PLC and Its Applications : A Wireless and Automatic Pet-Feeding System for Rabbits

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***Abstract*—In this paper we design a Supervisory Control and Data Acquisition system, which includes newly designed feeding device, programmable logic controller, a graphical human machine interface programmed with Visual Basic, plus, the Internet communication module. By using our system, the users only need a computer or a hand-held device that can connect to the Internet to achieve the goal of remote controlling and monitoring the feeding device.**

Keywords- programmable logic contorller (PLC); wireless; supervisory control and data acquisition (SCADA)

I. INTRODUCTION

According to Taiwan Taipei Rabbit Society Associations statistics, the number of people who keep a rabbit is up to 420,000 in 2010 in Taiwan [1]. The ranking of the most popular pets are led by dogs followed by cats and rabbits at the third place. The number of rabbit owners has increased rapidly around the world in the last few years. Since 2005, people begin to celebrate the "Worldwide Rabbit Love and Appreciation Day" in August [2]. However, Taipei Rabbit Society Associations warns whomever keeps a rabbit, need to take good care of it, since they are not as strong as cats or dogs.

Based on the statistics, the quantity of rabbits dying from abandoning and bad care is up to 17,000 per year. That is to say, nearly 67 percent of total death is caused by misconception [1]. Most of the abandoned rabbits die of heart paralysis or shock, due to their timid nature. However, holding a rabbit as a pet is not too difficult, since they only need to be fed twice a day. This also includes the supply with a sufficient amount of water. The purpose of the automatic feeder we proposed in this paper is to support people to maintain the basic needs of their pet.

The remote control and monitor system of this feeder is established by using Internet, Global System for Mobile Communication (GSM) and integrated Programmable Logic Controller (PLC). The whole system contains two parts, a remote control subsystem and a supervisory subsystem. Within the GSM covering range, complex logical actions can be controlled, instead of just operating an electrical switch.

In our study, a traditional PLC is used to control the hardware, and a simple Supervisory Control and Data Acquisition (SCADA) application software which can be used on mobile device and PC. Eventually, with the four wireless data transmission's major systems (Wideband Code Division Multiple Access (W-CDMA) [8], Code Division Multiple Access (CDMA) [9], General Packet Radio Service (GPRS) [10] and Personal Handy-phone System (PHS) [11]) cooperating and taking action, will turn the network transmit protocol (TCP/IP) into wireless operation. We will introduce the hardware we use in Section 2 and the prototype machine in Section 3.

II. MATERIALS

A. PLC

PLC is an electronic device with digital movement, its hardware design can be basically divided into two kinds, medium-large sized and miniature sized. Instead of mechanical equipment, the control function is reached by using integrated circuits and digital and analogy I\O modules [3]. PLC possesses order, timing, counting, computing, data process and communication, etc. The commands are stored in EPROMs. With the scientific and technological progress, the enhancement of CPU and single chip function, also improve PLC's abilities, functions and attachments can be offered by it thereupon increase.

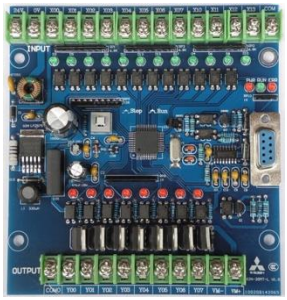

Figure 1. Mitsubishi PLC (FX2N-20MT-L)

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1) Mitsubishi's PLC Communication Protacal

The PLC device we chose is one of the Mitsubishi FX2N series which is shown in Figure 1. It is built as a master-slave-system. The PLC device is the slave, other device connected to the PLC is the master, for instance, the server that receive command from the client. In a master-slave-system the master sends commands to the slave systems. These slaves only send feedbacks only if receiving a request from the master. Hence data collisions are avoided. PLC device set up link through RS232, and PLC's Wi-Fi attachment, so we can let users control and manage the system in a browser or software by using a personal computer or mobile device. All functions can be controlled remotely like set up, daily arrange, food fall/stop, etc.

