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Real Time Monitoring IoT Based Methodology for Fault Detection in Induction Motor

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ABSTRACT

In present era, induction motors are used extensively in commercial processes. Induction motors have a significant advantage in terms of design durability and simplicity. It runs in any setting and is fairly affordable. This research provides information about how to incorporate an Internet of Things (IoT)-based remote control as well as monitoring device for an induction motor in enterprises, resulting in safer and more cost-effective conditions. External moisture, temperature, voltage and induction machine load current and are all monitored by the transducer modules and sensors, which are then sent to the processing unit. The processing unit communicates with the gateway module to transfer data to a cloud data base for remote monitoring. To avoid device failure, this project shows how to monitor the start and stop of an induction machine using both automatic and manual methods. It also includes an industrial programme for making the device more user-friendly and quicker.

***Keywords:** IOT, Induction motor, Node MCU, Arduino, Temperature sensor, Current sensor, Voltage sensor.*

1. Introduction

Induction motors are complicated electro-mechanical machines that convert electrical energy into mechanical energy in most industrial applications. It acts as the workhorse of manufacturing applications all over the world [11]. These motors are tough devices that can be used in a variety of situations, including harsh conditions and dangerous places. Pumps, manufacturing equipment, centrifugal machines, machine tools, conveyors, presses and elevators are all popular induction motor applications. Petrochemical as well as natural gas plants, on the other hand, use induction motors in dangerous areas, while coal plant machinery, grain elevators and shredders use induction motors in harsh environments. Induction motors are also extremely dependable, minimal-maintenance, and possess a relatively high performance. Furthermore, induction motors' broad power range meets the output requirements of several commercial functions [1].

The faults in motor are because of electrical as well as mechanical issues. Overloads and sudden load changes cause mechanical loads, which can lead to bearing failure and rotor bar rupture. Electrical strains, on the other hand, are normally linked to the supply of power. Induction motors can be powered by variable speed ac drives or power supplies of constant sinusoidal frequency [2]. Induction motors, on the other hand, are more prone to failure when driven by ac drives. This occurs because of ac drives' increased voltage tension on windings of the stator, stator current elements of increased frequency and stimulated bearing currents. Furthermore, due to the cable connection length from the motor to AC drive, motor overvoltages occur. Reflected wave transient voltages trigger this last effect. These electrical stresses can cause short circuits in the windings of stator, resulting in a complete motor failure.

1.1 Existing System

Induction motors, particularly squirrel cage induction motors, are extremely dependable machines. This motor's nature allows it to operate in a variety of harsh conditions. It can suffer from a variety of flaws or abnormalities. Bearing faults, stator faults, and rotor faults are among the different faults. Many of these flaws have their own consequences [3]. If the fault is left unattended, these side effects become dangerous to the engine. As a result, it's important to fix a problem as soon as possible. As a result, we need a device that identifies faults and disconnects the motor from the power supply when they exist. A sustained speed motor is an induction motor but with certain conditions, it is important for changing the motor speed and is utilized for further applications. As a result, a rapid control system is needed so that a single motor is used for multiple applications [12].

For detecting faults in an induction motor, a variety of methods are used. The identification of faults in the motors utilizes analysis of vibration, current spectrum and other approaches. The vibration and current of the induction motor were monitored to detect faults. Mechanical faults like damage in bearing are detected using the analysis of vibration spectrum, while electrical faults, like single phase with unbalancing supply, are detected using present analysis.

