

Capacitive and Inductive Effects in Fluorescent Light Fixtures

To ensure proper performance of fluorescent light fixtures, several physical and electrical characteristics must be considered in fixture design and maintenance; factors such as wiring methods and location of the lamps can significantly affect the performance of a fixture. Understanding best practices and electrical limitations of fixture components is especially important when working with fixtures that use dimming ballasts.

To limit the capacitive and inductive voltage losses to a lamp, the lead length from a ballast to the lampholders must be restricted. Because dimming ballasts operate lamps at a fraction of their rated current, adherence to these wire length restrictions is essential when working with dimming applications.

Three electrical phenomena can affect the performance of lamps within a dimmed fluorescent fixture:



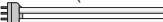

- Inductive Impedance:** To deliver superior performance and ultimate efficiency, Lutron® ballasts operate lamps at very high frequencies, usually greater than 40,000 Hz. Since voltage at high frequency can be affected by the inductance of wire, wire lengths of dimming ballasts is typically restricted; the longer the wire, the greater the inductive effect and voltage drop to the lamps.
- Capacitive Leakage to Ground:** Small amounts of electrical current transferred through a wire's insulation to a grounded metal surface is defined as capacitive leakage. More wire-to-metal contact within a fixture means more capacitive current leakage to ground.
- Capacitive Leakage, Wire-to-Wire:** Similarly to capacitive leakage to ground, electrical currents can be transferred capacitively from one wire to another. When wires are tightly bundled together, some of the current can transfer across the wires before reaching the lamp; bundling lamp wires of multiple ballasts can also cause electrical currents to transfer between ballasts in multi-ballasted fixtures.

Lampholder Lead Length Specification for Lutron® Dimming Ballasts

Since dimming a fluorescent fixture causes the lamp to operate at a fraction of its rated current, current leakages will have a more adverse effect on the performance of a dimmable fixture than on one that operates at full-rated current. To keep this leakage within a reasonable range and to maintain reliable dimming performance, dimming ballast manufacturers typically specify lead length limitations. Lutron's lead length limit is specific to the lamp type (see *Lamp Type/Lead Length Specification* table).

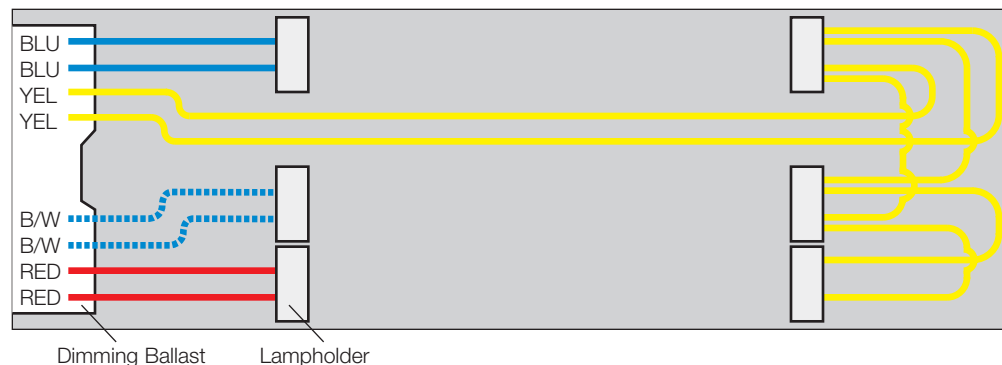
Because the geometry and design structure of fixtures vary, it is impossible to predict the effect of every fixture configuration on every dimming application. Therefore, **lighting manufacturers must test their fixture designs to ensure that the design is compatible with dimming.**

