How to Implement xDrive Designs

The xDrive is a unique all-in-one LED driver and dimmer combination designed to fit into a standard recessed electrical box for use with constant-voltage dimmable lighting applications. Combining the LED driver and dimmer in one module means the xDrive simplifies installations and eliminates poor dimming performances caused by incompatibility between the driver and the dimmer. Additionally, xDrive can drive multiple fixtures therefore eliminating the need for a driver in each fixture. This has the added benefit of separating the drivers from the LEDs, the main source of heat generation in a fixture, therefore resulting in a more reliable system.

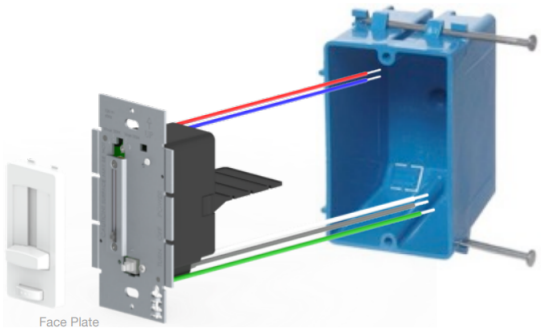


Figure 1. xDrive installed into Standard Recessed Electrical Box

The xDrive is a constant-voltage type LED driver and is available in 12V and 24V configurations, up to 100W, depending on the voltage output. All xDrive models require a 120V_{AC} line voltage. There are currently five models of xDrive available as shown below in Table 1.

Part Number	Nominal AC Line Voltage (V_{AC})	Nominal V_{OUT} (V_{DC})	Power Max (W)	I_{OUT} Max (A)
VSW40U-12-ERP	120	12	40	3.3
VSW60U-12-ERP	120	12	60	5.0
VSW60U-24-ERP	120	24	60	2.5
VSW60U-24-ERP	120	24	60	2.5
VSW100U-24-ERP	120	24	100	4.2
For additional options of output power and output voltage, contact your sales representative or send an email to: SaveEnergy@erp-power.com				

Table 1. List of xDrive Models Currently Available

Constant-Current vs. Constant-Voltage

LED drivers come in two different types: the constant-current type and the constant-voltage type. Typically LED drivers are the constant-current type which will maintain a fixed output current (i.e.: 350mA, 700mA, etc.) by utilizing a feedback loop which changes the voltage output to keep the predetermined fixed current output. The constant-current type drivers are generally used since each LED forward voltage does vary due to process variation, temperature, and drive current variation.

The xDrive on the other hand is a constant-voltage type driver. Constant-voltage drivers supply a constant-voltage output while the current output is determined by the LED load, due to the LED load impedance. Constant-voltage drivers are excellent for strip lighting, track lights, downlight applications, and other modular lighting fixtures because can simply add or subtract LED fixtures as needed. When you add or subtract a part of the LED load the driver will automatically adjust the output current accordingly and therefore the output power. However, when implementing constant-voltage type designs, one must limit the LED current (i.e. by using a ballast resistor) and one must pay close attention to matching the LED load forward voltage correctly with the driver voltage output range. Please refer to the sections Limiting the LED Current and Calculating Minimum Forward Voltage, respectively for more information.

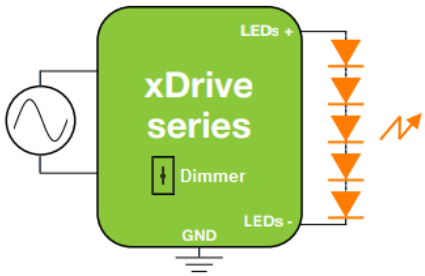


Figure 2. xDrive Block Diagram

Limiting the LED Current

When using a constant-voltage type driver, you must properly limit the LED current since a small change in voltage will produce a big change in current. When the voltage input fluctuates even a small amount, the corresponding current output will vary wildly, this effect can be seen in Figure 3.

