RF SYSTEM FOR THE INDUSTRIAL LINEAR ELECTRON ACCELERATOR AT KAERI (DAEJEON, KOREA)

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Abstract

Budker Institute of Nuclear Physics has developed and produced RF generators, feeder lines and a control system for an industrial linear electron accelerator at Korean Atomic Energy Research Institute (KAERI, Daejeon, Korea). The accelerator is based on two superconducting RF cavities produced by CERN. Design energy of the accelerator is 10 MeV and design beam current is 10 mA. A 2 MeV injector for the accelerator was made by BINP earlier. Two-channel RF system of the accelerator operates at the frequency of 352 MHz in CW mode. Each channel has two-stage tetrode amplifier with output power of 50 kW, 100 W transistor preamplifier and the control system. Both tetrode stages have identical design. TH571B tetrode tubes produced by THALES (France) are used. Output power of 45 kW per channel was reached in an equivalent resistive load. Now BINP continues development of the accelerator. The energy of 11 MeV and the beam current of 1.9 mA were achieved. The amplitude of accelerating voltage was 4.5 MV in each cavity, and the power delivered to the beam was 17 kW.

INTRODUCTION

Budker Institute of Nuclear Physics has developed and produced RF generators, feeder lines and control system for the industrial linear electron accelerator at Korean Atomic Energy Research Institute (KAERI, Daejeon, Korea). Design energy of electrons is 10 MeV, design beam current is 10 mA.

RF SYSTEM

The accelerating RF system operates at the frequency of 352 MHz. It consists of two superconducting RF cavities (produced by CERN) (Fig. 1), two RF generators and control system.

Fig. 1: Superconducting cavities

The injector RF system operates at the frequency of 176 MHz. It consists of a buncher and two accelerating cavities (Fig. 2), three RF generators with design power of 15, 150, 150 kW (Fig. 3) and control system.

Fig. 2: Injector

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Fig. 3: RF generators 176 MHz

Injector Cavities

The injector has similar design as the injector for the race-track microtron-recuperator [1]. Beam energy and current of the injector is 2 MeV and 10 mA respectively. The injector cavities are based on 180 MHz bi-metal cavities produced by BINP. In order to reduce the operating frequency, the design of "standard" cavities was slightly changed.

A cooper torr was inserted into the buncher cavity to increase its equivalent capacity (Fig. 4).

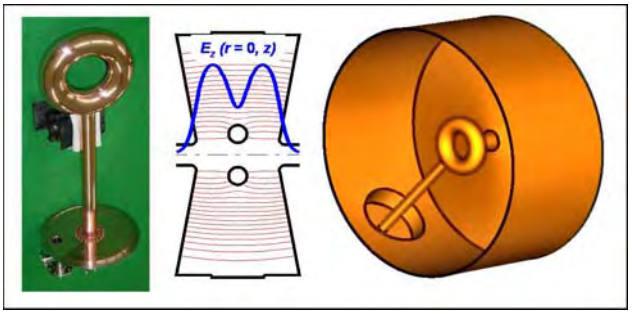

Fig. 4: Buncher modification

So as to save high breakdown voltage of accelerating cavities two cooper nose cones were welded to the side walls (Fig. 5).

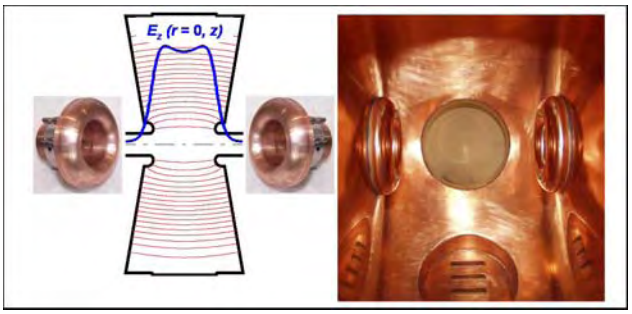

Fig. 5: Accelerating cavities modification

352 MHz Generators

Each RF generator (Fig. 6) consists of a two-stage tetrode amplifier and a 100 W transistor preamplifier. Both tetrode stages have similar design. They use TH571B tetrode tubes, produced by THALES (France).

