

YOSEMITECH

Conductivity Probe

MODBUS RTU Programmer Manuel

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Yosemitech

1 MODBUS RTU Overview

1.1 Scope

This document is about MODBUS of Conductivity probes with hardware Rev1.0 and software **Rev1.8** or later. This document is intended for software programmers with detailed information about MODBUS RTU protocols.

1.2 MODBUS Command Structure

Data format in this document:

- Binary number – shown with suffix B. For example: 10001B
- Decimal number – without nay suffix. For example: 256
- Hexadecimal number—shown with prefix 0x. For example: 0x2A
- ASCII character or string – shown with quotation marks. For example:” YL0914010022”

1.2.1 Command Structure

MODBUS defines a simple protocol data unit (PDU), which is transparent to communication layer.

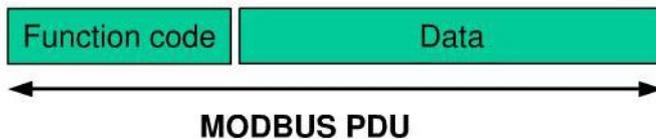


Figure 1: MODBUS Protocol Data Unit

The mapping of MODBUS protocol on a specific bus or network introduces some additional fields on the Protocol Data Unit. The client that initiates a MODBUS transaction builds the MODBUS PDU, and then adds fields in order to build the appropriate communication PDU.

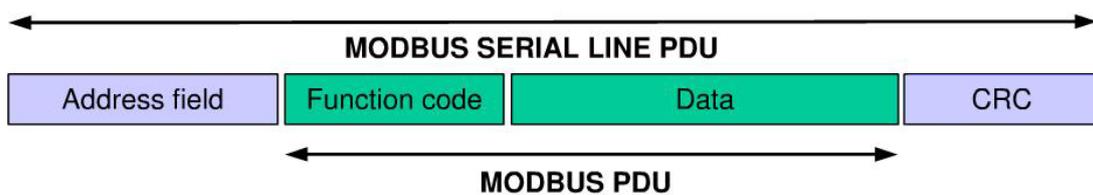


Figure 2: MODBUS Structure for Serial Communication

On a MODBUS serial bus, address field only includes addresses for slave devices.

Note:

- Slave address range for Conductivity sensor is: 1...247
- Master device sends a “request frame” with a targeted slave address. When slave device responses, it has to put its own address in the “response frame”, so that master device knows where the response comes from.
- Function code indicates type of operations
- CRC is the result of redundancy check.

1.2.2 MODBUS RTU Transmission Mode

When devices communicate on a MODBUS using RTU (remote terminal unit) mode, each 8-bit message contains two 4-bit hexadecimal characters. The main advantage of the RTU mode is that it has higher character density, which enables better throughput compare to ASCII mode at same baud rate. Each RTU message must be transmitted in a continuous string of characters.

RTU mode format for each byte (11 bits):

Encoding system 8 bit binary
 Each 8-bit packet contains 4-bit hexadecimal characters (0-9, A-F)

Bit per byte: 1 start bit
 8 data bits, least significant bit first
 No parity check
 1 stop bits

Baud rate: 9600bps

Serial transmission of characters:

Every character or byte is sent under this sequence (left to right):

Least Significant Bit (LSB).....Most Significant Bit(MSB)



Figure 3: RTU Mode Bit Sequence

CRC Field Structure:

Redundancy check (CRC16)

Frame Structure:

| Slave address | Function Code | Data | CRC | |
|---------------|---------------|---------------|---------|----------|
| 1 byte | 1 byte | 0...252 bytes | 2 bytes | |
| | | | CRC Low | CRC High |

Figure 4: RTU Message Frame Structure

Maximum size of MODBUS frame is 256 bytes.

1.2.3 MODBUS RTU Message Frame

In RTU mode, message frames need to be separated by an idle interval of at least 3.5 character lengths. In rest of this document, this idle interval is called t3.5.

