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PERFORMANCE ANALYSIS OF INDUCTION MOTOR USING IOT

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Abstract: This paper examines the induction motor performance during critical conditions such as under or over voltage, supply unbalance in industrial application in order to provide secured & economic condition. The proposed system utilizes IoT (Internet of Things), WIFI module and sensing devices. The sensors observe the parameters like Temperature, voltage and transmit to the (Arduino) processing unit. It will analyses and exhibit the parameters to send information for remote monitoring, the processing unit (Arduino) conveys with gateway module to cloud database. It also provides an industrial application to make the system become faster and user friendly. Test results confirm the possibility of the usage of the system.

Key words: Induction Motor, Internet of things, Temperature, Vibration.

1. INTRODUCTION

In the development of electrical innovation, the dc motors were broadly utilized diverse mechanical and industrial applications. After the development of ac motors particularly ac induction motors the perspective on industry becomes changed because of the wide and significant advantage of induction motors. The various deficiencies happen in induction motors are:

Electrical-related issues: These faults may occur due to unexpected frequency changes, abrupt change in voltage that may under or over voltage, phase sequencing etc.

Mechanical-related issues: The mechanical shortcoming may happen because of rotor bar broken, air hole unpredictability, harm in bearing, rotor and stator winding degradation.

The performance of the induction motor relies on the above electrical and mechanical parameters. The continues observation of induction motor is required for secure and reliable task of modern induction motors. The electrical and ecological parameters, for example, voltage, current, temperature and vibration of the motor, influence the great performance of motor. The mechanical factors, for example, vibration and irregular speed influence the great performance of the motor.

Parameter monitoring system for induction motor using Zigbee protocol It is equipped for playing out certain tasks like running and stopping the induction motor. Stage voltages, stage flows, winding temperature, speed can screen and control by utilizing this system. The deliberate qualities are moved to the PC and that qualities are shown graphically on the controlling PC utilizing MATLAB [3]. Wired network is progressively costly or unimaginable because of physical conditions. The remote monitoring system is useful to keep away from shortcomings happens at the moment of activity. They concentrated on a low estimated system for checking the parameters, for example, current temperature, voltage and speed of Industrial Motor likewise it can control the system with remote ZigBee technology [4]. Production process is not impeded and the required maintenance or replacement can be performed with the least possible disruption. This study has provided statistics not only for creating mathematical models but also for enabling the CMS operator to establish a motor maintenance schedule [3]. The most commonly used technique for the detection of faults in large three-phase induction motors is to measure the supply current fed into the motor and analyses the signal spectrum. This aspect allows companies to reduce downtime when repairing machinery and ensures that productivity does not suffer [5].
Prime objective of project is to, provide better, increased reliability of induction motor application by utilizing advanced technologies and this allows continuous observation and better control of high horse power IM in various industries. To increase system availability along with reliability various abnormal conditions are easily recognized and rectified. About 90% of the industries uses IM for production, which mainly requires economic data monitoring, hence by preventive maintenance of machines productivity of the industries can be upgraded. There by failure and cost investment of motors can be greatly reduced.

- Design and implementing protection system for induction motors build on internet of Things (IoT) make sure secured and economic information communication in various sectors
- System failures greatly reduced by automatic and manual control strategies to start and stop induction machines.
- Comparatively IoT is cheaper protection system, which is useful especially for small scale industries, agricultural field and household.

The real time information provided by the IoT and sensors are graphically exhibited continuously by visually using ThingSpeak. The system has a high independence, less maintenance, simple establishment, least support prices. Test results confirm possibility usage of system.

1.1 Voltage Balance and Unbalance:

The power supply is never excellently balanced hence under or over voltage problem occurs within the system. If the range of unbalance is small, then it doesn't impacts the working of machine adversely. When unbalance happens above some limited values it greatly causes dangerous impact on the operation of system. The definition for the power or voltage unbalance is the ratio of negative sequence voltage to positive sequence voltage for set of unbalanced voltage such as Vab, Vbc, Vca. Positive sequence voltage is considered as Vab1 and negative sequence voltage is considered as Vab2. The precision of voltage unbalance is given by,

$$Vab1 = \frac{Vab + a^{*} Vbc + a^{2} Vca}{3} \quad (1)$$

$$Vab2 = \frac{Vab + a^{2} Vbc + a^{*} Vca}{3} \quad (2)$$

% Voltage unbalance = maximum voltage deviation from the average voltage/average voltage *100 [3]

If three line to line unbalanced voltages are consider as Vab, Vbc, Vca, using above equation (1) we can deduce positive sequence voltage and by using equation (2) we can deduce negative sequence voltage. The exact value of voltage unbalance is calculated by utilizing above deduced values. For testing of IM above mentioned calculation is used, which a guideline is provided in IEEE and NEMA standards. The main reason for using above equations for calculating voltage unbalance is only to avoid the complex of algebra.

