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DEVELOPMENT OF IOT BASED REAL TIME CONDITION MONITORING SYSTEM FOR PERFORMANCE IMPROVEMENT OF DIESEL GENERATORS

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Abstract :
This paper presents an IOT (Internet of Things) based solution for condition monitoring and performance improvement of diesel generator by establishing a communication between Electronic Hardware and Cloud Computing, popularly known as IOT based applications, used especially for online and real time monitoring. or any other authorized personnel. Generally Generator suffers from abnormal conditions such as overheating and vibrations. To predict these abnormalities and to avoid unnecessary shutdowns an IoT based system is proposed. IoT driven remote DG set monitoring is surfacing as a basic prerequisite and a key enabler of the fourth industrial evolution (industry 4.0) by fostering cyber-physical interfaces for traditional generators. The present work developed an online generator monitoring system based on ThingSpeak, an IoT technology platform. The system can record the historical data of generators operation parameters, such as the measurement of fuel level, engine temperature, coolant temperature, oil level, oil pressure, vibration and engine speed of generator and provides details to the authorized person in real time. Results indicate that the proposed method has the potential to be used to speed up fault detection and perform fault diagnosis without the use of expensive diagnostic tools.

Index Terms—**Internet of Things, Industry 4.0, Diesel Generator, ThingSpeak**

I. INTRODUCTION

Recent years have witnessed a steep rise in energy demands owing to the economic growth and increase in population. Developing countries like India are facing serious challenges in meeting these exponentially growing demands. As a result, the need of backup power sources has increased manifold to partially bridge these energy gaps. Generators are fossil-fuel powered generators employed to supply electrical power both as a primary source in remote areas and a backup supply to main power lines.Around 90 percent of the generator failures are attributed to ignored alarms, battery issues, blocked heaters and fuel shortages. The aforementioned situations are mainly caused by ignorance of the owner and inability of the maintenance staff to monitor and timely address the deteriorating generator parameters, often resulting into heavy maintenance and recovery overheads at a later stage. Such losses can be reduced by proactively monitoring generator health parameters. However, it requires dedicated and trained manpower for periodic on-site inspections. Moreover, manual inspections are deemed to be labor-intensive and time consuming activities, besides being prone to human-errors and inaccurate evaluations. The task can be made further convenient and cost-efficient through the use of automation and real-time remote monitoring by leveraging the Internet of Things technologies.

The Internet of Things (IoT) has evolved from the convergence of wireless technologies, sensor networks, pervasive computing, ubiquitous connectivity, and cloud-driven big-data analytics, thus facilitating physical objects to be monitored and controlled remotely over the network. This has aided in abridging the gap and enhancing associations between operational and information technologies through processing of amorphous data generated by machines into useful and actionable information. In view of these far-reaching benefits, IoT has received a wide acceptance and rapid proliferation in all technological domains, in particular, consumer, industrial, automotive, health, and military sectors.The widespread distribution of wireless networks, embedded systems, and less expensive sensors has encouraged the rise of Industrial Internet of Things (IIoT). IIoT is the cornerstone of Industrial 4.0 implementation. Supporting all forms of new information technology, IIoT has the ability to continuously retrieve information from a variety of sensors and objects, securely transmit sensory readings to cloud-based data centers, and freely review related parameters in the form of a closed loop system. In this way, the IIoT is able to accurately monitor performance and detect failures.

2. LITERATURE REVIEW

TheAn indigenously developed and IoT-enabled predictive health monitoring system for power generators is proposed in [1]. The system records critical health parameters of generator and makes them available to a remote operator in real-time through IoT connectivity and cloud-driven data analytics. The solution also offers an indigenously-developed mobile app to monitor the critical generator parameters and trigger alarms in case their values fall outside the threshold limits. An online monitoring system for generator based on Thing Speak, the IoT technology platform, is built in the research [2]. The system can record historical details of the performance parameters of the generators, starting from the fuel level, engine temperature, to total power outage. Measurement data is used for offline analysis of generator operating conditions or to determine the time to the next periodic maintenance.

[3] presents IoT Based Monitoring of Generator’s Fuel & Battery Levels in Base Station Cell Sites with SMS Alert. The proposed system comprises of both hard-ware and software. [4] proposed a personalized healthcare preventive system to maintain the health of individuals as well as receive evidence of feedbacks. [5] presented the design and implementation of a IOT embedded system to measure load currents, over voltage, transformer oil level and oil temperature. This is implemented by using on-line measuring system using Internet of Things (IOT), with single chip Arduino microcontroller and sensors. Faults are being simulated using IOT based hardware equipment for test purpose and to create alters to the respected field operator on web page application in [6]. The signal obtained from the vibrations of the time zone is converted into a frequency domain using the FFT algorithm in gateway and waveform patterns are analyzed for error detection. The research conducted in [7] focuses on IoT in regards to the use of a free smart phone Application (App) to control actuators and to the cloud service (Sensor Cloud) readily available where the parameters can be viewed and analyzed graphically as well as creation of “virtual sensors” which can be derived through a combination of measured parameters from physical sensors.