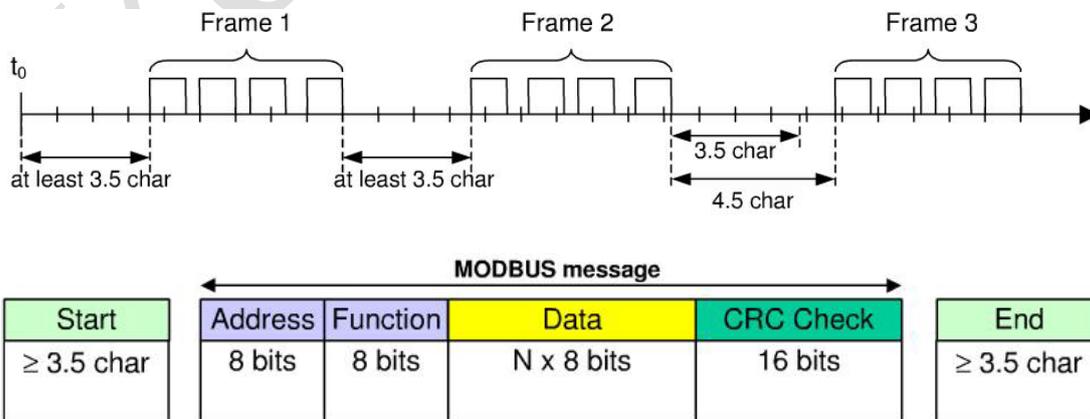


Figure 5: RTU Message Frame

Entire message frame must be sent as continuous stream of characters.

If idle time between two characters is longer than 1.5 characters, the message frame will be

considered incomplete, and will be discarded by receiving side.

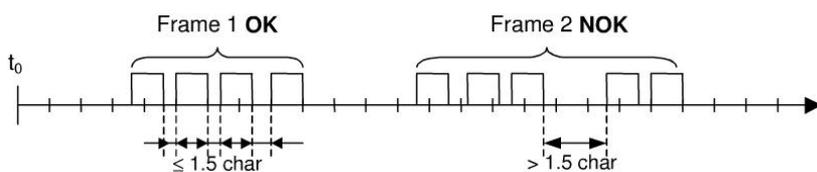


Figure 6: Frame transmission

1.2.4 MODBUS RTU CRC Check

In RTU mode, the error checking field is based on a cyclical redundant checking (CRC) method. The CRC field checks entire content of MODBUS message, regardless of the existence of parity check bit. CRC16 checking method is utilized. CRC result is a 16-bit value with two 8-bit bytes, low order 8-bit byte first followed by high order 8-bit byte.

1.3 MODBUS RTU for YOSEMITECH's Conductivity Sensor

Based on standard MODBUS definition, message frame starts with t3.5 idle interval, and similarly, ends with t3.5 idle interval. Device address and Function code are both 8-bit byte. Data character string has $n \times 8$ bits, it contains information about register start/end address and number of registers for read/write operation. CRC field is 16 bit in length.

| | Start | Device address | Function code | Data | CRC | | End |
|---------------|-------------------------------|----------------|---|--------------------------------|---------|----------|-------------------------------|
| Value | Idle for 3.5 character length | 1-247 | Comply with MODBUS function code format | Comply with MODBUS data format | CRC Low | CRC High | Idle for 3.5 character length |
| Length (byte) | 3.5 | 1 | 1 | n | 1 | 1 | 3.5 |

Figure 7: Message frame structure for Yosemitech's MODBUS

1.4 MODBUS RTU Function Code for YOSEMITECH's Conductivity Sensor

YOSEMITECH's Conductivity sensor has two MODBUS function codes:

0x03: Read registers 0x10: Write registers

1.4.1 MODBUS Function Code 0x03: Read Registers

This function code is to read a block of continuous registers from a remote device. Request PDU defines start address and number of registers for the read operation. Register addressing starts from 0. Therefore, addresses for register 1-16 are 0-15. Data for each register in Response message have two bytes. For each register data, first byte is for high bits, and second byte for low bits.

Request Frame:

| | | |
|---------------------|---------|-----------------|
| Function code | 1 Byte | 0x03 |
| Start address | 2 Bytes | 0x0000...0xffff |
| Number of registers | 2 Bytes | 1...125 |

Figure 8: Request frame for read registers

Response Frame:

| | | |
|----------------|--------------------|--------------|
| Function code | 1 byte | 0x03 |
| Number of byte | 1 byte | $N \times 2$ |
| Register data | $N \times 2$ bytes | |

N = number of registers

Figure 9: Response frame for read registers

Below is an example of Request and Response frames (Read register 108-110. Register 108 is read only with 2-byte value of 0X022B. Registers 109-110 have values of 0X0000 and 0X0064).

| Request Frame | | Response Frame | |
|---------------------------------|-------------|---------------------------------|-------------|
| Data format | Hexadecimal | Data Format | Hexadecimal |
| Function code | 0x03 | Function code | 0x03 |
| Start address(high bits) | 0x00 | Number of bytes | 0x06 |
| Start address (low bits) | 0x6B | Register value (high bits, 108) | 0x02 |
| Number of registers (high bits) | 0x00 | Register value (low bits, 108) | 0x2B |
| Number of registers (low bits) | 0x03 | Register value (high bits, 109) | 0x00 |
| | | Register value (low bits, 109) | 0x00 |
| | | Register value (high bits, 110) | 0x00 |
| | | Register value (low bits, 110) | 0x64 |

Figure 10: Example of request frame and response frame for read operation

1.4.2 MODBUS Function Code 0x10: Write Registers

This function code is to write a block of continuous registers at a remote device. Request frame contains register data. Each register data have two character bytes. Response frame contains function code, start address, and number of registers that completed write operation.

