Design and Construction of Distributed Control System (DCS) Based Power Distribution in University Campus

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Abstract—Due to the rapid development in automation system, control and monitoring are necessary for any modern system. DCS provides this control and monitoring for industrial automation. The system is designed and constructed Distributed Control System (DCS) based power distribution in university campus. The research has constructed hardware and utilized Microsoft Visual Basic software in software environment using a communication network and embedded controllers. All hardware and software components have been developed and integrated together. Data exchange mechanism, USB cable has been developed between the host computer and the embedded controllers that function in two way data exchanges between the two. This system uses PIC 18F4550 microcontroller to collect electrical parameters of devices in each departments. The Graphical User Interface (GUI) uses Visual Basic Software under Microsoft Visual Basic 2010 express to achieve data real-time display and status display for the loads.

Keywords – Distributed Control System (DCS), PIC microcontroller, Power Distribution System,

I. INTRODUCTION

Power distribution DCS is a computer based production process control and monitoring system. It uses the data acquisition module to monitor and control the operation of field devices so as to achieve data acquisition, device control. The power distribution DCS system has many advantages, such as information integrity, efficiency, correct grasp of system running status, speeding up decision-making, and can help quickly detect the failure state of the system. It has become an essential tool for power dispatching [1]. For power control and monitoring, many wire and wireless technologies are discussed. These are GSM, zigbee, SCADA, DCS and Microcontroller. In [2], [3] and [4], power monitoring module calculates power consumption for home appliances. Zigbee communication module is used to send measured data of current and voltage to server module and store it in computer. Authors design the GUI by using Visual Basic (VB) to provide user friendly environment.

The main aim of this paper is to design and construct a low cost controlling wired system between server and clients for power distribution in university campus using microcontroller. In this paper, power control and monitoring is designed by using DCS. DCS is suitable for power monitoring and control because it can control in various control system. This design mainly uses visual basic software to conduct configuration design for the power distribution monitoring system. By using DCS, the distribution system is made more secure, reliable and efficient because it is widely used for modern power system and more popular than any other control system [5]. DCS refers to a control system that available in manufacturing system, process or any kind of dynamic system, in which the controller elements are not central in location (like the brain) but are distributed throughout the system with each component sub-system controlled by one or more controllers. The entire systems of controllers are connected by networks for communication and monitoring. DCS is a very broad term used in a variety of industries, to monitor and control distributed equipment. DCS is connected to sensors and actuators to control the flow of materials through the plant [6]. The architecture of the DCS is shown in Figure 1.
A. System Architecture

The system architecture of the power distribution monitoring system can be divided into three portions, namely system monitoring, communication, and field device. The overall block diagram of the system is shown in Figure 2 and simple block of DCS based power distribution process is depicted in Figure 3.

In this system, 300 KVA AC main transformer is used to distribute electric power to all departments in university campus. This distribution system can be accomplished by using Distributed Control System (DCS). DCS includes master station including server and clients. In this system, the power threshold will be predefined between 180 and 230 V by the microcontroller. These voltage parameters are recorded at the server computer using a data acquisition device called Remote Terminal Unit (RTU) or PIC18F4550 Microcontroller. PIC will communicate with load to control them. PIC captures the voltage that is used for loading in each department. The stored voltage is transmitted using USB cable from PIC to client. Then server computer may know the condition of voltage that is distributed electric power to all departments form the client computer because the Ethernet switch is communicated among and clients and server. Based on the received information, controlling operation is performed. If the receiver receives the parameter which is greater than the fixed threshold voltage, then server commands to respective client to cut off power distribution.

Figure 1. Architecture of Distributed Control System

Figure 2. Overall block diagram of the system
III. POWER USAGE IN UNIVERSITY CAMPUS (MTU)

Electric energy enters the university with 11KV transmission line from the substation which is stepped down to 400 V by using 300KVA transformer. In this system, the three-phase, 4-wires transformer is used for power distribution to all departments in university campus. This transformer is distributed with the three lines 1, 2, 3 to all departments in university campus. To balance the load, the three lines must be shared equally. In distribution system, it is important to balance the load. As the load is not a constant one it is always an unpredictable thing. If the load is unbalanced, the fuse that is installed at the outgoing side of the transformer must be cut off.

The load power is the product of KVA and power factor (0.85). The lines that are used for all departments are illustrated in Table I. The load data sheet of the power consumption for all departments is shown in Table 2 and pie chart for power consumption is illustrated in Figure 4.

<table>
<thead>
<tr>
<th>TABLE I</th>
</tr>
</thead>
<tbody>
<tr>
<td>THREE PHASE, FOUR WIRES TRANSFORMER</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lines in Transformer</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 1</td>
<td>Sockets</td>
</tr>
<tr>
<td>Line 2</td>
<td>Lightings and Fans</td>
</tr>
<tr>
<td>Line 3</td>
<td>Aircons</td>
</tr>
<tr>
<td>Neutral</td>
<td>Ground</td>
</tr>
</tbody>
</table>

| TABLE II |
Table 1: Load Datasheet of Power Consumption for All Departments at MTU

