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Commissioning Measurements and DALI Programming for the Intensive Care Unit of a Hospital

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Thesis Abstract

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The purpose of this thesis was to install and program Digital Addressable Lighting Interface (DALI) system to an intensive care unit room in a hospital environment. Another task was to take the commissioning measurements of that room.

The thesis studied basic theory on commissioning measurements and specific standards that need to be applied in a hospital environment. Also basic information and the standards concerning DALI were studied together with the history of the technology.

The thesis focused on the steps that need to be taken before starting to work in an ICU room. Attention was paid to the choosing of the needed components and to the requirements set for the operation of the lightning. The thesis introduced the problems faced during the project and in the end the finished target was described.

Keywords: commissioning, DALI, ICU, lighting

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Opinnäytetyön tiivistelmä

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Tämän opinnäytetyön tarkoituksena oli asentaa ja ohjelmoida Digital Addressable Lighting Interface eli DALI-järjestelmä sairaalaympäristöön teho-osaston huoneeseen. Toinen tehtävä oli tehdä käyttöönottomittaukset samaan huoneeseen.

Opinnäytetyössä perehdyttiin käyttöönottomittauksen perusteoriaan sekä tiettyihin standardeihin, joita täytyy noudattaa sairaalaympäristössä. Siinä käytiin läpi aiheeseen liittyviä standardeja sekä perustietoa DALI- järjestelmästä, kuten esimerkiksi aiheeseen liittyvää teoriaa ja käytetyn teknologian historiaa.

Opinnäytetyö keskittyi työvaiheisiin, jotka täytyy käydä läpi, ennen kuin työt teho-osasto huoneessa aloitetaan. Työssä perehdyttiin oikeiden komponenttien valintaan ja tutustuttiin työselosteeseen, josta ilmenee kuinka valojen kuuluisi toimia. Opinnäytetyössä käytiin läpi työn aikana kohdatut ongelmat. Lopuksi valmis työkohde kuvailtiin.

Asiasanat: käyttöönottomittaukset, DALI, Teho-osasto, valaistus

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Terms and Abbreviations

DALI	Digital Addressable Lighting Interface, network based system that controls lighting in building automation.
LED	Light Emitting Diode, a junction diode which emits light while activated.
Lumen	SI derived unit of luminous flux.
Color temperature	Temperature of the radiation of a light source.
mA	Milliampere, a base unit of the electric current.
Power	Measurement for the amount of energy. SI unit is watt.
Network topology	Arrangement or structure showing how a network has been built.
ICU	Intensive care unit
TN-S	Electricity distribution system, where there are separated ground and zero conductors in the whole system.
TN-C	Electricity distribution system, where the ground and zero conductors have been joined together in whole system.
IEC	International Electrotechnical Commission is an international electrical industry standard organization.
Fluorescence	Emission of light by a substance which has absorbed light radiation.
UPS	Uninterruptible Power Supply. A System which provides electricity during blackouts and other problems in the basic grid.

Switchboard Device that directs electricity from one or more sources of supply to other smaller regions of usage.

IT- System System where any part of the electric grid is not connected to the ground potential. One point can still be connected to the ground through impedance.

Insulation resistance Insulation resistance describes the condition of the insulation between the contacting and touchable parts of an electrical device.

1 Introduction

This thesis was made as a part of the reconstruction of the intensive care unit of Seinäjoki Central Hospital. In June 2017 four electricians started working on the hospital reconstruction site. Later during the final rush at the end of September there were already sixteen electricians working until completing the worksite in end of January. The original timing for DALI programming was supposed to be in the beginning of December but because of delays it was started at end of January. The main object of this project was to learn how to use and program DALI in a public building and how to take the commissioning measurements there. It was also important to get to known all the necessary regulations and demands and to learn how to apply them in this kind of a target. The prime contractor was Lujatalo Oy and the electric contractor was Satakunnan Sähköasennus. The electric contractor was responsible for the commissioning measurements and DALI- programming. The electric contractor also did the wiring, mounted the electrical centers and installed the lights, switches and sensors needed for DALI. The main programmer for the DALI- system was another worker from the company with the required license to work with DALI so the thesis was made under his supervision.

2 Working fields in this thesis

Although the construction site had a lot of different targets to work with, eventually at the end of the year the thesis took all focus until the construction site was completed. The specific ICU room was ready for the measurements and DALI programming.

2.1 Commissioning measurements

After the electrical installations the commissioning measurements had to be taken. With this work area we followed the SFS-6000 and SFS 6000-7-710 standards. SFS 6000-7-710 is specified for medical areas and it requires that in these kind of areas the potential equalization has to be better than usual, so that the use of medical devices will not cause dangerous situations. (Maadoituskirja. 2007, 159.)

2.2 DALI

Modern Construction demands are getting higher and higher. Especially in public buildings but also in modern detached houses basic old fashioned lightning controls are not enough. They don’t provide flexibility nor the capability for controlling separate lights in a fully functioning system. That is why controlling systems like DALI have become more and more popular with their wide selection of different demands. With simplicity and great variety of applications it has been designed to become a new standard in the market and will gradually replace the analog interface.

