172 MHZ RF SYSTEM FOR VEPP-2000 STORAGE RING

Arbuzov V.S., Biryuchevsky Yu.A., Bushuev A.A., Volkov B.H., Volobuev S.V., Gorniker E.I., Kendjebulatov E.K., Kondakov A.A., Koop I.A., Krutikhin S.A., Kryuchkov Ya.G., Kuptsov I.V., Kurkin G.Ya., Mityanina N.V.,
Motygin S.V., Osipov V.N., Petrov V.M., Pilan A.M., Popov A.M., Prosvetov V.P., Rotov E.A., Sedlyarov I.K., Tribendis A.G., Shatunov Yu.M.
Budker Institute of Nuclear Physics, Novosibirsk, 630090, Russia

Abstract

The description of RF system of VEPP-2000 storage ring is given. Higher order modes of the accelerating cavity are damped by special loads. The cavity through feeding system is fed from 60 kW RF generator. The output stage of the generator is made on GU-101A tetrode. The control system provides frequency tuning of the cavity and control of accelerating voltage phase and amplitude. Results of measurements of radio engineering parameters of the cavity are given.

INTRODUCTION

VEPP-2000 electron-positron collider [1] will work at currents about 2 x 200 мA and beam energy up to 1000 MeV. RF system with 172 MHz "single-mode" cavity [2, 3] will be used for damping of beam coherent instabilities. The power of the generator compensates radiation and cavity losses.

CAVITY DESIGN

Cavity design is shown on the figure 1. The cavity is equivalent to half-wavelength coaxial line. For a reduction of its longitudinal size the cavity consists of two coaxial parts, one of which is located inside another. Cavity frequency tuning mechanism (pos. 5) moves internal part of the cavity relative to the external one and tunes the frequency of the accelerating mode within ±150 kHz. Basic characteristics of the cavity are given in the table 1.

Higher order modes (HOM) damping is carried out by coaxial and waveguide loads. The coaxial load (pos. 6) works in frequency range up to 3500 MHz. The choke filter (pos. 3) prevents a leakage of RF power of the accelerating mode to this load. Its attenuation is 60 dB.

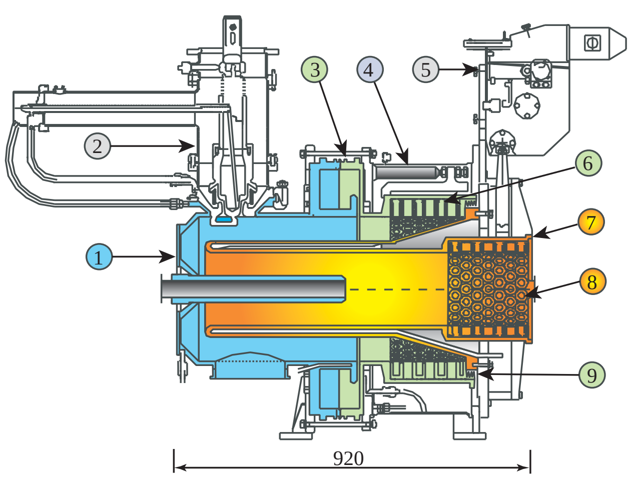

Figure 1: Sketch of VEPP-2000 cavity: 1-left side of cavity, 2-coupler input, 3-choke filter with a flexible right wall, 4-choke filter thermal tuner, 5-cavity mechanical tuner, 6-coaxial HOM load, 7-internal cavity part moved by mechanical tuner, 8-waveguide HOM load, 9-bellow.

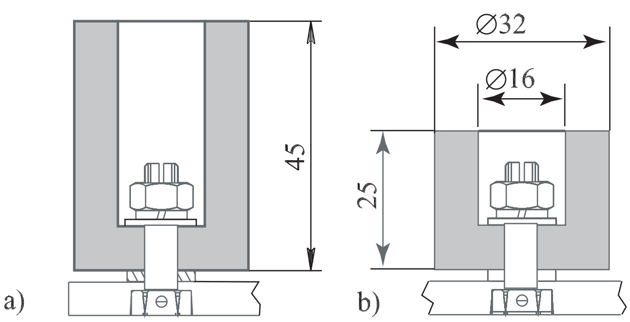

Figure 2: Load absorbing elements:
a) for coaxial load, b) for waveguide load.

Figure 3: Coaxial load during assembly.

The waveguide load (pos. 8) is attached to cavity internal part through a round waveguide. It provides additional damping of HOMs at frequencies above waveguide critical (cutoff) frequencies. For working mode the waveguide is cutoff, therefore the waveguide load does not influence its quality factor.

