LEDucation

Designers Lighting Forum

Supply Emergency Power to LED Systems

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March 16, 2022

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Learning Objectives

At the end of this course, participants will be able to:

1. Understand the role of forward voltage and the nature of Class 2 and non-Class 2 requirements utilized in the LED loads.

2. Recognize how different AC line voltages impact devices supplying emergency power.

3. Understand how LED systems create inrush and what considerations are given for emergency devices in the system.

4. Understand the different categories of LED retrofit (tube and screw-base) lamp designs and the effective methods of supplying emergency power to these lamp types.

Introductions / Presenters

Aswini Vallampati

Aswini Vallampati has guided emergency driver design for both IOTA® and Power Sentry® brands and is instrumental in developing effective LED emergency solutions for Acuity Brands® that meet electrical, mechanical, regulatory, and diverse application demands.

Daren Hatfield

Daren Hatfield has been involved with emergency lighting sector since 1999 as marketing manager for IOTA®. He has had firsthand experience of working with the technological shifts arising from the rapid transition to LED for broad commercial application and the resulting need for information on applying effective emergency solutions to these designs.

What We Will Cover…

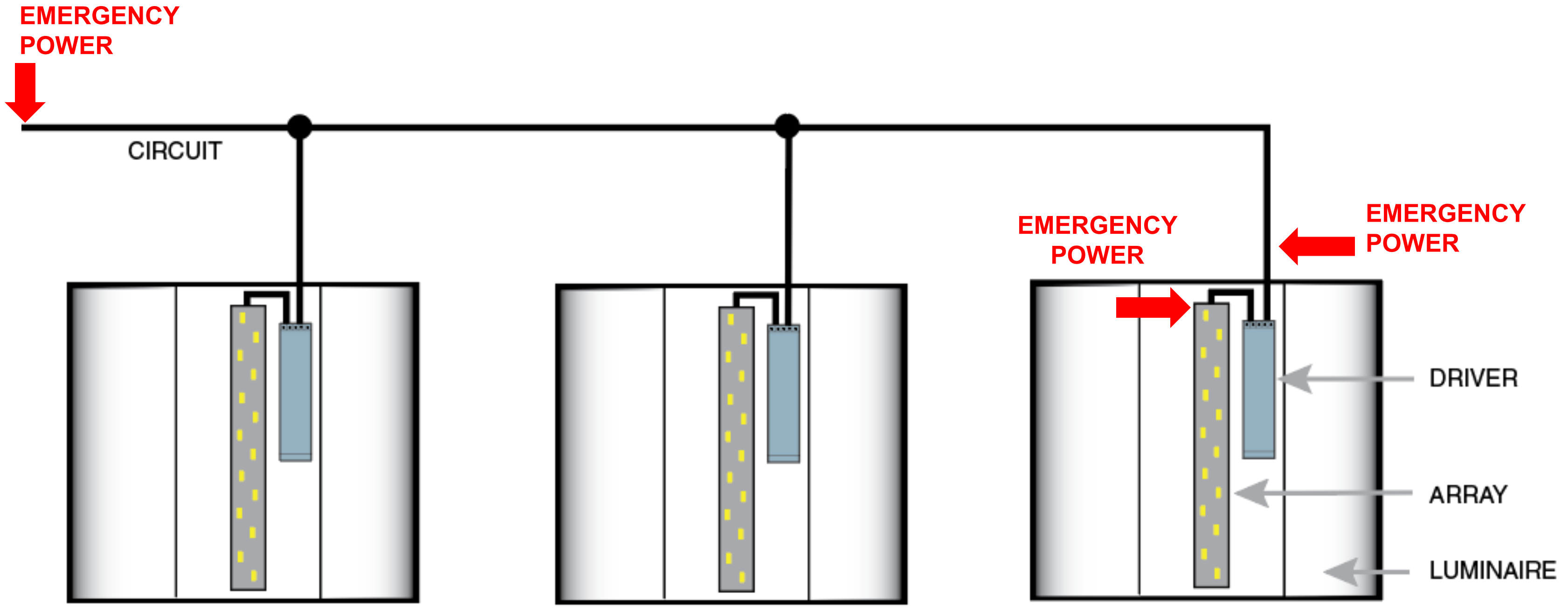
- Type of Loads - defining the different parts of the LED system to which emergency power can be supplied
- Supplying emergency power to LED components
- Supplying emergency power to LED luminaires
- Supplying emergency power to designated branch circuits
- Different LED retrofit lamp types and associated methods for supplying emergency power
- Conclusion

Types of Loads

In normal operation, AC line power is delivered via the **Branch Circuit** to the **AC ("Normal") Driver** which converts the Alternating Current (AC) to Direct Current (DC) for operating the **LED Component** (aka board, array, module, engine.)

When normal AC power is lost, **emergency power can be introduced in these different areas of the system**.

