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Design and simulation of a smart home using the KNX standard

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Abstract: This paper addresses the problem of high electricity consumption in public buildings, especially large buildings such as hospitals and others. By searching for the best solution to reduce electricity consumption, the KNX standard was identified.

The KNX standard was proven to be efficient in reducing electricity consumption through a previous study conducted by ABB. This standard was applied to a house and simulated on the KNX virtual program.

This paper discusses the basic structure of the KNX standard, through which we can add many things that make the building smarter and save electricity using hundreds of actuators and sensors provided by this standard.

Keywords: KNX standard, KNX virtual.

Introduction

As a result of urban development and the General Electricity Company's failure to keep up with this development and its cessation of building new stations for nearly eleven years to keep pace with this development and the increased demand for electricity, this resulted in the power being cut off for hours and sometimes days. During this period, the General Electricity Company began building new stations and maintaining old stations. In contrast, it will take a long time to achieve final stability. In parallel with the process of station construction and maintenance, electricity consumption can also be reduced, especially large public buildings such as hospitals and others that have excessive and high electricity consumption. From here, the journey of searching for the best solution to reduce electricity consumption began, which is called (smart buildings). Smart buildings are buildings equipped with smart devices that help optimize energy consumption and reduce electricity bills.

Smart buildings can reduce electricity consumption in several ways, including:

Temperature control: Smart buildings can analyze weather data and automatically adjust the temperature according to weather conditions

Lighting control: Smart buildings can analyze lighting data and automatically adjust lighting according to weather conditions and time of day.

Control of electrical appliances: Smart buildings can analyze usage data and automatically adjust electrical appliance usage based on weather conditions and time of day. It is possible to warn about fire and take necessary measures.

Review of previous research (previous studies)

The Paper is a by ABB company titled Energy Saving with KNX Case Study. March 1, 2018.

Summary: The first case study looks at student accommodation, where KNX controls were used for lighting, heating, ventilation, and energy management. The lighting controls provided up to 58% energy savings, and the heating controls resulted in around 15% savings compared to the property without controls, though this could be as high as 50-60% with more efficient heating systems. The integrated energy management and visualization features also provided benefits.

The second case study examines an office building, where a complete KNX lighting control system was installed. Compared to the previous traditional lighting system, the new KNX system provided 35% savings from presence/daylight detection and 10% savings from dimming, resulting in a total annual cost savings of over £34,000. The payback period for the KNX installation was estimated at 5-8 years.

The Paper concludes by highlighting that KNX can provide energy savings of up to 40-60% across various building systems like shading, room control, lighting, and ventilation. It emphasizes that energy efficiency is crucial for addressing economic, environmental, and social issues, and that KNX is an effective solution for optimizing building energy use

The problem

The problem lies in the high consumption of electricity in public and private buildings.

Research Objectives

Reducing electricity consumption.

What is KNX?

KNX, also known as Konnex, is an open international building control standard. It is a successor of three previous standards, European Home Systems Protocol (EHS), Bati BUS, and the European Installation Bus (EIB). The KNX standard is administered by the KNX Association which was founded in 1990. As of June 2010, the KNX Association has over 200 manufacturing members. [1]

Principle of operation

KNX is a bus-based system. Devices communicate independently without a central computer or a control system. The communication is accomplished by telegrams transmitted on the bus. With the same bus cable, the power is distributed to the bus devices. Below an illustration of a simple KNX system, the green line is the KNX bus and the red line is a 230 VAC line. (Figure 1) [2]

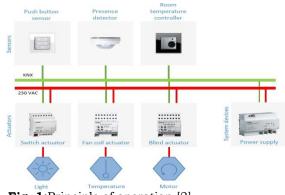


Fig. 1:Principle of operation.[2]

Data transfer media

The versatility of KNX is based not only on its protocol, but also on the broad range of available data transfer media. A bus can consist of a combination of media described in this section.

1) Twisted Pair Cabling

KNX TP is the term used when twisted pair (TP) cables are utilized as a KNX-medium. Twisted pair cabling is considered to be the best data transfer medium for KNX as it offers free topology. It is moderately low-cost and easy to install as the devices can be connected to each other without any hubs or switches. [3; 4]

2) Internet Protocol

KNX IP is the term used when the Internet Protocol (IP) is utilized as a KNX-medium. The benefits of Ethernet as a data transfer medium are: high bandwidth (100 Mbit/s), more or less cheap components, and widespread use. [5; 4]

3) Wireless Network System (WNS)

KNX RF is the term used when the Radio Frequency (RF) is utilized as a KNX-medium. A radio network is a suitable option when a twisted pair cable cannot be used as a communication medium. [3]

Topology

In this paper, only topology for twisted pair cabling is reviewed.

1) Line

A line consists of up to 4-line segments, and each segment of up to 64 connected devices. Each segment requires its own power supply. The maximum length for a line segment is 1000 m, and the maximum distance between a power supply and a bus device is 350 m. [2]

2) Area

If the capacity of the line is exceeded by the number of the devices connected to it or if it's practical to divide the automation system into smaller sections, areas can be utilized. It is possible to connect up to 15 lines to a main line with line couplers (LC). [3; 6; 2]

3) Multiple areas

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Several areas can be connected to a backbone line with a backbone coupler (BC). With a maximum of 15 areas, more than 58,000 devices can be connected to the bus. By dividing the bus installation into lines and areas, the functional reliability is increased considerably as every line has its own power supply, and the lines are galvanically isolated. [3; 6; 2]

Line Topology

1) Length Limitations

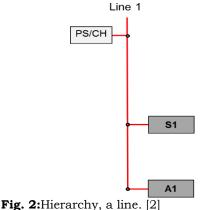
The maximum length for a line segment is 1000 m, and the maximum distance between two bus devices is 700 m. [5]

2) Power Supply

Each segment requires its own power supply, and the maximum distance between a power supply and a bus device is 350 m. [3]

3) Line Repeater

If a line needs to be continued with a line repeater (LR) to a line segment, the maximum total length of the line segment is 1000 m. [3]



Area Topology

1) Line Couplers

It is possible to connect up to 15 lines to a main line with line couplers (LC). [3; 6; 2]

2) Device Limitation

The maximum number of 64 devices connected to a main line is reduced by the number of line couplers connected to it as they are counted as devices. [3; 6; 2]

3) Timing Importance

If timing is critical for the automation system, the main line should be implemented with IP technology to provide a data highway. [3; 6; 2]

