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A Review on Monitoring of Electrical Machine Using IoT

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ABSTRACT

Real-Time monitoring is the effective way to observe factual data. Internet of things based online monitoring is useful to access data remotely. IoT is the network of physical objects embedded with electronics, software and sensors that enable to collect and exchange data. IoT enables the flexibility and liberty to access the machine placed in a remote area access to keep a continuous track of the machine behavior in real time. Application of this technology in electrical engineering is beneficial to observe different parameters which are not easy to access. Electrical equipment performance can be monitored on a real time basis to improve the operating span. This is carried out using online monitoring system. IoT is used to observe different parameters on real time scale. This helps to measure and sense various parameters like energy, voltage, current, temperature, power factor and frequency of any given electrical equipment. This paper reviews suitability of IoT based online monitoring system for electrical equipment.

Keywords – Online Monitoring, IoT, Machine, Performance etc.

I. INTRODUCTION

Electrical power system is divided broadly as generation, transmission, distribution and utilization. In every field of power system, there is a use of electrical machine, so proper monitoring of electrical machine must be done. Electrical Machines have transformed the industrial growth from their inception. Every part of a power system from generation of power to its final utilization at the consumer end requires extensive use of various electrical machines, especially Induction Motors which form the backbone of all industrial processes. As a result, proper monitoring and its maintenance has been a topic of great interest for industries around the world. It is imperative that importance that must be given to the proper monitoring of the operation of those machines are not just from technical perspective, but also from commercial perspective, as it will reduce the losses. Furthermore, proper monitoring of machines helps to determine the performance of the and thus, proper maintenance can

be done as and when required. This demands for a system capable of making those necessary observations for monitoring machine parameters and making the data accessible remotely.

The proper monitoring of the electrical machine helps us to determine the performance of the machine and thus proper maintenance can be determined. So, there is a necessity of measuring the electrical parameters of electrical machine. The paper composes a system that is capable to perform various tasks at a time. The proposed system is a bridge between the sensing of electrical parameters and IOT cloud computing. The hardware prototype includes sensing of electrical parameters like current, voltage, temperature, power factor and frequency. Measurement of current is done using non-invasive current sensor and voltage through using a step-down transformer. Only phase voltages are sensed and then using a level shifter, a dc shift is given to output of sensing circuit which will be fed to the MSP430 controller. By using algorithm, the frequency and power factor are calculated and obtained data is transferred to node MCU by serial communication through MSP430. This data is stored in cloud and it helps to fetch data from cloud to any device.

II. LITRATURE REVIEW

This survey involved many such monitoring devices for electrical machine which are already in existence. [**1**] It was realized that there is a meter based on IoT which is being implemented. a non-invasive current sensor was used because it had the advantage of small size and ability to be used wherever the power is being consumed. [**2**]It was understood that there are some algorithms which can be implemented in the microcontroller to calculate the power factor and frequency. [**6**]From this it was realized that MSP430 is low power consuming microcontroller of Texas instruments which can be used for long time running. Also the mentioned algorithm could be applied on this controller as its sampling rate is high. [**4**]Here, useGSM module is made for electric machine monitoring but it was realized that the it has some disadvantage which can be overcome by IoT system. From [**5**] it was realized that ESP8266 is a low cost IoT Wi-Fi module which has a full TCP/IP stack and also possess an onboard microcontroller. We are using NodeMCU module which has a Wi-Fi module as well as a microcontroller which help in programming such device easily. For data capture we can use Thingspeak, IBM, azure amazon web services etc.

The major challenge in the project lies in proper integration of multiple subsystems and their successful simultaneous operation. All the subsystems like sensors, microcontroller, communication with Wi-Fi module and upload to the cloud, should work in synchronization and should provide the expected result, with a fair and tolerable accuracy. Developing a familiarity with programming of MSP430 microcontrollers is of paramount importance for successful implementation of necessary algorithms and communication.

