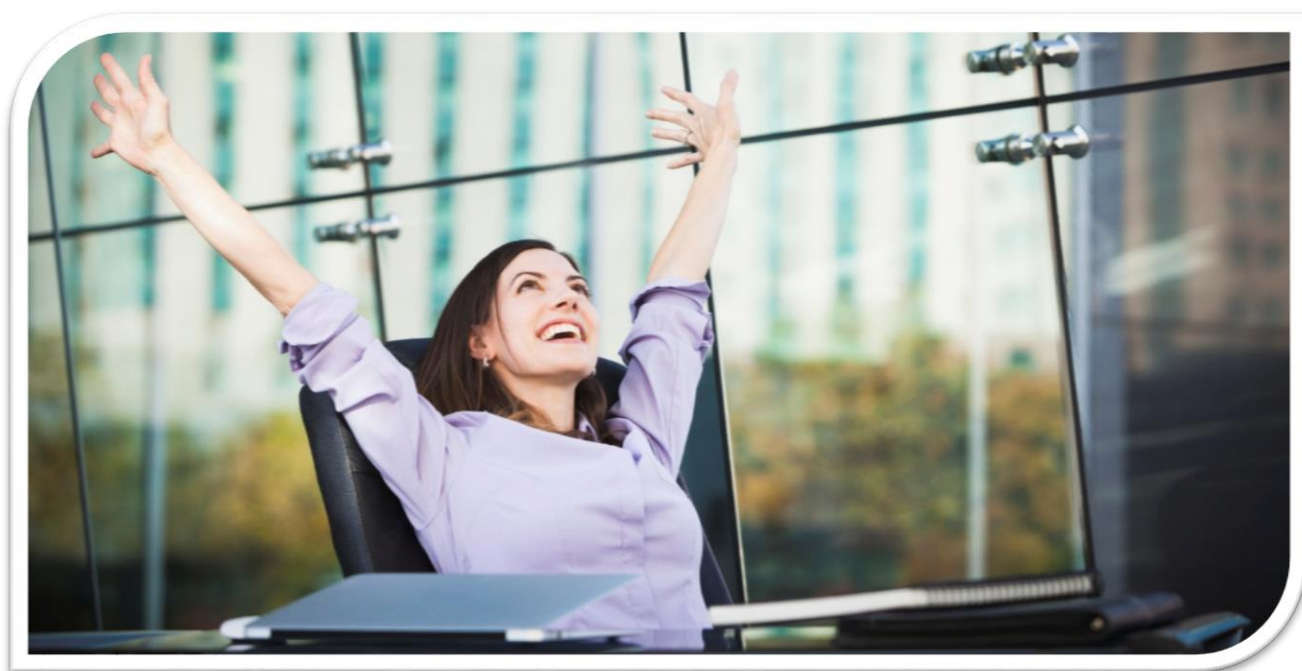


Application note

Tunable white

For KNX DALI gateway REG-K/1/16(64)/IP1



Safety Information

Important Information



Read these instructions carefully before trying to install, configure, or operate this software. The following special messages may appear throughout this bulletin or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of either symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, can result in death or serious injury.

CAUTION

CAUTION indicates a potentially hazardous situation which, if not avoided, can result in minor or moderate injury.

NOTICE

NOTICE is used to address practices not related to physical injury. The safety alert symbol shall not be used with this signal word.

Please Note

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction, installation, and operation of electrical equipment and has received safety training to recognize and avoid the hazards involved.

Safety Precautions

WARNING

HAZARD OF INCORRECT INFORMATION

- Do not incorrectly configure the software, as this can lead to incorrect reports and/or data results.
- Do not base your maintenance or service actions solely on messages and information displayed by the software.
- Do not rely solely on software messages and reports to determine if the system is functioning correctly or meeting all applicable standards and requirements.
- Consider the implications of unanticipated transmission delays or failures of communications links.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

The information provided in this documentation contains general descriptions and/or technical characteristics of the performance of the products contained herein. This documentation is not intended as a substitute for and is not to be used for determining suitability or reliability of these products for specific user applications. It is the duty of any such user or integrator to perform the appropriate and complete risk analysis, evaluation and testing of the products with respect to the relevant specific application or use thereof. Neither Schneider Electric nor any of its affiliates or subsidiaries shall be responsible or liable for misuse of the information that is contained herein. If you have any suggestions for improvements or amendments or have found errors in this publication, please notify us.

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All pertinent state, regional, and local safety regulations must be observed when installing and using this product. For reasons of safety and to help ensure compliance with documented system data, only the manufacturer should perform repairs to components.

When devices are used for applications with technical safety requirements, the relevant instructions must be followed.

Failure to use Schneider Electric software or approved software with our hardware products may result in injury, harm, or improper operating results.

Failure to observe this information can result in injury or equipment damage.

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Competencies

This document is intended for readers who have been trained on KNX/DALI systems. The integration should not be attempted by someone who is new to the installation of either product. It is mandatory to have knowledge of KNX commissioning through KNX ETS software. Optional knowledge of basic Wiser for KNX configuration in the scope described in the Product manual if Wiser for KNX is used.

1 Introduction

This Application Note (AN) describes how to expand the possibilities of LED luminaries with tunable white feature to improve health or wellbeing and to increase employees' work efficiency.

Typical user of this AN is a manager of a modern company who wants to:

- Improve work efficiency of his employees
- Support employees' good mood and happiness
- Enhance employees' concentration
- Raise safety level

A glossary is available in the appendix chapter of this document. Please refer to it whenever necessary.

1.1 System prerequisites

Commercial number	Device ID	Description
MTN6725-0001	KNX DALI gateway REG-K/1/16(64)/64/IP1	KNX DALI gateway with firmware 1.3.0
MNT630919	KNX ARGUS Presence with light control + IR	KNX ARGUS Presence with light control and IR receiver polar white
MNT630960	KNX ARGUS Presence with light control + IR	KNX ARGUS Presence with light control and IR receiver aluminium
MTN63xxxx	KNX ARGUS Presence 180/2.20 m flush-mounted, System M	KNX ARGUS presence detector in System M design
ALB4xxxx	KNX Movement detector 180	Basic KNX Movement detector, white or aluminium
MGU3.xxx.xx	UNICA KNX – Movement detector – 230 VAC – 2m	Basic KNX Movement detector in UNICA design
MGU5.xxx.xx	UNICA KNX – Movement detector – 230 VAC – 2m	Basic KNX Movement detector in UNICA design
Optional		
LSS100100	Wiser for KNX	KNX IP logic controller
LSS100200	spaceLYnk	KNX IP logic controller
MTN677290	KNX timer REG-K	KNX timer with DCF77 control
MTN6606-0008	KNX Year time switch REG-K/8/800	KNX timer with basic time scheduler

Table 1: Product references

2 Human centric lighting

“Human centric lighting” is a new term what emphasizes light as a main factor influencing human behavior in his life space. It simultaneously considers our requirements for good vision as well as our emotional and biological needs.

Claiming that better lighting can improve health is a big supposition. That said it is not outlandish to state that carefully designed lighting can aid or even correct, circadian rhythms in human beings.

The circadian rhythm is a 24-hour cycle that tells our bodies when to sleep and regulates many other physiological processes. This internal body clock is affected by environmental cues, like sunlight and temperature. When one's circadian rhythm is disrupted, sleeping and eating patterns can run amok. A growing body of research is examining the adverse health effects a disrupted circadian rhythm can have, like increasing the chances of cardiovascular events, obesity, and a correlation with neurological problems like depression and bipolar disorder.

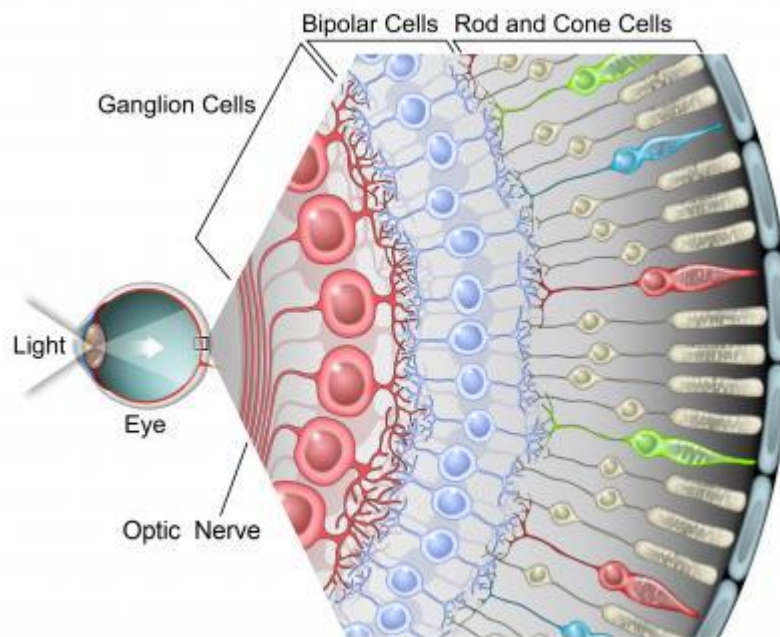
Over time, people have evolved in harmony with the Earth's natural lighting cycle, which has low light levels and low correlated color temperatures (CCT) in the early morning, high light levels and high CCTs at midday, low light levels and low CCTs during evening, and extremely low light levels and a medium CCT under moonlight. These varying light levels are at the heart of a human being's 24-hour internal clock, otherwise defined as circadian rhythm.