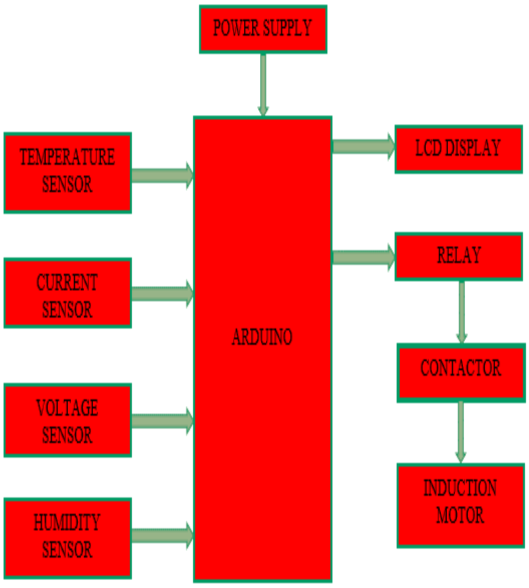

Fig.1. Block Diagram of Existing System

The protocol used by the method mentioned here is as follows:

- To begin, both the device and the motor are turned on.
- The Arduino then measures the voltage, current, and temperature.
- The parameters are then tested to see if they are within a reasonable range.
- If they are entering the danger zone, the LCD will display warnings.
- The motor is disconnected from the supply if they are absolutely outside of the safe range.
- After that, the fault parameters are transmitted to the data for data log purpose.

This device is made up of various sensors as well as measurement circuits that continuously track the motor's parameters. These sensors must be Arduino compliant, which means their resultant range of voltage is between 0- and 5-volts DC. Due to the measuring of AC, certain sensors demand equipment for conditioning of signal [4]. The current in the proposed system is estimated utilizing the ACS712 which estimates the current from +5A to -5A. It demands a 5V operating supply and the resulting voltage shows variation corresponding to current. Voltage is tested in our device using a possible transformer rated at 230V/9V AC and capable of handling a current of 500 mA. However, this AC is to be converted to DC by a rectifier circuit and the voltage is higher than 5V. As a result, a potential divider is needed to obtain the voltage down to a measurable level. This is linked to one of the Arduino's analogue pins [5]. The temperature is estimated utilizing the LM 35 that functions on 5V. The sensor range is -55^{o} C to 150^{o} C. The resulting voltage changes with current in a linear manner.

1.2 Objectives and Scope

The main goal is to improve the motor application's reliability by using current technological advancements. This research ensures that high-horsepower induction motors used in a number of industrial fields are continuously monitored and regulated. By maintaining system reliability, irregular conditions can be detected and corrected quickly. Since induction machines are utilized in virtually every industry, monitoring of economic data is essential. Industry efficiency can be improved by performing regular maintenance on induction machines. The failure of the machine and the expense of high-horsepower motors can be avoided by taking preventative steps.

- To use the internet of things (IoT) to track and operate an induction motor for secure and cost-effective data communication in economic sectors.
- Using automatic and manual control measures, start or stop the induction machine to prevent system failures.
- To keep track of and power the electric vehicle motors.

2. Related Works

The new era's industries are primarily concerned with the quantity and consistency of output over time. About 300 million industrial electric motors are in use around the world [6]. AC motors are preferred over DC motors because they only need a source for power, while DC motors need different sources of power for the rotor as well as stator. Aside from that, there are other characteristics that distinguish induction motors from other motors, such as their durable construction [7], low maintenance costs, high starting torque, performance, and reliability [7] In addition, motors are important, possessing ability to malfunction in certain condition. In the case of industrial motors, factors like electrical considerations, lubrication, motor cooling, alignments, as well as load of motor are few possible causes of motor failure.

These features trigger motor vibrations, a critical increase in motor temperature, or some other malfunction [9]. Condition monitoring can easily predict the condition of an induction motor that overrides the difficulties created by other methods of managing motor activity on a regular basis [14]. Motors that are not serviced on a regular basis may experience unexpected shutdowns. Condition monitoring, provides information on the motor's state and output and the sort of maintaining that is needed [10]. Condition monitoring has become increasingly important in recent years because it aids in predicting equipment health, optimizing equipment efficiency, and lowering maintenance cost [13].

Data gathered by sensors is wirelessly transmitted locally as well as cloud server for analysing. After the data is collected, a method that analyses the raw data has been conceived. With the Thingspeak cloud computing platform, the software is configured to handle real-time data and stores it in the cloud. This data can be accessed through the internet from anywhere [15][16].

