International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-7, Issue-6, March 2019

ESP8266 Based Pre-Paid Electricity System

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Abstract*: The need and the advantages of prepaid system can be seen all the way around and prepaid system has always proved its faithful working. The growing electricity theft has put a challenge towards power quality and customer comfort. Though, the frequency of contingencies clearance has much improved due to advancement in embedded and semiconductor systems, yet we have a long way to go because their lies a huge gap between the present technology and present electrical systems. A refined and much advanced concept of prepaid electricity distribution system has been discussed. Electrical System joining hands with IoT based home automation is area of interest in this project. A balanced result has to be produced by decision taken by micro-controller without taxing the customer satisfaction. Also, an algorithmic programmed home automation system has been proposed which will enable customer to save electricity bills. This system helps the users by alerting them about the billing status and unit consumption with the help of an indicator and also making necessary changes in load automatically.

Index Terms*: Electricity, IoT, Energy Meter, Power Consumption, Threshold Limit, Unit Consumption and Raspberry Pi.

I. INTRODUCTION

In Power Consumption Alert System [2], a circuit is designed which helps the consumer in taking care of the electrical energy consumption power and to control the excess consumption. This system will inform the consumer about their unit usage rate via SMS. Once the predefined (set) threshold value is reached, power is cut off with a prior notification to the consumer. Due to this, customer feels inconveniency in emergency condition. This system gives the alert to the consumer via SMS only. GSM based talking energy meter [5] is used to monitor and alert the consumer of their power usage. But the hardware required for this system is very complex. In Talking energy meter based on microcontroller [1] gives the alert and notification of energy usage if the set or threshold limit exceeds, billing status etc. The microcontroller is used is ATMEGA 328, it has 32K of flash memory, 1K of EEPROM and 2K of internal SRAM (Static Random Access Memory). A secure smart card based system for prepaid electricity bill payment [3] over the internet was proposed. The smart card system has been designed and implemented successfully using a three tier model client-server system, which was proven to be superior over the two tier client-server system model. The system notifies the customer in case the value of his power consumption goes below threshold with the help of IP based microcontroller. A prepaid energy metering system to control electricity theft [4], this system proposes a smart energy meter to be installed in every consumer unit and a server is maintained at the service provider side. Both the meter and the server are equipped with GSM module which facilitates bidirectional communication between the two ends using the existing GSM infrastructure. Recharging of energy meter is done by sending a PIN number hidden in a scratch card to the server using SMS. This paper also proposes steps to control meter bypassing and tampering. An extensive experiments on hardware using AT89S8252-ADE7755-AT90S2313 chip set, the implementation methodology of a prepaid electricity with bright display unit [6]. A prototype meter has been built, tested and found to work as per standard specifications. This system is capable of display remaining balance, check balance, disconnect load at zero balance, read the prepaid card, update the balance, etc are some of its proposed work. A raspberry pi based prepaid electricity system [7] is discussed for the people above and below poverty line. In this system an energy meter is connected to the 71M6543F microcontroller through current sensor. The energy meter will read the data and send it to the 71M6543F microcontroller ADC (analog to digital conversion) port. The measured and converted quantity will give the power consumption value, which is given to the Raspberry Pi 2 Processor. The information is sent to the both customer and electricity department. When the balance of units are less than the minimum limit prescribed by the electricity board, Raspberry Pi 2 Processor interrupts the relay to disconnect load automatically and no power will be supplied to the house and the customer will be notifies via GSM module.

In this paper, an ESP8266 (NodeMCU) microcontroller based prepaid electricity system is proposed, which is linked to home automation systems and hence a smart system is obtained. This system without challenging the comfort level of customer takes optimized decision of its own. Various features like recharging and emergency demand in need are made available to customers by logging into an online portal. Unlike any other proposed system this system takes decision to shift from grid supply to renewable energy sources available in smart home by keeping in track of peak hours and non-peak hours [8]. A simulation study of indicator system is proposed, it consists of a node MCU with an in-build wifi and few LED as load in prototype model. In real system, LED's are the actual load like fan, washing machine, air-conditioner, etc. This LED's are turned ON and OFF depending upon the peak and non-peak hrs, which is known to the controller by collecting the cost of per unit of electricity from a proposed website. This website will be updated and maintained by the electricity board and only two authorities', user and board will have login credentials.

Revised Manuscript Received on 30 March 2019.
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The website will display per unit cost of electricity, units remaining, balance/ amount left, units of electricity sold, current load, hours of electricity remaining on current load, amount to be paid as bill and two emergency portals. The "emergency demand portal" is services provided to customers like recharging of balance for extra units in case customer has used up his entire unit before a month due to certain occasions. Also, a "change of reference amount" is another service open to customer. The bill to be paid is calculation after careful consideration of units consumed and sold. This is how a complete transparent and effective system is established. To the switching block, sufficient sensors/relays are installed to collect the data from a smart home and take necessary decisions without compromising the comfort level of the customers. This set/reference values will also be updated on the website and hence the proposed system will be capable of reducing the electricity theft as the entire system is transparent.

