Real Time Implementation of Home Energy Management

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Abstract

Automation is the key word in every industry. Automation is essential to obtain the desired response much faster than the conventional methodologies. It ensures efficiency and increase in production and reduces human errors. The optimal goal of this project is to obtain a bi directional data communication by using the existing power lines. Here the energy consumed by the user is continuously measured and updated. At the end of the billing period, it can be received by the electricity board office on request. A processor IC senses the energy consumed, produces a digital pulse accordingly and displays the amount of energy consumed. These pulses are suitably modulated by the MODEM and superimposed along with the same power line. These pulses are alone retrieved at the electricity board's office by the other MODEM and stored in the PC database. The tariffs are calculated based upon the slabs fed in the PC and sent through the modem which is received by the other modem. The LCD provided displays the number of units consumed and the cost. In this project, along with the automatic meter reading two more important things are implemented, they are power on demand and prepaid system with recharging facility.

Keywords: *Automation, Energy Management, TANGEDCO, Prepaid Recharging.*

1. INTRODUCTION

Distribution of power is essential to improving society. These power grids were created many years ago with the primary objective of supplying homes and businesses with electricity from huge power plants. Yet, in recent years, we have seen the advent of cutting-edge ideas and advancements that will alter how we manage and use electricity. With the advancement of technology, all the conventional system needs a change. This even applies to bills for electricity. Our nation has a very traditional system for invoicing electricity in which employees of the TANGEDCO record the meter readings from each structure within a locality. As billing is done by hand, there is a very high likelihood of error occurring. For the method of managing power during the peak load period to meet out the demand, each city is disconnected from the supply for a particular duration of time which affects the normal life of people in the city. The home energy management system with automatic meter reading will enable the consumer to manage their energy usage efficiently. The shortcomings of the current system can be removed, and it can be made more effective, using automation. The prepaid system can also possibly be implemented in this methodology. In the postpaid system the power management at the consumer side is not efficient where the consumers will not aware about the wastage of energy. Prepaid systems can reduce the amount of energy wasted as a result of inefficient planning for the use of electricity. The prepaid-meter has the ability to automate not just meter reading but also prepaid recharging, and TANGEDCO and the consumer can share information about the amount of energy consumed. The information of the consumed data can be stored by the TANGEDCO computer for future verification. This project's primary goal is to streamline the billing process. The employees can work on this application with only a basic understanding of computations because to its user-friendly front interface.

2. ENERGY MANAGEMENT USING PLCC

Data is transmitted across a wire that is also able to distribute users with electricity or transmit AC power via power-line carrier communication (PLCC). Other names for it include mains communication, power line telecommunications, power line networking, and power line digital subscriber line. For many applications, including home automation, a variety of power-line communication technologies are required. Certain PLC technologies can bridge between two levels, although generally PLC techniques are limited to one sort of wires (such as premises wiring inside a specific apartment) (for example, both the distribution network and premises wiring). Transformers invariably prevent signal propagation, which calls for numerous methods to create very vast networks. In certain circumstances, different data rates and frequencies are employed. Our country widely uses low voltage power transmission at the distribution system and also Power line carrier communication is well suited and economical for low voltage side power transmission rather than high voltage side. Hence it is economical to adopt this communication technique. Wireless and power-line communication share a number of challenging technological issues, particularly those related to the operation of spread spectrum radio transmissions in a cluttered environment. But the power line carrier using code division multiple access avoids this problem of traffic in the data signals. The direct sequence spread spectrum technique technology in PLCC is immune to noise signals and Radio interference. A modulated carrier signal is added to the wire system in order for power-line communications systems to work. Power-line communications can operate in a variety of spectrum bands. Since the power distribution system was originally intended for transmission of AC power at a typical frequency of 50 or 60 Hz, low tension power wire circuits have only a limited ability to carry higher carrier frequencies. Each type of power-line communication is constrained by the propagation issue. Laws limiting radio service disruption are the key factor in choosing the frequencies for power-line communication. Unshielded wire emissions are regulated in several countries because they may result in radio transmissions. These countries typically demand that unlicensed usage take place in unregistered radio channels or below 500 kHz. Wire-line transmissions are further regulated in some jurisdictions (like the EU, where long wave broadcast has historically been popular). Several power-line communication protocols have significant differences in information rates and distance restrictions. For instance, remote operation of lighting as well as other devices without the need for extra control cabling to be installed within the home is conceivable with power-line communication systems. Home-control power-line communication devices normally work by modifying a carrier wave into the residence wiring at the transmitter that ranges in frequency from 200 Hz to 200 kHz. Digital signals modify the carrier. The signals sent across the home wiring and decoded at the receivers can independently prompt each receiver in the system, each of which has an address. These devices can either be firmly wired in situ or hooked into standard power outlets. Some control techniques contain a "residential address" that identifies the owner because the carrier signal can spread to neighbouring residences (or complexes) located on the same distribution network.