The work described in [8] aimed at analyzing and testing the use of mobile phones to remotely monitor an appliance control system through GSM based wireless communication. It works on Raspberry pie system, GMS can monitor various parameters such as temperature, oil level, humidity, fire resistance capacity of the generator. [9] made an effort to provide a low-cost solution to the existing health monitoring systems along with facility to measure various parameters like vibrations, noise, temperature, rotational speed, and power consumption. The low-cost controller Arduino Mega 2560 is used in conjunction with various sensors and is integrated with the MATLAB GUI to store and display acquired data. The advanced device was compared to existing systems and was found to have a good deal. This device can be used as a monitoring tool in small-scale industries where high-cost FFT analyzers become obsolete due to costing issue. generator. [10] deals with The IoT ‘Thingspeak’ web service which is a generous open API service that act as a host for the variety of sensors to monitor the sensed data at cloud level and composite a special feature of porting the sensed data to the MATLAB R2016a using a channel ID and read API key that is assigned by services and is able to track the data with the selected sample from time to time. The project also uses the Arduino UNO board, the ESP8266 Wi-Fi Module which helps to process and transfer data to Thingspeak Cloud. [11] focuses on detecting power failures and takes reflex action to solve the problem with the help of modem communications using GSM. Electrical failures will be reported to the Microcontroller which triggers the GSM modem to send a text message to the concerned person's cell phone number which is already installed on the Microcontroller and to monitor the parameters such as temperature, oil level and fuel level. When they exceed the predefined limits, an alert is send automatically to the authorized person. The global trend of wireless communication has escalated into a wide range of band details. This system provides an appropriate solution to problems caused by situations where wireless communication between the remote device and the control unit may not be possible.

3. RESEARCH METHODOLOGY

3.1 System Architecture

Fig. 1 shows the block diagram of the proposed IoT interaction model, applied over remote and real-time monitoring of generator health parameters. The desired parameters are acquired by both tapping data from the on-board sensors of the generator alongside integrating extra sensors to cover for the missing parameters. The analogue readings delivered by these sensors are converted into digital form using an embedded computing

module. Therefore, each sensor, when combined with the computing module, constitutes a sensor node. A sensor node does not have the processing power or the memory to deal with the data locally. Therefore, these sensor nodes transmit the collected data to an IoT gateway, often using a low-power and resource-efficient wireless communication protocol. The IoT gateway acts as a mediator by receiving IoT data from resource-constrained sensors and actuators, and relaying that data over the internet to a back-end server, used for data aggregation, archiving and analytics. These analytics can be performed either by leveraging available cloud-based solutions such as Things Speak.

