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I would like to dedicate this thesis to my mother for her unconditional support and love despite my strong character and to all the strong women who surrounded me, I am and will always be grateful.

LIST OF ABBREVIATIONS

DPT: Data Point Type

IEC: International Electrotechnical Commission

ISO: International Organization for Standardization

PWM: Power Width Modulation

REG: Series embodiment

TP: Twisted Pair

KNX: Konnex

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1. Introduction

1.1. Background

Home automation is the automatic centralized control of building's systems and that allow more convenience, more safety and higher energy savings. With the evolution of technology, the demand for building management systems is continuously increasing.

One of the problems of home automation could be complicated installations with excessive wiring. A good solution of that is the KNX standard, which all components communicate via one common language and it's a decentralized system what implies the amount of cabling is considerably reduced.

1.2. Purpose

The purpose of this project is the research and implementation of KNX in Domotics laboratory.

1.3. Scope

The tasks that would be carried out will be testing and researching with ETS5 the functions of the components in the KNX boxes in Domotics laboratory and write a manual programming ETS5 KNX for future Erasmus students, write a workshop about ETS Inside to introduce the software and implement some functions of temperature control with the currently devices in Domotics laboratory.

2. Domotic system

Domotics is the engineering discipline dedicated to studying the electronic technologies intended to assist in organising domestic life with the aim to get it functional and comfortable. It is composed of two words: “Domo” which means house, and “robotics”. So somehow we are talking about methods that allow a machine to realize the human labour.

2.1. Home automation

Home automation is a synonym to domotics. It refers to the automation and electronic control of household features, activity and appliances. Features of that system has to be easy to use because the end users may not be great familiarity with sophisticated electronic equipment.

2.2. Building automation

Building automation system manages and coordinates one or more major system functions required in a facility, related to the management of entire buildings. Basically, home automation is a subset of building automation, so most functionalities are shared and much more complex and advanced.

Building automation allows the control of:

- Lighting
- Security and access control
- HVAC (Heating, ventilation and air conditioning)
- Air quality
- Fire detection and alarms
- Energy control
- Audio/video configuration
- Electronic device control

Some benefits of building automations:

- Energy savings

- Environmental impact
- Improved security
- Building maintenance
- Operation convenience

2.3. Building automation installation

The installations are classified according their architecture in the following types:

- Centralised: There is only one central unit. The information from the actuators and sensors are managed by this unit and the devices from the installation are not able to communicate directly to each other.
- Distributed: All the devices have each own intelligence. Through a communication protocol, all devices are able to communicate with each other. Usually this system is wired in bus. KNX is a distributed (or decentralized) system.
- Mixed: It associates a centralized control unit to a series of central derived spread in the building that communicate between them. This architecture is very efficient, but very complex, especially suitable for building automation

2.4. The communication protocol

A communications protocol defines the rules for sending blocks of from one node in a network to another node. In domotics, is the medium of transmission which the various components of the domotic system interact with each other. There are two main types:

- Owner: Exclusively communication protocol managed by the manufacturer of the equipment. It can communicate with equipment to another manufacturer. Commonly used in small and medium sized installation and it is very cheap.
- Standardized/Open: Open communication protocol managed by any manufacturer and allows full interoperability (the ability for devices to talk to each other). Any manufacturer can make devices interoperating with this protocol because the operating specifications are mare in the public domain. KNX system belongs to this group.

There are a wide variety of protocols. Various reasons can affect to choose the ideal smart home protocol, like support a large number of devices and device interoperability, power consumption, bandwidth and cost. It depends on the requirements of the installation. Six of the most popular are:

- X10
- Insteon
- UPB
- KNX
- ZigBee
- Z-Wave

3. KNX Standard

KNX is a standardized (EN 50090, ISO/IEC 14543), OSI-based network communications protocol. KNX is the successor to, and convergence of, three previous standards: the European Home Systems Protocol (EHS), BatiBUS, and the European Installation Bus (EIB or Instabus) and with over 370 member companies have 7000 KNX certified product groups in their catalogues, it is a system of communication and certification that is recognized worldwide.

All products with KNX logo guarantee:

- System compatibility
- Interworking
- Interoperability

This project is based on KNX standard.

3.1. Configuration modes

The KNX Standard includes 2 different configuration Modes:

- Easy installation techniques (E-MODE): configuration is done without the help of a PC but with a central controller, push buttons, etc. (normally have limited functionality and are intended for medium size installations).
- System installation techniques (S-MODE): planning of the installation and configuration is done via a PC with the installed manufacturer independent ETS Software.

3.2. Communication media

Each communication medium can be used in combination with one or more configuration modes, which allows each manufacturer to choose the right combination for the target market segment and application.

Medium	Transmission via	Areas of application
Twisted Pair	Separate control cable	<ul style="list-style-type: none"> - New installations - Extensive renovations - Highest level of transmission reliability
Powerline	Existing network	<ul style="list-style-type: none"> - Twisted pair can't be installed - 230V cable available
Radio Frequency	Radio line	<ul style="list-style-type: none"> - Cables can't be installed
IP	Ethernet/Wifi	<ul style="list-style-type: none"> - Large installations, fast backbone is needed - For communication with mobile devices

Table 1 - Transmission medium

3.3. KNX Twisted pair (TP)

A two-core twisted pair data cable (bus cable) is the most common communication medium for KNX installations. The BUS cable is a physical line of communication that connects the various components. Twisted pair cables are cost-effective to buy and easy to install.

In the installations where twisted pair is used, the bus cable is laid parallel to the 230V cable. The advantages compared to conventional installation are the reduction of the amount of cabling, the increase of system functions and the transparency of the installation.

Control cable purpose is to connect actuators and sensors and supplies the bus devices in most cases. The rated voltage of the bus system is 24 V, while the voltage provided by the power supplies is 30 V.

KNX installations have a distributed architecture where all KNX bus devices have their own intelligence and consequently a central control unit is not necessary.

3.3.1. Data transfer and signal shape

Data transfer and signal shape are important features of KNX TP installations. The data transfer rate is 9.600 bits/s and the data travel serially via asynchronous data transfer. The communication via KNX TP is a symmetrical and non-earthed transmission. As radiated noise

affects both cores with the same polarity, it has no influence on the difference in the signal voltage.

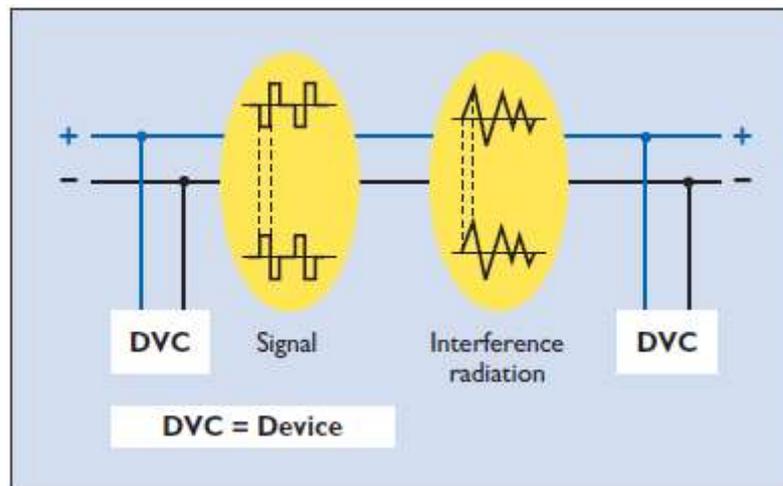


Figure 1- Symmetrical data transfer [2]

3.3.2. Telegrams

Information is exchanged between bus devices in the form of so-called telegrams. The entire information is transmitted in the form of 8-bit long characters.

The telegram consists of bus-specific data and the actual useful data, which. Inside of the bus-specific data we found different fields:

Control field: defines the priority and if the transmission is a repetition

Address field: specifies the Individual Address of the sender and the destination address (Individual Address or Group Address) of the receiver.

Checksum field: is used for parity checks

The data field, which can be up to 16 bytes long, contains the telegram's payload and provides information about the event.

3.3.3. Addressing

Individual address (or physical address) is the unique identification of bus devices KNX installation.

Communication between devices in an installation is carried out via group addresses, which links the functions of sensors and actuators.

3.4. KNX devices

There are two kinds of devices in a KNX system: system devices and end devices. System devices can be e.g. power supplies, couplers or programming interfaces, while end devices are e.g. sensors and actuators. Sensors, actuators and bus coupling units.

A minimum TP KNX installation consists of the following components:

- Power supply unit (DC 30 V)
- Choke (can also be integrated in the power supply unit)
- Sensors
- Actuators
- Bus cable (only two wires of the bus cable are required)

3.5. KNX Advantages

- Increased safety
- Economic use of energy during the operation of buildings
- Simple adaptation of the electrical installation to the changing requirements of the user
- Higher degree of convenience
- Future-proof installations
- Wide range of available off-the-shelf components from many manufacturers
- Large service network of qualified contractors/designers/integrators

4. Current facilities on the lab Domotics

Currently in the laboratory there are five boxes created by students to practice with KNX. These boxes simulate the automation of a room and they can fit together to simulate an entire building. Domotics laboratory of Odisee is a certified KNX training centre and all the components are certified by KNX.

Boxes are composed by:

- KNX bus devices
- A map of the room
- Lights and socket
- Bus cable



Figure 2 - KNX Boxes [5]

All the boxes have the same distribution and the elements are arranged as shown below.

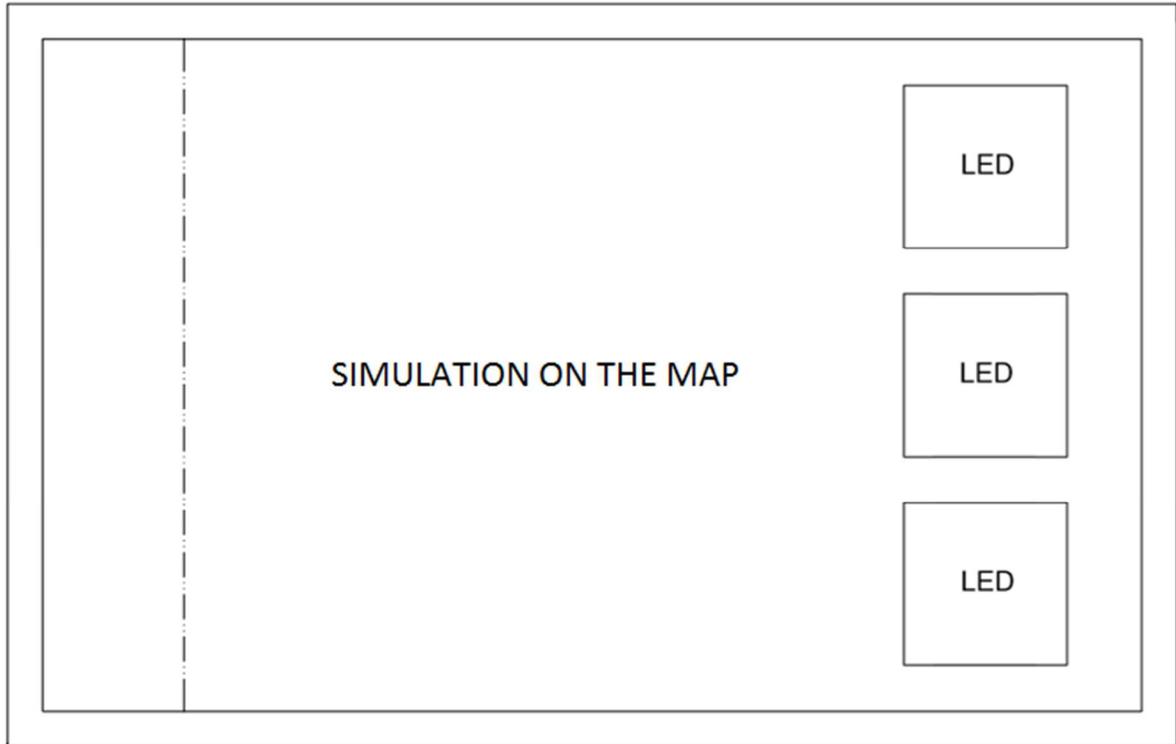


Figure 3 - Plan of boxes inside (Top) [5]

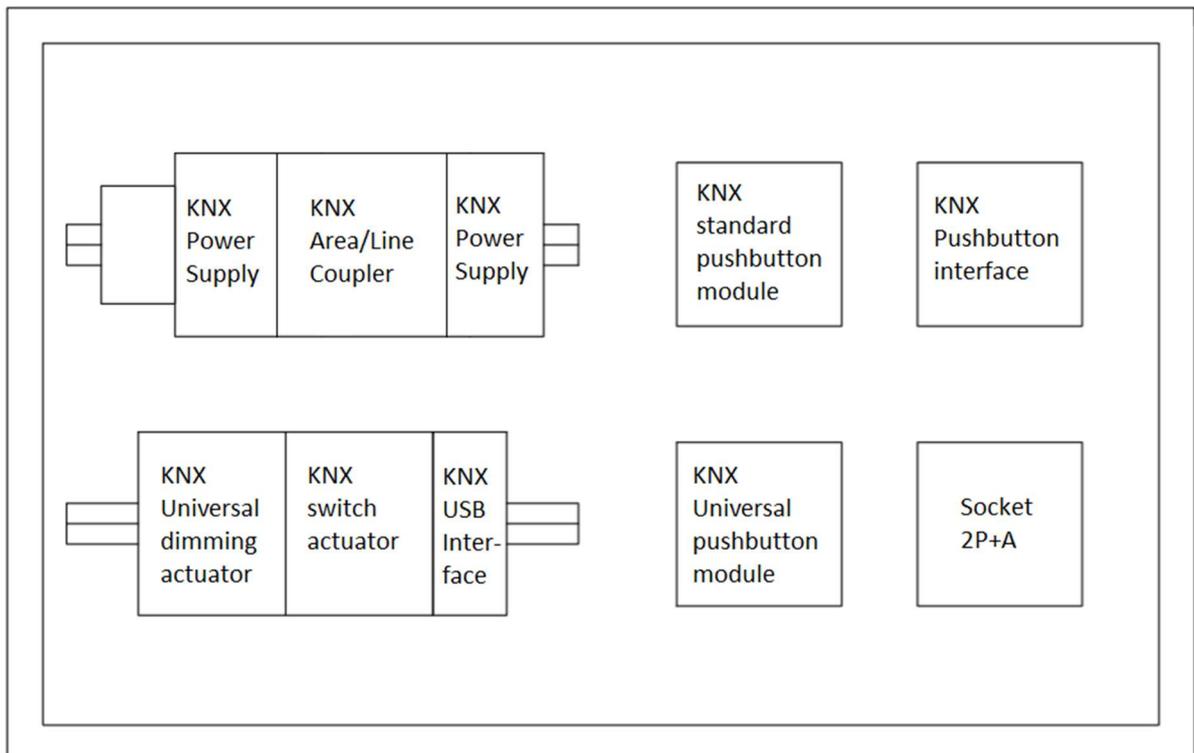


Figure 4 - Plan of boxes inside (Bottom) [5]

4.1. KNX Components

KNX Components in the box are some bus devices and the bus that connect them all. In this case, all the devices are from Jung company [7].

4.1.1. Power Supply

Power supply 320 mA
Art.-No.: 2005 REG

Input supplying Voltage:
161 V – 264 V AC, 50-60 Hz

Rated voltage:
28 V – 31 V DC, SELV



The power supply 320 mA produces and controls the system power for the KNX. The devices can be connected to a bus line via the terminal BUS, without an additional choke. Furthermore, the power supply offers a 30 V DC output to supply a further bus line (i.e. main line). For this an additional choke is required.

4.1.2. USB interface

KNX USB data-interface
Ref.-no.: 2130 USB REG

Connection KNX:
 KNX connecting terminal

USB port:
 USB socket, type B

Transmission protocol:
 compatible with USB 1.1/2.0

Length of USB cable:
 max. 5 m



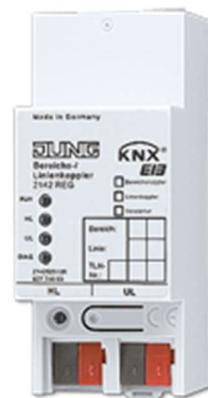
The USB data interface enables the coupling of a PC for the addressing, programming and diagnoses of KNX components. The power is fully supplied by the connected PC via the USB interface. This means that the USB data interface is no longer connected for the KNX if the USB cable is not plugged in. The device is only programmed locally with a physical address via the connected PC and therefore does not have a programming button or programming LED. The firmware of the USB data interface can be updated via a PC and is therefore safeguarded for future standards.

4.1.3. Area / line coupler

Area/Line Coupler
Ref.-no.: 2142 REG

Current consumption
 approx. 6 mA / 8 mA

Connection:
 KNX/EIB terminal for superordinate and subordinate line



The backbone/line coupler interconnects two KNX lines into a logical function area ensuring at the same the electrical separation between these lines. The exact function of the device is determined by the selected parameterization and by the physical address. It can be used as a backbone coupler, line coupler or line repeater for implementing line segments in existing new KNX installations.

4.1.4. Universal dimming actuator

Universal dimming actuator, 2-gang
Art. No. : 3902 REGHE

Rated voltage

AC 110 ... 230 V ~ (50 / 60 Hz)

Power loss

max. 4 W

Contact type

ε, MOSFET



The universal dimmer actuator works according to the leading edge phase control or trailing edge phase control dimming principle and makes switching and dimming of:

- incandescent lamps
- HV halogen lamps
- dimmable HV-LED lamps
- dimmable compact fluorescent lamps
- dimmable inductive transformers with LV halogen or LV LED lamps
- dimmable electronic transformers with LV halogen or LV LED lamps

It is also possible to activate dimmable HV-LEDs or compact fluorescent lamps.

4.1.5. Switch actuator / blinds actuator

Switch actuator, 8-gang / blinds actuator, 4-gang

Art. No. : 2308.16 REG HE

External supply - Rated voltage
AC 220 ... 230 V ~ (50 / 60 Hz)

Rated voltage KNX
DC 21 ... 32 V SELV

Power loss
max. 3 W



The switch/blind actuator receives telegrams from sensors or other controls via the KNX and switches electrical loads. The relay outputs can be set in ETS to blinds operation or to switching operation. Mixed operation is also possible.

Blinds operation

Control electrically:

- driven blinds
- shutters
- awnings
- venting louvers
- similar curtains for 230V

Switching operation

Switch electrical loads:

- lighting systems
- low voltage in switching operation

Table 2 - Switching actuator operation modes

4.1.6. Standard pushbutton module

Standard push-button module, 2-gang
Art. No. 5072 TSM

Rated voltage KNX
DC 21 ... 32 V SELV

Current consumption KNX
max. 12.5 mA



The function of this device depends upon the software. When its buttons are pushed, the universal pushbutton sensor modules send telegrams to the KNX, depending on the ETS parameter settings.

Pushbutton functions	Other characteristics
For instance: <ul style="list-style-type: none"> • switching • dimming • controlling blinds • value transmitter • calling up moods • etc. 	<ul style="list-style-type: none"> • One red status LED per button pair • One operation LED as an orientation light and to indicate the programming status • Integrated bus coupling unit

Table 3 - Standard pushbutton module

4.1.7. Universal pushbutton module

Universal push-button module, 2-gang
Art. No. 5092 TSM

Rated voltage KNX
 DC 21 ... 32 V SELV

Power consumption KNX
 max. 150 mW



Universal pushbutton module is very similar to Standard push-button module but the first one has more functions. In the following table there is a comparison between the devices above.

5072 TSM	5092 TSM
INTENDED USE	
Operation of loads, e.g. light on/off, dimming, blinds up/down, calling up and saving light scenes, etc. Installation in flush-box according to DIN 49073	
PRODUCT CHARACTERISTICS	
Push-button functions for switching, dimming, blinds control, valuator, light scenes, etc.	
	One or two functions per button
To be completed with cover kit	
Inscription field	Inscription field can be illuminated
One red status LED for a pair of buttons	One status LED per button, red, green or blue, adjustable
One operation LED as orientation light and programming status – red, green or blue, adjustable	
	Brightness of status LED, operation LED and inscription field adjustable, can be changed during operation, e.g. during night times
	Measurement of room temperature
	Extension unit for room temperature controller
	Disabling function: Disabling or change function mode of single or all button functions
	Alarm function, optional acknowledge by pressing any button
Energy saving mode	
Integrated bus coupling unit	
	Connection for a push-button extension module, 1-4 gang
Transparent cover kit (included) for temporary site use without design covers	

Table 4 - Comparison between 5072TSM and 5092TSM pushbutton modules

4.1.8. Pushbutton interface

Pushbutton interface
Ref-no.: 2076-2T

Supply. instabus EIB:
 21 – 32 V DC

Power consumption:
 typically 150 mW

Outputs for LEDs:
max. 2 constant current: 0.8 mA per output
Dimensions (W x H x D): 44 x 29 x 16 mm



The 2-channel push-button interface has 2 independent channels which can be used as an inputs or alternatively as outputs. The push-button interface can therefore be used to poll its inputs for the switching state of up to 2 potential-free push-buttons/switches with a common reference potential and send the corresponding telegrams to the KNX.

Input use	Output use
Telegrams can be: <ul style="list-style-type: none"> • switching • dimming • blind/shutter control • value transmitter applications: <ul style="list-style-type: none"> - dimming value transmitter - light-scene extension - temperature or brightness value transmitters Switch or pulse counters are available	<ul style="list-style-type: none"> • Channels 1 and 2 can control 2 LEDs. • To increase the output current these channels can also be connected in parallel with the same parametrization. • The outputs are protected against short circuits, overload and wrong polarity.

Table 5 - Pushbutton interface uses

5. ETS5

ETS is an engineering tool software, which runs on Windows© OS based computers. Is a tool to design and configure intelligent home and building control installations with the KNX system and is available for planner and installers.

ETS stands for Engineering Tool Software and ETS5 is the newest generation of ETS.

KNX offers several ETS versions depending on the user's knowledge and the using purpose.

ETS5 Demo	Free of charge test and trial version; very small test projects	Maximum of 5 KNX devices per project
ETS5 Lite	Small to mid-range projects	Maximum of 20 KNX devices per project
ETS5 Professional	All projects sizes; all functions	Full functionality
ETS5 Supplementary	Additional license for the full professional version on a second PC	Full functionality

Table 6 - ETS5 current versions [3]

6. Testing and researching with ETS5

The purpose of this section is testing and researching with ETS5 the functions of the bus devices indicated above, in the KNX in lab Domotics.

Assuming that the ETS5 is properly installed on the computer, the following steps can be followed to test the bus devices possibilities.

6.1. Creating a new project

Following parameters should be chosen:

- Name of the project
- Backbone medium
- Possibility of create line 1.1 and her medium
- Group address desired levels

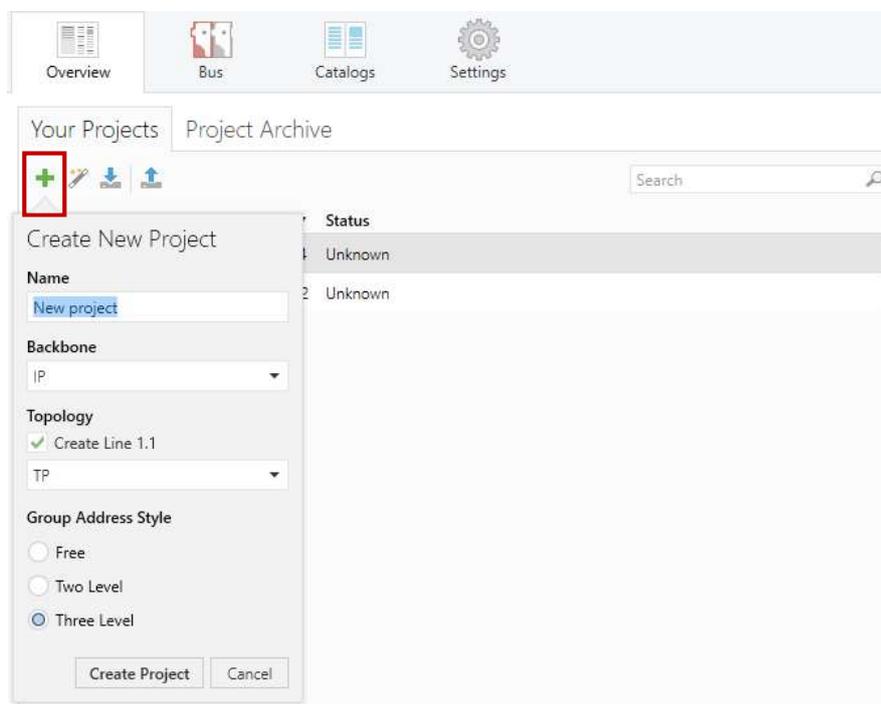


Figure 5 - ETS5 main page (create new project)

6.2. Create catalog

It is necessary import the bus devices to ETS to be available to use it. The product software can be downloaded on the webpage of the company. [7]

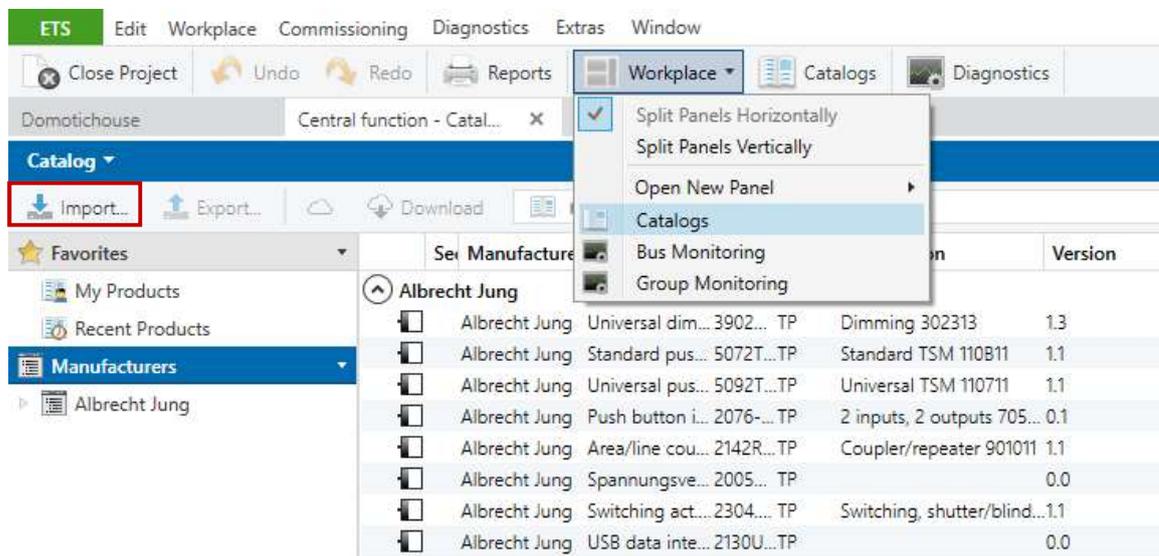


Figure 6 - ETS5 Import the components

6.3. Topology

Topology window is used to define how the devices are connected to the installation and the assignment of individual addresses. The aim is to observe the actual bus structure and represents it on ETS.

