AUTOMATIC METER READING USING ZIGBEE

By

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FINAL REPORT

Submitted to the Electrical & Electronics Engineering Programme

in Partial Fulfilment of the Requirements

for the Degree

Bachelor of Engineering (Hons)

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Universiti Teknologi PETRONAS

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

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Approved by,

_____

(Puan Zazilah binti May)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2013

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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MOHAMAD FIRDAUS BIN MOHAMAD ROSELEE

ABSTRACT

The real-time monitoring of a data is crucial in ensuring the accuracy of the acquired data. It determines whether the device is properly working or in fault. This paper proposed the design and implementation of a ZigBee-based wireless automatic meter reading system. It focuses on the development of a device that is capable of monitoring meter reader remotely. It sends the data hourly or daily using Zigbee as the transmitting medium. The proposed device uses software; XCTU, Arduino Programming Language, Multisim and hardware; Microcontroller, Pulse generating circuit, Zigbee antenna, 16X2 LCD Display to actually demonstrate the result. This device has a good potential in wireless meter reading due to its low-cost, low power consuming, and low data rate. The input is the pulse generated by the pulsating circuit and the output will be shown onto the LCD display and in the XCTU software proving that it transmitted wirelessly. The results successfully shows the data is received as what it is transmitted. If the prototype would be able to be completed within time limit, the author might explore more on using GSM/GPRS module to transfer the data further in term of distance. The report consists of an introduction, problem statement, objectives, literature review and methodology used to solve the problem. It further looks into the obtained results with consistent discussion.

ACKNOWLEDGEMENT

First and foremost, I would like to express my gratitude towards Allah The Almighty for giving the chance and strengths to face the odds and obstacles in completing the Final Year Project; FYP. Not to forget in guiding me towards finishing my project.

A special thank you shall be given to my project supervisor; Puan Zazilah binti May that have given me guidance in making this project a success. Besides, she is the one encourage me to enter the conferences in submitting the paper. This will benefit many people especially if the paper is selected to be presented in the conference. Not to forget, all technician that have also helped me while I am doing my project in teaching me theoretically and put it up for test.

I would like to thank my company which I had my internship with for giving me the idea on what topic that I should choose for my FYP topic. During my time of doing the internship, all the theory that I have learned has been a lot of help in designing the prototype. As this project is based on their idea to overcome power tapping, they hope that the prototype that I have design could be marketed in Malaysia and worldwide.

Lastly, I would like to thank my parents, siblings, and my course mate who have helped me directly or indirectly during my time finishing the prototype. Based on their opinion and continuous support have led me in detecting flaw that needs to be look into details. Their concern for me during the time of the project is highly appreciated.

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LIST OF ABBREVIATION

AMR   Automatic Meter Reading

UTP   Universiti Teknologi PETRONAS

OPC   Ordinary Power Consumer

LPC   Large Power Consumer

TNB   Tenaga Nasional Berhad

MYR   Malaysian Ringgit

HQ   Head Quarters

Chapter 1

INTRODUCTION

1.1   Background of Study

In the world, there are two types of meter reader. Those are meter reader for single phase and three phase user. For the three phase user, there are device that send the data to the electricity provider which is in Malaysia, the Tenaga Nasional Berhad (TNB) for monitoring purposes. For a single phase, there are no devices developed so far that have the ability as the one mention in the section of the three phase user. Most of the three phase user is the one that using a lot of electricity. The TNB called them Large Power Consumer (LPC). For the Ordinary Power Consumer (OPC), mostly the home user, the meter reader would only able to display the power usage only. Therefore, incorporate the device with the module the author suggested, Zigbee, this will then transfer across the line of network and at the end of this network will be the combination of all the previous data that have been jump from house to house. The accuracy would be determined by having checked all the data is correct as what the final outcome should be.

1.2   Problem Statement

In this section, the author will discuss on the problem that has been identified and the significance of the project.

1.2.1   *Problem Identification*

Power tapping is act of stealing electricity from the electric service provider. In Malaysia, the major electricity service provider is Tenaga Nasional Berhad (TNB). Due to power tapping done by the uncivilized people, TNB has lost about MYR 500M.

The conventional method adopted by the TNB involved a very tedious work as it cost both money and time. The implementation of this project will assist the TNB in monitoring their user.

1.2.2   *Significance of Project*

Power tapping usually happened when the home user is using electricity but their meter reader does not give out any reading. Therefore, the worker from the TNB has to go to their house manually well in order to check either it is working or not. Plus, they also send their worker to specific house to cut the electrical supply in case they did not pay their bills or caught tapping onto the line. Both of this needs the owner to be present at that time.

Sometimes, the aspect of bribery is done by the owner to hinder the worker for doing their work. This project will make the TNB easier in term of monitoring all the houses that they provide electrical with. When the data is sent to HQ, it will also make the job accountant easier as they know how much profit that they have gained so far.

1.3   Objective and Scope of the project

1.3.1   *Objectives*

The main objective is to design a prototype to be proposed to TNB for them that is able to access remotely the meter reader in every house in Malaysia by using Zigbee. This will enable interactions between TNB and the meter reader incorporated inside the house. The sub-objectives of this project are listed as follows:

    i. To produce a simulation of a pulsating meter reader.
    ii. To display the value in kWh.
    iii. To transfer the kWh data remotely.

1.3.2   *Scope of Project*

This project starts with literature review related to meter reading and basic concept of wireless communication which in this case is Zigbee. The meter reader

will give out pulse and show reading digitally. This will then be interpreted to kWh. The data will then be transmitted wirelessly using Zigbee.

1.4   Relevancy of Project

This device will reduce the lost due to power tapping or even make the loss to zero. If the issue of power tapping is not treated wisely, it will only make the problem worsen. The loss will add up and make TNB suffer even more annually. By implementing this project, it will make the loss into profit. The transportation cost for the worker to go to the specific house would be reduced. If there are 10 houses that power taps daily, a total of 300 houses per month. If these houses are not usually close to each other and the TNB would like to cut of the power supply, the cost would add up more in term of transportation to reach these houses. Continuous monitoring would be a better optionn.

1.5   Feasibility of Project

The project is done in two semesters which include three areas. Those are research, development and also improvement of the model itself. The objective is to develop a working prototype of the proposed product itself. The input will be obtained from the supplier about the reading from the proposed meter reader and this input will then be interpreted by the microcontroller.it then send using the Zigbee as medium of transfer. For the Zigbee part, a little programming need to be done to make sure it goes as what the author wanted it to be. Based on the description above, it is very clear that this project will be feasible to be carried out within the time frame.

Chapter 2

LITERATURE REVIEW

2.1 Importance of remote meter reading

With the rapid development of automation and measuring techniques, automatic recording of data in the meter reading instrument has gradually become the target of those who work, live, and housing conditions are those higher level of intelligence. Meanwhile, the utility also hoped that the development of new technologies will help to solve problems encountered in practical work on the meter scale, and no reliable protection and real-time accuracy, and enable both user-friendly public sector and improve efficiency and management. Meter reading system of the existing wire line has some big risks. Wire is more complex, to the detriment of the adjustment and maintenance. Long-term installation of internal and external will lead to aging, causing a short circuit and damage risk would be higher. For this reason, it has become an industry problem that cannot be resolved to design a remote meter reading system, the installation of long-term dependency and easy maintenance, which not only read data but also automatically monitors the operation status.

