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DC/DC Converters Offer Flexibility when Designing LED Drivers

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DC/DC converters are used in many of today's applications and products. They also offer some advantages for developing LED drivers. Steve Roberts, Technical Director of the RECOM group explains these advantages and shows when a DC/DC converter is the first choice.

For efficient and reliable LED lighting, the optimum matching of the driver to the LED must be taken into account besides a simple selection according to the required constant current. Until now it was common to always use an AC powered LED ballast, usually supplied as a kit with the purchase of the LEDs. However, LEDs offer solutions to many new applications that require dimming or mood lighting and a simple AC ballast is only one solution. In the future, it will become more important to offer a construction kit type lighting system with different options for various external control systems. Which control bus protocol will win the widest acceptance is still open, so it is important to be able to react flexibly to market developments – for example, today an analogue 10 V dimming control may be requested while tomorrow a color-changing solution with a DMX interface is all the rage. DC/DC LED drivers offer this flexibility already. The control interface can quickly and inexpensively adapt – even for low volume projects.

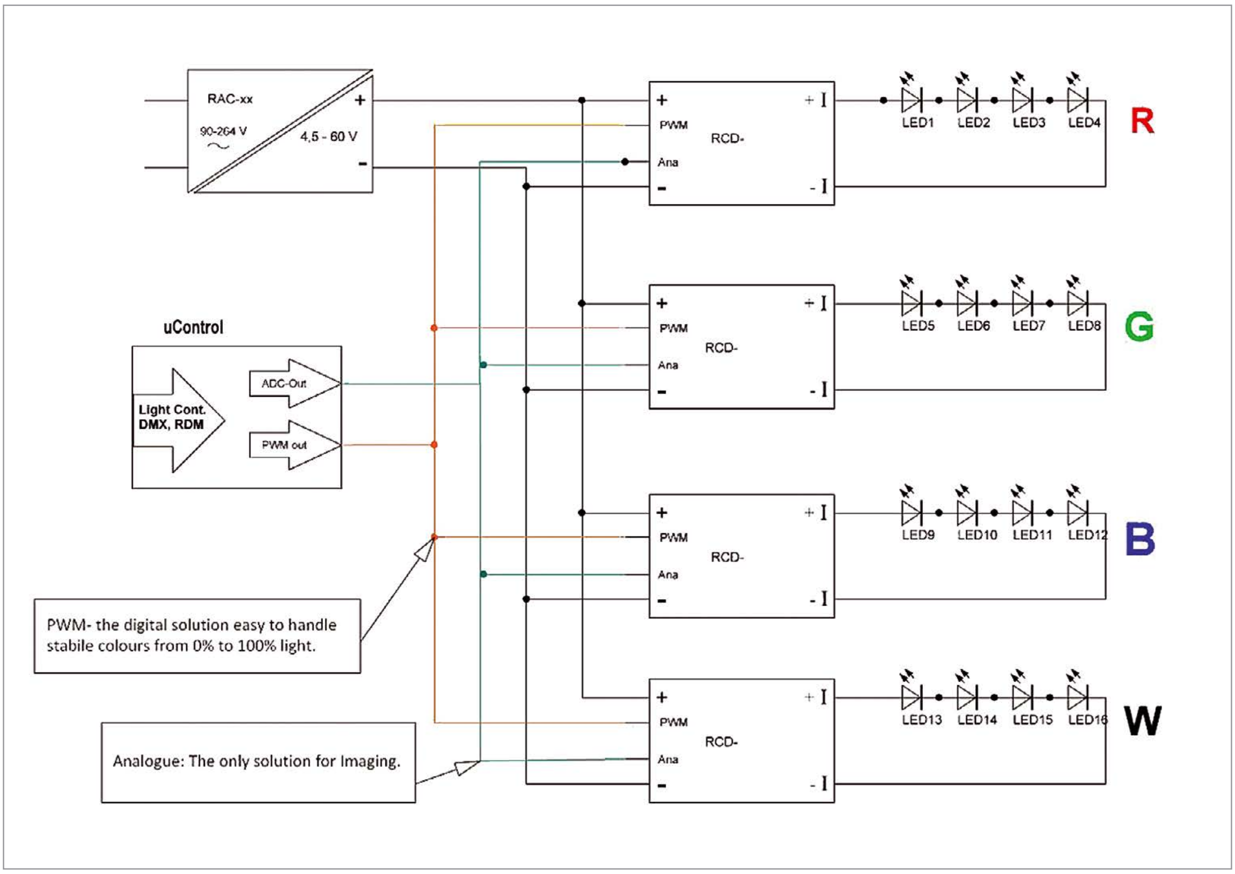


Figure 1: **Typical RGBW control system with the building block solution plus a microcontroller that can interface either with analogue or PWM signals to the drivers**

