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Long Life Incandescent Lamps using SIDACs

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APPLICATION NOTE

Abstract

Since the invention of the incandescent lamp bulb by the genius Thomas A. Edison in 1878, there has been little changes in the concept. Nowadays we are currently use them in our houses, and they are part of our comfort but, since we are more environmentally conscious and more demanding on energy cost saving products, along with their durability, we present here an application concept involved this simple incandescent lamp bulb in conjunction with the Bilateral Trigger semiconductor device called SIDAC, offering an alternative way to save money in energy consumption and also giving a longer life time to the lamp bulbs.

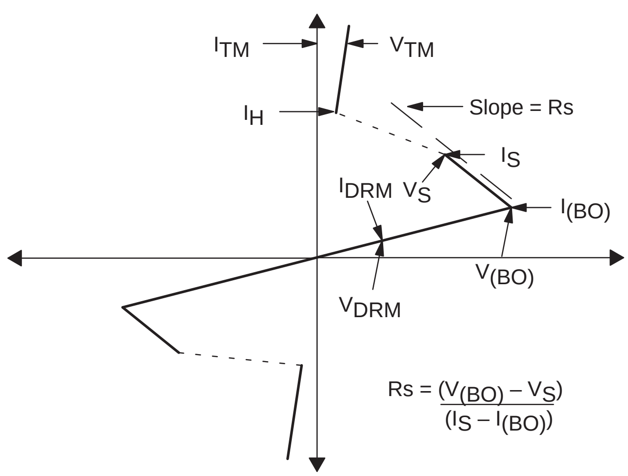
Theory of the SIDAC

The SIDAC is a high voltage bilateral trigger device that extends the trigger capabilities to significantly higher voltages and currents than have been previously obtainable, thus permitting new, cost effective applications. Being a bilateral device, it will switch from a blocking state to a conducting state when the applied voltage of either polarity exceeds the breakover voltage. As in other trigger devices, the SIDAC switches through a negative resistance region to the low voltage on–state and will remain on until the main terminal current is interrupted or drops below the holding current.

SIDAC's are available in the large MKP3V series and the economical, easy to insert, small MKP1V series axial lead packages. Breakdown voltages ranging from 110 to 250V are available. The MKP3V devices feature bigger chips and provide much greater surge capability along with somewhat higher RMS current ratings.

The high voltage and current ratings of SIDACs make them ideal for high energy applications where other trigger devices are unable to function alone without the aid of additional power boosting components.

The following figure shows the idealized SIDAC characteristics:



Once the input voltage exceeds V(BO), the device will switch on to the forward on–voltage VTM of typically 1.1 V and can conduct as much as the specified repetitive peak on state current ITSM of 20A (10µs pulse, 1KHz repetition frequency).

SIDACs can be used in many applications as transient protectors, Over Voltage Protectors, Xeon flasher, relaxation oscillators, sodium vapor lamp starters, etc.

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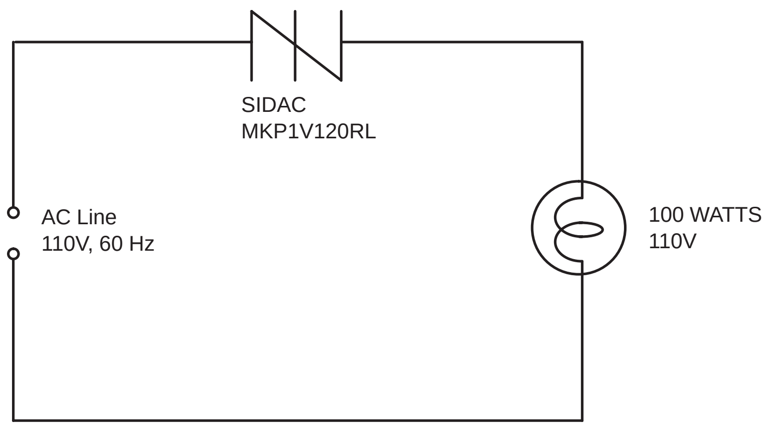
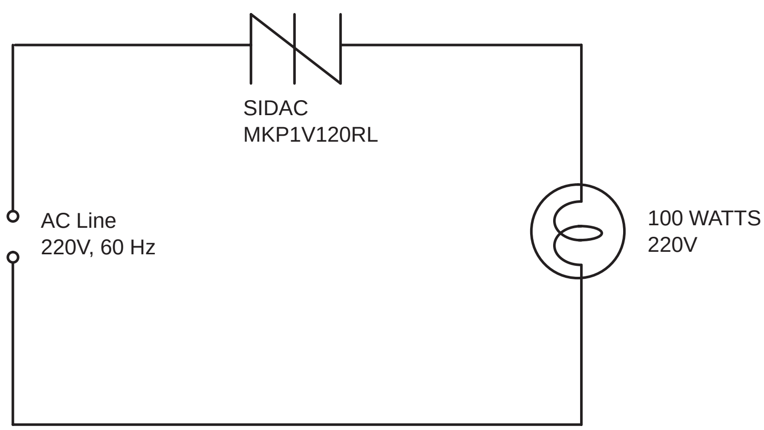
This paper explains one of the most typical applications for SIDACs which is a long life circuit for incandescent lamps.

