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White paper

Wireless M-Bus

Discovering the European wireless standard for consumption monitoring and billing

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Wireless M-BUS.
Discovering the european standard for wireless consumption monitoring and billing

ABSTRACT

Wireless devices are more and more used in monitoring applications.
This document analyses wireless M-Bus, explaining its main features, applicable standards and strength points in respect to other wireless technologies. Finally, some possible applications based on this technology are presented.

INTRODUCTION

Lately, we have seen a strong momentum in technology massive application to fairly any field of our life. An overwhelming dance, where innovation is driven by technology and technology is driven by innovation, is leading to big changes in traditional activities and creating new opportunities.
As far as monitoring of gas, water, heating, and electricity consumptions is concerned, we are witnessing the following trends:

- Efficiency and cost reduction policies encourage the installation of automatic reading systems
- The application of energy efficiency programs requires the monitoring of a big number of energy consuming loads also in retrofit applications
- Increased final user's awareness requires real time monitoring to take immediate actions and to estimate the consumption at the end of the month.

In this context, where more and more devices have to be interconnected in both new and existing installations, the increasing demand for wireless devices is easily understandable. Identifying the best wireless technology among the huge amount of options available today is not an easy task: in this document we are dealing with Wireless M-Bus communication, a commonly used technology[1] in the above application field.

WIRELESS M-BUS: WHAT IS IT?

Wireless M-Bus is a wireless communication protocol, based on the European Standard EN13757-4, for remote reading of consumption meters and sensors.

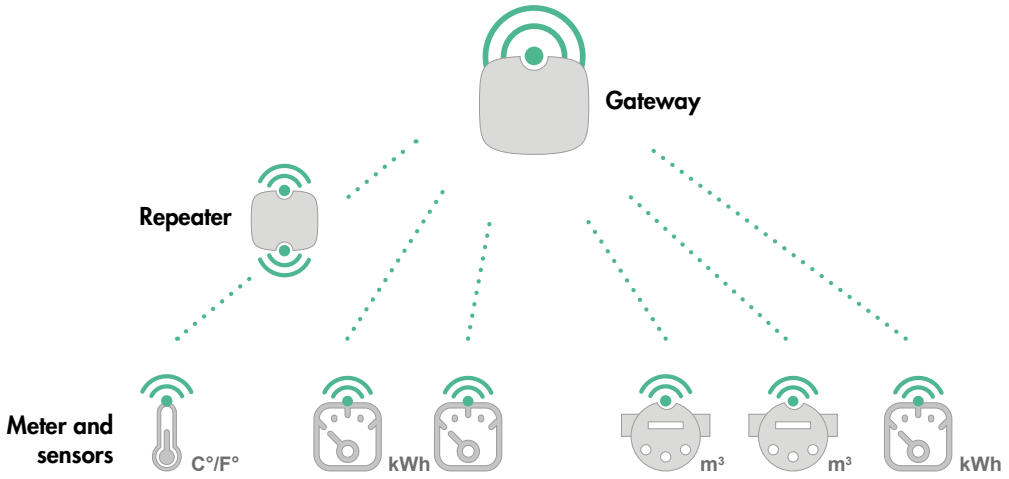
Together with the corresponding wired version, called M-Bus or Meter-Bus (and differently from other protocols designed to satisfy a wide variety of different needs), wireless M-Bus has been specifically designed for remote reading and therefore complies almost perfectly with the specific requirements of this application:

- Network expansion capability
- Fail-safe characteristics / robustness
- Minimum cost
- Meter minimum power consumption
- Application optimized transmission speed
- Identifier unicity to avoid manual addressing
- Standard variable identifiers to avoid manual mapping

The listed advantages have led to a wide adoption of this solution, especially for gas and water reading, environmental sensors and energy meters.

