Improvement in Performance of MHO Relay in Long Transmission line with Series Compensated Device

Jayesh Patel[1], Sanket Patel[2], Jay Ray[3]

[1]Jayesh PatelElectrical&Sigma Institute of engineering
[2]Sanket PatelElectrical&Sigma institute of Engineering
[3]Jay RayElectrical&Sigma institute of Engineering

---***---

Abstract -- This paper considers the potential difficulties looked by Conventional distance relays in case of Thyristor-controlled series capacitor (TCSC) compensated transmission system. The maloperations of back-up transfers can trigger huge scope cascade outages. detailed examination on maloperation of various zones of Distance relay due to TCSC activity will be completed. The impact of TCSC on the relays of Adjustment lines, which give back-up protection to the compensated line, will watch.

Possible answers to mitigate the problem issue related with the Impact of TCSC upon the conventional distance relay are talked about. The simulation studies are done on MATLAB. Mathematical modelling of TCSC and calculation for distance protection will simulate and results will analyse in different abnormal conditions.

Key Words: Series compensated line, Thyristor Controlled Series capacitor (TCSC), Mho Relay, MATLAB Simulation

1. INTRODUCTION:

Transmission line is proportional to its length, for distance measurement it is appropriate to use a relay capable of measuring the impedance of a line up to a predetermined point (the reach point). Such a relay is described as a distance relay and is designed to operate only for faults occurring between the relay location and the selected reach point, thus giving discrimination for faults that may occur in different line sections.

The basic principle of distance protection involves the division of the voltage at the relaying point by the measured current. The apparent impedance so calculated is compared with the reach point impedance. If the measured impedance is less than the reach point impedance, it is assumed that a fault exists on the line between the relay and the reach point.

Thereachpointofarelayisthepointalongthelineimpedancelocusthatisintersected by the boundary characteristic of the relay. Since this is dependent on the ratio of voltage and current and the phase angle between them, it may be plotted on an R/X diagram. The loci of powersystemimpedancesasseenbytherelayduringfaults,powerswingsandloadvariations may be plotted on the same diagram and inthis manner, the performance of the relay in the presence of system faults and disturbances may bestudied.

2. SELECTION OF TCSC PARAMETERS:

An appropriate value for capacitor is picked by a level of series compensation (K). ordinarily up to 70% of line, reactance is picked for compensation. decision of Inductor relies on the length of working area required for inductive and capacitive locate. It is entirely chosen by a factor 'ω', resonant factor. For picking a capacitor and inductor for a TCSC device, three fundamental significant estimates must be considered as follows (3).

3. IMPACT OF TCR ON TCSC:

Inductive susceptance of TCR, $B_{TCR}(\alpha)$ is changed by firing angle α in the same manner as the magnitude of fundamental component of current $I_{L1}(\alpha)$,

$$B_{TCR}(\alpha)=\frac{1}{\omega L}\left(1-\frac{2}{\pi}\alpha-\frac{1}{\pi}\sin 2\alpha\right)=B_L\left(\frac{\pi-2\alpha-\sin 2\alpha}{\pi}\right)$$

it is possible to control it by in from maximum value ($\alpha=0$, $B_{TCR}=B_L$) up to zero ($\alpha=\pi/2$, $B_{TCR}=0$), From eq (5) for inductive reactance of TCR we get (3).

$$X_{TCR}(\alpha)=\frac{1}{B_{TCR}(\alpha)}=X_L\left(\frac{\pi}{\pi-2\alpha-\sin 2\alpha}\right) \qquad X_L(=\omega L)\le X_{TCR}(\alpha)\le\infty$$

presently, as TCSC is that of XC, and a variable inductive reactance, $X_L(\alpha)$, that is,

$$X_{TCSC}(\alpha)=\frac{X_C X_L(\alpha)}{X_L(\alpha)-X_C} \qquad \text{where } X_L\le X_L(\alpha)\le\infty$$

Decreasing $X_L(\alpha)$ further, the impedance of the TCSC, $X_{TCSC}(\alpha)$ becomes inductive, reaching its minimum value of $X_LX_C/(X_L-X_C)$ at $\alpha = 0$, where the capacitor is in effect bypassed by the TCR. Therefore, with the usual

TCSC arrangement in which the impedance of the TCR reactor, X_L, is smaller than that of the capacitor, X_C, the TCSC has two operating ranges around its internal circuit resonance (3).