3. Proposed System

3.1 Summary

DC motors have been commonly used in a variety of industrial applications as electrical technology has progressed. Because of the numerous advantages of induction motors, the perception of industry varied prior the invention of ac motors, particularly ac induction motors. The stationary and moving portions of an induction motor are the two main components. Mutual induction connects two parts, which is the transformer theory. The key advantages of three-phase induction motors are ability to self-start, robust construction, high power factor, and reduced price, but the speed cannot be managed without sacrificing performance. Various faults are present in induction motors.

Unbalanced three-phase supply, overvoltage, and overloading are some of the causes of electrical faults. Mechanical-related faults: The mechanical fault may be caused by air gap eccentricity, broken rotor bar, rotor and stator winding failure or bearing damage.

The induction motor's output is determined by the electrical and mechanical parameters. For safe and reliable operation of industrial induction motors, continuous monitoring of induction motors is required. The motor's electrical as well as environmental parameters, like current, voltage, humidity and temperature and have an impact on its efficiency. Mechanical parameters like vibration and abnormal speed also have influence on the motor's output. Few electrical as well as mechanical factors cause serious harm to the induction motor's health, as well as serious problems in the applications where it is utilized. In the current situation, the industry works as quickly as possible to complete the operation. Induction motors are commonly used to handle products in many sectors.

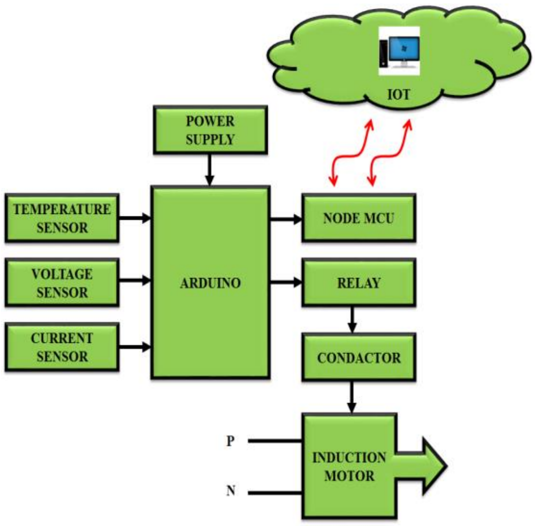

Fig.2. Block Diagram of Proposed System

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Recent advancement techniques are used to assure the efficient functioning of induction motors. The tracking and regulating are now performed automatically as a result of technological advancements. The internet of things permits to control and track the motor from afar. This approach is simple to use and reliable. Constant monitoring of electrical as well as mechanical parameters ensures the motor's reliability. If any irregular electrical or mechanical values are found, the motor-controlled automatic motor is switched off abruptly to prevent serious faults.

3.2 Remote Monitoring and Controlling

The data collected is constantly tracked both in the local centre and on the server. The server programme permits remote controlling of data collected. The data can be viewed from afar via the internet by using the Thinkspeak website.

3.3 Arduino UNO

The benefit of Arduino over other types of microcontrollers is that it is open source as well as minimal expensive than other types of microcontrollers. The simple nature in programming is utilized by more professionals. Arduino (Figure 3) is a category of ATmega328. Arduino possess analog as well as digital input/output pins. Arduino board requires 5V DC supply for operation. The Arduino UNO is at the core of this project for data collection as well as motor control. The condition regulating sensors and LCD display are connected to Arduino's input/output pins. The control circuit is also connected to the Arduino's output pins. The reset button, pins for connecting external sources, and a USB cable are all on the Arduino board. It also has a serial monitor pin and a transmitter pin. Arduino generates 3.3V and 5V as output.

