

ACCELERATING RF STATION FOR HIRFL-CSR, LANZHOU, CHINA

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Abstract

In accordance with the plan of cooperation with the Institute of Modern Physics (IMP), Lanzhou, China, the Budker Institute of Nuclear Physics (BINP), Novosibirsk, Russia has produced and supplied an accelerating RF station for the multipurpose Cooling Storage Ring system (CSR), which is being constructed at IMP. The RF station had been tested at IMP site and now is installed into the Main Ring of the facilities. The RF station operates in the frequency range of 0.25 ~ 1.7 MHz. Maximum accelerating voltage is 8 kV. The resonance frequency of the RF cavity is tuned in the whole frequency range by biasing of ferrites, which are used in the cavity. Ferrites of 600NN type were produced by a firm manufacture "Magnetron", St. Petersburg. The pressure in the cavity vacuum chamber is lower, than $3 \cdot 10^{-11}$ mbar. RF cavity, RF generator, and power supplies are made in one module. Maximum output power of the RF generator is 30 kW. Low level control electronics are placed separately in a rack. The RF station control is based on the Compact PCI bus and provides all functions of RF station control and monitoring.

INTRODUCTION

HIRFL-CSR, a new accelerator complex is being commissioned now at the Heavy Ion Research Facility in Lanzhou (HIRFL). It is a multipurpose Cooling Storage Ring system, which consists of a main ring (CSRm) and an experimental ring (CSRe). The heavy ion beams with the energy range of 10 ~ 50 MeV/u from the HIRFL-SSC will be accumulated, cooled and accelerated to the high energy range of 100 ~ 600 MeV/u in the main ring (CSRm) [1, 2]. The RF station is dedicated for acceleration of different types of ions in CSRm. Main parameters of the RF station are shown in the Table 1.

Table 1: Main Parameters of RF Station.

| | |
|---------------------------------------|-----------------------|
| Operating frequency range, MHz | 0.25 ~ 1.7 |
| Maximum accelerating voltage, kV | 8.2 |
| Harmonic number | 1 |
| Max. output power of RF generator, kW | 30.0 |
| Duration of operating cycle, sec | 3.0 |
| Vacuum in the cavity chamber, mbar | $<3.5 \cdot 10^{-11}$ |
| Ferrite type | 600NN* |

| | |
|--------------------------------------|------|
| Height of cavity axis over floor, mm | 1500 |
| Installation length, mm | 2600 |
| Vacuum chamber aperture, mm | 200 |

RF CAVITY

The RF station consists of RF cavity, RF power generator and control system. Accelerating cavity of the RF Station is made of two sections of shorted quarter – wavelength transmission lines which have a common gap (see Fig. 1). The space between conductors of the lines is filled with ferrites of 600NN type. These Ni-Zn ferrites with the initial relative permeability $\mu_r = 600$ were produced by the "Magnetron Plant" in Saint-Petersburg, Russia. Initially they had a form of plates, which after mechanical treatment were glued into rings. An inner diameter of the ring is ~ 340mm. The total number of ferrite rings is 68. Maximum magnetic flux density in ferrites is 130 gauss.

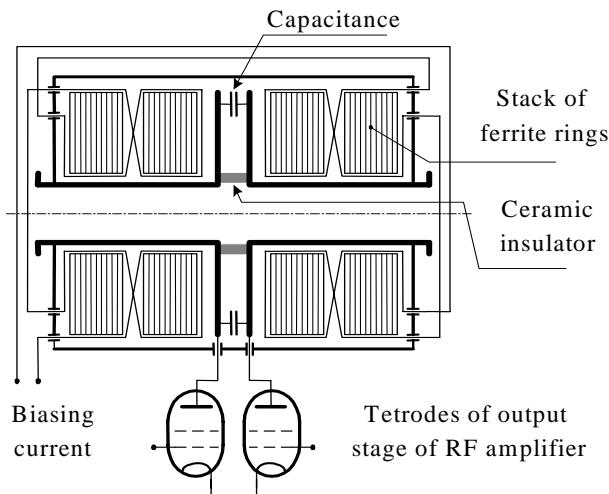


Fig. 1: Schematic diagram of RF cavity

The ferrites rings are grouped in 4 stacks. Each pair of stacks has a separate winding for DC biasing of ferrite. Wire loops around each stack of the pair are connected so, that the induced RF voltages are compensated. There are 96 turns of copper wire for each pair of stacks connected in series (only 2 turns are shown in Fig.1). RF cavity is tuned in the whole frequency range, when the biasing current changes from zero to 35A.

The cavity ferrites are water cooled. The heat dissipated

* Russian type of ferrite

in the ferrites is removed by the copper plates inserted between ferrite rings. The copper plates have a thermal contact at their outer diameter with the water cooled copper tubes.

For improving the thermal contact between ferrite rings and copper plates, mechanical stability of elements as well as for increase of the electric strength of insulation, a free space in the cavity is filled with a sealing compound. The average power dissipation in ferrites of the whole RF cavity is 2.2 kW, that corresponds to 15 mW per cubic centimeter of ferrite. The maximum temperature drop between the cooling water and the hottest point of ferrites is less than 10°C.

