



Photo: Peter Baas Photography, courtesy of MoreSenz

White paper

How To Wire DMX Lighting Systems

The DMX512 standard, which includes Remote Device Management (RDM) capability, is a robust and reliable system for lighting control. However, if not implemented correctly, problems can arise, such as random flashing of lights, erratic operation, and delays in responding to commands. This article, which explains the best practices in DMX wiring, ensures that installers and specifiers can get the performance they expect from every DMX installation.

Below, a typical DMX universe is shown. The DMX controller sends signals over the DMX cable to the drivers. At the last driver, the cable has to be terminated with a 120Ω resistor to prevent reflections which can disturb the DMX signal and cause lighting malfunctions. Any properly installed DMX network requires only a single 120Ω resistor at the end of the line of daisy-chained luminaires, connected as shown in Figure 1.

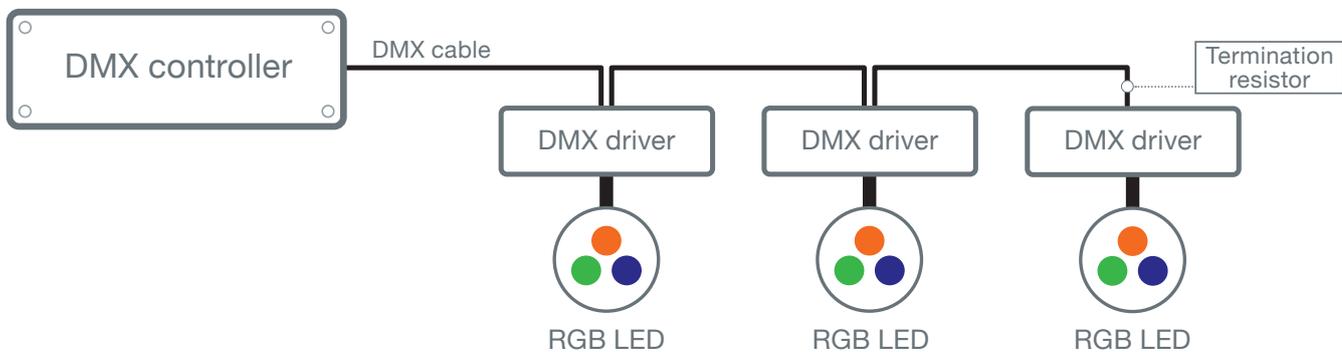


Fig. 1: a typical DMX universe, showing the 120Ω resistor required at the end of the line

Important things to consider are:

- DMX is a three-wire system. Use all three wires
- DMX is based on the EIA-485/RS-485 Standard
- Use cable specifically intended for DMX or RS-485 networks. These cables have an impedance of 120Ω and a low capacitance. For instance: Belden 9841 or 3105a

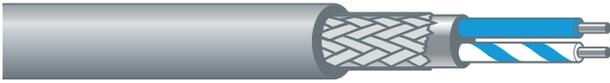


Fig. 2: DMX systems should be connected with three-wire cable intended for DMX or RS-485 networks

- Terminate a DMX network with a 120Ω resistor to prevent reflections
- Use a daisy chain topology. The DMX standard specifies that a network of DMX devices can only be connected in a simple linear, daisy-chain configuration, as shown in Figure 1. Never extend a DMX network via T-taps or Y-taps: when connected in anything other than a daisy-chain topology, DMX luminaires are susceptible to signal distortion or failure. This typically causes malfunctions such as delay or failure to respond to commands, flickering, and unwanted lighting effects. A luminaire manufacturer might be able to demonstrate a working DMX network with a topology other than a simple daisy chain in ideal, laboratory conditions and over a short cable run. In real world conditions, such a network topology

will almost certainly fail when exposed to sources of interference such as Wi-Fi and Bluetooth signals, and operating over a cable run of more than a few meters

- Use a repeater/booster after 32 unit loads at most. The recommendation of eldoLED when installing a new network is to insert a booster every 25 units: this gives headroom to allow for higher than expected signal attenuation. It also provides flexibility to add units at a later date without the need to insert additional boosters
- Keep the total length of the cable between the controller and the last driver to less than 300 meters

How To Connect 'DMX In' Terminals With eldoLED Drivers

A DMX driver such as the eldoLED POWERdrive 50W provides one set of DMX terminals: DMX in +, DMX in -, and DMX in shield. In all drivers, with exception of the last, the two ends of the DMX cable are terminated together in the appropriate terminal.

