2014 International Conference on Computer Communication and Informatics (ICCCI -2014), Jan. 03 – 05, 2014, Coimbatore, INDIA

Internet Enabled Tipping Bucket Rain Gauge

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***Abstract*— The tipping bucket rain gauge is one of the most widely used apparatus for measuring rainfall. Data loggers connected to these rain gauges keep count of the amount of rainfall being received and store it in their internal memory until it's collected. Internet-enabled loggers present currently in the market are very limited and extremely expensive.**

This paper presents a cheap and efficient tipping bucket rain gauge with an internet enabled data logger. The data logger posts the rainfall data to a SQL database located on our server through a microcontroller which has been interfaced with a GSM/GPRS module. This data is posted automatically to the server after every rainfall or once after every 24 hours even if there is no rainfall, along with temperature and humidity data obtained from the respective sensors interfaced to the microcontroller.

***Index Terms*—Tipping Bucket Rain gauge, GSM Module, Microcontroller, Embedded Systems, TCP/IP.**

I. Introduction

Tipping bucket rain gauges are the most widely used apparatus for measuring rainfall throughout the world. Data loggers attached to these rain gauges keep count of the rainfall being received by that rain gauge. Depending on the need these rain gauges may be located in easy to access areas or on the contrary in remote areas where regular collection is out of question.

For data collection manpower is required. It is required of a person to go to the location where the tipping bucket is placed and download the data from the data logger. When the place in consideration is a remote area it gets more complicated.

This paper describes our solution to this problem which enables the rain gauges to connect to the internet and upload the data to a database at required time intervals specified by the user. Thus, the manpower involved in the retrieval of data from the data logger is effectively nullified and data can be accessed from anywhere through a device with an active internet connection.
The data transmission takes place using a General Packet Radio Service (GPRS) link. The only requirement is that a mobile network exists in the area where the rain gauge is placed. If enabled by the user regular notifications are sent to the user via SMS whenever rainfall starts and ends. In addition to rainfall the system can also detect the temperature and humidity levels which it transmits along with the rainfall data. Tipping buckets with only SMS facility have been reported [1] but they do not make use of the GPRS facility provided by the module leading to a comparatively higher cost of operation. Designs for weather stations have also been reported which similarly use the SMS facility to transmit data but are missing of the capability to measure the rainfall [2-3].

II. Theory

The tipping bucket rain gauge is as specified the most widely used instrument for measuring rainfall throughout the world. The basic structure of the tipping bucket rain gauge is shown in Fig. 1.

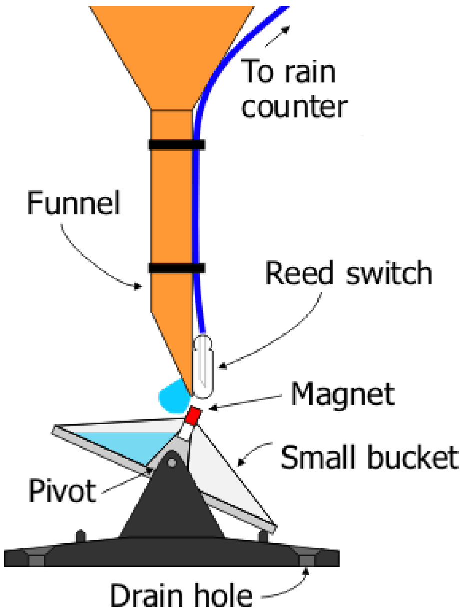

Figure 1. Diagramtic represntation of the tipping bucket rain gauge.

As rain falls it enters the funnel and is channeled through a narrow passage and comes out of the opening to fall into one of the calibrated buckets which are balanced on a pivot. When one of the buckets receives a certain amount of rainfall, it tips causing a change in the state of the reed switch momentarily due to the movement of the magnet attached to the buckets.

This closing of the switch sends out a pulse which can be detected by the circuitry i.e. the microcontroller in this case. Thus the total rainfall received in short can be calculated as

Total rainfall received = No. of tips received X Resolution of the tipping bucket

Reed switches are available in both forms as a normally closed switch or normally open switch, thus depending on the type of switch that has been built into the rain gauge a high-low-high transition or low-high-low transition has to be waited for.

