# ARM BASED EFFICIENCY MONITORING WITH PROTECTION TECHNIQUE IN INDUCTION MOTORS

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**Abstract**— This paper deals with protection of an electrical machine against over voltage, over current and over temperature along with which efficiency of the motor is also estimated and monitored through a wireless medium. The electrical signal from motor is acquired by the controller and efficiency is obtained. Thus in an ARM based technique the values are calculated and the efficiency is transmitted. The communication between the controller and personal computer is carried out through the wireless module zigbee. The reliability of the system is highly improved in several aspects of maintenance and preventing motor from failures. The transmission of the collected data to a personal computer improves several applications in different fields.

**Index Terms**— Controller, efficiency, over current, over temperature, over voltage, wireless, zigbee.

## 1 INTRODUCTION

The The power consumption is mainly handled by the motors which are driven by the mechanical system. Different types of motor are used in different fields according to it nature and necessity [1]. When a number of machines are incorporated in an industry any fault in the system will lead to the loss of time, production as well as reduction in the profit. Highly experienced people were indulged in monitoring the data through wired networks in several industries [2]. When the system is wired in order to transmit data from a particular set of calculating module to the system under monitoring then even a fraction of second failure in the transmitting unit will lead to a severe effect in the case of several problems like over voltage and current.

Due to the wired type of system to monitor the cost also increases. Nowadays, wireless sensor network is preferred in several fields for monitoring [14]. The wireless sensor networks used in industries can access multiple different kinds of signals simultaneously [15]. In most of the cases induction motor is preferred because of its reliability and ease of maintenance [2]. Monitoring of torque, efficiency and protecting the machine from failures plays an important role in avoiding severe catastrophic effects [3].

Several techniques were implemented for measurement of speed without the use of sensors. A number of efficiency calculation methods are there but all those require the motor to be stopped at some point that is there will be an interruption in the process of measuring [4], [5]. Several other methods are also used for efficiency calculation which is simple but resulting in low accuracy [6].

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Protecting an electrical machine from problems like over voltage, over current and over temperature is a must in order to avoid severe catastrophic effects to the surrounding. When these problems are considered to be negligible then it leads even to the loss of life of a human being under operation of that particular machine [7]. Thus providing prevention techniques is better than undergoing a loss or damage. The electric machine is considered to be a single phase induction motor. The protection techniques against over voltage, over current and over temperature and the efficiency monitoring is carried out on the single phase induction motor as a prototype model. The over voltage problem occurs due to several reasons. The wireless module initially costs higher than that of wired system but when compared to loss in the case of malfunction in the wired system it is better to be implemented with wireless system to avoid disaster.

An ARM based system is proposed in this paper with parameters of voltage, current, temperature and efficiency measurement and protection of the system when the value increases above than the standard level of value. The obtained efficiency is monitored through wireless module zigbee which is very useful in the case of maintenance checking in the field of energy auditing.

## 2 BACKGROUND

When the over voltage protection is given importance then the gain is much more compared to the loss and one time investment. Over voltages is nothing but very high voltages which leads to disaster when coupled with electrical and electronic devices.

**Due to several reasons over voltage arises they are transient switching operations, lightning due to atmospheric discharges, electrostatic discharges and faulty switching opera-**

**tions. Firstly, consider the lightning in which bolts of lightning possess very high current so even in well earthed buildings high** voltage occurs. A component of low resistance also gets affected affected by this voltage rise. Secondly, the transient switching operation in which the current varies from a very high value to a low value as the switching contact for ON and OFF of the current is asynchronous with the zero current of an alternating current [8].

Thirdly, the electrostatic discharge which are frictional charges like walking on a carpet which will produce several thousands of volts. When this charge strikes electrical machine it leads to a disaster. Finally, the faulty switching operations this will lead to over voltage in the case of improper wiring or failure in the power supply unit. All these are the main reasons for over voltage. Similarly, when over current is considered when the over voltage is brought back to its normal level the over current and over temperature also drops gradually but when the over current is produced due to several reasons like short circuit in the windings then the motor is set back to OFF condition.

In the same way when the temperature of motor is raised due to either external or internal problems motor is again set to it's OFF condition. Efficiency by which performance of the motor can be visualized is considered to be an important criterion. In several applications like in the case of energy auditing the maintenance of motor can be identified easily when monitoring its efficiency is made simple [9].

## 3 PROTECTION SYSTEM

The response time of a system must be very high in the occurrence of over voltage, over current and over temperature to avoid several effects. Thus the basic characteristics of a very good protection system are quickest response time, the current carrying capacity should be very high, and finally the left over voltage should be very low.

The basic components used in over voltage protection are spark over gaps, varistors and suppression diodes. In the spark over gaps very high voltages will be discharged through the spark gap which is a gas discharge tube. Nearly 100 KA is the discharging capacity of the spark gap. In varistors over voltage is reduced by allowing current to pass through it in which the discharging capacity is 40 to 80 KA.

In the suppression diodes current carrying capacity is much higher compared to that of zener diodes thus becoming conductive after a certain level of breakdown voltage. Combination of all the above components will ensure complete protection but still it is a complex process which involves the combination of three components like spark over gap, varistors and suppression diodes. Efficiency is monitored through a wireless medium of Bluetooth in which a very short range distance is covered.

