Energy Efficient Building Automation Using PLC and SCADA

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***Abstract*— The Market value of huge capital invested Buildings can be maintained only if they are operated cost effectively. Currently, buildings account for 40 percent of the energy consumed worldwide. Almost all multi-storied buildings, Malls, Multi specialty Hospitals etc. are designed to accommodate Building Automation, which results in a healthy room climate and higher user satisfaction thus minimizing ever increasing operating cost. SCADA (Supervisory Control & Data Acquisition) which is used to integrate different type of data's (Occupancy, temperature, illumination, energy meter, security system etc.) and enable monitoring in a centralized single window through PLC, which is used as a Logic solver and Interact with input sensors and output devices. These systems assure all the requirements of a building and offer as a tool to the Maintenance Management as user-friendlier interface, accessible from distance and from many places. The using of SCADA system had led to notable energy saving and reduced running costs. The controlled strategy is a combinational logic performed by programmable logic controller and the overall data acquisition energy monitoring performed by a centralized SCADA system, which interacts with PLC. Tests applied to the control of temperature, occupancy change detection in huge area rooms are presented. The novelty lies in this case in its treatment of the sensing systems, while Existing system techniques uses only the Point type detectors and wired sensors. The proposed system uses Occupancy change detection algorithm and Temperature sensors.**

Index Terms— Programmable Logic Controller (PLC), Supervisory Control & Logic Controller (SCADA), Human Machine Interface (HMI) Building Automation System (BAS)

I. INTRODUCTION

In order to optimize building energy consumption and comfort, integrated operational concepts are required. Energy consumption varies starkly for different types of buildings and users. All of the energy sources, be they heat, electricity, gas or renewable energies, must be optimized while maintaining a healthy indoor climate. The characteristics of the building, the type of use and the number of people (occupancy) within it constitute the framework conditions under which its energy-efficient operation is to be achieved through active monitoring and integrated, intelligent management. Additionally, security concerns have also pushed the development of automatic systems to be integrated in building automation. Advanced systems additionally integrate, in a network environment, security video cameras in real-time monitoring and control. Commonly all these data is made remotely accessible through Internet or phone-GSM communication networks.

II. SYSTEM DESCRIPTION

A.Programmable Logic Controller

The PLC [2] controls the lighting and cooling system in malls and buildings according to the Logic and the input status received from camera and sensors. The video frames output from the camera is processed using MATLAB [9] and Hardwired output fed as a digital input to the PLC and also the temperature Sensor signal as a Analog input fed into the PLC.It works on the basis of Sequence defined (Ladder Program) Logic [3] condition and execute the output devices accordingly. The generated output signals are sent to output devices such as relay, electromagnetic valve, motor drive, and control of a machine or operation of a procedure for the purpose of machine automation or processing procedure. The peripheral devices (e.g. personal computer/handheld programming panel) can easily edit or modify the program and monitor the device and conduct on-site program maintenance and adjustment. The ladder diagram is the most widely adopted language which adopts the symbols that are easy to recognize and shown on computer or data sheets.

B.SCADA

Simultaneously through Ethernet communication link SCADA HMI displays the Equipment running status and also the Energy consumed. Energy consumption meter input also fed into the PLC, so the SCADA [1] shall calculate the Energy Efficiency based on the standard load condition. Supervisory Control and Data Control is an automated system based on techniques of computer network and modern control. It is a multi-function system that can achieve equipment supervising and control, data acquisition,

state inspection, history data inquiring and alarm signal in case of running faults, etc. Human Machine Interface (HMI) & SCADA Solutions vary widely from simple and straight forward to complex and demanding Wonderware In touch HMI & Visualization software coupled with the Intouch Wonderware System Platform are uniquely positioned to be extremely easy to use as well a powerful and sophisticated to meet the most demanding and challenging of solution requirements.