III. System Description

A basic outline of the system is shown in Fig. 2. with all the major components that have been used being shown.
The internet enabled tipping bucket rain gauges are made possible by a combination of hardware and software that have to be synchronized properly in order to achieve the desired results. They are discussed below separately.

A. Hardware

The major hardware components involved are the Atmega2560 microcontroller, SIM900 GSM/GPRS module and the temperature and humidity sensor. The functionalities of each of these components and the role they play are described below:

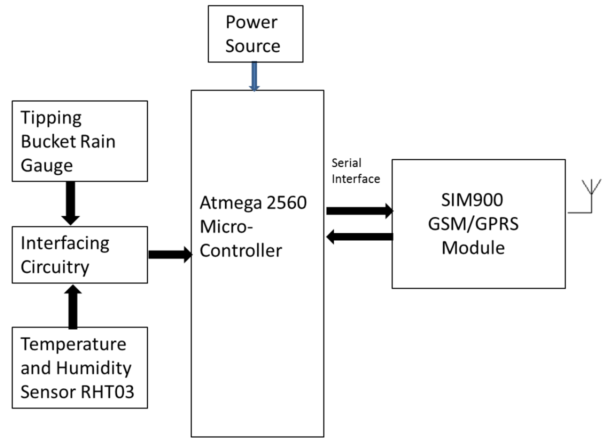

Figure 2. Basic block diagram of the Internet Enabled tipping bucket rain gauge.

1) Atmega 2560 Microcontroller:

The Atmega 2560 Microcontroller is the brain of the Internet enabled tipping bucket rain gauge. It's an 8 bit microcontroller with 64K programmable flash memory. It has a RISC architecture with an execution speed of 16MIPS at a clock speed of 16MHz [4].The major functions that are assigned to the Atmega 2560 are:

- Recognizing the tips when they occur.
- Keeping track of the number of the tips that occur.
- Acquiring temperature and humidity data from the sensor interfaced to it.
- Initiating a GPRS link through the SIM900 module.
- Sending the appropriate commands to the SIM900 Module in order to transmit the rainfall, temperature and humidity data to the server over the GPRS link.
- Shift the SIM900 module to low power mode after data transmission is complete.

The Atmega2560 was deemed suitable for this application due to its large internal memory which was the defining requirement in this application due to the high amount of data that will have to be stored before it is transmitted to the server.

2) SIM900 GSM/GPRS Module:

The SIM900 GSM/GPRS wireless module coupled with an antenna is the interface for microcontroller to the GSM network present in that area. The SIM900 module also has an internal TCP/IP stack which allows us to connect to the internet via a GPRS link which is what we have used [5]. The module has been specially designed for embedded applications and also has functionalities which enable us to call, send SMS etc.
The SIM900 is one of the few modules to support the GSM 900 standard that is used in many places throughout the world and offers sufficient data rate to transfer the rainfall data to the server thus making it the choice for this application.

Commands are sent from the Atmega 2560 microcontroller to the SIM900 module through serial communication. These commands are called AT commands (Attention commands) and have special pre-defined formats for each specific function that is required [6]. For example if we want to place a call to the number 987654321 we would send the command

"ATD987654321"

to the SIM900 module via Serial communication

3) Temperature and Humidity Sensor (RHT03):

The RHT03 is a quarter sized sensor with both temperature and humidity sensors on board. The specifications of these sensors are:

- 0-100% RH with an accuracy of +-2%RH
- -40 to 80 °C with an accuracy of +-0.5 °C

This sensor has a unique one wire interface. Each packet of data (consisting of 40 bits) that is sent has a certain format as shown below:

0000 0010 1000 1100 | 0000 0001 0101 1111 | 1110 1110
16 bits RH data | 16 bits T data | check sum

The check sum helps in verifying the integrity of the data that has been received:

Check sum=0000 0010+1000 1100+0000 0001+0101 1111=1110 1110

RH= (0000 0010 1000 1100)/10=65.2%RH

T= (0000 0001 0101 1111)/10=35.1

B. Software

The software component of the Internet enabled tipping bucket rain gauge is divided into two categories:

- The Embedded Software – This is the code that is placed inside the microcontroller and is the code which is responsible for detecting the tips of the rain gauge, keeping count of the number of tips received, retrieving data from the sensors and then initiating a GPRS connection and transferring the data to a database. This is primarily written in C.

