§13. Development of Filter Bank for Microwave Imaging Reflectometry

Yamaguchi, S., Nagayama, Y., Sugito, S.,
Kogi, Y., Mase, A. (KASTEC, Kyushu Univ.)

Microwave Imaging Reflectometry (MIR) is under development in the Large Helical Device (LHD)[1-2]. The MIR has the potential to investigate the micro-turbulence and the magneto-hydrodynamic instability in the magnetically confined plasma. Figure 1 shows the schematic of the MIR system. The probe wave illuminates the LHD plasma with the frequencies of 53, 66 and 69 GHz in X-mode or O-mode. The prove wave is reflected by the cutoff layer, and the fluctuation of the reflected wave represents the density fluctuation. The reflected wave is measured by the heterodyne receiver. The time resolution is 2.5 μs, and the spatial resolution is 84 mm to 110 mm.

A new type of the bandpass filter-bank with low insertion loss and high amplifier gain was developed by using the microstrip-line technology. This is based on the filter bank designed for the ECE radiometer[3]. Figure 2 shows the circuit pattern of the new filter-bank. It consists of three edge-coupled filters, three low pass filters and four surface-mounted RF amplifiers. The edge-coupled filter works as combination of the power divider and the bandpass filter. The edge coupled filter passes the fundamental frequency and also its higher harmonics. In order to remove it, the low pass filter should be installed on the output side of the filter. The RF amplifiers are surface-mounted on the same circuit board. The frequency range is DC to 10 GHz and gain of +13 dB. The unit price is very low of less than three dollars. Since double or triple amplifiers work well successfully, the total gain of +20dB to +30 dB is acquired. The filter-bank module is equipped with an additional low-pass filter with the cutoff frequency of about 12 GHz. It works significantly to remove the leakage of the Electron Cyclotron Resonance Heating (ECRH) power with the frequency of 77, 82.7 and 84 GHz, and the ECE from the plasma. These interferences causes the IF frequencies of 14 GHz to 30 GHz. Total material price is very low about 80 dollars, which is ~ 1/100 compared with the case of the standard microwave circuit. The cost effectiveness enables to develop the multi-channel microwave imaging system in the plasma diagnostics and industrial applications.

Figure 3 shows the test result of the new bandpass filter-bank. The IF signals (3, 6 and 10GHz) are amplified by +10 to +14 dB, and the higher frequency of over 14 GHz is rejected by -50 dB to -60dB. Since the insertion loss of the old filter-bank was about -10 dB, the new filter-bank improves the IF signal by over +20 dB. The ECRH and ECE interferences (14 - 30 GHz) are suppressed by -50 dB to -60dB. The signal-to-noise is enhanced enough to observe the small amplitude signal which cannot be measured in the previous setup.

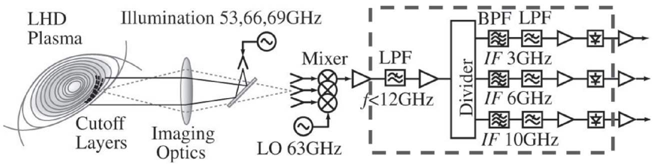

Fig.1 Schematic of the microwave imaging reflectometry with the new bandpass filter-bank (dashed line).

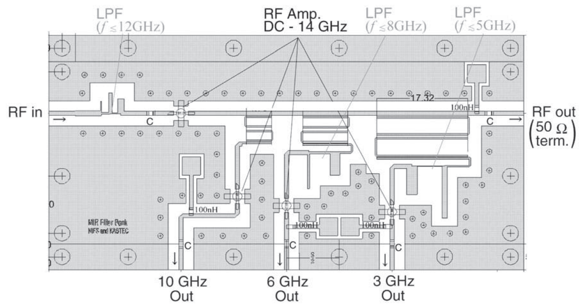

Fig. 2 The circuit pattern of the new bandpass filter-bank.

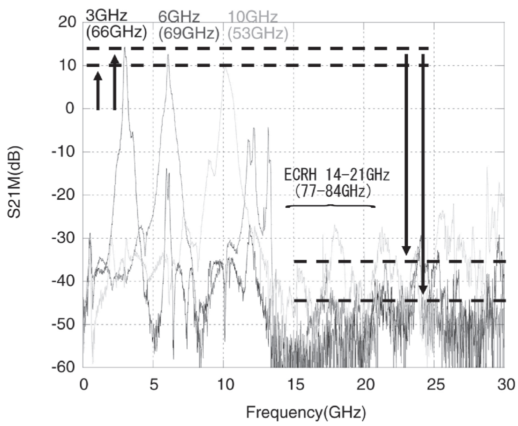

Fig. 3 The power spectrum of he bandpass filter-bank module.

1) S. Yamaguchi, et al., Rev. Sci. Instrum. **77**, (2006) 10E930
2) S. Yamaguchi, et al., Plasma Fusion Res. **2**, (2007) S1038
3) Y. Kogi et al., Proc. Int. Symp. on Laser-Aided Plasma Diagnostics, 80 (2007)