International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 04 | April - 2022 Impact Factor: 7.185 ISSN: 2582-3930

Protection of Three Phase Induction Motor Using Embedded System

P. Lakshmi Sravani [1], V. Niteesh Kumar [2], V. Harish Babu [3], N. Harish Kumar Reddy [4], V. Ramakrishna[5]

[1,2,3,4,5] Electrical and Electronics Engineering, Annamacharya Institute of Technology and Sciences, Rajampet.

Abstract:

This paper present a PIC microcontroller – based control system for the protection of a three phase induction motor. The use of microcontroller technology has enabled the design of energy efficient and cost effective reliable control systems for induction motors. Fault types of induction motor like unbalanced voltage, over voltage, under voltage, over current, phase failure, over heat and more considered in this work. Fault monitoring and diagnosis are performed using protest environment. Fault classification is achieved through the microcontroller which includes a program for fault classification. When the fault occurs, the microcontroller sends a signal to the interfaced digital relay to trip the motor circuit and another signal to an LCD to display the type of fault. The use of microcontroller reduce the response time of the protection system and make it more suitable for real time operation. The proposed protection scheme is simulated using MATLAB Simulink. MATLAB simulation results show that the well trained protest scheme is able to detect all types of internal faults at different locations. The microcontroller used in this work is the high performance enhanced flash PIC16F877A Microcontroller of microchip which has an on chip analogue to digital converter peripheral, among other features.

Keywords: PIC microcontroller, three phase induction motor, fault classification, Proteus environment.

Chapter-I

INTRODUCTION

1.1 Overview:

Three phase induction motor are used in many application because of simple and robust structure, and low production cost. It confronts to a damage when it is working, because the faults that may be happen to it. These fault may be overcurrent, unbalanced, overvoltage, under voltage, single phasing, overheat .we cannot prevent fault but we can sense it's after it happened to stop it before damage the motor. A microcontrollers also known embedded controller, is a solitary chip microcomputer developed by VLSI fabrication. Microcontrollers comprise a central processing unit, memory and several peripherals. They are divided into categories according to their memory size, internal architecture, number of bits and instruction sets. The most universally employed sets of microcontrollers include the 8051 family, peripheral interface controller (PIC) provided by microchip technology, advanced virtual RISC microcontrollers(AVR), Among others. Microcontrollers are basically employed to control the functions of embedded systems in various applications like machines, robots, home appliance, motor vehicles or any electric appliance that stores, measures and displays information. One of the most widely used areas of microcontrollers are the parts of the control circuits in industrial automation systems. The input components, such as the sensors of pressure, of level and of temperature are interfaced as peripherals to the input. The driver components of the control circuit such as contactors and solenoid valves are interfaced to the output. Microcontrollers have the advantages of reducing the size, cost and power consumption compared to designs applying separate microprocessor and input – output devices. The features encouraged further evaluation of microcontroller - based approaches in industrial applications like protection of induction motors. Induction motors are used in many industrial applications because of their simple and robust structure as well as low production costs. More features are versatility and good self – starting capability. The reliability of an induction motor is of great importance as the motors are frequently exposed to different hostile environments, misoperation and manufacturing defects which results in failures causing industrial production losses. A voiding the unexpected shutdowns is important task for industries. A fault tolerant control systems to avoid unexpected shutdowns implies early detection and correct diagnosis and classification of fault in early stages. Researchers have studied using microcontroller interfaces and integrated protection architectures to allow a reasonable approach to reduce total system cost and increase overall performance motor control system. In the following a sample previous research work is illustrated in [1-6], protection of three phase induction motor was done using microcontroller, current transformer and step down transformer from single phasing, under voltage, over voltage and over current. The process was monitored by ATmega32 microcontroller. Proposed a technique to protect a three phase 2KW induction motor from single phasing using PIC16F877 microcontroller [7-9]. The values of each phase are sampled and converted to low ac voltage by means of transformer. More recent research can found by [10-12]. This work presents a PIC microcontroller – based digital protection system for three phase induction motor. Fault types of induction motor detection like unbalanced voltage, over voltage, under voltage, over current, phase failure, over heat and more considered in this work. Fault monitoring and diagnosis are performed using protest environment.

CHAPTER 2

INDUCTION MOTOR DRIVE:

Introduction

An induction motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding. An induction motor can therefore be made without electrical connections to the rotor. An induction motor's rotor can be either wound type or squirrel-cage type.

Three-phase squirrel-cage induction motors are widely used as industrial drives because they are rugged, reliable and economical. Single-phase induction motors are used extensively for smaller loads, such as household appliances like fans. Although traditionally used in fixed-speed service, induction motors are increasingly being used with variable-frequency drives (VFDs) in variable-speed service. VFDs offer especially important energy savings opportunities for existing and prospective induction motors in variable-torque centrifugal fan, pump and compressor load applications. Squirrel cage induction motors are very widely used in both fixed-speed and variable-frequency drive (VFD) applications.

Principle of operation

In both induction and synchronous motors, the AC power supplied to the motor's stator creates a magnetic field that rotates in synchronism with the AC oscillations. Whereas a synchronous motor's rotor turns at the same rate as the stator field, an induction motor's rotor rotates at a somewhat slower speed than the stator field. The induction motor stator's magnetic field is therefore changing or rotating relative to the rotor. This induces an opposing current in the induction motor's rotor, in effect the motor's secondary winding, when the latter is short-circuited or closed through external impedance. The rotating magnetic flux induces currents in the windings of the rotor; in a manner similar to currents induced in a transformer's secondary winding(s).

