

Ambient Intelligence

KNX (Formerly: EIB)

Prof. Renato Nunes

renato.nunes @ tecnico.ulisboa.pt

KNX - Konnex



-
- Initially: **EIB - *European Installation Bus*** 
 - Technology developed by an association of companies
 - Siemens, ABB, Hager, Theben, Merten, Gira, ..., ...
(2016: there are more than 400 manufacturers, from 38 countries worldwide, that offer KNX compatible products)
 - www.knx.org
 - KNX was designed to integrate EIB, BatiBus and EHS (European Home System)
 - KNX is an international standard:
 - ISO/IEC 14543

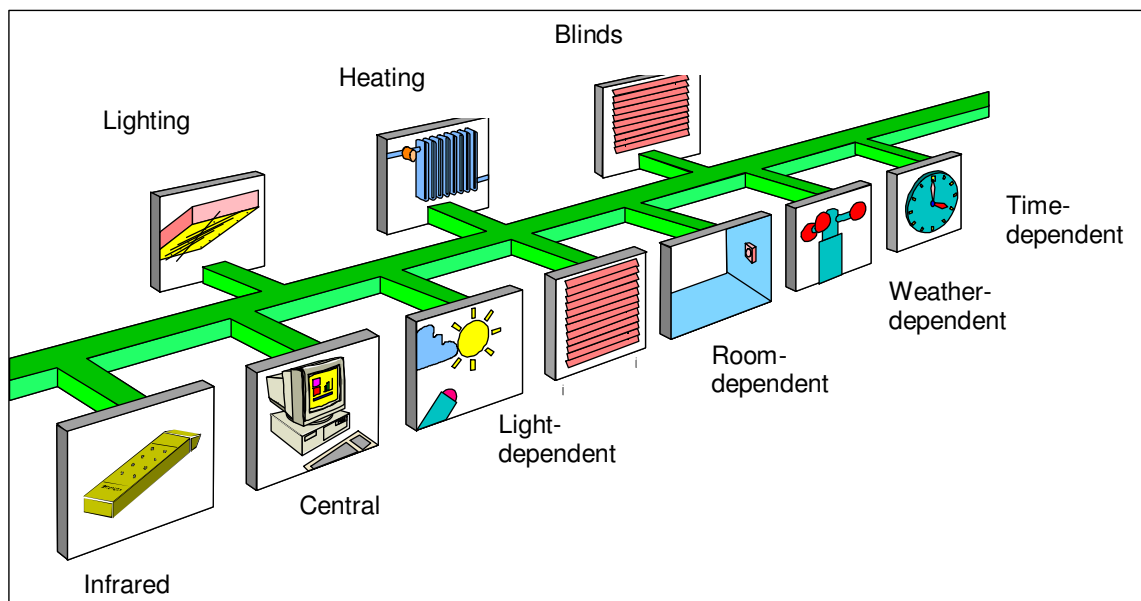


KNX – Application Domains

- Can be applied to the residential market but also to big buildings



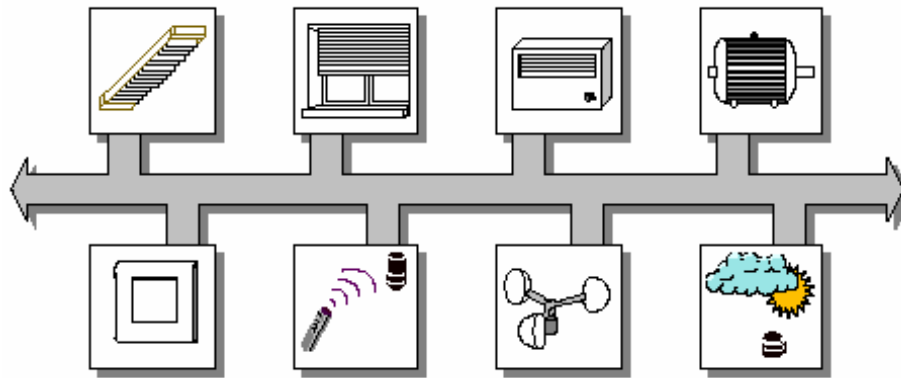
System Design



KNX

Suports Decentralized Solutions

- Devices interact directly with each other (peer to peer communication)

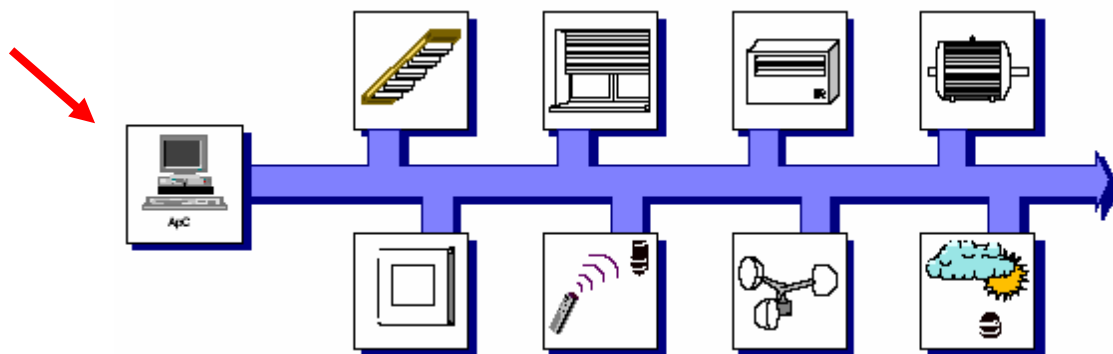


- This is the **typical** approach

KNX

Suports Centralized Solutions

- Decisions are taken by a dedicated application running in a computer connected to the KNX bus



Examples of KNX Devices



<http://www.knx-online-shop.de>

<http://www.eibshop.co.uk>

Prof. Renato Nunes

7

Modules for Electric Boards



Prof. Renato Nunes

8

Smart Terminals and Control Panels



"Smart Terminals"



"Control Panels"

