



钜地半导体  
Tudi Semiconductor

## Product Specification

TUDI-DS18B20

可编程分辨率单总线温度传感器

网址 [www.sztdbdt.com](http://www.sztdbdt.com) Q

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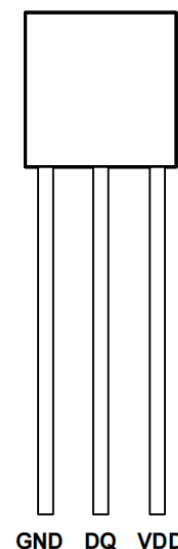
**semiconductor device  
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- Design
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- production
- and sales



## Features

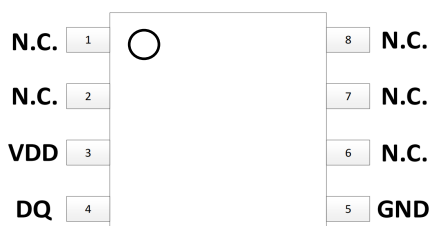
- Single-bus interface requires only one port pin for communication
- Each chip has a unique 64-bit number
- Multi-point distributed temperature measurement capability without external components
- Power can be supplied via the data line; supply voltage range is 2.5V to 55V
- Measurement range is -55°C to 125°C (-67°F to 257°F)
- Accuracy is  $\pm 0.4^{\circ}\text{C}$  in the range of -10°C to 85°C
- Temperature resolution is selectable from 9 to 12 bits
- At 12-bit accuracy, temperature conversion speed is less than 750ms
- User-definable non-volatile temperature alarm settings
- Alarm search command identifies flags devices exceeding the programmed temperature
- Ultra-strong electrostatic protection capability: HBM 8000V MM 800V
- Available in surface-mount MSOP8 and SOP8 packages, and 3-pin TO-92.



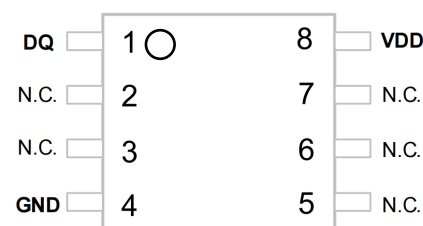
TO-92

## Application

- Temperature control
- Industrial systems
- Consumer goods
- Grain temperature monitoring
- Thermometers
- Any heat-sensing



SOP8



MSOP8

## Pin Description

| Pin       |       |           | Name | Description                                                                                                   |
|-----------|-------|-----------|------|---------------------------------------------------------------------------------------------------------------|
| MOSP8     | TO-92 | SOP8      |      |                                                                                                               |
| 2,3,5,6,7 | —     | 1,2,6,7,8 | N.C. | the control pin may not require connection                                                                    |
| 8         | 3     | 3         | VDD  | Power pin;in parasitic power supply mode,VDD pinThe foot must be connected to the ground                      |
| 1         | 2     | 4         | DQ   | Data input/output pins;when operating in parasitic power supply modeBelow,this pin supplies power to the chip |
| 4         | 1     | 5         | GND  | Grounding Pin                                                                                                 |



## Description

The DS18B20 digital thermometer provides temperature measurement with 9 to 12-bit resolution, and can lower and upper temperature alarms through programmable non-volatile memory units. The DS18B20 uses a single-bus protocol to communicate with the host computer, requiring only one line and one ground line. Its temperature measurement range is -55°C to 125°C. The test accuracy within the range of -10°C to 85°C can reach  $\pm 0.4^\circ\text{C}$ . In addition, it can also operate in parasitic mode, powering the chip directly through the signal line, thus eliminating need for an additional power supply. Each DS18B20 has a unique 64-bit serial number, allowing multiple DS18B20 to be connected series on the same single bus for networking. Only one processor is needed to control multiple DS18B20 distributed over a large area. This networking method is particularly suitable application fields such as HVAC environmental control, building, equipment, grain temperature measurement, industrial temperature measurement, and process monitoring and control.

Figure 1 shows the block diagram of the DS18B20. The uses a 64-bit read-only memory to store the unique serial number of the device. The internal registers of the chip contain two bytes of temperature registers, which are to store the data output by the temperature sensor. In addition, the chip also provides two bytes of temperature alarm threshold registers (TH and TL) and a one-byte configuration register. The configuration register allows the user to set the temperature measurement resolution to 9, 10, 11, or 12 bits. TH, TL, and the register are all non-volatile erasable registers (EEPROM), and the data stored in them will not disappear after the device is powered off.

The DS18B20 uses a single-bus protocol and communicates through a single-wire port. When all devices are connected to the bus through a tri-state port or an open-drain port, control line needs to be connected to a weak pull-up resistor. In this bus system, the microprocessor (master device) relies on the unique 64-bit serial number each device to identify the devices on the bus and record the addresses of the devices on the bus.

Since each device has a unique serial number, the number of devices that can be to the bus is actually unlimited. The single-bus protocol, including a detailed explanation of the instructions and "timing", can be found in the single-bus system section. function of the DS18B20 is that it can operate without an external power supply. When the bus is in a high-level state, DQ is connected to the-up resistor to power the device through the single bus. At the same time, the bus signal in a high-level state charges the internal capacitor (C<sub>pp</sub>). When the bus in a low-level state, the capacitor provides energy to the device, and this method of providing energy is called "parasitic power". Of course, the DS18B20 can also be powered by an external power supply through the VDD pin.

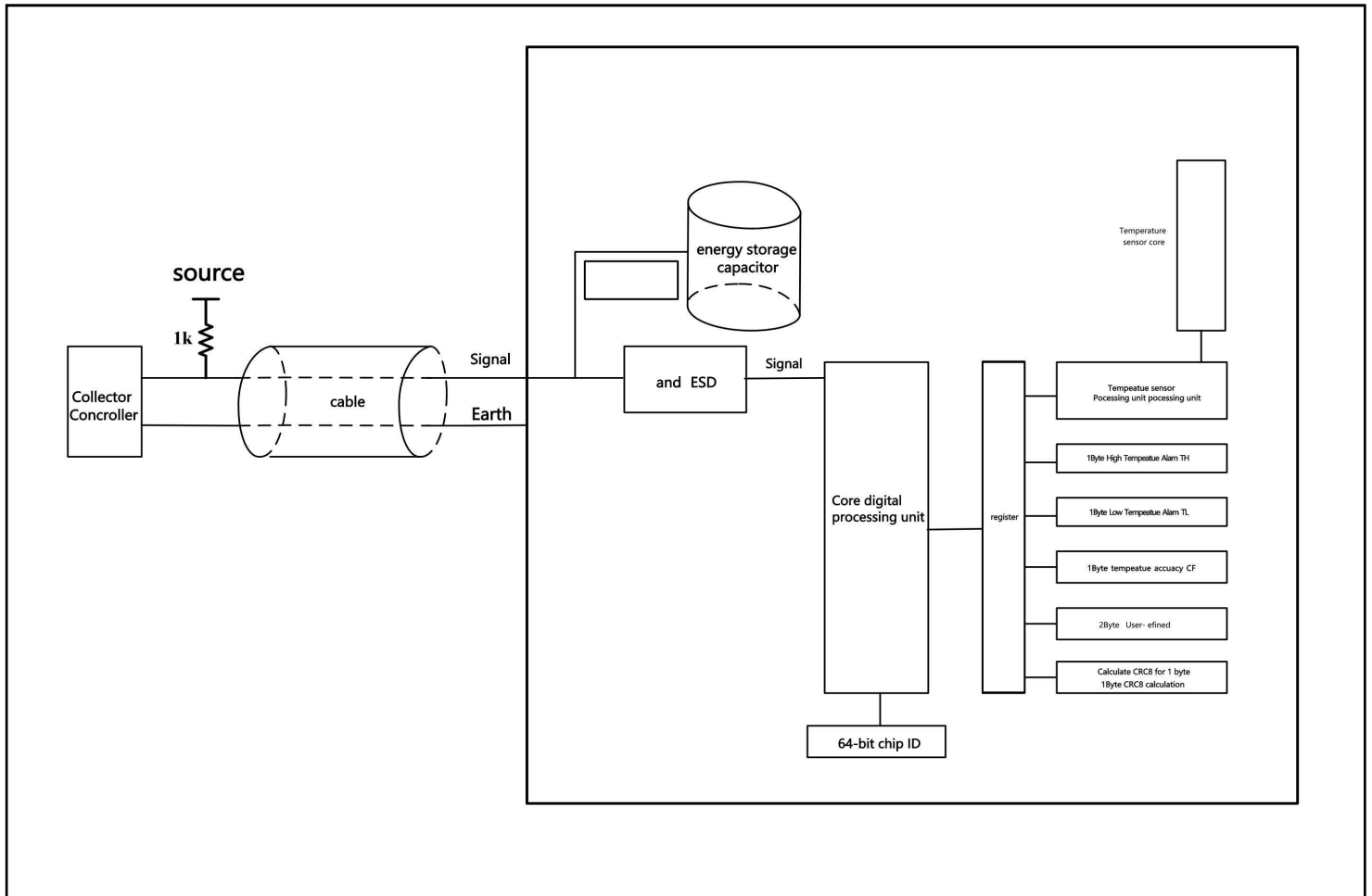


Figure 1. Structural flowchart of DS18B20



## Temperature Measurement Operation

The core function of the DS18B20 is its direct digital temperature sensor. The accuracy the temperature sensor is user-programmable to 9, 10, 11, or 12 bits. The temperature resolutions are 0.5°C, 0.25°C, 0.125°C, and 0.0625°C, respectively. The default accuracy of the chip upon-up is 12 bits. After starting, the DS18B20 remains in a low-power standby state; when a temperature measurement and AD conversion need to be performed, the bus controller must issue the [44h] command. After that, the generated temperature data is stored in the temperature register in the form of two bytes, and DS18B20 continues to remain in the standby state. When the DS18B20 is powered by an external power supply, the bus controller initiates a "sequence" (see the 1-Wire System section) after the temperature conversion command; the DS18B20 returns 0 while the temperature conversion is in progress and returns 1 when the conversion is complete. If the DS18B20 is powered by a parasitic power supply, there will be no return value unless the bus is pulled high by strong pull-up when entering the temperature conversion. The bus requirements for the parasitic power supply are explained in detail in the DS18B20 Power Supply section.

