LED Zone Controller

LEDR / LEDD / TCM 330

28 October 2016

Observe precautions! Electrostatic sensitive devices!

Patent protected:
WO98/36395, DE 100 25 561, DE 101 50 128,
WO 2004/051591, DE 103 01 678 A1, DE 10309334,
WO 04/109236, WO 05/096482, WO 02/095707,
US 6,747,573, US 7,019,241

REVISION HISTORY

The following major modifications and improvements have been made to this document:

Version	Author	Released	Date	Major Changes
1.00	MKA	MKA	07.07.2015	First public release
1.01	MKA	MKA	20.08.2015	Minor typo corrections
1.02	MKA	MKA	06.09.2016	Added behaviour after power loss
1.1	MKA	MKA	27.10.2016	Added default values to RECOM parameters

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The modules must not be used in any relation with equipment that supports, directly or indirectly, human health or life or with applications that can result in danger for people, animals or real value.
Components of the modules are considered and should be disposed of as hazardous waste. Local government regulations are to be observed.
Packing: Please use the recycling operators known to you.

TABLE OF CONTENT

1 INTRODUCTION AND RELATED DOCUMENTS

This document describes in detail the operation of EnOcean LED Zone Controllers (LEDR and LEDD products) which are based on the EnOcean TCM 330 module. If certain aspects apply only to one of these products then this is specifically mentioned.

Please familiarize yourself with the documentation of LEDR, LEDD and TCM 330 before continuing which can be found under the following addresses:

LEDR
https://www.enocean.com/en/enocean_modules_902mhz/led-relay-zone-controller-0-10v-ledr-oem/

LEDD
https://www.enocean.com/en/enocean_modules_902mhz/led-zone-controller-0-10v-ledd-oem/

TCM 330
https://www.enocean.com/en/enocean_modules_902mhz/tcm-330u/

EnOcean LED Zone Controllers work in conjunction with EnOcean wireless switches, occupancy sensors and light level sensors. Examples of these products include the following:

EnOcean Single and Double Rocker Switches (ESRP and EDRP)
https://www.enocean.com/en/enocean_modules_902mhz/wireless-switch-esrp-edrp-oem/

EnOcean Ceiling-mounted Occupancy Sensor (EOSC)
https://www.enocean.com/en/enocean_modules_902mhz/ceiling-mounted-occupancy-sensor-eosc-oem-1/

EnOcean Wall-mounted Occupancy Sensor (EOSW)
https://www.enocean.com/en/enocean_modules_902mhz/wall-mounted-occupancy-sensor-eosw-oem-1/

EnOcean Light Level Sensor (ELLS)
https://www.enocean.com/en/enocean_modules_902mhz/light-level-sensor-ells-oem/

2 GENERAL DESCRIPTION

2.1 Basic functionality

EnOcean LED Zone Controllers use wireless technology to communicate with other self-powered EnOcean based products to provide simple yet powerful solutions for dimming control of LED lighting.

They can control the dim level of connected LED light sources based on input from the following devices:

- Wireless Switches
- Occupancy Sensors
- Light Level Sensor
- Central Controller
- Demand Response Controller

Such solutions enable advance lighting control compliant with California Title 24 daylight harvesting scenarios.

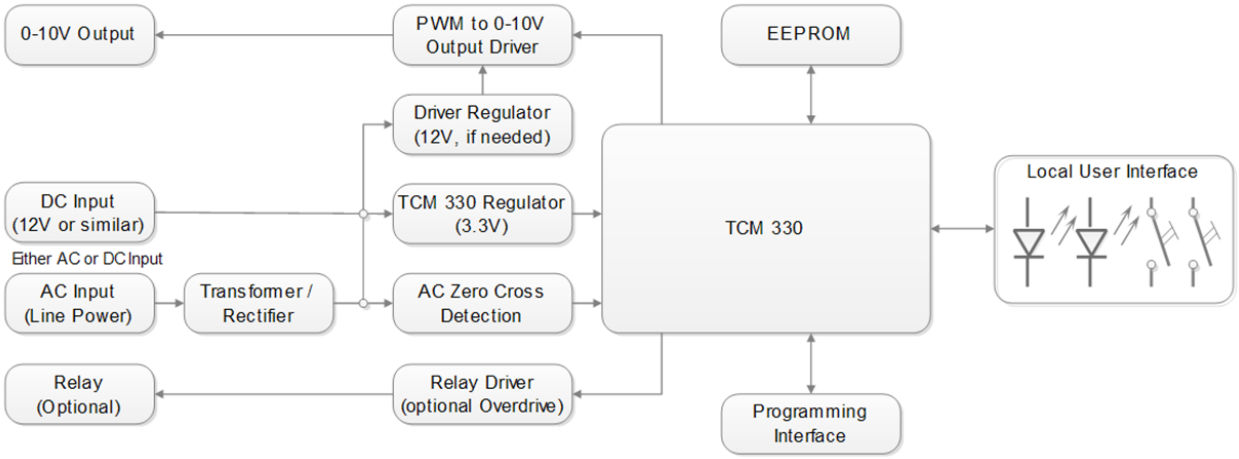
EnOcean LED zone controller enable both simple configuration via a local 2 button interface and advanced over-the-air parameterization using the EnOcean Remote Commissioning standard and the Navigan NWC 300 installation tool.

Built-in operating modes

- Switch ON / OFF and Dim UP / DOWN based on input from wireless switches
- Occupancy-controlled lighting based on input from wireless occupancy sensors
- Daylight-controlled lighting based on input from a Light Level Sensor
- Central control based on input from a gateway or controller
- Demand response based on input from a demand response controller

2.2 System architecture

The system architecture of EnOcean LED Zone Controllers is shown below.



2.2.1 Device Variants

EnOcean LED Zone Controllers are available in two system configurations:

- LEDD - DC (typically 12V) supplied system without relay
  Supply voltage is typically provided by an auxiliary power output of the LED driver.
  Line voltage transformer and rectifier are not implemented.
  The supply voltage of the LED driver is not controlled (no relay circuitry is implemented).

- LEDR - AC (line power) supplied system with relay
  Line power is used as supply voltage.
  Line power supply to the LED driver can be controlled by a relay in order to save power when the LED driver is in OFF state.

Both variants control the output of the connected LED driver by means of a 0-10V analog interface.

3 FUNCTIONAL INFORMATION

3.1 General description

EnOcean LED zone controllers provide simple solutions for dimming control of LED lighting. They can be wirelessly linked to EnOcean-based motion sensors, rocker switches and a light level sensor.

