# LEAD/LAG SSSC BASED CONTROLLER FOR STABILIZATION OF FREQUENCY OSCILLATIONS IN MULTI-AREA POWER SYSTEM

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**Abstract**

This paper proposes a new application of Static Synchronous Series Compensator (SSSC) to stabilization of frequency oscillations in a multi-area power system. To stabilize the frequency oscillations, the dynamic power flow control of the Static Synchronous Series Compensator (SSSC) located in series with the tie line between interconnected power systems, is employed. By regarding the system interconnection as a control channel, the power flow control by an SSSC via the interconnection creates a sophisticated method of frequency stabilization. To implement this concept, the robust design method of lead/lag controller equipped with the SSSC is used. SSSC is located in two different areas and the best location for compensation is shown. The technique of overlapping decompositions is applied to reduce the order of the study power system; meanwhile the physical characteristic is still preserved. Simulation study exhibits the significant effect of designed controller on the study four-area interconnected power system under different load disturbances.

## 1. Introduction

In recent years, energy, environment, and deregulation of power utilities have delayed the construction of both generation facilities and new transmission lines. These problems have necessitated a change in the traditional concepts and practices of power systems. There are emerging technologies available, which can help electric companies to deal with above problems. One of such technologies is flexible ac transmission system (FACTS), which is a family of power electronics products including the (STATCOM), (SSSC), (UPFC), etc. These are called converter-based FACTS controllers.

Furthermore, various kinds of apparatus with large capacity and fast power consumption such as magnetic levitation transportation, a testing plant for nuclear fusion, or even an ordinary scale factory like a steel manufacturer, increase significantly. When these loads are concentrated in a power system, they may cause a serious problem of frequency oscillations.

Under this situation, the conventional frequency controller, i.e. governor, may no longer be able to control the large frequency oscillations due to its slow response [1].

A new service of stabilization of frequency oscillations becomes challenging and is highly expected in the future competitive environment. To tackle this problem, the authors have proposed a new stabilization of frequency oscillations by Static Synchronous Series Compensator (SSSC) [2]. SSSC was first proposed by Gyugyi [3] in 1989 within the concept of using converter based technology uniformly for shunt and series compensation. SSSC is a Flexible AC Transmission Systems (FACTS) device that has been highly expected as an effective apparatus with an ability of dynamic power flow control [4]. In [2], the SSSC is located in series with the tie line between two area interconnected power system. By regarding the system interconnection as the channel of power flow control by SSSC, the system frequency oscillations under a sudden load disturbance can be stabilized effectively. However, the proposed control scheme of SSSC in [2] is designed based on a state feedback scheme of variables. Therefore, it is not easy to implement in a multi-area interconnected power system. In this paper, the lead/lag controller with a single feedback signal input is equipped with a SSSC. To determine the optimal parameters of the lead/lag controller, the tabu search algorithm (TSA) [5] is employed in Ref. [6]. In the formulation of the objective function, not only the attenuation of system disturbances, but also the robust stability of controller against system uncertainties was taken into consideration. In addition, the technique of overlapping decompositions is applied to reduce the order of the study power system for simplicity of control design.

The main aim of this paper is to identify locations of series connected FACTS controller (SSSC) in a four-area interconnected power system. SSSC is located in two different areas and the best location for compensation is shown.

First, the motivation of the proposed control of SSSC is provided. Next part deals with the design methodology including the coordinated control of SSSC and governors, the mathematical model of SSSC and the system reduction by overlapping decompositions. Subsequently, the evaluation of the proposed controller in a four-area interconnected power system in two different locations is outlined by simulation study.

## 2. Theoretical consideration

Figure 1 shows the four-area interconnected power system with a loop configuration. It is assumed that a large load with rapid change has been installed in area 1. This load change causes serious frequency oscillations. Moreover, Independent Power Producers (IPPs) that do not possess frequency control capabilities are included in area 1. Under this situation, the governors in area 1 can not sufficiently provide adequate frequency control.