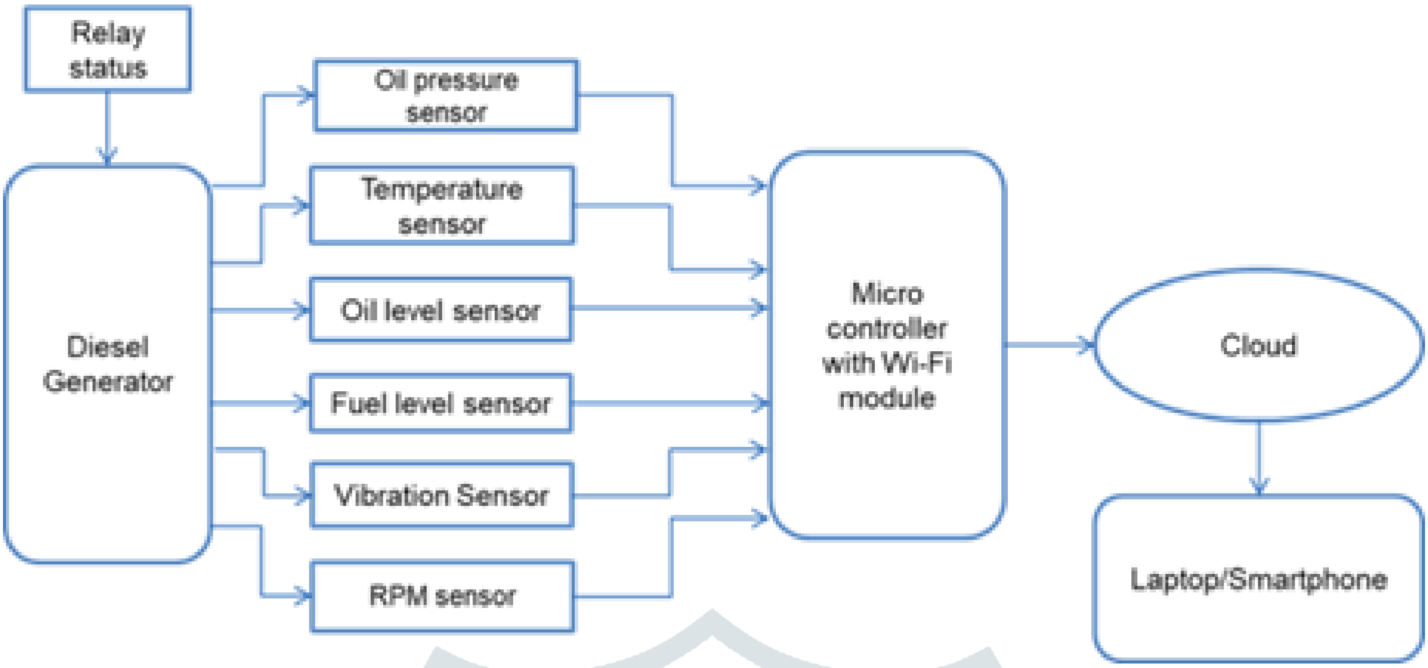

Figure1 System block diagram

The proposed system for monitoring and control of the diesel generator through IoT technology is composed of four components:

- Data sensing and acquisition
- Data upload to Sensor Cloud
- Data Visualization
- Alerts and Notification

3.2. System modelling and simulation

The proposed system is designed and simulated in Proteus Design Suite. It is a software tool suite used primarily for electronic design automation.The sensors used in the system consists of a temperature sensor, a fuel level sensor, an oil level sensor, a pressure sensor, a RPM sensor and a vibration sensor. The data measured by the sensors are processed by the Arduino microcontroller and immediately transferred to the cloud. Cloud platform provides sufficient processing, storage, analytics, networking and user interface for IOT applications. The data from the sensors are given to microcontroller unit, Algorithms are written in arduino IDE such that the logics for simulations are written and processed according to the data received and data received from sensors will be sent to edge gateway. The coding for the system is programmed in Arduino IDE (Integrated Development Environment) software and is transferred to the microcontroller via a type B USB cable.

