

DEVELOPMENT A SERIES IGNITION CIRCUIT FOR SIMMER OPERATION OF FLASHLAMP DRIVER

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ABSTRACT

This present paper describes the development of a series ignition circuit for flashlamp driver. A high voltage ignition pulse produced in series with DC simmer power supply. The ignition is based on a single stage of step-up circuit. A small step up transformer was employed together with SCR thyristor as a switch to generate high voltage pulse. In this development, ignition circuit was successfully demonstrated the production of giant pulse of 12 kV with duration of less than 1 μ s by injecting only 180 V dc. The pulse is enough to ignite and sustains flashlamp in simmer operation.

Keywords: Nd:YAG laser, optical pumping, flashlamp, ignition

INTRODUCTION

Flashlamp is pulsed optical pumping source used with pulsed solid-state laser. This lamp is an electric glow discharge lamp designs to produce extremely intense, incoherent, full-spectrum white light for very short duration [1]. There are several techniques can be used for flashlamp triggering method. The two most common methods for triggering flashlamp are external trigger and series injection [2]. Other method usually use in a flashlamp is simmer mode operation. By using this method, the efficiency and reproducibility of flashlamp as an optical pumping could be increased [3].

In simmer mode operation, the flashlamp must be triggered with a high voltage pulse to ignite a gas breakdown inside the flashlamp. The high voltage pulse required to ignite the flashlamp depends on the length of the flashlamp and sometimes it could reach up to 30 kV [4]. After the flashlamp is being ignited, a simmer current will flow through the flashlamp between anode and cathode. A low DC current is maintained through the lamp, typically in the range of milliamps to several amperes [5].

The high voltage requires to ignite the flashlamp could be generated by using a step-up transformer. This transformer can be connected either in series or parallel connection with simmer power supply as shown in Fig. 1. Fig 1(a) shows, the series connection of step up transformer. The step-up transformer is connected in series between simmer power supply and the flashlamp. With this arrangement, simmer current will flow through the secondary winding continuously during flashlamp operation and could also increase the efficiency of optical radiation.

However, for parallel connection (Fig. 1(b)), the simmer current is not allowed to flow into the secondary winding. Therefore, a high voltage blocking diode is required to prevent the simmer power from the high voltage of ignition pulse. This diode will cause a high forward voltage drop in simmer power supply [6, 7].

In this present paper, the development of a series ignition circuit for simmer mode flashlamp driver is reported. The ignition circuit comprise of 180 VDC power supply, SCR thyristor switch, and small step-up transformer. This ignition circuit also connects in series with DC simmer power supply and linear xenon flashlamp.

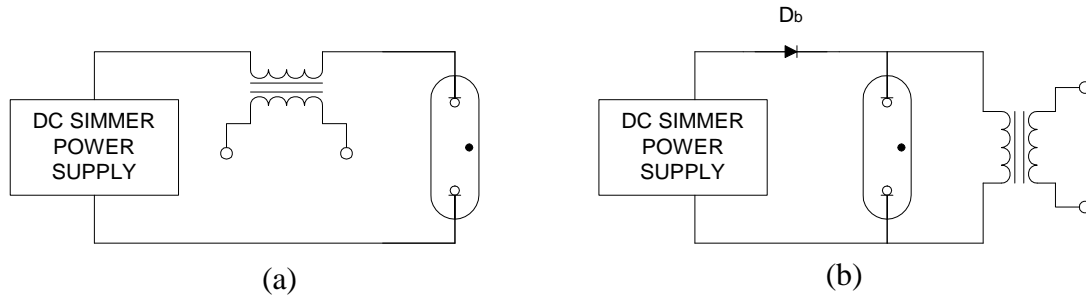


Figure 1: (a) Series connection. (b) Parallel connection.

CIRCUIT DEVELOPMENT

Figure 2 shows a simplified schematic diagram of ignition circuit. A DC simmer power supply is connected to a flashlamp through secondary winding of step-up transformer. The ignition circuit is supplied with 180 VDC and controlled by a SCR thyristor.

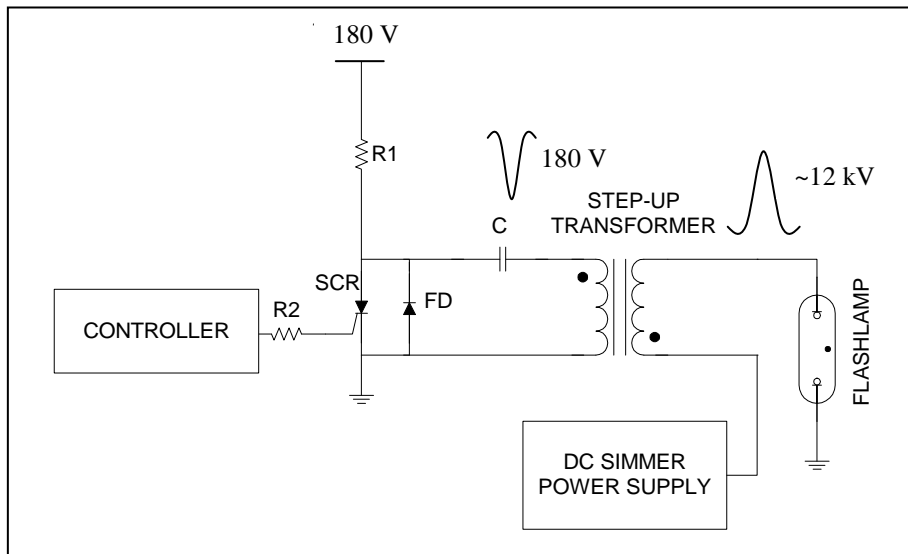


Figure 2: Series ignition circuit for simmer operation.

