iemn
Institute of Electronics, Microelectronics and Nanotechnology
UMR CNRS 8520

Multi-Physics Characterization Platform

PCMP Plateforme de Caractérisation Multi-Physique

C2EM

The C2EM service is devoted to both Electromagnetic Compatibility (EMC) measurements and, in generic words, to Electromagnetic (EM) characterization in a wide frequency range (few Hz to 20 GHz) with dedicated equipments and instrumentation.

EMC studies / EM interactions between electronic/electrical equipments and their functioning environment. The aim is to ensure that such equipments will operate correctly both with a sufficient level of EM immunity against external sources and without generating EM emissions susceptible to disturb communication systems.

EM characterization concerns all EM measurements (e.g antennas characterization) requiring a standard 'quite' site and the on-site measurements such as the telecom propagation channels characterization.

The service gathers in a same area of 180 m2 various measurement's chambers and cells, each of them attempting to represent a certain EM environment required for research and EMC testings.

1. Radio Frequency Anechoic Chamber (RF-AC): 6m x 6m x 2.8 m
2. Transverse ElectroMagnetic Cell (TEM-cell) : 2m x 1m x 0.6 m
3. Mode Stirrer Reverberation Chamber (MSRC), 5.6m x .4m x 2.8 m

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EMC CHAMBERS AND CELLS

RADIO FREQUENCY ANECHOIC CHAMBER (RFAC)

Lamine Kone

The actual RFAC consists in a 137m3 shielded room whose internal walls are covered with radio-frequency (RF) absorbing foams. It is intended to represent a standard free space propagation environment with known properties. The geometrical dimensions and the electromagnetic characteristics of the absorbing materials limit the bandwidth of the chamber, in particular in the lower frequency range. This chamber is devoted to ElectroMagnetic Compatibility (EMC) testing and to all electromagnetic (EM) characterization requiring quiet EM environment (e.g. for antennas radiation pattern and gain assessments). According to the application, the frequency range is from 30 MHz up to 18 GHz. For EMC purpose, the chamber meets the basic EMC requirements in terms of field uniformity and site attenuation for a 3 meters testing. Therefore, it is quite usable for EMC pre-compliance testing according to European and to some military and aeronautic EMC standards, for radiated immunity and emission.

To ensure its functioning, the following instrumentation is available:

- Spectrum Analyzer RS FSV30 (10 Hz -30 GHz)
- VNA RS ZVA 24 (10 MHz -24 GHz)
- Synthesized RF generator (10 MHz -20 GHz, 10 dBm)
- Turntable table
- Broad band antennas (30MHz -18 GHz) : bi-conical, log-periodic, double ridge
- Broad band amplifiers: 30W (1 MHz-1 GHz), 25W (800MHz-4 GHz)
- Broad band Electric field probe (100 kHz-6 GHz), E-field max 200V/m

→ ADVANTAGES & LIMITATIONS

- (+) High EM isolation against EM disturbances (90 dB min @1GHz),
- (+) Standard plane waves environment
- (−) Low frequency limitation for antennas characterization (Fmin=200 MHz),
- (−) Size limitation, e.g. 5 m distance max available for RFID tags characterization
- (−) Height scanning limited (1.2m to 1.80m) for EMC testing

→ MAIN EMC APPLICATIONS

- Radiated emissions and radiated immunity characterisation of electronic/electric equipments,
- Shielding effectiveness measurement of flat materials,
- Experimental validation of EMC numerical models

→ OTHER APPLICATIONS

- Characterisation of RFID (Radio Frequency Identification) tags performance (860 -950 MHz),
- Characterisation of antennas arrays (radiation pattern, gain, antenna factor),
- Experimental validation of antennas numerical models

TRANSVERSE ELECTROMAGNETIC CELL (TEM CELL)

Lamine Kone

The TEM cell is a shielded strip line like a tapered transmission line (TL) of rectangular cross-section with a flat inner conductor (septum). It is intended for establishing standard uniform EM field in the low frequency range (f<30 MHz) where RF-AC and MSRC are not functioning. The cell geometry is designed to give a 50 Ω characteristic impedance for the TL. Within the working volume (under the septum), the fields are those of a plane wave as far as the fundamental TEM mode remains dominant. The cell operates from DC to an upper frequency such that high order modes excited in the cell remain negligible compared to the TEM mode. Therefore, the maximum frequency of measurement depends on the dimensions of the cross-section of the cell and of the size of the device under test (DUT).

The TEM cell constitutes a powerful experimental tool which enables various experiments in EMC domain for the study of EM fields coupling phenomenon to cables and PCB traces.

