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GOT Assisted Smart Building Energy Management System

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Abstract: This paper presents the automation of building management system with the aided of Programmable logic controllers assisted with Graphical operating terminal(HMI).Manually controlling of devices & parameters is not only difficult but also monotonous. 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 electrical components are virtually connected to HMI through PLC. These components are monitored and controlled with the help of single person sitting in the control room. All the parameters are processed and can be constantly monitored with the help of HMI 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 LED screens, elevator control and common announcement.

Keywords: PLC, HMI, elevator, Virtual, automation.

I. INTRODUCTION

Electricity is an integral part of our lives all the electric devices need electric energy to function. Generally, bigger the building, greater is the number of electric devices in it. Electric devices if left on when not needed will not only waste energy but also add to our electricity bill. Smart buildings promise to improve efficiency by connecting these systems to reduce operating costs and increase the safety and quality of life of those who work and live inside their walls. Due to the human errors the wastage of electricity takes place because of leaving the electrical appliances on for a long period of time. In many of the year accidents the primary reason was due to the human error.

The objective of this paper is to control the wastage of electric energy in a building due to human errors. This is done by having the control of all devices of a building at one place or room. Devices can also be run for a desired period of time after which they turn off automatically without any human intervention, thereby saving energy due to man made errors. The following matters need to be concentrated to accomplish our intention.

A. Setting up all the hardware components according to the driving capability of PLC
B. Build the Ladder logic.
C. Attain grip on GT Designer3 software and develop screens to monitor the process.

The project entitled “HMI Based Smart Building Energy Management system” shows how to automate a few processes in and around residences. 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

Electricity is the most common energy sources used in commercial buildings, colleges. Some commercial buildings are supplied by district energy systems. When many buildings are close together, such as on a college campus or in a big city, it is sometimes more efficient to have a central heating and cooling plant that distributes steam, hot water, or chilled water to all the buildings[3]. Of all the commercial building types service buildings use the most total energy. Other commercial users of energy include offices, schools, health care and lodging facilities, food establishments, and many others.

The Democratic Alliance for the Betterment and Progress estimated that we pay Rs 50,000 million more on electricity per year because of our habit of wasting power - which is roughly Rs10, 000 per household. Of 1,126 people interviewed, 60.4 per cent said they kept the TV on even when nobody was watching it. Of the 1,016 respondents who had air- conditioners, 46 per cent said that even if it got too cold, they would rather wear thicker clothing or use a blanket than adjust it[9]. Nearly three out of 10 respondents said they regularly left the lights on in empty rooms.

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A. Innovation

The Electricity waste due to the mismanagement and human error can be reduced by implementing a smart energy management system. This system is applied to all the service building, schools, colleges, office building to manage the energy consumption of the building. The system consists of a HMI screen which is installed in the administrative room where in the management of the electrical supply to various parts of the building is carried out. Various types of controls are set according to the schedule. Basically this system consists of three types of control, they are as follows:

1) Individual Control
2) Quick Control
3) Dynamic Control

A programmable logic controller sends the control actions given from the administrative room. The virtual representation of the rooms and the electrical appliances can be seen over the HMI screen which is also used to give the control action to a particular room or a floor in a building.

III. SYSTEM ARCHITECTURE

The system architecture Fig.1 of smart energy management system consists of various blocks such as HMI unit, PLC, Relay module, SMPS.

A. Programmable Logic Controller (PLC)

Fx5U series PLC is used to perform controlling operations of Building automation.PLC is an industrial digital computer which has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, or robotic devices, or any activity that requires high reliability control and ease of programming and process fault diagnosis. This Compact PLC has the following features

