Politecnico di Torino

The LACE Antenna Test Ranges

1. Introduction

Politecnico di Torino is the oldest Technical University in Italy, with more than one and a half centuries of academic activity. It is a State University, and currently has Schools of Engineering and of Architecture, and a Graduate School **(http://www.polito.it**). There are more than 800 between lecturers and research staff, 800 technical and administration staff, and about 32,000 students, 18% of which from foreign countries. During the past 10 years the Politecnico di Torino has doubled in size and capability, offering its students excellence, and a challenging and stimulating environment.

Fig.1:The School of Engineering (left) and the School of Architecture at the Valentino castle (right).

The Antenna and EMC Laboratory (LACE) is a scientific and organizational sub-structure of the Department of Electronics and Telecommunications, one of the largest among the departments of Politecnico. From the administrative point of view, the LACE has been established about 10 years ago, as one of the winners of an externally-refereed competition of Politecnico to support excellence Labs. From the scientific and professional point of view it represents about 50 years of experience in experimental, numerical, and theoretical activities in antennas, EMC and applied electromagnetics, as well as of service to national and international companies with professional consulting and partnership in applied research.

LACE is a joint undertaking of Politecnico and the Higher Institute “Mario Boella” for information and communication technologies (ISMB). Its mission is to carry out experimental activity and characterization in the areas of antennas and in the electromagnetic radiation and susceptibility of electronic systems and devices.

The most significant activity of the Laboratory is the study, characterization and measurement of prototypes of innovative antennas, with particular interest to new applications in the area of telecommunications; modelling, characterization and verification of the electromagnetic channel, as well as EMC research and test for equipment certification in shielded anechoic chamber.

2. The antenna test ranges

Outdoor facilities

The existing test range, used since the early ‘60es for pioneering works on space antennas, has been replaced in 2008.

In the new outdoor test range, the Antenna Under Test (AUT), used in reception, and the Source (SRC) are placed on the roof of two different buildings, the Department of Electronics and Telecommunications and the Department of Control and Computer Engineering. The two buildings are far apart (more than 150 m) without obstacles in between, and the height of both AUT and SRC is 30 m above the ground; the range is shown in fig.2 (top view and elevation).

