§26. Design and Fabrication of Band Rejection Filter for ECE Diagnostics

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Second electron cyclotron heating (ECH) of 53.2GHz is being carried out on CHS. We modified the heterodyne radiometer system to investigate the electron heat transport during localized second ECH. The stray from the output of gyrotron coming into the receiver system is about two orders of magnitude larger than the electron cyclotron emission(ECE) signal and is comparable level to the output signal of local oscillator at the mixer. During the second harmonic ECH, the frequency range of interest is from 40GHz to 60GHz for ECE diagnostics. High stray power at 53.2GHz can make spurious signal for heterodyne system. To reject this stray power we designed the band rejection filter which has a sharp peak of attenuation at 53.2GHz.

This filter is made of rectangular parallelepiped aluminum block. A U-band(2.4mm × 4.8mm) waveguide passes through the center of this block. The signal in the waveguide is coupled with ten cylindrical cavities by coupling holes of 1mm radius. The distance of each coupling hole is set to be 4.3mm on the center line of the waveguide. This distance is set just $3\lambda_g/4$ (λ_g is the wavelength in the wave guide) so as to cancel out the reflected power at each coupling hole. The offset of the coupling hole from the center of the cylinder is 0.3mm (Fig.1). The wave mode in the rectangular wave guide is TE_{10}. The cavity mode is TE_{111}.

The theoretical value of the Q which indicates the ratio of the power loss and stored energy in a cavity[1] obeys following equations;

$$\frac{1}{Q} = \frac{1}{Q_0} + \frac{1}{Q_E}$$

$$Q_0 = \frac{\lambda_0}{\delta} \cdot \frac{\left(\chi_{[11]}^2 - 1\right)\left[\chi_{[11]}^2 + \left(\frac{\pi R}{L}\right)^2\right]^{\frac{3}{2}}}{2\pi\left[\chi_{[11]}^4 + 2\left(\pi\chi_{[11]}\right)^2\left(\frac{R}{L}\right)^3 + \left(\frac{\pi R}{L}\right)^2\left(1 - \frac{2R}{L}\right)\right]}$$

$$Q_E = \frac{36\pi a^2 b^2 L^3}{\alpha_m^2 d^6 \lambda_0^2 \lambda_g}\left(\chi_{[11]}^2 - 1\right)\left(\frac{J_1(\chi_{[11]})}{J_1\left(\chi_{[11]}\frac{r}{R}\right)}\right)^2 \frac{(rR)^2}{\left(\chi_{[11]}r\right)^2 + R^2}$$

where J_1 is the Bessel function and $\chi_{[11]}$ is the first root of J_1. α_m, L, and δ are the coupling coefficient, the length of cylindrical cavity and skin depth of the cavity wall, respectively. The calculated value of Q was 2000 and experimental Q data of one cavity of this filter is 1360. The difference in these Q values is attributed to the uncertainties in estimating the wall loss in the cavity.

The attenuation characteristics of this filter is shown in Fig.2. The attenuation at 53.2GHz is more than 50dB which is the limit of the measurement. The small peak around 42GHz appears from interval distance of cavities which is equal to $2\lambda_g$. The frequency band which has an attenuation more than 20dB is ±0.25GHz. It is sharp enough to get the electron temperature profile for the transport analysis.

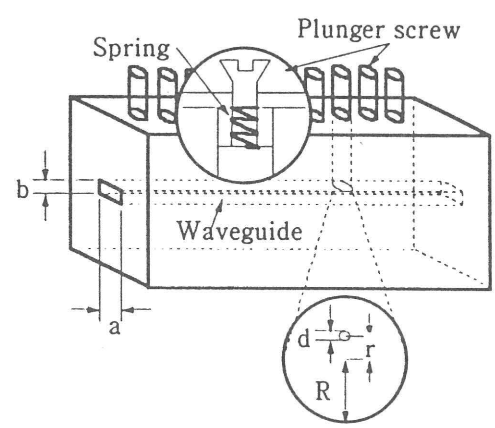

Fig.1. Outward form of the band rejection filter

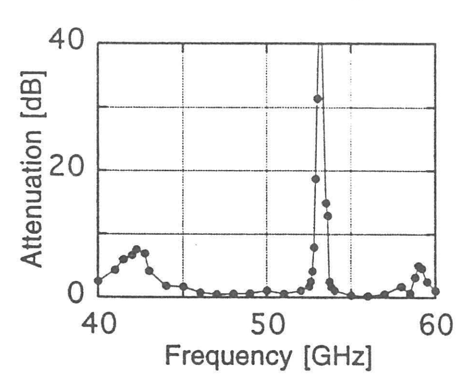

Fig.2. Attenuation data of the band rejection filter

References
1) John,D.J., Classical Electrodynamics (John Wiley & Sons,Inc.1962)