Effect of Power Swing on Transmission Line Protection (Distance Protection)

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Abstract- *electrical equipment have some withstand limits. These limits should never be crossed & it is the role of the protective system to prevent it. Also transformer protection is necessary as it is a costly & critical device. Protective scheme for power transformer should operate only for the internal fault and must be insensitive for any fault outside the zone of protection.*

Keywords- Distance protection, Mho Relay, PSCAD

I. INTRODUCTION

The continuity of power supply is industrial to the residential. The factories need the electricity to produce the products such as furniture, stationery and food for sell while at residential area, they need the electricity for washing, watching television, and cooking which make their live more easily. So just imagine their live without electricity. In addition, the safety of costumer's equipment also must be protected. The effect of disturbances in power system caused a tremendous impact on customers and economy in general. Thus, the protection system must be provided in power electrical system. The protection system likes protection relays initiate the isolation of faulted sections of the network in order to maintain supplies on the system. This then leads to an improved electricity service with better continuity and quality of supply. Power Swing Power swing is a power oscillation that occur basically due to the connection or disconnection of large amount of load in short amount of time. Power swings can be divided into two types such as stable and unstable power swing. When power swing occurred, the impedances measured by distance relays may move into the protection zones and can cause unwanted relay operations that can cause more worse in power system and lead to power outages.

The Institute of Electrical and Electronic Engineers (IEEE) defined a relay as an electric device that is designed to respond to input conditions in prescribed manner and after specified conditions are met to cause contact operation or similar abrupt change in associated electric control circuits One types of the protective relay is a distance protection relay Distance Protection Relay.

II. DISTANCE PROTECTION

A distance relay has ability to detect a fault within a pre-set distance along a transmission line from its location. Every power line has a resistance and reactance per length related to its design and construction so its total impedance will be a function of its length In other word, the impedance is proportional with the length (distance). A distance relay therefore looks at current and voltage and compares these two quantities on the basis of Ohm's law. Juan and Edward (2004) found that the distance protection is a non-unit type of protection and has ability to discriminate between faults occurring in different parts of the are classified depending on their characteristics in the R-X plane, the number of incoming signals. There are a few types of distance relays operating characteristics such as impedance relay, directional relay, reactance relay, and mho relay completely polarized mho relay, relays with lens characteristics, relay with polygonal (Quadrilateral) characteristics and relay with combined characteristics

The relays measure the absolute fault impedance and determine operation according to impedance boundaries of the R/X diagram Characteristic of Mho distance relay is shown in figure 1.

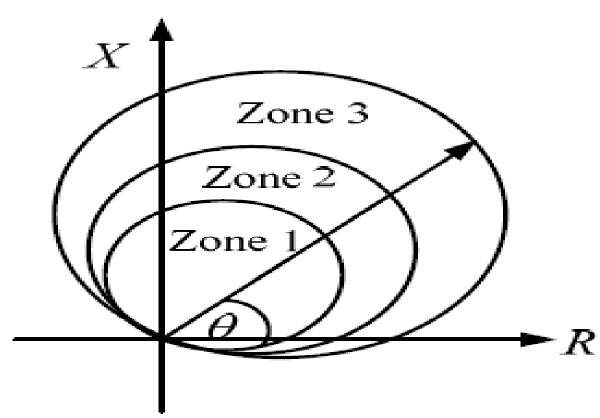

Fig. 1. Mho distance relay

The Mho distance relay type is circular impedance characteristic. A distance relay is designed to only operate for trajectory of faults occurring between the relay location and the selected reach point to set up time and remain stable for all faults outside this region/zone. In order to set the distance relay, 3 zones are normally used. The first zone (Zone 1) is designed to cover a section of the protected line while the second zone (Zone 2) is used as a backup protection of the next line section. The last zone (Zone 3) is also the backup protection that is extended to cover a part of the remote line section. The following describes a step-by-step distance relay setting for each protection zone according to figure 2.2 [1]. The distance relay also has a timing setting. For Zone 1, it must be tripped instantaneously to isolate any fault within the protected line. The operating time for Zone 2 is usually 0.25 to 0.4 s, and that of Zone 3 is in the range of 0.6 to 1.0.

