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Power Transformer Protection Using Adaptive Differential Relay Using For Fault Analysis

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Abstract— This paper discuss the fault analysis and differential protection scheme of the three phase power transformers. The relay operates mainly during the internal fault condition and it must be insensitive to any fault outside the zone of protection. In this paper, a fuzzy logic based differential protection schemes has been used. It blocks the tripping during external fault condition or magnetizing inrush current and it trips the relay during internal faults. The simulation result of fuzzy logic based differential relay for three phase power transformer shows the fast tripping during internal fault and also avoids the mal operation of relay during external fault.

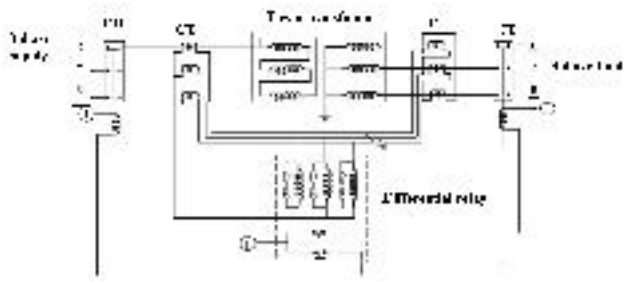
Keywords— Circuit Breaker, Differential relay, Fuzzy Logic Controller, Mat Lab, Power Transformer, Transmission Line .

I. INTRODUCTION

Power transformers (PT) are one of the most important components in a transmission line. So they require proper analysis and protection during faults period to avoid PT damage. For economic and reliable operation of power supply to the consumer need proper protection schemes applied to power systems. It must fast tripping during faults and more reliable which discriminates the internal faults, external faults and other operating condition (like magnetic inrush current, CT saturation). On the other hand, the protection schemes to avoid mal function or false tripping during faults occurred out of the protection zone. Differential protection is based on the fact that any fault within electrical equipment would cause the current entering it to be different, from that leaving it. Thus compare the two currents either in magnitude or in phase or both and issue a trip output if the difference exceeds a predetermined set value. In recent trends technology aimed at improved selectivity, sensitivity, and operation time of differential relays has been presented to overcome the related problems. But they need large data's and operating time is more. In this paper an improved fuzzy logic based differential relay is proposed which is capable of differentiating between magnetizing inrush current, internal faults, external faults and reduced tripping time. Proposed protection scheme is fast and auto reclosing of circuit breaker after the removal of fault. Power system with Fuzzy Based differential relay is modeled using matlab-simulink.

II.PRINCIPLE OF DIFFERENTIAL RELAY

The operating principle of power transformer differential protection as in shown Figure 1 is based on comparison of the transformer primary and secondary winding currents.



ISSN:0971-1260
Vol-22- Issue-14-December-2019

Fig. 1.Block Diagram of Differential Relay

During the normal operating condition, the current I1 enters the primary winding and I2 leaves the secondary winding of the transformer must be equal as shown in Figure 2.

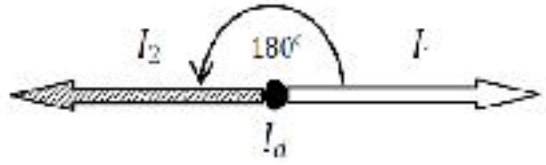


Fig. 2.Output Currents of the CT's Under Normal Conditions

If any unbalances are encountered in between both the currents which are due to the faults, the primary and secondary current are different as shown Figure 3, then the relay will actuate and gives trip signal to circuit breaker of both the primary and secondary side of the transformers[7].

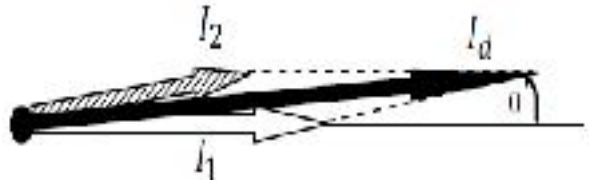


Fig. 3.Output Currents of the CT's Under Faulty Conditions

III.FUZZY RULE BASED DIFFERENTIAL RELAY

The block diagram of Differential relay based on Fuzzy System is shown in Figure 4, in which the first step is to acquire the data from primary and secondary windings of power transformer by using current transformer. After acquiring the data from both windings of power transformer, the data will be processed and differential currents are calculated. The differential current (also called operating current) Id will be obtained as the sum of currents entering and leaving the protected zone, according to the following equation,

