WifiSentinel

**WiFi Sentinel
Modbus RTU slave Operation
& Configuration manual**

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WiFi Sentinel

MODBUS RTU Operation and Configuration Manual

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1.- Introduction

The WiFi Sentinel (WFS-1000) is a serial to wireless converter and a Remote Terminal Unit (RTU) featuring analog and digital I/O as well as a lead acid battery charger to provide a complete wireless solution for instrumentation connectivity to automation systems like PLCs, SCADA, alarm panels, etc.

Depending on the model, different options can be selected. To see the options available refer to the WFS-1000 Data Sheet.

This manual is intended to provide information to configure the WFS-1000 when working as a Modbus™ RTU slave (Part numbers 10-01 and 10-02).

2.- Description

The WFS-1000 features two Analog Inputs, one discrete input, and one discrete output. It also provides one serial channel either RS-232 or RS-485 (two wires), and one WiFi Radio with an external antenna.

The WiFi Sentinel block diagram is shown in Figure 1. The technical specifications are found in publication: WFS-1000 Vr. 1.0. Data Sheet (Rev. 1)
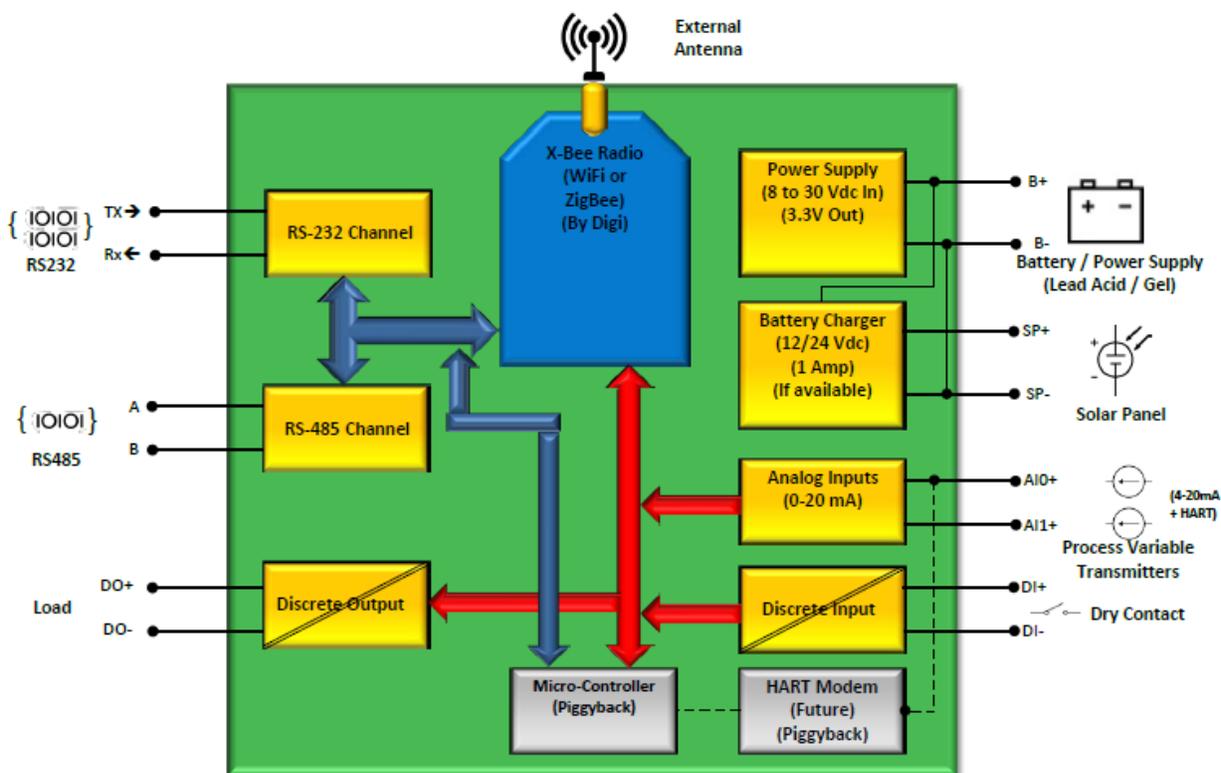

