

Development of an optical pumping driver using series injection method

Noriah Bidin, Johari Adnan, Asmawati@Fatin Najihah Alias and Ahmad Hadi Ali
 Physics Department, Faculty of Science, Universiti Teknologi Malaysia, Skudai 81310, Johor

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In this paper development and the performance of programmable flashlamp driver is reported. Programmability is provided by a microcontroller. The flashlamp driver uses series injection triggering circuit. The current setup allows the flashlamp to operate in a single mode. The result obtained shows that the current through the flashlamp during discharge time was 890 A with a source voltage of 2.75 kV. In this particular case the peak power produced was 2.44 MW with pulsewidth of 316 μ s.

I. INTRODUCTION

Flashlamp excitation is an attractive method to initiate laser material for lasing [1]. The flashlamp-pumped solid-state laser is now by far the most common pulsed laser system in the world with neodymium ions either in crystal or in glass as the preferred lasing medium [2]. There are many ways to trigger flashlamp. Back in 1966 [3] a single mesh circuit had been designed for driving xenon flashlamp. Pettifer *et al.* [4] have triggered flashlamp by using 60 kV supply. On the other hand Kim *et al.* [5] have designed a driver using a zero-current switching converter. They claimed that their technique could reduce switching loss and noises. In other case, a cheap and simple power supply using low frequency capacitor was reported by Hong *et al.* [6]. They used sequential charge and discharge circuit method to trigger the flashlamp. A simple and compact power supply using zero crossing control was designed by Kim *et al.* [7]. Hong *et al.*, [8] have used real-time one-chip microcomputer to drive flashlamp. They can create diverse pulse shape and strength using this technique. Similar to this technique was also reported by McCarthy *et al.* [9]. They used microprocessor to control laser pulse width and an IGBT device to switch the power supply. Recently a high-speed semiconductor

switch was employed to drive the flashlamp [10]. Inline with the controlling technique, we are also involved in designing a programmable flashlamp driver. This driver was developed based on series injection method. A microcontroller PIC16F84A, was employed to trigger the driver.

II. METHODOLOGY

The major components employed in the power supply are comprised of a u-shape xenon flashlamp, a high voltage dc charging supply and trigger circuit for the flashlamp. Fig. 1 shows a block diagram of the power supply for operation of the flashlamp. The high voltage dc charging power supply is used to charge an energy storage capacitor.

In general, arc lamps require trigger pulse to cause the initial ionization of the gas in the flashlamp. In this development series injection triggering was chosen. It triggers at low capacitor-charging voltage. The most important this method is safe and reliable.

In the series injection triggering, the secondary winding of a trigger transformer is in series with the energy-storage capacitor and the flashlamp. A pulse is generated in the primary winding of the transformer.

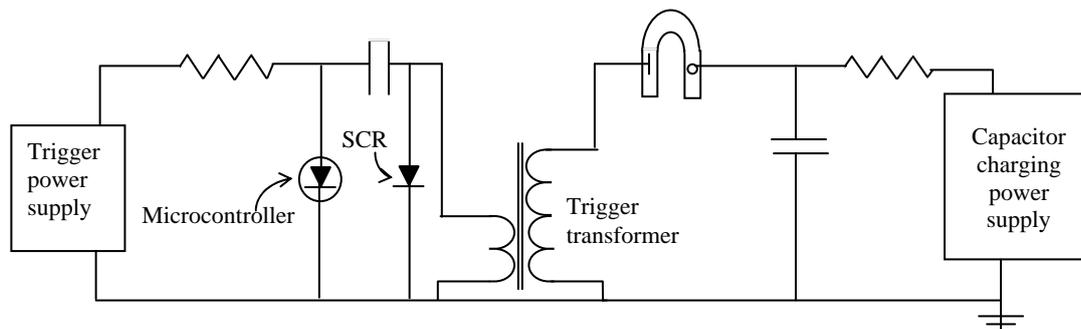


FIG. 1. Series injection trigger circuit.

A pulse generator is required to switch the flashlamp driver. The generator consists of PIC16F84A microcontroller, which is powered with +5 V power supply. This microcontroller allows program to be loaded and erased with ease. It can be programmed, tested in circuit and reprogrammed if necessary in a matter of a few minutes without the need of ultraviolet eraser.

