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Smart Home Meter Measurement and Appliance Control

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Abstract:
This paper presents the wireless measurement and control of smart home meter and appliances from far distance using cellular phone. Energy management is one of the main challenges to the world, particularly Malaysia, the one of developing countries. Appliance control is also a modern technology that people use it. The system design consists of a smartphone based energy measurement and appliances control system using SMS protocol and Blynk application for data transmission among each other. In addition, the prototype designed aims to measure the energy consumption, send it periodically to the server to update to the relevant user profile, provide live updates to the consumer's smartphone application and also provide a better control to the appliances by the smartphone application. One of the most interesting features of the designed prototype is that it doesn't need any replacement in currently existing energy meter.

1. Introduction

In the era of global, the use of mobile phones is important. The standard protocol for 2G digital cellular network is Global System for Mobile Communication (GSM). It is a replacement for the traditional 1G analogue cellular network. Initially, the data communication is through circuit-switched transport, then by the data packet transfer via GPRS and 2.5G EDGE. After that, 3G UMTS, 3.5G HSDPA and HSPA+ standards are developed and followed by 4G LTE and LTE-A standards. GSM is used by the people all over the world.
Smart meter is a two-way communication device that gathers the electrical energy consumption and send back to the central system. Home automation is the residential building automation that involves the control and automation of home appliances. The system consists of switches, sensors, and gateway through Wi-Fi connection. The users are able to remote home appliances through graphic user interface in mobile phones.
Abd. Wahab et al. (2010) has evaluated the study of using mobile phone to control the home appliances from a distance. Their idea of using GSM module technology which utilizing the short message service (SMS), enable them to automatically control the appliances OFF and ON switch of electrical home appliances such as lights, fans and water heater. Mohammad Suhaimi (2008) suggested a security system that will notify its owner using SMS if there is any undesired accident happens such as robbery or fire in the household while the owner is away. The system was built using a mobile phone, equipped with PIC16F877A micro controller circuits which connected to the computer interface. Tan, Lee and Mok (2007) developed a system that sends the information of electrical usage automatically to the billing company through e-billing. The system works by integrating the digital kWh meter with GSM modem. Abdullah (2008) designed a Temperature Status control via SMS which utilized PIC 16F877 to observe the level and temperature of the water in a pool. Vasilis (2003) used the system to control variety of electrical appliances using SMS. The system works when the user send a message of ON and OFF through a mobile phone.

2. Methodology

In the paper, the whole circuit diagram is shown in Figure 1 and Figure 2. It consists of some small parts of the circuits. These are Arduino MEGA, ACS712 Hall Effect based linear current sensor, relay circuit for the lamp bulb, relay circuits for the USB fan, resistance type USB fan speed controller, LCD display, LED indicator, and GSM module SIM900.

