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Power billing for electric vehicles and home appliances using smart energy meter (SEM)

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ABSTRACT

Smart Energy Meter(SEM) is a versatile device capable of monitoring and managing the power consumption of both electric vehicles and home appliances.Moreover, it indicates the amount of power consumed by the battery and appliances through SMS via user's electronic gadgets enables with Wi-Fi and GSM technology and displays the cost of energy consumed. Our Smart Energy Meter system, integrating GSM and ESP8266 technologies, allows real time monitoring and control of energy usage for electric vehicles and household appliances. It collects data through current and voltage sensors, accessible remotely via smartphone.Data encryption ensures secure transmission, while bidirectional communication permits remote appliance control.A power billing system will be developed based on the power consumption of home appliances which leads to efficient energy management solutions.

I. INTRODUCTION

The smart energy meter is developed at the user's premises and connected to the main power supply. It measures the power consumption of all appliances connected to the electrical system. Basically smart energy meter developed is used to calculated energy consumed by electric vehicles. In [1] that was developed by M.PadmaPriya, T.A.Ragavendrian. the energy meter calculates the energy consumption of each appliance in kilowatt-hours (kWh) and stores this data. The energy meter uses the recorded energy consumption data to calculate the total energy consumption for a given period (e.g., daily, weekly, or monthly). It also calculates the total cost based on the energy consumption and the applicable electricity tariff. The smart energy meter collects data on power consumption from all appliances. It calculates energy consumption and costs.In [2] a smart energy meter that can calculate many parameters at a time is proposed.

In [3] Based on the current electric energy meter, with the well-functioned ARM kernel microprocessor, it not only finishes the power data's measuring and processing, but also realizes the TCP/IP by cutting. By ARM kernel microprocessor controlling GPRS module, electric energy meter could be linked to the Internet by use of GPRS service. The overall system is stable and reliable because it is managed by mu C/OS-II operating system. In [4] the conference about power and energy control by the appliances and the transmission speed of information. This conference gives the idea about how to control power and energy consumed by the appliances. In our proposed system the GSM module sends billing details to users' electronic gadgets via SMS or a mobile app for easy access. The Wi-Fi module

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continuously updates energy consumption and cost details to a website. Users can access the website to view real-time data on their energy usage and billing details, helping them to monitor and manage their energy consumption effectively.

II. PROPOSED METHODOLOGY

II(a) Arduino UNO board(ATmega328P), 16*2 LCD display, Wi-Fi module(ESP8266), SIM800C GSM module, LDR sensor, Relay(IS09002), Single Phase Energy Meter, Lamp are used in smart energy meter for electric vehicles and home appliances. Fig.1. shows the block diagram of the SEM for billing system of electric vehicles.

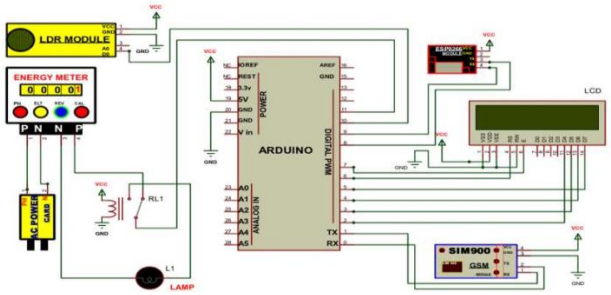

Fig. 1. Block diagram of Smart energy meter for electric vehicles and home appliances.

