UPGRADE SYSTEM OF VACUUM MONITORING OF SYNCHROTRON RADIATION SOURCES OF NATIONAL RESEARCH CENTRE KURCHATOV INSTITUTE

N. I. Moseiko, V. A. Dombrovsky, V.N. Korchuganov, Yu.V. Krylov, L.A. Moseiko, D.G. Odintsov, B.I. Semenov, A.V. Shirokov, National Research Centre Kurchatov Institute, Moscow, Russia
Yu. V. Efimov, CJSC RTSoft, Moscow, Russia

Abstract

Modernization project of the vacuum system of the synchrotron radiation source at the National Research Centre Kurchatov Institute (NRC KI) has been designed and implemented [1]. It includes transition to the new high-voltage power sources for NMD and PVIG–0.25/630 pumps. The system is controlled via CAN-bus, and the vacuum is controlled by measuring pump currents in a range of 0.0001–10 mA. Status visualization, data collection and data storage is implemented on Sitect SCADA 7.2 Server and SCADA Historian Server. The system ensures a vacuum of 10–7 Pa. The efficiency and reliability of the vacuum system is increased by this work, making it possible to improve the main parameters of the SR source.

INTRODUCTION

The vacuum system of the SR source (synchrotron) should ensure a vacuum of 10–7 Pa. In this case, NMD-type magnetic-discharge diode pumps with a pump capacity of 0.16 m3/s and 0.4 m3/s are placed on the small ring of the synchrotron. PVIG 250/620-type vacuum-ion-getter stations with a pump capacity of 0.25m3/s/630 l/s are placed on the large ring of the synchrotron.

EQUIPMENT OF THE VACUUM SYSTEM

Works on replacing outdated DIV-6 vacuum power sources with a 5-kV output voltage, used for energizing PVIG 0.25/630 pumps (800 pieces) in the BS storage of the synchrotron, are completed. The DIV-6 sources were replaced by new VIP-27 high-voltage four-channel power sources with a 5-kV/7-kV supply voltage [2]. The use of VIP-27 sources allowed us to increase pump capacity by 30% and reduce the time it takes to bring the system (after opening the chamber) to the operating conditions of the synchrotron by 10 h.

The VIP-27 source is controlled by BUP-27 units, which also measure the output voltages (*U*P) and currents of sources (*I*P) of the pumps (which used to be measured by outdated IVA-16 units). The VIP-27 power source with the BUP-27 control unit are placed in a standard 3U Euromechanics crate (Fig. 1). For powering 80 vacuum pumps of the large ring of the SR source, twenty crates with VIP-27 power sources and BUP-27 units are used. The SQL-server of the vacuum system controls the power source of all the pumps via a common CAN bus. Data on the pump currents (*I*P) obtained by it are transmitted to the main server of the SR source.

VIP-27 High-Voltage Power Source

Let us present the main technical characteristics of the VIP-27 source (Fig. 1) designed at OOO KBST (Vyborg). The VIP-27 source ensures the following: an open-circuit voltage of 5.0 ± 0.1 kV and 7.0 ± 0.1 kV, an output voltage no smaller than 4 kV with a load current of 4 mA and a setup open-circuit voltage of 5 kV, an output voltage no smaller than 6 kV with a current load of 4 mA and a setup open-circuit voltage of 7 kV, a short-circuit current of 10 ± 1 mA, and a remote switch to the START mode from the STOP mode and the other way around.

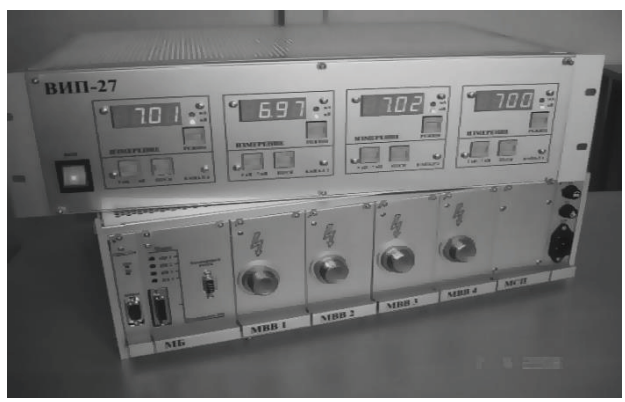

Figure 1: VIP-27 power source.

Physically, the VIP-27 source is fulfilled in a 19" Euromechanics standard basket with a 3U height (133 mm), 84TE width (426 mm), and 300-mm depth. The basket contains six 12TE modules of equal width (60 mm), namely, four high-voltage modules, one power-supply module, and one BUP-27 interface control/diagnostic module. The power system consumption is no higher than 150 W.

