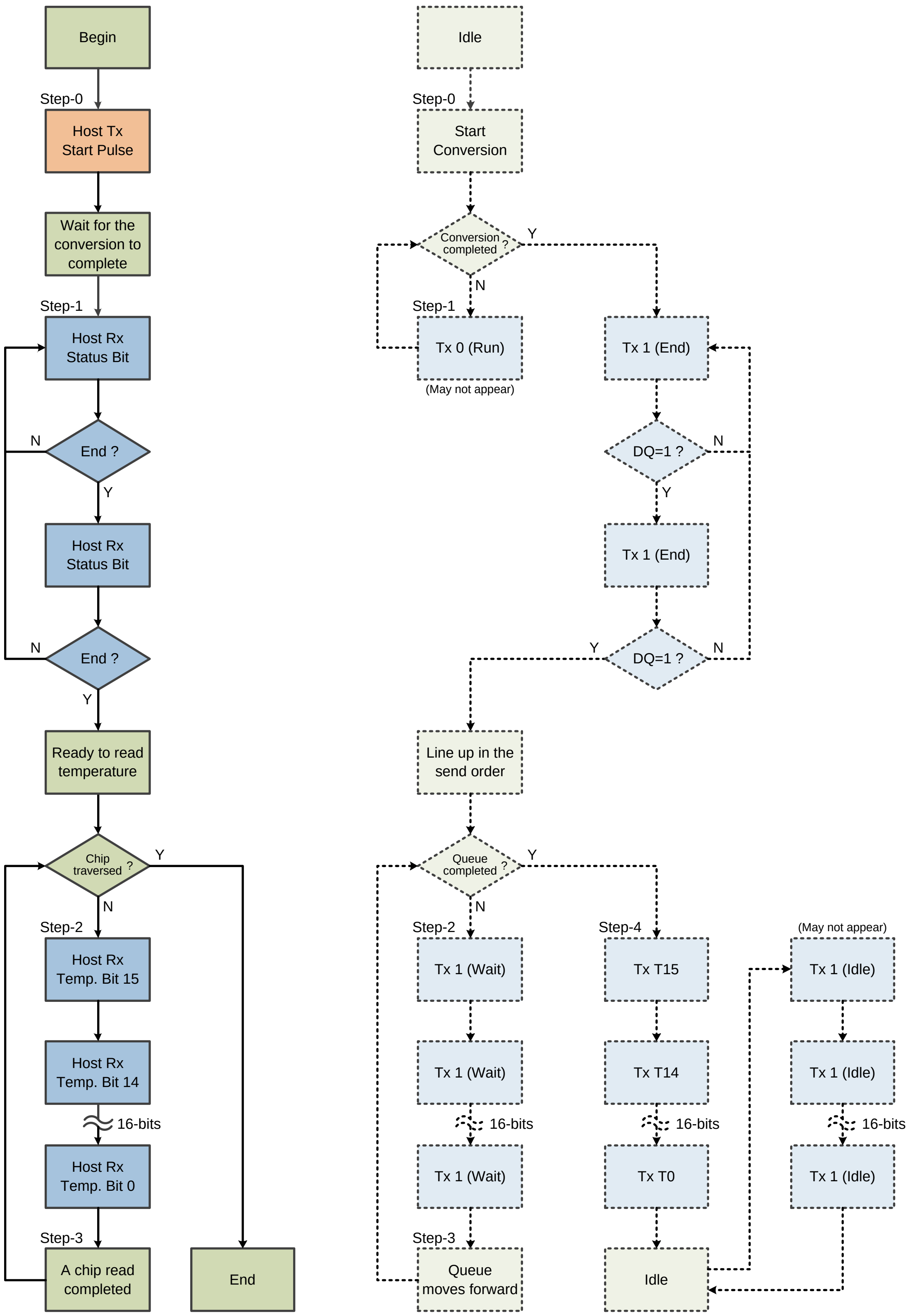


Figure 4. Flowchart of the temperature reading process (left: host; right: slave)

The processing logic of GD30TS110T in the temperature reading process is shown in Figure 4 (right), which corresponds to the host process in Figure 4 (left). The specific execution steps are as follows:

- Step-0: After GD30TS110T detects the start pulse, it starts temperature conversion, which takes about 120ms (typical value);
- Step-1: GD30TS110T sends data 0 (Run) or data 1 (End) according to the conversion situation. If the sending order is 1, jump to Step-4;
- Step-2: GD30TS110T is waiting in line, and the signal line is not driven in this round, that is, the 16-bit data 1 is sent (Wait);
- Step-3: GD30TS110T moves forward in the queue and returns to Step-2. GD30TS110T may participate in multiple rounds until the queue is completed and jumps to Step-4;
- Step-4: GD30TS110T sends the 16-bit temperature result and enters the idle state. After that, it no longer drives the signal line, that is, it sends data 1 (Idle).

