Midfielder - powered by TEPCO IMPACT project

(IMPACT - Integrated and Multi-purpose of Advanced Computational Tools for power system engineering)

Abstract

This paper describes the new scheme to enhance data handling for reducing efforts on power system analysis. The power system is very large and having many apparatuses. To reduce efforts on power system analysis efforts, it is necessary to increase efficiency of data handling. However, conventional power system analysis application has complicated data format so that power system operator and/or planner are required wide experience. In the other hand, the many useful data-handling schemes can be provided by information technology (IT). In this paper, graphical user interface and database function are applied to data handling. These data-handling schemes are installed to integrated power system analysis package, named IMPACT.

Power Systems Analysis, Graphical User Interface, Database, Stability Analysis, Power Flow Calculation

1 Introduction

There are many power system analytical packages in the world. In historical reasons, the conventional power system analysis applications are coded by Fortran language so that analytical data must be expressed by complicated data format. The operators and planners are required wide experience.

For example, bus and branch ID code are necessary in defining power system data. The performance of power system network depends on network configuration. The power system analysts find out preferable network configuration changing all of bus switchgear statuses in a network. When changing bus status, analytical data must modify all of ID codes for human effort if using conventional power system analysis program.

This paper discusses new data handling scheme applying recent information technology (IT) to power system analysis. Integrated power system analysis package, named IMPACT, has been developed by the authors. IMPACT is abbreviated name of Integrated Multi-purpose Package of Advanced Computational Tools for power system engineering. Graphical user interface (GUI) and database function are applied to IMPACT to evaluate advantages of using IT for power system analysis.

In the paper (Tada, *et al.*, 2000). , the effectiveness of GUI has been reported. However, reported GUI is deployed all of data on the memory so that a large power system cannot be treated. Also, this scheme is not preferable for data sharing for all of analysts. This paper discusses the effectiveness of combining GUI and database, which has affinity with Internet.

2 IMPACT Project

IMPACT is developed by the authors to reduce human effort for power system analysis. Especially, realizing this purpose is important in de-regulated environment because the case to be analyzed would increase in this situation. As well-known, graphical user interface (GUI) is preferable to management of system data. IMPACT has powerful graphical user interface, named ModelGen. Fig.1 shows one of example ModelGen's window. The components of IMPACT are ModelGen, many advanced application, post-processing interface and useful utilities. Fig.2 shows composition of IMPACT.

