



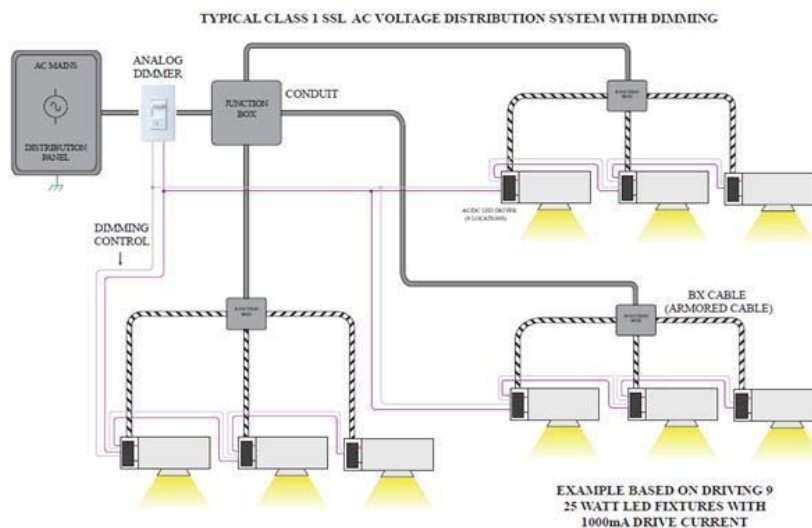
## Understanding the importance of power in SSL systems

### The Benefits of Low Voltage DC Power Distribution for LED Lighting

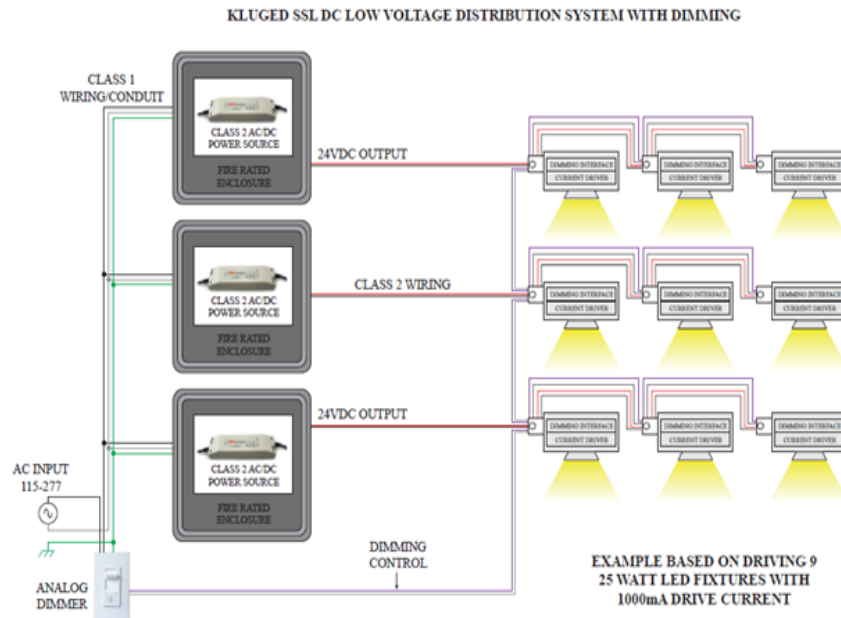
Lighting companies are struggling to transition from traditional lighting sources to providing reliable, energy efficient, high performance dimming-control solutions utilizing solid-state lighting (SSL) technology. Typically, there is a lack of technical knowledge or experience to integrate the power and control elements necessary to optimize an effective and energy efficient SSL solution, consequently eroding the primary benefits of LED technology.

Dimming quality influences the quality of the entire lighting system. Many available dimming solutions have either a noticeable flicker during changes in light intensity or a limited dimming range of 10% to 100% where light output drops abruptly from 10% to 0. In addition the proportional energy savings benefits of dimming are eroded by inferior power efficiency at lower power loads.

1. The most common methodology for power and control in a SSL system utilizes an AC voltage distribution scheme. Expensive class 1 wiring is required for power and class 2 wiring for dimming and control. Both sets of wiring are connected to every LED Driver within, or in close proximity to, the LED fixture further increasing costs and wiring complexity (see Figure 1).



