§42-22 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, and the internal LO module using MMIC technology.

A two-channel test module in Fig. 1 was fabricated, and the measurements of the frequency performance of waveguide transitions were performed. It is seen that the insertion loss of the waveguide transitions are less than −3.8 dB in the rage from 50 to 65 [GHz] as shown in Fig. 2. The measurements of the transmission property of multilayer were performed. It is seen that the insertion loss of the multilayer are less than −1.2 dB in the rage up to 3 GHz as shown in Fig. 3. Figure 4 shows the measurements of the conversion loss of mixer. When the LO level is +5.1 dBm and the RF level is signal −20 dBm, the conversion loss of that is −23.4 dBm. The evaluation of the eight-channel HMA will be reported in the near future.

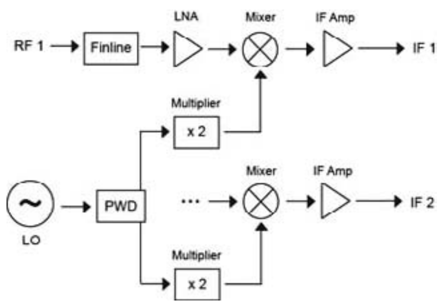

Fig. 1. Schematic diagram of two-channel module.

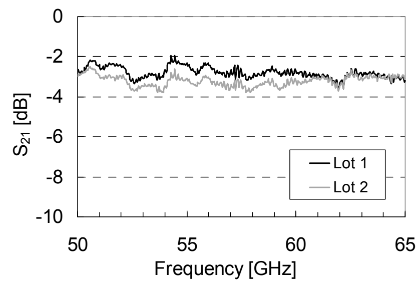

Fig. 2 Frequency performance of waveguide transitions.

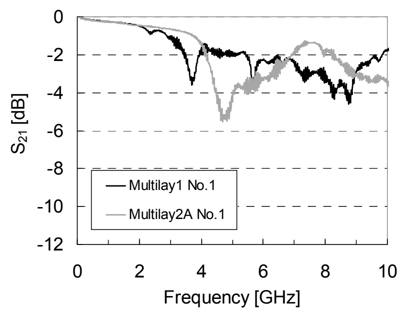

Fig. 3. Transmission property of multilayer.

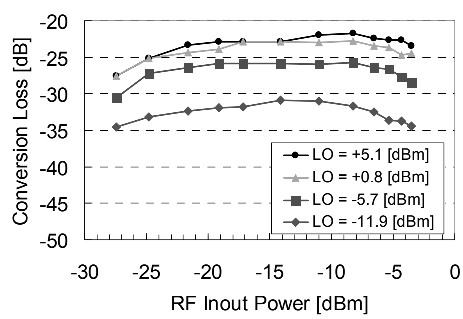

Fig. 4. Conversion loss of mixer.

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.