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Low Cost Cup Electronic Anemometer

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I. Introduction

Introduction - There is a wide variety of anemometers and the most common are Cup anemometers. They consist of Cups attached to stems that are fixed to a central axis. Other anemometers, such as hot wire that measure the temperature change of a wire heated electrically by the passage of wind; Pitot probes use the Bernoulli Principle and the propeller anemometers have a front propeller to determine wind speed. The first anemometer, applying scientific principles, was developed by [1]. In the meteorology studies, the anemometer is an important instrument in the atmospheric analyzes [2 - 3], where the authors used the equations of angular motion and frequency to determine the rotation of the instrument. The researchers [4] studied the influence of lattice towers on the Cup anemometers, analyzing the best distance of less turbulence between the tower and the anemometer. To develop a rotational anemometer of conical Cups, [5] used an electronic blocks system, requiring calibration to validate the results. Another application of the anemometer is in the estimation and measurement of the efficiency of wind turbines [6]. The most common use of Cup anemometers is in meteorology and agriculture, to optimize agricultural practices with more precise decision-making. The use of this equipment in Brazilian agriculture is limited by its high cost [7]. Instead of using a first degree function in anemometer calibration, [8] uses two harmonic constants, which represent the influence of Cup geometry. Also [9] refers to the use of anemometers in wind energy and uses the front and rear drag coefficients and the radius of rotation to determine the instrument constant. The device chosen for this work is the Cup anemometer because it is simple and uses only a reed-switch sensor to measure the rotation of the device.

II. Materials and Methods

Materials and Methods - To build the anemometer were used three 70 mm aluminum confectionery Cups, three 3 mm diameter stems, a center bearing for fixing the stems with screws, a central axis to support the assembly, a neodymium magnet and a reed switch sensor, as shows the Figs. 1(a) and Figs. 1(b) shows the top view of the anemometer with the stems, the central bearing, the Cups and dimensions.

