

# Wireless Energy Meter with Automated Tariff Calculation

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**Abstract**— The State Electricity Board (SEB) which is responsible for generation and distribution of power, are facing critical financial problems. The Electricity Distribution Sector which should have been one of the primary revenue contributing to the economic growth is being subjected to inefficiency and corruption. Transmission and Distribution (T&D) losses (mainly because of power theft), improper billing and inefficient revenue collection are the factors responsible for the downfall of SEB. This can be prevented by implementing an improvised energy meter system presented in this paper. The proposed Wireless Energy Meter can transmit the data that contains information about the energy consumed to the energy provider which will help to generate accurate bills. The data is transmitted to the SEB via Internet. The consumers can keep a regular check on the consumption of power and the cost (real time monitoring) on a mobile application. This real time monitoring could encourage the consumer to conserve the usage of electricity on a daily basis. Due to this proposed system, there is total transparency between the energy provider and the consumer in power consumption, bill generation and payment.

**Index Terms**—IoT, GSM, WSN, Digital Energy Meter, Visualization, Feedback System.

## 1 INTRODUCTION

Since the discovery of electricity, the number of applications in which it is being used has never come to a halt. Electricity is one of the basic needs of a human being. The consumption of electricity for domestic purpose has increased 50 times since 1997. But this doesn't seem to stop, mainly because of three reasons: India's plans for the development include that each household should be provided with 24\*7 electricity; the household incomes are increasing and in addition to affordable power resource the consumption of electricity is likely to increase; development in technology and their reduced cost has encouraged the common people to buy more electronic appliances [1].

India being the second most populated nation in the world, it is bound to face problems to meet the growing needs of electricity. There are mainly two sources from which energy is generated: the renewable sources of energy which include solar energy, hydro power, wind energy, bio mass is still not used widely even though they are ecologically harmless. On the contrary, the power sector is more reliable on fossil fuels which cannot produce sustainable energy for all. This results into depletion of fossil fuels which has been a concern since a long time. Other than that, the use of fossil fuels has adverse effects on the society. In order to generate power from coal the steps include mining, processing, transportation and burning of coal and disposal of coal waste leads to pollution and wastage. This harms the communities near the coal power plants [2].

Although the power sector should have contributed to the economic growth, analysis state that this sector is facing huge monetary losses. This is the result of poor management in tariff collection, T&D losses which is mainly because of power theft and improper billing [4]. It is necessary to use the available resources efficiently for sustainable development. There

are countries which have already implemented Smart Energy Meters which has advantages like feedback system i.e. transmitting information about the energy consumed by each household to the power supplier in real time, allows the consumer to keep a track of number of units consumed and its cost, automatic billing and prevent human intervention.

## 2 EXISTING SYSTEM

The power sector is controlled and managed by the Ministry of Power. In any power sector there are three main components which are: Generation, Transmission and Distribution of power. The generation is divided among three sectors Central sector, State sector and Private Sector. The Central sector or Public Sector Undertakings (PSUs) generate 29.78% of the total installed capacity. Other than PSUs there are State-level Corporations that produce 41.10% of overall generation. Private sector enterprises also play a major role which constitute 29.11% of total installed capacity.

The electricity is generated in power plants and a majority of them are using the coal reserves for this purpose. The power is transmitted to the transformer which increases voltage. This enables the power to be transmitted over a long distance. They are transmitted through high-voltage transmission lines. These transmission lines carry electricity from power station to a sub-station. Sub-stations have transformers that convert high voltage electricity into a lower voltage electricity once again. From the sub-station, distribution lines carry the electricity to our homes which use low voltage electricity.

The energy meters placed in the vicinity of a household measures the unit of power consumed by a household. It displays the unit of power consumed continuously. After a certain period of time an agent from the service provider comes

to note down the units consumed for every household. According to this recorded data, the service provider generates a bill in order to charge the household for the services provided.

### 3 Proposed System

#### 3.1 Problem Statement

On a regular basis, the consumers cannot interpret the amount of power being consumed until they receive their bill at the end of the month. Even though the present energy meters display the energy consumed, it does not display the corresponding cost which has to be paid. If the consumer is notified about the units consumed along with the cost, it would help them to keep a track and encourage them to plan their usage accordingly for the forthcoming months. In the current scenario, the residential consumption keeps on increasing at a faster rate and so the power sector ends up using more resources to meet their growing needs. Hence it becomes difficult to achieve sustainable development. The government has to endure huge amount of losses, in power transmission and distribution that in turn results in heavy monetary losses. A major cause for this problem is lack of an efficient feedback system. The service providers are not getting enough information to analyze the pattern of energy consumption. This hampers their need to meet the demands of energy requirements.

