Volume : 4 | Issue : 11 | November 2015 • ISSN No 2277 - 8179

Research Paper

Fault Detection Using Instantaneous Three Phase Power Based Function for Transmission Line Protection

Engineering

KEYWORDS : power systems, protection, distance relaying, active power.

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ABSTRACT

The protection of power system plays an important role in present society. It is very essential to protect power system components from faults. The normal relays are not reliable in situations like sudden load changes, switching operations etc., and it is very important to discriminate the faults and transients. Now a day so many new techniques are implemented to overcome above difficulties. This paper proposes an effec-tive power variation detection based algorithm and it is compared with other conventional methods-sample to sample method, cycle to cycle method. Finally it is observed that the proposed method is more effective to detect faults in power system. Simulations are carried out in MATLAB/SIMULINK.

INTRODUCTION

The electric power system is a network of interconnected components which generate electricity by converting different forms of energy, (potential energy, kinetic energy, or chemical energy are the most common forms of energy converted) to electrical energy; and transmit the electrical energy to load centers to be used by the consumer. Power systems have become more complex due to large increase in the demand of Electrical power over the years. Reliable operation of these systems when subjected to random disturbances is very essential for containing equipment damage and continuity of service. Protective relays are included in Power systems to detect such disturbances in various components like generators, transformers, transmission lines etc so that the faulted component can be quickly isolated from the healthy part of the network. Power system is a big network consisting of equipments like alternators, transformers, transmission lines and protective devices like relays. These equipments are very costly and play a major role in the power generation, transmission and distribution. Various abnormal conditions occur in the power systems which are caused accidentally through insulation failure of equipment or flashover of lines initiated by lightning stroke or through faulty operation.

These abnormal conditions can cause damage to the equipments and severely effects the operation of the power system and sometimes human personal safety will get disturbed. If the process of cascading failures continues, the system as a whole or its major parts may completely collapse. This is normally resulted to as system blackout. Therefore Power system protection is important for the effective operation of the power system and for protecting equipments from abnormal conditions. Faults fall into two general categories. They are Short circuit faults and Open circuit faults [5]. There are many techniques involved to protect the system against various faulty conditions. The main objective is to detect the fault and process the signal to relay for tripping. Then the relay closes its contacts and in turns opens the corresponding circuit breakers. Protective relays are the devices that detect abnormal conditions in electrical circuits by constant measuring the electrical quantities which are different under normal and fault conditions. The basic electrical quantities which may change during fault conditions are voltages, currents, phase angle and frequency. Having detected the fault the relay operates to complete the trip circuit which results in the opening of circuit breaker and therefore disconnection of faulty circuit. However the continuous supply of power is also very important criteria with power system protection. So it is very important to discriminate the faults from situations like noise, capacitor switching, spikes etc. some of the algorithms are fail to work at these situations because the algorithms are purely depend on the numerical calculations but not the conditions. So if the algorithm is able to differentiate above situations from faults then it going to be good algorithm. The sample-to-sample comparison of the current(voltage) signal is a straightforward approach for fault detection. Another simple approach is the comparison of the present current sample with the corresponding value before one or two cycles faults on transmission lines need to be detected, classified, and cleared as fast as possible[1],[2]. In power transmission-line protection, fault detection and fault classification are the two most important items which need to be addressed in a reliable and accurate manner. Fault detection plays an important role in distance relaying as it discriminates the normal state from the fault and activates the main relay algorithm. The overall performance of a relay depends very much on the speed and accuracy of the fault detection technique. Fault detection algorithms in a relay employ the faulted signal samples to discriminate the faulty situation from the normal state. The sample-to sample comparison of the current signal is a straightforward approach for fault detection. Another simple approach is the comparison of the present current sample with the corresponding value before one or two cycles. More complex techniques are also available in the literature using Kalman filtering and recursive least squares. Besides a higher computational burden, it is to be noted that conventional phasor estimation techniques based on discrete Fourier trans-form (DFT), recursive least squares, or Kalman filtering are not suitable for fault detection in relaying since the processing takes more than half a cycle of the fundamental period on typical dig-ital signal processors (DSPs)[3],[4]. Further, these methods are also sensitive to frequency deviation, harmonics, etc.

