

PAPER • OPEN ACCESS

A New Kind Of Fast Simulation Model for AC-DC Hybrid Power Grid

To cite this article: Junru Shan and Chongru Liu 2021 *J. Phys.: Conf. Ser.* **1754** 012074

View the [article online](#) for updates and enhancements.



ECS **240th ECS Meeting**
Digital Meeting, Oct 10-14, 2021
We are going fully digital!
Attendees register for free!
REGISTER NOW

The banner features a group of diverse professionals in a meeting setting, with a man in a white shirt and tie clapping and a woman in a grey patterned top looking at a tablet. The background is a blurred office environment.

A New Kind Of Fast Simulation Model for AC-DC Hybrid Power Grid

Junru Shan*, Chongru Liu

School of Electrical and Electronic Engineering, North China Electric Power University, China

Corresponding Author Email:1003434533@qq.com

Abstract. With the continuous operation of uhv AC-DC project in China, the system appears the problem of "strong direct current and weak direct current". With the increasingly significant influence between AC-DC and multi-DC, the power grid operation is accelerated rapidly, and higher requirements are proposed for the scale, accuracy and speed of power grid simulation. Through the use of power system modeling, multi-time scale simulation, digital-analog hybrid real-time simulation and other three aspects to summarize the status of simulation technology, and through the development of AC and DC power grid needs to analyze. It is pointed out that improving the modeling accuracy of complex models such as DC, new energy, FLEXIBLE AC transmission system and load, enlarging the electromagnetic transient simulation scale and improving the simulation efficiency of large-scale power grid will be the research emphases of improving the simulation capability of large-scale power grid.

1. Introduction

In order to meet the demand of resources, it has become a typical feature of the power grid to construct the power grid in the form of large-scale dc cross-regional power transmission and integrated AC/DC hybrid connection. The large-scale AC-DC hybrid brings profound changes to the characteristics of the power grid, and the ac-DC interaction and the interaction between the feed and receiving ends intensify, which puts forward higher requirements for the scale, accuracy and speed of power system simulation. To achieve high-precision simulation, accurate modeling is the first step. At present, the difficulty in modeling is the modeling of complex power electronic equipment. It is the basis of accurate simulation of large power grid to establish the accurate model of these devices and determine their parameters. At present, State Grid Corporation of China has completed 4 UHVDC projects and 13 conventional DC projects, with the scale of simulation nodes exceeding 30,000. According to the plan, by 2020, State Grid Corporation of China will complete and operate a total of 31 DC power transmission projects, including 18 UHVDC power transmission projects, and the scale of simulation nodes will exceed 50,000. In order to reflect the dynamic characteristics of ac-DC interaction, it is necessary to simulate the electromagnetic transient of ac-DC mixed grid with dozens of DC and thousands of bus lines. In addition, only having the ability of accurate modeling and large-scale simulation is not enough, the simulation analysis speed must be greatly improved, and an efficient simulation tool must be formed to adapt to the digital-analog mixed real-time simulation of ac-DC mixed grid containing tens of thousands of bus lines, so as to realize the rapid batch simulation analysis of multi-operation mode and massive anticipated faults. This paper summarizes the current status of simulation technology from three aspects of power system modeling, multi-time scale



simulation and digital-analog hybrid real-time simulation, and analyzes the challenges faced by these simulation technologies in view of the development needs of AC-DC hybrid Luen Power grid.

2. Methods

2.1. Multi-time scale simulation technology

According to the requirements of China's "Power System Safety and Stability Guidelines", it is necessary to make a comprehensive stability analysis and calculation of the power grid, in order to understand the characteristics of the power grid, and put forward targeted measures to improve the security and stability level of the power grid. The comprehensive stability analysis and calculation here mainly includes static safety analysis and dynamic safety analysis, among which dynamic safety analysis is the focus of attention and can be subdivided into power Angle stability, voltage stability, frequency stability and medium - and long-term stability. Power-angle stability and voltage stability can also be subdivided into large and small disturbances. The simulation methods for security and stability analysis include time domain simulation method, frequency domain simulation method and linearized characteristic root analysis method, among which time domain simulation analysis is the most widely used. Time domain simulation of power system includes electromechanical transient, electromagnetic transient, electromechanical - electromagnetic transient mixture, medium - and long-term process, etc. In the form of implementation, there are real-time simulation system, platform level software and stand-alone software, among which stand-alone software is the most common, including EMTP, EMTDC, PSD series software, PSASP, PSS/E, NETMAC and so on. The commonly used simulation tools are shown in Figure 1.