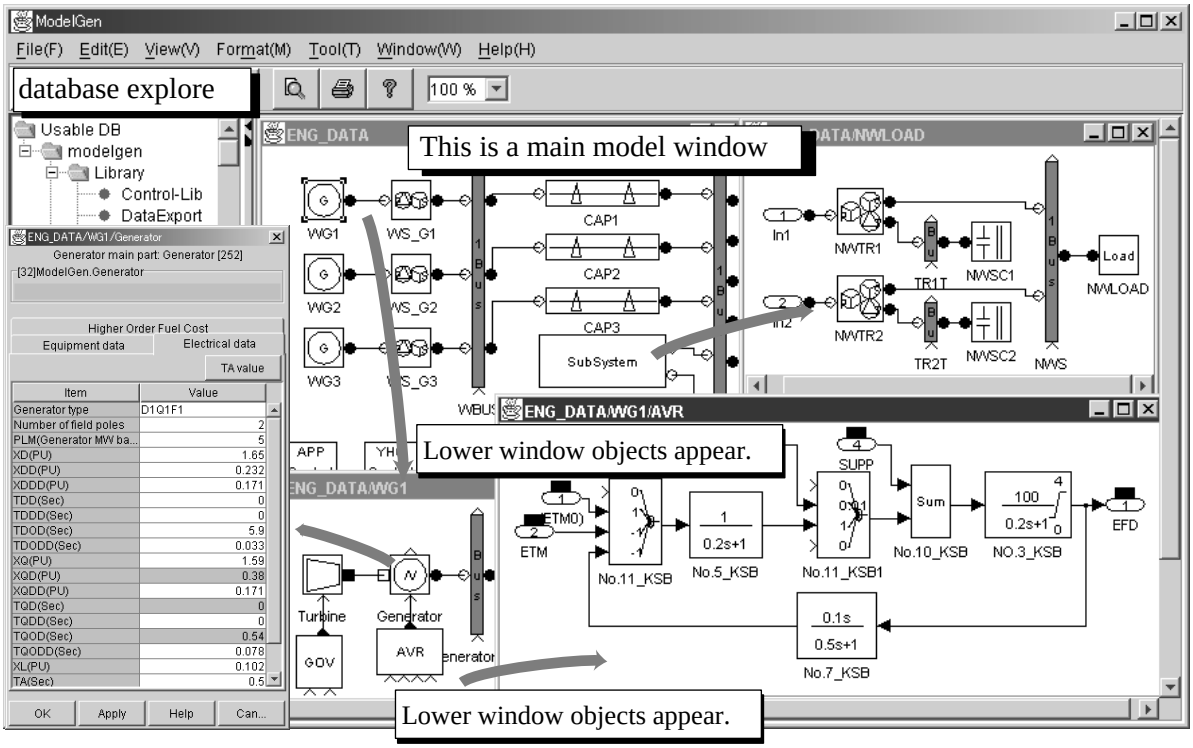

Figure 1: Example of ModelGen's Window

2.1 ModelGen

In IMPACT environment, all of power system analytical data is inputted by useful ModelGen interface.

In general, power system is so large that graphical window of personal computer is not enough to input whole power system data without contrivance. ModelGen employs sub-block concept. A sub-block is one of a child-window under the main one, and a containing data of sub-block is a one of the parts of whole system data. A power system data can group into small parts based on same geometrical region. Also, power network have hierarchical structure, for example, power station consist of generator, turbine and controller. Therefore, sub-block concept is a one of useful solution to input power system data using GUI. There are no constraints to create sub-blocks for any categorized subsets of data. A sub-block is appeared in main window only rectangle box so that drawing area is reduced. When double clicking sub-block, detail sub-block data appears and modifies any data. Sub-block can be defined recursively.

The window of ModelGen uses not only data inputting, but analytical results such as an initial power flow state can be displayed.

Bus Configuration The performance of power system network depends on network configuration strongly. The network configuration is decided by switchgear status of buses. In conventional power system analysis program, the user has to define logical bus ID to create node and branch data. The data maintenance needs large human effort. This job is very complicated and mistakable. Also, the mistake depended on this job is undiscoverable. In sum, the management of bus ID is not preferable for human job. The ModelGen can express any bus configuration such as single line diagram as shown in Fig. 3. Therefore, management of logical bus ID is not necessary by the user even if switchgear status of the bus would be changed.

Controller data The any controller data such AVR, Gov. and PSS can be also inputted by GUI as shown in lower-right of Fig. 1. IMPACT has controller parts library to arbitrarily express any controllers. Fig. 4 shows the parts of controller library window. Of cause, the controller data, which makes from arbitrary block parts and would be used frequently, can be put in a new user defined new library.

To design controller, CAD software like a Matlab/SIMULINK is very important. In IMPACT environment, inputted controller data from ModelGen can be converted to Matlab/SIMULINK (Release 12) file format. Using this function, frequency response of AVR would be able to easily apply Matlab/SIMULINK commands.

Data Converts From Testing Data to Analytical Data Some testing data of apparatus cannot use for analysis directly. For example, the data conversion is necessary by a user from testing data of three-winding transformer to three-branch analysis model data even though data conversion logic has already defined. This conversion is very messy and validation of analytical data is difficult. ModelGen support the automatic data conversion logic so that testing data can use in IMPACT