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II.TREDITIONAL TECHNIQUES

1. Sample to Sample Comparison technique:

In this method the algorithm is written based on sample to sample comparison of a current signal or a voltage signal. Under normal case the difference between samples to next sample is same. If any disturbance occur in the system leads to the deviation in the difference value. By fixing a threshold value, these situations can be detected. Mathematically Where represents the sample value of the signal at the th instant . A fault is recorded if Here is a threshold parameter. The following figures are related to fundamental current waveforms for steady state and transient states.

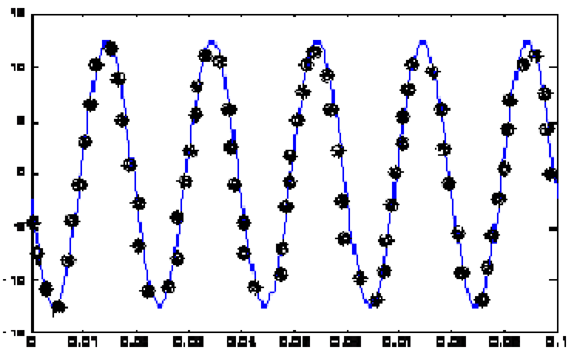

Fig 1: sample to sample comparison under normal case

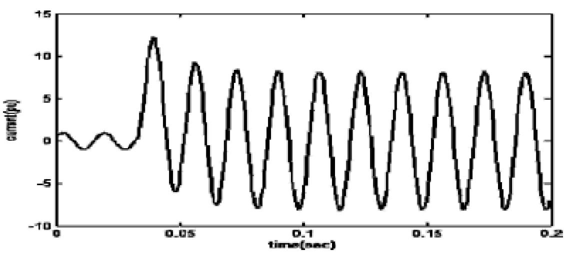

Fig 2 : current signal during fault .

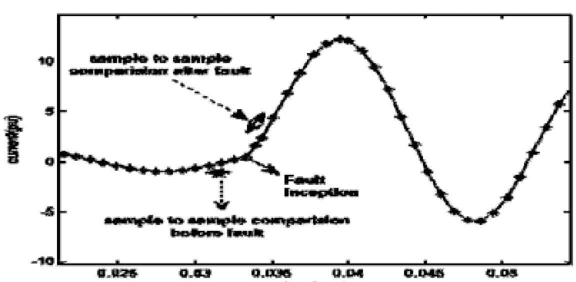

Fig 3: Sample to sample comparison during fault

2. Cycle to Cycle comparison technique:
This method is based on the difference of sample values which are one cycle apart. This difference is expected to be zero normally whereas after the onset of a fault, it would be high.

Here is the number of samples per cycle. When fault occurs Here is threshold parameter.