Central control is possible by linking the LED zone controller to a central controller or via a gateway to building automation systems like BACnet.

EnOcean LED zone controllers can be wirelessly configured over the air using the EnOcean Remote Commissioning standard. Configurable parameters are marked in *Italics* in the following chapters.

3.2 System components

Wireless lighting control systems based on EnOcean LED zone controllers contain one or several of the following components:

- EnOcean LED zone controllers
  EnOcean LED zone controllers receive input from linked devices and control the LED light level using 0-10V and relay (LED zone controller only) outputs.
  Each LED zone controller is connected to an LED driver which in turn supplies the LED string of the light source.

- Wireless switches
  Wireless switches can be used to send switch on / off and dim up / down commands to the LED zone controller

- Wireless occupancy sensors
  Wireless occupancy sensors can be used to signal presence or absence of persons in their vicinity to the LED zone controller

- Wireless light level sensors
  Wireless light level sensors can be used to report the amount of external light (typically daylight) being present in their vicinity

- Central controller
  Central controller can be used to provide a centralized control and user interface to the lighting control system. It can also act as a gateway to a building automation system like BACnet.

- Demand response controller
  Demand response controller can instruct LED zone controllers to temporarily reduce output setting to conserve energy during periods of energy shortage

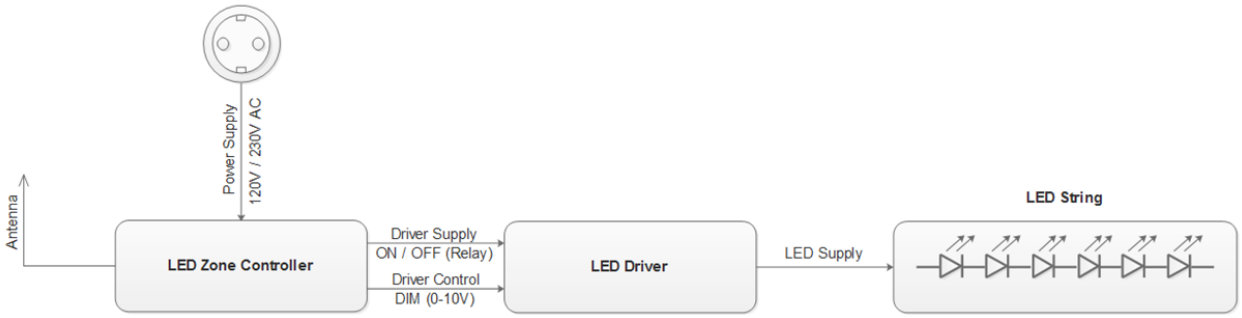
3.3 LED zone controller

EnOcean LED zone controllers act as the central receiver and processor of input data (commands or status messages) from linked components.

Based on this input data, they determine the appropriate lighting level and set the output signals connected to the LED Driver accordingly.

The LED driver then adjusts LED supply voltage and supply current such that the commanded light level is achieved.

The typical system setup for a line powered LED zone controller is shown below.



EnOcean LED zone controllers receive wireless input in the form of EnOcean wireless radio telegrams.

Power is provided by means of an AC power supply input (LED zone controller) or alternatively a DC input (LEDD).

LED zone controllers control the connected LED driver using two signals:

- Driver control signal (0-10V Output)
  LED zone controller signals the required dim level to the LED driver using a standard 0-10V interface where 0V means no illumination (OFF) while 10V means maximum illumination.

- Driver power supply (Relay Output – LEDR only)
  LED zone controller can control line power supply (120V AC) to the LED Driver by means of an integrated relay. In such setup, power to the LED driver would be provided only if the light is commanded to be ON.

Based on these signals, the connected LED driver will then set the right supply voltage and supply current to the LED string in order to achieve the requested illumination level.

3.3.1 PWM output functionality

The minimum output voltage can be configured using *MinVoltageLevel* (default 10% = 1.0V) and the maximum output using *MaxVoltageLevel* (default 100% = 10.0V). Dimming below *MinVoltageLevel* or above *MaxVoltageLevel* is not possible.

Level and ramp percentage levels given throughout this document refer to the interval between *MinVoltageLevel* (1%) and *MaxVoltageLevel* (100%). An output level of 0% equals OFF state.

3.3.2 Status message functionality

EnOcean LED zone controllers can report their current status at random intervals to a central controller or gateway. This functionality can be used both to enable system status control and to provide status visualization via a user interface.

LED zone controller can transmit a status message based on EnOcean Equipment Profile (EEP) D2-40-00 after each change of its output state (event-based messages) or periodically with a random delay after the *StatusMessageTimer* has elapsed.

Status messages can be switched off completely by setting *StatusMessageTimer* to 0.
Setting *StatusMessageTimer* to 0xFFFF will cause only event-based messages to be sent.

The following parameters are reported as part of the status message:

- Output state (OFF / ON)
  0x0: Output state = OFF
  0x1: Output state = ON

- Output dim level
  0x00 = 0%
  0xC8 = 100%

- Cause for transmitting the status message
  0x0 = Event
  0x1 = Heartbeat

- Occupancy state
  0x0 = not occupied (OccAutoOffTimer has timed out)
  0x1 = occupied
  0x2 = unknown (No occupancy information available)

- Daylight harvesting mode
  0x0: Daylight harvesting not active (no light level sensor is linked)
  0x1: Daylight harvesting active (light level sensor is linked)

- Demand response mode
  0x0: Demand response mode is not active
  0x1: Demand response mode is active

3.3.3 Repeater functionality

EnOcean LED zone controllers can provide repeater functionality.

Repeaters are used to extend radio range as they retransmit received telegrams after a random delay. LED zone controllers support both first level repeating (repeating only original telegrams) and second level repeating (where telegrams from a first level repeater are repeated for a second time).

Repeating in general and second level repeating in particular should be used only if required based on careful planning as it significantly increases radio traffic and thereby the likelihood of radio telegram collisions.

EnOcean LED zone controllers provide the option for Link-based Repeating where only such telegrams are repeated that originate from devices that they linked to.
The *RepeateLinkedDevicesOnly* option is enabled by default and should be disabled only if required.

3.3.4 Behaviour after temporary power loss

The behaviour of EnOcean LED zone controllers in case of a temporary power loss can be configured using the *ModeAfterPowerLoss* parameter.

In its default setting (*LAST STATE*), the device output will return to the last functional state that was set by a linked rocker switch.If the LED zone controller had most recently been switched ON via a linked rocker switch then the output will be set back to ON state after a temporary power loss. Conversely, if the LED zone controller had most recently been switched OFF via a linked rocker switch then light will remain OFF after a temporary power loss.

