Control System of the Linear Accelerator as a Part of Nuclear Facility NSC KIPT Neutron Source

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Abstract

NSC KIPT Neutron Source on the base of subcritical assembly involves 100 MeV/100 kW electron linear accelerator as a driver [1,2,3]. Because the Neutron Source is nuclear facility, all technological systems of the facility are under regulation of State Inspection of Nuclear Regulation of Ukraine that is working in accordance with international nuclear regulation legislation. This regulation demands certain requirement to the design and realization of the facility control system in order to provide the conditions of the facility safe operation. In the paper, the features of control system of the linear accelerators as a part of nuclear facility NSC KIPT Neutron Source are described.

The Structure of control system

Control System of the Linear Accelerator of "Nuclear Facility" is designed for monitoring and control the equipment of the accelerator and the accelerator transportation channel in all operation modes, ensuring the safety of the operation of the "Neutron source" and accelerator, the accelerator shut off for any violations of normal operation and accidents, control the power of a beam, the repetition rate and the charge of electron pulses. The Linac control system of nuclear subcritical assembling "Neutron source" consists of the following subsystems:

Low level:
- sensors and control driven equipment and devices:
- driven equipment of the triode electron gun control block of the Linac pulse start subsystem;
- driven equipment of the RF parameters control subsystem;
- driven equipment of controlled power supplies of the subsystem for control the parameters of magnetic elements;
- sensors and recording devices of control subsystem of the vacuum system parameters;
- sensors and control devices of the control subsystem of the cooling and thermostabilization system;
- sensors and recording devices of the electron beam parameters monitoring subsystem.

Middle level:
- subsystem of the Linac pulse start;
- RF field parameters control subsystem;
- control subsystem of the magnetic elements parameters;
- subsystem for control of the vacuum system parameters;
- subsystem of monitoring of the electron beam parameters;
- control subsystem of cooling and thermostabilization system;
- Fast interlock block
- electronic keys for opening the Linac start signal;
- media converters and optical keys for contact breaking of timing pulse;
- transmission and primary data processing system.

