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Demo board for a DALI router system (Helvar)

Extended capabilities of basic DALI

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Electronic engineering

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In this project, a demo board to introduce DALI lighting control protocol in a learning environment was constructed. The core of the demo system is a Helvar router that provides several extra capabilities to basic DALI installations. Thus, the aim was to create an arrangement that could help students to get an insight and experiment with DALI systems, extending its scope to non-DALI devices. With this approach, the system is able to provide full integration of different lighting installations relating them to building automation. The construction of the board was complemented with various documents and learning material to be used by Metropolia UAS students during their studies.

It has been proved that this type of systems offers enough tools and techniques to significantly improve energy efficiency and energy management within a building as well as user comfort. Using the router made also possible to apply some networking concepts in conjunction with another common lighting control protocol used in architectural lighting, DMX. Throughout the development of this project, it has been observed that extended DALI systems are an excellent solution for, both, simple and complex lighting control schemes providing flexibility while keeping simplicity in their planning and installation.

Keywords	DALI, lighting control, building automation, energy efficiency, DMX, networking

1 Introduction

The use of light is essential for humans, from natural light present in almost every activity of life beings to pure aesthetics of artificial light or involuntary-generated light by these activities. It is inherent to this consideration that the ability to control light in all its forms is a key factor in many aspects of human life. This has been true particularly over the last few years where new forms of artificial light have been developed having a huge impact in the energy consumption on Earth. As we all know, energy use and energy efficiency is a worldwide concern in our society, especially in developed countries, where CO_2 emissions associated with electricity consumption, exhaust of natural resources and economy must be treated very seriously by all community members and authorities.

Behind these aspects which often draw new laws and interventions by authorities, we find also more practical aspects for the necessity of building automation and lighting control such as comfort, aesthetics, productivity and, of course, reduction of costs. The latter is probably the main reason (besides compulsory changes in regulations) why most owners decide to invest in a lighting control system for their facilities. A properly designed and installed system can generate substantial direct and indirect savings as well as a number of benefits to end users that will also influence the general paybacks of the investment.

The aim of this project is to introduce a lighting control system in the form of an educational demo for students where they can experiment capabilities of a DALI based system. The demo will consist in a board with a simple installation including control devices and control gear (terminology that will be explained later in the report). It will include mainly “controlling” input devices and “controlled” output devices (primarily light sources) all connected to a router, which is responsible for the management of the system. The DALI devices used for the project come from Finnish firm Helvar Oy, an international company dedicated to manufacturing of luminaire components and integrated lighting control solutions.

General features of DALI will be covered further in the theoretical section of the report as this is a worldwide standard protocol used for lighting control either as stand-alone system or as part of a more complex building management system (BMS). Main technical characteristics of DALI interface and Helvar devices as well as some basic engineering concepts will be included since they are necessary to understand the main behaviour of the system but concentrating in the aspects that will help to use, experiment and hopefully develop such a system. This report is intended for sustainable building engineers or building services engineers with basic knowledge about electronics but with more advanced understanding about BMS and lighting sources and efficiency. For this reason we will focus in electronic engineering and DALI programming concepts with which those are less familiar.

The main section of the project explains the process of configuring the system for an experimental behaviour. Obviously, the scope of the demonstration is limited to the size of the installation and the resources available but it should be enough to introduce this type of systems and motivate students to experiment with further features in the future. In addition to this, we want to test if it is possible to implement basic building automation control using a dedicated lighting control interface. The project will be completed with instructions for its use as well as with preliminary instructions for additional programming, modifications and commissioning of the demo installation.

Thus, the main subject of this project is not lighting design or energy efficiency although these are very important topics behind any lighting control system but they will be used throughout the writing as functional requirements for our installation. Consequently, we will not study in detail design aspects like what type of light sources to use, what is the appropriate lighting level for an activity or what would be a correctly chosen schedule for an installation. The project targets the operational aspects of such a system from the electronic engineering point of view concentrating on the programming possibilities of a DALI-based system with the added intelligence from Helvar's router for the control of building lighting.

2 Theoretical background

2.1 Lighting control and energy efficiency.

Lighting is responsible for an important proportion of the electricity, and thus energy, used in this planet. According to International Energy Agency (IEA) lighting represents almost 20% of global electricity consumption, which is an amount similar to the energy produced by nuclear plants on Earth. There are many ways of reducing this consumption, from conceptual ideas such as social awareness, laws or environmental politics to more technical aspects such as design, lighting sources development or lighting control. In fact, IEA recommends the governments two main points to achieve energy savings in lighting:

- Phase-out inefficient lighting products as soon as technically feasible and economically viable.
- Require and promote improved lighting systems design and management by ensuring building codes promote the use of natural light and include minimum energy performance standards (MEPS) for lighting systems

Within this picture, we find that lighting control can play a significant role in reducing energy consumption considerably either directly or indirectly (for instance, lighting also produces heat that may affect other aspects of building management such as HVAC or security). A big part of the electricity used for lighting worldwide belongs to building lighting at which DALI, as lighting control technology, addresses mainly its design. Of course, there are other aspects that influence energy savings in lighting, from installation design and choice of luminaires to appropriate maintenance plans.

However, sustainability is not the unique reason for controlling light. Other aspects such visual comfort, aesthetics and more importantly reducing costs are even more important concerns when considering to newly install or update a lighting control system. Similar systems to this project´s should be able to provide a comprehensive solution for virtually all the requirements of a lighting control system within a building if careful design, selection of appropriate devices and correct programming is performed. For instance, adjustment of lighting levels on different areas of a building depending on the activities and the natural light available or programming lighting scenes according to schedules are competences of lighting control systems.

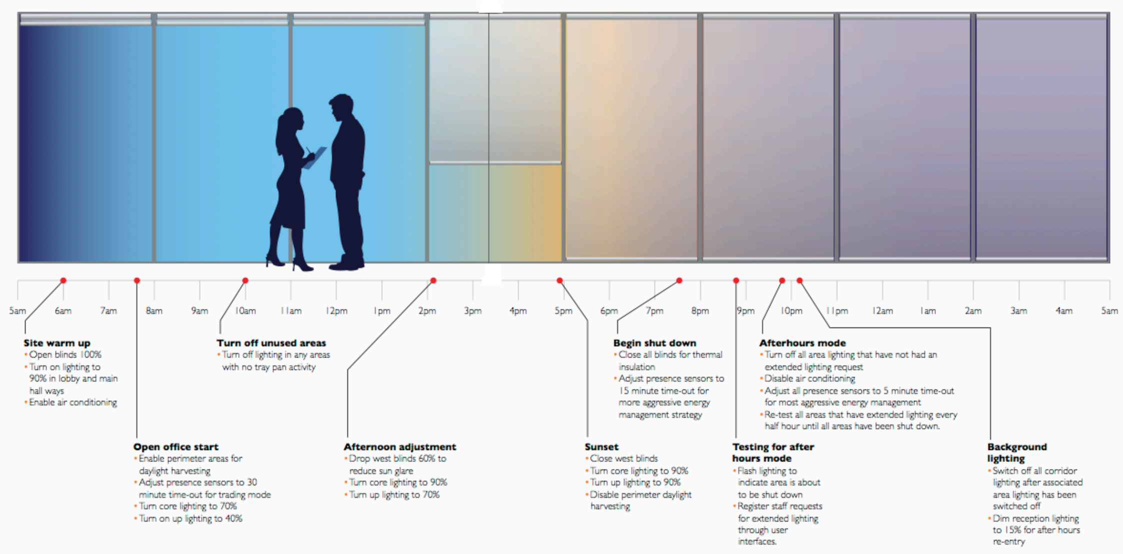


Figure 1. Daily cycle for energy saving of a typical office. (Phillips©, DALI lighting automation control solutions brochure 2012, 4 & 5, edited)

The figure above shows an example of how a schedule and lighting automation programming could be applied to an office building. We can see how we have scheduled events and tests, usually time dependant, which will occur automatically no matter what is happening in the building. There are also, scheduled configurations, which will not change the actual lighting but how sensors and controls will interact with the occupation and usage of the building. Naturally, the system will allow for user interaction and "on the go" modifications while it is possible to keep log of every activity of the system.

As a result, we have a lighting control system that will adapt to building's necessities, usage and schedule, applying different energy schemes that should result in important savings and a significantly improved energy management of the premises.

2.2 Building automation

Building automation is the aim of such called Building Management systems (BMS) or, more recently, Building automation systems (BAS). These control systems are computerized (intelligent) networks of electronic devices and their purpose is to provide buildings with certain functionalities regarding monitoring and control of HVAC, security, safety, mechanical and lighting systems.

BAS and BMS are examples of distributed control systems where it is possible to deliver functionality such as control based on occupancy and use of buildings, schedule of events, device failures information or remote monitoring and control of a system. This is often referred as “intelligent building” or “smart building” where the main concern is the energy management within a building in order to reduce operating and maintenance costs as well as accomplish to new building and energy regulations.

These systems are built around controllers, which are basically programmable devices with inputs and outputs (or connected to those by the network). The inputs more commonly found are sensors (light, temperature, humidity, flows, smoke detector or presence detectors), timers, switches or control interfaces. On the other hand, outputs may include relays, actuators, ballasts, drivers, switches controlling from valves or dampers to ballasts or frequency drives. Inputs and outputs can be analogue or digital depending on the application although the latters or even wireless systems are currently preferred.

There are several protocols and industry standards. They usually consist in a primary bus and a secondary bus and it is common to find dedicated sub-networks within larger systems. In this particular project, the primary bus would be Ethernet (as is the backbone used for communication between computers and routers) and the secondary would be DALI, which communicates the rest of the devices that are part of the system (sensors, input units, controllers, relay units, drivers, ballasts and so on).

Other protocols often used in building automation are KNX, LonTalk, Bacnet or EnOcean each having their pros and cons. One of the main discussions among manufacturers is whether or not a system is adequate for certain functionalities. For instance, DALI is specialized in lighting and can be perfectly integrated into other BMS systems but companies are building systems around it that may replace some building automation functionalities going beyond the mere lighting control. Certainly, a system based in DALI such as Helvar´s Imagine routers cannot reach at all the level of complexity for building automation provided by KNX but, on the other hand, KNX is often short in lighting control capabilities and functions. In fact, DALI systems are frequently used as subsystem of a KNX system.

2.3 DALI

This project is built around DALI so we need to get an insight into DALI technology and features. Although, the review can be made very extensive, we will focus in the details that concern our project as well as in providing a general overview of the different aspects of the system, primarily from a technical point of view.

DALI is a lighting control protocol mainly targeted to commercial, industrial and architectural lighting. DALI systems are simple, cost effective and flexible, offering probably the best solution for complex lighting control and, the increasing, energy efficiency requirements in buildings. There are many advantages in using DALI, from simple installation to flexibility of the configuration with small or little modification of the physical fitting.

Typical performance of a DALI lighting system allows customization of different spaces and environments for different activities or surrounding conditions, monitoring of the system lowering maintenance and energy costs, energy management, lighting automation, easy and high performance control, emergency lighting management or visual comfort. Due to the development of specific equipment by some manufacturers the capabilities of DALI can be expanded to deliver large scale and more complex designs to meet the lighting necessities for almost every type of building and functionality.

2.3.1 What is DALI?

DALI stands for “Digital Addressable Lighting Interface” and refers to an international standard protocol for the digital communication between the components of a lighting system. It was developed by all leading control manufacturers being defined in appendix E of the International Electrotechnical Commission (IEC) 60929 standard that covers the control of electronic ballast and lighting in building automation network-based systems. Now, the standard IEC 62386 specifies the commands and guarantee that products from different manufacturers marked with the DALI logo can be installed and have high functional security within the same installation. DALI was created to overcome the limitations of the analogue 1-10 V control and it was intended to become the new standard in the lighting market to give solution to complex lighting control issues.

2.3.2 Basic DALI features

The interface has been designed for a maximum of 64 single units (individual addresses), a maximum of 16 groups (group addresses) and maximum of 16 scenes (scene light values). Despite the fact of having controlling devices, the intelligence of the system is distributed and some set points and lighting values can be stored within the ballasts, drivers and other devices. These values are individual addresses and group assignments, light scene values, emergency lighting and power on levels or fading times.

DALI is bidirectional; as a result it is possible for device status messages, automatic search of devices and identification of unit type and tolerances. It is possible then to send feedback information such as ON/OFF, lamp state or actual brightness. If interruption of data transfer occurs the unit might enter into emergency operation where fixed light adjustments are interpreted automatically. The information from the luminaires can be used not only for maintenance purposes but also for statistics, energy consumption or some other administrative reasons by using third-parties DALI control software.

The luminous flux relation has been standardized with reference to the interface voltage and the dimming range is from 0.1% to 100% (lower limit dependant on the product). As a result of the dimming curve standardisation, an impression of similar brightness is achieved providing that the lower limit of the dimming range is equal for all units belonging to the same power class. Programmable dimming times are also possible.

Flexibility is one of the main advantages of DALI systems where new configurations and integration of new components is fairly easy. When a modification of a function on a currently installed and configured system is needed, no hardware modification or rewiring is required and it is only a question of re-configuration. Also, New components can be added wherever they are needed keeping in mind the limitations and the dimensioning of the power supply. It is always recommended that connection to BMS is made by means of converters.

2.3.3 Connectivity, arrangement and operation

There are not specific requirements in the arrangement of the network. Its structure is flexible and almost every configuration is valid apart from ring-shaped connection, which should be avoided (thus tree, linear, star or mixed topologies are possible).

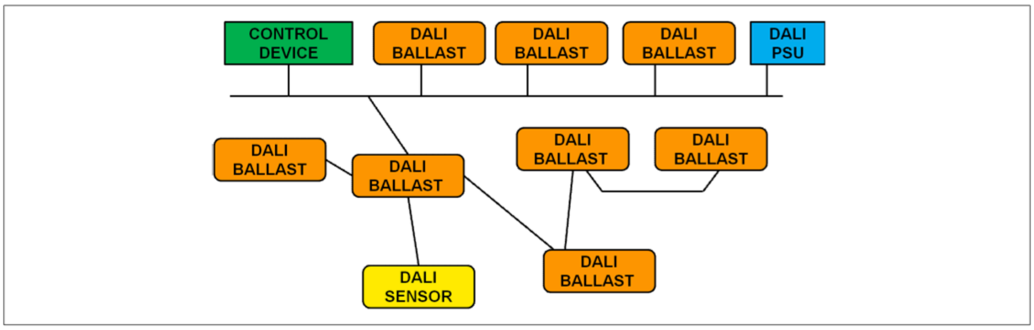


Figure 2. Freeform topology (Microchip©, AN 1465 Digitally Addressable Lighting interface communication 2012, 1).

Regarding hierarchy, there are two main possibilities to connect control units to control gear.

- One control unit operating as master of an interface line (single master) where all the control equipment such as sensors, panels, input units are connected to the router and this is connected to the ballasts, so the control is centralized.

- Several control units operating as a master in the interface line (Multi-master) where controllers can communicate directly with ballasts but they will have to follow certain traffic rules to avoid collision and function correctly

The multi-master option means that less wiring is required simplifying the installation but a higher level of complexity can be achieved with the use of the processing power of a control unit. Our project uses the single master choice where all the data is handled by a router.

2.3.4 Addressing

In a DALI system each unit must have a different address in order to differentiate one device or ballast from another and control them independently. A distinction is made between individual addresses and group addresses. Also, there are broadcast messages that are sent to all units of the system.

In a DALI subnet up to 64 addresses (ballasts) can exist and be controlled individually. Each of the ballasts (individual address) must have a unique address and may belong to a maximum of 16 groups. This addressing is performed via software and the system configuration can be changed without modifying the physical installation just by rearranging groups.

This channel limitation refers to a “DALI circuit” in basic DALI but nowadays with the use of devices such as routers and larger backbone networks this concept has been transformed into “DALI subnet”. A subnet has the limitations of DALI interface but it can be integrated in larger networks having several subnets each assigned to a router or hub. Additionally, there are routers that can handle more than one subnet, as it is the case of the router used in this project, which allows two DALI subnets on the same device. Moreover, it is possible to network dozens of routers in a single cluster depending or even several hundreds of routers when using multiple clusters so almost any installation size can be faced.

2.3.5 Dimming curve

The protocol provides 256 levels of brightness between “Off” and 100% according to the 8 bits ($2^8 = 256$) of information used. Light level is translated to the ballast/driver via logarithmic curve with larger increments at high dimmer levels and vice versa in an attempt to appear linear to human eye that has similar logarithmic behaviour. Human eye reacts with great sensitivity, particularly when there is low level of illumination.

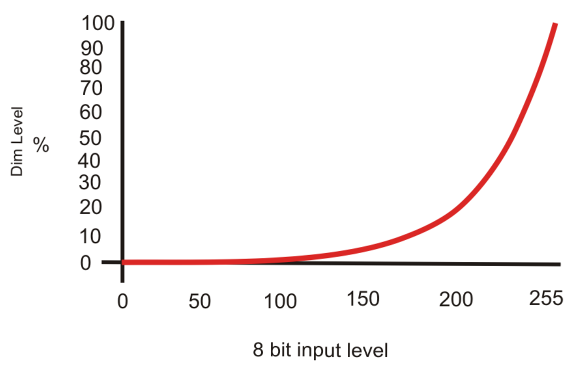


Figure 3. The DALI dimming curve tries to compensate human high sensitivity at low lighting levels (www.helvarsupport.com/dev/help/DALI_Logarithmic_Dimming_Levels.htm).

If different fixtures and manufacturer are used, dimming curves might not match. This is especially true at lower levels due to the small variations over a wide range of values of the curve at low dim levels.

2.3.6 Signal and data packets

DALI uses Manchester (bi-phase) coding at a data transfer rate of 1200 bits/sec. Due to this low transmission rate, the technique provides interference-free operation of the system. In DALI, the master sends 16-bit Manchester encoded data packets while the ballasts (or other units) can respond with an 8-bit encoded data, both with no error checking. As mentioned earlier, there are 64 channels available for the ballasts on each interface line and this line can have up to 16 groups with 16 scenes available. We will see now how this numbers are represented within the data packets.

Messages in DALI are bi-phase Manchester encoded packets. In this coding scheme, there is always a transition on every clock pulse. A logical ‘1’ is represented by a high to low transition (falling edge) and a logical ‘0’ is represented by a low to high transition (rising edge).

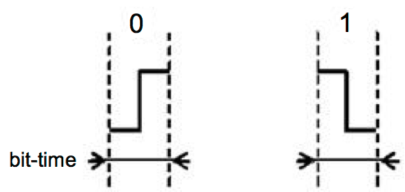


Figure 4. Manchester encoding of a bit. (Microchip©, AN 1465 Digitally Addressable Lighting interface communication 2012, 6).

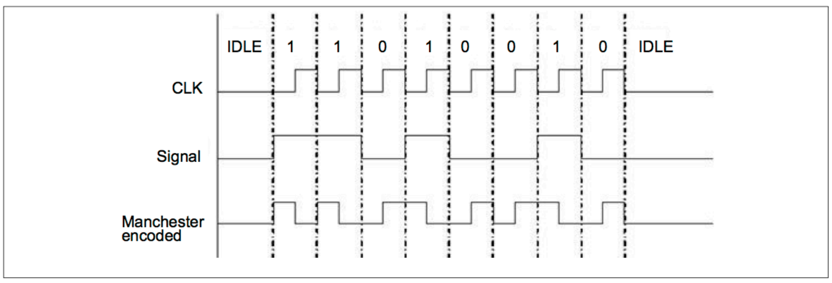
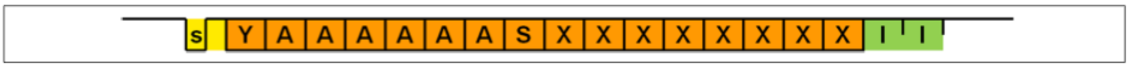


Figure 5. Manchester encoding of a data byte (Microchip©, AN 1465 Digitally Addressable Lighting interface communication 2012, 6).

