Technical E-Paper

Defining, choosing and testing the proper antenna for your application.

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Nowadays, not everyone can be an expert in everything, as Leonardo da Vinci certainly was in his time.

Five hundred years after the death of the great artist, scientist and engineer, it is really no longer possible for us to know every aspect of the multiple disciplines and technologies that inevitably affect our projects and our work.

So how is it possible, not having specific knowledge of the subject, to choose the most appropriate antenna for a specific product or application?

Let's try to provide some food for thought on this topic.

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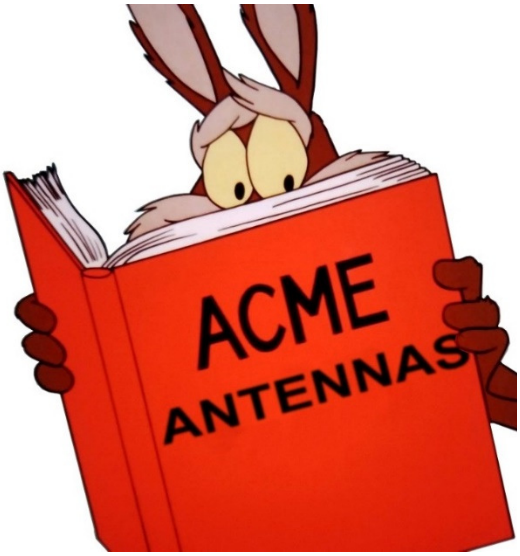
1. Introduction.

Nowadays, almost all industrial processes and products require multidisciplinary development activities that can rarely be fully supported within the same company, especially if it is a small or medium-sized one.



In general, the internal skills of SMEs grow around their own core business, in line with the main innovative contribution that they are capable of and aim to promote on the market.

However, the fact remains that components and accessories already available on the market have to be used with a certain frequency, mainly in order to reduce the development and installation costs of products or systems.

In the case of antennas, not all companies whose products or services involve the wireless sector have the need and/or the economic capacity to develop ad hoc projects to solve situations in an optimal way, or specific internal resources and skills in this particular sector.

Even if it may prove to be economically advantageous, a fundamental and legitimate aim for every Purchasing Office, procuring a commercial antenna is not intrinsically risk-free, especially in the case where it is necessary to fall back on a standard product, of which high quantities have to be purchased but which may not fully meet the required needs or when, for reasons of cost, a non-professional antenna has to be purchased, whose characteristics and performance may not be verifiable in advance.

As with other disciplines and technologies that can be considered complementary for a company, it is not important to have a comprehensive knowledge of every sector but to be able to understand the problem, so as to promptly identify potential errors of assessment.

Over more than twenty-five years in the antenna sector, I have had the chance to see and deal with numerous case histories, ranging from the banal to extravagant and disconcerting conspiracy theories regarding brain implants that use electromagnetic waves to mentally condition humans from afar.

Setting aside the second case, for obvious reasons, here I will try to provide some ideas on how to make an informed choice of the most suitable antenna to use for your product or application.

These ideas represent a synthesis of a broader procedure which, within our company, has been given the name *Safe Antenna*. Thanks to this method, we can to provide a highly specialized technical service that targets all those companies which, while not requiring custom products, have to use COTS antennas for their products or applications.

2. Electrical, mechanical and environmental specifications.

A so-called "real" antenna is defined by means of numerous parameters, which are or should always be supplied by the manufacturer, in a more or less detailed or exhaustive way, in the form of a product datasheet or leaflet.

The features are divided into three main families:

- *Electrical specifications;*
- *Mechanical specifications;*
- *Environmental specifications.*

From an industrial point of view, a detailed examination of this technical information allows a capable and competent Technical Manager to:

- write a purchase specification;
- verify the correctness and/or completeness of the technical-commercial datasheets provided by the manufacturer;
- commission a particular project based on specific needs;
- assess the correspondence of a specific antenna product with your application needs;
- size the radiating system for your wireless communication system.

The ***electrical specifications of an antenna*** define the way in which the antenna radiates or picks up electromagnetic waves in the surrounding space (*radiation specifications*) and the ways in which it is interfaced with the transmitting and/or receiving apparatus (*matching specifications*).

These parameters contain the essential information for sizing an antenna for a specific application, or for calculating the link budget of a communication system. Some of the most important electrical parameters are gain, radiation patterns, polarization, ROS or return loss, input impedance, maximum input power, etc.

The ***mechanical specifications of an antenna*** provide information about how the antenna was built and how it interfaces with the required installation or application.

