# Communication Protocol of WQ7C Bus Tie Controller


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# Foreword

Version updates

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# Contents

# 1. Introductiono

This communication protocol describes in detail the formats of reading and writing commands of the serial port communication of the native machine and the definition of internal information data, so that the third party can develop and use it.

The MODBUS communication protocol allows this device to communicate effectively with information and data among programmable sequential devices (PLCs), RTU, SCADA systems, DCS, or third parties with MODBUS-compatible monitoring systems of Schneider, Siemens, Modicon, and other internationally renowned brands. As long as a set of PC-based (or Industrial-Personal-Computer-based) master control display software of central communication(such as: Kingview, Intouch, FIX, synall and so on) can be added, a monitoring system can be set up.

# 2. Basic Rules of ModBus:

- All RS485 communication circuits should follow the master-slave mode. In this way, data can be transferred between a master station (such as PC) and 32 substations.
- All information that transferred by the initialized master station on the RS485 communication circuit.
- No communication can start from a substation.
- All communications on the RS485 communication circuit is transmitted in the form of "information frame".
- If the master stations or substations receive an info frame with an unknown command, they will not respond.

# 3. Data Frame Format:

Communication transmission is asynchronous and takes byte (data frames) as its unit. Each data frame passed between the master station and the substation is through 11-bit serial data streams.

Data Frame Format:

| | |
|---|---|
| Start Bit | 1 bit |
| Data Bits | 8 bits |
| Parity Check Bit | Null |
| Stop Bit | 2 bits |

# 4. Communication Protocol:

When a communication command is sent to an instrument, the device that matches the corresponding address receives the communication command, removes the address and reads the information. And if there is no error, it will execute the corresponding tasks and return the execution results to the sender. The returned information includes the address, the function code of executing the action, the data after the action is performed, and the error check code (CRC). If you make a mistake, no information will be sent.

## 4.1 Information Frame Format:

| Initial Structure | Address | Function Code | DATA | Error Check | Ending Structure |
|---|---|---|---|---|---|
| Delay(an equivalent of the time of 4 bytes) | 1 byte 8 bits | 1 byte 8 bits | N bytes N*8 bits | 2 bytes 16 bits | Delay(an equivalent of the time of 4 bytes) |

4.1.1 ADDRESS：

The address is the first data frame (8 bits) in the information frame transmitted by each communication, from 0 to 255. The address range of a single device is from 1 to 247. This byte indicates that the slave computer with the address set by the user will receive the messages sent by the host computer, and each slave device has a unique address, and all responses sent back start from their own addresses. The address sent by the host computer indicates the address of the slave computers to be sent to, and the addresses sent by the slave computers indicate the addresses of the slave ones which send back responses.

4.1.2 FUNCTION CODE

The function code is the second data transmitted for each communication. The ModBus communication protocol defines the function code as 1-255 (01H-0FFH). This computer uses some of the function codes. Being sent as the requests of the host computer, the function code is tells its slave computer what actions to take. As a response of the slave computer, the function code sent by the slave one is the same as the function code sent by the host one and indicates that the slave computer has responded to the host computer and operated. If the highest bit of the function code sent by the slave computer is 1 (function code > 127), the slave computer does not respond or has an error.

The following chart demonstrates the detailed definitions and operations of function codes

Some of Function Codes of ModBus

| Function Code | Definition | Operation |
|---|---|---|
| 01H | Read switching value | Read single or multiple switching values |
| 03H | Read register | Read data of single or multiple registers |
| 05H | Store data of single switching value | Store data of single switching value |

● 01H Read Switching Value

The host computer can use the communication command with function code of 01 to read various switching values within the device (such as switch closing, switch opening, switch faults, automatic or manual status and so on). The maximum number of switches that can be read at one time is 32.

● 03H Read Register

The host computer uses the communication command with function code of 03H to read the numerical register in the device. The numerical register holds the various analog quantities and set values of parameters collected). The input value of the register of the DATA mapped by function code of 03H is 16 bits (2 bytes). In this way, the register value read from the device is 2 bytes. The maximum number of registers that can be read at one time is 8.

The command format of the responses of slave computer is its address, function code, DATA, and CRC code. The data in the DATA is a set of double bytes made of two bytes where the high byte is in the front.

