FIRST RESULTS OF INR RAS LINAC TIMING SYSTEM UPGRADE

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Abstract

INR RAS linac was developed in late 1970s and build during 1980s. Its timing system is based on the fifty years old technologies and requires full upgrade due to system stability decrease, lack of spare parts, progressing hardware degradation and increase in RF jamming. Moreover, the timing system upgrade should be done without additional accelerator complex shutdowns. In this paper a project of a new timing system that fulfills all requirements is presented. Various features and production peculiarities of the new timing system hardware and software are described. Results of the implementation of new system first parts and its commissioning and plans for future upgrade are discussed.

Introduction

INR linac is a high-intensity proton and H- ions linear accelerator. Whole accelerator complex is divided into six sectors. Timing system of is a part of an automatic control system (ACS) and is also divided into six sectors that have a sequential connection with each other by coaxial cables. INR linac was developed in late 1970s and build during 1980s. Since the commissioning, hardware of the timing system has never got any serious upgrades. Spare parts are not produced for more than thirty years. Moreover, during the last several years RF system of the drift-tube linac part started to produce excessive jamming signals that disrupt the work of the timing system. All these factors eventually led to a decision that our timing system needs a full upgrade.

Architecture of the new system

Development of the new timing system started at September-October 2021 with colleagues from DIALTEK, who agreed to participate in the INR linac timing system upgrade. A project of the new timing system was ready by the end of the same year. The new system was proposed to be performed as a tree (figure 1) with three types of devices (amount of each device type is presented in table 1):

- Lead device (LDSS) that forms all timing series and connects with linac machine protection system.
- Switch device (TSSS) that is responsible for the fiber connections between timing system devices.
- End-point device (EPSS) that provides timing series to the other accelerator systems.

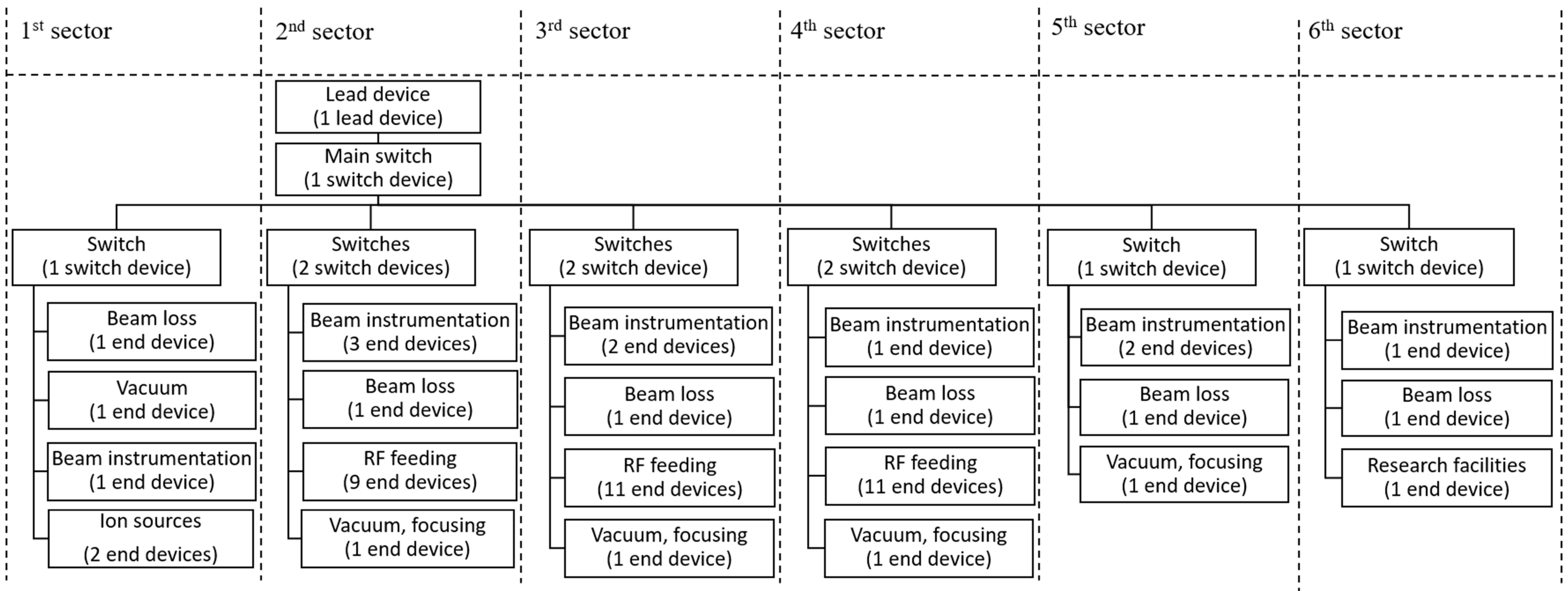


Figure 1: New timing system architecture tree.

