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Design of Real-Time Remote Monitoring System for Energy Efficiency Using PLC and HMI

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Abstract: The energy efficiency management system is a system that remotely monitors and controls the energy consumption of homes and buildings, collects and analyzes monitored energy related information and performs integrated management related to energy efficiency through simulation. In order to construct such a system, communication and control measures between energy consuming devices including energy consumption unit, major household appliances and communication method between remote and energy consumption points and simulation and software development are required. In this study, an energy efficiency management system was designed. In the ICT environment, remote monitoring and control facilities were used based on automation equipment such as PLC and DCS (Distribute Control System). It was designed and implemented a real time monitoring system by linking smart I/O interface with HMI (Human Machine Interface) Software package for PC. The PLC is connected to the server and the PC is connected to the client to run the system.

Key words: Energy efficiency management system, PLC, DCS, smart I/O interface, HMI Software, communication method

INTRODUCTION

The energy efficiency management system is a system that remotely monitors and controls the energy consumption of homes and buildings, collects monitored energy related information and provides integrated management related to energy efficiency through analysis and simulation (Lee, 1995). In order to construct such a system, communication and control measures between energy consuming devices including energy consumption unit, major household appliances, communication plans between remote and energy consumption points and software development and simulation methods are needed. Many researches were performed to reduce standby power in the region of chip, circuit, board and system (Thanachayanont and Sirimasakul, 2009; Tsai *et al*., 2009; Lee, 1995; Calboun and Chandrakasan, 2004; Heo *et al*., 2008; Huang *et al*., 2007). Those various technical researches contributed to the reduction of standby power of home devices.

The purpose of this study is to establish an energy efficiency management system, to enable remote monitoring and control of energy consumption and to collect and analyze scientific information on energy consumption information. This information is used as a basic data on energy policy and it is possible to utilize more efficient energy source by analyzing and predicting through simulation based on this information (Lee, 1995).

In addition by controlling the energy consuming device, the user can control the energy consumption of the energy consuming device which will result in enormous energy saving effect (Lee, 2010). In the future, this energy efficiency management system will be reflected in the energy use management system (energy saving system) of the comprehensive energy management system and it will be utilized as the data of the energy management informatization policy.

MATERIALS AND METHODS

Remote monitoring and control facility: The remote monitoring and control facility is an integrated management system that integrates ICT with existing energy processing technology based on automation devices such as PLC (Programmable Logic Controller) and DCS (Distribute Control System). It is a solution to manage and operate in an optimal state (Pyo, 2014). This solution can maximize the efficiency of resource consumption by inputting and outputting information on industrial sites or energy supply sites from standardized equipment with analog or digital values.

PLC: A PLC (Programmable Logic Controller) is a special form of microprocessor-based controller that uses programmable memory to store instructions and to implement functions such as logic, sequencing, timing,

Fig. 1: Process map of PLC

counting and arithmetic in order to control machines and processes. It is designed to be operated by engineers with perhaps a limited knowledge of computers and computing languages. They are not designed so that only computer programmers can set up or change the programs. Thus, the designers of the PLC have programmed it so that the control program can be entered using a simple, rather intuitive form of language (Bolton, 2015) (Fig. 1).

It is a device that integrates the functions of existing relays, timers, counters, etc., so that, it can be controlled by a program using a microprocessor. NEMA defines "digital electronic devices that use programmable memory to control special functions such as logic, sequencing, timing, counting and arithmetic through digital or analog I/O modules and controlling various types of machines or processors" have. Performs arithmetic, logic, function, adjustment and data processing as well as sequence control. It has superior reliability of control functions compared to existing relays. It can easily modify and change control contents and perform complex control functions (Han *et al*., 2011).

It is used extensively in various automation systems including process control devices. Especially, it is also indispensable in Computer Integrated production (CIM) construction because it can communicate with computers. The structure consists of three parts: a central control unit for control processing an input unit for receiving an input signal and passing it to a central control unit and an output unit for delivering the result of the processed signal to the control object.