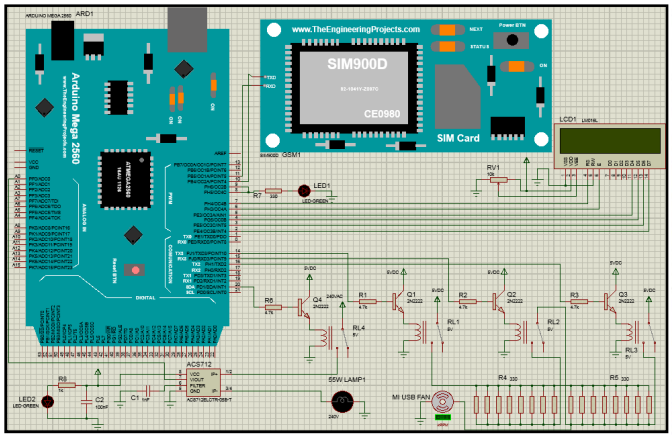

Figure 1: Circuit diagram on Proteus

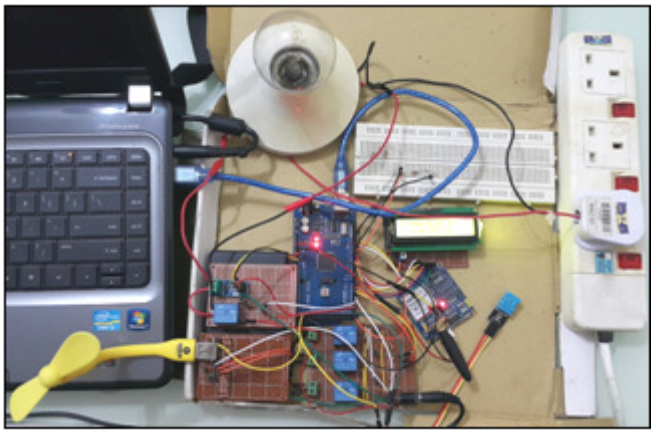

Figure 2: Circuit hardware prototype

First, the Arduino MEGA microcontroller is programmed by the Arduino Software (IDE). The Arduino MEGA is connected to ACS712 hall effect based linear current sensor, relay circuit for the lamp bulb, relay circuits for the USB fan, resistance type USB fan speed controller, LCD display, LED indicator, and GSM module SIM900.

The USB Serial is chosen as the method of establishing the internet connection to the Blynk cloud server. The Arduino MEGA is plugged into the laptop through USB serial cable and turned on. LCD display lights up and shows the first message "Booting …" in the screen.

In the laptop, click Start > All Programs > Accessories > Command Prompt to launch the Command Prompt interface. In the interface, type "cd C:\Users\Ying Kiat\Documents \Arduino \libraries\Blynk\scripts" in the interface and press Enter button,the action above goes into the directory which is the place of the file that is needed to run. To run the file, type "blynk-ser.bat -c COM23" and press Enter button. COM23 is the port name of the USB port which is connected to the Arduino MEGA. The Arduino MEGA is successful connected to the Blynk cloud server.

The net status LED D6 on GSM modem SIM900A is shown in Figure 3. The blinking status of the LED is observed. If the mobile network is registered successfully, the LED will blink every 3 seconds. The GSM modem SIM900A is ready to work. The Arduino MEGA microcontroller is starting to send the AT commands to the GSM modem SIM900A to set the GSM modem goes into SMS mode. Next, the Arduino MEGA will send a message "GSM Ready" to the saved user's mobile phone number through the GSM modem to notify the user that the system is ready to accept the commands from the SMS.

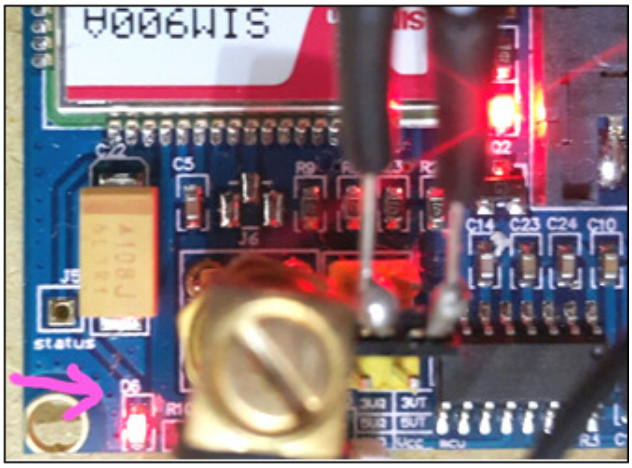

Figure 3: Net Status LED D6 on SIM900A

In the smartphone, Blynk application is launched by clicking the icon of the Blynk on the application drawer. After that, the Smart Meter is chosen in the Blynk. The main interface of the smart meter is shown in Figure 4. The middle two rows in the main interface is the reading of the smart meter in a few parameters those are getting from the Arduino MEGA which uploads the information into the Blynk cloud server through the internet.

The first left button which is marked with D8 is the fan speed button. The button needs to pressing for a while to change the fan speed. The second right button which is marked with D20 is the light switch button.

Besides using the Blynk application in the smartphone, the commands from the SMS also can obtain the readings from the Arduino MEGA and control the light and fan speed. The commands "#R" means to obtain the meter reading from the Arduino MEGA. The commands "#FX" means to control the fan speed such as #F0, #F1, #F2, and #F3. The commands "#LX" means to control the lamp bulb switch such as #L0, and #L1.

