Case History

169 MHz Yagi antenna optimized for *Smart Metering* applications

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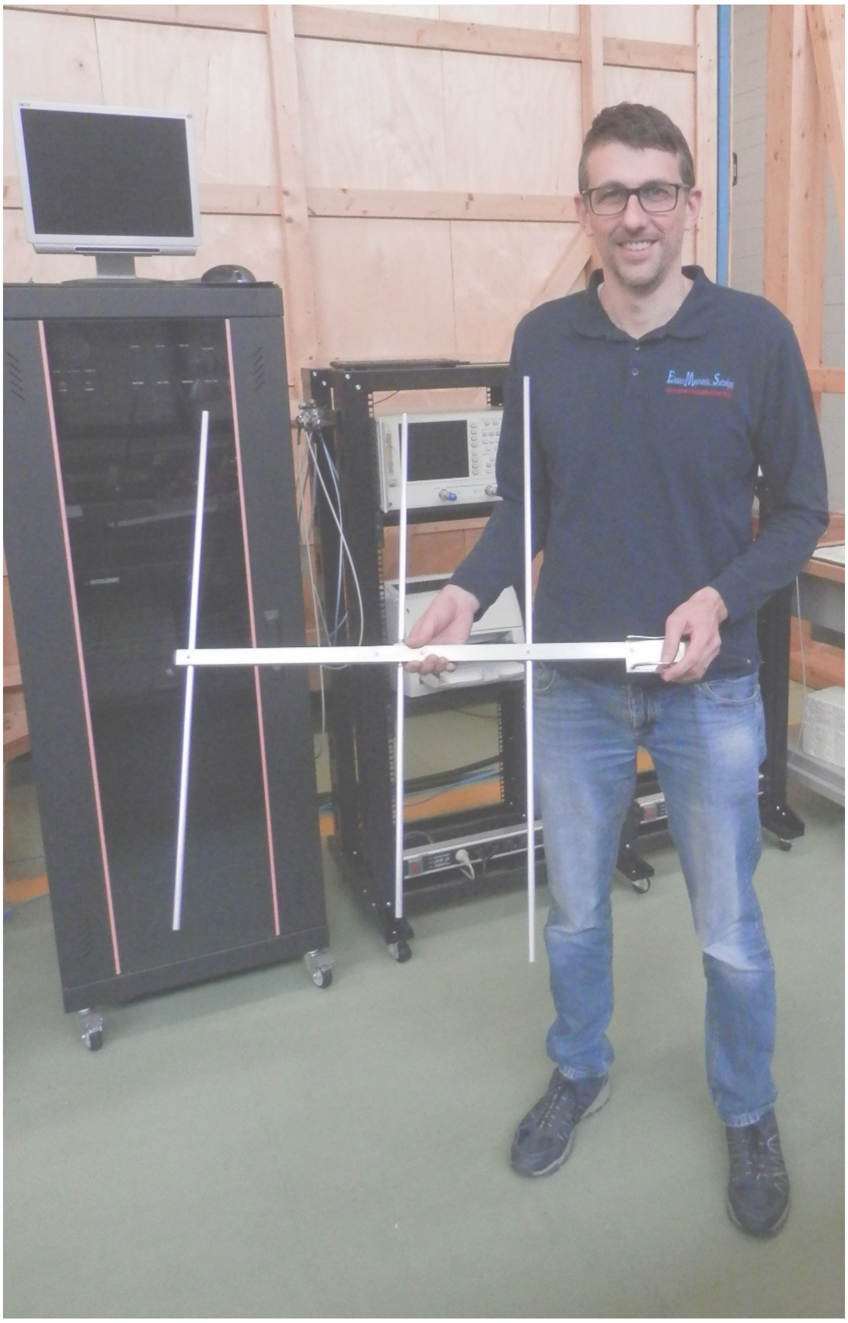
This article presents another case study of a wireless application: ***smart metering***, that is, remote reading of gas or water meters.

An ISM frequency band allocated to 169 MHz is used for data acquisition via radio, an application for which there was no specific antenna.

This is a prime example, in which the construction of an *ad hoc* antenna has brought both technical and economic benefits, while at the same time improving the performance of the data acquisition system and reducing installation costs.

So, let us tell you the story of our Yagi ***LY177V*** antenna.



ElettroMagnetic Services SRL

1. The Customer's request.

In this case study we will describe the **design and construction of a custom antenna** for a typical ***Smart Metering application*** **in the 169 MHz ISM band**.

