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A New Technique for Hot- Wire Anemometer

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Abstract

A new hotwire Anemometer has been designed and developed. This hotwire ia a software-based device that uses a combination of infrared transistors' differential heating system amongst others to sense windspeeds and wind temperatures at any instant in an area. It has been calibrated using standard procedures. It has a dual – output system and can measure up to 928.669cm/s of windspeeed and 255 deg. Celcius. The instrument was tested to measure aircirculation in a normal research lab/office under conditions of still air (natural convection) and strong draught. It was also used to measure airflow along a corridor and windspeeds over the Federal Polytechnic Ede campus sixhourly for five days. The results showed correlation with windspeed responses obtained using diferent instruments in the literature.

1. Introduction

Up till this time of discussion; it is not yet recorded historically the actual inventor of the first anemometer. Instead, renaissance Leon Battista Alberti is often referred to as the inventor of a swinging plate device, which was believed to have been the first mechanical anemometer around 1450 (Athelstan, 1953). Nowadays, there has been development of different versions of modern anemometer for the prediction and measurement of windspeeds at different levels of the atmosphere for meteorological uses. Also the properties of gas flows are ensured by these anemometers. Current anemometers are easier to use than their ancient counterparts and also are much more convenient and versatile as recorded in literatures. The modification to the first anemometer was done by Robert Hooke; his version of anemometer was associated with a circular or square plate, kept normal to the wind vane (Allen, 1983). The construction of an anemometer with the inclusion of the main part of a circuit was done by Kris Chalmers. He investigated works done by earlier scientist as regard the circuit used as well as the physical design of the unit. In his investigation, he noted that many designs did not have any circuits, they only spin to the same degree when the atmosphere was windy but with the American IC; complex circuit was observed (Franklin, 1972).

Kris Chalmers used a digital circuit that counts the number of switches over a pre-defined time when displayed in his own work. His circuit basically involved seven IC chips; the first was 74121 on the circuit. This was seconded by 555 timers, one running into the trigger of the other. One of the 555 timers can be replaced to ensure calibration because it has a variable resistor such that the frequency of the output can be changed (Iten, 1976). Conley Stephen's design involved the use of two cups, this is to ensure simplicity in the construction, and also the materials needed were of low cost. This design had problem when tested, because with the two cups used, there was possibility that the wind blew in one direction that made the anemometer spin; but with more cups the anemometer functioned more efficiently (Cintriniti, 1994). The modification of the three cups anemometer produced by Robinson (1846) was ensured by the Australian Derek Weston in 1991 to measure both wind direction and wind speed. Weston did add a tag to one cup which caused the cup wheel to increase and decrease as the tag moved alternatively with and against the wind. Wind direction was calculated from these cyclical changes in cup wheel speed while wind was determined from the average cup wheel speed

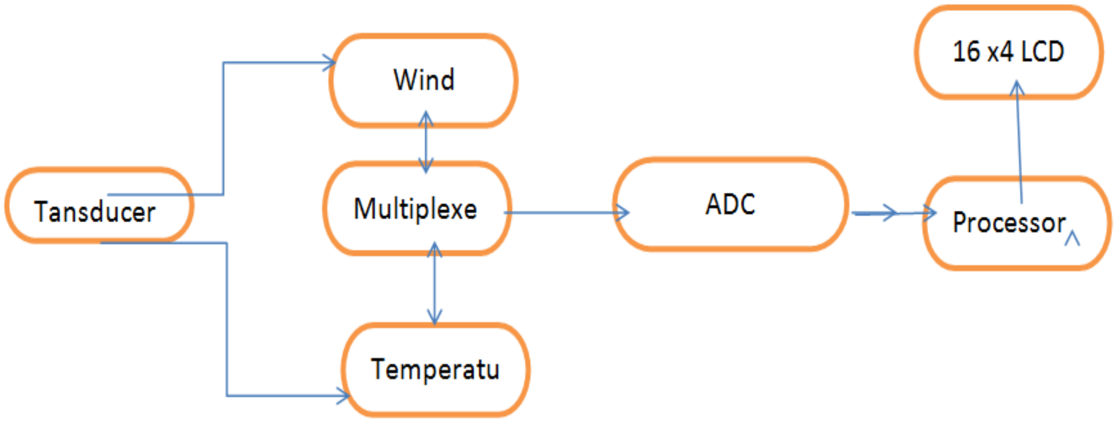
Hot-wire anemometer are thermal anemometers with exposed hot-wires, they measure change in wire temperature through heat loss as it is cooled by the wind which is converted into fluid velocity. These hot-wire anemometers display air velocity and temperature simultaneously on the dual-readout L C D. It averaged up to 20 air volume point for a mean calculation, other features include built-in Rs232 serial port, min/max, data hold, and author shut-off. This meter is ideal for duct and ventilation measurement, it average up to 20 air volume points for a mean calculation. The direct measurement of wind speed can be studied when considering a quick paper template overlaid on the meter bar graph, while on the meter the numerals are translated so as to get the actual wind speed, the graph when plotted directly against templates gave a calibration which can be followed accordingly to the routine of the wind speed in meter/sec to the available means.

Higher - resolution measurements with ultrasonic anemometers in clouds have been made (Curette et al. 2000; Siebert et al. 2006) but were observed to be limited in general to a resolution of around 10 cm because of line averaging over the path length (Kamal et al. 1968). Local statistical parameters such as local energy dissipation rate had been obtained, a record of at least 100 samples were used for the statistically stable estimation (Frehlich et al. 2004). The sensor of choice for many decades in wind experiment was the hot-wire anemometer. High resolution measurements for example with a sensor package carried out with a tethered balloon have been made (Muschinski et al. 2001). The constant temperature hot-wire anemometer with a platinum-plated tungsten wire (type 55P01) with a diameter of $5\mu m$ and overall length of around 3 mm was used to measure turbulence, whereas the sensing part was 1.25 mm long (Raymond ,2006). This work reports the measurement of windspeeds using differential heating of two infrared transistor-system using a software-based electronics circuits.