Until 200 years ago, 90% of our active time was spent outside. Now most of us spend 90% of our time indoors with electric lighting. While we're at work, our lighting is usually set at one light level with a constant CCT—this is not consistent with circadian rhythms. Without regular and direct exposure to such dynamic lighting, the circadian rhythm can be disrupted, which could lead to health issues.

During morning hours, with a natural circadian rhythm the human organism produces the hormone cortisol which stimulates metabolism. Its concentration in blood reaches its maximum at about 9 a.m., then during the rest of day its content continually decreases. Melatonin (hormone of sleep) is produced also during the night and its concentration in the human organism culminates at 3 a.m. Proper level and color of light can stimulate/decrease level of above mentioned hormones.

2.1 Tunable white mixture

Revealing the function of the third type of receptors in human eye (ganglion cells) belong among the biggest discoveries of the modern science. They can affect the production of melatonin, a hormone controlling the circadian rhythm of people. These receptors are sensitive to that part of the light spectrum which has the wavelength of 464 nanometers, i.e. the blue light.



Picture 1: Ganglion cells

This knowledge became the basis for the luminaries' producers – the lighting fixtures with a proper proportion of the blue part of the artificial lighting spectrum can affect the human activity effectively. From point of view of evolution, the blue light signals if it is day or night to human organism. In the space with a limited access of daylight, its presence is a key factor that significantly contributes to the feeling people's wellbeing. Its shortage stimulates the production of melatonin and signals that it is time for a rest and induces an increased need for sleep.

Persons will feel better thanks to:

- The approach to the natural daily cycle
- Hormones level can be stimulated by using a suitable temperature of light
- Remove the problems with seasonal affective disorder (SAD) in winter

What is the CCT

The correlated color temperature (CCT) is a specification of the color appearance of the light emitted by a lamp. It relates its color to the color of light from a reference source when heated to a temperature, measured in degrees Kelvin (K). The CCT rating for a lamp is a general "warmth" or "coolness" measure of its appearance. However, opposite to the temperature scale, lamps with a CCT rating below 3200 K are usually considered "warm" sources, while those with a CCT above 4000 K are usually considered "cool" in appearance.

Minimum lighting requirements recommended by EN 12464

European standard EN 12 464 describes quality aspects of lighting of workstations and their direct environment. Below table specifies minimal lighting requirements in accordance with the type of work and the visual task.

NOTE: See glossary at the end of this document for abbreviations explanation.

Type of area, task or activity	E _m [lx]	UGR	U0	CRI	Specific requirements
Offices					
Filing, copying, etc.	300	19	0.4	80	
Writing, typing, reading, data processing	500	19	0.6	80	VDU work
Technical drawing	750	16	0.7	80	
CAD work stations	500	19	0.6	80	VDU work
Conference and meeting rooms	500	19	0.6	80	Lighting should be controllable
Reception desk	300	22	0.6	80	
Archives	200	25	0.4	80	
Public areas					
Entrance halls	100	22	0.4	80	UGR only if applicable
Cloakrooms	200	25	0.4	80	
Waiting rooms	200	22	0.4	80	
Reception/cashier desk, porters desk	300	22	0.4	80	
Traffic zones inside buildings					
Circulation areas and corridors	100	28	0.4	40	<ol style="list-style-type: none"> 1. Illuminance at floor level 2. Ra and UGR like adjacent areas 3. 150 lx if there are vehicles in the route 4. The lighting of exits and entrance shall be providing a transition zone to avoid sudden changes in illuminance between inside and outside by day or night 5. Care should be taken to avoid glare to drivers and pedestrians
Stairs, escalators	100	25	0.4	40	Requires enhanced contrast on the steps
Elevators, lifts	100	25	0.4	40	Light level in front of the lift should be at least E _m = 200 lx
Loading ramps/bays	150	25	0.4	40	
Other rooms					
Canteens	200	22	0.4	80	

Kitchen	500	22	0.6	80	
Break rooms	100	22	0.4	80	
Rooms for physical exercises	300	22	0.4	80	
Cloakrooms, washrooms, bathrooms, toilets	200	25	0.4	80	In each individual toilet if these are fully closed
Sick bay	500	19	0.6	80	
Rooms for medical attention	500	16	0.6	90	4 000 K <TCP< 5 000 K
Plant rooms, switch gear places	200	25	0.4	60	
Mail rooms, telephone switch places	500	19	0.6	80	
Store and stockrooms	100	25	0.4	60	200 lx if continuously occupied
Dispatch packing handling areas	300	25	0.6	60	
Places of public assembly – Public car parks					
Traffic lanes	75	25	0.4	40	<ol style="list-style-type: none"> 1. Illuminances at floor level 2. Safety colors shall be recognizable
Parking areas	75	-	0.4	40	<ol style="list-style-type: none"> 1. Illuminances at floor level 2. Safety colors shall be recognizable 3. A high vertical illuminance increases recognition of people faces and therefore the feeling safety
In/out ramps (at nights)	75	25	0.4	40	<ol style="list-style-type: none"> 1. Illuminances at floor level 2. Safety colors shall be recognizable
In/out ramps (during the day)	300	25	0.4	40	<ol style="list-style-type: none"> 3. Illuminances at floor level 4. Safety colors shall be recognizable
Ticket office	300	19	0.6	80	<ol style="list-style-type: none"> 1. Reflection in the window shall be avoided 2. Glare from outside shall be prevented

Table 2: Minimum lighting requirements

2.2 Tunable white stimulation

The absence of the blue light in the spectrum can lead to reduced performance and disruption of the circadian rhythm of the human organism. On the contrary, its correct ratio in the light spectrum from an artificial light source can stimulate the performance efficiency and positively affect the employees' feeling of wellbeing. From this point of view especially the workplaces with a three-shift operation represent a challenge where enough of blue light can adjust the biorhythm of those employees who are working during the night shifts.

Warm colors with reduced blue part of visible light spectrum are calming and helping to fall asleep. Because without blue light of the specified wavelength the body starts producing melatonin, which brings about lower attention and makes people more prone to sleep.

Typical use cases of tunable white lamps in various segments:

- Education - Decreased fatigue and shortened wake-up times extended and deepened concentration periods.
- Office - Increased employee motivation and commitment, individualized maximization of concentration and energy.
- Industrial - Improved output and error rates of repetitive work steps, biorhythm adjustment for nightshift workers.
- Wholesale and retail - Daylight-compatible product presentations, extended daytime in shopping malls. Inviting a customer to buy goods and suggesting freshness and positive mood.
- Hospital - Enhanced drug efficiency, e.g., of antidepressants, reduced therapy times and capacity requirements.
- Hospitality - Colored accentuation of architecture and design, "Mood support" in wellness and dining areas.
- Residential - Prevention of depression and bad temper, integrated wake-up and relaxation support.

2.2.1 Use cases

Use case: Office

This curve sample serves for office use with working hours from 8:00 a.m. – 6:00 p.m. Tunable white lamp emits a blue accented light around 6000 K in the morning. By noon the tunable white lamp changes to orange tone around 3000 K. About 45 minutes later, there is a blue accented peak around 6500 K that energizes after lunch. Again, there is the light temperature drop to 3500 K. The 3rd peak around 6500 K represents happy hour. It provides an alertness boost ahead of the journey home. For people who working late, warm white around 4000 K creates “homely” atmosphere.

