Technical E-Paper

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Professional omnidirectional antennas for marine environments.

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Every sector that employs professional antennas is a potential candidate for the creation of custom antennas. Naturally, we are not talking about generic antennas for nautical use, which are already widely available on the market. Our focus, as always, is on custom antennas, designed to meet specific needs and applications.

The example discussed in this article examines the creation of antennas that, in addition to meeting electrical requirements, have stringent dimensional and environmental constraints. These antennas must withstand prolonged immersion up to depths of 300 meters below sea level and then reliably operate once the vessel they are installed on returns to the surface.

ElettroMagnetic Services SRL

1. Introduction.

The topic of "Omnidirectional Antennas" is certainly one of the most frequently discussed among industry professionals.

It is very common for us to be asked to verify the actual performance of a certain model of omnidirectional antenna, comparing it with the specifications indicated in the datasheet provided by the manufacturer. We often find substantial differences between what is promised in the datasheet and what is actually measured.

We have already partially addressed this topic in **TEP No. 2 - Omnidirectional Antennas: Mechanical Dimensions and Gain**, in which we suggested a very simple formula to estimate the reliability of the gain indicated by the manufacturer, based on the mechanical dimensions of the antenna.

Without this preliminary evaluation, the risk of encountering a substantial difference between the performance declared in the datasheet and the performance actually delivered by the antenna is real and can lead to two different situations:

- the antenna is still able to guarantee the minimum performance required by the Customer;
- the antenna is not able to guarantee the minimum performance required by the Customer.

While in the first case we can consider it an "asymptomatic" scenario with no consequences, the second case definitely entails a series of problems and difficulties for those actually using the antenna. This is where one experiences firsthand the difference between a professional antenna and any other antenna: the ability to truly meet the specifications stated by the manufacturer in the datasheet.

If you have never considered verifying whether the actual performance of your omnidirectional antenna matches the specifications listed in the datasheet, it is likely that your operations do not require the use of professional antennas. Conversely, if you need to install antennas that can ensure specific technical requirements, then using professional products will bring significant benefits and advantages to your business.

Based on the real request from one of our Customers, we want to analyze in detail some important aspects of omnidirectional antennas and how to proceed to ensure the required technical specifications are met.

2. The Customer's requested specifications.

In the specific case we have decided to examine, the customer has requested the development of two different omnidirectional antennas, operating within a rather broad portion of the UHF band. Let's look at the main requirements for each of the two antennas in detail.

Specifications for omnidirectional antenna No. 1:

- *single input omnidirectional antenna for installation in a marine environment;*
- *operating frequency: 403÷473 MHz;*
- *dimensions: 330mm (Length) × 40mm (Diameter);*
- *gain optimized according to available dimensions (minimum required 1 dBi);*
- *the antenna must be installed on a metal platform and it is necessary to minimize the platform's influence on the antenna's VSWR value;*
- *protection rating: IP67.*

Specifications for omnidirectional antenna No. 2:

- *dual input omnidirectional antenna with two independent and isolated connectors, for installation in a marine environment;*
- *operating frequency: 403÷473 MHz;*
- *dimensions: 330mm (Length) × 40mm (Diameter);*
- *gain optimized according to available dimensions (minimum required 0 dBi);*
- *the antenna must be installed on a metal platform and it is necessary to minimize the platform's influence on the antenna's VSWR value;*
- *protection rating: IP68;*
- *submersible and capable of withstanding depths of up to 300 meters*

No further specific details regarding the application have been communicated, as it remains confidential. It has only been added that the antennas must communicate with each other and that the required gain levels are the minimum calculated through a link budget to ensure radio communication. In case it is not possible to achieve the indicated gain in one of the two models, this difference must be compensated with an increased gain in the other.

For confidentiality reasons regarding the client who commissioned the project, we will not be able to provide specific details about the chosen solutions. Instead, our goal will be to define an operational method that can be used whenever selecting the ideal omnidirectional antenna for a given application. We will emphasize some aspects that are sometimes overlooked but, in our opinion, are fundamental.

3. Design of the omnidirectional radiating elements based on the available dimensions

Regarding this point, the two antennas present a substantial difference: the requirement of a single input for *ANTENNA No. 1* and a dual input for *ANTENNA No. 2.*

Concerning the design of *ANTENNA No. 1*, the task may initially seem relatively straightforward, as the usable space allows for a good range of solutions.

However, it is important not to overlook two crucial details: the required bandwidth (70 MHz, equal to 16%) and the need to ensure constant VSWR and gain levels across the entire frequency range.

Indeed, the mistake that is often made is considering only the maximum gain value found within the entire band, without evaluating its complete behaviour.

