# AUTOMATED DATA LOGGING INSTRUMENTATION SYSTEM FOR WIND SPEED AND DIRECTION MEASUREMENTS

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**Abstract**
Due to emergence of microcontrollers which enable real-time logging, viewing and analysis of data, many new generation data acquisition products have been developed. There is an increasing demand for an improved, efficient and up-to-date microcontroller-based data logger.In this study, a microcontroller-based data logger was developed to measure the wind speed and direction using anemometer and wind vane sensors respectively. The collected data was transmitted to a Personal Computer (PC) through an RS-232 serial interface, which was processed using the 208W Data logger support software and stored in EEPROM memory for post process analysis. In order to test the effectiveness of the logger, wind data measured by the microcontroller-based data logging system were analyzed through plotted line graphs, simple linear regression charts and wind rose diagrams.The correlation indices for the two three sets of wind speed data in the morning, mid-day and evenings were 0.997, 0.997 and 0.999 respectively. The wind speed measured by the calibrated sensor correlated well with JKUAT Meteorological data. The strong correlation indicated that developed system was effective and appropriate for measuring wind speed and direction. The system being automated, accurate, appropriate and at the same time cost effective, has potential use in weather forecasting, wind power plants, chemical manufacturing process and in airports among other applications. Further studies can be done to find the relationship between the wind speed and the frequency response of the encoder by use of a wind tunnel.

**Key words:** Data logger, microcontroller, sensors, wind, system for wind measurement

## 1.0 INTRODUCTION

WIND speed and wind direction sensing and recording on a continuous basis is required for many applications. Determination of wind speed and direction is very important for weather forecasting and air navigation. In general, constant wind direction and low to moderate wind velocity indicate a stable air mass and thus fair weather. High wind velocity with varying direction, on the other hand, indicatesan unstable weather [6].

Since natural energy resources are running out and the use of electricity is being increased in the daily life, mankind isforced to find new sources to produce electrical energy [4]. Although wind, which is one of the most attractive resource for electrical energy production has been used for many years in developed countries, the use of this energy has been accelerated recently in Turkey [3], United States (US), Russia, Denmark, Great Britain, Algeria, Western Germany and Kenya [2].

One of the most important activities in installing a wind power system is to choose an appropriate site where the system will be installed. It would be a waste of time and money to build wind power system without investigating wind potential of the site [7]. The period of return on investment is another important factor, even when the wind power potential is satisfactory [3]. Also if a wind power system is to be installed, it is necessary to carry out the feasibility study of wind power using accurate devices [9]. The aim of the paper is to calibrate an optical encoder for application in wind speed measurement and direction. Further,correlation and comparison on measurements of wind speed and direction results with those obtained using conventional methods were done.

## 2.0 Materials and Methods

### 2.1 Transparent Disk

The transparent disk, which was mounted on the rotating shaft, had patterns of opaque and transparent sectors coded into an incremental disk [5]. As the disk rotates, these patterns interrupt the light emitted onto the photo detector, generating a digital or pulse signal output. The output signal is fed into an incremental encoder which generates a pulse for each incremental step in its rotation.

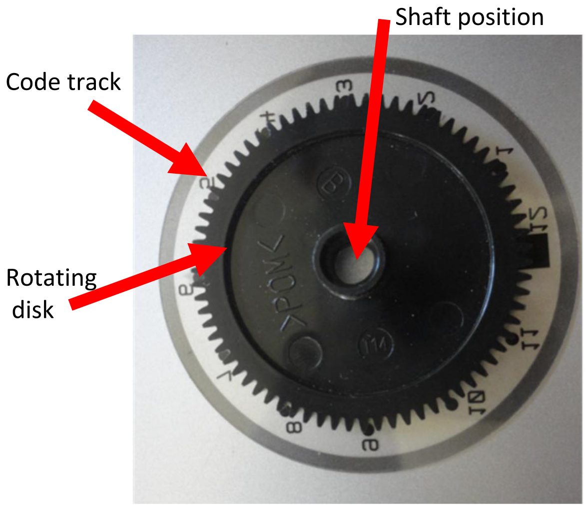


*Plate 1: Transparent disk*

The blowing air molecules exertforce on the anemometer cups (Plate 1) causing the shaft to rotate about its axis. As the air velocity increased, the anemometer shaft's rotational velocity increased proportionately. The output of incremental encoder is a pulse signal that is generated when the transducer disc rotates as a result of the motion that is being measured [8]. The signals were fed to Atmel Atmega32 microcontroller for determining both angular displacement and angular velocity by counting the pulses or by timing the pulse width using a clock signal. The wind vane sensor was calibrated out of an absolute optical encoder with peripheral track that was connected to the shaft being measured.

