International Journal of Research in Engineering, Science and Management
Volume-2, Issue-4, April-2019
www.ijresm.com | ISSN (Online): 2581-5792

IoT based Smart Talking Energy Meter (ISTEM)

A. Syed Mustafa[1], Soumya Shree[2], Afreen Bokhari[3], P. Anitha[4], S. Babitha[5], Nadiya Sayedi[6]
[1]*Professor, Dept. of Information Science and Engineering, HKBK College of Engineering, Bangalore, India*
[2,3,4,5,6]*Student, Dept. of Information Science and Engineering, HKBK College of Engineering, Bangalore, India*

***Abstract*: This paper describes us the Arduino UNO Microcontroller based architecture of smart energy meter using IoT. The system designed by us eliminates the need for human involvement in Electricity maintenance. The consumer needs to pay amount for the using of electricity, if he doesn't do so the electricity transmission is to be turned from the distant server autonomously. The user can monitor the energy consumption in units from a web page by providing device IP address. Theft detection unit connected to energy meter will notify company side when meter tampering occurs in energy meter and it will send theft detect information through Wi-Fi modem and theft detected will be displayed on the terminal window of the company side. Wi-Fi unit performs the IoT operation by sending energy meter data to web page which can be accessed through IP address. The Hardware interface circuit consists of Arduino UNO Microcontroller, MAX232, LCD display, theft detection unit, TRIAC switch circuit, DB18B20 temperature sensor, PIR sensor, GAS Sensor, Fire Sensor, APR 9600 and ESP8266 Wi-Fi module. Wi-Fi unit performs the IoT operation by sending energy meter data to web page which can be accessed through IP address.**

***Keywords*: energy meter, theft detection, Wi-Fi modem, Arduino UNO Microcontroller, IoT, Electricity maintenance.**

1. Introduction

In the Internet of Things (IoT) model, a large number of the living and non-living things that include us will be on the web in some structure. Driven by the ubiquity of contraptions enabled by wire-less mechanical development, for example, Wireless Bluetooth, Radio Frequency Identification, Wireless-Fidelity, implanted sensor, IoT has moved out from its starting stage and it is quite the edge of changing the present fixed between net into an all-around highlighted up and coming Internet. As of now there are right around nine billion between associated contraptions and it is assessed to contact very nearly fifty billion devices by 2020.Today the world is confronting such a domain, that offers difficulties [1]. Vitality emergency is the primary issue looked by our general public. An applicable framework to control and screen the power utilization is one of the answers for this issue [2]. One methodology through which the present vitality emergency can be tended to is through the decrease of intensity utilization in family units.

The consumers are increasing rapidly and also burden on electricity offering divisions is sharply on the rise [3]. The clients ought to be facilitated by giving them an ideal and a satisfiable solution with the idea of IoT (Internet of Things) meters and on the other hand consumers can be informed about the electric power thefts by constant monitoring.

By keeping above factors in mind, the idea of IoT meters is flourished comprising of 4 units: Microcontroller unit, Theft detection unit, APR Unit, Wi-Fi unit. The task portrays Arduino UNO Microcontroller based energy meter.

Today's Demand truly needs accessing the device characteristics remotely during a reliable method. One of the conceivable way to accomplish the task is to connect a device (energy meter) to internet by providing IP address to it [3].

ISTEM uses Microcontrollers which acts as a central control unit. It mainly focuses on power theft detection, power optimization and providing the relevant energy consumption information to user where they can monitor the energy consumption in units from a page through mobile app by providing device IP address. Theft detection unit connected to vitality meter will notify when meter tampering occurs in energy meter through LED blink and theft detected will be displayed on the LCD terminal and a voice output to alert consumers [3]. The block diagram of proposed ISTEM (consumer end) consist of Microcontroller unit, theft detection unit and Wi-Fi unit, APR unit and Sensing unit. Power offer section deliveries power to all or any the elements which needs Power. The microcontroller unit takes the information from the electricity meter and additionally carries out the appropriate control procedures and sends the required information like number of units through Wi-Fi module.

