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Appendix

Appendix 1 Modbus Communication Protocol

The ETAKE provides the RS232/RS485 communication interface and supports the Modbus communication protocol so that the user can implement centralized control, such as setting running commands and function codes, and reading working status and fault information of the AC drive, by using a PC or PLC.

■ About the Protocol

This protocol defines the content and format of transmitted messages during serial communication, including master polling (or broadcasting) format and master coding method (function code for the action, transmission data, and error check). The slave uses the same structure in the response, including action confirmation, data returning and error check. If an error occurs when the slave receives a message, or the slave cannot complete the action required by the master, the slave returns a fault message as a response to the master.

■ Application

The AC drive is connected to a "single-master multi-slave" PC/PLC control network with the RS232/RS485 bus.

Bus Structure

1. Interface mode

   The RS232/RS485 hardware interface is used.

2. Transmission mode

   The asynchronous serial and half-duplex transmission mode is used. At the same moment, either the master or the slave transmits data and the other can only receives data. During asynchronous serial communication, data is sent frame by frame in the form of packet.

3. Topological structure

   The system consists of a single master and multiple slaves. The address range of the slaves is 1 to 249, and 0 is the broadcast address. A slave must have a unique address in the network.

4. Protocol description

   The Modbus communication protocol used by the ETAKE is a serial master-slave communication protocol. In the network, only one device (master) can set up the protocol (that is, "query/command"), and other devices (slaves) can only provide data to respond to the "query/command" from the master or execute the action according to the "query/command" from the master. The master here is a PC, an industrial device, or a PLC, and a slave is an ETAKE AC drive. The master can communicate with a single slave or broadcast messages to all slaves. When the master communicates with a single slave, the slave needs to return a message (response) to the "query/command" from the master. For a broadcast message sent by the master, the slaves need not return a response.

5. Data format

   The data format of the Modbus protocol used by the AC drive is as follows:

   In RTU mode, messages are sent with an interval of at least 3.5-character time. The first field transmitted is the device address. The allowable transmitted characters are hexadecimal 0 ... 9, A ... F. The network devices keep detecting the network bus, even during the silent interval. After receiving the first field (the address field), each device decodes the field to determined whether itself is the

destination device. Following the last transmitted character, an interval of at least 3.5-character time marks the end of the message. A new message starts to be sent after this interval.

The entire message frame must be transmitted as a continuous stream. If a silent interval of longer than 1.5-character time occurs before completion of the frame, the receiving device refreshes the incomplete message and assumes that the next byte is the address field of a new message. Similarly, if a new message begins earlier than 3.5-character time following a previous message, the receiving device considers the new message as a continuation of the previous message. This results in an error, as the value in the final cyclical redundancy check (CRC) field is incorrect for the combined messages. A typical message frame is described as below.

- RTU frame format

Frame header: START	At least 3.5-character time
Slave address: ADR	Communication address : 1 to 249
Command code: CMD	03: Read slave parameters 06: Write slave parameters
Data content: DATA (N-1)	Data: Function code parameter address, number of function code parameters, and values of function code parameters
Data content: DATA (N-2)	
……	
Data content: DATA0	
CRC CHK low order	Detection value: CRC value
CRC CHK high order	
END	At least 3.5-character time

- CMD and DATA

  Command code: 03H, read N words (a maximum of 12 words can be read)

  For example, the AC drive start address F002 of the slave 01 reads two consecutive values.

  Master command information

ADR	01H
CMD	03H
High order of the start address	F0H
Low order of the start address	02H
High order of the number of registers	00H
Low order of the number of registers	02H
CRC CHK low order	56H
CRC CHK high order	CBH

Slave response information

When FD-05 is set to 0:

ADR	01H
CMD	03H
High order of bytes	00H
Low order of bytes	04H
Data F002H high order	00H
Data F002H low order	00H
Data F003H high order	00H
Data F003H low order	01H
CRC CHK low order	82H
CRC CHK high order	C7H

When FD-05 is set to 1:

ADR	01H
CMD	03H
Number of bytes	04H
Data F002H high order	00H
Data F002H low order	00H
Data F003H high order	00H
Data F003H low order	01H
CRC CHK low order	3BH
CRC CHK high order	F3H

Command Code: 06H, write a word

For example, write 5000 (1388H) into F00AH of the AC drive whose slave address is 02H.