Picture 1. DALI logo. (Diginet 2017)

DALI stands for Digital Addressable Lighting Interface and it is an international standard which guarantees the exchangeability of dimmable ballasts from various manufacturers, installations and end-users. DALI is a simplified way of communication to the needs of present day technology. (DALI AG. 2001, 10.)

3 Commissioning measurements

Before starting with the commissioning measurements it was necessary to get familiar with the regulations concerning hospital environments, which are much more demanding compared to example, a normal construction site. Knowing the regulations, the actual measurements were pretty simple to make although later there was a problem which led to a situation where all the measurements of the ICU rooms needed to be taken again. Later on in the thesis there will be more information on that problem.

In SFS 6000-7-710 medical areas have been divided into three groups from 0 to 2 (G0, G1 and G2). ICU rooms are in the highest group, in group 2 which stands for a medical space where medical instruments and their connecting parts have been meant to be used for functions needed in heart surgery, operating room and such intensive care units where the disconnection of power supply can cause the danger of losing life. (Maadoituskirja. 2007, 159.)

3.1 Regulations and standards for G2

In group 2 the electricity supply for a switchboard needs to be made with two separated supply lines. In a normal situation electricity comes from an emergency power system called UPS and another one from the normal grid which is used during disruptions and maintenance. (SFS 6000-7-710. 2017, 7.)

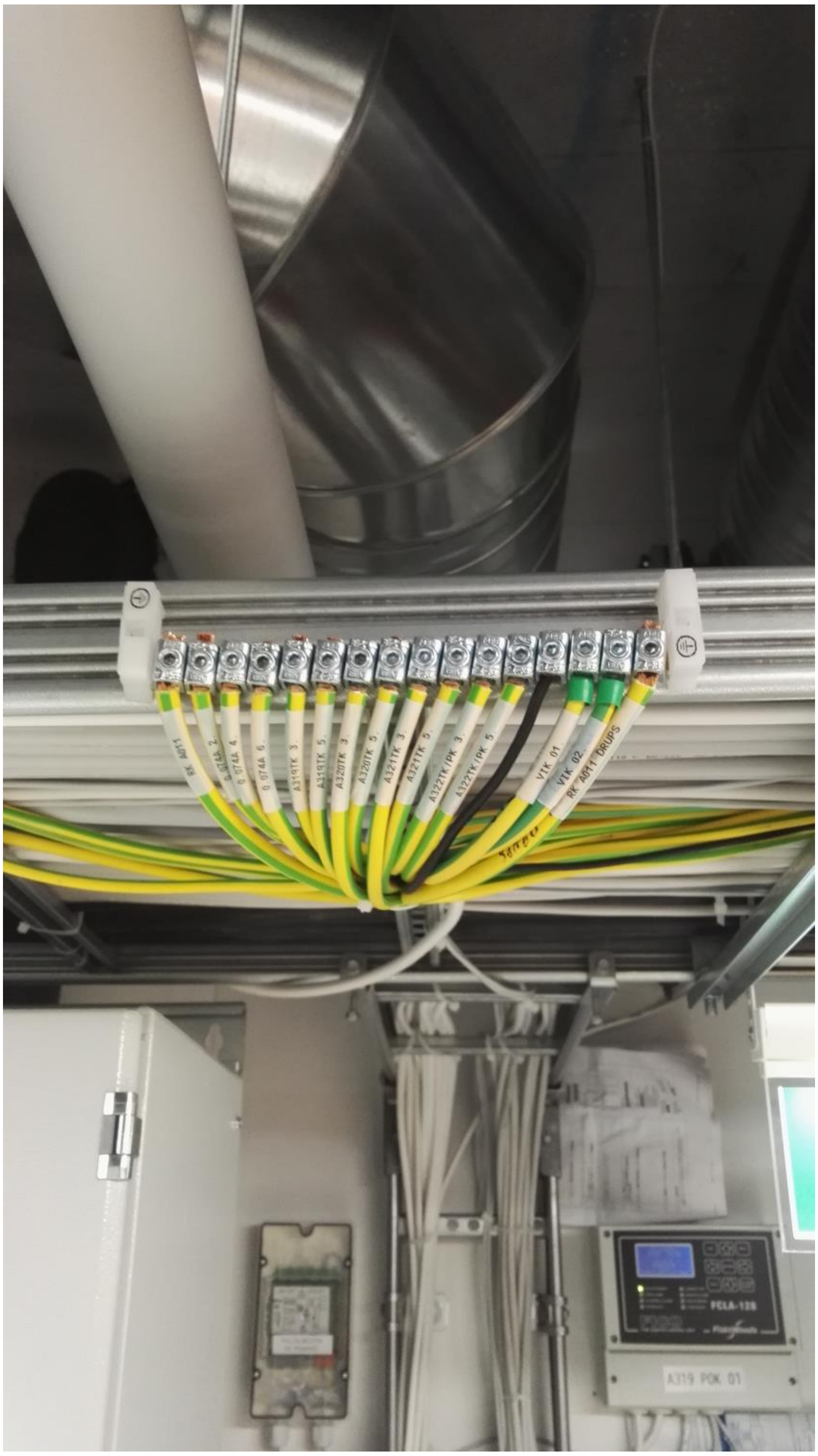
The lighting system needs to be made so that at least half of the lights are connected to the UPS system. All lights are installed in the emergency power system in operating rooms and the operating lights need to have the maximum of 0.5 second working time, which means the time that takes them to work again after blackout. Same working time concerns all the medical devices in the operating room. (SFS 6000-7-710. 2017, 7 - 8.)

