PRESENT STATUS OF THE ANGARA-5 FUSION FACILITY CONTROL SYSTEM

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Abstract.

The Angara-5 facility was designed 20 years ago. The main program of researches is the inertial confinement fusion. The facility contains 8 individual modules and can produced up to 5 MA current on the load. The current time rise is 80-90 ns. The algorithm facility operation includes two different stages:

- the long time (several hours) technological preparation of different facility parts;
- the short time (10^{-6}-10^{-9} sec) of the power generation process on load.

The structure of Control and Data Acquisition System (CDAS) corresponds to the technological properties of this facility. During the facility exploitation the hard- and software of CDAS was upgraded several times that was caused by both aging of the equipment and software development. The main changes were originated from the replacement of the computer type (DEC to IBM PC) and the analog-to-digital conversion (ADC) devices of fast signals (10-100 ns) that also required the upgrading of the software. The main CDAS architecture did not changed. Now CDAS structure includes the following:

- subsystem of technological preparation to shot;
- waveform subsystem 1 (ADC, a sampling time of 10-50 ns);
- waveform subsystem 2 (Tektronix oscilloscopes, a sampling time of 1 ns);
- synchronization subsystem;
- supervisor system.

The subsystems are controlled with PC and connected via ETHERNET line by the DECNET protocol. The upgrade was carried out without stopping of the CDAS operation. The hard- and software (DOS, C^{++} language based programs) of the old subsystems was not changed. The new subsystem software is based on the LabVIEW. In this paper the present CDAS status is given.

1. Introduction.

Facilities of superhigh electrical power (PPF), together with such areas of their application as, for instance, generation of powerful X-ray fluxes and beams of charged particles are being widely used as drivers in the investigations into thermonuclear fusion with inertial confinement. The facility A-5 developed over 10 years ago and providing a pulse power of over 10^{13} W is capable of producing on load a current pulse of up to 5 MA with a its front of the order of 10^{-7} sec. The operating mode of such facilities is monopulse (several working shots per day). Nowadays experimental schemes are under study in which light-weight liners are used as PPF loads; these liners can be arrays made from thin wires and also gas jets of a specified profile. Under the action of the flowing current the load substance turns into plasma being accelerated by self-magnetic field of the current toward the system axis. At a final stage of the load compression a Z-pinch forms with the plasma temperature being over 10^6 K, its density above 10^{20} cm^{-3} and duration of about 10^{-8} sec. The main part of this plasma spectrum of radiation is the region of soft X-ray which imposes certain requirements to the choice of diagnostic techniques. The operating cycle of the facility includes the following steps:

- preparation of the facility for its start up including pumping the experimental chamber, filling the gaps with gas up to required pressure, charging the capacitor banks up to required voltage and etc. (duration of this step is uncertain);
- measurement and analysis of the processes of power pulse formation on the load (the duration of the step is 10^{-6}-10^{-5} sec);

- measurement and analysis of the processes on the load (the duration of the step is under 10^{-8} sec).

The facility comprises eight separate modules that are set out in site of 10^4 m^2 area and operate in parallel. Its layout is shown in Fig. 1. To obtain the maximum power of the facility it is necessary to synchronize operation of these modules within several nanoseconds and, for this purpose, to monitor the processes proceeding in all the modules and in all the steps of the power pulse formation. The basic CDAS structure was defined at the stage of designing the A-5 facility. During the facility exploitation the hard-and software of CDAS was upgraded several times that was caused by both aging of the equipment and development of the software. The main changes were caused by the necessity to replace the computer type (DEC by IBM PC) and the analog-to-digital converter (ADC) devices of fast signals (10-100 ns) that also required upgrading their software. However, the basic CDAS architecture [2] did not change. The upgrading was performed without suspending the CDAS operation. Some of the subsystems experienced no changes.

2. CDAS structure

The Control and Data Acquisition System (CDAS) is a multilevel structure consisting of several local subsystems. A supervisor combines all the subsystems to CDAS. Now there are three groups of subsystems (fig. 1):

- subsystems of technological preparation for shot (ST);
- timing subsystems (SS);
- fast data acquisition subsystems (SW).

