Conference Proceedings Paper – Sensors and Applications

Energy and Water Monitoring System for Smart Metering and Consumer Awareness

Shiu Kumar *

Department of Electronics Engineering, Fiji National University, Fiji

*   Author to whom correspondence should be addressed; E-Mail: shiu.kumar@fnu.ac.fj or kumar.shiu@hotmail.com; Tel.: +679-9439-438.

Abstract: Smart meter facilitates real-time communication between the customer and the utility company offering various advantages to both the suppliers and the consumers. Problems such as meter reading, information on energy and water usage, demand requirements, varying tariff, billing and theft can be solved through smart metering. This paper presents the design and implementation of an automatic electricity and water meter system. The system consists of the smart meter comprising a GSM board, Arduino microcontroller, a clamp current sensor together with a water flow sensor for measuring the amount of electricity and water consumed. An in-house display which communicates with the smart meter via a RF link offers the consumers access to real-time data of their consumption. The in-house display system, which requires authentication to communicate with the smart meter, also offers the users to set usage limits with short message service (SMS) alerts, and turn on/off the supply of electricity or water. The usage details are also sent to the suppliers via a SMS for billing purpose. The supplier also has access to the smart meter system, as they can set usage limits or cut off supply in cases such as bills not being paid.

Keywords: automation; data acquisition; smart meter; SMS; wireless communication.

1. Introduction

High energy losses and poor reliability of power supply are a major concern to the electrical distribution utilities. The same problems are faced by water distribution utilities. In order to tackle these problems sufficient timely data which is accurate is needed in order to help day to day decision

making activities. Due to the large number of consumers, it is not viable to collect data manually using traditional approach and analyze them on a day to day basis as it will be time consuming and data collected may be inaccurate [1]. Thus an automatic system that can measure the consumption, notify of any irregularities and is capable of providing real time data is required. With the substantial amount of advancement in technology, it is now possible to measure and acquire the consumption data and analyze them. Smart meters are the monitoring tools for energy, water and gas consumptions and are designed for recording and displaying real time usage data with the goal of reducing the energy consumption and costs. A smart meter facilitates real-time communication between the customer and the utility company offering various advantages to both the suppliers and the consumers.

Various researches have been carried out with the aim of developing a smart meter system. However, currently there is no smart meter system available in the market that is affordable, reliable, flexible, efficient, and sustainable. A number of researches have been carried out looking at different aspects of the smart meter system. Xu and Liu [2] have designed a smart meter network system based on internet protocol version 6 (IPv6) and ZigBee protocol for measuring and monitoring residential power consumption. Thousands of meters will be interconnected in the smart meter network and as such Rahman and Mto[3] have stated that 100 BaseT communication link is most suitable for smart meter network. In [4], the design and implementation of an Automatic Meter Reading and Control System (AMRCS) using reconfigurable embedded platform together with software developed in LabView graphical programming environment is presented.

The authors in [5] conducted a research in smart metering and their finding are that feedback significantly increases a household's knowledge but improvements are not correlated with observed demand reductions. The Data used was from a randomized controlled smart metering trial in Ireland, which also collected extensive information on household attitudes towards the knowledge of electricity use. In [6], the use of the smart metering and home automation technologies for efficient utilization of energy, thus paving the way for a cleaner and greener environment for future generations have been presented. The authors have stated that tremendous work is going on in Advanced Metering Infrastructure (AMI), Smart Metering and Home Automation. Countries like USA, Australia and Italy etc. have already started using AMI solutions while countries like China, South Korea, Austria, Spain, Sweden, Finland, Denmark, Netherlands, Norway, Ireland and UK are in process of implementing AMI. Smart metering and ICT solutions have been planned to increase efficiency, loss reduction, reduce energy theft and for efficient data collection for better energy accounting in the electrical sector.

