

# Study of Optimal Location and Compensation Rate of Thyristor-Controlled Series Capacitor Considering Multi-objective Function

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**Abstract** – Flexible AC Transmission System (FACTS) application study on enhancing the flexibility of AC power system has continued to make progress. A thyristor-controlled series capacitor (TCSC) is a useful FACTS device that can control the power flow by adjusting line impedances and minimize the loss of power flow and voltage drop in a transmission system by adjusting line impedances. Reduced power flow loss leads to increased loadability, low system loss, and improved stability of the power system. This study proposes the optimal location and compensation rate method for TCSCs, by considering both the power system loss and voltage drop of transmission systems. The proposed method applies a multi-objective function consisting of a minimizing function for power flow loss and voltage drop. The effectiveness of the proposed method is demonstrated using IEEE 14- and a 30-bus system.

**Keywords:** Thyristor-controlled series capacitor (TCSC), TCSC optimal location, Flexible AC transmission systems (FACTS), Minimizing power loss

## 1. Introduction

Recently, the demand for electricity has increased dramatically in terms of load growth, but has not been accompanied by the expansion of power plants and transmission lines due to the current economic and social malaise. Nonetheless, the need for a reliable power supply continues to become increasingly important. To solve these problems, FACTS technology was proposed. FACTS devices, which were first defined by Hingorani in 1988, have a significant potential ability to enable power systems to operate in a more flexible, secure, and economically favorable way. Studies of the development of FACTS devices have been concerned with their impact on power systems. Study of the application of the FACTS is another significant approach to improving the performance of power systems. The TCSC is one of practical devices that can improve the implementation of FACTS. TCSCs could offer an alternative means of solving the heat capacity limits of transmission lines, loop power flow, load variation, voltage variation, Sub Synchronous Resonance (SSR), low frequency oscillation, and transient stability. At present, TCSCs are being considered for application to Korea's power system. In view of this possibility, the optimal location of TCSCs to improve the efficiency of the power system is an issue of great importance. The power system has two major characteristics, namely, a steady state and a transient state. The selection of an optimal location for

TCSCs typically gives priority to one of these two characteristics. A review of conventional studies regarding the optimal location of TCSCs shows that consideration is given to transient index factors, such as the system's eigenvalue, and the sensitivity analysis in the damping mode and the steady state, which can produce effects such as increasing the power transfer capability [1, 6]. The effects of the application of TCSCs in the steady state include not only an increase in power transfer capability but also improvements in transmission loss and voltage drop by means of line reactance control [4, 10, 11].

This study presents a method of utilizing TCSCs that involves adjusting the power flows in the power system. The focus is on the optimal location for the installation of TCSCs to reduce transmission losses and voltage drop. This study applies a proposed multi-objective function that considers the active power loss, reactive compensation, and voltage drop of the power system. In addition, we present the proper TCSC compensation value at the optimal location as obtained using the proposed method. In order to evaluate the effects of the proposed method, simulations were carried out on IEEE 14- and 30 bus-systems.

## 2. Tesc Compensation and Tesc Modeling

### A. TCSC compensation effect

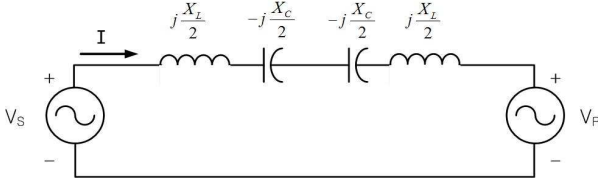
The power transmitted between the sending-end bus and receiving-end bus in an AC transmission system is dependent on the series impedance. Further, the impedance of a transmission line consists mostly of inductive reactance, with resistance accounting for only 5%~10% of

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the impedance. Therefore, if a series capacitor is inserted in a transmission line, the impedance of the transmission line could be compensated for by the capacitive supply. This concept of series compensation is illustrated in Fig. 1 [1, 12].



**Fig. 1.** Series compensation concept for power system

In theory, the series compensation rate  $S$  is available up to 100%. However, SSR may impede the power system stability if the compensation rate is excessively large. In practical applications, the compensation rate is limited to less than 100%.

Eq. (1) gives the compensation rate  $S$  as obtained using series compensation. Eq. (2) gives the compensated line impedance  $X$  [6, 12, 15].