The below schematic diagrams show the configurations of a SIDAC used in series with an incandescent lamp bulb through a fixed phase for the most typical levels of ac line voltages:

Option 1: ac line voltage 110V, 60Hz or 50Hz



Option 2: ac line voltage 220V, 60Hz or 50 Hz

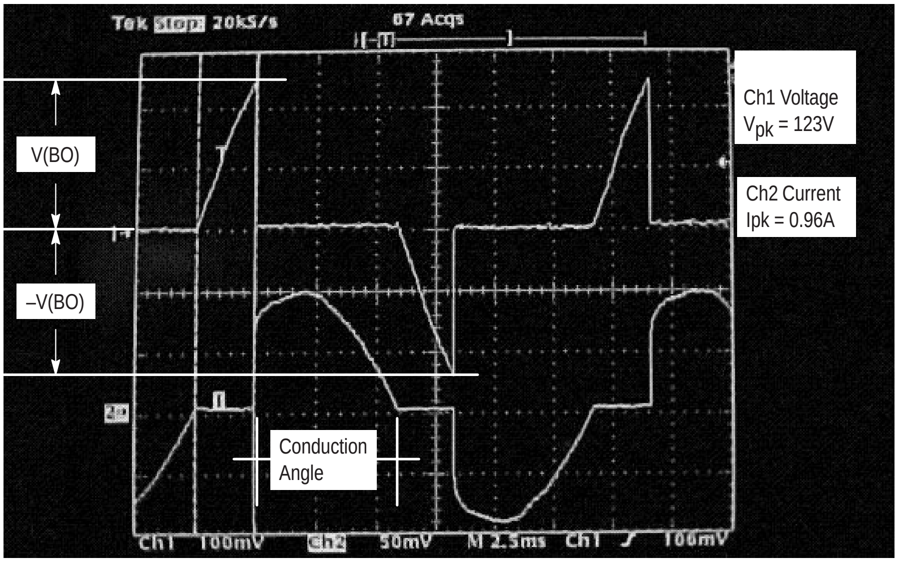


This is done in order to lower the RMS voltage to the filament, and prolong the life of the bulb. This is particularly useful when lamps are used in hard to reach locations such as outdoor lighting in signs where replacement costs are high. Bulb life span can be extended by 1.5 to 5 times depending on the type of lamp, the amount of power reduction to the filament, and the number of times the lamp is switched on from a cold filament condition.

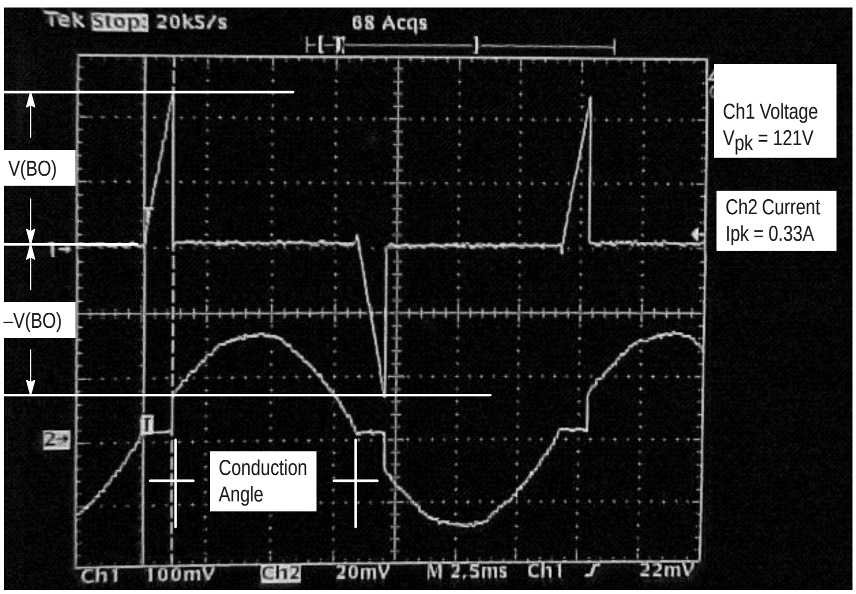
The operating cost of the lamp is also reduced because of the lower power to the lamp; however, a higher wattage bulb is required for the same lumen output. The maximum possible energy reduction is 50% if the lamp wattage is not increased. The minimum conduction angle is 90° because the SIDAC must switch on before the peak of the line voltage. Line regulation and breakover voltage tolerances will require that a conduction angle longer than 90° be used, in order to prevent lamp turn–off under low line voltage conditions. Consequently, practical conduction angles will run between 110° and 130° with corresponding power reductions of 10% to 30%.