The generic term *Smart Metering* refers to **a hardware and software infrastructure that allows remote reading and / or remote management of "*smart*" meters for gas, water and electricity distribution services.**

Although the VHF frequency band is not something new in itself, as it has been used for decades for various radiocommunication services in the civil, military, recreational and television broadcasting sectors, **the use of the 169 MHz band for these so-called *Multiservice Platforms***, that use *ad hoc* technologies and protocols for the transmission of data between the meters and the respective radio base stations, called *concentrators*, in a point-to-multipoint wireless network configuration **is certainly innovative**.

Since the first field trials of this recent application that, as mentioned above, uses a part of spectrum within the well-known band of the so-called *"civil VHF"*, it has been possible to use commercial antennas, both omnidirectional and directional, operating between 156 and 174 MHz. So, the first question is:

Are we sure that these antennas are really the most suitable ones for Smart Metering?

Besides **a specific analysis of the characteristics that have allowed the new antenna to stand out** from the other products on the market, this occasion can be used to address a situation encountered in various fields of application and which we can summarize as follows:

It has always been this way, why change?

This attitude, which at first sight **may seem conservative and risk-free**, can lead to a potentially dangerous situation in which **no assessment is made of the efficiency of the solutions** being adopted and the ensuing missed chance to **identify alternatives** able to offer better results.

Instead, in the case in question, it can be seen how **the Customer has** carried out a detailed analysis of the antennas already in use and **identified the changes** to be introduced to gain **tangible benefits compared to its competitors.**

The request received from the Customer is summarized below:

Is it possible to create a directional antenna in the 169 MHz band, for installation on Smart Metering concentrators, optimizing the gain/size ratio compared to the usual products on the market which are, in practice, those already used for the civil VHF bands (156 ÷ 174 MHz)?

2. Needs and requirements.

In the first meeting with the Customer, it was immediately clear that, **compared to the commercial antennas** currently used and essentially identical to those of the Customer's competitors, **significant benefits could be gained** by creating a custom product with a **smaller size and better performance**, mainly in terms of gain.

The advantages for the Customer would be tangible because a directional antenna with a higher gain could **reduce the number of antennas that need to be installed**, optimizing the position of the concentrators, with **benefits both from an economic point of view and from the point of view of visual and environmental impact**, a question local authorities are very sensitive to.

The minimum gain requirement is calculated at 7 dBi, a typical value of 4-elements Yagi antennas that cover the entire civil VHF band.

The antenna must also have **rugged and reliable mechanics** in order to **avoid frequent repairs or replacements**, but at the same time use **thin elements and booms** so as to be **barely visible** from afar, almost being mistaken for television antennas, to which the eye is already accustomed.

Parallel to the specifications of the antenna itself, the Customer also reported **a problem of saturation of the receiver** that sometimes occurs due to the existence of strong signals adjacent to the band used, given the wide use of this portion of the electromagnetic spectrum by various radio services. The question therefore arises of **the possibility of using an antenna filter** or something similar to help eliminate, or at least reduce, problems of this type.

Last but not least, an issue was raised regarding the **cost of the antenna** which, for an application of this type that requires the installation of a large number of concentrators, cannot be that of an antenna for a civil VHF service. Indeed, the Customer told us that his current choice is a 4-elements Yagi antenna that is not produced by companies operating in the professional antennas sector but by a company operating on the amateur radio market, so as to **respect the budget of the system**.

3. The preliminary analysis.

As generally happens at the start of every *Custom Antenna* project, the preliminary analysis focused on **the feasibility of the request, trying to identify any** *"weak points"* in the products on the market that can be exploited **to implement the required** – or at least, desired - **characteristics**.

Margins for improvement were identified, mainly due to the fact that **most of the antennas on the market** used for *Smart Metering* have been designed and constructed **for a wider operating band** (typically greater than 10%), a characteristic that **is not required** in our case and actually **turns out to be counterproductive**.

Therefore, by designing the new product from scratch on the Customer's specific band of use (169 MHz), **it would certainly be possible to optimise the dimensions**, thus achieving the required advantage.

The proposal was, therefore, to create a 3-elements Yagi-Uda directional antenna, with different electrical and, above all, mechanical specifications compared to the same antennas used to date in field tests.

The Customer confirmed his interest, the project went ahead and the results of the preliminary analysis were developed.

Figure 3.1

Comparison between the 3-elements Yagi optimized for 169 MHz (our model ***LY177V, below in the photo***) and an analogous 154÷174 MHz wide band Yagi manufactured by us (now out of production).

