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Controlling and Distribution of Prepaid Electrical Services Using Wireless Sensor Network

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Abstract—

In this paper, we present the controlling and distribution of electricity from a micro grid deployment in rural areas based on Wireless Sensor Network. The objectives of the project is to minimize the queue at the electricity billing counters , to restrict the usage of energy ,reduce the loss of revenue due to power thefts. The microcontroller is used as heart of the system. The main unit contain a ZIGBEE module which is connected to PC for controlling the electrical lines and the status of usage power will be displayed on PC. The consumer unit contains LPC2148 GSM (Global System for mobile communication) ZIGBEE module relay energy meter LDR and LCD. Energy Meter pulsing led as input to the LDR sensor which is interfaced to microcontroller, proportional to the energy consumed which is calculated by using counter microcontroller. A relay is used to make connection of load. The GSM technology is used so that the consumer would receive messages about the consumption of power (in watts) and if it reaches the minimum amount, it would automatically alert the consumer to recharge. When balance is zero GSM modem will send SMS to customer for further recharge of energy units and power cut off until recharge is done. The work system adopts a totally new concept of "Prepaid Electricity".

keywords: LPC2148, GSM, ZIGBEE, Energy meter and Relay.

I. INTRODUCTION

Now-a-days the numbers of Electricity consumers are increasing in great extent. It is hard to handle and maintain the power due to growing requirements. Maintenance of the power is an important task as the human operator goes to consumer's house and produces the bill as per the meter reading. The billing process takes much time if the consumers are not in the house while taking readings on energy consumption. Few issues related to existing power distribution system are listed below. A large number of inspectors have to be employed for meter reading and bill payment related tasks [4]. Take much time to rectify the complaint at any node failure in the architecture .Entire power will be off at any node rectifies. Incorrect meter readings, billing errors and errors due to estimated bills [4]. Reluctance of consumers for paying electricity bills on time. Uncontrollable demand growth [4]. Electricity theft [4]. The aim of the paper is to investigate a cost effective solution that will provide controlling of electricity remotely. The electricity control system with an affordable cost was thought to be built that should be mobile providing remote access to electricity controlling.

II. RELATED WORK

In existing methodology either an electronic energy meter or an electro-mechanical meter is fixed in the premise for measuring the usage. The meters currently in use are only capable of recording kWh units. The kWh units used then still have to be recorded by meter readers monthly, on foot. Every month we can see a person standing in front of our house from Electricity board whose duty is to read the energy meter and handover the bills to the owner of that house . According to that reading we have to pay the bills. The main drawback of this system is that person has to go area by area and he has to read the meter of every house and handover the bills. The thing is, Government will not appoint any particular persons for this duty. The people working in these boards will go on a particu lar

day and do their duty leaving all their pending works. Due to this, their work will be delayed and this is great loss for government. The recorded data need to be processed by a meter reading company.

III. PROPOSED METHODOLOGY

The present power usage reading is made manually by moving to the consumer locations. Manual billing is sometimes restricted and delayed by bad weather conditions. The printed billing also has the tendency of getting lost. If any node failure in architecture, the entire power will be off to rectify and take much time to identify. Over the last few years, Smart (Prepaid) Energy Meter has been proposed as an innovative solution aimed at facilitating affordability and reducing the cost of utilities. This system has an additional feature to off the power remotely from user if they don't use. This mechanism, essentially, requires the users to pay for the electricity before its consumption. In this way, consumers hold credit and then use the electricity until the credit is exhausted. If the available credit is exhausted then the electricity supply is cut-off by a relay. The development of GSM infrastructure in past two decades made meter reading system wireless. The GSM infrastructure, which has national wide coverage, can be used to request and retrieve power consumption notification over individual houses and flats.

IV. BLOCK DIAGRAM DESCRIPTION

The proposed work is divided into two parts. Those are main unit and consumer unit. The main unit contain a ZIGBEE module which is connected to PC for controlling the electrical lines and the status of usage power will be displayed on PC. The consumer unit contains LPC2148 GSM (Global System for mobile communication) ZIGBEE module relay energy meter LDR and LCD. The functional Block Diagram and hardware description of this system explained below.

