Near Field Measurement Simulation Using Planar Surface

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1. INTRODUCTION

It is well known that implementing antenna measurement test range require large real estate and high cost. In limited space availability, as in our Department, however require near field measurement facility in order to measure large antenna system. Therefore to overcome this problem, we plan to build near field measurement system.

There are three near field methods known which are: the planar, cylindrical and spherical surfaces [1]-[3]. The design of the near field method with planar surface is proposed due to the advantages of the formula and computation process simplicity compared with the other near field surface methods. Although this planar surface method is not an accurate method, this planar surface method can be used well to predict measurement of the antennaȏs radiation pattern.

The near field antenna measurement method conducted by [4] and [5] uses the planar surface method to transform the near field to far field measurement. Both [4] and [5] measured near field measurements and transformed it to far field measurement results. The transformation result of the near field measurement is than compared to the far field measurement, which is also measured.

In this paper, the measurement simulation program is developed and implemented to transform near field data to far field data. The developed near field to far field transformation program is compared to far field measurement simulation using Ansoft HFSS version 11.1.1. The comparison of the developed transformation program with HFSS program is than discussed.

2. The Near Field Measurement System

The measurement system, which is used, consists of a probe antenna as the transmitter and an antenna under test (AUT) as the receiver antenna. The probe antenna is a horn antenna with dimension of 4.93 cm x 6.73 cm. In the process of near field data, it is assumed as a horn antenna detector. While the AUT is a 2-dimensional array antenna with the dimension of 12 cm length, 4 cm width and 0.32 cm thickness. The probe antenna and the AUT are shown in Fig.1. With this dimension, the near field range of the antennas can be calculated.

The near field range of the AUT obtained is from 8.95 cm to 41.11 cm, while the probe from 2.65 cm to 2.99 cm. Therefore the distance between the AUT and probe antenna is 38 cm. For the planar surface method, the measurement system is designed to reach the point of ɗ in the range of 20.80^o to 158.89^o and ű in the range of -69.19^o to 68.89^o.

Both AUT and probe antenna will be used as data acquisition to obtain the near field data.

3. Near Field to Far Field Transformation

Following is the general far field equation, where ɗ is the elevation angle while ű is the azimuth angle from the point of the far field observation.

$$E(\theta,\varphi) = E_{\theta}(\theta,\varphi)\hat{\theta} + E_{\varphi}(\theta,\varphi)\hat{\varphi} \tag{1}$$

$$H(\theta,\varphi) = \frac{1}{\eta}[E_{\theta}(\theta,\varphi)\hat{\theta} - E_{\varphi}(\theta,\varphi)\hat{\varphi}] \tag{2}$$

The above mentioned equation can be obtained from the near field data. To transform the near field to far field data, the E-field from the probe antenna has to be determined. The determined E-field from the probe antenna is used to define the determinant of the system (Δ(ɗ, ű)), as follow [2]:

$$E_{\theta}(\theta,\varphi) = \frac{\sin\theta\cos\varphi}{\Delta(\theta,\varphi)}[I_H(\theta,\varphi)E_{\varphi}{}^{V}(\pi-\theta,\varphi) - I_V(\theta,\varphi)E_{\varphi}{}^{H}(\pi-\theta,\varphi)] \tag{3}$$

$$E_{\varphi}(\theta,\varphi) = \frac{\sin\theta\cos\varphi}{\Delta(\theta,\varphi)}[I_H(\theta,\varphi)E_{\theta}{}^{v}(\pi-\theta,\varphi) - I_V(\theta,\varphi)E_{\theta}{}^{H}(\pi-\theta,\varphi)] \tag{4}$$

Where,

$$\Delta(\theta,\varphi) = E_{\theta}{}^{H}(\pi-\theta,\varphi)E_{\varphi}{}^{V}(\pi-\theta,\varphi) - E_{\theta}{}^{V}(\pi-\theta,\varphi)E_{\varphi}{}^{H}(\pi-\theta,\varphi) \tag{5}$$

From the determinat of the system and from the probe response (I_v and I_H), the far field of the AUT can be obtained.The probe response is obtained from complex voltage of AUT.

$$I_V(k_y,k_z) = \exp(jk_x x_0)\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} v_V(x_0,y,z)\exp(jk_y.y + jk_z.z)dydz \tag{6}$$

$$I_H(k_y,k_z) = \exp(jk_x x_0)\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} v_H(x_0,y,z)\exp(jk_y.y + jk_z.z)dydz \tag{7}$$

where $k = \frac{2\pi}{\lambda}$, $k_y = k\sin\theta\sin\varphi$, $k_z = k\cos\theta$ and $k_x = k\sin\theta\cos\varphi$ (8)

The equation (6) and (7) can be solved using FFT, while $v_H(x_o,y,z)$ and $v_v(x_o,y,z)$ are the near field complex voltage of the AUT. In order to test the transformation, a measured simulation using HFSS is used.