3. NEED FOR ENERGY CONSERVATION

Energy conservation is the practise of lowering energy usage by utilising fewer energy services. Energy conservation differs from efficient energy usage, which refers to using less energy for a constant service. Riding less is one way to conserve energy, for instance. Energy efficiency can be demonstrated by commuting the same distance in a car with higher mileage. Energy reduction strategies include both energy savings and efficiency. Energy conservation would boost ecological integrity, national security, individual economic stability, and profits while it reduces the amount of energy services provided. On the pyramid of sustainable energy, it occupies the pinnacle. By avoiding resource scarcity in the future, it moreover reduces energy expenses.

4. RELATED WORK

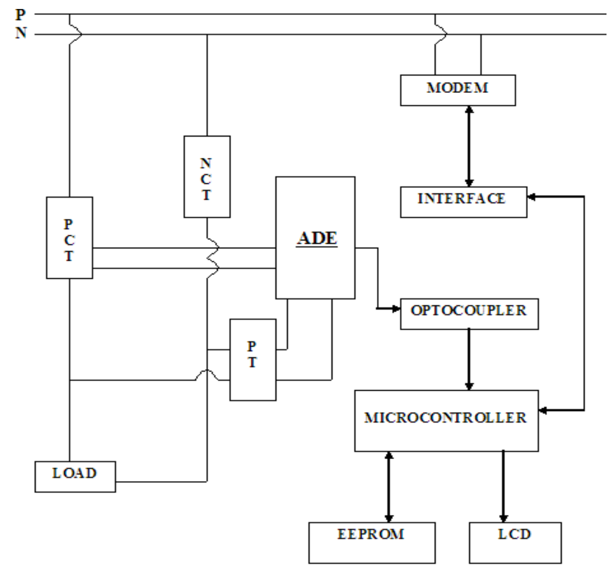
Each consumer's dynamic pricing plays a crucial role in effectively lowering the quantity of power used in residential settings. Load management data is provided via the in-home display device for every consumer's smart metering. [1-5]. Considering the building structure several types of in home display systems using 2.4 GHz Zigbee, RF technology and their solutions are discussed. A unique gadget is developed for transforming digital data transmitted through power lines. The transmitting circuit is passive, and a limited range disturbance is generated in the network employing a resonator circuitry (carrier signal). It has been discovered that the distribution transformer can also sense disruption communication at long distances. This demonstration establishes the suitability of power line carriers for communication across power lines without the use of repeaters or other components. [6-7]. PLC is a good solution to smart grid applications. The PLC system is modeled and analyzed through fading channels. The examination of the traffic modelling and smart grid control problems is then carried out to determine the communication needs. This analysis demonstrates that narrow band PLC signals can travel through the distribution transformer and are suitable for low voltage networks, in particular, the smart grid. Representation of results of the development and application of a PLCC library including single and double frequency line traps, line tuning units, transmitter, receiver and its characteristic behavior test was carried out. This library is developed for ATP-EMTP using ATPD raw. System level simulation was carried out to test the components behavior and to demonstrate the modeling capabilities [8-10]. Wireless sensor networks were used to examine the functionality of the energy management and buildings automated systems in intelligent environments. It builds a model, tests the chosen model in a real setting with a wireless sensor network, and then implements it for an in-home monitor [11-13]. A real-time price-based domestic energy regulating system is indeed offered [15], Time usage model is suggested to establish the prices for shoulder-peak and on-peak periods for administering the energy in residences incorporating IoT [14].