### 2.2 Measuring of Wind Speed and Direction

The wind sensors were clamped on a horizontal metallic support masked on a strong metallic vertical stand 2m height above the surface. The wind sensors were separated well enough to avoid the flow disturbance due to the blowing wind.

The signals from both anemometer and wind vane sensors were fed to CR 10 Campbell microcontroller based data logger which was used to measure 4 seconds averaged wind data, which it further averaged for one hour and stored in the EEPROM for 24 hours. Reading of wind speed was done at interval of 3 times a day alongside conventional instruments at the meteorological station for comparison.

### 2.3 Software Design

The language used is C which is a general-purpose programming language that can work on any microprocessor that has a C compiler written for it for AVR microcontrollers. The AVR studio is used to edit, debug, compile and load the code to the microcontroller's flash memory via STK500 circuit board. STK500 is a starter kit and a development system used to program Atmel AVR flash microcontrollers. It gives designers a quick start to developing code on the AVR, combined with features for developing prototypes and testing new designs. The STK500 interfaces AVR studio for code writing and debugging. It includes AVR studio software interface, RS-232 interface to PC for programming and configuration and a serial in-system programming (ISP) of AVR devices[1].

## 3.0 Results and Discussion

### 3.1 Wind Speed Output

Figure 1 shows wind speed output graphs for experimental data, extrapolated data and JKUAT meteorological data collected daily at 9.00 a.m starting from August 1st 2011 for a period of six weeks.

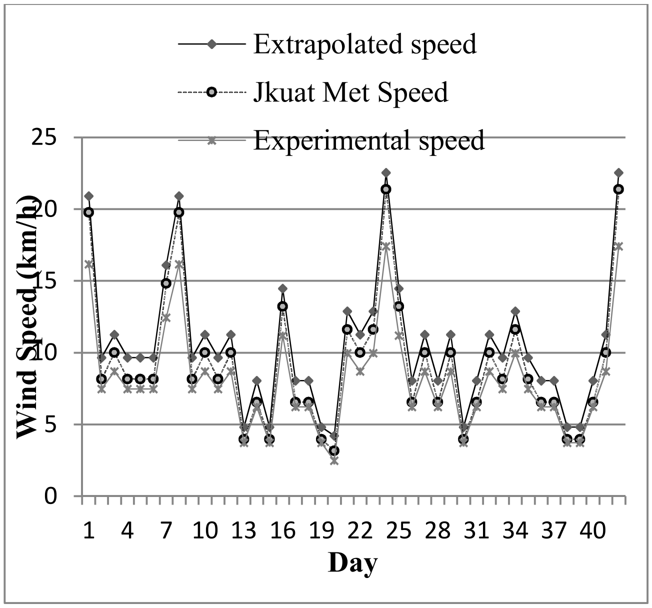


*Figure 1: Wind speed profile at 9.00 a.m*

Figure 2 shows wind speed output graphs for experimental data, extrapolated data and JKUAT meteorological data collected daily at 12.00 noon starting from August 1st 2011 for a period of six weeks.

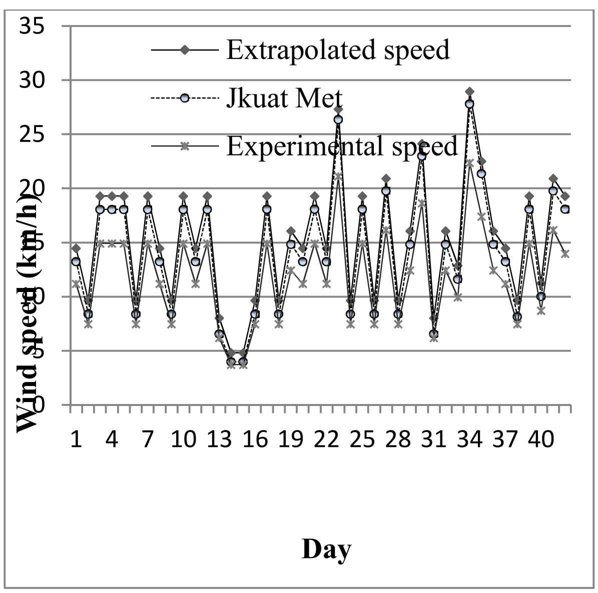


*Figure 2: Wind speed profile at 12.00 noon*

Figure 3 shows the graphs for experimental, extrapolated and JKUAT Meteorological output wind speed measurements at 5.00 p.m. starting from August 1st 2011 for a period of six weeks.

