Innovation and quality from the world leader in lighting controls

Lutron invented the world’s first electronic dimming ballast over 30 years ago. Lutron continues to lead the industry with innovative and energy-saving fluorescent dimming options, offering an extensive selection of ballasts and controls, and providing complete fluorescent dimming solutions.

This guide is designed to be a complete resource for all technical aspects of Lutron fluorescent dimming systems. The technical guide will review the basics of fluorescent lamps and dimming ballasts, including functional principles, lamp varieties, ballast factor, and lifetime expectations. Installation topics such as ballast mounting, grounding, lamp mounting height, wiring schemes, and troubleshooting will also be covered in detail.
## Lutron fluorescent dimming ballasts

For a complete listing of model numbers, see the Fluorescent ballasts and LED drivers Selection Guide or consult product pages on [www.lutron.com](http://www.lutron.com).

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<td>• EcoSystem® digital link</td>
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<td>• T5 HO linear: 24W, 39W, 54W, 80W</td>
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<tr>
<td></td>
<td>• T5 linear: 14W, 21W, 28W</td>
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<td>EcoSystem ballasts</td>
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<td>10%</td>
<td>Yes</td>
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<tr>
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<td>• T8 linear Reduced-Wattage: 25W, 28W, 30W</td>
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<td></td>
<td>• T5 HO linear: 24W, 39W, 54W</td>
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<td></td>
<td>• T5 linear: 14W, 21W, 28W</td>
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<tr>
<td></td>
<td>• T5 twin-tube: 36W, 39W, 40W, 50W, 55W</td>
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<td>5%</td>
<td>No</td>
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<td></td>
<td>• T4 4-pin triple-tube CFL: 26W, 32W, 42W</td>
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<td>No</td>
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<td></td>
<td>• T4 4-pin triple-tube CFL: 26W, 32W</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
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<td>• 120V @ 60Hz</td>
<td>• Tu-Wire® (fluorescent)</td>
<td>A-case</td>
<td>5%</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>• T4 4-pin quad-tube CFL: 18W, 26W</td>
<td></td>
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<tr>
<td></td>
<td>• T4 4-pin triple-tube CFL: 18W, 26W, 32W</td>
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How it works

How do fluorescent lamps work?

A linear fluorescent lamp consists of a glass tube containing low pressure mercury vapor with a tungsten filament at each end. Ultraviolet (UV) light is produced by striking an arc across the lamp from one filament to the other, causing the gas to glow. The amount of current passing through the lamp determines the light output. The UV light is converted to visible light by a thin coating of phosphor on the inside of the glass. U-bent, twin tube and compact fluorescent lamps are simply linear lamps with a varying number of bends.

How does Lutron dim fluorescent lamps?

Lutron ballasts adjust the current passing through the lamp to allow the user to control the light level. As part of the dimming process, it is important to keep the filaments heated by passing a current through them. Instant-start ballasts do not provide heat to these filaments and therefore can use sockets that connect the two filament pins together.

All Lutron ballasts are rapid-start-type, which provide supplemental heat to the filaments. It is therefore important that these two pins are not shorted together in the socket. Rapid-start sockets which keep these pin connections separate, must be used with Lutron ballasts. Using instant-start sockets with a Lutron ballast may cause permanent damage to the ballast, and will prevent proper operation.

Lamp type

Lutron offers dimming ballasts for every popular lamp type:

**Linear**
Linear lamps are straight lamps with pins at both ends. Lutron dimming ballasts work only with rapid-start lamps, which will have two pins at either end.

**U-Bent**
U-bent lamps have many of the same properties as linear lamps and are usually offered in the same sizes, except they are bent in a “U” shape. Lutron dimming ballasts for linear lamps will often control a U-bent of the same size and wattage.

**Reduced Wattage**
Reduced wattage lamps are designed to save energy through simply relamping from their standard wattage equivalents. Lutron offers dimming ballasts specifically designed to work with some reduced wattage lamps.

**Compact**
Lutron dimming ballasts for compact lamps are offered in quad tube and triple tube. Quad tube lamps appear to have two or four tubes, while triple tube lamps appear to have three. They mount in 4-pin rapid-start sockets.

**T5 Twin Tube**
Lutron also offers ballasts for the T5 twin tube lamps. T5 twin tube lamps use a locking-type 4-pin rapid-start twin tube socket.

Lamp seasoning and lifetime

Lamp life of fluorescent lamps is defined as the time for which the lamp can operate within its performance specification, i.e. produce the specified light output and strike within specification. Dimming fluorescent lamps without seasoning can reduce performance and lamp lifetime.

Contact the lamp manufacturer for their recommendations on lamp seasoning. As a general guideline, NEMA recommends 12 hours of operation at full intensity before dimming.

See NEMA LSD 23-2010 “Recommended Practice—Lamp Seasoning for Dimming Systems.”

Why keep the lamps at full intensity before dimming?
New fluorescent lamps can have impurities in them that lamp manufacturers cannot eliminate completely.