III. PURPOSE

In our research for potential project topics, we realized the pressing need for a system which can monitor the multiple number of machines simultaneously and make the data accessible to the concerned person beyond the locality of plant or area that hosts the machines. The existing systems, though efficient and accurate in measurements, lacked the accessibility beyond a particular area as they were mostly wired data acquisition systems. However, enabling the system with upcoming technology of Internet of things (IoT) will provide unlimited range of accessibility as the observed data can be accessed from anywhere around the world having internet connectivity. Furthermore, it was realized that many companies are in the process of developing such systems of much more

sophisticated nature. This cemented our belief in the necessity of this topic in the present world and it was decided to take it up as a project topic.

V. BLOCK DIAGRAM FOR EXISTING SYSTEM

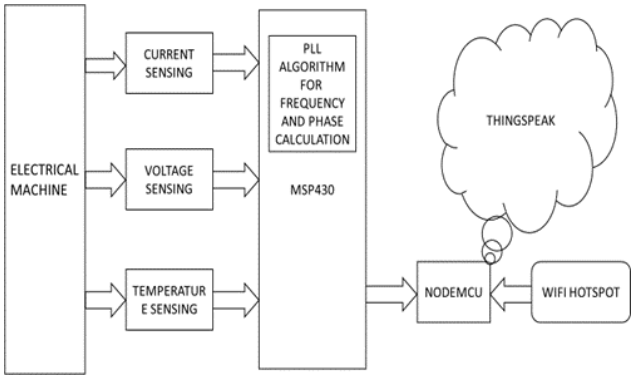

Fig 1. Generic Layout of the System

Through the literature review and detail research in the various industries, it was noticed that there is no such product available which has the property to link with IoT. There are devices which only measures electrical parameters of electrical machine but no such product is being introduced. So we proposed a device which will remotely measure or monitor the electrical parameters of an electrical machine and this data will be available in the cloud. This will enable the user to access and acquire the necessary details and status of the machine with ease and also take precautionary steps as and when required.

IV. SUBSYSTEMS

With introduction of IoT, machine learning, artificial intelligence, robotics and other automation techniques, it is evident that the industries are looking forward for products based on automation for maximum efficiency and we believe that the proposed product is a necessity in industries as our device is based on IoT and our device not only monitors but also provide controls to the machine using our the proposed product which is a potential extension of its current level of application in future.

The following components are used for following project.

1. MSP430
2. Current Sensor
3. Voltage Transformer D Temperature Sensor
4. NodeMCU
5. Electric Machine

A. MSP430

It was observed that microcontrollers used in industries are raspberry pi, Delfino c2000, Piccolo2000 and many more. This constitutes the main part of our system. The MSP430G2xx Value Series which features flash-based Ultra-Low Power MCUs up to 16 MIPS with 1.8–3.6 V operation. Includes the Very-Low power Oscillator (VLO), internal pull-up/pull-down resistors by Texas instruments. It is stated that the mixed signal processing microcontroller are good for monitoring processes and operations.

These factors played an important role in realizing the various advantages MSP430 series offers over other microcontrollers. They have a low power consumption that leads to reduced losses and lower current rating makes the handling of the electronics simpler. Good CPU capacity ensures sufficient data processing ability. Presence of other peripherals and ability to connect other booster packs by TI allows it to be the best recommended device for this project.

B. Current Sensor

Types of current sensing equipment available in the industry are ACS712, Non-invasive current sensors, Hall Effect sensors etc. The non-invasive type of Current sensor is chosen for the project. This is due to the fact that ACS712 gives out a discrete output of

values and so do the Hall Effect sensors. Whereas the current waveform was required to be obtained so as to further calculate the frequency and power factor of the supply.

This sensor however is a current transformer which steps down the current going through it and provides a voltage output through the internally connected burden at its secondary. Various rated values for this sensor are available. The chosen value is 15A/1V which says that for a 15A current flowing through the current sensor, it will give a 1V at the output port. It is a core type CT and noninvasive because it does not need any tampering with the established current line.