High level:
- the Linac operator's console;
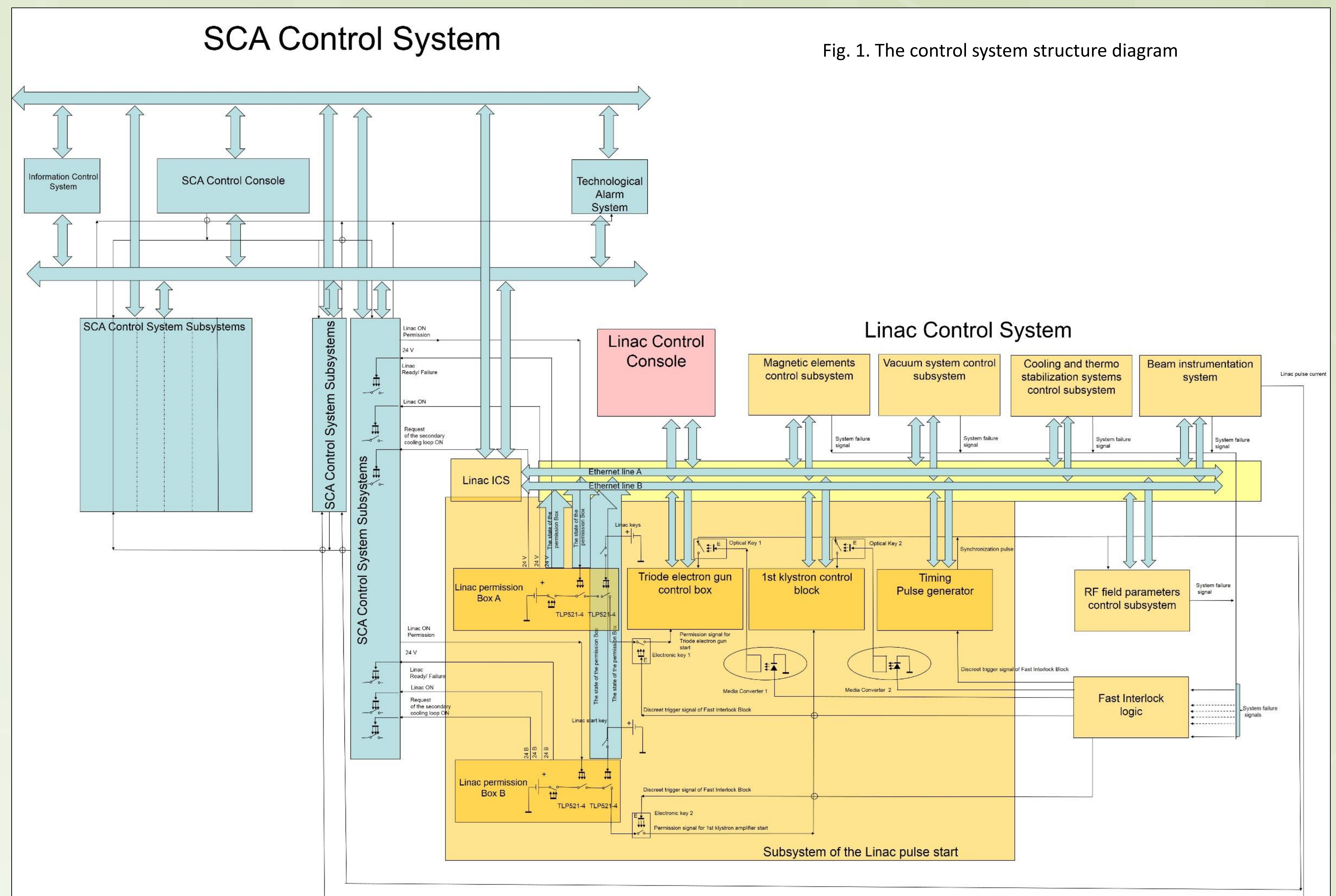- Software of Linac nuclear subcritical assembling "Neutron source".

Fig. 1. The control system structure diagram

Fig. 2. The control room

The Linac operator's console includes 4 workstations for control systems of the first loop (30 C) of the klystron generator cooling system, the first loop (30 C) of the cooling system for electromagnetic elements and equipment located in the accelerator tunnel, the first and second loop (40 C) of the cooling and thermostabilization system of the accelerating sections and the injector, accelerator system and waveguides, electron gun, klystron RF amplifiers and parameters of the accelerating HF field, magnetic elements, electron beam parameters, low level RF field.

Linac control system of the SCA "Neutron source" provides the formation and output:
- Discrete signals to the SCA Interlock system of "Neutron Source"
- Digital information to data-computing network of the SCA "Neutron source";
- Digital and analog information to the Neutron Flux measurement system to ensure synchronization of the operation of the "Neutron Flux density monitoring system" equipment (repetition rate from 1 to 625 Hz) and provide input data for the implementation of the algorithms for the primary calculation of the neutron K-factor for the neutron source, and synchronization of the start of the accelerator and the neutron flux registration system.

Linac control system provides input:
- Discrete signals from the SCA "Neutron Source" to the "Permission Box" of the Linac of the control subsystem of the Linac start control system;
- Digital information and directives of the SCA "Neutron Source" in the data-computing network of Linac control system.

Cable connections of discrete and digital lines, interaction of SCA "Neutron Source" and Linac control system are performed by duplicated cable lines.

The block for starting the Linac that is the "Permission Box" of the Subsystem of the Linac pulse start is duplicated

The safety ideology

The electron beam is switched on / off by: "Triode electron gun control box", "1st klystron amplifier control block" and "Timing Pulse generator". Switching on happens in the case of availability of the signal from the "Linac Permission Box" and the synchronization pulse from "Timing pulse generator" and when the signal "Beam Enable" is received by the Linac control system from the SCA Interlock system of "Neutron Source" .

