Lighting control not only enables the lighting to be adjusted to suit the visual requirements but also allows it to shape and interpret the architecture. Light scenes are easily set up using the appropriate software and can be recalled via an interface. The inclusion of light colours and the time dimension opens up a room for scenographic lighting with dynamic effects. Lighting control systems with sensors or time programs also help adjust the power consumption in a room to its usage and thus optimise the economic efficiency of a lighting system.
The atmosphere in a room can be changed by controlling a number of variables. These include basic functions such as switching circuits on and off through to automatically timed colour progressions. Programming the light scenes means that the settings are saved but can be redefined and adjusted to suit changing requirements.
Switching and dimming are two basic functions of a lighting control system that can be used to produce different lighting situations. Luminaires with variable light colours also include a colour setting mode. Features such as cross-fading and dynamic colour progression are crucial for dynamic lighting designs. Lighting changes can be initiated and regulated automatically via time and sensor control.
The easiest situation is to turn the light on and off with a switch or a push-button. For a variety of light scenes different circuits with separate switches are required. Suitably positioned switches result in easier usage. Most lamps produce full light output immediately. High-pressure discharge lamps, however, usually have a run-up time of several minutes and an even longer cooling-down period before re-ignition.
Dimming is the infinitely variable adjustment of the light output of a light source. It enables the creation of different light scenes, increases the visual comfort and optimises the power consumption. Dimming also prolongs the life of incandescent lamps. Thermal radiators such as tungsten halogen lamps are easily dimmed. Fluorescent lamps and LEDs require special dimmable control gear.
The light colour of luminaires with variable colours of light can be defined by hue, saturation and brightness. The possible colours depend on the lamp and the lighting technology used. Coloured light can change the atmosphere of a room and highlight individual objects. RGB colour mixing technology controls the individual primary colours red, green and blue to produce the required light colour.
A scene is a static lighting situation. It defines the state of all lighting components such as luminaires, light ceilings and light objects with their different switch and dimmer settings. The scenes can be saved in lighting control systems. The user can preset complex luminaire settings and conveniently recall them either manually or automatically.
In regard to lighting, cross-fading refers to the transition from one light scene to another. The cross-fading time is the period required for the scene change. It varies between instant change and a transition of several hours. High-contrast scenes with a short cross-fading time generate considerable attention. Subtle transitions with lengthy cross-fading times, on the other hand, are hardly noticeable. The scene change can be initiated by the user, a sensor, or a timer.
Dynamic colour progression refers to the chronology of colour changes. Within a defined total running time, specific colours are triggered at specified times. There are different options available to repeat this progression, including infinite loop and "forward and back".
A sequence refers to a progression of successive light scenes. The definition of a sequence requires both individual scenes and information on their transition. A sequence can automatically be repeated once completed or, alternatively, end.
A timer allows light scenes to be recalled at predefined times. Time and calendar functions provide great flexibility for the automation of scenographic lighting. Specified start and end times, for example, set the lighting to specific shop-opening times or licensing hours.
Sensors monitor properties such as brightness or motion and allow an automatic adjustment of the lighting to changing ambient conditions. A brightness sensor can be used for daylight-dependent lighting control. Motion sensors register movement in the room and control the light depending on activity to reduce power consumption.
Buildings increasingly use automatic control systems. The lighting is only one component, operation of solar screen equipment, air-conditioning and security systems are others. Special lighting control systems have the advantage that they can be designed to suit the requirements of a lighting design and are less complex than more extensive building control systems.
Lighting control systems switch and dim luminaires, set up light scenes and manage them in space and time. The decision to select a specific system depends on the size of the lighting system, the requirements in regard to controllability, user-friendliness and economic considerations. Digital systems that allow luminaires to be addressed individually provide great flexibility. Their user-friendly features include easy programming and operation along with a simple installation process. Lighting control systems can be integrated as a subsystem into a building management system.
1V-10V
Electronic Control Gear (ECG) is controlled by analogue 1V-10V signals. This technology is widely used in low-complexity lighting systems. The dimmer setting is transmitted via a separate control line. The control gear regulates the output of light from the luminaire. Since this type of ECG cannot be addressed, the control circuit for the control line must be carefully planned, because its allocation cannot be changed. The grouping of the luminaires is determined by the circuits in the electrical installation. Any change of use requires a new arrangement of the connection and control lines. Feedback on lamp failure, etc., is not possible with the 1V-10V technology.