Take three GD30TS110TBN mounted on a single line as an example (addresses are 0100b, 0001b and 1100b respectively), the signal timing of the temperature reading process is shown in Figure 6. After the host sends the start pulse, it needs to start at least 50 time slots. In chronological order, the serial data is read as 11b / 0001 0010 1100 0000b / 0001 0010 1011 1111b / 0001 0010 1100 0001b. This string of binary numbers (divided into four segments) represents that the polling result is valid, and the first temperature is output by Slave-1 (37.5°C), the second temperature is output by Slave-0 (37.4921875°C), and the third temperature is output by Slave-2 (37.50 78125°C).

To facilitate the demonstration of the polling mechanism, the orange area in Figure 6 represents the temperature conversion being performed by GD30TS110T, during which the three polling results are all data 0 (Run). If the host waits long enough, these three polling can be omitted. However, the two subsequent polling with data 1 (End) cannot be omitted.

The temperature result is a 16bit binary complement code, with the least significant bit representing 0.00781 25°C. Table 1 lists the digital outputs corresponding to some typical temperatures.

Table 1. Temperature Data Format

Temperature (°C)	Digital Output (Binary)	Digital Output (Hexadecimal)
+150.00000000	0100 1011 0000 0000	4B00
+125.00000000	0011 1110 1000 0000	3E80
+85.00000000	0010 1010 1000 0000	2A80
+37.50000000	0001 0010 1100 0000	12C0
+0.0078125	0000 0000 0000 0001	0001
+0.00000000	0000 0000 0000 0000	0000
−0.0078125	1111 1111 1111 1111	FFFF
−50.00000000	1110 0111 0000 0000	E700

