Probe Calibration for Accurate Electric-Field Measurements in the Vicinity of kHz-Band Wireless Power Transfer Systems

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There are increasing applications using electromagnetic (EM) fields at intermediate frequencies (300 Hz – 10 MHz) such as wireless power transfer (WPT) systems. In order to check their compliance against international standards to assure EM emission and human exposure levels, accurate measurements of electric field in the vicinity of the systems are required [1],[2]. In this study, we have developed a calibration system for electric-field probes using a shortened monopole antenna as a standard field source, performed calibration on optical electric-field probes, and compared their results with those obtained by using the conventional TEM-cell method.

In this paper, we use standard field method for calibration of a probe which is placed in a region where the EM field distribution is theoretically calculated. By measuring power flowing into the antenna, we can determine the electric field strength E_i at a specific point from the antenna theory. If a measured voltage at a probe terminal is denoted as V_i, then we can calculate the calibration factor as $F_i = E_i/V_i$, where the subscript i indicates one of three axes in orthogonal orientations. In case of rectangular coordinate system, $i = \{x, y, z\}$.

Fig. 1 shows configuration of the calibration system using a monopole antenna. The antenna whose length l of the monopole element is much shorter than the wavelength is placed on a large metal ground plane. We have found that in the proximity of a monopole antenna, when the height is approximately z = 0.6λ~0.7λ, E_z is almost zero and the dominant E-field component is E_ρ so that we can align a probe in the ρ direction and calculate the calibration factor at this position. A three-axis optical E-field probe (Seiko Giken, SH-03EX) is placed 0.5 m away from the monopole antenna at a height of z = 1.6 m, where E_z is almost zero as described in previous paragraph and one of three receiving elements in the probe is aligned parallel to the ρ axis. The E-field probe is connected to optical controller (Seiko Giken, C5-A11-1). Receiving optical signal is converted into electric signal and the received voltage is then measured at the 50 Ω terminator. Antenna incident power P_{inc} is set to 1 W, which creates an E-field strength of approximately 5.2 V/m at the calibration location.

Fig. 2 indicates the calibration factor calculated using our proposed method, compared with those of the TEM cell. Both results agree well each other and, hence, the validation of our method has been demonstrated. It was found that the error is less than 2 dB when f < 5 MHz and less than 1 dB when f < 3 MHz.

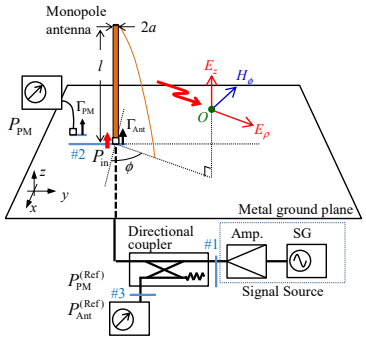

Figure 1. Standard electric-field method using shortened monopole antenna.

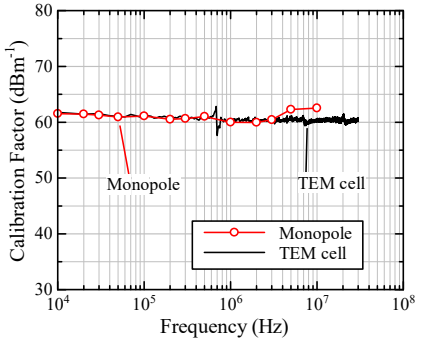

Figure 2. Calibration factor of a three-axis optical E-field probe (SH-03EX) combined with a controller (C5-A11-1).

This study was supported by the Ministry of Internal Affairs and Communications, Japan. The authors would like to thank Dr. Ifong Wu (NICT) for measurement and calibration of a probe using TEM cell.

Reference

[1] CISPR 16-1-6, Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-6: Radio disturbance and immunity measuring apparatus – EMC-antenna calibration
[2] ICNIRP, *Health Phys.*, vol. 74, pp. 494-522, Apr 1998.