Journal of Optoelectronics and Advanced Materials Vol. 1, No. 1, p. 73-75

SHORT COMMUNICATIONS

DESIGN AND CONSTRUCTION OF MODULAR MINIATURIZED POWER SUPPLY FOR REPETITIVE SOLID STATE LASERS

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(Received December 8, 1998; accepted January 12, 1999)

1. Introduction

The operating features of a laser head make the power supplies for solid state lasers to present several drawbacks such as: 1) modification of output laser parameters due to the aging of the flash lamp, of the active medium or of other mechanic-optical components which should require periodical manual settings; 2) large size as a result of low efficiency in the conversion of electrical energy into radiation.

In this paper we propose a new type of modular miniaturized power supply, which overtakes these shortcomings and exhibits higher performances. The miniaturization was achieved by using performant, small size electric and optoelectronic components, as well as a modular architecture of the power supply (the circuits were made on printed cards). A control card that continuously displays the parameters of the laser head and of the power supply assures the reproducibility of laser parameters. This is done by optoelectronic components that draw the ignition of the flash lamp and the laser emission and then correlate them with the voltage on the charge capacitor.

The new power supply presents also other important features: versatility of the primary supply (mains or battery), optional preset of the working voltage, a continuous and efficient display of state parameters, autotesting function, optional interface with a computer which is set up for a specific application.

2. Block diagram of a switched-mode d.c. converter

The power supply employed in pumping repetitive medium solid state lasers is a switched-mode d.c. converter (SMCC) [1] whose blocks diagram is presented in Fig.1. In comparison with a common linear power supply, SMCC presents several advantages as: enhanced efficiency, higher power/volume rate, low cost, diminished dissipation and absence of some large, expensive and heavy components (power transformers at main frequencies, smoothing capacitors with high capacity).

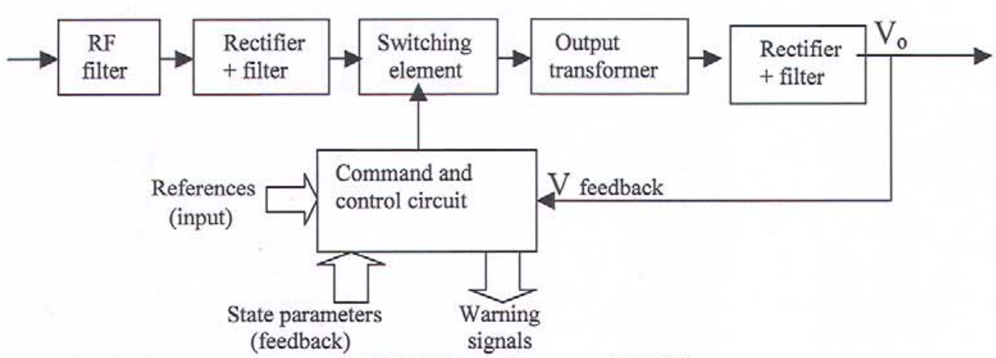
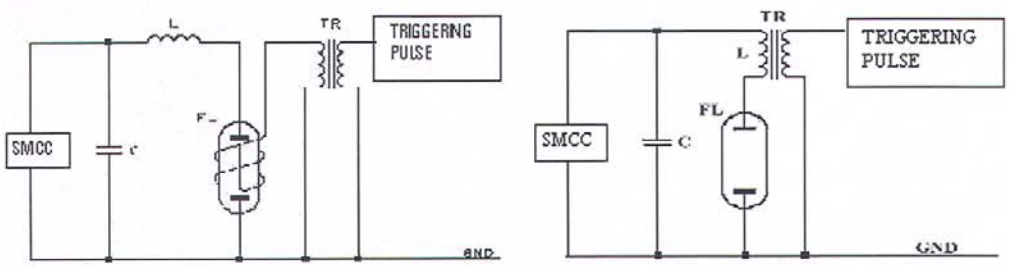


Fig.1 Block diagram of SMCC.

We used a flyback converter, which has the simplest inductive circuit – its output transformer being a multifunctional device: choke, set-up transformer and mains separator [2]. Another advantage is the possibility to obtain an increase in the output power and therefore a modular construction of the power supply by connecting more sources in parallel. For instance, if the power is to be increased twice, in addition to the corresponding output stages (containing the switching transistors, the output transformers and the afferent rectifier diodes), only two supplementary cards are necessary, the command card and the power module. A complete power supply should also be equipped with several specific components [3] such as: the charge capacitor, the triggering transformer and the triggering pulse circuit (Fig. 2). On technological considerations the charge capacitor and the triggering transformer are located outside the power supply unit, close to the laser head. The printed card of the triggering pulse is an integral part of the power supply.



a) parallel triggering b) serial triggering

Fig. 2 Flash lamp supply circuit.

When choosing a serial triggering (more convenient because the current leakage to the laser head is avoided), the block diagram of the power supply will contain the components in Fig.3.