In recent years with the development of wireless communication technology, comes the need for low-cost equipment wireless network technology, known as Zigbee. It is a short range, low complexity, low cost, low power consumption, and two-way data rate wireless communication technology with high network capacity, delay time, security and dependence. The main area for these industries includes industrial control, consumer electronics, automation, automobiles, agricultural automation, and control of medical equipment. The thrust of this technology established by the IEEE 802.15.4 Working Group, and the Zigbee Alliance, founded in 2002. It is responsible for high level applications, interoperability testing, and marketing. To date, the Zigbee Alliance has achieved more than 150 members' world-renowned companies including IBM, Ember, Mitsubishi, Motorola, and Philips, etc.

[1]. Many semiconductor companies are targeting the Zigbee market. Since the standards were launched not so long ago, chips in line with protocol have been available of multi-chip solution and single-chip solution. It can be expected that Zigbee will have comprehensive applications in the field of automation.

2.2 Electrical Energy Computation

Equation (1) is the basic things for computing the energy consumption E for any given load during a time interval $\Delta t (= t_2 - t_1)$

$$E = \int_{t_1}^{t_2} v(t)i(t)dt \quad (1)$$

Where v (t) is the supply voltage and i (t) is the load current.

In real life, a distinct version of Equation (1) is applied where the volt and current are sampled and digitized it by an 8 bit A/D converter after proper conditioning [4], operating it at a sampling frequency of 1082 kHz. The voltage and current is processed and the energy consumption is stored. The energy is then compared to a reference value (E_{ref}) for a 1kW load. The energy is computed and accumulated for A 100 periods of 924μs (a program cycle). The following equation shows the computation of the E_{ref} value:

$$E_{ref} = \frac{100.924\mu s.1000W}{3600s} = 0.00002567kWh$$

When the reference value of the energy, E_{ref} is reached, a counter is incremented and the comparisons start again. The limit value for the counter that is 38961, after it is reached, the counter is reset. The energy is indicated by a four digits display. This display works on a time sharing operation, where each digit is individually turned on for five program cycles (4.62ms), that is sufficiently fast for the human eye to perceive, hence no flickering is detected.

The above information is the one using a microcontroller. From reading the brochure, it is known that the device produce a pulse. This pulse is the one that may be used

without tampering the meter reader. If the device fails to produce any sorts of communication without tampering it, alternative may have to be considered. The supplier asks the author to discuss on the subject matter with him at his office so that both parties know what the other party wants. If the pulse is the one like what the author imagine it to be, these pulses will then be interpreted inside the Arduino microcontroller. If the pulses is the one that the author use, it will be then update in the next report.

2.3   Zigbee Wireless Network

As wireless communication devices, it uses 2 way directions. For transmitting part, it is called transmitter. Receiving end would be call receiver. Zigbee is a short distance wireless communication technology transfer at low cost, low complexity, low power consumption and low data rate. Usually, this device is used in the area of automatic control. It works on 2.4GHz ISM band with 20~250kbit/s data rate, 100m~1.5km maximum transmission range and a typical 100m distance [5]. Technical features includes as follows:

(1) Secure: it provides integrity of data checking and authenticating. Each application can be set on its safety properties.

(2) Reliable: using collision avoidance mechanism and at the same time reserving a dedicated time slot to require a fixed bandwidth of the communication service avoiding the conflicts when data is sent. MAC layer uses full confirmation of data transferring making the confirmation as the key in allowing data transfer.

(3) Low cost: The module is quite cheap rather than using any other sorts of wireless communication.

(4) Power saving: as short duty cycle is its mechanism, short time in transmitting and receiving data is persist making hibernation as an option if not in use

(5) High network capacity: the maximum it can accommodate is about 65536 devices.

(6) Short delays: typical device would take time up to 30s, but using this module, it is less than that.

2.4 Comparison between wireless communication technology

The main use of Zigbee application are only for short range purposes that is its data rate among the same equipment that is not very high. Typical data transfer that always been use in today are periodical data (sensoring data), intermittent data (humidity control) and repetitive low latency data (wireless keyboard). As Bluetooth and Wi-Fi are in the same group that is 802.15 protocols, they have quite a few similarities. Table 1 shows the comparison between wireless communication devices that is available so far.

Performance	Zigbee	Bluetooth	Wi-Fi
Working frequency	2.4GHz 868/915MHz	2.4GHz	2.4Ghz
System resource	4Kbyte~32Kbyte	250Kbyte	1Mbyte
Communication range	0.1~1.5km	0.1km	0.1km
Data rate	250 Kbps	1 Mbps	11 Mbps
Maximum network nodes	65536	8	32
Wake-up time	30ms	10s	3s
Encryption	128 bits AES	128 bits	SSID
Low power consumption	Support	No support	No support

Table 1: Comparisons between wireless communications

2.5 Topologies inside Zigbee network

For a Zigbee network, it supports 3 type of networking topologies. Three of them are; Star topology, Cluster tree topology and Mesh network topology. This can be shown as the picture in figure below [1]. This network has self-organizing and self-repair capabilities and supports complex network topology, making it sends messages and communicate between nodes through different routes. Network not only has good scalability, but it also makes data transmission more dependent. Multiple subnets consist of combination of these topologies might form a large network covering the whole area and if this happen, controlling the area that using this module would be at ease. Figure 1 illustrate the type o topologies in Zigbee
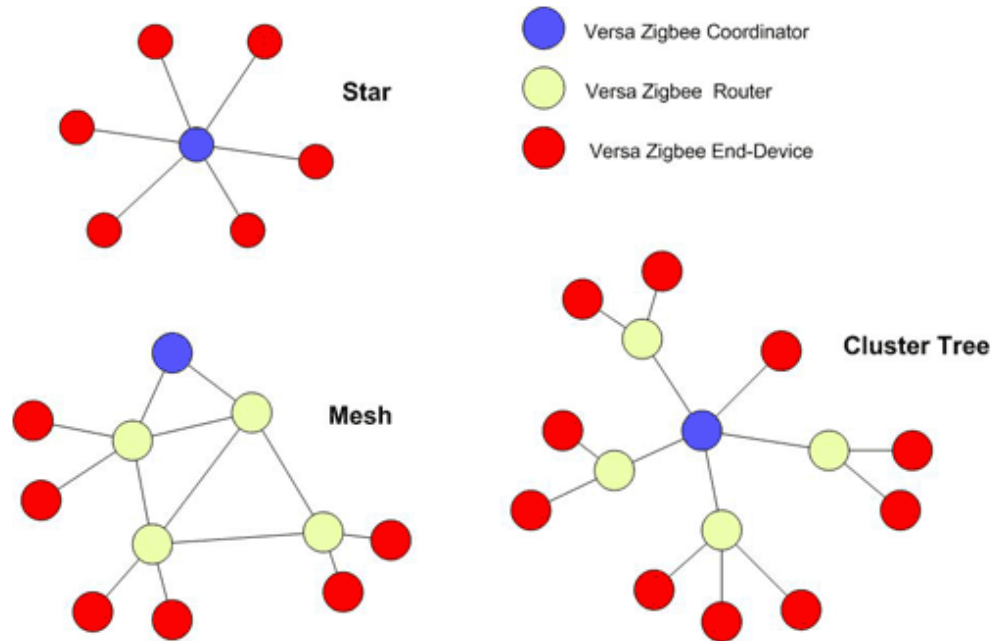
Figure 1: Topologies in Zigbee

2.5.1 *Advantage and disadvantage of each topology*

Mesh Topology:

Every device has a dedicated point-to-point link to every other device in a mesh topology. The term 'dedicated' means that between the two devices that is connected, they carries traffic link. Here, if we have n nodes, then we need to connect to n-1 nodes and n (n-1) physical links. If thinking about making it duplex (both directions), we need n (n-1)/2 links. Table 2 shows the advantage and disadvantages of using Mesh topology.