1. Table 1 does not provide data formats for all temperatures.

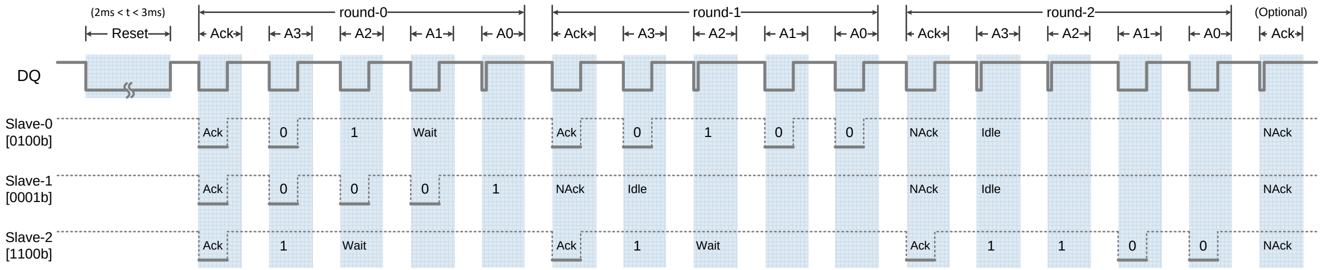


Figure 5. Signal Timing Diagram of the Search Process

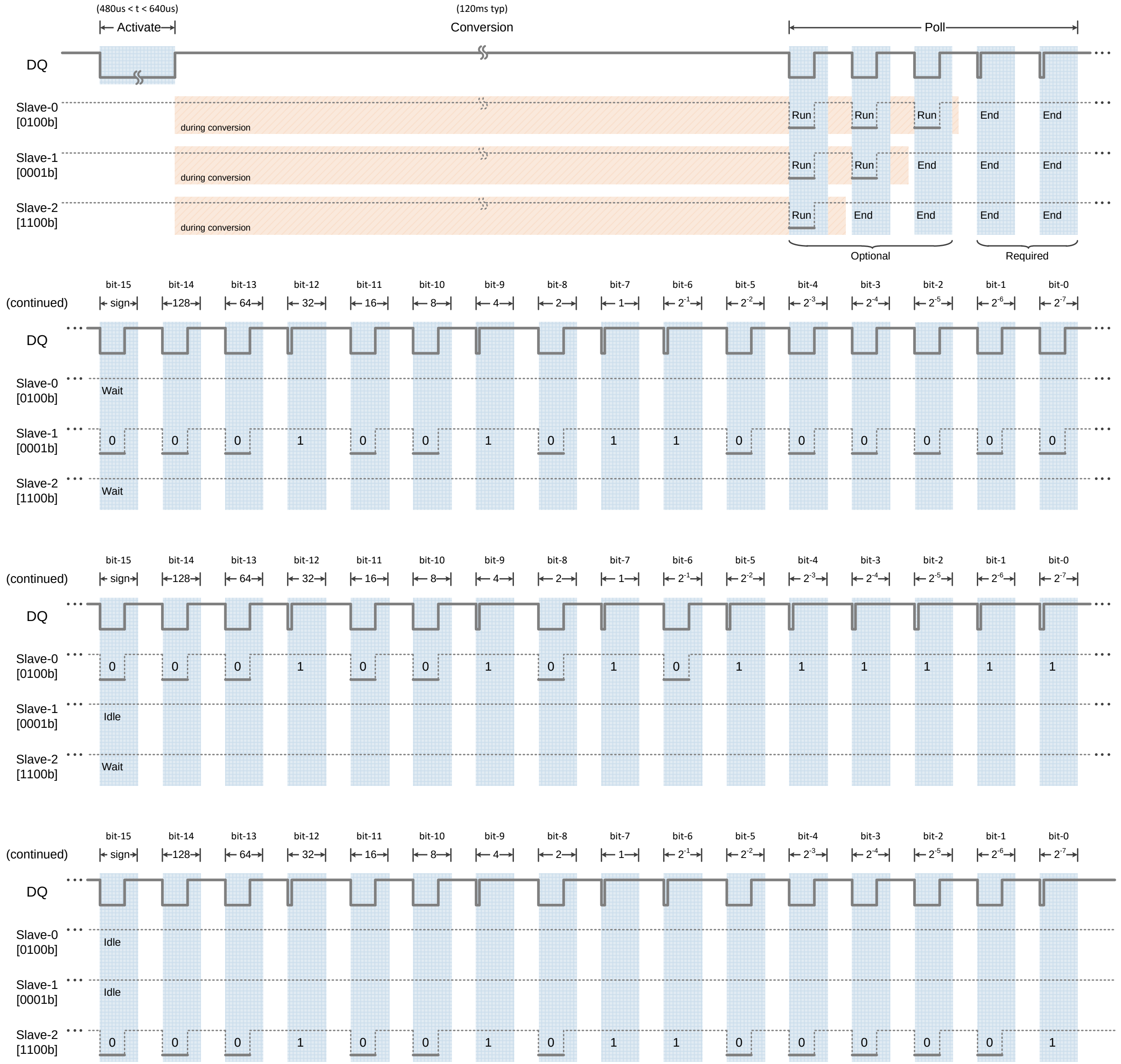


Figure 6. Signal Timing Diagram of Temperature Reading Process

7 Application Information

The conversion power consumption of GD30TS110T is extremely low, so an RC filter circuit can be added to the power pin to further reduce the impact of power supply noise. As shown in Figure 7 below, the resistance must be less than 1kΩ, the capacitance must be more than 0.1μF, and the power pin voltage cannot be lower than 1.6V.

