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FUZZY LOGIC BASED ELECTROMAGNETIC RELAY WITH IMPROVED SWITCHING TIME REACTION FOR THE SUBJECTED FAULT

Manish Vishwakarma[1], Ashish Kumar Rai[2], Vivek Koshta[3]

ABSTRACT: In an electric power system, a fault is any abnormal electric current and A fault is deemed to have occurred when there is a conducting path between points that are normally of different potential. In this thesis a MATLAB model with a transmission line is simulated with an artificial fault subjected to the system. The relay operates with the controlling of PI control technique and again with the fuzzy logic control technique and it was found practically in results that the switching action with fuzzy logic control is more secure as the fault current becomes zero at faulty time but with PI control the fault current is not zero which shows the insensitivity towards the fault protection system. fuzzy logic controlled relay is fast in its switching with an impulsive reaction which is demonstrated in the results.

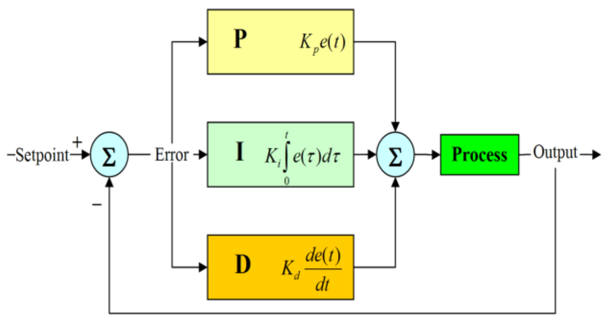
Key words: MATLAB, Relay, fault, FLC, PI

I. INTRODUCTION

Modern civilization makes use of large amounts of energy to generate goods and services. From the industrial plants, the providers of public services to the ordinary man, all of them need energy to satisfy and create the well being of modern society. The purpose of electric power systems is to provide energy for human use in a secure, reliable and economic manner. Electric power systems are made up of facilities and equipment that generate, transmit and distribute electrical energy. Electric power systems are one of the largest and more complex systems man has ever built. Power system protection is a branch of electrical power engineering that deals with the protection of electrical power systems from faults through the isolation of faulted parts from the rest of the electrical network. The objective of a protection scheme is to keep the power system stable by isolating only the components that are under fault, whilst leaving as much of the network as possible still in operation. Thus, protection schemes must apply a very pragmatic and pessimistic approach to clearing system faults. For this reason, the technology and philosophies utilized in protection schemes can often be old and well established because they must be very reliable. Protection system in power networks consist mainly of relays and their associated circuit breakers. Protective relays detect faults in power systems through current and potential transformers and subsequently activate the appropriate circuit breakers to isolate the faulty equipment from the system. They essentially act as switching mechanisms that disconnect the faulty region quickly, so as to minimize the damage. The general philosophy of relay application is to be dividing the power system into zones that can be protected adequately using fault recognition and removal, producing a disconnection of as few sections of the network a possible. The element in a power system typically consists of generators, transformers, buses, transmission/distribution circuits and motors. Each of these elements is protected by circuit breakers, located in three different zones of protection: primary, secondary and tertiary. In the event that a fault occurs, the circuit breakers in the primary zone are activated by the relays and trip first. The circuit breakers in the secondary zone provide backup protection to circuit breakers in the primary zone, in case they do not operate. Tertiary zone circuit breakers backup the circuit breakers in the secondary zone.

II. PI CONTROL THEORY

A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller calculates an "error" value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting the process control inputs. The PID controller calculation (algorithm) involves three separate constant parameters, and is accordingly sometimes called three-term control: the proportional, the integral and derivative values, denoted P, I, and D. Heuristically, these values can be interpreted in terms of time: P depends on the present error, I on the accumulation of past errors, and D is a prediction of future errors, based on current rate of change. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, or the power supplied to a heating element. The circuit diagram of PID controller is shown in fig3.5



The PID control scheme is named after its three correcting terms, whose sum constitutes the manipulated variable (MV). The proportional, integral, and derivative terms are summed to calculate the output of the PID controller. Defining u(t) as the controller output, the final form of the PID algorithm is:

$U(t) = MV(t) = K_p\, e(t) + K_i \int_0^t e(\tau)\, d(\tau) + K_d\, d/dt\, (e(t))$

Where
K_p: Proportional gain, a tuning parameter
K_i: Integral gain, a tuning parameter
K_d: Derivative gain, a tuning parameter
e: Error = SP – PV
Where e is the error or deviation of actual measured value (*PV*) from the set point (*SP*).
t: Time or instantaneous time (the present)
τ: Variable of integration; takes on values from time 0 to the present t .

