THYRISTOR BASED ASYMMETRICAL FAULT DETECTION TECHNIQUE IN DE-ENERGIZED DISTRIBUTION FEEDER

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Abstract: A distribution feeder is de-energized during the period of maintenance or in bad weather conditions such as rains, and heavy winds. After the completion of maintenance or clearance of the bad climatic conditions, the same feeder is re-energized again to supply the load. But before re-energizing the feeder it is good practice to check whether the feeder is free of faults or not, because during the maintenance or bad weather conditions there may be a chance of short circuits in the system. This article presents a thyristors based technique to detect the asymmetrical faults, if any that are present in the de-energized side of the distribution feeder. The current wave forms are analyzed in MATLAB computer simulation and the type of the fault that is present in the system is identified.

***IndexTerms*–De-energized distribution feeder, asymmetrical faults, thyristor, MATLAB**

I. INTRODUCTION

After the over head distribution feeder is de-energized for a certain period of time due to reasons like maintenance, storms and repairs the feeder is to be re energized again. As there is a possibility of humans or animals to get in contact with feeder unknowingly, the reclosing or re-energizing the system is major consideration for utilities point of view. Now a day's major contribution is made towards the development of techniques to check whether the de-energized system is free from short circuits or not, so that it can be re-energized again safely without causing any damage to the personel and or the connected equipments.

Compared to the detection of faults in energized feeder, detection of faults in de-energized feeder is more difficult. It requires the generation and application of a low level voltage signal initially sothat if any personel or animals incidentally in contact with the de-energized feeder may get a small shock and get away, then after the signal strength should be increased to detect the faults.

A fault detection technique called thyristor based device technique is proposed in this paper. Here the firing angle of the thyristor is changed to get t he desired signal strength. Low-voltage pulse can be created to satisfy the safety requirement, and a high-voltage pulse can be produced to break down an insulted gap of a high-impedance fault when necessary. The proposed device is also having the unique feature of detecting different kinds of faults. Faults may be symmetrical or asymmetrical and it may be between phase and ground or phase and phase. In this proposed device a low voltage power electronic device connected to KV/MV feeders through common utility primary-to-secondary service transformers. The device is installed permanently at the recloser or breaker locations and can be operated locally or remotely. As a result, there is no need to replace the existing breaker or recloser.

II. PROPOSED CONCEPT:

The major challenge for fault detection in de-energized feeder is to generate appropriate signal. As discussed earlier it is designed to produce low and high strength signal based on requirement. In the beginning the low strength signal is produced which acts as an alarm so that human or animal can sense it and move away from it. Later the signal magnitude should be increased gradually to a very high voltage to break down the insulated gap. This generation of detection signal is done by varying the thyristor firing angle. The single line diagram for the proposed concept is shown in figure:1. Here thyristor is connected in parallel with the circuit breaker or recloser, under normal condition switch is closed and under maintenance switch is open. When maintenance completed and the de-energized feeder is needed to be restored, operator can turn on the switch and control the thyristor to trigger at several degrees before the voltage crosses zero. The energized upstream line is thus momentarily connected to the de-energized side so that a detection pulse is created in the downstream. The thyristor automatically shuts off when its current drops to zero. A step-down transformer is used to decrease the voltage of the distribution line to a low level for thyristor operation and then a step-up transformer is used to restore the signal back to the system voltage level. Point X in Figure:1 is the location for measuring the current signals.

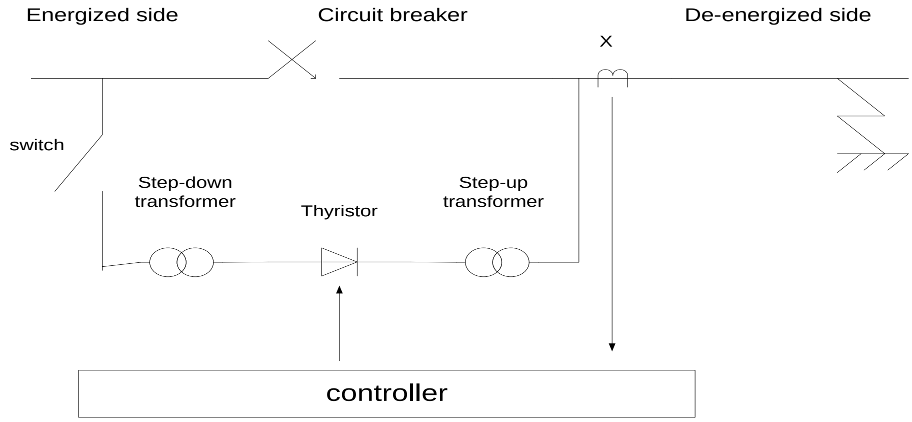


FIGURE: 1 SINGLE-LINE REPRESENTATION OF THE PROPOSED FAULT DETECTION METHOD.

In a three phase four-line system fault could be symmetrical or asymmetrical. It may be between phases or between phase and ground, so detection of faults is highly desired. To do this a three-phase thyristor cascade scheme is proposed. As shown in Figure:2, four thyristor cascaded structure is connected in parallel to the circuit breaker. The one end of the cascaded structure is connected to one of the three phases of the energized upstream and the other end is connected to the neutral line. To minimize the size and reduce the cost of power-electronics devices, transformers are used to let the thyristors operate at a lower voltage level. Once the detection signals are injected in de-energized side of distribution feeder, the current wave forms are anlyzed at point X to determine if there is a fault in the system. The detection for different kinds of faults depends on the gating signals that are applied to the four thyristors in the cascaded structrure. The overall fault detection logic is listed in Table:1 which include three steps that can detect all types of asymmetrical faults.

