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Intelligent Electric Power Management using Wireless Sensor Network with Advanced Metering Infrastructure

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Abstract—This paper describes about the development of advanced electric metering infrastructure and the power management system.Energy saving is the very important one in the world scenario. We need energy to do anything in this world. The demand of power is growing at a faster rate than the transmission capacity due to the increase in population growth and also increase in coal, fuel prices. To overcome the shortage of power supply, this paper provides an overview of wireless sensor network by managing an equal distribution of power to the consumers by using Zigbee technology and also to avoid the power theft problem. The Zigbee Digital Power meter (ZPM) which uses the Wireless sensor network to send the energy usage reading of the consumer node to the energy provider section. The energy provider side will display the energy unit consumed by the consumer in the LCD which placed in their homes. At the energy provider side they have the control to change priority of the devices when power distributed in low range.

Keywords— Power management system, wireless electric meter, Wireless sensor network, Zigbee,Smart Energy Meter,etc

I. INTRODUCTION

The World is now facing a most critical problem of not getting a uninterrupted power supply. In many countries, the people living there had not even getting the supply for their primary needs such as light,fan,tvetc.This occurs due to shortage of power supply.Due to enoromous growth in population the power distributed by the base station cannot be able to utilise equally by all the people living in the country.Because of over population,the demand of energy is increasing day-by-day.

Inorder to overcome the shortage of power supply,government is underlying many projects to provide continuous supply to the consumers by implanting nuclear power plants,by having MOU with foreign countries to get coal,fuelset,and many more.And also scientists are doing many experiments,researches to provide more power supply to fulfil the peoples need.The governments are now taking many steps to save the energy instead of underlying power generation projects and this paper will be one of key for that.

At existing system, the energy provider are shutting down the power supply inorder to save energy during the energy crisis time for more than 4hours per day. This causes discomfort to the below averaged and the middle class peoples are affecting more by power cut. The industries,companies,factories are having inverters to get continuous power supply.The peoples who does not have the inverters are suffering more. During the power shortage times many of them using AC(Air Conditioner),Fridge,Heateretc so demand of power is more i.e.,the inductive loads consuming more energy so the people who having single phase supply are having low-voltage problems. Through this method we can able to manage the power by providing energy only to the low power consuming devices like fans,light,computeretc which are the primary needs.And not allowing the power to the high power consuming devices like air conditioner,heater,etc.

To achieve this, system can be created which will differentiate between high power and low power devices at every node and allow only low power devices to be ON.Thiscan done by creating a wireless sensor network having number of nodes which communicate with each other in full duplex mode. The communication will consist of data transfer, controlling node operation. We are using zigbee protocol for the wireless communication.

The main advantage of using ZigBee protocol is that the nodes require very less amount of power so it can be operated from battery. If any node which consumes more power than the allotted energy then the power flows that node gets cutted through the interrupt given through the zigbee so we can avoid the power theft. Each node is measuring the power, which is being consumed by the appliance and it is sent to the energy provider section through wireless sensor network and also the units consumed by the node is displayed in LCD which is place at the consumer side. The appliance is controlled by the end device i.e. node. An overall operation of the system controlled by the control device.

The main purpose of the project is that the wireless sensor network will differentiate and control the devices in the network on the basis of power consumed by appliances to make the efficient use of power also to avoid power theft and units consumed by the node can also intimated to the consumer side and the energy provider side. Through that the consumer can able to monitor the usage of energy.

Also we proposed the e-billing system in this paper. Billing system for electricity consumption is manually done by human operator. Readings collected by human operator are used for bill calculation. Manual processing of billing system is very time consuming and it can cause human error also.The manual bill entry is inaccurate and inefficient.Due to the technology development we are using digital meter instead of analog meter. . It is convenient to implement wireless electric meter by interfacing Zigbee module with the digital electronic meter. All digital electronic meter along with Zigbee module can form a network. The use of Wireless Personal Area Networks has been steadily increasing in recent years. The inconvenience and logistical concerns of laying wires for a communication network lay the ground for a much more appealing technologies incorporating wireless transmission. Removing the constraints of the physical installation of wires, wireless solutions provide diversity and in many applications can reduce cost.

Data from electric meter such as meter reading can be transmitted to the energy provider Station from consumer node by forming a path using network topologies. Zigbee module support Star, Tree, and Mesh topology. Zigbee networks facilitate many applications, such as CommercialBuilding and Home Automation, Security, Healthcare Medical Monitoring, Vehicle Monitoring, Agriculture and Environmental Monitoring and so on.

