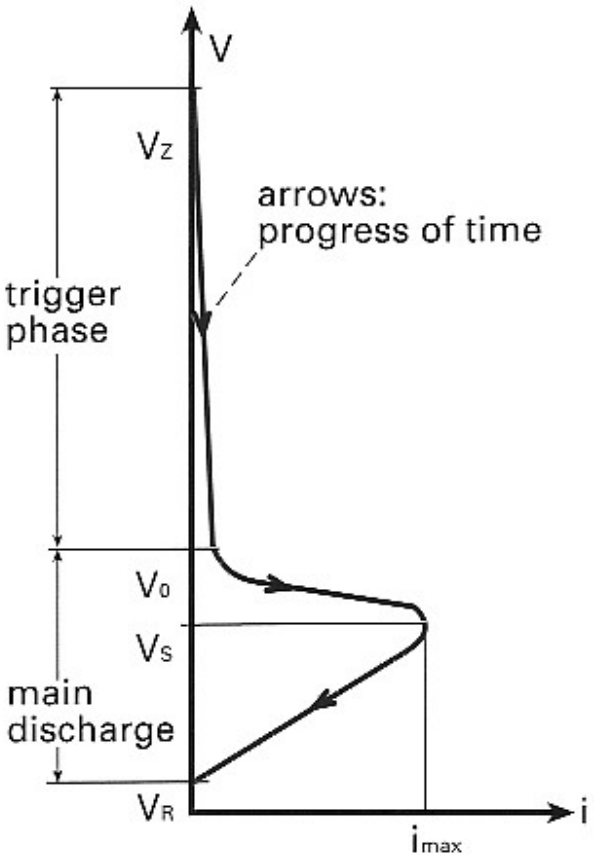
Application Notes – Discharge Circuits

Discharge Sequence

Flashtubes are connected with two different circuits:

1. The trigger circuits: operated in the trigger phase.
2. The main discharge circuits: operated in the main discharge phase.



The impedance characteristic (anode voltage V versus discharge current i) features the same form for all flash discharges. Its slope represents the characteristic of the discharge (increasing/decreasing).

First the trigger voltage Vz (2-20kV) causes ionization in the tube. This ionization alone is not sufficient for discharge. That is why the operating voltage V_0 of the main discharge circuit must be reached before the triggering can be performed (decreasing characteristic). This requires energy (1-100mJ) and time (trigger delay 1-10μs).

The main discharge can be subdivided into the current rise (1-10μs, slightly falling characteristic) and the current decay (up to 10μs, increasing characteristic).

During the decay phase under normal conditions most of the light output is generated. The following internal impedance R_i of the tube can be defined:

$$R_i = \frac{V_s}{i_{max}} \text{ (0.1 to 5 Ohms)}$$

Finally, the discharge extinguishes at a residual voltage of V_R (10 to 80V).

