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A novel design of pre paid energy meter

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ABSTRACT: Prepaid energy meter is a new concept in measurement of electricity consumption on periodic basis. This method of measurement and data collection discards the conventional method of taking the electric meter reading manually. In the present work, the author has designed, and developed a new digital energy meter which is connected with the compatible microcontroller, a display device and compatible software to capture, transmit, and maintain the record of the electricity consumption data of a particular user. Use of the meter enables one to avoid the manual data collection and also the periodicity of data collection may be reduced to as low as one minute.

I. INTRODUCTION

Electricity, since its invention, has always been one of the fundamental requirements for any modern civilization and its development. It is now at the heart of any property, whether it is residential, commercial or industrial. Thinking for a while, we can imagine how deep electricity goes through our lives. Factories, mills, laboratories, commercial institutions, traffic, communication, home lights, televisions, PCs and cell phones are just few examples on the present situation of Electricity Empire. Since beginning, research and development in the field of electrical energy has been concentrated on its generation, transmission, distribution, protection and line losses, etc. But, in all the generations of electrical power technologies, no significant changes in measuring methods of electricity consumption were noticed. Electric meter remains the very basic and traditional meter in its shape or functionality. The conventional meters in two different forms, are shown in Fig. 1.

Fig. 1. Conventional Electric Meters.

Developments in Meter Technology. With the passage of time and also need, conventional meters have undergone change in shape and design. Electromechanical induction meters have gradually been replaced by electronic and digital meters. In India, it has become mandatory to use the electronic meters in all new installations. Commercial and Industrial institutions are required to get digital meters installed in their premises. Electronic and digital energy meters are shown in Fig. 2 and 3 respectively.

Fig. 2. Electronic Energy Meter.

Fig. 3. Digital Energy Meter.

II. ALTERNATIVE SYSTEMS FOR METER READING

Various drawbacks and limitations of the conventional manual metering system motivated the technologists to go for alternative automatic approach for determining the electricity consumption. The primary driver for the automation of meter reading is not so much to reduce labour costs, but to obtain data that is otherwise

unattainable. Mostly electric meters, especially in multistoried buildings in metro cities, are located in places that are inaccessible to the meter reader and require an appointment with the homeowner for the purpose of meter reading. Electricity tends to be more valuable commodity as compared to others, and the consumed energy must be measured through actual readings instead of estimated readings. This has driven the electricity utility companies to consider for automation. This is commonly called Automatic Meter Reading or AMR.

III. TYPES OF AUTOMATIC METER READING (AMR)

Advent of electronic and digital energy meters facilitated the process of automatic meter reading. AMR may be based on various methods and designs. Few important methods are given below:

On-Site Automatic Meter Reading. In this method, a meter reader carries a handheld computer or data collection device with a wand or probe. The device automatically collects the readings from a meter by touching or placing the read probe in close proximity to a reading coil enclosed in the touchpad. When a button is pressed, the probe sends an interrogate signal to the touch module to collect the meter reading. The software in the device matches the serial number to one in the route data-base, and saves the meter reading for later download to a billing or data collection computer. Since the meter reader still has to go to the site of the meter, this is referred to as "on-site" AMR.

Fig. 4. Digital meter being used in the state of UP.

Power Corporation Ltd, in the state of UP, also uses similar method for the purpose of recording of data in industrial and domestic units. Instead of using RF signal optical contact using IR is being used as shown in Fig. 4. This method avoids the chances of recording incorrect reading due to human error. But even this method still requires the exercise to access each and every meter in person.