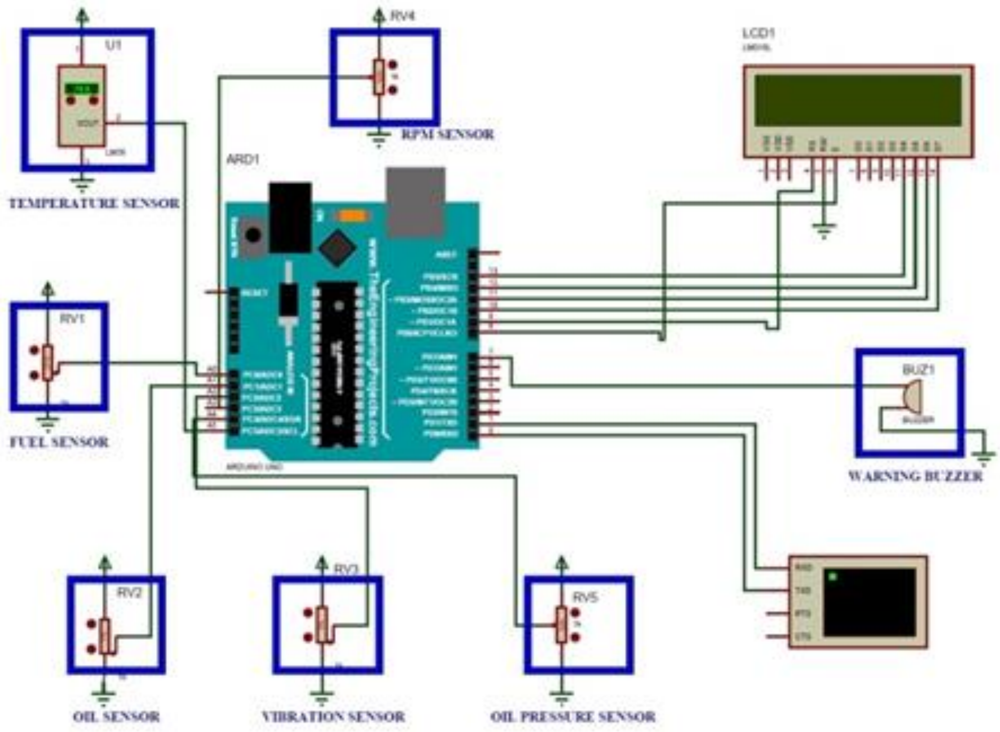

Figure 2 Simulation model of the system

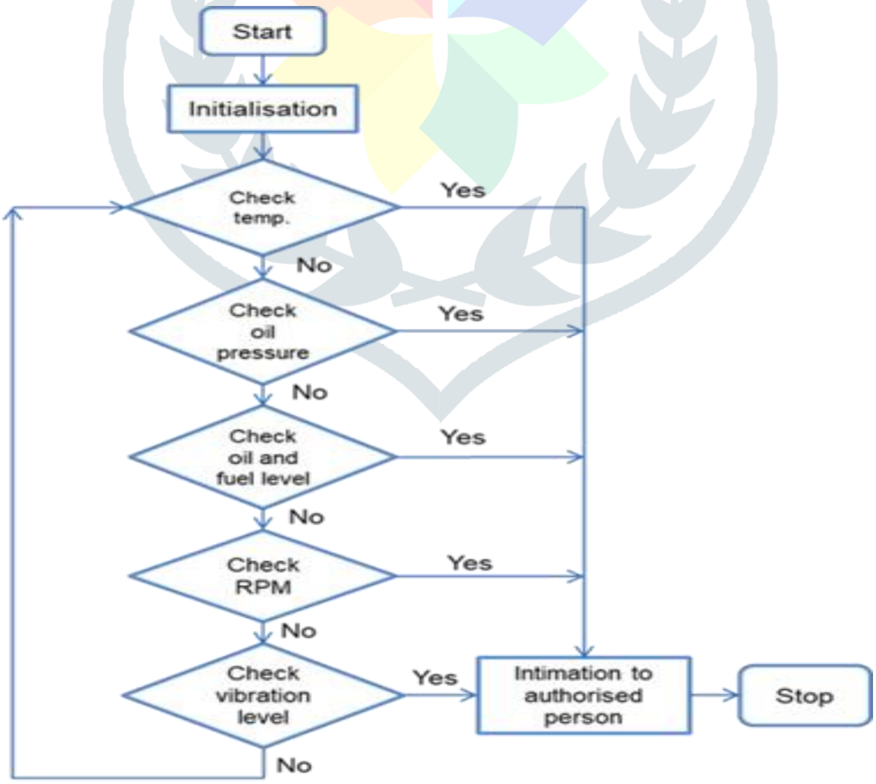

Figure 3 Flow chart

The algorithm of operation is as follows :

Step 1: Start the program
Step 2: To initialize the system
Step 3: Get Hardware Software for relevant application.
Step 4: To monitoring the generator status and parameter and if any abnormal conditions occur it is automatically intimated to authorized person.
Step 5: Check operation pattern
Step 6: Control the device based on status and operator can making a decision.
Step 7: Notify end user
Step 8: Go to step1

3.3. System implementation

Fig. 4 shows the hardware setup for implementing the system. It consists of sensors, a microcontroller, a Wi-Fi module and a buck converter. ADXL345 is the accelerometer used for measuring vibrations. This type has advantages over other vibration sensor technologies as it is very compact, can measure a wide range of frequencies, is reliable and can have high sensitivity. DHT11 sensor is used for temperature measurement. It is a basic, ultra low-cost digital temperature and sensor. Arduino is an open source hardware and software which acts like a gateway to collect sensor data, analyzing it and to connect to a network. The Arduino UNO is a microcontroller board based on the microchip ATmega328P and is designed to be programmed in C and C++ programming languages. The board has 14 digital I / O pins, six analog I / O pins, and can be configured with the Arduino IDE (Integrated Development Environment), via a type B USB cable.

