Remote Control of Residential Meter Involving E-Billing

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***Abstract*—In electrical energy distribution, losses are a challenging problem, among these losses electricity theft plays a prominent role. Not only Pakistan but many other countries throughout the world face this challenge. This paper presents a system based on smart meter to detect the approximate location of electricity theft. Along with electricity theft detection, this paper also proposes a system for the elimination of illegal consumers. The approach used is that the total energy is compared with the legally consumed energy. For communication between the meters wireless communication techniques are used including Global System for Mobile Communications (GSM) and Network Repository Function (NRF).**

Keywords—Remote Control Energy Meter, Smart Load-shedding Management, NRF24L01.

I. INTRODUCTION

Technology and the need for efficient, reliable, and sustainable energy management systems have transformed the energy business in recent years. Internet-connected smart meters are replacing electrical meters. These innovative technologies help create a more dynamic and responsive energy infrastructure by analyzing energy usage and allowing remote control and computerized billing. The Industrial Revolution has four distinct eras. Early in the revolution, new energy sources were found to power machines. Several noteworthy events took place during this time period, including the development of coal mining and the introduction of steam-powered facilities [1].

The second revolution, which is also referred to as the time of mass production and the introduction of electricity, was characterized by enormous breakthroughs in the industrial sector, notably in the expanded iron and steel industry. It was during this time that a number of large-scale factories were built, each of which was outfitted with assembly lines, which ultimately led to the establishment of new firms [2]. The introduction of computers and the first wave of communication technologies, such as telephone lines, were both made possible by the Third Revolution, which paved the way for the automation of supply chains [3]. It is anticipated that the Fourth Industrial Revolution would be driven by a number of contemporary technologies, including intelligent robots, 5G communication systems, and the Internet of Things (IoT) [4-6][3]. The Internet of Things (IoT) makes it possible to link a wide variety of devices, people, data, and processes in a seamless manner. Therefore, the Internet of Things (IoT) has the potential to improve a wide range of activities by making them more measurable and able to be analyzed. This is accomplished via the collecting and analysis of significant amounts of data [4, 7]. In a number of different fields, such as healthcare, urban planning, construction, agriculture, water management, and energy management, the Internet of Things (IoT) has the potential to help improve people's quality of life [5, 8]. The delivery of improved, immediate automated decision-making and the provision of humans with the tools to improve these judgments are the ways by which this objective is realized.

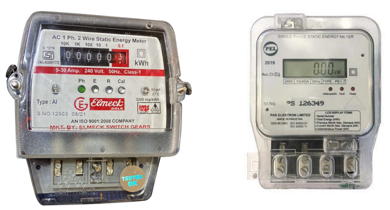
II. RELATED WORK

There are a number of inefficiencies and constraints associated with the conventional method of meter reading, which includes someone from the utility company making physical visits as traditional and digital energy meter shown in Figure 1(a) & 1(b) respectively. It is important to note that this method is labor-intensive, time-consuming, and presents logistical issues, especially in locations that are highly inhabited or have terrain that is difficult to navigate. Furthermore, incorrect invoicing might be the consequence of human mistakes during manual readings, which can lead to consumer unhappiness as well as financial repercussions for both users and energy providers [7].

One viable answer to these persistent problems is the implementation of household metering systems that may be controlled remotely. Utility companies are able to remotely access and monitor home meters without the need for actual site visits [8]. This is made possible by using modern communication technologies such as wireless networks, cellular systems, or power line communication. According to the results of [9], this method simplifies the process of reading meters, which in turn lowers operating expenses and improves the accuracy of the data. In [10], the authors offer a concept for a residential energy management system that makes use of the fog computing framework, a smart plug that is equipped with Internet of Things technology, and a smart meter. The root means square (RMS) value of the electrical current, the frequency, the factor of power, the amount of power that is active, and the amount of power that is reactive are all continually monitored and calculated by the intelligent plug. In [11], you should provide a proposition for the development and construction of a smart energy meter that is outfitted with technology that is connected to the Internet of Things (IoT). A basic, cost-effective, and efficient design was included into the meter's construction. Users are going to be provided with comprehensive information on the amount of energy that is being used by any electrical gadget.

In addition, the possibilities of remote control go beyond just reading them from the meter. Utility providers have the ability to use these technologies in order to adopt demand-side management tactics, which will allow them to optimize patterns of energy consumption and stimulate efforts to save energy. Utility companies are able to successfully control peak demands, reduce the danger of grid overloads, and eventually contribute to a more sustainable energy ecology, as proven in [12]. This is accomplished by remotely modifying settings or applying load shedding techniques.

