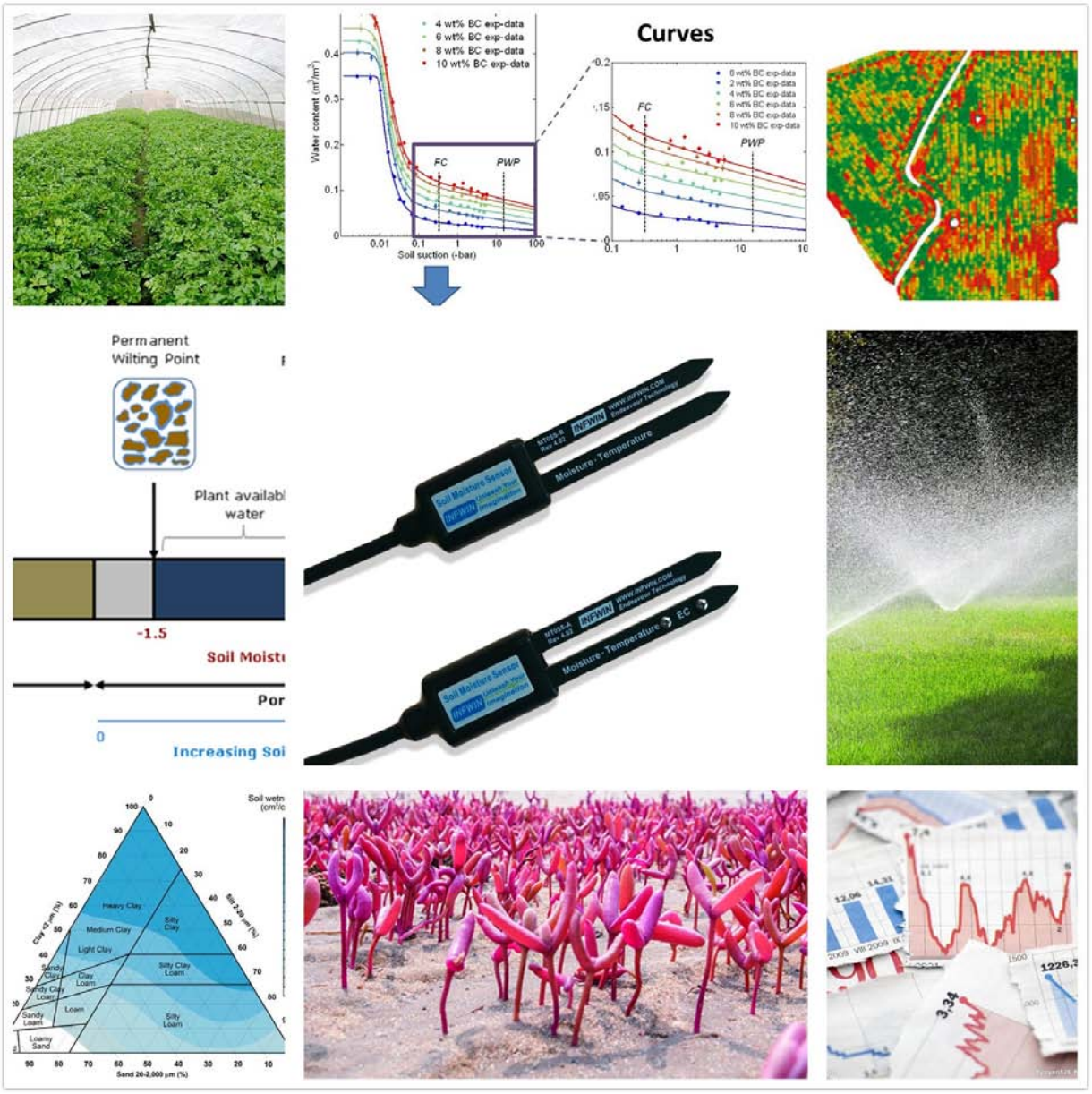
MT05S (1-Wire Interface)

Soil Moisture, EC and Temperature Sensor (MT05S-A)

Soil Moisture, Temperature Sensor (MT05S-B)

User Manual V1.1



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2 Introduction

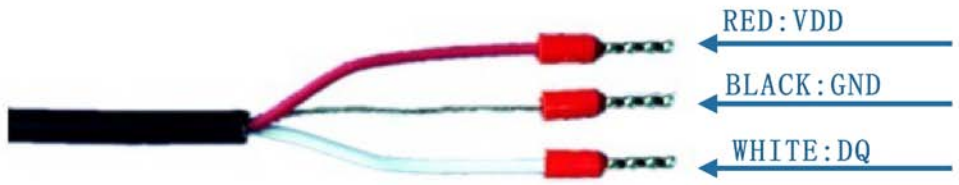
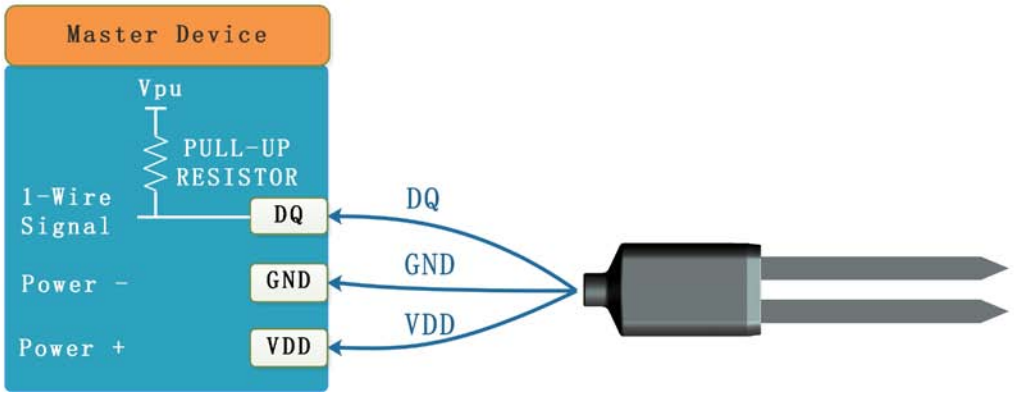
MT05S is 1-Wire soil moisture sensor, measuring soil moisture content, temperature and EC(Conductivity) according to the order information. It sealed with resin packaged plastic body with sensing rods which can be insert directly into the soil with long time stability. Sensor with relatively small size and can be used for pot culture and Seedling tray. The sensor is applicable for science research, irrigation, greenhouse, smart agriculture etc.

