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Conference Paper

Portable IoT Connected Device for Vibration and Temperature Measurement

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ABSTRACT

This study aims to design of portable IoT-connected device for vibration and temperature measurements that are installed on a wind turbine gearbox. The device consists of a battery 7.4 volt 6800 mAh, Arduino ESP32, sensor DHT22, sensor ADXL345, buzzer, SD card, connected to laptop and wifi. The device is placed in a wind turbine gearbox that is run at 220 rpm and a frequency of 15 Hz and is tested for 3 minutes. The first minute was under normal conditions, the second minute by giving vibration to the gearbox and the third minute normalized again the test results show that the treatment affects temperature, humidity, and acceleration on the x, y, and z axes of the gearbox. As a result of the treatment by giving vibration to the gearbox, the temperature increases, the humidity decreases, the acceleration of the x-axis increases, and the acceleration of the y-axis and the z-axis decreases.

Keywords: Portable IoT, temperature, vibration, wind turbine, ESP32

Introduction

Wind power generation has developed rapidly in recent years (Rudiyanto et al., 2019), but compared to traditional power generation systems, such as coal and natural gas (Budiprasojo et al., 2020), wind project maintenance strategies require more innovation due to relatively higher operating and maintenance costs (Rudiyanto et al., 2020). This situation is mainly because most wind turbines are relatively inaccessible. Therefore, it is necessary to reduce wind turbine maintenance costs with the use of fault diagnosis monitoring is considered an important tool for detecting failures.

Based on previous research, the main fault in wind turbines is the gearbox fault. 25% of all gearbox failures recorded in 2014 were gear failures in the gearbox (Qiao & Lu, 2015). The planetary gearbox (PGB) is one of the key components in the wind turbine drive system, which converts wind energy into electrical energy. To ensure regular operation of the wind turbine, it is very important to monitor the PGB. Currently, the fault diagnosis method used for gearbox condition monitoring is mainly based on vibration monitoring (Salameh et al., 2018), where vibration signals are obtained from sensors, such as accelerometers, mounted on the gearbox casing. However, in the case of wind turbines on the wind power plant, this method is difficult to apply because of its high position, which requires wireless vibration monitoring.

Vibration signals are generally obtained with wired accelerometer sensors (Yina et al., 2018) and the existing research is mostly focused on feature extraction and fault diagnosis of the obtained vibration signals. However, wired accelerometer sensors have a high cost in installation and maintenance, moreover, it is difficult to find faults when the accelerometer fails.

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In recent years, wireless sensor networks (JSN) have been used in both medical and industrial applications, due to their high adaptability. Wireless sensor nodes that can collect and process information without maintenance over a long period are an important part of a JSN.

The wireless system is adopted for fault diagnosis of power transmission and distribution systems, in addition, wireless sensors are used to monitor transformer conditions for fault diagnosis and health management (Akash et al., 2019). In the current study, a new wireless sensor node, developed for online monitoring of wind turbine gearboxes, was adopted to obtain vibration signals for subsequent fault diagnosis. Based on this description, this study aims to design a portable device for IoT-based vibration and temperature measurements that are installed on a wind turbine gearbox.

Material and Methods

Device system

The portable IoT device system consists of a battery 7.4 volt 6800 mAh which consists of 2 batteries 3.7 volts connected in series, Arduino ESP32, sensor DHT22, sensor ADXL345, buzzer, and SD card is shown in Fig. 1. The block diagram of the device system and receiver module using a laptop is shown in Fig. 2.

