Study on RF System and Cavity for CESS-Upgrade

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Abstract

RF system and cavity for CESS [1] (Compact Electron Synchrotron at Seoul national university)-Ugrade were studied. The cavity has been modeled with MAFIA and SUPERFISH code. HOM damping by two rectangular waveguides was chosen. Numerical calculation with MAFIA shows good HOM damping characteristics. Power delivery system, tuning system, amplitude/phase feedback system are also considered.

1 INTRODUCTION

Main purpose of CESS-Upgrade is to study the application of synchrotron radiation such as soft X-ray lithography. Table 1 shows main parameters of CESS -Upgrade.

Table 1: Main parameters of CESS-Upgrade

Injector	Race-track Microtron
Injection energy	100 MeV
Final energy	900 MeV
Maximum beam current	200 mA
Bending radius	1.7 m
Bending magnet field intensity	1.76 T
Bending magnet core material	low carbon steel
Critical wavelength	13 Å

A frequency 499.654 MHz was chosen for RF acceleration, considering physical size, available RF source, bunch length and number of bunches. A simple cavity structure and RF system were preferable for the reliable operation. As the impedances of HOMs (higher order modes) will cause longitudinal and transverse coupled beam instability, these coupling impedances arising from HOMs must be sufficiently reduced.

In this paper, the designs of RF cavity with HOM damper and RF system for CESS-Upgrade are presented.

2 CAVITY

As the cavity loss which is calculated 13.3 kW is not critical, the cavity shape was designed pillbox cavity with nose cone. A nose cone shape is chosen for high shunt impedance for the fundamental mode with respect to HOMs.

The principal paramerters and cavity shape were determined using the computer codes SUPERFISH [2] and MAFIA [3]. Determined RF parameters are given in table 2. It should be noted that Q and shunt impedance R in Table 2 have been obtained by considering all the effects such as tuning plunger, HOM waveguides and other auxiliary ports although SUPERFISH results give Q=32,000 and R=4.2 MΩ. The coupling coefficient β was determined for the matching of 200 mA beam current. The considered coupler was loop coupler which has the advantages that its dimension is small (as compared with aperture coupler) and coupling factor is adjustable by rotating it.

Table 2: RF parameters of CESS-Upgrade

Frequency	499.654 MHz
Shunt impedance	3 MΩ
Unloaded Q	20,000
Max. gap voltage	200 kV
Cavity dissipation	13.3 kW
Radiation loss per turn	34.2 keV
Coupling coefficient	1.75
Transmission loss	0.4 dB
Other miscellaneous loss	~ 3 kW
Required RF Power	30 kW
Tuning range	1.5 MHz

Schematics of the cavity is shown in Figure 1. For adeqaute cooling and keeping up the Q, oxygen free high conduivity (OFHC) copper was selected as the base material.

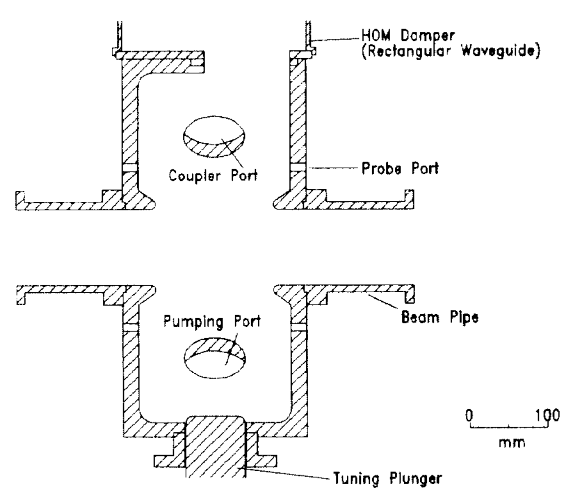

Figure 1: Cross-section of CESS-Upgrade RF cavity.

3 HOM DAMPING

The HOM parameters (up to the respective cut-off frequency of the beam pipe) of cavity were computed using MAFIA. Figure 2 shows the resultant mode spectrum. The frequency of the first dipole mode is 805.4 MHz and that of the first monopole mode is 932.1 MHz.

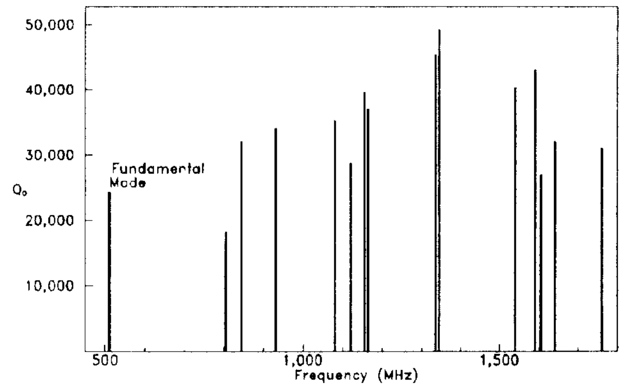

Figure 2: Mode spectrum of undamped cavity

For Damping HOMs, two rectangular waveguide are attached at the side wall of the cavity. The two waveguides are spaced 90° apart around the cavity azimuth. The waveguide-cavity coupling slots were located at the corner of the cavity where magnetic fields of HOMs are large. The waveguide size is 240 × 240 mm square section. Its TE_{10} mode cut-off frequency is 625 MHz, TE_{11} mode cut-off frequency is 884 MHz. This matches well the requirements such as far above fundamental mode frequency and below first dipole, monopole HOM frequencies.

The method of Kroll et al. [4],[5] was used to calculate the HOM frequencies and external Q's of waveguide loaded structure. Figure 3 shows 3-D mesh generated by MAFIA mesh generator.