- The Web backend – This is the code that lies in the server and is responsible for accepting the data that is sent to it from the location of the rain gauge and then storing it in a database. This is written in PHP and involves an SQL database.

1) Embedded Software:

The Embedded software is the code that is written for the microcontroller and is stored in it. It continually executes and is always on the lookout for the occurrence of a tip.
As soon as a tip occurs for the first time it keeps count of the number of tips received in this session. When the rain ends it transmits this rainfall data and the sensor data to the database located on our server.

The code also initiates communication with the GSM/GPRS via module serial AT commands. The code for the Embedded Software is written in C. The algorithmic workflow of the embedded code is shown in Fig. 3:

2) Web backend:

The web backend which is stored on our servers consists of two parts. A set of PHP scripts which are called by the GSM module and a SQL database. The microcontroller receives the sensor data and creates a HTTP link which contains the number of tips that have occurred, temperature and humidity data. A HTTP session is initiated and the link is called. The PHP script takes these data as its input and creates an entry in the database for this data. The format of the http link is as below:

http://tarunkaruturi.in/registertips.php?rainfall=”No. of tips goes here”&temp=”Temperature data goes here”&humid=”Humidity Data goes here”&location=”Location Name goes here”

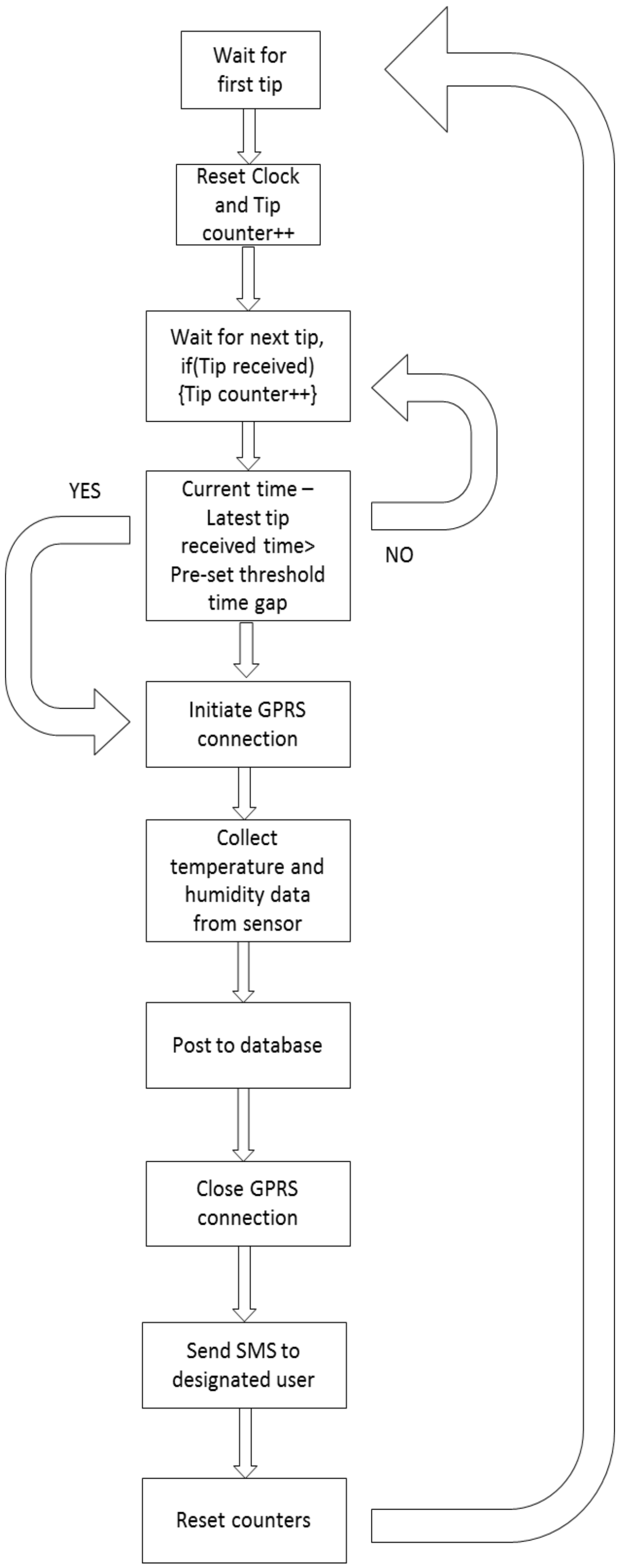

Figure 3. Process flow chart of the embedded code.

The data can then be easily downloaded at any time from the server. A small snippet of the database is shown in Fig. 4.

localhost » anna_rainfall » rainfall_data

Browse | Structure | SQL | Search | Insert | Export | Import

Sort by key: None

+ Options

	ID	Location	Rainfall	Temperature	Humidity	Time
Edit Copy Delete	102		20.00	27.5	57.8	2013-06-28 18:21:29
