Building Automation System for Energy Saving Using The Simple PLC and VDO Analytic

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Abstract— **Energy Saving in the building is the main concern for LEED certification for green building rating. In Thailand, the major load power consumptions are from Air-conditioning and lighting. The energy saving method introduced for last decade is to use the low-powered device and higher efficiency such as frequency inverter and LED lamp. However, the control device mostly specified by product manufacturer and costly to integrate in Building Automation Systems (BAS). Moreover, the sensing device using simple detectors, such as thermostat and light sensor, sometimes not comfortable for the users in the room and waste the energy. This paper introduces two major approach. Firstly, is to use simple PLC instead of DDC. Secondly, is to use to VDO Analytic for sensing and controlling. The simple PLC can communicate to any device either digital or analog signal. Unlike the IP-based controller, the PLC is optimized solution since the building I/O points is very few. The VDO Analytic, object detection color detection and face recognition algorithm, combine to the PLC gives the more accurate controlling and energy saving. The additional benefit of using CCTV for sensing device is to use also for security system of the building. The results show that the energy costs is decreased and get the better comfortable. The optimization of energy cost and cost of sensing device is also investigated.**

Keywords— LEED; Building Automation System; Energy Saving; PLC; VDO Analytic

I. INTRODUCTION

Currently, the energy crisis is the concern that the world's demands on the limited natural resources. Both governments and concerned individuals are working to make the use of renewable resources a priority, and to lessen the irresponsible use of natural supplies through increased conservation. Building Automation System (BAS) is one of solution of the energy crisis. Not only BAS concerns a security but also energy saving. However, peak demand is the one of energy saving problem because it is the problem of highly consumed energy.

Generally, controlling peak demand in BAS uses computer in controlling load. However, in re-design system for peak demand, PLC is one of the best solutions because it is easy to add input, output, and program. Air-conditioning is the one of big load in the building so is highly energy and peak demand. We can divide the air-conditioning energy saving methods into two groups. The first method is the predictive control method based [1]. This method tries to solve the long delay in temperature control of return air. Although this method can be used as prevention for waste of energy, it is difficult to construct the precise mathematical model for estimating cooling load of occupancy.

The second method is the fuzzy control based method [2]. This method concerns the nonlinear and uncertain characteristic in air-conditioning system by achieving both energy saving and the temperature of air-conditioning. For peak demand, in this paper, if we can control component of each load, a value of peak demand is highly reduced.

We propose sub local loads to reduce peak demand in the building. The sub local load is the component of global load. The remainder of this paper is organized as follow: Section II describes basic idea, section III describes proposed schematic, section IV provides experimental results, and finally, the last section is conclusion.

II. BASIC IDEA

LEED (Leadership in Energy and Environmental Design) is a globally recognized symbol of sustainability achievement used for green building rating system. Major concern to get LEED certification is energy saving. In Thailand, the most electrical power consumption is from cooling air-conditioning system and lighting system. The way to save the energy from air-conditioning and lighting is to use high efficient equipment and to use control device.

Fig. 1 Inverter for condensing unit

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For air-conditioning system, the frequency inverter and actuator have been integrated to the condensing unit as shown in Fig.1 and chilled water pipe as shown in Fig. 2 respectively.

The LED lamp is also replacing the fluorescent lamp to get higher lamp efficacy (lumen per watt) for lighting system as shown in Fig. 3. The inverter, actuator and LED lamp driver is designed to support the control system both digital (ON/OFF) signal and analog (0-100%) signal. The integration of sensing device, controller, control interfacing and management software called Building Automation System (BAS).

Fig. 2 Actuator for chilled water pipe

III. Problem Identification

A. Air-Conditioning Control (Original Scheme)

Original Air-conditioning control as shown in Fig. 4 of the BAS for central cooling system, such as chiller system, comprise of sensors and controller as followings:

- Sensors: temperature sensor chilled, chilled water temperature sensor, motion sensor
- Controller: DDC, actuator, fan starter

Fig. 3 LED dimmable driver

The simple control function for the BAS are

- temperature sensor detects room temperature then compare to the temperature set point
- Temp different of the detected temperature will adjust chilled water valve actuator to keep room temperature close to the temperature set point as feedback control loop.
- To on-off fan speed and valve actuator when motion detector detects no working in the room