Device type	Number of functioning devices	Number of spare devices
LDSS	1	1
TSSS	10	2
EPSS	55	2

Table 1: Amount of new timing system devices

Figure 2: LDSS manual controller.

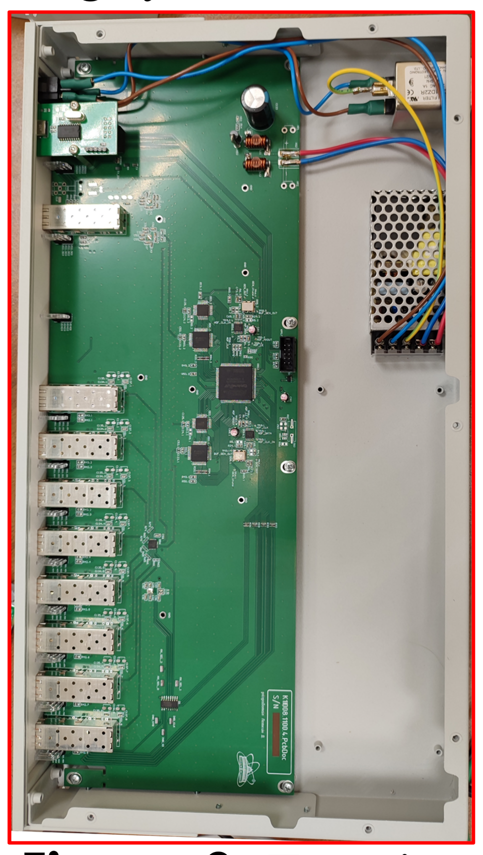
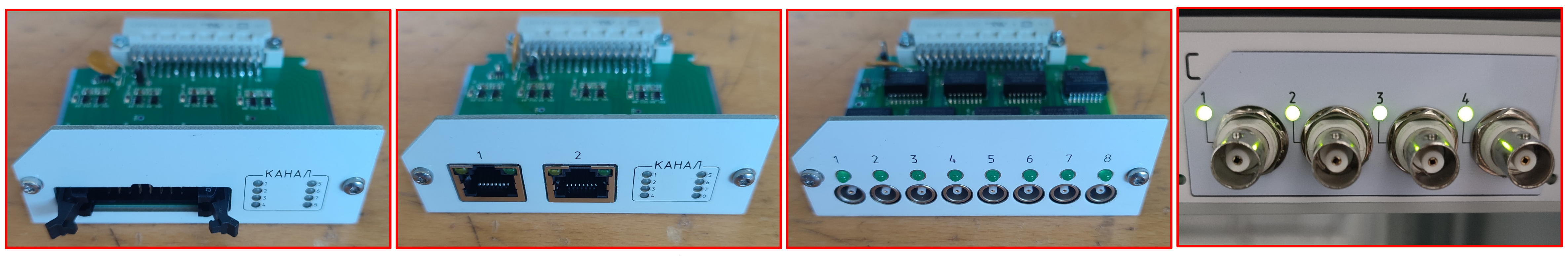


Figure 3: Top view on opened TSSS.

Hardware and software features

All devices use FPGAs for signal processing and a pair of serializer/deserializer for the timing series transmission. Control of devices is performed via UART-Ethernet module. The timing system works on a 40 MHz clock. LDSS can be controlled via timing system software or manual controller, which is shown in figure 2. Switch device (figure 3) has a Voltage controlled crystal oscillator (VCXO) for jitter minimization. Use of VCXO allows to branch the system almost without restrictions. Output system of EPSS is presented by several sub-modules (SM) that are installed by three in one end-point device. There are four types of sub-modules (figure 4). Software for the new timing system is based on TANGO. Software for EPSS control is presented in figure 5. User can enable or disable each channel, choose timing series that will be transmitted and control all timing delays.



Short connection cable SM | Long connection cable SM | Lemo SM | 1 MHz SM

Figure 4: EPSS sub-modules.

