SOLAR-POWERED DIGITAL WATER METER WITH WIRELESS CAPABILITY

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This Report Is Submitted In Partial Fulfillment Of Requirements For The Bachelor Degree Of Electronic Engineering (Telecommunication Electronic)

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JUNE 2014

DECLARATION

"I hereby declare that the work in this dissertation is my own except for quotations and summaries which have been duly acknowledged."

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SUPERVISOR DECLARETION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Electronic (Telecommunication Electronic)"

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ACKNOWLEDGEMENT

This thesis has benefited greatly from the support of many people, some of whom I would sincerely like to thank here.

To begin with, I offer my sincerest gratitude to my supervisor, Dr Kok Swee Leong, who has supported me throughout my thesis with his patience and knowledge. I attribute the level of my bachelor degree to his encouragement and effort and without him this thesis, too, would not have been finished or written. One simply could not wish for a better or friendlier supervisor.

I am thankful to Foo Zh Shem who has had very positive influence on me from the very beginning of my studies. His encouragement and full support in making me has confidence in my abilities to not only complete a degree but to complete it with excellence.

Furthermore, I would like to thank to my fellow friends for offering helpful guidance. I offer my regards and blessings to them who supported me in any respect during the completion of the project.

Finally, but first in my heart, I thank my family for supporting me throughout all my studies at University. They taught me the importance of education and always encouraged me to work harder and to take every opportunity in life to finally live my dreams. The education that I was able to enjoy while growing up has proven invaluable.

ABSTRACT

The current analogue water meter is commonly used in most of the residential area for water usage amount reading. However, the water meter are installed in the house is a problematic such that the staff cannot take the water usage reading when there is nobody home. In addition, it has accuracy problem due to incorrect reading taken by staff. To solve this problem, this thesis presents the solar-powered digital water meter with wireless capability to provide wireless access to user water consumption A solar photovoltaic is used to provide sufficient power source to activate the function of this system. The water flow sensor detects the water consumption. An Arduino Uno microcontroller is used for processing the data and the radio frequency 433MHz module acts as data transmission medium. Rechargeable batteries are used to store the energy and power up the system during night time. To validate the system design, the prototype is tested for operations such as water meter sensor accuracy, the charging type time of the rechargeable batteries, the durability of rechargeable batteries and the bit error rate of data transmission. Test results conducted within 15 meters distance between the RF transceiver to send and receive data from micro controlled-digital water meter. As the results, the average accuracy of water meter is 1.58% that has proven the water flow sensor accuracy is within the range of ±3%. The reliability and durability of the rechargeable batteries are proven can support the system for 16 hours without sunlight present. The package loss has increased when the distance becomes longer.

ABSTRAK

Meter air analog biasanya digunakan di kawasan kediaman penduduk untuk mengambil bacaan jumlah air yang digunakan. Walau bagaimanapun, meter air analog dipasangkan di rumah menyebabkan kesusahan petugas syarikat air untuk mengambil bacaan jumlah air yang digunakan apabila tiada orang di rumah dan meter air analog muncul masalah kurang ketepatan oleh sebab kesilapan petugas apabila mengambil bacaan. Jadi, Projek ini memperkenalkan meter air berdigit yang dikendalikan oleh tenaga suria dengan kemampuan wayarles yang berupaya membaca jumlah air yang digunakan. Fotovoltan suria digunakan untuk membekalkan tenaga yang cukup untuk mengaktifkan fungsi sistem ini air melalui sensor yang mengesan kealiran air dan ini akan dijadikan sebagai isyarat input kepada Arduino Uno. Arduino Uno berfungsi sebagai pegawalmikro akan memproseskan isyarat ini dan mengubah kepada jumlah air yang diguna. Modul radio frekueansi 433MHz bertugas sebagai medium penghantaran. Bateri setruman digunakan untuk menyimpan tenaga dan membekalkan tenaga kepada system ini semasa waktu malam. Prototaip ini telah disahkan dengan beberapa unjian seperti ketepatan sensor kealiran air, masa untk mengecas bateri, keutuhan bateri dan kadar ralat bit. Uji kaji dijalankan dalam jarak 15 meters di antara pemancar RF dan penerima untuk menghantar data dari pegawalmikro. Hasilnya, purata nilai ketepatan meter air ialah 1.58% yang dapat membuktikan ketepatan sensor kealiaran air di dalam jangka ±3%. Keutuhan bateri telah disahkan mampu menyumbang kendalian system ini selama 16 jam apabila tiada cahaya matahari.

