PROJECT OF RF STATION FOR “FAIR” ACCELERATOR FACILITY, GSI, GERMANY

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The project of RF station which is supposed to be used on accelerators of ions SIS100/300, and after a small modification in the storing ring NESR is presented. The maximal RF voltage on the cavity accelerating gap is 20 кV in the CW mode. The operational RF frequency range for all three accelerators is 0.9…2.8 MHz. The descriptions of the RF station design and of the control system are given.

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INTRODUCTION

The Budker Institute of Nuclear Physics, Novosibirsk participates in realization of the project of accelerating complex “FAIR”, GSI, Darmstadt, Germany. In the scope of the project, a large number of RF systems will be built at the GSI.

The Institute of Nuclear Physics in cooperation with experts of GSI has developed a project of RF systems for accelerating rings SIS100, SIS300 and NESR. Key parameters of RF of systems are given in Table.

Main parameters of RF systems

Parameter	SIS100/300	NESR
Operating frequency range:	1.1…2.8 MHz	0.9…2.7 MHz
Nominal gap voltage:	20 кV	15 кV
Output power of RF generator:	65 kW	45 kW
Maximum vacuum leakage rate:	$<1\cdot10^{-10}$ mbar l/s	$<1\cdot10^{-10}$ mbar l/s
Length of the cavities (flange to flange):	2800 mm	2800 mm
Circular beam tube aperture:	150 mm	200mm
Number of channels in RF system:	20 / 8	1

One channel of the RF system consists of an accelerating cavity, RF power amplifier and control electronics. The accelerating cavity and the output stage of RF amplifier are assembled as one module. Transistor RF preamplifier, power supplies of the RF generator and the control electronics are placed separately, in the radiation-safe zone. Power supplies of screen and control grid of the tetrode, RF preamplifier, cavity ferrites biasing power supply, control electronics and interlocks will be placed in one rack. The anode power supply of RF generator with the circuit of the fast protection against sparking in the tube will be made and installed by the firm BRUKER, France.

ACCELERATING CAVITY

Cavity design ideas and technology which were realized and tested in the projects of RF stations for the Institute of Modern Physics, Lanzhou, China [1], [2] were used in the design of RF cavity for GSI. The accelerating RF cavity consists of two shorted quarter wave pieces of a coaxial line. In the gap between open central conductors of the line a ceramic insulator is welded up, the internal space of the coaxial line is filled by ferrite of 400NN-2 type. Ferrite will be made by factory MAGNETON, St.-Petersburg first in the form of plates, which after machining will be glued up into rings (see Fig.1).

Thickness of a ring is 25 mm; total number of rings in the cavity is 56.

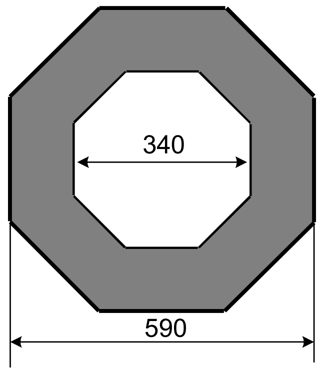

Fig.1. Outline of the ferrite ring

The ferrite stack of every half-cavity is divided in two equal groups. The ferrite biasing winding is wound up in these groups so, that the voltages induced in loops of both group are compensated (see Fig.2). Number of coils in a winding is 48, windings both половинок the resonator are connected in series. The biasing current in the winding varies in the range of up to 30 A for tuning the cavity resonant frequency in the whole range. The total resistance of the winding is less than 0.5 Ohm.

RF cavity ferrites are cooled by water. Copper plates with internal water channels are inserted between ferrite rings.

For better thermal contact between ferrite rings and copper plates, for mechanical rigidity of the design as well as for higher insulation strength the free space inside the cavity is filled with a silicon sealant. The maximal power dissipation in ferrite is 0.2 Вт/см^3.