If the *ModeAfterPowerLoss* parameter is set to *ON* then the LED zone controller will set the output to ON state after a temporary power loss.

If the *ModeAfterPowerLoss* parameter is set to *OFF* then the LED zone controller output will remain in OFF state after a temporary power loss.

3.4 Wireless switches

Energy harvesting wireless switches provide the flexibility and ease of use provided by wireless solutions without the need for maintenance found in battery-operated devices.

Energy harvesting wireless switches can be freely positioned anywhere within the radio range of the EnOcean LED zone controller. Setup is very easy as no wiring is required.

Energy harvesting wireless switches can be used to dim (adjust the illumination level) UP and DOWN or to switch the light ON (either to maximum or to system-defined brightness) and OFF.

Energy harvesting wireless switches can usually be either single rocker or dual rocker designs. The picture below shows an example of each design.

Additional product information for these energy harvesting switches can be found here:

https://www.enocean.com/en/enocean_modules_902mhz/wireless-switch-esrp-edrp-oem/

EnOcean LED zone controllers can accept input from up to 20 wireless switches using EnOcean End Equipment Profile (EEP) F6-02-02.

3.4.1 Functional behaviour of wireless switches

Wireless switches are used to manually set the desired light level.

EnOcean LED zone controllers can receive input from up to 20 wireless switches using EnOcean Equipment Profile F6-02-02. The following actions are supported for wireless switches:

- Short click (<0.7s) on “I” button
  Light comes ON and brightens from *MinVoltageLevel* (default 1.0V) to the most recent dimming value.
  At first usage or after a reset, the output will be switched to *MinVoltageLevel*.
  The rate of brightening is defined by *RockerSwitchOnSpeed* (default 20% per second).

- Double click (<0.7s) on “I” button
  Light is switched ON at *MaxVoltageLevel* (default 10.0V).
  The rate of brightening is defined by *RockerSwitchOnSpeed* (default 20% per second).

- Short click (<0.7s) or double click (<0.7s) on “0” button
  The current light level is stored, the light is dimmed down to *MinVoltageLevel* and then switched OFF.
  The rate of dimming down is defined by *RockerSwitchOffSpeed* (default 20% per second).

- Press and hold “I” button
  Light is brightened until button is released or *MaxVoltageLevel* is reached.
  The rate of brightening is defined by *RockerDimUpSpeed* (default 20% per second).
  This function can be disabled by setting *RockerDimEnable* = 0.
  If disabled then any press (short / long / single / double) on the “I” button will set the light level to 100 % (*MaxVoltageLevel*) immediately.

- Press and hold “0” button
  Light is dimmed until button is released or *MinVoltageLevel* is reached.
  The rate of dimming is defined by *RockerDimDownSpeed* (default 20% per second).
  This function can be disabled by setting *RockerDimEnable* = 0.
  If disabled then any press (short / long / single / double) on the “0” button will set the light level to 0% (OFF) immediately.

- Timer-based Auto OFF
  Light can be switched OFF automatically in absence of an occupancy sensor after time-out of *RockerSwitchAutoOffTimer*.
  This feature can be disabled by setting *RockerSwitchAutoOffTimer* = 0.
  This feature is automatically disabled if an occupancy sensor is present. In this case, automatic switch OFF of the light will be performed based on the input from the occupancy sensor.

3.5 Wireless occupancy sensors

Energy harvesting wireless occupancy sensors in conjunction with EnOcean LED zone controllers increase user convenience and help reduce energy cost. This is achieved by automatically switching the lights off and - optionally - also on according to the presence of persons within the detecting range.

Implementing occupancy-based light control is specified as part of Title 24 regulation.

Energy harvesting occupancy sensors are usually either wall-mounted or ceiling-mounted depending on the specific application needs. The picture below shows an example of each design (wall-mounted on the left, ceiling-mounted on the right).

Additional product information for these energy harvesting occupancy sensors can be found here:

https://www.enocean.com/en/enocean_modules_902mhz/ceiling-mounted-occupancy-sensor-eosc-oem/

https://www.enocean.com/en/enocean_modules_902mhz/wall-mounted-occupancy-sensor-eosw-oem/

Functionality of occupancy sensors is typically such that they immediately report motion if it is detected for the first time after a period without motion. This enables LED zone controllers to immediately switch ON the light upon motion detection.

Subsequently, detected motion is reported via periodical status update telegrams (e.g. every 2 minutes). These telegrams will cause the light to remain ON.

If no telegram indicating detected motion has been received for a certain period of time (e.g. 15 minutes) then the room is considered unoccupied. Light is switched OFF after such period has elapsed without reported motion. No dedicated “unoccupied” telegram has to be sent.

3.5.1 Functional behaviour of wireless occupancy sensors

Wireless occupancy sensors are used to switch OFF – and optionally switch ON – the light based on occupancy in a room.

EnOcean LED zone controllers can receive input from up to 10 wireless occupancy sensors using EnOcean Equipment Profiles (EEP) A5-07-01, A5-07-02 or A5-07-03.

The following actions are supported for wireless occupancy sensors:

- Occupancy-based Auto OFF
  If none of the linked wireless occupancy sensors reports motion for a period defined by *OccAutoOffTimer* (default 15min) then light is set to *OccAutoOffLevel* (default 0%).
  Note that *OccAutoOffTimer* should not be set to a period shorter than the normal motion reporting interval (typically around 2 minutes) as otherwise the light would be switched OFF even though the room is still occupied.

- Ramp-down speed is configurable via *SensorRampDownSpeed* (default 20% per second). This feature can be disabled by setting *OccAutoOffTimer* to 0.

- Occupancy-based Auto ON
  If at least one sensor reports motion then light is set to *OccAutoOnLevel* (default 100%). Ramp-up speed is configurable via *SensorRampUpSpeed* (default 20% per second).

3.5.2 Functionality depending on system configuration

Wireless occupancy sensors can be used in two different system configurations:

- Stand-alone
  Wireless occupancy sensors can be used without additional input devices such as wireless switches. This can be useful to automatically control lighting in places where light switches are not commonly used or easily available.

- In combination with wireless switches
  The more common application is to have both wireless switches and occupancy sensors working together in a system. This is especially useful in meeting rooms or other places where light should be automatically switched OFF if they are unoccupied.