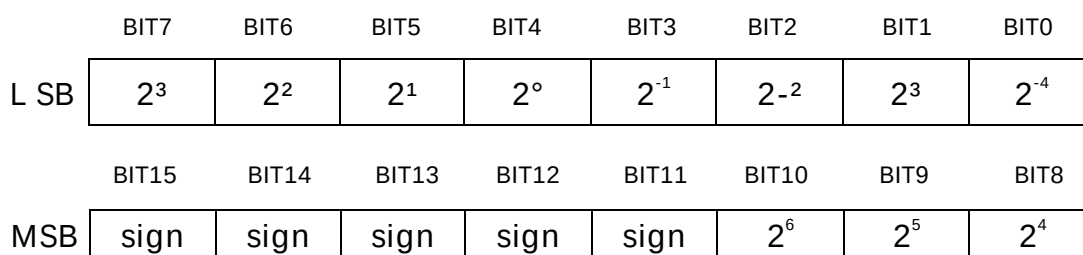


Figure 2. Temperature Register Format

Table 1. Temperature/Data Relationship

| temperature | Digital output (binary) | Digital output (hexadecimal) |
|-------------|-------------------------|------------------------------|
| +125        | 0000011111010000        | 07D0h                        |
| +85         | 0000010101010000        | 0550h                        |
| +25.0625    | 0000000110010001        | 0191h                        |
| +10.125     | 0000000010100010        | 00A2h                        |
| +0.5        | 0000000000001000        | 0008h                        |
| 0           | 0000000000000000        | 0000h                        |
| -0.5        | 1111111111111000        | FFF8h                        |
| -10.125     | 1111111101011110        | FF5Eh                        |
| -25.0625    | 1111111001101111        | FE6Fh                        |
| -55         | 1111110010010000        | FC90h                        |

The default value of the temperature register during power-on reset is +85°C.



## Alarm Operation

After completing a temperature conversion, the DS18B20 compares the temperature value with a user-defined alarm threshold stored in the TH and TL registers as shown in Figure 3). The sign bit (S) indicates whether the temperature value is positive or negative: S=0 for positive, S=1 for negative. The TH TL registers are non-volatile (EEPROM), Therefore, the data remains intact even after a power outage. The memory section explains how TH and TL are stored in the second and third bytes of the register.

|       | BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| TH/TL | sign  | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |

Figure 3. TH and TL register formats

When TH and TL are 8-bit registers, only bits 4 to 11 of the temperature are used in the comparison with TH and TL. If the measured temperature is higher than TH or lower than TL, the alarm condition is met, and an alarm flag is set inside DS18B20. This flag is updated every time a temperature measurement is performed. Therefore, if the alarm condition disappears, the flag will be cleared after the next temperature. The bus controller detects all DS18B20 alarm flags on the bus by issuing an alarm search command [ECh]. Any DS18B20 with set alarm flag will respond to this command, allowing the bus controller to precisely locate each DS18B20 that meets the alarm condition. If the alarm condition is met, the TH or TL settings have been changed, another temperature conversion will re-evaluate the alarm condition.

## Power Supply of DS18B20

The DS8B20 can be powered by an external power supply through the VDD pin, or it can operate in parasitic power mode. Parasitic power mode allows the DS1820 to operate in applications where external power is not available. Parasitic power mode is very useful in long-distance testing or space-constrained applications. The parasitic power control circuit shown in Figure 1. When the bus is high, this control circuit "steals" energy from the bus. Part of the "stolen" energy is stored in the power storage capacitor (CPP), and this energy is released to power the device when the bus is low. When the DS18B20 is in parasitic power mode, the DD pin must be grounded.

In parasitic power mode, the single bus and CPP can provide sufficient current to the DS18B20 to meet the specified timing and voltage for most operations (see DC and AC characteristics sections). However, when the DS18B20 is performing a temperature conversion or transferring data from the register to the EEPROM the operating current can be as high as 1.5mA. This current may cause an unacceptable voltage drop across the weak pull-up resistor connected to the single bus, which more current than the CPP can provide. To ensure the DS18B20 has an adequate power supply, a strong pull-up must be provided to the single bus during conversion or data copying to EEPROM operations. This is achieved by using a MOSFET to directly pull the bus up to the power supply, as shown in Figure 4. After issuing temperature conversion command [44h] or the copy register command [48h], the single bus must be switched to a strong pull-up within at most 10, and must remain in the strong pull-up state during the temperature conversion timing (tconv) or data copying timing (twr=10ms). No other actions are while the strong pull-up state is maintained.

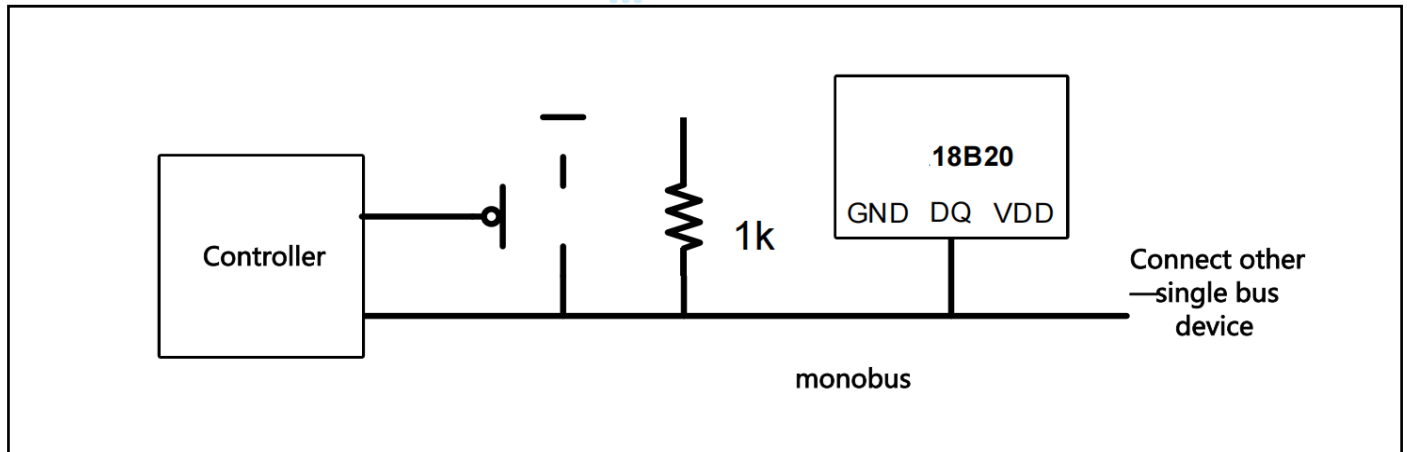


Figure 4. Power supply for the DS18B20 during temperature conversion for parasitic power supply

Another method of powering the DS18B20 is the traditional way of connecting an external power supply to the VDD pin, as in Figure 5. The advantage of doing this is that a strong pull-up is not required on the 1-Wire bus, and the bus does not need to be kept during temperature conversions.

For temperatures above 100°C, the use of parasitic power is not recommended because the DS18B20 exhibits a relatively large leakage at this temperature, which may prevent communication. In such temperature conditions, it is strongly recommended to power the DS18B20 through its VDD pin.

In cases the bus controller does not know whether the DS18B20 on the bus is using parasitic power or an external power supply, the DS18B20 provides a to indicate the power supply being used. The bus controller issues a Skip ROM command [CCh], followed by a Read Power command [B4h]. After this command is issued the controller issues a read timing command. Parasitic power will pull the bus low, while an external power supply will keep the bus high. If the bus is pulled low, the controller will know that a strong pull-up must be provided to the 1-Wire bus during temperature conversions.

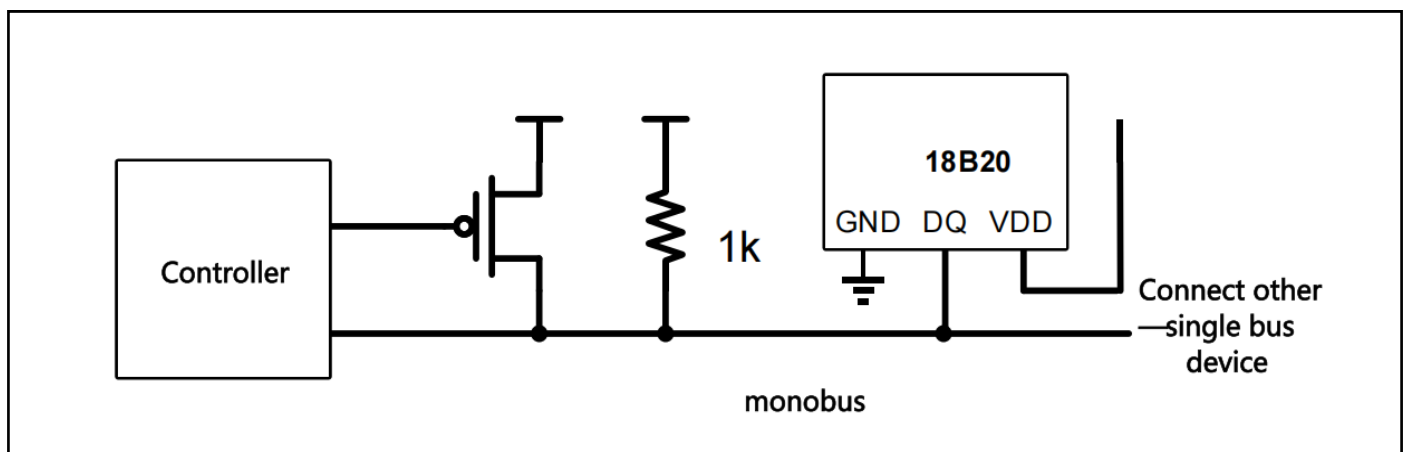


Figure 5. Powering the DS18B20 with an external power supply



## Storage: 64-bit Read-Only Memory

Each DS18B20 device has a unique 64-bit code stored in the ROM (see Figure 6). The first 8 bits represent the single-line serial code (28h). The subsequent 48 bits constitute a unique serial number, while the final 8 bits form the CRC code calculated from these 56 bits. A detailed explanation of the CRC is provided in the CRC Generator section. The 64-bit ROM and its operation control area enable the DS18B20 to function as a single-bus device and operate according to the single-bus protocol described in the Single-Bus System section.

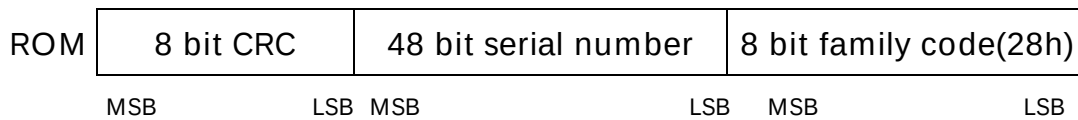


Figure 6. 64-bit ROM code

## Memorizer

The memory structure of the DS18B20 is shown in Figure 7. The memory consists of a temporary SRAM and non-volatile electrically erasable EEPROM that stores the alarm thresholds TH and TL. Note that when the alarm function is disabled, the TH and TL registers can be used as generalpurpose registers. All memory instructions are detailed in the DS18B20 Functional Instructions section.

