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Development of Smart system for Monitoring Windmill

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Abstract - *There has been a rise in renewable energy demands and windmills are commonly used. Production costs have fallen, but operating and maintenance costs haven't. It's difficult to operate and maintain windmills in remote areas with human intervention every day, as humans are susceptible to making mistakes.[2] Designing a data acquisition system based on the Internet of Things can collect data and monitor windmills from anywhere, alerting the individual if necessary. The analog data is converted into digital data by sensors and is fed to an Arduino controller. Depending on the data the controller responds to, the live data from the sensors are visualized directly on a dashboard for remote monitoring. Users can monitor live energy, voltage, current, and other measurements for every windmill on their dashboard. There are several measurements that are monitored, which can be visualized for each windmill.*

***Key Words*: Arduino UNO, Voltage sensor, Current Sensor, Temperature Sensor, GSM Module, Data Acquisition, IOT.**

1.INTRODUCTION

[1] With the increasing demand for renewable energy sources and falling construction costs, studies show that the wear and tear on the structures begin to increase substantially, quickly leading to an overall reduction in production but an increase in Operating and Maintenance costs.[3] To combat this, owners and operators can deploy SCADA systems to detect faults before there is any secondary damage. Through this early detection, repair costs can be reduced, representing significant savings.

Windmills are usually located in remote areas. Continuous monitoring of these windmills in these remote areas requires a lot of human effort if it is monitored by humans. As humans are prone to making mistakes, electronic devices such as sensors and microcontrollers can be entrusted to collect data and help in monitoring the equipment from any location and take necessary actions accordingly.

This project deals with developing a Data Acquisition which records various parameters in a windmill that should be monitored in order to maintain the optimum operation of the Windmill.

2. System Design and Components

Exposing owners to the true operations and maintenance costs of wind farms and component failures are driving excessive maintenance costs.[1] To combat this, owners and operators can use SCADA (Supervisory Control and Data Acquisition) systems to detect faults before they cause secondary damage. By identifying the reason for a fault can reduce the repair costs, which would result in significant savings. Hence, the aim of this paper is to develop a prototype of a monitoring system for windmills placed in remote areas and to ensure efficient working regularly and for data logging, which is cost efficient and user friendly.

2.1 System Controller

[2] Arduino UNO acts as the brain of this system and plays the role of the decision maker for the system. Based on the sensors values, the Arduino checks for an abnormality in the system.

The Arduino UNO board is a microcontroller board based on microchip ATmega328. The board consists of a set of Digital and Analog pins (14 Digital pins and 6 Analog pins), out of which 6 digital pins are capable of PWM operation. Uses a USB B port or a 9Volt battery to power up and accepts operating voltages around 5-20 Volts. It is programmable with the open-source Arduino IDE. With a clock frequency of 16MHz, including Special pin such as UART pins (RX, TX), SPI (Serial Peripheral Interface) pins, I2C pin and AREF (Analog Reference) pin. It is used to in this project as the main system controller in taking logical decisions when needed.

Fig 1. Arduino UNO

2.2 Data Transmitter and Receiver Module

[2] The SIM900A is the smallest and most economical GSM/GPRS module. Using a mobile SIM, the module provides GPRS/GSM technology for communicating with users. It can

transmit and receive mobile calls and messages on a 900 and 1800MHz frequency band. It has a command mode and a data mode. Every country has its own GPRS/GSM and protocol/frequency setups. Developers may change default settings in command mode to meet their own requirements. With a Power Input of (3.4-4.5) V, Transmitting Power range of 2V, Data transfer Link (Download speed of 85.6kbps and upload speed of 42.8kpbs). It has an Antenna Support, Audio Input/Output ports, serial port (I2C and UART).

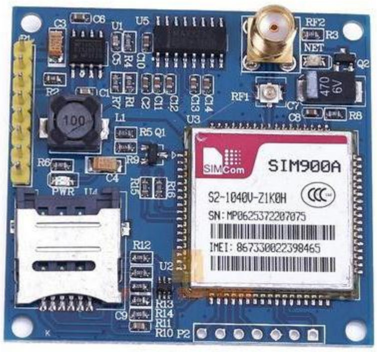

Fig 2. GSM Module (SIM900A)

2.3 Current Sensing Unit

The ACS712 is a hall effect-based linear current detector integrated with 2.1kVRMS voltage isolation and a low-resistance current conductor. It has an output sensitivity of (66-185 mV/A),80KHz bandwidth, Low-noise analog signal path, almost zero magnetic hysteresis, stable output offset voltage and 1.2mΩ internal conductor resistance.

Fig 3. Current Sensor (ACS712)

2.4 Humidity and Temperature Sensing Unit

[2] The DHT22 is a digital-output relative moisture and temperature sensor. It has a calibrated output digital signal. It has a capacitive moisture sensor and a thermistor. There is also a very basic chip inside that does an analog-to-digital conversion and sends out a digital signal with the temperature and humidity. A microcontroller can easily read the digital signal. It operates at (3-5) V, has an accuracy of 2-5% for (0-100%) humidity reading, and a ±0.5°C accuracy for (-40 to 80°C) temperature, no over 0.5Hz sampling rate.

