



UNSYMMETRICAL FAULT ANALYSIS & PROTECTION OF THE EXISTING POWER SYSTEM

R. S. Meena* & M. K. Lodha**

Department of Electrical Engineering,
Sri Balaji College of Engineering & Technology, Jaipur, Rajasthan
Rajasthan Technical University Kota

Abstract:

Now a day's electrical power system is in the process to convert in smart power system with interconnected national and regional grids. Modeling of power system has become a necessary in order to make right decision, check for any potential problems, and fault conditions in large interconnected network. In this paper we shell deal with unsymmetrical faults in a proposed network. In recent year power system engineers shifted protection method from classical methods to digital or numerical protection techniques, in this technique high crunching capability, which has made it possible to design digital filters in real time protection system with smart technologies. Multifunctional relay also installed in modern power system network for protection of transmission line, generator protection, motor protection, real time fault location, protection of busbar and other important equipments. This paper is devoted to abnormal system behaviour under conditions of unsymmetrical fault in power system networks using MATLAB Simulation Techniques.

Key Words: Modern Power System, Unsymmetrical Fault, Generator Protection, Interconnected Network, Digital/ Numerical Protection.

I. Introduction:

In the modern large interconnected power system, heavy currents flowing during a fault must be interrupted much before the steady state conditions are established. This paper is devoted to abnormal system behaviour under conditions of unsymmetrical fault in power system networks. Various types of unsymmetrical faults that occur in power system-

(a) Shunt type fault

(b) Series type fault

(a) Shunt Type Fault:

In shunt type fault also three category-

(i) Single-Line to Ground Fault (ii) Line-to-Line Fault (iii) Double -Line to ground Fault

(i) Single line to ground fault: in this type of fault at the fault point , the currents out of the power system and the line to line ground voltages are constrained as follows:-

$$I_b = I_c = 0$$

$$V_a = Z^f I_a$$

The symmetrical components of the fault current are

$$I_{a1} = I_{a2} = I_{a0} = 1/3 I_a$$

$$V_{a1} + V_{a2} + V_{a0} = Z^f I_{a1}$$

(ii) Line to line fault: line to line fault at any point in a power system then the currents and voltages at the fault can be expressed as-

$$I_a = 0, I_b = -I_c$$

$$V_b - V_c = I_b Z^f$$

(iii) Double line to ground fault: For this condition the currents and voltages at the fault are expressed-

$$I_a = 0, I_{a1} + I_{a2} + I_{a0} = 0$$

$$V_b = V_c = Z^f (I_b + I_c) = 3Z^f I_{a0}$$

(b) Series Type Fault:

It is also called open conductor fault, in series type fault two category mainly divided (i) One Conductor (ii) Two Conductor

Open conductor fault is in series with the line. Line currents and series voltage between ends of the conductors are required to be determined.

The set of series current and voltage at the fault are-

$$I_P = \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} ; V_P = \begin{bmatrix} V_{aa'} \\ V_{bb'} \\ V_{cc'} \end{bmatrix}$$

Symmetrical component of current and voltage are-

$$I_s = \begin{bmatrix} I_{a1} \\ I_{b2} \\ I_{c0} \end{bmatrix} ; V_s = \begin{bmatrix} V_{aa'1} \\ V_{bb'2} \\ V_{cc'0} \end{bmatrix}$$

Case-1 When two conductor open- the current and voltage due to this fault are expressed as

$$V_{aa'} = 0, I_b = I_c = 0$$

In term of symmetrical components, we can write-

$$V_{aa'1} + V_{aa'2} + V_{aa'0} = 0$$

$$I_{a1} = I_{a2} = I_{a0} = 1/3 I_a$$

Case-2 One conductor open- the current and voltage due to this fault are expressed as