Byte 0 and Byte 1 of the memory are the LSB and MS of the temperature register, respectively; these two bytes of memory are read-only. The 2nd and 3rd bytes are TH and TL. The 4th byte the configuration register data, which is detailed in the Configuration Register section. The 5th byte is reserved by the device and is write-protected; the 6th and 7 bytes are available for user use. The 8th byte of the memory is read-only and contains the CRC code for the above eight bytes; the CRC execution method is in the CRC Generator section.

Data is written to bytes 2, 3, 4, 6, and 7 of the memory using the Write Register instruction [Eh]; data must be transmitted starting with the 2nd byte as the least significant byte. To fully verify the data, the memory can be read after the data is written ( the Read Register instruction [BEh]). When reading the register, data is shifted out of the single-wire bus starting with Byte 0 as the least significant byte. The bus must issue the Copy Register instruction [48h] to transfer TH, TL, and configuration data from the register to the EEPROM. Data in the EEPROM memory is after the device is powered down; upon power-up, the data is loaded into the registers. Data can also be loaded from the registers into the EEPROM using the Recall EE command. After issuing this command, the bus controller issues a read timing; the DS18B20 returns 0 to indicate that the recall is in progress, and returns1 to indicate that the operation is complete.

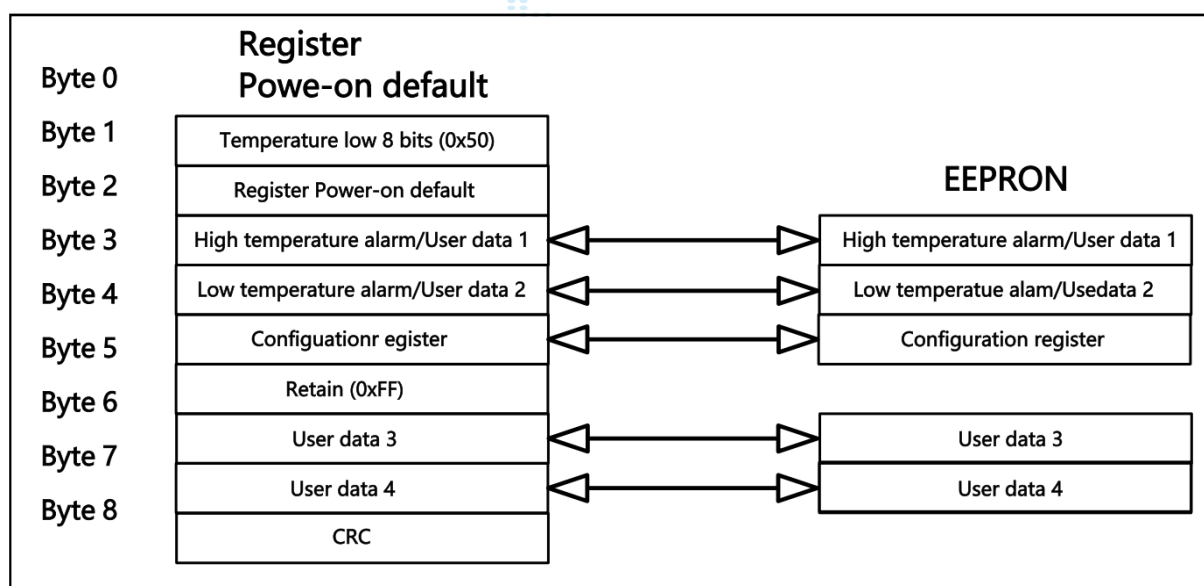


Figure 7. DS18B20 memory diagram

## Configuration Register

The 4th byte of the memory is the configuration register, whose structure is shown in Figure 8. Users can set the resolution of DS18B20 by setting the R0 and R1 bits as shown in Table 2. Power-on default settings: R0=1, R11 (12-bit resolution). Note: There is a direct relationship between resolution and conversion time. Bit 7 and bits 0 to 4 of the configuration register are by the device and are write-protected; when reading data, they all appear as logic 1.

|    | BIT 7 | BIT6 | BIT5 | BIT4 | BIT3 | BIT2 | BIT1 | BIT0 |
|----|-------|------|------|------|------|------|------|------|
| CF | 0     | R1   | R0   | 1    | 1    | 1    | 1    | 1    |

Figure 8. Configuration register

Table 2. Sensor Accuracy Configuration Table

| R1 | R0 | Resolution (BITS) | Maximum Conversion Time |           |
|----|----|-------------------|-------------------------|-----------|
| 0  | 0  | 9                 | 93.75ms                 | (tconv/8) |
| 0  | 1  | 10                | 187.5ms                 | (tconv/4) |
| 1  | 0  | 11                | 375ms                   | (tconv/2) |
| 1  | 1  | 12                | 750ms                   | (tconv)   |



## C R C generator

The CRC is stored in memory as part of the DS18B20 64-bit ROM. The CRC is calculated from the first 56 bits of the ROM and is included in the important bytes of the ROM. The CRC is calculated from the data stored in memory, so when data in memory changes, the CRC value also changes accordingly. The CRC can perform data verification when the bus controller reads the DS18B20. To verify whether the data been read correctly, the bus controller must calculate a CRC value from the received data and compare it with the value stored in the DS18B20's 64- ROM (when reading the ROM) or the 8-bit CRC value calculated internally by the DS18B20 (when reading the register). If the calculated CRC value the read CRC value, the data is transmitted without error. The comparison of the CRC value and whether The next operation is entirely determined by the bus controller. When the CRC value stored in or calculated by the DS18B20 does not match the calculated by the bus controller, there is no internal circuit in the DS18B20 that can stop the command sequence from proceeding. The CRC calculation formula is as follows :

$$CRC = X_8 + X_5 + X_4 + 1$$

The single-bus CRC can be generated by a polynomial generator consisting of a shift register and XOR gates, as shown in Figure 9. This circuit a shift register and several XOR gates, and each bit of the shift register is initialized to 0. Starting from the least significant bit in the ROM or the 0th byte the register, one bit at a time is shifted into the register. After 56 bits of data from the ROM have been transmitted or the most significant bit of the 7 byte of the register has been shifted in, the CRC value is stored in the shift register. In the next step, the CRC value must be shifted in cyclically. At this, if the calculated CRC is correct, the shift register will reset to 0.

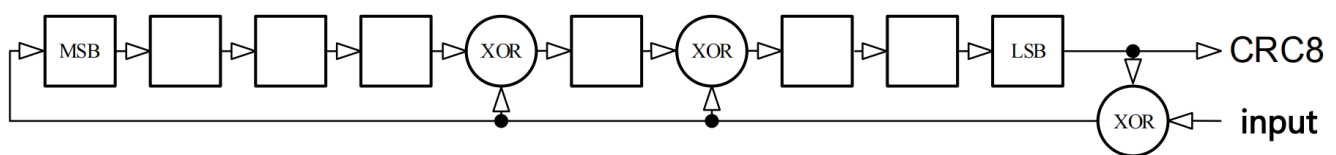


Figure 9. CRC Generator





## The 1-Wire system

The 1-Wire system uses a single 1-Wire controller to control one or more slave devices. The DS18B0 always acts as a slave. When only one slave is attached to the bus, the system is called a "single-point" system; if multiple slaves are attached to the, the system is called a "multi-point" system.

All data and command transmissions are sent over the 1-Wire bus starting from the least significant bit. The 1-Wire system is discussed in three aspects: hardware structure, execution sequence, and 1-Wire signals (signal types and timing).

## Hardware Structure

The 1-Wire system has only one defined signal line, and every device on the bus must be open-drain or tri-state output. Every device on the bus (master or slave) must be open-drain or tri-state output. This mechanism allows every device on the bus that is not transmitting data to release the bus for other devices to use.

The 1-Wire port (DQ pin) of the DS18B20 is open-drain, and its internal equivalent circuit is shown in Figure 10.

The 1-Wire bus requires an external pull-up resistor of about  $1k\Omega$ ; the idle state of the 1-Wire bus is high. If a transmission needs to be paused for some reason, the bus must remain in the idle state if the transmission is to be resumed. During the recovery period, if the 1-Wire bus is in the (high) state, the recovery time between bits can be infinitely long. If the bus remains at a low level for more than  $480\mu s$ , all devices on the bus will be reset.

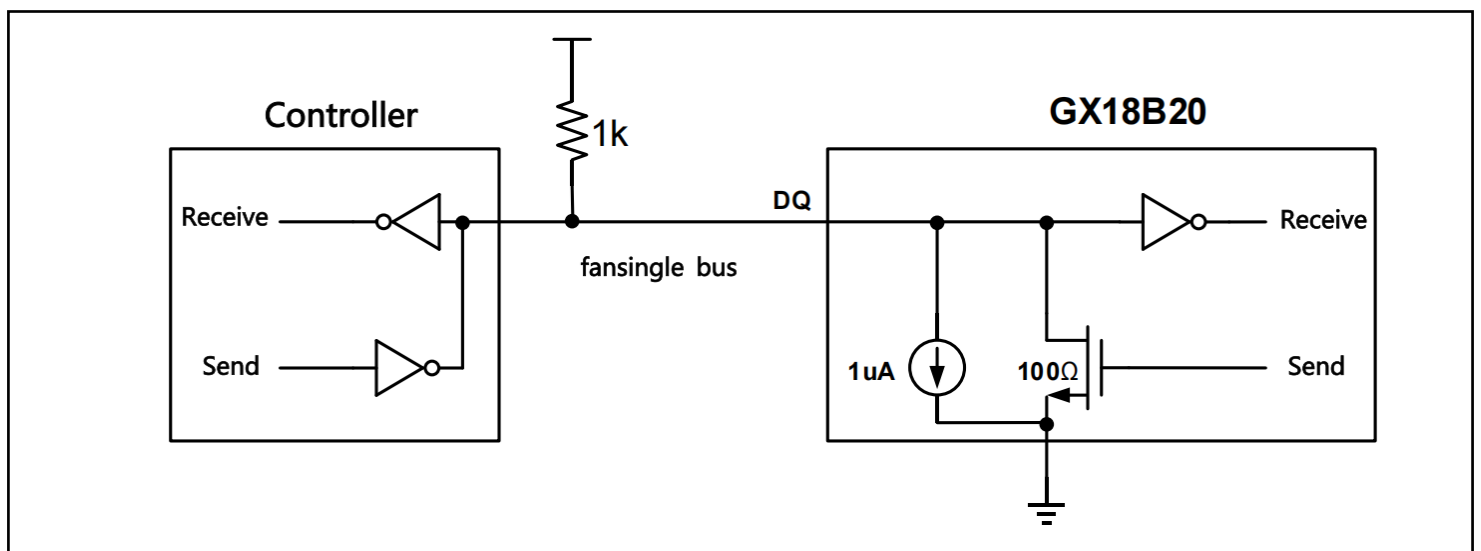


Figure 10. Hardware Send/Receive Architecture Diagram



## Execution Sequence

The execution sequence for accessing the DS18B20 via a single-wire bus is as follows:

Step1: Initialization

Step 2: ROM operation command

Step 3: DS18B20 function command

Every DS18B20 operation must satisfy the steps. If a step is missing or the sequence is out of order, the device will not return a value. The search ROM command and alarm search command are exceptions. When these commands are executed, the master controller must return to Step 1.