DMX
The DMX (Digital Multiplexed) digital control protocol is predominantly used for stage lighting. In architectural lighting, this protocol is used for features such as media facades or stage-like room lighting effects. The data is transmitted via a dedicated 5-core cable at a transfer rate of 250 Kbits/s which can control up to 512 channels. Each luminaire must have a bus address. When using multi-channel devices with colour control and other adjustable features, each function requires a separate address. For a long time, the data transfer was unidirectional and only enabled the control of devices. It did not provide feedback on aspects such as lamp failure. The DMX 512-A version now allows for bidirectional communication.

DALI
Digital Addressable Lighting Interface (DALI) is a control protocol that makes it possible to control luminaires which have DALI control gear individually. The system allows user-friendly light management in architecture and can be integrated as a subsystem into modern building control systems. The two-wire control line with a transfer rate of 1.2 Kbits/s can be run together with the mains supply cable in a 5-core cable. The bidirectional system allows feedback from the luminaires on different aspects such as lamp failure. The DALI protocol limits the number of devices to 64. The standard version stores the settings for a maximum of 16 luminaire groups and 16 light scenes within the control gear. General information on DALI: www.dali-ag.org

The ERCO Light System DALI, saves settings in a central controller with a greater storage capacity. This allows more luminaire groups, light scenes and fading times along with the coding of the control gear memory for other features. The system is compatible with other DALI devices. Light System DALI can provide both economical light management and scenographic lighting.
Building management systems are used to control different building systems such as the heating, solar screening equipment, and the lighting. They are more complex than systems that solely control the lighting and thus are more involved in terms of planning, installation and operation. An established protocol ensures communication between the systems over a flexible network. The control systems form the basis for building automation, to simplify and automate the different functions in a building. The building automation is divided into three levels: the management level for user-friendly visualisation, the automation level for data exchange, and the local level with sensors and actuators. There are no integrated receiving devices in the luminaires (interfaces) for decoding control signals; lighting control is achieved by wiring individual circuits.
**KNX**

Konnex (KNX), known through the European Installation Bus (EIB), is a standardised digital control system which controls not only the lighting but also other systems such as heating, ventilation and solar screening equipment. KNX is suitable as a network of electronic installations for building automation. Remote monitoring and control make it easy to use. The data is transmitted over a separate 24V control line-twisted pair wire at a rate of 9.6 Kbits/s. The decentralised communication is bidirectional so that the receiver can also provide feedback. Each bus device can transmit independently. An allocation of priorities ensures proper communication and prevents data collisions. Due to the individual addresses of the sensors and actuators, this allocation is flexible and can easily be changed. KNX is used in domestic buildings and in large installations such as offices or airports.

**LON**

Local Operating Network (LON) is a standardised digital control protocol which controls building systems and is also used in industrial and process automation. Via TCP/IP, LON networks can be combined to form cross-region networks and be remote-controlled. LON is based on intelligent sensors and actuators. The microprocessor of each LON node, called a “neuron”, can be programmed and configured. The data transfer for up to 32,000 nodes is over a twisted pair wire, as a separate control line, at a rate of up to 1.25 Mbit/s.
Lighting systems can be programmed with software to provide great flexibility and allow an adjustment of the lighting to individual requirements. This results in complex lighting systems with sensors and interfaces that often require professional installation and maintenance. Users require simple day-to-day operation that allows them to make changes themselves. Non-standard systems can include a great deal of complexity to cater for special building requirements.

Problems or changes, however, may require the support of a professional programmer. So, standardised lighting systems that allow certain parameters to be changed are easier to operate and enable lighting designers or users to make the necessary changes. The decision on the type of lighting control system and software depends on technical aspects such as the size of the lighting system, its integration with AV technology or building control systems, and the complexity of the installation. Further criteria for the user to consider are ergonomics, flexibility, and maintenance. A simple installation process, rapid familiarisation and easy to use software aid setup and operation.
Lighting control systems are composed of different components: sensors register changes in the surroundings, control panels enable light scenes to be recalled or new lighting parameters to be programmed. The output devices translate the control circuit signals into actions. The connection to the computer allows for easy operation of the lighting control system through software, while gateways facilitate the combination of different control systems.
Sensors are measuring devices that register ambient conditions such as brightness or motion. The lighting is adjusted when the lighting control system receives an impulse or a value above or below a predetermined level.
Light sensor

A light sensor monitors light levels and enables the automatic control of light scenes depending on available daylight. Using a lighting system in combination with changing daylight levels in rooms ensures a controlled illumination, which is useful, for example, in order to maintain minimum values for workplaces or to reduce the radiation exposure on exhibits in museums. A daylight sensor on the roof (external sensor) measures the illuminance of the daylight and controls the lighting inside. If the light sensor is in the room (internal sensor), it measures the total illuminance of the incident daylight and the lighting in the room in order to control the light level depending on the daylight. The first process is referred to as open loop control, the second as closed loop control.

