AUSTRALIA'S LED POWER AND
LIGHTING CONTROL SPECIALISTS

Application Guide to LED drivers

This white paper will guide you through the process of choosing a suitable LED power supply (LED driver) for your application and explain how to get the best out of you power supply.

There are a number of things you will need to know before you can start to select the most suitable power supply.

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Electrical Specifications of the LED Light Fitting

Before a LED driver can be selected the electrical specifications of the LED lighting need to be identified.

Depending on the design of the light fitting it will require either a constant voltage LED driver, or a constant current LED driver.

Constant Voltage LED Drivers

Constant voltage LED drivers are used to power LED light fittings, or LED strips that incorporate some form of electronic current regulation.

They maintain a constant voltage output by allowing the output current to vary.

The two most common voltages used are 12V and 24V and are readily available. However, there are light installations that require a higher output voltage. Reputable stockists will usually carry some stocks of the less common voltages.

Apart from the required voltage, you will also need to know how much power (WATTS) are required. If the LED driver is too small, it could become overloaded which has the potential to shorten the life of the LED driver.

Constant Current LED Drivers

Constant current LED drivers maintain a constant current output by allowing the voltage to vary.

This type of LED driver is used to power LED light fittings, or LED strips with no internal current regulation.

The actual current required to drive the LED light fitting can vary anywhere between 250mA, right up to 40A.

Once you have established the current required to power your lights, you will also need to know the forward voltage range required to drive the LEDs. The LED's electrical specifications should show the required current, which must remain constant and the voltage range in which the current should be delivered in order for the LEDs to work.

You can select a LED driver with a wider forward voltage range than required. It is important that the voltage range of the LED driver accommodates both the minimum and maximum voltage required to driver the lights.

Dimmable LED Drivers

If a dimmable LED driver is required, it is important to ascertain what type of controller will be used to dim the lights. This could be something as straight forward as the trailing, or leading-edge TRIAC dimmer switches you find in most homes, or it could be a DALI based lighting control system.

The most commonly used dimming controllers in Australia include:

- Trailing or leading-edge TRIAC dimmers.
- 1-10V, or 0-10V dimmers.
- Dimmers with a PWM output.
- Resistance.
- DALI lighting systems.

Trailing or leading-edge TRIAC Dimmers

The standard dimmer switch you find in most homes, or offices will most likely be a leading, or trailing-edge TRIAC dimmer. These are installed across the AC input into the LED driver and work by 'chopping' the AC input.

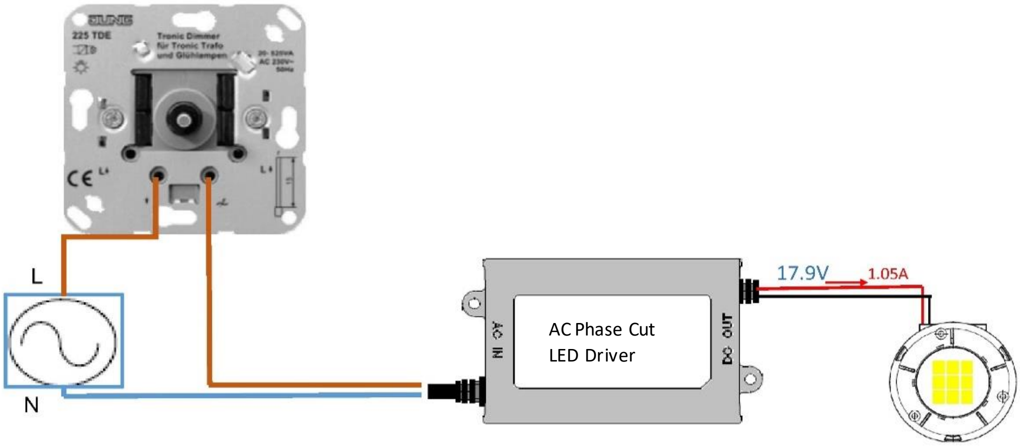
Some TRIAC modules, such as those from Hytronik can be installed in place of the existing dimmer switch, offering Bluetooth control of the lights without the need to install a full-blown home automation system.