In circuits where electricity is powering medical devices that are maintaining life and devices used for surgeries need to be connected to an IT- system. Each ICU room needs to have its own IT- system and it needs to have a monitoring device as regulated in the standard SFS-EN 61557-8, attachments A and B. The IT- system also needs to have an alarm system which informs the users in problem situations. This alarm system needs to be located so that the health care workers and the maintenance staff can monitor them continuously. In a problem situation the system needs to trigger an audible alarm. In other situations there need to be signal lights which show the current situation. A green light means that the IT- system is in a normal state and a yellow light means that the minimum rate of insulation resistance has been reached. (SFS 6000-7-710. 2017, 11.)

3.2 Grounding the system

In a hospital environment it is forbidden to use the TN-C- system. Instead of that the TN-S- system needs to be used in the whole installation, including the main switchboard. Resistance between wires, connections, potential equalization, electric sockets and fixed equipment is not allowed to get higher than 0.2 ohm. In the group 2 every room, or a room close to a group 2 room, needs to have an added potential equalization rail. That rail needs to be installed so that it can be seen and possibly disconnected easily. Below there is a picture of an installation tester that was used in the measurements (Picture 2). There is also an example of the equalization rail (Picture 3). (Maadoituskirja. 2007, 159-160.)

Picture 2. Multifunction installation tester. (Fluke 2018)



Picture 3. Potential equalization rail.

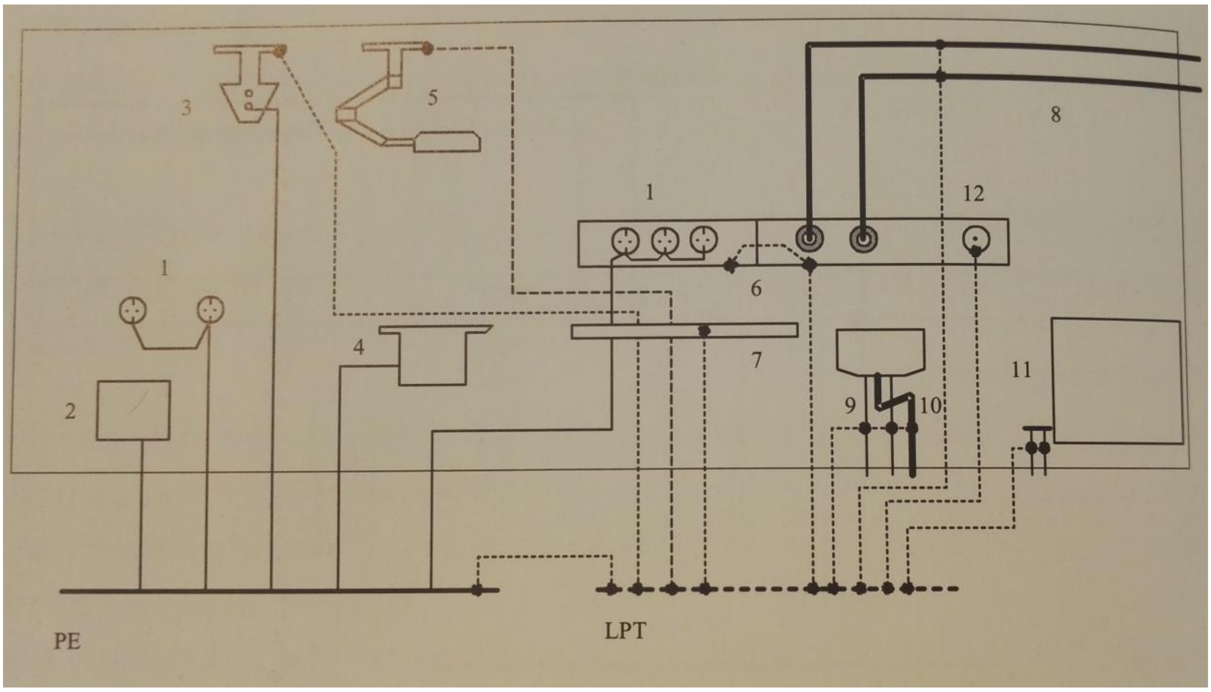
The purpose of these added potential equalization rails is to lower the potential differences between conductive parts. In group 2 each medical room needs to have its own additional potential equalization, which will be connected to an equalization rail, which will balance the potential differences between parts such as protective conductor, parts that conduct electricity, protection of interference fields, metal net of conducting floors and isolation transformer. (Maadoituskirja. 2007, 161.)

3.3 Recommendations

Potential equalization connections are isolated to avoid loop and stray currents. It also makes the measurements easier. The installations are recommended to be attached with screws. The cables should be marked with numbers or a wire address which can be seen in the diagrams. The equalization points are usually installed according to a star topology so that each point is connected with its individual 6 mm yellow-green copper wire to the equalization rail. It is possible to connect such objects as mirror light, sewer, water pipes or some other things like that to the same line to avoid too many cables in one equalization rail. (Maadoituskirja. 2007, 162.)