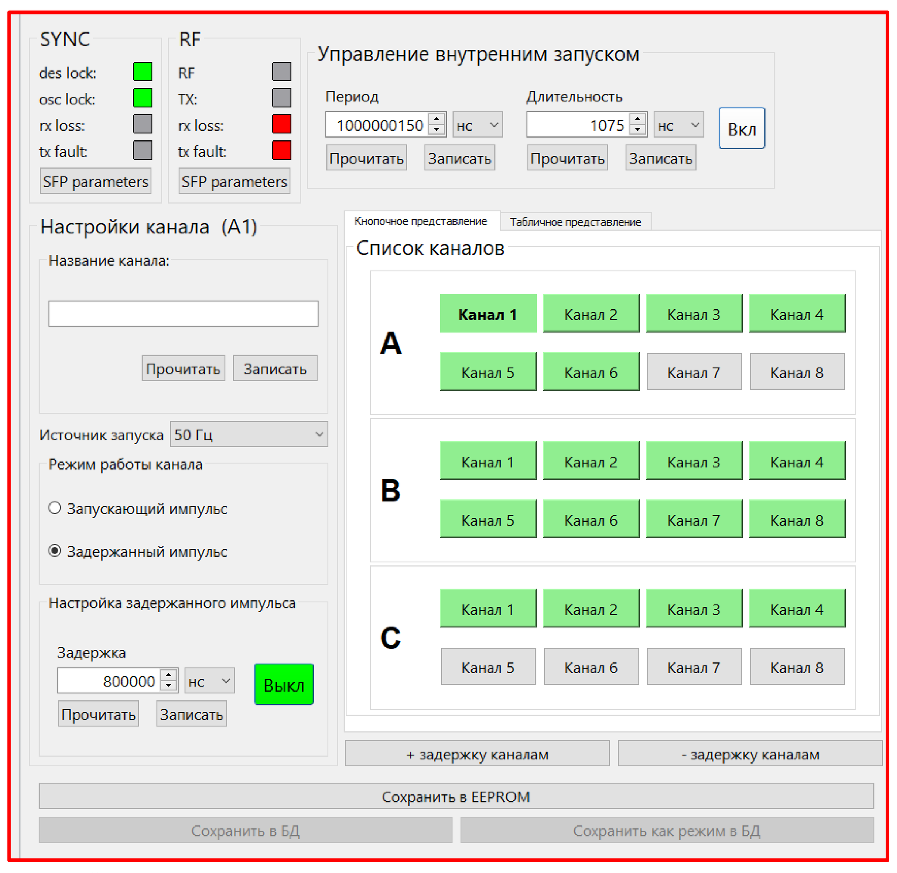


Figure 5: EPSS control software.

Timing system upgrade

Production and commissioning was separated into three parts that should be completed annually. For now devices for 1st ,2nd and 6th sectors were produced and commissioned. Production of the remaining devices will be completed by the end of 2024 and final commissioning will be done after the end of production. All production is done by DIALTEK. One of the adapter panels during assembly is presented in figure 6. For now, all produced devices are placed at the designed places (figure 7). Commissioning of the new system started in the end of 2023 with various compatibility checks. All in all the commissioning has been successful. Despite this, we did not risk to convert all accelerator systems on the new timing system because there was no much time before the next accelerator run. All cables have been reconnected only after the run. So the next accelerator run will be done with partially upgraded system. Until all equipment is produced and installed the timing system will work in hybrid mode.

