Enhanced FIS Operated Relay Model For Power System Overcurrent Protection

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Abstract: *Consumption of electricity has significantly enhanced the need for transmission of electricity from one point to another. This involves the use of transmission lines. With the changing conditions of environment possibility of occurrence of faults is higher. Overvoltage, over-current, short-circuit etc. are some of the faults which occur in the power systems. These faults affect the performance of the power systems. For the smooth operation of the power system it is necessary to remove the faults from the system. Various techniques have been proposed by researchers for detection of the faults and decision making. Different schemes like relay control, digital signal processing (DSP) were used by them. Input data taken from the relays is given to the DSP regularly and it makes the decision. This existing system is efficient but it lacks in operation time. To overcome this issue, in this paper a fuzzy logic based approach is used in the proposed system. The Mamdani type fuzzy logic is used here. The simulation has been performed which represents that proposed approach helps to achieve efficient power system.*

Keywords — *Fuzzy Logics, Power System, Over-current, Proactive Devices.*

I. INTRODUCTION

(Electric power system is the type, of network in which all the electric components are employed for providing the supply, transferring and using electric power. A power system network involves the electricity generation, its distribution and transmission. There is need for stability in power system in order to perform efficient and smooth operation. Stability is the ability of the power system to attain the equilibrium state for the given initial situations when it is exposed in the physical environment disturbances providing optimum variables bounded to preserve the system integrity. System integrity is saved when whole power system remains undamaged without tripping of loads or generators despite the disconnected by isolating them from the faulting elements tripped intentionally in order to save the regularity of the operation for other system part. Instability occurs when the disturbances cause the imbalance among two opposite forces. Power system is a highly nonlinear nature system which operates in the continuously varying scenarios, like output of generators, loads, topology, and main operating parameters vary regularly. When the system is exposed to the changing variations, stability in such situation will also depend on starting condition of the system along with the behaviour of the disturbance. It should also be capable of serving under worst conditions like short circuit over the transmission line or loss in large generator.

There are various fault types seen in electrical systems because of the internal or external affects [2].

- Overvoltage due to lightening;
- Short circuit due to mechanical effect [3];
- Over current due to equipment overloading [4];
- Aging;
- Human error
- Nature external influence

Protective devices are used for protecting the power system from getting damaged of addressing any failure and due to any fault [5].

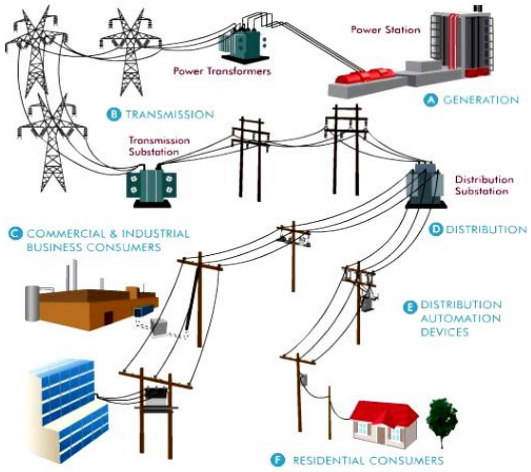

Fig 1: Electrical Power System [1]

Relays are the protection devices that can limit the fault and minimize the losses. These are the components which continuously monitor the system along with them and take the suitable decision as per the condition. They decide about which decision they should take and also with what time delay for process depending on the type of fault [6].

In these power system problems, one problem i.e. of overcurrent protection is crucial for the individual safety along with the protection from severe situations which are led by the ignition because of the unsuitable overload protection or short circuit safety.

In order to protect the transformers, motors, lines and generators, one of the simple and easy protection methods is over-current relays. Over-current relay comes into action when the current goes beyond rating.

For detection of impacts of relays on power system parameters and to control relay operations, different types of methods are used. DSP is used to control the relay operation. The purpose of DSP is to shield and control the power systems [7]. A sequence having design depends on time, equipment damage curve and upper relay tripping time on which relays are tripped, is controlled by digital signal processing.

The Information is manipulated mathematically for modification and this process is known as DSP. Representation of discrete frequency or time or other discrete domain signals through sequence of symbols or numbers and processing signals, contributes in characterization of DSP.

II. LITERATURE REVIEW

In order to make the power system more efficient and to remove the faults and issues, various researchers had proposed various approaches:

Author in paper [4] portrayed a novel electrical relay protection system design with the help of chip; which could be utilized to ensure electrical hardware during different conditions of faults. A scope of protection plans had been presented. Different propelled capacities like situation recording, keypad data entry, run-hour alert, etc. were discussed in the paper.

