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Fuzzy Logic Control of Three Phase Induction Motor: A Review

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Abstract:- The dynamic performance of an electrical drive must be very good so that the response to the changing speed and the torque is fast. This requirement can be fulfilled by using the fuzzy logic control of the electrical drive. The advantage of using fuzzy logic control is that it does not require complex mathematical modeling of the motor. By just knowing the behavior of the motor the control signals is manipulated to obtain the desired response characteristics of the motor. In this paper a fuzzy logic technique is proposed which is very simple and easy to implement in the actual scenario. Various methods to implement the fuzzy logic control is also proposed.

Keywords:- *fuzzy logic controller, three phase induction motor, fuzzification, defuzzification.*

I. INTRODUCTION

Electric drives are very much important in the industries as in industries the motors can be used in wide variety of applications. Earlier the motors that were used for variable speed applications were the dc motors while the motor for constant speed application were induction motors or the synchronous motors. This was because the speed controlling of an induction motor or the synchronous motors are quite complex in nature. The speed controlling of the dc motor is quite simple so it was used in the variable speed application.

Among all the motors the induction motor is the most reliable and rugged motor thus it was regarded as the most economical motor to be used in the industries. With the inventions of power electronic devices like the POWER DIODES, POWER MOSFET, GTO etc. it became easy to have a variable voltage and variable frequency ac supply through these devices. So by this the speed controlling methods of induction motor becomes quite simple by changing the voltage and frequency of the supply as per the need of the load.

As with the advent of power electronic devices the method of controlling becomes simple but still it needed the method so that the input voltage and frequency of the supply to the induction motor can be varied according to the need of the load which is to be run by induction motor. To achieve this various algorithms were given by different researchers to obtain the desired controlling. The algorithm proved to be useful but it required the mathematical modelling of the induction motor and to obtain a perfect mathematical model of an induction motor is still very much complex.

With the introduction of fuzzy set theory by Ltfi Zadeh in 1965 researchers were trying to use the fuzzy set theory for controlling purpose. The fuzzy logic control does not require any mathematical model of the system. Mere knowledge of the system behavior with the change in various input variable is sufficient. In this paper fuzzy control methodology is proposed. The input variable taken is the error in speed with respect to reference speed and change in speed error.

II. SPEED CONTROL OF INDUCTION MOTOR

The rotor speed of an induction motor is given by

$$N_r = (1-s)N_s$$

Here N_r= rotor speed, S= slip and N_s= synchronous speed of the induction motor.

The synchronous speed N_s is given by $N_s = \frac{120f}{P}$ where f is the frequency and P is the number of poles. So from the equation its seen that speed can be controlled by varying P, f and s.

Now the maximum flux in an induction motor is proportional to V/f. the maximum torque of an induction motor is proportional to the value of maximum flux so we can say that if the maximum flux in an induction motor is varied and maximum torque also gets varied. If the motor torque becomes lesser than the load torque the motor cannot run the load so it should always be kept in mind that the starting torque of an induction motor should always be greater than the load torque. Now as seen from the figure we can change the speed of an induction motor by varying the number of poles, the frequency and the slip. By varying the number of poles we can only control speed in steps. Slip control is possible only in slip ring induction motor as the slip control requires the variation of rotor resistance which is possible only in slip ring induction motor. So the best way by which speed can be controlled is variation of the supply frequency. For content maximum torque the raio of supply voltage and frequency must be kept constant. This can be achieved by giving the supply to the three phase induction motor through the three phase inverter which is controlled to match the desired speed.

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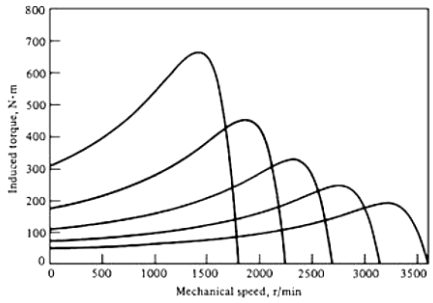

Fig 1:- Torque speed characteristics under variable frequency

With the advent of fast computers the fuzzy control of the three phase inverter for the speed control of the induction motor can be very much simple. It is very much known that frequency increase causes increase of speed and frequency decrease causes decrease of the speed. Thus from the feedback input of rotor speed the inverter can be controlled accordingly to obtain the desired speed.

