

Global System for Mobile Communication Based Automated Billing System for Electric Energy Meter

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DOI: <https://doi.org/10.30880/eeee.2021.02.02.116>

Received 4 July 2021; Accepted 17 October 2021; Available online 30 October 2021

Abstract: The bill of electricity usage typically is manually recorded. This practice is affected by human proficiency and during pandemic Covid-19, it causes the delivery of bill left behind the schedule. Thus, this paper presents the development of automatic electricity reading, recording and billing system using a microcontroller device. The system utilizes Arduino Uno, DS1307 real-time clock (RTC), liquid crystal display (LCD) and global system for mobile communication (GSM) to develop the prototype of the billing system. In this system, the mobile phone is an intermediate platform between a circuit for reading electricity and the Firebase online database which is acquired to store the reading of the circuitry. Thinkable software is used to develop a graphical user interface (GUI) application to access the cloud database, perform necessary calculations and show associated information to users. In conclusion, the prototype of the billing system is successfully being developed and it able to perform billing calculations, sends the billing cost via Short Message Service (SMS) and displays the billing cost on GUI.

Keywords: Global System for Mobile Communication, Automated Billing System, Electric Energy Meter, SMS

1. Introduction

Since the 19th century, electricity is monitoring by using electromechanical or electronic meters [1]. These meters are the master art of engineering designed a hundred years ago, but there has been an improvement from time to time. In the future, the smart meter will replace the electromechanical and electronic meter because it has many more features than others.

Malaysia's smart meter functions include more elegant control that allows the smart meter to share information with your myTNB application and the portal for track and adjust energy use to save money and the environment. The smart meter will continuously read the energy used to give an accurate bill and allow the user to pay the smart meter bill anytime, anywhere via the myTNB application [2].

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TNB smart meter transfers the data through 2.4GHz of radiofrequency. This frequency is already approved by the Standard and Industrial Research Institute of Malaysia (SIRIM) and Malaysia Communications and Multimedia Commission (MCMC).

Tenaga Nasional Berhad (TNB) will send the meter reader from premise to premise for electricity billing for the electromechanical or electrical meter. This situation requires a vast number of laborer operators and long working hours to achieve complete area billing [3]. So, power meter modernisation is an essential issue for the electricity market and modern society [4]. In this project, an embedded system using Arduino as the microcontroller will measure the electricity usage through the optocoupler as the intermediate in baud rate. The global system for mobile communications is the intermediate between the Arduino and Firebase platforms to transmit the data. Last but not least, a GUI application allows users to check the electricity usage and bill by retrieving data from the terminology cloud.

1.1 Problem Statement

Malaysia's premise facing problem was to receive monthly utility bills during the implementation of movement control order (MCO) due to the pandemic Covid-19. That is because of the current practice of utility suppliers. For example, TNB is sending a workforce, meter reader to visit every house, apartment, condominium, factory, and other residential areas to read the meter and generate monthly electricity bill using a personal digital assistant (PDA) to calculate the bill for each month [5]. It will require many workforces and is time-consuming and prone to error with this kind of system [6]. Even an application that will show the monthly billing was introduced. The user realises that the application only displays the estimated bill by referring to the past billing records before lockdown. Next, most of Malaysia's residences use the traditional electromechanical watt meter and the readings are not automated [7].

Consequently, the introduction of smart electricity reading, recording and billing system could overcome the problem and control the energy used to save money and energy [8]. This smart system shall be designated for automatically measuring the electricity usage and sending the data to be saved in the server's storage. So the records could be retrieved from the server from time to time. This situation can keep track of the consumer load on a timely basis, which can assure accurate billing, track maximum demand, and detect threshold value [9]. Last but not least, the smart system's automated feature eases the billing process and simultaneously eliminates the drawbacks like increases the monthly bill's accuracy and avoids the meter reader's mistake [10].

1.2 Hypothesis

In this research, it will use Arduino to measure and calculate the electricity usage and bill. This research will use the developed system, including a global system for mobile communications and a GUI. These methods used in this research should process the electricity as the input and electricity usage and a bill as the output. After the data are processing, it will send data to the terminology cloud and retrieve data to allow the user to read the analysis from the application

1.3 Objective

The project's main objective is to design an electricity reading, recording, and billing embedded system application using a microcontroller device. Thus the sub-objectives included developing a prototype to measure household electric power consumption using the modules. Next, implement an algorithm for capturing prototype data and processing it in the terminology cloud. In addition, developing an interface to access the terminology cloud and display billing information using an application. All of the theses are the sub-objectives that will be achieved in this project.