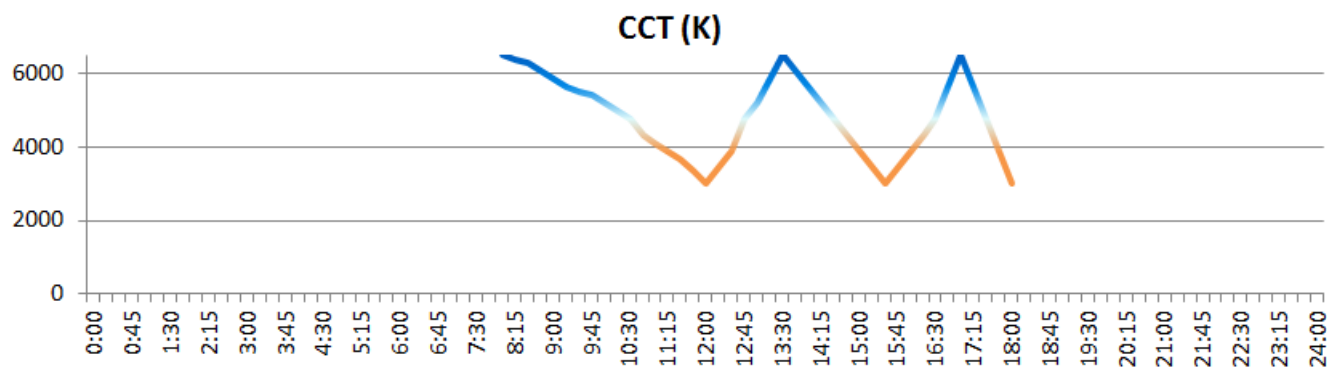


Table 3: Office curve

Use case: Retail and Industry

This curve serves for wholesale and retail. It will be highly demanded in jewelry stores as gold, silver and gems look well and more expensive under the cold light around 4500 – 6500 K. Bakers may follow same patterns but with lower CCT about 3000 – 4500K. It is also suitable for assembly hall with three-shift operation. Such lighting increases attention and safety and reduces errors.

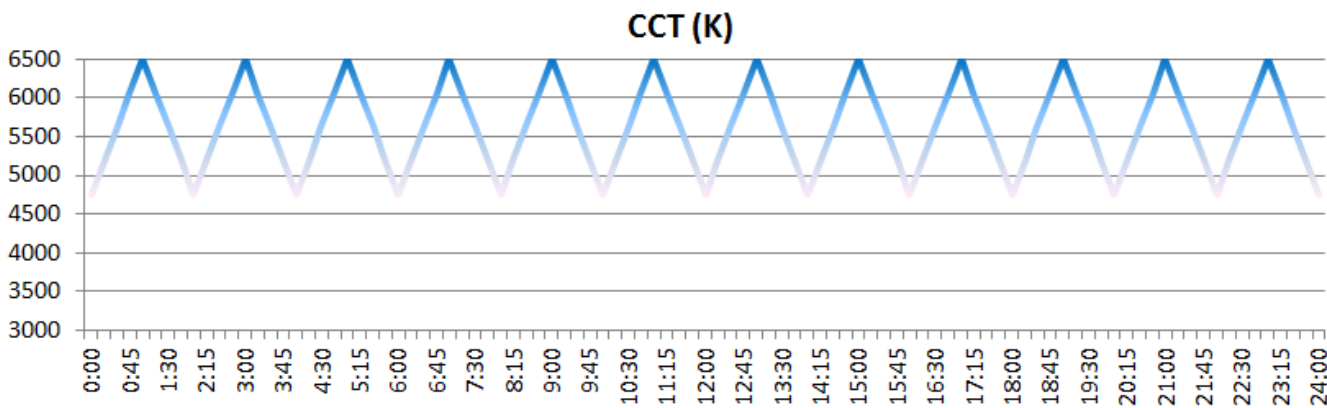


Table 4: Retail and industry curve

Use case: Residential

This curve is suitable for residential simulating daylight. It is particularly suited to the living rooms and bedrooms. In the morning, the light tones around 4000 K are soft and comfortable for eyes. At noon light with blue accent around 6000 K energizes. In the evening, warm tones around 4000 K help to fall asleep. This curve sample can also serve for florists, because it is like natural daylight.

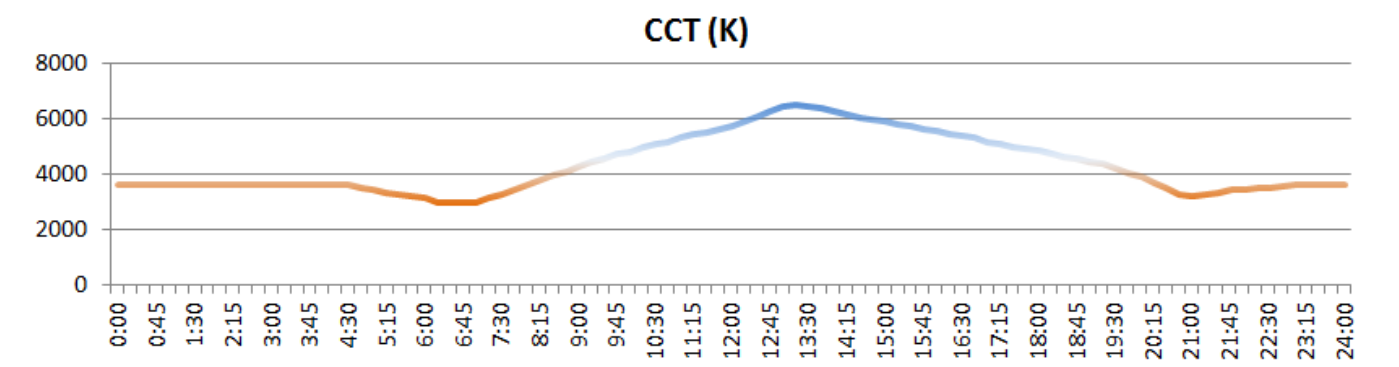


Table 5: Residential curve

2.2.2 Tunable white brightness dependence

To determine change of the brightness in dependence on the color of the light we used KNX ARGUS Presence with light control, OMS lamp AVIOR TRACK with Tunable white and KNX DALI gateway REG-K / 1/16 (64) / 64 / IP1. We found out that there is only a small relationship between light color and brightness. The brightness depends on chromaticity. The dependence is almost linear. Compensation can be performed with PIR detector with constant light functionality. The measurements were carried out in real conditions under negligible natural light deviation. **Measurement results show that change of the measured brightness due to different CCT is smaller than the minimum adjustable hysteresis of the PIR detector (10%) and therefore the CCT influence is not taken in account.**

Brightness dependence on CCT

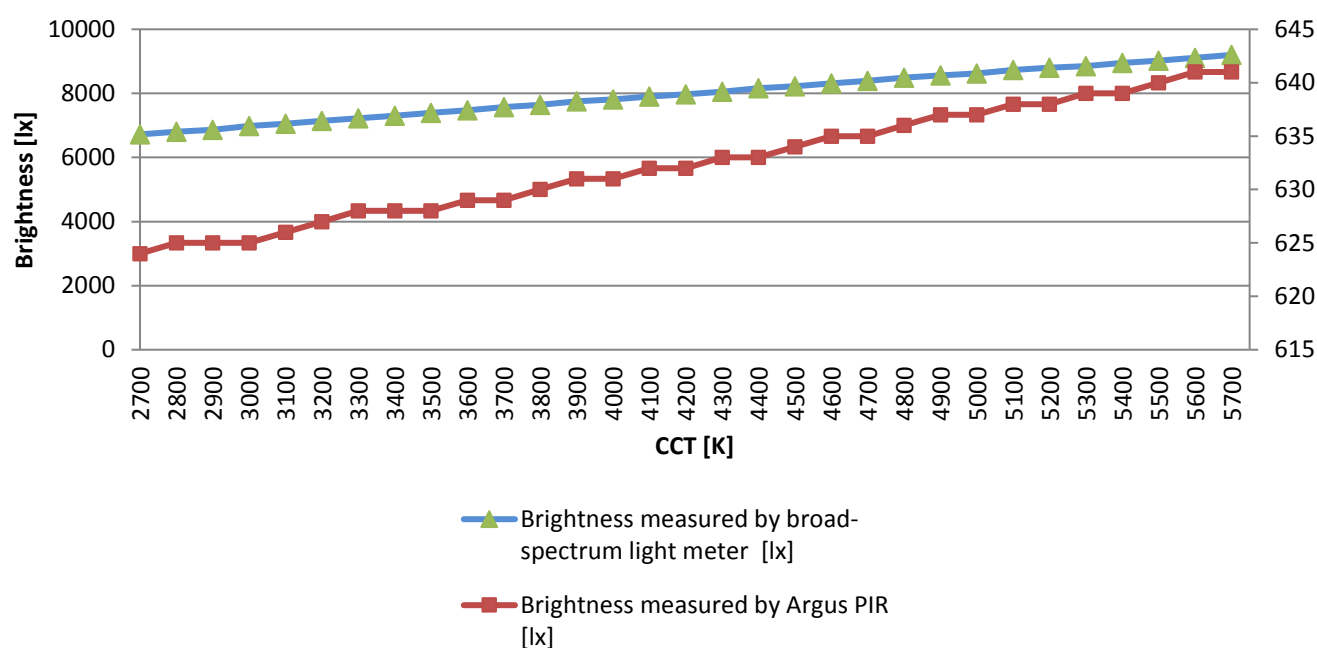


Table 6: Brightness and chromaticity dependence

2.3 RGBW

RGBW is a powerful feature to point out unique properties of marketed products. The RGBW mixing uses the simple theory of additive color mixing: the intersection of the colors creates new secondary colors. Different light combinations support higher sell price of products.

