SCADA Based Centralized Building Energy Management and Automation System

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ABSTRACT: This paper presents the automation of buildings by aided of programmable Logic Controller and SCADA system. Manually controlling of parameters is not only nexus and monotonous as well. So automated tools are required to control, supervise, collect, scrutinize data, and generate reports. The human error element is greatly reduced by highly dependable equipment. This paper puts forward a typical centralized automated building, where in all the electrical components are virtually connected to SCADA through PLC. These components are monitored and controlled with the help of single person sitting in the control room, which could make living better simpler, effortless, and smarter, reduces the manpower and energy management. Secondly, PLC and SCADA based water management are also being implemented that would effectively lessen the water wastage which is the biggest concern of today's society. The wastewater is then reused in gardening and as the saying goes "Put a stop to the drop - water is precious and we ought to save it". All the parameters are being processed and can be constantly monitored with the help of SCADA system, which updates the progress in the control room being manned by the individuals. Additionally, this idea can be extended to many more applications like car parking, security systems with LCD screens, elevator control and common announcement system.

KEYWORDS: Supervisory Control and Data Acquisition (SCADA) system, Programmable Logic Controller (PLC), automated tools, energy management.

I. INTRODUCTION

Automation is basically the delegation of human control function to technical equipment. It is the use of control systems such as computers, PLCs, Microcontrollers to control machinery and processes to condense the need for human sensory and mental requirements as well. It is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat-treating ovens, and other applications with minimal or reduced human intervention. Industrial Automation i.e., to "Automate Industry" is the basic need of almost every type of manufacturing and production unit today.

But the shift for automation in building or apartments has popped in very recently. Home automation is an integral part of modern lives that help to monitor and control the home electrical devices as well as other aspects of the digital home that is expected to be the standard for the future home. Home appliance control system enables house owner to control devices Lighting, Heating and ventilation, water pumping, gardening system remotely or from any centralized location. Automatic systems are being preferred over manual system. Similarly talking about apartment automation, by use of PLCs everything seems to be more accurate, reliable, and more efficient than the existing controllers. It is a combination of electrical, electronic, and mechanical section where the software used is Ladder Logic programming. The visualization of the status of the building elements is made possible with the use of SCADA screen which is interfaced to the PLC through various communication protocols. RS VIEW32 SCADA software is a powerful SCADA for industrial automation and supervisory monitoring.

The main objective of our project is to design and implement, Centralized Building energy management and Automation system. The following matters need to be concentrated to accomplish our intention.

1. Setting up all the hardware components according to the driving capability of PLC.
2. Build the Ladder logic.
3. Attain grip on SCADA software and develop screens to monitor the process.

The project entitled "SCADA Based Centralized Building Energy Management and Automation System" shows how to automate a few processes in and around residences. No doubt that there are advancements in civilization and technology but, the greatest concern which is bothering the world today is depletion of water resources, electricity, and safety at place. This paper result is just a prototype that was implemented in and around the vicinity of residences, it becomes difficult to supervise the entire process manually. Thus, there exists a dire need of automation. In order to accomplish the control action, a controller is necessary which handles the entire process of automation. Here a PLC is used as the controller which is mostly used in the industrial process control.

II. LITERATURE SURVEY

A Building Management System (BMS) or a (more recent terminology) Building Automation System (BAS) is a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as ventilation, lighting, power systems, water management, fans, gate and security systems. A BMS consists of software and hardware; the software program, usually configured in a hierarchical manner, can be proprietary[3], using such protocols as C-bus, Profibus, and so on. Vendors are also producing BMSs that integrate using Internet protocols and open standards such as Device Net, SOAP,XML, BACnet, Lon-Works and Modbus[4].

Building Management Systems are most frequently implemented in stupendous projects with extensive mechanical, HVAC, electrical, and plumbing systems [1]. Systems linked to a BMS typically represent 40% of a building's energy usage; if lighting is included, this number approaches 70%. BMS systems are a critical component to managing energy demand. Improperly configured BMS systems are believed to account for 20% of building energy usage, or approximately 8% of total energy usage in the United States. They can be used for the following applications.

1. Illumination (lighting) control
2. Electric power control & Plumbing
3. Heating, Ventilation and Air-conditioning (HVAC) control
4. Security and observation
5. Access control
6. Fans, gate control
7. Lifts, elevators control etc.

