Electromechanical-Electromagnetic Hybrid Simulation Based on E-Tran Plus

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Electromechanical-Electromagnetic Hybrid Simulation Based on E-Tran Plus

Yong Cui[1], Xiang-xiang He[2], Xiu Yang[2], Wei-hong Wang[1], Liang Cao[1], Ming-jie Jin[1]

[1]State Grid Shanghai Municipal Electric Power Company, Shanghai, China

[2]College of Electrical Engineering, Shanghai University of Electric Power, Shanghai, China

2252453936@qq.com

Abstract: The simulation software E-Tran Plus is used as the interface, and the mature software PSCAD and PSS/E are combined to form the electromechanical-electromagnetic hybrid simulation platform. The function and principle of the simulation software are introduced in detail, and a simple electromechanical-electromagnetic hybrid simulation and pure electromagnetic simulation research are compared through a small system. The theoretical and simulation results show that the electromechanical-electromagnetic hybrid simulation using the new software has higher accuracy. The hybrid simulation model based on E-Tran Plus can better reflect the dynamic characteristics of the AC system, and it is closer to the actual project, which provides an important reference value for the research of electromechanical-electromagnetic hybrid simulation of large-scale AC/DC grid.

1. Introduction

Depending on the time scale ， Common modeling methods are electromechanical transient modeling and electromagnetic transient modeling. For large-scale AC-DC power grid simulation, electromagnetic transient modeling is generally adopted. However, the pure electromagnetic transient modeling is simplified for the AC part of the large system by a voltage source and a resistor. The simple Thevenin model with the equivalent value cannot reflect the dynamic characteristics of the generator and governor. Therefore, it is inevitable that there will be some differences with the original system, resulting in inaccurate simulation modeling [1].

In recent years, some simulation softwares have been developed at home and abroad to conduct electromechanical-electromagnetic hybrid simulation research and analysis of AC and DC systems. The China Electric Power Research Institute took the lead in establishing a power system simulation software ADPSS to accurately simulate the dynamic response of the DC system and the interaction between AC and DC [2]. China Southern Power Grid Research Institute and North China Electric Power University have carried out RTDS-based real-time hybrid simulation of AC and DC power grids [3-4], and a new interface software TRI, which was recently released by PowerTech Labs in Canada. Hybrid simulation effectively solves the problem of power system global response and device local dynamic response parallel simulation. However, there is not much literature on the convenience of interface processing[5].

This paper details the functions of the new software E-Tran, E-Tran Plus and the combination of E-Tran and PSS/E and PSCAD to form the electromechanical-electromagnetic hybrid simulation.The interface software must be used for large hardware to solve the problem of electromechanical-

electromagnetic hybrid simulation interface.

2. Hybrid simulation with E-Ttran Plus interface

2.1 .Hybrid Simulation Principle and E-Tran Function Overview

Traditional electromagnetic transient simulation software can realize electromagnetic transient simulation, but it is difficult to realize large-scale AC-DC full-system hybrid network. E-Tran Plus can divide large-scale AC/DC network into two parts: electromagnetic transient model and electromechanical transient model. The DC network or the part with a small amount of communication is used as the detailed model of our research,which is used for the electromagnetic transient model[6-7]. The large-scale exchange part is not specifically studied using the electromechanical transient model, E-Tran Plus is used as interface software, achieving Electromechanical-electromagnetic hybrid simulation. Hybrid simulation can solve the problem that pure electromagnetic simulation can not establish multi-node model or the accuracy is not enough due to simplification, and can also make up for the shortcomings of pure electromechanical simulation that cannot be accurately simulated.

This simulation experiment uses the two functions of E-Tran software. One is to use the E-Tran translation function to start a pure PSS/E trend file, dynamic file, and steady state file, and run E-Tran to generate a pure electromagnetic simulation model in PSCAD. In the equivalent process, E-Tran software identifies the original network and replaces the generator, wires and load components with the originals independently set in the etran.plcx library to form a power network containing the specific originals. The second is E-Tran's accompanying software E-Tran Plus as a function of the interface software，We just need select the node boundary in PSS/E, input these nodes in E-Tran Plus, leave the AC system in PSS/E after running, and divide the DC system into PSCAD to form a set of electromechanical-electromagnetic hybrid simulation system. The advantage of the simulation program makes the simulation achieve high accuracy and high speed at the same time, which is impossible for any single simulation software.