- $\alpha_{Clim} < \alpha < \pi/2$ range, where $X_{TCSC}(\alpha)$ is capacitive,
- $0 < \alpha < \alpha_{Lmax}$ range, where $X_{TCSC}(\alpha)$ is inductive.

This can be seen in the impedance vs firing angle characteristics of TCSC as below:

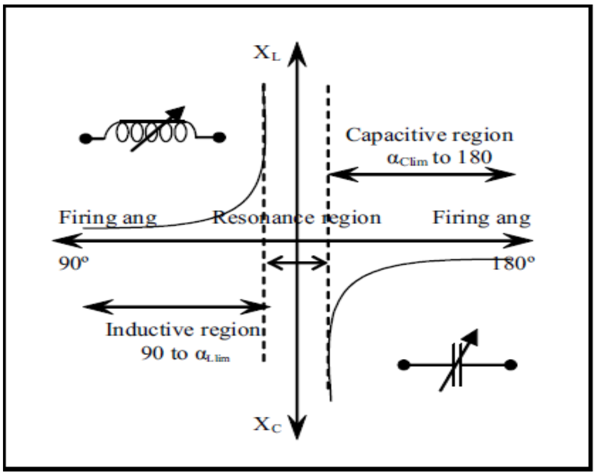


Figure 1. TCSC characteristics

4. DEGREE OF SERIES COMPENSATION:

level of series compensation (K) is a proportion of viable reactance of TCSC $[X_{TCSC}(\alpha)]$ to net reactance of transmission line $[X_{TL}]$.

$$K = \frac{X_{TCSC}(\alpha)}{X_{TL}} \qquad (0<k<1)$$

for all intents and purposes up to 70% of series, compensation is picked for line reactance compensation.

Think above a case of shunt network, X_C smaller than X_L and from the standard of circuit thesis, the variable reactance (X_{eff}) of the shunt combination follows the littler value of the two reactance as appeared in Fig. and (-) sign shows X_{eff} is in capacitive nature. Thus, just a single capacitive area is possible between 90˚ to 180˚ of firing angle in the reactance characteristics curve. (3)

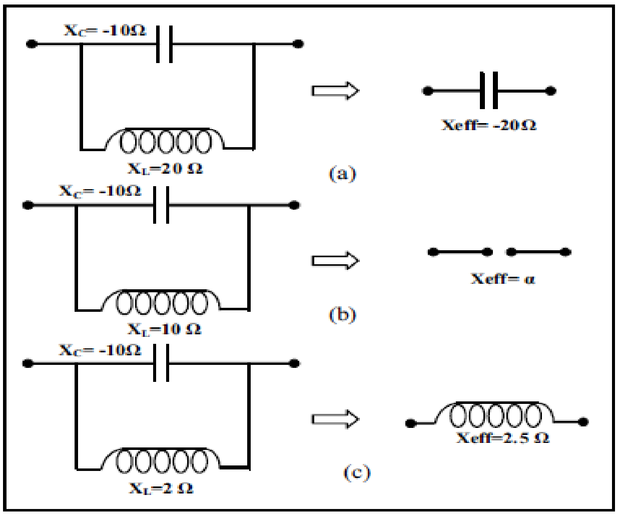


Figure 2. Basic characteristics of TCSC

If X_L is equivalent to X_C esteem as shown in Fig. at that point resonance occurs that result in boundless reactance, which is an unsuitable condition. At last, by picking X_L littler than X_C; makes effective reactance has inductive reactance as like Fig. Accordingly, $X_{TCSC}(\alpha)$ differs from inductive area to capacitive region with respect to 90˚ to 180˚ of firing angle. While changing the $X_{TCSC}(\alpha)$, the condition should not be permitted to occur "$X_L(\alpha) = X_C$", a resonance condition.