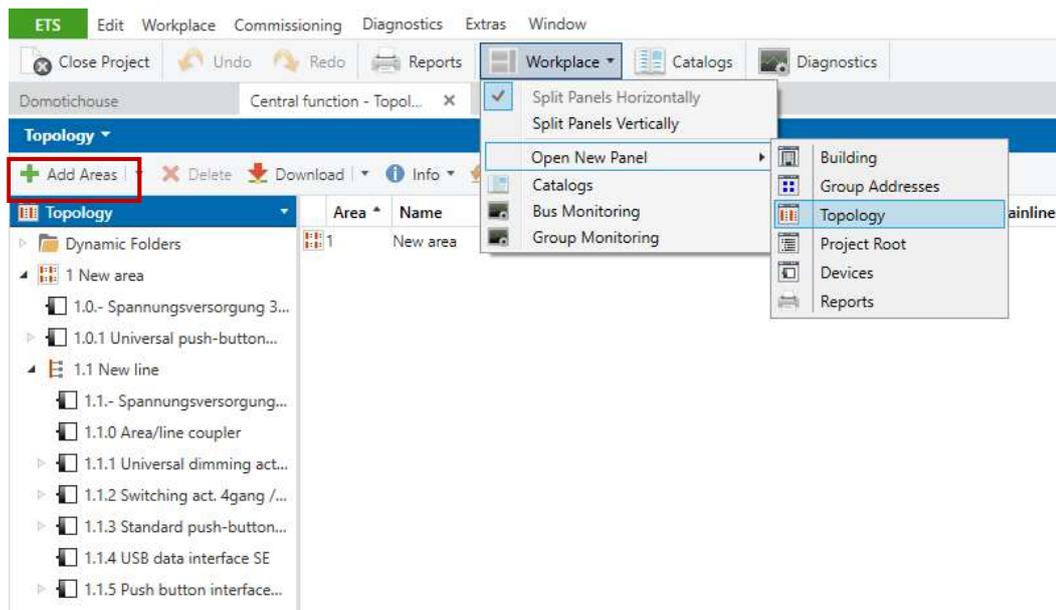


Figure 7 - ETS5 Topology

6.4. Building structure

In the “Buildings” windows the building structure must be created. Devices can be inserted in rooms, corridors, stairways or cabinets. All the devices on the topology must be there here as well.

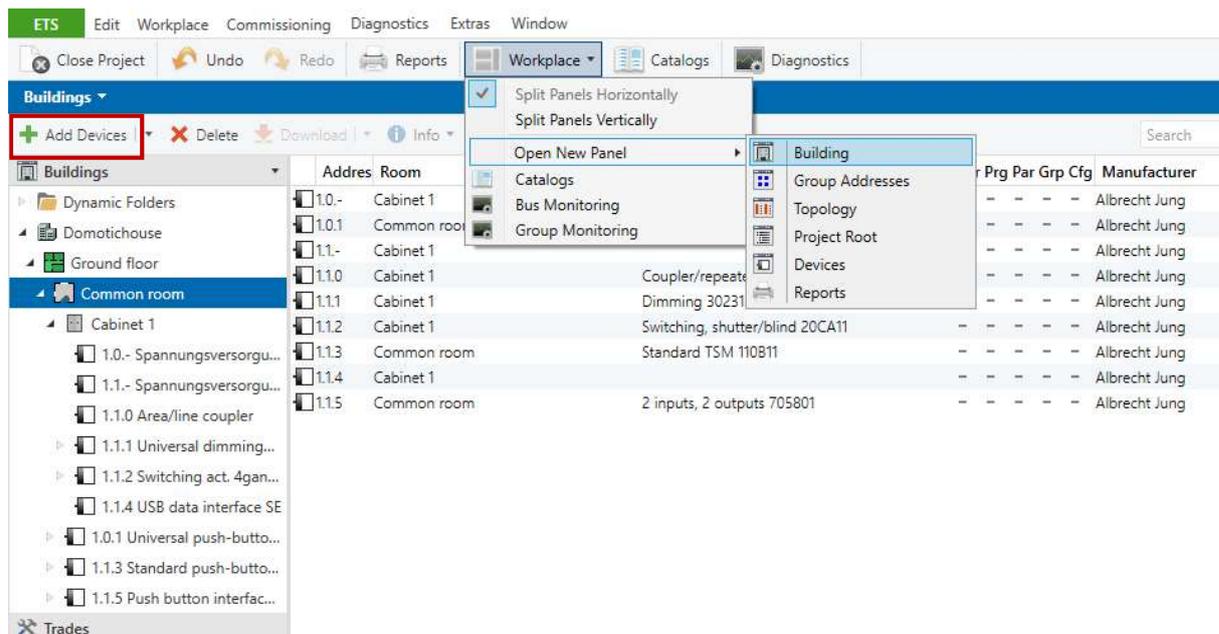


Figure 8 - ETS5 Building structure

6.5. Group Addresses

Group address is the normal communication between devices in an installation. In order to do this, the group addresses have to be linked with the corresponding group objects. The 3-level structure is used in this project. The group address structure is free, but the following one is very functional:

- Main function: Area of application (e. g. Light, blind, heating...)
- Middle group: Functions (e. g. switching, dimming, long operation...)
- Subgroup: Final receiver (e. g. Kitchen Light, Blind 1, All lights ON...)

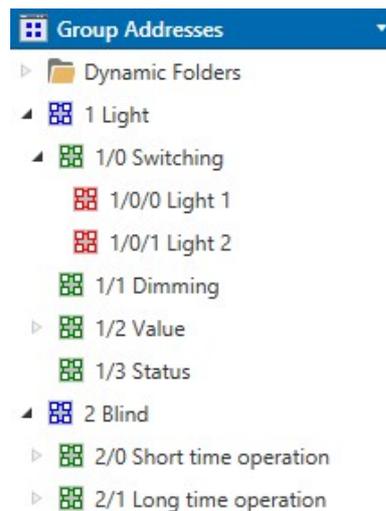


Figure 9 - ETS5 Group Address

6.6. Switching/toggle a light

To start we go to the parameters of the switching actuator. Regarding the switching actuator, we know that the output 1 and output 2 are connected to the lights and the output 3/4 is a shutter, so we always must have this configuration.

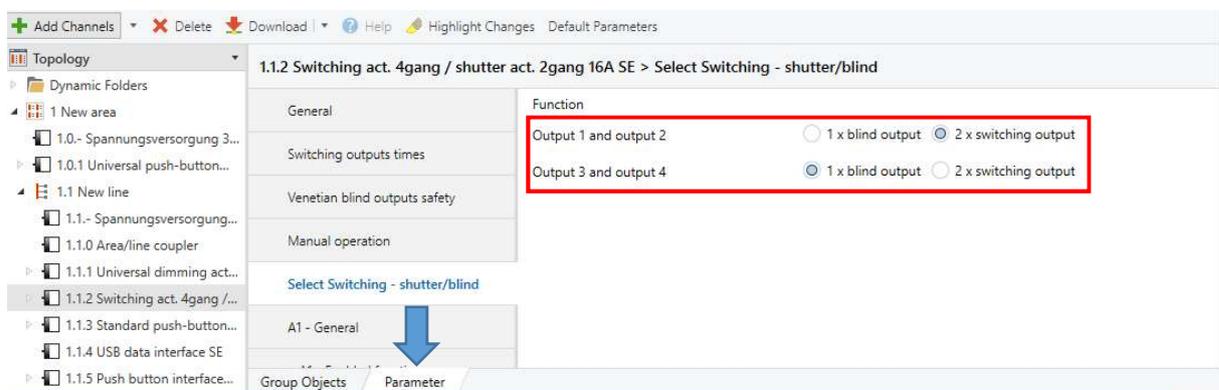


Figure 10 - ETS5 Switching actuator parameters (switching - shutter)

6.6.1. Switching a light

Devices used:

- Switching actuator
- Pushbutton (push-button interface)

Once this is done, we go to the parameters of pushbutton interface. In order to test properly the switch function, we can configure the pushbutton to turn on the light with one button and turn off the same light with the other button.

- Input 1: sends an ON telegram

1.1.2 Push button interface 2-gang > Input 1		
Function	Function input 1	switching
General	Command on rising edge Switching object 1.1	ON
Input 1	Command on falling edge Switching object 1.1	no reaction
Input 1, Disabling	Command on rising edge Switching object 1.2	no reaction
Input 2	Command on falling edge Switching object 1.2	no reaction
Input 2, Disabling	Response to bus voltage return	no reaction
	Cyclical transmission?	no cyclical transmission

Figure 11 - ETS5 Push button interface (Input 1)

- Input 2: sends an OFF telegram

1.1.2 Push button interface 2-gang > Input 2		
Function	Function input 2	switching
General	Command on rising edge Switching object 2.1	OFF
Input 1	Command on falling edge Switching object 2.1	no reaction
Input 1, Disabling	Command on rising edge Switching object 2.2	no reaction
Input 2	Command on falling edge Switching object 2.2	no reaction

Figure 12 - ETS5 Push button interface (Input 2)

Now, we have to link the group objects of the switching actuator and the group objects of pushbutton interface in the same group address with the objective of create a communication between the devices. When someone press the sensor (pushbutton) it sends a telegram. If the switching actuator is in the same group, it will listen for that telegram and will act according.

Only the group object with the same length can be in the same group. To switching and toggle the length is 1 bit.

- Output 1: listen telegrams from input 1 and input 2
- Output 1 turn on or turn off the light 1

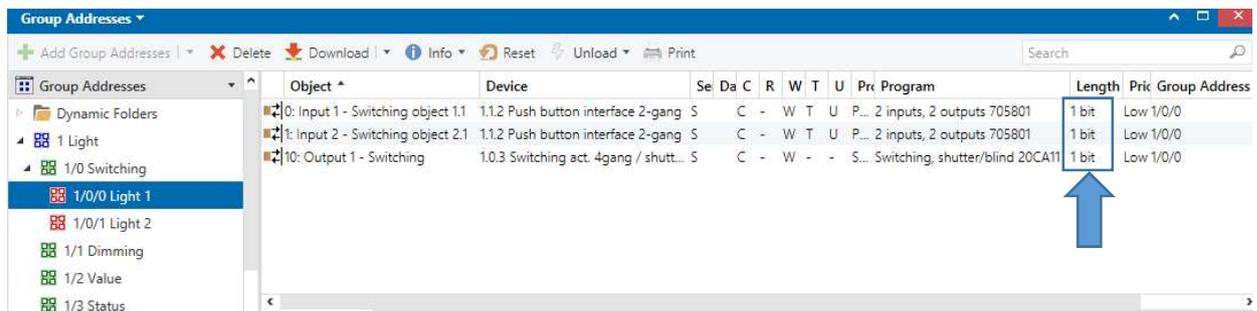


Figure 13 - ETS5 Group Address (switching Light 1)

6.6.2. Toggle a light

Devices used:

- Switching actuator
- Pushbutton (Universal push-button module)

The buttons of the Universal push-button module can work as a button or as a rocker (rocker is a combination of two buttons, usually one for on and one for off). To test the toggle function, one button is enough.

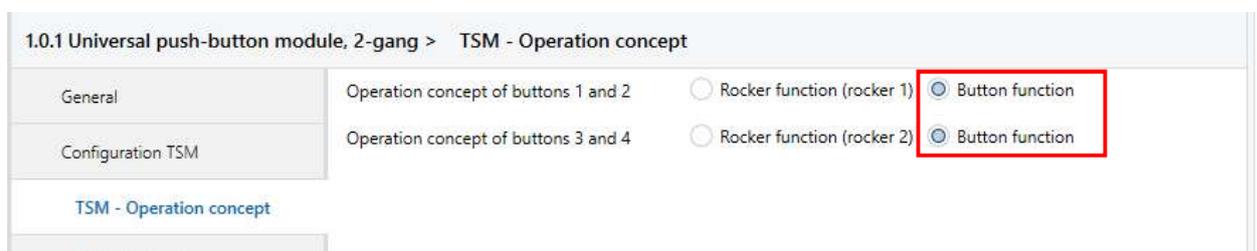


Figure 14 - ETS5 Universal push-button module (Operation concept)

- Button 1 sends a switching telegram with toggle command.

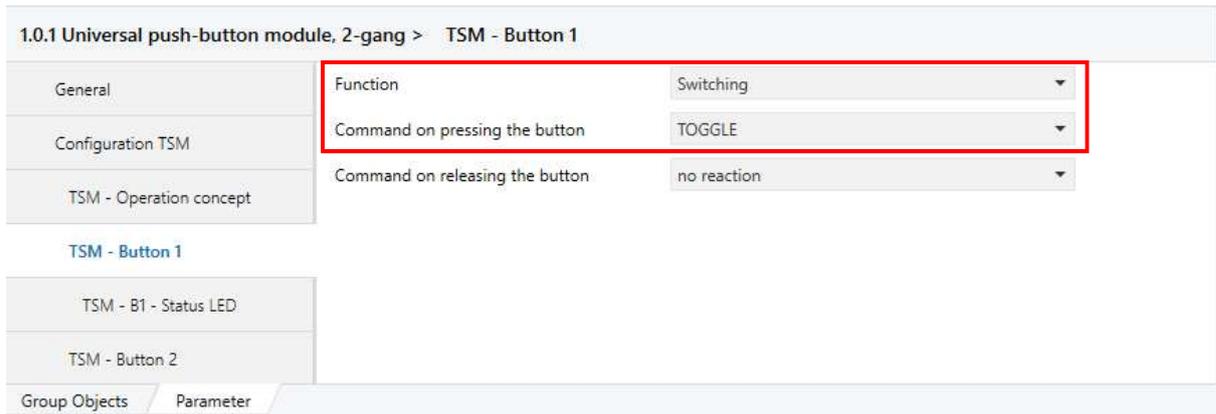


Figure 15 - ETS5 Universal push-button module (Button 1)

Now we can link the button 1 group object with the output 1 group object.

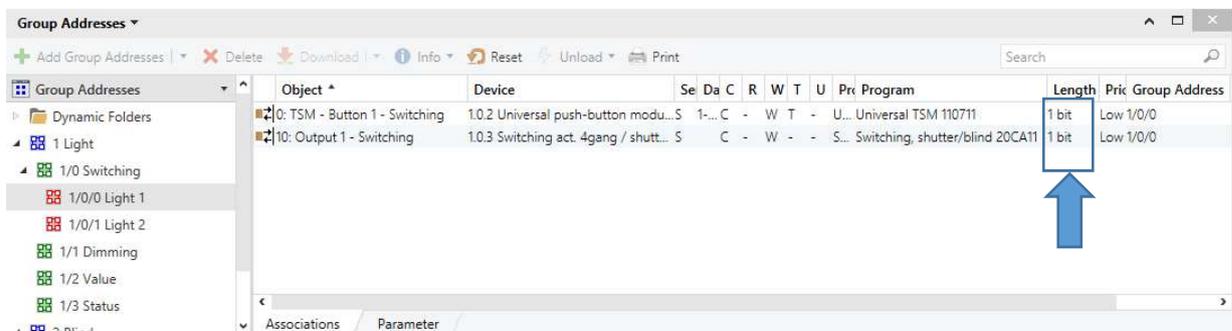


Figure 16 - ETS5 Group Address (Toggle Light 1)

If we want to do one step more of switching a light, we can switch a light with two buttons. We only have to put in the same group address the two switching objects of the button with the output.

6.7. Dimming a light

Devices used:

- Dimming actuator
- Pushbutton (Standard push-button module)

In this case, we will be able to switch and dimming a light. To do that we have to use the dimming actuator and one of the sensors, for example, the standard pushbutton. Rocker button is suitable to do the dimming function.

1.1.1 Standard push-button module, 2-gang > Rocker 1 (Buttons 1/2)

General	Function	Dimming
Operation concept	Command on pressing left rocker	<input checked="" type="radio"/> Brighter (ON) <input type="radio"/> Darker (OFF)
Rocker 1 (Buttons 1/2)	Command on pressing right rocker	<input type="radio"/> Brighter (ON) <input checked="" type="radio"/> Darker (OFF)
R1 - Status LED	Time between switching and dimming Left rocker (100...50000 x 1 ms)	400
Rocker 2 (Buttons 3/4)	Time between switching and dimming Right rocker (100...50000 x 1 ms)	400

Figure 17 - ETS5 Standard push-button module (Rocker 1)

When dimming function is selected, a dimming group object appears.

Number	Name	Object Function	De Gr	Length	C	R	W	T	U	Data Type	Priority
0	Rocker 1	Switching		1 bit	C	-	W	T	-	1-bit	Low
2	Rocker 2	Switching		1 bit	C	-	W	T	-	1-bit	Low
18	Rocker 1	Dimming		4 bit	C	-	W	T	-	dimming control	Low

Group Objects Parameter

Figure 18 - ETS5 Dimming group object

Now we must link switching objects to the switching group address and dimming objects to the dimming group address. Note that the dimming objects have 4 bits.

Object *	Device	Sending	Data Type	C	R	W	T	U	Product	Program
0: Rocker 1 - Switching	1.1.1 Standard push-button mo...S		1-bit	C	-	W	T	-	Standard push-butt...	Standard TSM 110B11
3: Channel 1 - Switching	1.0.1 Universal dimming actuat...S			C	-	W	-	-	Universal dimming...	Dimming 302313

Figure 19 - ETS5 Group Address (Switching Light 1)

Object *	Device	Sending	Data Type	C	R	W	T	U	Product	Program
6: Channel 1 - Dimming	1.0.1 Universal dimming actuat...S			C	-	W	-	-	Universal dimming...	Dimming 302313
18: Rocker 1 - Dimming	1.1.1 Standard push-button mo...S		dimming c...	C	-	W	T	-	Standard push-butt...	Standard TSM 110B11

Figure 20 - ETS5 Group Address (Dimming Light 1)

6.8. Shutter control (up and down, step stop)

Devices used:

- Switching actuator
- Pushbutton (Universal push-button module)

In our boxes the lights that represent the blinds are connected to the outputs 3/4 so we must choose the Venetian blind mode of operation for that output.

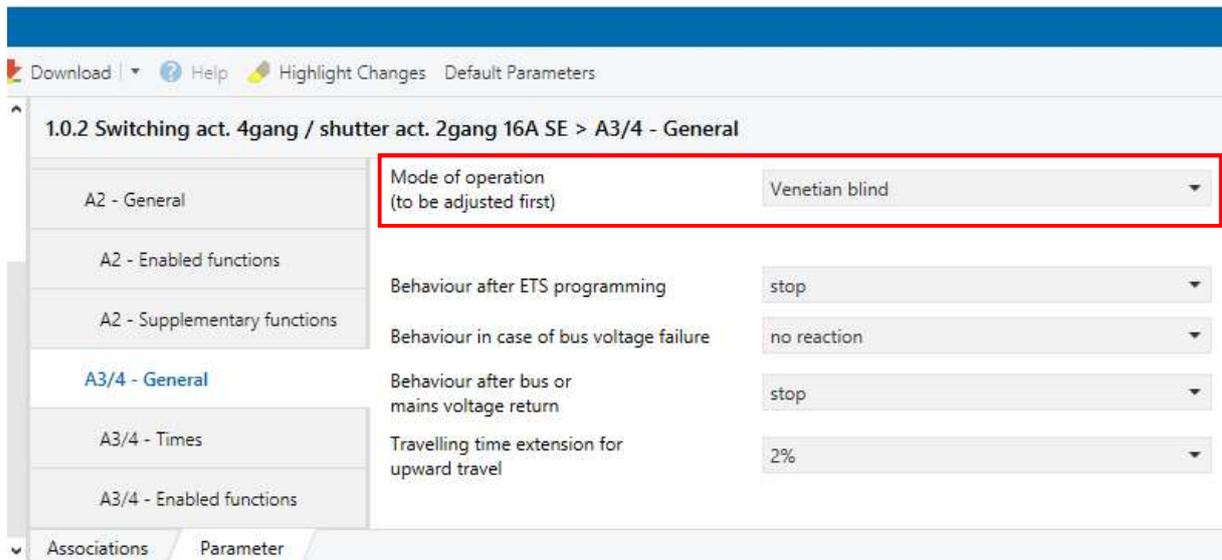


Figure 21 - ETS5 Switching actuator (Output 3/4)

We also have to configure the sensor in the venetian blind option. As it can see in the picture, there are a lot of Operation concept options. Explanation of that options are on the datasheet of the bus device (universal push-button module) and it is used to control de behaviour of the blinds and the slats.

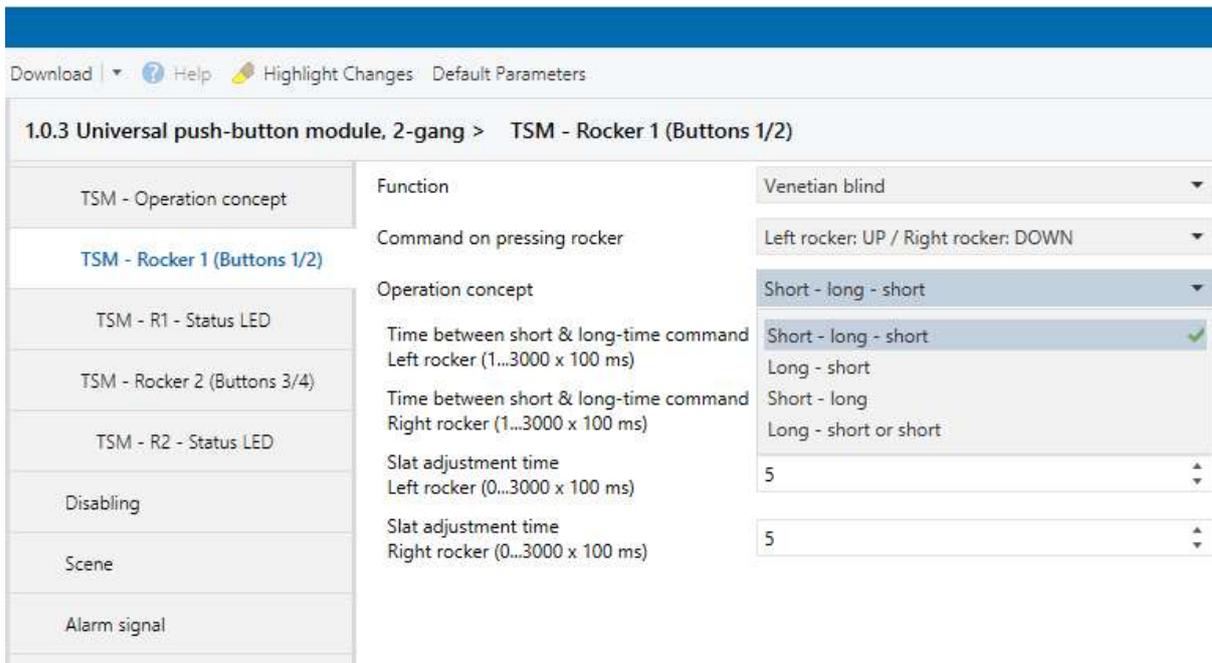


Figure 22 - ETS5 Universal push-button module (Rocker 1)

When the venetian blind function is selected, always appear two different group objects; long-time operation and short time operation. Group objects of the same type have to be connected together.

The screenshot shows the ETS5 Group Addresses window. The left sidebar shows a tree view with '2/0/0 Blind 1' selected. The main table displays the following data:

Object *	Device	Sending	Data Type	C	R	W	T	U	Product	Program	Length	Priority	Group Ad
0: TSM - Rocker 1 - Short time oper...	1.0.3 Universal push-button m...	S	1-bit	C	-	-	T	-	Universal push-butt...	Universal TSM 110711	1 bit	Low	2/0/0
37: Output 3/4 - Short time operati...	1.0.2 Switching act. 4gang / sh...	S		C	-	W	-	-	Switching act. 4gan...	Switching, shutter/blind 20CA11	1 bit	Low	2/0/0

Figure 23 - ETS5 Group Addresses (Blind short time operation)

The screenshot shows the ETS5 Group Addresses window. The left sidebar shows a tree view with '2/1/0 Blind 1' selected. The main table displays the following data:

Object *	Device	Sending	Data Type	C	R	W	T	U	Product	Program	Length	Priority	Group Ad
18: TSM - Rocker 1 - Long-time ope...	1.0.3 Universal push-button m...	S	up/down	C	-	W	T	-	Universal push-butt...	Universal TSM 110711	1 bit	Low	2/1/0
36: Output 3/4 - Long-time operati...	1.0.2 Switching act. 4gang / sh...	S		C	-	W	-	-	Switching act. 4gan...	Switching, shutter/blind 20CA11	1 bit	Low	2/1/0

Figure 24 - ETS5 Group Addresses (Blind long time operation)

6.9. Control the feedback LED in all cases

Devices used:

- Switching actuator
- Pushbutton (Standard push-button module)

The pushbutton modules have a LED indicator in every button. The function of the status LED is to show us the current situation of the light which is connected to. When we only have one button and one light it works automatically, but when we have two button and one light, we must use the feedback LED.

