A Literature Survey – For Certain Selected Issues In Power System

S.Lavanya, Dr.S.Meikandasivam, Dr.D.Vijayakumar

Abstract: On proper control in transmission network, overloading can be eliminated or reduced by power sharing in interconnected transmission system, by introducing FACTS device in power system network. To improve power system performance, TCSC device from FACTS family has high potential in applications including transient stability improvement, reduction in power loss, control over real power flow, capability of transfer of power enhancement in transmission system and mitigating sub synchronous resonance etc. This paper present TCSC- a facts device optimal size and proper location on transmission line system because of high cost and attain its benefits of TCSC in transmission system. This paper also describe, the discussion, work performed by researchers in this field of finding optimal location, size of TCSC- its application on power system stability improvement and control strategies.

Index Terms: Fact Devices, TCSC, System parameters, Optimization techniques, system stability.

1. INDRODUCTION

Power system stability in existing power network, a main problem facing by power engineers while increase in new demand in electricity trades. Voltage collapse occurs when voltage at all buses, not at nominal value result in instability, there by reactive power losses uncontrollable. The transmission system efficiency is affected under over loaded. So control measurement has been implemented to improve system stability, performance without interruption of power. This helps to mitigate overloaded and reduction in power loss [1].To overcome instability of power system, concepts of Flexible AC Transmission Line was proposed by Electrical power research institute (EPRS) in 1980's for problems in power systems. FACTS devices, generally power electronics based system to boost controllability and capability of increase in power transfer of the network. Three controllers - Series Controller (TCSC), Shunt Controller and Combined Controller. Power System Stability is enhanced by TCSC- a FACTS device which improves stability, by locating at optimal place, size of the transmission network [2]. Flexibility in transmission system, TCSC has major role in power system. TCSC, Fixed series compensation second of FACTS controller, provided fast variable and efficient compensation. Advantage of TCSC, ability to operate in three modes and control the amount of compensation of transmission system network. TCSC has blocking mode, capacitive mode and bypass mode [3]. In TCSC, Thyristor Controlled Reactor (TCR) with capacitor in parallel, effective impedance variation occurs when control firing angle of thyristor, in turn reactance of inductor varied. TCSC is variable impendence device. In general mode of TCSC capacitive mode increase in power flow between transmission lines. In several papers effect of TCSC investigation for power quality problem were analyzed [4].

2 LITERATURE REVIEW

The process of literature review of TCSC provides brief application of power system network. Many researchers proposed most sensitive method for obtaining optimal allocation of FACTS controller under various operating condition with best optimization techniques in multi objective function, single objective function for system stability. P.Naderi et.al,[4] proposed sensitive index method is implemented to determining the exact location of TCSC on line based on positive value of sensitive index reactive power loss. S.Varshney et.al, in proposed system voltage collapse critical line is determined based on line stability index. Optimization techniques focus on mitigation in line contingencies on small network.H.I shakeen et.al, [6] proposed system suggested for multi TCSC with minimum cost, optimal allocation, numbers and parameter of TCSC has determined by Genetic Algorithm (GA) and Particle Swarm Optimization (PSO). Two methods compared for optimal process and simulated in mat lab.
Ahmad khan et.al,[7] this paper suggested transient stability steady state stability dynamic stability has improved on TCSC, optimizing techniques of Eigen value on considering IEEE 14 bus system. S.Sakthivel et.al,[8]proposed stability of voltage in interconnected system applied Differential Equation Algorithm (DEA) to maintain loadability,line contingency outage condition. The proposed method test under IEEE 14 bus DEA with TCSC controllers maintain stability margin in power system. M.Hamed et.al,[9]proposed multi objective function, reduction in power loss system voltage deviation PSO algorithm tends to determined the parameter of TCSC result in stability of the system. The proposed method analyses two methods PSO with TCSC, Simple Genetic Algorithm (SGA) with TCSC for IEEE 30 bus system. Main drawback using FACTS device In power system issues is planning and control for multi objective process.

