DEVELOPMENT OF REMOTE CONTROL SYSTEM FOR H-MINUS IONS SOURCE OF INR LINAC

O.M. Volodkevich, V.N. Zubets, Yu.V. Kiselev, V.S. Klenov
Institute for Nuclear Research, Russian Academy of Sciences, Moscow, Russia

Abstract

A system of remote control of surface – plasma source of negative ions for INR LINAC was designed, constructed and put into operation.

The INR LINAC negative ions injector is based on the accelerating tube at energy of 400 keV and surface – plasma source of negative ions. Galvanic isolation and spatial separation of elements that are at potential 400 kV in the power rack of the ion source and the host computer are carried out by means of fiber-optic USB-interface extender from firms Icron. A set of multifunctional units from National Instruments allows to monitor the oscilloscope signals with up to 50 Ms/s and to control the ions source power settings. The data acquisition devices programming performed in a LabView graphical environment. Algorithm and LabVew code for fast and safe "conditioning" of the ion source discharge gap and extractor gap from arcing and breakdowns were developed.

INTRODUCTION

Negative ions injector for INR LINAC is based on the accelerating tube at energy of 400 keV [1]. In this scheme, an ions source with its power supply system is located under pulsed potential of 400 kV. Ions source is a surface-plasma source developed at INP SB RAS (Novosibirsk) [2]. In this source the increase of the negative ions yield achieved by reducing the work function of the electrodes by deposition on its surface the layer of alkali metal (cesium).

A characteristic feature of the source is the presence of several modes, which have different discharge voltage, discharge current and the output of negative ions."Pure hydrogen" mode of operation is characterized by high discharge voltage (400 V - 600 V) and low discharge currents (1 A - 10 A).The appearance in the discharge of cesium vapor causes decrease in discharge voltage (to 100 V - "low-voltage operation") and increase in the discharge current up to ~ 100 A. Furthermore, in the discharge gap may develop arcs with very low discharge voltage ~ (20 - 40) V and high current. Arcs can lead to significant erosion of the electrodes and are characterized by the absence of negative ions current at the output of the source.

Extraction of the negative ions from the plasma of a gas discharge occurs through the emission hole in the anode by apposition of extracting voltage with amplitude of 16 - 20 kV to the extracting gap with size of about 1.5 mm. Breakdowns in this gap can cause increased erosion of the electrodes and are also characterized by lack of output current of negative ions. Such breakdowns occur with the source electrodes training and during normal operation of the source.

The transition from "high-voltage" discharge mode in the "low-voltage" mode can occur quite quickly. The change in the discharge voltage is an indication of the emergence of cesium in discharge and is usually accompanied by a change in the intensity of H-minus beam.

This rather complex behavior of the discharge and the dependence of the negative ions yield from the history of the source, cause the urgent need for a reliable detailed control of key parameters of the source, which works with a pulse repetition rate up to 50 Hz. To do this, the operator is required to monitor the pulse waveforms of discharge current and discharge voltage, extracting voltage, extracted current of the H-minus ions and others, as well as to control a variety of continuous signals.

The use of the ions source in the injector of LINAC requires some additional conditions on the control system. In particular, it should be possible to integrate it into the control system of the linear accelerator and to choose the different places for the entrance to the source control system, including from the main control room of the LINAC.

STRUCTURE OF THE CONTROL SYSTEM

The control system is based on the connection of multi-function ADC / DAC units to the host computer via the USB-interface. The control system includes multi-function ADC / DAC unit NI USB 6363s, digital oscilloscope unit NI USB 5132, the control computer and fiber-optic extension of the USB-interface Ranger 2224. Block - diagram of the control system is shown at Figure 1.