The BUP-27 unit is based on a mini MODUL-167 SBC computer, and it is the interface card (Fig. 2). The VIP-27 unit is intended for the control of four channels of the VIP-27source via the CAN bus. It is connected to the computer through the CAN bus or RS-232 interface. It ensures the on/off switch of each channel, the selection of the output voltage (5.0/7.0 kV) of each channel, and measurements of the amplitudes of the output voltage and current of each channel to determine the vacuum.

ISBN 978-3-95450-139-7

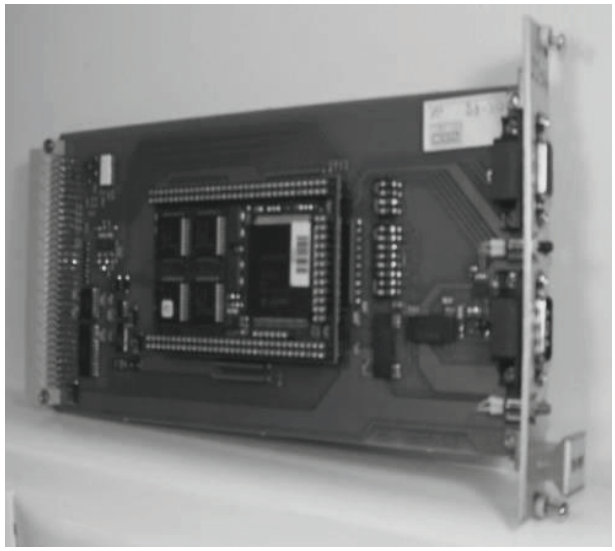

Figure 2: BUP-27 control unit.

The mini MODUL-167 of the SBC computer (further referred to as mM167) switches the channels of the VIP-27 source on and off using signals applied to output optical couplers. The output voltages and currents of the VIP-27 channels are determined with the use of the 24-bit AD7732 ADC, which measures the voltages of eight pseudodifferential signals, proportional to them. The printed circuit card of the BUP-27 controller is fulfilled in the Euromechanics constructive with a 3U height, 220-mm length, and 4TE width (20 mm) of the front panel.

SOFTWARE OF THE VACUUM SYSTEM

The software of the vacuum system includes three levels [3-4]. The lower level is the executive program operating in the BUP-27 unit under control of the RTX-166 operational system. The database is the MS SQL Server and inquiry formatter on the server (Pentium personal computer (PC) using Windows XP). The upper operator level is the network applications (which are the SQL server clients) for mapping the status and processing the data collected into the archive. The clients of the following three types are designed in Delphi and SQL languages. The first client ensures access to a dynamically changing parameter table, in which it reads the latest measured values of selected channels (currents and voltage of vacuum pumps). After processing, the data are outputted either in graphic form or to the information panel on the PC screen, which shows the status of the vacuum system; the serviceability of the equipment; and, using variations in color and in sound signals, warns the operator about deviations from the rated value. The client of the second type processes archives and outputs currents of selected pumps for the specified time interval in tabular or graphic forms. A separate client type, operating on the server in singular form, is a program which supports connections with the BUP-27 control units and constantly (with a 5-s period) replenishes the dynamic data table with new measured data.

DATABASE EDITING

We consider in more detail the operation of the modernized vacuum system using the finalized software version [3]. All database (DB) editing facilities in the dialog mode are brought into it. Figure 3 shows one of the main windows of the DB editing program.

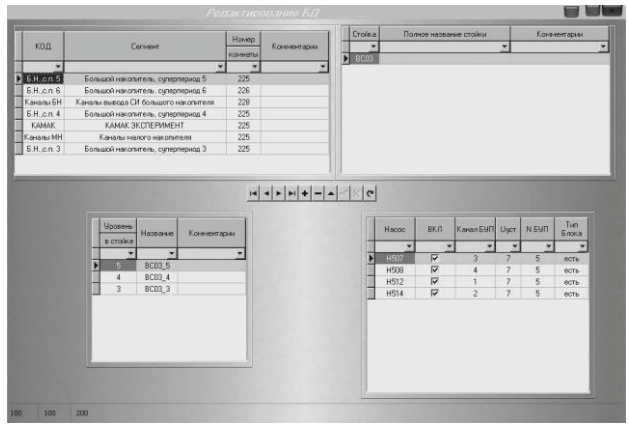

Figure 3: DB editing.

There are four tables in this window, which are filled from left to right and from top to bottom. First the upper left table is filled; then the upper right, the bottom right, and the bottom left tables are filled. After the filling of the next (in turn) table, it is necessary to press the key with a green arrow.