The compensation rate  $S$  of a series capacitor is as follows:

$$S = \frac{X_C}{X_L} \quad (0 \leq S \leq 1) \quad (1)$$

The series compensated line impedance is as follows:

$$X = X_L - X_C = X_L(1 - S) \quad [\text{PU}], \quad (2)$$

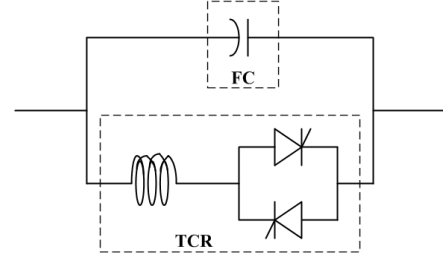
where  $X_L$  is the transmission line impedance and  $X_C$  is the series capacitor reactance [4, 6].

TCSC compensation effects include increased transmitted power capability, improvements in transmission power loss and voltage drop, and power oscillation damping. This study focuses on improving the transmission power loss and improving the voltage drop that accompanies these effects. A TCSC can control the power flow to minimize the power loss by means of line impedance control. A TCSC can also improve the voltage drop by minimizing the reactive power consumption of the transmission line. Improved power loss and voltage drop are important factors when considering effective power system operation and reliable power supply on the utility side.

### B. Static modeling of TCSC

The configuration of a typical TCSC from a steady state perspective involves a fixed capacitor (FC) with a thyristor-controlled reactor (TCR). The TCSC structure is shown in Fig. 2. The TCR consists of bidirectional thyristor valves and a fixed reactor with inductance  $L$ . The variable

reactance  $X_R$  of the TCR at a fundamental frequency is demonstrated in Eq. (3). Further, Eq. (4) gives  $X_{TCSC}$ , which corresponds to the equivalent impedance of a TCSC [4-5].



**Fig. 2.** Configuration of a typical TCSC

The variable reactance  $X_R$  of a TCR is as follows:

$$X_R = X_L \frac{\pi}{2(\pi - \alpha) + \sin 2\alpha} \quad (3)$$

The equivalent impedance  $X_{TCSC}$  of a TCSC is as follows:

$$X_{TCSC} = \frac{X_C X_R}{X_C - X_R} = \frac{X_C X_L}{X_C / (\pi(2(\pi - \alpha) + \sin 2\alpha)) - X_L} \quad (4)$$

where  $X_L$  is the reactance of the fixed reactor,  $\alpha$  is the firing angle of the thyristor valve by the zero crossing of the controller voltage, and  $X_C$  is the reactance of the fixed capacitor.

### C. Modeling of transmission line with TCSC

A simple transmission line represented by its lumped  $\pi$  equivalents connected between bus- $i$  and bus- $j$  is shown in Fig. 3. Complex voltages are denoted by  $V_i \angle \delta_i$  and  $V_j \angle \delta_j$  at bus- $i$  and bus- $j$ , respectively. Equations (5) and (6) give the real and reactive power flow from bus- $i$  and bus- $j$ , respectively [1, 14].

$$P_{ij} = V_i^2 G_{ij} - V_i V_j [G_{ij} \cos(\delta_{ij}) + B_{ij} \sin(\delta_{ij})] \quad (5)$$

$$Q_{ij} = -V_i^2 (B_{ij} + B_{sh}) - V_i V_j [G_{ij} \sin(\delta_{ij}) - B_{ij} \cos(\delta_{ij})] \quad (6)$$

where  $\delta_{ij} = \delta_i - \delta_j$ . Similarly, the real and reactive power flow from bus- $j$  to bus- $i$  can be given by Eqs. (7) and (8), respectively.

$$P_{ji} = V_j^2 G_{ij} - V_i V_j [G_{ij} \cos(\delta_{ij}) - B_{ij} \sin(\delta_{ij})] \quad (7)$$

$$Q_{ji} = -V_j^2 (B_{ij} + B_{sh}) + V_i V_j [G_{ij} \sin(\delta_{ij}) + B_{ij} \cos(\delta_{ij})] \quad (8)$$

A TCSC can be considered as a static reactance  $-jX_{TCSC}$  in the steady state. The real and reactive power flow from bus- $i$  to bus- $j$  and from bus- $j$  to bus- $i$  of a line having

series impedance and a series reactance can be given by Eqs. (9), (10), (11), and (12), respectively. Further, the active and reactive power loss in a TCSC installed on a line can be given by Eqs. (13) and (14), respectively. The transmission line model with a TCSC is shown in Fig. 4 [1, 14].

