Technical Paper

TLED Lighting Scenarios for Retrofit Applications

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Abstract

Retrofitting fluorescent fixtures with Tubular (or Troffer) Light-Emitting Diode (TLED) lamps can provide energy-efficient advantages at lower cost than a total lighting retrofit, but a full understanding of the various options and tradeoffs is necessary to manage expectations and achieve desired results.

In this whitepaper we will

- Define the types of TLED retrofits
- Examine concerns associated with TLED retrofits
- Recommend best practices for desired results

The goal of this whitepaper is to help lighting professionals specify and install an appropriate TLED solution in retrofit situations.

Executive Summary

In this whitepaper, Lutron offers background information, guidelines, and recommendations for using TLED products as retrofits with fluorescent fixtures and ballasts. We describe the implementation of three different scenarios, and compare advantages and challenges associated with each scenario –

1. UL Type A: TLEDs retrofitted with existing fluorescent ballasts
2. UL Type B: TLEDs wired directly to line voltage
3. UL Type C: TLEDs supplied with dedicated LED drivers

For best results in most applications involving TLED products as retrofits for fluorescent fixtures and ballasts, Lutron recommends the use of Scenario 3, a pre-certified solution consisting of a dedicated LED driver with low-voltage TLED tubes.

Introduction

This Technical Paper provides information and assistance for users considering Tubular (or Troffer) Light Emitting Diode (TLED) retrofit options. TLED upgrades of fluorescent fixtures offer advantages such as higher efficacy, longer life, and reduced energy usage compared to traditional fluorescent lighting. For a successful installation, a full understanding of the various TLED options and their tradeoffs is essential. Special consideration is necessary when using TLEDs with a lighting control solution and in dimming applications.

In this whitepaper, Lutron offers background information, guidelines, and recommendations for using TLED products. This information is especially critical when the installation currently includes Lutron ballasts and control systems.

As of 2016, as determined by an analysis of the LED Lighting Facts database run by the US Department of Energy, TLEDs are one of the fastest-growing categories of LED products[1], Growing demand for this category is attributable to the relative ease of installation, energy and maintenance savings, generous utility rebates, and increasingly broad availability of products.

There are some tradeoffs with TLEDs; and furthermore, when a dimming control system is already in place, proper product selection is critical to ensure the functionality of the existing system is not compromised. For example, the solution has to ensure that light levels can be fine-tuned (high-end trim, partial on, daylighting), or anticipated energy savings may not be achieved.

Types of TLED Retrofits

UL describes three categories of TLED retrofit products under standard 1598C ("Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits"), and each scenario may be considered for dimming or non-dimming applications –

1. UL Type A: TLEDs retrofitted with existing fluorescent ballasts
2. UL Type B: TLEDs wired directly to line voltage
3. UL Type C: TLEDs supplied with dedicated LED drivers

Note there are also related "retrofit kits" that are used to upgrade an existing fixture to LED technology, but do not use the existing T8 lamp form factor or sockets. Such products are outside the direct scope of this document, but may present the same concerns in many situations.

Scenario 1: TLEDs retrofitted with existing fluorescent ballasts (UL Type A)

In this scenario, the fluorescent lamps are removed and replaced with specialized LED lamps that work with the existing ballast. This type of LED lamp has sophisticated internal electronics that simulate the electrical characteristics of a fluorescent lamp, essentially tricking the ballast into thinking a fluorescent lamp is still connected. When the fluorescent ballast remains in place, installing TLEDs into existing fixtures requires minimum labor and no modification to existing wiring or sockets, but the additional circuitry typically adds cost to the LED lamp and decreases its efficiency compared to an LED lamp used with an LED driver.