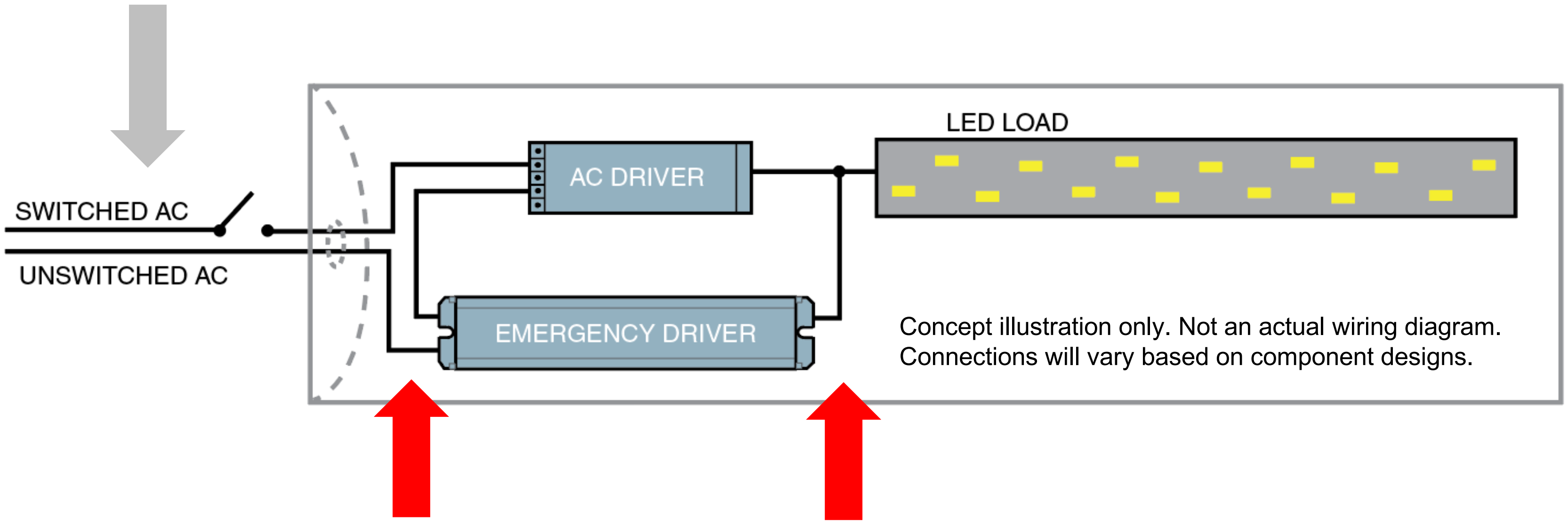
Different considerations are given depending on where emergency power is introduced.



Supplying Emergency Power to the LED Component

An **emergency driver** provides DC power to the LED component when the normal driver has lost power. The emergency light output is typically less than the normal light output.

This requires the luminaire to receive **two input power connections**: one to power the normal driver/luminaire and one *unswitched* connection for maintaining the emergency driver battery supply in a state or readiness.



The emergency driver must be compatible with both the **input voltage** of the system as well as the DC **forward voltage** requirements of the load.

Input Voltage

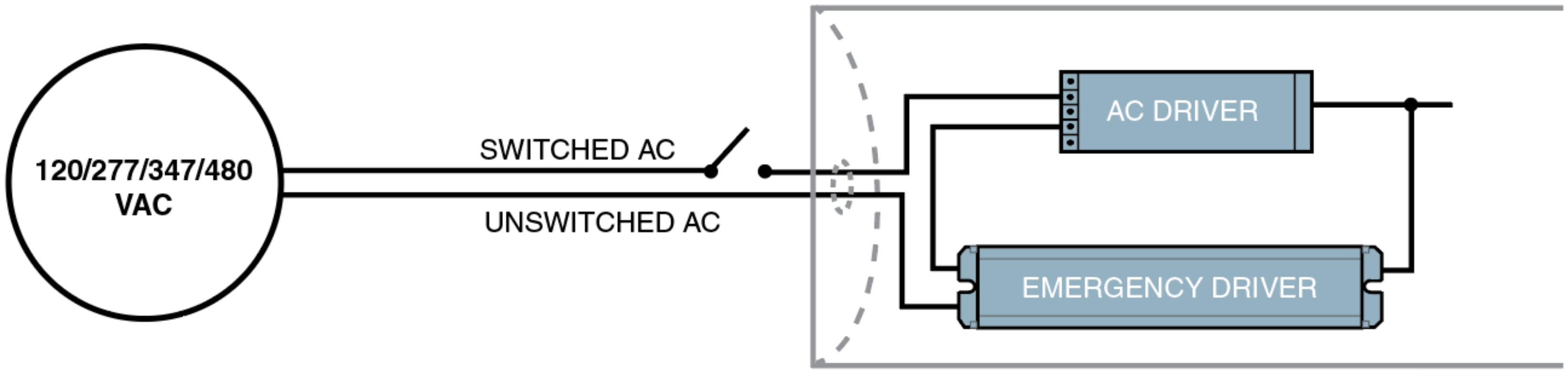
120-277VAC

Most emergency drivers are compatible with 120-277VAC and are straightforward options for this input voltage standard

347-480VAC

347VAC and 480VAC circuits can be found in industrial and international norms.

The input voltages of the normal driver and emergency driver should match to avoid incompatibility at the luminaire level as well as with any connected auxiliary devices within the system.