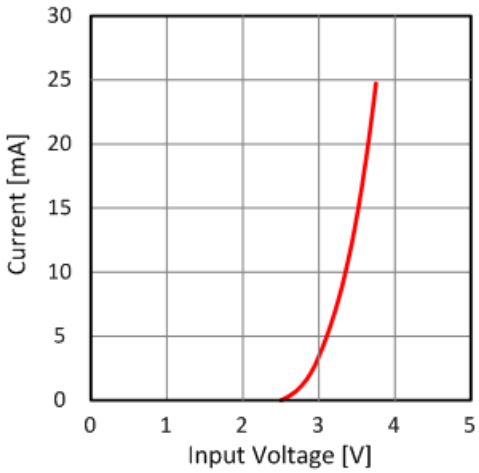


Figure 3. Typical I-V Curve of an LED

To keep the light output constant, the drive current must be controlled. Properly controlling the current would also control the temperature hence the lifetime and reliability of the system. Additionally, properly limiting the current will ensure no shimmering occurs at low dimming levels and the driver is not reaching over current protection, which could cause a flashing light output.

One can limit the current by either using a ballast resistor or a constant-current regulator. For xDrive designs we recommend ballast resistors and not active components, because active components can fight against the xDrive and may produce unwanted light outputs.
The simplest method of limiting LED current is with a ballast resistor. The ballast resistor is placed in series with a chain of LEDs as seen below in Figure 4. To determine the resistance of the ballast resistor, you must first know the following parameters:

V_{OUT}, the LED driver voltage output
N, the number of LEDs in each string
V_F, the forward voltage of each LED
I_{LED}, the nominal LED current

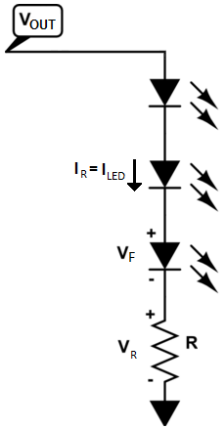


Figure 4. Ballast Resistor Calculation Example Schematic

Once you have determined the parameters, then you can determine the value required for the ballast resistor using Equation 1 below.

Equation	Example
$R = \frac{V_{OUT} - N(V_F)}{I_{LED}}$	$R = \frac{V_{OUT} - V_F}{I_{LED}} = \frac{12V - 3(3V)}{0.050\ A} = 60\Omega$

Equation 1. Ballast Resistor Calculation for Resistance Value

Keep in mind the ballast resistor's power rating. To calculate the resistor's power rating please refer to the Equation 2 below, you may consider adding an additional margin (i.e. 25% additional margin of the power required).

Equations
$P_R = I_R V_R = I_R^2 R = V_R^2 \div R$

Equation 2. Ballast Resistor Calculation for Power Rating

Typical xDrive LED Lighting Applications

The xDrive works great with the following two types of LED fixtures: LED strip lighting and the other general-purpose indoor modular lighting fixtures.

LED strip lighting, also known as LED tape lighting or ribbon lighting, is a flexible circuit board populated with LEDs and current limiting components which backing which is great for mounting inside a light fixture, along walkways, or underneath cabinets.

Figure 5. LED Strip Lighting

Strip lighting is modular, you can connect more strips together, or cut as needed. The strips can be cut with scissors at the indicated cut lines, as seen below in Figure 7, and reconnected as needed.

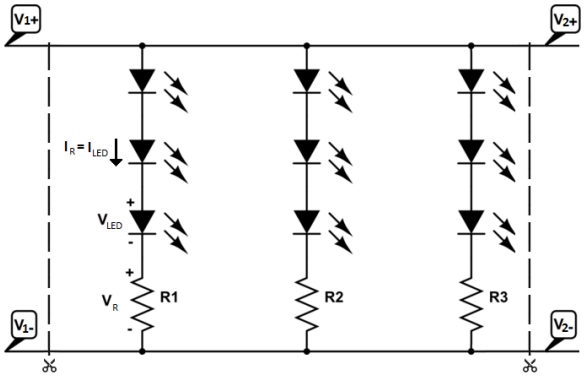


Figure 7. Schematic of a Single Segment of LED Strip Lighting

Every single segment of LED strip lighting is interchangeable, for example you can connect another strip in parallel with the original strip. The strip can connect in parallel as seen below in Figure 6.

