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FAULT-TOLERANT DAMPING CONTROL OF HVDC IN SMART GRID

Introduction

Fault-tolerant damping controller is used to supress the low frequency oscillation occurred in power system and it has the ability to maintain performance on a sensor-fault or noise interference condition.

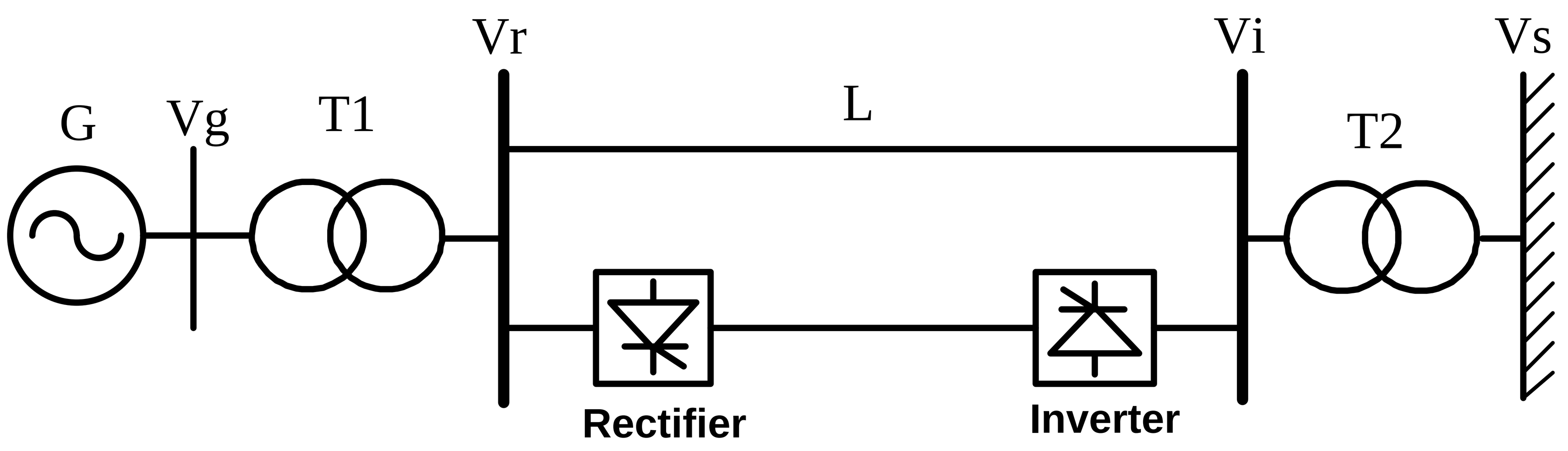


Figure 1 Single-machine infinite-bus AC/DC hybrid system

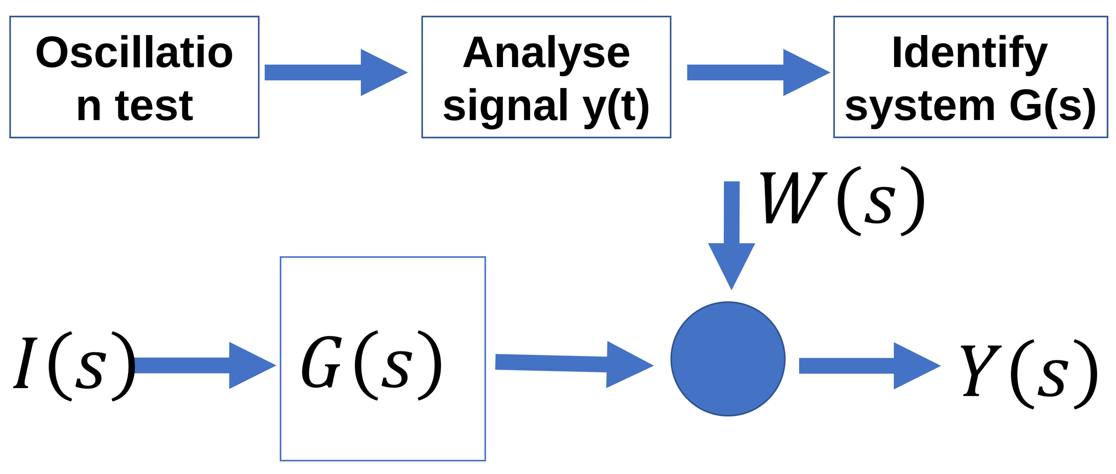
The proposed fault-damping controller is installed at rectifier station of HVDC system.