HOM loads consist of separate elements (see fig. 2) which made from a conducting ceramics KT-30 (30 % TiO_2, 69.86 % Al_2O_3 and 1.4 % MgO). These elements are attached inside to load water-cooled wall by bolts (see fig. 3).

The choke filter (fig. 1, poses 3) is a toroidal cavity with an adjustable gap. Filter gap voltage corresponds to cavity accelerating gap voltage approximately as 1:3. Filter frequency is tuned in a range of ±150 kHz by change of its gap size. Filter tuning mechanism consists of 3 aluminium rods (pos. 4) azimuthally allocated through 120^o. Rods have heating windings. A length of rods is changed by thermal expansion. Change of temperature $\pm 20^oC$ corresponds to the maximal change of rods length ±0.05 mm.

CAVITY PARAMETERS MEASUREMENT

Antenna type field probes were placed on cavity axis near central nose and waveguide load. Transmission coefficient between probes was measured. A range of measurements is up to 4000 MHz. Quality factor (Q) of almost all HOM did not exceed 100. The unique mode found poorly damped has quality factor Q about 1500 (see fig. 4). It is a higher order mode of the choke-filter. Its calculated effective impedance is 0.1 ohm. Thus results of measurements well coincide with calculations [2, 3].

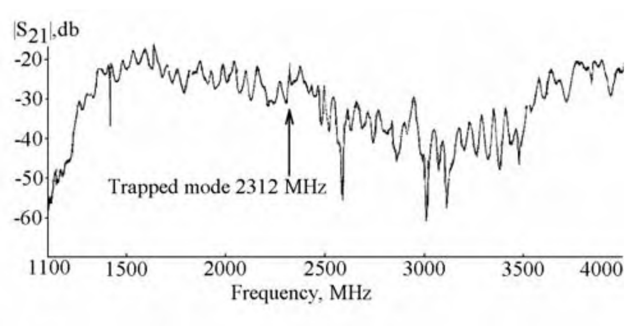

Figure 4: Measured HOM spectrum of VEPP-2000 cavity.

Table 1: General parameters of the cavity.

Frequency, MHz	172.09
Quality factor Q	8200
Transit time factor	0.9898
Effective impedance ρ, Ohm	28
Shunt impedance ρ·Q, kOhm	230
HOM shunt impedances, Ohm	≤ 300
Accelerating RF voltage, kV	120
Cavity power losses, kW	30
RF power transmitted to a beam, kW	24
Maximum of surface electric field, kV/cm	74

GENERATOR DESIGN

RF generator shown on the figure 5 provides 60 kW power (for bunch operating mode). It is similar to the injector 180 MHz 130 kW RF generator of the FEL microtron-recuperator [4, 5]. It is a power amplifier operated from a voltage-controlled modulator. For accelerating RF voltage stabilization the modulator is connected to the cavity with a feedback.

Maximum output power of the modulator is 20 W. For parasitic feedback reduction a frequency of the modulator is twice lower than cavity working frequency. The preliminary stage is made on GU92-A tetrode. It has power amplification Kp = 25 and maximal output power Pmax = 500 W. Similar preoutput stage has Pmax = 10 kW. Powerful output stage is made on GU101-A tetrode. It has power amplification Kp = 15 and working output power Poperat = 60 kW. The distribution of amplifications and powers on generator RF system is shown in the table 2. All amplifier stages (except the modulator) are installed in the VEPP-2000 storage ring hall. The output stage is connected to the cavity by coaxial copper feeder. All power supply system of amplifiers is placed in a generator hall. The length of feeding cables is about 70 meters.

Table 2: Distribution of amplification and power on generator stages.