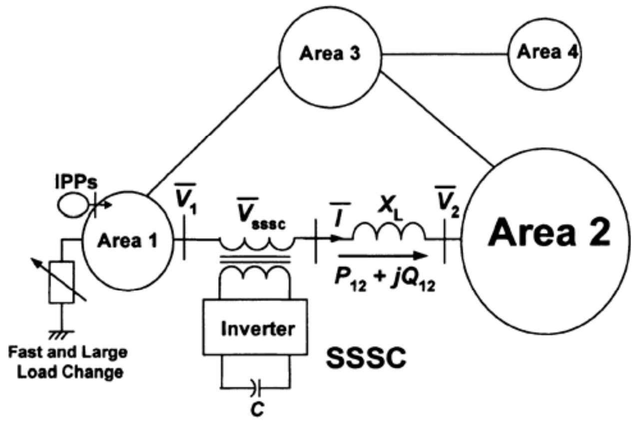


**Fig. 1. Presence of SSSC in a four-area interconnected power system.**

Therefore, area 2 or 3 offers a service of frequency stabilization to area 1 by using the SSSC. Area 2 has large control capability enough to spare for other areas. In the proposed design method, the SSSC controller uses the frequency deviation of area 1 as a local signal input. Therefore, the SSSC is placed at the point near area 1. The compensation (lead/lag) blocks are designed to improve the phase angles of the frequency responses, especially around the frequency of the modes of interest. Hence SSSC is expected to be effective in damping power system oscillations if it is equipped with a damping controller. This paper investigates different locations for SSSC (line 1-2 and line 1-3). Note that the SSSC is utilized as the energy transfer device from area 2 or 3 to area 1. As the frequency fluctuation in area 1 occurs, the SSSC will provide the dynamic control of a tie line power via the system connections. By exploiting the system interconnections as the control channels, the frequency oscillations can be stabilized.

## 3. Design of SSSC Controller

### A. Coordinated control of SSSC and governors

The performance of SSSC is extremely rapid when compared with the conventional frequency control system, i.e. governor. The difference in the performance signifies that SSSC and governors may be coordinated as follows. When an area is subjected to a sudden load disturbance, the SSSC quickly acts to minimize the peak value of the frequency deviation. Subsequently, the governors are responsible for eliminating the steady-state errors of frequency deviations. Based on this concept, the periods of operation for two devices do not overlap. Consequently, the dynamics of the governors can then be neglected in the control design of the SSSC for the sake of simplicity.

### B. Mathematical model of the SSSC

In this study, the mathematical model of the SSSC for stabilization of frequency oscillations is derived from the characteristic of power flow control by SSSC [4]. By adjusting the output voltage of SSSC ($\bar{V}_{SSSC}$), the tie line power flow ($P_{12}$ +j$Q_{12}$), can be directly controlled as shown in Figure 1. Since the SSSC fundamentally absorbs or produces only the reactive power, then the phasor ($\bar{V}_{SSSC}$) is perpendicular to the phasor of line current $\bar{I}$. Therefore, the current $\bar{I}$ in Figure 1, can be expressed as

$$\bar{I} = \frac{\bar{V}_1 - \bar{V}_2 - jV_{SSSC}\bar{I}/I}{jX_L} \tag{1}$$

Note that $\bar{I}/I$ is a unit vector of line current, $X_L$ is the reactance of the tie line, and $\bar{V}_1$, $\bar{V}_2$ are the voltages at buses 1 and 2, respectively. The active power and reactive power flow through bus 1 are

$$P_{12} + jQ_{12} = \bar{V}_1\bar{I}^* \tag{2}$$

where $\bar{I}^*$ is the conjugate of $\bar{I}$. Substituting $\bar{I}$ from (1) into (2) yields

$$\begin{aligned} P_{12} + jQ_{12} &= \frac{V_1V_2}{X_L}\sin(\delta_1 - \delta_2) - V_{SSSC}\frac{\bar{V}_1\bar{I}^*}{X_L I} \\ &\quad + j\left(\frac{V_1^2}{X_L} - \frac{V_1V_2}{X_L}\cos(\delta_1 - \delta_2)\right). \end{aligned} \tag{3}$$

where $\bar{V}_1 = V_1e^{j\delta 1}$ and $\bar{V}_2 = V_2e^{j\delta 2}$.

In the second term of the right hand side of equation (3), $\bar{V}_1\bar{I}^*$ is equal to $P_{12}$ +j$Q_{12}$ (see equation (2)). Accordingly, the relation in the real part of equation (3) provides

$$P_{12} = \frac{V_1V_2}{X_l}\sin(\delta_1 - \delta_2) - \frac{P_{12}}{X_l I}V_{SSSC} \tag{4}$$

In equation (4), the second term of the right hand side is the active power controlled by SSSC. Here, it is assumed that $V_1$ and $V_2$ are constant and the initial value of $V_{SSSC}$ is zero, i.e. $V_{SSSC}$ =0. By linearizing equation (4) about an initial operating point

$$\Delta P_{12} = \frac{V_1V_2\cos(\delta_{10} - \delta_{20})}{X_l}(\Delta\delta_1 - \Delta\delta_2) - \frac{P_{120}}{X_l I_0}\Delta V_{SSSC}$$
(5)

Therefore, equation (5) implies that the SSSC is capable of controlling the active power independently. The control effect by SSSC is expressed by the injected power deviation $\Delta P_{SSSC}$ instead of – ($P_{120}$ /$X_l I_0$) $\Delta V_{SSSC}$. As a result, equation (5) can be expressed as

$$\Delta P_{12} = \Delta P_{T12} + \Delta P_{SSSC} \tag{6}$$

where

$$\Delta P_{T12} = T_{12}(\Delta\delta_1 - \Delta\delta_2) \tag{7}$$

and $T_{12}$ is synchronizing power coefficient

$$T_{12} = \frac{V_1V_2\cos(\delta_{10} - \delta_{20})}{X_l} \tag{8}$$

## C. Design methodology

The linearized four-area interconnected system [7] including the active power model of SSSC is shown in Figure 2.

