§4. Intensity and Phase Pattern Measurement System for a Millimeter-Wave

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The low power test system to evaluate a performance of the mm-wave component in the ECH transmission line has been prepared. A Low power mm-wave source, a stage control, and a mm-wave receiving part are needed for this system. In previous system, the 2 dimensional stage control is available for the measurement, and a lock-in amplifier was used to get a high dynamic range in the intensity measurement. Using this system, the intensity patterns have been measured along the propagating axis. From this measurement, the intensity patterns or profiles were analyzed using a Gaussian optics, and some quasi-optical mirrors were designed for the launcher system of LHD.

When in particular, as the well-defined Gaussian, a beam is not treated, both of the intensity and phase measurements are necessary to investigate a property of the propagating wave. But the phase has not been measured due to its difficulty. For the phase measurement, a precise position control is needed along the propagating axis, in addition to the 2 directions perpendicular to the axis. The change in phase is more sensitive to the position of the propagating wave, compared to the intensity. Also, the phase is sensitive on the angle or tilt between the wave vector and observation direction. The 3 dimensional stage control is prepared for this phase measurement. The resolutions of the position setting in 2 directions perpendicular to the axis are 0.01mm, and the resolution for the axis is 0.025mm. The resolutions are sufficient, because those are in an order of 1/100 for the wavelength of the 100GHz-band that is used in the ECH study. The intensity and phase pattern within the area of 400cm2 are possible on the propagating distance of 1800mm. The stage is also controlled from a workstation through GPIB protocol. Figure 1 shows the control panel for this stage. At first, it is important this stage should be correctly equipped to the low power source part and the tested mirrors or equipment. By the He-Ne laser beam axis, the stage z-axis, that is, the propagating long axis is aligned. Then, the direction of the launcher of the mm-wave source is adjusted to face the axis of the propagating wave. If the phase profiles are measured, the angle or tilt is rather easily recognized. The tested mirror or equipment is set using the visible laser.

Figure 2 shows the whole of the low power test facility. The mm-wave radiated from the launcher (RF) is detected at the harmonic mixer of the receiving part on the stage. Two synthesizers are prepared to take high resolution and stability on the frequency. One synthesizer is used as a mm-wave source to the launcher, the other is used as a local oscillator with high stability of the frequency. Although the conversion loss at the mixer is not so low (typically 35dB), additional Intermediate Frequency (IF) amplifiers is used. Here, the frequency of IF is 20MHz. This intensity and phase of this IF signal are counted with network analyzer with respect to the reference IF signal that is measured at the mm-source side. Two IF signals are used in this measurement. The intensity measured at the receiving part on the stage is expressed as dB with respect to the reference. The phase is also counted the difference from the reference. In this system, a dynamic range is more than 70dB. This system can be used to in the frequency range up to 110GHz.

The phase pattern/profile of Gaussian beam are consistent with those expected from the dependence of the intensity pattern/profile on the propagating axis very well. The tilt of the propagating wave is accurately determined. This system will be used the fine measurement of both the intensity and phase pattern measurements.

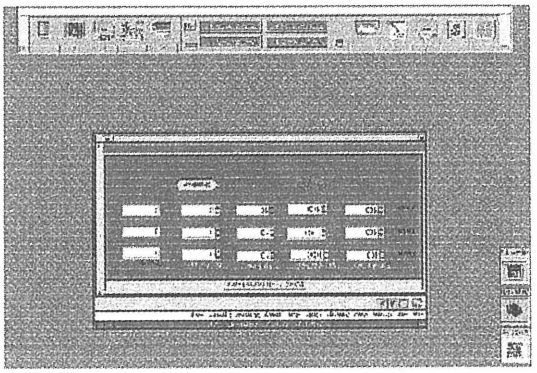

Fig. 1: Control Panel

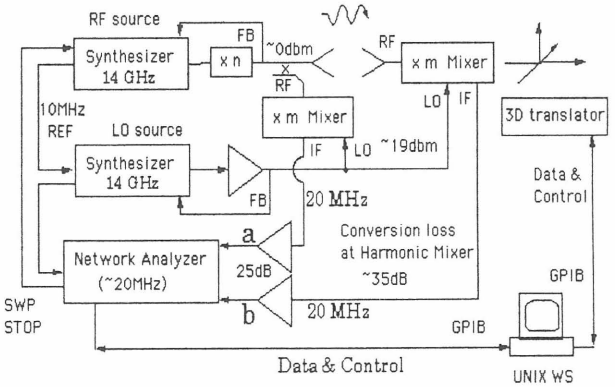

Fig.2 : Low Power Test System