	modulator	GU92-A	GU92-A	GU101A
Kp		25	20	15
Poperat	8 W	200 W	4 kW	60 kW

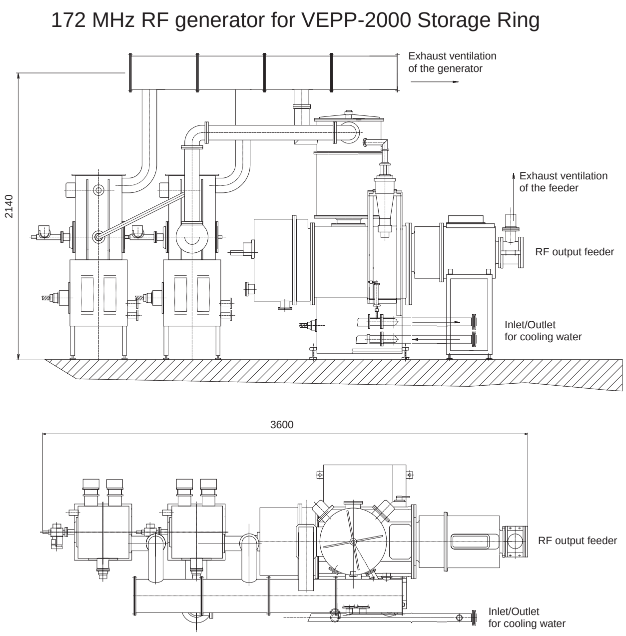

Figure 5: RF generator for VEPP-2000 storage ring.

Oil transformer TM200-10 is used for anode power supplies. Its secondary winding was modified for voltage 8 kV. Tube filaments are fed by the separate transformer. Midpoints of feeding windings are connected to the common wire through shunts. All operating parameters of the power supply and amplifier stages are monitored by ADC, working in CAN-BUS protocol. RF generator general block diagram (with feeding and cooling circuits) is shown on the figure 6. The fast protection circuit is used for anodes protection at breakdowns. Its switching-off time is 50 μs.

FEEDER

The copper coaxial feeder has wave impedance 75 Ohm and diameter 160/45 mm. Its electric length is equal to half of working wave length. The feeder is made basically from details used earlier on VEPP-2M. Now their completion comes to end.

CONTROL SYSTEM

The control system adjusts an amplitude and a phase of cavity accelerating voltage and carries out fine tuning cavity and choke-filter frequency.

CONCLUSION

172 MHz cavity for VEPP-2000 storage ring RF system is almost made. The cavity has the choke-filter and two HOM loads. Special ceramics elements are used for loads. The first measurements of the cavity with loads have shown the correctness of the numerical simulations.

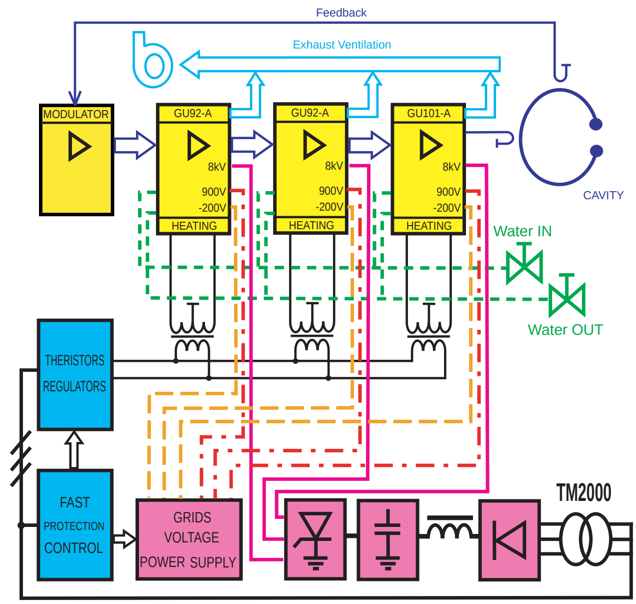

Figure 6: RF generator block diagram (with feeding and cooling circuits).

The 60 kW RF generator is similar to the 130 kW RF generator made earlier at BINP. Relaxed operating conditions of amplifier stages will increase the tube lifetime. All stages are made and placed in a storage ring hall.

REFERENCES

[1] Yu.M.Shatunov et al., “Project of a new electron-positron collider VEPP-2000”, in: Proc. of EPAC 2000, Vienna, Austria, 2000.

[2] V.N.Volkov et al., “VEPP-2000 single-mode cavity”, in: Proc. of 7th European Particle Accelerator Conferences, Austria Center Vienna, June 2000, p.2008-2010.

[3] V.Volkov et al., “Single mode RF cavity for VEPP-2000 storage ring based collider”, in: Proc. of EPAC 2004, Lucerne, Switzerland, 2004.

[4] V.Arbuzov et al.,”RF system of Electron Injector for the Race-Track Microtron-Recuperator”, in: Proc. of HEACC’98, XVII International Conference on High Energy Accelerators. Dubna 1998.

[5] V.Arbuzov et al., “RF System of electron injector for the Race-track microtron-recuperator and results of its operation with electron beam”, in: Problems of Atomic Science and Technology, v.4 (35), 1999, p.26-28, NSC KiPT, Kharkov, Ukraine.