# Power System Dynamic Simulation Method for Integrated Simulations of Active Power Control and Reactive Power Control
## — Development of a Computer Program for Dynamic Simulations of Electric Power Systems under Long-term Change in System Generations and Loads —

## Background

In the liberalization of electric power transaction, the active power will be treated separately from the reactive power. From viewpoint of the electric power supply security, however, it is necessary to consider the active and reactive power at one time. In addition, more severe operations of power systems will be requested from the need of more effective uses of existing power apparatus. In these situations, for technical studies on more proper operations of the active power control and the reactive power control, dynamic simulation method for integrated simulations of those controls becomes essential. However, conventional simulation methods for the active power control are not able to present behavior of the reactive power and voltage, and simulation methods for the reactive power control are not able to present behavior of the active power and frequency.

## Objectives

To develop a new power system dynamic simulation method for integrated simulations of the active power control and the reactive power control, and to demonstrate simulation performance of the developed method

## Principal Results

### 1. Features of developed method

A computer program for power system dynamic simulation method has been developed, which enables integrated simulations of the active power control and the reactive power control of power systems under the long-term change in power generations and loads. Summary of available simulation conditions and models of the developed program is shown in Table-1, and outline of structure of the program is shown in Figure-1. The features of the developed program are as follows:

1) A new numerical integration algorithm with variable time-step has been developed to achieve the high-accuracy and high-speed at the same time for the long-term simulations. The algorithm shortens the simulation time-step when fast phenomena such as the synchronous power swings occur.
2) The simplified models of the voltage/reactive control and the load frequency control can be comparatively easily replaced to the program user's inherent detailed models. This feature enables detailed simulations associated with needs of the user.

### 2. Performance of developed method

The results of application of the developed program to the IEEJ *1 EAST-30-generators test-power system shows that the power system dynamic behaviors under changes in the system generations and loads in the time frame of one-hour is simulated with around 1 to 2 minutes in CPU *2 time. The example of the simulations (Figure-2) shows dynamic responses of generator active powers, node voltages, system frequency and tie-line power flows, which cannot be simultaneously presented by the conventional simulation methods.

### 3. Expected application fields of developed method

The developed method is expected to be a new method for supporting technical studies on more delicate security control and more effective operation of power systems, including analysis of dynamic voltage stability, examination of proper generator regulation capacity for load frequency control and voltage control (Table-2).

## Future Developments

After enhancing the available simulation conditions and models, the developed method will be proposed to the electric power companies of Japan.

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***Reference***

T. Inoue, T. Kumano, "Power System Long-term Dynamic Simulation for Integrating Frequency/Active Power Control and Voltage/Reactive Power Control", CRIEPI Research Report No. T03046, April 2004 (in Japanese)

*1 : Institute of Electric Engineers of Japan
*2 : Intel Celeron 1.2GHz

**Table1** Available simulation conditions and models

| Simulation conditions and models | |
|---|---|
| Conditions | Change in system generations and loads |
| | On-line/off-line of generator |
| | Time series data of generations and loads |
| | Transmission line fault (3LG-O-C) |
| Models | Generator (detailed Park model) |
| (1) Generations | Generator AVR |
| | Generator OEL |
| | Generator prime mover (Fossil-fired plant) |
| (2) Loads | Induction motor |
| | Constant impedance |
| (3) System control | Simplified voltage/reactive power control |
| | Simplified load frequency control |

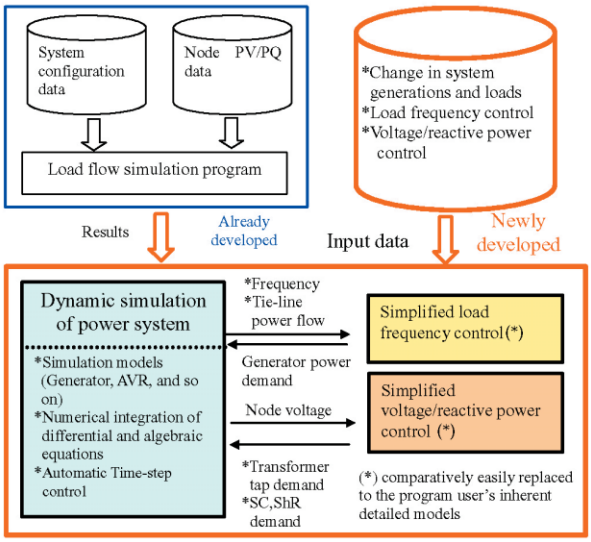
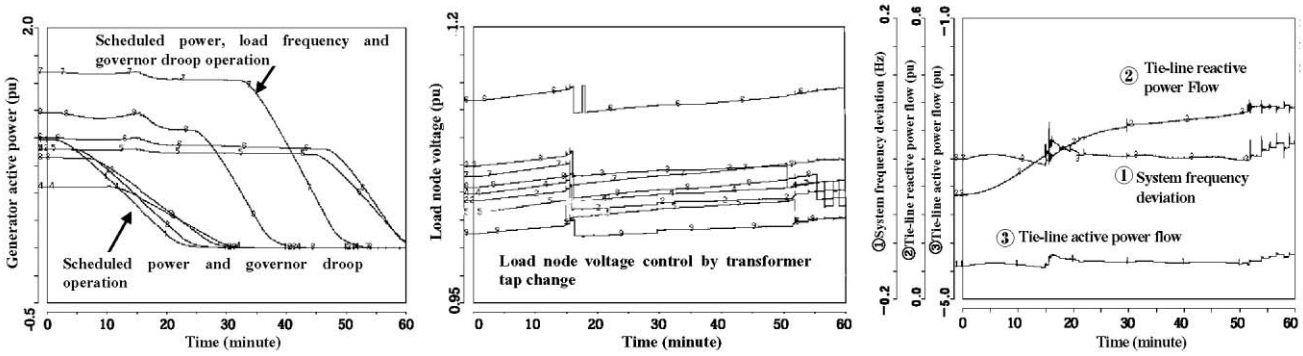



**Fig.1** Structure of developed method




(1) Regulation of generator active power (2) Load node voltage (3) Frequency and tie-line power flow

**Fig.2** Simulation results of dynamic behaviors of a test power system under system load decrease (example)
< IEEJ EAST-30-generators test-power system where 8 generators are operated in active power regulation >

**Table 2** Expected application fields of developed method

| Example of application fields | Advantage of developed method |
|---|---|
| Effective simulation of voltage stability including dynamic behaviors of generators and loads | Dynamic simulations of the voltage stability in rapid load increase period and so on can be implemented much faster than the conventional method. In the simulations, activation of the generator over-excitation limiter, and its ill effects upon the synchronous stability are included. |
| Technical studied on proper generator regulation capacity for load frequency control and voltage/reactive power control | Interaction between the generator active power regulation capacity for control of system frequency and tie-line power flow, and the reactive power regulation capacity for control of node voltages is able to be simulated. Thus technical studies on more effective generator regulation capacity and control scheme are available. |