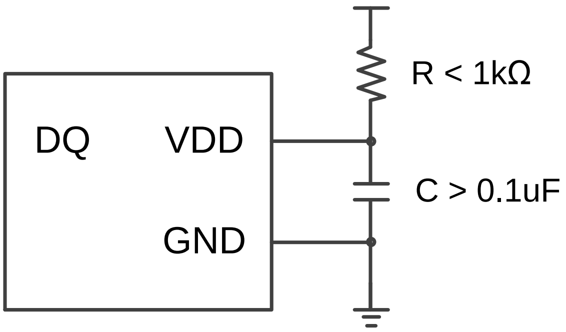


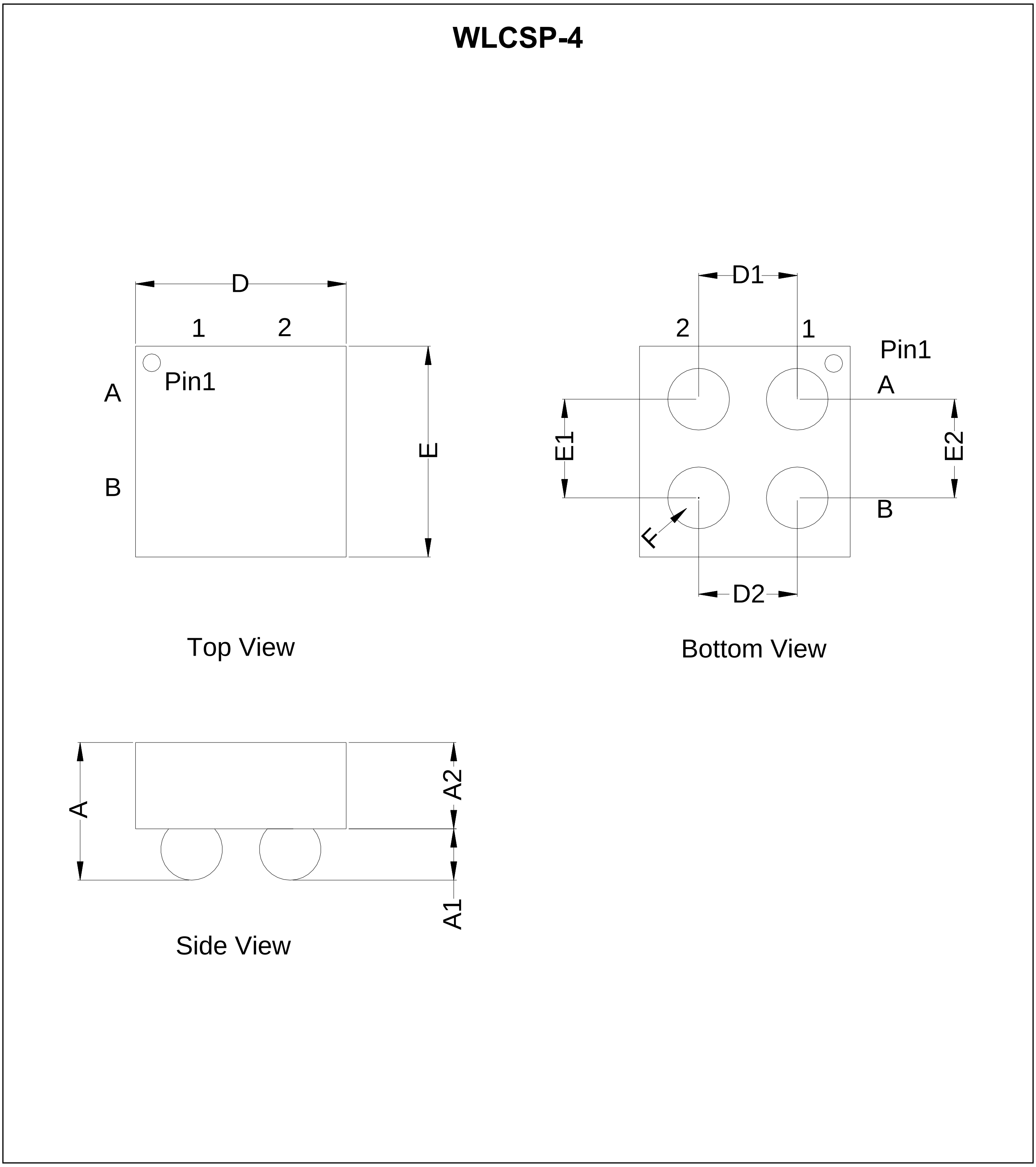
Figure 7. Power Supply Noise Suppression Techniques

GD30TS110T should be kept as far away from noise sources as possible, such as high-speed digital buses, coil components, and wireless antennas. GD recommends placing a low ESR ceramic capacitor between the power pin and the ground pin to filter out power noise. The capacitor needs to be as close to the power pin as possible, and the recommended value is 0.1μF. Under environments with severe noise, GD recommends using multiple capacitors with different capacitance values in parallel, such as 1μF+0.1μF+0.01μF, etc., to filter out digital noise in multiple frequency ranges.

GD30TS110T should be placed as close as possible to the heat source being monitored, and appropriate layout should be used to achieve good thermal coupling to ensure that temperature changes are captured in the shortest possible time interval. GD30TS110T has extremely low conversion power consumption, and the self-heating generated by power consumption can be ignored.

