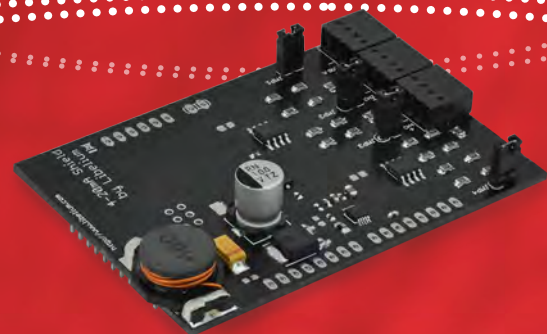


4-20 mA Current Loop Sensor Board



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1. General

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- The information on Libelium's websites has been included in good faith for general informational purposes only. It should not be relied upon for any specific purpose and no representation or warranty is given as to its accuracy or completeness.

1.1. General and safety information

- In this section, the term "Waspote" encompasses both the Waspote device itself and its modules and sensor boards.
- Read through the document "General Conditions of Libelium Sale and Use".
- Do not allow contact of metallic objects with the electronic part to avoid injuries and burns.
- NEVER submerge the device in any liquid.
- Keep the device in a dry place and away from any liquid which may spill.
- Waspote consists of highly sensitive electronics which is accessible to the exterior, handle with great care and avoid bangs or hard brushing against surfaces.
- Check the product specifications section for the maximum allowed power voltage and amperage range and consequently always use a current transformer and a battery which works within that range. Libelium is only responsible for the correct operation of the device with the batteries, power supplies and chargers which it supplies.
- Keep the device within the specified range of temperatures in the specifications section.
- Do not connect or power the device with damaged cables or batteries.
- Place the device in a place only accessible to maintenance personnel (a restricted area).
- Keep children away from the device in all circumstances.
- If there is an electrical failure, disconnect the main switch immediately and disconnect that battery or any other power supply that is being used.
- If using a car lighter as a power supply, be sure to respect the voltage and current data specified in the "Power Supplies" section.
- If using a battery in combination or not with a solar panel as a power supply, be sure to use the voltage and current data specified in the "Power supplies" section.
- If a software or hardware failure occurs, consult the Libelium Web Development section.
- Check that the frequency and power of the communication radio modules together with the integrated antennas are allowed in the area where you want to use the device.
- Waspote is a device to be integrated in a casing so that it is protected from environmental conditions such as light, dust, humidity or sudden changes in temperature. The board supplied "as is" is not recommended for a final installation as the electronic components are open to the air and may be damaged.

1.2. Conditions of use

- Read the "General and Safety Information" section carefully and keep the manual for future consultation.
- Use WaspMote in accordance with the electrical specifications and the environment described in the "Electrical Data" section of this manual.
- WaspMote and its components and modules are supplied as electronic boards to be integrated within a final product. This product must contain an enclosure to protect it from dust, humidity and other environmental interactions. In the event of outside use, this enclosure must be rated at least IP-65.
- Do not place WaspMote in contact with metallic surfaces; they could cause short-circuits which will permanently damage it.

Further information you may need can be found at: <http://www.libelium.com/development/waspmote>

The "General Conditions of Libelium Sale and Use" document can be found at:
http://www.libelium.com/development/waspmote/technical_service

2. Waspote Plug & Sense!

The Waspote Plug & Sense! line allows you to easily deploy Internet of Things networks in an easy and scalable way, ensuring minimum maintenance costs. The platform consists of a robust waterproof enclosure with specific external sockets to connect the sensors, the solar panel, the antenna and even the USB cable in order to reprogram the node. It has been specially designed to be scalable, easy to deploy and maintain.

Note: For a complete reference guide download the “Waspote Plug & Sense! Technical Guide” in the [Development section](#) of the [Libelium website](#).

2.1. Features

- Robust waterproof IP65 enclosure
- Add or change a sensor probe in seconds
- Solar powered with internal and external panel options
- Radios available: 802.15.4, 868 MHz, 900 MHz, WiFi, 4G, Sigfox and LoRaWAN
- Over the air programming (OTAP) of multiple nodes at once (via WiFi or 4G radios)
- Special holders and brackets ready for installation in street lights and building fronts
- Graphical and intuitive interface Programming Cloud Service (coming in 2017)
- Built-in, 3-axes accelerometer
- External, contactless reset with magnet
- Optional industrial protocols: RS-232, RS-485, Modbus, CAN Bus
- Optional GPS receiver
- External SIM connector for the 4G models
- Fully certified: CE (Europe), FCC (USA), IC (Canada), ANATEL (Brazil), RCM (Australia), PTCRB (USA, cellular connectivity), AT&T (USA, cellular connectivity)



Figure: Waspote Plug & Sense!

2.2. General view

This section shows main parts of Waspote Plug & Sense! and a brief description of each one. In later sections all parts will be described deeply.

2.2.1. Specifications

- **Material:** polycarbonate
- **Sealing:** polyurethane
- **Cover screws:** stainless steel
- **Ingress protection:** IP65
- **Impact resistance:** IK08
- **Rated insulation voltage AC:** 690 V
- **Rated insulation voltage DC:** 1000 V
- **Heavy metals-free:** Yes
- **Weatherproof:** true - nach UL 746 C
- **Ambient temperature (min.):** -10 °C
- **Ambient temperature (max.):** 50 °C
- **Approximated weight:** 800 g

In the pictures included below it is shown a general view of Waspote Plug & Sense! main parts. Some elements are dedicated to node control, others are designated to sensor connection and other parts are just identification elements. All of them will be described along this guide.

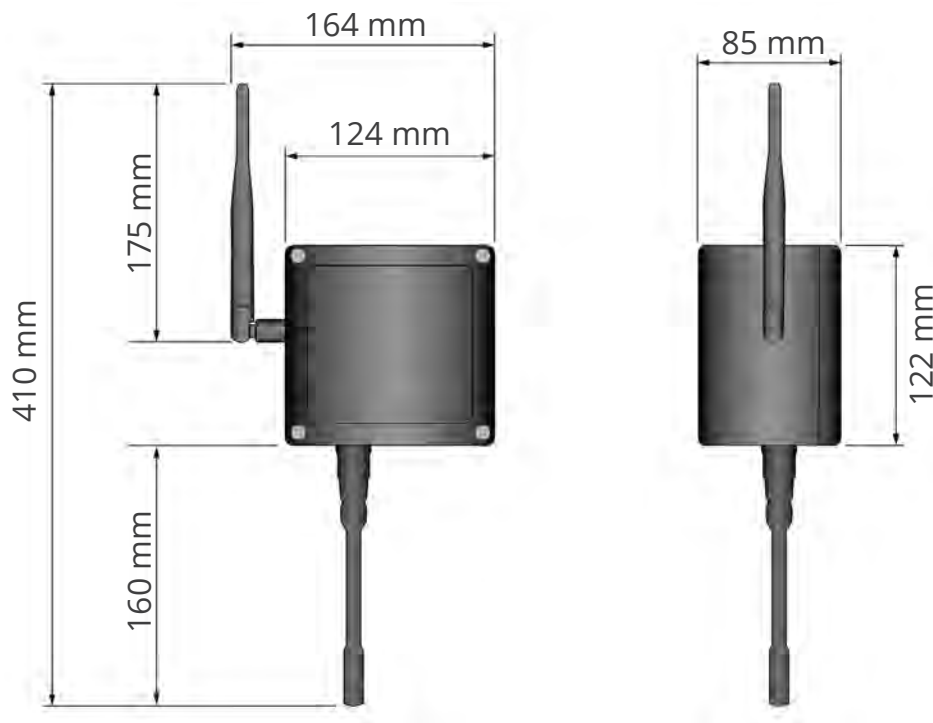


Figure : Main view of Waspote Plug & Sense!