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ABBREVIATION LIST

mcu	Microcontroller unit
RF	Radio Frequency
PCB	Printed Circuit Board
LCD	Liquid Crystal Display
PV	Photovoltaic
IV	Current Voltage
Ni-CD	Nickel Cadmium
Ni-MH	Nickel Metal Hydride
DC	Direct Current
CAD	Computer-Aided Design
dB	Decibels
LOS	Line-of-sight
dBm	Decibel in milliwatts
AF	Audio frequency
FCC	Federal Communications Commision
USA	United States of America
ISM	Industrial, Scientific and Medical
ASCII	American Standard Code for Information Interchange
TX	Transmitter
RX	Receiver
I/O	Input/output
USB	Universal Serial Bus
GND	Ground
VCC	Voltage at the Common Collector
VEE	Voltage at the Emitter
RS	Register select
R/W	Read/write
EN	Enable
DB	Data byte
LED	Light emitting Diode
L	Liters
IC	Integrated circuit
PIC	Programmable Interface Controller
ASK	Amplitude Shift Keying

CHAPTER I

INTRODUCTION

1.1 BACKGROUND OF STUDY

Today, sustaining the power demand for microelectronics is a vital issue. The energy storage growth has not been able to keep up with the development of microprocessors, memory storage, and wireless technology applications. Supplying sufficient electrical power is one of the major bottlenecks preventing the further miniaturization of microelectronics such as wireless devices. A continuous source of electrical energy to replace existing powering methods without battery recharging periodically would be highly desirable. One method of supplying the required power for small electronic devices is by harvesting the energy available in its operational environment.

Energy harvesting, or energy scavenging as the process is sometimes referred to, is associated with capturing residual energy as a by-product of a natural environmental phenomenon or industrial process and is therefore considered free-energy. Harvesting energy power from environment energy sources is an attractive and progressively more practicable option for several batteries-less micro-scale electronic systems such as microcontroller units (mcu) and wireless sensor nodes that need to operate autonomously for a long periods of times without needed batteries replacement and maintenance. Example of common target energy harvesting source include energy resulting from solar power source[1-2].

Energy harvested from the water flow inside the piping system has the potential to be developed. But the complexity and cost expenditure are more than the solar power. Solar power has the advantages of isolated unit structure and it is easier to obtain as Malaysia is richly endowed by nature, where the mean daily sunshine hours in Malaysia ranges between 4 to 8 hours per day. Thus, Malaysia receives between 4,000 to 5,000Wh per square meter per day. This means, in one day, Malaysia receives enough energy from the Sun to generate 11 years worth of electricity [3]. This is an incredible potential amount of energy into which Malaysia can tap. This high scale power generated by the sun has proven that the workability of the photovoltaic used in smaller power scale device such as digital water meter.

The metering is essential for our modern life. It uses a small scale of power to perform its daily function. The metering system includes water supply, electricity and domestic fuel etc. The charges incurred by a user can be calculated by using a metering system. For current typical metering system, four steps are usually involved. In the first step, a meter records the amount of water and power is consumed by the customer. Then, a worker records the reading of meter for each user. After that, the recorded readings input to a computer system to calculate the charge for each customer. Finally, a bill is generated and mailed to each customer.