E-billing offers a compelling answer to the complexity of conventional paper-based invoicing systems, which complements the remote-control feature of the system. The switch to digital billing systems not only lessens the impact on the environment that is caused by the waste of paper, but it also improves the ease and transparency of the billing process for customers [13]. Specifically, [14] highlights the fact that users are able to view their billing information in real time, track their patterns of energy use, and make educated choices about their usage habits. In order to solve this problem, you need provide a pricing strategy that is very efficient in [8]. There is a presumption that each and every user has an electrical energy consumption controller (ECC) that is included into their smart meter. Smart meters are able to establish links not only with the communication framework but also with the electrical grid.



(a) (b)

Fig. 1. (a) Traditional Analogue Meter and (b) Digital Smart

In addition, electronic billing systems make it easier to include dynamic pricing models. These models allow utility providers to modify price structures according to a variety of criteria, such the time of usage, peak demand times, or fluctuating energy sources [14]. Because of this flexibility, users are able to actively control their energy expenditures by changing their use to off-peak hours or adopting habits that are more energy efficient. Because of this, electronic billing encourages a cooperative approach to energy management, which in turn helps to cultivate a mutually beneficial relationship between utilities and their customers [15].

In addition, the combination of technologies that allow for remote control and electronic invoicing makes it possible for utilities to make use of sophisticated data analytics and machine learning methods. Through the analysis of huge datasets that are created from meter readings and billing information, utility firms are able to obtain important insights into consumption patterns, discover inefficiencies, and establish focused strategies for enhancing service delivery and customer satisfaction [9]. The work that was done by [16], [17], demonstrates the promise of these analytical tools in terms of improving operational efficiency and optimizing energy management. The Internet of Things (IoT) integrates various devices and systems to enable smart environments, enhancing data collection and communication capabilities, making it crucial in advancing applications such as smart cities, where IoT solutions improve efficiency and quality of life [19-21].

It is important to note that the adoption of remote control and electronic invoicing systems is not without its difficulties. It is necessary to address concerns surrounding data privacy, cybersecurity, and the dependability of the system in a thorough manner. According to [18], [22-24], it is of the utmost importance to implement stringent security measures, including encryption, authentication protocols, and access restrictions, in order to protect sensitive user data and guarantee the system's integrity.

III. System Design

The design of the proposed scheme shown in Figure 2, consists of software and hardware design. The proposed model has three modified energy meters shown in Figure 4:

Transformers Check Meter
Users Meter
2nd User Meter

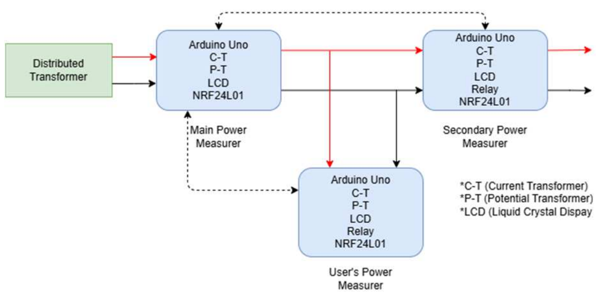


Fig. 2. Block Diagram of Proposed Model.

A. *Transformers Check Meter*

The meter (Main Check Meter) installed at the transformers output will measure the total output power of the transformer shown in Figure 2. At normal condition, the power of the transformer output will be equal or less than the sum of power of the Users meter. If the sum of the power of the user meter and check meter greater than the transformer rating power it's mean that the transformer is overload, the Transformer check meter (Control room) will remotely shut-off the power supply of some users. The power and energy are calculated by the following equations (1) and (2) respectively.

$$\text{Power} = V_{rms} \times I_{rms} \times \cos(\emptyset) \quad (1)$$

where, $V_{rms} = v_0/\sqrt{2}$ and $I_{rms} = I_o/\sqrt{2}$

$$\text{Energy} = \text{power} \times \text{time} \quad (2)$$

Fig. 3. Flow Chart of Mode

B. User Meter

The energy meter installed to consumer's are we called here User meter, will measure the total power consumed by the user, count the units and will communicate through NRF24L01 to transformer check meter (control room) shown in Figure 2. The transformer meter will receive the units consumed after every minute and will continuously monitor the system.

C. 2nd User Meter

The 2nd user meter will also measure the power and will communicate with the transformer meter through NRF24L01 with one minute of delay. The transformer meter will receive the units consumed after every minute and will continuously monitor the system.

IV. MERITS OF PROPOSED METHODOLOGY

The above IoT based smart modification of electrical distribution system will change the existing system with several aids, the existing system will come in category of Internet of Things (IOT), smart grid based energy metering system, remote control on residential energy meter, theft detection, E-Billing, Increases revenue, load shedding management and will also increases the efficiency of Distribution Companies (DISCOs).The proposed model along shown in Figure 2, with above mentioned advantages also have some other advantages which are, Cut-off of the supply of users in case of not paying electric bill on time, Reduces transformer burnout, Increases the efficiency of transformer by reducing the transformer burnout and Increases the efficiency of revenue.

