Principal Research Results

Assignment of LFC Regulation Capacity Considering Generator Dynamic Response
− Proposal of Control Logic for more use of LFC Generators with Long Time Delay in Output Power Response −

Background

LFC (Load Frequency Control) is an essential control scheme for maintaining the electric power system frequency to its target frequency (50Hz or 60Hz in Japan). In LFC, regulation capacity necessary for frequency control is assigned to on-line LFC generators and LFC regulation demand signals are transmitted to the generators to regulate their output power in response to the electricity demand change. The control logic currently used in LFC system of the electric power companies is almost based on the conventional logic developed several decades ago. Then the control logic is not designed for assigning the regulation capacity to the generators with long time delay in output power response to change in LFC regulation demand signals. The long time delay is usually shown in the recently constructed generators with coal-fired boilers adopting the sliding pressure control. Consequently the use of generators with long time delay is limited in current LFC.

Objectives

To propose new control logic for assignment of LFC regulation capacity considering generator dynamic response and to verify the effectiveness of the proposal in use of the generators with the long time delay in output power response;

Principal Results

1. Feature of proposed control logic

The proposed control logic has the following features.

(1) Assignment of ACE (Area Control Error) ＊1

In LFC, the amount of generation regulation necessary for momentarily balancing the supply with the demand is called ACE. In the proposed logic, ACE is assigned to each generator or generator group corresponding to the degree of quickness of the dynamic response of the generator in output power change. That is to say, the slow component of ACE is assigned to the generators with long time delay, and the fast component is assigned to the generator with short time delay (Fig.1(a)).

(2) PID ＊2 control of each generator

PID control is adopted in making LFC regulation demand signals for each generator to obtain stability and speed of the generator output power change in response to change in the assigned ACE. The values of the control parameters are calculated considering the generator dynamic response and the calculated values are adjusted through numerical dynamic simulations (Fig.1(b)).

2. Verification of proposed control logic

The effectiveness of the proposed control logic has been verified through simple numerical dynamic simulations where two on-line LFC generators are assumed; one is a fast generator with short time delay (10sec.) and the other is a slow generator with long time delay (60 sec.). In the simulations, ratio of the regulation capacity assigned to the slow generator has been increased from 0.0 to 1.0. The simulation result reveals the effectiveness of the proposed control logic as follows.

(1) The ratio of the regulation capacity assigned to the slow generator can be expanded up to 0.6 without increase (deterioration) of ACE (Fig.2(a)).

(2) The standard deviation of the output power change of the fast generator can be decreased by 30% when the ratio of the regulation capacity assigned to the slow generator is 0.6 (Fig.2(b)).

As described above, the generator with long time delay can be utilized by using the proposed control logic, and this effectiveness reduces the mechanical burden of the conventionally utilized generator with short time delay.

Future Developments

The proposed control logic will be suggested to the electric power companies to put the proposal to practical use.

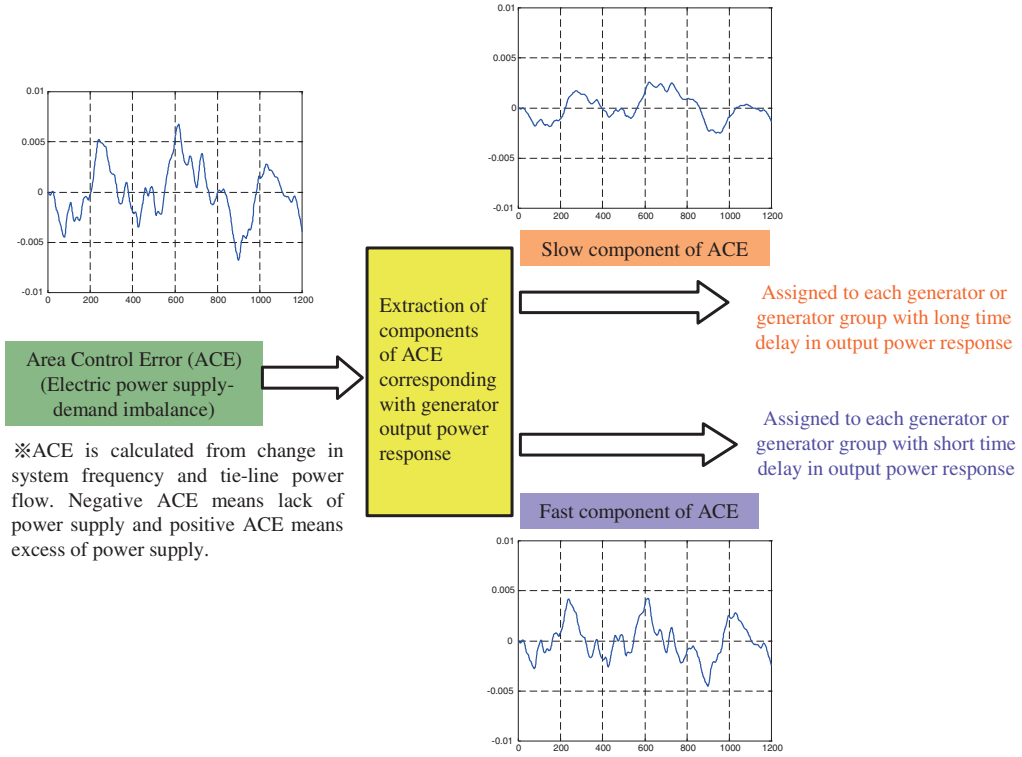
Main Researcher: Toshio Inoue,
Senior Research Scientist, Sector Leader, Electric Power Systems, System Engineering Research Laboratory