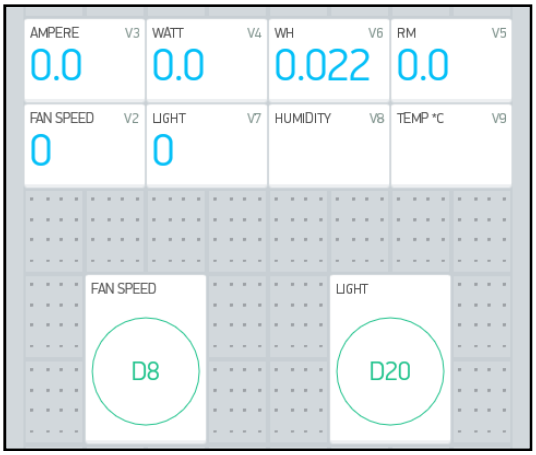

Figure 4: Main interface in Blynk Application

3. Results

3.1. Measuring Energy Consumption

In Figure 5, the Blynk application shows the information about the current of the load in Ampere, the power of the load in Wattage, the total energy consumption of the load in Watt-hour, the bill cost of the load in Ringgit Malaysia, the status of the USB fan speed, the status of the light condition, the humidity in the room and the temperature of the room in degree Celsius. The information in the LCD display will be synchronized with the Arduino MEGA in every second.

In Figure 6, the user sends the commands "#R" to the Arduino MEGA through mobile phone. Then, the Arduino MEGA gathers the information of the smart meter reading about the total energy consumption of the load in Watt-hour and the bill cost in Ringgit Malaysia. After that, the Arduino MEGA sends back the information to the user's mobile phone number through GSM modem SIM900A.

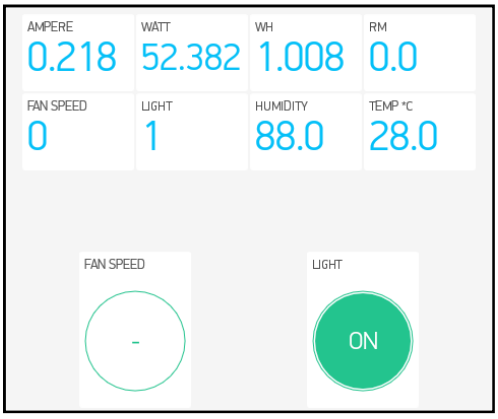

Figure 5: Blynk shows the information

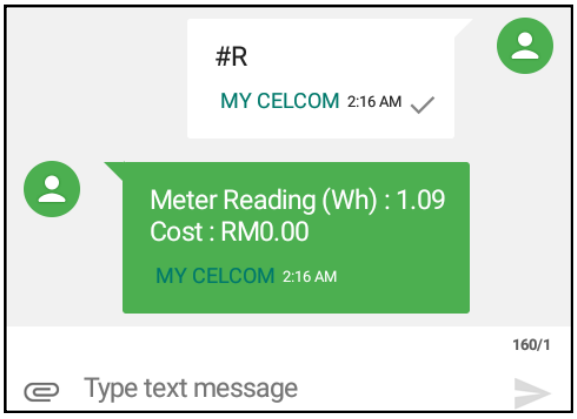

Figure 6: Users obtains the reading with SMS

3.2. Operating the Light Switch

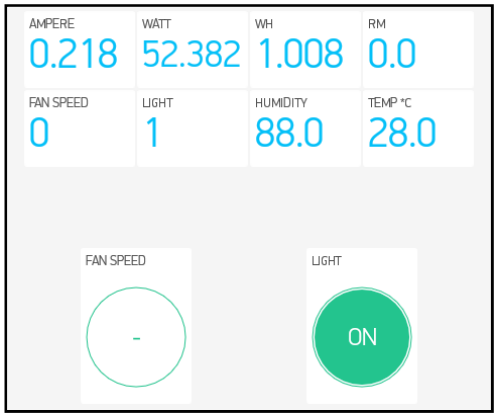

Figure 7: Users turns ON light through Blynk

In Figure 7, to turn on the light, the light switch button should be short-pressed once time to trigger the light relay to turn ON the light. To turn off the light, the light switch button should be short-pressed once time to trigger the light relay to turn OFF the light.