2. Materials and Methods

All the materials used in this work were sourced from the local market.
The design and development of the Anemometer was carried out in stages as illustrated on the block diagram on Figure 1:

Figure-1. Block Diagram of the Anemometer



2.1. Temperature Measurement

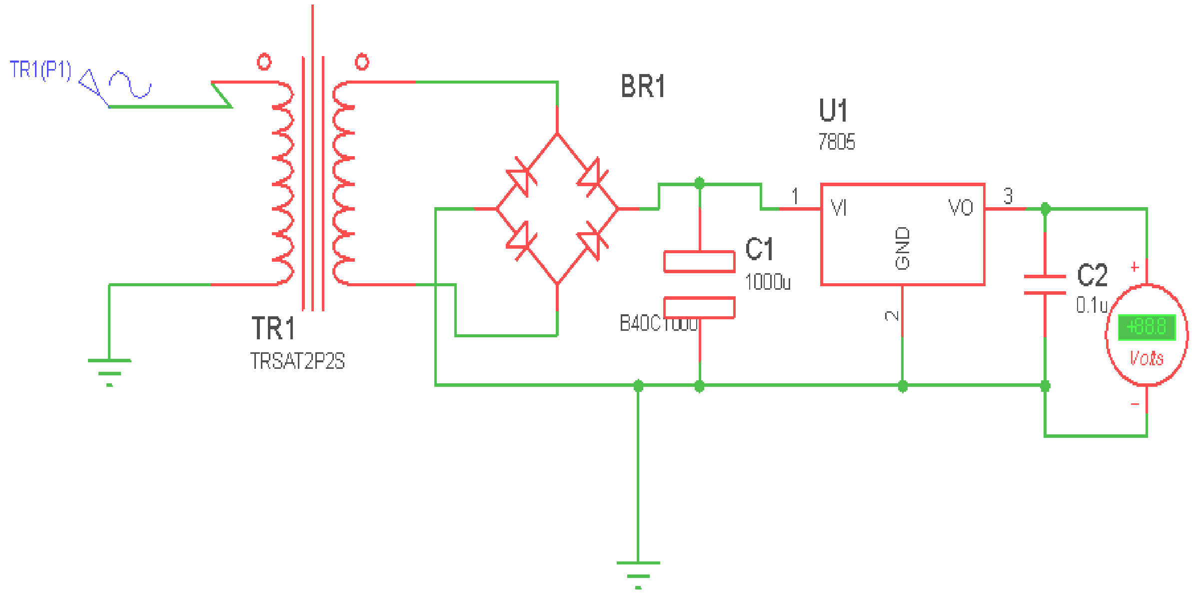
The temperature sensing device was the LM35 sensor which is a precision centigrade temperature IC .This sensor produces 10m /per degree Celsius. The output of the IC was sent to amplifier and latter to the ADC (ADCO804) as shown in the diagram of Figure 2.. The output of the ADC was then fed into the Micro controller and the output was sent to LCD (liquid crystal display) for ambient temperature measurement visual display.

2.2. Wind Speed Measurement

The two probes were the BC 107BP transistos. The connections were made as indicated in the circuit diagram shown in Figure 2. The output voltage from the transducer was being fed into the two op amps for amplification. The overall output was then fed into amplifier to ADC to microcontroller (AT89552) LCD. Power was supplied into the circuit from the power section of the device

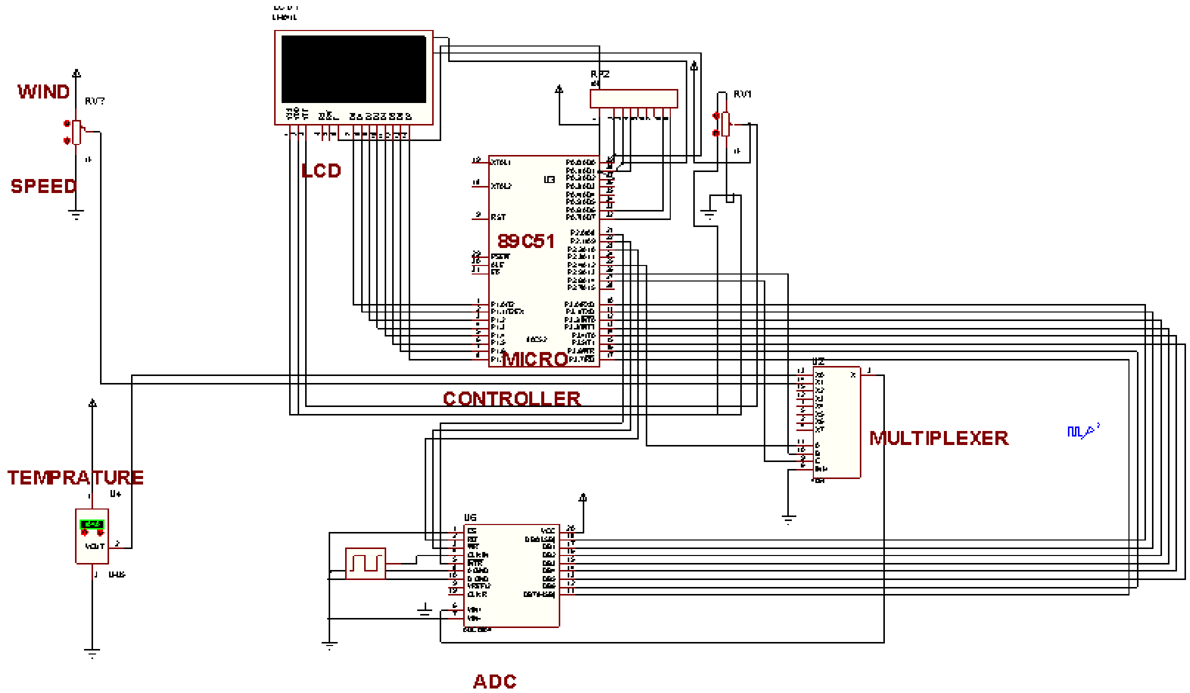
Figure-2. Schematics of the Hot-Wire Anemometer showing (a) Windspeeds and (b) Temperature Circuits

Figure-3. Power Stage



An OP – AMP Lm 358 used was a dual OP – amp. It was used to compare two signals or voltage levels. This implies that where the signal voltage (from wind variation) was different from the reference voltage (from the constant temperature of the probes) there would be an output, and when there were no differences, there would be no output. The IC also served as a good voltage amplifier.