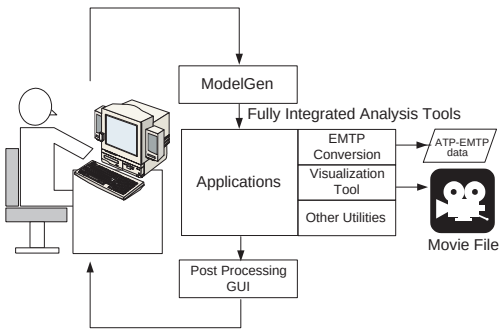

Figure 2: Outline of IMPACT

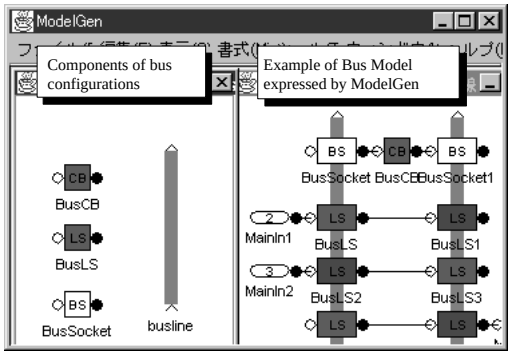

Figure 3: Bus Configuration Window

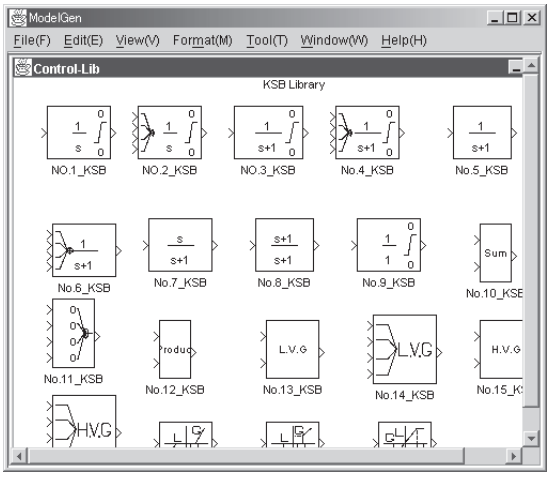

Figure 4: Example of ModelGen's Window

environment directly.

2.2 Applications of IMPACT

As described above, IMPACT includes many useful applications, as shown in Fig5. Since all of the applications have advanced and important functions to evaluate power system, which is essential to planning or operation of the system, we can find more value in combination of them. In this section, each application shall be introduced.

The important point to note is that we should just prepare the ModelGen data to run all the applications, because ModelGen automatically convert the data for each application. In this way, multidirectional analysis is achieved with ease. (All of IMPACT applications allow 300 generators, 3000 nodes, and 5000 branches.)

APP Advanced Power flow Program - APP is a tool for calculating power flow of a system. It contains advanced facilities such as voltage sensibility analysis of power system in steady state, or P-V curve drawer. These are available for verification of voltage stability.

VTS VTS is the abbreviation for Variable Time-step Simulation program. It is a tool for analyzing power system phenomena at time scale of several seconds or minutes, which is used to validate its stability or performance of controller such as speed governor or PSS. It should be

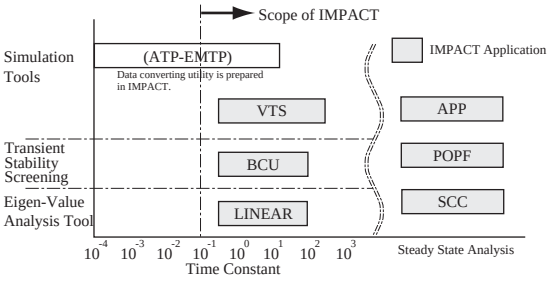

Figure 5: Target Region of IMPACT Applications

noted that VTS could automatically change simulation time step during the simulation. Therefore calculation time is efficiently reduced. It applies r.m.s. value.

BCU Boundary of stability-region-based Controlling Unstable equilibrium point - BCU is a screening tool for transient stability analysis. It screens out unstable cases from assumed contingencies without time-domain simulation. By use of this, simulation time we spent for contingency study in planning or operating stage could be reduced to 10% approximately (Chiang, *et.al*, 1995; (Tada *et.al*, 2002).

LINEAR Linearization and Eigen-Analysis Recipes - LINEAR is a tool for calculating eigen values, which linearize dynamic parameters in a power system. It helps you to design a control system such as PSS, to accomplish desirable small-signal stability.

POPF Optimal Power Flow program - POPF provides optimal operating conditions of equipments in a power system, with respect to fuel cost, transmission losses, injected reactive power, or combination of them. It helps power system operator, and is also available for presuming power system condition where some operating parameters are unknown, for instance in the planning stage. This application applies MINOS, which is an optimization tool developed by Systems optimization laboratory department of operations research, Stanford University.

SCC Short Circuit Current calculation program - SCC calculates short circuit currents for a single-phase fault and three phase fault, which could be a critical factor of network planning or operating. In addition, feasible reconfigurations can be checked to reduce short circuit current.