For these types of dimmers, a LED driver that has 'AC Phase Cut' dimming is required. The may also be referred to as a 'TRIAC dimmable LED driver'.

Some examples of TRIAC dimmable LED drivers available include the Power Source range of constant voltage TRIAC dimmable LED drivers and MEAN WELL's PCD series of constant current LED drivers.

When selecting an AC phase cut LED driver, it is preferable to check the compatibility of the LED driver with the dimmer switch that is being used. Ask your supplier if they have any data on dimmer switch compatibility. You can download the Power Source compatibility guide by following the below link:

Power Source LED Driver Dimmer Switch Compatibility Chart



1-10V and 0-10V Dimmers

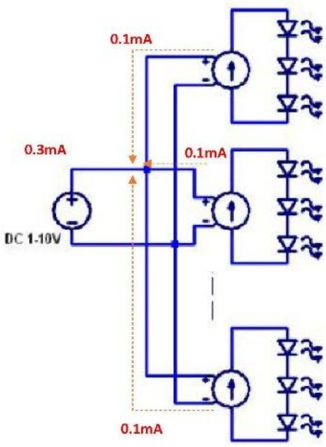
Some lighting control systems, such as Clipsal's C-Bus system use a 1-10V, or 0-10V analogue output to control devices such as LED lamps.

There are also 1-10V dimmer switches available that look very similar to a standard dimmer switch, such as SDF-30.

These dimmer switches are not wired across the LED driver's AC input. Instead the dimmer switch, or controller's output is wired to the dedicated terminals on the LED driver. A LED driver must be selected that is compatible with either 0-10V dimmers, or 1-10V dimmers.

When using a 1-10V dimmer with a LED driver that has 0-10V dimming, the LED driver will only dim down to a light level of 10%, even if the data sheet states that the LED driver can dim down to zero, or 'off'.

When using this dimming method, it is important to check the current required to provide the analogue signal. For example, you may find that need a current of 0.1ma per LED power supply. Therefore, if you are controlling 3 LED power supplies with one dimming controller, you will need a current of 0.3ma on the voltage control line, as shown in the below diagram.



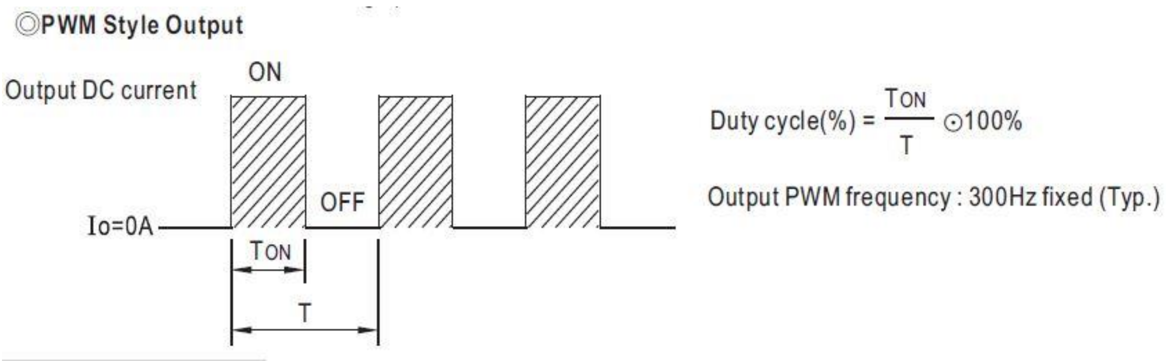
PWM Dimming

This is not to be confused with 'PWM output', which will be discussed later in this white paper.