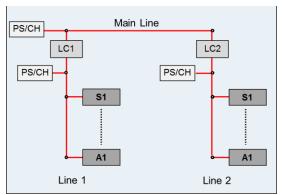


Fig. 3:Hierarchy, an area. [2]

Multiple Areas Topology

1) Backbone Coupler

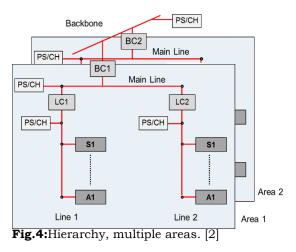
Several areas can be connected to a backbone line with a backbone coupler (BC). [3; 6; 2]

2) Device Limitation

The maximum number of devices connected to a backbone line is reduced by the number of backbone couplers connected to it as they are counted as devices. [3; 6; 2]

3) Data Highways

If the automation system is extensive, the main lines and backbone should be implemented with IP technology to provide data highways. [3; 6; 2]



THE DESIGN

1. Locators

The first step is to make site previews and identify public functions in each room, and this is where the home map is used, and all the job is located on the map. Each job is equipped with a specific code that occupies the function, its type, its place, sensors, push button and the home equipment included in the project, and compiles those functions on the excel paper so that it can be easily sought at a later date.

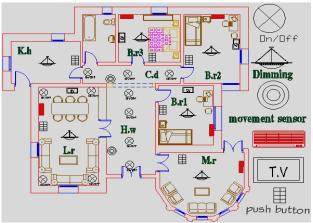


Fig. 5:The home map.

	B.r1	B.r2	B.r3	C.d	H.w	K.h	L.r	M. r	Total
Lighting Circuits				2	2		1		5
Dimming Circuits	3	3	3			2	2	2	15
Shutters	1	1	1			2	2	4	11
Air-Conditioning	1	1	1				1	1	5
Presence Sensor				1	1				2
heat alarm detector	1	1	1	1	1	1	1		7
smok detector						1			1
push button	1	1	1	1	1	1	1	1	8
TV	1	1	1				1		4

Table. 1:The functions.

2. Hardware

In this research, I used KNX devices from ABB for the target building, some of which are necessary in each project, such as power supply, line pairing and the Internet interface, and others according to the functions and loads required in the target building.

Programming

Settings

This research was programmed by ETS software and is an abbreviation for engineering tool software, it is a specialized program used in designing and configuring control facilities for smart homes and buildings. It operates within the KNX system, a standard for home and building automation. Catering to different project sizes, ETS offers different editions: ETS Professional for comprehensive solutions, ETS Lite for smaller projects, and ETS Demo for basic needs.[7]



Fig. 6:ETS6.

1. building structure

After entering the program and setting up a new project, we add the structure of the building used in the project, the number of floors and rooms in the target building.

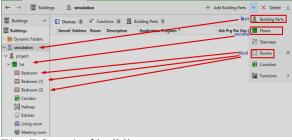


Fig. 7:Step 1 of building structure.

2. Add devices

In this step, we import the devices used in the project, here I will import the devices used in the project from KNX association so that I can simulate later which is the same way in all companies and the only difference is the parameters I will explain later. Fig. 8:download the catalogue.

About	Catalog Updates
Presentation	 Automatically download catalog updates
resentation	Update now
Language	-
Licensing	Content Selection
Lecensing	Market
ETS Apps	Saudi Arabia 👻
	Display only products containing the selected product language
Online Catalog	Display only products of the following manufacturers
Online Catalog Data Storage	
	Name *
	Name * KG-POWER
Data Storage Connection Manager	Name * KG-POWER KiloElec Technology
Data Storage	Name * KG-POWER KiloElec Technology Kluger Automation GmbH
Data Storage Connection Manager Troubleshooting	Name * KG-POWER KiloElec Technology Kluger Automation GmbH KNX Association
Data Storage Connection Manager	Name * KG-POWER KiloElec Technology Kluger Automation GmbH KNX Association KNX1
Data Storage Connection Manager Troubleshooting	Name * KG-POWER KiloElec Technology Kluger Automation GmbH KNXA Association KNX1 knXpresso
Data Storage Connection Manager Troubleshooting Shortcuts	Name * KG-POWER KiloElec Technology Kluger Automation GmbH KNX Association KNX1

3. individual address

After adding devices, we note that each KNX device has a unique address. The address that identifies this device in the KNX network. This unique address is called physical address or individual address. The way that the Physical addresses of the KNX devices are organized define the topology of the KNX network. 16 bits that represent Physical address are divided into 3 parts:

- 4 bits that represent Area number
- 4 bits that represent Line number
- 1 byte that represent device number [8].

🚺 De	vices 17	√ Functions	0 🖪 Bui	ding Parts 1
	rity Addre	ess Room	Description	Application Program *
	1.1.8	control panal		Binary Input Control
- D	1.1.7	control panal		Blinds/Shutter Control
	1.1.6	control panal		Blinds/Shutter Control
- E	1.1.4	control panal		Dimming
1	1.1.5	control panal		Dimming
1	1.1.10	Bedroom (1)		KliX
- E	1.1.9	Bedroom		KliX
- E	1.1.16	Living room		KliX
- E	1.1.17	Meeting room		KliX
- E	1.1.15	Kitchen		KliX
- E	1.1.14	Hallway		KliX
- E	1.1.11	Bedroom (2)		KliX
- E	1.1.12	Corridor		Movement/Presence Detection
- E	1.1.13	Hallway		Movement/Presence Detection
- E	1.1.3	control panal		Switching
- E	1.1.2	control panal		Switching
	1.1.1	control panal		Switching

Fig. 9:individual address for my project.

4. Adjust the parameters

When adjust the parameters it identifies the "Group Objects" available to the device on the KNX network, and also allows to adjust the behavior of the device on the network. For example, if you have one push button that supports three functions for buildings: switching, dimming and shutter, the button function is determined by a parameter called 'function', and this parameter is adjusted via the device parameters dialogue in ETS [9].

	Group Objects 18 000 Channe 9 KX.tp (D4) > CH-3 > Config		
	Room Temperature	Function :	Blinds/Shutter - Feedback (black/yellow/red)
+	CH-1		
+	CH-2		
-	CH-3		
	Config CH-3		
+	CH-4		
+	CH-5		
+	CH-6		
+	CH-7		
+	CH-8		

Fig. 10:when adjust the parameters for push button are four cases: switching, dimming, shutter, scenario.