1 According to [1] there are more than 80 million devices in Europe.

WIRELESS M-BUS ARCHITECTURE



A wireless M-Bus network architecture is made up of the following components:

- **Meters and sensors**: meters for electricity, gas, thermal energy or water consumption, as well as real time sensors (for example to measure temperature or relative humidity), allowing data transmission by means of wireless M-Bus technology. Measuring and communicating via wireless M-Bus are two functions that can be
  - embedded in the same hardware or
  - split into two physical devices, connected with a standard wired connection like M-Bus or Modbus RTU or a proprietary protocol (meter + adapter).
- **Repeater (optional)**: used when the range of the wireless M-Bus signal is below the distance among transmitter (meter/sensor) and the gateway/receiver, it transparently replicates the received signal by retransmitting a copy of the message without any modification.
- **Gateway/receiver**: communication device collecting data from meters and sensors. Metering values are transferred to the gateway and processed to be transmitted to AMM (Automated Meter Management) systems as well as to display collected data to consumers.

READOUT MODES

According to "gateway/receiver" installation, different readout modes are available:

- **Walk-by**: the receiver is a mobile device (for example a USB stick in combination with a notebook). The readout is performed by an operator walking through the area where the meters are installed. The advantage is that the same receiver is used to read data in different installations, but this option is typically implemented when only one or two readouts per year are required.
- **Drive-by**: this option is similar to the "walk-by" readout mode but is used to cover wider areas. In this case a lower transmission interval is used to avoid packet loss considering that the receiver is within the signal range for a lower time interval.
- **Stationary**: the receiver is installed in a fixed position within the area of signal range (extended, if necessary, with one or more repeaters) and typically connected to the Internet for remote data collection. In this scenario real time consumption data and trends are available, users are aware of their consumptions and energy efficiency policies can be implemented. Transmission recurrence is typically high to allow high granularity, but is reduced when not needed or when too many devices are installed in order to avoid packet collisions (the higher the transmission number, the greater the collision probability).

STANDARDS AND REGULATIONS

As any other device operating with radio communication, a wireless M-Bus device needs to be certified according to the radio equipment directive 2014/53/EU (RED), which sets essential requirements for safety and health, electromagnetic compatibility, and the efficient use of the radio spectrum.

At present, the countries where RED certified devices can be installed, without any further tests or certification, are the following:

Albania	France	Lithuania	Saint Martin (French part)
Austria	Georgia	Luxembourg	San Marino
Belgium	Germany	Macedonia	Slovakia
Bosnia and Herzegovina	Greece	Malta	Slovenia
Bulgaria	Hungary	Monaco	Spain
Croatia	Ireland	Montenegro	Sweden
Cyprus	Island	Netherlands	Switzerland
Czechia	Italy	Norway	Turkey
Denmark	Kosovo	Poland	United Kingdom
Estonia	Latvia	Portugal	
Finlan	Liechtenstein	Romania	

Wireless M-Bus devices work in license-free ISM frequency band that implies limitations in terms of emitted power and duty cycle. For example, emitted power at 868.95 MHz (in Europe) is limited to 25 mW (14 dBm). This is the upper limit that any wireless M-Bus device operating at this frequency shall mandatorily respect, thus defining a physical limit in terms of signal range.

The European EN 13757 standard describes the complete M-Bus protocol. EN 13757 is made up of seven parts, including EN 13757-4 dealing with Wireless M-Bus specifications for radio-based communications between utility meters and concentrators or smart meter gateways:

EN 13757-1	Basic data communication between meters and collectors
EN 13757-2	Physical layer requirements for wired M-Bus
EN 13757-3	Application Layer
EN 13757-4	Physical and Data Link layers for the Wireless M-Bus
EN 13757-5	Relaying and routing for range enhancements
EN 13757-6	Local Wireless M-Bus for short distance wired links
EN 13757-7	Transport and Security Services for communication systems for meters and remote reading of meters

THE PROTOCOL

It is important to analyze protocol architecture key points, without going into too many details, to better understand wireless M-Bus main features.

Note: should the reader not be interested in the technical part described in this chapter, he/she can skip it and refer to it only when needed. For a detailed analysis of the protocol, refer to the relevant standards.

The basic architecture is described in the following table:

Application layer (EN13757-3)
Data-link layer (EN13757-4/IEC60870-5-2)
Physical layer (EN13757-4)

PHYSICAL LAYER

[EN 13757-4:2013] Standard describes various variants of wireless M-Bus meter communication, covering all types of meter communication (including mobile and stationary readout modes).

