



Understanding Electronic Ballasts and LED Drivers and Their Impact on Photo Controls

Abstract

In new lighting technology applications, the endurance of traditional photo controls has fallen short of expectations due to detrimental effects caused by the electrical characteristics of the electronic drivers associated with these new fixtures. Electronic ballasts and drivers offer improved efficiency and control of LED, inductive and fluorescent lighting loads, but can also subject the associated lighting controls to high inrush currents when switched on, possibly causing damage or reducing the life of the photo control.

Numerous issues impact new lighting technologies and their control systems. Updated photo control designs offer solutions to the problems associated with high inrush currents. Intermatic has reviewed standards focused on high inrush currents and performed extensive qualification testing on its photo control products. As a result of this analysis, Intermatic is able to offer products with electronic ballast inrush current ratings and extended life designs that match the current lighting technology being deployed.

What are Electronic Ballasts?

Ballasts limit the amount of current from supply line voltage, while maintaining the necessary electrical conditions for proper lamp start and operation. Ballasts vary in design complexity. Older, simplistic magnetic models minimally include inductors, capacitors and a series resistor. Modern electronic ballasts employ solid-state circuitry, which successfully eliminates the stroboscopic effect of flicker in fluorescent lighting, while increasing ballast efficiency.

Electronic ballasts, or drivers, are used to drive various lighting loads, including light emitting diodes (LED), fluorescent (Linear and CFL), induction fluorescent (IF), and high-intensity discharge (HID) lamps. These designs have different electrical start-up characteristics that should be considered by control suppliers, such as Intermatic, to provide properly functioning devices that are able to match the increased life expectations of new lighting technologies.

The Proliferation of Electronic Ballasts

In an effort to conserve energy resources, many governments have already passed or are considering legislative acts targeted at lighting system energy reduction. A major initiative includes phasing out magnetic ballasts for traditional fluorescent light applications. Another initiative is the adoption of new lighting technologies, such as LED, CFL and IF, which exclusively use electronic drivers and ballasts for operation. Going forward, the most common drivers or ballasts will be electronic. Controls manufacturers must ensure that their controls are compatible with these new lighting fixtures.

New Technologies, New Challenges

Although LED and CFL features, such as extended life and reliability, prove to be beneficial, these options also present a compatibility challenge with legacy controls. Lighting specifiers and control designers must consider the properties of the driver’s electrical characteristics in order to optimize a lighting installation’s performance. In the case of photo controls, a more complex control unit is necessary for a reliable, turn-on/off with an extended life to match the lifespan of the light fixture.

Design Considerations for Electronic Ballasts

Inrush currents at turn-on, produced from some electronic ballasts can cause premature relay contact failures. These inrush currents can be much higher than those experienced with traditional tungsten or magnetic ballast loads because many electronic ballasts employ large energy storage capacitors. Such capacitors can charge up to 400V for a 277V line voltage, and will briefly draw high current from the line to achieve this voltage.

As mentioned above, these typically short inrush currents can climb as high as 100 times the nominal operating levels. (See Table 1 for typical inrush value comparisons.)

Table 1 – Typical Inrush Current for Several Load Types

Type of Load	Inrush Current vs. Steady State Current
Incandescent Lamp	10 - 15x
Fluorescent or HID Lamp with Magnetic Ballast	Up to 15x
Electronic Ballast (Capacitive Load)	Up to 100x

The inrush current magnitude and duration depends upon the value of the capacitance (measured in μF), along with circuit and power distribution network impedances. This current may weld relay contacts and other switching devices or possibly fuse semiconductors. Overall, these high-current transients can negatively impact the lifespan of photo controls.

New electronic ballast designs can provide low or zero inrush currents, but they are more costly to implement and have not been universally adopted in the marketplace, creating a challenge for control suppliers. Intermatic has designed electronic ballasts with worst case inrush currents, as characterized by the National Electrical Manufacturers Association’s (NEMA) survey of electronic ballast technologies.

Photo Control Design Solutions to Minimize the Effects of High Inrush Currents

Photo control suppliers must keep in mind the effect of high inrush currents for electronic ballast designs. Suggested solutions described below address the high-current transients delivered by electronic ballasts.

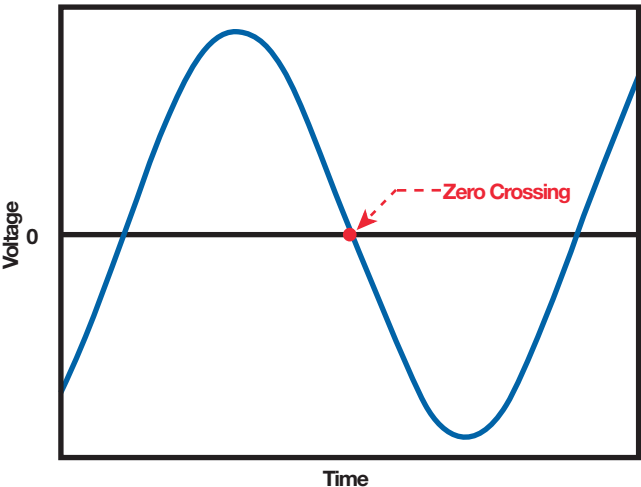
1. Employ a high-current rated thermal or electromechanical relay (Brute force approach)

An electromechanical relay life can be shortened when switching high inrush currents that exceed the relay’s electrical ratings. With high inrush currents, significant electrical sparks can occur during switching, causing pitting and wear on the relay’s contact surface. Relays with high current ratings take these transients more effectively, as they are designed with thicker, more durable conductive materials. Electronic ballast photo controls with high inrush currents require higher rated relays than what is suggested when considering the steady state current.

