Energy Management in Smart Home Using Plc and Scada

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Abstract— In the day today life, the power demand increases with increase in development of technology and modern tools, the utilization of the power progressively raises more than the power generation which results in power demand. To reduce the power demand, it is necessary to focus on the power generation while cost function minimization also plays a vital role. The home power management system is proposed with the objective to reduce the electricity cost and also to avoid the problem of high peak demand. Recently many methods have been discussed in the area of Home energy management, but monitoring and controlling the operation of power units from customer point of view has its own benefits depending on the comfort level of customer. The proposed method consists of a photovoltaic system with battery, PLC and SCADA. This controller schedules the power units in response to the demand of the customer. The available power units comprising of solar power, battery power, grid supply and the utilization of home appliance are categorized and monitored regularly in terms of current sensor. The primary power units, preferably solar are chosen automatically as per the instructions given to the controller. When the primary power unit (solar) is not able to supply power, due to its intermittent nature of generation, the controller shifts to next power units accordingly. The simulation results show that the proposed system based on Home Energy Management (HEM) reduces the electricity cost, peak demand problem and enhances the efficiency of energy use and efficiency. The smart controller is operated based on SHEM and selects the power units accordingly. The case study justifies the effectiveness of the proposed system for energy management system in smart home. The proposed system is developed and simulated in MATLAB/SimPowerSystem (SPS).

***Keywords**: Energy demand, Electricity cost, home energy management, APSC algorithm, PLC & SCADA.*

I. INTRODUCTION

The electricity consumption is increasing day by day, due to the technological development and also due to upcoming innovative smart home appliances. Thus the demand gets raised leading to power generation by means of fossil fuels. In order to reduce the demand, it is necessary to save energy by enhancing the use of Renewable energy. The most part of electrical energy consumption occurs in residential area. Therefore proper use of electricity in the residential area plays a vital role in saving electricity.

The home electricity demand varies throughout the day. When most of the residential, uses electricity at the same time (peak hour), the demand of electricity at the residential area increases. To avoid this high peak demand, degeneration, real time pricing (RTP), time of use (ToU), and critical peak Pricing (CPP) [1] are introduced. The smart home is defined as the home with smart sensors, power units with Renewable energy, smart controller with smart electrical appliances [2, 3]. Many research focuses towards the aim of reducing the electricity cost. A novel method is introduced that monitors the energy pricing and creates corresponding time schedule [4].Whereas [5][6] focuses on improving the power quality and reliability and it is achieved by combination of the pv system , wind power system and fuel cell system and explains the source side control process. Several papers focuses on Load sharing and power quality improvement [7][8]. In [10] Static converters are employed for the improvement of the power quality. A smart energy management is also introduced which is based on price variations [10][11]. PLC based controller is widely used because of its simplicity and effectiveness. It has the advantage of ease of handle by any human. The SCADA has its uniqueness in effective monitoring of source and load. These together perform a stable and reliable operation in the home side management system.

II. MODELLING OF HOME ENERGY MANAGEMENT SYSTEM

The proposed model consists of smart electrical appliances, power units PLC & SCADA based controller. Initially SCADA collects the information and status of appliances and power units. Then according to home power management algorithm, power units will be decided to provide power. This selection of suitable power units is done with the help of PLC.

The design of a smart home energy management system is shown in fig 1.The photovoltaic power unit is preferably chosen as the primary source of power. When the primary power is not able to meet the demand or unavailable, the secondary power source of storage system is selected. When secondary power source is unavailable or not able to meet the demand, next power source from grid is selected. In addition effective use of Renewable energy is enhanced since it is the preferred as the primary source of power.

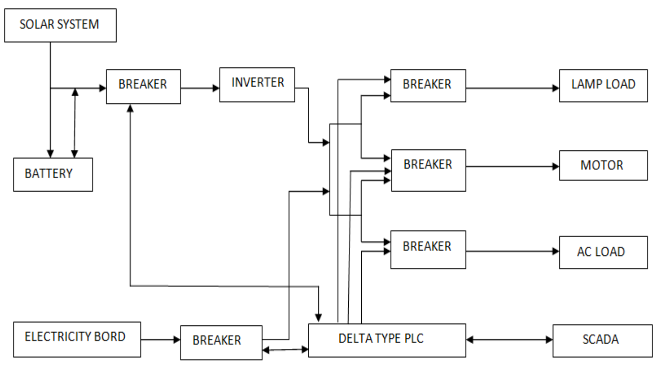

Figure 1: Smart home energy management system.