● 05H Store Data of Single Switching Value

The host computer uses this command to store the data of single switching value to the bit memory in the device (such as the switching value controlling the ATS conversion). The slave computer also uses this function code to return information to the host computer.

4.1.3 DATA：

DATAs changes with function codes.

4.1.4 CRC：

The host or slave computer can use the check code to judge whether the received information is wrong. Sometimes, due to electronic noise or some other interference, the information will change slightly during the transmission. The error check code ensures that the host or the slave computer does not influence on the information that is in error during the transmission. This increases the security and efficiency of the system. The error check code uses the CRC-16 check method.

In two-byte error check code, low byte is in the front and high byte is in the back.

***Notes:***

*All information frames have the same format: address, function code, DATA and error check code.*

The Cycling Redundancy Check (CRC) contains 2 bytes, i.e. the 16-bit binary system. The CRC code is calculated by the sending end and placed at the end of the transmitted message. The receiving device then recalculates whether the CRC code of the received message is the same as the received one. If they are different, then there will be an error.

The computing method of CRC code is to preset all 16-bit registers to 1s firstly and then gradually process every 8-bit data information. Only 8-bit data bits are used when calculating the CRC code. The start bit and stop bit are not involved in CRC calculation.

When calculating the CRC code, the result obtained through XORing the 8-bit data and the register data is shifted one bit to the lower bit, and the highest bit is filled with 0. Then recheck the lowest bit. If the lowest bit is 1, the content of the register and the the preset number need to be XORed . If the lowest bit is 0, the XOR calculation is needless.

This process needs to be repeated for many times. After the 8th shift, the contents of the next 8 bits are XORed with current contents of the register. This process needs to be repeated for 8 times as before. After all data information is processed, the contents of the last register are the values of CRC.

**Calculation Steps of CRC-16 Code:**

1、Set the 16-bit CRC register to hexadecimal FFFF;
2、XOR one 8-bit data with the lower 8-bit data of the CRC register and place the result in the CRC register;
3、Shift the contents of the CRC register to the right one bit, fill in the highest bit with 0, and check for the shift-out bit.
4、If the lowest bit is 0: repeat step 3 (shift again).
If the lowest bit is 1: the CRC register is XORed with the hexadecimal number A001.
5、Repeat steps 3 and 4 until you have shifted right for 8 times, so that the entire 8-bit data is processed.
6、Repeat steps 2-5 for the next data processing.
7、The final CRC register value is the CRC code. When transmitted, the lower 8 bits are transmitted firstly, and the higher 8 bits are transmitted later.

***Notes:***

*The calculation of the CRC code starts from <address of slave computer>, except for all bytes of <CRC code>.*

## 4.2 Examples of Information Frame Format

◎ Function Code 01H

The address of slave computer is 00. Read 20H(decimal 32) switching values whose start address is 0000H.

| Sent by Host Computer | Number of Bytes | Examples(hexadecimal) | |
|---|---|---|---|
| Address of Slave Computer | 1 | 01 | Send to Slave Computer 01 |
| Function Code | 1 | 01 | Read Switching Values |
| Start Address | 2 | 00<br>00 | Start Address is 0000 |
| Number of Switching Values to Be Read | 2 | 00<br>1C | Read 28 Switching values |
| CRC Code | 2 | 3D<br>C3 | CRC Code Calculated by Host Computer |

The value of the switch value 07–00 is expressed as 30H in the hexadecimal system and 00110000 in the binary system. Switch value of 07 is the higher bit and 00 is the lower one. The state of the switch value 07-00 is: OFF-OFF-ON-

ON-OFF-OFF-OFF-OFF.

◎ Function Code 03H

The address of slave computer is 01. Three points whose start address is 0026 H.

