# Protection System for Three Phase Induction Motor Using Fuzzy Logic Controller

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***Abstract*- This paper explores the various protections for Induction Motor using Fuzzy Logic controller. Induction motor is the most widely used motor in the industry due to its simple and rugged construction. It requires least maintenance as compare to the other electrical motors Mainly the induction motor needs protection from the variation of the input supply. For the proposed protections three inputs are applied to the Fuzzy Logic Controller to attain the objective. The inputs provided to the FIS editor are Current, voltage and Time. Current sensor is employed to sense a single phasing, any undesirable increase in current and time is calculated when this overcurrent appears and voltage sensors are provided to the controller for voltage protections. main objective is to limit the current and turn the motor OFF whenever necessary during undesirable changes in voltage and current. For an unsustainable high current for a longer time or during single phasing or during under/over voltage condition the motor is turned OFF.**

***Index Terms*—Fuzzy Logic controller, Overcurrent Protection, under/over voltage protection, Current Limit, motor off, single phasing condition.**

## I. INTRODUCTION

Induction motor is the most widely used motor in the industry due to its simple and rugged construction. It requires least maintenance as compare to the other electrical motors. Induction motor speed control is now a day's easier and versatile due to the advancement in the field of power electronics and hence is easy to replace other costly and controllable motors. The protection of induction motor plays an important role in its long life service. Mainly the induction motor needs protection from the variation of the input supply for small motors which is in common use not only in big industry but also in small scale industries. This paper focus on the overcurrent, under voltage, overvoltage and single phasing protection of Induction Motors.

The effective overcurrent protection using fuzzy logic, can be obtained by mutually calculating current and time. Depends on increase in current with time, we can employ current limiter so that increase in current can be limited to certain level and when current is large enough such that we can't limit to normal range then breaker should operate immediately. for getting this performance we have to set rules in fuzzy logic controller [1]. Three phase induction motor can becontinuing to run when single phasing occurs which results in will heat up motor quickly and also at the same time the losses increases twice when compare with steady state losses and shaft power reduces to nearly 70%. So that to protect the motor all the terminal should be open at the instant of single phasing [2][3].

Sometimes voltage at motor terminals may be higher than the nominal value in a complex industrial system and can be well below from nominal value in a heavily loaded industrial system. effect of unbalanced voltages on the three phase induction motor[8]. All the possible under voltage and over voltage effects are discussed. The worst cases of 3 phase under voltages affect the efficiency of motor. Positive sequence voltage and negative sequence voltages effects the power factor and efficiency. The derating of the motor is suggested in case of the voltage unbalance according to the NEMA MG1 Standards [5][7].Thermal effect can shorten the life of motor. The starting and running of motor with reduced voltage affects the thermal insulation of the motor [4]. Induction motors may be stable on a certain magnitude of voltage dip for finite duration and it may be desirable to delay the trip circuit which may isolate the motor from supply [6].

This paper explores the possibility of achieving over current, under voltage, over voltage and single phasing protection of motor using fuzzy logic controller. For these design scheme we require current sensor, voltage sensor and timer, with protective devices current limiter and three phase breaker. The Current sensor has to detect single phasing, over current and provide signals to the timer. The Voltage sensor has to provide voltage input to the controller. When the current is not too high or is sustainable, the fuzzy controller gives a signal to the current limiter to limit the current. When current is much higher for high time then controller sends trip signal to operate the breaker. similar in case of under voltage and over voltage condition controller send trip signal to the breaker. Also breaker has to operate for the single phasing condition seen by controller.

## II. METHODOLOGY

### *A. Motor Overcurrent and Single Phasing Protection*

Generally, overcurrent results from overload, earth fault etc. single phasing occurs due to opening one of the conductor out of the phases. So protection against both are much necessary. When load on induction motor get increases it

draws more current from supply. In case this current is further rises such that motor get damaged, so overcurrent protection with mutually calculating current and time results in preferred performance. And in case of single phasing current through one of the phases goes to zero, which result in increase in current through other two phases which is not permissible. So all terminals should be disconnected from supply to protect motor. For this single phasing and overcurrent protection system based on fuzzy logic controller is proposed in this work