3.5.2.1 Occupancy sensor in stand-alone mode

If wireless occupancy sensors are used stand-alone (without switches and light level sensor) then Auto ON functionality is always enabled because there is no other way to switch the light ON.

Light is switched ON (Auto ON function) immediately to *OccAutoOnLevel* (default 100%) in this configuration if motion is reported. *OccAutoOnDelay* (see below) is not used.

Auto OFF functionality is set according to the value defined by *OccAutoOffTimer*. Light is switched OFF (to *OccAutoOffLevel* - default 0%) if no motion has been reported for the period defined by *OccAutoOffTimer*.

Setting *OccAutoOffTimer* to 0 (which disables Auto OFF functionality) should be avoided if only occupancy sensors are linked.

3.5.2.2 Occupancy sensor and switches

If wireless occupancy sensors are used in conjunction with wireless switches then by default Occupancy Auto OFF functionality is enabled and Auto ON functionality is disabled.
I.e. the default behaviour in this setup is that occupancy sensor input will only be used to switch the light OFF in order to conserve energy.

Timer-based Auto OFF (as defined by *RockerAutoOffTimer*) is always disabled if at least one occupancy sensor is linked.

Occupancy-based Auto ON function can be enabled by setting *OccAutoOn* = ON. In this case light is also switched ON automatically if a linked occupancy sensor reports motion.

In that case, if the current light level is OFF (0%) and a linked occupancy sensor reports motion then the output light level is set to *OccAutoOnLevel*.

If the current light level is ON (any level > 0%) then the current light level is not changed if a linked occupancy sensor reports motion.

If a user has switched the light OFF via linked wireless switch then LED controller can be prevented from switching the light back ON based on input from linked occupancy sensors (if Auto ON functionality is enabled) for a period defined by *OccAutoOnDelay* (default 15 minutes).

In that case input from linked occupancy sensors is discarded during this period. This can be useful in a situation where Auto ON functionality is enabled and the user manually switches the light OFF, e.g. during a presentation.

If light has been switched OFF due to Occupancy Auto OFF function then light will be automatically turned back ON at the last state if occupancy is reported within a period set by *VacancyGraceTimer* period (default 45s) even when Auto ON functionality is disabled.

If *OccAutoOffLevel* is set to a value different from OFF (0%) – e.g. to 10% - then the Auto OFF function of the occupancy sensor will set the light to that level. Light can then be switched fully OFF by single or double click on the “0” button of a linked wireless switch.

3.6 Wireless light level sensors

Energy harvesting wireless light level sensors in conjunction with LED zone controllers help reduce energy cost by automatically adjusting the light level according to the amount of incoming light (typically daylight).

This process of adjusting the required illumination by considering the external light is sometimes referred to as “Daylight Harvesting”.

Implementing Daylight Harvesting is specified as part of Title 24 regulation.

Energy harvesting light level sensors are usually either ceiling-mounted in close proximity to the window from where incoming light is expected. It is important to set them up such that they only react to incoming (i.e. external) light and not to the internal lighting system.

The picture below shows an example of a ceiling-mounted energy harvesting wireless light level sensor.

3.6.1 Functional behaviour of wireless light level sensors

Wireless level sensors are used to adjust the light level based on available natural light.

The fundamental idea is that less artificial lighting is required if sufficient natural light is available. The concept of controlling the light level based on the amount of available natural light is called “daylight harvesting” and enables significant energy savings.

This approach is also referred to as “Open Loop Dimming” since it considers only the available natural light for regulation and does not measure the combines (natural + artificial) light level.

In contrast, “Closed Loop Dimming” (sometimes also called Constant Light Dimming) measures the total available light (natural and artificial) and tries to keep this level constant.

Closed loop dimming is a much more complex approach and relies on the ability to exactly measure the combined light level at the place where it is needed (e.g. office desk) which is not trivial. It can also result in noticeable variations in the light level which is not desirable.

Open loop dimming has therefore been chosen for EnOcean LED zone controllers.

LED zone controllers receive information about the amount of available natural light from one linked light level sensor using EnOcean Equipment Profiles (EEP) A5-06-02 or A6-06-03.

For correct operation it is essential that the light level sensor reports only natural light and is influenced as little as possible by artificial light. The light level sensor should therefore be placed at a position facing the window or skylight where it is not or only minimally influenced by light from the fixtures.

Two different dimming modes are possible based on light level sensor input:

- Five point (continuous) dimming
  In this mode, the user (or installer) can define the relationship between output light level and available artificial light reported by the light level sensor based on a dimming curve with five supporting points.
  This mode is commonly used for indoor lighting as it enables smooth dimming which is barely noticeable to the user.

- Two level (ON / OFF) dimming
  The light level sensor can alternatively be used to activate an automatic switching mode between *MaxVoltageLevel* and *MinVoltageLevel* based on light intensity.
  One typical application is a twilight switch where the light will automatically be turned ON during darkness.

The default operation mode is five point dimming. Two level dimming can be enabled by setting *DaylightingMode* accordingly. Both modes are described in more detail now.

3.6.1.1 Five point dimming

Five point dimming is implemented based on a continuous user-defined dimming curve which specifies the relationship between reported natural light level and requested output (artificial) light level.

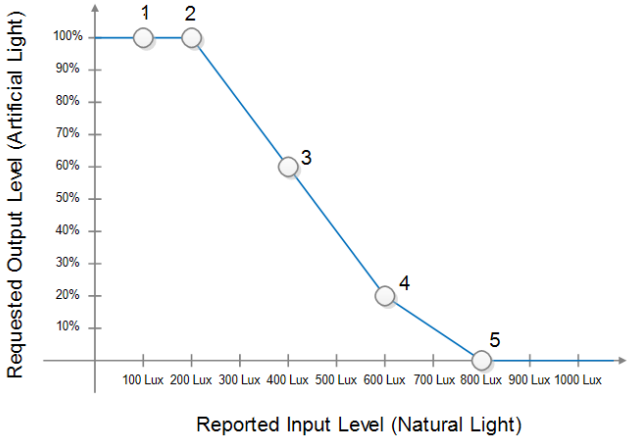
The general principle is that more reported natural light (input) should lead to less requested artificial light (output); therefore the dimming curve should be falling.

The dimming curve is defined based on five points. Each of these points is defined by the correspondence between a reported natural light level (*LEV1* … *LEV5*) and a requested output light level (*OUT1* … *OUT5*).

The dimming curve must be defined monotonous, i.e. *LEV1* < *LEV2* < *LEV3* < *LEV4* < *LEV5*.