Prof. Renato Nunes

9

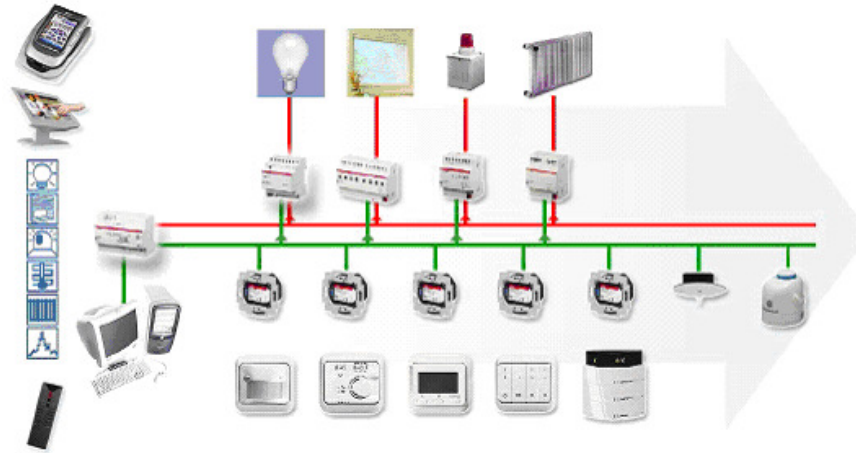
Ethernet Gateway



Prof. Renato Nunes

10

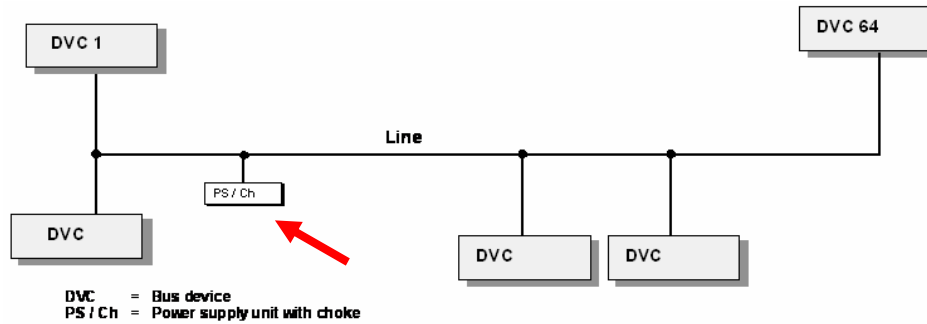
Example of a KNX system



KNX Internals

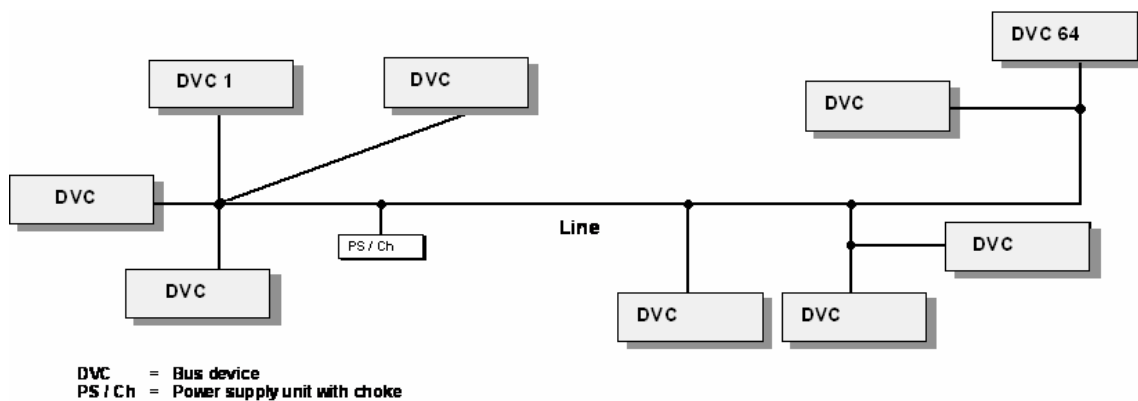
KNX Topology

- Basic topology: one bus, called a “Line”
- A “Line” must have a power supply (28 V)
- The connection between devices uses two wires that, at the same time, supply energy to the devices and support communication



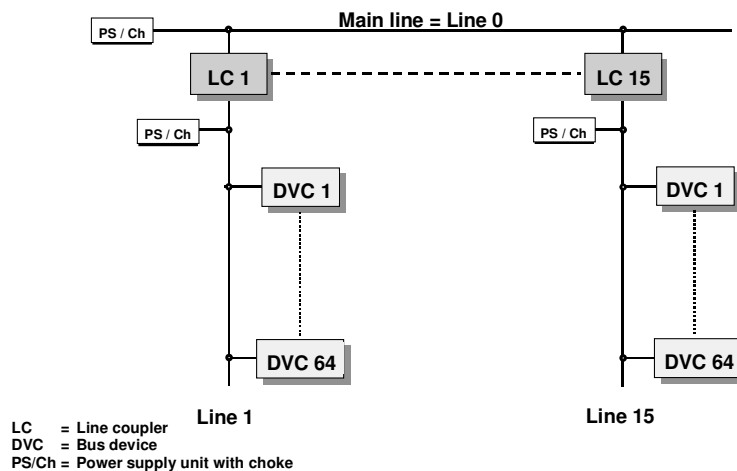
Topology: a “Line”

- Variants of a “Line”
- A line may have up to 64 devices (or more, using repeaters)



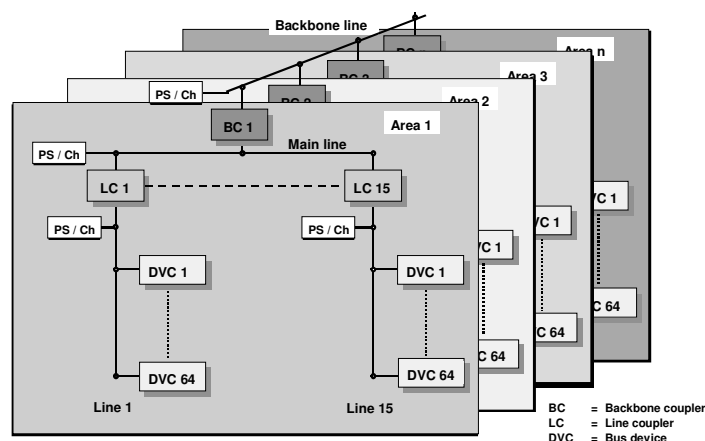
Topology: an “Area”

- An “Area” may have up to 15 Lines
- An “Area” has a “Main Line” (must include a power supply)
- Connection between “Lines” and the “Main Line” is done using special devices: LC – Line Couplers

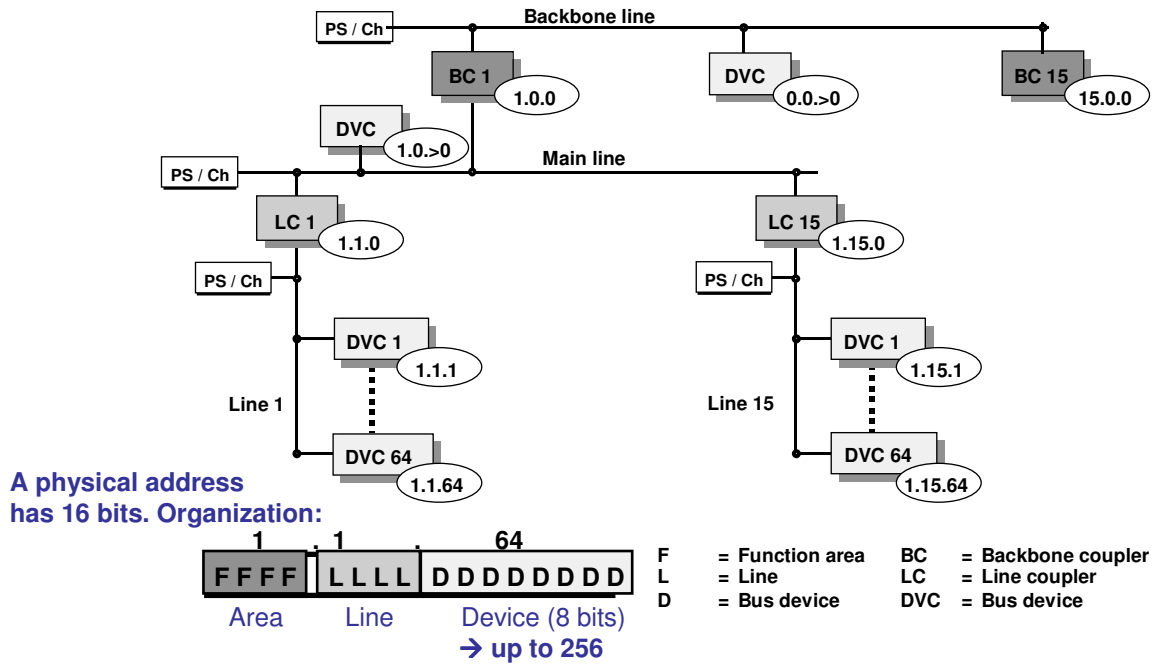


KNX Architecture

- A system may have up to 15 “Areas”
- “Areas” are interconnected through a “Backbone Line” (must include a power supply)
- Connection between “Main Lines” and the “Backbone Line” is done using BC – Backbone Couplers



Physical Addresses

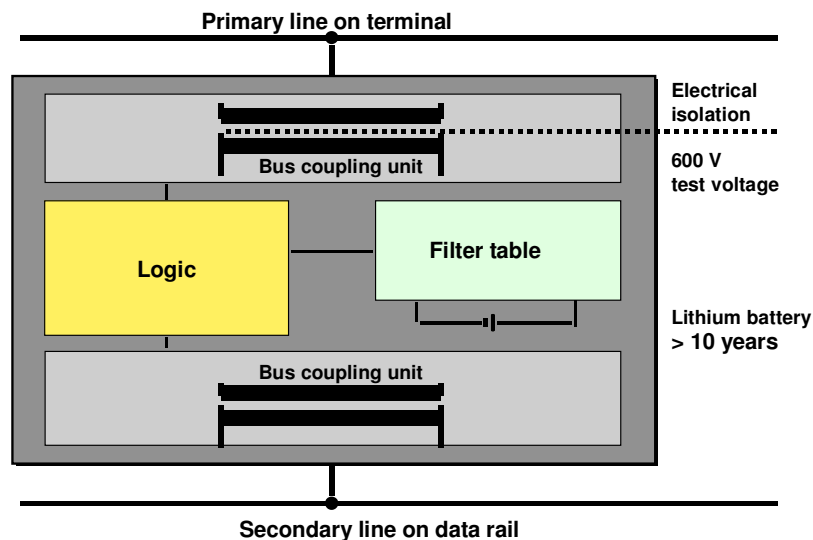


Prof. Renato Nunes

17

Coupling Unit – block diagram

- Coupling units allow address filtering (for bandwidth optimization)