The Zigbee protocol stack based on IEEE 802.15.4 offers a practical, cost-effective solution for low-cost and low power consumption WPANs. . Zigbee is based on the IEEE 802.15.4 standard along with other protocols like Wi-Fi and Bluetooth. Zigbee operates in the industrial, scientific and medical (ISM) radio band, specifically at 2.4 GHz internationally and 868MHz or 915 MHz in specific parts of the world. The simplicity and cost of Zigbee networks makes them a greater one for wireless control and monitoring applications. The Zigbee protocol can support over 65,565 nodes and can operate in three network topologies: Mesh, Star and Ring.

II. BLOCK DIAGRAM

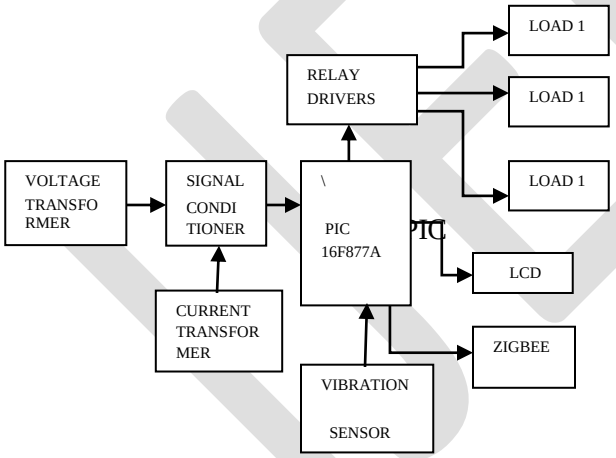

Fig 2(a). Customer Section

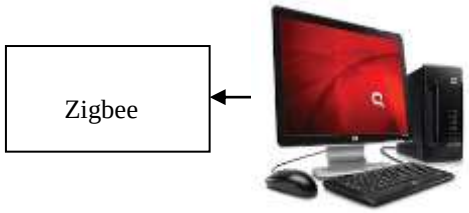

Fig 2(b). Admin Section

III. HARDWARE DESCRIPTION

3.1 PIC16F877A Microcontroller

It is a 40 pin 8-Bit CMOS FLASH microcontroller. The microcontrollers are similar to microprocessors, but they are designed to work as a true single-chip system by integrating all the devices needed for a system on a single-chip. The timing and control unit will generate the necessary control signals for internal and external operation of the microcontroller. Microcontrollers with internal ADC can directly accept analog signals for processing.
The switching pulses required for inverter operation are generated using PIC16F877A Microcontroller, thus reducing the overall system cost and complexity. The Microcontroller generates a PWM pulse at Particular frequency and switching pulses for the MOSFET switches.

The crystal oscillator is used to generate the required clock for the Microcontroller. Here we used Quartz Crustal oscillator. The maximum clock frequency of quartz crystal that can be connected to Pic16f877a microcontroller is 20MHz. The internal clock frequency of microcontroller is same as crystal frequency or externally supplied clock frequency. The Reset switch is used to reset the microcontroller in order to bring the controller to a known state, for proper reset the $\overline{RST}$ should be held low for at least 2 machine cycles.

3.1.1 Analog To Digital Converter

The Analog-to-Digital (A/D) Converter has eight inputs. The analog input charges a sample and hold capacitor. The output of the sample and hold capacitor is the input into the converter. The converter then generates a digital result of this analog level via successive approximation. The A/D conversion of the analog input signal results in a corresponding 10-bit digital number. The A/D module has high and low voltage reference input that is software selectable to some combination of VDD, VSS, RA2, or RA3.The A/D converter has a unique feature of being able to operate while the device is in SLEEP mode. To operate in SLEEP, the A/D clock must be derived from the A/D's internal RC oscillator.

3.1.2 LCD (Liquid Crystal Display)

LCD screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits.A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD,The data register stores the data to be displayed on the LCD. Liquid crystal displays are used for display of numeric and alphanumeric character in dot matrix and segmental displays.

3.1.3 Power Supply Section

Step down Transformer

When AC is applied to the primary winding of the power transformer it can either be stepped down or up depending on the value of DC needed. In this circuit the transformer of 230V/12-0-12V is used to perform the step down operation where a 230V AC appears as 12V AC across the secondary winding. One alteration of input causes the top of the transformer to be positive and the bottom negative. The next alteration will temporarily cause the reverse. The current rating of the transformer used in this project is 500mA. Apart from stepping down AC voltages, it gives isolation between the power source and power supply circuits.