RF GENERATOR

The output stage of RF generator has one tetrode RS1054SK, made by the firm Siemens/Thales. The anode of the tube is connected with the half-cavity through a decoupling capacity. For reduction of the inphase component of RF cavity gap voltage with the unbalance tube loading a pair of ∞-shape turns couples two quarters of the cavity ferrite stack. (see Fig.2).

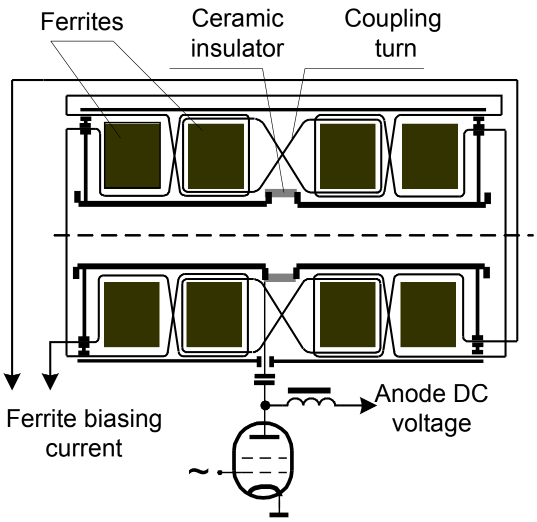

Fig.2. Sketch of RF cavity

Accelerating ring SIS100 will share the same tunnel with the SIS300, the SIS300 will be built on top of the SIS100, with a slight transversal displacement. The amplifier of SIS100 will be installed under cavity. The small distance between planes of their orbits compels to mount the SIS300 amplifier on top of the cavity SIS300. Therefore a design foresees the opportunity of connection cavity with RF amplifier in both cases without change of orientation in space of both constructions.

The high level of the induced radio-activity in the accelerating hall also imposes restrictions on arrangement of equipment and design of RF station. The equipment of an accelerating hall does not contain semi-conductor elements; RF generator box contains only tetrode and the transformer of the filament heater. For fast replacement of the tube it is located in a sliding module. Quick plug connections of the sliding module with the amplifier are used (electric connections, connections of the cooling water, air).

Accelerators operate with large current of charged particles. For reduction of interaction of RF system with ion bunches the negative feedback is introduced in the output stage. The voltage from the anode capacitor divider is applied to cathode of a tube through the inverting transformer. As a result, the output impedance of RF system seen from the beam does not exceed 3000 Ohm at the operating frequency.

A transistor preamplifier with the maximal output power of 1.5 kW in CW mode drives the tetrode stage of RF amplifier.

CONTROL SYSTEM

Control electronics together with power supplies for the tube's grids and the source of the ferrites biasing current are located in one rack. Control electronics have two feedback circuits. One of them stabilizes accelerating voltage at the RF cavity accelerating gap, the second tunes RF cavity to resonance by adjusting the ferrite biasing current.

Interlocks protect powerful elements of RF system and personal in case of emergency situations. A module which controls the tetrode power supplies together with interlock of RF power amplifier are made in one module using PLM "ALTERA" which guarantees online control of all input signals and increases reliability of the whole system. The remote monitoring and control of RF station is realized with the selection of the Siemens S7 modules.

MESUREMENT OF FERRITE PARAMETERS

Parameters of the 400NN-2 ferrite have been measured in regimes which correspond to regimes of the RF stations. Magnetic permeability and Q-value factor were measured in a frequency range of 0.9…3 MHz at various levels of RF and DC biasing.

