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Solar Powered Portable Wind Speed and Wind Direction Data Acquisition using LattePanda

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Abstract: *This study presents the development and implementation of a Portable Wind speed and wind direction data acquisition system using LattePanda. The integration of components, including anemometer, solar panel, charger, and battery, creates a functional system for accurate wind data collection. Wind data gathered from January to March offers insights into wind patterns and potential energy generation. Limitations, such as maximum wind speed measurement and operational duration, are recognized. The study's implications for the renewable energy sector, informed decision-making in wind turbine projects, and recommendations for future enhancements are discussed. In sum, this study contributes to informed sustainable energy decisions, advancing the transition to cleaner energy sources.*

Keywords: Wind Data Acquisition, LattPanda, Solar Powered

I. INTRODUCTION

The global imperative to reduce reliance on conventional fossil fuels has gained prominence due to their finite nature, contribution to global warming, and cost implications. This sentiment has evolved into policy directives for many nations and a global concern [1]. Wind, a renewable natural atmospheric phenomenon, offers numerous benefits alongside a few drawbacks. It is environmentally friendly, devoid of water, soil harm, or air pollution. Wind energy, captured from these movements, can be converted into various forms, either for direct mechanical use like water pumping or electricity generation through windmills connected to generators [2][3].

Former President Benigno S. Aquino III's query, "What if there's no wind when you erect wind turbines?" underscores the challenges of wind turbine installations, reliant on wind energy for power generation. The study delves into wind speed and direction statistics, visualizing their distribution. By accumulating a year's worth of wind data, the mean annual wind speed can be calculated, traditionally assessed through anemometers for speed and weather vanes for direction [4][5][11].

This study centers on a systematic guide to constructing a portable wind speed and direction data logging system utilizing LattePanda [4][5][11]. Comprising hardware and software components, the system leverages electronic elements for hardware and employs a database-driven approach for data storage, retrieval, visualization, and analysis.

1.1 Objectives

The study aims is to develop and implement a Portable Wind speed and wind direction data logging using LattePanda.

Specific Objectives

- To integrate an LattePanda as a the main computer for the Solar Powered Portable Wind speed and wind direction data acquisition
- To integrate an Anemometer that will serve as the wind speed senor for the Solar Powered Portable Wind speed and wind direction data acquisition
- To integrate an Solar Panel that will serve as the source of energy to generate electricity for the Solar Powered Portable Wind speed and wind direction data acquisition
- To integrate an solar charger that will serve as the charge controller for the Solar Powered Portable Wind speed and wind direction data acquisition
- To integrate an battery that will serve as the power bank for the Solar Powered Portable Wind speed and wind direction data acquisition during night time and sunlight is not present

- To collect and Visualize wind data at a height of 20 meters
- To use wind data to calculate wind power potential for the selected site

1.2 Scope and Limitation

This research is conducted primarily on the purpose of building a data acquisition device that will be used to study the specified location for possible installing wind turbines.

For the conduct of this study there are some unavoidable limitations:

- Wind speed can only be measured at a maximum speed of 30m/s.
- Device is limited at a maximum 3 working days without charging.

1.3 Significance of the Study

The most precise indicator of available wind resources at a location is achieved through direct on-site measurements using the primary wind assessment tools. On-site wind measurements play a significant role in predicting the power output of an individual turbine, a wind farm, or establishing the power curve of a wind turbine. The accuracy of these on-site measurements is crucial, as energy density and wind turbine power output are proportional to the cube of the average wind speed.

II. REVIEW OF RELATED STUDIES

The electricity output of a wind turbine hinges on the local wind speed, influenced by several factors like geographic location, nearby obstructions (trees, buildings causing turbulence), and height above ground level. Higher turbine placement height yields increased wind speeds and thus higher electricity generation potential. The precise relationship between wind speed and actual power output is intricate. Power output starts from zero up to the 'cut-in' wind speed (where power generation initiates), remaining steady above the 'rated' wind speed. Between these points, power output correlates roughly to the cube of wind speed, emphasizing the need to measure wind speed before turbine installation for financial viability [6][7].

Wind turbines operate by converting wind's kinetic energy into rotational and then electrical energy, supplied to the national grid. Energy conversion relies on wind speed and the turbine's swept area. In wind farm planning, understanding each turbine's projected power and energy output is vital to assess economic viability [8][12].

A data logger, or recorder, is an electronic tool that captures information over time for future reference. It features a sensor to gather data, a computer chip for storage, and can transfer data to computers for analysis. Comparable to a central-processing unit, signals are stored or sent for further analysis. For remote sensing of humidity and temperature, standalone data loggers are crucial, utilizing microcontrollers [9][10].

III. TECHNICAL BACKGROUND

The development of the system will use World Wide Web technologies such as PHP web application framework as a back-end tool. The Arduino IDE as the programming editor of the microcontroller. MySQL as the main database management system to be use in the acquired data from the micron roller through LattePanda. The system will be hosted in a virtual private server and having a Windows 10 as an Operating System.