#### 3.2 System Design

The proposed system architecture of Wireless Energy Meter with automated tariff calculation is shown in the figure,

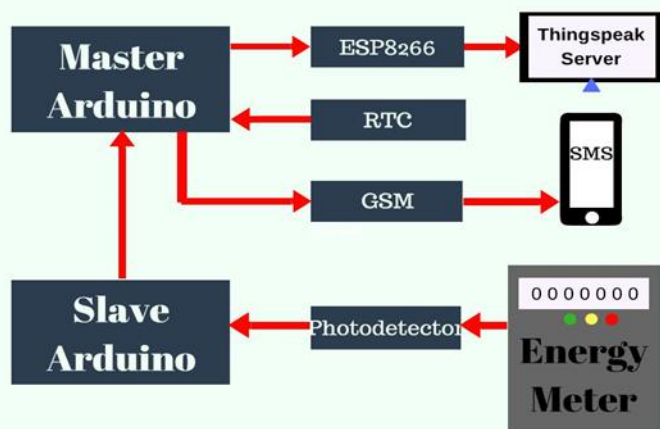


Fig.1. Block Diagram of the Proposed System

This system aims to automate the billing process for the amount of electricity consumed by the end user. This would help the State Electricity Board by making the entire process less tedious. Here, the bill is calculated by counting the number of blinks of the LED on the energy meter. As the consumer utilises electricity, the LED on the energy meter blinks with an impulse for consumption of units of electricity. This is interpreted by the photo-detector and it increments the impulses as received. The photo-detector feeds this analog count of blinking to the slave Arduino, where the slave Arduino converts it

into digital impulses and provides it to the master Arduino. There is a default impulse limit of 3200 impulses after which there is an increment in the total units consumed. So, as the counter reaches that limit of 3200 impulses, the counter increments and increases the total unit consumed by one. The units are then sent to the master Arduino by the slave Arduino. The master Arduino does all the financial processing and calculates the cost for amount of electricity consumed. This transfer of the compounded data from the slave to the master is done by using serial data bus transfer. The master-slave arrangement is put in place to compensate for the delay encountered while logging data onto IoT server. The master Arduino is synchronized with an RTC and it is interfaced with GSM SIM 900 and ESP 8266 by means of software serial to communicate. The readings or the calculated cost and amount of units consumed is updated on the IoT server at regular intervals of time. While this is being done, the consumer is also notified by means of an SMS that is sent by the GSM module. The data analysis visualisations can be seen on the server as well as the integrated android mobile application on the consumer's phone. Further, due to non-payment of dues, the electricity supply can be restricted by means of a relay. Thus, we intend to provide a reliable and cost-effective solution for the existent methodology in place.

#### 3.3 Hardware Tools Used

##### Arduino Uno

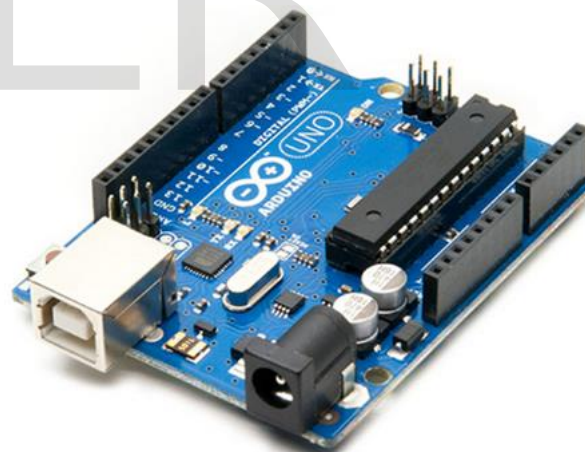


Fig. 2. Arduino Uno

Arduino Uno (Fig.1) is a very versatile hardware that can use programming languages like C and C++. Java and Python can be processed on a computer and then used to communicate with the Arduino. Among several versions of the Arduino that are available such as Arduino Uno, Arduino Due, Arduino Mega and Arduino Leonardo. The board that we are using is the Arduino Uno that uses a 16 MHz ATmega328. It has 14-digital I/O pins, where 6-pins as PWM (pulse width modulation outputs), 6 analog inputs, a reset button, a power jack and a USB (Universal Serial Bus) connection. Connecting the USB cable to the computer and powering the Arduino with an AC-to-DC adapter or battery followed by running the

Arduino IDE software to interface the board with the computer.