This standard defines several modes of transmission: some of them support unidirectional communication while the other modes support bidirectional communication.

Focusing on unidirectional modes, the main differences among them are frequency and maximum communication speed[1]:

Mode	Frequency	Max communication speed
S1	868.3 MHz	32.7 kbps
T1	868.95 MHz	67 kbps
C1	868.95 MHz	100 kbps
N1a-f	169 MHz @12.5 kHz	4.8 kbps
N1g	169 MHz @50 kHz	19.2 kbps

1 R, Q, P and F modes are also defined in the EN 13757 Standard, but they are rarely or never used.

DATA LINK LAYER

The Data link layer of the EN 13757-4 standard supports two different frame formats, A and B, defining the calculated fields (for example CRC) and the position of each field:

- **Frame format A**

L-field	C-field	M-field	A-field	CRC-field	CI-field	Data-field	CRC-field	Data-field	CRC-field
First block					Second block			Optional block	

- **Frame format B**

L-field	C-field	M-field	A-field	CI-field	Data-field	CRC-field	Data-field	CRC-field
First block				Second block			Optional block	

The M-field includes the Manufacturer ID, with the 15 least significant bits of these two bytes forming a three letter ISO 646 code (A…Z), which uniquely identifies a manufacturer (for instance Carlo Gavazzi is identified by "GAV").

The A-field includes the Address, a unique identifier of the specific device that, when the protocol is used together with the Transport Layer or the Application Layer of EN 13757-3, is a concatenation of

- 'Identification number',
- 'Version number' and
- 'Device type information'.

Note: the combination of M-field and A-field identifies uniquely a specific device.

APPLICATION LAYER

The application layer, that is in common with the wired M-Bus, makes wireless M-Bus a self-explaining protocol. In fact, differently from what happens in position-based protocols like Modbus, not only variable numeric values, but also

- unique variable identifiers (VIF/VIFE) and
- engineering unit identifiers (DIF/DIFE)

are transmitted.

This gives a big advantage: the fact that the variable and engineering unit identifiers[2] are defined by the standard means that there is no need for data manual mapping, as it typically happens for Modbus, since the receiver is able to recognize message content without any additional information.

2 It is the responsibility of each manufacturer to guarantee address unicity

ENCRYPTION

Data can be transmitted with encryption, to avoid that any wireless M-Bus receiver within the signal range freely detects metering data. This prevents privacy and even security issues (for example zero consumption means no people at home).

The following table provides an overview about the security profiles that are also supported by OMS (see next section):

Profile	Encryption	Authentication	Key
No Security profile	No encryption (ENC-Mode 0)	No MAC (MAC-Mode AT=0)	No key
Security profile A	AES128-CBC (ENC-Mode 5)	No MAC (MAC-Mode AT=0)	128 bit persistent symmetric key
Security profile B	AES128-CBC (ENC-Mode 7)	CMAC (8 Byte trunc.) (MAC-Mode AT=5)	128 bit ephemeral symmetric key (derived by KDF)
Security profile C	TLS 1.2 (ENC-Mode 13)	HMAC (TLS1.2) and additional CMAC (8 Byte trunc.) (MAC-Mode AT=5) for communication establishment.	256 bit elliptic curve key (384 bit optional) for TLS and 128 bit ephemeral symmetric key (derived by KDF) for CMAC

Note: security profile C requires bidirectional communication.

When OMS compliance is not required further security profiles are allowed.

THE OPEN METERING SYSTEM SPECIFICATION

As seen in the previous section, EN 13757 Standard is a flexible and open specification, where several options are available, and some parts are not described in detail or left for future implementation. Consequently, further definitions have been developed to create additional specifications, or "dialects", capable to ensure full compatibility among devices from different suppliers.

One of the most used specifications is "an open, vendor independent standard for communications interfaces", defined by the OMS group (a community of interest of associations) with enterprises in the field of accounting-oriented metering. It is being developed by the industry in order to guarantee a future-proof communication standard and interoperability between all the products.