These parameters are needed to understand if an antenna is suitable for a specific installation and, indirectly, they are useful to establish the congruity with the electrical parameters. Some of the most important mechanical specifications are size, type of mechanical interface, type of connector, etc.

Finally, the ***environmental specifications of an antenna*** are essential to establish the reliability of an antenna in operating conditions, or to indirectly assess the possible occurrence of problems or malfunctions during the entire life cycle of the wireless communication system. Some of the most important environmental specifications are operating temperature, resistance to corrosion or chemicals, IP protection degree, etc.

In an initial approach with a commercial product, the specifications that can be acquired are drawn up by the manufacturer or, at most, by whoever markets the antenna. Therefore, in addition to the technical value, it is always necessary to bear in mind that they have a commercial purpose.

3. Analysis of the required specifications based on the application.

In a preliminary phase, the choice of an antenna available on the market is based on a set of specifications necessary for the correct functioning of the product or system being built.

Before reading a technical datasheet, it is important to study these specifications, carefully assessing the following aspects:

- *Who drafted it, what is its origin?*

In fact, it is not uncommon for the purchasing department of a company, especially a medium or large-sized one, to refer, through no fault of its own, to obsolete or incomplete specifications or, worse still, to specifications containing errors or inaccuracies.

In fact, these specifications often refer to datasheets of antennas taken as a reference years ago, whose inaccurate or obsolete specifications can thus have repercussions on future supplies.

This is the case, for example, of some specifications concerning VHF/UHF omnidirectional antennas with a gain specification of 5dBi, which indicate antenna dimensions that are absolutely insufficient to obtain the required gain. From a technical point of view, this situation has led to a proliferation of products on the market with gain values that are a little too generous and abundant, declared as such in order to comply with these specifications, unfortunately still in being. For further information on this aspect, please refer to *Technical E-Paper* n.2 (*Omnidirectional antennas: the truth about GAIN vs SIZE*).

- *What is the order of importance of each requested technical specification?*

Starting from the data of the specifications, it is important to assign an order of importance and/or priority to each of the specifications reported, since some of them can have a decisive impact both on the cost of the antenna and on its availability on the market as a standard product.

This aspect reminds me, many years ago, of the case of some *DECT antennas* made to design with a very precise radiation pattern with the aim of optimizing the coverage of the service. However, it is a pity that, in fact, many of these antennas were installed in conditions that were anything but compatible with the type of product chosen, thus invalidating any technical advantage.

- *Are there specific requests that are not necessary or that can at least be updated?*

As a direct consequence of the previous point, it is worth asking whether there are technical specifications, at times even stringent ones, that are unnecessarily mandatory for the required application.

In this regard, an old specification comes to mind that set a precise specification on the type of antenna, which necessarily had to be a *Yagi type directive*. Obligation that certainly did not take into consideration the existence of directional panel antennas with electrical characteristics (gain and radiation patterns) that were much more stable in the band and with a lower impact of wind, ice and snow on the radome.

4. Assessment and choice of the product-antenna.

In a company, the assessment and choice of an antenna for professional use is made based on three different criteria or phases, which are generally not mutually exclusive and follow one another in the decision-making process. They are:

- The acquisition and study of the technical datasheets drawn up by the supplier;
- Obtaining product samples;
- Verification of samples be means of electrical measurements and/or field tests.

So, let's look at each of these three phases in more detail.

4.1. Study of technical datasheets.

The first step in choosing an antenna is to research what the market has to offer and may be compatible with my specific application. An initial assessment is carried out based on the datasheets provided by the manufacturer or distributor.

In the analysis and comparison of the technical datasheets of different products it is however necessary to bear in mind some aspects that may not be so obvious for people who do not work in the sector, taking into consideration that in the world of antennas the following two statements are valid:

1. ***The electrical specifications of an antenna are not easily measurable, at least if you do not have the appropriate skills and equipment, such as an anechoic chamber.***
2. ***In many applications, an antenna with poorer electrical performance than stated can, for better or worse, work all the same.***

Without wishing to be cynical or defamatory, it should be emphasized that these two statements are also well known to those who draw up the technical datasheets of the antennas and in some market sectors, where there are no particular needs or controls, certain "inaccuracies" declared in the specifications can be very frequent.

Some of the aspects to consider at this stage are therefore the following.

- *The consistency of the technical specifications provided in the datasheets.*

The reading of an antenna technical datasheet starts from a check of congruity of the electrical and mechanical specifications. For example, for a directional antenna it is possible to relate the width of the radiation patterns in the main planes with the directivity and, therefore, the declared gain.