BMS uses Computer based control system that controls & monitors equipment such as ventilation, lighting, fans & security systems which requires knowledge of special programming languages. It uses software and hardware which are usually proprietary and hence life cycle cost and changes would require specialized support from each control vendor and much higher cost than a PLC- SCADA system over the life of the equipment., In contrast to when all the control is the same vendor (PLC)/standard (Ladder Logic) and in- house maintenance/engineering can maintain and modify during the life of the equipment [2][1]. The program is fixed, and any changes needed can't be made and is a costlier affair to change as the software is bought from different vendors in contrast to PLC where the programming is done in Ladder logic which is similar to relay logic and hence can be even operated by electricians /technicians

III. DESIGN LAYOUT OF PROPOSED WORK

The layout diagram of proposed work (shown in Fig.1) describes the interfacing of field devices with the PLC (Programmable Logic controllers) to the SCADA system. Here Allen-Bradley PLC have been used for performing controlling operations [5]. This is a compact type of PLC, which has fixed input and output modules with fixed input

and output terminals. In this proposed idea 16 input devices & 10 output devices are used.14 input devices represent manual mode of switches, level sensors, some master start and stop buttons; these devices are in active mode of operation while failure case of SCADA system only [2]. Output devices are indicating Solenoid valves, lights, Fans, pumps Gate control units, firing systems and buzzers.
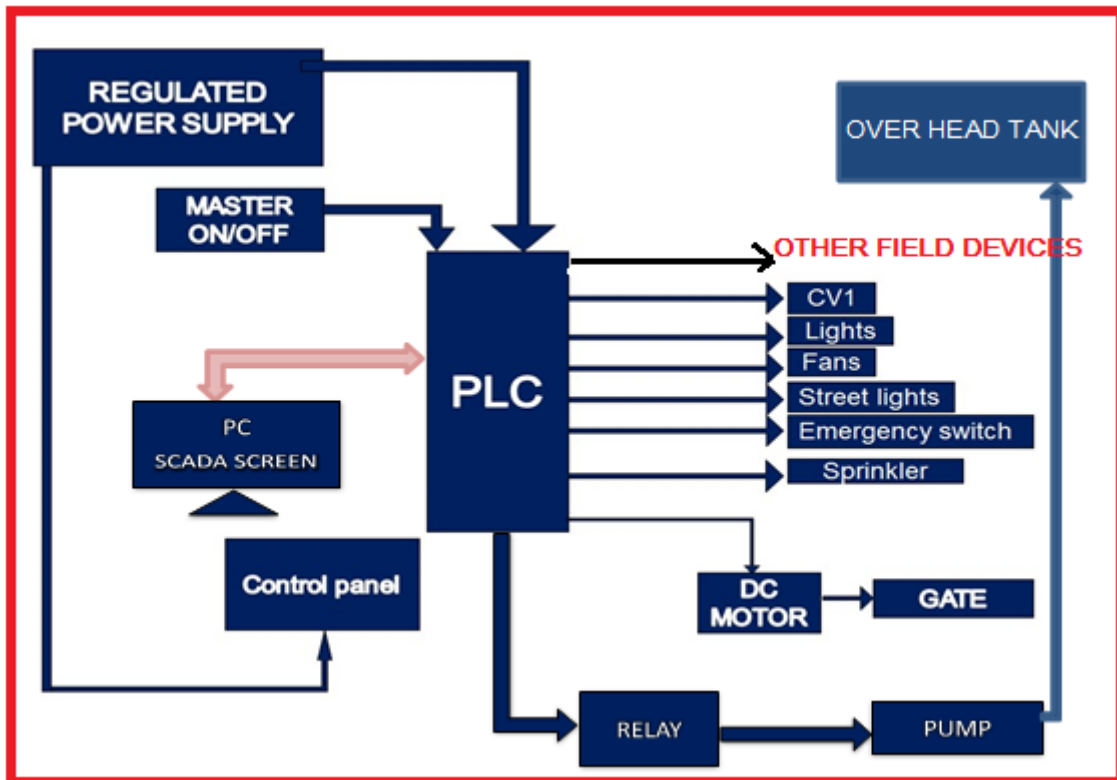

Fig.1 Layout diagram of Proposed work

Various input and output field devices are interfaced with the I/O modules of PLC. Addressing of ladder programming instructions follows the terminal connections. The following table.1 shows the addressing format of respective terminals for field device connections. Level sensors output is in the range of millivolts, so sensors require signal conditioning circuits [8]. In this implementation Allen-Bradley 1762-IF20F2 analog I/O modules are used to communicate analog sensors to PLC. This module supports particular range of current & voltages so output signal of interfacing sensor should meet the specifications of input modules. Device driver circuits are required at PLC out modules to drive the output devices which are connected to PLC output terminals.