OMS has decided to:

- allow only frame format A
- cover a subset of the modes in their specification.
- accept only the following security profiles:
  - no security profile
  - security profile A,
  - security profile B,
  - security profile C.

The allowed modes are S1, S2, T1, T2 and, since 2014, also C1 and C2, all operating in the frequency band 868 MHz to 870 MHz. The modes S1, T1 and C1 are defined for unidirectional communication from meter to gateway.
The modes S2, T2 and C2 provide a backwards channel for bidirectional communication.

- **Mode S** (stationary mode) permits greater communication distance, but maximum data rate strongly limits transmission recurrence, allowing only stationary applications
- **Mode T** (Transmit frequently) allows a more frequent transmission without increasing power consumption and collision rate, thus allowing granular analysis of consumption trends and drive-by or walk-by meter readout.
- **Mode C** has a compact data format, allowing transmission of more information.

ELL (EXTENDED LINK LAYER)

OMS recommends the application of the extended link layer (defined in [EN 13757-4:2013] as an extension of the regular Link Layer) for all kinds of message types. It permits to identify the type of message (for example synchronous/asynchronous or new/repeated).

Note: for downward compatibility to former OMS specification, ELL can be omitted, but only when Encryption Mode 7 or Encryption Mode 13 is not implemented, and asynchronous messages are not used.

WIRELESS M-BUS VS OTHER WIRELESS TECHNOLOGIES

When choosing a wireless technology among the wide variety of options available on the market, several factors shall be considered, taking into account that the best option is always the best compromise among different needs.

The optimal wireless solution should boast the following features:
- Low cost
- No operating expense
- Wide transmission range
- Low power consumption
- High communication speed
- Possible connection of a high number of devices
- Possible implementation of a private network

The features listed above can be used to compare wireless M-Bus with other wireless technologies, considering that in monitoring applications, where information is collected from several wireless devices installed on a wide area, transmission range is a key factor, while high communication speed is not important because a small amount of data is required.

WIRELESS M-BUS

	Low cost	No operating expense	Wide transmission range	Low power consumption	High communication speed	Connection of lots of devices
Wireless M-Bus	✓	✓	✓	✓	✗	✓

Wireless M-Bus allows transmission up to 100 m in typical applications and this limit, even if it may be reduced in case of concrete walls to 20-30 meters, can still be increased using one or more repeaters. The maximum communication speed is low compared to other wireless technologies, but suitable to transmit consumption and real time data in monitoring applications.

The main advantages of this technology in respect to other wireless technologies are the following:
- it is native for monitoring while most of other technologies are for generic applications
- being on the market for several years, it is widely adopted by utilities and system integrators who have developed their infrastructures using this technology and will continue doing so.
- existing systems can easily be extended by adding new meters, considering that installation is simple and does not require complex setups.
- commissioning is very simple and almost “plug and play” since there is no need of manual addressing (any device is identified uniquely) and a common dialect with standard variable identifiers (typically OMS) can be implemented.

LOCAL AND PERSONAL AREA NETWORK

	Low cost	No operating expense	Wide transmission range	Low power consumption	High communication speed	Connection of lots of devices
WI-FI	✗	✓	✗	✗	✓	✓
Bluetooth®	✓	✓	✗	✗	✓	✓

Most local and personal area network technologies, such as WI-FI and Bluetooth®, are not suitable for monitoring applications, due to limitations in transmission range typically around 5-10 m. WI-FI could be an option when a suitable number of hotspots is already available (for instance in a commercial building). However, this opportunity is rarely seized because of network access restrictions to internal LANs (for cybersecurity policies) and limited reliability of public networks.

CELLULAR NETWORKS

	Low cost	No operating expense	Wide transmission range	Low power consumption	High communication speed	Connection of lots of devices
Cellular networks	✗	✗	✓	✗	✓	✓

Cellular networks guarantee long distance transmission and signal coverage is available almost everywhere, however they require a monthly fee that is too high when multiplied by the number of devices.
In monitoring applications, they are therefore in use only in a central device that collects data from several meters and transmits all the data to a remote server.