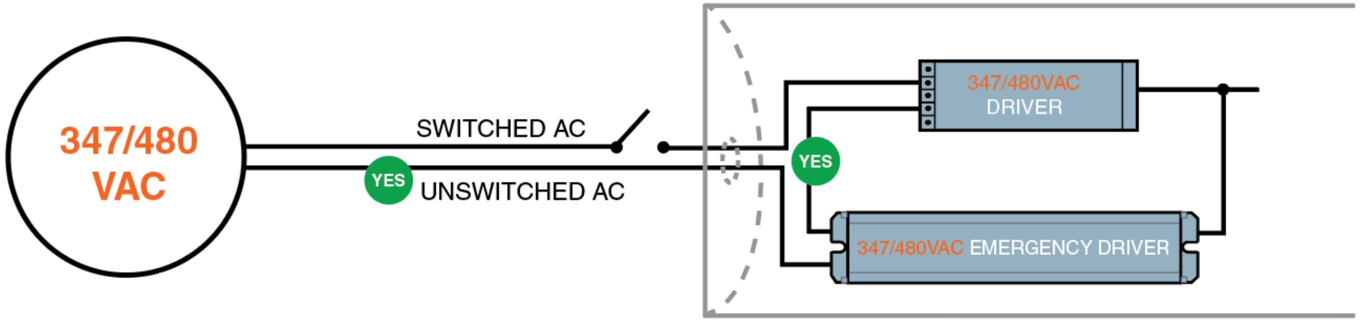


347VAC and 480VAC Considerations

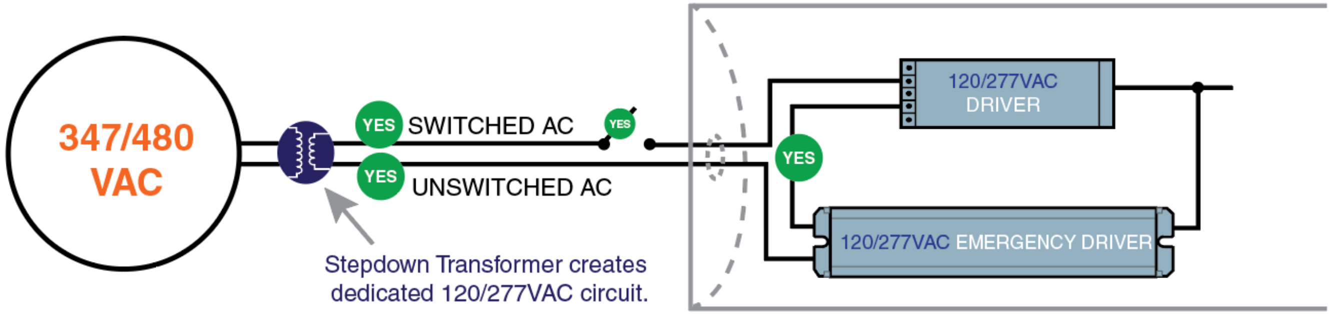
In higher voltages, the emergency driver should be compatible within the system (input, drivers, controls.)

Consideration should be given to protection against transients (surge) found in higher voltage industrial loads by using a emergency driver tested to **ANSI/IEEE** standards or using additional surge suppression equipment.

Since the emergency driver requires an unswitched input, the ideal solution is to have a 347-480VAC emergency driver for compatibility with both AC Input and AC Driver.



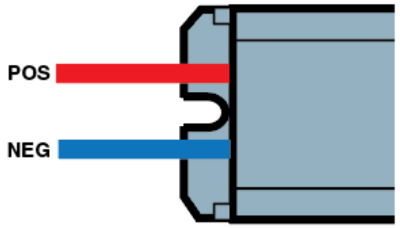
To use a 120/277VAC emergency driver in 347/480VAC, a step-down transformer can be used if the entire luminaire is compatible with 120/277VAC and there are no conflicts with switched 347/480VAC inputs or devices on the circuit.

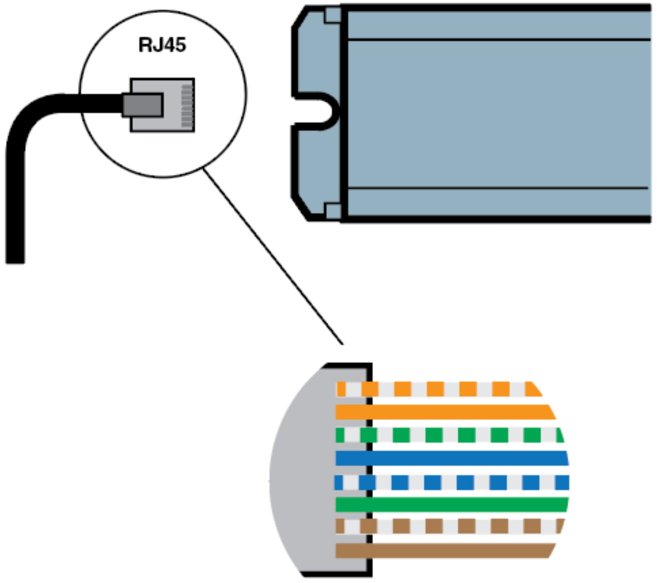


DC Input Voltages

For lighting systems using distributed DC voltages as the primary input source, the emergency driver must be **designed to accept DC voltage** for the purpose of maintaining battery readiness as well as detecting the loss of power.

DC power may be delivered via connected low voltage wiring (**POS and NEG leads**) or via ethernet cable. Within an **ethernet cable**, there must be compatibility with the individual pins of the cable. Some lines within the cable or dedicated to power and others to data. Connections must correspond between the emergency driver's port and facility cabling.