There are other criteria that can contribute to an evaluation of the technical specifications provided by the manufacturer that go beyond the scope of this article, but that can be decisive in gaining an idea of the overall truthfulness of what has been declared, which indirectly impacts the quality of the product you are going to buy.

- *The homogeneity of the technical specifications provided in the datasheets.*

Comparison of the technical characteristics of several antennas requires that the numerous specification items be present in the product leaflets and that they have been defined in such a way as to be comparable with each other.

Besides the more banal and easily remedied case in which homologous data present in the technical datasheets compared are simply reported with different units of measurement, it is possible to encounter less obvious or intuitive situations: for example, gain values indicated as "typical" or "average" or “better than” or not specified at all in the very frequent case where the maximum value is reported, usually referring to a point of the antenna operating band.

The radiation patterns, usually presented in a polar diagram, are represented in very different ways, using linear or logarithmic scales to highlight or hide certain characteristics of the antenna, such as the level of the side lobes or the front-to-back ratio.

In more complex cases, comparison of the homologous specifications of several technical datasheets can prove to be anything but easy, and therefore it becomes important to know the type of antennas that are proposed to us on these datasheets to be able to autonomously estimate whether or not they correspond to the declared specifications.

- *The existence of Application Notes, provided by the manufacturer.*

If you have to compare the technical specifications of SMD chip antennas, for example to choose the most suitable for incorporation in your own device, it is advisable to also refer to the so-called Application Notes of that specific antenna, provided by its manufacturer. In this case, the question becomes more complex, as the electrical specifications of these miniaturized antennas are declared with reference to evaluation circuit boards, on which they are assembled and adapted. Therefore, comparison of two or more antennas of the same type should be carried out strictly on its own printed circuit board, possibly similar in shape and size to that of the apparatus in which the antenna will be used.

- *Know the products you will use in depth.*

All the considerations and actions necessarily involved in the definition and choice of an antenna already available on the market have the aim of leading to full knowledge of the product that will be used in your applications or installations.

It is important to remember that in this sector, the completeness and truthfulness of a technical datasheet guarantees not only the certainty of being able to count on a product that meets your specific needs but is also an important sign of the seriousness and reliability of a supplier.

4.2. Evaluation of the samples.

As the catchphrase of a television advertisement from the 1980s said, “seeing is believing” is the second stage of the informed purchase of an antenna. Therefore, it is common practice, after having consulted the technical data sheets and having identified one or more suitable products, to want to obtain one or more samples to see them up close.

This will allow you to get a practical idea of the quality of a product, especially as regards the mechanical characteristics and the choice of materials used.

While not carrying out measurements or empirical tests, an expert eye can recognize the quality of materials and assemblies and estimate the reliability and duration over time of the antenna examined.

Since the cost also has a significant impact on the choice of a product or supplier, it may be worthwhile knowing in advance the weaknesses of an antenna that is cheaper than another in order to be able to overcome these in the installation phase, for example by reinforcing joints or couplings that are not watertight or are subject to corrosion with suitable products.

4.3. Control of samples with measurements and/or tests in the field.

The third and subsequent phase concerns practical tests on the samples of antennas obtained, especially in the case where, for reasons of cost, it is necessary to use non-professional products or, in any case, products characterized by:

- incomplete or not completely convincing product datasheets;
- no after-sales technical support;
- absence of product certifications.

Two criteria can be used to carry out these controls:

- *Field tests;*
- *Laboratory measurements*.

Field tests enable verification of the actual functioning of the antenna in operating conditions and therefore to know through an empirical approach if the wireless system works satisfactorily.

Although they are very useful for the practical test of a given antenna, they nevertheless have two main limitations:

- they do not allow verification of the exact compliance of the antenna with the specifications declared by the manufacturer and in the specifications;
- it is not easy to determine the cause in the case of wireless system malfunctions.

Laboratory measurements, carried out using suitable instruments and equipment generally not available within the company, allow characterization of the antenna and verification of compliance of the electrical specifications with those declared by the manufacturer and required by the specifications. If this method is used to compare multiple antennas and choose a product, it is not necessary to carry out a real certification measure and, consequently, the cost of this phase may be less.

If, for economic reasons, a company has to use antennas available on the market without adequate supporting documentation and technical assistance, a laboratory measurement on samples can prove to be a very efficient strategy as it often allows the product to be used, knowing its actual characteristics.

5. Technical support.

Since the antenna is in any case a complex product that embodies a more or less innovative technology, it is crucial to be able to count on after- sales technical support from the supplier.

In fact, even purchasing standard products, specific needs may frequently arise during their use which, if met by the supplier of the product, can be managed and solved easily and economically.