The induced currents in the rotor windings in turn create magnetic fields in the rotor that react against the stator field. Due to Lenz's Law, the direction of the magnetic field created will be such as to oppose the change in current through the rotor windings. The cause of induced current in the rotor windings is the rotating stator magnetic field, so to oppose the change in rotor-winding currents the rotor will start to rotate in the direction of the rotating stator magnetic field. The rotor accelerates until the magnitude of induced rotor current and torque balances the applied mechanical load on the rotation of the rotor. Since rotation at synchronous speed would result in no induced rotor current, an induction motor always operates slightly slower than synchronous speed. The difference, or "slip," between actual and synchronous speed varies from about 0.5 to 5.0% for standard Design B torque curve induction motors.[30] The induction motor's essential character is that it is created solely by induction instead of being separately excited as in synchronous or DC machines or being self-magnetized as in permanent magnet motors.

For rotor currents to be induced the speed of the physical rotor must be lower than that of the stator's rotating magnetic field (ns); otherwise the magnetic field would not be moving relative to the rotor conductors and no currents would be induced. As the speed of the rotor drops below synchronous speed, the rotation rate of the magnetic field in the rotor increases, inducing more current in the windings and creating more torque. The ratio between the rotation rate of the magnetic field induced in the rotor and the rotation rate of the stator's rotating field is called "slip". Under load, the speed drops and the slip increases enough to create sufficient torque to turn the load. For this reason, induction motors are sometimes referred to as "asynchronous motors".

An induction motor can be used as an induction generator, or it can be unrolled to form a linear induction motor which can directly generate linear motion.

Synchronous speed

An AC motor's synchronous speed, ns, is the rotation rate of the stator's magnetic field,

$n_s=2f/p$. Where f is the motor supply's frequency, where p is the number of magnetic poles and where ns and f have identical units. For f in unit Hertz and ns in RPM, the formula becomes

For example, for a four-pole three-phase motor, p = 4 and ns 120f/4 = 1,500 and 1800, RPM synchronous speed, respectively, for 50 Hz and 60 Hz supply systems.

The two figures at right and left above each illustrate a 2-pole 3-phase machine consisting of three pole-pairs with each pole set 60º apart.

Slip

Slip, s, is defined as the difference between synchronous speed and operating speed, at the same frequency, expressed in rpm, or in percentage or ratio of synchronous speed. Thus

S = (n_S-n_r)/n_s

Where ns is stator electrical speed, nr is rotor mechanical speed. Slip, which varies from zero at synchronous speed and 1 when the rotor is at rest, determines the motor's torque. Since the short-circuited rotor windings have small resistance, even a small slip induces a large current in the rotor and produces significant torque. At full rated load, slip varies from more than 5% for small or special purpose motors to less than 1% for large motors. These speed variations can cause load-sharing problems when differently sized motors are mechanically connected.

CHAPTER 3

FAULT DETECTION USING MATLAB SIMULINK PROGRAM

MATALAP program using to analysis the type of fault and what affective of faults in motor and to get a familiarity of it's behave and value. Then use these values as indictors for fault to do the protection system. IN this simulation we do all types of electrical fault that may happen in motor. The simulation blocks built is shown in figure 1.The three phase squirrel cage induction motor under test has the following specifications as shown in table .1.

Table 1: Data and parameters of three phase induction motor

Power rating	2.2 KW	Rated Speed	1440 rpm	Stator Resistance (r_s)	0.435 pu
Line Voltage	400V	Connection	Delta	Rotor Resistance (r_r)	0.816 pu
Rated current	4.6A	Class	E	Mutual Inductance (Xm)	26.13 pu
Frequency	50 Hz	Number of Poles	4poles	Stator and Rotor Leakage Reactance (X_{ls}), (X_{lr})	0.754pu

When single phasing occurred in stator that affective in balanced rotation of rotor as shown in figure 4. The block diagram and schematic diagram for microcontroller based fault classification system are built in proteus Simulink program shown in Fig.6 and Fig.7, respectively. The motor starts at rated condition. The stator currents and line voltages are monitored through current and voltage transformer.