3 THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC)

TCSC consists of Thyristor controlled reactor (TCR) which is shunted by a series compensating capacitor(C). By changing the inductive reactance of TCR which is connected in parallel to the capacitor, the impedance of TCSC is changed. The variation of inductive reactance X_L is achieved by perfect tuning of firing angle α. The firing angle α is tuned from 0˚ to 90˚. The transmission line reactance can be modified by varying the X_L from actual value to infinite, which result in variable capacitive reactance across the TCSC.

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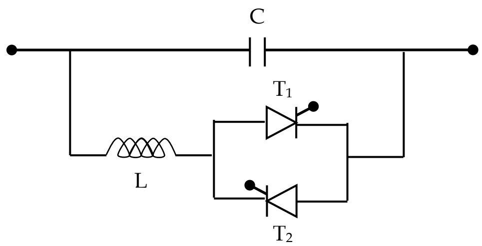

***Fig.1**. Schematic Diagram of TCSC Device*

3.1 TCSC equivalent circuit

The character tics curve of TCSC is drawn between the firing angle and reactance of TCSC. TCSC reactance operates in three regions

1. In inductive region, range of firing angle (α) $90 \leq \alpha \leq \alpha_{Llim}$. This region starts from X_L to infinity.
2. In capacitive region, firing angle varies from $\alpha_{Clim} \leq \alpha \leq 180^\circ$. This region decrease from infinity to X_C.
3. In resonance region X_C and X_L region are possible by varying the firing angle $\alpha_{Llim} \leq \alpha \leq \alpha_{Clim}$.

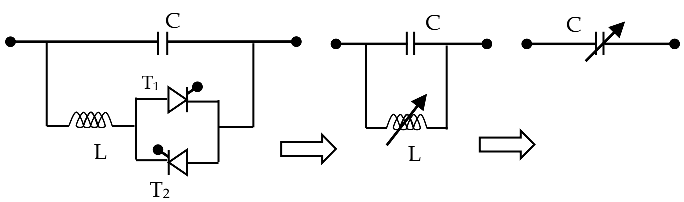

***Fig.2**.Equivalent Circuit of TCSC*

3.2 Characteristics Curve between firing angle and resonance.

a. By pass Thyristor Mode:

- In this mode, the net reactance is inductive nature $X_L||X_C$.
- $\alpha = 90^\circ$
- $I_{TCR} >> I_C$.
- Used for protective function and control purpose.

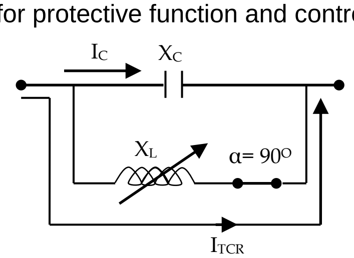

***Fig.3**. By pass Thyristor Mode*

- In this mode, the net reactance is capacitive nature $X_L||X_C$.
- $\alpha = 180^\circ$
- $I_C >> I_{TCR}$.

Used for control purpose.

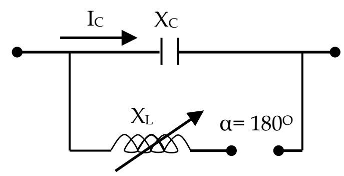

***Fig.4**. Block Region Mode*

C. Vernier capacitive mode:

- In this mode, it behaves as capacitive reactance X_C.
- $\alpha_{Clim} \leq \alpha \leq 180^\circ$
- $I_{TCR} < I_C$.

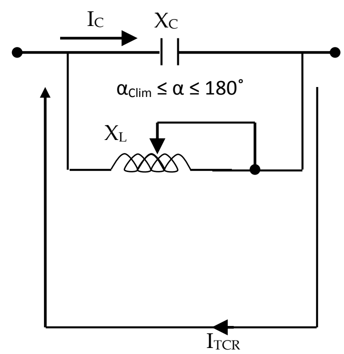

***Fig.5**. Venier Capacitor Mode*

d. Vernier inductive mode:

- In this mode, it behaves as capacitive reactance X_L.
- $90 \leq \alpha \leq \alpha_{Llim}$
- $I_{TCR} > I_C$.