5. FUNCTIONAL BLOCK DIAGRAM AND CIRCUIT CONNECTIONS

There are two sections present in this work. They are billing system with prepaid facility and power on demand. In the TANGEDCO billing system instead of conventional analog energy meters a digital energy meter is placed. The digital energy meter has a current transformer and a potential transformer which senses the energy consumed by the load, these data is processed by the microcontroller and stored in a memory. Whenever the TANGEDCO station sends request to the consumer, the data such as power consumed is sent to the TANGEDCO through PLCC MODEM automatically and the TANGEDCO bills for the energy consumed by the consumer and send the tariffs to the consumer through the PLCC modem installed at the TANGEDCO side. In the prepaid billing system a recharging card and card holder is installed at the consumer side additionally. The consumer can recharge the required amount of watts as per requirements in prior and the consumer can use till the balance watts becomes over. In the power on demand concept, load of each consumer is controlled by connecting a relay section across the load. During the peak load periods the maximum allowable power that can be used by each consumer is set and the consumer is advised to use only the light loads. When any consumer crosses the allowable limit only that particular consumer is disconnected from the supply thus maintaining equal and continuous supply to each consumer. The functional block diagrams both from Consumer side and TANGEDCO side are shown in Figures 1 and 2.

The "Real time implementation of home energy management" consists of Energy meter section, Microcontroller section, TANGEDCO (billing) section, Recharging and relay section.

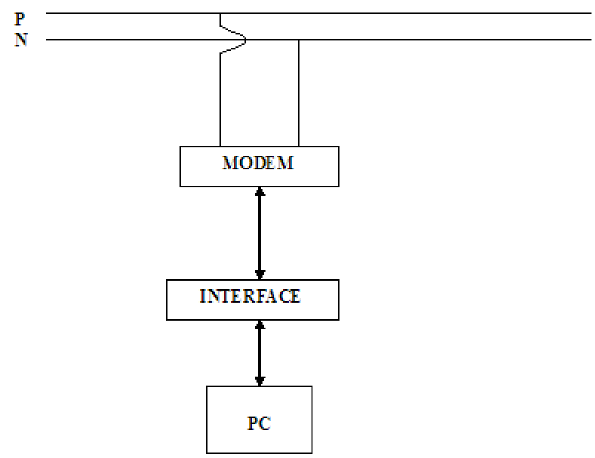
Figure 1: Block Diagram – Consumer Side



The ADE7751, a highly précised, fault tolerant electrical energy measuring IC designed to be used with 2-wire distribution networks, is part of the meter section along with two CTs, a PT, and other components. The phase and neutral current transformers are the two CTs. The amount of electricity utilised by the end user is measured using a PT and a CT. The ADE7751 is an analogue to digital converter that transforms the transformers' analogue signal into digital amplitudes before passing those signals on to the microcontroller. The two CTs are necessary since the ADE7751 chooses the higher amount of the two currents in a fault state. Together with the specific controller, this microcontroller component also has an opto-coupler, interface, EEPROM, MODEM, and LCD. The 89C51 microcontroller is the one used in this project. It has 40 pins and four ports. MCT2E is the optocoupler that is being used. Electrical isolation and optical coupling characterise the opto coupler. This shields the microcontroller from every transient. The throughput of the microcontroller is securely stored in the EEPROM, model number EE24C04. So, even in the event of a power outage, the information is not corrupted. MAX232 is the utilised interface. This is employed to regulate the speed with which information is transferred between the MCU and the MODEM. This project makes use of MODEM ATL90115-1. Using the current power lines, this is utilised to send information from the microcontroller to the TANGEDCO side as well as from TANGEDCO end to the MCU. At a frequency of 150 kHz, it does. The outcome is a complete reduction in outside noise. The TANGEDCO, or billing side, is made up of a Personal computer, an Interface, and a MODEM. All of the data necessary to calculate invoices based on the quantity of units used are supplied or pre-programmed into the computer. The Computer estimates the bill using the slabs provided into it after receiving the user's quantity of units spent. Via the same pair of MODEMS, it then transmits this information to the microcontroller on the customer side. The LCD then shows the units consumed as well as the associated cost.