3.1.4 Bridge Rectifier

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification. A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification. This is a widely used configuration, both with individual diodes wired as shown and with single component bridges where the diode bridge is wired internally.

3.1.5 Current Transformer

Instrument transformers (ITs) are designed to transform voltageor current from the high values in the transmission and distribution systems to the low values that can be utilized by low voltagemetering devices. There are three primary applications for whichITs are used: metering (for energy billing and transaction purposes); protection control (for system protection and protective relaying purposes); and load survey (for economic management of industrial loads.
Generally, the metering ITs require high accuracy in the range of normal operating voltage and current. Protection ITs require linearity in wide range of voltages and currents. During a disturbance, such as system fault or overvoltage transients, the output of the IT is used by a protective relay to initiate an appropriate action (open or close a breaker, reconfigure the system, etc.) to mitigate the disturbance and protect the rest of the power system.

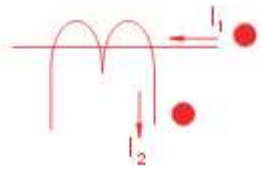

Fig 3.1.5 (a) Symbol of Current transformer

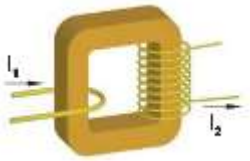

Fig 3.1.5 (b) Conceptual diagram of Current Transformer

3.1.6 Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are doublethrow (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay. You can see a lever on the left being attracted by magnetism when the coil is switched on. This lever moves the switch contacts. There is one set of contacts (SPDT) in the foreground and another behind them, making the relay DPDT.

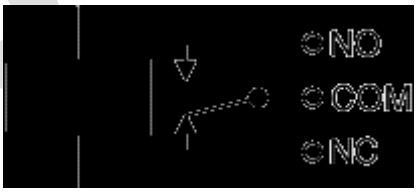

Fig. Relay Connection

3.1.7 Zigbee IEEE 802.15

Zigbee is the advanced version of Bluetooth. Zigbee is discovered in 1998, standardized in 2003, and revised in 2006 .The name refers to the waggle dance of honey bees after their return to the beehive. It has 60 to 256 kb internal flash memory. It is the way of communication between paired devices.Zigbee is based on an IEEE 802.15 standard. . Zigbee has a defined rate of 250 kbit/s, best

suited for periodic or intermittent data or a single signal transmission from a sensor or input device. In home automation applications, transmission distances range from 10 to 100 meters line-of-sight, depending on power output and environmental characteristics. Here we are using TARANG F4 ZIGBEE module.Tarang modules are designed with low to medium transmit power and for high reliability wireless networks. The modules require minimal power and provide reliable delivery of data between devices. The interfaces provided with the module help to directly fit into many industrial applications. The modules operate within the ISM 2.4-2.4835 GHz frequency band with IEEE 802.15.4 baseband.

Zigbee networks support operating in Star, Tree, and Mesh topologies. Depending on the application of the Zigbeenetwork, topology selection can drastically affect the behaviour of the network. For this reason, proper topology selection is very important.For every Zigbeenetwork theremust be one and only one coordinator. The coordinators responsibilities include initializing the network, selecting the transmission channel and permitting other Zigbee nodes to connect to its network. Router

A Zigbee router is responsible for message routing within a network.Arouting device can also act as an end device; however, its routing capabilities would be inactive. A router can have child nodes connected to it depending on the network topology implemented. End devices are the endpoints of a ZigBee network and contain limited functionality to talk to parent nodes (coordinator or a router).

IV. ZIGBEE SPECIFICATION

TRANSMISSION BAND	2.4GHZ
TRANSMISSION RANGE	100 METERS
NETWORK SIZE	65536 NODES (SHORT ADRESSING MODE)
	1.8X10^19 NODES(EXTENDED ADRESSING MODE)
DATA RATE	250 KBPS
CHANNELS	16

Table 4(a). Zigbee Specification

A. Star Topology

In Star topology, a coordinator is surrounded by a
group of either end devices or routers.This topology is attractive because of its simplicity, but at the same time it is having some key disadvantages. In the event that the coordinator stops functioning, the entire network stops functioning because all traffic travels through the centre of the star.

