INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

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Vol. 03, Issue 12, December 2023, pp : 64-70

e-ISSN : 2583-1062

Impact Factor : 5.725

COORDINATION CONTROL AND ANALYSIS OF TCSC DEVICES TO PROTECT ELECTRICAL POWER SYSTEMS AGAINST DISRUPTIVE DISTURBANCES

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DOI: https://www.doi.org/10.58257/IJPREMS32322

ABSTRACT

This paper investigates the effect of series compensation on transmission voltages under different fault conditions in 400KV transmission systems with performance comparison with TCSC. Inserting a series capacitor into a transmission line reduces net line reactance and thus improves the line's power transfer capability. This paper also includes recommendations for series capacitor operation. The paper also includes a comparison to TCSC. A series compensator controlled by a thyristor is made up of a series capacitance with a parallel branch that includes a thyristor-controlled reactor. It is used in power systems to control the reactance of a line dynamically.In this study, a 400kV transmission line from Khandwa to Seoni is used as an example and monitored.The system is simulated using the MATLAB software, and the results are discussed. The information provided here is useful for grid operators who work with compensated lines and switch in and out series capacitors.

1. INTRODUCTION

The growing use of nonlinear loads in industries based on power electronic elements caused serious perturbation problems in the electric power system. The high cost of building new transmission corridors in recent years has prompted a search for ways to increase the transmission line capacity of existing lines. With series compensation, the viable distances of AC power transmission increase to the point where distance is no longer a limiting factor for AC transmission in most cases. As a result, series compensation is an effective way to address these issues. It should be connected to the transmission line in series. The method of improving system voltage by connecting a capacitor in series with the transmission line is known as series compensation. In other words, in series compensation, reactive power is connected in series with the transmission line to improve system impedance. It improves the line's power transfer capability. It is commonly found in extra and ultra high voltage lines.

The advantages of series compensation are-

- Improvement in System Stability
- Increase in power transfer capability

The power transfer (P1) over a uncompensated line is given by ;

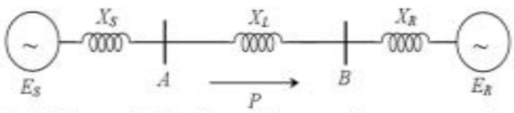

Fig-1 Transmission line without series compensation

$$P_1 = \frac{V_s V_R}{X_L} \sin\delta$$

The power (P2) transmitted through series compensated transmission line is given by;

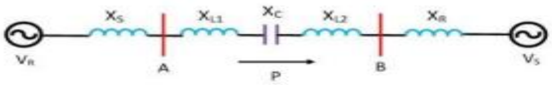

Fig. 2- Transmission line with series compensation

$$P_2 = \frac{V_s V_R}{X_L - X_C} \sin\delta$$

$$\frac{P_1}{P_2} = \frac{X_L}{X_L - X_C} = \frac{1}{1 - \frac{X_C}{X_L}} = \frac{1}{1-k}$$

K is degree of compensation which may lie between 0.4 to 0.8. The amount of transmitted power is increased with series compensation.

- Load Distribution on Parallel Lines
- Voltage control

The series capacitor can be placed at either the sending or receiving end of the line, or in the middle.They are sometimes found at two or more points along the line.

2. THYRISTOR CONTROLLED SERIES CAPACITOR

FACT controller is TCSC. The use of thyristor control to provide variable series compensation makes using series capacitors in long lines appealing. A series capacitor bank shunted by a thyristor controlled reactor constitutes a thyristor controlled series capacitor. Figure 2 depicts a linear reactor 'L' connected to an alternating current source via two anti-parallel thyristors. By switching the capacitor and controlling the current in the reactor, a parallel combination of switched capacitors and controlled reactors provides a smooth current control range from capacitive to inductive values.

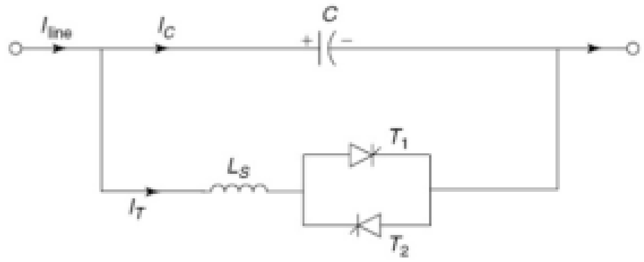

Fig. 3- Thyristor Controlled Series Capacitor

Thyristor-controlled series capacitors can be used to control current, improve stability, dampen oscillations, and limit fault current.

FACTS benefits include:

- increasing the loading capability of the lines in relation to their thermal capability; and
- overcoming their limitations through power sharing among lines.
- Provides greater flexibility in sitting new generation.
- FACTS devices improve the overall system's speed of operation.
- It improves the system's stability and thus makes the system secure.