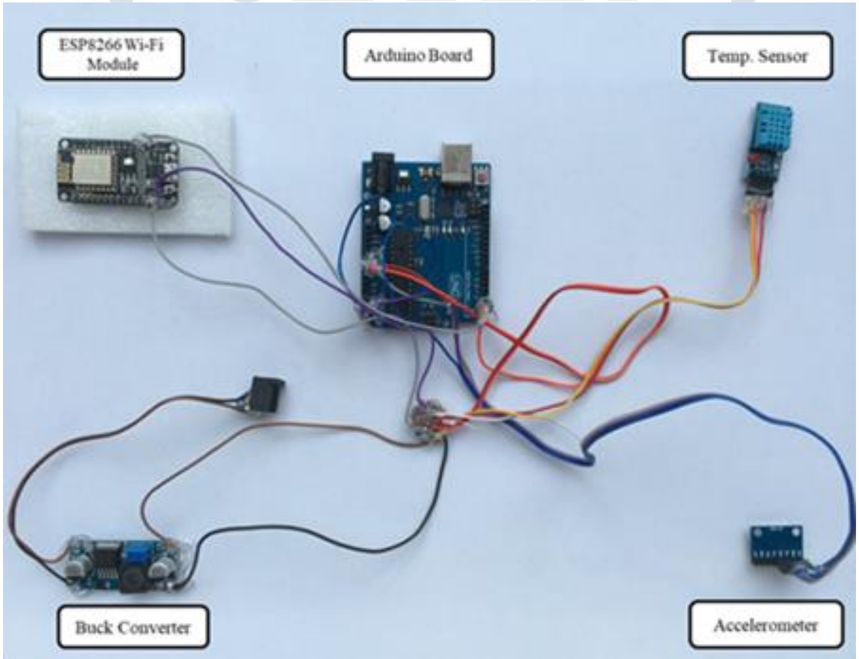

Figure 4 Experimental implementation of system

The acquired Generator parameters are processed, refined and accumulated by the Arduino device and was subsequently transmitted over a wireless channel to a centralized gateway, which uploads them to the cloud Node MCU is an open-source firmware and development board specially targeted for IoT based Applications. It Includes firmware running on ESP8266 Wi-Fi. The ESP8266 is a low-cost Wi-Fi microchip, with full TCP / IP stack and microcontroller capability. This small module allows microcontrollers to connect to a Wi-Fi network and make easy TCP / IP communication. The buck converter (step-down converter) is a DC-to-DC power converter that reduces the power from input (feed) to output (load). ThingSpeak is an IoT analytics platform service that allows you to compile, visualize, and analyze live data streams in the cloud. We can send data to ThingSpeak from your devices, create instant visualization of live data, and send alerts.

3.4. Sensors used

The different sensors used for measuring operating parameters of the generator is listed below.

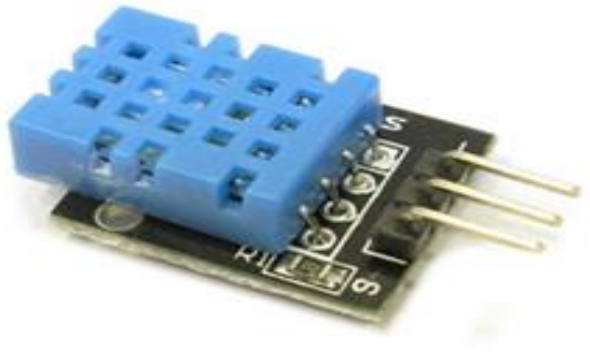

Fig 5 Temperature sensor

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use.

Fig 6 Vibration sensor

The type of vibration sensor to be used is a Micro Electrical-Mechanical System (MEMS) accelerometer. This type has advantages over other vibration sensor technologies as it is very compact, can measure a wide range of frequencies, is reliable and can have high sensitivity. Accelerometers with analogue or digital interfaces are available, and a SPI and I2C digital interface was chosen as it is more resilient against signal interference and again, does not require the ADC of the MCU. The chosen accelerometer, the ADXL345 from Analog Devices, offers three axes of measurement, with the ability to measure ± 16 g along each axis, can survive a shock of up to 10,000 g and it can measure static and dynamic vibrations.

3.5. Gateway

IOT gateway device bridges the communication gap between devices, sensors, equipment, systems and the cloud. Devices can communicate with gateway with wired communication like USB, I2C, SPI or wireless communication such as WIFI, Bluetooth, Zigbee, wireless USB, RFID etc., Gateways can control equipment based on data received from sensors and they offer local pre processing and storage solutions.

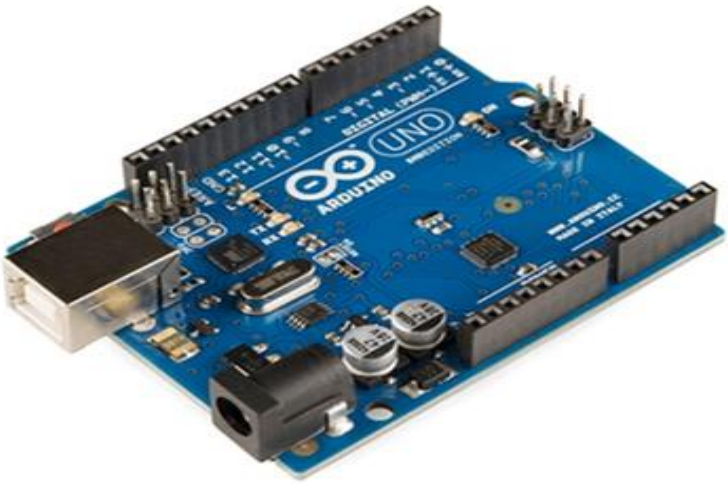

Figure 7 Arduino UNO

Arduino is an open source hardware and software which acts like a gateway to collect sensor data, analyzing it and to connect to a network. The Arduino UNO is a microcontroller board based on the microchip ATmega328P and is designed to be programmed in C and C++ programming languages. The board has 14 digital I/O pins, 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable.