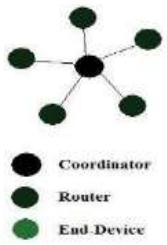

Fig 4.A (a) Star topology

B. Mesh Topology

In Mesh topology, Coordinator and routers are interring connected forming a spider-net like structure. End-devices are connected to routers. Communication between end-device is possible if a router is present in between them for data routing. Coordinator is solely responsible for network formation. End device neither add external device in the network nor communicate with external device or end-device in the network

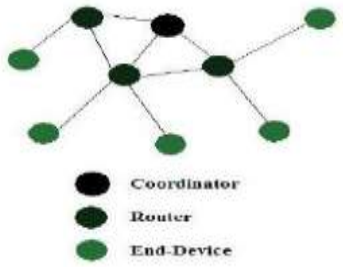

Fig 4.B (b) Mesh topology

C. Tree Topology

In a tree network, the coordinator is at the top(root) of the tree. End devices can connectto this root via a direct point to point connection or through a child router of the coordinator. For every child router connected, additional child routers can also be connected, creating different levels of nodes.

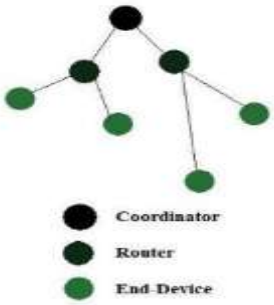

Fig 4.C (c) Tree topology

V. VIBRATION SENSOR

The vibration / shock sensor detects shock intensity caused by sudden knocks or hits and continuous vibration due to faulty ball-bearings on fans and other equipment.In this paper we used vibration sensor for tampering purpose.If anybody tried to change the meter or cause any disturbance to the meter means the warning message will be displayed to the admin section.

VI. LOAD

In this paper we are going to use lamp and a 5V DC motor as a loadand two plugs are provided to add additional loads.

VII. HARDWARE SPECIFICATION

The Fig 7 (a)., shown below represents the home section.It consists of power supply unit,Microcontroller unit,Vibration sensor,Voltage transformer,current transformer,Relay drivers,LCD,Loads,Switches etc.

The Power supply is given from the 230v transformer and it is converted to dc supply from ac using Bridge rectifier and it is rectified.Voltage transformer and current transformer is connected to the microcontroller section to sense the voltage and current produced in the node.The amount of energy consumed by the load is shown in the LCD which is interfaced to the MCU.And the relay drivers is also connected with the MCU unit to control the load by switching on/off the relay drivers through an interrupt given by the admin section via zigbee.Two plugs are provided to add additional loads.Vibration sensor is added to the customer section for tampering purpose.If any disturbance created by the user or anyother things it will intimated to the admin section and also displayed in the LCD with an alarm.

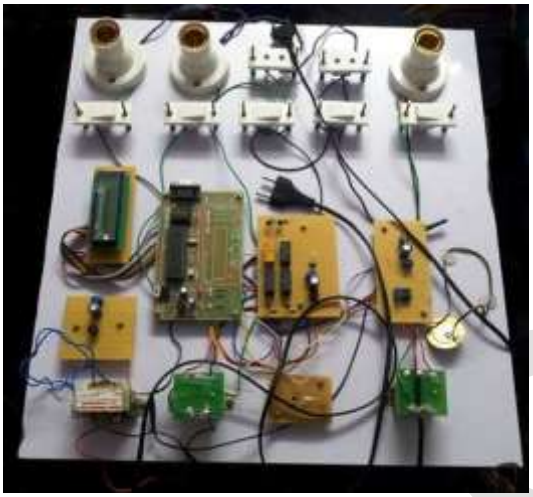

Fig.7 (a) Customer Section

Zigbee is used to transmit and receive the data from customer section and admin section.It is interfaced to MCU and the PC.The energy consumed by each load is sent to the PC via Zigbee.The interrupt is sent to the customer section via Zigbee for prority purpose.All these process can be done through Visual basic programming ,We use MP lab for simulation and flash magic tool to dumb the code in the PIC microcontroller.