8 Package Information

8.1 Outline Dimensions



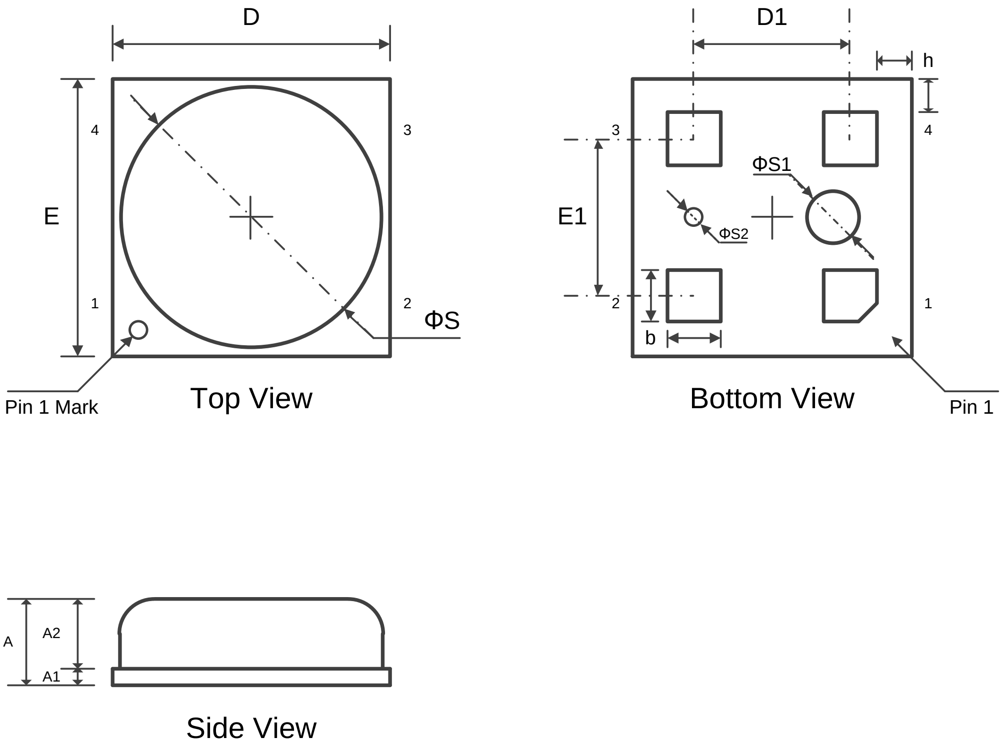
NOTES:

1. All dimensions are in millimeters.
2. Package dimensions does not include mold flash, protrusions, or gate burrs.
3. Refer to the *Table 2. WLCSP-4 dimensions(mm)*.

Table 2. WLCSP-4 dimensions(mm)

SYMBOL	MIN	NOM	MAX
A	0.5	0.54	0.58
A1	0.16	0.18	0.20
A2	0.30	0.32	0.34
D	0.70	0.73	0.76
E	0.70	0.73	0.76
F	0.22	0.235	0.25
D1	0.4 BSC		
E1	0.4 BSC		

