§11. Development of 1-Dmensional Antenna Array for Microwave Imaging Interferometer in GAMMA 10 Diverter Simulation Experiments

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Microwave imaging diagnostics can be potentially used to observe functions in the electron density and electron temperature profiles in magnetically confined high temperature plasma.[1,2] In LHD, a horn antenna mixer array (HMA) has been developed as a receiver of a microwave imaging reflectometry. Since HMA is a heterodyne type antenna array, it needs a local oscillation (LO) power to convert a radio frequency (RF) signal into an intermediate frequency (IF) signal. The LO distribution method of HMA adopted a space-irradiation method using a LO horn antenna. The LO signal and RF signal entered antenna element of HMA via each horn antenna.

This system has problems related to the LO optics. First, the beam splitter, which is utilized as a beam combiner of the RF and LO waves, attenuates its intensities. Second, there is difference in the conversion losses of the internal mixer between a center channel and an edge channel of the 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 overcome these problems, a new antenna system is designed.

The new HMA is designed such that LO irradiation is not necessary, and employs a microwave monolithic IC (MMIC) frequency quadrupler.[3] It converts an LO wave to a pre-LO signal having 1/4 of the frequency. By using the quadrupler, the mixer can receive the LO wave on the same PCB. When the frequencies of the RF and LO waves are 60.150 GHz and 60 GHz, respectively, 1/4 of the frequency of the LO wave is 15 GHz. The signal at the frequency of 15 GHz is easily divided, transmitted, and amplified on the PCB. In addition, signals in this frequency band can be transmitted with low loss by a coaxial connector. Therefore, the new HMA can provide LO waves to each mixer inside the antenna housing, without the LO optics.

Figure 1 shows details of the two-channel test module developed in the current fiscal year, and its conversion losses. In this module, SMA connectors are used with the IF outputs and a 1/4 LO input, and WR-15 flanges are used with the RF inputs. Figure 1(d) shows the results of the conversion loss test. In this test, the frequency and power of the 1/4 LO are 15 GHz and 10 dBm. Further, the frequency

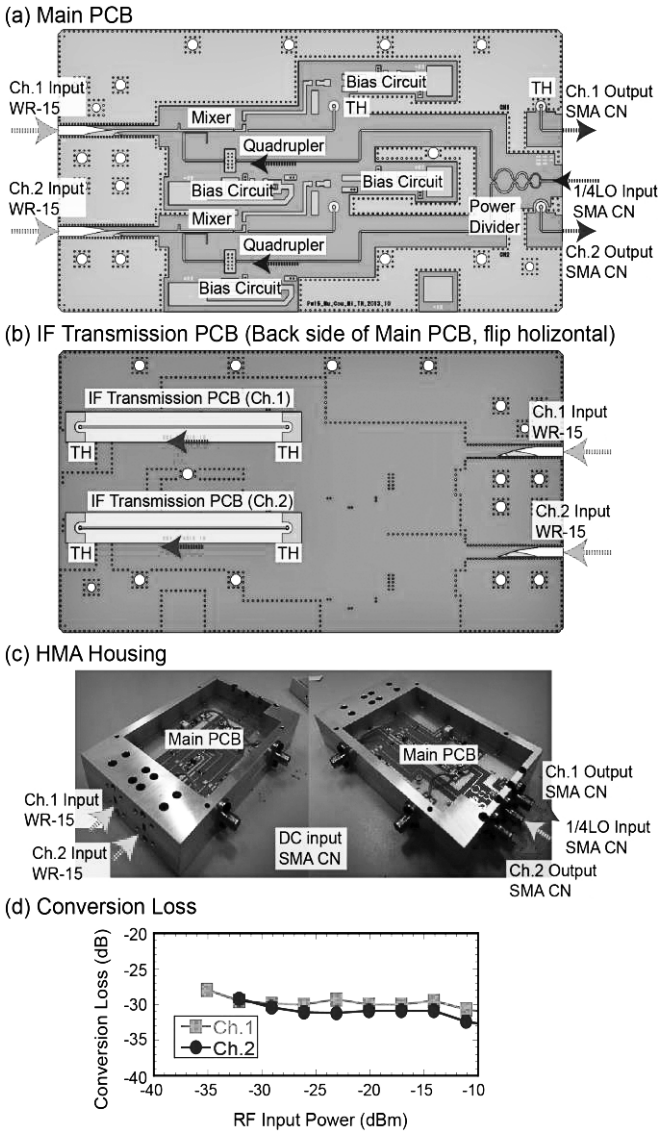

Fig. 1. Two channel test module: (a) top view of the main PCB (b) bottom view of the main PCB and IF transmission PCB (c) bird eye view of the test module, and (d) conversion loss

and power of the RF are 60.150 GHz and −10 to −35 dBm, respectively. According to Fig. 1(d), the conversion losses of channels 1 and 2 exhibit similar characteristics. These values are better than the former HMA.[1]

On the basis of former HMA, a new HMA, which has an internal LO module, was proposed for microwave imaging diagnostics. In order to demonstrate the new HMA, a two-channel test module was manufactured. In the next fiscal year, 8 channel antenna arrays will be developed and installed in GAMMA 10.

1) Kuwahara, D. et al.: *J. Plasma Fusion Res. SERIES* **8** (2009) 649.
2) Kuwahara, D. et al.: *Rev. Sci. Instrum*. **81** (2010) 10D919.
3) Kuwahara, D. et al.: *Rev. Sci. Instrum*. **85** (2014) 11D805.