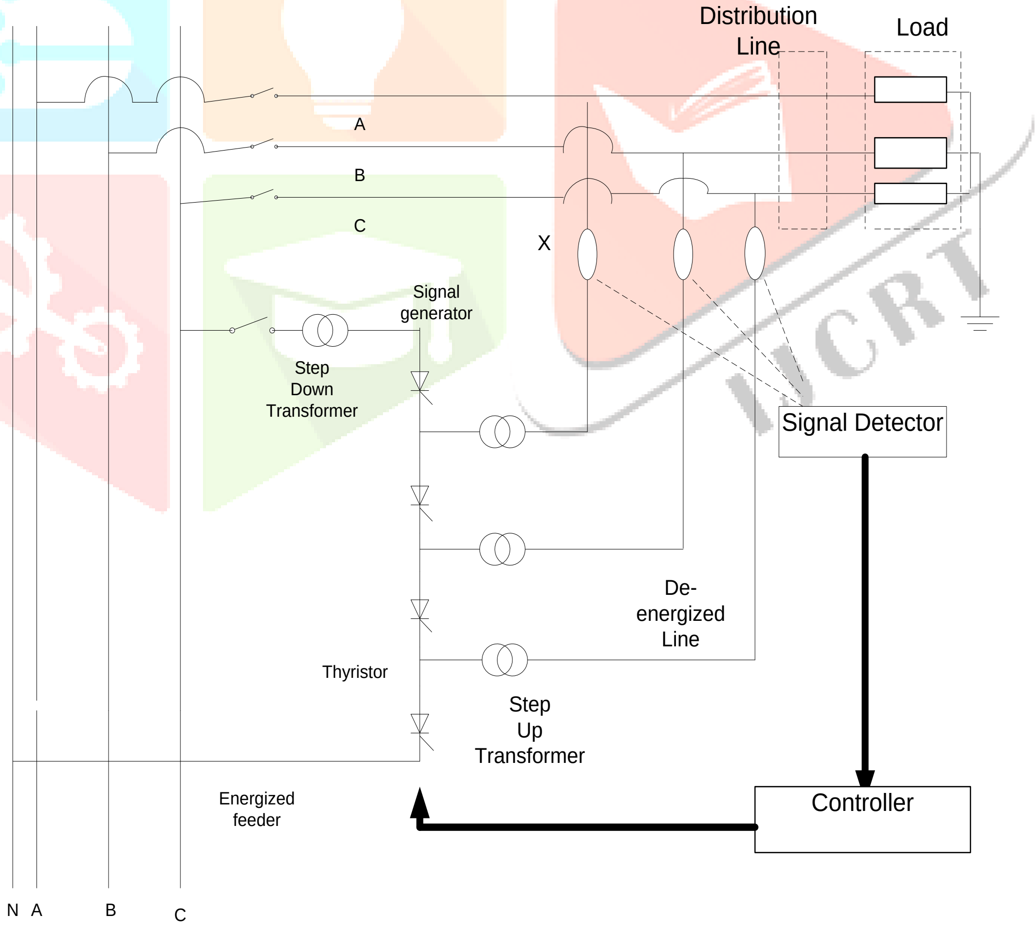
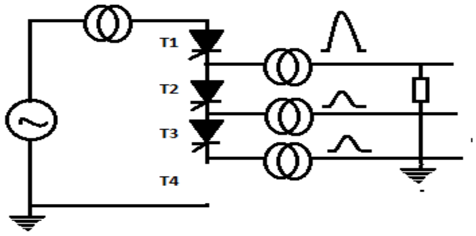
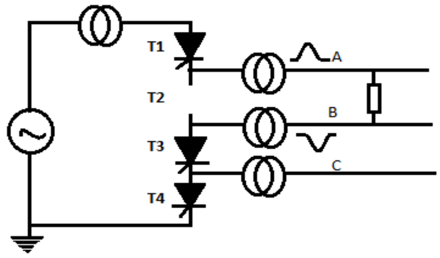
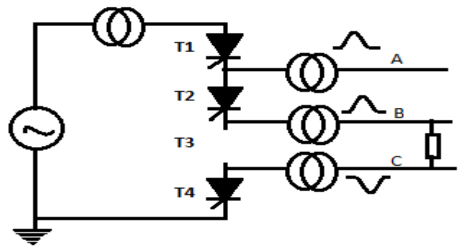


FIGURE :2 THREE PHASE CASCADED BASED FAULT DETECTION SCHEME

TABLE :1 CONTROL LOGIC OF THE CASCADED STRUCTURE

Type of Fault	Control logic	Current flow
Phase-to-Ground faults detection (both LG and LLG)	T1 ON T2 ON T3 ON T4OFF	
Phase-to-Phase fault detection (between phases AB and AC)	T1 ON T2 OFF T3 ON T4 ON	
Phase-to-Phase fault detection (between phases BC and AC)	T1 ON T2 ON T3 OFF T4 ON	

III. FAULT DETECTION METHODOLOGY:

A. PHASE TO GROUND FAULTS DETECTION:

In three phase power systems, a fault may involve one or more phases and ground, or may occur only between phases. In a "ground fault" or "earth fault", current flows into the earth. Literature have shown that phase to ground faults are the most common fault in a distribution system and are roughly about 70 to 80%. These faults may occure between one phase and ground (LG fault), or two phases and ground (LLG fault). To identify all these phase to ground fault thyristors T1,T2,T3 are triggered and thyristor T4 is made OFF and a low strenghth signal is injected in the feeder.

