

# CONTROL SYSTEM FOR INJECTION CHANNELS OF VEPP-2000 COLLIDER<sup>†</sup>

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## Abstract

The paper presents architecture, implementation and functionality of injection channels control system for VEPP-2000 collider. The software according to hardware system consists of different interacting subsystems responding on different injection channels parts.

The paper describes structure and implementation of the hardware of the collider control system. The system consists of pulse-elements; steering coils power supplies and nanosecond high-power kicker (60 kV, 20 ns). The system is based on modern industrial protocol CAN-bus, CAMAC standard and specialized electronic BINP manufactured blocks according the standards.

Software for the control system is based on several TCP/IP connected PC platforms working under operating system Linux and uses client-server techniques. CAN and CAMAC servers; different clients for control and power supply measurements; kicker control tools and their interaction with the rest of VEPP-2000 control system are described.

## OVERVIEW

There are two injection channels on VEPP-2000 collider facility. One for electrons, another for positrons. They have 15 meters length and complicated 3D geometry. Injection into collider ring occurs in horizontal plane in technical straight section with zero dispersion function. General view of the channels is shown on Figure 1 [1].

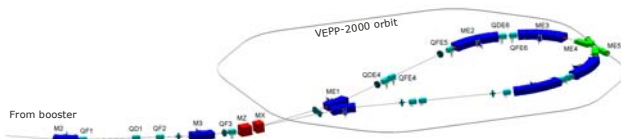


Figure 1: General view of VEPP-2000 injection channels.

Electron and positron channels have common part from booster to MZ element (Figure 1). Then electrons and positrons are deflected to opposite sides by MX deflector. Totally the channels consist from 35 pulsed elements: septum-magnets, quadrupole magnets, steering and deflecting magnets; 15 direct current steering coils and deflection/inflexion elements. So the main goal of the channels automation system is to provide to operator clear and convenient interface for beam tuning. Feasibility of beam transportation primarily depends from the quality of the system.

Different channels elements are powered with different types of power sources. Magnetic elements grouped by

power sources are presented in Table 1. All control and measuring devices are BINP developed and made [2].

Table 1: The overview of VEPP-2000 injection channels hardware: power sources and control units.

Elements	Power Source Type	Control Units	Protocol	N of PS
Extraction and injection magnets	Pulsed High Voltage Power Source	CPC*, TIG*	CAN-Bus	3
		PPMD*, OSC*	CAMAC	
Quadrupole, steering, deflection magnets	Pulsed Power Source (ACCORD)	CPC*, TIG*	CAN-Bus	30
		PPMD*, OSC*	CAMAC	
Direct current steering coils	PA-6, PA-20	DAC, ADC	CAN-Bus	15
Deflector, preinflexor, inflector	Nanosecond Pulsed Generator	CPC*, TIG*	CAN-Bus	5
		DPG*, TIMD*	CAMAC	

## PULSED HIGH VOLTAGE AND “ACCORD” POWER SOURCES

Control type for these two PSs is very similar. Pulse amplitude is preset by code of CPC. The time of shot (delay from the start pulse) is preset by code of TIG with less than microsecond accuracy. The measurement of the pulse parameters is carrying out by pulse parameter measuring device (PPMD) and digital oscilloscope (OSC) if it is needed. All aforesaid is illustrated by Figure 2.

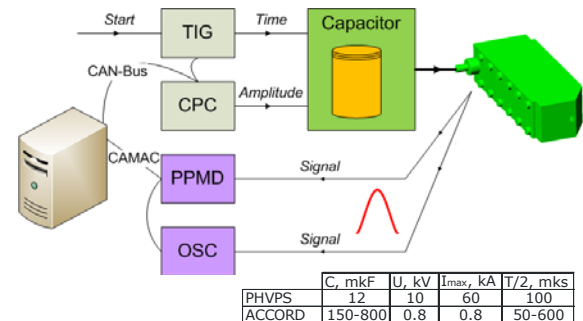


Figure 2: Scheme and main parameters of pulsed power sources. PPMD – pulsed parameters measurement device – integrating ADC.

All control and measuring devices are multi-channel ones and can serve several power sources. Moreover in order to reduce the number of power sources the subsystem has switches for power lines between different magnetic elements. For instance such switch commutates electron and positron injection magnets.

## PA-6 AND PA-20 POWER SOURCES

DC power amplifiers (PA) are used to supply steering

\* Abbreviations:

CPC - Code Porosity Converter. Sets the amplitude of generator pulse;

TIG - Time Interval Generator. Sets the time of the generator shot;

PPMD - Pulsed Parameters Measuring Device. Integrating ADC;

OSC - Digital oscilloscope;

DPG - Delayed Pulse Generator. Sets the time of deflector/inflexor pulse with nanosecond accuracy;

TIMD - Time Interval Measuring Device.