Advantages	Disadvantages
- When sharing links, it eliminates traffic problems. - It does not incapacitate the entire system if one link becomes unusable. Thus, act as robust.	- Difficult in installing and reconnection. - In connecting each link (I/O ports and cable), the hardware is expensive.

• Has privacy and security setting. • Point-to-point link easy in making fault identification and fault isolation.	• It is generally too costly and complex for practical networks.

Table 2: Advantages and Disadvantages of Mesh topology

Star Topology:

In using the star topology networking, each device is connected to a central hub. This network allows each device to have a point to the central hub. All of the traffic which transverse the network passes through the central hub. This hub plays as a role of a signal booster or repeater, to cover a lot more in term of distance. Table3 shows the advantage and disadvantages of using Star topology.

Advantages	**Disadvantage**
• It is easy to install and reconfigure. • When connecting or removing devices, no disruptions occur to the network. • Easy to detect faults and to remove parts. • Cheaper. • If one link fails, only that link is affected, other links remain active (robust).	• The whole system is dead if the hub fails. • If the hub, switch, or concentrator fails, nodes attached are disabled. • It requires more cable length than a bus topology. • Because of the cost of the hubs it is more expensive than bus topologies

Table 3: Advantages and Disadvantages of Star topology

Tree Topology:

The type of network topology in which a central 'root' node (the top level of the hierarchy), is connected to a level lower in the hierarchy (i.e., the second level). It is like a tree where the branch is the smaller part of the tree. The coordinator is the tree where the brain of the system. The branch is the router play role to find the shortest distance or device to hop on. The leaf acts as the end device transmit back to the coordinator. Table 4 shows the advantage and disadvantages of using Tree topology.

Advantages	Disadvantages
• Point-to-point wiring for individual segments. • Supported by several hardware and software venders.	• Limited by the type of cabling for overall length of each segment that is used. • The entire segment goes down if the backbone line fails. • More difficult to configure and wire than other topologies.

Table 4: Advantages and Disadvantages of Tree topology

2.6   Idea for the prototype

Below are the proposed steps in the process of developing the prototype

Step 1-	Send the command to the Zigbee transmitter
Step 2-	The command is transmit to Zigbee receiver
Step 3-	Command is interpret inside the microcontroller
Step 4-	Obtaining the reading from the meter reader
Step 5-	Transmit the data to the microcontroller
Step 6-	Data is passed back to the receiver
Step 7-	Data is receive back from the receiver
Step 8-	Data is displayed on the computer

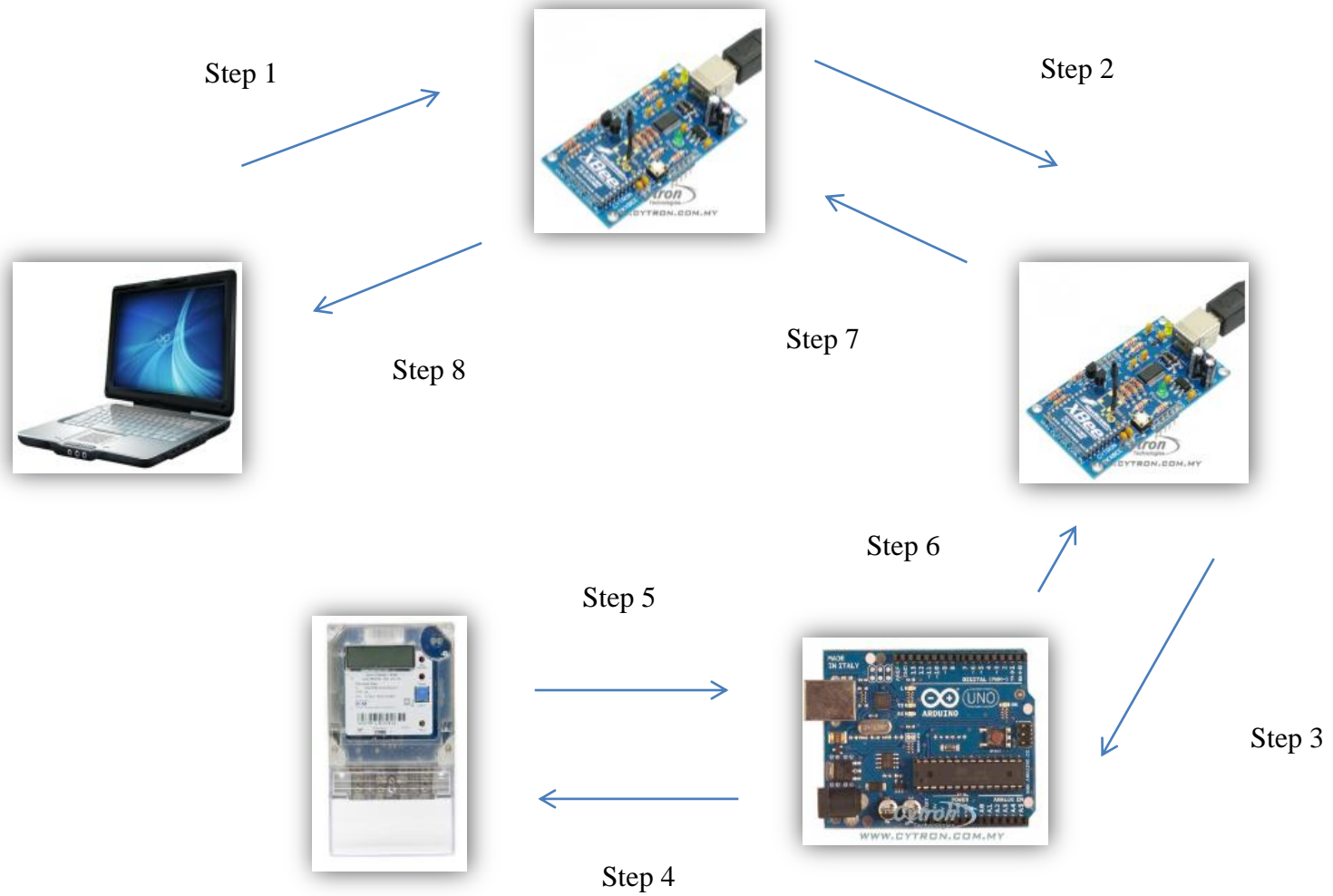**The illustration of the proposed steps is shown in Fig. 2

Step 1

Step 2

Step 8

Step 7

Step 6

Step 5

Step 4

Step 3

Figure 2: Illustration on the proposed idea

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Chapter 3
METHODOLOGY

3.1   Research Methodology

In order to achieve all the objectives; main objective and sub objectives of the prototype needs to be working. In doing it, research on the subject matter needs to be done and the programming of the device also needs to be finished early in order to troubleshoot to find any loophole in the designing process.

For FYP 1, most of the documentation needs to be done thoroughly as FYP 2, the prototyping phase began. The issues relevancy between the selected papers and our project's objective, need to be taken into account to ensure the credibility of this project.

The meter supplier asked the author to discuss it at their office. This discussion needs to be done as for both parties should not have miscommunication between them. If there are things that need to be clarified, further discussion will be done online through mail.

