The Features of the Pulsed Power Technology Control Systems

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Abstract

The pulsed power technology is being used for generation of intense x-ray and charged particle beams (electron, light ions), inertial confinement fusion researches, high current z-pinch experiments. The main part of the pulsed power facility is the generator with parameters: power $>10^{13}$ Wt, current $>10^{6}$ A, output pulse time duration $\approx 10^{-7}$ sec. The operation of pulsed power facilities have specific features, namely, a small number experiments (shot) per day, short time duration of processes in generator ($<10^{-6}$ sec), hundreds of measuring parameters during shot.

According to specific operation, the control equipment of facility contain several types of systems. One of them is the system for the technological preparation of the installation for a shot. Because technological parameters are changed slowly it is possible to realize on-line operation of this system. Second one is the data acquisition system for acquiring data during a shot. This system includes fast ADC of different types. Part of them have the time step of waveform measurements $<10^{-9}$ sec. The special timing system provides the synchronization of all systems operation in the wide time scale of events. In this paper control systems of pulsed power Angara-5 facility as an example is given.

1 Introduction

Pulse power technologinal systems are experimental facilities that produce electric power $\geq 10^{12}$ Watt during time 10^{-8}-10^{-7} sec. Designs of pulse power facilities (PPF) are very different, but the operation algorithm of one is very similar. There is the condenser of electric power. Usually it is a capacitor battery. After change, the condenser switches to power compressing device. Often as power compressing device the coaxial lines are used. As electric insulator of coaxial lines the distiller water is used very broadly. There are designs of PPF where the fast current switches from inductance to load are applied.

Now the PBFA facility [1] of Sandia National Laboratory is the most powerful facility of this type. One has 10^{14} Watt electric power. The Angara-5 facility [2] of Troitsk Institute Innovation and Fusion Research can produce the pulses of electric current on the load up $5*10^{6}$ Ampere.

The main application areas of PPF are the following:
- generation of intense light ion and electron beams;
- inertial confined controlled thermonuclear fusion;
- fast z-pinch experiment;
- simulation experiments.

2 Operation features of PPF

Usually PPF are operated in the single cycles (shots) mode (several shots per day). It is possible to separate working cycle in the following technological steps:
- preparation of facility for the working cycle;
- change capacitor battery during several minutes;
- switch condenser to the power compressing device during several mks;
- switch power compressing device to the load during several tens ns.

It is possible to realize feedback operation of control on the first and second steps only. On the later steps the functions of control are synchronization of all facility parts and date acquisition performance.

3 Typical control equipment of PPF

According to algorithm PPF operation, it is possible that the control systems divides on three main parts (Fig.1).

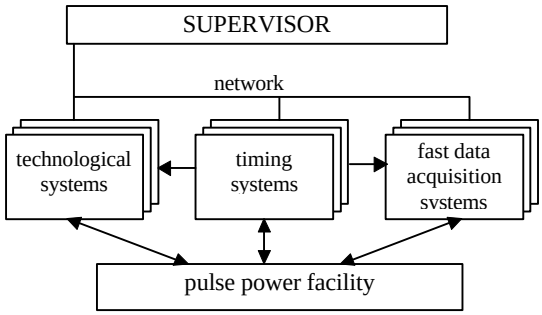

Fig. 1. Control sytems structure of the pulse power facility

The first one is technological system. This provides the facility preparation of working cycle, control of capacity charge and date acquisition of slowly changing parameters. At the Angara-5 facility this system provides gas pressures in switches (128 directions) and the charge of condenser batteries (16 directions). As hardware interface the CAMAC equipment is used.

The data acquisition system contains the analog to digital converters (ADC) of different kinds of measurement for fast signals from detector and sensors of facility. At the Angara-5 facility there are several subsystem with fast ADC. Each subsystem contains the definite ADC type. There are subsystems for waveform measurements, peak signal amplitudes and time start of signals. About 200 signals are measured during each shot. For waveform measurements with frequency ADC

operation more than 1 GHz, the TEKTRONIX hardware is used.

The timing system provides synchronization of facility equipment and measuring channels operation in the time scale that is ″attached″ to facility working cycle. At Angara-5 the time scale is determined by 100 MHz generator. The special timing blocks pass the definate pulse to the output. The accuracy of output pulse attachment to facility processes is 2.5 nsec.

Supervisor produces control all systems and provide processing, display and archiving information about facility operation.

All equipment is controlled by computers of IBM PC type on the subsystems levels. The local network ETHERNET is used.

4 Software structure

Usually PPF are used for different experimental programs. The program change connects with some reconstruction of hardware environment. By this, the types and number of measuring channels can change. The measuring channel includes sensors (detector), transmitting cable and ADC. Software must have structures that allow to adapt one according to new experimental environment during short time.

According to this requirement the special method of software design was applied for measuring systems of Angara-5 [3]. The method includes the description of the system composition by means of a computer aided design tool. This description is saved in the special date base and used by the system software for automatic initialization of the real hardware. Any change of the connection scheme or device types does not require a new design of the system software. It is necessary to edit the scheme inside the date base only. This method requires object-oriented programm-ing techniques and the hierarchical structure of the systems. At the same time the full documentation about the system structure is produced. The application of this method to systems with changeable configuration reduce the time of modification of one and prolong life time of software.

On the supervisor level, a special tool for descrip-tion of all experimental environment (DSR) is used [4]. The DSR program has the following funtionality:

- enter and edit the parameters of the system compo-nents;
- create the description file (experiment scheme) of a certain experiment′s measurement environment;
- output the experiment scheme as a doccument.

Usually the diagnostics methods of the installaton events researches are required to use the information about the measuring channels set and some algorithms of data processing. The experiment description on the diagnotics methods level is the DSR next step.

References

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