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A Smart Electronics Energy Measurement, Monitoring, Billing and Payment System using IoT

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***Abstract*—In India and many developing countries, electrical power usage has been calculated manually by observing the number of units in electrical power meter. Electrical power consumption bill amount is calculated manually and updated to the user as well as Electric board data base. The users need to pay the bill against the calculated amount, and it can be paid by direct cash or digital transaction. This conventional system involved more human resources. It has more chance for wrong calculations. Thus, the cost is too expensive, and the process takes too long. We proposed a system to allow consumers and service providers measure power usage, calculate bills for minimizing unnecessary power usage, and make remote bill payments in order to avoid falling into this trap. This study introduces the idea of an IoT (Internet of Things) enabled digital EB (Electricity bill) meter. The proposed system is developed using Arduino because it consumes less power, is faster and has two UARTs (universal asynchronous receiver-transmitter). Power transformers are used to calculate voltage and current level. Arduino control converts data into power unit using some simple calculations. Users can monitor the power usage, recharge, and pay the bill using android app or web page. The energy consumption is calculated continuously and if the user's electricity account balance reaches a low-level; warning will be given to the user. The electricity will be terminated when the available balance is less than the unit charge.**

Keywords— Digital Energy Meter, web based electrical load control, Smart billing system, Energy monitoring, Internet of Things

I. INTRODUCTION

The usage of electricity is increasing in the world day by day since electrical appliances and electronics gadgets are the part of every human life. So, the demand for electrical power is very huge. Also, the effective way of power distribution and effective usage of electrical energy are existing electricity billing system, electricity bill amount is calculated manually by visiting and referring meters in each building, unable to keep track of the electricity usage day wise and unable to control the load usage remotely to save the power. Also, the consumers are facing lot of issues while paying the bills like sometimes they will forget to pay the bill and the electricity connection will get terminated. Also, there is no mechanism to find the devices which one consuming the power. Sometimes they will forget to switch off the devices once their needs over. This leads to increase the unwanted and sometime accidents may happen or device may get damaged. The solution to all of these problems is to monitor the power usage of heavy loads continuously and remotely, which will be held to ensure accurate billing, high demand, minimizing the power wastage and low-cost acquisition. These are all factors that should be considered in designing an efficient energy billing system.

IoT based smart energy meter system was proposed for building automation system to improve the quality building automation and integrating the energy management system [1]. A Smart energy meter system for customer was developed, it measures the power consumption and sending the warning message to the customer's mobile phone when they have reached to the allotted power capacity through (Global System for Mobile Communication) GSM [2].

Intelligent energy meter was developed using Arduino Mega which monitors the units of power usage continuously and sends the power consumption data to web server using Ethernet Shield. These data are used to generate bill and find variations on the power usage [3].

In-depth investigation was done on the numerous power measuring gadgets now on the market as well as methods for learning how to read meters easily. The quantity of electricity consumed by a home, company, or electrical item is measured by a power meter, also known as an electrical energy meter. Each client building has an electric meter installed, which displays the units of electricity used for billing. The meters in use right now measure in kWh units. [4-6].

The mechanical rotation caused by magnetic induction is the basis on which the conventional power meter operates. It has numerous dental wheels as well as the Freewheel, an aluminum wheel that revolves. The other wheels rotate as a result of the Freewheels rotation, which is dependent on the power flow. The display portion will convert this to the appropriate values. Mechanical flaws and failures are common because there are so many mechanical components involved. The likelihood of fraud and present theft will be very high.

The Digital Micro Technology (DMT) foundation underlies the Electronic Energy Meter, which has no moving parts. Hence, the EEM is referred to as the "Static Energy Meter". ASIC (Application Specified Integrated Circuit), a specially created IC controls the precise performance of EEM. The same ASIC is now used in Washing Machines, Air Conditioning, Automotive, Digital Camera etc. [7].

The conventional and most of the existing systems various shortfalls such as

- Conventional energy meter is mechanical based energy meter. So, it gives the approximated reading and there is more possibility to vary the readings externally.
- They have no options to monitor the power usage and corresponding bill amount every time. It means power consumption units will be generated for every billing period. So, it's very difficult to reduce the power usage significantly.

Our proposed IoT based electronic energy meter addresses the problems of consumers and distribution companies/government agencies. IoT is a recent technology this is used recently in the design and development of various systems to monitor and control the various electrical and non-electrical parameters through internet using different wireless technology [8]-[10]. This paper talks a lot about an intelligent energy meter, which uses embedded system features namely a combination of hardware and software to implement the functionality as customer required.