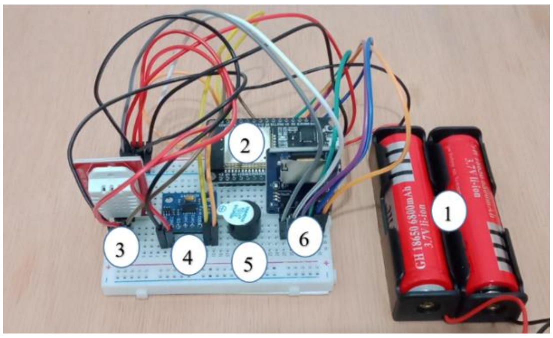

Figure 1. The prototype of portable IoT device system

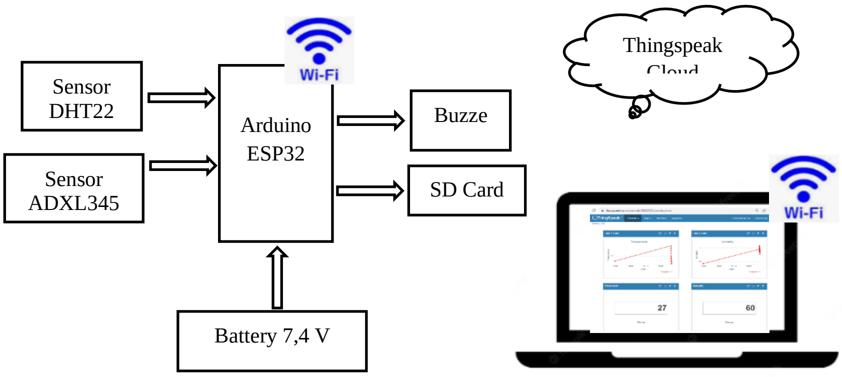

Figure 2. Diagram system of portable IoT device

DHT22 is a sensor that can measure temperature and humidity, the following sensors have a digital signal output. This DHT22 sensor has a very accurate setting at the cost of setting room temperature with the value stored in the integrated OTP memory. While the ADXL345 accelerometer is an acceleration sensor capable of measuring linear acceleration in three axes (x, y and z). This sensor has a high resolution (up to 13-bit) at its highest sensitivity. These sensors are connected to the Arduino ESP32 which is used to control the system. This ESP32 is the successor of the ESP8266 microcontroller. This microcontroller is compatible with the Arduino

IDE. In this microcontroller already available WiFi module and coupled with BLE (Bluetooth Low Energy) in the chip so that it is very supportive and can be a good choice for creating Internet of Things application systems. The specifications for the ESP32 microcontroller are Processor: Xtensa dual-core (or single-core) 32-bit LX6 microprocessor, operating at 160 or 240 MHz. Memory: 520 KB of SRAM. Wireless connectivity: Wi-Fi 802.11 b/g/n, Bluetooth v4.2 BR/EDR, and BLE (shares the radio with Wi-Fi) (Nari et al., 2016).

The buzzer is a medium for sound output, the buzzer can produce sound depending on the voltage received. If a full voltage of 5V is given, the buzzer will sound loud, and if the buzzer is given a frequency/oscillation voltage, the sound that comes out is a tone (Haerul, *et al.,* 2020). SD card module is a module that can read and write data and store it on the SD card memory with Arduino. The External Power Supply is a 7.4 volts battery. This battery is connected to an input voltage and to ground the Arduino.

This Arduino system is connected to a computer using Thingspeak as a data display. ThingSpeak is an open-source platform in the form of a website that provides services for IoT needs and can receive data using the HTTP protocol over the internet.

Device testing

The system device testing is done by placing the device at the top of the wind turbine gearbox as shown in Fig.3. The wind turbine gearbox used is Alliance-Italy IEC 34-1 380volt 1.5 kW 2 hp A-Y3A-90L-4B5. The device is connected to a laptop and connected wifi from a smartphone. The testing stages are as follows. First, the gearbox is run with a frequency of 15 Hz and 220 rpm under normal conditions without any external vibration influence. Second, the gearbox is run with a frequency of 15 Hz and 220 rpm with a treatment in the form of external vibration at the top of the gearbox for 1 minute. And continued with observations after treatment and then normalized again as in the first stage.