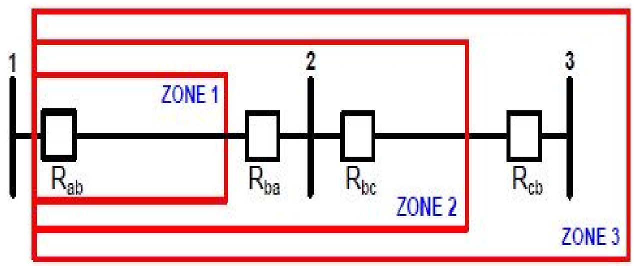

Fig. 2. Zone of protection

- Zone 1: (80% - 85%) × Z12
- Zone 2: Z12 + 50% × Z23
- Zone 3: Z12 + Z23 + 25% × Z34

III. POWER SWING EFFECT ON DISTANCE RELAY

In normal operation, the electric power system maintains a dynamic balance between generation and load. This disturbance will create power oscillation in transmission called as power swing. A power swing is stable when the rotation speed of all machines returns to synchronous speed while power swing is unstable when one or more machines do not return to synchronous speed, thereby losing synchronism with the rest of the system. During power swing, voltages and currents in the power grid will show a certain amount of oscillations in magnitude and phase angle, which can cause unwanted operation of distance protection relays. Moreover, the operation of protective relays may worsen system stability and lead to cascading power outages. A two-machine model used to explain the impedances trajectories measured by distance relays during power swings shown in figure 3

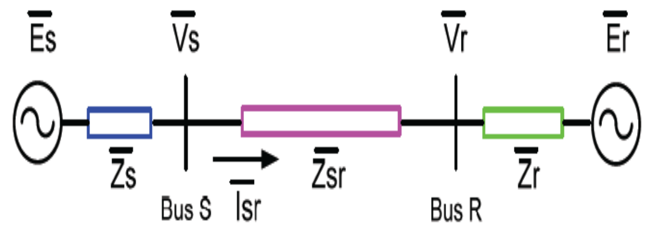

Fig. 3. The two-machine model

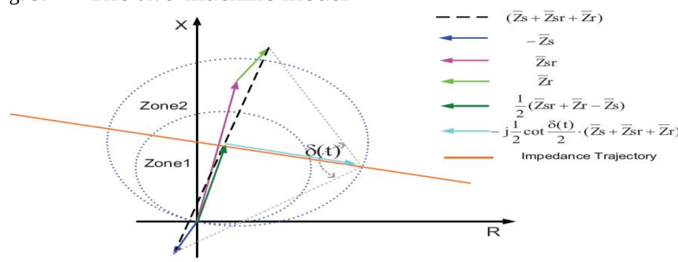

Fig. 4. Impedance trajectory between the two (voltage ratio k=1)

Figure 4 shows that during a power swing, particularly an out of step swing (δ (t)>180 degree), enter the protection zones of a distance relay Therefore, unwanted relay operation may occur because relays close to the more affected by power swings, more attention need on setting these relay.

IV. SIMULATION & RESULTS

Figure 5 shows the single line transmission system design in PSCAD software for the power swing event. Generator, circuit breaker, Multi meter, fixed load, bus bar, and a transmission line with 240 KM length were implemented in a transmission line system

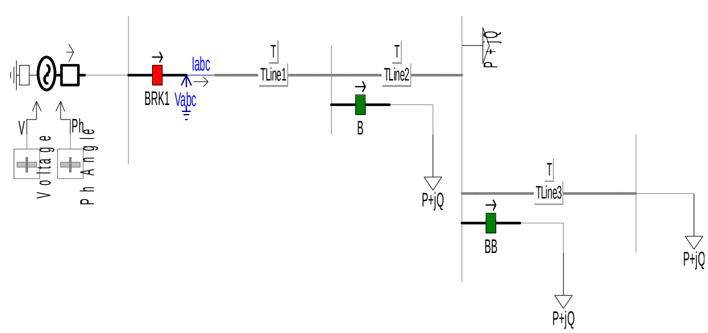

Fig. 5. 230 kV single sourced Transmission line system in PSCAD

The power swing event on the transmission line system typically was caused by the sudden connection and disconnection of large amount of load that would resulted the sudden change in electrical power system. This power swing would cause voltage and current waveform to oscillate in the electrical power system which can be seen by using the multimeter. The fixed load was placed at the end of busbar on the side of second power source generator with a timed breaker logic that used as a switch to control the connection and disconnection of fixed load as shown in figure 6.

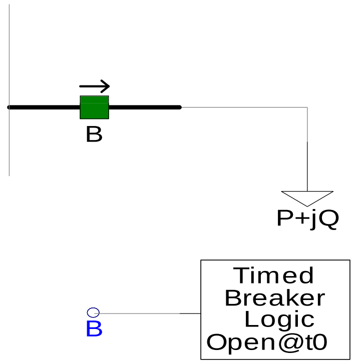

Fig. 6. The fixed load with the timed breaker logic for power swing event

The timed breaker logic can be set based on the number of breaker operation, initial state and time setting for breaker is by breaker logic. In this case, two breaker operations have been chosen at the open initial state and the time of first breaker operation meant that the time of connection with the load at 0.4s while the time of second breaker operation meant that the time of disconnection with the load at 0.6s in order to create a power swing in the transmission line system.