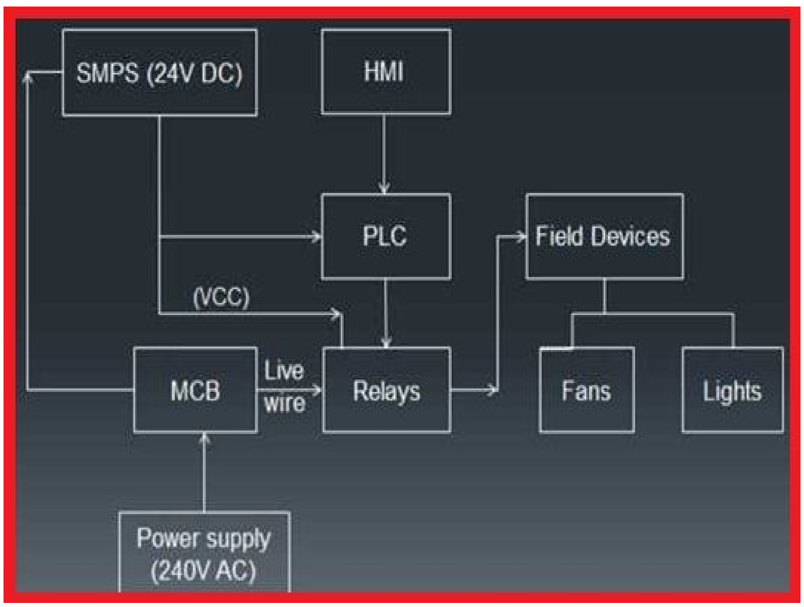

Fig. 1 System Architecture

In this proposed work, ladder programming is being used to control Field devices of the Building. Ladder logic is widely used to program PLCs, where sequential control of a process or manufacturing operation is required. The motivation for representing sequential control logic in a ladder diagram was to allow factory engineers and technicians to develop software without additional training to learn a language such as FORTRAN or other general purpose computer language. Development, and maintenance, was simplified because of the resemblance to familiar relay hardware systems. Implementations of ladder logic have characteristics, such as sequential execution and support for control flow features that make the analogy to hardware somewhat inaccurate. This argument has become less relevant given that most ladder logic programmers have a software background in more conventional programming languages.

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Table1: Features & Specifications of Mitsubishi Fx series PLC

Item		**Specification**
Control system		Stored-program repetitive operation
Input/output control system		Refresh system (Direct access input/output allowed by specification of direct access input/output [DX, DY])
Programming specifications	Programming language	Ladder diagram (LD), structured text (ST), function block diagram/ ladder diagram (FBD/LD)
	Programming extension function	Function block (FB), structured ladder, label programming (local/global)
	Constant scan	0.2 to 2000 ms (can be set in 0.1 ms increments)
	Fixed cycle interrupt	1 to 60000 ms (can be set in 1 ms increments)
	Timer performance specifications	100 ms, 10 ms, 1 ms
	No. of program executions	32
	No. of FB files	16 (Up to 15 for user)
Operation specifications	Execution type	Standby type, initial execution type, scan execution type, event execution type
	Interrupt type	Internal timer interrupt, input interruption, high-speed comparison match interrupt
Command processing time	LD X0	34 ns
	MOV D0 D1	34 ns
Memory capacity	Program capacity	64 k steps (128 kbytes, flash memory)
	SD memory card	Memory card capacity (SD/SDHC memory card: Max. 4 Gbytes)
	Device/label memory	120 kbytes
	Data memory/standard ROM	5 Mbytes
Flash memory (Flash ROM) write count		Maximum 20000 times
File storage capacity	Device/label memory	1
	SD Memory Card	2 Gbytes: 511*1
		4 Gbytes: 65534*1
Clock function	Display data	Year, month, day, hour, minute, second, day of week (leap year automatic detection)
Precision	-2.96 to +3.74 (TYP.+1.42) s/d (Ambient temperature: 0 ━ (32 ━)) -3.18 to +3.74 (TYP.+1.50) s/d (Ambient temperature: 25 ━ (77 ━)) -13.20 to +2.12 (TYP.-3.54) s/d (Ambient temperature: 55 ━ (131 ━))	
No. of input/ output points	(1) No. of input/output points	256 points or less
	(2) No. of remote I/O points	384 points or less
	Total No. of points of (1) and (2)	512 points or less
Power failure retention*2	Retention method	Large-capacity capacitor
	Retention time	10 days (Ambient temperature: 25 ━ (77 ━))
	Data retained	Clock data

B. Logic Programming

The programming of the PLC FX5U is carried out in GX Works3, powered by MELSOFT iQ. The engineering software is considered a fundamental part of the control system in addition to the hardware components. The core of the system, it includes various steps of the product life cycle, from the design stage all the way to commissioning and maintenance of the control system. Today, intuitive, easy-to-use software suites are expected as a standard for modern manufacturing needs.

GX Works3 is the latest generation of programming and maintenance software offered by Mitsubishi Electric specifically designed for the MELSEC iQ-R Series control system. It includes many new features and technologies to ensure a trouble-free engineering environment solution as shown in Fig.2. It is graphic based programming software, which provides a easy way to program. GX Works3 incorporates a system design feature that enables system components to be assembled directly in the programming software. It includes a parts library consisting of MELSEC iQ-R Series modules that can be used to simplify system creation.