- Baked goods and cheese look better under warm lighting around gold tone than under cold colors
- Jewels show their best in icy tones
- Meat and convenience food look best if presented in reddish light
- Support seasonal goods with appropriate background illumination



Picture 2: RGBW possibilities

2.3.1 IEC 62386-209:2011 standard

IEC 62386-209:2011 standard specifies a protocol and test procedures for the control by digital signals of electronic control gear that can change light colors. This publication is to be read in conjunction with IEC 62386-101:2009 and IEC 62386-102:2009.

- **color type**

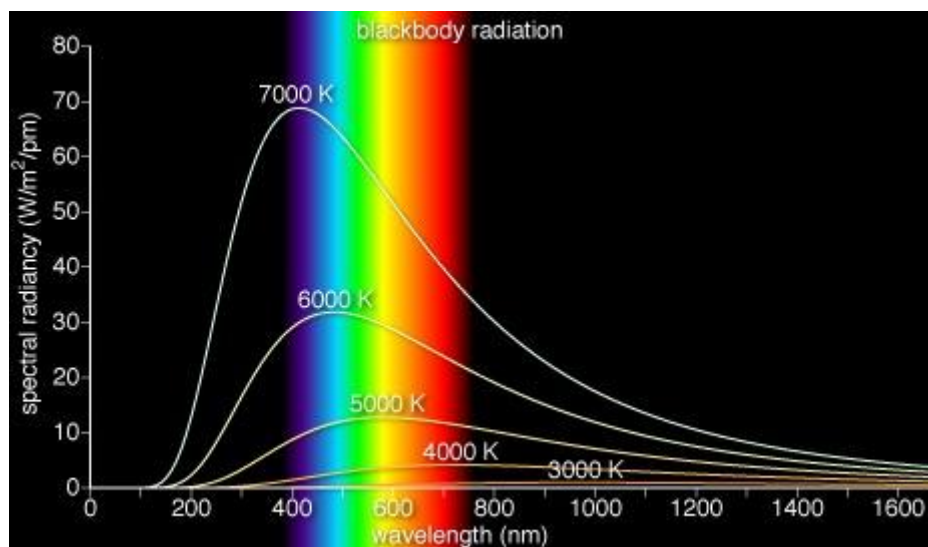
Mechanism how to set a color in an appropriate way

- **xy chromaticity**

Color type, representing the color matching functions of a standard observer according to the Commission Internationale de L'Eclairage (CIE) basis for colorimetry of 1931

- **color temperature T_c**

Color type, representing the color of a light source that matches the temperature of a black body radiator per Planck's law



Picture 3: Planck's law curve

- **correlated color temperature CCT**

Color temperature of the Planckian radiator whose perceived color most closely resembles that of the given stimulus at the same brightness and under specified viewing conditions (from CIE 17-4:1987)

- **primary N**

Color type, representing a single output channel of the gear

- **RGBWAF**

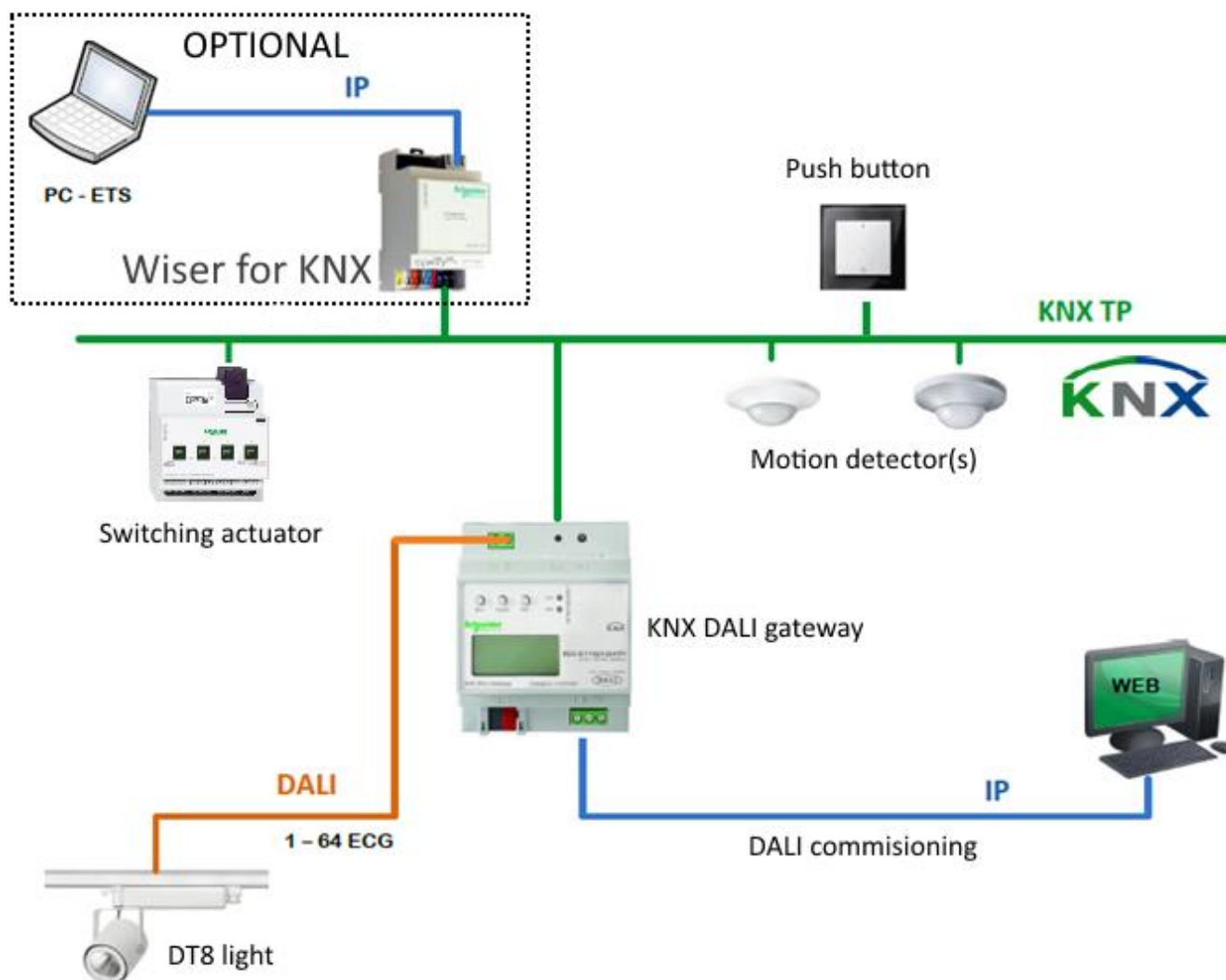
Color type, in which the output channels of the control gear can be associated with red (R), green (G), blue (B), white (W), amber (A) or free color (F)

- **RGBWAF dimlevel**

Term that specifies the set of red dimlevel, green dimlevel, blue dimlevel, white dimlevel, amber dimlevel and freecolor dimlevel

The Standard IEC 62386-209:2011 is available at <https://webstore.iec.ch/publication/6965>.

3 Architecture



Picture 4: Typical topology

Note that Wiser for KNX device can be used as for visualization purposes as well as for KNX diagnostic and control. Proper setting of PIR detectors in the ETS software is mandatory, because Wiser for KNX is receiving all data from KNX bus communication.

Time function in Wiser for KNX can be optionally replaced by similar function in following devices - MTN6606-0008 Year time switch or MTN677290 KNX timer.

NOTE: If date& time are updated by KNX synchronization, (i.e. 2:00 -> 3:00 am switch to summer time) commands in between this time frame are not executed, a switch to winter time will repeat the commands between 2:00 and 3:00.

4 KNX/DALI gateway

4.1 Benefits of new firmware version for DALI gateway

The new firmware version includes new possibilities such as tunable white, color control or possibility to switch off the password for the web server (admin and user).

There is no need to change hardware, just upgrade the software.

4.2 Checking firmware version of DALI gateway

RGB/tunable white templates are available only in the newest version of the firmware. Check the firmware version.