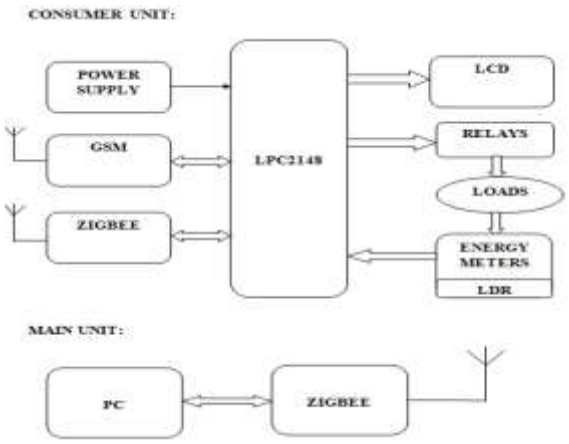

Fig.1: block diagram

i. Micro controller unit:

The LPC2141/42/44/46/48 micro controllers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. Due to their tiny size and low power consumption, LPC2141/42/44/46/48 are ideal for applications where miniaturization is a key requirement, such as access control end point-of-sale. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWMchannels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers suitable for industrial control and medical systems.

ii. GSM modem:

GSM (Global System for Mobile communications) is an open, digital cellular technology used for transmitting mobile voice and data services. GSM operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency

bands.GSM system was developed as a digital system using time division multiple access (TDMA) technique for communication purpose. The digital system has an ability to carry 64 kbps to 120 Mbps of data rates. A GSM modem is a device which can be either a mobile phone or a modem device which can be used to make a computer or any other processor communicate over a network. It can be connected to a computer through serial, USB or Bluetooth connection.

In this work i have selected GSM SIM800 because of its baud rate and low power consumption. ARM controller within very short time period read the sensor values and creates SMS AT (Attention) commands. This commands will be send to GSM modem connected to controller. Modem executes the commands to send/receive SMS alert to user at remote location. Some sample commands used to GSM are "AT+CMGL" List message, "AT+CMGR" Read message, "AT+CMGS" Send Message.

iii. ZIGBEE:

ZigBee is a wireless technology developed by Zigbee Alliance as an open global standard to address the unique needs of low-cost, low-power, wireless sensor networks [5].The standard takes full advantage of the IEEE 802.15.4 physical radio specification and operates in unlicensed bands worldwide at the following frequencies: 2.400–2.484 GHz, 902-928 MHz and 868.0–868.6 MHz .It can send data up to 30m and it has low power consumption (1mW for transmitting data). Zigbee works in 2.4 GHz frequency and offers three modes of operation; AT mode, Application Programming Interface (API) mode and API with Escape (ESC) character mode. API operation is chosen to be used in this project due to several reasons. Firstly, it can transmit data to multiple destinations without having to enter the command mode. Secondly, it can identify the source address of each packet and thirdly, it will receive update on the transmission status whether it is successful or fail.

iv. Relay:

Relays are simple switches which are operated both electrically and mechanically. Relays consist of a n electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. The main operation of a relay comes in places where only a low-power signal can be used to control a circuit. It is also used in places where only one signal can be used to control a lot of circuits. There are only four main parts in a relay. They are

- Electromagnet
- Movable Armature
- Switch point contacts
- Spring

Relays have the exact working of a switch. So, A relay is said to switch one or more poles. Each pole has contacts that can be thrown in mainly three ways. They are

- ***Normally Open Contact (NO)*** – **NO** contact is also called a make contact. It closes the circuit when the relay is activated. It disconnects the circuit when the relay is inactive.
- ***Normally Closed Contact (NC)*** – NC contact is also known as break contact. This is opposite to the NO contact. When the relay is activated, the circuit disconnects. When the relay is deactivated, the circuit connects.
- ***Change-over (CO)*** – This type of contacts are used to control two types of circuits. They are used to control a NO contact and also a NC contact with a common terminal.

v. Light Dependent Resistor:

A light dependent resistor (LDR) is a photo resistor whose resistance decreases with increasing incident light intensity. It can also be referred to as a photoconductor or CdS device, from "cadmium sulfide," which is the material from which the device is made and that actually exhibits the variation in resistance with light level. A light dependent resistor works on the principle of photo conductivity. When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers.

vi. Energy Meter:

Energy meter is an instrument which measures electrical energy. It is also known as watt-hour (Wh) meter. It is an integrating device. There are several types of energy meters single phase induction type energy meter are very commonly used

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to measure electrical energy consumed in domestic and commercial installation. Electrical energy is measured in kilo watt-hours (kWh) by this energy meter. A single phase induction type energy meter consists of driving system, moving system, braking systemand registering system.

Driving system: - This system of the energy meter consists of two silicon steel laminated electromagnets. One is the series magnet and the other one shunt magnet. The series magnet carries a coil consisting of a few turns of thick wire. By adjusting the position of these loops the shunt magnet flux can be made to lag behind the supply voltage exactly 90° . These copper bands are called power factor compensator (PFC). A copper shading band is provided on each outer limb of the shunt magnet these band provides frictional compensation.