Visiting every customer to collect the reading of meter is the current majority approach for metering. These utility staffers come to home by home to read the installed analogue water meter that shows the cubic meters consumed, and this reading is used to compile a bill to send to users. Although the current approach has been used for very long time, this system is problematic in such a way that meter reading is often complicated by the absence of tenants who are working during the day and lock their gates or doors so that utility staff cannot get access to the water-meters. Hence, it obtains room to improve. First, more manpower is required for current systems because all customers are visited regularly to collect the readings. Secondly, the process is time consuming because the data collection may not be completed in first visit. Finally, accuracy cannot be assured due to human error of incorrect readings [3].

This project presents a solar-powered digital water meter with wireless capability. The solar power does not require wiring installation and is isolated unit that is easy to use and implement. Such convenient power source could eliminate the need for maintenance. Hence, the solar-powered digital water meter has high potential to replace the current battery based digital water meter where the batteries required.

The system design consists of a photovoltaic solar with rechargeable battery, water flow sensor, Arduino Uno and 433MHz radio frequency module. The sunlight is converted into useful electric energy which is stored in battery to power up the Arduino Uno. The water usage reading will be transmitted to the water meter reading by using the 433MHz RF transceiver. During the night, the recharged battery replaces the function of photovoltaic solar to continue powering up the Arduino Uno to function. This project is to improvise the analogue water meter towards intelligent wireless digital water meter by using photovoltaic solar as power source.

1.2 OBJECTIVES

The objectives of the projects are:

1. To fabricate the PCB for the solar charger circuit and the microcontroller based digital water meter with wireless capability system.
2. To improve the accuracy of water meter by replacing the analogue water meter with digital water meter.
3. To test the complete system as a lab based scale experiment.
4. To analysis the result obtained.

1.3 PROBLEM STATEMENT

Figure 1.1: A typical water meter register showing a meter reading of 8.3 gallons. Notice the black "1" on the odometer has not yet fully turned over, so the red hand is read in its place.

Flow meters typically contain multiple components that introduce error into the flow measurement system. A simple flow measurement system may be comprised of a primary flow element and a transmitter that processes signals from the primary flow element. Sometimes the primary flow element and transmitter are physically integrated together as one piece, such as in potable water meters. More complicated flow measurement systems may include multiple components such as a flow computer or other electronic components for processing pressure, temperature, or others parameters.

It should not be forgotten that flow measurement systems are “systems” that measure flow. As an example, consider a hypothetical primary flow element that exhibits no error while the transmitter exhibits 5 percent accuracy. In this exaggerated example, the accuracy of the flow measurement system will be 5 percent. Assuming the flow measurement error is that of the primary flow element only is an error of omission. Users should constantly be on guard to identify this type of error.

In most flow meters, the primary flow element and transmitter are integrated electronically. For example, the wetted primary flow elements of mass flow meters, thermal flow meters, and magnetic flow meters are virtually useless without transmitters that contain their respective flow measurement algorithms and drivers. Therefore, flow meter performance typically includes the combination of a primary flow element and a transmitter. Further, the performance of most flow meters is predicated on the calibrated output that is usually the pulse/frequency output of the transmitter.

However, most process control applications of flow meters involve the use of an analogue output such as 4-20mA to represent 0-100 percent of the desired flow rate. The analogue signal is typically generated using circuits that convert the pulse or frequency signal to an analogue signal. This conversion introduces a measurement error that is constant throughout the signal range, so it can usually be expressed as a percent of full scale. The error introduced is typically between 0.03 and 0.10 percent of full scale, depending on the quality of the converter. To obtain the measurement accuracy of the analogue output, this error is mathematically added to the accuracy of the flow meter.

The analogue output error may seem small, but at low flow rates, this error can become significant and actually dominate measurement accuracy. For example, consider a vortex shedding flow meter that can operate from 10 to 100 units per minute with 0.75 percent of rate accuracy but has an analogue output accuracy of 0.10 percent of full scale. At 10 units per minute, the pulse/frequency output has an accuracy of 0.75 percent of rate, whereas the analogue output contributes an additional (0.1*100/10) or 1.00 percent rate error, so the measurement accuracy of the analogue output is 1.75 percent of rate [4].

