

Unified Meter for Electricity, Gas and Water with Automatic Billing and Payment

Anirudh K N¹, Sudhanshu S Sharma², Vivek R³ Praveen A⁴

¹⁻³Student, Dept. of Electronics and Communication Engineering, KSIT, Karnataka, India

⁴Asst. Professor, Dept. of Electronics and Communication Engineering, KSIT, Karnataka, India

Abstract - Every month it is seen that there are three bills generated for the consumption of the basic necessities like electricity, gas and water we use on a daily basis. The proposed system measures the consumption of all these resources and provides a unified billing and payment system for it. This has two sub-systems consisting of a sub-system for measurement and the server-controlled sub-system for data storage and analysis. Communication between these two sub-systems is done through wireless network. This system monitors the consumption of electricity, water and gasoline resources. The amount of resources consumed is updated in the server, and a consolidated bill is generated. Every user will be provided a mobile application where the billing details are updated on a monthly basis with a portal for payment. This process is achieved by using the concept of embedded system and IoT.

Key Words: IoT, Embedded-systems, Unified-billing, Sub-system, Wireless-network.

1. INTRODUCTION

Due to modern busy life, it is stressful and difficult to remember the different yet simple task of settling the bill for the utilization of the provided services. Among these, the major ones are settling the bill for the consumption of electricity and water which is periodic for every month. To meet the growing city demand, there will shortly be a provision of the LPG through pipelines to each and every house in the city, which will add on to every growing list for bill settlement. Using the concept of Embedded Systems and IoT, the burden of the citizens can be reduced by introducing a device which measures the consumption of electricity, water, and LPG per month for the given house and also calculates the total amount which is to be paid by the customer to the respective authorities. The unified bill thus generated will have the details regarding the usage of all the three services and the total and, individual cost due that month.

2. PREVIOUS WORK

In the paper "Analysis of Smart Meter Data for Electricity Consumers" the authors Grzegorz Dudek, Anna Gawlak, Mirosław Kornatka and Jerzy Szkutnik document about how smart meter systems are being deployed to improve grid reliability and promote energy, water, and gas efficiency while providing improved services to their customers. Smart metering which is installed in millions of households worldwide provides utility companies with real-time meaningful and timely data about electricity consumption and allows customers to make informed choices about energy, water, and gas usage. Smart meter data analytics has become an active area in research and industry. It aims to help utilities and consumers understand electricity consumption patterns. This paper provides analysis methods for load data including analysis of daily load profiles and similarity between them, analysis of load density, and analysis of seasonal and irregular components in the load time series. We evaluate our approach by analyzing smart meter data collected from 1000 households in Poland at a 15-minute granularity over a period of one year^[1].

In the paper "Smart Meter for the IoT" the authors F. Abate, M. Carratù, C. Liguori, M. Ferro, and V. Paciello document about how in recent years, smart devices are increasing. These devices allow making cities smart, enabling communication not only among people but also among things, creating a new system nowadays known by the term IoT (Internet of Things). A smart city is based on a smart grid that allows to intelligently manage the power grid. In order to do this, the network must have intelligent meters that can communicate bi-directionally with the network. This market has led to a proliferation of smart meters that give the opportunity to measure the consumption of every single device in homes. The most part of smart meters is based on a chip that calculates the parameters needed to estimate energy, water, and gas consumption. The authors consider a smart meter based on a common chip that calculates the power consumption and the meter characterization is reported^[2].

In the paper “Smart Energy,water and gas Metering and Power Theft Control using Arduino & GSM” the authors Visalatchi S and Kamal Sandeep K document about how the energy,water and gas theft is a very common problem in countries like India where consumers of energy,water and gas are increasing consistently as the population increases. Utilities in electricity system are destroying the amounts of revenue each year due to energy,water, and gas theft. The newly designed AMR used for energy,water and gas measurements reveal the concept and working of new automated power metering system but this increased the Electricity theft forms administrative losses because of not regular interval checkout at the consumer's residence. It is quite impossible to check and solve theft by going every customer's door to door^[3].