- Integrated with Soil Moisture, temperature or with EC (Conductivity) measurement
- 1-Wire bus interface, Operation compatible with DS18B20
- Directly connect with MCU, Arduino, Raspberry PI or other modules by only one I/O pin, No other signal conversion board required, Software library for DS18B20 can be reused to read/write the sensor
- ROMCODE can be set by extension function command for easily addressing
- Power Supply 2.7-12V DC, Low Quiescent current Max. 30uA
- Low salinity sensitivity and Minimal soil disturbance
- Water proof to IP68 ratings and can be directly buried into soil
- High accuracy with excellent stability
- Reverse power protection and Built-in TVS/ESD protection
- ODM/OEM Service

Specification-MT05S	
Measuring parameters	MT05S-A : Soil Moisture, EC and Temperature MT05S-B : Soil Moisture, Temperature
Power Supply	2.7-12V DC
Power Consumption	Quiescent Current : Max. 30uA (Standby mode) Measuring Current : 15mA during 100ms measurement (Active mode)
Output Interface	1-Wire bus interface with the same protocol and time slot as DS18B20's
Soil Moisture Measurement (FDR Method)	Soil Moisture (VWC-Volumetric Water Content): Range:0%-100% (air - water) Resolution: 0%-50%: 0.1%, 50%-100%: 0.5% Accuracy: 0%-50%: ±3%, 50%-100%: ±5% Apparent dielectric permittivity Epsilon: Range:0.88-81.88 (air - water) Resolution: 1.00-40.00: ±0.1, 40.00-81.00: ±0.5 Accuracy:1.00-40.00: ±1, 40.00-81.00: ±3
EC Measurement (Conductivity)	Range: 0-23ds/m (0-23000us/cm) Resolution: 0-5ds/m, 0.01ds/m; 5-23ds/m, 0.1ds/m

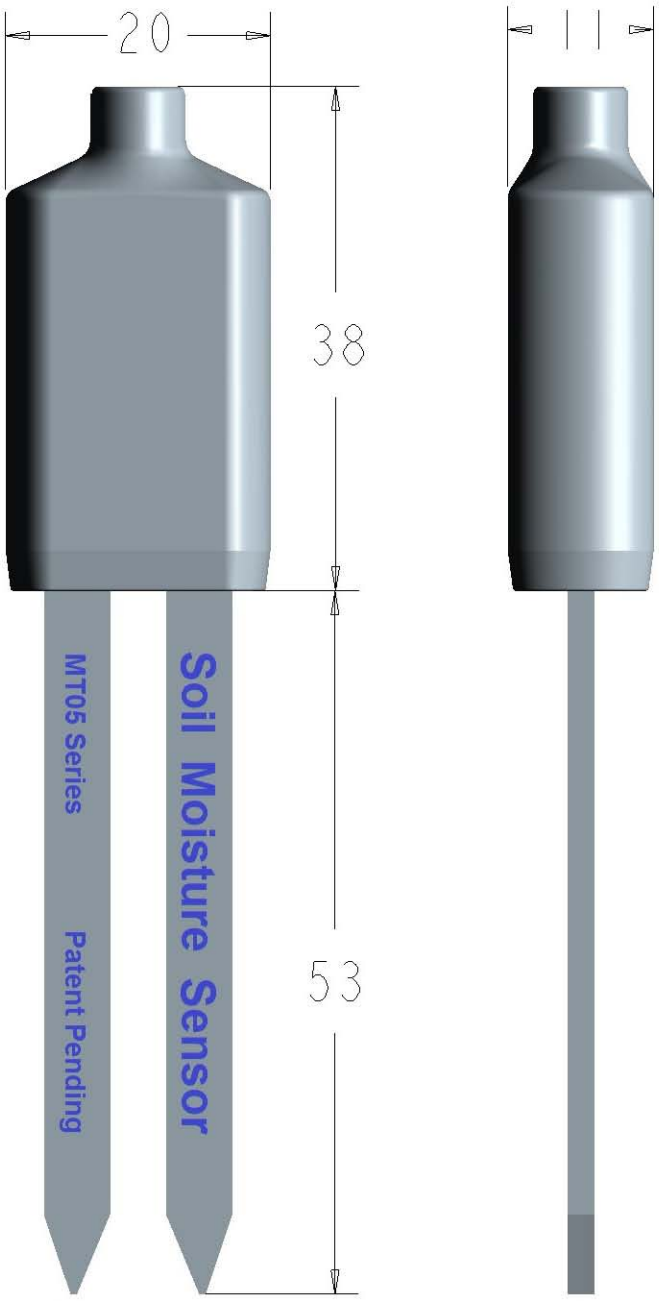
	Accuracy: 0-5ds/m, ±5%; 5-23ds/m, ±10% EC temperature compensation: 0-50℃
Temperature Measurement	Range: -40~80°C Resolution:0.1°C Accuracy:0-50°C: ±0.5°C; -40-80°C: ±1.0°C
IP Ratings	IP68
Operating Temperature	-40~85°C
Cable Length	5 meters
Dimension	20*11*95mm

3 Wiring diagrams

Type	Wiring Diagrams
MT05S 1-Wire interface	Cold pressed terminal  Tinned lead wires  Wiring Diagram 

4 Dimension and Ordering Infomation

4.1 Dimension



Unit:mm

4.2 Ordering Infomation

Parameters	Code	Comments
Code 1: Product Series	MT05S	MT05S series sensor with 1-Wire Interface
Code 2: Measuring Parameters	A B	Soil Moisture & Temperature & EC Soil Moisture & Temperature
Code 3: Power Supply	B	2.7-12V DC
Code 4: Connector	B C	Cold pressed terminal pre-tinning wire
Code 5: Cable Length	005	5 meters
Ordering Code Example: MT05S sensor with 1-Wire Interface, Measuring Parameters Soil Moisture & Temperature & EC, 2.7-12VDC Power supply, Cold pressed terminal, Cable Length 5 meters. Ordering Code is : MT05S-ABB005		

5 Safty ,Care and Installation

5.1 Care and Safty

■ The rods of the Sensor are sharp for ease insertion. Care must be taken and handling precautions followed.
■ Avoid touching the rods or exposing them to other sources of static damage, particularly when powered up.