Table.1: Addressing of respective terminals for field device connections

S.No	Device name	Device Type	Addressing of respective terminal
1	Centralized A.C system	OUTPUT	O0:0.0/0
2	Solenoid Valve-1	OUTPUT	O0:0.0/1
3	Solenoid Valve-2	OUTPUT	O0:0.0/2
4	Gate driving motor	OUTPUT	O0:0.0/3
5	Pump	OUTPUT	O0:0.0/4

6	Fans	OUTPUT	O0:0.0/5, O0:0.0/6
7	Lights	OUTPUT	O0:0.0/7, O0:0.0/8
8	Buzzer	OUTPUT	O0:0.0/9
9	Sump and overhead tank Level sensors	INPUT	CH1 & CH2
10	Master start /stop button	INPUT	I1:0.0/0
11	Toggle switches for Manual mode of operation	INPUT	I1:0.0/1 to I1:0.0/10
12	Manual mode switches for gate opening and closing	INPUT	I1:0.0/11 & I1:0.0/12

IV. SIGNAL CONDITIONING AND DEVICE DRIVER CIRCUITS

1.SIGNAL CONDITIONING CIRCUITS

output of the level sensor is in the range of millivolts. This voltage doesn't meet the specifications of PLC analog input modules, which supports 0Volts to 10Volts range or 4milliamps to 20milliamps of signals, but sensor produces millivolts of signal [7]. So, signal conditioning circuit is required, here circuit is designed with 741 IC. In view of this Rf can be considered as 1MΩ and Rin can be considered as 1kΩ. Signal conditioning circuit for level sensor is shown in Fig.2.
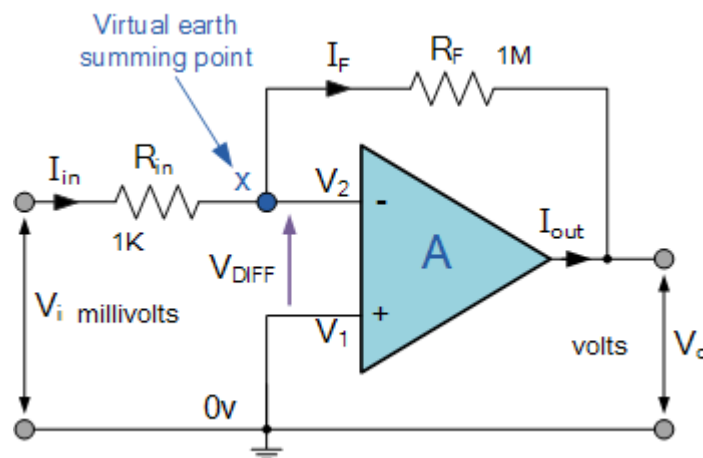

Fig.2.Signal conditioning circuit

From the above fig.2, Signal conditioning circuit is obligatory to get required voltage to meet the specifications of Allen Bradley 1762-IF20F2 module [8]. In this proposed work, ultrasonic level sensors are used to detect the liquid level of sump and overhead tank. The output of the ultrasonic sensors is amplified by the above amplifier circuit and output of signal conditioning circuit is connected to the channel of Allen Bradley 1762-IF20F2 module. Input voltage V_i is taken from the level sensor, in the of millivolts. Here we selected R_f =1MΩ and $R_{i=}$1KΩ. R_f is the feedback resistance and R_i is the input resistance. V_{out} is given to input module terminal of analog I/O module.