$$P_{ij}^c = V_i^2 G_{ij}' - V_i V_j (G_{ij}' \cos \delta_{ij} + B_{ij}' \sin \delta_{ij}) \quad (9)$$

$$Q_{ij}^c = -V_i^2 (B_{ij}' + B_{sh}) - V_i V_j (G_{ij}' \sin \delta_{ij} - B_{ij}' \cos \delta_{ij}) \quad (10)$$

$$P_{ji}^c = V_j^2 G_{ij}' - V_i V_j (G_{ij}' \cos \delta_{ij} - B_{ij}' \sin \delta_{ij}) \quad (11)$$

$$Q_{ji}^c = -V_j^2 (B_{ij}' + B_{sh}) + V_i V_j (G_{ij}' \sin \delta_{ij} + B_{ij}' \cos \delta_{ij}) \quad (12)$$

$$P_L = P_{ij} + P_{ji} = G_{ij}' (V_i^2 + V_j^2) - 2V_i V_j G_{ij}' \cos \delta_{ij} \quad (13)$$

$$Q_L = Q_{ij} + Q_{ji} = -(V_i^2 + V_j^2) (B_{ij}' + B_{sh}) + 2V_i V_j B_{ij}' \cos \delta_{ij} \quad (14)$$

where

$$G_{ij}' = \frac{r_{ij}}{r_{ij}^2 + (x_{ij} - x_{TCSC})^2}, \quad B_{ij}' = \frac{-(x_{ij} - x_{TCSC})}{r_{ij}^2 + (x_{ij} - x_{TCSC})^2}$$

The change in the line flow due to the series capacitance can be represented as a line without series capacitance, with power injected at the receiving and sending ends of the line, as shown in Fig. 5. The real and reactive power injections at bus-*i* and bus-*j* can be given by Eqs. (15), (16), (17), and (18), respectively [1, 14].

$$P_{ic} = V_i^2 \Delta G_{ij} - V_i V_j [\Delta G_{ij} \cos \delta_{ij} + \Delta B_{ij} \sin \delta_{ij}] \quad (15)$$

$$P_{jc} = V_j^2 \Delta G_{ij} - V_i V_j [\Delta G_{ij} \cos \delta_{ij} - \Delta B_{ij} \sin \delta_{ij}] \quad (16)$$

$$Q_{ic} = -V_i^2 \Delta B_{ij} - V_i V_j [\Delta G_{ij} \sin \delta_{ij} - \Delta B_{ij} \cos \delta_{ij}] \quad (17)$$

$$Q_{jc} = -V_j^2 \Delta B_{ij} + V_i V_j [\Delta G_{ij} \sin \delta_{ij} + \Delta B_{ij} \cos \delta_{ij}] \quad (18)$$

Where

$$\Delta G_{ij}' = \frac{x_c r_{ij} (x_c - 2x_{ij})}{(r_{ij}^2 + x_{ij}^2)(r_{ij}^2 + (x_{ij} - x_c)^2)},$$

$$\Delta B_{ij}' = \frac{-x_c (r_{ij}^2 - x_{ij}^2 + x_c x_{ij})}{(r_{ij}^2 + x_{ij}^2)(r_{ij}^2 + (x_{ij} - x_c)^2)}$$

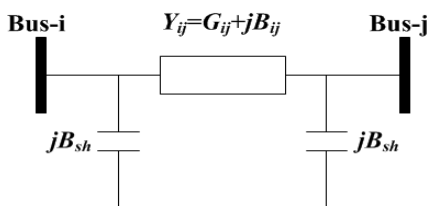


Fig. 3. Transmission line model

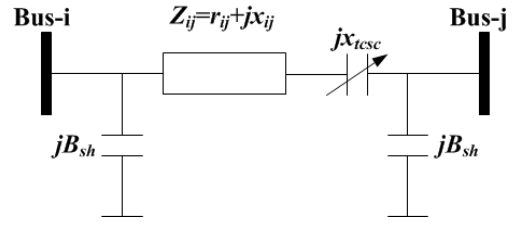


Fig. 4. Transmission line model with TCSC

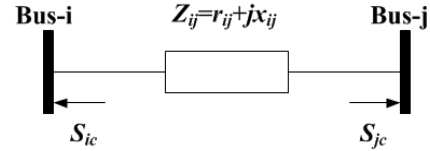


Fig. 5. Injection model of a typical TCSC

### 3. Optimal Location and Compensation Rate of Tcsc Considering Power Loss and Voltage Drop

#### A. Primary objective function

To select the optimal location and compensation rate while considering both power loss and voltage drop, it is necessary to use a power flow calculation to analyze whether a TCSC would be effective at several candidate locations where they would actually be installed. In this study, we use a multi-objective function to select the optimal location and compensation rate.