Based on explanation of section A, the dynamics of governors are eliminated in this figure. The active power controller of SSSC has a structure of the lead/lag compensator $K_{RB}$(s) with output signal $\Delta P_{\text{ref}}$. In this study, the dynamic characteristic of SSSC is modeled as the first order controller with time constant $T_{SSSC}$. Note that the injected power deviation of SSSC, $\Delta P_{SSSC}$ acting positively on the area 1 reacts negatively on the area 2. Therefore, $\Delta P_{SSSC}$ flows into both areas with different signs (+,-), simultaneously. This characteristic represents the physical meaning of equation (7). Equation (9) expresses the linearized system in Figure (2). $\Delta f_i$ is the frequency deviation of area i, $\Delta P_{Tij}$ is the tie line power deviation between areas i and j, $M_i$ is the inertia constant of area i, $D_i$ is the damping coefficient of area i, aij is the area capacity ratio between areas i and j, and $T_{ij}$ is the

$$S:\begin{bmatrix}\Delta \dot{f}_1\\ \Delta \dot{P}_{T12}\\ \Delta \dot{f}_2\\ \Delta \dot{P}_{T23}\\ \Delta \dot{f}_3\\ \Delta \dot{P}_{T34}\\ \Delta \dot{f}_4\end{bmatrix}=\begin{bmatrix}-\mathrm{D}_1/\mathrm{M}_1 & \mathrm{a}_{s12} & 0 & a_{s14} & 0 & 0 & 0\\ -2\pi T_{12} & 0 & 2\pi T_{12} & 0 & 0 & 0 & 0\\ 0 & -1/M_2 & -\mathrm{D}_2/\mathrm{M}_2 & -a_{23}/M_2 & 0 & 0 & 0\\ 0 & 0 & 2\pi T_{23} & 0 & -2\pi T_{23} & 0 & 0\\ 0 & a_{s52} & 0 & a_{s54} & -\mathrm{D}_3/\mathrm{M}_3 & \mathrm{a}_{34}/M_3 & 0\\ 0 & 0 & 0 & 0 & -2\pi T_{34} & 0 & -2\pi T_{34}\\ 0 & 0 & 0 & 0 & 0 & -1/M_4 & -\mathrm{D}_4/\mathrm{M}_4\end{bmatrix}\begin{bmatrix}\Delta f_1\\ \Delta P_{T12}\\ \Delta f_2\\ \Delta P_{T23}\\ \Delta f_3\\ \Delta P_{T34}\\ \Delta f_4\end{bmatrix}+\begin{bmatrix}a_{12/M_1}\\ 0\\ -1/M_2\\ 0\\ 0\\ 0\\ 0\end{bmatrix}\Delta P_{SSSC} \quad (9)$$

synchronizing power coefficient of the tie line between areas i and j, where i, j=1, . . ., 4. Here $a_{S12} = (a_{12}+T_{31}/T_{12})/M_1$, $a_{S14} = -T_{31}/(M_1T_{23})$, $a_{S52} = -a_{31}T_{31}/(M_3T_{12})$, $a_{S54} = (1+ a_{31}T_{31}/T_{23})/M_3$. The variable $\Delta P_{T31}$ is represented in terms of $\Delta P_{T12}$ and $\Delta P_{T23}$ by

$$\Delta P_{T31} = -\frac{T_{31}}{T_{12}}\Delta P_{T12} + \frac{T_{31}}{T_{23}}\Delta P_{T23} \quad (10)$$

This system has three conjugate pairs of complex eigenvalues and a negative real eigenvalue. The former corresponds to three inter-area oscillation modes and the latter the inertia center mode.

