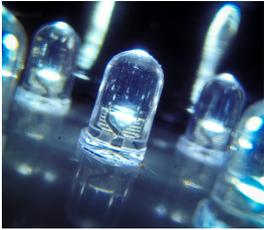


Cost Effective Driving of Standard LEDs from 10V_{DC} up to 110/230V_{AC} with Current Limiting Diodes

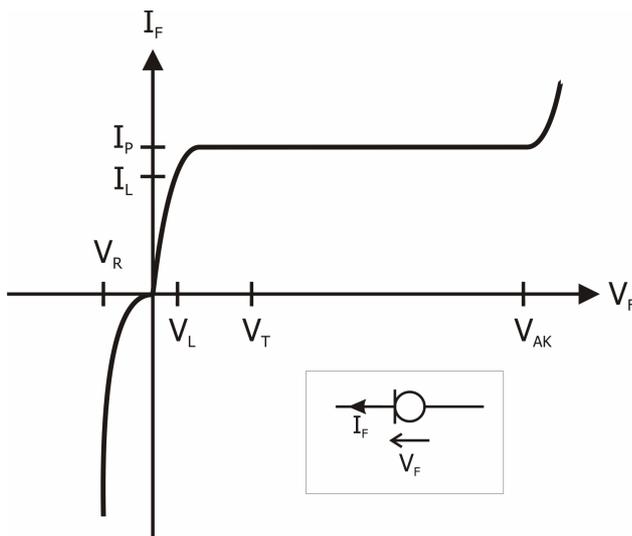


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Standard LEDs are widely used for all kind of lighting purposes such as optical indicators and signal lights, marking lights, display backlights, interior and furniture lighting and much more. New approaches even use standard LED arrays to replace fluorescent lights (neon tubes), especially in areas where no high-level lighting is required, e. g. floor lightings, wash and lunch room luminaire, outdoor lights etc. Standard LEDs are robust, long-living and available in high volumes at low costs; their power consumption is on a very low level below 100mW. The driving current of such devices is typically 20mA¹, resulting in a forward voltage drop between 2 and 4V. The following describes a cost effective solution to drive such LEDs by means of the Current Limiting Diodes **CL20M45** and **CL40M45** offered by Diotec.

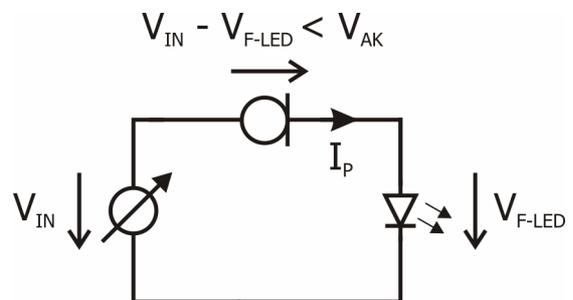


Current Limiting Diodes (CLD)



Like a Zener diode keeps a voltage constant over a wide range of Zener current, the Current Limiting Diode or CLD keeps a current constant over a wide range of forward voltage. The left figure shows the typical I_F vs V_F curve of such CLD device, including the symbol and current/voltage definitions. When applying a positive voltage from anode to the cathode (indicated by cathode mark), the current rises until it reaches a constant value I_P . The start of this current limiting area is defined by the limiting voltage V_L , above which $I_L = 80\%$ of I_P is reached. I_P remains constant, unless a maximum admissible voltage V_{AK} is reached, above which a breakdown happens and the device can be destroyed. In reverse direction, the voltage V_R is quite quickly reached. So operating voltage range is between V_L and V_{AK} , where current is kept to a constant value I_P ; the reverse direction is normally not used.

Taking the function of the CLD into account, such device can be used to drive LEDs with a constant current I_P from a variable voltage source V_{IN} , see right figure. The only condition is to limit the voltage across the CLD to a value less than V_{AK} ; that voltage is the difference between V_{IN} and the voltage drop at the LED, V_{F-LED} .



The **CL20M45** is designed for an I_P of 20mA, which is the typical driving current for Standard LEDs; the V_{AK} is 45V. So in the easiest case, this CLD can be used to drive a single LED from a voltage source ranging from about **10V_{DC} up to 45V_{DC}**. For higher driving currents, the **CL40M45** offers an I_P of 40mA. CLDs can be even operated in parallel; of course then the power dissipation / power losses will increase as well.