4. Simulation Results and Discussion

Simulation results of the transformation method compared to HFSS far field simulation is depicted in Fig.2a and Fig.2b. The Fig.2a shows the far field radiation pattern at ɗ plane, while Fig. 2b shows the far field radiation pattern at ű plane for both transformation method and direct simulation. It can be seen that the pattern has similarity. The ripple of the radiation pattern from the transformation method is still under consideration.

For the simulation of the transformation method, only angles from -70^{o} till 70^{o} is observed; therefore the simulation results show no back lobes from the AUT. The angle of observation depends on the scanning plane of the AUT and the distance between AUT and the probe antenna.

Future developments of this work will be implemented in the hardware of the near field measurement system.

Conclusion

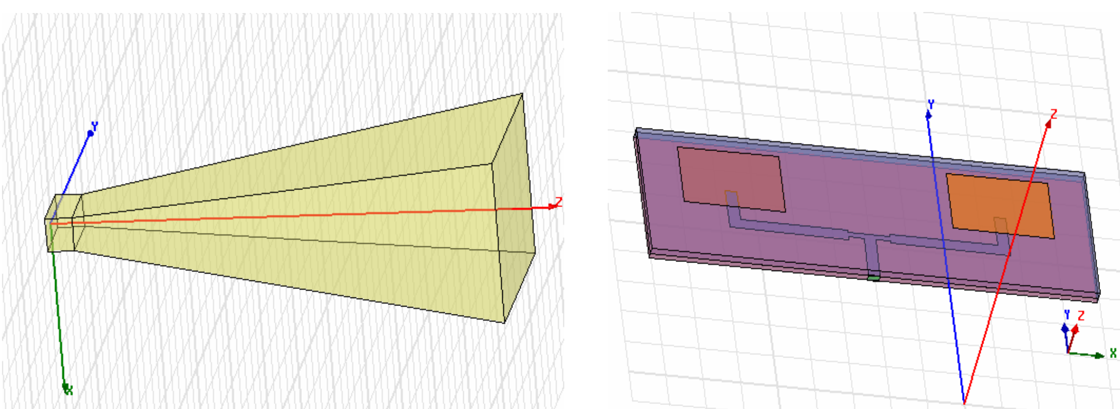
The simulation of near field measurements show that the far field radiation pattern can be produced using the near field measurement data generated by HFSS. The results have been compared and agree with the simulated far field radiation pattern. Therefore this transformation program can be used to predict the far field radiation pattern.

Acknowledgement

This work is supported by Universitas Indonesia under National Research Strategic grant contract no. 407C/DRPM-UI/A/N1.4/2009.