Ways to Obtain Seasoned Lamps

- Operate new lamps continuously (time period might include a weekend or holiday)
- Remove lamps with over 100 hours of use from another (non-dimmed) area; re-install in dimming area
- Use a lamp burn-in station to build an inventory of properly seasoned lamps
Ballast factor

Ballast factor (BF), also referred to as relative light output (RLO), is a measure of the light output of a fluorescent lamp on a particular ballast expressed as a percentage of its light output on a standard reference ballast. BF is not a measure of ballast efficiency, since there are ballasts that produce both lower and higher outputs than reference ballasts.

Range of BF
In the electronic fluorescent ballast industry, BF ranges from 0.7–1.2. Therefore for any lamp, there are ballasts available that are designed to provide anywhere from 70% to 120% light output of a reference. Ballast factors of all Lutron ballasts are indicated on the respective specification sheets.

Need for BF data
BF is important for fluorescent lighting design and specification as it helps to calculate the total lumen output of the lamps.

Example:

Actual lumen output
= 2,400 lm × 0.9
= 2,160 lm

When doing lumens per watt (lm/W) calculations to comply with watts per square foot (W/ft²) requirements in a region, the appropriate method to compare ballast efficiency is by using Ballast Efficacy Factor (BEF).

BF of Lutron dimming ballasts
The ballast factor of Lutron linear fluorescent dimming ballasts is 0.85 or greater and for compact fluorescent dimming ballasts it is 0.95 or greater. See ballast specification sheet for available ballast factors for a given lamp.

Selecting CBF
Lutron enables customers to order ballasts with a custom ballast factor (CBF): factory-tuned ballasts with reduced ballast factors that achieve greater energy savings, meet lumen/ft² specifications, and/or qualify for the highest levels for LEED.

CBF is an option for all Lutron ballasts with EcoSystem control capability including: Hi-lume 3D, EcoSystem, and EcoSystem H-Series, and can be selected by utilizing the Ballast Selection Tool: www.lutron.com/BallastTool

Ballast efficacy factor

Ballast efficacy factor (BEF) is the ratio of BF to the input power being supplied to the ballast. BEF considers both light output and correlated power consumption of a lamp-ballast system, allowing an effective comparison between different ballasts.

Example:

First ballast BEF
= 0.9 BF × 100
= 34 W
= 2.65 BEF

Second ballast BEF
= 1.0 BF × 100
= 38 W
= 2.63 BEF

This illustrates that the ballast with the lower BF may have greater efficacy and is therefore a lower energy usage product.
Power factor

Power factor measures how efficiently an electrical device operates. In electronic ballasts, the input power is used to operate the ballast and provide power to the lamps. Power factor compares the input power to the power actually made available to the ballast and lamps.

The electrical design of a device determines whether the input current and voltage are converted to maximum power within the unit. If the current draw is in-phase with the voltage, the power utilization is maximized. When the two are out of phase, some amount of power cannot be efficiently converted. Ballast Power Factor does not directly indicate the current supplied through the lamps, or how efficiently the lamps produce light when operated on a particular ballast.

Range of ballast power factor
High power factor products are rated greater than 0.9. Lutron electronic dimming ballasts achieve greater than 0.95 power factor by efficient design and use of high-quality components. Utility companies discourage low power factor devices because of their high device losses.

Power factor correction
Inductive loads generally have low power factors and present day designs add sophisticated circuitry to achieve a power factor close to 1. The solution is called power factor correction (PFC) and ensures more efficient power.

Power Factor = \( \frac{\text{Input Power}}{\text{Line Voltage} \times \text{Line Current}} \)

Power factor is always a value less than one.

Example:

\[
\begin{align*}
\text{Power Factor} & = 34.8 \\
& = \frac{277 \, \text{V} \times 0.13 \, \text{A}}{} \\
& = 0.96
\end{align*}
\]

Total harmonic distortion

Overview

Total harmonic distortion (THD) is a measure of the magnitude of all the harmonics (distortions) of the input current expressed as a percentage of the fundamental frequency current of 60Hz. THD is an important consideration for electrical safety, but lighting typically accounts for less than 30% of total building load and 10% of a building's overall load.

Why high THD is detrimental
Significant harmonics are put back on the line if the load type is not linear and draws current from the line in short pulses. Harmonic currents do not provide any power to the load, and flow in the neutral wire in a 3-phase system. Harmonics up to 33% are allowed by ANSI.

When line harmonics are present, the total current is the summation of the fundamental frequency current and the harmonic current. If the THD of an electrical device is 20%, it introduces 20% of the magnitude of its input current back on the line as harmonics. If this device constitutes 10% of the total electric load in a building, then it contributes only 2% to the total building THD. Codes and regulations require that total building THD not exceed 33%.

THD regulations
In the early 1980s when there did not exist a standard for THD of electronics, some dimming ballasts would produce up to 100% THD when dimmed down to low light levels. There have been many design improvements since, and ANSI C82.11-1993 now specifies maximum 33% THD for electronic ballasts.