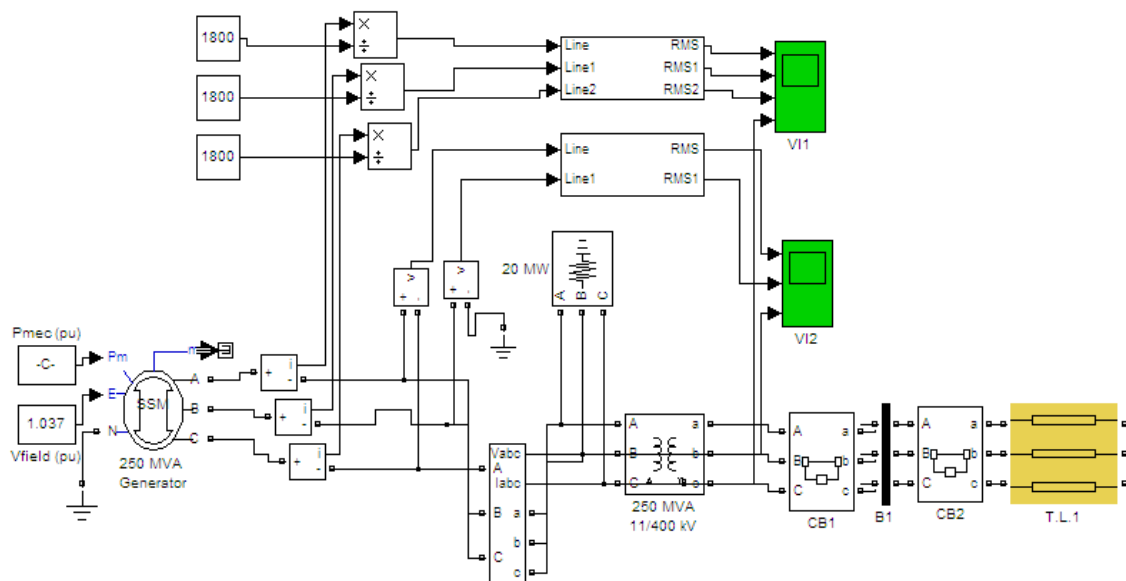
$$V_{bb'} = V_{cc'} = 0, I_a = 0$$

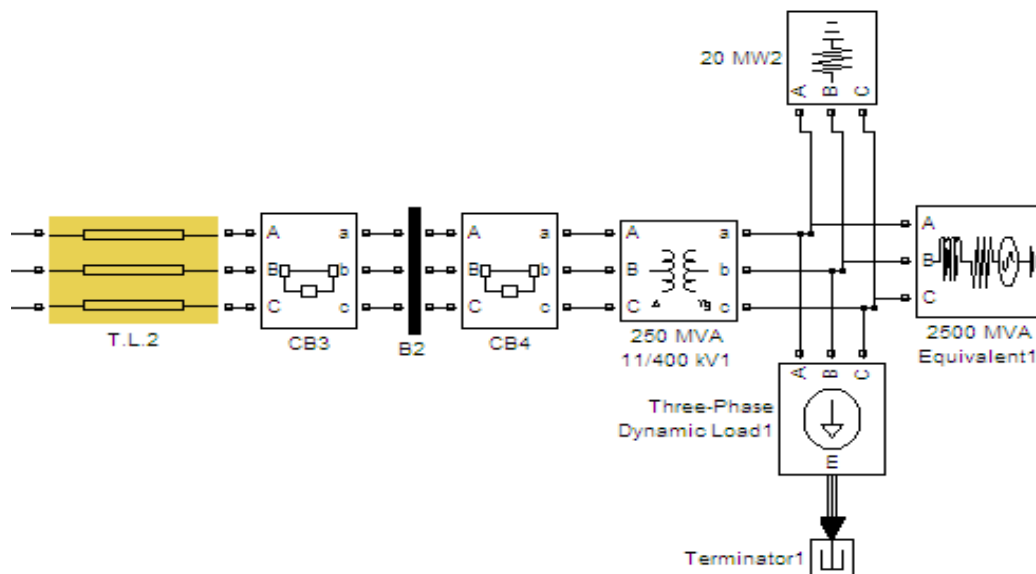
In term of symmetrical components, we can write-