A resistor of 0.1 Ω was placed in series with the flashlamp to measure indirectly the potential different across the flashlamp. Tektronix P6015 high voltage probe was coupled to a Tektronic 3034B digital oscilloscope to measure the voltage drop across the flash lamp. A Rogowski coil was employed to trace the current waveform. A IPL10050 photodiode was used to detect the signal of the flashlamp. An Ophir BeamStar CCD camera profiler was employed to visualize and recording the flashlamp light.

III. RESULT AND DISCUSSION

The performance of the developed flashlamp driver was described based on the pulse measurement as well as the recording images. The typical signal obtained to open the SCR gate is shown in Fig. 2. Channel 1 indicates the signal of TTL output pulse from the microcontroller. The signal at the SCR gate is indicated by channel 2. The pulsewidth of the signals is found to be 1 μs with an amplitude of +5 V. This is the minimum pulsewidth that can be generated from this microcontroller.

SCR acted as a switching element. A small gate current can control a much larger voltage or current in the circuit. In this particular experiment, the anode terminal of SCR was connected to +650 V. Current is inhibited until the gate of SCR was triggered. The typical voltage waveform obtained at the series injection transformer is shown in Fig. 3.

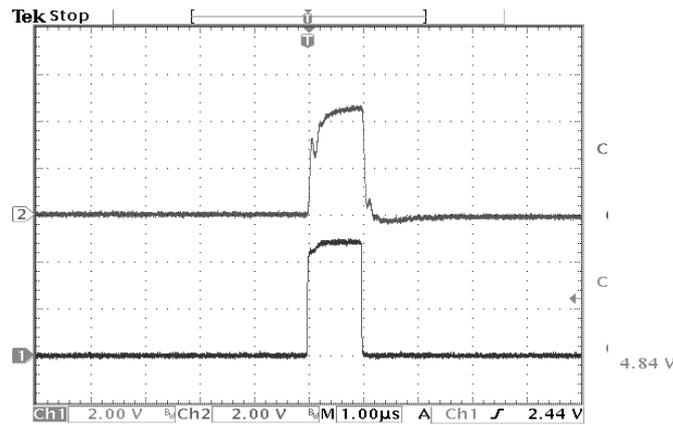


FIG. 2. A TTL pulse output from PIC16F84A and SCR gate turn-on signal.

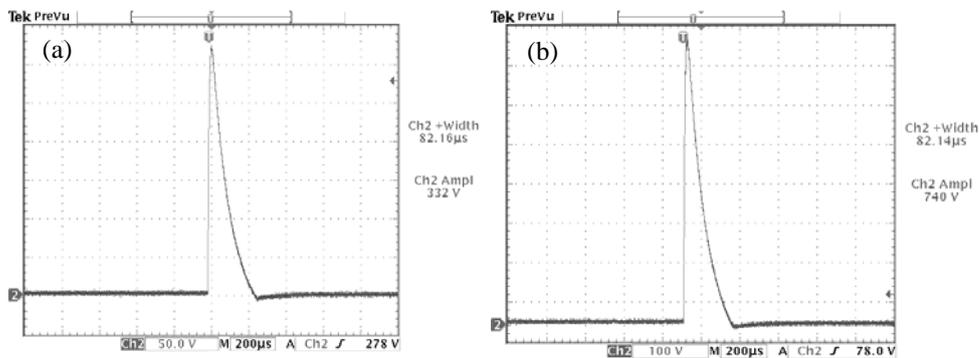


FIG. 3. Voltage waveform during SCR switching on (a) Voltage waveform at primary winding of the transformer, (b) Voltage waveform at secondary winding of the transformer.

After being triggered by the control unit, SCR allows current to pass through, producing a voltage of +332 V at primary of series injection transformer as depicted in Fig. 3(a). The secondary winding steps up the voltage of 740 V as illustrated in Fig. 3(b). No current will flow unless triggering pulse is press the SCR gate. A forced turned off method was employed to switch off the SCR. This is performed by introducing a tank circuit which generates a reverse voltage to switch off the SCR.