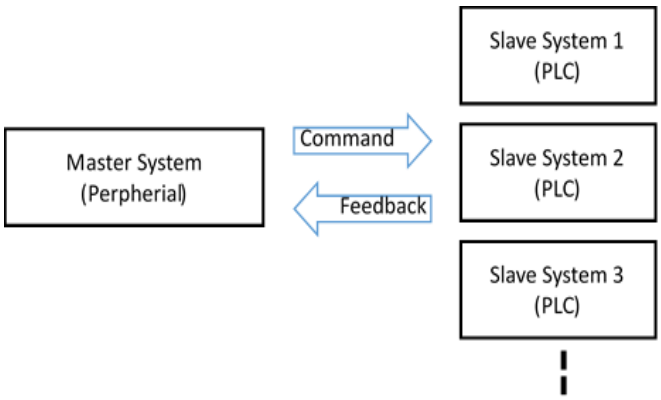


Figure 2. Fatek's PLC communication message format

2) Mitsubishi's PLC Communication Message Format

For possible kinds of messages, commands or feedbacks, the message can be split into 5 - 7 fields due to its command. All of these fields uses ASCII 16 bit code. In all cases the beginning letter is STX (02H). Field CMD are used to classify the command type (Table 1.), for example read/write, forced ON/OFF, etc. After asking data from Y0~Y7 (0A-00) and Y10~Y17(0A-01), which is shown in Figure 6. The slave system will pass the message back along with the data to the master system as shown in Figure 7.

Function	CMD	Assign to	Explain
Read	0	X,Y,M,X,T,C,D	Read Data
Write	1	X,Y,M,X,T,C,D	Write Data
Force ON	7	X,Y,M,X,T,C	Force Node ON
Force OFF	8	X,Y,M,X,T,C	Force Node OFF

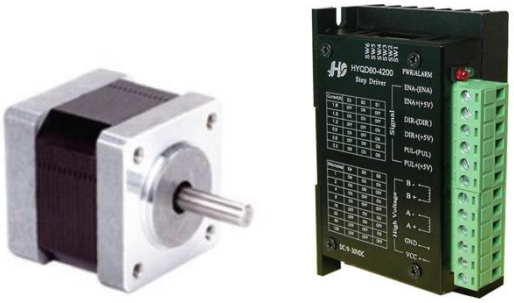
Table 1. PLC CMD code

The Device address is divided into two fields, and need to be read from the back, for example, Figure 10 is a command of forcing node Y1 (0501) to turn on, so the device address will be 0105. If the command is asking for data writing the fifth field will be the data that needs to be written, as shown in Figure 9, which is trying to write a value 3586. Next to it is the end-message code ETX (03H), let the system know the where the command ended. The last field SUM CHEK = CMD + DEVICE ADDRESS + BYTES + ETX, and only use the last two words, for example 30H+30H+30H+41H+30H+30H+32H+03H='166'H, so the check sum will be '66'H. For writing and force function command, the PLC will answer YES (06H) or NO (15H).

B. Stepper Motor And Motor Driver

Stepper motor is divided by the steps they need to complete a full rotation. The motor we use is a simplest two-phase stepper motor, it rotates 1.8 degree (±5%) every step. So, there will be 360/1.8 = 200 steps per full rotation. That is why the motor can finish simple but high accurate rotate/stop positioning. Advantages of stepper motors are low cost, high reliability, high torque at low speeds and a simple, rugged construction that operates in almost any environment.

After triggered by users, PLC will send the operate command with demanded motor speed and rotate quantity to the motor driver. The driver will converts the PLC command signals into electric pulse, which is provided by external power source, to energize the motor windings. The stepper motor then converts digital pulses into mechanical shaft rotation.



(a) (b)

Figure 3. (a) 35mm Series Motor (b) Motor driver

III. METHOD

A. Prototype Machine

The prototype machine is consists of PLC, motor driver, stepper motor, 50W external power source and home-made feeder shell. The PLC will send the signal to motor driver, the driver will then control the stepper motor to rotate the component which is attach on it. After stepping a few times, the pet food will fall into the bowl. The quantity of the food can be controlled by counting the motor's steps or timing the rotation.

Considering rabbits chewing habit, especially when they are hungry and it contains tempting smell of the food inside, the material of feeder's shell should avoid using plastic or anything that they should not been eating, so we decided to use wood. For the function of regular feeding,

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PLC's timer can easily finish the job, and for the quantity control, it is mentioned before. Beside our first prototype machine, we are considering using graphical user interface attachment for the ease of use. Therefore, after finishing our first prototype machine, we will take user survey into account and add new attachments in the future work.

B. *Combining Network*

For a typical industrial control system, the network fieldbus should be able to transmit real-time control messages and non-real-time maintenance messages. Nowadays, with the advantages of IEEE 802.15.4 standard's diversified network architectures, high reliability [5] and the advancement of wireless technology, a wireless network can be integrated into an existing fieldbus system. Due to this development, there are improvements in terms of mobility and flexibility and consequently in the ability to support applications [6] [7].