5. Group Object

After setting the parameters you will notice a change in Group Object which is a data point representing a specific function of the device, such as the relay of switch operator. It is part of KNX standard automation of commercial and residential buildings. The device can contain multiple mass objects, and each group object has a unique group address that connects it to other devices on KNX buses. The Group Object's properties include its name, description, priority, flags, data type, function, length, and group addresses. The Group Object can be linked to at least two group addresses, one for sending telegrams to the bus and the other for receiving from the bus [10].

🔲 Buildings 🗸 🗸	Group	Objects 32 000 Channels 8 샤워 Paramet
Buildings	Number	Na Object Function
> 🛅 Dynamic Folders	1	CH-1 : Movement Detected
✓ Ⅲ simulation	2	CH-1 : Enable/Disable Movement Detection
∨ <u>I</u> project	J 3	CH-1 : Presence Detected
	4	CH-1 : Enable/Disable Presence Detection
~ 🔚 1st	📑 11	CH-2 : Movement Detected
> 🚔 Bedroom	🛃 12	CH-2 : Enable/Disable Movement Detection
> 🔛 Bedroom (1)	13	CH-2 : Presence Detected
E Bedroom (2)	🛃 14	CH-2 : Enable/Disable Presence Detection
∼ 🖪 Corridor	21	CH-3 : Movement Detected
	22	CH-3 : Enable/Disable Movement Detection
> 🕕 1.1.12 MP.tp	23	CH-3 : Presence Detected
∼ 💭 Hallway	24	CH-3 : Enable/Disable Presence Detection
> 💀 control panal	31	CH-4 : Movement Detected
> • 1.1.13 MP.tp	32	CH-4 : Enable/Disable Movement Detection
	33	CH-4 : Presence Detected
> 🔟 1.1.14 KX.tp (D4)	🛃 34	CH-4 : Enable/Disable Presence Detection

Fig. 11:Group Object for movement sensor.

6. Group Addresses

Group addresses and their role in the KNX network are critical to the logical and semantic performance of the devices. Physical addresses, unique to each KNX device, are fundamentally different from group addresses. Group addresses provide logic and meaning in the KNX network, enabling devices to interact and communicate efficiently. It is important to understand the different structures of group titles, such as level 3 structure, level 2 structure, and freely defined structure.

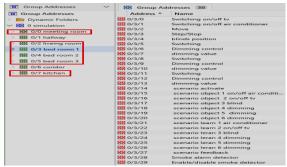


Fig. 12:when add group addresses for bed room 1 it differs from the rest of the rooms in number only.

7. Connect the group objects with their group address

Can link a Group Object to a Group Address by dragging and dropping the object onto the address or vice versa.

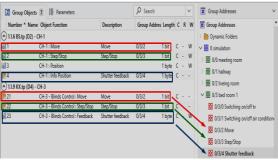


Fig. 13: example for link a Group Object to a Group Address for bedroom1 ·link shutter control with push button.

THE SIMULATION

KNX Virtual

The simulation process is done using KNX Virtual is a Windows-based application that simulates a KNX installation. It is designed to help users get acquainted with the KNX technology by setting up a simulated KNX installation, for free. The application represents more than 10 different types of KNX devices, all connected to one TP line. These KNX devices operate upon a number of 'building loads' like lamps, dimmable lamps, blinds, heating & cooling valves. KNX Virtual also makes it possible to experiment (rehearsal) with more advanced building features like weather modules, alarms, scenes and even logic operations.

KNX Virtual doesn't require any investment in hardware (such as power supply, USB or IP interface, KNX devices) as you will work with virtual devices, commissioned by ETS. [11]



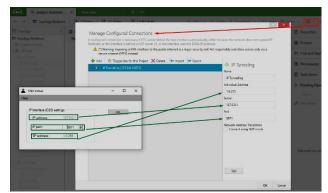


Fig. 14:Step 1 connect ETS with KNX Virtual.

• Step 2: we download the device we want to emulate by choosing from the download list download all.

🛾 Buildings 🛛 🗸	C Group Objects	211 III Channels	48 11 Parameters					P	s se	sarch	Download All	
Buildings	Number * Name	Object Function	Description	Group Addre	Length	с	R	w	т	U	Dat Download Partial	
Dynamic Folders	1.1.1 KX.tp (D4)										Download Indivi	fund Addres
III project Graduation 1	1	CH-1 - Switching : On.	Switching on/off to	0/3/0	1 bit	С			т			
1ST	PR 11		Switching on/off air conditioner.		1 bit	С			Т	•	swit- Overwrite Individ	lual Addre
Bedroom 1	P 21	CH-3 - Blinds Control.	Movement	0/3/2	1 bit	С	•	•			Download Applic	
	22	CH-3 - Blinds Control.		0/3/3	1 bit	С			Ŧ		step	ation
> 1 1.1.1 KX.tp (D4)	61 23	CH-3 - Blinds Control.		0/3/4	1 byte	С				- 1	percentage (0.100%)	-
Bedroom 2	21	CH-4 - Dimming : Dn	Switching	0/3/5	1 bit	с			T	•	switch	E To
🔛 Bedroom 3	B 32	CH-4 - Dimming : Di			4 bit			-			dimming control	
Corridor	6 33	CH-4 - Dimming : Fee.		0/3/7					-		percentage (0.100%)	D Pe
Halway	P 41	CH-5 - Dimming : On	Switching	0/3/8	1 bit	С			т	•	switch	
	P 42	CH-5 - Dimming : Di	Dimming control	0/3/9	4 bit	с			т	- 1	dimming control	
V I CONTROL FAMAL	64 43	CH-5 - Dimming : Fee.		0/3/10							percentage (0.100%)	0 Ce
> - III 1.1.0 Cip.tp	FR 51	CH-6 - Dimming : On	Switching	0/3/11	1 bit	С	•		Ŧ		switch	
> III 1.1.8 SA to (D7)	52	CH-6 - Dimming : Di	Dimming control	0/3/12	4 bit	С	-		т	•	dimming control	
> 1119 SAtp (D7)	53	CH-6 - Dimming : Fee.		0/3/13							percentage (0.100%)	
> 🕕 1.1.10 SA.tp (D7)	61	CH-7 - Scene Control.	scenario activate	0/3/14	1 byte						scene control	
	PR 62	CH-7 - Scene Control	scenario activate	0/3/14	1 byte	С	-		Т	•	scene control	
) 🕕 1.1.11 BS.tp (C22)	63	CH-7 - Scene Feedback	k scenario feedback	0/3/27	1 bit	С		w		•	boolean	
> 11.12 BS.tp (D2)	1 71	CH-8 - Switching : On.	.Enable/disable smoke detector	0/3/29	1 bit	С			т	-	switch	
> 10 1.1.13 DAtp (D0)	1.1.9 SAtp (D7) B1	+C										
> 111 1.1.14 DA to (D0)	a 1	CH-1 : OnOff	presence	0/6/0	1 bit	с	-	w	-		switch	
> - 11.15 SC.tp	61 11	CH-2 : OnOIf	movement	0/6/1	1.64	с		w			switch	
	6 21	CH-3 : OvOff	presence	0/6/0	1.68	с		w			switch	
> 1 12.18l.tp	31	CH-4 : OnOff	Switching on/off to	0/3/0, 0/3/16	1 bit	с		w			switch	