1.4 Related Works

From the journal of the S. Visalatchi and K. Kamal Sanddep, the proposed method is using the Arduino, solid-state relay (SSR) and global for mobile communications (SMS) as the main component to having the feature that can measure and calculate the electricity consumption and send the message to the utility company for billing [11]. Next, the utility has the feature that can remote cut off the power supply of the residential that don't pay the bill, tampering attempt detect which the cover of the meter is open and send the short message service (SMS) to the utility company and have the solid-state relay (SSR) to protect the equipment to avoid the damage from the not maintain power quality. Next, the journal of the Wenpeng Luan, Duncan Sharp and Stephen LaRoy, the proposed is to examines the implemented practical utility advanced metering infrastructure (AMI), which having a two-way communication network, smart meters, meter data repository and meter data management service (MDMS) as the critical element [12].

2. Materials and Methods

This paper framework can be distinguished into four main aspects. The first aspect compromises the embedded circuit design and simulates it using Proteus Professional 8.0 and Arduino integrated development environment (IDE) software. Next, the second aspect stores the data of the embedded circuit and end-user details by using the Firebase online database platform. In addition, the third aspect develops a GUI application that connects with the terminology cloud for display the data to the end-user by using the Thinkable software. Lastly, analysis of the result from the test conducted on the hardware that combines electronic components and uploads the programming code.

Proteus Professional 8.0 software is the resource used in the design and simulates the embedded circuit. In addition, Arduino IDE software is the resource used in developing the programming code and simulating the embedded circuit in serial by using its serial monitor function. Figure 1 shows the embedded system block diagram. Arduino Uno is the microcontroller of the system that always communicates with RTC that displays time on LCD and checks the time to meet the setup time for sending SMS through GSM.

Besides, the data was sent to the mobile phone as the intermediate between embedded circuit with terminology cloud. Firebase real-time database is used to store the data of the embedded circuit and user details. The real-time database also will update the data from the GUI application or the data entered manually. A user unique identifier (UID) is automatically generated by the Firebase online database platform and shown in the authentication section. So, a worker will enter the data by adding the child by a child below the "MyMeter" and user UID title. In addition, the user details are uploaded from the GUI application while the data of the electricity usage and bill is downloaded from the terminology cloud.

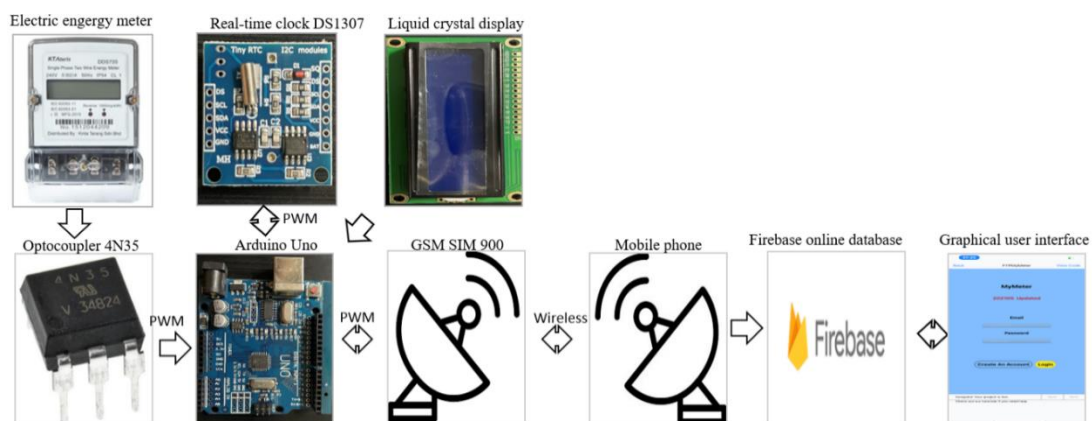


Figure 1: Embedded system block diagram

Figure 2 shows the embedded circuit operation flowchart. The embedded circuit is starting from the load consume the electric energy that causes electricity usage. The electric energy meter’s light-emitting diode (LED) connects with optocoupler 4N35, which generates a pulse to the Arduino Uno when there is a current pass through the LED. Then, the Arduino Uno will measure and calculate the electricity usage and bill using the programming code that developed and uploaded from the Arduino IDE software. The data calculated will record in the Arduino Uno microcontroller and it will send the SMS through the GSM SIM900A module to a mobile phone when the time set up by the programming code meet. After that, the data will be clear to zero and continue to collect the data in a new cycle.