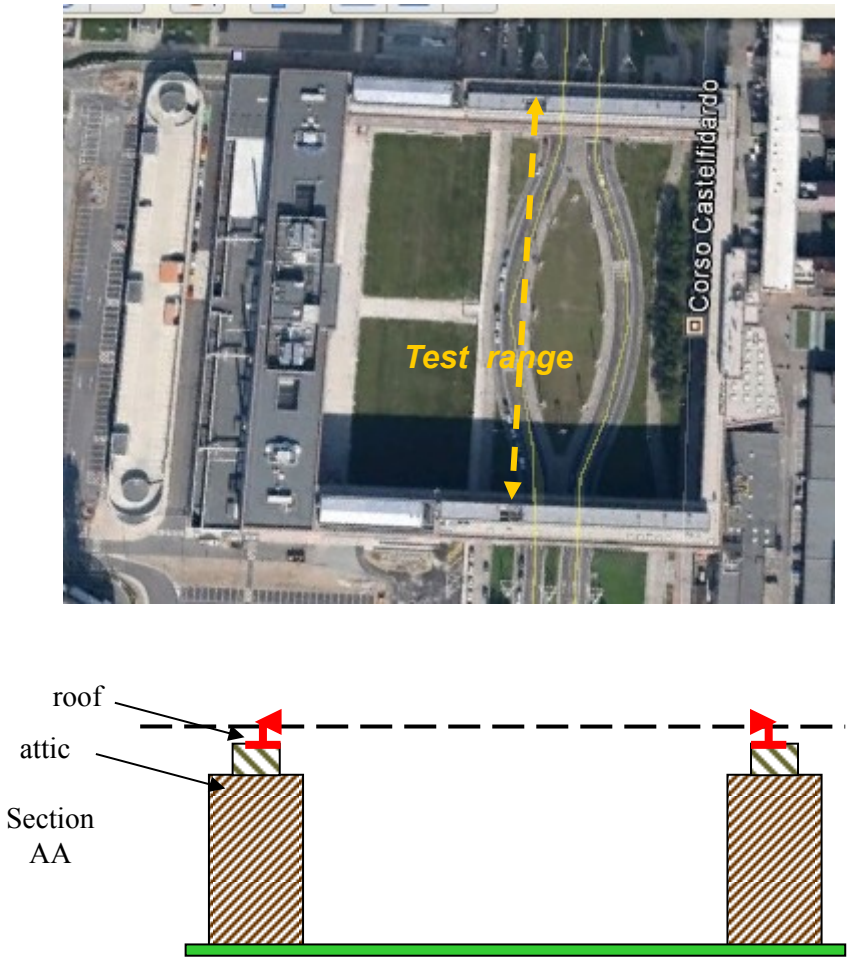

Fig.2: Scheme of the outdoor test range

Consequently, at microwave frequencies there is a large number of Fresnel zones without obstacles. The effects of the reflection on the ground can be removed by a time windowing, with some directivity of the source and also considering that the incidence angle on the ground is near to the Brewster angle.

The frequency range is 100 MHz-40 GHz (the upgrade from 20 to 40 GHz has been added in 2011), recently extended to higher frequencies (up to about 50 GHz). The distance between SRC and AUT allows to test antennas up to 0.7m diameter at 40 GHz; at lower frequencies the maximum size in meters is given by $D \cong 4.7/f^{1/2}$, where f is the frequency in GHz.
The dynamic range is around 90 dB (depending on the frequency). The receiver can handle up to 16 measurements channels, with external switching system, and 1 reference channel measured simultaneously with each signal channel, with 100 dB isolation Channel to Channel (110 dB Reference Channel to Signal Channel). The accuracy in amplitude (Logarithmic mode) is ±.05 dB/10 dB over the full dynamic range (excluding effects of temperature, cross-talk and noise) and ±0.4 °/10 dB in phase over full dynamic range; the noise figure is 17 dB at 0.1 to 18 GHz.

The positioning system of the AUT is a 3-axis system (roll over azimuth over elevation), consisting of: MI53150 Az/El and MI6111 rotary positioners. The Az/El accuracies are respectively 0.03° and 0.05° with max load 1136 kg and bending moment 3390 N·m; the roll accuracy is 0.05° with max load 455 kg and bending moment 678 N·m. As a practical guideline, the system can measure antennas up to 2m in size and to 70 kg in weight: actual limits depend however on the shape of the antenna. This positioning system allows to take pattern cuts as well as raster scan of the pattern, and to measure circular and linear polarization. Examples of measured radiation patterns are shown in fig. 4. The full system cabling diagram is shown in fig. 5.

Fig.3: Outdoor test range: the AUT mount (left) and the SRC mount (right).

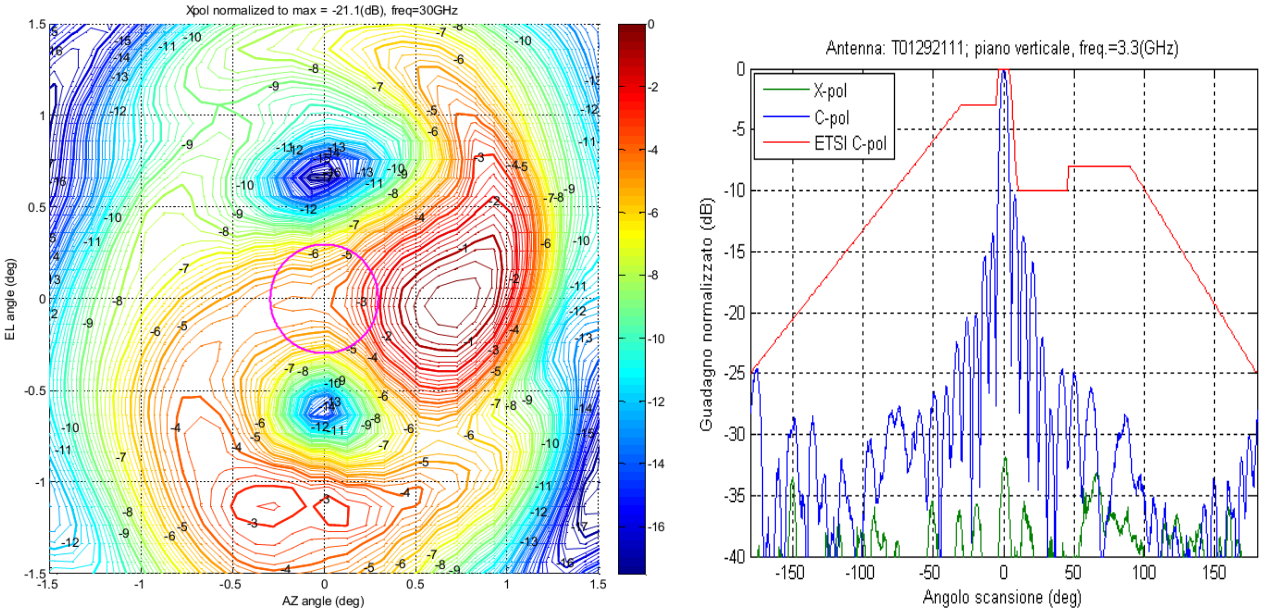

Fig.4: Examples of radiation patterns measured in the Outdoor Test Range.

