

SUPERVISOR ENDORSEMENT

“ I hereby declare that I have read through this report entitle “Energy Meter Data Logging System With Real-Time Clock And kWh Readings” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)”

Signature :

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Date :

**ENERGY METER DATA LOGGING SYSTEM WITH REAL-TIME CLOCK AND
KWH READINGS**

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**A report submitted in partial fulfillment of the requirements for the degree
of Electrical Engineering(Control, Instrumentation and Automation)**

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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I declare that this report entitle “title of the project” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name :

Date :

To my beloved family

ACKNOWLEDGEMENT

My greatest heartfelt appreciation and gratitude to my family, project supervisor, lecturers and friends that so hard give me encouragement, guidance and criticism in this project fulfillment. Not to forget, my panel that very patient in marking my report. Thank you very much to all.

ABSTRACT

The energy meter or kWh meter are use to measure the energy that has been used by the consumer. The existing system use the analog and digital energy meter, that only measure and display energy consumption in unit value, not displaying in real-time value. It also not saves the history of consumption if any analyzing is needed. Refer to that problems this project can improve the system by displaying the real-time usage of energy and display it in kWh then sent the logged data to the memory. The logged data from memory can also be viewed in GUI and then analyze if needed. The microcontroller is use to process the input signal from the sensor that measure the energy. While for display device, the generic serial LCD is used. Logging data is stored in computer hard disk and a Hall Effect sensor is use to capture the energy. The USB converter is also integrated so it can communicate with computer. The interface to display the logging data is created using computer GUI that can also display energy graph. The real time energy graph is very useful in making analysis because the different in usage can be easily spotted, so user can make appropriate action in order to use energy efficiently.

ABSTRAK

Meter tenaga atau meter kWj digunakan untuk mengukur tenaga yang telah digunakan oleh pengguna. Sistem yang sedia ada menggunakan tenaga meter analog dan digital, yang hanya ukuran dan penggunaan tenaga paparan nilai seunit, tidak memaparkan pada masa sebenar. Ia juga tidak menyimpan sejarah penggunaan jika analisis diperlukan. Merujuk kepada masalah yang projek ini boleh memperbaiki sistem dengan memaparkan penggunaan masa sebenar tenaga dan memaparkan dalam kWh, kemudiannya dihantar data yang dilog kepada memori komputer. Data yang disimpan boleh dilihat dalam GUI dan kemudian dianalisis jika perlu. Mikropengawal digunakan untuk memproses isyarat masukan daripada sensor yang mengukur tenaga. Manakala bagi peranti paparan, LCD siri generik digunakan. Data disimpan dalam cakera keras komputer dan sensor Hall Effect digunakan untuk menangkap tenaga. Penukar USB juga digunakan supaya ia boleh berkomunikasi dengan komputer. Antara muka untuk memaparkan data kegunaan tenaga dicipta menggunakan komputer GUI yang juga boleh memaparkan graf tenaga. Graf tenaga masa nyata adalah sangat berguna dalam membuat analisis kerana perbezaan dalam penggunaan mudah dikesan, jadi pengguna boleh membuat tindakan yang sewajarnya untuk menggunakan tenaga dengan cekap.

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LIST OF ABBREVIATIONS

EEPROM – Electrically Erasable Programmable Read-Only Memory

LCD – Liquid Crystal Display

GUI – Graphic user Interface

USB – Universal Serial Bus

UART – Universal Asynchronous Receive/Transmit

KWh – Kilo Watt Hour

PIC - Programmable Interrupt Controller

GSM - Global System for Mobile Communications

V – Volt

R – Resistance

A – Amps

W – Watt

M – Mega

Imp – impulse

IDE - Integrated Drive Electronics

ICSP - In-circuit serial programming

COM - Component Object Mode

CHAPTER 1

INTRODUCTION

1.0 Project Background

Energy Meter data logger is energy monitoring devices that easy to use for analyzing the energy consumption on electrical appliance. This device records data over time and store it in EEPROM before sending the data to computer for monitoring process. Furthermore, it also displays the energy consumption in real time via 16x2 serial LCD. It is very useful for monitoring efficiency of the electrical usage so people do not waste the energy. The element of data logging system for this project is shows in Figure 1.0.