The following plots show the basic voltage and current waveforms in the SIDAC and load:

Incandescent Lamp of 100W, 110V, 60Hz



Incandescent Lamp of 50W, 220V, 60Hz



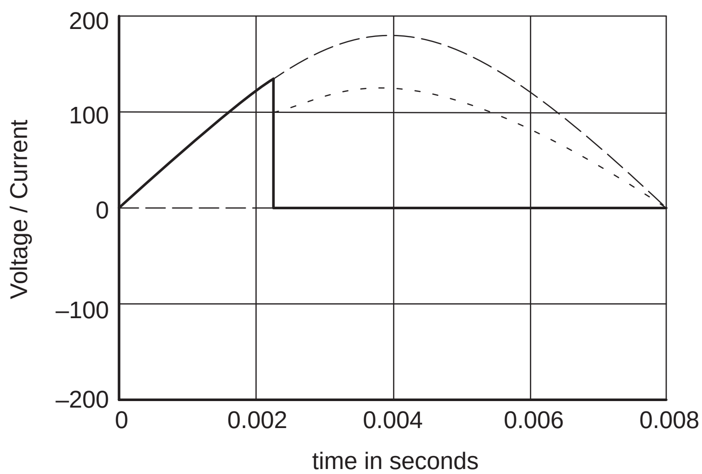
In both previous cases, once the ac line voltage reaches the V(BO) of the SIDAC (MKP1V120RL), it allows current flow to the incandescent lamp causing the turn–on of this at some specific phase–angle which is determined by the SIDAC because of its V(BO).

The fast turn–on time of the SIDAC will result in the generation of RFI which may be noticeable on AM radios operated in the vicinity of the lamp. This can be prevented by the use of an RFI filter. A possible filter can be the following: connect an inductor (100μH) in series with the SIDAC and a capacitor (0.1μF) in parallel with the SIDAC and inductor. This filter causes a ring wave of current through the SIDAC at turn on time. The filter inductor must be selected for resonance at a frequency above the upper frequency limit of human hearing and as low below the start of the AM broadcast band as possible for maximum harmonic attenuation. In addition, it is important that the filter inductor be non–saturating to prevent di/dt damage to the SIDAC.

The sizing of the SIDAC must take into account the RMS current of the lamp, thermal properties of the SIDAC, and the cold start surge current of the lamp which is often 10 to 20 times the steady state load current. When lamps burn out, at the end of their operating life, very high surge currents which could damage the SIDAC are possible because of arcing within the bulb. The large MKP3V device is recommended if the SIDAC is not to be replaced along with the bulb.

In order to establish what will be the average power that an incandescent lamp is going to offer if a SIDAC (MKP1V120RL) is connected in series within the circuit, some ideal calculations could be made for these purposes

Example: Incandescent lamp of 100W (120V, 60Hz).



v(t): ———————

i(t) x 100: - - - - - - - - - - -

V_L(t): — — — — — — —

v(t): Voltage waveform in the SIDAC

I(t): Portion of current waveform applied to the load (Multiplied by a factor of 100 to make it more graphically visible)

V_L(t): Voltage waveform in the Load

In this case, the conduction angle is around 130° (6 msecs) in each half cycle of the sinusoidal current waveform, therefore, the average power of the lamp can be obtained by calculating the following operations:

$$i_{eff} = \sqrt{\frac{2}{T} \times \int_{0}^{8.33 \times 10^{-3}} i(t)^2 dt}$$

$$v_{eff} = \sqrt{\frac{2}{T} \times \int_{0}^{8.33 \times 10^{-3}} v(t)^2 dt}$$

$P_{av} = i_{eff} V_{Leff}$

$P_{av} = 91.357$

Based on this, it is possible to observe that the average power output is a little bit lower than the original power of the lamp (100W), even though the conduction angle is being reduced because of the SIDAC.

In conclusion, when a SIDAC is used to phase control an incandescent lamp, the operation life of the bulb is going to be extended by 1.5 to 5 times which represents a big economical advantage when compared to the total cost of the lamp if it is changed. In addition, the original power of the lamp is not going to be reduced considerably which assures the proper level of illumination for the area in which the incandescent lamp is being used for. Finally, since the SIDACs are provided in a very small axial lead package, they can be mounted within the same place that the incandescent lamp is placed.

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