AMR Using Radio Frequency Network. Radio frequency based AMR can take many forms. The more common ones are Handheld, Mobile, and Fixed network. There are two-way RF systems and one-way RF systems in use that employ both licensed and unlicensed RF bands. In a two-way or "wake up" system, a radio transceiver normally sends a signal to a particular transmitter serial number, telling it to wake up from a resting state and transmit its data. The transceiver attached with the electric meter and the transceiver attached with the meter reader, send and receive radio signals and data to each other. In a one-way "bubble-up" or continuous broadcast type system, the transmitter broadcasts readings continuously every few seconds. This means that the reading device can be a receiver only, and the meter AMR device a transmitter only. Data goes one way, from the meter AMR transmitter to the meter reading receiver. There are also hybrid systems that combine one-way and two-way technologies, using one-way communication for reading and two way communication for programming functions.RF based meter reading usually eliminates the need for the meter reader to enter the property or home, or to locate and open an underground meter pit. The utility saves money by increased speed of reading; it has lower liability from entering private property, and has less chance of missing readings because of being locked out from meter access. The Technology based on RF is not readily acceptable everywhere. In several Asian countries the technology faces a barrier of regulations in place pertaining to use of the Radio Frequency of any radiated power. For example in India the radio frequency is not free for use even for a low power radio system of 10 milli watt.

AMR Using Mobile Van. Mobile or "Drive-by" meter reading is used where a reading device is installed in a vehicle. The meter reader drives the vehicle while the reading device automatically collects the meter readings. With mobile meter reading, the reader does not normally have to read the meters in any particular route order, but just drives the service area until all meters are read. Components often consist of a laptop or proprietary computer, software, RF receiver/transceiver, and external vehicle antennas. Wi-Fi technique is also implemented for this type of data collection system.

Power Line Communication. It is a method in which electronic data is transmitted over power lines back to the substation, and then relayed to a central computer in the utility's main office. This would be considered as a type of fixed network system -- the network being the distribution network which the utility has built and maintains to deliver electric power. Such systems are primarily used for electric meter reading.

Web-Enabled AMR. Broad-band availability at nominal cost and without much complexity, web-enabled AMR system is emerging at very fast pace. In this method electric meter is made net enabled so that useful data from the meter is periodically uploaded to the relevant site of the utility, from where analysis and billing job be performed automatically.

Prepaid Energy Meter. Prepaid Energy Meter has been proposed as an innovative solution aimed at facilitating affordability and reducing the cost of utilities. This mechanism, essentially, requires the users to pay for the electricity before its consumption. In this way, consumers hold credit and then use the electricity until the credit is exhausted. If the available credit is exhausted then the supply of electricity is cut off by a relay. But their use is still controversial. On the one hand, those who support the diffusion of prepaid meters claim that they benefit both consumers and utilities because they help users to consume more efficiently and to improve the management of their budget, while allowing firms to reduce financial costs, as well as the costs of operation and bad debts. On the other hand, those who are against prepaid energy meter argue that their adoption is expensive for firms and risky for low income consumers, as the insecurity and volatility of their income may force them to make little use of the service, or ultimately, bring about involuntary self-disconnection. Prepaid meters are usually installed by electricity supplier, if it feels that the customer cannot keep up payments on their energy bill. However, they can also be requested by the customer themselves and are often seen as a good method of budgeting. Generally speaking they are used by lower income households, such as people on welfare benefits, lone parents or those with no bank account. From a technological point of view, the prepayment system consists of three well differentiated components. The first is a service meter installed at the unit where energy will be consumed, such as a household dwelling or a store. In general, these meters are of the “two-gang” type, and consist of a user’s interface unit and a current measuring set. The interface unit is a device installed inside the building, which allows the user to “interact” with the meter. The metering unit, on the other hand, is the intelligent component that stores credit and consumption information, and makes up the element that either clears or switches off electricity supply. The second component of the system is the so-called credit dispensing unit, which is the vending machine where consumers can purchase electricity credit. In general, these sales outlets are located at the utility’s commercial offices, as well as in stores with long opening hours. The third component is the supporting device that links the various sales outlets to the utility’s management system.