Figure 8 ESP8266 Wi-Fi

The acquired operating parameters were processed, refined and accumulated by the Arduino device and was subsequently transmitted over a wireless channel to a centralized gateway, which uploads them to the cloud Node MCU is an open-source firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi. The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections.

Figure 9 Buck converter

A buck converter (step-down converter) is a DC-to-DC power converter which steps down voltage from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) typically containing at least two semiconductors, a diode and a transistor, and at least one energy storage element such as a capacitor, inductor, or the two in combination. Buck converters provide much greater power efficiency as DC-to-DC converters than linear regulators, which are simpler circuits that lower voltages by dissipating power as heat, but do not step up output current.

3.6. Cloud platform

Cloud platform provides sufficient processing, storage, analytics, networking and user interface for IoT applications. IoT is a computing concept that describes a scenario where physical objects are connected to the internet and network connectivity enables these objects to collect and exchange data and can identify themselves to other devices via IP address. ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyses live data streams in the cloud. We can send data to ThingSpeak from your devices, create instant visualization of live data, and send alerts.

4. Experimentation results

Once the sensor nodes and gateways are connected the data can be accessed on GUI through application program interface (API) keys. API provides an web interface between generator sensor platform and internet by providing a secure authentication. The main idea of the model is to transfer data for monitoring and realize the data analytics functions by simulating faults through switches. This will ensure the accuracy and reliability of the operation, whether warnings are sent to the field operator successfully or not if any abnormalities are present. For Arduino to send information to ThingSpeak the official ThingSpeak library is used. For setting up ThingSpeak, a user account and a channel is required. For Arduino to send data to ThingSpeak the official library for ThingSpeak is used. A Channel is where the data gets sent and stored and consists of 8 data fields. After the creation of an account and the channel, the API Key and Channel ID are issued and are used in the Arduino code to upload data.

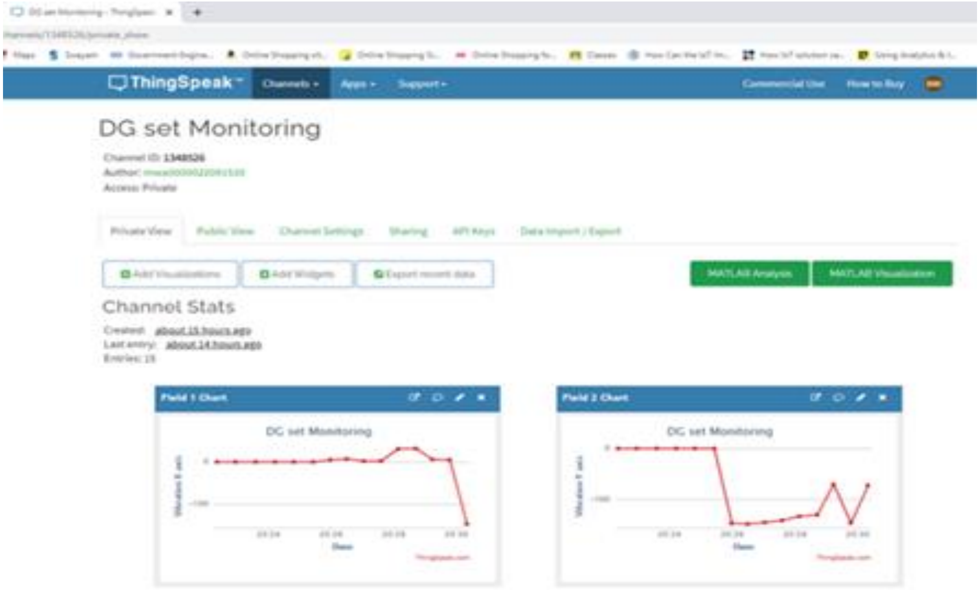

Figure 10 Thingspeak user interface window

The operating status of the generator is recorded and visualized graphically in the form of charts and widgets. If there is any abnormality or fault in the operating behavior of the system, it can be easily noted from the pattern of charts and its magnitude is displayed in the channel status window.

