Technical Note: 2

Designing FLASH LAMP TRIGGER CIRCUITS
For Flash-pumped Pulsed Solid State Lasers

Flash lamp solid state lasers such as Neodymium-YAG and Neodymium-Glass lasers are operated either simmer or non-simmer modes of operation. The *simmer module* maintains a relatively low-amplitude keep-alive current through the flash lamp at all times irrespective of whether the lamp is flashing or not. The current varies typically from a few tens of milli-amperes to several hundreds of milli-amperes depending upon the characteristics of the flash lamp. This mode of operation called the *simmer mode* has many advantages. It allows one to use a low-voltage (TTL, CMOS, etc) trigger pulse to transfer the energy stored in the capacitor to the flash lamp. It significantly enhances the flash lamp life, offers tremendous improvement on the pulse-to-pulse jitter, and overcomes most of the electromagnetic interference problems present in non-simmer mode of operation. In the non-simmer mode of operation of the flash lamp, the triggering of the flash lamp is done by applying high voltage trigger pulses with amplitude of the order of 10 kV to 15 kV. In this technical note, we shall discuss some common circuit schematics used for triggering of pulsed flash lamps operated in non-simmer mode of operation.

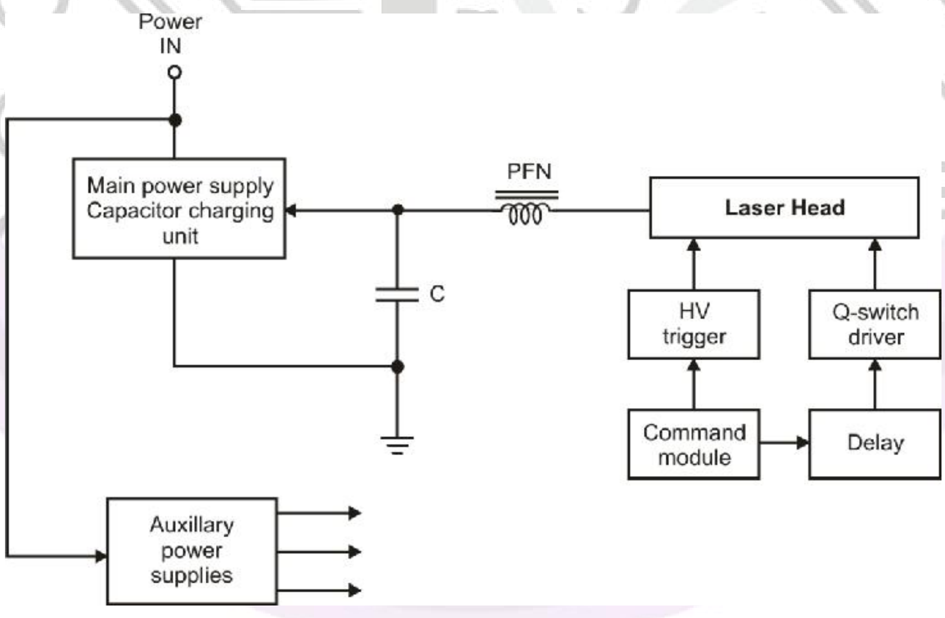

Figure 2.1
Generalized circuit schematic of electronics system of a Q-switched solid state laser operated in non-simmer mode

In the case of non-simmer mode operation, the energy storage capacitor is connected across the lamp and there is no isolation between the capacitor and the flash lamp as shown in the generalized schematic of **Figure 2.1**. The capacitor is made to discharge through the flash lamp by application of a high-voltage pulse of the order of 10 to 20 kV. In the case of simmer mode operation, the energy storage capacitor is kept isolated from the lamp by a series connected high voltage switch such as an SCR or a triggered spark gap. In this case, the trigger pulse is applied to this switch to turn it on thus allowing the energy storage capacitor to discharge through the flash lamp. The trigger pulse is a low voltage pulse in the case of an SCR and a high voltage pulse in the case of triggered spark gap. In the case of simmer mode operation, a high voltage trigger circuit is also needed for initiating a state of partial ionization for the simmer supply to take over. There are four types of high voltage trigger circuits that can possibly be used for the purpose with each having its merits and demerits. These include the following.

1. Over voltage triggering
2. External triggering
3. Series triggering
4. Parallel triggering

Over Voltage Triggering

In the case of *over voltage trigger circuit* (Figure 2.2), the DC voltage across the energy storage capacitor is sufficient to break down the gas inside the flash lamp and initiate the main discharge. The DC voltage appears across the flash lamp once the series-connected high voltage switch is turned on. The switch may be an SCR or a MOSFET or a triggered spark gap. Though the trigger circuit is simple, it is not common with solid state lasers.