## Initialization

All execution operations via the single-wire bus start with an initialization sequence. initialization sequence consists of a reset pulse issued by the bus controller and a subsequent presence pulse issued by the slave. The presence pulse lets the bus controller know that the DS18B0 is on the bus and ready for operation; see the Bus Signals section for details.

## ROM Commands

Once the bus controller detects a presence pulse, it a ROM command. If multiple DS18B20s are connected to the bus, these commands will provide the devices with their unique 64-bit ROM sequence codes allowing the bus controller to select the specific device to be operated. These commands can also enable the bus controller to identify how many and what models of devices are connected to the bus, similarly, they can identify which devices have met the alarm conditions. There are 5 ROM commands, all 8 bits in length. The bus controller issues a ROM command before a DS18B20 function command. The ROM command operation diagram is shown in Figure 11.

### SEARCH ROM [F0h]

When the system is powered on and initialized, the bus controller must identify all ROM sequence codes on the bus to determine the and models of the slaves. The bus control the device repeatedly searches for the ROM code using the Search ROM command to identify all slave devices. If there is only one slave on bus, a simpler Read ROM command (see below) can be used instead of the Search ROM command. After each Search ROM command, the bus controller must return to Step 1 (Initialization).

### READ ROM [33h]

This command can only be used when there is a single DS18B20 on the bus. This command allows the controller to read the 64-bit serial code of the slave without using the Search ROM command. If this command is used when there is more than one slave on the bus a data conflict will occur when all slaves attempt to transmit signals simultaneously.



### **MATCH ROM [55h]**

The MATCH ROM command is followed by a 64-bit serial number, allowing the bus controller to locate a specific slave device on a multipoint bus. Only the DS18B20 that exactly matches the 64-bit serial number can respond to subsequent memory operation commands; all slaves that do not match the 64-bit ROM serial number will wait for a reset pulse.

### **SKIP ROM [Ch]**

This command allows the bus controller to use function commands without providing the 64-bit ROM code. For example, the bus controller can first issue a Skip ROM, and then issue a temperature conversion command [44h] to complete the temperature conversion operation. Note: When there is only one slave on the bus, the Skip ROM command always be followed by a Read Register command [BEh]. When using this command in a single-point bus scenario, the device does not need to send back the 64bit ROM code, thereby saving time. If there is more than one slave on the bus and a Skip ROM command is issued, a data conflict will occur on the bus because multiple will transmit data simultaneously.

### **ALARM SEARCH [ECh]**

The operation flow of this command is the same as the ROM search command, and only slaves meet the alarm conditions will respond to this command. This command allows the master device to determine if any DS18B20 experienced an alarm state during the most recent temperature conversion. After each alarm search command cycle, the bus controller must return to step 1. For the alarm operation flow, see the Alarm Signal Operation section.

### **DS18B20 Function Commands**

After the bus controller uses ROM commands to identify the DS18B20 it wishes to communicate with, the master can issue a DS18B20 function command. These commands allow the bus controller to read and write the DS18B20 registers, initiate temperature conversions, and identify the power mode. The DS18B20 function commands are detailed below, summarized in Table 4, and illustrated with a flowchart in Figure 12.

### **CONVERT T [44h]**

This command is used to initiate a temperature conversion. After the temperature conversion command is executed, the resulting temperature conversion data is stored in the temperature register as 2 bytes, and DS18B20 then remains in a low-power waiting state. If this command is issued in parasitic power mode, a strong pull-up must be applied to the 1-Wire bus within 10 $\mu$ s (maximum) during the temperature conversion ( $t_{CONV}$ ), see the DS18B20 Power Supply section. If the DS18B20 is powered by an external power supply, the bus controller issues a read timing sequence following this command; if the DS18B20 is in the middle a conversion, the bus returns 0, and if the temperature conversion is complete, it returns 1. In parasitic power mode, this communication method is not used before the bus pulled high by a strong pull-up.



### **WRITE SCRATCHPAD [4Eh]**

This command writes data to the DS18B20 registers, starting at the register (the 2nd byte of the registers), followed by the TL register (the 3rd byte of the registers), and finally the configuration register (the 4th of the registers), with data transmitted starting from the least significant bit. The writing of these three bytes must occur before the bus controller issues a reset command, otherwise data conflict will.

### **READ SCRATCHPAD [BEh]**

This command is a host register read command. The read will start from the least significant bit of byte 0 and continue until 9th byte (byte 8, CRC) is read. If not all bytes need to be read, the controller can issue a reset command at any time to abort the read.

### **COPY SCRATCHPAD [48h]**

This command copies the contents of the TH, TL, and configuration registers, as well as user bytes 3 and 4 ( 2, 3, 4, 6, and 7), into the EEPROM. If parasitic power is used, the bus controller must activate a strong pull- within 10us of issuing this command and maintain it for at least 10ms, as described in the DS18B20 Power Supply section.

### **RE E2 [B8h]**

This command copies the TH, TL, and configuration data back from the EEPROM to the registers. After issuing this command, the bus controller a read timing sequence, and the DS18B20 will output a copy-back indicator: 0 indicates copying in progress, and 1 indicates copy-back complete. This operation is automatically performed when the DS18B20 is powered up, so that valid data is immediately available in the registers upon power-up.

### **READ POWER SUPPLYB4h]**

After issuing this command to the DS18B20, the bus controller issues a read timing sequence. If in parasitic power mode, the DS18B20 will pull the bus low; if in external power mode, the DS18B20 will pull the bus high. Detailed information on the usage of this command provided in the DS18B20 Power Supply section.



Table 3. DS18B20 Function Instruction Table

| order                          | Description                                                                                                                              | protocol | After the command is issued, the 1-Wire bus becomes active.                                                                    | irrigate |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|----------|--------------------------------------------------------------------------------------------------------------------------------|----------|
| Temperature Conversion Command |                                                                                                                                          |          |                                                                                                                                |          |
| Convert T                      | Initial temperature conversion                                                                                                           | 44h      | The DS18B20 transmits the conversion status to the host (not applicable for registered devices).DS18B20 for power generation). | 1        |
| Memory Command                 |                                                                                                                                          |          |                                                                                                                                |          |
| Read Scratchpad                | Read the entire register, including the CRC byte.                                                                                        | BEh      | The DS18B20 can send up to 9 data bytes to the host.The DS18B20 can send up to 9 data bytes to the host.                       | 2        |
| Write Scratchpad               | Write the data to register byte 2,3, 4, 6, and 7 (TH, T, with accompanying components)Address register and user byte).                   | 4Eh      | The host sends 3, 4, or 5 data bytes to the DS18B20.                                                                           | 3        |
| Copy Scratchpad                | Use TH, T, configuration registers, and the necessary components. Copy household byte data from the temporary register toEEPROM.         | 48h      | 无。                                                                                                                             | 1        |
| RecallE <sup>2</sup>           | Use TH, T, configuration registers, and the necessary components. The byte data is read from the EEPROM.Use the temporary storage unit.。 | B8h      | The DS18B20 sends the status to the host.                                                                                      |          |
| Read Power Supply              | Send the DS18B20 power supply to the hostModel Signal.                                                                                   | B4h      | The DS18B20 sends the power status to the host.                                                                                |          |

Note 1: For the DS18B20 in parasite power mode, a strong pull-up must be provided to the 1-Wire bus temperature conversion and data copying to the EEPROM, and there must be no other activity on the bus during this period.

Note 2: The bus controller can abort data transmission any time by issuing a reset signal.

Note 3: The writing of the three bytes—T<sub>H</sub>, T<sub>L</sub>, and the configuration register—must occur before the reset signal is.