ATP-EMTP data conversion In the same way, the ModelGen data can be converted for ATP-EMTP, which is probably one of the most reliable simulation tools to analyze electro-magnetic phenomena in the world. By use of the function, it is easy to compare instantaneous value analysis and r.m.s. value analysis, though generally it causes considerable manpower. The key technique of realizing this utility is that ModelGen converts controller data to TACS code of ATP-EMTP. This converting function is valuable to everyone who makes use of ATP-EMTP or intends to use it.

2.3 Numerical Example

To discuss effectiveness of IMPACT, this paper prepares simple model system shown in Fig. 6. The most important characteristic of model data is existence of series capacitor. The turbine model of GEN1 has three-mass system. The condition of sub-synchronous resonance (SSR) is satisfied.

Single-mass Model Case The detail mass system is not preferable to analyze transient stability. The ModelGen can convert detail mass data to equivalent single-mass data Fig. 7 (a) shows simulation result of VTS, then this result mean r.m.s. value analysis result. Fig. 7 (b) shows ATP-EMTP result. The ATP-EMTP data converting utility is used to create ATP-EMTP data from GUI data so that data-handling task does not consume time. Each results almost same even though simulation methods are different. The centralization of data handling is very important to

maintain adequacy of analytical results without increase human effort.

three-mass model case Using detail mass model, SSR phenomena can analyze in IMPACT environment with ATP-EMTP shown in Fig.8. In common way for analyzing SSR, many complicated data conversion is necessary. However, in IMPACT environment, additional task for this calculation from transient stability study is not necessary because data specification is well defined and irregular data is not immixed by the ModelGen interface. The integrated data handling has much possibility to reduce power system analysis efforts.

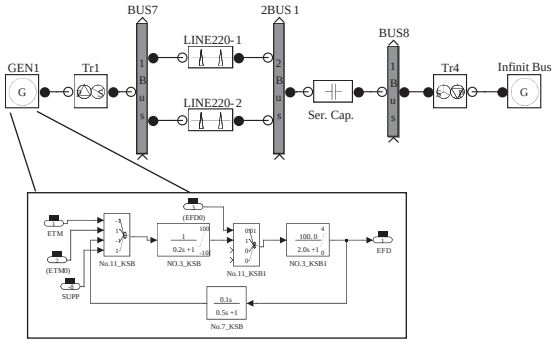

Figure 6: A Simple Model to Evaluate ATP-EMTP Data Conversion Function of IMPACT

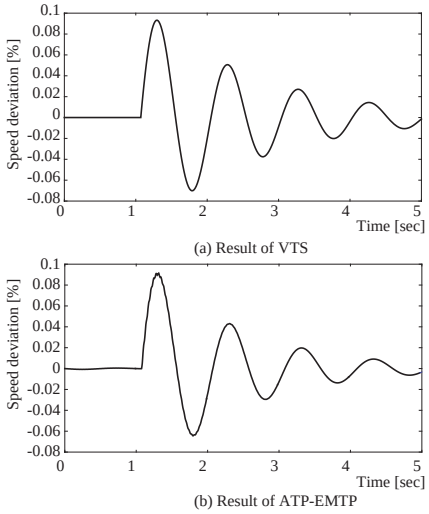

Figure 7: Calculation Results of VTS and ATP-EMTP with Single Mass Model

3 Database function of IMPACT

Although GUI is very useful and powerful, management of large power system data is impossible because GUI needs a lot of memory. In IMPACT, database function employs to solve this problem. The employed database system is PostgreSQL (http://www.postgresql.org/), which is a free software.