Flexible Modular DC/DC Solutions vs. AC Power Supplies

Every customer wants to have a solution that best matches their application. There are many lighting applications where a specially developed product makes sense and also covers the high development costs. On the other hand, there are many more applications with low volumes of up to, say, a thousand drivers, where a custom AC solution does not make financial sense. Typical problems that face the power supply designer are that the existing ready-made solution doesn't deliver the required power, or has four, instead of the required eight channels, or is too large to fit into the luminaire or does not feature a matching interface (for example analogue instead of DALI). The development of custom AC ballast is not economically feasible and therefore compromises must be made to the specification. However, DC/DC LED drivers offer flexible solutions when used as standard building blocks in a larger custom system. The user can assemble the required power supply quickly and by choosing the right building blocks can reduce the required components to a minimum, through which not only the BOM is simplified, but also the delivery times are kept short – a key factor in the rapidly moving illumination industry.

In the example shown in Figure 1, standard products can be controlled by either DMX or DALI bus protocols by using a microcontroller as a universal interface, many of which have the control protocol already imbedded as firmware. DMX is universally used in stage lighting and DALI (Digital Addressable Lighting Interface) is one of the widest accepted interface standards for white light electronic ballasts. Both systems offer a multiplicity of corresponding dimmers, switches and other controllers. These bus interfaces can also be purchased as standard modules and can thus be combined with standard drivers to realize a custom solution using standard components. Since the drivers feature both analogue and digital dimming control, they will work with any standard interface.

DC/DC Drivers Improve the Overall System Efficiency

LEDs are efficient light sources, but nevertheless they dissipate power in the form of heat. Additionally, AC ballasts can also generate heat, adding to the temperature stress within the light fitting. LEDs are semiconductors which are very sensitive to over-temperatures. Therefore it is important to keep the LED temperature as low as possible, in order not to shorten the well-known quality of a long LED-lifetime.

To keep the operating temperature of LED-systems under control, it is not enough to just design effective heat sinking; it also helps to reduce the heat generated by the drivers because the lower the losses, the lower the dissipated power. Dissipated power is dependent on driver efficiency. In other words, driver efficiency plays an important role in solid state lighting systems, not just because we want an efficient light, but also because it strongly influences thermal management.

Figure 2:
LED-system with AC ballasts

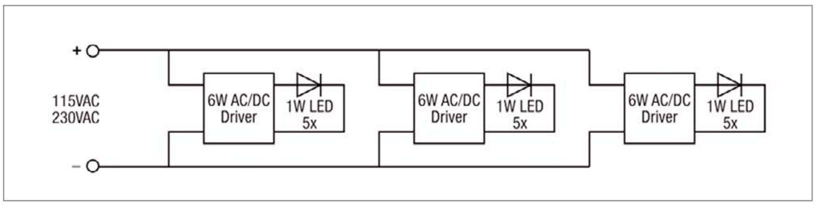
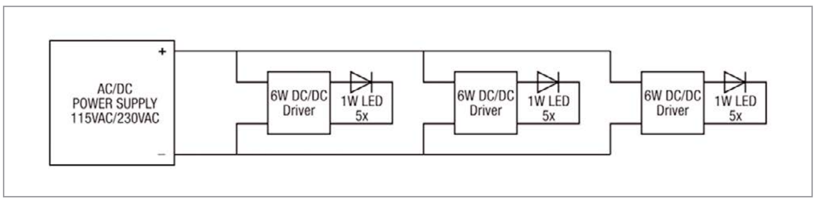


Figure 3:
High efficiency LED-system with AC/DC supply and separate DC/DC drivers



Which LED power supply topology offers the highest system-efficiency? The simplest solution is to use an AC ballast to power each LED from the mains AC supply. But an alternative is to use a central AC/DC power supply to power several DC/DC LED drivers. This topology has big advantages in many applications.