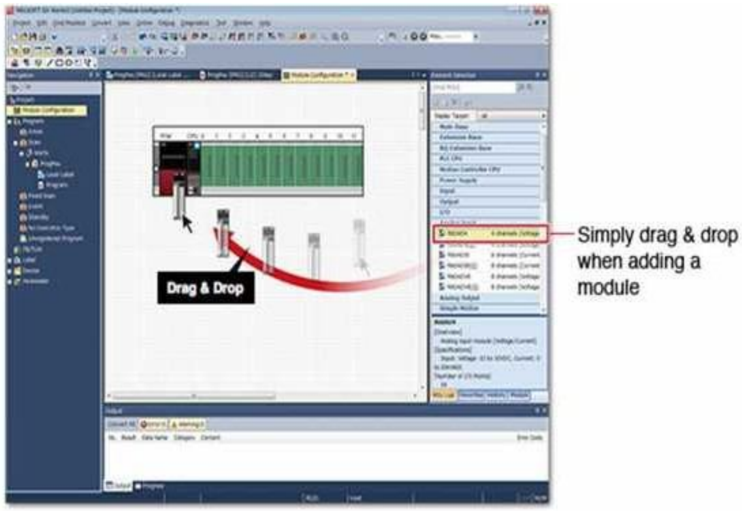

Fig 2: UI of GX WORK

GX Works3 is equipped with a special motion setup tool that makes it easy to change simple motion module settings (shown in Fig.3) such as module parameters, positioning data and servo parameters. Also, debugging is simplified using the fine-tuning cam data generation feature. Global and local variables (labels) are supported providing an easy way to share device names across multiple projects, other MELSOFT software and third party SCADA.

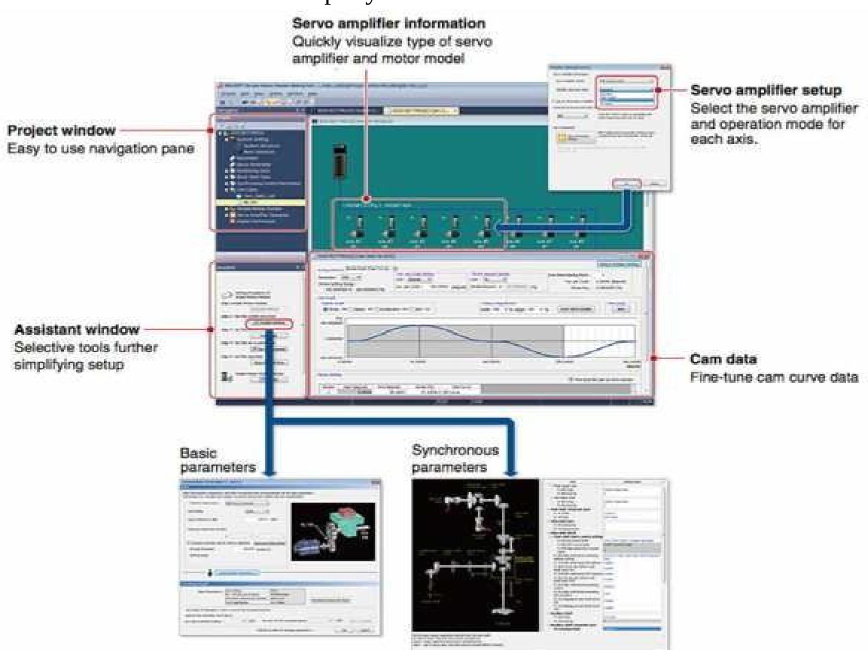

Fig 3: Integrated motion tool setup

C. Ladder Programming Instructions for Control Logic

The programming is carried out in ladder logic using GX-Works 3. The address locations of the devices given in the PLC are used in the status lamps of the HMI screen. SM400 is an always on switch. In the first rung of the program the data (input time in timer) present in D200 address is moved to D300 location. The time entered in the timer is in minutes scale. To convert it into seconds the given data that is present in D300 is multiplied with 60 and the resulting product is stored in D400. MX are memory bits addressing normally open switches used to control devices individually. MXY are memory bits addressing normally open switches that are used to control all devices in X^{th} row. M100 is used in dynamic control to control all the devices simultaneously. T0 is a normally closed switch (and also the address of the timer) which is used in series with M100 switch to break the circuit after the given input time has elapsed.