Prof. Renato Nunes

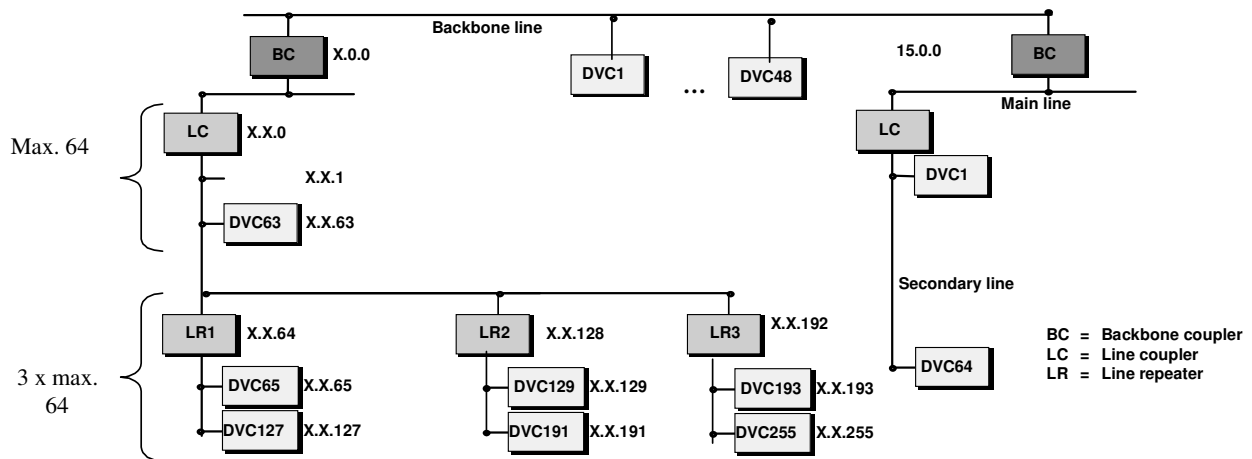
18

Types of Coupling Units

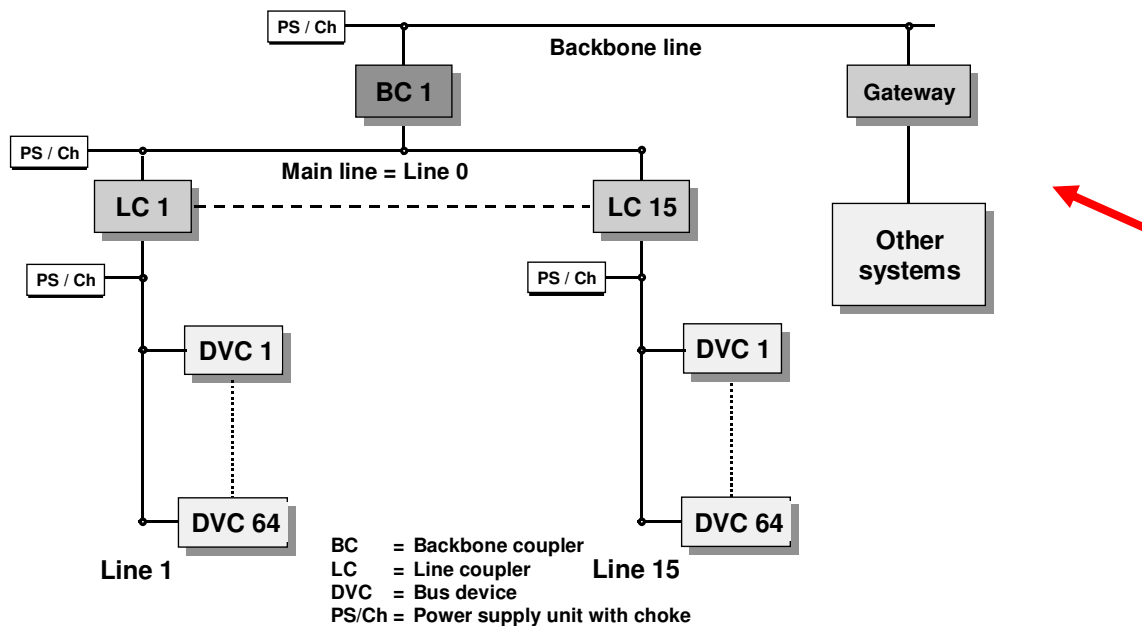
- Backbone Couplers, Line Couplers and Line Repeaters

Remember address filtering

Note addresses of couplers



Interface with other systems



Distance Limitations

- Line maximum length: 1000 m
- Maximum distance between two devices: 700 m
- Maximum distance between one device and the power supply: 350 m
- A line may have more than one power supply; minimum distance between them: 200 m

KNX Protocol

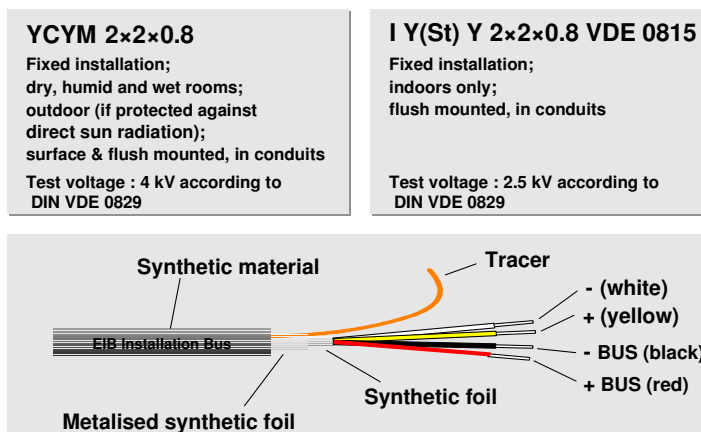
- Follows the 7 layers OSI model
- Communication media:
 - TP – Twisted Pair cable (most common and reliable)
 - RF – Radio Frequency (uses Z-Wave technology)
 - PL – Power Line
 - IR – Infra Red

Power Line Communication

- Asynchronous transmission, bidirectional, half-duplex
- Transmission rate: 1200 bps
- Modulation: Spread Frequency Shift Keying
- Maximum distance between two devices: 600 m
- Communication is affected by high levels of electromagnetic noise (communication errors may occur frequently)

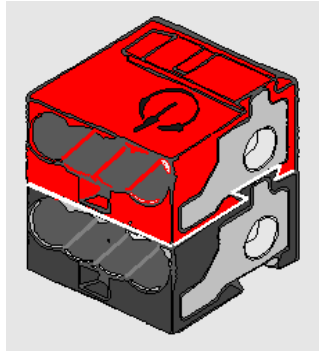
Twisted Pair Communication

- Asynchronous transmission, bidirectional, half-duplex
- Transmission rate: 9600 bps
- Medium access: Collision avoidance (CSMA/CA)



