

Automatic Washing Machine Control System Based on PLC

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Abstract: In this project, a fully automatic washing machine control system based on programmable logic controller (PLC) is designed and implemented for the automation needs of household washing machines. The replacement of traditional relay control by PLC technology improves the reliability, flexibility and maintainability of the system. The system adopts Mitsubishi FX5U-64M PLC as the core controller, combined with GT Designer3 touch screen software to achieve human-computer interaction, and supports automatic control of the whole process such as washing, rinsing, and dehydration. The experimental results show that the system can automatically complete the laundry process according to the parameters set by the user (such as water level, washing times, and spinning time), and has the functions of fault alarm, status monitoring and historical data query. By optimizing the program logic and hardware configuration, the system achieves the expected goals in terms of cost, efficiency and user experience.

Keywords: Fully Automatic Washing Machine; PLC; Touch Screen; Automated Control.

1. Introduction

As a household essential electrical appliance, the level of automation of washing machines directly affects the user's experience. Traditional washing machines are mostly controlled by mechanical or relay control, which has problems such as poor flexibility, high failure rate, and insufficient scalability. With the development of PLC technology, its high reliability, strong anti-interference ability and flexible programming characteristics in industrial control have been gradually applied to the field of home appliances. In this paper, a fully automatic washing machine control system is designed based on Mitsubishi FX5U PLC, which realizes parameter setting and status monitoring through the touch screen, which significantly improves the intelligent level of the system.

Well-known foreign brands (such as Siemens and Panasonic) have launched a variety of PLC-controlled smart washing machines, which support functions such as clothing weight perception and adaptive program adjustment. Domestic universities and enterprises are also conducting research in this field, but most systems still have problems such as high cost and single function. With the goal of low cost and easy maintenance, this design combines PLC and touch screen technology to achieve fully automatic control and user-friendly interaction of the laundry process.

2. General Design of System

The design of the fully automatic washing machine control system based on PLC is mainly composed of the following parts:

Input device: This section includes various sensors and switches for detecting the status of the washing machine and receiving user instructions. For example, a water level sensor is used to detect the water level, a door switch is used to detect the status of the door, and a touch screen or button is used to input instructions by the user.

PLC (Programmable Logic Controller): PLC is the core of the control system, responsible for receiving data from input

devices and performing data processing and output control according to preset program logic. A PLC will typically contain a microprocessor and memory for storing and executing programming logic.

Output equipment: This part includes actuators such as motors, solenoid valves, etc., which are used to drive and control various actions of the washing machine. For example, a motor is used to drive the rotation of the laundry bucket, and a solenoid valve is used to control water inlet and drainage.

Human-machine interface (HMI): HMI is used to display the status information of the washing machine and receive user instructions. It can be achieved through a touch screen, an LED display or an LCD display.

Communication interface: This part is used to realize the communication between the PLC and other devices or systems, such as data exchange with the upper computer software. Common communication interfaces include serial communication, Ethernet communication, etc. System framework

As shown in the figure below:

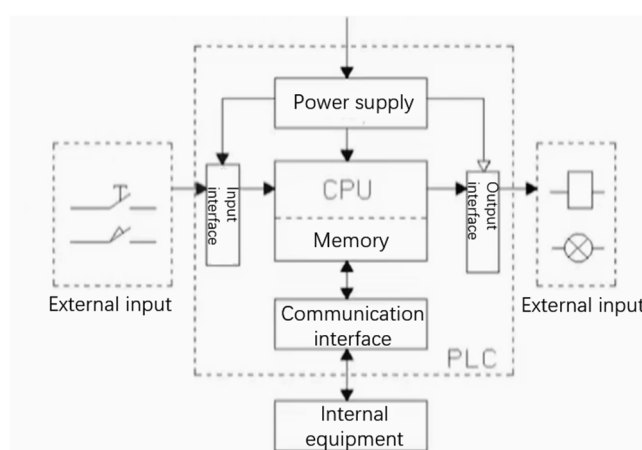


Figure 1. System composition

The main working principle of washing machine:
First, set the number of washing and rinsing times, throw

drying time and water level parameters and press the start button. At this time, the water level sensor detects whether there is water in the barrel or whether the water level meets the standard. If there is no water or the water level does not meet the standard, it will be fed back to the control. The system control system outputs the signal to the water injection solenoid valve. At this time, the water injection solenoid valve opens and water injection. As the water level rises. When the user's set value is reached, the water level sensor is transmitted to the control system again. The control system outputs the signal, closes the water injection solenoid valve, and completes the water injection process.

