# THE AUTOMATION OF ENERGY RAMPING FOR THE MAIN STORAGE RING OF KSRS

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*Abstract*

Kurchatov Synchrotron Radiation Source (KSRS) is the complex of electron synchrotrons specialized as a source of synchrotron radiation. The running cycle of KSRS main storage ring includes the energy ramping from 450 MeV up to 2.5 GeV. Fast and reliable energy ramping algorithm was developed and implemented at KSRS main storage ring. Using the hardware decisions on the basis of the NI units and CAN-bus interface, the control system is developed and launched for the power supplies of magnetic elements.

## ENERGY RAMPING PROCESS

Magnetic system of KSRS main ring includes one family of bending magnets, 6 families of quadrupole lenses, two families of sextupole lenses for chromaticity correction [1]. The supply current of the bending magnets varies from 1270 A up to 7200 A, it determines the machine energy. The currents of the quadrupole power supplies vary from 80 A up to 760 A depending on the energy and number of the family. The currents of sextupole power supplies vary from 0.4 A up to 8 A. As a result saturation of iron exists at high energy, while residual magnetization manifests at low energies. Thus, a simple proportional increase of the currents will lead to the betatron tune shifts during energy ramping.

The process of energy ramping between injection energy 0.45 GeV and working energy 2.5 GeV consists in proportional change of magnetic field in bending magnets, field gradients in quadrupole and sextupole lenses. To facilitate the energy ramping process, 9 intermediate regimes were introduced at a distance of 10 - 20% in energy one from another. The regime means list of power supply settings. Magnetic measurements were conducted to determine right currents for all power supply families in each regime. Field in bending magnets was measured with an accuracy of 0.00001 using NMR sensor. For the quadrupole lenses measurements were carried out by Hall effect sensor with an accuracy of 0.001. Relative changes of the field gradients in each family in all intermediate regimes were measured [2].

Complicated algorithm with 9 intermediate regimes (collections of power supplies settings) was developed to produce fast and efficient energy ramping. The correction of closed orbit, betatron tunes and chromaticity is accomplished in each regime in static conditions. Special file is used to provide acceleration or deceleration of power supplies in dynamic conditions. This scheme allows to compensate betatron tune shifts during energy ramping. Power supplies are not stopped on intermediate regimes; speed of current changing is continuous function of time.

Fast and reliable energy ramping algorithm was developed and implemented at KSRS main storage ring [2]. Whole process takes 2 minutes and 40 seconds, beam losses doesn’t exceed 2 – 3 %, betatron tune shifts are less than 0.015.

For more accurate reproduction of the results standard demagnetization cycle was introduced. After the work on the energy of 2.5 GeV currents of power supplies of the magnetic elements rise above the maximum working value, then gradually, over 80 seconds, fall below the minimum values of the injection energy, then regime of injection is restored. In every state a 30 seconds pause is maintained. The practice showed that after this demagnetization cycle betatron tunes returned to its initial values with a good accuracy of about 0.003.

## KSRS MAIN RING CONTROL SYSTEM

KSRS control system (CS) is the multilayer and multiprocessor design consisting of three levels: executive, server and operator (see in Figure 1).

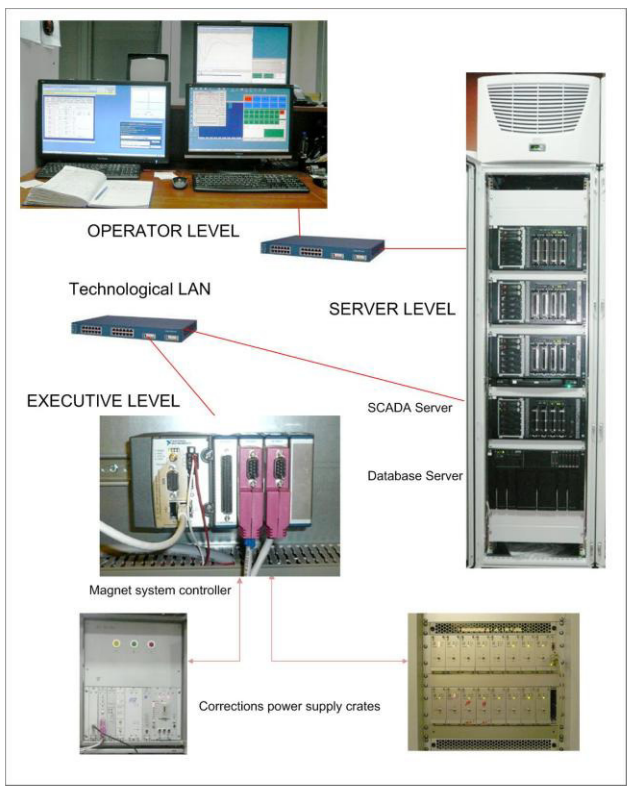


Figure 1: KSRS magnet system control.

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All equipment is connected by two local area networks: public and technological. The magnet subsystem controls a high-current power supply of linear optic elements and a low-current power supply of bending magnets and nonlinear optic elements. The process control subsystem realizes a direct control of all subsystems. For example, it controls electron beam energy ramping process or beam transfer between accelerators. Any control algorithms (global or local electron beam orbit correction, photon beam stabilization at user's beam lines, etc.) or mathematical data processing are performed by this subsystem [3].

The CS server level consists of application servers and database server, which are operated under Microsoft Windows Server 2008 operating system. The full-featured system for monitoring, control and data acquisition CitectSCADA is operated on applications servers. We have two application servers combined into redundant cluster. This cluster controls vacuum, magnetic, thermo control subsystems. The functional structure of the CS you can see at Figure 2.