Request Frame:

| | | |
|---------------------|--------------------|-----------------|
| Function code | 1 byte | 0x10 |
| Start address | 2 bytes | 0x0000...0xffff |
| Number of registers | 2 bytes | 0x0001...0x0078 |
| Number of bytes | 1 byte | $N \times 2$ |
| Register data | $N \times 2$ bytes | value |

N = number of registers

Figure 11: Request frame for write operation

Response Frame:

| | | |
|---------------------|---------|-----------------|
| Function Code | 1 byte | 0x10 |
| Start address | 2 bytes | 0x0000...0xffff |
| Number of registers | 2 bytes | 1...123(0x7B) |

Figure 12: Response frame for write operation

Below is an example of Request frame and Response frame (write 0x000A and 0x0102 to two registers starting from address 2):

| Request Frame | | Response Frame | |
|---------------------------------|-------------|---------------------------------|-------------|
| Data Format | Hexadecimal | Data Format | Hexadecimal |
| Function code | 0x10 | Function code | 0x10 |
| Start address (high bits) | 0x00 | Start address (high bits) | 0x00 |
| Start address (low bits) | 0x01 | Start address (low bits) | 0x01 |
| Number of registers (high bits) | 0x00 | Number of registers (high bits) | 0x00 |
| Number of registers (low bits) | 0x02 | Number of registers (low bits) | 0x02 |
| Number of bytes | 0x04 | | |
| Register value (high bits) | 0x00 | | |
| Register value (low bits) | 0x0A | | |
| Register value (high bits) | 0x01 | | |
| Register value (low bits) | 0x02 | | |

Figure 13: Example of Request frame and response frame for write operation

1.5 Data formats in Conductivity sensor

1.5.1 Floating-point number

Definition: floating point number, comply with IEEE754 (single precision)

| Note | Sign | Exponent | Fraction | Total |
|--------------------|------|----------|----------|-------|
| bit | 31 | 30...23 | 22...0 | 32 |
| Exponent deviation | 127 | | | |

Figure 14: Single floating point number definition (4 bytes, 2 MODBUS registers)

Example: Convert decimal number 17.625 to binary number

Step 1: Convert decimal number 17.625 to a floating point number with binary format

First, convert integer to binary

$$17_{\text{decimal}} = 16 + 1 = 1 \times 2^4 + 0 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$

Thus, integer 17 in binary format is 10001B

Then convert decimal part to binary

$$0.625_{\text{decimal}} = 0.5 + 0.125 = 1 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3}$$

Thus, 0.625 in binary format is 0.101B

Combine above together, 17.625 in binary format is 10001.010B

Step 2: Calculate exponent

Left shift the binary number 10001.010B until only bit left before the decimal point ---

10001.010B = 1.0001101 B $\times 2^4$, so exponent value is 4. By adding 127, we have 131, which is 10000011B in binary format

Step 3: Get fraction

Fraction is simply the number after decimal point. Thus from 1.0001101B, fraction number is 0001101B. IMPORTANT NOTE about the 23 bit fraction number: the first bit which on the left side of decimal point is hidden bit and does not need to be compiled.

Step 4: Sign definition

Sign bit is 0 if the number is positive. Sign is 1 if the number is negative. For 17.625, sign bit is 0.