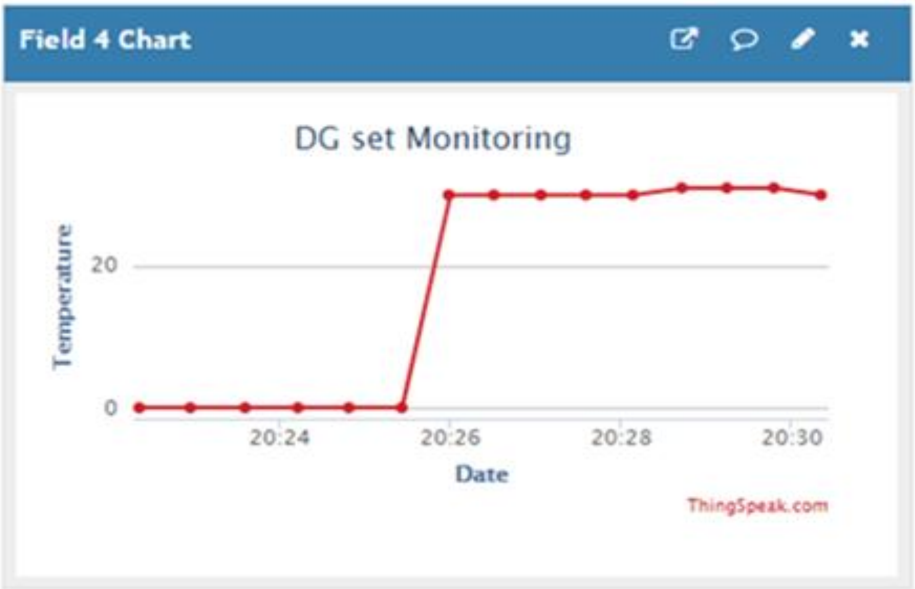

Figure 11 Temperature monitoring

The above figure shows the Thingspeak cloud interface for monitoring the temperature. Field window shows a graph which displays the real time operating temperature status of the coolant. Sudden temperature rise can be visualized from the chart and the time of occurrence and peak values can be identified from the notification window.

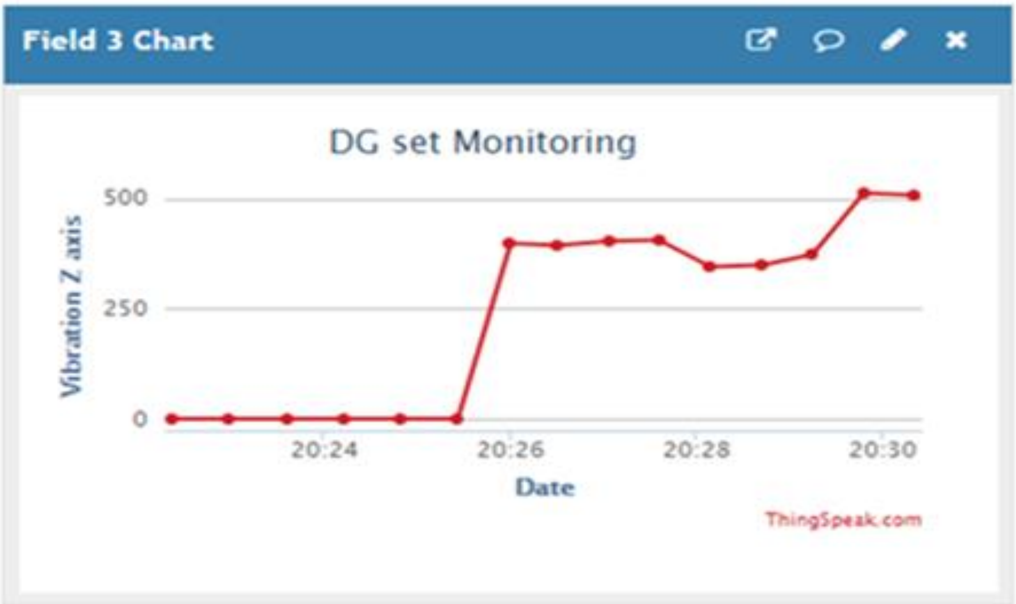

Figure 12 Vibration monitoring

The information which we acquire through accelerometer is downloaded from the cloud to the work area and it stacked in the excel work sheet. The information which we got from the cloud is time-space. Thus, play out the Fourier examination, remembering the true objective to change the data from time-space to frequency domain.

