A Review on Fault current mitigation and elimination in high voltage transmission line with PSB, OST and FCL unit

Mr Dipak R. Joshi[1], Mr. S. H. Thakare[2], Mr. Y. P. Sushir[3]
[1] ME Student, Electrical Engineering, Padm, Dr. V. B. Kolte College of Engineering Maharashtra, India
[2] Asst. Proffessor, Electrical Engineering, Padm, Dr. V. B. Kolte College of Engineering Maharashtra, India
[3] Asst. Proffessor, Electrical Engineering, Padm, Dr. V. B. Kolte College of Engineering Maharashtra, India

ABSTRACT

Due to the integration of multiple power electronic devices, the power system is becoming more and more complex by nature. The protection of such systems and the improvement of reliability and stability are highly dependent on limiting the fault current. Various types of fault current limiters (FCL) have been used in power systems because they provide fast and effective fault current limitation. In addition, modern distance relays also provide a power swing lockout (PSB) function to prevent unwanted operation of distance relay components during power swings. The main purpose of the PSB function is to distinguish between faults and power swings, and to prevent the distance or other relay components from operating during power swings. This article provides a comprehensive review of the literature on the use of PSB, OST, and FCL units to mitigate and eliminate fault currents in high-voltage transmission lines. This project includes the study of methods to detect power changes in transmission lines and the verification of methods to detect power changes based on the rate of impedance change. Here, this type of analysis requires software, because in real situations, the network is very complex. For the same system, modeling the entire component based on the real system helps to study the same network more easily without imposing it on real conditions. Therefore, to maintain the stability of the system, this emergency analysis plays a vital role. A three-region power system model is designed in SIMULINK software and simulation data is used for analysis. The impedance seen by the relay enters the area that is usually set to 90% of the impedance of the transmission line within a period, and is almost stable at an impedance equal to the fault impedance seen by the relay. In the case of Power Swing, the impedance changes slowly, and it takes a long time to enter the regional settings. So using this method we can detect faults in the loop. If the impedance changes slowly, we can prevent the operation of the relay.***Keywords: Contingency, Relay, Power Swing, Faults, Distance Relay.***

1. INTRODUCTION

A steady-state power system usually operates near its nominal frequency. There is a trade-off between active power and reactive power generated and consumed under steady-state operating conditions, and the final transmit and receive voltage difference is usually within 5%. The system frequency in a large power system usually varies by +/- 0.02 Hz in a 50 Hz power system. Power system failures, line switching, generator disconnection, and the loss or application of large loads can cause sudden changes in electrical energy, while the mechanical energy input to the generator remains relatively stable. These system disturbances will cause the machine rotor angle to oscillate and may cause sudden changes in power flow. Depending on the severity of the disturbance and the actions of the energy system control, the system can remain stable and return to a new state of equilibrium, undergoing so-called stable energy changes. On the other hand, severe system disturbances can cause wide separation of generator rotor angles, large oscillations in power flow, large fluctuations in voltage and current, and eventual loss of synchronization between generator sets or gensets. adjacent utility systems. Stable or unstable high power fluctuations will cause unnecessary relay operations at different locations on the network, further aggravating power system interference and can cause cascading power outages and power outages. Normally in Power system when resistance is neglected the amount of power (P) transmitted in the simple system shown in
Figure 1.1 can be represented by the following equation:

$$P= \frac{EsEr}{X} Sin\delta \qquad \text{--------------- [1]}$$

Where:
Es is sending end voltage:

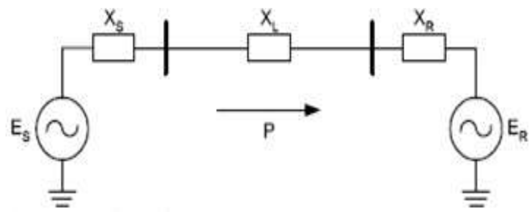

Fig 1. A Two- Source System

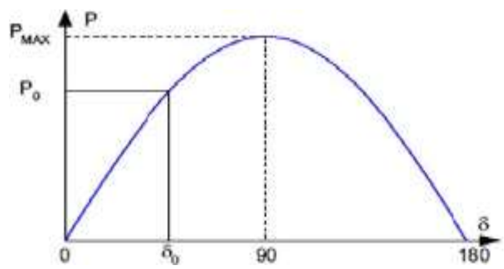

Fig 2. Power Angle Curve

1.1 Methods to Detect Power Swing:

Concentric characteristic scheme R-Point Scheme Continuous impedance calculation The first two methods are based on impedance changes, while the latter is not a complete impedance change, but is based on continuous impedance calculation.

