Development of automated weather Station: three cup anemometer and tipping bucket rain gauge

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Introduction

Weather is the state of the atmosphere with respect to wind, temperature, cloudiness, moisture, pressure, etc. Weather measurement tools are used to determine the actual weather and forecasting. Natural wind in the open air is a three-dimensional vector that has the directions of north, south, east and west in addition to vertical components and magnitude (i.e., wind speed). As the vertical component is ignored for most operational meteorological purposes, surface wind is practically considered as a two-dimensional vector. An anemometer or wind meter is a device used for measuring wind speed, and is a common weather station instrument. The rain gauge is an instrument that is used to measure the quantity of rainfall or precipitation over a particular time period at a specific region. The forms of precipitation may be in the liquid form that is the rainwater or the solid forms that are the sleet, hail, or even snow. In Sri Lanka it is as rainwater. In this work we have developed an automated weather station of three cup anemometer to measure wind speed and tipping bucket rain gauge to measure rainfall rate. The current wind speed and the rainfall of the past 24 hours were displayed in a LCD panel where the user can easily read and record the data.

Methodology

A fix magnet is attached onto the three cup anemometer. When the wind blows, cups and axel attached to then will spin relative with the wind speed, thus the magnet will trigger the Hall Effect sensor. A pulse will be generated as an output for each revolution. The time difference from each pulse (length of the pulse) is used to calculate the speed of the wind. The output from Hall Effect sensor will be transmitted to microcontroller to be processed and calculated. The calculated measurements are displayed on the LCD. It is displayed the length of the pulse in milliseconds. A prototype of three cup anemometer was made using Iron Shaft, 2 bearings, 3 Light weight metal rods, 3 cups and, piece of wood (Figure 01). A Hall Effect Sensor and a magnet fixed to the iron shaft were used to detect number of rotations. Electric signal produce due to the Hall Effect is fed to the 16F877A pic microcontroller. A prototype of tipping bucket rain gauge was built by using plastic jar, funnel and plastic, light weight bucket. A light weight ice cream cup was used to build the bucket which contains two separate parts inside the bucket to fill the water one after another and the tipping bucket was set to the lid of the plastic jar with two aluminium L shape pieces (Figure 02). Small magnet was placed at upper edge of the triangle in one side of the bucket. To count the toggling of the bucket, a normally opened reed switch was used and it was placed in one bucket side which has fixed the magnet and covers it with plastic cover to protect from water. Toggling of the bucket was counted by the reed switch.

Figure 01: Prototype of anemometer

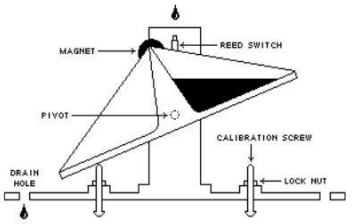

Figure 02: Tipping bucket mechanism

Rainwater collected in the receptacle is channeled through the funnel and poured into a tipping bucket. When it reaches a predetermined amount, the bucket tips and dumps the water into a drain cylinder, causing the reed switch to generate a pulse. Subsequent rainwater is poured into the other bucket. As long as precipitation continues, this operation is repeated and a pulse is generated each time a bucket tips. For the calibration, the volume of one side of the bucket was measured. The total amount of rainfall over a given period is expressed as the depth of water which would cover a horizontal area if there is no runoff, infiltration and evaporation. This depth is generally expressed in millimeters. Finally, the rainfall rate calculated in mm for the past 24 hours using the mathematical formula; $r = 4 / {}^{2}$ Where V is the bucket volume, and d is the rain gauge diameter (of the outer funnel).

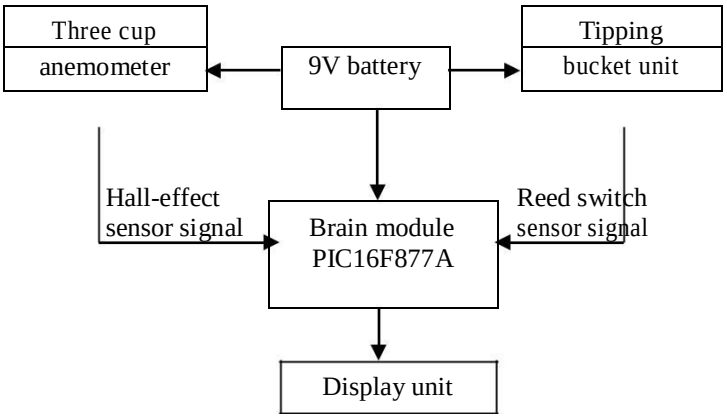

Figure 03: Block diagram of automated weather station: three cup anemometer and tipping bucket rain gauge

Results and Discussion

To measure the speed of wind this prototype uses the time taken by the cups to rotate one round. When the cups rotate iron rod also rotate with the same speed and it makes the magnet attached to the rod move along and due to the moving magnetic field the Hall Effect sensor produce a pulse. Controller circuit measures the length of this pulse in milliseconds. To obtain accurate readings it is important to place the anemometer in a horizontal plane and in a place where the wind blows without disturbances like trees and buildings. Also when constructing, the mechanical parts should be constructed to minimize frictional losses and electrical losses. Calibration is very important for any measuring instrument, to calibrate this prototype we have to generate wind of known speeds using a wind tunnel and take the reading of the instrument and plot a graph and develop an equation to convert time taken by the magnet to pass the Hall Effect sensor in one rotation into wind speed. In standard instruments the instantaneous wind speed in measured for a period of 10 minutes and the average is calculated.

The rain gauge was successful worked with measuring rainfall and displaying it on the lcd display. Funnel diameter was 10 cm and volume of one bucket was 5 ml. if the both buckets have toggle in different volumes calibration screws can used to equal both volumes. To conduct a good flow of water and prevent form spreading water it is need to cut the funnel's bottom part into around 45 degree angle. The funnel should also fixed well to the plastic jar to avoid water entering because of leakage. The advantage of the tipping bucket rain gauge is that the character of the rain whether it is light, medium, or heavy may be easily obtained. Rainfall rate is decided by counting the number of 'clicks' in a short fixed period and lets the observer decide the character of the rain.

As a further improvement, rainfall and wind speed measurement data can store in a database for further analysis.

References

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