Generally, the X_L/X_C ratio for practical TCSC would probably be in 0.1 to 0.3 range, contingent upon the application requirements and constraints. It is important that the natural resonance frequency of the TCSC does not coincide with, or is close to, two and multiple times the fundamental.

5. SimulinkModel:

This is Simulink model of compensated with TCSC and uncompensated without TCSC transmission line are show in this figure 4.4 and figure 4.5.

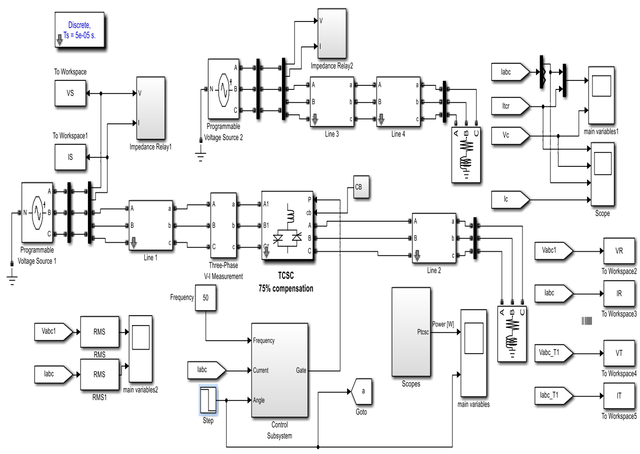


Figure 3. Simulink model of compensated system (With TCSC)

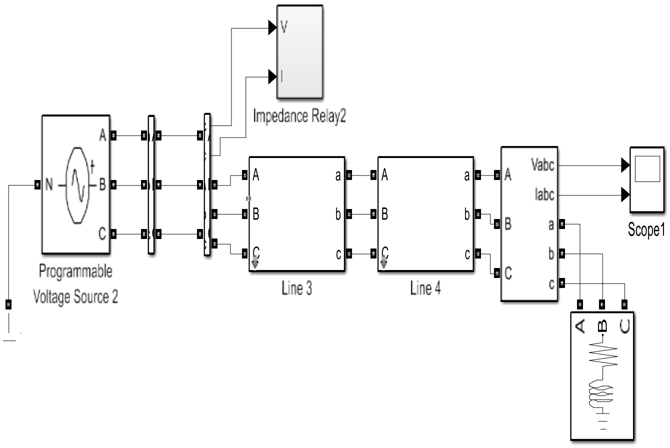


Figure 4. Simulink model of uncompensated system (Without TCSC)

Inthistransmissionlineinthethree-phasesourceareconnected, also TCSC are connected with the center of the transmission line, and the firing pulse are required to operate TCSC, and gate pulse are generated through firing pulse generator and the control of TCSC can be possible, this transmission line is compensated.

In other transmission line in the TCSC are bypass and then this TCSC effect are zero, this is uncompensated transmission line is show in this figure.

6. TCSC: THYRISTOR CONTROLLED SERIESCAPACITOR:

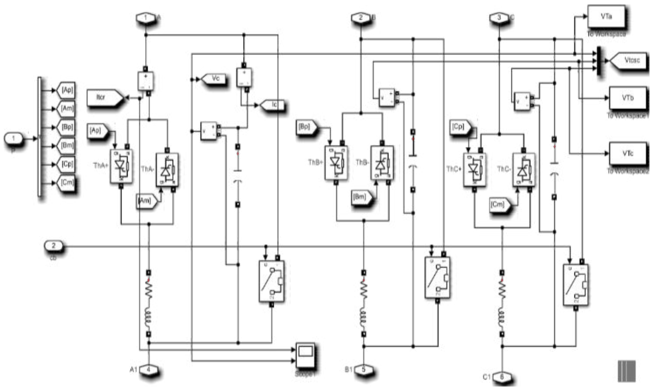


Figure 5. TCSC

ThreeTCSCareconnectedinthreephasesintransmissionlineineachphase.Inaddition, this TCSC firing angle are control and then the capacitor is variable in this TCSC, This TCSC are connect in center of the transmission line. Show in figure

