§27. Study for High Sensitive Microwave Imaging Reflectometry in LHD

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Millimeter-wave imaging diagnostics, such as phase imaging interferometry, microwave imaging reflectometry, and electron cyclotron emission imaging, have proven to be useful in obtaining 2-D images of electron density, electron temperature, and their fluctuations. These techniques are powerful tools for studying localized magnetohydrodynamic instabilities and micro instabilities, which are considered to be responsible for the anomalous transport of magnetically confined plasmas. Microwave imaging systems are now installed in the large helical device and the Tokamak EXperiment for Technology Oriented Research.

To ensure compatibility with the observation of a high-density plasma and the use of a phase detection method, the system employs both heterodyne and frequency signal is utilized to detect signals from the plasma and a radio frequency (RF) is utilized as a probe beam. However, this system has several problems with the local oscillator (LO) optics. First, the beam splitter, which acts as a beam combiner for the RF and LO waves, attenuates its intensities. Second, there is a difference in the conversion losses of the internal mixer between a center channel and an edge channel of the horn-antenna mixer array (HMA) because of a deformed LO beam pattern. Third, the LO supplied by irradiation requires an expensive high-power amplifier owing to low coupling efficiency between the irradiation horn antenna and each HMA element. To solve these problems, a new antenna system is proposed [1-3].

Each horn antenna receives both RF and LO waves, whereas the mixer generates IF signals. Various problems are caused by LO supplied by irradiation as in the original HMA. However, the new HMA is designed such that LO irradiation is not necessary, and instead employs a monolithic microwave integrated circuit (MMIC) frequency multiplier. The main element circuit pattern of the multi-channel HMA was designed by Microwave Office (National Instruments Corporation). A multi-channel horn mixer array comprises well-characterized mixers, the waveguide-to-microstrip transitions, IF amplifiers, the filters, and the internal LO module using MMIC technology.

In order to improve this system, the low pass filter (LPF) in Fig.1 was fabricated, and the measurements of the frequency performance of the LPF were performed. It is seen that the insertion loss of the LPF is above than −1.9 dB in the range from 1 to 9 [GHz], and less than −33.2 dB in the range from 14 to 18 [GHz] as shown in Fig. 2. And a band pass filter (BPF) in Fig. 3 was fabricated, and the measurements of the frequency performance of the BPF were performed. We can see that the band width of the BPF is above than 4.0 GHz as shown in Fig. 4. We will apply to these filters to the system in the near future.

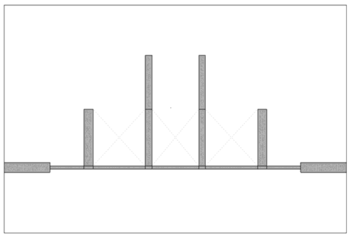
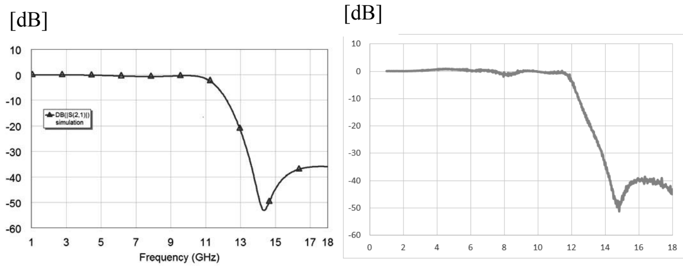


Fig. 1 Layout of LPF.



(a) (b)

Fig. 2 Performance of (a) calculated of insertion loss, and (b) measured one.

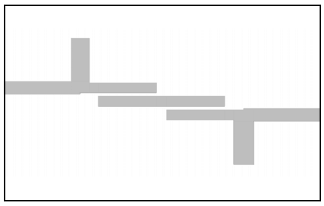
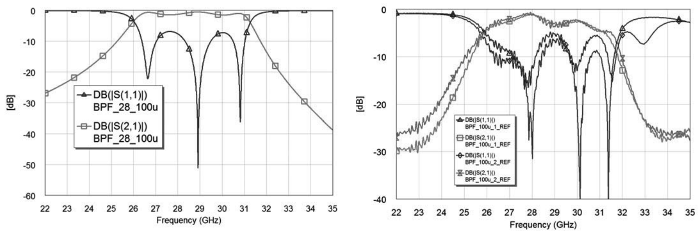


Fig. 3 Layout of BPF.



(a) (b)

Fig. 4 Performance of (a) calculated return and insertion loss, and (b) measured one.

1) Nagayama, Y. et al.: *Rev. Sci. Instrum*. **83** (2012) 10E305.
2) Kuwahara, D. et al.: *Rev. Sci. Instrum*. **85** (2014) 11D805.
3) Ito, N. et al.: *J. Plasma Fusion Res.* **10** (2015) 3402034.