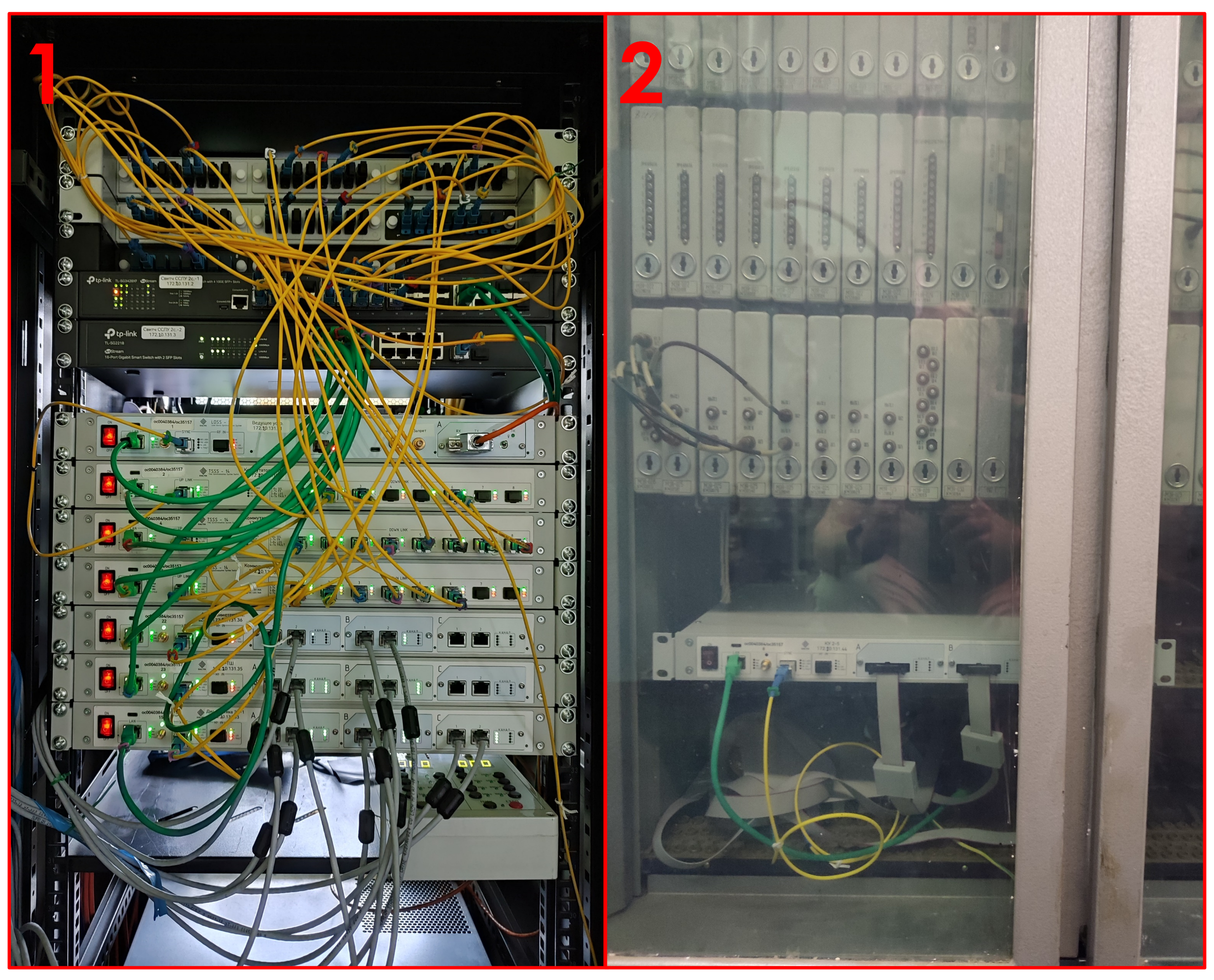


Figure 7: New system equipment in 19” rack (1) and in the old end-point device (2).

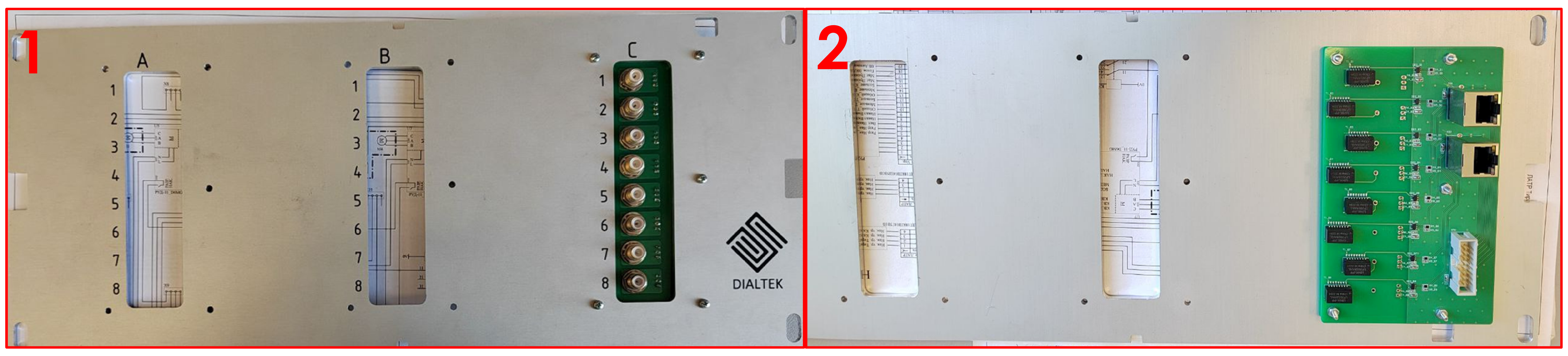


Figure 6: Adapter panel during assembly. 1 – front side, 2 – reverse side.