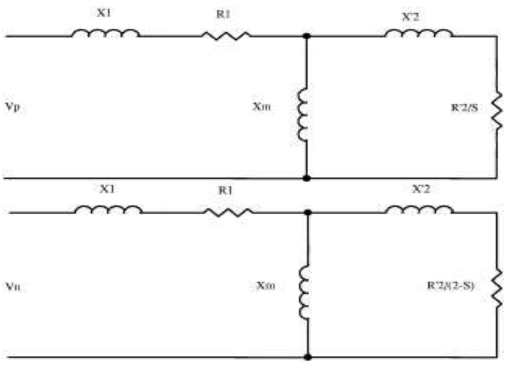

Fig 1: equivalent circuit of positive and negative sequence voltages

Equivalent circuit of positive and negative sequence voltages of IM are shown in fig 1, each arrangement of positive and negative sequence voltages produce comparing adjusted current in IM, the blend of the two arrangements of current vectors speaks to the actual flow of current in 3 phases of stator windings. Typically the conduct of positive sequence voltage is similar to the normal balanced operation of the machine. In the case of negative sequence voltage the operation is reversed compared to first case. The slip of rotor is considered as S in case of positive sequence, (2-S) in case of negative sequence current. Motor acts as a combination of two separate motors when one machine is operating with terminal voltage of Vp per phase at slip s, and other with slip (2-S) along with terminal voltage Vn, where

Vp: Positive sequence voltage
Vn: Negative sequence voltage
X1: Stator reactance
X¹2: Rotor reactance
R1: Stator resistance
R¹2: Rotor resistance
S: Slip

The maximum Power output given by,

$Pm = Ip^2 r_2 [(1-S) / S] - In^2 r_2 [(1-S) / (2-S)]$ W/phase [4]

Because of the presence of negative sequence voltage the overall output power will be reduced and the resultant torque will be,

$$T = \frac{r_2 [(Ip^2 / S) - (In^2 / (2-S))]}{W\ syn} \quad \text{N-m / phase} \quad [5]$$

Because of the presence of negative sequence current the output torque will be reduced, where Ip & In are the positive and negative sequence currents respectively, W syn is synchronous speed. The positive and negative arrangement flows are elements of their succession voltages, the motor parameters and the slip. Therefore utilizing the condition given underneath the both currents and are acquired utilizing the particular arrangement voltages and motor parameters and including the reliance on the slip. In the unbalanced supply the both sequence currents are formed by performance analysis of the system parameter. By utilizing the equivalent circuits the speed torque characteristics may be plotted shown in fig 2. The upper most curve clearly depict the positive sequence torque and this torque shows exactly the normal operation of IM and with the speed among zero & synchronous speed. The negative sequence curve forms negative torque with opposite rotating field. Even though the curve of negative torque is small it should be taken into account, so net torque is somewhat lesser compared to balanced supply torque. While the whole envelope of the torque-speed curve is redeuced, by the nearness of the negative sequence torque, three are focuses on the graph specifically compelling are the starting torque, breakdown torque and full load torque. In this way the significant implication of Fig. 2 is that the motor will take more time to keep running up in the nearness of unequal voltages. This expands the thermal stress in the machine and will prompt loss throughout everyday life. This is expected right off the bat to a decrease in the extent of the positive sequence voltage when contrasted with the unbalanced supply voltage. Also, the nearness of the negative arrangement current makes a negative sequence torque which subtracts from the positive sequence torque to yield a net torque that is even littler. On the off chance that full load is still requested, at that point the motor will be compelled to work at a higher slip, in this manner expanding the rotor losses also, heat scattering. Untimely failures must be counteracted by derating of the machine to enable it to work inside its thermal constraints. The decrease in the peak of torque diminishes the capacity of

the motor to ride through plunges and hangs, in this way influencing the solidness of the whole system.