III. CASE STUDY

In order to prove the effectiveness of the proposed system, detailed study of load demand and consumption of energy from grid is calculated and then generation of power from photovoltaic system is analyzed and tabulated.

Table 1: Static Analysis For Load Consumption

	A	B	C	D
1	TIME	LOAD CONSUMPTION(W)	GRID SUPPORTING LOAD(W)	SOLAR SUPPORTING LOAD(W)
2	6-8 AM	850	400	450
3	8-10 AM	500	0	500
4	10-12AM	6700	6200	500
5	12-2PM	1200	1000	200
6	2-4PM	1200	1000	200
7	4-6PM	400	0	400
8	6-8PM	330	0	330
9	8-10PM	330	0	330
10	10-12PM	5200	5000	200
11	12-2AM	25	0	25
12	2-4AM	25	0	25
13	4-6AM	25	0	25
14	TOTAL	15935	13200	2735

Table 1 and figure 2 shows the hourly load data and the load that is supplied by the grid and the load that is supplied by the photovoltaic system. It can be seen that the array supports one third of the total load and thereby reducing the cost by one third i.e., 33.33%. The load is classified into three categories as high, medium and low load based on demand. The system is designed in such a way that the high level loads are supported only by the grid supply. Low and medium load can only supported by all the power units. Thus power utilization from the grid is reduced considerably. Only during high demand or high power consumption, the power from grid is utilized.

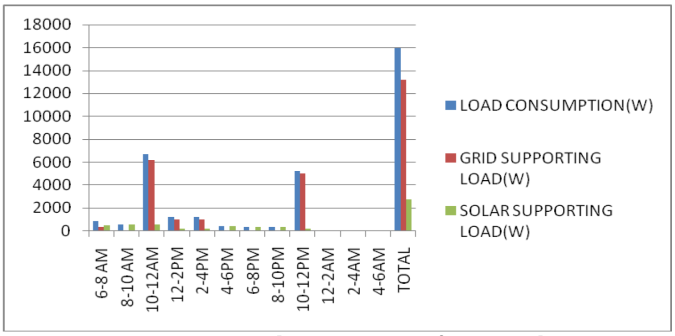

Figure 2: Load consumption for every hour

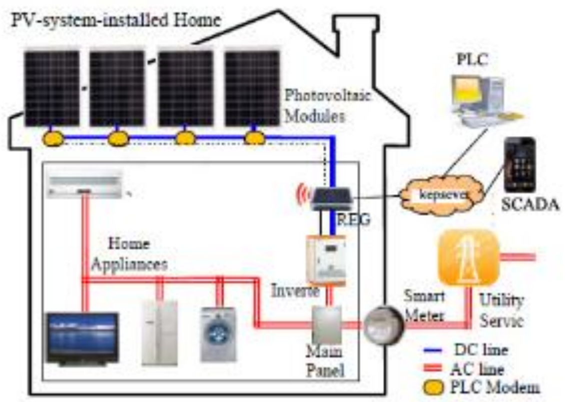

Figure 3 Architecture of smart home energy management system

The Architecture of smart home energy management system is shown in fig 3.The 1KW PV module and power from grid is connected in the main panel. The panel consists of a relay which is to be controlled for the selection of power source. Three different types of load presented in the home energy management system namely high load (above 1000w), medium load (100 to 1000w) and low load (below 100w).The connected electrical power is supplied to load within the control of main panel. Main panel circuit breaker and inverter operation are controlled by PLC gateway and monitoring process done by SCADA system. The current sensor gives the information about the load to the SCADA system and transmits the data to PLC. Thus the flexible power generation and utilization can be made through the PLC and SCADA system.