The primary objective function considers the improvement in the power system loss for selecting the optimal candidate location. The power system loss and the improvement in the power system loss are given by Eqs. (19) and (20), respectively.

$$P_{system\ loss} = \sum_{i=1}^n P_{loss\_i} \quad (19)$$

$$\Delta P_{system\ loss, k} = P'_{system\ loss} - P_{system\ loss, k} \quad (20)$$

where  $P_{loss\_i}$  is the active loss in line *i* and  $P'_{system\ loss}$  is the initial system power loss without TCSC.  $P_{system\ loss, k}$  is the total system power loss following a 1[%] compensation rate of the TCSC. The primary objective function and the scaled power loss sensitivity  $\alpha_{scaled}$  for selecting the optimal candidate location is given by Eqs. (21) and (22).

$$\max \left( \alpha_k = \frac{\Delta P_{system\ loss, k}}{P'_{system\ loss}} \right) \quad (21)$$

$$\alpha_{k, scaled} = \frac{\alpha_k}{\max \{|\alpha_1|, |\alpha_2|, \dots, |\alpha_k|, \dots\}} = \frac{\alpha_k}{\max \{|\alpha|\}} \quad (22)$$

where  $k$  is the transmission line on which the TCSC is installed.

### B. Secondary objective function

A previous TCSC location study considered only the optimal location. Here, we propose a secondary objective function for the standard compensation rate of the TCSC. The secondary objective function applies to the optimal candidate location by primary objective function. The secondary objective function to improve the bus voltage drop considers minimizing the apparent power loss by selecting positive values of power loss improvement obtained by the TCSC. The secondary objective function is performed by iteration of the power flow, which is applied in the control range of the TCSC in optimal location  $k$ .

The constraint of the secondary objective function is given by Eq. (23). The apparent power loss is given by Eq. (24). The applied control range of the TCSC is given by Eq. (25). The bus voltage drop improvement is given by Eqs. (26) and (27). The secondary objective function is given by Eqs. (28) and (29).

$$P'_{system\ loss} \geq P_{system\ loss,k}(x) \quad (23)$$

$$S_{system\ loss} = S_{G,total} - S_{D,total} \quad (24)$$

$$-0.9 \leq X_{tcsc,k} \leq 0.9 \quad (25)$$

$$VD_{system} = \sum_{i=1}^n |VD_i| \quad (26)$$

$$VD_{imp,k}(x) = \frac{VD'_{system} - VD_{system,k}(x)}{VD'_{system}} \times 100 \quad (27)$$

$$\min S_{system\ loss} = \min f(X_{tcsc,k}(x)) \quad (28)$$

$$f(X_{tcsc,k}(x)) = \{ P_{Loss}, S_{Loss}, VD_{system} \} \quad (29)$$

where  $P'_{system\ loss}$  is the initial power system loss in the system without the TCSC and  $P_{system\ loss}$  is the power system loss when the TCSC is installed in the system.  $S_{G,total}$  and  $S_{D,total}$  are the apparent power generation and demand in a system.  $x$  is the compensation rate [%] in line  $k$ .  $X_{tcsc,k}$  is the compensation reactance, expressed as  $x$  [%].  $VD'_{system}$  and  $VD_{system,k}$  are the initial total voltage drop in the system without the TCSC and the total voltage drop in the system with a TCSC.  $P_{Loss}$ ,  $S_{Loss}$ , and  $VD_{system}$  are the power loss, apparent power loss, and bus voltage drop of the system in which the TCSC is installed.

### C. Proposed method for determining optimal location and compensation rate

The optimal location and compensation rate are formulated as a multi-objective function for maximizing power loss sensitivity and minimizing apparent power loss. First, the optimal location problem is formulated as the maximum power loss improvement location based on the TCSC compensation rate change. Second, the optimal

compensation rate problem is formulated as the minimum apparent power loss at the optimal candidate location. Minimizing apparent power loss leads to reactive power reduction by the transmission line reactance control of the TCSC. This shows that the bus voltage drop is improved. In addition, we performed a full Jacobian matrix power flow calculation considering the nonlinearity of the power system. The power flow calculation constraint is given by Eq. (30). The result is evaluated in terms of power loss sensitivity ranking and bus voltage improvement. A flowchart of the proposed method is shown in Fig. 6.

$$P_{G,total} - P_{D,total} - P_{L,total} = 0 \quad (30)$$

where  $P_{G,total}$  is system generation power, and  $P_{D,total}$  is the system active power demand.  $P_{L,total}$  is the system power loss.