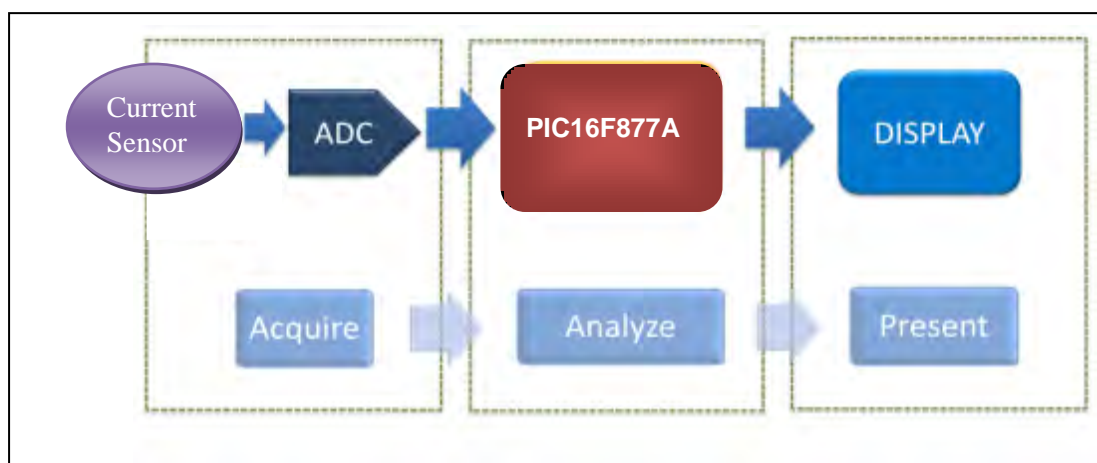


Figure 1.0 Element of data logging system

The Energy Meter Data Logger can detect the unseen fault in appliance such overloading. It will display increasing in energy consumption directly to the LCD and computer. A faulty appliance can cause by several effect mainly in motor powered appliance like washing machine.

The designed GUI can shows user the appropriate graph, so it easier to see if the energy usage are increasing. The GUI takes the reading from the sensor via USB-UART converter, then process the reading to generate energy graph. The communication between hardware and computer are establish using computer Hyper-Terminal link that read the data from hardware. This energy meter can act as precaution device that tells user the state of their appliance. User can repair their appliance before it's too late because they have been warned by the spiking in energy usage by the faulty appliance.

1.1 Problem Statement

The conventional Energy Meter only display numbers that must be calculated later to get the actual energy usage. Because of this the consumer do not aware of their energy usage and will use it unintentionally although the energy usage is exceeded their monthly expectation.

As the consumers do not know their energy usage, they only know the usage at the end of the month and nothing they can do to overcome this problem. This problem can affect more to the consumer that has big family with so many appliances running at once.

The energy meter also cannot record the energy usage that can be monitored by consumer in order to prevent over consuming the energy. They also cannot analyze the energy consumption if some faulty appliance making energy usage higher than it should.

1.2 Project Objective

1. The first objective of this project is to design a device and system that can display energy usage in real-time in kWh unit. The data from the energy meter can also be display in computer using serial communication.
2. Then, to record energy usages in user residence so the energy consumption in that residence can be monitored in order to use energy efficiently. The recording or logging process is controlled by the PIC and the data taken is stored in EEPROM. The data can be access using computer interface generated by Microsoft Visual Basic.
3. The appropriate graph can be also generated to give user more clearer view of their energy consumption. This graph will analyze and evaluate of the total energy consumption a lot easier. The accomplishing in building this system can surely make user more aware and effective in using electrical energy.

1.3 Project Scope

The scope of this project will cover both software and hardware development. The hardware part is about designing suitable circuit, Printed Circuit Board(PCB) layout and also include the correct component to make the hardware work as desired. After completing assembles the component, hardware test is needed to confirm it functionality.