Id = I1- I2

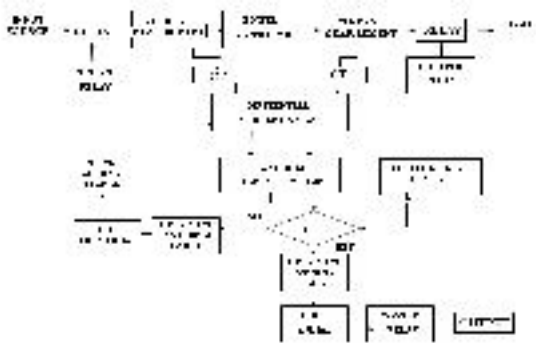


Fig. 4.Block Diagram of Differential relay Based on Fuzzy System

The differential relay actually compares between primary current and secondary current of power transformer. If any unbalance found in differential current, the data are sent to the inputs of the fuzzy logic system [8],[9]. The fuzzy system is designed to make a distinction between internal faults and other operating conditions (like inrush current) of power transformer. If the output is greater than the threshold value of the fuzzy system, then the relay sends a trip signal to the circuit breaker. The trip decision is based on the relative amplitude of the fundamental current component compared to components of differential current signal .

The proposed fuzzy logic based differential 9 rules to discriminate between internal faults and other operating conditions to make a distinction between two operating conditions i.e.

- Steady state and
- Internal faults.

The 9 fuzzy inference rules are classified to three categories depending on the matrix of input variable. In this work, the compositional fuzzy inference matrix were using, where (Max-Min) method is chosen to perform a mathematical operation.

The three input membership functions are connected with each other in Rule Editor. A membership function is a function that defines how each point in the input space (universe of discourse) is mapped to a membership value varies between 0 and 1.

ISSN:0971-1260
Vol-22- Issue-14-December-2019

Input variable 1 indicating as low value in primary side is shown Figure 5.

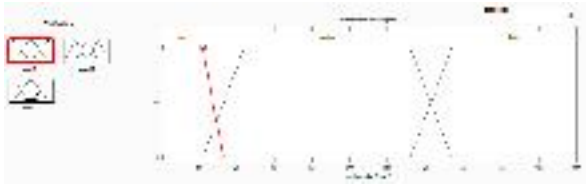


Fig. 5.Input Variable 1

Input variable 2 indicating as low value in the secondary side is shown Figure 6.

Fig. 6.Input Variable 2

Both the input variables are low to the transformer and the output has the steady valves is shown in Figure 7.

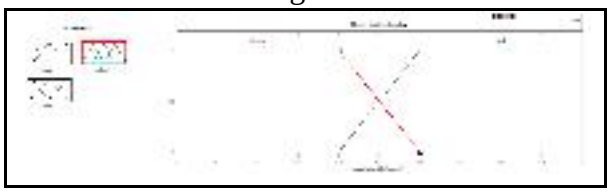


Fig. 7.Output Variable

Simple rules that have been implemented using the three input membership functions.

IV. SIMULATION RESULTS

LOAD VOLTAGE AND CURRENT WITHOUT FAULT CONDITION

Many of the commercial relays utilize the second harmonic component to block the differential relay against inrush current. Sudden current change and decaying dc component of the fault current generate a large amount of the second harmonic component which can block these relays for about 15 ms after the fault inception . Meanwhile, a fix time delay, for example, 4 ms is usually used to ensure occurrence of an internal fault. Accordingly, the trip command is issued about one cycle after the fault instant. The proposed approach not only decreases the intentional time delay by utilizing the adaptive weighting-based technique, but also is not directly blocked by the inrush detection unit. Consequently, this approach operate faster than the conventional differential relays.

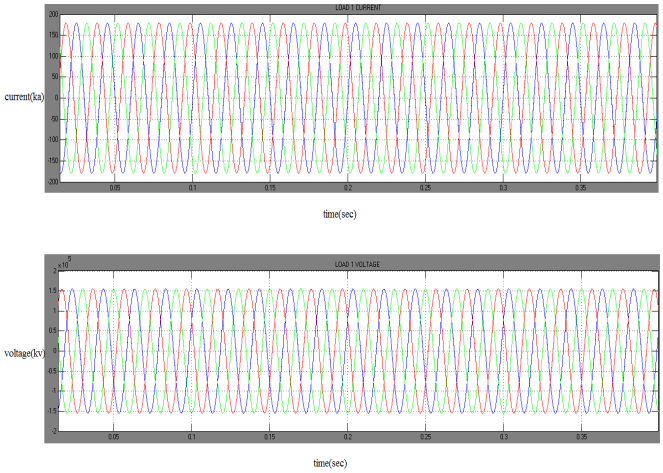
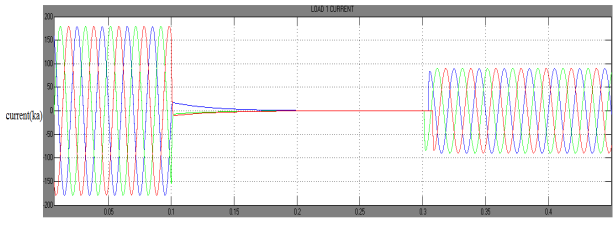