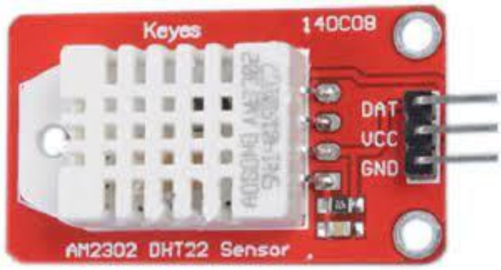

Fig 4. Humidity and Temperature Sensor (DHT22)

2.5 Speed measuring Module

An Infrared sensor is a radiation-sensor component which can detect radiations in infrared wavelength range. It comprises an emitter, which is basically just an IR LED, and a detector which is simply an IR photodiode. When the emitted IR light falls on the photodiode, the resistances and the output voltages change in proportion to the magnitude of the IR light received. It has an operating voltage of 5VDC, with a range of 20cm, the range of sensing is adjustable. It has a potentiometer which can be adjusted to vary the measuring range of the IR sensor. In this paper, we'll be using the IR sensor along with a metal piece to measure the rotational speed of the Windmill Blades.

Fig 5. IR Sensor

3. SIMULATION SOFTWARE

3.1 Proteus 8 Professional

Proteus 8 Professional is a proprietary software tool suite designed mainly for electronic design automation. We can use it for Schematic Capture, simulations, PCB layout design, microcontroller simulations and 3D verifications.

3.2 Arduino IDE

Arduino IDE (Integrated Development Environment) is an open-source electronic prototyping software that functions from C and C++. It is used to write and upload programs to Arduino compatible boards or other development boards.

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4. System Schematic

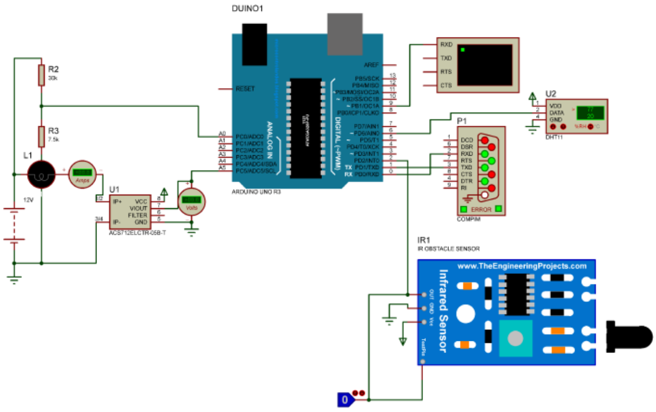


Fig 6. Schematic Diagram

4.1 CONNECTION

i. To get the generated voltage we use the voltage divider technique.

ii. A 30k ohm and 7.5k ohm resistors are used to find the generated voltage and is connected to A0 pin of the Arduino.

iii. The ACS712 Current sensing module has 8 pins. Pin 1,2 and 3,4 are shorted respectively. This module is powered by the Arduino with 5V at pin 8(Vcc). Pin 7(Vout) is connected to Arduino pin A5 and pin 5(Gnd) is connected to the ground.

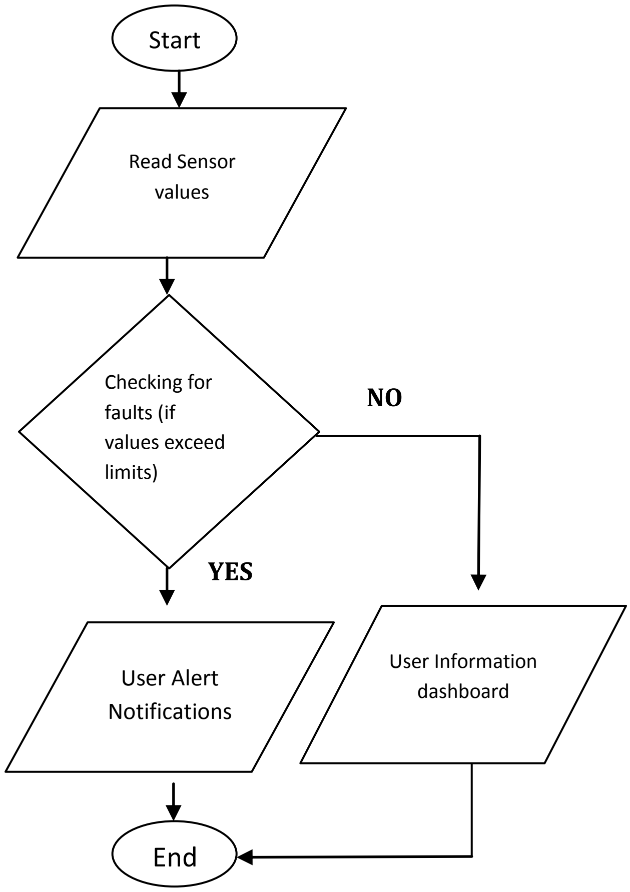
iv. A load(lamp) is connected in series to the current sensor pins (1/2) and pins (3/4) are connected with the common ground.

v. The Speed measuring module is powered with 5V and the signal pin is connected to Arduino digital pin (2).

vi. The humidity and temperature module is also powered by the Arduino and the data pin is connected with Arduino pin (6).

vii. Tx and Rx pins are connected to the virtual data transfer module and pin (9) of Arduino is connected to a virtual terminal to visualize the data in the virtual simulator.