Some possible needs may be the following:

- if I have to install the antenna in a particular condition, is the antenna supplier able to support me with advice, technical checks or measures?
- if, for my application, specifications are required that are not shown in the datasheet, is the antenna supplier able to provide them?
- if I intend to use a commercial product in a different installation than the typical one, can the supplier help me estimate the real performance of the antenna?
- if any technical information about the product is required, is it possible to have direct contact with the antenna supplier?

This aspect of customer care is of fundamental importance in the case where integrated antennas have to be used, or in the case where a standard product is chosen but which, for its good use and functioning, requires a high degree of customization.

For example, if you decide to purchase low-cost non-professional products, it is reasonable to believe that the immediate economic advantage obtained is more important than adequate after-sales technical support: the important thing in any case is to evaluate this choice carefully and be aware of it.

6. *Case history* : GSM / DCS / UMTS multi-band omnidirectional antenna.

A few years ago, one of our customers, following a problem encountered in the field, gave us a Chinese-made omnidirectional antenna whose only known specifications were the following:

- Frequency range: 900/1800/1900/2170 MHz ;
- Gain: 7.5 dBi ;
- Type : omni ;
- Power handling : 50 W ;
- Polarization : linear vertical ;
- VSWR: <1.9 ;
- Dimensions : L1100 × W34 × H34 mm .

Naturally, he asked us to understand if the problem lay in the antenna, a collinear of a length of “no less than” 1.1 meters with 7.5 dBi gain declared by the manufacturer, or if there were other possible causes due to its particular installation.

The main electrical characteristics of the antenna, such as ROS and gain, were checked in an anechoic chamber.

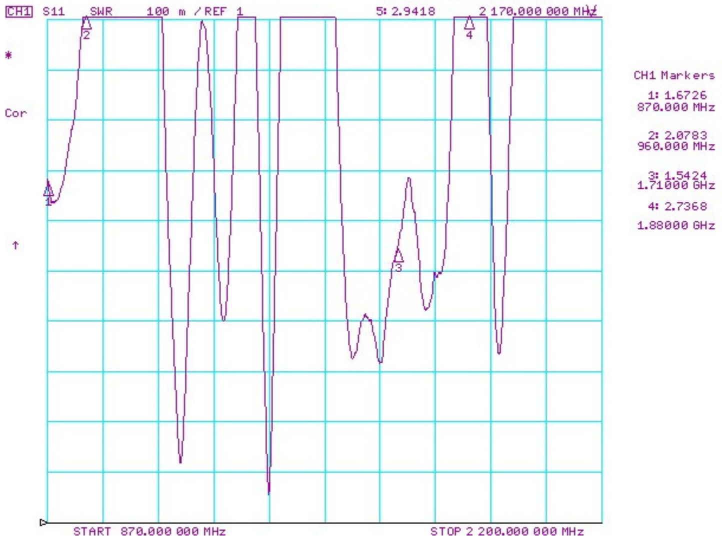
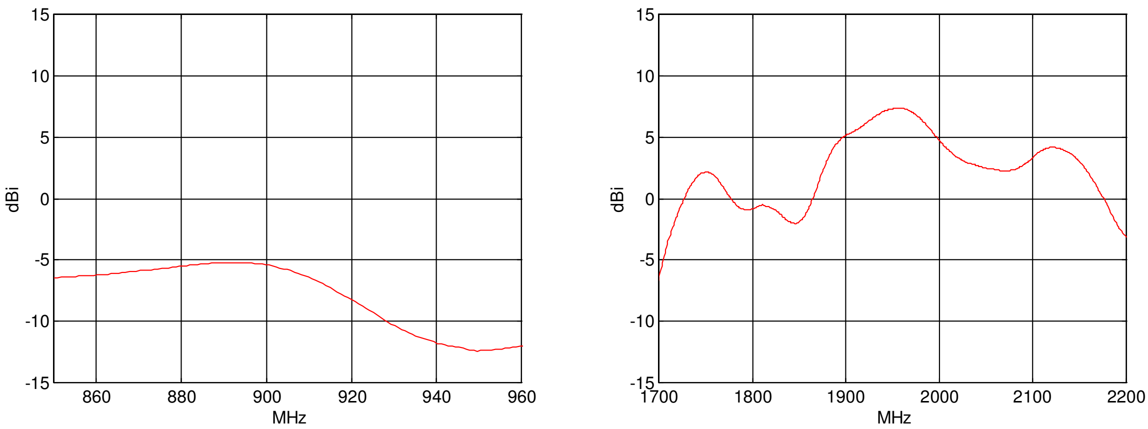


Figure 6.1
ROS measurement from 870 to 2200 MHz:
the vertical scale of the graph goes from ROS = 1 to ROS = 2.

