§5. Development of 1-Dimensional 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 a profile of electron density in magnetically confined high temperature plasma.[1] In LHD, a horn antenna mixer array (HMA) has been developed as a multi-channel 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 the 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. However, this system has problems related to the LO power supply. 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 antenna array named Local Oscillator integrated Antenna array (LIA) is designed such that LO irradiation is not necessary, and employs a microwave monolithic IC (MMIC) frequency quadrupler.[2,3] Figure 1 indicates schematic diagram of an interferometer system using the LIA. It converts an LO wave to a pre-LO signal at the frequency of 1/4. 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, the 1/4 LO frequency is 15 GHz. The signal around the frequency of 15 GHz is easily divided, transmitted, and amplified. In addition, signals in this frequency band can be transmitted with low loss by a coaxial connector. Therefore, the LIA can provide LO waves to each mixer inside the antenna housing, without the LO optics.

In this fiscal year, we developed eight channel LIAs for the GAMMA 10 experiment. Figure 2 shows a photograph of stacked LIAs. Each channel has a pyramidal horn antenna (open mouth of 19×19 mm), and channel separations of between each channel is 20 mm. Figure 3 indicates conversion losses of two LIAs.

In the next fiscal year, we plan to develop an upgraded LIA that has RF low noise amplifiers to improve the conversion loss.

1) Kuwahara, D. et al.: *Rev. Sci. Instrum*. **81** (2010) 10D919.
2) Kuwahara, D. et al.: *Rev. Sci. Instrum*. **85** (2014) 11D805.
3) Ito, N. et al.: *Plasma Fusion Res.* **10** (2015) 3402034.

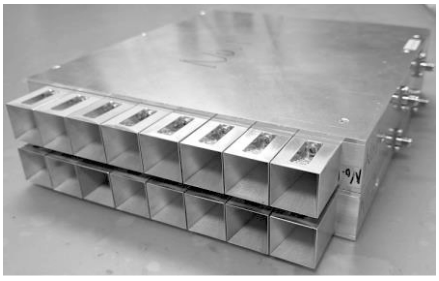

Fig. 2. Eight channel LIAs.

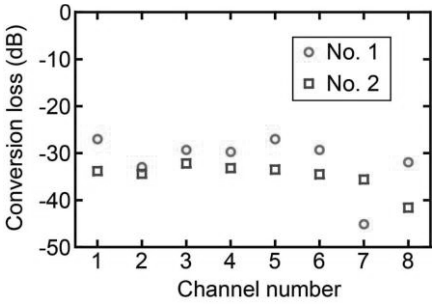

Fig. 3. Conversion loss of LIA.

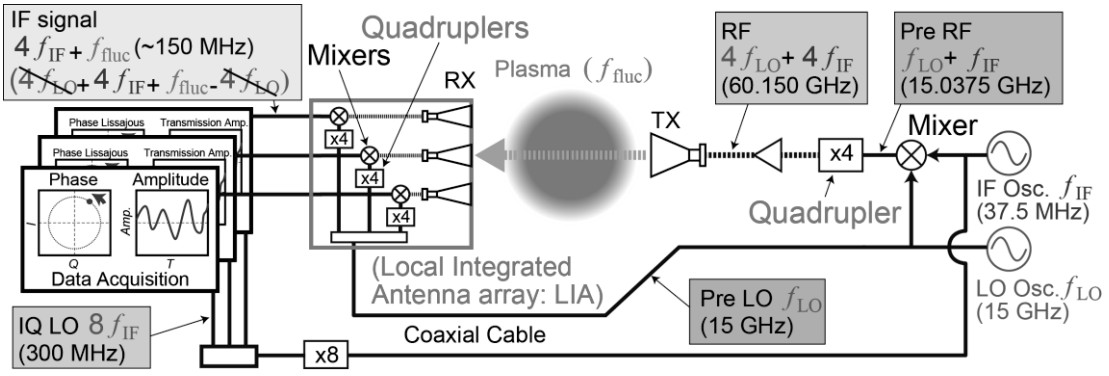

Fig. 1. Interferometer system using LIA.