In most circumstances, the requested output light level will also be monotonous, i.e. *OUT1* >= *OUT2* >= *OUT3* >= *OUT4* >= *OUT5*. This is however not a requirement from a technical point of view.

The default dimming curve is shown below.



Note that for reported natural illumination levels smaller than the one defined by point 1, the output illumination level defined by point 1 will be used. In many applications this illumination level will be 100%.

Similarly, for reported illumination levels greater than the one defined by point 5, the output illumination level defined by point 5 will be used. In many applications this illumination level will be 0 %.

Linear interpolation between the two neighbouring supporting points will be used for reported illumination levels between the five defined points.

The transition speed for each part of the curve is defined using *RAMP12*, *RAMP23*, *RAMP34* and *RAMP45* parameters and is applied based on the target light level. I.e. if the target light level is between point 4 and 5 then the ramp speed *RAMP45* is used irrespective of the current light level.

3.6.1.1.1 Dimming curve adjustment

If EnOcean LED zone controllers are operating in five point dimming mode and a wireless switch is linked then the dimming curve can be manually adjusted by the user.

This is achieved by setting a new dim level using Dim UP / DOWN functionality of a linked wireless switch and then shortly triple-clicking of the “I” button of it.

The LED zone controller will then replace the point closest to the reported natural light level with the current settings (reported natural light level and user selected output light level). The light will blink three times ON / OFF to indicate successful adjustment.

Doing so for different illuminations allows redefining the whole curve. This feature can be disabled by setting *LIsEnableCurveAdjustment* to OFF.

3.6.1.2 Two level dimming

Two level (ON / OFF) dimming is implemented based on user-defined thresholds for switching the light ON (*PhotoOnThres*) and OFF (*PhotoOffThres*).

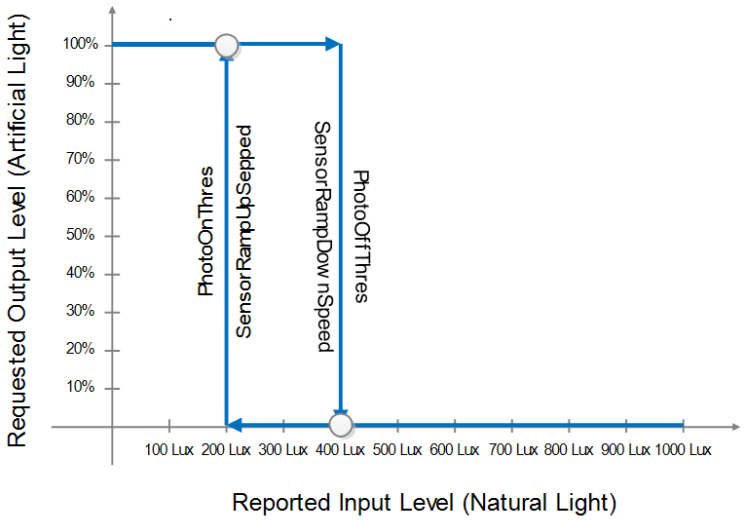
If the available natural light is below *PhotoOnThres* then the output will be set to 100% (maximum illumination level). If the available natural light is above *PhotoOffThres* then the output will be set to 0% (OFF).

The transition rate from 0% to 100% and from 100% to 0% output level is defined by *SensorRampUpSpeed* and *SensorRampDownSpeed* respectively.

Typically there should be a hysteresis between the two switching points, i.e. *PhotoOnThres* should be smaller than *PhotoOffThres.* This avoids the case where the output light level alternates between OFF and 100% if the reported natural light is around the switching threshold.

The default value of *PhotoOnThres* 200 lux is while the default value of *PhotoOffThres* is 400 lux.

The resulting default dimming curve is shown below.



3.6.2 Functionality depending on system configuration

The light level sensor can be used in the following system configurations:

- Stand-alone
- In combination with wireless switches
- In combination with occupancy sensors
- In combination with wireless switches and occupancy sensors

3.6.2.1 Light Level Sensor in Stand-alone Mode

Wireless light level sensor can be used without additional input devices such as wireless switches. This can be useful to automatically switch ON and OFF lighting in places where light switches and occupancy sensors are not commonly used or easily available.

One typical application would be a twilight switch where lighting is automatically turned ON during darkness and OFF during daylight.

If the wireless light level sensor is used stand-alone then its reported data will directly control the output light level.

Both two level (ON / OFF) and five point (continuous) dimming can be used in this configuration.

3.6.2.2 Light Level Sensor and Switches

If the light level sensor is used in conjunction with wireless switches then it is only active if light has been switched ON or dimmed up to any output level > 0% by a linked wireless switch.

If light has been switched OFF by a linked wireless switch then it will remain in OFF state irrespective of light level sensor input until it is switched ON again by a linked wireless switch.

If the user short-clicks the “I” button once (switch ON light to current output level) and the current dim level according to the defined dimming curve would be 0% (OFF) due to sufficient natural light then light will be initially brightened to *MinVoltageLevel.*

If the light level sensor is active then *LlsAdjustmentDelay* can be used to ensure that the light level set by the user (via a linked wireless switch and switch ON or dim UP / DOWN actions) is maintained for a certain period irrespective of the currently available natural light.

Setting *LlsAdjustmentDelay* to 0 will cause the output light level to be adjusted according to reported illumination as soon as a light level sensor telegram is received.

Note that this can lead to a case where the user switches the light ON during bright daylight but the light will be regulated back immediately to 0% (OFF) level due to input from the Light Level Sensor.

3.6.2.3 Light Level Sensor and Occupancy Sensors

If the light level sensor is used in conjunction with occupancy sensors then the Auto ON function of linked occupancy sensors is always active as it is the only way to switch ON the light.

Input from the linked light level sensor is considered only if light has been switched ON by a linked occupancy sensor (Occupancy Auto ON function).

Output light level is then set according to the most recent light level sensor data and the selected dimming parameters (2 level or 5 point dimming). *OccAutoOnLevel* is not used if a light level sensor is linked.

This means that light will remain at OFF (0%) level if occupancy is reported and the light level sensor reports sufficient natural illumination resulting in 0% output light level according to the selected dimming parameters.

Any update from the linked light level sensor will immediately cause an adjustment of the output light level. *LIsAdjustmentDelay* as described above is not used; it applies only to the case where the output light level is set using a linked wireless switch.

The rate of output change (ramp speed) is defined in five point mode by RAMP12, RAMP23, RAMP34 and RAMP45 parameters as described above. Likewise in two level mode, the ramp speed is defined by *SensorRampUpSpeed* (for switch ON) and *SensorRampDownSpeed* (for switch OFF).