C. Voltage Transformer

As for current measurement, there are many voltage sensing solutions available in the industry in the form of transducers, ICs etc. However, both transducers and ICs provide a discrete DC value for the instantaneous measured voltage and that was not sufficient. Voltage waveform was also required for power factor measurement and hence a different yet simpler alternative was chosen i.e. a Voltage Transformer. Further, through our literature survey, we realized that disturbances in the IC based and transducer based voltage sensors created significant errors in the voltage measured, which can be avoided with robust solution like a voltage transformer. It is essentially a step down transformer which lowers the phase voltage of 230V to the voltage range of microcontroller. The chosen rating of transformer for this purpose is 230/6V. This requires further reduction to a 3V range using voltage divider. A PT with direct conversion of 230V/3V can also be used. In either case, a DC shift will be necessary to obtain the same waveform in 0-3V range instead of –3 to 3V range. This is necessary because the ADC of microcontroller in consideration can sense only 0-3V variability.

D. Temperature sensor

Various temperature sensors are available for use. However appropriate choice needs to be made for proper selection. In the case of motor, best case sensing can be obtained through a temperature sensor embedded inside the stator of Induction motor, as is the case in many industrial motors. This not only ensures that data obtained is of the winding temperature which is important, but also increases resistance from the effect of external temperature on the readings. However, unavailability of such a motor, and complexity of embedding a new sensor into the windings, leads to the choice of surface-based strip type temperature sensor. This sensor is attached on the external surface of the motor and provides the temperature readings of the surface. Although it's not the direct readings of winding temperature, a close approximation can be made which should suffice. It is essentially a transducer that converts temperature to voltage that can be fed to the microcontroller as the obtaineddata.

E. NodeMCU

The chosen component was a NodeMCU, which also has a Wi- Fi module. A comparison on various aspects was made. Using a Bluetooth module like HC05 OR HC06, has a fix range of operation beyond which the access is not available.. RF transmitter has a greater range than Bluetooth but it is also limited within a region. In case of GPS or GSM, it needs a valid sim card for connection as they have concern of the range. So, a Wi-Fi module is considered for connectivity with IoT and it is an extension of ESP8266 in microcontroller with user friendly coding. Coding is done in its IDE or in Arduino IDE having the library of ESP8266. A simple link Wi-Fi module for IoT connectivity was thought of, but it is less cost effective as compared to the nodeMCU.

It is IoT platform that helps us to transfer the data to the cloud platform. It is the basic way of medium of communication. Its coding is user friendly as done in Arduino IDE. Nodemcu is a microcontroller with and in-built Wi-Fi module the WIFI modules ESP8266 in this has UART SPI and I2c communication between devices. As it is a Wi-Fi module, it has wide range of communication, as it is WIFI based while in Bluetooth and RF transmitter.

F. Electric machine

Electrical machines can be transformer, induction motor etc. The induction motors are widely used in industry because of its simple, robust and more reliable operation than any other machine. The electrical parameters related to induction motor are voltage, current, power factor and frequency. While we can also sense the vibration and the temperature of winding as well as the body as it will help in deducing the behavior of motor which help us to now the state of motor. From these parameters, we can also find if there are any faults as change in frequency would mean the decrease in speeds, representing the over load condition. Transformer, on the other hand is a static device and not rotating like motor. There are various type of transformer like power transformer, distribution transformer, instrument transformer, low voltage transformer etc. In this the parameters that can be deduced are voltage, current, frequency, temperature, oil level etc. From these parameters, the behavior of transformer can be observed but also realization of various fault occurred in transformer can be done, like overvoltage or under voltage due change in voltage parameter, over current and overload using current parameter, over fluxing in core by voltage and frequency and various fault can be recognized using these parameters

G. Thingspeak

[7] IoT platforms are hardware and software systems that facilitate management of IoT devices and the collection, storage, analysis and visualisation of IoT data. Platforms will include a dashboard to display and control devices. Additional features may include data collection and management, testing, device updates and inventory management.