## ROM命令

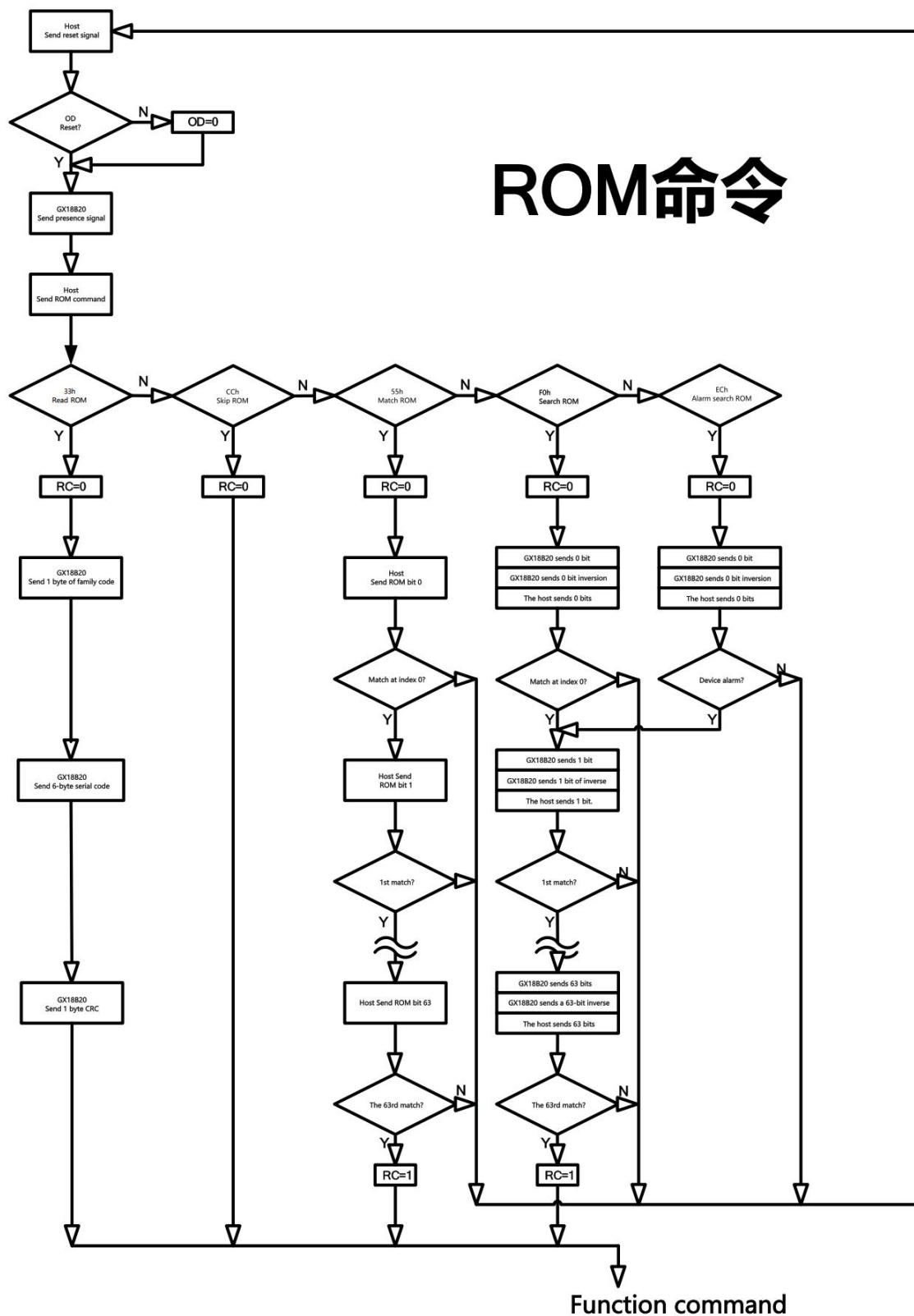


Figure 11. ROM Instruction Flowchart



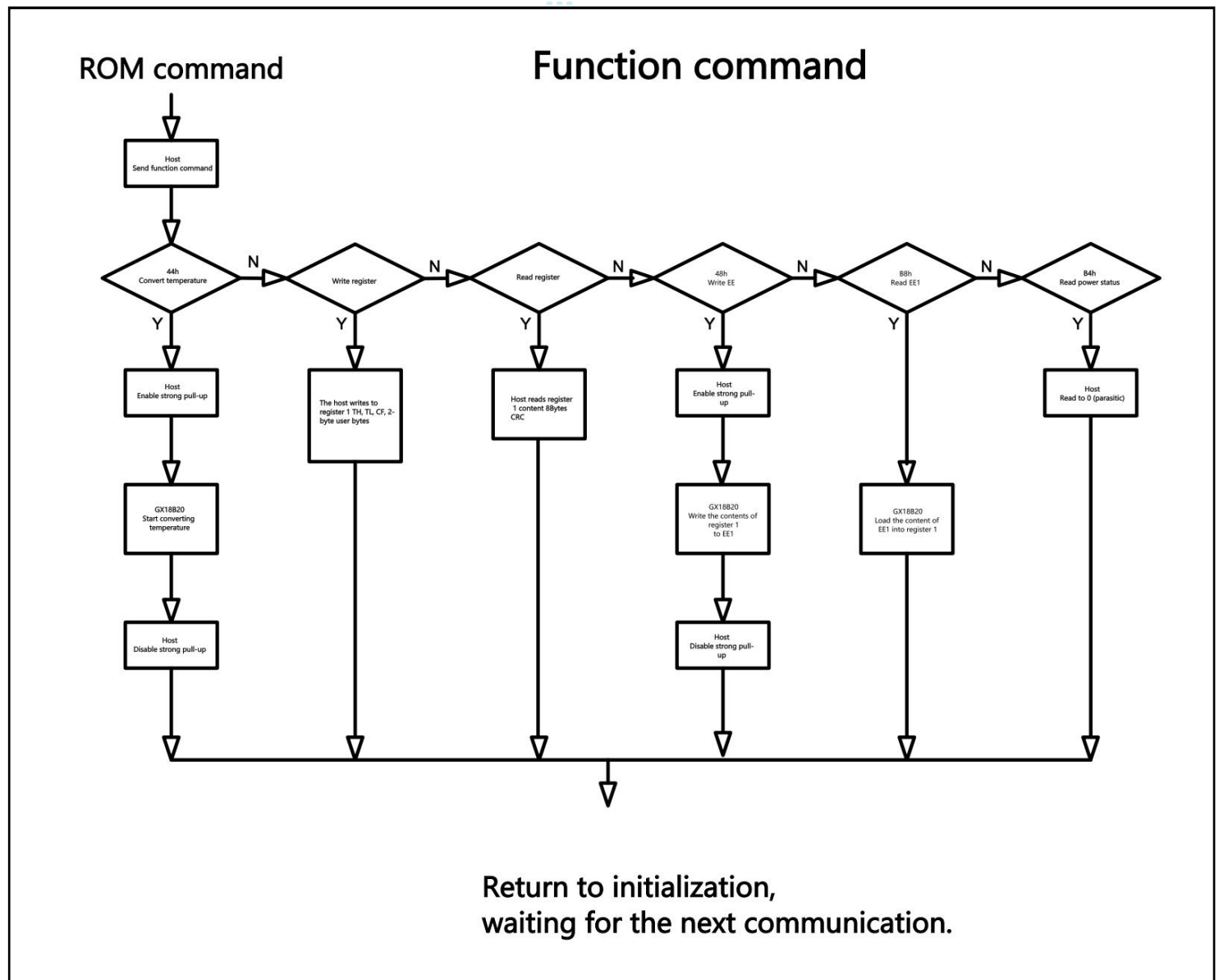


Figure 12. DS18B20 Function Instruction Flowchart



## Single-bus signal

DS18B20 requires a strict single-bus protocol to ensure data integrity. The protocol defines several types of-bus signals: reset pulse, presence pulse, write 0, write 1, read 0, and read 1. All these signals, except for the presence pulse are issued by the bus controller.

## Reset sequence: Reset and presence pulses

All communication with the DS18B20 begins with an initialization sequence, shown in Figure 13. A reset pulse followed by a presence pulse indicates that the DS18B20 is ready to send and receive data.

During the initialization, the bus controller pulls the bus low and holds it for 480us to issue (TX) a reset pulse signal, then releases the bus and enters the receive state(RX). When the bus is released, a 1kΩ pull-up resistor pulls the bus to a high level. When the DS18B20 detects a rising on the IO pin, it waits for 15-60us, and then issues a presence pulse consisting of a 60-240us low-level.

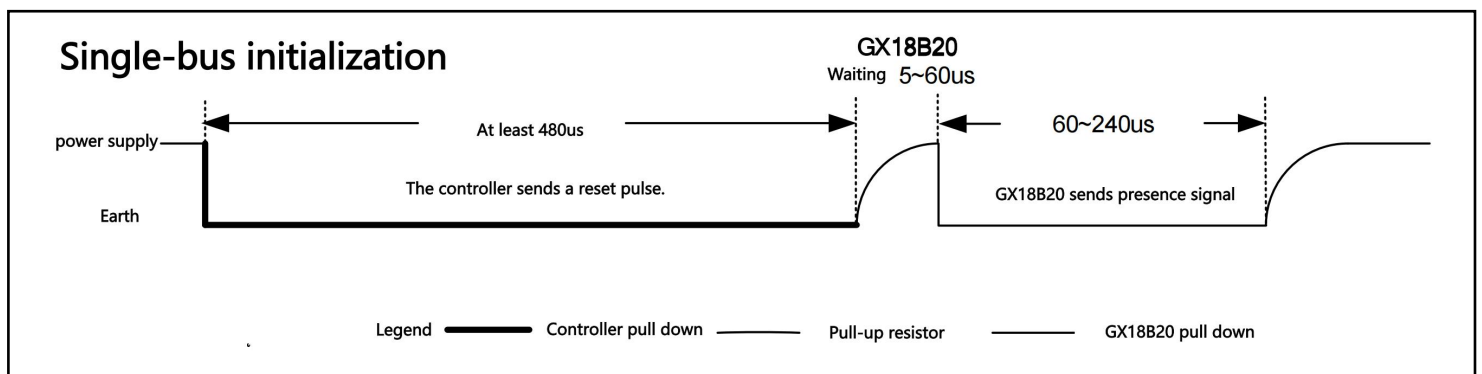


Figure 13 Sequence

## Read-write sequence

The data reading and writing of DS18B20 is carried out through timing processing for information exchange, with each timing transmitting 1 bit of data

### Write timing

The DS18B20 has two write time slots: the write-1 time slot and the write-0 time slot. The bus writes a logic 1 through the write-1 time slot, and a logic 0 through the write-0 time slot. The write time slot must last at least 6us, including a recovery time of at least 1us between two write cycles. The write time slot begins when the bus controller pulls the data line from a logic high level down a low level (see Figure 14). To generate a write time slot, the bus controller must pull the data line to a low level and then release it, and bus must be released within 15us. After the bus is released, the pull-up resistor pulls the bus high. To generate a write-0 time slot, the controller must pull the data line to a low level and keep it there for at least 60us.

After the bus controller initializes the write time slot, the DS18B20 samples the signal line within a window of 15us to 60us. If the line is at a high level, it is a write-1., if the line is at a low level, it is a write-0.

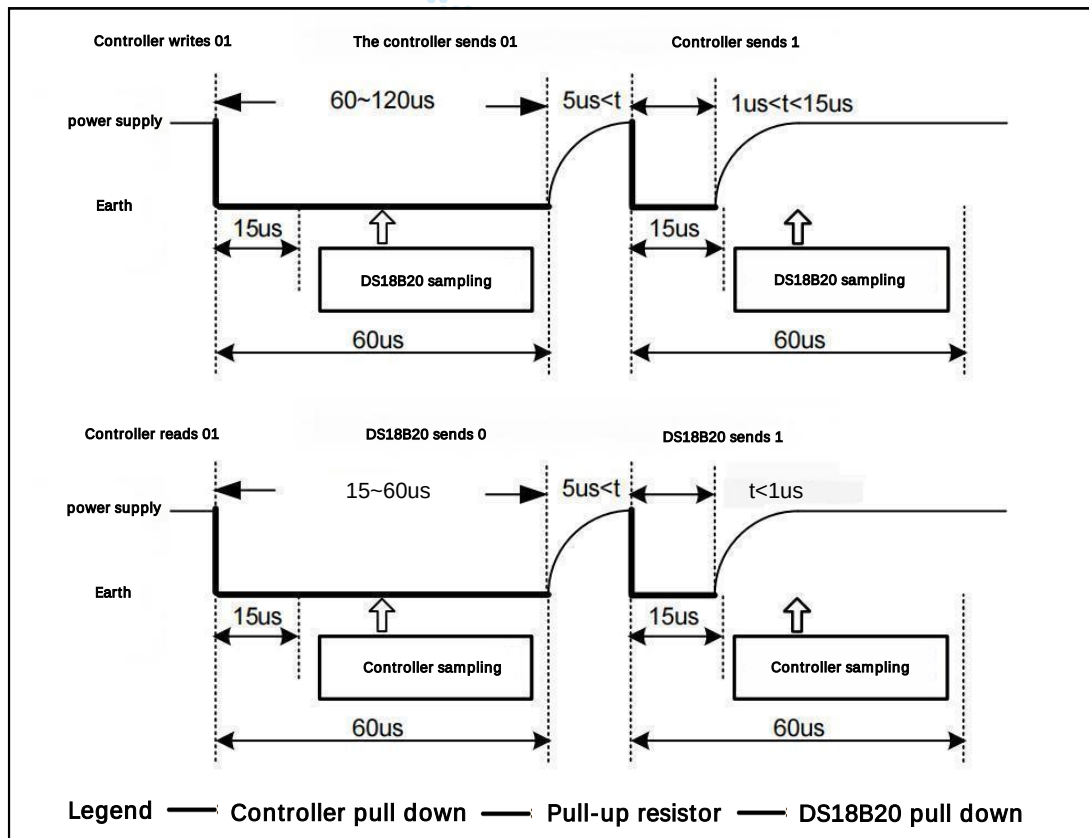


Figure 14. Reading/Writing Slot Timing Diagram

## Read Timing

When the bus controller initiates a read timing, the DS18B20 is only used to transmit data to the. Therefore, the bus controller must immediately start the read timing after issuing the read register command [BEh] or the read power mode command [B4h], so that the DS8B20 can provide the requested data. In addition, the bus controller initiates the read timing after issuing the temperature conversion command [44h] or the recall EEPROM [B8h], for details see the DS18B20 function command section.

