

**WIRELESS FAMILY DEVICES
ZB-CONNECTION
Introductory document**

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1) GENERAL DEVICE CHARACTERISTICS

The ZB-Connection family of devices composes a network of sensors and actuators. These sensors and actuators are able to convey their own operating data (input status, output settings, parameters, etc.) to a centering hub device called Gateway via wireless.

Two-way communication is established between devices and Gateway; besides transmitting their operating status, devices can receive data and commands.

It is possible to access data gathered by the Gateway through USB/485 serial communications and a Modbus-Rtu protocol or through an Ethernet port and Modbus-TCP/IP protocol.

The Gateway is transparent for the purposes of serial communications.

Whether it is a PLC or a PC with supervision software, the client connected to the Gateway can access all the data for each individual sensor in both read and write modes, individually addressing them as though they were wired.

The sensors/actuators are divided into two families: battery-powered sensors/actuators called end-devices and sensors/actuators powered by a steady, outside source called routers.

The radio devices in these two families are fundamentally different. In fact, the routers are also responsible for maintaining the radio network infrastructure and extending the capacity of the Gateway.

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2) BUILDING A NETWORK OF DEVICES

Construction of a new network of ZB-Connection devices involves the following phases:

- A) Establishing the Gateway address (see paragraph 3)
- B) Connecting the Gateway to a control/supervision system and turning it on
- C) Creation of the network by the Gateway (see paragraph 4)
- D) Opening the network by the Gateway (see paragraphs 5,6)
- E) Establishing addresses for new sensor/actuator devices (see paragraph 3)
- F) Turning on the new sensor/actuator devices
- G) Annexing the new sensor/actuator devices into the network (see paragraph 7)
- H) Closing the network by the Gateway (see paragraphs 5,6)

Points E, F, G must be repeated for all devices one wishes to include in the network.

If a new device is to be inserted in an existing network, points D, E, F, G, H must be performed.

3) DEVICE ADDRESSING

An essential prerogative of all ZB-Connection devices is that each one must have its own, unequivocal address.

Each device, except Router-Bridge devices and Repeaters devices, has a dip-switch that must be set to the address assigned to the unit.

The address must be set before the device is annexed to the network.

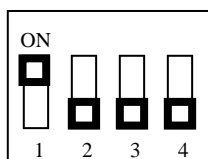
Gateway Addressing (except Ethernet version)

Gateway addressing makes it possible for the connected client to access the operating data for the Gateway itself and to set and manage the radio network parameters.

Valid Gateway addresses are numbers ranging from 1 to 7.

Each of these devices has a 3-setting dip-switch that uses binary logic: switch "1" corresponds to the least significant bit; the "on" position corresponds to a value of 1.

Example:



Address = 1

The DipSwitch is read only when switching the circuit board on; a modification in the DipSwitch's position is taken into consideration only after the device has been reset. DIP4 is not used for assigning the address but for choosing the speed of the serial port.

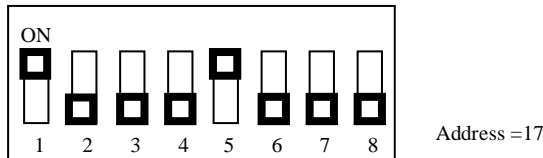
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Addressing sensor/actuator devices.

Valid sensor/actuator addresses are numbers ranging from 16 to 127.

Each of these devices has an 8-setting dip-switch that uses binary logic: switch "1" corresponds to the least significant bit; the "on" position corresponds to a value of 1.

Example:



The DipSwitch is read only when switching the circuit board on; a modification in the Dipswitch's position is taken into consideration only after the device has been reset. In order to reset the device, remove the battery from the device, press the pushbutton so that to make the residual energy in the circuit run out, then install the battery.

Attention: Be careful when assigning the addresses. Two devices with the same address would "pour" their data into the same Gateway container and this would generate ambiguity which would be difficult to identify in subsequent network operations.

4) CREATING THE NETWORK

Network creation can only be performed by the Gateway.

In fact Gateway is used to create the wireless network to which all devices will subsequently be annexed.