While for software development, it will include developing the system coding using MikroC for the microcontroller. The system coding must correctly integrated with the project input/output component such sensors and LCD display. Proteus 7.1 were used as simulation software for both hardware and software development.

Then, the interface for the computer to displaying the data from project memory is created using Microsoft Visual Basic 2008. The interface must properly in sync with the hardware so it can read the data. The software such HyperTerminal, PicKit and its driver also needed in order to make the interface working.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This literature reviews give the basic idea and information of other already done project that has similarity to my project. It also reviews the related hardware and software theory that need to be use in Energy Meter Data Logger Project.

The digital energy meter or kWh meter developments are very important for today energy monitoring or metering to measure the usage of energy that has been use for the specific costumer. To maintain the accuracy that energy had been used, a proper system must be made so it can measure accurately within time to time with minimal error. The energy meter system must have both single phase measurement and three phase measurement for higher energy usage facilities.

2.1.1 Single Phase Microcontroller Based Energy Meter

Based on this project its totally electronic single phase energy meter for residential use and using the Microchip Technology Inc PIC family to do it. The design takes into consideration the correct operation in the event of an outage or brown out, by recording the energy consumption in EEPROM memories internally available in the microcontroller. By using the EEPROM memory, after the energy supply restored from failure the meter can gather back the data taken before the supply failure so the data can be use to display the

overall energy consumption. The basis equation for calculating the energy for interval $\Delta t = (t_2 - t_1)$ is given below:[1]

$$E = \int_{t_1}^{t_2} v(t)i(t)dt \quad (2.1)$$

The A/D converter for microchip use in this project is 8 bits and the sampling frequency of 1,082kHz. While energy measured are compared with reference value (E_{ref}), for 1kW load and 100 period of 924 μ s the E_{ref} is given below:

$$E_{ref} = \frac{100 \cdot 924\mu s \cdot 1000W}{3600s} = 0.00002567kWh \quad (2.2)$$

While voltage measuring and sensing circuit, they use basic voltage divider circuit as show in Figure 2.1 and second order low pass filter to eliminate any DC component offset [1].

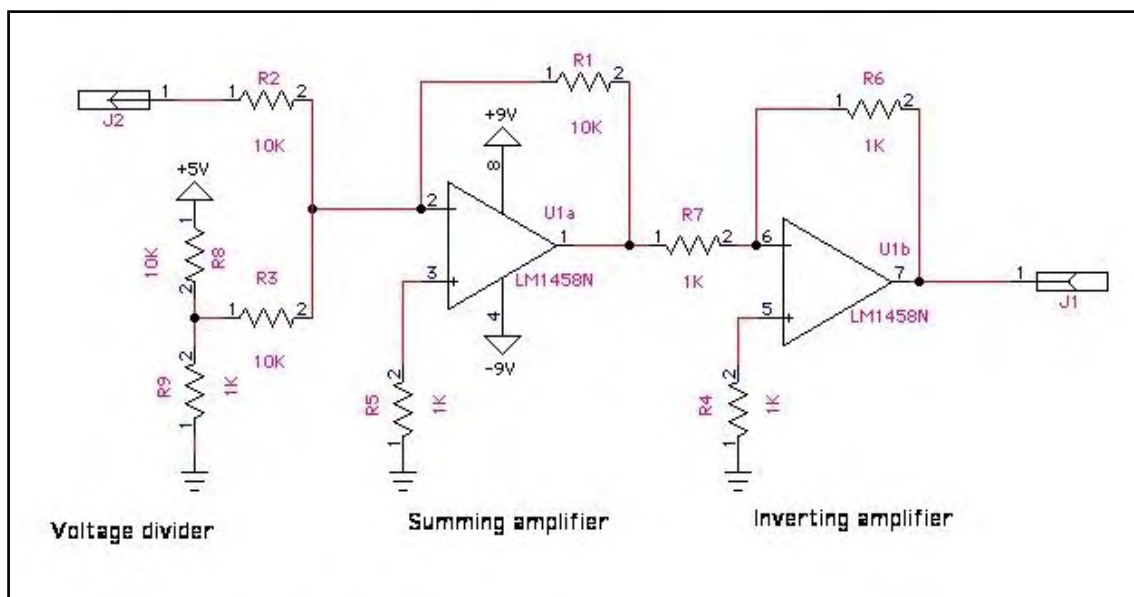


Figure 2.1 Voltage Sensing Circuit [1]