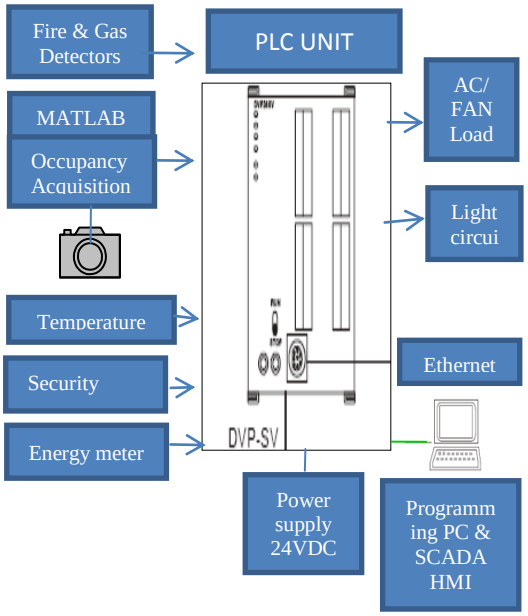

Fig 1. System Architecture

The presented system can be expanded to big building like hospitals, hotels, malls and office buildings etc.

III.Logic Control Strategy

PLC manages a set of distributed sensors and actuators (temperature, occupancy, HVAC, lights, fans etc) and all this distributed information is supplied to SCADA system. Different conditions of temperature, occupancy, fire&gas sensors input and security system inputs and other attributes in huge area rooms can be considered in the developed model. In this paper is shown the potential of this control system by implementing a logic controller at the control level, coupled with the SCADA supervisory control, as an example of how this strategy can manage complex logics. This supervisory and control strategy appeared first in complex multiple/input/multiple output industrial processes (MIMO) with multiple operating points that had to be fine monitored and controlled [8] Now facing the high complex environments within BAS, these industrial complex control strategies seem to be very suitable for BAS context.In this proposed control logic Ladder programme [6] written based on the cause and effect matrix table (Table 1). In this table the Load column values were assumed values for the simulation purpose,each lighting circuit consume 10% of the total power and each AC circuits consume 35% of the total power.

IV. SYSTEM IMPLEMENTATION

For single window centralized monitoring this system uses computer/server that runs InTouch Wonderware (Invensys Systems, Inc) version 10.1 All the data acquired from the building with the Analog /Digital modules are transmitted by the Delta PLC's [5] through the real time Industrial Ethernet [4] to this computer that is equipped with an Industrial Ethernet PCI board. SCADA is a powerful engineering and runtime HMI application for use on Windows operating systems, which communicates with both the operator and the automation system and thus operator, can run and monitor the process.

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Table 1 Logic simulation based on Cause & Effect

Occupancy change Detection using Two Dimensional

a.Cross Correlation

First the two images were sub divided into four equal parts each. This was done to increase the sensitivity of calculation where it is easier to notice the difference between part of image rather than a whole one. A two dimensional cross correlation was calculated between each sub image with its corresponding part image. This in the other process produces four values ranging from 0 to 1 depending on the difference of the two correlated images. Because the goal of this division was to achieve more sensitivity the minimum value of correlation will be used as reference to the threshold. In normal cases, Occupancy change can easily be detected when the measured minimum cross correlation value is used to set the threshold. The flow chart as shown in fig.2 for the steps involved in the Matlab works. The threshold value will be maximum of 1 and the flag bit will be 1 for start and 0 for stop bit through manual input.