Step 5: Convert to floating point number

| | | | | |
|------------|---|----------------|---|--------------------------|
| 1 Sign bit | + | 8-bit exponent | + | 23-bit fraction |
| 0 | | 1000011 | | 00011010000000000000000B |

(Corresponding hexadecimal number is 0x418D0000)

Sample code:

1. If your compiler has similar library functions, it can be called directly. For example if C language is used, we can directly call memcpy() function in C library to convert floating point number. Sample code:

```
float   floatdata;//floating point data to be converted
void*   outdata;
memcpy(outdata,&floatdata,4);
```

If floatdata=17.625,

In little-endian storage mode after the function is called:

Value at address of outdata is 0x00
 Value at address of (outdata+1) is 0x00
 Value at address of (outdata+2) is 0x8D
 Value at address of (outdata+3) is 0x41

In big-endian storage mode after the function is called:

Value at address of outdata is 0x41
 Value at address of (outdata+1) is 0x8D
 Value at address of (outdata+2) is 0x00
 Value at address of (outdata+3) is 0x00

2. If your compiler doesn't have the conversion function, then the following function can be used:

```
void memcpy(void *dest,void *src,int n)
{
    char *pd = (char *)dest;
    char *ps = (char *)src;
    for(int i=0;i<n;i++) *pd++ = *ps++;
}
```

Then you can get same result by calling this function memcpy(outdata,&floatdata,4);

Example: Convert binary floating point number 0100 0010 0111 1011 0110 0110 0110 0110B to a decimal number

Step 1: Separate this binary number 0100 0010 0111 1011 0110 0110 0110 0110B and get values of Sign , exponent and fraction.

| | | |
|------------|----------------|--------------------------|
| 0 | 10000100 | 11110110110011001100110B |
| 1 Sign bit | 8-bit exponent | 23-bit fraction |

Sign bit(s): 0

Exponent(E): $10000100B = 1 \times 2^7 + 0 \times 2^6 + 0 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0$
 $= 128 + 0 + 0 + 0 + 0 + 4 + 0 + 0 = 132$

Fraction(M): 11110110110011001100110B =8087142

Step 2: Calculate decimal value

$$\begin{aligned}
 D &= (-1)^S \times (1.0 + M/2^{23}) \times 2^{E-127} \\
 &= (-1)^0 \times (1.0 + 8087142/2^{23}) \times 2^{132-127} \\
 &= 1 \times 1.964062452316284 \times 32 \\
 &= 62.85
 \end{aligned}$$

Reference code:

```
float floatTOdecimal(long int byte0, long int byte1, long int byte2, long int byte3)
```

```
{
    long int realbyte0,realbyte1,realbyte2,realbyte3;
    char S;
    long int    E,M;
    float D;
    realbyte0 = byte3;
    realbyte1 = byte2;
    realbyte2 = byte1;
    realbyte3 = byte0;

    if((realbyte0&0x80)==0)
    {
        S = 0; //Positive
    }
    else
    {
        S = 1; //Negative
    }
    E = ((realbyte0<<1)|(realbyte1&0x80)>>7)-127;
    M = ((realbyte1&0x7f) << 16) | (realbyte2<< 8) | realbyte3;
    D = pow(-1,S)*(1.0 + M/pow(2,23))* pow(2,E);
    return D;
}
```

Note:

- Function parameters byte0, byte1, byte2 and byte3 represent the 4 sections of a binary floating number.
- Return value is value of decimal number after conversion

For example when a command is sent to a sensor to get temperature value, response frame from the sensor will have measured temperature. If the values are 4 byte floating point number 0x00,0x00,0x8d,0x41, then the following function can be used to get temperature in decimal value:

```
float temperature = floatTOdecimal( 0x00, 0x00, 0x8d, 0x41);
and temperature = 17.625.
```

1.5.2 Characters

Definition: Character is shown by ASCII code.

Example: String “YL” could be shown by corresponding ASCII codes (refer to ASCII character chart)

“Y” is 0x59

“L” is 0x4C

2 MODBUS RTU Commands for Conductivity Sensor

2.1 Overview

In order to communicate with Conductivity probe via MODBUS RTU, master terminal software will be needed. MODBUS RTU is an open standard. There are free commercial software tools available. For applications described in this document, MODBUS register address starts from 1. However, slave address in MODBUS protocol starts from 0, and usually master software compiles addresses. For example, register address 2090 will be compiled by master software as address 2089.

2.2 Command Description

2.2.1 Set Slave Device ID

Purpose: Set MODBUS slave address to a sensor probe. Range of address is 1~247.

