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A Review on Three-Phase Fault Analysis Using Simulink

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Abstract: Electrical power now becomes an essential part of our daily life work such as households, agriculture, commercial, industrial sectors, etc. A fault is an unwanted situation for the power system network which can affect the whole transmission and distribution network. In this paper, it has been discussed how to analyze the three-phase transient fault in the transmission section and for this MATLAB simulation is used, which will show how the three-phase fault occurs in the transmission system and what will be the effect on the voltage, current during the fault and after the fault condition.

Keywords: Simulation, Transient fault, Transmission Line.

1. Introduction:

A fault is an abnormal condition that arises in the power system network due to which values voltage and current parameter get affected from its fixed ratings, and current always flows in short circuit path or least resistive path. The faults in the power system cause over current, under voltage, unbalance of the phases, reversed power, and high voltage surges.

A fault in an electrical power system can be described as, any abnormal situation of the system that entails the electrical failure of the equipment such as; transformers, generators, busbars, , , etc. It can also be defined as the electrical fault is the deviation of voltages and currents from nominal values or states. The fault creates an abnormal condition which reduces the insulation strength between the conductors. The reduction in insulation causes excessive damage to the system.

Faults may occur in the three-phase or single phase power system due to the number of reasons like natural disturbances (lightning, high-speed winds, earthquakes), equipment insulation failure, falling off a tree, bird shorting, line overloads, etc.

There is some more reason for power system fault such as frequent electrical surges, sag, and dips in the transmission line, circuit overload, circuit breaker tripping, , , etc. Fault detection, protection of the power system equipment, and fault elimination from the lines are important tasks to protect the electrical power system.

Under regular running conditions, substation's equipment or lines carry fix ratings of the voltages and currents which end safer operation of the system.

A system is a network composed of passive and active electrical components that are used to supply and transmit electric power. There are various factors, which are responsible for fault in the line. Thus, a network system is required for the analysis of the fault. Here, we are trying to make a SIMULINK based model that is used to analyze the three-phase transient fault in the transmission line [1], [2], [3]. The result of the SIMULINK model will give us a brief knowledge of the transmission line transient fault. Here we have tried to make a short review of some of the common methods of the power system analysis for different types of faults in the power system and their consequences in brief. The various kinds of faults are presented in Fig. 1.

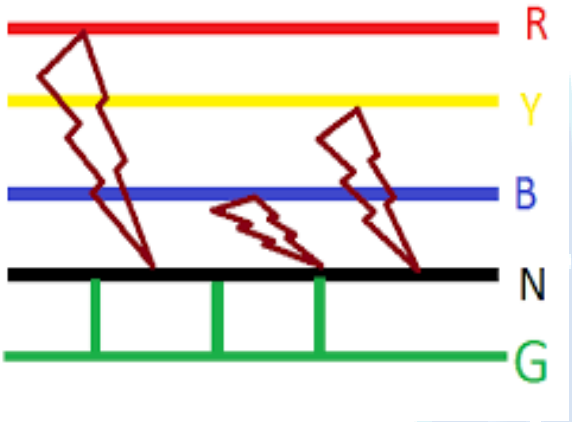

Fig. 1 Three-phase fault

2. Types of Three-Phase Fault

A short circuit fault may be a fault during which the conventional current deviates from the normal load. An open-circuit fault occurs if a circuit is interrupted by some failure, or anyone of the conductors gets open due to some electrical phenomenon such as heavy load current or physical phenomenon such as conductor may get opened physically due to losing contact or it may get broke. There is three types of the short circuit fault which is L-G (single line to ground), LL-G (double line to ground), LLL-G (triple line to ground). Current flows into the earth during the ground faults. The fault can be detected by the ratings of the voltage and current transformers, circuit breakers and relays, etc. In the modern power system, the whole switchyard system is automated; whenever the fault arises circuit breaker automatically breaks the switchyard from the incoming network for the protection of the substation machinery. When a fault occurs, it causes excessively high currents to flow which can cause damage to the equipment such as; transformers, generators, bus bars, etc. and devices in the distribution or transmission section [4, 5]. The design of suitable rating switchyard equipment like current and voltage transformer, circuit breaker, relays is an important task for any substation so that it may capable to handle the

fault situations for the particular substation. The various types of power system fault are discussed below:

2.1 ***Transient fault:*** The fault occurs in a very short time or an insulation fault which only temporarily affects a device's dielectric properties which are restored after a short time. For example lightning strikes on the transmission line [6].

2.2 ***Persistent fault:*** Fault in the underground cable. For example: cable drench broken due to heavy loads (JCB or Lorry going on the drench closing plates) on the drench shield.

2.3 ***Symmetric fault:*** Symmetrical fault involves all the three-phases, and these phases carry the identical fault current and phase difference which makes the system balance.