$$V_{aa'1} = V_{aa'2} = V_{aa'0} = 1/3 V_{aa'}$$

$$I_{a1} + I_{a2} + I_{a0} = 0$$

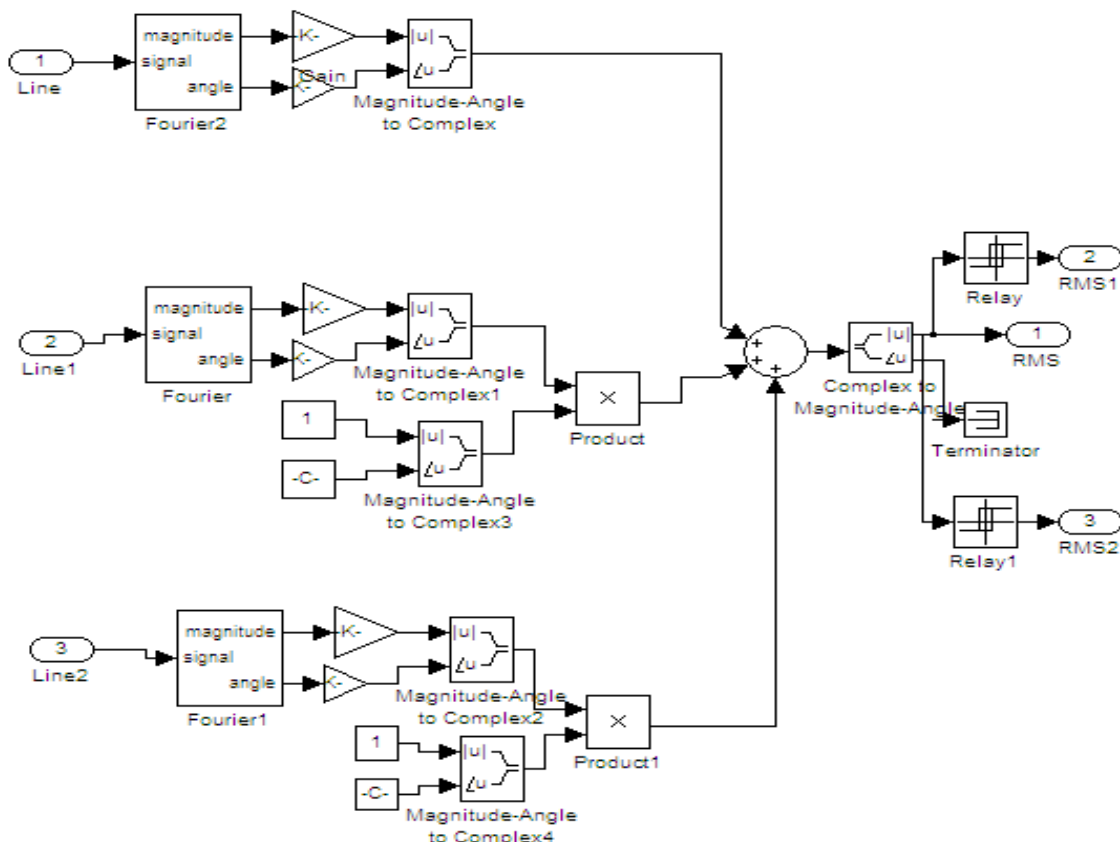
2. Proposed System:





(i)

A three phase electrical power system consists of 15KV, 50Hz transmitting power from a synchronous generator with 250MVA rating interconnected to an 2500 equivalent source which is a substation, through a 200Km transmission line. The transmission line is split in two 100Km lines connected between buses of single generator and equivalent source.



(ii)



This is a multifunctional relay model in which simulation and steady state analysis testing is done using Matlab. In this paper unsymmetrical fault under different fault condition at generator end is shown by their respectively graphs. A three-phase system is modeled in continuous mode using blocks from three-phase library available in simulink. Stator phase faults, over-voltages, under-voltages and negative sequence current are protected with the developed relay model. Voltages and currents are measured in each condition. There is some case of protection

All the stator phase faults including phase to ground, phase to phase and three phase faults are simulated. The protection against each fault is applied with the relay trip signal and opening of circuit-breaker. The simulation study also shows the normal



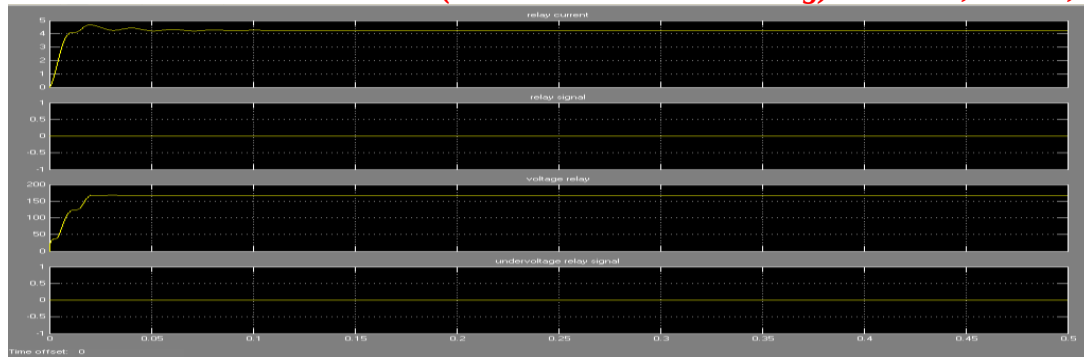


Fig.3 - Relay Operation in Healthy Condition

In the condition of fault occurrence the trip signal is sent to the main circuit-breaker which is also generator transformer circuit breaker (GTCB).