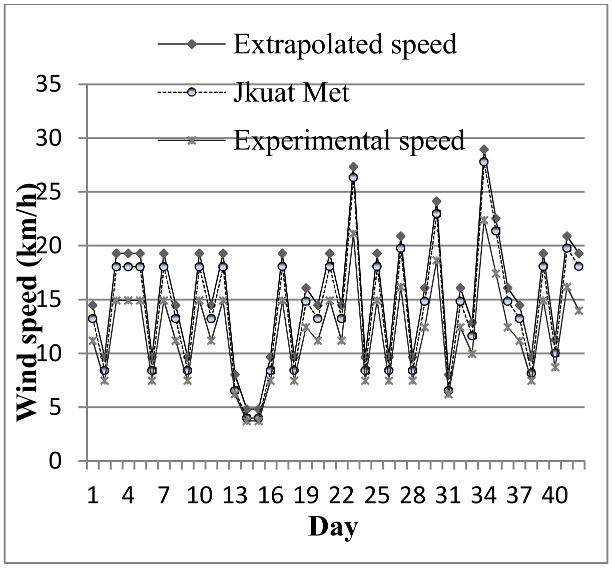


*Figure 3: Wind speed profile at 5.00 pm*

### 3.2 Wind Direction Output

Figure 4 shows a wind rose diagram for 2 m height at 9.00 a.m in Juja for wind direction output by the data logging instrumentation system for a period of six weeks from 1st August to 11th September 2011.

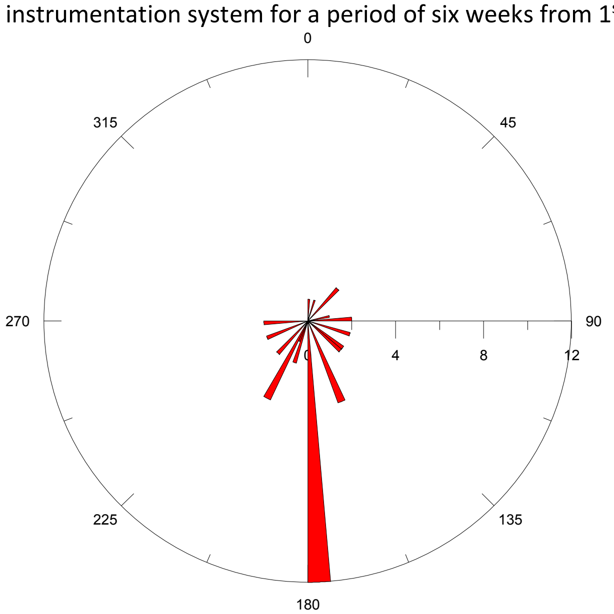


*Figure 4: Wind rose for 2 m height at 9.00 a.m in Juja*

Figure 5 shows a wind rose diagram for 2 m height at 12.00 noon in Juja for wind direction output by the data logging instrumentation system for a period of six weeks from 1st August to 11th September 2011.

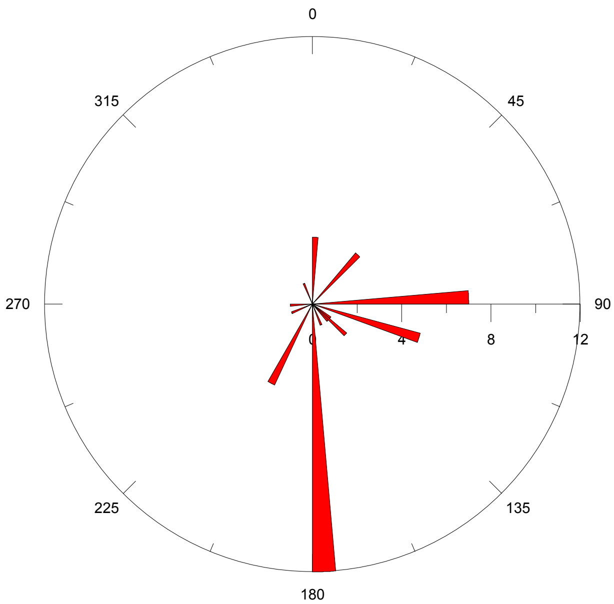


*Figure 5: Wind rose for 2 m height at 12.00 noon in Juja*

A wind rose diagram for a 2 m height at 5.00 p.m in Juja for wind direction output by the data logging instrumentation system for a period of six weeks from 1st August to 11th September 2011 is shown in Figure 6.

