Technical E-Paper

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# Case history:

# UWB antennas

## for position detection.

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An interesting case history regards a request for a position detection system that uses UWB (real-time locating system) technology.

Not only the electrical requirements, typical of UWB antennas, were defined for the application; mechanical and installation ones were indicated too.

A robust high-quality custom-made product was therefore produced, with constant radiation over the entire bandwidth, that could be installed in logistics and/or large-sized goods storage environments.

ElettroMagnetic Services SRL

## 1. The characteristics of a *real* broadband antenna for position detection in goods storage areas.

In this case history we will discuss our experience with one of our Customers, during the development of an omnidirectional UWB antenna to be used in a position detection system in large-sized goods storage areas.

The characteristic of systems based on UWB technology is that they transmit a series of extremely short pulses (from 10 to 10,000 picoseconds) using a much wider frequency range than the traditional systems.

This makes it difficult to detect the signal and so antennas with specific characteristics that allow all the components of the signal spectrum to be received with the same efficiency, without introducing significant distortions in the phase of these frequency components, have to be used.

Usually, these position detection systems are supplied with printed circuit board antennas with rather simple geometries that do not take into consideration the specific installation and then they are unsuitable to meet the particular needs of a professional applications.

In these cases, to develop the best product, we have to take into account requirements that are different from those used in traditional antennas.

At the end of this TEP we will give some tips and suggestions to bear in mind when you need to buy or build an antenna for professional systems that use UWB technology.

## 2. Needs and requirements.

The technical specifications received from the Customer are summarised below:

| | |
|---|---|
| *Bandwidth:* | *3.25GHz ÷ 4.25GHz;* |
| *Return loss:* | *> 10dB (SWR better than 2);* |
| *Azimuth plane pattern:* | *omnidirectional;* |
| *Elevation plane pattern:* | *40°, with 30° downtilt;* |
| *Maximum mechanical dimensions:* | *150mm × 150mm (Height × Diameter);* |
| *Mounting:* | *on the ceiling, using a special bracket designed by the customer.* |

Alongside these technical specifications, some specific needs, common to all broadband antennas designed for this application, are taken into consideration. These needs can be summed up in 3 main points.

- ***Characteristics of the radiation pattern have to remain constant over the entire bandwidth.***

To ensure the accuracy of the position detection system and, therefore, to give a practical example, the identification of the container within an area of considerable size, it is not only necessary for the antenna to have precise and clean radiation patterns, but also that the radiation characteristics remain constant within the entire bandwidth.

It is fairly common to come across antennas erroneously called *"broadband"* merely because they are able to maintain a sufficient return loss level within the bandwidth.


***Figure 1***
*Partly assembled radiating elements.*

However, in the case in question, it is important to use the term "*broadband*" in a broader sense, including other electrical specifications, so as to provide the Customer with an antenna able to guarantee the correct functioning of the entire system. Underestimating this fact and trusting products that do not meet this requirement can cause problems for systems already installed which may entail high repair costs.

- ***Compliance with the required mechanical dimensions.***

The antenna must be made respecting the maximum dimensions provided by the Customer.

Only in this way will it be possible to prevent it from being struck and damaged by machinery moving inside the area used for the storage of containers.

- ***Degree of protection suitable for outdoor installation.***

The antenna must have a mechanical strength that is suitable for installation outdoors, to prevent continued exposure to atmospheric agents, both in the summer heat and the winter cold, that would lead to the need for repairs and/or replacement activities.

An *IP66* degree of protection must be guaranteed, appropriately sealing the antenna to prevent water infiltration which could damage it and jeopardise the reliability of the entire system.

## 3. The preliminary analysis.


***Figure 2***
*Assembled radiating element, before being inserted in the radome.*

The first stage of the project involves a technical analysis to identify the best radiating element configuration, i.e., the one that ensures the following requirements:

✓ *Electrical characteristics that remain constant for the entire bandwidth;*

✓ *Elevation plane pattern that implements the required downtilt to ensure good coverage even in areas close to the antenna's point of installation;*

✓ *Possibility of installing the antenna on ceilings made of different materials, without this modifying the antenna's radiation characteristics.*

For reasons of confidentiality, we cannot provide more detailed information here about the different types of radiating elements investigated and analyzed and the ensuing choice.

Instead, we can list the main characteristics of the radiating element it was decided to use for this project:

*Intrinsically broadband radiating element configuration;*

*Asymmetrical structure to obtain the required downtilt in the E plane;*

*Addition of a metal reflector at the base to minimise the effect of the surface on which the antenna is mounted.*

After the ideal solution had been identified and after having shared the results obtained with the customer, we continued to develop the project.

## 4. Characteristics of the antenna and the final results.

The aim of the first stage of the project was to define the best radiating element for this specific application, mediating between the required electrical requirements and the mechanical specifications of the casing, consisting of the radome with the mechanical interface flange.

In this regard, numerous computer simulations were performed on five different electromagnetic models of UWB elements which could have been suitable for the purpose.


