PROJECT OF RF SYSTEM FOR 2.2 GeV ELECTRON STORAGE RING – SR SOURCE

I.K. Sedlyarov, V.S. Arbuzov, E.I Gorniker, A.A. Kondakov, S.A. Krutikhin, G.Ya. Kurkin, I.V.Kuptsov, S.V.Motygin, V.N. Osipov, V.M. Petrov, A.V.Philipchenko, A.M. Pilan, A.G. Tribendis, V.A. Ushakov, Budker INP,630090 Novosibirsk, Russia.

Abstract

RF system for 2.2 GeV dedicated electron storage ring – SR source being built in Zelenograd, Russia is pres ented. RF system operates at 181MHz and consists of two single-cell bi-metal cavities, waveguide power distribution system, power amplifier based on two TH781 THALES tetrodes and control sub-system. Design features of the RF system units are described. Parameters of the RF system, providing operation at 2.2 GeV, 0.3 A beam current, are given.

INTRODUCTION

New electron storage ring designed at BINP SB RAS is being built in Zelenograd, Russia as dedicated technological synchrotron radiation (SR) source [1]. This machine will provide SR in the range of 0.1÷2000 Å. Maximum electron beam energy – 2.2GeV. SR energy loss at this energy is 409keV per turn. Energy loss due to insertion devices is 105keV. The storage ring will operate both in a single bunch mode with average beam current of 0.1A and in multi-bunch mode with average beam current of 0.3A.

Accelerating RF system of the storage ring operates at 181.33MHz which corresponds to the 70th harmonic of the revolution frequency. Total accelerating voltage of 1MV is required for compensation of the energy radiation losses and obtaining enough life time. The injection to the storage ring is done at low energy of 450MeV when the radiation losses are 0.72keV per turn only. This sets additional requirements to the RF system operation frequency tuning and cavity higher order modes (HOM) detuning in order to ensure beam phase stability [2, 3].

Accelerating voltage amplitude has to be adjusted within wide range. RF systems of the injector and storage ring must be synchronized for precise injection to the target separatrix.

RF system consists of 2 bi-metal cavities. The cavities are placed in the storage ring at a distance between their centers of half-wavelength. The 2 cavities are driven by a single generator. Accelerating voltage and phase are controlled by control sub-system. Main parameter of the RF system are listed in table 1.

ACCELERATING CAVITIES

Cavity design is similar to that of the RF cavities of Novosibirsk FEL [4]. Cavity body (Fig. 1) is made from bi-metal (8mm of copper and 7mm of stainless steel). The bi-metal is produced by diffusion bonding. Water cooling channels are made in the outer stainless steel layer. RF current flows over the inner copper surface. The cooling
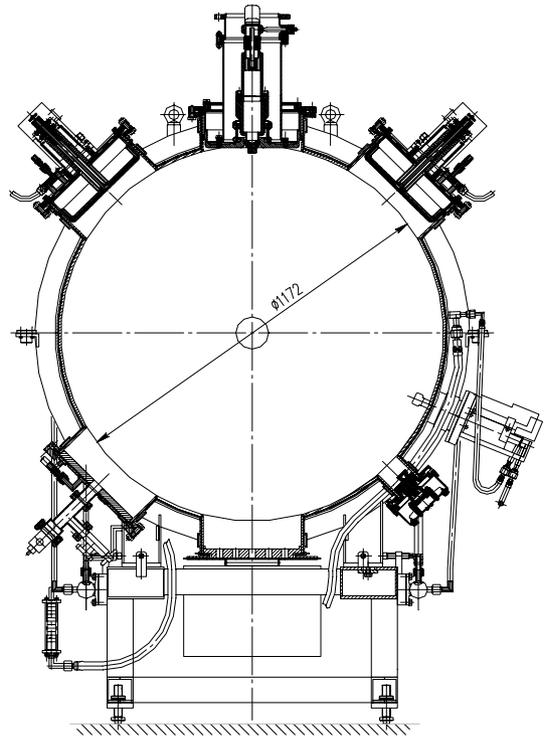
system is designed so that the operation fundamental frequency shift due to RF load is self compensated.

Figure 1: Schematic view of accelerating cavity

Table 1: Parameters of the storage ring RF system

Parameters	Value
Operating frequency	181.3 MHz
Harmonic number	70
Number of cavities	2
Total accelerating voltage	0.2÷1 MV
Cavity frequency tuning range	±180 kHz
Gap voltage U (ampl.) per cavity	0.1÷0.6 MV
Transit time factor	0.9
Cavity quality factor	39000
Cavity shunt impedance R= U²/2P	5.2 MOhm
Power loss per cavity at U=0.6MV	35 kW
Generator output power	300 kW

Operating mode is fundamental TM010. Each cavity has 2 contactless fundamental mode tuners and 2 HOM tuners. The tip of the HOM tuner has an infinity sign shape along the cavity axis. The HOM tuners have almost no effect on the fundamental mode, but shift the HOM frequencies. The dependence of the HOM frequencies on the tuner positions is mapped during low level RF measurements. During cavity operation in the storage ring the HOM tuners are set so that beam induced HOMs would not lead to phase oscillations build-up both in single and multi-bunch modes of operation.