The concept of overlapping decompositions is applied to the system (9) with the aim of extracting the subsystem where the inter-area mode between areas 1 and 2 or 1 and 3 is preserved. The system (9) is referred to as the system S. The state variables of S are classified into three groups, i.e. $x_1= [\Delta f_1]$, $x_2= [\Delta P_{T12}]$, $x_3 = [\Delta f_2, \Delta P_{T23}, \Delta f_3, \Delta P_{T34}, \Delta f_4]^T$. Therefore, the system S can be expressed in compact form as

$$\tilde{S}:\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}A_{11} & A_{12} & A_{13}\\ A_{21} & A_{22} & A_{23}\\ A_{31} & A_{32} & A_{33}\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}B_{11}\\ B_{21}\\ B_{31}\end{bmatrix}\Delta P_{SSSC} \quad (11)$$

The sub-matrices $A_{ij}$ and $B_{i1}$, (i, j=1, 2, 3) have appropriate dimensions identical to the corresponding state and input vectors. The system S can be decomposed into two interconnected overlapping subsystems

$$\tilde{S}_1 : \dot{z}_1 = \left(\begin{bmatrix}A_{11} & A_{12}\\ A_{21} & A_{22}\end{bmatrix} z_1 + \begin{bmatrix}B_{11}\\ B_{21}\end{bmatrix}\Delta P_{SSSC}\right) + \begin{bmatrix}0 & A_{13}\\ 0 & A_{23}\end{bmatrix} z_2$$
(12)

$$\tilde{S}_2 : \dot{z}_2 = \left(\begin{bmatrix}A_{22} & A_{23}\\ A_{32} & A_{33}\end{bmatrix} z_2\right) + \begin{bmatrix}A_{21} & 0\\ A_{31} & 0\end{bmatrix} z_1 + \begin{bmatrix}B_{21}\\ B_{31}\end{bmatrix}\Delta P_{SSSC}$$
(13)

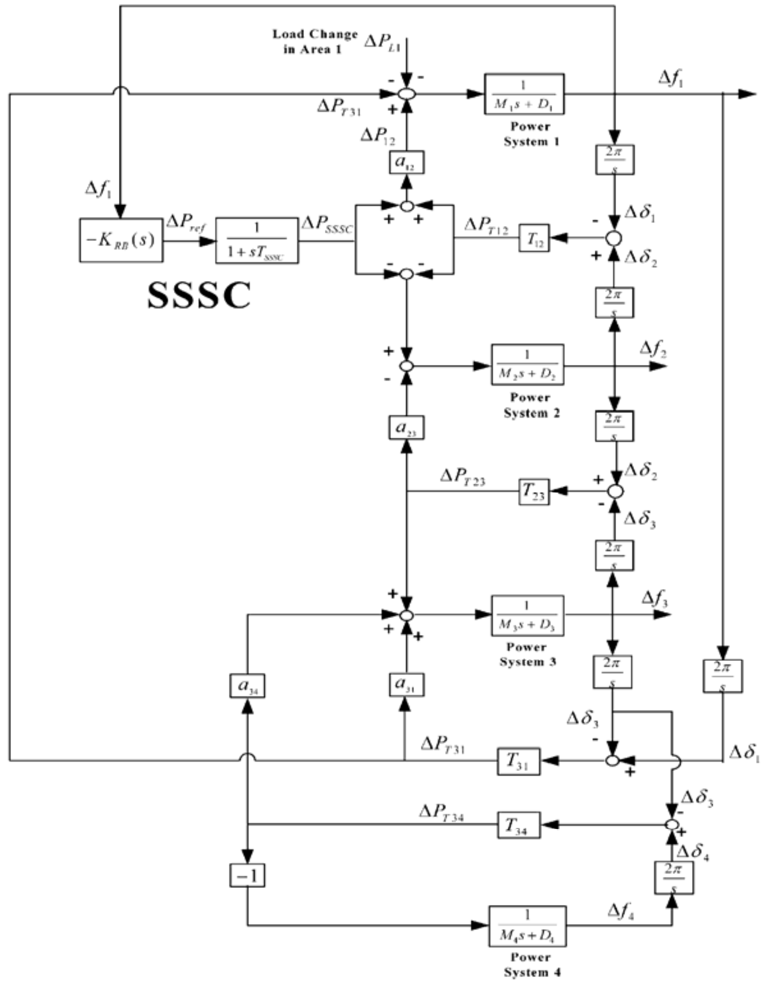


**Fig. 2. Presence of SSSC in a linearized four-area interconnected power system without governors.**

where,

$z_1 = \left[x_1^T, x_2^T\right]$ and $z_2 = \left[x_2^T, x_3^T\right]^T$

The state variable $x_2$, i.e. the tie line power deviation between areas 1 and 2 ($\Delta P_{T12}$), is included in both subsystems, which implies "Overlapping Decompositions".