3. MATLAB SIMULATION AND RESULTS

Simulink is used in MATLAB to simulate the 400 KV three phase gearbox systems. The model includes a 400 KV generation system and a step-up converter. 300-foot transmission line pi-section transformer km in length, series capacitors, or TCSC. The Three-phase gearbox systems are used. R-L Loading and connected through circuit breaker. When loaded A three-phase fault is simulated on one side. System of supply Voltage and current are measured. PGCIL Data in Use To obtain simulation results, has been used.

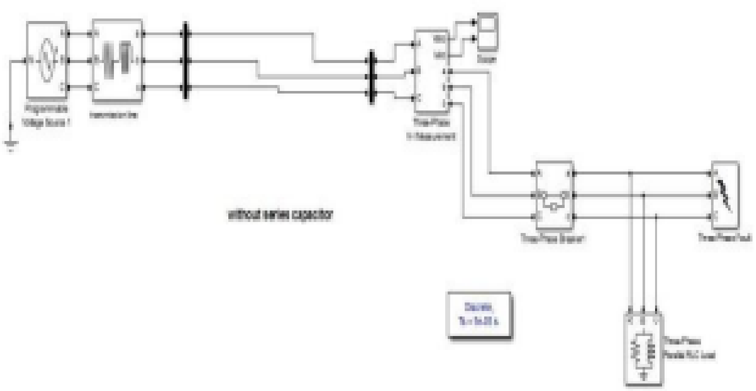

Fig. 4- simulink model of system without series capacitor

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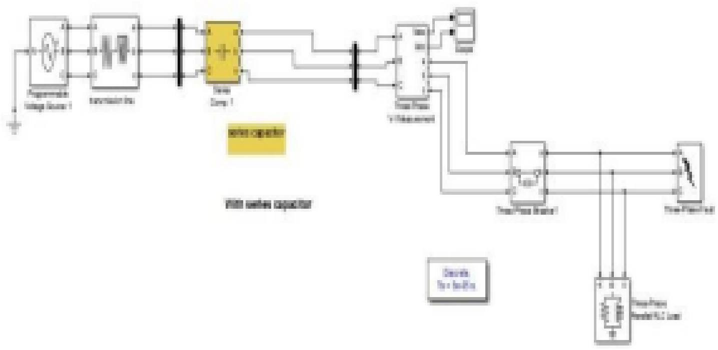