*Proposed Fuzzy Inference System*

In this paper A fuzzy logic controller is provided with two inputs current and time. Such that current and time are mutually calculated to get protection against over current and current is separately taken as actuating quantity for the single phasing protection. Proposed protection can be done with the help of two protective devices which are current limiter and three phase breaker. protection scheme is based on fuzzy logic model using MATLAB Simulink as follows:

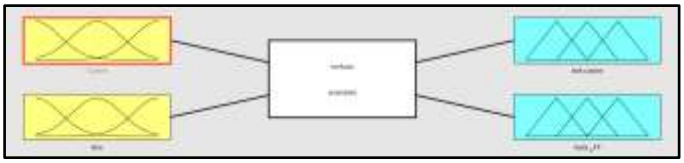

Fig. 1. Proposed System.

Fuzzy controller has Two inputs current and time. based on rule set for these two inputs controller generates output to decide whether motor has to run continues by limiting current by limiter or to be switched OFF by disconnecting from supply mains.

The inputs given are as follows:

1) Current
2) Time

In fuzzy logic we have to provide membership function for each input and output variables.

The membership functions of the first input current are as follows (Fig. 2)

1) Phase Out
2) Starting
3) Rated
4) Overload
5) Medium
6) High
7) Very High

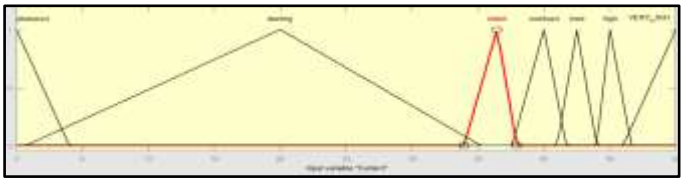

Fig. 2. Membership function for first input (Current).

The second input, time, is also separated into three membership functions as follows:

1) Less
2) Medium
3) Very High

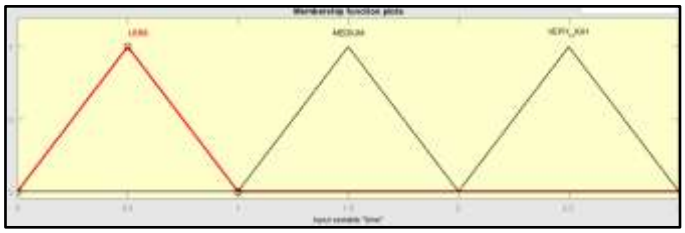

Fig. 3. Membership function for second input (Time).

Depends upon the two input membership function we are mapping these inputs combination out of which two outputs are taken are:

1) Limit Current
2) Motor Off

For the first output variable limiter, there are four membership functions are taken for limiting very small, low starting, medium and very high change in current. membership functions are given below:

1) Very Low
2) Low
3) Medium
4) High

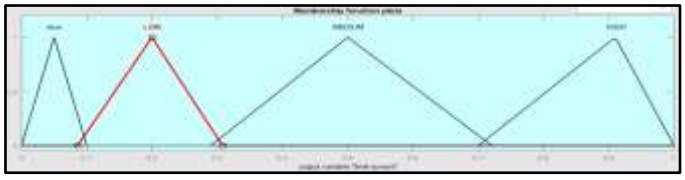

Fig. 4. Membership function for first output to limiting the current.

For the condition where the current is very high and cannot further limited or there is condition of single phasing then output membership functions are given below (Fig. 5):

1) Close
2) Open

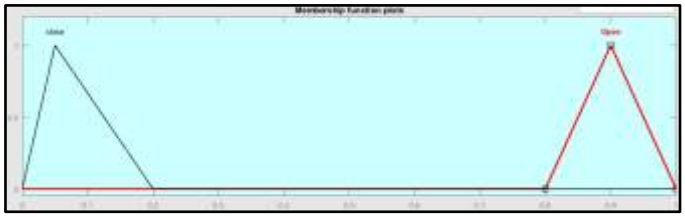

Fig. 5. Membership function for second output to switching the motor OFF.

Basic functioning of fuzzy logic controller is on the rules that has been set according to the input and output membership function for getting desired results. So for having single phasing and overcurrent protection we have sets 21 rules in

fuzzy logic controller. These rules are based on if-then logic are given below:

Fig. 6. If-then rules used for mapping the input current-time mf to the output limiter-breaker mf.