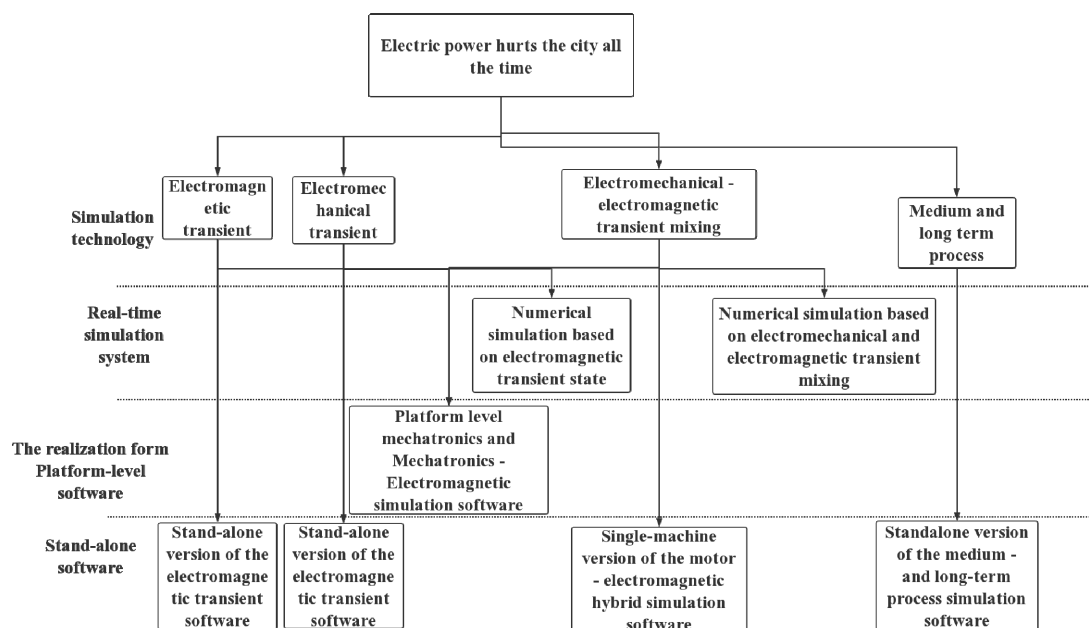


Figure 1 Common tools in time domain simulation

2.2. Hybrid simulation technology with different time scales

Multi-time scale hybrid simulation of power system USES different dynamic response speed of each part of the system to select different simulation step model and algorithm, which is expected to solve the current single time level simulation method is not accurate or inefficient, and provides a new idea for large-scale hybrid AC-DC power grid research. Hybrid simulation technology, as a compromise method between simulation accuracy and simulation efficiency, cannot fundamentally solve the problem of small-scale simulation of large-scale power grid. It is the key point of hybrid simulation

technology research how to reasonably select the simulation object and interface position of asynchronous length, and how to optimize the interface method to further improve the simulation accuracy. In order to improve the computing efficiency, the parallel computing method can be used to carry out mixed simulation with different time scales. As shown in Figure 2, the fast simulation sub-module and the slow simulation sub-module are calculated in parallel, and the interface data exchange is carried out in a big step.

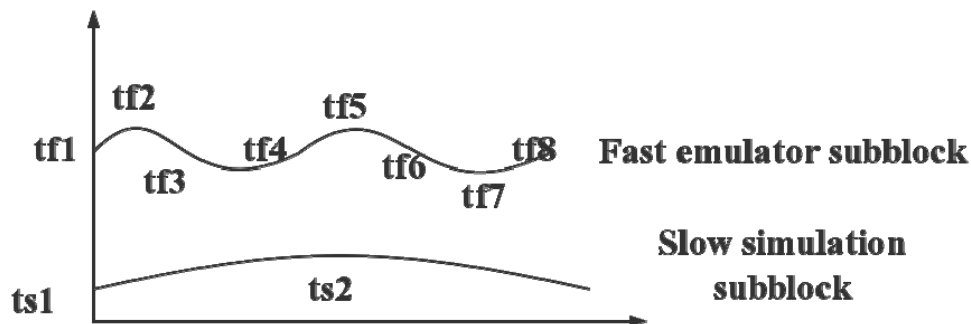


FIG. 2 Parallel hybrid simulation

A typical application of multi-time scale hybrid simulation technology is electromechanical - electromagnetic transient hybrid simulation technology. Combined with the advantages of electromechanical transient and electromagnetic transient simulation, the scale is similar to electromechanical transient, and the electromagnetic transient model is used for accurate simulation of dc equipment and other power electronic equipment. Figure 3 shows the interface principle of electromechanical and electromagnetic simulation. The steps on both sides are hundreds of times longer than each other, and the mixed simulation is realized by exchanging information through the interface.