Sensor probe slave address can be set via MODBUS register 0x3000:

| Start address | Number of registers | Register 1 | MODBUS Function code |
|---------------|---------------------|-------------------|----------------------|
| 0x3000 | 0x01 | New Slave address | 0x10 |

Figure 15: Register definition for Set Slave ID Command

Below is an example of request and response frames for setting slave device ID command. Old slave address is 0x01, new address is 0x14.

| Definition | Address | Function code | Start address | | Number of registers | | Number of byte | | Register value | | CRC | |
|------------|---------|---------------|---------------|------|---------------------|------|----------------|------|----------------|------|------|--|
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| Value | 0x01 | 0x10 | 0x30 | 0x00 | 0x00 | 0x01 | 0x02 | 0x14 | 0x00 | 0x99 | 0x53 | |

Figure 16: Request frame to Set Slave ID Command

*Note: byte 8 is reserved

| Definition | Address | Function code | Start address | | Number of registers | | CRC | |
|------------|---------|---------------|---------------|------|---------------------|------|------|------|
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Value | 0x01 | 0x10 | 0x30 | 0x00 | 0x00 | 0x01 | 0x0E | 0xC9 |

Figure 17: response frame for Set Slave ID Command

2.2.2 Get SN

Purpose: Get sensor probe's serial number (SN). Each sensor probe has a unique SN.

Serial Number can be read from 7 continuous MODBUS registers starting from address 0x0900.

| Start Address | Number of registers | Register 1-7 | MODBUS Function code |
|---------------|---------------------|--------------|----------------------|
| 0x0900 | 0x07 | SN | 0x03 |

Figure 18: Register definition for Get SN Command

Below is an example of request and response frames to get SN "YL0914010022" from a slave device (address 0x01).

| Definition | Address | Function code | Starting address | | Number of registers | | CRC | |
|------------|---------|---------------|------------------|------|---------------------|------|------|------|
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Value | 0x01 | 0x03 | 0x09 | 0x00 | 0x00 | 0x07 | 0x07 | 0x94 |

Figure 19: Request frame to Get SN Command

| Definition | Address | Function code | Number of byte | Register value | | | CRC | |
|------------|---------|---------------|----------------|----------------|----------------|------|------|------|
| Byte | 0 | 1 | 2 | 3 | 4-15 | 16 | 17 | 18 |
| Value | 0x01 | 0x03 | 0x0E | 0x00 | "YL0914010022" | 0x00 | 0x98 | 0x8c |

Figure 20: Response frame for Get SN Command

Note: SN value is in ASCII code as below:

| Byte | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|
| Value | 0x59 | 0x4C | 0x30 | 0x39 | 0x31 | 0x34 | 0x30 | 0x31 | 0x30 | 0x30 | 0x32 | 0x32 |

Figure 21: Sensor probe's SN

2.2.3 Start Measurement

Purpose: Set probe start measuring Conductivity. The Probe starts in auto-measure mode by default.

MODBUS register 0x1C00 is used.

| Starting address | Number of registers | MODBUS Function code |
|------------------|---------------------|----------------------|
| 0x1C00 | 0x00 | 0x10 |

Figure 22: Register definition of Start Measurement Command

Below is an example of request and response frames for sending a Start Measurement command to a device with slave address 0x01.

| Definition | Device address | Function code | Start address | | Number of registers | | Number of bytes | CRC | |
|------------|----------------|---------------|---------------|------|---------------------|------|-----------------|------|------|
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Value | 0x01 | 0x10 | 0x1C | 0x00 | 0x00 | 0x00 | 0x00 | 0xd8 | 0x92 |

Figure 23: Request frame to Start Measurement Command

| Definition | Device address | Function code | Start address | | Number of registers | | CRC | |
|------------|----------------|---------------|---------------|------|---------------------|------|------|------|
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Value | 0x01 | 0x10 | 0x1C | 0x00 | 0x00 | 0x00 | 0xc7 | 0x99 |

Figure 24: Response frame for Start Measurement Command

2.2.4 Get Temperature and Conductivity values

Purpose: Get temperature and Conductivity measurement results. Temperature unit is Celsius degree (°C), Conductivity unit is millisiemens (mS/cm). User calibration process is automatically applied to Conductivity value.

Temperature and Conductivity data can be read from 5 continuous MODBUS registers starting from address 0x2600 .(It also includes an error flag for indicating whether range switching is correct : 0—correct;0xFF—error)

| Start address | Number of registers | Register 1-2 | Register 3-4 | Register 5 | MODBUS function code |
|---------------|---------------------|--------------|--------------------|------------|----------------------|
| 0x2600 | 0x05 | Temperature | Conductivity value | Error flag | 0x03 |

Figure 25: Register definition for Get Temperature and Conductivity Command

Below is an example of request and response frames for getting temperature and Conductivity command, assuming slave device address is 0x01, returned temperature is 17.625°C , Conductivity value is 17.625 mS/cm and the error flag is 0.

| Definition | Device address | Function code | Start address | | Number of registers | | CRC | |
|------------|----------------|---------------|---------------|------|---------------------|------|------|------|
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Value | 0x01 | 0x03 | 0x26 | 0x00 | 0x00 | 0x05 | 0x8E | 0x81 |