In combination with scene control, light scenes can be controlled depending on the daylight, for example, by using a twilight switch. In the same manner, the sensor control can be used to operate solar screening equipment.

Motion sensor

Motion sensors register movement in the room and can be used, for example, in vacant offices to dim or switch off the light automatically in order to save power. In museums, the lighting on sensitive exhibits can be reduced when there are no visitors. Installed outdoors, motion sensors can reduce power consumption at night as lighting is switched on only when and where required. The switching thresholds must be set to suit the situation.
Simple applications only require a push-button to operate the lighting control system. Control panels with displays are recommended for sophisticated applications and can also be used to program the lighting system. A remote control device allows light scenes to be recalled from anywhere in the room.
**Push-button**

A push-button closes or opens a circuit to switch a luminaire group or light scene on or off. To use different functions, a system requires several push-buttons. The functions are determined when the lighting control system is installed.

**Switch**

A switch opens and closes a circuit. It locks into position and does not require continuous pressing as does a push-button. A light switch controls the lighting by switching it on or off.

**Remote control**

A remote control is used to control the light separately from wall-mounted control panels. In conference rooms, a remote control is a convenient device to recall different light scenes from anywhere in the room. An infrared remote control requires an IR receiver to recall any functions.

**GUI**

Graphical User Interface (GUI) is the familiar way of interaction with software on computers or control panels based on graphical images. Simple user interfaces prevent users having to learn complex command languages and simplify the operation. A GUI can be combined with a touch screen so that interaction takes place directly on the screen.
Output devices are actuators or controllers that translate the signals in a control circuit into an action. Actuators (e.g. relays) or dimmers operate or control the light output through voltage changes. Controllers have their own processors and send signals to the control gear.
Relay

A relay is a switch that is activated by electric current. When operating metal halide lamps, a run-up time of several minutes and a longer cooling-down phase before re-ignition must be taken into account.

Dimmer

The dimmer is used for the infinitely variable regulation of the output from a light source. Leading edge control is applied to incandescent lamps. Low-voltage halogen lamps with electronic transformer are dimmed using trailing edge technology. Thermal radiators such as tungsten halogen lamps are easy to dim. Fluorescent lamps require special control gear, while compact fluorescent lamps require special electronic control gear units. Conventional compact fluorescent lamps cannot be dimmed. LEDs can easily be dimmed with the appropriate control gear. In analogue 1V-10V technology, dimming is possible by using a special ECG with input for the 1V-10V control voltage and a potentiometer or a control system supplying analogue 1V-10V control voltage, such as the ERCO Area Net or KNX actuators. The dimmers are often installed in switch cabinets. The control lines are permanently connected to luminaires or groups of luminaires. The digital control protocol, DALI, on the other hand, allows for the individual control of the dimmable ECGs for all the connected luminaires.

Controller

Controllers are electronic units for process control. A lighting control system such as the Light System DALI saves light scenes and controls the luminaires. The amount of data which can be used to store the settings is limited by the storage capacity of the controller. The user operates the controller via software or a control panel. A control line establishes a connection to the luminaires and transmits the signals to the control gear.

In a LON system, D/A modules are used to save and recall light scenes. As output devices, they allow the connection of external dimmers or direct control of dimmable ECGs or transformers.
Interfaces or `Gateways` enable the exchange of signals and data between different data networks or bus systems. Where several control systems are used in a building, the data needs to be transferred between these systems. Lighting control systems can be integrated as subsystems into a building management system by means of a gateway. In the same manner, gateways can be used, for example, for DALI lighting control systems to activate 1V-10V controllers for the sun screening equipment.