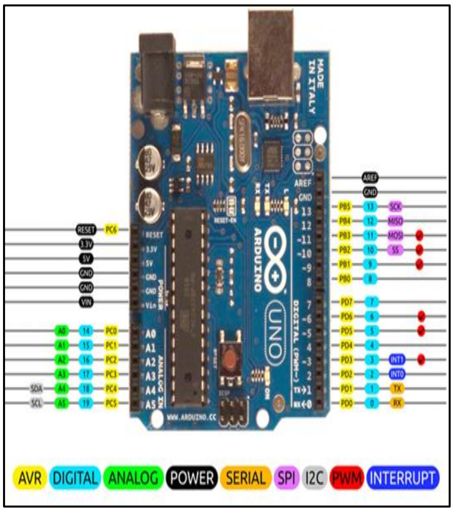

Fig.3. Arduino UNO

3.4 Power Supply

Various categories of power supply are designed for converting the AC Mains Voltage electricity to a relevant minimal voltage supply for electronic Circuits as well as other devices. A power supply can be deconstructed into a series of blocks, that each serves a specific purpose. The main AC supply is supplied to the step down transformer, which has several voltages.

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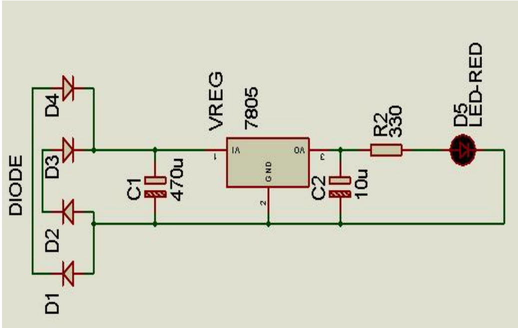

Fig.4. Circuit Diagram of Regulated Power Supply

The transformer's output is fed into the rectifier circuit. The AC voltage is converted to DC voltages in this rectifier circuit. The regulator circuit receives the rectified DC voltage. The regulator's output is determined by the regulator IC used in the circuit.

3.5 Temperature Sensor

Temperature sensors are the most common system used to monitor temperature in motors, and they are used to detect temperature rises in the engine. The motor will inform or send a warning to the user or manual controller if the temperature rises above the maximum of the motor's standard temperature level. LM35 is utilized as a temperature sensor and is a precision IC temperature sensor which results proportional to the temperature. Temperature can be calculated more precisely with the LM35 than with a thermistor. It also has a low self-heating capability, causing a temperature increase of less than 0.1^{o}C in still air. It operates at temperatures ranging from -55 to 150 degrees Celsius. The resultant voltage varies by 10 mV for every ^{o}C change in ambient temperature, implying a scale factor of 0.01V/^{o}C. The temperature sensor has a sensitivity of 10 mV/ oC, which can be addressed by the microcontroller, which can capture voltage levels below 5 MV.

Fig.5. Temperature Sensor

3.6 Voltage Sensor

Figure 6 shows a voltage sensing circuit that measures voltage and generates an output voltage according to the microcontroller's requirements.

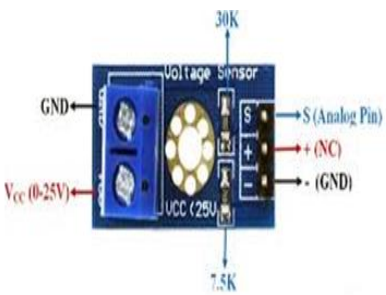

Fig.6. Voltage Sensor

A 230V/9V potential transformer is used, and the output is transferred to DC using a rectifier as needed. The rectifier result is rippled out by a capacitor, which is always high enough to feed to the microcontroller. As a result, a potential divider circuit is used to obtain the appropriate 5V voltage, which is then fed into the microcontroller's input.

3.7 Current Sensor

Economical as well as accurate solutions are issued by Allegro ACS712 for sensing of DC or AC current in communications, commercial as well as industrial systems. This sensor is connected in series with the circuit whose current must be measured. The current sensor module ACS712 is given in figure 7.

Fig.7. Current Sensor

3.8 Node MCU

The board includes an LDO voltage regulator for maintaining a stable voltage at 3.3V, as the ESP8266's operating voltage range is 3V to 3.6V. When the ESP8266 draws up to 80mA during RF transmissions, it can effectively supply up to 600mA, which is more than enough. The regulator's performance is also split out to one of the board's sides and numbered as 3V3. Power can be supplied to external components via this pin.