Core element of IoT-sensors/device: Sensors are the first stage in which objects recognize and produce information and various sensors can be developed depending on the objects to be sensed, the method, the implementation technology and the application field. It is an information device that measures physical/chemical/biological information from a measurement object and converts it into a signal that can be read by an observer or a system. The smart sensor currently in commercial use combines logic/judgment/high-precision, high-convenience, high-value-added sensor that performs self-diagnosis and decision-making functions (Han *et al*., 2011).

Recent developments of sensor devices and sensor network technology have led to the development of devices. The device creates new application services that utilize its own built-in sensors as well as smartphones and smart appliances that are commonly encountered. In addition to the existing built-in sensors, the application of IoT device can provide various services by utilizing external sensor information and external internet environment.

RESULTS AND DISCUSSION

Configuration of system

Smart I/O interface: The smart I/O interface is installed in a device that can control the energy supply. It can control network information, wiring reduction and real-time control of distributed input/output and supports Rnet, DeviceNet, Profibus-DP, Modbus (RS-422/485). This versatile smart IO device can be applied to many energy control applications to prevent and consume resource consumption (Fig. 2).

Ethernet communication: Smart I/O Modbus (RS-422/485) module is used as available Ethernet Module. This module is intended for use in communication with Programmable Logic Controllers (PLCs) used to automate and control machines in manufacturing plants or amusement parks. Although, the protocol is simple, it is used as a de facto standard protocol because it can perform the functions required for equipment control and monitoring and is widely used for connecting industrial electronic devices together. In addition, it is easy to install and maintain and it is easy to manipulate information in units of bits or words (16 bits) (Fig. 3).

Modbus can connect approximately 240 devices to each other. For example, several devices that measure temperature and humidity can be used to report to the monitoring server the current status. Generally, the server sends queries to the sensing devices and the devices respond in response. Supervisory Control and Data Acquisition (SCADA) systems also frequently use Modbus to connect the monitoring server to the Remote Terminal Unit (RTU).

Central control and monitoring solution: The centralized control monitoring solution collects data of various equipments installed in the energy supply site in real time

and establishes a data transmission system for the operator to monitor and analyze the operating status comprehensively. It is also a HMI (Human Machine Interface) software package for PCs with centralized monitoring function and a comprehensive system operating remotely. The system performs real-time monitoring functions in a wide area. The related software provides functions that can operate in the latest operating system thus enhancing the reliability of the automation system, the speed of processing and the ease of operation (Fig. 4).

Fig. 2: Smart I/O interface of LG

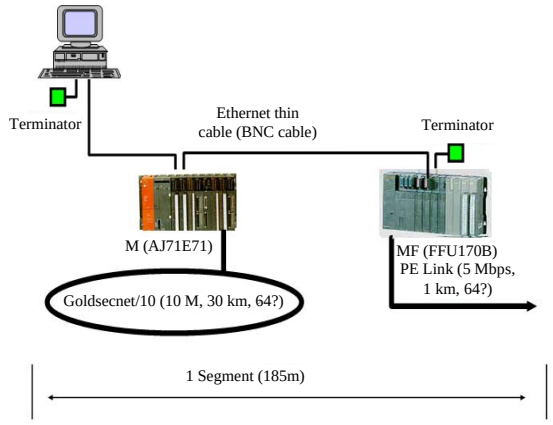

Fig. 3: System configuration between PC and PLC using Modbus

The data management function as a comprehensive system is a function that performs data collection, storage and calculation processing of the operating state and performs service for the operator's data request. In addition, the monitoring function which is the main technology of NEP authentication, provides the real-time data through the graph on the screen configured according to the operator's purpose and has the function of interpreting the encrypted HEX code type protocol used in Korea easily. By using this, each control point can synthesize the data of the PC where the solution is installed and the control observer can analyze it and calculate or control the statistics.