Figure-4. Circuit layout of the Complete Hot-Wire Anemometer



2.3. Assembling and Casing

For portability and safety, a plastic casing of dimension being 22.5cm x14.5cm x 6cm, was used for the packaging. The sensing transistors were protruded from within the casing to enhance being perpendicular to them. The major power source to the device was a 9 volts d.c. portable source.

3. Results

The fabricated device was tested on the Federal Polytechnic, Ede campus, using it to measure wind speed and temperature, six hourly, in the indoor, passage and outdoor to observe its performance. The tables of the results got are shown in the appendix, while the graphs are given below:

Figure-5. Graph of WindSpeed Vs Time (6 Hourly) [Indoor]

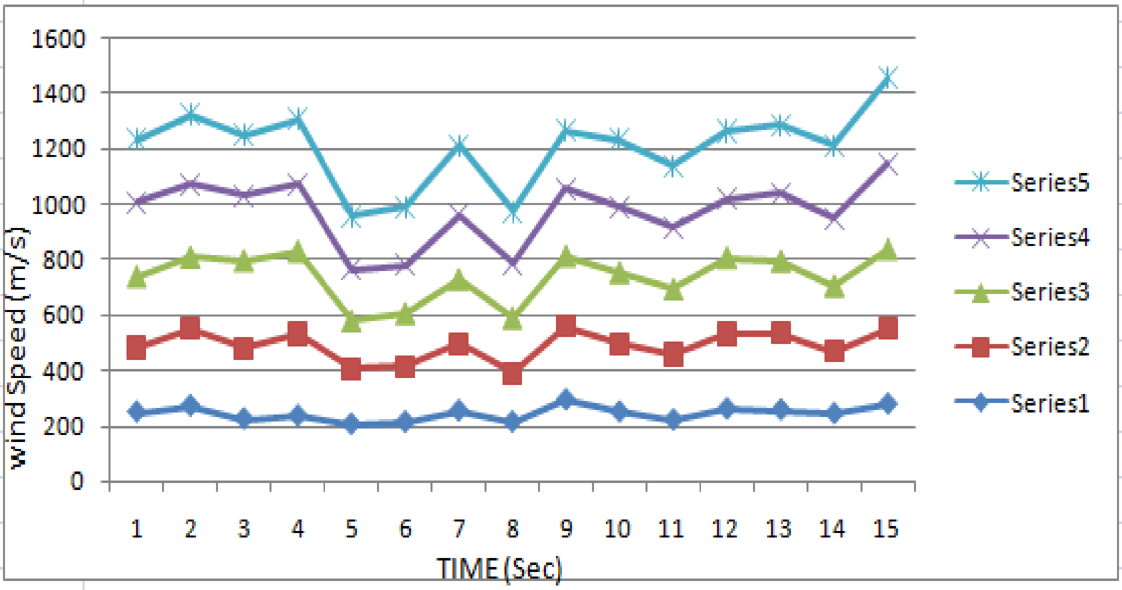


Figure-6. Graph of Average WindSpeed Vs Time (6 Hourly) Ìndoor]

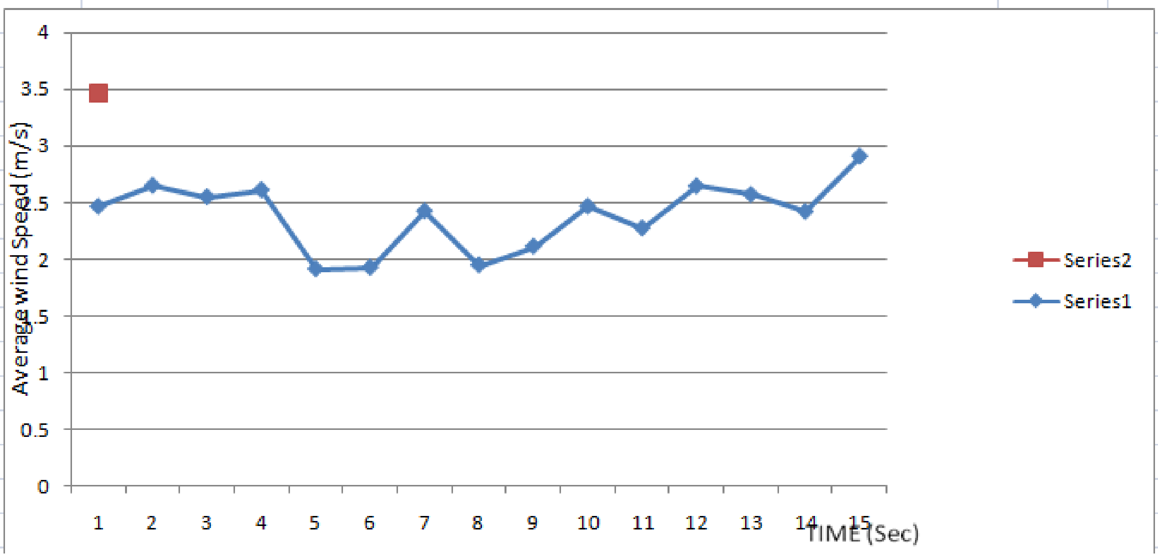


Figure-7. Graph of WindSpeed Vs Time (6 Hourly) [Passage]

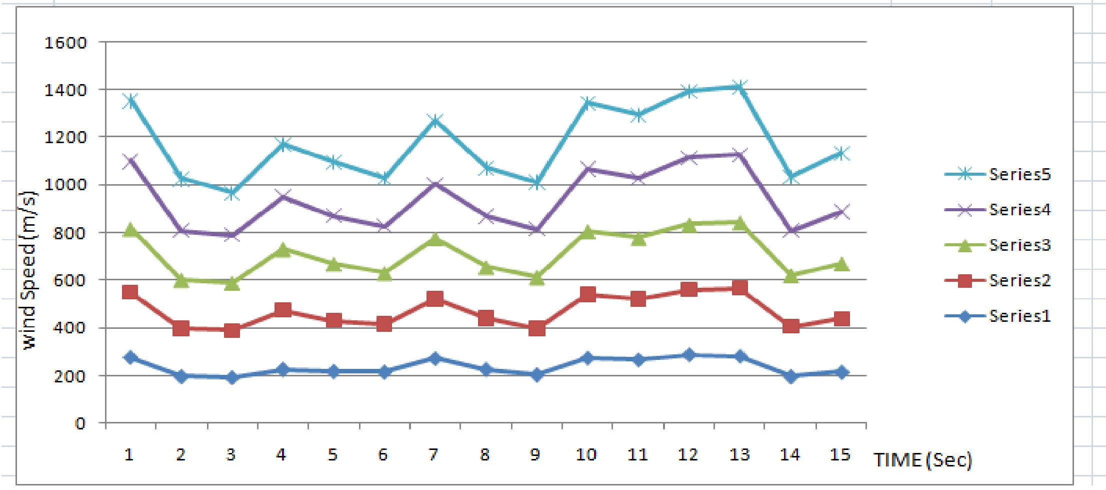


Figure-8. Graph of Average Windspeed Vs Time (6 Hourly) [Passage]