This often leads to measuring gain curves that show a peak at a certain frequency, followed by a significant decline in performance across the rest of the operating band. While this may be considered a minor issue for narrowband antennas, it becomes a critical requirement for those who need to use a wider band.

Figure 1
Constructive example of UHF radiating elements

In our specific case, to create a truly optimized radiating element for the application in question, it has been necessary to design a structure that also took this factor into account, conducting appropriate laboratory tests to verify the behaviour of these two parameters throughout the entire development phase.

Concerning *ANTENNA No. 2*, the task becomes decidedly more challenging due to the introduction of an element that further complicates the situation: the requirement for two inputs and significantly reduced space. In this case, two radiating elements must be accommodated instead of just one, as in the previous case.

When faced with a problem of this type, technical adjustments are typically employed to create "short" radiating elements with physical dimensions smaller than those of traditional λ/2 or λ dipoles (***Figure 1***).

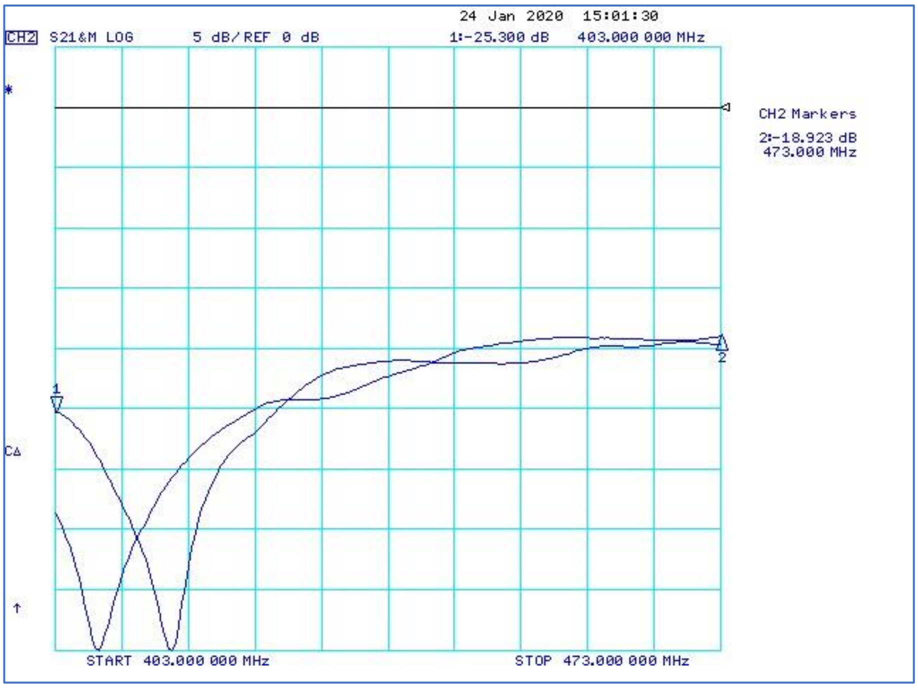

Figure 2
Isolation between ports of the dual-input omnidirectional antenna
(Curves referring to two samples)

The available solutions are varied, and it is not possible to define the best one in advance, as it must be evaluated on a case-by-case basis. This involves comparing the achievable performance, which is often inferior to traditional solutions, with the specific project requirements.

Furthermore, in defining the most suitable solution, an important parameter must be taken into consideration: the isolation between the two ports. Indeed, to ensure the proper functioning of the antenna, sufficient decoupling between the two inputs is necessary, which should be approximately in the order of at least 20 dB (***Figure 2***).

The situation thus becomes quite complex and, as is often the case, the experience and know-how accumulated from previous projects can be decisive factors in identifying the best approach.

Finally, it is advisable to pay close attention to details sometimes considered secondary, such as the choice of the appropriate connecting cable. Not all cables are the same and they exhibit very different characteristics. A cable with a suitable diameter and PTFE dielectric can be crucial in reducing losses and achieving better performance.

4. Minimizing the influence of the metal platform on antenna performance.

As already emphasized, a professional antenna has the characteristic of fully meeting the specifications indicated in the datasheet. Furthermore, these specifications must be known to both the manufacturer and the user.

It is therefore important that the characterization measurements are carried out in such a way that the performance obtained in the anechoic chamber is the same as that experienced by the customer when the antenna is correctly installed. Otherwise, the definition of a professional antenna would automatically be invalidated.

The request from our Customer should be viewed from this perspective. They want the assurance that the antenna's VSWR value remains virtually unchanged, regardless of the typology and size of the metal platform on which it will be installed (***Figure 3***).

