4-NOKS ZIGBEE HOME-AUTOMATION THERMOSTAT

products code:
ZED-TTR-2B-HA

Document Version	Compiling Date	Related Firmware Revision	Author
V2.1	17 February 2015	V1b159-20150130	Franco Pierazzoli

4-noks s.r.l.
Via per Sacile, 158 31018 Francenigo di Gaiarine (TV) - Italy
Tel +39 0434 768462 Fax +39 0438 694617
http://www.4-noks.com/ info@4-noks.com

1) GENERAL CHARACTERISTICS

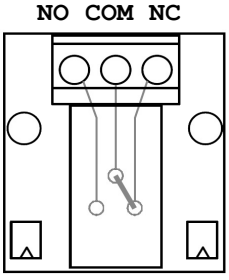
ZED-TTR-HA is a ZigBee Home Automation compliant Thermostat (not yet formally certified). It is a battery-powered device where thermostating function, temperature measuring function and user interface function are all performed by the same device.
The device is equipped with a bistable relay.

2) ELECTRICAL CHARACTERISTICS

POWER SUPPLY	2x1,5V AA Size Battery
BATTERY LIFE TIME	>2 year (at normal conditions)
WIRELESS CHARACTERISTICS	2405 MHz ÷ 2480 MHz DSSS Modulation Nominal transmission Power +8dBm Internal PCB Antenna Chipset Ember/SiliconLabs EM357 Stack EmberZNet5.3.1 IEEE 802.15.4 compliant
ZIGBEE PROFILE	Home Automation Profile (HA1.2) Profile ID: 0x0104 End-Point: 1 (=1) Device ID: 0x0301 (Thermostat) In-Cluster List: 0x0000, 0x0001, 0x0003, 0x000A, 0x0020, 0x0201, 0x0204, 0x0B05 Binding Table Size: 10 Reporting Table Size: 10
MEASURES	NTC Sensor Type 103AT (10K at 25°C; beta=3435K) Measurement range -50°C ÷ +100°C Reading resolution 0,1°C Reading accuracy ±0,5°C
RELAY	Bistable Relay Contacts Rated Current 5A (resistive load) Expected life: 100.000 cycles with resistive load
OPERATING CONDITIONS	-10 ÷ +55°C
PROTECTION CLASS	IP20

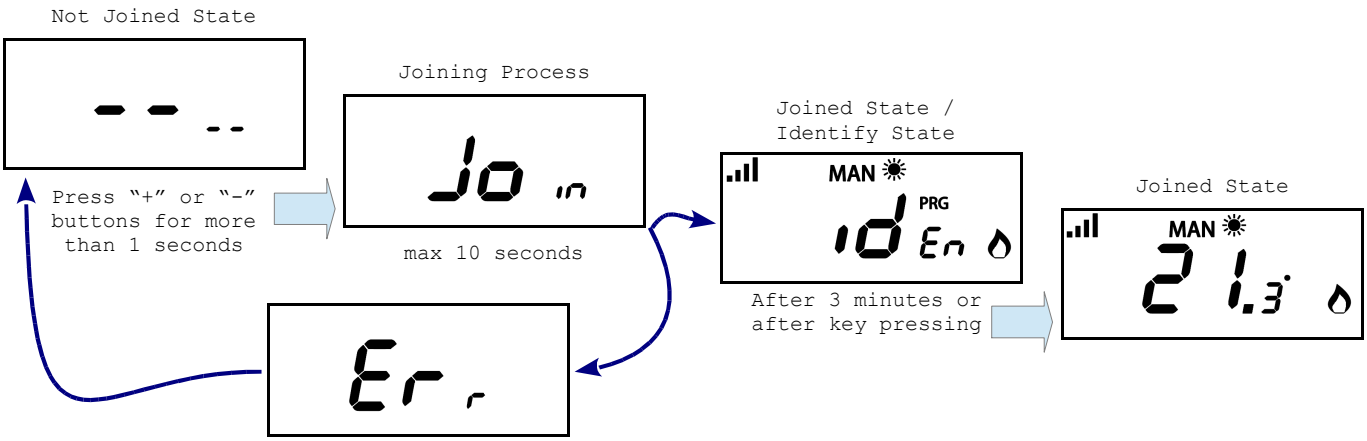
3) DEVICE VIEW

Relay Connections:



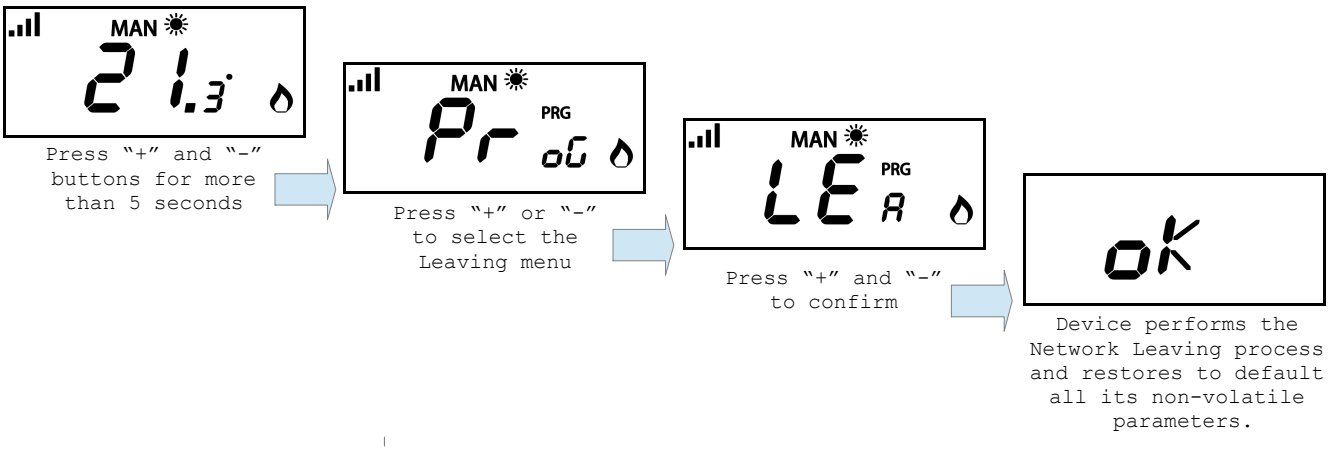
4) JOINING NETWORK

If the device is not part of a ZigBee Network (device not joined), a simple press of one of the device buttons starts the Joining process (Network Steering).
The Joining process consists in the search for a suitable open network through all the sixteen ZigBee channels; this process lasts less than ten seconds during which the device led blinks green.
If no open ZigBee HA network is found, ZED-TTR comes back to the not joined state ("----" message on the LCD), until another press of the device button restarts the joining process.
If the device finds a proper open network it joins to it; from that moment on, the device will keep being part of that network unless further command to quit the network is performed.



