DSPIC Based Fault Detection and Protection of Induction Motor

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ABSTRACT: Induction motors are generally utilized as a part of industry due to their rigidity and speed control flexibility. Three phase induction motors are industry's workhorses and widely used as electromechanical energy conversion devices. They suffer from various faults such as over voltage, under voltage, over current, temperature and single phasing. Failure do occur and may severely disrupt industrial processes and even lead to disastrous accidents. The aim of our project is to identify the above mentioned fault and protect the system by DSPIC controller. The computer based protection methods are costlier and the electrical parameters cannot be visualised by programmable logic controller (PLC) based method. The conventional method are complex. Hence to protect an Induction motor easily, DSPIC controller based fault detection and protection of induction motor is proposed. Several units in the systems are sensed by respective sensors and they are giving to the processor to achieve closed loop control of induction motor. This is the effective way of fault detection of induction motor.

KEYWORDS: DSPIC, Faults, Protection, Sensing units and Induction motor.

I.INTRODUCTION

 A large number of motors are being used for general purpose in our surrounding from house- hold equipment to machine tools in industrial facilities. Among all these motors Induction Motors are the most widely used motor for appliances, induction control, and automation; hence they are robust, reliable and durable. Although Induction Motors are reliable, they are subjected to some undesirable stresses, causing faults resulting in failure. Failure of such Induction motor may cause plant shutdown, personal injuries and waste of raw material. However, induction motor faults can be detected in an initial stage in order to prevent the complete failure of an induction motor and unexpected production costs. The main reason for the motor faults is mechanical and electrical stresses. Mechanical stresses are caused by overloads and abrupt load changes, which may cause bearing faults and rotor bar breakage. The electrical stresses may produce stator winding short circuits and result in a complete motor failure. The electrically related faults such as over-voltage, over-current, under-voltage, under-current, overload, and over-temperature. Various protection methods are available in literature which uses components such as timer, contactors, voltage and current relays are used. The protection using solid state relay has been discussed by designing sensing and control unit for the agriculture purpose using motor current signature analysis with wavelet transformer methods . Artificial intelligent fault monitoring approach [4] Fourier spectral analysis using FFT and MATLAB programming for fault frequency methods and Zig Bee based methods are proposed. The above said methods are simulation based methods. Recently the PLC based protection systems including all variable parameters of three phase induction motor have been proposed. This method is based on computer and programmable integrated circuit (PIC). This eliminates most of the mechanical components. But they are highly complex system and costlier. In order to overcome these problems, the microcontroller based fault detection and protection of induction motor is proposed. In this proposed system, the induction motor is monitored by using microcontroller which plays a major role. The presented methods monitor the operating induction motor continuously with the minimum interaction of human body. Microcontroller based protection is having advantages over computer and classical based protection. The advantages of the proposed system are low cost, simple and higher accuracy. The protection of induction motor by different faults such as over/under voltage, over current, over speed, phase failure, frequency and over temperature are considered in this proposed work.