Fault-tolerant damping controller

1. Oscillation analysis & system identification

The Prony's method is used to analyse the oscillation and identify the system parameters.

Prony's method could be used to extract the parameters by the given signal to a weighted exponential terms. After that, system transfer function could be determined.



$$Y(s) = I(s)G(s) + W(S)$$

Figure 2 Prony's method for Oscillation analysis and system identification

$$\hat{y}(n) = \sum_{i=1}^{p} b_i z_i^n$$

$$b_i = B_i \exp(j\theta_i)$$

$$z_i = \exp[(\alpha_i + j2\pi f_i)T]$$

$$G(s) = \sum_{i=1}^{n} \frac{R_i}{s-\lambda_i}$$

$$\lambda_i = (\alpha_i + j2\pi f_i)T$$

$$\frac{R_i - \lambda_i}{\lambda_i} = B_i \exp(j\theta_i)$$

2. Damping controller

Based on classic phase compensation, the lead-lag blocks are used in order to move the poles to the left half of the complex plane to improve the system stability.

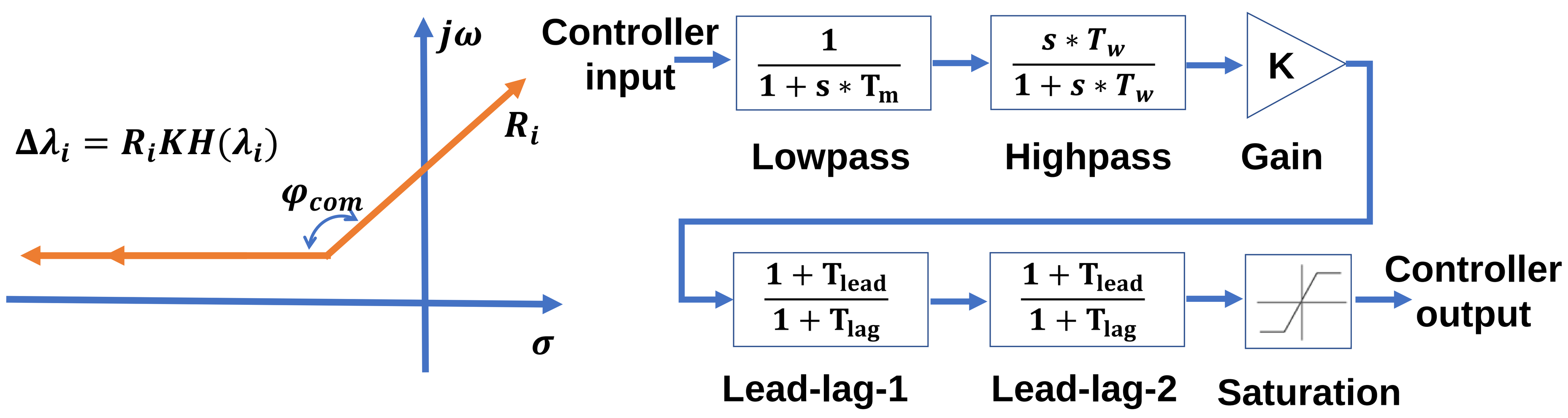


Figure 3 Concept of phase compensation [2]

3. Fault-tolerant controller

Federal Kalman filter is used to designed the fault-tolerant controller. The local Kalman filters provides the covariances between the measurements and the predicted values. The higher covariance, the lower reliability of the signal and the lower contribution of result from that local filter. The main filter is used to reconfigure the remote signal.