Fig. 15:Step 2 devices download from ETS to KNX virtual.

After pressing download all, the program will ask me to press the programming button for the device in the KNX virtual, and it will ask me every time I get up download press the programming button.

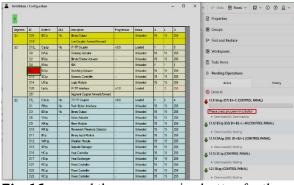


Fig. 16:pressed the programming button for the device in the KNX virtual.



Fig. 17:bedroom1 simulation for each of the: switch actuator, dimming control, blind/shutter control.



Fig. 18:bedroom1 simulation for each of the: scenario control, binary input control (there is a fire).

🗊 Buildings 🗸 🗸	C Group Objects	98 DE Channels	32 III Parameters		P	Serr	ch		~	E Properties	
Buildings	Number * Neme	Object Function	Description	Group Addre	Length	c 1	R N	T L	Date Typ		
Dynamic Folders	(a) 112 KX (p (D4)									- 88 Groups	
R. project Graduation 1		CH-1-Switching : Or		0.4/0	151			7 -	witch		
- III 111		CHE2-Switzing Or		0.007	188				TARCA	\$2 Find and Replace	
El Bedroom 1		CH 3 Block Control		0/4/2	164			T	uplicam	-	
		Old - Ninte Coatis							1540	H Workspaces	
V A tetrcom 2		CR 3 - Eliros Contro			1 byse		W		pecorial		
3 📳 LE2 KEAp (D4)		CHS4-Dimming: On		04/5	1ht				wren	💼 Iodo Items	
tetrcom t		CH-4 - Dimitting : Cli							damina		
1 🖬 Comitor		CH-4 - Dinning : Fe							percettag	Pending Operations	
~ DO Hallway		(045-Dimming) On		014.08					SARCE.	Artise	time
~ THE CONTROL PANNI		CHO Deming: Di						τ	denning		0073
ff 1.10 Cate		UI-5 - Dmming i Fer		076/10	1.000		W		Decessed.	Cancel all	
		CH 6 - Dimming : On Ct56 - Dimming : Di		0/4/11				1	damina	11.1.2 EX.zp (D4) (Bedroom 2)	
2 🗐 1.18 SAm (17) 83+H		CH-b - Omning : Di							danming parcentar	UL2 KA3p (D4) (Intercom 2)	
》 個 1.1.9 SAlp (07) 81 -C		CH-T - Scene Central		04/14					Dercentity	Vience press proceantmine butter	
2 11 11 10 SA tp (07) m+L+82		LH-/-Scene Control							scene con	Devrived Wit: Devrived nu	84
- 411 L111 85 to (02) 83 - K		CR.7. Same Basilia		04/27	10/20		w		formation		
2. 41 8112 8545 (02) 81-82+1+M			Lanialcisade statice detector	0/4/29	101				nutrin	LLIO SALIP (07) m+L+82 (CONT	ROL PANAL)
	() 110 SAIp (07) m		Competence and second		100					 Downoodskib Waiting 	
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1 III 114KLt (04)		DED GOT	Switching solar to	0444 04475					namen	-	
2 4EI 123 MRAS		CH 2 HAVO-DE	summing for an 2 control for	014/21	164			τ.	minh	► Deartinat(R); Walley	

Fig. 19: devices download for bedroom 2.



Fig. 20:bedroom 2 simulation for each of the: scenario control, binary input control (there is a fire).

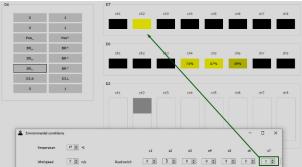


Fig. 21:bedroom 2 simulation for each of the: scenario control, binary input control (there is a fire).

