A Consumer Application with an Integrated Real-Time Power Theft Detection and Management System

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Abstract— Billing by a human operator is exposed to errors due to reading errors since the house's electric power is occasionally positioned in an inaccessible area. The notion of dynamic priority assignment to interruptions is presented, which decreases the delay time for less priority tasks that may become higher priority under certain situations. Interrupt time slicing is also being explored, which can help increase performance. The highest priority activities are completed more frequently and in a shorter amount of time. As a result, it does not need to wait for the slack time of other interrupted with greater priority. If the grid's power is reduced, the power will be maintained and controlled. When low-power generation occurs, our suggested system instantly switches to power management. When there is low power generation, all of the devices are managed based on a priority system and a timing system.

Keywords— EMC, RTP, DSM, EMS

1. Introduction

The term "embedded system" refers to a system that uses a mix of software and hardware to perform a specific operation repeatedly and indefinitely, both with and without human input. An embedded computer system that monitors and responds to an external environment to govern it. Sensors, actuators, and other input/output interfaces connect the environment to the system[20]. The embedded system must adhere to the environment's time and other limitations. In general, an embedded system consists of hardware, an operating system, peripheral devices, and communication software that allow it to accomplish predetermined tasks.

Unlike desktop computers, which perform a range of activities, embedded systems focus on a single, well-defined mission[18]. A CPU, supporting peripherals, and software for a specified purpose comprise the system. An embedded server is a computer that is designed

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to do one or a few specific functions, frequently under time limitations. It's commonly found as part of a larger gadget that includes physical and mechanical components. Such general-purpose computers, including a personal computer (PC), on the other hand, are designed to be adaptable and suit a wide range of end-user requirements[12-16].

Many modern devices are controlled by embedded systems. One or more primary processing cores, which are commonly microcontrollers or digital signal processors, control embedded systems (DSP). The most important attribute, however, is that it is dedicated to completing a certain task, which may necessitate the use of extremely powerful processors. Even though they entail mainframe computers and specialized regional or national networks connecting airports and radar sites, air traffic control systems, for example, can be seen as embedded[17].

Because the embedded system has been committed to a single purpose, design engineers may optimise it to minimise the product's size and cost while increasing its dependability and performance. Embedded systems are sometimes mass-produced to take advantage of economies of scale[21-23]. Large application systems will contain subcomponents at most locations along a spectrum between "general purpose" and "embedded," even though the system as a whole is "intended to execute one or a few specific functions," and it is thus suitable to designate "embedded." Thanks to miniaturization enabled by modern IC design, WSN couples whole wireless systems to smart tools, allowing individuals and businesses to measure a variety of objects in the real world as well as act on this knowledge through IT control systems. These motes are totally self-contained and may often function for many years on a battery supply before needing to be replaced or charged. Such an embedded system is just a computer programme that is pre-coded for a specific duty and embedded into the equipment it supports, so it cannot be modified by the user.

2. Literature Review

A. *Enabling Applicability of Energy Saving Applications on Appliances of the Home Environment*

This article proposes a novel network topology that is generic and applicable to household appliances, including white goods and audiovisual and communications systems, and therefore is capable of executing real-time monitoring of their energy consumption, given this same energy waste issue in modern households and the resulting need for optimal energy use[24-25]. The proposed architecture, which uses cutting-edge information and communications technologies, enables the creation of energy-saving application domains that undertake three primary components: real-time estimation of home environment energy consumption without the use of smart metering devices; regulation of domestic appliance energy use so that home environment energy consumption stays within user-defined limits; and fully independent assessment and treatment of standby decommissioning devices[8-11].

B. *Concurrent Error Detection:*

This article is about the smart grid age, which necessitates expertise in a variety of sectors, including information systems, communication, process automation, training, and nanotechnology, in addition to electric energy. This global endeavour will be successful if and only if energy management and control incorporate dependable data from precise measuring methods including voltage and current sensors[26-28]. These aims will need a wide range of skills and knowledge in electrical engineering, information systems, communications, process automation, education, and nanotechnology, not only in sectors directly connected to power and energy[7]. Modularity, expandability, dependency on fossil fuels, and the ability to offer clean energy at a fixed or reduced cost are the primary characteristics and problems of a smart grid.