This type of protection technique is completely carried out on the basis of ARM. Which refers to the software coding dumped into a controller in order to access the hardware prototype. The process of over voltage protection is mainly done by a method of controlling technique. Controlling technique involves two types. First one is when the voltage exceeds standard level then either it is brought back to its normal level or the electrical machine experiencing this problem is set for its stopped condition. When over voltage rises then it is brought back to normal condition. When the problem of over current and over temperature occurs then the motor is set for its stopped condition. Monitoring the efficiency continuously provides proper information on maintenance of the system.

Efficiency is obtained as the ratio of output power to input power. The air gap torque and the corresponding air gap power are obtained from the slip due to forward and reverse rotating field.

$$S_{forward} = 1-(n_r / n_s) \quad (1)$$

Similarly, $S_{reverse} = 2 - (1- (n_r/n_s))$ (2)

The air gap power for forward and reverse field is given by,

$$P_{forward} = I_1^2 (0.5R_F) \quad (3)$$

Similarly, $P_{backward} = I_1^2 (0.5R_B)$ (4)

The total power air gap is given by,

$$P_{air\ gap} = P_{forward} - P_{backward} \quad (5)$$

The torque value is given by,

$$Torque = P_{air\ gap}/Rated\ power \quad (6)$$

The obtained power is given by,

$$P_{obtained} = (1-S)\ P_{air\ gap} \quad (7)$$

By subtracting several losses the output power is obtained.

While using wireless module the data transfer may get affected by the environmental conditions. Hence, the implementation of wireless module has to be application specific according to its own ne and requirements [10].

Several features has to be considered in the implementation of wireless module like the compactness of the system such that it can be handled with ease, should be very secured thus preventing several hacking methodology [11].

## 4 OPERATION

The operations carried out are voltage monitoring and control, current monitoring and control, temperature monitoring and control and efficiency monitoring of a single phase induction motor through an ARM processor LPC 2148 kit. The voltage and current are measured by current transformer and the potential transformer and passed to the signal conditioning unit

where filtering and amplifying is done. Filtering is done because not all the frequency spectrum contains valid data as specified so in order to neglect the unwanted data or signal it is done.

Amplifying helps in improving the resolution of input signal and also to increase the signal to noise ratio. The signals are passed to the ARM. All the analog signals are converted into digital signals by the ARM. The value measured is compared with that of the reference value in ARM when the value exceeds then the exceeding level is clipped off by a MOSFET through its driver unit. The PWM generation is provided by the code designed in ARM. By which motor is prevented from the problems of over voltage, over current. Over temperature is measured through a temperature sensor and the motor is stopped.

When the voltage increases beyond a certain level due to several factors it is controlled and brought back to its normal state. Thus, when the voltage level rises above 230V, the clipping exists. As the voltage level gradually increases beyond a certain limit the clipping period also increases gradually thus preventing the system to be affected from over voltage. In the case of over current the motor is set to OFF. The operator has to initiate the start of motor again. Similarly, when the temperature rises above the standard level the motor is stopped and the operator has to initiate the process again. In this way the motor is prevented from three parameters of oer voltage, over current and over temperature.

Efficiency is identified with the basic value speed which is measured by an RPM sensor. The efficiency monitoring is carried out without interrupting the motor operation. Generally, the efficiency monitoring was carried out in an offline manner but when it is carried out in online manner the complexity is much reduced. The efficiency monitoring through a wireless medium is made simple by which the maintenance of the motor is carried out periodically avoiding the catastrophic effects.

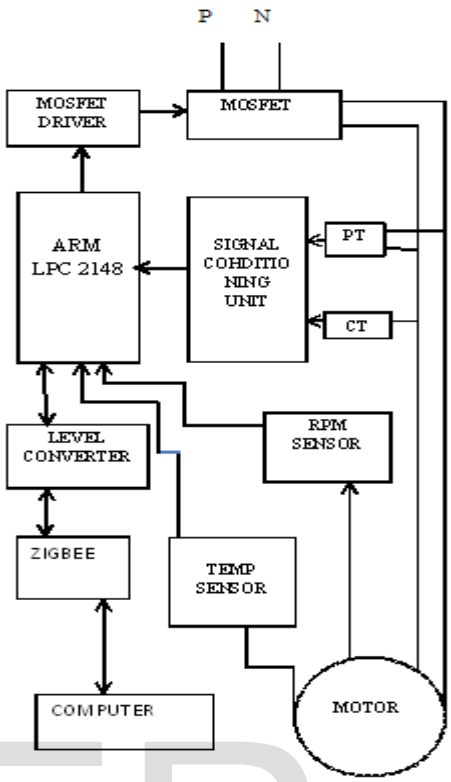


Fig 1: Block diagram of the system

As provided in Fig 1. The over voltage, over current, over temperature and efficiency are processed through ARM controller and monitored in the computer through the wireless network. In this way controlling and monitoring is carried out very efficiently.

## 4 Conclusion

A step by step approach in designing the microcontroller based system for measurement and control of three parameters has been followed. This system can overcome few shortcomings of the existing system by providing proper maintenance of the system.

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