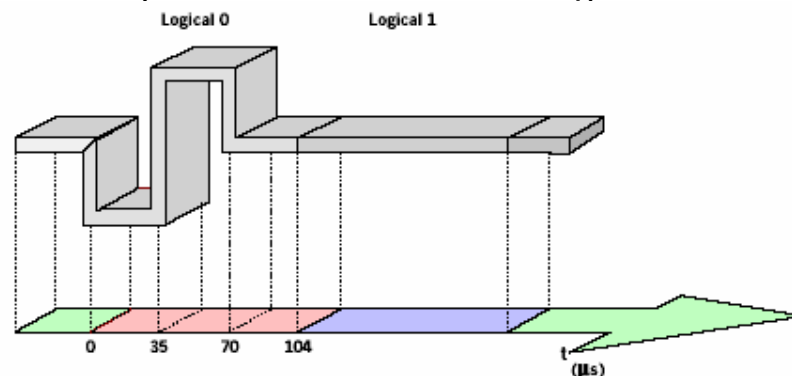
Bus connection block

- Allow removal of bus devices without interrupting the bus
- Mechanical protection against mismatching

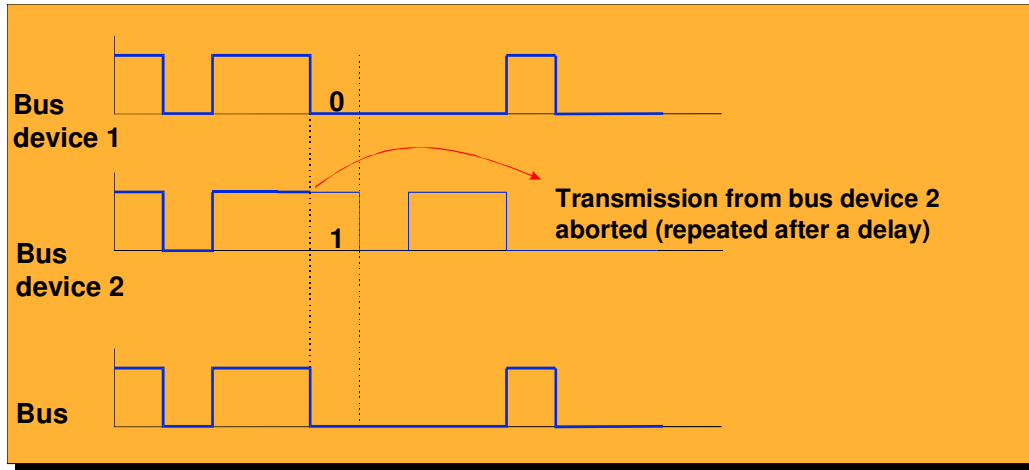


Signal Transmission

- Devices transmit only if line is in silence
- The symbol 0 is active while the symbol 1 is passive (no signal)
- In case of collision, the symbol 0 overrides symbol 1 (the device that is transmitting 1, detects that other device is transmitting 0 and stops transmitting, allowing the other to continue)
- One device is always successful in transmitting

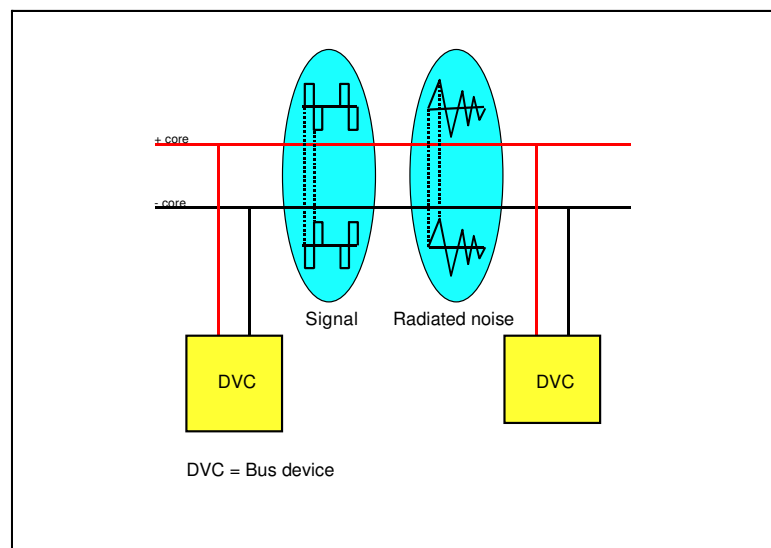


CSMA/CA Procedure



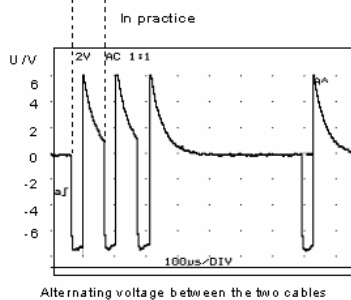
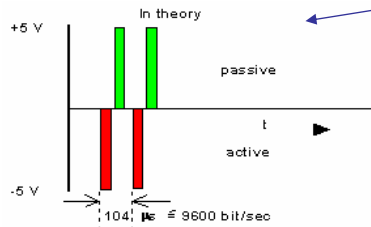
Symmetrical Transmission

- Helps eliminating the effect of noise
- Signal from one line is subtracted from the signal of the other line

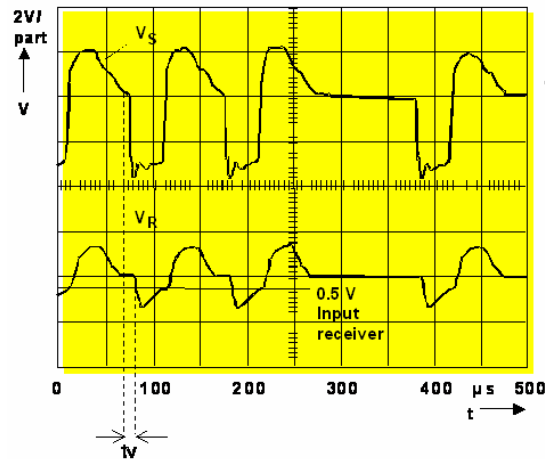


Signal Transmission

- Theory and practice



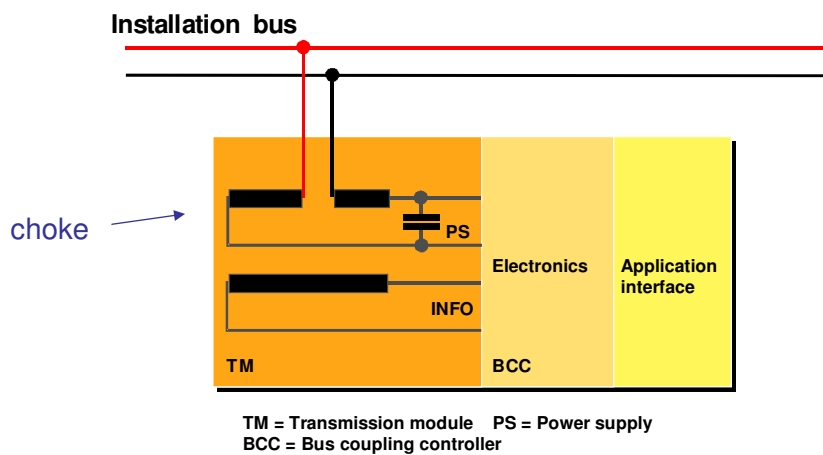
Positive spikes are due to the inductance (choke) present in power supply modules and in the devices