C. *Optimal Residential Load Control with Price Prediction in Real-Time Electricity Pricing Environments*

In the presence of such a real-time pricing tariff coupled with inclining block rates, an optimal as well as automatic residential energy usage scheduling framework that attempts to obtain a good trade-off between minimizing the electricity payment and minimizing the waiting time for the operation of each appliance in the household[1]. We have based our design on basic linear programming computations and it needs little effort from the consumers. When compared to the present widespread flat rates, real-time energy pricing methods have the potential to provide economic and environmental benefits[19]. They can, for example, provide end customers the option of reducing their power bills by reacting to pricing that fluctuates depending on the time of day. Recent research has found that a lack of user understanding about how to react to time-varying prices, as well as a lack of appropriate building automation systems, is two main impediments to fully harnessing the possible benefits of real-time charging tariffs. As a result, both end users and utility corporations benefit from the implementation of the suggested optimum energy consumption scheduling strategies[2-6].

3. Proposed System

In this research, we provide a general design of an energy management system (EMS) inside a home area network (HAN) based on smart grid technology, and then offer an effective scheduling approach for home power utilization. The demand response (DR) information, which indicates the real-time electricity price, is received by the home gateway (HG) and sent to an energy management controller (EMC). The EMC develops an ideal power scheduling system using the DR, which the HG may send to each electric appliance. As a result, all household appliances are fully automated in their most cost-effective manner. When just the real-time pricing (RTP) approach is used, it's possible that most appliances will be turned on when the power price is lowest. Our suggested power scheduling strategy would effectively minimise both electricity costs and PAR, while improving the overall system's stability. We employ optimization algorithms to tackle this problem since these types of combinatorial optimization are frequently nonlinear. Advanced technologies, including renewable energy generation, such as wind farms and solar cells, provide complexity and difficulty for numerous controllers at all levels of the power grid.

To deal with the increased complexity, the utility business has looked into important communication and information technologies.

- Utility firms are experimenting with demand-side management (DSM) technologies to regulate energy usage on the user side of a smart grid architecture that aims to ease the modernization of the traditional power system.
- Demand-side management technology may assist in moving energy-intensive workloads from peak to off-peak hours for load balancing and cost-cutting goals, both of which are important in a smart home system.

4. Proposed Methodology

- A smart grid is indeed a system that combines a physical power infrastructure with an information system that connects various equipment and assets to establish a customer care platform.
- A smart grid will most likely include some technological advances in communications, networking devices, enhanced metering, automated, distributed data, safety, and security, allowing for a significant increase in the dependability and resilience of the power network, lowering energy prices.
- Residents may lower their power costs by arranging the frequency of individual home electricity consumption based on real-time electricity pricing thanks to the advent of the smart grid.
- The authors get suitable objective total power consumption with all devices. However, the authors do not provide the precise power scheduling strategy for each device.
- To save money on electricity, use less power than both cancelable and non-interruptible loads; however, peak power needs may arise while electricity prices are low.
- The cost of power and peak demand is both lowered at the same time, but the scenario's assumptions appear to be unrealistic.
- Residents can utilize this information through the use of an in-home energy management controller (EMC) that also uses both pricing and user preferences to schedule power use if an energy management system (EMS) is installed in the home.

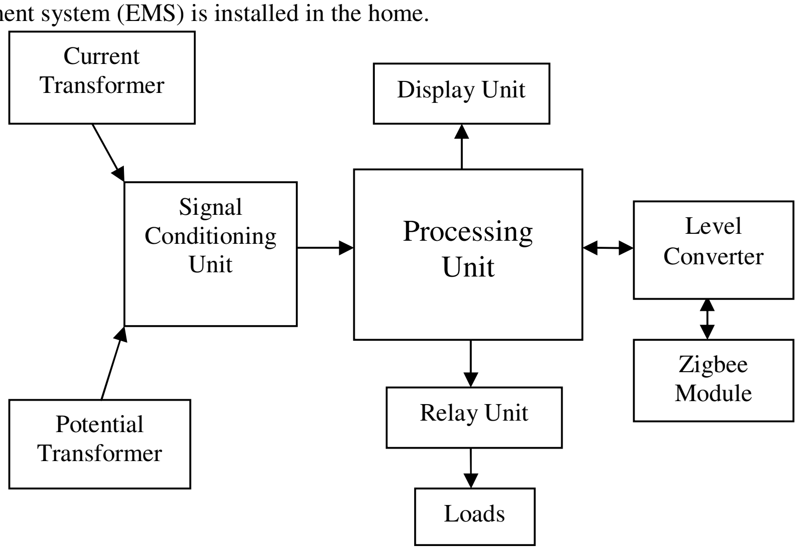
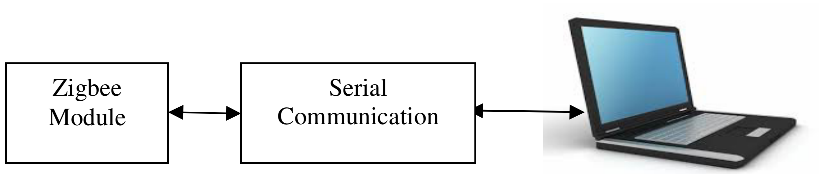


