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Operation and Fault Monitoring of Electric Generator using IOT

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***Abstract*—** The reliable and quality power supply is vital for power system operation. Its importance become significant when dealing with sensitive load areas like hospitals, banks, airports, radar system, military offices and data centers. Their proper operation depends on uninterrupted and reliable power supply. In this regard, there is an emergent need to provide generator backup capacity in the events of power failure or blackout. These Generators can only be effective if they are maintained and operated properly. Problems like the remote monitoring of fuel tank, total load and the battery voltage of the generator are of main concern for better operation. To prevent these problems, the advance IOT based monitoring system is designed using an Arduino controller board. This system uses the fuel gauge for sensing the fuel level and a current transformer measures the load on generator, giving real time analogue data to the controller. The data is converted into digital through an ADC convertor and the instructions are programmed for every parameter in an IDE (Integrated Development Environment). This data can also be monitored on an android app or on laptop using esp8266 WIFI module as an interface between controller and clouds. A hardware based prototype is developed and installed on real generator. Results show real time remote monitoring of generator ensuring its reliable operation and timely indication of need of maintenance.

***Keywords*—** gaugel sensor, controller, reomote monitoring, WIFI module, temperature sensor.

I. INTRODUCTION

Power systems are needed to provide electricity to their consumers without any interruption. Sensitive departments like hospitals, schools, military offices, data centers and traffic system etc. require reliable and uninterrupted power supply. Grids are the main source to power all the passive infrastructures. However, due to energy crisis, power availability is not reliable in developing countries like Pakistan. To overcome this problem, one of the possible solution is to use diesel generator units as instant back up to power the loads ranging from small apartment to large industries. These generator units act as standby power source which are available at all the time to meet load in absence of main supply. Availability of these generators are subjected to their proper maintenance which can be ensured by an active monitoring system. Monitoring of generator is very important for its continuous operation. Fuel level in the tank, temperature, electrical load on the generator and battery voltage are the important parameters to be monitored. These parameters play an important role in timely maintenance of generator. Maintenance of generator improved the performance and life of the generator and reduces the probability of failure by increasing mean time between failures [1]. Beside this, fuel level monitoring in the tank can reduce the operational cost. Many of the generator are located at remote areas and remote monitoring of fuel tank, load on the generator, battery voltage and run hours are the main challenges in the proper operation of the generator. Moreover, monitoring of fuel level in tank can be helpful in fuel leakage and theft detection. The fuel theft and leakage from tanks is of main concern. Fuel theft is an international problem, with news of fuel theft coming from the modern countries like Australia, UK and New Zealand as well as across US etc. Hence, monitoring of generators improves efficiency and reliability while reducing the cost of operation.

Mohammad Asif khan et. al have already discussed the remote monitoring of fuel tank only through GSM based [1]. In [2] author designed, constructed and implemented the fuel level monitoring through GSM module and use a status messege to send information of fuel to mobile phone. The author disscused the real time monitoring of fuel level by ultrasound sensor with the help of data acquisition system in [3]. J.A Goundal et al have designed a system which is composed of a pressure sensor, microcontroller, solenoid valves and a liquid pump. The pressure sensor measures the pressure inside the air column submerged in the tank, which is then calibrated to display level [4]. The author in [5] design a fuel management system in which monitoring device built on the Raspberry-Pi computer, it takes information about tank's fuel level in real time through its sensor and live streaming of the site, then uploads it directly to the internet, where it can be read anytime and anywhere through web application. In the [6] the author proposed a system which monitors the fuel level of vehicles tank and the fuel consumption with distance covered. The measured values are send mobile user through SMS service using GSM technology. Authors of the work, [7], proposed a cloud based real time monitoring and control of diesel generator using IOT technology. The work is done by using an ultrasonic sensor for diesel level measuring, GSM shield for sending information of

the controller to clouds and Thing Speak clouds and app for real time monitoring of the data.

In this paper, Remote Generator Monitoring System (RGMS) is designed specifically for backup power generators to monitor generator operations remotely to ensure increased generator availability and efficiency by monitoring the fuel level, electric load and battery voltage of the generator. This system provides monitoring of fuel level, battery percentage, run hours and load on the generator with the help of IOT technology to monitor on mobile app through Wi-Fi based wireless communication. Here, we have used arduino microcontroller, esp8266 Wi-Fi module, fuel level sensor, current transformers and mobile app to design RGMS.