III. FUZZY LOGIC RULE & CONTROL

Fuzzy control systems are rule-based systems in which a set of so-called fuzzy rules represent a control decision mechanism to adjust the effects of certain system stimuli. The aim of fuzzy control systems is to replace a skilled human operator with a fuzzy rule-based system. The fuzzy logic controller provides an algorithm which can convert the linguistic control strategy based on expert knowledge into an automatic control strategy. The fuzzy logic controller involves four main stages: fuzzification, rule base, inference mechanism and defuzzification . The error and change in error are taken as the inputs to the fuzzifier here the error is between the line voltage and the reference voltage (i.eVq and V_{ref}) and the change in error is taken by subtracting two consecutive error values by providing a unit step delay and giving the second input to the fuzzifier as shown in the figure. Triangular membership functions are used for the inputs and the output. The universe of discourse for both the inputs is divided into seven partitions (NL - Negative Large, NM - Negative Medium, NS - Negative Small, Z - Zero, PS - Positive Small, PM - Positive Medium, PL - Positive Large). The output is the voltage and again the universe of discourse is divided into seven partitions. Fuzzy rules are if then rules were these are specified by max –min operator functions .the fuzzy rules taken here are of the form:

i) If error is large negative (LN), AND change in error is large negative (LN); THEN output (u) is large positive (LP).

ii) For N linguistic variables for each of error and change in error there are N^2 possible combinations resulting into any of M values for the decision variable u. All the possible combinations of inputs, called states, and the resulting control are then arranged in a $NN2\times MM$ 'fuzzy relationship matrix' (FRM).

iii) The membership values for the condition part of each rule are calculated from the composition rule as follows: μ(Xi) = μ(e is LN, and Δe is LN) = min [μ (Δω is LN), μ (Δω̇ is LN)]; where i=1, 2,…N2 Here, Xi is the value of the N2 possible states (in-put-combinations) in the FRM.

iv) The membership values for the output characterized by the M linguistic variables are then obtained from the inter-section of the N^2 values of membership function μ(x) with the corresponding values of each of the decision variables in the FRM. For example, for the decision LN⊂M and for state *Xi*, we obtain, μu(Xi, LN) = min[μ(Xi, LN), μ(Xi)];Where i=1, 2, N2 the final value of the stabilizer output 'LP' can be evaluated as the union of all the outputs given by the relationship μu(LN)= max {μus (Xi, LN)} , for all Xi The membership values for the other M-1 linguistic variables are generated in a similar manner.

v) The fuzzy outputs μu(LN), μu(LP), etc. are then defuzzified to obtain crisp u. The popular methods of defuzzification are the centroid and the weighted average methods. Using the centroid method, the output of the FLC is then written as

$$\mu = \frac{\sum_{i=1}^{M} \mu_u(A_i) * A_i}{\sum_{i=1}^{M} \mu_u(A_i)}$$

$$\mu = \frac{\sum_{i=1}^{M} (\mu_u(A_i) * \text{threshold value of } A_i)}{\sum_{i=1}^{M} \mu_u(A_i)}$$

vi) A set of decision rules relating the inputs to the output are compiled and stored in the memory in the form of a 'decision table'. The rules are of the form