ISBN 978-3-95450-170-0

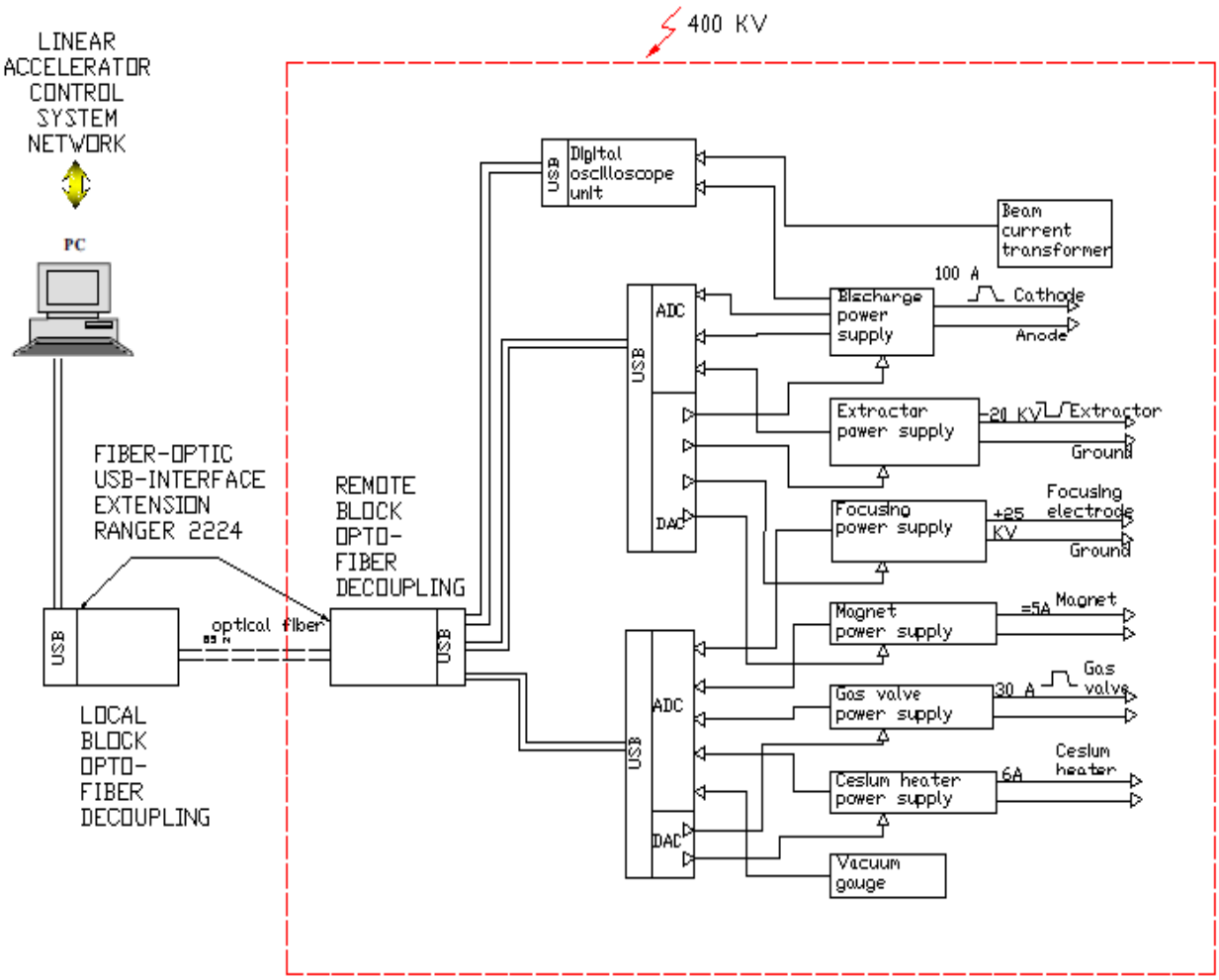

Figure 1: The block diagram of the remote control system of negative ions source.

This system allowed galvanically isolate and spatially spread at considerable distance (about 80 m) equipment of control system and host computer of the ion source operator. In this case, retains all the advantages of working with devices via USB-interface. The system provides a connection in the USB 2.0 standard at 480 MB/s, which allows you to connect a digital 2-channel oscilloscope with a bandwidth of up to 50 Ms/s, and the required set of ADCs and DACs.

PROGRAMMING

The data acquisition devices programming performed in a graphical environment LabView (2010 version). Using programmable blocks allowed to begin the development of the algorithm to control the blocks of power supply system of the ion source with the aim of lifting the parameters to the desired level, "conditioning" of the discharge gap and extractor, maintaining the specified parameters for a long time unattended.

In the development of the control algorithm, experimental work has been done to find the most optimal speed for changes of settings both in regular way to put ion source in the operating mode and in the case of an "emergency" situations. In the result "conditioning" of the ion source and putting it to the operating mode by using this algorithm and developed program allows it to increase the stability and reproducibility of the parameters, reduces the response time to changing conditions in the gas discharge (occurrence of breakdown, rapid transitions from "low-voltage" discharge mode to "high-voltage" and others). In particular, the program's reaction to the appearance of breakdowns in extracting gap and subsequent recovery of operating mode is shown in Fig. 2.