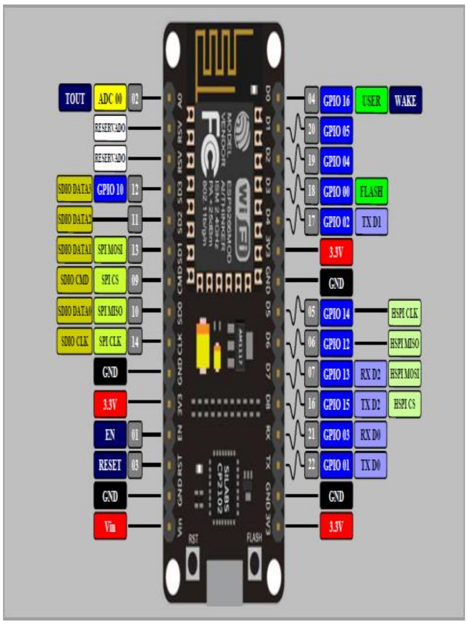

Fig.8. Node MCU

3.9 Contactor

A contactor is a switch that is operated electrically and is used to switch an electrical power circuit. A contactor is normally operated by a circuit with far less power than a switched circuit, like a 24-volt coil electromagnet operating a 230-volt motor switch. A basic contactor is given in figure 9.

Fig.9. Contactor

3.10 Induction Motor

An induction motor is one of the most widely used electrical motors. It always operates at a slower rate than synchronous. Since the stator's spinning magnetic field creates flux in the rotor, the rotor rotates. The rotor can never exceed its spinning magnetic field speed, i.e. the synchronous speed, because of the lag of rotor flux current with stator flux current. There are generally two categories of induction motors and its types of induction motors rely on the supply of input. The three-phase induction motor and single phase induction motor in which a three-phase induction motor has the ability to self-start, whereas a single-phase induction motor do not have the ability to self-start.

3.10.1 Induction Motor Operation

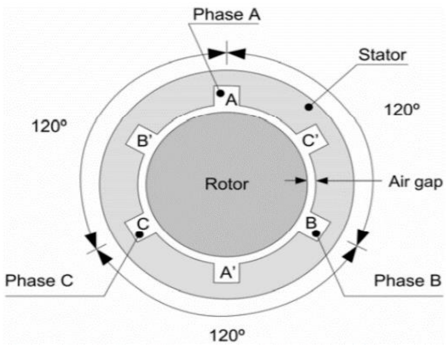

Fig.10. A Two-Pole Induction Motor Schematic

An induction motor's operating theory is thus dependent on a magnetic field that rotates synchronously. As shown in Figure10, the stator is made up of three electrically shifted windings at 120^{o}e. The three windings are linked to an AC power supply which is three phase. As a current passes across a coil, it creates a magnetic field in the coil with two poles. Magnetic field H generated varies with the current I and has a sinusoidal spatial distribution property, as well as performs inversion of polarity of every half period of 180°e. When the stator current of three phase, IA, IBB, IC, are applied along stator windings, three magnetic fields, HA, HB, and BHC, are created.

3.10.2 Induction Motor Faults

Induction motors are dependable electric devices, but they are prone to a variety of electrical as well as mechanical faults. Inter-turn short circuits in stator windings, open-circuits in broken rotor bars, stator windings and broken end rings are examples of electrical faults, while bearing failures as well as rotor eccentricities are examples of mechanical faults. Unbalanced stator voltages, currents, torque oscillations, performance loss, overheating, unnecessary vibration, torque reduction are all consequences of such faults in induction motors.

3.11 Relay

The 5V relay is utilized in the proposed method (figure 11) and is directly connected to the Arduino. The Arduino sends a pulse to the relay, and the relay's output is the contactor's input. If the Arduino detects an irregular condition in the acquired data, it sends a command to the relay for opening the contactor. A single pole single throw switch relay is utilized in this work.

