THE POWER SUPPLY SYSTEM FOR THE ACCELERATING COLUMN OF THE 2 MEV ELECTRON COOLER FOR COSY

D. Skorobogatov, M. Bryzgunov, A. Goncharov, I. Gusev, M. Kondaurov, V. Kozak, A. Medvedko, V. Parkhomchuk, D. Pureskin, A. Putmakov, V. Reva, D. Senkov, BINP SB RAS, Novosibirsk

Abstract

The 2 MeV electron cooler for the COSY storage ring (FZJ) is being assembled at BINP. The electrostatic accelerating column generates a high-energy electron beam. The power supply for the accelerating column of the electron cooling system consists of 33 controlled modules distributed by the accelerating potential. Each module has a precision controlled voltage source for 60 kV, 1mA and an additional supply for the solenoids of the magnetic system with a maximum current of 2.5 A. All the systems are controlled through the wireless ZIGBEE network. This report presents the structure of the power system, its parameters, and the results of tests carried out at BINP.

INTRODUCTION

In 2009-2012, BINP was involved in the creation of an electron cooler for heavy ions to be installed on the COSY accelerator of the Jülich accelerator center (Germany) [1, 2]. The main parameters of the cooler are as follows: the electron energy is 25 keV to 2 MeV and the current is up to 3 A. The energy instability will not exceed 10 ppm. Besides, the installation was designed with a proper account of limitations associated with the fact that it will be installed on an already-existing accelerator ring in an earlier-built building.

The accelerating column, where the electron beam is accelerated and recuperated, is one of the main components of the installation.

The main parameters of the accelerator column of the cooler are presented in Table 1:

Table 1: Main parameters of the accelerator column of the COSY cooler

Parameter	Units	Value
Electron energy	MeV	0.025 - 2.0
Energy instability, less than		10^{-5}
Magnetic field of the transport line	G	500
Field instability		10^{-3}
External power supply	V	600
Carrier frequency	kHz	26.2
Power consumption	kW	30-40
Total height of the column	m	3.7

To meet the requirements of the installation we had to develop a power supply system which along with precision output parameters would have high reliability in a strong magnetic field and at strong electrostatic discharges.

STRUCTURE OF THE ACCELERATING COLUMN

The structure of the accelerating column is shown in Fig. (1).

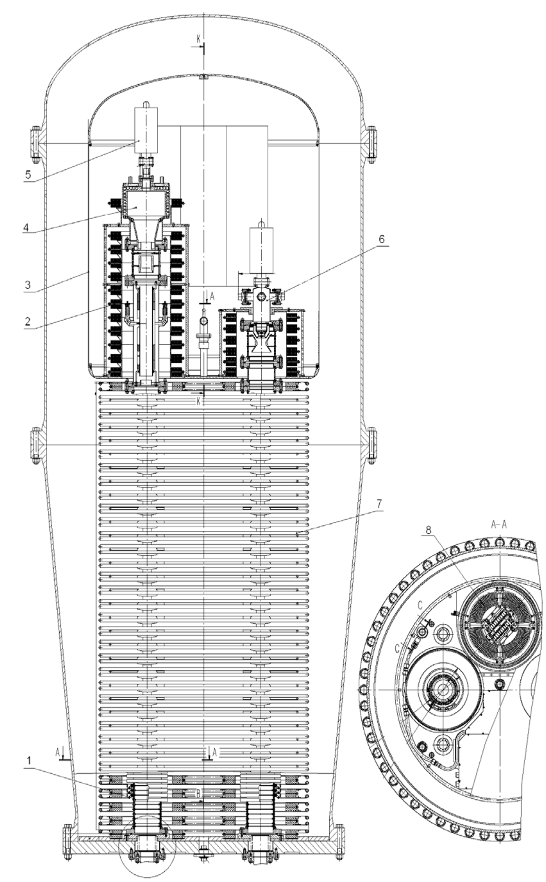

Figure 1: The structure of the accelerating column: 1 – accelerating tube; 2 – solenoid; 3 – high voltage terminal tank; 4 – collector; 5 – ion pump; 6 – electron gun; 7 – high voltage section; 8 – cascade transformer.

ISBN 978-3-95450-125-0

The accelerating column is a high-pressure tank, which is filled with SF_6, and houses accelerator tubes, high-voltage sections, cascade transformer, and high-voltage terminal. The high-pressure tank is limited in height by the existing building which houses the COSY accelerator.

The high-voltage terminal comprises an electron gun, collector, Wien filter, and various power supplies for these elements. The cascade transformer is to provide a required power for the acceleration sections and high-voltage terminal. The accelerating sections provide a voltage required for electron beam acceleration and in addition support magnetic field in the accelerating tubes.

