A Real-Time Control Using Wireless Network for Smart Energy Management and Billing System

[1] **Waqas Ahmad Mirza***, [2]**Muhammad Jamshed Abbas***, [3]**Muhammad Awais****,[4]**Muhammad Sadiq Orakzai***

Department of Electrical Engineering, *Riphah International University Islamabad, Pakistan
Transmission and Distribution Systems Research Institute, **North China Electric Power University Beijing, China
Emails: [1]waqasmirza@hotmail.com, [2]jamshed.abbas@outlook.com, [3]m.awais.warraich@outlook.com, [4]muhammad.sadiq@riphah.edu.pk

ABSTRACT

In recent years, the need of energy has increased. This increases a difficulty in instantaneous growth of energy. There may be a need for customers to tune their everyday power utilization in their homes. In Pakistan, shortage of power assets is confronted at some stage in the day. Therefore, the accountability of human to store and regulate these assets is likewise vital. In this contemporary generation, as the era enhances systematically, we go for the smart meters. The main disadvantage of formerly used conventional meters system does not have periodic updates of energy consumptions. The consumed data i.e. bill arrives to the customers in the manner of written format. It makes the possibilities for human error. The reading is taken after the month so chance of overbilling is always there. In this paper, smart system for energy management is introduced named as Energy Management and Real Time Billing System (EMRTBS), which facilitates the customer to know the statistics of intake of electricity for home equipment in their homes. In this system, an automated metering solution is deployed for customer i.e. automatic billing of the clients consumed energy. As power utilization is expanding gradually, there ought to be more focus on understanding utilization designs i.e. estimation and examination of utilization after some time is required. In case of developing countries, the era of using smart power meters remains unaware to many commonplace humans and electricity utilities. Therefore, there is a huge need for saving electricity through installing these meters.

Keywords: *Energy management, Smart meter, EMRTBS, Solution.*

1. INTRODUCTION

Smart meters are now a days new interesting issue in the energy management sector. We will have great influence in the progressive stages of our energy market, and meanwhile we will use our energy in our home. Now a day there are advanced TVs and PDAs, intelligent refrigerator coolers and intelligent indoor regulators [1]. A smart meter is named because they will consequently have the capacity to share how much energy you are utilizing with your energy provider. This will convey a conclusion to assess energy bills [2]. The point of this research work is to measure and analyze power utilization using meter. Likewise, of conserving power, meter data illustrates the conduct of clients in using devices [3]. In this paper, we introduced which is known as EMRTBS, in which an automated metering solution is deployed for customer.

For this purpose, we designed a specific web application on .net platform which will show us the transmitted data in web receiving terminal, recording the received information into the database where record is maintained and will automatically intake the data from the database [4]. EMRTBS is a Smart Metering System, providing automation and management of electricity. Following requirements were needed in carrying out this research:
1. Consumption monitoring of electricity
2. Web application
3. Windows application to insert live data in database
4. Archiving of data in DB

Operational Procedure of the system is as follows, Information Transmitting Module (ITM) the main gadget that keeps the record of utilization of power and sends back to the Information Receiving Module (IRM) after particular interval of time. ITM has X bit special ID and terminal name. Information Receiving Module (IRM) is the ace gadget introduced in the control room, it gets the information sent by the ITM. The IRM is further associated with the port of computer for inserting the live data into the data base. The systems utilized for the accumulation of information is through optocoupler, and then we moved to preparing of the extracted yield of the optocoupler, which then remotely transmitted to the system. The run-time billing application can produce the altered reports of information received by the IRM module.