*B. Over/Under Voltage Protection*

To have under and over voltage protection a single input given to the fuzzy logic controller. The input is as follows:

1) Voltage.

The membership functions of the first input voltage are given as Follows

1) Under
2) Rated
3) Over

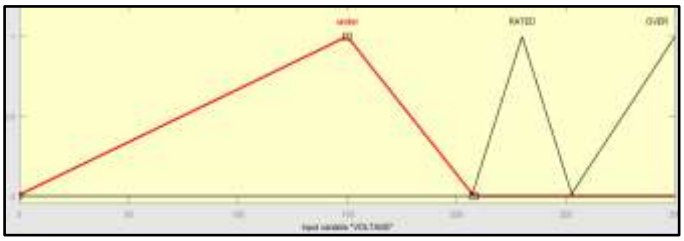

Fig. 7. Membership function for first input voltage.

Similarly, if rated voltage is well below the rated value that is under voltage or much higher than the rated then motor should disconnect from supply by changing the position of breaker from close to open. so membership function of breaker will be

1) Close
2) Open

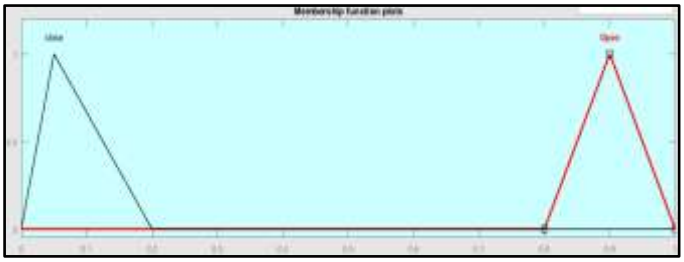

Fig. 8. Output Membership function for switching the motor OFF.

For getting desired under voltage and over voltage protection we set 3 rules in fuzzy logic controller are as follows:

Fig. 9. If-then rules used for mapping the input mf to the output mf.

*C. Proposed Protection System*

The current sensor senses the current flowing through the circuit and if the current is found greater than the rated current of the motor, it sends an indication to the timer. Similarly, voltage sensor sense the phase voltage. Since both current and voltage are Analog quantity so we have to convert into digital form with the help of Analog to Digital converter. Also the input to the limiter and breaker is Analog quantity so have to convert digital output signal from the fuzzy logic controller and converter into Analog signal with the help of digital to Analog converter. Proposed protection system is shown in fig. 10.

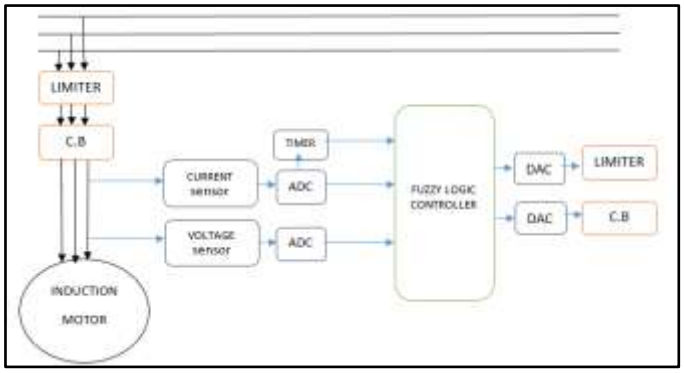


Fig. 10. Schematic Diagram of the proposed system.

## III. SIMULATION RESULTS AND DISCUSSION

For these various protections we need rated supply voltage and current. With the help of this we set various input-output membership function limits to get desired operation of protective devices**.**

❖ *Overcurrent and Single Phasing Protection*

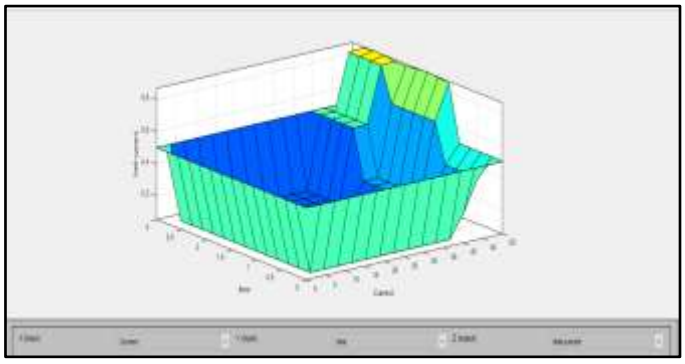

Fig. 11. Operating Surface between times, current with respect to current limiter.