II(b) HARDWARE AND SOFTWARE IMPLEMENTATION

Arduino UNO is a micro controller board based on ATmega328. This board is the brain of the SEM. It controls everything and makes sure everything works smoothly. It has 14 digital input output pins in which 6 are pwm outputs, 6 analog inputs, 16 HZ ceramic resonator, USB connection, Power jack, an ICSP header and reset button. We can connect it to a computer with USB cable or external supply via AC-DC converter.In [5] first international conference on advanced technology in science about IOT based smart energy meter was done by Rakibul Hasan, Eklas Hossain, Hossain Mansur Resalat Faruque, Tipu Sultan .In [6] a smart energy meter for home appliances is developed using ARM7 board by O. Homa Kesav, B. Abdul Rahim . In our system Arduino controller 1,0 pins are used as transmitter, receiver.Transmitter(Tx) of Arduino Controller is connected to pin1(Rx) of GSM module.Receiver(Rx) is connected to pin2 (Tx) of GSM module means here pin0,pin1 of Arduino micro controller are used as serial communication for GSM module. Moreover 8,9 pins of arduino are connected to Tx, Rx pins of Wi-Fi module(ESP8266). The 10th pin of Arduino micro controller is connected to LDR module and 11th pin is connected to relay(IS09002). LDR works on the principle called photo conductivity. GSM module typically communicates with host device using AT(attention) commands.All these commands are ASCII-based instructions that control various functions of GSM module like sending sms, connecting to internet. In [7] a Energy Consumption Monitoring and Controlling using Data Visualization and IOT was developed using Arduino and Blink app is developed using wifi module by Mikesh singh, Vaidehi walse, Rajeshwar Busa. In our system ESP8266 integrates a tensilica L106 32-bit micro control1er unit (MCU) which runs at a speed of 80MHZ. This MCU handles various tasks such as executing user application code and managing Wi-Fi connectivity. ESP8266 module contains GPIO pins that can be used for interfacing with external sensor.In [10] an international conference on connecting smart energy meter to mobile phone is done by M. Weiss, F. Mattern, T. Graml, T. Staake, and E. Fleisch. Relay(IS09002) is an electromechanical switch that uses electromagnet to mechanically control the switch. Typically we will connect the relay's output pin to digital output pins of micro controller. Software for microcontroller to control relay and code to establish communication with mobile over wi-fi are written in Arduino IDE.In [11] an

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international conference on the use of the smart metering and home automation technologies for efficient utilization of energy, thus paving the way for a cleaner and greener environment for future generations by S. Ahmad. In our proposed system Mobile app sends command to micro controller over GSM. Based on the command received micro controller activates the appropriate GPIO pin connected to relay module turns the relay ON or OFF. Here home energy meter calculates the amount of energy consumed by the electronic appliances. Moreover LDR sensor is used to sense the readings from home meter via an LED.The circuit for relay and Wi-Fi module to Arduino Uno were shown in 2.1,2.2. In our system the SIM800C GSM Module sends you billing details and alerts by text message. The ESP8266 Wi-Fi Module connects the SEM to your home Wi-Fi network, so you can check on your energy usage from your phone or computer.The 16*2LCD Display shows you how much electricity you're using, how much it costs, and if there are any problems or not.

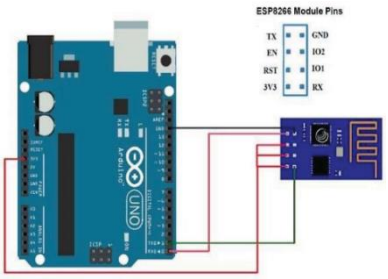

Fig 2.1 Wi fi module to Arduino Meg

Fig 2.2Relay IS09002

Arduino IDE uses a simplified version of C programming language. You write your code in the Arduino IDE editor, which consists of a text editor where you can write your program.The program you write is called a "sketch." Arduino sketches are made up of two main functions: setup () and loop (). Setup () function It runs once when the Arduino is powered up or reset. It is used toinitialize variables, pin modes, libraries, etc.Arduino IDE comes with a set of built-in libraries that provide pre-written code to simplify tasks such as controlling LEDs, reading sensors, and communicating with other devices. You can also install additional libraries to extend the functionality of Arduino boards.Once youhave writtenyour code, you canclick the "Verify" button (checkmark icon) to compile it.Compilation checks your code for errors and converts it intomachine-readablecode(binary)thattheArduino boardcanunderstand.Aftersuccessfullycompiling yourcode,youcanclickthe"Upload"button(right arrow icon) to upload the code to your Arduino board. The code is sent to the Arduino board via a USB cable connectedtoyourcomputer.ArduinoIDEincludesa SerialMonitor toolthatallowsyoutosenddata from your Arduino board to your computer and vice versa.It is useful for debugging and monitoring the behavior of your Arduino programs.Arduino IDE supports a wide range of Arduino boards. Before uploading your code, you need to select the appropriate board and serial port from the "Tools" menu. Arduino IDE allows you to customize various settings through the "Preferences" menu. You can configure settings such as code formatting, font size, and additional board manager URLs.Arduino IDE includes a collection of example sketches that demonstrate various features

