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Digital Household Energy Meter

Nor'aisah Sudin, Mohd Zeid Abu Bakar and Mohd Helmy Abd Wahab

Abstract—**It is undoubtedly that in the future, energy would cost more as the direct result of steady increases in power generation cost and since the energy consumption may exceed its productions. The idea of designing the Digital Household Energy Meter is due to the basis that it would indirectly helps to create a better understanding and awareness towards the value and the importance of electrical energy, energy saving, promoting of smart energy management as well as an innovation towards further improvement to proven existing system. It was also due to the fact that in times to come, the cost of electrical energy generation continuously increase and the energy consumption may exceed its productions or generations. By realizing such idea, end users are provided with the proposed system to assist them in carefully planning and managing their electrical consumption. Thus, power wastage could also be reduced to the minimum level and helps to ease the arising problems. The prototype is integrated with an interval meter, Mk 6 Genius electric meter that is capable of register the energy consumption in a specified period of time through an optical serial communication probe that is IEC1107 FLAG™ compatible to a central computer for processing. The serial port analog to digital converter was used in the communication system and attached to the computer through RS-232 interface. The computer will then display the electrical consumption pricing in a display panel. Microsoft Visual C++. NET is used as the development platform specifically for the data processing and user interface design. The prototype was meant to compensate the current system and able to provide accurate, reliable and instantaneous meter reading and displays the users' electrical consumption in terms of price unit.**

***Keywords*:** Electrical energy, Interval meter, Digital Household, Electrical consumption

I. Introduction

A. Background

Power or energy crisis has always be a major critical agenda to the world today. The never ending thirst for energy in industrial, commercial and everyday uses can undoubtedly be solved or at least be made less serious by practicing good power management. The currently assembled kilowatt-hour meter by electrical energy providers will only shows the current electrical consumption in terms of kWh rather than showing the cost of energy that we have spent.

Psychologically, the conventional system would not affect the trend of electrical consumption, but when the meter display the pricing information then it might function accordingly. Real-time pricing gives a real cost-controlling opportunity for those who know the detail load characteristics [8].

Essentially there are two types of electricity meters that were used by the power companies which are the electromechanical and the electronic meter. The display can take in many forms for example cyclotype, digital and the dial type registers.

Even though these kilowatt-hour meters are proven to be highly accurate and reliable instrument used to measure electrical energy consumed by the user during the month, it would not shows the latest pricing as well as recording the monthly energy consumption history. The idea is to develop a digital electrical pricing system which composed of the following elements:-

i. An interval meter capable of register energy consumption in a specified period of time.
ii. A communication system that upload usage data from the meter to a central computer for data processing.
iii. A display panel on the computer which display the real time pricing to the user.

The RS-232 serial port is used as the main communication medium which connected via an optical RS-232 9-pin female D connector probe.

The computer then displays the electrical consumption pricing on a display panel. The project is implemented using a standard visual programming language such as the Visual C++ .NET for data processing and user interface design. The system also provide with a simple, practical, logically organized and well labeled user interface design. The user interface is designed in such a way so that it would be more users friendly while still maintaining its practicality and workability. The

Nor'aisah Sudin is with the Computer Engineering Department, Faculty of Electrical & Electronic Engineering, Universiti Tun Hussein Onn Malaysia, Parit Raja Batu Pahat Johor Malaysia (phone: 07-4537642; fax: 067-4536060; e-mail: noraisah@uthm.edu.my).
Mohd. Zeid bin Abu Bakar is with Jati Terbit (M) Sdn. Bhd, Muar Johor Malaysia. (e-mail: sandre_niner@yahoo.com).
Mohd. Helmy Abd Wahab is with the Computer Engineering Department, Faculty of Electrical & Electronic Engineering, Universiti Tun Hussein Onn Malaysia, Parit Raja Batu Pahat Johor Malaysia. (e-mail: helmy@uthm.edu.my).

pricing information is based on the tariff rates given by the authorized energy provider known as "*Tenaga Nasional Berhad*" or in short TNB.