In this paper, a new procedure is followed based on MICROCONTROLLER Atmega328P to detect and control the energy,water and gas meter from power theft and solve it by remotely disconnect and reconnecting the service (line) of a particular consumer. An SMS will be sent automatically to the utility central server through GSM module whenever unauthorized activities detected and a separate message will send back to the microcontroller in order to disconnect the unauthorized supply. A unique method is implemented by interspersed the GSM feature into smart meters with Solid state relay to deal with the non-technical losses, billing difficulties, and voltage fluctuation complication^[4].

In the paper “An anti-power theft method for secondary circuit of energy, water and gas meter current transformer” the authors Sitao Li,Jinquan Zhao, Jianzhi Liu, Zhibin Zheng, Jing Zhang and Lixuan Jia document about the present, power theft ways become increasingly subtle and intelligent. Power theft not only has caused a great loss to the nation and the power sector but also has brought serious security risks to the equipment and personal health. Although the power theft behavior of the energy,water and gas meter voltage transformer secondary circuit has been well recognized and effectively suppressed, the anti-power theft method for the secondary circuit of the energy,water and gas meter current transformer is still a weak link. Therefore, this paper proposes a transient method based anti-power theft method for the secondary circuit of the energy,water and gas meter current transformer. This method applied the pulse signal to the secondary circuit of the energy,water and gas meter current transformer first, then obtained the

equivalent resistance and inductance parameter of the circuit by measuring the transient value of the circuit response current. Comparing these parameters with the original parameters of the circuit, we can judge the circuit state and power theft way. The simulation results verify the accuracy and reliability of the proposed method, which is a new anti-power theft method of the energy,water and gas meter^[5].

In the paper “Energy, water and gas Theft and Defective Meters Detection in AMI Using Linear Regression”, the authors Sook-Chin Yip, Chia-Kwang Tan, Wooi-Nee Tan, Ming-Tao Gan, and Ab-Halim Abu Bakar document about how electricity theft is always a ticklish problem faced by utilities around the world. To mitigate and detect energy,water and gas theft, utilities are leveraging on the consumers' energy,water and gas consumption dataset obtained from advanced metering infrastructure to identify anomalous consumption patterns. However, real energy,water, and gas theft samples, as well as the distribution station smart meter readings, do not exist in Malaysia because smart grid is not fully implemented. Therefore, we design and construct a small-scaled advanced metering infrastructure test rig in the laboratory to evaluate the performance and reliability of our previously proposed linear regression-based detection schemes for energy,water and gas theft and defective meters in small grid environment. Simulations and electrical tests are conducted and the results show that the proposed algorithms can successfully detect all the fraudulent consumers and discover faulty smart meters in smart grids^[6].

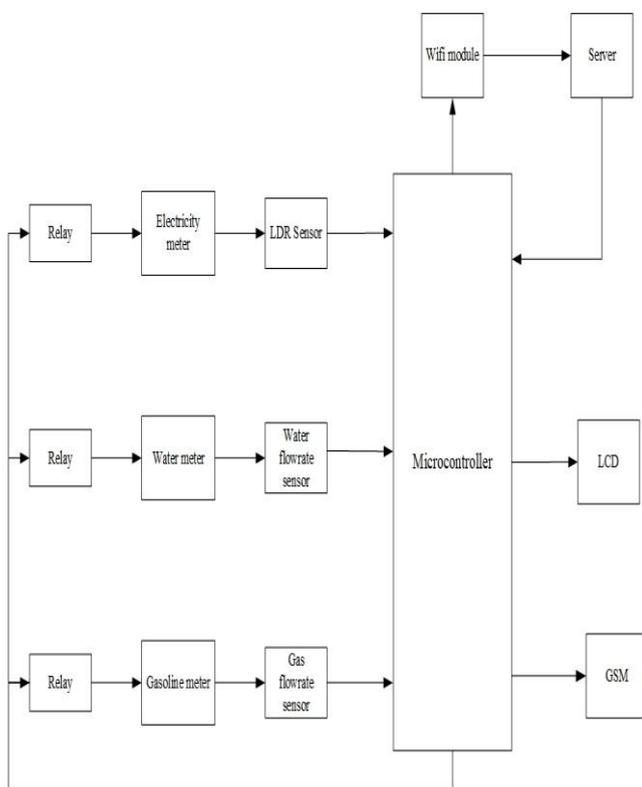
Security of the smart metering infrastructure, which is a part of the smart grid initiative, intended at transitioning the legacy power grid system into a robust, reliable, adaptable and intelligent energy utility, is an imminent problem that needs to be addressed quickly. Moreover, the increasingly intensifying integration of smart metering infrastructure with other ecosystem applications and the underlying communication technology is forcing both the consumer and the utility provider to meticulously look into the security and privacy issues of the smart grid. To achieve this, improvements on the existing architecture that uses smart meters interacting with smart grid is needed. This architecture would help in consolidation and aggregation of the energy usage and generation as intelligent communicators instead of focusing them as isolated passive units in the energy grid. The study