As we have taught before, to work with two button and one light we must have that three-group object in the same group address.

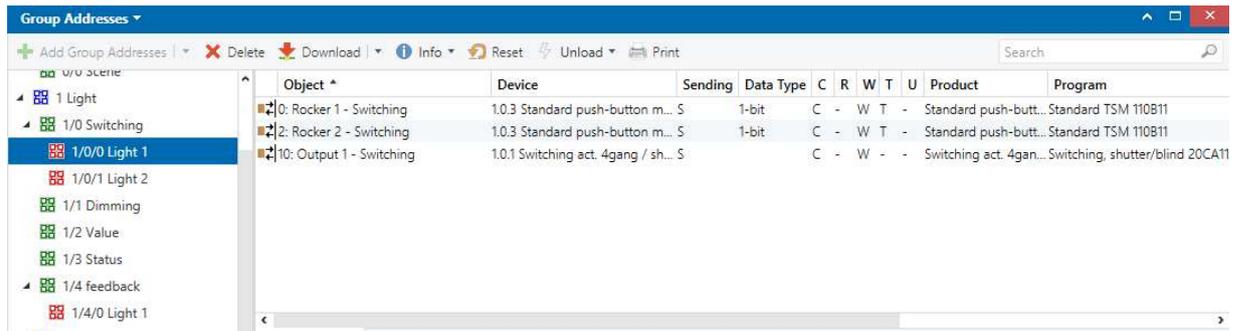


Figure 25 - ETS5 Group Address (two rockers switching Light 1)

But the important thing here is to work with the status LED. In that case, we are interested in work with a separate LED object.

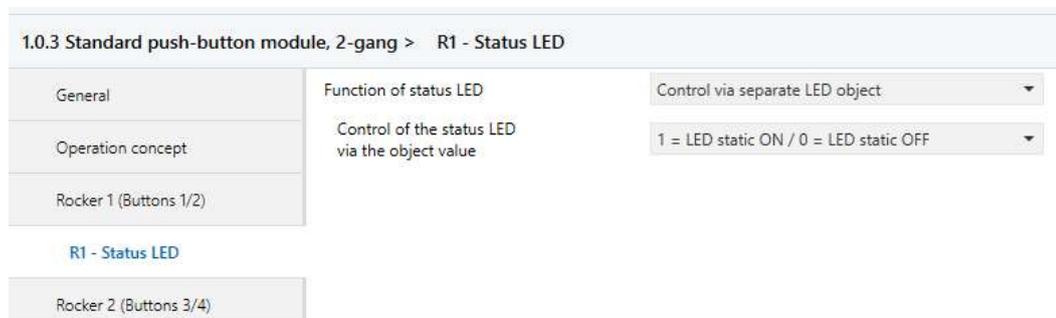


Figure 26 - ETS5 Standard push-button module (status LED Rocker 1)

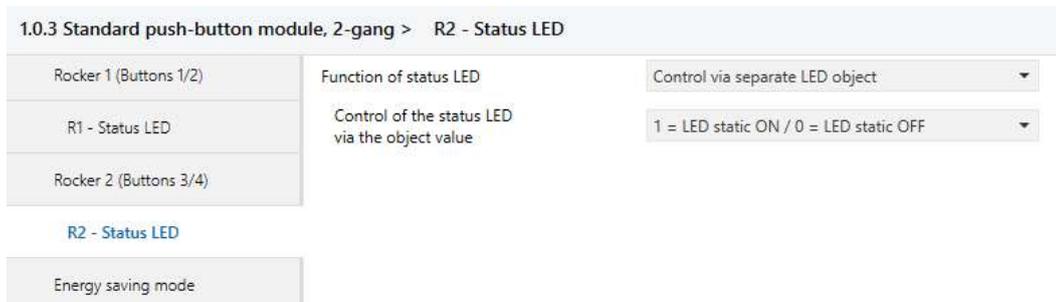


Figure 27 - ETS5 Standard push-button module (status LED Rocker 2)

The function mentioned before makes two group objects related to the status LED. After that, we have to enable the feedback function of the actuator of the light. That generates a group object too.

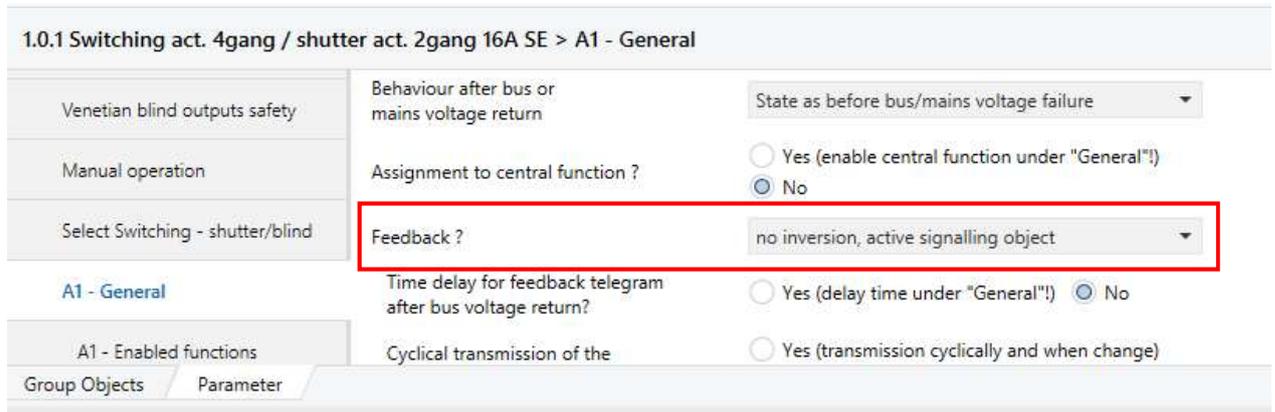


Figure 28 - ETS5 Switching actuator (Feedback output 1)

Now we only have to connect the three groups in the same group address. Therefore, the LEDS know the status of the output.

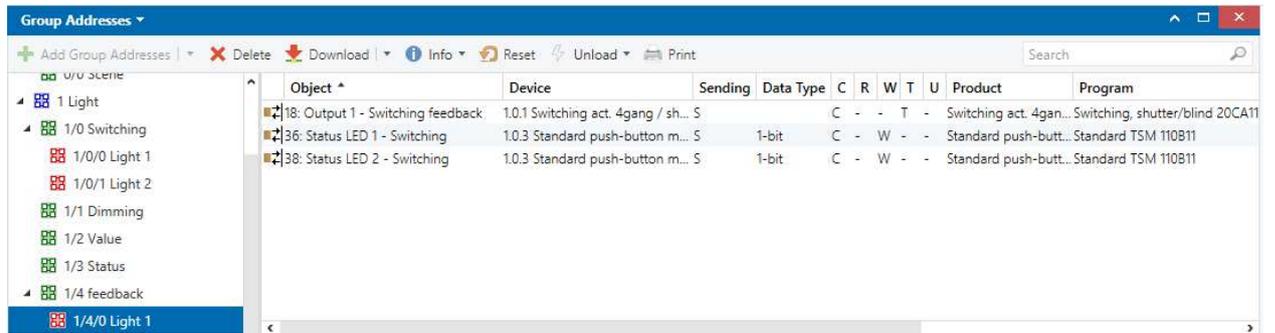


Figure 29 - ETS5 Group Addresses (Feedback LED Light 1)

In another case, we can use the buttons instead of the rocker. The steps are exactly the same as in the previous section.

Object *	Device	Sending	Data Type	C	R	W	T	U	Product	Program	Length	Priority	Group Address
0: Button 1 - Switching	1.0.3 Standard push-button m...	S	1-bit	C	-	W	T	-	Standard push-butt...	Standard TSM 110B11	1 bit	Low	1/0/0
2: Button 3 - Switching	1.0.3 Standard push-button m...	S	1-bit	C	-	W	T	-	Standard push-butt...	Standard TSM 110B11	1 bit	Low	1/0/0
10: Output 1 - Switching	1.0.1 Switching act. 4gang / sh...	S		C	-	W	-	-	Switching act. 4gan...	Switching_shutter/blind 20CA11	1 bit	Low	1/0/0

Figure 30 - ETS5 Group Addresses (Switching Light 1 via button 1 and button 3)

Object *	Device	Sending	Data Type	C	R	W	T	U	Product	Program	Length	Priority	Group Address
18: Output 1 - Switching feedback	1.0.1 Switching act. 4gang / sh...	S		C	-	-	T	-	Switching act. 4gan...	Switching_shutter/blind 20CA11	1 bit	Low	1/4/0
36: Status LED 1 - Switching	1.0.3 Standard push-button m...	S	1-bit	C	-	W	-	-	Standard push-butt...	Standard TSM 110B11	1 bit	Low	1/4/0
38: Status LED 2 - Switching	1.0.3 Standard push-button m...	S	1-bit	C	-	W	-	-	Standard push-butt...	Standard TSM 110B11	1 bit	Low	1/4/0

Figure 31 - ETS5 Group Addresses (Feedback LED Light 1)

But exist a specific situation that needs different feedback. If I want to turn on a light with two buttons and I put every button in different group addresses, the previous feedback doesn't work. In that case, we have to link the objects of the buttons on the feedback group address because they have to talk to each other.

Object +	Device	Sending	Data Type	C	R	W	T	U	Product	Program	Length	Priority	Group Address
0: Button 1 - Switching	1.0.3 Standard push-button m...	S	1-bit	C	-	W	T	-	Standard push-butt...	Standard TSM 110B11	1 bit	Low	1/0/0, 1/4/0
10: Output 1 - Switching	1.0.1 Switching act. 4gang / sh...	S	-	C	-	W	-	-	Switching act. 4gan...	Switching_shutter/blind 20CA11	1 bit	Low	1/0/0, 1/0/1

Figure 32 - ETS5 Group Addresses (Switching Light 1 with Button 1)

Object +	Device	Sending	Data Type	C	R	W	T	U	Product	Program	Length	Priority	Group Address
2: Button 3 - Switching	1.0.3 Standard push-button m...	S	1-bit	C	-	W	T	-	Standard push-butt...	Standard TSM 110B11	1 bit	Low	1/0/1, 1/4/0
10: Output 1 - Switching	1.0.1 Switching act. 4gang / sh...	-	-	C	-	W	-	-	Switching act. 4gan...	Switching_shutter/blind 20CA11	1 bit	Low	1/0/0, 1/0/1

Figure 33 - ETS5 Group Addresses (Switching Light 1 with Button 3)

Object +	Device	Sending	Data Type	C	R	W	T	U	Product	Program	Length	Priority	Group Address
0: Button 1 - Switching	1.0.3 Standard push-button m...	-	-	C	-	W	T	-	Standard push-butt...	Standard TSM 110B11	1 bit	Low	1/0/0, 1/4/0
2: Button 3 - Switching	1.0.3 Standard push-button m...	-	-	C	-	W	T	-	Standard push-butt...	Standard TSM 110B11	1 bit	Low	1/0/1, 1/4/0
18: Output 1 - Switching feedback	1.0.1 Switching act. 4gang / sh...	S	-	C	-	-	T	-	Switching act. 4gan...	Switching_shutter/blind 20CA11	1 bit	Low	1/4/0
36: Status LED 1 - Switching	1.0.3 Standard push-button m...	S	1-bit	C	-	W	-	-	Standard push-butt...	Standard TSM 110B11	1 bit	Low	1/4/0
38: Status LED 2 - Switching	1.0.3 Standard push-button m...	S	1-bit	C	-	W	-	-	Standard push-butt...	Standard TSM 110B11	1 bit	Low	1/4/0

Figure 34 - ETS5 Group Addresses (Feedback Light 1 with all the involved group objects)

6.10. Scene in a group address: all lights on/off

Devices used:

- Switching actuator
- Pushbutton (Universal push-button module)

Create a scene is usefully when we want to create different situations on the actuators pushing a single button. An example would be creating a scene called “watch TV” and that will involves put the lights in a determined value and turn off the blinds by pushing one single button.

What we do next is a scene that turn off all the lights when leaving home. That kind of scene is the easiest because it doesn't need a scene function.

For that kind of function have more sense using a button instead of a rocker, so we should go to the parameters of the pushbutton and fill the operation concept as a button function. After that, adjust the parameters of the desired button to send an off-command switch telegram.



Figure 35 - ETS5 Universal push-button module (Button 1 switching OFF)

For the scenes, we use the main group address “Scene”. It is a different group address concept because the final receiver of the subgroup can be more than one receivers. In the current example, “Leaving home” means turn several lamps off.

Finally, put the switching object of the pushbutton with all the outputs you want to turn off. We need to be sure that all the group objects have 1 bit length.

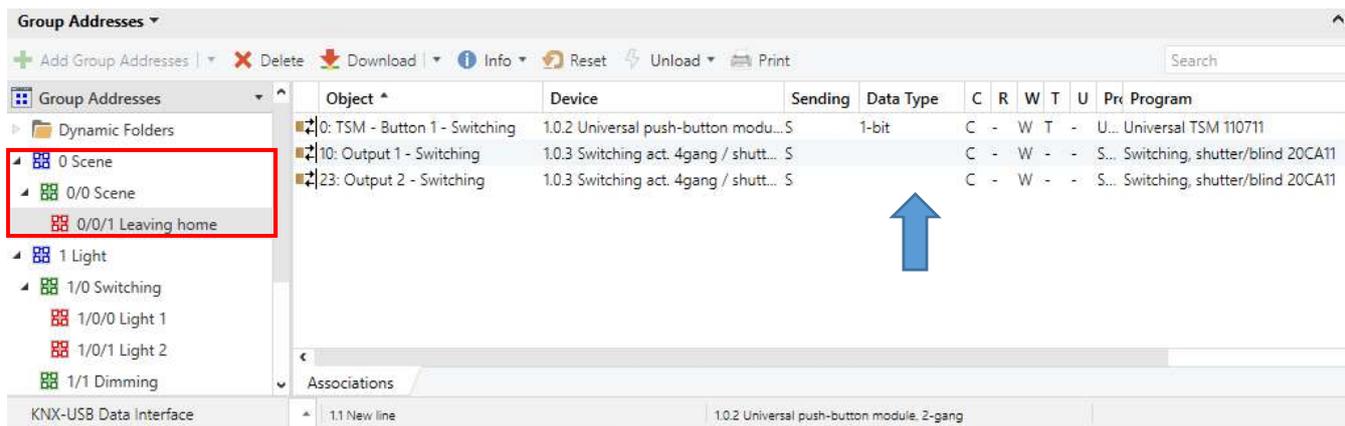


Figure 36 - ETS5 Group Address (Scene all off)

6.11. Scene in a pushbutton: e.g. a light on 60% and another light on 75%.

Devices used:

- Dimming actuator
- Pushbutton (Universal push-button module)

Another way to program a scene is by the pushbutton.

Adjust the parameters of the pushbutton to allow the scene function. After that, choose the desired data type of the outputs (in this case we need a value expressed by a percentage for two outputs).

1.0.3 Universal push-button module, 2-gang > Scene	
TSM - B3 - Status LED	Scene function ? <input checked="" type="radio"/> Yes <input type="radio"/> No
TSM - Button 4	
TSM - B4 - Status LED	Overwrite scene values on ETS download? <input checked="" type="radio"/> Yes <input type="radio"/> No
Disabling	Data types
Scene	Scene output 1 Value / Venetian blind position (0...100 %) ▼
Scene 1	Scene output 2 Value / Venetian blind position (0...100 %) ▼
Scene 2	Scene output 3 Switching ▼
Scene 3	Scene output 4 Switching ▼
	Scene output 5 Switching ▼

Figure 37 – ETS5 Universal push-button module (Scene function)

Inside the elected scene (Scene 2) we should write the output values.

- light 1: 60% of brightness.
- light 2: 75% of brightness.

1.0.3 Universal push-button module, 2-gang > Scene 2	
TSM - B3 - Status LED	Name of the scene (max. 40 characters) Scene 2
TSM - Button 4	
TSM - B4 - Status LED	Recall via extension object with scene number 2
Disabling	Scene output 1 Value/Ven. blind pos. (0...100%) 60
Scene	Allow save? <input checked="" type="radio"/> Yes <input type="radio"/> No
Scene 1	Allow transmission? <input checked="" type="radio"/> Yes <input type="radio"/> No
Scene 2	Transmit delay (1...1200 * 100 ms) (0=deactivated) 0
Scene 3	Scene output 2 Value/Ven. blind pos. (0...100%) 75
Scene 4	Allow save? <input checked="" type="radio"/> Yes <input type="radio"/> No
Scene 5	Allow transmission? <input checked="" type="radio"/> Yes <input type="radio"/> No
Scene 6	Transmit delay (1...1200 * 100 ms) (0=deactivated) 0
Scene 7	

Figure 38 - ETS5 Universal push-button module (Scene 2 outputs parameters)

Next step is very important. Once the scene is created we must choose a button in order to call it (in this case the button 2). Inside the button parameters select the function "Scene

extension” and “Recall internal scene without store function” and write the number of the scene below this.

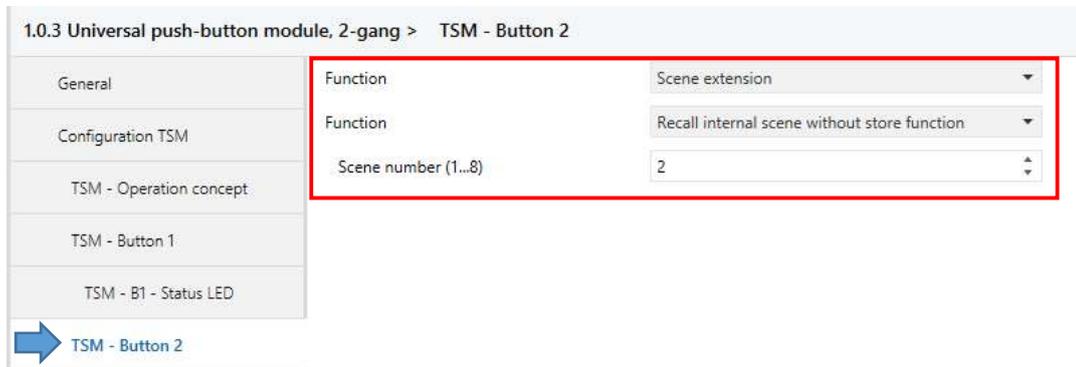


Figure 39 - ETS5 Universal push-button module (Button 2 recall Scene 2)

Doing that we are linking the scene 2 created on the parameter of the pushbutton with the pushbutton 2. Because the button and the scene are connected internally, the group object of the button 2 have disappeared. The groups object to work with is the “scene output 1” and “scene output 2”.

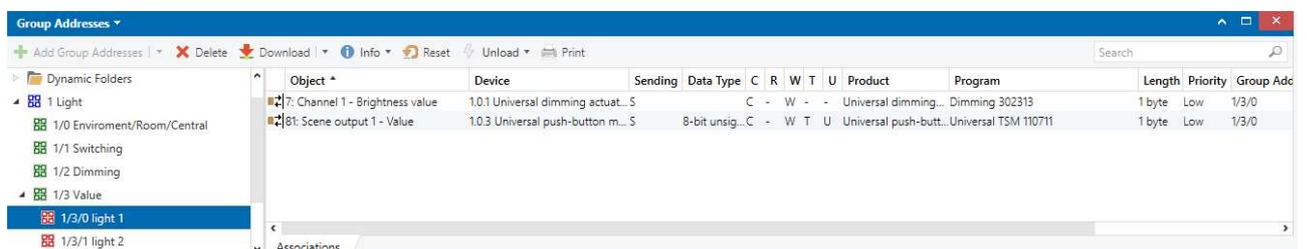


Figure 40 - ETS5 Group Addresses (Channel 1 of dimming actuator linked with Scene 2)

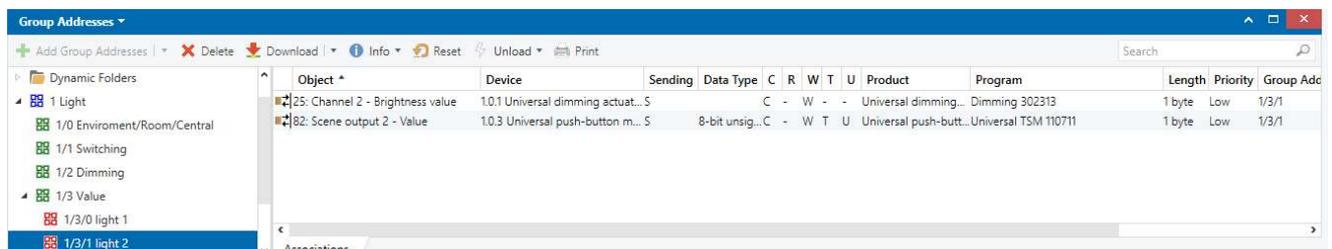


Figure 41 - ETS5 Group Addresses (Channel 2 of dimming actuator linked with Scene 2)

6.12. Scene in an actor: with one button turn ON the lights and put the shutter on 25%

Devices used:

- Switching actuator
- Pushbutton (Universal push-button module)

Furthermore, we can create a scene in an actuator. We must configure all the scene outputs individually and on the parameters of the actuator. First step is to allow the scene function of the actuator and then, adjust the parameters on the “Scenes” tab.

- Allow “Light scene function” on the output 1, output 2 and output 2/3.

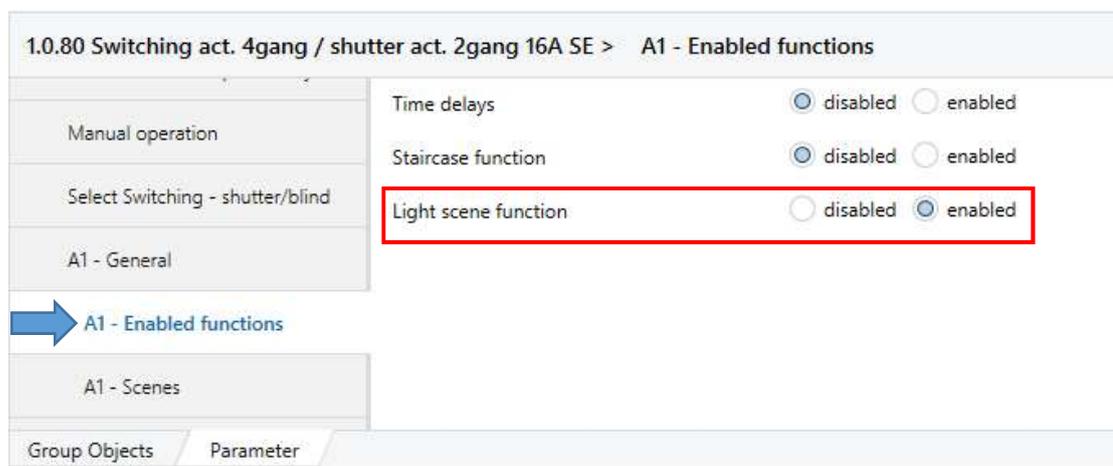


Figure 42 - ETS5 Switching actuator (Enabled functions)

After that, go to every output scene and configure it.

