Acknowledgement: NSF is gratefully acknowledged for the financial assistance through the research grant NSF/RG/2005/W&E/02. Dr. S. Dharmathilleke of IMRE, Singapore is acknowledged for the SEM measurements. Help given in making some of the AFM measurements by Dr. V. Kapaklis of the Department of Materials Physics, Uppsala University, Sweden is also acknowledged.

References

[1] L.C.Olsen, F.W. Addis. W.Miller, Solar cells 7 (1982) 247.

[2] B.P.Rai , Solar Cells 25 (1988) 265.

[3] W. Siripala et. al., Solar Energy Mat. Solar Cells 77 (2003) 229.

[4] M.J. Siegfried, Kyoung-Shin Choi, Adv. Mater. 2004, 16 (2004) 1743.

Development of an Automated Weather Station with Remote Data Transmission Capability

R. Weerasinghe[1], M.S.M. Aroos[1], A.S. Pannila[1], M.K. Jayananda[2] and D.U.J. Sonnadara[2]

[1] Electro Technology Laboratory, Industrial Technology Institute

[2] Department of Physics, University of Colombo

Abstract

The development of an automated weather station with remote data transmission capability is presented. The complete system consists of three separate modules for data collection, data storage and data communication. The modules communicate serially and are controlled by three separate PIC18F452 microcontrollers. The data collection module is interfaced to a set of sensors to collect weather parameters such as temperature, humidity, wind speed, wind direction, pressure and rainfall. The data storage module saves the captured data in real-time to a micro secure digital (SD) card. The data transmission module transmits data to a central station through a global system for mobile communication (GSM) or a general packet radio service (GPRS) network. The weather data can be viewed in real-time through a graphical user interface (GUI). The modular

nature of the design allows the user to replace the data transmission module by a radio frequency (RF) link to transmit data to locations within 100 meters.

1. Background

An automated weather station is an instrument that measures and records weather parameters using sensors, without the intervention of humans. The measured parameters can be stored in a built-in data logger or can be transmitted to a remote location via a communication link. If the data is stored in a data logger, the recorded data must be physically downloaded to a computer at a later time for further processing. However this is not a viable option especially when the weather station is located at a remote unattended location. Therefore a communication system is an essential element in an automated whether station.

Today, automated weather stations are available as commercial products, with variety of facilities and options [1-3]. Although automated weather stations can be built and implemented in remote parts of Sri Lanka to bring down the cost of maintaining remote stations, not much emphasis has been given to building and using such instruments locally.

A few years ago, the University of Colombo developed an automated weather station with a universal serial bus (USB) communication facility and a built-in data logging facility. The system used wired communication to transfer data to the monitoring station, through the computer's built-in USB interface [4]. However, in real situations, it is not feasible to have wired weather stations which require physical cable links to be established between the monitoring station and the weather station.

The main objective of this work is to develop a standalone modular weather station with a remote communication facility.

2. Overview of the System

A block diagram of the weather station, which consists of three separate modules for data collection, data storage and data communication is shown in Figure 1. Each of these three modules is controlled by a PIC18F452 microcontroller [5]. The microcontrollers communicate with each other through the in-built serial interface.

Six sensors were connected to the data collection module to measure the temperature, humidity, wind speed, wind direction, rainfall and pressure. In the present configuration, the sensors were interfaced using the existing input ports (5 analog and 3 digital) of the microcontroller.

The data storage module consists of another microcontroller which accepts the incoming serial data stream and saves the real-time data in a micro SD card in plain text format. Users can remove the SD card and download the data to a computer for offline analysis.

The communication module has its own microcontroller which accepts the incoming serial data stream and transmits it to a pre-programmed destination through a GSM modem. The microcontroller sends AT commands through the serial interface and identifies the availability GPRS network to send data. In case the GPRS coverage is not available, the system automatically switches to GSM network.

3. Features and Measurements

In this work, two types of sensors – analog sensors and digital sensors -were used. The sensors were interfaced through the built-in analog and digital ports of the PIC18F452 microcontroller.

- **Analog Sensors:** The sensors used to measure temperature, humidity, wind direction and pressure produced analog outputs. A 10-bit analog to digital converter (ADC) was used in this project to sample the analog signals. The sensor interfaces were designed to produce outputs between 0 and 5 volts to match the analog input ports of the microcontroller.

- **Digital Sensors:** The anemometer and the rain gauge produced digital outputs. A digital output is basically a pulse. The digital ports of the microcontroller were used to read the data directly from the above sensors and to count the pulses.