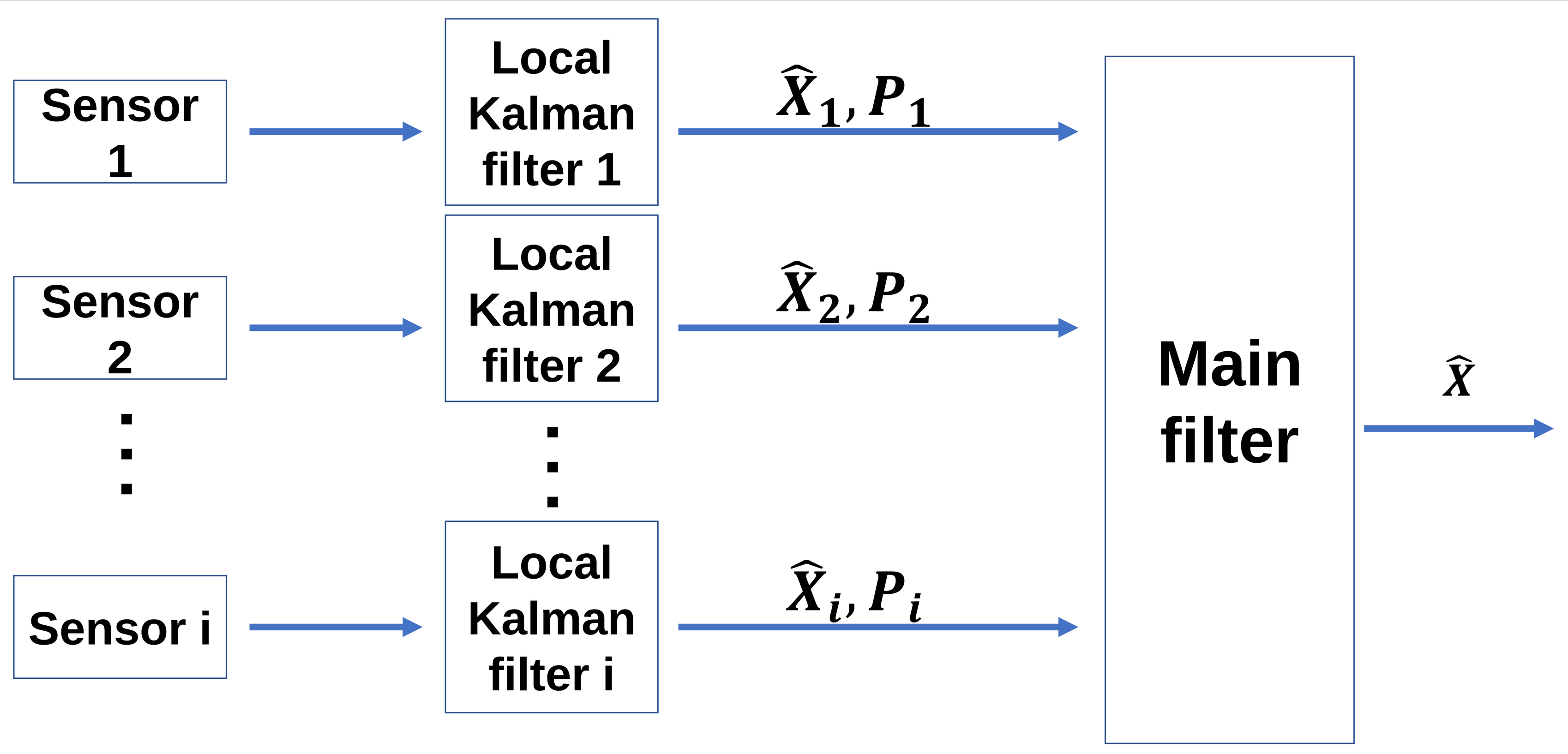


Figure 4 Federal Kalman filter

Simulation & results

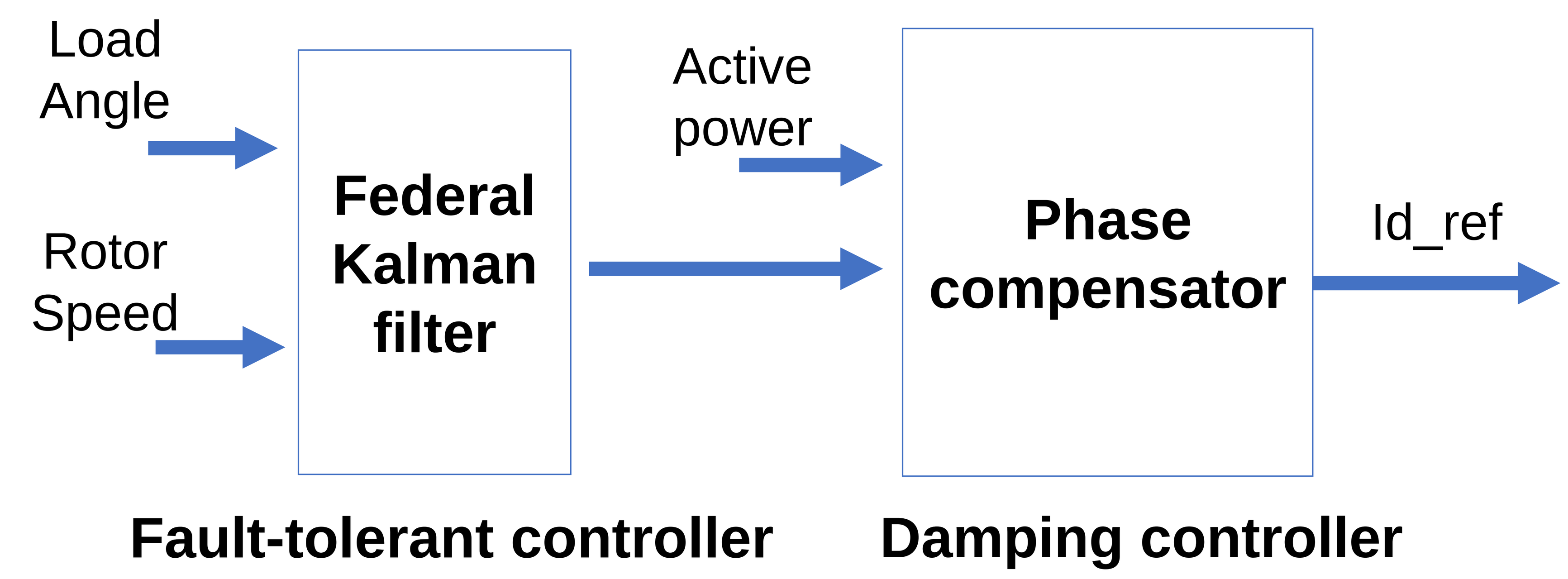


Figure 5 The structure of the proposed scheme

1. Case one

There is a grounding fault at 5 sec. as disturbance. The dynamic performances of system with/without supplementary damping controller are shown in figure 6.