In paper [8], authors had proposed the DSP system which took the samples from the input given to the load repetitively and took the respective action as per the need. In the paper author had discussed the internal connections of the relays in DSP. SIMULINK software tool in MATLB was used for analyzing the effect of DSP on protection relays.

Using the concept of custom power, in paper [9] author suggested a novel system device which served as the UCPC. There are power converters connected in series and parallel to the UCPC system in BESS for multipurpose operation of the battery system for the compensation of the changes in the voltage, reactive power, imbalance, UPS and flickering, peak power supply reactive and active power controlling in the transmission system. Circuit topologies used for controlling were taken into consideration.

In paper [10], author evaluated the DSP-based FLC for the battery charger. The fuzzy control algorithm was applied with DSP in order to optimize the fuzzy rule dependent system for generating the required amount of power.

In paper [11], author proposed a power system simulation model. It was designed for testing of complicated protection relays. The simulator of the power system described in this paper was designed to measure the security of complex relays. This technology simulates typical events with very low costs without the need for unnecessary computer functions.

Potential solutions to the safety problems have been explored in this paper [12] in DC Shipboard Power Systems. There were two different options addressed. The first choice was to use SSCBs to restrict and interrupt fault current. The 2nd technique considered was to use VSC to serve as crowbars themselves.

A protection system is advocated in paper [13] using a Multi-Agent idea for power distribution systems. Each digital over current relay (OCR) was constructed as an agent by adding its own intelligence, auto tuning and communication capabilities. To deal with rapid variations in the state and faults of network activity, an OCR device suggested in the paper.

Thus, there are various existing techniques which are used for protections from the variations in power. However these techniques are not sufficient in the modern used sensitive loads as these existing systems are not fast enough to detect the sudden and small fluctuations in the power system.

III. PRESENT WORK

Various techniques are designed in the past to overcome the issues in power systems. In the existing system researchers studied the effects of DSP on the protection from over-current and the processing time for the power systems. In this system researcher had used the DSP algorithm for the determination of the situations during fluctuations and make final decision. IDMT equation was used for calculation of the time during which voltage in power system changes. This time is calculated depending on the inverse characteristics. Although this system provides good results and help in detecting the faults in the power system but this is not sufficient for the modern real time devices because nowadays loads in systems are quite sensitive and they are affected by the minute fluctuations in the network. While the existing system use the IDMT equation for calculation of time to switch the circuit. This approach is not adaptive in the environment where there is need of quick response from the switching device so that the sensitive appliances could be saved from getting damaged and has better results. This real-time response is not achieved using the existing techniques.

Therefore, there is provision for upgrading the switching systems to save the loads from getting damaged during rapid fluctuation in the network. So in proposed system, a fuzzy logic controller is proposed to deal with these problems. The

information attained from the fuzzy system can be used effectively for tackling the effects in the systems output which are not required. Controller of Fuzzy analyses the faults present in the system. In case the amount voltage is higher than the particular limit it serves as switching device. With its use the devices or electronic appliance can be given safe environment for operation.

IV. METHODOLOGY

Following steps are involved in the methodology of the proposed system:

1. First step is to take the three phase power source. This three phase power source is taken from the transmission line coming from the power substations.
2. Once the power source is taken, next step is to take attach the load to the system. Voltage and current are also measured by taking the input from the three phase supply.
3. Fuzzy logic controller is attached to the transmission line circuit, which further connected to the three phase circuit breaker.
4. After measurement of the voltage/current, input is given to the fuzzy controller. Fuzzy uses if then rules for making decision about whether to break circuit or not. If the voltage is more than the rated value, fault is occurred in the system.
5. On detection of fault, fuzzy controller immediately sends the command to the circuit breaker for breaking the circuit.
6. Further three phase breaker is also provided with the VI measurement instrument which measures the level of voltage for comparison purpose.
7. A three phase fault is introduced in the circuit after the circuit breaker.
8. Succeeding the circuit breaker, load is attached.