If light has been switched OFF (because no occupancy telegram has been received from a linked occupancy sensor for a period defined by *OccAutoOffTimer*) then light will remain at *OccAutoOffLevel* irrespective of light level sensor input.

Note that *OccAutoOffLevel* does not have to be 0% (OFF).

3.6.2.4 Light Level Sensor with Occupancy Sensors and Wireless Switches

If the light level sensor is used in conjunction with both occupancy sensors and wireless switches then by default Occupancy Auto OFF functionality is enabled and Auto ON functionality is disabled.

I.e. the default behaviour in this setup is that occupancy sensor input will only be used to switch the light OFF in order to conserve energy. Occupancy-based Auto ON function can be enabled by setting *OccAutoOn* = ON

Timer-based Auto OFF (as defined by *RockerSwitchAutoOffTimer*) is always disabled if at least one occupancy sensor is linked.

If a user has switched the light OFF via a linked wireless switch then LED controller can be prevented from switching the light back ON based on input from linked occupancy sensors (if their Auto ON functionality is enabled) for a period defined by *OccAutoOnDelay* (default 15 minutes) as described before.

If light has been switched OFF due to Occupancy Auto OFF function then light will be automatically turned back ON at the last state if occupancy is reported within a period set by *VacancyGraceTimer* period (default 45s) even when Auto ON functionality is disabled.

Input from the light level sensor is only considered if light has been switched ON by a linked occupancy sensor (Occupancy Auto ON function) or by a linked wireless switch.

If light is switched ON by a linked occupancy sensor (Occupancy Auto ON function) then output light level is then set immediately according to the most recent light level sensor data and the selected dimming parameters (2 level or 5 point dimming) as described in the previous chapter.

If light is switched ON or dimmed UP / DOWN by a linked wireless switch then *LlsAdjustmentDelay* can be used to ensure that light level selected by the user is maintained for a certain period irrespective of the currently available natural light as described before.

If the user short-clicks the “I” button once (switch ON light to current output level) and the current dim level according to the defined dimming curve would be 0% (OFF) due to sufficient natural light then light will be brightened to *MinVoltageLevel* as described before.

If light has been switched OFF (because no occupancy telegram has been received from a linked occupancy sensor for a period defined by *OccAutoOffTimer*) then light will remain at *OccAutoOffLevel* irrespective of light level sensor input.

Likewise, if light has been switched OFF by a linked wireless switch then it will remain in OFF state irrespective of light level sensor input.

3.7 Central controllers

Central controllers can provide different functions in conjunction with LED zone controllers:

- Remote control of the light level
- Remote monitoring of system parameters (light level, occupancy, etc.)
- Gateway to building automation systems such as BACnet
- Demand response functionality

3.7.1 Functional behaviour of central controllers

LED zone controllers can be connected to a central controller based on EnOcean Equipment Profile (EEP) A5-38-08. They support the dimming command 0x02 of this EEP.

3.8 Demand response controllers

Demand response controllers allow lowering the output light level of LED zone controllers in order to conserve power in case of power shortage

3.8.1 Functional behaviour of central controllers

LED zone controllers can be connected to a demand response controller based on EnOcean Equipment Profile (EEP) A5-37-01.

4 SYSTEM CONFIGURATION

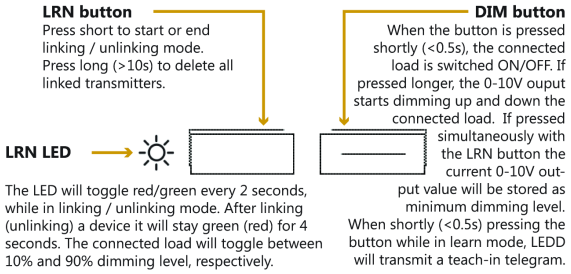
4.1 Local configuration interface

EnOcean LED zone controllers provide a simple local configuration interface based on two buttons (LRN and DIM) and a bi-colour LED (red and green). Their functions are described in the subsequent chapters.

If LEDR (not applicable to LEDD) is in normal operation mode then the LED will indicate the state of its relay. The LED will blink green if the relay is in active state while it will blink red if the relay is in inactive state (output state = OFF).

Note that all LED zone controller parameters can be configured using remote commissioning as discussed in chapter 4.3. Having a dedicated local configuration interface is therefore optional.

The illustration below shows the local configuration interface.



4.1.1 Linking

The LRN and DIM button of the local interface can be used for linking to transmitters or transceivers as outlined in chapter 4.1.4.

4.1.2 Device reset

The LRN button of the local interface can be used to reset all LED zone controller parameters (including PIN code) to factory state similar to a factory reset.

This functionality can be particularly useful if remote configuration access to the device is secured with a custom PIN code and this PIN code is lost.

In order to reset the LED Zone Controller to factory state, press and hold the LRN button for 10 seconds. After that the red LED output will be set to active for 10 seconds.

4.1.3 Setting the minimum output voltage

The local interface can be used to configure the minimum output voltage (*MinVoltageLevel*).

This level is typically set to avoid flickering and chosen to be the minimum level the load starts at when it is switched on. It will not be possible to dim the output below this value.

Use the following steps to configure this minimum dimming value:

1. Press and hold the DIM button.
   The load will start dimming up and down.

2. Release the button when the desired minimum output voltage (dimming value) is reached.

3. Shortly press DIM and LRN button simultaneously to store this value.

4.1.4 Linking

Linking is the process by which different components are configured to work with each other in a system. Sometimes this process is also called Teach-in or Learn-in.

Linking can be executed in two ways:

- Local linking (by user action) using the LRN button of local control interface described in chapter
- Remote linking (over the air) using remote commissioning with Navigan NWC 300 described in chapter 4.3

EnOcean LED zone controllers can link to two types of components:

- Transmitters (switches and sensors) can provide input data
- Transceivers (Gateways or controllers) can exchange data and commands

These two component types are described in more detail now.

4.1.4.1 Linking to transmitters (transmit-only)

Transmitters are typically energy-harvesting components that send RF messages to communicate a condition, level, or state.

The following transmitter types can be linked to an EnOcean LED zone controller:

- Wireless Switches
- Wireless Occupancy Sensors
- Wireless Light Level Sensor

Transmitters can only be linked to transceivers, not to other transmitters.