Energy conservation requires a continuous effort from the community. Providing this data to the people at large would facilitate the authority to reduce waste in a more effective and measurable way. The Digital Household Energy Meter project also provides an ample room for broader future expansion. Figure 1 illustrates the system architecture or more accurate it demonstrates the process on how the system operates.

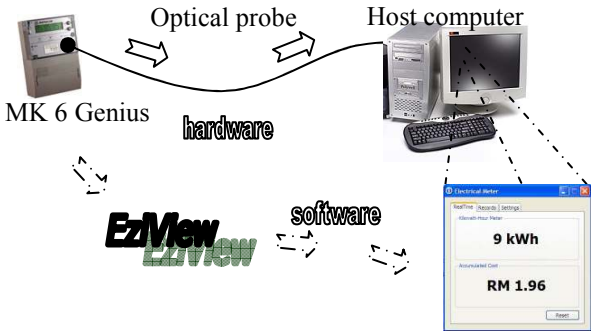

Figure 1: System Architecture.

B. Objectives

i. To design and build a prototype to show the electrical consumption pricing in real time.
ii. Providing instantaneous data transfer from the meter to the computer via a serial converter and accurate meter reading in terms of pricing.
iii. Creates awareness towards the values of electrical energy, energy saving as well as smart energy management through the recorded monthly usage cost which helps the user to determine the usage trends, plan and manage their electrical consumption effectively.

C. Scope of the Project

The main task is to develop a system which comprises of three main elements as described in the introduction. The project is used real time data acquisition from an interval meter which is capable of register domestic electrical energy consumption. The data is then fed to the home personal computer through a serial converter for analyzing and then display the exact and accurate real time pricing.

Besides developing a prototype, there is also required to writes a programming code for the data analyzing display of the results in real time. The Microsoft Visual C++ 2005 Express Edition with .NET Framework patch is used to program.

II. RELATED WORK

Recent study regarding electrical energy usage has gained a lot of attention nowadays. Optimizing the resource usage was one of the world agenda today in order to reduce the environment as well as economy. Energy use in homes represents 21% of US total energy demand in 2004[1]. Managing this sector is an important priority for addressing global warming, conserving resources and improving energy security. Elhadidy et. al [2] presented the trends of electric energy consumption in housing units having some construction and design and located in the same area are generally the same but the amount of energy consumption in a moth or over the year is vary from one another. Thus, mitigating energy in homes is an important challenge.

Improved control and management of energy use at home using information technology such has great potential to reduce residential energy This technique will also can influence behavior of making residents more aware of the economic and environmental implications of their home electrical energy decision. Currently, the only information sources on energy use in home for most people are monthly utility bills. Khan et. al [3] stated that billing automation system for public utilities (e.g. electricity, gas and water) have been widely studied and implemented in developed countries across the world. But in Malaysia, this technology is still on its way to be implemented for domestic as well as for industrial sector.

The similar previous work that has been established in [4], developed a wireless digital water meter with low power consumption. The meter use magnetic hole sensors to compute the amount of water consumption and transferred via ZigBee wireless protocol to a gateway. The work presented by [3] has developed a prepaid meter billing application for domestic gas consumer in Pakistan which required a prepaid card to keep the gas supply continue. Similarly for high gas consumption especially in industrial sector the meter is wirelessly connected with the regional billing office in order to keep track the usage. Therefore, the uses of energy can be monitored optimally.

As presented by [3] and [4] , the similar work apply in electrical domain by [5] which implements a flexible and affordable digital

energy meter for home usage. This meter uses a series of dials to display kWh consumption [6]. A digital hardware approach in introduce which has evolve dramatically over the past four decades [7].

The developed prototype is to display the electrical consumption and the pricing unit within a specified small period of time since this would keep the user noticed with the energy consumption.

III. REQUIREMENTS SPECIFICATION

A.. The MK6 Genius Electric Meter

The MK 6 Genius intelligent revenue meter as illustrated in figure 2 produced by Electronic Design and Manufacturing International, EDMI Limited has been chosen as the interval meter. MK 6 Genius is a revolutionary new design which combines the versatility of scripting and power utility measurement in an economical meter. Each meter is capable of providing flexible, smart metering for the user specific needs.

