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LINAC-200 GUN CONTROL SYSTEM: STATUS AND PLANS

M. Nozdrin*, V. Kobets, V. Minashkin, A. Trifonov
Joint Institute for Nuclear Research, Dubna, Russia

Abstract

Due to the development of the global Tango-based control system for Linac-200 accelerator, the new electron gun control system software was developed. Major gun electronics modification is foreseen. Current gun control system status and modification plans are reported.

INTRODUCTION

Linac-200 accelerator [1] is the core of the new electron test beam facility in JINR. It's quite hard to obtain necessary beam quality with standalone control subsystems, so the new global control system based on Tango is being developed [2]. In the frame of this work the existing gun control system part based on a standalone PC should be exchanged to a new one (Tango device & corresponding client).

HARDWARE

Electron Gun

Triode MIT-designed DC gun is used [3, 4]. Gun is placed in the SF_6 filled tank (pressure 6 atm) for better electric durability. Gun and cathode parameters are given in Tables 1 and 2 correspondingly.

Table 1: Parameters of the Linac-200 Gun

Type	Thermionic
Max. energy	400 keV
Beam intensity (peak)	200 mA
Normalized emittance	8π mm mrad
Pulse duration	200 mA

Table 2: Parameters of the Linac-200 Gun Cathode

Type	Dispenser
Max. energy	W + 20% Ba, Ca & Al oxides
Diameter	8 mm ($S = 50\,mm^2$)
Working I & U range	6.5 V / 4 A to 8.8 V / 5 A
Lifetime	15000–20000 hours

Cathode is mounted at the end of the HV column — multisectional vacuum insulator separating the vacuumed beam chamber and the gas-filled gun tank. Gun electro-optical system consists of the extractor electrode and 15 anodes with forced resistive ($R = 200$ M) potential distribution (about 30 kV per gap).

First focusing anode voltage can vary in the range from 8 to 20 kV. Extractor electrode pulse is generated by Marx generator. Possible voltage is from −400 V (turnoff voltage) to 5 kV, pulse length—from 100 ns to 50 µs.

Schematic view of the Linac-200 electron gun control system structure is presented at Fig. 1. Controller board architecture is shown at Fig. 2. Gun optics and electronics scheme is shown at Fig. 3.

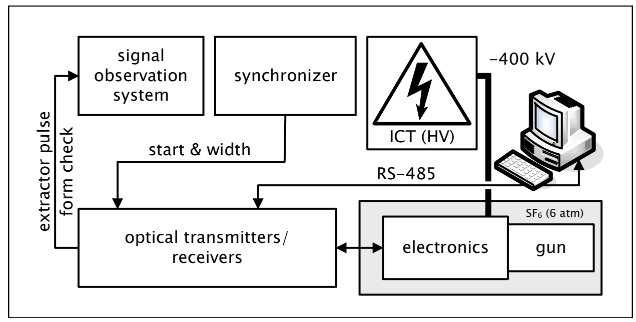

Figure 1: Linac-200 gun control system structure.

Gun Electronics

Cathode electronics is housed on the hot deck inside the tank. All cathode electronics assembly is "suspended" at a potential of −400 kV while the accelerator beamline is grounded.

Electronics consists of the following boards:

- Controller board acts as interface between the cathode electronics and the control computer.
- 50 kHz board supply transfiorms input voltage of 187 V / 50 Hz to 2 × 65 V / 50 kHz.
- Filament supply board sets the cathode filament current.
- Extractor pulser ensures the gun extraction pulse with necessary parameters.
- 1st focusing electrode voltage board is self-explanatory.

Controller Board

Board includes ATmega32 microcontroller, 4 DAC and 16 ADC channels, input register with 8 inputs, and output register with 8 outputs (TTL).

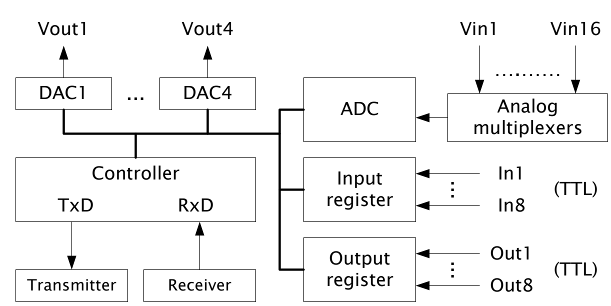

Figure 2: Controller board architecture.

