

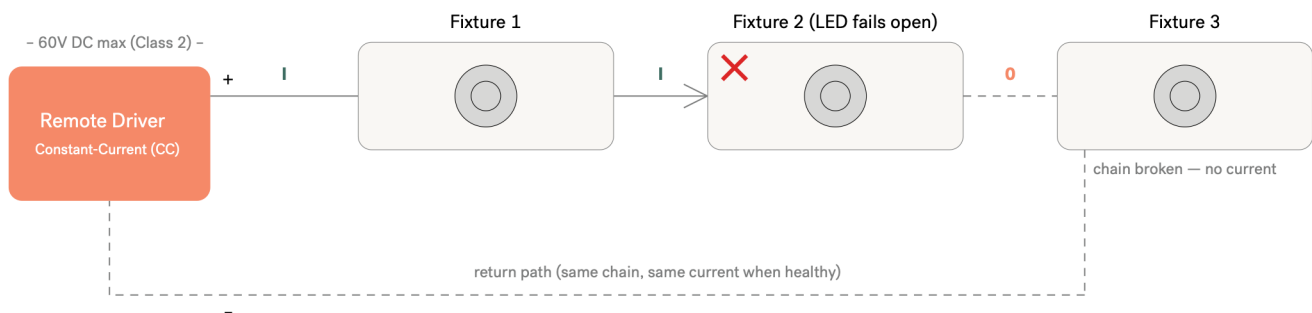
Understanding LED Wiring Topologies: The Advantages of In-Fixture Current Regulation

Low-voltage LED lighting systems are widely used in residential and commercial applications because they can simplify installation, integrate easily with architectural details, and when properly designed and listed, utilize Class 2 wiring methods. A common design choice is to power several LED fixtures from a single remote driver, simplifying installation and centralizing power management. However, how those fixtures are connected to the driver can have significant implications for performance, reliability, and design flexibility.

Many remote drivers used with point-source LED fixtures are constant-current (CC) devices. They regulate output current to a fixed value and let the voltage float to whatever the connected LEDs require. When multiple fixtures are connected to a single constant-current driver, installers traditionally choose between two topologies—series or parallel. Each has potential limitations. A third approach—using a constant-voltage (CV) source with independent current regulation within each fixture—can address many of these limitations while providing consistent performance and dimming across the installation.

Topology 1: Wiring Fixtures in Series

In a series configuration, the LED loads in each fixture form a single electrical path. The driver's regulated current flows through each fixture in sequence, so every fixture receives the same drive current, helping provide consistent light output across the run.



That consistency comes with several constraints:

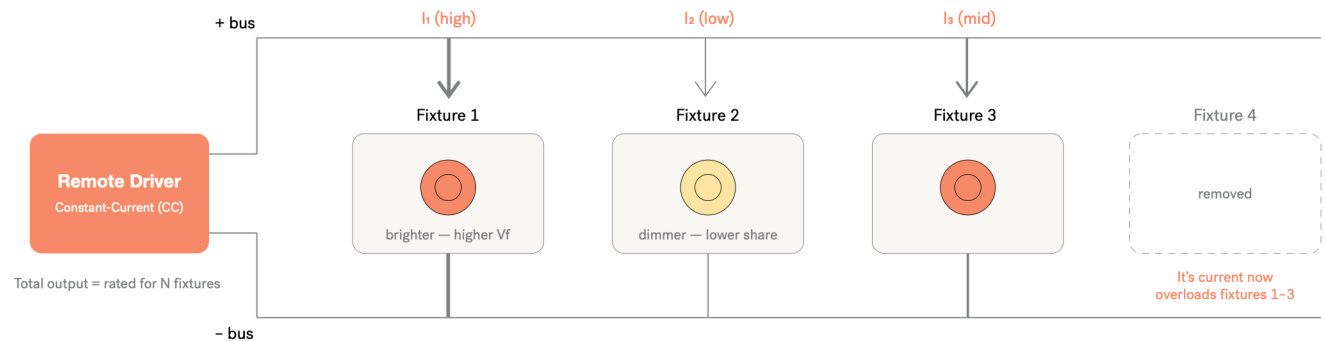
- **Class 2 voltage ceiling.** Each LED load adds its forward voltage to the total. For a Class 2 circuit, the DC voltage limit is 60V, so the cumulative voltage of the LED load must remain within the applicable circuit and driver limits. This can limit the number of fixtures, the LED load per fixture, or both.
- **Single-point failure.** Because the fixtures share a single current path, an open circuit in one fixture will interrupt current to the entire series string, causing the other fixtures on the run to turn off and complicating troubleshooting.
- **Limited flexibility.** Adding or removing fixtures changes the total voltage required by the series string. Field modifications can therefore affect the operating range of the driver and the voltage limits of the circuit.