■ Do not pull the sensor out of the soil by its cable.

■ If you feel any resistance when inserting the sensor into soil, it is likely you have encountered a stone. Stop pushing and re-insert at a new location.

5.2 Installation

Surface installation
■ Clear away any stones. Pre-form holes in very hard soils before insertion.
■ Push the sensor into the soil until the rods are fully inserted. Ensure good soil contact.
■ If you feel strong resistance when inserting the sensor, you have probably hit a stone. Stop, and re-insert at a new location.

Installing at depth
■ Make a 45mm diameter hole, preferably at about 10° to the vertical using an auger.
■ Push the sensor into the soil until rods are fully inserted. Ensure good soil contact.
■ Fill and repack the hole with soil.

Alternatively
■ Dig a trench, and install horizontally.

6 1-Wire Bus System

The 1-Wire bus system has a single bus master device, to communicate with one or multiple slave devices. The sensor is always a slave device. When there is only one slave on the bus, the system is a “single-drop” system; the system is “multi-drop” if there are multiple slaves on the bus. All data and commands are transmitted least significant bit first on the bus.

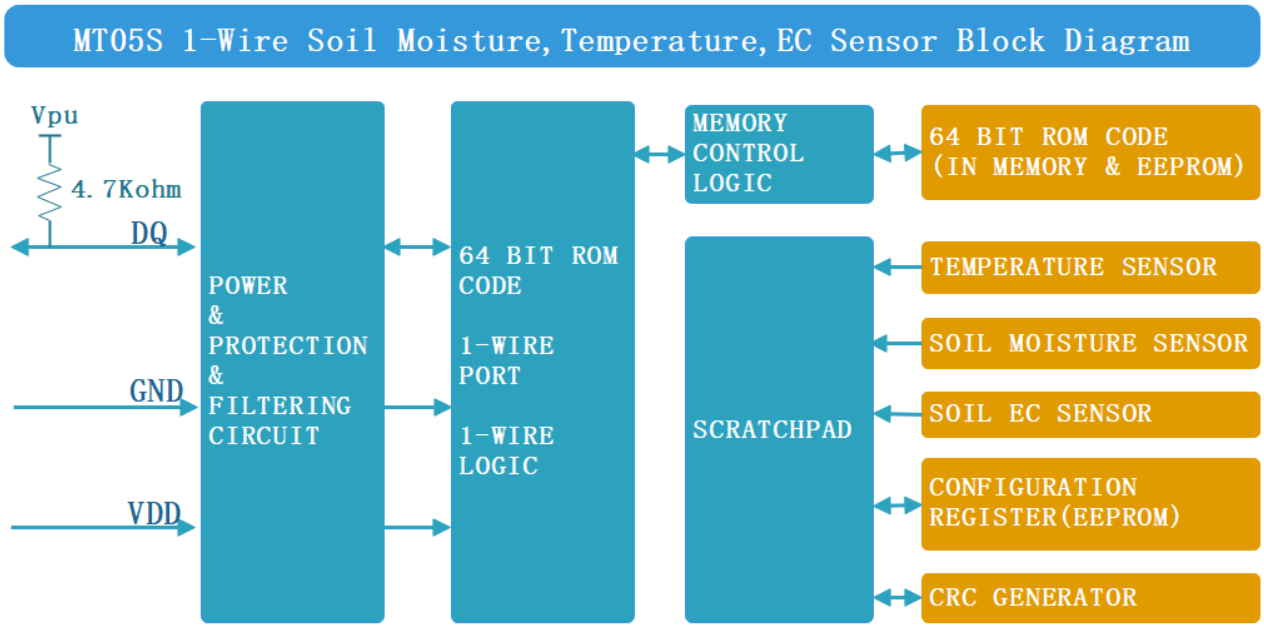


Figure 1: Sensor Block Diagram

6.1 Sensor Overview

The block diagram in Figure 1 shows the architecture of the sensor, The 64-bit configurable ROM CODE stores the device’s unique serial code and can be set by extension function command. The scratchpad memory contains the 2-byte temperature register, 2-byte soil moisture register which can be configured as VWC, EPSILON or RAWAD of the soil moisture, and 2-byte soil EC register. In addition, the scratchpad provides two configuration register, CONFIG0 and CONFIG1.

The configuration register allows the user to configure the sensor parameters like soil moisture value type, whether to pull down the DQ line during conversion, and whether to make a conversion when sensor power up.

The ROM CODE register allow the user to set the ROM CODE of the sensor to any desired value. We recommend that you set the ROM CODE under the rules of 1-Wire related standard. When ROM CODE is received by sensor, it will be saved to EEPROM and take effective immediately.

Both the configuration registers and ROM CODE are nonvolatile (EEPROM), so data will be

retained when the device is powered down.

The 1-Wire bus protocol that implements bus communication using one control signal. The control line requires a weak pull-up resistor since all devices are linked to the bus via an open-drain port (the DQ pin of the sensor). The microprocessor (the master device) identifies and addresses devices on the bus using device's unique 64-bit ROM code.

The sensor is not able to operate without an external power supply (known as "parasite power" of DS18B20), therefore you have to power the sensor with a proper DC power supply for sensor.