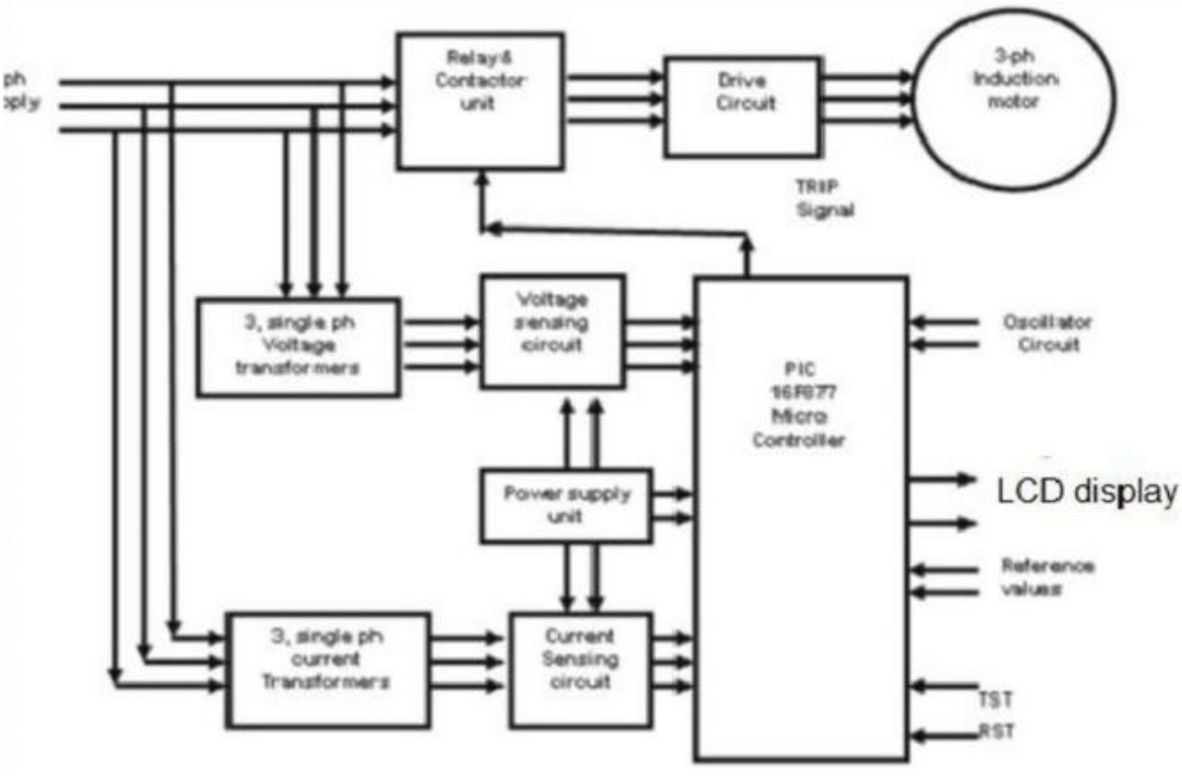


Figure (1): the block diagram for the micro controller based fault classification system.

Important Facts Related to Fault Detection Methods

i) Balanced over and under voltages

• Efficiency of induction motor decrease with reduced voltages on the induction motor even though all the three phases are balanced.

• When the percentage balanced under voltage (20%), increases the speed decreases drastically with increase in load.

• During balanced over voltage condition, the increase in speed is not proportional to increase in voltage. But increase in motor’s temperature

ii) Unbalanced supply voltages:

• Unbalance supply voltage causes the current flow of different magnitudes in all the three phases of induction motor. Hence heat produced in the stator windings and rotor is unequal which leads to failure of stator windings, rotor bars and bearings.

• The ripples in torque increase with increase percentage voltage unbalance (5%).

iii) Single phasing

• During single phasing condition, the losses are more.

• The heat dissipation is heavy which will damage the stator and rotor conductors.

• Also there is heavy pulsation in torque and speed.

iv) Over load

Due to over load, the current drawn by the motor is more and hence more heat dissipation in the motor.

v) Ground fault:

Ground faults produce more thermal stress on the motor and also hazards for human safety.

CHAPTER 4

SOFTWARE ALGORITHM

After get know about value of every fault .now we will do strategy to sense the fault then use proper method to protect the motor as shown in figure 7. A brief description for method control is given in the following:

Step 1: sense the current by current sensor if the current abnormal wait two second (starting current time), then sense again if the current abnormal that mean there is fault , then send signal to circuit breaker to cut the source and show in LCD overcurrent , if the current normal go to next step. Note we start the sense current because we need the time of starting not exceed time of starting. International Journal of Latest Research in Engineering and Technology (IJLRET) ISSN: 2454-5031 www.ijlret.com || Volume 05 - Issue 08 || August 2019 || PP. 01-10 www.ijlret.com 6 | Page

Step 2: sense the current of neutral, if it is abnormal the current cut the source and shown in LCD unbalanced. If the current normal go to next step.

Step 3: sense the voltage if the voltage less than 80% of rated voltage cut the source and show in LCD under voltage. If the voltage more than 110% of rated voltage the source is cut and show in LCD over voltage. If the voltage more 80% and under 110% of normal voltage go to next step

Step 4: sense the temperature sensor if the temperature is abnormal the source is cut and shown in LCD, if the temperature normal shown in LCD normal operation and go to first step. By this strategy that shown in steps and figure 6 we design code in C language and load it programmable integrated circuit (PIC) to do the protection.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 04 | April - 2022 Impact Factor: 7.185 ISSN: 2582-3930

