Application Note 110

Mounting Driver Remotely From Fixtures

Introduction

In certain applications it is necessary to mount LED drivers away from their respective light fixtures. A common question that arises in such applications is, how far away can the driver be located from the LED engine?

This application note will address that question for both Constant Current and Constant Voltage applications and provide tables that will help fixture designers quickly find the maximum permissible wiring length, for their specific installation application.

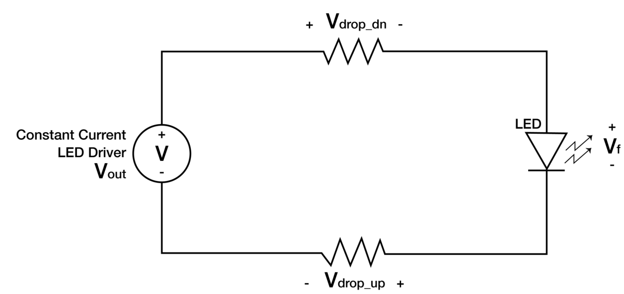

Figure 1. Constant current driver connected to an LED load circuit diagram.

Constant Current Drivers

For remote mounted applications, the voltage drop along the wires between the driver and the LED light engine will dictate the maximum distance.

This is because the driver “sees” the Forward Voltage (V_f) of the LED load as well as the voltage drop along the wires; and the sum of the two cannot exceed the driver’s maximum rated driver output voltage, V_{out_max}.

Equation 1 below is a representation of the above description, and Figure 1 shows the equivalent circuit diagram.

$$V_{f\_max} + V_{wire} \leqslant V_{out\_max} \text{.........(1)}$$

$$\text{Where: } V_{wire} = V_{drop\_dn} + V_{drop\_up}$$

To calculate the maximum allowable voltage drop along the wires we can solve for V_{wire} as follows:

$$V_{wire} \leqslant V_{out\_max} - V_{f\_max} \text{.........(2)}$$

V_{out_max} and V_{f_max} are known to the designer because they know which driver they’re going to use and what type of LED load will be connected to the driver.

With that we can compute the maximum allowable voltage drop along the wires between the driver and the load.

Let’s take an example:
If V_{out_max} is 42 V (supports the popular 37 V COBs) and if V_{f_max} is 40 V (under worst case LED conditions of highest current and lowest temperature) then:

$$V_{wire} \leqslant 42\text{ V} - 40\text{ V} \leqslant 2\text{ V}.$$

Looking at the circuit in Fig. 1 we can see that there is voltage drop along the wire going from the driver to the LED load (V_{drop_dn}) and a voltage drop along the return wire coming back from the LED load to the driver (V_{drop_up}). V_{wire} is actually the sum of two voltages as shown in Equation 3 below, and those voltages are equal given that the wires will be of the same gauge and length and carrying the same current:

$$V_{wire} = V_{drop\_dn} + V_{drop\_up} \text{.........(3)}$$

Going back to our example, we can see that $V_{drop\_dn} + V_{drop\_up} = 2$ V, which means the voltage drop along the wire from the driver to the load is 1 V. That is the maximum voltage drop allowed from the driver to the load for this specific design.

Another way to view this is that there is a limitation on the length of the wire that guarantees the total voltage seen by the driver does not exceed the max output voltage.

Calculating the maximum length for constant current applications:

The voltage drop along the wire depends on the resistance of the wire specified in Ohms per unit length (e.g. Ω/ft), the length of the wire and the current (I_{out}) flowing in the wire from the driver to the LED load.

To calculate the maximum length of the wire, Equation 6 below can be used:

$$V_{drop\_dn} = I_{out} \times R \text{.........(4)}$$

$$V_{drop\_dn} = I_{out} \times [\text{Resistance/ft} \times \text{length(ft)}] \text{.........(5)}$$

$$\textbf{Length (ft)} = \mathbf{V_{drop\_dn} / (I_{out} \times \textbf{Resistance/ft})} \textbf{......(6)}$$

Let's take an example. If:

- $I_{out} = 0.7$ A
- Resistance/ft = 0.006385 Ω/ft for 18 AWG copper wire
- Voltage drop allowed = 1 V

The maximum length will be:
Length = 1 V / (0.7 A x 0.006385 Ω/ft) = 224 ft.

For a more extreme example, let's increase the current and decrease the voltage drop allowed along the wire as follows:

- $I_{out} = 1.2$A
- Wire gauge 18
- Voltage drop allowed: 0.5 V

In this case the maximum length will be:
Length = 0.5 V / (1.2 A x 0.006385 Ω/ft) = 65 ft.

With a higher current and smaller voltage available to drop along the wire, the maximum length will be reduced.