The relay possess 5pins NO (normally open), NC (normally closed), 5V, GND as well as common pin. The relay works on the electromagnetism principle, when supply is fed to relay it acts as an electromagnet as well as changes the switch state.

The Arduino supply does not dependent on the supply that is turned ON and OFF.

Fig.11. Relay module

4. Results

Each sensor is independently tested and implemented in this design. The WI-FI module is accurately interfaced Arduino. The sensed values are graphically represented in real time on the IOT website while the motors are working. During abnormal condition, the motor is checked.

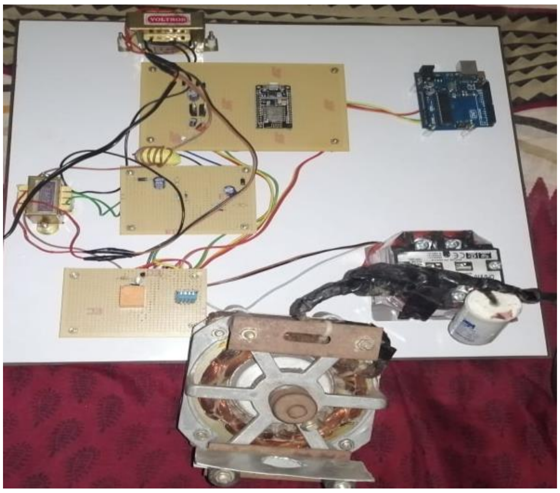

Fig.12. Hardware Component

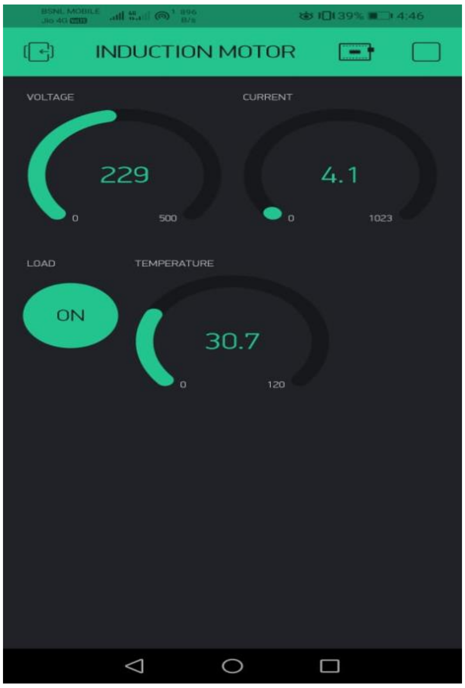

Fig.13. Fault Detection

5. Conclusion

The Internet of Things (IoT) is used in this project to detect and track motor system failures in a remote manner. The machine has the opportunity to blend various sensed parameters in real time in order to increase the accuracy of fault detection in motors. The motor system monitoring entails the measure of a variety of attributes, including the motor's vibration, speed, temperature, supply voltage, humidity and motor current. As a result, when opposed to other traditional systems, this device has a greater number of fields, allowing for alarms, warning messages, and easy control. The Internet of Things (IoT) is used to track and power the motor from afar. The data obtained from the controller node is graphically represented utilizing visual basics. The data is serially displayed and the work is updated for controlling of additional fields. Any electrical device today requires the application of the system. The system has the distinct advantage of requiring less maintenance, allowing for simple and fast data monitoring and access from a distance. The system's implementation is feasible, according to the results of the experiment.

Declarations

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This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The authors declare no competing financial, professional and personal interests.

Consent to participate

Not Applicable

Consent for publication

We declare that we consented for the publication of this research work.

Availability of data and material

Authors are willing to share data and material according to the relevant needs.

References

1. P. Waide, C. U. Brunner, Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems, Cedex, France: Intl. Energy Agency, 2011.

2. Kumar, K. Suresh, T. Ananth Kumar, A. S. Radhamani, and S. Sundaresan. "3 Blockchain Technology." Blockchain Technology: Fundamentals, Applications, and Case Studies (2020): 23.