LPWAN NETWORKS

	Low cost	No operating expense	Wide transmission range	Low power consumption	High communication speed	Connection of lots of devices
LoRaWAN®	✓	✓	✓	✓	✗	✓
NB-IoT	✓	✗	✓	✓	✗	✓
Sigfox®	✓	✗	✓	✓	✗	✓

LoRaWAN® and NB-IoT, together with other technologies such as SigFox®, have been developed for the market of the Internet of Things, where a small amount of data is transmitted over long distances with very low power consumption. These new technologies have obtained great results in terms of performance, reliability and transmission security.

- NB-IoT is based on cellular networks, so it requires a recurrent subscription payment, even if it proves much lower in comparison with 3G or 4G SIMs.
- Sigfox® is based on a public network so, similarly to NB-IoT, a monthly fee is required.
- LoRaWAN® is an extremely promising technology, able to guarantee up to 10 km of transmission distance in open air, low power consumption and the possibility of creating private networks where no recurrent fee is required. As an alternative, a monthly fee is applied for the use of public networks (similarly to other IoT technologies mentioned before).

The implementation of these technologies in wireless monitoring applications will be growing in the upcoming years, thanks to their outstanding signal range with low power consumption.
However, the wireless M-Bus commissioning is still easier and faster due to the few parameters required and the availability of standard variable identifiers.

CARLO GAVAZZI WIRELESS M-BUS SOLUTION

EM24 W1: THE DIN RAIL MOUNT WIRELESS M-BUS ENERGY METER

EM24 W1 is an energy meter based on wireless M-Bus. Differently from other manufacturers, proposing a solution with the combination of a standard energy meter (with Modbus RTU or wired M-Bus) and a wireless M-Bus adapter, Carlo Gavazzi offers an all-in-one solution, where the wireless M-Bus communication is embedded.

EM24, available with different output and communication options, has a proven reliability obtained through years of field experience. The W1 option (wireless M-Bus communication) is available in different variants to match different needs.

Depending on voltage and current inputs there are 3 different models:

- AV2 1X: single-phase systems, direct connection up to 65 A,
- AV2 3X: three-phase systems, direct connection up to 65 A,
- AV5 3X: three-phase systems, connection via 5 A current transformers.

Any of these is also available with MID certification, required for fiscal metrology and submetering. Based on the installation type the following options can be selected:

- internal antenna
- external antenna

EM24 W1, internal antenna version

EM24 W1, external antenna version

Without any significant difference in signal range, choice depends on the installation limits. Generally speaking, the best option is the one with an internal antenna, permitting a simpler installation thanks to its compactness (only 4-DIN modules). However, if transmission is not possible because a metallic cabinet or another obstacle blocks the signal, the external antenna version will solve the problem.