Fig. 5- Simulink model of system with series capacitor

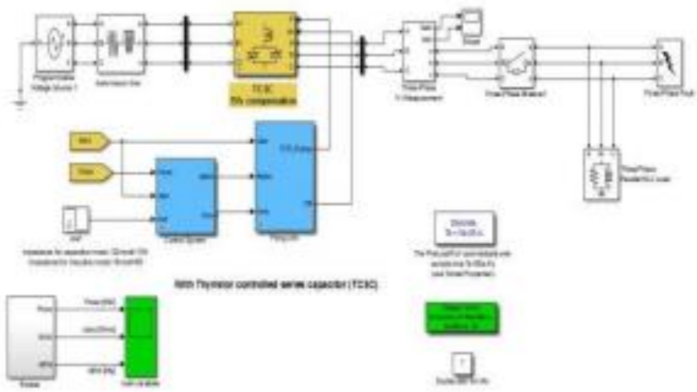

Fig. 6- simulink model of TCSC controller

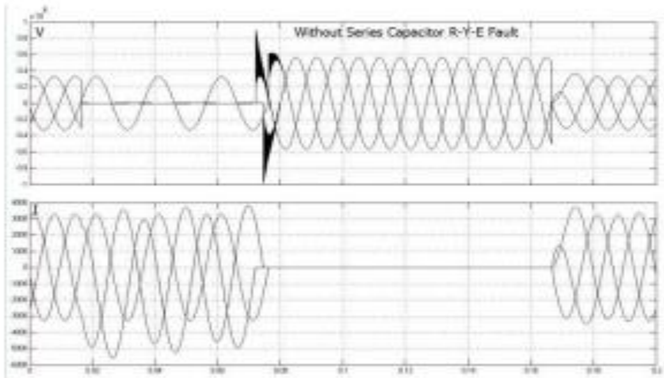

Fig.7-Waveform of V &I without series capacitor

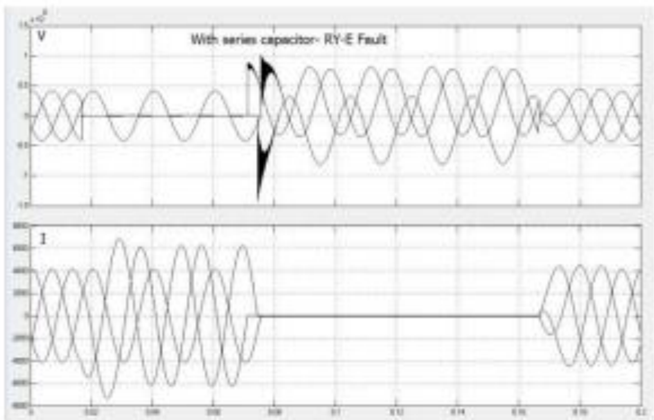

Fig.8-Waveform of V & I with series capacitor

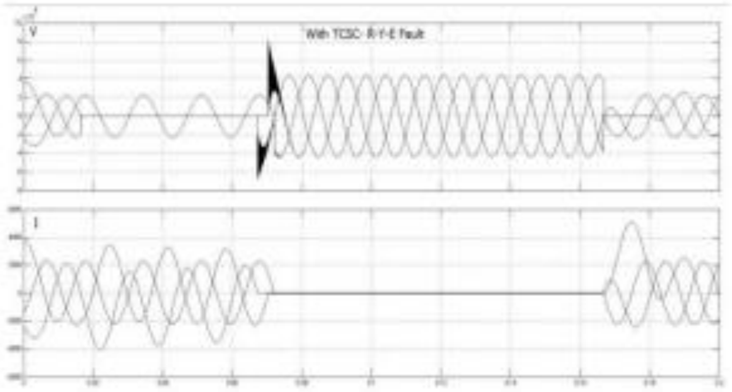

Fig.9- Waveform of V & I with TCSC

4. MEASUREMENT RESULTS

WITHOUT CAPACITOR		
1:	'UA: Three-Phase V-I Measurement'	231760.89 Vrms -51.64°
2:	'UB Three-Phase V-I Measurement'	231760.89 Vrms -171.64°
3:	'U C: Three-Phase V-I Measurement'	231760.89 Vrms 68.36°
4:	'U A:)1 '	231760.89 Vrms -51.64°
5:	'U B:)1 '	231760.89 Vrms -171.64°
6:	'U C:)1 '	231760.89 Vrms 68.36°
7:	'U A:) '	231760.89 Vrms -51.64°
8:	'U B:) '	231760.89 Vrms -171.64°
9:	'U C:) '	231760.89 Vrms 68.36°
10:	'I A:) '	2317.93 Arms -52.21°
11:	'I A:)1 '	2317.93 Arms -52.21°
12:	'I A: Three-Phase V-I Measurement'	2317.93 Arms -52.21°
13:	'I B: Three-Phase V-I Measurement'	2317.93 Arms -172.21°
14:	'I C: Three-Phase V-I Measurement'	2317.93 Arms 67.79°
15:	'I B:)1 '	2317.93 Arms -172.21°
16:	'I C:)1 '	2317.93 Arms 67.79°
17:	'I B:) '	2317.93 Arms -172.21°
18:	'I C:) ' 2317.93 Arms 67.79°	

WITH TCSC		
•1:	'U A: Three-Phase V-I Measurement'	377091.39 Vrms 4.55°
•2:	'U B: Three-Phase V-I Measurement'	377091.39 Vrms - 115.45°
•3:	'U C: Three-Phase V-I Measurement'	377091.39 Vrms 124.55°
•4:	'U A:)1 '	377091.39 Vrms 4.55°
•5:	'U B:)1 '	377091.39 Vrms - 115.45°
•6:	'U C:)1 '	377091.39 Vrms 124.55°
•7:	'U A:) '	658791.14 Vrms - 51.08°
•8:	'U B:) '	658791.14 Vrms - 171.08 °
•9:	'U C:) '	658791.14 Vrms 68.92°
•10:	'U_TCR/Voltage Measurement '	543786.80 Vrms 94.00°
•11:	'U_TCR/Voltage Measurement1 '	543786.80 Vrms - 26.00°
•12:	'U_TCR/Voltage Measurement2 '	543786.80 Vrms - 146.00°
•13:	'I A:) '	3771.44 Arms 3.97°
•14:	'I A:)1 '	3771.44 Arms 3.97°
•15:	'I A: Three-Phase V-I Measurement'	3771.44 Arms 3.97°
•16:	'I B: Three-Phase V-I Measurement'	3771.44 Arms - 116.03°
•17:	'I C: Three-Phase V-I Measurement'	3771.44 Arms 123.97°
•18:	'I B:)1 '	3771.44 Arms - 116.03°
•19:	'I C:)1 '	3771.44 Arms 123.97°
•20:	'I B:) '	3771.44 Arms - 116.03 °
•21:	'I C:) '	3771.44 Arms 123.97 °
•22:	'I_TCR/Current Measurement '	17.04 Arms 179.51°

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5. CONCLUSION

The comparison of the above waveforms demonstrates a significant increase in the transient stability margin in the system with TCSC. Power system oscillations can be effectively dampened using controlled series compensation. It is necessary to vary the applied compensation for power oscillation damping in order to counteract the acceleration and decelerating swings on the disturbed machines. To put it another way, as the rotationally oscillating generator accelerates and the angle increases, the electric power transmitted must increase to compensate for the increased mechanical input power. When the generator decelerates and the angle decreases, the electric power must be reduced to compensate for the insufficient mechanical input power.

Fixed series compensation is self-adaptive to load change and has a compensation effect on heavy load lines, but light load lines with high load fluctuation may cause abnormal voltage rise in front of the compensation point, necessitating the establishment of reasonable switching rules for series capacitors.

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