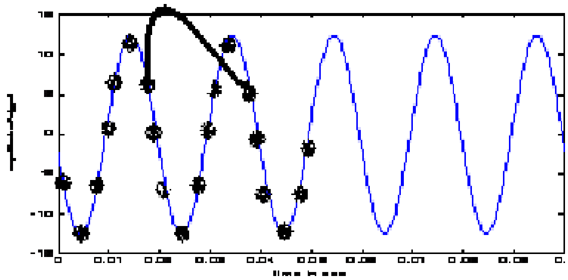

Fig4: cycle to cycle comparison under normal case

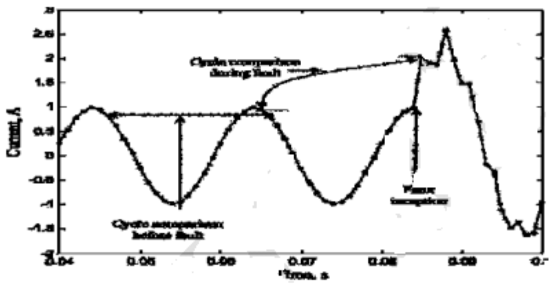

Fig 5 : cycle to cycle comparison under fault

III.PROPOSED METHOD

Many fault detector algorithms have been proposed over the years for improving the reliability of protection schemes. The two basic methods by which detection can be done use either voltage or current signals. Earlier two simple approaches are proposed namely sample to sample comparison and cycle to cycle comparison which were discussed in previous section. In this paper a new technique was proposed based on locus of two coordinates which were formulated using current signal of tested system. There are many techniques involved to protect the system against various faulty conditions. The main objective is to detect the fault and process the signal to relay for tripping. Then the relay closes its contacts and in turns opens the corresponding circuit breakers. Protective relays are the devices that detect abnormal conditions in electrical circuits by constant measuring the electrical quantities which are different under normal and fault conditions. The basic electrical quantities which may change during fault conditions are voltages, currents, phase angle and frequency. A new method is proposed in this paper using a 3-phase active and reactive power component which is shown in below block diagram.

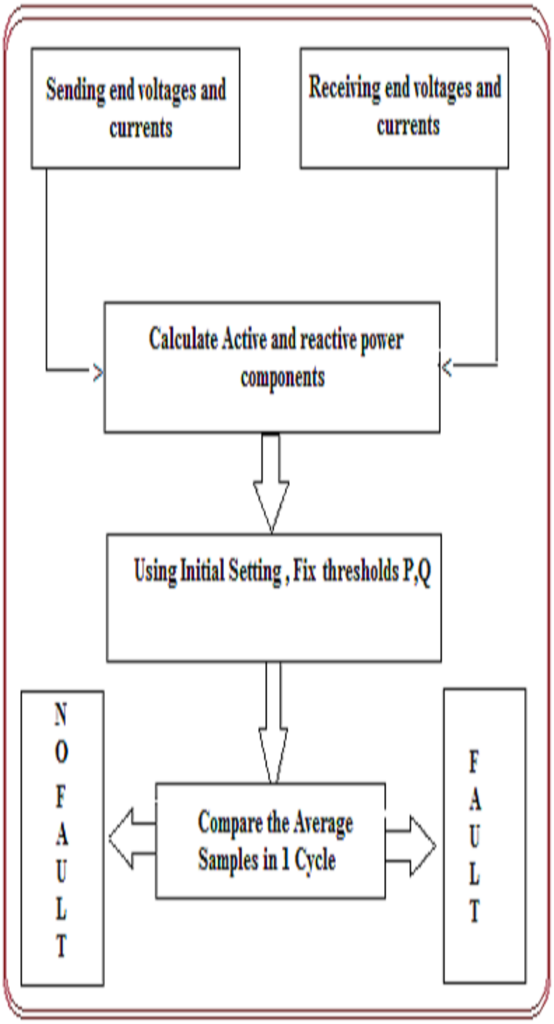

Fig 6: flow chart of proposed method.

IV.SYSTEM STUDIED

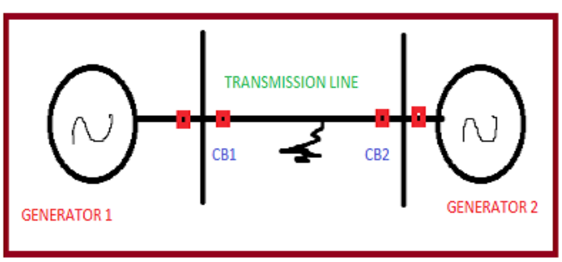

Fig7: system studied

A 25kV, 50-Hz two terminal transmission systems as shown in Fig. 8 has been chosen to assess the comparative performance of different fault detection methods. The system has been simulated using the EMTP model available in the MATLAB power system toolbox.

