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Wideband Operation of the Hybrid OTA Measurement Chamber

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Summary

The research paper demonstrates the capability to form an optimal multi-directional testing environment for wideband signals within the hybrid over-the-air (OTA) measurement chamber without the mechanical movement of the device under test (DUT). We show in simulations that signal can be predistorted to compensate for the scattering properties of the chamber.

1 Introduction

The integration level between device components, such as antennas and radio front-end/back-end, is continuously growing. Therefore, a device under test (DUT) should often be characterized as a single integrated unit, including the antennas. Over-the-air (OTA) testing becomes a major option to realize such a scenario.

The Hybrid OTA chamber [1, 2] combines the advantages of two extreme environments: rich multipath and line-of-sight (LoS), realized as reverberation chambers (RC) and anechoic chambers (AC), respectively, by employing a plane wave spectrum generator (PWSG) array inside an overmoded waveguide. It allows for: (i) fast directional measurements in LoS (gain, EVM, EIRP etc); (ii) synthesizing wide range of angles of arrival (AoAs); (iii) arbitrary channel emulation; (iv) TRP estimation etc. – all in one single environment.

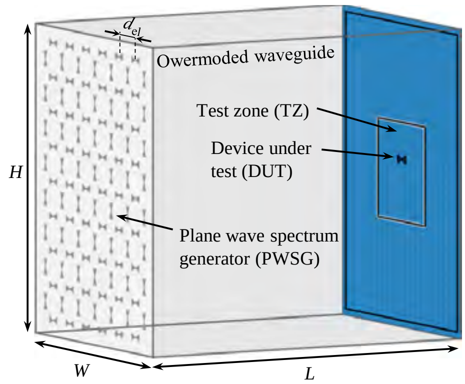


Figure 1. Model of the hybrid chamber.

Since the operation of the chamber utilizes multiple reflections from the WG walls (dispersive medium), an optimized signal waveform predistortion has to be applied to maintain a good-quality TZ in the whole frequency band of the signal. Digital predistortion technique often used for the compensation of nonlinear effects in transceivers and propagation environments for improving the system performance in terms of power, efficiency and linearity [3, 4]. This work describes the predistortion procedure that compensates for the scattering properties of the chamber and shows a numerical example demonstrating the capability of the hybrid chamber to realize far-field conditions for wideband signals.