$$V_{in} - V_{out} = (R_{in}+R_f)I_{in}$$

$$\text{Therefore, } I_{in} = (V_{in}- V_2)/R_{in}$$

$$= -(V_{out}-V_2)/R_f$$

$$I_{in} = (V_{in}/R_{in}) - (V_2/R_{in})$$

$$I_f = (V_2/R_f)- (V_{out}/R_f),$$

$$So ,$$
$$V_{in}/R_{in} = -\{V_{out}/R_f -V_2[1/R_{in} + 1/R_f] \}$$

$$And\ as,\ i= (V_{in}-0)/R_{in}$$

$$= -V_{out}/R_f$$
The closed loop gain (Av) is given as

$$A_v = V_{out}/V_{in}$$

$$A_v = R_f/R_{in}$$

2 DEVICE DRIVER CIRCUITS:

2.1 L293D motor driver IC:

In this prototype application, device drive circuit is required to drive 12v Dc motor in forward and reverse direction, which helps to opening and closing of Building gate**.** L293D is a typical Motor driver circuit, which allows DC motor to drive in either forward or reverse direction [7]. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. L293D is a Dual H-bridge Motor Driver IC **.**H-bridge is an integrated circuit which allows the current to be flown in either forward or reverse direction. As you know input voltage is needed to change motor direction for being able to rotate the motor in anti-clockwise or clockwise direction as shown in fig.3.

Here the Motor is connected on left side output pins (pin 3,6). For rotating the motor in clockwise direction, the input pins must be provided with Logic 1 and Logic 0.

Pin 2 = **Logic 1** and **Pin 7** = **Logic 0** | Clockwise Direction
Pin 2 = **Logic 0** and **Pin 7** = **Logic 1** | Anticlockwise Direction
Pin 2 = **Logic 0** and **Pin 7** = **Logic 0** | Idle [No rotation] [Hi-Impedance state]
Pin 2 = **Logic 1** and **Pin 7** = **Logic 1** | Idle [No rotation]
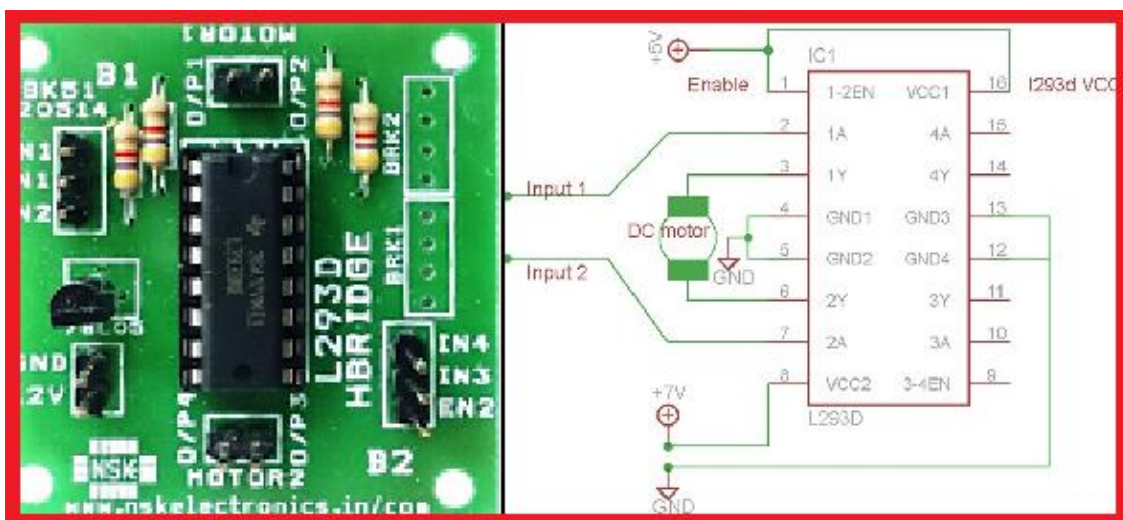
Fig 3 L293D motor driver circuit diagram

3.Relay Logic Circuit:

In this proposed idea all output devices are mostly operated at 230V A.C signal. But PLC output logic '1' value is 24 volts, so relay circuits are required to drive electrical devices like fans, lights, pumps, and Air Coolers [9]. Relays are simple switches which are working on electro-mechanical principles. The general-purpose relay is rated by the amount of current its switch contacts can be handled. In this project 5pin Relay circuit have been used to drive 230V A.C operated electrical devices. PLC with prototype model development is shown in below fig.4

Fig.4 PLC with proto type hardware setup

V. PROGRAMMABLE LOGIC CONTROLLERS

PLC is the brain of this proposed idea; this controller performs all logical controlling operations of building automation process [3]. Here all input and output field devices are communicated to PLC through various signal conditioning circuits and driver circuits. Allen-Bradley MicroLogix1200 PLC with 1762 IF20F2 modules (shown in fig.5) are used as controller for automation of building.