At the last driver, only a single cable end is disconnected in each of the three terminals. In addition, a 120Ω resistor must be connected between the DMX in + and DMX in - pins of the driver to prevent signal reflections, as shown in Figure 3.

In existing installations, some older eldoLED drivers might have an extra set of DMX terminals, marked DMX thru +, DMX thru - and DMX thru shield, or DMX out +, DMX out - and DMX out shield in addition to the 'DMX in' terminals. These DMX out or DMX thru terminals should never be used unless the installer has a specific instruction that it is necessary to use them. In a driver with 'DMX out' or 'DMX thru' terminals, all wires should in normal installations be terminated in the 'DMX in' terminals as shown in Figure 3.

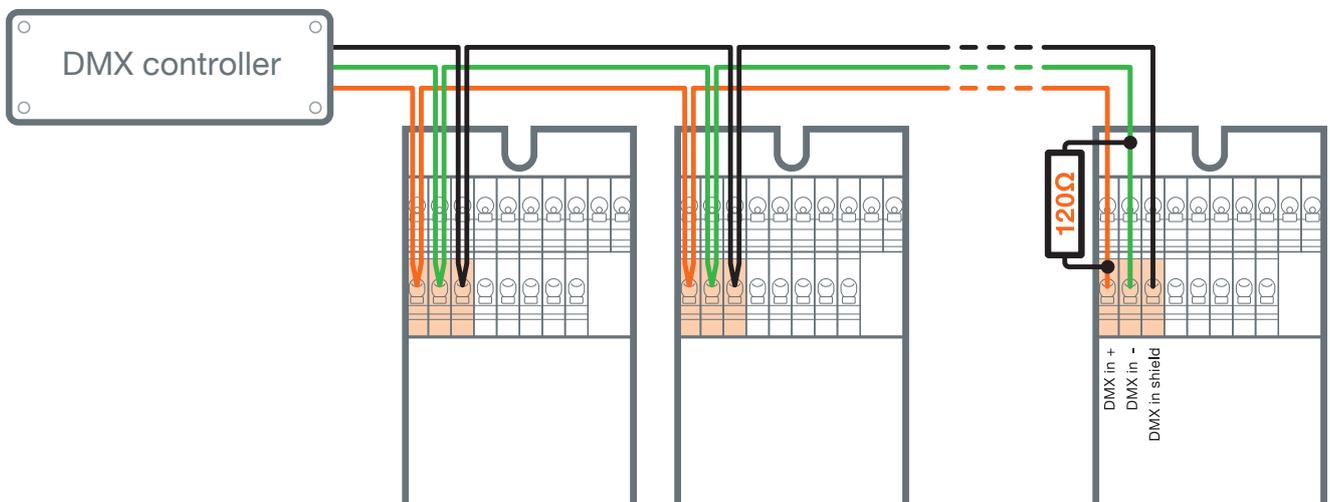


Fig. 3: the correct wiring configuration of a daisy-chained network of DMX fixtures

