ACCELERATING RF SYSTEM OF MICROTRON-RECUPERATOR FOR FEL

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Abstract

FEL (Free Electron Laser) for the Siberian Centre of Photochemical Research is constructed in Novosibirsk. Parameters and last results received on a RF system of the race-track microtron-recuperator for FEL are given in the report. The frequency of the RF system is 180.4 MHz. The RF system operates in continuous mode. The 16 cavities are used in accelerating system of the microtron-recuperator. The RF system is consists of two channels. Each of two 600kW generators drives 8 cavities. Each channel was tested at 7500 kV on the gaps of 8 cavities. The RF power was 630 kW per channel. Now, the accelerating RF system operates at 13600 kV on 16 cavities. Total power of generators is 1100kW.

INTRODUCTION

Project parameters for accelerating cavities voltage and output power of RF generators of RF system of a race-track microtron-recuperator for free electrons laser (FEL) of the Siberian Centre of Photochemical Research are achieved in the Budker Institute of Nuclear Physics (BINP).

The recuperation is carried out at 13.5 MeV beam energy and at 10 mA beam current (the injector current restriction).

RF SYSTEM

The RF system of the microtron-recuperator (Fig.1) operates on frequency 180.4 MHz at 1.2 MW CW mode.

The RF system consists of 16 cavities. Even and odd cavities are united into two groups. Each group of cavities is fed from its own RF generator. Project power of each RF generator is 600 kW.

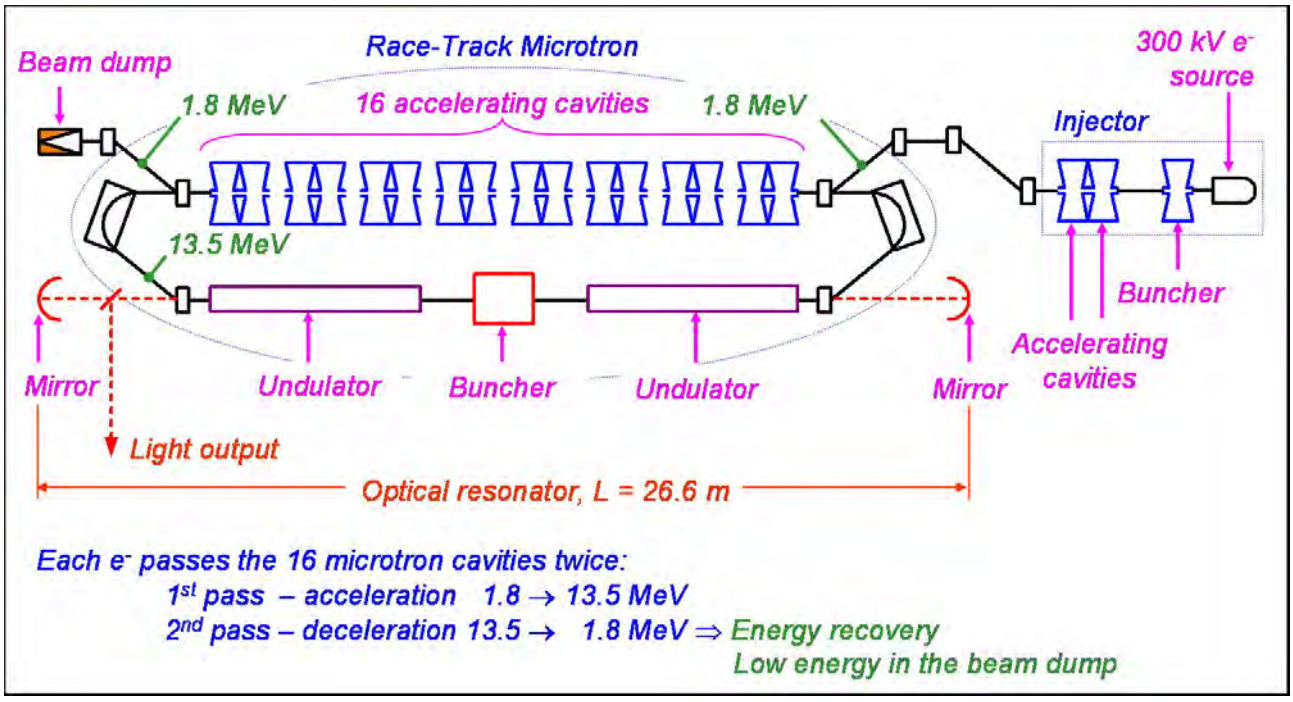

Fig.1: RF system of microtron-recuperator for FEL

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Cavities

In the RF system, bi-metal cavities are used (copper - stainless steel). The schematic drawing of cavities is shown on Fig.2.

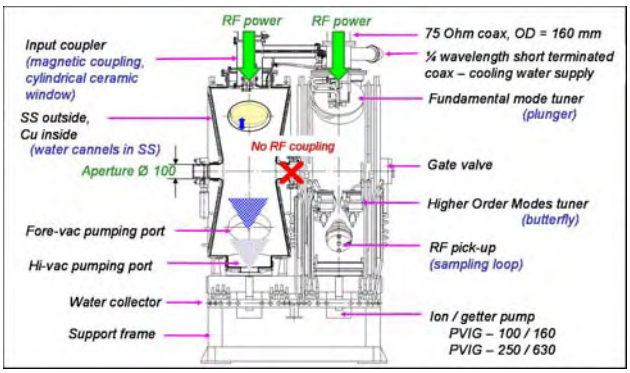

Fig.2: Bi-metal cavities

The general view of the cavities is shown on Fig.3.