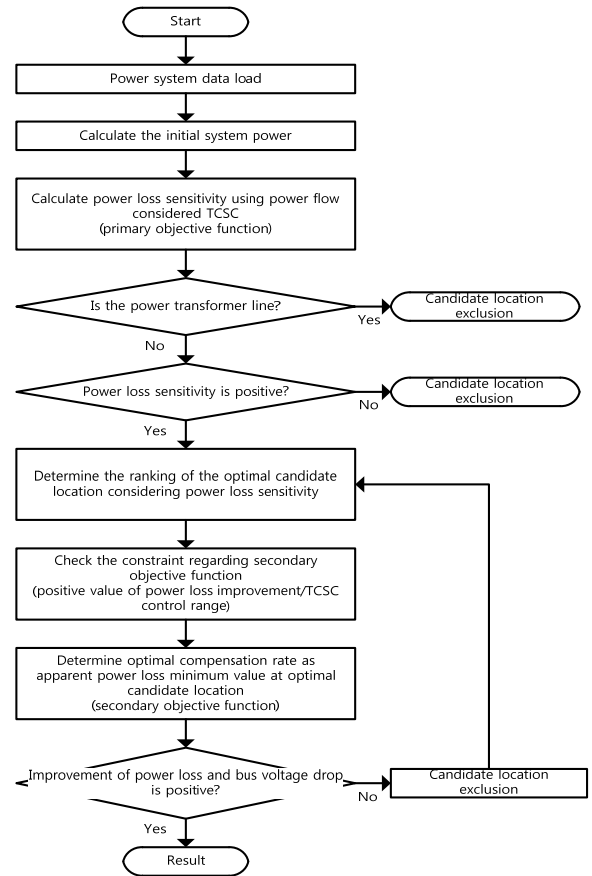


Fig. 6. Flowchart of proposed method

## 4. Test System and Case Study

### A. Test system

The proposed method was tested on an IEEE 14-bus and an IEEE 30-bus system, as shown in Fig. 7. The IEEE 14-bus test system has 20 lines, with 5 generators at buses 1, 2,

3, 6, and 8. It also has 11 load buses at buses 2-6 and 9-14. The IEEE 30-bus test system has 41 lines, 24 load buses, and 6 generators at buses 1, 2, 13, 22, 23, and 27. Details of the test system's lines and bus data are given in [8]. The purpose of this study is to determine the optimal location and compensation rate of a TCSC using the proposed method. The proposed method uses a full Jacobian matrix power flow calculation that considers the R and X of the transmission lines.

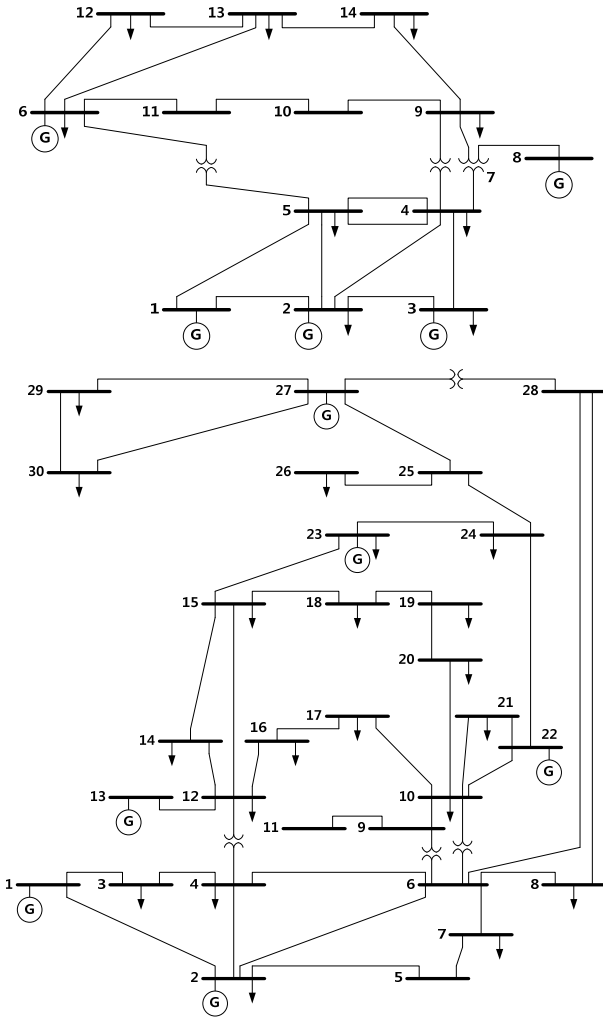


Fig. 7. IEEE 14 and 30-bus test systems

**B. Case study**

To determine the optimal location and compensation rate of a TCSC, we simulated the proposed method. The optimal candidate location is determined by the primary objective function, which regards the improvement sensitivity  $\alpha$  of the power system loss. The initial power system loss of the test system is needed in order to compute the power system loss sensitivity. The initial power system loss values of the IEEE 14-bus and 30-bus test systems, as calculated using MATLAB 7.1, were 6.89