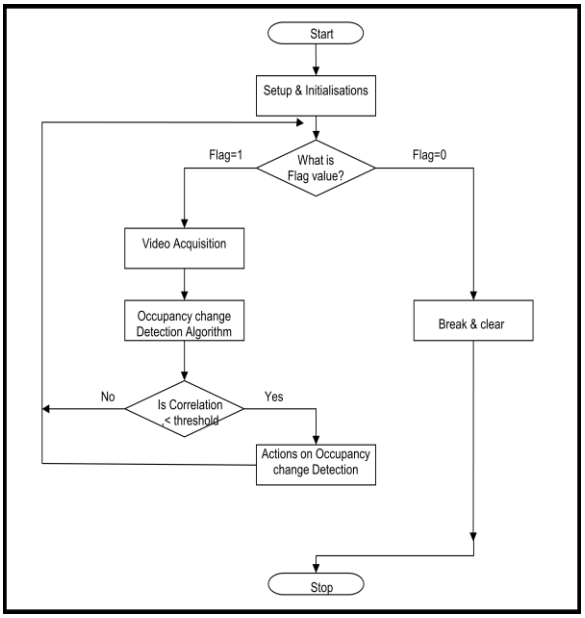

Fig.2.Occupancy change detection Flow chart

V. RESULTS

The results presented in this chapter aims to demonstrate the ability of the developed controller strategy. The controller developed in section 3 was tested. In fig 1 is shown architecture of an implemented controller, running in the PLC ladder Simulation Software and SCADA InTouch Viewer Simulation Software. This controller manages the temperature and occupancy of one conference room according to user preferences and subjected to the main constraint of energy consumption minimization. The occupancy detection algorithm cannot be implemented directly on the SCADA system since this system does not have complex mathematical operations requested by this detection algorithm. So it is necessary to develop a link between PLC and Matlab Software. The real time data acquired from PLC is communicated through Ethernet Protocol in SCADA HMI

a. Energy Saving

The ratio of energy input to the calculated or estimated amounts of energy required to cover the various requirements relating to the standardized use of a building serves as the measure of energy efficiency.

After the SCADA system is used, the energy consumption is reduced which leads to great economic benefits. Temperature is very important in the operation of cooling system (HVAC) as the indoor temperature changes, the cooling system loads will change correspondingly as shown in Fig 3 and for Occupancy change as shown in Fig 4. Since energy meter input is fed to the SCADA the consumption calculation can readily monitored, and can be controlled in efficient way.

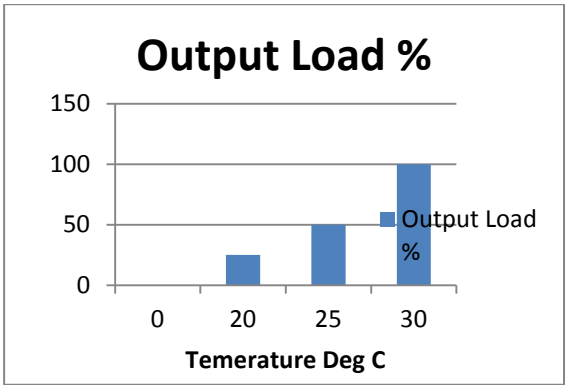

Fig 3. Load control according to real time Temperature

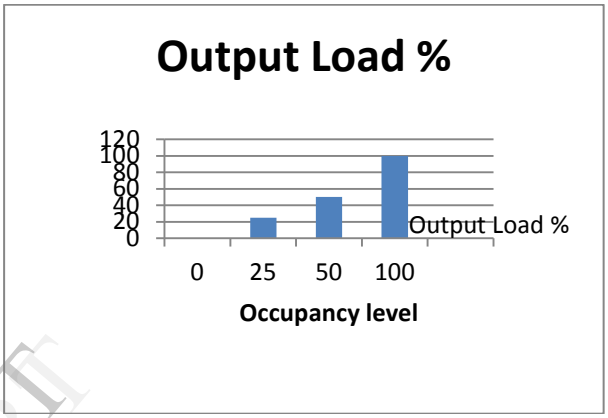

Fig 4. Load control according to real time Occupancy inside a conference hall

SCADA screen developed and interfaced with the PLC through Internet and the screen snap shot as shown in Fig 5 and the dynamic screen monitored for the PLC input changes also the Output devices running status including Temperature indication.