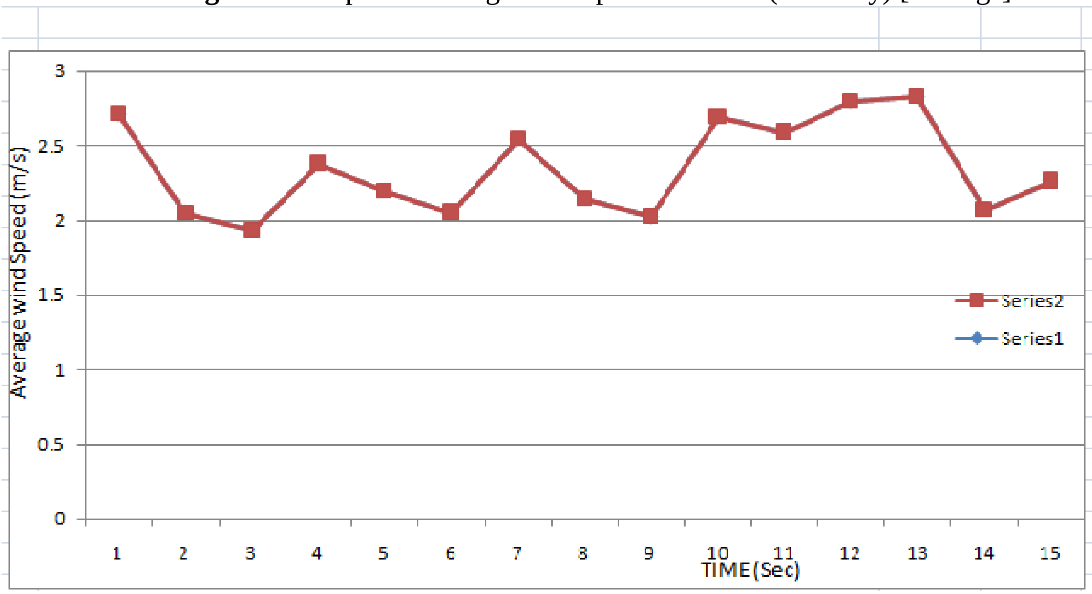


Figure-9. Graph of Windspeed Vs Time (6 Hourly) [Outdoor]

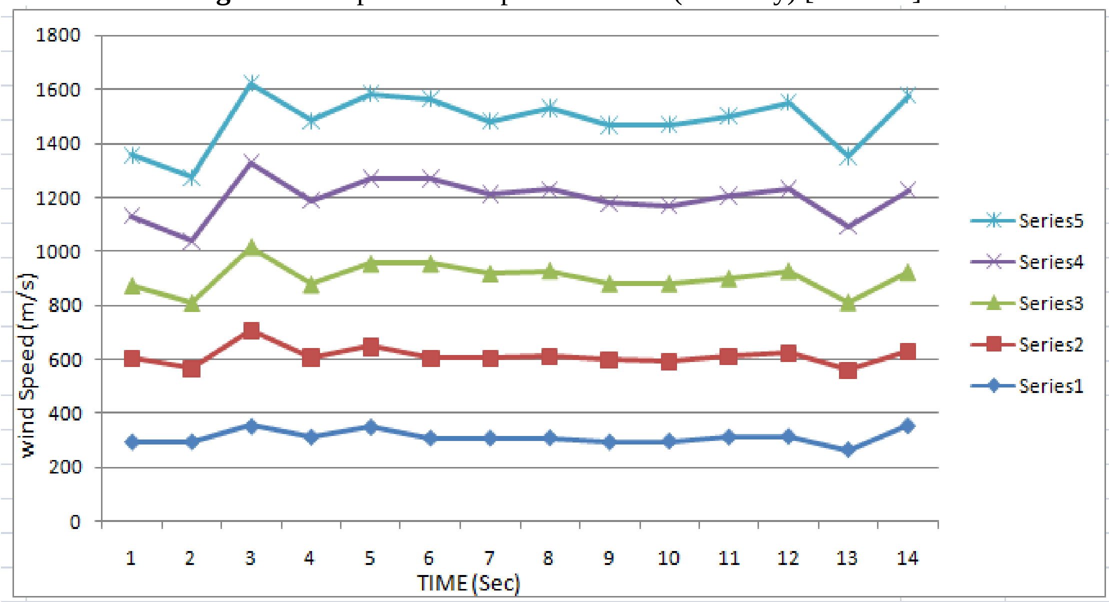


Figure-10. Graph of Average Windspeed Vs Time (6 Hourly) [Outdoor]

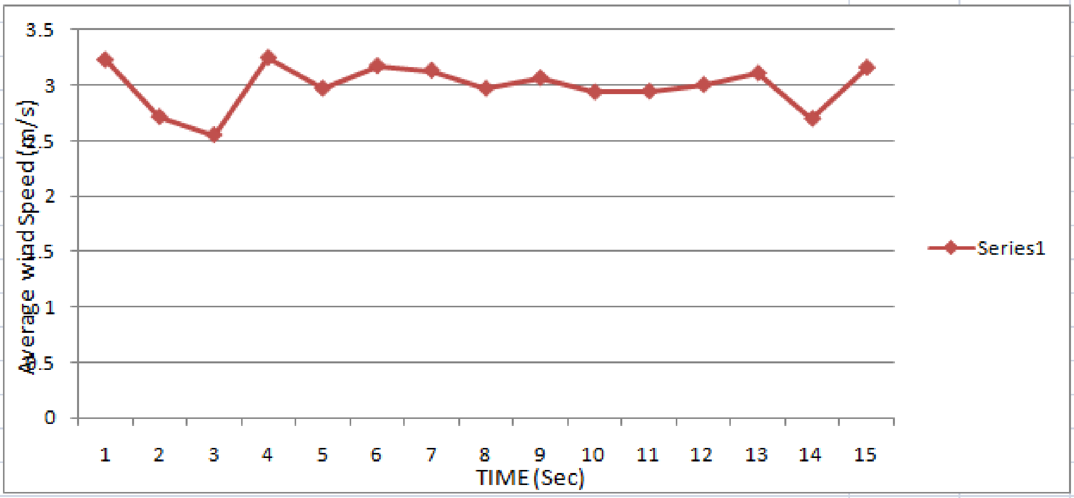


Figure-11. Graph of Windspeed Vs Time (6Hourly)