II. PROPOSED SYSTEM

Our proposed system uses the electronics energy meter, Wi-Fi modules, GSM, Web server, Billing/Payment Application and Arduino microcontrollers as shown in fig.1. Many monitoring or controlling devices are designed using microcontroller with various sensors, wireless technologies and output display devices [11]-[18]. With the use of a Wi-Fi module (ESP Board) the consumer and the service provider will receive a power reading of the appropriate value, when they reach their maximum value, which they have set. And with the help of a Wi-Fi modem the consumer can monitor the readings they have used and can set a limit on the web page. The electricity department can read monthly meter readings thanks to this method without having to go door-to-door. This can be done by using an Arduino device that continuously monitors and logs readings from energy meters in its fixed (permanent) memory. Live meter readings can be requested to be shown on a customer web page, and this programmed continuously records measurements. When necessary, this technology can also be used to turn off the home's power supply.

Since IoT is relatively expensive compared to SMS, low power meter monitoring is quite implementable. Daily power consumption details can be generated and monitored through internet (either users Android app or users web site). Also, android users can pay their electricity bills on their android system. Non-android users can see the reports about daily power usage on the website and they can pay the bills. The system is reliable and accurate the learning values collected in the energy meter. Live power meter readings can be viewed with the Android app. Also, readings can be viewed online. Human hard work is avoided, and all values are stored on a central server. The communication system is secure and interference with electricity meters can be easily detected. In the event of a system error, the average server value will not be updated. If the updated value exceeds the time limit, the system can determine if there is something wrong with the system and can report developers to EB. Thus, diagnosing an error becomes easier. The bills against power usage are available on a central website, it can be accessible from anywhere in the world by anytime.

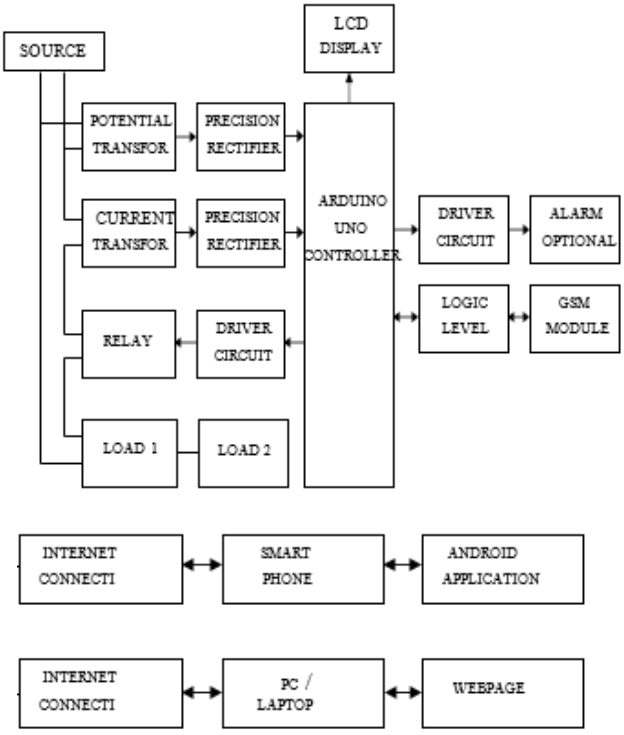

Figure 1. Block Diagram

Microcontroller is the heart unit of this process. Only the device can monitor and control all sensors and actuators. Here we use the Arduino uno development board

as a microcontroller unit. User-friendly user upgrades have more prospects compared to the base commonly known as 8051. The Arduino controller has an internal ICSP programming mode that simplifies editing tasks. The Arduino controller has a built-in analog-to-digital digital conversion register, a clean electrical system memory and a heartbeat production module. The SIM800L is a low-cost portable GSM module. The module connects to a UART protocol that does not require more than two PINs. Baud rate-based communication to speed up the process. Some of the startup commands are pre-configured for Arduino controls. After receiving the powerful control module, it will turn on GPRS using different AT commands.

Relay is an electro-magnetic switch, it is used to turn on or off the power source. The operating voltage of the controller is not sufficient to control the relay driver. Transistor based switching circuit will open the module transmitted using TTL logic voltage levels. Potential and current transformers are used to sense and calculate the load voltage and current level. An accurate converter is used to convert one current into a direct analog current voltage. The voltage level is supplied by a microcontroller. The controller converts the electric source to digital and displays it using a liquid crystal display.