The load sharing and load shedding is prepared according to the solar radiation, battery and load demand. Solar radiation varies during the condition the converter plays the important role in the conversion process. The program logic controller is exercised for controlling the selection of power source in home energy management system; the PLC is programmed by using suitable software. The PLC system is interconnected through the RS 232 cable. The ladder logic design is employed in the control logic for the PLC, the delta type PLC was presented in the system. The primary program is used to solve the troubleshooting and debugging problem. The SCADA system is operated for controlling and monitoring purpose, the SCADA system is used to form the logic according to the customer. The outer loop control process is controlled by the SCADA system, the inner control loop control process is scrutinized by the PLC. The complex algorithm is solved by MATLAB-PLC Platform.

IV. PLC

Programmable logic controller is computer designed software. PLC has the different type of programming language such as ladder logic, mnemonic etc. However the ladder logic is mainly used in PLC system .The "WPL soft" is a software tool for designing the ladder logic. It will convert ladder logic to the PLC logic.

The basic operation and performance are shown in fig 4.The delta type PLC is used for real time control system, its having the two type of memory variable which includes input relay type and output relay type .It denoted octal numbering mode which have 8 memory locations.

In proposed system control and operation is performed by DELTA PLC .It has easy storing capability, timing, counting and position control .Many type of control is usually applied for the industrial automation.

The delta type PLC performed high speed operation in addition to maintain in the system in stable condition and it can be used for high reliability application. The cost is also very less compared to the other type of PLC.

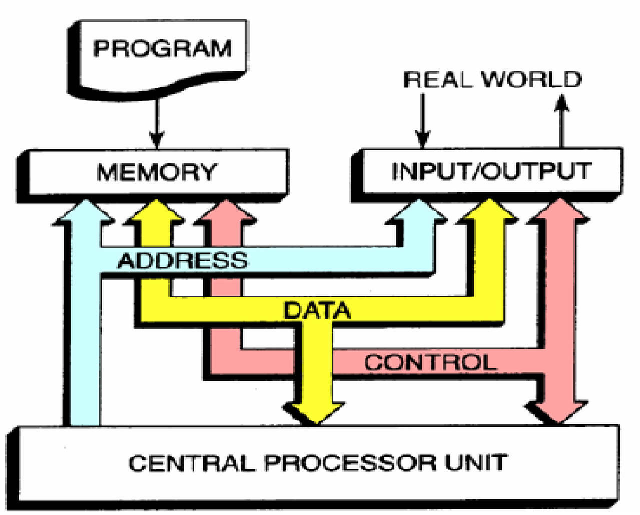

Figure 4.Architecture for Program logic controller.

V. SCADA SYSTEM

Supervisory Control and Data Acquisition System is used to control and monitoring purpose. It is used to the network status, enable remote area, optimize the system performance, dispatching the repairs and coordinates the other utilities.

A typical image of a SCADA interface is as shown in Figure 5 In this work, SCADA provides the balance between demand and generation. It is also used to monitor flow and the system is observed and the co-ordination with other utility during emergency condition is also established.

The operation of SCADA system shown in fig 5.The source and load side values are get through the sensor network. It sends the data to the PLC system. The PLC system again sends to the SCADA computer. The system helps to analyze and display the data. The SCADA system is used to minimize the time and cost function.

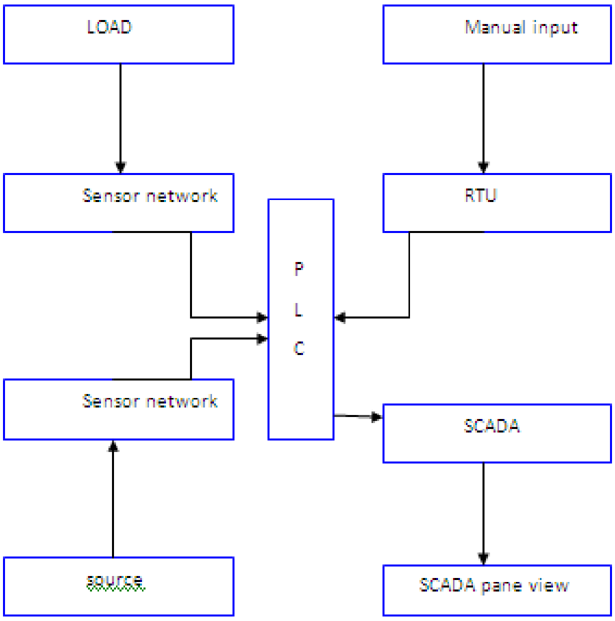

Figure 5: block diagram representation for SCADA system operation.