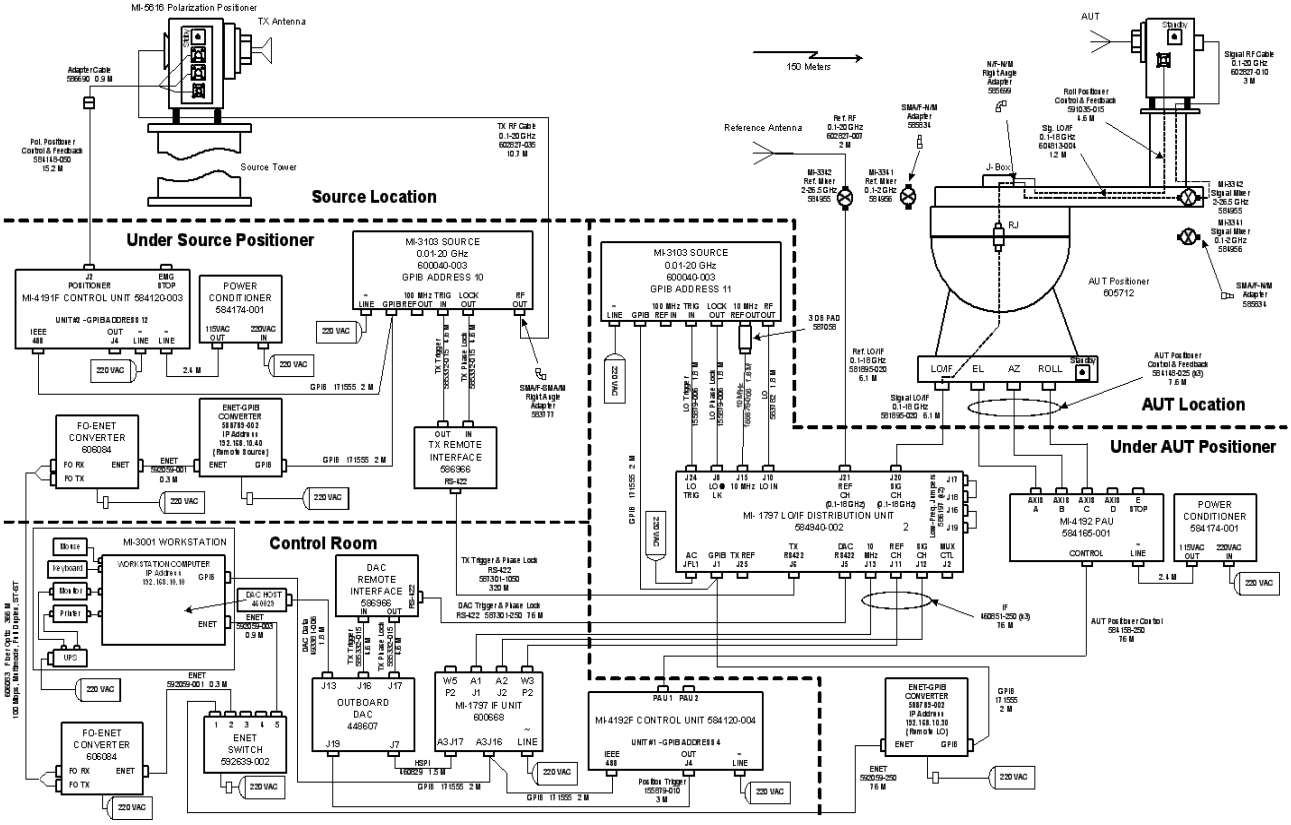

Fig. 5:The full system cabling diagram.