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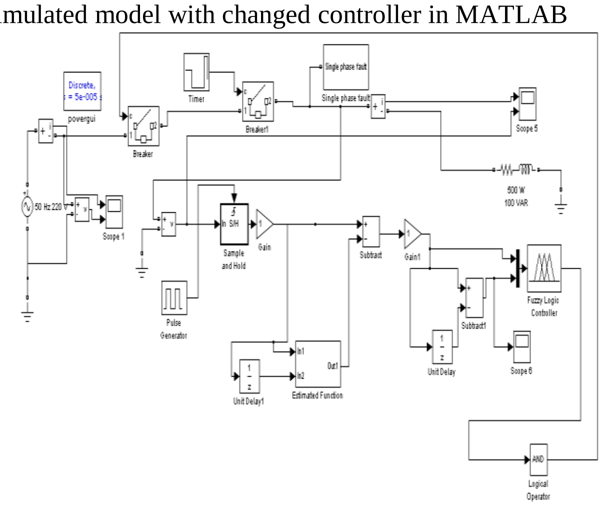
	NL	NM	NS	Z	PS	PM
NS	PS	PL	PL	PS	NM	NS
NM	PM	PL	PL	PM	Z	Z
NL	PL	PL	PL	PL	Z	Z
Z	PS	PM	PL	Z	NS	NM
PS	PS	PS	NM	NS	NS	NL
PM	Z	Z	Z	NM	NM	NL
PL	Z	Z	Z	NL	NL	NL

IV. SIMULATION MODEL CONSIDERED

A power system with single source of 220 V 50 hz with a simple power transmission is set up in the MATLAB. The source is connected at one end of the line & load is connected to the other end of the line. The line is then artificially subjected to a single line fault and the breaker timing is checked tripping with relay controlled by PI logic as usually used and is compared with Fuzzy logic rules approach.

An R-L load is taken at the receiving end with 500W and 100var capacity of active and reactive power also the model is connected with the discrete time delay logical controllers to determine the error and change in error at the scope

Two scopes are taken under considerations and the results are obtained as comparison results from scope 5. below is the simulated model with changed controller in MATLAB



V. RESULT ANALYSIS

- Resulta are compared for the same transmission model syatem were the relay operation once is controlled by PI controller and the second time it is controlled by the designed fuzzy logic rules,figure 1 and figure 2 are the results obtained from PI controltechnique and figure 3 and 4 are from fuzzy logic controller,all these 4 figures obtained are obtained from scope 5 as they are depicting the reaction of fault current ,fault voltage at the time of single line to ground fault.
- At the time of fault the relay practically should get open circuited as it can be cleary sen that with fuzzylogic control the fault current is zero and with PI control the fault current is having a certain value,and hence when the fault current is zero it depicts that the circuit gets open circuited for the faulty time interval completely with fuzzy logic control technique
- Methamaticalcomparision depicts that the results in the switching and accuracy are obtained with 19 % more activeness as can be calculated from the scope 5 graphical analysis
- Harmonic distortion are same for both but rather it is 4.4 % with relay operation with PI and 3.9 % with relay controlled by fuzzy logic approach.