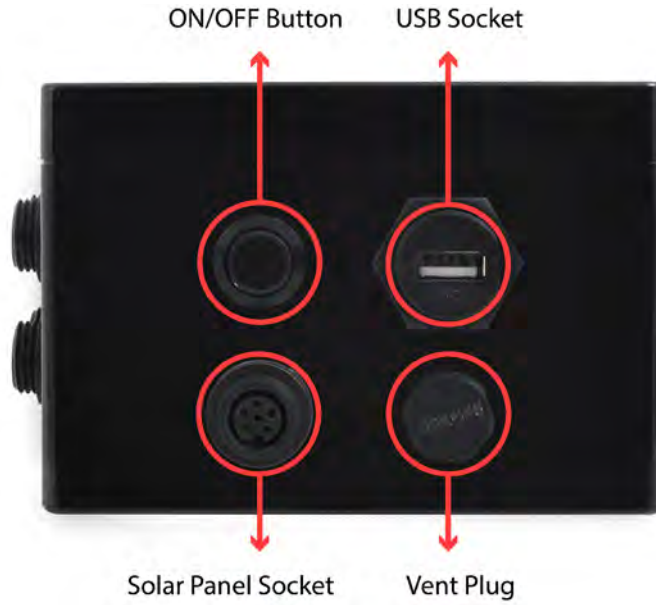


Figure : Control side of the enclosure

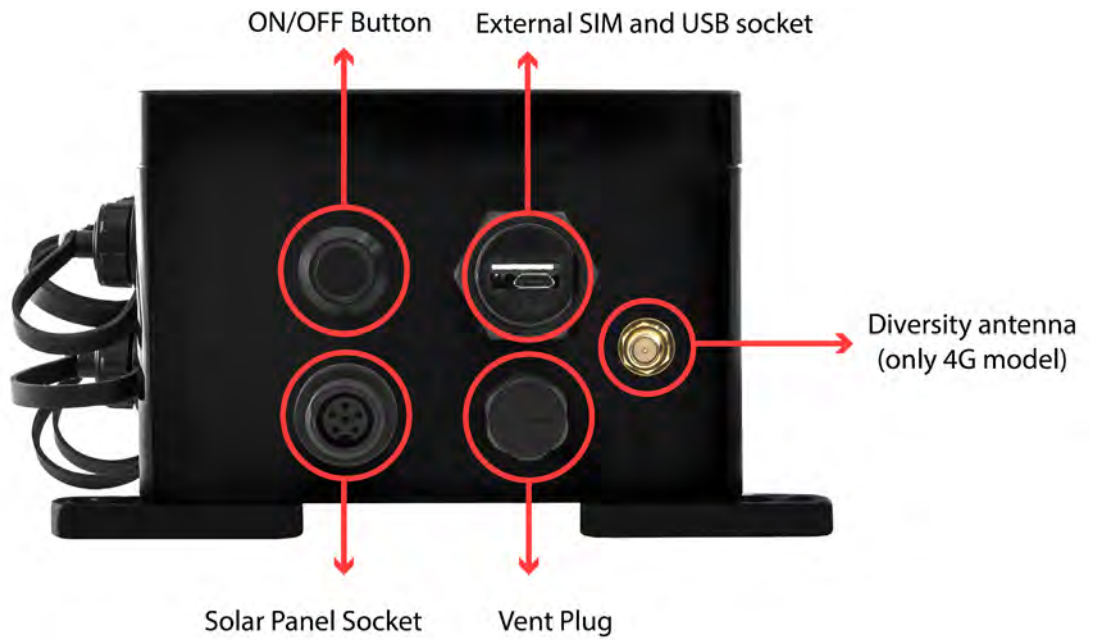


Figure : Control side of the enclosure for 4G model

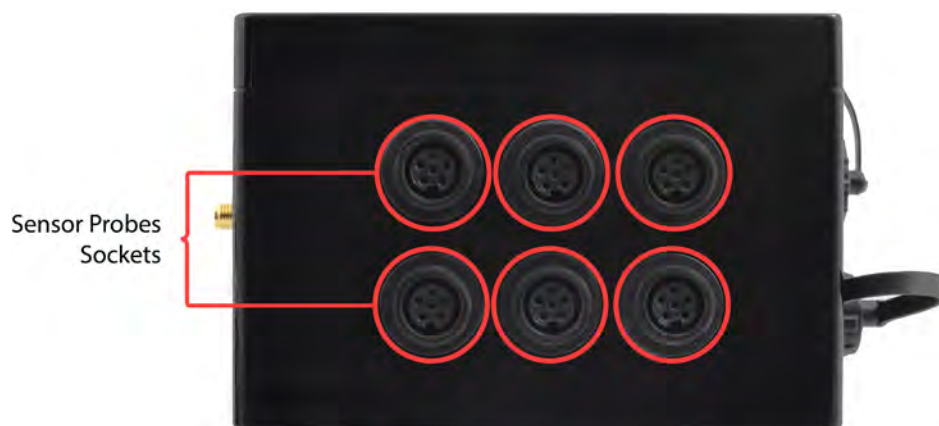


Figure : Sensor side of the enclosure



Figure : Antenna side of the enclosure



Figure : Front view of the enclosure



Figure : Back view of the enclosure



Figure : Warranty stickers of the enclosure

Important note: Do not handle black stickers seals of the enclosure (Warranty stickers). Their integrity is the proof that Wasmote Plug & Sense! has not been opened. If they have been handled, damaged or broken, the warranty is automatically void.

2.2.2. Parts included

Next picture shows Wasmote Plug & Sense! and all of its elements. Some of them are optional accessories that may not be included.



Figure : Wasmote Plug & Sense! accessories: 1 enclosure, 2 sensor probes, 3 external solar panel, 4 USB cable, 5 antenna, 6 cable ties, 7 mounting feet (screwed to the enclosure), 8 extension cord, 9 solar panel cable, 10 wall plugs & screws

2.2.3. Identification

Each Waspote model is identified by stickers. Next figure shows front sticker.

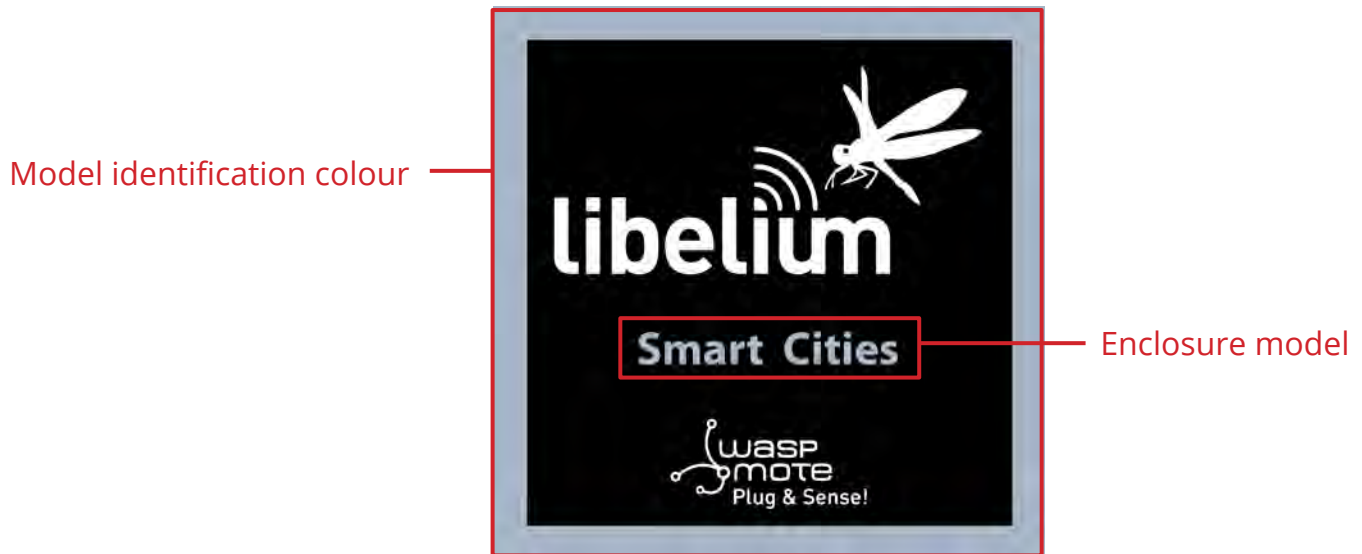


Figure : Front sticker of the enclosure

There are many configurations of Waspote Plug & Sense! line, all of them identified by one unique sticker. Next image shows all possibilities.



Figure : Different front stickers

Moreover, Wasmote Plug & Sense! includes a back sticker where it is shown identification numbers, radio MAC addresses, etc. It is highly recommended to annotate this information and save it for future maintenance. Next figure shows it in detail.