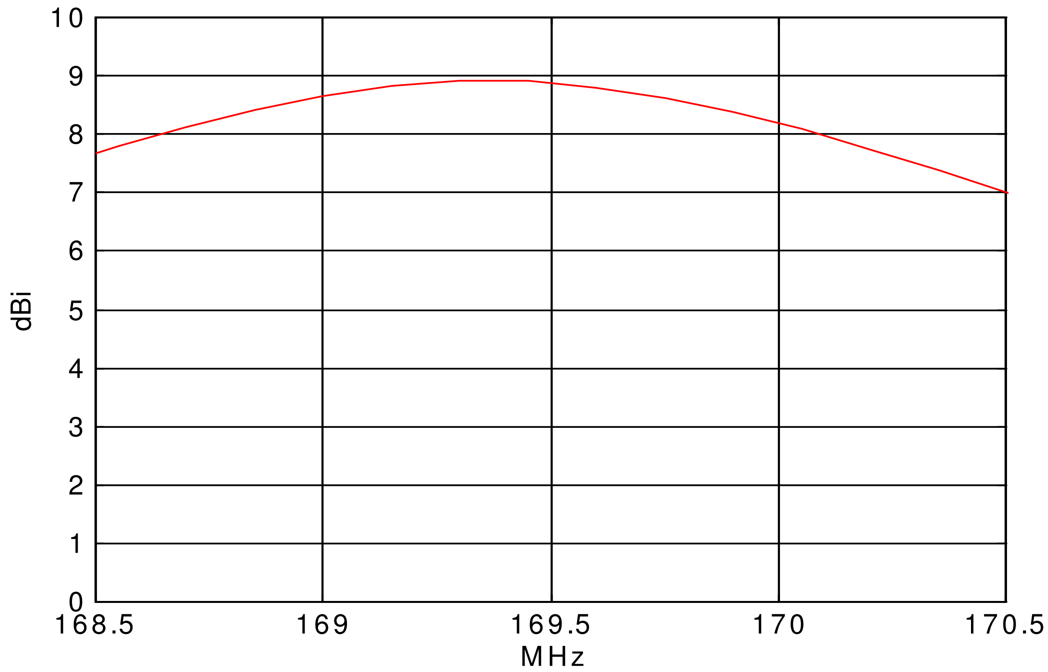


Figure 3.2

Gain curve of the ***LY177V*** 3-elements Yagi optimised for the 169 MHz band.

4. Electrical characteristics of the custom antenna.

In the simulations carried out during the initial phase of the project, **it immediately became clear that it would be possible** not only to keep the boom length unchanged, but even **to reduce it significantly**, *shortening it from the one meter twenty of the antenna in use to the eighty centimeters envisaged for the new one.* **The Customer**, who would have been satisfied even with the same length as the previous model, **could thus gain another advantage** that was much appreciated.

The design criteria were therefore the following:

- Antenna optimization for maximum gain;
- Installation of a power supply system (balun and adaptation network) with narrow band: this allowed implementation of a sort of band-pass filter in the antenna;
- Incorporation of the power supply system in the antenna boom: this reduced the visual impact, simplified assembly and installation and waterproofed the wiring;
- Use of thin and sturdy elements, with pole fixing brackets and stainless-steel bolts.

The first prototype was then built in the laboratory for the first checks of the simulated solution, also implementing the power supply system capable of guaranteeing sufficient adaptation.

Figure 3.1 shows the Yagi **optimized for 169 MHz compared to a similar** broadband antenna designed for use in civil VHF from 154 to 174 MHz. The latter, having been designed and optimized with different criteria, has a center bandwidth gain of 7.5 dBi and is bulkier and heavier.

For the 169 MHz antenna, the gain value obtained reached 9 dBi, more than satisfactory considering the minimum required value of 7 dBi (**Figure 3.2**).

Besides being able to **maximize the gain** in the portion of the band in question at 169 MHz, the choice of creating a narrow band design led to the creation of **a highly selective antenna**, as shown in **Figure 4.1**, **an advantage in terms of interferences** due to the presence **of adjacent out-of-band signals.**

Once the electrical performance was confirmed, we continued, **defining and engineering the power supply and summarization network** by incorporating all the wiring in the boom to **avoid the infiltration of water** that could impair the reliability of the antenna. This **operation is very important**, as it **avoids unnecessary costs** to repair damaged antennas.

The antenna, made with **sturdy mechanical parts**, was also equipped with **stainless-steel brackets for fixing to the mast and N female connector cable** that exits at the rear end of the boom, and has **a length defined by the Customer**. This solution also allows customization of the type of connector (N-f, UHF SO-239, Sma, etc.) according to the installation needs.

The production cost, included in the project requirements, also found **the right compromise between product quality and final price**.

In this sense, the design activity was carried out taking into account the **quantities forecast for subsequent productions**, in order to use suitable technologies to guarantee construction costs in line with the Customer's needs.