In firing pulse through gate signal are provide and this gate pulse come from control system. In this figure capacitor are connectedinparallelwiththyristors.Gatepulsecomesfromcontrolsysteminthissysteminput constant frequency, current and step signal in this step signal through mode are change in inductive mode and capacitive mode. In this mode are control bymanually.

7. TCSC FiringAngle:

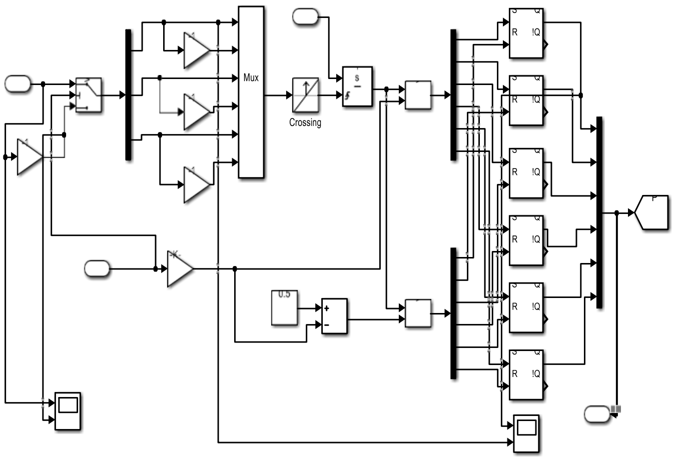


Figure 6 TCSC Firing Angle

In this figure for generation the firing pulses of appropriate conduction angle SR flip-flop is used. In the inductive mode, line current is inverted for the synchronization with firing pulse generation. In the control circuit, initially ramp signal is generated by detecting the zero-crossing detector of the line current. That ramp signal is compared with the firing angle. The resultant pulse generator together with the other pulse generated by the ADD operation is given to the SR flip-flop proper width of the firing pulse. SR flip-flop is one of the most common sequential logic circuit possible. This simple flip-flop is one-bit memory bit device, which has two import, one, which will "SET" the device leading to output 1, and another which will "RESET" the device, leading to output 0. Following is the truth table for the SR flip-flop:

S	R	Q	Q
0	0	0	1
0	1	0	1
1	0	1	0
1	1	0	1

Table 1 Truth table for the SR flip-flop

capacitive mode:

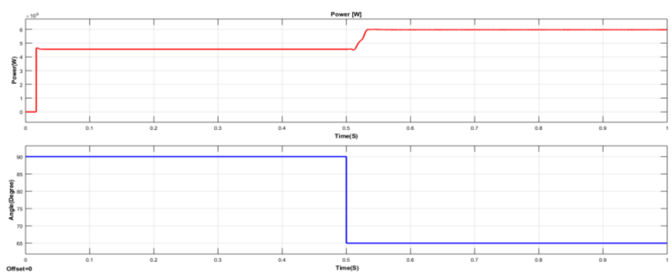


Figure 7. Simulation results at **α=65**°purely (C)