The forward frame packet is sent from control device to the control gear. There is one start bit, then the actual data packet (with eight address bits plus eight data bits) and two stop bits to finish the packet. Most significant bit (MSb) is sent first. The figure below represents its structure:



`s` = Start bit which is a logical 1

`YAAA AAAS` = Address byte

`XXXX XXXX` = Data byte

I = Stop bit (Idle line)

Figure 6. Forward frame. (Microchip©, AN 1465 Digitally Addressable Lighting interface communication 2012, 4).

From the figure we can see how the individual addresses are represented by 6 bits thus from 0 to 63 in decimal values (64 different values corresponding to the 64 addresses available on the interface line). Similarly, groups are represented by 4 bits that correspond to 0 to 15 in decimal values (16 different values corresponding to the 16 groups of the DALI subnet). In addition, we see how there are other 8 bits left for data corresponding to the light level. Other particular bit combinations are used to indicate broadcast messages, type of command or special commands.

A backward frame is sent from control gear to control unit in response to forward frame. There is one start bit, the actual data packet with 8-bits and two stop bits where MSb is sent first as well. When the data is all 1´s (‘*0xFF’* in hexadecimal format) it is considered as a ‘*Yes’* whereas if a response is expected and the line stays idle is considered as *‘No’*. Other values will depend on the command that the control gear responds to.

`s` = Start bit, which is a logical `1`

`XXXX XXXX` = Data byte

I = Stop bit (Idle line)

Figure 7. Backward frame (Microchip©, AN 1465 Digitally Addressable Lighting interface communication 2012, 5).

Probably, these and other more complex concepts such as bit timing are slightly out of the scope of this theoretical summary but they can be useful in order to understand how devices communicate, why control gear and control devices are distinct or why we have in DALI certain amount of addresses or groups.

2.3.7 Physical layer

The wiring and the illumination installation should follow same conditions applicable for power installations. Wiring is very simple since there is no polarity in DALI communication or group formation involved while it is still possible individual or simultaneous control of all units. Bus powered devices can be supplied with power with the same two wires used for data communication. Obviously, Devices providing these powered subnets (routers) or those dealing directly with loads (ballasts, drivers, non dimmable switches) they will need to be connected to mains. Another Interesting feature is that DALI can handle on and off function so there is no need for planning the switching of the loads.

A maximum voltage drop of 2 Volts (V) from source to destination is admissible on the leads of the interface. Safe operation in guaranteed by the large-scale interference voltage between the sender and the receiver side. Hence, there are no special requirements for wiring (twisted or shielded)

The typical bus voltage (supply voltage) is 16 V (9,5 V a 22.5 V), supply interface can be located anywhere in the system from a separate supply unit to a control unit. The maximum current for the system is 250 mA, the current allowed at the central interface power input. Members of the system may withdraw a maximum of 2 mA while the current limitation avoids overloading their switching function. However, it is good practice to allow a reasonable margin to guarantee reliable function and possibility to system expansion using the existing installation.

Voltage levels for high and low have been defined for transmitter and receiver as follows. Nominal high logical level is 16 Volts while low logical level is 0 Volts but there is an allowance range on each end of the communication channel represented in the next figure:

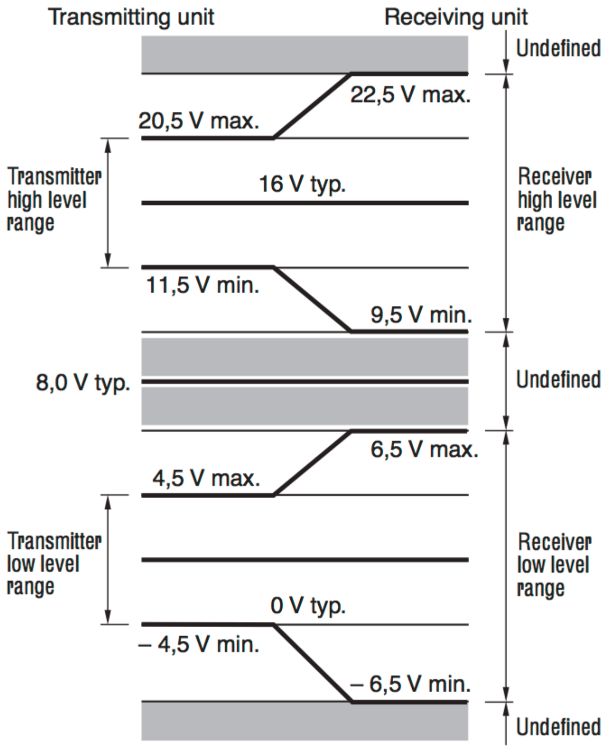


Figure 8. Voltage ratings of DALI data communication (DALI manual 2001, 18)

Two base-isolation should be provided between the two leads and single threaded isolation of a lead is enough (according to IEC 60 928 standard). Also, control and supply leads can be wired together where minimum cable diameters are as listed below:

- Lead length up to 100 meters with minimum diameter of 0.5 mm^2
- Lead length from 100 to 150 meters with minimum diameter of 0.75 mm^2
- Lead length above 150 meters with minimum diameter of 1.5 mm^2
- Lead length above 300 meters must be avoided.

There are no specific connectors dedicated but 2 wire (for data) or 5 wire connectors (data + mains) with common screw terminals or push fit surface are used. Also, some manufacturers have created specific systems to easily connect and install DALI systems.

Control input and mains voltage are galvanically isolated. Thus, all components of the system might be operated with different outer conductor (phases). In practice, this means that the control input is potential free and it is not important the polarity when connecting the wires. However, in most systems, control wiring shares the same sheath with mains wiring making 5-pole of common use for DALI installation.

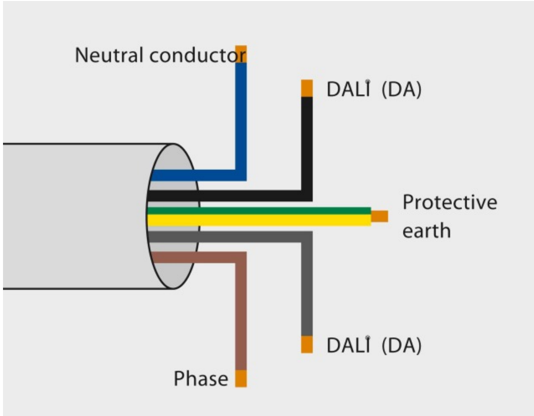


Figure 9. Typical DALI cable scheme similar to the MMJ 5x1,5 mm^2 used for this project (http://www.osram.ec/osram_ec/Productos_Profesional/ECG/DALI/index.html)

2.3.8 DALI and BMS

With respect to BMS, DALI itself is not suitable for building management and should be used only as a subsystem which traditionally could be integrated in different fashions:

- As stand-alone: Where control unit is not connected at all to the BMS and all the functions are performed locally.
- As stand-alone subsystem: Similar to the previous one but with the most important information being exchanged with the BMS hence connected but fully operational without the building management.
- As pure subsystem: Components installed in a part of the building (mainly controls and sensors) are connected and fully integrated within the BMS using its bus to communicate. The integration of DALI is made through a gateway, which provides bidirectional communication and translates between the building management and DALI.

However, with the aim of third party dedicated products, a DALI based system could fulfil some of the requirements of a building automation system. The aim of this project is to demonstrate some of these capabilities with the equipment manufactured by Helvar (Routers, Input units, relay units, blinder controllers are examples of such devices).

2.4 DMX

DMX512 or simply DMX stands for digital multiplexing being another lighting control protocol used primarily in the theatre and entertainment industry. While originally created to control dimmers, new lighting technology and its extension has pushed forward the protocol to other purposes such as intelligent luminaires and architectural lighting. The latter is of special interest for our project since Helvar´s Imagine 920 router includes a DMX port that will be used in our demonstration. Nowadays, many buildings incorporate DMX controlled lighting to enhance its appearance (generally external).

We will not go into much detail about the technical characteristics of DMX but it works under a similar principle to DALI but it is much simpler. Basically, values from 0 to 255 are sent to each channel with a maximum of 512 channels per DMX line (also called in the event industry “universe”). Channels can be a dimmer channel or a feature of a luminaire, for instance the red colour of an RGB LED, or the tilt movement of a moving light.

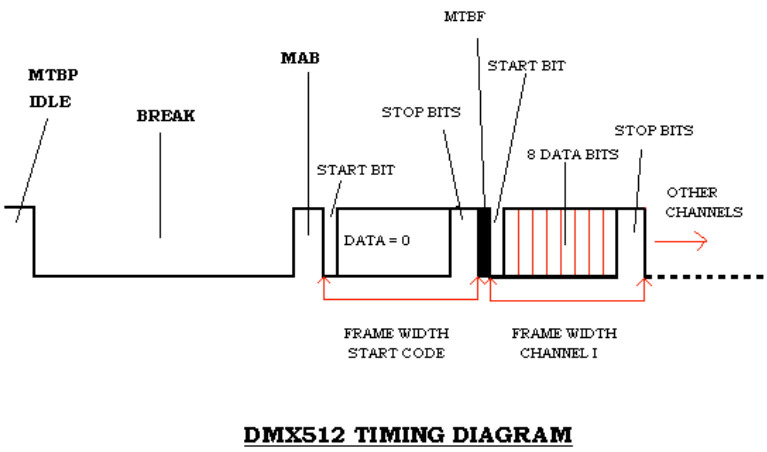


Figure 10. DMX packet (http://www.dmx512-online.com/packt.html)

Electrically uses the specification EIA-RS485 with a data rate of 250 kbauds/sec transmitted over a differential pair of shielded cable with voltage levels according to specification. It employs a multi-drop bus topology (also called daisy chain), which means that devices are connected in series from output to input. The standard allows for isolated transmitter ports and non-isolated ports.

There are two important differences in the physical layer compared to DALI. Firstly, a terminator resistance of 120 Ohms must be used at the end of the line to match impedance characteristics of the cable and avoid signal reflection.

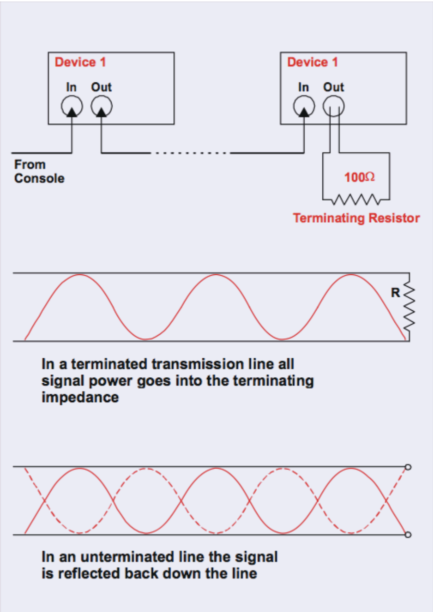


Figure 11. DALI line setting and the use of terminating resistors (Simpson Robert S. 2003. Lighting and control, Technology and Applications)

Secondly, polarity is essential and it is not possible to invert polarity of the connection, as it will result in uncontrolled behaviour of the devices. The specification states that 5-pin XLR connectors should be used with female connectors for outputs and male connectors on inputs. However, 2 of the pins (and consequently a pair within the cable) are not carrying any data and, although prohibited initially by the standard, 3-pin XLR connectors (pin-out shown in the picture below) and cables are widely used and adopted by the standard for short runs (less than 50 meters). In some applications it is also permitted the use of RJ-45 cable.

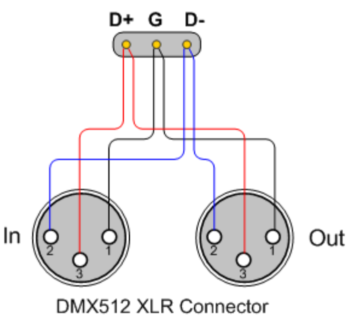


Figure 12. DALI pin-out for 3-pin XLR connector, for 5 pin numbering is the same and pins 4 and 5 are not used. (http://picprojects.org.uk/projects/dmx/dmx688/#Connecting_the_board)

The number of fixtures to be addressed in one bus-line is limited to 32 but it can be extended with the use of splitters to create parallel buses lines. The network bus length can be as long as 1200 metres according to the specification but this is frequency dependent; a more realistic and reliable approach recommends a maximum length of 250 meters.

One of the main advantages is that DMX is a worldwide-standardised protocol in the event industry (commonly shared with architectural lighting). Furthermore, new communication technologies allow DMX packets to be transmitted over other networks such as RDM, Ethernet or wireless (by means of specific interfaces). On the other hand, we can find some disadvantages if we compare it with DALI but the main drawback is the lack of feedback (DMX is not bi-directional but it was designed for 5-wire data communication for this reason).

Although the protocol is fairly simply, developments in lighting fixtures and consoles can make their control and programming very complex. Each fixture can have from, at least, one channel up to a few dozens of channels, each corresponding to the parameters of the fixture. Some common parameters are dimmer or intensity, pan, tilt (in moving fixtures); colour mixing channels such as red, green and blue (for LED fixtures) or cyan, magenta and yellow (for filtered colour mixing); focus, iris and so on. However, when a luminaire has various channels is enough to address it with the “starting address” and make sure the next “starting address” does not overlap with the range of the previous fixture (If there are 20 channels in one device and has a starting address of “1”, next available address will be at “21”). It is also possible to use same starting address for same type of fixtures and they will behave identical as if they were part of a group. Of course, by using computers and lighting consoles we can create groups, memories and cues (equivalent to DALI scenes), palettes, chases, sequences and many other actions that provide virtually endless combinations.

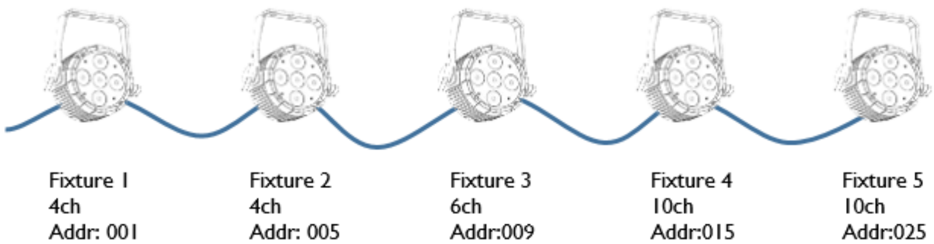


Figure 13. Example of a DMX line, with addressing for some fixtures with various channels (https://stagelightcompany.com/index.php?route=information/information&information_id=9)

2.5 Networking concepts

When programming and configuring a router based DALI system with the aim of certain software we might encounter some operations that, although they are basic in every programming environment, might not be so intuitive for some users without a formal electronic or programming background. Below we will discuss some concepts that will be useful when configuring our router and network.

2.5.1 IP networking

Helvar´s routers require an IP address in order to communicate with computers, other routers or to be part of a larger network. As we have said before, very large lighting systems can be controlled using a network of routers (divided or not in clusters) each needing a network address to be able to identify themselves and route commands from and to devices in their subnets.

2.5.1.1 IP address

An Internet protocol (IP) address is a unique number that identifies each device in a computer network that uses the Internet protocol to communicate. This number serves to identify and locate each member of a network. The Internet Assigned Number Authority (IANA) manages the IP address spaces globally delegating in regional Internet registries (RIRs) to allocate addresses to local Internet service providers (ISP) and other entities.

There are two versions of the IP protocol IPv4 and IPv6, being the first one still of most common use and the second one that will allow extension of the network when we run out of addresses. The main difference between them is the number of bits that are used to identify 32-bit in the case of IPv4 and 128-bit for IPv6 (for this project we only have to care about the IPv4).

Although the address consists on 32 bits we make it more human-readable by using four decimal numbers separated by periods (dots). Each of these numbers correspond to 8 bits thus these number will range from 0 to 255. As an example, the IP address 127.0.0.1 would be 11111110,00000000,00000000,00000001 in binary.

There are nearly $4\ x\ 10^9$ possible addresses in the IPv4 protocol. Out of them there are three special addresses, the first two are used for routing purposes while the third refers to your own computer:

0.0.0.0	- Default network address
255.255.255.255	- Broadcast address
127.0.0.1	- Loop-back address

2.5.1.2 IP Subnet mask

Another way of dividing the networks is the use of subnet mask. A set of four numbers (same fashion as IP address) that divides a network into two or more sub networks where the first bits refer to the networks and the last bits to members of each network. For instance, the subnet 255.0.0.0 means that the first 8 bits (all 1´s) are used for network and the remaining 24 bits (All 0´s) for hosts or devices in that sub network (which would correspond to a Class A network). Since all the members of the same subnet must have the same most-significant bits (first bits of any series of bits), this subnet “mask” helps the routing devices to direct more efficiently the messages to members of the subnet, we could say that acts like a tunnel that saves from the main street traffic.

2.5.1.3 Private networks

There are certain blocks of addresses that are reserved for private networks, that is, not intended to connect to the Internet. These networks are for internal use in home or company networks and the will be generally blocked by ISP. Here is a table of such address ranges:

Private Network ID	Subnet Mask	Network Address Range
10.0.0.0	255.0.0.0	10.0.0.0–10.255.255.255
172.16.0.0	255.240.0.0	172.16.0.0–172.31.255.255
192.168.0.0	255.255.0.0	192.168.0.0–192.168.255.255

Figure 14. Private network addressing (http://msdn.microsoft.com/en-us/library/dd163570.aspx)

2.5.2 Possible issues

Regarding addressing there are a couple of possible errors that we might encounter in an installation with various routers and computers as in a DALI router based system:

- Same IP address in two devices. This would cause a conflict, as the routers could not resolve who is the right recipient of the message.
- Use of DHCP (Dynamic Host Configuration Protocol). If computers or routers are configured to DHCP in an IP network those devices will ask the server for a new IP address every time they connect to the network (that´s is why is called dynamic). This is not valid for a fixed installation where routers and computers need to have fixed IP address.

2.6 Boolean logic

As we have introduced, we might need to make some actions dependant on certain conditions such as the state of a switch, a sensor, a value a timer and so on. This is usually accomplished by logic circuits using logic gates (microelectronics hardware) or with their equivalents in virtual environments where these conditional operations are called programmable logic. Boolean logic is a constituent of Boolean algebra created by George Boole (1815-1864) to solve logical problems through maths.

As the name implies some controlling devices are programmed to follow certain rules or to evaluate logical conditions to perform an action or next operation. For instance, if we apply this to a DALI device one situation could be as follow: *“If sensor x is not detecting a presence in a room (term 1) OR (Boolean operator) no switch has not been pressed (term 2) AND (Boolean operator) we are in a certain time (term 3) of a day switch the light off”.*

Obviously, It is not possible to speak like that to the machine so we have to use the logic to program the device. The software usually makes this task very easy and conditions are easy to interpret. It is however possible to combine this conditions (”terms”) using certain logic operations. To determine if a condition is true or false we must assess the state (true or false) of all its terms. Terms can be combined with certain Boolean operations to form conditions and the basic operators (those used by Helvar´s designer software) NOT, AND, OR, NAND and NOR. The result of these operations can be deducted by logic but they are also compiled in “truth tables” where we can quickly see what would be the result for each operator depending on the state of its terms.