The YX are output address given for each of the device individually. These output switches further collectively used for the control such as quick control and dynamic control. As mentioned above about the T0 switch it is the timer switch which is normally closed when the devices are used in the dynamic control. There are different types of functions used in the program such MOV, MUL, OUT, END.

The MOV function is used to move the values present in the registers of the PLC. The syntax for the MOV function is [MOV Source Register Destination Register]. Generally we can use registers from D0-D1024 to store the values. The MUL function is used to multiply the two values present in two different registers and stores the result in other register. The syntax for the MUL function is [MUL Operand1 Operand2 Destination Register].

Each output coil in the program represents a single device. The representation of the outputs is done in the octal format. For controlling the devices in a single row a common switch is used as MXX. Similarly for the dynamic control where all the devices are controlled at a time, the inputs of each device is collectively given to a common memory bit addressing normally open switch as MXX.

D. Power Consumption Calculations

For the calculation of power consumed by the device for a period of time we have to know the time for which the device is turned on, for knowing the time we have a function called HOURM. This function measures the on time of the input contact in unit of hours. The syntax for the function HOURM is [HOURM s, d1, d2].Here in the syntax of HOURM ‘s’ stands for pre-set value. The ‘d1’ register stores the accumulated value in terms of hours. The ‘d1+1’ register stores the value in terms of seconds. The ‘d2’ register stores the done bit. If the pre-set value is reached the ‘d2’ register gives a high output to the switch, its remains low.

IV. WIRING OF THE PROPOSED WORK:

The wiring in the project is shown in fig.4. The live wire is connected to the common port of the relay switch as shown in the figure. The device wire is connected to the normally open switch of the relay. A VCC of 5V is supplied from the SMPS to the relay. The input pin of the relay is connected to the PLC output channel.

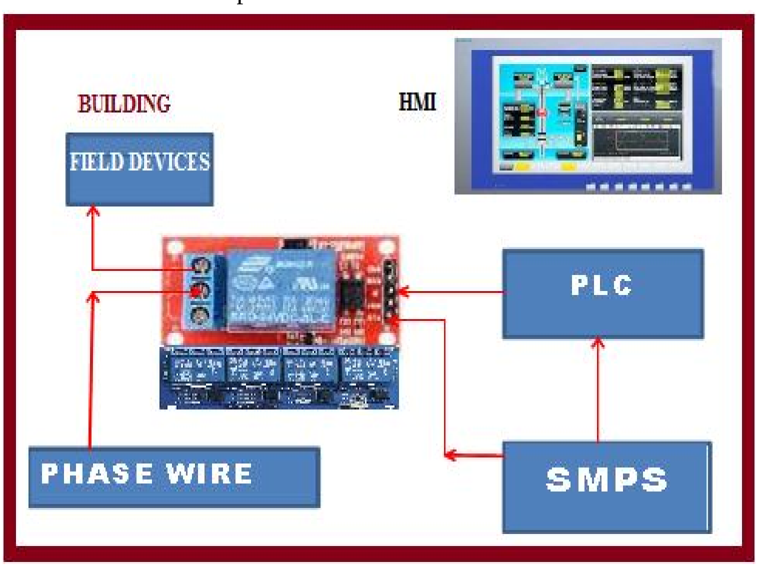

Fig 4. Wiring diagram of Field devices with PLC

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V. GOT SCREEN DEVELOPMENT FOR HMI UNIT

The MELSOFT GT Designer 3 software suite provides an intuitive and efficient screen design environment for GOT2000, GS Series and GOT1000 HMIs. Innovative features such as template screens enable quick design of attractive screens that provide a professional portal into machines. Data entry fields, dialog windows placement aids have been optimize to reduce development time and provide the flexibility every programmer demands. After screen development is complete, one touch simulation enables developers to debug and verify their projects using real-time variables and conditions. The following are the list of figures that can be used in HMI Screen Design.

The communication between the HMI and the PLC is carried out by using the ETHERNET. The switch address present in the PLC program are given to the memory switch present designed in the HMI screen. The address of a lamp that indicates the status of a particular device in HMI is same as the address provided for the particular device in the PLC program. The switching action in the HMI screen is set as alternate switching. Similarly the address of the timer function present in the PLC program is given to the Numeric Input function present in the HMI screen.

A. Classifications of Controls

Based on number of devices controlled using a single switch, there are three different types of control used for the controlling of the devices. They are as follows:

1) Individual control
2) Row control
3) Dynamic control

a) Individual control: In individual control (Fig.5) we can control the devices present individually. This is generally used when a few devices that are not in the same row are to be controlled. The individual control cannot be accessed when we use the row control and the dynamic control, to access the device individually we must exit the row control and the dynamic control.