and 17.589 [MW], respectively. The optimal candidate location ranks, as applied to the results for power loss sensitivity  $\alpha$  on the IEEE 14-bus and 30-bus test systems, are listed in Table 1. In Table 1, Compensated Line X means transmission line reactance per unit value using 100 [MVA] base value following a 1[%] compensation rate of the TCSC.

**Table 1.** Optimal candidate location ranks of the TCSC

IEEE 14 bus Rank	Line (from~to)	Scaled P_loss Sensitivity ( $\alpha_{scaled}$ )	Compensated Line X (PU)
1	1~5	0.8793	0.002 2
2	2~3	0.2758	0.002
3	9~14	0.2369	0.002 7
4	13~14	0.1751	0.003 5
5	9~10	-0.0017	0.000 8
6	10~11	-0.0344	0.001 9
7	6~11	-0.0414	0.002
8	12~13	-0.1174	0.002
9	6~12	-0.1514	0.002 6
10	4~5	-0.1601	0.000 4
11	3~4	-0.4344	0.001 7
12	1~2	-0.5082	0.000 6
13	2~5	-1.0000	0.001 7

IEEE 30 bus Rank	Line (from~to)	Scaled P_loss Sensitivity ( $\alpha_{scaled}$ )	Compensated Line X (PU)
1	2~5	1.0000	0.002
2	1~3	0.9786	0.001 9
3	3~4	0.1970	0.000 4
4	12~15	0.0126	0.001 3
5	10~20	0.0110	0.002 1
6	27~30	0.0072	0.006
7	6~8	0.0056	0.000 4
8	27~29	0.0045	0.004 2
9	19~20	0.0027	0.000 7
10	15~23	0.0026	0.002
11	10~21	0.0025	0.000 7
12	25~26	0.0024	0.003 8
13	4~6	0.0020	0.000 4
14	12~16	0.0020	0.002
15	29~30	0.0018	0.004 5
16	10~17	0.0013	0.000 8
17	16~17	0.0012	0.001 9
18	23~24	0.0006	0.002 7
19	21~22	0	0.000 2
20	8~28	-0.0008	0.002
21	18~19	-0.0012	0.001 3
22	14~15	-0.0014	0.002
23	25~27	-0.0026	0.002 1
24	22~24	-0.0028	0.001 8
25	15~18	-0.0039	0.002 2
26	10~22	-0.0039	0.001 5
27	12~14	-0.0071	0.002 6
28	6~28	-0.0073	0.000 6
29	24~25	-0.0123	0.003 3
30	5~7	-0.1467	0.001 2
31	6~7	-0.1906	0.000 8
32	2~4	-0.4032	0.001 7
33	2~6	-0.7181	0.001 8
34	1~2	-0.8399	0.000 6

Table 1 lists the results of the primary objective function. In the case of the IEEE 14-bus test system, four locations (lines 1-5, 2-3, 9-14, and 13-14) had a positive value for the scaled power loss sensitivity  $\alpha_{scaled}$ . The maximum value of power loss sensitivity  $\alpha$  was 0.8793, for lines 1-5. However, if a power system planner were to install a TCSC while considering lines 1-5, qualitative constraints could, in fact, still arise, such as the securing of the site, operational problems, and facility coordination. In addition, dynamic constraint could, such as the SSR phenomenon that may occur when a steam turbine-generator is connected to a long transmission line with series compensation [17]. For this reason, in this study, optimal candidate locations are considered to be those locations that have a positive value of power loss sensitivity  $\alpha$ . The change in the TCSC compensation rate is 1% in the primary objective function. In the case of the IEEE 30-bus test system, three locations (lines 2-5, 1-3, and 3-4) are the optimal candidate locations. These results are then applied to the secondary objective function in order to determine the optimal compensation rate with regard to the voltage drop. The TCSC compensation rate ranges from -90% to +90% in the secondary objective function. The proposed optimal compensation rate method uses an iterative power flow calculation with 0.01[%] step changes in the TCSC compensation rate within the compensation rate range. For the IEEE 14-bus, the results for lines 1-5, and for the 30-bus, the results for lines 2-5, of the optimal compensation rate are respectively shown in Figs. 8 and 9. In Figs. 8 and 9, O, □, and △ are the compensation rate considering only power system loss, the optimal compensation rate obtained using the proposed method, and the compensation rate considering only the apparent power system loss, respectively. The results show the following three cases: (a) power system loss, apparent system loss, and reactive power consumption obtained using the proposed method; (b) improvement in the value of the power system loss and apparent system loss obtained using the proposed method; and (c) improvement in the value of the total bus voltage obtained using the proposed method. Table 2 lists the results of secondary objective function. In Table 2, Comp\_