IV.SIMULATION RESULTS

In this paper investigations are carried out by giving all faults randomly and it is observed that all types are detected by the proposed algorithm. The figure shown below represents current, voltage and P-Q simulation graphs for normal state of power system.

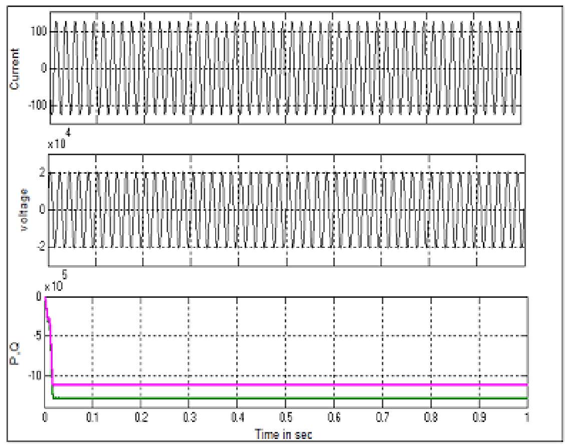

Fig 8: Current, voltage and P-Q simulation graphs for normal state of power system.

Case1: when the fault is LG type :When a line to ground fault(A-G,B-G,C-G) occurred at any point on a transmission line network, the proposed algorithm detects the condition of fault and the fault is incepted in a transmission line at 0.4 sec. Results are shown in figure 9.

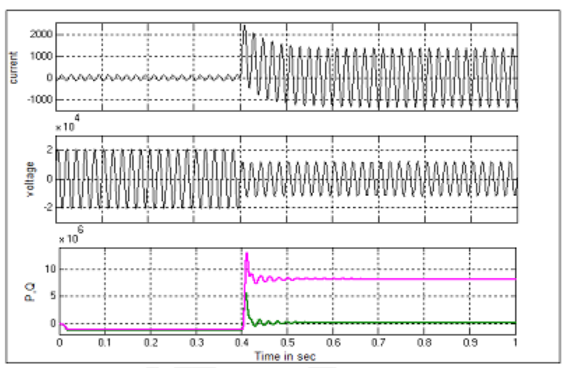

Fig 9 : Current, voltage and P-Q simulation graphs for LG fault

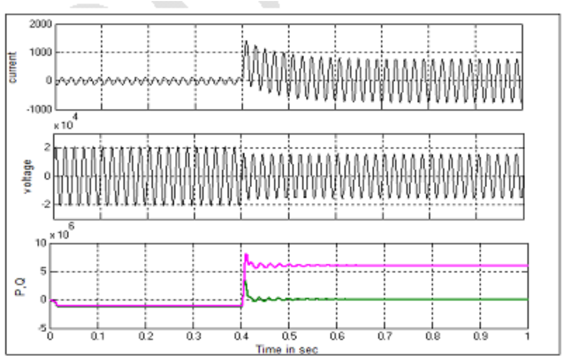

Fig 10: Current, voltage and P-Q simulation graphs for L-G fault

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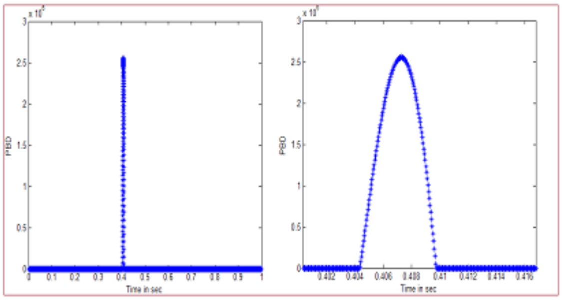

Fig 11: final Detection plot for LG faults

Case2: when the fault is LL type : When a line to line fault (A-B, B-C, C-A) occurred at any point on a transmission line network, the proposed algorithm detects the condition of fault and the fault is incepted in a transmission line at 0.4 sec. Results are shown in figure 12.