Lamp Type/Lead Length Specification

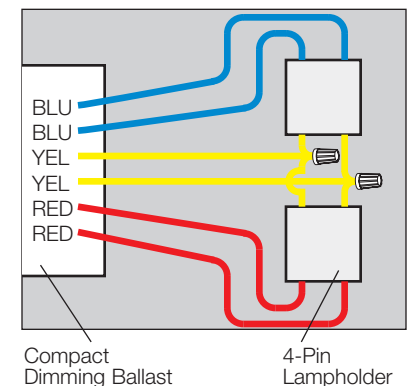
Lamp Type	Lead Length (max)
Linear (straight) T5  T8 	7 ft (2.1 m)
Twin Tube (2G11 base) T5 	3 ft (0.9 m)
Four-Pin compact (GX24 base) T4 	

Lampholder Leads

Linear Lamp Leads



Compact Lamp Leads



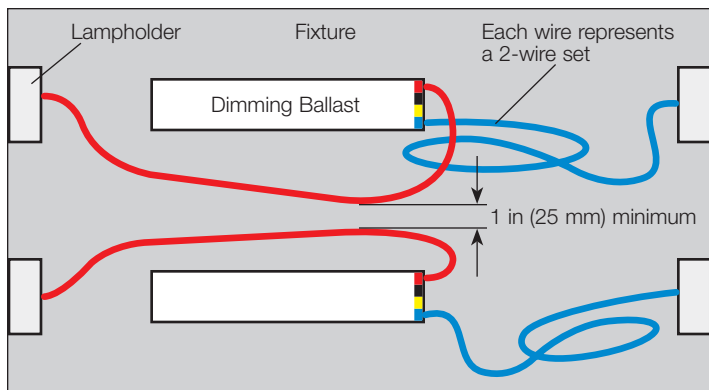
Best Practices

Even if a fixture adheres to the Lutron® lead length specification, it may not deliver perfect performance because of the wiring method employed. Follow these best wiring practices to help achieve reliable dimming performance. **Note:** Wiring examples within this section are schematic; a single lead of a color represents a set of two leads of that color.

General

- Use splices only when necessary.
- Separate lamp leads by at least 1 in (25 mm) within multiple-ballast fixtures.