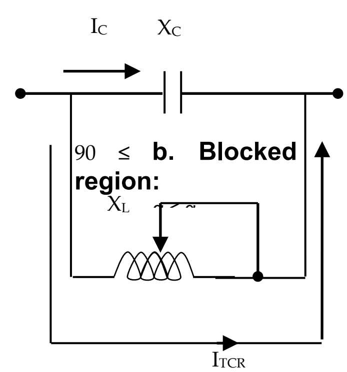

***Fig.6.** Venier Inductive Mode*

3.3 Selection Of TCSC

Normally, in transmission line while choosing K value, 100% compensation will not provided to neglect the series resonance. This case is possible in TCSC device of parallel resonance where variable inductor shunt with fixed capacitor of series compensator. The value of inductor and capacitor is based on K and ω. Degree of series compensation (K) is the ratio of fixed capacitance reactance of TCSC (X_C) to net reactance of transmission line (X_{TL}). The factor ω is the square root of ratio of X_C to X_L.

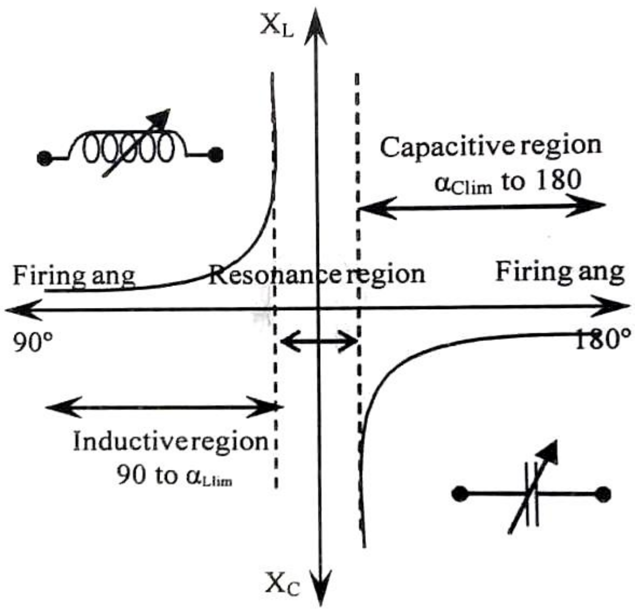

Fig.7.*Selection of TCSC*

4 APPLICATION OF TCSC IN POWER SYSTEM

Application of TCSC in power system has solving major power system problem in existing system. A researcher analyzes different objective and different techniques of optimization method for allocation, size of TCSC on transmission line. In following section TCSC controllers for different problem in maintaining stability of system is carried out for single objective and multi objective power system problem.

4.1 Transient stability

Control strategy in transient stability has been discussed earlier with complex structure by using many controllers. In power oscillation damping, frequency of oscillation and phase shift angle controller has an influence on it. Nishida Toshiya et.al,[10] In transient stability, a proposed method TCSC is implemented for stabilization of power system. The proposed system used index for TCSC location for critical clearing time from view point of transient stability. Quadratic durable stability control method is implementing as strategy of controlGuo.chunlin et.al,[11] proposed a power oscillations damping by implemented TCSC, observe the mode in main oscillation in interconnected network to control the damp oscillation. On consider two group of machines, the capacitive impedance output and speed deviation must be in phase and positive approach larger negative indicate smallest, the oscillation may calmed down faster. The proposed method described TCSC based transient stability an efficient control in power system. S.choudhury et.al,[12] To control TCSC parameter, Particle swarm optimization (PSO)is applied. For simulation in mat lab TCSC controller with single machine infinite bus system is investigated. This proposed method has efficiently tuning TCSC parameter in transient stability of power system.