Requirements to high voltage in the accelerator column are pretty tough: the ripple and long-term instability shall not exceed 10^{-5}. A voltage of 2 MV is generated by 33 high-voltage sections with a maximum voltage of 60 kV each. Besides the high voltage, is important to maintain the magnetic field along the accelerator tubes. The magnetic field is generated by a set of solenoids, two solenoids per accelerator section. Requirements to the power supply of the solenoids are not as stringent as to the accelerator voltage; the ripple shall not exceed 10^{-3}.

The general view of the section is shown in Fig. (2).

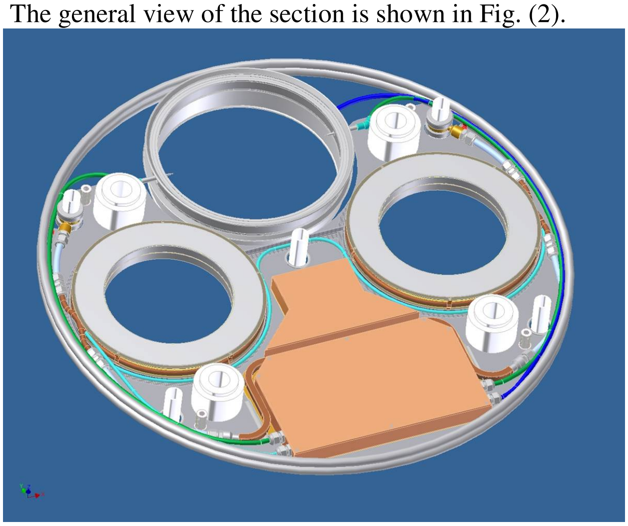

Figure 2: The general view of the section.

The high-voltage section is powered from the power-takeoff winding on the corresponding section of the cascade transformer. One section consumes no more than 350 W, about 90 W for generation of high voltage and the rest for maintenance of the magnetic field. Acceptable supply voltages vary from 100V to 250V. Externally, the section looks like a disc 40 mm high of 1000 mm in diameter, with a cut for the cascade transformer, closed with screens from above and below. The bottom screen is also a load-bearing element and supports the entire structure. Along the perimeter, the section is shielded with metal bands. A section comprises two solenoids and an electronics unit. Since the sections are arranged densely, natural cooling is rather hindered. That is why we provided an oil circulating system for cooling of the solenoids and electronics. The electronics unit is enclosed in a shielding housing, structurally divided into two parts. A general view of the unit is shown in Fig. (3).

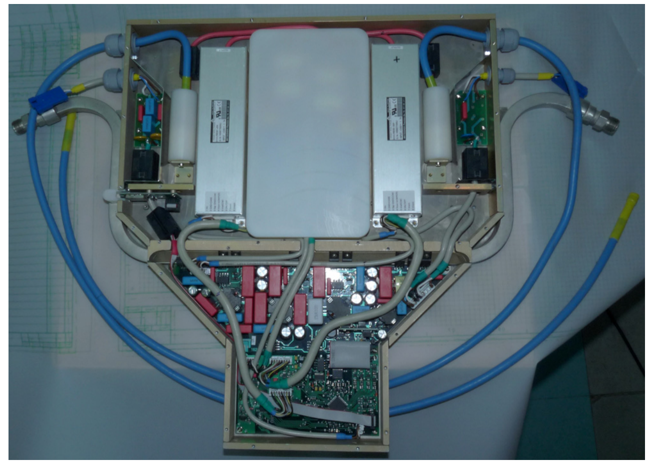

Figure 3: General view of the electronics unit of section with the shield panel raised.

The larger part of the housing is occupied by high-voltage sources and filtering and protection elements on the electrical inputs and outputs from the housing. This part also comprises a high-precision high-voltage divider for provision of feedback in the high-voltage stabilization circuits and a transceiver for communication with the controlling server by the radio frequency channel. The second part of the housing contains a power electronics board, which provides power supply to the high-voltage electronics of the solenoid, and the controller board.

KEY POINTS OF THE ELECTRONICS OF THE SECTION

From a user's point of view, the electronics of the high-voltage section is a high-precision regulated high-voltage power supply (1 mA 60 kV) and a regulated current source for powering the solenoids of the magnetic system, integrated into a single housing. The control interface is realized in a ZigBee self-organizing network based on Telegesis transceivers [3]. This network operates in the 2.5 GHz radio frequency band, which allows doing without a large number of optical lines and simplifies the mounting and maintenance of the system. The structure of the section is shown in Fig. (4).

Prior to beginning work on the accelerator column, we developed a prototype high-voltage section, on which we conducted preliminary tests of all systems of the section and debugged the feedback of the power supplies. In addition, we tested resistance to magnetic fields and electrostatic discharges. Optimal electronics shield housing was designed. In the course of high-voltage tests, different versions of passive protection in circuits external to the screened enclosure were tested, and the presence of strong magnetic fields made us use precision resistive shunts with galvanic isolation instead of current sensors based on the Hall effect.