1.2 Power-Swing Phenomena And Their Effect On Transmission Line Relaying

System Risks Due to Power Swings and Out of Step Conditions
Transient Recovery Voltage (TRV) causing Breaker Failure
Isolating Load and Generation
Equipment Damage
Cascading Tripping of Lines

Unexpected Cascade Trips from Generator Sets The power system or loss of synchronization between the generator and the power system can affect relays and transmission line systems in a number of ways. The settings required for the PSB and OST elements can be difficult to calculate in many applications. For these applications, extensive stability studies must be performed under different operating conditions to determine the fastest rate of power variation possible..

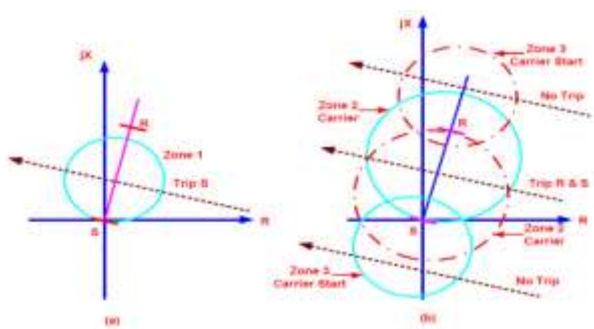

Fig 3. (a) & (b) Zone 1 and Directional Comparison Blocking Scheme Characteristics

Figure 3(a) shows the operation of a Zone 1 distance relay when the swing locus goes through its operating characteristic and figure 3(b) shows a directional comparison blocking scheme characteristic and how it may be impacted by the swing locus.

1.3 Impedance Measured by Distance Relays during Power Swings:

During a system Out-Of-Step event, a distance relay may detect the Out-Of-Step as a phase fault if the Out-Of-Step trajectory enters the operating characteristic of the relay. To demonstrate this, let us look at the impedance that a distance relay measures during an Out-Of-Step condition for the simple two source system. Considering Fig: 3.2, the current IL at bus A is computed as:

$IL = (ES-ER) / (ZS+ZL+ZR)$ -----------------[2]

The direction of current flow will remain the same during the power swing event. Only the voltages change with respect to one another. The impedance measured at a relay at bus A would then be:

$Z = VA / IL = (ES-ZS.IL) / IL = ES / IL - ZS = [ES (ZS+ZL+ZR) / (ES-ER)]-ZS$ -----------------[3]

Let us assume that ES has a phase advance of δ over ER and that the ratio of the two source voltage magnitudes $|ER/ES|$ is k. We would then have:

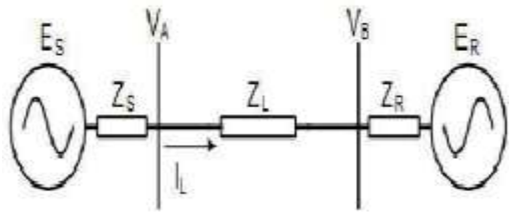

Fig 4. Two Machine System

$ES/ (ES-ER) = k (\cos\delta + j\sin\delta) / [k(\cos\delta + j\sin\delta)-1] = k[(k\cos\delta)- j\sin\delta]/[(k-\cos\delta)2 + \sin2\delta]$ ---------------- [4]

For the particular case where the two sources magnitudes are equal or k is one, equation 3 can be expressed as:

$ES/ (ES-ER) = ½(1-j\cot\delta)$ -----------------[5]

And finally the impedance measured at the relay will be:

$Z = VA/IL = [1/2 (ZS+ZL+ZR) (1-j\cot\delta)]-ZS$ ---------------- [6]

Remembering that δ is the phase angle between the sources, there is a geometrical interpretation to equation 5 that is represented in Fig 3.3(a). The trajectory of the measured impedance at the relay during a power swing when the angle between the two source voltages varies corresponds to the straight line that intersects the segment A to B at its middle swing. The angle between the two segments that connect P to points A and B is equal to the angle δ. When the angle δ reaches the value of 180 degrees; the impedance is precisely at the location of the electrical center.

