CONTROL SYSTEM FOR THE NEW LINAC LUE200 IN JINR, DUBNA

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Abstract

LUE200 - the 200 MeV electron linac for the pulsed neutron source "IREN" is under development in FrankLab of JINR, Dubna. The main systems of the linac, such as the general timing control, the high-power RF system, the control system of klystrons, the power supply system of magnets, the vacuum subsystem and the cooling system should be integrated into the control system of LUE200. Some subsystems units of the linac will be made by other manufacturers with different standards used. The technical integration will be based upon the Factory Suite corporation SCADA software. The personal computers will be applied as control devices and PLCs will be used at a lower level.

1 INTRODUCTION

IREN facility is an intense pulse source of resonant neutrons and represents a combination of LINAC and target–converter with multiplying shell. The beam of accelerated electrons produces the streams of braking γ-quanta and photoneutrons in the converter with high atomic number. Neutrons are multiplying in the shell surrounded with fission material (Pu_{239}) in deep subcritical state. Pulse streams of neutrons from the target are used for time-of-flight spectrometer. The purpose of the new facility is the reduction of neutron pulse duration at preservation of neutron beam high intensity in order to increase of spectrometer energy resolution. The integral neutron output of a source will make ~$9*10^{14}$ n/s at a multiplication factor of the target ~28 and duration of a neutron momentum 400 ns.

The main concept of LUE-200 is developed in the Budker Institute of Nuclear Physics [2]. The designed parameters of IREN neutron output set a mean power of an electron beam =10 kW that, in its turn, determines the energy of electrons ~200 MeV at pulse duration 250 ns, value of current of electrons in a pulse ~1.5 and pulse repetition rate of 150 Hz.

The booster consists of the electron gun, buncher, two accelerating sections, RF power sources, focusing system (including a beam transportation channel to the target), vacuum system, systems of diagnostics, control system. The RF-power supply is based on klystron amplifier built on the basis of klystron 5045 SLAC.

It is necessary to take into account some special factors for the installations of such type during the development process - availability of strong electromagnetic fields, high background radiation that entails the increased requirements to reliability of devices that are used.

2 STRUCTURE OF THE CONTROL SYSTEM

2.1 Software structure

The IREN control system consists of linac control system and subcritical multiplying target control system. The lower level of whole control system is based on PLCs and other intellectual controllers. The subcritical multiplying target control system which is being developed by the Research and Development Institute of Power Engineering is based on industrial solutions. It involves LINUX control computers and PLCs. The linac control system (Fig. 2) under development at the Joint Institute for Nuclear Research uses the Windows NT as a main operating system and the SCADA system by Wonderware as a basis for data storage and representation. Access to the database via internet is provided by the Factorysuite SCADA system that contains WWW server. The upper level of whole control system is equal for both subsystems, they have common database, control console, WWW server. Now, three variants of databases are under consideration: Oracle, MS SQL and MySQL databases. In any case, SCADA gives an ability to work with either of databases.

The reliability of data transmission is provided by the use of fiber-optic lines. A reserve control console is also provided for reliability purposes. The global interlock system is realized in hardware layer, so no destructive commands can be executed from control consoles or as a result of software errors.

The software engineering of an accelerating complex control system in a restricted time by a limited number of the experts is possible only within the framework of industrial SCADA system. The following components are included in the software structure:

- the software for the operator interface development,
- the software for controllers programming,
- a suite of I/O servers for different types of controllers,
- relational real-time databases,
- a suite for processes visualization through the Internet,
- systems for temporary and archive information storage,

- the programs for the analysis of events sequences (trends of control).

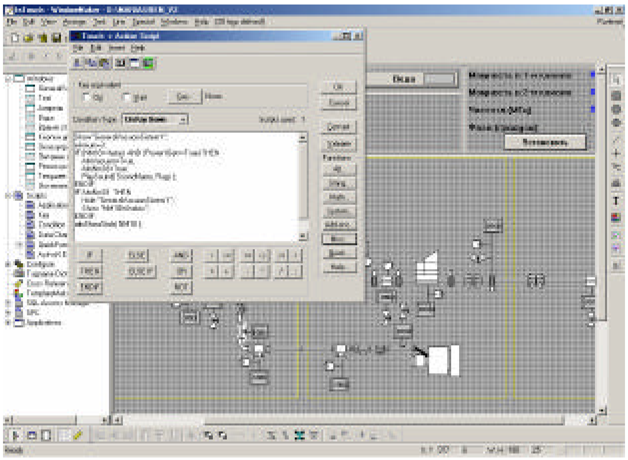

Figure 1. An example of user control interface under construction.