All Lutron ballasts have a THD rating of 20% or less. Hi-lume, Hi-lume 3D, and EcoSystem H-Series ballasts all have a THD rating under 10%.
Ballast lifetime

Overview

The lifetime of a ballast is defined as the actual number of operating hours that can be achieved using specified lamps operating within their specifications. Maximum lifetime is achieved not only by using long-life components, but also by not approaching the operating limits of those components. Ballast life is strongly correlated with the lifetime of the electrolytic capacitors, whose lifetime can be maximized by operating them at lower temperatures. Lutron ballasts are designed to operate for their rated lifetime under worst-case conditions; however, external factors such as dimming level and fixture mounting can help the ballast run cooler and last longer.

When fluorescent fixtures are dimmed down to 80% of their maximum light output, the ballast has to drive less current through the lamp. On average, dimming fluorescent lamps by 20% reduces the ballast case temperature by up to 10°C. Every 10°C reduction in ballast temperature doubles the lifetime of the electrolytic capacitors, and hence the ballast.

The operating temperature of a ballast can also be dramatically influenced by proper installation. Fixtures that mount a ballast to a metal surface and ensure full contact between the ballast and a conductive surface allow for proper heat sinking of the ballast, and therefore lower operating temperatures and longer life.

This should be verified by measuring the calibration point in the intended fixture during fixture design.

Ballast mounting

Notes:
1. Ballasts generate heat and MUST have a means to dissipate it.
2. Ballasts MUST be mounted flush to the fixture in order to provide the best heat transfer.
3. Screws, knockouts, dimples, or features that raise the ballast off the fixture (even slightly) are not acceptable as these will impair the ballast’s ability to dissipate heat.
4. Avoid mounting the ballast on the fixture cover plate that holds the lamps. This mounting location is often the hottest point on the fixture.

Grounding

Both the ballast and the fixture must be connected to earth ground. Grounding the ballast to the fixture requires “star-type” screws, washers or nuts in order to penetrate the paint finish on the ballast. To ensure safety and performance, proper grounding is essential.

Both ends of the ballast must be attached to the fixture to ensure proper grounding.

UL and NEC require that the ballast and all parts of the luminaire be electronically grounded.
Mounting and grounding

Lamp mounting height

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Distance from grounded surface</th>
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<tr>
<td>T8 Linear</td>
<td>0.125”–0.75” (3.2 mm – 19.1 mm)</td>
</tr>
<tr>
<td>T5 Linear</td>
<td>0.125”–0.50” (3.2 mm – 12.7 mm)</td>
</tr>
<tr>
<td>T5 Twin Tube</td>
<td>0.125”–0.50” (3.2 mm – 12.7 mm)</td>
</tr>
</tbody>
</table>

Mounting a fluorescent lamp too close to the grounded metal will make the minimum intensity too low and may reduce lamp life. Lamps should never touch metal surfaces. Mounting a fluorescent lamp too far away from the grounded metal may make the lamp flicker or not turn on at all.

The listed mounting height ranges ensure that dimming performance and lamp life is maintained. It is important to make sure that in installed fixtures these spacings do not change over time.

Note: If using 10% dimming ballasts, T5 twin-tube lamps can be mounted as close as 0.03125” (0.79 mm) and linear T5 and T8 lamps can be mounted at 0.0625” (1.59 mm).

Typical fixture mounted and wired ballasts

Typical 2-lamp linear fixture with ballast mounted in center trough

Why are sockets important?

T8 rapid-start socket

Fluorescent lamp

Flow of electricity for filament heating

Dimming ballasts must connect to both lamp pins to heat the lamp filaments—without heating, the lamp ends will become black and fail prematurely (may take anywhere from a few days to several weeks). Additionally, poor lamp to socket connections will result in poor dimming or lamp striking.

When installing Lutron ballasts, good lamp pin-to-socket contact and correct wiring are required to produce flicker-free dimming and ensure long lamp life. For best filament contact, use only recommended sockets.

High quality electrical lampholder connections are critical, especially in dimming fixture assemblies.

Lamp sockets must comply with IEC 60400. Inspect sockets for marks to ensure the socket complies with IEC 60400. Two examples of these marks are: ☑ and ✗. Sockets must have a ☑ mark as well. Use Rapid Start sockets.

DO NOT use instant start sockets with Lutron ballasts.

See Appendix A (based on Lutron Application Note 122) and NEMA Publication LSD 34-2006.

Identifying rapid-start sockets

Rapid-start sockets are necessary because each socket must be able to accept two separate wires from the ballast, and in some cases, two additional wires from another socket. High quality rapid-start sockets have a good grip on lamp pins and make reliable connections with all wires. The backing material of the socket should be the same as the rest of the socket body, and should not deform with over-insertion of wires or repeated lamp changes.

See Appendix A (based on Lutron Application Note 122) and NEMA Publication LSD 34-2006.

WARNING: Using Lutron ballasts with instant-start sockets may damage the ballasts.

