FREE ELECTRON LASER FOR THE SIBERIAN CENTRE FOR PHOTOCHEMICAL RESEARCH: THE CONTROL SYSTEM

Y.K.Avlasov, K.D.Bezmaternikh, A.V.Ovchar, A.D.Oreshkov, E.G.Miginskaya, T.V.Salikova, P.A.Selivanov, S.S.Serednyakov, S.V.Tararyshkin, A.G.Tribendis, N.A.Vinokurov.
Budker Institute of Nuclear Physics, 630090, Novosibirsk, Russia.

Abstract.

This article describes the software for the control system of the Free Electron Laser for the Siberian Center for photochemical research. The main components of subsystems composing the control system as well as their hardware and software components are considered. Also main features of each of the subsystems and of the whole control system are mentioned. The prospects of control system development to meet the future requirements are discussed.

INTRODUCTION

A high-power FEL, based on the accelerator-recuperator, [1] is under construction now at the Budker Institute of Nuclear Physics. The first phase of the project - the terahertz FEL - was commissioned recently [2]. As for many complex installations, the distributed control system was developed to control FEL. This article describes the architecture, component parts and the main capabilities of the FEL control system.

THE CONTROL SYSTEM ARCHITECTURE

A heterogeneous control system is realized at the Free Electron Laser facility, developed at the Budker Institute of Nuclear Physics. Its components, which control subsystems, were developed with application of different approaches and under different operating systems. Practically, all the systems have a weak level of integration, i.e. they can work independently on each other. The control system was created with the use of the IBM-PC-compatible computers and CAMAC and CAN-BUS interfaces.

All the subsystems can be divided into three groups according to the protocol tools they use:

- Subsystems under control of UNIX-like operating systems (LynxOS, Linux) based on tools for construction of control systems – EPICS.
- Subsystems under control of Windows-like operating systems (Windows 2000) with application of separate components of EPICS.
- Subsystems under control of Windows-like operating systems (Windows 9x) constructed on the LabWindows SCADA tools.

The main layout of control system and connection to control hardware are presented in Fig. 1.

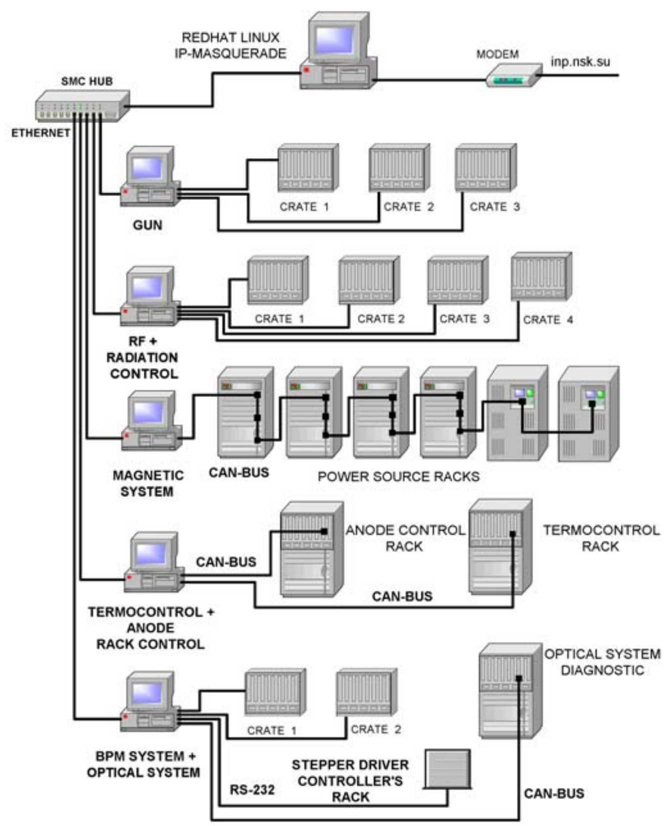

Figure 1: Main subsystems of the FEL control system and connections to control hardware.

Individual subsystems are connected with each other via the data communication interface Epics Channel Access. This interface allows remote monitoring of subsystems parameters on the base of the local network. Each parameter is presented as a variable referred to as “Process Variable”. Each variable contains information on the value of the parameter it controls and its state. The interface Channel Access is rather simple and convenient in use. Its main advantage is that it masks the mechanism of data transfer over the network, which provides a unified format of data communication for different operating systems.

COMPONENTS OF CONTROL SYSTEM

As mentioned above, the control system consists of number of independent subsystems, and use different hardware and software solutions. The Table 1 presents the main subsystems and the hardware and software components they use.

Table 1: Main subsystems components

Subsystem	Software components used (OS, Protocols)	Control Hardware used
Electron gun control	LynsOS, Epics	CAMAC
RF system control	Windows, LabWindows CVI.	CAMAC
Radiation control system.	Linux, Epics	CAMAC
Magnetic system control	Windows, IXXAT VCI, Epics Channel Access.	CAN-BUS
Temperature monitoring system.	Windows, IXXAT VCI, Epics Channel Access.	CAN-BUS
Anode Control Rack monitor system.	Windows, IXXAT VCI, MySQL.	CAN-BUS
Beam position measurement system	Windows, Epics Channel Access.	CAMAC
Optical system control	Windows, IXXAT VCI	CAN-BUS, RS-232

The main capabilities of subsystems are the following:

Electron Gun Control.