Figure 26: Request frame to Get Temperature and Conductivity Command

| Definition | Device address | Function code | Number of bytes | Register value | | | | CRC | |
|------------|----------------|---------------|-----------------|----------------|--------|------|------|------|------|
| Byte | 0 | 1 | 2 | 3-6 | 7-10 | 11 | 12 | 13 | 14 |
| Value | 0x01 | 0x03 | 0x0A | 17.625 | 17.625 | 0x00 | 0x00 | 0xC7 | 0x33 |

Figure 27: Response frame for Get Temperature and Conductivity Command

Note: Temperature and Conductivity values are floating point number in little-endian storage mode. See sample below:

| Temperature(3-6) | | | | Conductivity(7-10) | | | | Error flag(11) | Reserved (12) |
|------------------|------|------|------|--------------------|------|------|------|----------------|---------------|
| 0x00 | 0x00 | 0x8D | 0x41 | 0x00 | 0x00 | 0x8D | 0x41 | 0x00 | 0x00 |

Figure 28: Registers definition for temperature and Conductivity values.

2.2.5 Get Software and Hardware Rev

Purpose: Get current hardware and software Release Version.

Hardware and software release version numbers of a sensor probe can be read from 2 continuous registers starting from address 0x0700.

| Start address | Number registers | Register 1 | Register 2 | MODBUS function code |
|---------------|------------------|------------|------------|----------------------|
| 0x0700 | 0x02 | HW Rev | SW Rev | 0x03 |

Figure 29: Register definitions of Get Software and Hardware Rev Command

Below is an example of request and response frames for getting hardware and software release version, assuming device slave address is 0x01, returned value for hardware Rev is 1.0 and software Rev is 1.0.

| Definition | Device address | Function code | Start address | | Number of registers | | CRC | |
|------------|----------------|---------------|---------------|------|---------------------|------|------|------|
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Value | 0x01 | 0x03 | 0x07 | 0x00 | 0x00 | 0x02 | 0xc5 | 0x7f |

Figure 30: Request frame to Get Hardware and Software Rev Command

| Definition | Device address | Function code | Number of bytes | Register value | | | | CRC | |
|------------|----------------|---------------|-----------------|----------------|------|------|------|------|------|
| Byte | 0 | 1 | 2 | 3-4 | | 5-6 | | 7 | 8 |
| Value | 0x01 | 0x03 | 0x04 | 0x01 | 0x00 | 0x01 | 0x00 | 0xfa | 0x5f |

Figure 31: Response frame for Get Hardware and Software Rev Command

2.2.6 Stop Measurement

Purpose: After stable test result is obtained, stop measurement activities. If measurement need to start again , use command **Start Measurement**.

MODBUS register 0x2E00 is used for this command.

| Start address | Number of registers | MODBUS function code |
|---------------|---------------------|----------------------|
| 0x2E00 | 0x01 | 0x03 |

Figure 32: Register definition for Stop measurement command

Below is an example of request and response frames for a device with slave address 0x01 to stop measurement activities.

| Definition | Device address | Function code | Start address | | Number of registers | | CRC | |
|------------|----------------|---------------|---------------|------|---------------------|------|------|------|
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Value | 0x01 | 0x03 | 0x2E | 0x00 | 0x00 | 0x01 | 0x8D | 0x22 |

Figure 33: Request frame of stop measurement command

| Definition | Device address | Function code | Number of bytes | Register value | CRC | |
|------------|----------------|---------------|-----------------|----------------|-----|---|
| Byte | 0 | 1 | 2 | 3~4 | 5 | 6 |
| Value | 0x01 | 0x03 | 0x00 | meaningless | | |

Figure 34: Response frame of stop measurement command

2.2.7 Get User Calibration Coefficients

Purpose: Get two calibration coefficients K and B. (This is to eliminate measurement errors caused by aging or other reasons. User calibration equation is: $Cond_{final}=K*Cond +B$; default values are: K=1; B=0)

User calibration coefficients (K and B) can be read from 4 continuous MODBUS registers starting from address 0x1100.

| Start address | Number of registers | Register 1-2 | Register 3-4 | MODBUS function code |
|---------------|---------------------|--------------|--------------|----------------------|
| 0x1100 | 0x04 | K | B | 0x03 |

Figure 35: Register definition of Get User Calibration Coefficients Command

Below is an example of request and response frames for getting customer calibration coefficients from a device with slave address 0x01, assuming returned values are: K=1.0; B=0.0.