2. Implement predictive load transfer switching techniques (Cost-effective approach)

The inrush current exposure for relay contacts can be minimized with predictive load transfer switching. One technique, called zero crossing, limits the relay current by monitoring the AC supply voltage curve and timing the switching to occur as the AC voltage level passes through zero volts (See Figure 1). This effective technique extends relay contact life without relying on the rated contact current or the quality of the manufacturer, thus providing a more compact and cost-effective design.

Figure 1 – Zero Crossing Turn-on Waveform



3. Utilize photo controls with solid-state switches (Costlier approach)

Semiconductors such as triacs, SCRs, bipolar transistors and MOSFETs may directly switch loads. All are reliable, simple to control and successfully handle high inrush currents. However, because of their voltage drop ('on' resistance), they ineffectively conduct electrical currents for an extended amount of time, generating unwanted heat. Methods to remove this heat increase the size and cost of the control.

4. Utilize a hybrid solid-state/relay switch design (Costly approach)

The use of a hybrid semiconductor relay assisted circuit has proved effective in mitigating the heat rise issue with solid-state switching. However, costs are increased due to a higher component count. This circuit initially switches the load via the semiconductor to tolerate the inrush current, then transfers the current to a relay contact for reduced thermal operation.

Intermatic's premium electronic photo controls successfully utilize zero crossing techniques for extended lifespan. As a result, Intermatic is able to offer cost-effective, 8 to 12-year warranted electronic photo controls, while providing large inrush current carrying capacities.

NEMA 410 and Electronic Ballast Ratings

As LED lighting technology evolves, more efficient electronic ballast designs appear in the market. Many of these designs employ circuits that limit inrush current transients, while allowing for higher energy efficiencies. However, there is still broad variability in electronic ballast designs, resulting in a wide range of inrush current characteristics.

In an effort to provide better guidance to designers, manufacturers, and suppliers, NEMA has developed a standard that characterizes the electronic ballast current inrush phenomena and proposes a testing methodology to ensure lighting control and lighting load compatibility, called "NEMA 410 – Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts."

NEMA 410 outlines control device ratings based on transient inrush current waveform performance testing (See Figure 2). The control/switch device under test has to perform properly when subjected to the high-current pulses listed in Table 2.

...Intermatic is able to offer 8 to 12 year product warranties on these products while providing a large inrush current carrying capacity in a cost effective package.

Figure 2 – Test Pulse Waveform Definitions

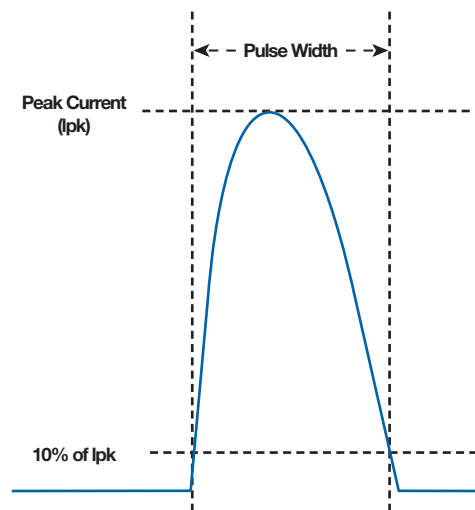


Table 2 – Examples of Load Requirements per NEMA 410

Ballast Steady Input Current Rating (amp)	@ 120 VAC			@ 277 VAC		
	Peak Current (amp)	Pulse Width (ms)	I ² t (A ² sec)	Peak (amp)	Pulse Width (ms)	I ² t (A ² sec)
2A	144A	0.70 ms	41	205A	0.85 ms	76
5A	192A	1.20 ms	74	320A	1.20 ms	205
8A	221A	1.25 ms	98	370A	1.25 ms	274

Intermatic Adopts NEMA 410 Qualification Testing for Photo Controls

Intermatic has implemented the test criteria of NEMA 410 for electronic ballast product compatibility qualification in its UL/CSA-certified testing laboratory (Figure 3). More specifically, products are tested up to the stated lifespan of ON/OFF cycles, which can exceed the minimum 3,650 cycles required by industry standards.

Intermatic's photo control products that have met or exceeded the NEMA 410 requirements, have been given an Electronic Ballast Rating, thus providing assurance that electronic ballast controls will reliably perform over their stated lifespans.



Figure 3. Intermatic's NEMA 410 Test Setup

As the market evolves, Intermatic anticipates the emergence of a new rating methodology that is based on actual inrush load characteristics, along with tested inrush control tolerances. This methodology will allow better coordination between loads and controls. In the meantime, the guidelines stated by NEMA 410 provide a universally conservative approach for electronic ballast photo control specifications.

Minimum performance standards for photo controls are established in ANSI C136.10, an industry standard for controls used in roadway and area lighting applications. All Intermatic photo control products meet or exceed this standard.

Conclusion

Intermatic has designed and tested its photo controls in order to prevent deleterious inrush loads in LED and other lighting applications that employ electronic ballasts.

These new photo controls mirror the life expectancy of electronic ballast operated LED fixtures. Intermatic has also evaluated its existing product lines for electronic ballast compatibility, utilizing NEMA 410. As a result, all Intermatic products meeting NEMA 410 have been given the Electronic Ballast Rating, assuring that these extended life products will optimally function with corresponding ballast sizes.

Due to this extensive testing, both customers and lighting designers alike can remain confident that Intermatic provides highly reliable, cost-effective photo controls for all LED and high performance lighting applications.

***With Intermatic photo controls
you can expect more!***

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