MCLGA-4



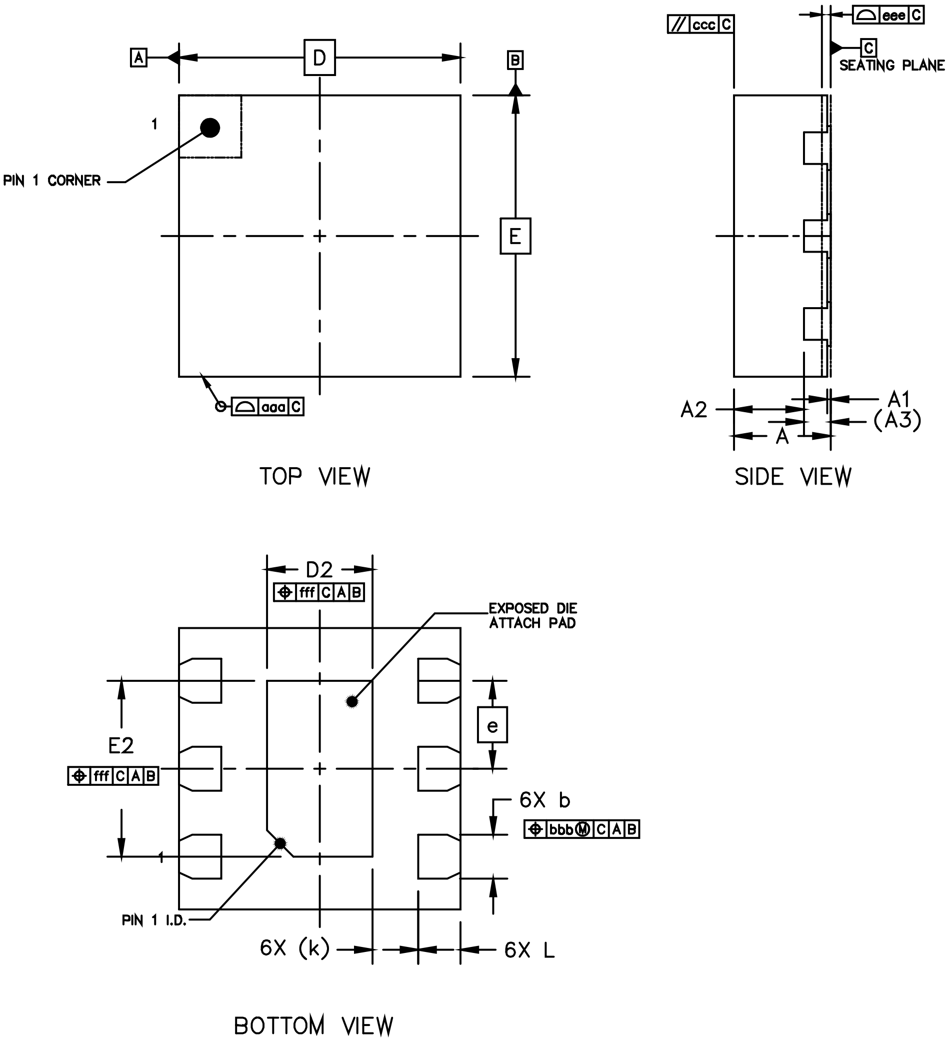
NOTES: (continued)

1. Refer to the Table 3. *WCLGA-4 dimensions(mm)*.

Table 3. WCLGA-4 dimensions(mm)

SYMBOL	MIN	NOM	MAX
A	0.90	1.00	1.10
A1	0.20	0.25	0.30
A2	0.70	0.75	0.80
D	2.90	3.00	3.10
E	2.90	3.00	3.10
D1	1.80 BSC		
E1	1.80 BSC		
b	0.55	0.60	0.65
h	0.25	0.30	0.35
ΦS	2.70	2.80	2.90
ΦS1	0.55	0.60	0.65
ΦS2	0.15	0.20	0.25