Some dimmer switches and control systems have an analogue output with a PWM signal. The LED driver's output is controlled by the variance in the duty cycle of the PWM output.

The LED driver must be compatible with PWM dimmers. The term "PWM output" does not mean the LED driver is compatible with such dimming controllers. In this context it is the dimmer switch that has the PWM output.

The below diagram shows the duty cycle of a PWM signal.



When the "On" period equates to 50% of the duty cycle, as it does in the above diagram, the light level will be at 50% of maximum brightness. If the "On" period equates to 100% of the duty cycle the lights would be at maximum brightness.

The LED driver will detect the change in the duty cycle if the incoming control signal and adjust the light output accordingly.

Resistance Dimming

With some LED drivers the output level can be controlled by applying resistance across a pair of dedicated dimming terminals.

The resistance can be provided via a potentiometer, for applications where the light output is to be adjusted to the desired level by the user, or a fixed resistor can be used.

Using a fixed resistor is one method that can be used to set a constant current driver to the required current output. This is useful for instances where it is difficult to source a LED driver which meets the exact requirements of the LEDs.

MEAN WELL manufacturers a comprehensive range of LED drivers, which have a feature called 3-in-1 Dimming.

3-in-1 Dimming means the LED driver can be dimmed with a PWM signal, or an analogue 0-10V signal (1-10V on some models), or by applying resistance. The LED driver automatically determines which type of input is being received and alters the output of the LED driver accordingly.

The below table is a snippet from the data sheet of a MEAN WELL LED driver with 3-in1 dimming, it shows the percentage of light output in relation to the value of the input signal being received.

※ Reference resistance value for output current adjustment (Typical)

Resistance value	10KΩ	20KΩ	30KΩ	40KΩ	50KΩ	60KΩ	70KΩ	80KΩ	90KΩ	100KΩ	OPEN
Output current	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%~108%

※ 1 ~ 10V dimming function for output current adjustment (Typical)

Dimming value	1V	2V	3V	4V	5V	6V	7V	8V	9V	10V	OPEN
Output current	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%~108%

※ 10V PWM signal for output current adjustment (Typical): Frequency range :100Hz ~ 3KHz

Duty value	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	OPEN
Output current	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	100%~108%

DALI Dimmable LED Drivers

DALI is a digital addressable dimming solution that is becoming ever increasingly popular. It is not a product in itself, but a protocol that is used in lighting control systems.

A LED driver with a DALI interface is required. Otherwise it may be possible to place a DALI converter between the output of the DALI controller and the LED drivers dimming input terminals.

The range of LED drivers with a built in DALI interface has grown noticeably over the past couple of years, so it is getting easier to find a LED driver with the required specifications.

Manufacturers such as MEAN WELL have expanded the available options by providing a DALI to PWM converter, which converts the DALI control signal into a PWM signal that can be used to control a suitable LED driver.

What Load Can Be Placed on a LED Driver?

Typically for non-dimming power supplies ADM recommends that the load on the LED driver does not exceed 80% of its maximum rated capacity. This is to allow some head room for unexpected spikes in the AC input.

However, for dimmable power supplies it is not always possible to follow this rule. If a dimmable LED driver has a PWM type output, then it is recommended you adhere to the 80% recommendation. This is because the dimming performance of this type of LED driver is not affected by the load on the driver. It is important to note that the term “PWM output” does not mean LED drivers that can be dimmed with PWM type dimming controllers. It means the LED driver itself has a PWM output on the secondary side.

Many dimmable LED drivers work by varying the amplitude of the output current. Constant voltage LED drivers using this dimming method are prone to “Dead Travel” and the load on the LED driver needs to be as close to its maximum rating as possible. ADM recommends a load of 90%-95% of the maximum rated capacity. Constant current LED drivers do not suffer from “Dead Travel”.

What is Dead Travel?