5) LEAVING NETWORK

If the device is part of a ZigBee Network (device joined), within one minute from the device reset, enter the "Program"/"Leaving" menu to quit the network.

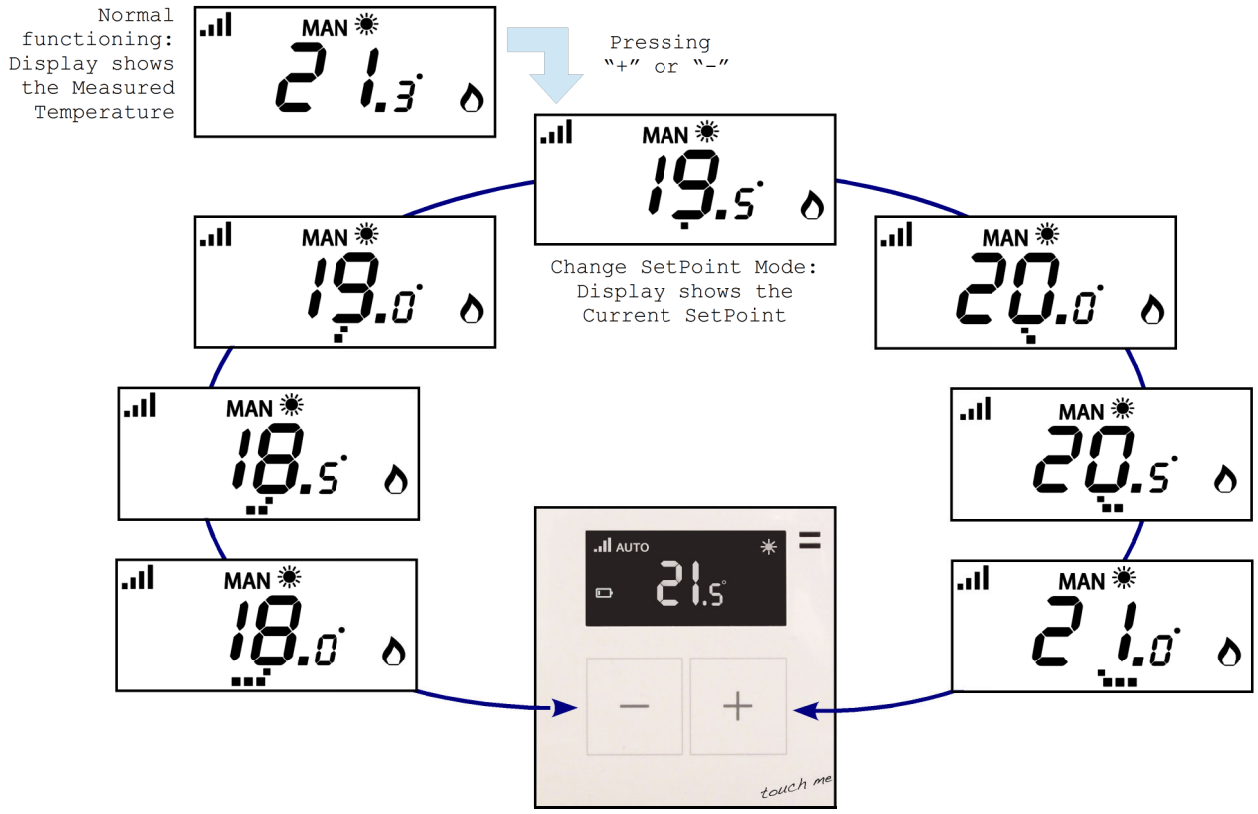


6) COMMISSIONING

If the device is part of a ZigBee Network, enter the "Program"/"Identify" menu to activate the EZ-Mode Target Finding and Binding commissioning process.
The process is also activated at the end of the Joining process, if a suitable network is found.
During this process, the device activates its own identify state and opens the network.
This process lasts maximum 3 minutes during which the device shows "Iden" message.
The process ends earlier if a button is pressed.