2. Problem definition

The conventional strategies that used these days like SMS are very costlier. Since IOT is financially savvy compared to SMS, monitoring of energy usage at lower cost is made conceivable. Daily consumption information in form of units are generated which might be monitored by user through mobile application and/or web portal. The system is a lot of reliable and correct reading values are collected from energy mistreatment devices. Live readings of devices can be viewed using Android application. Also, the readings can be viewed online. The human interference is avoided and all the values are kept maintained in the central server. The communication medium is secure and meddling of energy meters or thievery of

electricity will be known simply. Since the values of units are hold on the central information about energy consumption is accessible from anyplace within the world. Also, the server is online 24x 7[4].

ISTEM also delivers prepaid or postpaid access modes to electricity usage to consumers for flexible tariff plans[5] ,as the threshold is given to be five units when half of the units are consumed ,it should notify with a message that 50% consumed and when quarter of it is used it should indicate 90% ,energy units exceeds the threshold ,the system will alert users and automatically cut the power supply through relays and in case of postpaid a bill will be generated based on the units consumed.

3. Problem objective

Detect the current theft, Reduces the man power, Cost very low. To optimize time used for Bill Generation, there should be 24/7 connectivity, Immediate access to the user, Better security concerned to the theft, to detect and notify consumer about the fire breakouts due to inflammable materials (LPG leakage or smoke) in the vicinity using fire sensors and gas sensor. Automates the controlling of light in human absence.

4. Proposed system

Electricity is that the crucial demand for leading a snug life. It is to be properly used and managed. No correct designing of power distribution is resulting in tariff calculation issues. Many applied math errors prevail in monthly client request method. This idea of wireless information transmission is being projected to cut back the human dependency to gather the monthly reading and to attenuate the technical issues relating to the request method. This helps in extended reduction of power thefts moreover to calculate average power consumption of specific vicinity. Automatic meter reading system is associate degree economical approach of data assortment, that enable substantial saving through the reduction of meter browse, bigger accuracy, enable frequent reading, reduced tempering. It provides better customer services, by sending alert of power cuts and consumption updates. This paper presents a mobile communication technology that permits customers to see the meter reading often while not the person visiting every house by mistreatment Wi-Fi communication technology. This is terribly helpful for remote space or tiny villages. This system is terribly swift, correct and economical. ISTEM design is also equipped with a APR module connected to a speaker to get a voice output in case of alerts.

In this system we are connecting energy meters to the internet i.e., IoT concept. This system eliminates the human involvement in electricity maintenance. The block diagram of the system is shown. The major components used in the system are Arduino micro controller, energy meters (main energy meter and sub energy meter), interfacing circuit (optocoupler), relay circuit, LCD display and a PC. The interfacing circuit consists of an optocoupler. Optocouplers are used for providing optical isolation between an input source and output load just by using light.

The basic design of an optocoupler consists of an LED that produces infra-red light and a semiconductor photo-sensitive device that is used to detect the emitted infra-red beam. The pulses from the energy meter are converted into digital signals by using an optocoupler.

The live readings from the energy meters are collected by the microcontroller. This can be viewed through an LCD display which is connected to the micro controller. The LCD display shows the readings of the energy meters and the theft status.

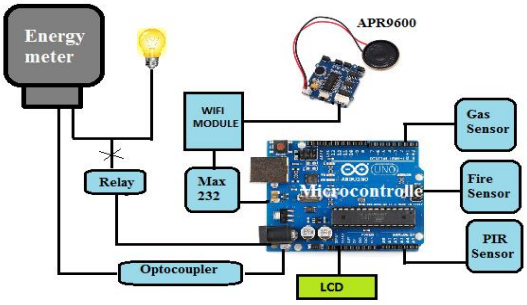

Fig. 1. Block diagram of proposed system

A. Sensing unit

Table 1
Different types of gas sensors

MQ2	It is a sensor of LPG, Propane, Methane and Hydrogen gas and can be used for domestic gas leak alarms.
MQ3	It is a sensor of Alcohol and Benzine and can be used for breath analyzer.
MQ7	It is a sensor of Carbon monoxide CO and can be used for car gases analyzer .detects well Benzine
MQ135	It is a sensor of NH_3, NO_X, Alcohol, Benzine, Smoke, CO_2 and can be used for quality of air analyzer.

