A Research on Modbus Communication between Pc Computer and Plc – Three Phase Asynchronous Motor-Inverter Systerm

Duong Quynh Nga[1], Duong Quynh Nhat[2]
Department of Electrical Engineering, Thai Nguyen University of Technology, Vietnam

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ABSTRACT: Modbus is a communication protocol standard widely used in industrial automation control today. The use of PC to change parameter settings and observations in PLC system control - Inverter - Asynchronous motor is of great significance, easy to update information and settings for the inverter. This article presents the Modbus communication method between the PC and the PLC system - Mitsubishi E700 Invt inverter - 3-phase asynchronous motor through the interface programmed on the computer. The research results have built an intuitive computer interface, updated settings, and fully displayed operating information of a 3-phase asynchronous motor inverter system. In addition, the results also show the applicability of industrial communication coupling for remote control and monitoring with modern electrical equipment in the industrial automatic electricity industry.
KEYWORDS: Inverter, Modbus communication, industrial communication coupling.

I. INTRODUCTION

When science and technology have not really developed, the problem of adjusting and stabilizing the AC motor's speed is difficult, the application scope of this control system is narrow, most of them use DC motors due to the special characteristics of DC motors. simple adjustment. However, the asynchronous AC motor has advantages: low cost, easy to operate, can work in explosive environment, continuous and long term, direct connection connected to the three-phase power grid... Thanks to these advantages, three-phase asynchronous motors are used more and more widely. Due to the characteristics of heavy industry (in factories: cement production, paper production,

steel production...) the engines will be designed for continuous, long-term operation in very hot weather and high temperature, high humidity. Therefore, the requirements for these motors must be performance and reliability, ease of installation and maintenance. Therefore, control system PLC - Inverter - motor is very interested in research. Currently, the research on industrial communication coupling is being developed very strongly with modern electrical - electronic devices, electric drives... In system designs, people often use HMI screens. , PLC connects to devices, the development of such applications is mainly applied to direct control at the system, performing simple, unattended operations from long distances. For remote monitoring, an industrial computer is used to connect to the system via SCADA software using Modbus protocol, but these studies mainly use built-in software such as WinCC or LabVIEW. Connecting and controlling by PC with industrial electrical - electronic equipment by Modbus protocol is still a matter of needing more attention. Therefore, the article went to find out how to build a software interface that can pair communication, collect data and control a common industrial electronic device, an inverter - 3-phase asynchronous motor.

II. OVERVIEW OF THE INVERTER

An inverter is an electronic device or circuit used to convert power from direct current (DC) to alternating current (AC). That is, the conversion of alternating current at one frequency to alternating current at another frequency can be controlled by semiconductor keys.

In practical application, the inverter is the most modern non-contact motor speed control automation device today. It has been and will be

widely applied to help people control more intelligently in electric drives and power management.Inside the inverter are components that have the function of receiving fixed input voltages (with fixed frequency) and then turning them into 3-phase variable voltage/frequency to control motor speed.

- The structure of the inverter:
Normally, the structure of an inverter includes:
• Rectifier: It is a diode bridge circuit
• DC filter: To smooth the signal from the rectifier output
• The inverter: It is a bridge circuit consisting of 6 IGBTs (Insulated Gate Bipolar Transistor) that converts DC voltage into AC.
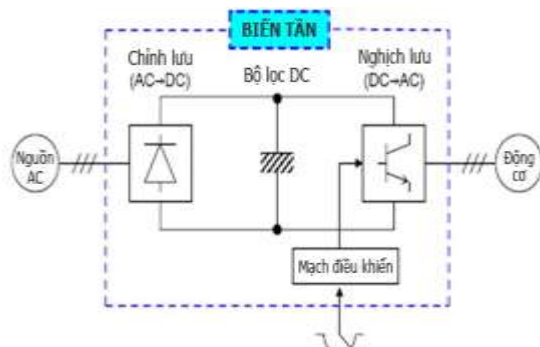