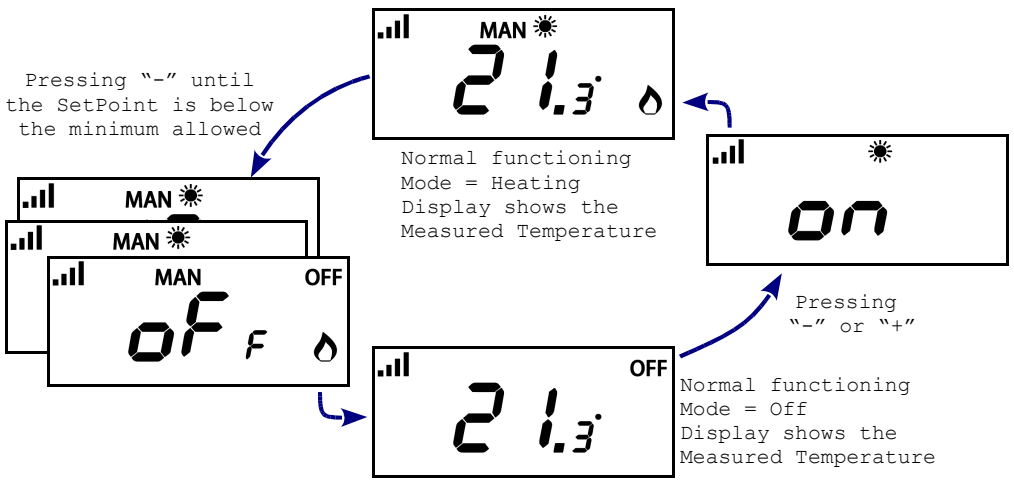
7) CHANGING SETPOINT

By pressing the "+" or "-" button you will enter in the Set-Point change menu.
The activation of this menu is highlighted by the lighting of the mid-point in the second line from the bottom; at the same time it is displayed the current value of the SetPoint.
Repeated or continuous pressing of one of these buttons increases or decreases by 0,5° the value of the Set-Point (within the limits imposed by the minimum and maximum attributes of the thermostat).
The bottom dotted line displays the Set-Point temperature difference compared to the current set-point (in step of 0,5°).
The new Set-Point will be confirmed after 5 seconds of inactivity of the keyboard.



8) CHANGING MODE

The Thermostat Mode selectable depends by "Control Sequence of Operation" attribute (Attribute-ID=0x001B, Cluster-ID=0x0201).
By default it is possible to switch from "Heating Mode" to "Off Mode" and vice versa.
To switch-off the thermostat press "-" button until the Setpoint is below the minimum allowed (default 7°C); to switch-on the thermostat simply press "-" or "+" button.



4-noks s.r.l.
Via per Sacile, 158 31018 Francenigo di Gaiarine (TV) - Italy
Tel +39 0434 768462 Fax +39 0438 694617
http://www.4-noks.com/ info@4-noks.com

9) TEMPERATURE ACQUISITION AND THERMO-REGULATION LOOP

ZED-TTR acquires the temperature measurement using its on-board NTC sensor at the interval of 30 seconds. This time is fixed at firmware level.
After the temperature measurement ZED-TTR executes the thermo-regulation cycle.
Here it compares the temperature value with the set-point value and turn on/off its relay accordingly.

System Mode (Regulation Mode):
The behaviour of the thermo-regulation cycle is managed by the "System Mode" Attribute (AttributeID=0x001C, Cluster-ID=0x0201) which control the thermostat's Off/Cool/Heat state.

System Mode	Temperature In-equation	Relay State
Off (0x00)	//	Off
Cool (0x03)	Temperature >= (Cooling SetPoint + High_Hysteresis)	On
	Temperature <= (Cooling SetPoint - Low_Hysteresis)	Off
Heat (0x04)	Temperature >= (Heating SetPoint + High_Hysteresis)	Off
	Temperature <= (Heating SetPoint - Low_Hysteresis)	On

10) THERMOSTAT SCHEDULER

ZED-TTR supports the weekly schedule extension described in the ZigBee HA specification.
It allows the using of up to 10 schedule-slot per 8 day (Sunday to Saturday plus vacation day). The whole structure is duplicate for Heat Mode and Cool Mode (thus allowing separate schedules for Heating and Cooling).
Each schedule-slot describes a Transitions Time expressed in minutes from midnight and a SetPoint value.
If scheduling is active, ZED-TTR compares its local time with all the schedule-slots relative to the current day; if it finds a match then the SetPoint is set as required by the relative schedule-slot.

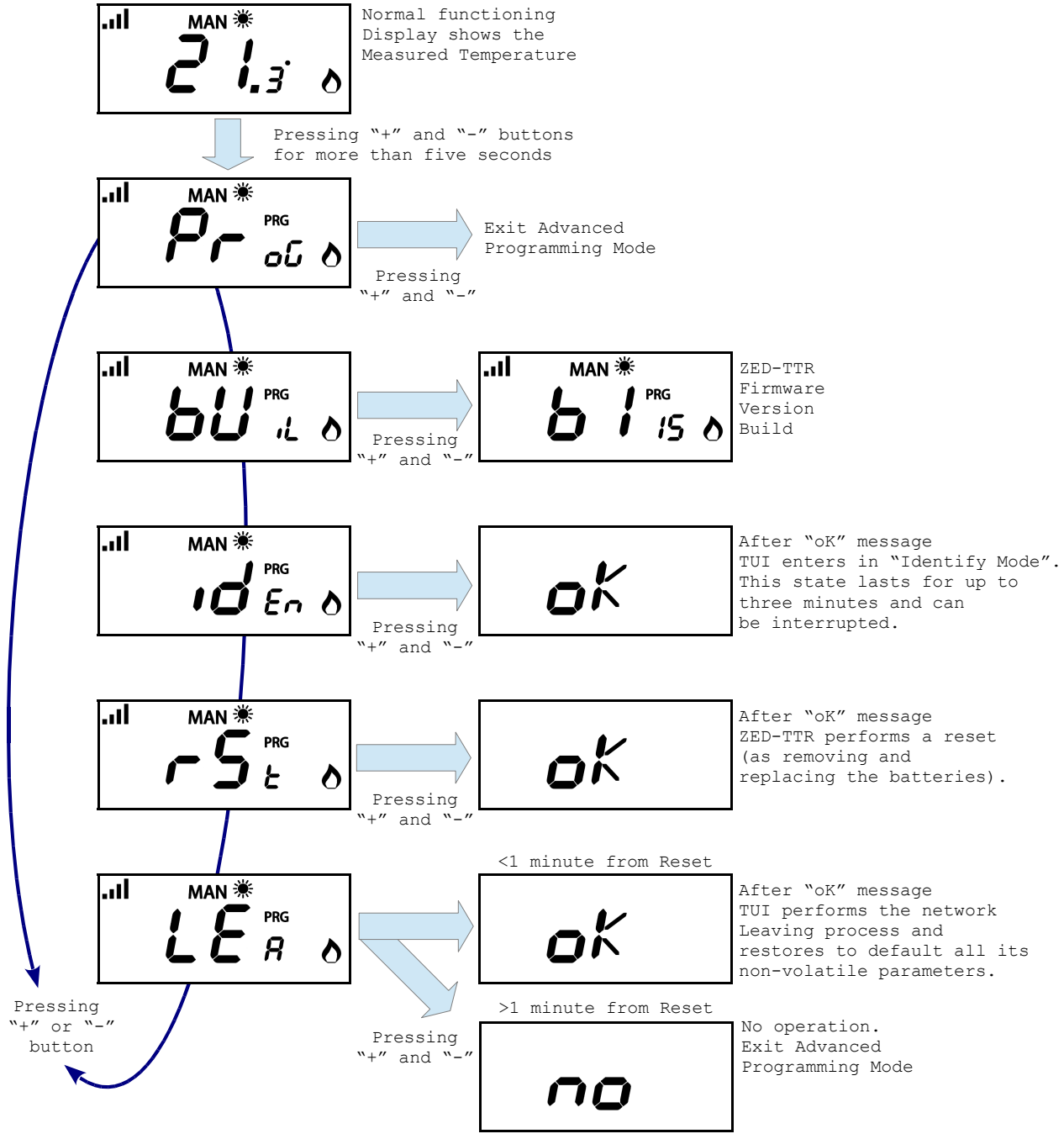
Thermostat Scheduler enabling:
The activation/deactivation of the Thermostat Scheduler is managed by bit#0 of "Thermostat-Programming-Operation-Mode" Attribute (Attribute-ID=0x0025, Cluster-ID=0x0201).