Figure 1.- WiFi Sentinel Block Diagram

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In a typical configuration (see figure 2), there is one WFS-1000 connected to a Master Terminal Unit (MTU) (for example a PLC) via the RS-232 or the RS-485 channel, and several WFS-1000 (slaves) deployed in the field. The Modbus RTU query requested by the MTU is retransmitted wirelessly by the WFS-1000 (Master) to the other WFS-1000 (Slaves) in the field. Each WFS-1000 must have a unique Modbus RTU slave address, only the one matching the query address responds to the MTU. The response received by the WFS-1000 (Master) is retransmitted via the serial channel to the MTU.
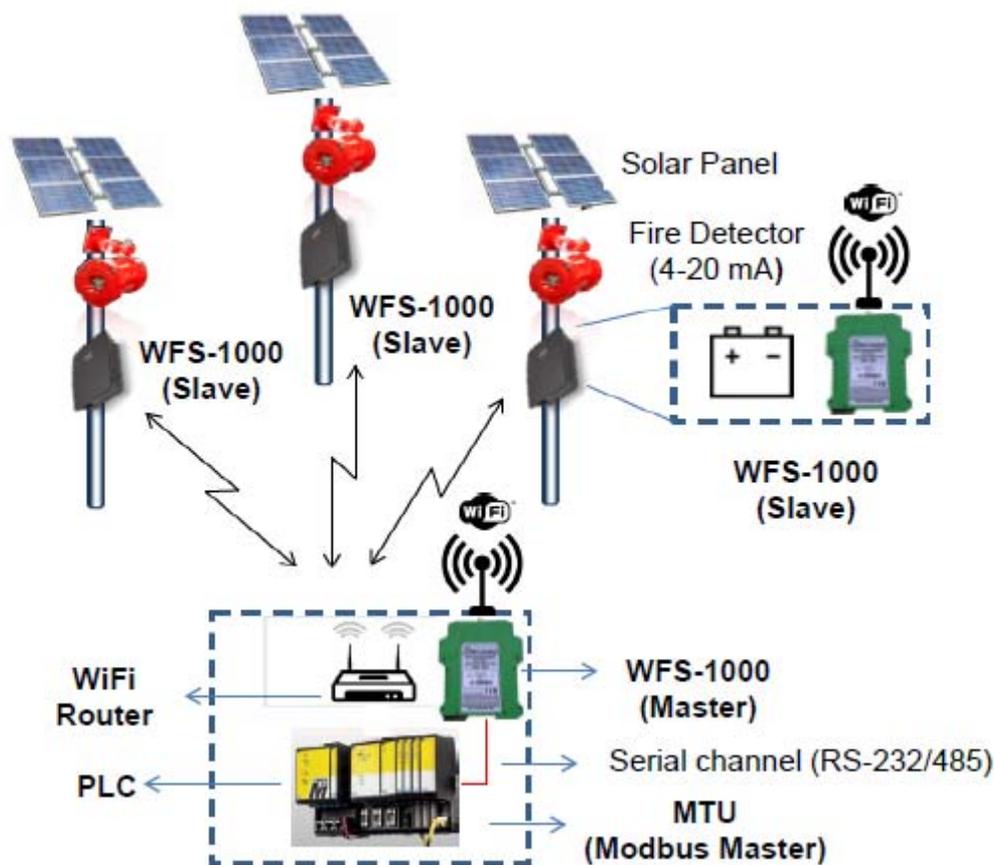

Figure 2.- Typical WFS-1000 application as Modbus RTU

Each WFS-1000 radio must have a unique IP address. The WiFi network is managed by a WiFi Access Point (Router), consequently all WFS-1000 must be connected to the same WiFi Network in order to communicate each other. The WFS-1000 working as a master send an UDP broadcast message having the Modbus RTU query, all the WFS-1000 in the field receive the message, and the one matching the proper Modbus RTU address respond via WiFi to the WFS-1000 master sending an UDP message with the response to the WFS-1000 master. The response message IP address must match the WFS-1000 master IP address.