Figure : Back sticker

Sensor probes are identified too by a sticker showing the measured parameter and the sensor manufacturer reference.



Figure : Sensor probe identification sticker

2.3. Sensor probes

Sensor probes can be easily attached by just screwing them into the bottom sockets. This allows you to add new sensing capabilities to existing networks just in minutes. In the same way, sensor probes may be easily replaced in order to ensure the lowest maintenance cost of the sensor network.



Figure : Connecting a sensor probe to Waspote Plug & Sense!

Go to the [Plug & Sense! Sensor Guide](#) to know more about our sensor probes.

2.4. Solar powered

The battery can be recharged using the waterproof USB cable but also the internal or external solar panel options.

The external solar panel is mounted on a 45° holder which ensures the maximum performance of each outdoor installation.



Figure : Waspote Plug & Sense! powered by an external solar panel

For the internal option, the solar panel is embedded on the front of the enclosure, perfect for use where space is a major challenge.



Figure : Internal solar panel



Figure : Waspote Plug & Sense! powered by an internal solar panel

2.5. Programming the Nodes

Waspote Plug & Sense! can be reprogrammed in two ways:

The basic programming is done from the USB port. Just connect the USB to the specific external socket and then to the computer to upload the new firmware.

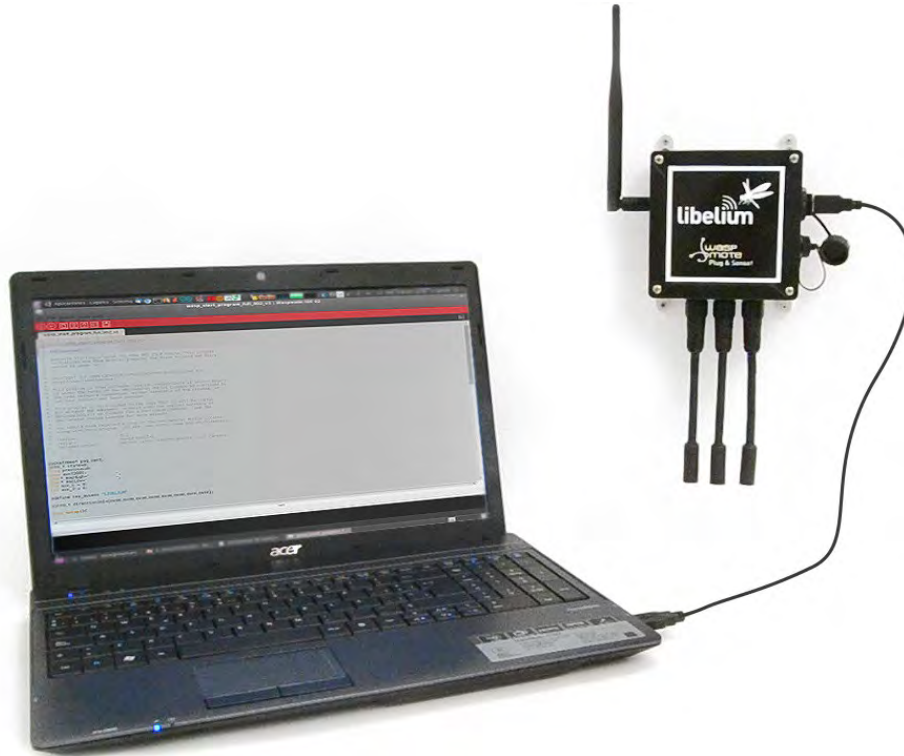


Figure : Programming a node

Besides, Libelium is developing a graphical and intuitive programming interface, the Programming Cloud Service (coming in 2017).

Waspote - Plug & Sense! - Code Generator

Select Model

Board model:

Select

Sleeping Time

Time (seconds):

Select sensor by socket

A: Select

B: Select

C: Select

D: Select

E: Select

F: Select

A B C

D E F

Additional information

Add Accelerometer 3 Axis data: ☐ Add GPS coordinates: ☐ Waspote identifier (nodeID): (Max 10 characters)

Select Communication Module

Communication Module:

USB (Debugging)

*** Mandatory fields**

Generate Code

Figure: Programming Cloud Service web application

Over the Air Programming (OTAP) is also possible once the node has been installed (via WiFi or 4G radios). With this technique you can reprogram, wireless, one or more Waspote sensor nodes at the same time by using a laptop and Meshlium.

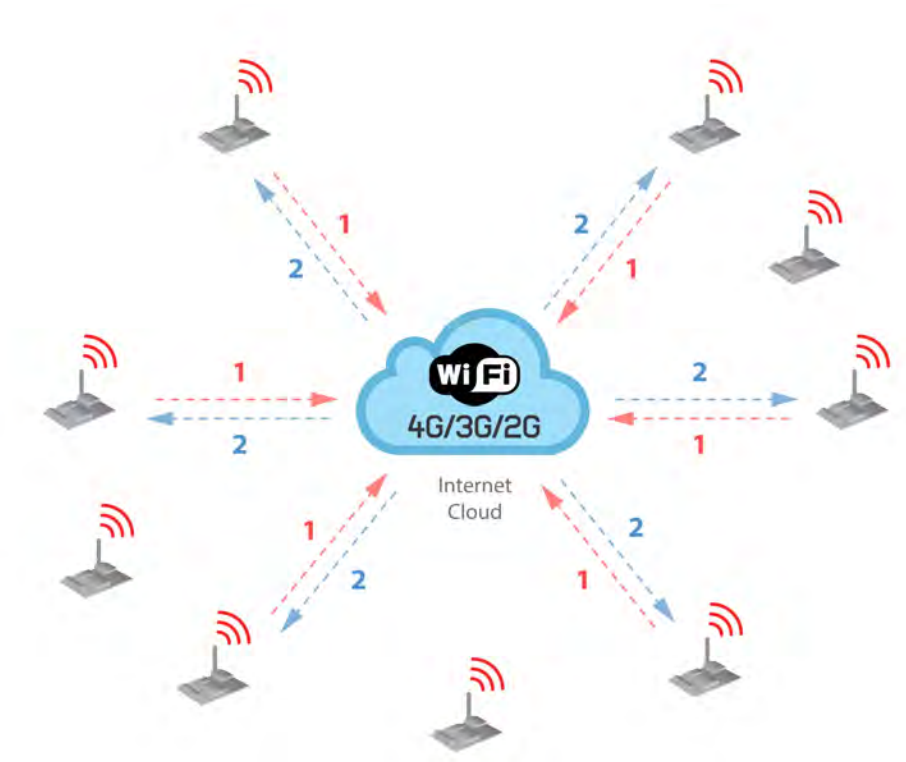


Figure : Typical OTAP process

2.6. Radio interfaces

Radio	Protocol	Frequency bands	Transmission power	Sensitivity	Range*	Certification
XBee-PRO 802.15.4 EU	802.15.4	2.4 GHz	10 dBm	-100 dBm	750 m	CE
XBee-PRO 802.15.4	802.15.4	2.4 GHz	18 dBm	-100 dBm	1600 m	FCC, IC, ANATEL, RCM
XBee 868LP	RF	868 MHz	14 dBm	-106 dBm	8.4 km	CE
XBee 900HP US	RF	900 MHz	24 dBm	-110 dBm	15.5 km	FCC, IC
XBee 900HP BR	RF	900 MHz	24 dBm	-110 dBm	15.5 km	ANATEL
XBee 900HP AU	RF	900 MHz	24 dBm	-110 dBm	15.5 km	RCM
WiFi	WiFi (HTTP(S), FTP, TCP, UDP)	2.4 GHz	17 dBm	-94 dBm	500 m	CE, FCC, IC, ANATEL, RCM
4G EU/BR	4G/3G/2G (HTTP, FTP, TCP, UDP) GPS	800, 850, 900, 1800, 2100, 2600 MHz	4G: class 3 (0.2 W, 23 dBm)	4G: -102 dBm	- km - Typical base station range	CE, ANATEL
4G US	4G/3G/2G (HTTP, FTP, TCP, UDP) GPS	700, 850, 1700, 1900 MHz	4G: class 3 (0.2 W, 23 dBm)	4G: -103 dBm	- km - Typical base station range	FCC, IC, PTCRB, AT&T
4G AU	4G (HTTP, FTP, TCP, UDP)	700, 1800, 2600 MHz	4G: class 3 (0.2 W, 23 dBm)	4G: -102 dBm	- km - Typical base station range	RCM
Sigfox EU	Sigfox	868 MHz	16 dBm	-126 dBm	- km - Typical base station range	CE
Sigfox US	Sigfox	900 MHz	24 dBm	-127 dBm	- km - Typical base station range	FCC, IC
LoRaWAN EU	LoRaWAN	868 MHz	14 dBm	-136 dBm	> 15 km	CE
LoRaWAN US	LoRaWAN	900 MHz	18.5 dBm	-136 dBm	> 15 km	FCC, IC

* Line of sight and Fresnel zone clearance with 5dBi dipole antenna.