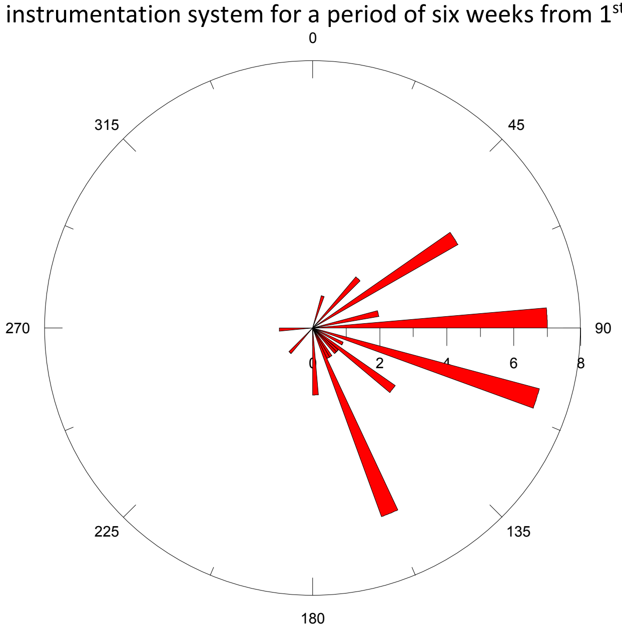


*Figure 6: Wind rose for 2 m height at 5.00 p.m in Juja*

A wind rose diagram for average wind direction data at the JKUAT meteorological station at 10 m height for same period of time is shown in Figure 7.

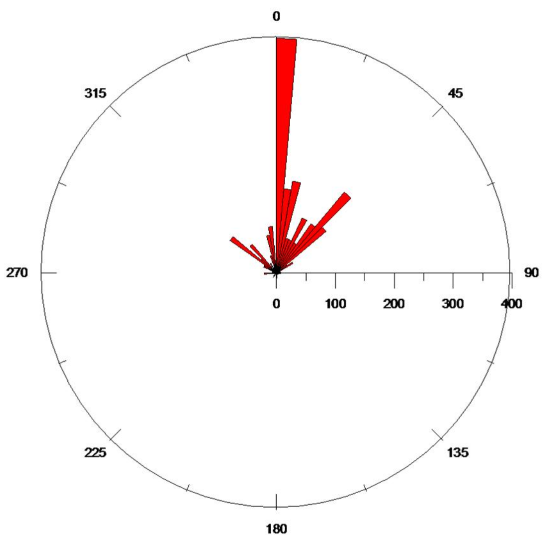


Figure 7: JKUAT Meteorological wind rose for 10 m

**4.0 Conclusion**

The calibrated system presented here provides an efficient way for measuring wind speed and detecting wind direction. Wind speed and direction were successfully measured by rotational anemometer wind vane sensors respectively. The two instruments were calibrated using optical encoders. Wind speed and direction measured by the microcontroller-based data logging system were analyzed by plotting line graphs, simple linear regression charts and wind rose diagrams. The wind speed data by the calibrated system was correlated to the JKUAT Meteorological wind data as the reference station. The two sets of data indicated high correlation indices hence measured data can be used to predict a general long-term pattern of wind regime to some degree of accuracy in magnitude of the wind speed. There is a large calm condition in the wind system in both sets of data although the maximum bulge of wind blowing indicated a high variation.From highly correlated wind data obtained between the calibrated system and the conventional system at the Meteorological station, there is a lowwind resource at the site.

**5.0 Recommendations**

More work should be carried at the site by positioning the wind sensors at higher heights of 10 m and above to obtain actual measurements so as to give a better comparison between the two sets of wind data. Use of power law can result to significant underestimations due to the non-linear relationship between wind speed and wind power if the wind resource of the site is needed.Other methods of measure, correlate and predict (MCP) should be applied for accurate long term wind pattern prediction and comparison.

Further studies can be done to find the relationship between the wind speed and the frequency response of the encoder by use of a wind tunnel. The use of a wind tunnel is to study the effect of air moving around a solid object and the sensitivity and accuracy of the encoder at different wind speeds.The wind coming through a wind tunnel would be calibrated to different wind speed. The wind would come through the tunnel then blow on the anemometer.

More studies should be carried out in different sites with a flat terrain far away from many trees and building obstacles to avoid rapid wind variations due to turbulence to ascertain the accuracy and endurance of the instrument when exposed to varying harsh weather.

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