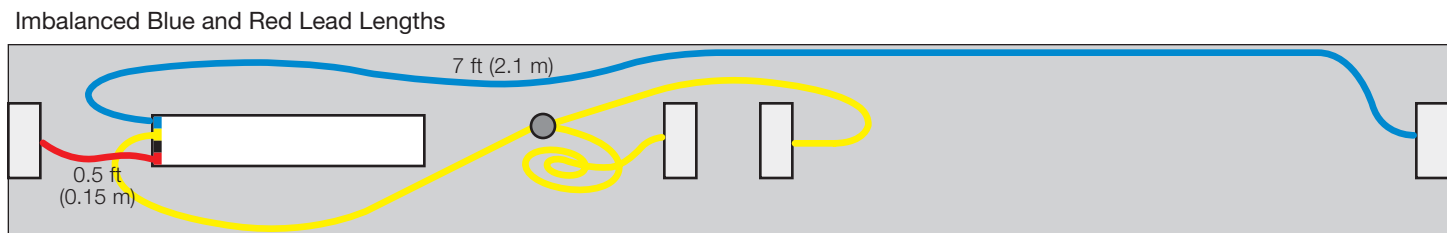
Wiring Example Key



Lamp Balancing

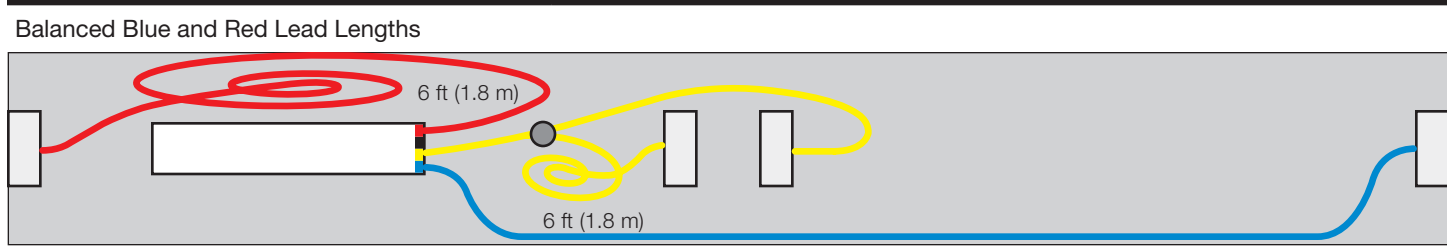
- **Blue and red leads** (and blue/white leads, where applicable)
 - Must never exceed 7 ft (2.1 m) or 3 ft (0.9 m) maximum length (see *Lamp Type/Lead Length Specification* table).
 - Must be of a similar length to each other (within 6 in [152 mm]) for proper lamp performance in certain applications. To achieve lamp lead balance, it may be necessary to add lead to a lampholder.

Problem



- Lengths of red and blue leads are unequal.

Solution



- Reorient ballast to center the leads between the lampholders. This shortens the distance to the farthest lampholder.
- Add length to the red leads.

Best Practices (continued)

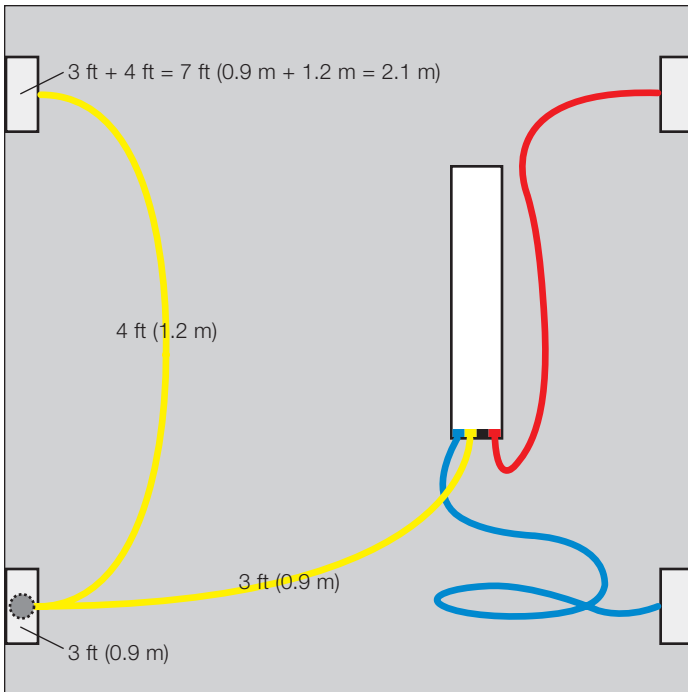
Lamp Balancing (continued)

- **Yellow leads**

- Make as short as possible.
- Must never exceed 7 ft (2.1 m) or 3 ft (0.9 m) maximum length (see *Lamp Type/Lead Length Specification* table).
- Leads to each lampholder must be of a length similar to each other (within 6 in [152 mm] is recommended).
- It may be necessary to set up equal-length home run wires from each yellow-wired lampholder and connect them, in-parallel, to the yellow terminals of the ballast.
- Yellow leads do not need to be the same length as the red and blue leads (and blue/white leads, if applicable).