III. FUZZY SET THEORY

Fuzzy logic is a superset of Boolean logic which has been extended to handle the concept of partial truth- truth values between "completely true" and "completely false". It is the logic basic modes of reasoning which are approximate rather than exact. Fuzzy logic replicates human knowledge in to control logic.

A. Configuration of Fuzzy Logic Controller

Principal components of Fuzzy logic controller:

- Fuzzification block or fuzzifier
- Knowledge base decision making block.
- Defuzzification block or defuzzifier

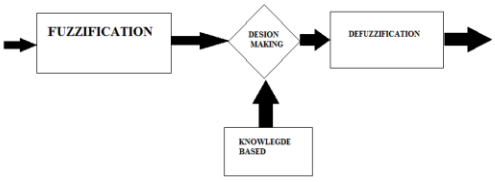

Fig 2:- Fuzzy block diagram

➢ *Fuzzifier*

This section of the fuzzy logic converts the input which is in numeric form to the linguistic form. As the fuzzy logic operates in linguistic variable this it is very much necessary to convert the input into the linguistic variable. For different range of input different linguistic variable name is assigned. The decision making logic is formed by considering the input in linguistic variable form.

➢ *Knowledge base decision making block*

Through this section of fuzzy logic the rules are set for the output according to the input given to the fuzzy control block. The rules are made according to the knowledge of the induction motor. Basically the input variable in the fuzzy logic control block is the error and the change in error. From the knowledge of the given system the error signal in reduced as fast as possible and the rules are made accordingly. The rules can be as many as possible according to the combination of the input variables. The output obtained is the control signal in linguistic form. The number of rules increases with the number of fuzzified input variable obtained after the fuzzification of the input variables.

➢ *Defuzzifier:*

It performs the task just opposite to that of fuzzifier. So the task of defuzzifier is to convert the linguistic variable into crisp one. There are different types of defuzzification techniques present for defuzzication.

- Centroid of Area (COA)
- Bisector of Area (BOA)
- Mean of Maximum (MOM)
- Smallest of Minimum (SOM)
- Largest of Maximum (LOM)

B. Fuzzy logic in induction motor control

For the speed control of an induction input taken is the rotor speed.the rotor speed is then compared with the reference speed to obtain an error signal e . Along with that we use another input to the fuzzy controller that is the rate at which the error is changing that is Δe. The two input that is error and rate of change of error is given to the fuzzy logic controller. The fuzzifier then fuzzifies these two inputs according to their values. The decision making rules are then set according to the basic knowledge of the induction motor. Output is obtained according to the rules made and the output is defuzzified by defuzzifier and provide output of the fuzzy controller. The output is the change in control variable needed that is change in speed. This change is then added with the motor speed and the result is fed to the inverter from where the input to the three phase induction motor is given. The frequency and magnitude of the voltage supply is varied so that the speed is changed without affecting the magnitude of maximum flux. It is done by constant v/f control.

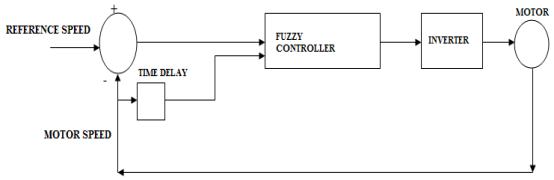

Fig 3:- Block diagram of fuzzy logic controller

C. Conventions to make rules

It is very much important in a fuzzy logic controller how rules are decided. In fuzzy logic controller rules are made not only to reduce the error but reducing the error as fast as possible. This makes the system more stable and accurate. This is achieved by using following conventions:

- If error is high and change in error is low then control signal must be large.
- If error is high and change in error is high then control signal must be medium.
- If error signal is low and change in error signal is low then control signal must be low.
- If error is low and change in error signal is high then control signal must be medium.

The error signal and the change in error signal can be fuzzified into many number of membership functions and the rules need to be made according to that number of membership functions but the thumb rule is that rule is made in such a manner that reduces error value as fast as possible.

IV. CONCLUSION

This study suggests that they fuzzy controlled drive can improve dynamic performance of the induction motor drive compared to the conventional electrical drive. Along with that it can reduce the complexity of the controller and makes the controller simple. It can provide better control in a frequent load changing conditions. In future attempts will be made to impart this control scheme in a three phase induction motor control.