Table 1. Truth tables for basic logic operations (Juan Pedro Gimenez 2014)

AND		
Term 1	**Term 2**	**Result**
TRUE	*TRUE*	*TRUE*
TRUE	*FALSE*	*FALSE*
FALSE	*TRUE*	*FALSE*
FALSE	*FALSE*	*FALSE*

NOT	
Term 1	**Result**
TRUE	FALSE

NAND		
Term 1	**Term 2**	**Result**
TRUE	*TRUE*	*FALSE*
TRUE	*FALSE*	*FALSE*
FALSE	*TRUE*	*FALSE*
FALSE	*FALSE*	*TRUE*

OR		
Term 1	**Term 2**	**Result**
TRUE	*TRUE*	*TRUE*
TRUE	*FALSE*	*TRUE*
FALSE	*TRUE*	*TRUE*
FALSE	*FALSE*	*FALSE*

NOR		
Term 1	**Term 2**	**Result**
TRUE	*TRUE*	*FALSE*
TRUE	*FALSE*	*TRUE*
FALSE	*TRUE*	*TRUE*
FALSE	*FALSE*	*TRUE*

As we can see above, the AND condition is met when all its terms are true while the OR condition needs only one of the terms to be true. The not operator basically inverts the term and if we apply this to AND and OR we get the NAND and NOR conditions.

3 METHODS AND MATERIALS

3.1 Design and development

The conceptual design for the demo board, presented to Jukka Riikkula (Helvar´s Sales and marketing manager), is shown below. Basically, the idea for the project was to show the possibilities of centralised control units in DALI systems and how it is possible to expand basic DALI capabilities with devices like Helvar´s imagine 920 router. These potentials included DALI, DMX and Ethernet communication managed by the router that would control some lighting devices through a control panel, a computer and a multi-sensor.

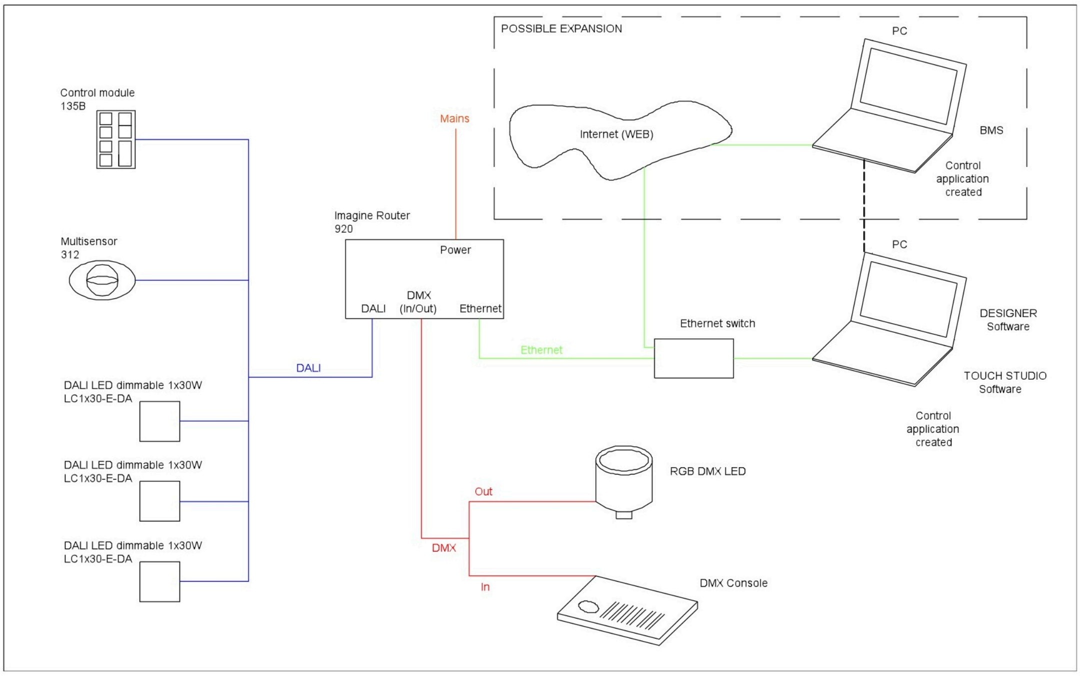


Figure 15. Initial conceptual scheme (Juan Pedro Gimenez 2014)

However, after the first meeting with Mr. Riikkula we decided to introduce more devices that would relate the project a bit more with building automation concepts and not only for dedicated lighting devices. Thus, remote Ethernet control or interfacing with other BMS devices was left out for future projects in benefit of including an input unit (942) and a relay unit (494) both from Helvar. There were some later additions but essentially, the final scheme in which the project was based prior to start its construction became reality.

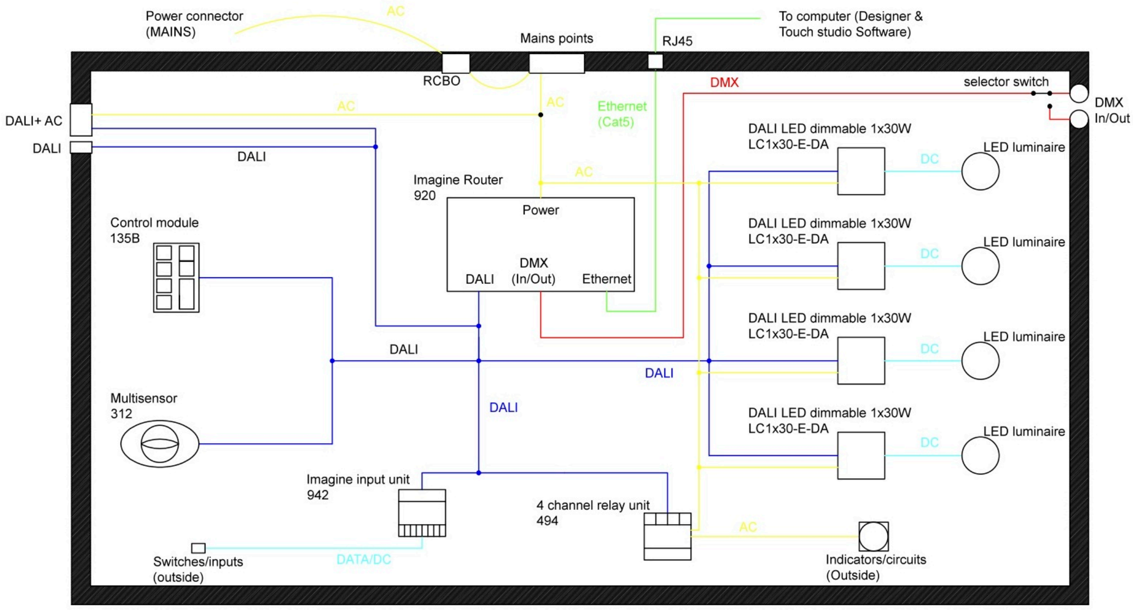


Figure 16. Scheme in which the project was based when construction and programming started (Juan Pedro Gimenez 2014).

As we were progressing in the construction of the demo board, we realised that probably the best idea was to make the project as compact as possible building the whole system around an electric box. Only, the LED drivers (introduced into the luminaires´ housing) and the controls were left outside the electric box. Also, the inputs and outlets for the non-dimmable loads (relay unit) were attached to the sides of the box so different type of loads could be plugged in. We will analyse in more detail the finalised construction in further sections but conceptually this is the base of the project. The layout decision was taken in collaboration with Jarmo Tapio, lecturer at Metropolia University of Applied Science and supervisor of this project.

3.2 Equipment and materials

3.2.1 Helvar´s equipment

As it has been said, we used mainly Helvar´s DALI equipment for the project. There are various reasons for choosing Helvar for the demo. First of all, it is a Finnish firm and it has been involved in the DALI group for development, being one of the leading manufacturers in the international market. Secondly, its product range allow not only to setup up a system which can perform all the original capabilities of DALI but also to add new features to make a more complex and complete system.

Equipment was purchased directly to Mr. Rikkula after having a coupe of meetings with him to explain what was our purpose. Helvar´s catalogue and website offers a detailed explanation of each product including installation instructions. Yet, this section will explain briefly main characteristics (extracted from Helvar´s catalogue) of each product and why it has been chosen for our project. Product specification sheets and connecting schemes for each piece of equipment are included in Appendix 1.

3.2.1.1 Imagine Router (920)

In this project, the router is the heart of the system and centralises its control. The Imagine 920 uses an Ethernet connection (TCP/IP) as a network backbone while it includes previous Helvar´s systems capabilities (S-DIM and DIGIDIM), 2 DALI subnets and a DMX port. The router also supports OPC (allowing connection to BMS) and DALI emergency devices. Additionally, this piece of equipment provides 250 mA power supply for each of its two subnets. All these features make this model a complete, comprehensive and future proof solution for building lighting control.

Figure 17. Helvar Imagine Router 920. (Helvar lighting controls catalogue 2013, 14)

In sum, this device offers a wide variety of extra control and processing functions for a DALI system allowing creating complex lighting control systems. If connected to the computer, it allows monitoring and logging the system as well as its control and programming with the aid of Helvar´s Designer software.

3.2.1.2 4 Channel Relay Unit (494)

This unit allows the control of non-dimmable loads. This means that it will basically switch on and off circuits but it will not be possible to regulate the voltage for each circuit output. This type of loads could be fans, locks, alarms, indicators or switching of a AC system to name a few. Obviously, other light sources, which do not allow DALI control, can also be connected to the relay converting these non-DALI units in controllable units (but without dimming). The Relay Unit has four relay channels normally open and volt-free, it is able to switch up to 10 Amps resistive loads (different capacity for other type of loads) summing all the channels together.

Figure 18. Helvar 4-channel Relay Unit 494. (Helvar lighting controls catalogue 2013, 25)

By including this device in the project we can experiment using a DALI system to implement other building automation actions and to interface with non-DALI loads that we will be likely to encounter in a real-world system.

3.2.1.3 1x30 W Dimmable DALI LED driver

LED drivers have become of crucial importance in lighting installations since they allow to connect the light source of present and future, the LEDs (working on DC voltage) to standard electrical installations (AC 230 V mains rated). Among the characteristics of this model we will highlight that it allows DALI control, having 1% to 100% dimming range, it works on constant current (Selectable between 300, 500 and 700 mA) and can supply up to 30 W.

Figure 19. Helvar LC1x30-E-DA LED driver. (Helvar lighting controls catalogue 2013, 83)

3.2.1.4 Imagine Input Unit (942)

This device can serve as interface to a wide range of controls and input devices such as sensors, switches or time clocks. It is compatible with Helvar´s router systems and it can be used with momentary and latching switches as well as with 0-10 analogue devices. It has eight voltage-free switched inputs and four analogue inputs (0 to 10 V range) of which only eight can be operated simultaneously.

Again, this unit has been chosen since it provides great flexibility and would allow connection of non-DALI controls and other standard components and measurements devices (through its analogue input capability) being then able to explore more advanced configurations of the system (as well as to include some building automation control techniques).

Figure 20. Helvar Input Unit 942. (Helvar lighting controls catalogue 2013, 64)

3.2.1.5 Multisensor (312)

Multisensor is a compact unit containing the necessary sensors to provide energy saving functions for lighting. The unit allows DALI communication and performs two basic functions in our system, measures lighting level (constant light sensor) and senses presence through passive infrared detector (PIR). The multisensory is also an infrared (IR) receiver for IR remote control. Usually the sensor is placed in the ceiling or luminaire housing being possible to adjust the angle of the reception area.

Figure 21. Helvar multisensor 312. (Helvar lighting controls catalogue 2013, 52)

The multisensor allows implementing various key functions in Helvar´s systems such as constant light, presence detection or corridor hold. Presence and light sensors have similarly become very important in energy saving schemes even when not connected to a higher level controlling system just by being directly connected to luminaires.

3.2.1.6 Control modules (135W)

From the range of DALI compatible customisable panel modules, the 135 configuration has been chosen since offers the most complete set of controls as it has four dedicated scene recall buttons, up and down buttons and off button (although these can be reconfigured via designer software to perform any desired action) all with indicator LEDs showing which is active. It also gives the option of remote operation through its IR receiver using DIGIDIM hand held remote controls. There is a wide range of module configurations available including custom made.

Figure 22. Helvar Control module 135. (Helvar lighting controls catalogue 2013, 45)

3.2.1.7 Graphical Interface application (Helvar TouchStudio software)

Touchstudio editor allows creating control applications in Ethernet enabled windows PC that can later be used in the same or different PCs or panels. Customised graphical and user-friendly interfaces can be easily created offering intuitive and visual control and monitoring of a Helvar lighting system. There are many possible applications to simplify not only the control but also the installation since it would be possible to reduce significantly the need for hardware panels and cabling.

3.2.2 Additional equipment

In order to complete the construction of the box and other elements needed for the project, we have used standard electronic and electrical material that does not need to be exhaustively explained, as it is familiar to technical people. However, we will mention what are these materials and why have them be used.

3.2.2.1 Switches and chassis connectors

For additional control of the system we have introduced a set of standard switches and controls in the same housing as Helvar´s control module. We have not used typical building automation switches as we wanted to demonstrate that any type of input can be used, this way it is easy to think how a potentiometer can be replaced by a temperature sensor (used to control HVAC) or a single on/off switch could be any magnetic, wireless or code controlled switch (used, for instance, in alarms). Another elements used are a push button, a rocker switch and a toggle switch. We will explain later in the report how these switches are used in our system.

Figure 23. From left to right: potentiometer, toggle switch, on/off switch, rocker switch and push button (Juan Pedro Gimenez 2014).

These standard components have also been used for the DMX section of the box where there are a male (DMX input) and female (DMX output) XLR connectors and a slider switch to select which of them will be connected to the router DMX port.

Table 2. DMX pin out from XLR to router (Juan Pedro Gimenez, 2014)

XLR pin	Line			Router DMX
1	Ground	Ground	Ground	***SC***
2	Data +	Positive	Hot	***B***
3	Data -	Negative	Cold	***A***

Table above shows the correct pin out in order to connect the DMX line to the router. This is often controversial as there are different naming conventions. For instance data + is also referred as hot or positive, this may not seem a big difference but in the case of the router the pins are named as A, B and Screen.

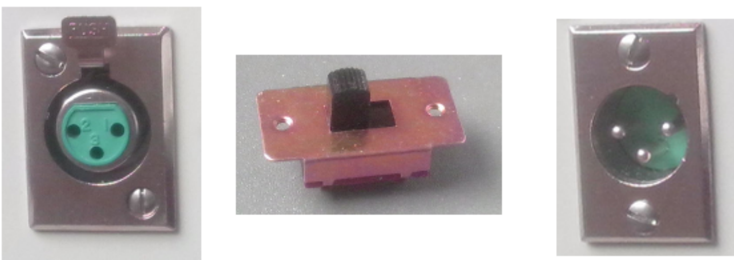


Figure 24. Components used for the DMX section. From left to right: female XLR connector, slider switch and male XLR connector (Juan Pedro Gimenez, 2014).

3.2.2.2 Electrical components

For protection, connections, indicators and sockets inside the box we have typical used certified equipment. The Schneider electric DIN rail mounted socket outlets have been used to plug two 230 VAC to 12 VDC transformers used to power the led stripe to illuminate the box and to provide a 0 to 10 V source for the potentiometer (although is really 12 V). There is also a DIN rail Hager RCBO (basically a residual current device including overcurrent protection) that provides adequate protection for the whole installation against human shock and overloading the circuit. Indications inside the box are accomplished by Hager SV12X series of indicators with different colours.

Figure 25. Shown the DIN rail devices. From left to right: RCBO, socket outlet and indicators (Juan Pedro Gimenez, 2014)

The output of the relay channels have been fitted with regular double surface mount socket outlets as well as a direct output (not from the relay) included so computers or other equipment to be connected to the system can be powered as long as the box has power (usually a controlling or programming computer or other testing device).

3.2.2.3 Cables and connectors

The connections in the box have been made according to the standards using certified material. The cables used in this project are:

- For power lines (we will call this to all lines connected to the 230 V supply) single core PVC 1,5 mm^2 has been used, assigning blue for “neutral”, brown for “live” and green/yellow for “earth”.

- For data lines such as DALI and DMX, the cable used is KLMA 2-core plus screen (2x0,8+0,8 mm^2) shielded cable.
- For connecting the input unit inputs with the different switches and the potentiometer 12-core (12x0,15 mm^2) braided shielded cable intended for data transmission and electronics, was chosen since the input device uses voltage-free switched inputs and there is a maximum of 12 V (with minimal current consumption) which are sent to and back from the potentiometer.
- Voltage transformers use their own cable.
- For the DALI circuit line, which carries the 230 V from mains with earth plus the DALI data the cable chosen has been MMJ 5x1,5 mm^2 ,provided by Metropolia University, as standard in this type of installations. This is also the cable used for connecting the luminaires (with Ensto 5-pole connectors)
- The power cord that supply that connects with mains is 3-core (3x1,5 mm^2) Aton A05RN-F.

A special consideration can be made here regarding typical cabling for this type of installations since, although DALI offers many possibilities for the cabling, there are standardised material used broadly in Finland. The KLMA 2x0,8+0,8 mm^2 is commonly used in building automation for data communication such as connection with sensors and input devices or for DALI transmission whereas the MMJ 5x1,5 mm^2 is typically used when the intention is to carry single phase mains together with a control protocol such as, again, DALI.

Also, we have chosen a special type of connectors from Ensto (shown in next image), which, although there is not a standard, is sometimes used for this purpose. It has been considered appropriate for full DALI circuits (those including single phase mains voltage) in fixed installations.

Figure 26. Ensto connectors used for DALI circuits with mains. From left to right: 5-pole Female, 5-pole male and 5-pole distribution block (http://products.ensto.com/catalog)

The following picture shows a connector from our project in which we can see the pin-out for the DALI circuit. This can be chosen freely but it has to be kept the same throughout the whole circuit. Poles 1 and 2 correspond to DALI data (these can be changed since there is no polarity in a DALI line. Earth and Neutral are attached to their corresponding lines while pole 3 carries the “Live” of the 230 V line.

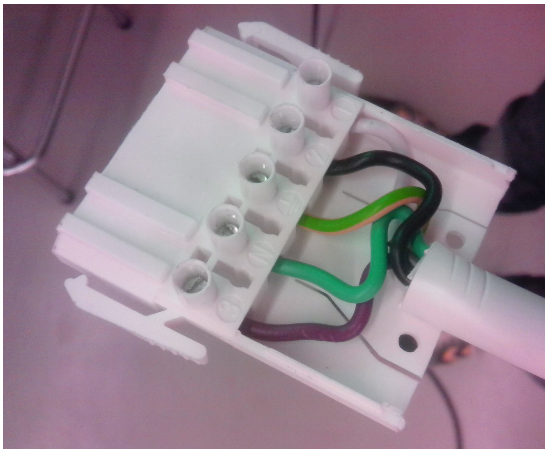


Figure 27. Pin out chosen for the 5 pole Ensto connectors (Juan Pedro Gimenez, 2014)

Inside the box, we have used terminal blocks to connect devices from different levels and duplicate circuits (using dedicated links). The blocks are numbered in order to identify easily these connections, this method helps to understand how the box is built and it is a very useful tool when troubleshooting. Plans and list detailing the connections are included in appendix 2.

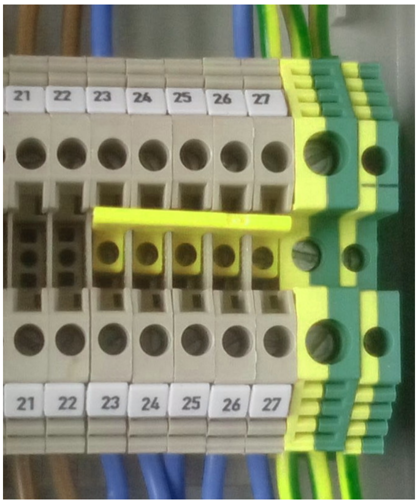


Figure 28. Set of terminal blocks as installed in the project (Juan Pedro Gimenez, 2014)

3.3 Demo board finalisation

Once the main components of the project and the connections have been described it is time to show the final result of the construction process. As we have introduced earlier, the demo board will consist in the "main box" (with all the peripheral accesses to the system on the sides of the box), an "interface box" including the multisensor attached to it and the luminaires placed around in a plywood plate. Additionally, there is some extra equipment (RGB DMX fixture, a small fan, one buzzer and a light bulb), which can be connected to the outlets from the Relay´s channels in order to have a more "realistic" perception of the system. These channels can anyway be monitored through indicators inside the box (except the DMX operation).