Figure 1: Circuit diagram of inverter
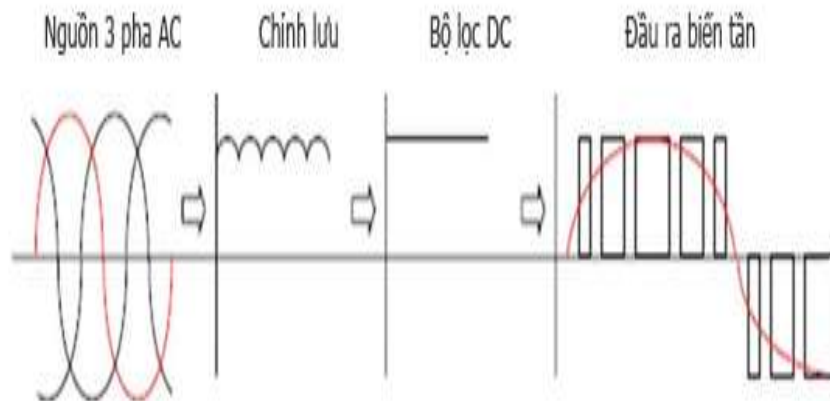
- Operation principle of inverter:

A single phase or three phase power source is rectified and filtered into a flat DC power source. This stage is performed by a diode bridge rectifier and a capacitor. Power input can be single phase or 3 phase, but it will be at fixed voltage and frequency (eg 380V 50Hz)

The DC voltage above will be converted (inversely) into a symmetrical 3-phase AC voltage. Initially, the DC voltage generated will be stored in the capacitor bank. Next, through proper self-triggering, the IGBT converter (short for an insulated gate bipolar transistor that acts like an ultrafast on and off switch to generate the inverter's output waveform) will generate a 3-phase AC voltage by PWM pulse width modulation.

- Advantages of Inverter:
Easily change the motor speed, reverse the motor rotation direction.
Reduced starting current compared to direct starting method, star-delta starting should not cause damagevoltage drop or difficulty starting.
The process of starting through a low-speed magnetic inverter helps to prevent the motor carrying a large load from having to start suddenly, avoiding damage to the mechanical part, the bearing, and increasing the life of the motor.
Using an inverter saves significant energy compared to the direct motor running method.
Inverters usually have electronic systems for overcurrent, overvoltage and undervoltage protection, creating a safe system for operation.

Figure 2: Voltage/frequency variation through the inverter

III. PAIRING PC COMPUTER COMMUNICATION WITH MITSUBISHI E700 INVERTER

a. Modbus communication protocol with Mitsubishi E700 Inverter

Modbus communication is a common communication protocol in the industry, devices can communicate with each other through this communication protocol via RS485 or RS422 communication port and Master-Slave model. In Modbus communication, there are three communication modes: ASCII, RTU and TCP, but with the Invt Mitsubishi E700 inverter, only two communication modes are configured, ASCII and RTU. A Master device controls the Slaves, the Master device sends a command signal, requests to other Slave devices and executes that commandfigure 1a.
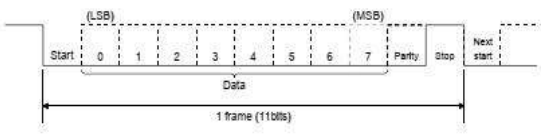
In this paper, the author uses the Master device as a PC, the Slave device as the Invt Mitsubishi E700 inverter, with a pairing diagram as shown in Figure 3b.

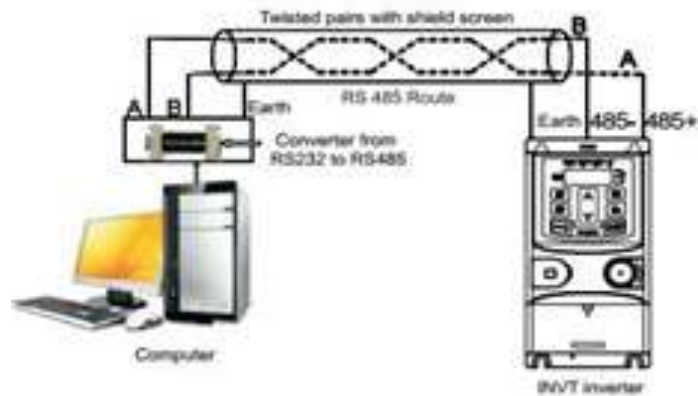**b. Modbus communication configuration with Mitsubishi E700 Inverter**

Modbus communication in Invt Mitsubishi E700 inverter is RTU communication mode. Each byte (8 bits) of the transmission frame is encoded as 2 ASCII characters (each character is encoded on one nibble), so that communication in RTU mode for a single transmission carries more information than with ASCII mode. The data communication frame in RTU mode is shown in Table 1.