| Definition | Device address | Function code | Start address | | Number of registers | | CRC | |
|------------|----------------|---------------|---------------|------|---------------------|------|------|------|
| | | | 2 | 3 | 4 | 5 | 6 | 7 |
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Value | 0x01 | 0x03 | 0x11 | 0x00 | 0x00 | 0x04 | 0x41 | 0x35 |

Figure 36: Request frame to Get Customer Calibration Coefficient Command

| Definition | Device address | Function code | Number of bytes | Register value | | CRC | |
|------------|----------------|---------------|-----------------|----------------|------|------|------|
| | | | | 3-6 | 7-10 | 11 | 12 |
| Byte | 0 | 1 | 2 | 3-6 | 7-10 | 11 | 12 |
| Value | 0x01 | 0x03 | 0x08 | 1.0 | 0.0 | 0x9E | 0x12 |

Figure 37: Response frame for Get Customer Calibration Coefficient Command

Note: K and B are floating point numbers in little-endian storage mode

| K(3-6) | | | | B(7-10) | | | |
|--------|------|------|------|---------|------|------|------|
| 0x00 | 0x00 | 0x80 | 0x3F | 0x00 | 0x00 | 0x00 | 0x00 |

Figure 38: Registers for two coefficients K and B.

2.2.8 Set Customer Calibration Coefficients

Purpose: Set two calibration coefficients K and B.

Customer coefficients (K and B) can be set at 4 continuous MODBUS registers starting from address 0x1100.

| Start address | Number of registers | Register 1-2 | Register 3-4 | MODBUS function code |
|---------------|---------------------|--------------|--------------|----------------------|
| 0x1100 | 0x04 | K | B | 0x10 |

Figure 39: Register definition for Set Customer Calibration Command

Below is an example of request and response frames for setting customer calibration coefficients, assuming slave address is 0x01, coefficients are K=1.0 and B=0.0.

| Definition | Device address | Function code | Start address | | Number of registers | | Number of bytes | Register value | | CRC | |
|------------|----------------|---------------|---------------|------|---------------------|------|-----------------|----------------|-------|-------|------|
| | | | 2 | 3 | 4 | 5 | | 6 | 7-10 | 11-14 | 15 |
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7-10 | 11-14 | 15 | 16 |
| Value | 0x01 | 0x10 | 0x11 | 0x00 | 0x00 | 0x04 | 0x08 | 1.0 | 0.0 | 0x81 | 0xAE |

Figure 40: Request frame to Set Customer Calibration Coefficient Command

Note: Coefficients K and B, floating point numbers in little-endian storage mode

| K(7-10) | | | | B(11-14) | | | |
|---------|------|------|------|----------|------|------|------|
| 0x00 | 0x00 | 0x80 | 0x3F | 0x00 | 0x00 | 0x00 | 0x00 |

Figure 41: Registers for two coefficients K and B.

| Definition | Device address | Function code | Start address | | Number of registers | | CRC | |
|------------|----------------|---------------|---------------|------|---------------------|------|------|------|
| | | | 2 | 3 | 4 | 5 | 6 | 7 |
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Value | 0x01 | 0x10 | 0x11 | 0x00 | 0x00 | 0x04 | 0xc4 | 0xf6 |

Figure 42: Response frame for Set Customer Calibration Coefficient Command

2.2.9 Get Slave Device ID

Purpose: Get current MODBUS slave address to a sensor probe. Use 0xFF as fixed Device address.

Sensor probe slave address can be read from MODBUS registers 0x3000.

| Start address | Number of registers | Register 1 | MODBUS Function code |
|---------------|---------------------|-----------------------|----------------------|
| 0x3000 | 0x01 | Current Slave address | 0x10 |

Figure 43: Get slave ID command

Below is an example of request and response frames for getting slave device id, assuming returned address is 0x03.

| Definition | Device address | Function code | Start address | | Number of registers | | CRC | |
|------------|----------------|---------------|---------------|------|---------------------|------|------|------|
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Value | 0xFF | 0x03 | 0x30 | 0x00 | 0x00 | 0x01 | 0x9E | 0xD4 |

Figure 44: Request frame of get slave device ID comment

| Definition | Device address | Function code | Number of bytes | Register value | | CRC | |
|------------|----------------|---------------|-----------------|----------------|---------------|------|------|
| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| Value | 0xFF | 0x03 | 0x02 | 0x03 | 0x00(reserve) | 0x91 | 0x60 |

