Technical E-Paper

14

Using the ANECHOIC CHAMBER in the design of antennas

PART THREE: laboratory equipment.

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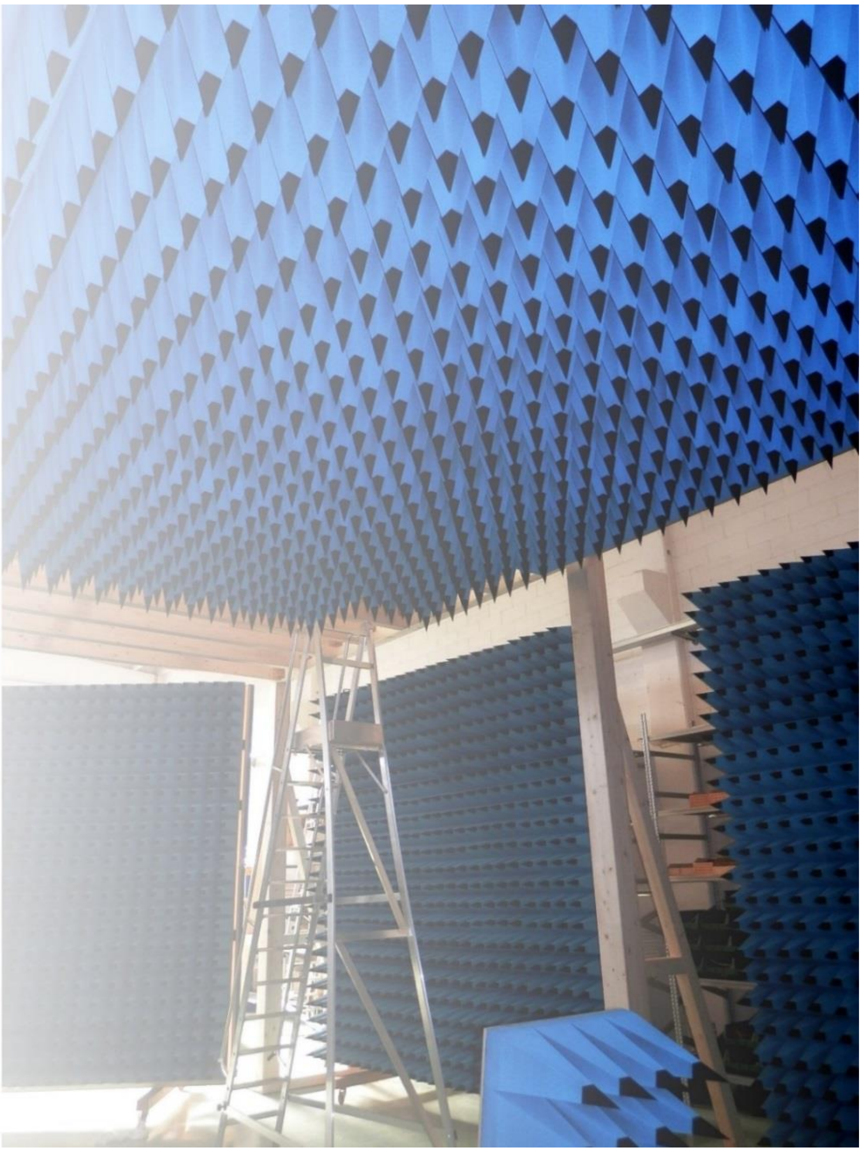
Now let us continue with the third and final part of the focus on one of the most important pieces of equipment used in antenna research and development: the *anechoic chamber*.



PART ONE:
What is an anechoic chamber and how is it constructed to measure the electrical parameters of antennas?

PART TWO:
What precautions can be taken to obtain reliable measurements during the design of a new antenna?

PART THREE:
What other laboratory equipment is needed to measure antenna radiation parameters?

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...continued from PART TWO:

7. Ancillary equipment.

Alongside the anechoic chamber as such, a range of equipment is needed in an R&D laboratory. This ancillary equipment is another important cost item and is essential when carrying out the antenna characterization measurements in the design and/or test stage.