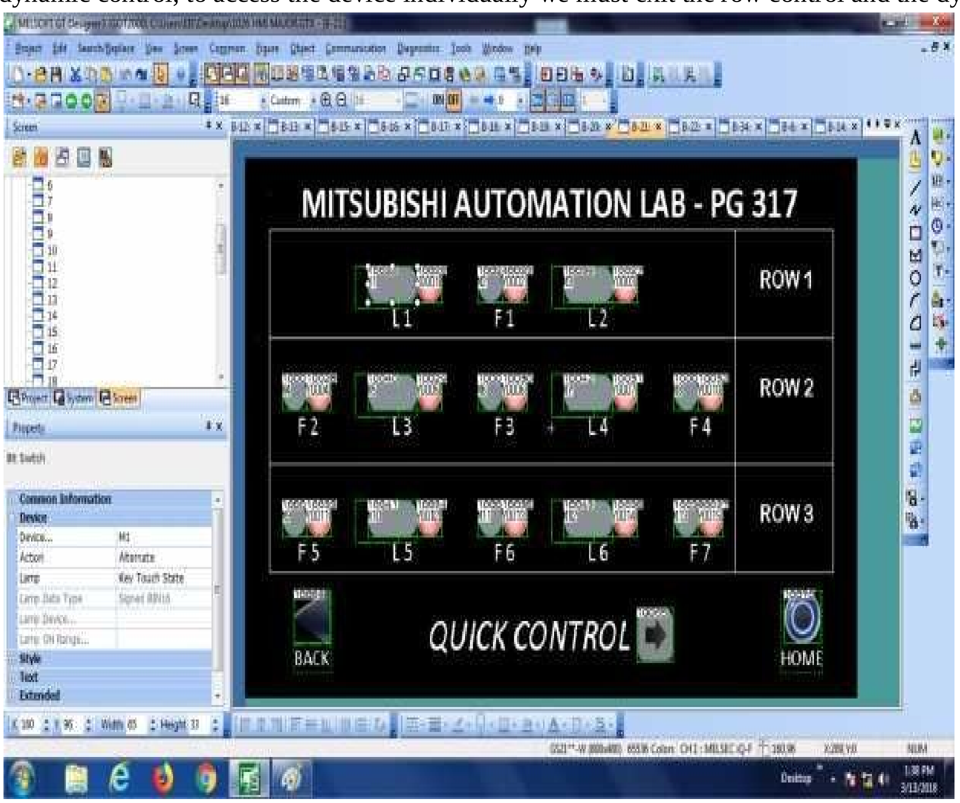

Fig.5.HMI screen for individual control

b) Dynamic control: It is used to control all the devices in a room simultaneously. Optionally, the devices can be made to run for a desired period of time after which they turn off automatically, thus saving energy. This is done by inputting desired time in the timer. Row control and dynamic control together constitute quick control (Fig.6, Fig.8, Fig.9, Fig.10)