As can be seen from the above examples, mounting constant current drivers remotely will not be an issue even in extreme situations. Table 1 below can be used to find the max wire length quickly assuming copper wire is used.

Voltage drop available (V)	I_{out} (A)	Wire gauge	Max Length (ft)	Wire gauge	Length (ft)
0.5	0.35	**18**	224	**16**	356
0.5	0.5	**18**	157	**16**	249
0.5	0.7	**18**	112	**16**	178
0.5	1.0	**18**	78	**16**	125
0.5	1.2	**18**	65	**16**	104
1	0.35	**18**	447	**16**	711
1	0.5	**18**	313	**16**	498
1	0.7	**18**	224	**16**	356
1	1	**18**	157	**16**	249
1	1.2	**18**	131	**16**	208

Table 1. Wire length table for constant current drivers using copper wire.

Constant Voltage Drivers

In CV drivers the voltage drop along the wires is lost voltage, which means the voltage across the load is reduced, potentially creating issues if the voltage drop along the wires is excessive. That is why limiting the wire length and/or decreasing the wire resistance, by choosing a lower gauge wire, is important.

Equation 7 is a representation of the above description and Figure 2 shows the circuit diagram:

$$V_{load} = V_{out} - V_{drop} \text{.........}(7)$$

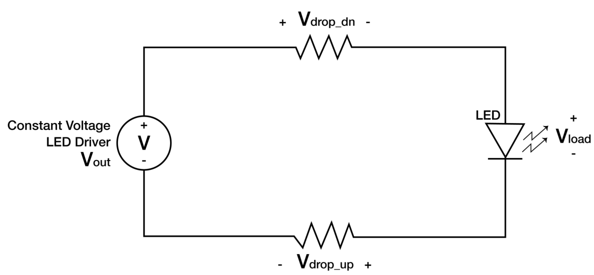

Figure 2. Constant voltage driver connected to an LED load circuit diagram.

The industry standard for an acceptable voltage drop (V_{drop}) for CV power supplies is 3% of the nominal output voltage.

Thus, maximum allowable voltage drop along the wire from the driver to load is half of 3%, i.e. 1.5%:

- For 12 V power supply max allowable drop = 12 V x 1.5% = 0.18 V
- For 24 V power supply = 0.36 V
- For 48 V power supply = 0.72 V

As can be seen, the higher the power supply voltage, the higher the allowable voltage drop and the longer the permitted wire length. That is why using a higher voltage power supply is advantageous.

Calculating the maximum length for constant voltage applications:

As stated before, the voltage drop along a wire is dependent on the current flowing through the wire, the wire resistance and the wire length:

Voltage drop = I_{out} x (Resistance/ft) x Length_max

Solving for the length we get:
Length_max = Voltage drop/ I_{out} x (Resistance/ft)

As an example, let's take a 24 V, 60 W power supply. At 60 W the max current is 2.5 A.

- Voltage = 24 V
- Current = 2.5 A
- Max allowed voltage drop is 24 V x 1.5% = 0.36 V
- 18 AWG copper wire has a resistance of 0.006385 Ω/ft

Substituting those values in the above equation yields:
Length_max = 0.36 V / (2.5 A x 0.006385 Ω/ft) = 22.55 ft

If the power supply is used at less than its maximum power, the actual current used by the load should be substituted in the above calculation.

For example, at 80% of output power, the power used by the load is: 60 W x 0.8 = 48 W.

- Voltage = 24 V
- Current = 2.0 A (48 W/24 V)
- Voltage drop = 0.36 V
- 18 AWG wire at 0.006385 Ω/ft

Substituting those values in the above equation yields:
Length_max = 0.36 V / (2.0 A x 0.006385 Ω/ft) = 28.19 ft.

Wire length quick reference tables for Constant Voltage applications:

Table 2 below can be used to find the max wire length quickly assuming copper wire is used.

Vout (V)	Power (W)	I_{out} (A)	Voltage drop (V) Max allowable	Length max (ft) 18AWG	Length max (ft) 16AWG
12	40W	3.3	0.18	8	13
12	60W	5	0.18	5	8
12	96W	8	0.18	3	5
24	40W	1.67	0.36	33	53
24	60W	2.5	0.36	22	35
24	96W	4	0.36	14	22
48	40W	0.83	0.72	135	216
48	60W	1.25	0.72	90	143
48	96W	2	0.72	56	89

Table 2. Wire length table for constant voltage drivers using copper wire.

Conclusion

When mounting drivers remotely from the LED load, the maximum allowable distance must be calculated to ensure proper operation of the fixture. This application note explained how the maximum distances are calculated and offered quick reference tables to simplify the process.

It is important to note that drivers that need to be mounted remotely, i.e. outside the luminaire, must be UL Listed.

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