ISBN 978-3-95450-125-0

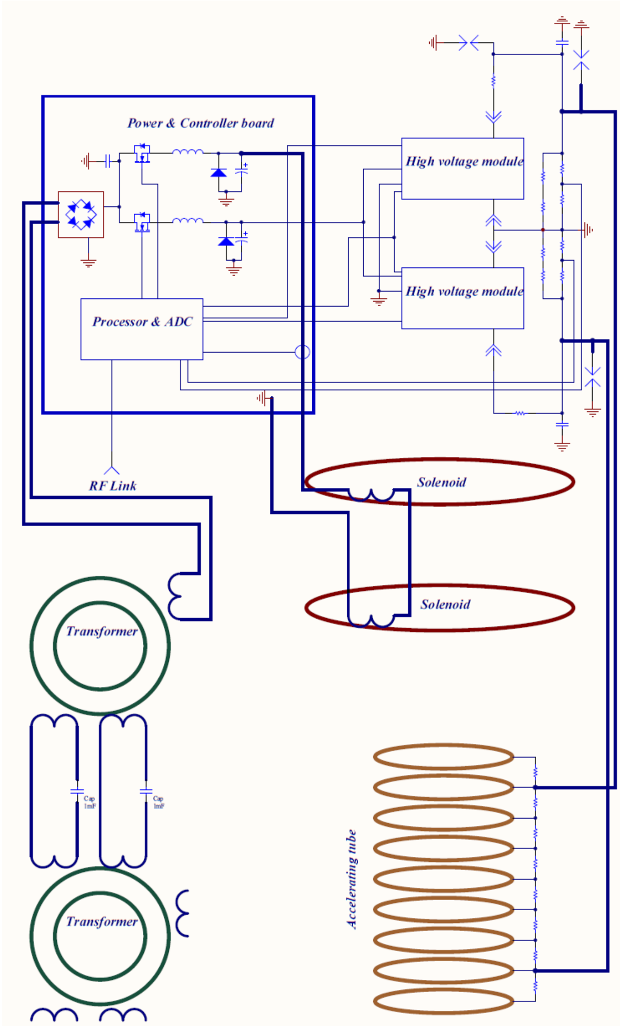

Figure 4: The structure of the section.

A set of programs with graphical interface was developed for control and monitoring of the accelerator column. The graphical interface of the program is shown in Fig. (5).

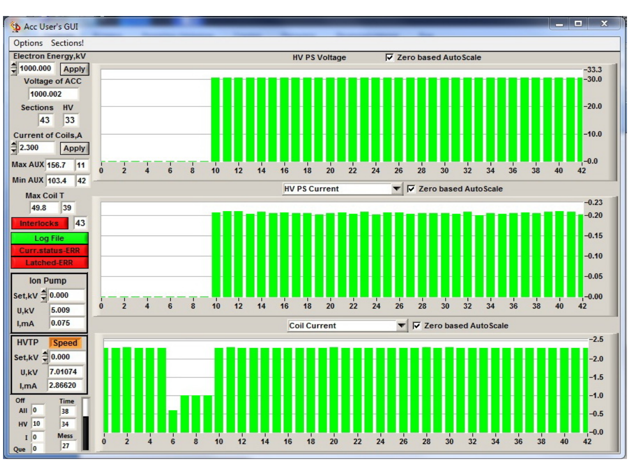

Figure 5: A screenshot of the graphical interface of the accelerator column control software. An accelerating voltage of 1 MV, a high voltage of about 200 μA, and a current in the solenoids of 2.3 A.

RESULTS

The entire electron cooling system and individual units of the installation were tested at BINP in the spring and summer of 2012. High-voltage tests were carried out at voltages in the column of up to 1.8 MW and a current in the magnetic system of up to 2.5 A.

Numerous high-voltage breakdowns at voltages of 200 kV in air and up to 1.6 MV in SF_6 at a pressure of 6 Bar allowed us to identify and eliminate trouble spots in the power supply system. The final high-voltage tests and operation of the system for approximately 5 days showed that the power supply system of the high-voltage column in general meets all the requirements of the electron cooler.

ACKNOWLEDGEMENTS

Special thanks to Alexander Semenov for the careful assembling of the sections and column.

REFERENCES

[1] J. Dietrich et al/ “Status of 2 MeV electron cooler for COSY-Julich/HESR” PAC’11 New York, NY, USA, WEP229, p.1918-1920.
[2] V. Reva et al/ “The first commission results of the high voltage magnetized cooler for COSY” COOL’11 Alushta, Ukraine, THIOA02, p.37-42.
[3] “ETRX357 ZigBee module” http://www.telegesis.com /downloads/general/ETRX35x_Product_Brief.pdf

ISBN 978-3-95450-125-0