Operation between client and server: Communication between the client PC and the PLC which is the server is requested from the PC and then the normal connection processing is completed when the server's PLC receives a response to the open request. In the next step, the data is communicated to the client and the server, respectively. In the final step when the close request is made on the PC by the close step, the server finishes the close process. As shown in Fig. 5, the system flow between client and PLC is as:

- Initialize the winsock in the PC and set the address family and socket type to create the socket
- Assign the address to the generated socket and bind it

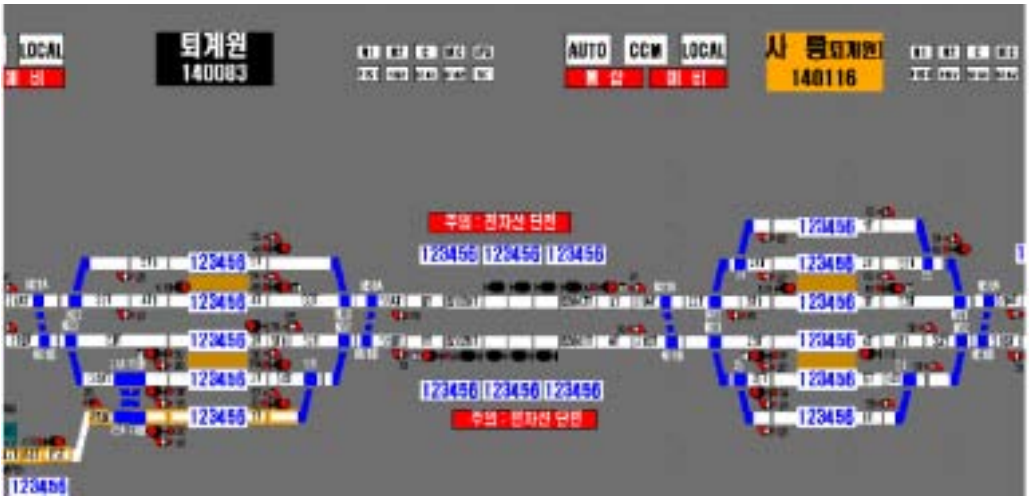

Fig. 4: UI of real-time monitoring system

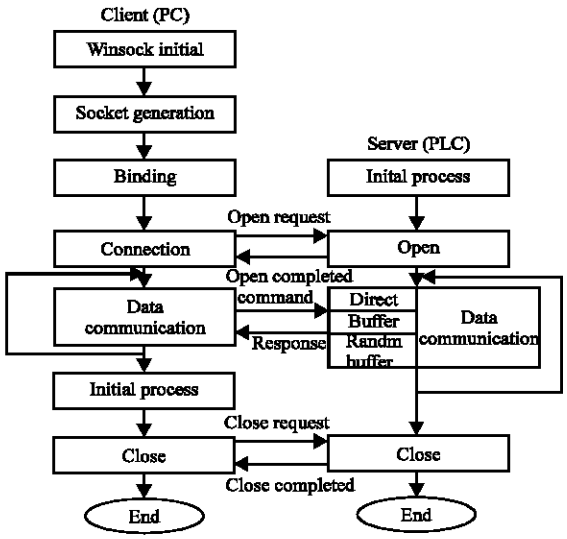

Fig. 5: System flowchart between client and server

- In the PLC, initialize the IP address and TCP/IP related timer of the local station
- The PC requests to open the PLC
- The PLC waits until the PC becomes active connection request. That is, it waits for a passive connection state and then completes the open operation to process the connection
- Send command for data communication in PC and send response signal in PLC
- Data exchange is performed repeatedly in PC and PLC
- When the data communication on the PC is finished, request to cancel the winsock
- When requesting the active close of the connection set in the PC, the PLC closes the passive close of the established connection

CONCLUSION

The current global energy crisis is becoming reality as the limits of existing energy become visible. The domestic reality is more urgent because of the dependence on high energy overseas due to lack of resources and the unstable structure of energy supply and demand. In order to solve this energy crisis, it is necessary to study efficiency management in terms of energy consumption. To do this, it was first designed a real-time remote control system that enables remote monitoring and control of energy usage of energy consuming devices.

RECOMMENDATIONS

Future needs include monitoring and control software for energy consumption devices, analysis software for analyzing the collected information and simulation software for testing the energy efficiency of buildings. Also, it is necessary to study the development of software suitable for building energy efficiency management system including function analysis of existing software by classifying the software required for building energy efficiency management system.

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