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임베디드 시스템을 이용한 인터넷 제어감시 시스템에 관한 연구

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A Study on the Internet Control and Monitoring System using an Embedded System

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Abstract : Recently embedded systems are widely used in various industrial fields as supervisory controller because they have many merits. One of merits seems to be that operating environment of embedded system is the same as development environment using PC. That makes developing and manufacturing period shorten and also proper time to market. Most of all machinery have sequential control system for their maneuvering which is composed of relays, contacts, timers, etc.

In this paper, software sequential control system is proposed to be able to replace hardware sequential control system by using embedded system. A lot of merits by the software sequential control system can be expected in the respect of economic reproduction, intelligent technologies and utilities. And porting of LINUX operating system to embedded system is carried out and device drivers and interface boards for LINUX OS are designed for controlling air compressor by software. Internet remote control and monitoring system of air compressor is implemented with Java script and CGI for these purposes. The experiment for operating air compressor system is taken through internet networks. The results show that developed system can be used for real plant.

Key words : embedded system, internet remote control, monitoring system, air compressor

1. Introduction

Many kinds of automation systems are used in the industrial fields such as design, manufacturing, control and instrumenta-tion. Automation enables the production activity more effective and interactive. It can be also applied to the design of products, control of manufacturing process,

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fault diagnosis and recovery, and quality control. Automated mass production facility keeps the product quality uniformly and the human labor minimized[1][2].

If the systems are constituted with embedded systems which have its own OS(Operating System), not only all kinds of functions supported by OS can be used easily and but also huge automation systems can be constituted with tiny compact systems.

In traditional remote control systems, factory automation systems are constituted with distributed control systems using microprocessor and network systems using RS232C/422A/485. But according to automation systems become huger and huger, installation budget of network become greater and so remote control systems using internet protocol become increased.

But for remote control systems using internet protocol control software should be installed in the equipment to be controlled and great budget should be needed to maintain systems hardware and software. Moreover different software should be installed depend on system hardware [5][6][7].

One of methods to overcome these disadvantages may be to use web browser although the control systems using web browser have inevitable drawbacks for fast control and monitoring from remote location due to unpredictable delay on internet networks. Control and monitoring system using web browser can be applied to air compressor system which fast controls and monitoring from remote location is less severe relatively.

As the first stage to build control and monitoring system which has an intelligent decision making and fault diagnosis capability, software sequence control system using web browser is proposed to control and monitor air compressor system via internet from the remote place with a Linux embedded system.

2. Device Driver and Web Programming

2.1 Device Driver

All physical devices must have their own hardware controller. These hardware controller have their own unique control and status register called CSRs which is depend on device. CSRs have their own software called device driver to treat and manage themselves.

In this paper character device driver to control air compressor was designed and timer interrupt was used to implement sequential control algorithm as shown in Fig. 2.1.

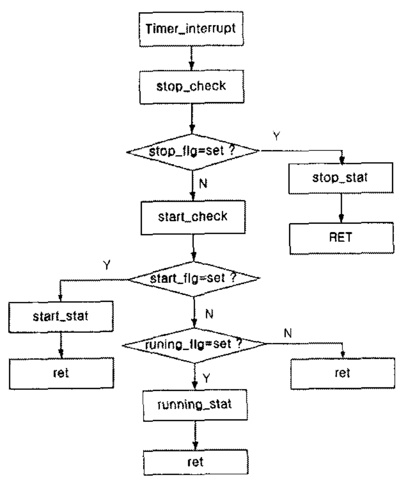


Fig. 2.1 Timer interrupt routine of character device driver.

2.2 Web Programming

Web server can be operated in embedded system which an OS is installed. So we can access to web server in embedded system via internet networks.

If remote control and monitoring systems are constituted with traditional application program, application program should be installed in every location to control the system.

Moreover compatibility problems may be aroused according to computer hardware systems[7][8][9].

To overcome these kinds of problems, remote control and monitoring system using web browser installed in computer commonly is proposed. And GoAhead, which is small web server program is used on embedded system.

Monitored data and their status can be displayed by web programming using JAVA script and CGI. Fig. 2.2 shows constitution of web program and Fig. 2.4 depicts an implementation. As in Fig. 2.2, web browser is programmed to have control buttons, edit boxes, status and alarm lamps, which can control plants and display their status and value informations.

If control button is pressed to control a plant, relative CGI would be active and device driver opened, then relative function called and carried out. Relative CGIs are carried out automatically at every sampling time to display various status and value by timer interrupt, and device driver opened and data or status retrieved.

But status display may be delayed due to image treatment through web browser and security problem may be aroused due to internet networks[10]-[14]. Only authorized person can access to the control web by acknowledgment process. Fig. 2.3 shows a login page for access.

If login process is succeeded then control and monitoring page is popped up as shown in Fig. 2.4. It has the same functions as traditional control and monitoring stand. Their function and buttons are such as start, stop, reset, emergency push button (EPB) and alarm lamps like low pressure alarm of air tank(TKP), over current alarm for motor(AMP), high temperature alarm of inlet air of air tank(AirT), low voltage alarm(VLT), high temperature alarm of lubrication oil(OilT), etc. Alarm lamp will be on for alarm status and off for normal.