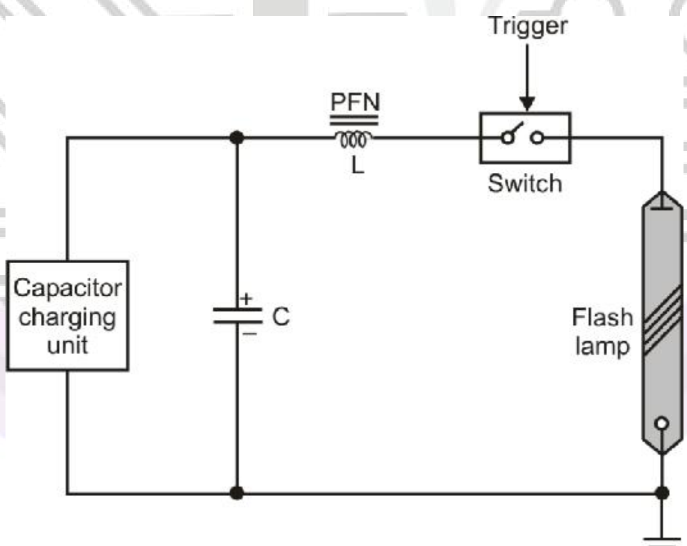

Figure 2.2
Over voltage triggering of flash lamp

External Triggering

In the case of *external triggering circuit* as shown in **Figure 2.3**, the high voltage trigger pulse is applied to a trigger wire wrapped around the outside envelope of the flash lamp. In the case of liquid cooled applications, the trigger pulse may be applied to the metal laser cavity. However, proper precautions should be taken in this case because of the high voltages involved. The main advantage of the external trigger is that it does not interfere with the main energy discharge circuit. The disadvantage is that high voltage trigger point is exposed and therefore needs to be properly isolated from the environment lest it causes problems in high altitude or humid conditions. External triggering is recommended for low repetition rate, low energy systems where the flash lamp is air cooled.

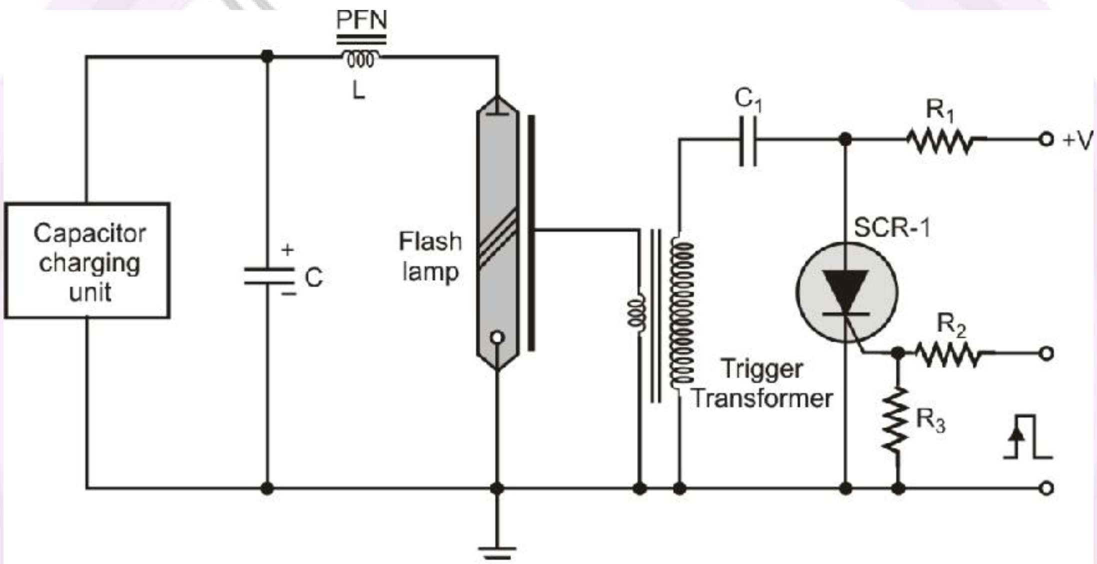

Figure 2.3
External triggering of flash lamp

Series Triggering

In the case of *series triggering circuit* (**Figure 2.4**), the secondary winding of the trigger transformer is in series with the energy storage capacitor. The secondary winding carries the flash lamp discharge current. The series trigger transformer is so designed that the transformer core saturates and the saturated secondary winding inductance serves the purpose of the PFN inductor also. Series triggering offers the advantages of reliable and reproducible triggering. Triggering is reliable even for low energy storage capacitor voltages. Reliability of triggering is enhanced by using a ground plane near the lamp. In the case of air cooled lamps, it may be done by wrapping a wire around the lamp and connecting one of the ends to the ground terminal. In the case of liquid cooled lamps, metal laser cavity may be used as the ground plane.

The disadvantages include large trigger transformer required to get the desired saturated secondary inductance. Also, the secondary winding uses a thicker wire so as to be able to carry high value of discharge current.