2.7. Industrial Protocols

Besides the main radio of Waspote Plug & Sense!, it is possible to have an Industrial Protocol module as a secondary communication option. This is offered as an accessory feature.

The available Industrial Protocols are RS-232, RS-485, Modbus (software layer over RS-232 or RS-485) and CAN Bus. This optional feature is accessible through an additional, dedicated socket on the antenna side of the enclosure.



Figure: Industrial Protocols available on Plug & Sense!

Finally, the user can choose between 2 probes to connect the desired Industrial Protocol: A standard DB9 connector and a waterproof terminal block junction box. These options make the connections on industrial environments or outdoor applications easier.



Figure: DB9 probe



Figure: Terminal box probe

2.8. GPS

Any Plug & Sense! node can incorporate a GPS receiver in order to implement real-time asset tracking applications. The user can also take advantage of this accessory to geolocate data on a map. An external, waterproof antenna is provided; its long cable enables better installation for maximum satellite visibility.



Figure : Plug & Sense! node with GPS receiver

Chipset: JN3 (Telit)

Sensitivity:

- Acquisition: -147 dBm
- Navigation: -160 dBm
- Tracking: -163 dBm

Hot start time: <1 s

Cold start time: <35 s

Positional accuracy error < 2.5 m

Speed accuracy < 0.01 m/s

EGNOS, WAAS, GAGAN and MSAS capability

Antenna:

- Cable length: 2 m
- Connector: SMA
- Gain: 26 dBi (active)

Available information: latitude, longitude, altitude, speed, direction, date&time and ephemeris management

2.9. Models

There are some defined configurations of Wasmote Plug & Sense! depending on which sensors are going to be used. Wasmote Plug & Sense! configurations allow to connect up to six sensor probes at the same time.

Each model takes a different conditioning circuit to enable the sensor integration. For this reason each model allows to connect just its specific sensors.

This section describes each model configuration in detail, showing the sensors which can be used in each case and how to connect them to Wasmote. In many cases, the sensor sockets accept the connection of more than one sensor probe. See the compatibility table for each model configuration to choose the best probe combination for the application.

It is very important to remark that each socket is designed only for one specific sensor, so **they are not interchangeable**. Always be sure you connected probes in the right socket, otherwise they can be damaged.

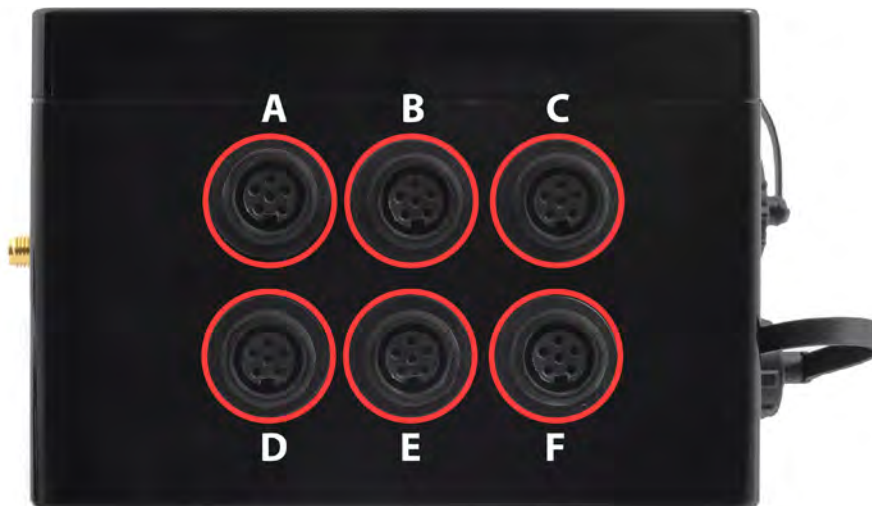


Figure : Identification of sensor sockets

2.9.1. 4-20 mA Current Loop

The applications for this Plug & Sense! model are focused on adding wireless connectivity to 4-20 mA devices and connecting them to the Cloud.



Figure: 4-20 mA Current Loop Waspote Plug & Sense! model

Sensor sockets are configured as shown in the figure below.

Sensor Socket	Sensor probes allowed for each sensor socket	
	Board channel	Reference
A	Channel 1 (type 2 and type 3)	9270-P, DB9-P
B	Channel 2 (type 2 and type 3)	9270-P, DB9-P
C	Channel 3 (type 2 and type 3)	9270-P, DB9-P
D	Channel 4 (type 4)	9270-P, DB9-P

Figure: Sensor sockets configuration for 4-20 mA Current Loop model

Note: For more technical information about each sensor probe go to the [Development section](#) on the Libelium website.

3. Introduction

This guide explains the 4-20 mA Current Loop Sensor Board features and functions. This product was designed for Waspote v12 and continues with no changes for Waspote v15. There are no great variations in this library for our new product line Waspote v15, released on October 2016.

Anyway, if you are using previous versions of our products, please use the corresponding guides, available on our [Development website](#).

You can get more information about the generation change on the document "[New generation of Libelium product lines](#)".

3.1. The standard

The 4-20 mA current loop is one of the most robust sensor signaling standard. Current loops are ideal for data transmission because of their inherent insensitivity to electrical noise. In a 4-20 mA current loop, all the signaling current flows through all components; the same current flows even if the wire terminations are less than perfect. All the components in the loop drop voltage due to the signaling current flowing through them. The signaling current is not affected by these voltage drops as long as the power supply voltage is greater than the sum of the voltage drops around the loop at the maximum signaling current of 20 mA.

Transmitting sensor information via a current loop is particularly useful when the information has to be sent to a remote location over long distances (500 meters, or more). The loop's operation is straightforward: a sensor's output voltage is first converted to a proportional current, with 4 mA normally representing the sensor's zero-level output, and 20 mA representing the sensor's full scale output. Then, a receiver at the remote end converts the 4-20 mA current back into a voltage which in turn can be further processed by a computer or display module.

This list includes some of the most common uses of the standard:

- Sensors and instruments
- Remote transducers
- Monitoring processes
- Data transmission in industrial ambients

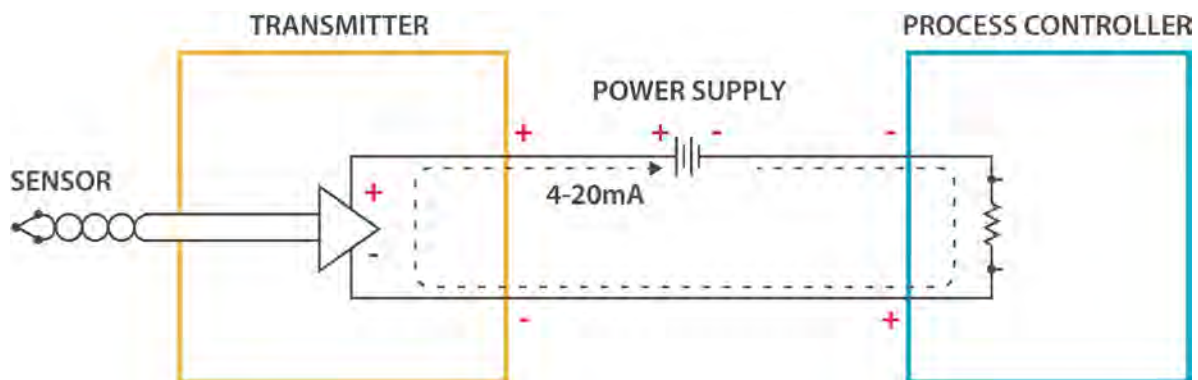


Figure : 4-20 mA standard typical connection diagram

3.2. Power Supply

The loop power-supply generally provides all operating power to the transmitter and receiver, and any other loop components that require a well-regulated DC voltage. In loop-powered applications, the power supply's internal elements also furnish a path for closing the series loop. +24 V is still the most widely used power supply voltage in 4-20 mA process monitoring applications. This is due to the fact that +24 V is also used to power many other instruments and electromechanical components commonly found in industrial environments. Lower supply voltages, such as +12 V, are also popular since they are used in computer based systems.