🖬 Buickings 🗸 🗸 🗸	Group Objects	87 IE Channels I	12 Bi Parameters		0	See	dh i			~	Froperties	
🖬 Buildings	Number * Name	Object Function	Description	Group Addre	. Length	c	R 1	N T	U	Data Typ		
Dynamic Isiders	() ILL RX IN EDG									•	88 Groups	
II. project Graduation 1	10.1	CH 1 Svitching: Dr.		0/5/0		c		7		rolitan	-	
~ III 151			Switching as lot air acaditation							eastra	5º Find and Replace	
2 E Robert 1		OH Q - Bincs Corpo.				C				us/down	ER Worloppon	
		CH-3 - Bireck Commun.				ć.				stepi	ER Worksprons	
> 🖾 (tetrzom 2		(34-) - Note Como,			Titybe.		- 8			percenter		
~ 🖂 Bodreom 2		OH & Dimming : On.			168.	¢.,		7		xeith ¹	Iodo Items	
3 E MALKAD (DH)		Di-L-Donning: Nu.								dimning/		
2 P Conidor		CH-4 - Dimming / Feb.			T toste					percettac	Pending Operations	
~ 50 Hallory		CH-5 - Direning : On.		0.5/8						anden 👘	Active	History
		D18+Denning10s	Damming control		dise.					denning "	Active	Halot
- III CONTROL PANAL	1148	CH & Dimming (Foc.			T byte		.V			percentag	Cancel all	
3 🔮 1.5.0 Cip tp		046 - Dimming : On.	Switching	0.5/11	1 he					eaders .		
> +E111555Atp (07)83+H		OH-6 - Denmang / Dis.	Exmining control			ς.)				danming	1.1.3 KX tp (D4) (Redroom 2)	
2 E 1.1.9 SAIN (D7) 81+C	100.55	CH-0-Dimning cRes.	admining value	0/5/13	3 byte	ĉ.	U			persenties.		
11.1.10 SA to (07) m-L+62	e1	(24-2-Scene Control.	, scenario activate	05/18	1 is te					core cor	Nesse press programming better-	
	20.02	CH 7 Secto Control.	- oconaria activato	0/0/14	T lasto	¢				ssens cor	 Destroy(N): Sevelanding 	
3 11 1.11 85 apr (D2) 83 + K	liel ex	DI-7-Scene Reedback	k scenacih feechark	0/5/27	5.58		- 32			hoolean	# 118 SA IN ID71 83+H (CONTROL PAN)	10
#II 1.1.12 85.1p (D2) 81-82+L+M	15 71	CH8-Setting Dr.	Enable/disable smoke detector	0/5/25	1.68	0				Setter:	·	
3 11111 0A4# (00) M+81-K	(1.1.8 SA.10 (D7) 83	1481									 Downsat/All: Waterg 	
10 11.14 C6 to (30) 21+82+L		CH-1: CHOT	Switching on/off to	0/5/0,0/5/15	366	С.	- V			volten	LL1185 (p (D2) 83 +K (CONTROL PAN	AL)
		HUnitetnis 1-153	scenario learn Ticn/ottov	65,21	The -					eastra	 DownloadsVID Weiting 	
		CH 3: OHOT	Switching on/off sir conditioner	03/1,03/10	168	C.	v			entres.		
2 III 121810	12	CH-2: Info DeOH	scenario learn 2 a'r conditioner	6%22	3.68			τ.		ratio	STATE DAte (00) M+B3+E (CONTROL I	ANAD
> @ 13.4 KUp (04)		04-3 : CeO#	movement soot light on/off	6/1/8	100		- 10			seitch	 Drassatiki Watter 	
○ 但 523 MPA5	10.71	014-0-01	mercenent sour labs unfulf	D/1/8	114	c .	v			Adding .	· the second vertice	

Fig. 22: devices download for bedroom 3.



Fig. 23:bedroom 3 simulation for each of the: switch actuator, dimming control blind/shutter control.



Fig. 24:bedroom 3 simulation for scenario control.

🖬 Buildings 🗸 🗸	Graup Objects	90 III Channels	32 18 Parameters		5	58	arch		~	Properties
Beldings	Number * Name	Object Function	Description	Group Addre	Length	c	R 10	TI	Data Type	
Dunamic Folders	(m) 115 KK.00 (D4)								•	88 Groups
III project Graduation I	(m)	CB-1 - Sinds Control	L. Movement	0/7/0	1.66	с.		τ.,	sp/Gonn	
- INI	BR 2	CH-1 - Binde Carensi	L. Step/Step						etep:	5ª Find and Replace
> Balroom I		CH-1 - Blinds Corpol							percentag	
	BR 11	CH-2 - Binds Coerci	Movement	0,/7;/3	1 bit	ć.			up/down	Workspaces
Bedroom 2	PR 12	CH-2 - Winds Corerol	Step/Stop	0.024	1.68				step	-
> 🔛 Badroom 3	84 13	CH 2 - Blinds Costrol	Li blinde position	0,755	1 byte		0		percentag	Todo Itoms
🗦 🔚 Camitar	21	OH3 - Omming : On							ewitzh	
~ 20 Balway	22	CH-3 - Dimming (Di.							dimming c	Pending Operations
VIE CONTROL RANA	Q4 23	CH-3 - Dimming : Fee							percentag	Active History
	IP 51	UH4 - Umming : On			1.01				switch	Actors multity
> #ff 1.10Cb/tp	82	CH 4 Dimming : Di				ς.			directings	O Cancel all
E 1.1.8 SAvp (D7) B1+H	Q4.13	OH-1 - Denning : Fee							presenting	
> 111 1.1.9 SAzp (D7) E1-C+k	[]? 41		L. Enalote/clisable smoke detector						switch	4 115 KK/p (D4) (Utchen)
> #E 1.1.10 S5.ts (07) m+L+82	[]? 51	CH-6 - Suitching : Or							switch	
> (III 1.3.11 #5.tp (D2) #3 +K	IP 61	CI 1-7 - Scene Control							scene coer	Plasse press programming button
) 11 1.1.12 B3.to (D2) B1+B2+L+M	82 62	CH 7 Scene Control			1 byte			τ.		 DraviderSL() Down and ing
	6 63	CH-7 - Scene Feedba		0,7;21					boolean	118 SA/p (D7) RI+C+k (CONTROL PANAL)
> (E 1.11) DA.(p (D0) M=83+K		CH-5 - Switching Or			1.68	ç			pwitch	•
E 1.1.14 DA.tp (D0) B1-82-L	119 SA/0 (D7) EI									 Developeijik () Walking
) 信 1.1.15 5Gtp	1 16	CH 1:0:07	STEADLE		1.64				anitati	11.11 BS.Ip (D2) B3 +K (CONTROL PANAL)
> 40 1218/2	Qd 11	C11/21040#	mountaint.	0,%/1	1.68				ewitch	 Developedia In Walting
11.1.4 (5.20 (04)	84 21	CH3:0x011	presence		1.68				switch	
	6 31	CH-4:0:0#	Switching on/off tx	0/3/0,0/3/16					nvitch	113 DAIp (DI) M-83+K (CONTROL PANAL)
> 40 123 MP/#	1 2	MCHO onl: 2-40	scenario learn 2 cn/off by						switch	 Downloadskitz Waiting
~ 💬 Kitchen	(i) 41	CH 5 : 0x017	Switching on/off all conditioner			c	. 0		anitati	
> 411 11.5 KX.(p (54)		(11-5 : Into OnOH	scenario learn 1 a r corditioner	0,0221	1 bit				ewitch	

Fig. 25: devices download for kitchen.



Fig .26:kitchen simulation for each of the: dimming control, blind/shutter control.

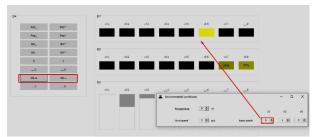


Fig. 27:kitchen simulation for each of the: scenario control, binary input control (there is a fire).