After the controller is enabled, it will launch the liquid crystal display and ESP module after which it will connect the server and download the data to the server. The internal memory of the controller ROM has a minimum amount of balance that is restored and stored in a global variable in system memory. If the balance is above the limit the controller checks the status of the switching condition. If both the balance is valid and the simultaneous switch is enabled, then the transmission is enabled for power activation. The controller updates the power measurements once every five seconds of the time interval. In the event of any changes in the balance or unit the controller pushes the data to the web server.

III. RESULTS AND DISCUSSION

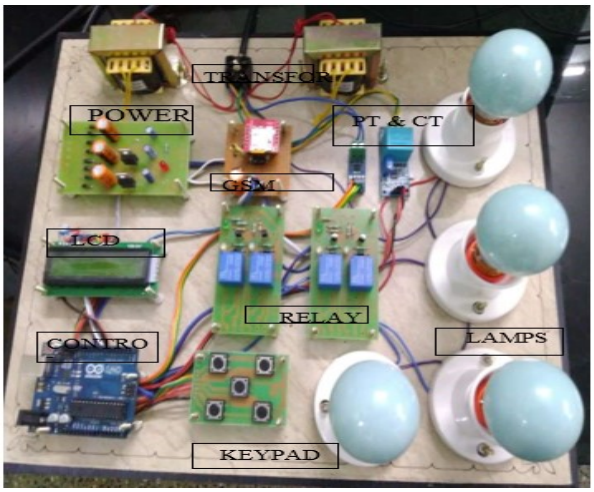

Figure 2. Final Prototype

Prototype and interconnection of the proposed system is shown in fig. 2. This prototype implemented with 4 lamps as the loads. When power is on it will take a few seconds to power the microcontroller unit and the controller will launch the liquid crystal display module and display the title on the display, after that display starts to display the readings about the load usage as shown in fig.3. Once LCD activated, power usage data sent to the server using ESP module. Meanwhile the received data displayed on the website as shown in fig. 4. Also, the website has designed to have the control panel to control the loads. The user can control the loads and check the status of the system online. Recent results stored on the site for the user to view specific data on the website. Status indicators show load status, and each widget card does the same

Figure 3. LED Display

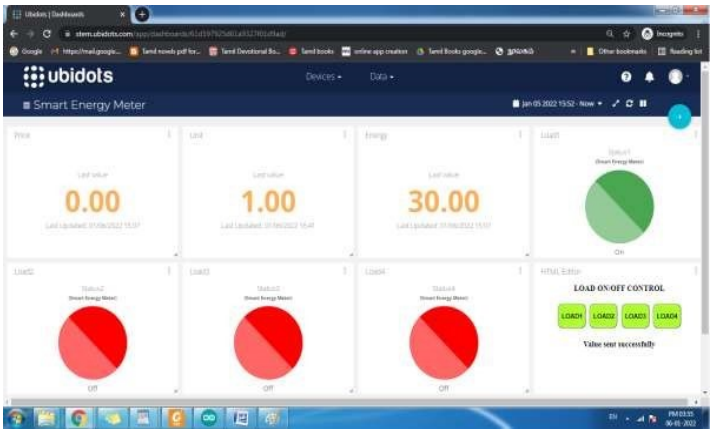

Figure 3. Website page with reading data and control panel

IV. CONCLUSION

The proposed system displays the load voltage, current, date and time. This system has the provision to control the load remotely through website which helps to save the unwanted power usage. Power consumption data periodically updated on the web server whenever unit of power consumed by the load and added to the account. This system aims to provide a general power meter infrastructure used for a smart city concept. Great future developments will make power meter readings, disruptive diagnostic techniques, and connections and disconnections and pre-existing information that gives users everything that will happen on the Wi-Fi network. This system will be easier for electricity board power consumption and billing management system in India. Also, easy to integrate the billing and payment systems with the proposed system. So,

the user can monitor, control the power usage and bill payment remotely using websites or Android Application.

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REFERENCES

[1]. Ożadowicz, Andrzej, and Jakub Grela. "Control application for Internetof Things energy meter—A key part of integrated building energy management system." 2015 IEEE 20th Conference on Emerging Technologies & Factory Automation (ETFA). IEEE, 2015.

