Improved Power Spectroscopy and Analysis of Pulse Response with Small Reverberation Chambers

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Abstract— Critical frequencies for electromagnetic interference can be detected from an increased power absorption in an electrical reverberation chamber (ERC). Further information on a target can be gained by analyzing its pulse response in the ERC. In this work, both hardware modifications and enhanced methods for data analysis are studied to guarantee an optimum noncontact detection of critical frequencies and further target properties, particularly in small ERCs. Hardware modification comprise antenna layout, stirrer geometry, and the use of field diffusers. With respect to data analysis, different filtering techniques and statistical resampling methods, such as bootstrapping with and without stratified ordering methods, are considered.

I. INTRODUCTION

Power spectroscopy (PS) is a promising tool to find possibly vulnerable coupling frequencies of a given device under test (DUT). By comparing measurements of a DUT in an ERC with data obtained from the empty chamber, the power absorption of the DUT at given frequencies can be revealed [1]. C. Schlie et al. [2] improved the basic measurement setup due to Fichte et al. [1] and applied the method to identify the coupling frequencies of various electronic devices, such as, e.g., RFIDs. Earlier, T. Hurtig et al. used ERCs to expose RFIDs to a power hardness test [3]. In [4], fitting methods are presented to recover antenna properties of targets from PS data, even for extremely noisy data sets. In the present work, further improvements both on the measurement hardware and on the data analysis are systematically studied. The former comprise variation of antennas, stirrer geometries, and the resonator's shape, as proposed by [5]. The latter resorts to filtering techniques and particularly boot strapping methods, as described in [6]. Characterizing quantities comprise injected power over the considered frequency range, the statistical E-field distribution, and the ERC's quality factor. Further to PS, this paper is also devoted to propose an environment to gain maximum information from a target's impulse response within an ERC.

II. HARDWARE IMPROVEMENTS

In a well suited ERC, a target's mean antenna reflection coefficient approaches its free space value as soon as the testing frequency is sufficiently high. Hence, it is favorable to design a low loss antenna with a low and nearly constant free space reflection coefficient to optimize the input power curve. Different antenna types, such as double cone-, loop- or patch-antennas are designed, simulated, constructed, and validated in an anechoic chamber. Based on antenna measurements in the ERC, the amount of noise and the ERC's ergodicity properties are studied. The latter can be improved by field diffusers and irregular chamber walls [5]. Further, to deliver a pulsed exposition to the targets in the ERC, particular antenna designs and measurement setups are proposed.
To validate the different measurement setups considered in this work, calibrated targets have been constructed, with matched monopoles proving optimum suitability. Those have been gauged by reference measurements in an anechoic environment and numerical simulations.

IV. ENHANCED DATA ANALYSIS

In addition to hardware improvements, also enhanced techniques for data analysis are studied to reduce data ambiguity and noise, which is unavoidable for small ERCs, but may spoil a successful detection of a critical frequency band. Hence, multiple filtering as well as reordering and resampling methods [6] are applied. Particularly, boot strapping with and without stratified ordering is used to ameliorate the explanatory power of information obtained. The compiled results may serve as a blueprint for EMC based hardening tests.

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