The components that are to be bought need to be done early. This is because some of the components need to be ship from overseas. This will take time as the shipment would take up to months' time. If there is stock from company in Malaysia, the time will be reduced more.

As the collaboration is between UTP and Tricubes Bhd; the company that the author have had interns there, there should be mutual understanding between both parties on what part they supposed to do. This is to ensure that there will be no miscommunication between both parties.

3.2 Flow Chart

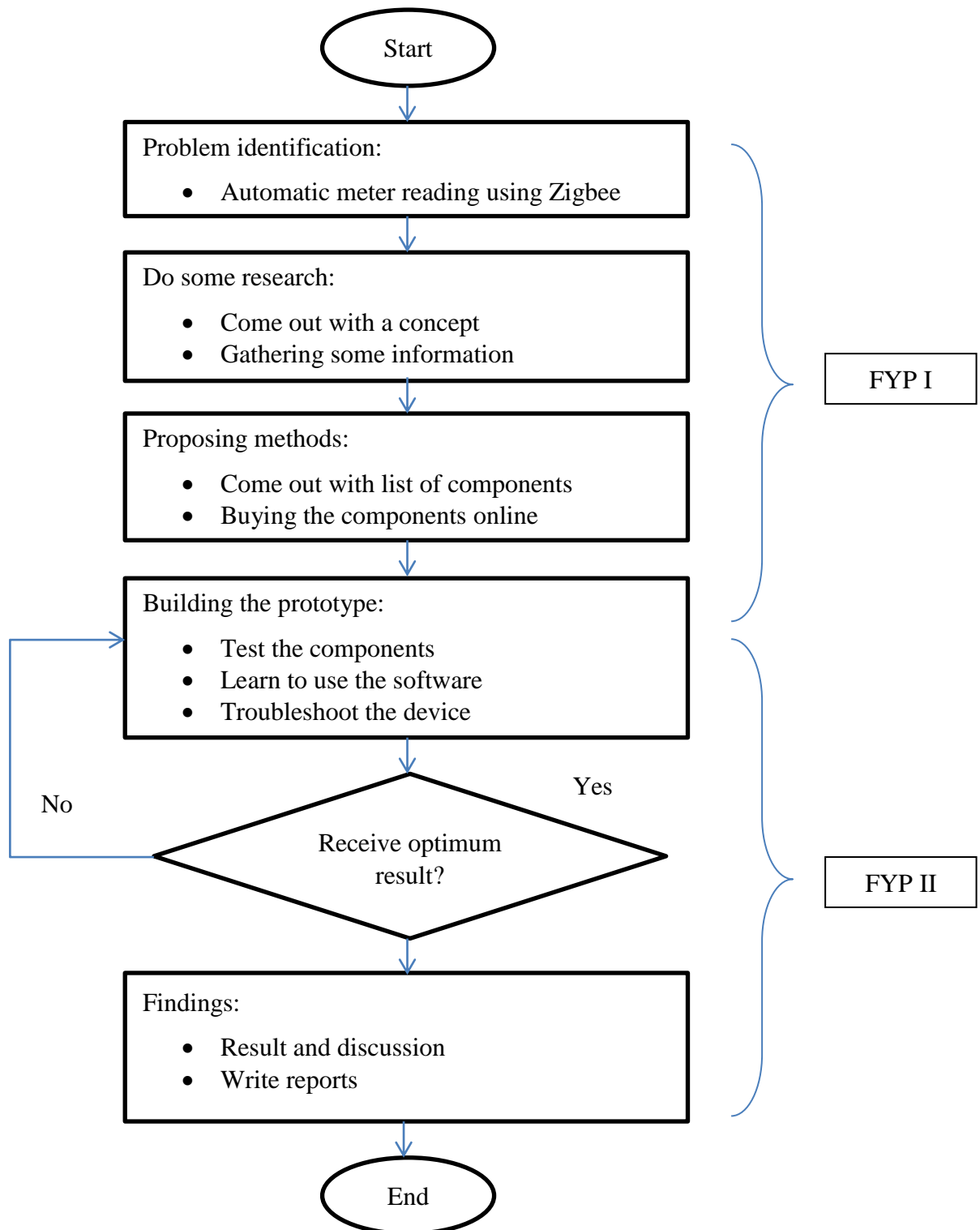Fig. 3 illustrate the flow chart for the project:

```
                        ( Start )
                            |
                            v
   +--------------------------------------------+
   | Problem identification:                    |
   |    • Automatic meter reading using Zigbee  |          )
   +--------------------------------------------+          |
                            |                              |
                            v                              |
   +--------------------------------------------+          |
   | Do some research:                          |          |
   |    • Come out with a concept               |          |    FYP I
   |    • Gathering some information             |          |
   +--------------------------------------------+          |
                            |                              |
                            v                              |
   +--------------------------------------------+          |
   | Proposing methods:                         |          |
   |    • Come out with list of components      |          |
   |    • Buying the components online          |          |
   +--------------------------------------------+          )
                            |
                            v
   +--------------------------------------------+
   | Building the prototype:                    |          )
   |    • Test the components                   |          |
   |    • Learn to use the software             |          |
   |    • Troubleshoot the device               |          |
   +--------------------------------------------+          |
                            |                   Yes        |
   No                       v                              |
          <  Receive optimum result?  >                   |    FYP II
                            |                              |
                            v                              |
   +--------------------------------------------+          |
   | Findings:                                  |          |
   |    • Result and discussion                 |          |
   |    • Write reports                         |          )
   +--------------------------------------------+
                            |
                            v
                         ( End )
```

Figure 3: Flow Chart for the project

3.3 Project Duration

In order to effectively monitor the progress of this project, a Gantt chart shows in Table 5, consists of semester duration had been constructed.

Activities	Week No													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Proposing project title	█	█												
Do some research on the topic		█	█											
Literature review				█	█	█								
Submit Extended Proposal (27/6)						█								
Search the supplier of the meter						█	█							
Proposal Defend presentation (4/7-11/7)								█						
Buy components online								█	█					
Make the circuit										█	█	█		
Troubleshoot the circuit													█	█
Try to apply the circuit with Microcontroller													█	█
Report Submission (10/8 & 15/8)														█

Table 5: Gantt Chart for FYP I

Table 6 shows the necessary preparation during the FYP II semester session.

Activities	Week No													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Literature review (for prototype build)	■													
Prototype building		■	■											
Prototype testing			■	■	■									
Simulation, testing and result				■	■	■	■	■	■					
Recommendations and modifications					■	■	■	■						
Preparation for exhibition and presentation										■	■	■		
Final report compilation and presentation												■	■	■

Table 6: Gantt chart for FYP II

3.4   Tools Required

- PIC Microcontroller

Arduino is an open-source physical computing platform based on a simple i/o board and a development environment that implements the Processing/Wiring language. Arduino can be used to develop stand-alone interactive objects or can be connected to software on your computer (e.g. Flash, Processing, MaxMSP). The open-source IDE can be downloaded for free (currently for Mac OS X, Windows, and Linux). The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. [8]

Additional features coming with the R3 version are:

- ❖ ATmega16U2 instead 8U2 as USB-to-Serial converter.

- ❖ 1.0 pinout: added SDA and SCL pins for TWI communication placed near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board and the second one is a not connected pin, which is reserved for future purposes.
- ❖ Stronger RESET circuit.

"Uno" means "One" in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform.