Edit Copy Delete	101		25.00	27.0	58.0	2013-06-26 13:12:04
Edit Copy Delete	100		27.00	21.3	27.2	2013-06-25 17:35:12
Edit Copy Delete	99		30.00	21.1	27.2	2013-10-11 17:38:47
Edit Copy Delete	98		32.00	21.1	27.2	2013-10-11 17:38:50
Edit Copy Delete	97		22.00	21.1	27.2	2013-10-11 17:39:13
Edit Copy Delete	96		25.00	0.0	0.0	2013-10-11 17:36:27
Edit Copy Delete	95		27.00	27.6	24.5	2013-10-11 17:39:17
Edit Copy Delete	94		30.00	21.1	27.2	2013-10-11 17:39:09
Edit Copy Delete	93		25.00	21.1	27.2	2013-10-11 17:39:24
Edit Copy Delete	92		33.00	21.0	27.0	2013-10-11 17:39:20
Edit Copy Delete	91		20.00	0.0	0.0	2013-06-24 09:11:08
Edit Copy Delete	90		22.00	0.0	0.0	2013-10-11 17:37:53
Edit Copy Delete	89		23.00	0.0	0.0	2013-10-11 17:37:59
Edit Copy Delete	88		21.00	0.0	0.0	2013-10-11 17:38:04
Edit Copy Delete	87		25.00	0.0	0.0	2013-10-11 17:38:19
Edit Copy Delete	86		24.00	0.0	0.0	2013-10-11 17:38:33
Edit Copy Delete	85	hyderabad	99.99	27.6	24.5	2013-06-24 08:33:00
Edit Copy Delete	103	ICRISAT1	33.00	26.5	67.6	2013-06-24 13:01:38
Edit Copy Delete	104		33.00	0.0	0.0	2013-06-24 13:06:03

Figure 4. Small snippet of the SQL database.

IV. RESULTS

The final system circuitry for the Internet enabled tipping bucker rain gauge is shown in Fig. 5.

The GSM module is interfaced with three major components which are the microcontroller, the SIM card and the antenna. The UART interface between the GSM module and the microcontroller enables communication between them. The pin of the microcontroller which is connected to the Reed switch of the tipping bucket is also connected to a +5v source.

When the Reed switch is open which is during the majority of the time that pin of the microcontroller reads a HIGH status. As soon as the Reed switch closes due to the occurrence of a tip the pin reads a low status for a certain small time period and then switches back to a HIGH status again. Thus a pulse is presented to the pin and these pulses are used for counting the number of tips that have occurred.