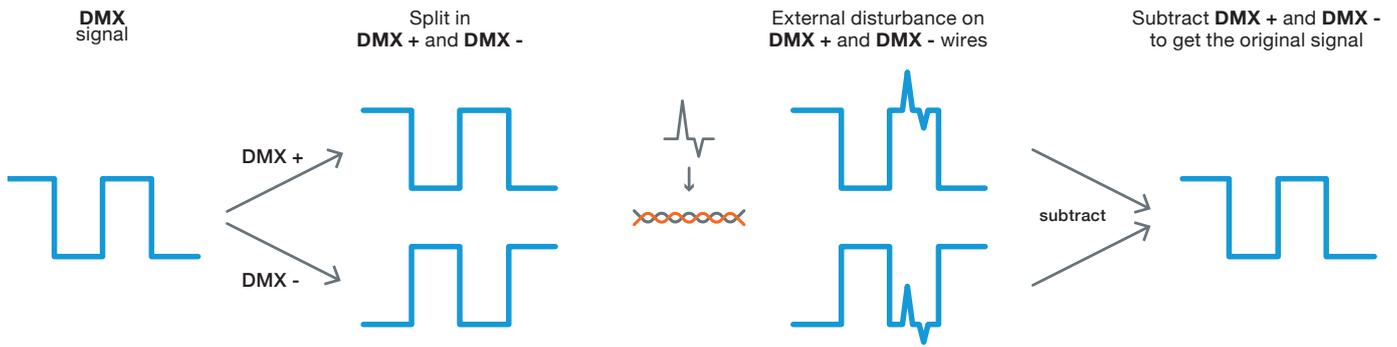


Fig. 4: DMX twisted-pair wiring cancels out the effect of interference

Why Choosing The Right Cable Is Important

External Disturbances

DMX is a balanced three-wire system. Two wires carry the data signals and one wire acts as the common reference. The advantage of a balanced system is that external signal disturbances (EMI or electromagnetic interference) can easily be reduced. Both signal lines in a balanced system carry the same signals with opposite polarity: they are subtracted from each other at the receiver (driver).

DMX cables should have twisted-pair conductors. This means that each pair of wires in the cable are twisted together. This ensures that any external disturbance signal will occur equally on both signal wires (DMX in + and DMX in -). Since the receiver subtracts signals on both wires, the equal disturbance signals will also be subtracted from each other and are cancelled out, as shown in Figure 4.

Two other measures reduce further the effect of external interference, which can come from the power wiring, and from RF emitters such as the Wi-Fi and Bluetooth signals in smartphones, tablets, smart watches and other such devices.

The use of **shielded cable** prevents external disturbances from reaching the signal wires. If a shielded cable is used, avoid connecting the DMX shield to mains ground. In an eldoLED driver, ground connections should be made to the special PE (Protective Earth) terminal. This ensures that each driver unit has its own dedicated ground connection, and is not coupled to the grounding for the entire DMX network.

Use of the PE terminal eliminates the risk of grounding malfunctions, the most common of which is the loss of RDM signals. Failure to ground the driver can also lead to blinking lights and the unwanted switching of lights.

A **driver with internal optical isolation** for the DMX signal prevents noise from the primary side of the power circuit (the mains) or the secondary side (the LED power supply) from interfering with the DMX signal. Users of optically isolated drivers will enjoy much more reliable network operation.

A driver with internal optical isolation also limits the effect of wiring errors to the driver itself, rather than disabling the entire DMX network. Since wiring errors are a common occurrence, this protection is valuable. An optically isolated driver is also protected from signal disturbance caused by power surges or lightning strikes.

Installers and specifiers who have worked previously with DALI or 0-10V networks will know that DALI and 0-10V drivers are isolated as standard. Strangely, optical isolation has not in the past been a standard feature of DMX drivers.

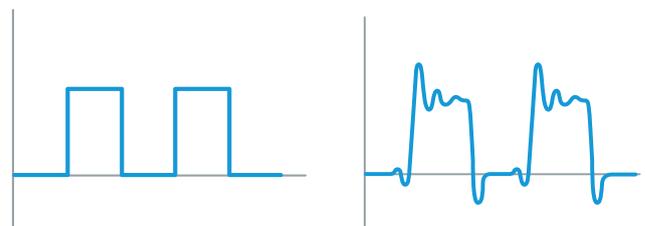


Fig. 5: comparison of an ideal DMX signal (left) and a distorted signal (right)

The POWERdrive 50W, a DMX driver from eldoLED, is optically isolated. This feature comes at a small additional cost compared to other drivers, but this cost is tiny compared to the cost of the post-installation service and repair work necessary to rectify the problems experienced by the typical user of non-isolated DMX drivers. In non-isolated drivers, the DMX functionality regularly fails or malfunctions due to signal disturbance from power cabling or sources of RF emissions.