presented in the paper analyses the various existing smart metering infrastructure, threats and vulnerabilities that has the potential to disrupt the operation and deployment of automation systems in smart grids. Furthermore, an elaborate study and subsequent analysis have been made on a live consumer meter setup in a non-invasive manner, which shows the various security loopholes and deficiencies of a large deployment of unattended smart meters^[7].

3. PROPOSED SYSTEM

The proposed system (Unified System) introduces a new method of meter reading electronically and transmitting the data for further processing. This helps in reducing the manual errors that occur in the present meter reading systems. The unified system can be used to take readings for different utilities such as electricity, water and gasoline.

Fig 1: Block diagram of Unified Meter



Let us consider an example for electricity consumption, here we are connecting the energy meter between main supply and load, by which microcontroller will be able to measure the energy units consumed.

When the various appliances of the household consume energy, the meter takes the reading continuously and this consumed load can be seen real-time on device. We can see that the LED on meter continuously blinks which counts the meter reading. Based on the blinking, the units are counted. Normally, 3200 blinks per one unit.

In our project we are trying to develop a system in which the Arduino Uno acts as the main controller, which continuously monitors the unified meter. As per the blinking of LED on energy meter the Arduino will measure the unit consumption. The measured reading with the calculation of the cost will be continuously displayed on LCD which is connected to the microcontroller. The time interval during which the consumption of these resources can be initialized to be monitored after which the bill is generated. This will notify the consumer regarding the number of units consumed in during that interval, the bill amount to be paid and when the bill has to be paid in order to avoid the penalty and hence the cut-off.

The Microcontroller computes the amount of energy consumed. Then the calculated values and are transmitted instantaneously via Wi-Fi to the main system and the necessary updates are performed in the database of the consumer.