3.3. Transmitters categories

Depending on the source of current for the loop, devices may be classified as active (supplying power) or passive (relying on loop power).

3.3.1. Type 2 loop current

Type 2 transmitters are energized by the current loop, where the supply voltage is included in the receptor. The transmitter is floating and the ground is in the receptor.

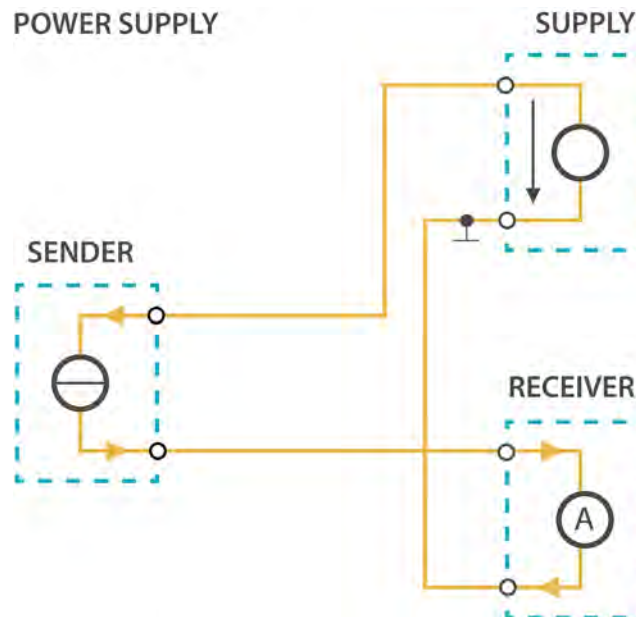


Figure : 4-20 mA type 2 connection

3.3.2. Type 3 loop current

Type 3 transmitters have 3 wires powered by the source voltage in them. In this case the transmitter is the power source for the current loop. The transmitter common is connected to the common of the receptor.

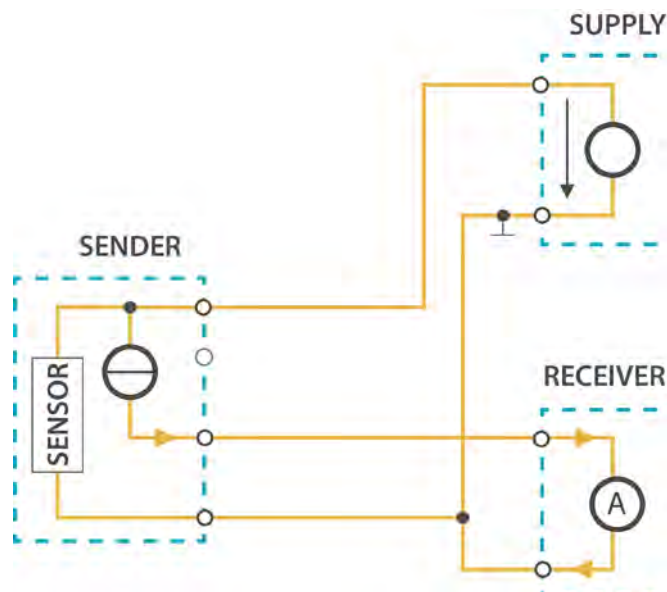


Figure : 4-20 mA type 3 connection

3.3.3. Type 4 loop current

Type 4 transmitters have 4 wires powered by the source voltage in them. The transmitter powers the current loop and the receptor acts a floating load.

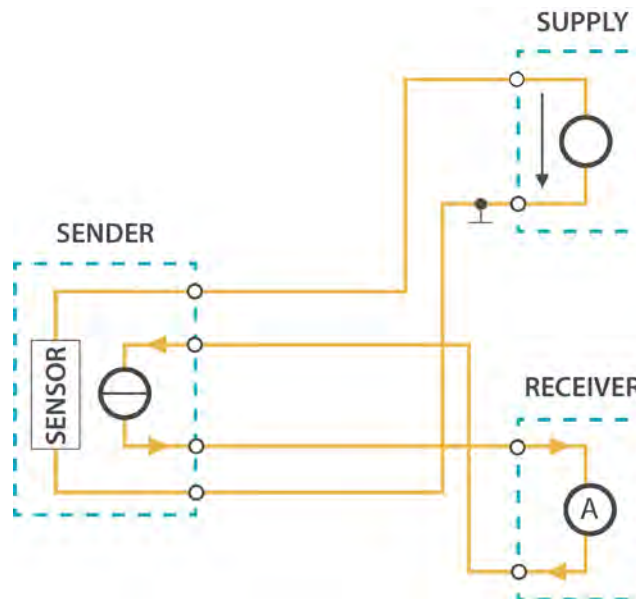


Figure : 4-20 mA type 4 connection

4. Hardware

4.1. Electrical characteristics

- **Board power voltages:** 4.2 V
- **Output voltage max:** +12 V
- **Output current max:** 180 mA
- **Converting resistance tolerance:** 0.1%
- **Temperature Range:** [0 °C, 85 °C]
- **Dimensions:** 73.5 x 51 x 1.3 mm



Figure : 4-20 mA Board connected over Wasp mote

4.2. Connection diagram

The 4-20 mA Board for Wasp mote has 4 input channels which allow the user to convert signals that come from 3rd party sensors or devices with this industrial standard. The 4-20 mA Board works with type 2, 3 and 4 current transmitters. Each channel can be configured for working with any of these types of connections: 2, 3 or 4:

- When the jumper of one channel is connected, this channel is compatible with type 2 and type 3
- If one jumper is moved away, this channel will be configured as float (type 4 connection)