Three PCs equipped with big screens and installed on the control console are foreseen for adjustment of the accelerator and the control of operation of its systems. One PC will assume the role of a database server of parameters of the accelerator. Creation of an Internet - server that will provide physicists with the limited access to information about the state of the accelerator is planned. Local network on the basis of 100MB/s Ethernet will be organized.

The user interface (Fig. 1) of operators workplaces gives an ability to monitor and control all connected devices in compliance with safety regulations. Operators workplaces may be added or removed without system restart. New parameters may be taken into account and be displayed without restart too.

2.2 Excitation and synchronization system

For control of two klystrons SLAC 5045, two modulators are needed which will be manufactured under the contract with the German "PPT" corporation. The application of PLC by Siemens is planned to be used in that control system.

The SLED system, consisting of the slot-hole bridge two high quality resonators and RF electronics unit is applied to increase the pulse power in accelerating sections.

The start of all LINAC subsystems are bound on time to a unified time sequence (Fig. 3). The thyratron modulators start pulses « Start mode » and electron gun start pulses « Gun start » can be moved relative to each other with the help of delay lines BZ-53 (Fig. 3). The main two-channel time generator RF GEN with a frequency 2856 MHz changes, by the command « Phase turn » a phase on outputs by 180 degrees what is necessary for SLED system. The klystron modulators excitation signals are produced by units U2856-5 (maximum amplification up to 500 W) as multiple bursts of base frequency with a duration 6ms. The repetition rate of trigger pulses can not exceed 150 Hz.

The units of controlled delay BZ-53 and the generator BS-5 are made in the CAMAC standard and are iniciated synchronously with frequency of power system. The BZ-53 delay can be adjusted in range up to 6 ms with a discretization 100 ns. An additional controlled delay lines with a step 1 ns are set for more fine tuning. The digital/analog converter KA009 will be used for regulation of RF output of two amplifiers U2856-5.

The channel amplifiers BGR8K are applied to transmit signals on long lines in heavy noise condition. The converter NIM/TTL KL027 is necessary for the matching of steering signal levels from an output of delay lines and amplifiers U2856-5. The module of interlock generates hardware inhibitory signal "Blk" for all systems in case of any violations that are dangerous for the staff or may result in a failure of the equipment. The CAMAC units are controlled by the personal computer through the crate controller KK009. The driving generator RF GEN is connected to a parallel port of the same computer, specifying the main operational frequency 2856 MHz.

2.3 The power supply system of magnets

The system of magnetic units is provided for passing and focusing of electron beam. It should ensure beam focusing in all ranges of energies of accelerated electrons. The channel of a quadrupole focusing is used for beam transportation from the first accelerating section to the second section and further transportation of a beam to the target. The channel consists of nine quadrupole lenses Q1 - Q9. Operating current in lenses is up to 300 ? .

The power supply system of magnets is being produced in Budker Institute of Nuclear Physics. The status monitoring of loads is provided with the help of bimetallic temperature sensors and hydro-sensors. The CANbus protocol is used for the control of CAN ADC 40*24 and CAN DAC16*16 units of the power supply system.. The exchange of the standard and expanded format CAN specification 2.0 is supported.