1.2 Effect of under and over voltage:

So as to incorporate overvoltages and undervoltages on the derating bend, the electrical and thermal models were created and demonstrates the association of the models. The electrical model is utilized to figure motor losses. These misfortunes are send into the thermal model to anticipate the motor temperature rise. Then how much motor get derated due to unbalanced condition and increased temperature can be deduced. Whenever there is under or overvoltage happened due to gradual increasing of unbalanced supply the core losses get increased.

2. PROTECTION SYSTEM BLOCK DIAGRAM OF INDUCTION MOTOR :

The bellow Fig.2 shows the proposed system block diagram of IM using IoT. ATmega 328 microcontroller and ESP8266 Wi-Fi module is used as controllers, sensing and monitoring system includes various sensors. The WiFi module and LCD display are collaborated properly.

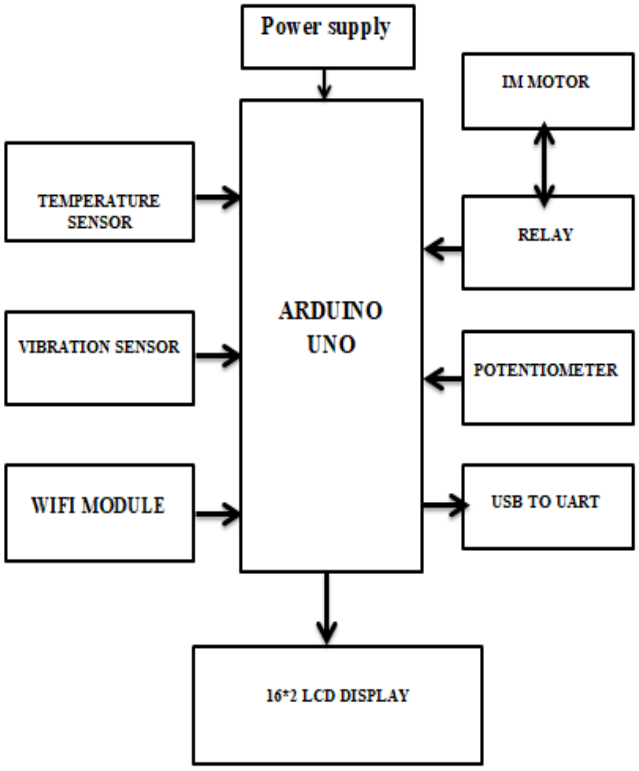

Fig 2: Block diagram of implemented protection system for IM

Single phase induction machines are simple, rugged and reliable, and are utilized in tremendous numbers particularly in household and business applications where 3 phase supplies are not accessible. The advantage of Arduino compare to other kind of microcontroller is ATmega328, It works ranging from 3.3V to 5.5V but typically we utilize 5V as conventional. The data collected by the Arduino are processed and transmit to server by using ESP8266 this wifi module needs extra library file to process data. By programming the microcontroller the information is updated every second. It has advantage over Bluetooth module (i. e) the data is send to remote areas. The running state of induction motor is persistently checked by effectively configurable and light weight sensors are for the most part utilized. The sensors in the proposed work are LM35 for estimating temperature, Piezoelectric sensor for estimating vibration, and voltage differing potentiometer for varying supply voltage. In this work the information is procured by the Arduino. The Arduino can process the information, send the information to distributed storage, store the outcome in nearby focus, give the alarm message to users and utilized in control applications. 5V relay is directly associated with the Arduino. Control signals from the Arduino is provided to relay, the yield of relay is the contribution of contactor. In the event that any unhealthy condition is recognized by the Arduino from procured information the order is given to

Arduino to relay in order to open the connection. LCD (liquid crystal display) display consisting of 16*2 display unit which collects data from various sensors to continuously exhibit outcome in form of character. Thingspeak allows modelling of sensor logging supplications. It facilitates the real time information acquisition, visualizing the collected information like graphical indications. Thingspeak is private channel which is created bases on our usage. Different kinds of fields are accessible for storing required data which has been sent through an Arduino.

3. DESIGN AND IMPLEMENTATION OF PROTECTION SYSTEM FOR IM USING IOT

Whenever power supply is provided to Arduino, WiFi module and all other interfacing components get the required supply. Sensing components detects the respective machine parameter, sends to Arduino then it will take data from different sensors & examines according to the provided instruction. Then processed sensor data is given to LCD & network gateway via WiFi. Induction motor used in this of single phase shown in fig (3). Arduino sends control signal to relay by analyzing commands from internet, this will control the induction motor. Sensor data is shown visually in server utilizing application called ThingSpeak. The protection for the Induction motor is given against under or overvoltage, vibration and temperature variations. All the faults are detected through the sensors for the above mentioned faults and is controlled by relay to switch ON or OFF through the microcontroller. Finally motor is shutdown when abnormal condition is detected.