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3.- Modbus communications

The WFS-1000 implements the Modbus™ RTU slave protocol. The available Modbus commands are described hereinafter.

- **Function Code 01 (0x01): Read Coils**
  This function code is used to read from 1 to 464 contiguous status of coils in a remote WFS-1000. The MTU specifies the starting address, i.e. the address of the first coil specified, and the number of coils.

- **Function Code 02 (0x02): Read Discrete Inputs**
  This function code is used to read from 1 to 464 contiguous status of discrete inputs in a remote WFS-1000. The MTU specifies the starting address, i.e. the address of the first input specified, and the number of discrete inputs. In the WFS-1000 discrete inputs are addressed starting at zero. Therefore inputs numbered 1-16 are addressed as 0-15.

- **Function code 03 (0x03): Read Holding Registers**
  This function code is used to read the contents of a contiguous block of holding registers in a remote WFS-1000. The MTU specifies the starting register address and the number of registers. In the WFS-1000 Registers are addressed starting at zero. Therefore registers numbered 1-16 are addressed as 0-15.

- **Function code 04 (0x04): Read Input Registers**
  This function code is used to read from 1 to 29 contiguous input registers in a remote WFS-1000. The MTU specifies the starting register address and the number of registers. In the WFS-1000 Registers are addressed starting at zero. Therefore input registers numbered 1-16 are addressed as 0-15.

- **Function code 05 (0x05): Write Single Coil**
  This function code is used to write a single output to either ON or OFF in a remote WFS-1000.
  The requested ON/OFF state is specified by a constant in the request data field. A value of FF 00 hex requests the output to be ON. A value of 00 00 requests it to be OFF. All other values are illegal and will not affect the output.
  The MTU specifies the address of the coil to be forced. Coils are addressed starting at zero. Therefore coil numbered 1 is addressed as 0. The requested ON/OFF state is specified by a constant in the Coil Value field. A value of 0XFF00 requests the coil to be ON. A value of 0X0000 requests the coil to be off. All other values are illegal and will not affect the coil.

- **Function code 06 (0x06): Write Single Register**
  This function code is used to write a single holding register in a remote WFS-1000.

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The Modbus register map is shown in table 1. All Modbus address can be accessed using any of the previously mentioned Modbus commands. The offset represents register's addresses.

Table 1.- Modbus register map

Offset	Description
00001	Analog Input 0 (AI0) value in counts (See register 00006 for scale factor)
00002	Analog Input 1 (AI1) value in counts (See register 00006 for scale factor)
00003	Power supply or battery voltage (AI1) value in counts (0 ➔ 0 V, 3000 ➔ 30 V)
00004	Reserved for Analog Input reference voltage
00005	Time elapsed since the latest valid query received from the Modbus Master in tenths of seconds
00006	*Discrete I/O values:* Bit 0: Discrete Input value Bit 8: Discrete output value
00007	*I/O Configuration:* <u>Bit 3:</u> AI0 scaling factor 0 (**Default**) ➔ 0-20mA (0-1000 counts) 1 ➔ 4-20mA (0-1000 counts) <u>Bit 7:</u> AI1 scaling factor 0 (**Default**) ➔ 0-20mA (0-1000 counts) 1 ➔ 4-20mA (0-1000 counts)
00008 to 00021	Reserved
00022	*RTU mode:* <u>Bit 0:</u> 0(default) ➔ WFS-1000 Connected via serial channel (RS-232/485) 1 ➔ WFS-1000 Connected via radio
00023	RTU status and requested commands feedback Bit 0: A command to change RTU, Baud rate, and WDT_COMM was accepted Bit 1: A command to write I/O configuration parameters was accepted Bit 2: A command to enable over the air WFS-1000 radio configuration via web page was accepted Bit 7: A command to enable changing configuration parameters was accepted Bit 8: Internal Watch Dog Timer (WDT) was triggered Bit 9: Modbus received message buffer overflows
00024	Internal seconds timer. Counts from 0 to 59. Increments each second.
00025	Modbus RTU address (valid values are from 1 to 247) (**Default value is 247**)
00026	*RS-232/485 channel baud rate.* Valid values are: 1 ➔ 4800 bps 2 ➔ 9600 bps (**default**) 3 ➔ 19200 bps 4 ➔ 38400 bps
00026	*Communication watchdog timer (WDT_COMM) set-point:* A Reset is applied to the WFS-1000 radio if no data is received when the timer expires. The timer is enabled after the first character is received. 0 (**Default**) ➔ Timer disabled 1 ➔ 3 seconds 2 ➔ 5 seconds 3 ➔ 10 seconds