This meter was chosen due to its communication and data storage capabilities, besides easier interfacing and its future market prospect as the TNB had currently started and will continue to use the same type of electric revenue meter in the future thus reflecting the overall performance and features of the meter. The move made the project to be very relevant with the current and future situation of Malaysia.

Figure 2 : The MK6 Genius Electric Meter.

A. Optical Serial Communication

The MK 6 Genius meter is fitted with an optical port that is hardware compatible with IEC1107 FLAG^{TM}. An optical serial communication probe with the RS-232 9-pin female D connector had been used to enable the interaction between the electrical meter and the host computer. The optical probe is a bidirectional interface that utilizes the infrared light. Once connected to the serial port of a host computer or terminal, communication with the meters will be permitted.

B. Microsoft® Visual C++ 2005 Express Edition

Microsoft Visual C++ 2005 Express Edition enables the use of Visual C++ to craft robust code for both Windows and .NET Common Language Runtime (CLR). It support the .NET Framework which enables the developer to write console application and the Windows Form application which is the exact look alike to the proposed Real Time Electrical Pricing project. It also provides a powerful visual design surface and drag-and-drop controls and components to quickly and easily create interactive Windows applications.

IV. IMPLEMENTATION

1. Meter Interfacing Test

Connection to the meter is configured by using the EziView interfacing software. The Mk 6 Genius had been directly connected to the serial port on the computer via an optical reader head or null modem cables, connected to the RS-232 port. The communication is made through the Communication Port 1 (COM1) while the *Baud Rate* must be set to the same rate as the meter which is defaulted to 9600 baud rate with no parity bit or flow control is set. The meter is then mapped. The whole process should only take a couple of seconds. Figure 3 illustrates a successful completion of mapping process.

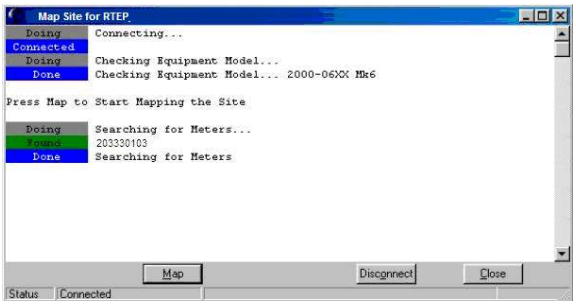

Figure 3 : A successful mapping process.

2. Real Time Electrical Pricing

The meter is connected to a 240V source with a frequency of 50Hz which is the standards for a single phase power distribution in Malaysia and given a 60W worth of load. However, it is observed that the actual incoming source is detected to be at 251.23V and the load is 65.78W with a power factor of 1.0 leading.

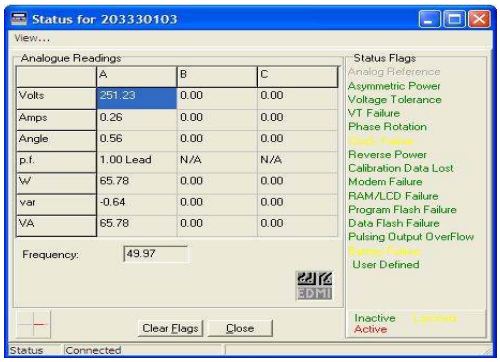

Figure 4 : the status screen for the mapped meter.

EziView can be directed to save a file of data from the meter. The continuous readings will be saved in a .TOU extension file. The first part of the file name may be either the serial number of the meter, or the plant number of the meter. It will also generate various other file in the computer. The Digital Household Energy Meter had been configured as the viewer of the .TOU file.

The file may be stored either in the same directory as the MTR file (*Meter File* option) or in a fixed directory for all meters that may be entered below the *Fixed Directory* option. In order to causes new data to always be appended to the file, the *Always Append* box is checked. The whereabouts of the required data meant for the pricing calculation can be found inside the .TOU extension file.