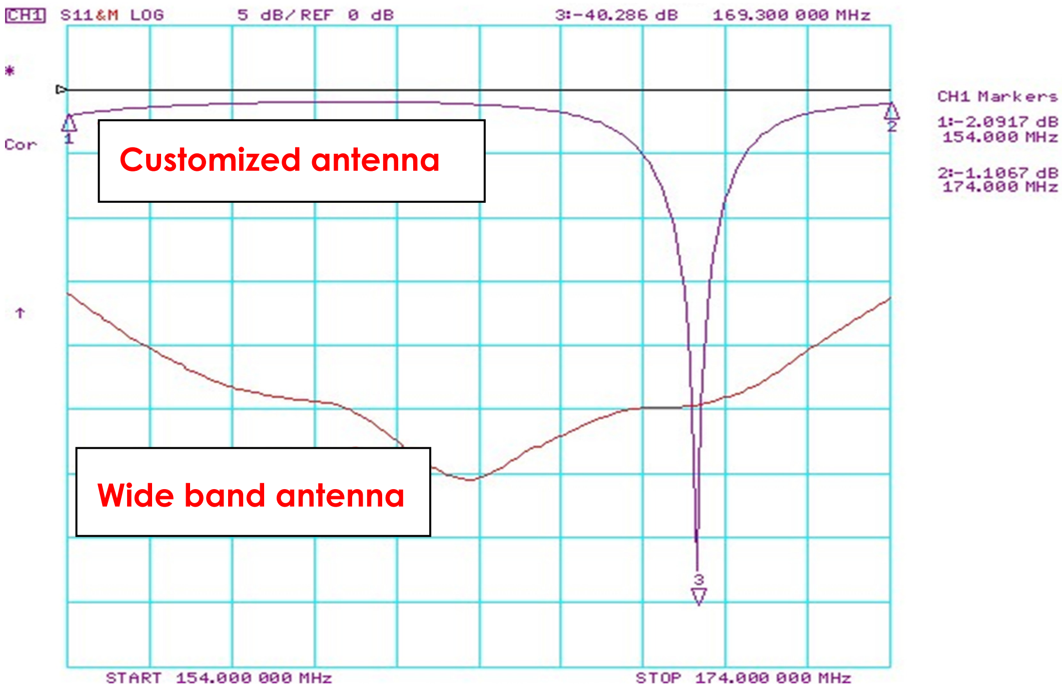


Figure 4.1

Comparison between the respective return loss curves of the two Yagi antennas shown in Figure 3.1, measured in the band from 154 MHz to 174 MHz.

5. Results.

As already mentioned, **the final characterization measurements confirmed the excellent performance of the antenna**, both in terms of **adaptation and gain** (9 dBi compared to the required 7 dBi).

The Customer's "field tests" also proved to be very satisfactory, **amply confirming the expectations both from an electrical and mechanical point of view.**

To date, more than four years after the first installations, we can confirm the Customer's satisfaction with the required degree of mechanical strength. At the moment, **no repairs or replacement operations** for damaged or non-functioning antennas have been necessary.

Furthermore, **the possibility of installing fewer antennas** than competitors, while still providing the same service, **has given our Customer an advantage** over companies that continue to use the *old* antennas.

6. Final considerations.

The situation that the Customer, the focus of this article, was able to avoid is more common than it may seem.

Solutions are often adopted without then performing a periodic assessment of their actual efficiency and possible alternatives. In this way, a chance is missed to make the appropriate upgrades that allow you to **stay ahead of your competitors**.

The usual justification is:

Everyone does it this way, there must be a reason ...

For sure there is a reason, but **it is always better to go beyond the obvious**, to study the question and check it out for yourself. When we then realize that all the other companies operating in the sector offer the same solutions, **we should exploit that to stand out** and propose something different, offering **unique and exclusive benefits**.

In the case analyzed in this article, the ability to identify the possibility of improving performance while keeping the overall dimensions unchanged **has allowed our Customer to offer the market a more advantageous solution than his competitors**.

In our experience, **in the field of professional antennas**, it is not uncommon to find situations in which **the standard antenna used has some weak points**, usually due to the **lack of specificity of standard solutions**.

Starting from these weak points, it is possible to design and build a *Customized Antenna* that is certainly better because it **is designed, optimized and built for a specific application.**

We would therefore like to **end with a piece of advice**, which **we,** first of all, **want to follow:**

periodically check the technical solutions that are being adopted, with the aim and ambition of seeking and finding alternatives capable of guaranteeing a strategic advantage over your competitors.

For further information please contact us at:

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