To ensure its functioning, the following instrumentation is available:

- Spectrum Analyzer RS FSV30 (10 Hz -30 GHz)
- VNA Agilent E8733 (30 kHz-6GHz)
- Synthesized RF generator (10 kHz -1 GHz, 13 dBm)

→ MAIN EMC APPLICATIONS

- Measurement of radiated emissions and susceptibility of embedded electronic devices,
- Characterisation of the EMC behaviour of partially shielded cables for aeronautic applications,
- Calibration of electrically small size E and H-field probes,
- Study and validation of numerical models of the EM coupling to cables

→ **Complementary with other techniques present at IEMN :** Pole SigmaCom for HF RFID tags characterization

→ ADVANTAGES & LIMITATIONS

- (+) Standard plane wave environment at low frequency
- (−) High frequency limitation (e.g, 100 MHz for our TEM-c)

C2EM

EM SITE CHARACTERIZATION

MODE STIRRER REVERBERATION CHAMBER (MSRC)

Lamine Kone

In contrast with the RFAC (Radio Frequency Anechoic Chamber), the MSRC is a very complex of high Q-factor measurement tool intended to simulate realistic EM environments such as that encountered by electronic devices in large screened boxes, aircrafts, automotive vehicles, etc. The MSRC consists in an electrically large chamber with highly conducting walls . The lowest working frequency (LWF) of a MSRC is such that its wavelength is smaller than the smallest dimension of the chamber. A MSRC is equipped with a metallic paddle (the stirrer) which can be moved by means of a continuous or stepped motor. Physically, a MSRC acts as an oversized cavity in which a high number of resonant modes can be excited around any frequency higher than the LWF. Thus, the rotation of the stirrer allows achieving different boundary conditions, and consequently, it generates a complex EM environment with randomly distributed field in amplitude, phase and polarisation. However, far from the wall > than a quater of wave length, the fields remain in average, statistically uniform and isotropic within the chamber. Consequently, all the physical quantities (e.g. E-field, power, etc) are measured as averaged values of sets of data collected when the stirrer is moving. Uniformity and isotropy properties are checked through a normalized calibration procedure based on the standard deviation (STD) of E field samples acquired at different locations in the chamber. Due to the high Q-factor, high field level can be achieved with low input power

To ensure its functioning, the following instrumentation is available:

- Spectrum Analyzer RS FSV30 (10 Hz -30 GHz)
- VNA RS ZVA 24 (10 MHz -24 GHz)
- Synthesized RF generator (10 MHz -20 GHz, 10 dBm)
- Broad band antennas (30MHz -18 GHz) : log-periodic, double ridge
- Broad band electric field probe (100kHz – 6 GHz)

→ MAIN EMC APPLICATIONS

- Measurement of radiated emissions and susceptibility of electric/electronic equipments
- Characterisation of the shielding effectiveness of flat materials, shielded cables and connectors

→ OTHER APPLICATIONS

- Characterisation of RFID (Radio Frequency Identification) tags radiation efficiency
- Emulation of telecom multipath propagation channel
- Emulation of diffuse environment for assessing human body specific absorption rate

→ Complementary with other techniques present at IEMN : Pole SigmaCom, CHOPE

→ MSRC is an alternative EMC testing site to RFAC

→ ADVANTAGES & LIMITATIONS

- Low cost equipment v.s RFAC
- High Q (quality) factor environment enabling high level of E- field inside the chamber with low power amplifier.
- Low insertion loos v.s free space and RFAC
- Spatial homogeneity of the field over the working volume
- No need of changing antennas polarization and using turntable table when performing EMC testing.
- Capability for measuring the total isotropic power radiated by an equipment
- Loos of antennas directivity,
- Need of rotating the stirrer during any measurement