- Output 1: Switch on
- Output 2: Switch on
- Output 3/4: 25%

1.0.80 Switching act. 4gang / shutter act. 2gang 16A SE > A1 - Scenes

A1 - General	Delay scene recall ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
A1 - Enabled functions	Overwrite values stored in the device during ETS download ?	<input checked="" type="radio"/> Yes <input type="radio"/> No
A1 - Scenes		
A1 - Supplementary functions	Scene 1 activatable by scene number (scene number "0" = scene deactivated)	1
A2 - General	Switching state in scene 1	<input checked="" type="radio"/> switch on <input type="radio"/> switch off
A2 - Enabled functions	Storage function for scene 1	<input checked="" type="radio"/> Yes <input type="radio"/> No
A2 - Scenes	Scene 2 activatable by scene number (scene number "0" = scene deactivated)	2
A2 - Supplementary functions	Switching state in scene 2	<input type="radio"/> switch on <input checked="" type="radio"/> switch off
A3/4 - General	Storage function for scene 2	<input type="radio"/> Yes <input checked="" type="radio"/> No
A3/4 - Times	Scene 3 activatable by scene number (scene number "0" = scene deactivated)	3
A3/4 - Enabled functions	Switching state in scene 3	<input type="radio"/> switch on <input checked="" type="radio"/> switch off
A3/4 - Scenes	Storage function for scene 3	<input type="radio"/> Yes <input checked="" type="radio"/> No

Group Objects / Parameter

Figure 43 - ETS5 Switching actuator (Output 1 Scene 1)

1.0.80 Switching act. 4gang / shutter act. 2gang 16A SE > A2 - Scenes

A1 - General	Delay scene recall ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
A1 - Enabled functions	Overwrite values stored in the device during ETS download ?	<input checked="" type="radio"/> Yes <input type="radio"/> No
A1 - Scenes		
A1 - Supplementary functions	Scene 1 activatable by scene number (scene number "0" = scene deactivated)	1
A2 - General	Switching state in scene 1	<input checked="" type="radio"/> switch on <input type="radio"/> switch off
A2 - Enabled functions	Storage function for scene 1	<input type="radio"/> Yes <input checked="" type="radio"/> No
A2 - Scenes	Scene 2 activatable by scene number (scene number "0" = scene deactivated)	2
A2 - Supplementary functions	Switching state in scene 2	<input type="radio"/> switch on <input checked="" type="radio"/> switch off
A3/4 - General	Storage function for scene 2	<input type="radio"/> Yes <input checked="" type="radio"/> No
A3/4 - Times	Scene 3 activatable by scene number (scene number "0" = scene deactivated)	3
A3/4 - Enabled functions	Switching state in scene 3	<input type="radio"/> switch on <input checked="" type="radio"/> switch off
A3/4 - Scenes	Storage function for scene 3	<input type="radio"/> Yes <input checked="" type="radio"/> No

Group Objects / Parameter

Figure 44 - ETS5 Switching actuator (Output 2 Scene 1)

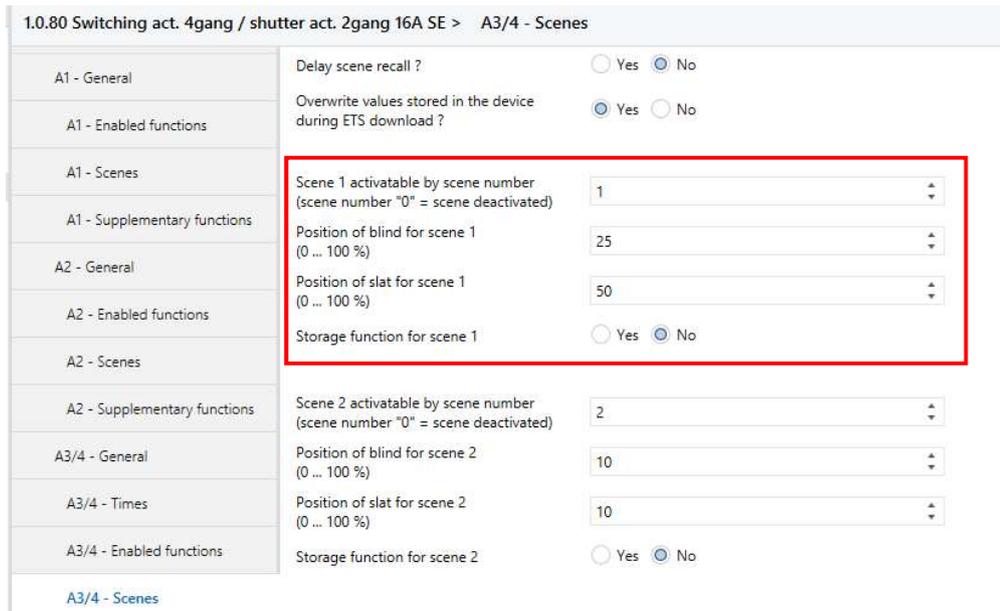


Figure 45 - ETS5 Switching actuator (Output 3/4 Scene 1)

Scene group objects appears automatically for every output and their length is 1 byte.

We need a button to turn on the scene. This button has to have “Scene extension” and “Scene extension without storage function” activated.

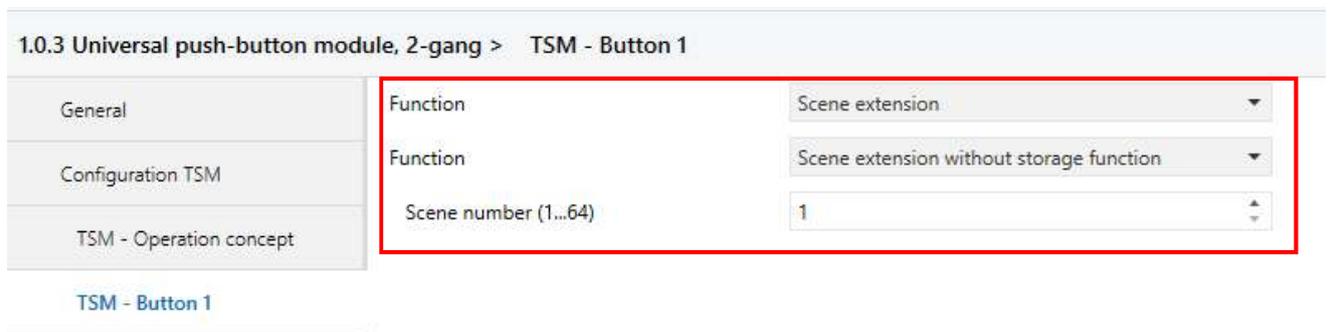


Figure 46 - ETS5 Universal push-button module (Button 1 Scene extension)

Finally, we must link all the scene group objects of the actuators with the scene extension group object of the button. Note that the length of scene group objects is 1 byte.

Object	Device	Sending	Data Type	C	R	W	T	U	Product	Program	Length	Priority	Group
0: TSM - Button 1 - Scene extension	10.3 Universal push-button m...	S		C	-	-	T	-	Universal push-butt...	Universal TSM 110711	1 byte	Low	1/5/0
16: Output 1 - Scene extension	10.80 Switching act. 4gang / s...	S		C	-	W	-	-	Switching act. 4gan...	Switching. shutter/blind 20CA11	1 byte	Low	1/5/0
29: Output 2 - Scene extension	10.80 Switching act. 4gang / s...	S		C	-	W	-	-	Switching act. 4gan...	Switching. shutter/blind 20CA11	1 byte	Low	1/5/0
39: Output 3/4 - Scene extension	10.80 Switching act. 4gang / s...	S		C	-	W	-	-	Switching act. 4gan...	Switching. shutter/blind 20CA11	1 byte	Low	1/5/0

Figure 47 - ETS5 Group Addresses (Scene 1)

6.13. Scene with central function

Devices used:

- Switching actuator
- Pushbutton (Universal push-button module)

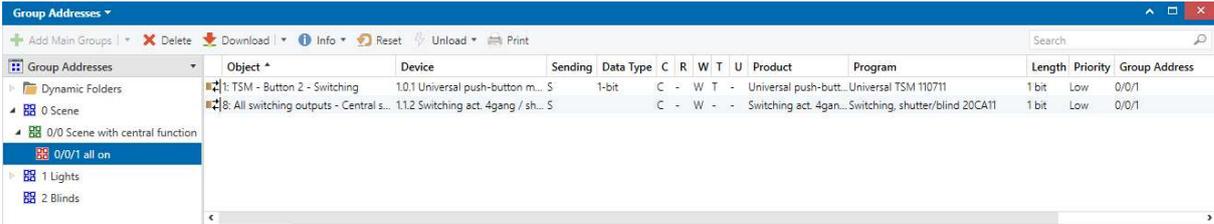
The actuator offers the possibility of linking selected individual or all switching output channels with a 1-bit central communication object. The behaviour in case of activating an output via the central function is comparable to a central group address linked with all "Switching" objects.

First of all, enable the central function on general parameter page. After that, the "Central switching" communication object is visible.

1.1.2 Switching act. 4gang / shutter act. 2gang 16A SE > General

General	Delay after bus voltage return Minutes (0...59)	0
Switching outputs times	Seconds (0...59)	17
Venetian blind outputs safety	Central function for switching outputs ?	<input checked="" type="radio"/> Yes <input type="radio"/> No
Manual operation	Central object polarity	<input checked="" type="radio"/> 0 = switch off; 1 = switch on <input type="radio"/> 0 = switch on; 1 = switch off
Select Switching - shutter/blind	Central function for blind outputs ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
A1/2 - General	Use collective feedback for switching outputs ?	No
A1/2 - Times	Time for flashing (all assigned switching outputs)	1 sec
A1/2 - Enabled functions		

Figure 48 - ETS5 Switching actuator (General)



Group Addresses	Object +	Device	Sending	Data Type	C	R	W	T	U	Product	Program	Length	Priority	Group Address
Dynamic Folders														
0 Scene														
0/0 Scene with central function														
0/0/1 all on	1: TSM - Button 2 - Switching	1.0.1 Universal push-button m...	S	1-bit	C	-	W	T	-	Universal push-butt...	Universal TSM 110711	1 bit	Low	0/0/1
1 Lights	8: All switching outputs - Central s...	1.1.2 Switching act. 4gang / sh...	S		C	-	W	-	-	Switching act. 4gan...	Switching, shutter/blind 20CA11	1 bit	Low	0/0/1
2 Blinds														

Figure 49 - ETS5 Group Address (Button 2 active central function)

6.14. Send a value to a light

Devices used:

- Dimming actuator
- Pushbutton (Universal push-button module)

To send a value to a light we can use the functions of the pushbutton. The function “Value transmitter 1-byte” allow percentage values.



1.0.3 Universal push-button module, 2-gang > TSM - Button 3

TSM - Button 3	Function	Value transmitter 1-byte
TSM - B3 - Status LED	Function	<input type="radio"/> Value transmitter 0...255 <input checked="" type="radio"/> Value transmitter 0...100 %
TSM - Button 4	Value (0...100 %)	70
TSM - B4 - Status LED	Value adjustment by long button-press	<input type="radio"/> enabled <input checked="" type="radio"/> disabled
Disabling		
Scene		
Scene 1		
Group Objects	Parameter	

Figure 50 - ETS5 Universal push-button module (Button 3 Value transmitter)

A 1-byte value group object is created, and we have to link it with the brightness value group object of the dimming actuator.

- Dimming actuator “Channel 1” listen the value from Button 3.

Object	Device	Sending	Data Type	C	R	W	T	U	Product	Program	Length	Priority	Group
2: TSM - Button 3 - Value	1.0.3 Universal push-button m... S		8-bit unsig...	-	-	W	T	-	Universal push-butt...	Universal TSM 110711	1 byte	Low	1/3/0
7: Channel 1 - Brightness value	1.0.1 Universal dimming actuat... S			C	-	W	-	-	Universal dimming...	Dimming 302313	1 byte	Low	1/3/0

Figure 51 - ETS5 Group Address (Button 3 sends a value to Channel 1 of dimming actuator)

6.15. Send a value to a shutter

Devices used:

- Switching actuator
- Pushbutton (Universal push-button module)

Is exactly the same as in the previous case, but here we must link the value group object of the button with the “Position of blind” group object of the switching actuator.

1.0.3 Universal push-button module, 2-gang > TSM - Button 3

TSM - Button 3	Function	Value transmitter 1-byte
TSM - B3 - Status LED	Function	<input type="radio"/> Value transmitter 0...255 <input checked="" type="radio"/> Value transmitter 0...100 %
TSM - Button 4	Value (0...100 %)	70
TSM - B4 - Status LED	Value adjustment by long button-press	<input type="radio"/> enabled <input checked="" type="radio"/> disabled
Disabling		
Scene		
Scene 1		
Group Objects	Parameter	

Figure 52 - ETS5 Universal push-button module (Button 3 Value transmitter)



Object *	Device	Sending	Data Type	C	R	W	T	U	Product	Program	Length	Priority	Group Add
0: TSM - Button 1 - Value	1.0.3 Universal push-button m...S		8-bit unsig...C	-	W	T	-		Universal push-butt... Universal TSM 110711		1 byte	Low	0/2/0
54: Output 3/4 - Position of blind	1.0.80 Switching act. 4gang / s...S		C	-	W	-	-		Switching act. 4gan... Switching, shutter/blind 20CA11		1 byte	Low	0/2/0

Figure 53 - ETS5 Group Address (Button 3 sends a value to Output 3/4 of the switching actuator)

6.16. Check all the functions of the diagnose (very important)

Diagnostics window has a lot of functions and it helps you to find an error.

6.16.1. Group Monitor

Group monitoring is used to recording and analysis of group telegrams also to reading and sending of group address values. This diagnostic function does not need an exclusive use of the connected interface (“Bus Monitoring” needs it).

The information displayed on the group monitoring of each telegram is explained in the next chapter “Bus Monitor” because in the both cases is the same.

By marking a specific telegram in the list, his information is displayed in the “Properties” window.

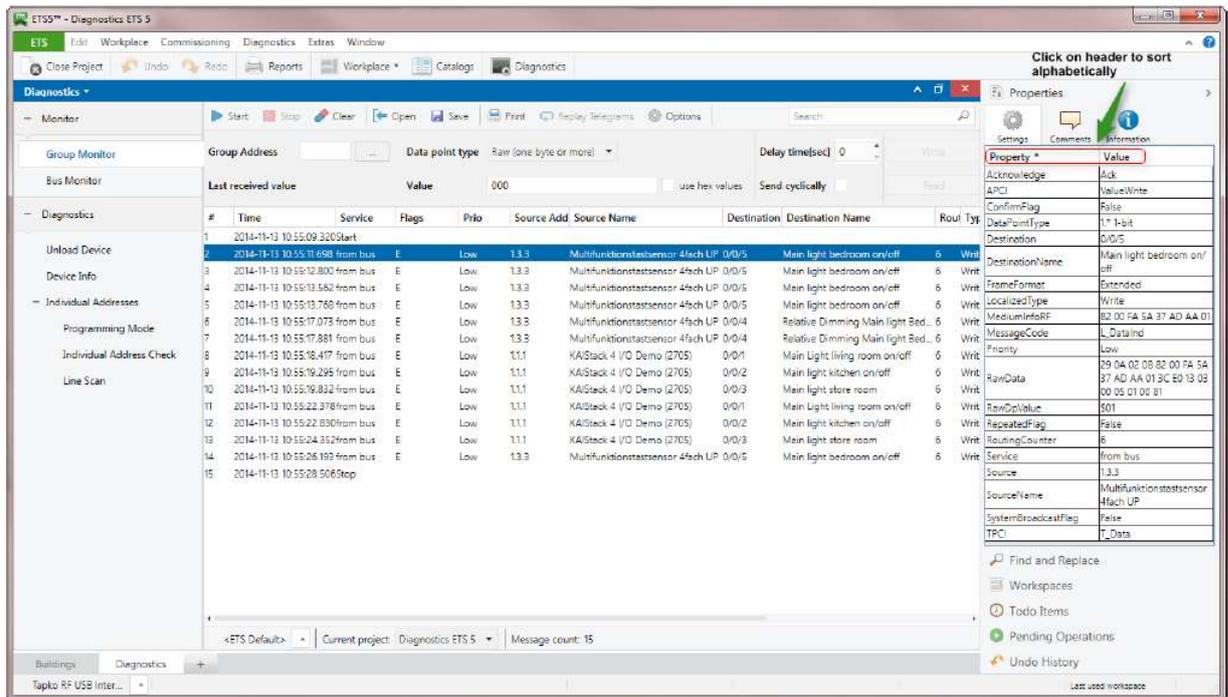


Figure 54 - ETS5 Group Monitor (Telegram Info.) [1]

- Read value

In the “Group Monitoring” window there is the option of read the current status of a group object. The following step has to be followed:

1. Hit the “Start” button
2. Enter the group address or select it from the existing list
3. Press “Read” button

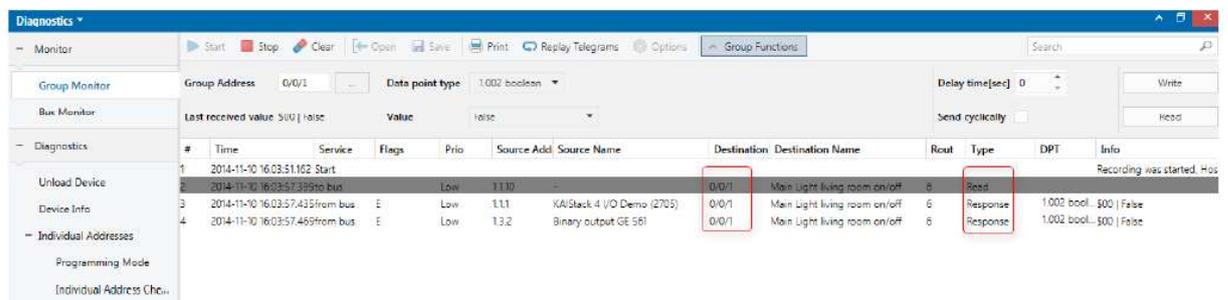


Figure 55 - ETS5 Group Monitor (Read) [1]

Resulting telegrams:

Type:	Read	Response
Source Address:	Individual address of the bus interface	Individual address of the bus device
Info:	-	Value of the response telegram (current status of the group object). \$ → means a hexadecimal value.

Table 7 - Resulting telegrams from Read a group address

- Write value

The same concept applies in this function; overwrite the current status of a group object.

1. Hit the “Start” button
2. Enter the group address or select it from the existing list
3. Setting the data point type (DPT)
4. Setting the value of the useful data
5. Optional: “Delay time” and “Send cyclically”
6. Press “Write” button

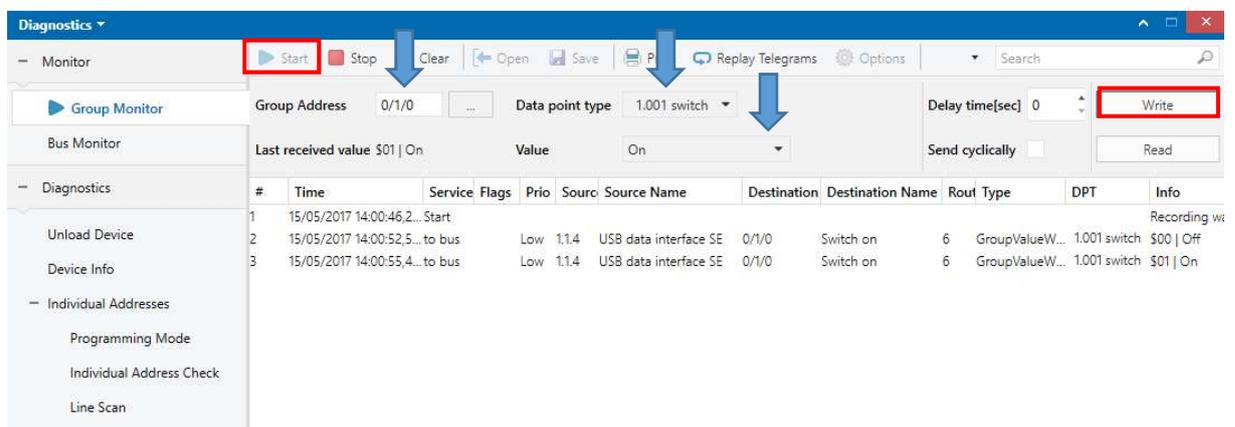
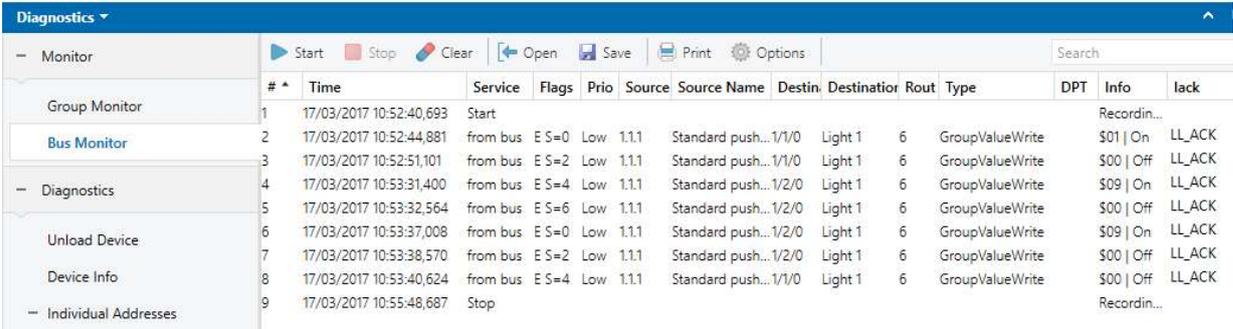


Figure 56 – ETS5 Group Monitor (Write)

Bus Monitor

Bus monitoring are used to recording and analysis of all run-time telegrams on the bus.



#	Time	Service	Flags	Prio	Source	Source Name	Destin	Destinator	Rout	Type	DPT	Info	Lack
1	17/03/2017 10:52:40,693	Start										Recordin...	
2	17/03/2017 10:52:44,881	from bus	E S=0	Low	1.1.1	Standard push.../1/0	Light 1	6	6	GroupValueWrite	\$01	On	LL_ACK
3	17/03/2017 10:52:51,101	from bus	E S=2	Low	1.1.1	Standard push.../1/0	Light 1	6	6	GroupValueWrite	\$00	Off	LL_ACK
4	17/03/2017 10:53:31,400	from bus	E S=4	Low	1.1.1	Standard push.../1/2/0	Light 1	6	6	GroupValueWrite	\$09	On	LL_ACK
5	17/03/2017 10:53:32,564	from bus	E S=6	Low	1.1.1	Standard push.../1/2/0	Light 1	6	6	GroupValueWrite	\$00	Off	LL_ACK
6	17/03/2017 10:53:37,008	from bus	E S=0	Low	1.1.1	Standard push.../1/2/0	Light 1	6	6	GroupValueWrite	\$09	On	LL_ACK
7	17/03/2017 10:53:38,570	from bus	E S=2	Low	1.1.1	Standard push.../1/2/0	Light 1	6	6	GroupValueWrite	\$00	Off	LL_ACK
8	17/03/2017 10:53:40,624	from bus	E S=4	Low	1.1.1	Standard push.../1/0	Light 1	6	6	GroupValueWrite	\$00	Off	LL_ACK
9	17/03/2017 10:55:48,687	Stop										Recordin...	

Figure 57 - ETS5 Bus monitor

- **#:** Telegram counter
- **Time:** Date and time of the telegram
- **Service:** Start/Stop or from bus
- **Flags:** Control information
- **Prio:** Telegram Priority, Low by default.
- **Source Address:** Individual address of sender
- **Source name:** Name of the bus device source
- **Destination address:** Individual address or group address
- **Destination name:** Destination name device
- **Rout:** Value of the telegram routing counter
- **Type:** KNX telegram APCI* service decoding (Write, Read...)
- **DPT:** Datapoint type of the sending group object
- **Info:** Additional information
- **Medium Info:** used for PL/RF
- **Lack:** Acknowledgement

* KNX provides a range of application layer functions to interact with bus devices for retrieving information, changing configuration values or other maintenance tasks. KNX map implements wrappers for various functions that allow easy interaction with bus devices. The APCI wrappers are available via the APCI subcommand.

6.16.2. Device Info

This function allows you to know the description of the device

When you write the individual address, it shows you which device is associated and the information of that.



Figure 58 - ETS5 Device Info (read individual address)

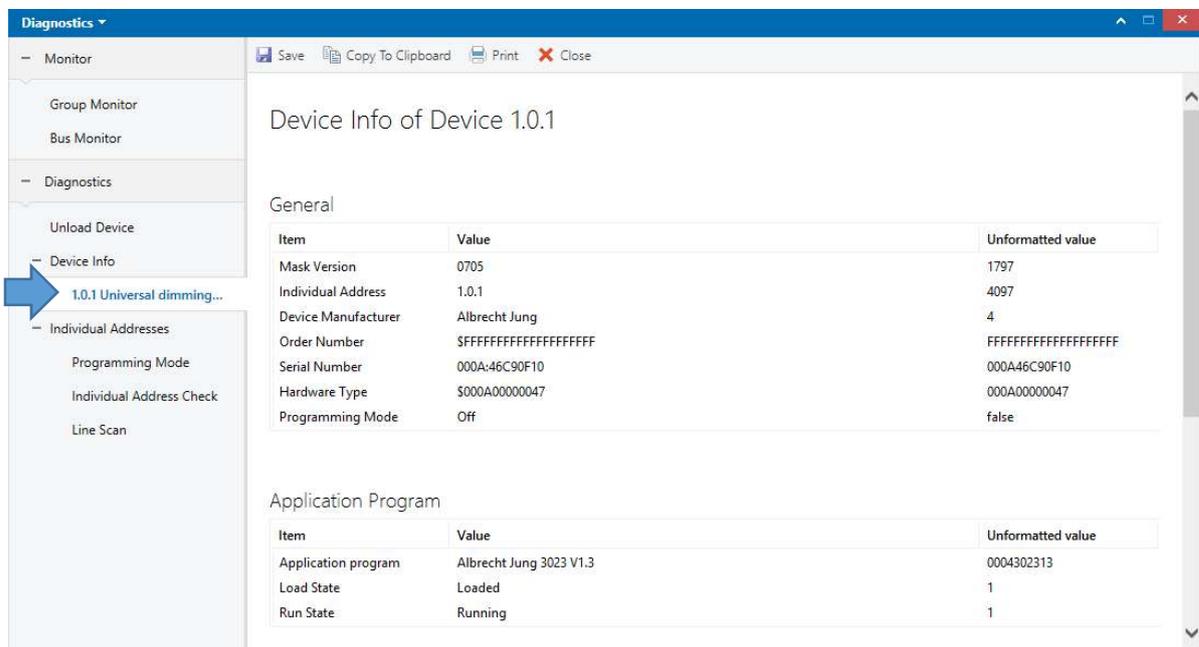


Figure 59 - ETS5 Device Info (device found)

6.16.3. Individual Addresses – Programming mode

The first option of the diagnostics function “Individual addresses” is used to search for the devices which are in programming mode. If you start it and you have a bus device in the programming mode it will appear. Clicking on the stop button, listening of devices in programming mode are stopped.