As mentioned in Ref. [6], if each decoupled subsystem can be stabilized by its own input, the asymptotic stability of the interconnected overlapping subsystems $\tilde{S}_1$ and $\tilde{S}_2$ are maintained. Moreover, the asymptotic stability of the original system S is also guaranteed. Consequently, the interactions of the decoupled subsystems with the interconnection subsystems in equations (12) and (13) are regarded as perturbations. They can be neglected during control design. As a result, the decoupled subsystems of $\tilde{S}_1$ and $\tilde{S}_2$ can be expressed as

$$\tilde{S}_{D1} : \dot{z}_1 = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} z_1 + \begin{bmatrix} B_{11} \\ B_{21} \end{bmatrix} \Delta P_{SSSC} \tag{14}$$

$$\tilde{S}_{D2} : \dot{z}_2 = \begin{bmatrix} A_{22} & A_{23} \\ A_{32} & A_{33} \end{bmatrix} z_2 \tag{15}$$

In equations (14) and (15), there is a control input $\Delta P_{SSSC}$ appearing only in the subsystem $\tilde{S}_{D1}$. Here, the decoupled subsystem $\tilde{S}_{D1}$ is regarded as the designed system, which can be expressed as

$$\tilde{G} : \begin{bmatrix} \Delta \dot{f}_1 \\ \Delta \dot{P}_{T12} \end{bmatrix} = \begin{bmatrix} -D_1/M_1 & a_{S12} \\ -2\pi T_{12} & 0 \end{bmatrix} \begin{bmatrix} \Delta f_1 \\ \Delta P_{T12} \end{bmatrix} + \begin{bmatrix} a_{12}/M_1 \\ 0 \end{bmatrix} \Delta P_{SSSC} \tag{16}$$

It can be verified that the eigenvalues of equation (16) are complex conjugate and are assumed to be $-\sigma \pm j\omega_d$. These complex eigenvalues correspond to the inter-area oscillation mode between areas 1 and 2 in the original system S. By virtue of overlapping decompositions, the physical characteristic of the original system S is still preserved after the process of system reduction. This explicitly shows the merit of overlapping decompositions.

By incorporating the dynamic characteristic of the SSSC, equation (16) becomes

$$G:\begin{bmatrix}\Delta\dot{f}_1\\ \Delta\dot{P}_{T12}\\ \Delta\dot{P}_{SSSC}\end{bmatrix}=\begin{bmatrix}-D_1/M_1 & a_{S12} & a_{S12}/M_1\\ -2\pi T_{12} & 0 & 0\\ 0 & 0 & -1/T_{SSSC}\end{bmatrix}\begin{bmatrix}\Delta f_1\\ \Delta P_{T12}\\ \Delta P_{SSSC}\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1/T_{SSSC}\end{bmatrix}\Delta P_{ref}$$

17)

For the input signal of SSSC controller, two available local signals, i.e. area 1 frequency deviation ($\Delta f_1$) and the tie line 1-2 power deviation ($\Delta P_{T12}$) are taken into consideration. By calculating the right eigenvector of the oscillation mode between areas 1 and 2, the degree of activity [8] of $\Delta f_1$ and $\Delta P_{T12}$ in this mode can be evaluated. The magnitudes of elements of the right-eigenvectors that correspond to $\Delta f_1$ and $\Delta P_{T12}$ are 0.6088 and 0.1953, respectively. As a result, $\Delta f_1$ provides higher degree of activity in this mode. Consequently, $\Delta f_1$ is used as the input signal of SSSC controller. The negative feedback control scheme of SSSC controller can be expressed by

$$\Delta P_{ref}=-K_{RB}(s)\Delta f_1 \qquad (18)$$

The robust controller $K_{RB}(s)$ is in form of a lead/lag stabilizer as

$$K_{RB}(s)=K\frac{T_w s}{1+T_w s}\frac{(1+T_1 s)}{(1+T_2 s)}\frac{(1+T_3 s)}{(1+T_4 s)} \qquad (19)$$

where K is the controller gain; $T_1$, $T_2$, $T_3$, $T_4$, are lead/lag time constants; and $T_W$ is washout time constant. All signals are passed through a washout block having a time constant of $T_W$ to filter out the DC and attenuate the very low frequency content of the signal. Here, $T_W$ is set to 10s. The control parameters K, $T_1$, $T_2$, $T_3$ and $T_4$ are searched based on the objective function explained in Ref. [6]. The following transfer function was obtained for the robust controller of SSSC when the peak frequency deviation is limited to $M_{p(design)}$ =1.2.

$$K_{RB}(s)=3.5206\frac{10s}{1+10s}\frac{(1+0.7758s)}{(1+2.5074s)}\frac{(1+1.9660s)}{(1+3.7269s)}$$

(20)

In the next section, these controllers with SSSC are used in tie line 1-2, 1-3 and the results are compared.

## 4. Simulation results

The disturbance attenuation performance is investigated in the linearized model of the four-area interconnected system. Figure 3 indicates that in case of no governors, the frequency oscillations which are composed of the inter-area mode and the inertia center mode are very large and undamped.