In this paper, the design and implementation of a smart meter system is presented in order to help the energy providers to be able to automatically get the monthly usage data of the domestic users. This will help reduce the time and man power needed for meter reading. The smart meter developed can also be used by the consumers to monitor their energy consumption. The remaining of the paper is organized as follows. In the next section, the details of the design and implementation of the proposed smart meter system is presented. In Section 3 the results are presented and discussed. The paper then concludes making recommendations for future work that needs to be carried out.

2. Design and Implementation

The overall architecture of the proposed energy and water monitoring system is given in Figure 1. It comprises of the main controller and the remote display. The main controller monitors the energy and water usage details, while the real time usage details are displayed on the remote display.
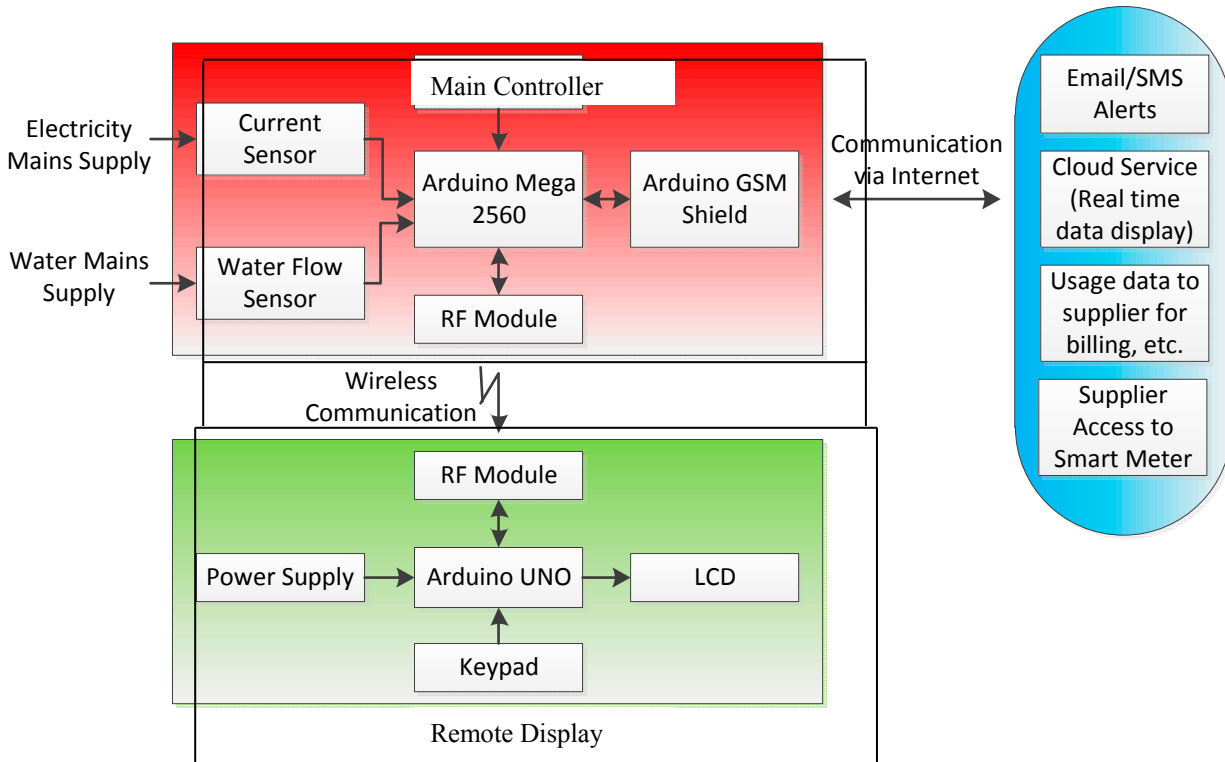

Figure 1. The overall architecture of the proposed energy and water monitoring system.