Fig.3: Bi-metal cavities, general view

The electrical parameters are given in Table 1.

Table 1: Cavity parameters

Parameters of the fundamental (TM_{010}- like) mode			
Resonant frequency	f_0	180.4	MHz
Tuning range	Δf_0	320	kHz
*Characteristic impedance *)*	R/Q	133.5	Ohm
Unloaded quality factor	Q_0	40000	
*Shunt impedance *)*	R	5.3	MOhm
Operating gap voltage (amplitude)	$V_{gap\,m}$	0…950…	kV
Power dissipation @ $V_{gap\,m}$= 950 kV	P	85	kW
*Transit time factor **) (β_e = 1)*	τ	0.9	

**) $R = V^2_{gap\,m}/2P$ **) $V_{acc} = V_{gap}\,\tau$*

Generators

Each generator consists of four stages (Fig.4). First and second amplifier stages are made of tetrodes GU-92A. Third and fourth (output) stages are made of modules based on tetrodes GU-101A. Vacuum tubes are made by the company "SED-SPb", ("Svetlana"), St. Petersburg, Russia.

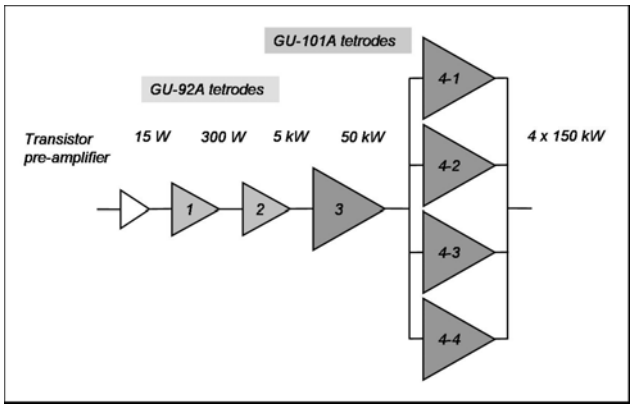

Fig.4: RF generator diagram

The modular design of the RF generator (Fig.5) essentially simplifies the power addition from several tubes, and simplifies manufacturing and adjustment of the whole generator. The 600 kW output stage is assembled with four modules. The single module is used as a preamplifier (the third stage of the RF generator).

Fig.5: RF generator, general view

Feeder System

Feeder system is made of aluminum rectangular waveguides and coaxial lines. The system of power division (Fig.6) is a rectangular waveguide (with cross-section 958x415 mm) connected with cavities by coaxial feeders. Groups of even and odd cavities are connected to the different waveguides.

Fig.6: RF power division system

Power division between cavities in a group is achieved as follows (Fig.7).

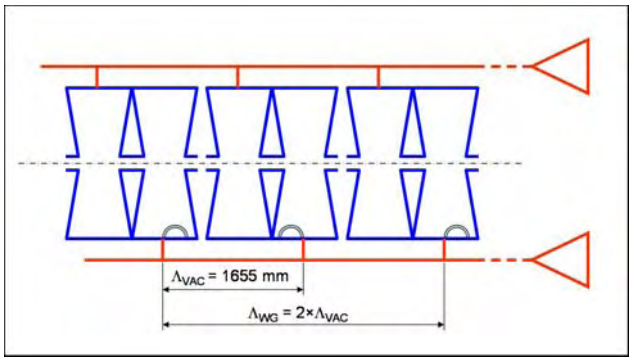

Fig.7: Phase matching of RF cavities

The distance between cavities is equal to wavelength in vacuum (1655 mm). The wavelength in the waveguide is twice more than in vacuum. Hence, field intensity amplitudes inside the waveguide on cavities inclusion cross-sections are identical, and phases are differing on 180 degrees. Correct cavities phase matching is achieved by a turn of coupling loops in the neighbor cavities of a group on 180 degrees.

Control System

Control and interlock systems are common for both generators. The common anode power supply (8 kV, 320 A) is equipped with tubes breakdown protection system. This system can remove the anode voltage from tubes in less than 50 us.

The control system adjusts amplitude and phase of the RF voltage of accelerating cavities, tunes the cavities, and removes a RF excitation from the generator in emergency conditions.

The control system consists of two identical independent channels.

The signals from eight accelerating cavities of the channel come to the amplitude detectors. The sum of the detector outputs is used as a feedback signal that operates the input power of the RF generator.

The phase tuning circuit adjusts the accelerating voltage phase of each channel to a master oscillator phase within the range of 360 degrees.

SUMMARY

Each channel was tested at 7500 kV on the gaps of 8 cavities. The RF power was 630 kW per channel. The efficiency factor of the output stage is 57 %.

Now, the accelerating RF system operates at 13600 kV on 16 cavities. Total power of generators is 1100kW.

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