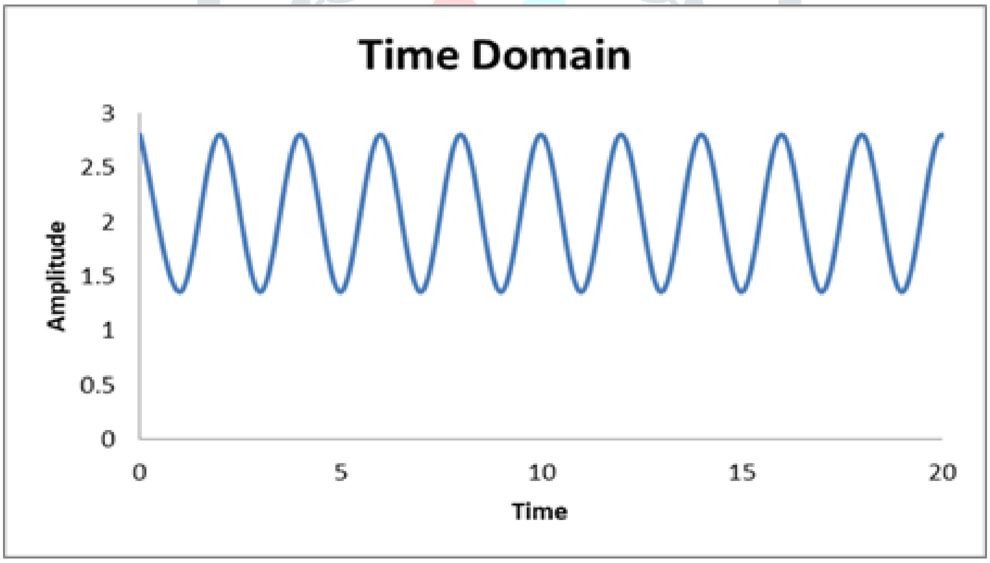

Figure 13 Time domain signals

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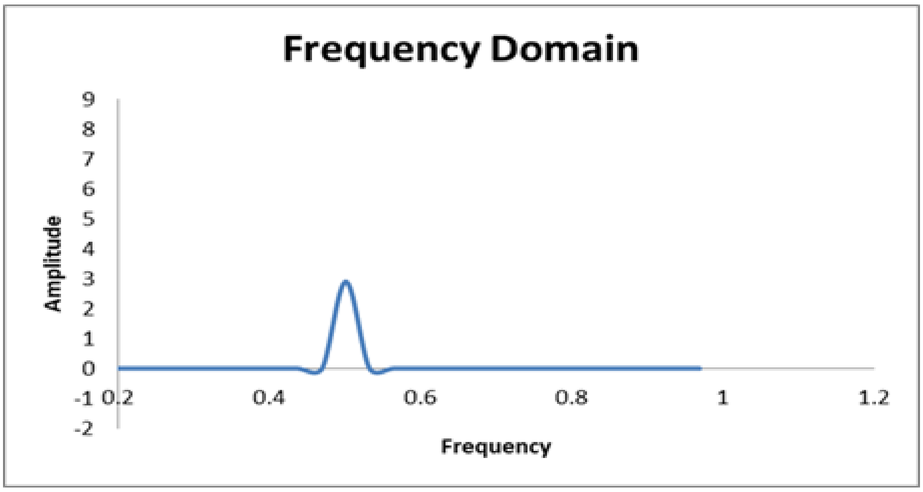

Figure 14. Frequency domain signals

When a machine is faulty the accelerometer detects some additional vibrations, which can be plotted in the frequency domain using a Fast Fourier Transform algorithm. The additional peaks apart from natural frequency are the unwanted ones which prove the presence of defects or faults in the machine.

5. Conclusion

This paper explored the IoT platform for monitoring and controlling diesel generators. This approach eliminates the need for on-site monitoring and focuses on industrial areas where IoT can become a reality even in small production facilities. By using this method we can provide certain information about the generator. By noticing the provided various parameters of the generator we can conclude how long the generator will work. Successful monitoring of the generator depends on the availability of real time information which reflects the health state of a machine The main advantage of this method is to reduce the production loss, decision-based maintenance due to the initial recommendations given and thus extend the working life of the generators. The reliability of monitoring system has to be high in order to meet the need of continuous monitoring and because of communication which is established due to this network connectivity provides an efficient online condition monitoring solution for generators in IOT platform. The proposed method is simulated under various operating conditions as described above, and is found to work satisfactorily. IoT driven remote generator monitoring is surfacing as a basic prerequisite and a key enabler of the fourth industrial evolution (Industry 4.0), by fostering cyber-physical interfaces for traditional generators, being widely operational in manufacturing industry, military infrastructures and the consumer sector. This system extends much needed facilities of proactive maintenance, reduced labor costs, minimal equipment down-time and better fault-management.

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