Another major advantage of our proposed system will not interrupt the power supply of priority zones and places. For example, in time of loads shedding of a feeder, if there is Hospital, School and University or another priority place for which can't cut-off the supply so, we can remotely OFF all else priority zones supply for loads shedding shown in Table 1.

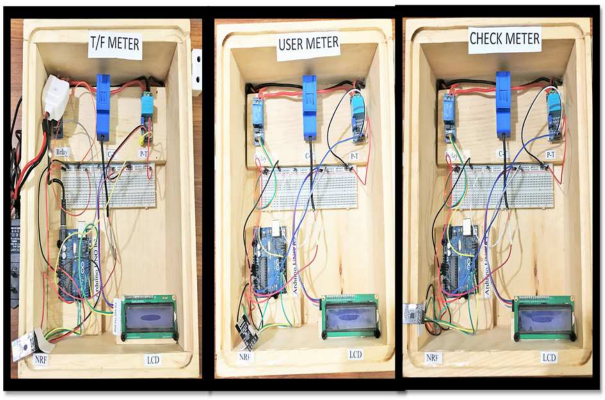


Fig. 4. Modified user's Smart meters and transformer check meters.

V. RESULTS

A. Remote Control of Residential Meter

In this proposed model, the transformer check meter (control room) will Cut-off the power supply of the user's meter wirelessly. The control room will send a special command to that user smart energy meter if the user is not paying the bill or if the transformer is overloading. The interface of transformer check meter (control room) is shown in Figure 2.

TABLE I. COMPARISON KEY FEATURES OF OUR MODIFIED SMART METER WITH OTHER METERS

Key Features	Traditional Analogue Meter	Digital Energy meter	Our Modified Smart Energy Meter
Remote Control	×	×	✓
E. billing	×	×	✓
Load Shedding Management	×	×	✓
Distribution Transformer Over-load Protection	×	×	✓

B. Electronic billing or E-billing

For E. Billing, our proposed IoT based model for demonstration and validation of our solution of E. Billing system. We used the utility software named "Cool Term", which communicates data to the PC (laptop) from transformer check meter. which shows on PC how many units consumed by an individual user with time, Date and generates the bill accordingly shown in Figure 3.

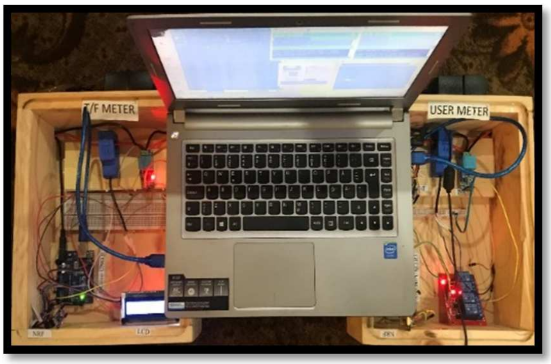


Fig. 5. E. billing Implemented Project Setup.

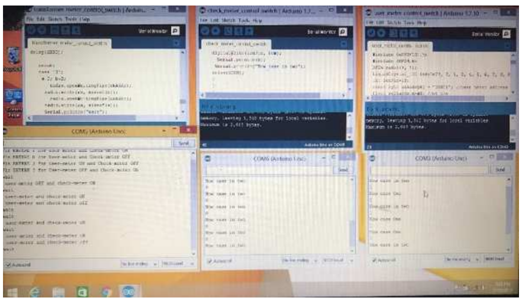


Fig. 6. Remote Control Run Time Snapshot

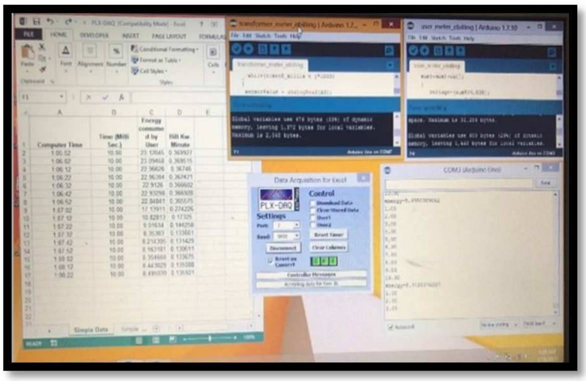


Fig. 7. E. billing Run Time Result Snapshot

VI. CONCLUSIONS

From the simulation and hardware implementation results, we conclude that we can control the residential meter from the control room. Our proposed solution is for distribution companies, in case of non-payment of utility bill on deadline, overload/over-rating of distribution transformer, loadshedding management and the other main key feather is non-cut-off of power supply of priorities zone or places like Hospitals, Schools, Security System and Industries during load shedding on feeder. The meter-reading and billing system of the electricity is currently manned. From the above modified meter system, the meter-reading and billing system will become unmanned, and the existing power grid system will upgrade to smart-grid and the traditional electric energy meter will be replaced by smart meter.

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