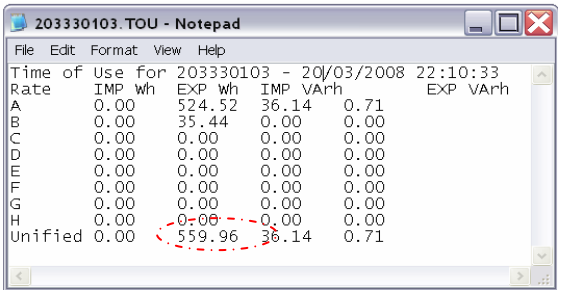

Figure 5: The .TOU file for the MK 6 Genius meter with S/N 203330103.

Figure 6: The kWh reading and its accumulated cost for 559.96 Wh.

The system will seek for updates in the .TOU file in figure 5, in every second. Note that if the EXP Wh is at 559.96 Wh, the system will retrieve it and performs the pricing calculations and displayed it back as shown in figure 6.

As stated in the TNB domestic tariff in table 1, for the first 200 units per month, the tariff rates is set at 21.8 cents for a kWh. Since 0.559 kWh is far below 200 units, then the accumulated cost can be calculated as 0.559 kWh x RM 0.218 which is equivalent to RM 0.12. Thus, table 2 demonstrates the different values of kWh that has been tested using the system.

Table 1: Tenaga Nasional Berhad (TNB) Domestic Tariff
(source taken : http:// www.**tnb**.com.my/)

TARIFF CATEGORY	UNIT	RATES
Tariff A - Domestic Tariff		
For Monthly Consumption Between 0-400 kWh/month		
For the first 200 kWh (1 - 200 kWh) per month	sen/kWh	21.80
For the next 200 kWh (201 -400 kWh) per month	sen/kWh	34.50
The minimum monthly charge is RM3.00		
For Monthly Consumption More Than 400 kWh/month		
For the first 500kWh (1-500kWh) per month	sen/kWh	30.00
For the next 100 kWh (501-600kWh) per month	sen/kWh	39.00
For the next 100 kWh (601-700kWh) per month	sen/kWh	40.00
For the next 100 kWh (701-800kWh) per month	sen/kWh	41.00
For the next 100 kWh (801-900kWh) per month	sen/kWh	43.00
For the next kWh (901 kWh onwards) per month	sen/kWh	46.00
The minimum monthly charge is RM3.00		

Table 2: Different kWh inputs and its' displayed cost.

kWh Readings	Displayed Cost
10.883	RM 02.37
100.64	RM 21.94
200.13	RM 43.63
500.45	RM 121.12
1000.045	RM 250.01
10000.045	RM 2752.01

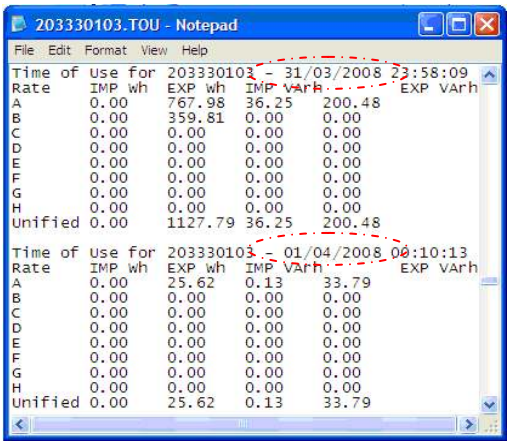

Figure 7: The March TOU reading automatically reset on 1st of April.

The system also has been configured accordingly that for each completed cycle of a month, the kWh and the accumulated cost readings automatically recorded in the pricing history. Figure 8 shows the billing record on 1st April 2008.

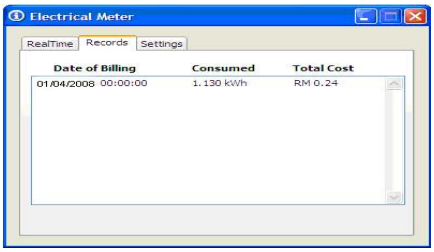

Figure 8: Billing record on 1st of April 2008 at 12 o'clock midnight.