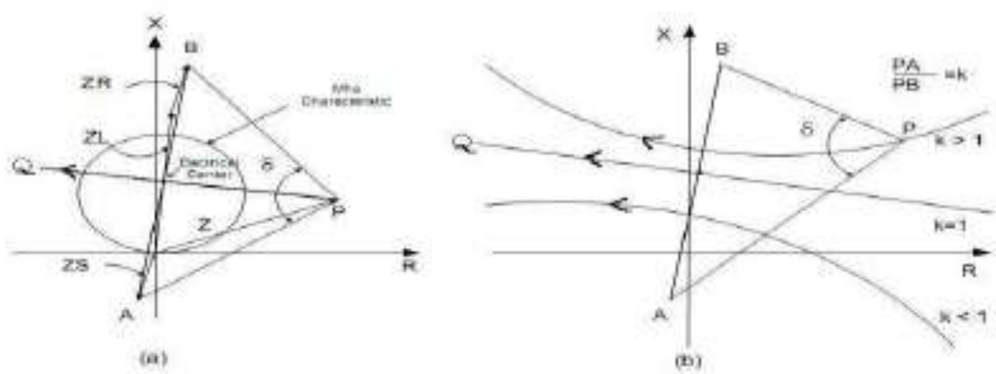

Fig 5. (a) & (b) Impedance trajectories at the Relay during a Power Swing for Different k Values

The performance of distance relays during swings is dependent to some extent on the relative magnitudes of system and line impedances. For instance, if the line impedance is small with respect to the system impedances, it is likely the various distance relay zones will trip only on swings from which the system will not recover.

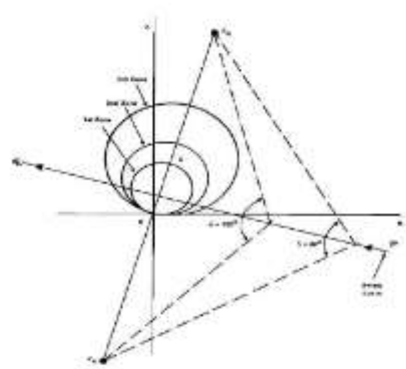

Fig 6. Impedance Locus when Line Impedance is small

Terminal C in Figure illustrates this situation. As shown in the figure, only when the angle difference between the systems is more than 120 degrees, the oscillation path will enter the distance relay characteristic. In this case, any of the three zones can provide triggering. If the glide between the systems is slow and the timing settings for the second and third zones are low, the second or third zone relay or both may operate during the swing. If these two areas do not run, when the trajectory enters its characteristics, the first area will definitely run.

2. METHODS FOR DETECTION OF POWER SWING

2.1 Continuous Impedance Calculation:

This method determines a power swing condition based on a continuous impedance calculation as shown in fig 3.1. Continuous here means, for example, that for each 5 ms step an impedance calculation is performed and compared with the impedance calculation of the previous 5 ms. As soon as there is a

assumed but not proven yet. The next impedance that should be calculated 5 ms later is predicted based on the impedance difference of the previous measured impedances.

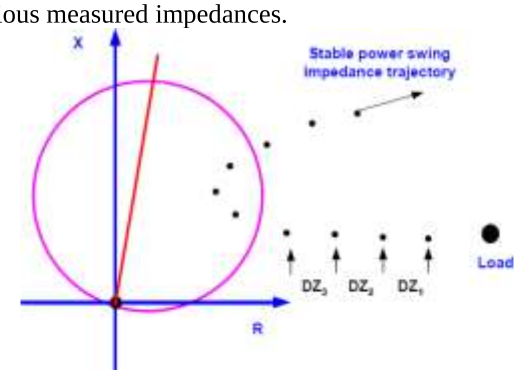

Fig7. Power swing detection with continuous impedance calculation

If the prediction is correct, then it is proven that this is traveling impedance. In this situation a power swing condition is detected. For security reasons additional predictive calculations may be required.

2.2 Conventional Rate of Change of Impedance PSB and OST Methods:

The traditional power swing blocking scheme is mainly based on the positive sequence impedance measurement of the relay position. Under normal operating conditions of the system, the measured impedance is the load impedance, and its location is far away from the protection characteristics of the relay. When a fault occurs, the measured impedance immediately moves from the position of the load impedance to the position in the impedance plane that represents the fault. During a system failure, the impedance change rate seen by the relay is mainly determined by the amount of signal filtering in the relay. During system oscillation, the measured impedance moves slowly in the impedance plane, and the impedance change rate is determined by the slip frequency of the equivalent dual-source system. The traditional power swing blocking scheme uses the difference between the impedance change rate during the fault and the power swing to distinguish the fault from the swing. In order to achieve this distinction,

usually places two concentric impedance characteristics in the impedance plane, separated by ΔZ impedance, and uses a timer to measure the duration of the impedance trajectory moving between them. If the measured impedance intersects the concentric characteristic before the timer expires, the relay declares the event as a system fault. Otherwise, if the timer expires before the impedance crosses the two impedance characteristics; the relay classifies the event as a power supply change.