3.4 Inspections

The commissioning measurements need to be taken so that the added potential equalizations follow the regulations. Inside group 2 there should be used 10 A. testing currency. In group 1 the testing currency is 200 mA. Both inspection measurement results need to be written down. Inspections for these measurements need to be done every 6 years. (Maadoituskirja. 2007, 162.)



Picture 4. Example of the ground and potential equalization connections in a group 2 ICU room. (SFS 6000-7-710. 2017, 36)

Explanations for the numbers used in the picture above. At the end there is also an explanations for the PE and LPT.

1. sockets
2. solid installed equipment
3. roof object with its own sockets
4. electrically used operation table
5. operation light
6. wire route with connected potential equalization
7. accessory rail
8. hospital gas and pneumatic pipes
9. water pipes
10. sewer system

11. radiator

12. potential equation socket

PE. distribution protection center

LPT. added potential equalization rail

3.5 Detected problem

The SFS 6000-7-710 standard also regulates that in group 2 it is recommend that the continuity of the protective conductor should be monitored continuously. That was also the case in the studied ICU room, but long after the commissioning measurements had been taken, the main inspector found a problem with this monitoring system. The problem was basically that even though one part from the ground level was taken off the grid, the monitoring system said that everything was ok. After some time of searching for the reason for the problem, it was found inside the ICU room equipment, where the device vendor had used wrong kind of terminal blocks which were connected to ground. This was, of course, not allowed in this kind of a system so they needed to change all the terminal blocks to right kind of ones. This also meant that the commissioning measurements needed to be taken again for these rooms to get the right results. In the picture below you can see the devices where the wrong kind of blocks had been used (Picture 5).

Picture 5. Medical devices, where the problem appeared.

This problem happened in all the ICU rooms because vendor used the same blocks in every device so number or incorrect installations was between 15 to 20 ICU rooms.

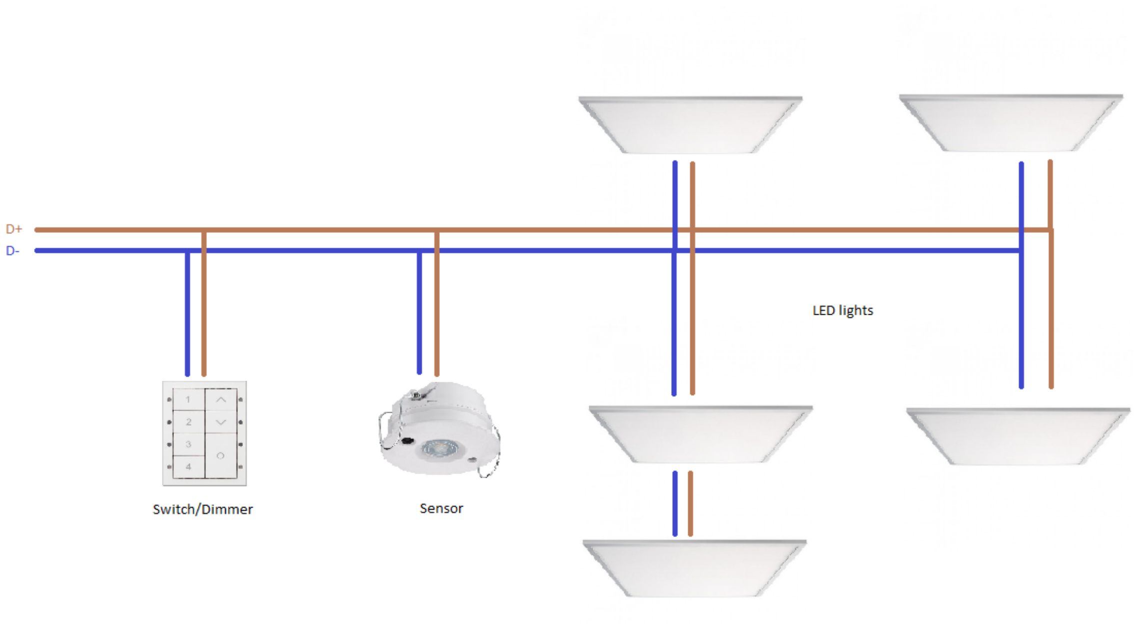
4 DALI-Technology

The lighting industry’s agreement to adopt a protocol for addressable control of luminaires has opened unlimited number of options for adjusting and controlling the artificial lighting in all applications. The DALI protocol has now been internationally standardized through the IEC. The DALI has new standardization which means that there are no longer any restrictions with the applications of this technology. Any source of a light can be controlled irrespective of whether they are installed in a numerous of targets.

DALI was produced by Tridonic with the operating manifacturers and control equipment. Nowadays, these manufacturers belong to the DALI Activity Group which suggest the use of DALI. The DALI standard was defined in the EN 60929 Annex E until 2009 but now it has been defined in the IEC 62386. This standard describes the differences between the various types of device. Because of that long time compatibility among the manufacturers is proofed and the DALI standard is ensured for a secure future. In addition, compatibility between products from different manufacturers is supported by a test procedure standardized by the DALI Activity Group. All products that carry the logo of the DALI Activity Group have passed this standardized test. (DALI manual. 2013, 4)

4.1 System

In the DALI- system the main idea is that every component in the lightning control system has its own address, this includes lights, sensors and switches. With their own address, installation is really simple and all components are just connected in parallel with each other. With latest versions of the DALI programs, options for adjusting lights has grown with wide selections where it is possible to control, for example the light temperature which is important feature especially in the hospital environment.