Master command information

ADR	02H
CMD	06H
Data address high order	F0H
Data address low order	0AH
Data content high order	13H
Data content low order	88H
CRC CHK low order	97H
CRC CHK high order	ADH

Slave response information

ADR	02H
CMD	06H
Data address high order	F0H
Data address low order	0AH
Data content high order	13H
Data content low order	88H
CRC CHK low order	97H
CRC CHK high order	ADH

- CRC check

In RTU mode, a message includes a CRC-based error-check field. The CRC field checks the content of the entire message. The CRC field is two bytes, containing a 16-bit binary value. The CRC field is calculated by the transmitting device, and then added to the message. The receiving device recalculates a CRC value after receiving the message, and compares the calculated value with the CRC value in the received CRC field. The CRC is first stored to 0xFFFF. Then a procedure is invoked to process the successive 8-bit byte in the message and the value in the register. Only the eight bits in each character are used for the CRC. The start bit, stop bit and the parity bit do not apply to the CRC. During generation of the CRC, each eight-bit character is in exclusive-OR (XOR) with the content in the register. Then the result is shifted in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. The LSB is extracted and examined. If the LSB was a 1, the register then performs XOR with a preset value. If the LSB was a 0, no XOR is performed. This process is repeated until eight shifts have been performed. After the last (eighth) shift, the next eight-bit byte is in XOR with the register's current value, and the process repeats for eight more shifts as described above. The final value of the register, after all the bytes of the message have been applied, is the CRC value. The CRC is added to the message from the low-order byte followed by the high-order byte. The CRC simple function is as follows:

```
unsigned int crc_chk_value（unsigned char *data_value,unsigned char length）
{
    unsigned int crc_value=0xFFFF;
    int i;
    while（length--）
    {
        crc_value^=*data_value++;
        for（i=0;i<8;i++）
        {
            if（crc_value&0x0001）
            {
                crc_value=（crc_value>>1）^0xa001;
```

```
                    }
                        else
                    {
                        crc_value=crc_value>>1;
                     }
                }
            }
            return（crc_value）;
    }
```

■ Address definition of communication parameters

1. This part describes the communication content used to control the running, status, and parameter setting of the AC drive.
2. Function code parameters are read and written (certain functional codes cannot be changed, and can only be used by the manufacturer or for monitoring).
3. The group numbers and identifiers of function codes are used for expressing the parameter addresses.
4. High-order bytes: F0 to FF (groups F), A0 to AF (groups A), 70 to 7F (group U)
5. Low-order bytes: 00 to FF
6. For example, F3-11, the address is expressed as F30B.

Note

- Group FF: factory parameters. The parameters cannot be read or changed.
- Group U: These parameters can only be read.

Certain parameters cannot be modified when the AC drive is running. Certain parameter cannot be modified regardless of the state of the AC drive. Users need to meet the requirements for the range, unit, and related description when modifying function code parameters.

Function Code Group	Communication Address	Function Code Address in RAM
Groups F0 to FE	0xF000 to 0xFEFF	0x0000 to 0x0EFF
Groups A0 to AC	0xA000 to 0xACFF	0x4000 to 0x4CFF
Group U0	0x7000 to 0x70FF	-

Frequent storage to the EEPROM reduces its service life. Therefore, in the communication mode, users can change the values of certain function code parameters in the RAM rather than storing the setting.

For groups F parameters, users only need to change high order F of the function code address to 0.

For groups A parameters, users only need to change high order A of the function code address to 4.

The function code addresses are expressed as follows:

High-order bytes: 00 to 0F (groups F), 40 to 4F (groups A)

Low-order bytes: 00 to FF

For example, if function code F3-11 is not stored into EEPROM, the address is expressed as 030B; if function code A1-05 is not stored into EEPROM, the address is expressed as 41-05.

It is an invalid address when being read.

Users can also use the command code 07H to implement this function.