Then, the control system then supplies power to the motor drive circuit, and the motor starts to operate, and according to the different procedures, it rotates forward, stops, reverses and cycles in sequence according to a certain time pattern. The clothes in the laundry bucket rotate at the same time as the pulsator. With the help of detergent, through the slap and rubbing movement, the stains on the clothes are dissolved in water and then discharged. After the number of washes set by the user is completed, the output signal of the control system is provided to the leakage solenoid valve, and the image drain solenoid valve is opened to start the drainage process.

After the drainage is completed, it enters the rinsing mode. After meeting the setter's rinsing mode, the water level controller gives the control system a signal, and then the control system controls the motor to rotate at high speed in one direction and starts the dehydration process. After the dehydration time is completed, the control system gives a signal and the drain solenoid valve is closed. According to the washing procedure and the set washing time, when the entire washing process is completely finished, the buzzer sounds, and the control system then cuts off the power supply. At this point, the entire washing process is Finish.

3. Hardware Design of Control System

(1) PLC

FX3U is a third-generation micro programmable controller of Mitsubishi. It has two high-speed communication interfaces (RS-422 and Mini-USB), and has built-in high-speed counters with 2-channel 60KHZ and 4-channel 10KHZ, which can be connected to FX3U-4AD-ADP or Adapters such as FX3U-ENET-ADP, implement analog, Ethernet, MODBUS and other functions.

According to the practical application of this design, we choose FX3U-64M.



Figure 2. FX3U-64M

(2) Touchscreen

When selecting touch screen software, the following factors need to be considered:

Functionality: Different touch screen software has different

functions, including data processing, graphical interface design, device control, etc. Software with necessary functions needs to be selected according to actual needs.

Compatibility: The selected touch screen software needs to be compatible with the hardware device used to ensure stability and performance.

Ease of use: The ease of use of software is very important to users. Easy-to-learn and use software can improve work efficiency.

Cost: The prices of touch screen software of different brands are different, and you need to choose according to your budget. At the same time, the software maintenance and upgrade costs need to be considered.

To sum up, choosing a touch screen software requires evaluation based on actual needs and taking into account the above factors. The touch screen software we selected for this design is GT desinger3.

4. Software Design

(1) GT desinger3 software screen design

The design of touch screen mainly needs to consider its convenience and practicality. Among them, the beauty of the user interface and the simplicity of the control system are also essential.

First of all, the user interface design needs to be concise and clear and easy to operate. The touch screen should include the basic function buttons of the washing machine, such as starting, stopping, washing, rinsing, dehydration, etc., as well as some customizable display lights. At the same time, the interface should also display information such as washing status, number of washing times, etc., so that users can understand the working status of the washing machine in real time.

Secondly, the design of the control system needs to be fully automatic control combined with PLC technology. Through the touch screen inputting the washing program and washing parameters, the PLC automatically controls the workflow of the washing machine based on the input information and the state of the washing machine. At the same time, the PLC also needs to communicate with the touch screen in real time and feedback the status information of the washing machine to the touch screen so that users can understand the real-time working status of the washing machine.



Figure 3. Touch screen interface

To sum up, the design of a fully automatic washing machine touch screen based on PLC needs to focus on multiple aspects such as user interface design and control system design to improve user experience and operation efficiency. Based on this, the design screen is roughly divided

into three interfaces: the control area, the data display area and the indicator light display interface. The control interfaces are high, medium and low water level buttons, washing/rinse times buttons and start, pause and full stop buttons; the data display area can display the user's preset

number of washing/rinse times and dehydration time; the indicator interface can be visually displayed. The laundry steps performed. The Fig 3 shows the design screen.