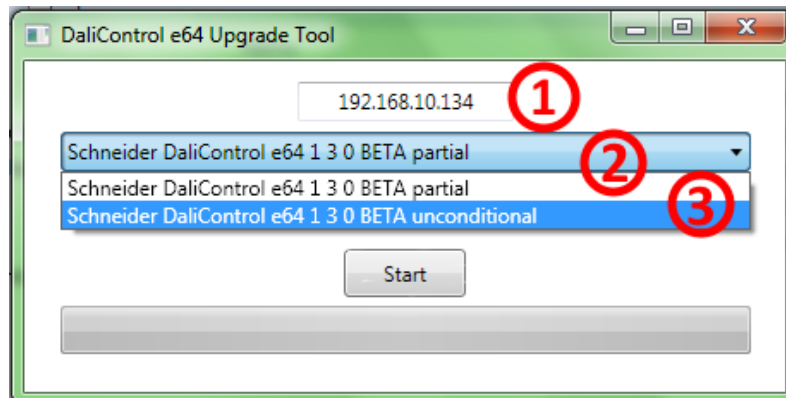
- Login to DALI gateway (default login/password is admin; admin)
- Click on “I” icon (1)
- The actual firmware version at the bottom (2)



Picture 5: DALI software version

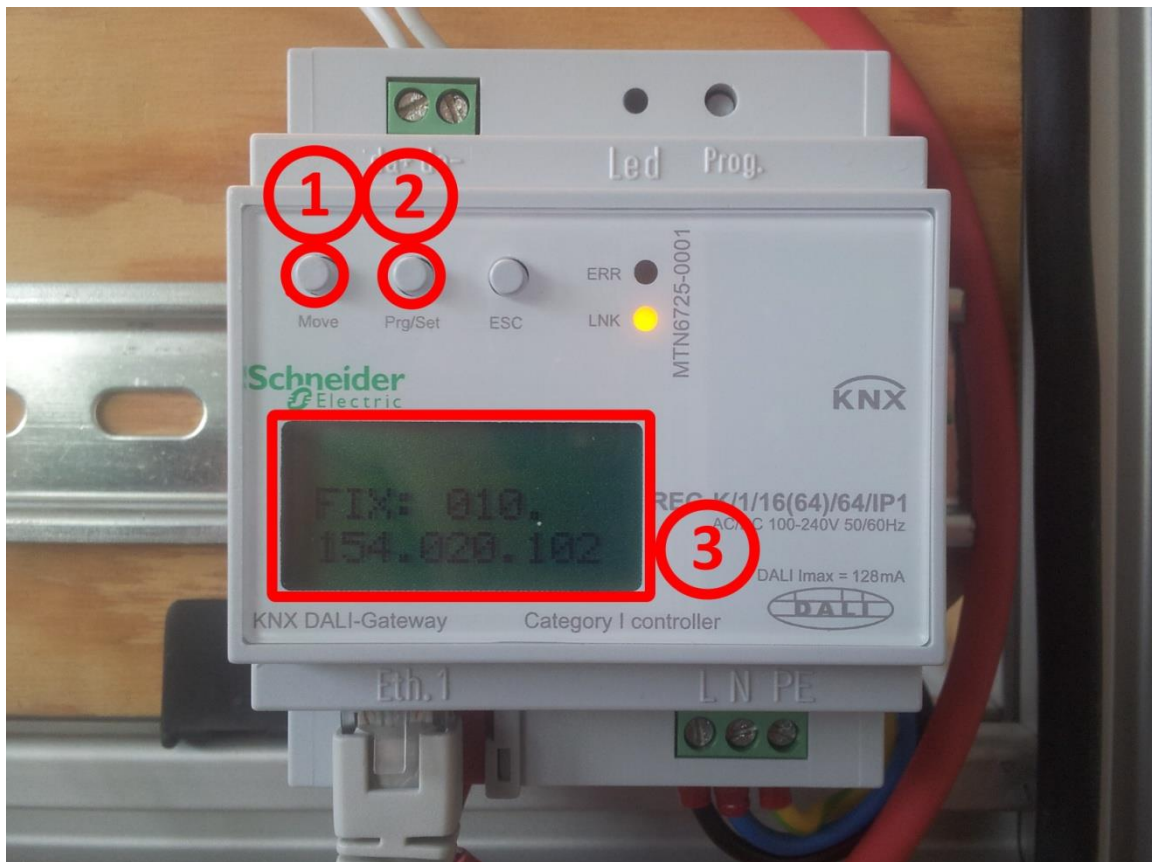
4.3 DALI gateway firmware upgrade

Upgrade the DALI gateway to version 1.3.0 with upgrade tool that is attached to this AN. Run the upgrade application. Double click to IP address (1) and write IP address of the DALI gateway that you want to upgrade. Select the type of installation. If you have already existing project and you want to preserve it, select partial (2). Unconditional option (3) will erase all data in existing project.



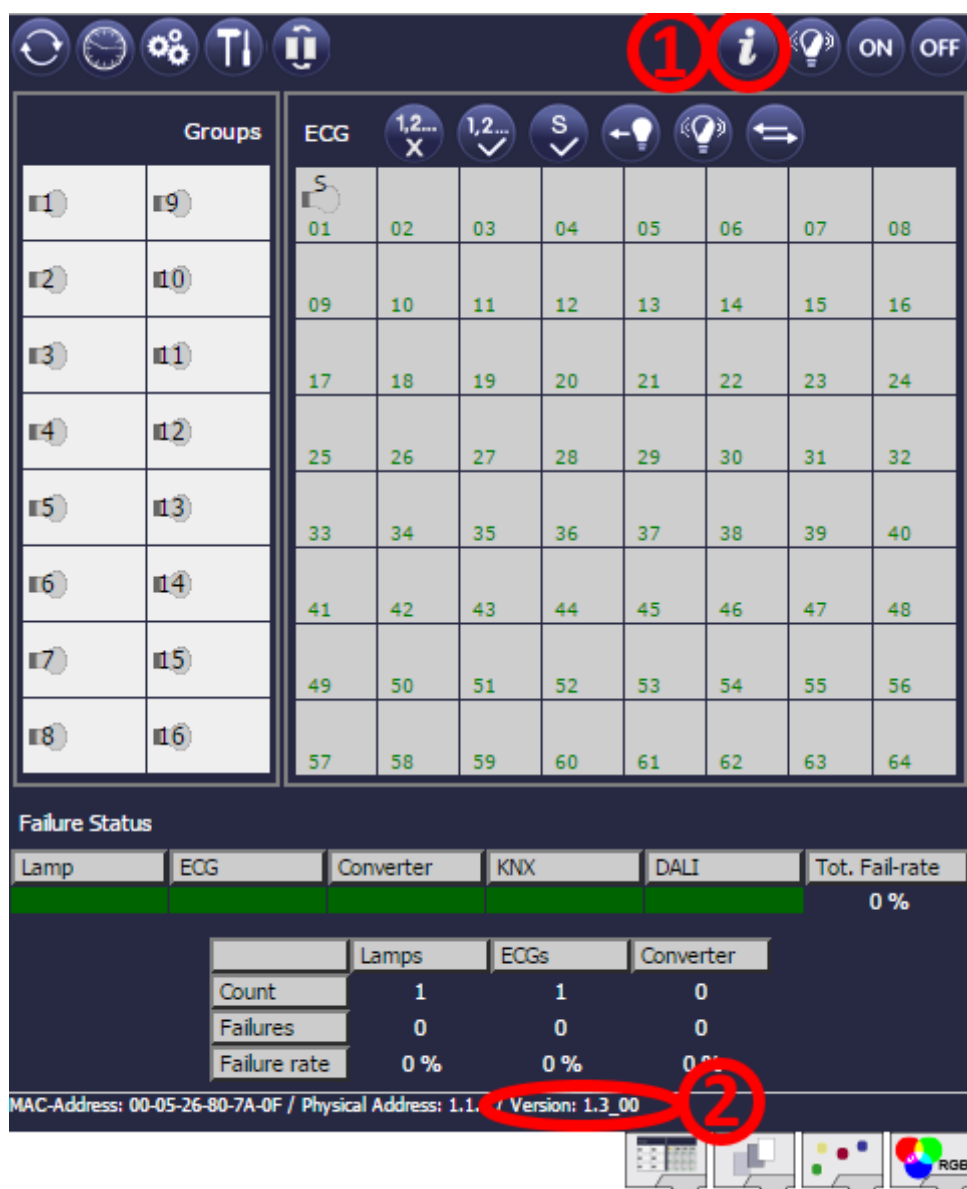
Picture 6: DALI upgrade tool

After the installation check physically the IP address on the device. Push *Move* button (1) then *PRG/SET* button (2) and IP address will be displayed (3).