There are many IoT platforms, which includes Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform, Oracle, MySQL and many more Oracle, MySQL platforms required SQL language for transferring data to cloud. A leading unstructured language (referred to as a document store) is called MongoDB and has been gaining importance. As we are using ESP8266 as Wi-Fi module for transferring data to cloud, transferring data from ESP8266 to MongoDB platform directly is not possible. We required node.js as an intermediate bridge to perform the transfer of data. After going through various platforms we found ThingSpeak will suit our project best. ThingSpeak is an open source IoT Platform. It is integrated with MATLAB SOFTWARE. So as we are familiar with MATLABit will be easier for us to programming.

ThingSpeak Key Features

- Enabled to configure the devices and send data toprivate cloud using popular IoT protocols with ease.
- Easy to observe real time statistics and parameters
- Third-party sources can extract and observe data ondemand.
- Embedded with Matlab which provides user friendly environment.
- Run your IoT analytics automatically based on schedules or events.
- Simple setup with no additional requirement of creating servers or developing web software. IoT and prototypes can be built according to required need

V. WORKING

Working of the system is divided into two parts:

A. Sensing

In this sensing part, we have used voltage transformer, current transformer and temperature sensing. The data obtained is level shifted using level shifter circuit as the MSP430 input is analog in nature. It has to be noted however that, analog read capability is only from 0-3v. Therefore, we need to have a dc shift of the waveform of the current sensor and voltage transformer output. Which is level shifted and kept in range of 0-3V. While the temperature sensor output is directly fed to the MSP430and through this we get the output of current, voltage and temperature value in the MSP430 memory. So to calculate the power factor and frequency, an algorithm is applied in the code which helps in deducing the power factor and the frequency of the system. The mentioned electrical parameters of electric machine like voltage ,current ,frequency, power factor ,power and temperature are sensed this way .

B. IoT

This data is transferred is serially using UART communication to nodemcu module via TX and Rx pin of both the boards. In this the TX pin of MSP430 is connected to Rx pin of nodemcu module. In nodemcu, the set the web server is used to transfer the data to cloud setup and the data is stored in the database of the cloud like MySQL etc. A web server set in which all the data will be displayed so that the data can be accessed remotely as well as online access to the data is possible. Softwares like Grafana can also be used and a waveform of the behavior of the voltage and current can be obtained.

It can be seen that most of the companies have deployed the monitoring system for the electrical machine in their farm but there is no deployed IoT based monitoring system for the electrical machine in the industries. So a product of the above mentioned capabilities can be used in almost all industries as all industries are growing towards a revolution of industrialization with deployment of automation with some smart intelligence. So the concept used are IoT, machine learning, artificial intelligence, robotics and many more. So, the product is best suited for the monitoring system in the industries as this device not only monitors can also be extended to provide control to the machine based on the operating parameters.

Electrical equipments based on usage are broadly classified as transformer and motors since they acquire major electrical sector of market. Suitability of online monitoring is decided based on number of parameters to be sensed, speed of data transfer. Table 1 shows transformer parameters and suitable selection of monitoring system.

TABLE I: SELECTION OF MONITORING SYSTEM

Type of Electrical Equipment	Parameters to be measured	Online Monitoring System with sensors
Transformer	Temperature ,pressure, dielectric strength, lossess, faultdetection	
Motor	Shaft position, wear tear,temperature, copper losses, fault detection	

VI. CONCLUSION

Online monitoring of electric machine were reviewed. The connection with IoT will help the industries to determine and analysis the behavior of the electric machine and identify the faults or any abrupt change in the electric machine behavior. This system can be implemented on any electric machine in any sector. This is the next stage for

monitoring of electric machine. Through various algorithms we can also automate the electric machine and make it a self-learned machine. Application of IoT on monitoring of electric machine will reduce the task of the manpower. It gives clarity of electrical machine performance. This improves life span, reliability and system performance.

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