All read timings must be at least 60us, including a recovery time at least 1us between two read cycles. When the bus controller pulls the data line from a high level to a low level, the read timing begins, the data line must be for at least 1us, and then the bus is released (see Figure 14). After the bus controller issues the read timing, the DS18B20 1 or 0 by pulling the bus high or low. When the transmission of 0 ends, the bus will be released and return to the high-level idle state through pull-up resistor. The data output from the DS18B20 is valid within 15us after the falling edge of the read timing appears. Therefore, the controller releases the bus within 15us after the start of the read timing and then samples the bus state to read the state of the data line. Figure 15 that the sum of TINIT, TRC, and TsAMPLE must be less than 15us. Figure 16 indicates that the system time can be maximized by the method: keeping the TINIT and TRC hold times as short as possible, and placing the controller sampling time at the end of the 15us cycle

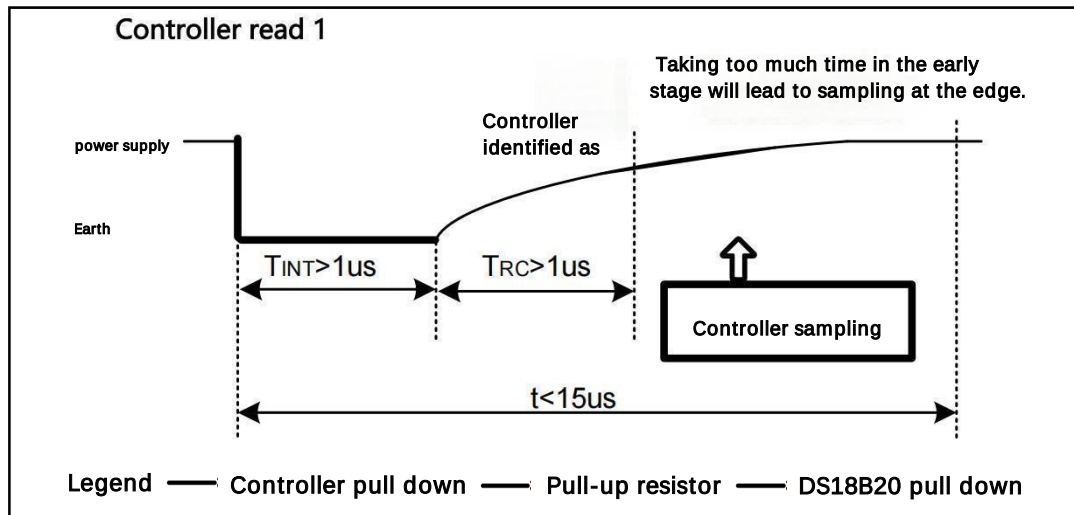


Figure 15. Detailed timing sequence of the controller reading 1

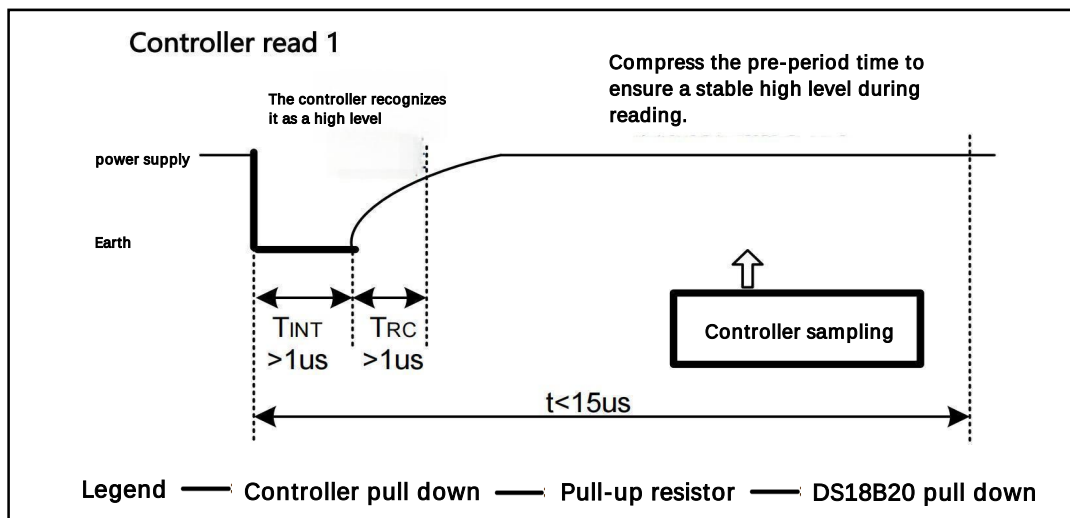


Figure 16. Recommended control read 1 timing sequence



## Operation Example

### Example 1

In this example, multiple DS18B20 powered by parasitic power are connected to the bus. The bus controller initiates a temperature conversion for a specific DS18B20, then reads its registers and recalculates the to verify the data.

| MASTER | MODE | DATA (LSB FIRST)                   | COMMENTS                                                                                                                                                                                                                                                                                                                            |
|--------|------|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tx     |      | Reset                              | The controller sends a reset pulse.                                                                                                                                                                                                                                                                                                 |
| Rx     |      | Presence                           | 18B20 returns a pulse presence                                                                                                                                                                                                                                                                                                      |
| Tx     |      | 55h                                | The main controller issues the matching ROM instruction.                                                                                                                                                                                                                                                                            |
| Tx     |      | 64-bit ROM code                    | The main controller sends the GX18B20 address.                                                                                                                                                                                                                                                                                      |
| Tx     |      | 44h                                | The main controller issues a temperature conversion instruction.                                                                                                                                                                                                                                                                    |
| Tx     |      | DQ line held high by strong pullup | The DQ signal maintains a strong pull-up level during the conversion process, completing the temperature conversion.                                                                                                                                                                                                                |
| Tx     |      | Reset                              | reset pulse                                                                                                                                                                                                                                                                                                                         |
| Rx     |      | Presence                           | 18B20 returns a pulse presence                                                                                                                                                                                                                                                                                                      |
| Tx     |      | 55h                                | The main controller issues the matching ROM instruction.                                                                                                                                                                                                                                                                            |
| Tx     |      | 64-bit ROM code                    | The main controller sends the 18B20 address.                                                                                                                                                                                                                                                                                        |
| Tx     |      | BEh                                | Main Control Read Register Instruction                                                                                                                                                                                                                                                                                              |
| Rx     |      | 9 data bytes                       | Read the entire register along with CRC: the controller recalculates the eight numbers read from the register. According to ByteDance's CRC algorithm, compare the calculated CRC value with the read CRC value; if they differ... If the values match, the controller proceeds downward; if they don't match, repeat the operation |

### Example 2

In this example, there is only one parasitic-powered DS18B20 on the bus. The controller writes  $T_H$ ,  $T_L$ , the configuration register, then reads the register and calculates the CRC to verify the data. The main controller copies the data from the register to the EEPROM.

| MASTER | MODE | DATA (LSB FIRST) | COMMENTS                                                                   |
|--------|------|------------------|----------------------------------------------------------------------------|
| Tx     |      | Reset            | reset pulse                                                                |
| Rx     |      | Presence         | returns a pulse presence                                                   |
| Tx     |      | CCh              | Skip the ROM instruction                                                   |
| Tx     |      | 4Eh              | Write register instruction                                                 |
| Tx     |      | 3 data bytes     | Write three data values to $T_H$ , $T_L$ , and the configuration register. |
| Tx     |      | Reset            | reset pulse                                                                |
| Rx     |      | Presence         | returns a pulse presence                                                   |
| Tx     |      | CCh              | Skip the ROM instruction                                                   |
| Tx     |      | BEh              | Read register instruction.                                                 |



|    |                                    |                                                                                                                                                                                                                                                                                                               |
|----|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Rx | 9 data bytes                       | The main controller reads all registers, including the CRC register; the controller then recalculates the value from the registers.<br>Read the 8-byte CRC from memory and compare the calculated CRC with the read CRC.<br>Compare; if identical, proceed downward; if different, repeat the read operation. |
| Tx | Reset                              | reset impulse                                                                                                                                                                                                                                                                                                 |
| Rx | Presence                           | GX18B20 returns a pulse presence                                                                                                                                                                                                                                                                              |
| Tx | CCh                                | Skip the ROM instruction.                                                                                                                                                                                                                                                                                     |
| Tx | 48h                                | Copy Register Instruction                                                                                                                                                                                                                                                                                     |
| Tx | DQ line held high by strong pullup | When performing the copy operation, the controller applies a strong pull-up signal to DQ and maintains it for at least 10 ms.                                                                                                                                                                                 |

## Extreme Usage Conditions

|                                               |                          |
|-----------------------------------------------|--------------------------|
| Voltage range of each pin relative to ground. | -0.5V to +6.0V           |
| operating temperature range                   | -55°C to +125°C          |
| Storage Range                                 | -55°C to +125°C          |
| Welding Temperature Range                     | Refer to Rule J-STD-020A |

The above outlines the environmental conditions required for the device to operate normally; prolonged operation under extreme conditions may affect its reliability.