Picture 7: Checking DALI IP address

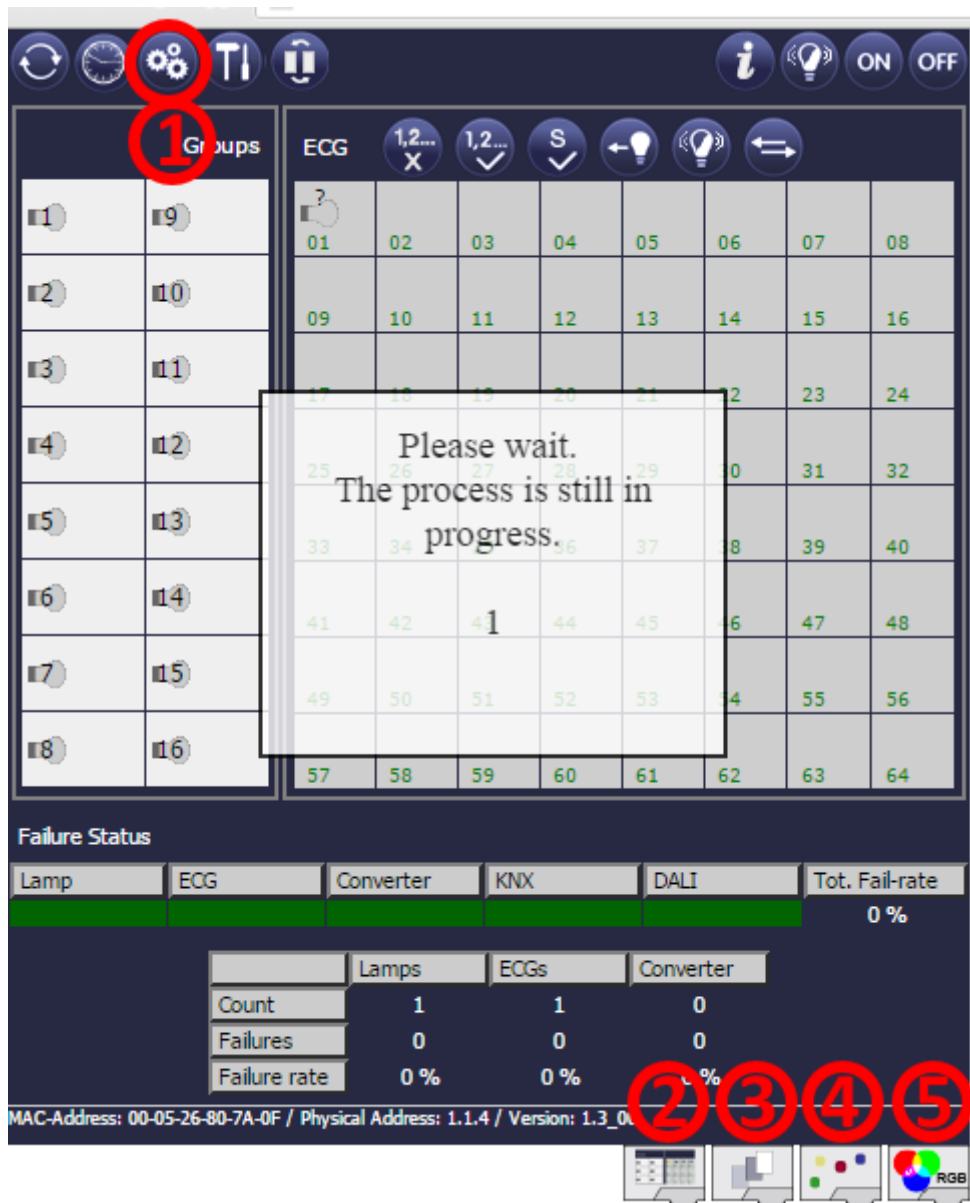
Write the IP address of the upgraded device to the internet browser. Log into the device, click on „I“ (1) and check the firmware version (2).



Picture 8: Checking DALI new firmware version

4.4 Setting the tunable white templates in DALI gateway

- 1) To perform a *New installation*, click on the *gears* icon. Wait until the installation utility finds all ECGs.

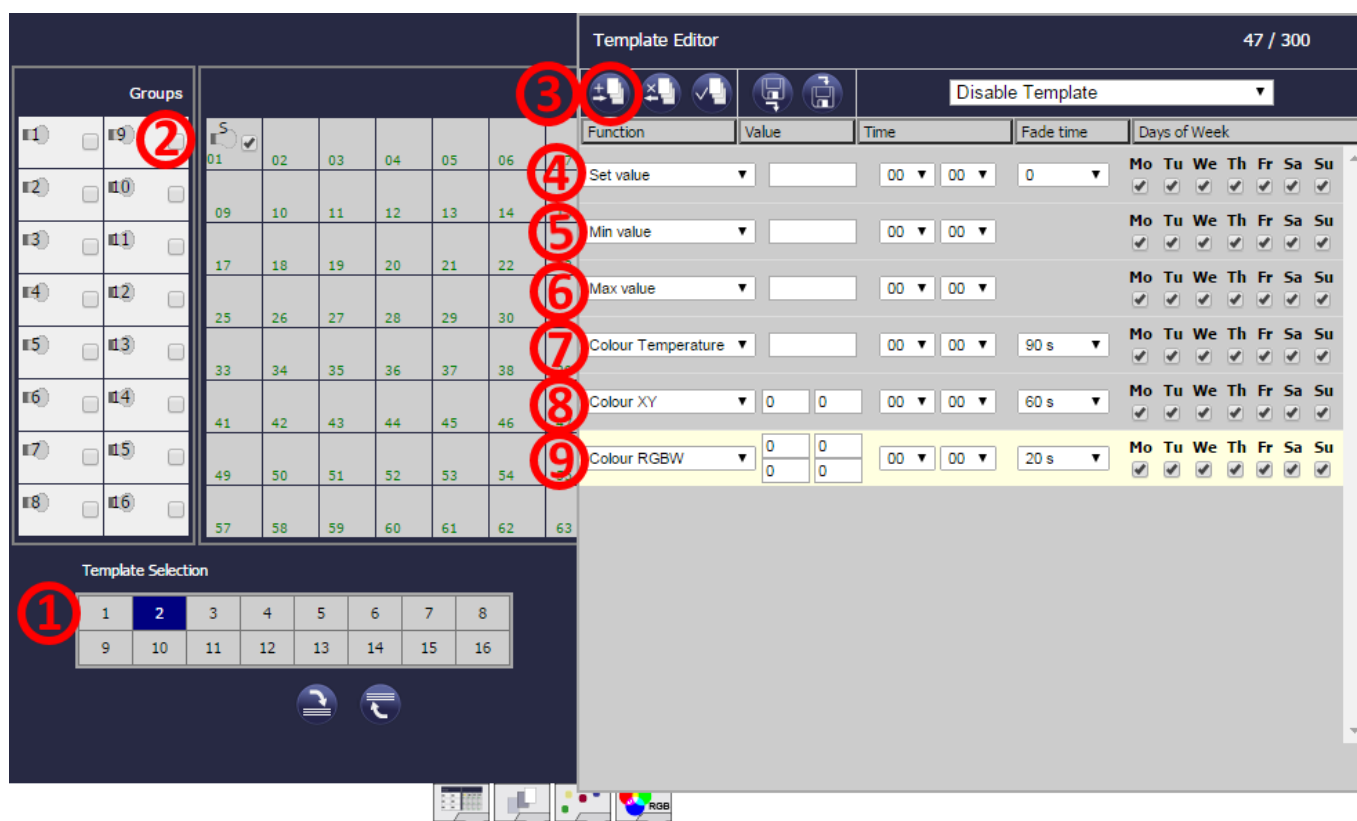


Picture 9: DALI new installation of ECGs

Click on TAB icons for:

- 2) ECGs groups assignment
- 3) Scenes assignment
- 4) Effects assignment
- 5) RGB assignment (including color temperature configuration)

In RGB assignment (5) from picture 9 choose a Template number (1). Add ECGs or groups into it (2). On the right side add desired functions (3):



Picture 10: DALI RGB Template editor

Feature	Range	Description
Set value (4)	0 -100%	Control brightness
Min value (5)	0 -100%	Controls minimal adjustable brightness
Max value (6)	0 -100%	Controls maximal adjustable brightness
Colour Temperature (7)	Depend on used lamp [K]	Controls CCT
Color XY (8)	0 - 1	Controls full RGB color setting
Color RGBW (9)	0 – 100% for each color channel	Sets values for each of 4 color channels