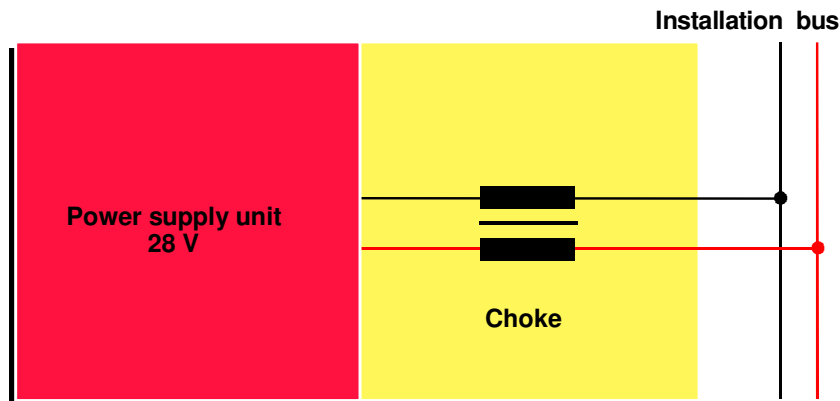
VS = Sending signal from a bus device

VR = Received signal after 700 m with 64 connected bus devices

BCU – Bus Coupling Unit

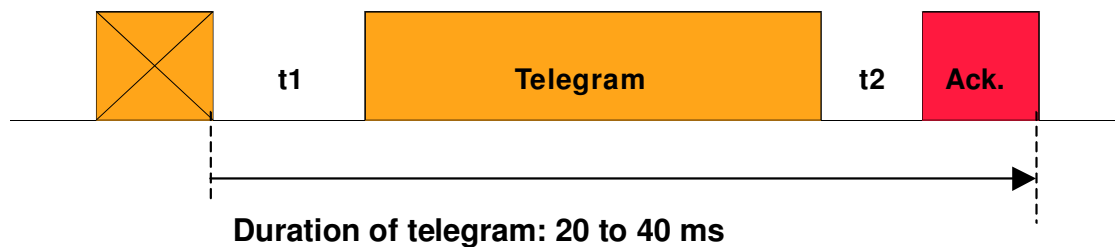


Power Supply with Choke



KNX Protocol

- Access to the communication medium

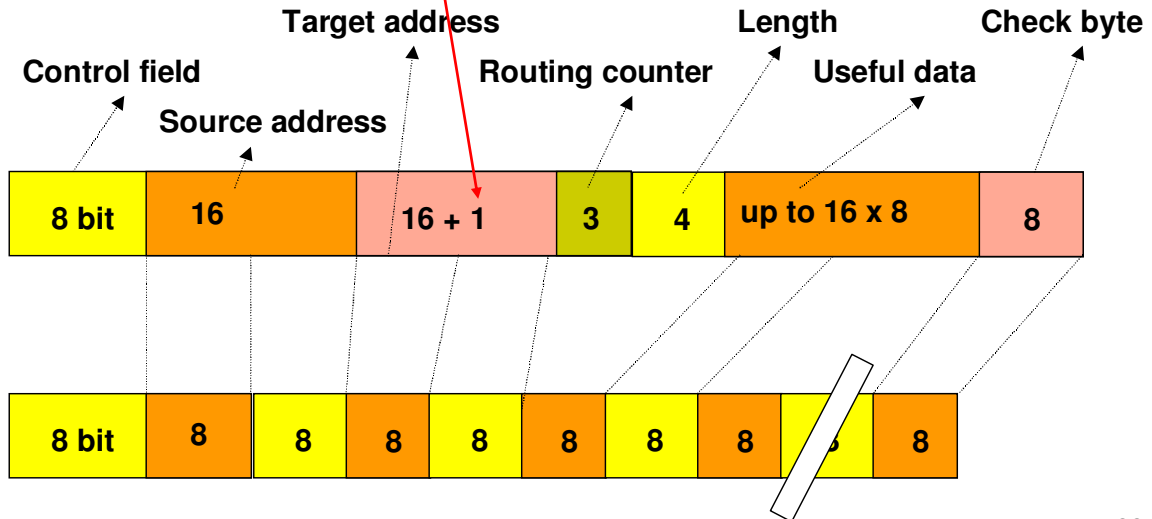


Telegram Structure

Source address = Physical address (16 bits)

Target address = Physical address (16 bits) or Group Address (16 bits)

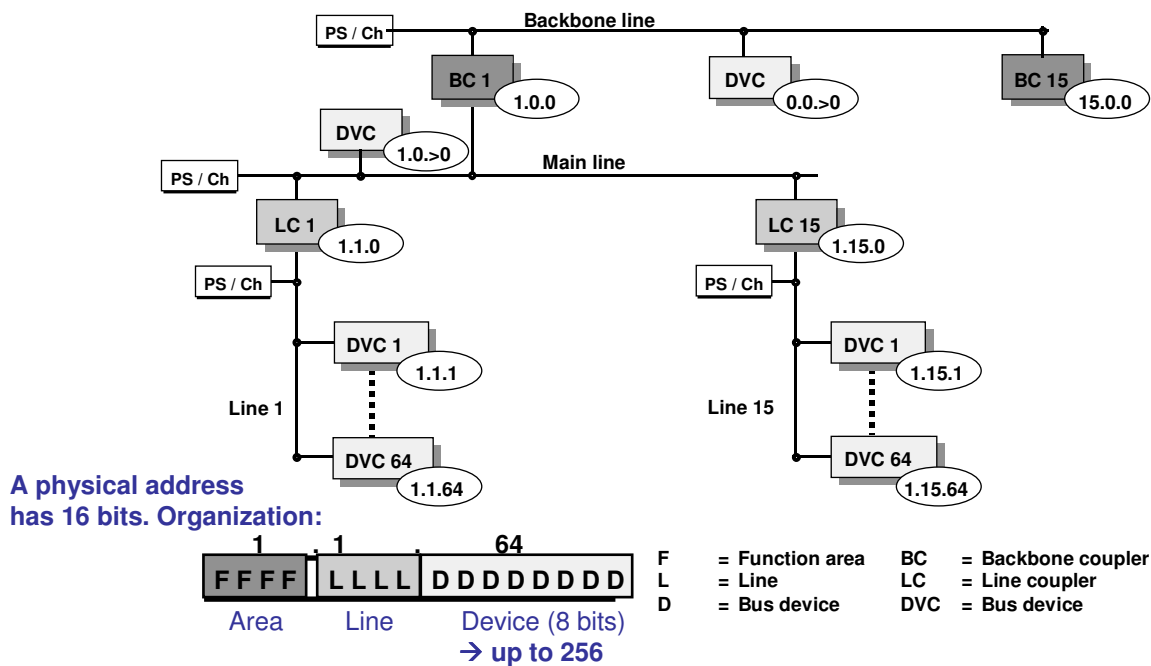
This bit specifies the address type: physical or group



Prof. Renato Nunes

33

Physical Addresses

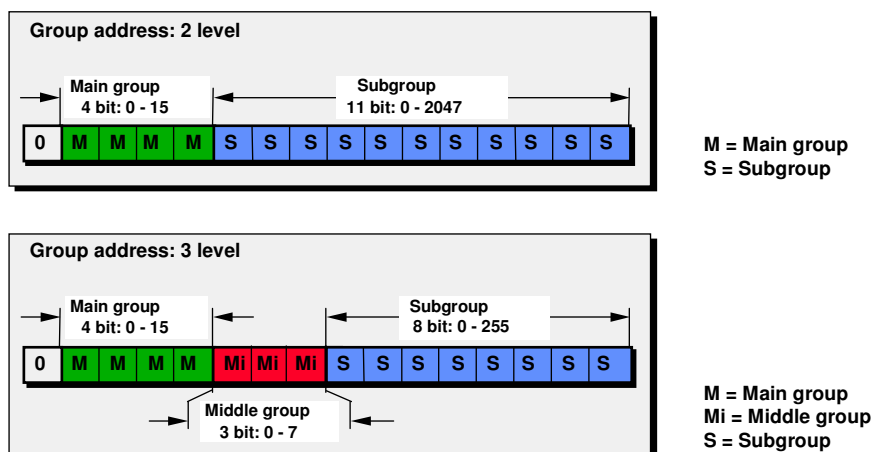


Prof. Renato Nunes

34

Group Address

- Used for functionalities
- Devices that interact functionally, share a group address
(e.g.: for a switch to control a light, both need to use the same group address)

