APPROACH TO CREATING AN INFORMATION-CONTROL SYSTEM OF HYBRID POWER SYSTEM SIMULATOR

Aleksey A. Suvorov[1, *], *Alexander* S. Gusev[1], *Almaz* O. Sulaymanov[1], and *Olga* V. Suslova[2]

[1] Tomsk Polytechnic University, 634050, Tomsk, Russia
[2] Scientific and Technical Center of Unified Power System JSC, 194223, Saint-Petersburg, Russia

Abstract. The results of development and experimental investigations of information and control hybrid simulator system of conventional and smart grids are considered in the paper. The fragments of the given system experimental investigation and its software tools are provided. Performed results illustrate the possibilities and features offered to a user and necessary for solution of complex power system design, research and exploitation tasks.

1 Introduction

Obvious condition of the reliable and effective solution of complex challenges of design, research and operation of modern electrical power systems (EPS), according to their operation, is existence of a possibility obtaining, including in real time, full and reliable information about the processes in the equipment and EPS in all possible standard, emergency and post-emergency operational regimes. The mathematical modelling of EPS is the main way of obtaining this information in view of the known specifics and complexity of EPS. At the same time full and reliable mathematical model of any real EPS, taking into account a possible simplification, always contains very stiff non-linear system of the differential equations of high order, which satisfactory solution is improbable by means of numerical methods, according to the discretization technique of ordinary differential equations [1]. Therefore in all digital tools for calculation regimes of EPS, inevitably used these methods, are applied significant simplifications and limitations of mathematical models and EPS in whole. Moreover, in all cases the methodical error of the solution is unknown and may be accumulated. Meanwhile, mentioned known simplifications and limitations become even less acceptable for modelling smart grids [2, 3].

2 The information-control system structure of hybrid power system simulator

* Corresponding author: suvorovaa@tpu.ru

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As the designated reason has fundamental character and within unilateral especially numerical simulation of EPS isn't removable, the alternative way to simulation of EPS is hybrid approach. Developed according to this approach the concept and tools of adequate simulation in real time of EPS, including smart grids, are considered in [4-6]. Hybrid Real-Time Power System Simulator (HRTSim) is developed according to this concept. The information-control system of HRTSim consists of adapted specialized processors (SP). The adaptable set of SHP is combined by the three-phase switch according to the topology of the modelled power system, this set provides continuous methodically accurate solution in real time and with the guaranteed instrumental error of full three-phase mathematical models of all types significant power equipment and EPS in whole, including smart grids.

All information-control functions, including modelling of relay protection, emergency automatic, etc., are carried out in each SHP by means of the microprocessor unit (MPU), which includes central processing unit (CPU). CPU is connected by the local area network (LAN) between themselves and with the HRTSim Server. In this way, the set of MPU and specialized software tools (SST) constitute the information-control system (ICS) of HRTSim. For users – clients, as a part of ICS, the modern automated user's workstations (WS), established without restrictions on external computers, are developed.

Depending on specifics functions and necessary resources for its, the processing of its may be possible in MPU, Server or WS. Therefore, ICS represents multilevel program and hardware system:

- at the level of the Server are carried out the information interactions with MPU SP, WS and all system functions, including modelling of various system and centralized means of automatic equipment, etc., and also various scenarios of modelling are realized;
- at the level of MPU SP interaction on LAN of their CP and Server, and also CP and peripheral processors (PP) MPU is provided by the processors of analog-digital converting and processors of series and shunt digitally controlled three phase switches;
- at the level of WS are realized external the interactive, automatic and combined information interactions with his Server, which can be also various external devices: the existing tools of simulation of power systems, relay protection devices, supervisory control and data acquisition (SCADA) and etc.

The Fig. 1 is demonstrated the structure of multilevel ICS.

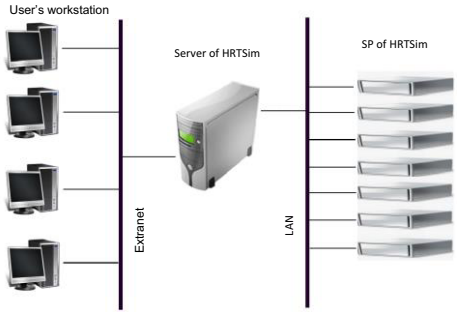

Fig. 1. Block diagram of ICS HRTSim.

According to the block diagram, the HRTSim Server contains two network interface cards. By means of one of them via network switches and LAN control information interactions with all CP are carried out. Within broadcasting interactions are provided: modes of the loader or working CPU, initialization of the MPU databases, synchronization of MPU and Server, various regimes of simulation. Tasks and changes of parameters and coefficients of mathematical models in SP, inquiries and import of simulation results for their converting and display by various software devices: digital, chart, vector, tabular,

oscillographic, etc. on specialized dynamic monitoring and control panel (DMCP) are carried out by local interactions, also for implementation of various local and system scenarios of simulation, management means of power systems. Hardware interactions of the CPU with the Server are carried out by means of the Ethernet driver.