If the load on the LED driver is only 50% of its maximum rated capacity the LEDs won’t start to dim until the dimmer switch has been turned down past the 50% level. Once the dimmer switch has been turned past 50% the light level will suddenly drop to the minimum. The drop is that rapid that it is impossible for the user to adjust the light to the required level and they will presume the lights to be faulty.

Dead travel poses an additional challenge if more than one LED driver is being controlled via a single controller.

All of the LED drivers need to be loaded to exactly the same level (as a percentage of the LED driver's maximum rated output) otherwise, they will not dim synchronously.

For example, if you a 150-Watt LED driver and a 240-Watt LED driver are being used, the load on each of the LED drivers would need to be as follows:

150-Watt driver: Actual load required is 142.5 Watts

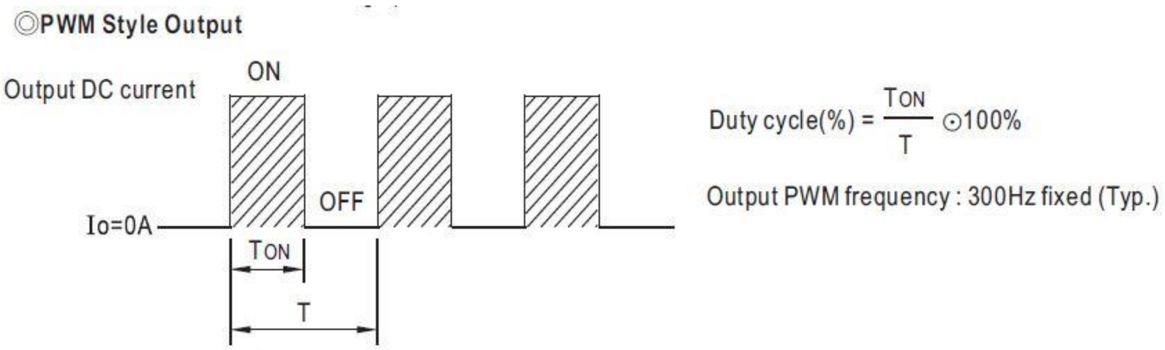
240-Watt driver: Actual load required is 228 Watts

The actual load values shown above are equal to 95% of the maximum capacity of the LED driver.

LED Drivers with PWM Output

Constant voltage LED drivers with a PWM output cycle the LEDs on and off at a fast rate. The on/off rate has to be high enough so that the flicker is undetectable by the human eye. A single on/off cycle is called the 'duty cycle'.

The below diagram shows the duty cycle of a LED driver with PWM output.



When the "On" period equates to 50% of the duty cycle, as it does in the above diagram, the light level will be at 50% of maximum brightness. If the "On" period equates to 100% of the duty cycle the lights would be at maximum brightness.

The LED driver will alter the duty cycle according to the output of the dimming controller.

One advantage of this dimming method is that changes in the colour temperature are unnoticeable at different brightness levels. This makes it ideal for architectural lighting projects, where colour stability is a must.

The other advantage is that the LED driver will dim smoothly, regardless of the load on the LED driver.

If a LED driver has a PWM output it does not necessarily mean it is compatible with a PWM dimming controller, although there are LED drivers available that are. There are also LED drivers with a PWM output available that can be dimmed via a DALI controller, an analogue voltage signal (0-10V, or 1-10V), or are compatible with leading and trailing-edge TRIAC dimmers.

Power Factor Correction

Power Factor is the ratio of the real power flowing to the load, to the apparent power in the circuit. Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. A negative power factor occurs when the device which is normally the load generates power, which then flows back towards the device which is normally considered the generator. In an electric power system, a load with a low power factor draws more current than a load with a high-power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system. For this reason, many LED drivers have built in power factor correction to prevent this from occurring.

It is recommended that a LED driver with power factor correction is used where possible to improve the energy efficiency of the electrical circuit. In larger installations power factor correction will help reduce energy costs, due to the elimination of 'non-productive' power in a circuit.