Figure 1 Block diagram



A. Current Transformer

The systolic ME is used as a CUT in this study to show that the suggested EDDR design is feasible. ME has some latches and registers finish the storage and data shift. A current transformer is a device that measures and inputs the current flowing through a power supply to a protective relay system. To aid in the identification and location of system failures, electrical power distribution networks may necessitate the employment of a number of specialized circuit quality monitoring equipment. In the field of electronic circuit breakers, current transformers and current sensors are well-known for generating the electronics inside this circuit breaker trip unit and measuring the circuit current inside that protected circuit.

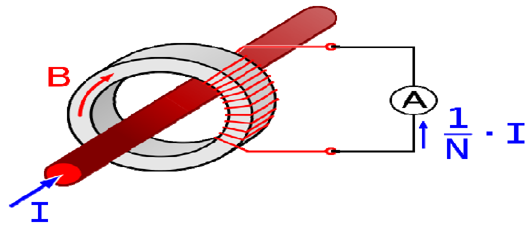


Figure.3 Current transformer

B. LED Display

The materials used in liquid crystal displays (LCDs) combine the qualities of both liquids and crystals. This has such a temperature range in which the molecules are

Practically equally mobile, even though they would have been in a liquid, yet they are clustered together in an organized shape akin to a crystal. A liquid crystal display (LCD) is made up of two glass panels with liquid crystal material in between them. The LCDs are thin and light, measuring only a few millimetres thick. LCDs are compatible with low-power electrical circuitry and can be operated for lengthy periods of time since they consume electricity.

Figure 4 LCD Display

C. ZIGBEE CC2500

Texas Instruments created the C2500 wireless transmitter receiver, which is utilized for 2400–2483.5 MHz ISM/SRD band devices. In this project, the input from the transmitter atmega8's PORTD is wirelessly sent to the receiver atmega8's PORTD. This project demonstrates how to setup the CC2500 registers, issue commands to the CC2500, and activate the transmission or reception mode of the CC2500 using an SPI interface with a microcontroller.

5. Result and Discussion

A. Hardware Output

The consumer portion is our hardware kit, and the software VB is being used to receive data from the EB section. The outcome is reduced power, power ON, and power cut.

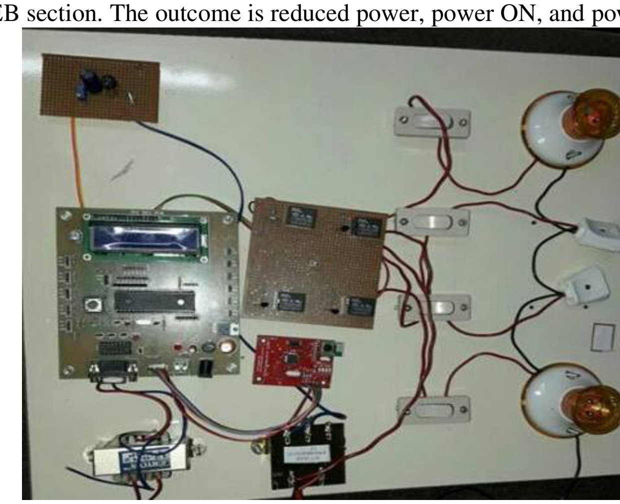


Figure 5 Kit diagram of smart metering infrastructure

Figure 5 depicts a smart metering infrastructure kit diagram. There is a present and prospective transformer available. These are used to measure current and voltage. A signal conditioning unit is located next to this. The appropriate current is filtered, and the needed signal is sent to the controller. We're utilizing a PIC controller here. The PIC is equipped with an LCD display. A relay driver is located next to this. It has the function of a switch. Through a relay switch, the load was linked to the PIC controller. A ZigBee module is used to connect with an EB section. The CC2500 RF wireless module is utilized in this application. The ZigBee in-home part sends data to the EB section regarding power use and energy costs in the specific home. The RS232 cable or USB cable is used to interface ZigBee with the EB section system.