6.1.1 Electrical Characteristics

■ DC Electrical Characteristics (-40°C to +80°C; VDD = 2.7V to 12V)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	VDD	N/A	2.7		12.7	V
Pull-up Supply Voltage	VPU	N/A	2.5		5.5	V
Input Logic-Low	VIL	sink current of 4mA	-0.3		0.8	V
Input Logic-High	VIH	source current of 1mA.	+2.4		5.5	V
Sink Current	IL	VI/O = 0.4V	4			mA
Standby Current	IDDS	Note 1			30	uA
Active Current	IDD	VDD = 5V		25		mA
DQ Input Current	IDQ	Note 2		5		uA

Note 1: To minimize IDDS, DQ should be within: GND ≤ DQ ≤ GND + 0.3V or 2.4V ≤ DQ ≤ 5.5V.

Note 2: DQ line is high ("high-Z" state).

■ AC Electrical Characteristics–NV Memory (-40°C to +80°C; VDD = 2.7V to 12V)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
NV Write Cycle Time	N/A	-40~-60°C			10	ms
EEPROM Writes	N/A	-40~-60°C	50K			writes
EEPROM Data Retention	N/A	-40~-60°C	10			years

■ AC Electrical Characteristics (-40°C to +80°C; VDD = 2.7V to 12V)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Power up Time	tPWRON	PowerOnMeasurement=ON PowerOnMeasurement=OFF			110 10	ms
Conversion Time	tCONV	N/A			100	ms
Time to Strong Pullup On	tSPON	Start convert T command issued	10			us
Time Slot	tSLOT	Note 1	60		120	µs
Recovery Time	tREC	Note 2	1		500000	µs
Write 0 Low Time	tLOW0	Note 1	60		120	µs
Write 1 Low Time	tLOW1	Note 1	1		15	µs
Read Data Valid	tRDV	Note 1			15	µs
Reset Time High	tRSTH	Note 1	480			µs

Reset Time Low	tRSTL	Note 1	480		µs
Presence-Detect High	tPDHIGH	Note 1	15	60	µs
Presence-Detect Low	tPDLOW	Note 1	60	240	µs
Capacitance	CIN/OUT	N/A		25	pF

Note 1: Please refer to details in DS18B20 1-Wire document.

Note 2: The maxim recovery time for sensor is 500ms while DS18B20 has no limitation on this.

6.1.2 Measuring

The sensor measure soil temperature, moisture, and EC (Conductivity). When power up, the sensor can make a power on measurement (depending on the power on measurement bit in CONFIG0 REGISTER) and then enter into the low-power standby state.

After power on, To initiate a measurement, the master can issue a Convert T [44h] command. Following the conversion, the measurement data are stored in the scratchpad memory and the sensor returns to its standby state.

The master can issue “read time slots” after the Convert T command and the sensor will respond by transmitting 0 while the conversion is in progress and 1 when the conversion is done (Whether to pull down the DQ line during measurement can be configured in scratchpad CONFIG0-Bit3-SensorPowerMode). **Please be noted that, the sensor does not support parasite power mode.**

The temperature data is stored as a 16-bit signed integer value; The moisture data is stored as a 16-bit unsigned integer value; The EC (Conductivity) data is stored as a 16-bit unsigned integer value.

6.1.2 Alarm Signaling

The sensor does not support Alarm Search [ECh] command. If an Alarm Search [ECh] is received the sensor will not response and enter into standby mode.

6.1.3 Powering the sensor

The sensor must be powered by an external supply on the VDD pin, “Parasite power” mode is not supported. If the master issue a Skip ROM [CCh] command followed by a Read Power Supply [B4h] command followed by a “read time slot”, During the read time slot, the sensor will let the bus remain high(if Sensor Power Mode in CONFIG0 REGISTER is 1) , or let the bus remain low(if Sensor Power Mode in CONFIG0 REGISTER is 0).

6.1.4 ROM Code and Memory

Each sensor has a unique 64 bit ROM Code stored in EEPROM and can be changed by extension FUNCTION COMMAND. The least significant 8 bits of the ROM code contain the Sensor’s 1-Wire family code: 28h (28h is DS18B20’s family code, You may change ROMCODE by

extension command). The next 48 bits contain a unique serial number. The most significant 8 bits contain a CRC checksum byte that is calculated from the first 56 bits of the ROM code. A detailed explanation of the CRC bits is provided in the CRC Generation section.

The sensor's memory is organized as shown in Figure 2. The memory consists of an SRAM scratchpad with nonvolatile EEPROM storage for CONFIG and ROM CODE. All memory commands are described in detail in the Function Commands section.