II. PROPOSED METHODOLOGY

Internet of Things (IOT) concept began as a simple idea of connected devices. The IOT promises to make our environment, homes, offices and vehicles smarter and more measurable. The IOT is being used in smart girds, smart city, industry, connected cars, automated industries, digital health and more others. IOT performs device-to-cloud communication. The IOT device connects directly to an Internet cloud are discussed in [8]. In [9] with the help of IOT, the different monitoring and controlling devices can generate, exchange and use data without or very little human intervention. For example, home and industry controlling and monitoring, human health (devices attached or placed inside human body to monitor human health, fitness and wellness), plant health (temperature, soil moisture, humidity, light intensity) enhanced learning are only a few examples of possible application scenarios in which the new technology IOT play a vital role. The most essential component of IOT is the cloud service where data are stored and analyzed. There are three types of services provided by cloud service providers and these include; Infrastructure as a service (IaaS), Platform as a service (PaaS), and Software as a service (SaaS) [10], [11, [12].

Proposed System Model is elaborated in Fig 1. The generator monitoring System is consists of the following three parts.

The System is consist mainly of

- Data Collection

  Sensors are placed to sense and measure required parameters. Different sensors collect data from generator and give this data to arduino control system.
- Controller

  Controller consists of an Arduino board and ESP8266 wifi module. Arduino take data from sensors, convert it into digital form, process and send to ESP8266 wifi module through TX and RX port.
- Thingspeek results

Thingspeek is a free cloud server. Wifi module of our controller send data to thingspeek server through Application Program Interface (API).

The arduino microcontroller is powered by a battery and this battery is charged when generator is running. The complete flow diagram of monitoring system is shown in fig.01. The data collection is done by current sensors and guage sensor which are connected to arduino microcontroller. The microcontroller is connected to IOT cloud through WIFI module esp8266. The data is visualized on the IOT web application as well as on smart phone app ThingView. The fuel consumed by the disesel generator in a specific time period is measured by both guage sensor as well as current sensors. The results of the sensors are compared, if there is a big difference between the two then there is a theft of fuel from the tank or the tank is leaked.

III. BLOCK DIAGRAM

The block digram is shown in Fig. 1.

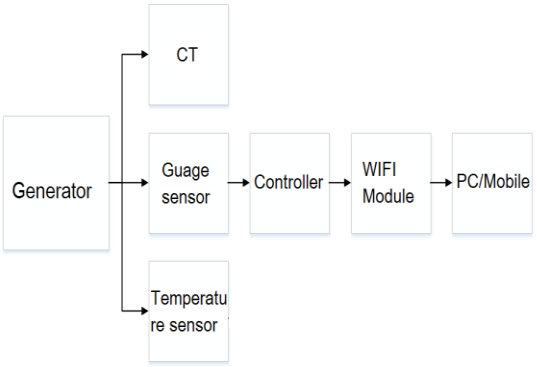


Figure 1: Flow Diagram of Proposed System

A. Fuel Level Sensor

A fuel gauge (or gas gauge) is an instrument used to indicate the level of fuel contained in a fuel tank. Commonly used in most motor vehicles, these may also be used for any tank including underground storage tanks. The gauge consists of two parts, sensing unit which is in the tank and indicatory unit which is on dashboard (serial monitor in this case).

The sensing part consists of a float which is connected to a thin, metallic rod. A variable resistor is connected to the end of the rod. As resistor opposes the flow of current, the more resistance there is, the less current will flow and vice versa. The variable resistor consists of a strip of resistive material whose one side is grounded. A wiper connected to the gauge slides along this strip of material, conducting the current from the gauge to the resistor. If the wiper is close to the grounded side of the strip, there is less resistive material in the path of the current and therefore, resistance is small. If the wiper is at the other end of the strip, there is more resistive material in the current's path and resistance is large. In the sensing unit, fuel has to drop below a certain level before the float starts to drop. When the float is near to the top of the tank, wiper on the variable resistor rests close to the grounded side, which means that the resistance is small and a relatively large amount of current passes through the sensing unit. As the level in the tank drops, the float sinks and wiper moves downward. As a result, resistance increases and the amount of current decreases. Indicating part measure and display the current flowing through the sensing part. If maximum current is flowing, the tank level is high and serial monitor shows a full tank. When lesser current is flowing as compared to maximum current, level of tank is

indicated correspondingly lower depending on amount of current flowing.

B. Generator load measurement

i. Current Measurement

Current transformer (CT) is used to measure large magnitude of alternating currents such as current from large generators or heavy loads. The split core type CT is particularly suitable for this purpose. They are clipped either the live or neutral wire for curent measurements. It has a primary winding, a secondary winding and a magnetic core. In proposed system, yhdc 100A current transformer is used.

The measured current is alternative, and CT is calibrated to measure a maximum of 100A RMS value of current. Transformation ratio of used CT is 1:2000. Hence, peak-peak current can be calculated by simple relation:

$I_{peak} = \sqrt{2} * I_{RMS}$ (i)

Output current of CT can be calculated as:

$I_{out} = I_{in} / (ns)$ (ii)

Where ns is number of turns at secondary side of CT.

a. CT-Arduino Interfacing

Output of CT is alternating current while Arduino is designed to accept analogue & digital voltage signal as input. A circuit shown in Fig. 2 is designed to interface CT and Arduino. First, it convert current signal into voltage using a burden resistor R13. Then AC signal is converted into analogue by adding 5V dc offset to make it compatible to use as Arduino input.

