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IMPACT ANALYSIS OF STATCOM ON DISTANCE RELAY PERFORMANCE

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Abstract-*The paper presents impact of the Static Synchronous Compensator (STATCOM) on the performance of distance relay in transmission lines. A typical 400 kV, 300 km transmission system employing STATCOM is modeled using MATLAB/Simulink. The effect of STATCOM on distance relay for different fault conditions and different fault locations is analyzed. Simulation results indicate that the presence of the STATCOM in the transmission system significantly changes the line impedance which is observed by the distance relay to be smaller or greater than the actual line impedance. In that way the action of the distance relay changes and results in overreaching or under reaching. Based on those results the performance of distance relay can be found. It can be verified for the transmission line with STATCOM having different zones are proposed based on this analysis.*

Keywords- *distance relay protection, flexible AC transmission, MATLAB*

I. INTRODUCTION

The advantages that MATLAB have make convenient tool for direct communications with relay program. It describes how to use MATLAB tool for automatic and high performance testing relay system. Some simulation results are also provided with respect to the paper.

The demand of electricity is growing very fast rate. The protection of the transmission is very important aspect when we consider the security of the power system as it is used to transfer large quantity power from one place to other. Variable protection schemes protect the transmission line like over-current protection, distance protection, etc. The distance protection of the transmission line gives us the more reliable and fast action to detect fault in the zone of protection and give the information about trip or no trip. It becomes extremely difficult constructing new transmission lines because of economic and environmental pressures. For getting better utilization of existing lines, without giving up the quality and reliability of electrical power, thus necessary to find alternatives. In this respect, due to the recent advances in FACTS technology has been proposed to solve this problem the installation of the FACTS devices such as static synchronous compensator in the transmission line increase the power transfer capacity of line and supply better utilization of the system capability. For using the maximum capacity of the transmission line the best point for the installation of the FACTS device is mid-point of the transmission line. STATCOM is a device use to controls the connecting point bus voltage near to stable condition and also increase system stability either by inject or absorb reactive power into the system. Distance relay based on impedance are widely used for protecting extra high voltage or high voltage transmission lines base on their operating characteristics. By noting the voltage and current signals at the relay location, relay measures the apparent impedance of the fault loop, and then the relay find the fault location by using apparent impedance. Due to the presence of STATCOM in the fault loop measured voltage and current signals gets changed. When the STATCOM injects reactive power into the transmission system, the measured current at the relay point decreases and increases when the STATCOM draws reactive power from the system. If the measured impedance is less than the actual measurement then distance relay will be over reach and the relay will be under reach when the impedance is greater than the actual measurement. So found that in presence of STATCOM in the fault loop the distance relay functions will get affected. So it is necessary to find the effect of STATCOM on the distance relay to be design to find the accurate fault location. The model of STATCOM is proposed firstly and then the analytical results based on symmetrical component transformation for SLG fault on a transmission line employing STATCOM are described and finally the simulation results show the impact of STATCOM on distance relay characteristics.[2]

II. POWER SYSTEM WITH STATCOM

Reactive power compensation is the most important factor electric power systems. When reactive power increases it reduces the transmission capability and increases the losses. Also reactive power flows can cause large amplitude variations in the receiving side of power system. The FACTS technology a collection of all controllers, which can be apply single or together with others to control more interconnected system and overcome the limitations of a designated transmission line. The possibility of current can be controlled at minimum cost enables to increase capacity of transmission line by the use of FACTS controllers under normal and faulty conditions. The ability of FACTS Controllers explain the operation of transmission systems including parameter like voltage, current, load angle, frequency, impedance. With flexibility, FACTS

Controllers carry power closer to its rating. Mechanical switching needs fast response power electronics devices. It states that STATCOM is capable of generate and absorb reactive power whose output can be controlled so as to maintain parameters of transmission system. Normally system is balanced, but during faulty condition it gets disturbed. The effect of STATCOM can be studied by using simulink system toolboxes in MATLAB. Now a day's power systems face increasing demands of better quality power and higher reliability at less cost. A STATCOM is a independent application and controlled reactive-power source.