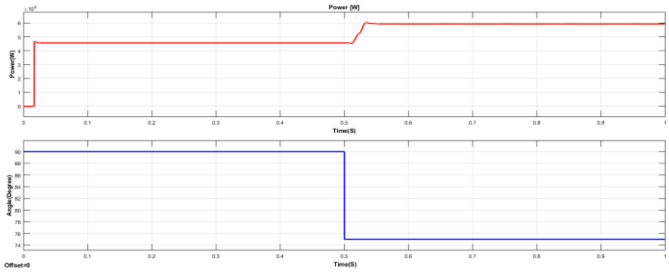


Figure 8. Simulation results at **α=75°(C)**

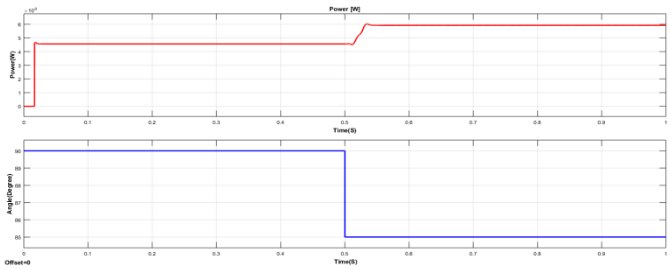


Figure 9. Simulation results at **α=85°(C)**

Inductive mode:

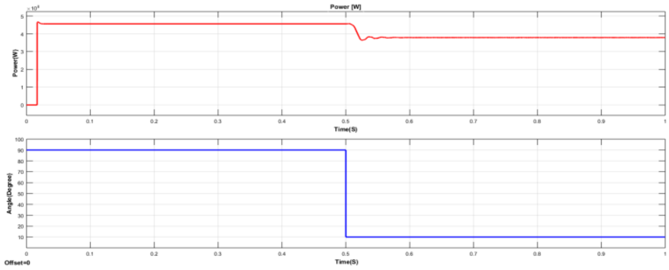


Figure 10. Simulation results at **α=10°** **(L)**

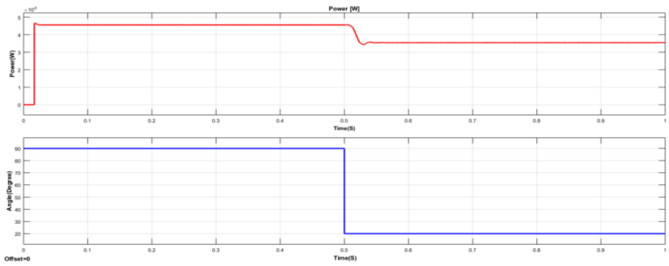


Figure 11. Simulation results at **α=20°** **(L)**

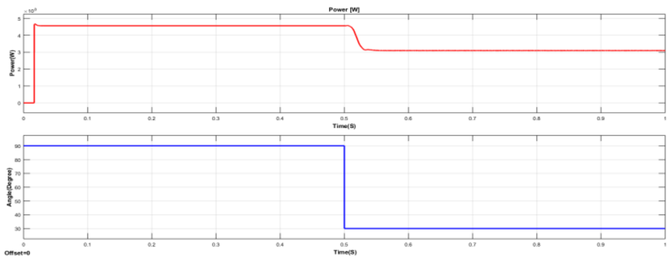
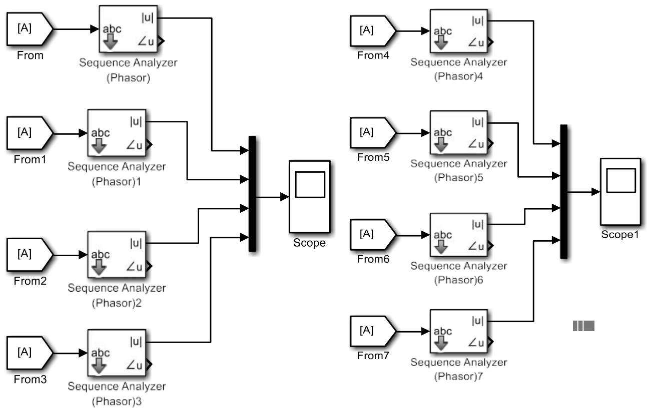


Figure 12. Simulation results at **α=30°** **(L)**

8. Mho relay:

Figure 13. TCSC Firing Angle

Amhorelayisahigh-speedrelayandisknownastheadmittancerelay.Inthisrelay, operating torque is obtained by the volt-amperes element and the controlling element is developed due to the



voltage element. It means mho relay is a voltage controlled directionalrelay.