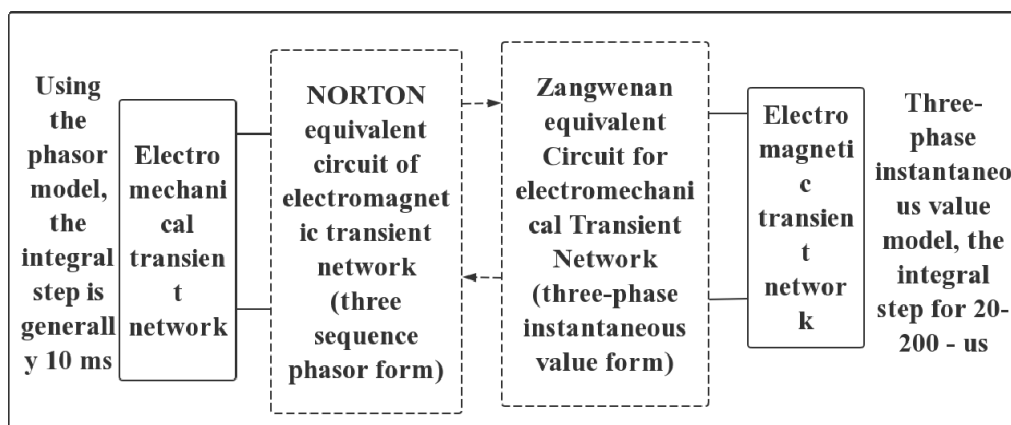


FIG. 3 Principle of electromechanical - electromagnetic transient hybrid simulation

2.3. Real-time digital simulation system

At present, hardware platforms for digital real-time simulation include embedded board CARDS (RTDS) and high performance servers (RT-LAB, Hypersim, ADPSS, etc.). The mainstream digital real-time simulation system in the world is shown in Table 1.

Table 1 Real-time digital simulation system

system	country	Hardware and software platform	modeling	application
RTDS	Canada	PowerPC processor, FPGA, Vxworks operating system	Class EMTP model library	Power system, power electronics, etc
HyperSim	Canada	Multi - core processor, FPGA, Linux operating system	Class EMTP model library	Power system, power electronics, etc
RT-LAB	Canada	Multi-core processor, FPGA; QNX/Linux operating system	Matlab/Simulink	Power system, power electronics, etc
ARENE	France	Multi-core processor, Unix operating system	Class EMTP model library	The power system
dSPACE	Germany	Multicore processor	Matlab/Simulink	Automobile, aerospace, etc
DDRTS	China	Multi-core processor, Windows operating system	Class EMTP model library	The power system
ADPSS	China	Multi - core processor, FPGA, Linux operating system	EMIP model library, electromechanical transient model library	Power system, power electronics, etc

3. Experiment

For the DC simulation system, the control and protection devices of the DC transmission system belong to the most critical core part. When connecting Hypersim and control protection devices, it is necessary to ensure the suitability of the interface as well as the suitability of the communication mode. The interaction between Hypersim and the control protector is limited only to the control of the semaphore. The voltage is usually controlled in the range of $-15 \sim 15\text{V}$, under which condition the interface belongs to the signal interface. The semaphore of interface interaction includes several kinds represented by the trigger pulse of converter valve. Most of the semaphore can be converted into A level signal, and the voltage level is fairly close to A/D, D/A, D/I, and D/O. Can be carried with the help of the level conversion chip semaphore normal interaction, simulation program by D/A control the output control signal to provide direct protection device, the device will be represented by switch amount of information via A/D and D/I submitted to the simulation program, interactive signal transmission needed A special cable to be addressed, to ensure that the signal without distortion. See Figure 4 for the interconnection between the full digital simulation program and the control protection device.