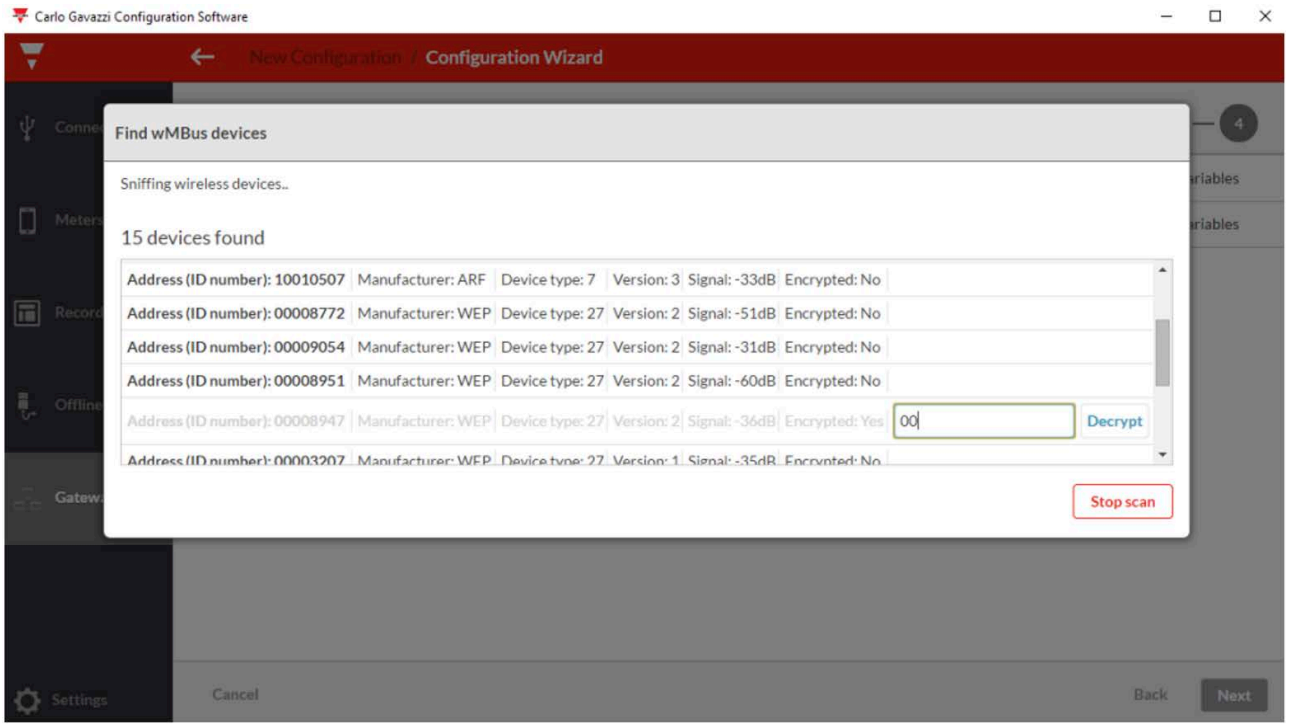
EM24 W1 is compatible with Carlo Gavazzi or third party gateways/receivers implementing transmission mode T1 or C1 and at least one of the following security profiles: no encryption, security profile A (ENC-Mode 5), security profile B (ENC-Mode 7). ELL (extended link layer) support is also required .

SIU-MBM-02: THE MODBUS TCP GATEWAY FOR M-BUS AND WIRELESS M-BUS

The gateway/receiver offered by Carlo Gavazzi is SIU-MBM-02, which is able to integrate up to 20 wired devices and 32 wireless devices and can transmit data via Modbus TCP/IP (Ethernet port).

Differently from other solutions requiring the manual addition of devices (along with the relevant variables), SIU-MBM offers an incredibly powerful solution.

Automatic network scan, enabled via Carlo Gavazzi UCS software, is able to identify not only available devices, but also the relevant variables, scale factors and engineering units for each of them.



SIU-MBM-02 wireless network automatic scan via UCS software

APPLICATIONS

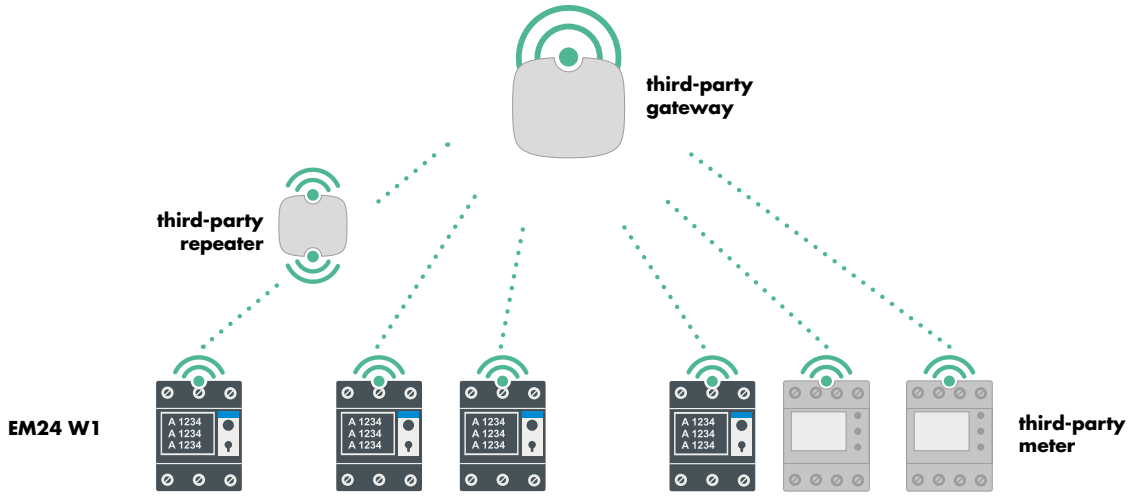
EM24 W1 and SIU-MBM-02 are ideal solutions for the following applications:

- **fiscal submetering**: EM24 W1 are installed in all the apartments of a residential building to allocate single tenants' electricity expenses.
- **cost allocation and energy efficiency**: each EM24 W1 measures energy consumption of a single load, also in retrofit applications where cabling is not possible, to correctly allocate electricity costs or to detect the actions that could be taken for improving energy efficiency.

ARCHITECTURE

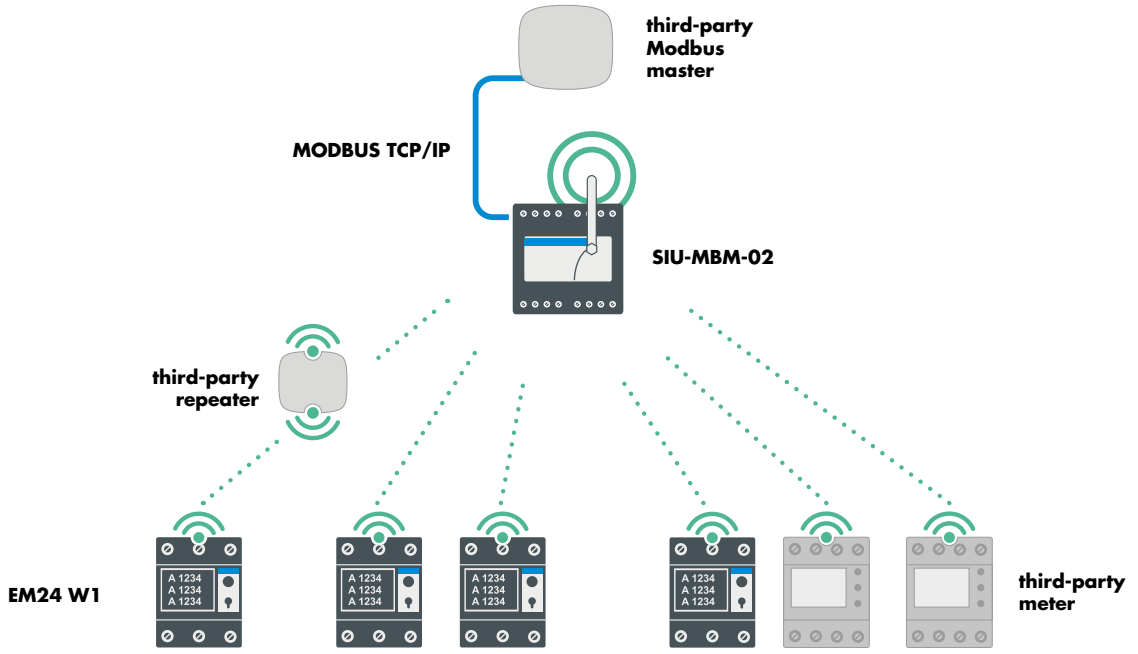
Carlo Gavazzi devices (EM24 W1 and SIU-MBM-02) can be combined with third-party devices according to one of the following scenarios:

1) Third-party gateway



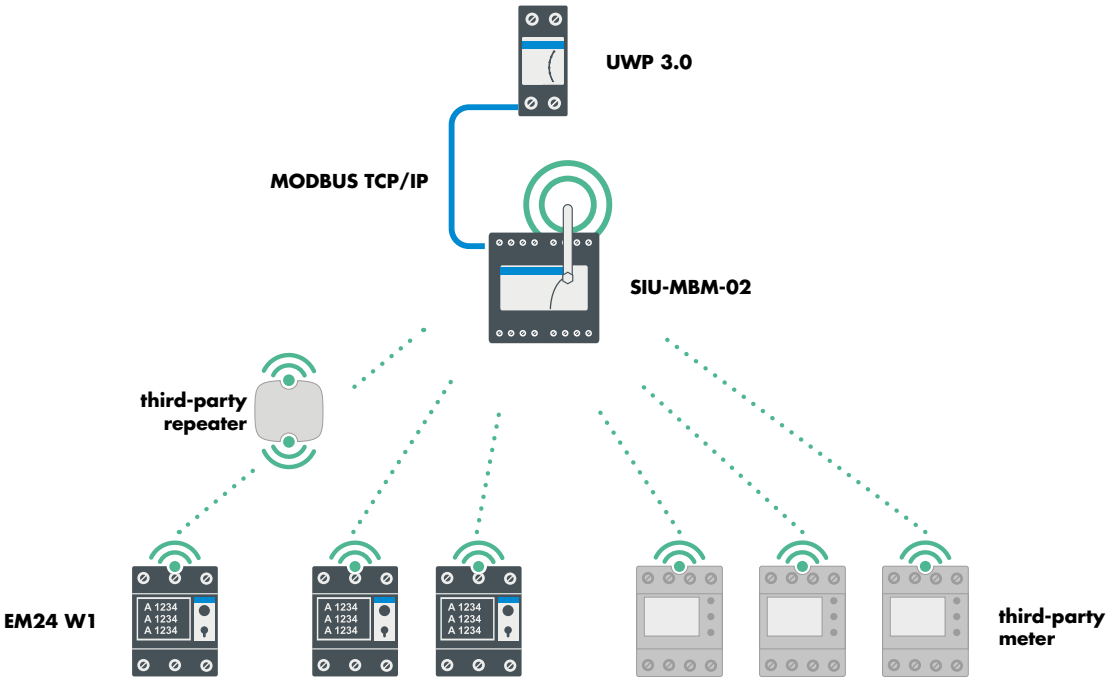
- **EM24 W1** transmits data to a third-party gateway that optionally collects third-party data from other third-party meters.
- A third-party repeater is optionally used to extend the signal range.

2) SIU-MBM-02 and third-party Modbus master



- **EM24 W1** and/or third-party meters transmit data to **SIU-MBM-02**.
- A third-party repeater extends the signal range (optional).
- A third-party Modbus Master collects data from **SIU-MBM-02**

3) SIU-MBM-02 and UWP3.0



- **EM24 W1** and/or third-party meters transmit data to **SIU-MBM-02**.
- A third-party repeater extends the signal range (optional).
- **UWP3.0** collects data from **SIU-MBM-02**

CARLO GAVAZZI AND THE OPEN METERING SYSTEM

Carlo Gavazzi is a member of the OMS-Group, that means, committed to supply interoperable meters. OMS is a future-proof communication standard as it is based on European norms and is supported by the industry.
Carlo Gavazzi's OMS approved meters can be easily combined with other manufacturer's OMS approved meters.
Carlo Gavazzi's meters, because of the OMS certification, being part of the meter park, retain its value in the long term.
OMS meters and therefore Carlo Gavazzi OMS approved meters are an essential part of the energy landscape of the future.

MEMBER
OMS®
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EM24-DIN W1 with wireless M-Bus is an OMS approved meter.

OMS®

CONCLUSIONS

Wireless M-Bus boasts a proven reliability in wireless monitoring applications based on years of field experience, and an extensive market penetration with millions of units installed. Adopted standards help interoperability of devices from different manufacturers and make commissioning easier, thanks to the address unicity and to the variable identifiers defined by the standard.

Other emerging technologies, such as LoRaWAN®, can transmit over longer distances but, when wireless M-Bus range is able to satisfy installation requirements, it is preferred because it is native for monitoring applications, commissioning proves easier and system integrators are familiar with this technology, which has already been implemented in many existing installations.

Carlo Gavazzi offers a solution based on EM24 W1, a DIN rail mount meter, and SIU-MBM-02, a gateway with Modbus TCP/IP communication. They can be installed together, and also with UWP3.0 to collect data, or can be used in combination with third-party devices.

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