Very often, as for example in our company, this equipment is constantly evolving, due both to the continuous improvement and upgrading of the laboratory, and to meet new needs that may arise at the kick-off of some projects.

Ancillary equipment can be divided into the following main categories.

- ***a)*** *Instrumentation*, divided into: *RF instrumentation* and *acquisition devices*.
- ***b)*** *Connection cables*, divided into: *RF cables, control cables* and *service cables*.
- ***c)*** *Reference standards*, divided into: *reference antennas* and *calibration kits*.
- ***d)*** *Mechanical interfaces*, divided into: *supports* (*masts*), *positioners* and *fixtures*.

A brief description of the four items listed above is provided to understand all the aspects of an antenna measurement in an anechoic chamber.

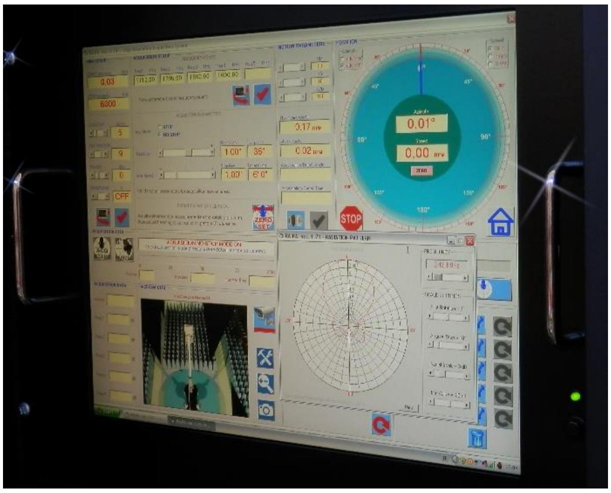
a) Instrumentation.

RF instrumentation includes all those measuring devices that on one hand allow the radio link to generate a calibrated RF signal and, on the other hand, to receive it, measuring its electrical characteristics in a relative (S_{12} or S_{21}) or absolute (*received power*) way. This category may include not only the best-known measuring instruments, such as the *VNA* (*Vector Network Analyser*) and the spectrum analyser (***Figure 14***), but also signal generators, amplifiers and measuring receivers.

Figure 14
Example of RF instrumentation.

Acquisition instrumentation usually consists of a rotating platform or support controlled by a computer using ad hoc software.

The example in ***Figure 15*** shows the control screen of the acquisition system used by our company, which controls a rotating platform (visible in other photos in this article) with a diameter of 1.6 meters, placed in the anechoic chamber.



Figuea 15
Example of acquisition software.

The whole system, developed and built internally by the company, allows rotation of the *AUT* with a position accuracy of less than one tenth of a degree and is interfaced with the RF instrumentation. In this way it is possible to carry out accurate radiation pattern measurements in a fully automated way.

b) Connection cables.

The cables connecting the anechoic chamber to the external laboratory must have specific electrical and mechanical characteristics, since they can cause both errors in the measurement and transfer radio-electric noise into the chamber itself. This latter aspect is critical in anechoic chambers used for electromagnetic compatibility tests even if, in the characterization of antennas, in the past I have used an anechoic chamber in which the internal lights, if turned on, generated electrical noise that was clearly affecting by the instrumentation readouts.

RF connections include coaxial cables characterized by electrical (SWR, attenuation, phase stability, etc.) and mechanical (dimensions, flexibility, minimum bend radius, etc.) specifications suitable for the purpose. In the case of small antennas, it is important to have precision coaxial transitions, more flexible pieces of cable (*pigtails*) and smaller dimensions. To prevent the coaxial cable that connects the *AUT* to the instrumentation containing currents that can alter the measurement, special cables shielded with ferrite cores are often used.

The *control cables, on* the other hand, include all the connections that exchange data with the acquisition system and with any other equipment present in the chamber. In some projects for EMC, these cables are in optical fiber with the aim of preventing radio-electric disturbances inside the chamber. For example, in our company's laboratory, the main control cables include an *IEE-488* bus that communicates with the electronics residing in the rotating platform and a video cable for an internal camera which surveil the *AUT* during the measurement.

