State Of The Art Of Near-Field Scanning: Contemporary Standards And Methods

Sviatoslav Voskresenskyi, Iqra Aitbar,
Erjon Ballukja, Karol Niewiadomski,
David W. P. Thomas, Steve Greedy
GGIEMR
University of Nottingham
NG7 2RD, Nottingham, UK
siatoslav.voskresenskyi@nottingham.ac.uk

***Abstract*—This paper presents a review of a number of techniques used for near-field scanning and detection of electromagnetic radiation sources. It also gives an overview of standards, related to technical requirements for the devices as well as scanning methods. Subsequently, a comparison between Far Field (FF) and Near Field (NF) is given. We present the advantages of NF over FF, and list the common problems for NF scanning, such as calibration, protraction in overall scanning time. Finally, we refer the possible solutions and improvements for scanning setup and software.**

***Index Terms*—EMC, Near-Field, Far-Field, time domain, frequency domain, standards, compliance.**

I. Introduction

With the increase in embedded electrical circuits on the market, it is important to ensure that the technical requirements for electromagnetic compatibility (EMC) among devices are met. Since any equipment or assembly which includes electrical parts becomes an electromagnetic source, it is important to align the design with the existing EMC standards such as those in [1]–[3]. The classical method of FF measurement can provide general information about the emission level without identifying a particular source of the emission on the surface of a device. Moreover, this method is suitable only for low-frequency sources with simple radiation patterns [4]. As such, it is used for device compliance testing purposes [5]. On the other hand, FF is not suitable for pre-compliance testing during the design stage of a device. Therefore, another technique, e.g., NF scanning, may be used. In fact, NF scanning allows testing the electromagnetic emissions near the surface of the device under test (DUT) for a wide range of frequencies [6]. In addition, the NF scanning technique can be used instead of the FF when the explicit prediction of the far field emission is required [7]–[9].

However, the methods of the NF scanning technique can vary depending on the device prescription. Mainly, the DUT could be split into two main categories: intentional and unintentional emission sources. The intentional devices, which are mainly antenna-under-test (AUT) devices are mainly represented by antennas of any kind. For AUT the near-field measurements of the magnetic (H) or electric (E) field probes could be used, depending on antenna type and antenna design. Predominantly, the E-field measurements in the NF region are performed for AUT. Following the ”Hairy ball theorem” [10], there’s no such thing as the perfect omnidirectional antenna, hence all antenna has a certain directivity. Thus for AUT the planar scanning or cylindrical scanning surface methods are applicable. Unintentional EM sources are more relevant to faults in the electrical design of the device. Since most of the modern electronic products are based on using embedded PCB design the impedance in NF is quite low, the H-field probing is mainly used for testing. In contrast with intentional emitters, unintentional sources have unpredicted emission patterns, sometimes including the main lobe and sidelobes with unknown directivity. For DUT, the NF scanning can also be performed in planar and cylindrical surface domains, however, due to unclosed types of surfaces the entire emission pattern can’t be embraced during one scanning attempt, thus several scans of the single device are needed.

This project research is funded by the European Union’s Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No. 812391 and 955646.

II. Conclusion

The NF scanning technique is preferred to the FF in cases where the precise location of the emission hot spots on the DUT surface is imperative. The overall compactness of the set-up and testing area, as well as the number of methods for estimation of the FF from the data obtained in the NF region, makes this technique valuable for characterising devices with complex emission patterns. For instance, this technique is used in PCB applications, or custom-designed long-range antennas, for which the ordinary open-area-test-site (OATS) technique could be problematic due to the considerable wavelength of custom-designed long-range antennas. Despite the advantages introduced so far, the NF technique presents some drawbacks, related to the long scanning time and the complex calibration process. Additionally, when used in a Cartesian scanning surface setup, which is widely used for testing on narrow-beam antennas because of its cheapness and overall simplicity, it does not allow obtaining the side-lobe emission patterns, leading to the truncation errors [11]. One of the approaches to resolve the truncation error is the application of the Gerchberg-Papoulis iterative algorithm for the reconstruction of missed fields. [12], [13]

The idea of spherical surface setup proposed in [14] partially tackles the aforementioned problems. However, the setup complexity and cost make the use of the spherical surface setup difficult for practical applications. The aim of the project that follows this review paper is to explore new methodologies and approaches aiming to improve the testing setup by involving the multichannel scanning approach in spherical coordinate surface, as well as the control software for probe positioning system, making it standalone from the side software updates and not requiring deep knowledge of programming. Future studies should focus on increasing the availability and versatility of the NF scanning technique.

REFERENCES

[1] International Electrotechnical Comission, "IEC 61000-6-1:2019 — Electromagnetic compatibility (EMC) — Part 6-1: Generic standards - Immunity standard for residential, commercial and light-industrial environments," Standard, February 2019.

[2] International E1ectrotechnical C omission, "IEC 61000-6-2:2019 — Electromagnetic compatibility (EMC) — Part 6-2: Generic standards - Immunity standard for industrial environments," Standard, February 2019.

[3] "EN 55011:2016/A11:2020 — Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement," Standard, March 2020.

[4] A. Yaghjian, "An overview of near-field antenna measurements," *IEEE Transactions on Antennas and Propagation*, vol. 34, no. 1, pp. 30–45, 1986.

[5] "IEC 61000-4-3:2020 — Electromagnetic compatibility (EMC) - Part 4-3 : Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test ," Standard, September 2020.

[6] IEC TS 61967-3:2014 — IEC Webstore. [Online]. Available: https://webstore.iec.ch/publication/6186

[7] X. Tong, D. W. P. Thomas, A. Nothofer, P. Sewell, and C. Christopoulos, "Modeling electromagnetic emissions from printed circuit boards in closed environments using equivalent dipoles," *IEEE Transactions on Electromagnetic Compatibility*, vol. 52, no. 2, pp. 462–470, 2010.

[8] H. Rezaei, J. Meiguni, M. Soerensen, J. Fan, and D. Pommerenke, "Source reconstruction in near field scanning using inverse mom for rfi application," in *2019 IEEE International Symposium on Electromagnetic Compatibility, Signal Power Integrity (EMC+SIPI)*, 2019, pp. 584–589.

[9] F. D'Agostino, F. Ferrara, C. Gennarelli, R. Guerriero, and M. Migliozzi, "An Innovative Direct NF-FF Transformation Technique with Helicoidal Scanning," vol. 2012.

[10] E. Bormashenko, "Obstructions imposed by the poincaré–brouwer ("hairy ball") theorem on the propagation of electromagnetic waves," *Journal of Electromagnetic Waves and Applications*, vol. 30, no. 8, pp. 1049–1053, 2016. [Online]. Available: https://doi.org/10.1080/09205071.2016.1169226

[11] M. A. Maisto, R. Solimene, and R. Pierri, "A truncation criterion in planar near field techniques," in *12th European Conference on Antennas and Propagation (EuCAP 2018)*, 2018, pp. 1–4.

[12] E. Martini, O. Breinbjerg, and S. Maci, "Reduction of Truncation Errors in Planar Near-Field Aperture Antenna Measurements Using the Gerchberg-Papoulis Algorithm," vol. 56, no. 11, pp. 3485–3493.

[13] F. Cano-Fácila, S. Pivnenko, and M. Sierra-Castaner, "Reduction of Truncation Errors in Planar, Cylindrical, and Partial Spherical Near-Field Antenna Measurements," vol. 2012.

[14] X. Liu, C. Huang, and J. Xiao, "An automatic antenna near-field measurement system for narrow beam array antennas," vol. volume1, pp. 1–3, 2021.