Power System Loadability Enhancement Using Tcsc: An Adaptive Gravitational Search Algorithm

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Abstract: The modern power system with low power losses is accomplished when there is an efficient transmission of power from power plants to consumer loads. To meet such a need, a recently evolved technology is FACTS devices. In this paper, FACTS device such as Thyristor Controlled Series Compensator (TCSC) and is considered for efficient power transfer between the transmission lines. For improving the maximum power transfer capability by these devices, an improved version of gravitational search algorithm (IGSA) is proposed. In the proposed algorithm, velocity of each agent is maximized. If the velocity is high then the agents move to a good solution or else the optimal solution may not be achieved. Here, all solutions are contributing to select the best solution through mass determination of each agent. Maximum power loss of the system is used as fitness function for the IGSA algorithm to optimize the capacity of FACTS devices which improves the maximum power transfer capability with economic cost. The proposed algorithm is implemented in MATLAB platform and the maximum power transfer capability of TCSC is evaluated. The performance evaluation is validated with IEEE 14 bus bench mark system.

Keywords: TCSC, maximum power, velocity and position, IGSA.

1. INTRODUCTION

Modern power system is identified as a multifaceted network together with numerous generators, transmission lines, variety of loads and transformers . The power system turn into more and more hard to function as power transmit amplifies and insecure with natural power flows and higher losses. Arrangement and process the significant problems have been put collectively as mathematical optimization problems in power system. In current power system, due to electricity production and losses in communication lines, needs the optimal function and strategy for minimizing system cost. FACTS devices can solve the above problems efficiently and economically. In this paper TCSC is used to maximize the power transfer capability.

The following section-2 describes literature review. Section-3 describes modeling of TCSC. Section-4 gives result & discussion followed by conclusion in section-5.

2. LITERATURE REVIEW

K Vijayakumar *et al*. have offered an alternate algorithm, using genetic algorithm to work out the optimal power flow problem integrating stretchy AC transmission system devices (FACTS) in a multi machine power system [1]. M Basu have offered a multi-objective optimal power flow with FACTS appliances to optimize cost of production, mission and dynamic power communication power systems [2]. Bhattacharya *et al.* [3] has offered a GSA for functioning out the multi-objective optimal power flow problem. H. Farahmanda *et al.* have suggested an enhanced evaluation of Available Transfer Capability (ATC) [4]. G Madhusudhana Rao *et al.* [5] have suggested real code GA for optimizing the location and controlling parameters of TCSC and SVC for accomplishing maximum available transfer capability (ATC). Suppakarn Chansareewittaya *et al.* [6] have offered evolutionary programming (EP), split and non split search space managing techniques for optimally sitting and settings of FACTS tools to improve the power transfer capability among generators and load buses

3. MODELLING OF TCSC

TCSC is a variable impedance type FACTS device and is connected in series with the transmission line to increase the power transfer capability, which improves transient stability, and reduce transmission losses. The TCSC concept is defined as, it consists of capacitor which is inserted directly in series with the transmission line and the thyristor-controlled inductor is mounted directly in parallel with the capacitor. Using the bi-directional thyristor valves, impedance on the transmission line is varied. Actually, TCSC does not exchange real power with the AC system and only generates or absorbs the reactive power required for compensation by the capacitor or reactor banks. Here, TCSC connected between buses i and j is shown. It is a series connected device which varies the line impedance as per requirement. It consists of: one capacitor C, one inductor L and two thyristor switched T_1 and T_2. The equivalent circuit model of the illustrated TCSC is presented in figure 1.

