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POWER SUPPLY FOR XENON FLASH-LAMP

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ABSTRACT: Xenon flash-lamp is a device that emit large amounts of spectral energy in short duration pulses. When an accumulated energy in a storage capacitor is released and dissipated, it forms highly excited xenon plasma within the flash-lamp. This article reports the development of a power supply of xenon flash-lamp which is used to pump optically a pulsed solid-state laser.
The developed pulsed-power supply comprises the three parts to supply the flash-tube. The first one is the external trigger circuit which allows the initial ionization of the gas into the lamp by providing a high voltage pulse (around 20 kV). The second one is the simmer circuit which maintains a partial steady-state ionization of the gas by establishing and maintaining a low-current dc arc between the lamp electrodes. The third one is the main discharge circuit formed by the charging unit used to charge the storage capacitor. The capacitor charging process must be completed within the inter-pulse time of the laser. The principal capacitor discharge through the flash is ensured by an electronic switch (thyristor). The capacitor, the inductor and the flash-lamp resistor constitute the circuit that provides the desired shape pulse during the discharge. The power supply was tested at the repetition frequency of 1Hz.

KEYWORDS: discharge tubes, Xenon flash-lamp, pulsed solid-state laser

1. Introduction

Pulsed Xenon flash-lamps are gas-discharge devices designed to produce a pulsed radiation. They convert an electrical energy to an optical radiation [1]. This intense pulse of radiant energy is used in many applications. In our case they are used for pumping solid-state lasers.
The linear xenon flash lamp used in our experiment, as shown in figure 1, is a flash-lamp model P537 (Flash-Heralus Noblelight ltd) with the following parameters: arc length L_A=6 cm, arc diameter d_A=4 mm, gas fill pressure P =450 Torr and a constant N dependent on a gas type (N=450 for xenon).

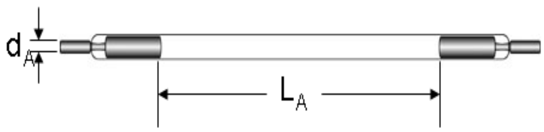


Figure 1: Linear flash-lamp

To supply the flash lamp there are several circuits and methods. For us we adopted the simmer mode circuit which has a number of advantages such as: increasing flash-lamp life time and increasing efficiency. In the next part a description of this power supply is given.

2. Simmer Mode Power Supply

Figure 2 represents the simmer mode power supply. This circuit comprises: the external trigger circuit, the simmer circuit, the main discharge circuit and the switching element (thyristor) allowing the discharge of the capacitor *C* through the flash lamp. At this moment the flash lamp produce an intense pulse of an optical radiation.