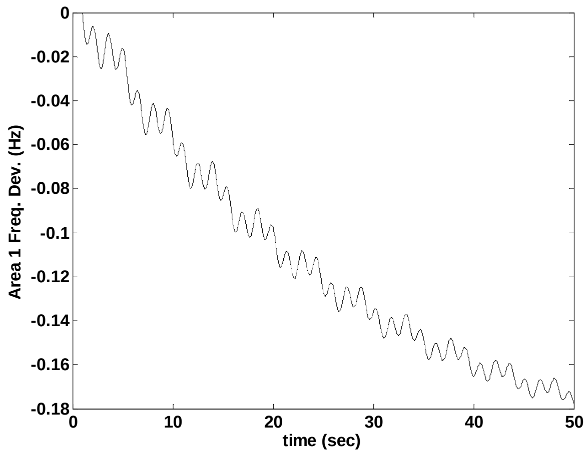


**Fig. 3. Frequency deviation of area 1 (without SSSC).**

After applying an SSSC, Figure 4, the first overshoot of frequency deviation is suppressed as expected by the design specifications. At the same time, the oscillatory parts due to the inter-area mode are also stabilized completely. Although, the frequency deviation by the influence of inertia mode increases indefinitely due to the unbalancy between generation power and load power, the governors are able to solve this problem.

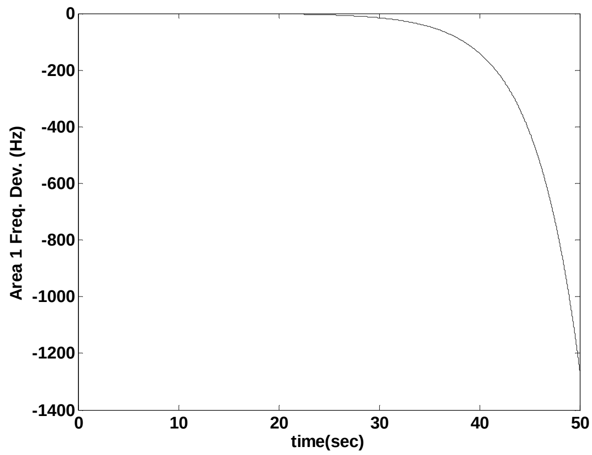


**Fig. 4. Frequency deviation of area 1 (with SSSC).**

In order to evaluate the disturbance attenuation performance of controller, a sudden step load of 0.01 p.u. MW is applied to area 1 at t=1.0 s. System parameters are given in Ref. [6]. The frequency deviation of each area is depicted in Figures 5-8 when SSSC is located in tie line 1-2 and tie line 1-3, respectively. Without control of the SSSC, the fluctuations of frequency deviations in all areas are large with poor damping. After the inclusion of both controllers, frequency oscillations in all areas are effectively stabilized. Especially, the peak value of frequency deviation in the controlled area 1 is significantly suppressed. In addition, the oscillating shapes are also stabilized completely. Meanwhile, steady-state errors of frequency deviations are eliminated slowly due to the effects of the governors.