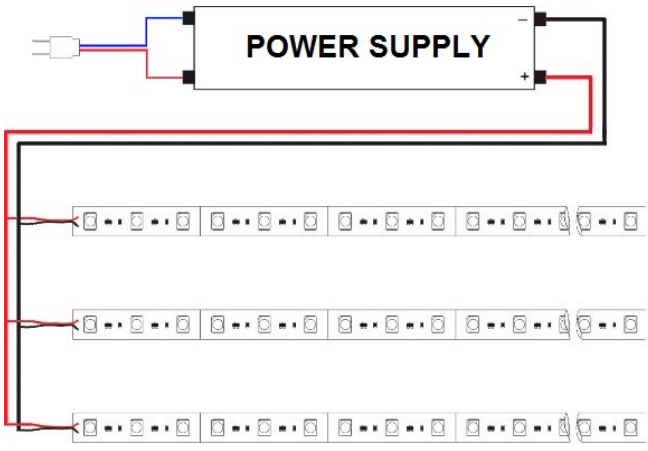


Figure 6. Strip Lighting Application Example

The longer the length of the strip, the higher the required power. The example below shows a 12V strip light that has a power drop of about 3.4 watt/foot, seen below in Table 2. The overall power requirement of a strip light may differ, it is recommended to measure the power required from the actual LED load.

Distance of Strip Light (Feet)	Power (W)	I_{OUT} (A)
1	3.4	0.28
5	17.0	1.42
10	34.0	2.83
15	51.0	4.25

Table 2. Strip Lighting Power Requirement Example

The xDrive is a perfect fit for strip lighting for two main reasons:

1. Strip lighting is available in 12V and 24V types
2. The LED current is conveniently already limited by embedded ballast resistors

The xDrive is also an excellent option for other constant-voltage general purpose lighting fixtures such as track lights and downlights. Keep in mind you will need to limit the LED current and ensure the LED load minimum forward voltage is higher than the xDrive's voltage output off-state. Please refer to the sections Limiting the LED Current and Calculating Minimum Forward Voltage, respectively for more information.

Figure 8. Track Lighting

Calculating Maximum Number of Fixtures

The xDrive is available in 40W, 60W, and 100W power ratings. To determine the maximum number of fixtures each xDrive can supply, first find the power of each fixture. To determine this, we multiply the fixture's nominal voltage with the nominal current.

Equation	Example
$P_{fixture} = V_{fixture} \times I_{fixture}$	$P_{fixture} = 12V \times 1A = 10W$

Equation 3. Individual Fixture Power Calculation

As an example, the maximum number of fixtures based on the 60W driver, assuming each fixture consumes 11W of power, is determined as shown below. The result must be rounded down since you cannot power a fraction of a fixture.

Equation	Example
$N_{MAX} \cong P_{driver} \div P_{fixture}$	$N_{MAX} \cong 60W \div 11W = 5.45 \rightarrow 5$

Equation 4. Maximum Number of Fixtures Calculation

Calculating Minimum Forward Voltage

The xDrive is not a general purpose constant-voltage LED driver. When the driver is in the off-state, the voltage output is not zero volts. Therefore, during the off-state the xDrive has a voltage output minimum. Best case or lowest forward voltage of the LED load should be higher than the voltage output in the off-state.

Equation
$(V_F)_{best\ case} > (V_{OUT})_{OFF}$

Equation 5. Minimum Forward Voltage Equation

Please consider if the LED load forward voltage is lower than the voltage output in the off-state then an undesirable strobing can happen during the off-state. Therefore, special attention must be paid to the minimum forward voltage of LED load to ensure it is within the voltage output range. If your LED load has a higher forward voltage than the voltage output in the off-state you will not see a visible light output during the off-state. A typical power cycle is shown below in Figure 9, as you can see during the off-state the driver has a pulsing voltage output.