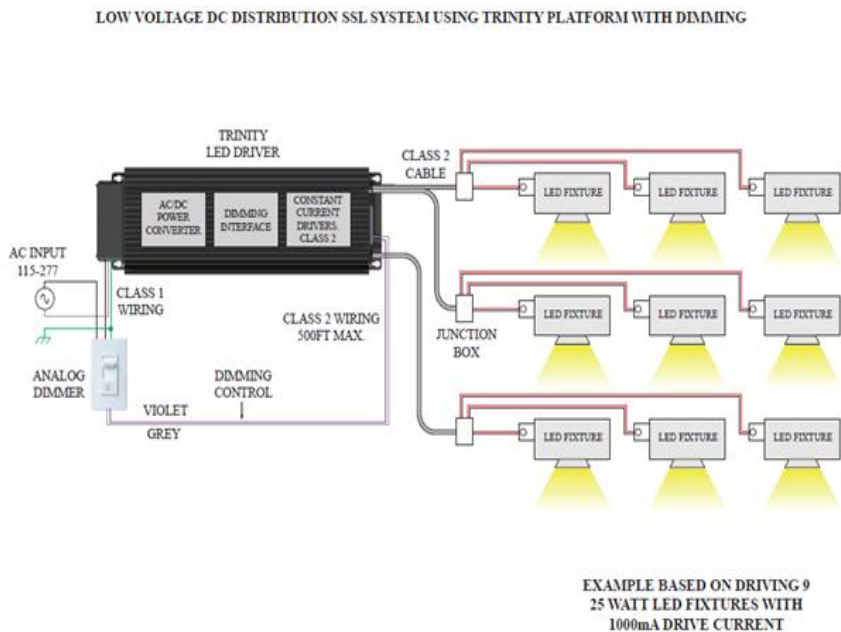
2. A second methodology utilizes a 'kluged' low voltage DC power distribution scheme. This power and control solution typically combines disparate components such as remote mounted AC/DC power sources, a dimming control interface, and current drivers. Current drivers located within the LED fixture contribute additional heating, reducing the longevity and light output performance of the fixture. Furthermore, the current driver and control/dimming interface are located within every LED fixture increasing the wiring complexity and component count and therefore reliability of the entire SSL system (see Figure 2).



3. The optimal methodology realizes that energy saving potential, reliability, and dimming performance of a SSL system is directly related to the power conversion and dimming/control design. The technology solution illustrated is an integrated “3 in 1” **Trinity platform** that combines the blocks of an AC/DC Power Converter with power factor correction, multi channel current drivers and a control-dimming interface.

The **Trinity platform** is intended for remote mounting in a wiring cabinet, closet, rack or potentially above a drop ceiling air space in non-plenum locations. The platform requires a single input AC mains connection, which converts to low voltage DC power to multiple LED fixtures and is capable of being interconnected via the control/dimming interface as part of a networked solution. It also offers a deep dimming capability providing smooth and wide dynamic range dimming from 100% of light intensity to less than 1% light intensity.

The **Trinity platform** offers superior power conversion efficiency, more intelligence, and potentially lower costs for installation and dimming control. The cost saving and technology benefits with this approach are significant (see Figure 3).



### Installation Cost Savings Potential

A major cost benefit comes from the typical AC voltage distribution approach where AC voltage is distributed by expensive Class 1 electrical wiring infrastructure compared to low voltage DC Class 2 distribution which is less expensive and easier to install. From a safety perspective, the DC approach is classified as a low voltage, energy limited DC distribution system.

Installation of the **Trinity platform** early on in the wiring to the LED fixtures as part of a low voltage DC distribution system reduces the amount of conduit or armoured cable and reduces the number of dedicated lighting panels saving both material and installation costs.

The **Trinity platform** includes a dimming/control interface to control and dim up to 12 output current drivers and up to 12 LED fixtures with a single wiring dimming interface connection. This approach reduces the wiring complexity and cost compared to an AC voltage distribution method where a discrete wiring connection for dimming control needs to be made to each LED Driver connected in close proximity to every fixture.

Similarly, in the case of a kluged low voltage DC system where the current drivers and dimming interface are embedded within the LED fixture, there is a significant cost and wiring complexity since a wiring connection for dimming control also needs to be made to every LED fixture.

### Maintenance Cost Savings and Safe Access Potential

The remote mount capability of the **Trinity platform** enables safe accessibility for maintenance personnel in secure locations such as prisons and psychiatric hospitals or in hazardous locations. Its inherent safety with a low voltage, energy limited power distribution approach also enables the safety of end users.

The implementation of a networked **Trinity platform** provides high system reliability and lower maintenance costs compared to an AC voltage distribution method. The AC voltage distribution method requires multiple LED Drivers incorporating both power factor correction and AC/DC power conversion circuitry for every LED fixture increasing over all component count.

The low voltage DC distribution approach using the **Trinity platform** also increases the longevity of the LEDs compared to the kluged DC distribution approach by separating the current drivers from the LED fixture. Current drivers within the fixture contribute to the heating the fixture reducing both the lifetime of the LEDs and light output.

