Fault Analysis

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Abstract- *In a power system, fault analysis is a very important process to follow for its planning, protection equipment selection, and overall system reliability assessment. When a fault (e.g., a short circuit) occurs at any point in the network, the normal operating conditions of the system gets distorted; if the fault is persistent severe loss of load and property can occur due to fire or explosion, and steep economic losses can arise as undesirable consequences. Therefore, the correct modeling of components and the correct fault analysis in power systems are critical to ensure safety and reliability of the power system.*

Keywords- Fault analysis, Power system, modeling of components, Operating conditions.

I. INTRODUCTION

Any abnormal condition in a power system can be considered as a fault. The steady state operating mode of a power system is balanced 3-phase a.c. is the steady state operating mode of a power system. However, due to any abrupt external or internal changes in the system due to the occurrence of fault, this condition is disrupted. At the time of insulation failure at one or more points or a conducting object comes into contact with a live point, a short circuit or a fault occurs. Different technical computer methods were used for performing fault analysis of symmetrical components. The fault impedance Zf was taken as zero. There different kinds of faults for which different program codes were developed to analyze them were as follows:

- **Symmetrical fault:**

The cause of a three phase symmetrical fault is application of three equal fault impedances Zf to the three phases. If Zf = 0 the fault is called a solid or a bolted fault. These faults can be of two types:

  - line to line to line to ground fault (LLLG fault)
  - line to line to line fault (LLL fault)

Since the three phases are equally affected, the system remains balanced, because of this reason the fault is called a symmetrical or a balanced fault and its fault analysis is done on per phase basis. The behavior of LLLG fault and LLL fault is similar to each other due to the balanced nature of the fault. This is a very severe fault that can occur in a system and if Zf = 0, this is usually the most severe fault that can occur in a system. Fortunately, such faults occur in very indefinite times and are not very frequent in nature and only about 5% of the system faults are three phase faults.

- **Unsymmetrical** fault:

Faults in which the balanced state of the network is disturbed are called unsymmetrical or unbalanced faults. The most frequently occurring type of unbalanced fault in a system is a single line to ground fault (LG fault). The other types of unbalanced faults are line to line faults (LL faults) and double line to ground faults (LLG faults). These faults are shown below:

  - Line to line fault
  - Line to ground fault
  - Double line to ground fault

A symmetric or balanced fault affects each phase of the transmission system equally. In transmission line faults, about 5% are symmetric. These types of faults can be analyzed via the same methods as any other phenomena in power systems, and in fact many software tools exist to accomplish this type of analysis automatically. All the three phases of the system are not affected equally in an asymmetric or unbalanced fault, the different types of asymmetric faults are line to line fault, line to ground fault and double line to ground fault which are roughly 5%-10%, 65-70%, and 15%-20% respectively. The underlying assumptions used in three-phase power, namely that the load is balanced on all three phases does not hold true in the presence of an asymmetric fault.

II. NEED OF FAULT ANALYSIS

- Rapid information about the type and the location of the fault can assist the task of repair and maintenance, thereby minimizing the economic effects of power interruption.
- High-voltage transmission and distribution networks are one of the most important components of modern power generation and distribution systems. Faults on

the transmission system can lead to severe economic losses.

- An analysis of system disturbances provides a wealth of valuable information regarding power system phenomena and the behavior of protection systems.
- Helps to improve reliability and availability of the system.

III. REQUIREMENT FOR FAULT ANALYSIS

- DFR Report: DFR monitors power system voltages and currents, frequency, phase angle etsectra.
- SER Report: Sequence of events recorder (SER) monitors relay outputs, breaker and disconnect switch positions, alarms, relay targets and relay communication channels.
- Relay settings: It helps to configure actions of a relay system and the amount of intentional time delay offered to successfully perform it.

By the help of DFR and SER reports in conjunction we can provide information such as:

1. Sequence of operation
2. Fault types
3. Clearing time
4. Reclosing time
5. Relay problems such as:
   a. Failure to trip
   b. Failure to target
   c. Failure to reset
   d. Delayed clearing
6. Circuit breaker problems such as:
   a. Contact arcing
   b. Unequal pole closing
   c. Unequal pole opening
   d. Re-strike
   e. Re-ignition
7. Fault current and voltage magnitudes to confirm a short-circuit
8. C.T. Saturation
9. Asymmetrical current caused by dc (direct current) offset
10. Fault locations, currently provided by numerically based distance relaying

IV. FAULT STATISTICS

Most faults in an electrical utility system with a network of overhead lines are one-phase-to-ground faults resulting primarily from lightning-induced transient high voltages and from falling trees and tree limbs contacts.

1. Line to ground fault: 70%-75%
2. Double line fault: 16%-18%
3. Double line to ground fault: 08%-10%
4. Triple line fault: 02%-04%

V. Fault Origin:

- External:

1. Atmospheric causes:
   a. Thunderstorm and lightning
   b. Wind
   c. Snow
   d. Ice and Hoarfrost
   e. Earthquake
2. Physical or mechanical causes:
   a. Fire explosions
   b. Falling trees or tree limbs contacts
   c. Physical contact by animals (birds, rodents etc.)
   d. Unfortunate people contacting live equipment
   e. Physical accidents like: Vehicles hitting poles or contacting live equipment

- Internal:

These faults can occur into the electrical networks without justification from any external cause or external intervention. Faulty operation owing to an equipment failure or a human error such as opening of an isolator-switch on load.

1. Human error
2. DC Earth fault
3. Wrong relay setting
4. Hot Spot

VI. FAULT CONSEQUENCES

Usually significant changes in the system quantities are provided by the system faults, which can be used to distinguish between tolerable and intolerable conditions.

These changing quantities include:

1. Over current
2. Under voltage or Over voltage power
3. Power factor and/or phase angle
4. Power current direction
5. Impedance

6. Frequency
7. Temperature
8. Physical movements
9. Pressure

Anyhow, the most common fault indicator is a sudden and generally significant increase in the current and decrease of the phase(s) voltage.

VII. FAULT LIMITING DEVICES

Minimizing the causes like human errors are possible, but not environmental changes. Fault clearing is an important task in power system network. If we manage to disrupt or break the circuit when fault arises, it reduces the considerable damage to the equipments and also property.

Some fault limiting devices which helps in protecting or reducing occurrence of such type of faults includes fuses, circuit breakers, relays, etc. and are discussed below.

Fuse: It is a primary protecting device. It is a thin wire enclosed in a casing or glass which connects two metal parts. This wire melts when excessive current flows in the circuit. The type of fuse depends on the operating voltage of the system in which it is going to be operated. Manual replacement of wire is necessary once it blowout.

Circuit breaker: It makes the circuit at normal as well as breaks at abnormal conditions. It causes automatic tripping of the circuit when a fault occurs. It can be electromechanical circuit breakers like vacuum/oil circuit breakers etc, or ultrafast electronic circuit breaker.

Relay: It is condition based operating switch. It consists of a magnetic coil and normally open and closed contacts. Fault occurrence raises the current which energizes relay coil, resulting in the contacts to operate so the circuit is interrupted from flowing of current. There are different kinds of protective relays such as impedance relays, mho relays, etc.

VIII. CONCLUSION

The work starts with an occurrence of fault in the system and then after a detailed fault analysis on it, we can conclude about the different types of fault occurring in a system, there origin, consequences, devices used for limiting them and methods of fault analysis according to the type of fault in the system.

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