II.SYSTEM MODEL AND ASSUMPTIONS

Fig 1. Controller circuit diagram
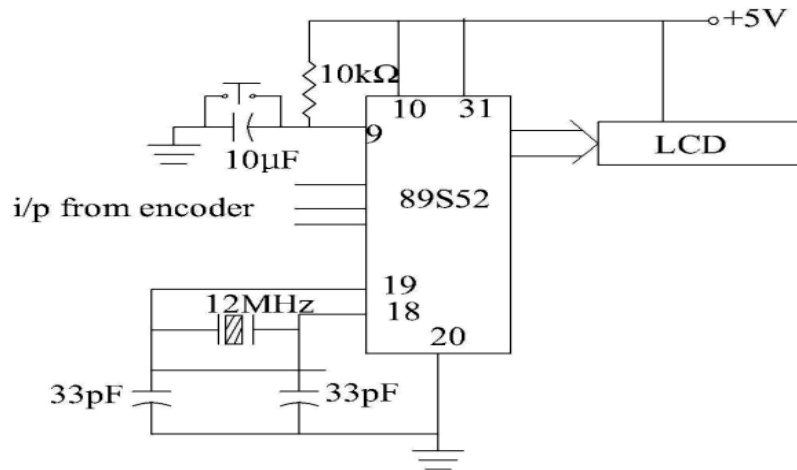
The designed system implementation has been carried out using two different implementations, namely hardware and software implementation. In hardware implementation six sensing circuits were designed and those six sensor circuit outputs are connected to the 8:3 priority encoder circuit using IC 74148 as shown in figure 2. This encoder generates three bit BCD output and one bit enable output. The BCD output which is generated by the priority encoder is completely based on the input provided by the designed sensing circuits. The BCD outputs are connected to the 89C52 microcontroller. The main function of microcontroller is to display the fault conditions on LCD display with audio system with buzzer as shown in the figure. To minimize the starting surge current drawn by the motor, a delay of 30 seconds is generated using enable output of the priority encoder. The enable output of encoder is used to prevent tripping of the circuit at the starting and it generates the control signal to drive the relay driver. Which in turn isolate relay from switching of the motor during the faulty conditions. The faulty conditions considered are Over/Under voltage, over current, over temperature, phase failure, over speed and frequency. In software implementation has been carried out using the algorithm has been carried algorithm for the implementation of program is given below. If any fault occurs then the microcontroller sense the corresponding fault and displays the result on LCD display with audio signals.

III.OPERATION OF CONTROLLER

A. Over /under voltage sensing circuit
The over voltage occurs when any one of the line voltage increases above the rated voltage and it leads to harmful effect on machine insulation. In order to overcome this problem, over voltage sensing unit is designed. The designed unit consists of three potential transformers to step down the line voltage to 12V. This step down voltage is rectified and filtered to get dc voltage proportional to the line voltage. This dc voltage is compared with reference voltage which has set by the pre set value. This comparator is formed using quad op-amp IC LM 324 and the output of the comparator is fed to priority encoder IC 74148.
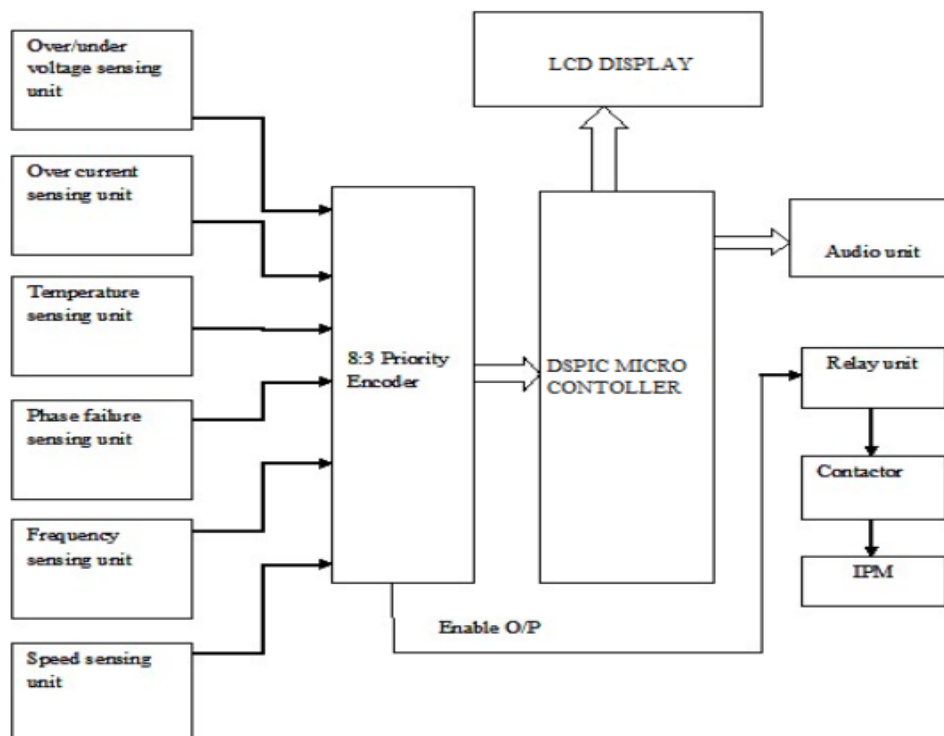B. Overload sensing circuit
When there is increase in mechanical load on the motor beyond the rated value then the overload situation occurs. Due to this increase in current beyond the rated current then motor gets heated up and causes harm to the motor. In order to overcome this situation, the overload sensing circuit is designed. The designed circuit is used to monitor the load current using Hall Sensor module AC5712, which senses the current up to 20Amp. This module gives dc output proportional to the input ac line current. This dc voltage is further amplified and compared using comparator with reference voltage. The output by the comparator is fed to one of the input of priority encoder IC 74148.
C. Temperature sensing circuit