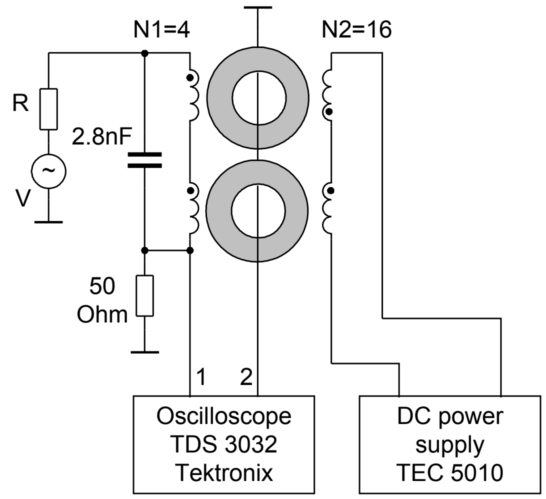

Fig.3. Setup for measuring the ferrite ring parameters

A setup was made for the ferrite measurement (see Fig.3). Two rings of 400NN-2 material with outside dimensions of D x d x h = 32 x 20 x 6 mm were tested. 16 turns of ∞ – shape were wound up around rings for biasing and 4 turns of 0 – shape made inductance for the resonance LC circuit. One turn of 0 – shape was used to measure RF magnetic flux in ferrite, RF voltage at 50 Ohm indicated losses in ferrite and was use to calculate the equivalent shunt impedance of the circuit. Knowing capacitance of the LC circuit (2.8 nF), the Q – value of ferrite was calculated.

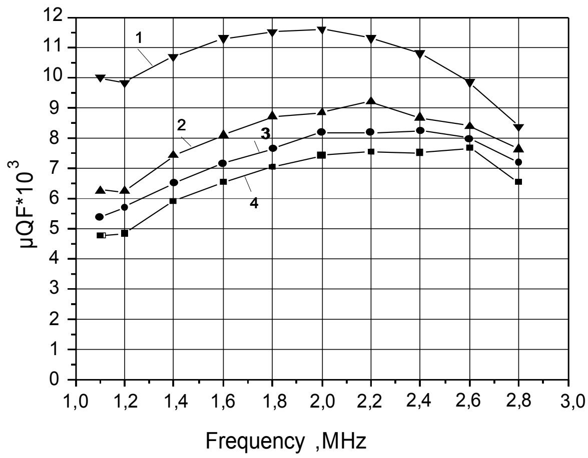

Fig.4. Dependence of μQF product of ferrite ring versus frequency

The resonant LC circuit was excited from a signal generator Aligent 33250A through a broadband amplifier with the maximal output power of 15 W. Fig.4 presents the μ QF product of ferrite versus frequency. Each curve of the plot is made on condition that product of the measurement frequency and of RF magnetic flux density is constant, i.e. **F · B = const**. Thus the curves 1, 2, 3, and 4 corresponds to RF voltages of 10 kV, 14.9 kV, 17.1 kV and 20 kV accordingly at the real cavity accelerating gap.

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ПРОЕКТ ВЧ-СТАНЦИИ ДЛЯ УСКОРИТЕЛЬНОГО КОМПЛЕКСА “FAIR”, GSI, ГЕРМАНИЯ

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Представлен проект ВЧ-станции, которую предполагается использовать в ускорителях ионов SIS100/300, а также после небольшой модификации в накопителе NESR. Максимальное напряжение на ускоряющем зазоре резонатора 20 кВ в непрерывном режиме. Диапазон рабочих частот ВЧ-станции для всех трех ускорителей 0.9…2.8 МГц. Приводятся описание конструкции ВЧ-станции и построение системы управления.

ПРОЕКТ ВЧ-СТАНЦІЇ ДЛЯ ПРИСКОРЮЮЧОГО КОМПЛЕКСУ “FAIR”, GSI, НІМЕЧЧИНА

В.С. Арбузов, Ю.А. Бірючевський, Е.І. Горникер, Я.Г. Крючков, С.А. Крутихін, Г.Я. Куркін, В.Н. Осипов, В.М. Петров, А.М. Пілан

Представлено проект ВЧ-станції, що передбачається використати в прискорювачах іонів SIS100/300, а також після невеликої модифікації в накопичувачі NESR. Максимальна напруга на прискорювальному зазорі резонатору 20 кВ у безперервному режимі. Діапазон робочих частот ВЧ-станції для всіх трьох прискорювачів 0.9...2.8 МГц. Приводяться опис конструкції ВЧ-станції і побудова системи керування.