Network creation can only be performed if the Gateway is not already part of a network.

The network creation operation is performed by pressing the push-button on the Gateway or by using the Modbus protocol to send the Gateway a special command.

After network creation has been completed, the Gateway stores the parameters describing the network in its non volatile memory so that, when the Gateway is turned off, subsequent operation is not compromised and, when it is turned on again, it will resume functioning on the previously formed network.

5) OPENING AND CLOSING THE NETWORK

The term "open network" indicates a network to which new devices can be annexed; the term "closed network" indicates one which cannot accept any new devices.

The network made up of ZB-Connection devices is a normally closed network.

The network can only be opened from the Gateway.

Network opening and closing operations are performed by pressing the push-button on the Gateway or by using the modbus protocol to send the Gateway a command.

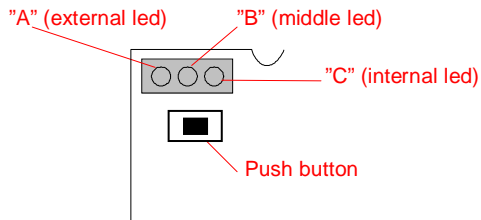
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6) GATEWAY LED/PUSH-BUTTON INTERFACE (USB/RS485 VERSIONS)

The Gateway has three leds through which it is possible to obtain information on the device's operating state.

Furthermore, the Gateway has a push-button which makes it possible to send commands to the device.

Nomenclature of Gateway leds:



Behaviour of leds at the start-up:

At the reset of Gateway all leds lighted for 2 seconds, then all leds flash fast for another 2 seconds.

At the end of flashing, device starts the normal functioning.

How the leds function when the Gateway is NOT on the network:

Led "A" lighted steady, leds "B" and "C" off

How the leds function when the Gateway is on the network:

Led "A": Working State

Slow flashing (1Hz) -> Closed Gateway

Fast flashing (4Hz) -> Opened Gateway

Led "B" (middle led): Radio Link

Turned off -> No router with good link in the proximity

1 flash -> One router with good link in the proximity

2 flashes -> Two routers with good link in the proximity

3 flashes -> Four or more routers with good link in the proximity

Led "C": Radio Activity

Usually turned off

Shortly Lighted on transmitting or receiving a radio message

Creating the network

When the Gateway is not on the network, a pressing of the push button turn led "B" on.

If the push button is not pressed again within ten seconds, the scanning processes starts to search for the best wireless channel.

This scanning process takes approximately 20 seconds, during which only led "B" is on.

Once the scanning process has been completed, the Gateway has created a network and led "B" starts flashing.

Opening the network

When the Gateway is on a network, pressing the push button on the circuit board opens the network (in this case led "A" flash).

Closing the network

When the network is open, pressing the push button on the circuit board closes the network.

If the network is left open, it closes automatically 15 minutes after it having been opened.

7) JOINING NEW DEVICES TO THE NETWORK

New devices can be annexed to the network only when the Network is open.

Once joining has been completed, the device stores the parameters describing the network in its non volatile memory so that, when it is turned off, subsequent operation is not compromised and, when it is turned on again, it will resume functioning on the network it was previously joined to.

The process for join a device to the network differs depending on the type of sensor/actuator involved.

Joining end-device type sensors/actuators to the network

To be joined to the network, end-devices must be stimulated by pressing the push-button on their circuit boards.

The joining process generally takes 20 seconds. Once the process has been completed, if the device did not find an available network, it reverts to energy-saving stand-by mode waiting for the push-button to be pressed again.

Joining router sensors/actuators to the network

To be joined to the network, router type devices do not require any particular stimulation.

If on and not in a network, they automatically scan the ether in search of an available network. This scanning phase runs indefinitely until the router device has found an open network.

8) REMOVING DEVICES FROM THE NETWORK

All devices, including the Gateway, are able to run the operation needed to disconnect them from the network and restore their default status (non joined device).

To perform this operation, press the push-button on the circuit board within 20 seconds of turning on the device and keeping it pressed for more than 10 seconds.