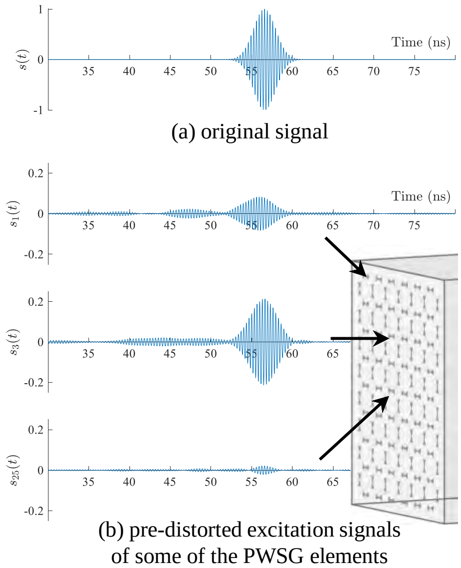


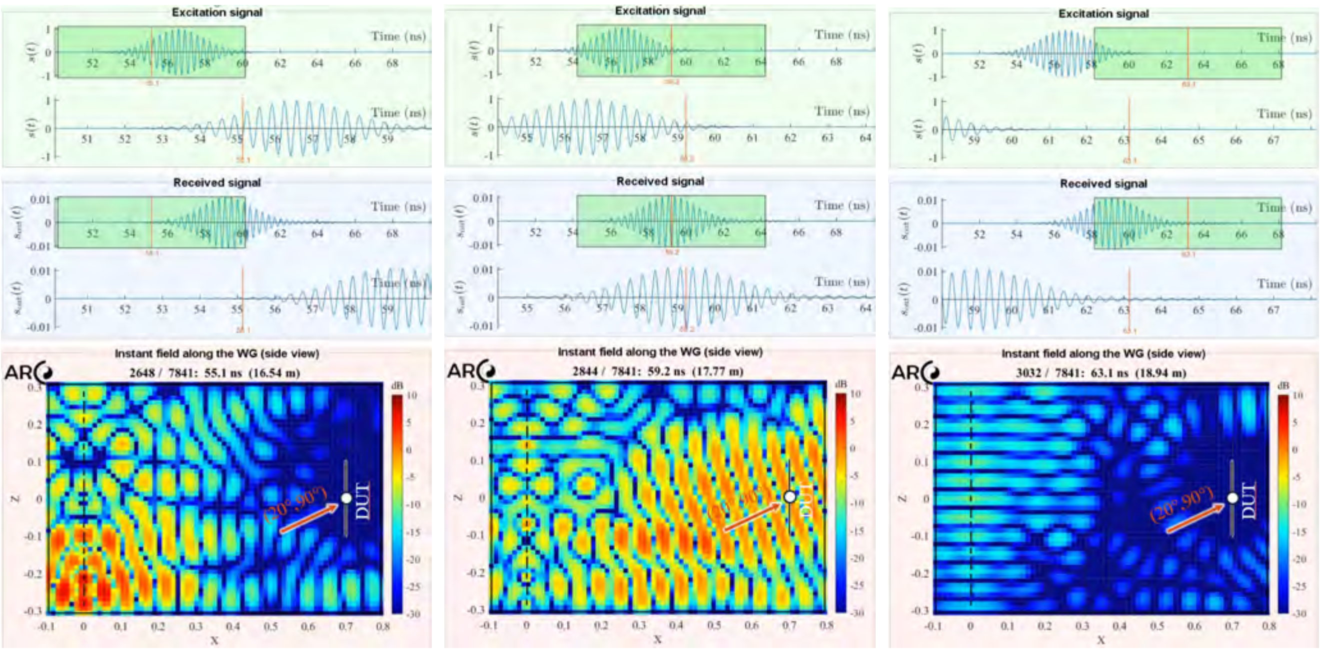
Figure 2. Original signal and predistorted signals for several elements of the PWSG.

2 The hybrid chamber layout

The hybrid chamber considered at this work is shown in Figure 1. It is designed to perform OTA measurements of small DUTs (up to 20×20 cm^2) at frequencies around 3 GHz. The chamber consists of the metal waveguide with dimensions $(W,H,L) = (0.5, 0.625, 0.7)$ m, and the PWSG array antenna located at the left end of the WG and consisting of bowtie antennas with inter-element spacing $d_{\text{el}} = 0.7\lambda$. The test zone is denoted by a rectangle at the opposite open end of the WG. The DUT is placed in an arbitrary location within the TZ.

3 Waveform predistortion and numerical example

A Gaussian pulse is chosen as a representative example of a wideband signal. It has central frequency of 3 GHz and bandwidth of 500 MHz at -20 dB level of the signal spectrum magnitude. The signal's waveform is shown in Figure 3(a).



(a) (b) (c)

Figure 3. The E-field distribution at three time samples.

The goal here is that the DUT receives the pulse coming from the angle-of-arrival (AoA) $(\theta, \phi) = (20^\circ, 90^\circ)$. For that, the linearly constrained minimum variance (LCMV) beamformer is used as described in [2] to find the complex excitation coefficients for each PWSG element, which are stored in the vector $\mathbf{w}$. Since the signal is wideband, $\mathbf{w}$ must be a function of frequency and is calculated at the center of each frequency sub-band with bandwidth B smaller than the *instantaneous bandwidth* of the chamber [2]. Then, the spectrum of the original signal is weighted by $\mathbf{w}$ and the waveform for the each element of the PWSG is obtained performing the inverse Fourier transform of the corresponding weighted signal spectrum. The excitation waveforms for the PWSG elements #1, #3 and #25 are shown in Figure 3(b). It is noted that the array elements should be excited slightly before the original pulse starts to form the desired plane wave condition in the TZ with minimum distortion.

The E-field distribution in the vertical plane along the WG is shown in Figure 3 at three time samples: (a) the signal starting to radiate but haven't reached DUT yet; (b) DUT is experiencing a plane wave incident from AoA $(\theta, \phi) = (20^\circ, 90^\circ)$; (c) the energy left in the WG is leaving it passing the TZ after the whole pulse is received by the DUT. It is also seen from the figure that the pulse is received by the DUT nearly undistorted despite the wideband signal is propagating in the dispersive environment.

4 Acknowledgements

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