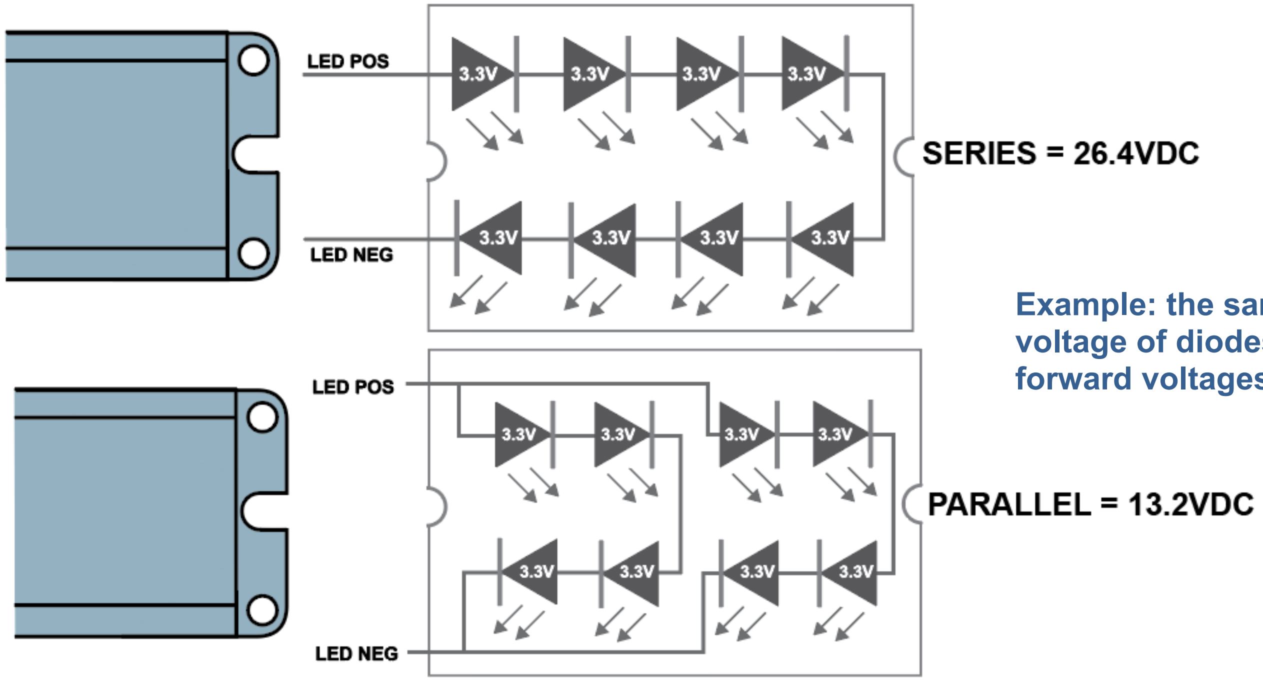


Forward Voltages

Forward voltage specifically addresses the **DC voltage** delivered to operate the LED load.

The LED load requires a particular voltage to "forward bias" (illuminate) the LED by collapsing the P/N junction within the diode.

The required voltage for the total array/board/module will vary based on the manufacturer's design. Forward voltage can vary based on diode design, the number of diodes used, and whether the diodes are connected in series or parallel.



Example: the same number and voltage of diodes require different forward voltages to operate.

Class 2 Voltage

NEC (National Electric Code) defines a class 2 electrical system as one that does not exceed **60-volts** AND does not exceed 100-watts of system power.

Industry has largely accepted design practices to utilize class 2 loads for lighting in indoor commercial and exterior fixtures.

Class 2 emergency drivers will deliver a forward voltage *within* the 1-60VDC range.
A wider forward voltage range means wider LED load compatibility.

Wide compatibility is particularly critical with field-installation of emergency drivers since the required forward voltage is not necessarily known.

Voltages Greater Than 60 Volts

Exceeding the 60VDC voltage will classify the luminaire as "Class 1" which includes more stringent mechanical design and circuit requirements.

Loads with a forward voltage **greater than 60VDC** are typically found in industrial fixture designs considered "not readily accessible." (industrial high bays, for example).

The selected emergency driver must be able to deliver the higher forward voltage requirements for these 'Class 1' loads.

Emergency Lumen Output

The ability of the emergency driver to deliver egress lighting is affected by both the luminaire design and how it manages electrical **current** to produce **wattage**.

Visible light produced by the luminaire is measured in lumens. The net effect of the components (LED array, reflectors, lenses, etc.) used in the luminaire determines how efficiently power is converted into visible light (Efficacy, rated in lumens per watt.)

The lumens delivered in the *emergency mode* will be **wattage multiplied by the lumen efficacy**. Lumens ultimately achieve foot-candle requirements outlined by the Life Safety Code.

Lumen Package	CCT	Lumen	Wattage	Efficacy
Low Lumen	3500K	2430	19.7	123.4
	4000K	2594	19.7	131.7
	5000K	2483	19.5	127.3
Med Lumen	3500K	3289	28.4	115.8
	4000K	3583	27.2	131.7
	5000K	3369	28.2	119.5
High Lumen	3500K	3914	35.7	109.6
	4000K	4280	33.7	127
	5000K	4009	35.5	112.9
	3500K	2399	19.1	125.6

Luminaire design determines the efficacy.