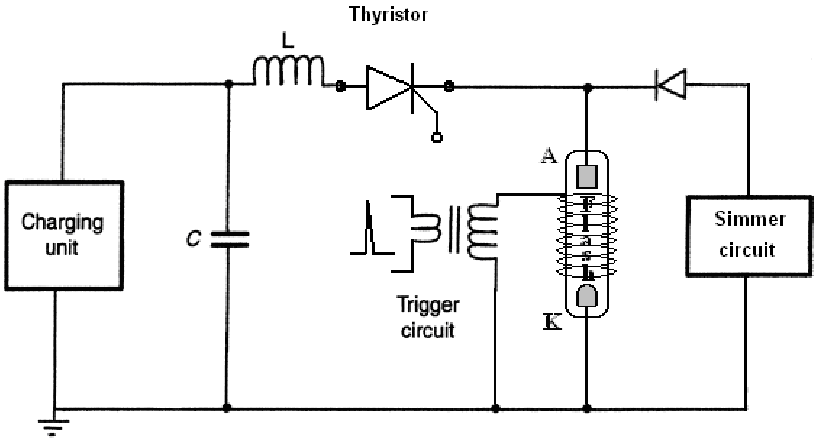
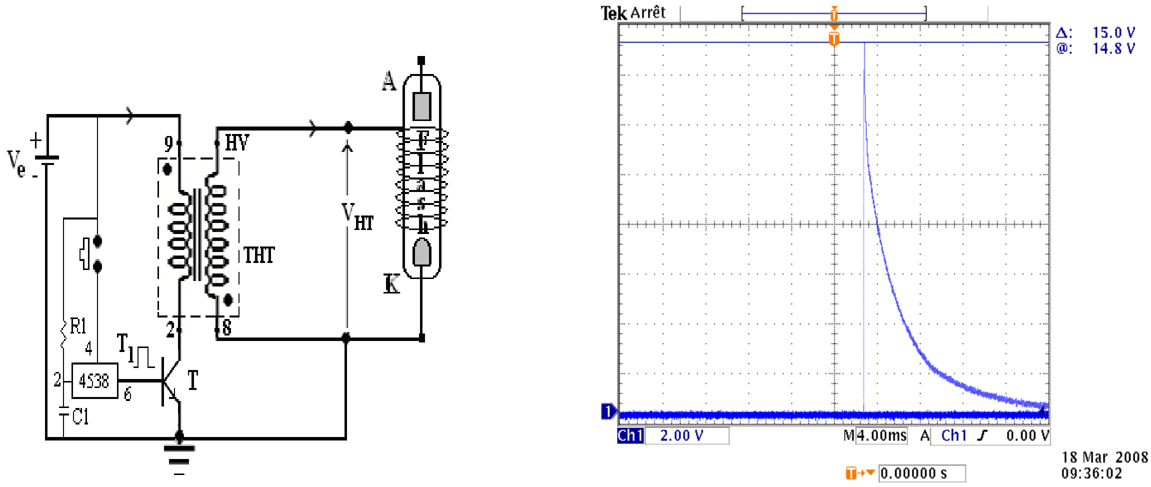


Figure 2: Principle diagram of the flash-lamp power supply

2.1. External Triggering

In external triggering, the high-voltage trigger signal is applied directly to a trigger wire outside the lamp envelope, as illustrated in figure 3-a. The developed trigger circuit consists on a switching power supply (fly-back) using a high voltage transformer [2]. The experimental shape of the output voltage (around 15kV) is given by Fig. 3-b.



(a) (b)

Figure 3: External triggering circuit (a)
and the triggering pulse (b) (trace vertical: 2kV/div)

2.2. Simmer Circuit

After the triggering, the flash lamp impedance varies in a nonlinear way where its measured value is given within 1 kΩ and 17 kΩ [3]. The developed simmer circuit will be able to follow the variation of the lamp impedance. The proposed simmer, as shown in figure 4, uses a voltage multiplier which is supplied by 200 V as an alternative voltage given by a switch mode power supply. This voltage multiplier delivers 1.2 kV and 100 mA when the flash-lamp is non-ignited. At the ionized state, these values vary in accordance with the flash lamp resistor load [3]. After the triggering, the simmer circuit maintains a partial steady-state ionization of the gas as shown in figures 5a and 5b.

