An Implementation of FPGA Based smart meter for Home Energy Management

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Abstract- Home Energy Management (HEM) for Smart Grid focuses on the power management on consumer side, where home appliances can be monitored and controlled to balance and optimize the power supply and consumption. Among various applications of Smart Grid technologies, Home Energy Management is probably the most important one to be addressed. HEM basically consists of smart meters, smart appliances and advanced control systems. The fundamental task of the HEM system is improving energy efficiency, data measurement, and transmission. The real-time consumption data gathered from each appliance of home are measured and transferred to a data concentrator and back to the utility and view of power consumption data and electricity pricing can be enabled in smart meter. Smart meter initiatives seek to enable energy providers and consumers to intelligently manage their energy needs through real time monitoring, analysis, and control. The energy efficiency communication needs of HEM systems on customer premises can be handled with ZigBee protocol. In this paper the new architecture of FPGA implementation of Home Energy Management for Smart Grid is developed. It estimates the energy consumption of appliances by measuring the voltage, current drawn by the appliances. The other function such as price predictor, communication to the consumer can also be performed in this architecture.

Keywords: Home Energy Management (HEM), Smart Grid (SG), Field Programmable Gate Array (FPGA), Analog to Digital Converter (ADC), Smart meter.

1. INTRODUCTION

The electricity delivery systems of most countries were built almost 100 years ago, where electricity travels hundreds of thousands of kilometers from central power plants to consumers with major energy losses. The structure of the current power grid is not well suited to meet the future energy demand. Hence, the SG has become one of the most important items on the agenda of many governments and utilities, since it is the key to increasing the recognition of the current problems and meets the electricity demand.

Traditional power grids are being transformed into Smart Grids (SG) using advanced information control and communication technologies to offer higher reliability, security and efficiency in power systems. Smart Grid consists of smart meter for Home Energy Management via energy efficient communication technology. To support both dynamic pricing and a two-way flow of electricity between homes (or micro grids) and smart meters are being widely deployed. In Compared to conventional analog meters, smart meters measure power consumption at a much finer granularity.

Currently, the electricity meters are installed on consumer's premises and the consumption information is collected by meter-readers on their fortnightly or monthly visits to the premises. Meters in the past, and today in a few countries are electromechanical devices with poor accuracy and lack of configurability. Theft detection is also a challenge. This method of billing is also not suitable for the electricity supply company because it gives inaccurate account of the overall electricity consumption in Manuscript received Recent developments in this direction seem to provide opportunities in implementing energy efficient metering technologies that are more precise accurate and error free.

The proposed methodology overcomes the overcomes of the existing technology by developing efficient home energy management using smart meter architecture. In this method to design energy efficiency, and low complexity of smart meter for home energy management using smart grid communication based FPGA. The new architecture of FPGA implementation of smart meter is one method reading and processing consumed energy data of each home appliance automatically with computer and communication and also gives the accurate account of the overall electricity consumption through main wireless communication protocol, ZigBee is chosen as lower layer communication protocol. With these applications, the standard is optimized for low data rate, low power consumption, security and reliability.

2. ARCHITECTURE OF HOME ENERGY MANAGEMENT USING SMART GRID COMMUNICATION

Home Energy Management focuses on the power management on consumer side, where home appliances can be monitor and controlled to balance and optimize their power supply and consumption. HEM consists of smart meters, smart appliances, in-home displays, and advanced control systems. The fundamental task of the Home Energy management system is improving energy efficiency, data measurement, and transmission.

The real-time consumption data gathered from each appliance can be measured and transferred to a data concentrator and back to the utility. Hence, statistical analysis, intelligent advice generation, various kinds of query support, and the view of consumption data and electricity pricing can enable in-home displays to inform customers about their consumption behavior. Communication Requirements of Home Energy Management: The communication needs of HEM systems on customer premises can be handling with low power, short-distance technologies, such as ZigBee, Bluetooth, and Home Plug. There is no need for a large amount of bandwidth or communication speed, since such applications are not counted as mission critical.

