LED LIGHTING INRUSH CURRENT AND OVERCURRENT PROTECTION DEVICES

LEDs are solid state devices that produce light when electrical current is passed through them. They are low-voltage devices that require addition electrical components to convert the standard AC mains (120VAC) line voltage to the lower DC voltage required to drive them. The portion of the electrical circuit that performs this high to low voltage conversion is typically referred to as a driver. These circuits typically consist of a combination of components that can be characterized as a combination resistive and capacitive load. When power is initially applied to the LED lighting system a brief surge of current rushes into the driver as the capacitors are charged up. This initial surge can be many times the nominal, steady-state, current draw and is referred to as inrush current. This is not unique to LED lighting systems as all electrical devices exhibit varying degrees of inrush current.

Overcurrent protection devices, or circuit breakers, are an essential component of any electrical distribution system for protection against both electrical shock to humans and prevention of damage to equipment and facilities. Typical thermal-magnetic circuit breakers have two modes of operation which may cause a unit to open or "trip." These conditions are typically characterized by the device's time-current curve or tripping curve. This curve plots the response curve of these devices as a relationship between electrical current and time. Time, on the Y axis is in units of seconds. Current, on the x axis, is the circuit current divided by the device nominal or rated current. In this way one can refer to the "number of times the rated current" for a given time duration. Any combination of time and current to the left of the curve represents the "no trip" zone. To the right of the curve is the "guaranteed trip zone." The gray area represents the zone where a trip is likely to occur



but cannot be guaranteed due to many factors including combined manufacturing tolerances and application conditions. The trip curve for a Siemens BL-type commercial-grade circuit breaker is shown in Figure 1. The upper half of the curve is referred to as the long-time setting. It represents the current at which the device will trip after anywhere from 1 second to several minutes. This is typically aligned with the nominal rating of the device. Internally a bi-metal strip deforms as it is heated due to current flow. At some point the metal deforms enough to open the circuit. For example, a 20A circuit breaker might trip if the current exceeds 20A for ~1 second or more. This portion of the curve is designed to protect the facility wiring from damage due to overheating during long periods of operation at high electrical currents.

The lower portion of the curve is referred to as the short-time setting. This portion of the curve is designed to protect against injury or damage from short circuit faults. Typically, these are much faster events at much higher current levels. Internally a magnetic solenoid is the core component that enables the functionality of this device. It should be noted that the current required to trip in the short-time setting is much higher than the long time setting. This enables the circuit breaker to allow some inrush current due to the normal operating nature of electrical devices. For example, a motor starting up, an air conditioning unit cycling or the initial surge of current from turning on a cold filament in an incandescent lamp. The time window in the short time setting is typically measured in milliseconds and microseconds.

When determining the appropriate combination of LED lighting products and the circuit breaker to be used in an application all of these parameters must be considered. While an LED lighting product will typically have a much lower power consumption than traditional products the inrush current can still be the limiting factor in how many devices can be circuited per circuit breaker. By selecting LED lighting products that minimize inrush current peak value and duration the number of lighting devices per circuit can be maximized. In addition, by using digitally controlled lighting products the number of devices on a circuit is not limited by the zoning or grouping requirements of the design of the space.

Ketra manufactures LED lamps, luminaires and control devices. By developing products with extremely low, and brief, inrush currents we have been able to significantly reduce total installation project costs by maximizing the number of devices connected to each circuit. Our lighting products are all digitally controlled therefore zoning and grouping is all done after installation regardless of how the products are circuited. This further reduces costs by enabling contractors to maximized the number of devices per circuit without worrying about wiring individual zones.

As an example consider the inrush current plot in figure 2 (shown on the next page) for the Ketra S38 lamp. This product exhibits a peak current draw of 300 mA at 50 microseconds following application of power. The total duration of the event is 190 microseconds; after which it settles to the nominal current draw. In this case the nominal current draw is 60 mA for the device that was tested at a given light level, however it can be

FIGURE 2



calculated for a number of other intensities by simply dividing the power consumption by the line voltage or 120VAC. If one were to select the Siemens BL-type circuit breaker mentioned earlier we could look at the short time zone and see the maximum current the device can handle without tripping for ~0.2 milliseconds. As can be seen in Figure 3 the device can reliable handle 8 times the nominal rated current. For a typical 20 A device this would be 160 A. At a peak current draw of 300 mA per lamp, and assuming a 20% de-rating for lighting as a constant load device per NEC guidelines, we can expect to be able to supply power to over 400 lamps without tripping the breaker during the short-time inrush event. However, the nominal steady-state power

FIGURE 3



consumption for this lamp at full output is 18W, which at 120VAC is 150 mA. This value applies to the long-time portion of the curve as shown in Figure 4. In this case the 20A rated device is shown to be able to handle the full rated load for upwards of 3 hours (10,000 seconds). Again, taking the 20A rating and de-rating by 20% by treating lighting as a constant load we can safely connect 106 lamps to this device.



The following illustrations on the next page show typical inrush currents for a selection of Ketra's lighting and controls products.

Designed in Austin, TX

PRODUCTS

S38 Lamp



G2 Linear Luminaire



Continued on the next page

PRODUCTS continued

N3 Satellite Interface



X1 Touchpad Control



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