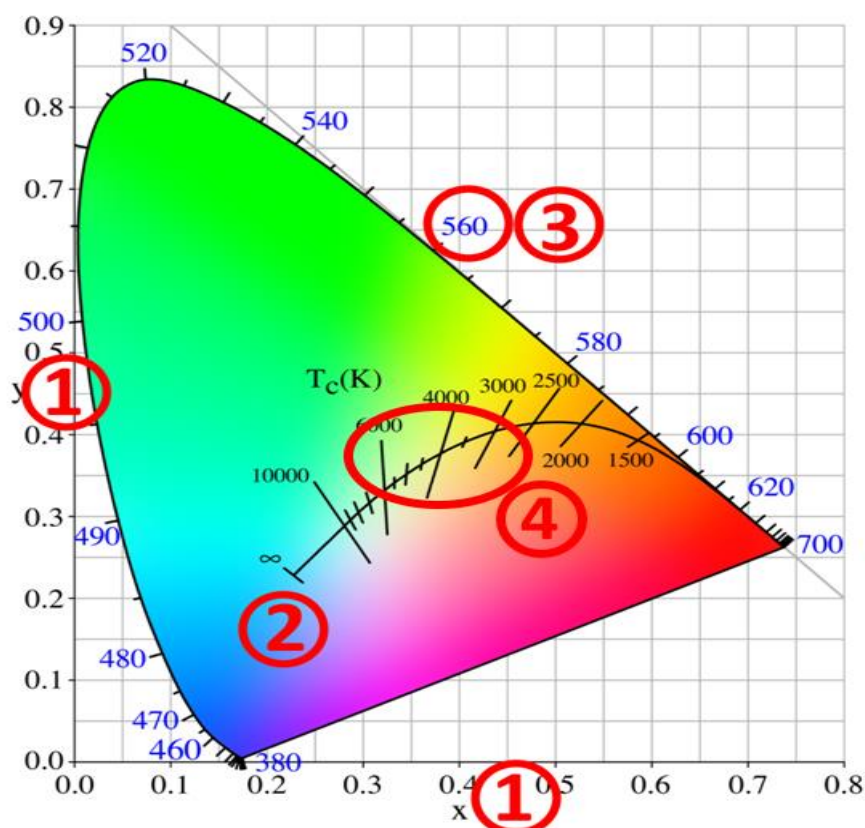
Table 7: DALI Template functions

4.5 Setting of colors in DALI gateway

Colors can be set by following methods depending on used lamp:

- 1) XY coordinate: to select nearly every color; ($0 < x < 1$; $0 < y < 1$)
- 2) Color temperature tunable white control along the **Black Body Line**
- 3) The blue numbers represent wavelength of light
- 4) XY, Possible color range can be limited by the lamp. Check the lamp documentation for details.

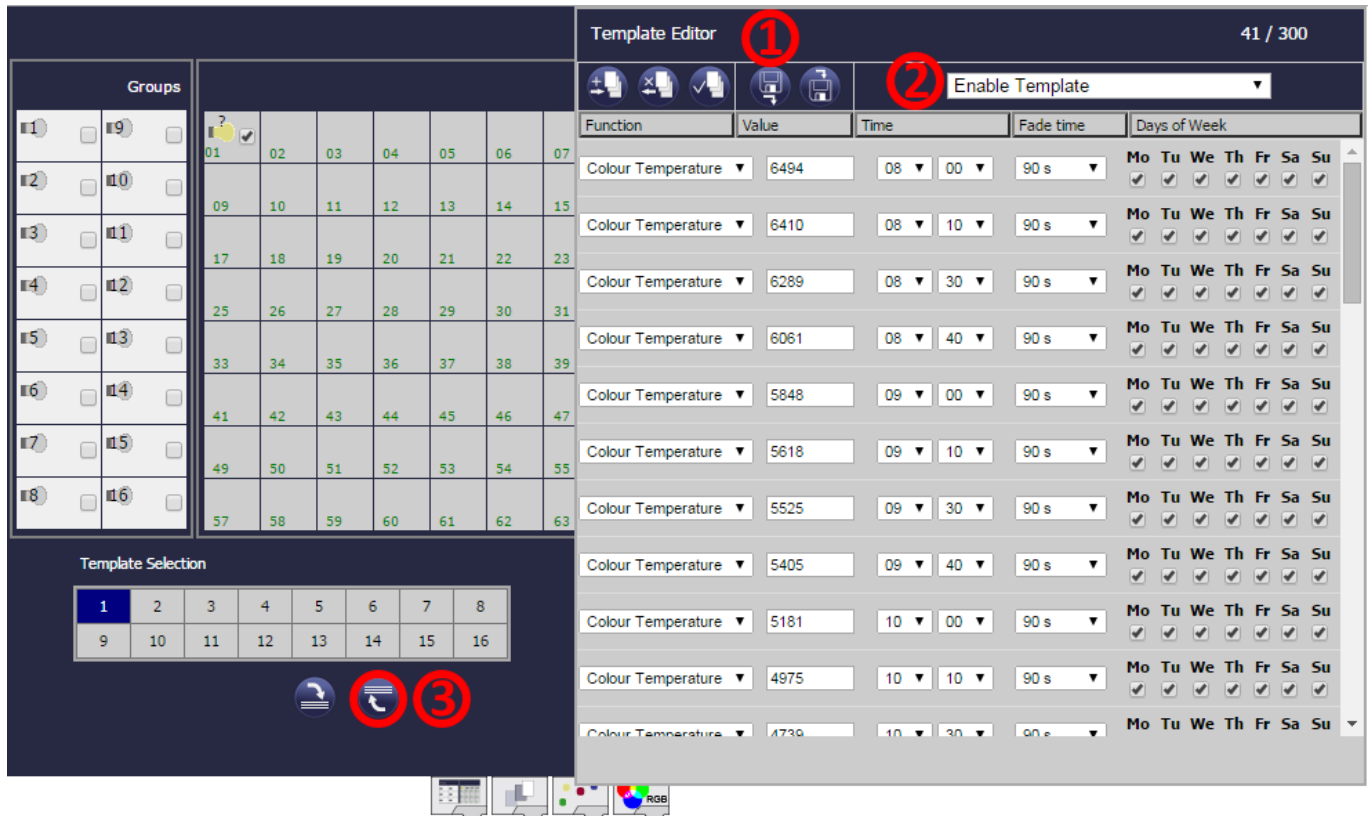
Color definition by four %-values for red, green, blue and white [for RGBW] insert direct parameter



Picture 11: Spectrum and Planckian locus

4.5.1 Configuration steps sample for Office use case (see chapter 2.2.1)

- Select predefined template attached to this AN
- Click on the *floppy disk* symbol (1)
- Import the template in *.csv format
- After download select enable template (2)
- You need to upload settings (3) to the gateway for changes to take effect