**RTC Module**

RTC MODULE DS1307 is a clock that causes occurrences of a regular interval interrupts on its each tick (time out). The DS1307 (RTC) Real Time Clock IC (an I2C real time clock) is an 8-pin device using an I2C interface with 8 read/write registers respectively storing seconds, minutes, hours, day, date, month and year. An interrupt service routine executes on each timeout (overflow) of this clock. This timing device once started never resets or never gives error readings once it is loaded with the right initializing time. Once it is set, it is not modified later. The RTC is used in a system to save the current time and date. The RTC is also used in a system to initiate return of control to the system (OS) after the preset system clock periods. RTC provide system clock and it has a number of applications. This timing device once started is generally never reset or never reloaded to another value.

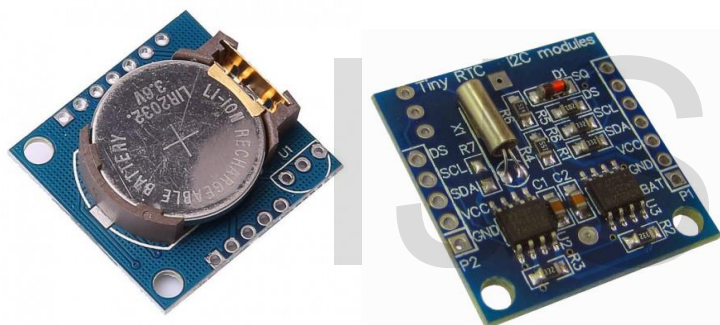


Fig. 3. RTC DS1307

**ESP 8266 Module:**

The ESP8266 Wi-Fi Module is an easy to use self-contained SOC (System On Chip) with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or dumping off all Wi-Fi networking functions from another application. Each ESP8266 module comes pre-programmed with an AT command set firmware. Using the serial port to use the AT commands to set the module. Linking the module to the Arduino device/ microcontroller gives us Wi-Fi ability. The ESP8266 module is an extremely cost effective board with ever growing usages. We power the module using 3.3V (Voltage above 5V could damage the module) from the Arduino and set it to 9600 baud rate as all our devices are communicating at the same baud rate. This module has a powerful on-board processing and storage capability that allows it to be integrated with the sensors and other application specific de-

vices through its GPIOs (General Purpose Input Output). The ESP 8266 module aids in using multiple instructions and functions to transform any system into an IoT (Internet of Things) solution. ESP8266 Wi-Fi Module has a flash disk size from 512k to 1MB which enables it to perform as a high performance and fast processing device.



Fig. 4. ESP8266 Wi-Fi Module

**Digital Electricity Meter:**

An electricity meter, electric meter, electrical meter, or energy meter is a device that measures the amount of electric energy consumed by a residence, a business, or an electrically powered device. Electric utilities use electric meters installed at consumers' premises to measure electric energy delivered to their customers for billing purposes. They are typically calibrated in billing units, the most common one being the kilowatt hour [kWh]. 3200 impulses per kilowatt hour [imp/kWh] is the value we associate to the blinking of the LED on the Energy meter. "Time of day" metering allows electric rates to be changed during a day, to record usage during peak high-cost periods and off-peak, lower-cost, periods. Also, in some areas meters have relays for demand response load shedding during peak load periods.



Fig. 5. Digital Energy Meter

**GSM SIM 900A Module:**

GSM MODEM is a wireless modem that works with a GSM wireless network. The behavior of a dial-up modem is replicated by this wireless GSM wireless network. The

main difference being that a dial-up modem sends and receives data through a fixed telephone line while a wireless modem sends and receives data through radio waves (wirelessly). The working of GSM modem is based on AT (which means Attention) commands that finish with a character. The AT commands are given to the GSM modem with the help of PC using an Arduino or microcontroller. The GSM modem is serially interfaced with the Arduino with the help of MAX 232. For serial interface GSM modem requires the signal based on RS 232 levels. GSM modem SIMCOM SIM900 is a complete Quad-band GSM/GPRS module in a SMT type and designed with a very powerful single-chip processor integrating AMR926EJ-S core, leading to a small

dimension resulting it being cost-effective solutions. GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mm x 24mm x 3 mm, SIM900 can fit almost all the space requirements in M2M applications, especially for slim and compact demands of design.



Fig. 6. GSM Module

#### 4 CONCLUSION

The need for progress in the distribution and billing of electricity will never end. With the proposed system, live monitoring of energy consumption will be made possible. Wireless technology helps to further reduce human intervention and therefore reduce human errors. Since less human intervention is required, the amount spent on hiring human labor can be saved and put to better use. Wireless technology also helps to automate the system. Total transparency is achieved between the service provider and the consumer since the billing process is totally transparent and can be monitored anytime, anywhere. It will encourage the common man to save energy and thereby move towards sustainable development. This system provides visualization for both consumer and provider. With the help of visualization, the usage pattern of energy can be noted and improved. It can also help the electricity

board to maintain the proper demand and supply of electricity.

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