To link an EnOcean LED zone controller with a transmitter, the LED zone controller must be powered and within wireless range of the transmitter it is to be linked to. Please follow these steps to link a transmitter using the local control interface:

1. Shortly press the LRN button to enter linking / unlinking mode.
   The LRN LED starts toggling red / green indicating that linking / unlinking mode is active. In addition, the connected load will toggle between 10% and 90%.
   Once activated, this mode stays temporary active to provide time to link / unlink multiple devices.
   The mode will stop after 30 seconds if no LRN telegram is received.

2. For the transmitter to be linked, do one of the following according to the type of device:

   - Sensor: click the designated link button
   - Rocker Pad: click the “I” button (top button marked on the switch plastic or “I” symbol on the back of the switch) 3 times quickly.

3. If the device has been linked successfully, the LRN LED will display solid green for 4 seconds. The LED zone controller is now ready to accept new links.

NOTE: After a device is linked, additional learn telegrams received in operating mode (not in linking / unlinking mode) from that device will cause the connected light to toggle three times between OFF (0 V) and maximum output level (default 10 V) if the EnableLinkChecker parameter is set to ON.
This allows quickly checking the connection between this device and the LED Controller.

To exit linking / unlinking mode and return to normal operation, wait 30s without sending new LRN telegrams, or shortly press the LRN button again.

For a linked transmitter to be unlinked, please use the same actions as described above.
If the device has been unlinked successfully then the LRN LED will display solid red for 4 seconds and the load will be switched to a dimming level of 10% for 4 seconds.

4.1.4.2 Linking to transceivers (transmit & receive)

EnOcean LED zone controllers are transceivers.

Transceivers are controlling devices that send as well as receive RF messages. They also process relevant control logic, and actuate the appropriate outputs (switching a light ON or OFF for example).

LED zone controllers can be linked to other transceivers if desired. The following other transceiver types are supported:

- Central Controller
- Demand Response Controller

To link an EnOcean LED zone controller to another transceiver (gateway or central controller), please follow these steps:

1. Set the other device into linking mode
2. Shortly press the LRN button.
   The LRN LED starts toggling indicating that linking / unlinking mode is active.
   The connected load will toggle between 10% and 90%.
3. Shortly press the DIM button.
   This will cause the LED zone controller to transmit a teach-in message identifying the status message EEP used by it.
4. Shortly press the LRN button again to return to normal operation.

4.2 Factory-configurable parameters

Certain LEDR (not applicable to LEDD) parameters that are critical for correct operation can only be modified during factory production using a dedicated programmer to access the configuration area of the LED zone controller.

These parameters cannot be modified during normal operation using remote commissioning (see chapter 4.3) or the local configuration interface (see chapter 4.1).

These parameters are listed in the table below.

Parameter	Default Value	Note
Relay Utilized	True	
Relay Switch On Time	4.6ms	50us steps
Relay Switch Off Time	1.5ms	50us steps
Relay Overdrive Active Time	110ms	Active only on OFF to ON transition

Please contact EnOcean for support if modification of these parameters is required.

4.3 Remote commissioning

Remote commissioning in conjunction with a suitable tool such as Navigan™ Wireless Commissioner NWC 300U can be used to wirelessly link transmitters and transceivers with EnOcean LED zone controllers.

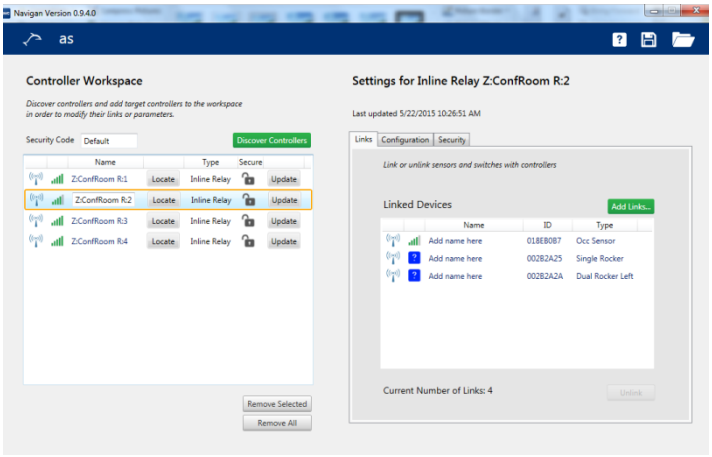
In addition, all configuration parameters of EnOcean LED zone controllers can be set wirelessly over the air using this tool.

4.3.1 Navigan™ Wireless Commissioner NWC 300U

Navigan™ Wireless Commissioner NWC 300U consists of two main components:

- NWC 300U USB transceiver with EnOcean Remote Commissioning (RECOM) support
- Navigan™ User Interface

The illustration below shows NWC 300U (on the left) and the Navigan™ User Interface on the right.



For more information please see http://www.navigan.com/

4.3.2 Configurable Parameters

The table below summarizes the parameters which can be configured via remote commissioning. This table is also available at

4.3.2.1 Rocker Switch Parameters

Parameter	Description	Minimum	Maximum	Resolution	Default Value	Comment
RockerSwitchOnSpeed	Ramp-up speed when rocker input request light switch ON	0%/10s	10000%/10s	1%/10s (0.1%/s)	200%/10s (20%/s)	0= No ramp (immediate)
RockerSwitchOffSpeed	Ramp-down speed when rocker input request light switch OFF	0%/10s	10000%/10s	1%/10s (0.1%/s)	200%/10s (20%/s)	0= No ramp (immediate)
RockerDimUpSpeed	Ramp-up speed when rocker input request light dim UP	0%/10s	10000%/10s	1%/10s (0.1%/s)	200%/10s (20%/s)	0= No ramp (immediate)
RockerDimDownSpeed	Ramp-down speed when rocker input request light dim DOWN	0%/10s	10000%/10s	1%/10s (0.1%/s)	200%/10s (20%/s)	0= No ramp (immediate)
RockerSwitchAutoOffTimer	Delay after last switch action before light is switched OFF automatically	0s	4300000s	0.001s	0 (Disabled)	0 = Disabled (no auto switch OFF)
RockerDimEnable	Enables or disables dimming via rocker switch	0 (Disabled)	1 (Enabled)	N.A.	1 (Enabled)	