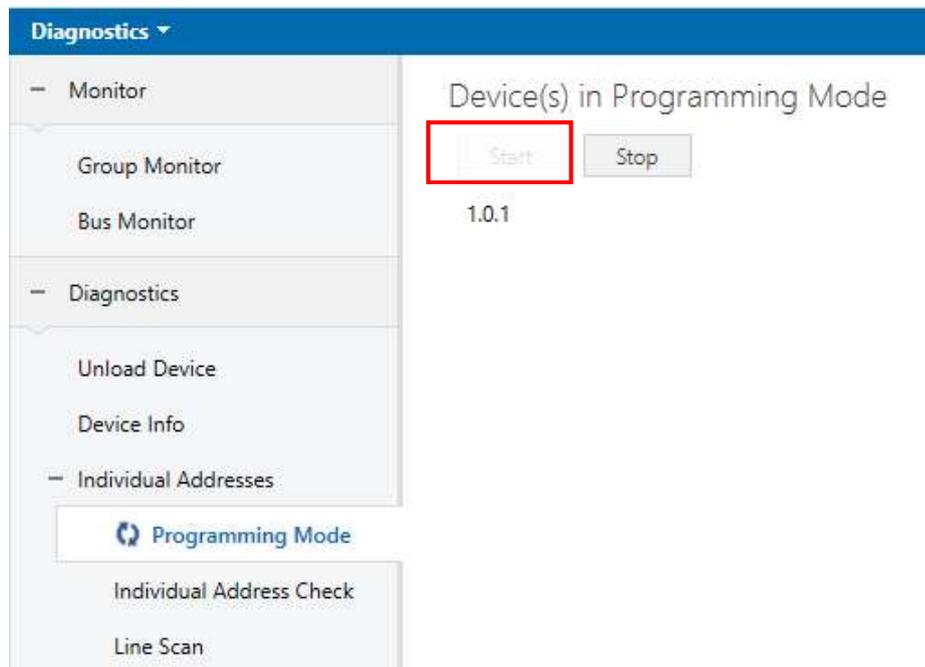


Figure 60 - ETS5 Devices in Programming Mode

6.16.4. Individual Addresses – Individual Address Check

The second one is used to check if a certain individual address exists in this way locating device. In this case, we are searching 1.0.5 individual address, and that exists because the icon appears in green. If we want to know where the bus device is located I have to put the device led on or flashing and search it.

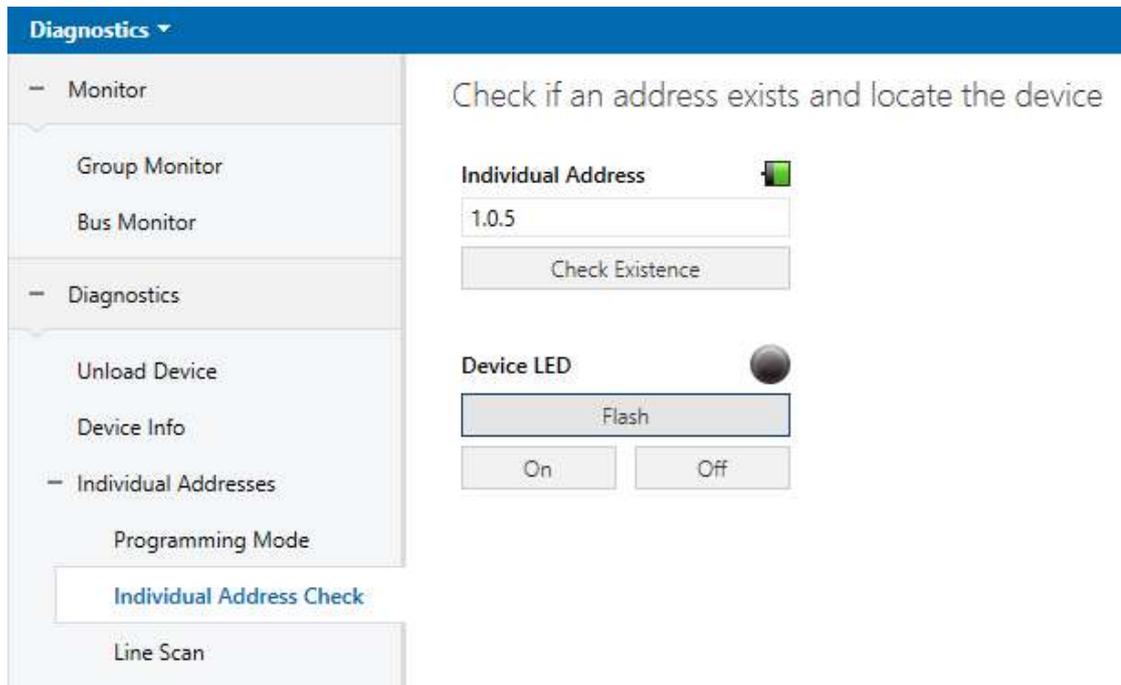


Figure 61 - ETS5 Individual Address Check

6.16.5. Individual Addresses – Line Scan

This function scan all devices in a line and shows which individual addresses have already been assigned. The desired Line Address and the medium used must be selected. Devices will be shown with their mask version.

The screenshot shows the ETS5 software interface. The 'Diagnostics' menu is expanded, and the 'Line Scan' option is selected. The main window displays the 'Line Scan' configuration and results. The 'Scan' button is highlighted with a red box. The 'Line Address' is set to '1.0 Main line' and the 'Scan mode' is 'TwistedPair'. A table below shows the results of the scan, with the table itself also highlighted by a red box.

Address ^	Mask version
1.0.5 (local)	
1.0.10	\$0705
1.0.20	\$0705
1.0.30	\$0705
1.0.40	\$0012

Figure

62 - ETS5 Line Scan

In order to check which of those individual addresses are in the ETS project you can select “Compare to Project”.

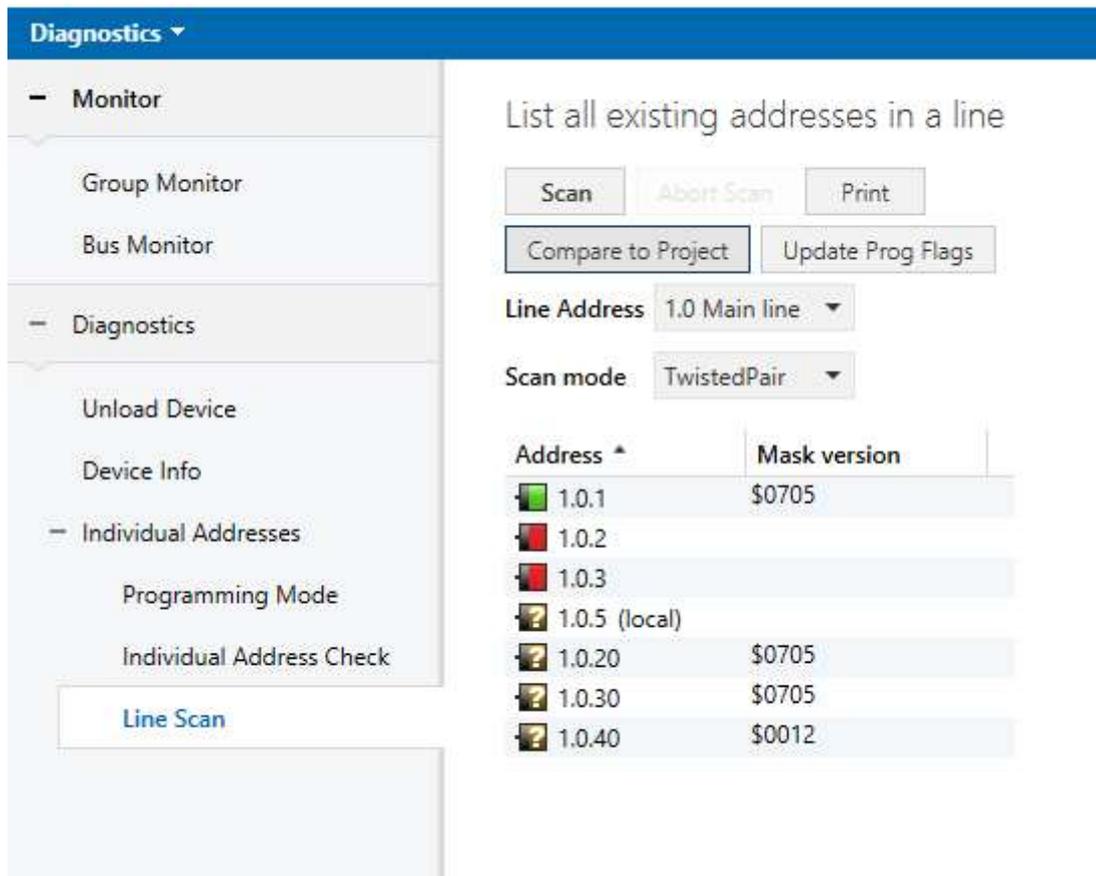


Figure 63 - ETS5 Line Scan (Compare to Project)

	Device found in the actual line and configured in the ETS project
	Device found in the actual line but not configured in the ETS project
	Device not found in the actual line but configured in the ETS project

Figure 64 - Possible results of the comparison [1]

6.17. Check the bus connection and check if the USB-interface has the same physical address as in your topology

The communication between the installation and the PC is done by the linked of the bus and the appropriated PC cable. This is done by an interface which is “KNX-USB Data Interface”.

When the PC is connected properly to the KNX installation, the interface is displayed on the window: “BUS → Connections → Interfaces”. Individual address must match the one assigned on the topology.

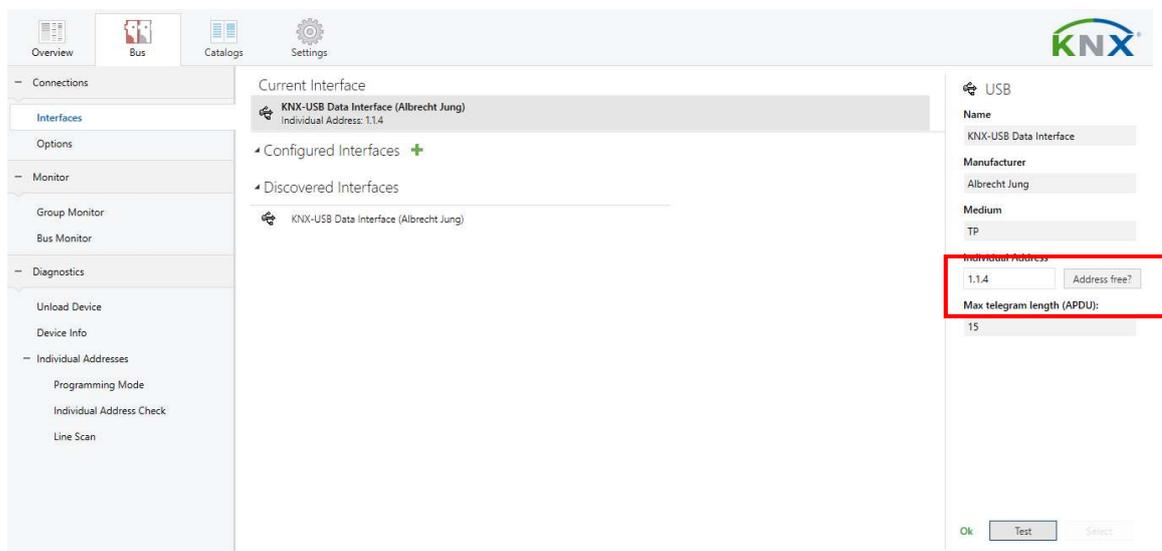


Figure 65 - ETS5 Bus page (Individual address of the USB Interface)

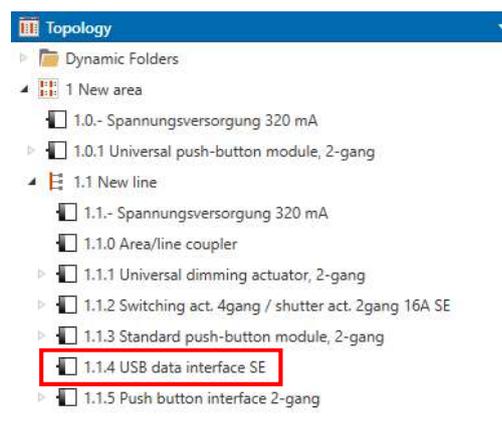


Figure 66 - ETS5 Topology (Individual address of the USB Interface)

6.18. Logical functions

Devices used:

- Switching actuator
- Pushbutton (Universal push-button module and Standard push-button module)

Logical functions are used when a function cannot be traced back to a single circumstance. The KNX components from several manufacturers have logic operations to be implemented. The communication objects and parameter settings of these devices use the basic principles of digital technology.

If we focus on our switching actuator, a logic function can be parameterized separately and independently for each output. This function allows the logic operation of the "switching" object state and an additional logic operation object.

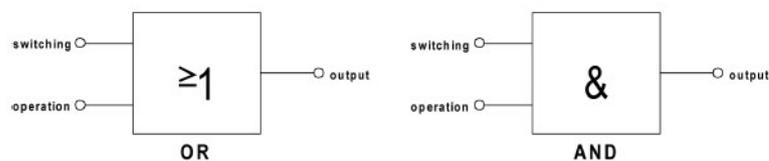


Figure 67 - Logic operation of the switching actuator [7]

6.18.1. AND function

One way to try this function is by the situation of turn on a light by pressing two buttons at the same time.

First step is allowing the "Logic operation function" and select the AND type.

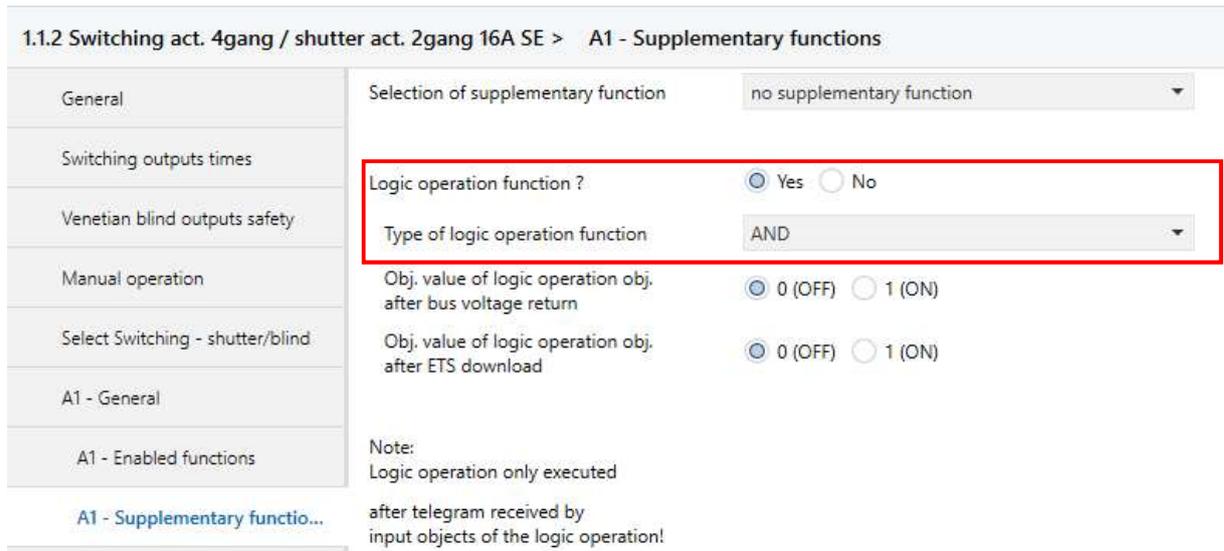


Figure 68 - ETS5 Switching actuator (AND operation)

A new logic operation group object is displayed. When logic operation group object of output 1 and output 1 group object receive an ON telegram, the light will turn on.

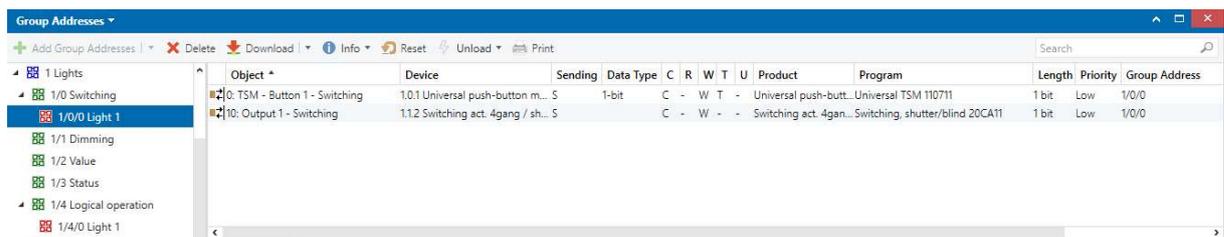


Figure 69 - ETS5 Group Address (Button 1 switch the output 1)

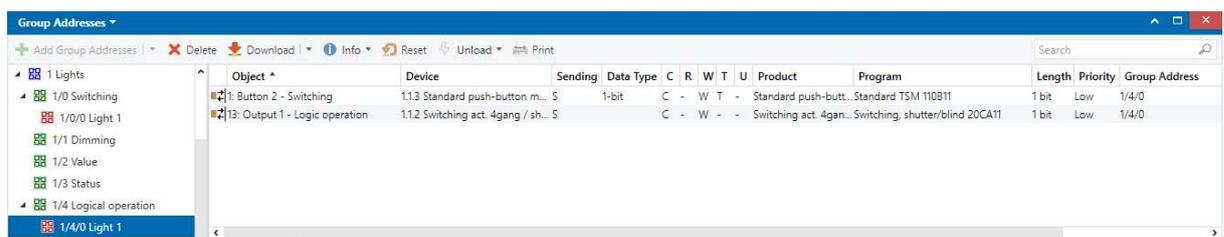


Figure 70 - ETS5 Group Address (Button 2 switch the Logic operation output 1)

OR function

When logic operation group object of output 1 or output 1 group object receive an ON telegram, the light will turn on.

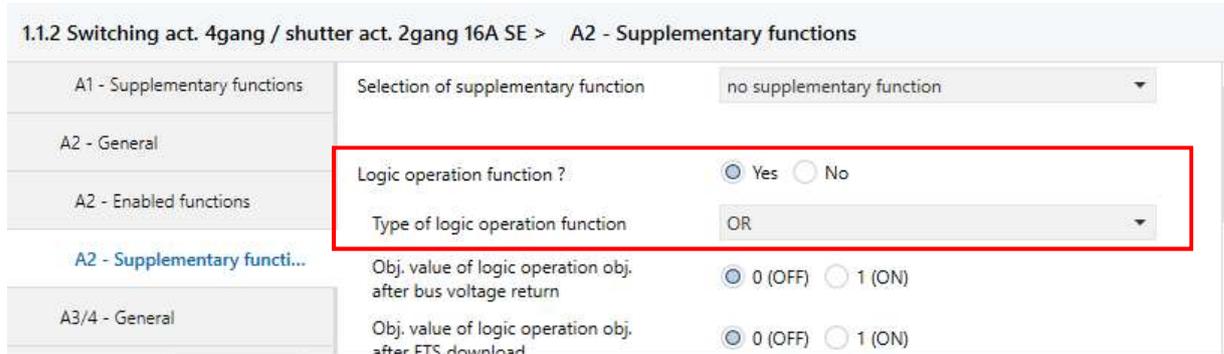


Figure 71 - ETS5 Switching actuator (OR operation)

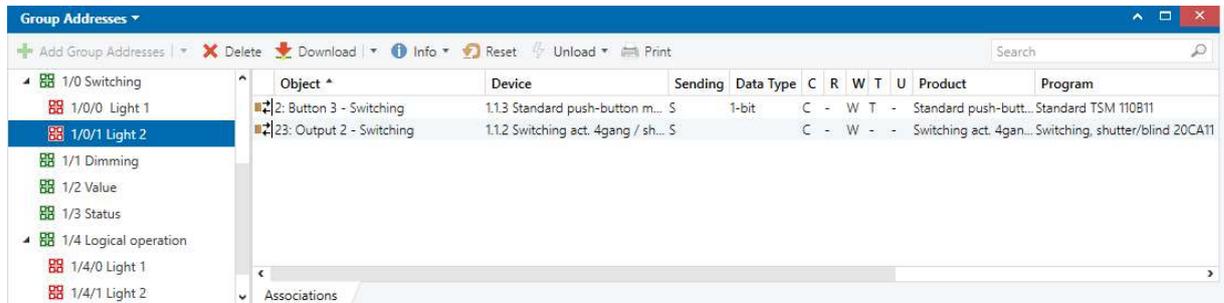


Figure 72 - ETS5 Group Address (Button 3 switch the output 2)

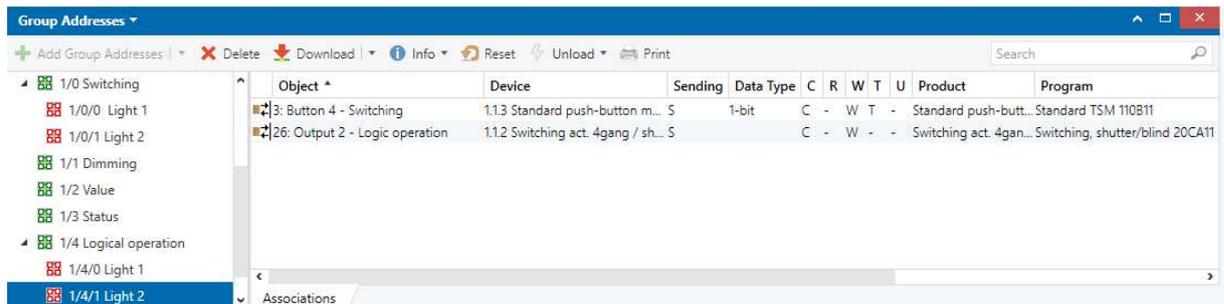


Figure 73 - ETS5 Group Address (Button 4 switch the Logic operation output 2)

Block function

A new group object appears when the disabling function is selected. The disabling group object is linked to one output of the actuator, and when a signal is received by disabling group object the related output is blocked. His behaviour depends on the parametrization on ETS5.

The following functions can be configured:

- Polarity of the disabling object
- Behaviour at the beginning of the disabling function

no change of switching state	The relay of the output shows no reaction and remains in the current switching state. Thereafter, the output is again locked.
switch off	The output switches off at the beginning of the disabling function and locks itself.
switch on	The output switches on at the beginning of the disabling function and locks itself.
Flashing	The output flashes on and off during the disabling function and is locked during this time. The flashing time is configured generally for all outputs under "General". During the flashing, the logical switching state is "on -1".

Table 8 - Disabling function (Behaviour at the beginning)

- Behaviour at the end of the disabling function

no change of switching state	The internal switching state is not changed at the end of the disabling function. Thereafter, the output is again enabled.
switch off	The switching state is set to switch off at the end of the disabling function. The output is enabled again.
switch on	The switching state is set to switch on at the end of the disabling function. The output is enabled again.
Flashing	At the end of the disabling function, the output will flash on and off and be enabled again. The flashing continues until a new switching state is specified. The flashing time is configured generally
setting tracked state	At the end of the disabling function, the last switching state existing before the disabling function or the switching state internally tracked during the disabling function will be set. Any time functions or staircase functions that are still in progress will also be taken into account if necessary.

Table 9 - Disabling function (Behaviour at the end)

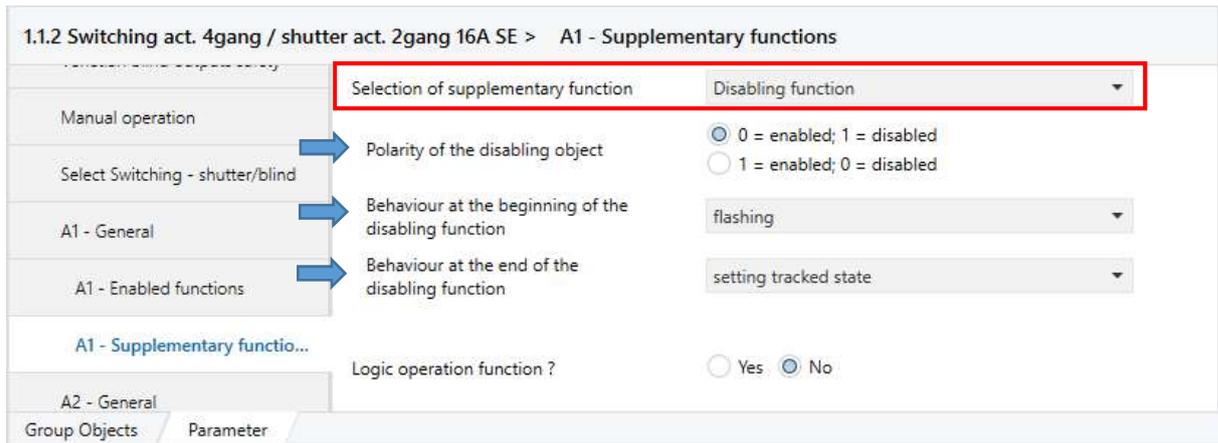


Figure 74 - Switching actuator (Disabling function)

A good way to test this function is choosing the parameters of the figure above, because when the block function is activated the output starts to flashing.

Object *	Device	Sending	Data Type	C	R	W	T	U	Product	Program
1: Button 2 - Switching	1.1.3 Standard push-button m...	S	1-bit	C	-	W	T	-	Standard push-butt...	Standard TSM 110B11
12: Output 1 - Disabling	1.1.2 Switching act. 4gang / sh...	S		C	-	W	-	-	Switching act. 4gan...	Switching, shutter/blind 20CA11

Figure 75 - ETS5 Group Address (Button 2 linked to Disabling function output 1)

In the “Disabling” group address we have the button 2 group object and the disabling group object from the output 1.

6.19. Dimming brightness value via fading

If you want to do a scene who switch two lights with different values of brightness, the light with the lowest value will spend few time than the other. That’s uncomfortable to our eyes. What we can do is use the fading function and then set a time to assume the maximum brightness.

1.0.1 Universal dimming actuator, 2-gang > K1 - Scenes

K1 - General	Delay scene recall ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
K1 - Enabled functions	Behaviour when recalling a scene	Dimming brightness value via fading
	Fading time (0...240 s)	5
K1 - Scenes	Overwrite values stored in the device during ETS download ?	<input checked="" type="radio"/> Yes <input type="radio"/> No
K1 - Supplementary functions	Scene 1 activatable by scene number (scene number "0" = scene deactivated)	1
K1 - Dimming characteristic	Brightness value for scene 1	50%
K2 - General		

Figure 76 - Universal dimming actuator (Scenes)

7. ETS Inside

ETS Inside is an official tool software by KNX Association that allows to installers and end users customize homes features (lighting, windows shades, heating and cooling, home security, etc.). ETS Inside is controlled by an app and can be accessed by a PC, tablet or even a smartphone.

