Technical E-Paper

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A custom solution for smart water/gas metering

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The *smart metering* technology for water and gas meters, i.e. remotely reading consumption using a radio device connected through a measuring device to a telecommunications network, has offered both end users and service managers significant benefits.

While users can benefit from this technology by avoiding unforeseen costs due to estimated readings and the consequent adjustments, operators can count on significant savings above all on the cost of the staff needed to manually read the meters, along with the possibility of monitoring leaks or faults in the distribution line in real time.

This article highlights how a *custom solution* can solve a serious connectivity problem – not uncommon in these systems – caused by meters installed in positions that are unable to guarantee an effective radio connection with the data collection network.

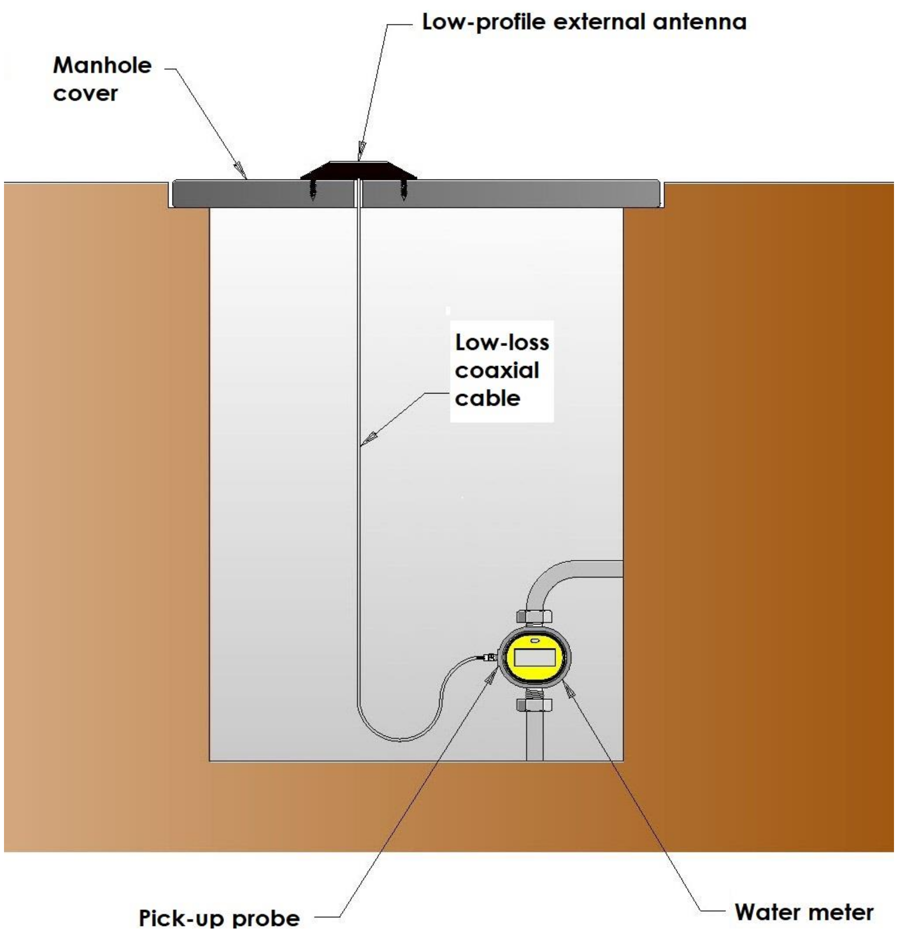

Figure 1

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1. Radio connection and coverage problems.

Meters, both **water** and **gas**, **enabled for remote reading** use **a technology** which, by means of a communication protocol, **periodically transmits data via radio** to a **base radio station** belonging to the mobile radio network or to **a dedicated infrastructure** with numerous receiving stations, called ***concentrators***.

Some of these systems use **mobile radio technology** (*GPRS*), others use ***ISM* frequencies** (169 MHz, 868 MHz, etc.) or **bands expressly assigned** for this purpose. **A protocol** currently used, that is **extremely efficient for long-distance** data transmission using **low power**, is ***LoRa*** (***Lo***ng ***Ra***nge), based on a ***CSS*** (*Chirp Spread Spectrum*) technology.

