How to choose the right circuit breaker?

Inrush Current

You switch on your just installed LED lighting system, but nothing happens. Of course you will check the circuit breaker and to your surprise it has tripped.

What just may have happened is that the inrush currents of your drivers triggered the circuit breaker.

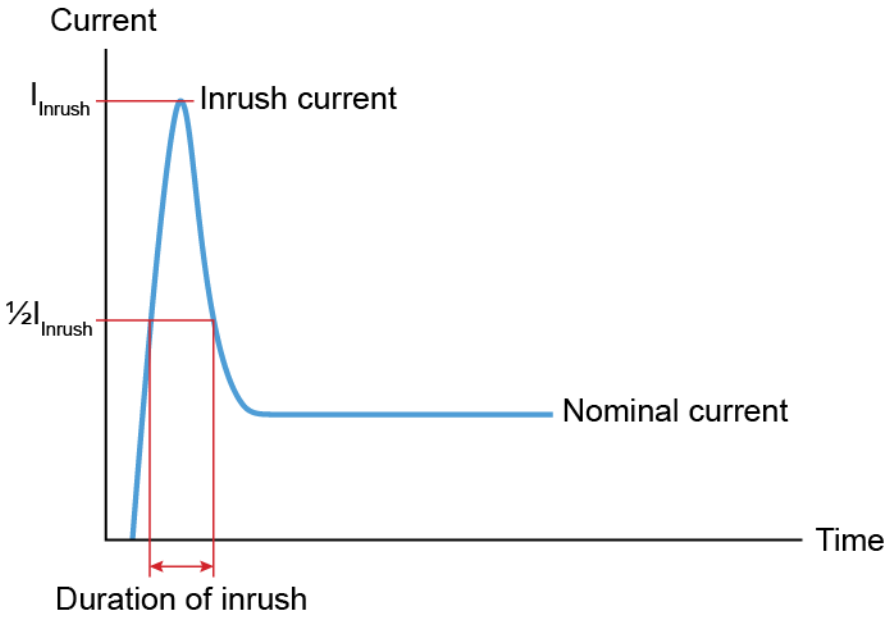

Figure 1 – Inrush current

An LED lighting system can – when switched on – cause an initial electric current that can be several times higher than the nominal current during normal operation. Typically, these inrush currents last for less than 10 ms but still they may cause some circuit breakers to engage. Inrush current is caused by the charging of capacitors in the power supplies of the LED drivers or because magnetic flux has not yet built up in the transformer in the power supply.

Calculating the number of drivers that can be connected to one circuit breaker

To calculate the number of drivers that you can connect to your circuit breaker (or: MCB – Miniature Circuit Breaker) you have to consider two calculations: *nominal current calculation* and *inrush current calculation*.

Nominal current calculation

For the nominal current calculation, you have to take the actual power used by the luminaire and divide that by the used voltage to get the nominal current. For example, a 75 Watt luminaire will have a nominal current of 75W / 230V = 0.33A.

If we take the ABB S200 16A type B MCB that can handle 16A and connect it to a 100W LED driver, the maximum amount of drivers would be 16 / 0.33 = 48.5. However, we also have to consider the efficiency of the driver, which can be found in the driver datasheet. For eldoLED 100W drivers the efficiency is specified as 90% at full load and as 87% at half load. With 75W, our luminaire is in between these numbers; therefore, we take the lower efficiency number. So, the maximum number of drivers we can connect to our MCB would be 48.5 × 87% = 42.

Inrush current calculation

Inrush current calculation is only necessary for eldoLED drivers with a maximum power output of 100 Watt or more. Inrush current on LED drivers with a lower maximum power output is insignificant, so for these drivers you can use the outcome of the nominal current calculation. Drivers from other manufacturers may have higher inrush currents on drivers below 100W. Therefore, you should always lookup the inrush current specification to see if you need to perform the inrush current calculation.

Data for the driver can be found in the driver datasheet. For instance, the inrush current specifications for the eldoLED POWERdrive 106/S are:

- 35A 240µs @ 120V/60Hz
- 67A 240µs @ 230V/50Hz
- 75A 240µs @ 277V/60Hz

Data for the circuit breaker can be obtained from the supplier of the MCB. You should ask for the maximum inrush current capability of your circuit breaker of choice. Note that not all MCB manufacturers specify these data in the datasheets of their circuit breakers.

For instance, ABB's S200 16A type B MCB has a maximum inrush current capability of 672A at 200µs and 533A at 250µs. Unfortunately, we have no specification for 240µs. For a rough estimation you can use the first value above 240µs. So, that is 533A at 250µs. To get the maximum number of drivers, divide the maximum inrush current capability of the MCB by the inrush current of the driver. That is 533 / 67 = 7.9. So we can connect 7 drivers.

If we want a more precise calculation with 240µs, we need to interpolate these values with the following formula:

$$I = I_0 + (I_1 - I_0) \times \frac{t_0 - t}{t_0 - t_1}$$

where I is the current we want to calculate at 240µs, I_0 the lowest current of the MCB – in this case 533A – and I_1 the highest current – here: 672A. t is the time specified in the datasheet of the driver, here that is 240µs, t_0 and t_1 are the half value times of the MCB. In our example t_0 = 250µs and t_1 = 200µs. So the maximum inrush current in our example will be:

$$I = 533 + (672 - 533) \times \frac{250 - 240}{250 - 200} = 560.8A$$

To get the number of drivers we can connect to this MCB we now only have to divide the calculated current by the rated inrush current of the driver. For 230V, that is 560.8 / 67 = 8.3.

Nominal current calculation gave us a maximum of 42 drivers. We can only use the lowest number of our two calculations. So, with this MCB and the selected POWERdrive 106/S driver, we can use 8 drivers.

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