These are the signals and circuits available directly from outside the box via connectors around the box:

- Outlet sockets for each of the Relay channels
- Direct power outlet socket from the RCBO
- DALI line 1 (Router) plus mains (230 V)
- DALI line 2 (Router)
- DMX In and Out from the Router (selected by switch)
- "Interface box" with all the controls including the multisensor

3.3.1 "Main box"

We can see below the finalised main box as it was installed in the demo board and the annotated version showing what are the main sections. Two 230 VAC to 12 VDC transformers (One for a LED stripe and another to provide a DC source for the potentiometer connected to the 0 to 10 V analogue input of the Input Unit) and a LED stripe have been added to improve vision inside the box as the cover of the box is not as transparent as we expected.

We have omitted in the annotation naming indicators, sockets or terminal blocks (that have been described previously in the chapter) for simplicity, as the intention is to show where the main sections are. For the pictures we can also see where is it possible to access the different data and power lines of the system.

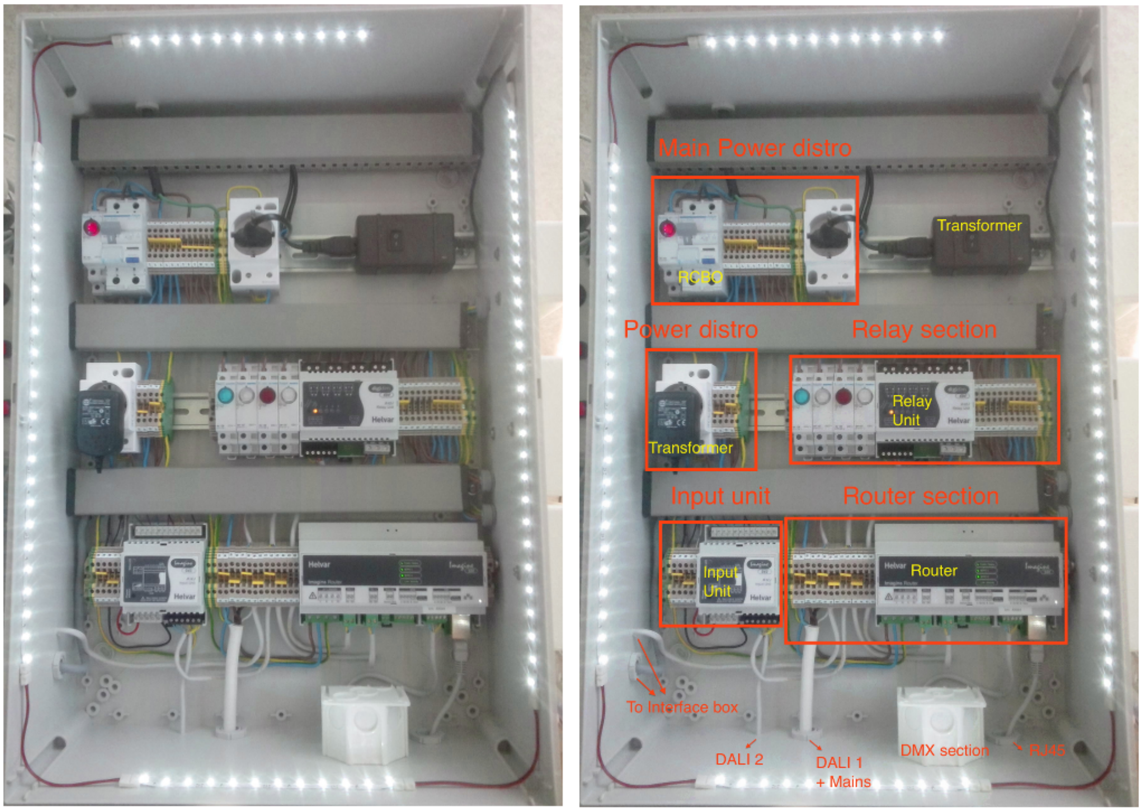


Figure 29. Main box of the project in the original and annotated version (Juan Pedro Gimenez, 2014)

Following two pictures of the right hand and bottom side of the box where we can access different signals from the board.

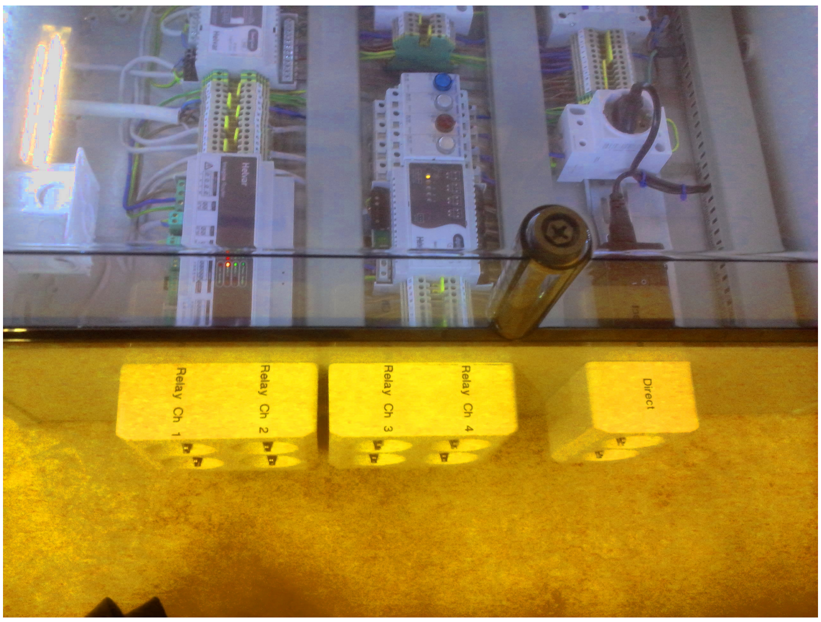


Figure 30. Detail of the relay channels outlet sockets (Juan Pedro Gimenez, 2014)

Figure 31. View of the bottom side of the box (Juan Pedro Gimenez, 2014)

3.3.2 The “control box”

We have also mentioned what we have called “interface box” or control box as it has all the necessary controls for our system. From the box we find as well the multisensor (312) attached internally to the DALI connectors of the control module (135W) belonging to DALI line 1. Next picture shows the front side of such box

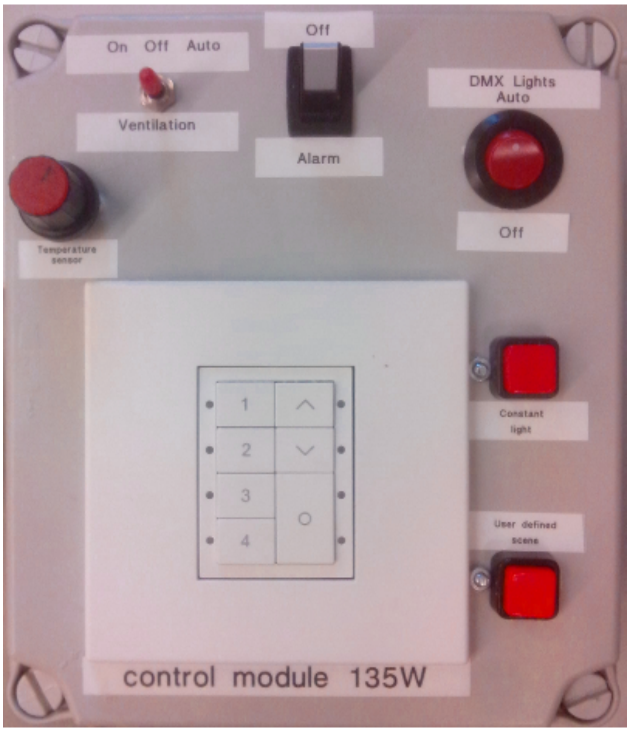


Figure 32. “Interface box” or “control box” labelled (Juan Pedro Gimenez

The following table indicates the patch from the switches to the Input Unit:

Table 3. Patch, control box switches to Input Unit (Juan Pedro Gimenez, 2014)

Input unit In	type	Control	Function
com	An/Dig	All	All
1	Analogue	Potentiometer	Heating
2	Digital	Toggle switch (On)	Ventilation
3	Digital	Toggle switch (Auto)	ventilation
4	Digital	Rocker switch	Outside light
5	Digital	NC	
6	Digital	On/Off switch	Alarm
7	Digital	Push button top	lighting
8	Digital	Push button down	lighting

More details about how the control box operates the system can be found in the "Instructions for the demo" document included in Appendix 4.

3.3.3 Luminaires

The luminaires have been built with experimental purposes for the project and they are not aimed for commercial purposes. We needed a low consumption unit and we wanted the LED driver to be located inside the luminaire housing. Thus, we chose these T5 luminaires, emptied them and fitted with the LED driver and LED stripes to match the 350 mA load (one of the available options) in the LED driver.

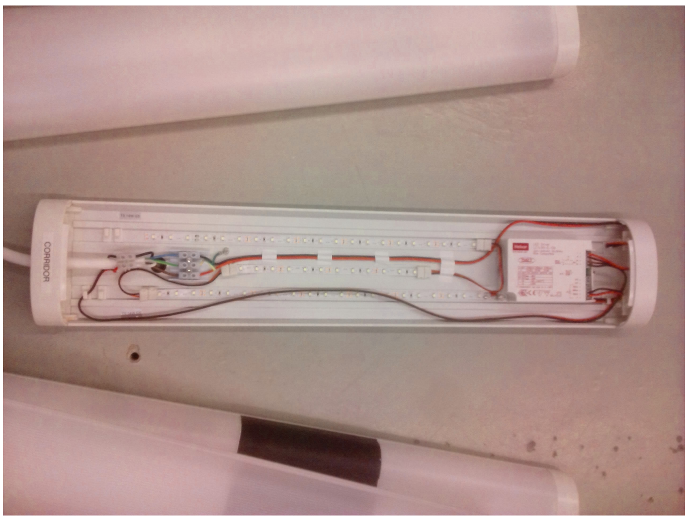


Figure 33. Luminaires customised for our project (Juan Pedro Gimenez, 2014)

3.3.4 The demo board

The electric box, the control box and the luminaires were attached to a board screwed to a stand. This configuration is very appropriate for teaching and experimenting. Jarmo Tapio helped in the planning and construction of the board.

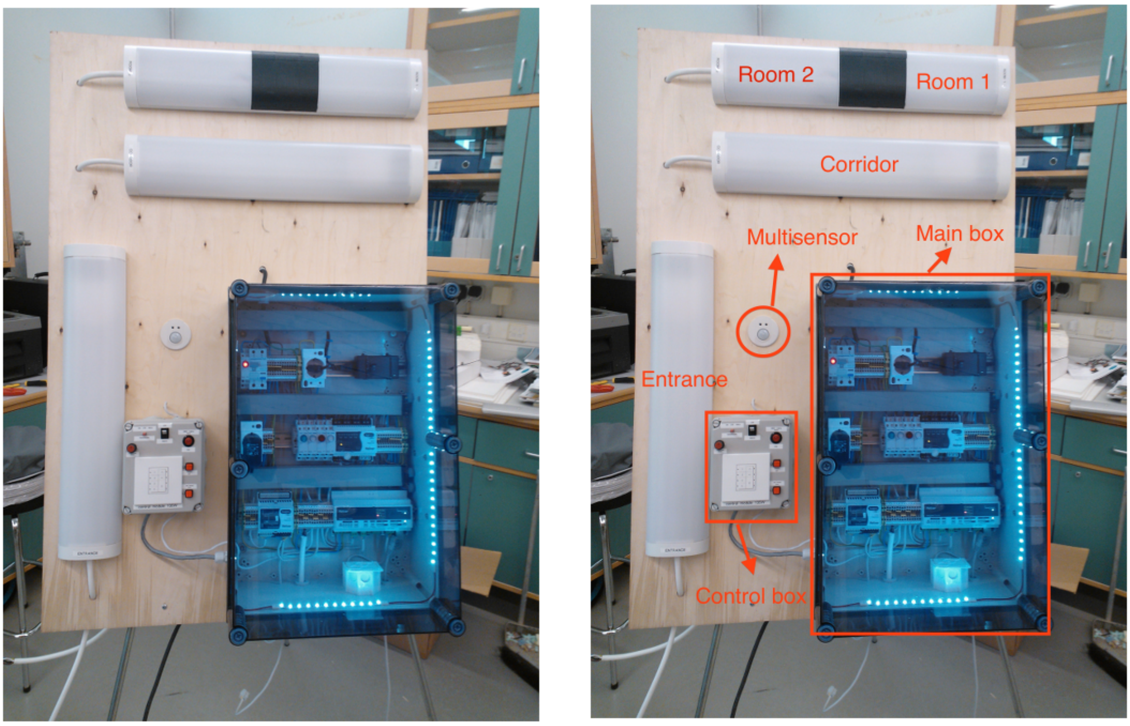


Figure 34. Finalised demo board real vs annotated version (Juan Pedro Gimenez, 2014)

As we can see, it can be used to explain the system in a presentation as well as to have the system in front for monitoring while programming. Also, the board is flexible enough because it is possible to interface with the system easily. On one hand, we have one each cables for accessing the Ethernet port of the router and the DALI 2 circuit directly (shown in figure 31). The outlets for non-dimmable loads are also accessible from the outlet sockets (Shown in figure 30) so the loads can be interchanged for different experiment purposes.

Following this idea, the multisensor can also be moved around the board (1 metre margin) to perform tests. The box have been also equipped with an extra socket outlet which has direct power intended for connecting testing or programming equipment.

Figure 35. Working environment with board connected to a computer (Juan Pedro Gimenez, 2014).

4 Design considerations and operation of the system

4.1 Description and functionality of the system (simulating a small office installation)

As we have announced in earlier sections, this project does not comprise a real lighting design since the demo has a limited amount of devices. For instance, there are only four luminaires that have been allocated to mimic some spaces for identification purposes and to give a functionality that can be related to the behaviour of a real building. Another limitation is that there is only one Helvar control panel for the whole system, which has to serve for all the "rooms" while the normal situation would be one per room. Taking all this into account, the scenes, routing and scheduling aim to demonstrate some possible features of the system made with "real world" installations and situations in mind. Having said that, some of the scenes and functions might seem not very practical but they help to understand the behaviour and capabilities of this type of systems. In appendix 4 we can find a detailed instruction about the operation of the system but we will state now the key points.

4.1.1 "Indoor" lighting

There are four LED drivers (Helvar LC1x30-E-DA) in the project board. All of them have been fitted with a white LED stripe of 85 cm consuming approximately 4.1 Watts and drawing 342 mA of current (close enough to one of the outputs of the driver having nominal output 350 mA). They have been built into modified luminaire cases, which originally correspond to fluorescent lights since we have considered adequate to fit the drivers in and with enough space inside to manipulate without loosing the look of a real luminaire (shown in picture 32).

Nevertheless, we have assigned each of these drivers a name corresponding to a virtual space in a virtual building. In this case the spaces considered are "Room 1" and "Room 2" (packed within the same physical envelope), "Corridor" and "Entrance" so each physical luminaire represents a space. Obviously, in a real life situation each of these spaces is likely to have several luminaires (or addressed lighting devices if we speak about a DALI system).

As dedicated control devices for lighting we have a control module (Helvar 135W) and a multisensor (Helvar Multisensor 312). These devices only require to be connected to a simple DALI circuit since they obtain their power supply from the bus. Each of the buttons of the control panel has been assigned to a scene except the two buttons with the arrows that rise and lower the lighting level for the group that have been assigned to (more on groups in section 4.3). The multisensor is capable of two functions, one as presence detector where it will recalls a scene when a space is occupied. The other is as light sensor where it will sense the lux level of a space in order to maintain a constant lighting level in a room (or to switch off lights when a certain value is reached). Also, the two push buttons have functionality related with the LED lighting; one serves as scene recall (and store on long press) and the other calls a constant light scene.

We have created a simple a Graphical Interface Application (GIA) as additional way of controlling and monitoring the operation of the system from a screen (in favour of showing another additional capability of our system). The interface consists basically in few virtual controls organised in different screens where it is possible to navigate between them allowing to change and monitor lighting levels as well as recalling scenes in the same fashion as we do with physical buttons. It is worth noting that there is one screen having the same controls as the physical control panel. These two are synchronised meaning that changing a scene in the application will result in changing the indicator corresponding to that scene in the physical control and vice versa. How it can be used to control the system is explained in section 4.4.1.2 and in Appendix 3 and 4, there we can find more details about its configuration and functions.

4.1.2 Architectural lighting

We often find that buildings have a lighting installation to enhance the actual architectural aspects of the building or for advertisement of the image of a company. It is also quite common that this lighting equipment is controlled via DMX since it is usually closer to the event and entertainment range of fixtures. For this reason, we have included an RGB LED device connected to the router making use of its DMX port for data communication while power comes from one of the channels of the relay unit (DMX does not allow switching off the device). The rocker switch connected to the Input Unit combined with the scheduler controls the switching of the circuit.

4.1.3 Building automation and non-DALI devices

One of the purposes of this project was to demonstrate that a system based in DALI could also be used for some basic building automation applications. In order to demonstrate this, we have included a switch input unit (Helvar Input Unit 942) and four relay channels (Helvar Relay Unit 494).

The Input Unit has eight inputs (already explained in the equipment section) so we have used various components connected to it such as switches, buttons and a potentiometer. The rocker switch and push buttons and their function have been defined for “indoor” lighting and architectural lighting. The potentiometer is connected to the first input (configured as analogue), which simulates the output of a temperature sensor as it is commonly used to control HVAC devices (in this case has been associated to heating). The toggle switch controls the operation of the ventilation, it has three positions: “on”, “off” and “auto”; using two inputs of the 942. Finally, the on/off switch is used to activate and deactivate the alarm and it simulates any activating switch commonly used for alarms such as magnetic keys or coded switches.

The relay unit has four channels thus is able to control four non-dimmable loads. For our project, this circuit will control a lamp (simulating a heating system), an alarm buzzer, a fan (representing a ventilation system), the power for external illumination devices and the heating system. As indicated in section 3.3 (to help compactness of the project box) the outlets for each relay channel have been attached to the side of the box instead of being hard-wired to the loads, using this configuration there is flexibility to connect any load to be controlled by the Relay Unit in the future.

4.2 Software used

4.2.1 Helvar Designer

Helvar Designer Software Suite (DSS) is the essential piece of software for this project (and most of the projects) as it can be used to design, commission, program, test and monitor our system.

With DSS we can create off-line designs that can then be uploaded into real systems but it is also possible to program online or commission the system (identification, testing, naming and grouping) once the physical devices are installed. After this stage, the intelligence and functionality of the system is programmed to satisfy the demands of the designer or end user. Monitoring and logging and reporting are also features from DSS. We can check that our system has been correctly programmed, log the system into windows compatible files (such as Excel) or perform diagnostic reports to help in maintenance and troubleshooting.

As we can see, this is a powerful piece of software that allows working in a lighting system throughout all its stages. Additionally, DSS offers more functionality such as emergency tests or integration into BMS or Ethernet networks via OPC (open connectivity) and Helvranet (I/O module for direct router system access with Ethernet commands such as TDP or UDP). There is another feature that we would like to mention here, that is, the possibility of a chat window for all designers that would be connected to the same workgroup in a network. This makes easy to teamwork even from remote locations while in the same project.