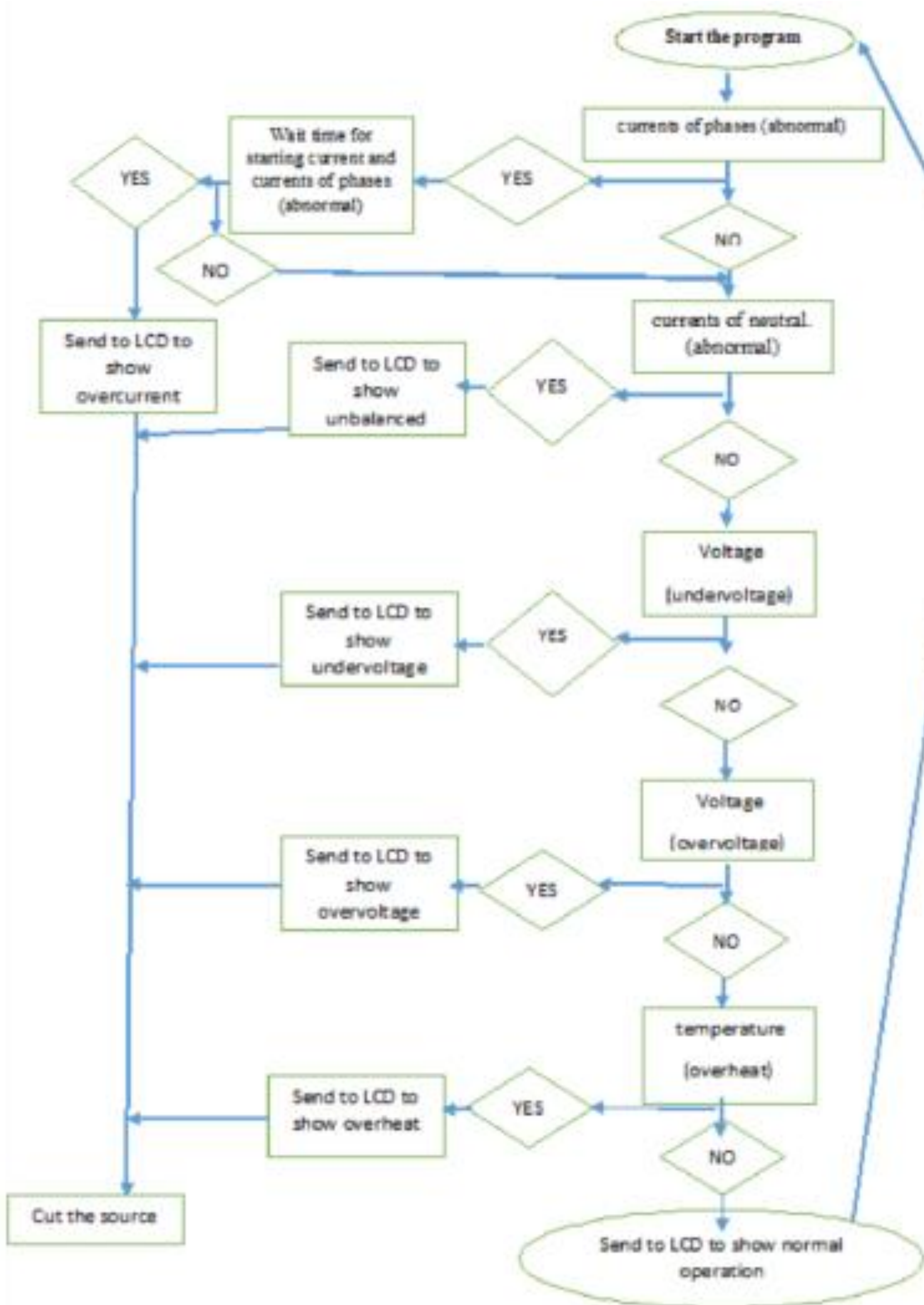
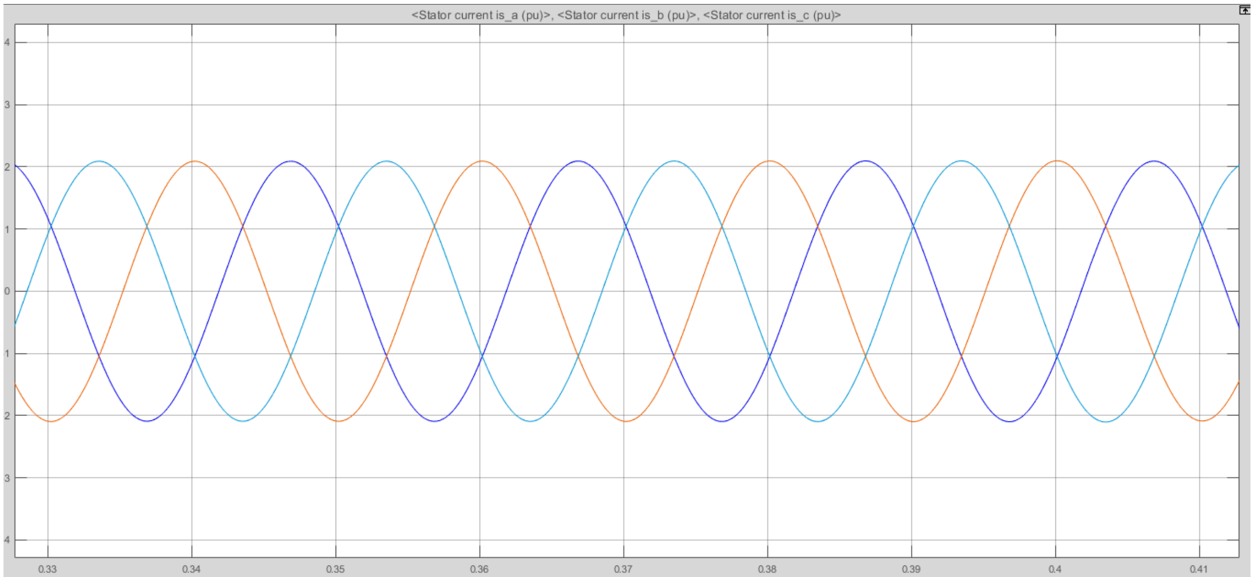