Problem

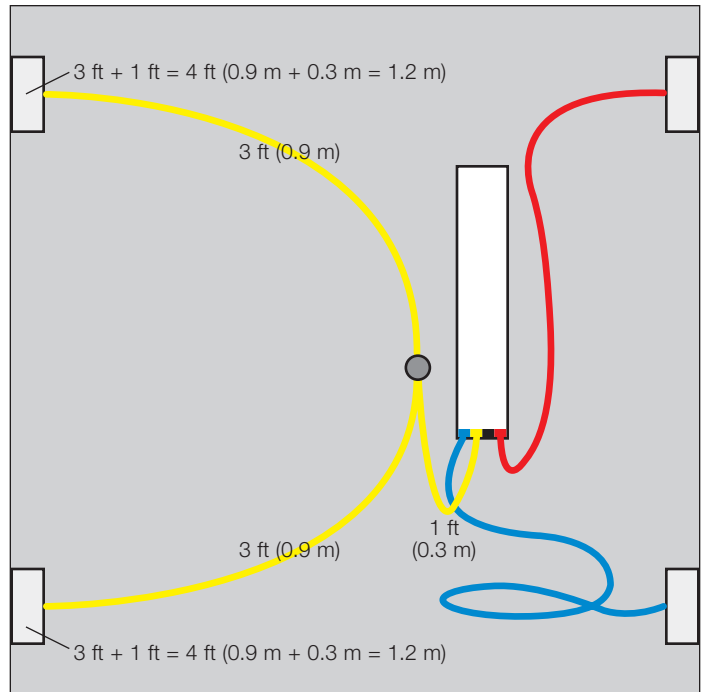
Imbalanced Yellow Lead Lengths (4 ft [1.2 m] Square Fixture)



- Lengths of yellow leads are unequal:
 - Lead length to first lampholder is 3 ft (0.9 m).
 - Cumulative lead length to second lampholder is 7 ft (2.1 m).

Solution

Balanced Yellow Lead Lengths (4 ft [1.2 m] Square Fixture)



- Splice yellow leads to create parallel home run configuration:
 - Cumulative lead length to first lampholder is 4 ft (1.2 m).
 - Cumulative lead length to second lampholder is 4 ft (1.2 m).

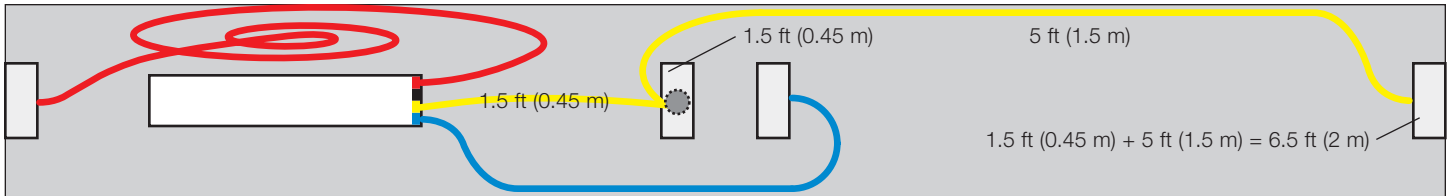
Best Practices (continued)

Lamp Balancing (continued)

- Yellow leads (continued)

Problem

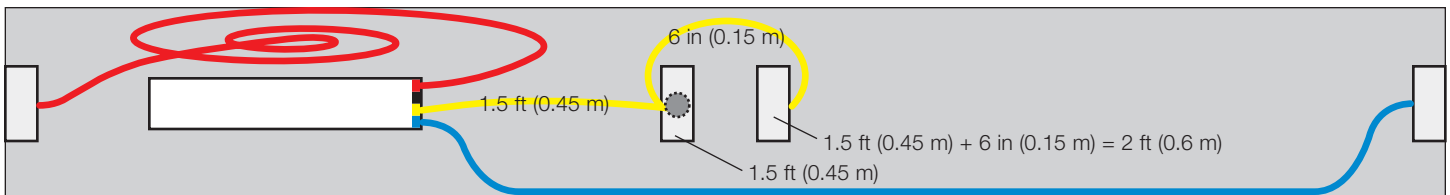
Imbalanced Yellow Lead Lengths



- Lengths of yellow leads are unequal.

Solution

Balanced Yellow Lead Lengths



- Connect yellow leads to center lampholders.