4.2 TCSC in Transmission Network using SBM

Noorsakinah Abu Baskar et.al,[13] proposed a high reliability and efficiency of transmission network has improved by compensate the reactance in transmission line by introduce TCSC from FACTS family in optimal place of transmission line. This approach Sensitivity Index Method (SMB) for reactive power loss implemented in small network and IEEE 14 bus system. His research objective is reduction in power losses, load ability in line increase, managing contingencies in line. To find optimal location of TCSC in transmission network, method of sensitivity of real power floe index is introduced. In this paper, the author calculated the sensitive index for both small and large network. In case 1 by consider 5 bus systems and line 2 – 5 (small network) they selected for optimal placing of a TCSC. Bus 1 considers as slack bus, Bus 2 and 3 is generator having 100MW and 200MW. The bus 4 and 5 are load bus having 171MVA and 85MVA. They analyzed TCSC is placed at line 3 – 5 where they observed congestion at 104% in the same line. The load ability for small network has been congested in line 2-5,2-3 and 4-5. Without TCSC the reactive power loss is 18Mvar and after placing TCSC the reactive power losses reduced to 15.30Mvar. In case 2- 14 IEEE bus system is consider, line 2-5 (large network).this large system contains I slack bus, generator four, load eight and transformer two. TCSC is placed at line 2-5 with congestion is observed at 107%. The reactive power loss is reduced from 51.32 Mvar when compared to without TCSC reactive power loss 54.54Mvar. In proposed method reactance in transmission line is decrease by placed the TCSC parameter in line. By using line index stability approach, the voltage stability and critical line point of the system can be determined including largest index value define the overall voltage stability of the given system. This work give analysis of load ability of line is increase from 20% to 50% of compensation increased, which result in reactive power losses reduced in that lines.

4.3 Enhancement of power system stability by negotiating its oscillations

A.Kazemi et.al,[14] in this paper, TCSC is applied in a three phase,750KV line,6*350 MVA power system, the line length is 700km.Two case studies are analyzed over the above system. Case 1: For a three phase fault condition, this is triggered at line 1. TCSC is in by passed mode and protective circuit breaker of the line handles the line contingency. For the above certain important results are obtained.

a) The behavior of power system load angle.
b) The plot of generator terminal voltage.
c) Transformer bus voltage and current.

Case 2: Similarly for case 2, the results are obtained for the same power system network. Here in this case TCSC is made active in the circuit (Power system). The same results as for case 1 is obtained. It is very clear from the results that the network with TCSC in active mode handles the emerging fault condition. Moreover the above results are validated with EMTP – ATP draw program and these results also confirm the same as obtained above. Here before going to the important segment of their work (analyzing a three phase fault with and without TCSC for a three phase power system network) the authors have found the optimal control region for a simple TCSC circuit. These results (finding the optimal firing angle “α”). Also finding the optimal change in the current and impedance values with respect to change in the firing angles. There by clearly defining the best control region for the TCSC have also found by the authors. For getting the above results they have tested the power system with TCSC with certain empirical firing angles and have obtained and validated their results with

a) Root locus method (RLM)
b) Nyquist plot method (NP)

From the above methods the authors have found the optimum firing angle of the optimum control area where the TCSC is explained to its fullest ability to negotiate and handle any type pf dynamic or sharp change in the power system disturbance. To summarize their work

1. They have found their work methodology (RLM & NP) to find and check the optimum control area of the TCSC.
2. They have applied their results finding the optimum control angle to a higher power system.
3. The above obtained results are revalidated by EMTP tool.
4. The higher power system is tested with and without TCSC models.

This work clearly gives us an idea of how to understand the behavior of TCSC for improving power system stability by reducing power system oscillations during a fault condition.