For the battery voltage measurement, circuit shown in Fig. 3 is designed. The D1 is use for reverse flow protection whereas R1 and R2 work as voltage divider and C1 is for purpose of noise removing. Arduino IN port will give status of the battery voltage to the Arduino controller.

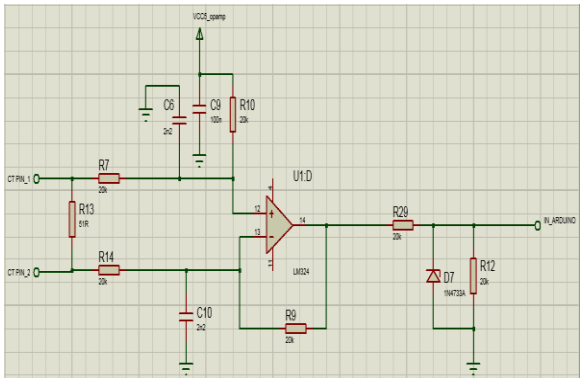


Figure 2: CT-Arduino Interface Circuit

ii. Battery Status

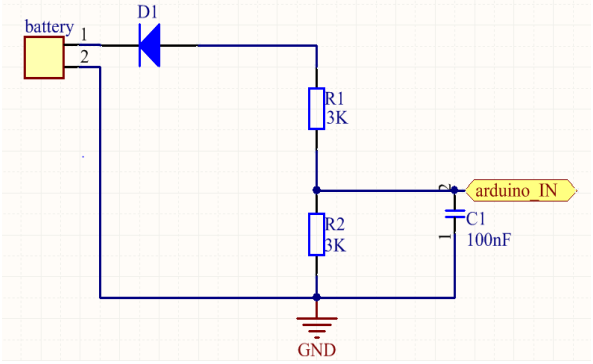


Figure 3: Circuit diagram for battery status

iii. Arduino Uno

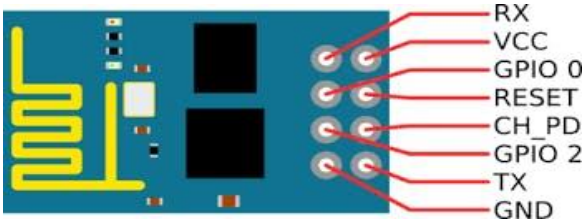
Arduino Uno is a microcontroller board based on the ATmega328P controller. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs and a 16 MHz quartz crystal. It can be powered by USB cable connection, by an AC-to-DC adapter or a 12V battery.

It is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs i.e. light on a sensor, a finger on a button, or a Twitter message and turn it into an output i.e. activating a motor, turning on an LED or publishing something online. Arduino Integrated Development Environment (IDE) is used to program the controller to perform different tasks.

iv. Module - ESP8266

The ESP8266 WiFi Module is a self contained system on chip (SOC). It is integrated with different protocols like TCP/IP that can give access any microcontroller to your WiFi network. The ESP8266 has capablability of sending and receiving data and commands to/from clouds and a microcontroller. The ESP8266 module is a small and cost effective board with multifunctionalities.

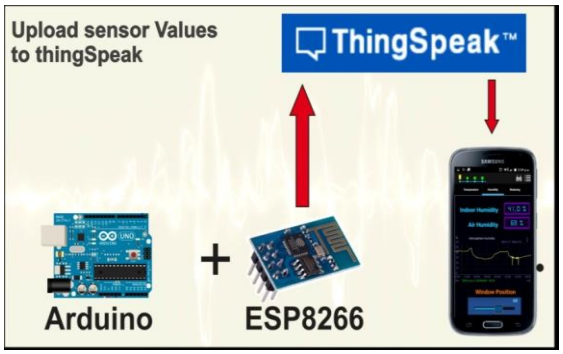
The ESP8266 module send and receive inforamtion through TX and RX pin. When we interface the module with Arduino and upload a programm to scan different networks and connect it to desire one. Service Set Identification (IEEE 802.11 wireless networks) and password is provided in the code for connection.



v. Uploading data to IOT Cloud

In the proposed system, WIFI module ESP8266 is used to upload data to IOT cloud (ThingSpeak). ThingSpeak provide

free cloud service to read/write and visualize data. Establishing connection of ThingSpeak with Arduino require channel ID and read/write API key which is provided by ThingSpeak to individual user.