When the motor runs for longer period under loaded condition of the motor and it gets heated up which reduces the efficiency of the motor. In order to sense over temperature, Semiconductor IC LM35 is used. This sensor provides 10mv/°c output voltage proportional to the increased temperature of the motor. This output is amplified by using op-amp LM 324 and the output is compared with the reference voltage in the comparator formed by op-amp LM324. The output is fed to the priority encoder IC 74148.

Fig 2 : Block diagram of DSPIC based speed control of induction motor

D. Phase failure sensing circuit
In case of 3-phase Induction motor, three phase supply is needed. If any one of the phase fault occurs then remaining two phases are overloaded and gets heated up. In order to overcome this problem the phase failure sensing circuit is designed. This unit uses the three low ac voltages from three step down transformers for sensing the three phase voltage. These ac voltages are fed to Schmitt trigger formed by IC555. The outputs of three Schmitt triggers are fed to AND gates formed by IC CD4081. The digital outputs are then fed to priority encoder IC 74148.

E. Line Frequency sensing circuit
Frequency is directly proportional to speed of the motor. If any change in frequency then the speed also varies and that will effects on the bearing, shaft connected to load of the motor due this winding may burned out. In order to avoid this, frequency sensor circuit is designed. This frequency sensing circuit measures the frequency of the electrical signal and sense the fluctuation in the line frequency. This measured frequency is given to frequency to voltage converter IC LM 331.

F. Speed sensing circuit
Increase in speed leads to increase in operating temperature and decreases the functional horse power, which leads to reduce the life of motor. In order to sense the speed, the speed sensing circuit has been designed. The circuit consists of proximity sensor to send the speed of the motor. The output of the sensor is proportional to the speed of the motor and

it is dependent on voltage. which is proportional to the dc voltage. This dc voltage is compared with reference voltage in the comparator formed by LM 324. Then output is fed to the priority encoder IC 74148.