## Direct-current characteristic

(-55°C to +125°C;  $V_{DD} = 2.5V$  to  $5.5V$ )

| parameter              | symbol,   | condition              | least value | representative value | crest value                                        | unit | fix on |
|------------------------|-----------|------------------------|-------------|----------------------|----------------------------------------------------|------|--------|
| service voltage        | $V_{DD}$  | Local Power Supply     | +2.5        |                      | +5.5                                               | V    | 1      |
| Pull-up supply voltage | $V_{PU}$  | Parasitic power supply | +2.5        |                      | +5.5                                               | V    | 12     |
|                        |           | Local Power Supply     | +2.5        |                      | $V_{DD}$                                           |      |        |
| temperature error      | $t_{ERR}$ | -10°C ~ +85°C          |             |                      | ±0.4                                               | °C   | 3      |
|                        |           | -55°C ~ +125°C         |             |                      | ±1.2                                               |      |        |
| Input logic low level  | $V_{IL}$  |                        | -0.3        |                      | +0.8                                               | V    | 1,4,5  |
| Input logic high level | $V_{IH}$  | Local Power Supply     | +2.2        |                      | 5.5 and $V_{DD} + 0.3$<br>The lower one among them | V    | 16     |
|                        |           | Parasitic power supply | +2.5        |                      |                                                    |      |        |
| Circuit Current        | $I_L$     | $V_{VO} = 0.4V$        | 4.0         |                      |                                                    | mA   | 1      |
| Standby current        | $I_{DDs}$ |                        |             | 750                  | 1000                                               | nA   | 78     |
| working current        | $I_{DD}$  | $V_{DD} = 5V$          |             | 1                    | 1.5                                                | mA   | 9      |
| input current on       | $I_{DQ}$  |                        |             | 5                    |                                                    | μA   | 10     |
| excursion              |           |                        |             | ± 0.2                |                                                    | °C   | 11     |

### Note:

- 1) All voltages are referenced to ground potential.
- 2) The pull-up voltage is obtained as follows: assuming the pull-up device is ideal, the pull-up high ceiling should be to VPU. To meet the VIH specification of the DS18B20, the actual transistor pull-up supply must include the voltage drop limit; therefore  $V_{PU\_ACT} = V_{PU\_IDEAL} - V_{TRANSISTOR}$ .
- 3) Typical curves are shown in Figure 17.
- 4) The logic 0 level is obtained at sink current of 4mA.
- 5) In the low voltage state of parasitic power mode, to ensure the presence of a pulse,  $V_{ILMAX}$  may need to be reduced 0.5V.
- 6) The logic 1 voltage is obtained at a source current of 1mA.
- 7) The standby current is defined at 7°C; the typical standby current value at 125°C is 3uA.
- 8) To reduce  $I_{DDs}$ , the range of DQ is as follows:  $\leq DQ \leq GND - 0.3V$  or  $V_{DD} - 0.3V \leq DQ \leq V_{DD}$ .
- 9) Dynamic current involves temperature conversion and writing to EEPROM memory.
- 10) The DQ data line is high ("high-impedance" state).
- 11) Data drift is obtained by testing for 100 hours at 125°C with a supply voltage  $V_{DD} = 5.5V$ .





## AC characteristic

nonvolatile memory(-55°C to +125°C;  $V_{DD} = 2.5V$  to 5.5V)

| parameter             | symbol     | condition      | least value | representative value | crest value | unit   |
|-----------------------|------------|----------------|-------------|----------------------|-------------|--------|
| NV Write Cycle Time   | $t_{WR}$   |                |             | 8                    | 12          | ms     |
| EEPROM Writes         | $N_{EEWR}$ | -55°C to +55°C | 1000        |                      |             | writes |
| EEPROM Data Retention | $t_{EEDR}$ | -55°C to +55°C | 10          |                      |             | years  |

(-55°C to +125°C;  $V_{DD} = 2.5V$  to 5.5V)

| parameter                   | symbol       | condition                     | least value | representative value | crest value | unit    | fix on |
|-----------------------------|--------------|-------------------------------|-------------|----------------------|-------------|---------|--------|
| Temperature Conversion Time | $t_{CONV}$   | 9-bit resolution              |             |                      | 93.75       | ms      | 1      |
|                             |              | 10-bit resolution             |             |                      | 187.5       |         |        |
|                             |              | 11-bit resolution             |             |                      | 375         |         |        |
|                             |              | 12-bit resolution             |             |                      | 750         |         |        |
| Time to Strong Pullup On    | $t_{SPON}$   | Start Convert TCommand Issued |             |                      | 10          | $\mu s$ |        |
| Time Slot                   | $t_{SLOT}$   |                               | 60          |                      | 120         | $\mu s$ | 1      |
| Recovery Time               | $t_{REC}$    |                               | 1           |                      |             | $\mu s$ | 1      |
| Write 0 Low Time            | $t_{LOW0}$   |                               | 60          |                      | 120         | $\mu s$ | 1      |
| Write 1 Low Time            | $t_{LOW1}$   |                               | 1           |                      | 15          | $\mu s$ | 1      |
| Read Data Valid             | $t_{RDV}$    |                               |             |                      | 15          | $\mu s$ | 1      |
| Reset Time High             | $t_{RSTH}$   |                               | 480         |                      |             | $\mu s$ | 1      |
| Reset Time Low              | $t_{RSTL}$   |                               | 1           |                      |             | ms      | 1      |
| Presence-Detect High        | $t_{PDHIGH}$ |                               | 15          |                      | 60          | $\mu s$ | 1      |
| Presence-Detect Low         | $t_{PDLOW}$  |                               | 60          |                      | 240         | $\mu s$ | 1      |
| Capacitance                 | $C_{IN/OUT}$ |                               |             |                      | 25          | pF      |        |



Note:

1) The typical characteristic curve is shown in Figure 17.

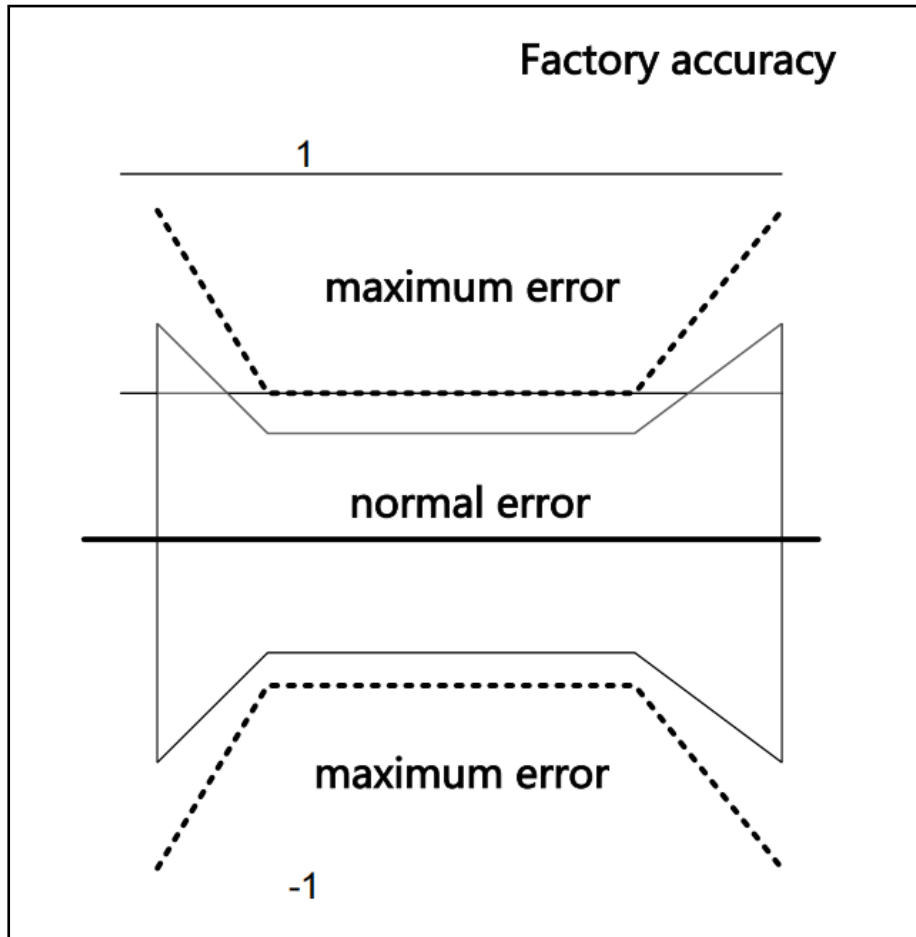


Figure 17. Typical characteristic curve



2) For information regarding the time sequence, refer to Figure 18.

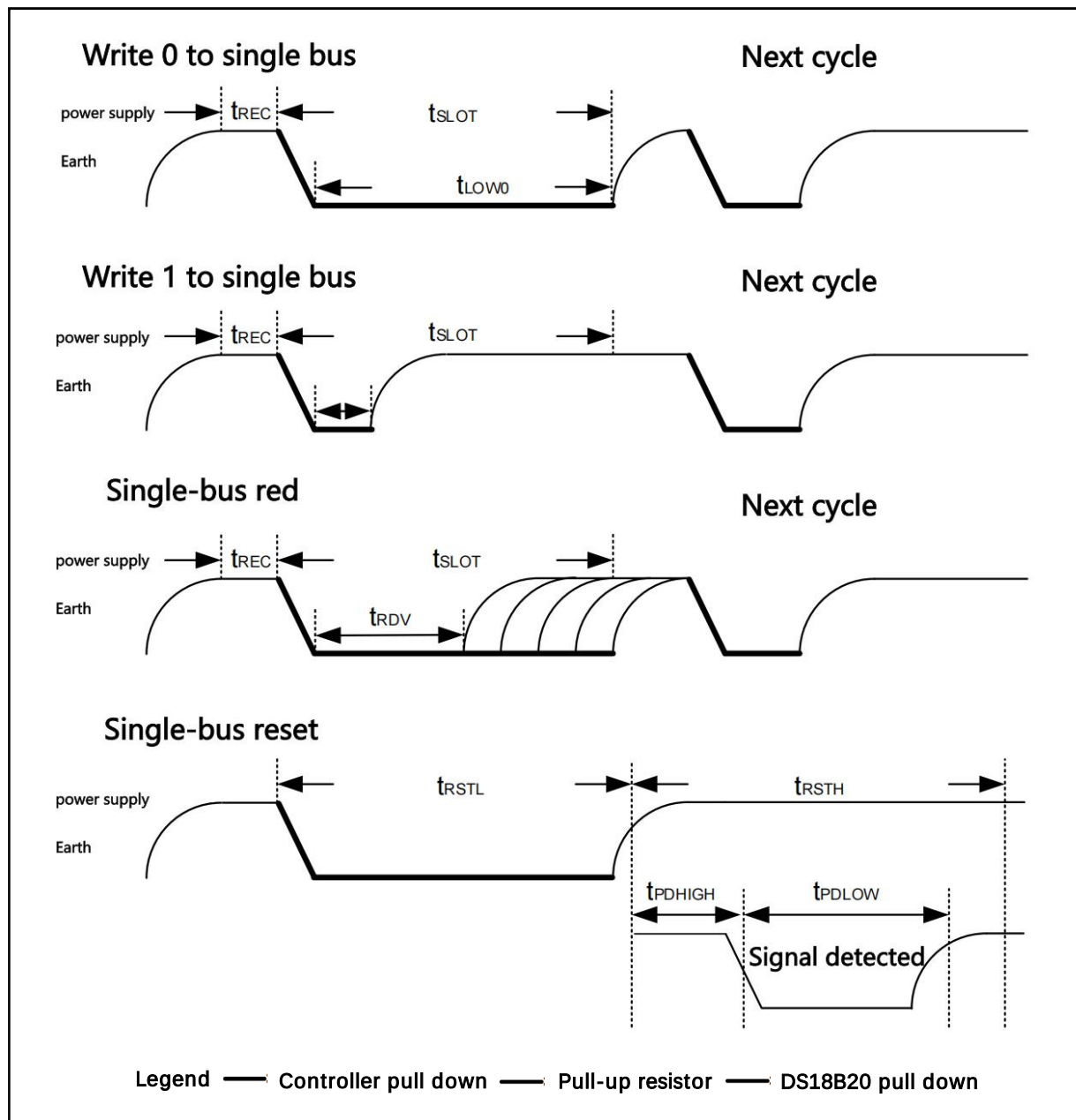
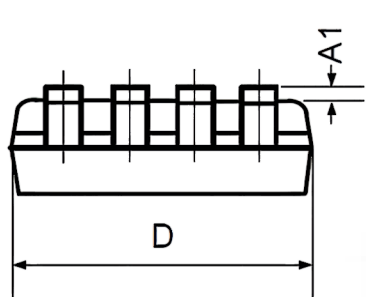
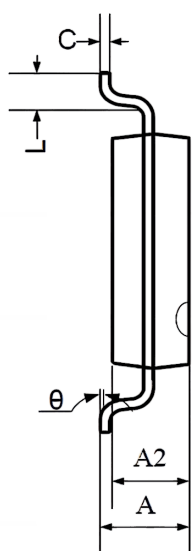
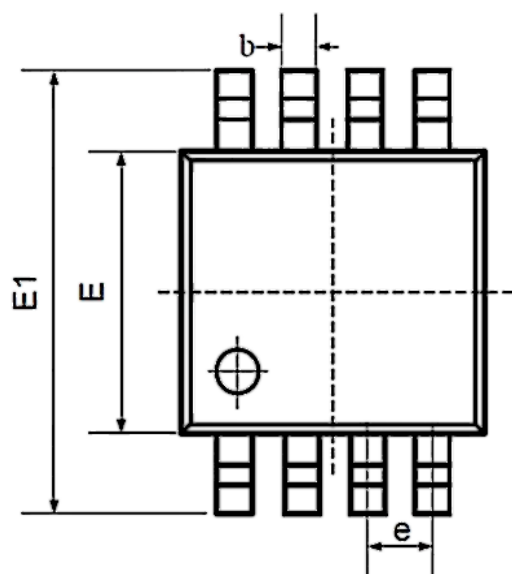