Aswin Raj C. et al. [1] carried out a wide range of research on automation in the function of smart meters and the appearance of few sensors and highly specific processors have made smart meters a reality. Critical advancement has been made to give a substitution to the traditional energy meters. The Italian utility ENEL presented smart meters as of now in 2001 in their Telegestore project ENEL has decided for a smart power meter that communicates through PLC to the closest substation. Next, centralized together control rooms read the information through GSM. Before the finish of 2005, ENEL had 27 million smart meters introduced, of which 24 million meters are as a rule remotely oversaw and bimonthly read [5]. Smart meters measurements and other information is transmitted by radio signals from meter to assembly point. This information is then transferred to a system to process useful data in a different strategic at a focal area. Utility pricing, management and different systems, utilize the information for operational purposes.

RF advances are generally two unique sorts: Smart meter communicate with each other (hop) to create a LAN cloud to the gatherer. The collector transmits the data to the service area using distinctive WAN strategies. Advantages of Mesh RF Technologies include acceptable delay, wide bandwidth, and frequency of operation at 9157MHz. The disadvantages of mesh technologies are landscape and distance experiments for rural areas, proprietary communication and multiple collection points. Point-to-Point RF innovations include positive points, little or no latency, direct communication with each endpoint, large data transfer capacity

for better efficiency. Khushbu V. Mehta, Bhavika Prajapati [6] and Umang Sharad Wani, EEI and AEIC Meters [5] Committees present the idea of Intelligent Meter measurements and other information can be transmitted to the collection point via the grid power lines.

The information was then passed on to the system to process it at the central location. Innovative Power Line Carrier (PLC) technology advantages include the utilization of existing utility facilities for poles and wires, more robust in difficult landscape and the ability to operate at long separation. PLC flaws, longer data transfer (more dormancy), less transfer speed and output, distribution automation (DA) has a limited interface, high cost in urban and suburban areas [7]. Fig.1 shows, Intelligent Samsung Grid, providing customers with full details and control of the power grid. Connects with Samsung devices and allow customers to manage them according to needs. Borenstein et al. [8] found that intelligent networks use automation to meet their energy needs using a two-way interactive system, that is, they collect data from the customer and use it to increase overall reliability and efficiency of transmission lines.

Figure 1 Samsung Smart Grid Solution

An innovation standard called Smart Energy Profile (SEP) has been produced and advanced by benchmarks groups in the U.S. as a route for smart meters and similar devices to incorporate with home systems. SEP 2.0 keeps running on top of IPv6, servicing Wi-Fi, Home Plug and different wireless standards. The Open Smart Grid Protocol (OSGP) is an option wireless network incorporation scheme encouraged in Europe. A growing number of wireless meters incorporate ZigBee network technology to help coordinating with home automation system. SEP was initially developed particularly to help ZigBee systems, which support SEP 1.0 and all-newer version. Kottha Niharika et al. [4], present an application for a remote wireless automatic meter reading system (WAMRS) that participates in the widely used GSM network. Using GSM as a WAMRS tool provides a cost effective, wireless, continuously connected bi-directional information interface between the service provider and WAMRS. Advanced Metering Infrastructure (AMI) is not a single innovation application; it is also a fully designed infrastructure that must be included in existing and new service procedures and applications. These infrastructures integrate information into thermostats and other in-house controls, smart

meters, systems for communicating with local information concentrators from meters, back-haul communication systems, enterprise data centers, meter data management systems (MDMS), endpoints existing, new programming application platforms. AMI offers an extremely smart initiative to modernize the entire power system. Fig-2 below graphically illustrates AMI technologies and how they look.
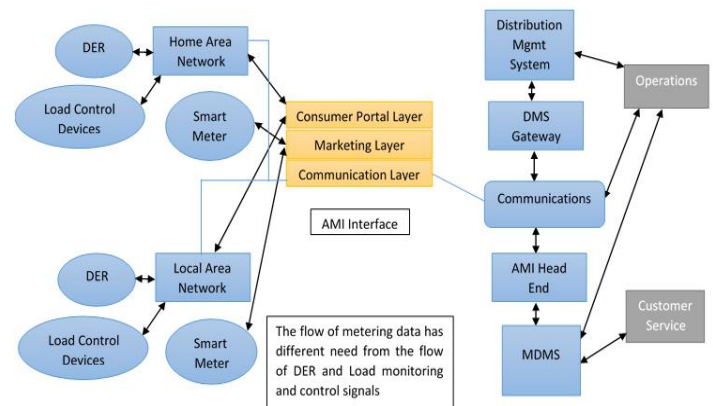