Line X means transmission line reactance per unit value using 100 [MVA] base value following a compensation rate of the TCSC object.

In the case of the IEEE 14-bus for lines 1-5, the initial power system loss and the apparent power system loss without the TCSC are 6.89 [MW] and 9.865 [MVA], respectively. The compensation rate considering only the minimum power system loss of 6.854 [MW] with a TCSC is 17[%], and the consequent apparent power system loss and bus voltage improvement values are 9.01 [MVA] and 2.206[%], respectively. The compensation rate considering only the minimum apparent power system loss of 7.605 [MVA] with a TCSC is 58[%], and the consequent power system loss and bus voltage improvement values are 7.314 [MW] and 8.548[%], respectively. The optimal compensation rate obtained using the proposed secondary objective

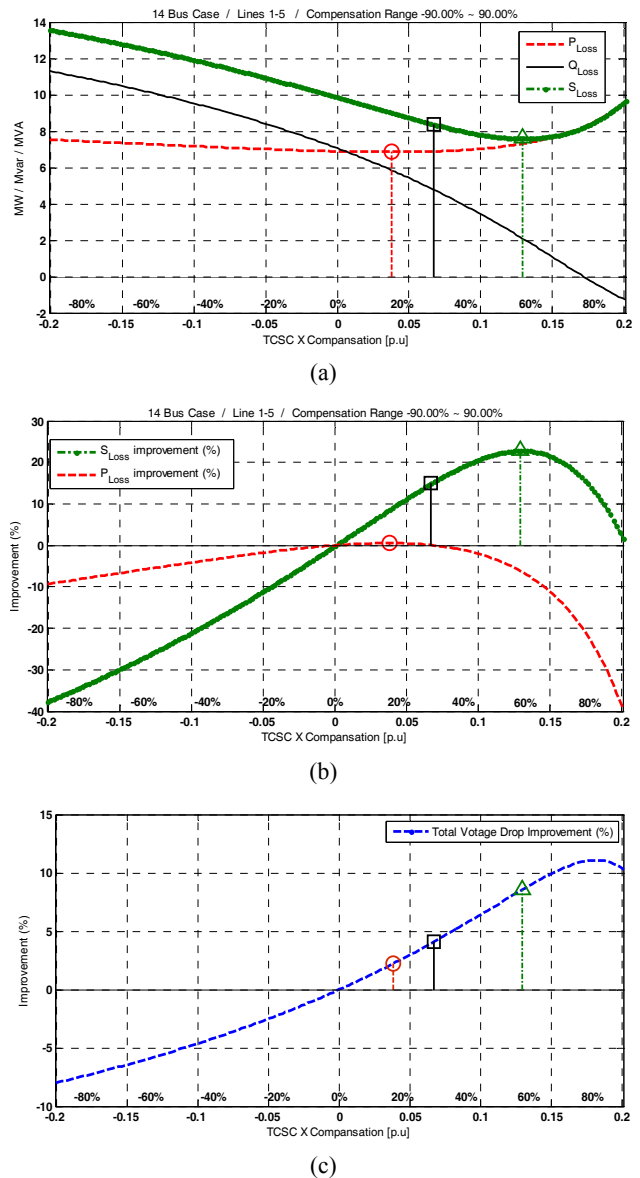


Fig. 8. Optimal compensation rate results for IEEE 14-bus, lines 1-5

Table 2. Optimal compensation rate results of the TCSC

Line	Ob_ject	Comp_Line X (PU)	Comp_Rate [%]	S_Loss [MVA]	P_Loss [MW]	VD_Imp [%]
14-bus 1-5	○	0.0379	17	9.01	6.85	2.21
	□	0.0669	30	8.39	6.87	4.09
	△	0.1294	58	7.61	7.31	8.55
30-bus 2-5	○	0.0476	24	25.62	17.47	3.89
	□	0.0853	43	23.53	17.59	7.2
	△	0.1487	75	21.16	18.83	11.5

function is 30[%], and the consequent power system loss, apparent power system loss, and bus voltage improvement values are 6.876 [MW], 8.389 [MVA], and 4.09[%], respectively. In the case of the IEEE 30-bus for lines 2-5, the initial power system loss and the apparent power system loss without a TCSC are 17.589 [MW] and 28.278 [MVA], respectively.