Figure 18: Time Sequence



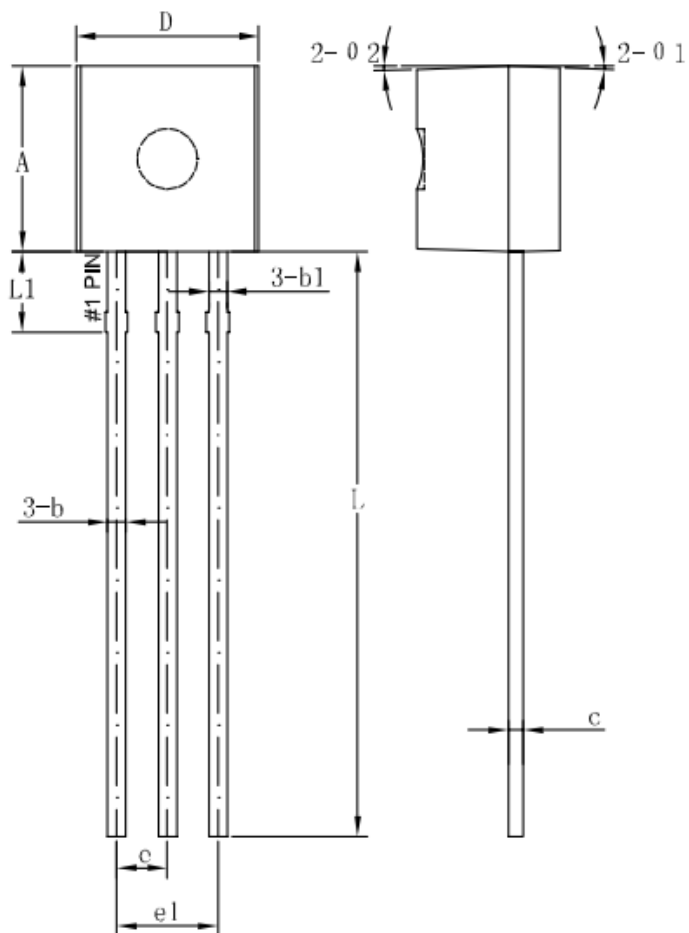
## Package MSOP8



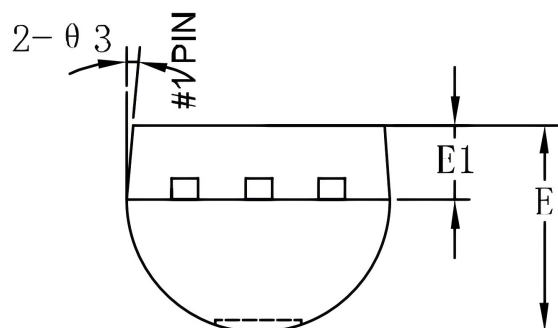
| Symbol | Dimensions<br>In Millimeters |       | Dimensions<br>In Inches |       |
|--------|------------------------------|-------|-------------------------|-------|
|        | Min                          | Max   | Min                     | Max   |
| A      | 0.800                        | 1.200 | 0.031                   | 0.047 |
| A1     | 0.000                        | 0.200 | 0.000                   | 0.008 |
| A2     | 0.760                        | 0.970 | 0.030                   | 0.038 |
| b      | 0.30 TYP                     |       | 0.012 TYP               |       |
| C      | 0.15 TYP                     |       | 0.006 TYP               |       |
| D      | 2.900                        | 3.100 | 0.114                   | 0.122 |
| e      | 0.65 TYP                     |       | 0.026 TYP               |       |
| E      | 2.900                        | 3.100 | 0.114                   | 0.122 |
| E1     | 4.700                        | 5.100 | 0.185                   | 0.201 |
| L      | 0.410                        | 0.650 | 0.016                   | 0.026 |
| θ      | 0°                           | 6°    | 0°                      | 6°    |



## Package TO92

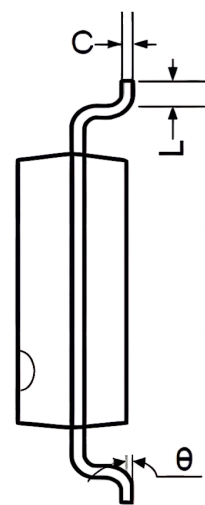
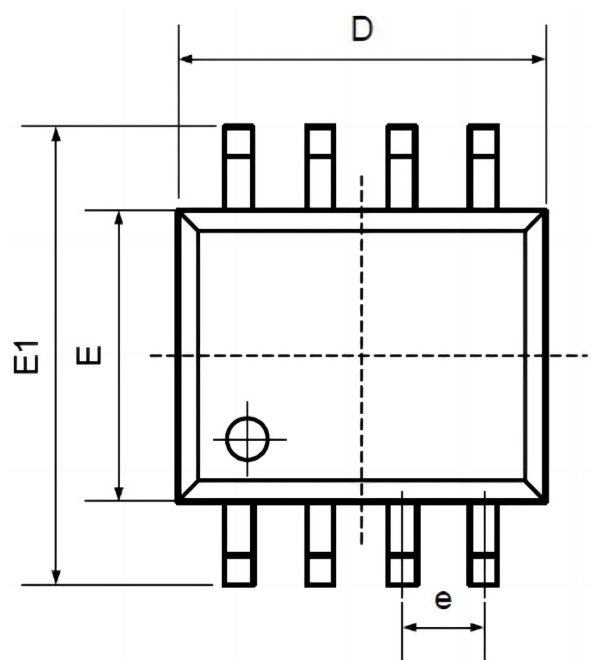


| Symbol | Mechanical Dim./mm |      |      |
|--------|--------------------|------|------|
|        | Min.               | Typ. | Max. |
| A      | 4.5                | 4.6  | 4.7  |
| b      | 0.38               | 0.45 | 0.56 |
| b1     |                    | 0.45 |      |
| C      | 0.36               | 0.38 | 0.51 |
| D      | 4.5                | 4.6  | 4.7  |
| E      | 3.45               | 3.6  | 3.75 |
| E1     | 1.2                | 1.3  | 1.4  |
| e      |                    | 1.27 |      |
| e1     |                    | 2.54 |      |
| L      | 13.5               | 14.5 | 15.3 |
| L1     |                    | 1.96 |      |
| θ1     |                    | 2°   |      |
| θ2     |                    | 2°   |      |
| θ3     |                    | 5°   |      |

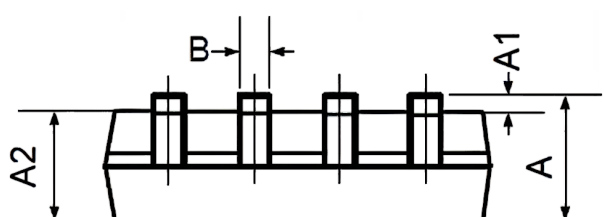




## Package SOP8



| Symbol | Dimensions<br>In Millimeters |       | Dimensions<br>In Inches |       |
|--------|------------------------------|-------|-------------------------|-------|
|        | Min                          | Max   | Min                     | Max   |
| A      | 1.350                        | 1.750 | 0.053                   | 0.069 |
| A1     | 0.100                        | 0.250 | 0.004                   | 0.010 |
| A2     | 1.350                        | 1.550 | 0.053                   | 0.061 |
| B      | 0.330                        | 0.510 | 0.013                   | 0.020 |
| C      | 0.190                        | 0.250 | 0.007                   | 0.010 |
| D      | 4.780                        | 5.000 | 0.188                   | 0.197 |
| E      | 3.800                        | 4.000 | 0.150                   | 0.157 |
| E1     | 5.800                        | 6.300 | 0.228                   | 0.248 |
| e      | 1.270TYP                     |       | 0.050TYP                |       |
| L      | 0.400                        | 1.270 | 0.016                   | 0.050 |
| θ      | 0°                           | 8°    | 0°                      | 8°    |



## Orderinformation

| Order Number  | Package | Package Quantity | Marking<br>On The park | Temperature    |
|---------------|---------|------------------|------------------------|----------------|
| DS18B20-TUDI  | TO92    | Bag,2000         | TD18B20                | -55°C to 125°C |
| DS18B20U-TUDI | MSOP8   | Tape,Reel,2500   | TD18B20                |                |
| DS18B20Z-TUDI | SOP8    | Tape,Reel,2500   | TD18B20                |                |





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