

A Novel Method to Measure Antenna Cut-Plane Patterns For EMC Antennas —Combination of Radio-on-Fiber Technique and 1-D CNFFFT—

Masanobu HIROSE and Satoru KUROKAWA

National Metrology Institute of Japan, AIST 1-1-1 Umezono, Tsukuba, Ibaraki, 305-8563 Japan

E-mail: {masa-hirose, satoru-kurokawa}@aist.go.jp

Abstract We propose a novel method to measure the far-field absolute-gain patterns in any cut planes for EMC antennas such as double-ridged waveguide horn (DRWH). The proposed method combines the Radio-on-Fiber technique and the 1-D Circular Near-Field to Far-Field Transformation (1-D CNFFFT) method. The Radio-on-Fiber technique realizes an ideal antenna pattern measurement. This means that there is no metallic cable such as coaxial cable to connect the antenna and the vector network analyzer. The 1-D CNFFFT method realizes rapid and accurate far-field absolute-gain pattern measurements in any 1-D cut plane at a few meter distance. We demonstrate the usefulness of our method by measuring a commercial DRWH.

Keywords Radio-on-Fiber technique, 1-D CNFFFT, EMC antenna, far-field absolute-gain pattern measurements

1. Introduction

Recently EMC regulations require antenna patterns in several cut-planes for an antenna used in EMC measurements [1]. To meet the requirements of the antenna pattern measurements for this purpose, conventional far-field measurements are done because the far-field distances are a few meter.

In the antenna pattern measurements, coaxial cables often deteriorate the patterns because the cables are metallic. The influence from the cables is not predictable due to the complexity of the coupling. To overcome the problem, we propose a technique using Radio-on-Fiber (RoF) system [2].

In addition, the position of the radiation center of the antenna causes a large error in the measurement because the measurement distance is not so large compared to the position of the radiation center. To solve the problem, we propose a method using 1-D Circular Near-Field to Far-Field Transformation (1-D CNFFFT) [3] that is less sensitive to the position of the radiation center. The measurement procedure is completely the same as the conventional far-field measurements but the post-processing is different.

To demonstrate the usefulness of our proposed method, we have measured the various kinds of the patterns of ETS-Lindgren 3117 (often used as EMC test antenna) and compared the results by the far-field method, the 1-D CNFFFT method, and the cylindrical near-field (CNF) method. The results of the 1-D CNFFFT method agree well with the ones of the CNF method.

2. Measurement Setup

Figure 1 shows the measurement setup for our proposed method. The antenna under test (AUT) is set on a glass-fibered tripod which is placed on a rotation table. The configuration of the AUT on the

tripod is often used in the EMC measurements. An optical-to-electrical converter is attached to the AUT and an electrical-to-optical converter is set on the rotation table and connected to an electrical rotary jointer to a vector network analyzer (VNA) through a coaxial cable. That is, the RoF system is used to connect the AUT and the VNA. In our proposed method, it is decisively important to use the RoF system that can measure definitely and stably the amplitude and the phase of the RF signal. The RoF system consists of a laser diode and a photo diode operated by batteries, which is manufactured by SEIKO GIKEN Co. Ltd., Japan.

An open-ended waveguide (OEWG) is used as a receiving antenna because the OEWG has a well-known definite phase center and the radiation pattern. Therefore the distance between the center of the rotation and the radiation center of the OEWG is definitely determined. The cable between the OEWG and the VNA cannot deteriorate the antenna pattern because the cable is covered by radio absorbing materials.

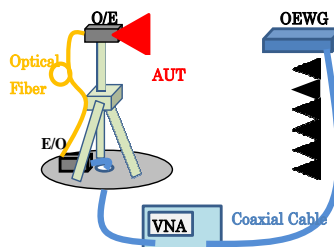


Fig. 1 Measurement setup for proposed method.

3. 1-D CNFFFT

Combining the RoF system, our proposed system uses the 1-D CNFFFT method to obtain the far-field absolute-gain pattern in any cut plane. Figure 2 shows the concept of the measurement using the 1-D CNFFFT method.

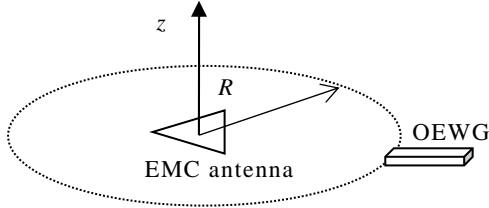


Fig. 2 Measurement using the 1-D CNFFFT method.