Basically the ignition circuit consists of pull-up resistor, R1, small filter capacitor, C, SCR thyristor as a switch, and a step-up transformer. Additional components are also provided such as free-wheeling diode to protect the SCR and current limiting resistor, R2 at SCR gate terminal. The step-up transformer winding is connected in mutual polarity. This transformer was built using a ferrite core to ensure the high efficiency between the input and the output at a very high frequency pulses. The winding ratio between primary and secondary is 3 to 200 turns which is capable to amplify the voltage up to 66 times.

The ignition circuit has a simple operation in order to generate a high voltage pulse. After connected to dc supply, a capacitor, C inside the circuit will be charged as it acts as a filter capacitor. Meanwhile, the SCR is in open circuit condition as long as there is no signal from controller. When a 5 volt pulse produced by a controller given to SCR, the capacitor will discharge through SCR and produce negative pulse at primary winding. Hence, the negative voltage pulse at the primary winding will be amplified approximately

66 times by secondary winding. Then the high voltage pulse generated at secondary winding will be used to ignite the flashlamp consequently breakdown the xenon gas. After the breakdown, the low simmer current is maintained to flow across the flashlamp. At this moment, the xenon flashlamp is operated in simmer mode.

EXPERIMENTAL SETUP

Figure 3 shows a block diagram experimental setup for series ignition circuit. The ignition circuit was supplied by 180 volt dc. A 650 volt dc simmer power supply connected in series with secondary winding of step-up transformer to a 67 mm linear xenon flashlamp. A high voltage probe model P6015 was employed to detect the electrical signal. Voltage pulse is measured at a primary and secondary winding of step-up transformer. The electrical signal before, during and past ignition process is displayed using an oscilloscope model Tektronix TDS3054 A.

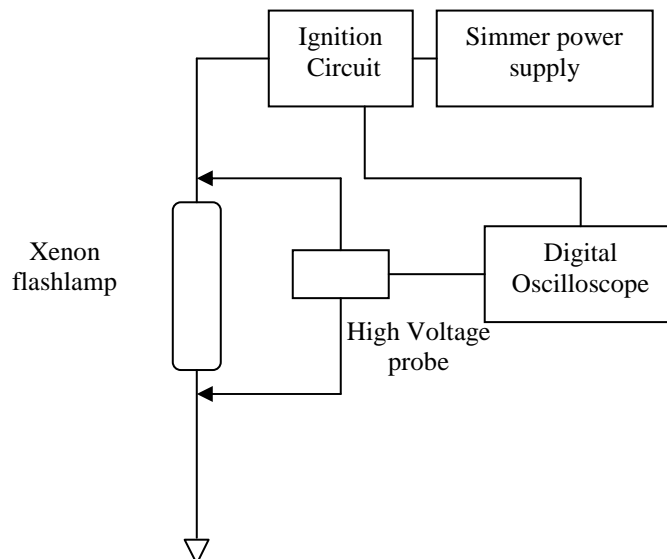


Figure 3: The block diagram of the experimental setup.

RESULT AND DISCUSSION

Figure 4(a) shows the signal of 180 Volt DC supply of the ignition circuit. After the SCR receives a signal from controller, a negative voltage pulse signal with the same amplitude of DC supply is generated at primary winding as shown in Figure 4(b). Subsequently, the step-up transformer amplified the voltage approximately up to 12 kV. The impact of the secondary winding voltage without the presence of the flashlamp is shown at Figure 4(c). The primary voltage pulse of step-up transformer in negative amplitude causes by the direction of capacitor, C discharge current. During SCR turn on, the charge inside C will discharge in opposite direction of charging current, so this produces a negative pulse at primary winding. The high voltage pulse and current from secondary winding after connected to the flashlamp electrodes is shown in Figure 4(d).