It provides control over the electron gun with electron energy up to 300 kV, current pulse duration of 1,5 ns, bunch charge of 0,5 to 2 nC, bunch repetition frequency in the range of 22,5 kHz to 22,5 MHz. The control system allows:
1.Setting and measurement of energy, charge and repetition frequency of bunches.
2.Switching on/off and measurement of parameters of the electron gun.
3.Emergency outage of the gun if some measured parameters are out of normal range.

RF System Conrol.

Provides total remote control over the RF system.
The control system allows:
1.Setting and measurement of amplitudes and phases of voltages at the accelerating resonators, currents in feeders, values of detuning of resonators, storage and restoration of a set of all controlled parameters.
2.Switching on/off and measurement of parameters of high-power RF generators, regulation of anode voltage, control of tuning of the generator output resonant circuits, control of the state of emergency shut-down systems.
3.Performing of training of the RF cavities against RF multipactoring (scheduled operation).

Magnetic System Control.

Provides control of low-current (3A and 10A) and high-current (1000A and 2500A) DC supply sources of electromagnets. The control system allows:
1.Setting and measurement of currents in the electromagnet windings.
2.Comparison of the measured current with the set one, check of existence of current and voltage stability in current sources.
3.Simultaneous (synchronous) setting of currents in several elements with different proportionality coefficients.
4.Remote control over the system (setting and monitoring of currents) from any computer in the local network according to the Epics Channel Access protocol.

Beam Position Measurement System.

It reads-out from sensors of the electrostatic type (pick-up electrodes) and computes the electron beam position in the vacuum chamber. The system includes 28 stations. The main capabilities of the system are as follows:
1.Cyclic measurement of the beam position from all the sensors and computer screen layout of the orbit with rate as high as 5 cycles per second.
2.Approximate determination of beam current losses at each of the stations relative to the initial current value.
3.The possibility of simultaneous observation of both the accelerated and decelerated electron beams on the sensors of the accelerating straight section.
4.The possibility of observation of stability of signal from any sensor.
5.The possibility of transfer of the measured values to the local network by the Epics Channel Access protocol.

Radiation Control System.

The system reads-out from 6 sensors inside the accelerating hall and 2 sensors outside it. The main capabilities of the system are as follows:
1.Measurement of the dose rate at different points of the facility and screen layout of it.
2.Color indication of reaching a certain dose value (i.e.,200 μR/h).

3.Recording of the history of all parameters of the system to the database in the EPICS system. The possibility of browsing the history of parameters of the system.

The vacuum control system.

The system reads-out from 30 current sensors of the ion pumps. 19 of them are placed in the accelerating cavities. The rest are distributed over the whole vacuum chamber of the facility. The main capabilities of the system are as follows:
1.Measurement of currents of the ion pumps at different points of the facility and screen layout of them in the logarithmic scale.
2.Color indication of reaching certain current values.
3.Recording of the history of all parameters of the system to the database in the EPICS system. The possibility of browsing the history of parameters of the system.

The temperature monitoring system.

The system reads-out from 160 sensors and converts them to temperature values. Main capabilities of the system are as follows:
1.Measurement and screen layout of the temperature of the temperature sensors.
2.Chime at reaching a certain limits for temperature and temperature growth rate values.
3.Recording of the history of all parameters of the system to the database with the use of the MySQL protocol. The possibility of browsing the history of parameters of the system.
3.Program interlock of the electron beam if temperature of one of the sensors reaches the critical value. The Channel Access protocol is used for it.

Optical system control.

The system includes mechanical movement of the optical cavity mirrors and measurement of different characteristics of the system (e. g., radiation power). Main functions and capabilities of the system are as follows:
1.Control over step motors that manage rotation of the optical cavity mirrors and insertion of calorimeters.
2.Measurement of coherent radiation power and other parameters of the optical system in real time.
3.Other measuring processes:

- Measurement of the radiation spectrum using rotating Fabri-Perot interferometer.
- Measurement of the intensity profile of coherent radiation.

The control system for the anode power supply of the RF generator.

The system analyzes the state of thyristor assemblies of the anode power supply, converts it to the digital form and sends them to the control computer. Main capabilities of the system are as follows:
1.Screen layout of the state of every thyristor in real time.
2.Recording of the history of all states to the database with the use of the MySQL protocol.
3.A system for browsing the history of system states for any time interval.

CONCLUSION

This realization of the control system is not a final one. Until the present moment, the main attention at construction of the systems was being paid to the capabilities required for commissioning and adjustment of the facility, fault tracing and so on. At the stable operation stage, new capabilities of the existing systems and, possibly, creation of new systems will be required. Now a system for archiving of all parameters of the facility is being designed. Systems for analysis of stability of facility operation in different modes, systems for quick rearrangement of operating modes of the facility and others may also become necessary.

The extension of the control system up to the second FEL stage is also planned. In so doing, main changes will relate to the magnetic system, temperature monitoring system and beam position measurement system. The number of elements of these systems will be increased approximately two times. Some insignificant modification of the rest systems is also possible.

REFERENCES

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