IV. LITERATURE SURVEY

The author has reviewed a large number of literature including research papers, technical broachers, specification sheets, government rules and project reports in connection with the proposed work. These are described below: presented that prepaid energy meter is electronic in nature; it accepts voltage inputs representing local voltage and current in an electrical power system and converts them to digital using over on managing energy in industry, with many test measurements and recordings to determine usage patterns before deciding what can be done to reduce consumption. The author also mentioned the developments in digital metering over the past several years that have significantly improved both meter accuracy and repeatability. The advent of microprocessor based test devices and meters has greatly improved the ease of operation, making the equipment "user-friendly" even to the novice. Details presented in this paper include an introduction to metering objectives, practical metering applications, latest metering techniques to employ in the process of measurement and certain pitfalls in the process that should be avoided. [3] the use of internet enabled modem chip for the benefit of the service provider and the end user. As per the author, de-regulation, new technologies, energy shortages, price increases, heightened attention to conservation and increased global competition are all causing sweeping changes to the utility industry, in both residential and commercial sectors. These changes heighten the importance of load management and motivate consumers to change their usage patterns to balance the loads. In order to efficiently adapt to these changes and facilitate load balancing, utility companies and their customers require new management and control capability. Advanced communications techniques can provide these new capabilities and improve operating efficiency.[4] the development of an efficient algorithm that implements a flexible and affordable digital energy meter intended for home usage. As a first step, the algorithm is downloaded into an FPGA prototype board. The algorithm architecture comprises four main modules: power, energy, billing and display. Two digitized inputs, which are assumed to come from single-phase voltage and single-phase current, will be fed into the digital energy meter and the output is expected to be the energy consumed and the corresponding billing. The timing analysis and circuit synthesis, have been performed on suitable platforms. Using digital synthetic test data it has been proven that the model is tested successfully. This work forms the first phase of developing a commercial but affordable digital energy meter for home usage employing digital techniques. Another step will be to make the meter communicable with remote control. [5] described a single-phase power/energy meter with tamper logic. The design is such that, the meter measures active power, voltage, and current in a single-phase distribution environment. It differs from ordinary single-phase meters in that it uses two current transducers to measure active power in

both live and neutral wires. This enables the meter to detect, signal, and continue to measure reliably even when subject to external attempts of tampering. The heart of the meter is an AVR microcontroller. All measurements have been carried out in the digital domain and measurement results are available in the form of frequency-modulated pulse outputs and as plain-text values, accessible over the USART interface. This enables the design to be used in cost-effective applications based on mechanical display counters. Alternatively, the design easily fits more computerized applications with features such as remote reading, demand recording, multiple tariffs, and several other [6] has described Smart metering using the IEEE P1451.2 Protocol, Energy meter standards have also been described in this paper along with the requirements for such a meter and use of the technique for the quality power measurement are also mentioned. Paranhos I. et al. in [7] emphasized that nowadays, the control over every minimal cost is being very important for the market competition. Since the electric energy bills represent a great amount of expenses for the companies, the monitoring of the power quality helps to lower the energy costs and to prolong the machine's life. But, not every company can pay for an expensive resource that helps to minimize the expenses. This paper presents study and development of a low cost electrical energy monitoring system, that consists of a digital energy meter, a software for the system management, a data-base to store the measurements and a web-page to monitor the energy quality from anywhere, through the internet. Algorithms based on calculus, were proposed for implementation. Physical environment and communication protocols have also been proposed. Markow John, in [8] described microcontroller based energy metering using the IC AD 7755. The author also described how the Energy Meter's IC AD 7755 could be used in three-phase energy metering with power outage detection and measurement backup, remote, automated, multiple-rate metering. Specification sheet of IC ADE 7754 in [9] , described multifunction poly-phase energy metering IC with serial port interface, from Analog Devices. It described the use of this IC as interface between measuring equipment and serial port of the computer. This can be used as an analytic tool for electrical measurement. Specification sheet of IC ADE 7758 from Analog Devices, in, [10] described multifunction poly-phase energy metering IC with serial port interface. The specifications for the microcontroller based IC ADE 7758 to be used as analytic tool for electrical measurement, are also described the specifications for the microcontroller based IC ADE 7754 to be used as analytic tool for electric measurement. Loss P.A.V. *et al*. presented in [11] a microcontroller based energy meter, a totally electronic single-phase energy meter for residential use, based on Microchip Technology Inc. PIC family of microcontrollers. In this paper author explained the basics of energy measurement, in integration with the use of microcontroller. This paper has demonstrated the possibility of measuring the electrical energy consumption with a microcontroller based meter, as an alternative to the conventional electromechanical meters. The design proposed in the said paper takes into consideration the correct operation in the event of an outage or blown out, by recording the energy consumption in EEPROM memories internally available in the microcontroller. When the supply is restored, the energy consumption computation is properly initialized. Also, a four digit display is used to show the energy consumption. Chavan S *et al* [12] proposed an open standard protocol for networking of energy meters under the simple network-management protocol (SNMP) environment. Since the SNMP is quite popular for network enabling uninterruptible power supplies, the necessary support hardware and software already exist. Hence, migrating energy meter connectivity to the transfer control protocol/Internet protocol-based SNMP would be an easy task. A sample network has been created under the Lab VIEW virtual instrumentation environment and studied to validate the proposed open standard protocol for networking of energy meters. Cao Liting *et al*. [13] suggested the mesh technology for cluster of networked meters. Meters at a particular location are networked together and connected to one gateway server from where wireless link is made to the main control centre. This paper gave an insight to the connections of the meter. Naphade S.P. in [14] has focused on the cost reduction benefits of the automatic meter reading. This is a motivational paper to promote the use of automatic meter reading further. Doraswami Anand in [15] has insisted upon the need for an electronic meter at domestic as well as industrial level. Specification sheet [16] provided by Atmel for 8-Bit microcontroller IC AT89S52 with 8KB in system programmable flash memory provides the methods to develop the circuit as per the requirement. Specification sheet [17] provided by Atmel for Energy metering IC ADE 7755 with pulse output provides great insight for power measurement in digital domain. This paper also provides the way to incorporate microcontroller in the process of energy measurement.