2.3 Psb and Ost Protection Philosophy

Protection relays that monitor voltage and current can respond to changes in system voltage and current and cause additional equipment to disconnect, thereby weakening the system and possibly causing cascading power outages and shutting down the main part of the system. power system. In addition to distance relays, other protection relays are prone to responding to stable or unstable power fluctuations and causing unexpected trips of transmission lines or other power system components, including overcurrent, directional overcurrent, and undervoltage. The PSB and OST relay principle is simple and straightforward: prevent power system components from tripping during stable oscillations. Protect the power system in unstable or out of date conditions. When two areas of the power system or two interconnected systems go out of sync, the areas must be separated from each other quickly and automatically to prevent equipment damage and shutdown of major parts of the power system. Uncontrolled tripping of circuit breakers must be avoided, and well-designed and controlled system separation is required to prevent equipment damage, large-scale blackouts, and minimize interference effects.

2.4 Method for Determining Need for Power Swing and OOS Protection:

This section shows a simplified form of showing energy detection, PSB and OST protection with specific transmission lines in the power system.

Equivalent source system of 2 simplified foods with equal food and receives end voltages, the impedance trajectories cross the total impedance of the system at right angle of the protected line and the impedance of transmission tendency / reception of Terminal

. This method. This method It consists of determining that the electrical center of the system and the electric center are on the line according to the investigation. The method will be described using the simple system shown in Figure 4.1. By using this method, it is important to keep in mind that the current does not change, but the voltage leaves 180 degrees each other.

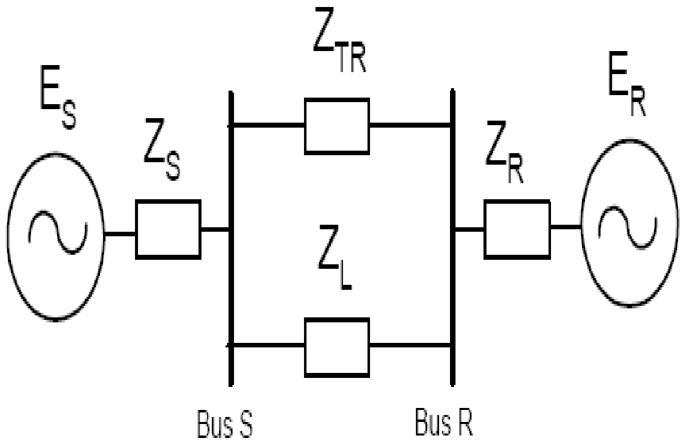

Fig 8. Two-Source System Equivalent

Where,
ES = Equivalent sending end voltage
ZS = Equivalent sending end source impedance
ZL = Line impedance
ER = Equivalent receiving end voltage
ZR = Equivalent receiving end source impedance
ZTR = Equivalent impedance of the system interconnecting sending and receiving buses

4. CONCLUSIONS AND FUTURE SCOPE

The results of the above simulation verify that the positive sequence impedance shift method is useful for detecting power swings. But you must have a protective team that can react faster to react quickly to detect it. This analysis helps enable the relay Power System Lockout (PSB) setting. Both stable and unstable power fluctuations will cause widespread power outages in the power system, resulting in cascading trips of power system components. This article describes the protection of power systems against stable and unstable power fluctuations. The document describes power fluctuations, their causes and detection. Methods for detecting and protecting power systems from power fluctuations have been discussed and explained. A detailed study of the steady state and transient state system is required to determine the application of protection against power swings. Extensive stability studies must be performed under different operating conditions to determine the rate of change of power fluctuations. Protection relays use a variety of methods to detect the presence of power changes, the most common of which are positive sequence impedance changes. Other variables of the power system have also been used for the detection of power oscillations, such as the power and its rate of change, the transmission line or the difference of the phase angle of the path and its rate of change.

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