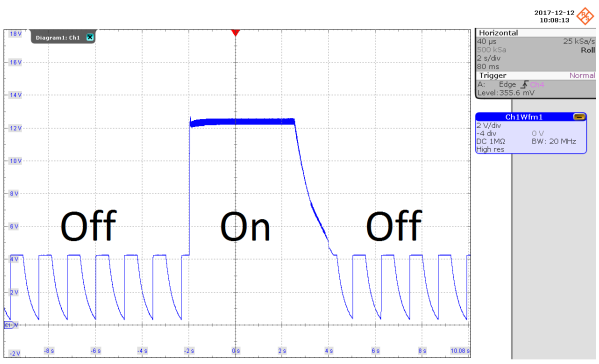


Figure 9. 12V Strip Lighting V_{OUT} during on/off Power Cycle

The xDrive's voltage output range is listed below in Table 3. If you wish to raise the xDrive's minimum voltage output, please use the voltage adjustment feature. Refer to the Voltage Output Adjust Feature section for more information.

Part Number	V_{OUT} Regulation (V_{DC})	$(V_{OUT})_{OFF}$ (V_{DC})
VSW40U-12-ERP VSW60U-12-ERP	11.1-12.9 (+/- 0.9)	≤7.1
VSW60U-24-ERP VSW100U-24-ERP	22.2-25.8 (+/- 1.8)	≤14.2

Table 3. xDrive's Voltage Output Range

xDrive Specifications

The xDrive specifications are provided below in Table 4.

Nominal V_{IN} (V_{AC})	V_{OUT} Ripple	I_{OUT} Minimum (A)	Efficiency	Max Ambient Temperature	Max Case Hot Spot Temperature	THD	Power Factor	Dimming Range
120	<10%	0	Up to 91% typical	40°C	90°C	<20%	>0.9	1-100%

Table 4. xDrive Specifications

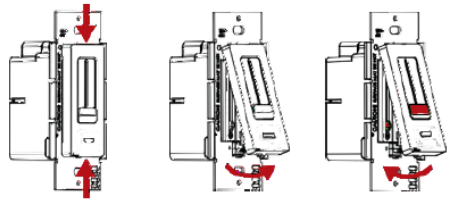
The xDrive voltage regulation and other information is provided below in Table 5.

Part Number	Nominal V_{OUT} (V_{DC})	Maximum Power (W)	Maximum I_{OUT} (A)	V_{OUT} Regulation (V_{DC})	$(V_{OUT})_{OFF}$ (V_{DC})
VSW40U-12-ERP	12	40	3.3	11.1-12.9 (+/- 0.9)	≤7.1
VSW60U-12-ERP	12	60	5.0	11.1-12.9 (+/- 0.9)	≤7.1
VSW60U-24-ERP	24	60	2.5	22.2-25.8 (+/- 1.8)	≤14.2
VSW100U-24-ERP	24	100	4.2	22.2-25.8 (+/- 1.8)	≤14.2
For additional options of power output and voltage output, contact your sales representative or send an email to: SaveEnergy@erp-power.com					

Table 5. xDrive Model Voltage Regulation

Voltage Output Adjustment Feature

If the fixture is showing noticeable light degradation on minimum output voltage the xDrive can provide a voltage output boost. Pop off the faceplate as shown in Figure 10. Then use a small screwdriver to adjust output minimum voltage by turning adjustment dial clockwise as shown in Figure 11.



a. Gently squeeze top and bottom of face plate.

b. Lift face plate from housing.

c. Insert face plate back into top housing groove. Position housing slider and face plate slider at min brightness (bottom level) and pop on face plate.

Figure 10. How to Remove the Face Plate

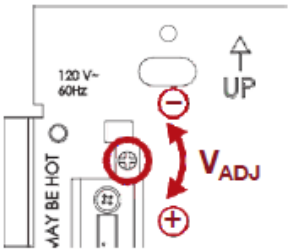


Figure 11. Voltage Adjustment Potentiometer

Maximum Remote Mounting Distance

When mounting the xDrive a sizeable distance away from the LED load at the installation site, please consider the longer the remote mounting distance between, the more the voltage drops. We recommend the 24V xDrive for longer remote mounting distances. For best performance and lumen output, ensure proper wire gauge is installed to compensate for voltage drop due to the impedance wire with low voltage circuits. To determine the maximum remote mounting distance, refer to the 12V table in Figure 12 or the 24V table in Figure 13.