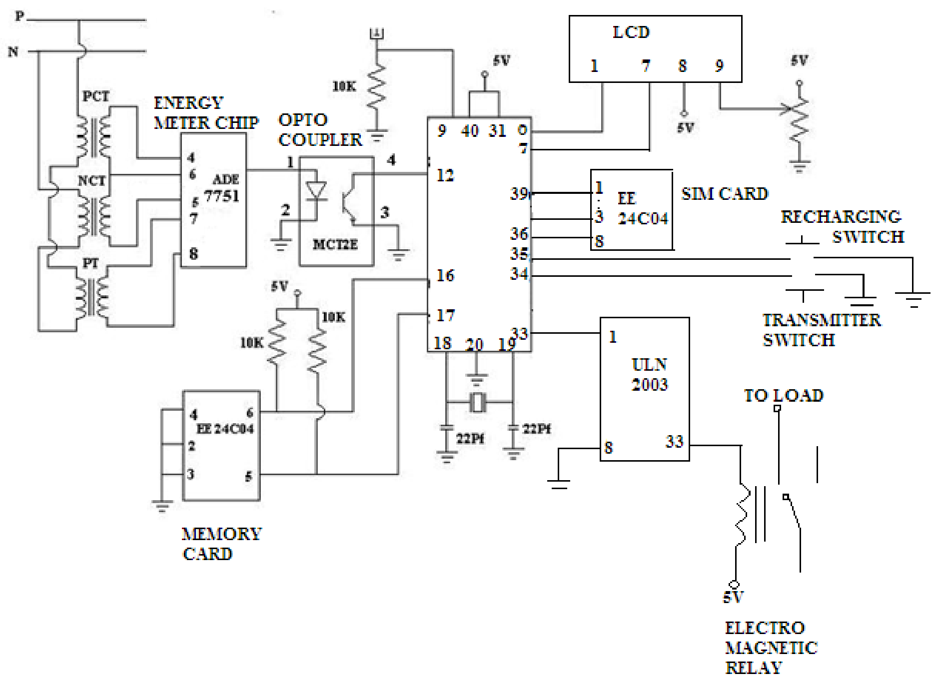
The recharger section consists of Recharger IC. When the money is paid, certain amount of watts is allocated to the consumer. The consumer can use electricity until the balance unit got over. While the balance power reaches a certain level the TANGEDCO side PC sends information to that particular consumer. The consumer can recharge again whenever need arrives. The relay section consists of an electromagnetic relay with a Driver circuit. The TANGEDCO can access and control the load through the relay installed at the consumer side. Whenever the consumer crosses the limits during the peak load period and during the nonpayment of tariffs the consumer will be disconnected from the supply. Proteus software is used for controlling through the microcontroller.

Figure 2: Block Diagram – TANGEDCO side



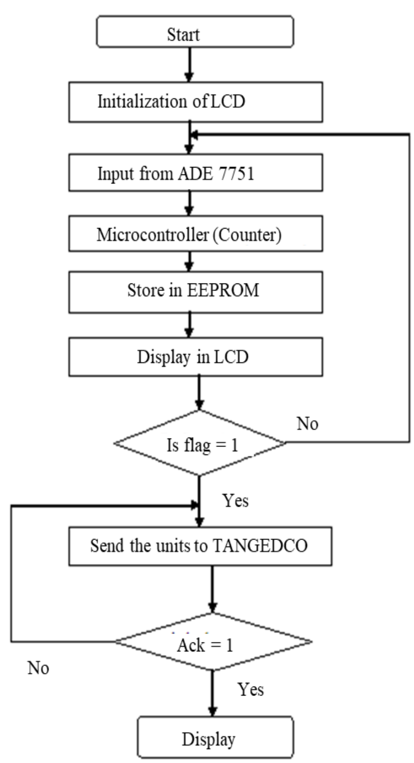
The Power Line Carrier (PLC) modem employed in this study offers 50/60 Hz and bi-directional half-duplex information transmission over any main supply voltage up to 250V AC. It is protocol independent since it doesn't need any protocols to work.