4.4 Variation Of Real Power Flow Between Two Line In A Power System By Effective Tuning The Firing Angle Of TCSC

K.Manjusha et.al,[15]. In this paper, the author has placed the TCSC in two identical transmission lines (TL). Single phase ac is applied at bus 1.TL-1 and TL-2 is connected to bus 1 and the load is connected to bus 2. The power drawn by the load is shared by both the TL-1 and TL-2.TCSC is place in line 2, by varying the firing angle of the TCSC, smooth variations of reactance for the TL-2 is achieved. Three modes of operations has been considered for varying the line reactance of TL-2 and the change in the power flows of TL-1 and TL-2 have been clearly analyzed. From the observations of character tics of TCSC

1. The reactance increases, when "α" is increased from 90˚ to around 140˚, the reactance tends to infinity when "α" is increased beyond 140˚.so from α 90˚ to 140˚, the reactance behavior is analyzed and it is in inductive mode.

2. Firing angle from 150˚ to 180˚, the reactance behaves as capacitive region.

3. The firing angle between 140˚ to 150˚, more exactly at 145.2˚,it behaves as resonance region $X_L = X_C$. In this mode TCSC does not operate.

Observations from the research article:

The Matlab simulation is done on 2 bus system. A bus 1 act as source and to the bus 2, load is connected. Simulation results are obtained for various reactances in line 2, correspondingly power flow in the TL is also observed. From the simulation results it is observed that from firing angles between 90˚ to 130˚, the reactance increases in TL-2, accordingly the power is shared between both the lines. For the firing angle 130˚ to 150˚, it is in resonance region, so TCSC does not manipulate any reactance values. From 150˚ to 180˚, the line reactance decreases in line 2, obliviously the power of line 2 increases, accordingly the power flow is adjusted in other line (TL-1).

Finally, from the results, it is clearly proved that, in inductive mode, the power flow is reduced in line2 where as the power floe improves in capacitive mode and smooth control of real power flow variations are studied between the two TL. This paper summarized the manipulation of real power flow control within two TL under various firing angles. Also this research article explains the correlation between "α", shift in reactance and shift in real power flow. This research article helps, under the effective usage of TCSC as a series device in TL system either to increase or decrease the power flows.

4.5 Voltage And Current Profile In Electrical Power System:

Kazemi.A et.al,[16] propose method about Fuzzy Power System Stabilizer(FPSS) with TCSC, is more efficient reliable for improving voltage and current profiles. In this paper three phase short circuit fault was applied near bus one, voltage and line current of the system was oscillate under PSS with TCSC .For same fault system will be quick stable by implementing FPSS with TCSC.

4.6 Power quality Enhancement

Mojtaba khederzadel et.a,[17] This paper described about power quality problem such as voltage sag under disturbance or sensitive load. During disturbance, the proper mode of TCSC is achieved to investigating the voltage sag of the system and concluded TCSC suitable for power quality problem. In this paper, the author analyzed about dynamic response of TCSC in harmonics line under three phase fault and also deemed about the system oscillation when TCSC transfer from one mode to another mode. The author presented with simple mode by considering two line connected to the two bus. The bus 1 connected to certain load. TCSC analyzed for two cases. TCSC performance is analyzed under three phase fault occur in line. During case 1 TCSC operates or by pass mode to safe the capacitor from over voltage during case 0 TCSC transfer to capacitor mode, if voltage sag of this line is at its lower value, the voltage sag on the line, without TCSC can effectively disturb the load at the bus. Due to presence of TCSC on this line, the voltage sag and oscillation are arrested; hence the power quality can be increased in power system.

5 CONCLUSION

In this paper, a detail review of TCSC location problem in transmission line, considering one or more problem to enhance power system performance in transmission network. Objective of major problem solved by implementing proper optimization techniques such as fuzzy logic, Genetic algorithm, PSO to attain stability of the system. Several research analyzed, major objective as placing TCSC in proper location, size because of its cost, including transient stability, voltage control, power quality etc., to maintain the system stability. From literature, the details of controller FPSS with TCSC for transient stability problem, Gravitational search algorithm based TCSC for improvement in system stability, Aritifical intelligence based TCSC for single functional objective, Genetic algorithm and Fuzzy logic rule for stability at power grid. These sensitive controllers are fast and accurate for power system stability.

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