4.2 Algorithm/ Flow chart



4.3 METHODOLGY

i. Data acquisition: Translation of the physical phenomenon into an analog measurement, which is then converted into digital format.

ii. Data processing: conversion of the digitized measurements into meaningful indications of component health.

iii. Detection: Classification of the condition indicators as "normal" or "abnormal".

iv. Diagnosis: Validation of the fault and determination of its location and severity.

v. Prognosis: Estimation of how much longer the faulted component will last before it needs to be replaced.

vi. Transmission: Transmitting Data to the user dashboard using low latency protocol.

vii. Recommendation: Determination of what maintenance action is necessary and when it should be performed.

4.4 WORKING DESCRIPTION

This project shows the design of a working model Windmill Monitoring System:

Different Sensors are used to record and convert the analog signals of the environment into digital signals. Here we have used DHT22 sensor to measure the heat levels at the oil tanks, gearbox and brakes. A Hall effect sensor is used to record the speed. The ACS712 is used to read the current being supplied by the generator. The voltage divider is used to read the generated voltage. The data is transmitted to the Arduino.

The Arduino compares the values with the preset values and checks for errors, if any; it notifies the owner or user either through SMS or app notification. The voltage, current and other values are displayed in the user dashboard, which is transmitted with the help of the GSM module. The owner or manager can view the data with the help of the mobile or web application.

This helps record and analyze the data with no human intervention, needing to check and monitor the windmill regularly.

4.5 IMPLEMENTATION

A DC Shunt Generator Windmill was used in place of an AC Alternator Windmill. Which gave an output of 25V, which was used to charge Lead-Acid batteries within the building. The Parameters such as Voltage, Current, Power, Speed etc., were recorded with a help of a Data Acquisition system and transmitted with the help of GSM Module.

The Windmill is automatically turned according to the Wind direction to use the wind energy efficiently with the help of a mechanical yaw which is fitted at the rear of the windmill. A brake system is used in maintaining the windmill in standstill position when power production is not needed.

5. RESULTS

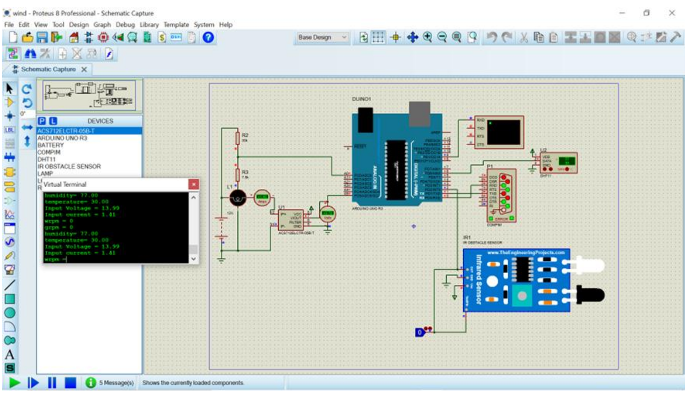


Fig 7. Simulation Output.

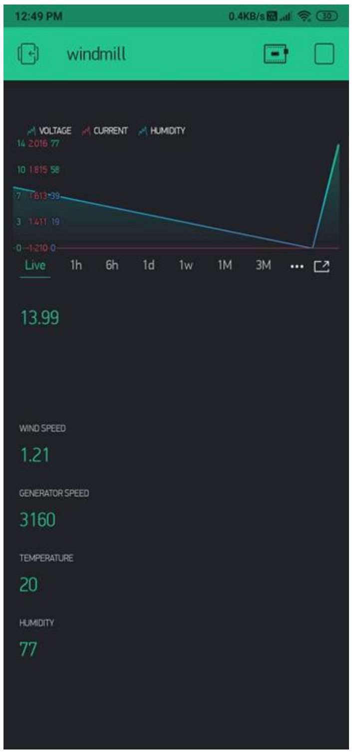


Fig 8. Android App Interface

Fig 8.1 Dashboard Output

6. CONCLUSIONS and FUTURE SCOPE

i. The Simulation of the Windmill Monitoring System model has been designed and tested. The DAS or SCADA system can be used to efficiently monitor and maintain the performance and operating characteristics of not just an individual windmill but also a whole windmill farm.

ii. If any parameter is not within the set limit the system will alert the user accordingly.

iii. AI methods can be installed to allow self-repair and self-control, enhancing performance and maintenance.

iv. Due to cost constraints, only few important parameters are being monitored. If cost wasn't a constrain the more sensors can be used to read more analog values of the system.

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APPENDIX

Components model:

i. System Controller – Arduino UNO

ii. Data Transmitter module - GSM (SIM900A)

iii. Current Sensing Module – ACS712

iv. Humidity sensing Module – DHT22

v. Speed Detector – IR sensor