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Designing of an Automated Power Meter Reading with Zigbee Communication



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Abstract - This paper presents the design and implementation of Automatic Power Meter (APM), The APM is implemented using an ARM and Zigbee Based power meter Communication Module. The design presents a new methodology for avoiding the high construction and maintenance costs in the existing meter reading technology. Using an APM with network technologies has become a trend today. The designed PMZCM system avoids the human intervention in Power Management. If the Consumer doesn't pay the bill in time, the power connection will be disconnected from the remote server automatically. It displays the corresponding billing information on LCD and sends data to the server through the Zigbee Module. The ARM based hardware system consists of a processor core board and the peripheral board. The entire programming is based on Embedded C Language. This system provides efficient meter reading, avoiding the billing error and reduces the maintenance cost. This paper also addresses advantages of implementing the Zigbee communication module and design detail and discusses the advanced security of the data communications/transmission.

Keywords— Automatic Power Meter (APM), Zigbee, ARM7 (LPC 2148) Microcontroller

I. INTRODUCTION

With the rapid developments in the Wireless communication technology with the use of the microcontrollers, there are many improvements in automating various industrial aspects for reducing manual efforts. The traditional manual Meter-Reading was not suitable any longer as it spends much human and material resource and brings about additional problems in collecting the readings and billing manually.

Now-a-days the number of Electricity consumers is increasing in a great number. It became challenging in both generating and maintaining the power as per the growing requirements. Maintaining the power is also an important task as generating the power presently; the human operator goes to the consumer's house and produces the bill as per the meter reading. If the consumer is not available, the billing process will be pending and human operator again needs to revisit the pending houses. Going to each and every consumer's house and generating the bill is a laborious task and requires lot of time. It becomes very difficult especially in rainy season. If any consumer did not pay the bill, the operator needs to go to their houses to disconnect the power supply. These processes are repetitive and take so much time. Moreover, Human operator cannot find the Un-authorized connections or malpractices carried out by the consumer to reduce or stop the meter reading/power supply.

APM puts more control into the hands of both utilities and consumers by giving them more detailed information about power consumption. This allows utilities to better regulate supply. APM (Automatic Power Meter) can solve above difficulties. So, remote APM and management through kinds of network technologies has become a trend now [1].

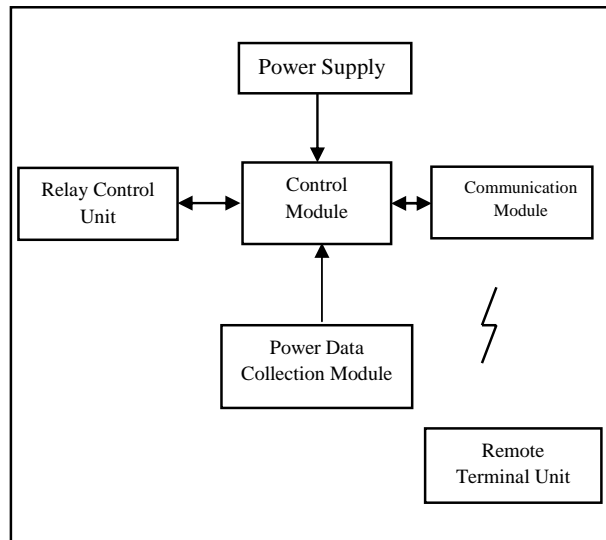


Figure.1 Block diagram of the Automatic Power Meter.

The high level block diagram of the APM is shown in Figure.1. The Power Supply section supplies all other components with required Power. The control module takes the data from the power data collection module and performs the necessary control operations like breaking the circuit through Relay control unit and the required information to the server via the communication module.

The organization of the paper is as follows: In section I, The problem with the design methodology used in the existing power meter, the advantage of using the Zigbee and high level architecture are discussed. In section II, wireless communication system used in this work is described. In section III, the method used to implement automatic power meter system using Zigbee in the present work is discussed. In section IV, experimental results are discussed. Paper concludes in section V.