Appendix 3 consists in a quick but detailed tutorial for the basic programming of simple systems such as our project. Although it is difficult to cover the many options included by the software, reading that tutorial complementing this report and with the aid of Helvar´s Designer help file (can be found at Helvar´s website) it should be possible to create, at least, basic DALI systems.

4.2.2 Helvar TouchStudio

Another common way for designers and users to control lighting installation is by means of graphical applications in a client computer, tablet or interface control panel. Helvar has dedicated software to design these interfaces called TouchStudio Editor (TE). TE allows creating control applications for Ethernet enabled windows PC.

Once the graphical application has been created, it can be uploaded to third party windows based PC peripherals. In order to execute the graphical interface, we find another Helvar application called TouchStudio Runtime (TR) that ensures the execution of the graphical folder (created via TE) on the physical device (PC or panel).

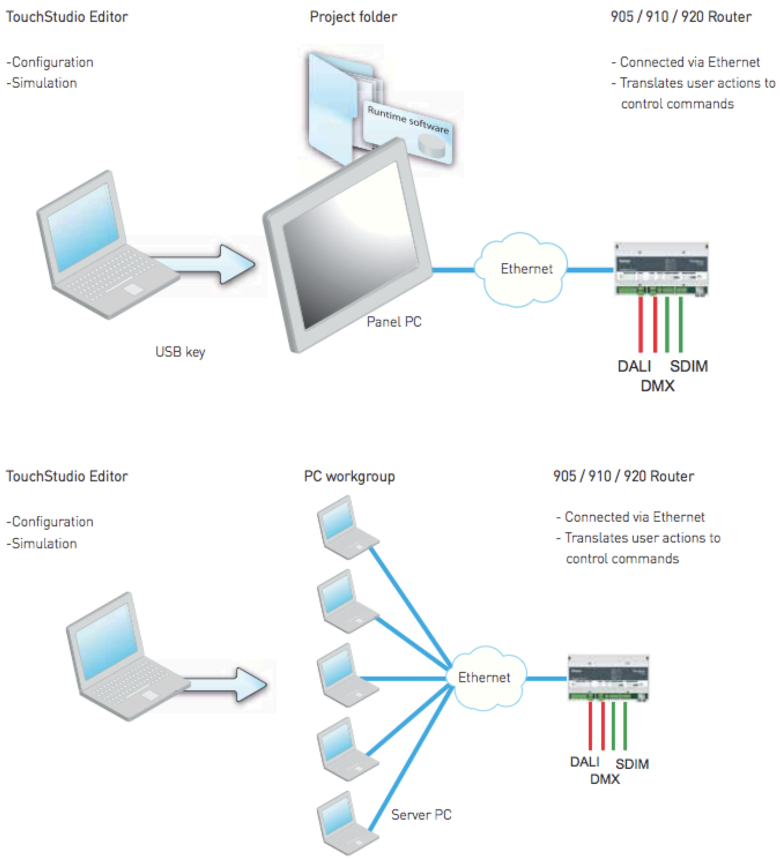


Figure 36. workflow and configuration of TouchStudio software (Helvar lighting controls catalogue 2013, 77)

Customised graphical and user-friendly interfaces can be easily created offering intuitive and visual control and monitoring of a Helvar lighting system. There are many possible applications not only to simplify the control but also the installation since it would be possible to reduce significantly the need for hardware panels and cabling. The PC with the graphical interface executed by TR has to be connected to the routers via Ethernet (either directly or throughout a switch).

4.3 Programming

4.3.1 Designing the lighting system

With Designer software Suite (DSS) we can either work on existing lighting system or design a new lighting system. If we work on an existing design DSS can create a model of the current system just by connecting the computer to the system (to the router more specifically). The system can then be modified, tested or have its configuration stored.

For new designs, Helvar Designer help file offers a checklist of tasks to be performed. This can be very useful for starting designers. The process consists in some stages that will now be listed (as they appear in Designer help file) but it is recommended to go through them in detail from the document aforementioned.

1. Collect information about the lighting system (number and location of channels and devices, group information and functionality)
2. Allocate channels and devices to routers (DALI, SDIM and DMX subnets)
3. Create design in Designer
4. Configure subnets
5. Edit scenes
6. Test devices
7. Create routing entries
8. Create Scheduler entries
9. Upload design to “Real Workgroup”
10. Test the real lighting system

4.3.2 Essential Helvar systems concepts

There are various important concepts when working in Helvar systems that will help us to understand the programming concepts. Although, there are many others that we could mention here, the following can be identified as crucial for this project. Their definition is directly extracted from Designer help file.

- “Control gear” are controllable devices that receive messages from controllable devices (via router) and perform the relevant action.
- “Control devices” are devices which, upon input, send a control message to the router. The router then processes the information and forwards the message to the relevant control gear. As the simpler example, a user presses one button and a Scene is recalled.
- “Workgroup” is a collection of routers that work together. In Designer help file we have two concepts related to workgroups:
    - “Workgroup design” is a simulation of a lighting system that might correspond or not to devices in a real system

- "Real workgroup" is a group of devices in a real lighting system and its representation in Designer.

More detailed information about workgroups can be found in Appendix 3 and Helvar´s help fiile.

- "Subnet" is a part of a router. In the case of the Imagine 920 router can be SDIM, DMX or DALI. For instance, there are two DALI networks in this router and each of them (collection of devices connected to one cable) uses the DALI protocol to communicate between devices where the router sets automatically the addresses.

4.3.3 Network

4.3.3.1 Topology

In the theoretical section we explained about possible topologies of DALI. In this project, we have followed a (mixed) tree topology for DALI. Next figure show this configuration as well as the DMX and Ethernet lines.

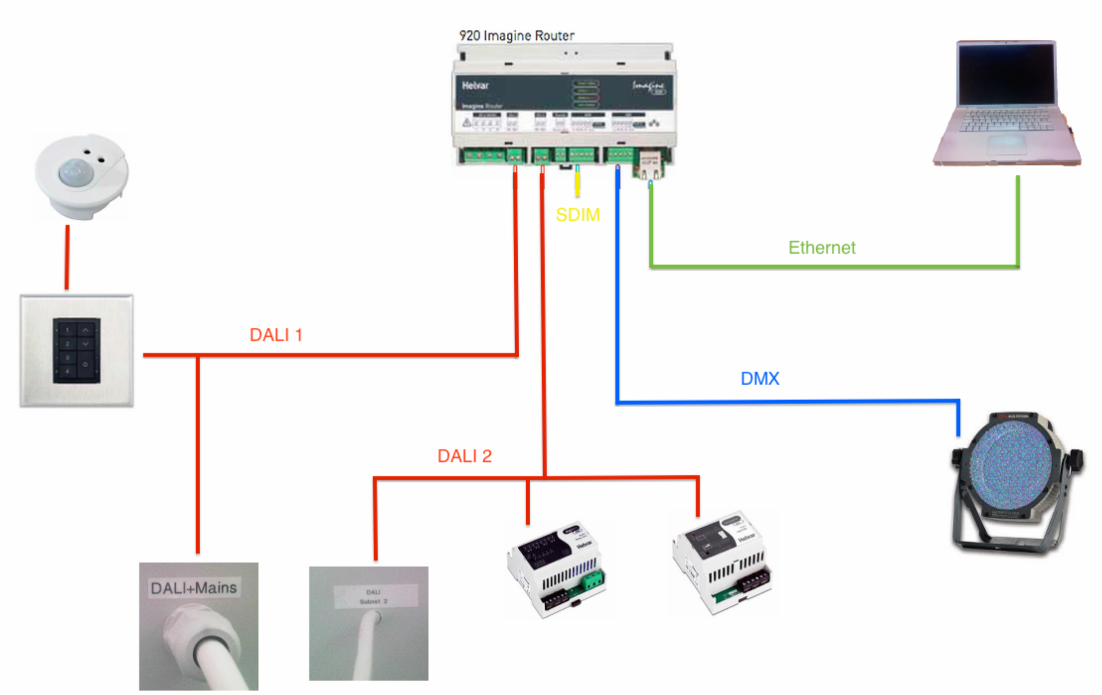


Figure 37. Layout of the mixed network topology followed in our project (collage from different images mentioned in this project and own material, Juan Pedro Gimenez, 2014)

4.3.3.2 Clusters and IP address

In computer technology terms a cluster is a group of computer modules that behave as one single computer. In a Helvar system, a cluster is a collection of routers that work together with two possible options single cluster or multi cluster topology. The former is used when there are up to 30 router while the latter is recommended when there are 31 or more routers (being compulsory over 100 routers).

Following the explanation on section 2.5 of this report we have to use addresses for client computers and routers that comply with those rules. The IP address of a client has the following structure:

Octet	1 (MSB)	2	3	4 (LSB)
Usage	Prefix		Cluster ID	Member ID

Figure 38. Structure of IP address for PCs or routers in Helvar systems (Helvar Designer Software Suite help file 4.2.17, 42)

The prefix for all the routers and clients in the same workgroup (Helvar Designer software´s term for a system or installation) has to be the same and correspond to the first two octets of the IP address, that is the most significant 16 bits corresponding to the first two decimal numbers in an IP address (**nnn.nnn**.nnn.nnn).

IP Address = **nnn.nnn.x.y** where **n =** prefix number
x = Cluster ID (**1..253)**
y = Cluster Member ID (**1..254)**

Figure 39. Example of address in Helvar system ((Helvar Designer Software Suite help file 4.2.17, 43)

4.3.3.3 Configuration of clients

To make the computer connect with the router is it important to configure the right settings in both systems. We have listed in the theoretical section some ranges of private IP address and it will be one IP within those ranges that we will use for our system. These are the recommended steps:

1. Set computer to a fixed IP address (not to DHCP)
    - IP address: 10.254.254.99
    - Subnet mask: 255.0.0.0
2. Set router to a adequate IP address
    - IP address: 10.254.1.1
    - Subnet mask: 255.0.0.0

If we analyse these settings we can see how both clients are part of the same network (**10**.254) where the identification inside the network correspond to a second number (10.**254)** that has also to be identical. We know what part correspond to the network ID from the subnet mask (only the first number) but for practical use in this type of systems we can consider the whole prefix (the first two numbers) to be part of the same network or, to be more precise to be part of the same “workgroup”. When using a multi-clustered system the computer must be in cluster 254 (which is the default cluster for multi-cluster) while cluster member can be any number from 1 to 254 as long as it has not been used before in the same network.

4.3.4 Addressing

Different from network address is the DALI address of the devices in a DALI subnet. Each ballast, LED driver, control panel, Input unit and any other device will have an address in the network that will identify it for DALI communication. We have explained already the limitations of this DALI addressing system so for each subnet we will have 64 possible addresses. If a device has more than one channel as the 494 Relay unit or other Relay and Dimmer units for example, each of these channels will take an address so there is not room for 64 devices but for 64 DALI channels (considered as each individually controlled output). However, we have seen how routers might have more than one subnet. For addressing purposes all subnets, no matter if the are S-Dim, DMX or DALI, have to be identified so the will have another number in front of the device address of the network.

Combining these two numbers we have half of the DALI address of a device. As an example of the aforementioned addressing scheme, we can say that address 2.46 will correspond to device with address “46” in the subnet “2”. Yet, we have to include two more numbers in front of these two, those corresponding to the router identification. In this case, it is easy because they correspond to the cluster and member IDs. Following the same example, a typical address used by the router in its network could be 1.1.2.46 which would be used to send data to the device “46” in the subnet “2” of the member “1” of the cluster “1”. Moreover, if there is a device with subdevices these will be added in the same fashion at the end of the address, the longest address possible would be: *[Cluster ID.Cluster member.Subnet.Device.Subdevice].*

When programming with the Designer software, we can name all the components of a network devices so, instead of identify them by their address, we can give them a practical name that will be carried through the design. Naming also applies to any other action or parameter within the software, from scenes or groups to conditions. Of course, it is possible to rename and change address of any item at any time in the design or implementation process.

4.3.5 Channels and groups

We could simply say that a channel is a load or, using Helvar´s terms, a control gear. Nevertheless, there are some loads that have more than one channel. For instance, our Relay Unit has four channels each having a different address (thus can be controlled separately) but the relay itself is a load. Thus, a more convenient way of defining channel is a device or subdevice that can be addressed and controlled independently.

In order to send information (lighting levels basically) to several addresses at the same time we have groups. As we explained earlier, DALI allows up to 16 groups where the group information can also be stored in the ballast, driver or any other DALI device. However, extended DALI capabilities of Helvar router and designer software allow 16.383 groups (valid group numbers are 1 to 16383). Thus, we have to assign each element of a subnet at least one group (but it can be part of several groups). To assign the groups of each device we have to add those in the properties section of each device in Helvar Designer software. Some control devices need to be in the same group as the control gear in order to perform their function although there are ways to get around this issue by using “links” (special feature of the router intelligence).

4.3.6 Scenes and blocks

A scene (also known as “situations” in Finnish environments) is a collection of lighting levels assigned to the same group as the scene. Scenes can be assigned to a control (such a button of a control panel or in response to a sensor) in such way that every time that button is pressed the lighting levels assigned to a group of channels (scene) are recalled. This method is typical in basic DALI but, alternatively, the router allow for scenes to be recalled in other ways such as links, schedules, reacting where certain conditions are met or a combination of them.

In Helvar router systems there are “scene blocks”. Blocks are sets of 16 scenes, which permit, for example, that LED indicators from different control panels within the same space are synchronised all showing the current scene selection. There can be 8 scene blocks per group so the identification of a certain scene is made using both the block and the scene number separated by a dot. Thus, a scene for a certain group could be 1.12 meaning scene “12” in block “1” (for that group). In a workgroup there can be:

- A total of 128 scenes (16 scenes x 8 groups)
- A total of 16,384 groups
- A total of 2,097,152 scenes (16,384 groups x 128 scenes)
-

This is true from a point of view of the router and Designer software because there are only 128 scenes available but they can be recalled for each group, hence we could say that there are over two million combinations for scene recalling but the values in scene, let´s say, 1.5 (block 1, scene 5) are the same for any group (although they can be re-called from different groups).

Another point worth to mention is the fact that in a group, the scene might not modify some channels appertaining to that group if they are marked with an asterisk (“*”) in the scene table or brought to the last level before power off when they are marked with an “L”. We have just mentioned scene tables so this concept needs an explanation. A scene table is basically a table in designer software where it is possible to modify light-ing levels for each scene (more detailed explanation in the “instructions for the demo board” document found in Appendix 4).

An extra DALI characteristic is the use of “fade times” which basically the time to make a transition between one scene (or lighting level) to another. This is also modified in the properties windows of Designer software.

4.3.7 Controls and sensors

Earlier, we have defined control devices as those devices that perform an action upon input. These actions are mainly scene recalls but they can be complemented with routing entries, schedules, conditions or group assignment obtaining elevated levels of flexibility and complexity. In our project we have used lighting sensors, Input Unit, control panels and a graphical application interface, representing an important part of control devices available at Helvar systems.

We have also mentioned earlier that the simplest control would be a button pushed in a control module that directly recalls a scene but we could add rules to this action. For instance, we could configure the press of that button to affect only some particular lights or to work only during weekdays or even to assign different functions to a short and a long press. Additionally, we could link a scene recalled by this button to other scenes or condition the use of a sensor to the action of this button. As we can see, possible combinations are endless. Summing up, these devices are the way for the lighting system to interface with outside world either via router or directly to the control gear.

There are still some controls techniques available from Helvar that we have not used and that could be also an interesting addition in future developments of the project such as EnOcean devices (wireless system with switches getting kinetic energy from the push of a button) or Infrared remote controls (where multisensor can also act as receiver)

4.3.8 Scheduler

In Helvar designer is possible to schedule some actions that the router will perform according to its time data. The actions to be performed vary from scene recalls to emergency tests or daylight saving schemes activation. Apart from the fact that this schedule can be combined with conditions, there are different ways to state when the action will be executed.

We can specify the time at which the action will take place either by setting a clock time or making it dependant on dawn or dusk time. If we want to use the latter options and make our schedule dynamic the router will have to be set with the correct latitude and longitude of the location in which the router is installed. On top of this, schedule can be complemented with conditions (that can also be combination of other conditions) or range of times such as weekdays, weekends, calendar months and so on.

4.3.9 Routing entries

Routing entries is another essential concept when dealing with workgroups in Designer. As the name implies, these are routing functions triggered by a scene recall and accomplished according to certain rules, parameters or conditions. There are various types of routing entries, each having different parameters or properties. As usual in Designer, is possible to combine routing entries with conditions creating complex and synchronised function of the system. Types of routing entries are:

- Scene condition, the scene is recalled only if a condition is met.
- Redirect, this command redirects scene recall commands to other scenes, blocks or groups indicating if the new command has to be executed after or instead of the original.
- Link, similar to redirect but only links a scene command to another scene, scene block or group
- Presence detection uses information from a PIR detector to respond with a certain routing function to it.
- Corridor hold, similar to redirect, sending commands to an extra desired corridor (or ay other space for that matter) as well as to the original group. The corridor PIR will perform as if it had detected presence in the corridor.
- Constant light uses readings from a light sensor to maintain the light level in a space. Again, levels and other parameters can be adjusted, in the properties section of the routing entry.

4.3.10 Conditions and terms

Conditions allow control actions to be executed only if a condition is met thus making it conditional to one or various factors. Routing entries, scheduler or controls can be made dependant on conditions and these conditions can be formed by up to 32 terms. To evaluate the conditions, we have to use Boolean logic (explained in section 2.6) assessing if the terms are true or false and applying the algebra of the operators. A term is a statement that may be true or false. It can be can a time range, a given time, a certain date, an analogue or switch input or a reference to another condition.

4.4 Control and operation of the system

Once more, it is worth to point out that the functionalities of the system have been inspired by “real world” applications but it may not correspond fully to these situations since this is only a demo project and resources are limited. Indeed, We to demonstrate capabilities of systems that might operate in whole buildings with several devices, spaces and uses. Thus, users of the system may encounter that the operation of the system is not logical to their point of view but, normally, the functionality varies depending on the final application and more importantly on the client´s (the person who pays to get the installation done) demands so it remains a subjective issue. Furthermore, the aim of this project is to show as many features as possible from the system and some of them have been included because they were considered interesting to show.

The project is completed with a user guide to know which controls are used for each function and this guide is included in Appendix 4 where we can also find further information about channels, groups and scenes. Again, we will point out now the key characteristics of the current configuration of the system.

4.4.1 Control of LED lighting on different spaces

The “Indoor building lighting” (corresponding to the LED drivers in our design) can be controlled in various ways from dedicated Helvar DALI devices to standard controls connected to the Input Unit.

4.4.1.1 From the 135W Helvar´s button panel

- The numbered buttons 1 to 4 each recall the first 4 scenes of block 1 for group 5 (formed by Room 1, Room 2 and Corridor).
- The up and down arrowed buttons raise up and lower down respectively channels included in group 5.
- The “0” button recalls scene 1.15 in group 5 on single press while recalls 1.16 in group 5 on timed press.

4.4.1.2 From the application interface

- The same controls with the same functions as the physical button panel are replicated in the main screen of the interface.
- There is one screen for each simulated space (Room 1, Room 2, Corridor and Entrance) accessible from main screen where it is possible to modify the level of the device corresponding to each space from 1% to 100%, monitor its level as switch the light completely.
- Another screen is used to monitor the state of the building automation services.

  Dedicated buttons on each screen (identified by logos) provide a way for users to navigate between the different screens.

