§18. Development of 2-D Antenna Array for Microwave Imaging Reflectometry on LHD

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A 2-D antenna array for the Microwave Imaging Reflectometry (MIR) has been developed for the Large Helical Device (LHD). Microwave Reflectometry is a radar technique for the measurement of electron density profiles and density fluctuations by probing the electron density-dependent cutoff layer in plasma. This measurement has a good spatial resolution and sensitivity by using a phase detection method. Microwave Imaging Reflectometry (MIR), a multi-channel reflectometry system equipped with the imaging optics, is one of the most powerful tools to study turbulence and instabilities.

In former MIR system in LHD, three pyramidal horn antennas were equipped as receiving antenna array. The toroidal and poloidal wave numbers of fluctuations were tried to measure, it was impossible because antenna channels were too few. Therefore the V-band (50 – 75 GHz) 5x8 channel antenna array has developed for the new MIR system. At the first, we developed the compact, high gain and wide band antenna as an antenna element of the 2-D antenna array. Finally, the half-divided pyramidal horn antenna was developed. Fig.1 sketches a schematic view of the V-band 1-D horn antenna array assembly. It has three parts of upper structure, PCB, and lower structure. Fig.1(a) shows a reversed view of the upper structure, and Fig. 1(b) shows the lower structure. The upper and lower structures are made of aluminum alloy, and horn shape and waveguide slots are made by electrical discharge machining. By attaching these slots, a horn antenna is formed. In the upper structure, another slot is formed for passing the micro-strip-line. Figure 1(b) shows PCB, where the mixer diode is mounted. Low-pass filter (LPF) and RF amplifiers are also installed on the PCB. By stacking 1-D horn antenna arrays, a 2-D antenna array is formed. Besides the antenna element, the antenna array has Intermediate Frequency (IF) circuits. In Fig.1, a mixer diode tip is mounted in the middle of the waveguide, and is connected to the ground pattern and the micro-strip-line. The diode is separated by 1.8 mm from the waveguide end. It down coverts reflected waves from plasma to IF signal. The LPF rejected the heating power leakage. The IF amplifiers amplify the IF signals with low noises. Eight antennas and IF circuits are arranged in line, the 1-D eight channel antenna array was composed. And By stacking of five 1-D antenna array, the 2-D antenna array was composed. The following performances of the 2-D antenna array were measured: the frequency response, the directivity, the radial resolution and separation between channels at the test optic bench. As a result, it was confirmed that the 2-D antenna array has fundamental function which the MIR system for 2-D/3-D observation in the plasma diagnostics required.

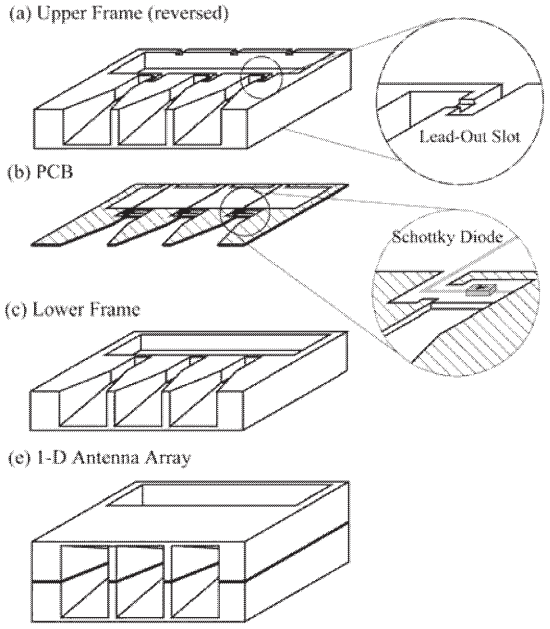

Fig.1 Schematic view of the 1-D horn antenna array assembly. (a) reversed view of upper structure, (b) PCB, (c) lower structure, (d) completed form.

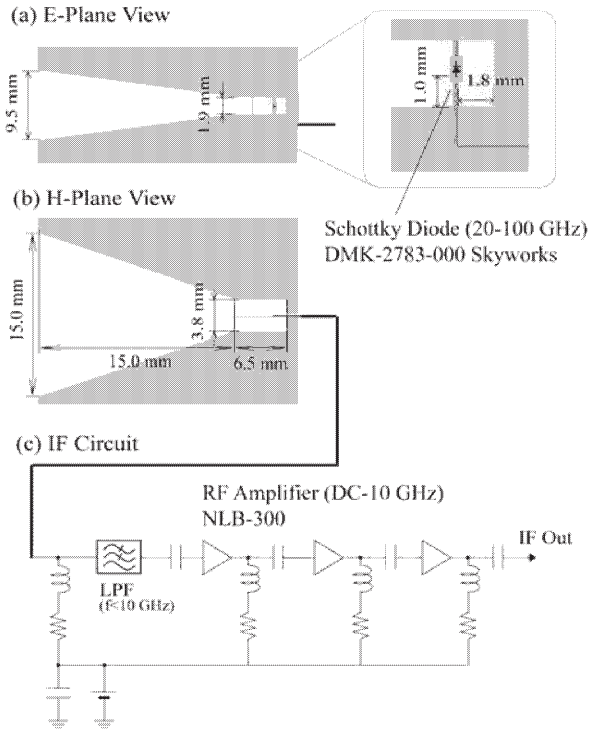

Fig.2 (a) E-plane view and (b) H-plane view of horn antenna element of the V-band (50 to 75 GHz) 2-D antenna array. (c) Schematic diagram of intermediate frequency (IF) circuit on the antenna PCB.