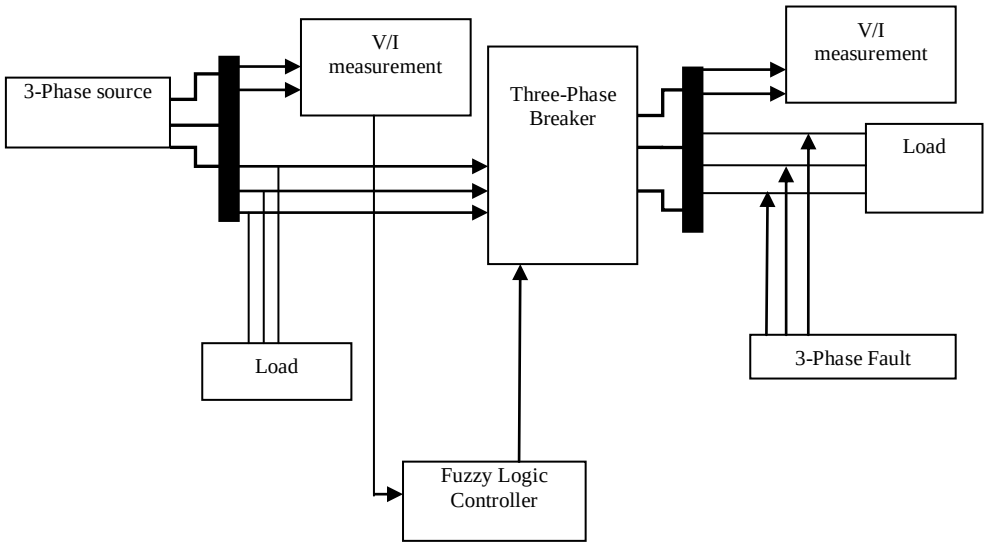

Fig 2: Methodology of proposed work

V. RESULTS AND DISCUSSIONS

In this paper, fuzzy logic controller is used for controlling the switching operation of the power systems during the fault conditions. A three phase supply is used as the power source. Continuously the V/I of the circuit is measured. Whenever the voltage goes beyond the prescribed level, fuzzy logic sense it and command to break the circuit is sent to the circuit breaker employed in the circuit. Simulation results of the system model designed in the MATLAB software are discussed as follows:

Graph in the figure 3 shows the voltage and corresponding current when no controller and circuit breaker is used for limiting the overvoltage. Voltage is shown along y-axis and time is represented along x-axis. It can be seen from the graph that even after the set time limit of 0.1 sec for the voltage, circuit is not broken and current is continuously flowing in the circuit (current graph).

Fig 3: Voltage/ Current without any Controller

Fig 4: Voltage/Current in presence of Relay

Figure- 4 shows the graph of voltage and current when the relay is employed in the circuit for controlling the voltage. From the graph it can be seen that after 0.1 second, voltage in the circuit goes beyond threshold level. But the circuit is not broken yet, as it takes some time and with delay. Relay breaks the circuit after 0.4 seconds.

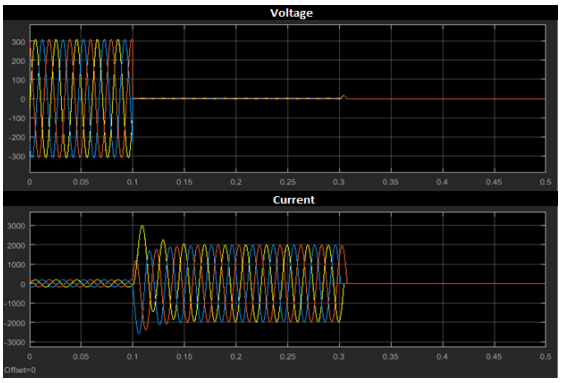

Fig 5: Voltage/Current with FLC

Figure-5 shows the voltage and current characteristics during the presence of fault and fuzzy logic controller for breaking the circuit. It can be clearly seen from the graphs that operation time for circuit breaker using fuzzy logic controller is reduced from 0.45 to 0.3sec.

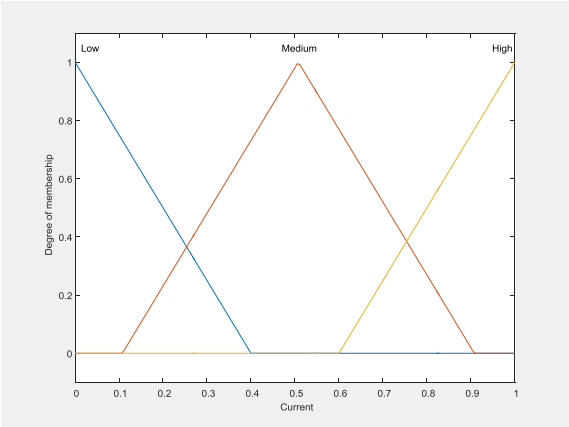

Fig 6: Current membership functions

Fig 6 shows the degree of membership functions. A membership function defines the degree of truth of the fuzzy system. Here membership function defines the current level. Three categories for Current membership functions are low, medium and high represented with blue, orange and yellow line respectively.