Wire Gauge	10 W .83 A	20 W 1.7 A	30 W 2.5 A	40 W 3.3 A	50 W 2.1 A	60 W 4.2 A
18 AWG	34 ft/10.4 m	17 ft/5.2 m	11 ft/3.4 m	8 ft/2.4 m	6 ft/1.8 m	5 ft/1.5 m
16 AWG	54 ft/16.5 m	27 ft/8.2 m	18 ft/5.5 m	13 ft/4.0 m	10 ft/3.1 m	9 ft/2.7 m
14 AWG	86 ft/26.2 m	43 ft/13.1 m	29 ft/8.9 m	21 ft/6.4 m	17 ft/5.2 m	14 ft/4.3 m
12 AWG	134 ft/40.8 m	68 ft/20.7 m	45 ft/13.7 m	34 ft/10.4 m	27 ft/8.2 m	22 ft/6.7 m
10 AWG	199 ft/60.7 m	99 ft/30.18 m	66 ft/20.1 m	49 ft/14.9 m	39 ft/11.9 m	33 ft/10.1 m

Figure 12. 12V xDrive Voltage Drop & Wire Length Distance Chart

Wire Gauge	10 W .42 A	20 W .83 A	30 W 1.3 A	40 W 1.7 A	50 W 2.1 A	60 W 2.5 A	70 W 2.9 A	80 W 3.3 A	100 W 4. 2 A
18 AWG	134 ft/40.8 m	68 ft/20.7 m	45 ft/13.7 m	33 ft/10.1 m	27 ft/8.2 m	22 ft/6.7 m	19 ft/5.8 m	17 ft/5.2 m	14 ft/4.3 m
16 AWG	215 ft/65.5 m	109 ft/33.2 m	72 ft/22.0 m	54 ft/16.5 m	43 ft/13.1 m	36 ft/11.0 m	31 ft/9.5 m	27 ft/8.2 m	22 ft/6.7 m
14 AWG	345 ft/105.2 m	174 ft/53.0 m	115 ft/35.1 m	86 ft/26.2 m	69 ft/21.0 m	57 ft/17.4 m	49 ft/14.9 m	43 ft/13.1 m	36 ft/11.0 m
12 AWG	539 ft/164.3 m	272 ft/82.9 m	181 ft/55.2 m	135 ft/41.2 m	108 ft/32.9 m	90 ft/27.5 m	77 ft/23.5 m	68 ft/20.7 m	56 ft/17.1 m
10 AWG	784 ft/239.0 m	397 ft/121.0 m	263 ft/80.2 m	197 ft/60.1 m	158 ft/48.2 m	131 ft/39.9 m	112 ft/34.1 m	98 ft/29.9 m	82 ft/25.0 m

Figure 13. 24V xDrive Voltage Drop & Wire Length Distance Chart

A remote mounting example is provided for the 12V xDrive below in Fig 14. First, we determine the LED load is roughly 55W, so we will round up to the nearest column which is 60W in this case. Second, we determine the remote mounting distance to be 20 feet, so we will round to the 22 feet row. Finally, we can determine the recommended wire gauge which is 12 AWG.

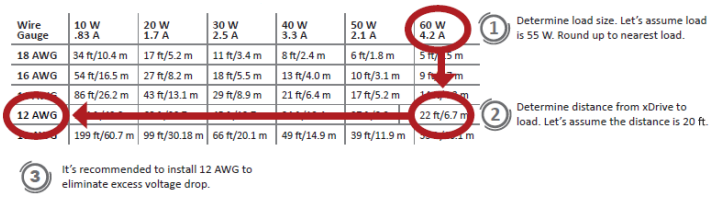


Figure 14. Example: 12V xDrive Voltage Drop & Wire Length Distance Chart

Conclusion

The xDrive is a very unique all-in-one product that simplifies lighting applications by eliminates poor dimming compatibility, simplifying designs, simplifying installations, and increases reliability. You can add or subtract modular LED loads as needed since the driver is the constant-voltage type. However, with constant-voltage drivers the LED current must be limited. One day to do this is to use an LED load with current limiting components such as ballast resistors. Please be aware the xDrive is not a general purpose LDE driver, special attention must be made to ensure the LED load's minimum forward voltage is higher than the voltage output during the off-state.

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