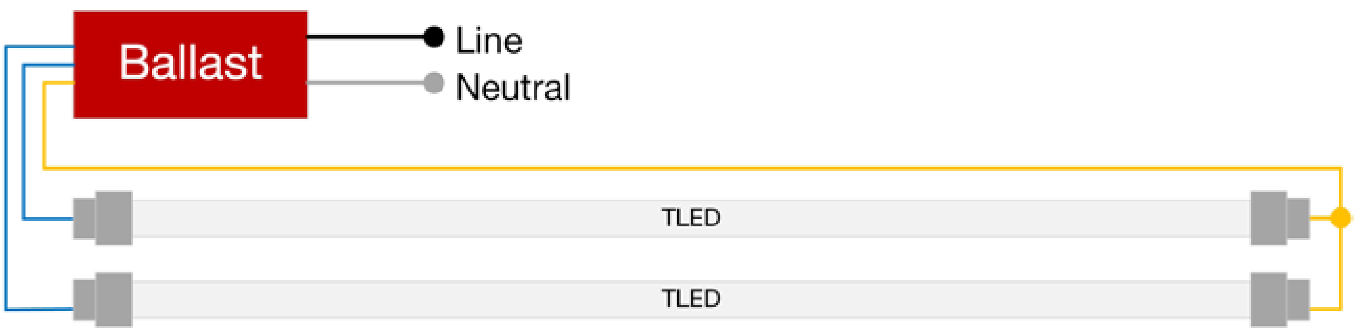

Figure 1: UL Type A TLED wiring example

Because all ballasts are not created equal, compatibility issues may arise, and this seemingly simple scenario can quickly become complicated and time-consuming. Not all fluorescent ballasts are compatible with all LED lamps; therefore, TLED lamp manufacturers often provide compatibility lists showing combinations that have been previously tested to indicate good performance. LED compatibility issues are particularly problematic with fluorescent dimming ballasts because the precise electrical characteristics of the LED lamp are more critical for proper dimming performance. Specifically, a TLED lamp on a fluorescent dimming ballast may dim, but not low, smooth, or linearly enough to satisfy customer expectations derived from their fluorescent dimming experience.

It is important to carefully consider lamp and ballast ratings. Fluorescent ballasts are tested and rated for one or more lamp wattages by a Nationally Recognized Testing Lab (NRTL), such as Underwriters Laboratories (UL). A ballast rated for 32W lamps has only been tested and approved for use with 32W lamps, but many TLED lamps actually achieve their claimed energy savings by operating at a lower wattage. For example, a TLED designed to replace a 32W T8 fluorescent lamp may only draw 28W, or even fewer. Unless the installed ballast has been tested and rated specifically to operate 28W lamps, it is being used outside the parameters of it's design rating and intent.

With the exception of a small number of ballasts designed for use with reduced-wattage “energy saver” lamps, most Lutron fluorescent dimming ballasts are designed for a single lamp wattage. Using the ballasts with lower-wattage TLEDs violates the ballast's design rating.

Scenario 2: TLEDs wired directly to line voltage (UL Type B)

This option has only one component: a lamp with an integrated line voltage driver. The benefit of this approach is there is little rewiring. The installer just needs to remove the existing ballast and directly connect line voltage to the existing sockets, then plug the LED lamp with integrated driver into the sockets.

Some UL Type B lamps have a hot connection on one end of the lamp, and a neutral connection on the other. Others have hot and neutral on the same end of the lamp, one on each pin, necessitating the use of non-shunted sockets (which often means replacing the installed shunted sockets). In the latter case, the opposite socket is used for mechanical support only.