A disconnected device can be reinserted in the previous network by repeating the annexing process. This does not hold for the Gateway; if it is disconnected, any subsequent network creation would cause the device to generate a new network that differs from the previous one. In this case it would be impossible to reach any of the devices in the previous network.

9) GATHERING SENSOR/ACTUATOR DATA

All sensor/actuator devices in a ZB-Connection network send to Gateway radio messages with full description of their status at regular, programmable intervals.

In response to this message, the Gateway sends a message indicating the actions to be performed or any variations to be made to their parameters.

10) ACCESSING SENSOR/ACTUATOR DATA IN READ MODE

The Gateway stores the data transmitted by sensors/actuators in its local memory. These information can be accessed from memory at any time through the Modbus protocol.

When user accesses data of a specific device, these data do not refer to the instant in which the reading is performed but rather refer to the last message received from the specific device.

11) ACCESSING SENSOR/ACTUATOR DATA IN WRITE MODE

A change in a sensor/actuator's parameter is initially written in the memory of the Gateway.

In the case of end-device sensor/actuator, the Gateway sends the message containing the new parameter only after it has received a message from the sensor/actuator itself.

On the other hand, in the case of router sensors/actuators, the Gateway immediately sends out the message containing the new parameter.

12) BASIC NOTIONS ON THE MODBUS PROTOCOL

The data stored in the Gateway can be read and modified using the modbus-RTU protocol if it is a USB/RS485-type Gateway or using the modbus-TCP/IP protocol if it is an Ethernet-type Gateway.

In the case of the modbus-rtu, the communication frame is as follows:

START	ADDRESS	FUNCTION	DATA	CRC	END
delay of 4 bytes	1 byte	1 byte	n bytes	2 bytes	4 byte delay

The CRC is a 16-bit type and it is calculated, in compliance with the modbus standard, with the polynomial $X^{16}+X^{15}+X^2+1$.

The Gateway implements the following function codes:

- 01 - READ COIL STATUS
- 02 - READ INPUT STATUS
- 03 - READ HOLDING REGISTER
- 04 - READ INPUT REGISTER
- 05 - FORCE SINGLE COIL
- 06 - PRESET SINGLE REGISTER

For an extensive indication of the protocol, see the pertinent documentation.

13) MAPPING DEVICE DATA

Each component in the ZB-Connection family of devices has a specific data mapping.

For a description of this mapping, see the pertinent documentation for the individual devices.

14) BASIC NOTIONS ON THE RADIO NETWORK

From the radio point of view, the ZB-Connection devices make up a network built on the zigbee standard from which it inherits its structure and properties. It is a proprietary-type network. For this reason the devices in this network cannot interoperate with other zigbee devices produced by different manufacturers.

From the network point of view, it is composed of three different types of nodes:

- C) Coordinator Node (Gateway)
- R) Router (Repeater) sensors/actuators
- E) End-Device sensors/actuators

A correctly built network is composed of a single **C**-type node and a variable number of **R** and **E**-type nodes.

The **C** (coordinator)-type node has the fundamental task of creating the network. The **R** (router)-type nodes are the basic constituents of the network; they play an active role in maintaining and routing radio traffic from and to other devices in the network.

The prerogative of the **C** and **R**-type nodes is that they are always on and have no constraints regarding power consumption. For this reason the **C** and **R**-type nodes are generally powered from the mains.