Figure.8. Load Voltage and Current Without Fault Condition

LOAD VOLTAGE AND CURRENT WITHTHREE PHASE FAULT CONDITION

The relay output value one concludes that in case of fault within the protected zone, i.e., internal fault it attains the value above the threshold and it sends the trip signal to the circuit breaker. After that the fault clearing period the relay auto reclosed and give the supply to the load. The total output current waveform of fuzzy based differential relay as shown in Figure 9. During the faults period 0.1ms to 0.33ms the relay in turnoff period, that means the input does not give the load. After that the fault cleared, the relay auto-reclosed and gives the supply to the load from period of 0.33ms.



ISSN:0971-1260
Vol-22- Issue-14-December-2019

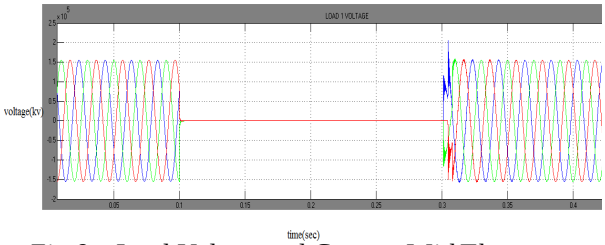


Fig.9. Load Voltage and Current WithThree Phase Fault Condition

PHASE A TO GROUND FAULT

Simulation result for A-G external fault is shown in Figure 10, in internal fault condition, the current through transformer varies but a reliable differential relay must not give a tripping signal to the circuit breaker in this case.

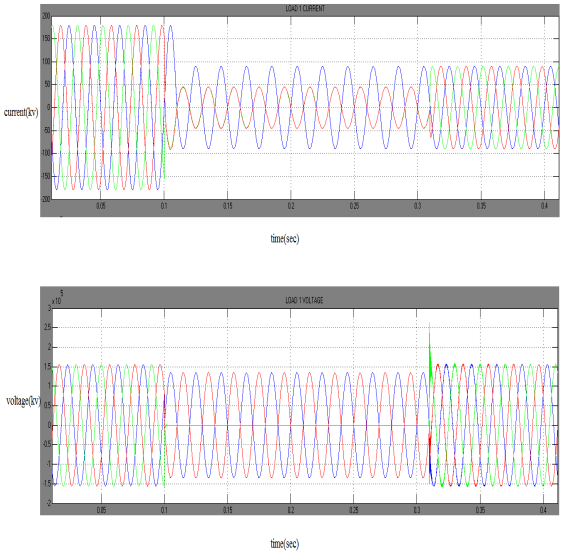


Fig.10. Phase A to Ground Fault

PHASE B TO GROUND FAULT

In internal fault condition the current through transformer varies during the period of 0.1 to 0.3, the differential relay must not give a tripping signal to the circuit breaker. So that the fuzzy control avoid the false tripping of relay from the fault outside the protective zone. The simulation output waveform of phase B-G as shown in Figure 11during internal fault condition.

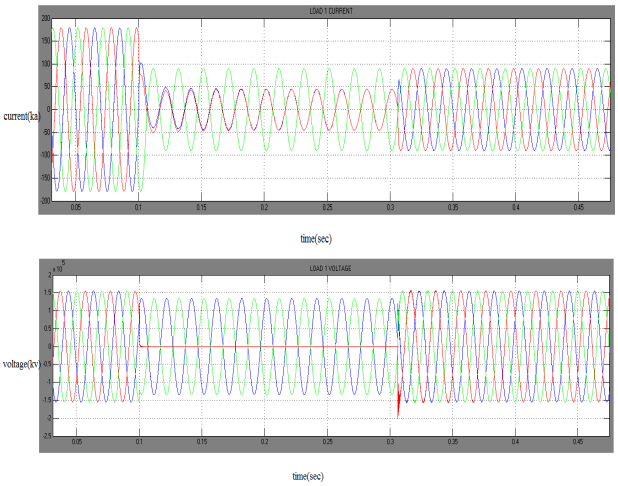


Fig.11. Phase B to Ground Fault

PHASE C TO GROUND FAULT

Simulation result for phase C-G as shown in Figure 12, the line current is high during an external fault condition the proposed relay senses but it does not give the trip signal, so the relay is more sensibility and reliability.

