Electrical Peak Demand Control in Hotel Building by Programmable Logic Control

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Abstract

This research proposed method to electrical peak demand control in hotel building by programmable logic control. Touch screen display is used for shows the electrical parameters data and setting the electric peak demand setpoint via communication port RS-232C to the PLC. The power and energy meter is used for receive the electrical power signal from sensors and sending the signal data through serial port RS 485 to the PLC. PLC will process all data and send control signal to control the electric loads in order to reduce the electrical peak demand (Maximum Demand) charge. In hotel building, the electrical bill is charged on electrical peak demand from coefficient of electrical peak demand at each month (Demand Factor). This research firstly study and checks the power of all electrical loads in the hotel then grouping the same load and arrangement the priority of loads to on-off or dimming its. Three types of electrical load are simulated and installed its. A part of software, PLC controller is programmed and simulated test before using its to control the real electrical loads. The samplings of peak demand setpoint are set at 10 kW, 9 kW, 8kW, and 6 kW. Result of experimental found that the peak demand control system is correct operation cover the boundary condition of research and the proposed method is approached to the setting point better than the conventional method about 1.2 to 7.3 percent.

Keywords: peak demand systems, PLC controller

1. Introduction

Electrical equipments such as the air conditioning system, water pumping system, laundry system, elevators, lighting, and etc, are used in hotel building and it consumes the high electric power, must be pay the high cost for the electrical energy. Therefore, energy management system is importance to manage its problem and get maximum performance. Control level of the electrical peak demand is one way to reduce the cost of energy. Currently the building automation system is used in the some hotel building but it has high investment costs. Therefore, this research uses the PLC that extensively in the industry, operates with the touch screen control, and power meter transmitter. The programming language for PLC control system is the ladder diagram and test the step operation on its by PLC simulation then using its to control the level of peak demand load. The performance of PLC controller where comparing the types of control on the water pumping, analog and digital is considered.

2. Theory

2.1 Electrical loads in the hotel

Figure 1 shows many places in the hotel that consumption electrical power differently because of in that place has many types of electrical load such as air condition, water pump, lift, heater, lighting, ventilation motor, and etc.

2.2 Demand value

Electric power that using in the hotel building is metered in two ways: on maximum kilowatt use during a given time period in 15-minute intervals is calling demand value (kW) typically and on total cumulative consumption in kilowatt hours (kWh). This power is calculated and billed by a kW demand meter, which records the highest kW value in one 15 minute period over a month. The average demand value in figure 2 can be calculated from the equation (1).

\[ P_{ave} = \frac{1}{T} \int_{0}^{T} p(t)dt \]  

Where \( P_{ave} \) is the average power in window time  
\( P(t) \) is instantaneous power equation  
\( T \) is the window time that considering.

2.2 Programmable Logic Controller (PLC)

A Programmable Logic Controller, PLC is a digital computer used for automation of electromechanical processes, such as control of electric motor in factory. PLC consists of the
components as Central Processing Unit (CPU), Memory, input modules, output modules and power supply. A PLC hardware block diagram is shown in figure 3.

Fig. 3 Diagram connection of PLC.

3. Experimental setup

3.1 Hardware setup

More than many kinds of loads in hotel building can be simulated in experimental setup of this research in three types are air conditioning, lamps, and three phase motor, has the name load 1 to load 9 as shows in figure 4. Touch screen display is used for shows the electrical parameters data and setting the electric peak demand setpoint. The power meter is used for receive the electrical power signal from sensors and sending the signal data to the PLC. PLC is processing all data and send control signal to control the priority loads until process value is equal the setpoint value. Motor load 9 is tested under condition on-off or digital control and linear control that using the inverter to control speed of its. Figure 5 shows PLC controller, power meter sensor, display or touch screen, and load types setup.

Fig. 4 Experimental setup.

3.2 Software setup

Ladder programming language is used for write the command to the PLC demand controller and shows in the figure 6 a). In figure 6 b.), Peak demand fortunately at the rated time limit can be calculate from:

$$PF = P + \frac{\Delta P}{\Delta t} (T - t)$$

(2)

Where:

- $PF$ = Peak demand at the rated time limit (kW)
- $P$ = Peak demand at the interesting time (kW)
- $T$ = Time period at the rated time limit (min)

4. Experimental results

The display main menu and screen controls can be shown in figure 7. The peak demand setpoint and the method to control are considered and found that the developed control that using analog output has percent error less than another one can be shown in table 1 and figure 7.

Fig. 7 The display and control screen controls.

Table 1. Comparing the percent error when various the control method and peak demand setpoint.

<table>
<thead>
<tr>
<th>Peak Demand Setpoint</th>
<th>Old control by digital</th>
<th>New control by Analog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psp (kW)</td>
<td>Ppvo (kW)</td>
<td>%error</td>
</tr>
<tr>
<td>6</td>
<td>8.65</td>
<td>-44.2</td>
</tr>
<tr>
<td>8</td>
<td>8.83</td>
<td>-10.4</td>
</tr>
<tr>
<td>9</td>
<td>8.27</td>
<td>8.1</td>
</tr>
<tr>
<td>10</td>
<td>8.71</td>
<td>12.9</td>
</tr>
</tbody>
</table>

Fig. 5 All equipments that using in this research.
Fig. 6 Comparing the Performance of PLC controller when various the method of control and another setpoint a.) 6kW, b.) 8kW, c.) 9kW, d.) 10kW.

5. Conclusion
The power peak demand setpoints are set at 10 kW, 9 kW, 8kW, and 6 kW and found that the peak demand control system is correct operation cover the boundary condition of research. Result of its also found that the proposed method is approached to the setting point better than the conventional method about 1.2 to 7.3 percent.

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References