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Offset	Description
	4 ➔ 60 seconds 5 ➔ 120 seconds
00028	*Configuration commands:* Each bit must be set to one individually to apply changes Values are written in the WFS-1000 non volatile memory Bit 0: Command to change RTU, Baud rate, and WDT_COMM Bit 1: Command to write I/O configuration parameters Bit 2: Command to enable over the air WFS-1000 radio configuration via web page Bit 3: Command to change the RTU mode Bit 4: Command to reset the WFS-1000 CPU Bit 7: Command to enable configuration changes via Bits 0 to Bits 3. Once this bit is set, configuration changes are enabled for 1 minute, and the WFS-1000 is ready to accept configuration commands by setting bits 0 to bit 3 of this register. At the end of the one minute period no configuration changes are accepted.
00029	Firmware version

4.- WFS-1000 configuration

The WFS-1000 Modbus RTU protocol configuration and the WiFi radio configuration are performed independently. The Modbus RTU protocol must be configured first. Typically Modbus protocol configuration is factory set to the default values (see table 1). If for some reason the Modbus protocol configuration is lost, the factory default values can be restored by removing the power and setting jumper J20 to the position shown in figure 3, then remove again the power, and set the Jumper J20 to the normal position.
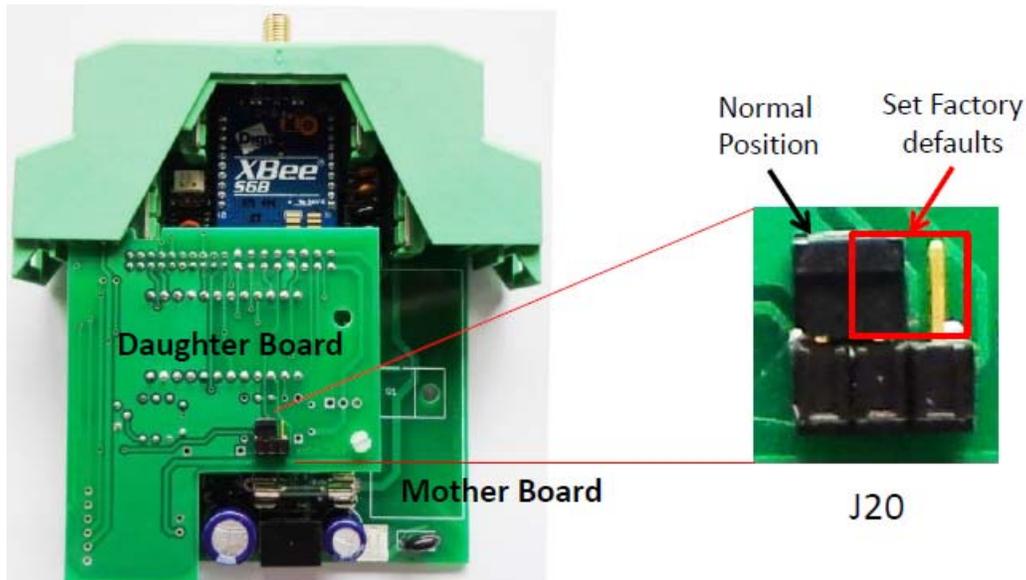