3. Christopher J. Schantz, Steven B. Leeb,” Self-Sensing Induction Motors for Condition Monitoring” DOI 10.1109/JSEN.2017.2700386, IEEE.

4. Samuel, TS Arun, M. Pavithra, and R. Raj Mohan. "LIFI-Based Radiation-Free Monitoring and Transmission Device for Hospitals/Public Places." In Multimedia and Sensory Input for Augmented, Mixed, and Virtual Reality, pp. 195-205. IGI Global, 2021.

5. Chilaka Ranga, Ashwani Kumar Chandel, "Advanced Tool Based Condition Monitoring of Induction Machines by Using LabVIEW–A Review," IEEE UP Section Conference on Electrical Computer and Electronics (UPCON), 2015, DOI: 10.1109/UPCON.2015.7456693.

6. Praveen Kumar Shukla, Ankur Namdeo, Abhishek Dixit, "Condition Monitoring of 3-F A.C Induction Motor Using PLC," International Journal of Science and Research (IJSR), vol.1, Issue 5, May 2015.

7. S. S. Goundar, M. R. Pillai, K. A. Mamun, F.R.Islam, R. Deo “Real Time Condition Monitoring System for Industrial Motors”, School of Engineering and Physics, Faculty of Science, Technology and Environment.

8. Sugumaran Muthukumarasamy, Ananth Kumar, John Ayeelyan Tamilarasan, and M. Adimoolam. "Machine learning in healthcare diagnosis." Blockchain and Machine Learning for E-Healthcare Sys.: 343.

9. Ramachandiran Gunabalan, Padmanaban Sanjeevikumar, et al., “Analysis and Implementation of Parallel Connected Two-Induction Motor Single-Inverter Drive by Direct Vector Control for Industrial Application”, IEEE Transactions on Power Electronics, Vol: 30, no: 12, pp. 6472 – 6475, 2015.

10. Ruiwu Cao, Yi Jin, Minghang Lu, Zheng Zhang, “Quantitative Comparison of Linear Flux-Switching Permanent Magnet Motor With Linear Induction Motor for Electromagnetic Launch System”, IEEE Transactions on Industrial Electronics, Vol: 65, no: 9,pp. 7569 – 7578, 2018.

11. Kenichi Ikeda, Taketsune Nakamura, Tomoharu Karashima, Naoyuki Amemiya; Masaaki Yoshikawa; Yoshitaka Itoh; Toshihisa Terazawa, Yoshimasa Ohashi, “Hysteretic Rotating Characteristics of an HTS Induction/Synchronous Motor”, IEEE Transactions on Applied Superconductivity, Vol: 27, no: 4, 2017.

12. Kumar, T. Ananth, R. Rajesh, and P. Sivanainthaperumal. "Performance analysis of NOC routing algorithms for 5× 5 mesh based SOC".

13. Kumar, P. Praveen, and K. U. M. A. R. T Ananth. "Risk Analysis on Drilling Rig in Oil and Natural Gas Using Engineering Tools." i-Manager's Journal on Future Engineering and Technology 13, no. 3 (2018): 50.

14. Zhi Yang, Fei Shang, Ian P. Brown, Mahesh Krishnamurthy, “Comparative Study of Interior Permanent Magnet, Induction, and Switched Reluctance Motor Drives for EV and HEV Applications”, IEEE Transactions on Transportation Electrification, Vol: 1, no: 3,pp. 245 – 254, 2015.

15. Kumar, T. Ananth, S. Arunmozhi Selvi, R. S. Rajesh, and G. Glorindal. "Safety Wing for Industry (SWI 2020)–An Advanced Unmanned Aerial Vehicle Design for Safety and Security Facility Management in Industries." In Industry 4.0 Interoperability, Analytics, Security, and Case Studies, pp. 181-198. CRC Press, 2021.

16. Xiaoting Ye, Zebin Yang, Jianguo Zhu, Youguang Guo, “Modeling and Operation of a Bearing less Fixed-Pole Rotor Induction Motor”, IEEE Transactions on Applied Superconductivity, Vol: 29, no: 2, 2019.