Picture 6. DALI wiring.

4.2 Features and benefits

As said, one of the biggest benefit with the DALI is that system network topology installation is really simple and wiring can be made in series, star of mixed form as can be seen in example wiring in picture above (Picture 6). Because of this there is no interference in the data communication. (DALI manual. 2013, 5.)

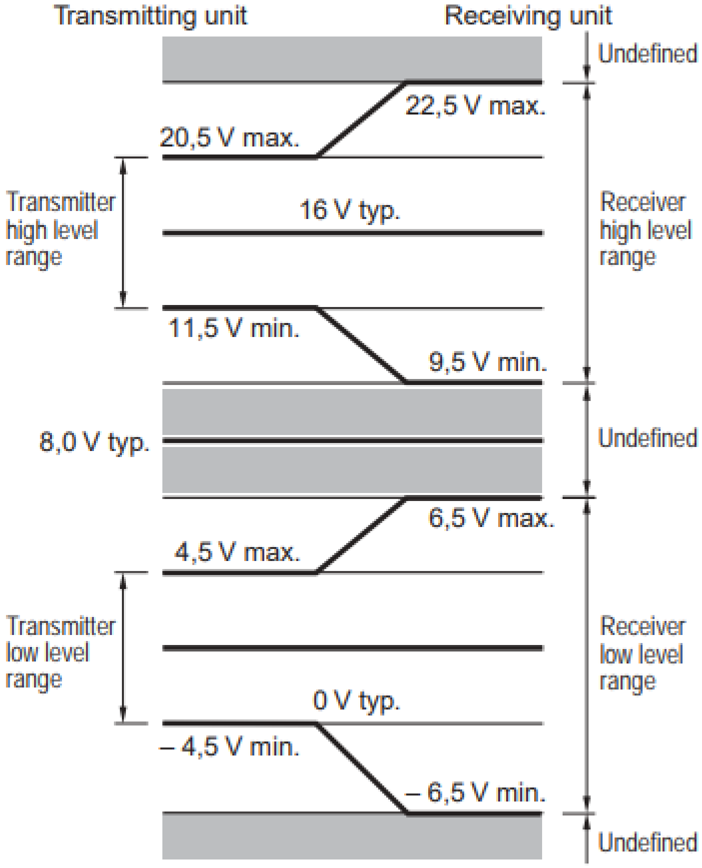
While installing the DALI, it does not matter how you connect polarity (+/-) to the control line. This will low the cases where connection is wrong so possible errors decrease. Whit the DALI it is possible to control either individual units or groups. Also simultaneous control through the broadcast addressing is possible which makes it ideal system to use in large systems like for example hospitals. Also because system has individual units with their own addresses, control device can give status messages like fault information or reports options by group or by unit. It is possible to adjust default values for operational tolerances to control the energy savings. Options for the emergency lightings are also possible by choosing specific dimming levels for certain group of lights. System costs are lower compared to older system 1-10V. Definition in the IEC 60929 allows combination with units from the different manufacturers. (DALI AG. 2001, 11-12.)

4.3 Tracking of the DALI

The Dali is not first kind of system for the light control. Compared to systems like LON and KNX it is still useful addition for the practical application of lightning controllers. Difference with these systems is that the DALI provides support for building control systems even in small installations in which other types of control systems could not be economical. The ComfortDIM concept is base for user friendly lighting solutions with huge flexibility for future expansion. It uses the DALI protocol which is standardized protocol that ensures maximum investment protection and future proofing. It also provides security of planning and high levels of flexibility even after set-up. (DALI manual. 2013, 7-8.)

4.4 Limits

In a one DALI channel maximum addresses is 64, option for 16 groups and 16 different controlling situations. The highest current for one channel is 250 mA. Data transfer rate for one channel is 1200 bits per second. The voltage range is between 9.5 V and 22.5 V on the receiving side. The highest voltage decrease of 2 V between sender and receiver. (DALI AG. 2001, 12, 17.)



Picture 7. Voltage ratings. (DALI AG. 2001, 18.)

4.5 Appurtenance

Supplies used in the ICU room were limited because regulations and the size of the room. Components used in the ICU rooms are introduced in programming section. These are other common components used in large projects like this hospital.

Picture 8. DALI PS. (DALI manual. 2013, 10.)

DALI power supply modules with a rated current of 200 mA. DALI PS module is suitable for installation in switching cabinets.

Picture 9. DALI multicontroller. (DALI manual. 2013, 11.)

DALI MC has four inputs which are possible to edit with a maximum of two options assigned to each input. Options are short, long press, toggle and relay mode.

Picture 10. DALI sequencer moduleDALI-SQM. (DALI-manual. 2013, 12.)

Sequencer module is sending broadcast addressed calls at intervals defined by user. When the last scene is done the cycle starts again.

Picture 11. DALI RC and IR smart Controller. (DALI-manual. 2013, 12.)

Remote controls for user friendly controls.

Picture 12. DALI USB. (DALI-manual. 2013, 13.)

The DALI USB enables parametrized installation with PC.

Picture 13. DALI 3-RM-C. (DALI-manual. 2013, 14.)