<table>
<thead>
<tr>
<th>Departments</th>
<th>power factor</th>
<th>Rated voltage</th>
<th>Power Rating (KVA)</th>
<th>Power Consumption (KW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop</td>
<td>0.85</td>
<td>400</td>
<td>80.5</td>
<td>68.4</td>
</tr>
<tr>
<td>Mechanical</td>
<td>0.85</td>
<td>220</td>
<td>26.06</td>
<td>22.151</td>
</tr>
<tr>
<td>Civil</td>
<td>0.85</td>
<td>220</td>
<td>24.02</td>
<td>20.415</td>
</tr>
<tr>
<td>Chemical</td>
<td>0.85</td>
<td>220</td>
<td>24.96</td>
<td>21.215</td>
</tr>
<tr>
<td>Mechatronic</td>
<td>0.85</td>
<td>220</td>
<td>23.118</td>
<td>19.65</td>
</tr>
<tr>
<td>Electrical Power</td>
<td>0.85</td>
<td>220</td>
<td>34.74</td>
<td>29.526</td>
</tr>
<tr>
<td>Other Departments</td>
<td>0.85</td>
<td>220</td>
<td>68.6</td>
<td>18.474</td>
</tr>
<tr>
<td>Total</td>
<td>0.85</td>
<td>220</td>
<td>281.998</td>
<td>200</td>
</tr>
</tbody>
</table>

Figure 4. Pie Chart for power consumption of each department

IV. HARDWARE IMPLEMENTATION

After collecting all design related information which is necessary for power distribution, the next step is to construct the perfect and compatible H/W components to control power distribution. The power supply circuit and testing with proteus software is expressed in Figure 5 and Figure 6. The development PIC 18F4550 has been used for programming through USB cable, also the development PIC 18F4550 microcontroller will be used as interfacing tool to connect the PIC with the inputs and outputs signals of process and to connect the PIC with the PC which contains a GUI through (USB) cable. The PIC deals with TTL level voltage (0-5) VDC, the (0) VDC represents
logic (0) and the (5) VDC represents logic (1) to PIC. Thus the input voltage which has a voltage value more than (6) VDC that might burn the PIC, hence each input signal to PIC from computer is rated on (5) VDC using USB cable.

The output relay circuit is connected to provide signals from PIC to load. The relay is one of devices used in this proposed design in order to ensure a flexible connection between PIC and the load. It’s switched ON or OFF according to the level of signals generated from PIC microcontroller. Figure 7 shows the hardware output circuit design for power distribution process for a department. The relay circuit replaces the manual switches of power distribution with computerized switching. Such that the enable signal from PIC can handle a (230) VAC High Voltage. The outputs allow command for switching ON or switching OFF each relay. The photo of the overall circuit is shown in Figure 8.

![Figure 5. 220V AC to 12 V Power Supply Circuit](image1)

![Figure 6. Power Supply Circuit Testing with Proteus Software](image2)
Figure 7. Circuit diagram of power distribution process for a department

Figure 8. Photo of Complete circuit for power distribution process
V. SIMULATION WITH PROTEUS SOFTWARE

Before design and constructing the compatible circuit, the simulation results are tested with virtual and 7 segment LCD Display power level by using Proteus software. In this simulation, a variable resistor is utilized instead of a sensor. LED is used for relay. This is a simple voltage monitoring which measures 0-255V. When the input voltage is between 180 and 230 V, LED will be ON and display the voltage on 4 digits seven segment LCD. And then, if the voltage level is below and above 180 and 230V, the relay will be OFF state. These results are shown in Figure 9.

1) Design procedures for microcontroller: In this simulation page, the procedure for the proposed system is described as follows:

- Define the parameters for LCD and Data registers.
- Initialize the input and output ports of the microcontroller.
- Assign a value for relay.
- The function defined for capturing the voltage values is called and executed.
- The displaying function is called and the parameter values are displayed on LCD.

![Figure 9. Voltage monitoring (OFF state) using Proteus](image1)

2) Voltage monitoring testing with virtual terminal: In this simulation, Virtual Terminal is utilized to monitor and display the condition of power level as a PC before testing with real circuit and computer. This is shown in Figure 10.

![Figure 10. Voltage monitoring (ON state) using Virtual Terminal](image2)
VI. SIMULATION RESULTS

The proposed system has been tested for monitoring and control of a power distribution system. These windows design are created by Visual Basic form in Microsoft Visual Basic 2010. The GUI design of DCS based power distribution is presented in this section.

a. Simulation Result of main and hardware window

This window is essential for the overall process. It includes only one button. This button is used to show the result for power distribution process. Figure 11 is the main page of this system.

![Figure 11. Simulation result of the main page](image1)

b. Simulation result of the power distribution process

This simulation window is the main process for power distribution process. It shows the monitoring and control of power distribution to all departments. This window form is considered and tested with the sample circuit for power distribution. This window shows the conditions of the power distribution process by changing the colours of LED. The start button is used to operate power distribution process. The stop button is pressed to end the power distribution process. This window is shown in Figure 12 and photo of linking the hardware and software is depicted in Figure13.

![Figure 12. Simulation page for power distribution process](image2)
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VII. CONCLUSION

This research work is a development of DCS based electric power distribution system for the monitoring and control of significant parameter (Voltage). In this research, design and implementation of the power distribution process that used Visual Basic.Net programming for the monitoring and control of DCS system have been studied. Communication system uses USB cable and hardware units for this process is designed and constructed and tested by connecting both hardware and software. PIC microcontroller is used in this system instead of PLC. The use of microcontroller has been shown to be a good platform upon which the distribution system can be developed. Its flexibility in programming allows for easy future modification and implementations. The use of DCS for the monitoring and controller of electric distribution system has been identified as one of the major way to provide efficient and reliable electric power to electricity consumers. By using this system, it can be easily controlled and monitored for the distribution of electric power not only all departments in university but also homes in cities or towns.

REFERENCE


Figure 13. Testing the Circuit using VB.Net programming by Linking with Hardware