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Wireless Portable Microcontroller based Weather Monitoring Station

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ABSTRACT

Weather monitoring and its forecasting has become vital part of day-to-day life because of its numerous applications in agriculture, farming, fishery, shipping and military operations. Measuring the weather using conventional or manually operated Weather Monitoring Stations requires skilled labor for operation and demands regular maintenance which invariably increases the life cycle cost of the Weather Monitoring Station. To address these issues, the authors of this paper have attempted to design and implement inexpensive Wireless Portable Weather Monitoring Station using PIC16F887 microcontroller. The implemented Weather Monitoring Station is equipped with sensors to measure weather variables such as relative humidity, atmospheric pressure, rainfall, solar radiation, wind speed, wind direction, surface and ambient temperature. Besides of these capabilities, the designed Weather Monitoring station also includes some unique features like Modbus communication protocol, which provides seamlessly communication of real time weather measurements to the base station (PC\Laptop) over both wired (RS serial) and wireless (Xbee Pro modules) interfaces. Further, at the base station, the received data is logged and uploaded to an online data server to enable worldwide ubiquitous access to the weather measurements.

1. Introduction

In India, weather monitoring can be traced back to Vedic period literature, which presents extensive discussions about the seasonal cycles caused due to the movement of earth around the Sun, formation of clouds and rainfall [1]. Weather changes at its normal conditions greatly influence the daily moods [2] and activities of man such as agriculture, farming, fishing, entertainment, shipping and military operations [3–5]. But over the years, many events have made significant impact on mankind by destroying valuable property and took away many lives, in the form of floods, storms and hurricanes. Again, the weather conditions after twentieth century is even more worst due to population explosion, over migration, deforestation, global warming and other activities. Hence, in order to monitor and track weather changes, Weather Monitoring Stations are employed worldwide [6].

A typical modern Weather Monitoring Station uses multiple meteorological sensors to monitor weather changes by sensing weather variables such as temperature, relative humidity, dew point, atmospheric pressure, wind direction and wind speed. These meteorological sensors may not be limited to mechanical but also derived from advanced technologies such as Solid State and

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Micro-Electromechanical System (MEMS) [7,8]. Interfacing these meteorological sensors to microcontroller is easy and inexpensive using simple electronic circuits to acquire accurate weather measurements automatically without any interruption and maintenance [9–11]. Thus, the overall lifecycle cost of Weather Monitoring Station can be minimized.

In this paper, an attempt has been made to design and implement the Wireless Portable Weather Monitoring Station to measure relative humidity, atmospheric pressure, rainfall, solar radiation, wind speed, wind direction, surface and ambient temperature by interfacing meteorological grade sensors to PIC16F887 microcontroller. Further, industrial standard Modbus communication protocols has been implemented to acquire data from Weather Monitoring Station and communicated to base station (PC\Laptop) over Zigbee wireless (XBee-Pro radio modules) and serial interfaces (RS232\RS485) seamlessly. At the base station, the acquired data from Weather Monitoring Station is logged and uploaded to online MYSQL data server to provide ubiquitous sharing of the acquired weather data.

2. Related work

Author of [9] has presents a implementation of weather station which consists of TEMT600 luminosity sensor, SCP1000 pressure sensor and SHT15 temperature cum humidity sensor interfaced to ATmega328 microcontroller using SEN-08311 USB Weather Board, along with GSM module. The station can be controlled through the SMS service of mobile phones. Authors of [10] has implemented low cost distributed monitoring system for collecting environmental parameters like temperature, humidity and wind direction using TINI microcontroller card. TCP/IP protocol is used for data transmission and GUI has been developed to observe environmental parameters. Authors of [11] have designed a prototype of low-cost microcontroller based system for continuous and automated monitoring of crop conditions using inexpensive electronic components and solid-state sensors. This system designed to monitor soil moisture, soil temperature, air temperature, and canopy-temperature levels in cropped fields. Authors of [12] have implemented an Intelligent Transportation System (ITS) employing TxDOT Environmental System. TxDOT Environmental System includes sensors such as roadway water depth, rainfall gauge, wind speed, wind direction, temperature, stream velocity along with pavement temperature and moisture sensors. The values from these sensors are sent to local flood control agency using low frequency radios to alert the motorist during severe weather conditions. Authors of [13] have implemented a Multi-Tiered Portable Wireless System to monitor forest fires. The local area weather conditions such as relative humidity, wind direction, wind speed and temperature are acquired using Mica2 sensor nodes. A webcam is provided to monitor live video of the regions affected by forest fires. The acquired data is communicated to local base station through multi-hop technique. Authors of [14] have implemented On-site dynamic wireless sensor monitoring system to optimize energy consumption and to improve user comforts within the building. The system includes Zigbee devices to acquire parameters such as light intensity, temperature, relative humidity and air quality within the building. Further, Zigbee devices measures battery and building electrical power consumption through a current/ammeter sensor interfaced to the sensor nodes. A software tool called Building Monitoring System receives sensor values and updates its database through well established wireless sensor network and performs controlling, monitoring and reporting operations.

The rest of the paper is organized as follows Section 3 and Section 4 describes the block diagram of the implemented system and software architecture. Section 5 outlines the testing procedure and its results. Section 6 concludes the paper.

3. Hardware implementation

The block diagram of Wireless Portable Microcontroller based Weather Monitoring Station is shown in the Fig. 1. The implemented station consists of temperature and humidity sensor, wind speed and wind direction sensor, rain gauge sensor, solar radiation sensor, pressure sensor, surface and ambient temperature sensors along with TLV2543 serial ADC, PIC16F887 microcontroller and control switches. The XBee-Pro module provides wireless communication, MAX-232 and MAX-485 modules are provided for serial communication.

3.1. Relative humidity and temperature sensor (SHT11)

The Relative Humidity (RH) is defined as the ratio of the amount of water vapor in the air at any given temperature to the maximum amount of water vapor that the air can hold. In general RH is expressed in terms of percentage (%). Similarly, the atmospheric temperature is defined as the measure of temperature at different levels of Earth's atmosphere which is expressed in degree Celsius (°C).

The SHT11 sensor is employed to measure both relative humidity and atmospheric temperature. SHT11 incorporates a capacitive sensor element to measure relative humidity and band gap sensor to measure temperature. These sensors are connected internally to serial interface through high precision 14 bit Analog to Digital Converter (ADC). On the request of the host microcontroller, the SHT11 communicates the relative humidity (SO_{RH}) and temperature (SO_T) readouts through serial interface using I2C protocols [15]. The interfacing schematic for SHT11 sensor to PIC16F887 is shown in Fig. 2.

The readouts SO_{RH} is converted to true relative humidity and SO_T is converted to true temperature using Eqs. (1) and (2) respectively. The Eqs. (1) and (2) are referred from the SHT1x datasheet [15]. The coefficients C_1, C_2, C_3 in Eq. (1) and d_1, d_2 in Eq. (2) are selected from Tables 1 and 2 respectively based upon the conversion bit length of SO_{RH} and voltage (V_{DD}) applied to sensor.

$$\text{Relative humidity} = C_1 + C_2 \times SO_{RH} + C_3 \times SO_{RH}^2\% \quad (1)$$

$$\text{Temperature} = d_1 + d_2 \times SO_T\ ^\circ\text{C} \quad (2)$$