Coaxial input power coupler with cylindrical ceramic window is placed on top of the cavity. Cavity gap voltage is monitored with inductive probe. An ion pump is attached to the cavity from the bottom. Two RF shielded vacuum gate valves are installed on the cavity beam pipe flanges. Each cavity will be separately baked at 300°C and tested up to 1000kV gap voltage in CW mode at special test stand.

GENERATOR AND FEEDER

The RF system has a CW generator with output power of 300kW. Output stage of the generator has modular design. It utilizes 2 THALES TH781 tetrodes. Each TH781 tetrode is driven by a preliminary stage on GU92A tetrode (SED SPb, Saint-Petersburg). These preliminary stages are driven by 20W solid state amplifier through a single GU92A tetrode stage. Anode and low voltage power supplies are assembled in special cabinets.

Anode power supply has fast thyristor discharger to protect the tetrode grids at breakdowns. The discharge time is less than 50 µs.

The generator is located quite far from the cavities. Although the RF frequency is low, an aluminum rectangular waveguide is used for power transmission. At 300kW of transmitted CW power rectangular waveguide is more reliable and easier to manufacture than a coaxial feeder. One can afford having waveguide dimensions (986mm x 150mm) substantially less than those optimized for lowest attenuation. The generator and the cavities are connected to the waveguide through waveguide-to-coaxial transitions.

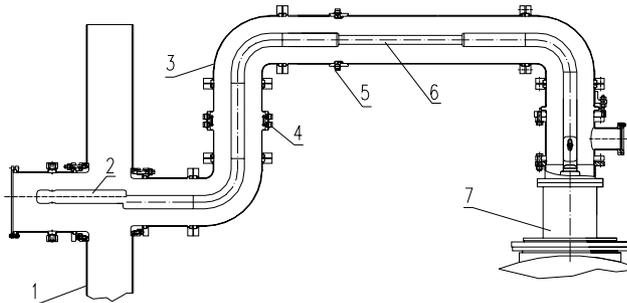The scheme of RF feeder between the waveguide and one of the cavities is shown in Fig. 2.

Figure 2: Scheme of RF feeder between the waveguide and one of the cavities.

Each cavity (7) is connected to the waveguide (1) through a coaxial feeder (3) with characteristic impedance of 75 Ohm. The cavities are driven in anti-phase due to proper rotation of the input coupler loops. RF power is equally split between the 2 cavities by the waveguide-to-coaxial transition (2). Both coaxial feeders are connected to the waveguide at the same cross-section symmetrically relative to the middle of its wide wall. The equivalent circuit of the transition is an ideal transformer with 3 windings. When the coaxial feeders are matched, the waveguide is matched as well. The design allows regulating quite easily the power distribution between the cavities within ±1dB. This is done by rotating the parts of coaxial feeder inner conductors which are eccentric inside the waveguide.

The distance between the waveguide-to-coaxial equivalent transformer and the cross section in the feeder, corresponding to the voltage minimum when the cavity is detuned, is multiple odd number of quarter wavelengths. Thus if any of the 2 cavities is detuned the feeder current is limited to the value determined by the maximum power of the tuned system. A quarter wavelength transformer (6) is placed in the coaxial feeder to match the waveguide at maximum beam current. The transformation ration can be adjusted within 1 to 1.33 range. The transformer is placed at the distance of quarter wavelength from the voltage minimum when the cavity is detuned. Input coupler current pick-up loops (5) are shifted by half wavelength from this cross section. VSWR in the feeder is measured with directional couplers (4).

CONTROL SUB-SYSTEM

Control sub-system has feedback loops for adjustment and stabilization of the total accelerating voltage and a feedback loop for resonant frequency tuning.

The total accelerating voltage is combined from the signals of the 2 cavities pick-up loops. This voltage is phased by the storage ring master oscillator signal at 181.33 MHz. Also the RF voltage of the injector is phased by the same master oscillator which ensures precise synchronization of the injection to the storage ring is below 0.1nsec.

The total accelerating voltage amplitude and phase stabilization feedback loops have time constant of 100µsec. Resonance frequency tuning feedback loop has time constant of ~0.1sec. The sub-system has also an interlock board that protects the equipment and personnel in case of failure.

CONCLUSION

RF system that allows obtaining the design parameters of the technological electron storage ring -SR source has been developed. The design work is being completed. A new RF generator had been developed using Thales tetrode TH781. Most of the RF system parts are in production at the moment. After assembling and testing at BINP all the parts of the RF system will be sent

to Zelenograd. Commissioning of the RF system is scheduled for 2009.

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