A jumper may have been installed for instant-start applications. This jumper must be removed.
Sockets and lampholders

Linear fluorescent lamps

Sockets for T8 Linear Lamps
The sockets should be rotary locking type, with metal contacts that make good, firm contact with the lamp pins. The sockets may also be slide-in or knife-edge variety. The fixture must have a grounded metal surface near the lamp (see pg. 11). The sockets MUST be rapid-start type.

Socket wiring for T8 Linear
For ballasts that control more than one lamp, sockets wired to the yellow or blue-with-white stripe leads of the ballast MUST be wired in parallel, not in series.

Sockets for T5 Lamps
The sockets should be of the rotary locking type. The fixture must have a grounded metal surface near the lamp (see pg. 11). The sockets MUST be rapid-start type.

Socket wiring for T5 linear
For ballasts that control more than one lamp, sockets wired to the yellow or blue-with-white stripe leads of the ballast MUST be wired in parallel, not in series.

Compact fluorescent lamps

Sockets for T4 Compact Lamps
T4 compact sockets must be the 4-pin type and must be used with 4-pin compact lamps. Instant-start sockets with 2-pin connections can only accept 2 wires and will not work. Sockets MUST be 4-pin rapid-start type.

Socket wiring for T4 Compact 4-Pin
Typical 2-lamp installation

Sockets for T5 Twin Tube Lamps
Use only 4-pin “locking” sockets that hold the lamp in place. T5 twin tube lamps require proper lamp support at the opposite end from the lamp base, to hold lamp pins in full contact with socket. The sockets MUST be rapid-start type.

Socket Wiring for T5 Twin Tube
Typical 2-lamp installation

T4 Compact 4-Pin

T5 Twin Tube

T8 Linear

T8 U-Bent

Typically Yellow (or Blue with White Stripe) wires
Note: Yellows wired in parallel

Note: Yellow wired in parallel

Red

Note: Yellows wired in parallel

Blue

Typically Yellow (or Blue with White Stripe) wires
Note: Yellows wired in parallel

T5 Linear

Typically Yellow (or Blue with White Stripe) wires
Note: Yellows wired in parallel

Red

Note: Yellows wired in parallel

Blue

Note: Yellow wired in parallel
Lamp wiring diagrams

Linear 1-lamp

Available in C-case, J-case, G-case and M-case

Linear 2-lamp

Available in C-case, J-case, G-case and M-case

Linear 3-lamp

Available in G-case

Note: Lamp terminals accept only one 18 AWG wire. Ballast-to-lamp wire lead lengths must not exceed 7 ft (2 m) for all wiring scenarios shown above.

T5 twin-tube 1-lamp

Available in G-case and J-case

T5 twin-tube 2-lamp

Available in G-case and J-case

T5 twin-tube 3-lamp

Available in G-case

Note: Lamp terminals accept only one 18 AWG wire. Ballast-to-lamp wire lead lengths must not exceed 3 ft (1 m) for all wiring scenarios shown above.
In addition to offering ballasts with different low-end dimming levels, Lutron offers dimming ballasts with a variety of control options.

**EcoSystem® digital link**
- **Models available:** EcoSystem H-Series, EcoSystem, and Hi-lume® 3D ballasts
- **Dimming levels available:** 1%, 5% and 10%

The EcoSystem digital link is a wired communication technology that facilitates individual ballast addressing, connection of multiple control devices, and control of ballasts individually or in groups. The digital communication wires are polarity insensitive and may be wired in any topology. They may be run with the line-voltage wiring (Class 1) or separately from the line-voltage wiring (Class 2). The EcoSystem digital link allows for the quick connection of devices and re-configurability.

**3-wire**
- **Models available:** EcoSystem, Hi-lume and Hi-lume 3D ballasts
- **Dimming levels available:** 1%, 5% and 10%

3-wire control is a line-voltage phase-control dimming method. Along with Hot and Neutral, the dimming signal is communicated via a third wire called Dimmed Hot. All three wires are rated Class 1 and can be run within the same conduit. 3-wire control is stable over long wire runs, allows for maximum circuit loading, and is very easy to wire.

**2-wire**
- **Models available:** Tu-Wire® ballasts
- **Dimming levels available:** 5%

2-wire control is a line-voltage phase-control dimming method. The ballast receives the dimming signal through the Dimmed Hot wire. Intended for small-scale retrofit applications, the 2-wire control method is often the easiest way to implement dimming in existing fluorescent fixtures.
EcoSystem ballasts

Overview

Lutron EcoSystem lighting control systems start with one simple, but essential building block, the EcoSystem dimming ballast. EcoSystem digitally addressable dimming ballasts employ revolutionary technology allowing each device to listen, think, decide, remember, and react to its environment.

A variety of sensors or wallstations can connect directly to the ballast to create an efficient lighting control system, whether the system contains only one ballast or up to 64 ballasts connected together. Sensors and wallstations can also be connected to the system through sensor modules and control panels to allow for maximum flexibility. EcoSystem redefines fluorescent lighting control as a cost-effective solution that is easy to design, install and maintain.