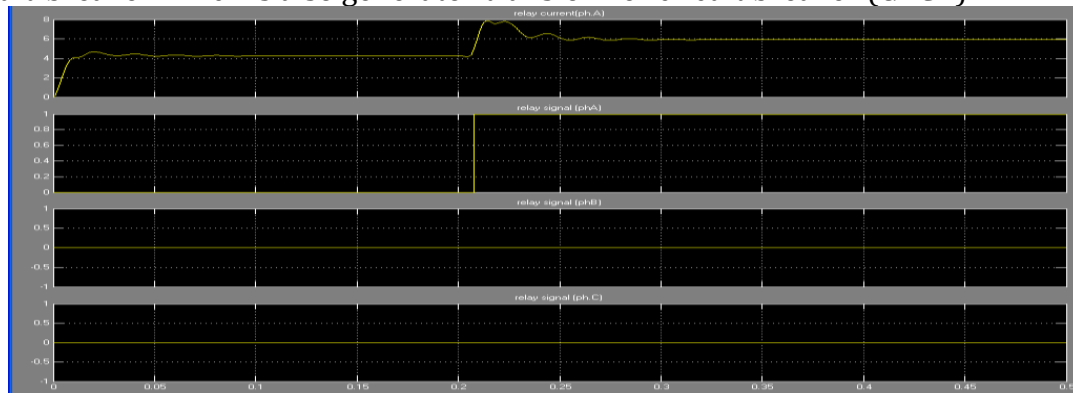


Fig.4 - Line to Ground fault

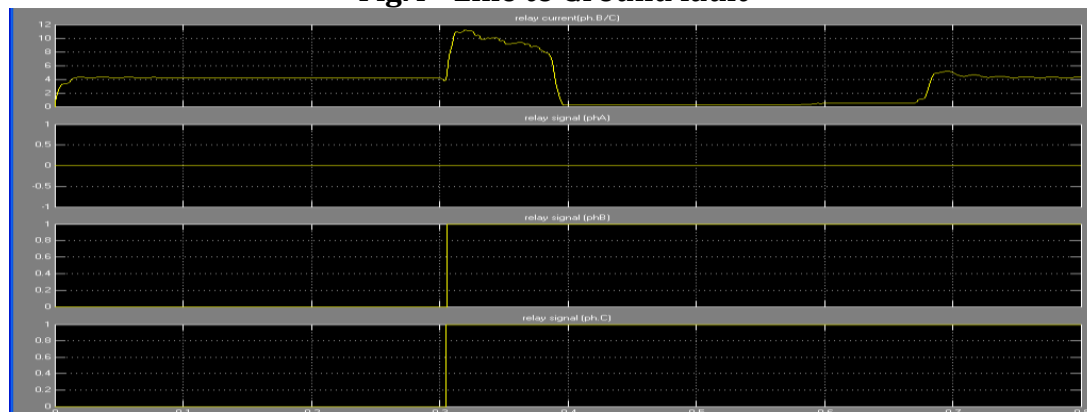


Fig. 5 - Line to Line Fault

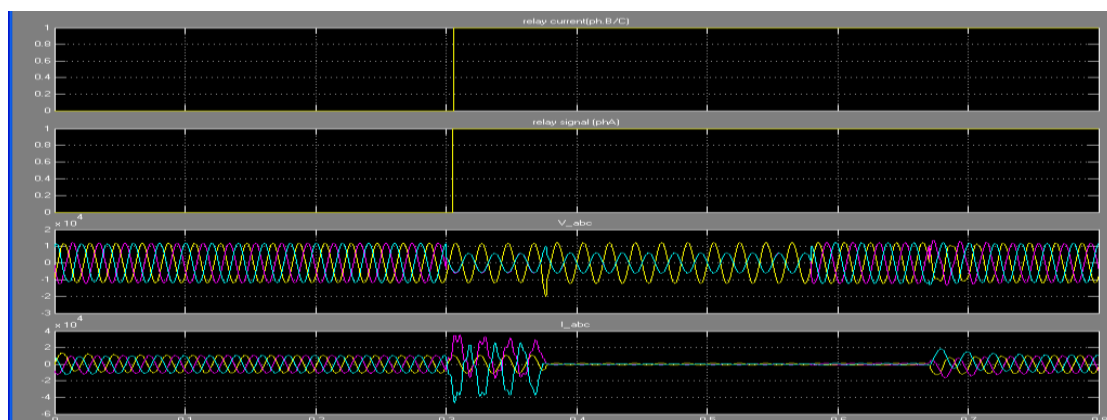


Fig.6- Relay trip signal for Line to Line fault

(B) Abnormal Conditions:

There are many no. of abnormal condition such as over-voltages, under-voltages and negative sequence current. Those can cause insulation failures, dip in the voltage and heating of the machine.