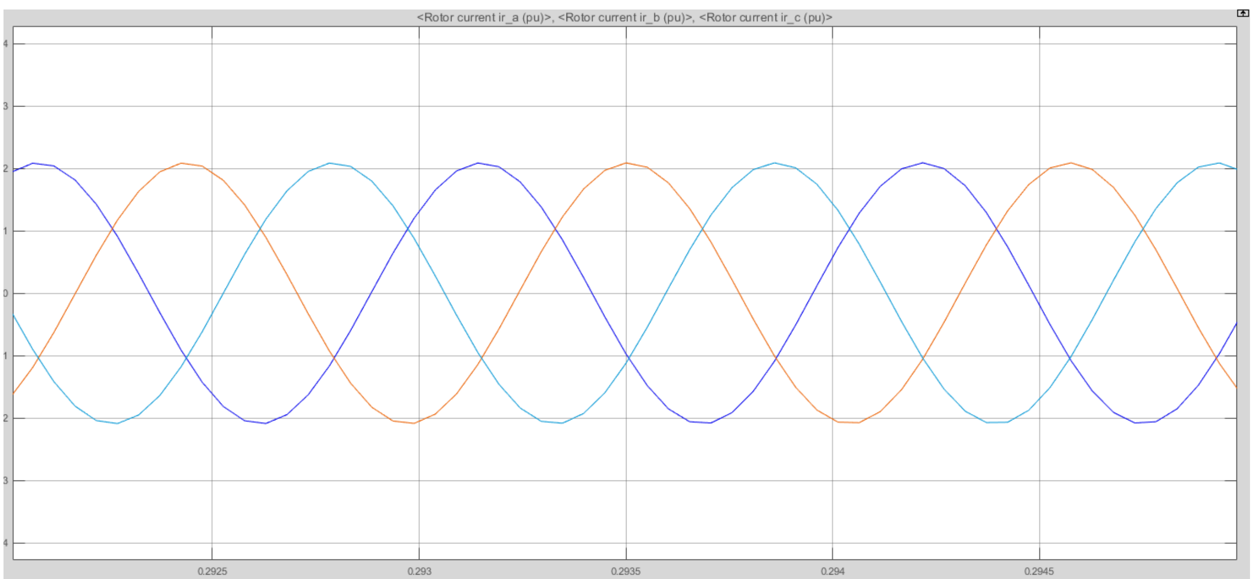
Figure (2): Flow chart of control method

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 04 | April - 2022 Impact Factor: 7.185 ISSN: 2582-3930

RESULTS

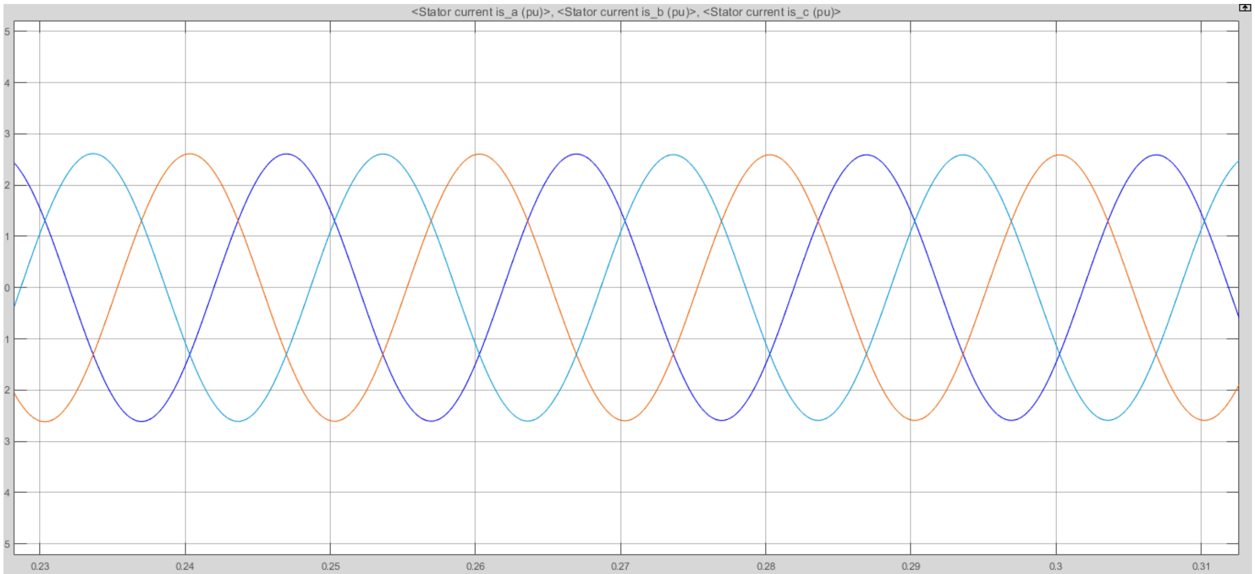


(3.a)