2.4 ***Asymmetric fault:*** It means the fault involves one phase to ground or between the phases. In asymmetric faults all three-phase lines become unbalanced. Asymmetric faults are L-G, L-L-G, L-L-L-G, L-L, L-L-L [7, 8].
Where, L= Line, G= Ground

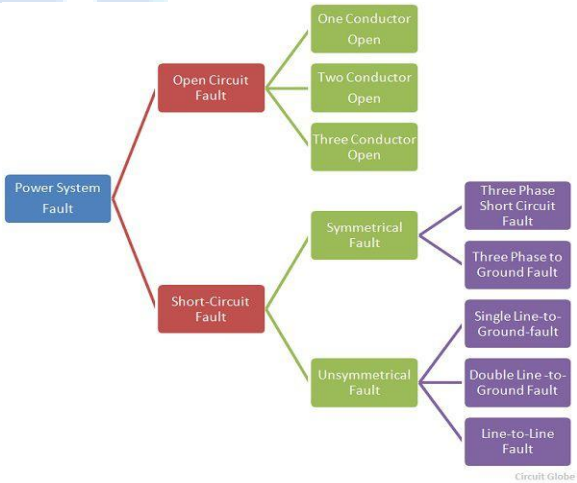

Fig. 2 Classification of power system faults

2.5 ***Open Circuit Fault:*** The open-circuit fault occurs when one or two conductors may break. The flow of current during this fault gets stop i.e. no current flow throughout the circuit. This fault affects the reliability and sensitivity of the network. The open-circuit fault is categorized as:

- Open conductor fault
- Two conductors open fault
- Three conductors open fault

2.6 ***Short-Circuit Fault:*** During this fault, two or more than two phases come to contact with each other, due to which very high rating of current starts to flow in the circuit due to which the whole power system may get affected. The short - circuit has two type, the symmetrical and unsymmetrical fault.

2.6.1 ***Symmetrical Fault:*** The faults which involve all the three-phases are known as the symmetrical fault. This fault may remain balanced even after the fault. The symmetrical faults frequently occur at the generating stations. The symmetrical fault is sub-categorized into the line-to-line-to-line fault and three-phase line-to-ground-fault [9].

a. ***Line–Line–Line Fault:*** This fault is symmetrically balanced fault; it means the system remains symmetrically balanced before and after the fault. This type of fault occurs occasionally in the power system, but it is the most type of fault because it involves the excessively large current. The rating of the circuit breaker and relays will be decided by this current.

b. **L–L–L–G (Three-phase line to the ground fault)** – When all the three-phases come to contact with each other and these phases also contacted with the ground, then L-L-L-G fault occurs . It involves all three-phases and ground. This type of fault arises rarely in the power system (less than 2%).

2.6.2 ***Unsymmetrical Fault:*** This fault is an unbalanced fault which means during the fault, the current and the voltage of each phase are not the same and the power factor of each phase may also vary. In this type of fault, two or more than two phases get involved. There is three type of unsymmetrical fault which are as below:

a. Single line to ground (L – G) fault
b. Line to line fault (L – L)
c. Double line to ground (L – L – G) fault

The unsymmetrical fault is the most common type of fault occurs in the power system [10].

a. ***Single line to ground fault:*** When one conductor falls to the ground or contact the neutral conductor, a single line to ground fault occurs. Approximately 80% fault of the power system is a single line to ground fault.

b. ***Line to line fault:*** When two phases of a circuit come to contact with each other, then a line to line fault occurs. The main cause of this kind of fault is heavy wind. Both the phases of the circuit contacts with each other due to this heavy wind. Approximately 15-20% of the power system fault is line to line fault.

c. ***Double line to line ground fault*:** In double line to ground fault, the two lines come in contact with each other along with the ground. Approximately 10% of the power system fault is line to line ground fault.

3. The Need for Fault Analysis

- Rapid information about the type and location of the fault can assist the task of repair and maintenance, thereby minimizing the economic effect of power interruption.
- High voltage transmission and distribution network are the backbones of modern power generation and

distribution and fault in the transmission section can lead to serving economic loss.

- Analysis of the system disturbances provides a wealth of valuable information regarding power system phenomena and the behavior of the protection system.

4. Fault Statics and Its Scenario

Most of the fault in the electrical power system with the network of the overhead line is one phase to ground fault resulting primarily from lightning-induced transient high voltage from falling trees and limb contact.

- One phase to ground fault- 70% to 80%
- Phase to phase to ground- 17% to 10%
- Phase to phase – 10% to 8%
- Three-phase – 3% to 2%

It helps to improve the reliability and availability of the system.

5. Conclusion:

The rapid growth of the electric power system has in recent decades increased the number of transmission lines and total power outage. The challenge of a fast-growing electrical grid has also resulted in huge increases in overhead lines and their total length. Fault detection and fault elimination of the transmission lines are important tasks to protect the electrical power system. This paper is developed for the analysis of three-phase power system fault using Simulink model of the same. In recent years, the modern power system has now become more complex, broader, and more deregulated, and to maintain security and supply in the grid, the fast fault location technique is needed.

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