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and capabilities of Arduino boards.In [13] an international conference on Innovative Technologies for an Efficient and Reliable Electricity Supply and Introduction to Smart grids in residentials was done by J. Stragier, L. Hauttekeete, L. De Marez.

III.RESULTS AND ANALYSIS

Qualitative Analysis

Here the amount of energy consumed by the appliance and cost of energy consumed are updated in a website. The graphical representation of amount and energy consumed are displayed in website. Basically website is an open source that can be modified according to our requirements. Graphs of amount and energy are displayed in fig 3.1,3.2

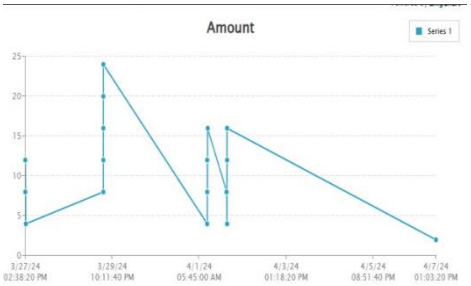

Fig 3.1 Graphical View Of Amount

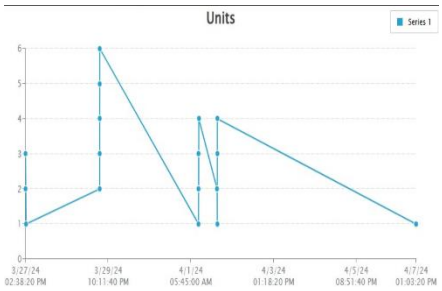

Fig 3.2 Graphical View Of Units

Moreover the data is displayed in a website for future reference in a tabular form. The readings will be displayed for every 2 seconds to determine the changes in power consumption and changes in cost.Fig 3.3 displays the number of units consumed and cost that are updated continuously in website.

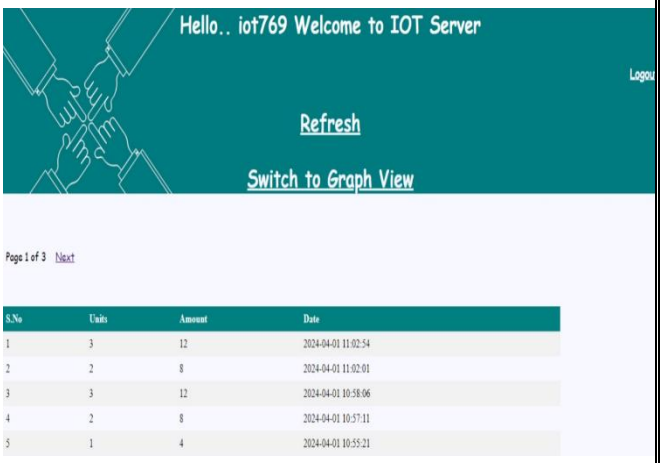

Fig 3.3 Consumption details of Appliances in Website

Quantitative analysis

There are three SEM simulation scenarios available for the customer. The first two scenarios utilize GSM communication, while the third scenario employees Wi-Fi communication show in Fig 4.1, Fig 4.2 and Fig 4.3. In the first scenario, the billing system is operating. The SEM responds to the request, as depicted in Fig. 4.4. Subsequently, the relay is activated, allowing electrical energy to flow to the electronic appliances and other circuits.

As a result, the SEM screen displays units and energy cost in rupees. The billing information is monitored by the customer through SMS.In [15] smart energy meter for home appliances is developed which sends data directly to mobile application without displaying the data on LCD display by Alfoni Jose Kezhiyur, P.Prasanna Kumar.