Scheduled Set-Point Overriding:
A manual or remote change to the SetPoint remains unchanged until the next scheduling.

Behaviour at Start-Up:
At the re-ignition of the ZED-TTR after a power failure (or after a reset), the device searches for the first schedule-slot preceding the current time and loads the corresponding SetPoint, this unless the last change of the SetPoint has been remote, in which case the SetPoint will remain until the next scheduling.

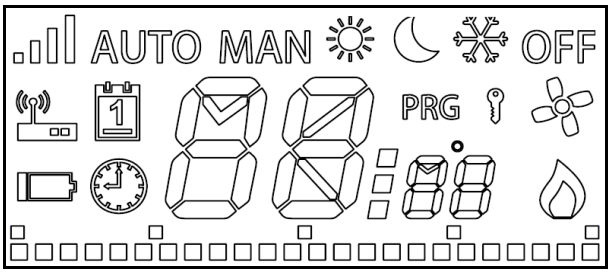
11) ADVANCED PROGRAMMING MODE

By pressing the "+" and the "-" buttons together for more than five seconds you will enter in the "Advanced Programming Mode".
Inside this modality you can force some special commands on the ZED-TTR.



12) LCD

This is the display of the device with all the icons lit:



Meaning of the icons:

Icon	Meaning
	Radio link with radio parent is present no dash → no radio link with radio parent 1 dash → Signal < -80dB (signal weak) 2 dash → Signal -80dB -:- -70dB 3 dash → Signal -70dB -:- -60dB 4 dash → Signal >= -60dB (signal strong)
	Thermostat Scheduler is enable (see note 1)
	Thermostat Off Mode
	Thermostat Heating Mode
	Thermostat Heating Mode – Relay On
	Thermostat Cooling Mode
	Thermostat Cooling Mode – Relay On
	SetPoint changed by ZED-TTR (see note 2)
	SetPoint externally changed (see note 2)
	Gateway Link Icon (see note 3)
	Low Battery Warning (see note 4)
	Advanced Programming Mode
	Keyboard Locked
	Moon – Not used icon
	Calendar – Not used icon

Note 1:
The clock icon is bound to Thermostat Programming Operation Mode attribute (Attribute-ID =0x0025, Cluster-ID =0x0201) and with the presence of a correct time reference.
If the less significant bit of this attribute is set (scheduler active) and the time reference is present then the icon is lighted.

Note 2:
The "MAN" and "AUTO" icons are bound to Set Point Change Source attribute (Attribute-ID =0x0030, Cluster-ID=0x0201) and Setpoint Change Source NetworkId custom attribute (Attribute-ID=0x0201, Cluster-ID=0x0201).

SetPoint Change Source	Setpoint Change Source Network Id	"MAN" and "AUTO" Icons State
<> 2	any	"MAN" unlighted "AUTO" unlighted
= 2	= ZED-TTR Network ID	"MAN" lighted "AUTO" unlighted
= 2	<> ZED-TTR Network ID	"MAN" unlighted "AUTO" lighted

Note 3:
The "GATEWAY" icon is bound to Gateway Link Timer (Attribute-ID=0x0202, Cluster-ID=0x0201) custom attribute. The icon is lighted if this attribute is different by zero. This attribute is decremented to zero each second by ZED-TTR.

Note 4:
The "BATTERY" icons is bound to Battery Alarm State (Attribute-ID=0x003E, Cluster-ID=0x0001). This icon is lighted if the Battery Voltage drops below 2,5V (changeable threshold.

12) ZIGBEE DATA AND REFERENCES

The following sections describes some ZigBee characteristics of the device.
More detailed information can be found in the ZigBee Alliance documents quoted in the references.

REFERENCES:
[R1] ZigBee Document 075123r04ZB - ZigBee Cluster Library
[R2] ZigBee Document 05-3520-29 - ZigBee Home Automation Public Application Profile
[R3] ZigBee Document 075356r16ZB - ZigBee Smart Energy Profile Specification

HA.1) END-POINT

Device Name	ZigBee Node Type	End-Point	Device ID	Main Function
ZED-TTR-RB-HA	Sleepy-end-device	1	0x0301	HA Thermostat

HA.2) CLUSTER LIST

Cluster Name	End-Point	Cluster-ID	Client/Server
Basic	1	0x0000	Server
Power Configuration	1	0x0001	Server
Identify	1	0x0003	Client/Server
Time	1	0x000A	Server
Poll Control	1	0x0020	Server
Thermostat	1	0x0201	Server
Thermostat User Interface Configuration	1	0x0204	Server
Diagnostic	1	0x0B05	Server

HA.3) BINDING TABLE SIZE

The Device's Binding Table (non-volatile) has room for 10 entries

HA.4) REPORTING TABLE SIZE

The Device's Reporting Table (non-volatile) has room for 10 entries

HA.5) EZ-MODE COMMISSIONING

The Device acts as an EZ-Mode Target.
When the EZ-Mode is invoked (by entering in the specific user-menu) it activates its identifying state for up to 3 minutes.