The value of fixed load was set as 15 MW for real power, 15 MVAR for reactive power and 230 kV for load voltag

Simulation Results

The figure 7 shows the current waveform of simulated system. And figure 8 shows the voltage waveform. Simulation is carried out in PSCAD

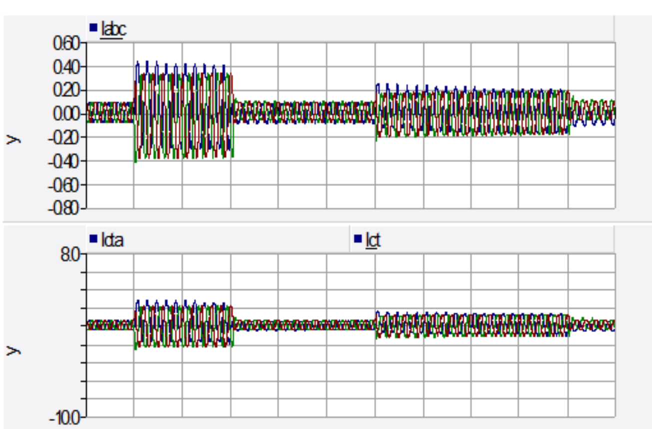

Fig. 7. Current waveform under power swing event

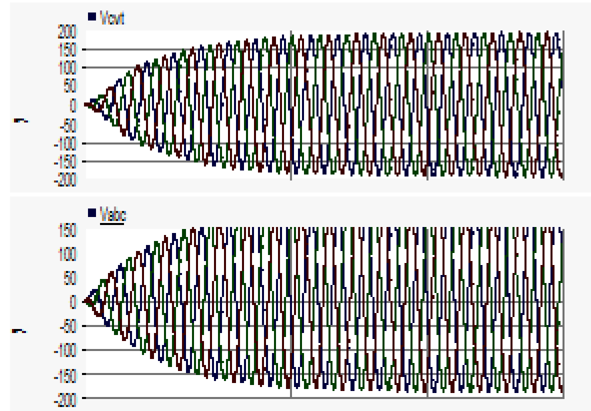

Fig. 8. Voltage waveform event under power swing event

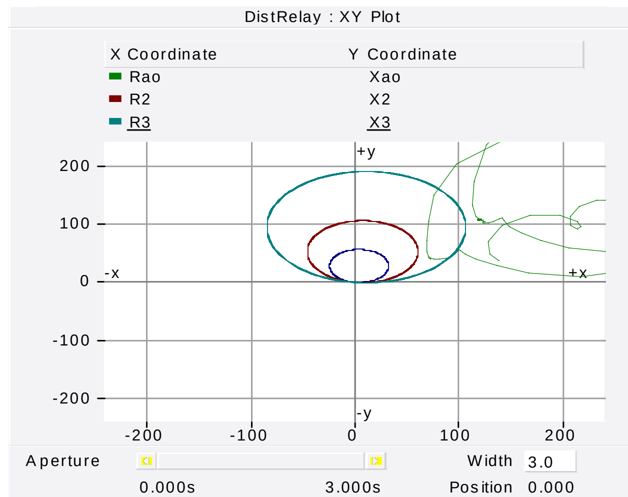

Fig. 9. MHO characteristics during power swing event(3rd zone operat

V. CONCLUSION

The results simulated systems shown in figures. As shown in figure 9 during the power swing event distance relay operate in 3rd zone.

Appendix

Transmission lines Data:-

Length: 240 km.

Positive sequence impedance: 0.12 + j 0.88 Ω/km

Zero sequence impedance: 0.309 + j 1.297 Ω/km

Positive sequence capacitive reactance: 487.723 × 10^3 Ω.km

Zero sequence capacitive reactance: 419.34 × 10^3 Ω.km

Generators data:

Gen-1: 100 MVA, 230 kV, 50 Hz;

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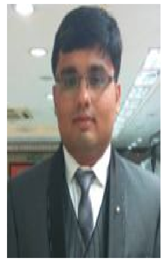

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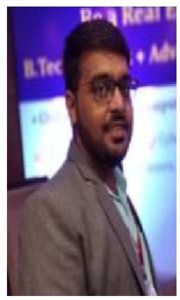

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