The main controller is the heart of the energy and water monitoring system for smart metering and comprises of the Arduino microcontroller for processing, the Arduino Global System for Mobile Communications (GSM) board, the current and water flow sensors, and the nRF24L01+ Radio Frequency (RF) Transceiver module. For monitoring the energy/power consumption the current is monitored and the real power is calculated. The SCT-013-000 Non-invasive AC Current Sensor Transformer, which is clamp current sensor with a maximum current sensing capability of 100 amperes is used. The current sensor will be clamped to either the active or neutral line of the power supply for which the power consumption is to be measured or monitored. Figure 2 shows the details of the current sensor and its connection. On the left the clamp current sensor is shown and on the right the figure shows how the current sensor will be clamped to measure the power consumption. The output of the current sensor is fed to the circuit in Figure 3, which is designed so that it is transformed to a form that can be read by the Arduino microcontroller. The output of the circuit is then read by the Arduino from its analog pin at which it is connected. The emonTx library has been used for converting the analog value to the equivalent current value.

The Global System for Mobile Communications (GSM) shield is utilized to send data to the cloud via internet for display of real time energy and water consumption data (optional feature for the

consumers). A RF module connected to the master controller is used to transmit data to the remote display module which will be inside the consumer's home and will comprise of Arduino UNO Microcontroller, Liquid crystal Display (LCD) and RF module for receiving the data from the master controller. The system has features such as email and Short Message Service (SMS) notification when the energy or water usage exceeds the normal or desired usage.

Figure 2. The current sensor and how it will be connected for monitoring energy usage.
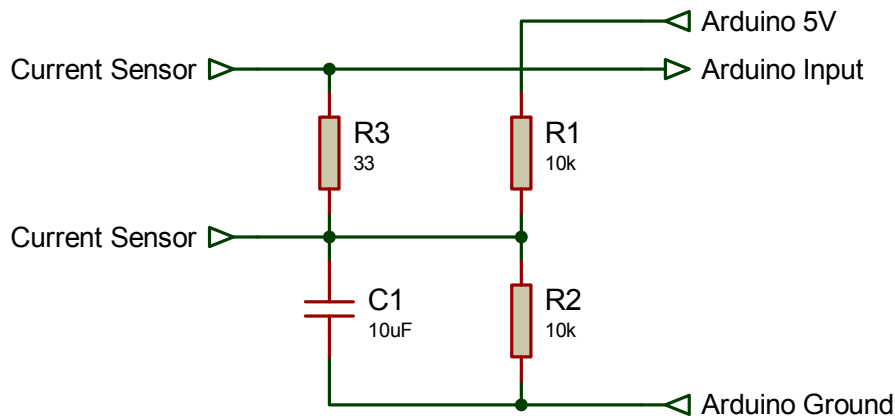

Figure 3. Circuit used to allow Arduino to read and determine the current.