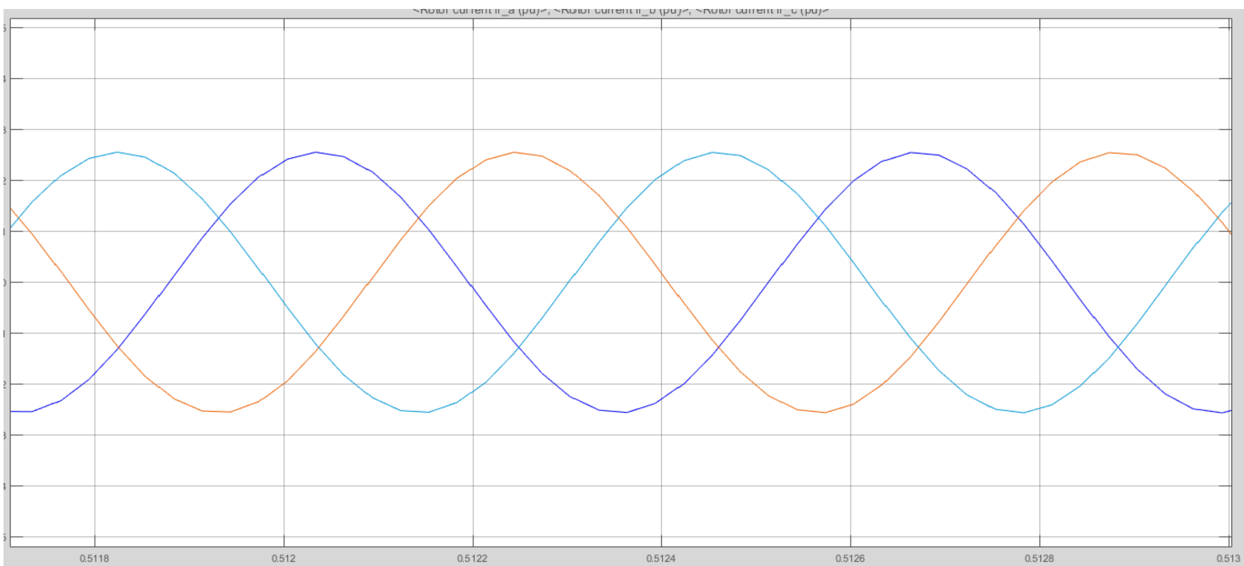


(3.b)

Figure (3): the normal condition (2.a) stator (2.b) rotor

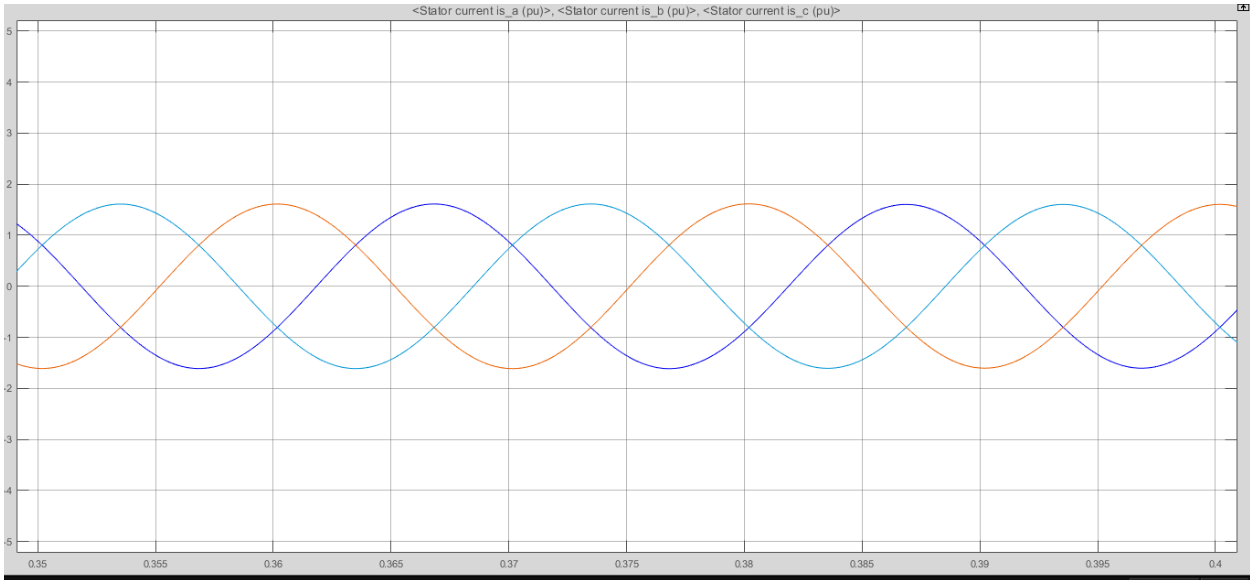


(4.a)