1.4 SCOPE

The scope of the project are to;

- Fabricate a solar-powered digital water meter based on photovoltaic cell to produce 5Vdc to supply electricity to the water flow sensor and 5V Arduino Uno microcontroller;
- Off-the shelf Water flow sensor model YF-S201 from Sea water company is used;
- Use off-the shelf 433MHz model FS1000A radio frequency transmitter and receiver module.
- Use four AA 1.2v nickel metal hydride rechargeable batteries with capacity og 1800mAh.
- Multisim is used to simulate the circuit and Proteus is used for PCB design;
- Conduct the test within a range of 5 meters;
- Assume test is under the ideal condition where the sunlight is shining during day light;
- The prototype is tested on the lab based scale;
- Flow rate of the water will not be covered.

1.5 SIGNIFICANT OF THE PROJECT

The solar-powered digital water meter with photovoltaic cell based is an eco friendly device and could be identified as an add-on value to the residential households. The utility staff shall compile the bill to the unit easily with a portable meter reading. The advantages are:

- Customers can get rid of the accumulated reading due to incorrect reading;
- Improve the efficiency and accuracy of metering; and
- Wireless capability enables the staff to access the water usage reading in anytime.
- Integration of wireless and costless radio frequency where wireless to use to transmit the data and costless is the wireless transmission requiring no cost.

1.6 THESIS STRUCTURE

This thesis consists of five chapters, which are Chapter 1, 2, 3, 4 and 5. Chapter 1 includes the background of study, problem statements, objectives, scope and significant of the project.

Chapter 2 is about literature review of this project. This chapter studies the background and the fundamental knowledge of photovoltaic solar and solar charger circuit. The types of rechargeable batteries and the charging rate of different types of rechargeable batteries are briefly introduced. This is followed by introducing to the fundamental of digital water meter, Arduino Uno, radio frequency communication, radio frequency 433MHz module and lastly the LCD display introduction.

For Chapter 3, it is about to explain the process of undergoing this project. This chapter consists of two parts, which are hardware development and software implement. The solar charger circuit and the coding configuration are developed with the aid of flowchart. The system test performance process also discussed and procedures are carried out in this chapter.

Chapter 4 describes about the observation results and discussions on these results. the test of determination on the accuracy of water flow sensor are measured and discussed. The durability of rechargeable batteries is characterized for with load, without load and without transmission, total of three conditions. The packages loss of the data transmission is discussed in the end of this chapter.

Chapter 5 concludes this thesis project followed by recommending some suggestions for the future works.

CHAPTER II

LITERATURE REVIEW

2.1 BACKGROUND OF PROJECT

Current water meter system in Malaysia is based the collecting water amount used shown on the analogue water meter by water supply corporation of each state. The price of each cubic metre (m^3) is according to the price set by the water corporation of each state as well. Water meters are an important component of a local drinking water utility for a number of reasons. They allow the utility to:

a) charge customers for the volume of water used;
b) monitor the total amount of water produced and sent to the distribution system, and;
c) detect and fix leaks in the distribution system.

They allow the customer to:

a) monitor the volume of water they are using;
b) have some control over their water bill;
c) detect and fix leaks at their location, and;
d) take measurement to conserve water.

Accurate metering is also required for effective accounting and rate making, to identify and study peak and non-peak water use, verification of water and cost savings, the implementation of water efficiency and conservation measures, to allow the utility to make informed decisions on operations, maintenance, capital investment, and customer service, and to facilitate and improve management of the water utility.

Water meters are not perfect instruments, and do not always provides accurate measurements. Over time, as the meter ages, wear and tear on the components and the accumulation of sediment, lime scale, and impurities reduces the accuracy of the meter [5]. The accuracy vulnerabilities of the analogue water reading taken as resulted. Hence, the potential development of wireless digital water meter with solar-powered has the capability to provide accuracy, precise and efficient water meter reading and capacity for innovation in Green Technology development with the use of photovoltaic solar to power up the system.