Connecting sensors and wallstations

To connect a daylight sensor, occupant sensor, wallstation and/or infrared receiver, refer to the instruction sheets provided with the devices. Diagrams for the Class 2 Sensor/Wallstation terminals are shown below.

NOTE: The ballast accepts only one infrared input connection from a daylight sensor, IR sensor or wallstation.

Example: sensor wiring connections

G–case with daylight and IR sensor

J–case with occupancy sensor

G–case with wallstation

EcoSystem ballasts are available for many voltages and lamp types. If a ballast is not available for direct control via the EcoSystem digital link, a Lutron 3-wire dimming ballast can be connected using a Ballast Module. The system provides continuous, flicker-free dimming from 100% to 10%, 5% or 1% depending on lamp type. Lamps can be turned on at any dimmed level without first flashing to full brightness. The digital link control allows for re-zoning without rewiring, and miswire protection is included in the EcoSystem link. Components are 100% performance tested including burn-in before shipping, and include a 5-year limited warranty with field service commissioning (3-year warranty standard).
Emergency backup ballast

Overview

In commercial fluorescent applications, battery backup ballasts are sometimes used for required emergency and egress lighting. Battery backup ballasts provide one solution for addressing emergency lighting. These ballasts provide light on a temporary basis when normal power has been interrupted. Some of the major manufacturers are Bodine Emergency Lighting, Exide Technologies and Iota Engineering.

Emergency Ballast Recommendations

Lutron fluorescent ballasts are designed to provide lamps with a precise amount of voltage to ensure long lamp life, flicker-free performance and lamp balance. The addition of an emergency ballast can affect the amount of voltage delivered to the lamps. It is imperative that any emergency ballast should not significantly alter the amount of voltage that is delivered to the lamp and filaments. We recommend choosing emergency ballasts from manufacturers who take these considerations into account. Please refer to the emergency ballast manufacturer for compatibility.

Wiring Recommendations

While the wiring method may change for each manufacturer, the main function is to illuminate one lamp or two lamps within the chosen fixture in an emergency condition. There are several guidelines for using this technology with Lutron dimming ballasts.

• Always keep the lamp wires as short as possible. The total lamp wire length for Lutron fluorescent ballasts includes the wire length of the backup device. Please see Lutron ballast specifications for maximum allowable lamp wire length.
• Depending on the fixture layout there may be a slight imbalance of illumination on a multi-lamp ballast during normal operation.
• Contact Lutron Technical Support for further information.

Typical wiring diagram

The below diagram is an example emergency ballast wiring diagram showing single lamp emergency operation. Wiring varies by manufacturer.

Note 1 – Some emergency ballasts switch the neutral instead of the switched hot to the normal ballast.
Ballast troubleshooting

Fluorescent fixture troubleshooting

### Issue/problem | Possible solution/easy solution
---|---
**Lamps are flickering, flashing, or dropping out**
- If the ballast is 3-wire controlled, verify that the Dimmed-Hot & Switched-Hot input wires are not reversed.
- Verify ballast model number matches the lamp wattage and number of lamps.
- Verify that the lamp sockets are rapid-start type, not instant-start.
- Ensure the sockets are wired correctly according to the wiring diagram on the ballast. Yelows must be wired in parallel, not series.
- Verify that the lamp wire length does not exceed the maximum length specified on the ballast label.
- Ensure that the lamp is not touching any metal part of the fixture.
- Make sure ballast is grounded. Verify grounding by measuring resistance from the enclosure to a known good ground.
- Replace the lamp. If this resolves the symptom, refer to the "Lamp Failure" issue.

**Lamps do not strike**
- If the ballast is 3-wire controlled, verify that the Dimmed-Hot & Switched-Hot input wires are not reversed.
- Verify ballast model number matches the lamp wattage and number of lamps.
- Verify proper line voltage present at the ballast.
- Ensure the sockets are wired correctly according to the wiring diagram on the ballast. Yelows must be wired in parallel, not series.
- Verify that the lamp sockets are rapid-start type, not instant-start.
- Replace the lamp. If this resolves the symptom, refer to the "Lamp Failure" issue.
- Verify that the lamp wire length does not exceed the maximum length specified on the ballast label.
- Contact lamp vendor to ensure that lamps are compliant to the appropriate ANSI or IEC lamp specification. Lutron cannot certify lamp compliance, only ballast compliance.

**Lamps do not dim, or are stuck at one level**
- Verify that ballasts are dimmable.
- Verify that the control wiring for the dimmer/dimming system is properly connected.
- Make sure the dimmer/dimming system is the proper control type for the ballast.
- If there is an emergency ballast in the fixture, confirm that it is wired properly and not interfering with the dimming.

**After initial warm-up, light output is pink or too low.**
- Lamp may be too cold. Shield the lamps from air flow.
- Lamps may be damaged, have low mercury content, or at the end of their life. Swap lamps with known good one to see if the problem follows the lamp.
- Replace the lamp. If this resolves the symptom, refer to the "Lamp Failure" issue.
- Check the low end light level rating of the ballast (1% 5% or 10%).
- Contact lamp vendor to ensure that lamps are compliant to the appropriate ANSI or IEC lamp specification. Lutron cannot certify lamp compliance, only ballast compliance.