The example of the programmable transition of ion source in the operating mode with the adjustable parameters of the discharge current (Id) and extracting voltage (Uo) shown in Fig3.

ISBN 978-3-95450-170-0

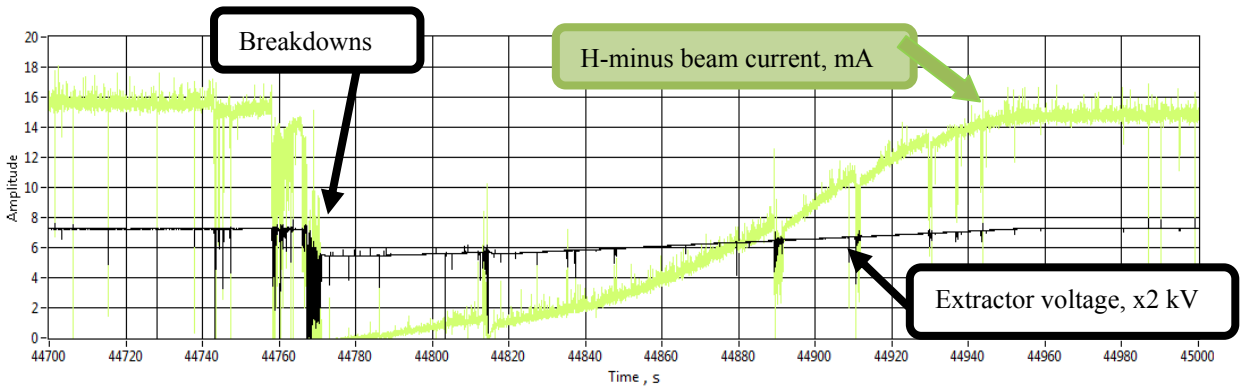

Figure 2: Example of processing by control program breakdowns in the extracting gap voltage (Uo) and restore the beam current (I-).

As characteristic of the quality settings of the ion source can serve relative standard deviation of the measurements of the pulsed ion beam current of H-minus ions. A value of pulse signals in each pulse is obtained by averaging 20 measurements with a period of 5 ms for the middle part (100 ms) of pulse.

The relative standard deviation in the values of pulsed H-minus beam current was achieved by this program less than 1% of the mean pulse current.

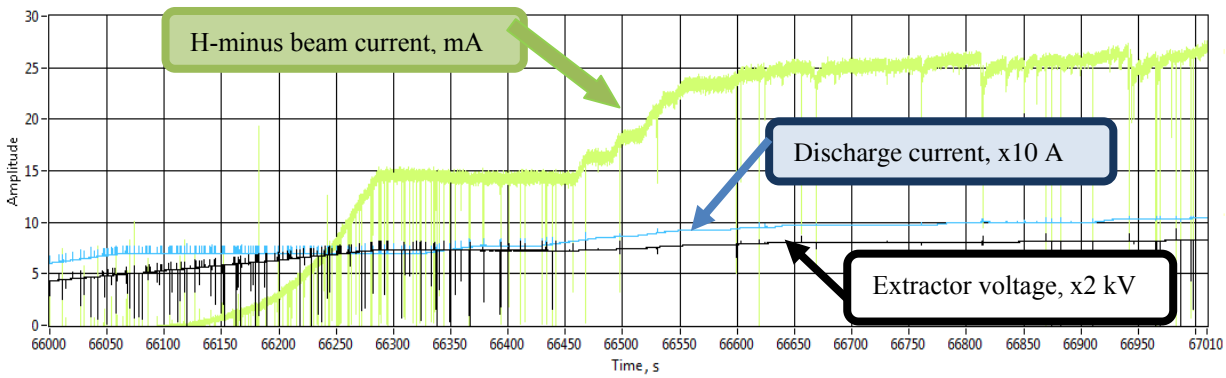

Figure 3: Example of lifting extracting voltage (Uo) and discharge current (Id) by control program and reaching the H-minus ion beam (I-) current 26 mA.

CONCLUSION

The remote control system of negative ions source can adequately control the operating modes of the source, ensuring the completeness of the resulting information on the control computer screen. System allows for programmable control of the ADC units for the purpose of "conditioning" of the ions source, outputting it to the operating mode and maintain over long periods of time."Conditioning" of the ion source using software control of power settings allow you to achieve the stability of the ion beam at the output of the source of better than +-1%.

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ISBN 978-3-95450-170-0