Addresses of point data in this example:

| Address | Data(hexadecimal) |
|---|---|
| 0026 | 0014 |
| 0028 | 0014 |
| 002A | 0005 |

| Responses of Slave Computer | Number of Bytes | Examples(hexadecimal) | |
|---|---|---|---|
| Address of Slave Computer | 1 | 01 | Sending to Slave Computer 01 |
| Function Code | 1 | 01 | Read Points |
| Number of Switching Values to Be Read | 1 | 04 | 28 Switching Values(a Total of 4 Bytes) |
| Data1 | 1 | 30 | Contents with the Address of 07—00 |
| Data1 | 1 | 00 | Contents with the Address of 0F—08 |
| Data1 | 1 | 93 | Contents with the Address of 17—10 |
| Data1 | 1 | 0A | Contents with the Address of 1C—18 |
| CRC Code | 2 | 18<br>26 | CRC Code Calculated by Slave Computer |

| Sent by Host Computer | Number of Bytes | Examples(hexadecimal) | |
|---|---|---|---|
| Address of Slave Computer | 1 | 01 | Send to Slave Computer 01 |
| Function Code | 1 | 03 | Read Points |
| Start Address | 2 | 00<br>26 | Start Address is 0032 |
| Number of Switching Values to Be Read | 2 | 00<br>03 | Read 3 Points(A Total of 6 Bytes) |
| CRC Code | 2 | E4<br>00 | CRC Code Calculated by Host Computer |

| Responses of Slave Computer | Number of Bytes | Examples(hexadecimal) | |
|---|---|---|---|
| Address of Slave Computer | 1 | 01 | Send to Slave Computer 01 |
| Function Code | 1 | 03 | Read Points |
| Number of Bytes to Be Read | 1 | 06 | 3 Points(A Total of 6 Bytes) |
| Data of Point 1 | 2 | 00<br>14 | Contents with Address of 0026 |
| Data of Point 2 | 2 | 00<br>14 | Contents with Address of 0028 |
| Data of Point 3 | 2 | 00<br>05 | Contents with Address of 002A |
| CRC Code | 2 | 91<br>71 | CRC Code Calculated by Slave Computer |

◎Function Code 05H

The address of slave computer is 01. A switching value with the start address of 0002H. Set the unit of 0002 to 1.

Data addresses of switching values in this example:

| Address | Data(hexadecimal) |
|---|---|
| 0000 | 0 |
| 0001 | 1 |
| 0002 | 0 |

Explanation: the switching values of hexadecimal values of FF00 and 0000H are forced to 1 and 0 separately. Other values are illegal and do not affect the state of the switching values.

| Sent by Host Computer | Number of Bytes | Example(hexadecimal) | |
|---|---|---|---|
| Address of Slave Computer | 1 | 01 | Send to Slave Computer 01 |
| Function Code | 1 | 05 | Force Switching Values |
| Start Address | 2 | 00<br>04 | Start Address is 0002 |
| Data | 2 | FF<br>00 | Set Switching Value to 1 |
| CRC Code | 2 | CD<br>FB | CRC Code Calculated by Host Computer |

| Responses of Slave Computer | Number of Bytes | Example(hexadecimal) |
|---|---|---|

| | | | |
|---|---|---|---|
| Address of Slave Computer | 1 | 01 | Send to Slave Computer 01 |
| Function Code | 1 | 05 | Force Switching Values |
| Start Address | 2 | 00<br>04 | Start Address is 0002 |
| Data | 2 | FF<br>00 | Set Switching Value to 1 |
| CRC Code | 2 | CD<br>FB | CRC Code Calculated by Host Computer |

## 4.3 Error Handling

When the device detects an error other than the error of CRC code, it must send a feedback message to the host device. Set the highest bit of the function code to 1, which means the function code resent by the slave computer is adding 128 to the basis of the function code sent by the host computer. The following codes show that there is an unexpected error.

If the information received from the host computer has a CRC error, it will be ignored by the device.

The formats of error codes resent by the slave computer are as follows (except CRC):

| | |
|---|---|
| Address | 1 Byte |
| Function Code | 1 Byte(the highest bit is 1) |
| Error Code | 1 Byte |
| CRC Code | 2 Bytes |

Error Function Code:

01 Illegal function code
Unsupported received function code

02 Illegal data address
Appointed address which exceeds the range of the slave computer

03 Illegal data value
Data value received by host computer exceeds the data range of the corresponding address.

# 5. Appendix: address and data

Chart 1: Switching-Value Area Mapped by Function 01H.