The numbers of the superperiods of the BS storage and the names of synchrotron systems on which the vacuum pumps are placed are entered into the *Segment* table of the vacuum system. The names of racks which belong to the selected segment are entered into the *Rack* table. The numbers of VIP-27 power sources are entered into the *Level* table. The names of vacuum pumps with the number of the BUP-27 control unit and the number of the channel to which each pump is connected are entered into the *Pump* table. The operating parameters of the BUP-27 channel (pump power supply On/Off; 5-kV or 7-kV power-supply setup) are also set.

The dialog DB editing method is intended to promptly change the configurations of the vacuum system, connecting pumps to different VIP-27 power sources, BUP-27 units, and their channels. This reduces the time and resources to ensure the uninterrupted operation of the complex and multichannel vacuum system of the SR source.

SERVER LEVEL

The server level of new control system consists of application servers and database server. This servers 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 4 application servers combined into 2 redundant clusters. The first cluster controls pulse and RF

ISBN 978-3-95450-139-7

and process control subsystems. The second one controls vacuum, magnetic, thermocontrol and thermostabilization subsystems.

To store the data about current state of the accelerator complex the data acquisition and reporting system CitectHistorian v.4.3 is used. This system based on database management system Microsoft SQL server 2008. In addition, this DBMS is used as the common database to store information about input/output channel parameters and description (for example, critical values, conversion factors, sampling rate, etc.).

TESTING OF THE VIP-27 POWER SOURCES

To test the VIP-27 power source controlled by the VIP-27 unit, a program was designed which is intended to promptly check the serviceability of all channels and determine the technical characteristics of the channels: the speed of operation and measurement errors of currents in each channel of this source by the BUP-27 unit and errors of voltages produced by the VIP-27 source to the vacuum pumps. Reference passive loads were used when the channels were tested.

Before the test startup, the test is intended to specify the data transmission rate via the CAN bus from 125 Kbaud up to 1 Mbaud, the number and order of BUP/VIP-27 tested channels, the interrogation period of channels of the source from 1 ms up to 10 s, and the VIP-27 unit measurement error of voltages of 0.1 V or 1 V and source currents of 0.1 μA or 1 μA. After the test startup, it allows one to select a 5-kV or 7-kV supply voltage for each channel and to switch on or off the power-supply unit of any channel.

The measurement results of current and voltages (running values, average values of the last 100 measurements, and variance) are outputted in digital and graphic form. The testing of the BUP-27/VIP-27 channels demonstrated that the equipment operates reliably; the vacuum measurement rate of the new vacuum equipment can reach 500 Hz (i.e., it is 100 times higher than older equipment); and the measurement error of 5-kV/7-kV supply voltages and currents of the source for reference passive loads does not exceed 0.1 V and 0.1 μA, respectively (when load currents reach 100 μA), at a stable temperature (a change within 5°C) in a range of (20–35)°C.

The high measurement rate and large memory of the computer of the BUP-27 unit allow one to accumulate up to 2500 sample/s in each channel for an interrogation cycle of the vacuum system. These data can make it possible to more accurately diagnose the vacuum state in channels and to more quickly find failures of the system operation and reasons for vacuum violation. The interrogation period is 100 ms; 7-kV voltages were connected in turn to 1, 2, 3, and 4 channels.

CONCLUSIONS

The new system provides reliable work of all 132 vacuum pumps. As a result of our works, the throughput of pumps significantly increased and the time and resources for ensuring the uninterrupted operation of the complex and multichannel vacuum system of the SR source were substantially reduced. The increase in the efficiency and reliability of the vacuum system allowed one to improve some important parameters of the SR source such as the lifetime of electrons in the SIBERIA SR source.

REFERENCES

[1] M. Blokhov et al., “Kurchatov Synchrotron Radiat ion Source Facilities Modernization,” WECHY02, in *Proceedings* of RuPAC 2010, Protvino, Russia, pp. 136–140; www.JACoW.org

[2] Y. Krylov et al., “Enhancement of Vacuum Monitoring System of KCSR Accelerator Facility,” MODP30, in *Proceedings* of RuPAC 2006, Novosibirsk, Russia, pp. 264–266; www.JACoW.org

[3] E. Kaportsev et al., “The Expanded Program Tools for KSRS Operation with Archivation of Data,” WEPSB007, in *Proceedings* of RuPAC 2010, Protvino, Russia, pp. 187–189; www.JACoW.org

[4] N I. Mosejko, Yu.V. Krylov, L.A. Mosejko, et al. “Modernization of the Vacuum system of Synchrotron Radiation Sources at the National Research Centre Kurchatov Institute,” ISSN 1547-4771, Physics of Particles and Nuclei Letters, Vol. 9, No. 4-5 (2012) pp. 456-460.

ISBN 978-3-95450-139-7