Table 1. Modbus communication frame in RTU mode

Baud speed	9600/19200/38400/57600
Start bit	1 bit
Data bit	8 bit
Parity bit	0 bit
Stop bit	1 bit
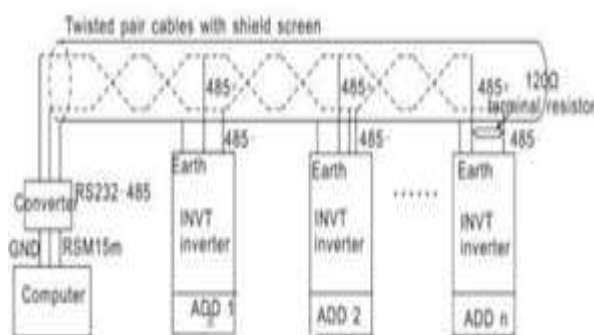
(a)

(b)
Figure 3. (a) Modbus connection diagram between PC and multiple inverters via RS485 standard,
(b) Modbus connection diagram between PC and Invt Mitsubishi E700 inverter via RS485 standard

With the Mitsubishi E700 Invt inverter, the Modbus communication mode is set by setting the inverter's communication parameters at address P14 which is the address used for Modbus communication.

P14.00: Used to set the communication address, can be selected from 1~247;

P14.01: Used to select Baud rate;

P14.02: Set transmission frame.

The Modbus communication data packet structure of the Mitsubishi E700 Invt inverter in RTU mode is shown in Figure 2.

- ADDR address byte: identifies the device carrying the address to receive data (for Slave) or from which address (for Master). This address is specified from 0-254;

- CMD instruction code byte: specified from the Master, specifying the data request from the Slave device, where 03h: read Byte instantaneous data from the Slave, 06h: write Byte instantaneous data to the Slave.

- DATA data byte: identifies the data exchanged between the Master and the Slave;

- Byte CRC: 2 bytes of error checking of the transfer function, the value of Byte CRC is 16 Bit.

The process of the Master receiving data is shown in Table 2, in which the table shows the receipt of 2 consecutive data bytes of 0002H from address 0004H from the Mitsubishi E700 Invt inverter with communication address 01H.

Table 2. Communication packet structure for receiving data

START	T1-T2-T3-T4
ADDR	01H
CMD	03H
High bit of the start address	00H
Low bit of the start address	04H
High bit of data number	00H
Low bit of data number	02H
CRC low bit	85H
CRC high bit	CAH
END	T1-T2-T3-T4

The master process of data transmission is shown in Table 3, the table shows the transmission of 2 consecutive data bytes 1388H to address 0004H of the inverter with communication slave address 02H.

Table 3. Communication packet structure for data transmission

START	T1-T2-T3-T4
ADDR	02H
CMD	06H
High bit of writing data address	00H
Low bit of writing data address	04H
High bit of data content	13H
Low bit of data content	88H
CRC CHK low bit	C5H
CRC CHK high bit	6EH
END	T1-T2-T3-T4

The master process of data transmission is shown in Table 3, the table shows the transmission of 2 consecutive data bytes 1388H to address 0004H of the inverter with communication slave address 02H.
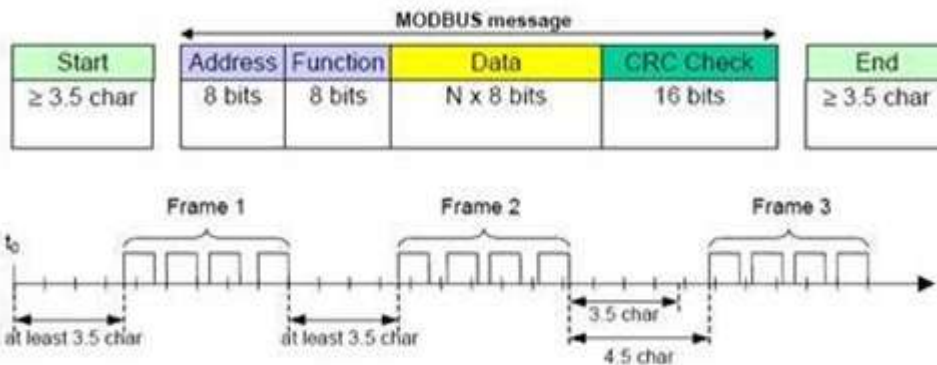