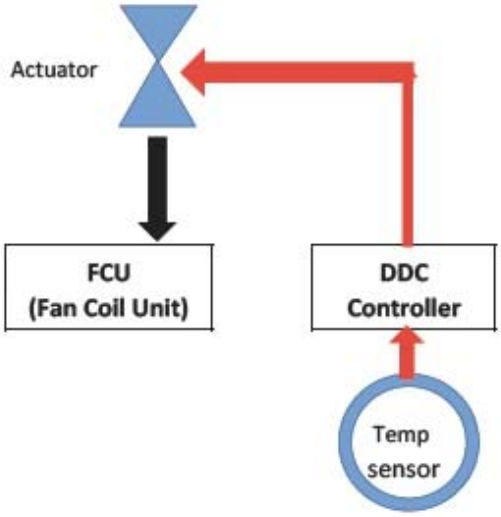

Fig. 4 Air-conditioning control (Original Scheme)

The original BAS for air-conditioning control still can be developing for more energy saving. The idea is to reduce the waste cooling point in the room

- To adjust room temperature set point according to type of room, room owner comfortable, number of working people in the room or type of activity
- To reduce speed or shut-off the motor fan for the waste cooling zone in the room

B. Lighting Control (Original Scheme)

Original Lighting control as shown in Fig. 5 of the BAS comprise of sensors and controller as followings:

- Sensors: light sensor, motion sensor
- Controller: DDC, dimmable LED driver

The simple control function for the BAS are

- Light sensor to on/off or dim the LED lamp according to lux level requirement.
- Motion sensor to on/off the LED lamp according to the usage of the room or required security zone.

The original BAS for lighting control still can be developing for more energy saving. The idea is to reduce the lighting of the waste zone.

- To dim the lighting at the zone has no activity in the room

- Replacing stepping light sensor by actual continuous light level controlling

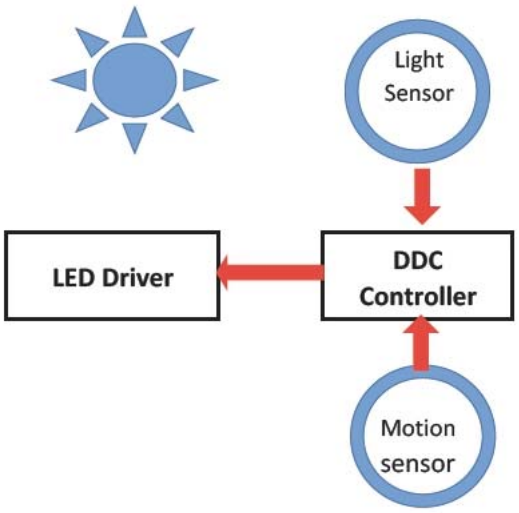

Fig. 5 Lighting control (Original Scheme)

IV. Proposed Schematic

A. Air-conditioning control (Proposed Scheme)

The proposed Air-Conditioning Control of the BAS for central cooling system using simple PLC instead of DDC. The PLC control has been introduced to extract actual load for split-type air conditioning [1] as shown in Fig. 6. The additional VDO Analytic using CCTV is introduced instead of motion sensor to get more precisely detection.

The simple control function of the PLC are as followings:

- To on-off fan speed and valve actuator according to the detected working people in the zone
- To automatically adjust the temp set point according to the type of activity. For example, the multi-function room shall have different temp set point by meeting function compared to dining function.
- To adjust temp set point according to activity of each person using face-recognition VDO analytic. For example, when the movement of detect staff comes to in the room from the hotter area, he/she may require more cooling capacity at the beginning.

The proposed Lighting Control of the BAS using CCTV and VDO Analytic instead of light sensor and motion sensor to get more precisely detection as shown in Fig. 7.

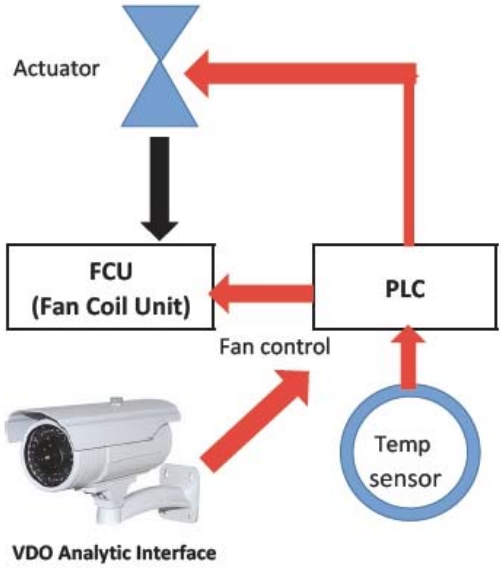

Fig. 6 Air-conditioning control (Proposed Scheme)