Environmental considerations.

As previously mentioned, it is important to understand the environment that the LED driver will be expected to operate in. Will the power supply be exposed to dust or water ingress?

IP Ratings

There are a wide range of LED drivers available that claim to be "water proof". ADM prefers to use the term "weather proof" because "water proof" can be interpreted in many different ways and could be unintentionally misleading.

The best way to ascertain a LED drivers' resistance to moisture, or dust ingress is to check its IP rating. The IP rating number indicates the level of protection against dust and water ingress.

The IP rating number consists of two numbers. The first indicates the level of protection against ingress from solids. The second number indicates the level of protection against ingress from liquids.

The following table details what each digit in the IP ratings means.

IP	Solid Protection	IP	Liquid Protection
1	Protection against a solid object thicker than 50mm, such as a hand.	1	Protected against vertically falling drops of water. Limited ingress permitted.
2	Protection against a solid object thicker than 12.5mm, such as a hand.	2	Protected against vertically falling drops of water, with enclosure tilted at 15° from vertical. Limited ingress permitted.
3	Protection against a solid object thicker than 2.5mm, such as a screwdriver.	3	Protected against sprays to 60° from the vertical. Limited ingress permitted.
4	Protection against a solid object thicker than 1mm, such as a wire.	4	Protected against water splashing from all directions. Limited ingress permitted.
5	Dust protected. Limited ingress of dust permitted.	5	Protected against jets of water. Limited ingress permitted.
6	Dust tight. Zero ingress of dust permitted.	6	Protected against strong jets of water. Limited ingress permitted.
		7	Protected against the effects of immersion between 15cm and 1m. (Test duration: 30 mins).
		8	Protected against long periods of immersion under pressure.

For example, IP67 is totally protected against dust ingress and against the immersion in water between 15cm and 1m for a duration of up to 30 minutes. IP65 is totally protected against dust ingress and against low pressure water jets from all directions. Some water ingress is permitted under this rating.

Regardless of the IP rating ADM strongly recommends that LED drivers are never submerged in water.

Generally speaking, a LED driver with an IP65 rating or higher can be mounted outdoors. Although care needs to be taken not to mount it in direct sunlight.

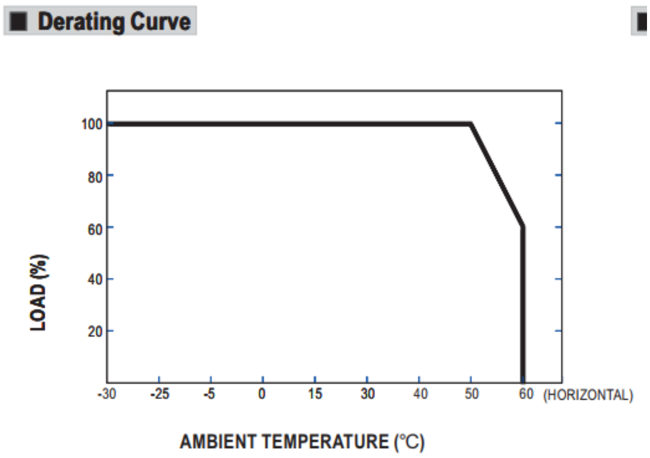
Sunlight and Temperature

It is important to understand that temperature can affect the lifetime of components within the LED driver. Reputable manufaturers conduct tests on the affects of temperature on critical components. The product data sheet will show the permissable maximum operating temperature. Should the LED driver be exposed to higher temperatures there is a risk of failure. ADM recommends that power supplies should not be exposed to heat sources such as direct sunlight.

It should also be noted that most plastic bodied LED drivers are not UV stabilised. Therefore, even if they have an IP rating of IP65, or better they still may not be suitable for mounting outdoors.

De-rating a power supply in higher ambient temperatures.

Reputable manufacturers will publish a temperature derating curve in their data sheets, such as the one shown in the below example.



