Electromagnetic Environment Measurement Procedure for a Moving Car

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***Abstract*— A dynamic electromagnetic environment such as automotive is difficult to be fully described due to its unpredictability. It is known that the interior of a car can behave as a reverberant space and should hence be characterized using statistical methods. The complexity of such environment in terms of both field magnitude and time variance is even higher considering that it is placed in a dynamic external environment, e.g. when the car is moving. The coupling of the external fields into the car chassis resembles the source stirring technique common for reverberation chambers. Following this principle, this paper discusses the effects of alterations in time, frequency, and space domains on the internal environment of a moving car, based on the ergodicity concept. These findings may help to understand the complexity of such an environment and find a conclusive way to characterize it in the future, especially for the needs of the risk-based electromagnetic compatibility.**

Keywords—automotive, electromagnetic environment, risk-based EMC

I. Introduction

The rapid changes especially in wireless communication technologies in the last few decades are making a great impact on the electromagnetic environment (EME) of modern applications. The numerous embedded devices and the rise of new-age technologies such as 4G and 5G create a complicated environment that is difficult to be described as well as predicted. Such environments can be hospitals, vehicles, spacecraft, aircraft as well as ships. The interest in understanding these complex EMEs lies in detecting and further avoiding any electromagnetic interference (EMI) issues. The electric field distribution in a large reflective cavity cannot be considered as field in an anechoic chamber (AC) or free space. The field can fluctuate significantly, even over small distances. A useful measurement method, random-walk technique, for measuring the EME in electrically large reflective spaces has been introduced in [1]. Utilizing lightweight and portable equipment one can statistically characterize the variations of field magnitude over space, as well as over frequency, which is very useful for estimating the worst-case scenarios, linked to the severity parameter used in the risk estimation. However, the variability of the field magnitude over time, linked to the probability parameters in risk analysis [2], at a single point, i.e. what an actual static victim would experience, is missing. Furthermore, practical difficulties of performing a random-walk in a moving car limit its usability in such a case. Nonetheless, this technique is a useful tool to be used and has also been successfully applied in medical [3] and automotive [4] environments. In [4], the EME measurements of a parking car were performed utilizing both random-walk and fixed-position technique.

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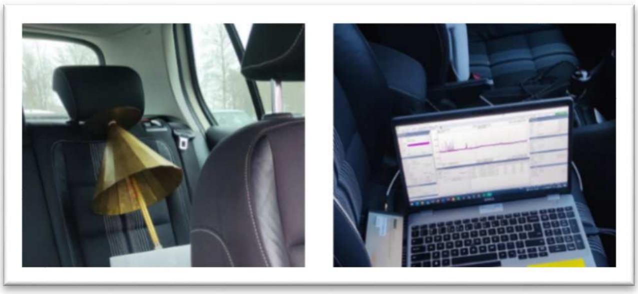

Fig. 1. The measurement set up for fixed-position technique (**left**: discone antenna; **right**: RTSA and laptop)

The findings were evaluated in terms of EMI risk-based approach, i.e. focusing on the probability and severity parameters. This paper extends this study by also measuring the electric field in a moving car to better understand these two parameters to estimate the risk of EMI in such a dynamic environment.

II. Measurement Setup

The EME outside the car changes continuously and the car is exposed to the electromagnetic field from different angles. Therefore the interior of the car can be considered as a source-stirred environment [5]. The measurements were performed using both fixed-position and random-walk techniques while a combustion engine car was moving in a typical urban environment. The measurement setup is show in in Fig. 1 and consisted of a portable, lightweight real-time spectrum analyzer (RTSA), a linearly polarized, broadband discone antenna and a laptop used to continuously store the data obtained throughout the campaign. The measurements were performed from 400 MHz to 4 GHz to cover the GSM and WI-FI bands as well as the frequencies where the car chassis behaves like a reverberant environment.

III. Preliminary Measurement Results

The preliminary measurements are given in Figure 2 and Figure 3. The peak values of measurements performed with fixed position is similar to that performed by the random-walk technique, yet carry different information.

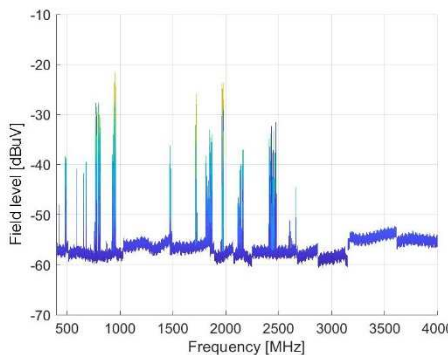

Fig. 2. The preliminary measurement results from fixed position technique

The fixed position measurement shows what a victim located inside the car experiences during the drive. However, it is clear that the field level is higher in the measurements made with the random-walk technique compared to the fixed-position technique. These findings show that the random-walk technique is a stronger technique than fixed-position technique in terms of finding the worst case situation related to the severity parameter used in EMI-risk assessment.

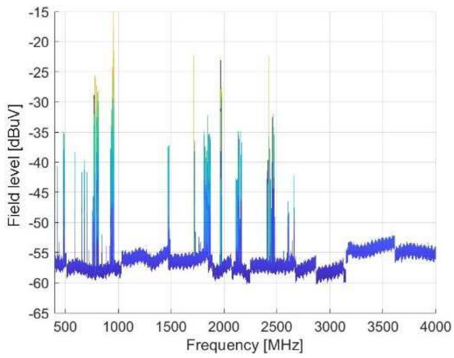

Fig. 3. The preliminary measurement results from random-walk technique

IV. CONCLUSION

This paper discusses the techniques of evaluating the dynamic electromagnetic environment by comparing the fixed-point technique with random-walk inside a moving car. Following the theory of reverberation chambers, source stirring can be statistically equivalent to volume sampling. Following this principle, the parameters used for EMI risk assessment have been addressed. The methods have been evaluated in terms of accuracy as well as practicality, showing that the random-walk technique is preferred to estimate the worst-case scenario linked to the severity parameter, while the fixed position yield more accurate results regarding the probability parameter.

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