The system also has been tested and approved to be bug free. Let say if the input were alphabetical instead of numerical, then the program will display the "*Problem reading file '203330103.TOU' Input string was not in a correct format"*. For every updates made, the program will display its exact date and time.

V. CONCLUSION & RECOMMENDATION

A. Conclusion

The core of the project which was to design and develop a working system that is able to provide accurate meter reading and displays of the user's electrical consumption in terms of price unit. During the testing, the system proved to be very reliable in providing instantaneous data transfer from the meter to the host computer via an optical communication port with no margin of errors. The system also has been tested as bugs free and capable to record the monthly energy usage price as intended.

It is hoped that the development of the Digital Household Energy Meter may soon provides the answers to the users inability to carefully plan and manage their electrical consumption trends. This project will also be able to create a better awareness towards the values of electrical energy, energy saving as well as smart energy management while promoting a practical environment for every family.

B. Recommendations

The Digital Household Energy Meter project has taken into considerations the matter about the further improvements amongst its first development phase.

Once a program can provides an accurate meter reading in terms of pricing unit has been successfully developed, the focus can now be shifted towards connecting or concentrating the developed system which scatters in different places for a centralize billing system. In other words, each meter or the program is connected on the network via a modem. The MK 6 Genius provides a variety of communication possibilities such as the GPRS and GSM.

With the centralize billing and monitoring system, power distributor company such as TNB could experience reduction in operating cost since the system promotes automation and is paperless. This would only means that the number of labors could be reduced as the company is not required to appoint extra personnel for house to house meter reading. The system would also provide an extra security and data integrity since meter tampering and any fault to the meter can be detected in advanced. Such move would definitely helps to minimize damage to the properties, lost of income and saves lives. The consumer would also be benefited through the online bill payment of the expanded system. Besides, each user will be provided with an online account that enables them to conveniently view their electrical consumption, payment history, trends and even lodge a report.

The scope of the targeted user can be made wider such as those from the industrial sector, commercial community and the government itself since there were still plenty of rooms for improvement.

VI. REFERENCES

[1] E.William, S. Mathews, M. Brethon, and T.Brady, " Use of a Computer-Based System to Measure and Manage Energy Consumption in the Home," presented at IEEE International Symposium of Electronics and Environment, 8 – 11 May 2006. pp. 167- 172.

[2] M.A Elhadidy, M. Haq, and A. Ahmad, " Electric Energy Consumption in Selected Residential Buildings at KFUPM, Dhahran Saudi Arabia" presented at 2000 Mediterranean Conference for Solar and Environment.

[3] M.F. Khan, A. Zohar, and R.L Ali , "Design an Implementation od Smart Billing and Automated Meter Reading System for Utility Gas," presented at IEEE International Conference on Information and Emerging Technology 2007, 6-7 July 2007 Page(s):1 - 6

[4] Y. W. Lee, S. Eun, and S.H Oh, "Wireless Digital Water Meter with Low Power Consumption for Automatic Meter Reading," presented the IEEE International Conference on Convergence and Hybrid Information Technolgy 2008.

[5] M.I. Riaz, M.S. Rahman, F. Mohd-Yasin , M.S. Sulaiman, F. Choong, and A.Alaudeen, " Development of an Efficient and Flexible Algorithm for Implementing a Digital Househol Energy Meter : An FPGA Approach," presented at the third International Conference on Electrical & Computer Engineering ICECE 2004, 28-30 December 2004, Dhaka, Bangladesh.

[6] Djokic, B., Bonsjakovic and P. Bogovic, M., "New method for reactive power and energy measurement", IEEE Transaction on Instrumentation and Measurement, vol. 41, Issue 2, 1992, pp. 280-285.

[7] M.F. Schwndtner, "Digital Measurement System for Electricity Meter", 3-5 July, 1996, Conference Publication N0. 426, IEEE.

[8] Y.C Ming, W.H Cha (2001). "*Development of PC based Energy Management System for Electrical Energy Saving of High Voltage Customer*" IEEE. 7-12.