The first measurement carried out, VSWR in the declared operating bands, is shown in **Figure 6.1** where, against a maximum ROS specification (VSWR) of 1.9, a non-compliance is immediately identified. The best adapted band turns out to be that of 900 MHz, although at 960 MHz the ROS rises to over 2. In the higher bands, the VSWR worsens considerably and in the UMTS sub-band (1920 ÷ 2170 MHz) there are values well over 2 (out of range in the graph).

Following these findings, it was decided to proceed with a gain measurement in an anechoic chamber, obtaining the results shown in **Figure 6.2 (a)** and **(b)**, in the 850 ÷ 960 MHz and 1700 ÷ 2200 MHz bands respectively.



(a) **(b)**

Figure 6.2
Gain measurement in the operating bands.

This measurement shows that the gain value declared by the manufacturer (7.5 dBi) corresponds in fact to the maximum value, obtained only in a small frequency range around 1960 MHz.

In practice, leaving aside the VSWR specifications (non-compliant) and evaluating only the gain, the curves in **Figure 6.2** show that:

- the antenna has a gain that is commensurate with its mechanical size only in a band of about 50 MHz centered at 1960 MHz;
- in the DCS (1710 ÷ 1880 MHz) and UMTS (1920 ÷ 2170 MHz) band, the antenna has a gain comparable to a 2dBi antenna; that is, a simple coaxial dipole, in λ/ 2 or λ, about 15 cm long;
- the worst results are obtained in the GSM band (860 ÷ 960 MHz), with gain values similar to those of an integrated SMD printed circuit board antenna.

At this point, overcome by curiosity, the radome was opened to see what kind of radiant element was installed in it. **Figure 6.3 shows** the disassembled antenna.

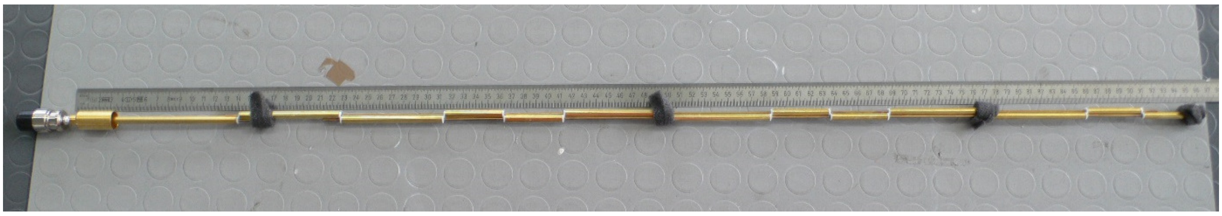


Figure 6.3
Omnidirectional antenna without radome.

The technical description of this collinear radiant structure with rephased elements, with its advantages and limitations, is not the subject of this article.

What is interesting now to say is that, even with a visual inspection of the product by a competent technician, it would have been possible to affirm that this structure is not suitable for the construction of an antenna operating satisfactorily on the frequency bands defined in the specifications.

In conclusion, we have brought an example of how an evaluation of the product carried out with adequate skills and tools can prove to be decisive in the choice of an antenna for professional use, especially in the case in which large quantities have to be purchased.

7. Conclusions.

Not all wireless connectivity needs require high-end, high-cost, or custom-built antennas.

In fact, in the vast majority of cases, it is possible to find one or more products on the market that seem to be suitable for the required application, even without necessarily being optimized.

However, it is essential that, in the professional field, you have all the means and resources to make a correct choice of the best product available, based both on the technical data issued by the manufacturer and, if the latter are incomplete or not provided, on tests and controls in the field and/or in the laboratory.

An examination of the technical specifications and their comparison with the characteristics of the products on the market are the first steps for both the Technical Manager, who can thus define the best solution and the other consequent design choices, minimizing the risk of having to review them in a more advanced phase, and the Purchasing Department, which can identify the right expense and avoid unnecessary costs and waste.

If you believe that these skills are already part of the technical background of your company, I hope that what is reported in this article can be of help to consolidate and make your work even more efficient and effective.

If, on the other hand, you believe it is better for your company to focus exclusively on certain specific activities in your sector, how much could it help you to be able to contact an expert, with suitable skills and equipment, able to prevent and solve all the problems deriving from the installation of the wrong antenna at any time?

How could your company benefit from this in terms of saving time and resources?

Knowing the product you decide to use in depth is the only way of understanding your choices and gaining a real advantage over your competitors.

For more information about our *Safe Antenna service* write to:

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