4.3.2.2 Occupancy Sensor Parameters

Parameter	Description	Minimum	Maximum	Resolution	Default Value	Comment
OccAutoOn	Defines if a signal from an occupancy sensor automatically switches ON lights (True/False)	0 (Disabled)	1 (Enabled)	N.A.	0 if at least one switch is linked 1 if no switch is linked	
OccAutoOnLevel	Dimming value at which light is switched on in case of Auto ON event from occupancy sensor	0	1	0.5%	1	
OccAutoOnDelay	Time before the occupancy sensor can switch the light back ON in Auto ON Mode after the user switched it OFF using a linked rocker	0s	4300000s	0.001s	900s (15min)	
OccAutoOffTimer	Time after which lights will be switched to OccAutoOffLevel in case of no motion	0s	4300000s	0.001s	900s (15min)	0=Disabled
OccAutoOffLevel	Dimming value to which lights will be dimmed after an occupancy sensor Auto OFF timer event	0	1	0.5%	0	
VacancyGraceTimer	If occupancy is detected within the VacancyGraceTimer period after an occupancy Auto OFF event, lights are turned back ON	0s	4300000s	0.001s	45s	

4.3.2.3 Light Level Sensor Parameters

Parameter	Description	Minimum	Maximum	Resolution	Default Value	Comment
DaylightingMode	2-level or 5 point continuous daylight dimming	0 (2-level)	1 (5 point)	N.A.	1 (5 point)	
PhotoOnThres	In case of 2-level mode, light is switched to MaxVoltageLevel if light level is below PhotoOnThres	0Lux	1020Lux	1Lux	200Lux	1020 Lux is the maximum supported by EEP A5-06-02 (A5-06-03: 1000 Lux)
PhotoOffThres	In case of 2-level mode, light is switched to MinVoltageLevel if light level is above PhotoOffThres	0Lux	1020Lux	1Lux	400Lux	1020 Lux is the maximum supported by EEP A5-06-02 (A5-06-03: 1000 Lux)
LEV1...5	Defines 5 input light levels for open loop dimming curve (LEV1<LEV2<...<LEV5)	0Lux	1020Lux	1Lux	100, 200, 400, 600, 800 Lux	1020 Lux is the maximum supported by EEP A5-06-02 (A5-06-03: 1000 Lux)
OUT1...5	Defines the LED controller output values for the corresponding input light levels	0	1	0.5%	100%, 100%, 60%, 20%, 0%	
RAMP12, 23, 34, 45	Ramp speeds between light levels 1 and 2, 2 and 3, 3 and 4 , 4 and 5	0%/10s	10000%/10s	1%/10s (0.1%/s)	10%/10s (1%/s)	
LlsAdjustment-Delay	Time before the light level sensor can adjust the output light level after it was set by the user	0s	4300000s	0.001s	900s (15min)	
LlsEnableCurveAdjustment	Enables or disables user adjustment of the 5 point dimming curve using triple click on the “I” button	0 (Disabled)	1 (Enabled)	N.A.	1 (Enabled)	

4.3.2.4 Generic Sensor Parameters

Parameter	Description	Minimum	Maximum	Resolution	Default Value	Comment
SensorRampUpSpeed	Ramp-up speed when change is triggered by an occupancy or	0%/10s	10000%/10s	1%/10s (0.1%/s)	200%/10s (20%/s)	0= No ramp (immediate)
SensorRampDownSpeed	Ramp-down speed when change is triggered by an occupancy or light level sensor (2 point mode)	0%/10s	10000%/10s	1%/10s (0.1%/s)	200%/10s (20%/s)	0= No ramp (immediate)

4.3.2.5 System Parameters

Parameter	Description	Minimum	Maximum	Resolution	Default Value	Comment
MinVoltageLevel	Minimum 0-10V output voltage level when light is switched ON	0V	10.0V	0.0002V (0.2mV)	1.0V	
MaxVoltageLevel	Maximum 0-10V output voltage level when light is switched ON	0V	10.0V	0.0002V (0.2mV)	10.0V	
0-10VRelayDelay	Delay between switching the relay on and starting to ramp up the 0-10V output	0s	66s	0.001s (1ms)	0.05s (50ms)	Applies only to devices with relay
ModeAfter-PowerLoss	ModeAfterPowerLoss (ON/OFF/LAST STATE)	0 (OFF)	1 (ON)	2 (LAST STATE)	2 (LAST STATE)	
StatusMessageTimer	Defines, how often status messages are transmitted (seconds)	0s	4300000s	0.001s	0xFFFFFFFF (Only event triggered)	0x0000=No status messages 0xFFFFFFFF=Only event triggered
RepeaterFunction	Defines the repeater level of the device (OFF/1-Level/2-Level)	0 (Disabled)	1 (1-level)	2 (2-level)	0 (Disabled)	
RepeatLinkedDevicesOnly	Configures the repeater to only repeat telegrams from devices linked to it	0 (Disabled)	1 (Enabled)	N.A.	1 (Enabled)	
EnableDebugMessages	Enable or disable debug messages	0 (Disabled)	1 (Enabled)	N.A.	0 (Disabled)	
EnableLinkChecker	Enable or disable link checker (If a learn telegram from a linked device is received while in operating mode, the 0-10V output will toggle once between 10% and 90%)	0 (Disabled)	1 (Enabled)	N.A.	1 (Enabled)	

5 APPLICATION INFORMATION

5.1 Transmission range

The main factors that influence the system transmission range are type and location of the antennas of the receiver and the transmitter, type of terrain and degree of obstruction of the link path, sources of interference affecting the receiver, and “dead” spots caused by signal reflections from nearby conductive objects.

Since the expected transmission range strongly depends on this system conditions, range tests should categorically be performed before notification of a particular range that will be attainable by a certain application.

The following figures may be used as a rough guide only:

- Line-of-sight connections: Typically 30 m range in corridors, up to 100 m in halls
- Plasterboard walls / dry wood: Typically 30 m range, through max. 5 walls
- Line-of-sight connections: Typically 30 m range in corridors, up to 100 m in halls
- Ferro concrete walls / ceilings: Typically 10 m range, through max. 1 ceiling
- Fire-safety walls, elevator shafts, staircases and supply areas should be considered as screening.

The angle at which the transmitted signal hits the wall is very important. The effective wall thickness – and with it the signal attenuation – varies according to this angle. Signals should be transmitted as directly as possible through the wall. Wall niches should be avoided.

Other factors restricting transmission range:

- Switch mounted on metal surfaces (up to 30% loss of transmission range)
- Hollow lightweight walls filled with insulating wool on metal foil
- False ceilings with panels of metal or carbon fibre
- Lead glass or glass with metal coating, steel furniture

The distance between EnOcean receivers and other transmitting devices such as computers, audio and video equipment that also emit high-frequency signals should be at least 0.5 m

A summarized application note to determine the transmission range within buildings is available as download from www.enocean.com.