2.2. The implementation principle of using E-tran Plus as interface software

Interface processing is one of the main cores of electromechanical electromagnetic hybrid simulation. The basic idea is to treat the electromechanical side and the electromagnetic side system separately. In the hybrid simulation, the system is divided into two parts: the electromechanical subsystem and the electromagnetic subsystem. Then, when processing the electromagnetic transient part, the transient part of the electromechanical side is subjected to the Thevenin equivalent process to form a voltage source and a resistor. When the electromechanical side is processed, the electromagnetic part is equivalent by Norton. After the electromechanical side and the electromagnetic side are processed, the E-Tran Plus interface software is needed to exchange data on both sides.

Two user-defined PSS/E models are called ETRCOM and INITA-D in the E-Tran Plus library. ETRCOM is the core interface model between PSSE and PSCAD emulators, which allows the exchange of power flow between two programs between each larger time step(In the development of this model, the general PSSE always has a large time step). The INITAD model is used to map IP addresses and establish connections between PSCAD and PSSE [6-7]. The main function of the hybrid simulation is to export the data from PSCAD to PSS/E and update the PSS/E internal array from PSCAD. As shown in Figure 1, the E-Tran Plus data signal transmission principle between PSS/E and PSCAD is clearly analyzed.

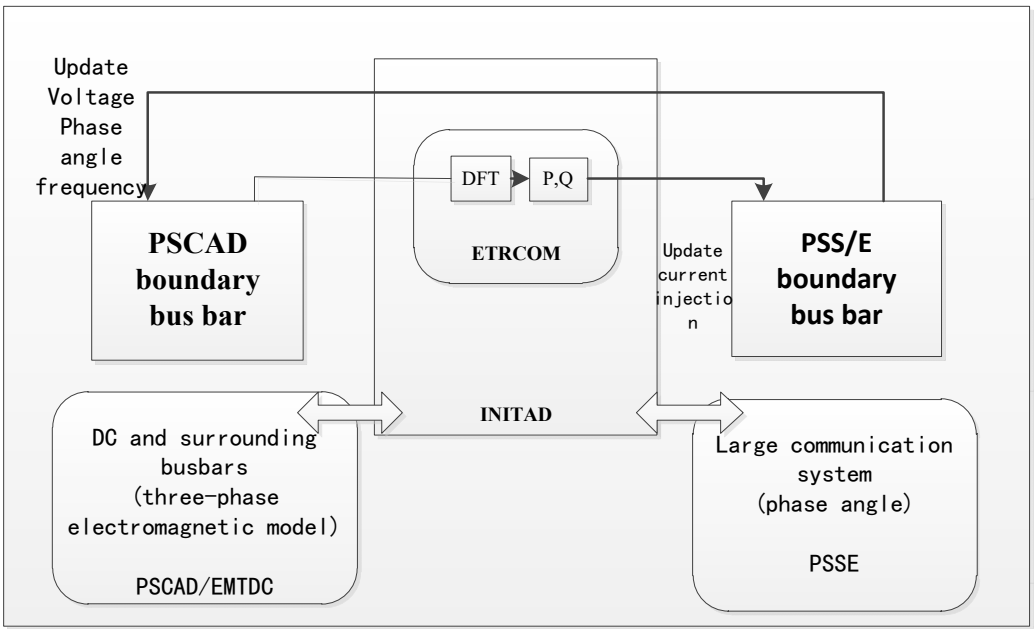

Figure 1. hybrid simulation architecture

The voltage amplitude, phase angle and frequency information from the PSSE simulation is sent to the PSCAD simulation, in which E-Tran Plus is used to update the equivalent voltage source(Equivalent diagonal of the system automatically created based on the power flow admittance matrix). On the other hand, the discrete sequence Fourier transform (DFT) is used to extract positive sequence active and reactive power from PSCAD simulation and send it to PSSE simulation. In this process, E-Tran Plus is used to update the generator model. The generator or power model is used as the current injection of the system admittance matrix in the PSS/E simulation, and the new voltage at the interface point is calculated by performing a power flow calculation.