Features:

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

- • Zigbee transmitter and receiver

XBee has becoming extremely popular among robot builder and embedded wireless communication. It can be used for control and monitoring, data streaming, real time wireless update and also wireless downloader. Finally user can enjoy another simple yet reliable wireless communication for robots. However, using XBee OEM RF module need extra work to interface since it is 3.3V power and offer 3.3V interface. With these reason, Cytron Technologies has designed Starter kit for user to easily use XBee module. With SKXbee, user only requires 4 simple wiring to offer wireless communication to 5V microcontroller. On board, USB interface can easily turn SKXBee into XBee dongle. [9]

Features:

❖ Communication range up to **100 meters**
❖ Soldered with XBee module and tested before being shipped
❖ USB Plug and Play UART function
❖ 5V powered
❖ 5V UART interface, ready for microcontroller interface
❖ Default baud rate of 9600bps
❖ Long Range Data Integrity
❖ Low power consumption
❖ Compact yet easy and reliable platform
❖ As serial port replacement (wireless)
❖ Point-to-point, point-to-multipoint and peer-to-peer topologies supported

• GSM modem (further development)

GSM/ GPRS modem can be connected directly to your computer's serial port for wireless GSM communications including sending and receiving text messages. It can also be connected to your remote RS232 serial equipment allowing you to 'dial up' your system for remote management. This includes data loggers such as Data Taker and Pace Scientific. GPRS connectivity also allows you to integrate this modem in your application for an 'always on' remote management system. Available with a built-in TCP/IP stack and you can easily create software to interface to the modem over your standard internet connection. [10]

Features:

- Supporting both English and Chinese SMS data communication
- Supporting 900/1800/1900 MHz Tri band
- Status lights indication
- Supporting AT Command Set
- Serial port interface
- Sim Card holder available

3.5   Software used

The two sotware used are XCTU and Arduino Programming Language. These software can be downloaded online and it is a freeware; no license needed.

3.5.1   *X-CTU*

It is software used to program the transmitter and the receiver for the Zigbee. Using this software would make the two of the Zigbee interacting wirelessly. Fig. 4 shows the image of the XCTU software.
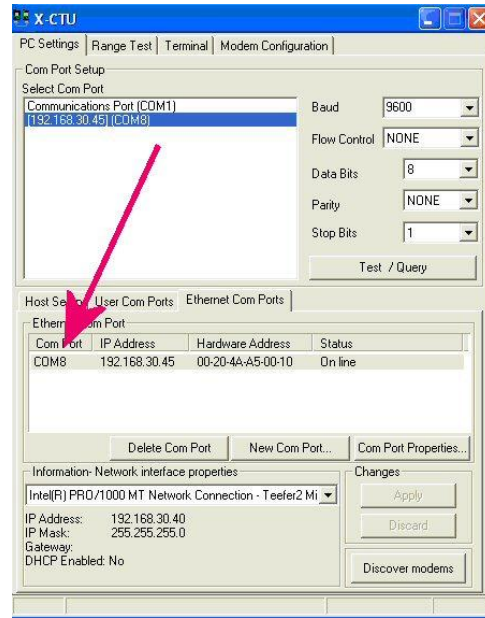
Figure 4: Image of X-CTU Software

3.5.2 Arduino software

This software is design specifically for the use of Arduino. It is very user friendly as some of the commands already given in the example for the user to try it out. Fig. 5 shows the image of the Arduino Programming Language software.

Figure 5: Image of Arduino Programming Language Software

Chapter 4

RESULTS & DISCUSSION

4.1 Chapter Overview

This chapter includes the results obtained from the prototype during the two semesters. Below shows the method to generate the pulse and the coding that is used in programming the microcontroller. Some of the example is listed below in making the foundation or all the processes.

4.2 Pulsating data for representing meter reader

From the discussed method on how to transmit the data, first the author have design to simulate the process of counting pulse like the one in the meter reader. In meter reader, the kWh is count based on the pulse counted. There are several devices having to count up to 1000 pulses then it will increase the kWh value. It is up to the program embedded inside the meter reader until what pulse would only it increase the value of the kWh. For this case, the author has decided to demonstrate the device to count up to 30 pulses would it increase the value of 1kWh.

To do this, the author decided to use 555 timer IC in making the pulses. There are many uses for 555 timer. The purpose of the author uses the 555 timer due to the pulse made by the timer is accurate as using the crystal clock. If the clock is used, the pulse generated could not be altered by any means. In this case would be hard to show the pulse in making it faster or slower. When using the actual meter, the meter will have a

closer time if the loads attached to it are increased and vice versa.
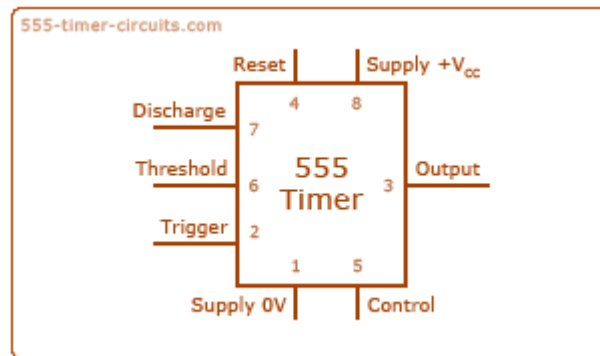

Figure 6: 555 timer configuration pin

The pin for the 555 timer is and it is often drawn like the one shown above. Notice how the pins are not in the same order as the actual chip, this is because it is much easier to recognize the function of each pin, and makes drawing circuit diagrams much easier.

There are three modes for the 555 timer. Those are:

- **Monostable mode**

  For this function, it is a "one shot". Its' output would only exist when the input pin is trigger. After the triggering would only the output be exist. Such applications are used such as in timers, missing pulse detection, bounce free switches, touch switches, frequency divider, capacitance measurement, pulse-width modulation (PWM).
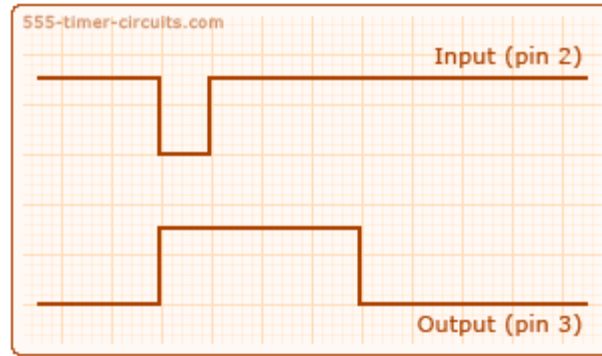
Figure 7: Monostable mode of 555 timer

- **Astable**

  It is like a clock where the 0 and 1 is alternating continuously. It would also be like an oscillator. Oscillating repeatedly like the one in clock. Such a mode is used in many applications such as LED and lamp flashers, pulse generation, logic clocks, tone generation, security alarms, and pulse position modulation.
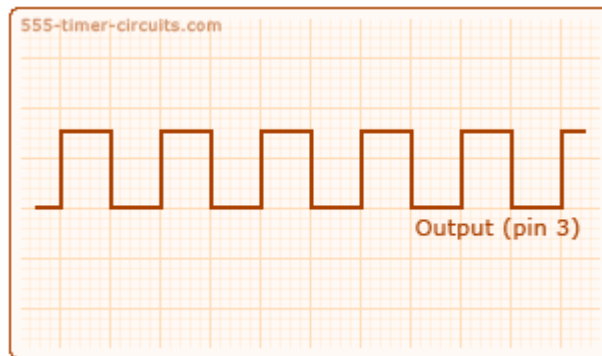