4.4.1.3 From common push buttons

There are 2 inexpensive push buttons located next to the Helvar modular panel which are also dedicated to lighting control:

- The first one is used to activate “constant light”. With this feature the luminaires intensity will be automatically reduced or augmented to maintain a certain lighting level in a room. This constant light scene will still be active until a new scene is recalled (measurement of current lux level is performed by the multisensor).
- The second button will recall a user-defined scene. This button performs two actions. The first one, on a single press, will recall lighting scene number 6 which we have configured to be user defined. The second, on a long press (at least 10 seconds) will store the current value of all the luminaires including

modifications we might have introduced as scene number 6, becoming the new scene to be called on single press. It has to be noted that this button has been configured to store the current values from all four spaces (luminaires).

4.4.2 Control of building services

The switching of building services is made through the relay unit, which has 4 outputs. We have connected these outputs to loads (socket outlets) that represent the corresponding services of a building.

- There is an alarm, connected to output 1, in this case, the alarm is a industrial buzzer with lighting similar to those which could be used in a real building. The alarm is activated or deactivated by the on/off switch.
- There is also a fan, a small-scale unit that represents a ventilator or air conditioning device. In our system this is tied to output 4. This will be controlled from a double rocker switch (auto, on and off positions) in combination with the router´s scheduler.
- A simple bulb represents the heating device (output 3). When the light is on it means that the heating would be on and when is off the opposite. The heating would act as controlled if by a thermostat, in a real life situation a temperature sensor would be used but we have substituted this by a potentiometer for easiness of demonstration. By turning up and down the knob we will simulate temperature going up and down from the sensor. In the designer software a threshold value has been programmed for switching on and off of the “heating” system.
- The RGB fixture is plugged to the outlet socket 2 of the relay unit., which will power up the luminaire up the rocker switch is on and the time of the day is between the sunset and sunrise. Whenever the RGB lighting is “on”, a chase will be activated that will loop the red, green and blue colours.

4.4.3 Late additions to the project

By the time of finishing the report we have designed two more implementations for our project. We will not be able to include these or their results in this report since the final test of those will be included performed later for in the video presentation that will be part of the learning material produced. They both have been simulated successfully and there should not be any problem in the real system.

One of the additions is a DMX control screen included in the Graphical Interface Application (GIA) where it will be possible to control each colour of the RGB fixture and its intensity via slider. Then the current scene for the RGB fixture (all four channels) can be stored in scene 8.5 (dedicated button) and recalled from the same screen (dedicated button). Another button have been included to continue with the existing chase. As usual to these screens in the GIA, by pressing Helvar´s logo button we will return to the main screen.

The other addition is also related to the GIA. It will consist in more than one computer where we will load the project folder and the Runtime application from TouchStudio. Then, it should be possible to use of various computers to control the system. PCs and router will be connected through a router. In order to do this, it should be enough to apply network configuration explained in section 4.3.3.3 to each additional computer.

4.4.4 Further capabilities

Helvar router systems are very powerful and, via Designer, we can implement many tasks that have been left out of the scope of this project due to time, resources and size constrains. In fact, they can be included in further development of the system in future projects or activities.

Some of these tasks have been already mentioned when describing Designer Suite capabilities but we could, for instance, run (manual or scheduled) emergency test or device fault reports. Another interesting task would be that of programming scheduled system log reports to be exported to an excel or CSV file. Also, it is possible to control and monitor the system remotely via OPC and Helvarnet. This would be definitely another interesting assignment to explore networking capabilities of router-based systems.

4.5 Manuals and indications

There are some complementary documents created to support this project such as user manuals, product data sheets, and connection schemes and programming instructions, which are not the core of the thesis. Accordingly, all these are included in the appendix section of the report since they only either give extra technical information about the construction and devices used for the project or give programming help and tips for Designer software. The documents included are:

- Product characteristic sheets for DALI equipment used. Appendix 1.
- Plan and connection list are included in appendix 2
- A programming introduction to Helvar´s Designer software (“Helvar Designer 4.2.18 tutorial for Metropolia”) is incorporated in a scaled version (Full version available from thesis demo board responsible). Understandably, it is only a quick start guide containing brief explanations for the basic commands used in this project. For a more complete insight into the software, readers should refer to extra help and training material available from Helvar. Appendix 3
- The User manual (“Instructions for the operation of the demo board”) is included in a scaled version (Full version available from thesis demo board responsible) providing the indications to experiment with the demo. All the programmed functions are detailed so anyone can “play” with them and get an insight into a router based DALI system. Appendix 4.

5 Conclusion

The result of our project is very satisfactory, as we have accomplished and, in some circumstances, extend the main goals of the project plan. Basically we have produced a demo board in which students can experiment with a DALI system from simple operation to programming. This report is also complemented with a programming tutorial for Helvar Designer software suite and a user manual with instructions for the operation of the demo, both attached as soft and hard copy with the demo board (and included in Appendixes 3 and 4 in a scaled version). Additionally, we have planned extra learning materials to be developed in the next few weeks comprising a practical exercise about programming DALI, a video presentation of the current system and a lecture class.

Interestingly, the system have been implemented with a Helvar router system allowing several added functions for lighting control to those part of basic DALI system. In fact, we have used many of the different features of the system and exploit the potential of the devices purchased. Thus, not only basic DALI has been covered but also an insight to DMX and networking concepts.

Another purpose was to test how a router´s based DALI system could perform in terms of lighting control. As a result, we found that this type of system is very powerful for lighting control and automation. A high level of complexity and flexibility can be achieved maintaining a fairly simple design and implementation process. Actually, when comparing to non lighting-dedicated systems (such as KNX) we found advantages in using this DALI router system, regarding especially simplicity of installation and flexibility of configuration. In exchange, the programming side could be slightly more complex but software available simplifies importantly this task.

Furthermore, we wanted to evaluate if Helvar system´s capabilities could be extended for some simple building automation tasks. In consequence, we can say that, although DALI was not designed to replace existing BMS functions, some of them can be implemented using the extra functionalities provided by routers and additional equipment (Relay Units, Input Units or Blinder Controllers).

It is clear that some functions commonly associated with lighting control have influence in other areas of services building and automation. For instance, a blinder action may affect temperature in a room (thus HVAC are influenced) or privacy and security of a space. Following this approach, we have simulated some actions that could be performed by our system finding that it is possible to add simple building automation functionalities to our system using non-dimmable loads control and third party control devices. It is true however that real life situation might require a more complex integration process of the controlled devices.

Clearly, these systems cannot currently replace building automation systems as they are not initially designed for it, we should keep having in mind that the system was designed for lighting control. Yet, a DALI router system could be integrated into a more complex BMS network where BMS controlling devices would be the backbone network in which DALI system would be integrated. As a matter of fact, this would be the most adequate control scheme if we want complex building automation control plus complex lighting control. In this situation, the DALI router would control lighting and this, in turn, would be controlled and monitored by a higher-level control network via interface or using special protocols such as OPC or Helvarnet.

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Reference list

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Appendix 1: Spec sheets

Imagine router 920

Imagine

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freedom in lighting

Imagine **Router** (920)

The 920 Imagine Router uses an Ethernet connection (TCP/IP) as a network backbone to combine DIGIDIM / DALI, DMX and S-DIM networks seamlessly together. A PC can be connected to the system for control, monitoring and logging purposes.

Key Features

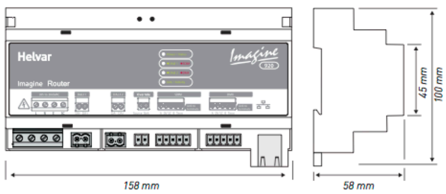
- Two DALI subnets with 250 mA power supply
- S-DIM port for Helvar Imagine systems
- DMX-port (in or out)
- Override port for S-DIM
- Supports OPC, allowing connection to BMS
- Supports Ethernet I/O communication
- Supports DALI Emergency devices

Technical Data

Supply voltage:	85 - 264 VAC, 45 Hz - 65 Hz
External MCB protection:	6 A
Stand-by power:	N/A (active device)
Power consumption:	23 VA (with both DALI subnets fully loaded)
Max. total losses:	2.5 – 4.3 W (Depending on loading)
DALI power source:	2 x 250 mA (built-in)
Ambient temperature:	0 ... 40 °C
Relative humidity:	90 % max, non-condensing

Dimensions

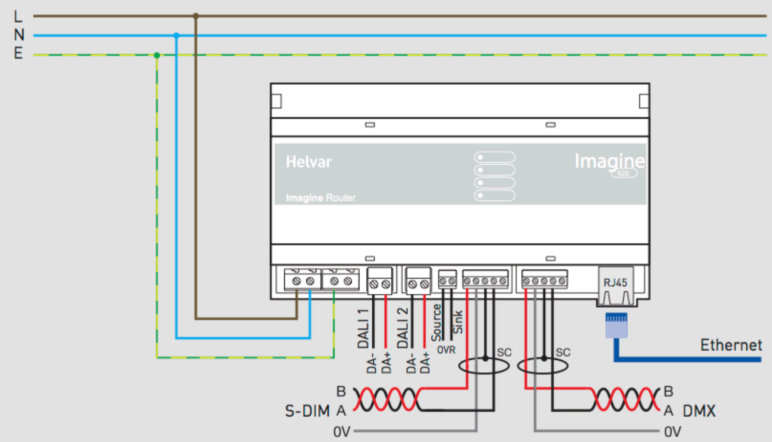
CE



DIN-rail case 9U-wide. Weight 260 g

Product Order Code: 920

Connections



Input Unit 942

Imagine

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Imagine Input **Unit** (942)

The Input Unit is an interface allowing customer-specified switches, sensors and time clocks to be incorporated into Imagine and DIGIDIM Router systems. It has 8 volt-free switch inputs which can be momentary or latching. Inputs 1 - 4 may be configured as 0 - 10 V analogue inputs.

Key Features

- Status led
- Can be used with momentary or latching switches
- Can be used with 0-10 V analogue devices
- DIGIDIM / DALI

Note: *Compatible with 905, 910 or 920 Routers.*

Technical Data

DALI consumption:	10 mA
Ambient temperature:	0...35 °C
Relative humidity:	90 % max, non-condensing
Storage temperature:	-10 °C...+70 °C
Isolation:	4 kV

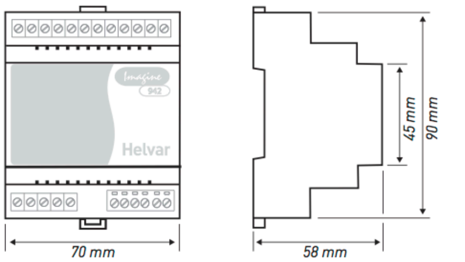
Voltage-free Switched Inputs

Overload protection:	±35 V
Short-circuit current:	0.5 mA maximum

Analogue Inputs

Input range:	0-10 V
Over voltage protection:	±15 V
Input impedance:	7.5 kΩ

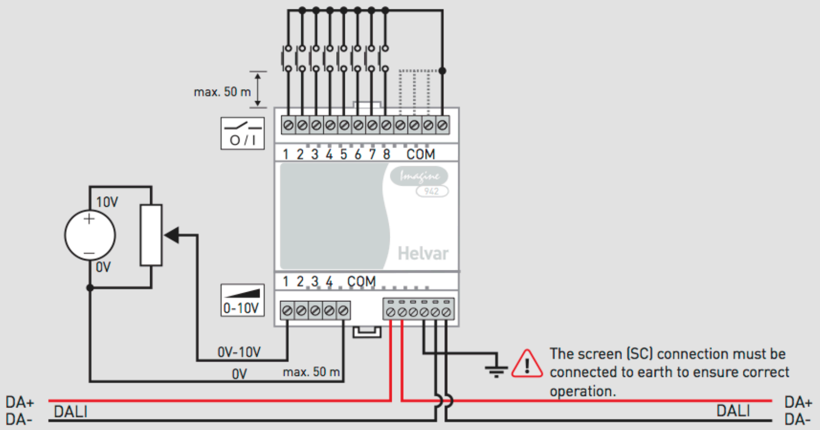
Dimensions



DIN-rail case 4U-wide. Weight 110 g

Product Order Code: 942

Connections



Relay Unit 494

digidim

Helvar
freedom in lighting

4 Channel **Relay Unit** (494)

Four channel DALI Relay Unit, designed to allow control of non-dimmable loads. The relay unit is a DIN-rail mounted unit that has four individually programmable relays. The relays are 'normally open', volt free and can switch up to 10 A resistive loads.

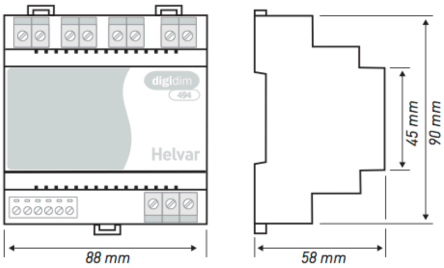
Key Features

- Isolated relays, normally open and volt free
- Manual override
- Status LED

Technical Data

Supply voltage:	220-240 VAC, 50-60 Hz
External MCB protection:	6 A (control circuit)
Relay loads:	10 A (resistive) (any phase)
	8 A (incandescent)
	5 A (inductive)
	15 pcs ballasts / drivers
Standby Power:	1.3 W
Max. total losses:	6 W
DALI consumption:	2 mA
Ambient temperature:	0...40 °C
Relative humidity:	90 % max, non-condensing

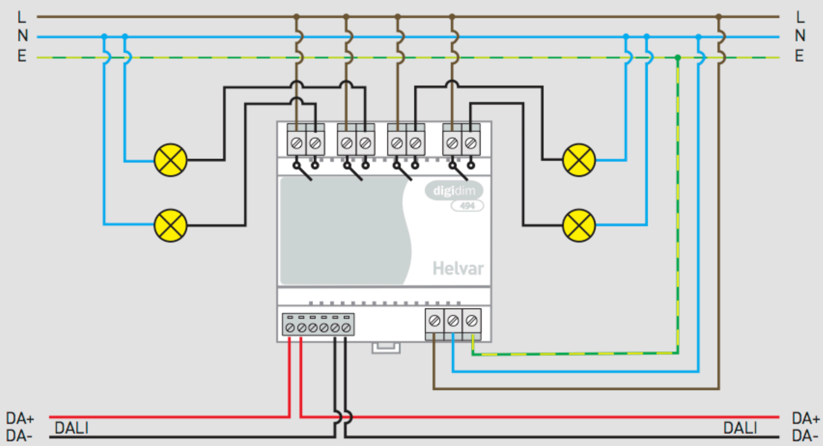
Dimensions



DIN-rail case 5U-wide. Weight 300 g.

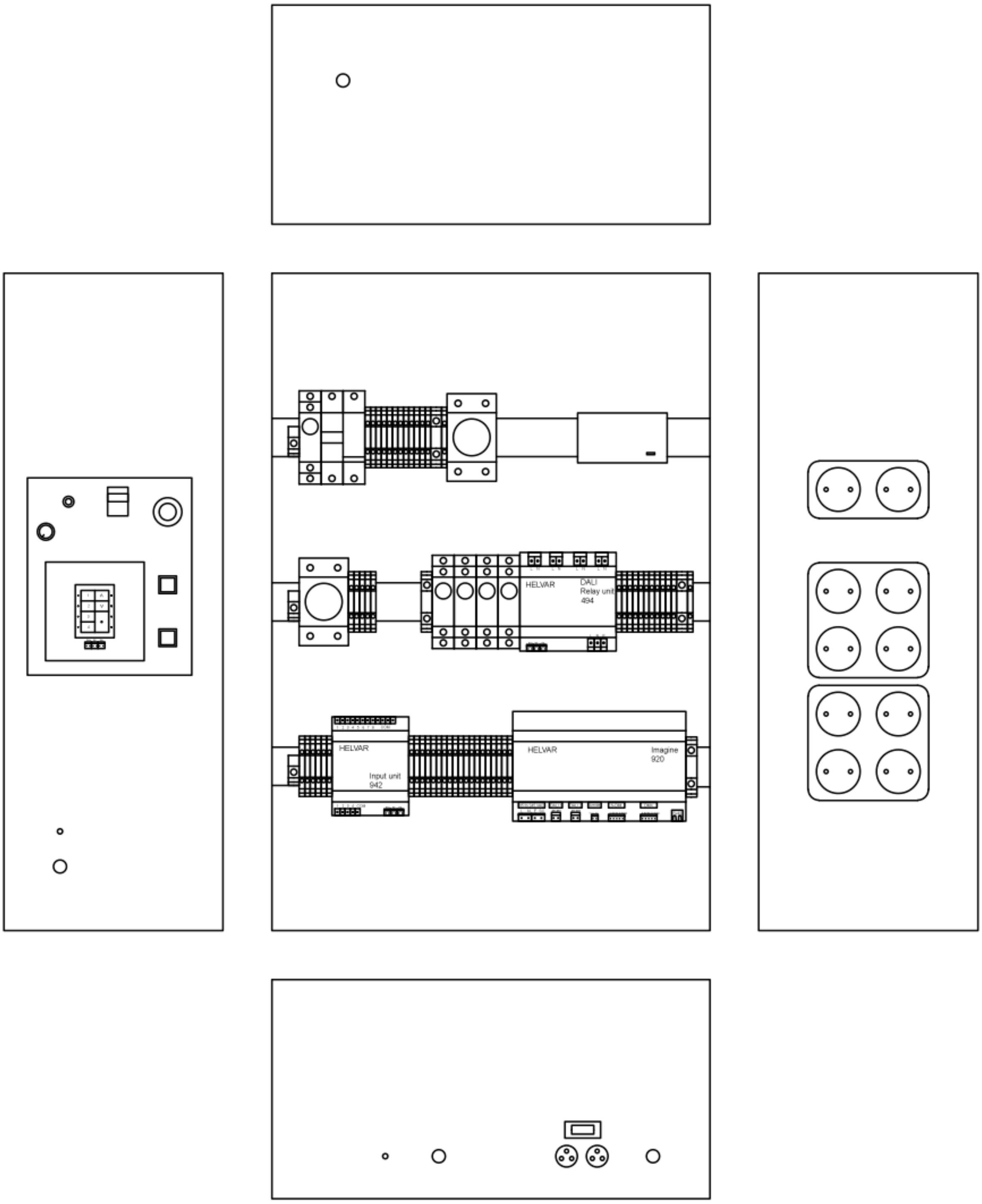
Product Order Code: 494

Connections

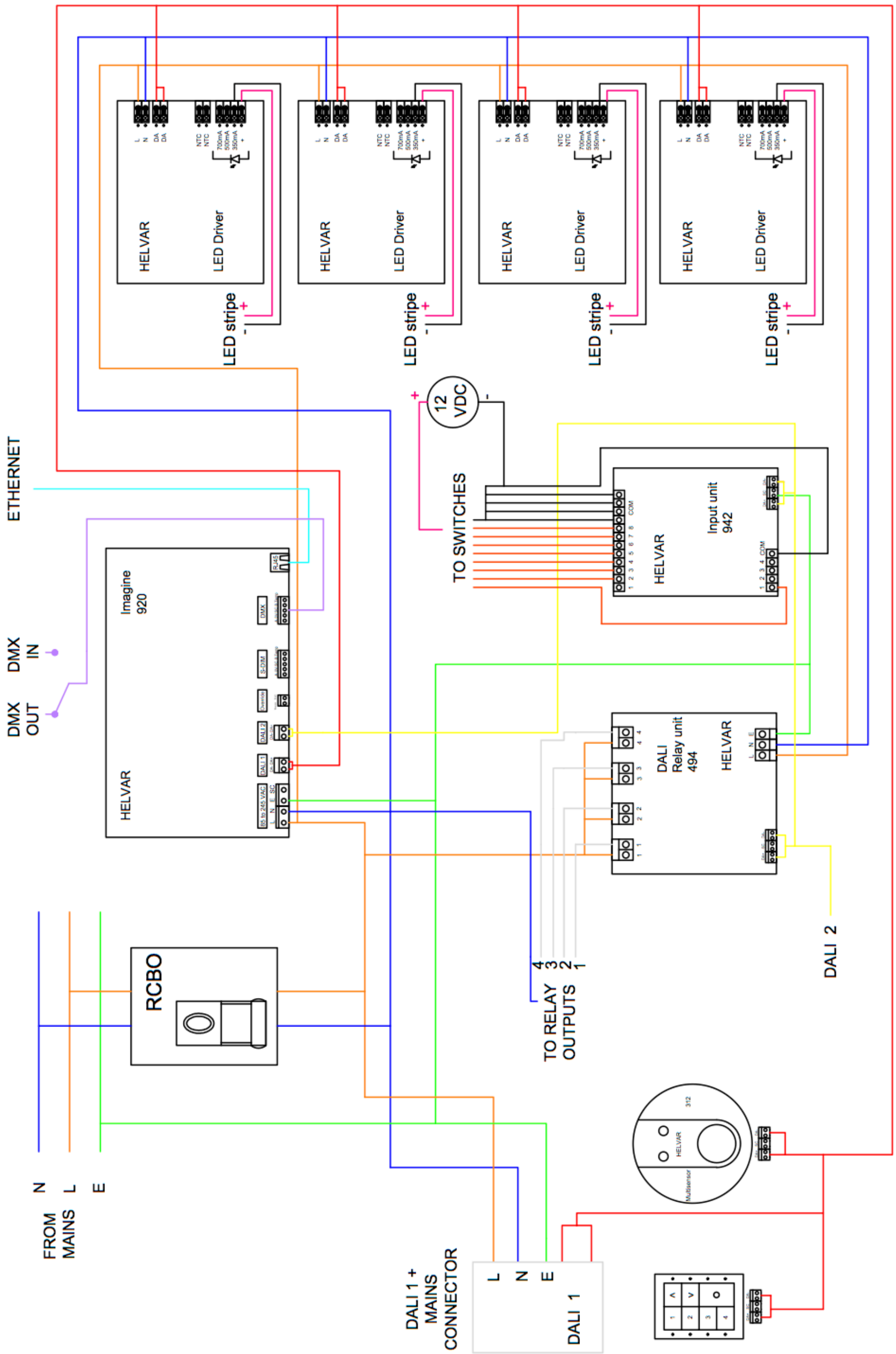


Appendix 2: Plans and connection lists

“Main box” plan (sides projection)



