The design of medical ruby laser power supply system using LLC resonant converter

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Abstract

Because of its usability, the use of ruby laser for medical therapy has attracted a lot of interest. LLC resonant converter is used to control laser power density in ruby laser power supply. Zero voltage switching(ZVS) is implemented to minimize switching loss by LLC resonant converter. We use DAB(Dual Active Bridge) to charge the capacitor. We obtained maximum laser output of 0.5J. Repetition of laser out is 3Hz.

Keywords: Ruby laser, LLC resonant converter, ZVS, DAB

1. Introduction

According to development of laser over almost all industrial fields, the application using laser in medical field is also expanding rapidly. Nowadays, as a one of the most convenient and strong clinical devices, the range of laser use is becoming wider more and more in clinical parts such as not only curable disease but also diagnosis and treatment of disease, and frequency of use is increasing.

Medical ruby laser was used for vascular lesion at the beginning of development but not used now. Recently, laser is used widely in dyspigmentation, for example freckle or blemish, and used in tattoo removal

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using Q-switched pulse increased strength and shortened irradiation time.

This paper aims the development of power supply for laser output of 3Hz*0.35J. The Power supply was designed using LLC resonance converter in 2kW class.

2. Laser power supply

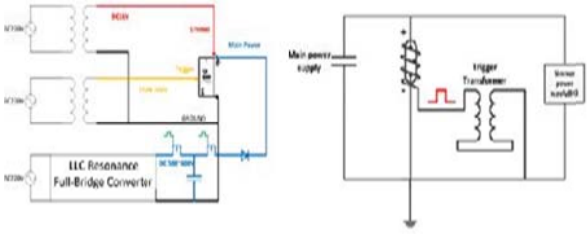

Figure 1 Laser power supply(left) and Simmer mode triggering circuit(right)

Solid laser power supply consists of trigger power supply, simmer power supply, and main power supply, as shown Fig.1. Laser is generated by intense visible lay made from Xenon lamp through conducting high current instantaneously to Xenon lamp. For conducting high current lamp, impedance should be low. Lowering lamp impedance is triggering. Through this we can make visible ray in Xenon lamp in condition of relatively low voltage.

In this paper, we use simmer mode triggering circuit like Fig 1. This method enables miniaturization and has large advantage of enabling to secure stability of circuit by separation main power from triggering power supply. Lamp is ionized stably by keeping low current DC voltage in Xenon lamp.

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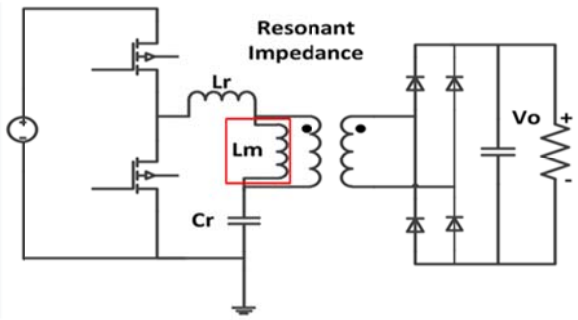
When triggering acts like Fig.2 steamer discharge is generated in Xenon lamp. Then lamp impedance is lowered, so Arc discharge can be made of relatively low voltage.

3. LLC resonant converter design.

The main power supply was designed applied LLC resonant converter. The aims of main power supply are charging voltage into high capacity condenser continuously, generating Arc discharge through high current conducted into Xenon lamp when the capacitor discharges.

The converter enables L_m to be concerned with resonant tank through reducing difference between L_r and L_m compared with LC resonant converter. LLC resonant converter can make regulated power over wide range of input voltage and in condition of relatively little frequency fluctuation. Also the efficiency of converter is increased by ZVS(Zero Voltage Switching) that reduces switching losses.



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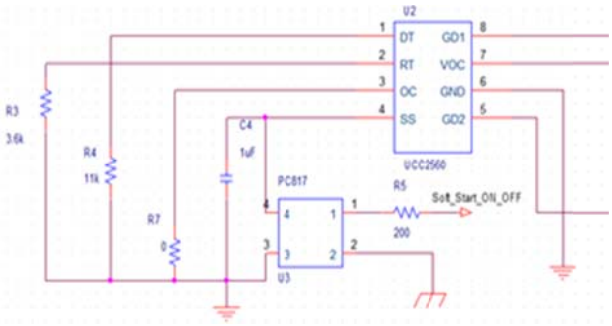
4. Soft start applied UCC25600

In laser power supply, excessive inrush current occur because when laser oscillation, the voltage charged in capacitor is discharged so to recharge this. Therefore soft start should be applied to block the inrush current so to assure stability of power supply in addition to beginning parts, whenever laser oscillation occur. This is made by combining photo coupler and SS pin , controlling soft start operation of the chip, of UCC25600

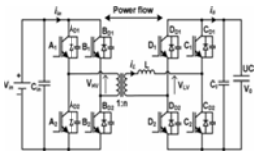
As shown Fig. 4, capacitor is discharged when photo coupler act, and then the capacitor recharged operated soft start.

Table 1. Specification of converter

Maximum input voltage	310V
Minimum input voltage	270V
Average input voltage	290V
Output voltage	600V
Output current	3.5A
Maximum power	2.1kW



5. Dual Active Bridge



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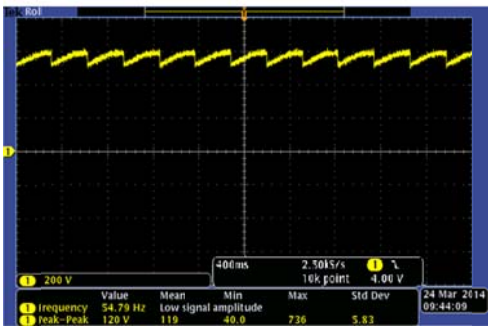
Shown Fig.5, we use DAB to charge a capacitor. The DAB is a bidirectional converter having characteristic of Phase shift, Buck+Boost biderection, not needing additional snuber and high efficiency and ZVS.

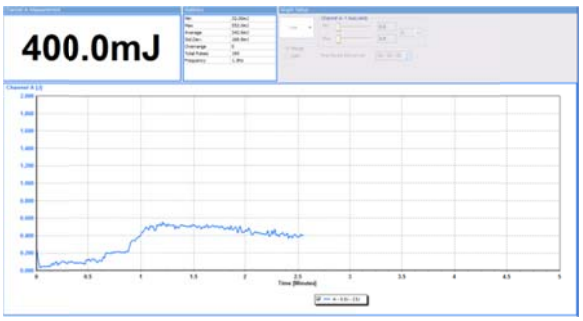
It is appropriate low voltage battery charge system so generally used for robot battery charge system.

We use this circuit just restrictively to test this circuit before design robot battery charge system.

6. Result

In 3Hz experiment, 0.5J of light output is generated with 600V of charging voltage. Depending on increasing charging voltage, laser output increases.





7. Conclusion

Today, a medical laser is the most actively studied field of many laser fields and the optimization of power supply is urgent. In this study we design ruby laser power supply that has 3Hz*0.35J output and research the change of laser output with regard to charging voltage. When charging voltage increases, light output also increases and 0.5J of light output is generated at 600V, the maximum charging voltage. If we increase repetition to 4Hz, it is expected to 0.25J of light output generated.

8. References

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