help desk

LED dos and don'ts | By Wayne Howell

"Done well, LED tape looks great, but there are a number of pitfalls that lead to unpleasant effects . . ."

In my previous column, I looked at how Ohm's Law relates to LEDs. As a reminder, Georg Simon Ohm's Law says V = IR. The law is demonstrated by the following diagram. The rectangle in the middle is a resistance of value R (in Ω). This could be an electrical component called a resistor, or just the inherent resistance that exists in a copper cable.

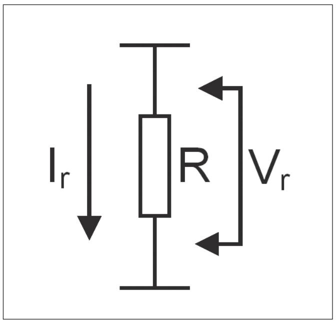

Figure 1

The voltage across the resistance is Vr. Ohm's Law tells us that the current through the resistance (Ir) is Ir = Vr /R

LED TAPE

LED tape is the go-to light source for many applications ranging from cove lighting to retail displays and TV sets. Done well, LED tape looks great, but there are a number of pitfalls that lead to unpleasant effects such as variable intensity, colour temperature and flicker. An understanding of the circuit used in LED tape can help the installer get it right.

Figure 2 below shows the likely circuit of LED tape between two scissor cut points. The rectangle marked R is a resistor and the arrow symbols represent individual LEDs. Why are there multiple LEDs per resistor? The number of LEDs between cut points is set by the manufacturer in order to define the supply voltage (V) of the product.

The trick is to set the number of LEDs such that the power wasted by the resistor (R) is minimised. That's not just good for the product's efficiency, it reduces the heat generated by the tape which improves its life. As we discussed last time, each LED has a forward volt drop of Vf and there will also be a voltage dropped across the resistor, Vr. The current (I) through the circuit must be limited to a value that is safe for the LEDs. The voltage required is V = (N * Vf) + Vr where N is the number of LEDs.

Let's say the manufacturer has decided on a 24V product using LEDs with a Vf of 4V and operating current of 50mA (values which are pretty standard for white LED tape).

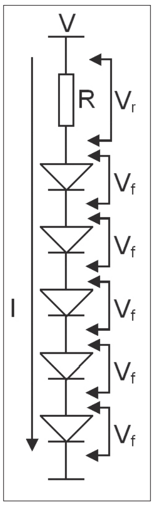

Figure 2

It's easy to see why five LEDs in series (N=5) works well. The cumulative Vf is 20V leaving just 4V to be dropped by the resistor. Ohm's Law tells us that a resistance R of 80Ω will achieve that.

DROPPING VOLTS

The diagram above represents the LED circuit between two cut points. So presumably, the diagram for the entire tape just duplicates that many times? Sadly not - voltage drop along the tape is a crucial consideration.

Figure 3 shows the effective circuit of the LED tape (well - a short section of it).

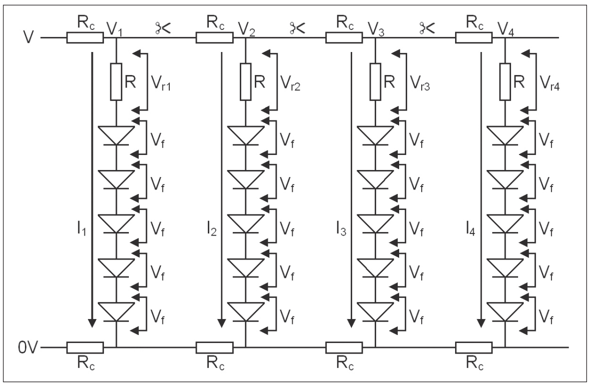

Figure 3

The tape is powered from the left at the terminals, marked 0V and V. In this example, we will continue to talk about 24V tape, so V = 24V.

The copper tracks on the tape have an inherent resistance; I have shown that as a resistor Rc between each cut point. Ohm's Law tells us that a voltage will be dropped across each Rc, which means the voltage across each series of LEDs (V1, V2, V3, V4 etc) will gradually drop. The maths is non-trivial because the current through each Rc is different: V4 = V - 2* [(I1+I2+I3+I4) * Rc - (I2+I3+I4) * Rc - (I3+I4) * Rc - (I4) * Rc].

The multiplication by two is often forgotten - there is resistance in both conductors. Do we care? Yes: for three reasons. One, the gradual reduction in voltage means less current flowing through the LEDs further along the tape. That will become a visible difference in brightness. Two, if the voltage drops below the Vf of the series LED, they will not illuminate. And three, at the point where the voltage drops to Vf, flickering will happen.

Wayne Howell is the CEO of Artistic Licence, the lighting controls company that he founded in 1988. Wayne invented Art-Net and is actively involved in the ESTA technical standards programme.

TAPE VOLTAGE

The most common LED tape voltage is 24V. 12V tape is also commonly available, as is 48V tape from specialist companies. Why are there different voltages and what are the pros and cons?

Higher voltage minimises the effect of voltage drop in the leader cables and over the length of the tape. Lower voltage reduces the number of series LEDs, which means the scissor cut points can be closer together. Lower voltage also tends to give a better fade from black when dimmed.

Generally, I recommend 24V tape for most applications. But it is worth considering 48V when doing outdoor work, as it allows the electronics to be located much further from the light.

RULES OF THUMB

Better quality LED tape is significantly more expensive than the cheapest one can buy. There are two key reasons for that: one, quality tape will use LEDs with better 'binning', i.e. all LEDs on the tape have a good match of Vf and intensity at a given current. Two - quality tape uses much thicker copper tracks, which reduces the voltage drop.

A quality 24V LED tape will likely drop no more that 1.2V over a 5m length and that voltage drop - in my experience - cannot be seen. So 5m of 24V LED tape is the maximum I would drive as a single run from one end. That said, there are a number of wiring tricks available . . .

STARS & RINGS

Figure 4 shows the way in which many people parallel connect multiple lengths of LED tape. It is a mistake, because the voltage drop across the first tape is being fed to the second.

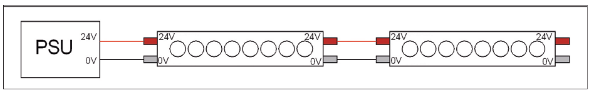

Figure 4

A much better scheme is in *Figure 5* below. This is called star-wiring because every single length of LED tape wires back to the PSU or dimmer.

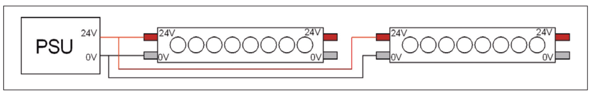

Figure 5

An even better arrangement is to use a 'ring main' and make connections to both ends of the tape, as shown in *Figure 6*.

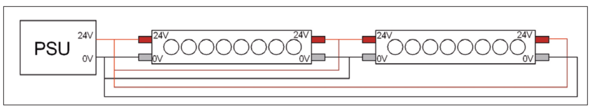

Figure 6

Feeding power from both ends effectively halves the voltage drop through the tape.