3. Electromechanical-electromagnetic hybrid simulation modeling of AC and DC grid

It is analyzed by a simple system model with 6 generators and 14 nodes. The voltage of the rectifier side AC system is 212V and the rated voltage is 230V. The inverter side AC system voltage is 242V and the rated voltage is 230. In PSS/E Create trend files, stable files, dynamic files, and more.

3.1. Pure electromagnetic transient model

Based on PSS/E trend files, dynamic files, and steady-state files, run E-Tran to generate a pure electromagnetic simulation model in PSCAD, E-Tran identifies the original network, The independently arranged originals in the etran.plcx library replace the wires and the load originals to form a power network containing a specific original, The electromechanical part with the generator is equivalent by a combination of a voltage source and a resistor.

3.2. Electromechanical-electromagnetic hybrid model

We should Select several busbar nodes to form a boundary for a group of buses, divide the original network, and place the busbar end load with DC on the PSCAD end. The other large networks are all placed in the PSS/E. The channel formed by the PSCAD interface equalizes the power flow data to the PSCAD. The power flow data in the PSS/E is calculated by an ideal voltage source and an impedance. The effect circuit is displayed in the PSCAD interface to form an electromechanical-electromagnetic hybrid simulation platform. The E-Tran Plus automatically synchronizes the data in the PSS/E into the components of the PSCAD. The simulation starts with PSS/E and PSCAD running internally (the simulation sets the data exchange time to 1 second). After one second, the positive sequence active reactive power calculated in PSCAD is injected into the PSS/E through the above several ports (the port is the diagonal matrix formed by the LDU decomposition method), and the voltage and frequency in the

PSS/E are also passed through the port and the PSCAD. We just want to achieve the hybrid simulation required for this experiment.

4. Analysis of mixed simulation experiment results

Using PSCAD's own drawing function to realize real-time data information drawing, the following is a simulation experiment conducted by performing steady state, single-phase fault and three-phase fault on models A and B respectively.

In the steady state, the two models respectively set the simulation time of ten seconds, and measure the DC voltage and the arc extinction angle on the inverter side of the DC transmission line. The simulation graph is shown in Figure2-3:

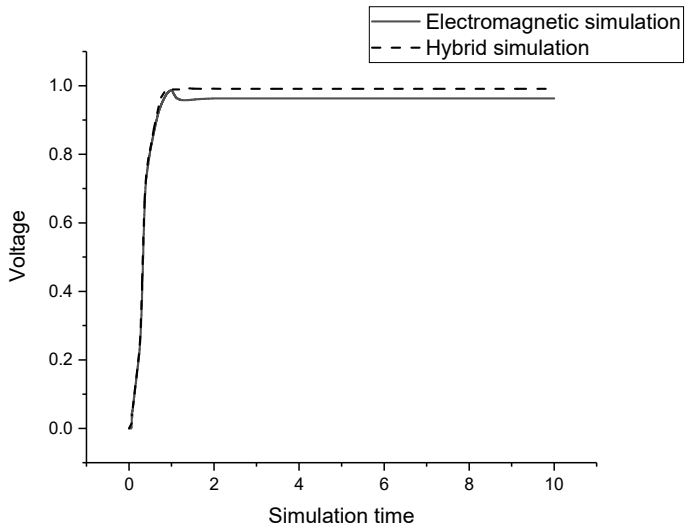

Figure 2. Pure electromagnetic simulation and hybrid simulation voltage at steady state

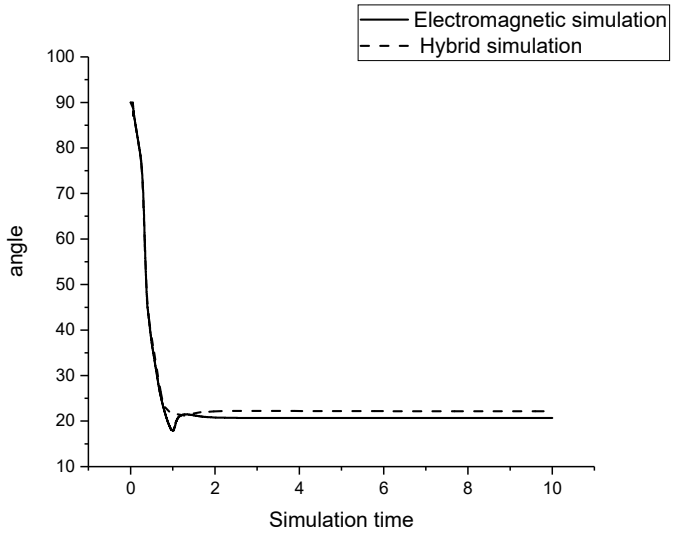

Figure 3. Pure electromagnetic simulation and mixed simulation arc extinction at steady state