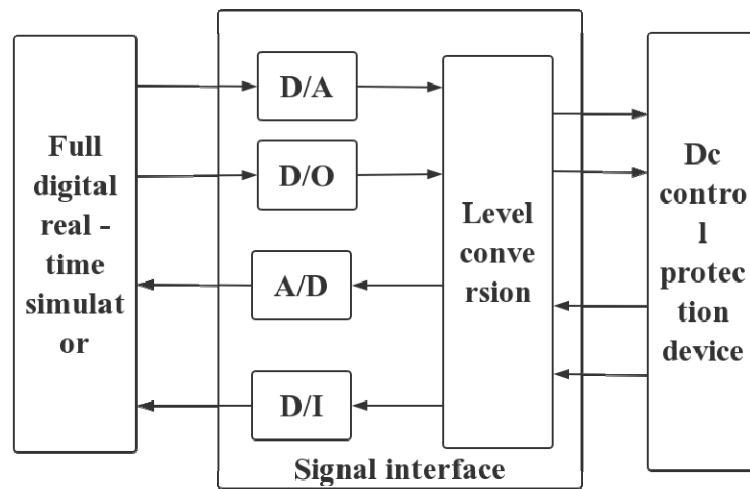


FIG. 4 Interconnection of all-digital simulation program and control protection device

The hardware implementation of the digital-analog hybrid simulation power connection interface based on Hypersim is shown in Figure 6. The digital side converts the node voltage obtained through system calculation through D/A and transmits it out. After processing by the power amplifier and transformer, it is provided to the analog simulation device. The voltage and current signals corresponding to the analog side interface are converted into feedback analog quantity after the corresponding measurement and processing by the CURRENT transformer. After receiving A/D conversion, they are finally submitted to the digital simulation system. In this way, the normal power interaction between the digital side and the analog side can be completed.

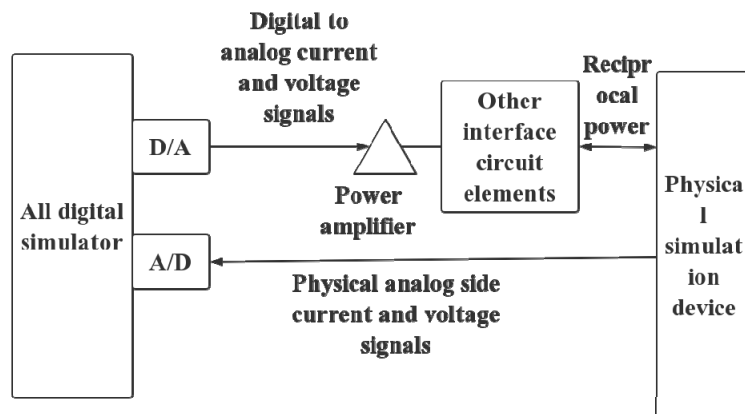


FIG. 5 Schematic diagram of power interface hardware circuit

4. Results

The simulation test system designed in this study shows ideal expansibility in both platform hardware and computing resources, and can meet the practical requirements of various applications. The reality is that the scale of the power grid is very large, and it is impossible to completely simulate it based on the current technical conditions. Therefore, how to improve the utilization rate of the platform and the scale of simulation will be an important direction of future research in this field.

5. Conclusion

Suitable simulation tools are selected for different scenarios, and the existing simulation means are adopted to meet the current simulation and test of power grid. Due to the continuous expansion of scale and increasing complexity, in-depth research needs to be carried out. The SIMULATION technology of UHV AC-DC mixed Ga power grid fully absorbs the cutting-edge technologies of various disciplines and develops new algorithms, new hardware, new tools and new means to meet the demand for simulation tools for the rapid development of power grid.

Reference

- [1] Zhenya Liu. UHV grid [M]. Beijing: China Economic Press, 2005:159-166.
- [2] Qin Qin , Qiang Guo , Qinyong Zhou, et al. The security and stability of power grids in 13 th Five—Year Planning and Countermeasures [J]. Electric Power, 2015, 48(1): 25-32.
- [3] State Grid Corporation. State Grid Corporation of China "12th Five-Year" grid Development Plan [R]. Beijing: State Grid Corporation of China, 2012.
- [4] ya Zhen, Qiping Zhang. Study on the development mode of national power grid of China [J]. Proceedings of the CSEE, 2013, 33(7):1-10.
- [5] Fang Tian, Yanhao Huang , Dongyu Shi , et al. Developing trend of power system simulation and analysis technology [J]. Proceedings of the CSEE, 2014, 34(13):2151-2163.
- [6] Yong Tang. Present situation and development of power system simulation technologies [J]. Automation of Electric Power Systems, 2002, 26 (17):66-70.
- [7] Wenzhuo Liu, Yong Tang, Lei Wan , et al. Modeling and simulation technologies for large UHVDC power grid [J]. Power System Technology, 2008, 32(22):1-3,7.