The 1-D CNFFFT is derived from an approximation to the fundamental equation of the conventional cylindrical near-field to far-field transformation (CNF). However the approximation becomes quite accurate when the distance R becomes larger than a few wavelengths.

Finally the measured s_{21} between the AUT and the OEWG is given by

$$S_{21}(\phi) = \frac{4\pi k}{kZ_0} \sqrt{\frac{2\pi k}{R}} e^{j\frac{\pi}{4}} \sum_{n=-\infty}^{\infty} e^{jn\phi} A_n \sum_{m=-\infty}^{\infty} C_m H_{n+m}^{(2)}(kR) \quad (1)$$

where A_n and C_m are cylindrical coefficients of the AUT and the OEWG assuming that the AUT has only the horizontal or vertical polarization.

Following the same procedure of the conventional CNF method and using the previously known C_m , we obtain A_n . That is, we can determine the far-field absolute-gain pattern on the cut plane including the measurement circle.

4. Comparison Among Various Methods

We have measured the far-field absolute-gain pattern for ETS Lindgren 3117 in the three methods (far-field method, CNF method, 1-D CNFFFT method).

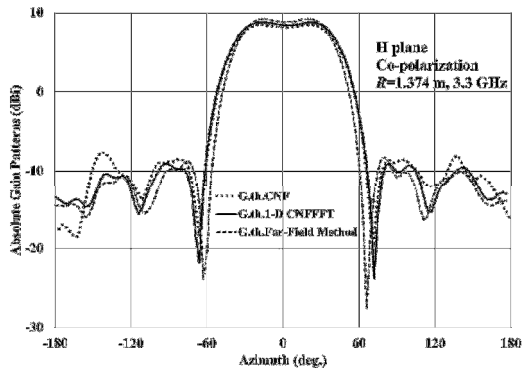


Fig. 3 Measured far-field absolute-gain patterns of the co-polarization of 3117 obtained by the CNF method, the 1-D CNFFFT, the far-field method.

Because the radius R is 1.374 m and frequency is 3.3 GHz, the far-field distance is about 0.56 m, which is about one third of the radius R and seems to be far enough for the far-field measurement.

Figure 3 shows the far-field absolute-gain patterns of the co-polarization (vertical polarization) obtained by the three methods. The co-polarization main beam patterns by the CNF and the 1-D CNFFFT agree well

within 0.3 dB on average, whereas the pattern by the far-field method is thinner than the others because the radiation center of the AUT is not on the rotation center. This means that the ratio of the radiation center position to the radius R should be much less than 1 even if R satisfies the far-field condition in the far-field measurements.

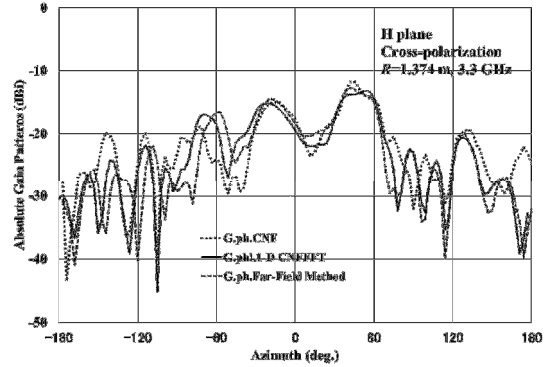


Fig. 4 Measured far-field absolute-gain patterns of the cross-polarization of 3117 obtained by the CNF method, the 1-D CNFFFT, the far-field method.

Figure 4 shows the cross-polarized patterns by the three methods and indicates that the results by the 1-D CNFFFT method and the CNF method agree, whereas the results by the far-field method are slightly different from the other two methods.

5. Conclusion

We have proposed a novel method to measure the far-field absolute-gain pattern on any cut plane using the Radio-on-Fiber technique and the 1-D Circular Near-Field to Far-Field Transformation.

Using an ETS-Lindgren 3117 (popular as EMC antenna) as the antenna under test, we have demonstrated that our method can determine the far-field absolute-gain pattern of both polarizations on a cut plane.

In the near future, we will extend the 1-D CNFFFT that is applicable to various kinds of antennas.

References

- [1] IEC CISPR 16-1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements, March 2010.
- [2] S. Kurokawa, M. Hirose, M. Ameya, and Y. Toba, "Antenna measurement by simple optical link system using radio on fiber technologies," Proc. Int. Sympo. on EMC, pp.670-673, Tokyo 2014.
- J. H. Kim and H. K. Choi, "Antenna radiation pattern measurement at a reduced distance," IEEE Trans. Instru. & Meas., vol.54, no.2, pp.673-675, April 2005.