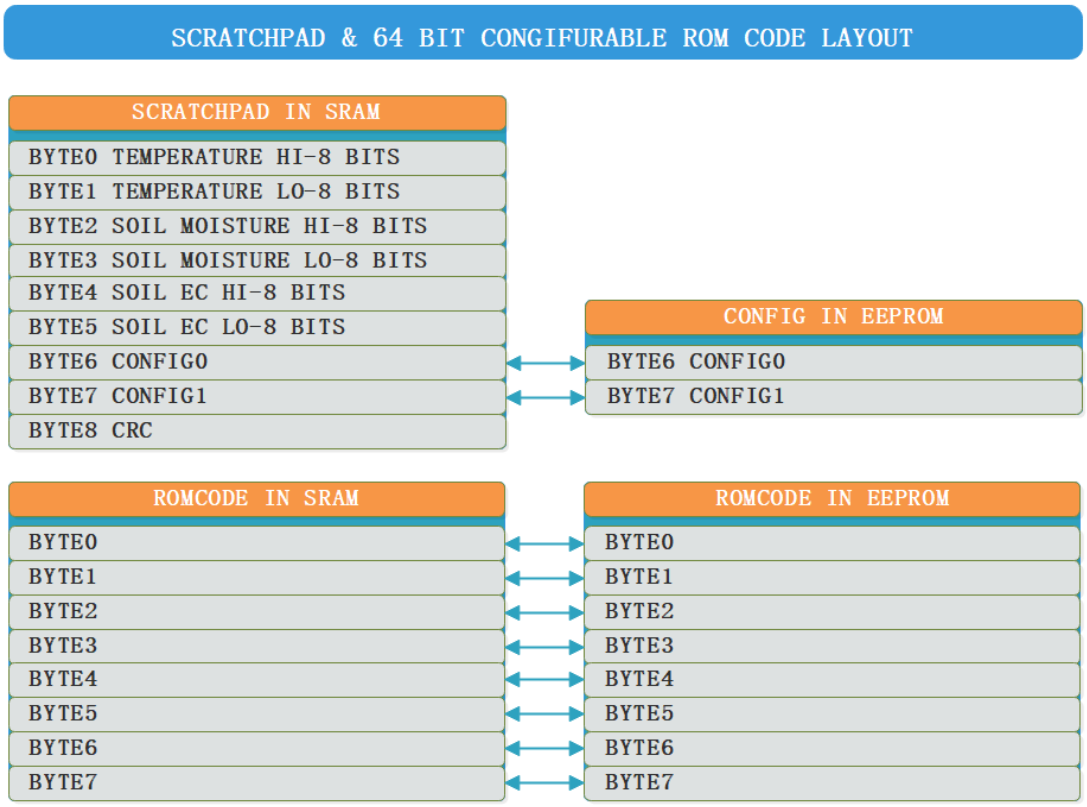


Figure 2: ROM Code and Memory Layout

Table 1: Scratchpad Details Description

SCRATCHPAD	REGISTER NAME	EXAMPLE	DESCRIPTION
BYTE0 (RO)	TEMPERATURE HIGH 8-BITS	0x04/0xFB	INT16, Value range from -4000 to 8000 temperature=(16 Bits REGISTER VALUE)/100.00 ■ For 0x04CE, temperature=(INT16)0x04CE/100.00=1230/100.00=12.30℃ ■ For 0xFB32, temperature=(INT16)0xFB32/100.00=-1230/100.00=-12.30℃
BYTE1 (RO)	TEMPERATURE LOW 8 -BITS	0xCE/0x32	
BYTE2 (RO)	SOIL MOISTURE HIGH 8-BITS	0x04	UINT16, The meaning of 16 Bits REGISTER VALUE depends on SCRATCHPAD-CONFIG0, BIT1 & BIT0(Soil Moisture Value Type Selection) ■ When Value Type=Volumetric Water Content. Value range from 0 to 10000, Volumetric Water Content=(16 Bits REGISTER VALUE)/100.00=(UINT16)0x04CE/100.00=1230/100.00=12.30%
BYTE3 (RO)	SOIL MOISTURE LOW 8-BITS	0xCE	

			■ When Value Type = Epsilon. Value range from 88 to 8188, Epsilon=(16 Bits REGISTER VALUE)/100.00=(UINT16)0x04CE/100.00=1230/100.00=12.30 ■ When Value Type =RAWAD. Value range from 0 to 4000, RAWAD=(16 Bits REGISTER VALUE) =(UINT16)0x04CE=1230
BYTE4 (RO)	SOIL EC HIGH 8-BITS	0x04	For Sensor type MT05S-A: UINT16, Value range from 0 to 23000 EC=(16 Bits REGISTER VALUE) ■ For 0x04CE, EC=(UINT16)0x04CE=1230us/cm=1.230ms/cm=1.230ds/m For Sensor type MT05S-B: This value is always 65535(0xFFFF).
BYTE5 (RO)	SOIL EC LOW 8-BITS	0xCE	
BYTE6 (RW)	CONFIG0	0x08	Configuration register 0 ■ BIT7: Reserved for future use. ■ BIT6: Reserved for future use. ■ BIT5: Reserved for future use. ■ BIT4: Reserved for future use. ■ BIT3: Sensor Power Mode. The sensor only support external power supply, the configuration here is used to configure DQ line status in 44h(Convert T), 48h(Copy Scratchpad), or B4h(Read Power Supply). 0- PARASITE: The sensor will release DQ line in 44h(Convert T), 48h(Copy Scratchpad), and pull down DQ line in B4h(Read Power Supply). 1- EXTERNAL (default value) : The sensor will pull down DQ line in 44h(Convert T), 48h(Copy Scratchpad), and release DQ line in B4h(Read Power Supply). ■ BIT2: Enable power up measurement. 0-DISABLED (default value) 1-ENABLED-Make a measurement when sensor power up. ■ BIT1 & BIT0: Soil Moisture Value Type Selection. 00: Volumetric Water Content (default value) 01: Epsilon 10: RAWAD 11: Volumetric Water Content
BYTE7 (RW)	CONFIG1	0x00	Configuration register 1 ■ BIT7-0: Reserved for future use.
BYTE8 (RO)	CRC	N/A	CRC code for bytes 0 through 7 of the scratchpad Refer to CRC Generation Chapter

NOTE1: RO is Read Only, RW is Read/Write

NOTE2: INT16 is 16 bits signed integer (encoded in two's complement), UINT16 is 16 bits unsigned integer (encoded in original code)

The sensor does not support partial reading of the scratchpad, you should read all 9 bytes of data using the Read Scratchpad [BEh] command. Partial Reading causes the sensor enter into signal recovery timeout procedure and then enter into STANDBY mode when timeout.

In order to keep the same write scratchpad protocol with DS18B20, when writing data to scratchpad, although there's only two writable register BYTE6 and BYTE7 in scratchpad, You should append a dummy byte following with BYTE6 and BYTE7. That is write BYTE6, BYTE7 and BYTE DUMMY (value=0) to scratchpad by Write Scratchpad [4Eh] command; the data must be transmitted to the sensor starting with the least significant bit of BYTE6. To verify data integrity, the scratchpad can be read (using the Read Scratchpad [BEh] command) after the data is written. When reading the scratchpad, data is transferred over the 1-Wire bus starting with the least significant bit of BYTE0. To transfer the CONFIG0 and CONFIG1 data from the scratchpad to EEPROM, the master must issue the Copy Scratchpad [48h] command.