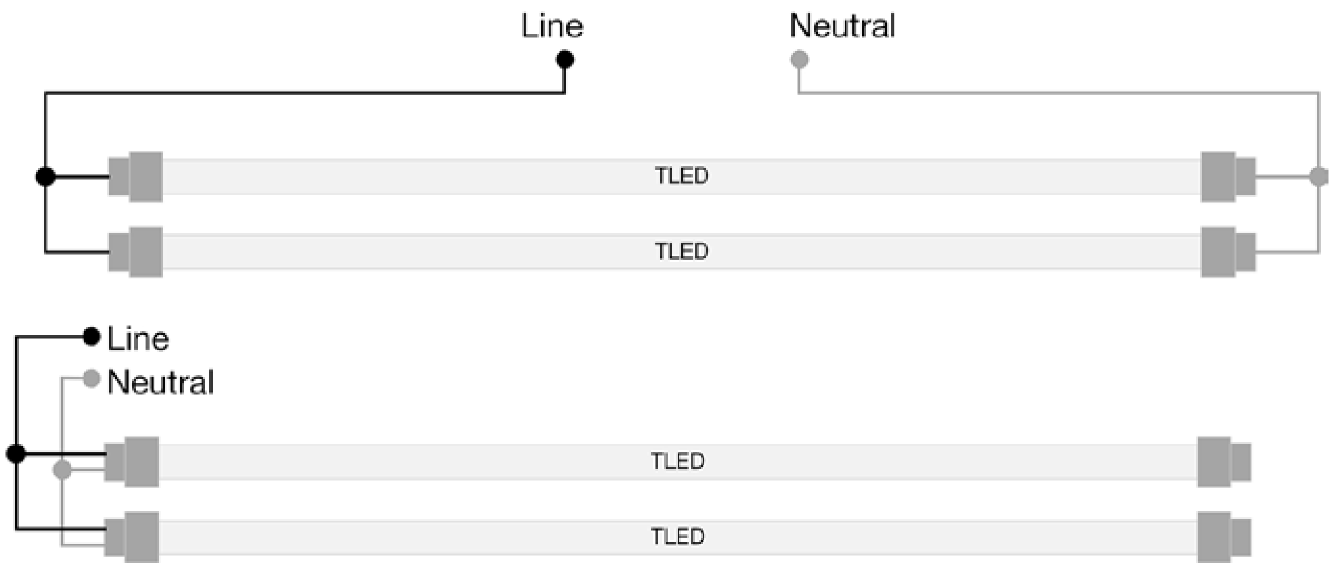

Figure 2: UL Type B TLED wiring examples

This approach presents some risks. First, there is a significant safety issue inherent in replacing the fluorescent lamp with an LED lamp in a rewired socket. At a future time, for example, a facilities installer may be unaware that the wiring was changed and plug a fluorescent bulbs into the socket – the line voltage will overload the lamp and may pose a safety issue. Installers who choose to implement Scenario 2 are required by code to educate future users by installing an informational sticker that clearly indicates fixture wiring is non-standard.

Scenario 2 involves more labor than Scenario 1, as changes must be made to the line voltage wiring. The existing sockets may need to be replaced, and the existing ballasts properly disposed of.

Scenario 3: TLEDs supplied with dedicated LED Drivers (UL Type C)

This option involves a kit consisting of LED drivers, LED lamps, and labels that have been tested to meet the requirements of UL 1598C. The kit may also include new wires and lamp sockets.

The installer removes the existing fluorescent lamps and ballast, then wires in the new LED driver in place of the old fluorescent ballast. The driver may wire to the LED lamps via the existing (or new) sockets, or via dedicated wire. Sockets may be used electrically, mechanically, or not at all.