In that, three phase three levels IGBT type of STATCOM is used. The input of controller is an error signal get from the reference voltage and measure rms value having its terminal voltage. That error is provided to PI controller the output getting an angle, which is fed to the Pulse width modulation signal generator.[1]

III. DISTANCE PROTECTECTION SCHEME

Distance protection is most important and popular type of protection scheme applied globally to protect transmission lines to fulfill the requirements like reliability, speed. The main principles of distance relay based on line impedance which is constant along the line and directly proportional to the length of the line and independent of the magnitudes of the current and voltage.

So, the impedance from the relay point to any fault point along the line is proportional to distance of the same hence the fault location can easily find out if it included within the protected zone of line. Operation of such relay based on the measured distance so it referred a distance relay. Impedance can be calculated by different technique by using three-phase current and voltages. Basic principle of distance relay as if setting impedance is more than that of measured one then the relay concludes fault in the transmission line. By that way distance relays also known as under impedance relays. In distance protection scheme there are various factor like frequency imbalance, SLG fault, power swings affects the system. Three types of distance relay as namely impedance relay, reactance relay and mho relay. Out of those the quadrilateral distance relay is best option for the protection of line as it covers minimum area in R-X diagram which is quite close to ideal relay. As short-circuit fault occurs, distance relay provide protection as it disconnect the faulty portion from the healthy section with tripping characteristics the circuit breaker.[4,6]

IV. EFFECT OF STATCOM ON DISTANCE RELAY

The measured impedance at the relaying point in the presence of FACTS devices like STATCOM is calculated. Tripping characteristic of distance relay depends on the, short circuit levels at end line, power system structural conditions, pre fault conditions, voltage magnitude ratio, load angle and mostly the ground fault resistance. So to analyze the effect of STATCOM on distance relay, the various locations like zone wise section are considered for simulation. The installation locations set at the near end, at the far end and at the mid-point of transmission line. With the help of measured impedance, it shows that how much a distance relay get subjected to mal-operation in the presence of shunt compensation which are located at different zone.

A. STATCOM location at end of line

It have less effect on distance relay tripping characteristics because Statcom not present in the fault loop for the first zone of distance protection.

B. STATCOM location at midpoint of line

When fault is after Statcom as it present in fault loop and have great effect on the tripping characteristics.

V. SIMULATION SCHEME

When a fault occurs on long transmission lines, the current and voltages get disturbed. In that oscillation may contain, high frequency oscillation quantities, decaying dc components and subsystem frequency transients. The higher frequency can be eliminated by low pass anti-aliasing filters with appropriate cut-off frequency but as they cannot remove dc components completely which makes the phasor very difficult which affects the relay characteristics. So the use the mimic filter is better to remove the dc-offset components. A digital filter is used to remove the unwanted disturbances using various techniques. Also algorithm can be used to describe the relay function which is disturbed by fault in power system. While simulating the distance relay, following steps are to be considered:

Step1: Get the data of current and voltage signals from simulation which is in discrete form.

Step 2: Apply the technique of filtering to that signals for removing dc-offset components.

Step 3: Estimate phasor calculation by using DFT.

Step 4: For each phase under fault conditions calculate the measured impedance values.
Step 5: Draw the impedance trajectory.
Step 6: By connecting STATCOM, compares the results with and without STATCOM.