3.2 Hardware Specifications

The study is anchored in the concept of embedded system since the project use hardware and software components which worked for a certain function. The study also anchored Arduino IDE for programming the system.

In the hardware part, we use some electronic devices. An electronic component is any basic discrete device or physical entity in an electronic system used to affect electrons or their associated fields. It includes the following.

- ***LattePanda*** – a windows 10 development board for everything.
- ***Anemometer*** – is a device used for measuring the speed of wind, and is also a common weather station instrument.

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- ***Battery*** – is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices
- ***Solar Charger*** – employs solar energy to supply electricity to devices or charge batteries. They are generally portable. Solar chargers can charge lead acid or Ni-Cd battery banks up to 48 V and hundreds of ampere-hours (up to 4000 Ah) capacity.
- ***Solar Panel*** – devices which are used to absorb the sun's rays and convert them into electricity or heat.

3.3 Software Applications

From a specialized perspective ordinary information procurement frameworks have least three segments. These segments are either compacted in one device or are a separate device associated through wired or remote correspondence. Some center segments are as per the following:

- ***Sensors*** - sensors collect information from the physical environment and feed to the system. For example, infrared sensor detects the presence of a person
- ***Main Control Unit*** - this main control device acts on environment by means of logging based on the information read from the sensors. The information extracted from the sensors is processed by this control device according to the setting parameter provided by the user and sending it to the database server. The setting parameters are provided through a control panel.
- ***Control Panel***- control panel is the user interface to manually set parameters or configure the visualization to a personal suitable setting.

IV. METHODOLOGY

The methodology that the researcher used in order to implement this study, it underwent different process and methods to gather data and information regarding the research study. The first step was gathering of information to determine the study that includes searching and finding some information and concepts in the internet that is needed and related in the study.

4.1 Data Gathering

There are several approaches in gathering of data and this research use specific technique of data collection. The experimental set-up designed for the wind resource assessment on selected location was made up of two wind sensors, a data acquisition device, a Data Retriever software. The field monitoring tower used for the wind data collection was actually a building tower. It consisted of a hollow concrete base and simply a steel tube equipped with one wind vane and a data, solar panel. The completely assembled tower was installed on the selected..

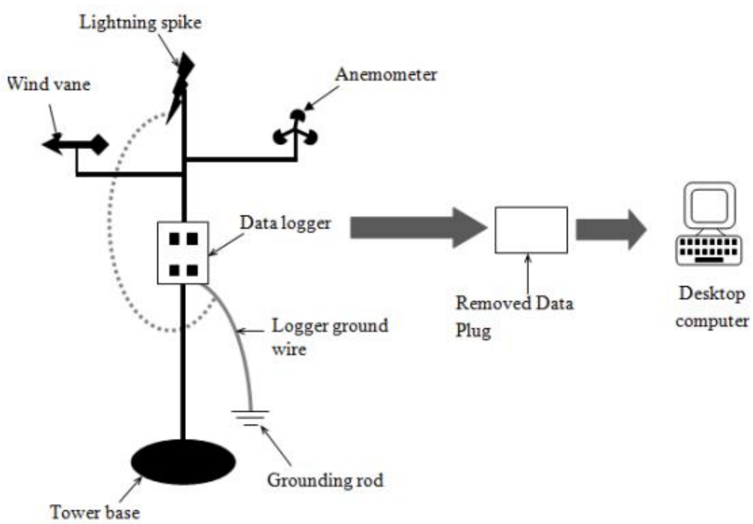

Fig. 1. Experimental Setup

The anemometer was in installed 15 m above the ground. The wind vane was about 10 cm below the anemometer. The fully assembled and raised tower was also electrically protected by using a lightning spike, a grounding rod and a copper conductor. Both the speed and the direction data as measured by the anemometer and the wind or direction vane respectively were captured. The standalone battery operated data acquisition device was powered by 9 12-volts 7.2 AH lead acid battery batteries. Due to the special feature of data acquisition device mentioned above, wind data retrieval and analysis were done in two different ways. The experimental set-up is diagrammatically represented in Fig. 1

4.2 Proposed Architecture

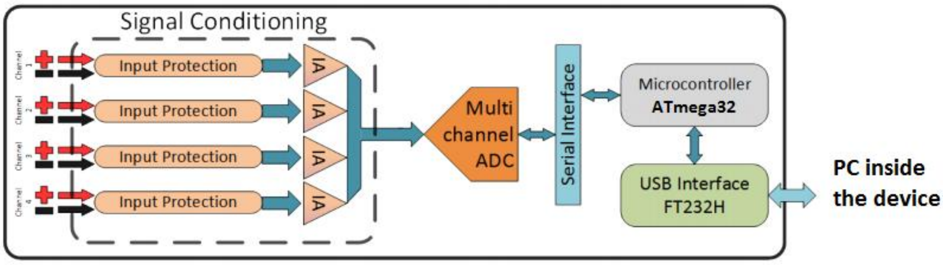

Fig. 2. System Architecture

Fig. 2 shows the proposed system architecture of the study. The primary component is the ATmega32 microcontroller with USB and serial interfaces. The interfaces serve as the interface for input signals the external devices.