**Lamp failure**
- Lamps may be at the end of their life. Compare how long they were running with the lifetime of the lamp.
- Verify that the lamp sockets are rapid-start type, not instant-start.
- Ensure that the lamp is not touching any metal part of the fixture.
- Contact lamp vendor to ensure that lamps are compliant to the appropriate ANSI or IEC lamp specification. Lutron cannot certify lamp compliance, only ballast compliance.

**Lamps dim down to mid level and cannot be manually raised**
- Check if there is a daylight sensor in the system. Daylight levels may need to be adjusted if lights are not at the desired level.
- Verify that the control wiring for the dimmer/dimming system is properly connected.
- Make sure ballast is grounded. Verify grounding by measuring resistance from the enclosure to a known good ground.
- Make sure the dimmer/dimming system is the proper control type for the ballast.
- Ballasts may be running above rated temperature. Verify calibration point on the ballast is not being exceeded.

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### Issue/problem | Lutron instructions | Consequence
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**Flush mount ballast to fixture for heat transfer and grounding**
- Ballast mounting with paint piercing mounting hardware
- If the ballast is not properly heat sunk, it could operate above its maximum temperature rating and fail prematurely. If the ballast is not grounded properly, the lamps can flicker or have trouble striking.

**Ground ballast with paint piercing mounting hardware**
- Ballasts should be a minimum of six inches apart
- If ballasts are mounted too close together, they may overheat, which could cause it to operate above its maximum temperature rating and fail prematurely.

**Contact Lutron Tech Support for guidelines on mounting multiple ballasts in a single fixture**
- Lamps must never touch the grounded metal parts of the fixture
- When lamps touch grounded metal, they could have difficulty striking, have poor or erratic dimming performance, or may fail prematurely.

**Proper strip lengths**
- If wires are not stripped long enough, they may not be making a connection. If wires are stripped too long, they may be shorted together or to the fixture which could cause the lamps to flicker or have trouble striking.

**Proper wire gauge and type**
- Proper wire lengths
- Using improper wire gauge or type can result in poor connections, and/or damage the ballast and lamp socket connectors.

**Proper wire lengths**
- If maximum wiring length is exceeded, lamps may flicker or have trouble striking.

**Yellows lamp socket leads must be connected with the lamp flaments are in parallel, not in series. See ballast label or "Ballast Installation Guide" for wiring diagram.**
- All lamp performance, dimming, stability, and life will be compromised

**Use sockets complying with IEC 60400**
- IEC compliant sockets guarantee a high level of quality. Using sockets without this rating could lead to poor connections in the socket, which can result in flicker, trouble striking, dropping out, or premature lamp failure.

**Use rapid start sockets NOT instant start sockets**
- Instant start sockets shut out the pins of the lamp, which will result in flickering, trouble striking, dropping out, or premature lamp failure.

**Flowing air should not blow directly on lamps. The minimum starting temperature is 10 °C / 50 °F.**
- If the lamps are too cold, they may flicker or have trouble striking. They may also appear pink or too dim. This could also cause premature lamp failure.
Appendix A: Application note

Lampholder and lamp installation

Overview
When fluorescent lamps are dimmed, they require continuous electrical current to heat the lamp filaments. Lamps fail prematurely if this filament heat is absent. This type of failure is characterized by extreme darkening of the ends of the lamp. The common cause for lamp failures is either poor connection between the lamp pins and the lampholder, poor connection between the lampholder and the ballast, or incorrect wiring of the ballast to the lampholder. It is important that high quality lampholders are used and installed correctly in fixtures to provide reliable and trouble-free lamp operation. This specification recommends which lampholders to use and best practices for installing the lamp and lampholders.

Specification
I. Lampholder Requirements
1. Lampholders shall be UL listed, and meet IEC-604001, "International Standard: Lampholders for tubular fluorescent lamps and starters." The IEC specification already lists many design requirements that are essential for fluorescent dimming. Some of them are repeated below for emphasis.
   a. The wire/lampholder connection shall meet IEC 60400 section 9.5. The force to remove wires from the lampholder shall have sufficient mechanical connection between lamp and lampholder. Metal parts shall resist corrosion, e.g., phosphor bronze. A metal contact that corrodes increases the resistance of the connection, which reduces the power delivered to lamp filaments and results in premature lamp failure.
   b. Lampholder material shall be rated per IEC 60400 sections 17, 18, and 15.6, which specify mechanical resistance to heat, stress, and corrosion. Lampholders shall not deform due to operating temperatures expected under normal use and luminaire design. Deformation of the lampholder could result in a broken electrical connection, resulting in poor dimming performance and premature lamp failure.
   c. Lampholder housing shall not deform due to wire or lamp insertion. Cardboard backing can deform during wire insertion, which could allow the wire to be over-inserted, resulting in poor contact with lampholder.