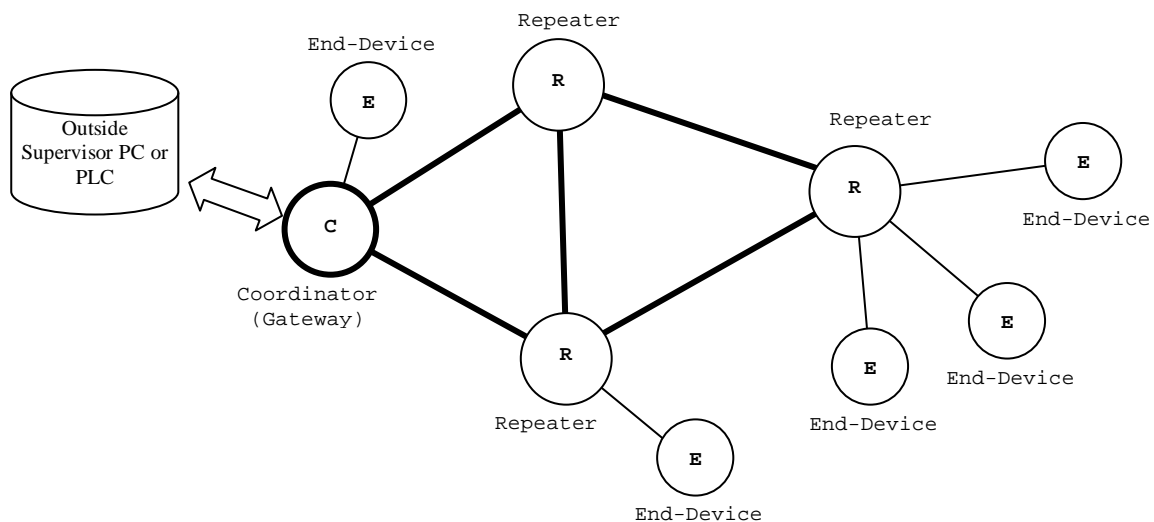
The **E** (End-Device)-type nodes do not actively participate in network management; they engage in a wireless dialogue with the other devices only when this proves necessary to deliver a message (and possibly to receive a response to the message).

For this reason the **E**-type nodes require less power and can thus be powered by a battery allowing a reasonable battery life.

To be able to communicate, the **E**-type nodes must establish an unequivocal link, called relationship, with a **C** or **R**-type node.

For this reason, the **E**-type nodes must be installed in the vicinity of at least one **C** or **R**-type node.

Example of the topology of a ZB-Connection network



15) LIMITATIONS IN THE NUMBER OF DEVICES

In its minimal extension, the ZB-Connection network is composed of one Gateway and one Router or one End-device.

To determine the maximum network extension, that is the maximum number of nodes that can be used in the network, several factors must be taken into consideration.

- 1) Device addressing space: internal Gateway constraints limit the maximum number of devices internally mapped to 112 (with addresses ranging from 16 to 127).
- 2) Maximum Number of End-Devices: The maximum number of end-devices that can, at any one time, be 'children' of a given Router (or Gateway) is 32. Practical questions of safety and redundancy recommend having at least two possible parent routers for each End-Device installed, and this leads to use of at least one router every 16 End-Devices.
- 3) Practical reasons recommend never exceeding the limit of 60 Routers.

16) NOTES ON THE RADIO CAPACITY OF THE DEVICES

The radio capacity of the devices is approximately a hundred meters in the open field, that is without the presence of any obstacles.

In the closed field, the capacity is significantly reduced and highly variable, depending on the individual case.

Often dividing walls or reinforced floors can prove to be insurmountable obstacles.

It is not always possible to determine the best position for the devices, particularly the routers, according to theory; rather it must be determined empirically by trial during the actual installation.

17) NOTES ON BUILDING A NETWORK OF DEVICES

There are some practical rules for correct construction and installation of a network of ZB-Connection devices.

- 1) When possible install the Gateway in a central position respect to the other nodes.
- 2) The Gateway must be able to communicate with at least two routers.
- 3) Each router must be able to communicate with at least two other routers.
- 4) Each router must not be able to communicate with more than sixteen other routers.
- 5) The number of routers must be calculated according to the number of End-Devices. Arrange at least one router every 16 End-Devices.
- 6) Each End-Device must be able to communicate with at least two routers.
- 7) When possible install all devices in high positions and at a distance from metal masses.
- 8) When possible install the devices so that they fall within eyesight.
- 9) Limit the radio traffic as much as possible: experience has taught us that it is best never to exceed an overall maximum number of messages every three seconds. This limit thus becomes the minimum setting for the transmission frequency parameter for each node and this, in turn, depends on the number of nodes in the network. If "n" indicates the number of nodes in the network, we recommend that, for each node, the automatic transmission time must be set greater or equal than "3*n" seconds.