INRUSH and LED Drivers

All TRP drivers comply with NEMA 410. It's a technical document covering the definition, measurement and test characteristics relevant to lighting control use on electronic fluorescent ballasts and LED drivers. NEMA 410 defines Inrush Current as:

"Input current of short duration during initial start-up that is much greater than the operating or steady state current".

Without going into an overblown explanation of how electronic components work, we can say that at start-up LED Drivers draw higher than normal operating current for a short duration. This current occurs because of various capacitors distributed throughout the design. These capacitors perform different functions in the design like limit electromagnetic interference, filter switching noise, and/or store energy. By and large the greatest contributors to inrush are the energy storage capacitors.

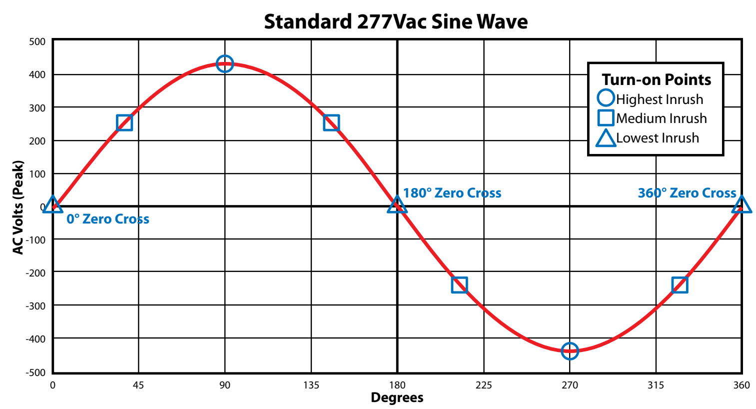
Simply put, a capacitance value times the change in voltage across it divided by the time it takes for that voltage to change causes a current pulse to flow that is of the same time duration as the voltage change. This is given in the equation below. So if the capacitor value and voltage change are large but occur in a very short amount of time, there is a large current flow through the capacitor. That current drawn from the AC line is inrush.

$$\frac{C \times \Delta V_{(t)}}{t} = \Delta i_{(t)}$$

WAVEFORM

LED Drivers powered by the AC line see a sinusoidal waveform *(as in the figure below)*. There are 360° to one complete AC line cycle, just as a circle or a compass has 360°. When a LED Driver is energized (start-up) by the power line, it occurs (turn-on) at approximately 1° of the 360° line cycle. In real life and with manual switches you never know what degree that turn-on will occur; but it matters. A sine wave has a peak and a trough at 90° and 270°. These degrees are where the varying magnitude sine wave respectively reaches its maximum and minimum peak voltage values. Also, the 0°, 180°, and 360° points are where the sine wave voltage is exactly zero.

A turn-on at zero voltage is relatively benign. The change in capacitor voltage can be muted. In this case the inrush current is drawn during the normal change of the line voltage in the appropriate line cycle time and/or with any additional circuitry that may try to push a higher voltage in a shorter amount of time across internal capacitors; however, here the inrush will be much less than if turn-on is at 90° or 270°. Of course, turn-on at the 90° maximum or 270° minimum means the change in the capacitor voltage expected is near instantaneous; hence, a large positive (at maximum) or negative (at minimum) current spike must occur that is more or less superimposed upon that which would have occurred if turn-on was at the zero voltage crossing.



The inrush current spike itself has a magnitude and a width. It's normally characterized for its peak and time width (the time at which 10% magnitude occurs). It's also measured at some source impedance, the highest nominal AC line voltage of specified driver operation, full load, a nominal 25°C temperature, and a time at which it has not been recently switched on. The source impedance is a standard value given in NEMA 410.

WHAT IT MEANS

High inrush current can create potential negative effects. NEMA 410 defines limits of acceptable inrush currents to prevent this. All TRP drivers are designed to stay within the limits. The highest nominal voltage on a universal driver would be 277VAC--this will obviously vary for drivers with other operating voltages. Full load is the normal test load. A 25°C cold start is considered worst case. Lastly, you want all the internal capacitors to be fully discharged so that no residual voltages present.

Unacceptable inrush can potentially damage relays. Standard relays can switch anywhere in a standard line cycle. As discussed above, switching at certain parts of the line cycle will allow for a maximum inrush. This can cause damage by degrading relay contacts and sometimes welding them closed, due to arcing at the contact. Standard component analysis techniques MUST be employed to determine the load derating to use on a relay, as well as the kind of inrush it can accept. There are few hard and fast rules that will substitute for good component engineering practice. Lastly, whole classes of relays that only switch at the zero crossing of the AC line voltage are available for use in controls, control panels and sensors. They allow for limited inrush to maximize the life of the relay.

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