Indoor ranges

Two anechoic chambers are available: a smaller one (3.5 x 2.2 x 2.2 m), for far field measurements at higher microwave/ mm-wave frequencies. Fully lined with 8" absorbers, it is used above 1.5 GHz up to 90 GHz. The SRC/AUT distance is 2.8 m, thus accommodating antennas with max size (in m) $D \cong 0.65/f^{1/2}$ where f is the frequency in GHz. The AUT has a 2 axis precision roll-over-azimuth positioning system, and the possibility of a precision horizontal translation, as shown in fig.6.

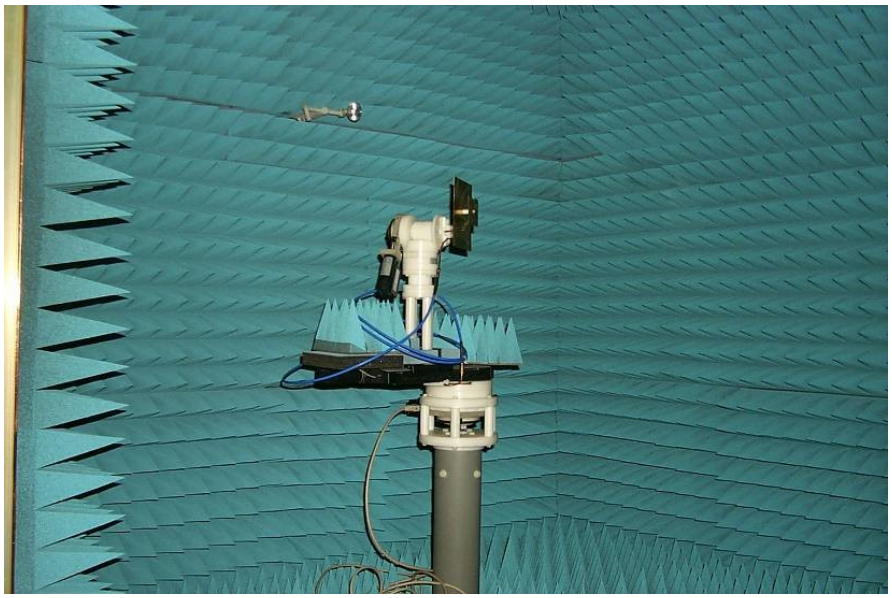

Fig.6: AUT in the mmw anechoic chamber.

Radiation pattern measurements in this test range are usually done with HP83650L synthesizer as source and HP8563E Spectrum Analyzer for frequencies below 50 GHz. For higher frequencies, or if phase measurements are required, Agilent PNA E8361A is used. This latter is also generally used for impedance, matching and isolation measurements.

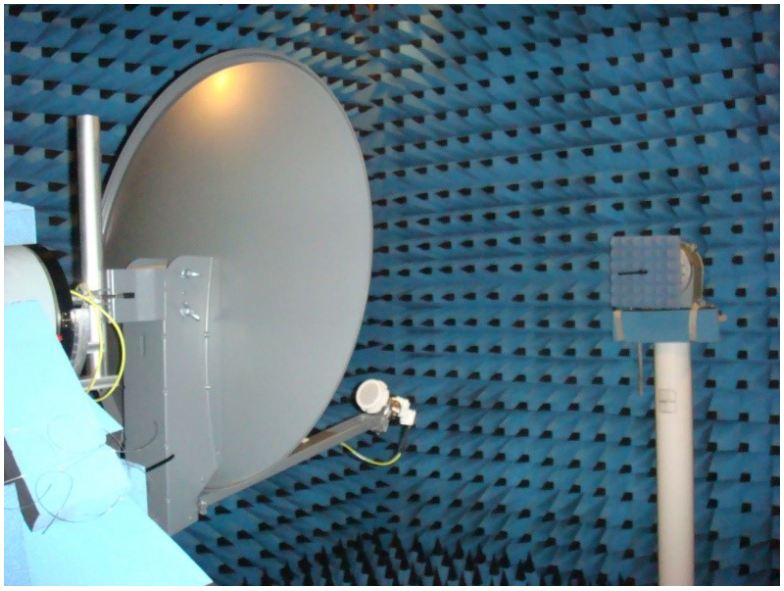

Fig.7: Anechoic chamber in Vercelli and Spherical Near/Far Field test range.

LACE has also a larger anechoic chamber, located in the former Politecnico's School of Engineering in Vercelli, a city at about 70 km from Turin, midway between Turin and Milan. The size of the chamber is 5 x 5 x 4 m. It is fully lined with 18" absorbers (see Fig.7), and it is used between 700 MHz and 40 GHz. This chamber has an indoor test range, with spherical near field, operating from 700 MHz up to 40 GHz, installed and active since July 2009. Examples of measured radiation patterns are shown in fig. 8 and 9.