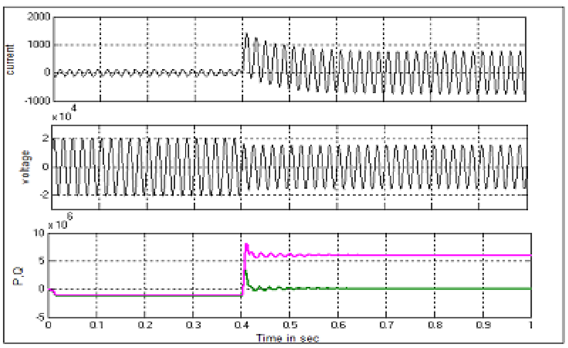

Fig 12 : Current, voltage and P-Q simulation graphs for L-L fault

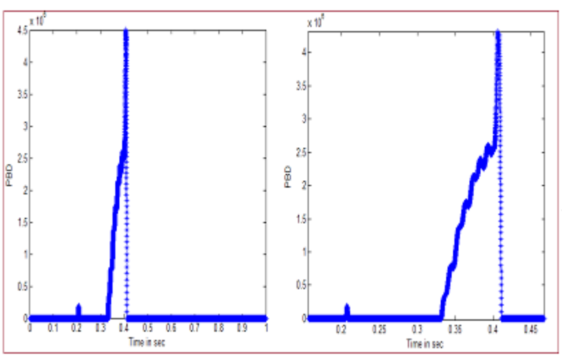

Fig 13: final Detection plot for L-L faults

Case3: when the fault is LLG type : When a line to line fault (A-B-G, B-C-G, C-A-G) occurred at any point on a transmission line network, the proposed algorithm detects the condition of fault and the fault is incepted in a transmission line at 0.4 sec. Results are shown in figure14.

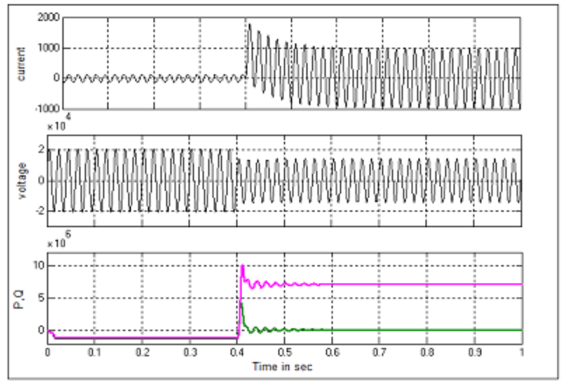

Fig 14: Current, voltage and P-Q simulation graphs for L-L-G fault.

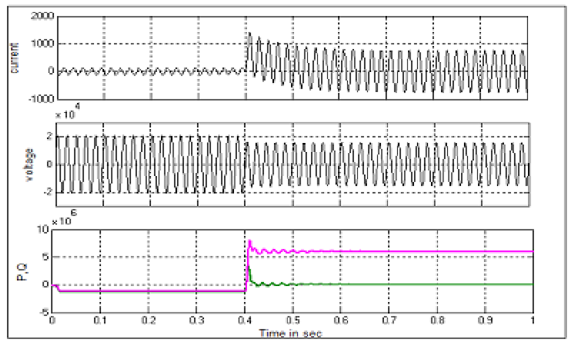

Fig 15: Current, voltage and P-Q simulation graphs for L-L-G fault.

Case4: when the fault is LLL and LLLG type :When a line to line fault (A-B-C,A-B-C-G) occurred at any point on a transmission line network, the proposed Euclidean distance based algorithm detects the condition of fault and the fault is incepted in a transmission line at 0.4 sec. Results are shown in figure 16 .