Whatever the technology adopted, **a problem arises for water meters** due to their **typical point of installation**, i.e. below street level, inside **a manhole** with **concrete walls** and a **cast iron cover**. In these conditions, the meter, which incorporates the radio terminal with the antenna, is located in a **pseudo-Faraday cage** that neutralizes any connection with the outside. Furthermore, it is common for **the manholes** in which these meters are installed **to flood when it rains**. These conditions cause **extra attenuation** on the radio link that can **reach or even exceed 30 dB.**

The situation **is not much different** in the case of **gas meters** which, while not being positioned underground, are installed inside **concrete structures** with galvanized or grilled **sheet metal doors.**

This article deals specifically with a **Customer** who manages an infrastructure using the 868 MHz ***LoRa* protocol for smart metering** and who came to us to find **a connectivity solution** to use in these conditions, that reflect the **majority** of water network meter installations.

2. The *external antenna kit* for smart meters.

This **specific installation** of water meters immediately pointed highlighted the **need to "collect" the signal transmitted** by the meters themselves and **carry it outside the manhole** to then be **effectively emitted** through an external antenna.

Figure 2
External antenna kit with pick-up probe made specifically for the type of water meter used.

It is important to note **three fundamental aspects**:

- **Impossibility of connecting an external antenna directly** to the meter because this completely sealed device (**IP68**) **does not have a dedicated connector**.
- **Exclusion of any active system** which would require **a dedicated power supply** and would in any case be **ineffective** if placed **inside the manhole**.
- **Need to create a low-profile antenna** that can be **mounted on the manhole cover**, also **sealed with IP68 protection** that can be **walked on** or even **driven over**.

The diagram on the first page of this article (**Figure 1**) shows this type of solution, the implementation of which is shown in **Figure 2;** this can **roughly** be considered a sort of **passive repeater comprising the following parts**:

a) **RF signal pick-up system** to be connected to the meter, hereinafter referred to as ***pick-up probe***, connected to **an external antenna** via a **low-loss coaxial cable link**;

b) **Low-profile external antenna**, that can be walked on or driven over, to be installed on top of the manhole.

3. The *pick-up* probe.

The first phase involved **designing a device** capable of **near-field coupling** with **the antenna incorporated in the meter** so as to be able to **pick up the signal as efficiently as possible**, i.e. with **minimal insertion loss**.

This device, called ***a pick-up probe***, **developed *ad hoc*** for the water meter used, is shown in **Figure 3**.

It consists of a **coupling element**, **sealed with IP68 protection** in a plastic sheath that fits **perfectly** on the body of the meter. A **1.8 meter low loss LMR-240 cable pigtail**, ending with an **SMA connector** for connection **to the external antenna,** is connected to this element.

Figure 3
Detail of the *pick-up probe*, made specifically for the type of water meter used.

The **creation and optimization** of the *pick-up probe* entailed **in-depth analysis of the antenna incorporated** in the meter, identifying **a reference section** through which **the characterization measurements** of this device could be made.

Indeed, **the pick-up probe** mounted on the meter was treated as **a two-port network** in which **port 1** is represented by the **input section of the antenna incorporated** in the meter, while **port 2** is located at the **SMA connection connector** of the pick-up to the external antenna.

Therefore, by dealing with the system as **a sort of directional coupler**, it was possible **to optimize its performance**, optimizing all the network S_{ij} **parameters**, i.e. verifying **the impedance matching (**S_{11} and S_{22}**)** and **minimizing the insertion loss** $|S_{21}|$.

Using this methodology, **an insertion loss** $|S_{21}|$ **of less than 6 dB** including cable attenuation **was obtained**, with a **good matching** on both ports.

4. The low-profile external antenna.

The external antenna is also a **fundamental component** in **improving the performance** of the entire system. It consists of a rigid, sealed **sheath with a maximum thickness of 20 mm**, **treadable and drive-over**, **mounted on the manhole cover** using **self-tapping screws**, and its appearance recalls **roadside signs** (reflectors).

Figure 4 shows **the antenna** mounted on a cast iron manhole cover, although **it can function correctly** if **installed on a non-conductive surface**. Indeed, if it is necessary to avoid protrusions on the road surface, the antenna can be installed **to the side of the manhole,** in a **special hole in the tarmac**.

The low-profile radiating element is **magnetic** to achieve **vertical polarization**. It has an **omnidirectional radiation pattern in the azimuthal plane, while in elevation the polar pattern shown in Figure 5** is obtained.

Figure 4
Low-profile antenna, mounted on a cast iron manhole cover.

The metal structure below the radiating element **allows the radiation to be concentrated in the upper half-space: a gain of 5 dBi** is thus obtained for an antenna with a **diameter of 140 mm** and a **thickness of just 20 mm** (**Figure 6**).