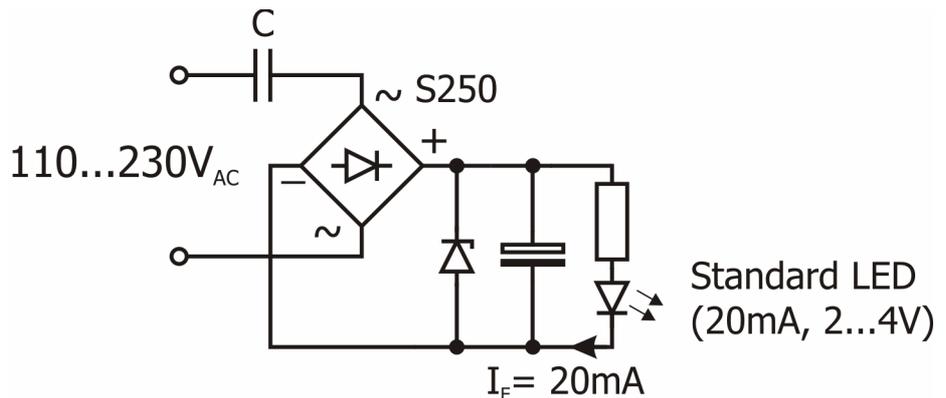
¹ One should not mix up Standard LEDs with Power LEDs, where driving current is in the range of 350 to 700mA (thereabout refer to the Application Note "Diotec Products for Power LED Drivers")

However, in most cases there is an AC voltage source, so additionally a (bridge) rectifier device is required. If the circuit is connected directly to the 110V/230V_{AC} mains, V_{IN} can reach quite high levels up to 350V peak. So existing designs require a lot of additional devices, in order to reduce the incoming voltage to an acceptable level; they further require electrolytic capacitors to keep that voltage constant. As a result, such circuits are complex and expensive, and their lifetime is limited mainly by the electrolytic capacitors used.

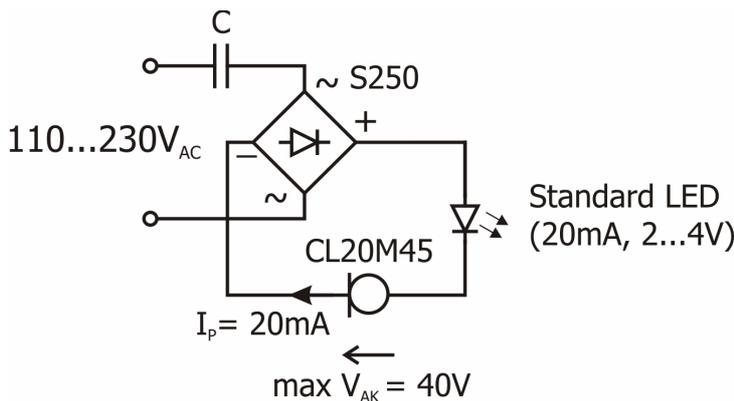
The following describes how by means of just a bridge rectifier, one or two CLDs, either an array of LEDs or an AC capacitor, a circuit for direct operation at 110V_{AC} or 230V_{AC} mains can be build².

Solution up to now: requiring 5 components, having limited lifetime

The right picture shows how up to now LEDs are driven at AC mains. The Zener diode, electrolytic capacitor and power resistor is required to keep the forward current I_F through the LED constant. The electrolytic capacitor has got the shortest lifetime of all components in the circuit and is the limiting element. During turn-on, a current peak can occur at the bridge, caused during initial charge of the AC and electrolytic capacitor. Therefore here the S250 by Diotec is used, featuring a very high forward surge rating of 40A (at 50Hz).



