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Design and Implementation of Clustering Wind Turbine For Scada Data Based Fault Detection Using IOT

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ABSTRACT

Renewable energy sources, particularly wind energy, play a crucial role in sustainable power generation. However, wind flow variability poses a significant challenge in maintaining a stable output from windmills. This project proposes an intelligent windmill monitoring and stabilization system using a motor coupled with the windmill generator. When wind flow drops below a critical threshold, the Kalman filtering algorithm is employed to estimate and predict wind speed fluctuations in real-time. Based on these predictions, the coupled motor is activated to maintain a consistent rotational speed of the windmill, thereby stabilizing the output power. The systemuses an Arduino Uno microcontroller to interface with multiple sensors, including voltage and current sensors, temperature sensors, vibration sensors, and speed sensors, to monitor key parameters of the windmill's performance. The Kalman filter processes noisy sensor data to provide accurate and reliable measurements, ensuring optimal motor control. A Supervisory Control and Data Acquisition (SCADA) system is integrated via serial communication with a PC to visualize real-time data, track windmill performance, and alert operators to any anomalies. The SCADA interface displays essential metrics such as wind speed, generator output, motor status, and system health.

KEYWORDS: SCADA, internet of things (IOT), Battery,Kalman filtering algorithm

1. INTRODUCTION

Wind energy has emerged as a vital renewable energy source, offering a clean and sustainable solution to meet the growing global energy demands. Wind turbines convert the kinetic energy of wind into electrical power, reducing reliance on fossil fuels and lowering carbon emissions. However, wind power generation is inherently intermittent, as it depends on the availability and strength of wind flow. This unpredictability poses a challenge to maintaining a stable power output from windmills. To overcome this, advanced monitoring and control systems are essential. A windmill monitoring system plays a crucial role in ensuring the efficient and safe operation of wind turbines. It continuously tracks key parameters such as wind speed, turbine speed, voltage, current, temperature, and vibrations. These parameters provide real-time insights into the windmill's performance and help detect potential faults or inefficiencies. In this project, a motor is coupled with the windmill generator to compensate for low wind flow conditions. When the wind speed drops below a threshold, the coupled motor is activated using a Kalman filtering algorithm. This algorithm efficiently estimates the system's states by filtering out noise and predicting optimal control actions. As a result, the output power from the windmill remains stable despitefluctuations in wind speed.Furthermore, a Supervisory Control and Data Acquisition (SCADA) system is integrated into the design. SCADA enables remote monitoring and control of all windmill parameters, providing a user-friendly interface for operators. It allows real-time data visualization, fault detection, and automated alert enhancing overall system reliability and efficiency. solutions. Simulation and experimental results validate the proposed approach, demonstrating its potential for improved energy efficiency, cost reduction, and enhanced load adaptability.

2. EXISTING SYSTEM

In conventional windmill systems, power output is solely dependent on wind speed. The generator converts mechanical energy from the windmill blades into electricalenergy, but fluctuations in wind speed cause unstable output power. These systems typically lack intelligent control mechanisms to stabilize power generation, relying instead on passive methods like mechanical inertia to smooth short-term variations. Sensor data is often monitored manually or through basic data loggers without real-time processing or remote control. As a result, system responses tolow wind conditions are delayed, leading to energy losses. The absence of predictive algorithms means no proactive measures are taken to compensate for insufficient wind speeds. Additionally, traditional systems do not utilize coupled motors for supplementary mechanical input, further reducing their adaptability during variable wind conditions. This limits the windmill's efficiency and integration into smart grids. Without advanced monitoring like SCADA, system faults or inefficiencies can go unnoticed until significant damage occurs.

3. PROPOSED SYSTEM

The proposed windmill monitoring system incorporates an advanced Kalman filtering algorithm to stabilize output power by activating a coupled motor when wind flow is insufficient. The system utilizes an Arduino Uno to collect data from various sensors, including voltage, current, temperature, vibration, and speed sensors. This data is transmitted to a SCADA (Supervisory Control and Data Acquisition) system through serial communication, enabling real-time monitoring and control. The Kalman filter predicts wind speed and power output, ensuring seamless motor activation when wind flow drops below the threshold. The coupled motor compensates for the reduced wind power, maintaining consistent energy output. Additionally, the system stores historical data forfurther analysis and future optimization. An LCD display shows live sensor readings, while the relay manages power flow between the windmill generator and the motor. The SCADA interface provides remote access for operators to monitor windmill performance, detect generation under fluctuating wind conditions.