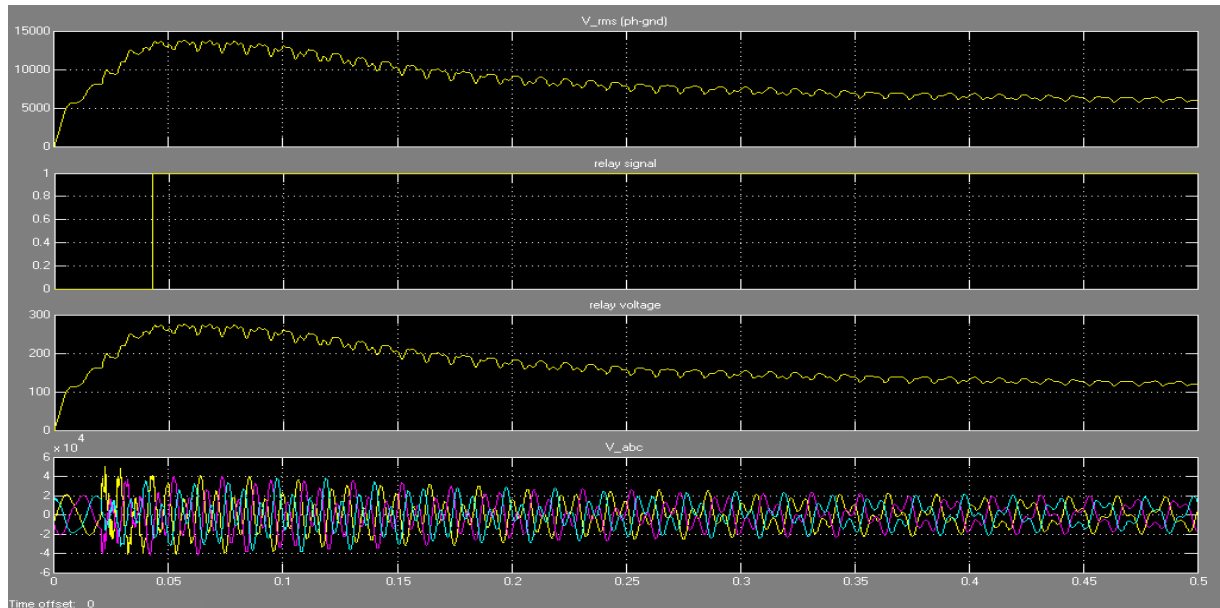


Fig. 7 - Overvoltage Relay Signal

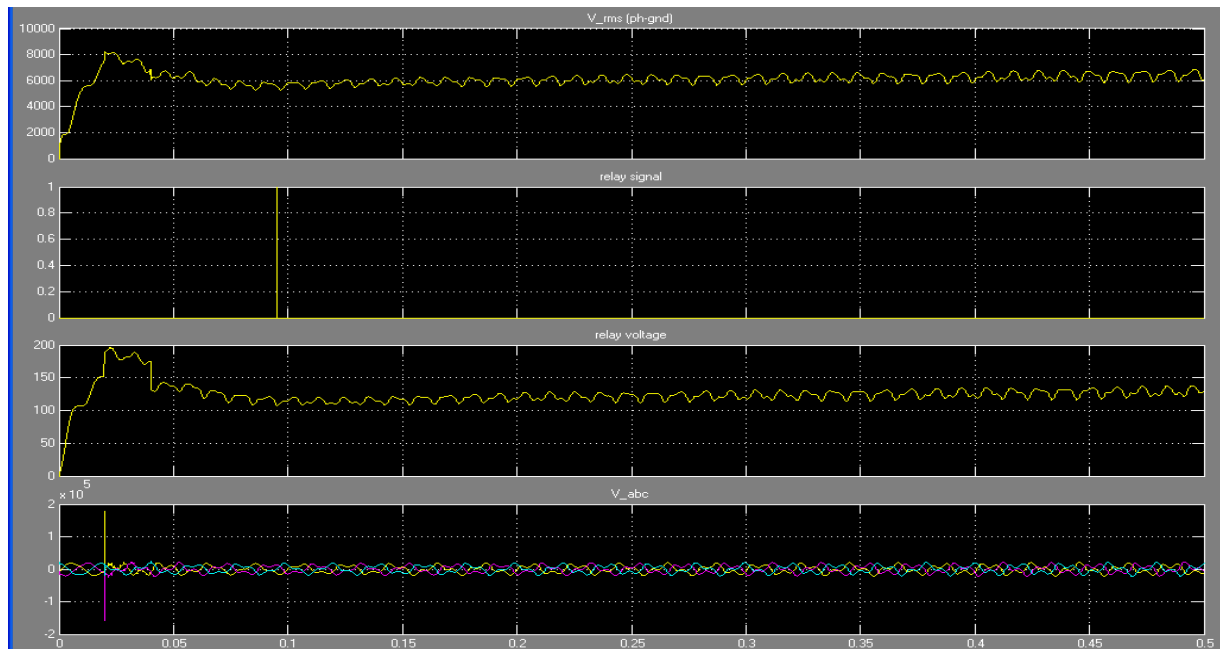


Fig.8 - Under-Voltage Trip Signal

The condition of overvoltage and under voltage is produced in such a way that it should not cause the sudden rise of current in three phases otherwise the relay will operate for over current protection. Negative sequence current arises in the condition of unbalanced load and is computed from three phase current in the stator using unsymmetrical analysis. For this purpose a subsystem is developed using MATLAB simulink and is introduced in the protective relay