Figure 8: Astable mode for 555 timer

- **Bistable mode**

  It is also known as Schmitt trigger. The term of flip flop could be only described as the mode for this. It is likely to have 2 inputs for this to work. This two inputs

act as triggering button and reset button. The modes such as this application is applied are bounce free latched switches.
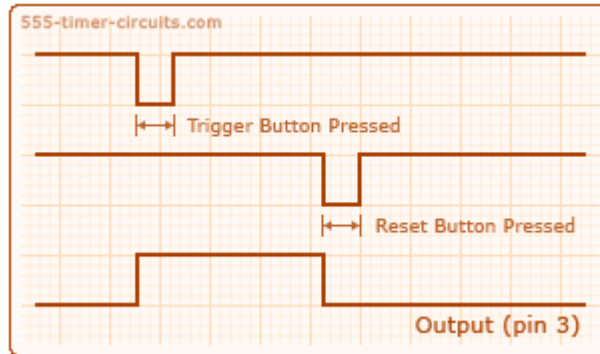

Figure 9: Bistable mode for 555 timer

For this project, the mode that the author will be using is Astable mode; the second mode from the listed modes above. This is because the pulse needs to be continuous. The other two methods would not make the continuous pulse. Therefore, the other two is rejected. Reconsider in using the bistable mode for the resetting part.

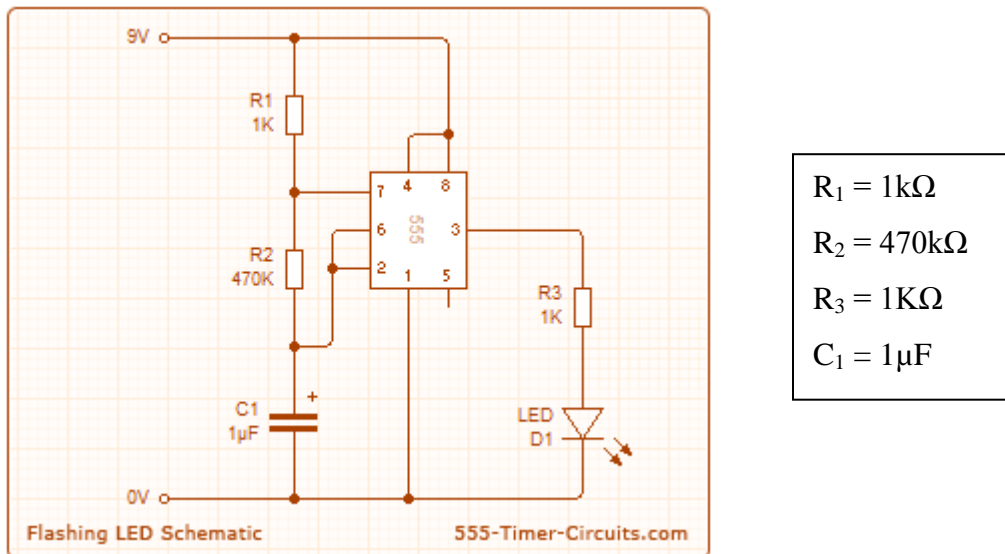The schematic diagram and the result are shown below:

$R_1 = 1k\Omega$

$R_2 = 470k\Omega$

$R_3 = 1K\Omega$

$C_1 = 1\mu F$

Figure 10: Schematic diagram of pulsating circuit
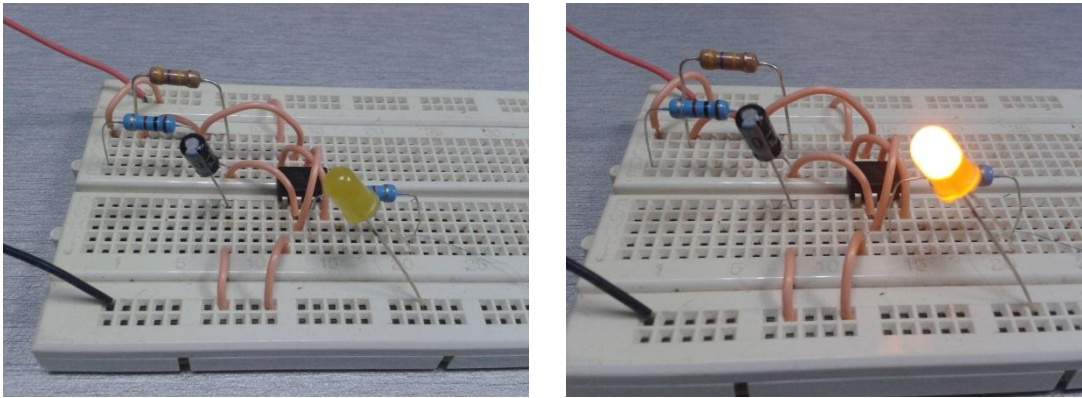
There are several equations with regards to this astable circuit that the author will be designing. Those equations are listed as below:

Time when it is HIGH state, $T_H(s) = 0.693(R_1 + R_2) \cdot C$

Time when it is in LOW state, $T_L(s) = 0.693 \cdot R_2 \cdot C$

Frequency of the device, $F(Hz) = 1.44/\big((R_1 + R_2 + R_2)C\big)$

Duty cycle percentage $DCP\,(\%) = \big(T_H/(T_H + T_L)\big) \cdot 100$

4.3   Pulse architecture

For the design of the pulse, below is the architecture to make it easier understanding on the process flow.
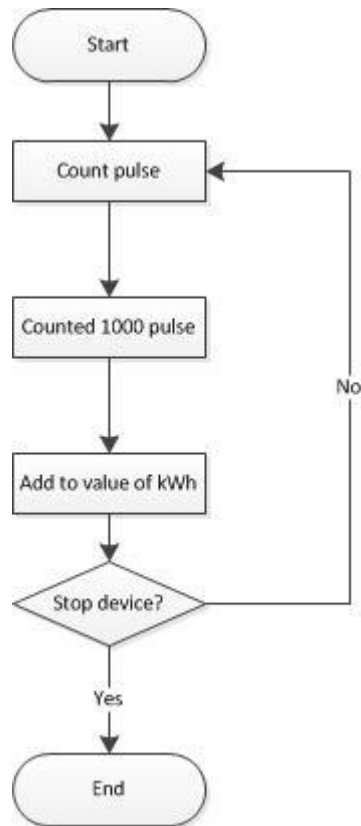
Figure 12: Architecture for pulsating circuit

4.4 Coding

For the coding part of the prototype, there are many examples that the author can use to develop this product. There are 3 major examples that the author have taken in order to make the coding for his prototype. Those are:

4.4.1 *The display on LCD project*

For the display of the LCD for this project, the author tries to familiarize with some of the example that can be found in the internet. The best example that is available is such as the one given below. From this example, it will display 'hello, World!'. The author tries to implement this example to display the value of kWh of the prototype after 10

successful counts of the pulse. The code for the example is as below:

```
// library code in the memory of the microcontroller
#include <LiquidCrystal.h>

// initializing the library with the numbers of the interface pins
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

void setup() {
  // no. of columns and rows are set up for the LCD:
  lcd.begin(16, 2);
  // Print a message to the LCD.
  lcd.print("hello, world!");
}

void loop() {
  // set the cursor to column 0, line 1
  // (note: line 1 is the second row, since counting begins with 0):
  lcd.setCursor(0, 1);
  // print the number of seconds since reset:
  lcd.print(millis()/1000);
}
```