This relay module controller allows up to 3 contactors with 24 V DC to be controlled so that various loads can be control by DALI commands.

Picture 14. LCAI ECO one4all, C003. K350. (DALI-manual. 2013, 15.)

Led control gear in this series is dimmable constant current device with adjustable output current.

Picture 15. PCA ECO Ip xitec II. PCA ECO is digitally dimmable control gear for fluorescent lamps. (DALI-manual 2013, 16.)

Picture 16. PCIS outdoor DIM B011. Interface designed for outdoor applications. Depending on the lamp its load can dim down to 40% to save energy. (DALI-manual 2013, 17.)

Picture 17. TE one4all. (DALI-manual 2013, 17.)

Electronic safety transformer for low-voltage halogen lamps. It can enable halogen lamps with low voltage to be integrated in the DALI circuit directly. It can also fade them up and down.

Picture 18. DALI Repeater. (DALI-manual. 2013, 20.)

DALI Repeater is an amplifier module for repeat the DALI signal. With this repeater it is possible to increase the length of the control line from 300m to 600m.

Picture 19. DALI RM. (DALI-manual. 2013, 14.)

Relay module controller enables a contactor with 12/24 V or 230 V to be controlled so that various loads are possible to be switched with DALI commands. This controller was used in some parts of the construction site.

4.6 Difference between DALI and DALI 2

The second version of DALI called DALI 2 improves first version with now including the standardization of control devices. These includes for example light sensors, push buttons, occupancy sensors and relative input devices. Additional change with the DALI 2 is the grown scaling of applications like the standards of automated building. This has resulted in better interoperability between DALI compliant devices which brings many major benefits. These benefits are for example extended possibilities with the dimmable lights, more energy efficient lighting than before, even easier customization and lower installation costs. (GREAlpha. 2017.)

4.7 Next step

Although there are other new control technologies, the DALI protocol's reforms makes it essential for upcoming years. The standard has been showed improvements in speed reliability in latest innovations. Together with the modern LED lights it will progress to more efficient and adaptable system. (GREAlpha. 2017.)

5 Programming

For this thesis work, the company decided to choose one ICU room where DALI was programmed under the supervision of a co-worker who had the license needed for working with DALI. Before starting the programming it was necessary to get familiar with the exercise report which explained in detail how the lights should work in an ICU room. As a switch there was Helvar 135 W module which has 4 scenes, an off button, and up and down buttons for dimming the lights (Picture 20).

135 W
4 scenes,
Off + Up/Down

Picture 20. 135W Switch. (Helvar 2013)

There were also two impulse switches for situations where nurses should switch on or off all the lights in the room (Picture 21). One was located in the ICU room and another was in the toilet.

Picture 21. Impulse switch. (Schneider Electric 2008)

Picture 22. Sensor. (Helvar 2018)

There are no sensors in the main ICU room, but for the toilet next to the room there is Helvar PIR- sensor 311. This sensor was mostly used in the whole hospital constructions site (Picture 22).

Picture 23. Alfa G2. For LED- lights there was Alfa G2 with the power of 52 W and flux of 5200 lm. (Greenled 2018)

Picture 24. Helvar digidim routers

As the router there is DIGIDIM Router 910, which is used in the whole hospital (Picture 24). It is built to control large systems, which made it ideal for this construction site.

5.1 Exercise report for the ICU room

In the exercise report it was explained command for each situation you can choose by pressing modules buttons 1-4 and 0. Up and down buttons were used for adjusting dimming of present situation.

Situation 1: All lights are on in the ICU room and from the time you start action 1, the adjusting of the amount of light and color temperature (2700 – 6500 Kelvin) is happening dynamically during the day. In the morning the light is warm and the amount of light is rising from low to the highest point while turning cool and going back to low in the evening. Also the color temperature turns back to warm color in the evening. So situation 1 is basically the standard adjustment when the ICU room is not active.

Situation 2: All the lights are 100% on with the 1000 lux level for research and management actions in the room. In situation 2 the room is in an active state.

Situation 3: All the lights are on with the 300 lux level. This situation is the standard state for simple research and management actions.

Situation 4: All the lights are on with the 20 lux level. This situation is typical for night time.