The NETLIGHT pin of the GSM module is connected to a LED and the frequency of blinking of the LED can be used to detect any problem in connecting to the network or if the SIM card hasn't been recognized.

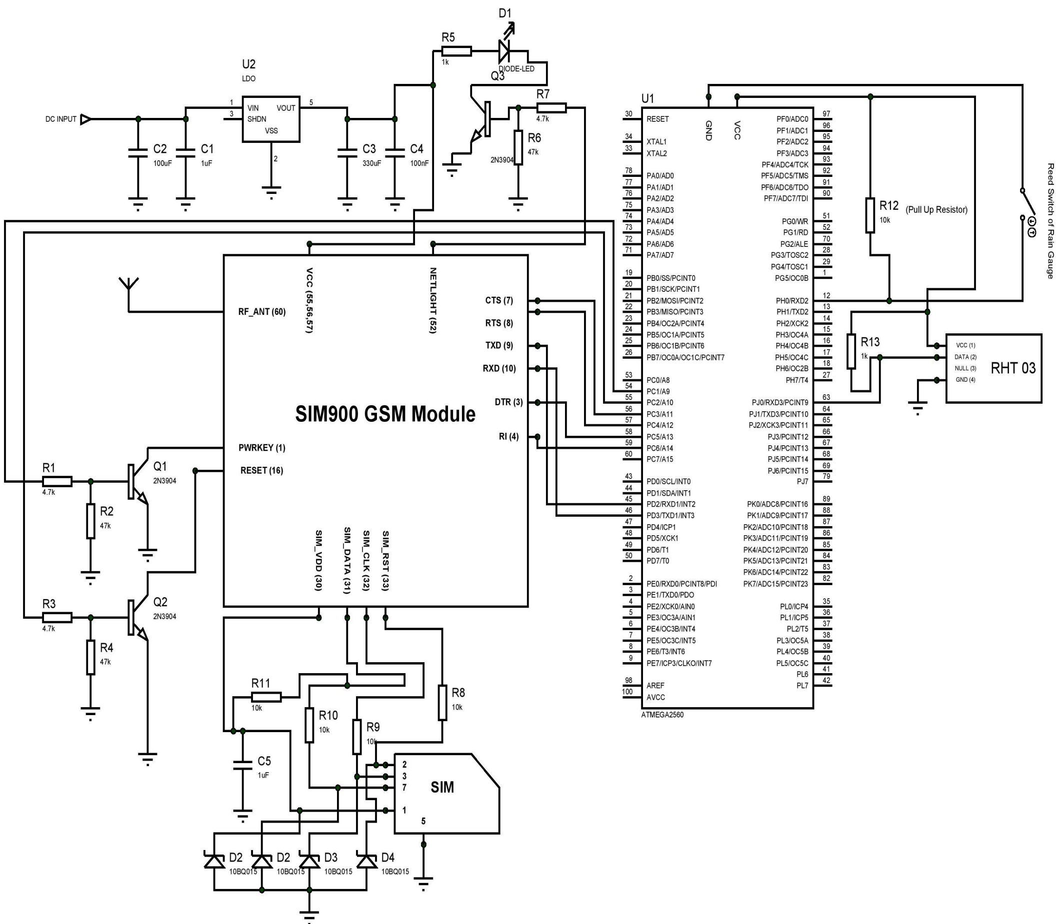

Figure 5. Circuit diagram of the Internet enabled tipping bucket rain gauge.

V. Conclusion

The complete design and working of an internet enabled tipping bucket rain gauge has been presented. The design has been tested on field and rainfall, temperature and humidity data has been successfully posted to the database on our server.

After the data has been acquired by the microcontroller the delay observed in posting the data to the database has been 10-15 seconds. This time was consumed in initiating the GPRS connection posting the data to the database and then terminating the GPRS connection to save power.

Further improvements are being planned out for the system which includes making the data available on a mobile app so that the user can access the data anywhere, without a PC directly on the phone. Another major area for improvement is optimizing the algorithm so that the power consumed by the GSM module (which consumes the largest amount of power in the circuit) is reduced to a minimum.

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