Moreover, considering the requirement of remote control, besides using normal RJ45 to connect self-home network station, we use Wi-Fi attachment (Figure 4) to control and monitor PLC from PC without virtual line. Other like WSN (Wireless Sensor Network) [4], can also achieve the same goal.

Figure 4. PLC Wi-Fi attachments (upper one for PLC, other one for PC)

C. *System Working Process*

The working process of our device is shown in Figure 5. After complete the start-up diagnose, users can connect to the system through virtual IP address, which is provided by the Wi-Fi attachment, to monitor and control. When the commands are sent, user-side will be waiting for the system to reply. Meanwhile, if the connection is good, the system will start process the command and send back a message whether it is success or not. After comparing the Checksum, the message will be displayed on user's device. Otherwise, the system will report error or timeout.

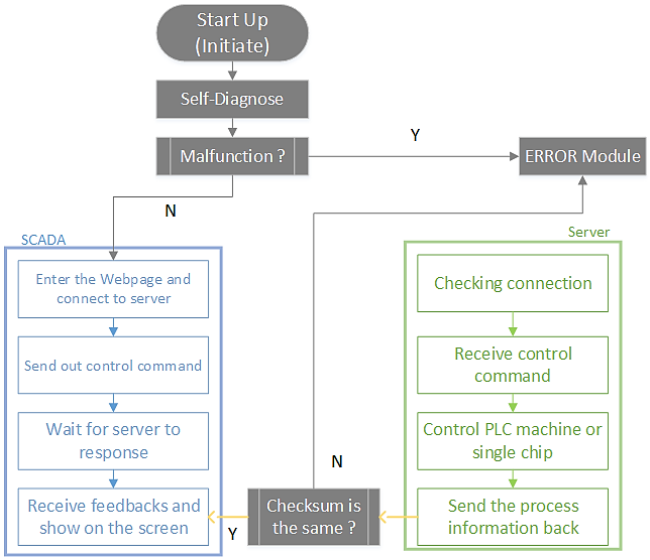

Figure 5. PLC's working process

D. *Webpage Graphical Human Machine Interface*

Graphical Human Machine Interface focus on using words, numbers, and pictures to transmit or reveal the relevant joint state and the value in data register. To control the device from far side, the simplest way is to write a server end program, then through a third-party software to achieve remote controlling, but people will need to pay for the software. With the advance of mobile devices and the wireless data transmission, a simple webpage or software can achieve the same goal, also, the computers have various types of browsers, it is much far more convenient than using other commercial software. To browse from web, programmers must build a server station which can connects to the Wi-Fi attachment first, it can control and process all PLC required function in the server, then sent the data back and shown in the webpage.

IV. CONCLUSIONS & FUTURE WORKS

In this paper, we have finished the build of our first prototype, the basic mechanism device. And our future work is to achieve the goals we mentioned earlier. We plan to find volunteered users to test the system's practicability and ease of use in our future work for system improvement. The final goal is to combine it with normal feeder and grass feeder. Once the system has been developed, it will be possible to lower the rate of pet abandoning and increase pet owners' willingness to actively take care of their new friends by knowing that : "Pets are our friends, not burdens".

After it's finished, we hope our research provides a good inspiration and make our idea fit for any other pets. If this idea can spread, by lowering the manufacture cost, every pet owners can enjoy the convenience of our system.

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STX	CMD	DEVICE ADDRESS	BYTES	ETX	SUM CHECK
CHR(2)	0	00A0	02	CHR(3)	66
02H	30H	30H 30H 41H 30H	30H 32H	03H	36H 36H

Figure 6. communication form – read data

STX	Y7~Y0	Y17~Y10	ETX	SUM CHECK
	35	86		D9
02H	33H 35H	38H 34H	03H	44H 39H

Figure 7. communication form – PLC return

Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0	Y17	Y16	Y15	Y14	Y13	Y12	Y11	Y10
0	0	1	1	0	1	0	1	1	0	0	0	0	1	0	1
3				5				8				6			

Figure 8. communication form – node data

STX	CMD	DEVICE ADDRESS	BYTES	WRITE	ETX	SUM CHECK
CHR(2)	1	00A0	02	3586	CHR(3)	3D
02H	31H	30H 30H 41H 30H	30H 32H	33H 35H 38H 36H	03H	33H 44H

Figure 9. communication form – write data

STX	CMD	DEVICE ADDRESS	ETX	SUM CHECK
CHR(2)	7	0105	CHR(3)	00
02H	37H	30H 31H 30H 35H	03H	33H 44H

Figure 10. communication form - force ON