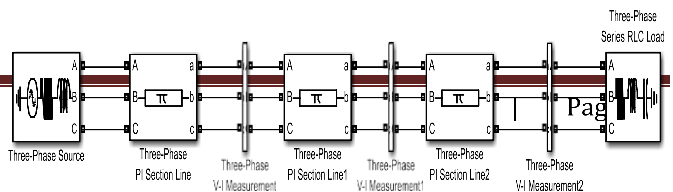
9. SimulationResults:

A distance protection of TCSC transmission line with mho relay has been tested on 400kv and 50 HZ, 400 km long and 75% compensated line. A mho relay is set to protect up to 85% of transmission line for zone one. In many cases are taken to test relay for over reach and under reach effect at different location in various compensation level and load angle are change.

In line to ground (LG) fault is created at location beyond the zone of transmission line with different levels of capacitive compensation. Net fault impedance of transmission line reduces. Due to capacitive compensation net fault impudence of transmission line reduce. This is called over reaching problem in this system.

In line to ground (LG) fault are created at some location in zone one at transmission line with different level of inductive compensation. due to present of inductive reactance, a fault impedance of transmission li ne increases. So, relay cannot sense inside the zone one. this is called under reaching problem in this system. Shown this graph in the Ztcsc and Zuncom, various change at which zone fault are created shown in this graph.A Mho relay in this simulation results are show in differentangle and different zone wise protection is provide Alsodistance are change in this figure.