The different types of fire sensors and their usages:

Table 2
Different types of fire sensors

Ultraviolet detector	This type of detectors works by detecting the UV radiation emitted at the instant of ignition. While capable of detecting fires and explosions within 3–4 milliseconds,
Near IR array	Near infrared (IR) array flame detectors (0.7 to 1.1 µm), also known as visual flame detectors, employ flame recognition technology to confirm fire by analyzing near IR radiation using a charge-coupleddevice (CCD).
Infrared	Infrared (IR) or wideband infrared (1.1 µm and higher) flame detectors monitor the infrared spectral band for specific patterns given off by hot gases.
UV/IR	These detectors are sensitive to both UV and IR wavelengths, and detect flame by comparing the threshold signal of both ranges.
IR/IR flame detection	Dual IR (IR/IR) flame detectors compare the threshold signal in two infrared ranges. Often one sensor looks at the 4.4 micrometer carbon dioxide (CO2), while the other sensor looks at a reference frequency.
Ionization current flame detection	The intense ionization within the body of a flame can be measured by means by the phenomena of Flame Rectification whereby an AC current flows more easily in one direction when a voltage is applied. This current can be used to verify flame presence and quality.

The sensing unit consists of fire sensor, gas sensor and IR sensor that is connected to main supply. The voltage used was a 240v to 6v step down current transformer. Whereas, the current sensor was a SCT-013-000 non-intrusive sensor, clipped over a single wire either neutral or live, to sense the passing current [6]. This sensor's output is voltage, so, to get current reading, a burden resistor is connected to the two terminals of the sensor. The reading of the component is transferred to the next unit for further processing.

The different types of IR sensors and their usages:

Table 3
Different types of IR sensors

Active infrared sensors	Active IR detectors provide count, presence, speed, and occupancy data in both night and day operation. The laser diode type can also be used for target classification because it provides target profile and shape data.
Break beam sensors	Infrared source transmits a beam of light towards a remote IR receiver creating an "electronic fence". Once a beam is broken output of detector changes and associated electronic circuitry takes appropriate actions.
Reflectance sensors	This type of sensors house both an IR source and an IR detector in a single housing in such a way that light from emitter LED bounces off an external object and is reflected into a detector.
Passive infrared sensors	A passive infrared system detects energy emitted by objects. It does not emit any energy of its own for the purposes of detection. Passive infrared systems can detect presence, occupancy, and count.

B. Control unit

The control unit mainly consists of microcontroller, which is Arduino UNO ATmega328. It has 14 digital input/output pins, 6 analog input, a 16 MHZ crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The Arduino Uno can power via the USB connection or with external power supply. External power can come either from an AC to DC adapter or battery. The board can operate on an external supply of 6 to 20 volts. If supply with less than 7v, however, the 5v pin may supply less than five volts and the board maybe unstable.

The Arduino are programmed using a dialect of feature from programming language embedded C. In addition to using traditional compiler tool chains, the Arduino provide integrated development environment (IDE) based on processing language project using Arduino suite [7]. Data received from these using unit are passed as an input to the built-in analog to digital converter(ADC) in the microcontroller. Afterwards, the data is processed then used units in kilowatt hour and remaining balance and units.