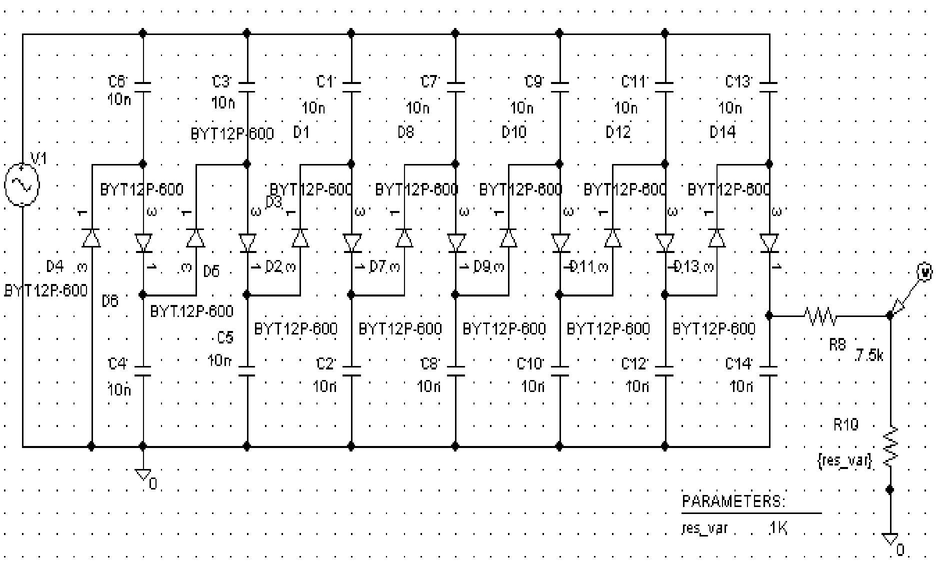


Figure 4: Simmer circuit

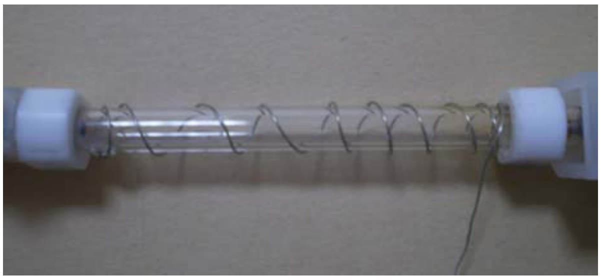


Figure 5a : Xenon flash-lump

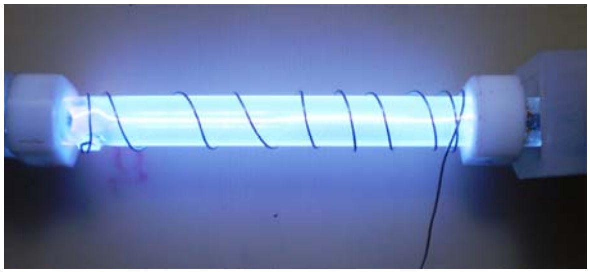


Figure 5b : Partial steady-state ionization of the xenon gas

2.3. Main Discharge Circuit

The main discharge circuit comprises the capacitor charging unit, the capacitor *C* and the inductance *L*. The charging unit is used to charge the storage capacitor *C* and where the charging process must be completed within the inter-pulse time of the laser. The main capacitor discharge through the flash is ensured by an electronic switch: thyristor as shown in figure 2. The capacitor *C*, the inductance *L* and the flash-lamp resistor R_f constitute the circuit that provides the desired shape pulse during the discharge. The operation of the laser and the flash-lamp characteristics allow to fixe the values of *C* and *L* [1]. These values are given by the following equations:

$$C = \left(\left(0.09 E_0 t_p^{\,2}\right) / K_0^{\,4}\right)^{1/3} \qquad (1)$$

Where k_0 is the lamp-impedance parameter given by:

$$k_0 = 1.28\left(L_A / d_A\right)\left(P / N\right)^{1/5} \qquad (2)$$

The value of the inductance *L* is given by:

$$L = t_p^{\,2} / 9C \qquad (3)$$

The capacitor *C* is charged to a voltage V_0 given by:

$$V_0 = \sqrt{2E_0 / C} \qquad (4)$$

The flash-lamp current is given by:

$$i(t) = (V_0 / L)t\,exp\left(-\frac{R_f}{2.L}t\right) \qquad (5)$$

And R_f is the flash-lamp resistor when C is discharged equal to:

$$R_f = \sqrt{L/C} \qquad (6)$$

The shape of the flash-lamp current according to the equation 5 is given by the figure 6.