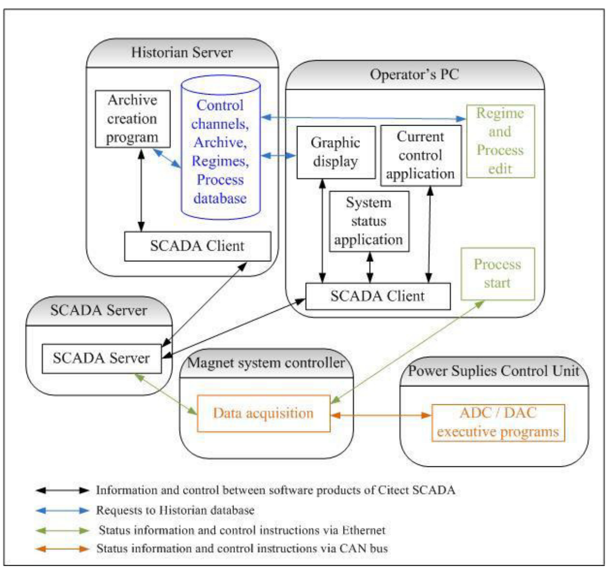


Figure 2: Functional structure of software.

To store the data about state of the accelerators, the data acquisition and reporting system Citect Historian v.4.3 is used. This system based on database management system (DBMS) MS SQL Server. In addition, this DBMS is used to store information about input/output channel parameters and description (for example, critical values, conversion factors, sampling rate, etc.). At this server level the following are realized:

- algorithms assignment;
- the data exchange between controllers, servers and operator's workstations;
- monitoring of the facility operation and some mathematical data processing;
- data storing into the database, acquisition and processing on user's requests.

The CS upper level includes automated operator's workstations, workstations of technology services staff and the facility users. At this level, as well as server level, the system CitectSCADA is operated. But at this level the CitectSCADA has other tasks, namely:

- the processes visualization in graphical mode and alarms control;
- the detailed reports preparation and statistical process control.

The executive level includes magnet system controller (NI platform) and embedded controllers in power supply, which operates as a node of CAN field bus. Specialized tool kit was developed for adjustment and calibration of power sources [4].

## *Operator's Interface*

The video frame of the operator's program of the magnet system is shown in a Figure 3. This program solves following tasks:

- representation on the monitor of the circuit and the status of magnet system of main ring KSRS;
- display of preventive and alarm messages;
- control of tuning of power supply units of magnet systems;
- operator's authorization.

By clicking on the element of listing of power supply units one can control of this element. The technical status of power supply is shown on the screen and is highlighted a colour warning in case of a deviation from a normal mode of operation.

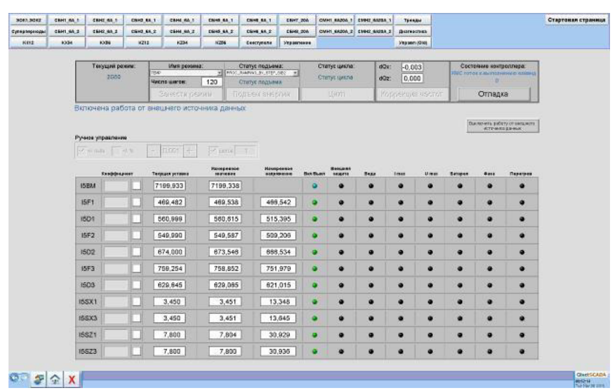

Figure 3: The video frame of operator's program.

This program has additional functions:

- job of the regimes – collection of power supplies settings;
- launch of energy ramping;
- start of a magnetization cycle;
- support of useful applications such, as local electron beam orbit correction, photon beam stabilization at user's beam lines.

The video frame of the history trends program of the magnet system is shown in a Figure 4.



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Figure 4: The video frame of history trends program.

This program represents of archive and current parameter values in the form of diagrams. The graphic interface allows the user to choose control channels and the form of graphic representation.

### *Work in Progress*

This upgrade of the magnet system control is a part of the project of modernization of KSRS control system. In the first phase is created test stand, which is designed to develop and debug software for local subsystems and CAN-bus equipment [5]. By the present moment the control of magnet system is tested, collected and launched, the moment of tests of energy ramping is recorded on the diagram in Figure 4.

## REFERENCES

[1] V.Korchuganov, et al., "The Status Of The Facilities Of Kurchatov Synchrotron Radiation Source", Proceedings of RuPAC 2014, Obninsk, Russia, 2014. http://accelconf.web.cern.ch/AccelConf/rupac2014/papers/thy02.pdf

[2] A.Valentinov, et al., "Energy Ramping At Siberia-2", Proceedings of RuPAC 2012, Saint-Petersburg, Russia, 2012. http://accelconf.web.cern.ch/AccelConf/rupac2012/papers/weppd008.pdf

[3] V.Dombrovsky et al., "Modernization Of The Automated Control System In The Kurchatov Synchrotron Radiation Source Using SitectSCADA." Proceedings of RuPAC 2014, Obninsk, Russia, 2014. http://accelconf.web.cern.ch/AccelConf/rupac2014/papers/thpsc42.pdf

[4] N. Moseiko, et al., "The Power Supply System For Electron Beam Orbit Correctors And Focusing Lenses Of Kurchatov Synchrotron Radiation Source", Proceedings of ICALEPCS 2013, San Francisco, 2013. http://accelconf.web.cern.ch/AccelConf/ICALEPCS2013/papers/thppc049.pdf

[5] Y. Fomin, et al., "New Automated Control System At Kurchatov Synchrotron Radiation Source Based On SCADA System Citect", Proceedings of ICALEPCS 2013, San Francisco, 2013. http://accelconf.web.cern.ch/AccelConf/ICALEPCS2013/papers/moppc020.pdf

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