Figure 3: Hardware circuit diagram



Data flow across PLC modems as though they were channels, making them accessible to data peripherals. As a result, many devices can be linked to the power supply without interfering with one someone else's functioning if the person uses the correct identification and communicating protocol. Making interface circuits is not difficult. It includes an integrated AC coupling circuitry on board that enables a direct and easy link to the mains. A straightforward data-in and data-out serial link serves as the user's data device interface. A single +12V DC source is used to operate the PLC Modem circuitry unit. The hardware circuit including all the sections is displayed through Figure 3. Also, the flowchart for consumer side meter reading is given in Figure 4.

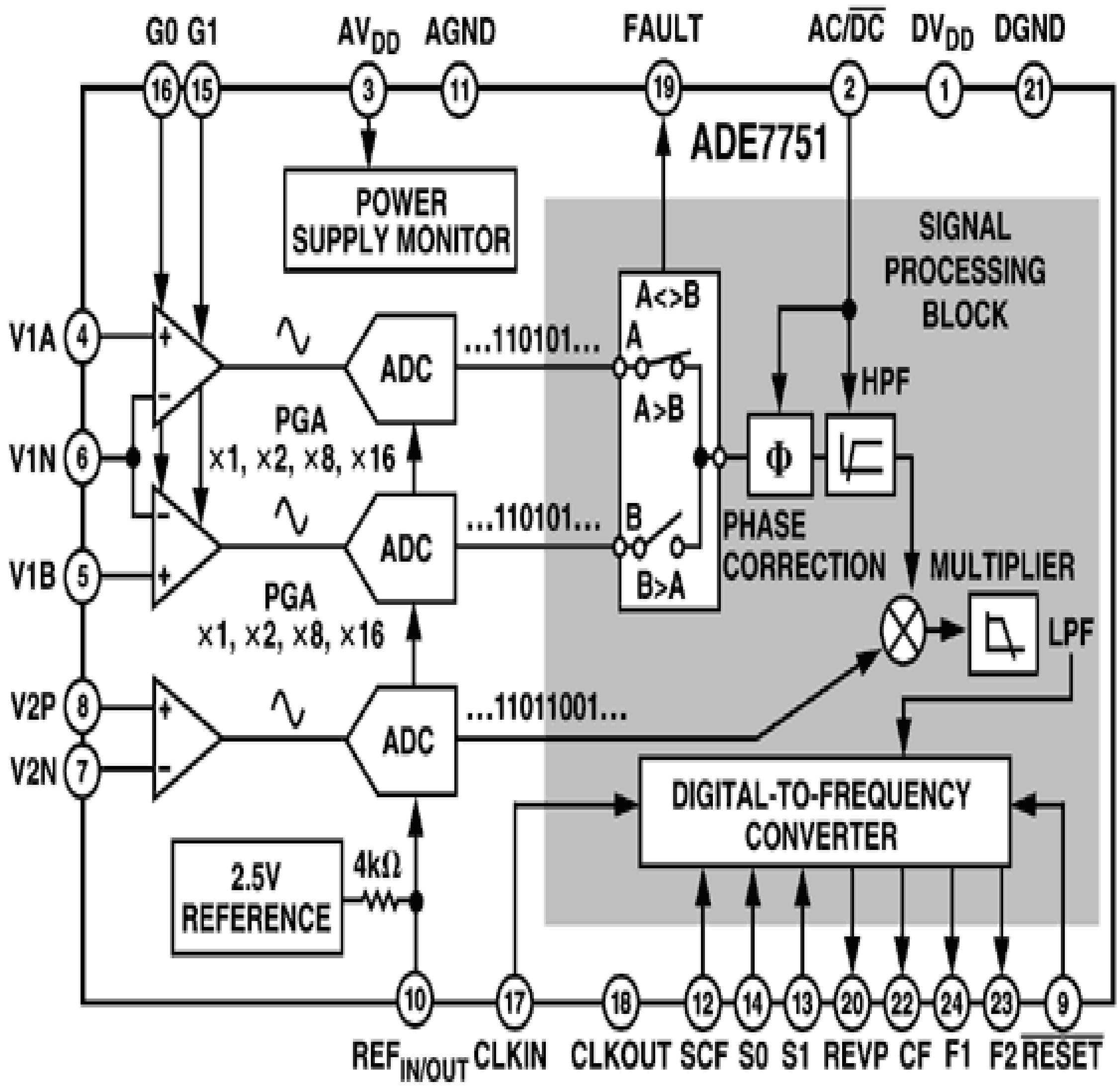
Figure 4: Flow Chart – Consumer Side



6. REAL POWER CALCULATIONS

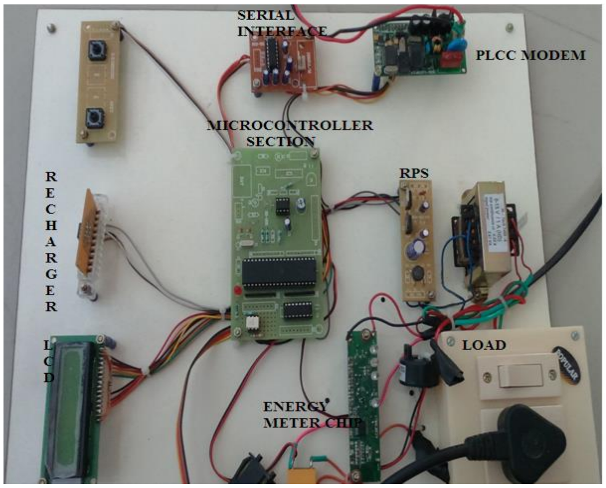
The instantaneous power output is used to calculate the real power. The current and voltage signals are multiplied directly to get the instantaneous power output. The instantaneous power data is low-pass filtered to isolate the true power component (i.e., the dc part). True power for non-sinusoidal current and voltage waveforms is appropriately calculated using this approach for all power factors. For the best stability across time and temperature, all signal processing is done in the digital realm. The ADE7751 generates its low-frequency output by compiling this real power data. Due to the low frequency, there is a significant buildup period