Variable assignments are shown in the following table:

Table 1. List of Data Register variables

Input		Output	
Data register	Data object	Data register	Data object
X0	Start button	Y0	Water inlet indicator light
X1	Stop button	Y1	Forward rotation indicator light
X2	All stop button	Y2	Reverse indicator light
X10	Low water level button	Y3	Drain indicator light
X11	Mid-water level button	Y5	Dehydration indicator light
X12	High water level button	Y6	End indicator light
X13	Washing times setting button		
X14	Rinse number setting button		
X15	Dehydration for five minutes button		
X16	Dehydration button for ten minutes		
X17	Dehydration for fifteen minutes button		

(2) PLC program

First, according to the requirements, use the mov command to design the water inlet time for high, medium and low water levels, respectively: low water level 2 minutes; medium water level 3 minutes; high water level 4 minutes. The three keys X3, X4 and X5 are controlled respectively. Before pressing the start button (X0), you need to select one. Similarly, set the dehydration time, and use the buttons X10, X11, and X13 to control dehydration for 5 minutes, dehydration for 10 minutes and dehydration for 15 minutes respectively.

Then use the INC command to set the number of washings and rinsing times. The user can set the number of washings according to the number of times the button (X6) is pressed, and set the number of times the button (X7) is pressed. After the user makes initial settings, press the start button (X0) and the washing machine works fully automatically. Press the stop button (X1) to pause the washing machine. Pressing the full stop button (X2) can terminate the washing machine. The program is shown in the following figure:

