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Control and monitor Mitsubishi PLC-Inverter-Motor master slave system via Modbus RTU communication

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ABSTRACT:
The report presents an overview of control and monitoring technology for 3-phase asynchronous motors operated in industrial production lines applied in practice. From there, we implemented the design and application of the Modbus RS485 communication system and through the FX3G-485-BD Module controlled the PLC - Inverter - Motor system, helping to stabilize the speed of the 3-phase asynchronous motor. At the same time, build an interface to monitor system parameters on GT Designer3 software.

KEYWORDS: Control, monitoring, Mitsubishi PLC, inverter, 3-phase asynchronous motor, Modbus communication

I. INTRODUCTION

With many outstanding features, high performance, energy saving ability, precise speed adjustment and long-term operation. Application of PLC - inverter - motor system is suitable for many applications from basic, versatile to specialized, modern in many different industries.

The structure of control and monitoring of agricultural station applying IoT technology is proposed as Fig.1. Including the coordination between LoRa and Internet communication waves.

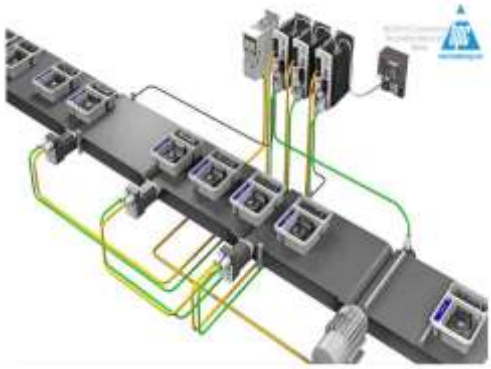

Figure1. Application in conveyor control

Benefits of the solution:
+ Precise control of engine speed.
+ Ensure the ability to synchronize speed between structures and stages in production.
+ Easy to control and operate.

In conveyor control systems, inverters help protect conveyors and mechanical equipment by accurately controlling motor speed and torque, extending conveyor operating time and minimizing operating costs and expenses. maintenance. Control the start and stop process accurately on the conveyor system [1], [2], [3].

II. METHOD OF CONTROLLING MOTOR SPEED AND MAIN EQUIPMENT OF PLC SYSTEM – INVERTER - MOTOR

Method for controlling the speed of a 3-phase asynchronous motor
- Adjust the voltage supplied to the motor using a thyristor converter.
- Adjust the rotor circuit resistance pulse.

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- Adjust sliding power Ps.
- Adjusting the frequency of the power supply to the motor using frequency converters - (selection method)

Advantages: Precise speed control, smooth control over the entire speed range, virtually no fluctuations, high efficiency, energy saving, increased motor life

Disadvantage: More complicated control, need to adjust PID parameters to calculate control voltage based on error between set speed and actual speed of the motor

Figure 2. Tree-phase asynchronous motor

PLC controller Mitsubishi FX3G – 60MT/ES
- Number of inputs: 36
- Number of outputs: 24, Transistor (Sink) type.
- Power consumption: 32 W.
- Communication: USB, RS232C, RS485
- High speed counter: 60Hz x4 channels and 10Hz x2 channels.
- Internal memory: 32 Kb.
- Can expand 16 - 128 input/outputs.
- Integrated real-time clock
- Origin: Mitsubishi – Japan
- The task of the PLC in this project is to process the signal, receive the signal from the encoder, compare it with the set speed and then send the inverter control signals.

Figure 3. PLC FX3G – 60MT/ES

FR-E720 1.5K inverter
- FR-E720 is a 3-phase inverter, voltage 200V, capacity 0.1KW to 15KW.
- Can connect to PC via Mini USB cable, set parameters on computer.
- Can add additional I/O cards, communication cards CC-LinK, DeviceNet, Profibus-DP,...
- Mitsubishi FR-E720 inverter is often used for heavy conveyors, cranes, mold presses, lathes, and complex applications with a capacity of less than 15 KW
- In this project, the inverter is used to increase or decrease the rotation speed of the motor through increasing or decreasing the frequency of the power supply to the motor, and at the same time controlling the motor to rotate forward and reverse.

Figure 4. FR-E720 1.5K inverter

Communication module FX3G-485-BD
- Maximum communication distance 50m
- Connection type: Terminal
- Transmission method: Half-duplex
- Connection port: 5 Pin Male.
- Transmission type: RS485
- Used for PLC types: FX3G.
- Isolation design: no (between communication line and CPU)
- Module FX3G-485-BD is used to connect signal communication from the PLC to the inverter, thereby controlling the motor speed

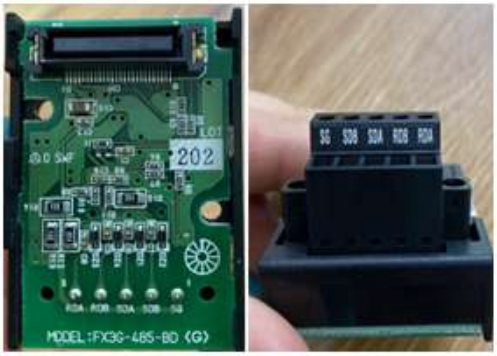

Figure 5. FX3G-458-BD module

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Encoder Omron E6B2-CWZ6C
- Voltage used: 5 - 24VDC.
- Current consumption: max 80mA
- Number of pulses: 1000 pulses / 1 cycle (1000 p/r)
- Number of pulse channels: 3 separate pulse channels A, B, Z
- Maximum response frequency: 100kHz
- Standard: IEC 60529 IP50
- Cable length: 2m
- Working temperature: -10 ~ 70℃
- Working humidity (%RH): 35% - 85%
- Pulse input type: NPN open collector (needs a resistor hanging on VCC to create a high level)
- Shaft diameter: 6m