MATLAB is software which finishes all of algorithms for protective relays. With that advantage simulation of faults also the design of relay can be find out. The following figures having 400KV, 300Km rating single line diagram of transmission line distributed by zones Z_1,Z_2.Z_3 with statcom connected at midpoint of transmission line

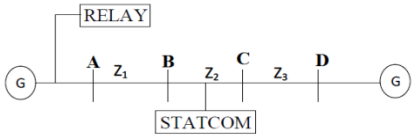

Figure 1.Single line diagram for distance relay With mid connected STATCOM

VI. SIMULATION RESULT

In present simulation STATCOM is connected at the midpoint and taking the results with and without STATCOM at different zones, if fault occurs in zone one then results with and without STATCOM

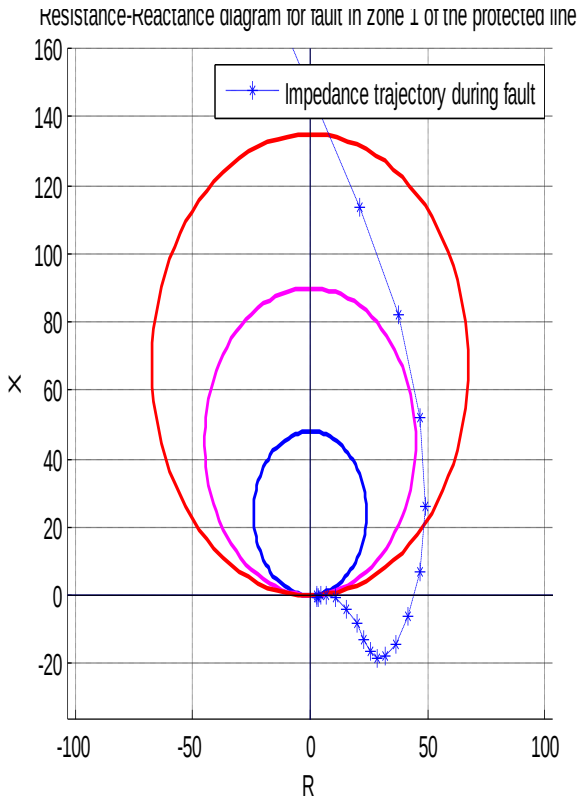

Figure 2.Impedance trajectory without STATCOM

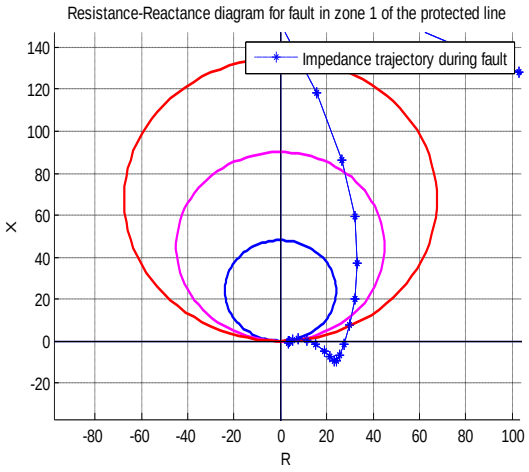

Figure 3.Impedance trajectory with STATCOM

In zone 1, STATCOM is not in fault zone so because of that there is no more effect. And fault resistance 0.01 is taken. If fault occurs in zone 2, the characteristic are as shown below,