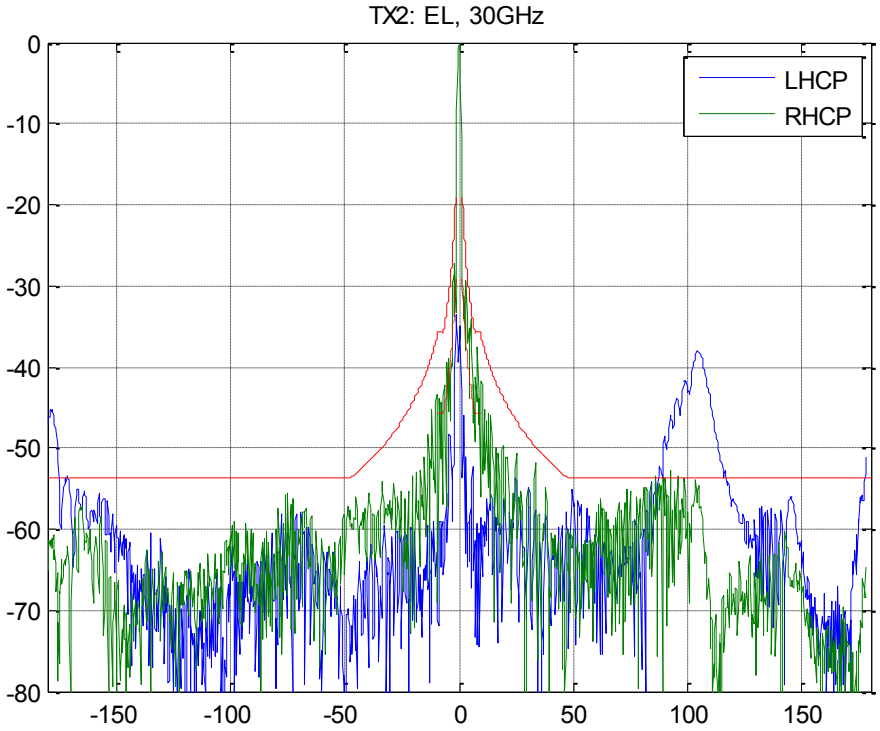

Fig.8: Example of radiation patterns measured in the Indoor Test Range.

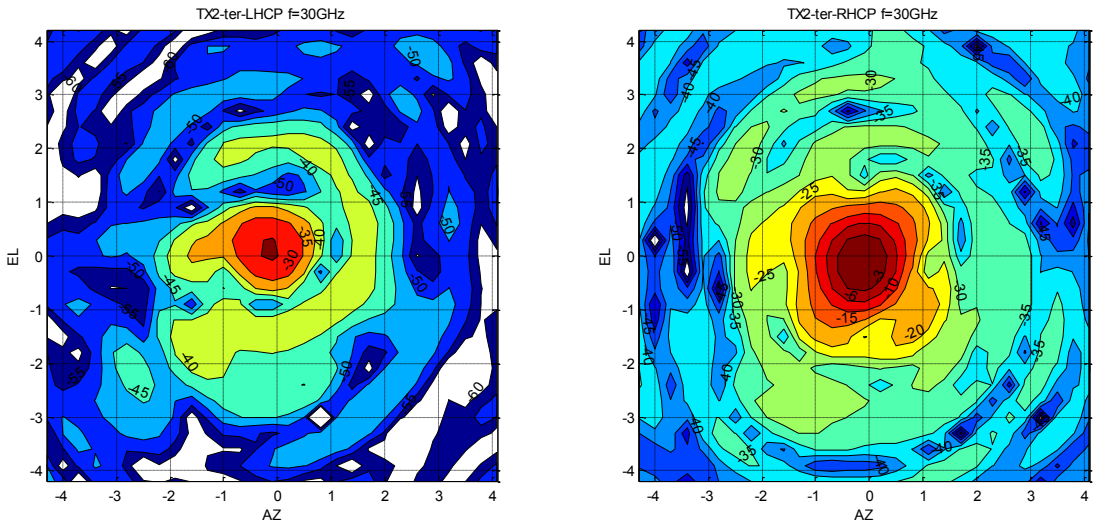

Fig.9: Examples of raster scan radiation patterns measured in the Indoor Test Range.