In this example the derating curve shows at 60 degrees Celsius the maximum load on the driver should be limited to 60% of its maximum rated capacity. It is important to check the derating curve, as it may be necessary to use a larger capacity LED driver than originally anticipated.

Failure to take derating into account to could potentially lead to a failure of the LED driver. Such failures are not covered by manufacturers' warranties.

Wiring LEDs to Constant Current LED Drivers

LEDs should not be connected to a constant current LED driver in parallel.

Constant current LED drivers are used to power LEDs that have no internal current regulation.

Connecting multiple LEDs to a constant current LED driver in parallel, runs the risk of reducing the life span of your LEDs.

Do Not Connect LEDs to a Constant Current LED Driver in Parallel

First, it is important to understand that all LEDs have a manufacturing tolerance. This means that even though several LEDs with exactly the same part number are being used, there can be slight variances in the voltage at which the LEDs start up.

For example, consider a constant current LED driver with a 1A output powering 5 LEDs with an input current rating of 200mA.

Due to the permissible manufacturing tolerance one of the LEDs will come on once the output voltage of the LED driver reaches 9V, another will come on at 9.3V, and the others at 9.5V, 9.6V and 9.7V.

Because the first LED is on before the others, it will draw a slightly higher current than it needs. The other LEDs will be slightly under powered. As the first LED is being over driven, there is a risk that its lifespan will be reduced, and it could fail prematurely.

This failure has a knock-on effect. Because there are now only four LEDs connected to the LED driver, they will all be driven with a current of 250mA. This means all 4 LEDs are now being overdriven. This will most likely result in another of the LEDs failing soon. Of course, the remaining 3 LEDs are now driven with 333mA, which means it won't be long before they too fail.

Only connect multiple LEDs to a constant current LED driver in series. This way the power is cut should one of the LEDs fail, protecting the other LEDs from being over driven.

Electrical Safety and EMC Approvals

All LED drivers used in Australia must display an RCM mark.

No other approval marking is recognised in Australia, including CE and CB.

The RCM mark indicates the LED driver's compliance with both Australia's EMC regulations and the electrical safety regulations that apply, according to the category of LED driver.

Under Australia's electrical safety regime, LED drivers will fall into one of two categories:

- In Scope: Level 3
- In Scope: Level 1

Level 3 LED drivers require a higher level of safety testing and certification than those classed as a Level 1 product.

LED drivers that are connected directly to the AC mains supply and can be accessed by anyone other than a qualified electrician will be classed as a Level 3 device. This type of LED driver is usually installed externally from the light fitting.

Level 3 LED drivers must be tested for electrical by a test facility that has been accredited by the Australian regulators, and certified by one of Australia's state-based regulators or an accredited third-party agency.

LED drivers that have been designed to be installed inside a light fitting, and DC to DC LED driver are classed as a Level 1 device.

There is no requirement to have these tested by an Australian accredited test laboratory. An international certificate may be used to demonstrate that the driver is electrically safe. However, the light fitting itself may need to be tested in accordance with any electrical safety electrical regulation pertaining to lighting.

Regardless of the class of LED driver, it must comply with Australia's EMC regulations.

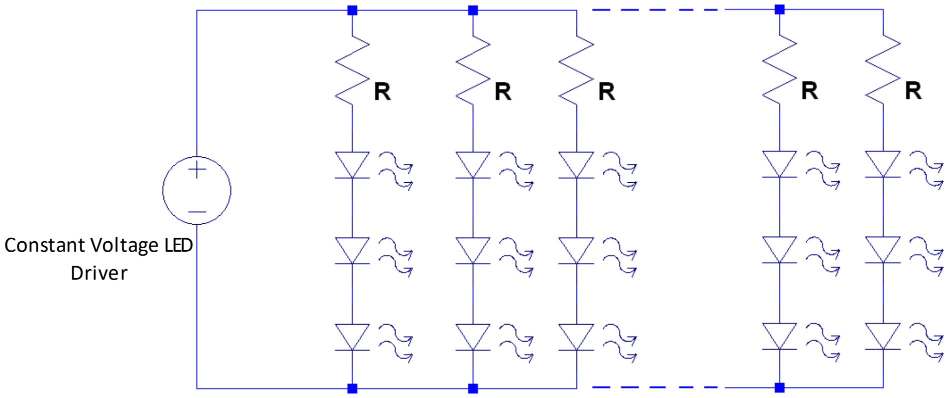
Information for Original Equipment Manufacturers and Designers