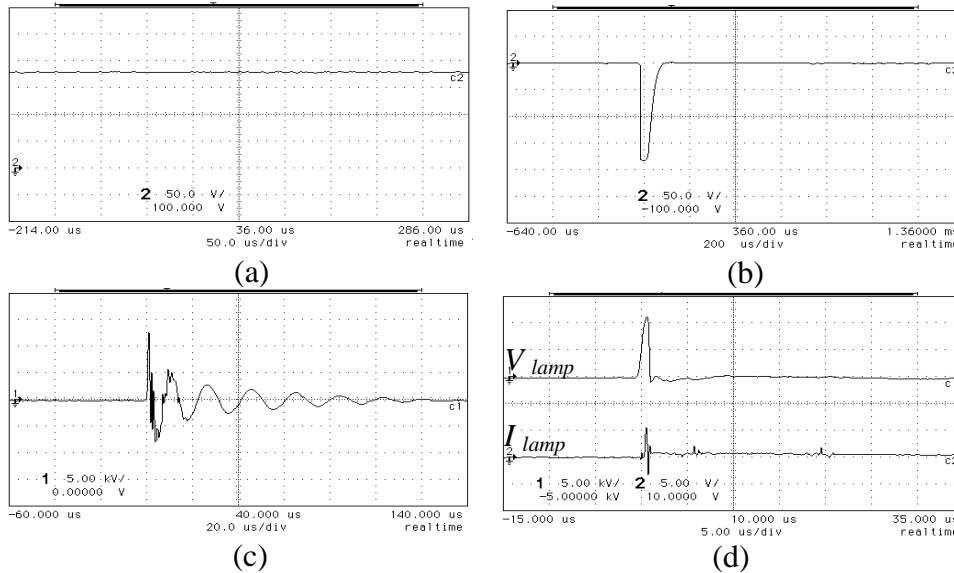


Figure 4: (a) Dc supply to ignition circuit. (b) Negative pulse generated at primary winding. (c) High voltage pulse at secondary winding. (d) High voltage pulse and current during the flashlamp ignition

The xenon gas inside the flashlamp between electrodes is breakdown at about 12 kV, corresponding to peak current of 54 A with a pulse duration less than 1 μ s. During ignition process, the xenon gas produces small plasma. The simmer DC power supply is maintained the current flow inside the flashlamp as shown in Figure 5.

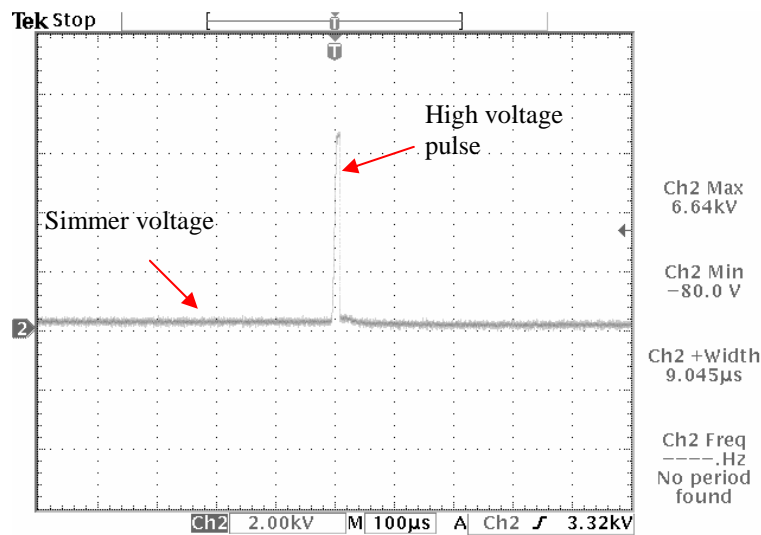


Figure 5: The high voltage ignition signal across the xenon flashlamp

CONCLUSION

A series ignition circuit for simmer mode flashlamp driver was successfully developed. A giant pulse of 12 kV corresponding to 54 A peak current and 1 μ s pulse duration was produced cause the breakdown of xenon gas inside flashlamp. A low simmer current is maintained to flow across the flashlamp and flashlamp operated in simmer mode.

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REFERENCES

- [1] Kuhn K.J. (1998) *Laser Engineering*. New Jersey: Prentice-Hall.
- [2] Koechner W. (1988), *Solid State Laser Engineering 2nd Edition*. New York: Springer-Verlag.
- [3] Kretchmer C , Noble L and Reed L. (1974), Optical Pumps for Nd:YAG lasers: Simmer Mode Flashlamp Operation. *IEEE Journal of Quantum Electronics*. 9(10):760-761
- [4] A.J.W. Brown and C.H. Fisher (1993), A 6.5-J Flashlamp-Pumped Ti:Al₂O₃ Laser. *IEEE Journal of Quantum Electronics*. 23(29):2513-2518.
- [5] R.Arya, Joy M. Thompson, A.G. Bhujle, and D.D. Bhawalkar. (2000), Effect of Simmer Current on Flashlamp Impedence and Their Combined Influence on the Output of a Quasi-CW Nd:YAG Laser. *IEEE Journal of Quantum Electronics*. 36(7):872-878
- [6] Chin S. Moo, Tsai F. Lin and Ting C. Chuang (1999). Designing an Ignitor for Short-Arc Xenon Lamps. *IEEE Journal of Quantum Electronics*. 23(29):2513-2518. *Proc of Industry Applications Conference, 1999. Thirty-Fourth IAS Annual Meeting*. Volume 1:612 - 617
- [7] Chin S. Moo, Tsai F. Lin and Ting C. Chuang (2002). Proc of An Electronic Gear for Short-Arc Xenon Lamps. *Power Conversion Conference, 2002. PCC Osaka 2002*. Volume 3:1468 - 1472