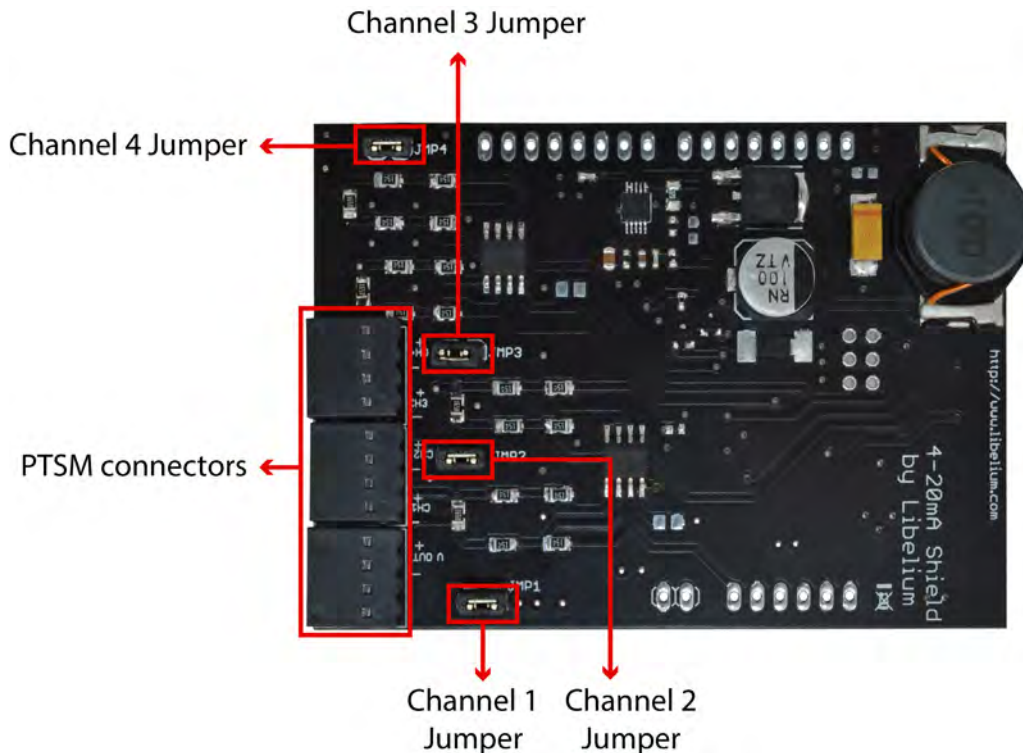


Figure : 4-20 mA Board diagram of connections

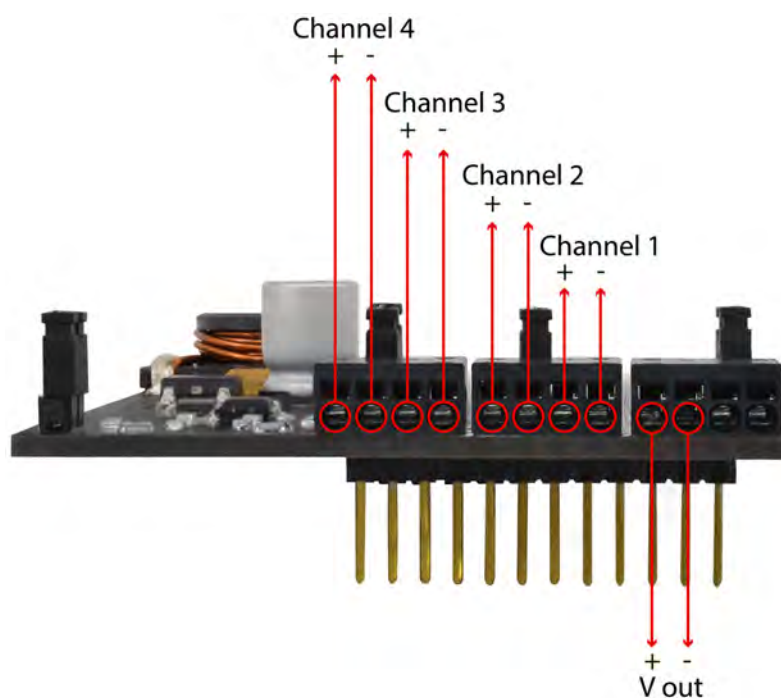


Figure : Channels from 1 to 4 and power supply connections

4.3. Channel wiring for Plug & Sense!

The 4-20 mA board for Plug & Sense! has the same features as the Wasp mote version. The four channels are accessible through the sensor sockets following this correspondence:

- channel 1 → socket A
- channel 2 → socket B
- channel 3 → socket C
- channel 4 → socket D

However, the transmitter categories cannot be modified on Plug & Sense! because the user has no access to the selection jumpers. Channels 1, 2 and 3 are predefined as type 2 or type 3, while channel 4 is type 4 only (its jumper is removed inside the enclosure).

Finally, each signal is wired following the next table.

Terminal box probe	DB9 probe	Signal
1	1	Channel n +
2	2	Channel n -
3	3	Vout +
4	4	Vout -
5	5	-
6	6	-
-	7	-
-	8	-
-	9	-

Figure : 4-20 mA channel wiring for the DB9 and terminal box probes

4.4. Sensor connection on Plug & Sense!

4.4.1. Terminal box probe

To provide access to the board signals in the Wasp mote Plug & Sense! encapsulated line, a waterproof terminal block junction box is provided as an accessory probe, making the connections on industrial environments or outdoor applications easier.



Figure : Terminal box probe connected to the Plug & Sense! 4-20 mA current loop

It consists of 2 cable glands and 6 terminal block connectors with screw. The junction box can be easily opened by removing the four external screws and the cover. Then, the user is able to make the necessary connections using the terminal block connectors. Finally, the cable glands should be adjusted and the junction box should be closed properly to avoid water ingress.



Figure : Terminal box probe

Note: Please double check the terminal block connections to avoid wrong wirings or short circuits between poles. The Wasp mote Plug & Sense! unit can be seriously damaged. Besides, ensure that the junction box is properly closed to avoid damage in outdoors applications. Libelium warranty will not cover damages caused by a wrong installation.

4.4.2. DB9 probe

The DB9 connector is commonly used in many applications with data transmission on industrial ambients. Libelium provides this probe as an accessory with a standard DB9 female connector and a cable with length of 1.5 meters.



Figure : DB9 probe

4.5. Consumption

The consumption of the 4-20 mA Board depends on several factors. When the battery is fully charged, the consumption of the board is lower due to the DC-DC converter. This DC-DC converter rises the voltage from the battery voltage level to 12 V, so if the battery level decreases, the energy needed to maintain the 12 V level is higher. The nominal consumption of the board is 8 mA without sensor. Also, if the 4-20 mA Board is used to power other sensors, the consumption will increase.

4.6. Connectors

For connecting the 4-20 mA sensors, the 4-20 mA Board includes PTSM connectors. These connectors (PTSM from Phoenix Contact) allow to assemble the wires of the probe simply by pressing them into it. To remove the wire, press the slot above the input pin and pull off the wire softly.

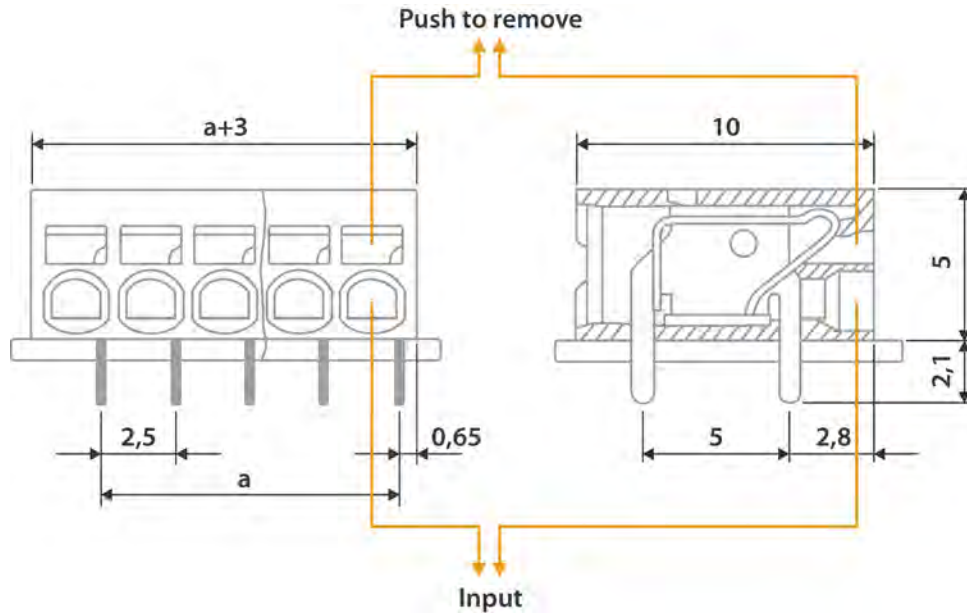


Figure : Diagram of a socket extracted from the Phoenix Contact data sheet

4.7. Powering sensors from the 4-20 mA Board

The 4-20 mA Board includes a 12 V output that can be used as power supply for sensors. The majority of 4-20 mA sensor works in the 9-24 V range. Before connecting a sensor to the 4-20 mA Board, you must be sure that 12 V fits the sensor's range of the power supply. If you are going to use all channels, the consumption of the board will increase. It is important to know that the 4-20 mA Board is not designed to power industrial devices such as PLC's and thermostats: the maximum current output is about 180 mA.

5. Applications

The 4-20 mA Sensor Board allows the user to interface the Waspote ecosystem with 4-20 mA systems. Waspote allows to perform two main applications:

1°- Add wireless connectivity to 4-20 mA devices

Waspote can be configured to read the information from the bus and send it to the [Libelium IoT Gateway](#) using any of the wireless radio modules available: 802.15.4, 868 MHz, 900 MHz, WiFi, 4G, Sigfox and LoRaWAN, Bluetooth Pro, Bluetooth Low Energy and RFID/NFC.

