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Field Estimation in Short Range Wireless Communication

C－1　　近距離無線通信における電磁界分布についての検討

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1. Introduction:

Evaluating propagation environment between two antennas in short range communication is a necessary task. To emulate short range propagation environment, a model of two identical waveguide probes (WR-15) facing toward each other was used. Simulations are conducted on both the Method of Moments (WIPL-D) and the Finite Elements Method (HFSS) to derive field intensity. This study gives few physical estimations then compare with simulated results to show common agreements.

2. Analysis condition：

Dimension and feeding condition of WR-15 is shown as in Fig. 1. Simulation model consists of two identical probes locating along z-axis, as described in Fig.2. Only E_y magnitude along z-axis is discussed because TE10 mode is dominant mode of WR-15. Reflection coefficient S11 changes according to feeding location as for WIPL-D and HFSS lumped port. While in HFSS wave port, impedance is automatically matched. For comparison, all of calculated results were normalized by the radiated power P:

$$P = \left(1 - |S_{11}|^2\right) P_{input} \quad (1)$$

P_{input} constantly at 1W in HFSS while varies in WIPL-D.

3. Standing Wave in Transmitting Antenna:

We observed the electric field E_y inside the transmitting antenna. We observed a very similar E_y standing wave pattern as shown in Region I of Fig. 2. Average VSWR is then derived to calculate S11 as below:

$$S_{11} = \frac{VSWR - 1}{VSWR + 1} \quad (2)$$

VSWR read from graph is 1.76 and S11 calculated by (2) is -11.27 (dB). This is close to S11 value of -11.42 (dB) simulated by HFSS wave port which has impedance matching. We can conclude that reflection inside probe is not determined by feeding condition, but aperture boundary condition.

4. Space between two antennas:

Fig.2's Region II displays field attenuation in free space. We estimate the attenuation by fitting the result with $1/r$ curve. Magnitude of E_y decreases along the fitting line, especially clearly shown at WIPL-D's result. Since electric field's intensity attenuates by the order of $1/r$ as spherical wave propagation, we can conclude that TE10 mode wave becomes spherical wave after irradiated from aperture.

5. Standing Wave in Receiving antenna:

Different standing wave patterns are in Region III of Fig.2. Field intensity of HFSS wave port is almost flat, implies it contains only travelling wave. Thus, with wave port model is reflect neither feeding power nor incoming wave from outside, we can conclude reciprocal theory is satisfied. On the other side, standing wave patterns of HFSS lumped port and WIPL-D model are at different level. Therefore, VSWR at receiving antenna is expected to be a function of S11. Referring to unreliable of standing wave's minimum value, if standing wave central level and peak value are well defined, S11 can be reversely calculated.

6. Future consideration：

Mesh operation, convergence setup, PML boundary in HFSS, S11 & S21 mechanism in WIPL-D should be concerned. Moreover, Evaluation should be conducted at shorter range. Specifically, the effect of multiple reflection should be taken into consideration.

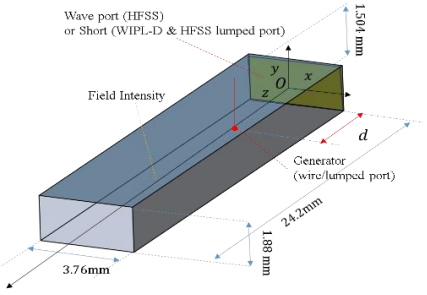


Fig.1: WR-15 waveguide probe

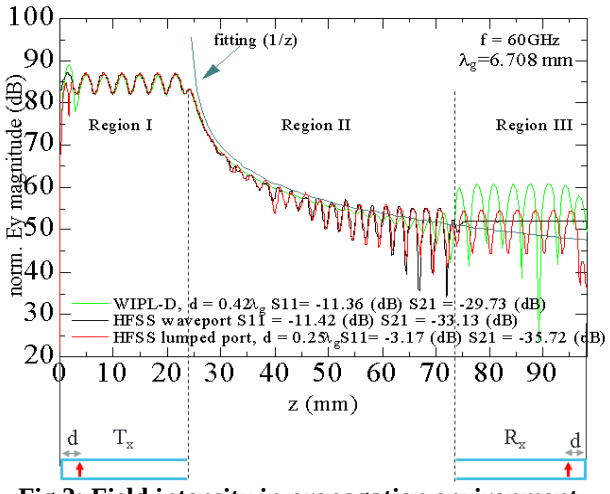


Fig.2: Field intensity in propagation environment