3 Software tools of hybrid power system simulator information-control system

All interactions in ICS are carried out in the form of quasiparallel processes. At the same time the interaction with WS is carried out via TCP/IP, this protocol uses the squeezed for acceleration XML messages, which are coded and converted into BASE64. Each user connects to the Server by means of login and password. Any external devices with various data's formats interact with the Server by means of the interfaces created for this purpose. Special SST for user's WS are developed, which is the main tool for interactive using of HRTSim. All program of this SST for WS are professionally focused and structured:

1. DMCP represent the graphic forms used for display of schemes of the equipment, energy area and their regime state, and also for interactive management in real time by parameters, settings, longitudinally cross three-phase and incremental commutation. Realization of this properties and opportunities is provided with the corresponding program management information devices placed on DMCP: digital, chart, vector, tabular, indicator, etc. Moreover, the edition by users of the existing DMCP and creation new are provided in SST for WS. Basic purpose of DMCP is display of the set regimes and processes in the equipment and interactive control of them. Examples of DMCP are given in Fig. 2.

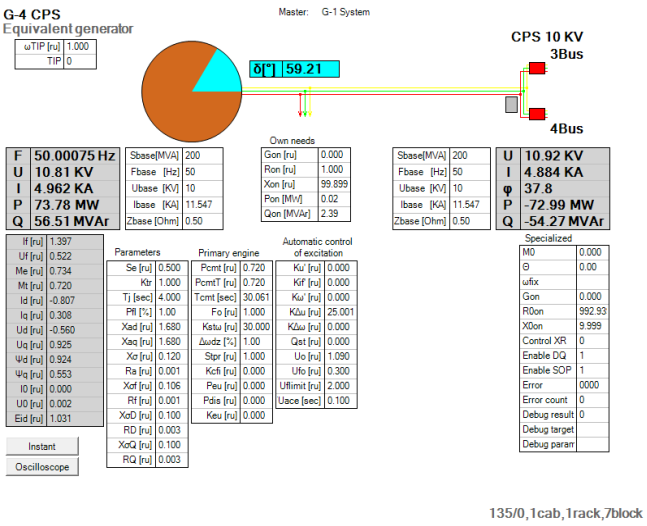

Fig. 2. DMCP of the G-4 generator of thermal power plant.

2. Multipurpose and multibeam oscilloscope represent the program devices used for display of the processes proceeding in the equipment, EPS and also for their in-depth analysis. Processes, their list and combinations in one or several windows of oscilloscopes are chosen by the user. Two types of oscilloscopes are provided in SST for user's WS:

– continuously functioning for display and the analysis of the quasi-steady state and slow transition processes;
– functioning on the set time interval for fast transition processes: electromagnetic, including switching overvoltage, etc.

Examples of using the mentioned program tools are given in Fig. 3.

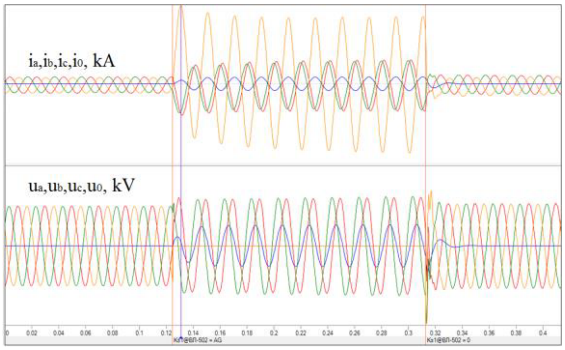

Fig. 3. Single-phase (AG) short-circuit 220 kV transmission line: i_a, i_b, i_c – phase currents; i_0 – zero sequence current; u_a, u_b, u_c – phase voltage; u_0 – zero sequence voltage.

3. Scenarios of simulation represent the program procedures made by the user at discretion with use of the standard symbols and equipment names, parameters, etc. modelled EPS, used for automatic implementation of various scenarios of simulation. In view of essential difference between quasi-steady state and transition processes, two types of the scenarios are provided in SST of WS: quasi-static and dynamic. Scenarios of a quasi-static are intended for changing the necessary set modes. Scenarios of dynamics are intended for reproduction of various abnormal regimes and processes.

4 Conclusions

1. The developed ICS of HRTSim provides necessary set of management information properties and opportunities for the solution of complex challenges of design, research and operation of EPS, including smart grids.
2. The results of experimental research the developed ICS created on the basis of modern IT technologies have confirmed reliability and efficiency of functioning of these tools in the user's WS and in HRTSim in general.

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