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Fig3.4SmartenergymeterwithGSMdisplay16*2

Fig3.5ConnetingToWiFiModule

Fig3.6Wi Fi readytouploaddatatoServer

Fig3.7Registeringtomobilenumber

Typing "1#" as illustrated in Fig.3.9 allows customers to monitor billing information. To stop the billing,customers can send "*2#" or "*0#" via SMS. Following this, the SEM replies to the customer with a summary of the billing information, as to show in Fig. 3.8Subsequently, the relay is turned off. For every customer request an SMS is sent from the user to the SEM.

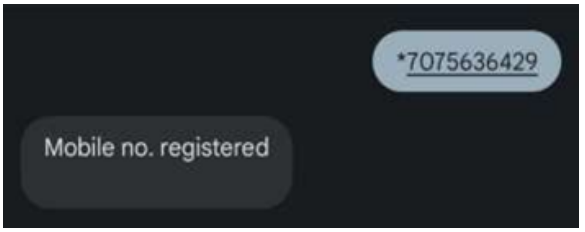

Fig3.8 Mobilenumber registration

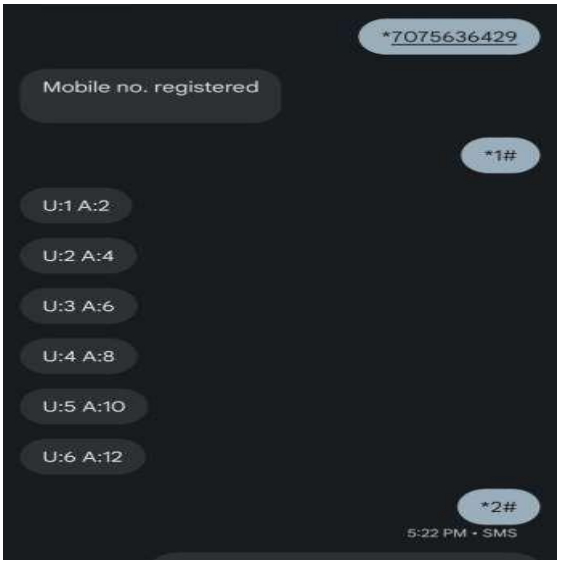

Fig3.9ConsumptiondetailsofSmartEnergy Meter

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Typing“*1#”asshowninFig.3.9TheBillingcan bestoppedviaSMSbytyping"*2#”or“*0#". And,SEMrepliedtocustomerthebillingsummaryinfo rmationasshowninFig 3.9.Then, relay was OFF. An SMS was sent from the SEM to the operator for every agreed customer request, the SMS was also received by operator from SEM after thebillingwasstopped,fillingsummarywasstored and uploaded in server.

The updated scenario with the additional information about cancellation and android-based application access:

1. The customer can cancel the request by typing an SMS to SEM. Cancellation information is received by the customer on android-based applications.

2. When the customer request was continued, the same information was received by the customer as in the first scenario with additional authority to access SEM from the android-based application. SEM gave the private key for that access. Private keys were three random numbers from 100 to 999 that were created when a customer requested by using the android-based application.

Billing information or billing stop were done by the customer using the private key, as shown respectively.

IV. CONCLUSION

The smart energy meter for electric vehicles and home appliances offers real- time insights into energy consumption, empowering users to optimize usage and reduce costs. Rigorous testing validates reliability, making it suitable for widespread deployment. Moreover, the system facilitates remote access and control capabilities through Wi Fi and GSM modules, enabling users to manage devices conveniently from anywhere. Through a web interface, SMS alerts, users can monitor energy usage, receive billing updates, and control appliances remotely, enhancing convenience and flexibility in energy management. From a utility provider perspective, the deployment of smart meters and automated billing systems streamlines operational processes, reduces manual intervention, and enhances billing accuracy. By leveraging data analytics and automation capabilities, utility providers can gain valuable insights into consumer behavior optimize grid performance, and implement demand-side management strategies effectively. Future integration with emerging technologies promises further advancements in energy Management.

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