II. DESCRIPTION OF WORK

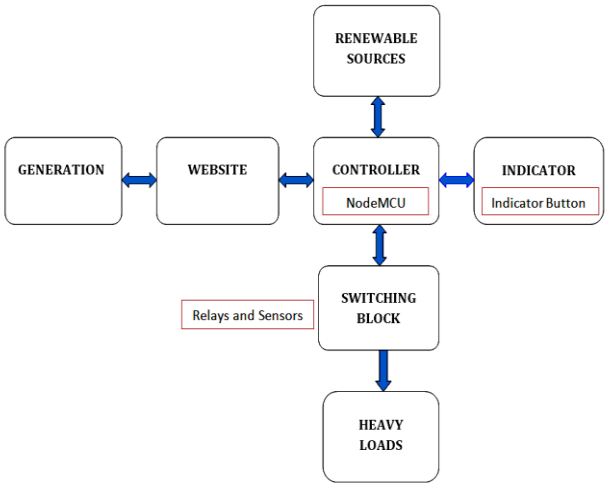

Fig.1 Design Setup

The figure 1 represents the model of proposed system; we can infer that the design is completely transparent i.e. the information will be shared from generation to customer and from customer to generation via website. The controller processes i.e. sends or receives the data and the processed output is displayed on the indicator through LED's. The switching is the key block to measure the loads smartly and sending the data to the controller, at the same time controller receives the cost of per unit of electricity and decides whether to access supply from grid or natural sources. In case the customer wants to switch OFF the heavy load after indication to save electricity bill, the intelligent system automatically does so as programmed in controller.

2.1 Indicator

For the proposed system, indicator is designed and its response is recorded. The indicator reacts by turning the LED's ON or OFF, the red LED is turned ON in case the cost of per unit electricity is higher than normal (peak hour) and to its response if the customer wants to save money on electricity bill, can do so by switching the concerned appliance OFF. Moreover, the indicator consists of as many LED's as there are heavy load appliances in smart home of the customer. Not only this, along with the LED's a beep alarm is also present to notify the user of the peak hours, to switch OFF the appliance or if recharged balance is low to drive the appliances. However, in case of notification from the indicator if the customer still wants to use the heavy load appliance, for example air-conditioner can do so by reacting to the indicator button. Otherwise in all cases the appliance will be turned OFF after a fixed period of time, the period to switch OFF the appliances and reaction to peak hour is programmed in the controller and managed by switching block by analyzing each load and hence, the proposed system never challenges the comfort level of the consumers.

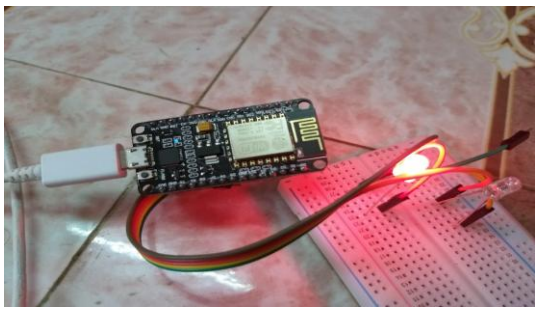

Fig.2 Indicator Setup

2.2 Controller

This is the heart of the proposed system. The NodeMCU (Node Microcontroller Unit) is open source software and hardware development environment that is built around a very inexpensive System-on-a-Chip (SoC) called the ESP8266. Moreover, it has an inbuilt wifi so, we can connect NodeMCU to internet very easily. NodeMCU have enough RAM (128KB) and ROM (4MB flash) to carry out the operation easily and speedily. It can be programmed using Arduino IDE in C language. Most of the decisive process is carry out by the NodeMCU, it is responsible for initiation of tasks like sending the signal to switching box to turn OFF the appliances, sending the data of loads to the website, collecting the per unit cost of electricity at discrete interval of time from the website, doing various calculation, preparing the system to receive the power from grid or natural sources, setting the device to buy or sell the electricity.

2.3 Website

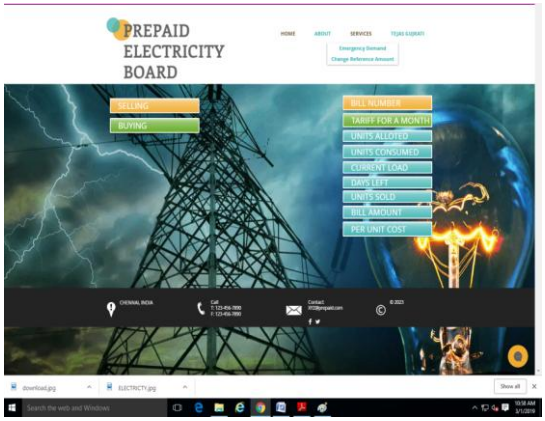

Fig.3 Website View

A dynamic website is designed and codes for the same are burnt into the NodeMCU. All the minor and major updates of the loads or the cost of electricity, recharged balance of the customer, remaining amount, units of electricity remaining, net amount to be paid for next month as bill, number of days the electricity would last if the customer use same load, etc. Moreover, services like Emergency demand portal and change reference amount links will be provided to all customers.