The phase to ground faults detection process is done with the following criteria:

1. Measure the the magnitude of currents in all the three phases.
2. If all the three current magnitudes become equal then there is no phase to ground fault (neither LG not LLG fault) in the system.
3. If all the three phase current magnitudes are not equal then there may be either sngle line to ground fault or double line to ground fault is present in the system and the type of the fault is decided by observing the wave forms of each phase current.
4. If any one phase current is higher than the remaining two phase currents then it is said to be a single line to ground fault (LG) is present in the system.
5. If any two phase currents are equal and higher than the third phase current then it is said to be a double line to ground fault (LLG) is present in the system.

B. PHASE TO PHASE FAULTS DETECTION:

Phase-to-phase fault is a short circuit between any of two phases not involving the ground and is caused by ionization of air, or when lines come into physical contact, for example due to a broken insulator. In transmission line faults, roughly 5% - 10% are asymmetric Phas-to-phase faults. These phase to phase faults are identified by triggering the thyristors in two steps.

In first step thyristors T1, T3,T4 are ON by giving a riggeering pulse to all at the same time and thyristor T2 is made OFF. The fault analysis is done as follows.

1. Observe the the magnitude of currents waveforms in all the three phases.
2. If there is no current in Phase C and the currents in phases A and B are in opposite diection then there exist a phase toPhase fault between phase A and Phase B.
3. If there is no current in Phase B and the currents in phases A and C are in opposite diection then there exist a phase toPhase fault between phase A and Phase C.

Then, in second step, thyristors T1, T2,T4 are ON by giving a riggeering pulse to all at the same time and thyristor T3 is made OFF. The fault analysis is done as follows.

1. Observe the the magnitude of currents waveforms in all the three phases.
2. If there is a nominal current in Phase A and the currents in phases A and B are higher than nominal current and are in opposite diection then there exist a phase toPhase fault between phase B and Phase C.
3. If there is a nominal current in Phase B and the currents in phases A and C are higher than nominal current and are in opposite diection then there exist a phase toPhase fault between phase A and Phase C.

Combining both the phase to ground fault and phase to phase faults detection schemes, the overall fault detection algorithm is summarized and shown in figure:3.