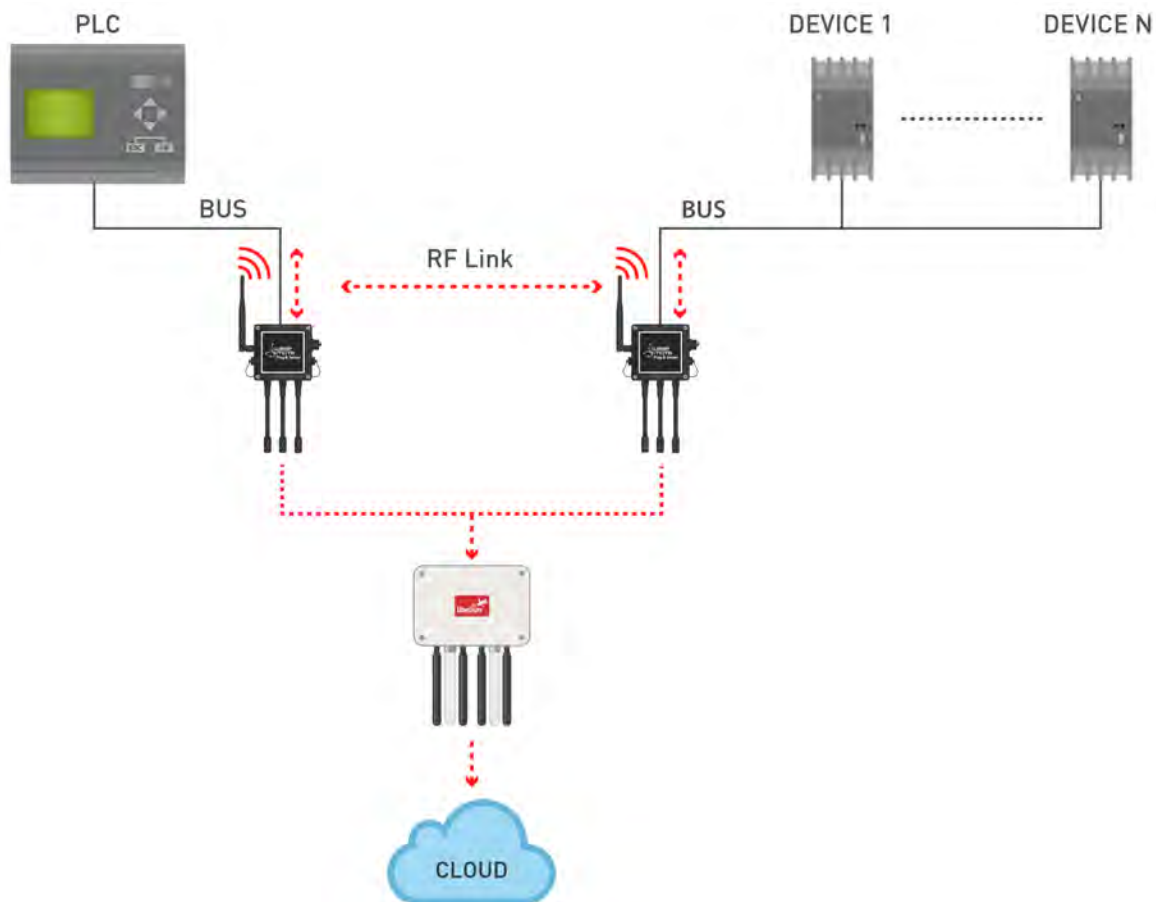


Figure : 4-20 mA wireless application

2°- Connect to the Cloud 4-20 mA devices

Waspote can be configured to read the information coming from the 4-20 mA sensors and send it wirelessly directly to the Cloud using WiFi, GPRS, GPRS+GPS, 3G and 4G radio interfaces.

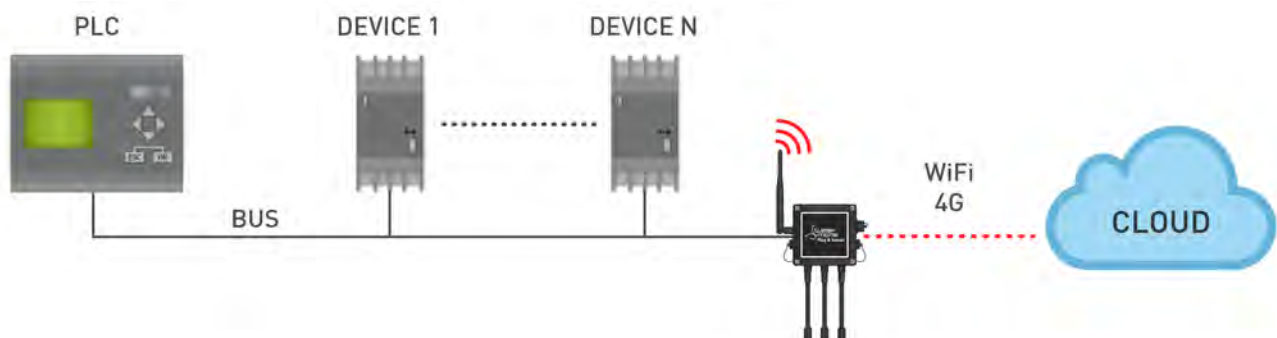


Figure : Cloud connection

6. Libelium library

It is mandatory to include the 4-20 mA library when using this board. The following line must be introduced at the beginning of the code:

```
#include <currentLoop.h>
```

Wasp mote's API 4-20 mA files:

- currentLoop.cpp
- currentLoop.h

API's functions

- Public functions:

<code>uint8_t ON(uint8_t powerSupply)</code>	Powers on the 4-20 mA supply (5 V or 12 V)
<code>uint8_t OFF(uint8_t powerSupply)</code>	Powers off the 4-20 mA supply (5 V or 12 V)
<code>int readChannel(uint8_t channel)</code>	Gets the sensor value in integer format
<code>float readVoltage(uint8_t channel)</code>	Gets the sensor value as a voltage
<code>readCurrent(uint8_t channel, float offSet)</code>	Gets the sensor value as a current in mA and introduce an offSet correction factor
<code>float readCurrent(uint8_t channel)</code>	Gets the sensor value as a current in mA
<code>uint8_t isConnected(uint8_t channel)</code>	Checks if the current loop is well connected

Figure : Table of public functions

When using the Plug & Sense! 4-20 mA model, the correspondence between the board channels and the external sockets is defined like this:

- channel 1 → socket A
- channel 2 → socket B
- channel 3 → socket C
- channel 4 → socket D

This way, a Plug & Sense! user with a sensor on socket A (channel 1 of the 4-20 mA sensor board) will use the next line to read it:

```
int value = currentLoopBoard.readChannel(SOCKET_A);
```

7. Library functions

7.1. Library constructor

To start using Wasp mote 4-20 mA library, an object from class `currentLoop` must be created. This object, called `currentLoopBoard`, is created inside Wasp mote 4-20 mA library and it is public to all libraries. It is used through this guide to show how Wasp mote 4-20 mA library works. When creating this constructor, all the variables are defined with an initial value by default.

7.2. Switching the board on

The 4-20 mA Board includes a 12 V output that can be used to supply sensors, and can be controlled from the library functions, by a digital pin of Wasp mote. The electronic measurement circuits use the 5 V power (so it is always mandatory to switch this option on), and is necessary to switch on this power supply before getting data from the sensors.

On the other hand, it is only necessary to switch the 12 V on when we want to power 3rd party sensors.

Example of use:

```
{  
  // Sets the 5 V switch ON  
  currentLoopBoard.ON(SUPPLY5V);  
  delay(100);  
  
  // Sets the 12 V switch ON  
  currentLoopBoard.ON(SUPPLY12V);  
  delay(100);  
}
```

See an example of use here:

<http://www.libelium.com/development/waspote/examples/4-20ma-01-current-loop-basic-example>

7.3. Switching the board off

This function can be used to switch OFF the power supplies of the 4-20 mA Board. The 12 V and 5 V power supplies must be switched off separately as shown in the next example.

Example of use:

```
{  
  // Sets the 5 V switch OFF  
  currentLoopBoard.OFF(SUPPLY5V);  
  delay(100);  
  
  // Sets the 12 V switch OFF  
  currentLoopBoard.OFF(SUPPLY12V);  
  delay(100);  
}
```


7.4. Reading data

The 4-20 mA library includes the necessary functions to read data in several formats. The 4-20 mA standard sends the sensor information as a current, and this information can be transformed in voltage with a simple conversion function.