B. Lighting control (Proposed Scheme)

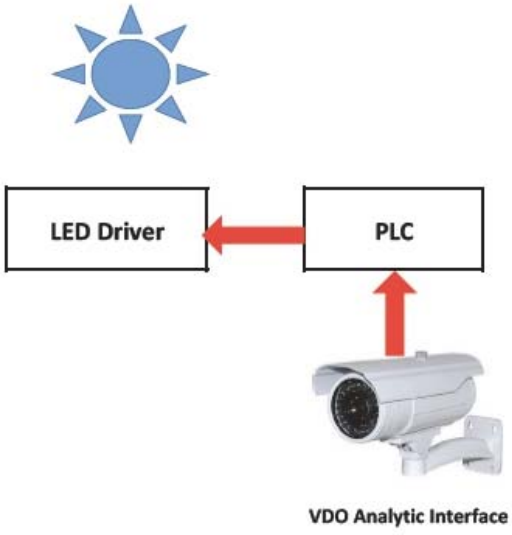

Fig. 7 Lighting control (Proposed Scheme)

The simple control function of the PLC are as followings:

- To dim lighting according to the detected working people in the zone
- To automatically adjust the light level according to the type of activity. For example, the multi-function room shall have different lux level by meeting function compared to working function.
- To adjust light level according to activity of each person using face-recognition VDO analytic. For example, the light will turn on only the path and the room area for his/her office zone only.

V. Simulation Results

The simulation using energy cost and investment cost estimation has been calculated and compared between original scheme and the proposed scheme.

The assumptions of the simulated systems are as followings:

- I/O points < 24 points (1 DDC, 1 PLC)
- Replace one light sensor one motion sensor by 1 sets of CCTV + VDO analytic
- Target investment cost increasing for VDO analytic not more than 100,000 THB
- Target energy cost saving 10%, TOU metering (average 3.5 THB/kWh)
- Target payback period < 2 year
- Hardware cost excluding (Air-conditioning, LED lamp, PLC, DDC)

The results show that the break-even point (2 year payback) is to use with the room that consume energy > 12000 kWh/month as shown in Fig. 8.

VI. Conclusion

The benefit of using CCTV for sensing device and VDO analytic is not only for security purpose but also for the energy saving, better work condition and more comfortable. The system load 12,000 kWh/month if saving 10% by investing CCTV/VDO Analytic for 100,000 THB shall payback within 2 years as shown in Fig. 2. The lower investment cost and the more energy saving the shorter payback period. The larger scale of I/O points shall reduce investment unit cost. The prototype is being develop for further study and combine to the smart-grid system.

Acknowledgment

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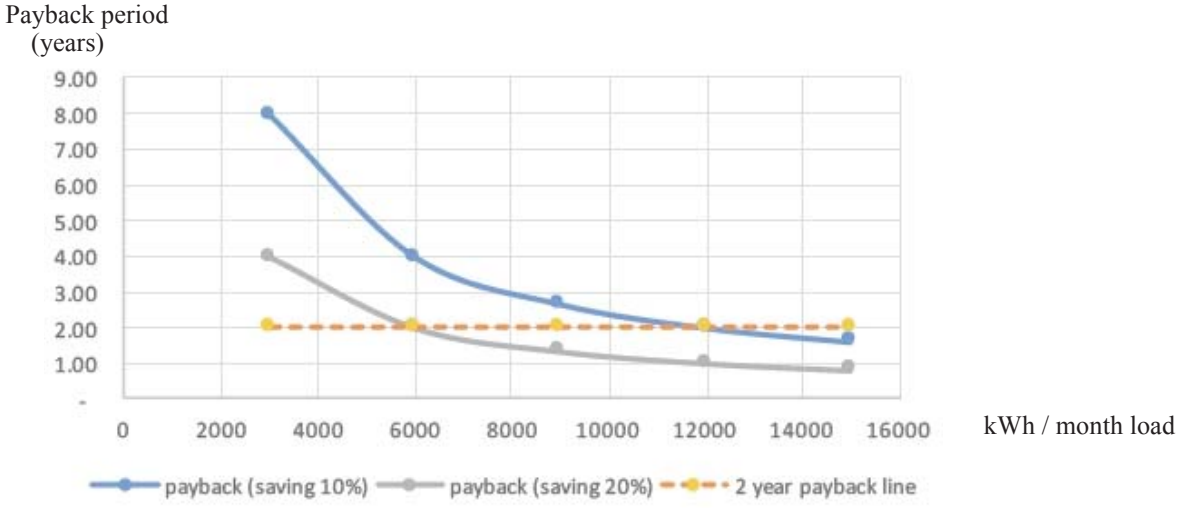

Fig. 8 Payback period vs. kWh per month load