Fig.5 Allen-Bradley MicroLogix1200 PLC with 1762 IF20F2 modules

PLC Ladder programming has been developed in RSLogix500 Software as shown in Fig.6, Fig.7 & Fig.8. Ladder Programming which mainly deals with Normally Opened and Normally Closed Inputs. Other than those two, timer functions have been used as to include a delay of sometime among multiple processes. From the developed ladder logic programming, the first part of the program is the master start switch which is linked to the whole program rungs the program output will be obtained if and only if the master start switch is ON. The working of pump i.e., how a pump gets ON or OFF through relay [8]. Pump cannot be directly connected at output of PLC because PLC provides only

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 1, January 2018

24V. Thus, a relay is connected which then drives the pump by making the contact open or close [10]. We see that when master on off is ON then 24V is passed to the PLC CPU where it gets stored in input registers. The status of the two other bits (DN bits of two different timers) are also stored in hold registers. According to the program as we see in rung 0000, when master on off is ON and both the DN bits of timer T4:1 and T4:8 are 0 then the status of the corresponding output register for the relay gets 1. Thus, 24V passes to the output terminal 0 and then the relay makes connection between the mains and the pump, thus switching the pump ON.
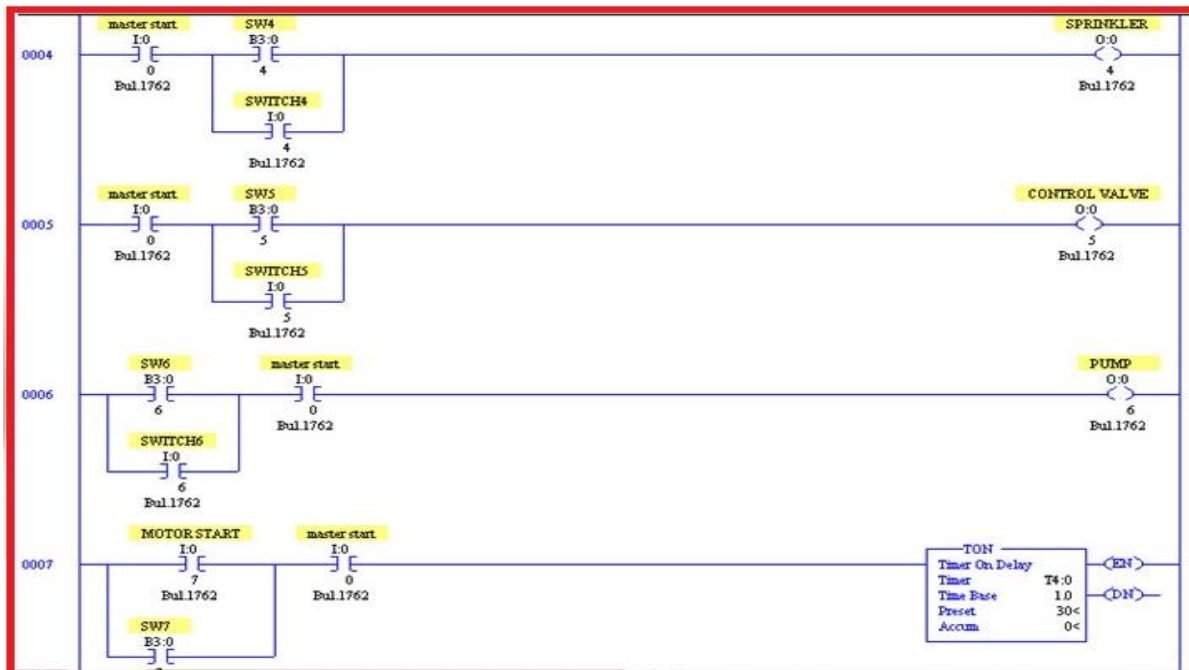