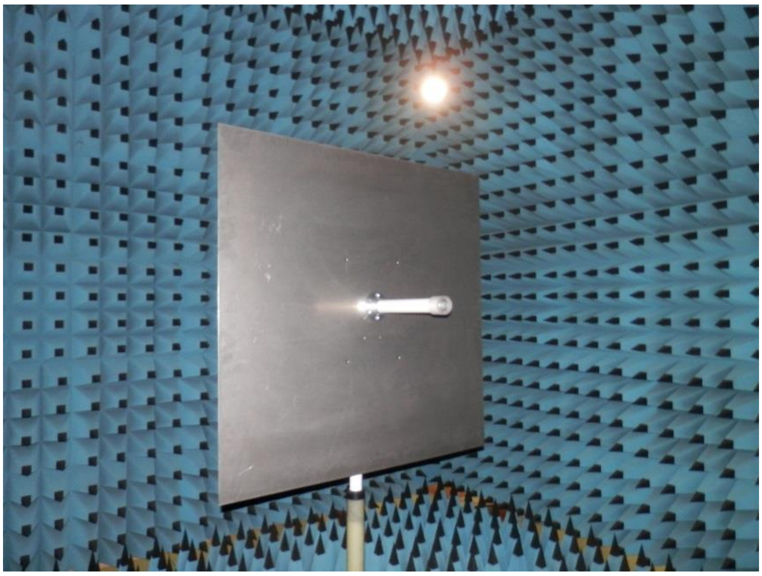

Figure 3
Verification of the influence of a ground plane on radiation patterns through anechoic chamber measurements.

This request is typically met through the use of a balun, properly designed and integrated into the antenna.

In this way, adequate decoupling between the antenna and the cable is achieved, preventing current from flowing on the outer braid of the cable. This minimizes the influence of the metal platform on the VSWR value, which remains virtually unchanged.

The issue of performance repeatability in omnidirectional antennas is a significant concern.

We take this opportunity to offer a couple of tips that may be useful when deciding to purchase any omnidirectional antenna.

1. *Verify whether the antenna you are purchasing has a ground plane or if it needs to be installed on a metal surface;*
2. *Verify whether the antenna you are purchasing is equipped with a balun, making it less susceptible to variations in its specifications.*

If, on the other hand, you need to develop and manufacture a custom antenna, to ensure measurement repeatability, it is good practice to consider the typical installation of the antenna both during the design phase and during the final characterization measurements (***Figure 4***).

In this way, it will be possible to optimize its performance and, at the same time, obtain reliable measurements that the customer can verify during the subsequent installation in the operational position.

Furthermore, if the task involves designing an integrated antenna, considering the "environment" in which the antenna will be placed becomes essential to achieve a product capable of meeting the Customer's requirements.

For those interested in the topic of integrated antenna design, we refer to the following technical insights:

- ***TEP No.3 – Types and design of integrated antennas for wireless and IoT applications***
- ***TEP No.4 – Integrated antennas: electrical specifications on datasheet and measurements***
- ***TEP No.11 – Integrated antennas engineering and industrialization***

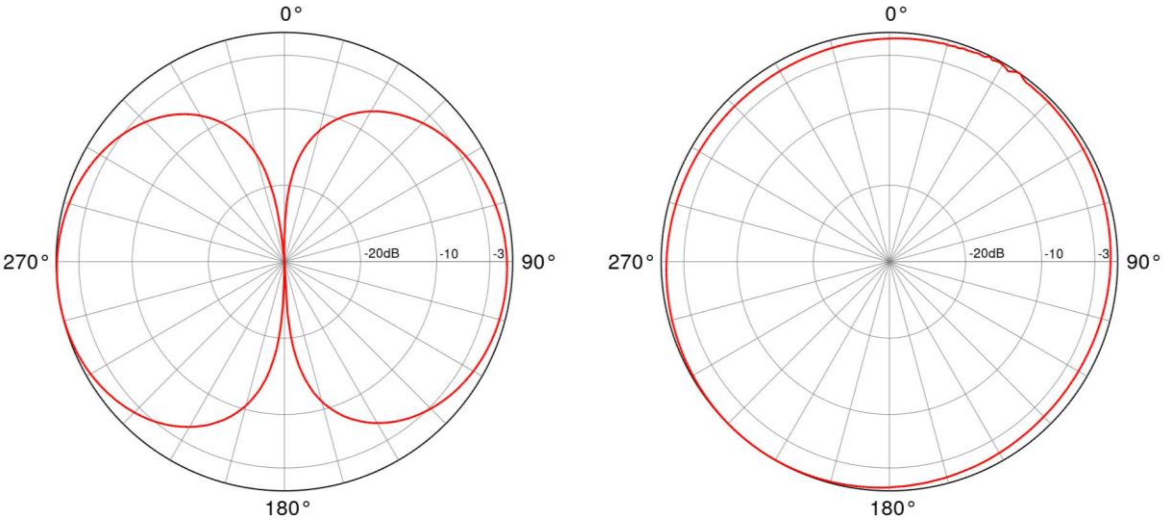

Figure 4
Examples of measured radiation patterns.