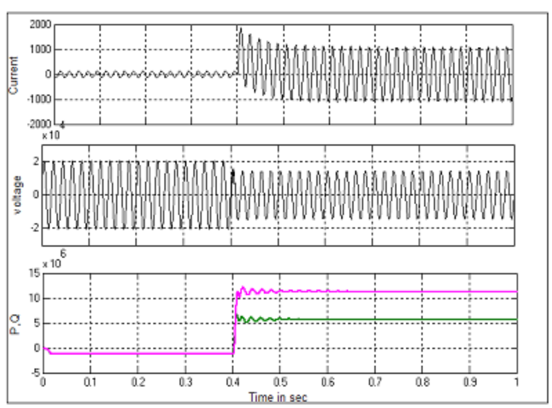

Fig 16: Current, voltage and P-Q simulation graphs for L-L-L-G fault.

Case 5: Fault with different resistances: Impedance based classification is one of the type of classification for faults. Generally faults having low impedance and they can be easily detected. But faults with high impedance are cannot be detected by all algorithms. The proposed algorithm detects every type faults with high impedance that are occur on transmission line network. In this paper invistigations are carried out by giving all high impedance faults randomly with different fault impedances. The major disadvantage of this method is which detects the high impedance faults of maximum impedance 50 Ohms . Results are carried out in matlab, which are shown in figure 17-19.

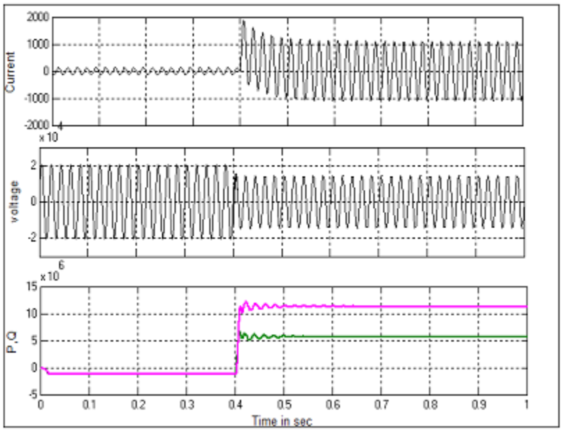

Fig 17: Current, voltage and P-Q simulation graphs for L-G fault with low impedance.

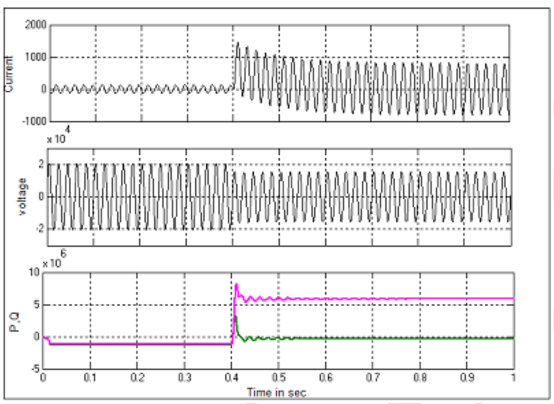

Fig 18: Current, voltage and P-Q simulation graphs for L-G fault with Rf= 30 ohms.

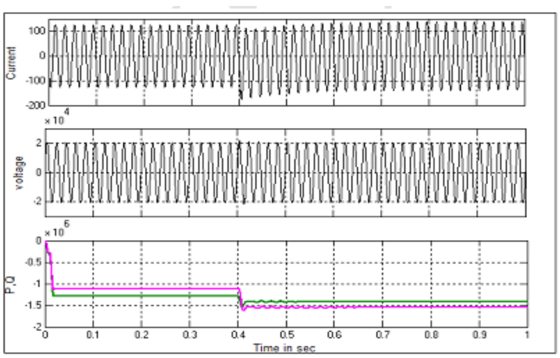

Fig 19: Current, voltage and P-Q simulation graphs for L-G fault with Rf= 80 ohms.