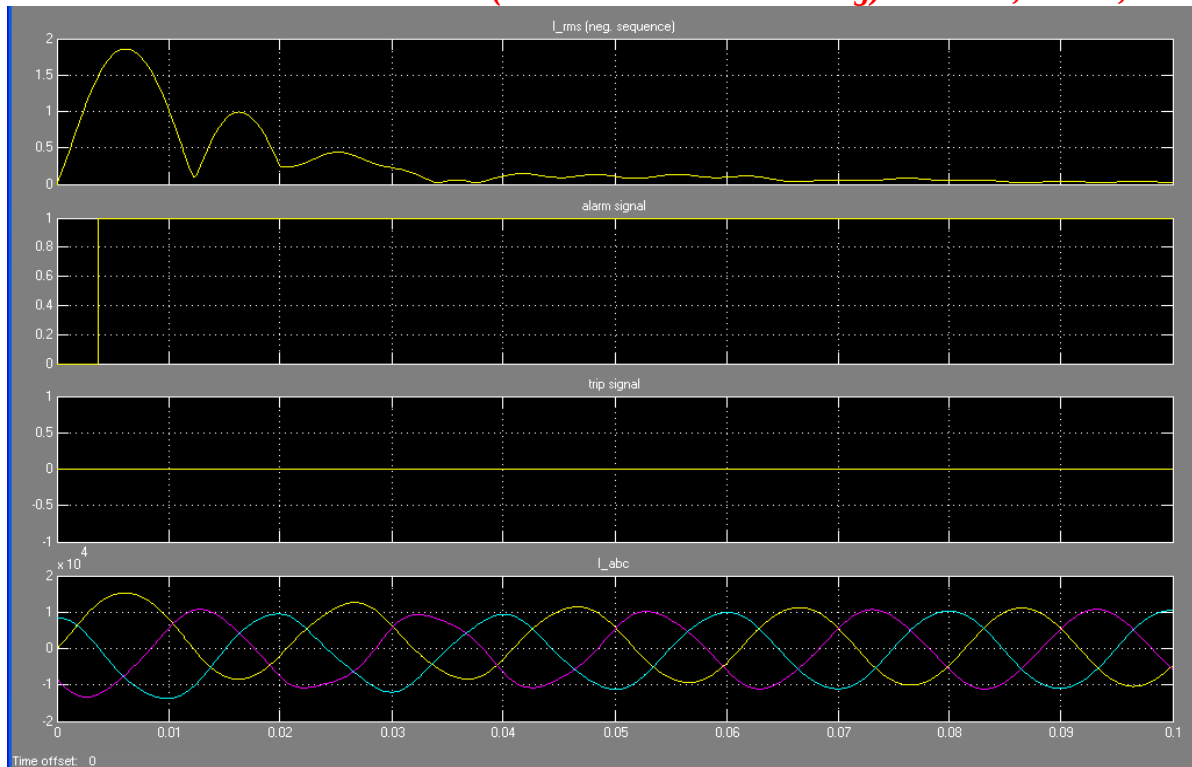


Fig.9 - Negative sequence alarm

3. Scope:

The need of Continuous and reliable power supply has increased due to this protection and monitoring of modern power system is necessary with in low cost and smart handling technique. Multifunctional relay scheme also helpful to protect generator against the stator fault, overvoltage, symmetrical, unsymmetrical balanced and unbalanced conditions. This relay system can be further implemented for the development to multi-functionalize the bus-bar, transformer and distance protection. Besides this the modern switchgear with vacuum circuit breaker is also being developed. This will be very interesting area to be studied further.

4. One Relay One Feeder:

The following solutions are available within one relay family- Separate control and protection relays, Feeder protection and remote control of the line circuit-breaker via the serial communication link, combined relays for protection, monitoring and control. Mixed use of the different relay types is readily possible on account of the uniform operation and communication procedures. It sounds good for better protection of existing system. Modern relay families offer the user a uniform technique covering the whole range of protection applications. This includes a uniform operator concept, uniform housing technology, common communication protocols and a uniform technology. This offers a number of advantages for the user: Reduced engineering and testing efforts due to well-suited functions Reduced training due to uniform operation and setting Uniform data management due to a common operator program For the simulation study, a power system model having a synchronous generator interconnected with a substation is considered and analyzed under different faults, abnormal conditions faced by generator and protection against them. A subsystem for the calculation of negative sequence current has been developed. It has been observed that one relay performs combined protection of generator feeder.

5. Conclusion:

From this study it can be concluded that combined relays should be used for protection and control. In transmission type substations, separation into independent hardware units is still preferred, whereas on the distribution level a trend towards higher function integration can be observed. Here, combined feeder/line relays for protection, monitoring and control are on the march. Relays with protection functions only and relays with combined protection and control functions are being offered. Relays support the "one relay one feeder" concept and thus contribute to a considerable reduction in space and wiring. With the development of digital technology modern protective relay supports both stand-alone and combined solutions on the basis of a single hardware and software platform. The user can decide within wide limits on the configuration of the control and protection functions in the line, without compromising the reliability of the protection functions.

6. Reference:

- [1] D P Kothari, I J Nagrath, 'Modern Power System Analysis', 4 Edition ISBN 978-0-07-107775-0.
- [2] Soman S A, S A Khaparde and Shubha Pandit, Computational Methods for large sparse power system analysis, KAP, Boston, 2002.
- [3] Gross, C A, Power System Analysis, Willy, New York, 2000.
- [4] K Ferling and H Rljanto, "Influence of the Latest Technologies on the Development of Protective Relays," International Conference on Electricity Distribution, Brighlo, pp: 101 - 103.
- [5] Robert A.Kennedy and Larry E.Curtis. "Overcurrent Proleclive Device Coordination by Computer," IEEE Transactions on Industry Applications, Volume I A-1 8, No.5, October 1982. pp: 445 - 456.
- [6] IEEE Industrial and Commercial Power Systems Department Working Group Report of the Protection Committee, "Application Considerations of Static Over current Relays: A Working Group Report" IEEE Trans. Industry Applications., Vol. 33, pp.1493 - 1499.
- [7] M. S. Sachdev, "Advancements in Microprocessor Based Protection and Communication, "A tutorial publication of the IEEE, Piscataway, NJ: IEEE Cat. No. 97TP120-0, pp.127.