Best Practices (continued)

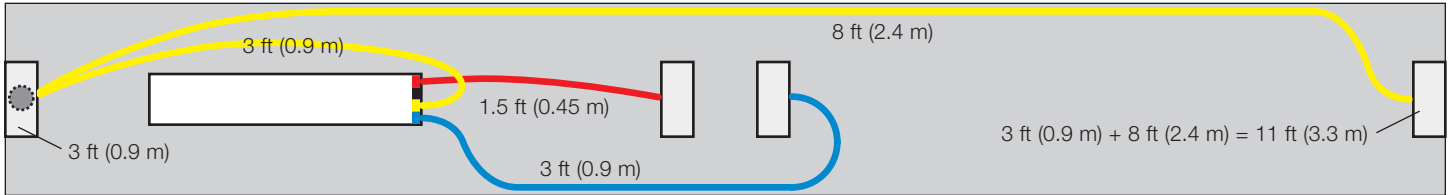
Lamp Balancing (continued)

• Fixtures With Lamps In Tandem (end-to-end)

- Mount ballast so that lamp lead terminals are as close to the center of the fixture as is practical.
- Connect the yellow leads, in-parallel, to the center two lampholders, making the jumper between the lampholders approximately 6 in (152 mm).
- Connect the red and blue leads to the outboard lampholders; ensure that both wire sets are less than 7 ft (2.1 m) long and of equal length.

Problem

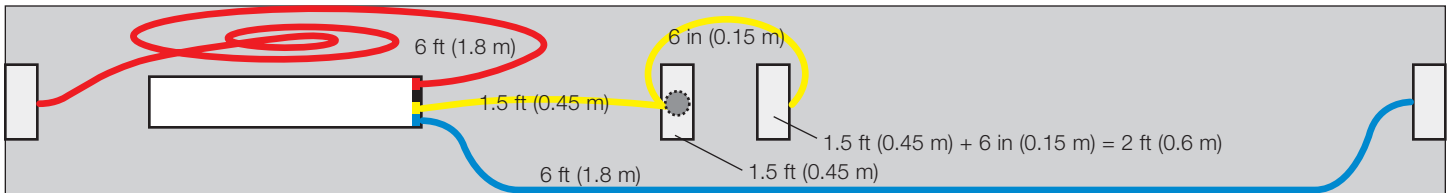
Imbalanced Red and Blue Lead Lengths; Imbalanced Yellow Lead Lengths



- Lengths of red and blue leads are unequal.
- Lengths of yellow leads are unequal.

Solution

Balanced Red and Blue Lead Lengths; Balanced Yellow Lead Lengths



- Connect red and blue leads to outboard lampholders.
- Connect yellow leads to center lampholders.

Best Practices (continued)

Lamp Balancing (continued)

• Rigid or Flexible Metal Conduit, Remote Mounted Ballast

- Make conduit as short as possible to limit capacitive leakages.
- May require bundling opposite-colored leads to balance the capacitive leakage (e.g., if blue and yellow leads pass through a conduit, then bundle the red and yellow leads together to balance the capacitive losses).