HA.6) POLLING RATE

ZED-TTR is a Sleepy-End-Device, therefore it can receives radio messages only after it has sent to its parent (router) a Polling message (Data Request).
The parent device has the task to keep messages for their children until the receiving of the polling message, this up to a limit of 7,68 seconds (as requested by standard ZigBee HA).
During normal functioning, ZED-TTR sends a poll message each 7 seconds.
After the pressure of any button, ZED-TTR enters in a state of "fast polling" for the duration of 20 seconds, in this state it sends one polling per half second.
ZED-TTR implements the Poll Control Cluster (Cluster-ID 0x0020), therefore it is possible to change the long poll interval and the fast poll interval, moreover it is possible to manage the "Check-in" server-side command in order to simplify the communication management in devices which wish to communicate with ZED-TTR. Note that the poll parameters strongly influence the battery lifetime.

HA.7) REJOIN MECHANISM

The Rejoin process is the process by which a sleepy-end-device already part of a network tries to find another parent (due to the fact that the old parent was deemed as not working).
The rejoin process is very expensive in energy terms, so to preserve the battery life, has been chosen this rejoin strategy:

- At beginning of the orphaning state rejoin each 2 minutes
- After one hours, rejoin each 30 minutes

As a consequence of this, if all the routers in the closeness of ZED-TTR are turned off for more than one hour, when they return to function the ZED-TTR returns to work up to 30 minutes after.

CL.1) SERVER SIDE CLUSTER DESCRIPTION – BASIC CLUSTER (CLUSTER-ID=0x0000)

Implemented Attributes:

Attribute-ID	Name	Attribute Type	Range	Access	Attribute Default Value
0x0000	ZCL Version	0x20 (int8u)	0x00÷0xFF	R-	1
0x0001	Application Version	0x20 (int8u)	0x00÷0xFF	R-	1
0x0002	Stack Version	0x20 (int8u)	0x00÷0xFF	R-	2 (ZigBee Pro)
0x0003	HW Version	0x20 (int8u)	0x00÷0xFF	R-	2
0x0004	Manufacturer Name	0x42 (String)	0÷32 bytes	R-	"4-noks s.r.l."
0x0005	Model Identifier	0x42 (String)	0÷32 bytes	R-	"ZED-TTR-2B-HA"
0x0006	Date Code	0x42 (String)	0÷16 bytes	R-	Serial number
0x0007	Power Source	0x30 (enum8)	0x00÷0xFF	R-	0x03 (Battery)
0x4000	SW Build ID	0x42 (String)	0÷32 bytes	R-	Firmware build like: "V1b159-20150130"

Commands Received (Client to Server):

Command-ID	Name
0x00	Reset to Factory Defaults

CL.2) SERVER SIDE CLUSTER DESCRIPTION – POWER CONFIGURATION CLUSTER (CLUSTER-ID=0x0001)

Implemented Attributes:

Attribute-ID	Name	Attribute Type	Range	Access	Attribute Default Value
0x0020	Battery Voltage	0x20 (int8u)	0x00÷0xFF	R-	--
0x0035	Battery Alarm Mask	0x18 (bit8)	0x00÷0xFF	RW	1
0x0036	Battery Voltage min Threshold	0x20 (int8u)	0x00÷0xFF	RW	25 (2,5 V)
0x003E	Battery Alarm State	0x1B (bit32)	0÷ 2^{32}-1	R-	--

Note about Attribute Battery Voltage (Attribute-ID 0x0020)
This attribute is expressed in tenths of volts (0x1E = 30 → 3,0V) and represents the battery voltage measured by the device each 30 seconds.

Note about Attribute Battery Alarm Mask (Attribute-ID 0x0035)
This attribute is an enabling mask configuration.
The less significant bit of this attribute enables the management of the Battery Alarm flag (default value).

Note about Attribute Battery Voltage Min Threshold (Attribute-ID 0x0036)
This attribute is expressed in tenths of volts.
If the battery value drops below this threshold and the Battery Alarm Mask is enabled then the corresponding bit in Battery Alarm State attribute is set.

Note about Attribute Battery Alarm State (Attribute-ID 0x003E)
If the bit#0=1 (LSB) of this attribute is set it means that the Battery Voltage is below the alarm threshold.
The Battery Alarm Icon is associated to the less significant bit of this attribute.

See specification [R1]

CL.3) SERVER SIDE CLUSTER DESCRIPTION – IDENTIFY CLUSTER (CLUSTER-ID=0x0003)

Implemented Attributes:

Attribute-ID	Name	Attribute Type	Range	Access	Attribute Default Value
0x0000	Identify Time	0x21 (int16u)	0x0000÷ 0xFFFF	RW	0

Commands Received (Client to Server):

Command-ID	Name
0x00	Identify
0x01	Identify Query

Commands Generated (Server to Client):

Command-ID	Name
0x00	Identify Query Response

See specification [R1]

CL.4) SERVER SIDE CLUSTER DESCRIPTION – TIME CLUSTER (CLUSTER-ID=0x000A)

Implemented Attributes:

Attribute-ID	Name	Attribute Type	Range	Access	Attribute Default Value
0x0000	Time	0xE2 (UTC Time)	0÷ 2^{32}-1	RW	0
0x0001	Time Status	0x18 (bit8)	0000xxxx	RW	0
0x0002	Time Zone	0x2B (int32s)	-86400 ÷ +86400	RW	0
0x0003	Daylight Saving Time Start	0x23 (int32u)	0÷ 2^{32}-1	RW	0
0x0004	Daylight Saving Time End	0x23 (int32u)	0÷ 2^{32}-1	RW	0
0x0005	Daylight Saving Time Shift	0x2B (int32s)	-86400 ÷ +86400	RW	0
0x0006	Standard Time	0x23 (int32u)	0÷ 2^{32}-1	R-	0

0x0007	Local Time	0x23 (int32u)	0÷ 2^{32}-1	R-	0
0x0008	Last Set Time	0xE2 (UTC Time)	0÷ 2^{32}-1	R-	0xFFFFFFFF
0x0009	Valid Until Time	0xE2 (UTC Time)	0÷ 2^{32}-1	RW	0xFFFFFFFF

Note about Attribute Time Status (Attribute-ID 0x0001)
ZED-TTR allows only setting/resetting of bit#1 (Synchronized) of this Attribute.