Few features:

- You can create KNX projects quickly and easily
- Small and medium-size projects
- User-friendly user interface
- Runs on tablets and smart phones

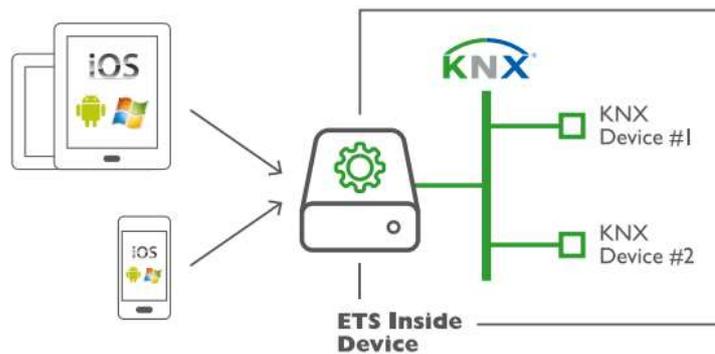


Figure 77 - ETS Inside [6]

Decoupling of the user interface from the ETS data

KNX basic software that acts underlying is installed on the ETS Inside device. That hardware is a part of the installation and contains the KNX project and offers a web server for a decoupled user interface. This new concept allows project editing on all common operating systems and on tablets and smartphones. [6]

- It is possible to design and to commission small and medium-sized projects (residential, commercial and public buildings)
- All media are supported: TP, IR, RF and PL.

- Projects from ETS Inside can be synchronised with ETS Professional (second half of 2017)

7.1. ETS Inside installation

As explained above, ETS Inside needs KNX basic software and an app, so both software has to be downloaded.

You can make the installation of the ETS Inside server and the Windows ETS Inside client on the same device.

7.1.1. ETS Inside Server

1. If you would like the full functionality, go to MyKNX and buy a license. If you only need the demo version go to the Downloads section of MyKNX.
2. Copy the setup file where do you want to install ETS Inside server.
3. Install it by double clicking on the setup file.

7.1.2. ETS Inside Client

Depending on the operating system of your device where the ETS Inside client will be installed, you will have to follow different steps.

There are three options:

- Windows device: Download the ETS Inside app from the Windows Store
- Android device: Download the ETS Inside app from the Play Store
- iPad: Download the ETS Inside app from the App Store

7.2. Connecting to the ETS Inside server

After the installation, ETS Inside server and ETS Inside client have to be connected to each other.

- Auto connection

If the ETS Inside client has detected any ETS Inside servers, then they will show up when opening the ETS Inside client in the 'Auto' panel. ETS Inside server as well as the ETS Inside client have to belong to the same network. To select one of the found ones, just click on the server.

In case any server is found, for Android and iOS clients pull down the list of servers in order to refresh the list. For windows clients click the Manual tap and then the Auto tap again.

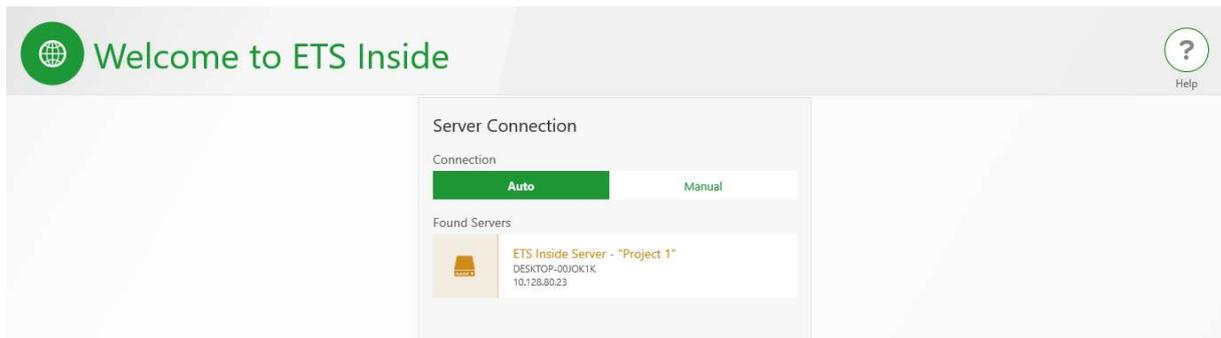


Figure 78 - ETS Inside Home Page (Auto Connection)

- Manual connection

Another option is tap the panel "Manual" and write the IP address of the ETS Inside server.

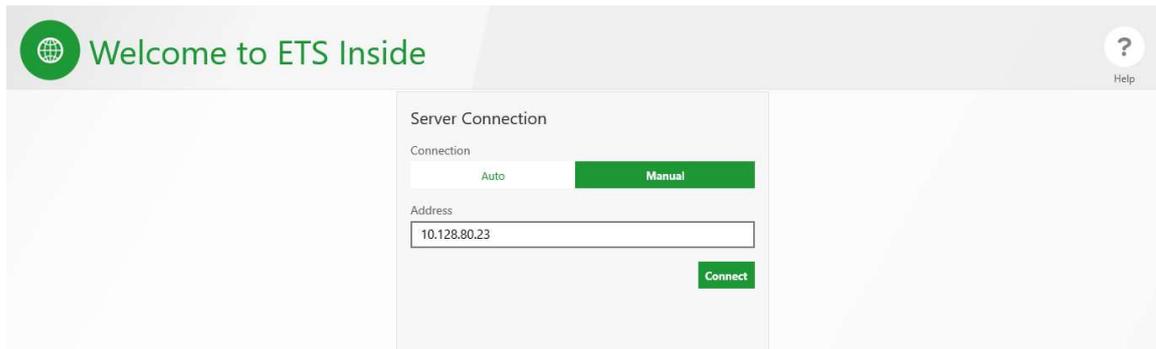


Figure 79 - ETS Inside Home Page (Manual Connection)

7.3. Create a project

Nowadays, projects from ETS Professional can't be synchronised with ETS Inside. In the near future, this functionality will be enabled in one of the first mandatory updates for the ETS Professional version. So, at the moment the option is create a new project.

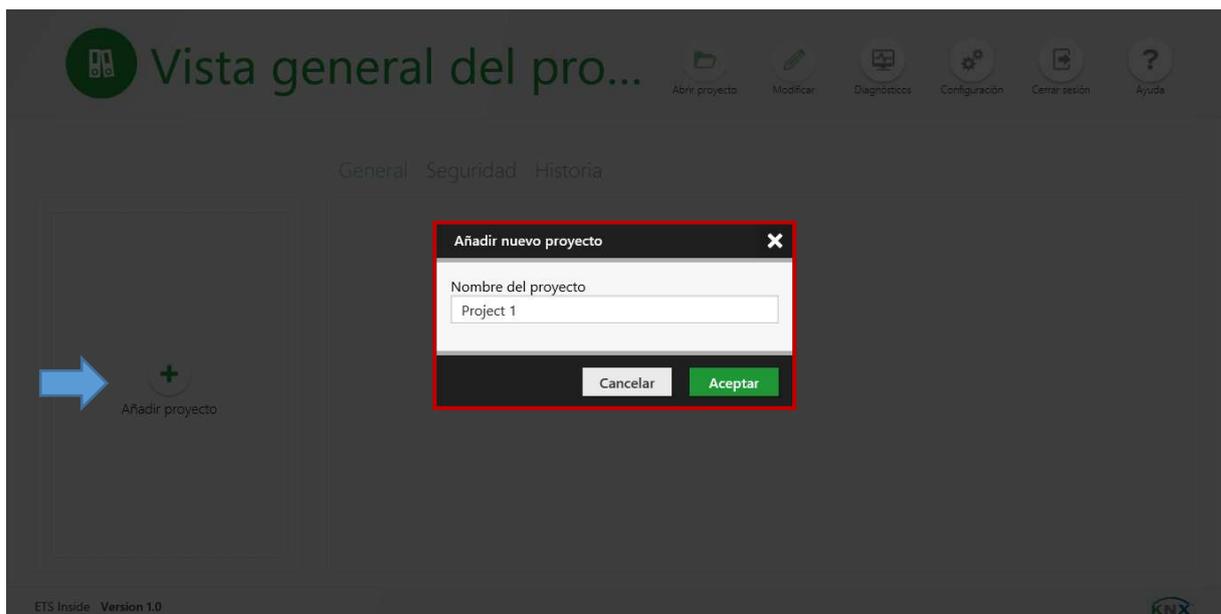


Figure 80 - ETS Inside Name of the project

7.4. Building structure

Building structure is very similar to ETS5, it represents the real physical building structure. Several elements are available to create it.

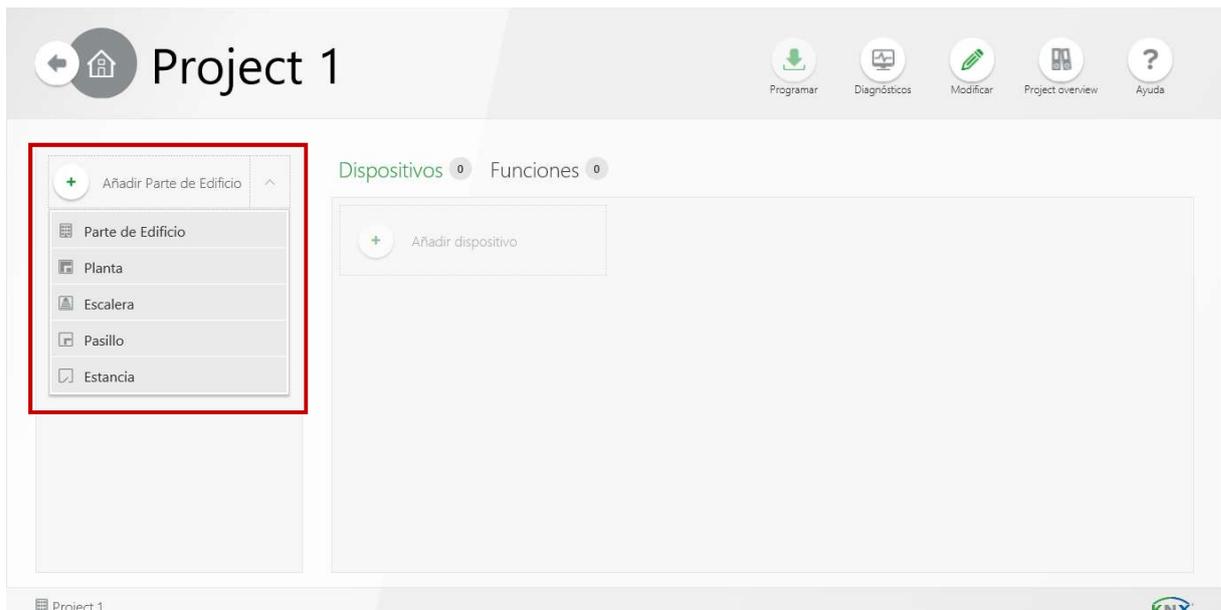


Figure 81 - ETS Inside Building structure (Parts of the building options)

7.5. Devices

Once the building structure is done, the devices must be placed into the individual elements of the building structure.

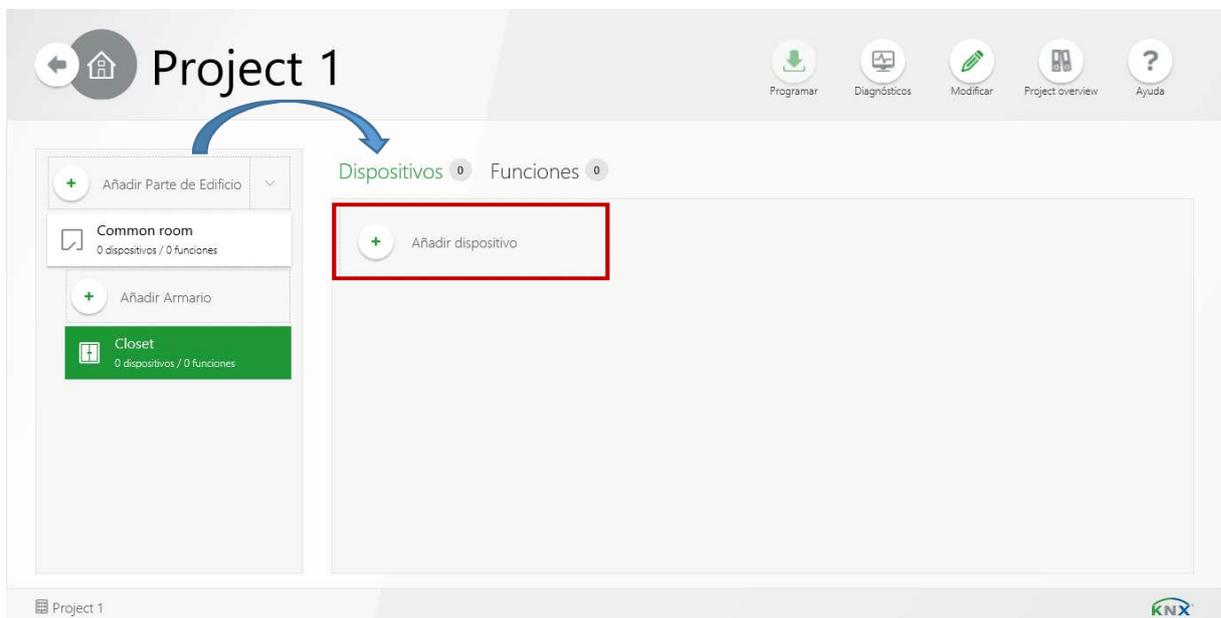


Figure 82 - ETS Inside (Add devices to a part of the building)

The Online Catalog access is available by tapping the button Add device. All the device will be displayed grouped by manufacturer. When one of them is selected, is automatically added to the selected building element.

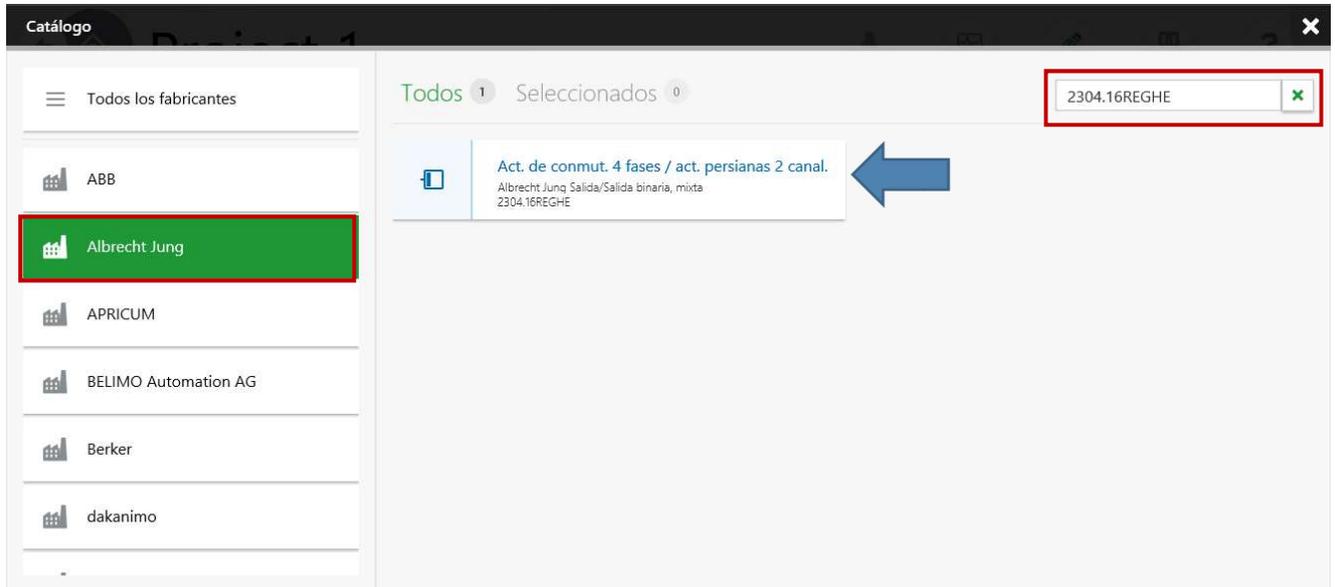


Figure 83 - ETS Inside (Searching the devices via the manufacturer)

When all the devices of the installation are added, Parameters can be changed by tapping to the device you want to configure.

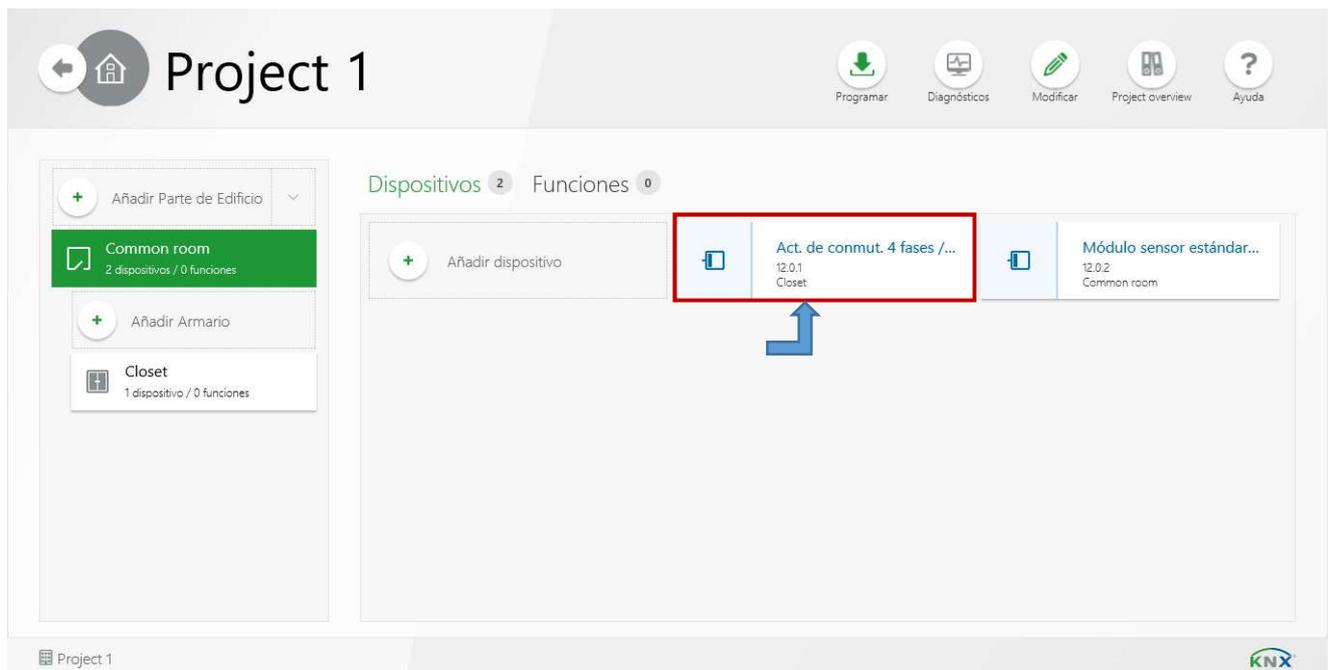


Figure 84 - ETS Inside (Devices of the project)

On that device view, we can see all the details, the group objects and the parameters of the device and when they will be added, the functions.

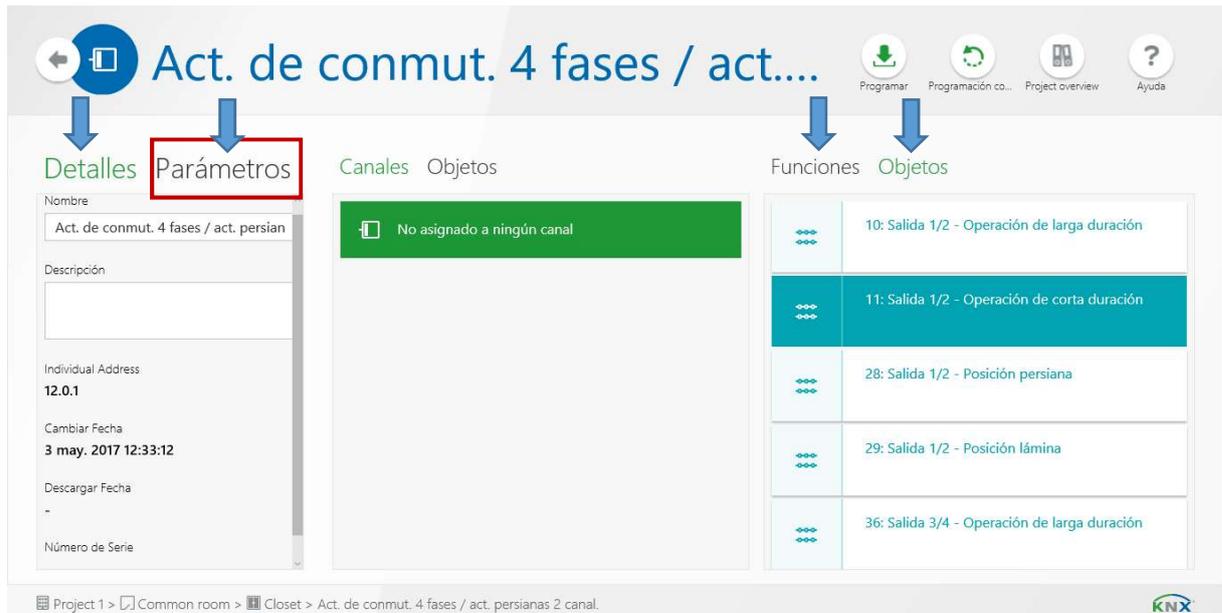


Figure 85 - ETS Inside (Details of the switching actuator)

By tapping on the parameters, all the features can be configured. This is exactly the same on ETS5.



Figure 86 - ETS Inside (Parameters of the switching actuator)

7.6. Functions

Instead of create a group address and link the devices on it like in ETS5, on ETS Inside the groups are created automatically in every function type.

As a reminder: Group address is communication between devices in an installation, it is linking the functions of sensors and actuators.

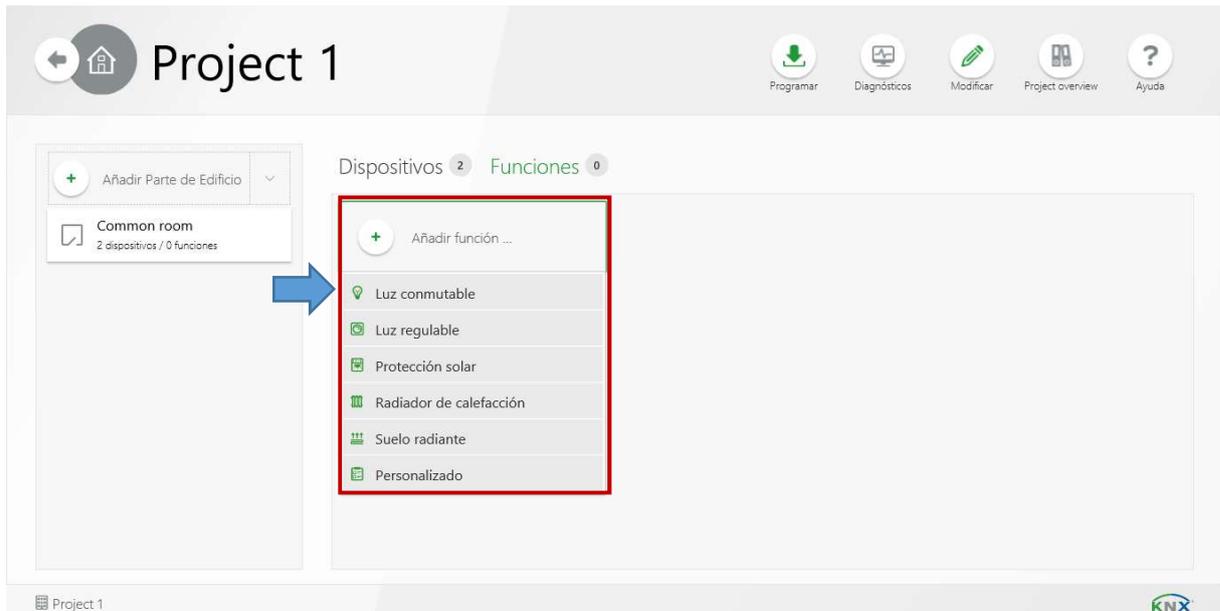


Figure 87 - ETS Inside (Functions)

When a function type is selected, e. g. “Switchable light” some standard groups are generated by default. You can add, delete and modify the groups.

