There are different lighting control systems that work well with LED lighting. The most commonly used systems in professional LED lighting are DALI, 0-10V, 1-10V and DMX. Phase cut dimming is also used, but is less suited for professional LED lighting.

Except for phase cut dimming, the used protocol has no influence on the quality of light with regards to dimming. Perfect dimming behaviour is possible with all of these protocols.

Which system should you use?

Different dimming protocols have their own characteristics and advantages and disadvantages. The system to choose depends on your requirements.

DALI
DALI is very flexible and makes it possible to create different groups that can be controlled separately with easy wiring. DALI’s flexibility also brings with it that specialised knowledge is required for installing and commissioning. DALI is a bidirectional protocol which makes for easier commissioning and greater flexibility in control gear – for instance infrared presence sensors and light sensors.

0-10V and 1-10V
0-10V and 1-10V are easy to understand systems and commissioning does not require specialised knowledge. However, to get different control groups each group needs separate wiring. 0-10V and 1-10V do not support bidirectional communication – so if sensors are required, additional systems may be necessary.

DMX
DMX was originally created for the theatre industry, but today DMX is also widely used for dynamic architectural lighting. One of the benefits of DMX is that it is fast – changes in intensity and colour can be made virtually instantly. With DMX/RDM, bidirectional communication is possible. DMX/RMD can be used for automatic addressing during commissioning and for status reporting of connected devices.

Summary
DALI: Flexible system with possibility to create separate lighting groups with easy wiring. Special knowledge is required for software commissioning.

0-10V / 1-10V: Low cost system with easy commissioning, but less possibilities than DALI.

DMX/RDM: System specifically suited for dynamic (colour) lighting, for instance stage lighting in theatres or architectural lighting.
More about DALI

The DALI name is an acronym for Digital Addressable Lighting Interface. DALI is a digital lighting protocol and is mainly used for general lighting. DALI is a language for controllers and luminaires like English is a language for people.

![DALI control device diagram]

Figure 3 – DALI is a language

DALI is used mainly in general lighting applications like office lighting, museum lighting and hospital lighting. DALI is a very flexible system and can control lighting systems with only one controller and one luminaire, or advanced systems with several lighting groups.

Installing and commissioning of a DALI system

One of the benefits of DALI is that wiring is polarity independent, so connecting the DA+ terminal of one DALI ballast to the DA- terminal of the next is a perfectly valid connection. So no installation errors are possible due to polarity errors.

![DALI wiring diagram]

Figure 4 – DALI wiring is polarity independent

Another benefit is that the bus topology of a DALI installation is very flexible. Bus, daisy-chain, mesh and star are all valid topologies.

When to use DALI?

Use DALI when flexibility is needed in your system. For instance, when different groups of light must be able to be set at different brightness levels. DALI is also a bidirectional system – the controlled lighting group gives feedback to the DALI controller about its state, like current brightness level. Bidirectional communication can also be used for light sensors and presence detectors.
DALI Advantages

- Open IEC standard (IEC 62386) and can be used by anyone.
- DALI has an active organisation and DALI is constantly improved and extended.
- Full digital control – group creation or individual control of fixtures.
- Bi-directional communication makes for easier commissioning and greater flexibility in control gear.
- Polarity independent two wire control.
- BUS based protocol.
- Standardised dimming curves – better compatibility between controllers and LED drivers.

DALI Disadvantages

- Maximum 64 clients per controller.
- Slow – less suitable for fast brightness changes.
- Specific knowledge is required during commissioning.
- Hardware and software commissioning is required.
- Only 254 digital values (from 0-100%) gives low dimming resolution.

0-10V and 1-10V

0-10V and 1-10V are analogue protocols used for dimming general lighting. Both systems use voltage levels to ‘communicate’ with the driver.

A voltage of 10 Volt is used for maximum light output and lower voltages are used for lower light output. But as you can see in figure 5, between 9.1V and 10V there is no change in brightness and between 0.5V and 1.5V there is also no change. These margins are necessary to compensate for tolerances that are inherent to the 0-10V and 1-10V systems. Below 0.5V the light goes off.

The difference between 0-10V and 1-10V

0-10V and 1-10V are two different standards:

- 1-10V – IEC60929 (Annex E).

The main difference between 0-10V and 1-10V is the direction of the current between dimmer and driver.