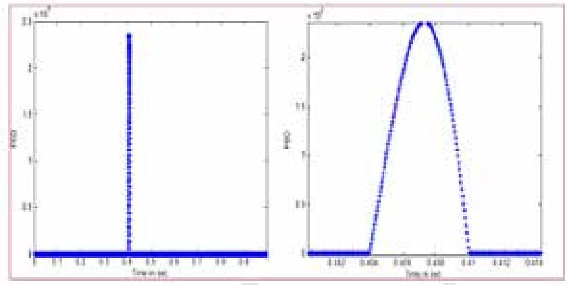

Fig 20: final Detection plot for HI faults.

Case 6: The proposed technique has been tested on spikes. Load change is also in these situations where current changes its magnitude at the instant of load switching. Thus, the fault detector faces a problem in distinguishing fault and load change. All these situations are simulated and tested. The proposed algorithm works very effectively under these situations. Simulated results are shown in figure 21. However the remaining situations like frequency deviation, sudden change in load (increase or decrease) ,fault at different inception angles are also examined. The method is suitable for Transmission lines of

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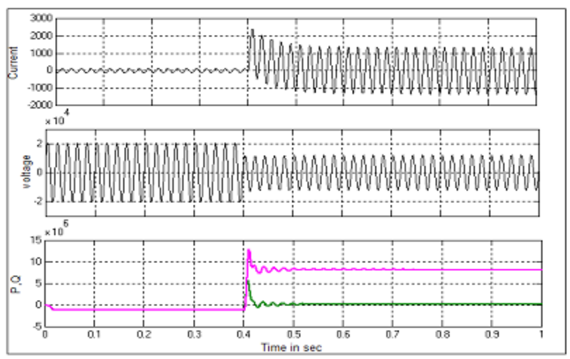

Fig 21: Current, voltage and P-Q simulation graphs for medium lines.

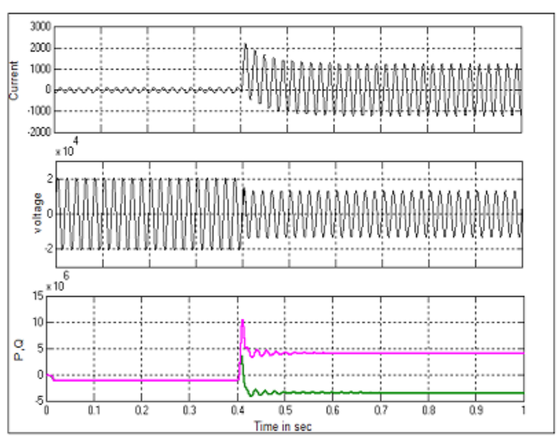

Fig 22: Current, voltage and P-Q simulation graphs for long transmission lines.

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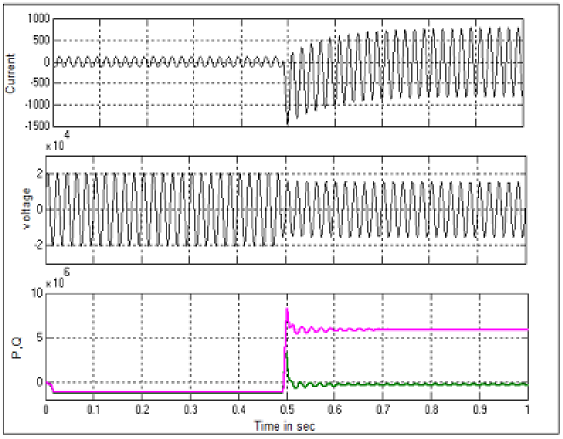

Fig 23: Current, voltage and P-Q simulation graphs for faults at zero inception angles.

VI.CONCLUSION

An Active and reactive power components based approach is proposed for the Detection of faults in transmission lines. The method is found to be a better tool to be used with power system relays and the same method is extended to identify faulty phase selection.

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