Cabling scheme



Connection list DIN rail 1

TERMINAL BLOCK CONNECTIONS LIST						
Terminal source			Destination			Electrical
Number	Side	Location	input	Device	Location	
1	*top*	*DIN rail 1*				
	bottom		*N*	*MCBO*	*DIN rail 1*	*N*
2	*top*	*DIN rail 1*	*N*	*Indicator*	*DIN rail 2*	*N*
	bottom		*13 top*	*Terminal block*	*DIN rail 2*	*N*
3	*top*	*DIN rail 1*				
	bottom		*27 top*	*Terminal block*	*DIN rail 2*	*N*
4	*top*	*DIN rail 1*				
	bottom		*N*	*Socket outlet*	*Outside*	*N*
5	*top*	*DIN rail 1*				
	bottom		*N*	*Socket outlet*	*DIN rail 1*	*N*
6	*top*	*DIN rail 1*				
	bottom					
7	*top*	*DIN rail 1*	*L*	*MCBO*	*DIN rail 1*	*L*
	bottom		*L*	*Indicator*	*DIN rail 1*	*L*
8	*top*	*DIN rail 1*				
	bottom		*15 top*	*Terminal block*	*DIN rail 2*	*L*
9	*top*	*DIN rail 1*				
	bottom		*17 top*	*Terminal block*	*DIN rail 2*	*L*
10	*top*	*DIN rail 1*				
	bottom		*L*	*Socket outlet*	*Outside*	*L*
11	*top*	*DIN rail 1*				
	bottom		*L*	*Socket outlet*	*DIN rail 1*	*L*
12	*top*	*DIN rail 1*				
	bottom					
Earth	*top*	*DIN rail 1*	*E*	*Mains*	*outside*	*E*
	top		*E*	*Socket outlet*	*DIN rail 1*	*E*
Earth	*bottom*	*DIN rail 1*	*E*	*Earth block*	*DIN rail 2*	*E*
	bottom		*E*	*Socket outlet*	*outside*	*E*

Connection list DIN rail 2

13	top	DIN rail 2	2 bottom	Terminal block	DIN rail 1	N
	bottom		34 top	Terminal block	DIN rail 2	N
14	top	DIN rail 2				
	bottom		N	Socket outlet	DIN rail 2	N
15	top	DIN rail 2	8 bottom	Terminal block	DIN rail 1	L
	bottom		36 top	Terminal block	DIN rail 2	L
16	top	DIN rail 2				
	bottom		L	Socket outlet	DIN rail 2	L
17	top	DIN rail 2	9 bottom	Terminal block	DIN rail 1	L
	bottom					L
18	top	DIN rail 2	L Channels (1,2,3,4)	Relay unit	DIN rail 2	L
	bottom		L	Relay unit	DIN rail 2	L
Earth	top	DIN rail 2	E	Earth block	DIN rail 1	E
	top		E	Socket outlet	DIN rail 2	E
Earth	bottom	DIN rail 2	E	Earth block	DIN rail 3	E
	bottom		E	Earth block	DIN rail 3	E
19	top	DIN rail 2	Ch1	Relay unit	DIN rail 2	
	bottom		Ch 1 L	Socket outlet	Outside	L
20	top	DIN rail 2	Ch2	Relay unit	DIN rail 2	
	bottom		Ch 2 L	Socket outlet	Outside	L
21	top	DIN rail 2	Ch3	Relay unit	DIN rail 2	
	bottom		Ch 3 L	Socket outlet	Outside	L
22	top	DIN rail 2	Ch4	Relay unit	DIN rail 2	
	bottom		Ch4 L	Socket outlet	Outside	L
23	top	DIN rail 2	Channels (1,2,3,4)	Indicator	DIN rail 2	N
	bottom		Relay N	Relay unit	DIN rail 2	N
24	top	DIN rail 2				
	bottom		Ch 1 N	Socket outlet	Outside	N
25	top	DIN rail 2				
	bottom		Ch 2 N	Socket outlet	Outside	N
26	top	DIN rail 2				
	bottom		Ch 3 N	Socket outlet	Outside	N
27	top	DIN rail 2	3 bottom	Terminal block	DIN rail 1	N
	bottom		Ch 4 N	Socket outlet	Outside	N
Earth	top	DIN rail 2	E	Earth block	DIN rail 1	E
	top					
	bottom		E	Socket Ch1&2	Outside	E
Earth	bottom	DIN rail 2	E	Socket Ch3&4	Outside	E
	bottom		E	Relay unit	DIN rail 2	E

Connection list DIN rail 3

Earth	top	DIN rail 3	E	Earth block	DIN rail 2	E
	bottom	DIN rail 3	E	Input unit	DIN rail 3	E
28	top	DIN rail 3	Power supply	DC source	DIN rail 2	12 V (-)
	bottom		Analog comon	Input unit		12 V (-)
29	top	DIN rail 3	Potentiometer (-)	Potentiometer		12 V (-)
	bottom					12 V (-)
30	top	DIN rail 3	Power supply	DC source	DIN rail 2	12 V (+)
	bottom					12 V (+)
31	top	DIN rail 3	Potentiometer (+)	Potentiometer	Outside	12 V (+)
	bottom					12 V (+)
32	top	DIN rail 3	Variable OUT	Potentiometer	Outside	0 to 10V
	bottom		Analog IN 1	Input unit		0 to 10V
Earth	top	DIN rail 3	E	Earth block	DIN rail 2	E
	top					
Earth	bottom	DIN rail 3	E	Router	DIN rail 3	E
	bottom		DALI CIRCUIT OUT N	MMJ	Outside	E
33	top	DIN rail 3				
	bottom		DALI CIRCUIT OUT N	MMJ	Outside	N
34	top	DIN rail 3	13 bottom	Terminal block	DIN rail 2	
	bottom		N	Router	DIN rail 3	N
35	top	DIN rail 3				
	bottom		DALI CIRCUIT OUT L	MMJ	Outside	L
36	top	DIN rail 3	15 bottom	Terminal block	DIN rail 2	
	bottom		L	Router	DIN rail 3	L
37	top	DIN rail 3	45 top	Terminal block	DIN rail 3	DALI 1 +
	bottom		DALI CIRCUIT OUT DA +	MMJ	Outside	DALI 1 +
38	top	DIN rail 3				
	bottom		Control panel DA +	Control panel	Outside	DALI 1 +
39	top	DIN rail 3	46 top	Terminal block	DIN rail 3	DALI 1 -
	bottom		DALI CIRCUIT OUT DA -	MMJ	Outside	DALI 1 -
40	top	DIN rail 3				
	bottom		DA -	Control panel	Outside	DALI 1 -
41	top	DIN rail 3	DA +	Relay unit	DIN rail 2	DALI 2 +
	bottom		DA -	Input unit	DIN rail 3	DALI 2 +
42	top	DIN rail 3				
	bottom		DA2 +	Router	DIN rail 3	DALI 2 +
43	top	DIN rail 3	DA -	Relay unit	DIN rail 2	DALI 2 -
	bottom		DA +	Input unit	DIN rail 3	DALI 2 -
44	top	DIN rail 3				
	bottom		DA2 -	Router	DIN rail 3	DALI 2 -
45	top	DIN rail 3	37 top	Terminal block	DIN rail 3	DALI 1 +
	bottom		DA 1 +	Router	DIN rail 3	DALI 1 +
46	top	DIN rail 3	39 top	Terminal block	DIN rail 3	DALI 1 -
	bottom		DA 1 -	Router	DIN rail 3	DALI 1 -

Appendix 3: Designer software tutorial (9 pages per sheet version)

HELVAR DESIGNER 4.2.18 TUTORIAL FOR METROPOLIA UAS

Juan Pedro Gimenez Catalán
Metropolia ammatikorkeakoulu

May 2014

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HELVAR DESIGNER 4.2.18 TUTORIAL FOR METROPOLIA UAS
INDEX

Introduction

The following document shows some basic instructions for using *Helvar* ***Designer*** software (from now on we will refer to it simply as ***Designer***). The aim is to provide quick tips and indications in order to help newcomers to the use of the software. Obviously, this is not intended to substitute help files (which are strongly recommended) and will not cover all the topics used in the project as well as not covering many of the large amount of options included in the software. Thus tutorial has been created for the configuration of our project consisting, programming wise, in a computer and a *Helvar* router *Imagine 920*

Some of the indications provided have been extracted from *Helvar* ***Designer 4.2.18 help file*** (available on *Helvar´s* website and directly from the help system of the application) or from ***Designer 4.2.18 training*** material from Miikka Etelälahti (26.02.2014). However, most of them have been originally produced based on my programming experience. In order to understand this tutorial, it is recommended to read the thesis report as some of the concepts used are explained there.

Also, the document "Instructions for the operation of the demo project" (included in this theses) that has been produced for the system installed in the demo should help to clarify some issues that might arise from this tutorial and its reading is equally recommended.

General considerations

Designer software uses typical menus, windows and options from windows programs and most users should be familiar to them. Although, the way these menus can be organised and we can find common operations such as cut, copy, paste, save and so on.

Likewise, download and installation processes are well known by most windows users so we will not go into details about these issues so we can concentrate in particular details of the software (*Helvar* web support offers instructions for this issues).

As usual, we have to back up periodically. While programming we have to make a distinction when saving:

- If we are connected to the router (***online***), the changes we are making are stored directly in the router (every time we click the **"OK"** button in properties window or scene table) but not in our design workgroup unless we save it to a new design or replace an older version.
- If we are not connected to the router we will be saving normally to our design.

Similarly to any other programming processes, it is recommended to give meaningful names and to provide as much indications as possible. This practice simplifies troubleshooting and development of the projects especially when different designers have to work in the same design but also useful for yourself.

Workgroups

First, it is important to clarify a concept that might lead to misunderstandings, workgroups. In the context of a Helvar lighting system a workgroup is a collection of routers that work together and communicate to each other.

- Every lighting system must have at least one group
- A lighting system is usually one workgroup
- There could be more if, for instance, there are different buildings in a company´s headquarter or a university campus. In that situation, each building could be a workgroup within the same lighting system.
- Every workgroup requires one instance of ***Designer***
- A workgroup can have up to 100 routers.

When in ***Designer*** we will always work in a "*workgroup design"* (equivalent to project in other software).

- ***Workgroup design:*** This is a simulation of a lighting system that might correspond or not to devices in a real system.
- ***Real workgroup:*** This corresponds to what is actually stored in routers. A group of devices in a lighting system and its representation in **Designer.**

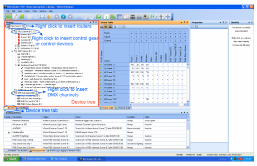
A workgroup can be, of course, renamed, saved, saved as and all the typical operations. In a workgroup design is where you can create your design by inserting items, those will appear

Insert and creating

If we want to add devices to our project, create a schedule or a routing entry we can do it by **"right click"** and **"insert"** which will display menus with all the possible options to insert.

Insert devices

Devices are managed in the ***device tree*** and here is where we will right click to insert devices. It is important where we do the right click to insert, for instance, if we do it in a subnet we can insert a device, if we do it in a workgroup we will be able to insert a router or if we do it in a DMX (output) subnet we can insert a DMX channels.



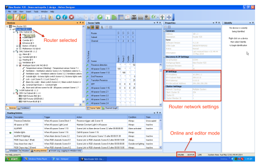
* Note the symbols for each device as they might help to identify items in the beginning.

There are other items to be inserted or created such as scheduled events, routing entries, conditions or terms in a condition. It is a matter of right clicking in the corresponding tab to access each insert menu.

Network settings

We have to make sure that correct IP addresses are set in both, the router and client computer.

1. To set computer address we have to follow regular procedure for Windows (depending on the system) going to Internet Protocol (TCP/IP) properties and changing from DHCP (usual setting for Internet LAN networks) to:
   - IP address: 10.254.254.99
   - Subnet mask: 255.0.0.0
2. To set router´s IP address (although it might be set automatically) we have to go into the properties section of the router and change it.



Make sure that all the routers in the same workgroup have the same cluster ID. A valid configuration is:

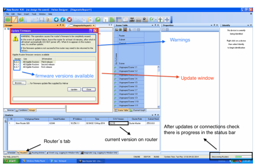
- Client Cluster ID: 254
- Cluster ID: something from 1 to 253

The router can also be renamed. It is also essential that all routers in the same workgroup must have the same workgroup name.

NOTE: In order to make changes in devices in the workgroup Editor mode has to be activated (more on modes in the following section). If we want to make changes in the router we also have to be ***online***

Upgrading the router

Before we start any programming it is highly recommended that we update router´s firmware. In order to do this we need to be ***online*** (that is connected to the router, explained in the next section).



We have to open router tab, right click and **"upgrade firmware"**, then we will choose the last version and click **"upgrade"** and finally press **"finish"**. After few seconds the router will appear again in the router´s tab of designer.

NOTE: If failure while uploading do not power off, it will restart automatically after 10 minutes. The password for firmware upgrade is hydrogen1066 and we have to consider that upgrading the firmware will delete all the programming in the software.

A good way to know if the router is connected and has the right address is by right click on the router and "ping" it, the device should respond with an OK and its IP address.

Modes

There are six modes of operation corresponding to 3 options:

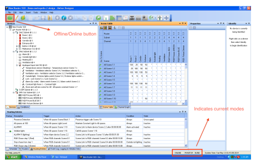
- Offline vs Online
- Monitor vs Editor
- Blind vs Live

Offline vs Online

In ***offline*** mode ***Designer*** is not connected to a ***Real workgroup*** (that is a workgroup in a physical router, a lighting system which can have Client PCs, Routers, Control devices, Control gear and lamps). In this mode is possible to work and test the design before is actually implemented.

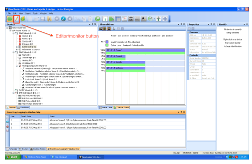
When **Online**, **Designer** is connected to a **Real workgroup** and it is possible to ***monitor*** and change configuration of the lighting system behind the router/s.

NOTE: When going online it will ask for the workgroup to connect to the available systems (Routers). In our case there will be only one router with the same name we have put previously.



Editor vs monitor

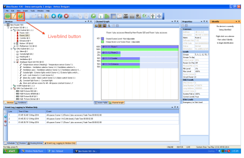
In monitor mode it is not possible to make configuration changes to a workgroup (real or design) but, apart from monitoring, it is possible to change light levels or call scenes when in ***Live*** mode. ***Editor*** mode allows configuration changes to the ***workgroup design***.



NOTE: A firewall might be blocking ***Designer*** to see workgroups to connect. To solve this problem, either disable firewall or make sure it is configured so that Designer can communicate freely.

Blind vs live

Finally, Live and Blind mode refers to how the changes made in designer apply to the real workgroup. In Live mode these will be executed immediately while in blind mode changes will not affect the real system. Both modes are only available when Online.

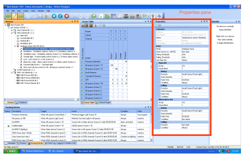


In general, a lit button means the active options (***online, editor and live***) while unlit buttons mean ***offline, monitor*** and ***blind***. However, we can use the status indicator (bottom right) of the interface to know what mode we are in.

Also, the first time we change to a higher level of protection mode (that is the lit options) it will ask for a password.

Properties

The properties window is where all configuration changes to devices, routing entries, conditions, schedules and so on take place. There it is possible to change names and addresses, assign to groups, apply conditions to certain actions or set scene recalls. The best way to know what configurations are available for a device or action is to select it and explore the properties window (some options have a drop down menu for the allowed options). Also, selecting an entry in this window will display a brief info at the bottom of the pane.



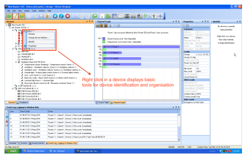
As any other window or pane can be moved, docked and all the typical possibilities of windows programs. **"F4"** with any device or action selected will open properties. Identification and organisation of the system

Organising the system

It is very important to keep the system and design as organised as possible. Hence, we have to think a way of addressing and naming devices that makes sense to us and that is clearly understandable for others. Of course, It is also important to do this with the requirements of the design in mind.

The same applies to grouping, we have to assign groups for each device in order to recall scenes and to operate or be operated. Initially devices are "Ungrouped" and groups are assigned in the properties window. Controllable devices (control gear) may belong to more than one group while control devices may only belong to one group. However, each button in the same module can be member of different groups.

Right click in any device will display a menu where it is possible to access all device configuration options.

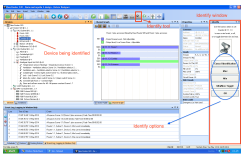


*Taking a look into the "group configuration" section of the document "Instructions for the operation of the demo board" also attached to this thesis can help to understand these concepts.

Identify

From the previous picture we can see that there is a **"Identify"** tool, which is essential when commissioning a system. When we connect a system all devices have short addresses but we don´t know which is which so we need to identify those in order to start programming correctly and assign names and groups to the right devices in the real system. There are various ways of identification hich are indicated in the Identify window as well as a brief mention of what would be the method of

identification for each selected device (a ballast might flash the lamp while a input unit or control panel might flash its LEDs).



In general, everything can be changed in later stages of the design or implementation process but good planning can save us a lot of time and effort .

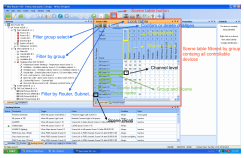
Scene table and channel graph

Scene table

To modify values of each channel for each group and scene we have to use the scene table. There are 8 blocks of 16 scenes.

- The values for each channel and scene can be modified in a 0 to 100 fashion where there are two special symbols:
- **"*"** means that the channel will keep the previous value when that scene is recalled.
- **"L"** means that, on the scene recall the channel will take the last channel before power off.