* nozdrin@jinr.ru

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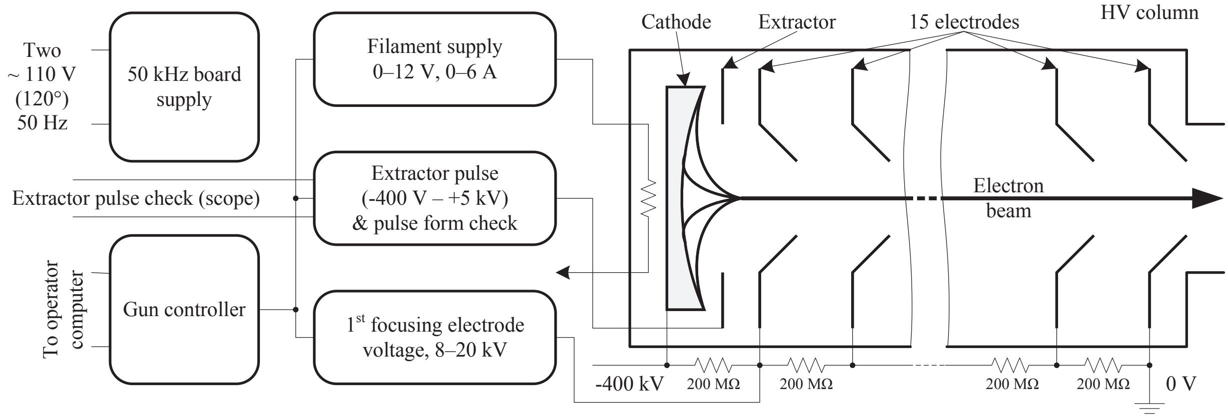

Figure 3: Gun optics and electronics.

Current implementation uses the following channels:

- 3 DAC are responsible for refetence voltages setting (to control filament supply, 1st focusing electrode and extractor voltages).
- 6 ADCs are used for measurement of the gun analog parameters (filament voltage and current, cathode electronics board voltage, pressure and temerature of the SF_6 gas, and 1st focusing electrode voltage).
- 2 input register stand for disrete parameters—status of two cathode electronics coolers in the tank (ON/OFF).

The rest channels are for future use / as spare ones.

Communication Line

To exchange information between the cathode electronics and outside equipment (–400 kV potential difference), optical fibers are used. Outside the gun RS-232 is used, than it converts to RS-485 to transmit information to control room (and receive it from it), and again to RS-232 to connect to the control PC.

New Setup

The only device changed in the frame of the integration of the gun control system to the global Tango-based system, is the control PC. It is changed to the same form-factor 4U industrial PC, which now runs under Debian 9. Tango server runs on this PC, client—at operator PC (as all the clients do). All the rest equipment, including the communication line, remains in service so far.

SOFTWARE

Communication Protocol

Information exchange between the gun controller and control computer is performed via the following protocol. PC (master) sends four bytes (device address, controller function to perform, and two data bytes) and waits an aswer from the controller. Delay between bytes is about 50 µs. Gun controller (slave) receives these four bytes, and sends an answer:

- Three bytes in the case of normal operation. First byte is the same as in control message, the other two contain data.
- Two bytes in the case of error. First byte again repeats the control message one, second byte contains an error code.

Timing diagram of one data exchange cycle is presented at Fig. 4. Full duration of one cycle is about 1 ms.

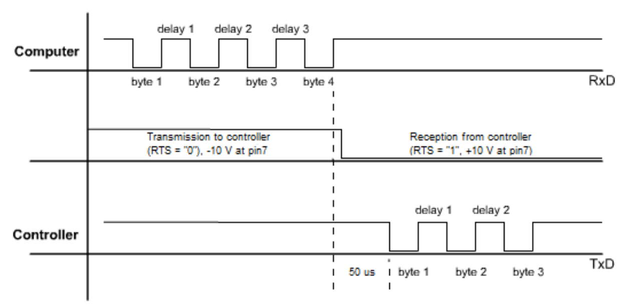

Figure 4: Timing diagram of one data exchange cycle between gun controller and control PC.