The emergency driver design influences **WATTAGE**.

Calculating Wattage

Watts (P) are calculated by multiplying Voltage (E) by Current (I): **P = E x I**

There are two methods for delivering power to LEDs – constant current or constant voltage. With either topology, output power (watts) is always dependent on the remaining variable in the equation.

In a **constant current** system, the fixed current valued is multiplied by the fixed forward voltage to determine the delivered wattage. This is a simple driver design, but emergency illumination will vary depending on the connected load.

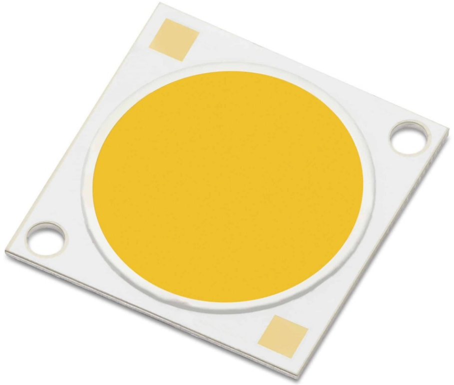
A unique attribute in LED emergency technology is the concept of **constant power**. In a **constant power** system, the output wattage value is fixed and current is inversely proportional to the voltage. This means delivered emergency light is easily calculated and remains unchanged throughout operation, but the emergency driver requires a higher degree of design.

Integrated Systems

Integrated systems, such as system-on-a-chip (SOC), are board designs where the normal driver function is handled by components **embedded** as a part of the LED module.

Since the LED load and driver module are joined in an integrated design, the LED load cannot be isolated for supplying emergency power separately.

In these applications, emergency power must be supplied ahead of the integrated component. This is covered in the next section: "**Supplying Emergency Power to the Luminaire**."



Supplying Emergency Power to the LED Component

TAKE-AWAYS

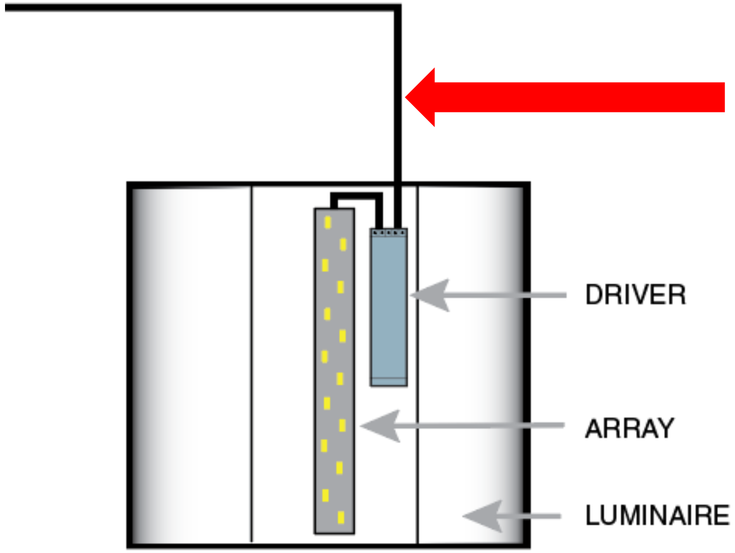
- An **EMERGENCY DRIVER** delivers DC power directly to the LED load in place of the 'lost' normal driver. Light output is typically at a reduced level from normal output.
- Voltage considerations must be made for both the **INPUT VOLTAGE** needed to charge the battery and the **FORWARD VOLTAGE** needed to power the LED Load
- Electrical designs are distinguished by **CLASS 2** (low voltage) and **CLASS 1** (power limited systems). It is necessary to determine the electrical classification of your LED load before supplying forward voltage.
- Emergency drivers can electrically operate as either a **CONSTANT POWER** or **CONSTANT CURRENT** device to **SUPPLY WATTAGE** to the LED load for delivering path of egress illumination.

Supplying Power to the Luminaire/Driver

Emergency AC power can be supplied ahead of a **single fixture** to power the AC driver rather than the directly to the LED load. This is typically achieved by using a **small inverter**.

Inverter Theory of Operation

Inverters deliver AC power to the load by using an internal circuitry that inverts the battery's DC current to AC output. This allows the emergency supply to simulate line power, enabling the connected load to operate as if it were running on normal power.



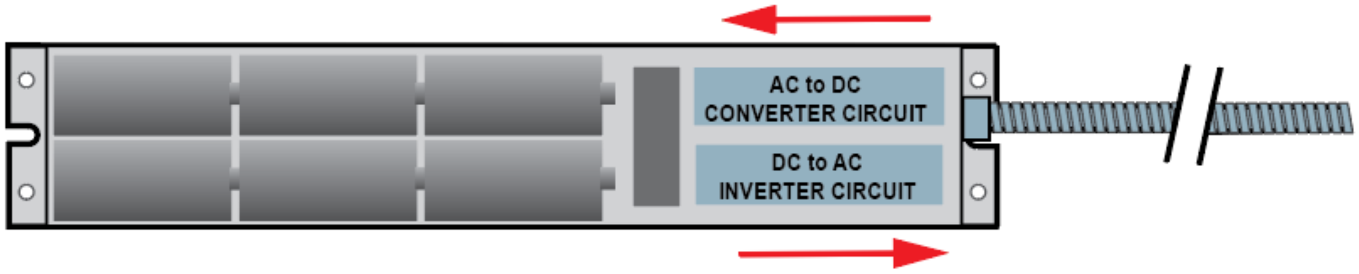
Fixture-level Inverter Application

Inverter solutions are generally grouped into three different size categories:

- Greater than 1000W/kVA
- Between 100 and 1000W/kVA
- Less than 100W

Fixture-level solutions typically fall into the **less than 100W** category.