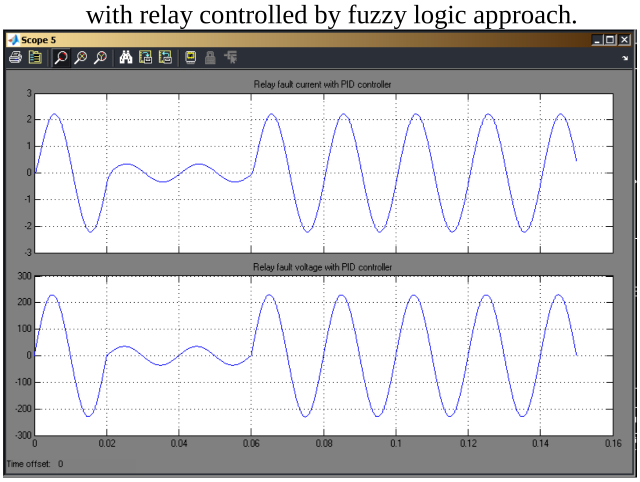


Fig 1 :- relay fault current during fault with PID control

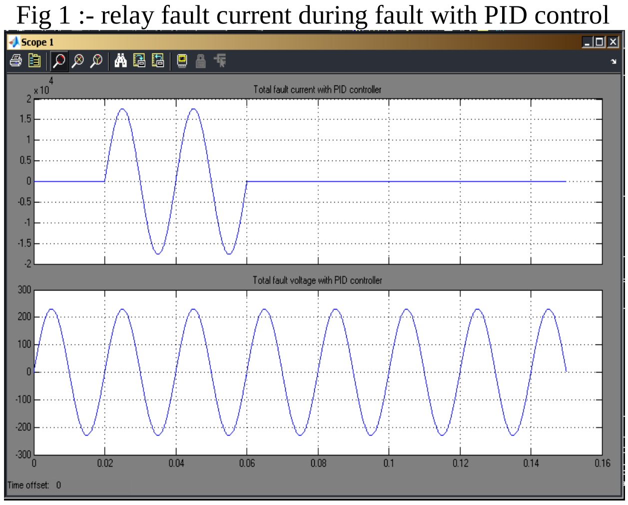


Fig 2 :- total fault current during fault with PID control

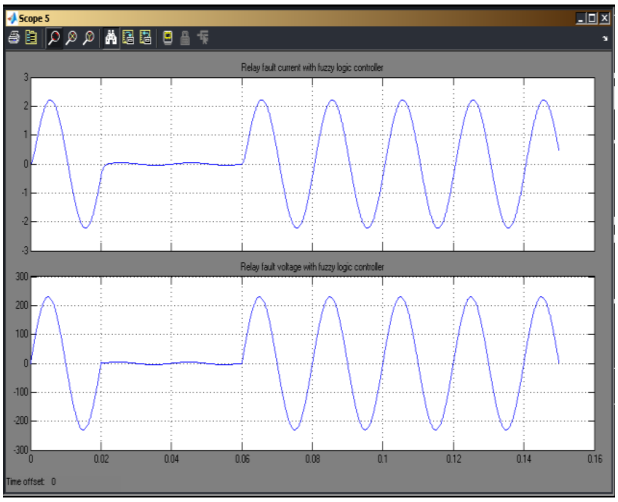


Fig 3 :- relay fault current during fault with fuzzy logic control

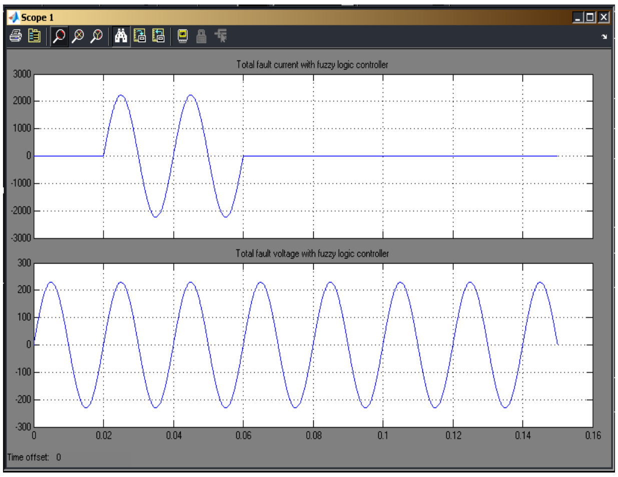


Fig 4 :- total fault current during fault with fuzzylogic control

VI. CONCLUSION

In this paper, experimental results of a protective relay based on PI controller, PID controller and fuzzy logic controller were presented. It can also detect Transient fault and handle it successfully. In addition to the theoretical aspect of fuzzy logic, mathematical definition of the value estimation, detection and measurement of faulty current and faulty voltage, determination of its duration for both i.e. faulty current and faulty voltage, decision mechanism and detailed system architecture were also introduced.

Fuzzy inference is a process that makes a decision in parallel. Because of this property, there is no data loss during the process and so final fault detection will be far more precise than that of conventional relaying techniques.

FUTURE WORK

Application of expert fuzzy system include power system planning, fault detection and transient stability analysis and more development in this way are expected. They also describe about a knowledge based system support used for data acquisition in power system and an "online" diagnosis and advisor tool recently incorporated to a microprocessor based power network control cEnter simulator. Following a brief review of simulator capabilities, reasons that motivated the use of an expert system are stated together with a description of the added package and typical system is used. It can be solved more effectively by using neuro-fuzzy, neuro-genetic, fuzzy-genetic hybrids.

REFERENCES

[1] G. Panda and R. R. Mishra, "Fast intelligent relaying using fuzzy logic technique", IEEE in 2000.

[2] Md. Aminur Rahman, Kazi Main Uddin Ahmed, Md. Rayhanus Sakib, "Modeling of a novel fuzzy based over current relay using Simulink®" , International Journal of Scientific & Technology Research Volume 1, Issue 4, May 2012.

[3] [3] Myong-chul Shin, Chul-won Park and Jong-Hyung Kim, "Fuzzy logic based relaying for large power transformer protection", IEEE Transaction on power delivery, Volume 18,No. 3, July 2003.