TRANSFER IMPEDANCE (ZT) BENCH TEST

Lamine Kone

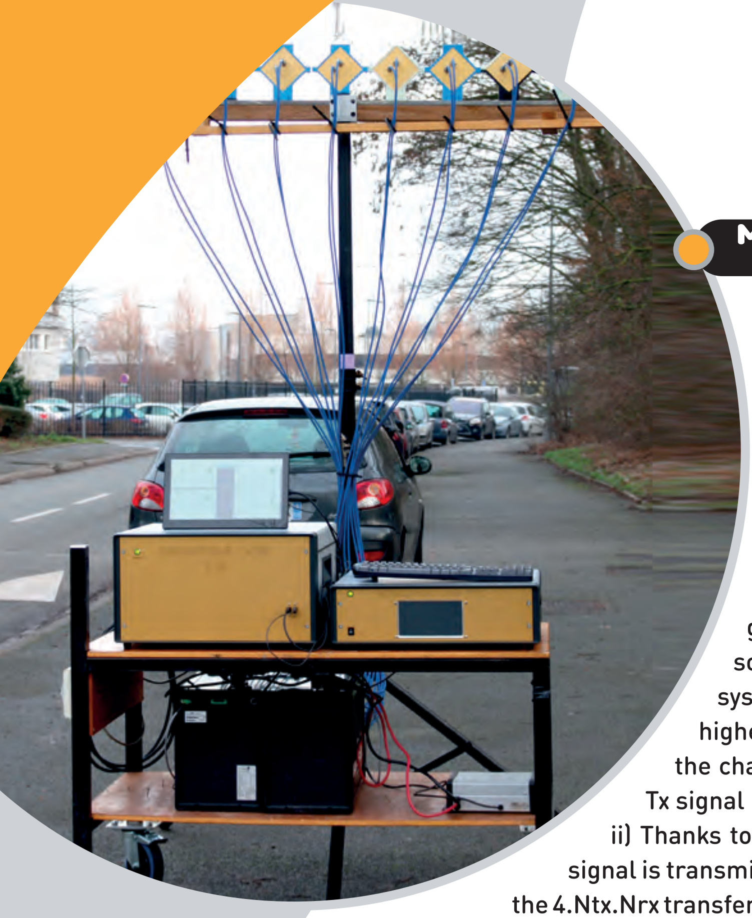
In EMC problems, cables play an important role both in the radiation and in the susceptibility phenomenon of the equipments they interconnect. When the cables are shielded, their EMC performance is generally evaluated, (depending on the field of application), either by a measure of the shielding effectiveness or by measuring a well-known parameter: the transfer impedance denoted Zt.
The IEMN staff TELICE is pioneer in studying Zt measurement's methods. The Zt bench test used in C2EM service as been studied and constructed according to IEC (International Electrotechnic Commission) requirements.

→ APPLICATIONS

- Transfer impedance and shielding effectiveness measurement of shielded cables and connectors

→ ADVANTAGES & LIMITATIONS

- Wide frequency range (few kHz to 2 GHz),
- High sensitivity (e.g. $0.1\mu\Omega/m$) in low frequency range (few kHz to 30 MHz)
- Low frequency sampling above 100 MHz



MASSIVE MULTIPLE INPUT MULTIPLE OUTPUT SYSTEM ACQUISITION (MAMIMOSA)

Pierre Laly Lamine Kone

Channel sounder MIMOSA (Multiple Input Multiple Output System Acquisition) real-time MIMO (16Tx, 16Rx) and Massive MIMO (64Tx, 16Rx) channel analyzer. The actual model can operate from 1.3 GHz until 10 GHz. Two frequencies are available for now, 1.35GHz and 5.89GHz with 80MHz bandwidth. The sounder is based on numerical processing by FPGA coupled at a computer for data recording.

MaMIMOSA is based on space-frequency division multiplexing, giving a large possibility of tone and antenna allocation. This channel sounder belongs to the new generation of software radio design based systems. The architecture of proposed approach was designed with the highest flexibility thus opening a wide range of applications. In addition, the channel sounder has been built to avoid heavy post-processing: i) the Tx signal is pre-processed to include the non-linearity of the Tx and Rx chain, ii) Thanks to the high sampling frequency of the FPGA, a real digital baseband signal is transmitted to the RF chain avoiding I/Q impairment, iii) the output file gives the 4.Ntx.Nrx transfer function in a versatile binary format. Finally, the power consumption of the sounder is low and can be powered with a 24 V battery with a 8 hours autonomous.

→ MAIN APPLICATIONS

- Real-time propagation channels characterization in indoor,
- Real-time propagation channels characterization in mobility context (such as vehicular, aerial, ship, etc.),

→ OTHER APPLICATIONS

- Cybersecurity,
- Staff fall detection in a confined environment (e.g. ship)
- Localization in a complex environment (e.g. forest)
- Test of new communications techniques (5G, 6G, etc

→ Complementary with other techniques present at IEMN : Pole SigmaCom

→ ADVANTAGES & LIMITATIONS

- Real Time
- Flexibility
- Low post-processing
- "Mobile"
- New filters for new frequencies,
- Mobile but need to adapt to the new environment.

Signal in Baseband		Radio Frequency	
• Multiplex • Used sub carrier • Outputs • N subcarrier / output • Delta frequency • Symbol duration	IFDM 6560 8 820 97.7 kHz 81.92 µs	• Frequencies • Bandwidth • NTx (switched mode) • Power / Tx • NRx • AGC Dynamic	1.35 GHz / 5,89GHz 80 MHz 8 (16 ou 64) 1 to 100 mW 16 63 dB
Sounding characteristics			
• CIR* • Max CIR*	10.24 µs 50 M	- CIR Resolution - Matrix H(16,16,1024) - Matrix H(16,64,1024)	12.5 ns 1 Mo 4 Mo

Manufacturer: IEMN/Telice/Univ. Gent

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