Figure 45: Response frame of get slave device ID comment

3 Procedure to get Conductivity value

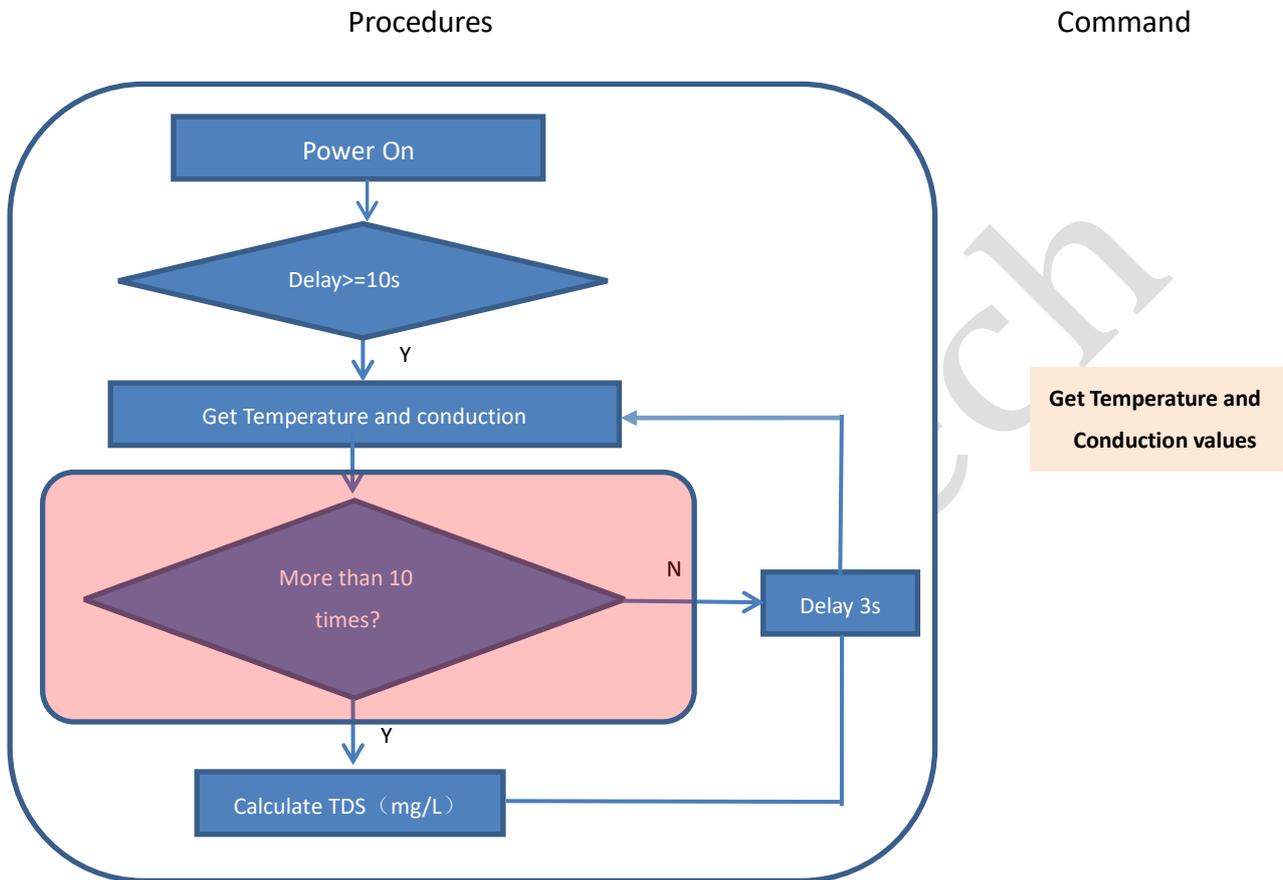


Figure 40: Flow chart to get Conductivity measurement

- **Get Temperature and Conductivity values** – Get measurement results including temperature (°C) and Conductivity (mS/cm) after 10 seconds of measurements.

Note: Please pay attention to highlighted portion (red) in the flow chart above. It's highly recommended that customers get an average Conductivity results after 10 consecutive measurements, then convert the average Conductivity value in mS/cm unit(Cond) to a TDS value in mg/L unit.

- **Calculate TDS (mg/L)**, converting the average Conductivity value in mS/cm unit to a TDS value in mg/L unit:

According to the formula: $TDS(mg/L) = Cond(uS/cm) * 0.64$;

$Cond(uS/cm) = Cond(mS/cm) * 1000$.

- Then get Temperature and Conductivity values every 3 seconds.