Toward Standard Near-Field Measurement Solutions for Stochastic Electromagnetic Fields

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***Abstract** - This paper calls for standardization of Near-Field measurement solutions for stochastic electromagnetic fields. State of the art Single-Probe, Dual-Probe and Multi-Probe(Array) based Near-Field measurement techniques are evaluated in terms of their RF, reliability (including mechanical stress) performances and Test-time for industrial applications.*

1. Introduction

Power Integrity (PI), Signal Integrity (SI) and EMC/EMI requirements represent the bottlenecks of present and next generation communication systems towards high data rate, low consumption and immunity to unwanted disturbances. Near-Field measurement of radiated emissions from Chip-Package-PCB-Antenna circuits and systems is mainly motivated by the following objectives:

1) Verification of EMC/EMI compliance for product evaluation and qualification (*certification-oriented*).
2) Diagnosis of Power Integrity (PI), Signal Integrity (SI) and EMC/EMI problems for design improvement (*Debug-oriented*).

Beyond the classical EMC/EMI compliance evaluations essentially based on Pass/Fail certification approach, there is an increasing demand for use of Near-Field measurement solutions for diagnosis purposes with loop-back to modeling analysis for design improvement. Including Near-Field measurement verifications as part of conventional product design/development and evaluation procedures will be very helpful in ensuring First-Time-Right success target with reduced Time-to-Market. Recent progress in electronic technologies together with the advent of modern signal processing techniques have led to the proliferation of increasingly faster, accurate and cost-effective Near-Field scanning systems. However, the effective use of available Near-Field scanning systems, in the context of industrial applications, remains limited by throughput Test-time, reliability constraints and reproducibility of measurement results.

2. Toward Standard Near-Field Measurement Solutions for Stochastic EM Fields

A proposal for standardization of Near-Field measurement of Stochastic [1-4] Electromagnetic Fields led by the European *COST Action 1407* [3] has been initiated. This initiative has resulted in an *IEEE* standard being specified for Single-Probe, Dual-Probe and Multi-Probe scanning systems. The Single-Probe, Dual-probe and Multi-Probe based measurements are compared in terms of their RF, accessible resolution, reliability (including mechanical stress) performances and Test-time for industrial deployment.

Main technical challenges include the following assessments:

- Attributes of Time-Domain versus Frequency-Domain measurement solutions.
- Effects of Probe-System/DUT interactions on measurement accuracy.
- Requirements for stochastic electromagnetic fields measurements.
- Simulation and measurement complementarities.

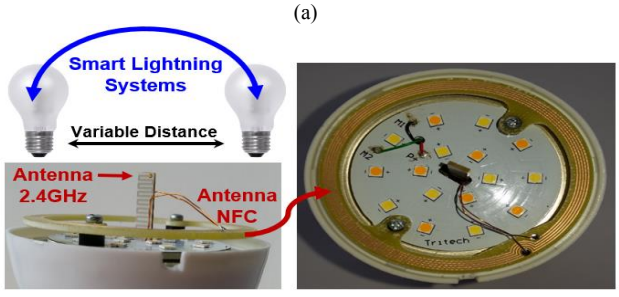
3. Results & Discussions

Canonical carrier test structures are identified in the perspective of emerging applications [6-7] such as MIMO, Phased-Arrays, Gesture Recognition, or Time-Reversal/Imaging Source-Retrieval:

- Passive Chip-Package-PCB interconnects
- Coupled MIMO/Phased-Array antennas for 5G
- Analog-Digital Co-habitation in Payload embedded systems

Fig.1 shows an experimental setup using *EMSCAN* [5] very-near field scanner array operating in the frequency-domain composed of a built-in adapter, a built-in spectrum analyzer and X/Y step motors.

(a)



(b)

Fig.1 : Near-Field *EMSCAN* technology (a) for experimental characterization of radiated emissions from Chip-Package-PCB circuits. Coupled smart lighting system with integrated WiFi and NFC antennas (b).