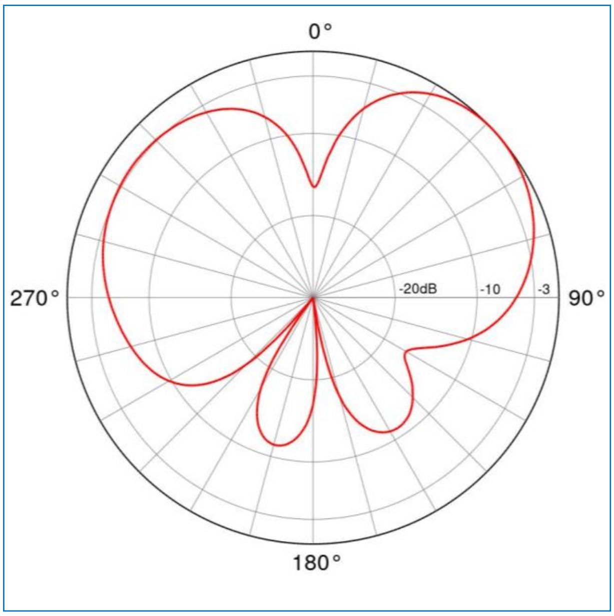

Figure 5
Radiation pattern in the vertical plane of the low-profile antenna (co-polar component in vertical polarization), measured at 868 MHz with the antenna mounted on the cast iron manhole cover as shown in Figure 4.

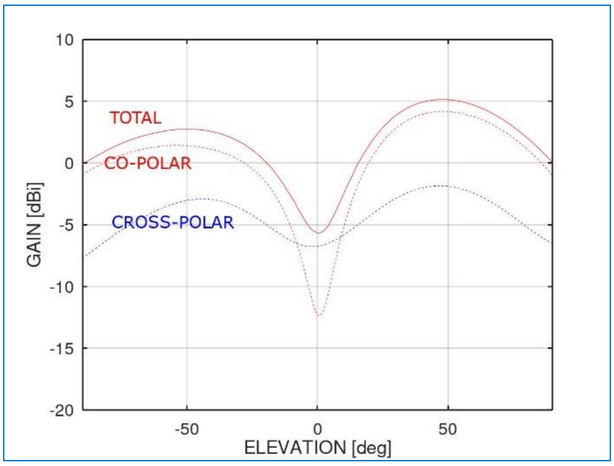

Figure 6
Directive gain of the low-profile antenna in Figure 4, measured at 868 MHz, as a function of elevation angle (co-polar, cross-polar and total components).

5. Conclusions.

This article **presents a *custom solution*** for a **typical problem of water meters** that causes real problems for ***smart metering* service managers** and their installers.

An external antenna system was therefore developed and proposed as a kit (**low profile external antenna plus pick-up probe**) for the **specific meter used** that allows the **connectivity problem to be effectively resolved** in the case of shielded or underground installations.

The overall performance of the radio data transmission system is therefore defined as the **algebraic sum** of the **gain of the low-profile antenna** and the **total insertion loss** of the pick-up probe that interfaces with the meter, with **the aim of obtaining a client device** (meter with external antenna kit) that has **the same or better performance** as the **smart meter installed alone in a free space**.

In this sense, the field measurements carried out by the Customer led to excellent results, so much so that it was deemed appropriate to proceed with the production of the specific kit in large series.

For our part, in order to **solve this specific problem, the following fundamental points were identified** during the development of the system:

- **A custom solution had to be created, able to adapt to the specific type of meter, with specific reference to the *pick-up probe***. Only in this way we can create a system able to **transfer a sufficient level of RF power**, especially if we consider that, **to guarantee the necessary degree of protection** (IP68), it is not possible **to make any changes** to the meter.
- **A project of this type must be developed using a method** that involves performing **very precise laboratory measurements**, aimed first of all at **identifying the radiation behavior** of the antenna incorporated in the meter.
- As regards **the external antenna**, it is essential to **create a radiating element** with a **radiation pattern that is suitable for the type of application**, contained within **a robust and treadable structure**, suitable for the particular type of installation.
- In view of **subsequent field testing**, it is also advisable **to build a prototype** that is **as identical as possible to the product** that will then be **produced**, not only in terms of **the electrical configuration**, but also as regards the **mechanical and environmental characteristics.**

For all these reasons it is **important to have adequate equipment,** able to support **the entire design and development phase**, starting from **the initial analysis** through to the **creation of the prototypes.**

It is also essential to have **adequate electromagnetism** and **engineering skills** so as to obtain **a product that can satisfy all the requirements** of this specific application.

If you need specialized technical support for the choice, measurement or design of your new antenna, write to:

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