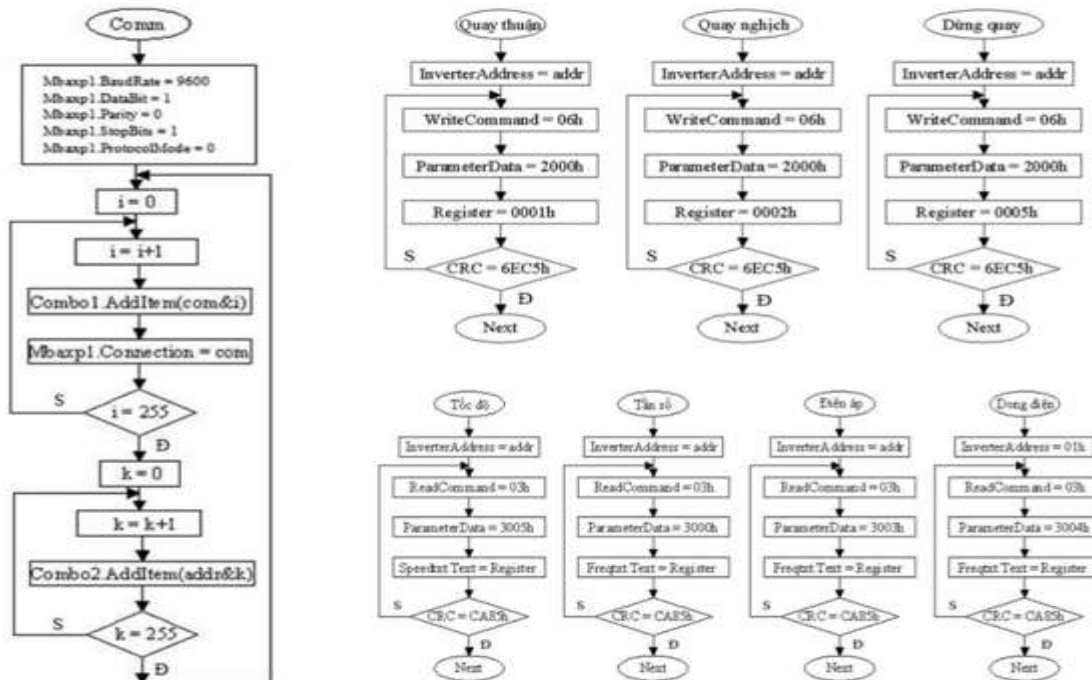Figure 4. Modbus communication data packet in RTU mode

Figure 5: Modbus communication interface programming algorithm for PC paired with Inverter

IV. INTERFACE DESIGN AND COMMUNICATION PROGRAMMING PROGRAMMING ON PC

Designing an interface on a PC using Windows operating system can use many different programming languages such as Visual C++, Visual C#, Visual Basic, Delphi,,… In this article, the authors use Visual Basic 6.0 (VB6.0) language, a simple and intuitive object-oriented programming language on the Windows environment, VB6.0 provides a complete set of tools. to simplify application programming deployment, to pair computers, and to allow the use of dynamic-link libraries with the *.dll, *.ocx extensions. It can be said that this is the fastest and best way to develop applications on Microsoft Windows.

To program the Modbus communication protocol in a Visual Basic environment one must use a Modbus.

ActiveX Control (Figure 6). Then, on the toolbar of VB 6.0 we have a Modbus control with its properties, allowing us to easily use it for programming Modbus communication pairing using VB 6.0 [1].

From the information that needs to be displayed of the Invt Mitsubishi E700 inverter such as: voltage, current, speed, frequency, ... and information to control the inverter such as: forward rotation, reverse rotation, frequency adjustment (speed) rotation speed, the authors build a control interface like Figure 7, the algorithm flowchart of the program is shown in Figure 5.
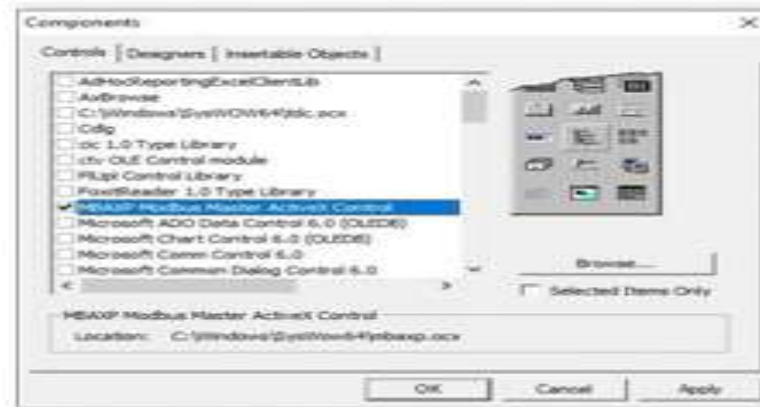