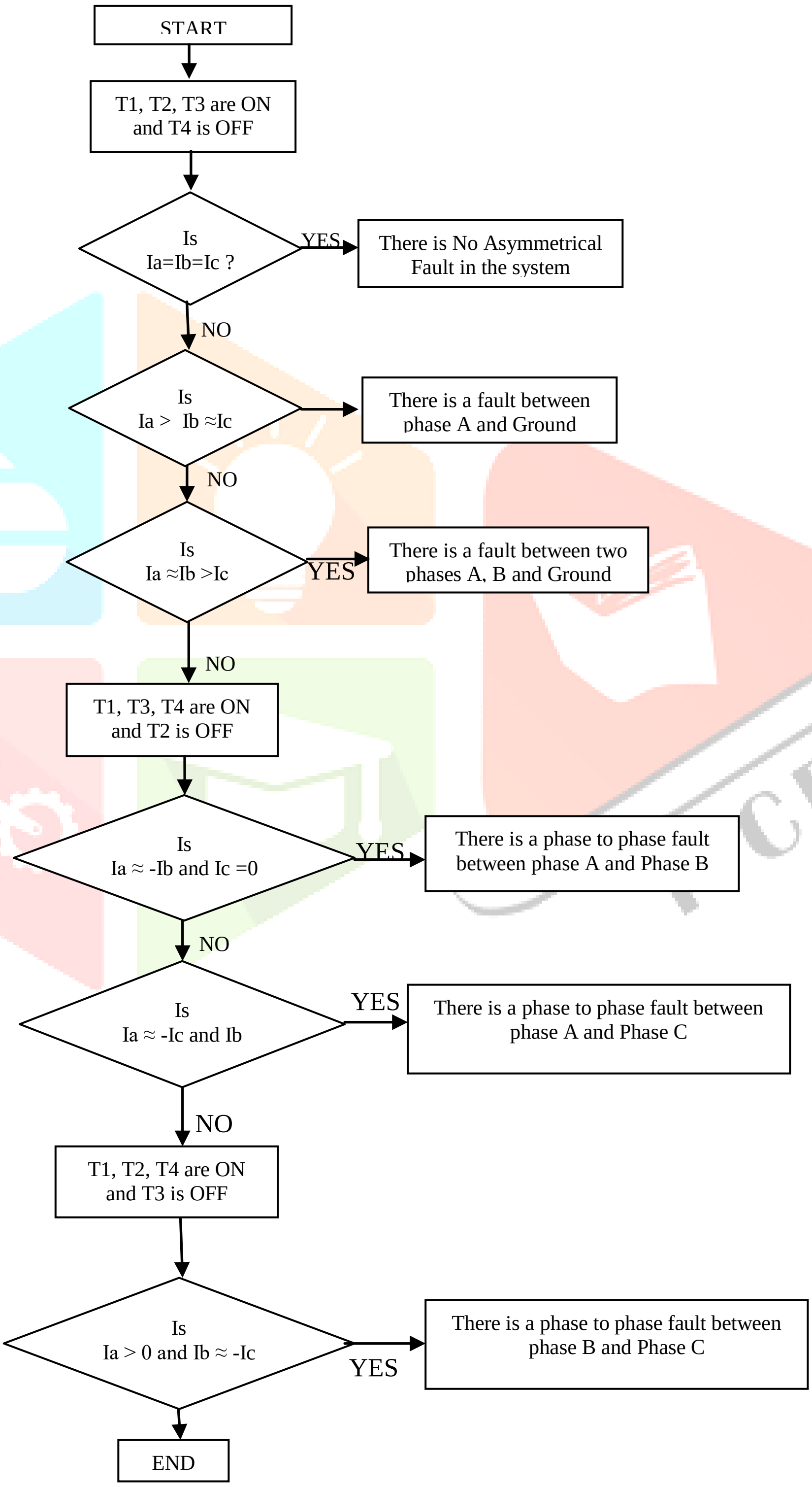


FIGURE 3: FLOW CHART FOR THE DETECTION OF ASYMMETRICAL FAULTS

IV. MATLAB SIMULATION RESULTS AND DISSCUSSION:

Computer simulations are performed in MATLAB to verify the above discussed analysis. The rated voltage of the distribution feeder is taken as 11KV and a three phase thyristor based cascaded structure is connected to upstream phase C feeder and neutral through a single phase transformer as depicted in Figure:2. In de-energized side of the distribution feeder is connected to the joints between two thyristors. As the current pulses through the transformer are not balanced, three separate step-up transformers are used instead of three phase transformer to reduce the interference between phases. The other parameters are listed as follows.

Utility	:	Phase to Phase RMS Voltage 11KV
Transformers	:	Step down transformer:11KV/440V, 5MVA, single phase
		Step up transformer: 440V/11KV, 5MVA, single phase
Signal generator	:	four casded thyristor structure, firing angle 150o
Feeders	:	both line1 and line2 are 5Km, the positive sequence R1= 0.2138 Ω/Km, X1=0.3928 Ω/Km,
B1=		4.2315 μS/Km; X0=1.8801 Ω/Km, B0=1.6058 μS/Km.
Load	:	4MVA, lagging, power factor = 0.95, fed with a 5MVA, 25KV/440KV, Yg/Yg transformer
Fault	:	Resistance Rf = 50Ω

According to the gate signl conrol logic shown in Table:1 defferent types of asymmetrical faults are detected in the de-energized side of the distribution feeder. The MATLAB simulations are performed and the results are shown as following.

