EWSによる長時間系統特性解析プログラムの開発

発電プラント系の動特性と系統の周波数・電圧特性の解析

EWS based Development of a Program for Analyzing Long Term Power System Dynamics

Power plant dynamics, power system frequency and voltage analysis

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Major disturbances like a severe fault on tie lines in a radial power system may lead to severe frequency and voltage deviations which may last for several minutes. Such large deviations may further trip other facilities resulting in a power failure. In order to devise measures to handle such situations, a long term power system dynamic simulation tool is needed. We have, thus, developed such a tool which can perform long term dynamic simulation with better accuracy and numerical stability.

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放射状に構成された電力系統において、例えば連系線に重故障が発生した場合、周波数や電圧に数分間と言う比較的長い変動が生じ、この変動が大きい場合には結果として停電に至る可能性がある。このような状況に対する方策を考えるためには、数分〜時間オーダーの電力系統及び発電プラントの動特性を解析することが必要となる。そこで、より精度良くかつ数値的安定性に優れた長時間動特性シミュレーションツールを開発した。

1 Background & Objective

Major disturbances, consisting of a sequence of events, in a large interconnected power system or a severe fault on a tie line in a radial power system may result in islanding with the possibility of unbalance between the generation and loads and may lead to severe frequency and voltage deviations for the period of several minutes. To avoid power failures in such conditions, commonly used short term stability analyzing tools are not sufficient, so a long term power system dynamic program simulation tool is needed. It is, thus, the objective of this research to develop a program to analyze the long term power system dynamics considering the main components both on the power network side as well as on the power plant side. The program provides high flexibility for inclusion of user defined models for better accuracy with the help of user friendly MMI (Man Machine Interface).

2 Program Outlines

The general intent of a long term power system dynamics program is to analyze the effects of power system frequency and voltage excursions for longer periods of time taking into account the response of power plant models like boiler, turbine, governor, etc.
In realization of this program, the following three steps are repeatedly performed:

- Computation of system voltage and power unbalance : Uses load flow calculations considering all machines, frequency and voltage dependent loads, and machine's inertia constant to distribute unbalance power among machines.
- Computation of system average frequency: Inter-machine oscillations are omitted and all the machines are combined to represent a single equivalent machine in order to make swing all the machines with system average frequency.
- Computation of power plant dynamics : Employs detailed plant models including their controllers relating to each machine and uses the information of system average frequency and power values in the plant dynamics evaluation.

A simplified representation of model configuration is shown in Fig. 1, and the general flow chart depicting the main steps of the algorithm used for long term power

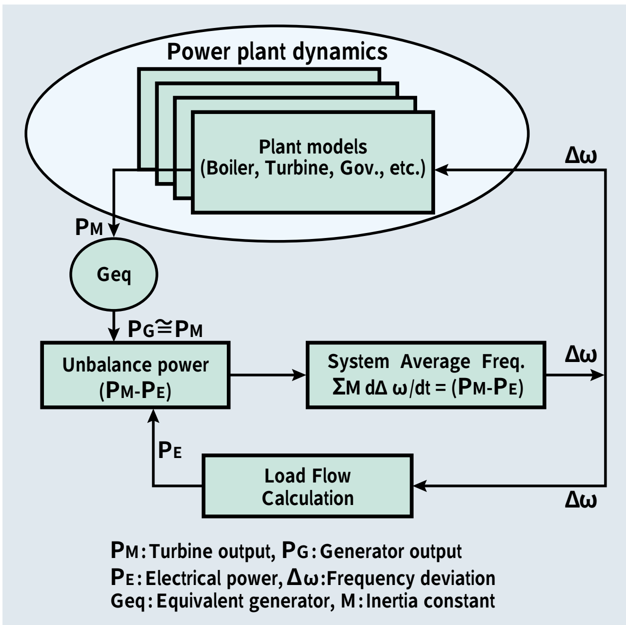


Fig.1 Configuration of models

system dynamics is shown in Fig. 2.

3 Program -Salient Features and Merits

- No limit on the system size, number of machines.
- Program can be used to check the functioning of various relays, real power balance controllers, reactive power balance controllers.
- Provision of MMI which allows the user to draw power system map and then to perform data input and output representation with the system map as a basis.
- Allows inclusion of user defined control schemes.
- Uses numerically stable implicit trapezoidal method to dynamic system equations and quadratic convergent Newton-Raphson to solve power network equations.

4 Simple Illustration of Program Functioning

A simplified model of a power system having 4 nodes and one generator is considered to be operating as an isolated power system at a 60 Hz. nominal frequency. All protective relays of a generator are made inactive and its mechanical power is considered to be controlled by a simplified governor model.

Two cases were considered; Case (i) Load L4 at node 4 is reduced to zero; Case (ii) Load L4 at node 4 is made two times the base load. For both cases, the load changes were effected at 0.2 seconds from the start of simulation. Fig. 3. shows the frequency deviation plots for these cases.

5 Future Plans

Next year, it is planned to use the developed program to investigate the functioning of SSC (System Stabilizer Controller) to cope with the frequency changes occurred in case of an isolated power system.