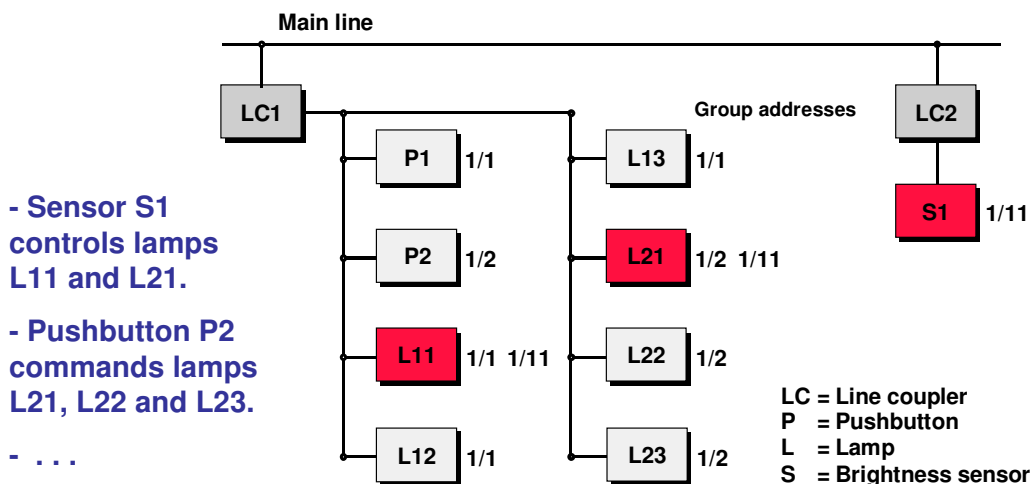


Prof. Renato Nunes

35

Group Address – Example

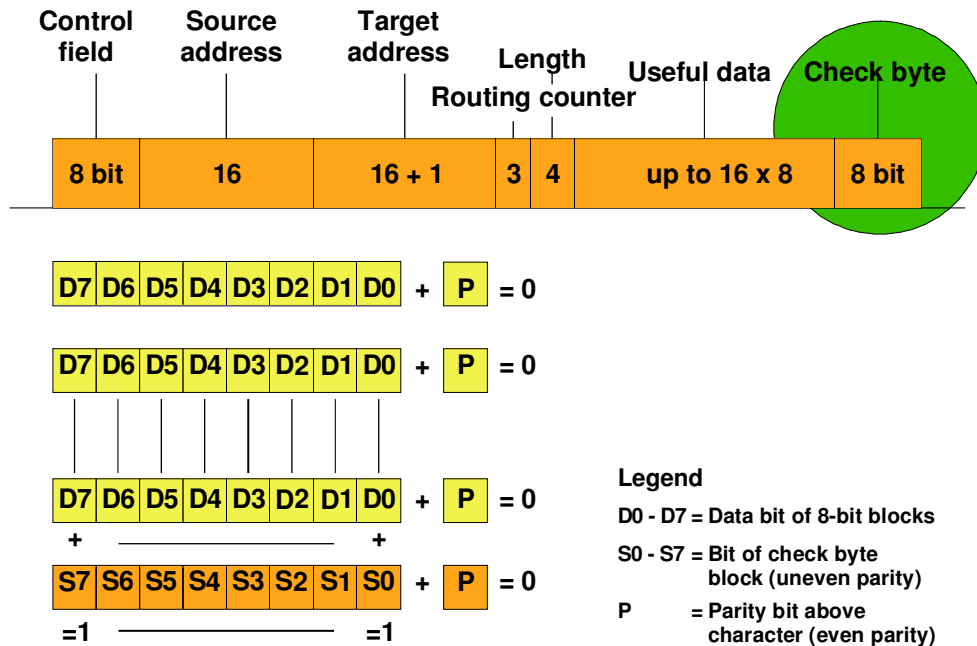
- A device may have multiple group addresses
- Group addresses allow to associate functionally different devices



Prof. Renato Nunes

36

Telegram Check Byte



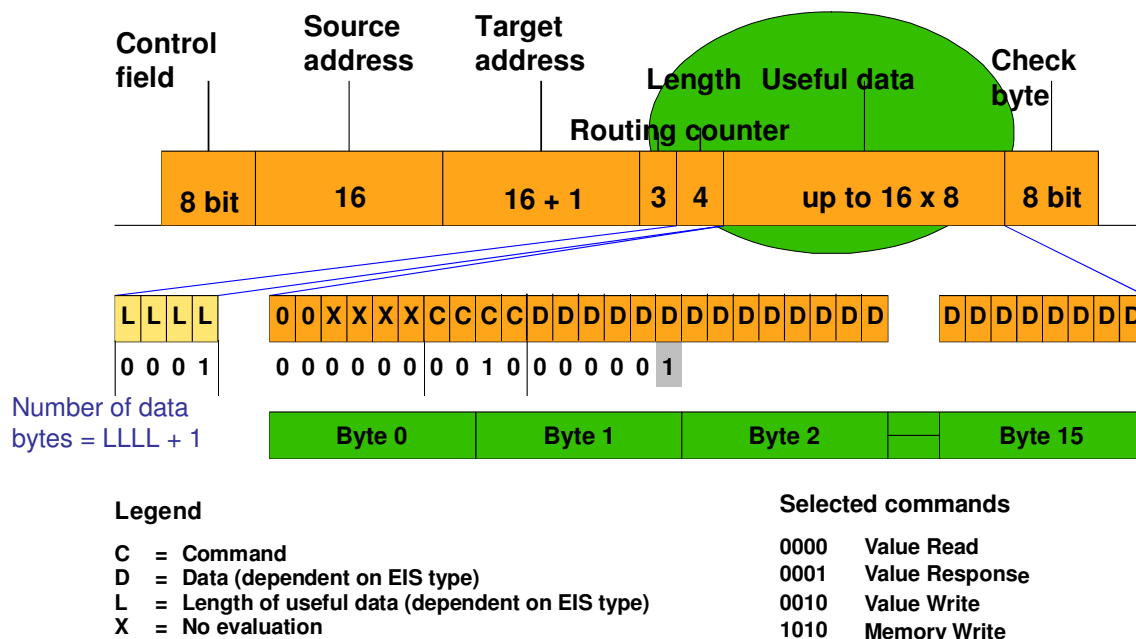
Telegram Acknowledge



D7	D6	D5	D4	D3	D2	D1	D0	Read direction of the data bit
N	N	0	0	B	B	0	0	Acknowledgement message
1	1	0	0	0	0	0	0	BUSY Still occupied
0	0	0	0	1	1	0	0	NAK Reception incorrect
1	1	0	0	1	1	0	0	ACK Reception correct

B=00 BUSY
N=00 NAK

Telegram Useful Data



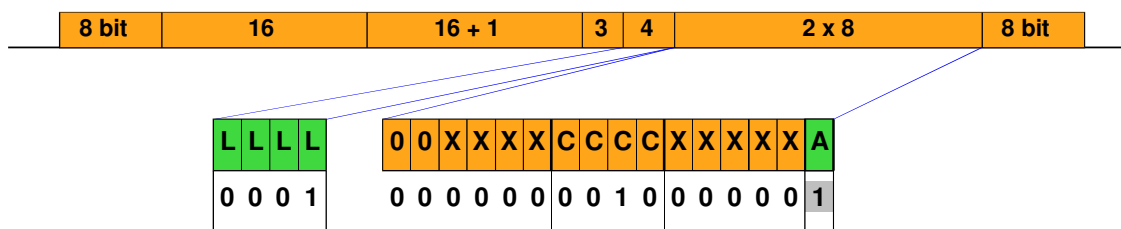
Data Formats

Size of data	Representable values	Term in digital technology	EIB application (selection)
1 bit	2	Bit	Switching EIS 1
2 bit	4		Priority EIS 8
4 bit	16	Tetrad, nibble	Dimming EIS 2
8 bit	256	Byte	Valuator EIS 6
16 bit	65.536	Word	Floating point EIS 5
32 bit	4.294.967.296	Double word	Counter EIS 11

EIS = EIB Interworking Standard

Now: KNX standardized Data types (european standard EN 50090)

EIS Type 1 – “Switching”



Communication object
1 bit

Values:
1 = On / release / true / alarm
0 = Off / lock-out / false / no alarm

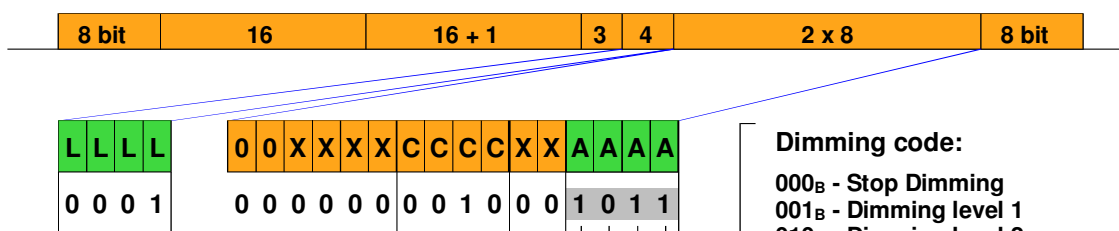
Legend:

A = Switching object
C = Command
L = Length of usable data (byte 0 to byte 1)
X = Not evaluated

Telegram example:
Actuator channel switches on

EIS – EIB Interworking Standard
Now: **KNX standardized Data types** (european standard EN 50090)

EIS Type 2 – “Dimming”



Dimming direction:
1 = Dim brighter
0 = Dim darker

Dimming code:

000_B - Stop Dimming
001_B - Dimming level 1
010_B - Dimming level 2
011_B - Dimming level 4
100_B - Dimming level 8
101_B - Dimming level 16
110_B - Dimming level 32
111_B - Dimming level 64

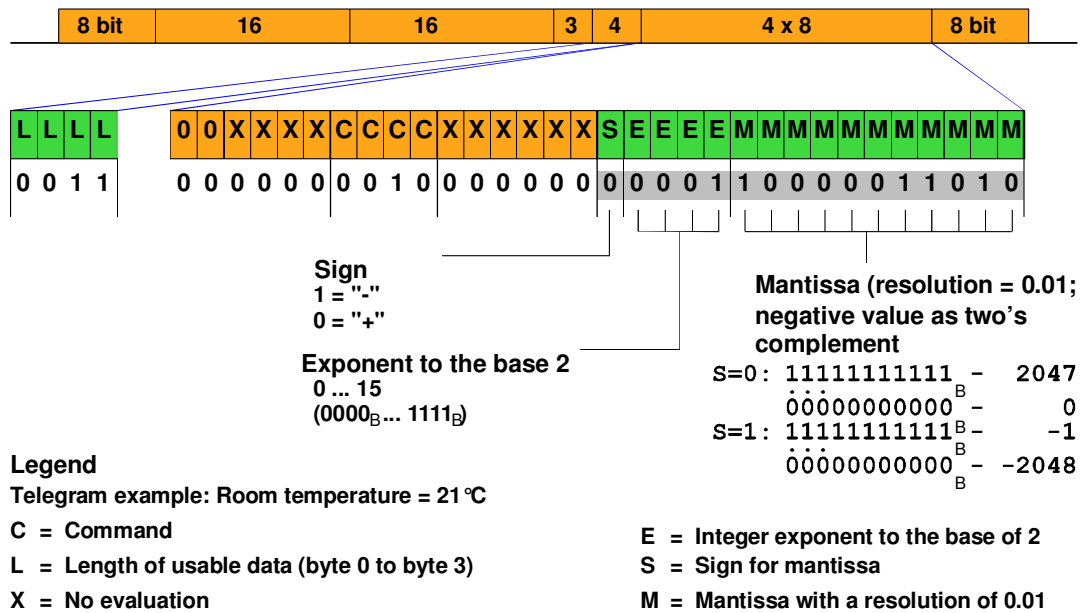
Range = 1 / Dimming level

Legend

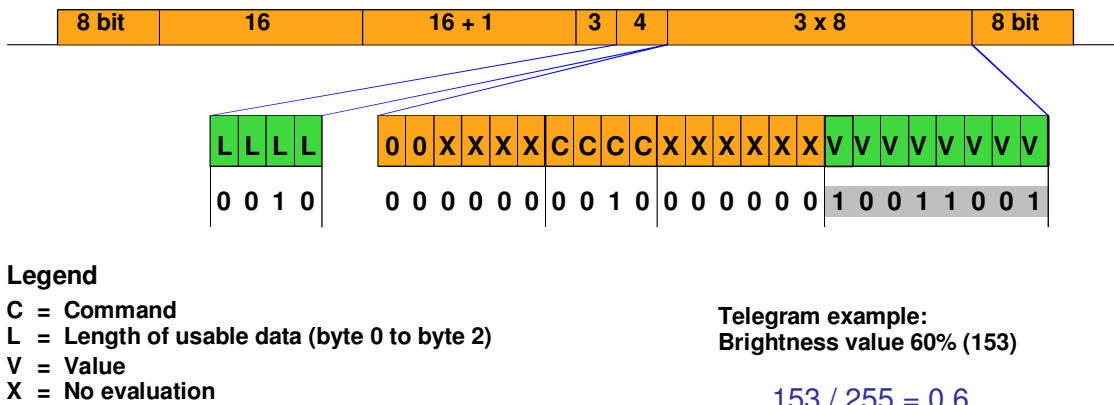
A = Dimming object
C = Command
L = Length of usable data (byte 0 to byte 1)
X = No evaluation

Telegram example:
dimming brighter by 25%

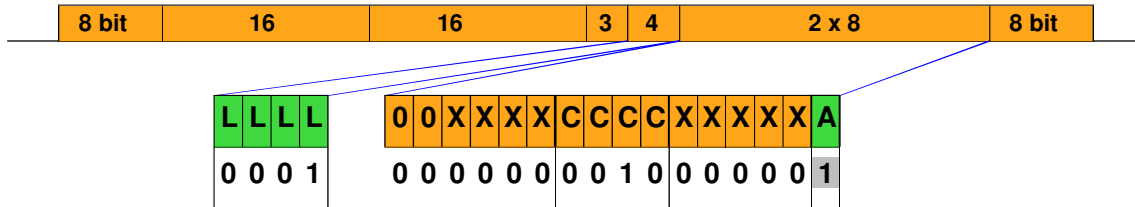
EIS Type 5 – “Floating Point”



EIS Type 6 – “Relative Value”



EIS Type 7 – “Drive Control” (Motor)



Communication object:
1 bit

Legend:

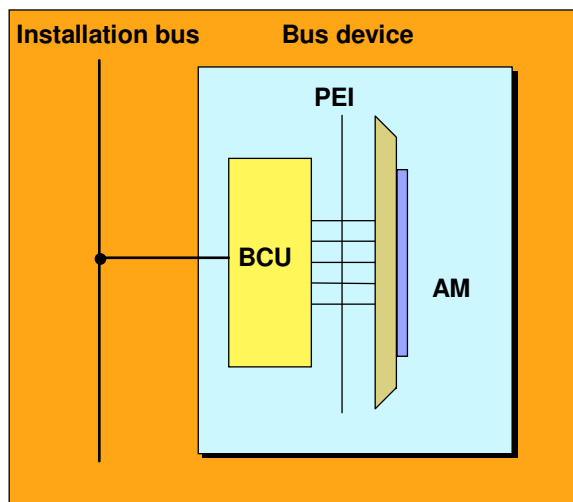
A = Drive object
C = Command

Values (Move):
1 = Lowering / Extending
0 = Raising / Retracting

Values (Step):
1 = Stop / Step down
0 = Stop / Step up

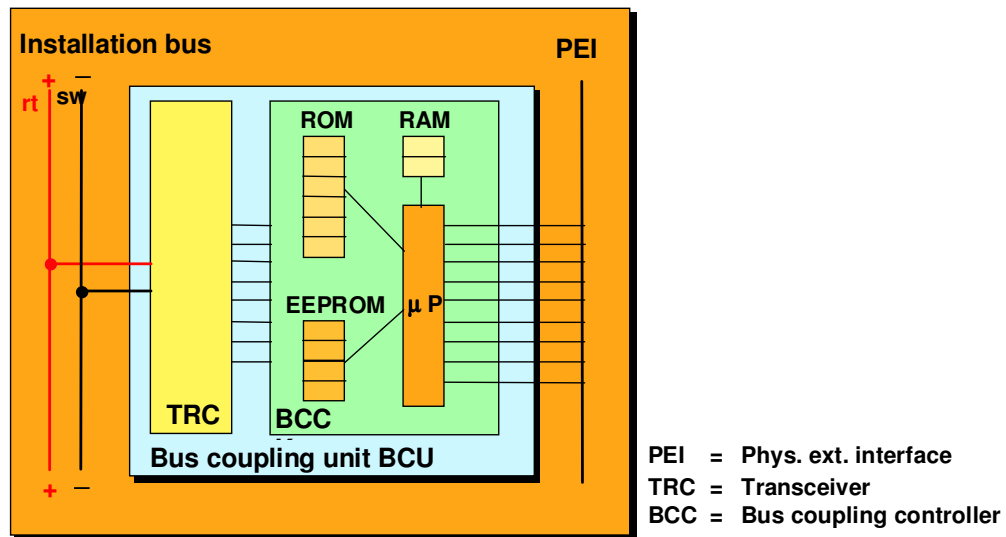
Telegram example: Shutter is lowered
L = Length of usable data (byte 0 to byte 1)
X = Not evaluated