Lighting control software turns any PC connected to a lighting control system into a control panel and programming device for the lighting system. The PC can be connected to the lighting control system using interfacing standards such as USB. The brightness and light colour settings are combined in light scenes. The light scenes are programmed using the software and recalled via control panels. The software can provide many additional functions, such as spatial and timed control. A timer program ensures lighting control according to predefined sequences or calendar settings. With sequential control, the light scenes are repeated in cycles. The calendar function recalls the light scenes according to predefined times or days. The DALI system with individually addressable luminaires allows flexible allocations and regrouping. The firmware is the software required for the operation of devices and is saved in a flash memory. The PC software is used to operate the lighting control system on the computer and is saved on the hard drive.
The application area for a lighting control consists of the functional adaptation of the individual lighting requirement, the optimisation of the use of energy and the differentiated design of architecture, exhibition and presentation.
Room of museum for presentation of paintings and sculptures. Requirements: The illuminance level is kept low as long as no visitors are in the room. When someone enters the room the optimum exhibition lighting is switched on.
Planning

Circuit options:

- Track outside = 3 circuits
- Track inside = 2 circuits

Circuit 1/2
- Wallwashers with compact fluorescent lamps (switched)
  - each 6 x TC-L 16W EC 9

Circuit 3
- Wallwashers with mains voltage halogen lamps (dimmable)
  - 10 x 150W

Circuit 4/5
- Spotlight with PAR 30 (dimmable)
  - each 2 x 100W PAR 30
Observation

Requirements: Several illuminance levels can be set; they are controlled dependent on the daylight. It is operated via push-buttons on the door. A maximum of four different lighting levels can be selected via the push-buttons. The light scenes are defined for different uses according to the illuminances. The actual regulation to the set value within the light scene is performed via the daylight regulation.
Observation
The Downlights are connected in rows parallel to the window wall = 3 circuits.

Circuit 1-3
Recessed downlights for compact fluorescent lamp
(>10V dimmable)
each 4 of 2x TC-DEL28W
ECG 5-110V
Observation

Requirements: The lighting program is made up of differentiated light scenes. It is operated via a Preset at the reception. A daylight control optimises the power consumption.
Observation

Planning

Circuits

Wallwasher = 2 circuits
Doorly = 3 circuits
Low voltage downlights = 1 circuit (reversing door)

Circuit 1
Wallwasher downlights (dimmable)
6 x 150W

Circuit 2
Wallwasher downlights (dimmable)
8 x 150W

Circuit 3
Low voltage downlights with 50W tungsten halogen lamp (dimmable)
4 x 100W/12V Magnetic transformer

Circuit 4
Spotlights low voltage 100W (dimmable)
4 x 100W/12V magnetic

Circuit 5, 6
Spotlights H1T 150W (switched)
each 4 x 160W H1T
Observation

Requirement: different light scenes can be recalled at breakfast, lunch and dinner times.
Observation
**Planning**

**Circuits**

**Circuit 1, 2**
Recessed downlight for low-voltage halogen lamps (dimmable)
each 3 x 100W/12V magnetic transformer

**Circuit 3**
Recessed downlight for low-voltage halogen lamps (dimmable)
6 x 100W/12V magnetic transformer

**Circuit 4**
Uplighter for halogen lamps (dimmable)
3 x 300W

**Circuit 6**
Recessed downlight for halogen lamps (dimmable)
6 x 150W

**Circuit 8**
Recessed wallwasher for halogen lamps (dimmable)
each 8 x 100W

**Circuit 7**
Recessed downlight for low-voltage halogen lamps (dimmable)
3 x 100W/12V magnetic transformer

**Circuit 9**
Recessed downlight for low-voltage halogen lamps (dimmable)
10 x 100W/12V magnetic transformer
Multifunctional room

Requirement: Various light scenes for different purposes with different room allocation:
- training/seminar, large room
- meeting, large room
- training, small room
Guide

Lighting control | Design examples

Multifunctional room

Observation

Large room

Planning

Circuits

Circuit planning must always contain all options in partitioned rooms. The electrical circuits each side of the partition must be separate.

- **Circuit 1, 5**: Downlight for compact fluorescent and low voltage lamps (dimmable) each 12 x 2 x TCD 25W 12V or 1-10V
- **Circuit 2, 6**: Downlight for compact fluorescent and low voltage lamps (dimmable) each 12 x 35W/12V electronic transformer 1-10V

- **Circuits 3, 4, 7, 8**: Track mounted spotlight 12W/50W (Electronic transformer) (dimmable) each 2 x 50W/12V

- Presentation
- Projection
- Reception

- Downlights (Fluorescent)
- Downlights (Halogen)
- Spotlights

- Planning

- Observation

- Large room
Observation
Small room

Guide
Lighting control | Design examples
Multifunctional room