VI. RESULTS & DISCUSSIONS

The PLC layout diagram of the smart home energy management system is shown in fig 6.Here XO is the relay control of PV power source and M1 is relay control of grid power. The current sensor values are calculated from the load and source. The comparator is employed for comparing both load and source. Photovoltaic power is utilized during low load and medium load. When solar power exceeds the required load next priority power source is selected automatically. In the layout, (Y1) is the low-level load,(Y2) is the medium load. The result shows the selection of photovoltaic power source when low(Y0) and medium(Y1) load were operated. During which load(Y2) is off.

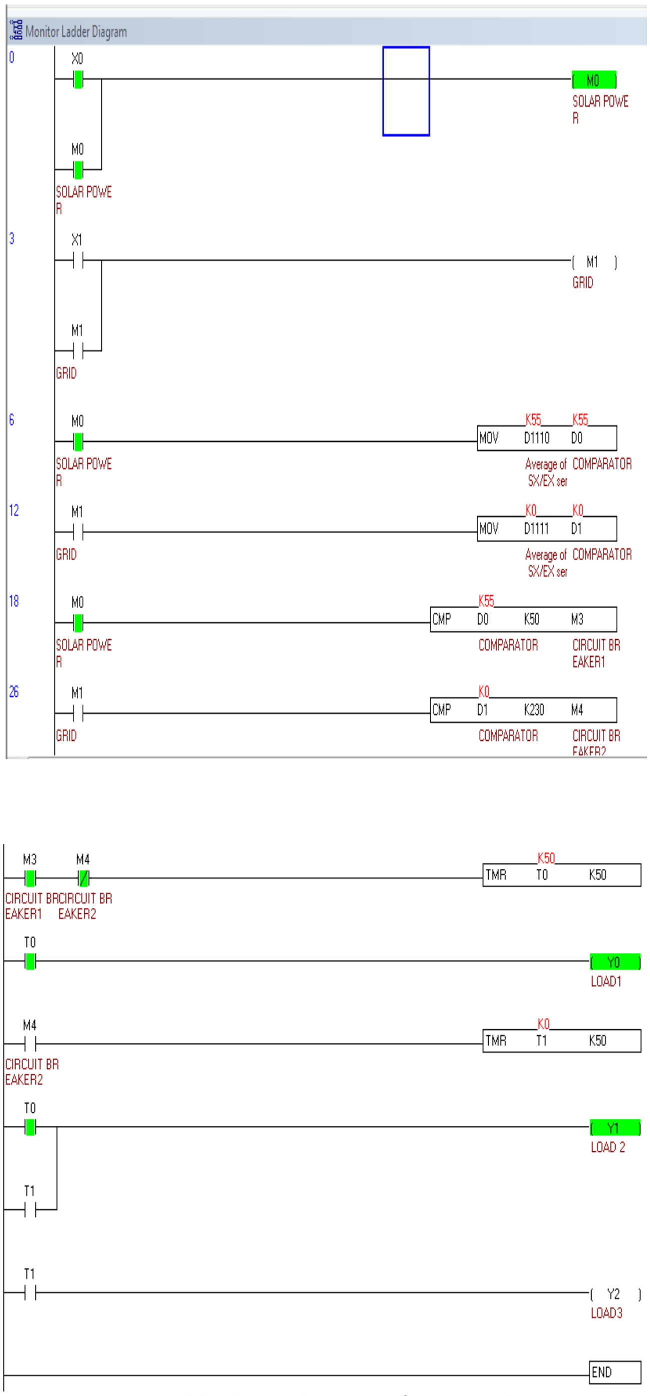

Figure 6: Ladder logic diagrams for Smart home energy management system.

A. *APSC CONTROL STRATEGY*

Automatic power supervision control algorithm is implemented in this paper. Three different processes are conduct based. Comparison process is employed between the source side and load side. The timer circuit is used in which situation which can be operated is designed .Three different load are controlled by applying the pulse to the circuit breaker. Based on the circuit breaker operation the load and power generation is controlled.APSC control strategy is shown in figure 7.