V. CONCLUSIONS

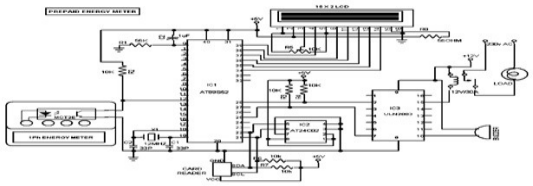
Prepayment systems have been proposed as an innovative solution to the problem of affordability in utilities services. In spite of being a popular system in European and African countries, the use of such mechanisms remains controversial. Among the main

arguments in favor of its dissemination are the advantages concerning lower costs of arrears, running costs and finance charges for the service provider and the better allocation of resources it implies for users. The arguments against prepaid meters are based on the higher cost of the technology and the possibility of self-disconnection of low-income users. The monopolistic power distribution market in Asia is gradually transforming into a competitive marketplace. Differentiation in service is going to be the key competitive factor to improve market share in the deregulated power markets. Prepaid meters with their advantages over conventional ones are likely to help power distributors to differentiate and offer value-added services to consumers. Encouraging consumers to opt for prepaid meters on a voluntary basis and offering tariff or non-tariff incentives to those consumers who prepay their power charges, would help the utilities to implement this system.

LIST OF COMPONENTS

S.No.	Components	Description	Quantity
1	AT89S52	40 Pin	1
2	AT89C2051	20 Pin	1
3	AT24C02	8 Pin	2
4	ULN 2003	16 Pin	1
5	MCT2E	6 Pin	1
6	Resonator	Ceramic 12 Hz	1
7	Relay	12V/30A	1
8	LCD	16*2	1
9	Buzzer		1
10	LED	Green Red	1 1
11	Resistor	56K 10 K 330 OHM 56 ohm	2 2 9 1
12	Capacitor	1MICROFARAD/16V ELECTROLYTIC 1MICROFARAD CERAMIC 33pF CERAMIC	1 1 4

SIMULATION DIAGRAM



CIRCUIT DIAGRAM

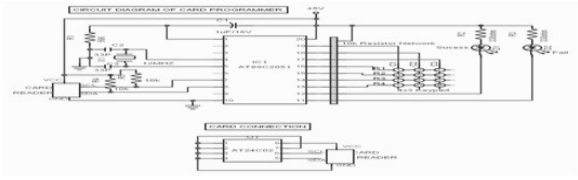


Fig. 5. Prepaid Energy Meter.

The circuit diagram of prepaid energy meter is shown in Fig. 5.

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