Data in the EEPROM registers is retained when the device is powered down; When sensor power up, the EEPROM data is reloaded into the corresponding scratchpad locations. Data can also be reloaded from EEPROM to the scratchpad at any time using the Recall E2 [B8h] command. The master can issue read time slots following the Recall E2 command and the sensor will indicate the status of the recall by transmitting 0 while the recall is in progress and 1 when the recall is done.

6.1.5 Configuration Register

BYTE6 and BYTE7 of the scratchpad memory contains the configuration register, which is illustrated in Table 1. The functionality of confutation register is as followings:

- User can select the soil moisture value type in CONFIG0 as shown in Table 1. When selected as "Volumetric Water Content", BYTE2 and BYTE3 in scratchpad denote the most commonly used soil volumetric water content value. When selected as "Epsilon" or "RAW AD", BYTE2 and BYTE3 in scratchpad denote the epsilon or raw A/D value of soil moisture, which can be used for water content calibration of special soil or non-soil substrate.
- User can enable/disable the power on measurement when the sensor power up in CONFIG0 as shown in Table 1. During the power up measurement, DQ line always won't be pulled down by sensor. The power on measurement is useful in some battery powered system (the power supply pin VDD of the sensor should be controlled by the data acquisition board), In each power up cycle, the sensor automatically make a conversion without any CONVERSION T command sent by master, then you can read the measurement value directly by READ SCRATCHPAD command, to decrease the running time and power consumption of data acquisition system.
- User can enable/disable DQ line to be pulled down during measurement in CONFIG0 as shown in Table 1. When enabled, the DQ line will be pulled down during measuring and released when measurement done. When disabled, the DQ line keeps its original state.

Reserved bits in the configuration register are reserved for future use by the device and not recommended to be used by user.

6.1.6 CRC Checksum and Generation

CRC bytes are provided as part of the sensor's 64-bit ROM code and in the 9th byte of the scratchpad memory.

Please refer to details in 1-Wire document for CRC calculation.

6.2 Hardware Configuration

The 1-Wire bus has only a single data line. Each device (master or slave) interfaces to the data line via an open-drain or 3-state port. The bus requires an external pullup resistor of approximately 5kΩ. The pullup resistor value depends on the cable length and number of sensors on line.

6.3 Transaction Sequence

The transaction sequence for communicating with sensor is as follows:

- Step 1: Initialization
- Step 2: ROM Command (followed by required data exchange)
- Step 3: FUNCTION Command (followed by required data exchange)

It is very important to follow this sequence every time the sensor is accessed, as the sensor will not respond if any steps in the sequence are missing or out of order. Exceptions to this rule are the Search ROM [F0h] and Alarm Search [ECh] commands. After issuing either of these ROM commands, the master must return to Step 1 in the sequence.

6.3.1 Initialization

All transactions on the 1-Wire bus begin with an initialization sequence. The initialization sequence consists of a reset pulse transmitted by the bus master followed by presence pulse(s) transmitted by the slave(s). The presence pulse lets the bus master know that slave devices are on the bus and are ready to operate.

6.3.2 ROM Commands

After the bus master has detected a presence pulse, it can issue a ROM command. These commands operate on the unique 64-bit ROM codes of each slave device and allow the master to single out a specific device if many are present on the 1-Wire bus. These commands also allow the master to determine how many and what types of devices are present on the bus or if any device has experienced an alarm condition. There are five ROM commands, and each command is 8 bits long. The master device must issue an appropriate ROM command before issuing a FUNCTION command.

■ Search Rom [F0h]

The sensor support this command, Please refer to command details in 1-Wire document.

■ Read Rom [33h]

The sensor support this command, Please refer to command details in 1-Wire document.

■ Match Rom [55H]

The sensor support this command, Please refer to command details in 1-Wire document.
Only the slave that exactly matches the 64-bit ROM code sequence will respond to the function command issued by the master; all other slaves on the bus will wait for a reset pulse.

■ Skip Rom [CCh]

The sensor support this command, Please refer to command details in 1-Wire document.

■ Alarm Search [ECh]

The sensor does not support this command. If an Alarm Search is received, the sensor will not respond and enter into standby mode, to wait another RESET signal.

6.3.3 FUNCTION Command

After the bus master has used a ROM command to address the sensor with which it needs to communicate, the master can issue FUNCTION commands. These commands allow the master to write to and read from the sensor's scratchpad memory, initiate conversions and determine the power supply mode.

■ Convert T [44h]

This command initiates a single conversion. Following the conversion, the resulting data is stored in the scratchpad memory and the sensor returns to its standby state. **The sensor does not support parasite power mode**. The master can issue read time slots after the Convert T command :

The sensor will respond by transmitting a 0 while the operation is in progress and a 1 when the conversion is done. (When Sensor Power Mode in CONFIG0 REGISTER is 1)

The sensor will respond by releasing the DQ line (bus remain high) while the operation is in progress. (When Sensor Power Mode in CONFIG0 REGISTER is 0)

■ Write Scratchpad [4Eh]

This command allows the master to write 2 config bytes of data to the sensor's scratchpad. **In order to keep the same write scratchpad protocol with DS18B20, when writing data to scratchpad, although there's only two writable register BYTE6 and BYTE7 in scratchpad, You should append a dummy byte following with BYTE6 and BYTE7. That is write BYTE6, BYTE7 and BYTE DUMMY (value=0) to scratchpad by Write Scratchpad [4Eh] command**. Data must be transmitted least significant bit first. All three bytes MUST be written before the master issues a reset, or the data may be corrupted.