Figure 6. Omron E6B2-CWZ6C encoder

III. SYSTEM STRUCTURE DIAGRAM

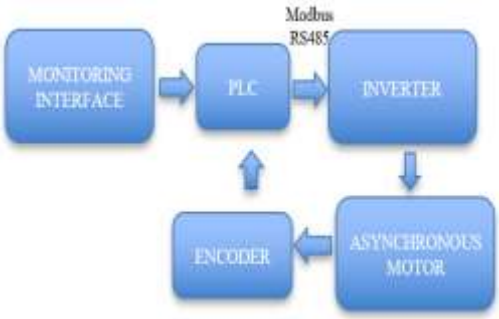

Figure 7. Block diagram of the control system structure

Functions of blocks [4], [5], [6], [7]:

Monitoring interface: can be an HMI screen or a design interface on a PC used to set the motor speed, display the set speed, the actual speed of the heating device, control buttons or working mode job.

PLC: is the central processor used to process signals, receive signals from the encoder, compare with the set value and then send signals to control the inverter.

Inverter: is an electrical device that changes the input current frequency from one frequency (50Hz, 60Hz) to another output frequency (commonly from 0 to 400 Hz), the inverter is used to control Increase or decrease AC motor speed by increasing or decreasing frequency.
Encorder: used to detect the position, direction of movement, speed... of the motor by counting the number of rotations of the shaft and then sending signals to the central controller (PLC).

System power circuit connection diagram

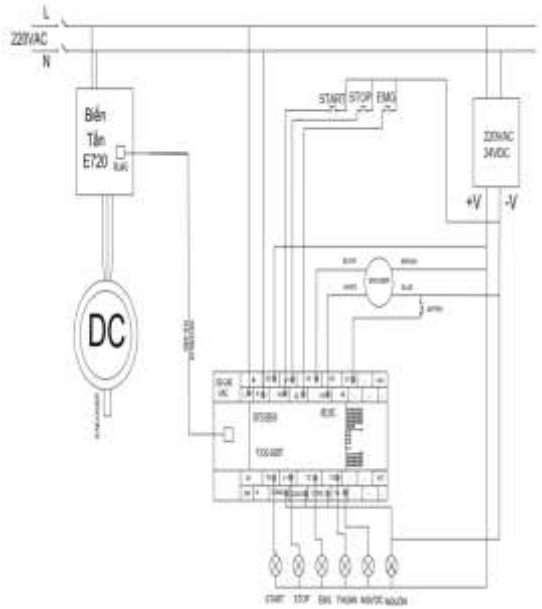

Figure 8. Dynamic circuit connection diagram

Our inverter supplies 220V power, the 3-phase output of the inverter is connected to the 3-phase KDB motor. The inverter control signal is transmitted from the PLC via MODBUS RS485 communication (using RJ45 cable) and FX3G-485-BD module.

The encoder is coaxially connected to the 3-phase KDB motor, powered via a 24VDC honeycomb power supply. The encoder returns pulse signals through two wires OUT A and OUT B connected to pins X3 and X4 of the PLC.

Operating principle of the system:
First power the system, the power indicator light is on.

Next press the START button on the control panel → The "RUN" indicator lights up on both the monitoring interface and the control panel. Set the parameters N_set, Kp, Ti, Td of the PID controller on the HMI. Then press SET and SENT on the HMI to send parameters from the monitoring screen to the PLC and inverter. When

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the SET and SENT buttons on the monitoring screen change state (change color), we continue to select the engine's rotation direction by pressing the Fordward or Reverser button, then the control panel will light up the forward or reverse indicator light. These operations will be sent to the PLC to control the inverter. By looking at the data table and graph on the monitoring interface, you can see the value of the set speed and actual speed of the motor through the ENCODER signal sent to the PLC. When you want the motor to stop, press the STOP button on the control panel or press the SENT and SET buttons on the HMI to stop the motor, then the "STOP" indicator light on the control panel will light up. When a problem occurs, we set up the EMG emergency stop button on the control panel to completely stop the system and at the same time the "EMG" indicator light will light up.

IV. DESIGN THE MONITORING INTERFACE ON THE SOFTWARE

Figure 10. Engine speed monitoring control interface

Figure 11. Actual model image

Comment: After calculating and setting the parameters Kp, Ti, Td, the system operates stably, the engine runs smoothly, the engine speed increases evenly, sticking to the set speed. The monitoring screen displays the motor control voltage, set speed and actual motor speed.

V. CONCLUSION

Built and applied the Modbus RS485 communication technique of the Mitsubishi FX series PLC to the problem of master-slave system control technology at the school level, specifically the control of the PLC-Inverter-Motor system which is being widely applied in many applications. current production line.

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