Proposal for Low Cost GSM based Electric Meter for Efficient and Automated Meter Reading for Developing Countries

Muhammad Saadi, Rabeel Manzoor, Lunchakorn Wuttisittikulkij

***Abstract*— Intelligent choice between energy technologies plays a vital role in energy planning and efficient electricity management. Scare resources, lack of expertise and shortage of capital are the major hurdle for developing countries opting cutting edge technologies. Cheap and outdated billing system is prone to error and source of corruption. The purpose of this paper is to introduce improvement in currently installed metering system in developing countries specifically in Pakistan. Electromechanical meter is the most common way to measure energy consumption in developing counties. By making low cost alterations in already installed meters can improve the system thus removing the main disadvantages of analog energy meter i.e. prone to corruption and unreliability in its measurements.**

***Index Terms*— Electromechanical meter, corruption, Intelligent billing system**

I. Introduction

ENERGY planning and management involves decision making which directly associates context and choice of technologies [1]. Thus energy planning and management requires right choice of energy technologies keeping capital and available resources in mind.

Electricity has become one of many necessities of our everyday life. The right use of electric energy is very important to provide this valuable resource to as many people as possible. The efficient use of electric energy is highly dependent on energy metering. In developing countries, the electromechanical meter is the most common way to measure energy usage through analog method. The main disadvantage of analog energy meter is that it is corruption prone and unreliable in its measurements.

Pakistan, at present, is facing severe power crisis. The accelerating economic growth and rate of electrification have led to a proportionate boost in electricity demand in recent years [8]. The continuing negatives of the situation have now engulfed the national economy in a stifling embrace. Industrial productivity has gone down and situation portends badly for exports and the ensuing balance of payments. It is important to mention that Pakistan is currently experiencing power shortage of 3,000 to 4,000 MW during summers [2]. Without new investments and heavy infrastructure improvement and maintenance, situation cannot be improved. Besides, it is most important that innovative and needed technologies must be introduced as necessary tool from time to time. Situation can be managed by taking steps both on supply and demand side [8]. The supply side measure would include installation of new power plants and improving the currently installed system.

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II. Current Meter Reading and Billing System

The currently installed system in Pakistan by electricity supplying companies in Pakistan and other developing countries is manual. A meter reader is assigned number of energy meters in a geographical region and it is his duty to visit each and every meter and note down its reading. Meter reader reads the electromechanical meter manually and notes it on a piece of paper. The reading is further transferred to computer center where this noted reading is entered in to the computerized data base which enables the electricity supplying companies to generate the monthly electricity bill for each consumer. So whatever the feedback is given by the meter reader, the same will be entered in the system whether it is right or falsified. Therefore the system is prone to human error and corruption.

Solution to eliminate this source of corruption and error is not to get the meter reading checked by another meter reader but to develop an automated billing system in which human involvement can be reduced if not eliminated and meter reading can be entered in to the billing generation system automatically.

III. Suggested Improvements

Replacing all the electromechanical meters with the digital meters is very expensive when the numbers of energy meters are in millions. It requires huge capital and might be not feasible for electricity supplying companies to opt for. Therefore a low cost design is the need of the hour. The purpose of this paper is to introduce the design, which is a better way of measuring energy consumption. By automating the measurement process, the aim is to eliminate

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corruption and enable the availability of reliable energy consumption data. A microcontroller based solution for measurement of energy data from a meter, as it is flexible and low cost in nature in contrast with FPGA based solution. GSM technology is introduced to further automate the process by sending the measurements through a mobile to a server, where the billing database was populated. Hence, it can eliminate the need of a meter reader and record data which is error-prone and major source of corruption. This is highly desired by the Water and Power Development Authority (WAPDA), the organization responsible for energy consumption in Pakistan [3].

A. Design Details

The electromechanical induction meter principle of operation is by counting the revolutions of an aluminum disc. The aluminum disc is calibrated so that its rotation speed is proportional to the power. The number of revolutions is thus proportional to the energy usage [4]. After some research into meter data sheets, it can be realized that the aluminum disk has a small hole on it. Thus, if detection of hole is possible then the number of rotations can be measured exactly and hence, the energy consumption of the meter.

To detect the black spot on the aluminum disk, opto-coupler can be used. Opto-coupler is basically used to transmit a signal from one end to the other by the use of a short optical transmission path. In this particular case an LED (photo diode) and a detector served the purpose. The light from the LED is blocked until the hole on the aluminum disc comes in direct contact with LED; at this stage light from the LED is allowed to pass through the hole and thus reaches the detector (transistor), which on