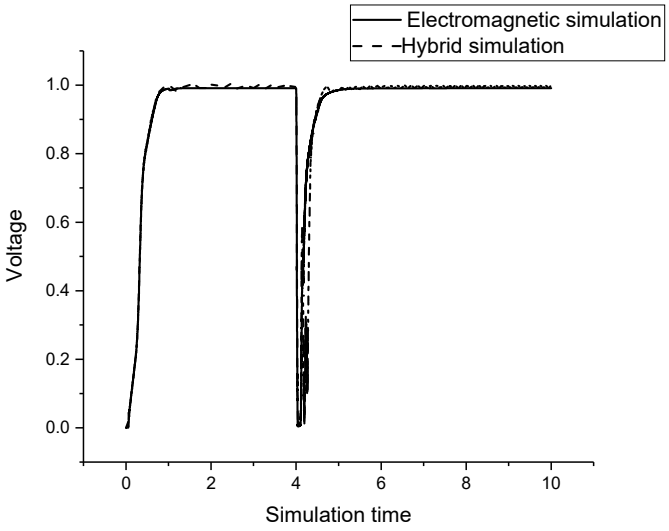

Figure 4. Pure electromagnetic simulation and hybrid simulation voltage for three-phase faults

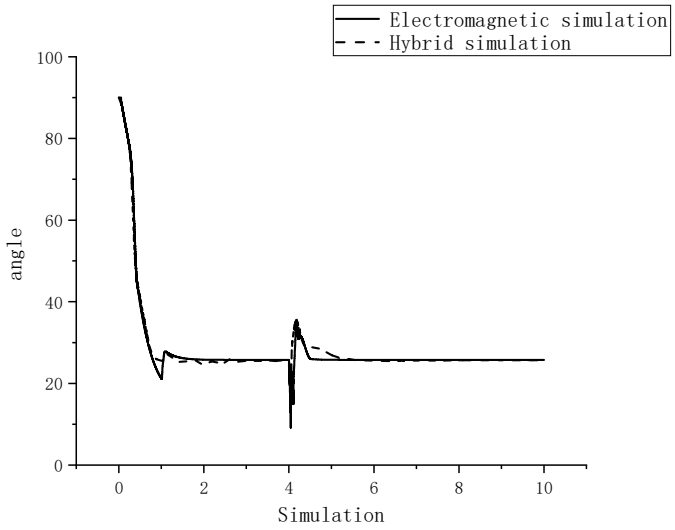

Figure 5. Pure electromagnetic simulation and mixed simulation arc-extinguishing angle under three-phase fault

The response of the hybrid simulation model during the fault is basically the same as that of the pure electromagnetic. The correctness of the hybrid simulation is verified again, and then the curve of the extinction angle of the recovery phase after the fault disappears is compared. the part of the pure electromagnetic transient AC system is equivalent to the system composed of the voltage source and the resistance, the hybrid simulation part is still the electromechanical transient simulation of the AC grid. It can be used to simulate the dynamic characteristics of the generator and governor on the AC side and the transient process is relatively slow. It is probably slower by 0.7s. Hybrid simulations have more precise characteristics than equivalent pure electromagnetic transient models.

5. Conclusion

This paper analyzes the principle of E-Tran Plus as electromechanical-electromagnetic hybrid simulation interface software, and verifies the correctness of electromechanical-electromagnetic hybrid simulation based on E-Tran Plus, and concludes that the hybrid simulation is large by comparison with pure electromagnetic experiments. And the simulation speed is fast and the simulation accuracy is high.

This provides an important reference value for the study of electromechanical-electromagnetic simulation and commutation failure of large-scale East China Power Grid.

Acknowledgement
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