II. Lampholder wiring
1. Rapid-start sockets shall be used with dimming ballasts. Instant-start sockets can not be used. Instant start sockets short out the pins of the lamp, so the ballast cannot provide supplemental heat to the filament.
2. Wiring between ballast and lamp sockets shall follow diagram provided by ballast manufacturer. Some manufacturers wire "yellow" filaments in parallel, other manufacturers wire "yellow" filaments in series. The ballast design provides the correct filament heat only if the lamps are wired according to the diagram.
3. Lampholders shall provide a separate channel for each wire that connects to a lamp pin, and accommodate a specified range of wire diameters. Insertion of a second wire into the lampholder must not compromise electrical connection of the first. Therefore the socket should have a separate locking mechanism for each wire. Inserting wires of different sizes must not compromise the electrical connection.

III. Lamp installation
1. Lamp design shall have obvious indication that lamp installation is correct. If lamps are partially inserted, intermittent contact may result in arcing. Example, rotate-and-lock sockets for T5 and T8 linear lamps. Correct installation should be visibly obvious to someone with minimal experience installing lamps.
2. Lampholders shall be mounted according to recommendations of lampholder manufacturers. Secure mounting of the lampholder is required to prevent pivoting or other movement. Socket to socket spacing is important for linear fluorescent lamps as lamp dimensions may vary, and intermittent contact between lamp and socket may result.
3. Lampholder shall be mounted to the fixture so as to provide the correct spacing between the lamp and the grounded fixture. The distance between the lamp wall and ground plane for proper dimming function varies depending on the lamp type. See pg. 12 for Lutron recommended distances. (The recommended lamp heights are for lamps dimmed from 100% down to 1%. For lamps that are only dimmed from 100% down to 10%, the minimum distances can be further reduced to the following: T8 linear: 0.80 mm (0.031”); T5 linear and T5 twin-tube: 1.6 mm (0.062”).
4. Fixture design and packaging shall ensure lampholders meet this specification after shipping and installation. Lampholders must be mounted rigidly. Fixture design and packaging must prevent deformation during shipping, installation, and/or usage that would cause lamps to make poor contact with lampholders.

IV. Provisions for twin-tube and U-bent lamps
1. Fixtures for twin-tube lamps shall have mechanical support for the end opposite the cap. Otherwise the weight of the lamp may cause intermittent connections between the lamp pins and the lampholder.
2. The mechanical support for the twin-tube end opposite the cap shall be thermally isolated from the fixture. Lamp should not be thermally connected to fixture, otherwise a secondary cold-spot will result in uneven wearing of the lamp.
3. T3 tube support shall withstand conditions of operation, including but not limited to temperature, UV exposure, and vibration. Years of exposure to heat and lamp UV causes some plastics to become brittle. Insertion of a lamp into an unembrittled support may then cause the support to break, resulting in intermittent contact between the lamp and the lampholder.
4. Lamp should be supported in the fixture to withstand insertion force of the lamp. Repeated insertions and removals should not compromise lamp-pin-to-holder contact.
EcoSystem Digital Link is wired Class 1.

In the configuration diagrammed below the EcoSystem Digital Link is wired Class 1.

I. Class 1 wiring methods follow the NEC Requirement 725.48

1. Class 1 circuits shall be permitted to be installed with other circuits as specified in 725.48 (A) and (B)

A. Class 1 circuits shall be permitted to occupy the same cable, cable tray, enclosure, or raceway without regard to whether the individual circuits are alternating or direct current, provided all conductors are insulated for the maximum voltage of any conductors in the cable, cable tray, enclosure or raceway.

B. Class 1 circuits shall be permitted to be installed with power supply conductors as specified:
   1. Class 1 and power supply circuits shall be permitted to occupy the same cable, enclosure, or raceway only when functionally associated.

II. Since the EcoSystem Digital Link is designed for the more stringent requirements of a Class 2 installation, EcoSystem Digital Link devices can be installed in a Class 1 manner when Class 2 markings are eliminated. The NEC allows the reclassification of Class 2 circuits provided:

   1. 725.130 Exception No. 2: Class 2 and Class 1 circuits shall be permitted to be reclassified and installed as Class 1 circuits if the Class 2 markings … are eliminated and the entire circuit is installed using the wiring methods and materials in accordance with Part II, Class 1 circuits.

III. The EcoSystem Digital Link is labeled “Class 2” rather than “Class 1 or Class 2” because the ballast is a sink of power, not a source. According to UL 935 SB12.3:

   1. When the ballast is the sink of a Class 2 limited power circuit, the circuit shall be identified as such with the words “Class 2 Circuit” to indicate that the ballast is intended for connection to a Class 2 circuit and that the controlling circuit is not affected by the presence of the ballast. Since the ballast is not a source for this link, it is prohibited from being marked as “Class 1 or Class 2” even though it is allowed to be wired as Class 1 or Class 2.