4. BLOCKDIAGRAM

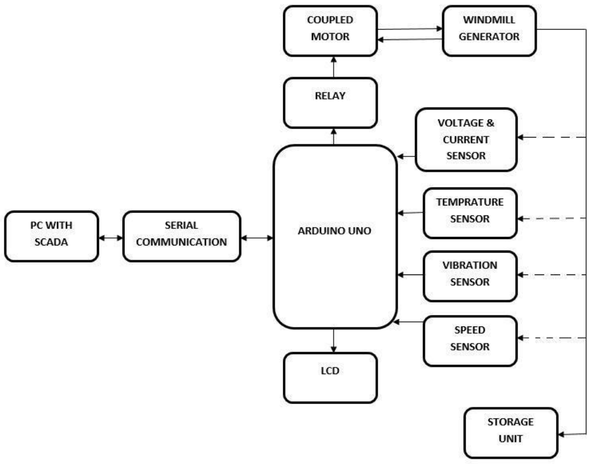
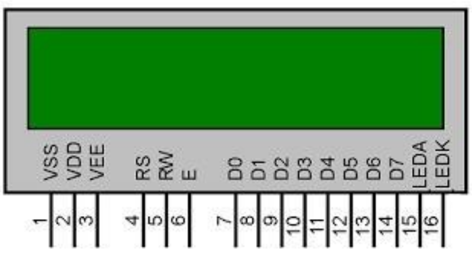


Fig:1 Block Diagram

5. HARDWARE DESCRIPTION

6.1 16x 2 LCD MODULES LCD DISPLAY

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred overseven segments and other multi segment LEDs. The reasonsbeing:LCDs are economical; easily programmable; have no limitation of displaying special &evencustom characters (unlike in seven segments), animations and so on.



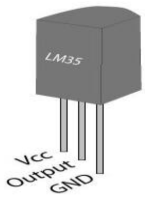
6.2 Battery 12 V

A battery is a device that can create electricity using a chemical reaction. It converts energy stored in molecules inside the battery into electricity. They produce direct current (DC) electricity (electricity that flows in one direction, and does not switch back and forth). Using the electricity from an outlet in a house or building is cheaper and uses less energy, but a battery can provide electricity in areas that do not have electric power distribution. It is alsouseful for things that moved around and cords would get in the way.12V batteries are available for the use. And current will vary. Two wheelers have 7A and four wheelers have 40A. We use a 7a battery for this demonstration purpose.

Figure:4.3 Battery 12v

6.3. TEMPERATURE SENSOR

The measurement of temperature is one of the fundamental requirements for environmental control, as well as certain chemical, electrical and mechanical controls. Many different types of temperature sensors are commercially available, and the type of temperature sensor that will be used in any particular application will depend on several factors. For example, cost, space constraints, durability, and accuracy of the temperature sensor are all considerations that typically need to be taken into account. Various types of temperature sensors are known including liquid-in-glass (LIG) thermometers, bimetallic.

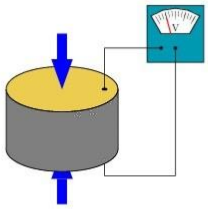


6.4 Relay

Relays are components which allow a low-power circuit to switch a relatively high current on and off, or to control signals that must be electrically isolated from the controlling circuit itself. Here is a quick rundown. To make a relay operate, you have to pass a ‘pull-in’ and ‘holding’ current (DC) through its energizing coil. And relay

6.5 VIBRATION SENSOR

Principle	Strain Sensitivity [V/µ*]	Threshold [µ*]	Span to threshold ratio
Piezoelectric	5.0	0.00001	100,000,000
Piezoresistive	0.0001	0.0001	2,500,000
Inductive	0.001	0.0005	2,000,000
Capacitive	0.005	0.0001	750,000



6. IOT Platform

A web page is used to provide a suitable interface between the user and the Microcontroller Based Swapping Of Batteries For Electric Vehicles with health condition monitoring System. A particular IP address is provided for the particular industry and this IP does not change as it is hosted on Amazon Web Server. The screenshot in Figure 4.8 depicts the connecting page as seen on the user's mobile phone. The screenshot shown in Figure 4.9 is the home screen that is displayed once login is successful. This contains the different columns representing different data. This is continuously updated every second and keeps track of previous data too server..

Fig 4.8: Connect Page To The IOT

Fig 4.7. Real time IOT based industry monitoring

RESULTS

The implemented system was tested efficiently and tested for proper working. The initialization of the IOT and working of the sensors were verified. Messages were obtained after each alert and corresponding data uploaded on to the cloud storage. The buzzer and sprinkler also worked efficiently.

7. CONCUSION

The development of an Intelligent Windmill Monitoring and Stabilization System using the Kalman Filtering Algorithm and SCADA Integration presents a significant advancement in the domain of renewable energy management. By leveraging the Kalman filter, the system effectively minimizes sensor noise and enhances the accuracy of real-time data estimation, which is critical for ensuring the stable operation of wind turbines under variable wind conditions. This intelligent filtering mechanism allows for dynamic adjustments in rotor control, yaw alignment, and blade pitch, thereby optimizing performance and preventing mechanical failures. The integration of SCADA further amplifies the system’s capabilities by offering remote monitoring, data visualization, and control features. Operators can access real-time turbine data, receive alerts on abnormal behavior, and execute control commands from a centralized location, significantly improving responsiveness and decision-making. Additionally, the ability to log and analyze historical data supports preventive maintenance strategies, reducing downtime and extending the operational lifespan of windmill components.

FUTURE SCOPE

The system has been tested for various operating conditions and results analyzed rigorously. The developed battery management system is effectively charge the batteries as well as protects the battery from overcharging and over discharging. The developed maximum power point algorithm also performed well with maximum power point tracking IOT.The based battery management system is better system for dynamo charging of battery in electric vehicle application..

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