In concept, a fixture-level inverter is similar to an emergency driver but contains the inverter circuit needed to provide AC output to the luminaire's driver needs for powering its LED load. By receiving AC power, the normal driver is able to operate the load per its topology/programming, just as it would under normal operating conditions.



Fixture-level Inverter Considerations

Fixture-level inverters offer different advantages but with some **additional considerations** compared to the emergency driver approach.

The ability to simulate normal AC power means the fixture will operate at **full brightness** (assuming any dim settings or local fixture controls are bypassed.)

Supplying power ahead of the fixture **avoids the considerations of forward voltage requirements** or limitations posed by **system integrated designs**.

Like an emergency driver, the fixture-level solution will **require a separate unswitched input** to maintain the battery supply. Will most likely require that input and output voltages match.

Due to the larger capacity requirements and internal AC inverter circuitry, inverters are **larger in size** compared to an emergency driver, usually requiring them to be external to the fixture.

Supplying Power to the Luminaire/Driver

TAKE-AWAYS

- A small inverter design can provide emergency power to a **single fixture** on the branch circuit.
- Requires a **dedicated unswitched input** to charge the battery, just like an emergency driver.
- Fixture-level inverters deliver AC power to the driver rather than to the LED load, **eliminating concerns about LED (forward) voltage compatibility.**
- By supplying AC power, the **fixture operates as it would during normal operation** (at full brightness, for example.)
- Simpler in application, but **larger in physical size** and more involved product design than emergency driver alternatives.

Supplying Power to the Branch Circuit(s)

Inverter and generators deliver larger levels of AC emergency power to an **entire circuit** (or facility) for continued operation of connected loads.

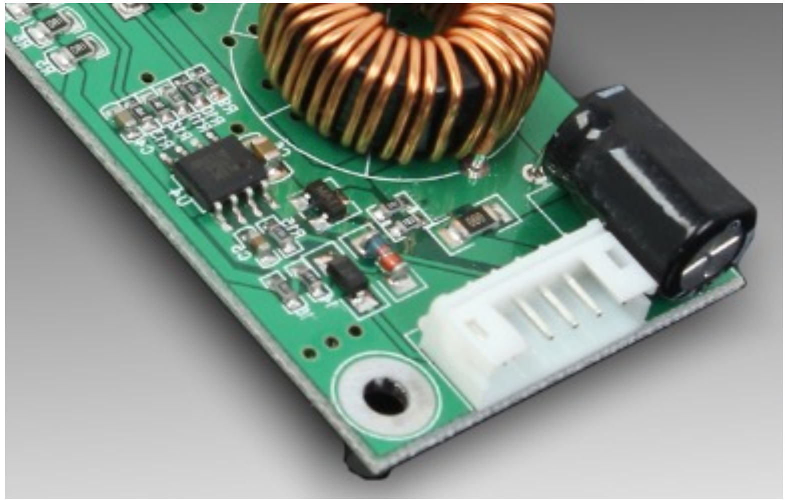
Both generators and inverters can supply auxiliary power to the designated circuits. Generators are widely used in larger applications and more complicated loads, such as motor equipment. For the scope of this discussion, the focus will be on inverter equipment that is likely to be UL 924 Listed for emergency lighting and LED applications.

Whether using a generator or inverter for emergency power, either solution must be sized accordingly to accommodate increased power requirements at start-up **(INRUSH)**

Presence of Inrush

"Inrush current, input surge current, or switch-on surge is the maximal **instantaneous input current drawn** by an electrical device when first turned on"

Solid-state lighting is more likely to create the electrical condition of inrush than its fluorescent and incandescent predecessors. This is due to the need for capacitance.