Main Discharge Circuits

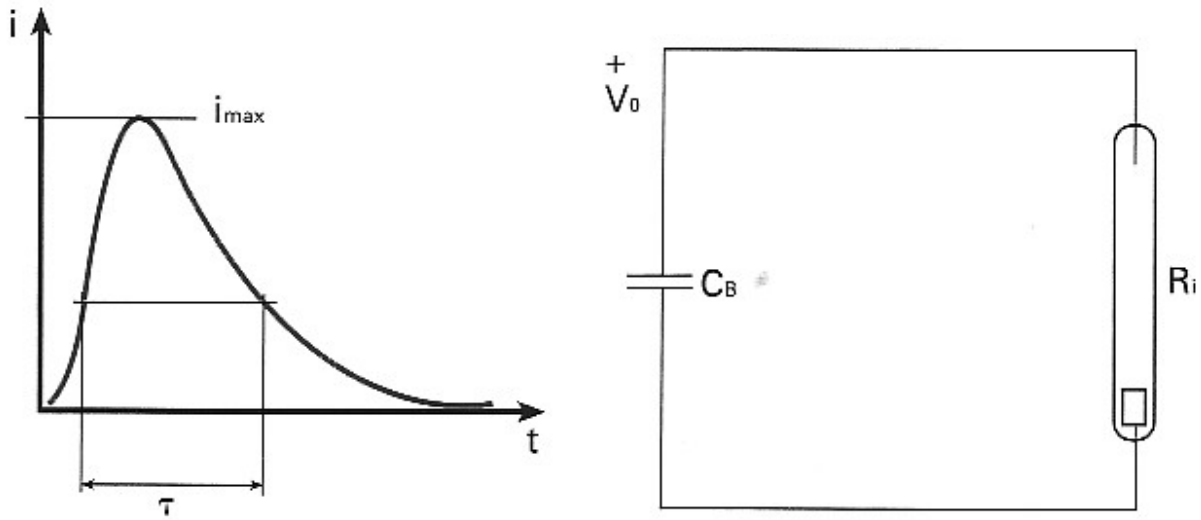
1. Free Capacitor Discharge

The energy E stored in a flash capacitor C_B (voltage V_0) is defined as

$$\text{flash energy } E = \frac{1}{2} C_B V_0^2$$

E [Ws]
V_0 [V]
C_B [F]

neglecting a low percentage of residual energy in C_B.



Free capacitor discharge

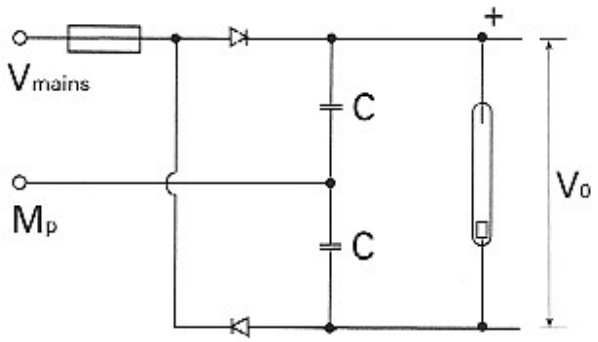
After peak current i_{max} has been reached, am almost exponential discharge of CB takes place, since the internal resistance R_i of the tube remains constant. The time constant $T=R_iC_B$ is a measure for the flash duration (~1/3 value). V_0 ranges often between 200-400V. This is due to the electric strength of the electrolytic photoflash capacitors.

In stroboscopic applications, the tube's medium power load P results from the energy E of the individual pulse and the repetition rate f:

$$P = E \times f$$

P [W]
E [Ws]
f [Hz]

2. Voltage Doubler



Voltage doubler

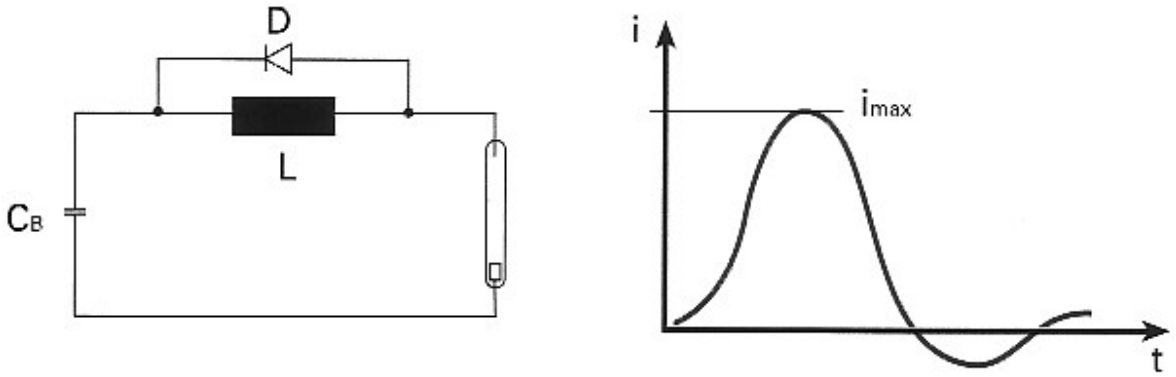
A variation of the free capacitor discharge is the voltage doubler, which is often directly connected to the a.c. mains