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coils of injection channels [3, 4]. PA current is set by multichannel DAC, current and voltage are measured by multichannel ADC. Schematic of the coil powering is shown on Figure 3.

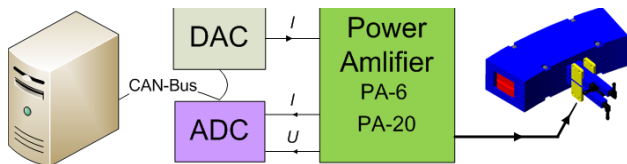


Figure 3: Steering coils supplying schematic.

**NANOSECOND KICKER GENERATOR**

Special power source was developed in BINP to supply inflection plates with 60 kV, 20 ns travelling wave pulse. Control and measuring schematic of the generator is shown on Figure 4.

The PS “ACCORD” is used as a capacitor for the generator. DPG device is used for precise nanosecond time tuning. Strongly reduced signal from the kicker is forwarded to TIMD to measure the time of the “shot”.

At the VEPP-2000 facility one such generator is used for supply booster deflector and four ones is used for supply pre-kicker and kicker in electron and positron modes.

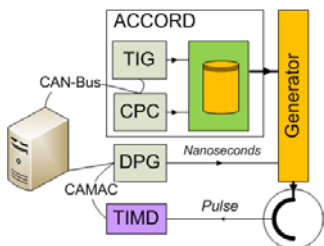


Figure 4: Schematic of inflector generator.

**SOFTWARE**

Special automation system was designed for VEPP-2000 injection channels. The system is based on client-server model over TCP/IP protocol.

Low (server) level responses for CAMAC and CAN-Bus communications with control and measuring devices. Reasoning from peculiarities of hardware the software low level was separated on three independent applications: DC-server, Pulse-server and CAMAC-server. This approach led to significant simplification of internal server’s logics and allowed to unite similar elements into subsystems (DC, Pulse). These servers obtain initial information (correspondence between the element name and hardware addresses of control and measuring channels) from respective databases. The databases were designed taking into account peculiarities of each subsystem to facilitate its configuration as much as possible.

GUI application level at present time consists from three clients: Channel Control, Kickers Control, and Pulsed Parameter Measurement.

The Channels Control application (Figure 5A) is intended for tuning the majority of injection channels magnetic elements. It gets initial configuration from two databases (DC and Pulse) to unite elements of different types into one interface. Elements are grouped by itself function: quads, vertical deflectors, horizontal deflectors, etc. The program functionality allows independent tuning electron and positron channels; saving, reviewing and recovering saved elements settings; automatically changing settings according to electron or positron facility operation mode.

Kickers Control (Figure 5B) was extracted to individual application dew to complexity of the generators control and measurements. It communicates with two servers (Pulse and CAMAC) to provide to the operator all possibilities of the kicker tuning “at one place”. That means that different typed kicker control and measurement channels are united in groups named by the kicker’s purpose. The application provides almost the same functionality as the previous one. The main features of the program are: independent electron and positron modes tuning and storing measurements; automated changing modes settings.

Figure 5C presents Pulsed Parameter Measurement application. Its goal to provide to the operator pulsed elements measurements data. The program can store good values to further channels tuning with previous program.



Figure 6: Digital oscilloscope application. There are four pulses of different elements of injection channels.

Another software subsystem, based on OSC module, is intended for digital oscilloscopic measurements of different pulsed signals at the facility. It does not have rigid connection to the injection channel automation and can be used as a standalone solution for different tasks. Nevertheless the subsystem is also works by client-server technique and can be involved into the VEPP-2000 facility automation system. The frontend of it is shown at Figure 6.

### TIME SYNCHRONIZATION

Special designed in BINP device produces two referenced to RF phases of booster and collider rings pulses: “pre-injection” and “injection”. The former starts all TIG devices simultaneously 1230 mks before the later. This delay defined by discharging properties of pulsed power sources. The “injection” pulse starts DPG control units of deflector and kickers, starts nanoseconds measurements and at the same time stops pulsed parameter measurements. The device allows changing booster and collider RF synchronization but its consideration is out of the present paper.

### CONCLUSION

The worked out control system for VEPP-2000 injection channels is one of key points of successive beam injection into collider ring. The automation system is based on modern client-server model and consists from three specialized hardware server applications and three main GUI clients providing needed to operator functionality. The designed system allows tuning, storing, reviewing and recovering electron or positron modes of the facility operation.