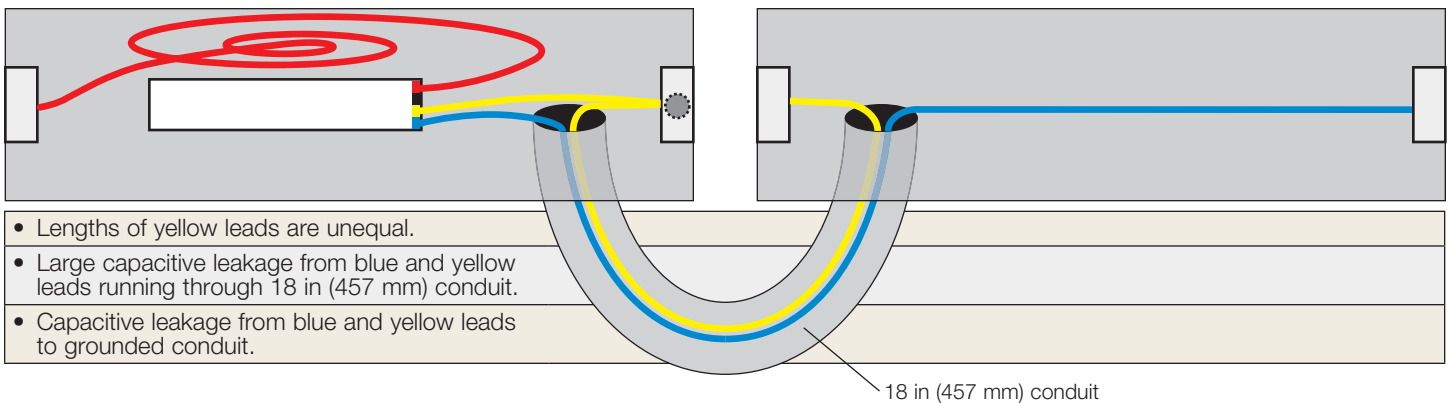
• Fixtures With Battery Backup Emergency Ballasts

Most emergency ballasts have wires that route the voltage from the “normal powered” ballast through a disconnect relay within the emergency ballast and then on to the lamp. Often, these wires are 6 ft (1.8 m) or longer.

- Ensure that the maximum lead length for emergency fixtures is not exceeded.
- To prevent lead length imbalance or exceeding the maximum lead length for a ballast, trim emergency ballast leads to the shortest length possible.

Problem

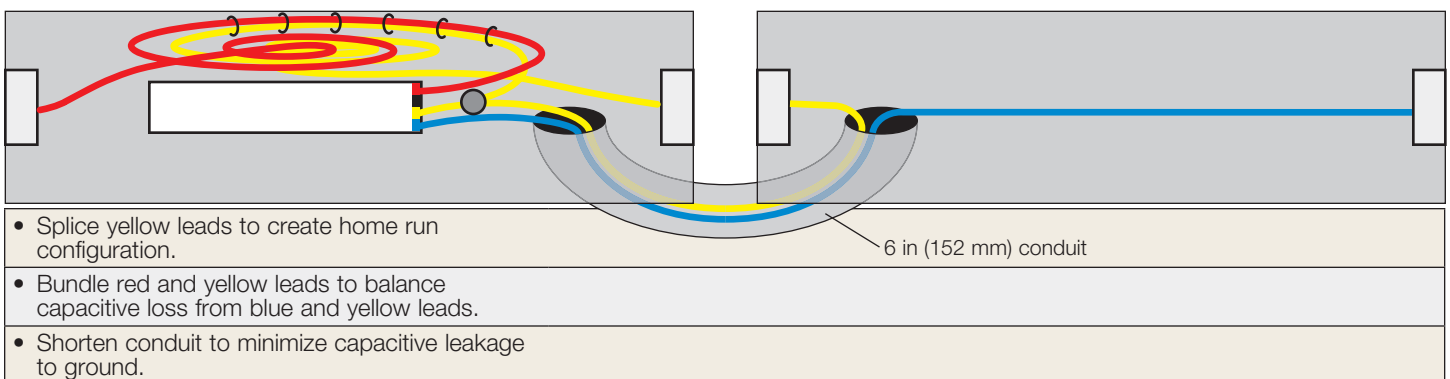
Master/Slave Fixture Conduit With Capacitive Leakage



- Lengths of yellow leads are unequal.
- Large capacitive leakage from blue and yellow leads running through 18 in (457 mm) conduit.
- Capacitive leakage from blue and yellow leads to grounded conduit.

Solution

Master/Slave Fixture Conduit With Reduced Capacitive Leakage



- Splice yellow leads to create home run configuration.
- Bundle red and yellow leads to balance capacitive loss from blue and yellow leads.
- Shorten conduit to minimize capacitive leakage to ground.

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