■ Read Scratchpad [BEh]

This command allows the master to read the contents of the scratchpad. The data transfer starts with the least significant bit of BYTE0 and continues through the scratchpad until the 9th byte (BYTE8 CRC) is read. **The sensor does not support partial reading of the scratchpad. You should read all 9 bytes of data using the Read Scratchpad [BEh] command. Partial Reading causes the sensor enters into signal processing timeout procedure and then enter into STANDBY mode.**

■ Copy Scratchpad [48h]

This command copies the contents of the scratchpad CONFIG0, CONFIG1 registers (BYTE6 and BYTE7) to EEPROM. The master can issue read time slots after the Copy Scratchpad command :

The sensor will respond by transmitting a 0 while the operation is in progress and a 1 when the conversion is done. (When Sensor Power Mode in CONFIG0 REGISTER is 1)

The sensor will respond by releasing the DQ line (bus remain high) while the operation is in progress. (When Sensor Power Mode in CONFIG0 REGISTER is 0)

■ Recall E2 [B8h]

This command recalls the CONFIG0, CONFIG1 data from EEPROM and places the data in bytes 6, and 7 in the scratchpad memory. The master device can issue read time slots following the Recall E2 command and the sensor will indicate the status of the recall by transmitting 0 while the recall is in progress and 1 when the recall is done. The recall operation happens automatically at power-up, so valid data is available in the scratchpad as soon as power is applied to the device.

■ Read Power Supply [B4h]

The master device issues this command followed by a read time slot to determine if any sensor on the bus are using parasite power. **The sensor does not support parasite power mode**. During the read time slot, the sensor will let the bus remain high(if Sensor Power Mode in CONFIG0 REGISTER is 1) , or let the bus remain low(if Sensor Power Mode in CONFIG0 REGISTER is 0).

■ Write ROMCODE [0Fh]

The ROMCODE can be set by user to desired value by using this command. The master device issues this command followed by 2 flag data byte F0H 00H, and 8 bytes ROM CODE (LSB FIRST) to sensor, then Master device should read 2 bytes writing status data [WRESULT0],[WRESULT1] from sensor.

When ROMCODE write successfully, [WRESULT0=00H],[WRESULT1=03H].

When ROMCODE write failed, [WRESULT0=00H],[WRESULT1=C0H].

TABLE 2: Function Command Set

COMMAND	PROTOCOL	DESCRIPTION	1-WIRE BUS ACTIVITY AFTER COMMAND IS ISSUED	NOTES
CONVERSION COMMANDS				
Convert T	44H	Initiates Conversion	DS18B20 transmits conversion status to master.	Note 1
MEMORY COMMANDS				

Read Scratchpad	BEH	Reads the entire scratchpad including the CRC byte.	DS18B20 transmits up to 9 data bytes to master.	Note 2
Write Scratchpad	4EH	Writes 3 bytes data into scratchpad bytes 6, bytes 7, and bytes dummy (0).	Master transmits 3 data bytes to sensor.	Note 3
Copy Scratchpad	48H	Copy Scratchpad	Copies CONFIG0, CONFIG1 register data from the scratchpad to EEPROM.	Note 1
Recall E2	B8H	Recalls CONFIG0, CONFIG1 register data from EEPROM to the scratchpad.	Sensor transmits recall status to master.	N/A
Read Power Supply	B4H	Signals sensor power supply mode to the master.	Sensor transmits supply status to master.	N/A
EXTENSION COMMANDS				
Write ROM Code	0FH	Master device write new ROM CODE to sensor.	Master device read 2 bytes writing status data.	N/A

Note 1: Sensor will pull the DQ line low to indicate the operation in process and release the DQ line when operation done.

Note 2: All nine bytes must be written before a reset is issued.

Note 3: All three bytes must be written before a reset is issued.

6.4 Sensor Operation Example

■ Conversion and Read Scratchpad

In this example there are multiple sensors on the bus. The bus master initiates a conversion in a specific sensor and then reads its scratchpad and recalculates the CRC to verify the data.

MASTER MODE	DATA(LSB FIRST)	COMMENTS
Tx	Reset	Master issues reset pulse.
Rx	Presence	Sensor respond with presence pulse.
Tx	55h	Master issues Match ROM command.
Tx	64-bit ROM code	Master sends ROM code.
Tx	44h	Master issues Convert T command.
WAIT	N/A	Wait tCONV for conversion done. Or read DQ line state when sensor power mode is “EXTERNAL”
Tx	Reset	Master issues reset pulse.
Rx	Presence	Sensor respond with presence pulse.
Tx	55h	Master issues Match ROM command.
Tx	64-bit ROM code	Master sends sensor ROM code.
Tx	BEh	Master issues Read Scratchpad command.
Rx	9 data bytes	Master **SHOULD** reads **ENTIRE** scratchpad including CRC. The master then recalculates the CRC of the first eight data bytes from the scratchpad and compares the calculated CRC with the read CRC (byte 9). If they match, the master

		continues; if not, the read operation is repeated.

In this example there is only one sensor on the bus. The bus master initiates a conversion in a specific sensor and then reads its scratchpad and recalculates the CRC to verify the data.

MASTER MODE	DATA(LSB FIRST)	COMMENTS
Tx	Reset	Master issues reset pulse.
Rx	Presence	Sensor respond with presence pulse.
Tx	CCh	Master issues Skip ROM command.
Tx	44h	Master issues Convert T command.
WAIT	N/A	Wait tCONV for conversion done. Or read DQ line state when sensor power mode is “EXTERNAL”
Tx	Reset	Master issues reset pulse.
Rx	Presence	Sensor respond with presence pulse.
Tx	CCh	Master issues Skip ROM command.
Tx	BEh	Master issues Read Scratchpad command.
Rx	9 data bytes	Master **SHOULD** reads **ENTIRE** scratchpad including CRC. The master then recalculates the CRC of the first eight data bytes from the scratchpad and compares the calculated CRC with the read CRC (byte 9).

■ Write Rom Code

In this example there is only one sensor on the bus. The bus master initiates a WRITE ROMCODE extension function command and then reads the result from sensor to verify the operation, then master issue the SEND ROM command to get rom code from sensor.

