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Development of O-mode Microwave Reflectometry in LHD
LHDにおけるOモードマイクロ波イメージング反射計計測の開発

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The O-mode microwave imaging reflectometry (O-MIR) system has been intensively developed in the Large Helical Device (LHD). In 2013, the U-band system was built by modifying the previous X-mode system. We have developed metal beam splitters (BS) with long holes of random length. The signal level U-band system was significantly improved because of improvements in BS and oscillator, but the experiment was failed due to the spurious oscillation in the horn-antenna mixer array (HMA). The Ka-band system is under development.

1. Introduction

Microwave Imaging Reflectometry (MIR) has been intensively developed in Large Helical Device (LHD)[1]. The X-mode MIR system has been working since 2010. Figure 1 shows typical example of n_e profile, and the cutoff densities of the 63 GHz X-mode wave and the 30 GHz O-mode wave. Since the n_e profile is hollow, the X-mode reflectometry is useful to observe the plasma center. However, observable plasma is very limited because the frequency of the X-mode depends on the magnetic field. We are developing the O-mode MIR (O-MIR) in order to observe wide variety of plasma.

2. Oscillator

In 2013, we modified the V-band oscillator for the X-mode MIR (X-MIR) to the U-band oscillator for O-mode MIR as shown in Fig. 2. The frequency of O-mode is much lower than the X-mode as shown in Fig. 1. The mixer (Hittite HMC521LC4) works as a down-convertor by connecting -90°signal of the quadrature divider to IF2, and 0°signal to IF1. In the X-mode system, microwaves for the plasma illumination and the local oscillation are transmitted through the X-band waveguide to avoid the effect of magnetic field. In the O-mode system, the ×6 frequency multipliers and the microwave power

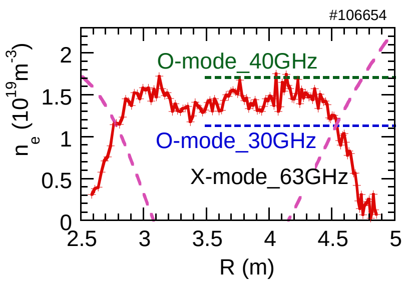

Fig. 1 Typical example of ne profile, and the cutoff densities of the 63 GHz X-mode wave and the 30 GHz O-mode wave.

amplifiers are installed near the antennas, but no effect from the magnetic field is observed. The microwave power to illuminate the plasma is increased by the factor of 3.

3. HMA

The microwave image is detected by the horn-antenna mixer array (HMA). Since the cutoff frequency of V-band HMA for the X-mode

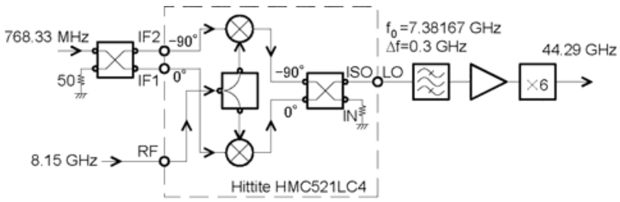

Fig. 2 Down convertor for the O-mode MIR system.

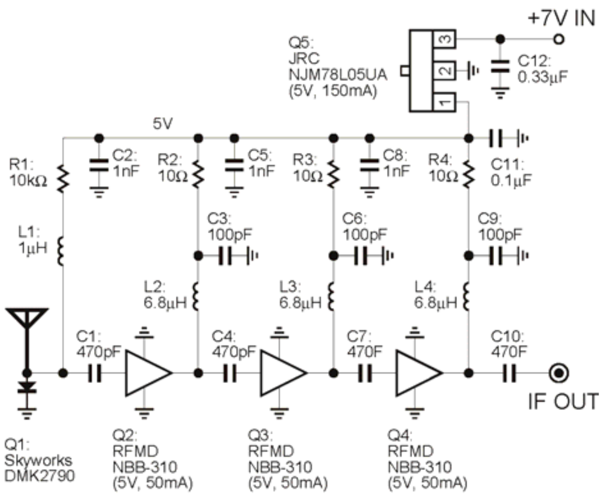

Fig. 3 Electrical circuit of the U-band HMA.

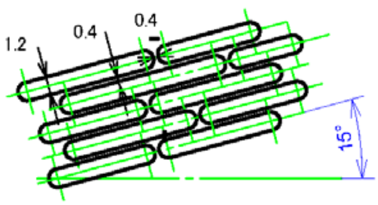

Fig. 4 Detail of the beam splitter for the O-MIR.

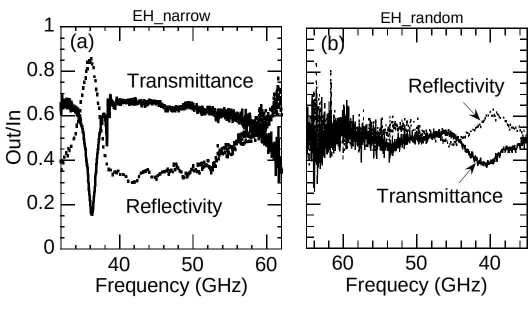

Fig. 5 Transmittance and reflection of beam splitter. (a) The hole length is 9 mm, (b) the hole length is random between 4 mm and 15 mm.

MIR is 50 GHz, we have developed U-band HMA. The circuit of the U-band HMA is the same as the V-band HMA, as shown in Fig. 3. The U-band HMA has the waveguide with the inner width of 2.5 mm, the height of 5 mm and the length of 13.5 mm. The diode mixer (Skyworks DMK2790) is installed in the waveguide and the distance from the waveguide edge is 2.5 mm. The mouse size of horn is 20×20 mm and the horn angles are 40 degree in the E-plane and 34 degrees in the H-plane.

4. Beam Splitter

Since the E-component of the microwave follows the field line as propagating towards the plasma core[2], the E-component should be along the field line, which is about 30 degree at the plasma edge. Beam splitters (BS) are aluminum plates with narrow and long holes, as shown in Fig. 4. The angle of long holes is 45 degree from the E-component. This structure is similar to the BS with wire grids. Wire grids may fluctuate easily in the MIR optics due to the air fluctuation. BS with narrow holes of constant length imitates the BS with wire grids, but it has a frequency response with peaks and dips, as shown in Fig. 5(a). Peaks and dips in the frequency response eliminated by using narrow holes with random length, as shown in Fig. 5(b). By using new BS, the reflection power increases by 3.

5. Preliminary Results

The O-MIR system worked at the first moment when it was installed to LHD. Signal level was significantly improved comparing the previous sysem[1]. However, U-band HMA got a trouble of spurious oscillation, so that the experiment was failed. Now, we are building new O-mode system working in the Ka-band system. The Ka-band HMA utilizes fin-line transition from the waveguide to the micro-strip line, and double-balanced mixer for the heterodyne detection. The Ka-band O-mode system is expected to be useful to investigate the density fluctuation in the internal transport barrier (ITB) region.

Acknowledgments

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