

Review on Home Energy Management System (HEMS) Using FPGA

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Abstract

Now a days, energy saving is one of the most important issue for development of smart grid. The electric grid operation consists of vertical structure consisting of generation, transmission and distribution with the necessary infrastructure to ensure reliability, stability & efficiency. The hardware prototype of HEMS automatically switches the load between the battery & electric grid thereby reduces the energy consumption of the grid. The HEMS is implemented in SPARTAN 3 FPGA board, which in turn sends control signal to the relay connecting the load to the supply. The battery is solar energy charged battery which helps use of natural resource thereby managing the energy system. The FPGA controller checks for both demand limit & comfort level violations of the user. The use of solar operated battery inverter will help in energy management by using the natural energy source, sun to produce energy through solar panel. This will reduce the energy consumed by each household from the grid which in turn reduces the electricity cost.

Keywords- Home Energy Management System(HEMS), Spartan-3 FPGA, Inverter, Relay

I. INTRODUCTION

India is one of the world's largest producers of electricity. Today, the electric grid operation consists of a vertical structure consisting of generation, transmission and distribution with the necessary infrastructure to ensure reliability, stability, and efficiency. Smart Grids communicates between all grid generators, operators, consumers and other electricity market stakeholders to meet their needs and fully utilize their capabilities. Smart grid relieves any congestion in the grid caused by an unexpected peak demand by distributing the available electric energy intelligently thereby reducing the peak load and flattening the load profile. Implementation of this intelligence to manage demand response is the main aim of home energy management system. It will also reduce the electricity costs at home or business as the smart grid will enable optimized energy usage by appropriate scheduling of device operation by any automated control systems.

II. LITERATURE SURVEY

The paper by Dan Wang, et al. summarizes related researches of the Integrated Energy Distribution System (IEDS) and explores energy operation characteristics and coupling mechanisms compared with the traditional power distribution system [1]. In the paper published by Hussain Shareef, et al provides a comprehensive review on previous & current research related to HEMS by smart technologies by considering various DR programs, smart technologies, and load scheduling controllers [2]. The paper by Sarika Ambadas Shinde, The HEMS with demand response is proposed in which different loads are used and correspondingly priorities are adjusted of the user. The controller board is used which make the decision to switch ON/OFF action of the selected and end user appliances [3]. The referred paper by Arockia Cecilia A and Sudrsanan K, shows new architecture of home energy management using smart grid communication has revisited the need for domestic energy management for efficient consumption of electricity in smart grid. Architecture of FPGA implementation of HEMS for smart grid that estimates energy consumption of appliances by measuring the voltage, current, drawn by the appliances [4]. In the paper published by Tesfahun Molla, et al, it enables consumers to control and schedule the consumption pattern of their appliances,

minimize energy cost, Peak-to-Average Ratio (PAR) and peak load demand. The objective deals with the minimization of monthly electricity cost, minimization of the power average ratio and maximum peak load demand[5]. The referred paper by ShitalMahajan, et al, presents a cost effective solution that uses FPGA controller at the core system based on Inter-Integrated Circuit (I2C) protocol which provides easy communication between slave memory and FPGA. This system leads to a low cost system that can be easily scaled up. As it uses GSM interface the system can be used in remote areas also[6]. In the paper published by AnuPriya., et al, shows that the difference between the traditional method of energy meter billing and the latest energy metering method with the designing of a access to the billing information from anywhere round the globe. The communication takes place through Bluetooth module wirelessly[7]. We referred the paper by VivekDharmarajan which describes hardware prototype of HEMS that automatically reduces loads between battery & grid thereby reducing energy consumption from grid. The EMS is implemented in SPARTAN 6 FPGA board, which in turn sends control signals to the relays connecting the loads to the supply. This reduces the energy consumed by each household from the grid which in turn reduces their electricity costs[8].

III. METHODOLOGY

The electrical system consists two sources of ac supply. Alternating current (AC) supply is obtained from either the electric grid or from the inverter connected to a battery. A Double Pole Double Throw (DPDT) relay is used to switch between these two sources of ac supply. This relay is activated only if the load is switched on from the switchpanel. These inputs from the switch panel are first send to the local controller, SPARTAN 6 FPGA board, which in turn sends control signals to the relay connecting the loads to the ac supply. Switching of ac sources is based on the status of the battery charge and the amount of load it can drive. The battery state is obtained by measuring the voltage across its terminals with the help of a charge controller. The charge controller is charged using the solar panel to 12V direct current (DC). The charged energy is stored in the battery. The inverter kit is used to convert 12V dc into 12V ac. The step-up transformer is used to increase the 12V ac supply to 230V ac supply. This 230V ac supply is provided to the DPDT relay. This provides power supply to the load through inverter. Also, if the charge of the battery is low, load is always connected to the grid. Switch helps in changing of power supply from grid to inverter or vice-versa. The FPGA controller checks for both demand limit and comfort level violations of the user. The use of solar panel inverter helps in management and the saving of energy.