***Figure 3***
*Pair of prototypes, assembled and operational.*

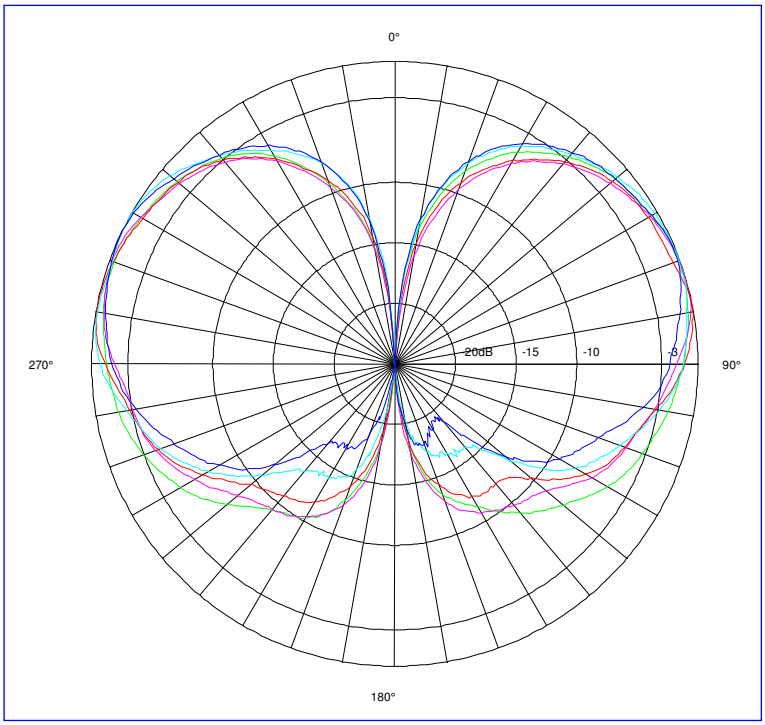


***Figure 4***

*Patterns measured in the E plane (vertical) at 5 frequency values, spaced uniformly in the 3.25÷4.25 GHz bandwidth.*

We would also like to point out that, to avoid constructing an antenna that is not able to fully satisfy the exclusivity requirements of the specific application, the choice of the types of UWB radiating elements to base the project on must not be made by a software simulation, as often happens in current electromagnetic tools, but must be based on long-standing experience and know-how of antenna design.

In this way it was possible to accurately define both the optimal radiating structure and the shape and mechanical dimensions of the radome in order to minimise the distortion of the radiation parameters in the bandwidth.

Once the electromagnetic model of the previously identified radiant element had been optimised, we developed the first prototype in the in-house mechanical workshop.

The radiating element is made of brass, while the reflector is made of aluminium, with a conductive anodising treatment in the final version.

The SMA female connector is fixed to the centre of the aluminium reflector positioned at the base of the antenna.

There is also a plastic (PVC) centering device to be inserted on the radiating element to ensure that vibrations do not break the power cable that connects it to the connector.

Both the radome and the flange with holes to fix it to the bracket are made of suitably thick PVC in order to obtain high mechanical rigidity.

The antenna is fixed to the flange using a two-component glue that ensures the creation of a completely airtight structure that meets the waterproofing needs expressed by the customer.

The antenna characterisation measurements performed in the anechoic chamber confirm that the performance levels contemplated at the start of the project were achieved, making a product that meets the expectations.

The Customer, after having tested the prototype delivered at the end of the project, confirmed that it is also compliant with their mechanical requirements for outdoor installation.

## 5. Tips and suggestions.

To conclude, here are four tips if you are thinking of buying a *UWB omni-directional antenna* for use in a position detection system.

- ***Control of the characteristics within the entire bandwidth.***

As said earlier, UWB systems transmit low-power pulses within a much wider frequency range than traditional systems. This entails the need for antennas with special characteristics, able to adequately receive these signals, maintaining constant electrical characteristics throughout the bandwidth.

Some antenna models are presented as having *UWB* characteristics merely because they have a guaranteed return loss level within the entire bandwidth. Obviously, this is not sufficient and the same applies to the other electrical characteristics. Specifically, it is advisable to check that the radiation patterns have very similar characteristics for the entire declared frequency range.

- ***Characteristics of radiation patterns.***

For applications of this type, it is necessary to pay attention to the radiation patterns. These must have highly specific characteristics, both in terms of beam width and any downtilt that allows optimal coverage of the area concerned. Furthermore, these characteristics must be kept constant for the entire bandwidth.

All of these requirements often result in the need to create a customised product, specific and optimised for your application, as the technical compromises resulting from the choice of a standard antenna do not offer the performance required by the system to be installed.

- ***Verification of the mechanical dimensions.***

When the antenna is to be installed in areas where machinery and large objects are expected to be in movement, it is always important to check that the antennas are positioned in safe areas, protected from the passage of these machines.

For this reason, it is advisable to check that the antenna has mechanical dimensions that allow it to be installed in these areas, so as to minimise the need for repairs due to damage.

Obviously, in the design stage of the system, it is necessary to define spaces of a suitable size for the installation of the antennas that take into consideration the mechanical dimensions that an antenna of this type must necessarily have in order to be efficient.

- ***Suitable IP protection degree.***

Again, with reference to the application discussed in this article, it is advisable to assess the installation of an antenna with a suitable IP rating for outdoor installation, without affecting performance.

To do this, it is necessary to use materials that are compatible with the electrical and environmental characteristics of the finished product, as regards both the metal and plastic parts.

It is also necessary to have an airtight radome, in order to avoid dangerous infiltrations of water, and appropriate guards for the connectors present both on the antenna and on the connection cable.

Obviously, these are general indications.

Further advice can be given if the specific application and other details about the type of installation are known.

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