🖬 kildings 🔍 🗸	Croup Objects	98 BD Charmals	32 III Parameters		5	Sue	nh			*	Properties
1 Belldings	Number * Name	Object Function	Description	Group Adda	Length	s c	R 3	V T	U Data 1	æ	
Dynamic Folders	(-) 116 KL + (D4)									^	SE Groups
R present Conduction 1	I 1	CI-1-Suitching: Or	sSwitching on/all spot light	0/210	1.64				switch.		
V 🚺 15T	UP 11	CH-2 - Seitching : On	s . Switching on/eff ty	0/2/2	1.61				switch		3P Find and Replace
E Bedroom 1	BP 21			0/2/3	110				surface -		
	31	CH-4 - Blinds Control		97254	1.68				Up/Sos		H Workspaces
Bedroem 2	B 32	CF-4 Blinds Control		0/2/5	1.61			Т			
E Bedros m 3	Gel 33	CH-4 - Blinds Control		0/2/6	1 byte				peccent		Todo Items
E Corridor	B 41	CH-5 - Blinds Control		0/2/7	1.68				upidon		
~ 30 Hallow	BR 42	CH-5 - Blinds Control		0/2/8					varp		Pending Operations
~ I CONTROL RANAL	84G	CL-5 - Binds Control		0/2/9					percent	22	Active History
> CLLCCk.w	B4 21	CH-6 - Dimming : On		0/2/10					peith		None marri
	BP 52	CH-6 - Dimming : Di.		0/2/11					dmnin		S Concel all
) 📶 1.1.8 SA20 (D4) 83+H	16 53 1	CH-6 - Dimming : Fee		SI-2712					percent	89	
> 信 1.1.9 SA:p (D7) 81+C+k	019 64	CH 7 Dirming On		0/2/18	1.64			7			11.6 KC tp (D4) (Living room)
> 1.110 SAIp (D7) m+L+82	IP 62	CH-7 - Dimming (DL		0/2/14					câmmin		-
> 40 1.1.10 81.00 (52) 82 (6	61 63	CH-7 - Dimming : Fer		0/2/15					percert		Please press programming button > Descripted 2015 Coart pating
> 1112 R54p (00) 81-82+1+M	0 1 71	CH-8 - Scene Control		0/2/16					MATE D		
2 11.1.13 DA.12 (D01 M+83 -K	PR 72 8173	CL i+8 - Scene Control		0/2/16					beplear		3130 SAIp (D/) m+L+82 (CONTROL PAN4L)
		CH-8 - Scene Feecba	ck scenario recusado	0/2/31	1.64		- 11		000162		 Downlowskillt Wwong
> 🔚 1334 DAJp (D0) 81+82+6	 11.30 SA.tp (07) # 										
> 411 1.1.15 SC1p	101 S	CH-1: 0x0E	srecks alarm datactor	0/0/38	154				switch .		LL1/2 B5/p (D2) B1+B2+L+M (CONTROL PANAL)
> - 🖅 1.2.1 8Jp	al 11	CF-2: QrOT		0/2/32					- switch		 Download(All): Whiting
> 40 114 KO2 (94)		CH-2-DRUT CH-2-INFA CHOR	smoke alarm detector	W2-52	161				switch .		a 11M DAtp (DI) 81+82+L (CONTROL PANAL)
> 4E 122 MP.W		CH-3 I DIOT	Switching on/aff tr	0/430.0/4/15					switch		•
> Q Kitchen	101 21 101 22	CH-3 : Info ChOY	socrario loarn 2 gn/off tr						- switch		 Download(Al); Welting
	14 31	054:0:08	Solitching on/aff air conditioner						owitch		
🗠 👸 Living room	12 22	CH-4 Into CriOff	scenario learn 1 sir conditioner						pwitch		
> 11 116 KK.tp (04)	0144		second rear in an obtained of						- period		

Fig. 28: devices download for living room.

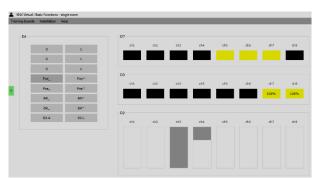


Fig. 29:living room simulation for each of the:1-switch actuator 2-dimming control 3-blind/shutter control.

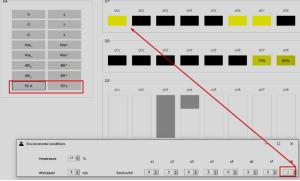


Fig. 30:living room simulation for each of the: scenario control, binary input control (there is a fire).

📱 Buildings 🔍 🗸	🚺 Group Objects	22 Dannels	24 (II) Parameters		٩) Sea	nch			×	Properties		
Buildings	Number * Name	Object Function	Description	Group Addre	e Length	c	R	N T	U	Data Type			
Dynamic Folders	114 KX.tp (D4)										88 Groups		
I project Graduation 1	IR 1	CH-1 - Switching : On	. locking presence	0/1/6	168			Ŧ		switch			
- IST	I 11	CH-2 - Switching : On	. locking movement	0/1/7	1b≿			Т		switch	P Find and Replace		
E Bedroom 1	R 21	CH-3 - Switching : On	. locking movement	0/6/2	1bk			T		switch			
	P 31	CH-4 - Switching : On	. locking presence	0/6/3	1bk			T		switch	H Workspaces		
) 🛱 Bedroom 2	R 41	CH-5 - Switching : On	Enable/disable smoke detector	0/1/1	1bb			Т		switch	-		
) 🔛 Bedroom 3	P 51	CH-6 - Switching : On			168			ī		switch	Todo Items		
) 🖁 Conidor	P 61	CH-7 - Switching : On			16k			T		switch			
√ 31 Halway	P 71	CH-8 - Switching : On			1bk			Ŧ		switch	Pending Operations		
V III CONTROL PANAL	118 SAtp (D7) 83								Active History				
) 110Ciptp	611	CH-1: OnOff	Switching on/off tv	0/5/0,0/5/15	168		- 1	í •		switch	inter internet		
	I? 2	CH-1 : Info DriOff	scenario learn 1 on/off tv	0/5/21	1bk			T		switch	S Cancel all		
> 📶 1.1.8 SA.tp (D7) 83+H	id 11	CH-2 : OnOff	Switching on/off air conditioner		168		- 1	í •		switch			
) 📶 1.1.9 SA.tp (D7) B1+C+k	I 2	CH-2 : Info DriOff	scenario learn 2 air conditioner	0/5/22	1bk			T		switch	LL4 KX.tp (D4) (Haliway)		
) 🖅 1.1.10 SA.tp (D7) m+L+B2	ki 21	CH-3 : OnOff	movement spot light on/off	0/1/8	1bk		- 1	1 -		switch			
) 🗐 1.1.11 85.tp (02) 83 +K	6 31	CH-4: OnOff	movement spot light on/off	0/1/8						switch	Please press programming button		
) 11.12 85.tp (02) 81+82+L+M	<u>el</u> 41	CH-5: OnOff	movement spot light on/off	0/1/8						switch	 Download(AI): Downloading 		
	6 51	CH-5 : OnOff	movement spot light on/off	0/1/8						switch	1.1.8 SA.tp (D7) 83+H (CONTROL PANAL)		
) 📶 1.1.13 DAtp (DD) M+B3+K	61	CH-7:OnOff	presence	0/1/9	1bk		- 1	1 -		switch	 Download XII: Walting 		
) 🗐 1.1.14 DAtp (DD) 81+82+L	6 71	CH-8 : OnOff	presence	0/1/9	1bž		- 1			switch			
) 📶 1.1.15 SC.tp	12.3 MRap										123 MRtp (Hallway)		
) 🗐 1.2.1 BUp	IR 1		. movement spot light on/off		1 bit						 Download(WI): Walting 		
> 11.4 KX.tp (D4)	612	CH-1 : Enable/Disable								erable			
	I 13	CH-2 : Presence Dete.								boolean			
> 🗐 12.3 MPtp	6 14	CH-2 : Enable/Disable.	locking presence	0/1/6	1bb		. 1			erable			