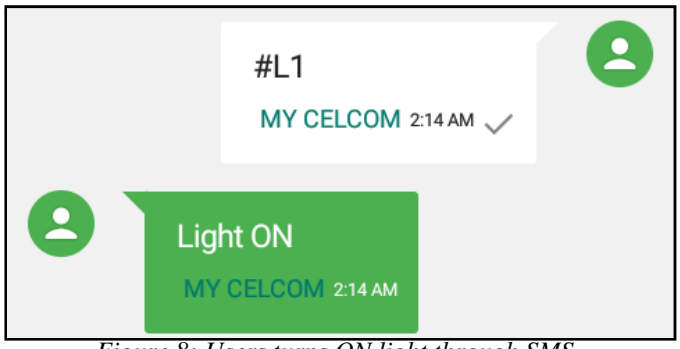

Figure 8: Users turns ON light through SMS

In Figure 8, the user sends the commands "#L1" to the Arduino MEGA through mobile phone. The Arduino MEGA analyses the SMS commands and run the corresponding loop to control the light relay to turn ON the light. This is shown practically in Figure 9. After that, the Arduino MEGA replies the message to the user's mobile phone number to notify that the light has been switched ON. To turn off the light, the user sends the commands "#L0" to the Arduino MEGA through mobile phone. The remaining process is same as above.

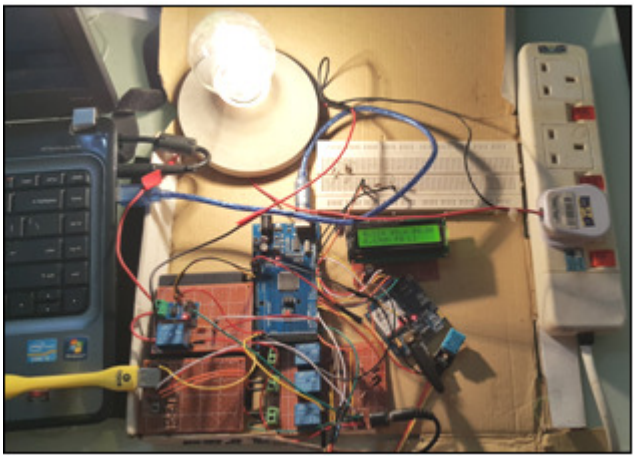

Figure 9: The light has been switched ON

3.3. Changing the Fan Speed

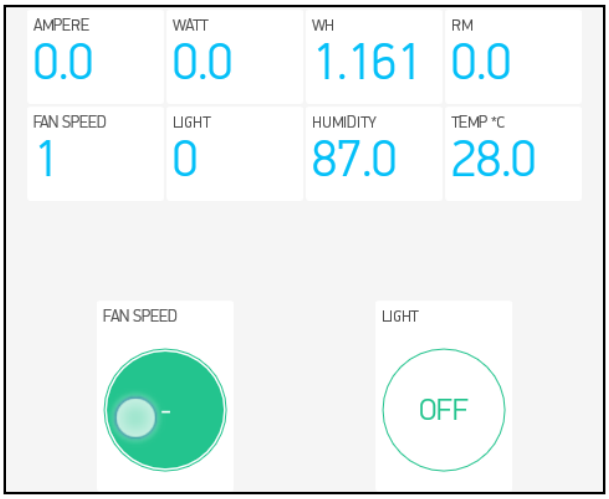

Figure 10: User changes fan speed through Blynk

In Figure 10, to change fan speed, the fan speed button should be long-pressed to trigger the fan relay to change the fan speed into 1, 2, 3, or 0.