Note about Attribute Valid Until Time (Attribute-ID 0x0009)
ZED-TTR sets this attribute with the value of UTC Time immediately after a setting of the time.

Time Reference
The time reference is required for the properly operation of the Thermostat Scheduler.
ZED-TTR is not provided with a backup-battery Real Time Clock (RTC) therefore it does not retain a precise time reference through the absence of power supply (battery-replacement).
The internal crystal oscillator used has an error of about ±100ppm, therefore the expected time reference error is about ±5 minutes per month.

Gateway Requirements
The customer's Gateway has the responsibility of maintenance a more precise time reference, the setting of the correct TimeZone and the setting of the annual beginning/end of summer time (DST).

To do that the Gateway must:
1) implements the Server-Side Time Cluster (Cluster-ID 0x000A).
2) keeps its UTC Time Attribute (Attribute-ID 0x0000) as precise as possible.
3) sets the correct value to its TimeZone Attribute (Attribute-ID 0x0002).
4) sets the correct value to its (annually changing) Dst Start, Dst End, Dst Shift Attributes (Attribute-ID 0x0003, 0x0004, 0x0005).
5) sets bit#0 (Master) and/or bit#3 (Superseding) and sets bit #2 (Master Zone Dst) on the Time Status Attribute (Attribute-ID 0x0001)

Time Reference Synchronization
ZED-TTR synchronizes its time reference following the rules described in ZigBee Cluster Library Specification.
After a time between 2 and 10 minutes from the reset (chosen randomly), and every 24 hours post, ZED-TTR looks for the best time server presents on its radio network.
If it finds a suitable time server then it collects the relevant time attributes.

Note on Time Attributes

The Utc Time Attribute (Attribute-ID 0x0000) is expressed in seconds from 1/1/2000.

Standard Time Attribute (Attribute-ID 0x0006) is calculated as:
Standard Time = Utc Time + TimeZone

Local Time Attribute (Attribute-ID 0x0007) is calculated as:
Local Time = Standard Time (if Utc Time is not between Dst Start and End)
Local Time = Standard Time + Dst Shift (if Utc Time is between Dst Start and End)

Thermostat Scheduler uses the Local Time Attribute.

All the time attributes except Utc Time, Standard Time and Local Time, are saved in non-volatile memory.

CL.5) SERVER SIDE CLUSTER DESCRIPTION – POLL CLUSTER (CLUSTER-ID=0x0020)

Implemented Attributes:

Attribute-ID	Name	Attribute Type	Range	Access	Attribute Default Value
0x0000	Check-in Interval	0x23 (int32u)	0 ÷ 0x6E0000	RW	57600 (4 hours)
0x0001	Long Poll Interval	0x23 (int32u)	0 ÷ 0x6E0000	R-	28 (7 sec)
0x0002	Short Poll Interval	0x21 (int16u)	0x0001 ÷ 0xFFFF	R-	2 (0,5 sec)
0x0003	Fast Poll Time Out	0x21 (int16u)	0x0001 ÷ 0xFFFF	RW	240 (60 sec)
0x0004	Check-in Interval Min	0x23 (int32u)	-	R-	180 (45 sec)
0x0005	Long Poll Interval Min	0x23 (int32u)	-	R-	20 (5 sec)
0x0006	Fast Poll Time Out Max	0x23 (int32u)	-	R-	480 (120 sec)

Commands Received (Client to Server):

Command-ID	Name
0x00	Check-in Response
0x01	Fast Poll Stop
0x02	Set Long Poll Interval
0x03	Set Short Poll Interval

Commands Generated (Server to Client):

Command-ID	Name
0x00	Check-in

Note about Check-in server to client command:
This command is sent to all devices which are bound with ZED-TTR through the cluster Poll Control.
This command is sent at the frequency controlled by the Check-in Interval attribute.
This command expects a Check-in Response command sent back from the Poll Control Client.
If ZED-TTR does not receive a Check-in Response it returns to the normal polling rate, according to the Long Poll Interval Attribute.

Note that the poll parameters strongly influence the ZED-TTR battery lifetime.

See specification [R2]

CL.6) SERVER SIDE CLUSTER DESCRIPTION – THERMOSTAT CLUSTER (CLUSTER-ID=0x0201)

Implemented Attributes:

Attribute-ID	Name	Attribute Type	Range	Access	Attribute Default
0x0000	Local Temperature	0x29 (int16s)	0x954D ÷ 0x7FFF	R-	--
0x0001	Outdoor Temperature	0x29 (int16s)	0x954D ÷ 0x7FFF	R-	--
0x0002	Occupancy	0x18 (bit8)	0000000x	R-	1
0x0003	Abs Min Heat Setpoint Limit	0x29 (int16s)	0x954D ÷ 0x7FFF	R-	700 (7°C)
0x0004	Abs Max Heat Setpoint Limit	0x29 (int16s)	0x954D ÷ 0x7FFF	R-	300 (30°C)
0x0005	Abs Min Cool Setpoint Limit	0x29 (int16s)	0x954D ÷ 0x7FFF	R-	1600 (16°C)
0x0006	Abs Max Cool Setpoint Limit	0x29 (int16s)	0x954D ÷ 0x7FFF	R-	3200 (32°C)
0x0010	Local Temperature Calibration	0x28 (int8s)	0xE7 ÷ 0x19	RW	0 (0°C)
0x0011	Occupied Cooling Setpoint	0x29 (int16s)	Min ÷ Max Cool SetPoint Limit	RW	2600 (26°C)
0x0012	Occupied Heating Setpoint	0x29 (int16s)	Min ÷ Max Heat SetPoint Limit	RW	2000 (20°C)
0x0013	Unoccupied Cooling Setpoint	0x29 (int16s)	Min ÷ Max Cool SetPoint Limit	RW	2600 (26°C)
0x0014	Unoccupied Heating Setpoint	0x29 (int16s)	Min ÷ Max Heat SetPoint Limit	RW	2000 (20°C)
0x0015	Min Heat Setpoint Limit	0x29 (int16s)	0x954D ÷ 0x7FFF	RW	700 (7°C)
0x0016	Max Heat Setpoint Limit	0x29 (int16s)	0x954D ÷ 0x7FFF	RW	3000 (30°C)
0x0017	Min Cool Setpoint Limit	0x29 (int16s)	0x954D ÷ 0x7FFF	RW	1600 (16°C)
0x0018	Max Cool Setpoint Limit	0x29 (int16s)	0x954D ÷ 0x7FFF	RW	3200 (32°C)
0x001B	Control Sequence Of Operation	0x30 (enum8)	0 ÷ 5	R-	2 (Heating)
0x001C	System Mode	0x30 (enum8)	0 ÷ 5	RW	4 (Heat)
0x0020	Start Of Week	0x30 (enum8)	0 ÷ 6	R-	0
0x0021	Number Of Weekly Transitions	0x20 (int8u)	0 ÷ 0xFF	R-	70
0x0022	Number Of Daily Transitions	0x20 (int8u)	0 ÷ 0xFF	R-	10
0x0025	Thermostat Programming Operation Mode	0x18 (bit8)	00xxxxxx	RW	0

0x0029	Thermostat Running State (hvac relay state)	0x19 (Bit16)	000000xx	R-	0
0x0030	Setpoint Change Source	0x30 (enum8)	0 ÷ 0x02	R-	0
0x0031	Setpoint Change Amount	0x29 (int16s)	0 ÷ 0xFFFF	R-	0x8000
0x0032	Setpoint Change Source Timestamp	0xE0 (DayTime)	0 ÷ 0xFFFFFFFF	R-	1

Commands Received (Client to Server):

Command-ID	Name
0x00	Setpoint Raise/Lower
0x01	Set Weekly Schedule
0x02	Get Weekly Schedule
0x03	Clear Weekly Schedule

Commands Generated (Server to Client):

Command-ID	Name
0x00	Current Weekly Schedule

Note about Attribute Local Temperature (Attribute-ID 0x0000)
This value represents the local temperature, measured by the built-in probe.
This value is used in the thermo-regulation cycle.

Note about Attribute Outdoor Temperature (Attribute-ID 0x0001)
Same value present on the above attribute.

Note about Attribute Occupancy (Attribute-ID 0x0002)
Currently the Occupancy sensor management is not yet implemented, the value of this attribute is fixed to 1 (space occupied).

Note about Attribute Local Temperature Calibration (Attribute-ID 0x0010)
This attribute is used to correct the temperature of the local thermal measure.

Note about Attribute Control Sequence Of Operation (Attribute-ID 0x001B)
This Attribute is used to permit or not the selection of Cooling and Heating Mode.

Control Sequence of Operation	Description	Possible values of System Mode
0x00	Cooling Only	0x00(Off) / 0x03(Cool)
0x01	Cooling with Reheat	0x00(Off) / 0x03(Cool)
0x02 (Default)	Heating Only	0x00(Off) / 0x04(Heat)
0x03	Heating with Reheat	0x00(Off) / 0x04(Heat)
0x04	Cooling and Heating 4-pipes	0x00(Off) / 0x03(Cool) / 0x04(Heat)
0x05	Cooling and Heating 4-pipes with Reheat	0x00(Off) / 0x03(Cool) / 0x04(Heat)

Note about Attribute System Mode (Attribute-ID 0x001C)
This Attribute is used to chose the thermo-regulation mode.

System Mode	Description
0x00	Off
0x03	Cool
0x04 (Default)	Heat

Other values are not allowed.

Note about Attribute Thermostat Programming Operation Mode (Attribute-ID 0x0025)
Bit#0 of this attribute controls the enabling of the Thermostat Scheduler.

Note about Attribute SetPoint Change Source (Attribute-ID 0x0030)
This Attribute is used to determine the source of the last changing of the SetPoint.

SetPoint Change Source	Description
0x00	Manual, user-initiated SetPoint change via the thermostat
0x01	Schedule/internal programming-initiated SetPoint change
0x02	Externally-initiated SetPoint change

Other values are not allowed.

Note about Thermostat Scheduler Programming (Command-ID 0x01)
The Thermostat Scheduler programming procedure follows the ZigBee HA specifications (see [R2], Paragraph 10.2.3.4.1.1 (Set Weekly Schedule), page 325).

Example:
you want the schedule will be made as follows:

Time 06.30 → SetPoint = 22,5°C
Time 08.30 → SetPoint = 18,0°C
Time 12.00 → SetPoint = 20,0°C

This only for days:
Monday, Tuesday, Thursday, Friday

This only for the Heat mode.

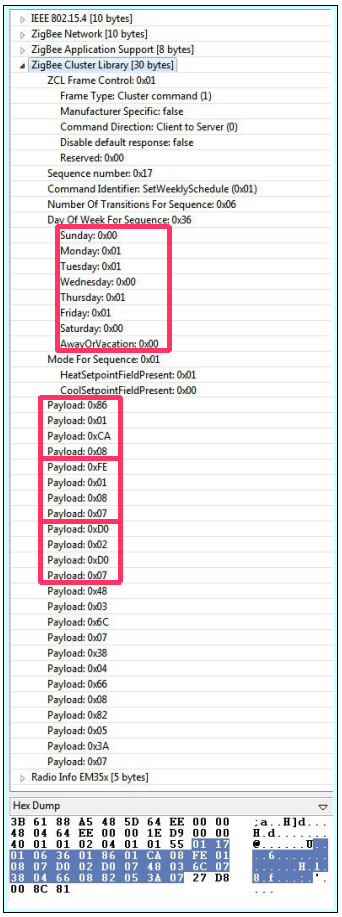
This translates into the programming of 6 schedule-slots.