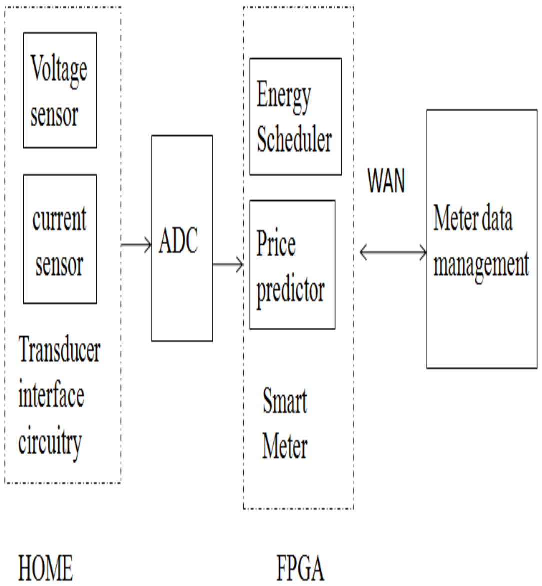

Fig- 1: Block Diagram of System Implemented In FPGA

The transducer consists of Voltage sensor and current sensor first measures the each home appliance voltage and aggregate current, producing the signals v(t) and i(t). These signals are sampled and quantized by an analog-to-digital converter (ADC) that produces the samples v[n] and i[n]. The FPGA processes these samples to compute each home appliance power. The other function such as energy scheduler, price predictor and communication to the consumer can also be performed in this FPGA architecture. These data transmitted to another computation device for analysis. The FPGA provides control logic for each of the subsystems.

The electricity meters are installed in consumer's premises and the power consumed is collected by meter-readers on their fortnight or monthly visits to the premises from current meter. In existing methodology, metering devices have gone through improvements and are expected to become even more sophisticated, offering more and more services. Meters in the past, and today in a few countries are electromechanical devices with poor accuracy and lack of configurability. Theft detection is also a challenge. Such meters are limited to providing the amount of energy consumption on site. This method of billing is also not suitable for the electricity supply company because it gives inaccurate account of the overall electricity consumption in Manuscript received Recent developments in this direction seem to provide opportunities in implementing energy efficient metering technologies that are more precise accurate and error free.

The advantage of proposed Home Energy Management provides the accurate account of overall electricity consumption to the consumer side. It provides the power demand required by the consumer to the Smart Grid. Figure 1 shows a block diagram of Home Energy Management system using smart grid communication implemented in the FPGA architecture.

Energy management is a broader term, which applies differently in different scenarios, but we are concerned about the one which is related with energy saving in homes, public sector/ government organizations or business. In this scenario the process of monitoring, controlling and conserving energy in an organization/ building may be termed as energy management. In smart grid where the consumers can generate local energy from several distributive generation units and where there is a plenty of space for different pricing schemes, the need for energy management programs has been pointed out by many researchers.

3. RESULTS AND DISCUSSION

3.1 TRANSMITTER FOR HOME ENERGY MANAGEMENT USING SMART GRID COMMUNICATION

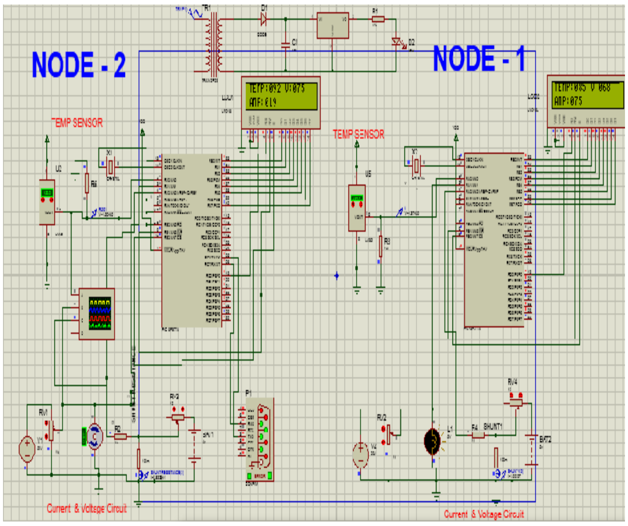

Fig -3.1: Output for Home Energy Management Transmitter Using Smart Grid Communication