Fig. 31:devices download for hallway.

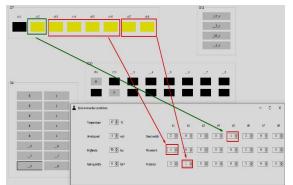


Fig. 32:when there is movement and presence in hallway and there is a fire.

07	di1 di2	eđ	014 da5	di6 di7	<i>d</i> 8		D12	یری بری بری بری			
D4	0	1	D10 ch1 H	d2	3 _4	_5 _6		2			
	0	1		16						- 0	×
	•	1		ΣΦ «c							
	٥	4	Terperature	1/10 C		s1 s2	s)	54 15	56	\$7	51
	0	1	Tiled speed	5 😨 nh	Reed switch	0 🖨 0	0 0	0 😳 🕽	• • •	0	0 🗄
	_6	_6	bytres	50 🖉 lux	Novement	10	00	0 0	0 0	0 0	0 0
	_7	_7 _8	Rain quantita	0 (0 (m)	Preserve		00	0 0 0	0 0 0	0 0	0 0

Fig. 33:when there is movement only.

🚺 Group Objects 🔢 🔳 Channels 16 🔠 Parameters					, Ps	earch		~	Properties			
Number * Name Object Function Description			Group Addre Length C R W T U Data Type									
(A) 119 SA to (07) 81	I+C+k								St Groups			
611	CH-1: OnOff	presence	0/6/0	1 bit		W		pubch				
6111	CH-2:010ff	movement	0/6/1	1 bit		W		pwitch	Find and Replace			
0 21	CH-3:0+0#	presence	0/6/0	1 bit		W		switch	-			
6 31	CH-4:0+0ff	Switching on/off tr	0/3/0, 0/3/16	1 bit		W		switch	El Workspaces			
P 32	CH-4 : Info OnOff	scenario learn 2 on/off tv	0/3/22	1 bit				switch	-			
	CH-5:010ff	Switching on/off air conditioner	0/3/1, 0/3/15	1 bit		W		snitch	E Todo Items			
	CH-5 : Info OnOff	scenario learn 1 air conditioner	0/3/21	1 bit				switch				
		somke alarm detector	0/3/28						Pending Operations			
									Later .	History		
		smoke detector	0/7/34						ACIVE	risiory		
									O Cancel all			
									-			
	CH-8 : Info OnOff			1.68				switch	LL9 SA tp (D7) B1+C+k (CONTRO 1000)	IL PANAL)		
									12.2 MRtp (Corridor)			
6 14	CH-2 : Enable/Disab	le locking presence	0/6/3	1 bit		W		erable	 President 3.D. Weiting 			
									 Contraction manage 			
	Number * Name (*) 119 SA.tp (07) 8 (*) 1 (*) 1 (*) 1 (*) 2 (*) 2 (*) 3 (*) 3 (Nutset Status Object Franklin 11 0.41 / 0.001 0.41 / 0.001 11 0.41 / 0.001 0.41 / 0.001 11 0.43 / 0.001 0.41 / 0.001 12 0.44 / 0.001 0.41 / 0.001 12 0.44 / 0.001 0.41 / 0.001 12 0.44 / 0.001 0.41 / 0.001 12 0.44 / 0.001 0.40 / 0.001 12 0.44 / 0.001 0.40 / 0.001 12 0.44 / 0.001 0.40 / 0.001 12 0.44 / 0.001 0.40 / 0.001 12 0.44 / 0.001 0.40 / 0.001 12 0.44 / 0.001 0.40 / 0.001 12 0.44 / 0.001 0.40 / 0.001 12 0.44 / 0.001 0.40 / 0.001 12 0.41 / 0.001 0.40 / 0.001 13 0.42 / 0.001 0.41 / 0.001 14 0.01 / 0.001 0.001 15 0.41 / 0.001 0.001	Description Description 01 Description 02 Description 03 Description 04 Description 05 Description 06 Description 07 Description 08 Description 08 Description 08 Description 08 Description 09 Description 010 Description 011 Description 011 Description 011 Description	Number Verwich Copy Data Operation Operation<	Numer State Objection Original Opposite Opposite	Number Object from Company Description Description <thdescription< th=""> Description <thdescripti< td=""><td>Numer Street Control Despiration Despiration Despiration Despiration C II II 011 01-1000F memore 668 134 C III C IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII</td><td>Note + Step + Deck Step + Deck<td>Numer State Object Access Orage/Access Orage/Access Orage Access 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 011 116 C - W main 011 01-000F memore 011 116 C - W main 011 01-000F memore 011 116 C - W main 011 01-000F 114</td><td>Numer Object And Directory Oneyholds lange C 1 W 1/ U totage Directory Official Directory Directory Directory</td></td></thdescripti<></thdescription<>	Numer Street Control Despiration Despiration Despiration Despiration C II II 011 01-1000F memore 668 134 C III C IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	Note + Step + Deck Step + Deck <td>Numer State Object Access Orage/Access Orage/Access Orage Access 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 011 116 C - W main 011 01-000F memore 011 116 C - W main 011 01-000F memore 011 116 C - W main 011 01-000F 114</td> <td>Numer Object And Directory Oneyholds lange C 1 W 1/ U totage Directory Official Directory Directory Directory</td>	Numer State Object Access Orage/Access Orage/Access Orage Access 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 00 114 C - W main 011 01-000F memore 011 116 C - W main 011 01-000F memore 011 116 C - W main 011 01-000F memore 011 116 C - W main 011 01-000F 114	Numer Object And Directory Oneyholds lange C 1 W 1/ U totage Directory Official Directory Directory Directory		

Fig. 34:devices download for corridor

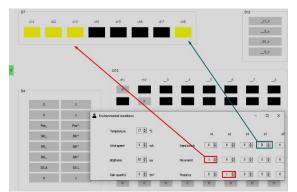


Fig. 35:when there is movement and presence in corridor and there is a fire.