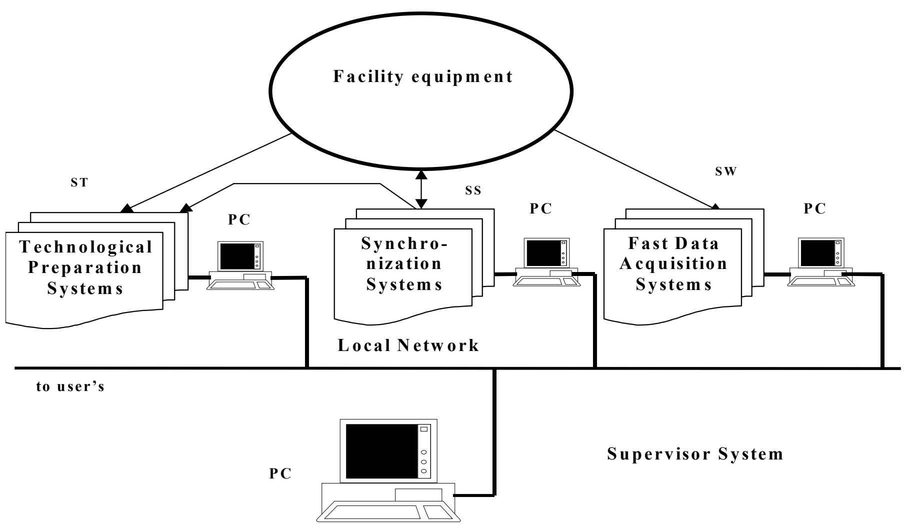

Fig. 1. The Control and Data Acquisition System of the Angara-5 facility.

The technological preparation subsystem is actuated before an operating cycle starts. There are lots of control parameters but they change rather slowly. The data processing speed is not in excess of 10^6 bit/sec and PC is quite suitable for use as a feed-back element. PC is connected to the facility equipment by CAMAC. These subsystems are most conventional and operate by DOS. When the necessary technological parameters (vacuum, mechanical elements, gas pressure and so on) are obtained, the capacity batteries are start charging. On charging termination PC records all of these parameters and permits execution of shots.

The timing subsystems have two functions:

- synchronization of technological and diagnostic systems operation;
- measurement of time when various installation units come into action.

The hardware of the subsystems is similar to that of CAMAC. The number of control and measurement channels is 64. The time measurement accuracy is ±2.5 ns.

Fast data acquisition subsystems provide waveform parameters recording this information flow in every shot and making its preprocessing. The data processing time ranges from 10^{-5} to 10^{-8} sec. These subsystems have been upgraded several times and now they contain digital waveform devices of different types. The crate blocks of the CAMAC type with various sample rates (20 MS/S-!00 MS/S) are currently used to record data processing in the time interval from 10^{-5} to 10^{-8} sec. For faster recording digital Tektronix oscilloscopes (the sample rates are 1 GS/S and more) are used. The numbers of measurement channels vary between 50 and 100 depending on the experimental needs.