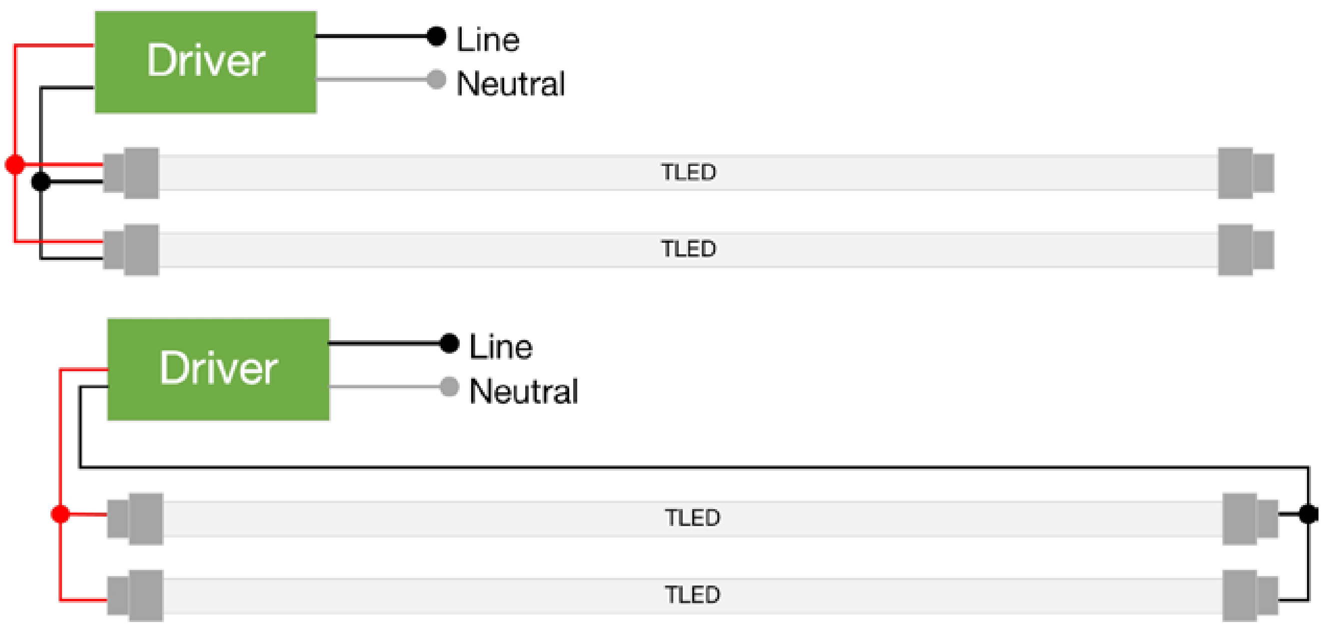

Figure 3: UL Type C TLED wiring examples

Scenario 3 is a certified, tested, reliable solution where ***<u>all the supplied components have already been tested together as a certified system</u>***. Unlike UL Type B solutions, the lamp remains low-voltage, eliminating the risks associated with line-voltage sockets.

In this scenario, it is also possible to add dimming capability by using a dimmable LED driver with existing power wiring and a compatible control system, saving even more energy. If existing control wires are not already run to the fixture (such as EcoSystem or 0-10V wires), adding a dimmable LED driver may be more complicated than adding a non-dimmable driver. In some cases, dimmable drivers can use existing line-voltage (2-wire phase control), making them drop-in replacements for switching drivers. Alternately, wireless control modules can be added to the fixture at the time of the retrofit, eliminating the need for control wires in the fixture.

While it is the most labor-intensive, Scenario 3 offers predictable and warrantied performance. The LED driver is pre-tested and pre-approved for use with the LED lamp, and the compatibility between the driver and control system can be confirmed in advance.

Concerns of TLED Retrofits

Efficiency

When considering how much electrical input power makes it to the LEDs, the three scenarios provide different tradeoffs for the overall efficiency of the system. In Scenario 1, the ballast has to convert the line voltage to a regulated current and voltage. The electronics in the lamp then have to re-regulate the current and voltage specifically for the LEDs. This double-regulation creates additional losses in the system as compared with Scenarios 2 and 3. In some situations, TLEDs will have to simulate the filaments in the ends of a fluorescent lamp, which often causes additional losses and decreases in efficiency.

Scenarios 2 and 3, which use dedicated LED drivers, will typically have higher system efficiency than solutions using Scenario 1.

Optical Quality

In a new construction or major renovation project, the design team takes great care to ensure the selected luminaires provide adequate lighting for the space. The photometrics of various fixture types and manufacturers are analyzed and compared to determine the best solution for the space.

In all three TLED scenarios, the difference in optical characteristics between LEDs and fluorescents is an area of common concern. Most TLED tubes do not have a light distribution pattern that matches fluorescent lamps. Specifically, most TLEDs do not emit light in an even 360 degree pattern as fluorescents do, and some TLEDs have a beam pattern as low as 105 degrees. This may cause fixtures using these lamps to disperse light differently, or to alter the amount of light available in the space or on desired horizontal and vertical surfaces.

The existing fixture reflector is specifically designed to use light from all outgoing angles of a fluorescent lamp to throw an even illuminance below the fixture. Replacing the fluorescent lamp with a TLED, which is not omnidirectional, can cause the illuminance distribution to become uneven, which in turn can create non-uniformity on the work surface (desk, tabletop, etc.).

TLEDs are often designed to provide a similar amount of lumens out of the fixture, but out of a smaller aperture. This typically results in more concentrated luminance and possibly creates glare for the occupants of the space. To determine how a particular TLED design will affect lighting levels, an independent study looked at various TLED designs in combination with several different styles of fixtures. The study concluded the only way to accurately predict resulting light levels is to individually test each TLED with each fixture[2].