There are a number of different architectures available to electronics design engineers.

All have their advantages and disadvantages.

Simple Constant Voltage (CV)

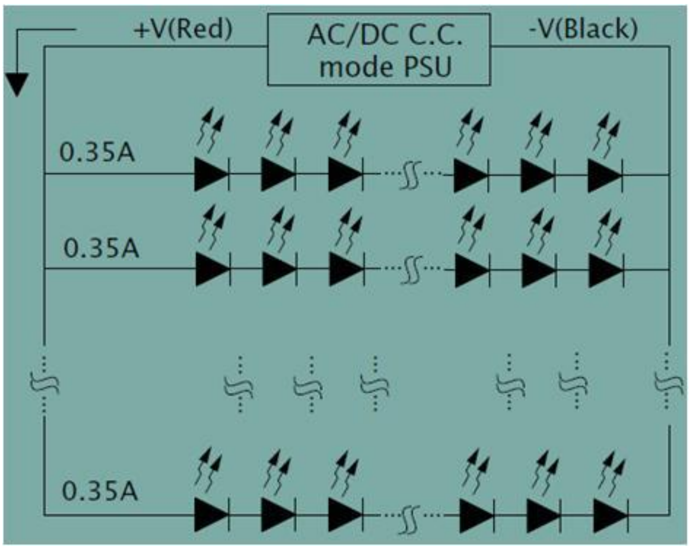
This architecture is commonly seen in low cost LED strips used for decorative lighting.



It has a low level of complexity and is a low-cost solution. However, it has poor current regulation and low efficiency.

Direct Drive Constant Current (CC)

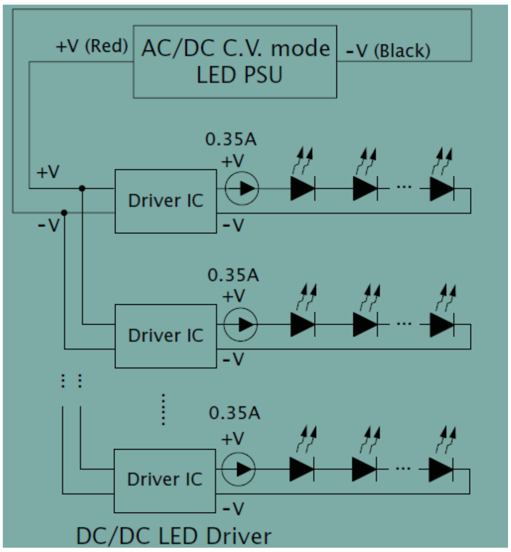
This architecture will require a high level of engineering knowledge, due to current imbalance.



Again it has a low level of complexity, but a high level of efficiency. It is also a low-cost solution. As previously mentioned, it is prone to current imbalance. For example, if you have one LED drawing more current it could result in a voltage drop on that string, altering the brightness of the LEDs. This architecture is also vulnerable should a single LED fail.

Constant Voltage & Constant Current

You will see this architecture in good quality LED strips and is one option we suggest you consider.