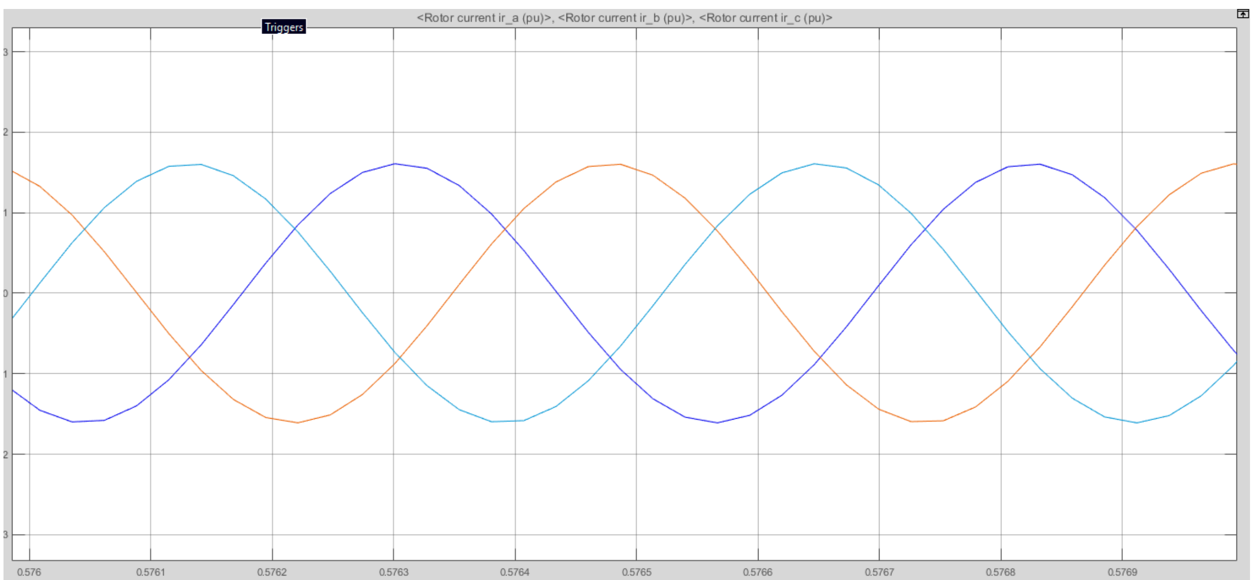


(4.b)

Figure (4): over voltage condition (2.a) stator (2.b) rotor

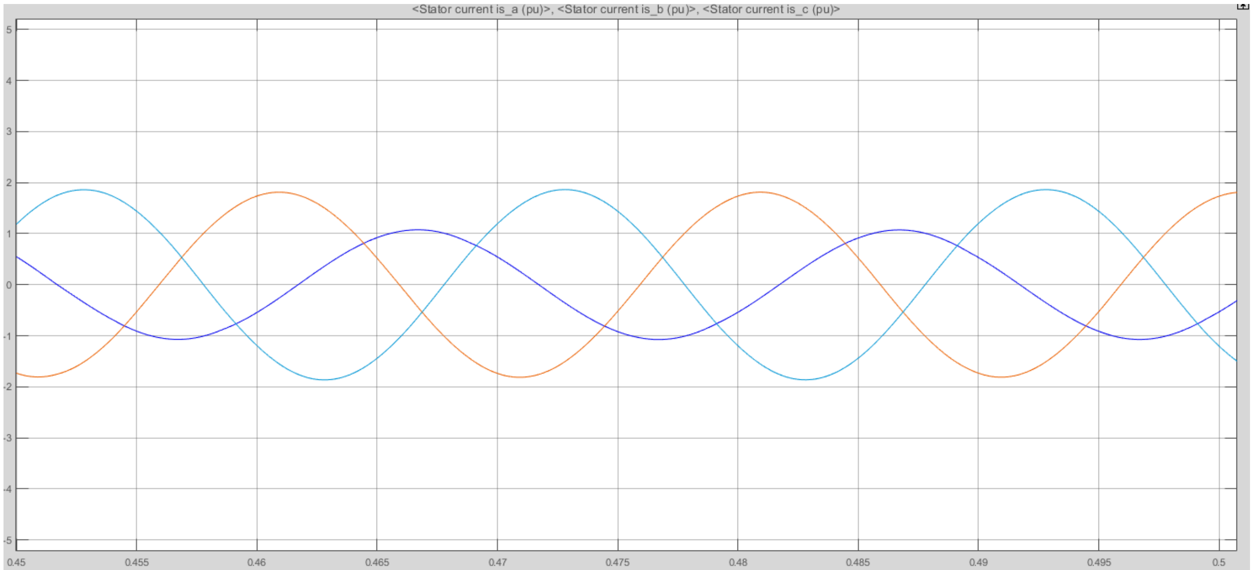


(5.a)