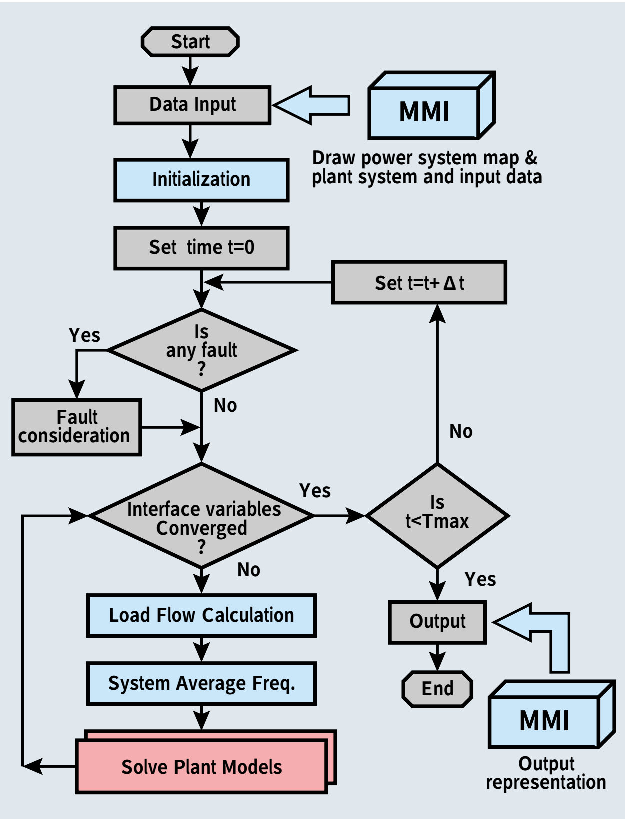
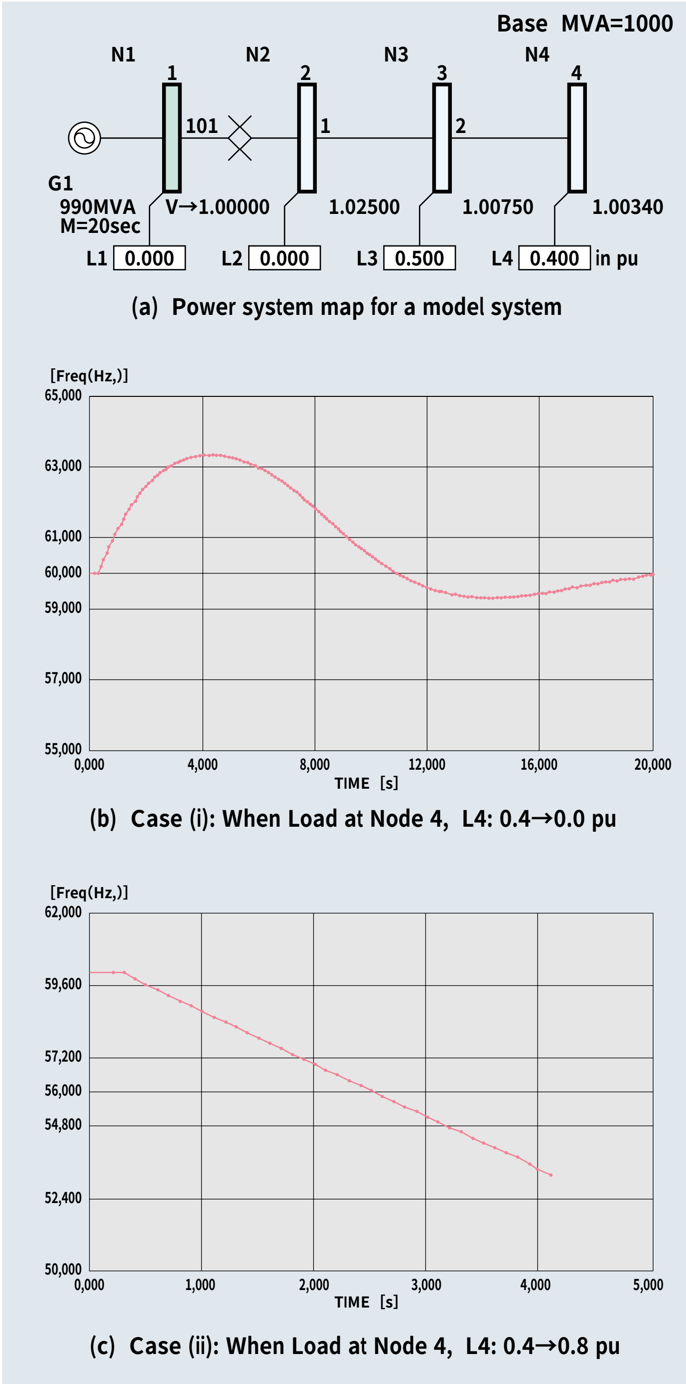


Fig.2 Flow Chart for Long Term Power System Dynamics



(a) Power system map for a model system

(b) Case (i): When Load at Node 4, L4: 0.4→0.0 pu

(c) Case (ii): When Load at Node 4, L4: 0.4→0.8 pu

Fig. 3.