§12. Development of Electron Cyclotron Emission Imaging system Using LO-Integrated Horn Antenna Mixer Array

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Microwave imaging diagnostics are powerful tools that are used to obtain details of complex structures and behaviors of such systems as magnetically confined plasmas. For example, microwave imaging reflectometry and microwave imaging interferometers are suitable for observing phenomena that are involved with electron density fluctuations; moreover, electron cyclotron emission imaging (ECEI) diagnostics enable us to accomplish the significant task of observing MHD in- stabilities in large tokamaks. However, microwave imaging systems include difficulties in terms of multi-channelization and cost. Recently, we solved these problems by developing a Horn-antenna Mixer Array (HMA)[1], a 50 - 110 GHz 1-D heterodyne- type antenna array, which can be easily stacked as a 2-D receiving array, because it uses an end-fire element. However, the HMA still evidenced problems owing to the requirement for local oscillation (LO) optics and an expensive high-power LO source. To solve this problem, we have developed an upgraded HMA, named the Local Integrated Antenna array (LIA)[2,3], in which each channel has an internal LO supply using a frequency multiplier integrated circuit. Therefore, the proposed antenna array eliminates the need for both the LO optics and the high-power LO source. This paper describes the principle of the LIA, and provides details about an 8 channel prototype LIA.

Figure 1 indicates a block diagram of an ECEI LIA (50 ~ 57 GHz type). The LIA consists of six important elements: horn antennas, waveguides to microstrip line transition (WMTs), mixers, an LO module, an LO power divider, and IF transmission lines. The horn antennas and WMTs are part of a sandwich of a high-frequency printed circuit board (PCB) placed between upper and lower aluminum frames, each of which are engraved with half of the horn antenna and waveguide shapes. The receiving wave (RF) enters the mixer via a horn antenna and a WMT, which is converted to the IF signal by the LO wave generated by the quadrupler. Pre LO signals are supplied to each quadrupler by a power divider using the Wilkinson power divider method. Since the LO power divider is installed between the mixer and the output connecter, the IF signals sent to the output channel by a transmission line.

Figure 2 shows a schematic view of a new ECEI system in LHD. A tentative plan of the ECEI system is as follows: eight poloidal channels, four toroidal channels, and observation frequencies: 50~57 GHz (1 GHz step, 8 channels) and 98~113 GHz (1 GHz step, 16 channels).

In this fiscal year, developments of important elements of the ECEI LIA, e.g., the quadrupler, the low noise amplifier, the mixer and the band-pass filter were done. In the next fiscal year, we plan to develop an eight channel LIA (50 ~57 GHz type).

1) Kuwahara, D. et al.: *Rev. Sci. Instrum*. **81** (2010) 10D919.
2) Kuwahara, D. et al.: *Rev. Sci. Instrum*. **85** (2014) 11D805.
3) Kuwahara, D. et al., *J. Instrum.* **10** (2015) C12031.

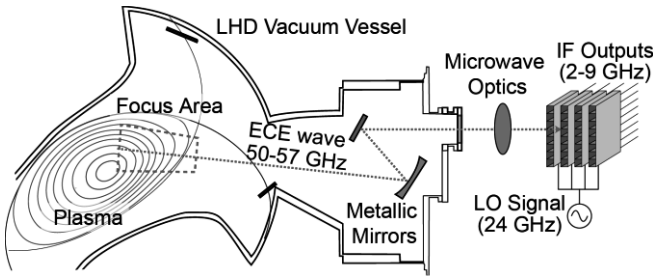

Fig. 2. New ECEI optics.

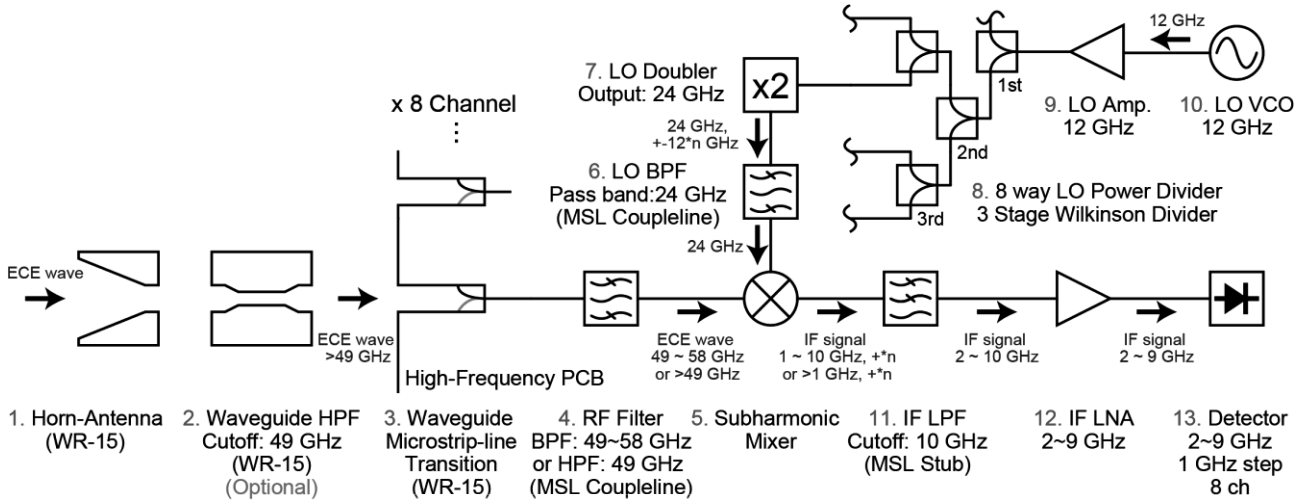

Fig. 1. Block diagram of ECEI LIA (50 ~ 57 GHz type).