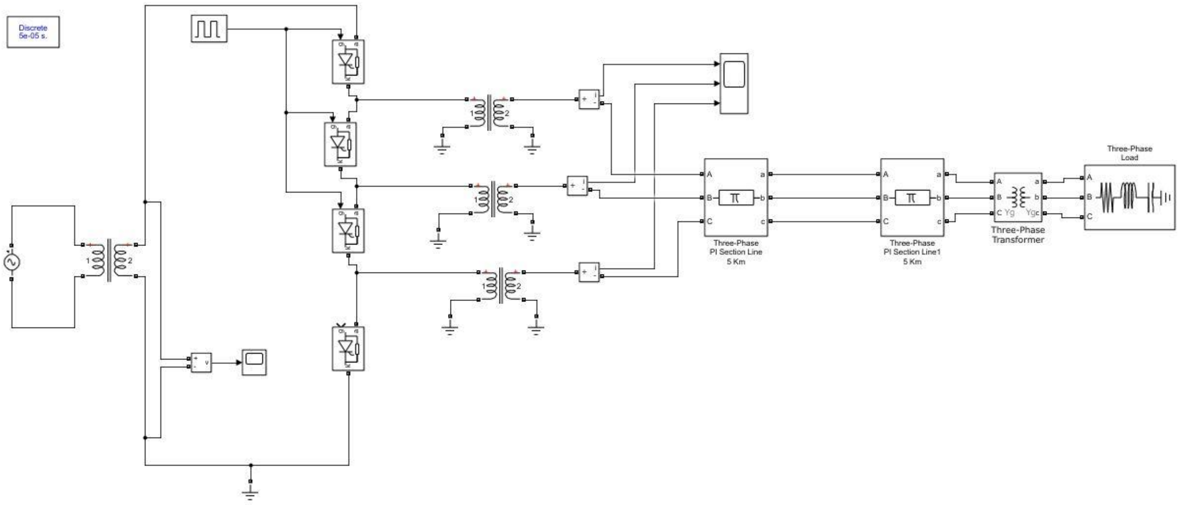


FIGURE 4: MATLAB SIMULATION OF PROPOSED SCHEME UNDER NO FAULT CONDITION

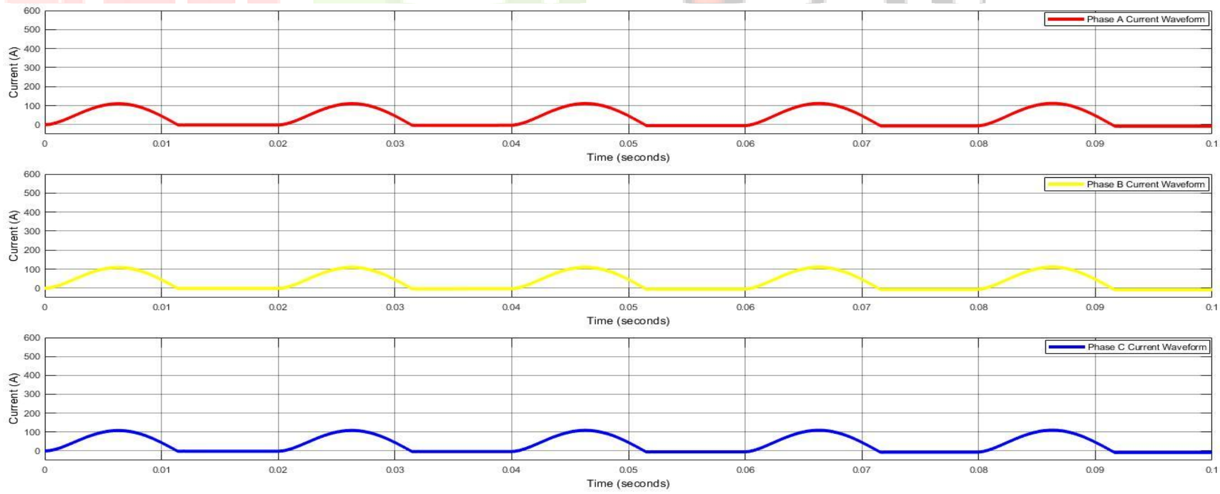


FIGURE 5 : CURRENT WAVEFORMS FOR NO FAULT CONDITION

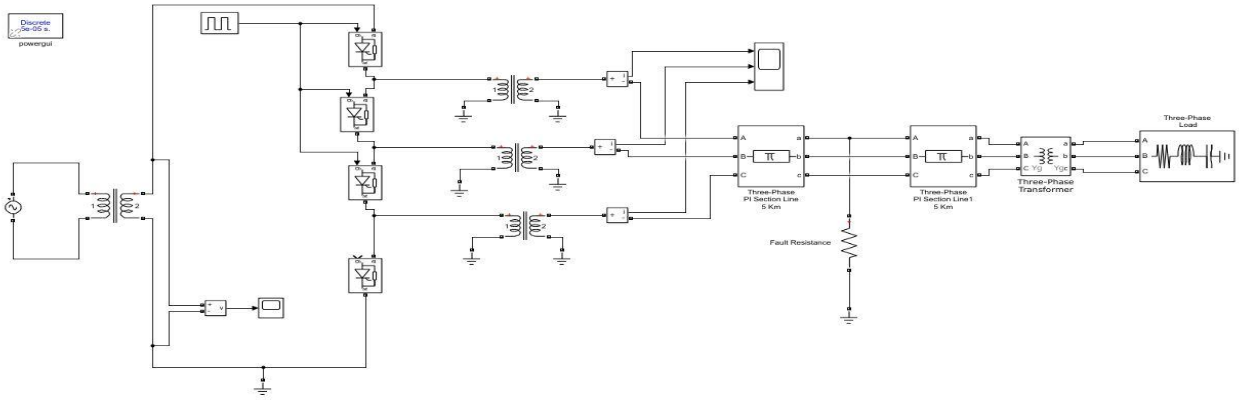


FIGURE 6: MATLAB SIMULATION OF PROPOSED SCHEME UNDER PHASE-A TO GROUND FAULT CONDITION

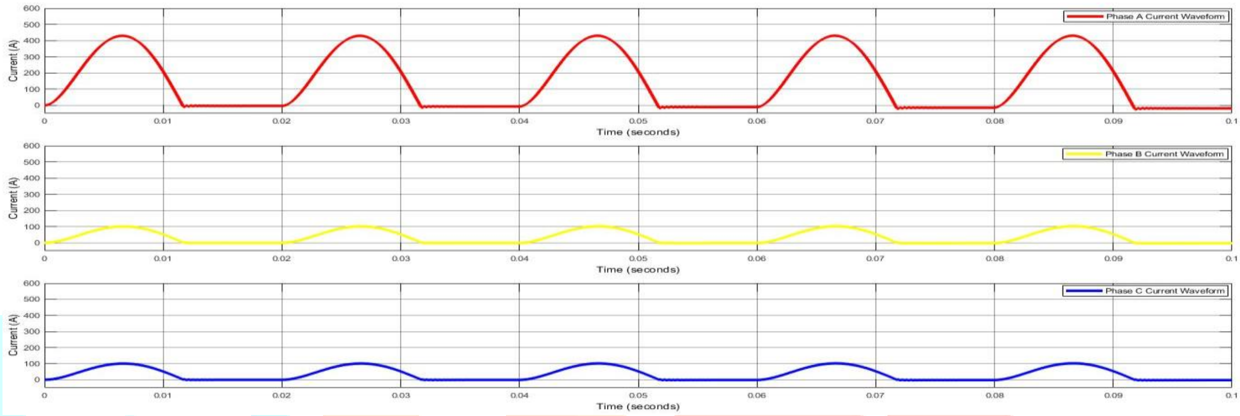


FIGURE 7: CURRENT WAVEFORMS UNDER PHASE-A TO GROUND FAULT CONDITION

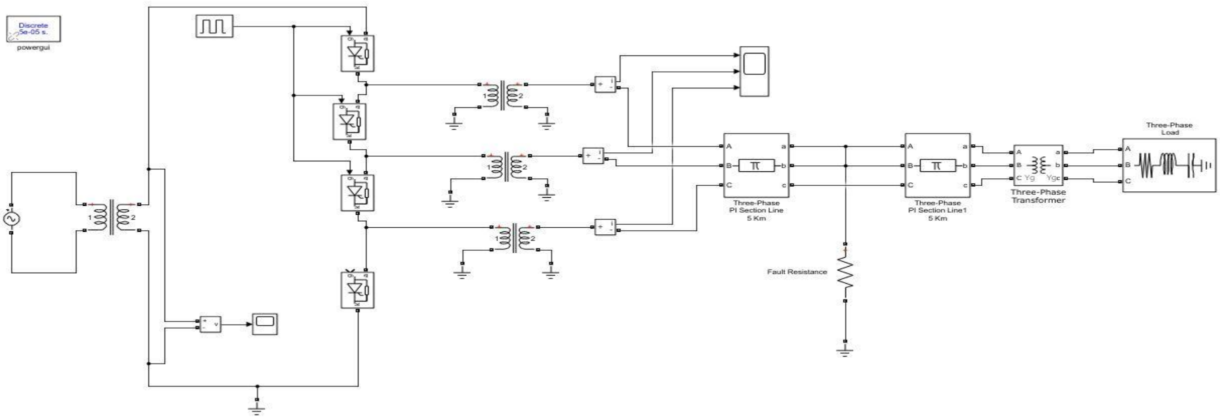


FIGURE 8: MATLAB SIMULATION OF PROPOSED SCHEME UNDER PHASES-A,B TO GROUND FAULT CONDITION

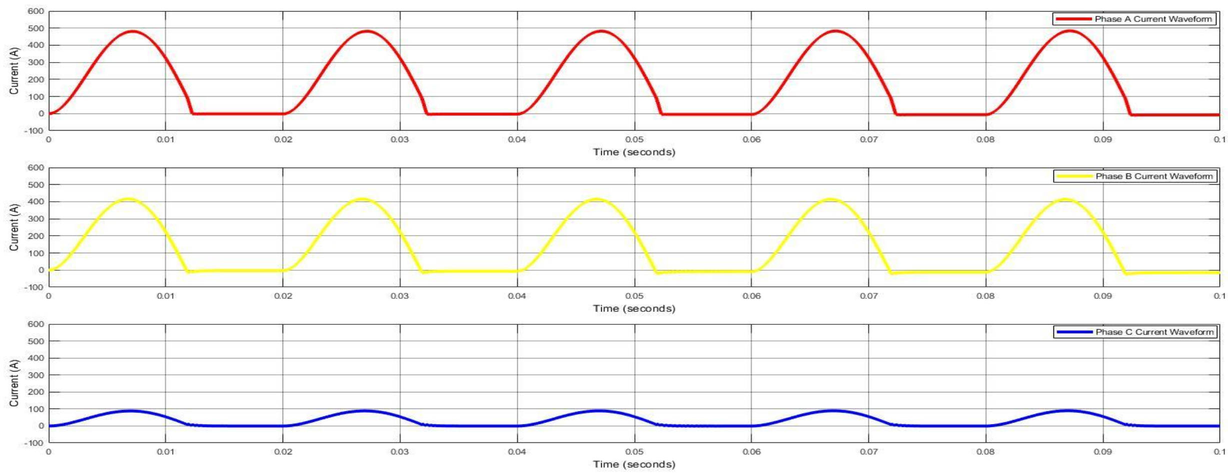