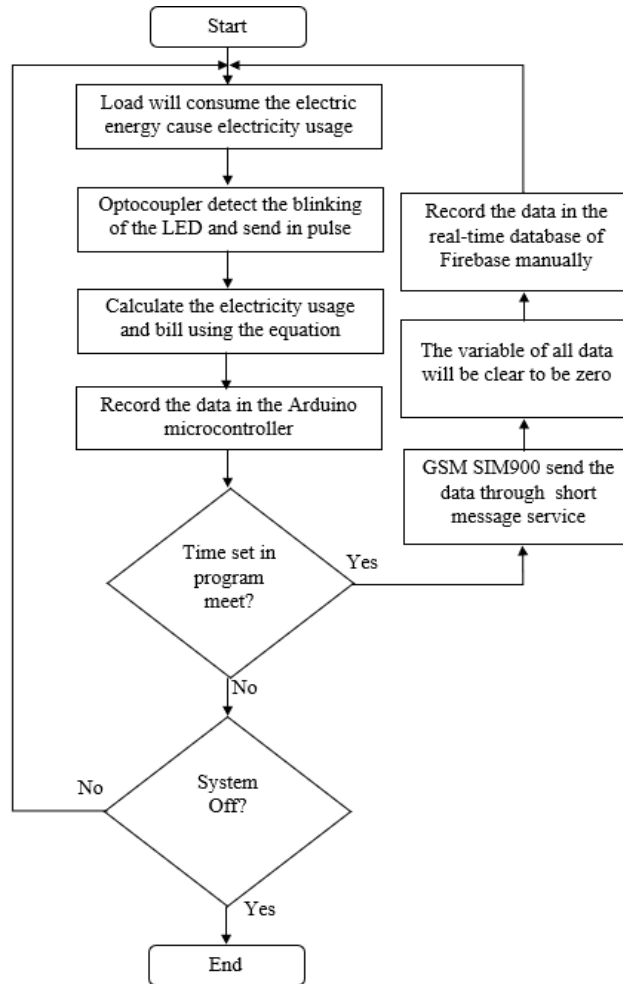


Figure 2: Operational flowchart for the billing system

Figure 3 shows the GUI application operation flowchart. When the application is launch, it will load into the main screen of the application. If the user is not an existing user, the user can click the “Create An Account” button and direct to the register screen. After entering the username and password in the input column, click the “Register” button. Then, an alert will display with the sentence “A verify email was sent to your email.” After that, a verification email is sent to the mailbox. If the user does not verify the email before login, an alert will pop up “Please verify your email!” If the wrong password and forgot password, an alert will display “The password is invalid or the user does not have a password.” After confirming the first alert, the following alert will display “Please check your email for a link to reset password” indicate a reset password link email is sent to the mailbox. If the login process is successful, the user will direct to the user details screen, which has three labels and input for the user’s name, address and contact number. The user’s information just needed entered once, then click the “Next” button that direct into the list screen. The list screen contains a list with the title year and month in the middle of the screen. After selecting the specific year and month, the application will retrieve the

corresponding data from the terminology cloud and display it on the result screen. The “Back” button in the result screen enables the user to return to the list screen for the following manipulation. In contrast, the “Log Out” button of the list screen allows users to log out of the application and direct to the main screen.