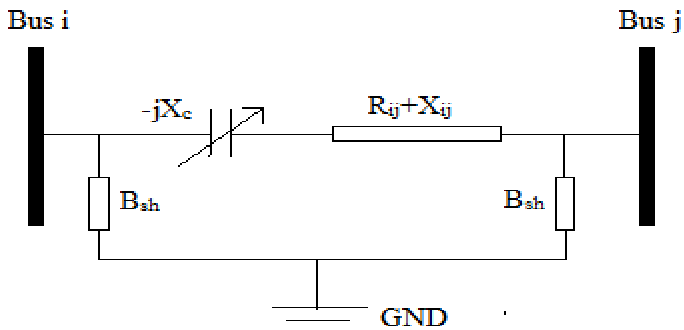

Figure 1: equivalent circuit diagram of TCSC

In figure 1, equivalent circuit model of the TCSC is presented in terms of variable impedance (-jX_c). As the TCSC represents only variable impedance, this alters only the admittance matrix element which makes the modeling of TCSC for load flow studies is simple. The power flow equations of TCSC connection between buses i and j are given as follows:

At bus i,

$$P_i = V_i^2 G_{ij} - \Gamma_{ij}\left(G_{ij}\cos\theta_{ij} + B_{ij}\sin\theta_{ij}\right) \quad (1)$$

$$Q_i = -V_i^2\left(B_{ij} + B_{sh}\right) - \Gamma_{ij}\left(G_{ij}\sin\theta_{ij} - B_{ij}\cos\theta_{ij}\right) \quad (2)$$

And at bus j,

$$P_j = V_j^2 G_{ij} - \Gamma_{ij}\left(G_{ij}\cos\theta_{ji} - B_{ij}\sin\theta_{ji}\right) \quad (3)$$

$$Q_j = -V_j^2\left(B_{ij} + B_{sh}\right) + \Gamma_{ij}\left(G_{ij}\sin\theta_{ji} + B_{ij}\cos\theta_{ji}\right) \quad (4)$$

With

$\Gamma_{ij} = V_i * V_j$, $\theta_{ij} = \theta_i - \theta_j$, $\theta_{ji} = \theta_j - \theta_i$ and

$$G_{ij} = \frac{R_{ij}}{R_{ij}^2 + \left(X_{ij} - X_c\right)^2}$$

$$B_{ij} = \frac{-\left(X_{ij} - X_c\right)}{R_{ij}^2 + \left(X_{ij} - X_c\right)^2}$$

Where

G_{ij} and B_{ij} are the conductance and susceptance between buses i and j after connecting TCSC, R_{ij} and X_{ij} are the resistance and reactance of line between buses i and j, X_c is the variable capacitive reactance of the TCSC.

4. RESULT AND DISCUSSIONS

IGSA method is used in IEEE-14 bus system and implemented in MATLAB (R2012a) platform. In Table 4.1 power flow at various buses is shown for best fitness bus 5 and 6. Only maximum power loss buses are selected and power flow is analyzed. Maximum power loss buses are 2 and 3, 5and 6. Power flow is increased when TCSC is connected between bus 5 and 6. Table 4.2 shows power loss of the system. After connecting TCSC and using IGSA approach power loss is improved in the system.

TABLE 4.1 Power flow comparison of IEEE 14 bus system

		Without TCSC (Base Case)		**With TCSC connected between best fitness buses 5 & 6**	
From bus	To bus	P(MW)	Q(Mvar)	P(MW)	Q(Mvar)
5	6	42.322	11.427	43.197	20.814
6	11	6.368	0.161	9.018	8.638
6	12	7.562	2.071	8.152	3.128
6	13	17.192	5.362	18.710	9.856
10	11	2.817	2.068	5.335	6.440
12	13	1.384	0.309	1.970	1.358
13	14	4.850	0.570	6.911	4.895

TABLE 4.2 Power Loss Comparisons

Bus no.		Power loss	
		Base case(MW)	IGSA (MW) with TCSC
From Bus	To Bus		
2	3	13.5929	6.3678
5	6	13.5929	13.1996

5. CONCLUSION

It is seen that TCSC increases the power flow and also improves the power loss of the system using IGSA approach. Thus using TCSC with IGSA approach the maximum power transfer capacity of the transmission line is enhanced.

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