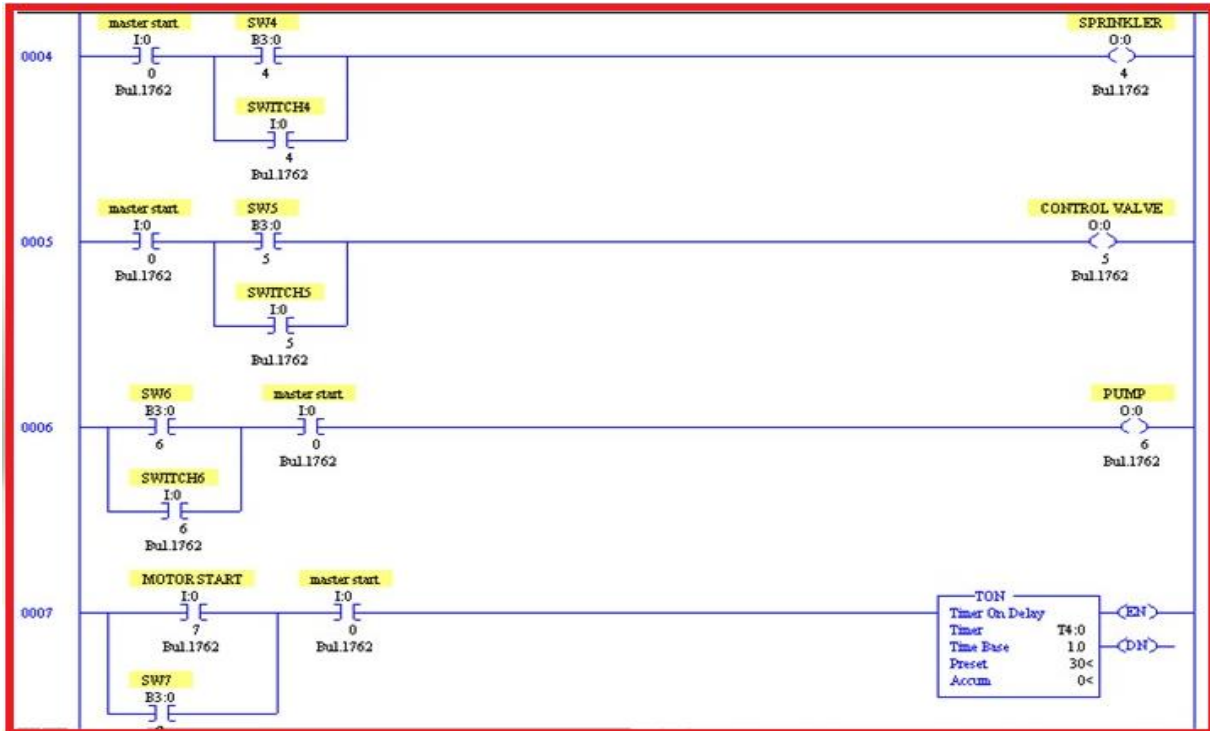Fig.6.PLC Ladder programming-1

Fig.7.PLC Ladder programming-2

Fig.8.PLC Ladder programming-3

VI. SCADA SYSTEM & RESULTS

Complete Building automation could be implemented by integration of PLC with RS VIEW32 SCADA. Entire Building power distribution, water distribution and status of electrical devices can be monitored Through this SCADA system [1]. Operator simply perform the controlling operations through graphical symbols, which represents the SCADA screens.

Development of SCADA screens and communication of PLC with RS VIEW32 SCADA are done by follows some protocols and configuration settings. In view of this, after creating a new project, go to system and double click on channel. In the Channel editor, select a channel and assign the appropriate network type to it. In the Primary Communication driver field, assign a driver to the channel. For example, select DH-485as the network type, select the Primary Communication Driver as AB-DF1-1 and select the check box primary for active driver as shown in Fig.9. Create nodes according to the number of inputs and outputs required in the program. For each node assign the station by clicking the station browse option [9]. There are two ways by which tags can be created. The first way is in the Tag Database editor, create tags. For each tag, select Device as the data source and assign the nodes and scan classes that you have defined. If device is chosen i.e., if we are taking the field devices and connecting to PLC then we need to choose device and give proper addressing format with its scan class and attach them to specific node
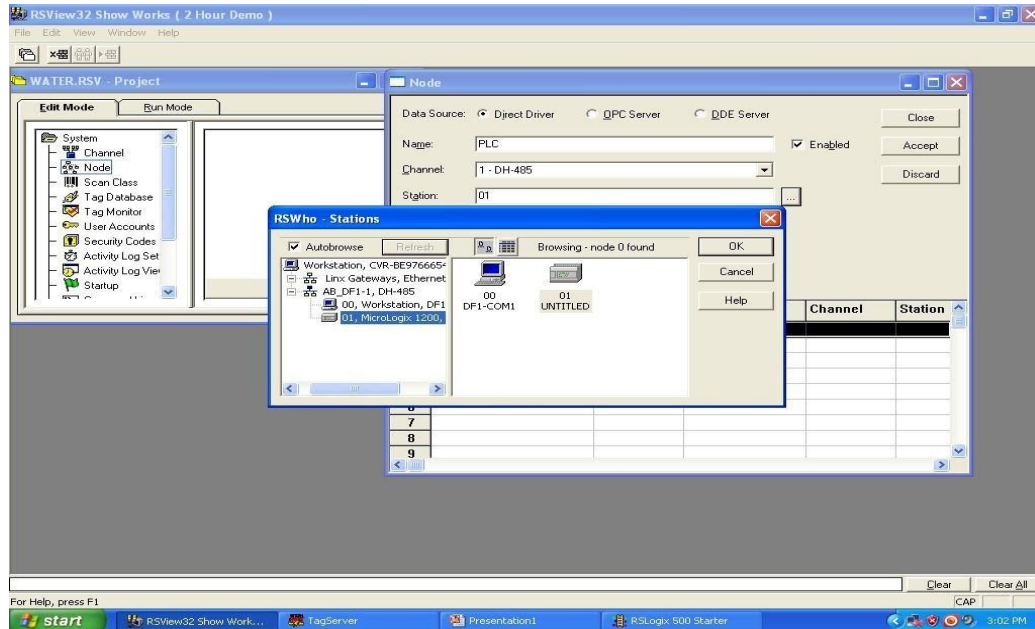
Figure 10: Creating Nodes for direct driver communication