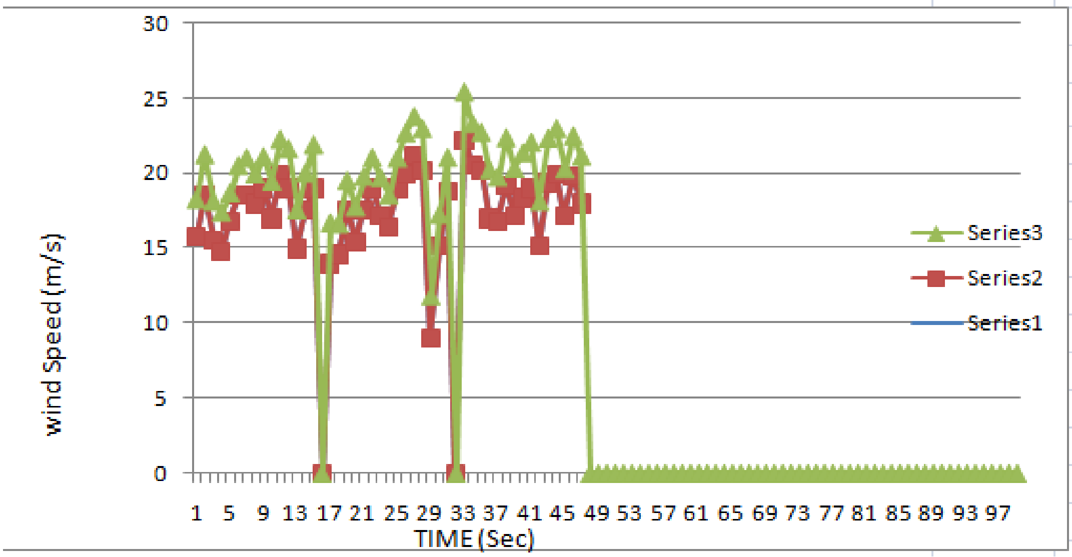


Figure-12. Graph of Wind Temperature Vs Time (6 Hourly) [Indoor]

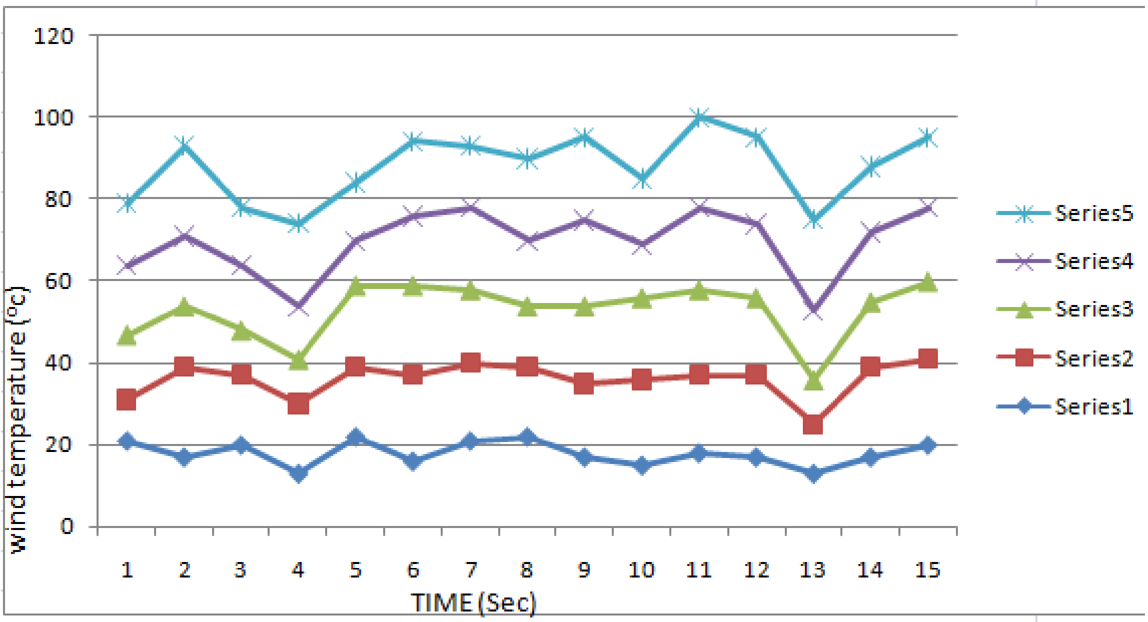


Figure-13. Graph of Average Wind Temperature Vs Time (6 Hourly) [Indoor]

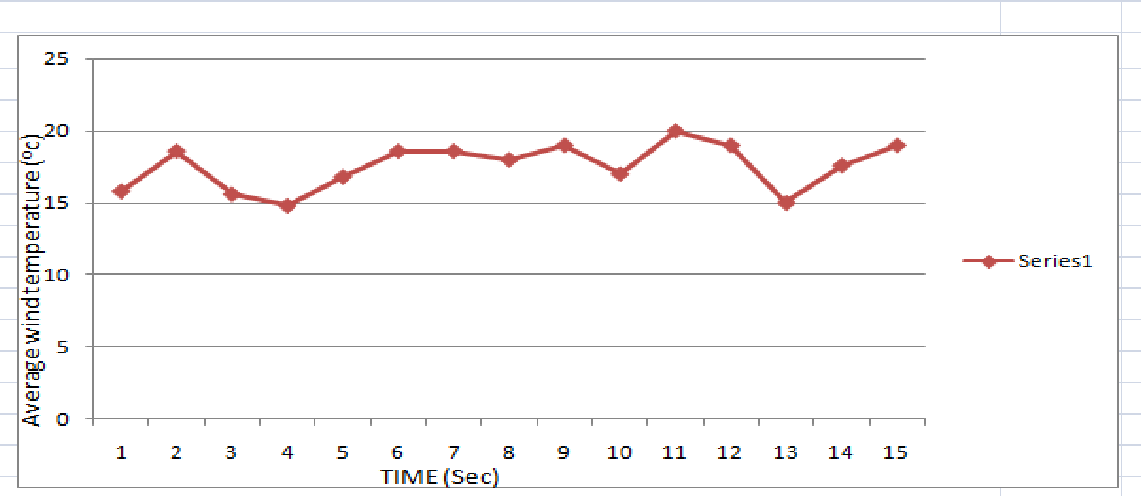


Figure-14. Graph of Wind Temperature Vs Time (6 Hourly) [Passage]