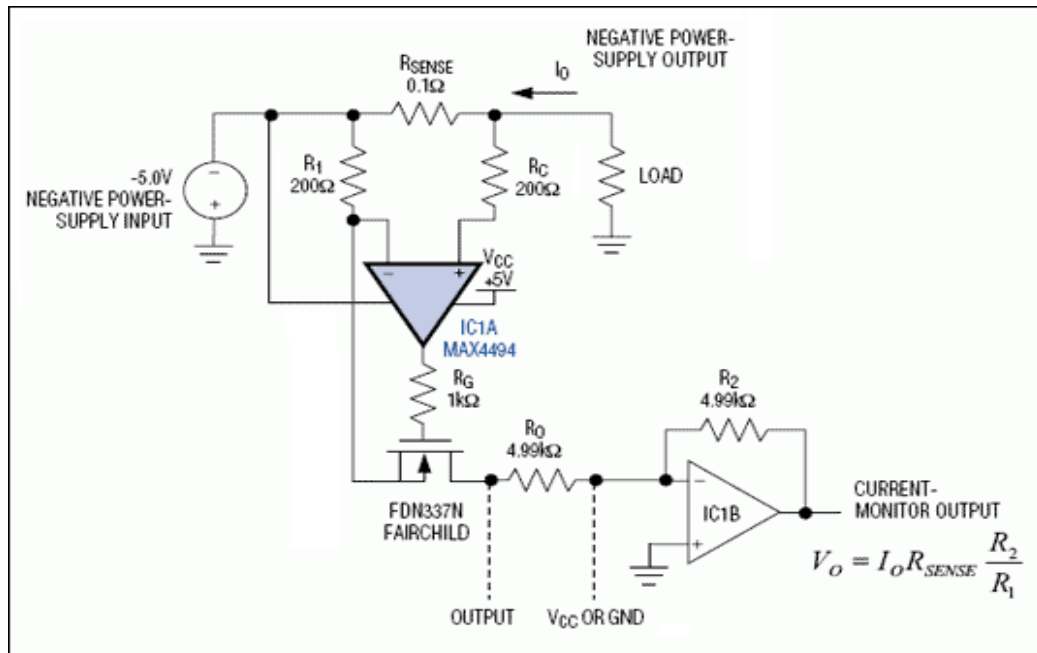


Figure 2.2 Current Sensing Circuit [1]

To measure current, the operational amplifier circuit in Figure 2.2 is used. Other circuits that are used for this project such as Oscillator circuit for determining the PIC clock frequency. Then, Supply voltage level detector also needed to enable the EEPROM memory when the supply voltage to PIC is drop less than 4.2V so the energy consumption can be stored to the memory. The Disabling circuit are also used to shut down the PIC if supply voltage becomes less than pre-defined level to prevent PIC from working in low voltage level. After the project has completely done the hardware must be tested and the result are shows in Table 2.1.

Table 2.1 Meter Precision Test Result [1]

Load	Actual Time	Measured Time	Error (%)
1kW	3600s	3643s	1.19
0.75kW	4800s	4769s	0.65
0.5kW	7200s	7304s	1.44
0.33kW	10800s	10855s	0.5
0.25W	14400s	14635s	1.63
0W*	36s	36.01	0.03

The precision experimentally obtained for this new meter better than 97%. This value is compatible with the electromechanical meters in the market. In addition, the process of reading the energy consumption is facilitated by the four-digit display, which is simpler than the analog meters. The calibration process is implemented by using a RS232 interface from any microcomputer that runs the Windows Terminal program. This communication form is simple, since it makes use of the basic configuration available in the microcomputers [1].