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Topology 2: Wiring Fixtures in Parallel

In a conventional parallel configuration, multiple LED loads connect directly across the driver's output. With a CC driver supplying the combined load, current distribution among the fixtures depends on the electrical characteristics of the individual LED loads.



Parallel wiring eliminates the single-path failure mode of a series circuit, but it can introduce other challenges:

- **Current sharing can be uneven.** LEDs do not all have identical forward voltages, even within the same bin. Small voltage differences cause large differences in current draw, so fixtures wired in parallel rarely share current evenly. The result is visible brightness variation between fixtures that should look identical.
- **Fixture failures or changes affect the remaining loads.** If a fixture is removed or a branch opens, the driver's regulated current can be redistributed among the remaining loads. Without independent current regulation or appropriate current limiting at each fixture, the remaining fixtures can be subjected to higher-than-intended current, potentially reducing their reliability.
- **Driver configuration depends on the load.** With a conventional CC architecture, the driver must be selected and configured to accommodate the combined current requirements of the connected fixtures. Changes to fixture quantity may therefore require changes to the driver or its configuration.

An Alternative Approach: SpectraDrive™ DC-to-DC Regulation

The DMF low-voltage system combines the installation simplicity of parallel wiring with independent current regulation at each fixture. Instead of relying on a remote CC driver to regulate the combined LED load, each DMF True 1 downlight incorporates its own SpectraDrive™ DC-to-DC regulator to regulate LED current locally. The system is powered by a constant-voltage pulse-width modulation (PWM) source, with the fixtures connected in parallel across the supply.

Because each fixture independently regulates its own LED current, every fixture on the shared constant-voltage bus can perform uniformly, despite any normal differences in forward voltage. This provides consistent operation as fixtures are added, removed, or serviced within the rated capacity of the system.



DMF's SpectraDrive™ DC-to-DC regulator is located inside each True 1 downlight.

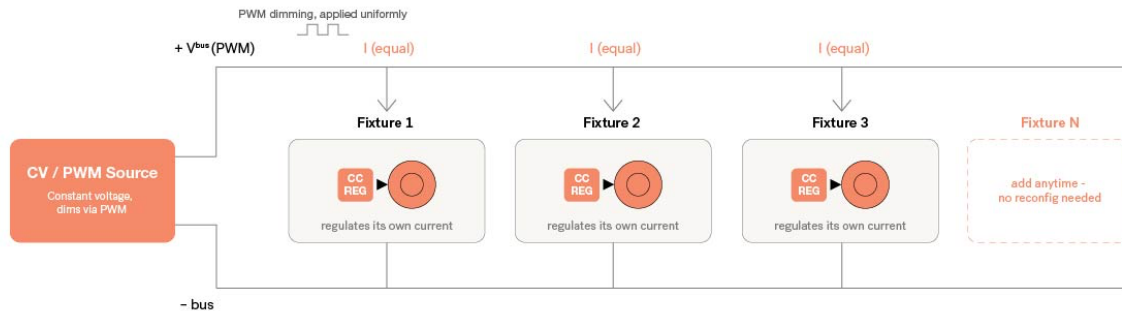
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With this approach, the True 1 downlight family operates with a single driver configuration that can accommodate one to five fixture, simplifying system configuration and installation.

Constant-Voltage PWM Bus + In-Fixture Regulation

SpectraDrive™ DC-to-DC regulator inside every fixture; each fixture sets its own correct current



Benefits of SpectraDrive™ DC-to-DC Regulation

- **Simplified wiring and design.** Fixtures wire in parallel across a common bus. Designers and installers do not need to calculate cumulative LED voltages, plan series chains around the 60V Class 2 cap, or match driver output current to the fixture count.
- **Consistent light output.** Each fixture independently regulates its LED current, helping maintain consistent light output regardless of the number of fixtures connected to the bus or normal variations in LED forward voltage.
- **Greater resilience to fixture changes and failures.** Adding, removing, or servicing a fixture does not inherently change the regulated LED current of the other fixtures. The remaining fixtures continue to operate at their intended current, subject to the rated capacity and operating limits of the system.
- **Smooth, uniform dimming.** PWM control is applied across the constant-voltage bus, allowing all fixtures to respond consistently to the same dimming signal.
- **Future-proof installations.** Within the rated capacity of the constant-voltage source, fixtures can be added, removed, or reconfigured without changing the LED current setting of the individual fixtures.

By moving LED current regulation into each fixture and powering the system from a constant-voltage PWM source, the DMF low-voltage architecture combines the straightforward wiring of a parallel system with the controlled current operation required by LEDs. The result is a lighting system designed for easier specification, simpler installation, consistent performance, and greater flexibility when project requirements change.