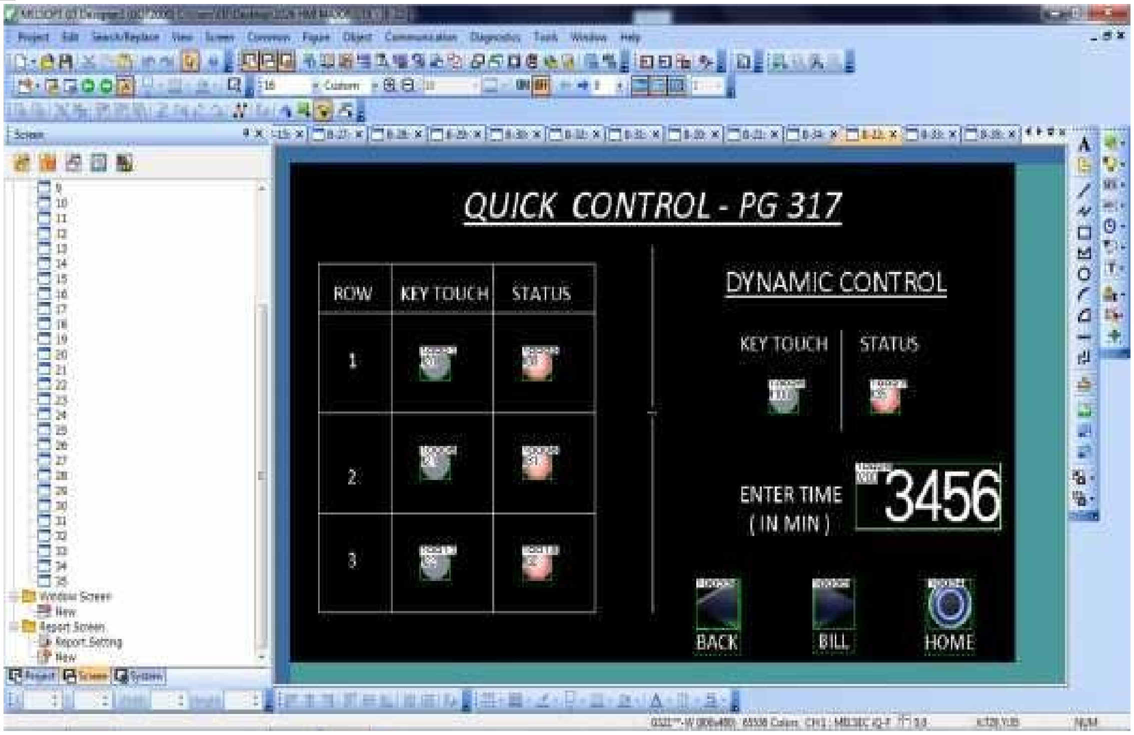

Fig.6.HMI screen for Quick control

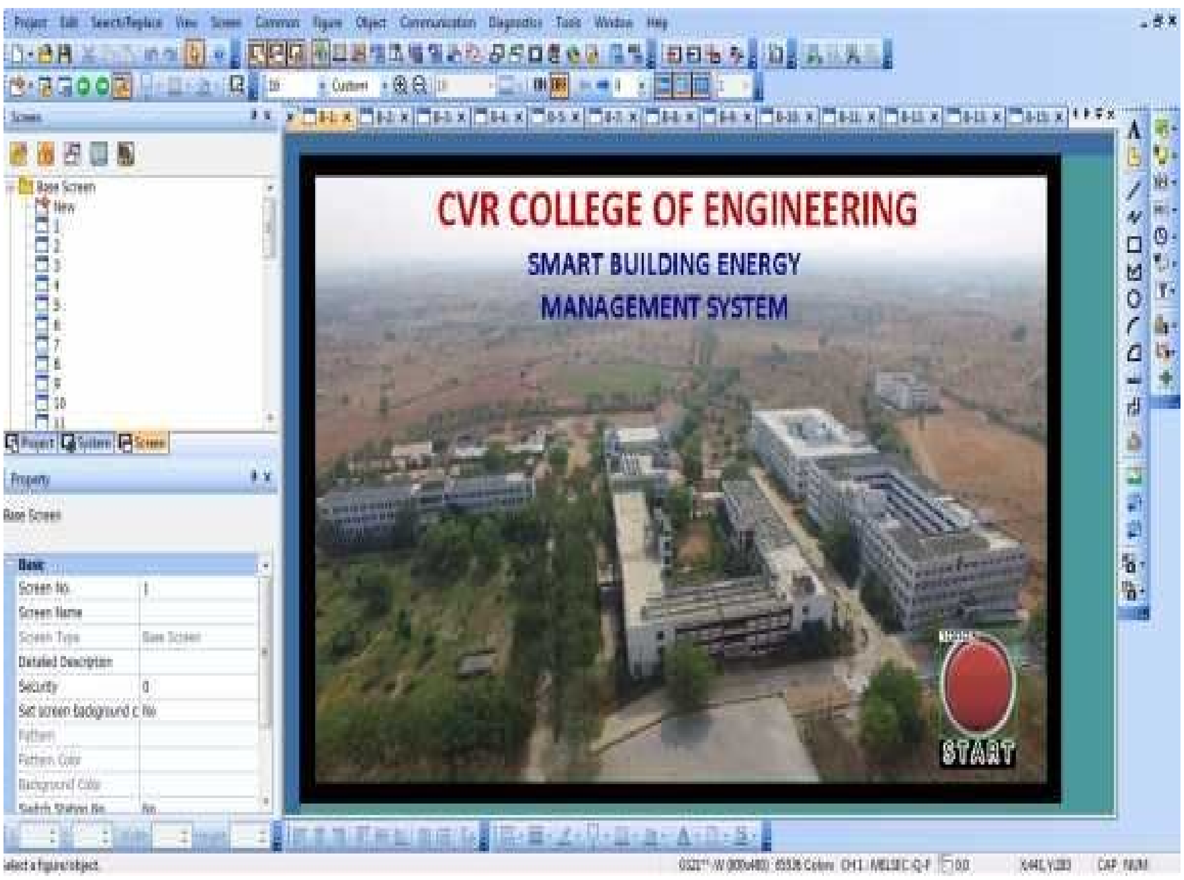

Fig.7.HMI screen for Home page

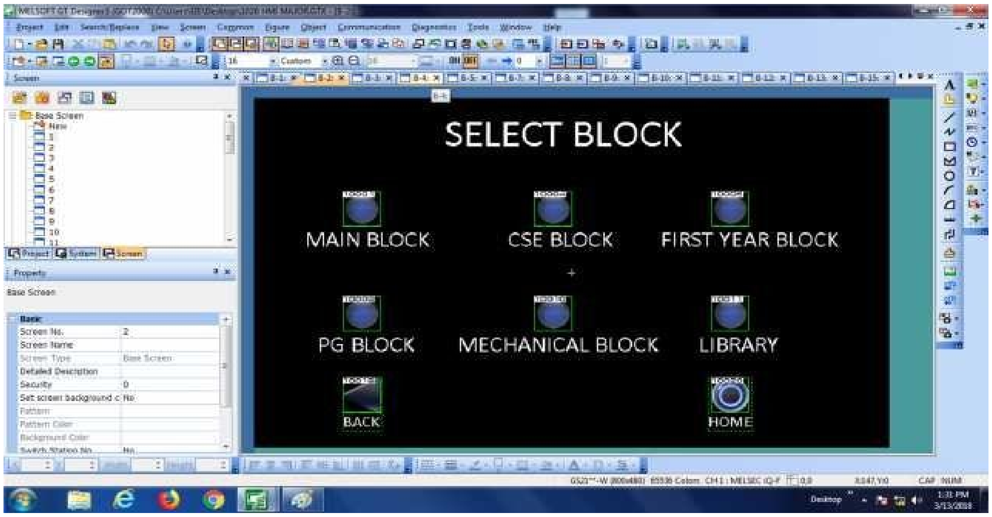

Fig.8.HMI screen for selection of block

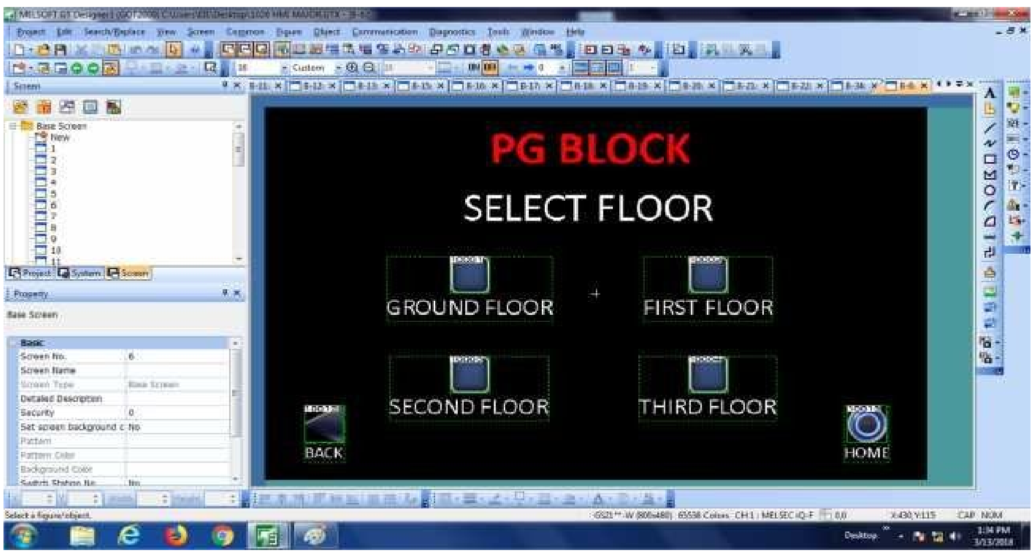

Fig.9.HMI screen for selection of floor in the block

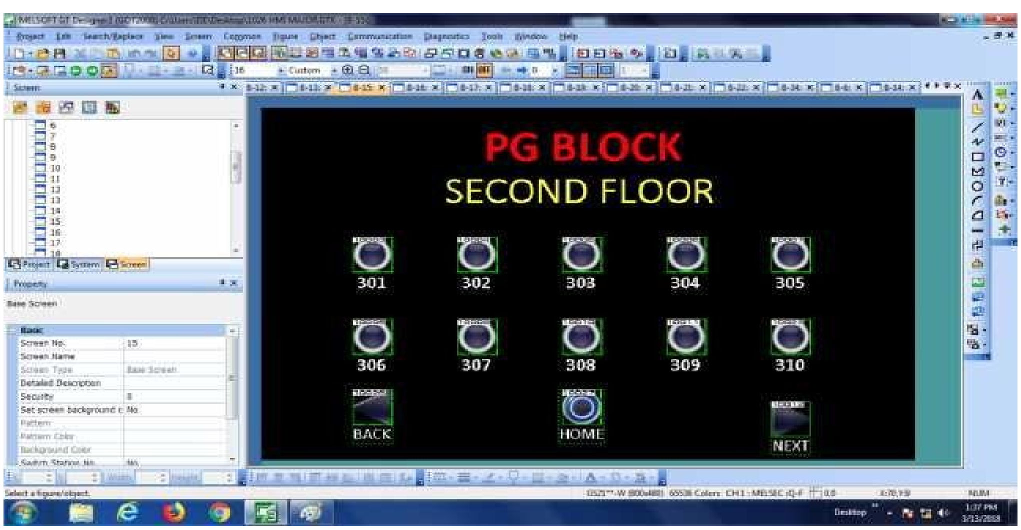

Fig.10.HMI screen for selection of room in the floor

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The generation of the bill takes place when we press the generate bill switch