Configuration databases are another main parts of the control system. Their architecture is designed according to the hardware specifications to make as easy as possible configuration of each subsystem and searching and elimination its inevitable malfunctions.

The servers and databases, described in the paper, serve not injection channels automation system only. They are used by other applications as well. For instance collider ring control application.

There are several applications which have not found their consideration in the present paper. For instance client for measurement and on-line visualization several tuning pulses of kicker’s generators.

In spite of sufficient tuning functionality at present time the system is not totally finished. Some applications is under designing, other have to be designed.

### REFERENCES

- [1] Beams Injection System For e+e- collider VEPP-2000. D.E.Berkaev at al. EPAC-06 Proceedngs, MOPLS037.
- [2] <http://www.inp.nsk.su/activity/automation/2009>.
- [3] Power Amplifiers UM-6 and UM-20 to Supply of the Corrector Magnets of the VEPP-2000. O.V.Belikov, D.E.Berkaev, V.R.Kozak, A.S.Medvedko. Preprint BINP 2007-14, <http://www.inp.nsk.su/activity/preprints/>
- [4] Power supply system for corrector magnets of VEPP-2000 complex. O.V. Belikov, D.E. Berkaev, V.R. Kozak, A.S. Medvedko (BINP Russia). RuPAC-06 Proceedngs, TUHO06.

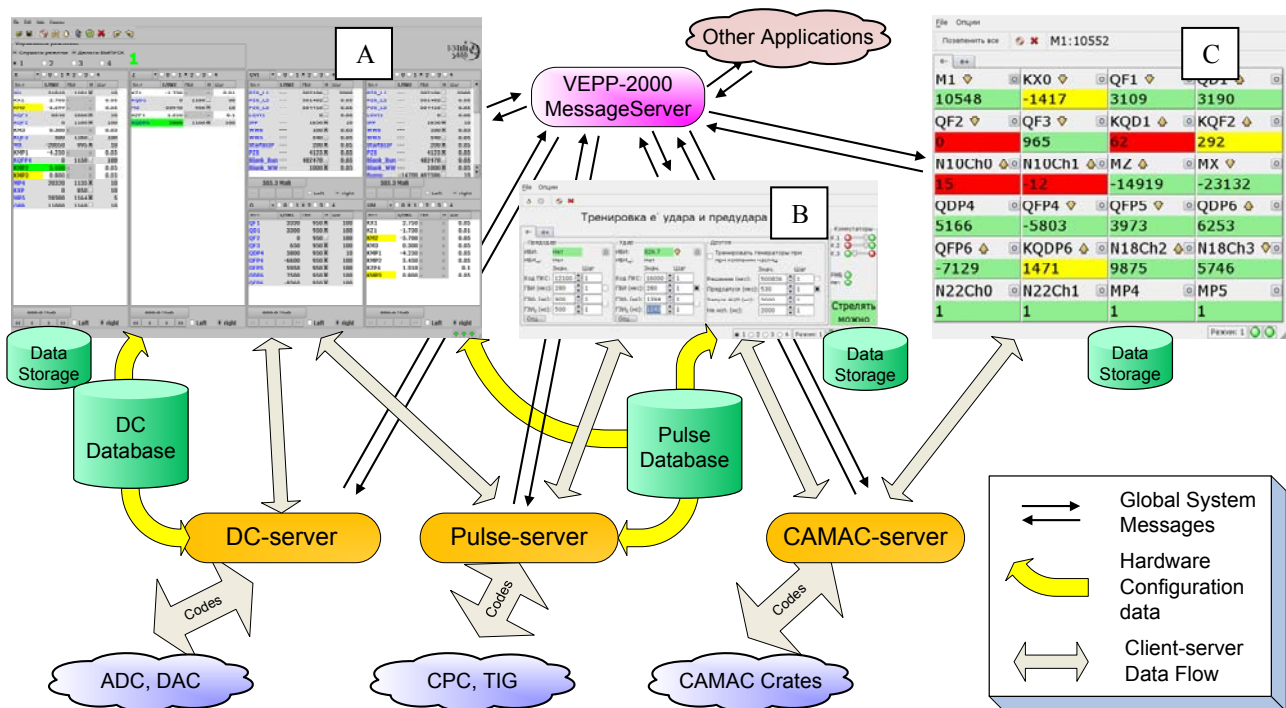


Figure 5: VEPP-2000 injection channels automation system layout. Three servers and three GUI applications provide needed functionality for channels tuning. “Global System Messages” allows to the application to exchange with messages about mode changing, different global settings changing, failures, etc.