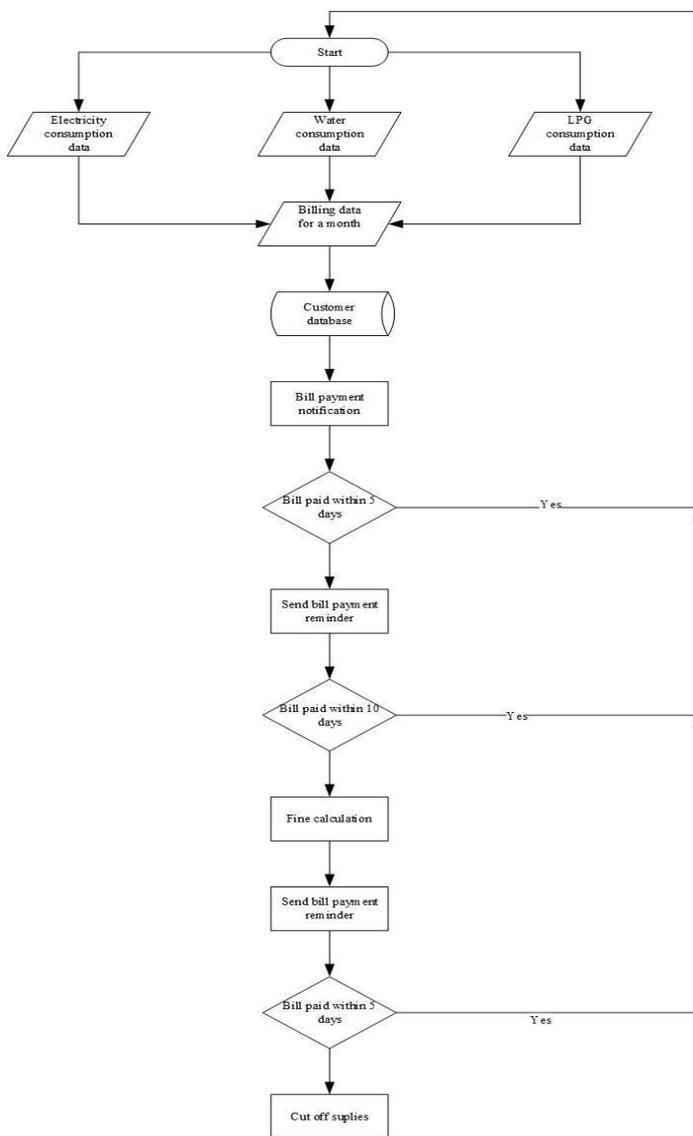


Fig 2: Flowchart for the proposed system

The unified meter for electricity, water and gas works by communicating directly with wireless data protocol with the respective supplier, so the company will always have an accurate meter reading and there's no need to take a meter reading by the assigned government official. The unified meter for electricity, water and gas can work in a variety of different ways, including using wireless mobile technology to transmit and receive the data. The unified meter for electricity, water and gas monitor shows how much energy consumed per day. This system will also show how much units of electricity is consumed by each household device and how it can be used efficiently.

The unified meter for electricity, water and gas will provide accurate, consistence information about

the usage. So, user can go through the bill work on a method to efficiently utilize the appliances to reduce the monthly usage.

The unified meter for electricity, water and gas are expected to provide economic, social and environmental benefits. This project proposes a new kind of meter that can digitally send meter readings to the supplier, through which the electricity bills, water and gas bills are generated and sent to the respective consumers. This can ensure more accurate bills. The meter also comes with LCD display, through which the usage can be better monitored. Sending details to consumer or utility company through SMS using Wi-fi network by the Arduino microcontroller is a distinct feature.

Advantages of Proposed System include:

- ☐ The unified meter is remotely read.
- ☐ Increased accuracy by automating the meter reading.
- ☐ Customers can track their real-time everyday usage and the amount to be paid.
- ☐ E-billing promotes go green.

Description of Components

A. Arduino Uno

Each of the 14 digital pins on the Uno can be used as an input or output, using pin mode (), digital write (), and digital read () functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller. In our project, the Arduino is used as the main microcontroller for calculation of units consumed and computation of the bill. It controls the entire metering and billing system. It also transmits the data such as consumed energy, generated bill and security services (Line ON/OFF).

B. LCD Display

A LCD is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. The options for selecting automatic and manual mode of the meter is made available on this LCD Display. It is also used to show the units consumed in case of Electricity, Volume used in case of water and Gas sensors. The LCD shows the output

of these readings and bill generated. Also, we can choose if we want to continue to pay the bill or not.

C. Energy Meter

Watt hour meter or energy meter is an instrument which measures amount of electrical energy used by the consumers. Utilities install these instruments at every place like homes, industries, organizations to charge the electricity consumption by loads such as lights, fans and other appliances. Most interesting type are used as prepaid electricity meters. Basic unit of power is watts. One thousand watts is one kilowatt. If we use one kilowatt in one hour, it is considered as one unit of energy consumed. In our project, this meter calculates energy taking into account the number of blinks. Since our load is small, we have considered three blinks to be equal to one unit. This power is integrated over a period which gives the energy utilized over that time period.

D. Water Flow Sensor

Water flow sensor consists of a plastic valve body, a water rotor, and a hall-effect sensor. When water flows through the rotor due to which the rotor rolls. Its speed changes with different rate of flow. Each time the magnet on the blade comes in contact with the sensor on the casing, it indicates as one rotation. The hall-effect sensor outputs the corresponding pulse signal hence indicating the flow rate.

E. Gas Flow Sensor

The MQ series of gas sensors use a small heater inside with an electro-chemical sensor. They are sensitive for a range of gasses and are used indoors at room temperature. They can be calibrated more or less but a known concentration of the measured gas or gasses is needed for that. The output is an analog signal and can be read with an analog input of the Arduino.