2.1.2 Data Logging Solution for Digital Signal Processors

By using the Digital Signal Processors (DSPs), the most powerful processor of the world with clock speed up to 1Ghz. The specification for this project they choose the DSK6416T, a starter kit from TI based around the 6416T DSP. The 6416T is a 1 GHz fixed point DSP with 1 MB of onboard RAM. The 6416T also has three multi-channel buffered serial ports (McBSPs) that can implement an SPI interface. The signal processing algorithms that are used to analyze such data are complex and can be difficult to debug if results are not as expected. Having the ability to store the data that is being analyzed by the DSP allows for post processing of data so that the algorithm can be perfected outside of actual testing conditions. This capability of "playback" can drastically reduce the time and cost of system testing [2]. Figure 2.3 below shows the system block of data logging [2].

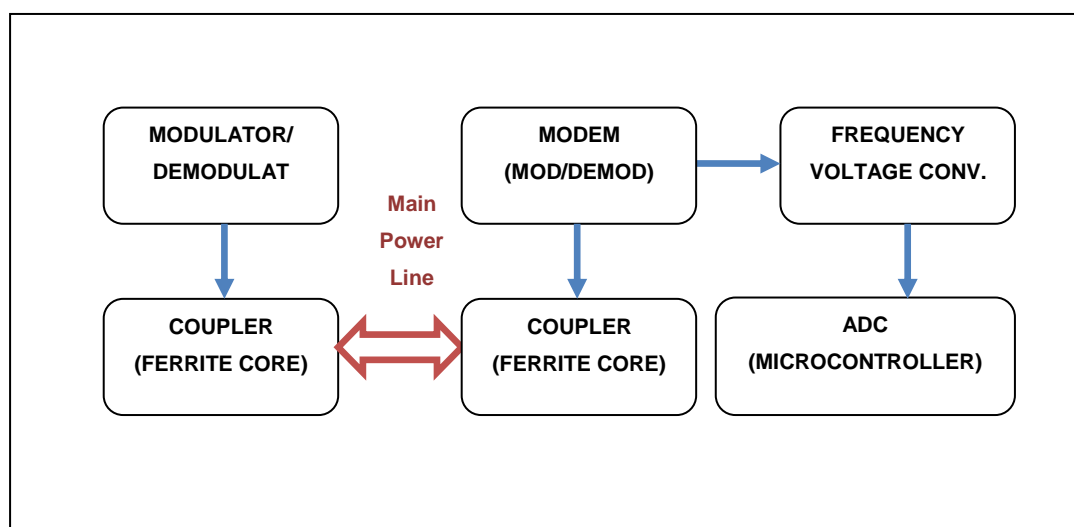


Figure 2.3 Block diagram of Data Logging system [2]

2.1.3 Electronic Energy Meter with Instant Billing

Using postpaid concept which automatically disconnects the power line when it reaches the set value seems quite interesting, they use hardware Figure 2.4 to accomplish this system.

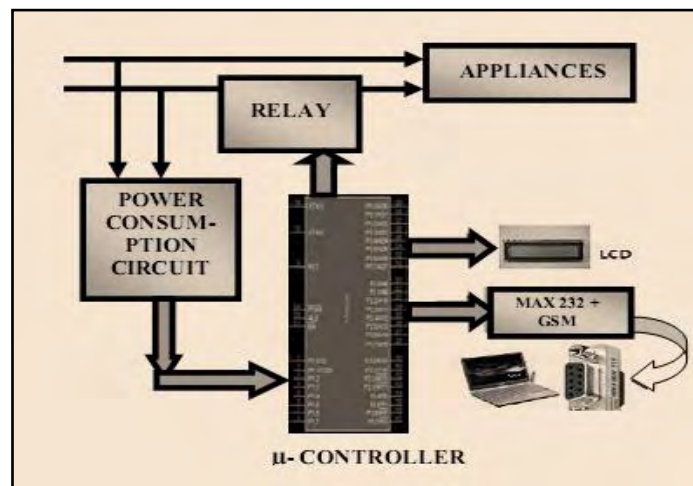


Figure 2.4 Hardware Circuit For Instant Billing [3].