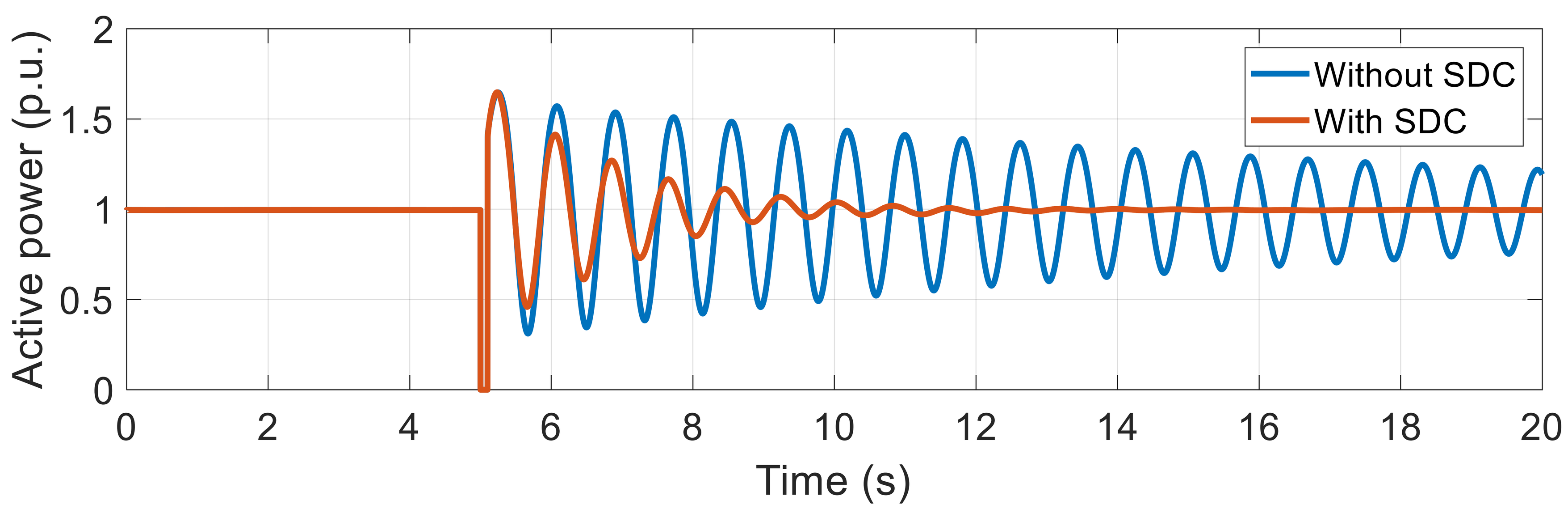


Figure 6 Active power oscillation with/without damping controller

2. Case two

There is a grounding fault at 5 sec as disturbance and the supplementary damping controller has been installed. There is noise interference Q(0,5) added to remote signal. The dynamic performances of system with/without fault-tolerant controller are shown in figure 7.