Figure 2 Overview of AMI

Optocouplers (or optical coupler), an interface between the two circuits respectively, operating at different voltage levels. The main advantage is electrical isolation between input and output circuits. With the optocoupler, the only contact between the input and the output is a beam of light. Optocouplers are signal converters that works well in high voltage AC or DC signals. Optocoupler contains an infrared LED and a photodetector (a photodiode, a pair of Darlington, phototransistor, an SCR or triac) is attached to a single package (IR-LED). The microcontroller unit used here is a PIC-16f877A. The core controller is a middle-range family with an internal SPI host system.
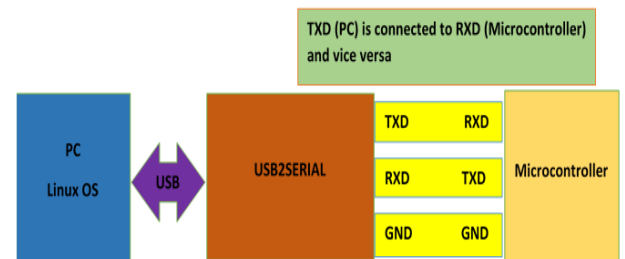

Figure 3 Serial Communication Topology

The 16F877A has enough I/O lines for the current need. It has the ability to launch all of the inter system communications. The main controller controls each function of the system with a supporting device. The PIC16F877A, 256 bytes EEPROM data memory, self-programming, ICD, 2 comparators, 8-channel A/D converter, capture/compare/PWM functions, synchronous serial port, 3 Serial Peripheral Interface (SPI) And Universal Various serial communication standards

such as RS232, SPI and I2C are available. RS232 is an asynchronous method. This means that the clock does not have a synchronization line. One-way data only requires one conductor line. Since there is a bidirectional communication, there are two lines between the two devices. One to send the data called TX and one called RX. Communication is full duplex, which means that data can be sent while data is being received.

2. PURPOSED METHODOLOGY

There are two main modules (Hardware and Software) and four sub modules of the proposed solution. We have designed two Hardware devices one named as ITM and second device is the receiver of ITM, which we named as IRM. This device can be deployed at any site, the main power cable will go through the ITM and then distributed. This device holds the electricity consumption record and returns it to the receiving terminal after a certain period. There is a unique device ID for this device to identify and the name of the device meets this ID. There is a numeric display for unit/KWHs, so that the user can see how much KWH he has consumed.

The Information Receiving Module (IRM) is the main device installed in the control room, which receives the data sent by the ITM. This device is also connected to the PC connection point, which is a web application. This is web-based management application use to calculate the bill and displays customized reports for management purposes. .NET Framework used to develop this application. The windows application developed, it is used to insert live data transmitted by ITM into Microsoft Access Database. The benefit of this application is to eliminate manual entry of data. Wireless communication is taking place between transmitting terminal and receiving terminal 431-MHz 2-way half-duplex communication wireless transmitter receiver is used.

The range of this wireless is around 1000 meters using FSK modulation. Operating voltage is DC5V, communication speed is 1.2kbps -115.2kbps and data transmitting rate is 9600bps. There is UART interface; it is easy to realize the wireless data transmission with only providing the UART data. Smart meters continuously record energy usage and send this data to the administrations at a desired time interval. Integrating smart meters with a smart network can be especially helpful in serving customers, especially in energy saving areas.