provided on screen . The bill generation screen appears (Fig.11) and displays the electricity bill. The numeric display function of the HMI screen is provided with the address of the register which stores the final value of the calculated electricity bill.

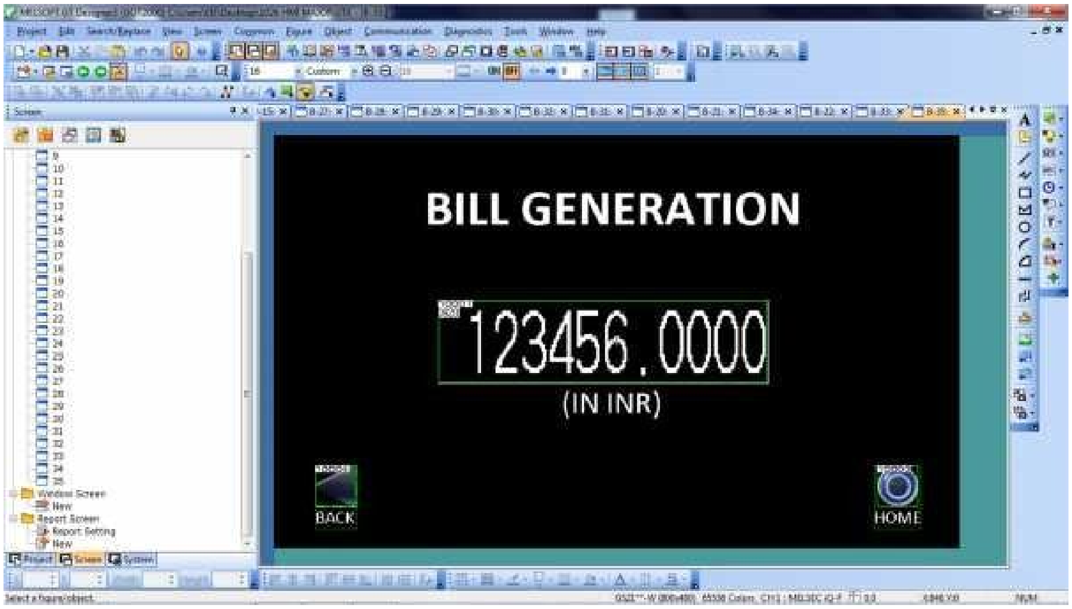

Fig.11.HMI screen for Electricity bill generation

VI. CONCLUSION & FUTURE SCOPE

The HMI based Smart building energy management system is developed for a building, such that the energy wastage in the building is reduced, but the amount of energy saved cannot be known accurately. It is well known that increasing the length of wires increases their resistance. Hence, the signal transmitted through wires may not reach their other end (loading effect). This is prominent in huge buildings where control location is far from relays/devices. To avoid loading effects and the hassle of wiring, wireless networks can be used employing arduino boards and Wifi technology. The main reasons for using arduino boards are - they are cheap and easy to program.

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