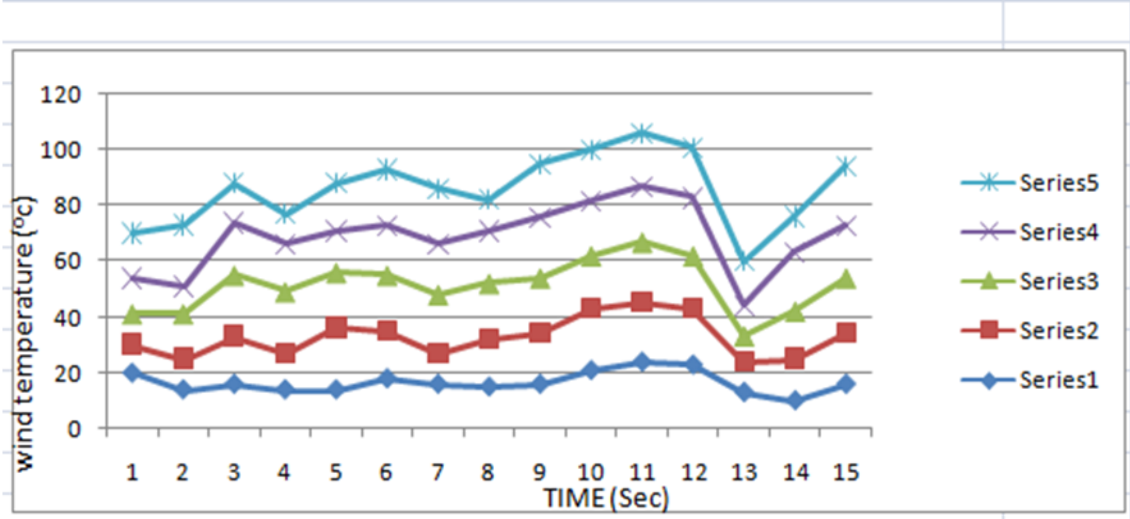


Figure-15. Graph of Average Wind Temperature Vs Time (6 Hourly) [Passage]

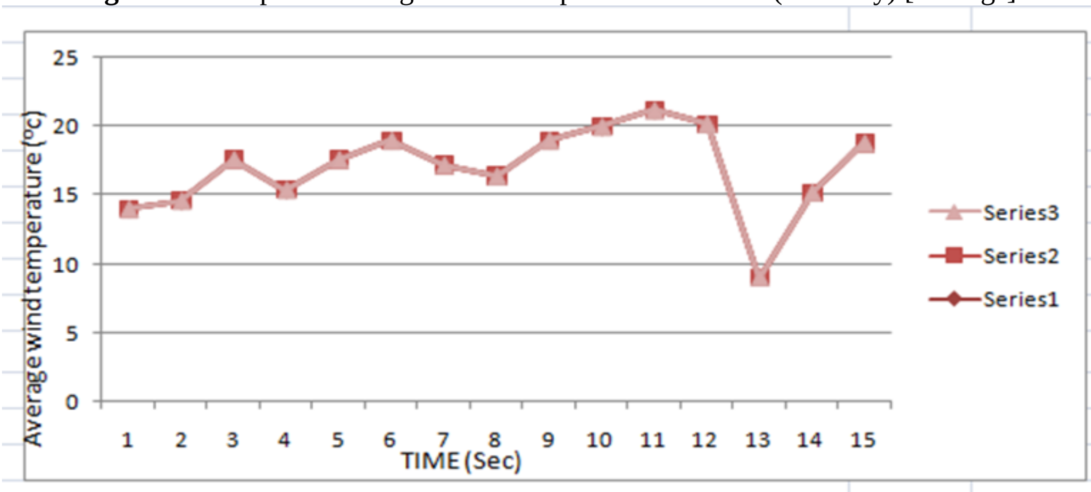


Figure-16. Graph of Wind Temperature Vs Time (6 Hourly) [Outdoor]

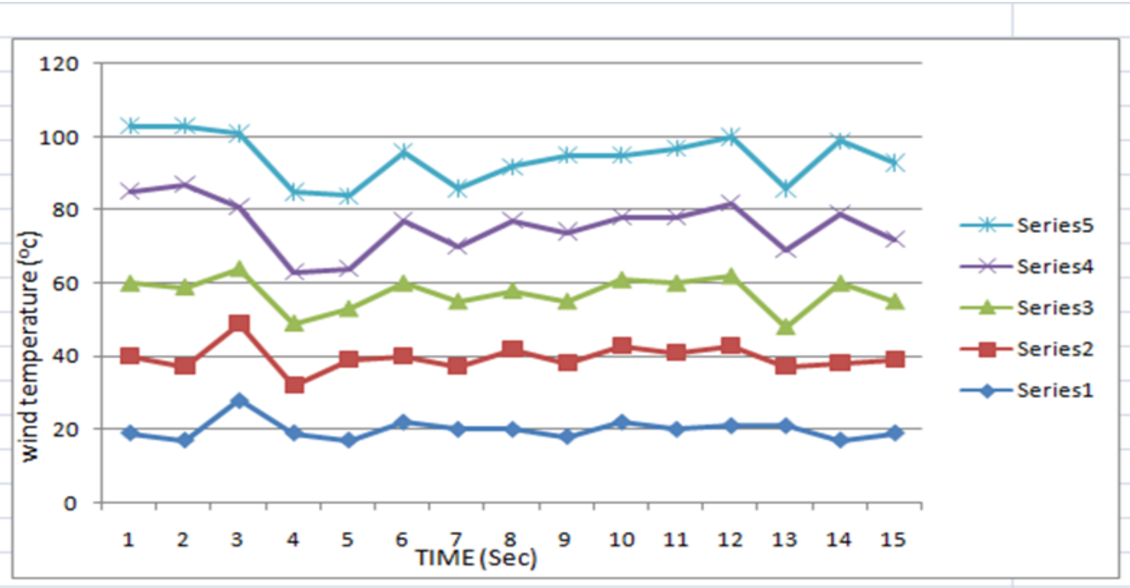


Figure-17. Graph of Wind Temperature Vs Time (6 Hourly) [Outdoor]