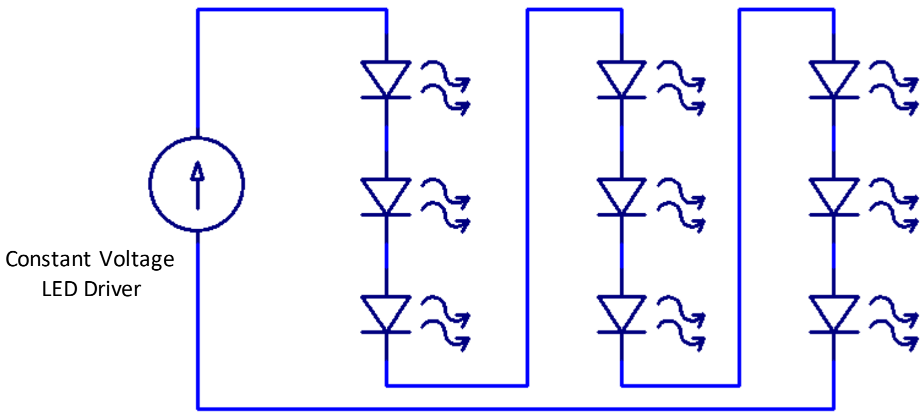


Each string of LEDs is driven by a driver giving a constant current output. These drivers are supplied from a constant voltage power supply. It gives more accurate control over each string and single LED failure can be easily controlled. It offers flexible design particularly with multi strips.

This does mean it is a more complex architecture, with a higher cost.

What Topology? Series or Parallel?

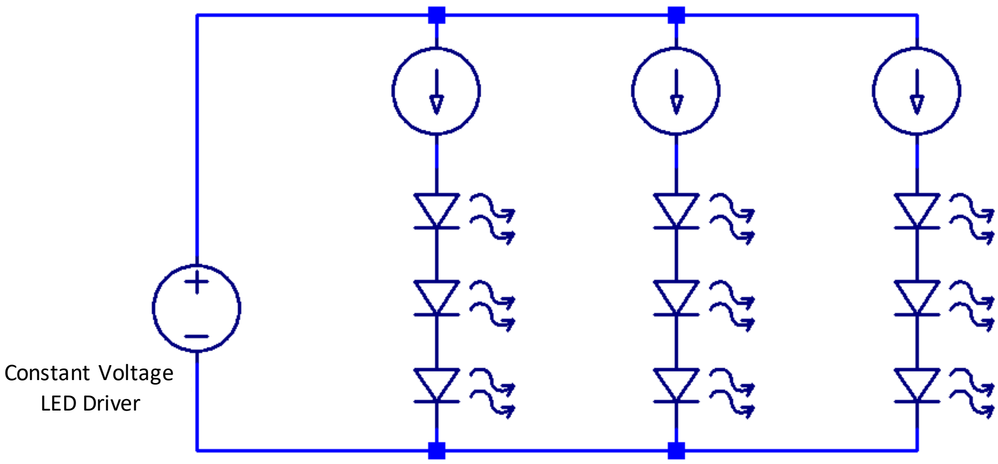
Configuring LEDs in series will result in a single current path, as well as a relatively simple design. However it does have its drawbacks.



Firstly, for very long strings the brightness of the LEDs gets dimmer the further down the string they are. This is because each LED adds a little resistance to the circuit. Under normal circumstances it is not enough to affect the performance of the LEDs. But the aggregate resistance in a long string can cause a voltage drop to make enough of a difference to effect the function of an LED.

Using a series topology also mean that your design will not offer SELV (safety extra low voltage), which is usually required on applications that maintenance electricians may later be working on.

Configuring your LEDs in parallel will give you much more flexibility in design and avoids the need to use a high-powered LED driver.



Direct drive architecture can be prone to imbalance if there is one LED drawing a bit more current than it should, or if one has failed completely. Using IC type drivers will prevent this problem but incurs a higher cost.

It is recommended that the circuit is designed by a qualified electronics design engineer.

Further Information

If you require any further information on selecting the correct LED driver for your application or have any questions about information contained in this white paper, then please contact ADM Systems.

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