Standalone

The control software version developed for initial Linac-200 startup [5] was written in the Borland Pascal 7.0 under DOS and was interacting with the serial port using the `Port` predefined array. Next version was developed in Borland Delphi (Object Pascal) and was running under Windows XP [6].

Tango Device Class (Server)

Tango class `Gun` is written in C++ and runs under Debian 9. Due to communication protocol nonstandartness the UART driver was also included (instead of using corresponding communication device classes from Tango catalogue. Class structure in Pogo class generator is shown at Fig. 5.

Tango Device Client

The client application (Fig. 6) provides a graphical interface for controlling the electron gun. It is implemented in

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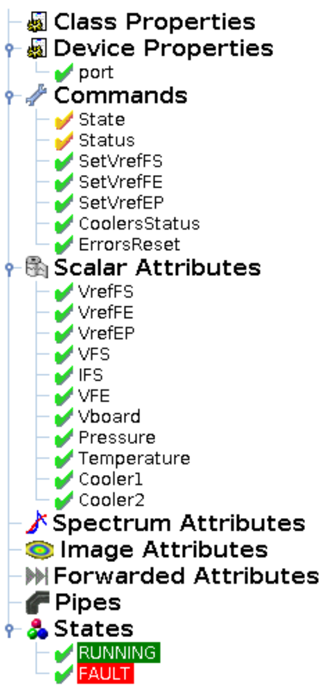

Figure 5: Gun class structure in Pogo.

C++ using the Qt5 framework and QTango library, and has the following functionality:

- control of the filament supply reference voltage;
- control of the 1st focusing electrode reference voltage;
- control of the extractor reference voltage;
- monitoring of the filament supply real voltage and current;
- monitoring of the 1st focusing electrode real voltage;
- provides information about the electron gun device server status.

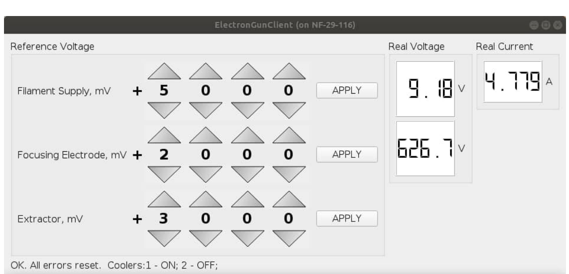

Figure 6: Gun client application.

Some gun parameters (SF_6 pressure and temperature, cathode electronics board voltage) are not presented, because corresponding sensors are not installed yet.

Emulator Tests

For preliminary testing the gun emulator was developed. The initial idea was to develop it also as Tango device by making use of an event mechanism. But it turned out that minimal polling interval is 5 ms (which is not sufficient). So the emulator was written as a common Linux C++ console application.

The emulator is a "semihardware" one, it takes one COM-port and acts like it is a gun controller I/O. So it's possible to work both with two PCs (one represents "gun", another—control computer), or with one PC representing both "gun" and control computer at different COM-ports.

The first configuration (two PCs) was used during emulator development and debugging. New PC with emulator was connected by RS-232 to the old gun operator PC. The emulator was considered as fully ready only when it could be fully recognized by the old (standalone) GunCtrl software as the real gun (no any errors, correct data exchange etc.)

After that, debugging of the Tango device class has been performed (now using one PC configuration with two ports connected by RS-232).

CONCLUSION & OUTLOOK

- C++ Tango device class and QTango client for Linac-200 electron gun were developed.
- C++ gun emulator was developed for testing.
- All software was successfully tested with emulator, tests with equipment will start after the end of the accelerator shutdown.
- The following hardware R&D is planned:
  - Bench for cathode electronics tests and repair works.
  - Full redesign of the cathode electronics using modern components.

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