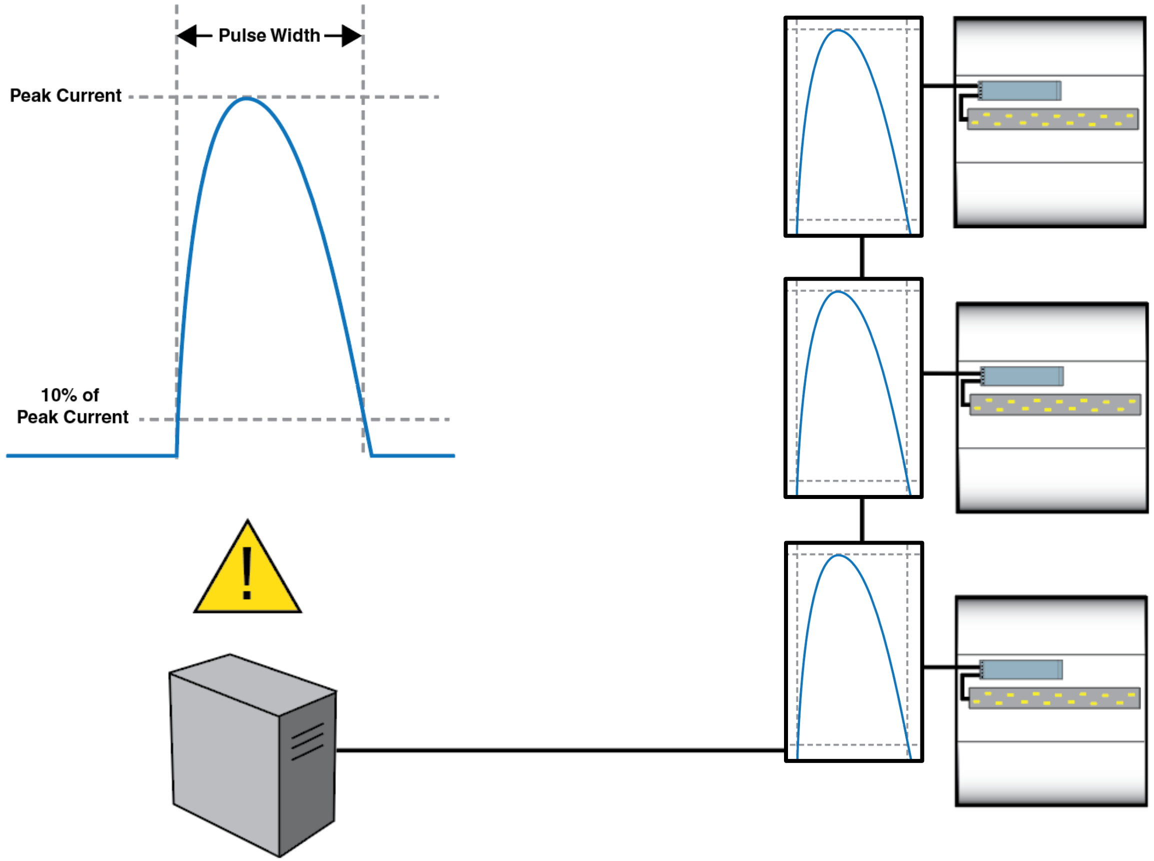


By itself, this inrush spike is usually inconsequential and is not of any immediate concern when supplying emergency power to an individual component or fixture. But when **supplying emergency power to a circuit that consists of several LED fixtures**, the cumulative inrush can become significant and negatively impact the device supplying emergency power.

Inrush Considerations

NEMA's recommended "best practice" when designing a product is to limit the inrush using the expression I^2t (multiplying the square of the max Peak Current by the Pulse Width duration (in milliseconds), essentially controlling how much power the device draws and for how long.

In an emergency power situation, fixtures on the circuit may be powered simultaneously. Since the supply is limited in its capacity (rated for a certain amount of max power), an immediate demand for power in excess of rating can trigger the unit to shut down.



Addressing Inrush

When supplying emergency power to a branch circuit with multiple LED luminaires, the emergency system must therefore account for the inrush potential on the circuit(s) connected to the supply.

Calculate and combine the different inrush of all devices on the circuit to find the needed max power level for the circuit - (not practical or practicable)

De-rate the emergency supply* – General practice is to allow for 20% more capacity in the inverter supply than is actually present on the connected circuit.

*This practice is intended for inverter supplies. NEMA has established different guidelines for sizing of generator supplies.

Determine if the rated capacity of the emergency supply is **qualified to NEMA 410 standards** – If a product states that a load is rated per NEMA 410, predicted inrush has been taken into account for that load type based on NEMA recommendations. No further de-rating is needed.

Supplying Power to the Branch Circuit(s)

TAKE-AWAYS

- **Inverters and generators** can deliver emergency AC power supply to designated branch circuits.
- LED capacitance results in **inrush demand on the circuit.**
- The circuit's **cumulative inrush can have a negative impact** on the connected emergency supply.
- To **address the combined inrush**, branch-circuit inverters solutions should be de-rated by 20% unless the specifications indicate the rated capacity for LED loads is qualified to NEMA 410 and inrush has been factored.

LED Retrofit Lamps

During the transition to LED technology, designs allowed customers to take advantage of the benefits of LED designs while **utilizing existing fluorescent and incandescent equipment**. These LED solutions appear similar to fluorescent lamps or Edison screw-base bulbs.

UL has helped standardize the development of various LED replacement lamp designs by categorizing designs into three different groups:

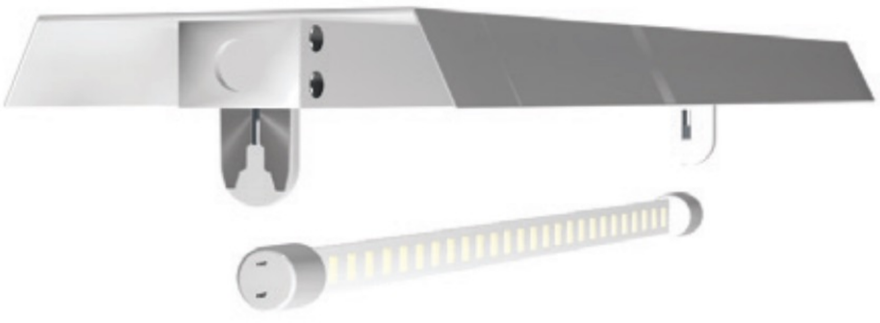
- **Type A**
- **Type B**
- **Type C**

When used in commercial applications where emergency lighting is required, the correct type of emergency solution will depend on which type of retrofit lamp technology is being used.