II. WIRELESS COMMUNICATION TECHNOLOGY

Choosing an appropriate Wireless Communication System is one of main tasks in this work. At present, most APM systems are generally based on media such as RF (Radio Frequency) [1-3], PLC (power line carrier communication) [4-6], GPRS (General Packet Radio Service) [7-8], HFC (Hybrid Fiber-Coaxial) and so on, to transfer data between power meter and manage center. All the above communication media have both merits and shortcomings as well in many aspects like short transmission distance, high transmission cost, maintenance difficulty and unsafe data transmission. Shortcomings of PLC's are that its communication signals cannot go through the transformer directly and the low-voltage power line carrier is vulnerable to be impacted by the environment. It is real-time, wireless and extensive to use GPRS meter reading, but the cost of current GPRS module and the communications-cost are high. Until the cost reduces to the extent that ordinary people can accept, it cannot be used widely. Reading power meter by wire is costly too, for in forepart it's hard to make net-line beyond the wall and make hole in the wall and in later period the maintenance cost is also high in network connection and security. Zigbee is a recently developed two-way wireless communications protocol designed to meet very low power consumption and low cost. The higher protocol layers are being defined by the Zigbee Alliance group while interests in the lower layers of the stack (MAC, PHY) are being defined by the IEEE 802.15 working group 4 (802.15.4) which is aimed at achieving data throughput of 250kbps in the 2.4GHz band and Signees can be implemented in Network layer and Application layer Zigbee has been developed to meet the growing demand for capable wireless networking between numerous low-power devices. In order to solve these problems, we can consider applying Zigbee Wireless communication

system, which is popularly used in the world, to transmit power data.

Here, Zigbee based wireless communication sub-system is responsible for receiving and transferring data. Zigbee wireless open standard technology is being selected around the world as the energy management and efficiency technology of choice in terms of reliability and timing. Microcontroller is playing a major role in how energy is priced and used. Remote monitoring and manipulation is achieved through this Zigbee module in this work.

III. APM SYSTEM HARDWARE

The Hardware architecture of APM consists of Power supply module, Power Data Collection Module, Wireless Communication Module, Relay Control Unit, LCD Module, Controller and Remote Terminal Unit (RTU), as shown in Figure. 2.

Power supply module generates 5v as well as 3.3v as this system requires multiple operating voltages to operate LPC2148 on 3.3v and remaining components on 5v.

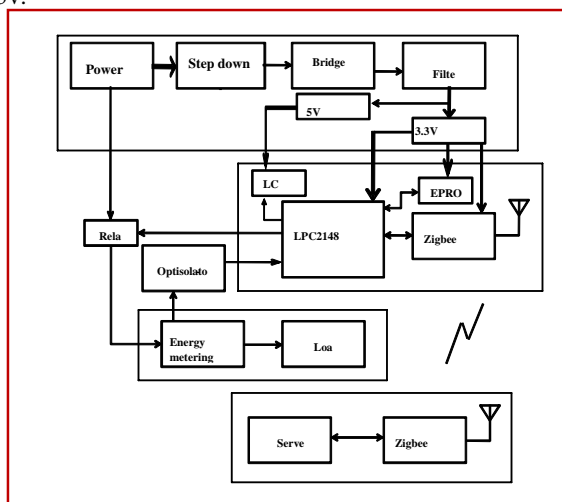


Figure 2. Architecture of the Automatic Power Meter

Power data collection module is composed of ADE7757 which is an energy metering IC with integrated oscillator and load and which produces the analog signal can be converted into digital signal and that digital signal in the form of pulses and ADE7757 outputs average real power information based on the load. These outputs are interfaced with the LPC2148. One more feature in ADE7757 to enhance the capability of this work is having a power supply monitoring circuit on the V_{DD} supply pin of the ADE7757. Due to this, proper device operation is achieved at power up and power trigger down modes. High degree of immunity to false triggering from noisy

supplies is attained due to built in hysteresis and filtering operations in power supply monitor of the ADE7757.

Communication Module consists of Zigbee wireless communication module (XBee-PRO 2.5). It is used to transfer the data of the user meter from LPC2148 controller to RTU by Zigbee wireless module.

Relay control unit is used to shutting off the electric power supply when the due date is over. Whenever the user pays the bill the electric power supply is resumed by the relay module. The relay is driven by the LPC2148 controller.

The user can monitor power consumption details on LCD. Controller of the APM is one 32bit ARM7 CPU (LPC2148). The APM system communicates with the RTU through communication module.

The Controller LPC2148 is of its low power consumption, cheaper to make and less clock cycles to execute an instruction, it is suitable for power sensitive applications, cost-sensitive applications and portable devices.

Depending on the data received from the Power Data Collection Module, it sends information of the user meter to RTU through wireless communication module. In addition to that, the same information is sent to the user through LCD. Depending on the information received from the RTU, the LPC2148 can control the Relay module to shut off or resume the electric power supply.

IV. RESULTS AND DISCUSSIONS

The proposed system is tested in the place of conventional power meter and achieved good results. Figures 3 and 4 shows the actual photographs of the proposed system Server and APM. LPC2148 is interfaced with Zigbee module, LCD module, Power Data Collection Module, the Relay Control Unit, and remote terminal unit (RTU).