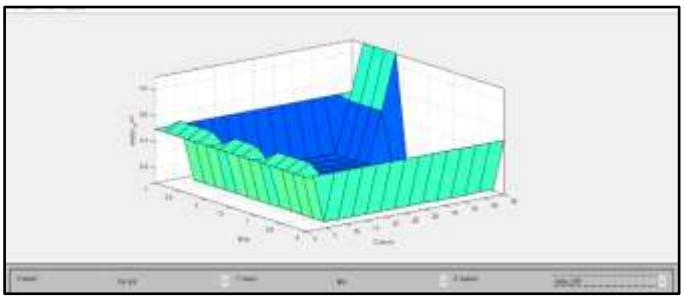

Fig. 12. Operating Surface between current, times with respect to switching the motor OFF.

❖ *Voltage Protection*

Voltage protection can be setting up operating range according to motor rating.

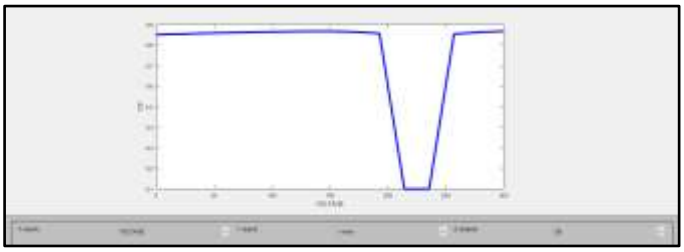

Fig. 13. Operating Surface between Voltage with respect to switching the motor Off.

❖ *SIMULATION RESULTS*

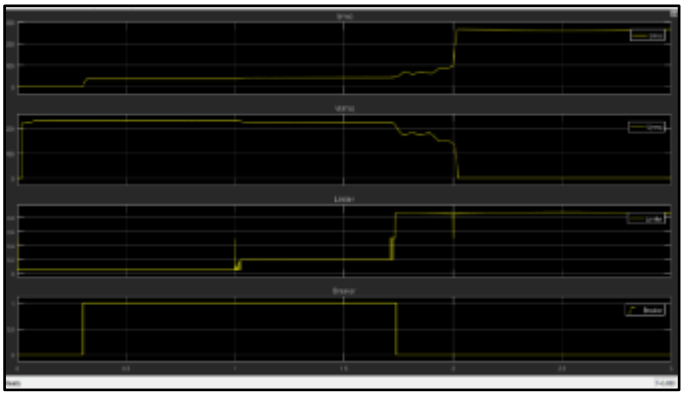

Fig. 14. Limiter and Breaker Output on Induction Motor.

Fig 14 gives the actual simulation result, it gives the fuzzy controller output to limiter and breaker with respect to motor input current and voltage respectively. From this result we can see that when both condition of rated voltage and rated current are satisfying then only breaker is close that is motor is on. For Other undesirable conditions like overcurrent, single phasing and under-over voltage condition motor get disconnected from supply by opening of breaker. Although overcurrent and under voltage is occurs simultaneously in induction motor, this protection system sends actuating signal to the breaker for both this conditions. so reliability of proposed scheme is more as compare to other protection schemes.

## IV. CONCLUSIONS

The 21 sets of rules for overcurrent and single phasing and 3 rules for voltage protection permit the system to attain the preferred performance. Employment of current limiting device to the circuit prevents the high current rushing to the motor winding during starting period and hence offering the characteristics of a starter. In this paper over/under voltage, over current and single phasing protection techniques are involved and protection system is found to be reliable, portable, simpler in construction andrequires very small space requirements as it uses only a Breaker and current limiting device. This design using fuzzy is expected to give a most favourable performance. Future scope is to analysis of protection system for large machines with this model.

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