These calculations were performed as follows: first calibration values for the current and voltage are calculated as shown in equations (1) and (2), where 0.707 value is used to convert the measured value to RMS value, 1024 is the maximum reading of Arduino input pins, 36 is the value of the burden resistance used with the current sensor and 240 is the maximum voltage that can be read by the meter. Current value read from the supply is calculated using a loop which takes 200 samples from the microcontroller analog pins connected to the sensor and finds the maximum and minimum values [8]. Then the current is calculated as shown in equation(3). On the other hand, voltage is calculated by taking the reading of the analog pin of the microcontroller connected to the transformer as shown in equation (4), using software function analog Read(). Figure3 represents the voltage and current waveforms passed to the meter.

Calibration I = Standard value / (maximum reading from Arduino Input pin * burden resistance)

Calibration I = 0.707 / (1024 * 36) (1)

Calibration V = (Standard value * maximum voltage) / maximum reading from Arduino Input pin.

Calibration V = (0.707 * 240) / 1024 (2)

Current = (max I – min I) * Calibration I (3)

Voltage = analog Read (A1) * Calibration V (4)

Afterwards, the control unit issues warnings for the user when either 20% or 10% is left in the balance. At zero balance, 24-hours allowance time is given to user, as a chance to recharge before electricity is cutoff. The calculated values are then passed to the communication unit.

C. APR unit

The voice recording and playback circuit is widely used in everyday life. For example, the leaving message and response of the telephone, game machine, and toy voice playback and recording [9].

Fig. 2. Audio Playback and Record (APR) unit

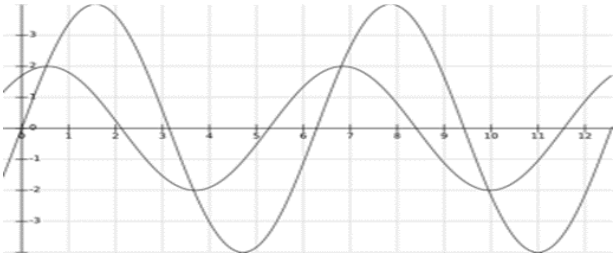

Fig. 3. Output voltage and current waveform

1) Power Theft Detection Unit

In the power theft detection unit of the proposed smart meter, an infrared sensor is used for theft detection [10]. The IR sensor is fixed on energy meter for identifying the tapering of the seal and when any one tries to break the seal, it detects power theft. A message is sent to the user immediately through wifi communicator and also the central server is notified about it through the internet.

D. Communication Wi-Fi unit

Communication unit mainly consists of Wi-Fi communicator and mp3 module that is APR9600 with a speaker.

Table 5
Comparison between proposed and existing meter.

Feature	Proposed Design	Existing system	Research paper Design–2016
Communication Type	Wifi communicaton.	SmartCard	Zigbee
Payment Method	Prepaid and postpaid.	Prepaid	Prepaid
Data Displayed On LCD Screen	Remaining Credit-used units. Cost of units Used. Left units.	Remaining Balance-Used units	Power consumption bill
User Friendly Interface	LCD Screen Alerts on power theft.	LCD Screen	LCD Screen
Allowance Period	Electricity cuts off when balance is <threshold>	24Hours	48 hours
Cost	LowCost	High cost About 100 Euros	High cost-2paymentmodes
Sensing Unit	Fire,gas, PIR Sensors are used.	Sensing unit Not existed.	Sensing unit Not existed.