2.4 Calculations

Assuming a situation in which the customer has used up first 200 units of electricity. So now, according to the government rates he will be charged at Rs.4.80 per unit. So,

Tariff for 1 month chosen = Rs 5000
1 unit = Rs 3.70 (for first 200 units)
Units used = 200
Bucks remaining = Rs 4260
Now if the current load in home is 1000 watts = 1Kw.
Cost of electricity = Rs 4.80

According to tariff, (if 887.5 unit is used for 1 hr the tariff will be exhausted)

So, if the same 1000 watts is used the electricity will last up to approximately 887.5 hours or 37 days.

Note- The above calculations are made for non- peak hours.

III. OUTPUT AND SIMULATION RESULTS

A highly transparent, secure and IoT based prepaid electricity system is proposed and various simulation on indicator is carried out. It is inferred from the simulation that the controller takes the information or data (updated by generation or distribution) from the designed website and carry out calculations. Once, an optimized result is obtained by the controller, various actions are performed like turning OFF of appliances, switching to natural sources, etc.

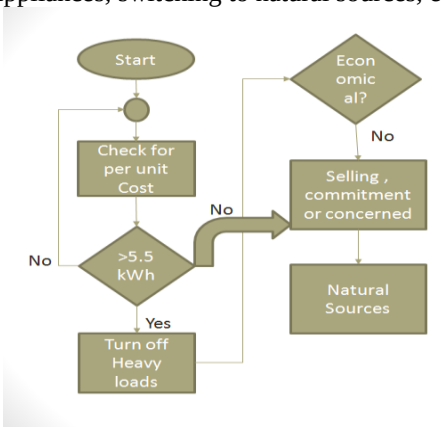

Fig.4 Algorithm

Fig.5 Indicator Simulation

The figure 4 shows the flow chart of the operation, here assumption is made for reference of a unit cost (5.5kWh). Also, it can be inferred how the algorithm switch the load from grid source to natural source.

Fig.6 Indicator Simulation

The above figures 5 & 6 are simulation result for indicator. The programming is done in Arduino IDE, the codes for programming NodeMCU has codes for website design. The simulation is carried out for two appliances and hence, two LED's are shown. Here, the algorithm is similar i.e. the NodeMCU collects the updated information from the website, produces the optimized output and signals the user.

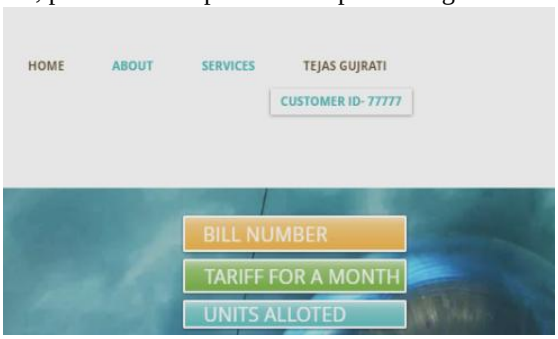

Fig.7 Login view of Website

Customers will be provided a unique ID (figure 6) after successful registration. The login credentials will be given to the user via email or message and he will be solely responsible for it.

Fig.8 Services provided to customer

Figure 7, shows the services provided to the customers. In case of any emergency demand of units due to occasions or if

the customer finishes completes the credit units before a month, the following contingencies can be eliminated by signing in and filling a form.

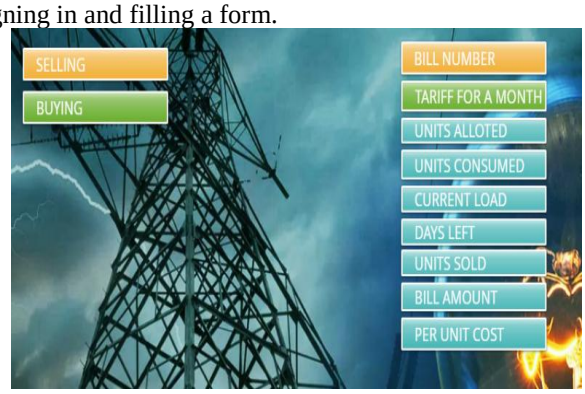

Fig.9 Options on Website

IV. CONCLUSION

The ESP8266 (NodeMCU) based prepaid electricity system is designed for users to save electricity bill. The proposed system is transparent, secure and can be used to reduce electricity theft. The controller is the heart of the system which performs all the decisive actions, calculations and produces the most optimized output. The website code is written in c programming and is burnt in the controller. Additional services are provided to customer on website in case of any contingencies. The simulation of the indicator setup is done, after receiving the data from the website updated by the generation or distribution (here random data is given to website) the controller signaled the user. To the future scope of the system more advance and responsive controller can be used. Also, many other services including GSM module can be included in the system to enhance reliability.

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