Example of use:

```
{
  // Get the sensor value in integer format (0-1023)
  int value = currentLoopBoard.readChannel(CHANNEL1);
  USB.print("Int value read from channel 1: ");
  USB.println(value);

  // Get the sensor value as a voltage
  float voltage = currentLoopBoard.readVoltage(CHANNEL1);
  USB.print("Voltage value read from channel 1: ");
  USB.print(voltage);
  USB.println("V");

  // Get the sensor value as a current in mA
  float current = currentLoopBoard.readCurrent(CHANNEL1);
  USB.print("Current value read from channel 1: ");
  USB.print(current);
  USB.println("mA");
}
```

Sometimes, it is necessary to introduce a correction factor to correct offset deviations in the measurement process. The next function can be used for this:

```
{
  // Get the sensor value as a current in mA
  float current = currentLoopBoard.readCurrent(CHANNEL1, OFFSET);
  USB.print("Current value read from channel 1: ");
  USB.print(current);
  USB.println("mA");
}
```

See an example of use here:

<http://www.libelium.com/development/waspmote/examples/4-20ma-01-current-loop-basic-example>

7.5. Current loop state

One of the most important features of the 4-20 mA standard is the possibility of detecting a broken wire or failed instrument. The 4-20 mA library includes a function to detect the current state of the line.

Example of use:

```
{
  if (currentLoopBoard.isConnected(CHANNEL1))
  {
    // Get the sensor value as a current in mA
    current = currentLoopBoard.readCurrent(CHANNEL1);
    USB.print("Current value read from channel 1: ");
    USB.print(current, 3);
    USB.println("mA");
  }
  else
  {
    USB.println("The sensor is not connected...");
  }
}
```

See an example of use here:

<http://www.libelium.com/development/waspmote/examples/4-20ma-02-current-loop-connection-state>

8. Real application example

As a real application we are going to connect a generic 4-20 mA sensor to the 4-20 Sensor Board and power the sensor with the Board's 12 V output. This sensor is a type 2 transmitter. Type 2 transmitters are energized by the current loop, where the supply voltage is included in the receptor. The transmitter voltage is floating and the ground is in the receptor, so it is necessary to connect the corresponding jumper.



Figure : 4-20 mA sensor connected to the 4-20 mA Board

In the case of Plug & Sense!, the sensor can be connected to channel 1 (which is type 2 and type 3) using the terminal box probe connected to socket A. The two sensor wires are connected on positions 1 (channel +) and 2 (channel -).



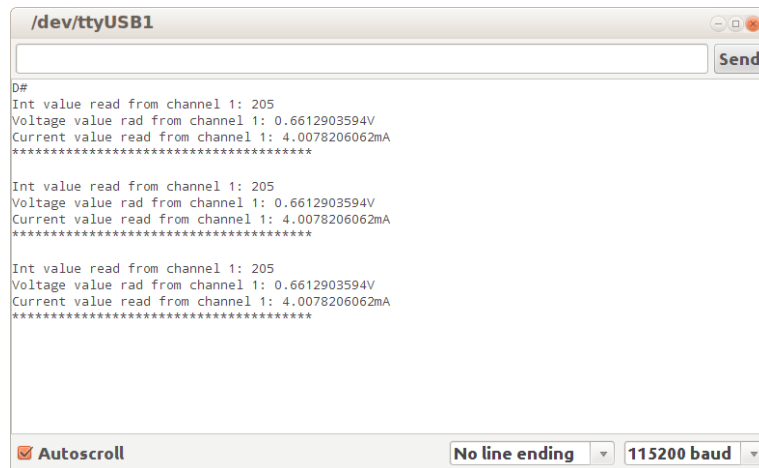
Figure : 4-20 mA sensor connected to the Plug & Sense! 4-20 mA current loop model

After connecting the sensor, you only have to upload one of the example codes included in the Wasp mote IDE, for instance the example number one:

<http://www.libelium.com/development/waspmote/examples/4-20ma-01-current-loop-basic-example>

In the serial monitor you should see that the sensor is transmitting 4 mA. The 4 mA “bottom of span” signal allows the receiver to **detect a broken wire or failed instrument**. Remember that in normal operation, a 4-20 mA sensor delivers between 4 and 20 mA. Any current above or below means malfunction.

The constant-current feature of a current loop cancels out voltage drop errors due to long wiring runs (of course this would also be true if you selected different current values for zero and span [e.g., 5-30 mA]).



```
/dev/ttyUSB1
D#
Int value read from channel 1: 205
Voltage value rad from channel 1: 0.6612903594V
Current value read from channel 1: 4.0078206062mA
*****
Int value read from channel 1: 205
Voltage value rad from channel 1: 0.6612903594V
Current value read from channel 1: 4.0078206062mA
*****
Int value read from channel 1: 205
Voltage value rad from channel 1: 0.6612903594V
Current value read from channel 1: 4.0078206062mA
*****
Autoscroll No line ending 115200 baud
```

Figure : Data reception from the 4-20 mA sensor

9. Code examples and extended information

For more information about the Wasp mote hardware platform go to:

<http://www.libelium.com/waspmote>

<http://www.libelium.com/development/waspmote>

In the Wasp mote Development section you can find complete examples:

<http://www.libelium.com/development/waspmote/examples>

Example:

```
/*
 * ----- [4-20mA_01] Current Loop Basic Example -----
 *
 * Explanation: This sketch shows how to use the most important
 * features of the 4-20 mA Current Loop Board in Wasp mote. This
 * standard is used to transmit information of sensor over long
 * distances. Wasp mote uses analog inputs for reading the sensor
 * values.
 *
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 *
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 * (at your option) any later version.
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 * This program is distributed in the hope that it will be useful,
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 * You should have received a copy of the GNU General Public License
 * along with this program. If not, see <http://www.gnu.org/licenses/>.
 *
 * Version:          0.1
 * Design:           David Gascon
 * Implementation:   Ahmad Saad
 */

//Include this library for using current loop functions
#include <currentLoop.h>

//Instantiate currentLoop object in channel 1
currentLoop sensor(CHANNEL1);

void setup()
{
  // Power on the USB for viewing data in the serial monitor
  USB.ON();
  delay(100);

  // Sets the 5 V switch ON
  PWR.setSensorPower(SENS_5V, SENS_ON);
  delay(100);
}

void loop()
```

```
{
  // Get the sensor value in int format (0-1023)
  int value = sensor.readChannel();
  USB.print("Int value read from channel 1: ");
  USB.println(value);

  // Get the sensor value as a voltage
  float voltage = sensor.readVoltage();
  USB.print("Voltage value read from channel 1: ");
  USB.print(voltage);
  USB.println("V");

  // Get the sensor value as a current in mA
  float current = sensor.readCurrent();
  USB.print("Current value read from channel 1: ");
  USB.print(current);
  USB.println("mA");

  USB.println("*****");
  USB.print("\n");

  //Delay after reading
  delay(2500);
}
```

10. API changelog

Keep track of the software changes on this link:

www.libelium.com/development/waspmote/documentation/changelog/#4_20_mA

11. Documentation changelog

From v7.1 to v7.2

- Added clearer explanations about channels and 2-3-4 types

From v7.0 to v7.1:

- Added references to the integration of Industrial Protocols for Plug & Sense!

12. Certifications

Libelium offers 2 types of IoT sensor platforms, Waspote OEM and Plug & Sense!:

- **Waspote OEM** is intended to be used for research purposes or as part of a major product so it needs final certification on the client side. More info at: www.libelium.com/products/waspote
- **Plug & Sense!** is the line ready to be used out-of-the-box. It includes market certifications. See below the specific list of regulations passed. More info at: www.libelium.com/products/plug-sense

Besides, Meshlium, our multiprotocol router for the IoT, is also certified with the certifications below. Get more info at:

www.libelium.com/products/meshlium

List of certifications for Plug & Sense! and Meshlium:

- CE (Europe)
- FCC (US)
- IC (Canada)
- ANATEL (Brazil)
- RCM (Australia)
- PTCRB (cellular certification for the US)
- AT&T (cellular certification for the US)



Figure : Certifications of the Plug & Sense! product line

You can find all the certification documents at:

www.libelium.com/certifications