Finally, some lesser-quality LED drivers (whether integral or external) can cause flicker that didn’t exist when fluorescent lamps were used. Because LEDs change their light output very rapidly in response to any changes in input current, any power fluctuations caused by a driver will result in visible fluctuations in the light output (flicker). Lesser-quality drivers can also be prone to “passing-through” normal power line disturbances, which are present in many commercial installations, which can manifest as flicker or shimmer.

Product Lifetime

In many Scenario 1 situations, a TLED is used with a ballast that has already been installed for a significant portion of its expected life. If the ballast is not replaced at the same time as the TLED is being installed, the benefit of adding that long-life LED lamp is actually reduced from a maintenance standpoint. If the ballast fails before the lamp's expected end-of-life, facilities personnel will have to get back up on a ladder, remove the lamps, remove the ballast housing and then replace the ballast. If a new ballast (or driver in Scenario 3) is installed at the same time as the LED lamp, there should be no problem with system life, and maintenance costs are generally reduced over the lifetime of the fixture.

Dimming

In many Scenario 1 cases, the installed fluorescent ballast is a switching ballast. Many TLEDs support dimming, but the benefit of dimming (which further reduces energy costs and can support task-appropriate light levels) cannot be achieved unless the existing ballast is changed to an LED driver. Today's building energy codes are compelling the adoption of energy-saving controls, as well as including mandates for occupancy/vacancy sensing, and daylight harvesting[3]. Sensor controls generally save even more energy and enhance occupant comfort when dimming is available. In some cases, dimming is required by code.

As previously noted, experience shows that the installation of TLEDs can significantly alter the amount of light in a space, which may lead to uneven light levels, different distribution patterns on walls, and even glare[4]. Having the capability to dim the TLED down to the appropriate light output may mitigate these factors while increasing energy savings.

Note that not all LED dimming options are created equal. Customers are conditioned to expect high-performance, flicker-free dimming of fluorescent and incandescent lighting. They expect lights to dim smoothly and continuously to levels of 10% or less. Poor quality dimmable drivers or improper control compatibility can lead to dimming that flickers, is not smooth, and possibly leads to premature driver, ballast, or control failure. Proper product selection and matching of the LED driver, LED lamps, and controls for your application is crucial to optimal performance.

Switching TLEDs

Most electronic ballasts in use today comply with NEMA 410, which stipulates the maximum amount of inrush current that an electronic device, such as a ballast or driver, can draw. Complying with this industry standard ensures that turning the load on and off will not cause any unnecessary stress to the switching control, and will never cause false tripping of circuit breakers.

Many LED drivers (including those used internal-to or external-from TLEDs, as in Scenarios 2 and 3), do not meet NEMA 410 standards. This means that, despite their lower wattage, LED drivers may cause undue stress on switching controls, leading to potential welding of the switch contacts and failure of the control. In extreme situations, heavily loaded circuits that turn on simultaneously (such as the situation after a power failure), may cause nuisance tripping of a circuit breaker. As an installer or customer, insist that TLED products that use internal or external LED drivers comply with NEMA 410 inrush current limits.

Conclusion

In conclusion, the choice of a TLED retrofit solution is a careful balance – ease of installation vs. cost vs. performance. Even beyond performance, safety is the overriding factor in any electrically-based operation. For optimal performance and the highest level of safety, Lutron recommends Scenario 3, the use of a pre-certified solution consisting of a dedicated LED driver with low-voltage TLED tubes, for most retrofit applications of TLED drivers.

Users are encouraged to review the Lutron High Performance Fixture List (www.lutron.com/findafixture) for complete details and specifications on Lutron's LED products including fixture retrofit options, and contact OEMs to request Lutron drivers available in TLED retrofit kits.

[1] US Department of Energy CALiPER Snapshot, "Linear Lamps (TLEDs),"
http://www.lightingfacts.com/Downloads/LightingFactsSnapshot-TLEDs.pdf

[2] US Department of Energy CALiPER Report 21.2, "Linear (T8) LED Lamp Performance in Five Types of Recessed Troffers,"
http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_21-2_t8.pdf

[3] See www.lutron.com/energycodes for details on control requirements for ASHRAE, IECC, and California Title 24

[4] US Department of Energy SSL Technology Fact Sheet, "Upgrading Troffer Luminaires to LED,"
http://www1.eere.energy.gov/buildings/publications/pdfs/ssl/led_troffer-upgrades_fs.pdf