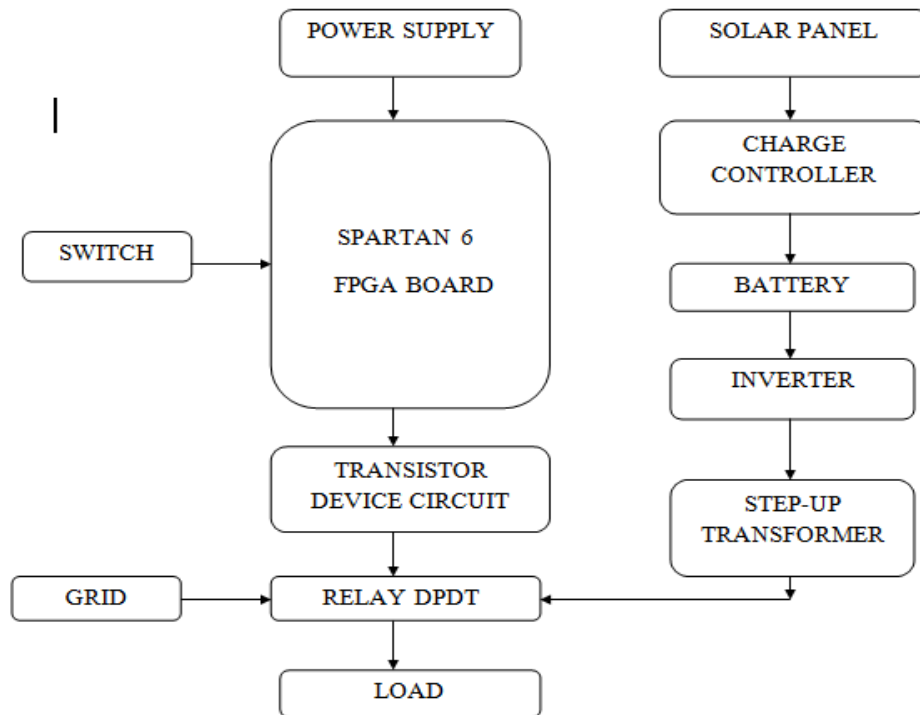


Fig.1: Block Diagram of FPGA based Home EnergyManagement Implementation

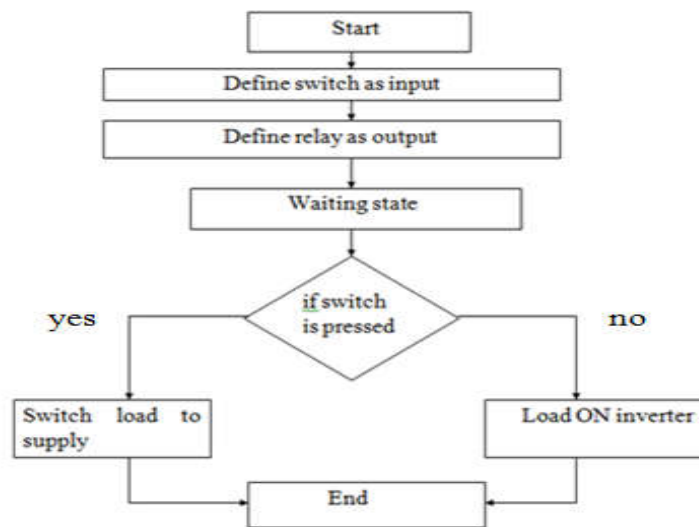


Fig 2. Flowchart of a system

IV. SIMULATION RESULTS

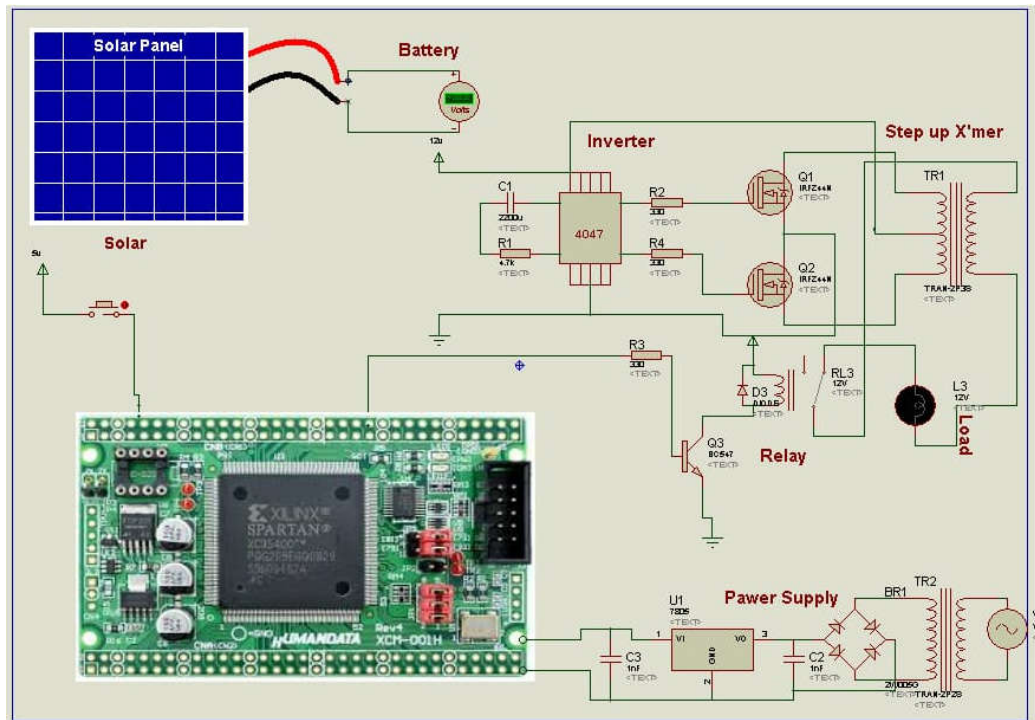


Fig 3. Simulation of the circuit

V. CONCLUSION

The given system of Home Energy Management System (HEMS) using Spartan 6 FPGA development board consists of switching between a battery source and electric grid based on the type of load connected in the electrical system. Energy Management System plays an essential part in realizing Demand Response in smart homes in the smart grid environment. Based on load priority, utility control signals and customer's preference, EMS will enable to control load and will try to focus on effective measures to reduce the cost of power consumption and using renewable energy source to overcome power supply cut-off problem.

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