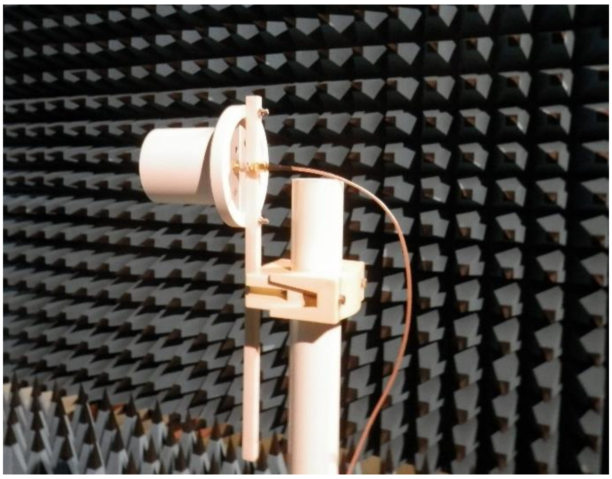


Figure 16

Small antenna, ready for measurement, connected with a *pigtail* in RG-316 wire and assembled on a simple *fixture* made in PVC. The *mast* supporting it is also in dielectric material (fiberglass).

Finally, the *service cables* carry the power supplies, both for the acquisition system and for the internal lights of the chamber. If necessary, mains filters are interposed to prevent electrical noise entering in the chamber.

c) Reference standards.

This generic term refers to both the *AR* reference antennas used in gain measurements and the *calibration kits* needed to calibrate the instrumentation (*VNA*) before each measurement, thus purifying the acquired data from the influence of the RF cables connecting the antennas (*AUT* and *AR*) to the instrumentation.

Reference antennas (AR), characterized by a known gain curve within the operating bandwidth, can be of two types: antennas with a calibration certificate supplied by an external certifying body or antennas with calibration performed internally by the company.

While an antenna of the first type may be indispensable in finding the optimal position for the *AUT* in limit conditions of use of the chamber, in normal activities a reference antenna of the second type is generally used, often made ad hoc for the project being developed.

In our laboratory, all the *ARs* built and manufactured expressly for certain projects enrich the so-called "library" of reference antennas and remain a company asset for future use.

For gain measurements, the optimal reference antenna should have the following characteristics:

- Gain curve that is as constant as possible in the operating bandwidth;
- Directional antenna, with a main lobe that is neither too wide nor too narrow, approximately in the order of 50° ÷ 70° in both planes;
- Compact ***D*** dimension, especially along the direction of maximum radiation or towards the *AUT*;
- Robust construction, with brackets and connectors suitable for fast/frequent deployment and disassembly.

d) Mechanical interfaces.

The installation and positioning of the *AUT* and *AR* antennas inside the anechoic chamber require the use of suitable mechanical interfaces, all made in dielectric materials, both high and low density.

The ***supports*** are support poles (*masts*) of various lengths and diameters, with a suitable base. In our specific case they are made of fiberglass (***Figure 16***).

The ***positioners*** are adjustable mechanical interfaces with the purpose of allowing the assembly of the *AUT* in a given point in space (X_0, Y_0, Z_0) inside the anechoic chamber. An example can be seen in ***Figure 17*** which shows a positioner mounted on the rotating platform, at the base of the mast, with the aim of adjusting the position of the axis around which the *AUT* is rotated during the acquisition of the radiation patterns. Being a mechanical detail that can be subject to considerable stress, in the present case it was made of thick PVC, with the various parts assembled by interlocking and gluing using a specific product.