[4] Abdullah I. Al-Odienat, Ayman A. Al-Lawama, "The advantages of PID fuzzy controllers over the conventional types", ISSN 1546-9239, 2008.

[5] K. Erenturk, "A new digital protective relay based on fuzzy logic and value estimation", Transaction A, Vol. 29, No. A2, 2005.

[6] Das B. , Reddy J.V. "Fuzzy-logic-based fault classification scheme for digital distance protection", Power delivery, IEEE Transaction, Volume: 20 , Issue: 2, Page(s): 609 – 616, April 2005.

[7] Youssef O.A.S., Suez Canal Univ., Egypt , "Combined fuzzy-logic wavelet-based fault classification technique for power system relaying", Power delivery, IEEE Transaction, Volume: 19, Page(s): 582 – 589, April 2004.

[8] Rusu-Anghel S., Panoiu C., Panoiu M., Topor M., Mezinescu S. "Improvement of electric railway transportation protection systems using a relay based on fuzzy logic", Conference, Page(s): 1 – 4, 8-11 May 2011.

[9] Barbosa D., Netto U.C. , Coury D.V. , Oleskovicz M. "Power Transformer Differential Protection Based on Clarke's Transform and Fuzzy Systems", Power Delivery, IEEE Transactions, Page(s): 1212 – 1220, April 2011.

[10] Yang Q.X., Xu Z.Y. , Lai L.L. , Zhang Z.H. , Rajkumar N. "Fault identification during power swings with symmetrical component", Energy Management and Power Delivery, 1998. Proceedings of EMPD '98. 1998 International Conference, Volume: 1, Page(s): 108 - 111 vol.1, 3-5 Mar 1998.

[11] Pujiantara M., Surabaya, Indonesia, Abdillah M. "Intelligent over current relays based on interval type 2 fuzzy logic approach", Green and Ubiquitous Technology (GUT), 2012, International Conference, Page(s): 58 – 61, 7-8 July 2012.

[12] Jena P. , Pradhan A.K., "Directional relaying during power swing and single-pole tripping", Power Systems, 2009. ICPS '09. International Conference,

Page(s): 1 – 6, 27-29 Dec. 2009.

[13] Etemadi A.H. , Sanaye- Pasand M., "High-impedance fault detection using multi-resolution signal decomposition and adaptive neural fuzzy inference system", Generation, Transmission & Distribution, IET, Volume: 2 , Issue: 1, Page(s): 110 – 118, January 2008.

[14] Zainul A.A. , Ramasamy A. , Abidin I.Z. , Nagi F.H. "Over current time delay determination using gain scheduled PID controllers", Energy and Environment, 2009. ICEE 2009, 3rd International Conference, Page(s): 89 – 93, 7-8 Dec. 2009.

[15] Ren Yu , Zhao Chengyao "Optimal PID controller design in PMSM based on Improved Genetic Algorithm", Industrial Mechatronics and Automation (ICIMA), 2010, 2nd International Conference, Volume: 2, Page(s): 123 – 126, 30-31 May 2010.

Mr. Manish Vishwakarma is a M-tech scholar in corporate institute of science and technology Bhopal. He is a good specialization in the power sector protection system of devices by the approaches of relay .Currently he is working on the protection system in jaiselmer Rajasthan.

Mr. Ashish Kumar Rai is Asst. Prof. & HOD of Electrical & Electronics branch in Corporate Institute of Science & Technology Bhopal, pursuing PhD from RGPV, Bhopal MP India. He has 12 years of teaching experience and 3 years of industrial experience in Power Sector with Adani Power Ltd. & Jindal Power Ltd. His area of interest is Thermal Power Plant Performance improvement, Clean coal technology application, Integration of renewable resources in conventional power generation process. He has published number of research papers in various national and international journals and conference proceedings.

Vivek koshta has done his BE in ELECTRICAL AND ELECTRONICS ENGINEERING and completed his MTECH in HIGH VOLTAGE ENGINEERING from GEC JABALPUR. He is an Asst.proffessor in CORPORATE INSTITUTE OF SCIENCE AND TECHNOLOGY BHOPAL and he has wide area of expertise in Academics in high voltage study and instrumentation.