For demonstration purpose, 60Watt bulb is used as load to examine our system. The bulb is connected to ADE7757, which is used to measure the average real power information. The test is continued for 15 days and power consumption is observed. During this period the bulb glows continuously which is shown in Fig.4. After the due date, the LPC2148 controller turned-off the bulb through the relay, which proves the accuracy of our system in terms of the power calculation and remote controlling.

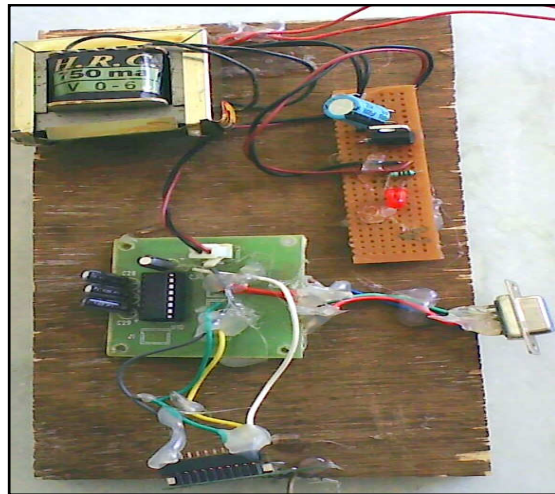


Figure 3. Automatic Power Meter Server PCB

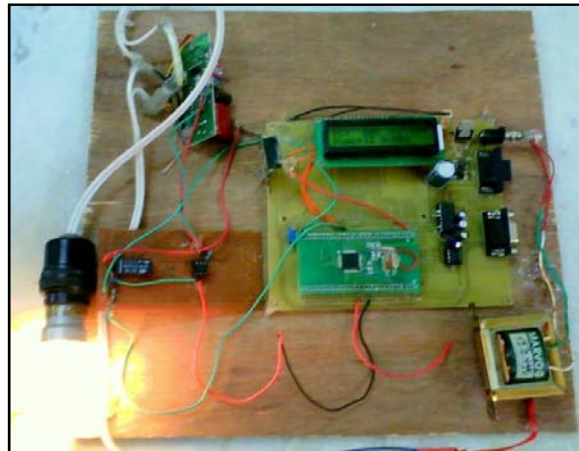


Figure 4. Photograph of Automatic Power meter PCB showing Load.

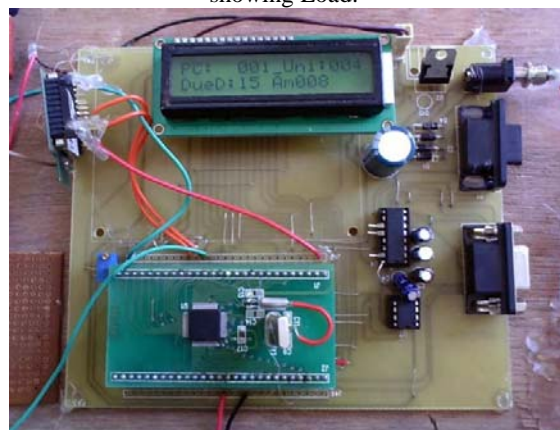
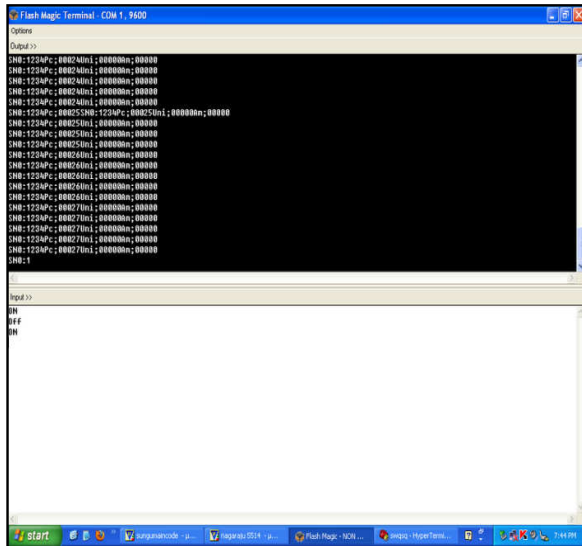


Figure 5. Automatic Power meter PCB showing Readings



V. CONCLUSION

In the present work Automatic Power Meter (APM) unit is designed to continuously monitor the meter reading and to shut down the power supply remotely whenever the consumer fails to pay the bill. It avoids the human intervention, provides efficient meter reading, avoid the billing error and reduce the maintenance cost. It displays the corresponding information on LCD for user notification.

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