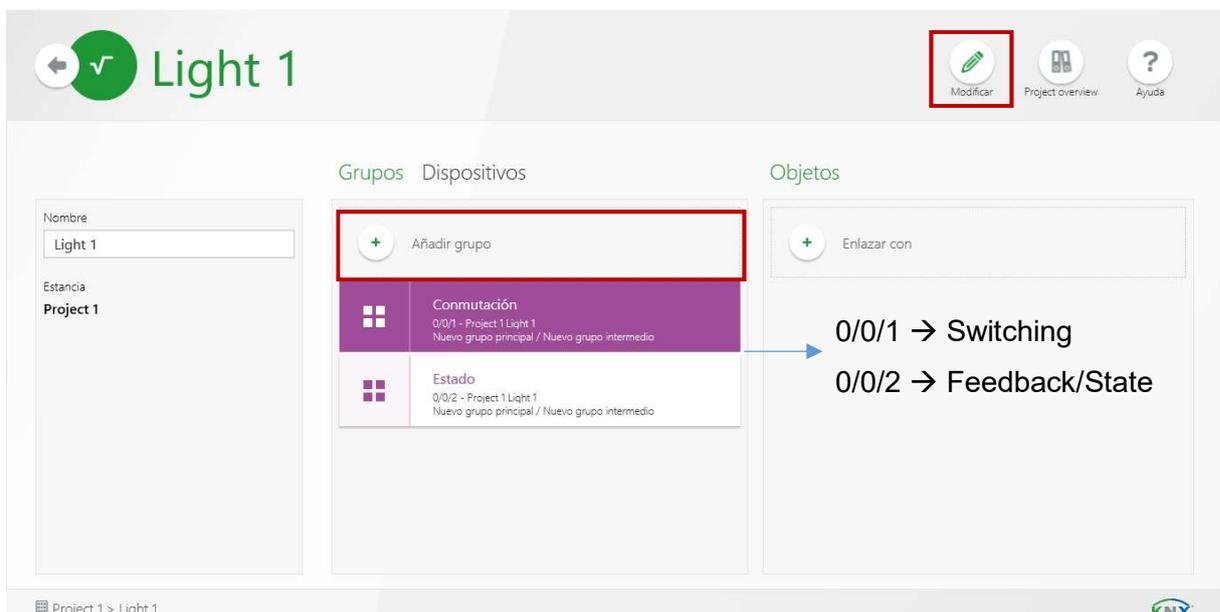


Figure 88 - ETS Inside (Group Addresses)

As we all know, only similar group objects can be linked to the same group address. So, when we tag on “Link with”, only the group object that can be liked together are shown.

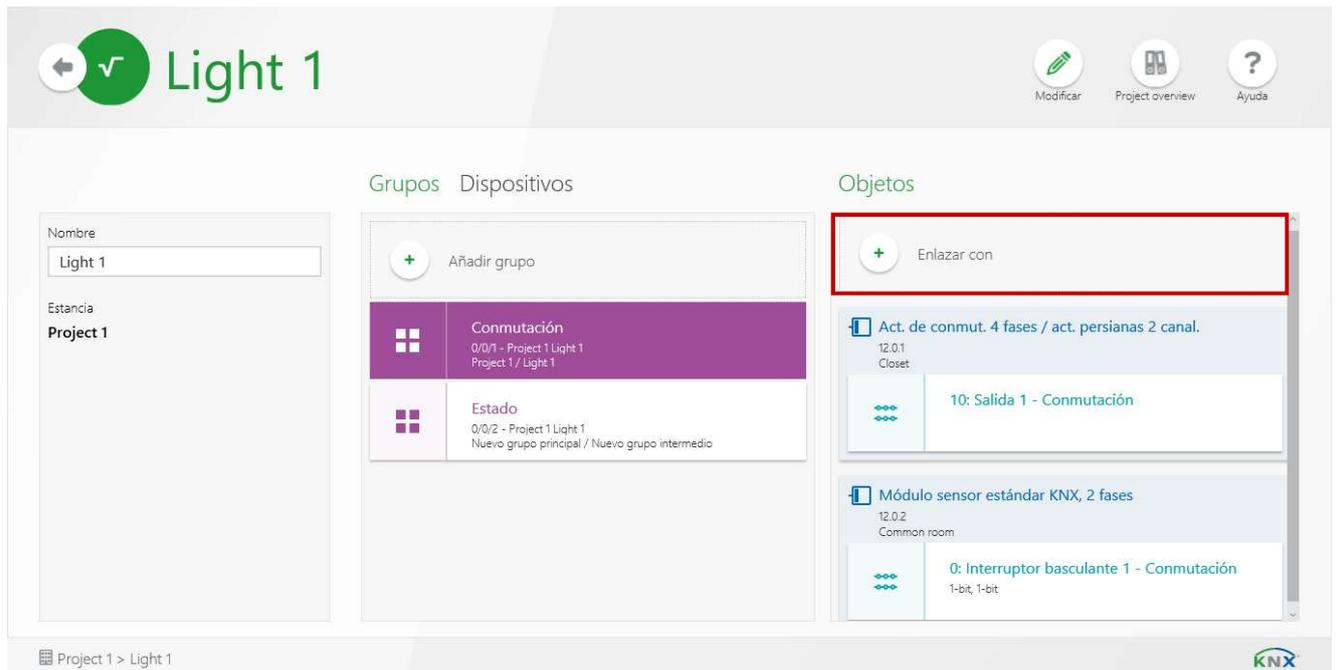


Figure 89 - ETS Inside (Linking group addresses with group objects)

7.7. Bus connection

In order to define the way of the ETS Inside server is connected to the installation, go to the main menu of the project and tap the “Connections” button.

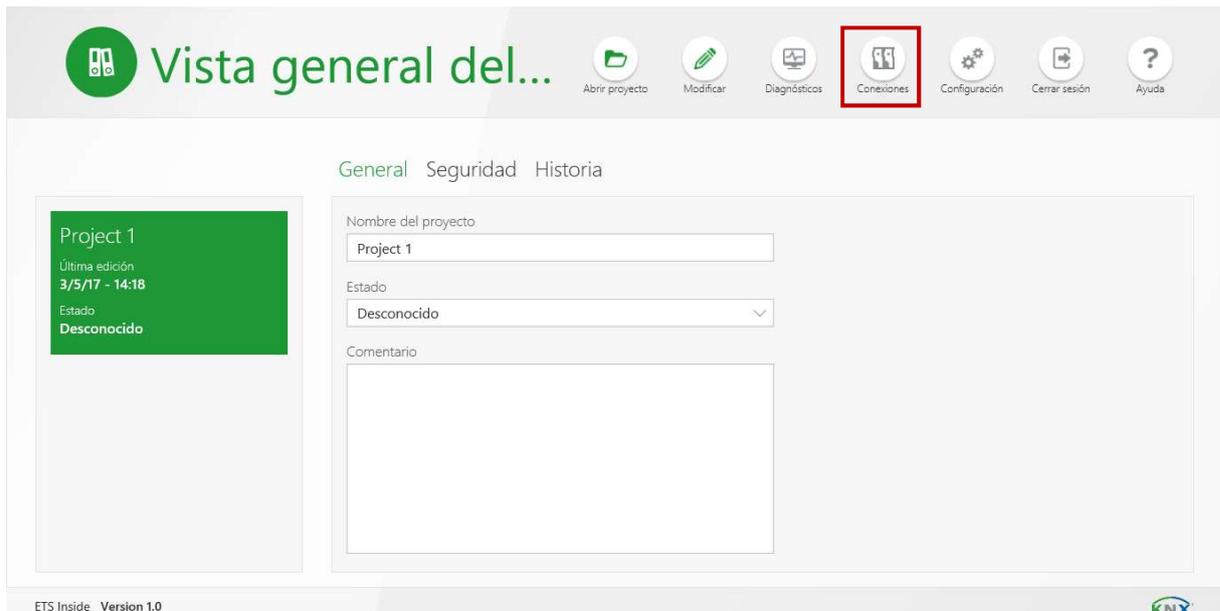


Figure 90 - ETS Inside Main page (Connections)

All possible KNX interfaced founds appears in that page. To select one only tap on it.

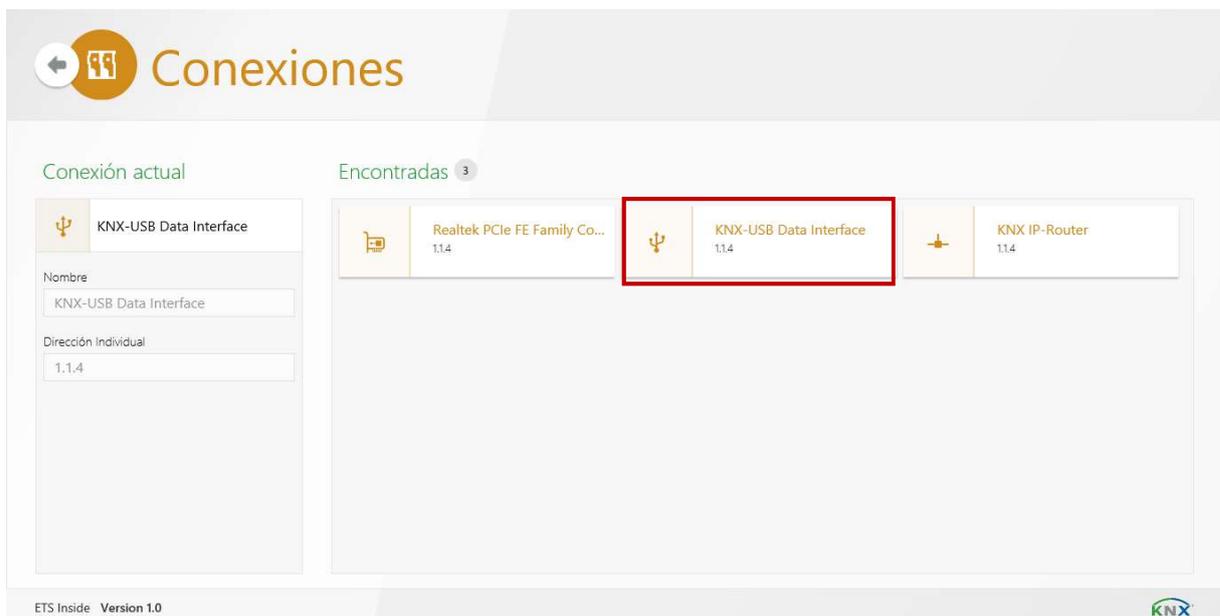


Figure 91 - ETS Inside (Connection page)

7.8. Downloading the configuration

When the device configuration is done, and every time we want to change it, you have to download it to the physical device of the installation. To do that, only tap the Download button.

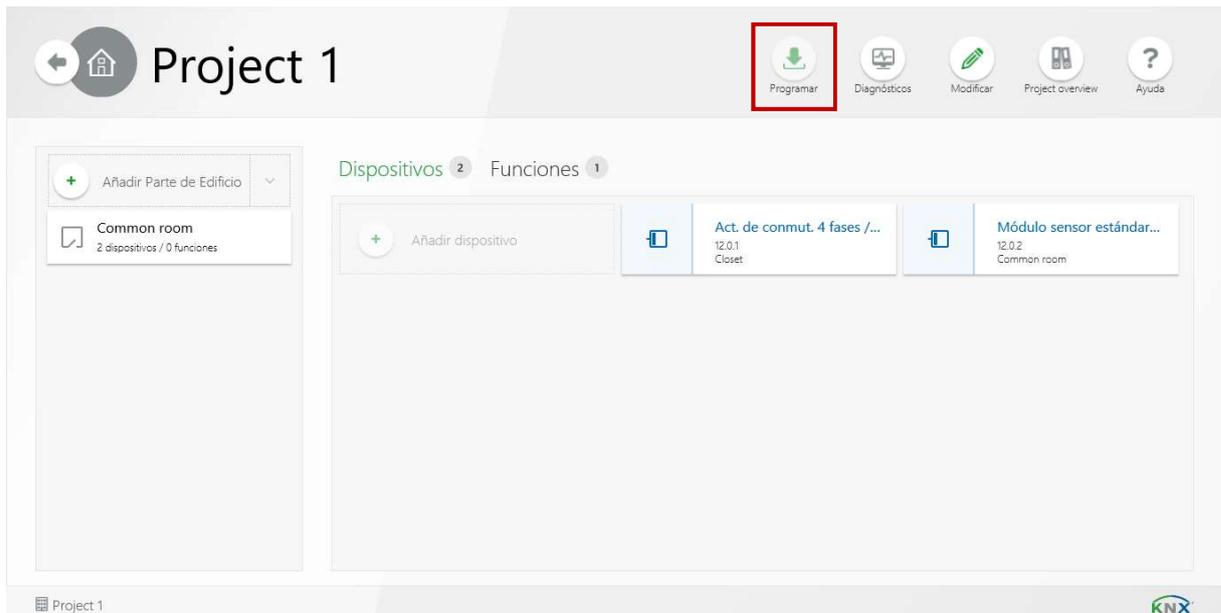


Figure 92 - ETS Inside (Download)

The download starts automatically. If is the first time that you download the configuration of this device you will have press the programming button of it (like when we download the individual address on ETS5).

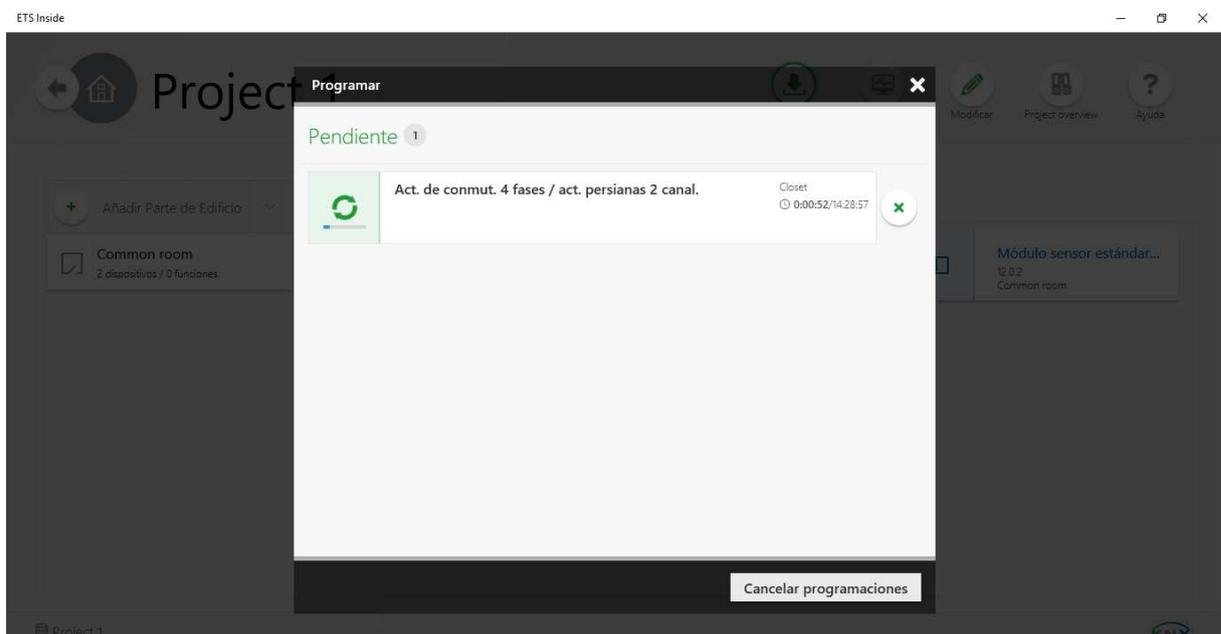


Figure 93 - ETS Inside (Downloading Program)

8. Temperature control

The aim of this chapter is to test some functions of the temperature control with KNX devices. This chapter is based on the thesis “Study of Energy Efficiently and room control with KNX” written by Yulia Popova in 2015 [4]. The aforementioned thesis is mostly a theoretical study, so this chapter seeks to address the practical application.

The devices present in the Domotics laboratory for this purpose are:

- Heating actuator 6-gang (Art. No. 2336 REGHZHE)
- KNX Room temperature controller (Article. no. 2178)

The target of these devices is to control the radiators via an electro-thermal valve drive. For this reason, the experience is focus on the heating options.

8.1. KNX Room temperature controller

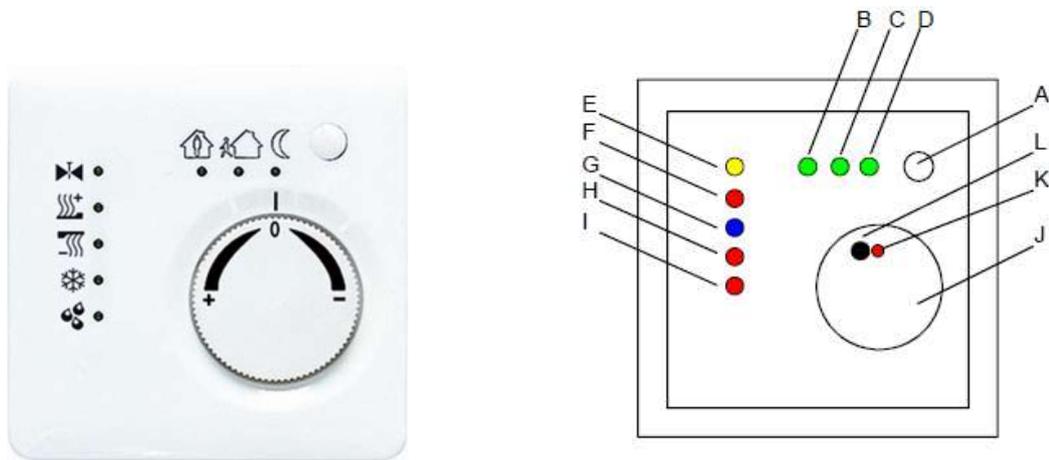


Figure 94 - Room temperature controller 2178 [7]

The room temperature controller function is control the temperature of individual rooms. According to the temperature set-point and the current temperature, the information is transmitted to the KNX bus in order to control the heating or cooling system.

8.1.1. Control option

The following control options are available: “heating”, “cooling” and “heating and cooling” each with or without additional stage. As explained above, this chapter is focused on the heating control.

1.1.3 Continuous action controller > General

General	Control option	heating
Setpoint values	Type of heating control	continuous PI control
Functions	Type of heating	hot-water heating (5 K / 150 min)
Room temp. measurement	Operating mode switch-over	<input checked="" type="radio"/> via value (1-byte) <input type="radio"/> via switching (4 x 1-bit)
Actuating variable and status o...	Operating mode after reset	comfort mode

Figure 95 - ETS5 Continuous action controller (Heating control)

8.1.2. Operating modes

Temperature controller offers five operating modes. Each operating mode has their own temperature set point. The first option to the “Set point values” tab is the “Basic temperature after reset”. Value filled here will be the temperature set point for the comfort mode and becomes the main value. The other temperature set points are based on it except for the “Frost/heat protection” mode.

- Comfort: should be activated if there are people in the room. Can be activated via presence control. (LED B).
- Standby: For the unoccupied rooms for a few hours. (LED C)
- Night: During the night or if a room is unoccupied for many hours. (LED D)
- Frost/heat protection: To avoid critical values being reached (LED H)
- Comfort mode extension (temporary comfort mode): By pressing the presence key the comfort mode can be activated for a time period.

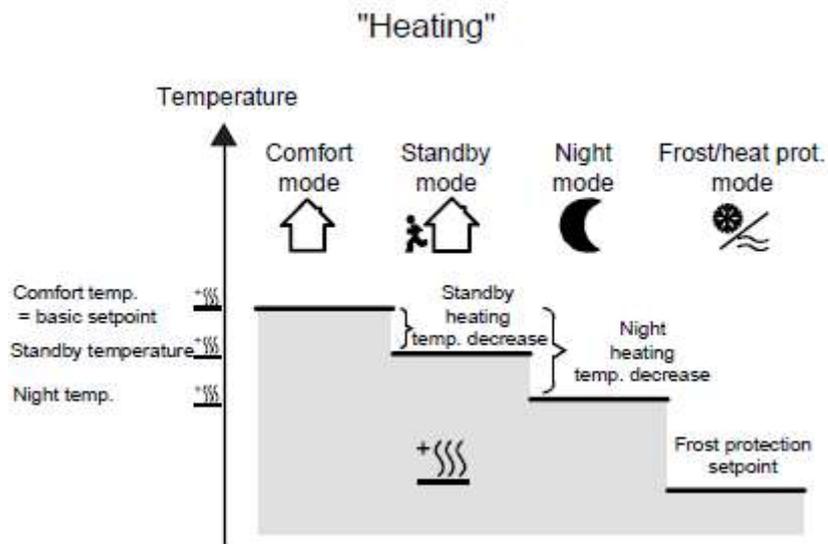


Figure 96 - Operating modes of heating control [7]

Therefore, for the following values we must set the following parameters:

- Comfort mode set-point: 21°C
- Standby mode set-point: 18°C
- Night mode set-point: 16°C
- Frost protection set-point: 10°C

1.1.3 Continuous action controller > Setpoint values

General	Basic temperature after reset (7 ... 40) * 1 °C	21
Setpoint values	Basic temperature setpoint change	<input type="radio"/> deactivated <input checked="" type="radio"/> permit via the bus
Functions	Adopt basic temperature setpoint permanently	<input checked="" type="radio"/> NO <input type="radio"/> YES
Room temp. measurement	Frost protection setpoint temperature (7...40) * 1 °C	10
Actuating variable and status o...	Transmission when setpoint temperature changes by (0..255) * 0.1 K; 0=inactive	1
	Cyclical transmission of setpoint temperature (0...255)*1 min; 0=inactive	0
	Adjustment of setpoint to higher temperatures	+ 3 K
	Adjustment of setpoint to lower temperatures	- 3 K
	Decreasing the setpoint temperature in standby mode (heating) (-128...0)*0.1 K	-30
	Decreasing the setpoint temperature in night mode (heating) (-128...0)*0.1 K	-50

Group Objects Parameter

Figure 97 - ETS5 Continuous action controller (Set point values)

There are two types of set point value. The so-called basic set point is the one that we put on ETS (in the figure above). We have a basic set point to each operating mode but we can change this value by rotating the wheel. The maximum deviation value from basic set point can be chosen on ETS.

1.0.50 Continuous action controller > Setpoint values

General	Basic temperature after reset (7...40) * 1 °C	21
Setpoint values	Basic temperature setpoint change	<input type="radio"/> deactivated <input checked="" type="radio"/> permit via the bus
Functions	Adopt basic temperature setpoint permanently	<input checked="" type="radio"/> NO <input type="radio"/> YES
Room temp. measurement	Frost protection setpoint temperature (7...40) * 1 °C	10
Actuating variable and status o...	Transmission when setpoint temperature changes by (0..255) * 0.1 K; 0=inactive	1
	Cyclical transmission of setpoint temperature (0...255)*1 min; 0=inactive	0
	Adjustment of setpoint to higher temperatures	+ 3 K
	Adjustment of setpoint to lower temperatures	- 3 K
	Decreasing the setpoint temperature in standby mode (heating) (-128...0)*0.1 K	-30
	Decreasing the setpoint temperature in night mode (heating) (-128...0)*0.1 K	-50

Group Objects Parameter

Figure 98 - ETS5 Continuous action controller (Set point maximum deviation)

8.1.3. Switching the operation modes

The different operation modes can be switched for different reasons. There are listed according to the priority:

- Forced control
- Window sensor
- Presence detector
- Switch control

We can reproduce the implementation of this functions with a push-button module.

- Window sensor

The group object “Window status” is created to be linked with a window sensor. The aim is when a window is opened in the room, the operation mode must change to Frost/heat protection mode in order to save energy. Because of the group object has 1 bit length, we can simulate the window sensor with a rocker with the ON and OFF function.



Figure 99 - ETS5 Standard push button (Rocker 1)

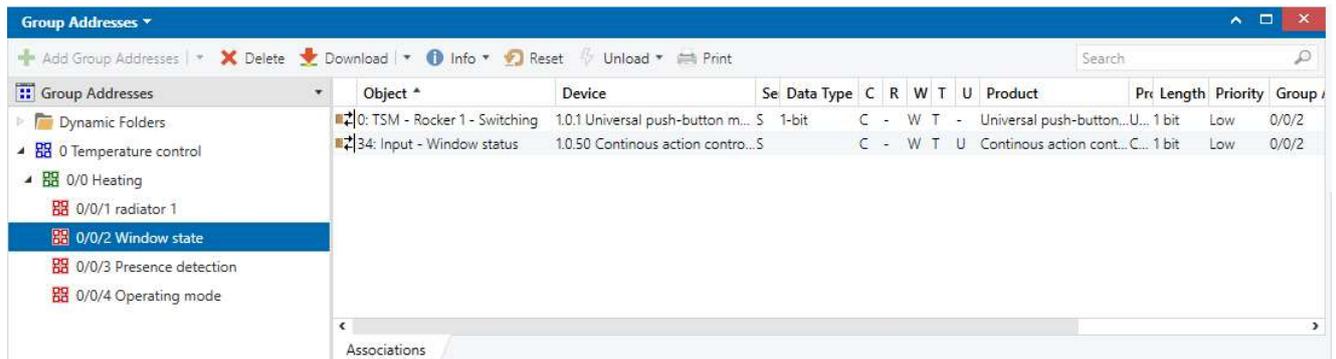


Figure 100 - ETS5 Group Addresses (Rocker 1 linked to Window status group object)

- Presence detector

Presence key: The presence detection takes place via a presence key on the controller or via the presence object (e.g. presence detector). A press on the presence key activates the comfort mode extension. The duration of comfort mode extension can be adjusted in the parameters. Once this time period is expired, the

1.0.50 Continuous action controller > Functions

General	Presence detection	presence key
Setpoint values	Duration of comfort mode extension (0 .. 255) * 1 min; 0 = OFF	30
Functions	Switch-off controller (dew-point)	<input checked="" type="radio"/> NO <input type="radio"/> via the bus
Room temp. measurement	Valve protection	<input checked="" type="radio"/> NO <input type="radio"/> YES
Actuating variable and status o...		

Figure 101 - ETS5 Continuous action controller (Presence key)

Presence detector: The presence detection takes place via an external presence detector. The detector will be coupled via the presence object. If presence is detected, the comfort mode will be activated as long as the presence detector detects movement. The presence key is without function.

1.0.50 Continuous action controller > Functions

General	Presence detection	presence detector
Setpoint values	Switch-off controller (dew-point)	<input checked="" type="radio"/> NO <input type="radio"/> via the bus
Functions	Valve protection	<input checked="" type="radio"/> NO <input type="radio"/> YES
Room temp. measurement		
Actuating variable and status o...		

Figure 102 - ETS5 Continuous action controller (Presence detector)

Whether one of these functions is being chosen, the “Presence Object” group object appears. It is a 1-bit length group object so we can simulate the presence sensor with a pushbutton.