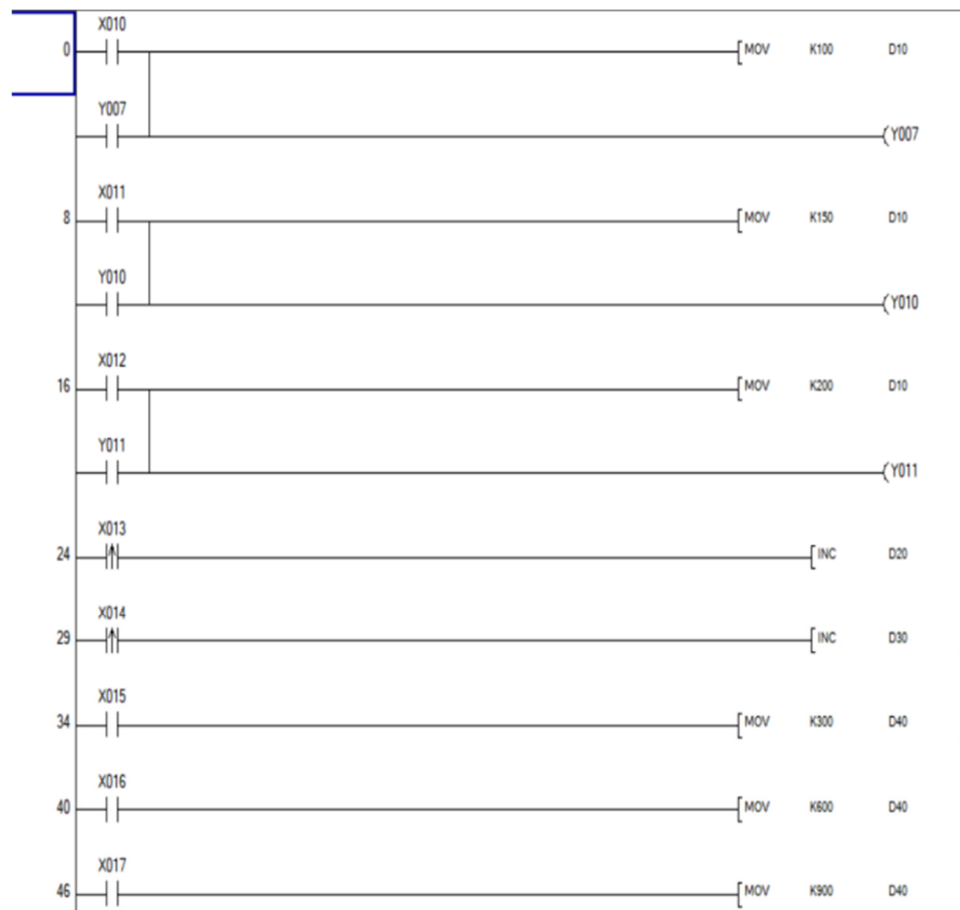


Figure 4. Parameter configuration program I

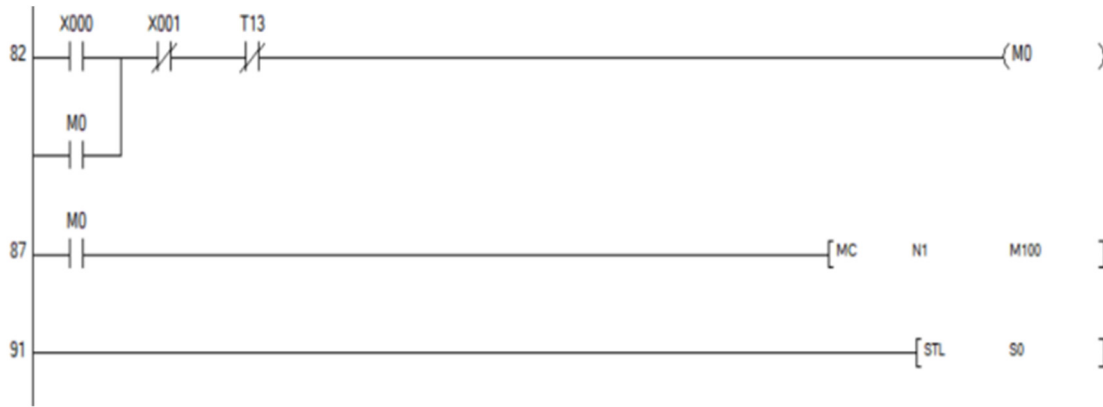


Figure 5. Parameter configuration program2

As mentioned above; after pressing the start button, the washing machine starts to inlet water according to the high,

medium and low water level selected by the user. The water inlet procedure is shown in the figure below:



Figure 6. Water inlet procedure

Similarly, after the water inlet is completed according to the requirements, the motor will rotate 30S forward, 3S pause, and continue to reverse 30S, so that the washing machine can complete the first washing process. According to the number of washes selected by the user, the laundry will automatically cycle according to the requirements. The program is as follows:

5. Experimental Results and Analysis

After the PLC program and touch screen program are

designed, in the GX Developer software, click the tool menu, select the ladder diagram logic test start from the drop-down list, write the compiled PLC program into the GX Simulator simulation debugger, and perform PLC virtual simulation. In the GT Designer3 software, click the emulator to start and start GT Simulator3. After starting, the program can be debugged. The final laundry process results are shown in the figure below. Note: (It is convenient to show that our operation of buttons is consistent with the actual object)



Figure 7. Loop program 1



Figure 8. Loop program 2



Figure 9. Loop program 3

First press the low water level button, the screen is shown in the following figure:



Figure 10. Press the low water button

Then we press the twice-wash setting button, the one-wash setting button and the five-minute dehydration button in turn, and the data display area changes accordingly. The picture is shown in the following figure:

After completing the initial setup, the washing machine starts to work, and the indicator lights such as water inlet, forward and reverse are lit in sequence according to the settings. Some of the screens are shown in the following figure:



Figure 11. Set operation parameters

6. Conclusion

In the process of system design and implementation, we make full use of the collaborative working ability of PLC and touch screen. The GT designer3 software is used to design the touch screen interactive interface. In a fully automatic washing machine, the PLC receives input signals from various sensors and controls the operation of various actuators according to preset algorithms and programs. For example, the user can automatically select the appropriate washing program based on factors such as the material of the washing material, stain degree, etc.; and automatically adjust the water level and washing time according to the operating status of the washing machine. These functions are implemented

through the programming of PLC.



Figure 12. System is running

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