MASTER MODE	DATA(LSB FIRST)	COMMENTS
Tx	Reset	Master issues reset pulse.
Rx	Presence	Sensor respond with presence pulse.
Tx	CCh	Master issues Skip ROM command.
Tx	0Fh	Master issues WRITE ROM extension function command.
Tx	2 flag data bytes : F0h, 00h	Master sends function command parameters.
Tx	8 data bytes ROM codes: LSB FIRST. e.g. 28h,00h,14h,08h,12h,00h,00h,64h	Master sends rom codes.
WAIT	N/A	Wait about 20ms for sensor’s operation.
Rx	2 data bytes operation result.	Success value: 00h,03h Fail value: 00h,C0h
Tx	Reset	Master issues reset pulse.
Rx	Presence	Sensor respond with presence pulse.
Tx	33h	Master issues READ ROM command.
Rx	8 data bytes	Sensor sends 8 bytes ROM CODE.

■ Write Scratchpad

In this example there is only one sensor on the bus. The bus master initiates a WRITE SCRATCHPAD command.

MASTER MODE	DATA(LSB FIRST)	COMMENTS
Tx	Reset	Master issues reset pulse.
Rx	Presence	Sensor respond with presence pulse.
Tx	CCh	Master issues Skip ROM command.
Tx	4Eh	Master issues WRITE SCRATCHPAD function command.
Tx	3 data bytes including CONFIG0,CONFIG1, and a DUMMY BYTE.	Master sends data. Including a dummy byte(00h) to sensor.

6.5 Signaling and Timing of 1-Wire bus

The sensor uses 1-Wire communication protocol with several exceptions listed below in BLACK BOLD FONT. Several signal types are defined by this protocol: reset pulse, presence pulse, write 0, write 1, read 0, and read 1. The bus master initiates all these signals, with the exception of the presence pulse.

■ Initialization Procedure—Reset And Presence Pulses

All communication with the sensor begins with an initialization sequence that consists of a reset pulse from the master followed by a presence pulse from the sensor. When the sensor sends the presence pulse in response to the reset, it is indicating to the master that it is on the bus and ready to operate.

The signaling and timing of reset and presence are the same with standard 1-Wire protocol, Please refer to details in 1-Wire document.

■ Write Time Slots

There are two types of write time slots: “Write 1” time slots and “Write 0” time slots. The signaling and timing of reset and presence are the same with standard 1-Wire protocol. Please refer to details in 1-Wire document.

Exception:

Regarding to DS18B20, All write time slots must be a minimum of 60μs in duration with a minimum of a 1μs recovery time between individual write slots.

Regarding to sensor MT05S, All write time slots must be a minimum of 60μs in duration with a recovery time from 1us to 500ms between individual write slots. That means in each recovery state, sensor starts a 500ms timeout detection to detect next write slot, if there’s no activity on bus in 500ms, the sensor will discard the current operation and return to the standby status, to wait another 1-Wire transaction issued by master device.

■ Read Time Slots

The sensor can only transmit data to the master when the master issues read time slots. So the master must generate read time slots immediately after issuing a Read Scratchpad [BEh] or Read

Power Supply [B4h] command, so that the DS18B20 can provide the requested data. In addition, the master can generate read time slots after issuing Convert T [44h] or Recall E2 [B8h] commands to find out the status of the operation as explained in the FUNCTION Commands section.

The signaling and timing of reset and presence are the same with standard 1-Wire protocol. Please refer to details in 1-Wire document.

Exception:

Regarding to DS18B20, All read time slots must be a minimum of 60μs in duration with a minimum of a 1μs recovery time between slots.

Regarding to sensor MT05S, All read time slots must be a minimum of 60μs in duration with a recovery time from 1us to 500ms between individual read slots. That means in each recovery state, sensor starts a 500ms timeout detection to detect next read slot, if there's no activity on bus in 500ms, the sensor will discard the current operation and return to the standby status, to wait another 1-Wire transaction issued by master device.

■ Other Exception in Signaling and Timing

Exception:

After a specific ROM command (Read Rom [33h], Match Rom [55H], Skip Rom [CCh]) is issued by master device, the sensor starts waiting for a FUNCTION command in 500ms timeout checking period. The sensor will discard RESET signal issued by master device in this period, and return to the standby status if timeout, to wait another 1-Wire transaction issued by master device.

7 FAQ and Trouble Shooting

Question: I can not communicate with sensor when I extend additional cable length. **Answer:** When the cable length is long, the parasitic capacitance (load capacitance) of cable must be considered. Larger parasitic capacitance leads to bad signal wave. In this case, please use lower pull-up resistor (e.g. from 4.7K to 2.0K) to improve the signal quality.
Question: I can communicate with one sensor but can't when I use multiple sensors on the same 1-wire bus. **Answer:** When there are multiple sensors on the same bus, the parasitic capacitance (load capacitance) of cable must be considered. Larger parasitic capacitance leads to bad signal wave. In this case, please use lower pull-up resistor (e.g. from 4.7K to 2.0K) to improve the signal quality.
Question: Can I set ROM code to desired value. **Answer:** Yes, ROM code can be changed by function code, please refer to related chapter in user manual.
Question: Can I use this sensor with DS18B20 on the same 1-wire bus. **Answer:** Yes, In this case load capacitance should be considered to guarantee the signal quality.
Question: What is the main difference between sensors with/without EC measurement? **Answer:** The only difference is the EC value register is always 65535(0xFFFF) for sensor without EC measurement.
Question: How can I tell MT05S-A and MT05S-B, besides the appearance? **Answer:** **(1)** For MT05S-A, EC value will be 0-23000; For MT05S-B, EC value will always be 65535(0xFFFF). **(2)** You can set special ROMCODE for different sensor to identify the sensor type. **(3)** You can set CONFIG1 register in ScratchPad for different sensor to identify the sensor type.
Question: How can I lower the power consumption? **Answer:** The average standby current consumption is 30uA Max.; You can also use a power switch (e.g. PMOS) to switch off the power to achieve zero current consumption, and please consider the signal line handle in this case.

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