■ Stop/RUN parameters:

Parameter Address	Parameter Description
1000H	Communication setup value (-10000 to 10000) (Decimal)
1001H	Running frequency
1002H	Bus voltage
1003H	Output voltage
1004H	Output current
1005H	Output power
1006H	Output torque
1007H	Running speed
1008H	DI tag
1009H	DO tag
100AH	AI1 voltage
100BH	AI2 voltage
100CH	AI3 voltage
100DH	Count value input
100EH	Length value input
100FH	Load speed
1010H	PID setting
1011H	PID feedback
1012H	PLC stage
1013H	Pulse setting frequency (unit: 0.01 kHz)
1014H	Feedback speed (unit: 0.1 Hz)
1015H	Remaining running time
1016H	AI1 voltage before correction
1007H	Running speed
1008H	DI tag
1019H	Linear speed
101AH	Current power-on time
101BH	Current running time
101CH	Pulse setting frequency (unit: 1 Hz)
101DH	Communication setting value
101EH	Actual feedback speed
101FH	Main frequency X
1020H	Auxiliary frequency Y

Note

- The communication setting value indicates the percentage: 10000 corresponds to 100.00%, and -10000 corresponds to -100.00%.
- With regard to frequency, the communication setting frequency is a percentage of F0-10 (maximum frequency), and this parameter can be read and written via communication. With regard to torque, the communication setting toruqe is a percentage of F2-10, A2-48, A3-48, A4-48 (respectively corresponding to motors 1, 2, 3, and 4).

■ Control command input to AC drive (write-only):

Command Word Address	Command Word Function
2000H	0001: Forward RUN
	0002: Reverse RUN
	0003: Forward jog
	0004: Reverse jog
	0005: Coast to stop
	0006: Stop according to the stop mode in F4-10
	0007: Fault reset

■ Read AC drive state (read-only):

Command Word Address	Command Word Function
3000H	0001: Forward RUN
	0002: Reverse RUN
	0003: Stop

■ Parameter lock password check

If "8888H" is returned, it indicates that the password check is passed.

Password Address	Password Content
1F00H	*****

■ DO terminal control (write-only)

Command Address	Command Content
2001H	BIT0: DO1 control
	BIT1: DO2 control
	BIT2: RELAY1 control
	BIT3: RELAY2 control
	BIT4: FMR control
	BIT5: VDO1
	BIT6: VDO2
	BIT7: VDO3
	BIT8: VDO4
	BIT9: VDO5

■ AO1 control (write-only)

Command Address	Command Content
2002H	0 to 7FFF indicates 0% to 100%.

■ AO2 control (write-only)

Command Address	Command Content
2003H	0 to 7FFF indicates 0% to 100%.

■ Pulse output control (write-only)

Command Address	Command Content
2004H	0 to 7FFF indicates 0% to 100%.

■ AC drive fault description

AC Drive Fault Address	AC Drive Fault Information
8000	0000: No fault 0001: Reserved 0002: Overcurrent during acceleration 0003: Overcurrent during deceleration 0004: Overcurrent at constant speed 0005: Overvoltage during acceleration 0006: Overvoltage during deceleration 0007: Overvoltage at constant speed 0008: Snubber resistor overload 0009: Undervoltage 000A: AC drive overload 000B: Motor overload 000C: Input phase loss 000D: Output phase loss 000E: Module overheat 000F: External device fault 0010: Communication abnormal 0011: Contactor abnormal 0012: Current detection fault 0013: Motor auto-tuning fault 0014: Reserved 0015: Parameter read/write abnormal 0016: AC drive hardware fault 0017: Motor short-circuit to ground 0018: Reserved

AC Drive Fault Address	AC Drive Fault Information
8000	0019: Reserved 001A: Running time reached 001B: User-defined fault 1 001C: User-defined fault 2 001D: Power-on time reached 001E: Load becoming 0 001F: PID feedback lost during running 0028: Fast current limit timeout 0029: Motor switchover fault during running 002A: Speed deviation too large 002B: Motor overspeed 002D: Motor overheat 005A: Reserved 005B: Reserved 005C: Reserved 005E: Speed feedback incorrect