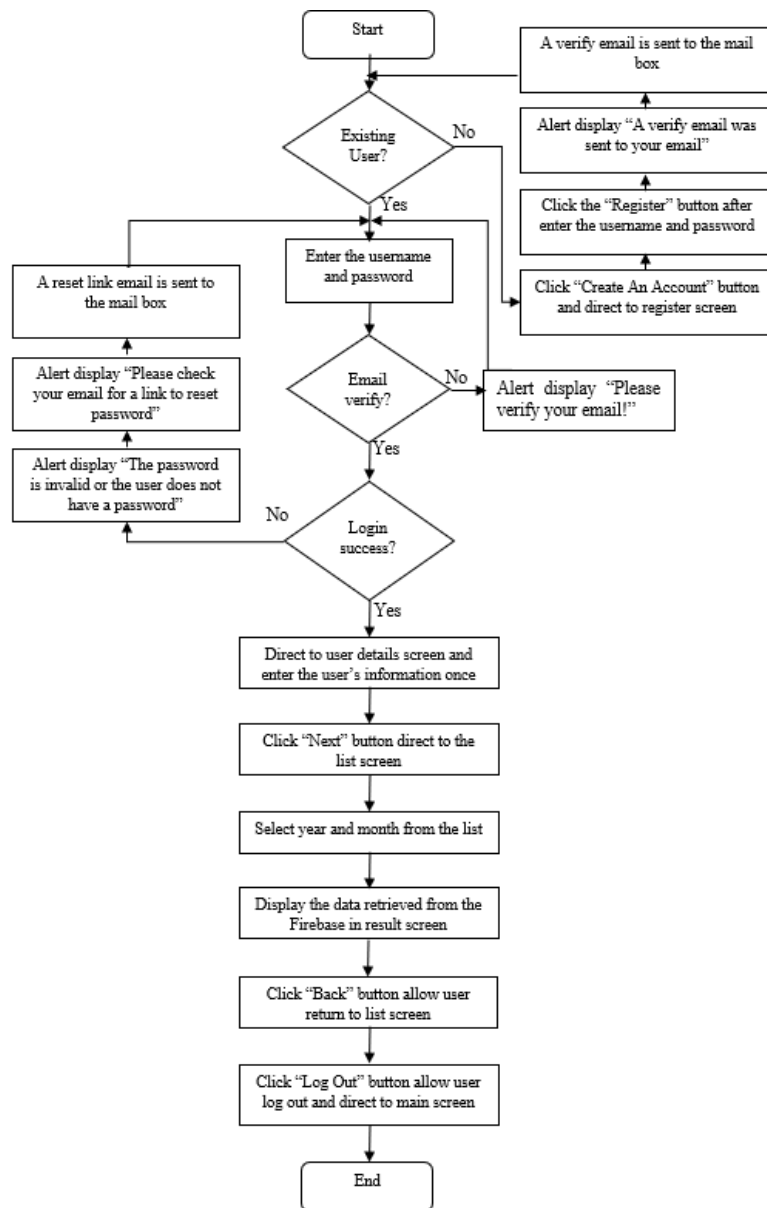


Figure 3: Graphical user interface application operation flowchart

3. Results and Discussion

The embedded system is implemented by using the software of Proteus Professional, Arduino IDE, Firebase, Thuankable, Hardware and mobile phone to receive the SMS. In this research paper, the result of each aspect display in the following part.

3.1 System simulation

Figure 4 shows the circuit design of the embedded system circuit created by using Proteus Professional 8.0. The DS1307 RTC was used to configure and provide real-time of the embedded circuit. Arduino Uno microcontroller was the brain that executes the task and processes the data. The LCD displays the information and result of the embedded circuit. The ULN2003 relay switch was used to

control the completion of the circuit. The LED was the load of the circuit. Four resistors in a line represent the electric energy meter’s terminal because the Proteus Professional software did not have the module.

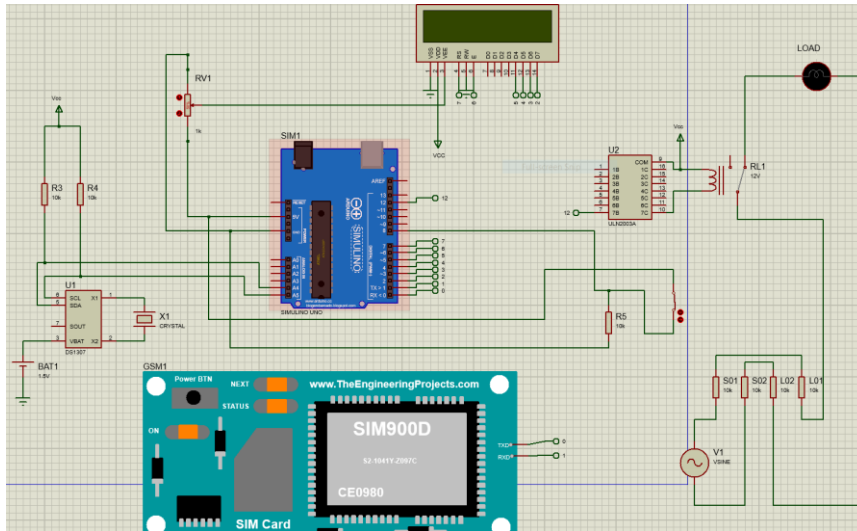


Figure 4: Embedded system circuit

Figure 5 shows the first loop result of the electricity usage and bill. The time frame is 1 second for each screen. The LCD indicates 2021.1.10 and time at 17:30:57, pulse count in 5 units, electricity consumption with 10kWh and electricity bill in RM 6.30.