7.1 PROPOSED TOPOLOGY

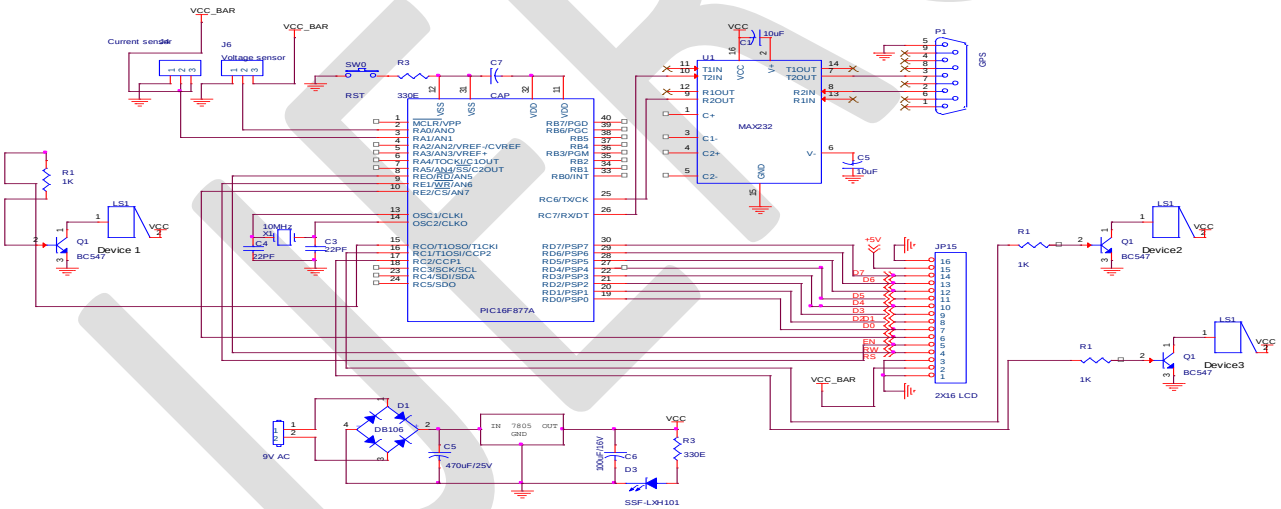

Fig 7.1 (a) Proteus Design

VIII. ADVANTAGES OF PROPOSED SYSTEM

- Efficiency is high for fundamental frequency switching.
- Theft can be detected through continuous monitoring of power consumption by the load.
- Power cut achieved from EB office through wireless
- Man power can be decreased
- Customer service well

- Power Management

IX. APPLICATIONS

- Fan/blower loads
- Drilling rigs for oil
- Variable speed drive for high-power medium-voltage motor

X. FUTURE SCOPE

- We can interface printer to the home section,so that the customer can take the printout of e-bill,after paying the amount through mobile or net banking.
- We can also interface GSM with Microcontroller section to receive a message about the unit consumed by the customer.
- We can use Raspberry pi instead of PIC to make the kit compact and efficient.

XI. ACKNOWLEDGEMENT

We are extremely thankful to our Professors who have helped us in understanding the concept and inspired us by encouraging in everything we did. This helped us to publish this paper successfully.

XII. CONCLUSION

Through this design the Zigbee which send the unit consumed by the load to the admin section and it also display the cost of the unit and previous month unit.If any load which consumes more energy it can be controlled through zigbee and tampering can be detected by interfacing vibration sensor to the home section.

REFERENCES:

[1] H. Fujita, S. Tominaga, and H. Akagi, “Analysis and design of a dc voltage controlled static var compensator using quad-series voltage-source inverters,” IEEE Trans. Ind. Appl., vol. 32, no. 4, pp. 970–977, Jul./Aug. 1996.

[2] K.Hasegawa and H. Akagi, “A newdc-voltage-balancing circuit including a single coupled inductor for a five-level diode-clamped PWM inverter,” IEEE Trans. Ind. Appl., vol. 47, no. 2, pp. 841–852, Mar./Apr. 2011.

[3] L. M. Tolbert, F. Z. Peng, and T. G. Habetler, “Multilevel PWM methods at low modulation indices,” IEEE Trans. Power Electron., vol. 15, no. 4, pp. 719–725, Jul. 2000.

[4] F. Z. Peng, J.-S. Lai, J. McKeever, and J. VanCoevering, “A multilevel voltage-source converter system with balanced DC voltages,” in Proc. Conf. Rec. IEEE Power Electron. Spec. Conf., Jun. 1995, pp. 1144–1150.

[5] L. M. Tolbert, F. Z. Peng, and T. G. Habetler, “Multilevel converters for large electric drives,” IEEE Trans. Ind. Appl., vol. 35, no. 1, pp. 36–44, Jan./Feb. 1999.

[6] T. Hoevenaars, I. C. Evans, and A. Lawson, “New marine harmonic standards,” IEEE Ind. Appl. Mag., vol. 16, no. 1, pp. 16–25, Jan./Feb. 2010.

[7] J. Li, S. Bhattacharya, and A. Q. Huang, “A new nine-level active NPC (ANPC) converter for grid connection of large wind turbines for distributed generation,” IEEE Trans. Power Electron., vol. 26, no. 3, pp. 961–972, Mar. 2011.