amongst output pulses. As a result, the output frequency is inversely correlated with the average actual power. This average true power data can then be added to (by a counter, for example) to produce real-energy data. The CF output is proportionate to the instantaneous real power owing to its high output frequency and consequently quicker integrating time. This is helpful when calibrating a system, which should be done with a constant load. The hardware of ADE7751 is shown in Figure 5.

Figure 5: ADE7751 – Hardware Description



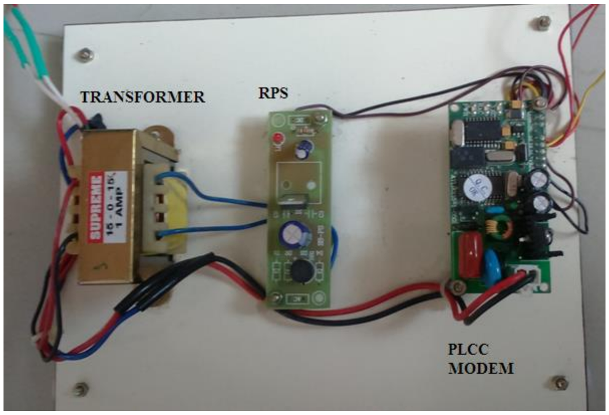
7. HARDWARE IMPLEMENTATION

Figure 6: Experimental Setup – Consumer Side



The experimental setup of the consumer side and TANGEDCO sides are shown in Figures 6 & 7.

Figure 7: Experimental Setup – Consumer Side



8. CONCLUSION

Initially the Power system was designed only for the generation of power and transmitting the generated power to the consumers. The energy management was not a great concern in the earlier days. But to meet the demand of the consumers the government is now showing a greater interest to energy conservation and management. Especially the home energy consumption requires a control. Nowadays TANGEDCO is recommending the public for energy management at houses. Hence this digital energy meter with prepaid billing system enables the consumer to aware and manages the power consumption in houses. Using PLCC the uniform and continuous power distribution to each house can be maintained without interrupting the normal life of the consumers.

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