Figure 3.- Configuring Modbus factory default settings

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4.1 Setting Modbus RTU configuration parameters

To change the Modbus RTU configuration parameters any Modbus RTU scanner software can be used, for example "CAS Modbus Scanner" (Chipkin Automation Systems). This software is free, and can be downloaded from http://www.chipkin.com/products/software/modbus-software/cas-modbus-scanner/.

If the Modbus RTU configuration current values are not know, run the procedure previously described to set the factory default values.

If this is a WFS-1000 master (see figure 2), connect the Modbus scanner to the WFS-1000 via RS-232 port and then perform the following steps:

1) Enable configuration changes by setting to one the bit 7 of Modbus register 00028 (writing a 128 will set the corresponding bit to 1). This action will enable changing configuration parameters for one minute. If the command is accepted the bit 7 of Modbus register 00028 will be set to one;

2) Write the new parameter to the corresponding Modbus register;

3) Write the corresponding bit in the "Configuration commands" register (Modbus address offset 00028). This will store the new value in the WFS-1000 non volatile memory. If the command was accepted the corresponding bit in register 00028 will be also set (only valid for bits 0 to 2). Parameters must be changed one at a time. If the one minute window elapses, then go to step 1 to enable again the configuration changes.

If this is a WFS-1000 slave (see figure 2), connect first the Modbus scanner to the WFS-1000 master via RS-232, then apply steps 1 to 3 previously described on the corresponding remote WFS-1000 slave.

⚠️**Warning:** Changing the Baud Rate or the RTU address will disconnect the Modbus scanner.

4.2 Setting the WiFi radio configuration parameters

There are two ways to change WiFi radio configuration parameters.

Changing WiFi Radio configuration parameters over the air. To perform this procedure a WiFi enabled device (laptop, tablet, smart phone, etc) with a web browser is needed.

- To perform this procedure it is first needed to disconnect the WFS-1000 from the current WiFi network. To do that, the bit 7 of Modbus register 00028 must be set to one (enable configuration changes), and the bit 2 of Modbus register 00028 must be set to one. After 30 seconds the WFS-1000 will behave as an access point. You have 10 minutes to change parameters in this mode, after this period of time, the radio is reset and if configuration is not finish changes will not be applied, and the radio will revert to its original configuration.
- Then you have to search for an xbee-xxxxxxxxxxxx WiFi network (xx… is the radio MAC address), and connect to it. Be aware that your WiFi enabled device must be in the range of the WiFi signal transmitted by the WFS-1000 you are trying to configure.
- Once connected to the Xbee-x… network, use a browser to connect to the WFS-1000 radio IP address. A web page as shown in figure 4 will be displayed.
- Using the Web Browser, set the following parameters:
  o SSID (ID): Type the ID to the Access Point where the WFS-1000 will be connected.
  o Encryption Enable (EE): Select 2- WPA2 (AES) security