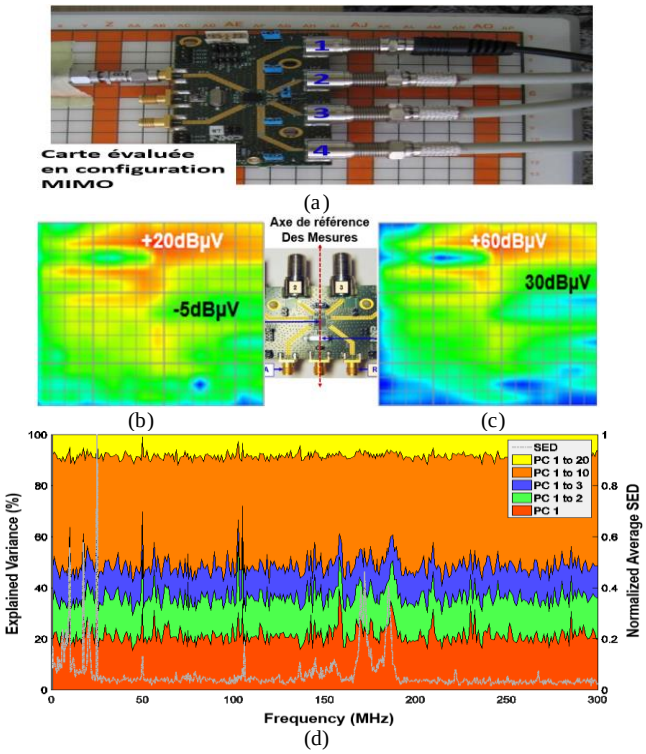


Fig. 2 Measured radiated emissions (b),(c) from Chip-Package-PCB circuit using *EMSCAN* Multi-Probe scanner (a). Measured Spectral Energy Density (SED) (d) as function of cumulative principal components using Dual-Probe scanner.

Fig.2(a) depicts the measured Spectral Energy Density (SED) as function of cumulative principal components measured using Dual-Probing system. It is observed that more than 90% of the Spectral Energy Density is carried by the first 10 principal components, this opens new perspectives for complexity reduction by filtering.

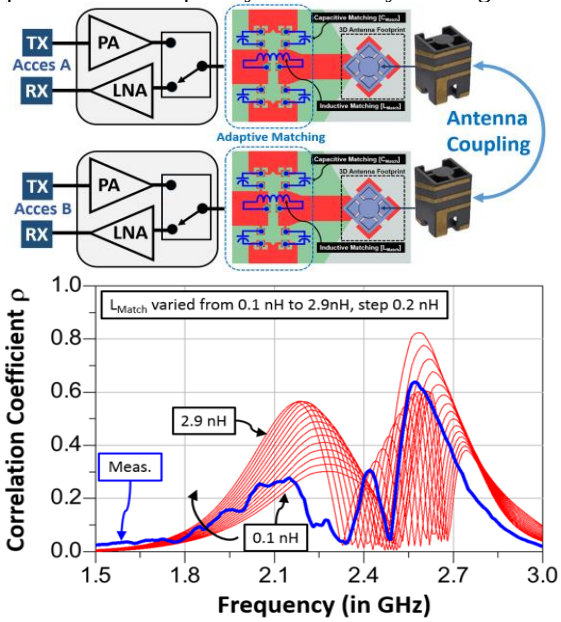


Fig.3: Full-wave EM simulation of MIMO antenna correlation as function of frequency for different values of inductive matching network compared to measurement.

Fig.3 shows coupled MIMO [7] antennas cross-correlation as function of variable matching network combined with front-end IC circuits for 5G communication. The extracted cross-correlation can be linked to the general theory of coherence [8], [1].

Fig.4 presents stochastic emissions radiated from DSP/Microcontroller PCB circuits embedded in UAV [9] payload.

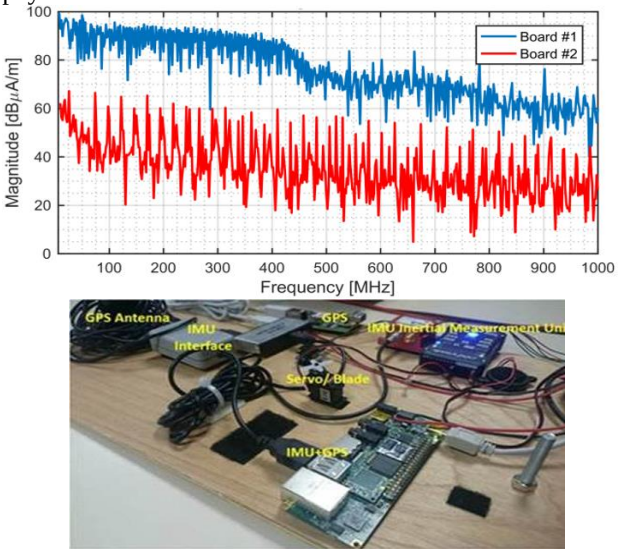


Fig.4: Near-Field probing of radiated stochastic emissions from Processor and Controller units embedded in development board for home-made UAV system.

For deterministic noise power density distribution, the challenge of energy detection of unknown signals in presence of noise is discussed in [10]. For stochastic signals, it is established that numerical values of noise amplitudes cannot be specified. Thus, for modeling and measuring stochastic signals, it is required to deal with energy and power spectra [2].

4. Bibliography

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