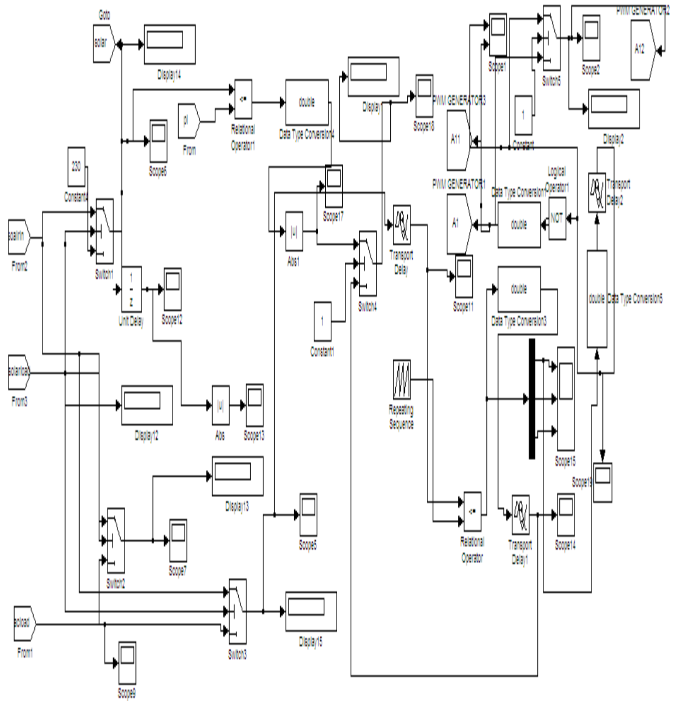

Figure 7: APSC strategy simulation diagram

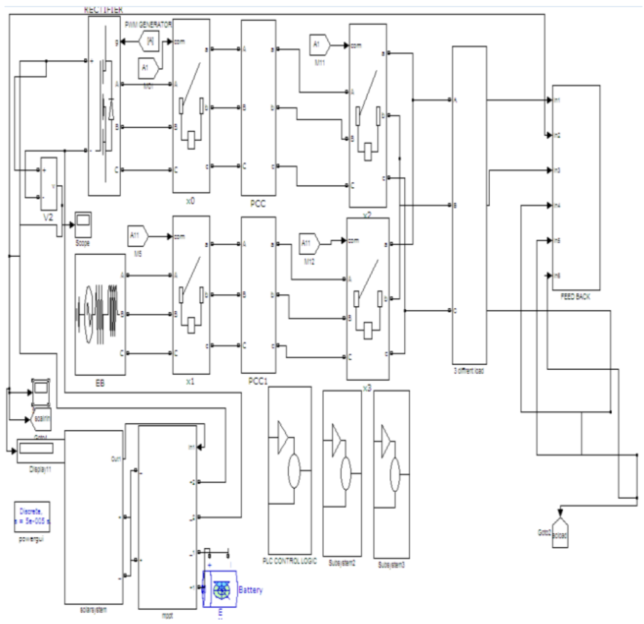

Figure 8: simulation diagrams for Smart home energy management system

The overall simulation diagram is shown in the figure 8.The elementary models of solar array ,battery, sepic converter and load are interconnected and irrespective controls were modeled using simulink library.

VII. SIMULATION RESULTS&DISCUSSION

The APSC control strategy based home energy management system is achieved by the following condition.

1)From the figure 9.it is observed that during t=0 to t=0.1s the medium load is supported by the solar panel. From t=0.1s to 0.2s the high load is supported by grid power.

2) From the figure 10,it is observed that during t=0 to t=0.2s the high load is supported by grid.

3) From the figure 11,it is observed that during t=0 to t=0.1s the high load is supported by grid after t=0.1s to 0.2s the medium load is supported by solar panel.

4) From the figure 12.it is observed that during t=0 to t=0.1s the high load is not supported by the solar panel during the condition the grid supports the high load.