REFERENCES

1. J.-S. R. Jang, C.-T. Sun, E. Mizutani, "Neuro-Fuzzy and Soft Computing," Pearson Education Pte. Ltd., ISBN 81-297-0324-6, 1997, chap. 2, chap. 3, chap. 4.
2. R.Ouiguini, K. Djeffal, A.Oussedik and R. Megartsi, "Speed Control of an Induction Motor using the Fuzzy logic approach.", ISIE"97 - Guimariies, Portugal, IEEE Catalog Number: 97TH8280, vol.3, pg. 1168 – 1172.
3. G. El-Saady, A.M. Sharaf, A. Makky, M.K. Sherriny, and G. Mohamed, "A High Performance Induction Motor System Using Fuzzy Logic Controller," IEEE Trans. 07803- 1772-6/94, pp. 1058-1061, 1994.
4. Gilberto C. D. Sousa, Bimal K. Bose and John G. Cleland, "Fuzzy Logic Based On- Line Efficiency Optimization Control of an Indirect Vector-Controlled Induction Motor Drive" IEEE transaction on industrial electronics, vol 4, no 2, april 1995.
5. F. Blaabjerg, J. K. Pedersen, S. Rise, H. H. Hansen, and A. M. Trzynadlowski, "Can softstarters help save energy," IEEE Ind. Applications. Mag., vol. 3, pp. 56–66, Sept./Oct. 1997.
6. Fin Haugen , Article "Zeigler Nicholas Closed Loop Method",17 July 2010.
7. J. Nevelsteen and H. Aragon, "Starting of large motors—Methods and economics," IEEE Trans. Ind. Applications, vol. 25, pp. 1012–1018,Nov./Dec. 1989.
8. G.Bhuvaneswari, "Intelligent Induction Motor Drive", Ph.D Thesis,IIT, Madras, 1992. Ltd., ISBN 81-297-0324-6, 1997, chap. 2, chap. 3, chap. 4.
9. Chitra V., Prabhakar R.S., "Induction Motor Speed Control Using Fuzzy Logic Controller," World Academy of Science, Engineering and Technology 23, 2006.
10. Fonseca J., Afonso J.L., Martins J.S., Couto C., "Fuzzy Logic Speed Control of an Induction Motor," Microprocess. and Microsyst., Vol. 22, pp.523 - 534., 1999.
11. Leão A.T., Teixeira E.P., Camacho J.R., "A robust fuzzy speed control applied to a three-phase inverter feeding a three-phase induction motor" International conference on electrical machines, Espoo, Finland, pp. 685-689, 2000.
12. [12] Baghgar H., Varjani A., Asghar T., "Using Fuzzy Controller in Induction Motor Speed Control with Constant Flux" World Academy of Science, Engineering and Technology, Vol. 5, ISSN 1307-6884, 2005.
13. Crowder R., Electric Drives and Electromechanical Systems, UK: Elsevier Linacre House, 2006.
14. Novotny D.W., Lipo T.A., Vector control and dynamics of AC drives, Oxford University Press Inc., New York, 1996.
15. Bose B.K., "Power Electronics and Motion Control-Technology Status and Recent Trends." IEEE Transactions on Industry Applications, Vol. 29, no. 5., 1993.
16. Arkhipov M., Krueger E., Kurtener D., "Evaluation of Ecological Conditions Using Bioindicators: Application of Fuzzy Modeling" International Conference on Computational Science and its applications - ICCSA 2008, Part I, LNCS 5072, pp. 491-500, 2008.
17. Bonivento C., Fantuzzi C., Rovatti R. (ed.), Fuzzy logic control: advances in methodology, World Scientific Publishing Co. Pte. Ltd., Singapore, 1998.
18. Li H., Guota M. M. (ed.), Fuzzy logic and intelligent systems, Kluwer Academic Publishers, USA, 1995.
19. Ross T.J., Fuzzy Logic with Engineering Applications, 3rd Edition. Wiley and Sons, 2010.
20. Rashid M. H. (ed.), Power electronics handbook: devices, circuits, and applications, Academic Press, USA, 2007.
21. IEEE Std 519-1992, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical