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Identification of Faults in Power System Using Fuzzy Logic Technique

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Abstract:- Power reliability and quality of electrical power supply is mostly affected by occurrence of faults in transmission/distribution network. To reduce the time of power outages and for the immediate restoration, the fault identification method must be very effective. Under faulty condition system operator receives very complex information difficult to make decision on restoring a tripped feeder to normal operation. Hence, to build the decision making ability effectively, fuzzy logic based fault diagnosis method is presented in this paper. This method can classify and identify the ten types of shunt faults that occur to Radial topology of transmission/distribution network. This method uses three phase feeder current, neutral current and phase voltages as input to the fuzzy inference system (FIS).

Keywords:- Power system network, Fault Identification, Rule based fuzzy logic.

I. INTRODUCTION

Nowadays, the substantive increase in complexity and diversity of the consuming market, the Electric Power System has been demanding a considerable updating and also a significant improvement on the monitoring, control and protection equipment. On the distribution system, the fault's location is usually estimated at information provided by the consumers and also by the accumulated experience of the technical areas, which aids the direction of the support teams to the suspicious places. The faults of the power system affect the overall performance of the power system. The factor like lightning, equipment damage, tree, animal, natural disaster and human affect the power system operation. These factors are not predictable. When outages occur, fast and proper restoration of feeder is important to maintain the good power quality and customer satisfaction. Hence, to reduce the time of outages and immediate restoration, the expert systems are needed to identify the faults of power system.

Although, a large number of techniques are available for fault identification and classification. These previous techniques have their own advantages and disadvantages. Also in contrast to the transmission lines, the distribution system feeders are short and hence mostly un-transposed. As a result there is a significant amount of mutual coupling with the three phases of the distribution feeder. Hence, for a fault on any of the phases, the other phases also get affected [1-2]. The researchers are interested in finding solution to the problem of vagueness, incomplete fault information, error in fault data and information redundancy. For the fault location algorithms, correct information about fault type is needed. So the accurate, fast and reliable fault classification technique is an important operational requirement in modern day automated power transmission / distribution system. There is a difficulty in classifying the type of faults of the parallel lines using conventional techniques, principally because a faulted phase on one circuit has an effect on the healthy phases due to mutual coupling with the two circuits [3-4]. To overcome above uncertainties rule based fuzzy logic expert system is presented in this work. The purpose of developing is to reduce the human computation error and reduce the computation time. The other expert system like neural network is not chosen because it requires abundance of computation training time. This will cause the diagnosis inefficient and require longer time to identify the fault. The paper focuses on design procedure of fuzzy logic model.

In [5], a combination of hybrid cause -effect network and fuzzy rule based method has been used to identify the types of fault. But this technique has two limitations. First, it assumes that the information regarding any device opening and closing and the real time measurement data are known. Thus, this method requires considerable amount of data onto correct fault identification. Secondly, this method determines whether the fault is single line to ground or double line or double line to ground faults or three phase faults, but does not identify the phases (A, B, or C) involved in the fault. In [6], addresses the problems encountered by the conventional techniques at fault type classification in double circuit transmission lines, these arise principally due to the mutual coupling between the two circuits under fault conditions, and this mutual coupling is highly variable in nature. In [7], presents a new approach to real time fault detection and classification in transmission systems by using neuro-fuzzy technique. The integration with neural network technology enhances fuzzy logic systems on learning capabilities. In [8], discusses the practical application problems including data insufficiency, threshold setting and imbalanced data constitution that are often faced in power distribution. In [9], fuzzy logic based method to identify the faults type in radial, unbalanced distribution system has been developed. The proposed technique is able to accurately identify the phases involved in all ten types of faults that may occur in an electric power distribution system under different fault types, fault resistance, fault inception angles, loading levels and system topology. The proposed method needs only three line current measurements available at the substation to classify the various faults. In [10], a methodology is presented to detect high impedance faults in distribution feeders by means of fuzzy logic reasoning. This technique is based on the analysis of the feeder responses to impulse waves which are periodically injected at the feeder inlet. These responses are compared to standard responses which were previously stored in database.

On one hand, correct information about type of faults is readily needed for fault location methods. On the other hand, for the proper operation of protective relays correct identification of the type of fault is prerequisite in the digital protection scheme. In this work, rule based fuzzy logic is used to identify the ten types of faults occur mostly to the radial topology of power system. The proposed method is able to accurately identify the phase(s) involved in all ten types of faults that may occur to an electric power transmission/distribution system. The proposed method needs currents & voltages measurements available at the substation to train a rule based fuzzy logic system. The system is easy to understand and gives the effective results. From the output crisp values of the fuzzy fault detection system, we easily identify the type of faults and phases involved in it

II. FAULT ANALYSIS

The great majority of faults on the power system are of unsymmetrical nature; the common type being a one line to ground i.e. single lined to ground faults. When such faults occur, it gives rise to unsymmetrical current i.e. the magnitude of fault current at the faulted phase goes very high and causes the unequal phase displacement of three line currents. The symmetrical fault i.e. all three phases short (L-L-L) or all line short circuited with a ground (L-L-L-G) gives rise to symmetrical fault current i.e. fault current in the three lines is equal in magnitude and displaced 120^0 from one another these faults imposes heavy duty cycle on the circuit breaker. When faults occur, the faulted line current starts to increase, this faulted current is greater than the currents in healthy lines. In case of single line to ground faults, only one line current increases greatly, while in case of double line to ground faults, two line currents are greater than the third line current. In general, when faults occur, currents increases in magnitude and voltages go down as per the severity & occurrence of faults. Table 1 shows the different faults with severity.

Table I: Different Faults with Severity

Fault	Severity	Occurrence
3-∅ (LLL, LLLG)	Severe	5%
Phase to phase ground (LLG)	Severe	10%
Phase to phase fault (LL)	Less Severe	15%
Single line to ground Faults (LG)	Very less	70%

III. PROBLEMS IN FAULT CLASSIFICATION IN POWER SYSTEM NETWORK

The performance of the transmission line is mostly affected by the occurrence of faults. This affects the generation of power and also effect on the consumers. If faults occur in any of the phases the healthy phase also gets affected because of the effect of mutual coupling. The nature of the healthy waveform also gets change and it is difficult to identify the type of faults by the conventional techniques. Under certain fault conditions the coupled healthy phase may sometimes be wrongly diagnosed as being the faulted phase. As an example, consider a simple power transmission system as shown in fig.1

In this system, the fault (double line to ground) has been applied and the three phase voltage and current waveforms are shown in the following fig.2.

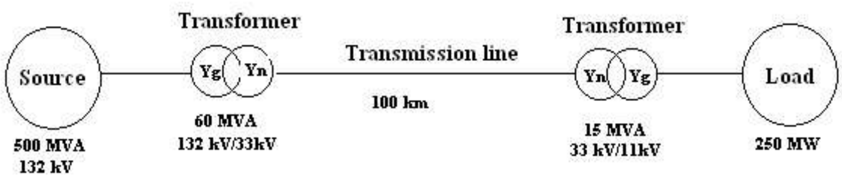

Fig.1: Single line diagram of power system.

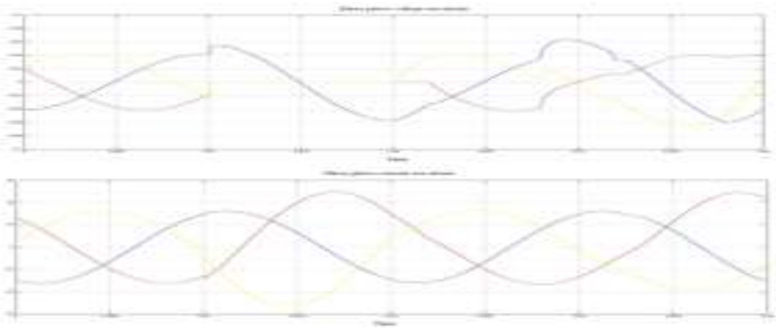

Fig.2: Voltage and current waveforms for L-L-G (A-B-G) fault

The fault is assumed to occur at 0.1 sec. From this figure, it is clear that due to the mutual coupling, the healthy phase 'C' is also affected for A-B-G fault. As a result, the other healthy phase(s) may also sometimes be identified as the faulted phase(s).Thus, there is a strong need to develop an appropriate technique to differentiate between the faulted and healthy phases.

IV. FUZZY LOGIC

Fuzzy logic algorithm is simple & does not require any complex computation. In fuzzy set theory concepts of possibility used and defined by a number between zero and one. Fuzzy provide a mathematical way to represent vagueness in humanistic system. The membership function describes the degree that the universe belongs to fuzzy set. The vague terms high and low can be represented by fuzzy sets. By taking the RMS values of measuring quantities appropriate fuzzy sets are design: Low, Normal, and High.

A. Fuzzy Algorithm

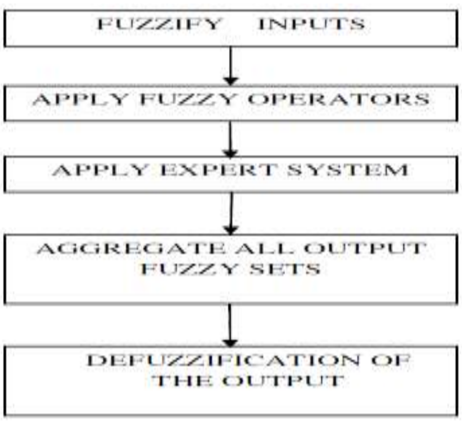

Fig.3: Algorithm for the Design of the Fuzzy Inference System.

B. Membership functions and fuzzy rules

Different levels of the fault voltages and currents for different fault conditions on the transmission/distribution line are classified into membership function Low, Normal and High. In general, as faults occur, currents increase in magnitude and voltages go down. The membership functions are used to form the rule based fuzzy fault detection system

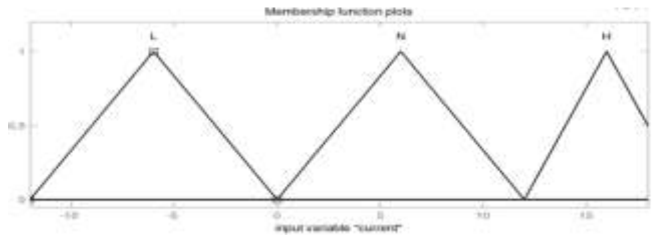

Fig.4: Membership function for IA, IB, IC

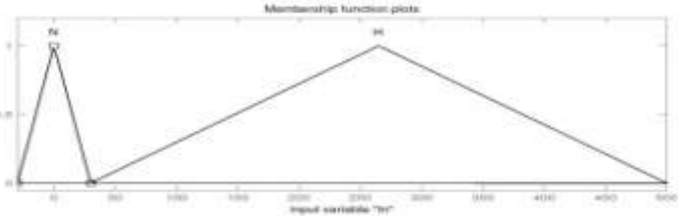

Fig.5: Membership function for IN

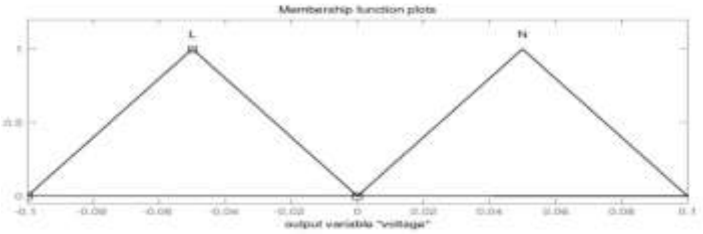

Fig.6: Membership function for VA, VB, VC

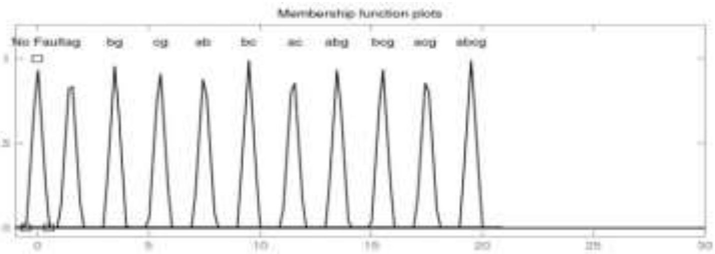

Fig.7: Membership function for different types of faults

The fuzzy Rule Base is formed by rules , extracted from the ten types of shunt faults. The rules are structured as follows :

1. **IF** I_A is High, I_B is Normal ,I_C is Normal , I_N is High, V_A is Low, V_B is Normal and V_C is Normal **THEN** Fault type is single line to ground fault in phase A (SLG-A).
2. **IF** I_A is High, I_B is High ,I_C is Normal , I_N is Normal, V_A is Low, V_B is Low and V_C is Normal **THEN** Fault type is line to line fault in phase AB (DL-AB).
3. **IF** I_A is High, I_B is High ,I_C is Normal , I_N is High, V_A is Low, V_B is Low and V_C is Normal **THEN** Fault type is double line to ground fault in phase AB (DLG-AB).
4. **IF** I_A is High, I_B is High ,I_C is High , I_N is Normal, V_A is Low, V_B is Low and V_C is Low **THEN** Fault type is Three phase symmetrical fault.

V. SIMULATION AND RESULT

The single line diagram shown in the fig.1is taken as a system model and analysed using the MATLAB/SIMULINK® software. The simulations for the various types of faults were carried out for various faulted & non-faulted conditions. Currents & voltages under these conditions were recorded. The fault detection block is shown in fig 8, which is used to detect various types of faults. The currents and voltages are given as inputs to the fuzzy logic controller placed in the fault detection block and the output crisp values and neutral current is the input of the subsystem shown in the fig 9.

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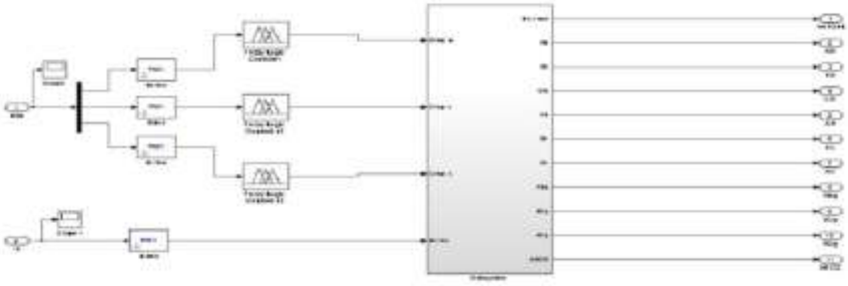

Fig.8: Fault detection block.

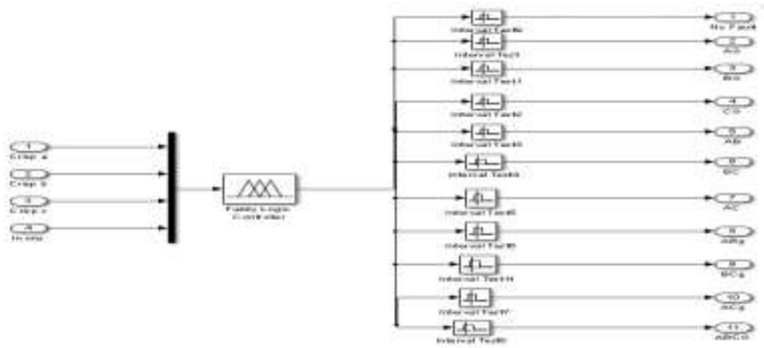

Fig.9: Fault detection subsystem

In the subsystem the output of the fuzzy controller is provided to the interval test block. The various types of fault membership functions are designed. For *e.g.* in case of normal condition the fault membership functions are specified in the range between -0.5 to 0.5 so as in case of no fault condition the output of fuzzy controller is in the range of -0.5 to 0.5 and this output is provided to the interval test block. The interval test block shows outputs TRUE if the input is between the values specified by the lower limit and upper limits parameters *i.e*. TRUE in case of no fault if the input to the interval test in the range -0.5 to 0.5. The block output is FALSE if it is not in the specified range. This fuzzy based fault identification system is able to detect all the ten types of faults *i.e*. single line to ground fault in phase A, B, C, Line to line fault in phase A-B, B-C, A-C, Double line to ground fault A-B-G, B-C-G, A-C-G, and the Three phase symmetrical fault. The various types of faults are carried out in the logical model of power system and the output of fault detection block on the displays is tabulated in the table 2.

Table II: Output of Fault Detection Block

FAULT TYPE	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D 10**	**D 11**
NO	1	0	0	0	0	0	0	0	0	0	0
A-G	0	1	0	0	0	0	0	0	0	0	0
B-G	0	0	1	0	0	0	0	0	0	0	0
C-G	0	0	0	1	0	0	0	0	0	0	0
A-B	0	0	0	0	1	0	0	0	0	0	0
B-C	0	0	0	0	0	1	0	0	0	0	0
A-C	0	0	0	0	0	0	1	0	0	0	0
AB-G	0	0	0	0	0	0	0	1	0	0	0
BC-G	0	0	0	0	0	0	0	0	1	0	0
AC-G	0	0	0	0	0	0	0	0	0	1	0
3Phase	0	0	0	0	0	0	0	0	0	0	1

VI. CONCLUSION

The mathematics behind the fuzzy logic is easy to understand and easy to design. In this paper, fuzzy logic is effectively used for identification of the faults. The three line currents, phase voltages are sufficient to identify the ground faults but for the line to line fault the neutral current is necessary to distinguish the nature of the double line to ground and line to line fault. Hence, for the successful implementation of the system line currents, phase voltages and neutral current taken as input to the fuzzy logic. The accuracy of the proposed technique is very high and does not affected by during the fault condition.

The various conclusions are drawn from the proposed fuzzy logic faults detection system presented in this work

1. The proposed method is very easy to understand and simple to design.
2. The proposed method has approximately 96 % of accuracy to identify the type of fault.
3. The proposed algorithm has membership function design according to experimental results obtained.

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