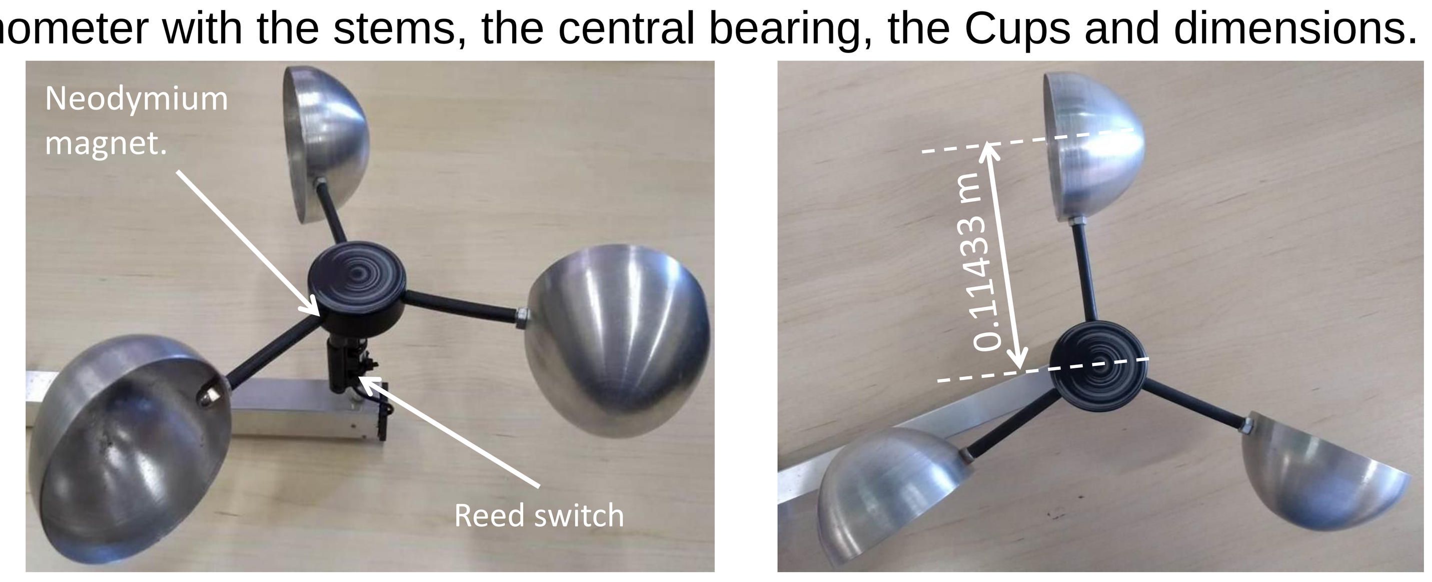

Figure 1. (a) Anemometer assembly; (b) Dimensions.

The spacing between the magnet and the reed-switch sensor [10] is 3 millimeters and when these two components are crossed, the sensor "S1" closes the circuit (Fig. 2), counting one pulse at each full revolution. The pulse register is counted and controlled by the Arduino software [11], which was previously loaded into the processor memory. The 10 kΩ resistor adjusts the logic signal.

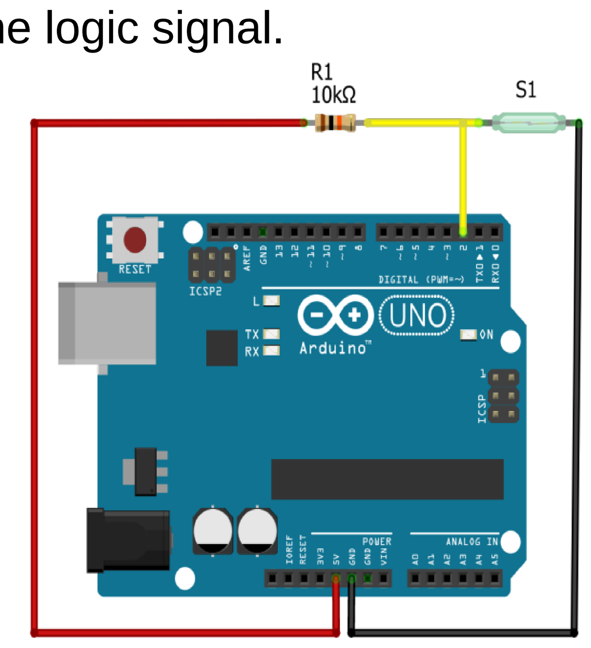

Figure 2. Electronic circuit.

To calculate the air speed, [12] suggest the calculation procedure described in Equations (1), (2) and (3), where k_d is a relationship between the frontal and rear drag coefficients, $c_{d1} = 1.42$ and $c_{d2} = 0.3$, respectively, extracted from [13]. The anemometer factor (K) is defined by the aerodynamic characteristics of the Cups, extracted from Equation (2) or a relationship between air speed (V), with anemometer radius $r = 0.11433\,m$ and angular speed (ω) defined in Equation (4). Also with the Equation (5) is determined air speed in $[m/s]$. The index (f) represents the pulses per revolution measured at reed switch sensor.

$$k_d = \sqrt{c_{d1}/c_{d2}} \quad (1)$$

$$K = V/r \cdot \omega = (k_d + 1)/(k_d - 1) \quad (2)$$

$$V = K \cdot \omega \cdot r \quad (3)$$

$$\omega = 2\pi \cdot f \quad (4)$$

$$V = 2.27f \quad (5)$$

The same calculation procedure was used by [14] and [15].

A. Programming the Arduino platform

A small part of the Arduino programming is shown in Fig. 3, where air speed is calculated from constant 2.27 shown in (5) and (f) are the pulses measured by the reed-switch sensor.

```
}
Pulse = 1000.0*countPulse/(millis()-timeold);
if (pulse==0){
  AirSpeed=0;
}
  else if (pin==2){
    AirSpeed = 2.27 * f;
  }
}
```

Figure 3. Part of Arduino programming.