The input of analog signals are given to the home appliances and output analog signals are converted into digital signal using analog to digital converter and their voltage, current, temperature values are transmitted to smart meter using ZigBee communication**.** For example in this simulation, Node 1 and Node 2 represent the motor and light.

3.2 RECEIVER FOR HOME ENERGY MANAGEMENT USING SMART GRID COMMUNICATION

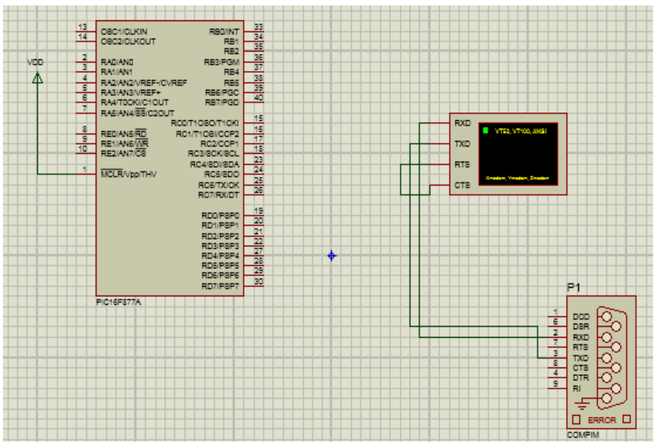

Fig 3.2: Receiver for Home Energy Management Using Smart Grid Communication

For every home appliance, the voltage, current, temperature values are received from Smart Meter using Smart Grid communication technology such as zigbee.

3.3 OUTPUT FOR SMART METER

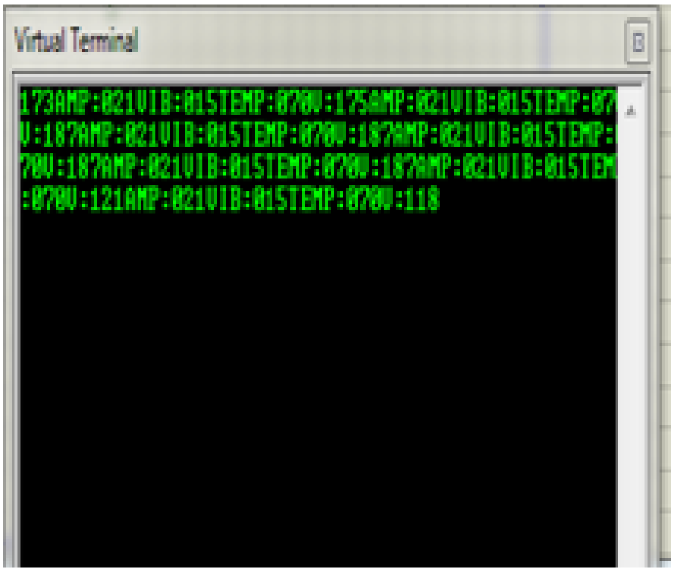

Fig 3.3: Output for Smart Meter

After implementing this method, the smart meter is used to find the voltage value, current value and temperature value of each appliance using energy efficient communication technology. The variation of voltage, current and temperature values of each appliance are shown in smart meter. The energy used by home appliances is obtained and it also helps to reduce the electricity.

4. CONCLUSION

As discussed in this paper, a 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. Consuming electrical energy efficiently results in reducing peak load, lowering electricity bills and minimizing the power consumption. In smart grid where there is wireless communication and better home automation, effective home energy management system can be designed. This proposed methodology has discussed home energy management schemes where different energy scheduling, pricing schemes have been applied to get economical and social advantages.

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