DFN-6



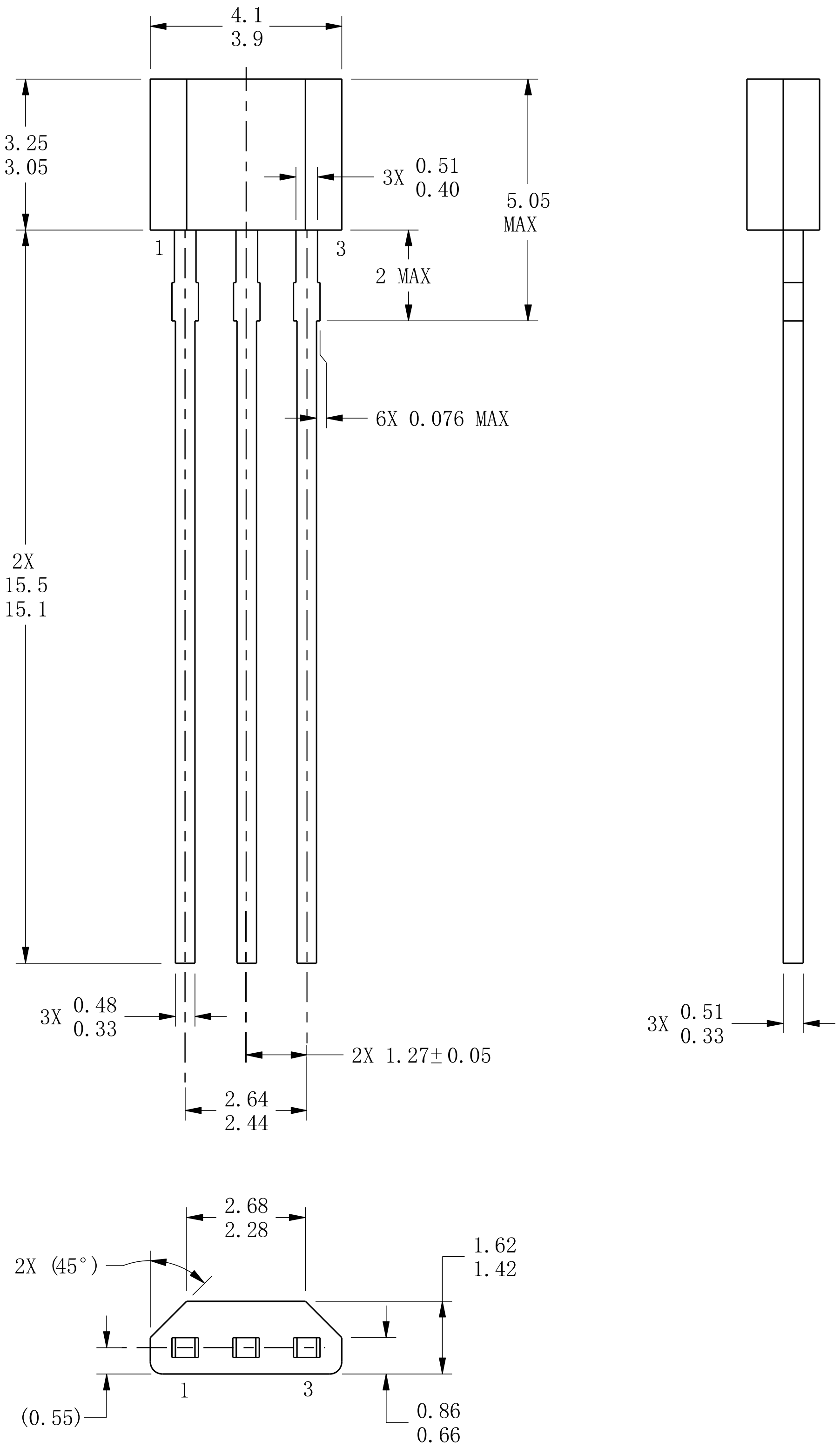
NOTES: (continued)

1. Refer to the Table 4. *DFN-6 dimensions(mm)*.

Table 4. DFN-6 dimensions(mm)

SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0	0.02	0.05
b	0.20	0.25	0.30
b1		0.18 REF	
c		0.203 REF	
D	1.90	2.00	2.10
D2	0.60	0.70	0.80
E	1.90	2.00	2.10
E2	1.50	1.60	1.70
e		0.50 BSC	
K		0.30 REF	
L	0.30	0.35	0.40
h	0.20	0.25	0.30

TO-92S


4.1
3.9
3.25
3.05
3X 0.51
0.40
5.05
MAX
1
3
2 MAX
6X 0.076 MAX
2X
15.5
15.1
3X 0.48
0.33
2X 1.27±0.05
2.64
2.44
3X 0.51
0.33
2.68
2.28
2X (45°)
1.62
1.42
1
3
(0.55)
0.86
0.66

9 Ordering Information

Ordering Code	Package Type	ECO Plan	Packing Type	MOQ	OP Temp(°C)
GD30TS110TJYTR-I	WLCSP-4	Green	Tape & Reel	3000	−40°C to +125°C
GD30TS110TJVTY-I	MCLGA-4	Green	Tray	490	−40°C to +125°C
GD30TS110TSETR-I	DFN-6	Green	Tape & Reel	4000	−40°C to +125°C
GD30TS110TBNBU-I	TO-92S	Green	Bulk	2000	−40°C to +125°C
GD30TS110TJYTR-Ixx	WLCSP-4	Green	Tape & Reel	3000	−40°C to +125°C
GD30TS110TJVTY-Ixx	MCLGA-4	Green	Tray	490	−40°C to +125°C
GD30TS110TSETR-Ixx	DFN-6	Green	Tape & Reel	4000	−40°C to +125°C
GD30TS110TBNBU-Ixx	TO-92S	Green	Bulk	2000	−40°C to +125°C

1. The xx in the ordering code represents the slave address, ranging from 01 to 0F(Hex). Without "xx," it represents the slave address as 00(Hex).

10 Revision History

REVISION NUMBER	DESCRIPTION	DATE
1.0	Initial release and device details	2024
1.1	Add slave address description in the *Ordering Information*.	2025

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