(The maximum number of switches that can be read at one time is 32)

| Switching Values | | |
|---|---|---|
| Address | Item | Explanation |
| 0000H | 1# Breaker Closing/Opening | 1: Close 0: Open |
| 0001H | 2# Breaker Closing/Opening | 1: Close 0: Open |
| 0002H | Bus Tie Breaker Closing/Opening | 1: Close 0: Open |
| 0003H | Auto/Manual | 1: auto 0: manual |
| 0004H | 1# Voltage is Normal | 1: normal 0: abnormal |
| 0005H | 1# Voltage is too high | 1: too high 0: normal |
| 0006H | 1# Voltage is too low | 1: too low 0: normal |
| 0007H | 1# Loss of Phase Lines | 1: phase missing, 0: normal |
| 0008H | 2# Voltage is Normal | 1: normal 0: abnormal |
| 0009H | 2# Voltage is too high | 1: too high 0: normal |
| 000AH | 2# Voltage is too low | 1: too low 0: normal |
| 000BH | 2# Loss of Phase Lines | 1: phase missing, 0: normal |
| 000CH | Comprehensive Alarm | 1: alarming 0: None |
| 000DH | 1# Breaker Close failure | 1: alarming 0: None |
| 000EH | 2# Breaker Close failure | 1: alarming 0: None |
| 000FH | Bus Tie Breaker Close failure | 1: alarming 0: None |
| 0010H | 1# Breaker Opening failure | 1: alarming 0: None |
| 0011H | 2# Breaker Opening failure | 1: alarming 0: None |
| 0012H | Bus Tie Breaker Opening failure | 1: alarming 0: None |
| 0013H | 1# Breaker Trip | 1: alarming 0: None |
| 0014H | 2# Breaker Trip | 1: alarming 0: None |
| 0015H | Bus Tie Breaker Trip | 1: alarming 0: None |
| 0016H | 1# Phase Sequence Wrong | 1: alarming 0: None |
| 0017H | 2# Phase Sequence Wrong | 1: alarming 0: None |
| 0018H | Forced Open | 1: alarming 0: None |
| 0019H | Controller lock | 1: alarming 0: None |
| 001AH | Two sources of power are in parallel | 1: alarming 0: None |
| 001BH～001FH | Retained | Undefined |

Chart 2: Switching-Value Area Mapped by Function 05H.

| Switching Values | | |
|---|---|---|
| Address | Item | Explanation |
| 0000H | Remote Control 1# Breaker Close | 1(FF00H): close<br>0(0000H): null |
| 0001H | Remote Control 1# Breaker Open | 1(FF00H): open<br>0(0000H): null |
| 0002H | Remote Control 2# Breaker Close | 1(FF00H): close<br>0(0000H): null |
| 0003H | Remote Control 2# Breaker Open | 1(FF00H): open<br>0(0000H): null |
| 0004H | Remote Control Bus Tie Breaker Close | 1(FF00H): close<br>0(0000H): null |
| 0005H | Remote Control Bus Tie Breaker Open | 1(FF00H): open<br>0(0000H): null |
| 0006H | Auto/Manual Setting | 1(FF00H): auto<br>0(0000H): manual |
| 0007H | Release Alarm | 1(FF00H): Release<br>0(0000H): null |

Chart 3: DATA Mapped by Function Code 03H.

(The maximum number of registers that can be read at one time is 8).

| DATA | | |
|---|---|---|
| Address | Item | Explanation |
| 0000H | 1# Ua | 1# A Phase Voltage |
| 0001H | 1# Ub | 1# B Phase Voltage |
| 0002H | 1# Uc | 1# C Phase Voltage |
| 0003H | 1# Uab | 1# AB Line Voltage |
| 0004H | 1# Ubc | 1# BC Line Voltage |
| 0005H | 1# Uca | 1# CA Line Voltage |
| 0006H | 1# Fr | 1# Power Frequency （Unit：0.1Hz） |
| 0007H | 2# Ua | 2# A Phase Voltage |
| 0008H | 2# Ub | 2# B Phase Voltage |
| 0009H | 2# Uc | 2# C Phase Voltage |
| 000AH | 2# Uab | 1# AB Line Voltage |
| 000BH | 2# Ubc | 2# BC Line Voltage |
| 000CH | 2# Uca | 2# CA Line Voltage |
| 000DH | 2# Fr | 2# Power Frequency （Unit：0.1Hz） |
| 000EH | Retained | Undefined |
| 000FH | Retained | Undefined |