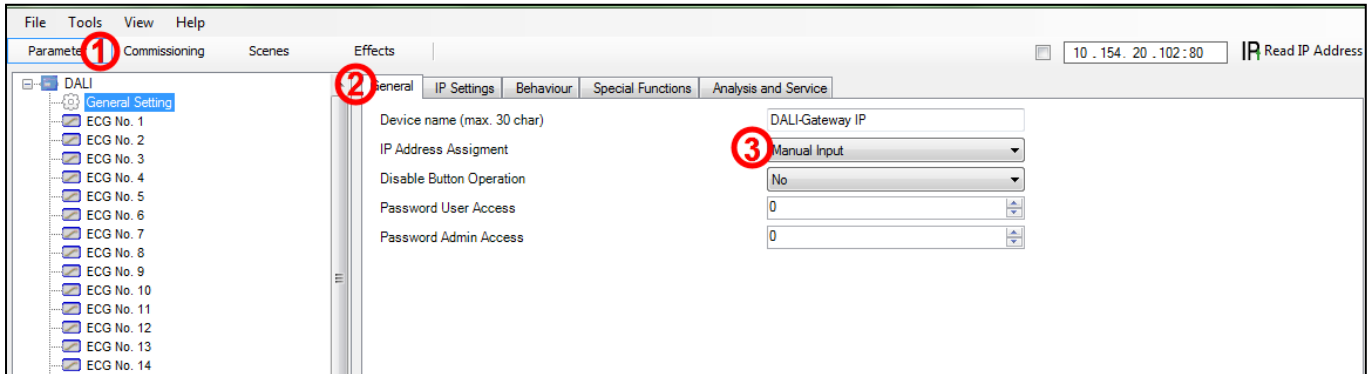


Picture 12: DALI RGB Template editor detail

4.6 ETS5 configuration of DALI gateway

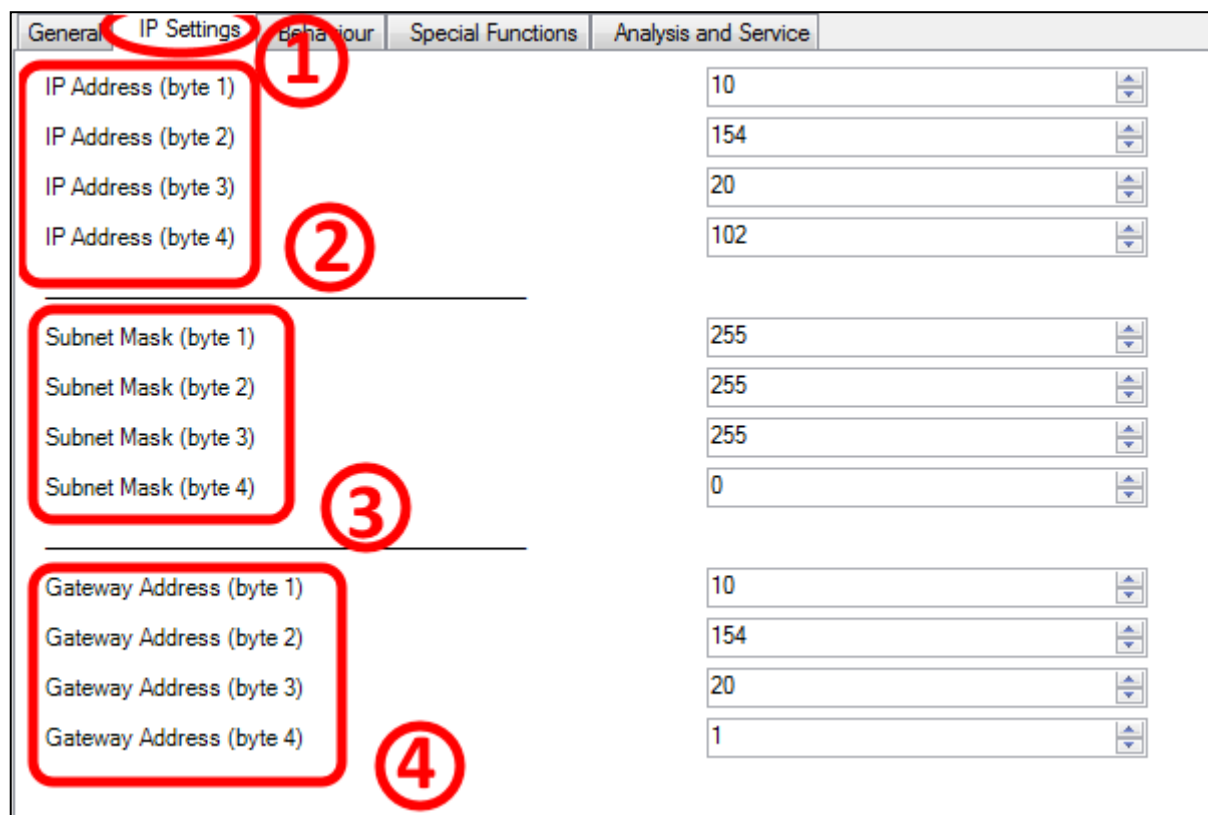
Create new project, make required building structure and topology. Add the right gateway REG-K/1/16(64)/64/IP1. Open product specific parameter dialog window in Parameter TAB.

Set static IP address in Parameter (1) -> General (2) -> IP address assignment -> set Manual Input (3).



Picture 13: DALI IP setting ETS

Fill IP Setting (1) and set the IP Address (2), Subnet mask (3) and Gateway Address (4). Changes will take effect with next application download of DALI gateway.



Picture 14: DALI IP setting ETS 2

4.6.1 Time&Date settings

For using RGB templates it is mandatory to have a valid source of time&date from external time&date object. Time&date object can be generated by one of these devices:

- MTN6606-0008 Year time switch
- MTN677290 KNX timer
- LSS100100 Wiser for KNX

Assign time&date communication objects of DALI gateway (object 21 and 22) (1) to one of above mentioned devices.

Number	Name	Object Function	Description	Group Address	Length	C	R	W	T	U	Data Type	Priority
8	General Failure	Yes/No			1 bit	C	R	-	T	-		Low
9	DALI Failure	Yes/No			1 bit	C	R	-	T	-		Low
10	General Failure Exceeds Thres...	Yes/No			1 bit	C	R	-	T	-	boolean	Low
11	General Failure in Total	Value			1 byte	C	R	-	T	-	counter p...	Low
12	Lamp Failure Exceeds Thresh...	Yes/No			1 bit	C	R	-	T	-	boolean	Low
13	Lamp Failure in Total	Value			1 byte	C	R	-	T	-	counter p...	Low
14	ECG Failure Exceeds Threshold	Yes/No			1 bit	C	R	-	T	-	boolean	Low
15	ECG Failure in Total	Value			1 byte	C	R	-	T	-	counter p...	Low
16	Converter Failure Exceeds Thr...	Yes/No			1 bit	C	R	-	T	-	boolean	Low
17	Converter Failure in Total	Value			1 byte	C	R	-	T	-	counter p...	Low
18	Status Switching Lamp	Status			1 byte	C	-	W	T	-		Low
19	Status Value Lamp	Status			2 bytes	C	-	W	T	-		Low
21	Time	Time	Time	1/1/10	3 bytes	C	-	W	T	U	time of day	Low
22	Date	Date	Date	1/1/11	3 bytes	C	-	W	T	U	date	Low
23	Group 1, Switching	On/Off			1 bit	C	-	W	-	-	switch	Low
24	Group 1, Dimming	Brighter/Darker			4 bit	C	-	W	-	-	dimming...	Low

Picture 15: DALI time & date setting

5 KNX ARGUS Presence with light control

5.1 Constant light control (CLC)

For correct function of tunable white in demanding installations (e.g. Offices, Hospitals, Schools) it is also important to consider use of CLC function. The overall brightness level of the installation controlled via DALI gateway is depending on ambient light level (e.g. clouds on the sky, shade of outside structures) and actual color of lamps (see Table 6). Without considering above factors actual brightness level may fall outside demanded limits.

For correct setting see AN032 Lighting solution for comfortable environment using spaceLYnk chapter 3.3.

6 Sample of DALI light with DT8

LED AVIOR TRACK TW by the SLE

AVIOR TRACK TW is eligible sample of modern tuneable white LED light suitable for commercial use.

This concrete light was used for all above tests.



Picture 16 LED tunable white light AVIOR TRACK TW

Mounting	Suspended / ceiling surfaced lighting track system - suitable for GLOBAL Trac (TRS)
Consumption	1x31 W
Optical system	Facet reflector (FRE) 24°/40°/60°1700-2700 lm
Light distribution	Direct
Wiring	Electronic control gear DALI (EDA) DT8
Materials	Housing: die-cast aluminium + sheet steel Reflector: facet anodized aluminium
Accessories	Exchangeable reflectors Various types of connections and suspension equipment (GLOBAL Trac)
Service lifetime	50,000 hours / L70
Ambient operating temperature	From -20 to + 35°C

7 Conclusion

We are one of the first companies which offer these functions conform to KNX & DALI with a KNX DALI-Gateway.

If customers have already bought our Gateway and the right lamps installed, they can extend their existing installation with this interesting & powerful features later on. They need an update of the firmware 1.3 and the date & time synchronization.

8 Appendix

8.1 Glossary

The following table describes the acronyms and defines the specific terms used in this document.

Abbreviation	Description
LED	Light-emitting diode
DALI	Digital Addressable Lighting Interface
Melatonin	Melatonin makes us feel drowsy, slows down bodily functions and lowers activity levels to facilitate a good night's sleep. It also ensures that many metabolic processes are wound down.
Cortisol	Cortisol is a stress hormone. It stimulates metabolism again and program the body for day-time operation.
Serotonin	Serotonin acts as a mood-enhancing motivating messenger. While the level of cortisol in the blood falls during the day in a counter-cycle to melatonin, serotonin helps us achieve several performance peaks.
CCT (correlated color temperature)	Determines the atmosphere in the room. Low temperatures create warm light and high ones the cooler ones

CRI (Color rendering index)	fidelity color reproduction
RGBWAF	Red, Green, Blue, White, Amber, Free color
UGR	The standard specifies two measures to limit direct glare. A minimum shielding angle in all directions is specified depending on the lamp luminance. Also, a Unified Glaring Rate, UGR limit value (UGRL) is specified for every visual task. The standard values range from UGR 16 (not blinding) to UGR 28 (blinding).
*.csv	Comma-separated values. File stores tabular data (numbers and text) in plain text. Plain text means that the file is interpreted as a sequence of characters, so that it is human-readable with a standard text editor.
Planck's law	Planck's law describes the electromagnetic radiation emitted by a black body in thermal equilibrium at a definite temperature.
Em	the minimum required average illuminance (i.e. maintained illuminance) per task
VDU	Visual Display Units. This is basically the monitor of a computer and it will more than likely involve you sitting in front of a computer and inputting data.
U0	Lighting uniformity is ratio of the minimal illuminance over the area weighted average illuminance: $u = E_{min} / E_{average}$

Table 7: specific terms

8.2 References

Document title	Reference
Human Centric Lighting	http://humancentriclighting.com/wp-content/uploads/2012/07/Stan-Article-SSL1.pdf
Tunable white	http://www.sleprojects.com/tunable-white
RGBW	http://www.sleprojects.com/rgb-colour-mixing
CRI	http://www.sleprojects.com/colour-rendering-index
Glare prevention	http://www.sleprojects.com/glare-prevention
Illumination level	http://www.sleprojects.com/illumination-level
EN 12464	http://www.licht.de/fileadmin/Publikationen_Downloads/Guide_DIN-EN-12464-1.pdf

Table 8: reference

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