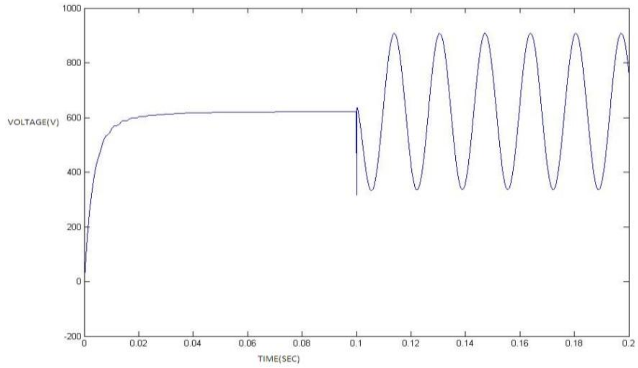

Figure 9: Simulation diagram for PV power generation to low level load

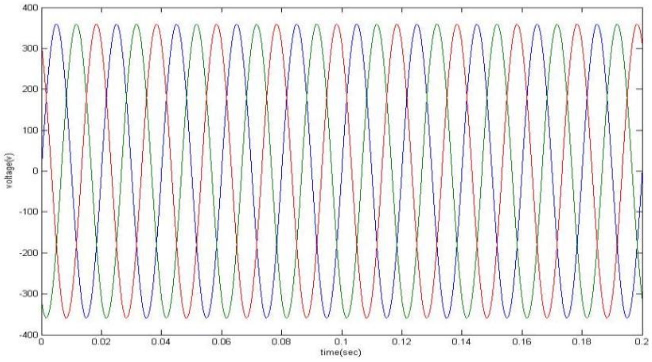

Figure 10 Grid output Simulation diagram for heavy load

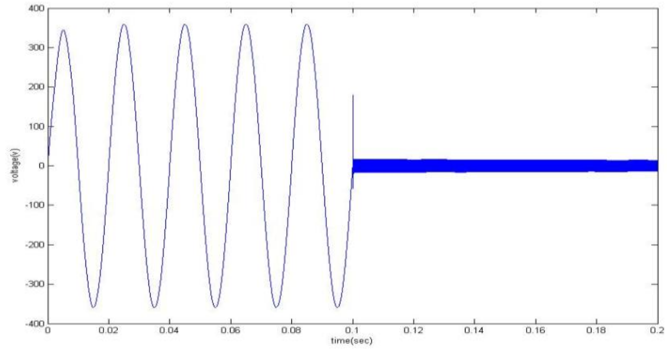

Figure 11: Grid and solar support to the medium load

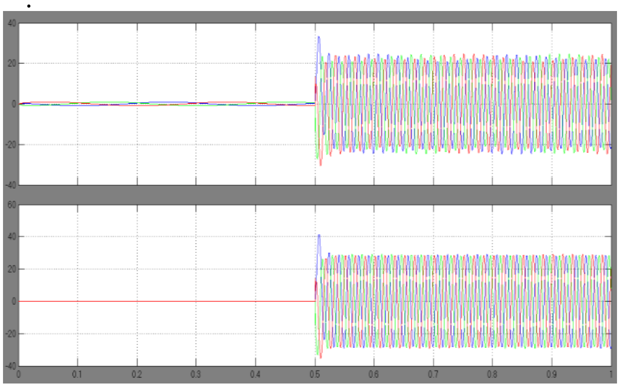

Figure 12: Voltage and Current value for heavy load

CONCLUSION

In this paper, APSC algorithm is developed in order to reduce the electricity cost and also to avoid peak demand problem for a smart home with the help PLC and SCADA system. According to the APSC algorithm, the main PLC controller selects the power units that will meet the power demand of smart home according to the data received from SCADA system. Since APSC can handle dynamic variations of environment, accurate and realistic home power management is provided by means of real time profiles of appliances. The proposed model of energy saving reduces 24 units of power from grid and this units are utilized from PV generated solar energy. This helps in the reduction of peak hour demand. This finally reduces the electricity cost of the residential home. The proposed model reduces □ .26,000 annually for the case of chosen residential home. Thus this paper introduces the methodology to achieve solutions to reduce electricity cost and to maintain uninterruptible power supply by controlling the selection of power unit with the help of PLC and SCADA.

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