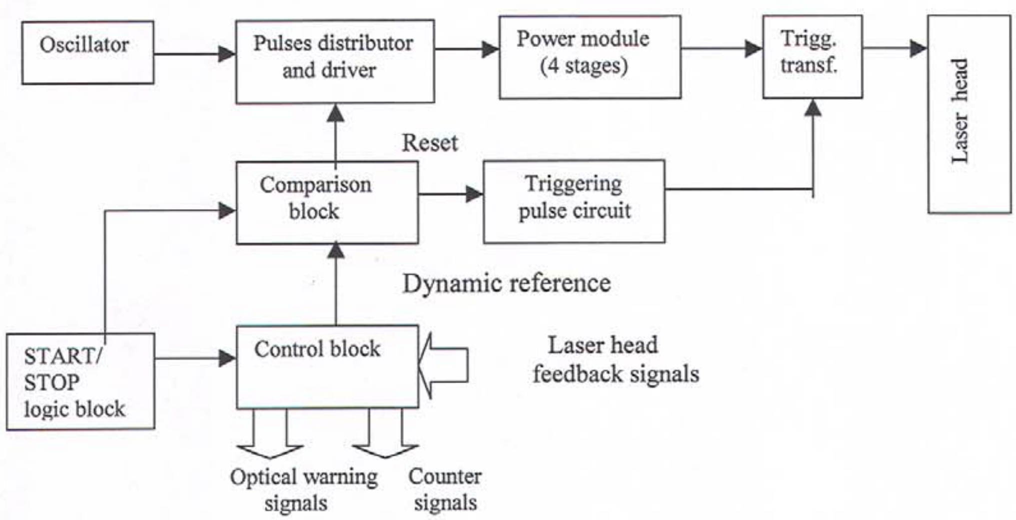


Fig. 3 Block diagram of the power supply.

Discrete components (most of them CMOSs) are preferred as they can enssure the imposed functions, an enhanced reliability and an easy maintenance of the power supply at low energy consumption. Our previous experience showed that a device with just one specialized integrated circuit diminished the control opportunities (no access to internal stages) and provided a low reliability of the system.

The power supply operates by charging the energy storage capacitor to a preset voltage (the system enables the selection of the working voltage) – and then simultaneous commands stop the charging (the pulse distributor device is reset) and release the trigger pulse.

The novelty provided by our power supply consists on the monitorization of its operation and the modification, when necessary, of the dynamic reference i.e. of the charge voltage level. Thus, when the triggering pulse appears, a train of pulses well localized on the charge-discharge curve is released and compared with the signals received from the laser head. This way, the occurrence of the laser emission, the localization of the point corresponding to laser emission on the charge-curve can be checked out, and if necessary the dynamic reference can be varied to obtain a high performance operation of the power supply. All information which is automatically processed by the system is provided as both optical warning signals (advanced pulse, delayed pulse, missing effect, optimum working) and command signals to the system counters (triggering pulses, flash lamp, laser effect). Analysis of these data provides complete information about the system at any moment.

In conclusion, we may say that the main element of the power supply is the circuit for the dynamic reference setting (Fig. 4).

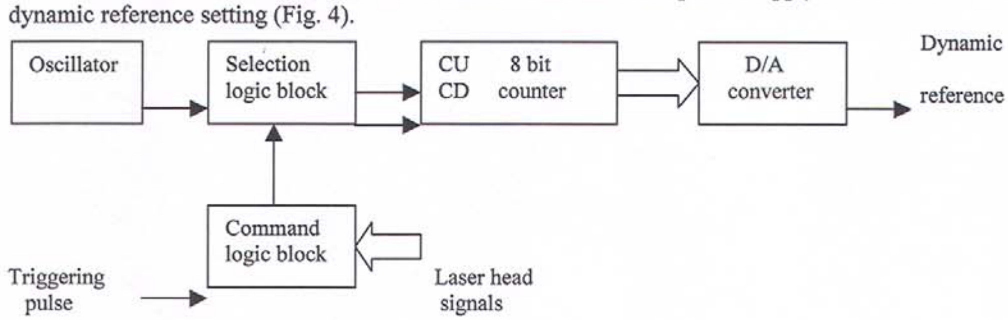


Fig. 4 Block diagram of the dynamic reference setting circuits.

The setting stage of the dynamic reference works as follows: the oscillator pulse is applied to the 8 bits counter by means of a logic selection block, which is turned on by the logic command block and this one compares the moment of triggering pulse application with the moment of laser emission. Following this comparison the oscillator pulse will be applied either to the count up entry or to the count down entry, increasing or decreasing the level of reference voltage i.e. of voltage level on the charging capacitor. As the signals are continuously compared, the reference voltage will be permanently fitted, providing an optimum operation of the device.

3. Conclusions

The proposed modular miniaturized power supply has a modern design, low electric power consumption, high reliability, a permanent operation self control and is easy to handle and maintain. This device can be successfully integrated in solid state laser medical equipment with light emission in the IR range such as: Nd:YAG (λ = 1.064 μm), Ho:YAG (λ = 2.1 μm) and Er:YAG (λ = 2.94 μm) lasers.

References

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