4.4.2 *The pulsating input*

For the major coding of the device is to count the pulses. By these pulses, it is then display onto the LCD display. The example that I have found in the web is to count the Rotation Per Minute (RPM). Such example is used inside a motor that rotates to calculate the speed of the moving motor. In the example, it is given that after 1800 or more pulses is obtained it will do something. This part is left blank so that the one that wanted to use this coding may add up later. The code is as below:

```
#define PPR 5  //encoder PPR

int RPM=0;     //Calculated RPM
int rpmPin=5;
int rpmStateLast = LOW;

void setup() {
  pinMode(rpmPin,INPUT);
}
```

```
void loop() {


 if (digitalRead(rpmPin)==HIGH) {
  if (rpmStateLast==LOW) {
       rpmStateLast=HIGH;
       CalcRPM();
   }
 } else {
  rpmStateLast=LOW;
 }


 if(RPM>=1800) {
   //do stuff
 }
}

void CalcRPM() {
 static unsigned long oldTime;
 unsigned long currentTime;
 unsigned long deltaTime;

 //calculate the RPM and store it
 currentTime=micros();
 deltaTime=currentTime-oldTime;
 RPM=(1000000/PPR)/deltaTime;

 //record the old time
 oldTime=currentTime;
}
```

4.4.3 *The Xbee transferring data*

For the data transferring part of the Xbee, the coding below is the best that the author could find in the web. The coding is based on the temperature sensor that senses the temperature and then keeps on sending the data to the computer through Xbee as a transfer medium. The coding is as below:

```
int temp_analogpin = A0 ;
int LED = 2 ;
```

```
void loop()
{

 int temp_value, LED_trigger;

 temp_value = analogRead (temp_analogPin) ;
 temp_value = temp_value/2 ;

 Serial.print("Current Temperature:") ;
 Serial.println(temp_value) ;

 Serial.print ("LED (ON = 1) (OFF = 0) ;") ;
 while (!Serial. available()) ;
 Serial.println() ;
 LED_trigger = Serial.read() ;
 LED_trigger = LED_trigger – 48 ;
   if (LED_trigger == 1)digitalWrite(LED,HIGH) ;
   if (LED_trigger == 0)digitalWrite(LED,LOW) ;

   }
```

4.4.4 *The final coding for the prototype*

The final coding for the prototype is still in the process as the coding is not yet finalize.

The coding is the combination of these 3 codings. The coding is as follow:

```
#include <SoftwareSerial.h> //include software serial library
#include <EEPROM.h> //include eeprom library
#include <LiquidCrystal.h> //include LCD library

 LiquidCrystal lcd (8, 9, 4, 5, 6, 7); //LCD Keypad Shield's input
 SoftwareSerial xbee(0,1); //Tx and Rx pin or Xbee
 const int IMPULSE = 1000; // Enter here the pulses per kWh of electricity meters
 const int long COUNTIMP = 3600000 / IMPULSE * 1000;
 const int SOBUs  = 12; //input pin to calculate the pulse
 int long ElapsedTime = 0;
 int long StartTime = 0;
 int long WATT = 0;
 int long COUNT = 0;
 float KWH;
```

```
int impState = 0;
int lastimpState = 0;


void setup () {
 xbee.begin(9600); //deault baudrate of the xbee
 digitalWrite (SOBUs, INPUT); //read the input
 //digitalWrite (SOBUs, LOW); //read high input only
 beginning();

}

void loop () {

 impState = digitalRead (SOBUs); // pin 2 read

 if (impState != lastimpState) {
  if (impState == HIGH) {

    ElapsedTime = millis () - StartTime;
    StartTime = millis ();
    WATT = COUNTIMP / ElapsedTime;

    COUNT ++; //count the pulses

    KWH = (float) COUNT / IMPULSE; //calculate the kWh

    lcd.clear ();  //clear the LCD screen
    lcd.setCursor (0, 0); //setting the cursor
    lcd.print ("Watt"); //print on the lcd
    lcd.setCursor (9, 0);
    lcd.print (WATT); //print the value of watt

    lcd.setCursor (0, 1);
    lcd.print ("kW / h");
    lcd.setCursor (9, 1);
    lcd.print (KWH);

    xbee.println ("Watt"); //print onto the XCTU
    xbee.println (WATT);
    xbee.println ("kW / h");
    xbee.println (KWH);

    delay (20);
  }
 }
```

```
 lastimpState = impState;
 }

 void beginning ()
{

 lcd.begin (16, 2);  //the initial start up display
 lcd.setCursor(4, 0);
 lcd.print("Welcome to");
 delay(1000);
 lcd.setCursor(6, 1);
 lcd.print("A   M   R");
 delay(1000);

 lcd.clear();
 lcd.setCursor(0, 0);
 lcd.print("Automatic");
 lcd.setCursor(11, 0);
 lcd.print("Meter");
 lcd.setCursor(6, 1);
 lcd.print("Reader");
 delay(3000);

}
```

4.5   Results from completion of the prototype

There are several results that can be shown. It can be categorized to three different groups. Those are:

4.5.1   *Pulsating circuit*

This pulse can be seen on the oscilloscope. The x-axis has shown the time taken for the pulse while the y-axis has shown the value of the pulsating circuit in term of its voltage.
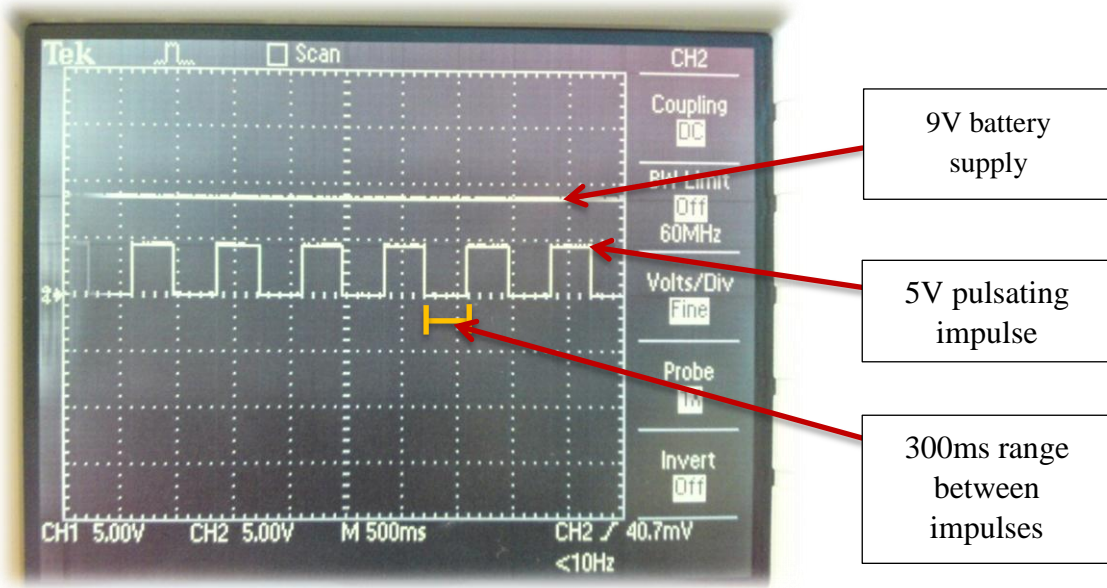
Figure 13: Pulsating circuit viewed under oscilloscope

The time range might be differ if different capacitor is used. This result is based on 1µF capacitor is used. Based on the theory in the earlier part of this paper, it is known for the value of time high, time low, frequency and duty cycle percentage of the circuit.