o Passphrase (PK): Set the Access Point password
o In the addressing section set the: "Module IP address" (MY) to the IP address to be assigned to this radio and the "Destination IP address" (DL) to the WFS-1000 master radio IP Address. If this is the WFS-1000 master radio, then set broadcast IP address for this network (xxx.xxx.xxx.255). Set the "Source Port" (C0) to 2617 if this is the WFS-1000 master radio or to 2616 if this is a slave radio, and set the "Destination port" (DE) to 2616 if this is the master radio or to 2617 if this is the slave radio. Also configure the "IP Address of Gateway" (GW) to match the Access Point IP address where the WFS-1000 will be connected, and set the "IP Address Mask" (MK) to 255.255.255.0. Do not change any other configuration parameter.
o Go to the end of the web page and click "Apply" button. This will save the parameters, and reset the radio, then the radio will attempt to connect to the selected access point. If the connection is successful, then you will be able to ping to the WFS-1000 IP address once connected to the Access Point network, if the connection is not successful, the radio will return to the access point mode allowing you to repeat the procedure from the beginning.
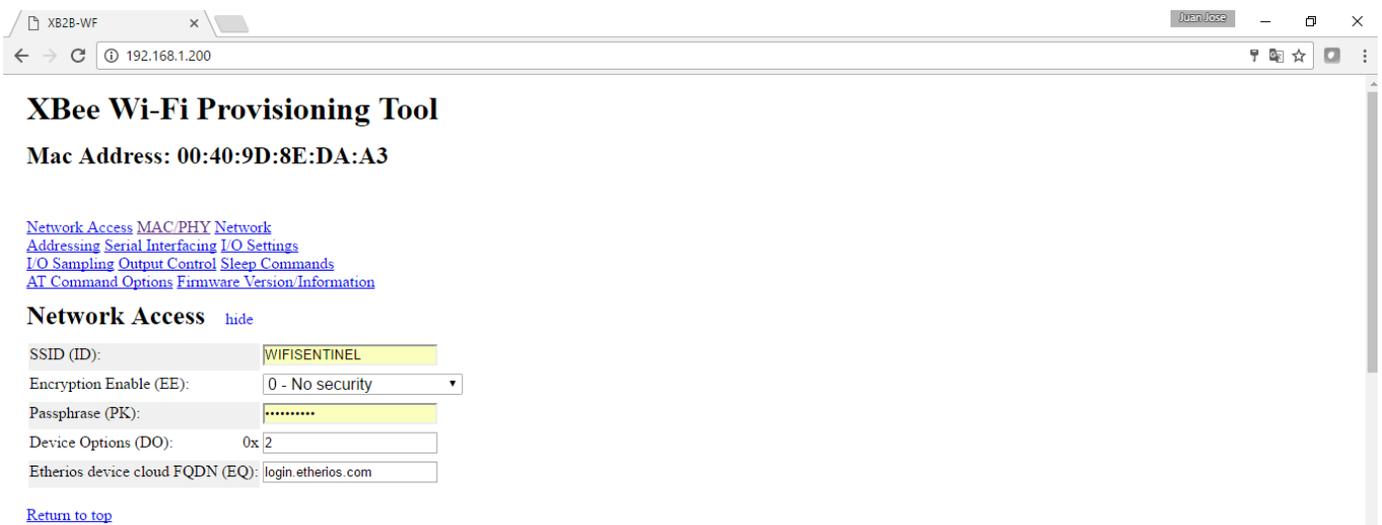

Figure 4.- WFS-1000 Radio Configuration web page

⚠️**Warning:** Changing any other configuration parameter might affect the communication performance or even stop it completely .

⚠️**Warning:** While over the air radio configuration is enabled, Modbus communication is interrupted.

Changing WiFi Radio configuration using the radio configuration utility XCTU.

• To perform this procedure it is first needed to download the radio configuration utility from the Digi web page (https://www.digi.com/products/xbee-rf-solutions/xctu-software/xctu).
• Then you have to remove the WFS-1000 from the box, and disconnect the WFS-1000 Daughter Board from the Mother Board (see figure 3).

