Design of anIndigenous Infrared Wind SpeedSensor

by

Magdalene HARRISON[1]
Efevode ELSTON[2]
Ademola Oluwadamilola ODUGUWA[3]

[1]Institute of Education, Department of Social Studies, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria
[2]Department of Electrical &Electronic Engineering, University of Ibadan, Oyo State, Nigeria
[3]Department of Electronic & Electrical Engineering, ObafemiAwolowo University, Ile-Ife, Osun State, Nigeria

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CONTACTS:

magharry@yahoo.com
elstonekoh8@gmail.com
ademola.oduguwa@gmail.com

EXECUTIVE SUMMARY

The need to design a sensor that measures a weather or hydrological variable in Sub-Saharan Africa which is both inexpensive and robust for the TAHMO initiative has inspired the design of an efficient wind speed sensor from waste material such as disposable cups, straw, broom, stick and foam.

Similar tothe standard anemometer but in an innovate approach, theindigenous wind speed sensor is made up of 4 disposable cups, with each cup attached to the end of a horizontal arm made by a straw but reinforced by a broom to form a solid structure. Two of this structure is held togetherat the center to form asingle structure,making the four cups perpendicular to each other. This structureisheld down on a central axis by a pin where it is free to rotate with highly negligible friction. When wind pushes into the cups the structure rotates, the faster the wind, the faster the structure spins on the axis.

To get the speed of the wind,a line of sight is established via an infrared light emitter and an infrared receiver which are constantly monitored by a microcontroller. As each opaque cup rotates past the line of sight, it obstructs the light.The number of obstructions (N_O) of the line of sight per minutes is directly proportional to how fast the wind blowsi.e.the speed(V_S)of the wind. Thereforerevolution of the structure per minute (Rpm) is gottenby (N_O/ number of cups +1). The circumference (C) formed by the rotation of the structure in inches is a constant and gotten by $2\pi r$. The Speed (V_S) of the wind in miles per hour is given by (C/63360 x Rpm) / 60.The resolution of wind speed capture, data calculation and all control is done automatically by the microcontroller.

The cost of construction falls well under $1 for production of 20,000 unit of the sensor, the sensor was tested and worked efficiently.

1.0 Design

The wind speed sensor is made up of four cups so that it can more accurately measure wind speed. Each opaque cup is attached to the end of a horizontal arm, each of which is mounted on a central axis, like spokes on a wheel. When wind pushes into the cups, they rotate the axis. The faster the wind, the faster the cups spin the axis. As the sensor rotates, the cups intermittently cut/obstruct an invisible line of light established between an infrared transmitter and an infrared receiver. The line of sight is restored when the cups no longer obstruct the line of light of infrared emitter and receiver. The revolution per minute (Rpm) is gotten by the number of cuts per minute (N_O) via (N_O / number of cup +1), since a complete revolution will ensure the line of sight is cut by each cup and the starting cup returning back to its starting position. The Microcontroller records the number of cuts to determine wind speed.