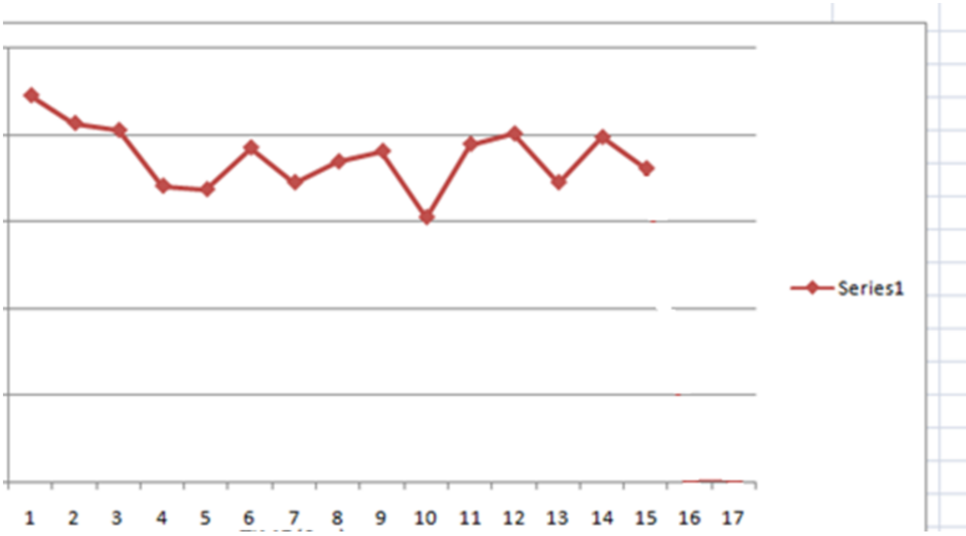


Figure-18. Graph of Average Wind Temperature Vs Time (6 Hourly) [Outdoor]

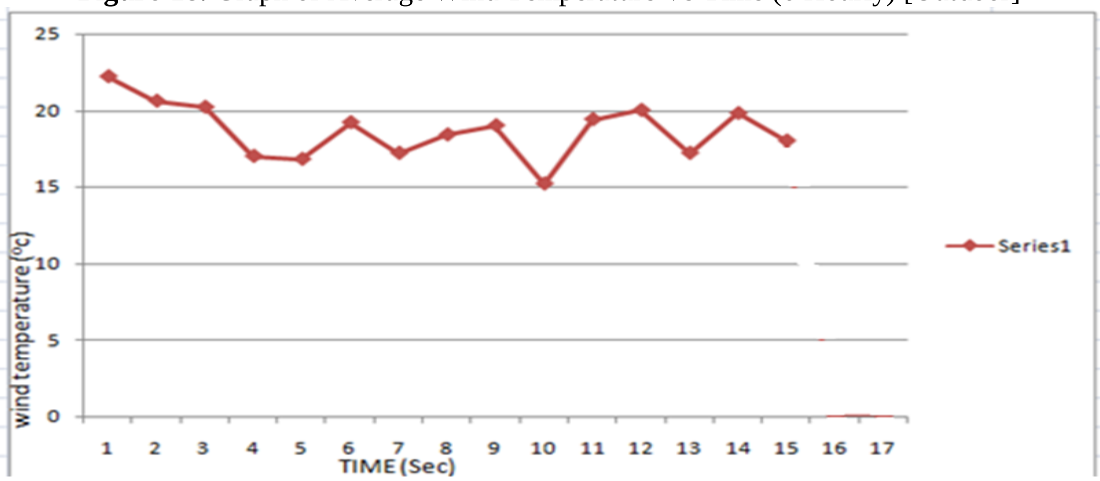


Figure-19. Graph of Wind Speed Vs Temperature [Indoor]

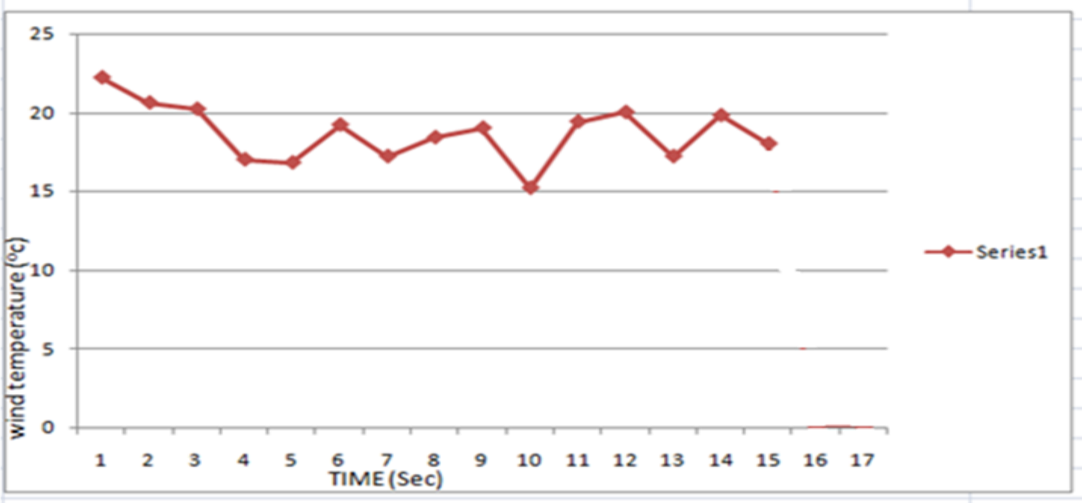


Figure-20. Graph of Wind Speed Vs Temperature [Passage]