3. Results and Discussion

The proposed monitoring system has been designed in order to help consumers to be aware of their usage details in real time. The current sensor has been calibrated to obtain the current value as accurately as possible. Figure 4 shows the actual and calculated values of the current. A current meter was used to measure the actual current value. It can be noted that the actual and calculated values of current are almost same. A deviation of ±0.02 amperes is noted over the current range of 0 to 16 A. The power meter was used to measure the energy consumed together with the proposed system for an office for two weeks. It was noted that the energy consumption calculated with the proposed system gave a very promising result with only ±0.05 kWh deviation with that compared to the value measured using the power meter. The deviation can be due to the fact that the power meter used varying power factor depending on the connected load where as for the system developed in this research a fixed value of power factor for calculating the real power consumed is used. The system is developed with reference to the local meters used where the meters are calibrated to be used at a fixed power factor value, which is calculated by averaging the power factor at different load tests. The current sensor has been tested to accurately measure up to 16 A of current as the system developed is targeted mostly for domestic consumers whose meter fuse or circuit breaker ratings is also 16 A.
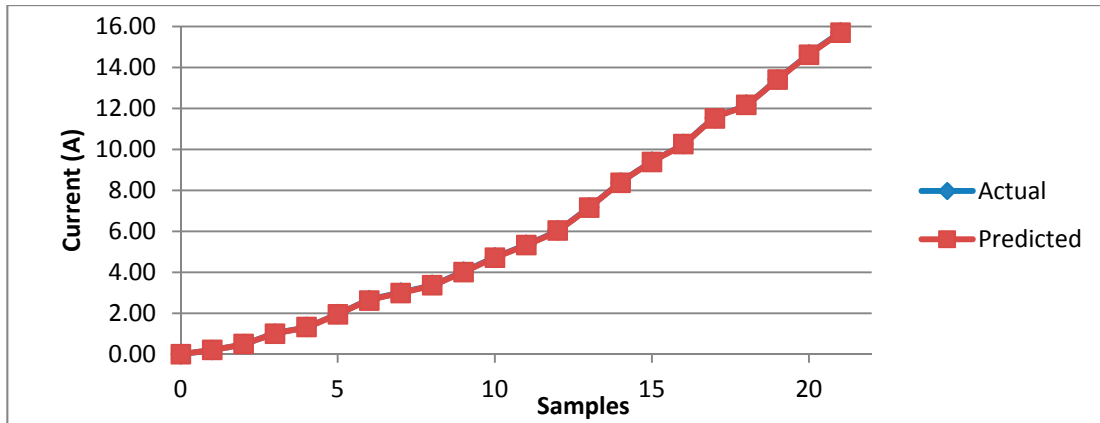
Figure 4. Graph showing the actual and calculated values of the current.

The remote display gives the consumers the opportunity to monitor their energy/water usage details in real time. Each smart meter will have a unique identification code (ID). The remote display connects to the smart meter via the RF link using this unique ID, which also requires user authentication. The remote display can be used to set monthly usage limits, or to switch off the mains supply when required.

4. Conclusions

Smart metering and energy/water usage awareness would solve a number of problems. The energy monitoring system developed shows promising results and have paved the way for further works to be carried out to develop a complete smart meter system with all desired features. Future works will be carried out to calibrate the water flow sensor. Provisions will also be made for the suppliers (Water Authority of Fiji and Fiji Electricity Authority) to be able to get the usage data either via internet or SMS, which can then be collated and used for billing information, etc. After implementation of the system, it will be used to evaluate the difference or improvements if any that the energy and water monitor system will contribute to. Cloud services will be used to develop the optional feature of offering the users to be able to view their usage data in real time via internet when they are away from home.

Acknowledgments

Conflicts of Interest

The authors declare no conflict of interest.

References

1. Palanichamy, C.; Babu, N.S.; Chelvan, R.K.; Nadarajan, C. Restructuring the indian power sector with energy conservation as the motive for economic and environmental benefits. *IEEE Transactions on Energy Conversion* **1999**, *14*, 1589 - 1596.

2. Xu, D.; Liu, J. Ipv6-based smart metering network for monitoring building electricity. *Advances in Mechanical Engineering* **2013**, *5*.

3. Rahman, M.; Mto, A. Investigation of bandwidth requirement of smart meter network using opnet modeler. *Smart Grid and Renewable Energy* **2013**, *4*, 378-390.

4. Singh, J.; Singh, R.; Aggarwal, S.K.; Saini, L.M. Design of substation amr and control system with reconfigurable embedded system. *International Journal of Energy Science* **2011**, *1*, 62-66.

5. Carroll, J.; Lyons, S.; Denny, E. *Reducing electricity demand through smart metering: The role of improved household knowledge*; Trinity College Dublin: 2013; p 29.

6. Ahmad, S. In *Smart metering and home automation solutions for the next decade*, International Conference on Emerging Trends in Networks and Computer Communications (ETNCC), Udaipur, 22-24 April, 2011; IEEE: Udaipur, pp 200 - 204.