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- Next, move the configuration jumpers (J1 and J5) in the mother board to the configuration position (see figure 5).
- Energize the mother board, and connect the WFS-1000 via RS-232 to a host computer where the XCTU software is installed (an USB to RS-232 converter may be needed).
- Run the XCTU software and connect to the WFS-1000. Baud rate is factory set to 38400 bps, no parity, and one stop bit.
- Follow the XCTU instructions to get connected to the WFS-1000 WiFi radio.
- Change the configuration parameters mentioned at the beginning of this section.
- Save the parameters to the radio non volatile memory.
- Remove the power from the WFS-1000
- Return the configuration Jumpers to its normal position (See Figure 5)
- Insert the WFS-daughter board.
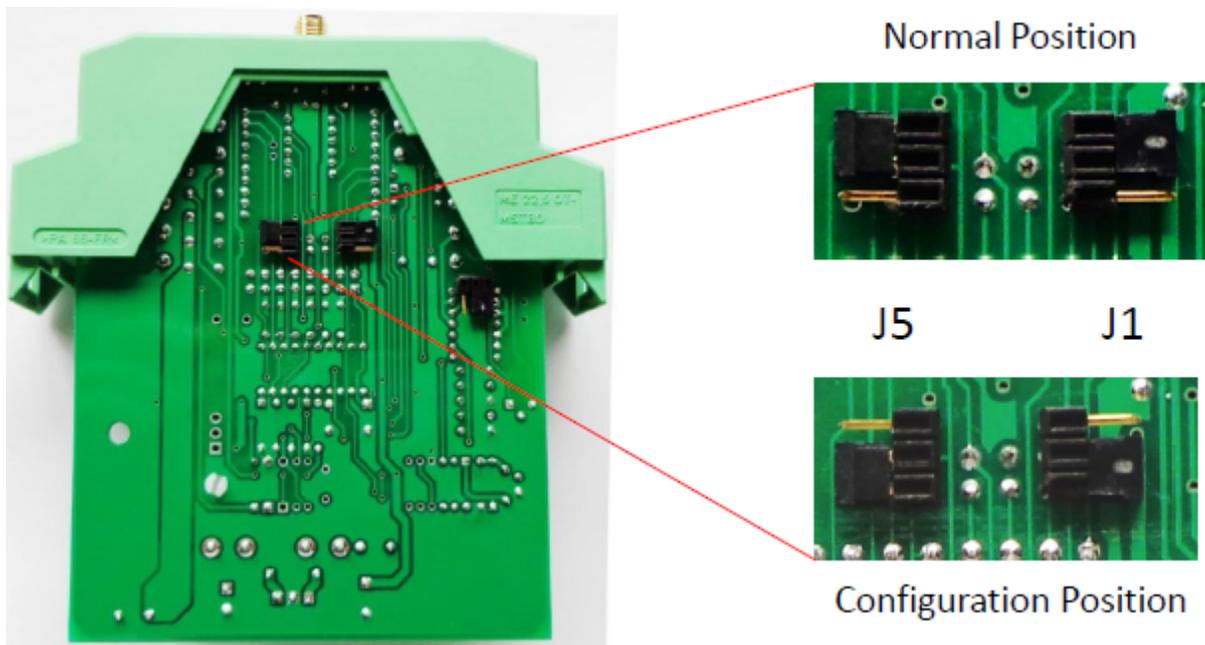- Insert the boards in the Box.
- Connect the WFS-1000
- Apply power.

Figure 5.- Radio configuration jumpers

4.3 Setting the Access Point Wireless parameters

For optimal performance, set the Access Point configuration parameters as follows.

- SSID: Set as required. The WFS-1000 SSID setting must be equal to this value.
- Channel: Select the least congested channel (between 1 and 11). Don't leave in Auto.

- Mode: 11g only
- Wireless security: WPA-PSK / WPA2-PSK
- Encryption: AES
- Transmit power: High
- Beacon Interval: 40 mS
- DTIM interval: 1

Configure the other parameters as required.

4.4 Recommended Modbus Master settings

For optimal performance, set the Modbus Master configuration parameters as follows:

- Baud rate: 38400 bps (must match the WFS-1000 master baud rate).
- Response timeout: not less than 250 ms.
- Inter-characters delay: not less than 20 mS (if applicable).
- Scan time: not less than 500 mS
- Number of retries: between 3 and 10. Start with 3 retries, and rise the value if no responses from the slave are frequent.

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