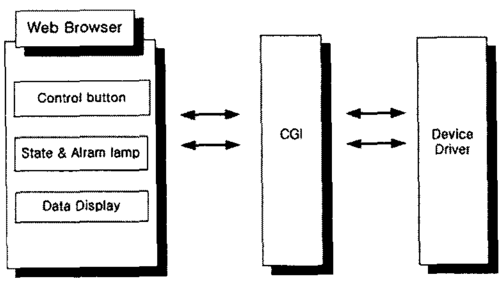


Fig. 2.2 Overall structure of web program

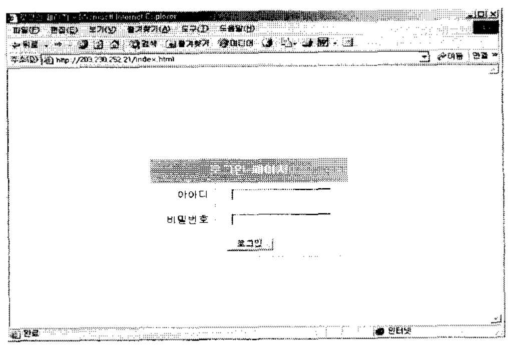


Fig. 2.3 Login page of web browser

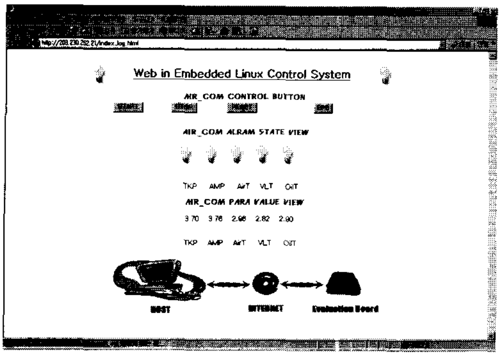


Fig. 2.4 Air compressor control page of web browser

3. Proposed Systems Configuration

3.1 Embedded Systems and Its Peripheral

Embedded systems are composed of MPC860T processor board and its drive circuit, LCD(4 line×20 characters), Keypad, A/D Converter and I/O extension.

Various timers and relays in traditional control panel are replaced with software timers and digital outputs of embedded systems, and all kinds of temperature, pressure transmitters and analog gauges with A/D converters and digital gauges. LCD and keypad are used for maneuvering, setting of various parameters and display. Fig. 3.1 shows block diagram of embedded systems and its peripherals and Fig.3.2 is implementation.

3.2 Configuration of Control Panel for Air Compressor

Interface devices between microprocessor board and control circuits of air compressor should be needed due to 440V/15A AC power supply for air compressor.

Even though proposed system can replace various timers and relays which are used in traditional starter and control panel of air compressor with TRIAC circuits, embedded systems and its I/O circuits and software timers, but magnet relays for motor driving are used due to their high current. But these can reduce the size of control panel a little, and moreover control and monitor mechanical system remotely through internet networks without any other alternative equipment.

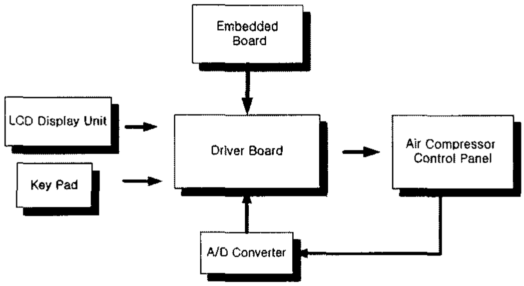


Fig. 3.1 Configuration of embedded systems and its peripherals

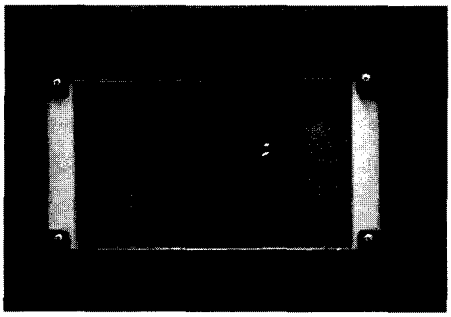


Fig. 3.2 Proposed air compressor control panel using embedded system

Fig. 3.3 shows traditional start and control circuit for air compressor. For replacement of these kind of relays and timers, digital outputs of embedded systems are isolated with high speed photo couplers and photo driver circuits for TRIAC.

All pressure and temperature switches

are replaced with transmitters to read pressure, temperature and digital outputs isolated from digital ports of embedded systems.

These kinds of software control circuit design will increase productivity because only software revision will be able to cover the changes of hardware, while in traditional design hardwares should be reproduced for every change of sequential control circuits. Much advantage will be that mass production of hardware and reduction of manufacturing price can be achieved.