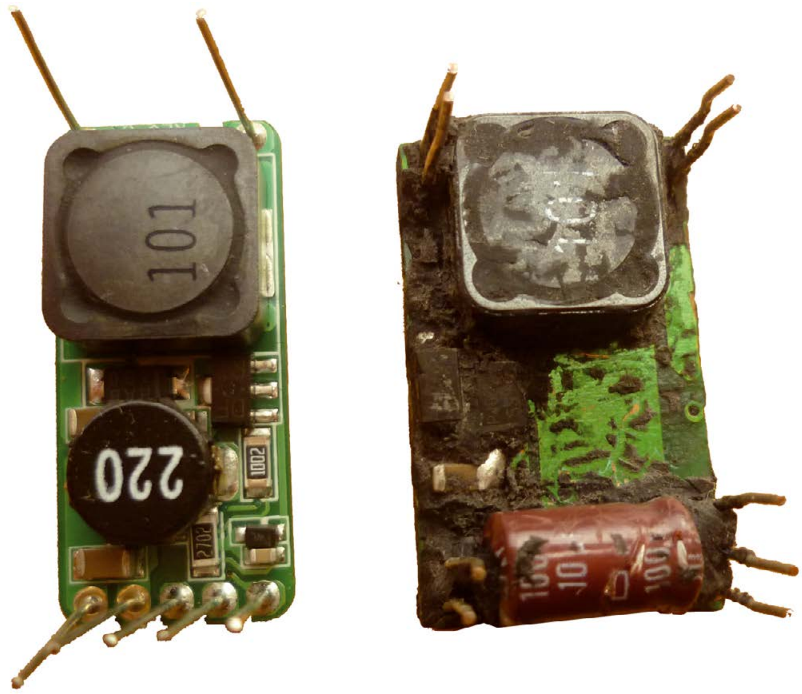
Low power AC ballasts for 6W LEDs (equivalent to a 60W incandescent) normally offer efficiencies of approximately 65% (Figure2). This means that 35% of the total energy will be lost as heat. Altogether the efficiency of the complete light fitting sinks considerably further, if one still takes the losses of the LED through the increased temperature, the optical losses and further light-performance-reductions through reflectors into account. The higher losses also conceivably have an influence on the lifespan of the light.

With the introduction of a 20 W constant voltage power supply with PFC (power factor correction), the power supply efficiency rises to approximately 88%. The LEDs are individually powered (and dimmable) via DC/DC LED drivers that have a typical efficiency of 96%. This yields a total system-efficiency of approximately 84% (0.88 x 0.96). The main loss of only 12% (a third of the previous example) occurs away from the LEDs, with only a little over 1% being dissipated close to the LEDs, which leads to a much longer LED lifespan. PF correction is stipulated for AC power supplies >25 W in the lighting industry, which means that many low power AC ballasts could be legally installed without PFC but yet have a significant combined interference on the mains supply. With the indicated 2-stage concept shown in Figure 3, the central power supply with active PFC will typically have a power factor of >0.95.

Ceramic Capacitors Increase Reliability

The most critical component affecting the lifespan of a power supply is usually the electrolytic capacitors. Despite this, it is common to find DC/DC LED drivers at the lower end of the

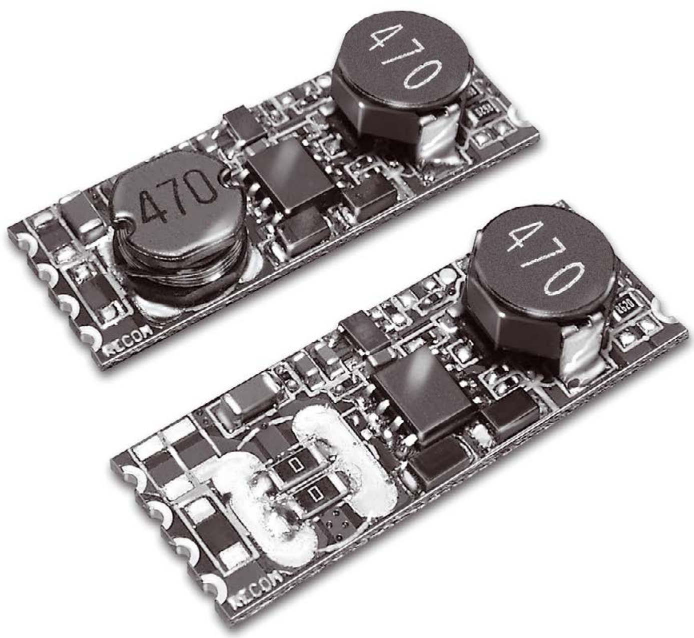
Figure 4:
DC/DC driver with ceramics capacitors (left) compared to a competitor's product with electrolytic capacitors (right). The ECAP is the large brown object



market that still use electrolytic capacitors because of their low cost. The end customers must bear the costs of replacing units that have failed in the field because the supplier usually guarantees replacement-only and does not cover any resulting costs. But the biggest loss is to the end customer's image.

Why are Electrolytic capacitors ("ECAPs") such a problem? ECAPs contain a liquid electrolyte that can boil if the capacitor overheats or dries out at elevated temperatures. If the capacitor is well de-rated and used in benign conditions, it will last a long time, but in order to save costs many low price suppliers run the capacitors close to their limits. If a driver fitted with ECAPs is used adjacent to the hot heat sink of an LED light, a premature failure is almost inevitable. For this reason, quality manufacturers only use ceramic condensers in their DC/DC LED drivers which do not have a liquid electrolyte and do not suffer such rapid degradation at elevated temperatures.