New Solution, Example 1: only 3 components and improved lifetime

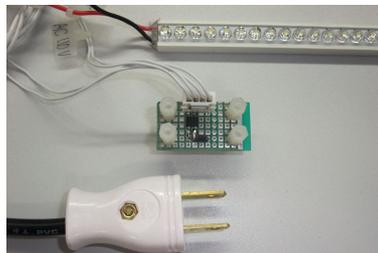
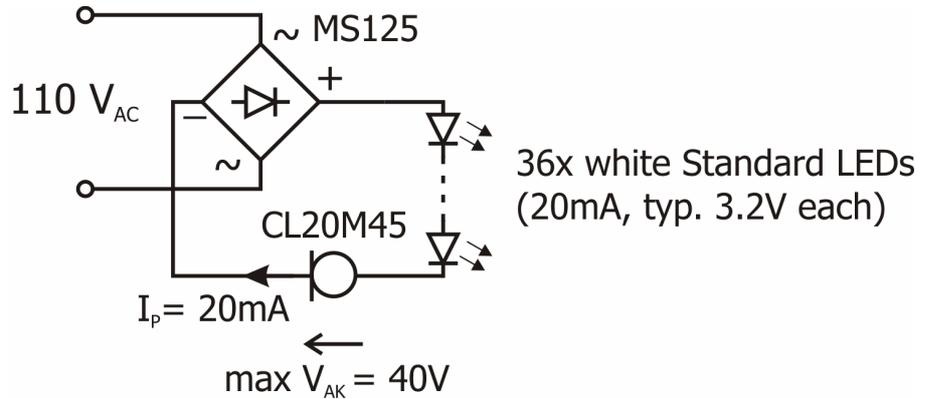


The circuit on the left simply needs 3 components to drive one (or more) Standard LEDs at a wide input range. The AC capacitor C has got a certain dynamic impedance $X_C = 1/(2\pi fC)$. Depending on the output power (and related to that, the input or mains current), there is a voltage drop across this impedance. C has to be chosen such way that the voltage drop is big enough to ensure that V_{AK} of the CLD is not exceeded.

² This design idea describes an application proposal and shall not be considered as assured and proven characteristic of a circuit. No warranty or guarantee, expressed or implied is made regarding the capacity, performance or suitability of any circuit etc, neither does it convey any license under its patent rights of others.

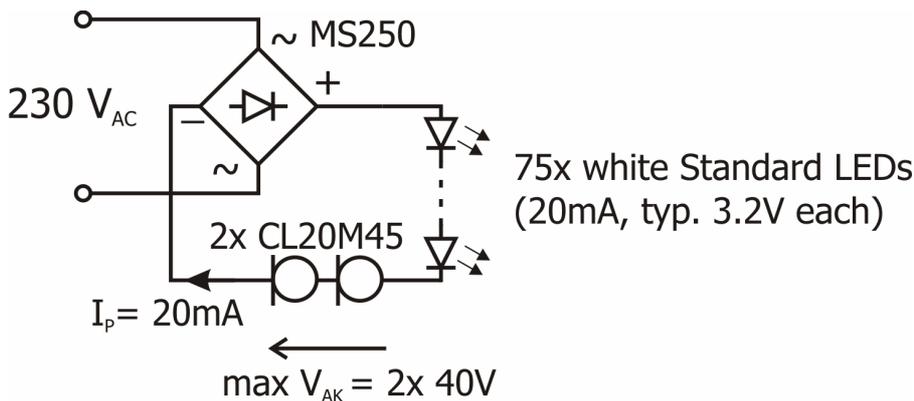
New Solution, Example 2: only 2 components for driving LED arrays at 110V_{AC}

Here not only one, but an array of Standard LEDs is used. The resulting voltage drop across the series of LEDs is big enough to ensure V_{AK} is not exceeded. Thus, by only one rectifier bridge and one single CLD a complete LED luminaire, operated at 110V_{AC}, can be done. Since there is no inrush current, the lower cost MS series of bridge rectifiers can be used.



LED array driven at 110V_{AC} by a bridge rectifier and a CLD

New Solution, Example 3: only 3 components for driving LED arrays at 230V_{AC}



Here the same circuit, but operated at 230V_{AC} mains. Due to the higher peak voltage, more LEDs have to be connected in series, and also two CLD are used. Anyway, a single rectifier bridge is enough to complete the whole circuit!

In the above circuits, no electrolytic capacitors are needed nor other complex devices³. One may add a simple inductor (coil) in series to the LEDs, in order to reduce the (small) ripple in driving current (occurring during the zero-crossing of mains voltage). Furthermore, a mains fuse can provide circuit protection in case of any unforeseen shorts.

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