After completion of the animations for each object according to the program, save the display and it can be retrieved from the library again then run both the PLC ladder program and test run for the SCADA screen created as shown in Fig 10. We see that the current state of the inputs and output buttons or field devices is reflected on the screen at every instance.
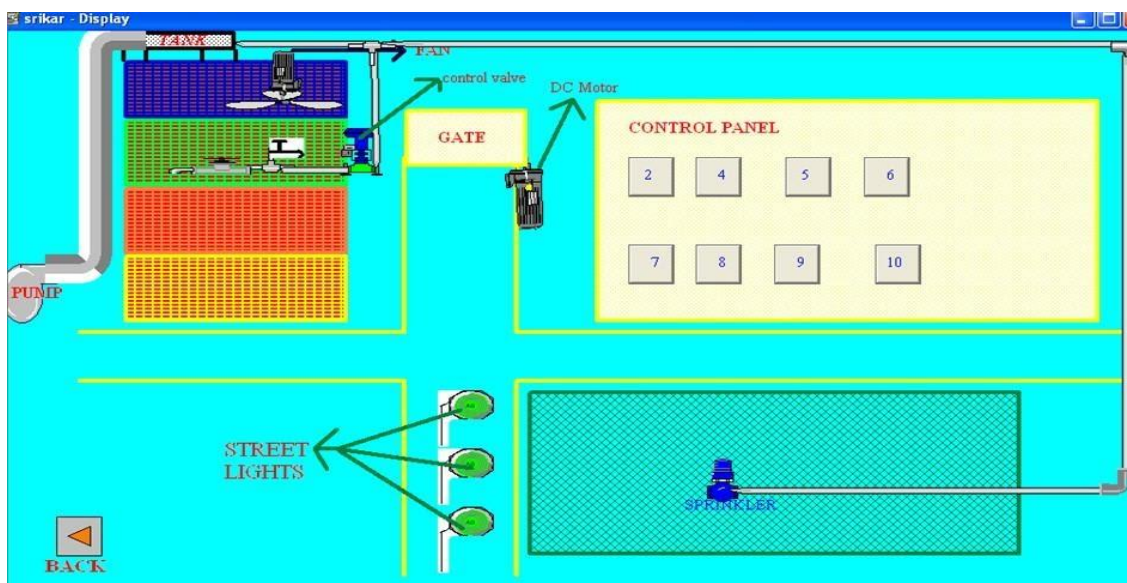

Fig.11.SCADA screen Result for Building Automation

VII. CONCLUSION

This paper presents the implementation of cost-effective automation system for buildings. This method of commence is very user friendly for the operator or control engineer to troubleshoot the process if any errors occur and can also be kept track of what is happening in the process. SCADA screens have been successfully developed and tested by connecting prototype devices through PLC. This kind of implementation has many features, these are Increased level of comfort, time saving, money saving during maintenance, Effective monitoring of the processes, Improved Reliability, Flexibility on change of building use and   Ease of storing reports of the systems.

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