2.1 PHOTOVOLTAIC SOLAR

Solar energy is produced from sunlight shining on photovoltaic solar panels. Solar panel is always referring to photovoltaic solar, or PV cell. Individual solar cells typically only generate tiny amounts of electricity energy. To make useful amounts of electricity, these cells are connected together to make a solar module, otherwise known as a solar panel or, to be more precise, a photovoltaic module.

Photovoltaic is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Solar cells generate most of their electricity directly from sunlight. However, they also generate electricity on cloudy days and some systems can even generate very small amount of electricity on bright moonlit nights.

A solar photovoltaic is a low-carbon electricity generator: the sunlight is free and the system maintenance is extremely low. Solar cells work as light-dependent current generators. While the open-circuit output voltage depends only relatively slightly on illumination over decades, the short-circuit current varies directly proportional to light intensity and solar cell area. The delivered power is however not quite linear. It is slightly reduced due to its voltage dependence and internal peripheral leakage currents. These effects become more considerable the smaller the cell area and lower the light intensity. Brightness is the term that describes how intense a light source is perceived by the human eye and is measured in lux (lx) [7].

2.2 SOLAR CHRGER CIRCUIT THEORY

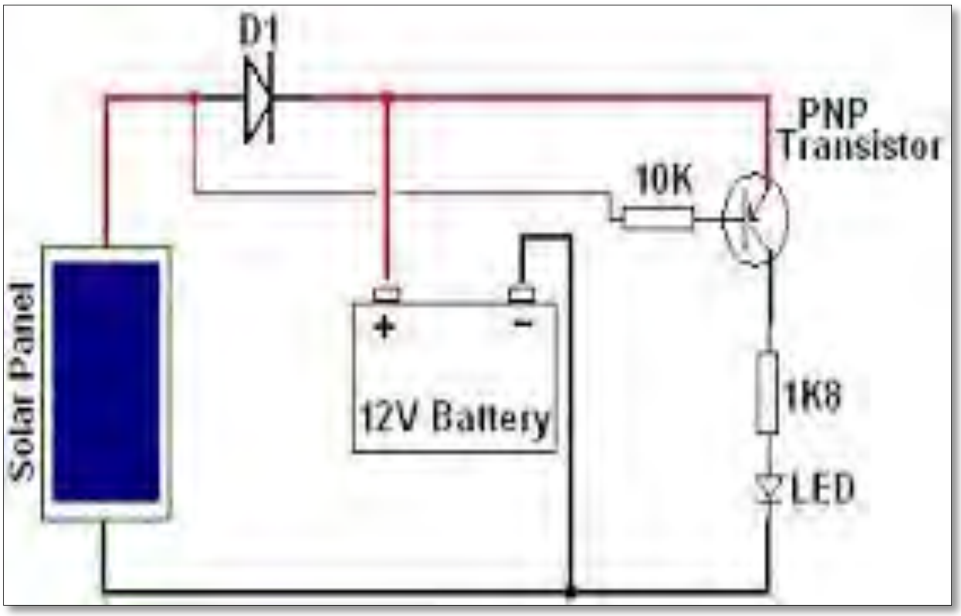

Figure 2.1: Typical solar charger circuit.

In energy harvesting systems, an energy buffer is used to store the intermittently energy available from the energy harvester. The stored energy is then used to power the system. The commonly used energy buffers include rechargeable batteries of different chemistries, as well as super capacitors.

Solar cells are inherently inefficient devices, but they do have a point of maximum power output, so operating at that point seems an obvious design goal. The problem is that the IV characteristic of maximum output power changes with illumination. A monocrystalline solar cell's output current is proportional to light intensity, while its voltage at maximum power output is relatively constant , as can be seen from Figure 2.1.