Designing Low Cost Smart Energy Meter

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Introduction

Smart energy meters are the next generation of electricity or gas meters which are software-based, power efficient devices that accurately track the energy consumption. The Smart energy meter offers major benefits to both the customers and companies, in terms of efficiency, reliability, and cost saving. There are three kinds of electricity meters available in the world. They are electromechanical meters, Electronic meters and multiple tariff (variable rate) meters. Electronic meters or smart energy meters, as opposed to traditional mechanical and/or electromechanical solutions in use, provide benefits as more accurate bills, lower bills, sell energy back to the grid, and flexible tariffs. Introducing smart energy metering to domestic electricity consumption has many advantages like reducing electricity consumption in peak hours, drawing consumer attention on their energy consumption and etc. These energy meters are commercially available in the market today. But to replace all the existing manual electrical meters with smart energy meters, large amount of money has to be invested. Therefore, designing a low cost smart energy meter will be the best solution for issues of increasing electricity consumption in the country. Acordingly, this project aimed to design a low cost smart energy meter to minimize energy consumption and energy costs for consumers by introducing a system to save energy and control the utilization of electricity at peak hours. And this project also focused to introduce a degree of automation, including Automated Meter Reading (AMR).

Methodology

The energy meter was designed using MCP3906 energy metering IC, Current Transformer to measure the load current, Resistor voltage divider network to measure the voltage, PIC18F2550 USB microcontroller for control unit, a LCD display, a Real Time Clock and EEPROM.

The MCP3906 is a Digital Signal Processor based instantaneous power integrator that supplies a pulse output proportional to the amount of energy consumed. The MCP3906 uses an internal 14-bit ADC to sample the voltage and current.

The software is to have an overall control of the hardware at all time and to determine the energy (counting the pulse) and save with different location in EEPROM (peak and off-peak energy). Hardware controlling consists of input devices, power circuit, EEPROM, RTC and LCD with external peripherals. In addition, base on the selected algorithm, the software must be able to continue tracking the input Energy meter IC pulse signals, convert to energy and send those data to LCD display. (Time, Date, currently usage Energy, once the button pressed shows -Total Peak energy usage and Total off-peak energy usage).

After overall planning, the principle of energy calculations is in first priority to work on, and follow to instruct the microcontroller to execute for Initialize, pluses check, communicate with RTC and EEPROM, button check, USB check and data sending to LCD and MS Access database.

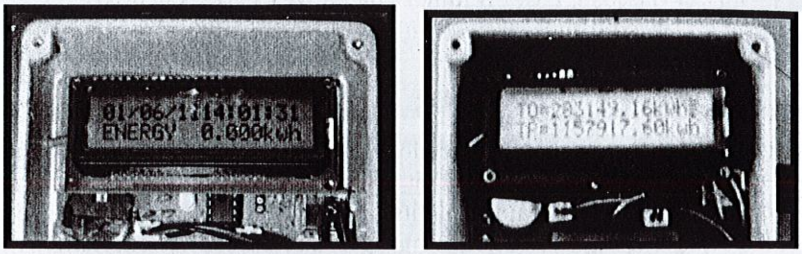

Figure 1: LCD user interface

Results

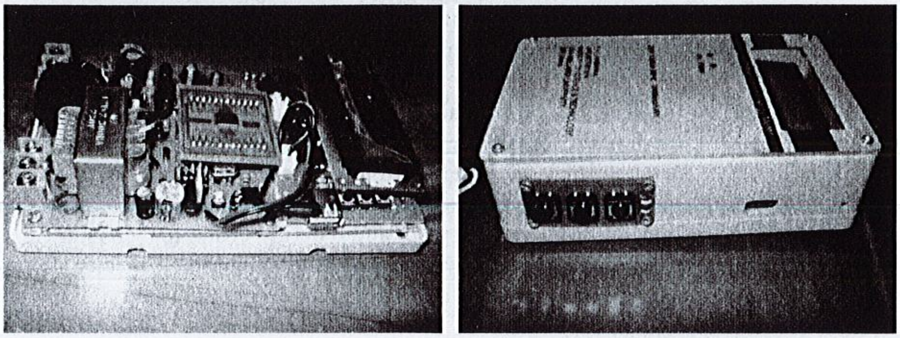

Figure 2: Designed smart energy meter

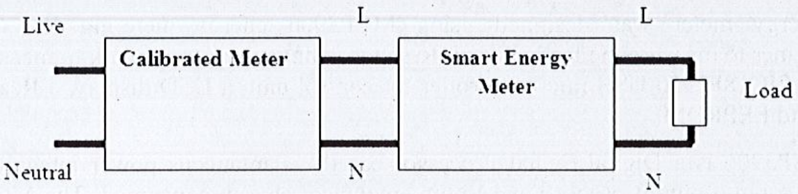

Figure 3: Test setup for Experiment

An experiment was carried out to determine whether the energy measurement circuitry was able to measure the overall energy usage up to the required accuracy. Specifically, the accuracy maintained between loads of different magnitude was determined, in effect measuring the linearity of the energy meter's accuracy. As both the device under test and the control device output a pulse proportional to the amount of energy consumed, it is merely necessary to check that the amount of pulses that both meters output over time and with different loads stay proportional

Although the testing performed was limited, from the results, during an each time interval the pulses counted from the control circuitry were constant (constant load). And it can thus be concluded that the pulses counted by the control circuitry are a very good (if not perfect) representation of the energy consumed (according to the energy metering circuit).

Discussion

The energy measurement accuracy test of the designed meter performed good results in order to be accepted in working environment. The designed system uses a Current Transformer to measure load current. This Current Transformer is specially designed for this system to overcome the problems of unavailability of required shunt in local market for the purpose and available Current Transformer in local market are bigger in size (this will ultimately increase the size of the product and cost). By using required standard Current Transformer (specially designed for energy meters) can increase the accuracy of the system as well as it will increase the capacity of the meter.

The system is capable of storing the pulse readings in EEPROM within short time period. There is higher potential of increasing this capacity and efficiency of the meter by using a backup power supply. This may help to avoid any inconvenience of missing data/readings of energy consumption during billing.

The meters currently in use are only capable of recording kWh units. The kWh units used still have to be recorded monthly by meter readers on foot. The recorded data need to be processed by a meter reading company (Ceylon Electricity Board) for processing bills. There is a good potential that meter readings can be transmitted to distributors/utilities over wireless media thus, eliminating the need of a manual meter reading collection process.

Available smart energy meters in nowadays are equipped with a range of communication technologies including Low Power radio, GSM, GPRS, Bluetooth and etc. The designed system has USB communication facilities. Therefore using USB GSM modem can easily achieve this target.

The results of the overall system of the designed smart energy meter were acceptable and can be thus be accepted to be in a working condition with further modifications, based on the duties that the system should perform.

Conclusions

Introducing smart energy metering to domestic electricity consumption has many advantages like reducing electricity consumtion in peak hours, drawing consumers attention on their energy consumption, avoiding meter reading cost and etc. Designing a low cost smart energy meter will be a best solution for issues of increasing electricity consumption in Sri Lanka. This project has been successfully developed and implemented. To reduce electricity consumption in peak hours and to draw consumers' attention on their energy consumption this kind of smart energy meter is a better solution. The system designed was low cost which can be built around Rs.3000.00. This is cheaper than those smart energy meters available in market.