Distance Protection Problem in Series-Compensated Transmission Lines

Abstract—Enhancement of series capacitor in transmission line diminishes net transmission reactance of line and it stretches greater power transfer competence of the lines. It also progresses power flow control & voltage parameter of lines. But it also results in problem to the conventional distance protection system during fault condition. The chief delinquent to the distance relay is to quantify correct impedance from relaying point to fault point when series capacitor remains in fault path. This paper briefly deliberates need of series compensation, problems due to series compensation and over-reach.

Keywords—Distance protection, positive sequence impedance, power system simulation, series compensation, transmission line.

I. INTRODUCTION

Series compensation is defined as insertion of reactive power elements into transmission lines. In the case of series compensation, the objective is to reduce the transfer reactance of the line at power frequency by means of series capacitors. This result is an enhanced system stability [1]. These relays measure the positive-sequence impedance to the fault and compare it with their predefined characteristic.

Fig. 1: Characteristic of mho relay
II. CONVENTIONAL PROTECTION ALGORITHM

In normal conditions, the power system is only demonstrated by a positive-sequence network and its corresponding zero- and negative-sequence networks are open circuit. The flowchart of the conventional protection algorithm is depicted in Fig. 2. It should be noted that this algorithm describes the first zone of the relay, and it can be easily developed for zones 2 and 3.

Fig. 2: Conventional protection algorithm

Since the nature of positive sequence impedance are resistive and inductive, a characteristic similar to the mho relays can be used for the conventional protective relay. A typical characteristic is represented in Fig. 1. This characteristic is only for the first zone, where is equal to 85% of the positive sequence impedance of the main protected line.

III. SIMULATION RESULTS

In this section, the conventional protection technique is verified in dissimilar cases where the series capacitor is located at the start of the transmission line Fig. 3 is Transmission line model in PSCAD/EMTDC software. The scheme data are given in Table I [7]. The line XY is compensated by a series capacitor (SC). The degree of compensation is 30%. Moreover, the mho relay is denoted by Rx.
Three-phase voltages and currents are shown in Fig. 4 and Fig. 5. Fig. 6 and Fig. 7 demonstrates performances of the conventional distance protection. Fig. 8 shows the measured voltages and currents. Similarly, Fig. 9 shows that protection methods provide reliable performances in non-compensated lines. However, as shown in Fig. 10, the conventional distance protection may experience an over-reach condition for external faults and lose its security.

The different percentage of over-reach with different percentage of compensation data and different fault location are given in Table I and Table II respectively.
Table I: % Over-reach with % Compensation

<table>
<thead>
<tr>
<th>%Xc(Compensation)</th>
<th>%Over-reach</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>40%</td>
</tr>
<tr>
<td>20%</td>
<td>70.58%</td>
</tr>
<tr>
<td>30%</td>
<td>114.11%</td>
</tr>
</tbody>
</table>

Fig. 8: External LG fault, for Three-phase voltages

Fig. 9: External LG fault for Three-phase currents

Table II: Fault Location

<table>
<thead>
<tr>
<th>Fault Location</th>
<th>Line Length (km, from X bus)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL1</td>
<td>10</td>
<td>Internal</td>
</tr>
<tr>
<td>FL2</td>
<td>110</td>
<td>External</td>
</tr>
</tbody>
</table>

Fig. 10: Simulation results for an external fault for Distance protection without SC
IV. CONCLUSION

This paper successfully demonstrates the problem of over-reach of distance relay with conventional distance relaying. The mho relay application to distance protection of series compensated line is successfully simulated using PSCAD/EMTDC. Authors are presently working on replication of a reported scheme to detect and prevent this over-reach using mutual impedance of the line.

REFERENCES


AUTHORS’ BIOGRAPHY

Prof. Vikramsingh P. Parihar is an Assistant Professor in Electrical Department, PRMCEAM, Badnera-Amravati having 6 years of experience. He has received the B.E degree in Instrumentation from Sant Gadge Baba Amravati University, India, in 2011 and the M.E degree in Electrical and Electronics Engineering, Sant Gadge Baba Amravati University, India, in 2014. He is editorial board member of 7 recognised journals and life member of ISTE, HKSME, ICSES, IJCSE and theIRED. His domain of research includes Electrical Engineering, Instrumentation, Electrical Power Systems, Electrical and Electronics Engineering, Digital Image Processing, Neuro Fuzzy Systems and has contributed to research in a commendable way by publishing 17 research papers in National/International Journals and 4 papers in IEEE Conferences.

Prof. Anagha P. Dhote is an Assistant Professor in Computer Science & Engineering Department, PRMCEAM, Badnera-Amravati having 2 year of experience. She received the B.E. degree in Electronics & Tele-Communication Engineering from the Sant Gadge Baba Amravati University, India, in 2012, the M.E., in VLSI & Embedded System from Savitri Bai Pune University in 2014 and M.Sc. degree in Electronics from the Sant Gadge Baba Amravati University, India, in 2016. Her domain of research is Digital Image Processing, Electronics Engineering, Embedded System. She has presented and published 3 technical papers in international conferences and one technical paper in international journal.

Fig. 11: Simulation results for an external fault for Distance protection with SC