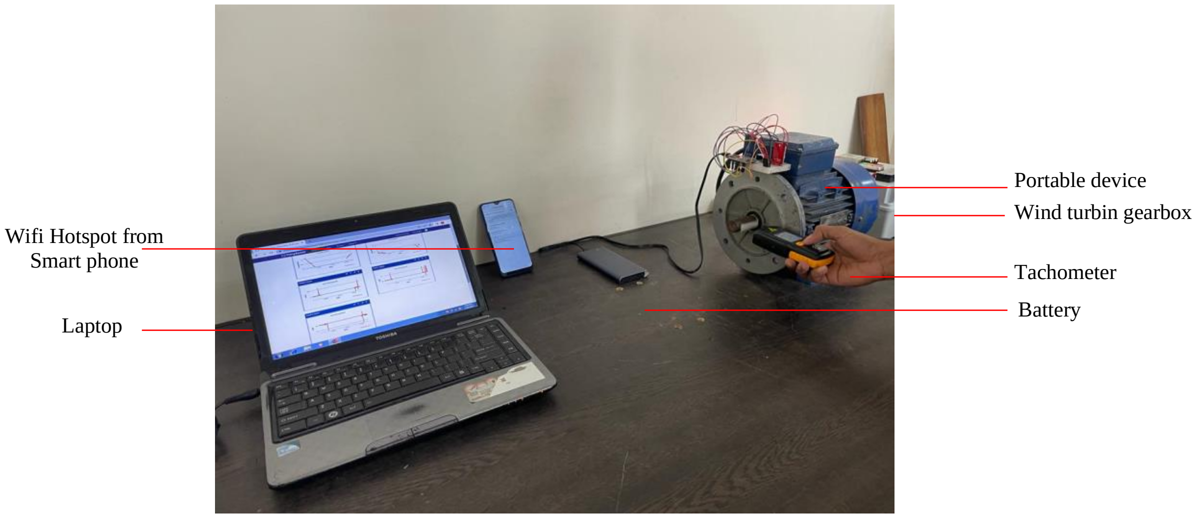

Figure 3. Device placement and testing

Results and Discussion

This study was carried out in three stages to compare the effect of vibration on temperature, humidity, and acceleration. The results of testing stages one, two, and three can be seen in fig. 4, 5, and 6 respectively.

Under normal conditions, the gearbox temperature is in the range of 28 - 29 °C, humidity is in the range of 58%, and the x, y, and z accelerations are stable. When the gearbox received treatment in the form of vibration for 1 minute, the gearbox temperature increased to more than

29 °C, the humidity decreased to 57.5%, and the x, y, and z accelerations experienced are changing. After getting treatment, the gearbox temperature continued to show an increase around more than 30 °C, the humidity was below 57.5% and the x, y, and z accelerations were still changing.

Fig. 7, 8, and 9 show the results of the portable device test on the gearbox which was run for 3 minutes, the first minute was under normal conditions, the second minute the gearbox was treated by giving vibrations on the top of the gearbox, and the third minute was back to normal after the treatment. Changes in temperature in the presence of the three treatments are shown in Fig. 7, during the first minute the gearbox temperature was in the range of 28.6 °C and increased in the second and third minutes until it reached 30.5 °C.

The relationship between humidity changes in the three treatments for 3 minutes can be seen in Fig. 8. In the first minute, the gearbox humidity was around 58.2% and decreased in the second and third minutes to 56.2%. Fig. 9 shows the relationship between the three treatments for 3 minutes on the acceleration of the x, y, and z axes experienced by the gearbox. The x-axis acceleration in the first minute is stable in the range of 0.5 m/s^2, increasing in the second minute from 1.88 to 3.3 m/s^2. In the third minute, the acceleration stabilized at 3.26 m/s^2. The y-axis acceleration in the first minute was stable in the range of -0.2 m/s^2 and decreased in the second minute from -0.35 to -3.46 m/s^2. In the third minute, the acceleration stabilized again with a magnitude of -3.26 m/s^2. The z-axis acceleration in the first minute was stable at around 9.4 m/s^2 and decreased in the second minute from 8.59 to 8.39 m/s^2. In the third minute, the acceleration stabilized again with a magnitude of 8.36 m/s^2.