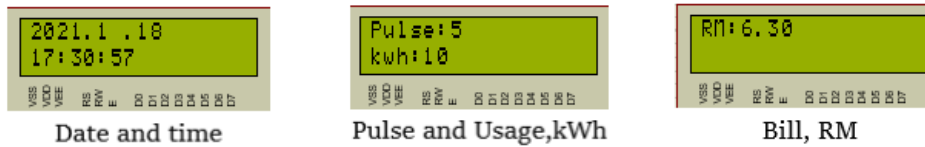


Figure 5: Simulation of the embedded system circuit (First cycle)

3.2 Creating cloud database using Firebase

Figure 6 shows the result of the data entered manually into the real-time database of the Firebase platform. The data will update data and enable the end-user to use the GUI application developed by using the Thinkable software to retrieve data from the terminology cloud immediately.

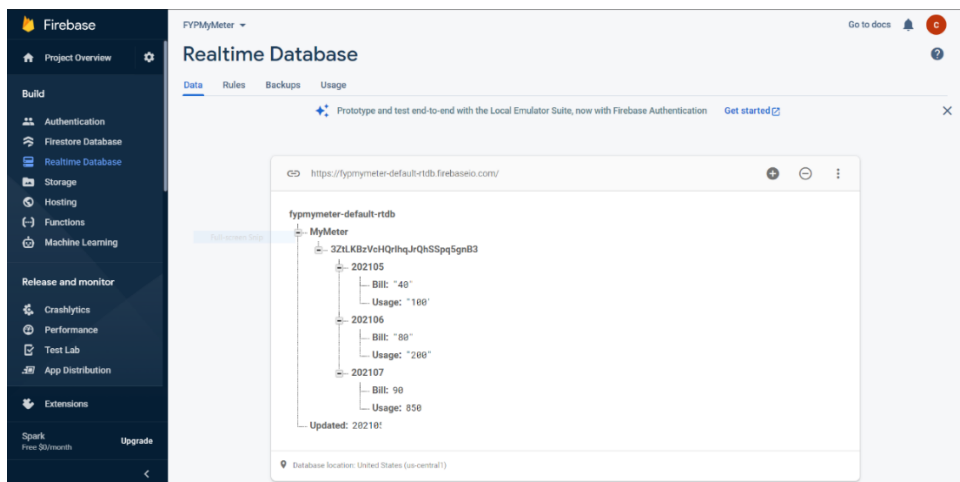


Figure 6: Real-time database of Firebase platform

3.3 Creating GUI application using Thunkable software

Figure 7 shows the design of the main screen’s GUI application by using the Thunkable software. This is the workplace using “drag and drop” to develop the working principle or algorithm of a screen of the application. So, all the validated input and output or buttons are developed using the block connection to get the desired performance.