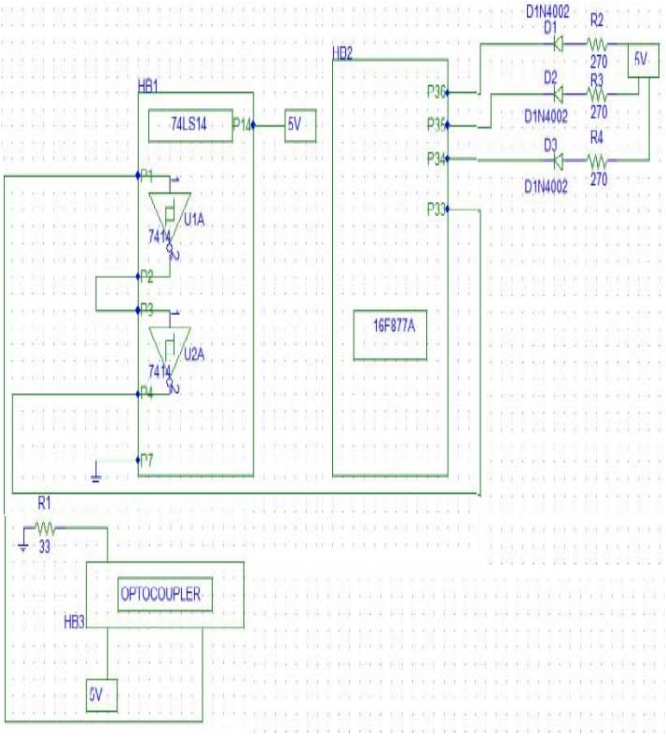

Fig. 1 PIC Microcontroller and Opto-coupler interface

receiving the light passes an interrupt to the IC connected directly to it. For accurate measurement of the number of holes detected in a given amount of time, the opto-coupler is interfaced with the PIC microcontroller. In this way, accurate number of revolutions of the aluminum disc can be counted and a digital reading mechanism can be established. Following screenshots show an opto-coupler and hardware for PIC interfacing:

Mobile phone is also interfaced with the microcontroller so that sms can be generated after regular interval of time which can be sent to the regional data base center for further processing of the billing. In the fig. 2 below the TX pin25 of PIC is connected to Pin3 of RS232 which is TX pin. Pin5 of RS232 is ground as it is the ground pin. Pin9 of RS232 is ring indicator is connected to pin3 through a resistor. The reason to connect the diode and 5V is that when mobile is connected to the RS232 it will not draw battery power of mobile phone. This interfacing will give the supply to cell phone to charge and indicate the phone is connected and working. The role of ring indicator is to indentify that cable is connected and working. Null modem connection can be used which does not require data set ready (DSR), request to

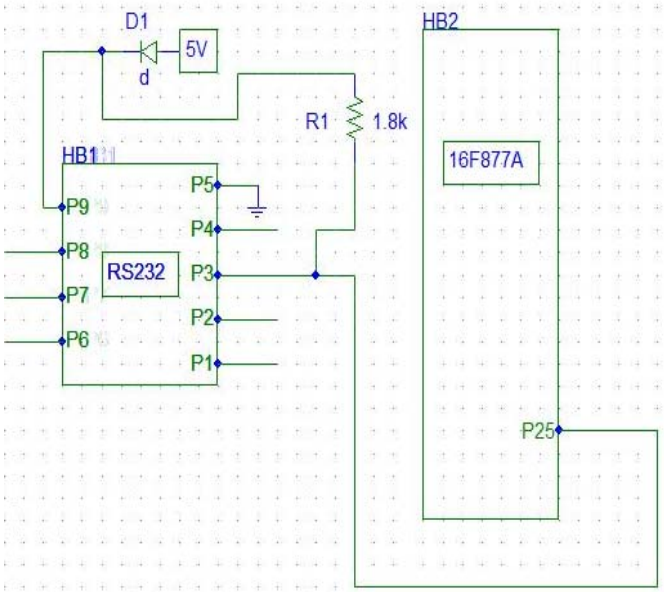

Fig. 2. RS232 interface with the Microcontroller

send (RTS), clear to send (CTS), data terminal ready (DTR) and data carrier detect (DCT). The send function in software sends a character string character by character [5].

B. Software Details

All hardware must be supported by software for cost reduction which is the first and foremost priority of this design. Brief technical details of the software are as follows. Sony Ericsson phone is used and thus AT commands of Sony Ericsson were used for establishment of successful connection. First the ATE, AT+CPMS, AT+CMGF are sent to initialize the mobile, that the echo are cancelled in message as DCE (Data Communication Equipment) is not connected, as null modem connection is called DTE-DTE connection. Then the preferred message storage of mobile phone is set which is set phone message storage. After that message format command is sent to indicate the mobile to use text message. Destination number is send after setting the above parameters. Destination number is send by sending the AT command of AT+CMGS which is the

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command to send the text message to destination mobile. AT+CMGR command is set to select receive unread message, this command was set if the server sends command to mobile to send the meter reading. Lastly the string containing the meter reading is sent to mobile. The delay is given to each command execution as it takes some time to execute. Also a delay is given in software to indicate that message will be sent after regular interval of time which can be modified as per needs. The Baud rate of UART is set to 9600 as the baud rate of mobile phone for GSM transmission without compression is 9600 or 14400. 14400 are not set in the UART as it is not supported by the controller at 10MHz oscillation frequency. 9600 is supported by the controller at 10MHz. At 9600 baud rate the error rate is 0.16% [5].