Refer to Figure 2.4 above, every house has separate number of the energy meter corresponding to authority and using MAX 232 connector to enable the microcontroller sent a message to a predefined phone number. It must also need the GSM module to achieve this task, the schematic on Figure 2.5 is used.

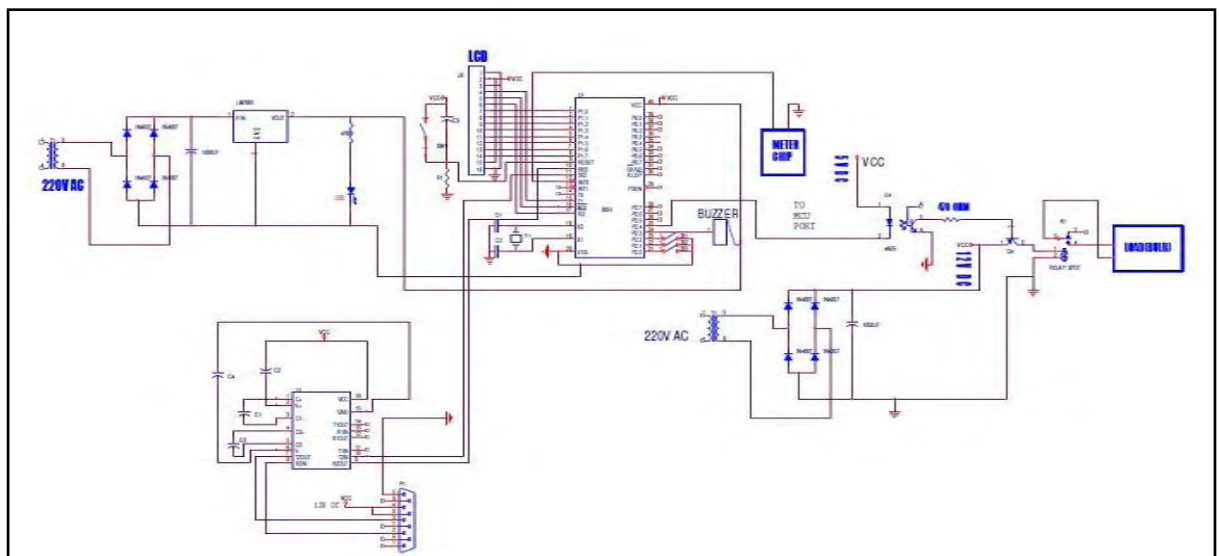


Figure 2.5 Schematic Circuit of Instant Billing systems [3]

By using the IC AT89C52 then programmed using assembly language to make the system works. Firstly, the program must set initial serial data rate to 9600, initialize LCD and GSM module, read SMS sent by user, check the validity of the number, bill received on cell phone then clear the message array for new data. While for the hardware, the flows are [3]:

- 1) It will transmit the consumption amount to GSM
- 2) It will act as a master to communicate with memory
- 3) Whenever a command is sent to reset the memory, controller resets the memory
- 4) Controller takes the pulses from the energy meter and increments the Unit which depends upon the calculations and stores in memory.
- 5) Microcontroller also switches off the energy meter whenever the command is sent from the server. This happens when the owner has consumed all the set credits.

2.1.4 Smart Energy Meters for Energy Conservation & Minimizing Errors

Afterward, the power quality must also take into the consideration to help lower the energy cost and prolong the machine's life. Smart Energy Meters For Energy Conservation & Minimizing Errors by Syed Shahbaz Ali, Madiha Maroof and Sidrah Hanif are really good example how to do it. This project use such 4x16 LCD to display the real energy consumption, PLCC(Power Line Carrier Communication) as the data transmission line then will be processed by application software for preparing monthly billing report[4].

While for data logging, the raw data that has been recorded are manipulated by the software and then uploaded to the web-server. User can view their energy consumption anywhere by log in to the system web page using the assigned ID and also can pay the bill with help of online billing system. The raw data is logged by the data base server that involves the MS-Access then SQL standard language are used to access the data, Table 2.2 below is the sample of the data taken from MS-Access.