FIGURE 9: CURRENT WAVEFORMS FOR PHASES-A,B TO GROUND FAULT CONDITION

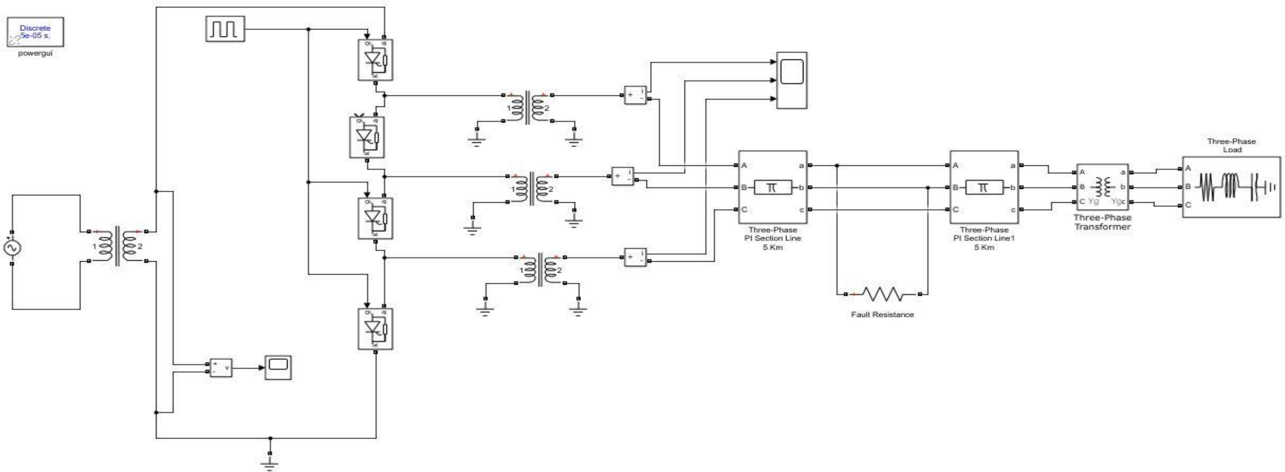


FIGURE 10: MATLAB SIMULATION OF PROPOSED SCHEME UNDER PHASE-A TO PHASE-B FAULT CONDITION

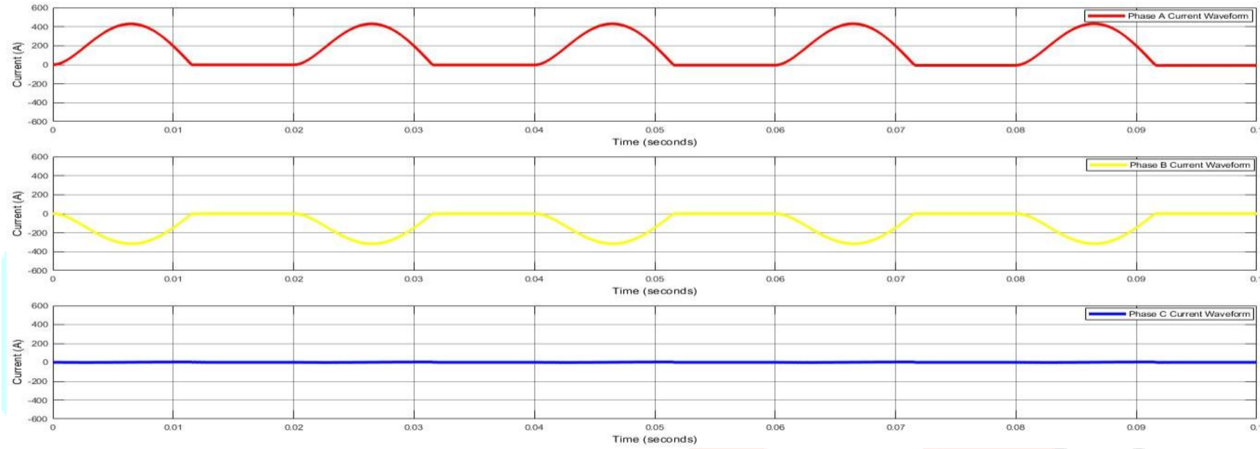


FIGURE 11: CURRENT WAVEFORMS FOR PHASE-A TO PHASE-B FAULT CONDITION

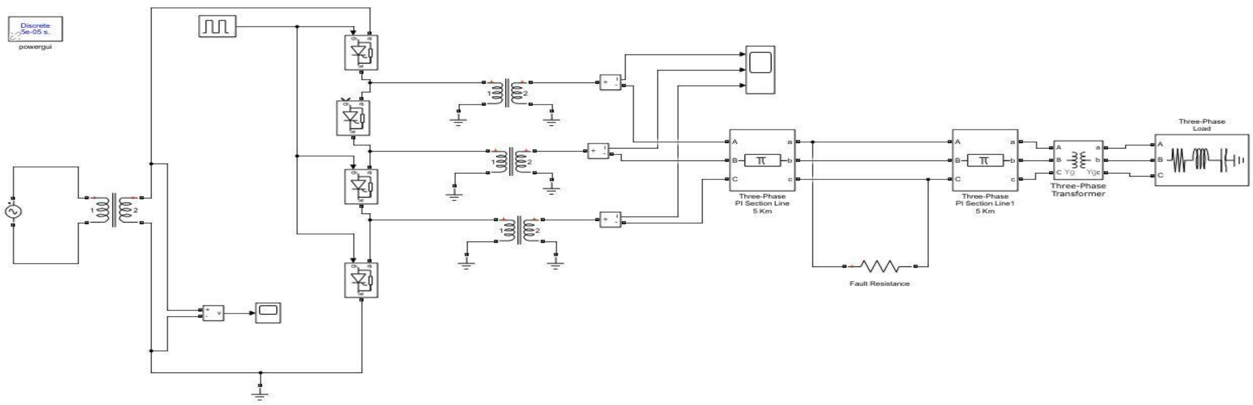


FIGURE 12: MATLAB SIMULATION OF PROPOSED SCHEME UNDER PHASE-A TO PHASE-C FAULT CONDITION

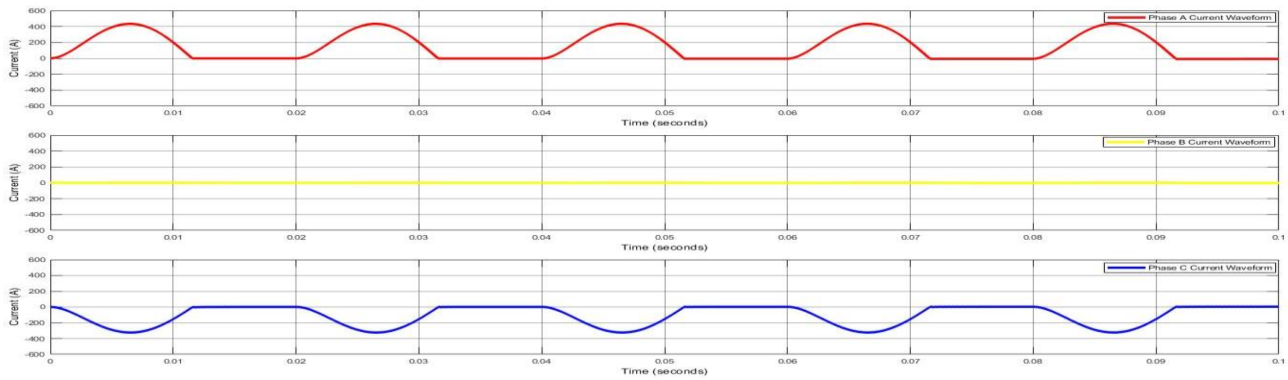


FIGURE 13: CURRENT WAVEFORMS FOR PHASE-A TO PHASE-C FAULT CONDITION

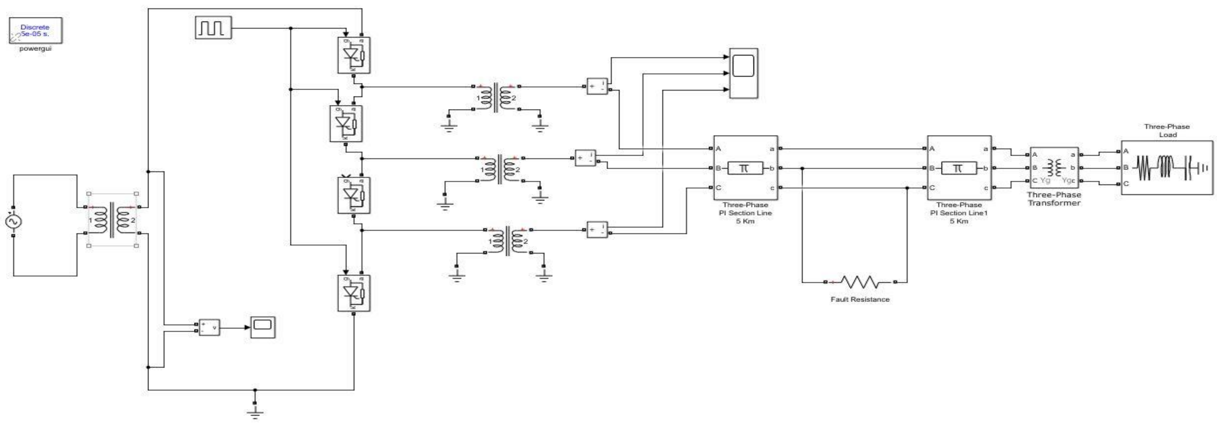