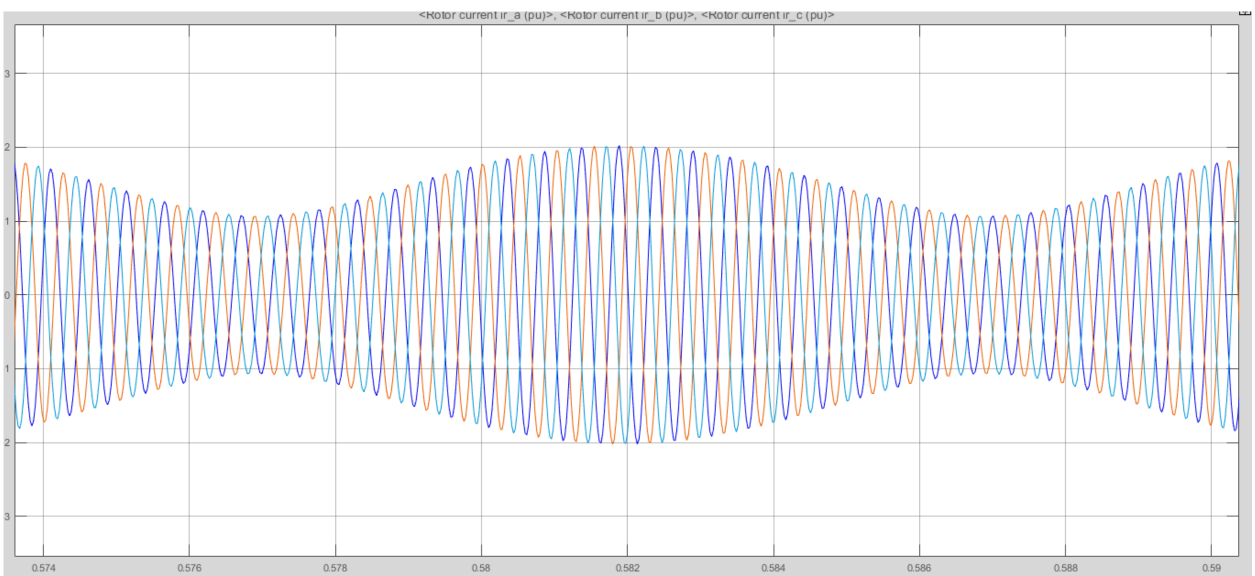


(5.b)

Figure (5): under voltage condition (3.a) stator (3.b) rotor



(6.a)



(6.b)

Figure (6): single phasing condition (11.a) stator (11.b) rotor

Conclusion:

External motor faults can cause unbalance in motor performance and failure to motor parts. In this study, a microcontroller – based protection system for three phase induction motor during external fault condition has been proposed. MATLAB Simulink is used for motor fault detection. The monitoring and operational diagnosis of three phase induction motor was achieved by using eight output. PIC microcontroller is used for fault classification and control to tripping the motor circuit through the interfaced digital relay. The application of microcontroller decrease the response time, very fast and low cost of the protection system. The measurement of electrical quantities itself give sufficient information about the fault mode behavior of induction motor. The method is simple and reliable compared to invasive technique of fault analysis. The proposed protection system can develop in easy way be change the coding and use for wide range of motor by small change in coding. The proposed protection system works with any motor design up to 200 A at full load condition, and provides a high degree of accuracy. By providing suitable current transformers and potential transformers, the range of the relay can be extended for high capacity motors. The method is very sensitive, fast and detects faults while running and before start.

References

[1]. Sudha, M. and P. Anbalagan, A "protection scheme for three-phase induction motor from incipient faults using embedded controller'' Asian J. Scientific Res.,pp. 28-50,2009.

[2]. Ching – Yin Lee "Effects of Unbalanced Voltage on the Operation Performance of a Three-Phase Induction Motor", IEEE Transactions on Energy Conversion , Vol 14, No.2, pp.202-208, 1999.

[3]. D. Ibrahim. "Microcontroller Based Applied Digital Control"John Wiley & Sons Ltd, England,pp 57- 60, 2006.

[4]. Ayhan B., M. Y. Chow and M.H. Song," Multiple signature processing – based fault detection schemes for broken rotor in induction motors" IEEE Trans. Energy Converts., 20: 336-343, 2005.

[5]. Bellini, A.,F. Filippetti, C. Tassoni and G. A. Capolino" Advanced in diagnostic techniques for induction machines" IEEE Trans. IND. Electron., 55, pp. 4109-4126, 2008.

[6]. Dalwinder S., Kuldeep S., Rahul M., Rohit K., Harpreet K., "Modelingand Simulation of Machine Overheat Detection With Alert System" International Journal for Innovative Research in Science & Technology"| Volume 3 | Issue 11 |,pp 3-10, November 2017.

[7]. Chee-munong "Dynamic simulation of Electric machinery using MATLAB/Simulink", Prentice hall, PTR, New Jersey. pp76,88,1998

[8]. Jaywant, P.S., P.S. Sambhaji and P.P. Deepak. "Fault detection and correction of 3-phase induction motor" Int. J. Adv. Res. Electro. Common. Eng., 3:322-828, 2014.

[9]. Thota, R. and N.S. Reddy,"A microcontroller based protection and control of a low voltage motors by ysing ZIGBEE technology. Int. J. Eng. Sci. Res., 4: 1214- 1222, 2013

[10]. Grang, G. and A Sinha,"An improved method for protection of three phase induction motor using microcontroller". Proceedings of International Conference on Power, Control and Embedded Systems, December 26-28, Allahabad, India, pp. 1-6, 2014.

[11]. Anand B. Gediya, Hitisha M. Modha, Kuldeep V. Khant and Jaydip sinh B. Zala"3 Phase Induction Motor Protection using Numerical Relay"IJIRST –International Journal for InnovativeResearch in Science & Technology| Volume 3 | Issue 11 | April 2017

[12]. El Sayed M. Tag Eldin and Nivin G, "A pic Microcontroller – based protection System of three phase induction motor" International Journal of Soft Computing 11 (3), pp. 212-220, 2016