4.3 Implementation

Implementing the design is one of the final phases of embedded system design. Traditionally, the design and implementation of control systems are often separated, which causes the development of embedded systems to be highly time consuming and costly. Having accurate design of architecture and system model helps to save money and time in the implementation phase. After implementation, functional testing selects tests that assess how well the implementation meets the requirements of the product.

V. RESULTS AND DISCUSSION

This section presents the results of the implemented Portable Wind speed and wind direction data acquisition system using LattePanda. The collected data and their implications are discussed in detail, addressing the objectives and limitations set in the earlier chapters. The section also provides an analysis of the data's significance and how it can contribute to the field of wind energy.

5.1 Data Collection and Analysis

Month	Max Wind Speed (m/s)	Min Wind Speed (m/s)	Mean Wind Speed (m/s)
January	10.2	3.5	6.8
February	11.5	4.1	7.2
March	9.8	3.7	6.5

Table 1. Summary of Wind Speed Statistics

Table 1 presents the summary of wind speed statistics. The wind speed data for the months of January, February, and March reveal varying conditions at the site. January had an average wind speed of 6.8 m/s, indicating moderate wind. February exhibited stronger wind with an average speed of 7.2 m/s. March's average wind speed was 6.5 m/s, slightly lower. These variations suggest that the location experiences moderate to strong winds, making it potentially suitable for wind energy projects.

5.2 Achievement of Objectives

The study successfully achieved its objectives, seamlessly integrating vital components into the system. The LattePanda acted as the core processor, while the anemometer measured wind speed accurately. The solar panel and charger provided sustainable energy, complemented by the battery for continuous operation. Together, these components harmonized to create a functional data acquisition system, ensuring reliable wind speed and direction measurements.

5.3 Wind Power Potential and Site Suitability

The wind data spanning January to March forms a basis for estimating the site's wind power potential. Using these wind speed measurements, we can project potential energy generation by wind turbines. However, limitations include the data's three-month duration and the need to consider factors like seasonal variations and local conditions. A longer data collection period and a comprehensive analysis of various influencing factors are necessary for more accurate energy predictions.

5.4 Discussion of Limitations

This study encountered certain limitations that warrant attention. The anemometer's maximum wind speed measurement capped at 30 m/s, potentially missing extreme events. The system's battery-operated nature limits continuous operation to three days without charging. Environmental factors like obstructions and seasonal variability could influence data accuracy. The short three-month data collection period may not capture annual wind variations fully. Acknowledging these limitations emphasizes the need for refined methodologies and extended data collection to enhance accuracy and broaden the study's scope.

5.5 Implications and Significance

The gathered wind data from January to March holds pivotal implications for renewable energy, particularly wind turbine installations. This data empowers informed decision-making by offering precise insights into site-specific wind conditions. Accurate wind speed measurements aid in predicting turbine performance and energy output. This contributes to optimized turbine selection, placement, and sizing, enhancing overall project efficiency and financial viability. The data's significance extends to advancing renewable energy goals and sustainability efforts, aligning with global initiatives for a cleaner energy future.

5.6 Future Improvements and Recommendations

To improve wind energy assessments, extending data collection to a year for accurate seasonal insights is suggested. Exploring higher-capacity anemometers would enhance extreme condition data capture. Power management upgrades, larger batteries or backups, ensure sustained operation in adverse weather. Integrating environmental parameters like temperature and pressure enriches understanding. Refining analysis techniques could unveil subtle wind patterns. Incorporating local topography offers insights into wind behavior. These enhancements promise a more informed and accurate wind energy project assessment.

V. CONCLUSION

The study successfully developed and implemented a Portable Wind speed and wind direction data acquisition system using LattePanda. The integration of components, including the LattePanda as the central processing unit, the anemometer for wind speed measurement, solar panel and charger for sustainable energy supply, and battery for uninterrupted operation, showcases the system's potential for accurate wind data collection.

The wind data collected between January and March provided valuable insights into wind patterns, enabling preliminary assessments of wind energy potential. While limitations such as the maximum wind speed measurement, operational duration without charging, and the data's short duration were acknowledged, they highlight areas for refinement.

The implications of this study for the renewable energy sector are significant. Accurate wind data aids in informed decision-making for wind turbine projects, predicting turbine performance and overall energy output. The recommendations for future enhancements, guided by real-world data, promise a more robust system and refined wind energy assessments.

Ultimately, this study contributes to the broader renewable energy discourse, facilitating informed sustainable energy decisions and advancing the transition to cleaner, more efficient energy sources. By leveraging the insights gained and considering the recommendations provided, stakeholders can approach wind energy projects with greater accuracy and confidence.

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