[2]. P. Loganthurai, M. Veeralakshmi, A. Vanmathi, Professor, Department of EEE, K.L.N College of Engineering, "Smart Energy Meter Billing using GSM with Warning System",IEEE 2017

[3]. OsmiJaiswal, Dilip Chaubisa, B.E, Student Department of ECEL.D College of Engineering,"Arduino Mega and IOT based Intelligent Energy Meter (IEM) to Increase Efficiency and Accuracy in Current Billing Methodology" ICE-CDS-2017

[4]. Md. Masudur Rahman,OhidulIslam, Md. SerazusSalak in," Arduino and GSM Based Smart Energy Meter for Advanced Metering and Billing System," Pabna University of Science and Technology, Pabna, Bangladesh 2015 IEEE.

[5]. Himshekar Das, L. C. Samika, GSM Enabled Smart Meter and Automation of Home Appliances, National Institute of Technology, Silchar, India 2015 IEEE

[6]. Nikhil V. Patil, Dnyaneshwar R. Bondar, Rohan S. Kanase Department of Electrical Engineering, Rajarambapu Institute of Technology, Islampur, India "Intelligent Energy Meter with Advanced BillingSystem and Electricity Theft Detection" ICDMAI,2017

[7]. TanmoyMaity and ParthaSarathi Das, "Intelligent online measurement and management of energy meter data through advanced wireless network" IEEE Wireless communications ,2011

[8]. Manikandan, P., et al. "Soil nutrients monitoring and analyzing system using Internet of Things." 2022 2nd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE). IEEE, 2022.

[9]. Manikandan, P., Reddy, B. N. K., Bhanu, M. V., Ramesh, G., & Reddy, V. P. (2021, July). IoT Based Air Quality Monitoring System with Email Notification. In *2021 6th International Conference on Communication and Electronics Systems (ICCES)* (pp. 616-620). IEEE.

[10]. G. Ramesh, P. Manikandan, J. JolinDorrothi, R. Nithya Shree and S. K. Prabhavathy, "IOT Based Cable Defect Location Tracker Using GPS and GSM," 2022 4th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), Greater Noida, India, 2022, pp. 1395-1398, doi: 10.1109/ICAC3N56670.2022.10074119.

[11]. Manikandan, P., et al. "Arduino Based Automatic Hand Sanitizer Dispenser System." 2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N). IEEE, 2021.

[12]. Manikandan, P., S. Manoj Kanna, S. Deva Kishore Reddy, and Sai Subhash. "Water Quality Identification System Using Arduino." In 2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), pp. 704-708. IEEE, 2021.

[13]. Ramesh, G., et al. "Microcontroller based Wheel Alignment and Compulsion Scrutinizing System." 2022 International Conference on Edge Computing and Applications (ICECAA). IEEE, 2022.

[14]. Manikandan, P., Reddy, M. R. S., Mehatab, S., & Sai, P. M. (2021, July). Automobile Drivers Distraction Avoiding System Using Galvanic Skin Responses. In *2021 6th International Conference on Communication and Electronics Systems (ICCES)* (pp. 1818-1821). IEEE.

[15]. Manikandan, P., Thenmozhi, A., Ramesh, G., Naidu, T. R. K., Reddy, K. V., & Reddy, K. B. K. (2021, December). Crops Protection System from Animals using Arduino. In *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 682-685). IEEE.

[16]. P. Manikandan, G. Ramesh, P. Syam Mohan Reddy, J. Suman, M. Dhanush Vasavai Kumar and K. Chandra Siddhardha Reddy, "Smart Voice Assitance System for Visually Impaired Persons," 2022 4th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), Greater Noida, India, 2022, pp. 1859-1862, doi: 10.1109/ICAC3N56670.2022.10074529.

[17]. P. Manikandan, G. Ramesh, V. Muneeswaran, S. S. Kumar, P. V. Siddartha and A. K. Koushik, "A Smart Paperless Electronic Ticketing System using RFID and Bluetooth Technologies," 2022 4th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), Greater Noida, India, 2022, pp. 1326-1329, doi: 10.1109/ICAC3N56670.2022.10074108.

[18]. G. Ramesh, P. Manikandan, U. R. Venkatathathagari, G. Bandi, A. Garlapti and M. Attar, "Covid-19 Vest for Social distancing and Monitoring," 2022 4th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), Greater Noida, India, 2022, pp. 1358-1361, doi: 10.1109/ICAC3N56670.2022.10074515.