CONTROL SYSTEM OF THE BOOSTER INJECTION POWER SUPPLY

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The report describes requirements for the Booster injection system, its operation algorithm and realization details. The control system is based on National Instruments CompactRIO equipment and realizes injection devices control, synchronization and monitoring. The results of high voltage tests are presented.

Keywords: NICA, Tango Controls, National Instruments, LabVIEW, accelerator injection

1.Introduction

The purpose of the NICA / MPD project (Nuclotron based Ion Collider fAcility and Multi Purpose Detector) is the creation of an accelerator complex designed to carry out a program of research in particle physics at the advanced level at JINR. The experiments will be carried out on fixed targets using beams with kinetic energy up to the maximum designed (4.5 GeV/n for $^{197}Au^{79+}$) and in the colliding beams of heavy ions with energy in the center of mass system $\sqrt{S_{NN}}$ = 4 ÷ 11 GeV/n at of the average luminosity L = $10^{27} cm^{-2} \cdot s^{-1}$. Another goal of the NICA project is to conduct experimental studies on spin physics in colliding polarized beams of protons and light nuclei [1].

Three pairs of electric deflecting plates will be placed in the Booster ring. They will provide injection of heavy ion beam into the Booster in one-turn, multi-turn and multiple modes [2]. At the starting minimum, we use only 1 section of deflecting plates. In order to control the system for starting minimum, this is made on chassis cRIO-9068 by National Instruments with the use of LabVIEW. For easier control and mobility was made two Tango Controls device servers and two GUI clients.

2. Technical requirements for the power supply system of deflecting plates for the starting minimum

The main requirements for the deflecting plate power supply:

- Maximum electrical potential on the plate 60kV
- Charging time of the plate<50μS
- Duration of the plateau of the pulse, not less than30μS
- Heterogeneity of voltage on the plateau ≤1%
- The discharge time of the plate ≤0.1μS
- Residual voltage after discharge of plates ≤0.5kV
- Number of pulses in a row 1 – 3
- Pulse iteration rate 10 Hz.

3. Power scheme and requirements for the devices

On the starting minimum, only one deflecting section with two plates will be used with one plate grounded. The simplified scheme of the plate power supply is presented on the Figure 1. It has control and high voltage parts. The control part consists of chassis, Sorensen DCS300-3.5 power supply and thyristor pulse generator designed in JINR. Requirements for the power supply and thyristor pulse generator are following:

- remote start;
- output level control in the range 0 - 300 V with accuracy 0.1%;
- switching output of the power supply (about 10 ms before switching thyratron) with time step1ms;
- switching on the output pulse (about 100 ms before injection) with time step 1 ms;
- switching off the output pulse (about 10 ms before injection) with time step 1 μs.

The high voltage part of the scheme consists of thyratron with driver, step up transformer GE-36 and equivalent load of 450 pF. The requirements for the high voltage part are:

- Adjustable start with time step and jitter ≤ 10 ns;
- Control of grids and filament voltages.
- Measurements of the output pulse amplitude and shape in range of 0 - 5 V with accuracy 0.1%.

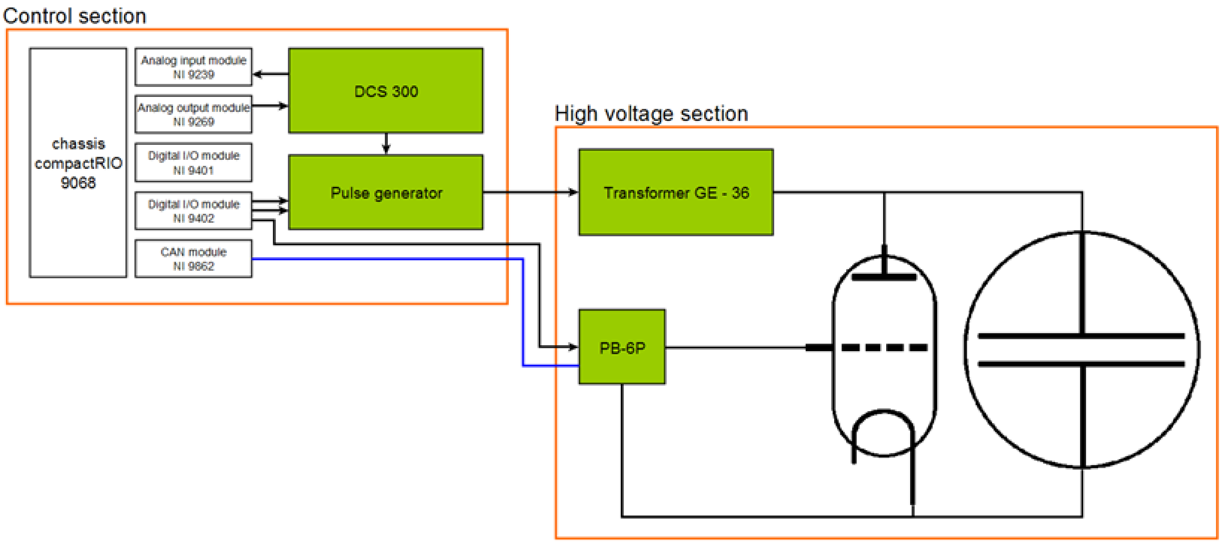

Figure 1. Power and control scheme

4. Control system layout and operation

The control system is based on a chassis cRIO-9068 and few acquisition modules:

- NI 9239 – 4-channel analog input module, for voltage measurement;
- NI 9269 – 4-channel analog output module, for voltage control;
- NI 9401 – 8-channel slow digital I/O module, for safety and interlock signals;
- NI 9402 – 4-channel fast digital I/O module, for triggering of individual blocks;
- NI 9862 – 2-channel CAN interface module, for thyratron driver control.

The chassis cRIO-9068 includes Zync-7200 FPGA, 2-core ARM processor with 667MHz clock and 512MB onboard RAM. The FPGA is clocked with 120MHz and performs all synchronization and acquisition tasks. The FPGA firmware has been developed using LabVIEW with FPGA module. The onboard ARM processor runs Linux OS. Few TANGO controls device servers has been developed using C++ to perform thyratron driver control, interface with FPGA firmware and communications with the main control system.

TANGO GUI clients were developed to perform the system management (Figure 2, Figure 3).

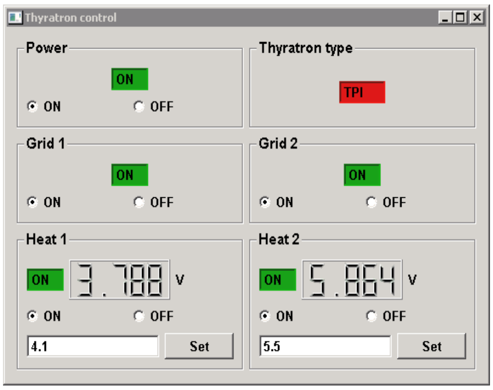

Figure2. The GUI client for thyratron control

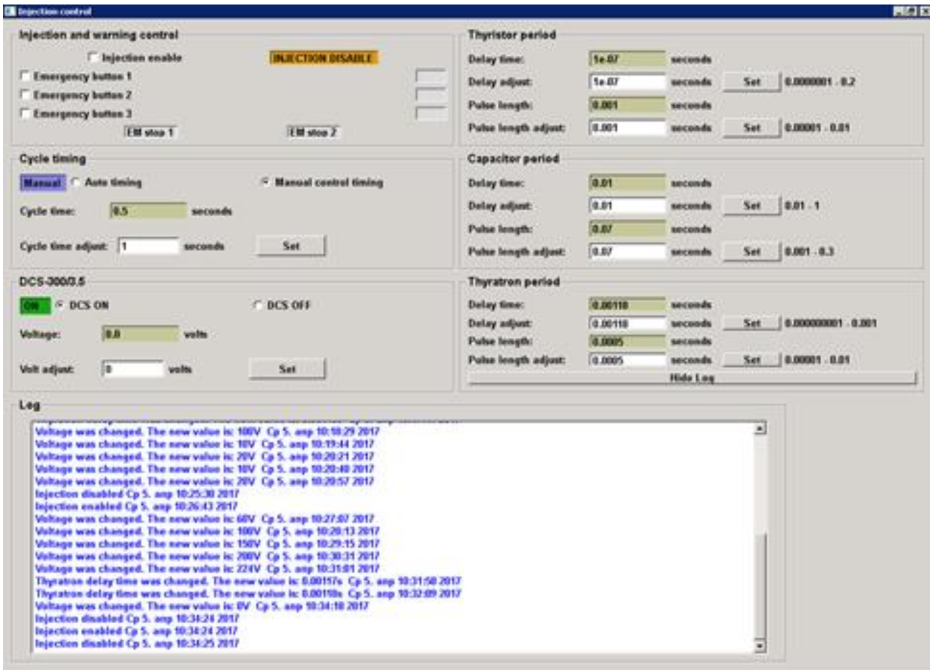

Figure 3. Main GUI client

5. Results

The system for deflecting plates control and monitoring has been developed and tested. The main result of the tests was the obtaining of the required parameters of a high-voltage output pulse at equivalent load of 450 pF(see Figure 4):

- The voltage on the equivalent load exceeds 60 kV with residual post-pulse voltage less than 300V;
- the discharge time does not exceed 100 ns with jitter less than 10ns.

A successfully completed test program allows us to conclude that the main parameters of the power supply system of the Booster inflector plates comply with the technical specification and the system is ready for tests on the real load.

The system is ready to connect to the real load on the Booster installation.

Figure 4. Test results

References

[1] A. Averichev et al. NICA technical design report - Dubna, 2015, vol. 2

[2] V. Bulanov, E. Gorbachev, N. Lebedev, A. Tuzikov, A. Fateev. Conceptual project of the power source system for deflecting plates of multivariate injection into the Booster of the NICA accelerator complex - Physics of Particles and Nuclei Letters, 2014