Reflections

DMX works with high frequency signals. In an unterminated cable, these signals will be reflected when they reach the end of the cable. These reflections can cause erratic behaviour such as random flashing of lights, unintended brightness levels, visible flicker, and unstable operation.

Signal loss

Long wires always cause some signal attenuation due to the resistance of the cable. Therefore, the maximum cable length between the controller and the last driver must be less than 300 meters.

Signal loss is also an effect of the loading of the connected drivers. The DMX512 standard states that a maximum of 32 unit loads can be connected to one DMX cable. eldoLED drivers are one unit load. If the total unit load exceeds 32, a repeater or booster can be used, as shown in Figure 6. Note, however, that repeaters and boosters may also add to the total unit load.

eldoLED Recommended Best Practices For DMX Wiring

Here's a summary of best practices we recommend for how to wire DMX lighting systems:

- Use twisted-pair cables with an impedance of 120Ω and a low capacitance. UTP Cat5 or Cat6 network cable is another option but it has a slightly lower impedance of 100Ω
- Terminate at the last driver using a resistor with an impedance of 120Ω
- If shielded cable is used, only connect shield to ground on one side (typically, the controller should have its shield terminal connected to ground)
- DMX is designed to use three wires
- Not following the above recommendations may seem to work at first, but can cause problems, sometimes after weeks of seemingly normal operation. The cost of rectifying these problems after installation is far higher than the cost of preventing them on installation by using correctly specified equipment, including a DMX driver with built-in optical isolation

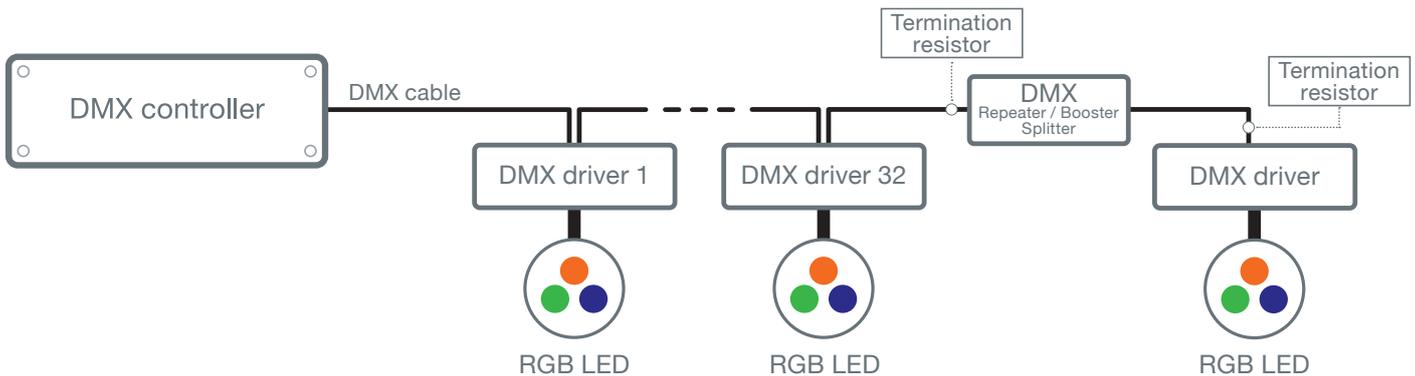


Fig. 6: the DMX standard requires the insertion of a signal booster for every 32 luminaires. On first installation, eldoLED recommends a booster every 25 luminaires

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