IV. RESULTS

A hardware is developed based on proposed solution and installed on 200kVA backup generator for a distribuiton network. Generator load, temperature, fule consumption and battery charging status are monitored for different times. These monitored parameters can be observed at any device using internet. Results show a great degree of easeness in remotely monitoring of generator parameters. Fig.4 show generator fuel level against time. Fuel tank is filled up to its maximum level in start and checked remotely to see its status. Then, fuel tank is made full empty and status is observed to check if it is following real status of tank. This sudden change may represent theft of fuel and using our remote monitoring system it can be easily and timely detected. Moreover, gradual change in fuel level represents fuel usage by generator to meet load.

As shown in Fig.5, there is no laod on generator in start. After some time the back up generator is on and load is added to generator. Maximum load on generator phases is 70 ampere. Load is monitored at different running time of generator.

In Fig 6 battery SOC is shown against time. The columns show state of charge of generator battery in percentage. Fig. 7 shows the temperature of generator with time. It can be clearly concluded that temperature of generator increases with its running time. Rise in temperature above its allowed limit can cause severe damage and should be avoided. This increases the importance of its monitoring and designed system is able to remotely monitor temperature with other important parameters.

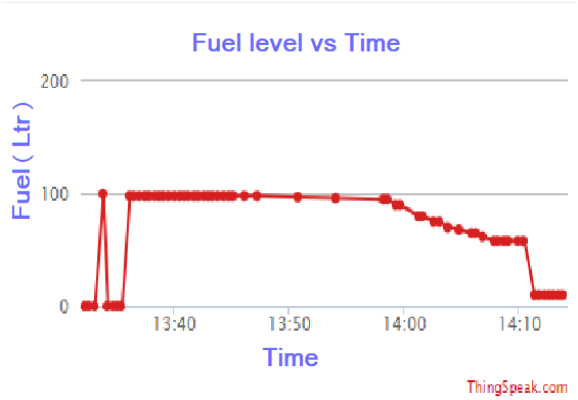


Figure 4: Fuel Level Vs. Time

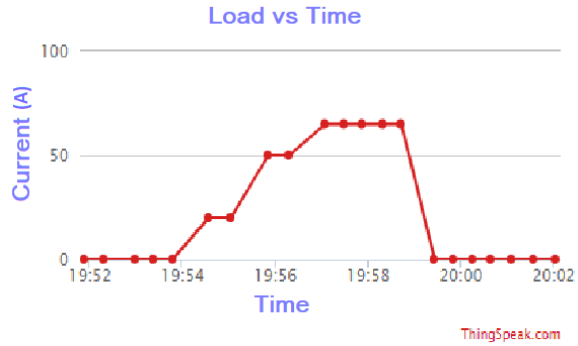


Figure 5: Generator load at different time

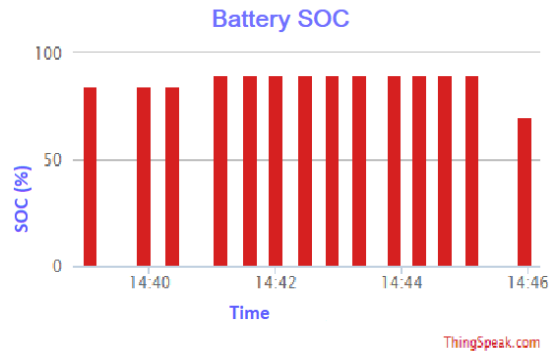


Figure 6: State of Charge (SOC) of Battery

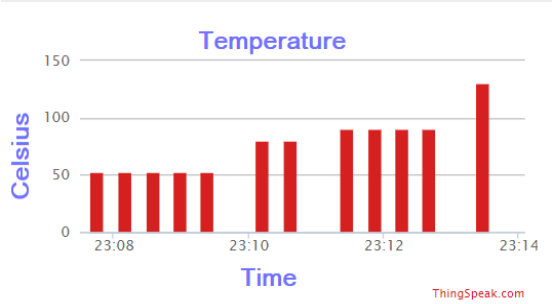


Figure 7: Generator Temperature in Celsius

CONCLUSION

Current work has focused on monitor of generator through two parameters tank and load on the generator so it is very limited to give information about generator there are so many important paramter like temprature ,rpm and mobile oil quality and remote on off of the generator to monitor through thingspeak. The sensors efficiently measure different paramter and send it to controller. The controller read the signals and convert it into useful meaning for further processing. The main focus of this work is to provide information about fuel level in the generator tank and can easily monitored from mobile App or computer. The proposed work will detect the fuel theft from the tank and leakage in case of tank crack. The proposed solution is much intelligent to differentiate the leakage and fuel theft from tank. Battery voltage and temperature is easily monitored to keep the generator healthy. The whole system ensure high level of maintenance and proper operation of generator.

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