### Upgrade Savings Potential

Future generations of LED light engines are expected to provide better efficacies in terms of higher lumens/watt.

In the case of a typical Class 1 AC Voltage distribution installation, a future upgrade would require every LED engine and every LED Driver whether located within the fixture or in close proximity to it to be replaced. Installation of one Trinity platform with up to 12 output current drivers reduces the installation effort for the LED Drivers by a factor of 12.

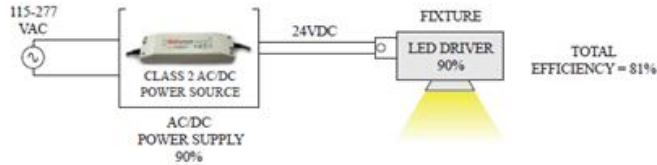
The **Trinity platform** incorporates microprocessors to provide numerous configuration options for drive currents (350mA to 1400mA), dimming-control protocols and channel configuration that facilitates adaptation to the newest generation of LEDs.

### Energy Savings

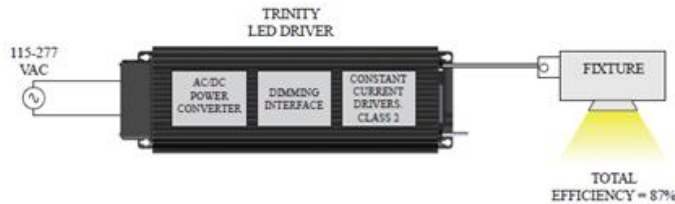
The integrated power conversion stages within the Trinity platform utilize digital feedback control in order to optimize energy efficiency. This approach provides superior energy efficiency compared to a kluge solution over a wide range of load conditions such as 25%, 50%, 75%, and 100% with an average efficiency over these load conditions exceeding 80% (see Figure 4 and Figure 5).

## The Kluge vs. Trinity Platform

### Energy Efficiency

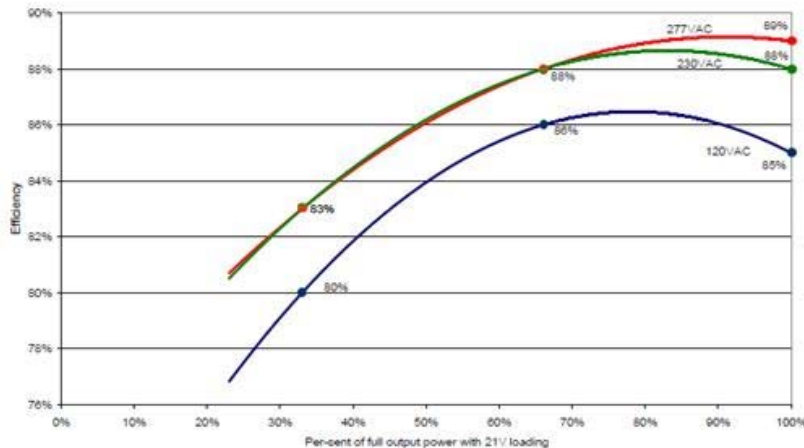


The Kluge Offers 81%



The Trinity Platform Offers 87%

Trinity6 Efficiency While Dimming  
(700mA unit, 21V Load)



### Key Performance Benefits

- Reduced Wiring Complexity and Cost:** An integrated '3 in 1' **Trinity** platform combines AC/DC power conversion, multi channel current drivers and a dimming control interface with remote mounting capability. This approach facilitates a low voltage DC distribution method to reduce wiring complexity and cost.
- Energy Efficiency and Energy Star Compliance:** The digital feedback control implemented in the Trinity platform results in average efficiencies exceeding 80% for loads of 25%, 50%, 75% and 100% enabling SSL integrators and OEMs to achieve Energy Star compliance.
- Smooth and Deep Dimming Capability:** A proprietary current pulsing algorithm provides deep dimming capability to as low as 0.2% and flicker free dimming over the full dynamic dimming range from 100% to 0.2%.
- Reliability:** The integration of a single AC/DC power converter and dimming interface to power and dim up to 12 current drivers and corresponding LED fixtures reduces over all component count in a networked solid state lighting application.
- Flexibility:** Use of microprocessor technology enables the company to configure for a wide range of drive currents as well as software upgrades for future generations of LEDs. Also, a modular dimming interface provides interface options for various protocols such as DMX512A, Analog 0-10Vdc for IEC60929, DALI for IEC62386-102, and others.
- UL Listed:** The Trinity platform is UL Listed, reducing time to market and reducing costs for safety approvals of a complete SSL system. Kluged low voltage DC distribution schemes and AC voltage distribution schemes integrate

UL recognized power supplies and drivers thus requiring final safety approval adding cost and delaying time to market.

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