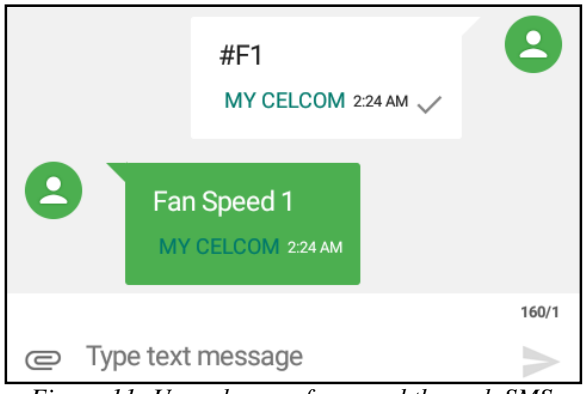

Figure 11: User changes fan speed through SMS

In Figure 11, the user sends the commands "#F1" to the Arduino MEGA through mobile phone. The Arduino MEGA analyses the SMS commands and run the corresponding loop to change the fan speed into 1. After that, the Arduino MEGA replies the message to the user's mobile phone number to notify that the fan speed has been changed into 1. The procedure is same for the user changes the fan speed into 2, 3 and 0 by sending the commands "#F2", "#F3" and "#F0" to the Arduino MEGA through mobile phone. This is also practically observed in Figure 12 and 13.

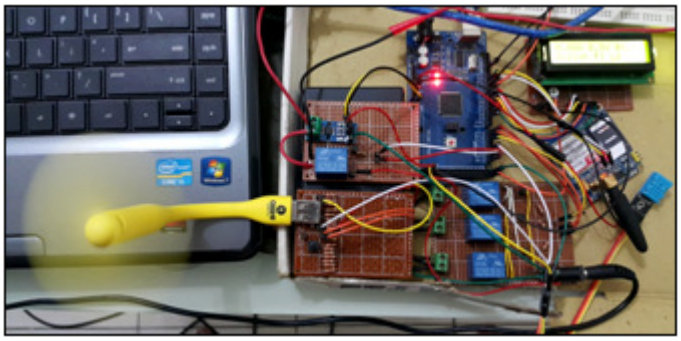

Figure 12: The fan is operating in speed 1

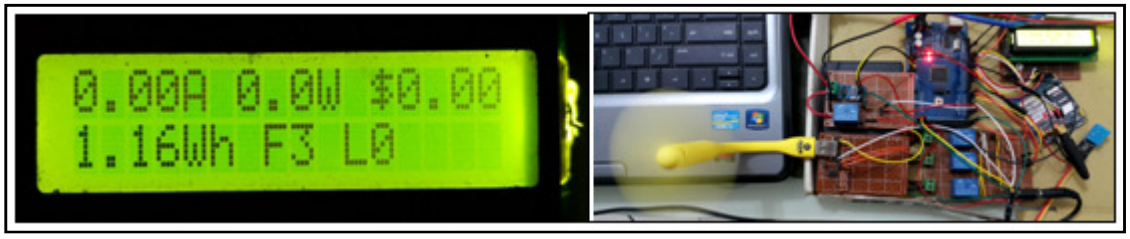

Figure 13: The fan is operating in speed 3

4. Discussion

The measurement of the amount of the current passing through the load is using the ACS712 which is a Hall Effect based linear current sensor in full-integrated IC packaging. Hall Effect is an existence of the potential different between the electricity conductors which are horizontal to flow the current in the electricity conductor. The applied magnetic field is at the angle of 90 degree to the flowing current. The voltage is also called Hall voltage.

The equation of current sensor for the conversion from the sigma input reading to current in Ampere is as follow:

$$current\_amps = intercept + slope * inputStats.sigma()$$

By using the try and error method, every reading of the current sensor is recorded and analyzed. After every reading is taken, the modification of the value of the intercept and slope is made for the accuracy of the current reading. The process will stop if the current reading is in the most accurate condition. After all of the reading is taken, the final value of the intercept and slope is as follow:

$$Intercept= -0.1129, slope=0.0405$$

Malaysia's energy providers provide the power supply at 240V. Since the current reading is taken, the power of the load can be calculated as follow:

$$P = IV$$
$$Watt = current\_amps * 240$$

With the power of the load is obtained, the energy consumption of the load can be calculated in Watt-hour. Since the current sensor is set to take the reading in every second, the energy consumption of the load should be calculated as follow:

$$Wh = \frac{Watt}{3600}$$

The new reading is taken every second. The old reading should be added with the new reading to accumulate all of the reading together to show the total energy consumption in the time being.