Fig. 6: RF generators 352 MHz

The schematic diagram of each stage is shown on Fig. 7 and the description of construction units is given in Table 1.

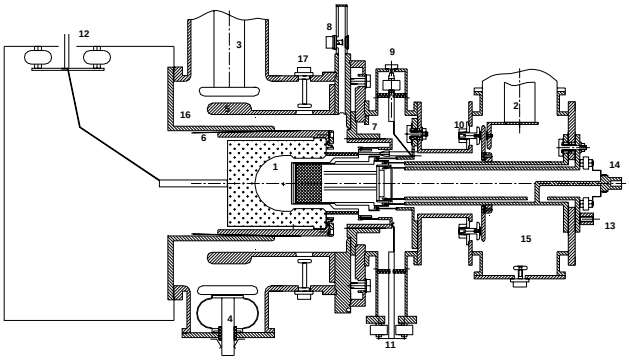

Fig. 7: Sketch view of TH571B based stage

Table 1: Constriction units description

1	TH571B
2	Input coaxial line
3	Output coaxial line
4	Output tuner
5	Cylinder tuner
6	Anode blocking capacitor
7	Screen grid blocking capacitor
8	Output contour higher modes suppressor
9	Screen and control grid resonance suppressor
10	Input tuner
11	Screen grid input
12	Anode power input
13	Filament input
14	Filament and cathode input

15	Input contour
16	Output contour
17	Anode blocking capacitor
18	Cathode blocking capacitor
19	Filament blocking capacitor

The operation regimes are given in Table 2.

Table 2: Operational regimes of two-stage generator

Parameter	Output stage	Input stage
Operating frequency	352.2 MHz	352.2 MHz
Output power	45 kW	1 kW
RF losses	2 kW	1 kW
Load impedance	50 Ohm	50 Ohm
Load VSWR at maximum power	1.1	1.3
Input power	1 kW	< 30 W
Filament voltage	+ 7.2 V	+ 5.4 V
Anode voltage	+ 8.1 kV	+ 8.1 kV
Screen voltage	+ 650 V	+ 650 V
Bias voltage	- 120 V	- 100 V
Anode current	7.8 A	1.3 A
Anode power dissipation	16 kW	9 kW

The design power per channel is 50 kW in CW mode. The output power of 45 kW was reached on equivalent resistive load of 50 Ohm.

After successful tests the generators were connected to the cavities. The feeder lines were adjusted to obtain the required value of multiple half wavelengths. There was obtained empirical proof of generator stability loaded by very high-Q load in static and dynamic mode of operation.

Control System

The control system controls amplitude and phase of accelerating voltage, tunes the cavities, and also controls and monitors the cryogenic system. The control system has necessary interlock and protection circuits.

The quadrature method for accelerating voltage control is used, i.e. the feedback circuits independently measure sine and cosine components of the accelerating voltage vectors and regulate them to obtain the required amplitude and phase.

The monitor and control circuits for the cryogenic system process signals from a lot of probes, generate signals to control liquid helium level and protect the cavities and the cryogenic system in the case of failures.

The computer control codes written at BINP provide convenient control and monitor of the RF system operation regime.

SUMMARY

After commissioning of the RF system the energy of 11 MeV and the current of 1.9 mA were achieved. The amplitude of accelerating voltage was 4.5 MV per each cavity and the power delivered to the beam was 17 kW.

The development of the accelerator is in progress.

REFERENCES

[1] S.V.Miginsky, V.V.Anashin, V.S.Arbuzov et al. Status of a 2 MeV CW RF injector for the Novosibirsk high-power FEL //Proc. Of 2nd Asian Conference on Particle Accelerators (APAC'2001).- 17-21 September 2001, Beijing, China.