Moving system: - The moving system consists of a thin aluminum disc mounted on a spindle and is placed in the air gap between the series and the shunt magnets. It cuts the flux of both the magnet forces are produced by the fluxes of each of the magnets with the eddy current induced in the disc by the flux of the other magnets. Both these forces act on the disc. These two forces constitute a deflecting torque.

Braking system: - The braking system consists of a permanent magnet called brake magnet. It is placed near the edge of the disc as the disc rotates in the field of brake magnet eddy current are induced in it. These eddies current react with the flux and exert a torque. This torque acts in direction so that it opposes the motion of disc. The braking torque is proportional to the speed of the disc.

Registering system: - the disc spindle is connected to a counting mechanism this mechanism records a number which is proportional to the number of revolutions of the disc the counter is calibrated to indicate the energy consumed directly in kilo watts-hour (kWh).

vii. LCD:

A liquid-crystal display (LCD) is a flat-panel display or other electronic visual display that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly.[1] LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and 7-segment displays, as in a digital clock. It is based on the HD44780 microcontroller (Hitachi) and can display messages in two lines with 16 characters each. It displays all the alphabets, Greek letters, punctuation marks, mathematical symbols etc.

V. RESULTS

- The real time view of the project is shown below.

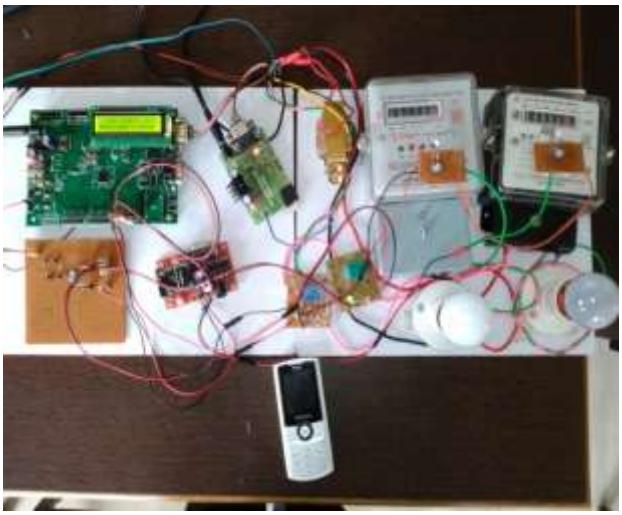

Fig.2: View of project

- Initially the system sends predefined message to all the clients "PLEASE RECHARGE" and it waits for message from the user.

Fig.3: output at mobile

- After sending valid recharge coupon code"H1 RC10" or "H2 RC10"which indicates an amount of recharging 10 units to particular account so that a particular line will be enabled by the main unit.

Fig.4:output at LCD

- The messages will be displayed at the terminal of main unit end and the particular loads gets activated

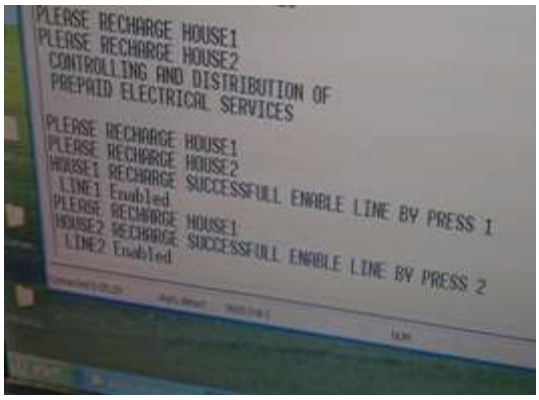

Fig.5: output at main unit

- We can stop the supply if we are not in reach to stop the load , we can send a message typed as "STOP 1"or "STOP 2" for respective loads off.

Fig.6: Display of successful line off

- If the leftover units become less the controller will send an alert message "RECHARGE IMMEDIATELY" to the authorized person through GSM.

VI. CONCLUSION

Paper is intended to present an overview of pre-paid electricity, which can control the usage of electricity on consumer side to avoid wastage of power. Since there is need to utilize energy in better and efficient way, so this pre-paid services proves to be a boon in the power sector. This system is secure and reliable because it can be accessed only by authorized number. The distribution company has to receive huge amounts in the form of pending bills, which results in substantial revenue losses and also hurdles to modernization because of lack of funds. Thus, the device has the capability to revolutionize the energy meter market and will become help to the country revenue by stopping current theft and punishing the dishonest customers.

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