Reference

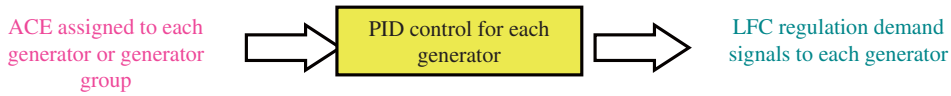
T. Inoue, et.al., 2006, “Assignment of LFC regulation capacity considering generator dynamic response - proposal of control logic for more use of LFC generators with long time delay in power output response - ”, CRIEPI Report R05021 (in Japanese)

＊1：Imbalance between the electric power supply and demand of the system concerned. Positive value means excess of the power supply and negetive value means lack of the power supply.

＊2：Control method which combines proportion action (P) , integration action (I) and derivative action (D).



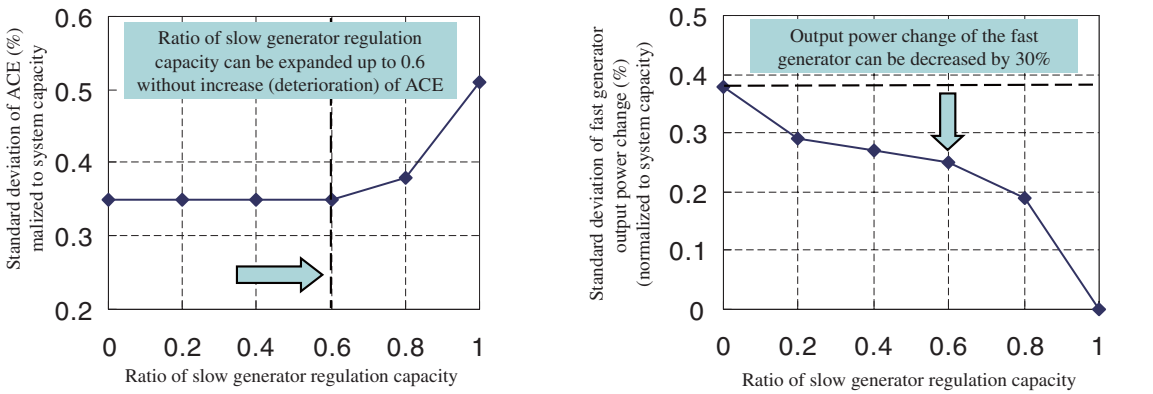
(a) Assignment of ACE (Area Control Error)



※PID control to obtain stability and promptitude of generator output power change

(b) PID control of each generator

Fig.1 Features of proposed control logic for LFC



(a) Increase (deterioration) of ACE

(b) Decrease of fast generator output power change

Summary of assumptions of numerical dynamic simulations
- Power system capacity: 10,000MW, power-frequency characteristic: 10%MW/Hz
- Standard deviation of system load change: 0.5%MW, LFC regulation capacity: ±1.6%MW
- Time delay of fast generator: 10 sec., Time delay of slow generator: 60 sec

Fig.2 Effectiveness of proposed control logic in use of slow generator with long time delay in output power response