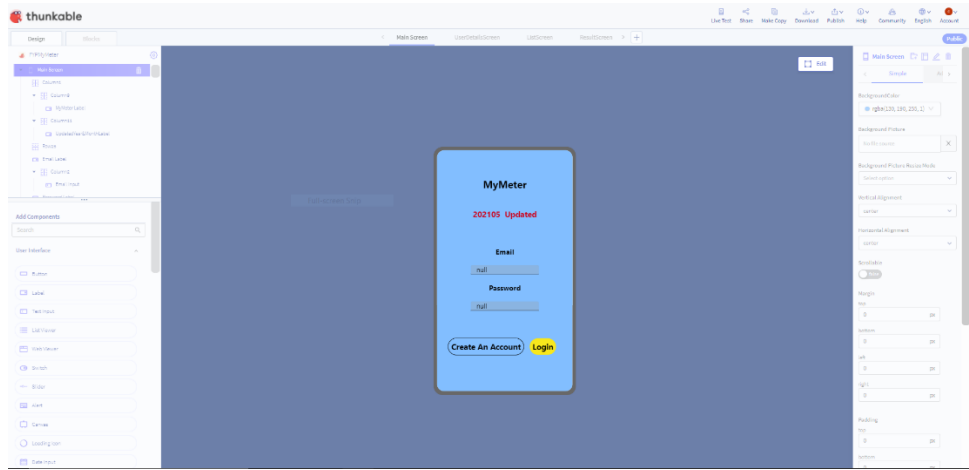


Figure 7: Main screen graphical user interface design in Thunkable

Figure 8 shows the outcome of the GUI application on each screen. There are the screen that possesses by the GUI application which included the main screen, register screen, user details screen, list screen and result screen. Each screen has its function and the data is connected to the real-time database.



Figure 8: Graphical user interface application screens

3.4 Prototype simulation

Figure 9 shows the embedded circuit prototype. The combination of components involved in making a low-cost global system for mobile communications-based automated billing system for electric energy meter is multifunctional and robust. Therefore, this system can reduce the production cost, billing cost, and others cost for replacing the old version electric energy meter into the smart meter from the utility viewpoint.

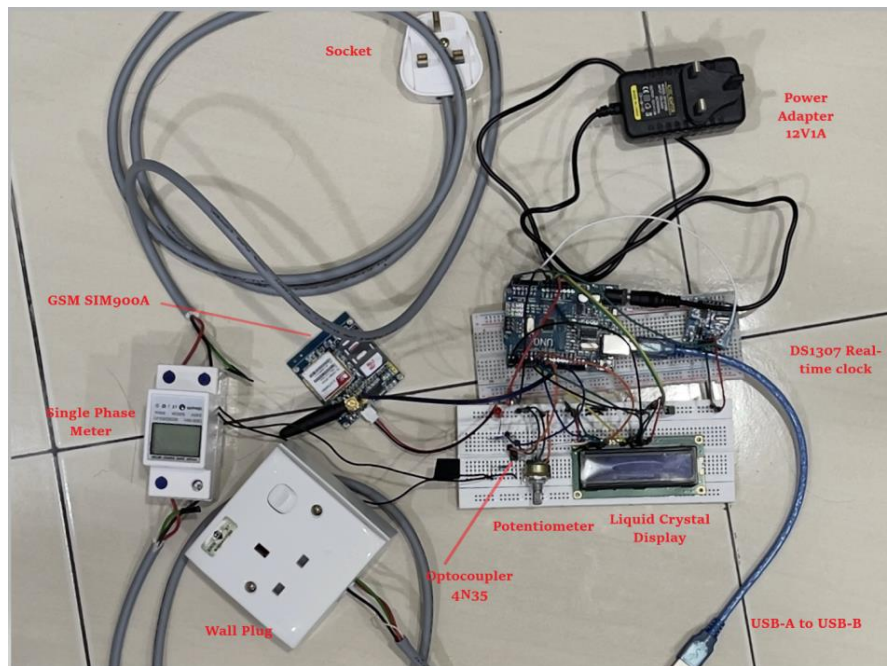


Figure 9: Embedded circuit setup

Figure 10 shows the calibration between the GSM SIM900A with the Arduino Uno microcontroller in the serial monitor of Arduino IDE software. The reply message “OK” for the “AT” command means a connection between the module and the microcontroller. Next, the reply message “+CSQ 7,0” for the “AT+CSQ” command means signal strength indication and channel bit error rate from the mobile terminal. In addition, the reply message “896001200977311881” for the “AT+CCID” command means an integrated circuit card identifier (ICCID) from the subscriber identification module (SIM) card. Last, the reply message “+CREG: 0, 1” for the “AT+CREG” command, which “1” means the serving cell is registered and play as a home network and “0” access technology is through the GSM.