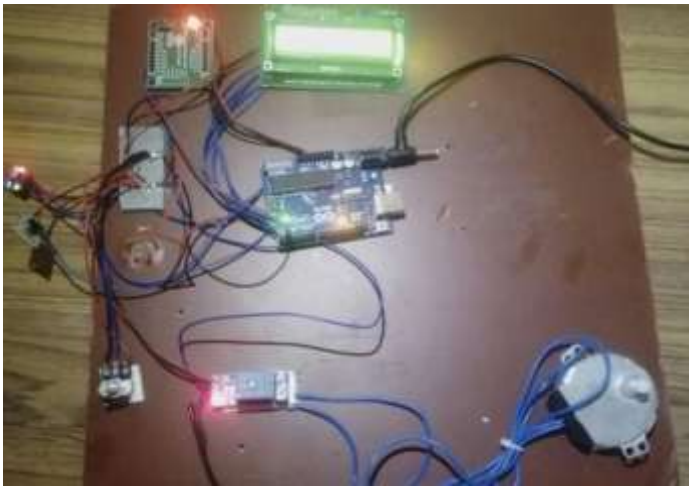

Fig 3: Design and Implementation of protection system for induction motor using arduino

4. RESULTS AND DISSCUSSION

In this project every sensor is examined separately then implemented accordingly. The WiFi module and LCD display are collaborated properly. Under normal operating condition of the machine, sensed readings are exhibited continuously in serial monitor of Arduino ide also in ThingSpeak application in the form of chart or graphically. Motor is tested for unhealthy conditions, if sensed data is exceeds above threshold as in fig (4.a) the voltage exceeds above limit shows over voltage condition, as in fig (4.b) voltage falls below rated shows the under voltage condition. In the fig (4.c) temperature is exceeds threshold value shows higher temperature.in the fig (4.d) temperature is normal and then increased. Likewise values are as per the given instructions, if exceeds automatically motor will disconnects and outcome is displayed in LCD, serial monitor as well as in thingspeak website. Resultant graphs are given bellow in fig (4).

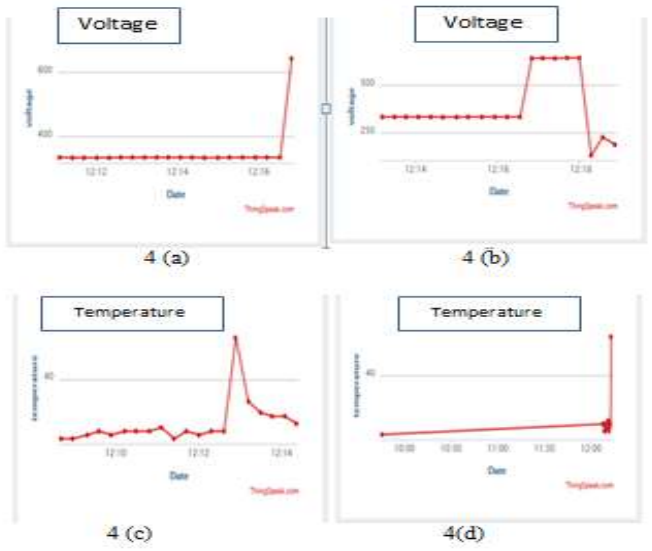

Fig 4: Resultant graphical representation of voltage and temperature

5. CONCLUSION

This venture idea of Internet of Things for early discovery that observing of motor system parameter remotely and analysis performance of IM under unbalanced supply. Positive and negative sequence equivalent circuits are depicted with speed torque curve, effect of negative sequence component on torque value also examined. The system has a high independence, less maintenance, simple establishment and low support costs. Test results confirm the possibility of the usage of the system. The following are the factors observed by this performance analysis.

- As voltage unbalance increases, the motor efficiency decreases steeply.
- High power consumption of motor occurs mainly during under voltage condition.
- As compared to under voltage condition power factor is poor during over voltage.
- There are increased losses due to decreased efficiency which is caused by under voltage.
- Due to various losses, motor temperature increases then the windings heats up causing damage to windings and reduces the life of motor.

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