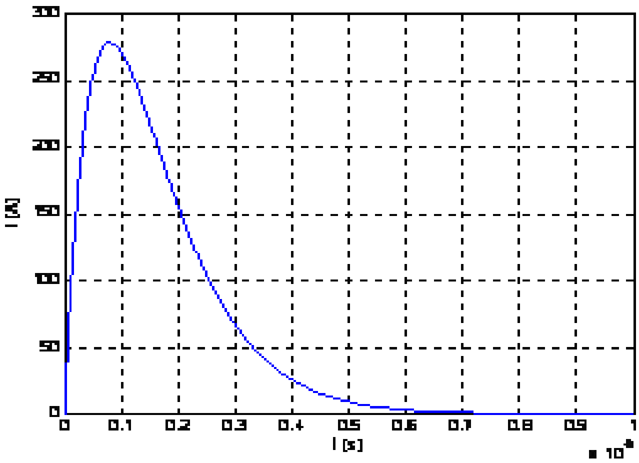


Figure 6: Waveform for a flash-lamp current pulse (trace vertical: 50A/div, trace horizontal: 200µs/div)

The electrical energy E_0=20 joules and the flash-lamp current pulse length is t_p = 240µs. We obtain: C=91.72µF, L=69.7mH and V_0= 660V.
The developed charging unit is a fly-back power supply designed and developed for a repetition frequency of 10 Hz [4].

3. Experimental Results

For the experimental tests: C=110 µF and L=70 µH. Figure 7 depicts the charging and discharging process of C for a repetition frequency approximately equal to 1Hz. Figure 8 depicts the flash-lamp current pulse during the main discharge of C.

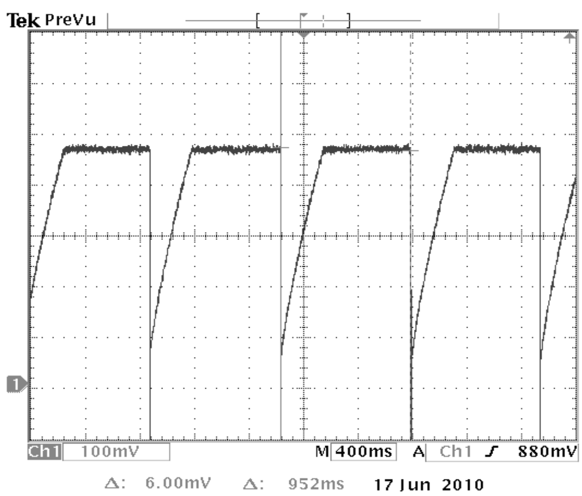


Figure 7: Waveform of the charging and discharging process of *C* (trace vertical: 100V/div, trace horizontal: 400ms/div)

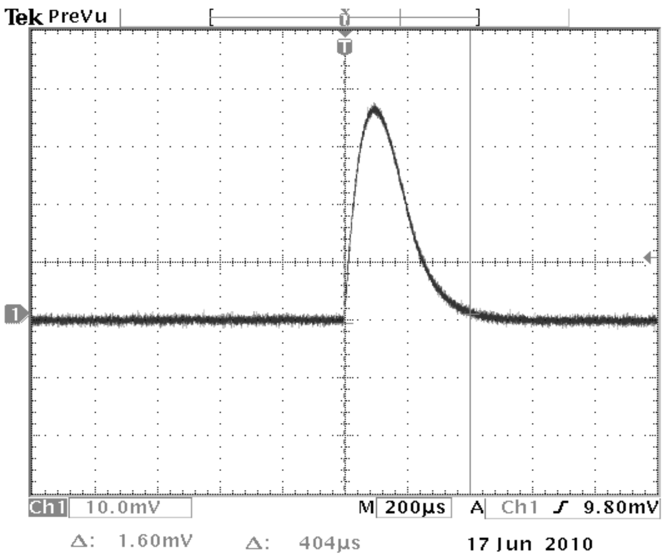


Figure 8: Waveform of the flash-lamp current pulse (trace vertical: 50A/div, trace horizontal: 200µs/div)

4. Conclusion

This work enabled us to develop a power supply for xenon flash-lamp which presents some advantages as compactness and weight. The different parts of this power supply have been developed using the switch mode power supply concept. The power-supply was tested with the flash-lamp model P537 (Flash-Heralus Noblelight ltd) and we obtained good results et a repetition frequency of 1Hz.

References

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