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COM4
19:42:02.937 -> GSM Based Atuomate Billing System For Electric Energy Meter
19:42:03.931 -> GSM Initilizing...
19:42:09.433 -> AT
19:42:09.433 ->
19:42:09.433 -> OK
19:42:10.501 -> AT+CSQ
19:42:10.501 ->
19:42:10.501 -> +CSQ: 7,0
19:42:10.501 ->
19:42:10.501 -> OK
19:42:11.504 -> AT+CCID
19:42:11.504 ->
19:42:11.504 -> 8960012009773118819F
19:42:11.504 ->
19:42:11.504 -> OK
19:42:12.525 -> AT+CREG?
19:42:12.525 ->
19:42:12.525 -> +CREG: 0,1
19:42:12.525 ->
19:42:12.525 -> OK
19:42:13.511 -> System Ready
    
```

Figure 10: Calibration of GSM SIM900A module with Arduino Uno microcontroller

Figure 11 shows the SMS received from the embedded circuit using the standard calculation for the electricity usage, which is 1000 impulse indicate 1kWh. The first line is the terminology cloud user id, followed by the electricity usage and bill in kWh and RM, respectively. The electricity usage and bill readings are 0kWh and RM0.00 respectively.

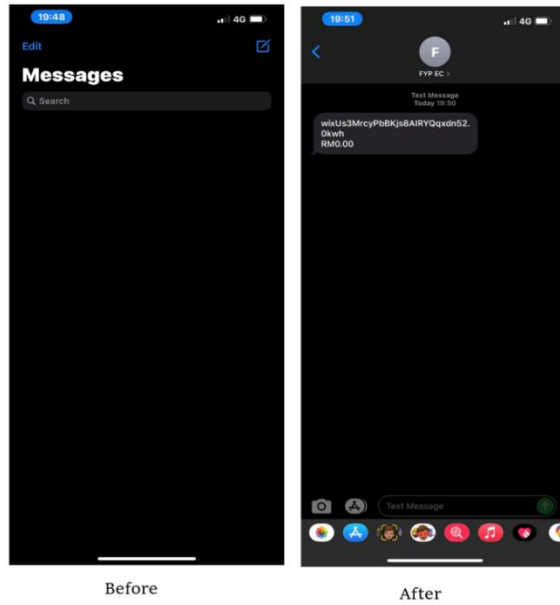


Figure 11: SMS from the embedded circuit (Standard calculation)

Figure 12 shows the SMS received from the embedded circuit using the magnify ten times calculation for the electricity usage, which is 1 impulse indicate 10kWh. The first line is the terminology cloud user id, followed by the electricity usage and bill in kWh and RM, respectively. The electricity usage and bill readings are 140kWh and RM84.98 respectively.

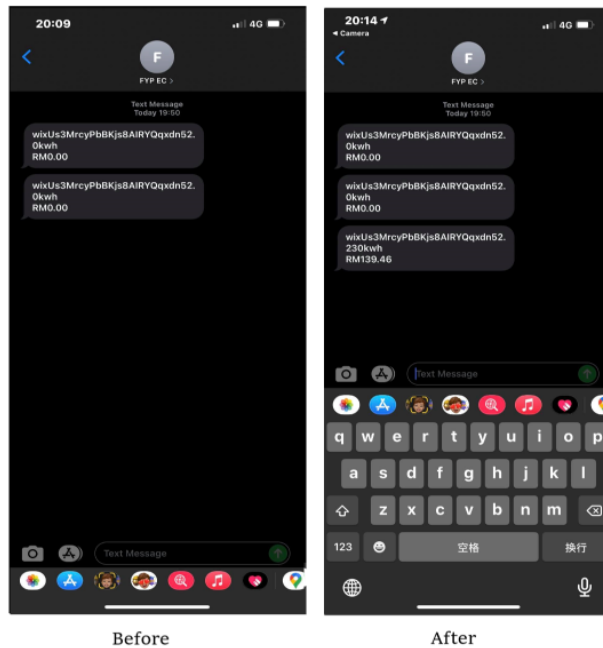


Figure 12: SMS from the embedded circuit (Magnify calculation)

4. Conclusion

The global system for mobile communication-based automated billing system electric energy meter was developed successfully in this project. The embedded system has features for the utility company to save many costs and increase billing efficiency. This is conduct by the system will deliver the data to the utility company through a short message service within an interval time. Then, the utility worker will manually enter the data in the online database platform called Firebase. The data entered include

the electricity usage of the premises and the total bill of the month. The user can retrieve the data through the graphical user interface application developed using the Thinkable application. Furthermore, this project has the value of improving the embedded system to provide more features by improving the programming code and the GUI application. Therefore, it can become an alternative solution to replace the electromechanical meter and electronic meter using a smart meter.

Acknowledgement

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

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