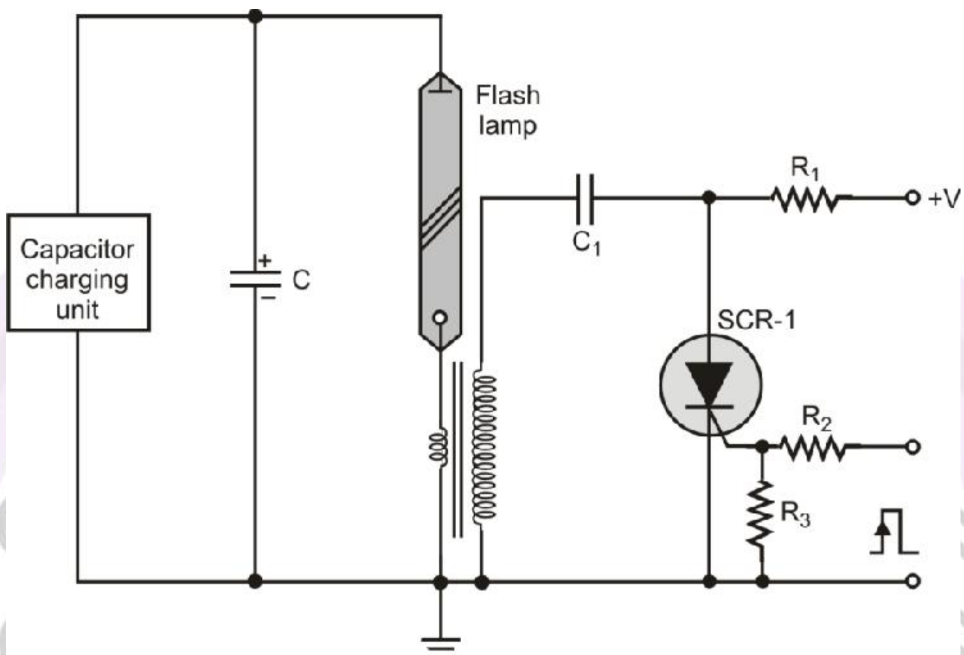

Figure 2.4
Series triggering of flash lamp

Parallel Triggering

In the case of *parallel triggering circuit* (**Figure 2.5**), the secondary of the trigger transformer is connected in parallel. The circuit has all the advantages of series triggering and in addition uses a small trigger transformer. In this case, however, the secondary of the transformer needs to be isolated from the energy storage capacitor by using a capacitor or a diode This method is rarely used due to prohibitively high cost of protection components.

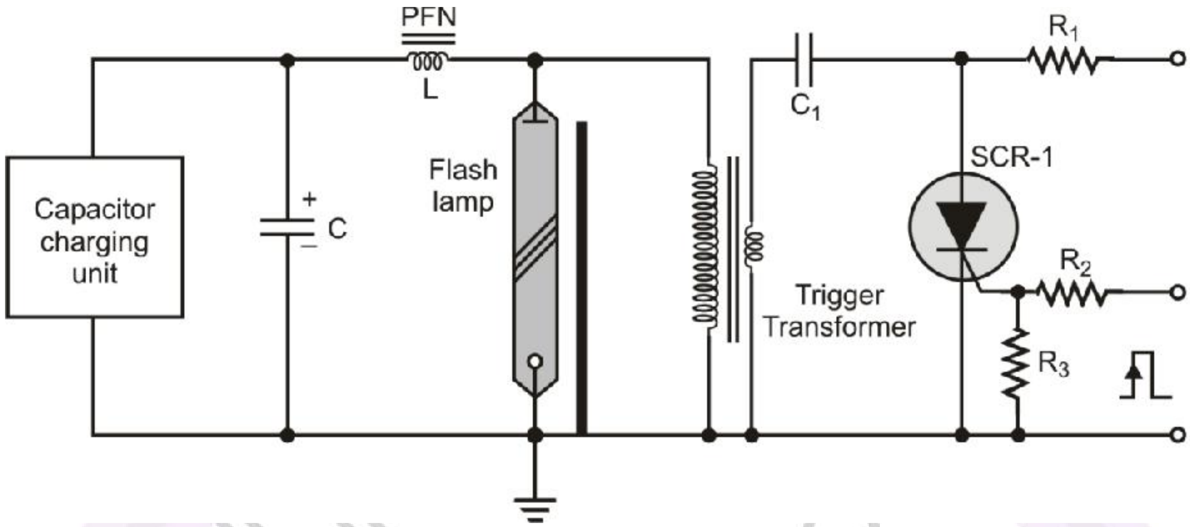

Figure 2.5
Parallel triggering of flash lamp

Design Tips

In different triggering circuits discussed in the preceding paragraphs, with the exception of over voltage triggering, the trigger pulse is generated by discharging a capacitor into the primary winding of a trigger transformer using an SCR as a switch. The trigger voltage amplitude appearing across the secondary of the trigger transformer is in the range of 10 kV to 20 kV. Trigger pulse energy of the order of 100 mJ and trigger capacitor in the range of 0.1 μF to 1.0 μF charged to a voltage in the range of 300 V to 800 V serves the purpose. The trigger pulse duration is typically few micro seconds. Trigger pulse duration of a minimum of 60 ns/cm of arc length of flash lamp is recommended. The anode to cathode breakdown voltage of the SCR is typically twice the voltage to which the capacitor connected in the primary winding of the trigger transformer is connected. Also the charging resistance connected in series with anode of SCR should be such that the current (V/R) is less than the holding current of the SCR. A large variety of trigger transformers is available off the shelf to suit the circuit design requirement in terms of input and output peak voltages, turns ratio etc.