with $V_0 = 2\sqrt{2}\,V_{mains}$

flash energy $E = 2\,C\,V^2_{mains}$

3. Pulse forming network

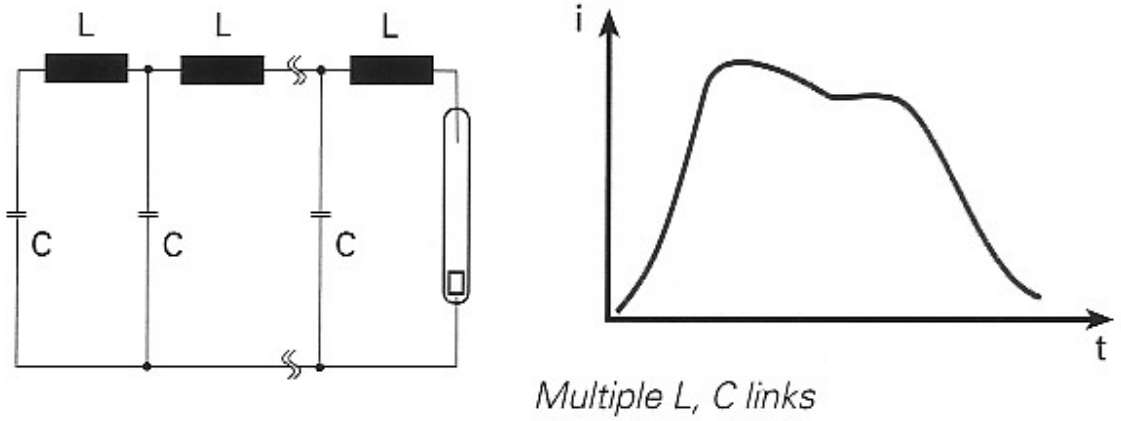
The circuit illustrated below shows the simplest network. L, C_B forms a resonant circuit, which is damped by the tube.



Single LC link

The reversal of current can be suppressed by a diode D. In comparison to the free capacitor discharge, the current rise and peak current i_{max} are reduced.

By using multiple LC links, an almost rectangular discharge pulse can be obtained.