Angle 15, distance 50s



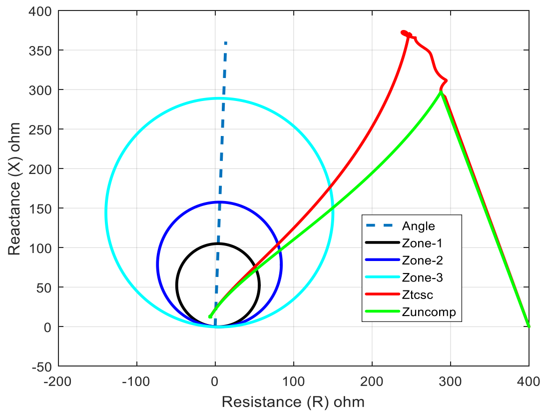


Figure 13

Distance 50 angle 55

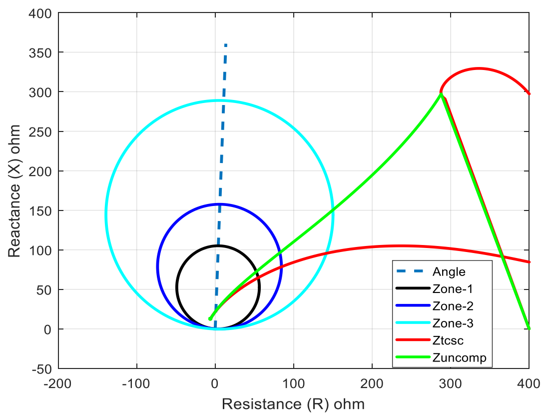


Figure 14

Distance 100, angle 30

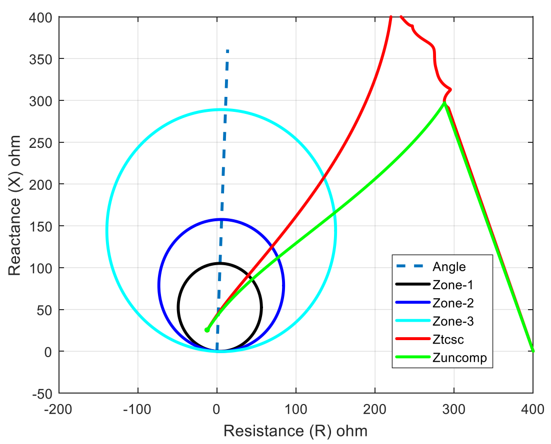


Figure 15

Distance 100, angle 65

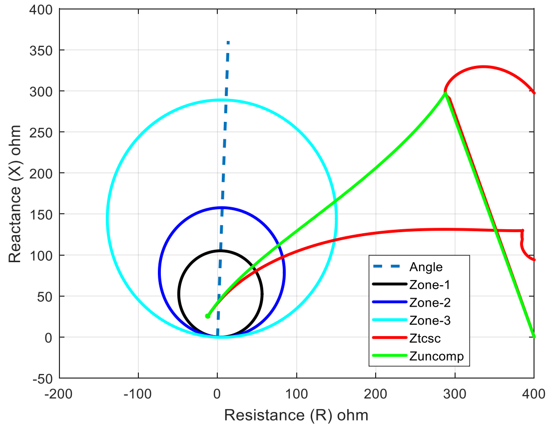


Figure 16

Distance 250, angle 15

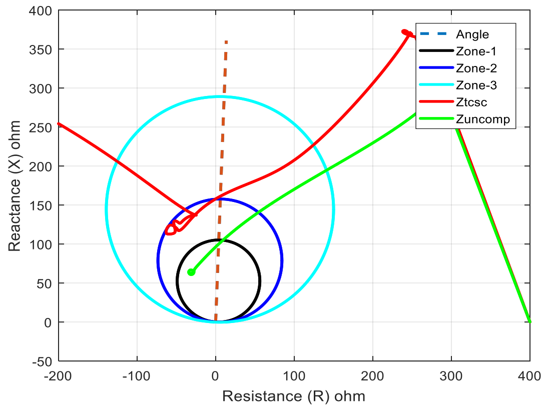


Figure 17

Distance 250, angle 55

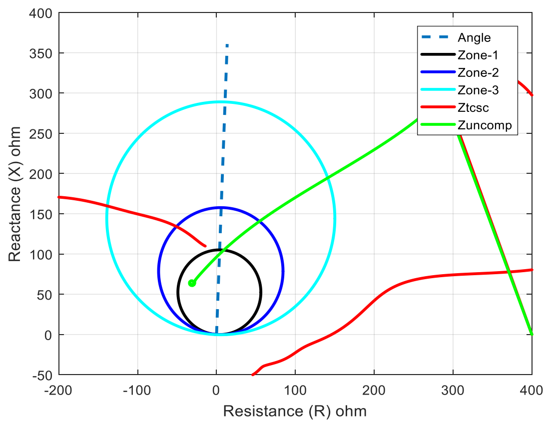


Figure 18

Distance 300, angle 30

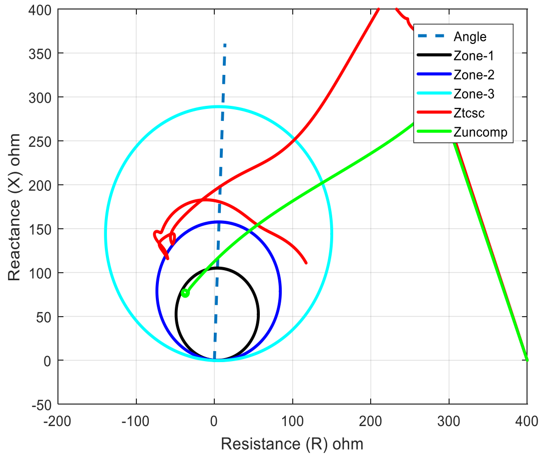


Figure 19

Distance 250, angle 60

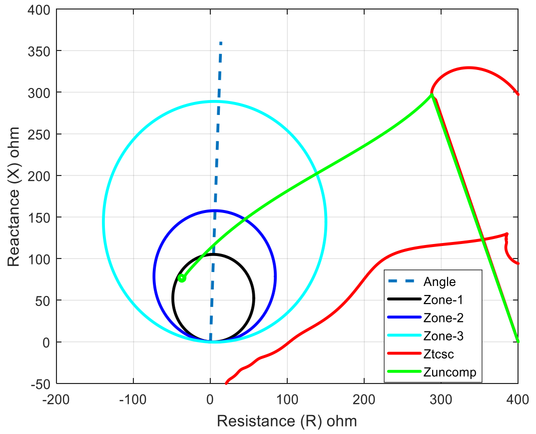


Figure 20

10. CONCLUSIONS

The operation of TCSC at firing Angle and Thus concludes that TCSC improves power transfer capability of the system, if used with proper control techniques to fire the SCR in proper region with proper conduction angle. It has been referred that in the inductive mode TCSC acts as a variable inductor leading to the increase in the overall inductance of the transmission line and thus decreasing the power flow. Whereas in the capacitive mode the TCSC acts as a variable capacitance decreasing the reactance of the transmission, line depending on the firing angle and thus increasing the power flow. Parameter selection is also oneoftheimportantthingsforTCSCasitcanavoidtheconditiont hatcanresultsintoreduced operating range ofTCSC. Theuseof TSCS,whichgive new algorithm forMhorelaytodoaccuratefaultdetection. Amhorelayisproposedfortheprotectedofseriescompensatedli neunderfaultcondition.The detailed analysis is carried out in MATLAB simulation software. A relay is set to protect85% of transmission line for zone and tested wide range of load angle and compensation level. Simulation results show that propose mho relay operate for fault inside zone at all location. It is also concluded from the result analysis that the propose mho relay is accurate and reliable. Mho relay simple and easy to implement and it does not require much alteration in Mhorelay.