■ Communication fault information description data (fault code)

Communication Fault Address	Fault Description
8001H	0000: No fault 0001: Password incorrect 0002: Command code incorrect 0003: CRC check error 0004: Invalid address 0005: Invalid parameter 0006: Parameter modification invalid 0007: System locked 0008: EEPROM operation

When Fd-05 is set to 1 (Standard Modbus protocol), the corresponding relationship between the standard protocol exception codes and the current exception codes are as follows:

Communication Fault Address	Fault Description
8001H	0000: No fault 0001: Password incorrect 0002: Command code incorrect 0003: CRC check error 0004: Invalid address 0005: Invalid parameter 0006: Parameter modification invalid 0007: System locked 0008: EEPROM operation

When Fd-05 is set to 1 (Standard Modbus protocol), the corresponding relationship between the standard protocol exception codes and the current exception codes are as follows:

Standard Protocol Exception Code	Current Exception Code
Standard Protocol Exception Code	Current Exception Code
01: Command code incorrect	0002: Command code incorrect
02: Address incorrect	0004: Invalid address
03: Data incorrect	0005: : Invalid parameter, 0001: Password incorrect
04: Command cannot be processed	0006: Parameter modification invalid, 0007: System locked

■ Group Fd communication parameter description

Function Code	Parameter Name	Setting Range	Default
Fd-00	Baud rate	Unit's digit (Modubs)	6005
		0: 300 bps	
		1: 600 bps	
		2: 1200 bps	
		3: 2400 bps	
		4: 4800 bps	
		5: 9600 bps	
		6: 19200 bps	
		7: 38400 bps	
		8: 57600 bps	
		9: 115200 bps	

This parameter is used to set the data transmission speed between the host computer and the AC drive.

Note that the baud rate of the host computer must be the same as that of the AC drive. Otherwise, communication shall fail. The higher the baud rate is, faster the communication will be.

Function Code	Parameter Name	Setting Range	Default
Fd-01	Data format	0: No check <8,N,2>	0
		1: Even parity check <8,E,1>	
		2: Odd parity check <8,O,1>	
		3: No check, data format <8,N,1>	

Note that the data format of the host computer must be the same as that of the AC drive. Otherwise, communication shall fail.

Function Code	Parameter Name	Setting Range	Default
Fd-02	Local address	1–249	1
		0: Broadcast address	

This parameter is used to set the address of the AC drive. This address is unique (except the broadcast address), which is the basis for point-to-point communication between the host computer and the AC drive.

When the local address is set to 0 (that is, the broadcast address), the AC drive can only receive and execute broadcast commands of the host computer, but will not respond to the host computer.

Function Code	Parameter Name	Setting Range	Default
Fd-03	Response delay	0–20 ms	2 ms

This parameter is used to set the delay from the time when AC drive receives the frame matching the local address to the time when it AC drive starts returning a response frame. Too short response delay may make the host computer fail to receive the frame in time. If the response delay is shorter than the system processing time, the system processing time shall prevail. If the response delay is longer than the system processing time, the system sends data to the host computer only after the response delay is up.

Function Code	Parameter Name	Setting Range	Default
Fd-04	Communication timeout	0.0–60.0s	0.0s

When the AC drive does not receive the communication signal within the time set in this parameter, it will report the communication timeout fault (Err16).

When this parameter is set to 0.0s, the system does not detect communication timeout.

Generally, this parameter is set to 0.0s. In applications with continuous communication, you can use this parameter to monitor the communication status.

Function Code	Parameter Name	Setting Range	Default
Fd-05	Communication protocol	Unit's digit: Modbus 0: Non-standard Modbus protocol 1: Standard Modbus protocol Ten's digit: Reserved	31

FD-05 = 1: Standard Modbus protocol

FD-05 = 0: For the read command, the slave returns an additional byte. For details, see "Data Format" in this appendix.

Function Code	Parameter Name	Setting Range	Default
Fd-06	Current resolution read by communication	0: 0.01 A 1: 0.1 A	0

This parameter is used to set the unit of the output current read by communication.