IV. RESULT AND DISCUSSION

In the proposed system variable resistance (preset) is used for adjusting reference voltages for different parameters such as under/over voltage, over current, over temperature, over speed, frequency and phase failure. The values are set for the max. 430v, current 7.1amp, temperature50ºC.observations are listed in table , shown below. If the value of any parameter goes beyond the reference value than the relay unit releases the contact of the motor from the circuit. Hence the motor automatically turned–off. This is how the Induction Motor can be protected easily from the faults using this microcontroller based protection system. This system can be tested with various different rated Induction Motors.As per the designed value, the system withstand current up to 20amp,voltage up to 450V,temperature up to 120 ºC and speed of 6000rpm
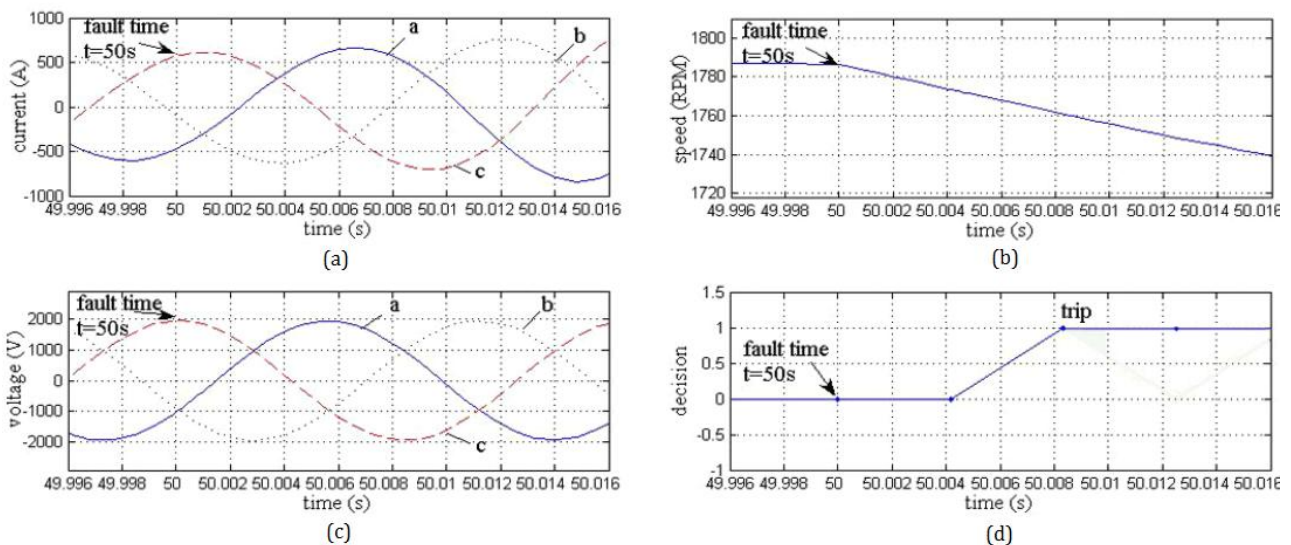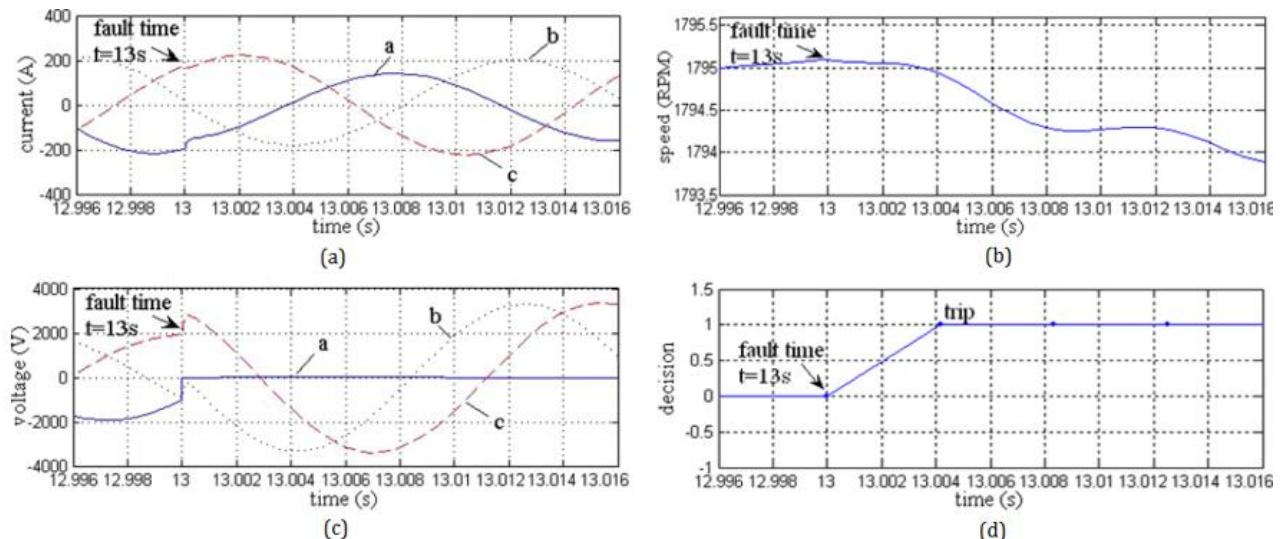
Fig. 3 Simulation of locked rotor fault

Fig. 4 Simulation of line to ground fault

V.CONCLUSION

Protection of three phase induction motor from over/ under voltage, over current, over speed, temperature, frequency and phase failure provide the smooth running of motor which also improves its lifetime and efficiency. To make induction motor run efficiently and to protect it from various faults, six different sensing circuits have been designed along with audio system. These sensing circuit sense the faults occur in an induction Motor. These faults are monitored by the protection system and if any fault occurs the motor automatically turned off.

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