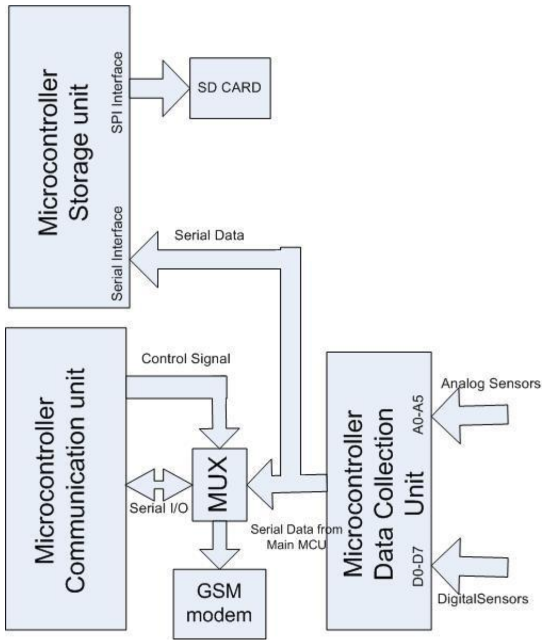
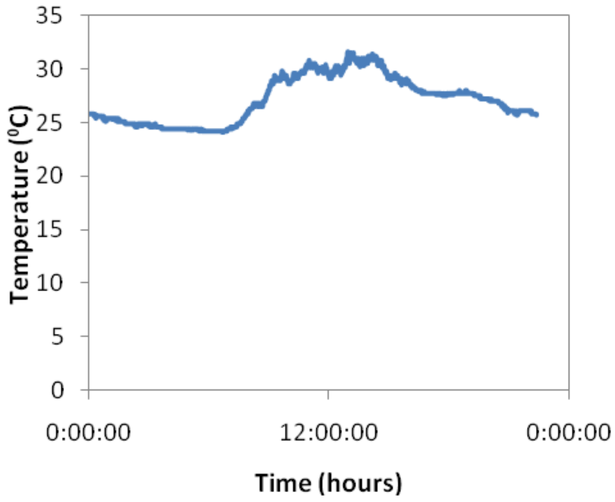


Figure 1: Block diagram of the automated weather station with three microcontrollers

- **Communication System:** The communication system consists of a GSM modem and a microcontroller. The firmware was written for the microcontroller to check the availability of the GPRS coverage first and then do the data transfer through the GPRS network. If the GPRS network is unavailable, the system detects the GSM network and composes the data to a text message and sends data as an SMS. A Standard AT command set was used for the communication between the microcontroller and the modem. At the receiving end, the data could be viewed through a GUI. A LabView interface [6] was also designed to show the parameters graphically; this is similar to a supervisory control data acquisition SCADA system.

- **Data Storage System:** The data storage system receives the data in serial format through the serial port of the data acquisition system. The data is written to a micro SD card as a text file and the text file can be imported to a spread sheet application to carry out further analysis offline. The micro SD card was interfaced to the microcontroller through the serial puerperal interface (SPI) interface and the program was developed in micro C language.

During field tests, the automated weather station was operated outside the Electro Technology Laboratory of the ITI for approximately two months. As an example, the diurnal variation of temperature and humidity captured by the weather station is shown in Figure 2(a) and Figure 2(b).



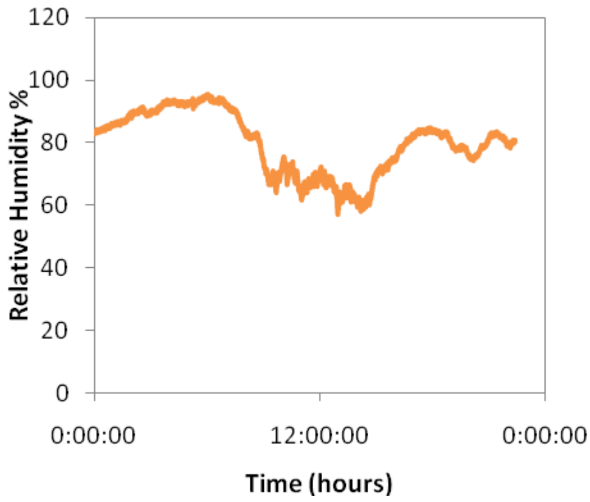


Figure 2: Diurnal variation of weather parameters (a) Temperature (b) Humidity

4. Conclusions

Compared to traditional weather stations, automatic weather stations provide a number of benefits to the users. With the existing technology, today, these stations can be built locally and maintained at remote locations to transmit digitized data at regular intervals. The work showed that multiple weather parameters can be captured precisely at pre programmed intervals in real-time. Online measurements are important to detect extreme events as well as to issue necessary warning messages to the general public.

References

[1] Campbell Scientific, Data loggers, Sensors and Weather stations, http://www.campbellsci.co.uk/

[2] Visala, Automatic weather stations, http://www.vaisala.com/en/products/

[3] Prodata, Affordable automatic weather stations, http://www.weatherstations.co.uk/

[4] Hettiarachchi H.A.P.K. & Fernando I.M.K., USB based high speed data acquisition system for an unmanned weather station, 2nd International Conference on e-governance (2004).

[5] PIC18F452 datasheets, http://www.datasheetsite.com/datasheet/PIC18F452

[6] Travis J. & Kring J., “ LabView for everyone”, Third Edition, Pearson Education.