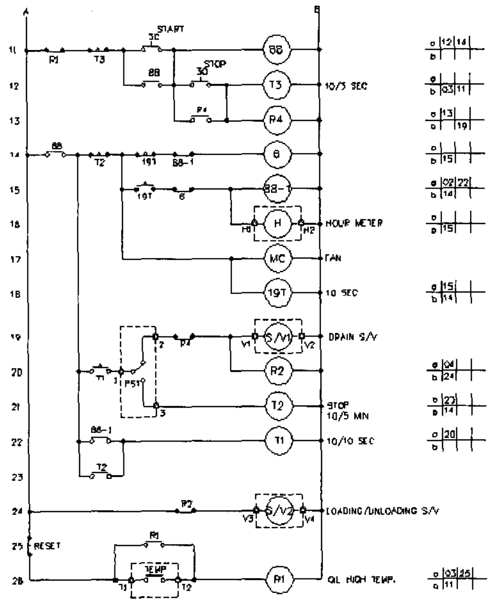
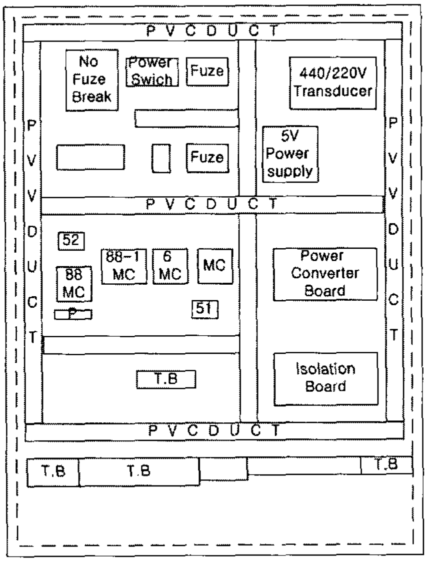
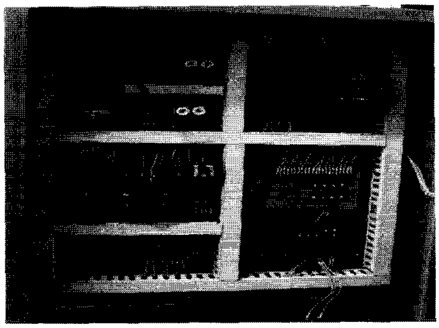


Fig 3.3 Traditional control circuits of air compressor

Fig. 3.4 shows newly designed software control panel using embedded systems. As shown in Fig. 3.4 only circuit breakers, magnet contacts for motor drive and transformers for voltage down are used except embedded system and interface board for I/O.



(a) Block diagram of control panel



(b) Photo of control panel

Fig 3.4 Proposed air compressor control panel

3.3 Overall Configuration of Systems

Overall system is composed of client PC on internet networks, embedded system acting as server installed on the control panel and control panel H/W as shown in Fig. 3.5.

Various data and status of air compres -sor can be collected and controlled by embedded system software through device driver from various sensors in control panel H/W.

According to the mouse click on GUI of client web browser on internet remotely, client web browser accesses to web server installed on the embedded systems and takes and treats data collected on device driver of air compressor through CGI. These process can make air compressor be controlled through device driver according to control commands.

4. Experiment and Analysis

Fig. 4.1 shows configuration of experi -mental equipment. Host PC is only used for downloading the OS Kernel and application software by NFS(Network File System) method. After downloading the software to embedded system, PC doesn't play any roles for control. If the embedded system of RAM disc version for merchandise is available, PC will not be used.

For the performance tests, remote control experiments on web browser and local control on keypad of embedded systems are carried out as changing voltage of potentiometer that is dummy signals of temperature and pressure transmitters. Temperature alarm aroused and compressor stopped when inlet temperature dummy signal of air tanks was over alarm set point and pressure of air tanks reached compressor stop set point. When the pressure dummy signal was lower than compressor start set point, magnet contact 88 and 6 was on and compressor motor started as Y connection. After 10 seconds magnet contact 6 off and 88-1 on resulted in Δ connection operation of it. The experiment for automatic and manual operation in the case of remote and local control acts same as traditional control panel.

Fig. 2.4 shows performance test on web browser. Results of performance tests on web browser are same as those on key pad.

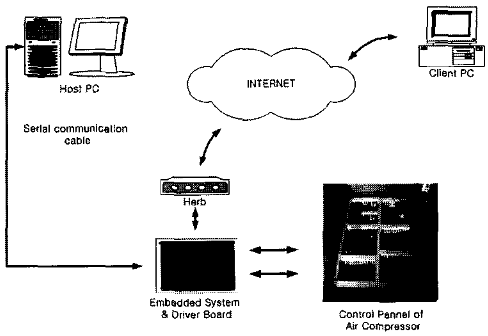


Fig. 4.1 Configuration of experiment

5. Conclusion

In this paper internet remote control and monitoring system using embedded system is proposed. For internet control and monitoring device drivers are designed for air compressor system and H/W and S/W are implemented. This kind of design results in increasing productivity because only software revision will be able to cover the change of hardware, while traditional design should be reproduced hardwares for every change of sequential control circuits. Moreover start and control panel is compact due to replacement of various timers and relays with software timer and digital outputs. For the performance tests, control experiments on web browser and on key pad of embedded system are carried out and show satisfactory results for merchandise.

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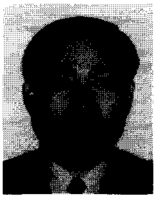

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