Reference Information

- Code quotations, guidance, and wiring guides above are listed for reference only. Always follow local and national wiring requirements.
- NEC 2008 was used as a reference in this Application Note. More recent releases of the National Electrical Code should always be consulted.
- The National Electrical Code (NEC) is a registered trademark of the National Fire Protection Association, Quincy, MA.
Glossary

**Ballast** An electrical device used in fluorescent and HID fixtures. It furnishes the necessary circuit conditions (voltage, current, and waveform) for starting and operating a lamp.

**Ballast Efficacy Factor (BEF)** The ballast efficacy factor directly measures the efficiency of the ballast by illustrating that the higher the light output for a given power rating, the more efficiently the ballast will operate.

\[ \text{BEF} = \frac{\text{Ballast factor} (\%)}{\text{Input power (W)}} \]

**Ballast Factor** A ballast's light output with respect to a reference ballast’s light output. The reference ballast is a ballast which produces full light output to a reference ballast's light output. The reference will operate.

**Incandescent Lamp** An electric lamp in which a filament gives off light when heated by an electric current.

**Inrush Current** The current flow occurring at the instant of turn-on. (The level of inrush current depends on the load type and can be substantially higher than the normal operating current.) All Lutron ballasts incorporate inrush current limiting circuitry.

**Instant-Start Lamp** A class of fluorescent lamps which do not require filament preheating and can start instantly. Lutron dimming ballasts cannot be used with instant-start lamps.

**Intensity** The brightness of a lamp as a percentage of maximum brightness (e.g., 66% intensity describes a lamp dimmed to 2/3 of its maximum brightness).

**KWH (Kilowatt hour)** A unit of energy equal to one kilowatt of power expended for one hour.

**Lamp** A device for producing light (such as a bulb or tube).

**LED Driver** Auxiliary device(s) needed to operate and vary the intensity of light output from LED lamp source(s) by regulating the voltage and current powering the source. There are both dimming and non-dimming types.

**Line Voltage** The voltage between the lines of a supplying power system.

**Load** The device which a dimmer is controlling (i.e., incandescent lamp, ceiling fan, fluorescent lamp).

**Low-end Trim** Adjustable setting on a dimmer that establishes its minimum output, therefore, establishing minimum light level.

**Lumen** The quantity of light that is emitted by a lamp, used in reference to efficacy (lumens per watt). Luminance describes the light emitted or reflected from a source or object in a particular direction. Luminance produces the sensation of brightness and is measured in candelas per square foot (or square meter) of a source or object surface area in the direction of viewing.

**Luminance** Describes the light emitted or reflected from a source or object in a particular direction. It is the lumens per watt from a light source (amount of light per watt of power).

**Lux** 1 lux = 1 lumen per square meter.

**Phase Control** A common method of dimming that removes part of the line cycle, therefore reducing the RMS voltage.

**Power Factor** Ratio of the average power delivered to the lamp ballast system to the product of voltage and current (the ratio of the average power to the VA). This shows how effectively available power is being used.

\[ \text{Power Factor} = \frac{\text{Input power}}{\text{Line voltage x line current}} \]

**Radio Frequency Interference (RFI)** Electrical noise that may be picked up by sensitive audio and radio equipment. Lutron builds filters into every control and ballast to reduce this noise. Also called electromagnetic interference (EMI). See Filter.

**Rapid-Start Lamp** A class of fluorescent lamps having filaments which must be constantly heated by an external circuit.

**Relative System Efficacy (RSE)** Relative system efficacy is a metric used to rank ballast and lamp efficacy. It is used almost exclusively to describe dimming ballast efficacy and uses lamp rated efficacy to normalize Ballast Efficacy Factor.

\[ \text{RSE} = \frac{\text{Ballast factor x Total rated lamp power}}{\text{Ballast input power}} \]

**Source** Refers to the type of lamp, (e.g., fluorescent, incandescent, low voltage, HID, etc.).

**Square Law Dimming** Dimming with a direct correlation between the position of the slider and the perceived light level (e.g., if the slider is halfway down the travel, the perceived light level is 50%). With Square Law Dimming, gradual movement of the linear slider results in a proportional change in the perceived light level—allowing for easy, precise adjustment of the light level setting.

**T4** A fluorescent lamp which has a diameter of 1/2” (12.7 mm).

**T5** A fluorescent lamp which has a diameter of 5/8” (15.9 mm).

**T8** A fluorescent lamp which has a diameter of 1” (25.4 mm).

**3-Way Dimming** 3-way dimming control (as opposed to single-pole, multi-location, or Omni-based control) allows dimming from one location only (using a 3-way dimmer) and on/off switching from a second location (using a 3-way switch).

**Total Harmonic Distortion (THD)** The total amount of current at frequencies other than 60 Hz (the main frequency), expressed as a percent of the 60 Hz current. No power is delivered to the load by current at these other frequencies.

**UL Listed** Indicates that the product has been evaluated and undergoes continual assessment by Underwriters Laboratories Inc. to comply with safety standards established by Underwriters Laboratories Inc.