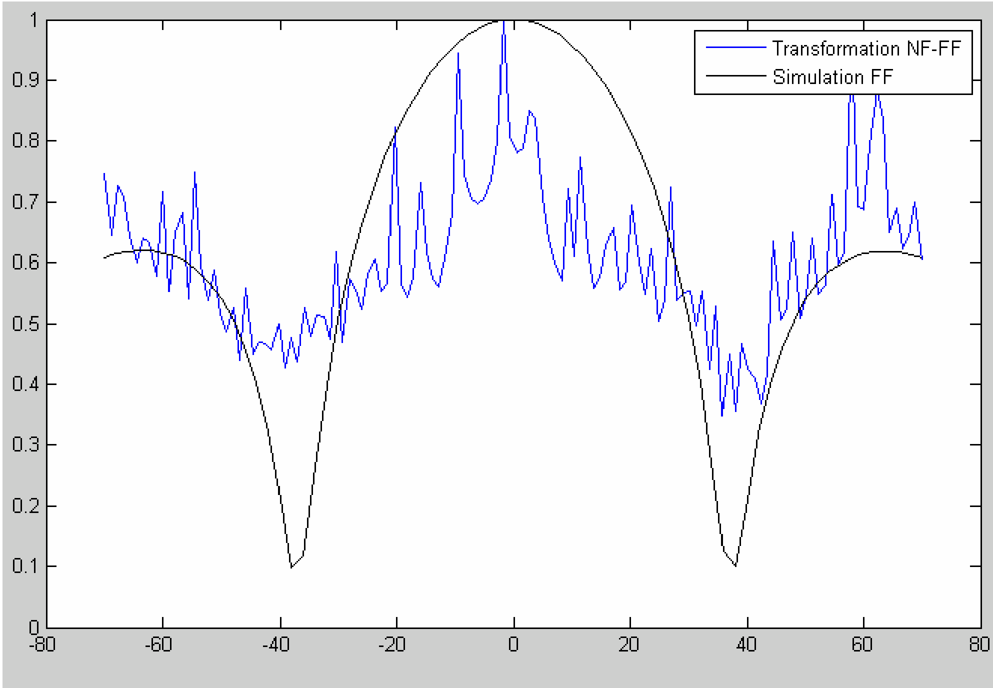
References

[1] A. D. Yaghjian, ñAn overview of near-field antenna measurementsò, IEEE Trans. Antennas Propagat. , Vol. AP-34, no. 1, pp. 30-45, January 1986
[2] E. B. Joy, W. M Leach, and G. P. Rodrigue, ñApplications of probe-compensated near-field measurementsò, IEEE Trans. Antennas Propagat., Vol. AP-26, no. 3, pp. 379-389, May 1978
[3] D. T. Paris, W. M. Leach, and E. B. Joy, ñBasic theory of probe-compensated near-field measurementsò, IEEE Trans. Antennas Propagat., Vol. AP-26, no. 3, pp. 373-379, May 1978
[4] B. Yan, S. A. Saoudy, B. P. Sinha, ñA low cost *planar* near-field/far-field antenna measurement systemò, C-CORE, Memorial University of Newfoundland, IEEE, 1997
[5] D. Slater, G. Hindman, ñA low cost portable near-fieldò, Near field System Incorporated, October 9-13, 1989
[6] M.S. Narasimhan and M.Karthikeyan, ñEvaluation of fourier transform integrals using FFT with improved accuracy and its applicationsò, IEEE Trans. Antennas Propagat., vol. AP-32, no.4, pp. 404-408, April 1984

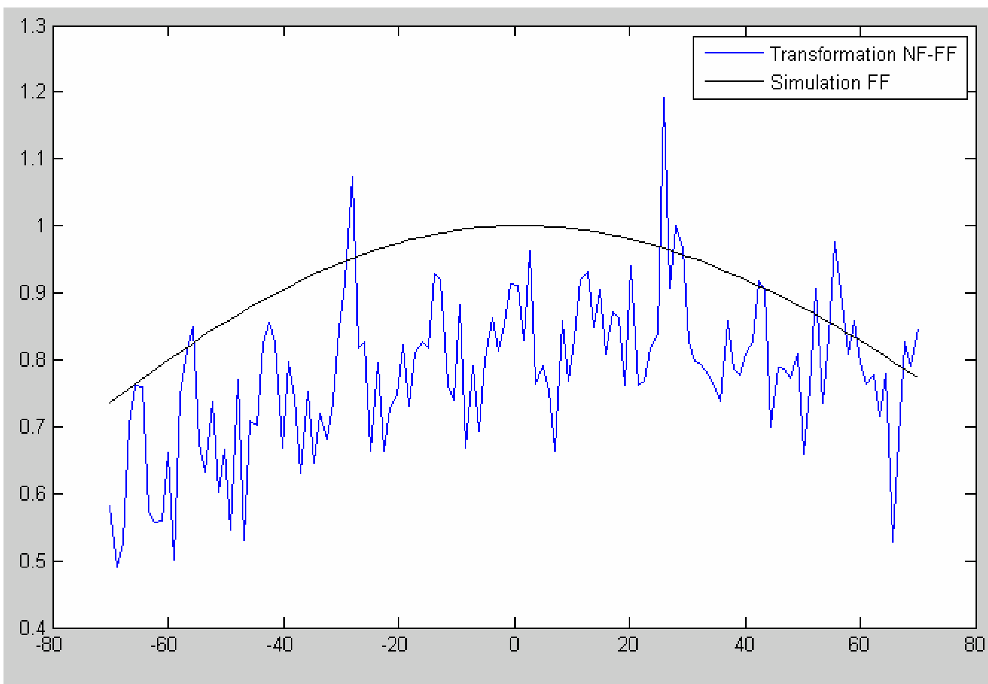


(a) (b)

Figure 1: a) Probe Antenna
b) Antenna under Test



(a)



(b)

Figure 2: a)Comparison of radiation pattern in ď plane
b)Comparison of radiation pattern in φ plane