1) ESP 8266 Wi-Fi Communicator

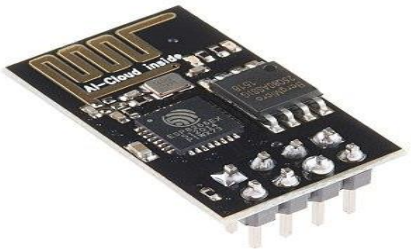

Fig. 4. ESP8266 Wi-Fi Communicator

Table 4
Module description

Meter	Existing Digital meter that is Enhanced by adding the below Components.
Current Transformer	A DC Component used for Converting Alternating Current to Direct Current and to supply electricity to entire board.
Load	DC load in the form of DC- LED lights.
Optocoupler	Reading the Energy meter Blinks count.(200 blinks=1unit)
Fire Sensor	To detect any presence of Fire or smoke in the Surroundings. If yes then particular action is performed.
Gas sensor	To detect any Gas leakage. Depending on the input to the sensor the corresponding output is generated in the form of action.
IR Sensor	Detects the Presence of Human at home , sensor returns a value 0 on LCD display if it finds nobody at home, thereby having control over the Switching of lights.(Home automation)
LCD 16*4	Displays the Number of Units Consumed.
Arduino UNO Microcontroller	Data received from the sensing unit are passed as input to the built-in analog to digital convertor in the microcontroller.
Max 232	To Convert RS232 Program into a form which the Microcontroller Understand.
Relay	Turns Off the Energy meter upon receiving input from the sensor.
APR 9600	ARP is a high performance device equipped with a mike for pre-recording and playback system.
MP3 Speaker	Provides a Voice Output.

2) ESP 8266 Wi-Fi Communicator

When ESP8266 hosts the application, and when It is the only application processor in the device, it is able to boot up directly from an external FLASH [11]. It has integrated cache to improve the performance of the system in such applications, and to minimize the memory requirements.

The communication unit's main functionality is to establish a communication between the control unit and the application. The Wi-Fi module is connected to the control unit, in the metering system [12]. Additionally, it enables the user to track his/her usage at any time and view metering data.

5. Conclusion

In the era of smart city advancement, this project is concentrated on the connectivity &networking factor of the IoT. In this project, an energy consumption calculation based on the counting of calibration pulses is designed and implemented using Arduino Uno MCU in embedded system domain. In the proposed work, IoT based meter reading system is designed to continuously monitor the meter reading and service provider can disconnect the power source whenever the customer does not pay the monthly bill and also it eliminates the human involvement, delivers effective meter reading, prevent the billing mistake.

References

[1] Shalli Rani, et. al. "A Novel Scheme for an Energy Efficient Internet of Things Based on Wireless Sensor Networks", Sensors, vol. 15, pp. 8603-28626. November 2015.
[2] Waleed Ejaz et. al, "Efficient Energy Management for the Internet of Things in Smart Cities", in Efficient Energy Management for the Internet of Things in Smart Cities, vol. 55, Issue 1, January 2017.
[3] Jacques Benoit, "The Internet of Things and the energy sector: myth or opportunity", in Power and Energy Automation Conference, Spokane, WA March 2016.
[4] ShikhaRastogi, Manisha Sharma and Pratibha Varshney. "Internet of Things based Smart Electricity Meters", International Journal of Computer Applications, vol. 133. Issue 8, January 2016.
[5] Ellery E. Queen. "Smart Meters and Smart Meter Systems: A Metering Industry Perspective". Washington, D.C., United States: Edison Electric Institute (EEI). March 2011, pp. 3-5.
[6] Patel Umang and Modi Mitul. "A Review on Smart Meter System". International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, vol. 3. Issue 12, pp. 70-73. December 2015.
[7] Al-Naima, Jalil, "Building a prototype Prepaid Electricity Metering System Based on RFID", International Journal of Electronics and Electrical Engineering, vol. 1, Issue 1, Iraq. 12 March 2012.
[8] Au Thien Wan, Suresh Sankaranarayanan and Siti Nurafifah Binti Sait. "Smart Agent Based Prepaid Wireless Energy Meter". International Conference on Cloud Computing and Internet of Things, pp. 77-81. December 2014.
[9] Mohammed Reyasudin Basir Khan and Razali Jidin. "USB Data Acquisition Device for Energy Monitoring," presented at Student Conference on Research and Development, Selangor, Malaysia, 2011.

[10] P. Pawaskar, P. Chawande and S. Jadhav, "Design and implementation of low cost three phase energy meter," *2016 IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT)*, Bangalore, 2016, pp. 296-300.
[11] M. Aboelmaged, Y. Abdelghani and M. A. A. E. Ghany, "Wireless IoT based metering system for energy efficient smart cites," *2017 29th International Conference on Microelectronics (ICM)*, Beirut, 2017, pp. 1-4.