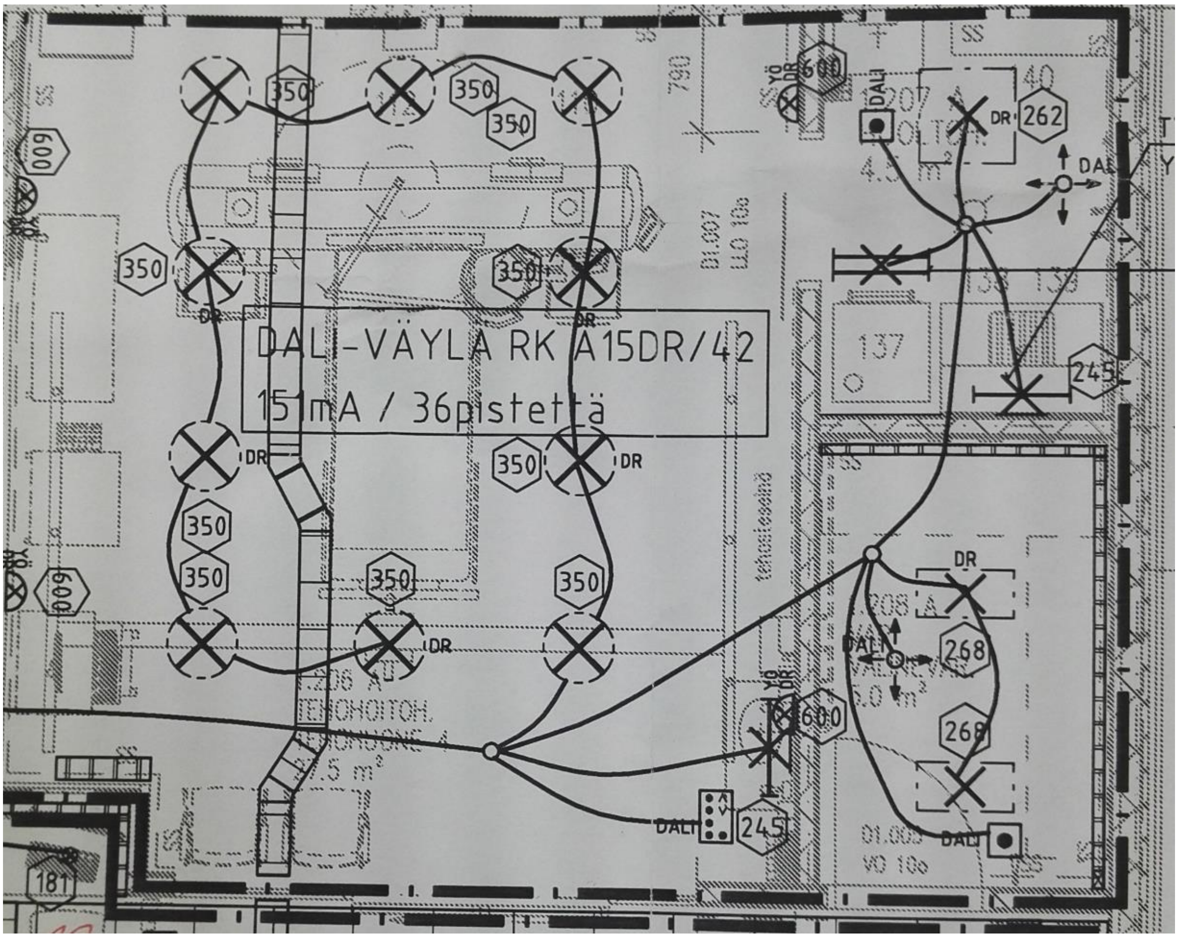
Situation 5 (0- button): All lights off.

If the user wants to switch all lights on or off manually, it can be done with the impulse switches. With this option levels of the lights are 100% while on.

For the toilet, where the lights are controlled with a sensor, the report said that after the sensor stops being in an active state, two lights on the walls turn off directly and the ceiling lights will dim for 5 minutes to the level of 20% and turn off completely after 15 minutes.

In the picture below you can see the electrical drawing of the room where you can see the DALI components and wiring. The little room in bottom right is not a part of the thesis exercise although it is in the same circle with the ICU room. The four lights in every corner of the room are night lights which are controlled manually from outside the room so they are not a part of the DALI system either.

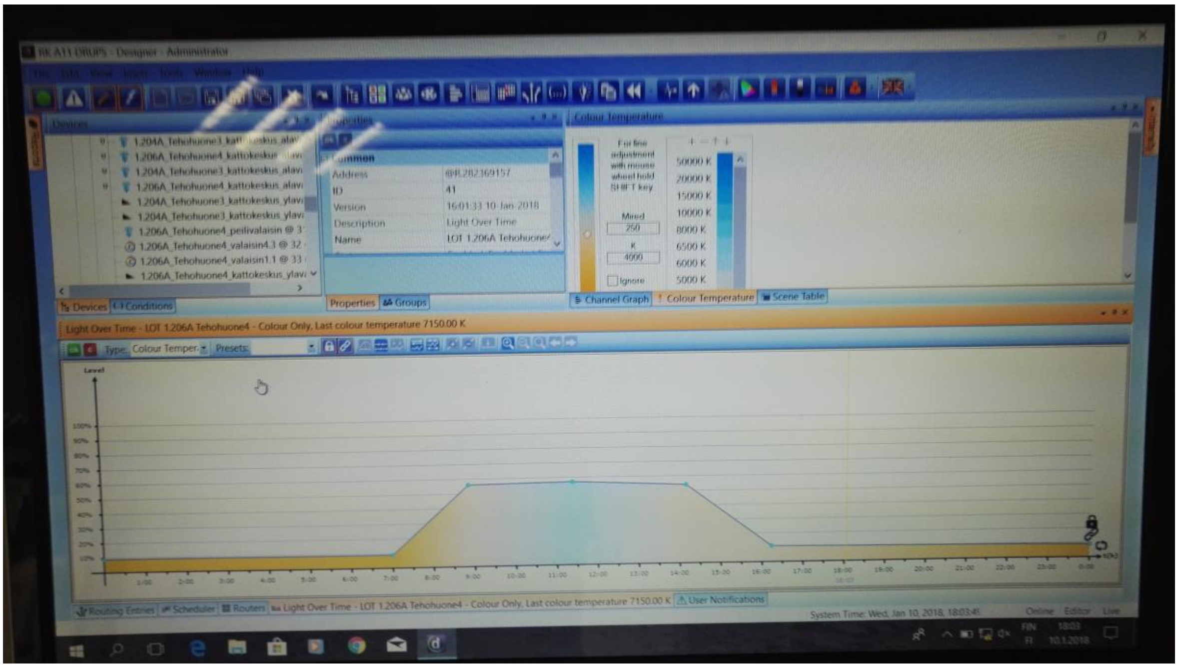
The DR marking next to the couple lights stands for a generator, which means electricity generated during blackouts and other problem situations.