5. Installation in marine environments.

Both omnidirectional antennas created for this project will be installed in a marine environment, which is known to be particularly aggressive and limiting for their lifespan. To meet this requirement, it is essential to use suitable materials capable of withstanding such corrosive conditions.

Here are the precautions that have been taken for both antennas:

- *VTR radome;*
- *Aluminum flange treated with epoxy primer and anti-algae paint;*
- *Cap made of UV-resistant plastic material;*
- *Watertight cable glands on the flange with direct exit of pigtail coaxial cable at the base of the antenna.*

To make ANTENNA No. 2 submersible up to 300 meters, equivalent to a pressure of over 30 atm, every cavity inside the radome has been filled with a special epoxy resin (Figure 5).

The choice of this resin was made by verifying its dielectric properties to ensure it does not negatively impact the electrical specifications of the antenna. Special attention was also given to the contact area between the flange and the metal platform. An O-ring with a dedicated groove was provided here to isolate and protect the area where the cables exit the base of the antenna through the cable glands. Finally, to prevent the deposition of algae or other impurities, the radome was coated with a layer of anti-algae paint, commonly used on boats and outboard motors below the waterline.

All these precautions will allow the antennas to operate for a sufficiently long time in particularly aggressive environments.

Figure 5
Filling the internal cavities of the antenna with dielectric resin.

6. Conclusions.

The design of these antennas has been used as an example because it represents some typical needs of those who use professional omnidirectional antennas.

Here they are summarized:

1. The gain value indicated in the datasheets of omnidirectional antennas does not always reflect the actual performance. Therefore, it is advisable to take precautions to estimate the reliability of the various datasheets.

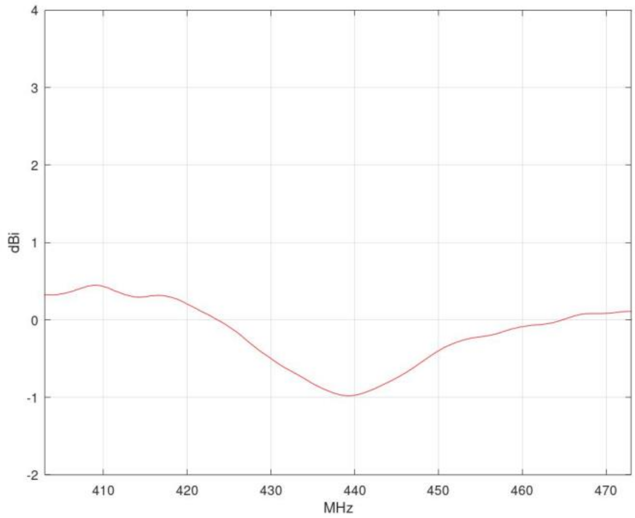

Figure 6
Measured gain curve across the band for the
dual-input omnidirectional antenna (Worst case).

2. The reliability of the specifications indicated in a datasheet and the repeatability of measurements are distinctive characteristics of professional antennas. When requesting the design of a custom antenna, it is necessary to ensure that adequate precautions are taken both during the development and characterization phases.

3. Except for very narrowband antennas, knowing the peak gain value is not always sufficient. It is advisable to verify the behavior of the gain curve across the entire frequency range (***Figure 6***).

4. When it is necessary to fit two radiating elements within a confined space, a critical parameter to consider is the isolation between the two inputs.

5. When purchasing an omnidirectional antenna, it is important to verify if it requires a ground plane to function properly and if installation on a metal surface can affect its performance (use of a balun).

6. When planning to use antennas in a marine environment, it is advisable to construct them with suitable materials capable of withstanding prolonged exposure to aggressive and corrosive climates.

7. When there is a mechanical need to fill an antenna enclosure with epoxy resin, it is recommended to pay special attention to the technical characteristics to prevent it from negatively impacting the electrical specifications of the antenna.

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All the information and experiences presented in this article are the result of the design, development, and production of custom professional antennas carried out by ***ElettroMagnetic Services Srl*** using the ***AntennaCustomizer*** method.

For questions, clarifications, or further information on this or other topics related to professional antennas, please contact **bollini@elettromagneticservices.com**.

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