0-10V is a current source system, which means that the dimmer provides the power for the 0-10V signals – a mains connection to the dimmer is necessary.
1-10V is a current sink system. This means that the dimmer does not need mains power. However, to switch off the light a mains switch is necessary. eldoLED drivers support a ‘light off’ function without the need of switching mains power. In figure 7, this ‘light off’ function is implemented – the mains switch connections off the dimmer are also connected to the 0-10V input of the LED driver. If the mains switch is activated, the driver switches the light off.

![Diagram of 1-10V system with 'light off' function](image)

**Figure 7 – 1-10V system with 'light off' function**

**When to use 0-10V / 1-10V?**

0-10V and 1-10V systems are best suited for simple installations. In complex systems, installation can get complicated because each group need its own wiring. 0-10V is mostly used for entertainment lighting, 1-10V is more common for general lighting.

**Wiring**

The 0-10V signal is sensitive to external disturbances. The 0-10V wires should not run next to mains cables or be placed next to potential noise sources like big motors or fans.

Due to different lengths in signal wires, voltage drops can cause different light outputs. Larger diameter wiring causes less apparent differences in light outputs. Best would be to have equal length signal wiring if possible.

**Dimming curves**

Not all manufacturers publish their controller’s dimming curve, so test upfront. eldoLED drivers can change the dimming curve via the FluxTool programming tool to adapt your driver to different dimmers.

**Advantages of 0-10V dimming**

- Traditional way of dimming, known protocol.
- No (software) commission needed.
- Low cost dimming method.

**Disadvantages of 0-10V dimming**

- No addressing is possible, all connected LED-drivers react identical on a command from their controller.
  - Groups options can only be created by adding extra 0-10V networks (i.e. extra controller and extra cabling).
  - Polarity sensitive wiring.
  - Dimming curve is not standardized on shape and tolerance (linear, logarithmic, square, soft-linear).
  - Long wire distance needs special attention because of voltage drop and potential noise from environment.

**DMX/RDM**

DMX is a digital protocol and is typically used for dynamic colour lighting systems. Originally, DMX is used for stage lighting in theatres and concerts, but it is also widely used for architectural lighting.

DMX is a unidirectional protocol. This means that the DMX controller only sends signals to the driver – the driver cannot send signals to the controller. However, the protocol enhancement RDM is developed, which adds bidirectional communication to DMX.
The protocol

A DMX controller sends messages to each device in its network. The protocol sends a value between 0 and 255 to each of the 512 channels. For example:

<table>
<thead>
<tr>
<th>Channel:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>…</th>
<th>509</th>
<th>510</th>
<th>511</th>
<th>512</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value:</td>
<td>63</td>
<td>42</td>
<td>167</td>
<td>0</td>
<td>…</td>
<td>3</td>
<td>0</td>
<td>255</td>
<td>98</td>
</tr>
</tbody>
</table>

The value can be used to set a light level, but also to set the position of a moving head or to change gobo’s.

One device can use multiple channels. For example, a four channel LED driver assigned to channel 5 will also use channels 6, 7 and 8 – one channel for each colour. Even if only three outputs are connected as the middle driver in figure 8.

![DMX Network Diagram](image)

Figure 8 – Typical DMX network

RDM

RDM adds bidirectional communication to DMX. This is especially useful during commissioning. Without RDM, a channel must be assigned to each device. And if a channel must be changed of a device hanging high above the stage in a theatre, someone has to go to that device physically to change its channel. With RDM, channels can be assigned automatically by the controller, without the need to program each device separately.

When to use DMX?

DMX is developed for use with dynamic coloured lighting. Use it for stage lighting, colour architectural lighting, or all other projects with dynamic coloured lighting.

Wiring

DMX uses three signal wires plus mains wiring. The maximum cable length is 300 meter from the controller to the last driver. Every 32nd driver needs a repeater and the last driver in the system needs a termination resistor of 120Ω.

DMX uses EIA-485 (RS-485) rated cable or CAT5E Ethernet cable.

Advantages of DMX

- Standardised protocol (USITT DMX512-A) and based on RS-485.
- Made for colour dynamics, but also for sound & moving heads.
- Fast – suitable for highly dynamic light shows.
- One DMX universe can handle 512 individual addresses.
- Large distance possible between the controller and the last driver (up to 300 meters).

Advantages of DMX/RDM

- No need to program the driver individually – can be done via the RDM controller.
- Possibility to report status of connected devices.
Disadvantages of DMX & DMX/RDM

- Complex – specialised knowledge is needed.
- Special cables required for control signals (EIA-485 or CAT5E).
- Individual programming of drivers is needed (not with RDM).