The "Linac Permission Box" generates the Linac start signal by closing the electronic relay when receiving the 24 V signal "Switch on the Linac" from the SCA Interlock system of "Neutron Source" without using the Linac software. The software is used to monitor the status of the block and check the logic of its operation.

The drive lines of the start signal from the "Linac Permission Boxes" are equipped with electronic keys. The keys provide the transmission of signals from the "Linac Permission Boxes" only at the absence of a signal about the failure of the operation of Linac technological systems from the "Fast Interlock Block".

The synchronizing pulse transmission line of the "Timing Pulse generator" to the "Triode electron gun control box" is equipped with an optical key with a media converter. The key allows to transmit the signal and the synchronizing pulse of the "Timing Pulse generator" to the "Triode electron gun control box" only in the absence of a signal about the failure of the Linac technological systems from the "Fast Interlock Block".

The synchronization pulse signal line of the "Timing Pulse generator" from the "Control unit of the 1st klystron amplifier" to the 1st klystron amplifier is equipped with an optical key with a media converter . The key allows to transmit the signal and synchronizing pulse of the "Timing Pulse generator" to the 1st klystron amplifier only in the absence of a signal about the error of Linac technological systems from the "Fast Interlock Blocks".

The "Fast Interlock block" is an electronic device at the inputs of which analogue interlock signals from Linac technological systems are entered. The electronic circuit of the "Fast interlock Block" is realized as a device with "and" logic. If there is an interlock signal at least on one of the inputs, the interlock signal appears at the output of the "Fast Interlock Block". Thus, if there is an error in the operation of Linac technological systems, the Linac startup is blocked without the use of Linac control system software.

Linac control system provides fast shutdown of the electron beam in the case of failure of any technological subsystems of the Linac by breaking the synchronization pulse of the "Timing Pulse generator" by the electronics of the "Fast interlock Block" .