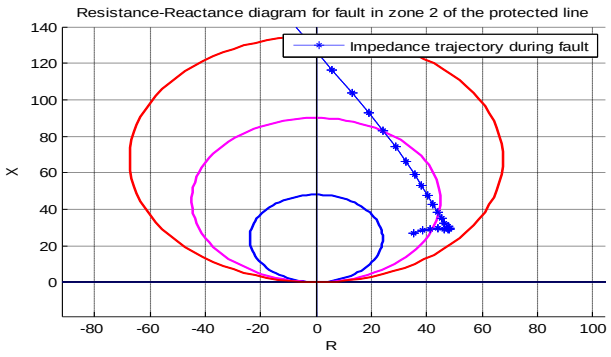

Figure 4.Impedance trajectory without STATCOM

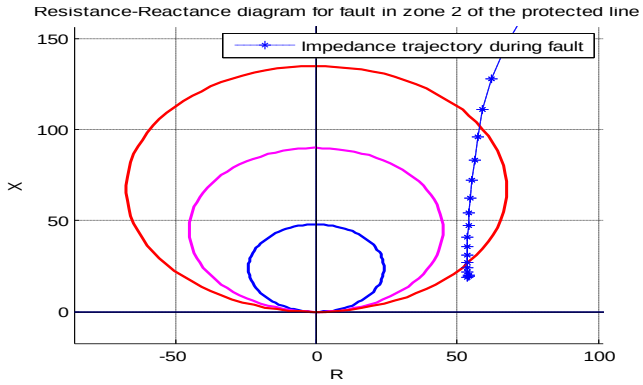

Figure 5.Impedance trajectory with STATCOM

It is seen that the fault occurs in zone 2 but characteristics shows it is out of zone when STATCOM is connected in the line. STATCOM is in fault loop therefore it has great effect, distance relay get maloperates. The fault occurs in zone 3 the characteristics are as follows,

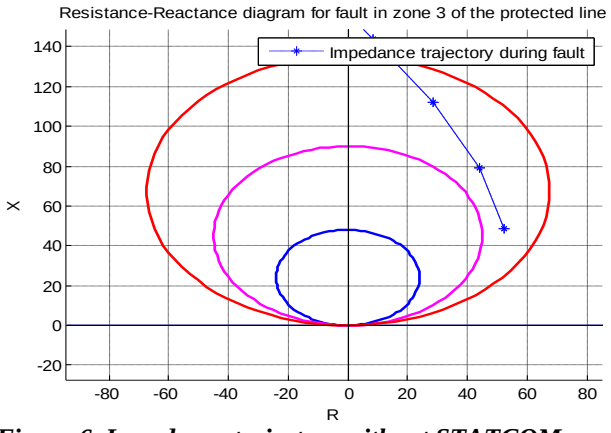

Figure 6. Impedance trajectory without STATCOM

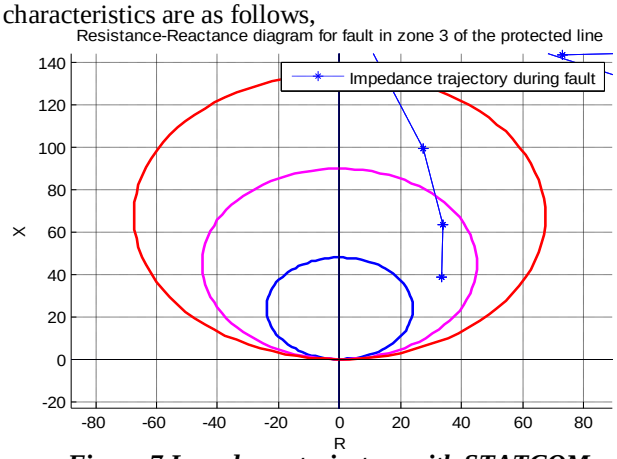

Figure 7.Impedance trajectory with STATCOM

It is seen that when STATCOM is connected in the line, the fault occurs in zone 3 but characteristics shows it is in zone 2, relay get maloperates.

VII. CONCLUSIONS

The result shows the adverse effect of the midpoint connected STATCOM, on distance relays performance at various location which results in errors in measurement impedance and wrong phase selection. And plotted impedance trajectory diagram by observing relay tripping characteristics in MATLAB. From the simulation results it is proved that during a fault, absorb or inject current of the STATCOM form an error in measured impedance and because of that distance relay may over reach or under reach. From that simulation results it is seen that effect of STATCOM on distance relay under various faulty locations. So with STATCOM connected transmission line, the conventional distance relay should be avoided. And there is a need for relay to adjust to new settings in its properties and adapted to transmission line in order to avoid mal operation.

VIII. FUTURE SCOPE

The effect of the statcom can be minimizing by using many methods like modifying the input voltage and current at the relays, modifying the logic in the existing channel-aided scheme. Also implementing same scheme for phase to phase fault preventing the adverse effect.

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