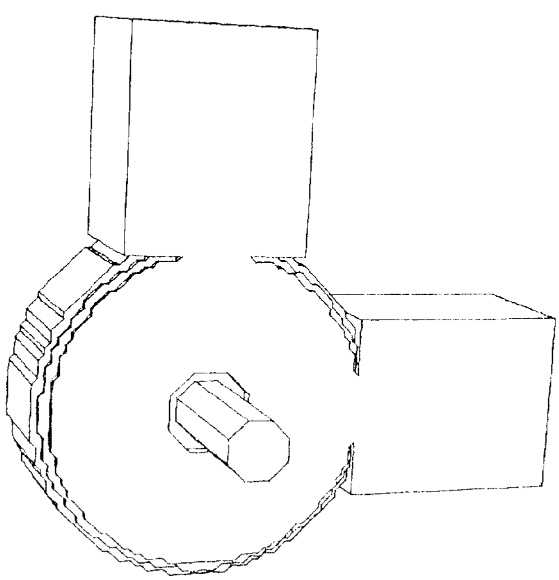

Figure 3: MAFIA 3-D mesh of cavity with damper

Four MAFIA runs per one boundary condition were carried out to obtain phase-frequency plot with waveguide shorted at different length. The calculated results are in figure 3 and show good damping characterictics.

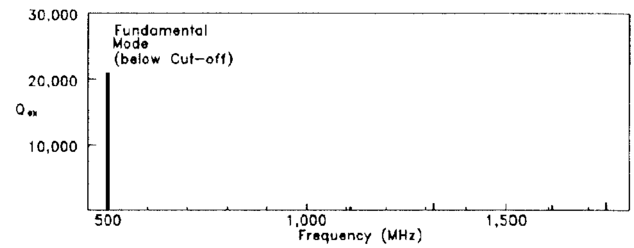

Figure 4: Mode spectrum of cavity with rectangular waveguide damper

4 RF SYTEM

4.1 Power Delivery System

The RF system takes the reference signal (500 MHz, 10 mW) from the signal generator of injector, and then solid state amplifier amplifies this signal to 10 W. This power is controlled by the variable attenuator and the power supply. The CESS-Upgrade main power amplifier is a standard broadcasting type klystron. The transmission of the ouput power from klystron is carried by coaxial line having a flexible section. In spite of larger transmission loss than waveguide, coaxial line is preferable for its small size and flexibility in this system.

4.2 Tuning System

For minimizing reflected power and required generator power, detuning is necessary [6]. Selected tuning type is the motorized plunger. From MAFIA runs, 80 mm dia. 30 mm stroke plunger can provide the tuning range of more than 1.5 MHz. For matched system, the required amount of detuning is -20 kHz. This is easily accomplished by this tuner. Figure 4 shows the cavity resonance frequency shift as a function of tuner position.

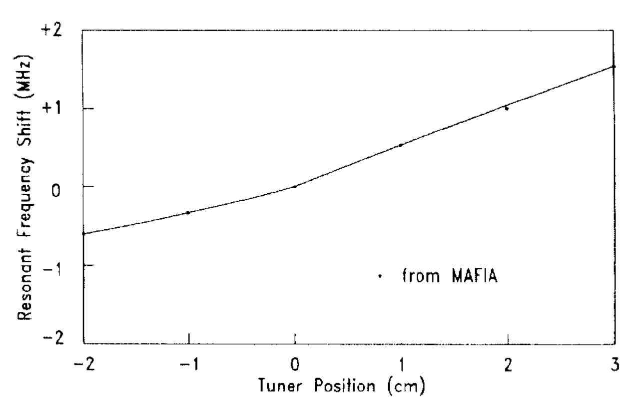

Figure 5: Resonant frequency shift as a function of tuner position

4.3 *Amplitude/Phase Feedback System*

Figure 6 shows the overall RF system schematics of CESS-Upgrade including amplitude/phase feedback system.

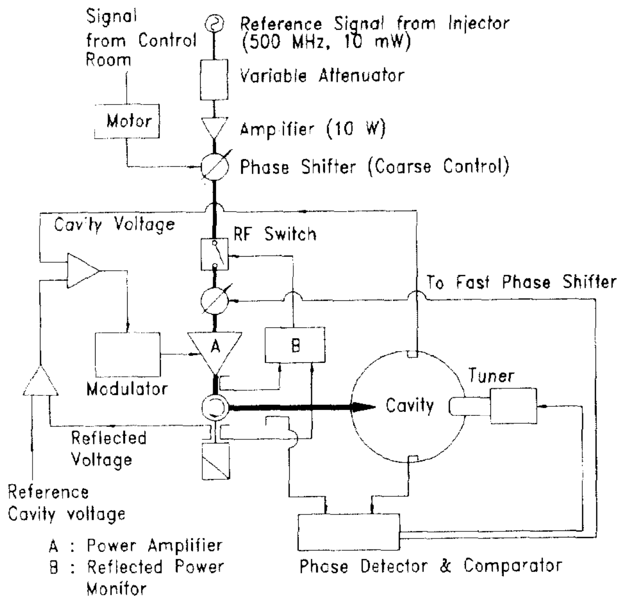

Figure 6: RF system of CESS-Upgrade

5 CONCLUSION

Designs of the cavity with HOM damper and RF system of CESS-Upgrade were carried out. The cavity shape is modified pillbox with nose cone. Two waveguide HOM damer provides good damping characteristics. For complete design the thermal study of the cavity and detailed electronics of the RF system are needed in the future work.

6 REFERENCES

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