The ability to communicate with customers and the same way with the grid is one of the extraordinary qualities of smart meters. The automatic meter allows billing, accounting, and energy control to be controlled remotely. Real-time pricing is a fundamental use of intelligent energy meters that benefit customers and service organizations. With this system, the customer can obtain a more comprehensive data on energy usage. Electrical company associations may provide concessions for power use during light work hours. Smart counters help to provide every important information needed to implement such a time-based tariff. Customers can manage heavy-duty operation accordingly.

Embedded systems are where the software meets the physical world. As we put tiny computers into all sorts of systems (door locks, airplanes, pacemakers), how we implement the software is truly, terrifyingly important. Writing software for these things is more difficult than computer software because the systems have so few resources.

3. IMPLEMENTATION OF PURPOSED ALGORITHM

This paper discusses both hardware and software part. We have designed the project of energy management and real time billing system using microcontroller (pic16f877a) and software implementation done on the visual studio .NET Language. The project consists of the analog meter, optocoupler sensor, wireless transceivers, matrix keypad, LCD, max 232 for serial communication and the billing application. For optocoupler, we have used the slotted optocoupler, which will detect one revolution as the disc of the meter complete a round and passes through it. The optocoupler then send an impulse to the microcontroller.

We have used wireless transceivers for the communication between meter and grid station. Its working voltage is 5v. It is incorporated with standard RS232 DB9 COM interface. An important device max 232 is used in serial communication. It operates within the range of 5v to 12v.We have used LCD 20x4 interfaced with microcontroller for GUI, which allows us to see the consumption and all the settings that needs to be done. The processed data coming from the microprocessor is displayed on it.

The matrix keypad is used for adjusting the settings of the device and it can access different features like setting the device id, data transmission time, changing the password and resetting the user consumption is just allowed to authorize personals only. The software implementation part is, where the application for the billing is built, a data base application which receives the transmitted data, and store it into the database with some specifications. Thus, whenever we need to calculate the bill, the billing application is executed, after adding the system parameters (price, additional charges, device id) bill is calculated that can be saved in pdf format.

Figure 4 Automated Record Entry Form

Figure 5 Report of the Bill

Figure 7 Billing App-Login Pane

All simulations were tested on microprocessor (pic16f877a) which has done all the processing. When an impulse from the optocoupler sent to the microcontroller, it did some processing and the result was then displayed on the LCD. Meanwhile in the fixed time the data is also send to the grid station wirelessly. Below Fig.5 is simulation diagram of the project designed on Proteus.
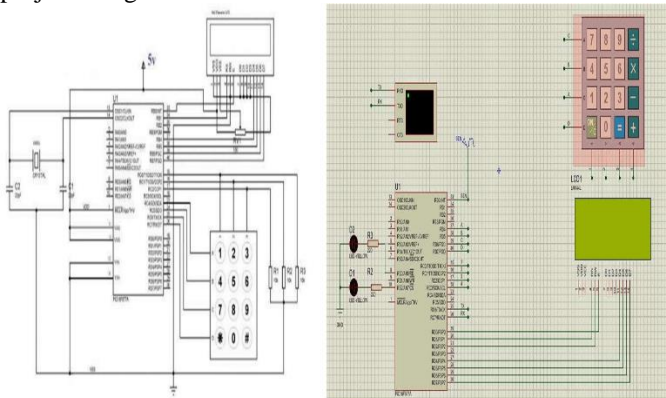

Figure 6 Simulation

4. RESULTS

The web-based management application use to calculate the bill and view customized report for the management purpose. .Net framework is used to develop this web application. There are two types of user, one is administrator and second is costumer. Both users have to login in the system to use it. After login, admin will be redirected to administration panel. Here are some tasks, which can be performed only by the administrator. In this area, admin can see the report of records. Login panel can be seen in the Fig.7.