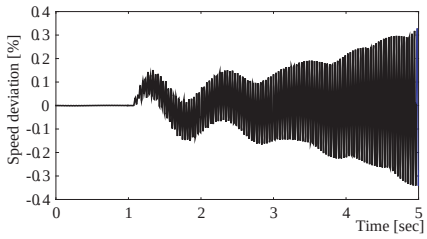

Figure 8: Calculation Result of ATP-EMTP with Three Mass Model

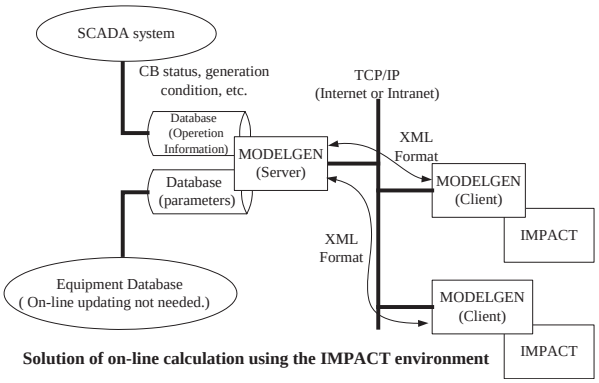

Figure 9: Example of ModelGen's Window

3.1 Basic function of database

Fig. 9 shows diagram of ModelGen database function. The basic functions are follows,

1. A very large power system data can be handled. The practical limitation with respect to size does not exist.
2. The database allows multi-user access same data via TCP/IP protocol. Therefore, data sharing is realized on Internet and/or Intranet environment.
3. Data transaction between server and client uses XML so that data handling flexibility very large.
4. ModelGen data base can be treated as apparatus database.

In general, the relationship between security of database and operationality is trade-off. ModelGen has original user authentication methods. ModelGen has only three access rights, which are administrator, power-user and user. When a user logs in ModelGen server, any user name is available and selects a right with correct password. In this method, user administration is not necessary, then operation of database is very easy.

3.2 Optional Data Handling Function

GUI is very convenient, but mouse operation becomes one of onerous task for a power user. Additionally, a synoptic table of same apparatus is useful but data inputting dialogue of ModelGen cannot express that one. To solve these problems, the ModelGen prepares a function, which CSV file format data outputs for synoptic table and also is inputted to database table directly.

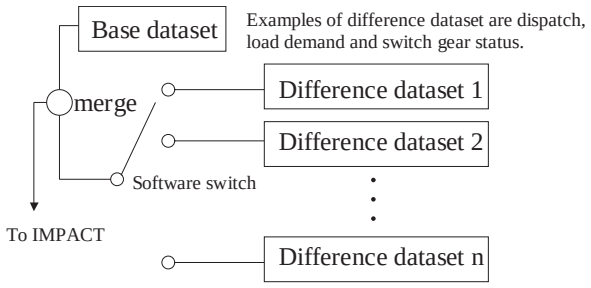

Figure 10: Example of ModelGen's Window

3.3 Management of Difference Data

In power system engineering, comparison of the performance in some cases, which are different from only a few parameters, is important. Conventional analytical system, even though difference data is little, many whole analytical data are prepared. The database of IMPACT is able to manage difference datasets efficiently shown as Fig.10. The importance of this function may be increase in de-regulated environment because parameter study case must be increase in the environment.

4 Conclusions

This paper discusses importance of data handling of large power system for power system analysis. Several solutions to enhance data handling are proposed. The effectiveness and disadvantage of GUI to input whole power system data is discussed, then this paper pointed out improving method of data handling based on GUI. Also, necessity of database for data handling large power system

The task for the future to improve IMPACT system is follows,

1. Study for realizing to connect IMPACT environment to SCADA system
2. To use IMPACT environment for training simulator
3. To create a function that Matlab/SIMULINK data converting to ModelGen data
4. To create control language to manage all of IMAPCT functions for to reduce human effort for repeating calculation such a confirming N-1 criteria

To sum up the matter, the authors has a plan to establish IMPACT environment for all of power system analytical calculation interface.

References

Y. Tada, A. Kurita, M. Masuko, Y. Takahara, K. Koyanagi (2000), "Development of an Integrated Power System Analysis Package ", *IEEE PES. PowerCON 2000*, Dec. 2000, Perth Australia

H.D. Chiang, C.C. Chu and Gerry Cauley, " Direct Stability Analysis of Electric Power Systems Using Energy Functions: Theory, Applications and Perspective ", *Proceedings of the IEEE*, Vol. 83, No. 11, November, 1995, pp.1497-1529.

Y. Tada, A. Kurita, Y. Zhou, K. Koyanagi, H.D. Chiang, Y. Zheng (2002), " BCU-guided Time-Domain Method for Energy Margin Calculation to Improve BCU-DSA System ", IEEE/PES T&D Asia Pacific 2002, Oct. 2002, Yokohama Japan