TABLE I
CIRCLE WISE STATEMENT OF 1 PHASE AND 3 PHASE METERS INSTALLED

Circle	Single Phase	Three Phase	Total
G.City	448329	22630	470869
G .Cantt	475940	23172	449112
Gujrat	678890	9245	688105
Sialkot	710958	12680	723638
Total	**2314027**	**67697**	**2381724**

G = Gujranwala

TABLE II
CLASSIFICATION OF METERS AND THEIR QUANTITIES

Type	Quantity
Domestic	20,61,682
Commercial	2,400,01
Industrial	47,078
Agricultural	32,455
Others	508
Total	**2,381,724**

IV. BIRD EYE VIEW ON GEPCO ENERGY METERS INSTALLATION

GEPCO has divided the regions into 5 circles for ease and efficient management. There are total 2,381,724 meter installed in GEPCO out of which 2,314,027 are single phase meters and remaining are 3 phase. Furthermore energy meters have been classified into domestic, commercial, industrial and agricultural categories as PEPCO have different billing charges for different categories. The data about the meters for GEPCO can be summarized by Table 1 and Table 2.

TABLE III
MONTHLY DISTRIBUTION LINE LOSSES JULY 2010

Period	Units (Millions)			%Losses
	Received	*Billed*	*Lost*	
July 2010	768.3	673.5	112.8	14.35

TABLE IV
TRANSMISSION LINE LOSSES

Units (Millions)			% Losses
U.R	*U.S.O*	*Lost*	(July10)
804.34	786.34	18.00	2.24

U.R = Units Received, U.S.O = Units Sent Out

TABLE V
OVERALL COMPANY LOSSES

Units (Millions)			% Losses
U.R	U.S.O	Lost	(July10)
804.34	673.51	130.83	16.27

U.R = Units Received, U.S.O = Units Sent Out

V. LINE LOSSES IN GUJRANWALA ELECTRIC POWER COMPANY (GEPCO)

Line loss in a power system can be defined as the wastage of electricity during its distribution from generation to its distribution to the tail consumers. Poor management of transformers, feeders and out dated equipment installation also increases the line losses. Substandard transmission and distribution system is not only the reason for the line a loss in the electricity distribution system but illegal meters and theft of electricity also worsen the situation. In standard, the transmission and distribution system has a net line loss of less than 10% from the total production but unfortunately this is not the case in Pakistan which gives a huge loss in billions to the national revenue. In the last four years, Punjab province has an average loss of 13% where as Sindh has a average loss of 35% [7]. Table 3, 4 and 5 gives a detailed view of line losses for the month of July 2010 and situation is nearly same for rest of the months [9].

VI. COST ANALYSIS

In the current billing system, the main source of error in the billing system is because of the meter reader and that error may be intentional or unintentional. A meter reader is an official who used to go to every meter and read its current reading on monthly basis manually. GEPCO has 1,510 meter reader and their salary is progressive depending upon their experience ranging roughly from Pak Rs. 19,000 only (25 years experienced) to Pak Rs. 9,500 only (fresh). Average salary of a meter reader in GPECO is around Pak Rs. 14,405. Other than medical, transportation, mobile phone usage facilities to the meter reads and billing staff, GEPCO is paying Pak Rs. 2,17,51,550 (US$ 255900) per month to the meter readers. If we extend these calculations nationwide then this figure will increase dramatically as GEPCO utilizes less than 5% of the total energy produced in the country.

Pak Electron Limited (PEL), Micro Tech Laboratories, and Escorts Pakistan (PVT) Ltd are the market dominated companies in Pakistan providing energy meters to WAPDA and Pakistan Electric Power Company (PEPCO). Installation of new digital meter will cost Pak Rs. 7,000 to 12,000 depending upon the manufacturer and its specifications. The total expected cost for the replacement will be more than US$ 2,800,00,000. In addition to that, heavy investment which has already been made, when analog energy meter will be replaced by digital meter, will be wasted. Doing some alterations in the currently installed

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electromechanical meters in Pakistan, which will cost a very nominal cost per meter, revolution can be brought. Addition of an opto-coupler, microcontroller and mobile interfacing device will cost Pak Rs. 1,000 (less than US$12) per unit.

VII. CONCLUSION

From the above discussion, it can be concluded that other than the built in line losses in the system, theft, illegal meter installation and other ways of corruption are destroying the economy of the country thus directly affecting the revenue generation. Developing countries like Pakistan where unlawful meter usage and thievery is a common norm, automated meter reading is inevitable. Highly sophisticated and cost effective changes must be brought into the system to improve the situation. Our proposed changes in the currently installed system will improve the system efficiency tremendously with low modification cost and ultimately consumers can also enjoy cheap electricity. The only negative side of the proposal is that fewer employees will be needed for billing system thus shrinking the work force.

ACKNOWLEDGEMENT

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