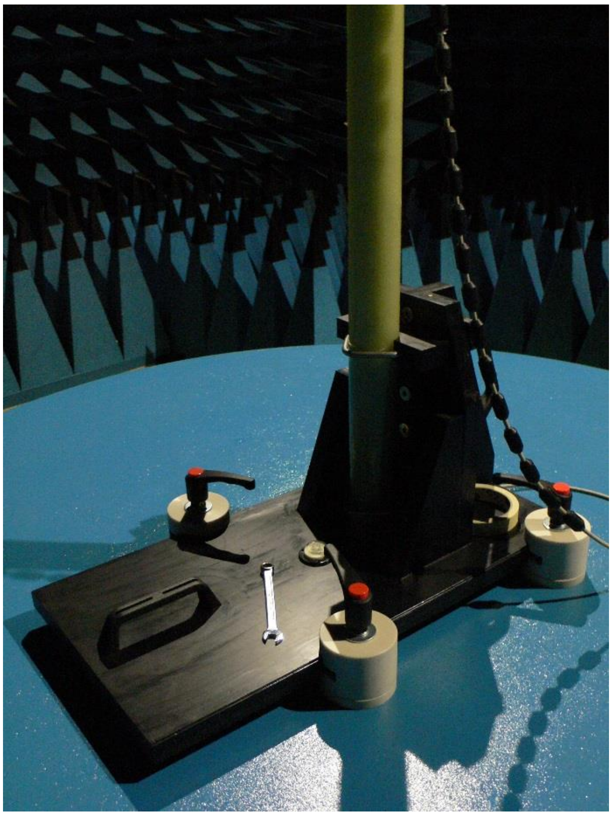


Figure 17
The adjustable positioner of the rotating platform.

In the same photograph, note the ferrite-coated RF cable that connects the *AUT* to the instrumentation. If it is necessary to make special measurements, such as the determination of the phase center of an antenna, micrometric positioners which operate on two or three axes must be used.

Finally, the term ***fixture*** refers to the mechanical interfaces for mounting the *AUT* on the mast which often have to be created ad hoc for particular antennas to be measured. ***Figure 16*** shows a simple *fixture*, in plastic material, for mounting the UWB antenna which can also be seen in the photo.

On a well-made *fixture* it must be possible to install the *AUT* in an easy, precise and repeatable way, without this interface affecting the electrical characteristics of the antenna being tested.

In the case of integrated antennas, it may be necessary to create rather complex *fixtures*, with the aim of simulating the real operating conditions of the antenna as precisely as possible, as well as supporting the antenna itself during the measurement phases.

7. Conclusions.

For a company that deals with research and development in the field of antennas, it is essential to have a laboratory and a measurement system with which it can measure its products, assessing their electrical parameters both during the design stage and at the end of it, in the final test.

In this context, the most important laboratory equipment is certainly the *anechoic chamber*: there are various types and sizes of chamber, depending on the type of application and the measurements that can be carried out in it.

Naturally, the type of application and purpose for which an anechoic chamber is necessary determine both the criterion with which it is built and the relative methods of its use.

In the specific case of a company that deals with the design and development of antennas, the chamber must be able to ensure reliable pre-certification measurements that can be carried out quickly and easily: for the customer or contractor, this translates into savings in design costs and in the availability of a quality product, with defined and guaranteed electrical specifications.

The purpose of this article, in which we have tried to deal with the topics from an operational point of view, was to provide a brief overview of how the anechoic chamber is built and used in practice for antenna measurements.

Since this is a vast and complex subject, the path taken here was to provide a detailed description of the anechoic chamber used in our company, as well as to give specific examples of how antenna measurements are made, even reaching the physical limits of operation of the chamber itself if particular products have to be characterized.

It was also important to mention the instrumentation and other equipment needed to carry out the measurements correctly and accurately: all of this is part of the company's heritage and *know-how*, even if in a less evident form.

In fact, it is the company's responsibility to create and guarantee a product for which every technical characteristic is known in detail and precisely, in particular the customer's specifications which can be subject to subsequent validation by external bodies or controls on the field.

And, finally, it is the Customer's responsibility to request from the supplier, in addition to the mere economic offer, how and with what resources the antenna project will be controlled since the early stages of development, so that the final product fully complies the required electrical specifications, preventing issues and unpleasant surprises.

8. References and insights.

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