F. Light Dependent Resistor (LDR)

A light dependent resistor works on the principle of photo conductivity. There are continuous blinks on the meter which falls on the LDR which gets triggered. Here, each blink is equal to one count and three counts is equal to one unit which can also be altered for real-time usage.

G. ESP8266

The ESP8266 is a low- cost chip that gives the Arduino access to our Wi-Fi network. This System on Chip can be hooked up with Arduino, and integrated with sensors and specific applications. It is basically used for communication of data, that is computed in

the microcontroller, to the user through an application. The user can see the readings and the bill generated on his mobile phone or his console with the help of ESP8266.

4. RESULT

The proposed system generates a unified billing and payment method for the electricity, water and gas consumption which can be accounted for monthly usage. The system also generates individual bills for each of them if the customer wishes to pay them at different intervals of time. If the payment is not made within the due date, the supply of that resource will be turned off until the bill is paid.



Fig 3: Bill Generation

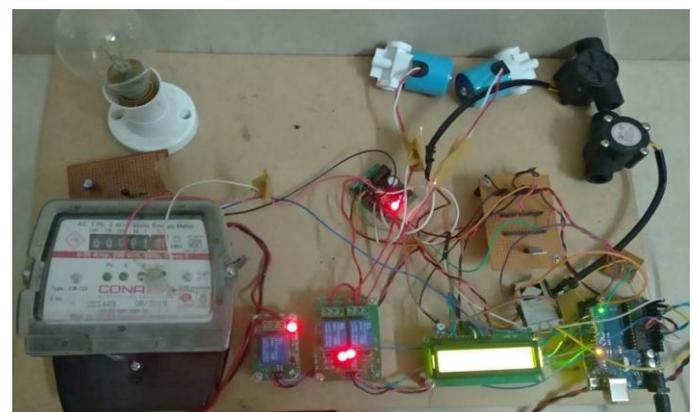


Fig 3: Electricity Cut-Off



Fig 3: Gas and Water Cut-Off

5. CONCLUSION

The unified meter for electricity, gas and water with automatic billing and payment (Unified system) is based on is capable to measure and control the amount of the consumption of these resources simultaneously in a single package thereby can meet the policy of monitoring energy, water and gas consumption. This is a user-friendly and straightforward solution that is economical feasible, easy to install, maintenance free and tamper-proof. This system has indicated the most practical solution for water resources monitoring and management. As a result of using this system the loss trend in water tables is proved to be effectively controllable.

6. REFERENCES

1. "Energy theft and defective meters detection in AMI using linear regression", Sook-Chin Yip; Chia-Kwang Tan; Wooi-Nee Tan; Ming-Tao Gan; Ab-Halim Abu Bakar, IEEE 2017.
2. Smart energy metering and power theft control using Arduino & GSM Automated Smart Metering; S Visalatchi; K Kamal Sandeep, IEEE 2017.
3. "An anti-power theft method for the secondary circuit of energy meter current transformer" Sitao Li; Haibo Yu; Helong Li; Jinqun Zhao; Jianzhi Liu; Zhibin Zheng; Jing Zhang; Lixuan Jia, IEEE 2017.
4. "Analysis of Smart Meter Data for Electricity Consumers" Grzegorz Dudek; Anna Gawlak; Mirosław Kornatka; Jerzy Szkutnik, IEEE 2018.
5. Landi, C.; Dipt. daring. dell"Inf., Seconda Univ. di Napoli, Aversa, Italy; Merola, P.; Ianniello, G, "ARM-based energy management system using smart meter and Web server", IEEE Instrumentation and Measurement Technology Conference Binjiang, pp. 1 – 5, May 2011.
6. Garrab, A.; Bouallegue, A.; Ben Abdallah, "A new AMR approach for energy saving in Smart Grids using Smart Meter and partial Power Line Communication", IEEE First International Conference on Renewable Energies and Vehicular Technology (REVET), pp. 263 – 269, march 2012.
7. Pallab Ganguly; Sumit Poddar; Sourav Dutta; Mita Nasipuri, "Analysis of the security anomalies in the smart metering infrastructure and its impact on energy profiling and measurement" 2016 5th International Conference on Smart Cities and Green ICT Systems (SMARTGREENS).