Random Coupling Model for Wave-Chaotic Cavity with Aperture Excitation

Hong Soo Park and Sun K. Hong
School of Electronic engineering
Soongsil University
Seoul 06978, Republic of Korea
hosu0202@soongsil.ac.kr; shong215@ssu.ac.kr

Woosang Lee and Jin Soo Choi
Agency for Defense Development
Daejeon, Republic of Korea

Abstract— For statistical prediction of electromagnetic (EM) coupling in the wave-chaotic cavity, the random coupling model (RCM) has been utilized. RCM can also be a useful tool for practical applications such as cavity with aperture excitation, but there are limited experimental verifications. Here, we present a method for predicting the statistical properties and induced voltage in a wave-chaotic cavity where an EM wave is incident through an aperture. Utilizing the aperture impedance based on transmission line theory, the effectiveness of the proposed approach is demonstrated via measurement.

Keywords-HPEM, EMC, random coupling model, wave-chaos, aperture excitation

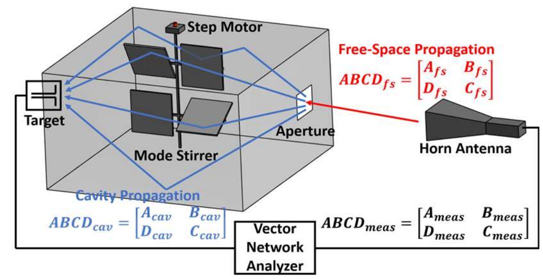
I. INTRODUCTION

In recent years, the random coupling model (RCM) has received considerable interest in the field of electromagnetic compatibility and high-power electromagnetics in that it can predict the statistical properties of waves inside electrically large cavities in the short-wavelength regime based on wave-chaos [1]. By utilizing the impedance and scattering parameters of cavities and ports, RCM provides statistical predictions of electromagnetic (EM) coupling effects on the target of interest [2].

However, in order to employ RCM in a broader range of applications, it is desirable to predict coupling effects in a more practical environment where the input power is incident through the aperture. Hence, we present an extended RCM for predicting statistical properties and induced voltage in a wave-chaotic cavity with aperture excitation. The proposed concept can be demonstrated using a scattering matrix derived from the aperture impedance.

II. RCM WITH APERTURE EXCITATION

Figure 1 illustrates the experimental setup and general idea of RCM prediction in a wave-chaotic cavity for an incident EM wave from external radiation through an aperture. The cavity (1.2 m × 1.2 m× 0.7 m) is composed of a rectangular aperture (0.2 m × 0.15 m), a target (receive antenna), and a mode stirrer (generating 200 different sets of ray trajectories). With the aperture, our experimental investigation involves two-stages: stage 1) the free-space propagation stage where the wave is incident on the aperture of the cavity, and stage 2) the cavity propagation stage where the incident wave undergoes ray-chaotic propagation and couples to target with the loss parameter α.



$$ABCD_{cav} = ABCD_{fs}^{-1} * ABCD_{meas}$$

Figure 1. Illustration of the experimental setup and ABCD parameters for each stage based on the proposed approach.

Here, the purpose is to predict only the statistical properties inside the cavity using the RCM by obtaining α. To this end, α should be determined using the scattering matrix in the stage 2, but the measurement provides the scattering matrix between the transmit horn antenna and the target, which includes both stages. Hence, our proposed approach is to obtain the ABCD parameter of the stage 1 ($ABCD_{fs}$) through theoretical derivation, and then calculate the ABCD parameter of the stage 2 ($ABCD_{cav}$) through matrix operation with the converted ABDC matrix from the measured scattering parameter ($ABCD_{meas}$). Since the surface of the aperture can be represented as a transmission line, the aperture impedance and the resulting $ABCD_{fs}$ are calculated through transmission line theory [3].

III. CONCLUSION

A method for predicting the EM coupling in a wave-chaotic cavity through aperture excitation is proposed. By utilizing the aperture impedance, the statistical properties inside the cavity can be predicted using RCM even for the coupling of incident power entered through an aperture. Further development of impedance analysis for other aperture shapes can expand the scope of the proposed RCM approach.

REFERENCES

[1] Z. B. Drikas, et al. “Application of the random coupling model to electromagnetic statistics in complex enclosures,” *IEEE Trans. Electromagn. Compat.*, vol. 56, no. 6, pp. 1480–1487, Dec. 2014.
[2] J. G. Gil, et al. “Prediction of induced voltages on ports in complex, three-dimensional enclosures with apertures, using the random coupling model,” *IEEE Trans. Electromagn. Compat.*, vol. 58, no. 5, pp. 1535–1540, Oct. 2016.
[3] C. Hao and D. Li, “Simplified model of shielding effectiveness of a cavity with apertures on different sides” *IEEE Trans. Electromagn. Compat.*, vol. 56, no. 2, pp. 335–342, Apr. 2014.