1° slot:
Time 06.30 = 390 minutes from midnight = 0x0186
Heat SetPoint = 22,5°C = 2250 (cents)°C = 0x08CA

2° slot:
Time 08.30 = 510 minutes from midnight = 0x01FE
Heat SetPoint = 18,0°C = 1800 (cents)°C = 0x0708

3° slot:
Time 12.00 = 720 minutes from midnight = 0x02D0
Heat SetPoint = 20,0°C = 2000 (cents)°C = 0x07D0

To the right the message sent from Gateway to a ZED-TTR, captured by the Ember radio sniffer.



CL.7) SERVER SIDE CLUSTER DESCRIPTION
THERMOSTAT USER INTERFACE CONFIGURATION CLUSTER (CLUSTER-ID=0x0204)

Implemented Attributes:

Attribute-ID	Name	Attribute Type	Range	Access	Attribute Default
0x0000	Temperature Display Mode	0x30 (enum8)	0 ÷ 1	RW	0
0x0001	Keypad Lockout	0x30 (enum8)	0 ÷ 5	RW	0
0x0002	Schedule Programming Visibility	0x30 (enum8)	0 ÷ 1	RW	0

Note about Attribute Temperature Display Mode (Attribute-ID 0x0000)
- 0 → temperature unit °C
- 1 → temperature unit °F

Note about Attribute Keypad Lockout (Attribute-ID 0x0001)
- 0 → No Lookout
- 1 → Mode Looked
- >=2 → Mode and SetPoint looked

Note about Attribute Schedule Programming Visibility (Attribute-ID 0x0002)
This attribute is not yet used

CL.8) SERVER SIDE CLUSTER DESCRIPTION – DIAGNOSTIC CLUSTER (CLUSTER-ID=0x0805)

Implemented Attributes:

Attribute-ID	Name	Attribute Type	Range	Access
0x0000	Number of Resets	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0104	Mac Tx Unicast Retry	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0105	Mac Tx Unicast Fail	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0106	APS Rx Broadcast	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0107	APS Tx Broadcast	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0108	APS Rx Unicast	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0109	APS Unicast Success	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x010A	APS Tx Unicast Retries	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x010B	APS Tx Unicast Failures	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x010C	Route Discovery Initiated	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x010D	Neighbour Added	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x010E	Neighbour Removed	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x010F	Neighbour Stale	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0110	Join Indication	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0111	Child Moved	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0112	NWK Frame Control Failure	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0113	APS Frame Control Failure	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0114	APS Unauthorized Key	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0115	NWK Decrypt Failures	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0116	APS Decrypt Failures	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0117	Packet Buffer Allocate Failures	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0118	Relayed Unicast	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x0119	Phy to MAC queue limit reached	0X21 (int16u)	0 ÷ 0xFFFF	R-
0x011A	Packet Validate drop count	0X21 (int16u)	0 ÷ 0xFFFF	R-

CC.1) 4-NOKS MANUFACTURER SPECIFIC EXTENSIONS

The device has some manufacturer specific extensions added to the standard ZigBee Clusters by using Manufacturer Specific Commands and Manufacturer Specific Attributes. These functionalities are accessible by using the 4-Noks's Manufacturer Code 0x1071.

CC.2) 4-NOKS SPECIFIC EXTENSIONS – BASIC CLUSTER (CLUSTER-ID=0x0000)

4-Noks Specific Commands Received (Client to Server):

Command-ID	Name	Payload Size	Payload
0xFC	4-NOKS COMMAND	2	1° int16u: Command value

List of 4-NOKS COMMAND values and their action:

4-NOKS COMMAND value	Command Issued
0x1968	Activate Bootloader (for OTA firmware upgrade)
0x196E	Reload Default Parameters
0x196F	non-volatile memory total initialize
0x1970	Reset
0x1971	Disassociation
0x1972	Disassociation with reload default parameters
0x1973	Disassociation with non-volatile memory total initialize
0x1975	Rejoin
0x2100 -:- 0x21FF	Change Transmission Power (value in the low byte, from -30 to 8)

CC.3) 4-NOKS SPECIFIC EXTENSIONS – THERMOSTAT CLUSTER (CLUSTER-ID=0x0201)

4-Noks Specific Implemented Attributes:

Attribute-ID	Name	Attribute Type	Range	Access	Attribute Default Value
0x0101	Thermostat High Hysteresis	0x21 (int16u)	0 ÷ 0x03E8	RW	25 (0,25°C)
0x0102	Thermostat Low Hysteresis	0x21 (int16u)	0 ÷ 0x03E8	RW	25 (0,25°C)
0x0201	Setpoint Change Source Network-ID	0x21 (int16u)	0 ÷ 0xFFFF	RW	0xFFFF
0x0201	Gateway Link Timer	0x21 (int16u)	0 ÷ 0xFFFF	RW	0

Note aboute Hysteresis Attributes (Attribute-ID 0x0101, 0x0102):
The two custom attributes control the high value of hysteresis (hysteresis added to the set-point) and the low value of hysteresis (hysteresis subtracted to the set-point).
The default value of both these attributes is 0,25°C.

Note about custom Attribute Setpoint Change Source NetworkId (Attribute-ID 0x0201)
This is the Network-ID of the source of the last radio SetPoint change.

Note about custom Attribute Gateway Link Timer (AttributeID 0x0202)
If this attribute is set to a value different by zero, then it is decremented by ZED-TTR by one unit per second. If the value of this attribute is different by zero the "Gateway" icon on the ZED-TTR is switched on.