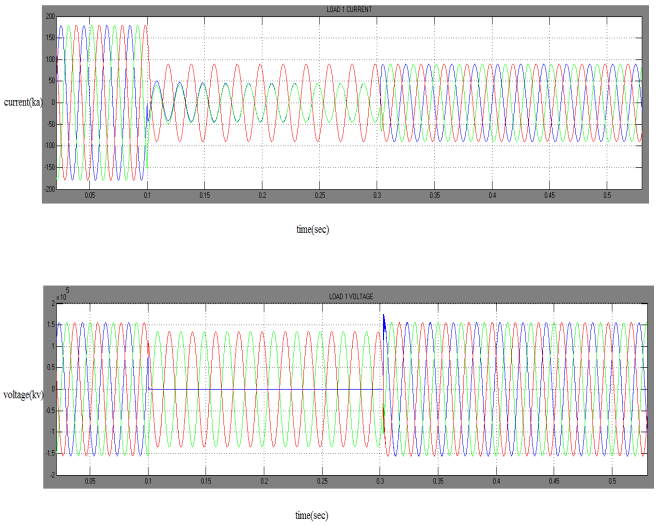


Fig.12.Phase C to Ground Fault

OUTPUT WAVEFORM OF FIS SYSTEM

The differential current acquire from the primary and secondary of the current transformer is increased above the threshold value is 0.55, the FIS system

ISSN:0971-1260
Vol-22- Issue-14-December-2019

gives the control signal to relay to trip the circuit breaker. After clearing the fault, circuit breaker auto-reclosing the circuit and give the supply to the load.The output waveform of Fuzzy Inference System is shown in Figure 13.

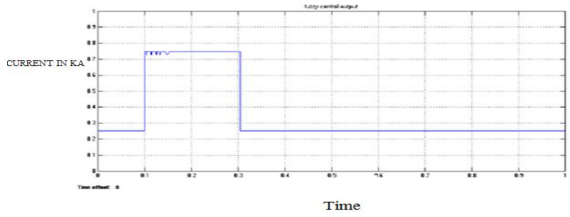


Fig.13. Output Waveform of FIS System

OUTPUT WAVEFORM OF DIFFERENTIAL RELAY

After receiving the signal from FIS system, then the relay gives the trip signal to the circuit breaker during the internal fault from the period of 0.1ms to 0.33ms as shown in Figure 14.

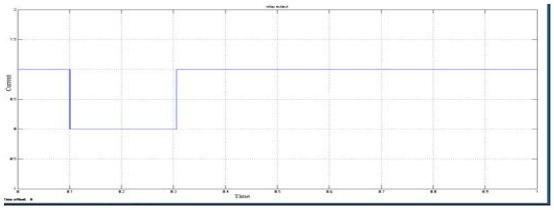


Fig.14.Output Waveform of Differential Relay

The Fuzzy Inference Based differential relay sends a trip signal to circuit breaker under faulty condition and isolates the transformer from the system. The proposed approach has no trip output signal for start of operation and external faults.

Table.6.1 Result Analysis

SI.NO	Operating time(ms)	
	Existing System	Proposed System
AG	**17**	**0.22**
BG	**17**	**0.22**
CG	**17**	**0.22**
ABC	**04**	**0.22**

The obtained result illustrate that the proposed fuzzy based differential relay represents an appropriate action to issues the trip command much faster than the conventional relay and existing system in the case of an internal fault and avoid mal function of relay during external fault which are outside the protection zone.

CONCLUSION

An improved intelligent approach for differential protection scheme for power transformer is Fuzzy Based Differential Relay. The technique is analyzed and tested for different fault conditions that justifies the rules based theory of fuzzy logics mentioned earlier through waveforms. Fuzzy Based Differential Relay is able to discriminate between internal, external faults and magnetizing inrush conditions. Simulation results show that fuzzy based differential relay is fast response in internal fault condition and more reliability in discrimination between faulty and normal conditions. The fault is removed, the disconnected phases are automatically closed based on auto reclosing phenomenon. It make relay a novel protection device for power transformer safety and continuity of supply.

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ISSN:0971-1260
Vol-22- Issue-14-December-2019

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