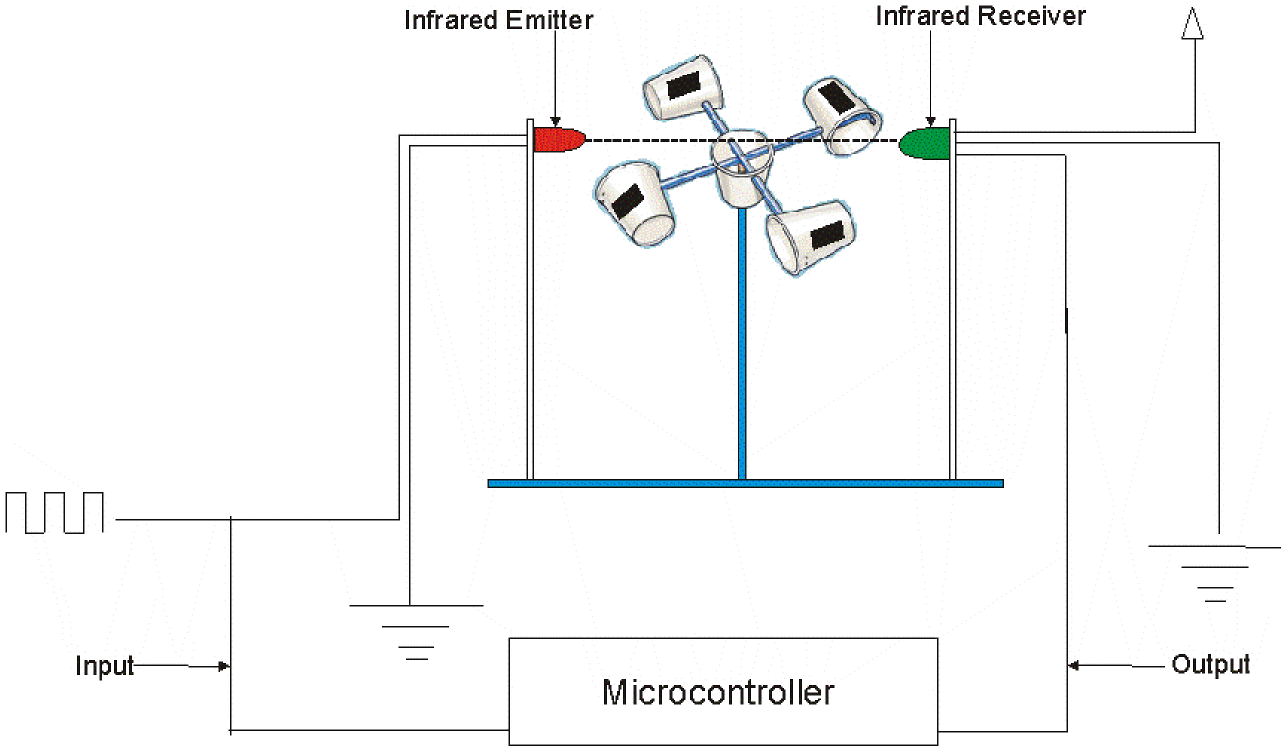


Fig 1: Setup of Indigenous Infrared Wind speed Sensor

1.1 The Infrared Emitter

The infrared emitter is configured to continually emit invisible light with the help of the microcontroller. It sends light pulses at 38KHz which is only detectable by the infrared receiver and this helps to nullify the effect of other sources of light.As shown in the fig 2the line of sight is not been obstructed by the dark cup during rotation.

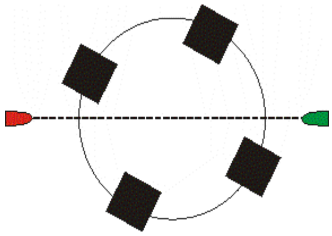


Fig 2. Line of sight between infrared emitter and receiver, receiver output is LOW

1.2 The Infrared Receiver

When the infrared receiver detects infrared light at 38KHz, the output pin is HIGH, if it doesn't detect infrared light, the output pin become LOW. Hence the microcontroller employs an interrupt technique to detect changes from HIGH to LOW at the output of the infrared emitter, this would occur when there is an obstruction of the line of sight established between the emitter and receiver as the below figure depicts, hence the receiver doesn't receive the light from the emitter.

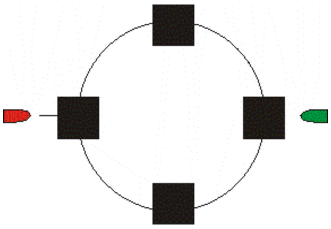


Fig 3. Line of sight between infrared emitter and receiver been obstructed, receiver output is HIGH

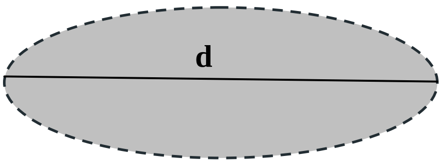
1.3 Revolution per Minute (Rpm)

As the structure rotates, the revolution per minute is used to determine the speed of the wind. It is gotten from the number of times there was an obstruction of the line of sight **(N_O)**for a specific period of time e.g60 seconds. However for higher accuracy and precision, the revolution per 60/Yseconds is utilized; where the level of resolution is given by Y. Therefore as Y increases the wind speed for a very short time can be obtained

The Revolution per minute for any resolution Y is therefore gotten by(N_O per 60/Y seconds)/5 * Y

1.4 The Revolution circumference (C)

The revolution circumference **(C)** in inches is a constant, it is the invisible circular part made by the rotation of the sensor about the axis. It is derived from the equation $\mathbf{2\pi(d/2)^2}$ where **d** is the diameter of the invisible circular part formed.



1.5 Wind Speed

Wind Speed **(V_S)** given in Miles Per Hour (mph)is automatically and continuously calculated by the microcontroller by:

V_S =(C/63360 x Rpm) / 60mph

Where **C** = Revolution Circumference(inches)
Rpm = Revolution per minutes
and 63360 is the conversionconstant from inches to Miles and 60 is the conversion constant of minutes to hour

Table 1. Component Cost Analysis

COMPONENT	PRICE (USD)	QUANTITY	TOTAL
Disposable Cups	0.03	5	0.15
Straw	0.006	2	0.012
Pin	0.006	1	0.006
Infrared Emitter **940nm**	0.12	1	0.12
Infrared Receiver **TSOP38238**	1.95	1	1.95
Microcontroller	1.2	1	1.2
LED **Red Light**	0.03	1	0.03
Sensor Stand	0.12	1	0.12
Resistor **220 ohms**	0.03	1	0.03
Connectors **Connecting Wires (100cm)**	0.5	1	0.5
TOTAL			**2.65**

* Prices are sourced from local electronic stores and are expected to be cheaper when sourced from manufacturing company

1.6 CONCLUSION

With just a cost of $ 2.65an indigenous infrared wind speed sensor has been designed with great accuracyusing waste material. its does its functions automatically and hence reduces maintenance. It worked fine.

1.7 BIBLIOGRAPHY

Scientific American www.scientificamerican.com