In order to decrease the lowest margin of the station frequency range for a given number of ferrite rings, the RF cavity is loaded with a capacitance connected in parallel to the cavity gap. The total capacitance is equal to 6200 pF and it consists of 28 ceramic capacitance 220 pF with 15 kV of maximum rating voltage. The phase length of a half cavity is equal to 11°.

The RF cavity has one accelerating gap with a ceramic insulator welded into it. Maximum RF voltage at the insulator is 8.2 kV.

After baking out the cavity vacuum chamber and the insulator at the temperature of 350°C we obtained vacuum better than $3.5 \cdot 10^{-11}$ mbar.

RF POWER GENERATOR

The output stage of RF power generator with maximum output power of 30 kW has 2 vacuum tetrodes 8281/4CX15000A with air cooling. Tubes are switched into the common cathode circuit and their anodes are connected directly to the accelerating gap of the cavity on RF. A water cooled broadband preamplifier is based on transistors and drives the tetrodes in the whole frequency range without tuning. Maximum output power of the preamplifier is 0.5 kW in CW mode. The input power of the preamplifier is 0.5W max.

CONTROL SYSTEM

The Control System is based on the Compact PCI bus and provides for a complete control and monitoring of all parameter of RF station. The control system provides regulation of the operating frequency of RF station by a given program, controls amplitude and phase of accelerating voltage of RF cavity and fine tuning of its resonant frequency.

The Main Control Module is installed in the Compact PCI crate and contains the Master Oscillator of RF station using DDS technology, the DACs providing DC reference signals for RF cavity amplitude and tuner control and ADC for monitoring of RF station parameters during the

cycle. The RAM section of the module stores the information, which determines the key parameters during the operating cycle: the output frequency of DDS, amplitude of accelerating voltage of RF cavity and rough setting of the biasing current. The station can be controlled from the Central Control Room of the CSRm through Ethernet or/and from a local monitor and a keyboard.

FEATURES OF MECHANICAL DESIGN

RF cavity body is fastened on a frame, which rests on the floor at four legs. 3 boxes are inserted under the frame (see Fig. 2). The extreme left box in the picture contains anode and screen grid power supplies, the middle one has tetrode tubes and transformers for filament heating. The

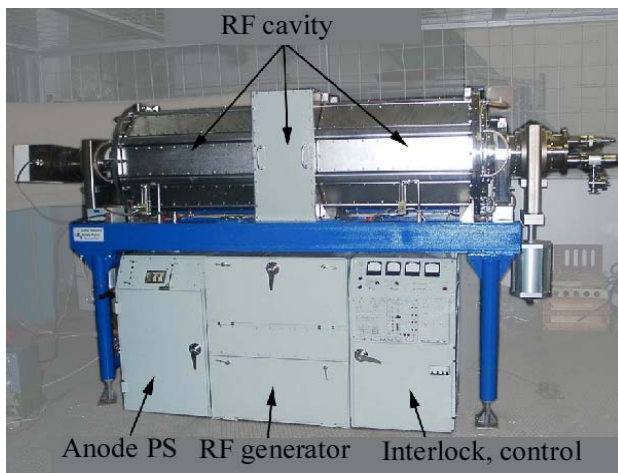


Fig. 2: Photo of RF station. Overall dimensions of RF station are: length is 2600 mm, height is 1878 mm, width is 1878 mm

DC amplifier for RF cavity biasing, its power supply and electronic modules of RF generator control and interlocking are placed in the extreme right box. The Control System modules are placed in a separate cabinet.

RESULTS OF RF STATION TEST

After shipment of RF station to Lanzhou it was reassembled there and the required vacuum in the cavity was obtained. The commissioning testing of the cavity was made during 72 hours non-stop. The RF cavity voltage instabilities was measured to be within 0.2%, accuracy of the cavity tuner was inside 10 degree. Fig.3 shows oscillogram of RF cavity voltage from amplitude detector. After successful completion of the test the RF station was moved into CSRm ring, installed there and now is ready for operation.

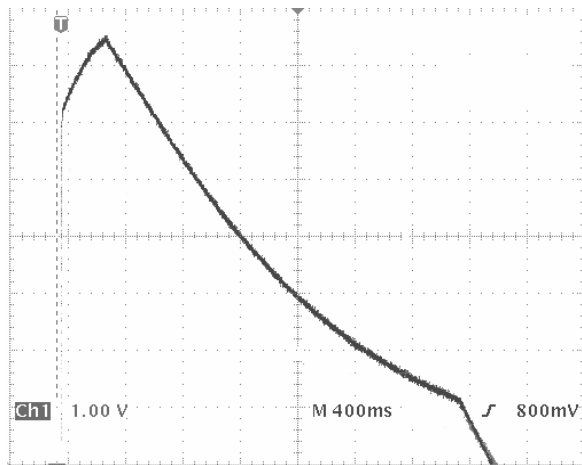


Fig. 3: Oscillogram of the RF cavity voltage amplitude. The highest value corresponds to 8.2 kV

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