Figure 4. Display on thingspeak.com when bearing is in normal condition

Figure 5. Display on thingspeak.com when gearbox is treated

Figure 6. Display on thingspeak.com when when normalized again

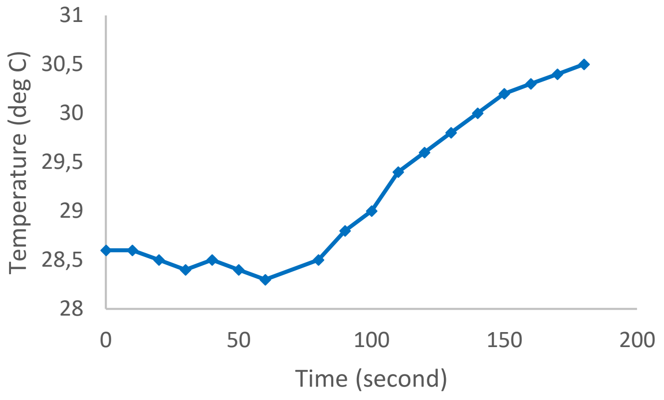

Figure 7. Graph of the relationship of temperature changes with time

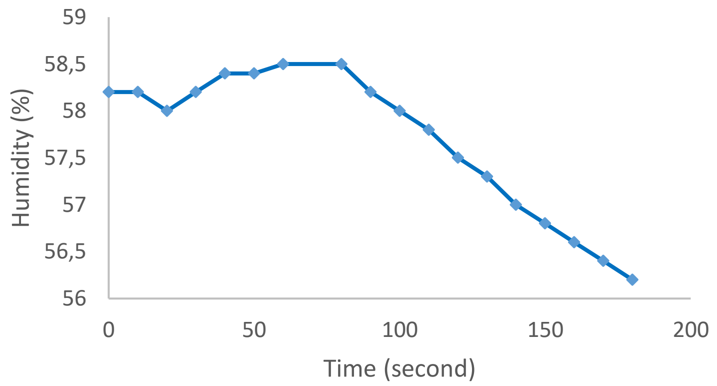

Figure 8. Graph of the relationship of humidity changes with time

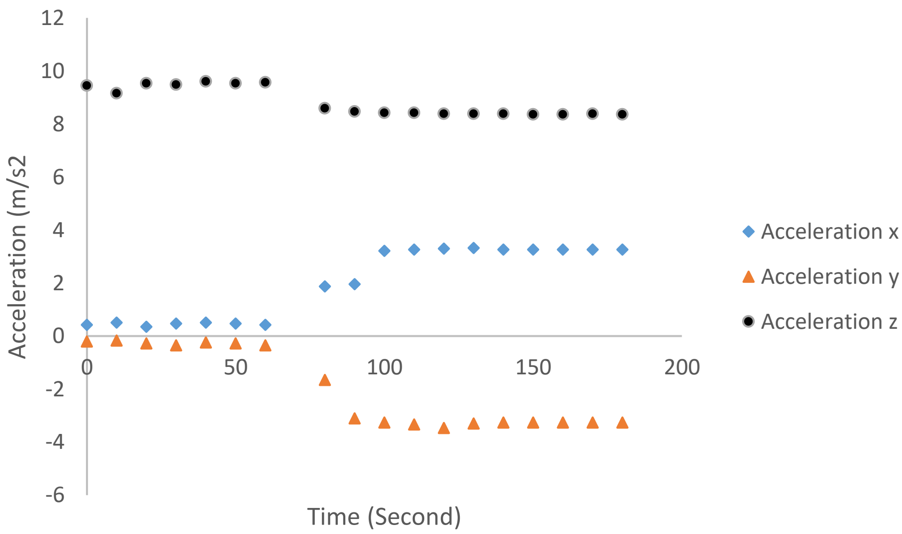

Figure 9. Graph of the relationship between changes in the acceleration of x, y, and z with time

Conclusion

Portable IoT-connected device for vibration and temperature measurements that is installed on a wind turbine gearbox consists of battery 7.4 volts 6800 mAh, Arduino ESP32, sensor DHT22, sensor ADXL345, buzzer, SD card, connected to laptop and wifi. The device is placed in a wind turbine gearbox that is run at 220 rpm and a frequency of 15 Hz and is tested for 3 minutes. The first minute was under normal conditions, the second minute by giving vibration to the gearbox and the third minute normalized again. The test results show that the treatment affects temperature, humidity, and acceleration on the x, y, and z axes of the gearbox. As a result of the treatment by giving vibration to the gearbox, the temperature increases, the humidity decreases, the acceleration of the x-axis increases, and the acceleration of the y-axis and the z-axis decreases.

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