Internal Structure of a Device

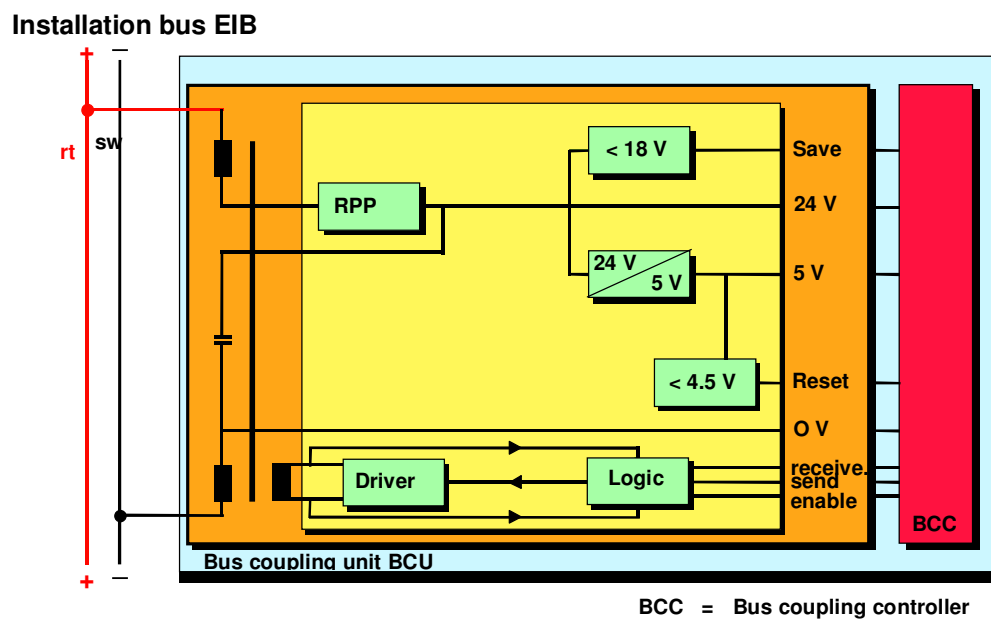


PEI = Physical ext. interface
BCU = Bus coupling unit
AM = Application module

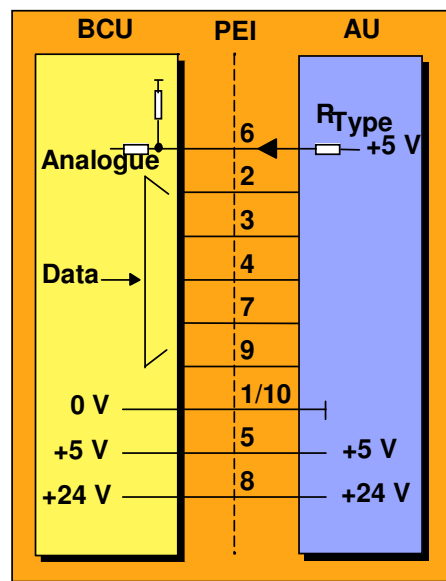
Bus Coupling Unit



The Transceiver

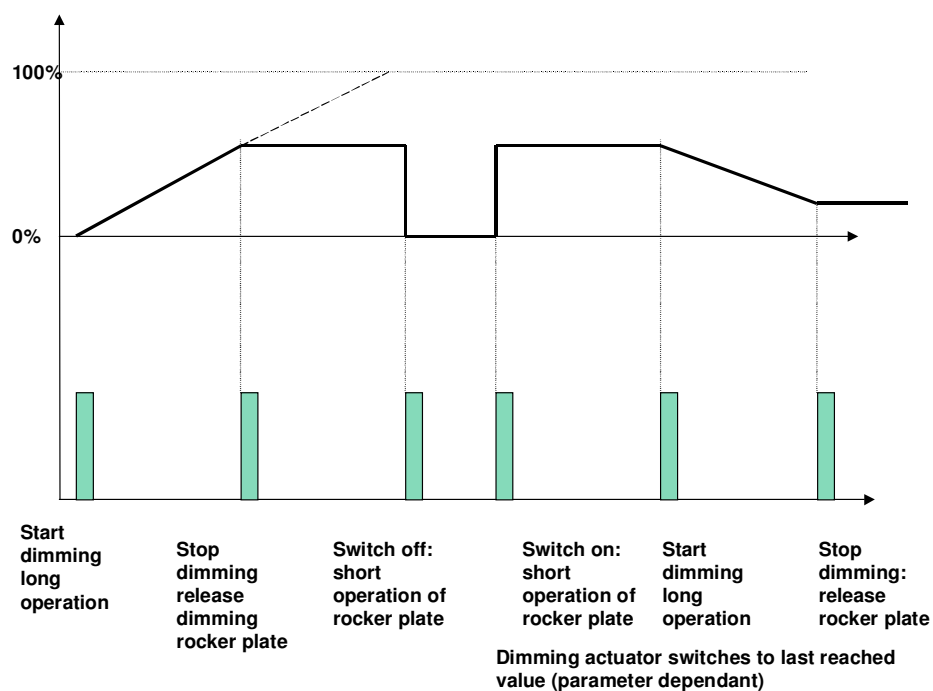


Application Module



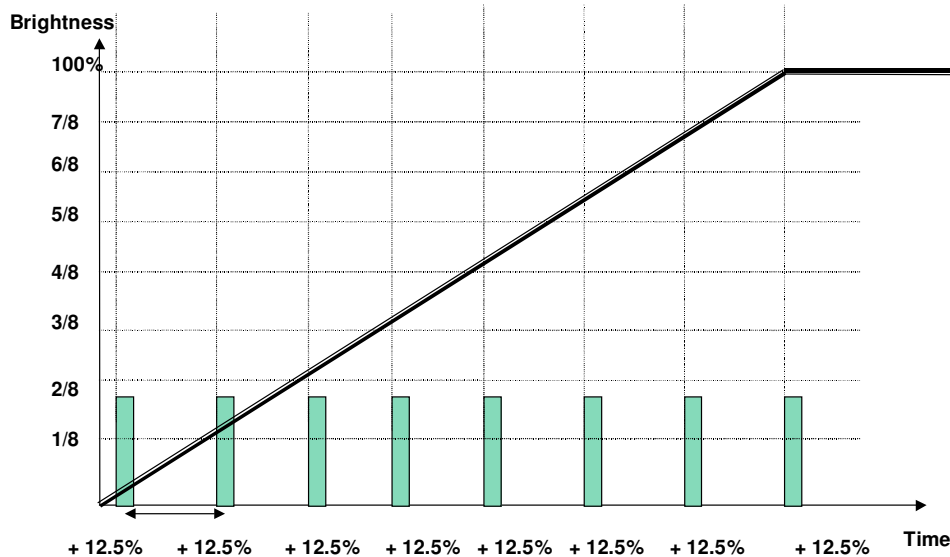
BCU = Bus coupling unit
AU = Application unit
PEI = Physical ext. interface

Application Function: Dimming with Start/Stop Telegrams



Application Function: Dimming with Cyclical Telegrams

Dimming speed of the actuator shall be adapted to the cyclical transmission of dimming telegrams



Conclusion

- Main advantages:
 - Robustness and reliability
 - High degree of functionality
 - Supports the design of complex systems for big installations
- Main disadvantages:
 - Complexity of installation and configuration
 - KNX requires certification of installers
 - Requires usage of the ETS software (expensive)
 - Devices and other system components are expensive

Questions?