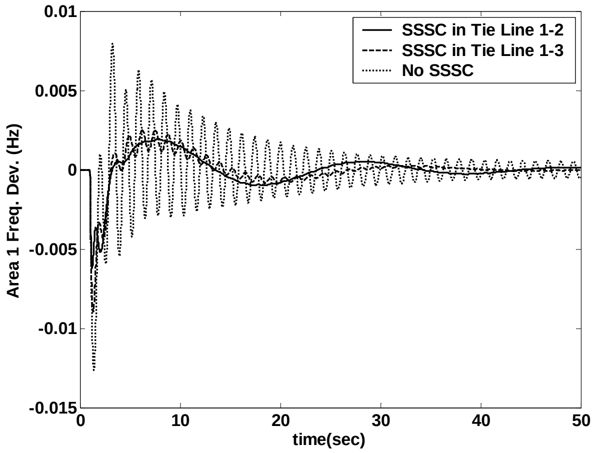


**Fig. 5. Frequency deviation of area 1 due to a sudden step load in area 1.**

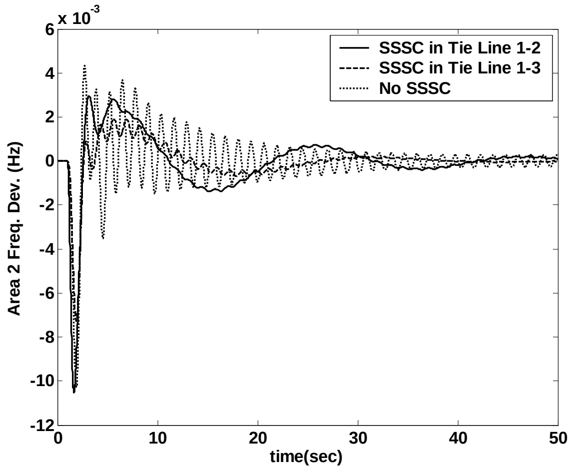


**Fig. 6. Frequency deviation of area 2 due to a sudden step load in area 1.**

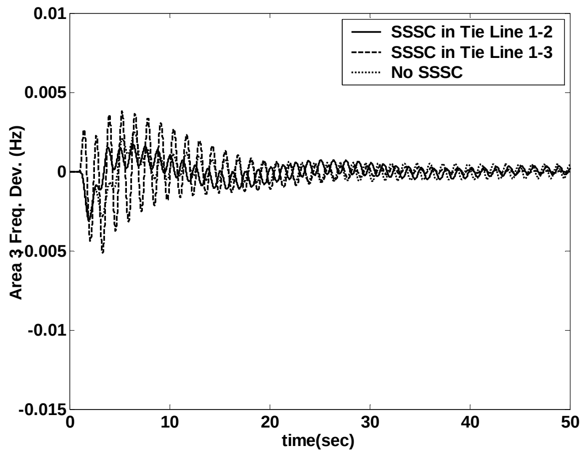


**Fig. 7. Frequency deviation of area 3 due to a sudden step load in area 1.**

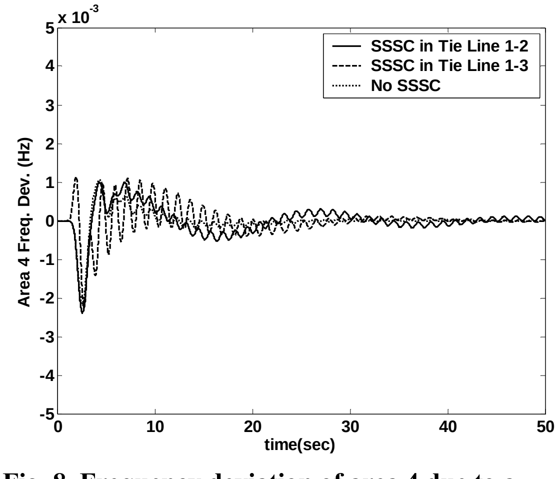


**Fig. 8. Frequency deviation of area 4 due to a sudden step load in area 1.**

Furthermore, the tie line 1-2 power deviation and the tie line 1-3 power deviation illustrated in Figures 9-10 are also effectively stabilized by SSSC. As shown in Figure 11, the maximum injected power deviation of SSSC is 0.0058 and 0.0062 p.u. MW.