B. Power ON

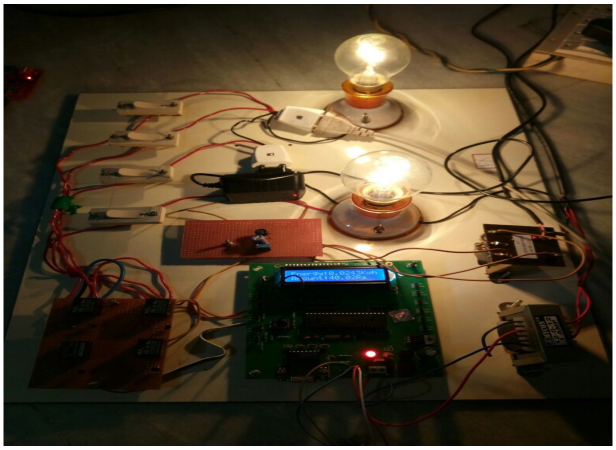


Figure 6 Power ON

Figure 6 depicts the power switch being turned on. All loads will function normally when the power is turned on. The power is distributed throughout the substations by the central station.

C. Power ON – EB section

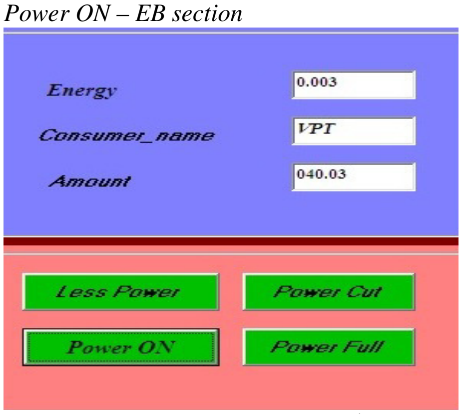


Figure 7 Power ON – EB section

Figure 7 depicts the EB section diagram. When the electricity is turned on, the energy consumption varies and the amount utilised is displayed.

D. Less power

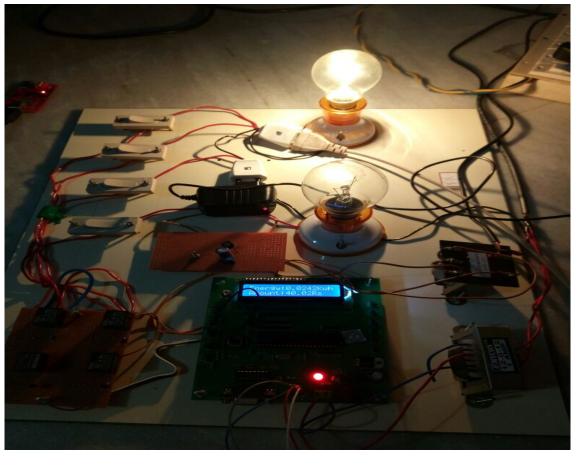


Figure 8 Less power

In this figure 8, shows less power. During less power, only the necessary loads based on priority will work. Central station distributes the power to home priority based loads.

E. Less power – EB Section

In this figure 9, shows the EB section. During less power, the energy will vary and it displays the consumed amount.

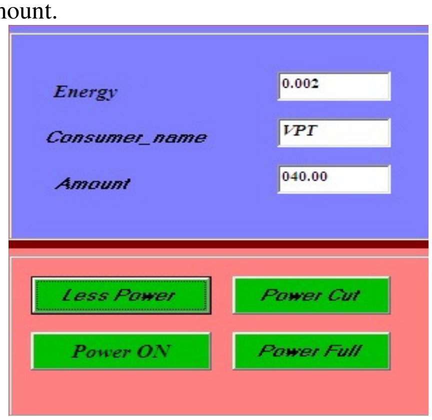


Figure 9 Less power – EB section

F. Power OFF

Figure 10 Power OFF

The power OFF diagram is shown in Figure 10. Electricity theft causes the power to be turned off. The EB section will turn off the power to the affected residence due to power theft.

G. Power OFF – EB section

Figure 11 Power OFF – EB section

Figure 11 depicts the EB section diagram. Because there is no energy flow owing to the power loss, the energy in the LCD display will not fluctuate when the power is turned off. As a result, the quantity of energy utilised will not be displayed.

6. Conclusion

The electricity board is housed at the utility company it consist a ZIGBEE modem and a PC that uses a communication network to receive data on power consumption from the consumer unit. For level conversion, a serial to USB converter is also employed. The VB programme is being used to receive data as well as deliver bill amounts to customers. Then comes the process of acting on the higher-priority items. There are also low and high power options. If the consumer does not pay the energy bill, the EB section will immediately disconnect the consumer's power. The EB section will immediately identify power theft if the consumer uses unlawful power. Finally, our procedure completed the power usage and theft.

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