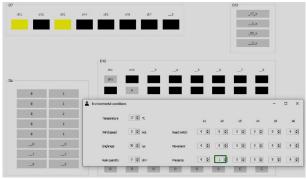


Fig. 36:when there is presence only.

II Buldings v × III Charrols 40 12 GeorgeOperty IIIE 10 Parentics							v	D Properties				
I Net assared to a room	Number 1 Name	Object Function	Linked with Group Addre	Leigh	C 8		T U	Data Type				
	(A) 117 KE (0 10									器 Groups		
🖉 beldnp-		Cit+1 + Switching / OnCit	SE DRUTH SARching JPD/19	102 -				Switch				
· Il project Graduation 1		CH-2 - Blinds Control (Move	ve 88.00/1 Movement and/1 Table C T - uproblem		SP Find and Replace							
 • • • • • • • • • • • • • • • • • • •	12	CF-2 Binds Central Stee Stee	89 0/0/2 Stat/Stop. 9/0/2	114			τ.	view				
) El Betroom 1	111	CF-2 - Elimite Control (Familiani	82 D/D/D Minute posts (BrD/D	Links.		- 52		percentarge (0.100%)		B Workspaces		
) El Retroam2		Ct+3+ Bank Cantral chines	88 0/0/4 Educement 10/0/4	the .			T 1	a prelower.				
Delivera 2	27	13 - 3 - Back Cantol Stepling	Si della Septimp. Brite	1 he				1940		🗒 Todo liens		
		CR-0 - Black Control (Feedback	82 QID/8 blods post /8/0/8	1 bjfe				percentage 30.100%				
Comdor		Ch-4 - Blinds Central Move		162			1	upridown		Panding Operations		
~ јіј парату	22.32	CF-4 Blines Control : Step-Step		162			τ.	step.				
~ I CONTROL REAL	al 33	CH-4 - Blincs Central : Feedback		t byte		19		percentege (0.100%)		Active History		
> 4 1,10 Cipto		ChuS + Bleete Control (Mexe		The				spectrum.		O Cancer all		
2 4T 12/8/m		13 +5 + Illinox Control (StepStrep		2.94				1945				
#E 1.18 SAIN (07) E3+8		CH-5 + Blinds Control Feedback		T byte		154		percentage (0.10056	LL7 KKtp (D4) (Meeting room)			
		CE-8 - Deterring OnOlf					Ţ.,.,	pator				
》但1/19/55/p10/010+C+b	22 22	CH C Directing Directing Control		362			Ŧ.	dinning central	 EventualA(:Jembraley 			
> -EII 13/0 SA(p10/) ex+L+82	14 53	Ch-8 - Dimming : Feethack Dimm.		1 byta				percentage (0.100%)		E 1110 SA to (07) m+L+B2 (CONTROL PANAL		
> 400 1.1.11 05.5p-(50) 03 -K		O -7 - Dimming : OnOH		1 he				seetch.		* Synthood A D Weitry		
> -ET 11/285.m (D2:81-82-1-N		13-2 - Damming (Dimming Control		the -				data cardeal				
> E 11/2 DA 10 (DB) M+83+8	101 60 100 Y	Ck-7 - Danning FeetbackDimm.		T Uple				percentage (0.100%)		STATE BS 10 (D2) B1+B2+L+M (CONTROL PAN		
1011114004to (DI) //1+92+1		CH-8 Scene Control : Aptivato		1 byte				score control		* Exercised A D Walling		
	172	CF-8 - Score Control - Learn CF-8 - Score Familiasts	83 0/0/20 scenario, 9/0/20 83 0/0/27 scenario, 9/0/27	1 kg/kg 1 kg				someoned		E 1113 DA & GO M+E3+K CONTROL PANAL		
> @ 1.113.90.1p			SS GROAF HIMMANN, BEGAT	The :		100		insidears				
2 4TT 1.23 MP /p	① 11.10 SA.tp (07) m									* Exercised A D Weing		
III LLA KCLU (D4)		CF CHOIT	89 040/08 seruka al., 8/0/38	161		14		and take		ELLEI BLID ICONTROL PANALI		
> C Kitchen		Ch-Trible Crick		1 be				saa lah		•		
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Fig. 37: devices download for meeting rom.



Fig. 38:meeting room simulation for each of the:1- switch actuator 2-dimming control 3-blind/shutter control.



Fig. 39:meeting room simulation for scenario control.

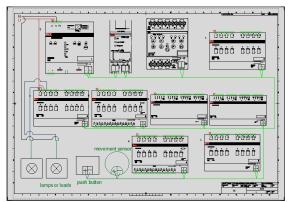


Fig. 40:control panel

Conclusions

Automation can provide useful functions for buildings. The most important functions are those that can save energy and provide security, as a building automation system, KNX has proven to be a very excellent choice.

KNX has been around since a long time and they have become a standard. There is a wide range of products offered by more than 500 factories. Minor modifications can be easy to do because they may not need any wiring just reprogramming.

This search was implemented on an apartment that includes all the devices in it. Those functions were programmed on the ETS6 program, a simulation of the functions was performed to ensure that the programming was done correctly and the results were satisfactory. A design was made for the control panel with some connections for explanation using AutoCAD. I had a lot of difficulty, including the lack of information, especially in matters of programming and linking to the simulator. I hope that the project is simple and helps to understand this system.

Recommendations

We strongly recommend that state institutions adopt this standard in all government buildings because it has many advantages that state institutions lack, the most important of which is the provision of electricity and that special laboratories be provided for this standard in colleges so that it can be studied in practice.

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