Picture 25. Electrical drawing for DALI

5.2 Importing the program to the system

For programming the latest version of Helvar Designer version 4.2.50 – 10/2016 was used. It was ideal for such a work environment as a hospital because it offers great possibilities for controlling light temperatures with a graphic layout which can be seen in the picture below (Picture 26). This made fine adjusting simple and easy. In the picture it can be seen that only the situation 1 needed adjusting. At 7:00 in the morning the amount of light starts to rise and the warm color starts to turn cool. Around 9:00 the light level is at its peak and stays there until 14:00 when it starts to get lower and the color turns warm again.



Picture 26. Helvar designer

The programming was finished eventually without any bigger problems. Only finding the correct lights caused some difficulties in the beginning. The only problem with DALI is that when every component has its own address all the components are mixed when Designer or some other program is connected to the circle. So the first thing to do is to locate the components and give them real names. For example Light 1 or Switch 1 and so on. Luckily the Designer program has a feature which makes it possible to blink one address at a time so that it is easier to locate all the components one by one.

6 Finished construction site

When intensive care unit is ready to be taken in use in April 2018 it is first of a kind in Finland. This is the first time when patients have single rooms with all special care and control units in the same space. Earlier patients in a room have been separated only with a curtain between them. The new single rooms increase privacy, provide better sleep at night and allow visitors regardless of the situation with other patients in the unit. Private rooms also reduce the spread of infections and cut down possible malpractices. This kind of arrangement also helps medical staff with their work and communication. The doctor can be consulted faster and there is no need to move the patient to other units. (Yle. 2018.)

Picture 27. ICU- room with a landscape photo wall. (Yle. 2018.)

Another difference compared to old hospitals is that there is natural light in the ICU room which is made possible by DALI programming. Natural light supports patients' adaptation and helps to alleviate fear and stress. Rooms which do not have windows with a landscape view are decorated with a wall-sized picture of a traditional countryside (Picture 27). (Yle. 2018.)

BIBLIOGRAPHY

Tiainen, S. 2007. Erikoistilojen maadoitukset ja potentiaalintasaukset. In: Maadoituskirja E. Tiainen (ed.). Espoo: Sähkö- ja teleurakoitsijaliitto STUL ry.

SFS 6000-7-710. 2017. Pienjännitesähköasennukset. Osa 7-710: Erikoistilojen ja asennusten vaatimukset. Lääkintätila. [Web document]. SESKO ry [Ref. 29 March 2018].

DALI AG. 2001. DALI manual. [Web document]. DALI. [Ref. 16 March 2018]. Available at: http://www.dali-ag.org/fileadmin/user_upload/pdf/news-service/brochures/DALI_Manual_engl.pdf

DALI manual. 2013. DALI manual. [Web document]. Tridonic. [Ref. 22 March 2018]. Available at: http://www.tridonic.se/it/download/technical/DALI-manual_en.pdf

Diginet. 2017. [Online publication]. An Introduction To DALI 2017. [Ref. 17 March 2018]. Available at: http://www.diginet.net.au/an-introduction-to-dali-2017/

Fluke. 2018. Fluke corporation. [Online publication]. Fluke 1654B Multifunction Installation Tester. [Ref. 26 March 2018]. Available at: http://www.fluke.com/fluke/m2en/installation-testers/fluke-1654b-multifunction-installation-tester.htm?pid=72324

GREAlpha. 2017. GRE ALPHA LTD. [Online publication]. DALI VS. DALI 2. [Ref. 28 March 2018]. Available at: https://grealpha.com/news/dali-vs-dali-2-why-you-must-know-the-difference/

Helvar. 2013. [Online publication]. Helvar modular panels. [Ref. 17 March 2018]. Available at:

https://www.helvar.com/media/pd/2017/20170227/13xx_DATASHEET_FI.pdf

Schneider Electric. 2008. [Online publication]. Merten by Schneider Electric. [Ref. 17 March 2018]. Available at: http://www.merten.com/M-Smart.234.0.html

Helvar. 2018. [Online publication]. 311 Kattoasenteinen PIR- tunnistin. [Ref. 17 March 2018]. Available at: https://www.helvar.com/fi/tuotteet/311/

Greenled. No date available. [Online publication] ALFA G2. [Ref. 17 March 2018]. Available at: https://greenled.fi/led-valaisimet/tuote/alfa-g2/

Yle. 2018. [Online publication]. Yhden hengen potilashuoneet käyttöön tehohoidossa Seinäjoella. [Ref. 25 March 2018]. Available at: https://yle.fi/uutiset/3-10146003