$$Wh2 = Wh2 + Wh$$

The rate per kWh is following the tariff rate of Tariff A (Domestic Tariff) of Tenaga Nasional Bhd. The total cost in Ringgit Malaysia (RM) for the total energy consumption of the load can be calculated as follow:

$$The\ cost\ per\ kWh = RM0.218$$
$$The\ cost\ per\ Wh = \frac{RM0.218}{1000}$$
$$= RM0.000218$$
$$RM = Wh2\ x\ RM0.000218$$

The formulae of the calculation are programmed into the Arduino MEGA microcontroller through Arduino Software (IDE).
For the USB fan, a potentiometer is used to test the maximum resistance can be used to make the USB fan operated at the lowest speed before it stops completely. In the experiment, it is found that the maximum resistance is about 40 Ohm for the USB fan operated at the lowest speed. By using the 330 Ohm resistors, the number of resistors need to be connected in parallel can be calculated as follow:

$$\frac{1}{330}\ x\ N = \frac{1}{R}$$
$$\frac{1}{330}\ x\ N = \frac{1}{40}$$
$$N = \frac{1}{40}\ x\ \frac{330}{1}$$
$$N = 8.25$$
$$N = 8$$

It means that the current flows through the 8 parallel resistors (R4) to the fan will operate the fan in the lowest speed (speed 1). By operating the fan in the medium speed, the value of the resistors needs to be halved, that is 20 Ohm. By using the 330 Ohm resistors, the number of resistors need to be connected in parallel can be calculated as follow:

$$\frac{1}{330}\ x\ N = \frac{1}{20}$$
$$N = \frac{1}{20}\ x\ \frac{330}{1}$$
$$N = 16.5$$
$$N = 16$$

It means that the current flows through the 16 parallel resistors (R4 and R5) to the fan will operate the fan in the medium speed (speed 2). By operating the fan in the maximum speed (speed 3), the current will by pass the resistors to the fan directly. Figures 12 and 13 illustrate this purpose.

5. Conclusion

In a nutshell, wireless measurement and control of smart home meter using GSM is built to read and send data via wireless protocol network using GSM technology and internet connection via Arduino MEGA microcontroller. This paper shows a brief of convenient way for the consumer to monitor the energy consumption of the load in the house and for finding the factor of using the energy excessively to reduce the consumption. Besides, it also shows the convenient way for the consumer to control the lighting and fan by using the Smartphone.
This way can be recommended to develop in the home automation system. It includes the control and automation of lighting, heating, ventilation, air conditioning, security and other home appliances, which is beneficial to the users. Home automation may make the user's life easier and more convenient. Besides, its security system can be built to provide a help in an emergency. Electric bills will

go down when the appliances are automatically turned off when not in use. Home automation can monitor how much energy used for each appliance. Home automation will also provide the benefits to the disabilities.

6. References

i. Abd. Wahab, M. H., Mohd. Muji, S. A. & Md. Nazir, F. (2007). Integrated billing system through GSM network, Proceeding of 3rdInternational Conference on Robotics, Vision, Information and Signal Processing. Penang: Malaysia.

ii. Abdullah, M. N. (2008). Acquiring Water Level and Temperature Status Via SMS (Bachelor Degree Thesis) Kolej Universiti Tun Hussein Onn Malaysia.

iii. Lock, K. A. (2004). Remote and Security Control via SMS (Bachelor Degree Thesis), Kolej Universiti Tun Hussein Onn Malaysia

iv. Tan, H. G. R., Lee, C. H. R. & Mok, V. H. (2007), Automatic power meter reading system using GSM network, Proceeding on Power Engineering Conference 2007, 465-469. Kuala Lumpur: Malaysia.

v. Vasilis, S. (2003). SMS Remote Control for EricssonT10 GSM Mobile Phone, Retrieved from http://www.serasidis.gr