2.4 The diagnostic systems

The objectives of the diagnostic system of electron beam of LUE-200 are the following

- The control of power and quality of electron beam, including:
    - The control of amplitude and pulse duration of electron beam current,

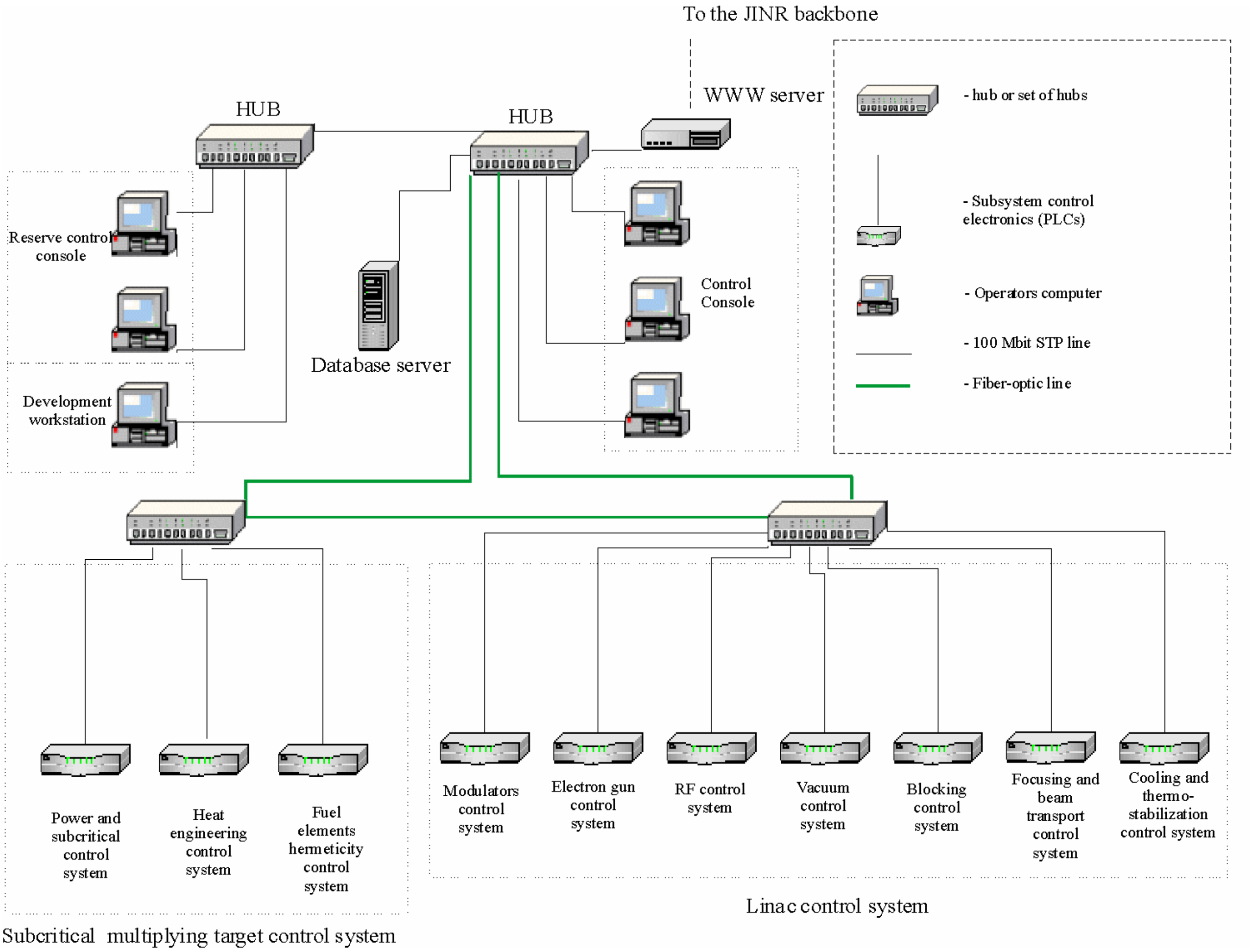

Figure 2: IREN control system structure.

- The control of a position and cross direction profile of an electron beam,
- Measurement of energy and power spectrum of an electron beam;
- The control of an electron beam position on a target entrance;

- The collecting, registration, documenting, presentation and storage of information on the parameters of an electron beam.

Four posts of diagnostics are placed in an interval between the electron gun and the first accelerating section, between the first and second accelerating sections, after the second accelerating section and at the end of a beam transportation channel before an input flange of the target.