Type A Lamps

UL Type A tubes are designed for easy installation within an existing fluorescent application **including the installed fluorescent ballast**.

Type A LED lamps have an internal driver that takes a **controlled AC current** input from the fluorescent ballast and converts it to DC forward voltage to operate the load.



Two options for delivering emergency power to Type A lamps:

1) Use an **inverter** to supply AC power to the fixture's fluorescent ballast

2) Use a **suitable fluorescent emergency ballast**

- The fluorescent emergency battery must provide AC current output (since that is what the LED tube lamp is requiring)

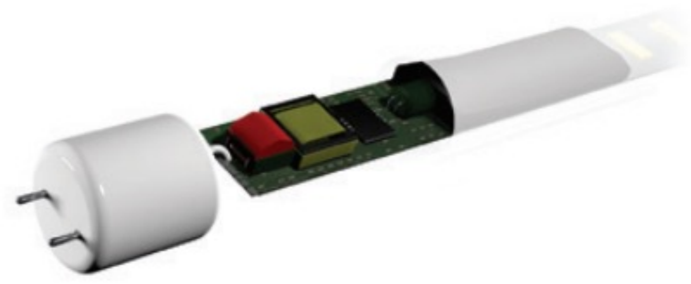
  AND

- The fluorescent emergency ballast must be UL Listed for operating that specific LED load.

Type B Lamps and Screw-Base

Type B lamps are designed to connect **directly to AC power** (no fluorescent ballast) to convert the full normal AC input to DC power for operate the lamp's internal LED load.

Screw-base LED designs are the same – using an internal driver to convert the socket's AC power to appropriate DC power for the load.

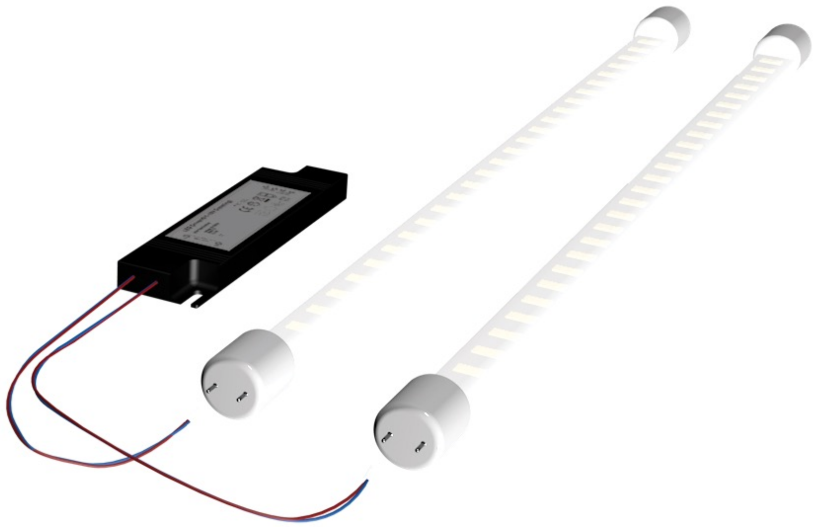


Emergency Solutions for TYPE B Tubes and Screw-Base Lamps/Bulbs

For either of these applications, an **inverter (or generator)** emergency supply would be the solution, since the load requires full AC power to operate.

Type C Lamps

Type C solutions replace both the lamp(s) and the ballast within the fixture with an LED load and paired compatible LED driver. Combined, these kits **replace any of the fluorescent electrical components with LED system components**. The “lamps” may take the form of either an enclosed LED tube design or an “open” LED board for installation behind the lens.



Emergency Solutions for TYPE C Retrofit Kits

In these applications, the driver component is remote (not internal) which allows an emergency LED driver to power the LED load directly. Follow the practices laid out for emergency components discussed at the beginning of this presentation “Supplying Emergency Power to the LED Component”

LED Retrofit Lamps

TAKE-AWAYS

- Know the different types of LED retrofit solutions:

  Type A, Type B and Screw-Base, Type C.

- Methods for supplying **emergency power is based on the LED lamp type**
  - **Type A** would use an **inverter/gen set** or **properly-certified fluorescent emergency ballast**
  - **Type B** would use an inverter or generator to **deliver AC power** to the lamp
  - **Type C** kits would use a **compatible emergency LED driver** to work in conjunction with the normal driver component in the kit.

Conclusions

- **Emergency lighting can be supplied to various points within the system** (component level, fixture level, or branch circuit level) depending on system capability and application requirements or preferences.

- When supplying emergency power to the **LED components**, be mindful of **input voltage** compatibility, **forward voltage** range, and emergency driver design (**constant power** or **constant current** output.)

- Supplying emergency power at the **fixture level (small inverters) means supplying AC power to the normal driver**. The inverter **simulates normal power** so the driver will operate the load as it would during normal operation.

- When supplying **emergency power at the circuit level**, cumulative **inrush must be taken into consideration**. The inverter or generator supplying emergency power can be 'de-rated' (using a larger capacity rating for a smaller load size) or verified that the specified rating is per NEMA 410 guidelines for accommodating inrush.

- **Retrofit LED lamps are offered in different types (A/B/C).** The proper emergency power supply will vary based on the type.

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This concludes The American Institute of Architects Continuing Education Systems Course

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