Linac control system provides a fast emergency shutdown of the electron beam by electronics of Linac "Permission Boxes" in case of removing the signal "Switch on the Linac" from SCA Interlock system of "Neutron Source" by switching off the triggering signal of the triode electron gun and the first klystron amplifier by two Linac "Permission Boxes", then switching off the triode electron gun by the triode gun control unit, switching off of the first klystron amplifier by the control unit of the first klystron amplifier and switching off of the synchronizing pulse by the "Timing Pulse generator".
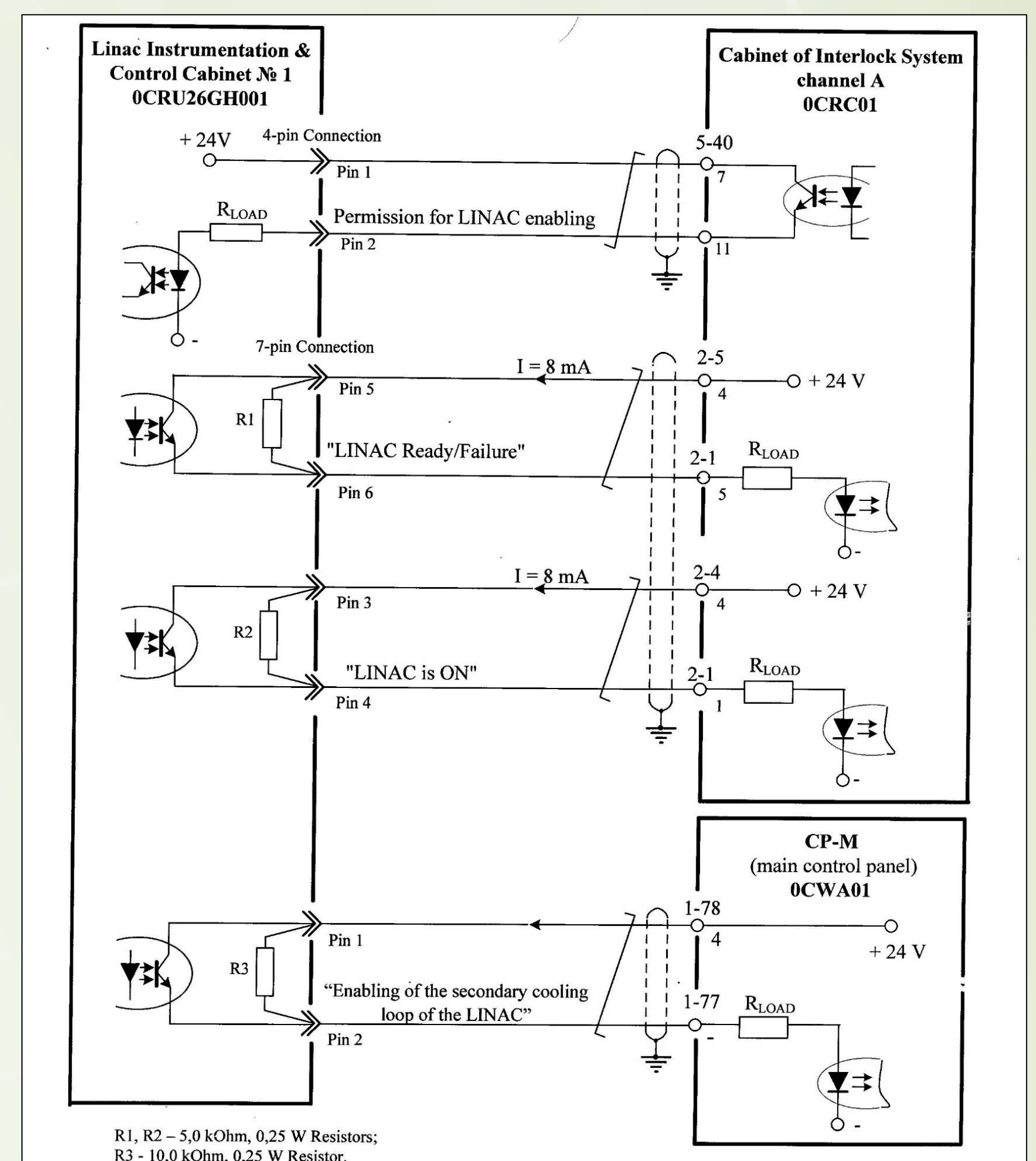

Fig. 3. Scheme of interaction of one of permission boxes with control system of SCA "Neutron Source"

Conclusion

Control System of the Linear Accelerator is on the final stage of development. All comments and suggests made by State Inspection of Nuclear Regulation of Ukraine were realized.
The testing and commission of the control system is going to be held on Dec. 17

References

[1]O. Bezditko et al. NSC KIPT Neutron Source on the base of Subcritical Assembly Driven with Electron Linear Accelerator// Proc. Of IPAC'2013, 12-17 May, 2013, Shanghai, China, THPFI080, pp. 3481-3483, http://www.JACoW.org
[2]Yunlong *Chi* et al. 100 MeV/100 kW Electron Linear accelerator driver of the NSC KIPT Neutron Source// Proc. Of IPAC'2013, 12-17 May, 2013, Shanghai, China, THOAB203, pp. 3121-3123, http://www.JACoW.org.
[3]A. Zelinsky et al. Test and Commissioning Results of NSC KIPT 100 MeV/ 100 kW Electron Linear Accelerator, Subcritical Neutron Source Driver// IPAC'2017, 14-19 May, 2017, TUPIK033,   http://www.JACoW.org.
[4] O. Bezditko et al. Status of the NSC KIPT Neutron Source// ICALEPCS'2017, 07-13 October, 2017, TUPHA061, Barcelona, Spain, http://www.JACoW.org.

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