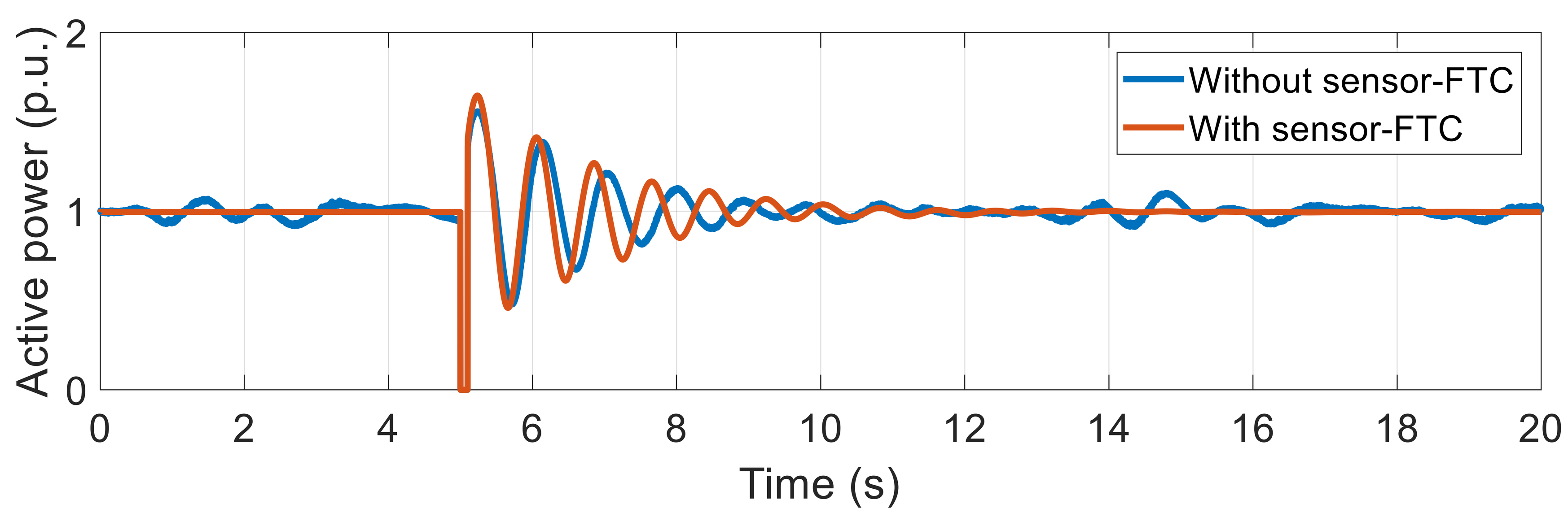


Figure 7 Active power oscillation with/without fault-tolerant controller on sensor fault condition

Conclusions

This project has proposed a fault tolerant damping controller for HVDC in order to supress low frequency oscillation even in a sensor fault condition.

- **Prony's method is used to analyse the oscillation and identify the system parameters.**
- **Phase compensation is used to design the damping controller. Through lead-lag blocks, the system poles are moved to the left half of the complex plane in order to improve the system stability.**
- **Federal Kalman filter is used to achieve fault-tolerant control, which is able to reconfigure the remote signal in an even of sensor fault.**

As shown in figure 6 and 7, the proposed scheme is able to supress the low frequency oscillation in a AC/DC hybrid system and its performance is kept in an even of noise interference.

Reference

[1] D.A. Pierre, D.J. Trudnowski and J.F. Hauer, "Identifying Linear Reduced-Order Models for Systems with Arbitrary Initial Conditions Using Prony Signal Analysis.", IEEE Transactions on Automatic Control, Vol. 37, No.6, 1992.

[2] Y. Li, et al. "Interconnected power system. ", Berlin Heidelberg: Springer-Verlag, DOI: 10.1007/978-3-662-48627-6, ISBN: 978-3-662-48625-2, 2016.