From this table we can also recall scenes and edit and save the scenes. A lock button is included to keep the selection regardless of scene calls (which usually will change the groups shown in the scene table accordingly).



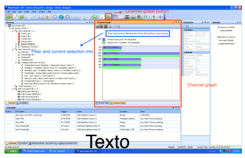
It is important to understand that the scenes values are the same, so there are only 128 scenes possible in designer (8 blocks of 16 scenes each). But, they can be recalled or filtered from different groups. It is even possible to name those scenes differently depending on the group. The scene table, we can filter by group, subnet, router or workgroup.

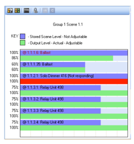
*Taking a look into the "scene configuration" section of the document "Instructions for the operation of the demo board" also attached to this thesis can help to understand these concepts.

NOTE: Sometimes some recently created groups do not appear in the filter selection menu. Double clicking in the subnet or router before opening the group selection can solve this issue.

Channel graph

The channel graph instead represents each channel level in the stored scene plus the current output level (it might have been modify without recalling any scene) device. If not locked, it will change to display values of the last scene called.

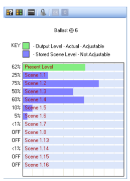




Obtained from Helvar´s help file, not corresponding to our project

NOTE: If there is a faulty device channel graph will also display an error (from web help file, picture not corresponding to project design)

Also, It is possible display the values of a selected device (by double clicking) for each scene (from web help file, picture not corresponding to project design).



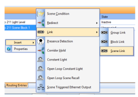
Obtained from Helvar´s help file, not corresponding to our project

Creating entries

In the demo project report we have explained how it is possible to configure the functions of the system by using certain rules translated to Designer and to the router by means of routing entries, scheduler and conditions. These have been introduced covered in the report but for further information about its parameters refer to ***Helvar´s help file***.

We have already explained how to insert devices in the design. In order to create or "insert" operations the process is similar but we will have to right click in the corresponding tab, window or item depending of what we want.

The following picture shows insert options for "routing entries" obtained when right click in the routing entries window (selected through its tab).



Obtained from Miikka Etelälahti´s Designer training material, does not correspond to demo project.

To configure the actions following an entry or a schedule we have to proceed equally:

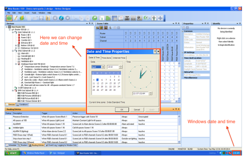
- Create the entry
- Select the entry and modify its parameters via properties window.

NOTE: Options and parameters for each entry are explained in the help file but the best way is to investigate what are the options on each action.

Testing the scheduler

We have seen so far how what is a scheduled event (in the thesis report) and how to create them and modify its parameters (via properties window). Then, in order to test these, we have to "cheat" the system since it would not make sense to wait until the weekend to see if we have programmed correctly a function that only happens in that time

If ***Designer*** is open and connected to the router, the latter will synchronize continuously with computer´s time (if the option is enabled at router properties). So, if we want to test something happening at a different time or date we will have to modify windows system´s time by clicking in the date and clock icon.



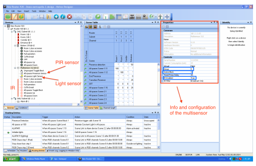
*IMPORTANT: We have to remember to put the right date and time before going offline or the router will keep the wrong configuration until next time it is connected.

Multisensor

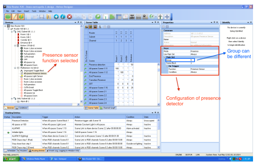
It is worth to dedicate a section to the multisensor included in our project and some of its programming options. It will also help to see what is the process when creating and configuring one device and its possible configurations.

- Create the device and assign it to a group. In the case of the sensor can be a different group for a different function (but each function should be in the same group as the controlled loads)
- Configure its properties and functions

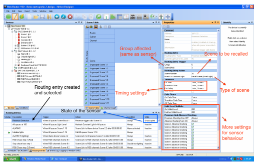
Again, we have to give sensor a group in order to function but it can be a different group for each function of the sensor.



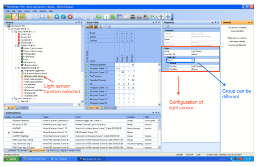
Selecting the presence sensor in the device tree we can configure its settings in the properties window.



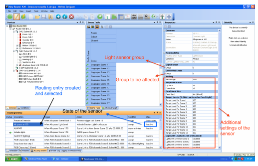
Additionally, a **“presence detection”** routing entry has to be created when we establish how this presence sensor will interact with the system and what will be the parameters of this entry.



Similarly the light sensor function of the multisensor can be configured individually



Likewise the presence detector, for the light sensor to interact with the system we need to create a **“constant light”** routing entry.



Buttons and other controls

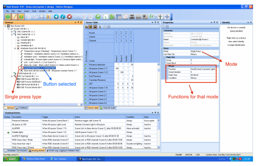
Inputs from control panel´s buttons (*Helvar´s 135W* control panel for our project) and controls connected to input units are used to recall certain scenes on its operation. To configure them we follow initially the same steps as with the multisensory:

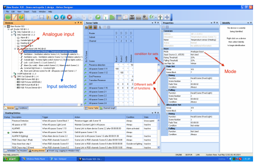
- Create the device and assign it to a group. In the case of the panel module can be a different group for a different module or button (but each function should be in the same group as the controlled loads)
- Configure its properties and functions

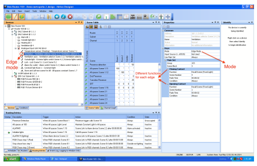
These controls are generally easier to configure as they usually are assigned only to scene recalls. However, the way in which the button behaves might vary depending on parameters such as type of input, mode or conditions. It is even possible to assign various actions to the same button. ***Designer help file*** offers a description of each function for each of the input devices.

For instance, there can be an analogue input (for sensors or 0 to 10 V controls), push button or a toggle switch each having various functions depending on how the button is pressed (single or timed), if the analogue input is increasing or decreasing or if a

condition is met. Moreover, we could combine these functions to obtain the desired results.

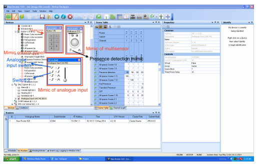






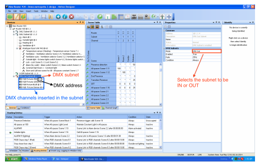
Mimic

Double clicking on any device opens a virtual representation in designer, which replicates its functionality. It is possible then to interact with it and monitor its behaviour. If we are ***online*** and ***live*** we can see these changes in the real system.



DMX configuration

The DMX port can be **“In”** or **“out”.** If we configure it to output DMX, the channels inserted (same way of inserting as explained but right click in the DMX subnet) will be automatically DMX channels.



If we assign address “1” of the DMX subnet it will be channel “1” of the DMX network (and DMX device addressed to “1” will respond to values on the scene as DMX values. Thus, if we want to send “Red” colour channel of our DMX fixture at 80%, we will have to put 80 in the corresponding scene and group (these channels they also have to be in a group).

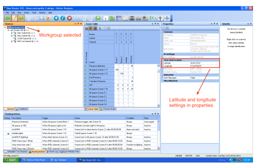
If we set the port to be “In”, we will insert loads in the DMX subnet to be controlled by the DMX channels. Thus, if we insert (right click on the DMX subnet changed in the properties as “In”) one controlled channel (a load, for instance, a LED light of our system) to DMX channel “1”, the load will be controlled externally by a DMX control device like a lighting console.

NOTE: a DMX subnet of one router cannot be “In” and “Out” within the same project as the share the same physical port.

Latitude and longitude

For some scheduling and conditional operations we can use time ranges that dynamically change such as sunset and sunrise time or dawn and dusk time. In order to do this we have to set the workgroup and this will be loaded into the router as well the latitude and longitude of where the installation is located.

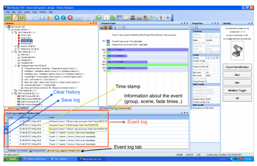
This way, the system will know if the sunset or sunrise has happened or not which clearly will affect or lighting system (although there are other factors to take into account such as weather conditions, orientation of the building and so on).



Having selected the workgroup and being in **editor** mode we can change this setting.

Event log and other tools

One important feature that we have used in our project is the event log window. This is very useful when monitoring and testing the system as every action gets reflected there. We can for instance see if one scene links to another or if the scheduler has recalled a certain scene.



Yet, there are many other tools in Designer software to find conflicts or check devices as well as for creating logs and reports. These tools are found under the **“Tools”** menu. More information about tools can be found in one of the most important tools (that has been several times used in this tutorial) the ***help file***.

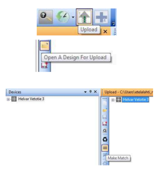
Upload mode (from design to real workgroup)

There are many occasions in which we want to upload a design to the router. The reason might be that we have to upload a backed up design, an design created offline or database to a new router that has been replaced or to return to a previous working version of a design. For this purpose we have the **upload** tool. We haven't used much this option as we have been working **online** for this project but it is an essential tool for commissioning.

In order to upload a design we have to follow these steps:

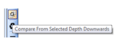
- Open **upload tool**
- Find and select a design to upload
- Match items ***(“make match”*** or ***“compare from selected downwards”)***

The following picture show these steps for the “make match” option.



Obtained from Mikka Etelälahti´s Designer training material, does not correspond to demo project.

It is possible to ***“match”*** whole workgroups or individual items. But there is a quicker option consisting in choosing the ***“compare from selected downwards”*** option and it will match all devices under the device selected when applying this option (can be a full workgroup, a subnet or a device with subdevices..)



Obtained from Mikka Etelälahti´s Designer training material, does not correspond to demo project.

Once the process is finished we just click ***“finish”*** to confirm

Finally, the program will ask what to do with conditions, schedules, entries (it is our choice)

Appendix 4: Instructions for demo board (9 pages per sheet version)

INSTRUCTIONS FOR THE OPERATION OF THE DEMO BOARD

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May 2014

INSTRUCTIONS FOR THE OPERATION OF THE DEMO BOARD
INDEX

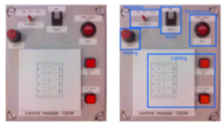
Indications

The following document includes instructions on how to operate the demo project as it has been programmed at this stage but, of course, controls can change their function. As it has been explained in the report, the values and functions assigned to the controls are just an example and they aim to show various possibilities of the system.

We have built a control box to interface with the project. It has basically a control panel from Helvar (135 W) and a few controls such as potentiometer, rocker switch, push buttons and on/off switch. We have used standard controls to demonstrate that many different controls can be used to fit our needs.

For instance, the potentiometer (heating) is aimed to replicate the behaviour of a temperature sensor the toggle switch (ventilation) replicates a building automation control with 3 positions, the on/off (alarm) could play the role of any coded or magnetic switch.

The "control box"

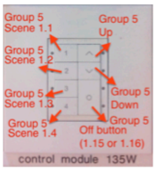


Lighting

In order to control the lighting we have *Helvar´s 135 W* panel, two push buttons and the PC application. The following picture show the scenes recalled by each control. They all aim ***group 5 scenes in block 1***.

Control module 135W

Helvar's 135 W panel is used to directly recall scenes having priority to everything since they are not subjected to any condition or schedule. They all aim ***group 5 scenes in block 1***.



All the buttons have function only in single press apart from the **"off" button** which ***recalls scene 1.15 in single press and scene 1.16 in timed press*** (press for at least 10 seconds).

The **"up" and "down"** arrows simply ***increment and decrement*** the intensity of ***group 5*** fixtures

Push buttons

The push buttons have been also assigned to more special functions to control lighting but these functions could have been assigned also to any button in the control module.

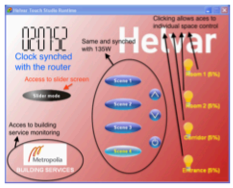
- The button labelled **"constant light" *recalls*** a ***constant light scene (5)***, which has been programmed to keep lighting level at 100 lux (measured at the sensor).
- **"User defined"** button has two functions:
  - ***Single press*** recalls ***scene 1.7***
  - ***Time press (>10s) stores*** current value of group 5 fixtures into ***scene 1.7***

Graphical Interface Application

An interface application to run in Windows computers has been also created. Its operation is quite simple and it is similar to other screen navigation controllers or control panels. Indications are also written on each screen. **** Some screens are protected by password ("admin")***

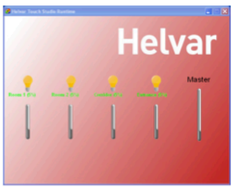
There are various screens in the application. The main screen has controls for lighting linked to the panel module (same functions) access to the monitoring of building services and to the "slider mode" (space's lighting levels are controlled via sliders.

Then, there is one screen for each space accessed via the space monitoring sections (light bulb corresponding to each space) in main screen. To come back from those screens to the main one press the light bulbs top left on each secondary screen. Picture below shows ***main screen***

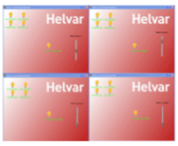


Next, the ***building service monitoring screen***

Following, ***"Slider mode" screen***



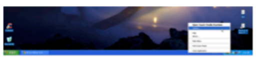
Finally, the four screens corresponding to each space. ***Helvar´s logo returns to main screen*** in all of them.



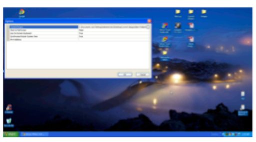
Configuration of Graphical interface application (GIA)

We have just describe the function of the GIA in the system but we will now mention how we can set up the **TouchStudio Runtime application** (section 4.2.2 of the thesis report offers an insight into TouchStudio software) to execute the project folder created with **TouchStudio Editor.**

First ,we have to open **TouchStudio Runtime** application and ***right click*** in the ***icon*** on Windows toolbar.



After clicking options, we have to choose the correct location of the project folder with usual exploring windows system.



It is also possible to do this configuration by **opening** current **TouchStudio project in Runtime application** and then ***"Main menu", "options" and "project folder"***

Multisensor

With the multisensor we perform energy saving actions. It has been programmed for two functions:

- ***PIR presence detector*** recalls various scenes depending on the state:
  - If the sensor is not active and ***detects presence recalls scene 1.10***
  - If the sensor has not sense any presence for a certain amount of time (***1:30 minutes*** in our demo***) after the detection***, the ***transition scene 1.13*** is triggered.
  - ***After the transition time*** has passed and there is not presence detection ***scene 1.14*** is triggered.
- ***Light sensor*** maintains fixed lighting levels corresponding to a constant light scene.

**** If*** the ***last scene called is 1.15 or 1.16*** there is an ***exit time*** of ***1:30 minutes*** until the PIR sensor is active again.

Building services

To control the relay unit´s outputs (that we have assigned to different building services as an example) we have standard switches. As we have explained, each of the outputs simulates one building service.

- Relay **output 1 - *Alarm***
- Relay **output 2 - *DMX fixture (Architectural lighting)***
- Relay **output 3 - *Heating***
- Relay **output 4 – *Ventilation***

Alarm

The on/off switch represents the alarm activation. It has two positions without any other consideration on for its behaviour.

- The **"Alarm"** position **activates the alarm**. ***If*** the alarm is activated and the ***presence detector*** is triggered ***scene 1.6 and 2.2 (alarm ON)*** will be ***recalled***

- The **"Off"** position ***deactivates alarm or turn off alarm*** if triggered

**** If*** the ***last scene called is 1.15 or 1.16*** there is an ***exit time*** of ***1:30 minutes*** until the PIR sensor is active again. So this is used as exit time for the alarm as well. Then, we have to **press the "0" module** in the control module ***before alarm activation to use it as exit time for the alarm***.

Architectural lighting (DMX)

A rocker switch is used to activate the DMX fixture (representing architectural lighting on a facade of a building) and the colour chase that will run on it. The action of this control is conditioned by a certain rules.

- The **"Auto"** position makes the output work in a scheduled manner. In this mode, will automatically ***switch on at sunset*** and ***switch off at sunrise***.
- The **"Off"** position keeps ***lights off unconditionally***

* ***Outside light ON*** corresponds to ***scene 4.2*** while ***outside light OFF*** is ***scene 4.1.*** There is a colour ***chase associated*** when the DMX fixture is powered up. The light will change colour from red ***(scene 8.1)*** to green ***(scene8.2)*** to blue ***(scene 8.3)*** continuously until the DMX fixture is off ***(scene 8.4).***

Heating

For easiness when testing the project, a potentiometer has been used to represent a temperature sensor. This will be used to control the switching of the heating.

This control ***only works*** in cold seasons ***(from 15th of November to 15th of April)***

- ***Turning potentiometer clockwise*** (simulated temperature increase) will ***turn on*** "heating" (***scene 7.2***) when passing the threshold

- ***Turning potentiometer anti-clockwise*** (simulated temperature decrease) will ***turn off*** "heating" (***scene 7.1***) when passing the threshold.

* In the picture the approximated ***trigger point*** is marked with a black line.

Ventilation

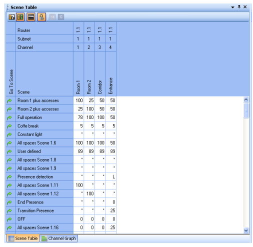
A toggle switch, which has 3 positions, is used to simulate a typical building automation switch. The switch has been assigned in our virtual operation of building services to ventilation.

- **"On"** position will switch ***ventilation on unconditionally (scene 3.2)***
- **"Off"** position will switch ***ventilation on unconditionally (scene 3.1)***
- **"Auto"** switches ***ventilation on*** a scheduled fashion. ***Weekdays 6:00 a.m. to 17:00 p.m***.

* An extra scheduled control of ***ventilation*** has been programmed to ***stop at midnight everyday*** in case the ventilation has been left "on" in manual on mode.

Scene configuration

Next picture details scene table for group 5. This group correspond to the LED luminaires on the demo board ("Indoor lighting"). There are other groups but they have been created mostly to practice. All the controls that refer to lighting address this group and they will recall scenes for group 5.



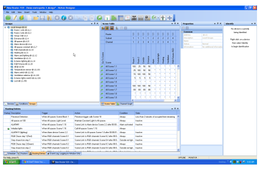
Scene Table

Router	1.1	1.1	1.1	1.1
Subnet	1	1	1	1
Channel	1	2	3	4
Scene	Room 1	Room 2	Corridor	Entrance
Room 1 plus accesses	100	25	50	50
Room 2 plus accesses	25	100	50	50
Full operation	78	100	100	50
Coffe break	5	5	5	5
Constant light	*	*	*	*
All spaces Scene 1.6	100	100	100	50
User defined	89	89	89	89
All spaces Scene 1.8	*	*	*	*
All spaces Scene 1.9	*	*	*	*
Presence detection	*	*	*	L
All spaces Scene 1.11	100	*	*	*
All spaces Scene 1.12	*	100	*	*
End Presence	*	*	*	0
Transition Presence	*	*	*	25
OFF	0	0	0	0
All spaces Scene 1.16	0	0	0	25

The names of the scenes are assigned only for that group. If we would filter the scene table by another group the channel values on each scene would not change (as it is the same) but the name would be the original. For instance, Group 6 Scene 1.6.

Group configuration

In this project we have created many groups for practical purposes as we can see in the next picture that shows all the groups created. Most of the groups only include one member and others comprise many different channels that are not related (they were created to have more channels viewed at the same time when filtering by group in the scene table). As we can see, we have given meaningful names to all of them and this is how they will be identified throughout the design (although we can still see the group number after each name).



As usual, we can get more information selecting a group and looking to the properties window.

Two important groups in our design are group 5 and group 10 as they include the lighting. A good practice exercise would be to create a group made of the channels that belong to these two groups and name it maybe "all lighting".

Next page show some details about these groups. We can see how, when we assign a name to a group, the group is referred by its name every time it appears in the design (automatic process by **Designer**)