Three detectors are included in each diagnostic post: the beam current sensor (Rogovsky belt), sliding two-coordinate screen monitor of a beam profile and sliding television "beamviewer" - device of beam videoinspection that includes phosphor screen with a video camera. The screen beam profile monitor and a phosphor screen are placed inside the vacuum cell, which constitute a part of electron pipeline of the LINAC. The profile sensor and beamviewer are destructive sensors and will be used only for beam set-up in the location of the sensor because of a considerable angular dispersion of particles of a beam incident on wires, or passes through the beamviewer screen. The eddy current belts are sensors which do not destroy the beam, and are used for monitoring and control of beam position.

The system of beam diagnostics includes a magnetic spectrometer with the position-sensing lamellar detector for measurement of energy (50 - 200 MeV) and power dispersion of beam particles. The spectrometer detector is developed in the Frank Laboratory of Neutron Physics design office. It consists of 30 total absorption lamellas made from lead. The charge of electron beam fragments, absorbed in lamellas, is measured on capacitors, connected to lamellas. The signals from lamellas of the detector are digitized and are represented on the operator screen monitor as distribution histograms of particles of a bundle according to energies.

2.5 The vacuum monitoring system

The required pressure of residual gas in the LINAC should be less than 10-5 Pa. This is achieved by ion pumps such as IPT20, IP?50, IP?100 (manufactured by Vakuum Praha), NMD5 (INP, Novosibirsk), NMD100 (Nord). The multi-channel vacuum gauges of the corporation PFEIFFER such as TPG300 and TPG256A are provided for vacuum measurement. The vacuum gauges have measuring sensors and relay outputs, which generate signals at the excess of established threshold levels of rarefaction.

The additional control of vacuum level is carried out by measurement of the high-voltage current of ion pumps.

The fast emergency gate valves of the corporation VAT with actuation time less than 20ms are set, apart from manual valves on the vacuum ?hannel. The control of emergency gates with pneumatic activators is provided by highly sensitive vacuum sensors which are capable to respond on appearance of an oil smoke or water in smallest doses. The control of gates is made by special controllers VAT ser. 87 (770VF-16NN).

The gate of biological protection is set for staff safety who work in halls of the linac on accelerating truct. The gate of biological protection in closed position provides multiple attenuation of the ionizing radiation emitted in the accelerating ?hannel from induced activity of the converter and fuel elements of the multiplying target.

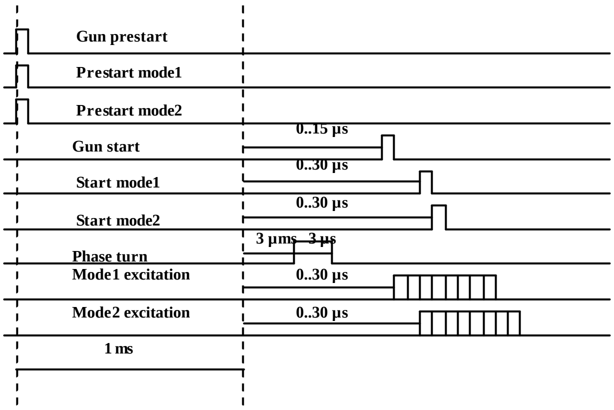

Figure 3: Start pulse sequence

2.5 The cooling and thermostabilisation system

The accelerating sections and resonators of RF power multiplying requires maintenance of an operation temperature in the range 35-45º? with an accuracy not worse than 0,4º?. Pressure control in the cooling system and position of valves should be performed simultaneously. The operation of thermostatic control system on the basis of Eurotherm906 controller and set of TENs, controlled by thyristor regulators, was successfully tested at the stand [3].

3 THE CONCLUSION.

The activities on software engineering for the LUE-200 control system are carried out now in Dubna. The logical controllers DL05 of the corporation Koyo Electronics are bought and the programs for application of these controllers in systems of the linac are being debugged. The products from the industrial automation package Factory Suite2000 of corporation Wonderware are tested. The link of several control computers of a distributed control system is simulated. The database used as a part of SCADA system are now tested including MySQL and MSSQL. The scientific teams at the JINR and INP develop and carry out trial starts of instrumentation, of hardware[3] and software [4] on full scale test stands at the JINR and operational installation of the UEPP injector in BINP.

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