The SCR is protected by a free wheeling diode connected parallel to the secondary of the series injection transformer. This diode is designed to withstand high voltage of 2 kV. The voltage is not enough to initiate gas breakdown in the flashlamp. When this voltage is mixed with trigger voltage of 740 V, gas breakdown occurs. This electrical short circuit draws large amount of current. A large percentage of the gases

become ionized. Electrons are accelerated and increased the excitation through collisions. De-excitation of these ionized gas results in the fluorescence.

The typical signal obtained for the measurement of voltage and current waveform are shown in Figs. 4(a) and (b) respectively. The voltage obtained was 89.01 V, and the corresponding peak current was 890.1 A. The flashlamp beam was detected and the oscillogram of the signal obtained is shown in Fig. 4(c). The means pulswidth of the flashlight signal was 316 μ s.

The typical beam profile of the flashlamp is shown in Fig. 5. The 3D profile is depicted in Fig. 5(a). The flashlamp beam is distributed in the Gaussian form. The two-dimensional topographic map of the flashlamp beam is shown in Fig. 5(b). The beam is spreading since it is a conventional light with hottest region in the center as indicated by the darker image density.

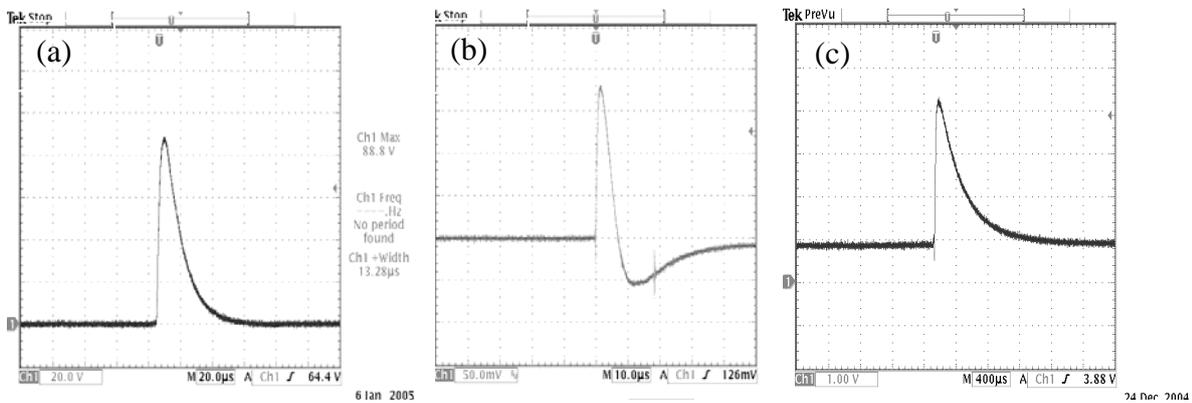


FIG. 4. (a) Voltage waveform of flashlamp, (b) Current waveform of flashlamp (c) Signal of xenon flashlamp detected by photodiode.

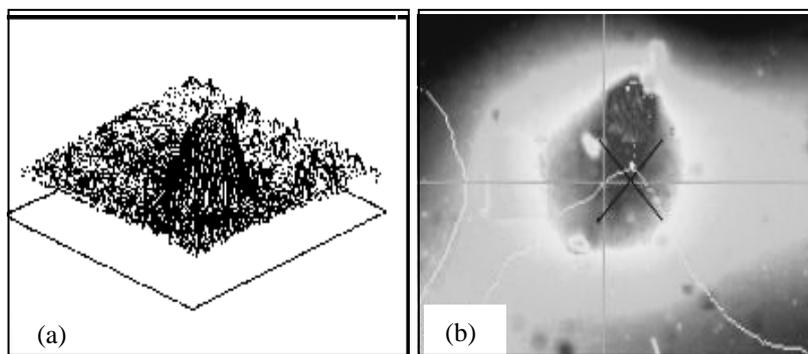


FIG. 5. Arc intensity profile of the flashlamp (a) Gaussian profile of xenon flashlamp in 3D, (b) The topographic map of the flashlamp.

IV. CONCLUSION

A programmable driver for flashlamp was successfully developed. A series injection method was used to trigger the driver. A SCR was used as switch that was controlled by a microcontroller. When the SCR was triggered, 2.74 kV was required to cause gas breakdown consequently result in the light emission of the flashlamp. The pulsewidth of the flashlamp signal obtained was 316 μ s.

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