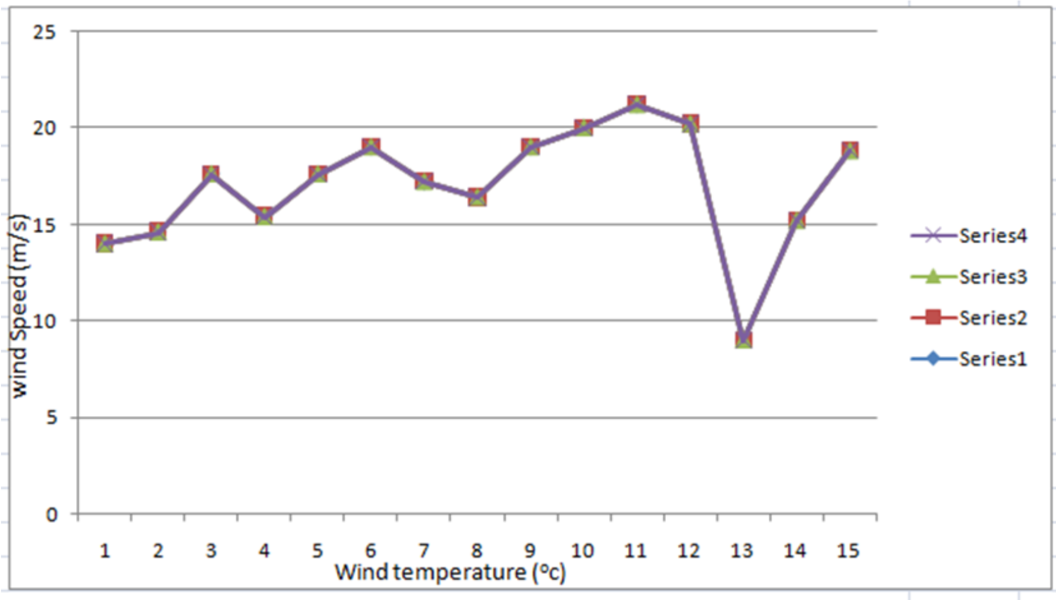
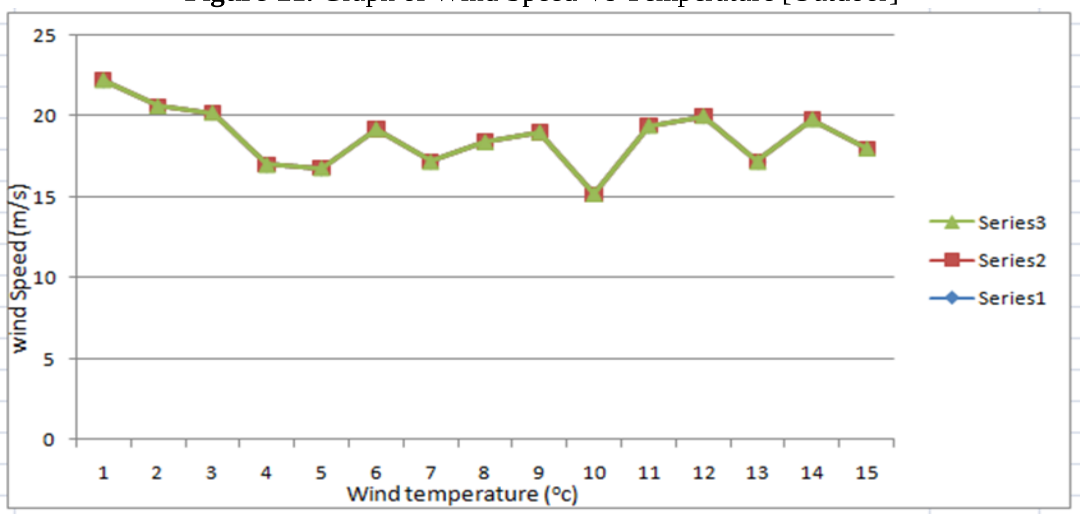


Figure-21. Graph of Wind Speed Vs Temperature [Outdoor]



4. Discussion

From the results obtained as shown on the Figures above, the variation of the wind speed and the wind temperature can appreciably be studied with the device.The analysis of the Figures on wind speed against time suggest a regular pattern for the; indoor, passage and outdoor. The lines drawn could be likened to isobars (the lines connecting places of equal air pressure, indicating the amount of pressure change occurring in places and is expressed as pressure gradient). Vivid consideration shows a slightly steep gradient i.e. the lines indicate a weak pressure gradient and therefore light winds. The light breezes may be attributed to the pressure gradient.

Also, there is a direct relationship between the wind speed and temperature based on the graphs connecting both, as the responses are similar. Environmental temperatures affect the atmospheric pressure which in turn affects the wind speed. Winds are known to be created by differences in air pressure, therefore when hot air raises a low pressure area is created, when cold air sinks a high pressure area is created.The air is pushed out of high pressure areas to low pressure areas. If the pressure gradient (difference in pressure levels) is steep, winds become stronger. As a result of this, if an area is heated more than the surrounding areas, a strong low pressure area develops, leading to strong winds.

It was observed also that slower air flow was noticed from the indoor analysis, this could be explained by comparing the indoor with a pipe, in which the air flows through since it has a constant diameter, hence a cooler temperature would result in a slower flow speed because colder temperatures cause gases to become denser. On the contrary, the airflow across the corridor (passage) behaved as pressure gradient at sudden contrition leading to increased strength of the wind. Analysis of the outdoor (morning) suggests that cold air (motion) may be felt due to the increased evaporation of skin, though the cloud cover interplay is more significvant during the raining tropical season. Environmental ttemperatures correlate directly with the wind speeds as expected.

5. Conclusion

A hot wire anemometer has been constructed, it is found suitable for the study of the air circulation /flow in offices, passages/corridors and outdoor wind speeds. The relatively high outdoor windspeeds observed in this study explain why we sometimes have strong winds blowing off roofs on the Federal Polytechnic Campus.

6. Recommendation

The design of rooftops on the Polytechnic campus should take into consideration very high windspeeds towards the north direction. This will save avoidable expenses on re-roofings after rainstorms common in the raining season. Generally, due considerations should be given to the direction of major windflow in the design and construction of rooftops for buildings.

7. Acknowledgements

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