Figure 6. Modbus ActiveX Control in Visual Basic 6.0

V. RESULTS AND DISCUSSION

Based on the research and algorithm development in Sections III and IV, using the Visual Basic interface design environment, the authors have designed a Modbus RTU communication interface on a PC for the inverter system. - 3-phase asynchronous motor as shown in Figure 7. After connecting the PC with the inverter using RS485 communication standard, the authors have completed the Modbus communication test system with PC computer - the inverter as shown in Fig. 8.

System operation in no-load mode is performed as follows:

- Set Comm port for Master as PC and Slave's address as inverter on Combos of interface, confirm by Connect button on interface as shown in Figure 7;
- Set graphing mode, set frequency at SV frame;
- Let the system operate by pressing the FWD forward button or the REV reverse button.

At that time, the inverter - motor system will operate, the motor will rotate forward or reverse with different speeds according to the frequencies set on the SV frame shown in Table 4;

- To stop the engine, click the Stop button or stop the connection, click the Disconnect button on the PC interface.

Table 4. Frequency set for inverter - motor system and parameters measured and displayed on the software

No.	f (Hz)	I (A)	U (V)	n (RPM)
1	25	0,6	110	750
2	50	0,6	219	1500

3	30	0,6	131	900
4	15	0,6	66	450
5	45	0,6	175	1350

From the experimental system as shown in Figure 6 and the frequency setting values as shown in Table 3, information such as voltage, current, rotational speed is displayed, updated in real time on the interface. The interface has displayed accurately, more real-time updates than the inverter's LED screen, which can only display one information at the same time.

Figure 7. Modbus communication interface on PC for pairing with inverter
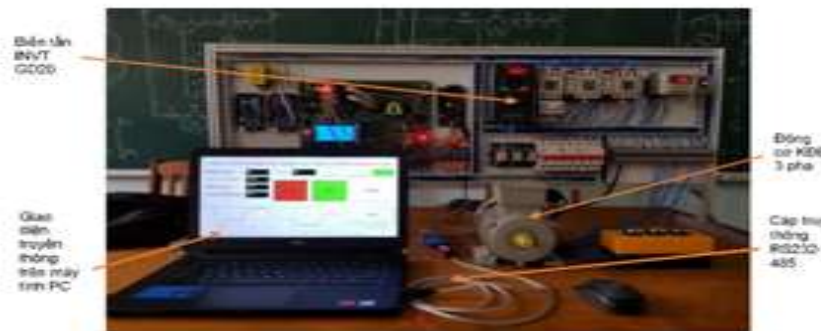

Figure 8. Modbus communication connection experimental system between PC and inverter – motor

Figure 9. Displaying information of the inverter - motor system on the computer

In addition, the interface automatically updates the set frequency data and automatically reads the correct frequency from the system and plots the frequency change characteristic as shown in Figure 7. The results show that, from the The frequency set is different from the computer, the

system is stable, the readings are accurate. With a simple system design, the interface is laid out clearly and intuitively, fully displaying the operation information of the inverter, convenient for teaching in the practice room.

VI. CONCLUSION

Modbus communication from a Master device to a Slave is the inverter - motor system commonly used in industry with high application in practice, the Master device can be implemented in many different ways such as: HMI screen, WinCC-PC interface, Microcontroller, PLC, etc. In this paper, the inverter-motor system is successfully paired with a PC via Modbus communication using the added Visual Basic language. A new way of communicating in an object-oriented programming language. The operating results of the system show that the system works stably, accurately, and is easy to manipulate, suitable for lecturers and students in teaching and learning about industrial communication and machine control. electricity. However, the limitation of the paper is that it only stops testing when the system is operating in idle mode, the communication interface developed in the Visual Basic 6.0 environment is still simple, which is a classic design environment. . In the future, the author team will continue to research and design richer communication interfaces, with a newer version of Visual Basic, and experiment with the system operating in many different load modes.

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