Time high	= 0.326 s
Time low	= 0.326 s
Frequency	= 1.533 Hz
Duty Cycle Percentage	= 50.053 %

**These values are based on rounded result to three decimal points.

4.5.2 *Result displayed on 16X2 LCD display*

When the microcontroller counts the pulse, it will then display the value onto the LCD display. The result is shown as below:
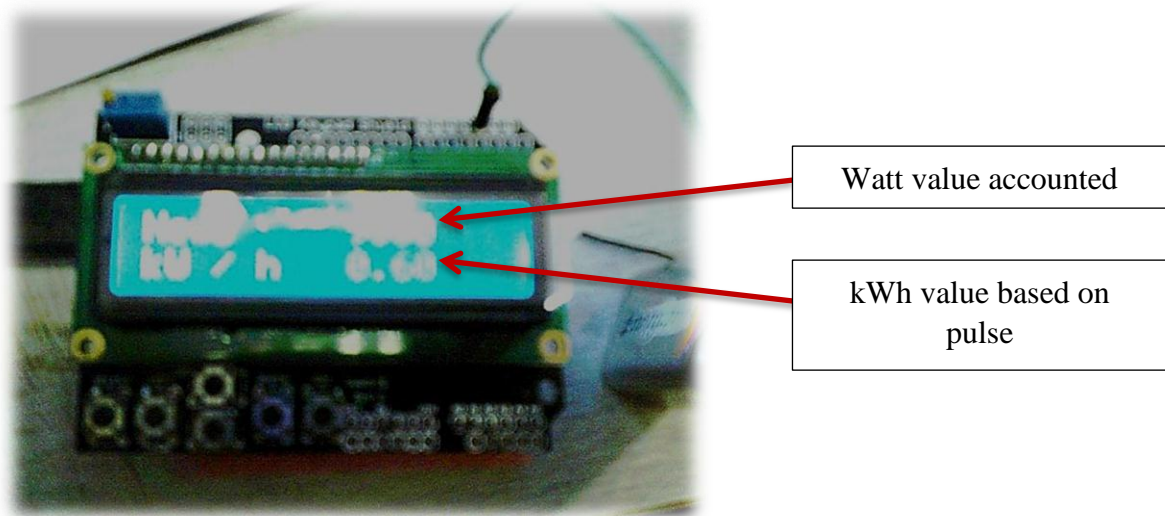
Watt value accounted

kWh value based on pulse

Figure 14: LCD Display after pulse counting

The LCD display will only display the value based on what the microcontroller have calculated using the coding that have been compiled inside the programmable chip. Based on Figure 14, it is shown that it is 0.60 kWh, which meant it had already count for 600 pulses. This is based on 10 pulses will be count as 0.01 kWh. The coding that has been compiled is designed to be like that; 1000 pulses for 1 kWh. We can change the pulses counted per kWh in the coding. After successfully compiled will it be then follow as what we programmed it to be.

4.5.3 *Results transmit wirelessly*

After the result have been displayed onto the LCD, it is then needed or it to be transmitted wirelessly. The software needed is the XCTU while the hardware needed is the Xbee transmitter and receiver. As what the data is displayed onto the LCD, it will also be displayed onto the XCTU software, which is displayed on the laptop screen. Below are the displayed data:
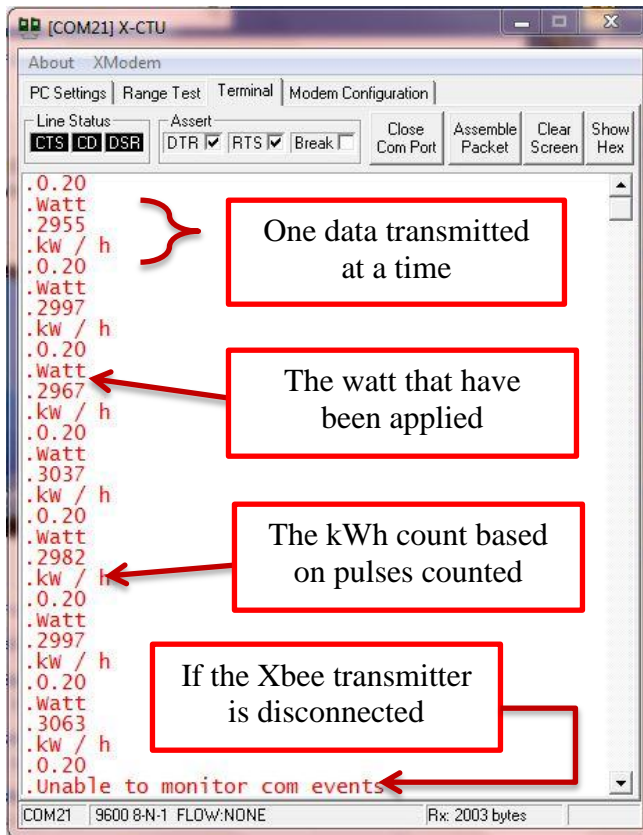
Figure 15: Data displayed on XCTU Sotware

Chapter 5

CONCLUSION & RECOMMENDATIONS

5.1   Conclusion

The main objective of the project is to design a prototype of remote meter reader that is able to transmit data wirelessly. The most important criteria are the programming of the microcontroller. Most of the circuitry part is already been done. Unless changes that will be made in case to add up any extra features. Troubleshooting of the design to make it as our desired one would require better understanding of the programming language which in this case, it is Arduino Programming Language. As stated in the above chapters, the author is trying to program the device. The prototype is finish as what the objectives stated. It is finished in time as per time allocated in the Gantt chart attached.

The author has finished the programming for the counting of the kWh as per what it is hoped to be. The programming is based on 1000 pulses per kWh. Inside the programming also, the pulse can be change is case the meter reader is based on 800 pulses per kWh. The data is successfully transmitted wirelessly. The data is transmitted every second. The transmitted data can also be programmed to transmit the data according to the user preferred time. There are also feature that enable the data to be transmit once it receive the command. For this kind of feature, further development is needed.

5.2   Recommendations

The transmitted signal is only between the two Zigbee devices. It is limited to make a robust network which in this case the data jump from one device to another one to reach maximum length of connectivity. It would be recommended to buy two or three more Zigbee products in order for it to reach maximum length. Increase in the number of transmitting device means increase in the number of pin for programming. The better option to do this is to buy a more input pin for the microcontroller. For the prototype that the author intended to use is Arduino Uno Rev-3 board. Advance applications would need extra input/output pin. Perhaps microcontroller such as Arduino Mega 2560 R3, Arduino Mega ADK or Arduino Mega would better suited the advance application.

For future development, it is recommended to use GSM for data transmission. This is because, it covers a lot more distance rather than off Zigbee that would only cover for up to 1.5km. The only disadvantages in using GSM are that the device would need to use telecommunication network. In order to do this, it will require data to be sent in form of SMS rather than using Zigbee that would cost for the material device only. For Zigbee also, it would have certain boundaries that it cannot be enclosed in an area. That is for Zigbee starter kit that the author uses. If the prototype would be used in the market, the Zigbee pro would be used as it covers more distance and its performance is much greater.

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