Figure 5:
The compact RCD-24-PL series is available with either class A (below) or class B filters (above) built-in EMC filters



EMC-Filter Affects Design and Price

LED lighting is strictly regulated regarding Electromagnetic Compatibility (EMC). The strict limits laid out in standards such as EN55022 and EN55015 are not to be underestimated. Dependent on the application area of the LED driver, there are different standards that must be fulfilled. For example, for DC/DC applications, the requirement is either EN55022 Class A for industrial applications or the more stringent Class B for domestic uses. EMC information is usually missing in many datasheets, and the costs of redesigning and adding external filters after a product has failed the EMC test can be very expensive. The EMC filter's effect on the design, size, weight and price is often overlooked. And any change to the system configuration may need costly re-qualification. To simplify this process, RECOM offers SMT mounting DC/DC drivers with built-in Class A or Class B EMC filters.

Safe Extra Low Voltage (SELV)

Electronics classed as SELV, which in practice means no voltages above 60 VDC, require no protection against direct and indirect touch to any of the conductive parts. This makes meeting the safety standards relatively easy. This is a big advantage, since safety-isolation usually increases the costs considerably and can impair the thermal cooling, which leads to a shorter lifespan. As SELV is a fixed limit, it makes economic sense to use the maximum voltage permitted to drive the maximum length of LED chain. However, due to the limitations in IC construction, most DC/DC drivers can only be used up to around 40 V and very few can be used above 48 V. This is a problem as more and more LED manufacturers are offering new high voltage LED arrays that offer the user considerable advantages in terms of light intensity, ease of mounting and efficacy. Many of these new generation arrays require forward voltages of up to 50 V. In order to accommodate these arrays, RECOM

Figure 6:
A selection of RECOM's DC/DC-driver designs

has developed the RCD-48 series which can drive these high power LEDs at up to 1.2 A constant current and up to 56 V forward voltage (67 W).

Buck and Buck/Boost Drivers

Buck drivers, like the RCD-24, are a good solution if the input voltage is higher than the LED string voltage. The driver efficiently converts a higher input voltage down to a lower output voltage with higher constant current. An example might make this clear: say we want to drive three 500 mA LEDs from a 24 V DC supply. A single LED requires 3.3 V forward voltage, so three LEDs in series require about 10 V. Buck drivers are highly efficient converters (>96%), so the 5 W LED load will also draw 5 W from the 24 V supply, or about 210 mA.

A buck/boost driver is required if the input voltage is not fixed, for example, from a lead acid battery. If the battery is fully charged it may deliver 14 V, so we could still use the buck driver as in the previous example. But if the battery is fully discharged it will deliver 9 V or less and the buck driver solution will not work. The RBD-12 buck/boost design offers a constant 10 V / 0.5 A output over an input voltage from 8 V up to 36 V, so it could be used with both 12 V and 24 V battery solutions. In addition, the buck/boost can be used in pure boost mode to drive up to seven 500 mA LEDs from a 12 V supply with an output voltage of 24 V. This is useful for photovoltaic (PV) applications and the RBD-12 has been designed to be compatible with PV panels, so, for example, the panel itself can be used as a light sensor to automatically switch on the LEDs at dusk.

The selection of the optimum LED driver is thus very dependent on the required LED application. The RCD-24 is suitable for general purpose applications, the RCD-48 is better for the latest generation higher voltage LED arrays and the RBD-12 has the advantage of regulating a variable input voltage that is both above and below the LED forward voltage.

Matching the LED Driver to a Wide Variety of Applications

There are as many LED lighting solutions as there are applications and the rate of new applications within the lighting spectrum shows no sign of slowing down. DC/DC LED drivers find uses in many widely different areas - from street lighting to transport applications, in photovoltaic systems, in demanding marine and aeronautics illumination or for mobile battery-powered applications, to name but a few.

Depending on the application, the way that the driver is fitted can be very different. Therefore, it is a big advantage if the driver is available with different mounting options to match the miscellaneous requirements of the application. DC/DC LED drivers are available in compact dimensions for SMT mounting, or in sealed cases for PCB through hole assembly or with wired connections for building into lighting fittings or fitting above suspended ceilings. Modules are available with plastic cases, robust metal-cases or as open-frame versions, so these DC/DC drivers can be found to fit into any LED-lighting system. Moreover, such drivers are dimmable with both digital PWM and analogue control systems and offer auxiliary reference output voltages to power external sensors or to easily permit manual potentiometer dimming. ■