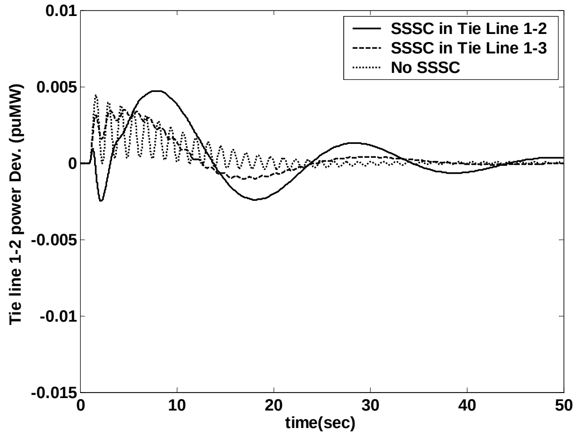


**Fig. 9. Tie line 1-2 power deviation due to a sudden step load in area 1.**

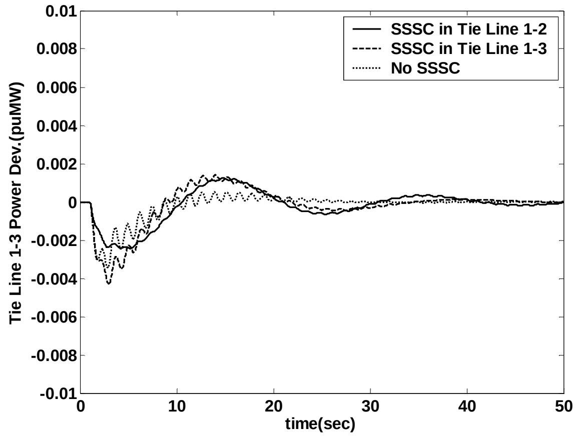


**Fig. 10. Tie line 1-3 power deviation due to a sudden step load in area 1.**

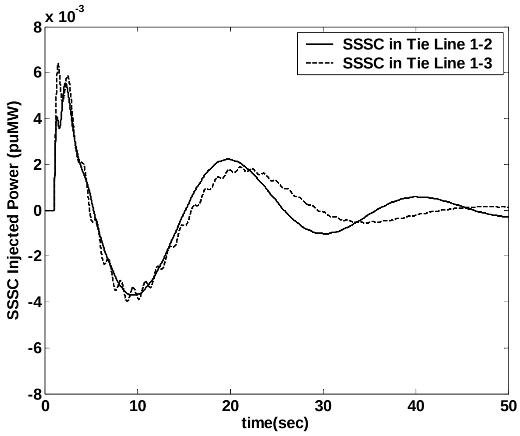


**Fig. 11. Injected power deviation of SSSC.**

Here, the robustness of each designed controller is evaluated. A random load disturbance composed of several oscillation frequencies is applied to area 1. $\Delta P_{L1} = 0.002\sin(3t) + 0.005\sin(6t) + 0.007\sin(9t)$. At the same time, the damping coefficient in area 1 ($D_1$) is changed from 0.006 p.u. MW/Hz (positive damping) to -0.8 p.u. MW/Hz (negative damping). As clearly illustrated by the area 1 frequency oscillations in Figure 12, the system completely loses stability in case of no SSSC. On the other hand, the Robust SSSC explicitly maintains its performance against large uncertainties and severe perturbations. Frequency oscillations in area 1 and other areas are perfectly stabilized. The efficiency of the Robust SSSC is evident in Figure 13, where SSSC is located in the tie line 1-2 and tie line 1-3.

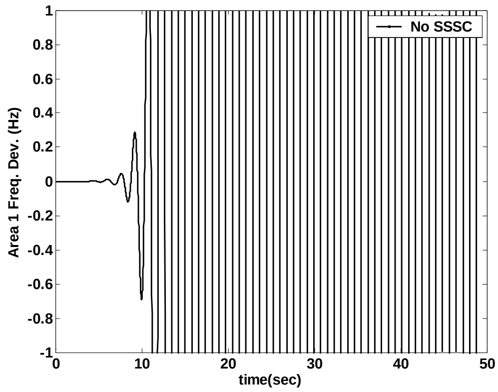


**Fig. 12. Frequency deviation of area 1 due to several frequency oscillations.**

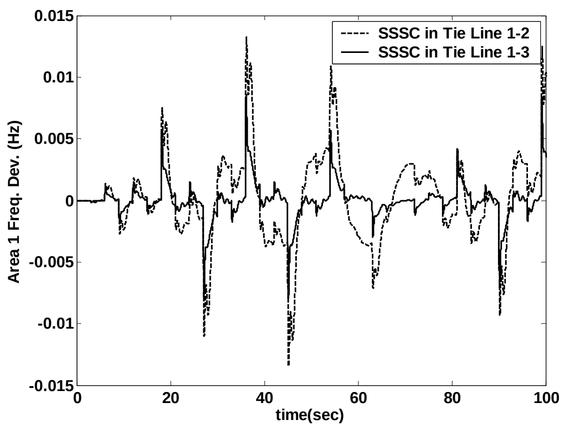


**Fig. 13. Frequency deviation of area 1 due to several frequency oscillations.**

## 5. Conclusion

In this paper, a design of the lead/lag controller equipped with the SSSC for stabilization of frequency oscillations in an interconnected power system is used while SSSC is located in two different areas. Time domain simulations using the system model are performed to confirm that lead/lag SSSC based controller can suppress oscillations successfully. The technique of overlapping decompositions is applied to reduce the order of the study power system; meanwhile the physical characteristic is still preserved. Here the designed controller uses only the frequency deviation of the controlled area as the feedback-input signal. Simulation study exhibits the significant effect of designed controller on the study four area interconnected power system under different load disturbances and variation of system parameters. It is observed that in some condition the performance of SSSC in tie line 1-3 is better than SSSC in tie line 1-2, although the area 2 has large control capability enough to spare for other areas. Results denote the parameters of each area have significantly effect on performance of SSSC.

## Appendix A

$M_i$ : inertia constant (p.u. MW s/Hz) of area i
$D_i$ : damping coefficient (p.u.MW/Hz) of area i
$T_{ti}$ : turbine time constant of area i
$T_{gi}$ : governor time constant of area i
$R_i$ : regulation ratio (Hz/p.u. MW)
$B_i$ : bias coefficient (p.u. MW/Hz)
$K_{ii}$: integral gain (1/s)
$T_{ij}$ : Synchronizing coefficient (p.u. MW/rad) between areas i and j
$a_{ij}$ : area capacity ratio between areas i and j
$T_{SSSC}$ : time constant of SSSC

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**Statik sinxron series kompensatorlar əsasında çoxzonalı energetik sistemlərdə tezlik ossilyasiyalarını stabilləşdirən nəzarət sistemi**


**Каземи А., Амини А.**



Məqalədə çoxzonalı energetik sistemlərdə tezlik ossilyasiyalarını stabilləşdirmək üçün statik sinxron series kompensatorun tətbiq olunması təklif edilmişdir.


**Контроллер для стабилизации частотных осцилляций в многозонных энергетических системах на основе статических синхронных сериесных компенсаторов**


**Каземи А., Амини А.**



В статье предложено новое применение Статического Синхронного Сериесного Компенсатора для стабилизации частотных осцилляций в многозонных энергетических системах