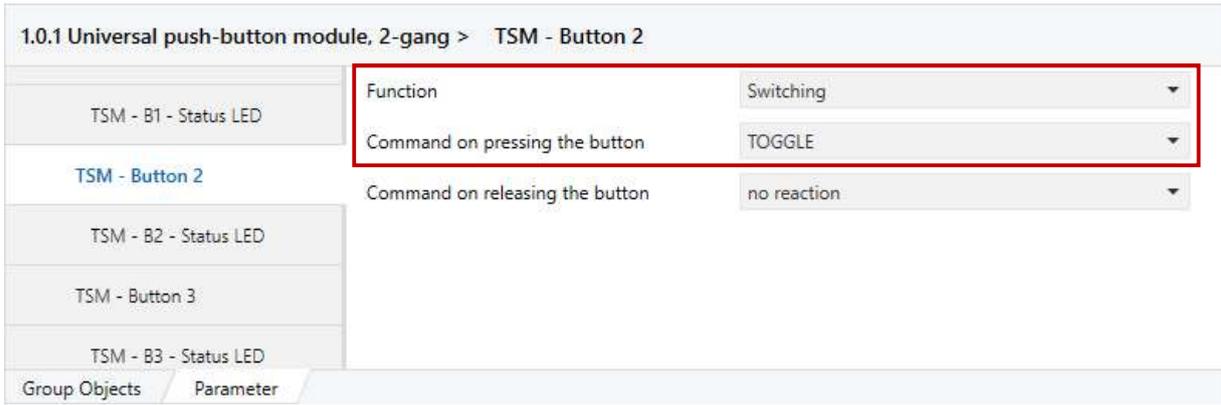


Figure 103 - ETS5 Universal push-button module (Button 2 toggle function)

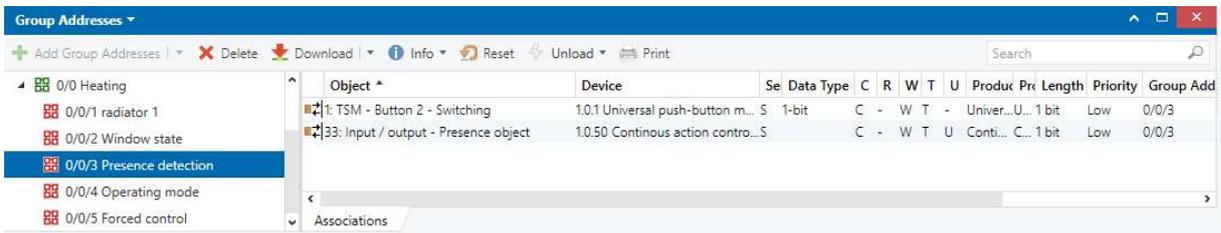


Figure 104 - ETS5 Group Addresses (Presence object linked to Button 2)

- Switch control

The operating mode can be switched-over via separate 1-bit objects or, alternatively, via the 1-byte objects. In the following figure is showed how to choose it.

The screenshot shows the configuration interface for a '1.0.50 Continuous action controller' in the 'General' tab. On the left is a sidebar with menu items: 'General', 'Setpoint values', 'Functions', 'Room temp. measurement', and 'Actuating variable and status o...'. The main area contains several configuration fields:

- 'Control option': heating
- 'Type of heating control': switching PI control (PWM)
- 'Type of heating': hot-water heating (5 K / 150 min)
- 'Operating mode switch-over': This field is highlighted with a red border and contains two radio button options: 'via value (1-byte)' (which is selected) and 'via switching (4 x 1-bit)'.
- 'Operating mode after reset': comfort mode

Figure 105 - ETS5 Continuous action controller (Operating mode switch-over)

The 1-byte switch-over group object switch the modes with a value. Each operation mode is assigned to an exact value:

- 00 → no/last operating mode
- 01 → Comfort mode
- 02 → Standby mode
- 03 → Night mode
- 04 → Frost/Heat protection

So, sending a value to that group object you can change along all the modes. In order to test it, we can send a 1-byte value via a pushbutton. In the following figure, we are sending a value which switch on the "Night mode".

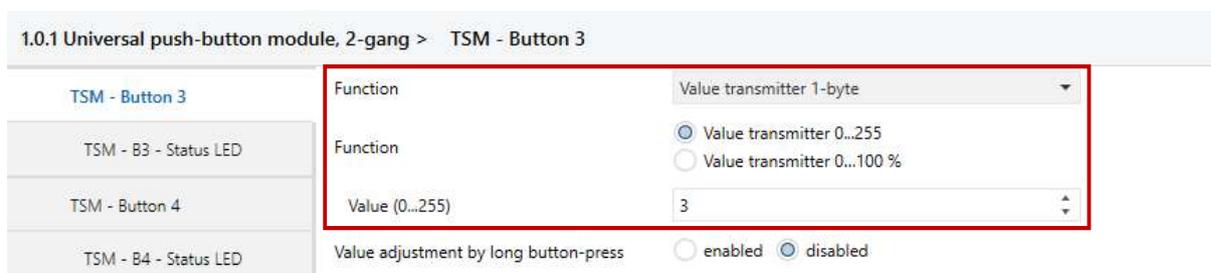


Figure 106 - ETS5 Universal push-button module (Button 3 value transmitter 1-byte)

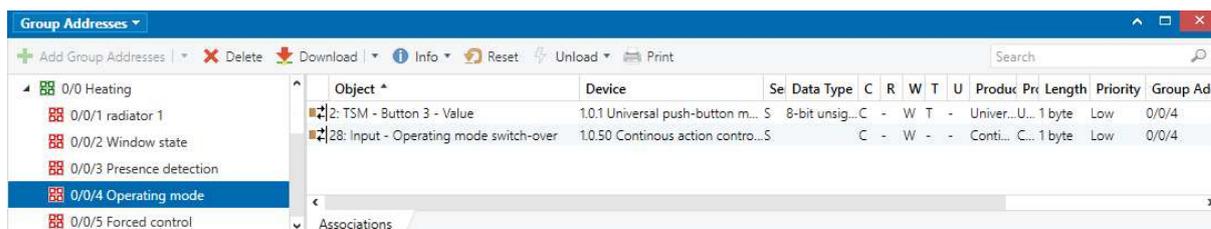


Figure 107 - ETS5 Group Addresses (Button 3 linked to Operating mode switch-over group object)

On the other hand, by selecting the operating mode switch-over via "switching (4 x 1 bit)" 4 group object appears, one for each mode operation:

- "Comfort mode" 1-bit (input)
- "Standby mode" 1-bit (input)
- "Night mode" 1-bit (input)
- "Frost/Heat Protection" 1-bit (input)

Each one of these objects allows to switchover the current operating mode. To test it, is as easy as link every group object to a button of a pushbutton with the switching mode active.

- Forced control

In addition, there is a second 1-byte object available which can (by forced control and higher ranking) set an operating mode independent of all other available switch-overs.

Like the above-mentioned case, in order to test it we can send a value by the pushbutton. The button In the following figure is parametrized to switch on the "Standby mode".



Figure 108 - ETS5 Universal push-button module (Button 4 value transmitter 1-byte)

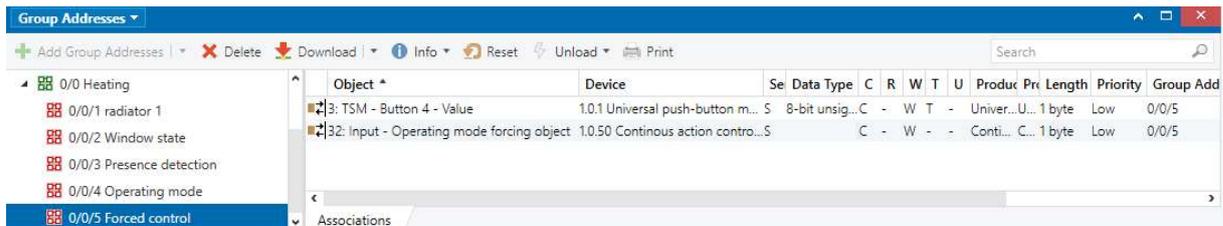


Figure 109 - ETS5 Group Addresses (Button 4 linked to Operating mode forcing object)

EXAMPLE: TESTING THE PRIORITY

If we have followed the steps above, we have the next situation:

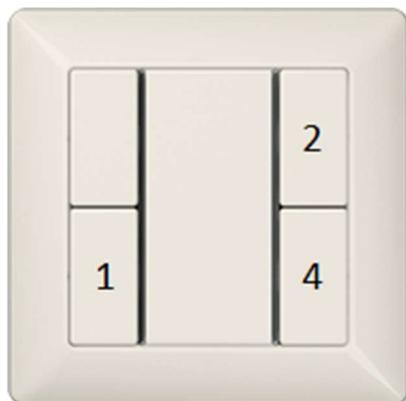


Figure 110 - Universal push-button module [7]

- 1 – Operating mode switch-over.
Value = 3 (Night mode)
- 2 – Presence object (presence detector)
- 4 – Operating mode forcing object.
Value = 2 (Standby mode)



Figure 111 - Standard push-button module [7]

3 – Window state

Left button: opened window

Right button: closed window

Following the next steps the priority is tested.

By pressing button 1 → Night mode is activated.



Figure 112 - KNX Room temperature controller (Night mode)

By pressing button 2 → Comfort mode is activated. If the button 1 is pressed, there is no reaction. We can return to the night mode by sending an OFF telegram to the presence object (pressing the button again).



Figure 113 - KNX Room temperature controller (Comfort mode)

By pressing left rocker 3 → Frost protection mode is activated. If the button 1 or 2 are pressed, there is no reaction. We can return to the previous mode by sending an OFF telegram to the presence object (pressing right rocker).



Figure 114 - KNX Room temperature controller (Frost protection mode)

By pressing button 4 → Standby mode is activated. If the button 1, 2 or 3 are pressed, there is no reaction.



Figure 115 - KNX Room temperature controller (Standby mode)

Note: the other symbol with the switched-on LED represents the control option “heating”.

8.1.4. Control algorithms

The control algorithm determines the actuating variables controlling the valves/drives. To achieve this, it considers the set-point temperature and the actual temperature. The following scheme show the control process (control system) of our specific components:

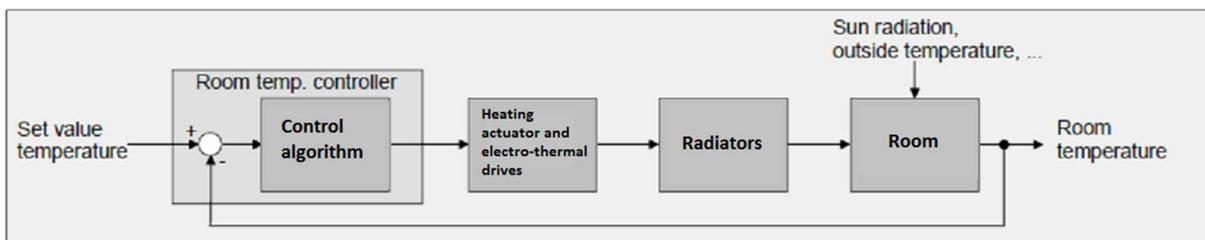


Figure 116 - Control process scheme

The room temperature controller allows three standard forms of heating control: switching 2-state, switching PI and continuous PI.

The actuating variables calculated by the control algorithm are output via the "Actuating variable heating" group object and the control algorithm selected determines the format of the group object (it can be 1-bit or 1-byte).

Because the heating actuator only allows the first two (switching 2-state control and switching PI) the continuous PI control is not explained in this document.

- Switching 2-state control

The switching 2-state control is a very simple temperature control. The actuating variable commands are switch-on or switch-off. If the temperature is above the set point, the output will be switched-off, and vice versa.

Two hysteresis temperature are predefined, in order to avoid the excessive switching. In heating mode, the controller will switch-on the heater if the temperature falls below the lower hysteresis value and will switch-off only if the upper hysteresis value has been exceeded.

This type of control algorithm is very simple, but the main disadvantage is the fluctuating temperature. This control should not be used in slow heating systems, because can have a very strong temperature overshoot.

The screenshot shows the configuration interface for a '1.0.50 Continuous action controller > General'. The 'General' tab is selected. The 'Control option' is set to 'heating'. The 'Type of heating control' is set to 'switching 2-state control (ON/OFF)'. The 'Lower hysteresis of the 2-state contr. heating (5 ... 127) * 0.1 K' is set to '-6'. The 'Upper hysteresis of the 2-state contr. heating (5 ... 127) * 0.1 K' is set to '6'. The 'Operating mode switch-over' is set to 'via value (1-byte)'. The 'Operating mode after reset' is set to 'comfort mode'.

1.0.50 Continuous action controller > General	
General	Control option: heating
Setpoint values	Type of heating control: switching 2-state control (ON/OFF)
Functions	Lower hysteresis of the 2-state contr. heating (5 ... 127) * 0.1 K: -6
Room temp. measurement	Upper hysteresis of the 2-state contr. heating (5 ... 127) * 0.1 K: 6
Actuating variable and status o...	Operating mode switch-over: <input checked="" type="radio"/> via value (1-byte) <input type="radio"/> via switching (4 x 1-bit)
	Operating mode after reset: comfort mode

Figure 117 – ETS5 Room temperature controller (switching 2-state control)

In this case, the group object associated to this function is the 1-bit length "Actuating variable heating".

- Switching PI

As reflected in the project “Study of Energy Efficiently and room control with KNX” mentioned before, PI (Proportional Integral control) is a control algorithm that calculates the size of the error between the set point and current temperature, and compares this to an averaged time function to give a 1-byte output. [4]

To develop this concept further we can focus on the structure of a PI controller algorithm.

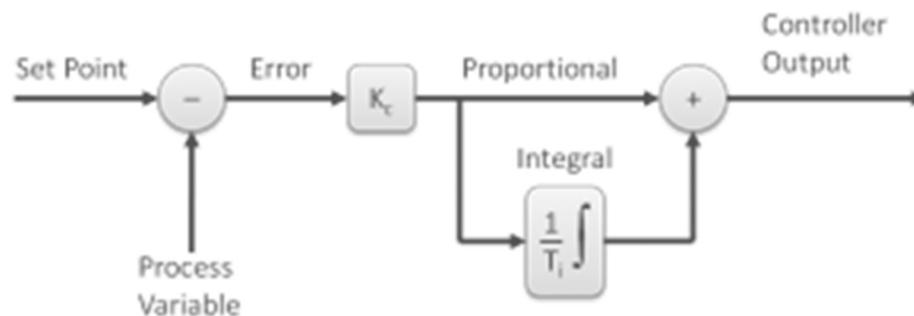


Figure 118 - PI controller algorithm

In the current case:

- Set point: Set-point temperature
- Process variable: Current temperature
- Error: difference between set-point temperature and current temperature

Proportional control → The proportional component depends only on the Error term. The proportional gain (K_c) determines the ratio of output response to the error signal.

Integral control → The integral component sums the error term over time. As long as there is an error present (process variable not at set point), the integral control mode will continuously increment or decrement the controller's output to reduce the error. Given enough time, integral action will drive the controller output far enough to reduce the error to zero.

With the switching PI control system, the actuating variable is calculated every 30 seconds but it is output to the bus after a cycle time. The output is a 1-bit switching object with the converted PWM signal.

The following figure shows the output actuating variable switching signal depending on the actuating variable internally calculated (first 30 %, then 50 % actuating variable; actuating variable output not inverted).

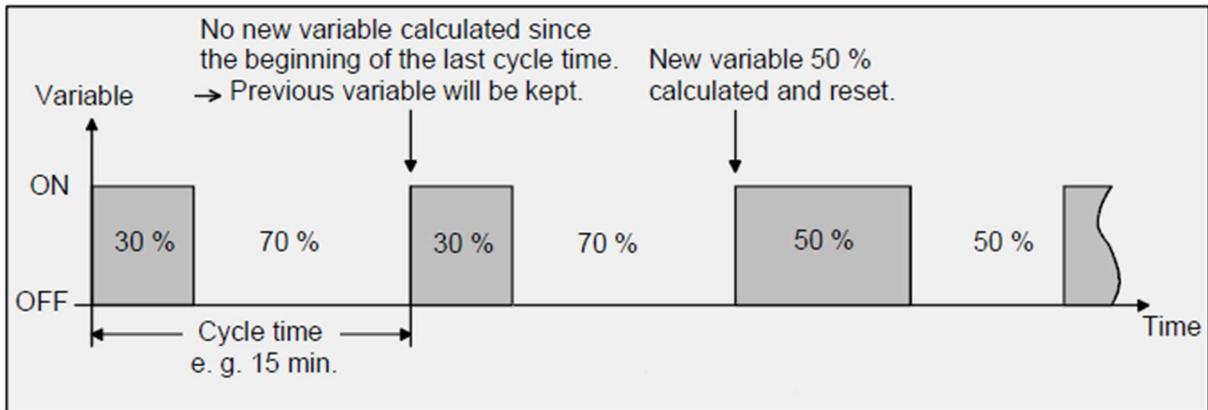


Figure 119 - Output actuating variable switching signal

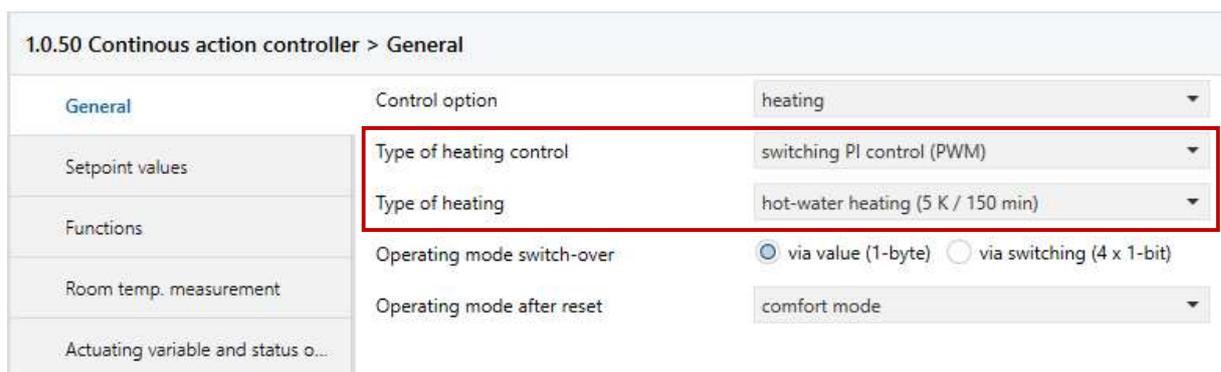


Figure 120 – ETS5 Room temperature controller (switching PI control (PWM))

There are two objects related to this parameter:

Number	Name	Object Function	Description	Group Address	Length	C	R	W	T	U	Data Type	Prio
34	Input	Window status	Window state	0/0/2	1 bit	C	-	W	T	U		Low
36	Output	Controller status			1 byte	C	-	-	T	-		Low
42	Output	Act. variable heating (PWM)	Radiator	0/0/1	1 bit	C	-	-	T	-		Low
46	Output	PWM act. var. heating			1 byte	C	-	-	T	-		Low
50	Output	Setpoint temperature			2 bytes	C	-	-	T	U		Low
52	Output	Setpoint shift feedback			1 byte	C	-	-	T	U		Low

Figure 121 – ETS5 Room temperature controller (switching PI control (PWM)) group objects associated

- “PWM actuating variable heating”: 1-byte object with PWM actuating variable for status feedback of the actuating variable value for heating operation. → is used to monitor the continuous variable values. Even in case of a switching PI control, the controller always calculates internally with continuous actuating variable values.
- “Actuating variable heating (PWM)”: 1-bit object for the output of the continuous PWM actuating variable for basic heating operation. → is used to send the signal to the heating actuator.

8.2. Heating actuator



Figure 122 - Heating actuator 2336 REG HZ HE

Product characteristics:

- Switching operation or PWM operation

- Actuators with characteristics opened or closed without power
- Valve drives 230 V or 24 V controllable
- Disabling of individual outputs via bus
- Overload-protected, short circuit-protected
- Protection against jamming valves
- Cyclical monitoring of the input signals can be parameterized
- Feedback via bus, e.g. in case of overload or sensor failure
- Bus connection with standard bus connecting terminal i PWM operation: electrothermal actuators only have the positions "open" and "closed". In PWM operation, switch-on and switch-off during the drive's cycle time achieves an almost constant behaviour.

The heating actuator is used for the activation of electrothermal actuators (ETA) for heating or cooling systems. It possesses 6 electronic outputs, each of which can silently activate up to 4 (AC 230 V) or 2 (AC 24 V) actuators. Both deenergized closed and deenergized opened actuators can be connected.

The heating actuator receives 1-bit or 1-byte command value telegrams, transmitted, for example, by KNX room temperature controllers. The actuator controls its valve outputs either in switching form or with a PWM signal, according to the data format of the command values and the configuration in the ETS. The cycle time for constant PWM output signals can be configured separately for each valve output of the heating actuator. This allows individual adaptation to different actuator types.

8.2.1. Control value

As we saw in the previous section, the group objects of the temperature room controller which have the objective to send a signal to the heating actuator all have 1-bit length. Therefore, whether we want to use a switching PI or switching 2-state control, we must select the "Switching (1 bit)" on the heating actuator parametrization.

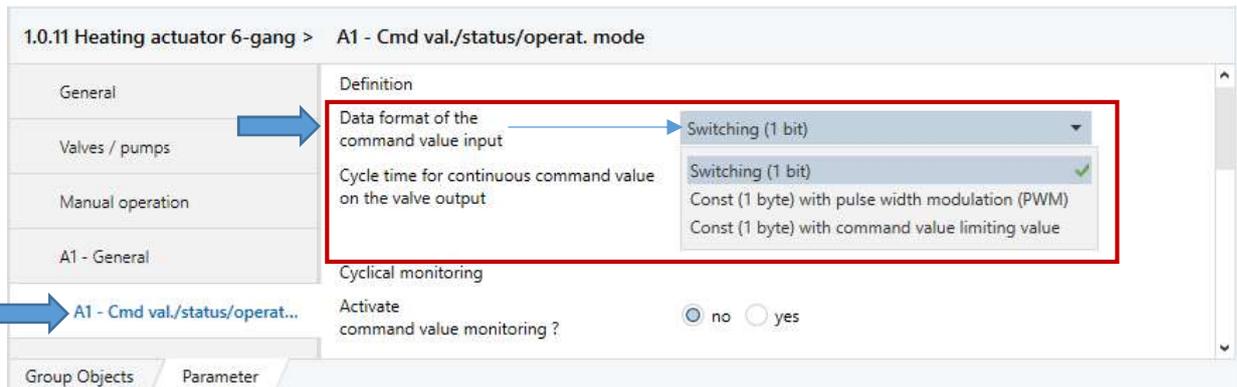


Figure 123 – ETS5 Heating actuator (Input data format 1 bit)

Although the option to choose a 1-byte PWM object communication is available and we can't use it, this will not be a problem because would have the same behavior. In any case, the valves will always close and open completely, the intermediate positions are not possible.

- Connection with the temperature room controller (type of heating control → switching PI control (PWM)).

Object	Device	Sel	Data Type	C	R	W	T	U	Product	Priority	Length	Group Ad
20: Valve output 1 - Input - Command value	1.0.11 Heating actuator 6-gang	S	switch	C	-	W	-	U	Heatin...H...	Low	1 bit	0/0/1
42: Output - Act. variable heating (PWM)	1.0.50 Continuous action contro...S	S		C	-	-	T	-	Conti... C...	Low	1 bit	0/0/1

Figure 124 – ETS5 Group Address (Heating actuator and room temperature controller)

- Connection with the temperature room controller (type of heating control → switching 2-state control (ON/OFF)).

Object	Device	Sel	Data Type	C	R	W	T	U	Product	Priority	Length	Group Ad
20: Valve output 1 - Input - Command value	1.0.11 Heating actuator 6-gang	S	switch	C	-	W	-	U	Heatin...H...	Low	1 bit	0/0/1
42: Output - Actuating variable heating	1.0.50 Continuous action contro...S	S		C	-	-	T	-	Conti... C...	Low	1 bit	0/0/1

Figure 125 - ETS5 Group Address (Heating actuator and room temperature controller)

9. Conclusions

The current project fulfils the objective of the research and implementation of KNX in Domotics laboratory.

Due to the great versatility of the KNX products it has been possible to perform the many and varied tasks that we proposed doing.

The explanation of the components in the KNX boxes is enough to get a handle of the features and functions as well as to get an idea of their application area. Obviously, the KNX devices have a lot of functions that do not appear on this paper but you can find all of them in the datasheet of each component which is available to all.

ETS5 English manual designed to the future Erasmus students contain a detailed explanation of all the basic applications that can be carried out with the lab boxes. By following the steps of the manual, one can have a basic background programming ETS5.

ETS Inside workshop is an introduction to this new software created to programme little installations of KNX. First steps are explained, and also a guide to install it because may be a little complicated. As we can appreciate in this chapter, ETS Inside is really easy to use and someone who knows programming with ETS5 will have no difficulty to use ETS Inside.

The last part of this document is an implementation of the theory concepts of the KNX room temperature controller and the heating actuator presents in a previous project [4]. The aim of this chapter is to program both components in order to control the room temperature via an electro-thermal valve drive connected to the radiator, so only the heating control have been considered.

9.1. Extra experience

In addition to all the things explained in the current document, during my stay in Odisee as an Erasmus student I have undertaken other tasks related to Domotics laboratory which have been an enriching experience.

One of these tasks was doing the English powerpoints to the *KNX Basic Course* [1]. It was very useful to me to understand deeply all the concepts about KNX. I also taught a class of a chapter of this course, specifically the *KNX Telegram* chapter which was a good challenge for me.

In addition, I have been fortunate to took the opportunity to do the Basic course of KNX. As a general conclusion, I have acquired in-depth knowledge and experience of KNX and his components.

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