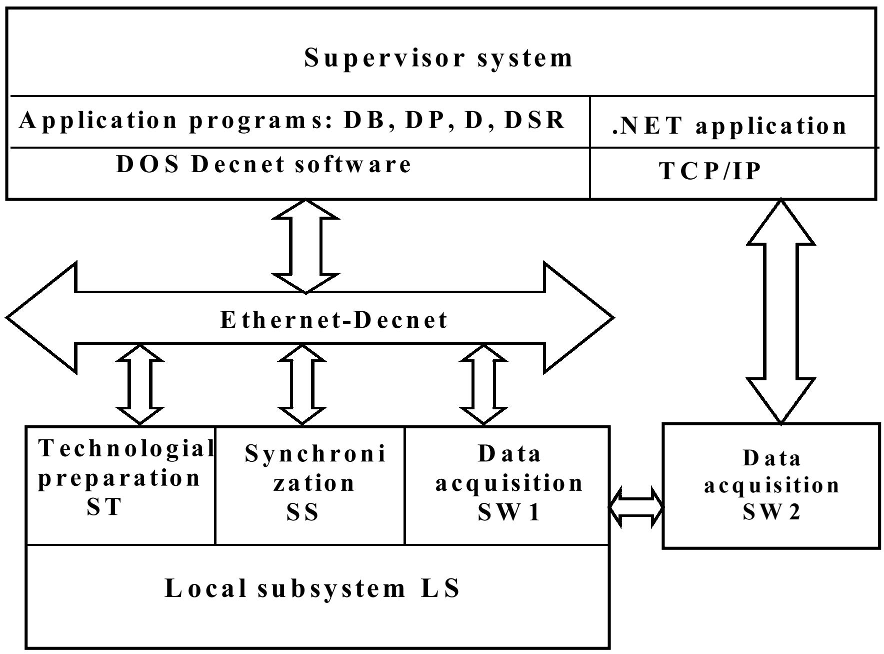

Fig.2. Software composition of new CDAS

3. Software structure

The CDAS structure provided the initial period of the A-5 exploitation was based on a computer facility of the DEC type with RT11and RSX operation systems. The first CDAS upgrade was connected with the replacement of the computer base to IBM PC and operation system to MS DOS.

The software instrumental means by this are as follows:

- operational system MS DOS;
- language MS Quick C and Borland C^{++};
- local network protocol DOS Decnet.

Some object-oriented programs insuring the CDAS operating cycle have been developed and used for a long time (fig.2):

- experiment description program DSR;
- dispatcher program specifying the CDAS operation conditions, initiating the operation cycle start and providing the supervisor connection with local systems D;
- local systems control programs and their testing; DR;
- database including also stationary parameters of measurement channels DB;
- users application programs.

The other upgrading was caused by an increase in the number of analog-digital converters on the basis of Tektronix oscilloscopes.

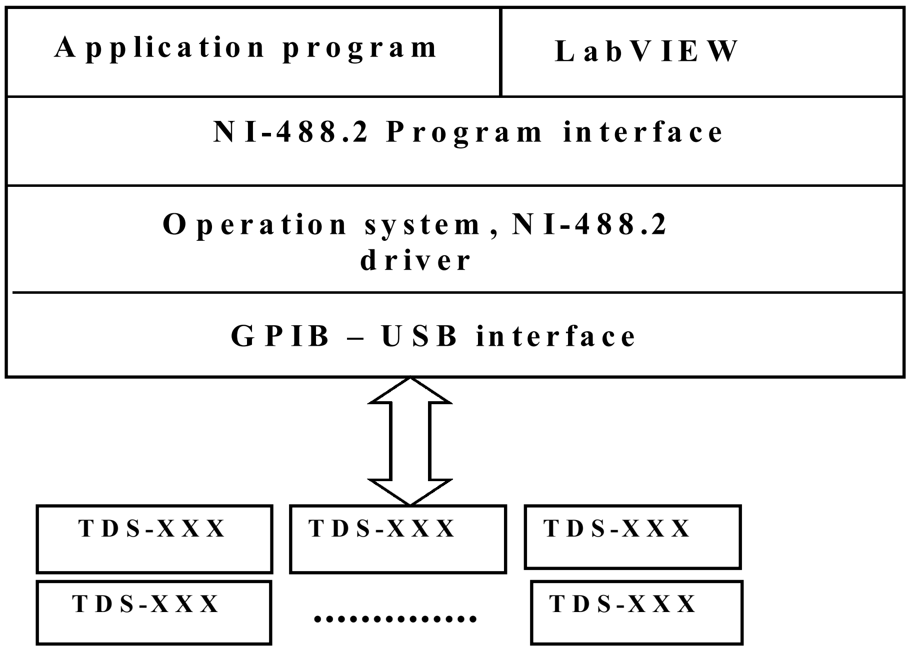

Fig 3. The software of a local system based on Tektronix oscilloscopes

The IEEE 488.2 interface combines the oscilloscopes into a separate local system. The software on the basis of LabVIEW of National Instruments Co. insures the system operation (Fig. 3). The connection with the supervisor is being developed on the basis of the TCP/IP protocol. For the time being we are engaged in upgrading of the supervisor system. The new dispatcher is based on the application of the Remote Administrator (Radmin) system. The supervisor system is grounded on the MS .NET Framework. The software of the old subsystems will stay unchanged. A special code was developed for transformation of data format of these subsystems. The main instrument for data processing is MatlLab.

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