5. CONCLUSION AND FUTURE WORK

The real-time price plan implies that it comes from searching or from the customer. This will provide a number of advantages to industrial customers as well as local customers. Real-time pricing fills up as a competent approach to energy conservation, since it synchronizes electricity costs with demand response curves. Customers can save more on electricity bills by running lighter loads during peak hours and planning heavy-duty operation in times of low demand. In addition to protection, real-time pricing also ensures that substantial progress can be made in ensuring and protecting the quality of equipment used by power service companies. Real-time distribution refers to the uniform distribution of load throughout the day.

In future, this project can be changed with a great deal more upgrades. We have utilized simple meter later we can utilize redid advanced meter to compute the utilization of power. Rather than utilizing remote transmission, we can send information over the network to limit remote module cost. Circuit breaker, fire alert, voltage alert system can be integrated. Supervisory control and data acquisition (SCADA) can incorporated in EMRTBS too. From programming perspective, the entire equipment can be controlled through the product at a single tick. Two-way interchanges should be possible amongst equipment and programming. Bill Calculation application can be changed with even more ongoing prerequisites, which are utilized by WAPDA. This research can also be modified in different ways i.e. faster power restoration and problem resolution, remote switch on/off, data transferring over internet, auto connecting and disconnecting of power.

6. REFERENCES

[1] Borenstein, Severin, Michael Jaske, And Arthur H. Rosenfeld, Dynamic Pricing, Advanced Metering, And Demand Response In Electricity Mar- Kets. Center For The Study Of Energy Markets Working Paper 105, October 2002.

[2] Aswin Raj Ca, Aravind Ea, Ramya Sundaram Ba, Shriram K Vasudevanb, SMART GRID Technologies, Smart Meter

Based On Real Time Pricing, Procedia Technology 21 (2015) 120 124, August 6-8, 2015.

[3] Praveen Vadda, Sreerama Murthy Seelam, Smart Metering For Smart Electricity Consumption, School Of Computing, Blekinge Institute Of Technology, 37179 Karlskrona, Sweden, May 2013.

[4] Kottha Niharika, M. Ravinder, Automatic Meter Reading System Using Gprs, Volume Viii /Issue 3 / Feb 2017.

[5] Smart Meters And Smart Meter Systems: A Metering Industry Perspective An Eei-Aeic-Utc White Paper A Joint Project Of The Eei And Aeic Meter Committees.

[6] Khushbu V. Mehta, Bhavika Prajapati And Umang Sharad Wani, Design And Implementation Of An Intelligent Electricity Meter With Comparativ Analysis
Of Communication Technologies, Vol. 4, Issue 2, Apr 2014, 239-248.

[7] F. Benzi, N. Anglani, E. Bassi, And L. Frosini, Electricity Smart Meters Interfacing The Households, IEEE Transactions On Industrial Electronics, Vol. 58, No. 10, Oct.2011, Pp. 44874494.

[8] Borenstein, Severin, The Long-Run Efficiency Of Real Time Electricity Pricing, The Energy Journal, Vol. 26. No. 3 (April) 2005, P. 93-116.

[9] ADVANCED METERING IN FRASTRUCTURE, Conducted By The National Energy Technology Laboratory For The U.S. Department Of Energy Ofce Of Electricity Delivery And Energy Reliability February 2008, NETL.

[10] Christian Beckela, Leyna Sadamoria, Thorsten Staakeb, Silvia Santinic, Revealing Household Characteristics From Smart Meter Data, Preprint Submitted To Elsevier, 6 October 2014.

[11] Rob Van Gerwen, Saskia Jaarsma And Rob Wilhite, Smart Metering, Kema, The Netherlands, July 2006.

[12] Damminda Alahakoon, Member, Ieee, And Xinghuo Yu, Fellow, Ieee, Mart Electricity Meter Data Intelligence For Future Energy Systems: A Survey, Ieee Transactions On Industrial Informatics, Vol. 12, No. 1, February 2016.

[13] Naveenkumar, Jagadeesh S K, Smart Energy Meter, International Journal Of Technical Research And Applications, Volume 4, Issue 3 (May June, 2016), Pp. 126-129