FIGURE 14: MATLAB SIMULATION OF PROPOSED SCHEME UNDER PHASE-B TO PHASE-C FAULT CONDITION

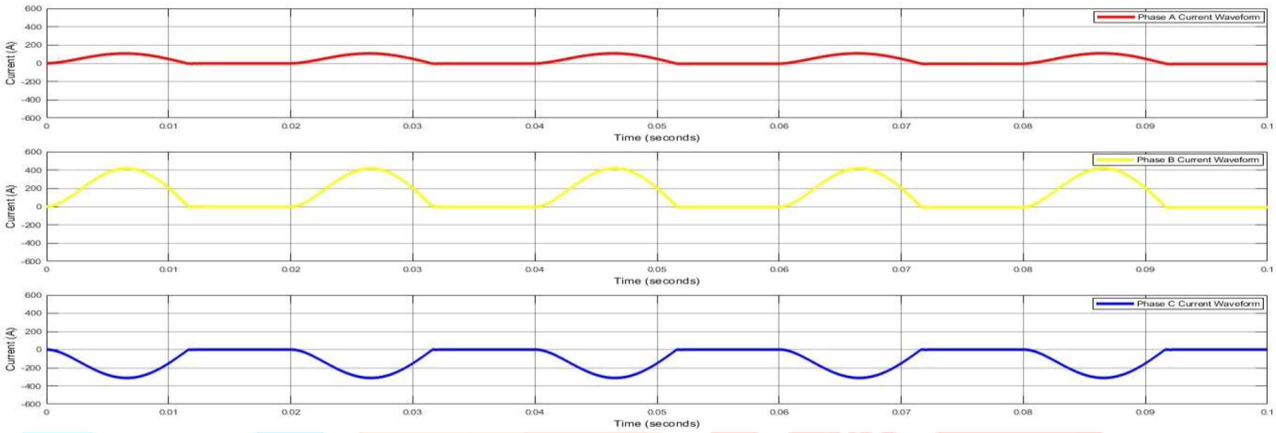


FIGURE 15: CURRENT WAVEFORMS FOR PHASE-B TO PHASE-C FAULT CONDITION

V. CONCLUSIONS:

In this paper a thyrisor based device is proposed for the detection of faults in the de-energized distribution feeder. This device can detect various asymmetrical faults by using only one device. The device is connected in parallel to the circuit breaker or recloser to generate a controllable signal which is applied to the de-energzised side of distribution feeder to detect the faults by analyzing the current waveforms. Also it ensures safety reclosing of the feeder. The operation of the thyristor based device is performed in three steps which generally take only few minutes, so it is sufficiently fast method to detect the faults in de-energized distribution system. In First step, phase-to-ground faults (LG and LLG) are detected and in second and third steps, phase-to-phase faults (LL) are detected. Asymmetrical fault analysis is done and an algorithm is developed for detecting the asymmetrical faults. The computer simulation is developed in MATLAB to analyze the practical working of the proposed scheme.

VI. ACKNOWLEDGEMENTS

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