IV. Results and Discussions

Results and Discussions - The calibration procedure for instrument certification was carried at IPMet-UNESP Bauru/Brazil from 08:00 to 19:00, with a measurement interval of 1 minute. The reference instrument was a propeller anemometer [16], generating a linear function and coefficient of determination (R^2), which were included in the graphic of Fig. 4(a). With the anemometer air speed (V_{Cup}) is inserted into calibration equation, thus obtaining the calibrated airspeed (V_{Real}). The Fig. 4 (b) shows the comparison between the two instruments, with small variations in the acceptable range of 4.5 and 7.3 m/s.

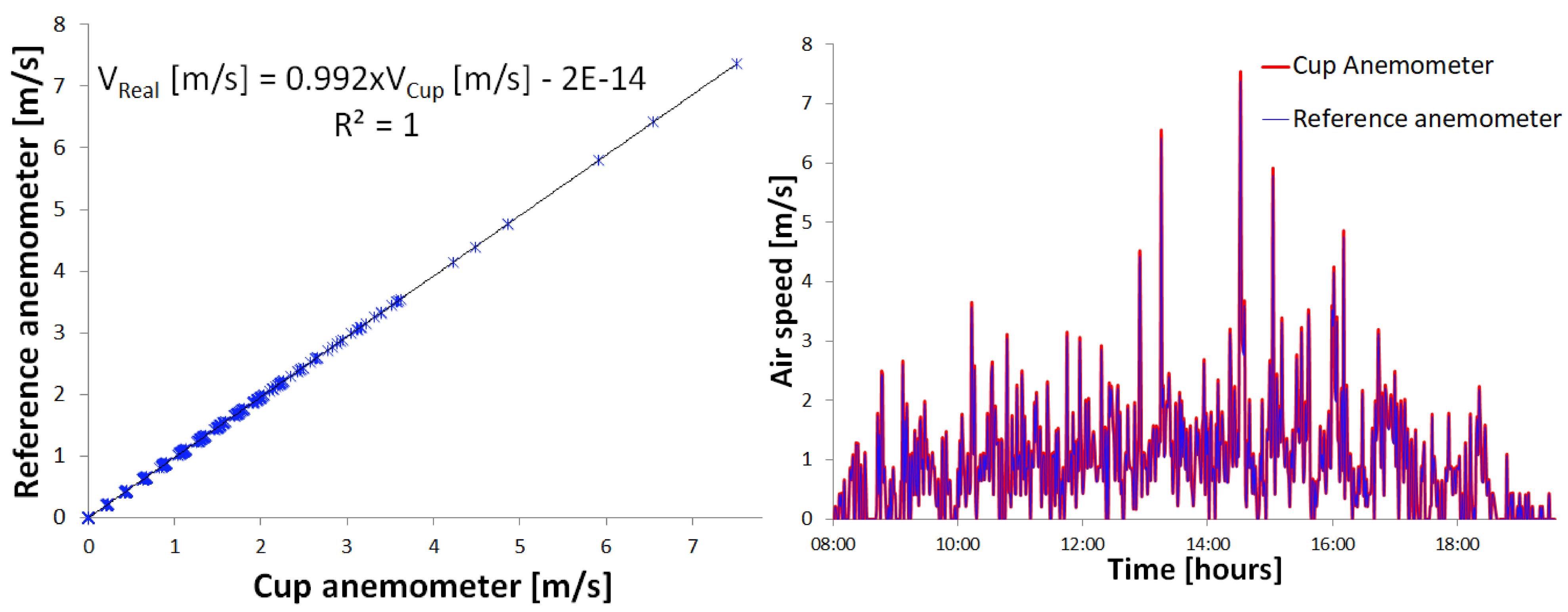

Figure 4. (a) Calibration curve; (b) Air speed comparison curve.

V. Conclusion

Conclusion - The Cup anemometer presented excellent agreement with the reference sensor. It is a great choice for use not only for small farmers, but also for evaluation of wind turbines and especially for meteorological stations. The great attraction of this instrument is its low cost, with a value of US$ 50.00, even considering the value of the machining time, because its components are very simple.

VI. References

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