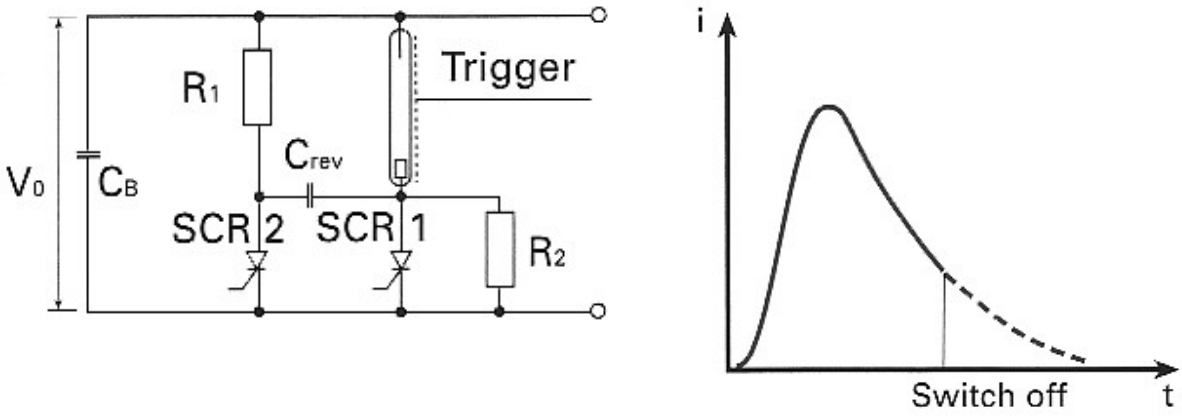


Multiple L, C links

Discharge control by semiconductor

1. Double Thyristor (SCR)

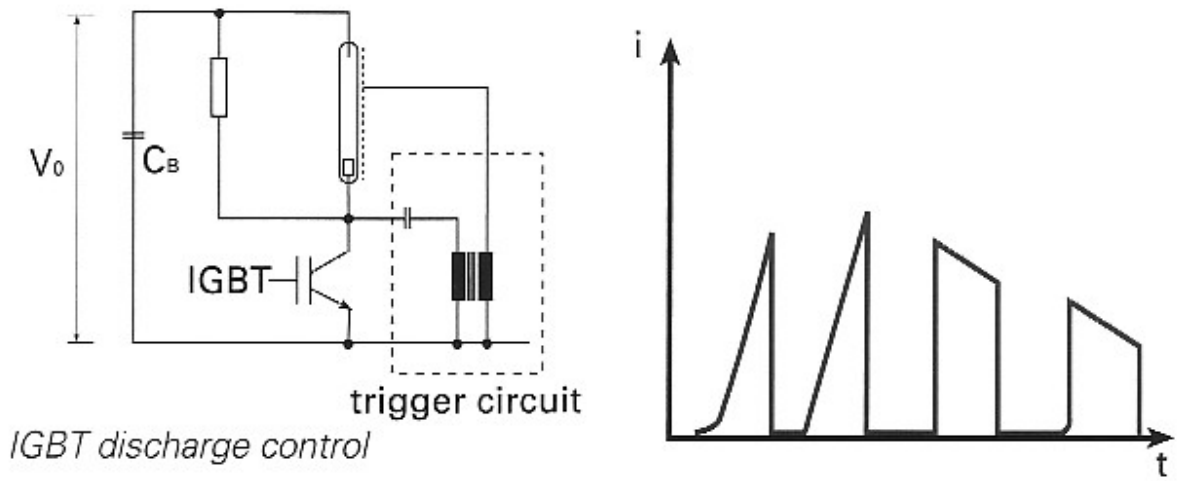
The typical circuit for on/off switching a flashtube works with a pair of SCRs.



Double thyristor discharge control

Switching on is done by synchronizing the lamp trigger and the gate of SCR1. For switching off, SCR2 is fired, discharging C_{rev} and reversing SCR1. This circuit is sensitive for the values of R_1, R_2, C_{rev} and the retaining current of the SCRs. The repetition rate is limited by recharging C_{rev}.

2. Power Mos-Fet or IGBT



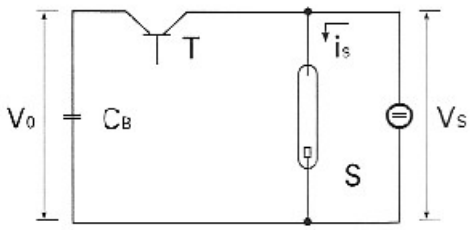
IGBT discharge control

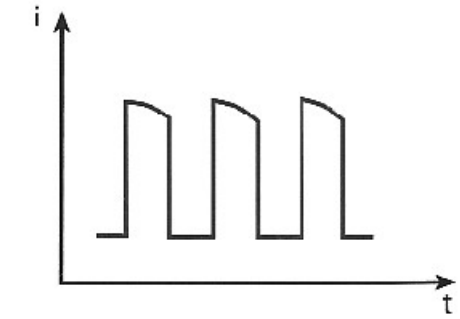
The IGBT offers high peak current, high frequency switching with very low loss and simple driving circuit. This concept is ideal for discharge control of flashtubes. The IGBT also operates the tube's trigger circuit. All pulse patterns,

preflash and manipulation of the main flash are possible. PerkinElmer Optoelectronics has developed special “high-impedance” flashtubes for photographic application.

3. Simmer Operation

The constant current source S maintains a “simmer” current i_s in the tube. When the semiconductor T is operated, any pulse-discharge pattern can be superimposed to i_s. The simmer current should be as small as possible.





Simmer operation