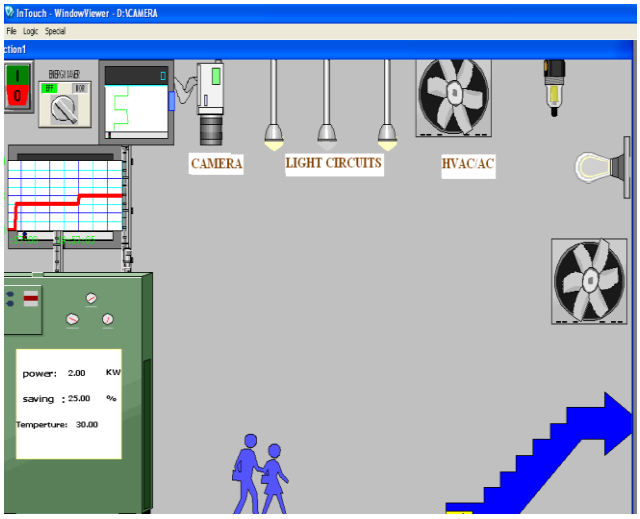

Fig.5.SCADA HMI Simulation result

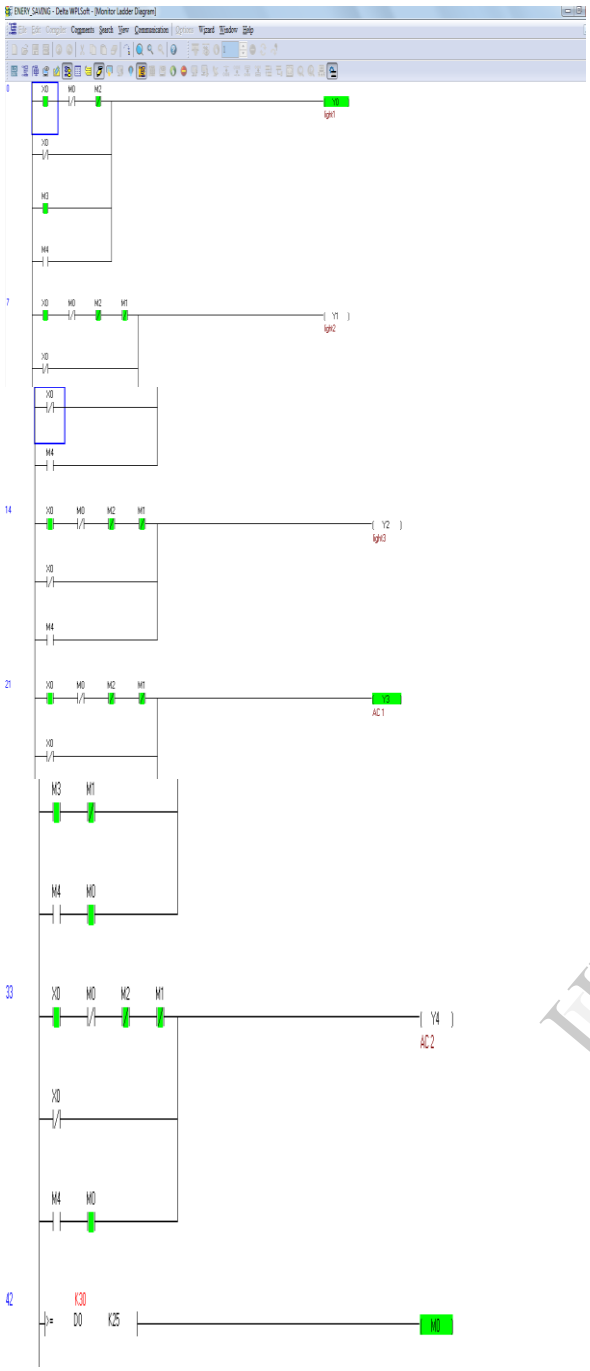

Fig.6.PLC Ladder Logic Simulation result

VI. CONCLUSION & FUTURE ENHANCEMENT

Experimental results illustrate that this approach achieves the remarkable performance. SCADA Monitoring simulation and PLC simulation for the BAS system achieves auto control operation of Building Lighting and HVAC's, improves room environment and has notable energy saving effect.

For future work we tend to conceive to validate the planned schemes and by using occupancy change detection algorithm in Matlab and generating digital logic output which will be hardwired to PLC digital input.

The proposed Occupancy change Detection Using Two Dimensional Cross Correlation will improve the control very precisely and ultimately save energy. This was done to increase the sensitivity of calculation where it is easier to notice the difference between part of image rather than a whole one. A two dimensional cross correlation was calculated between each sub image with its corresponding part in the other image. Because the goal of this division was to achieve more sensitivity the minimum value of correlation will be used as reference to the threshold. In normal cases, Occupancy change can easily be detected when the measured minimum cross correlation value is used to set the threshold. This integrated SCADA system shall be extended to more rooms or Building facilities to have centralized HMI Facility and also for remote monitoring using server and Internet.

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