11. REFERENCES

1. 1. A.B.Shah, Member of IEEE, V.K.Sood, Follow IEEE, O.Saad and V. Ramachandran, Follow of IEEE "**Mho Relay For Protection of Series Compensated Line**" E-Mail:abhaybshah@ieee.org,vijay.sood@uoit.ca,Saad .omar@ireq.ca,Kamala@ece.concord ia.ca,

2. S.Meikandasivam, "**Investigation of split TCSC on Kanpur to Ballabhgarh Transmission system**" International Scholarly and Scientific Research& Innovation, E-mail: meikandasivams@gmail.com,

3. Dr. Vijay Makwana, Gujarat, India, International Journal of Advance Engineering and Research Development "**Thyristor Controlled Series Capacitor: Simulation and Analysis**" Volume 2, Issue5,May-2015.

4. X.G.Magagula,D.V.Nicolae,A.A.YusuffDepartment ofElectricalEngineering,Tshwane University of Technology Pretoria, south Africa "**The Performance of Distance Protection Relay on Series Compensated Line Under Fault Condition**" E-Mail: Magaguxg@eskom.co.za, NicolaeDV@tut.ac.za,YusuffAA@tut.ac.za.

5. Ashok Maori, Manoj Tripathy, H.O. Gupta, Department of Electrical Engineering IIT,India
J.P. Institute of Information Technology, Sector-128, Jaypee Wish Town Village, Noida- 201304, Uttar Pradesh, India "**An Advance Compensated Mho Relay For Protection of TCSC Transmission Line**" E-Mail: ashok12monori@Gmail.com,manojfee@ernet.in, hariomgupta@gmail.com.

6. Seyyed Mohammad Nobakhi, Mehdi Akhbari, Electrical Engineering Department, "**ANewAlgorithmforFaultLocationin series Compensated Transmission line with TSCS**" 0142-0615/2013 Elsevier Ltd. All Rights Reserved. E-mail: nowbakhti@gmail.com.

7. A. B. Shah is with Concordia University, Montreal, QC, Canada, and V. K. Sood is with the Department of Electrical Engineering, University of Ontario Institute of Technology, Oshawa, O. Saad is with IREQ, QC, Canada "**Mho Relay for Protection of Series Compensated TransmissionLines**"E-mail: abhaybshah@ieee.org,V.sood@ieee.org, saad.omar@ireq.ca.