Development of a New Control Design Scheme Using Nonlinear Analysis
− PSS Parameter Design Effective for Suppression of Oscillatory Instability −

Background

Eigenanalysis, which is a type of linear analysis, has often been applied in design of generator control systems for improvement of power system stability. In such a control design, optimality for small disturbances can be achieved, however, we cannot exactly obtain optimality for large disturbances [1] where nonlinearity ha a significant influence.

Our institute has developed a new nonlinear analysis where we can consider the nonlinearity in regard to oscillatory instability [2]. There is a possibility of increasing power transfer limit by improvement of oscillation stability applying the nonlinear analysis to the design of generator control system.

Objectives

To develop a new design scheme of generator control system effective for suppression of oscillatory instability using nonlinear analysis and to verify its effectiveness;

Principal Results

1. Development a new design scheme of generator control system

We developed a design scheme of generator control system based on our nonlinear analysis where oscillation stability can be improved. The outline of the control design scheme is as follows and we can decide efficiently parameters of generator control system using it.

(1) Basic concept: In order to increase power transfer limit, we perform a design where stability for large disturbances can be improved. However, when we perform such a design, damping for small disturbances decreases in comparison with the conventional control design based on the eigenanalysis where the optimality for small disturbances is achieved. Therefore we retain the damping for small disturbances in the allowable range (Fig.1).

(2) Methodology: We start with the parameters obtained by the conventional control design. We adjust the parameters so as to increase a stability index for large disturbances obtained by our nonlinear analysis (Fig.2). The stability index means amplitude of oscillation in marginally stable cases.

2. Verification of the effectiveness of the developed control design scheme

We applied the developed control design scheme to PSS (Power System Stabilizer) parameter design in IEEJ 10-machine System Model. The result shows that the power transfer limit for a large disturbance near the generator increases by about 8 % maximum in comparison with the conventional control design.

Future Developments

We will verify the effectiveness of the developed control design scheme in a full-scale power system model.

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Reference

H. Amano and T. Inoue, 2006, "Development of a New Control Design Scheme Using Nonlinear Analysis - PSS Parameter Design Effective for Suppression of Oscillatory Instability - ", CRIEPI Report R05003 (in Japanese)

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[1]： small disturbance and large disturbance; a small disturbance means a slow load variation or an ordinary system operation and so on; a large disturbance means ground fault or short circuit and so on.

[2]： H. Amano, T. Kumano, and T. Inoue: "Application of Nonlinear Stability Indices of Power Swing Oscillation to Analysis of Autoparametric Resonance in Longitudinal Power Systems", T. IEE Japan, Vol.125-B, No.7, pp.663-670 (2005-7) (in Japanese) . It is possible that an oscillatory instability occurs for a large disturbance due to nonlinearity although stability for small disturbances is ensured. In such a case we can analytically estimate amplitude of oscillation in marginally stable case by the developed nonlinear analysis (Fig.1).
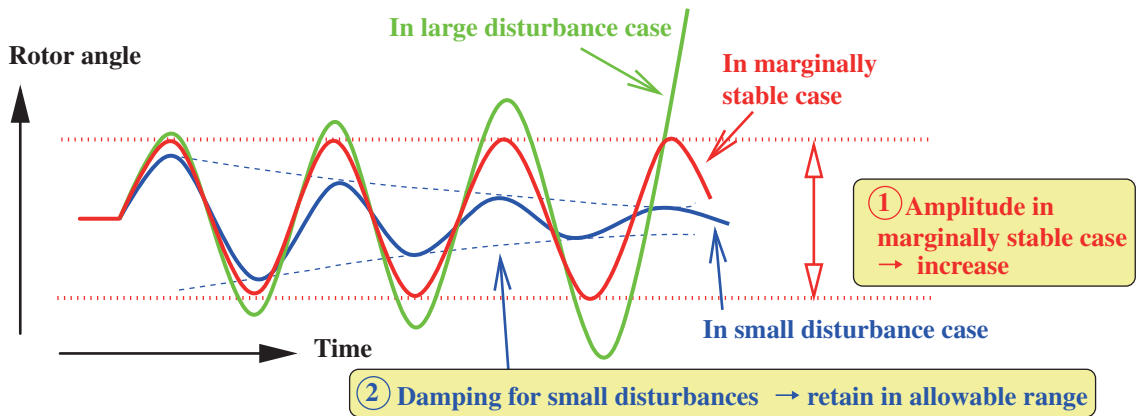
Fig.1 Basic concept of developed control design scheme

① In order to improve stability for large disturbances, we suppress oscillatory instability by increasing amplitude of oscillation in marginally stable case.
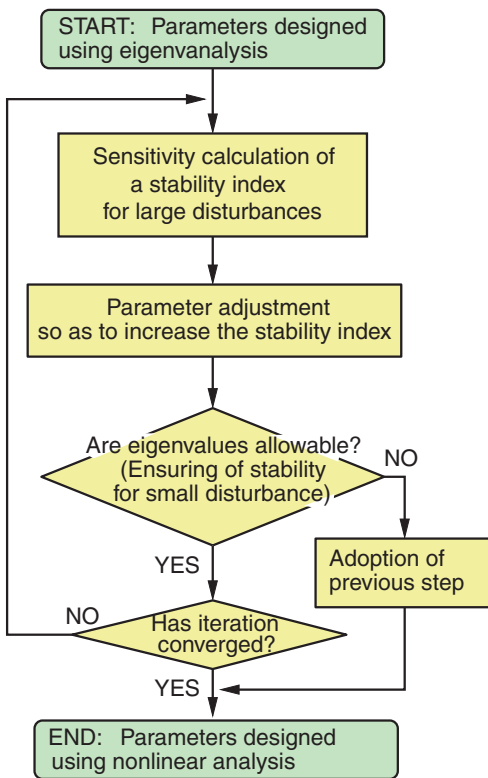

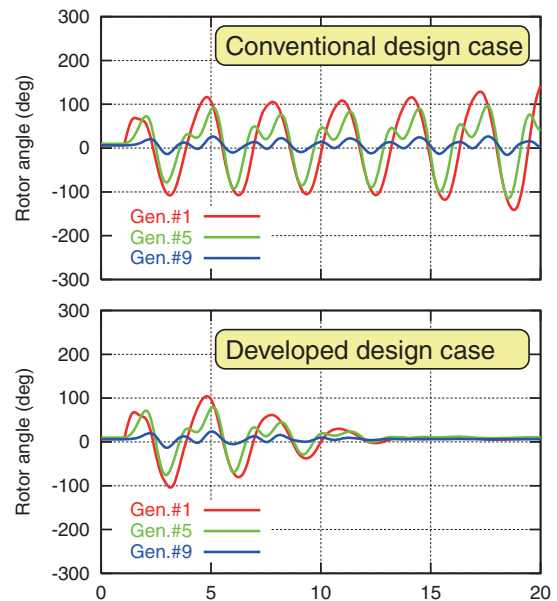**Fig.2** Flow chart of developed method

Fig.3 Example of time-domain simulation result

Although an oscillatory instability occurs in the conventional design case, it can be suppressed in the developed design case.

Table 1 Increase effect of power transfer limit by developed method

	Generator which we applied the developed method	Increase effect
West 10-machine system	Gen. #10	+3%
	Gen. #10	+2%
East 10-machine system	Gen. #10	+8%