As the results show, the proposed method can provide alternative approaches to determining the optimal location and compensation rate of TCSC, considering improvements in the power system loss and in the bus voltage drop obtained using a TCSC. If the compensation rate considers only the minimum power system loss and the apparent power system loss, the improvement in the bus voltage drop is less than it is in the other cases, or the power system loss is not improved. However, the proposed

method does consider all types of power system losses and voltage drops.

### 5. Conclusion

Until now, the optimal location of a TCSC has only been considered as one aspect of the potential for achieving reduced power system loss, improved bus voltage drop, enhanced stability, etc. under the intended TCSC implementation plan and operating conditions. In this study, we present a method of determining the optimal location and compensation rate that considers both the power system loss and the bus voltage drop. The primary objective function, which is the power system loss sensitivity  $\alpha$ , is used to determine the optimal location of a TCSC. The secondary objective function is used to determine the optimal compensation rate of a TCSC. The proposed method was implemented using MATLAB software and applied to IEEE 14- and 30-bus test systems. The results of the proposed method showed the ranking of the optimal candidate locations in terms of power system loss sensitivity  $\alpha$  and compensation rates by considering the factors of power system loss, apparent power system loss, and the factor that this proposed method was used.

We expect that proposed method, which considers power system loss and bus voltage drop using the proposed objective function, will provide more suitable solutions to power system planners who must consider multiple objectives.

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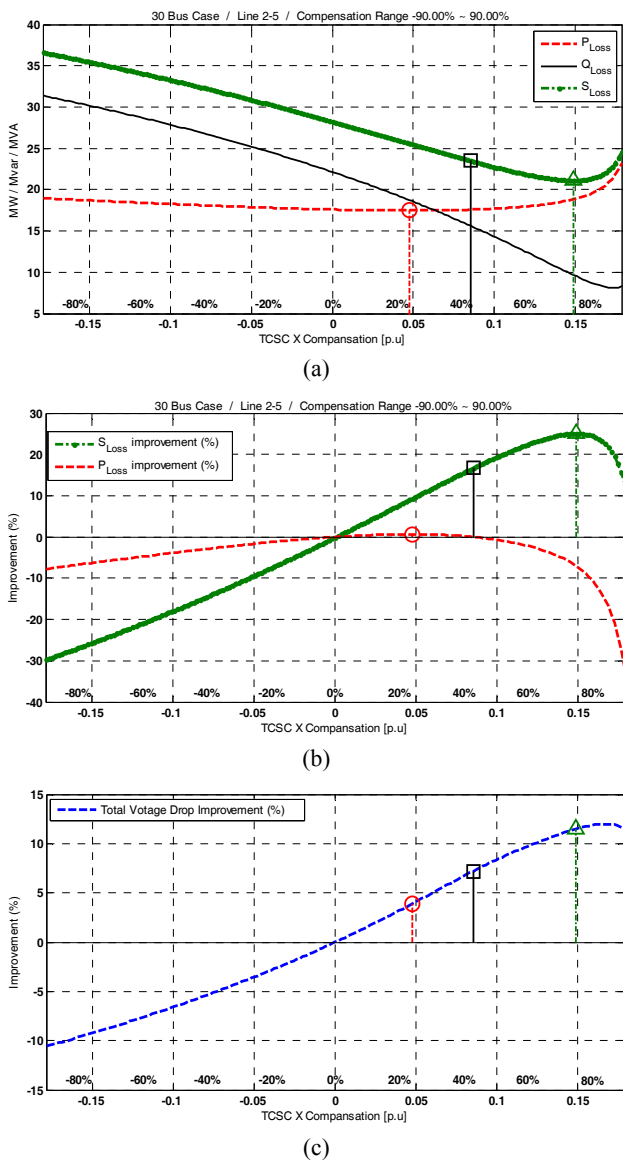


Fig. 9. Optimal compensation rate results for IEEE 30-bus, lines 2-5

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