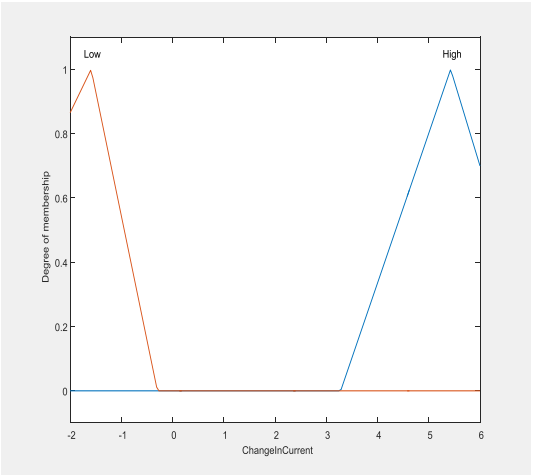

Fig 7: Membership function for change in Current

Figure 7 shows the membership functions for current change. Graph shows the change in current with respect to two categories of membership functions i.e. low and high. These are shown in the graph with yellow and blue line.

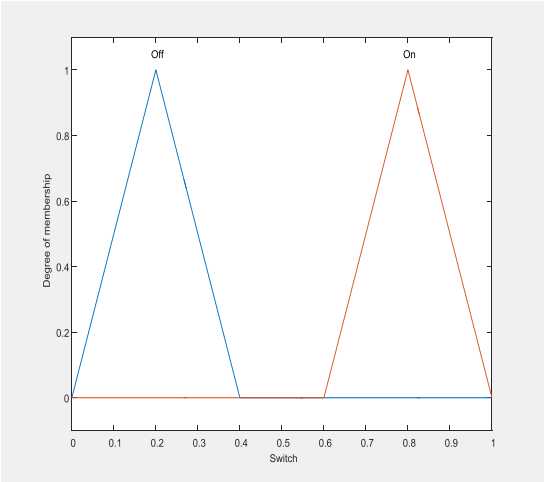

Fig 8: Switch operation of Fuzzy controller

Figure 8 shows the switching operation of the fuzzy logic controller during the occurrence of fault. Graph shows that degree of membership function during OFF is 1 and after 0.4 the switch gets OFF and value for degree of membership function is 1.

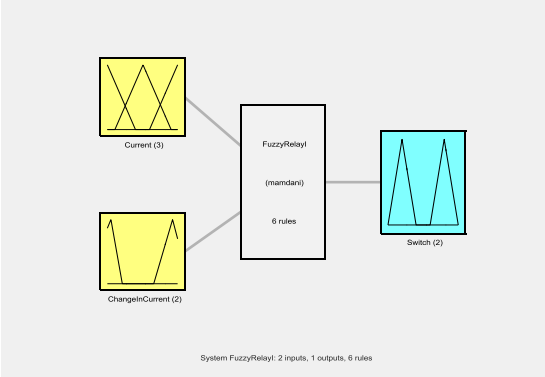

Fig 9: Derived Fuzzy system for Power system control

Figure-9 shows the block diagram for the obtained system for power system using Mamdani fuzzy logic controller. For the current, three membership functions are defined i.e. low, medium and high. Similarly for the variation in current, two membership functions are defined in the proposed system. These both serve as the input for the fuzzy system and make 6 fuzzy rules.

Mamdani fuzzy system gives the output as the switch. This switch is used for breaking the circuit at particular time.

VI. CONCLUSION AND FUTURE SCOPE

Various types of faults occur in the power system. These faults affect the smooth working of the power systems. Overvoltage largely affects the system performance. There is need for breaking the circuit at appropriate time whenever fault occurs in system so that appliances and devices could be saved from getting damaged.

Fuzzy logic Controller is the human-thinking based system used for decision making. It works on if-then simple rules. So in the proposed work, FLC controller is used for controlling the circuit breaker operation. Here 3-phase power supply is taken as the source input for the model. In between the circuit breaker a FLC controller is used. Whenever the voltage goes beyond the certain specified level, after interjection of fault in the system the circuit is broken. Three membership functions for the current i.e. high, low and medium are taken for analysis. For change in current two membership functions are represented in the graph. The entire proposed system model is designed in the MATLAB simulation software. From comparison with the existing system it is seen that with the conventional method the operation time was 0.3017 while with the proposed fuzzy logic approach, operation time is reduced to 0.1979 which is quite less than the existing one. This helps in saving the devices from getting damaged.

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