# Laser pulse shaping with liquid crystals

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## Abstract

A method of unpolarized laser pulses shaping is reported. The basis of the method is the use of an hybrid optical bistable device with nematic liquid-crystals, similar to the one previously reported by us. A sample of the input light constrols, by an asymmetrical electronic comparator, a 1 x 2 electro-optical total switch. The output pulses are reshaped and maintain the same polarization properties as the input light. From triangular input light signals, symmetriacl and asymmetrical output pulses have been obtained. The minimum pulse width achieved was 0.1 msec. A representation of the output versus input light signals gives an hysteresys cycle in the asymmetrical case.

## Introduction

In this paper we present some of the results that can be obtained in the field of laser pulse shaping when liquid crystals are employed as nonlinear media. The basis of the system, as we will shown later, is the use of a 1 x 2 switch reported by us previously[1]. Moreover, several other 1 x 2 switches can be employed too. The main advantage of our system is the the very low voltages needed, around 5 volts, compatible with I.C.'s devices.

The basic objetives of our system are:

- Optical sampling with variable characteristics.
- Laser output pulses width reduction.
- Signal to noise ratio improvement in a laser pulses train.
- TRansformation from symmetrical to asymmetrical laser pulses.
- Transformation from asymmetrical to symmetrical laser pulses.

## Basis of the system

The basis of the system is the use of a 1 x 2 switch based on liquid crystals. Two have been the employed types. Both of them are able to work with an unpolarized input laser beam. The first type is shown in Fig. 1 . This switch was reported by us[1] and is composed by a conventional Wollastrom prism, a twisted nematic liquid crystal cell and two pairs of nematic liquid crystals wedged cells with homeogeneous configurations. In this device, the unpolarized input light, after crossing the Wollastrom prism, is splitted into its two orthogonaly polarized components. These two components crosses the twisted cell and, if no voltage is applied betwwen the cells internal faces, undergo a π/2 rotation on their polarizations. If a voltage, higher than a certain threshold, is applied, the internal moleculae of the cell will adopt an homeotropic configuration. Hence, no rotation will affect to the beams polarization. The resulting exit rays go through the liquid crystal wedged structures recombining to give rise to a single output beam. If the applied voltage to the twisted nematic liquid crystal cell is smaller than the threshold voltage, the output ray will be A. If it is larger than the threshold, the output ray will be B.

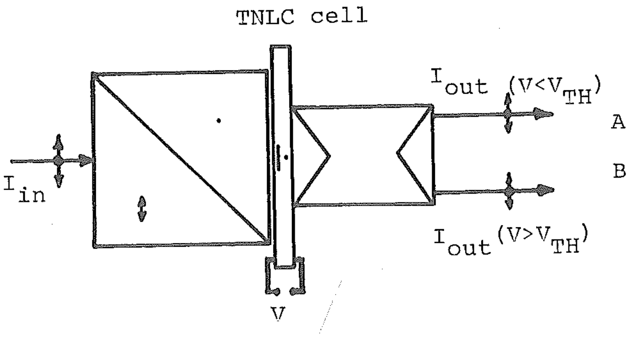

Fig. 1

The other employed 1 x 2 switch has been the one reported by Wagner and Cheng[2] and is described in the literature.

If any one of the two above described 1 x 2 switches is located in a set as the one shown in Fig 2, a system for laser pulse shaping is obtained. The input light is splitted into two rays with a ratio of 50:1. The ray with smaller intensity, D, is detected by a phototransistor and resulting electric signal, after amplification, is carried to an electronic comparator. Depending on the resulting signal, an order is given to the optical switch, conducting ray C to one of the two possible optical switch outputs.

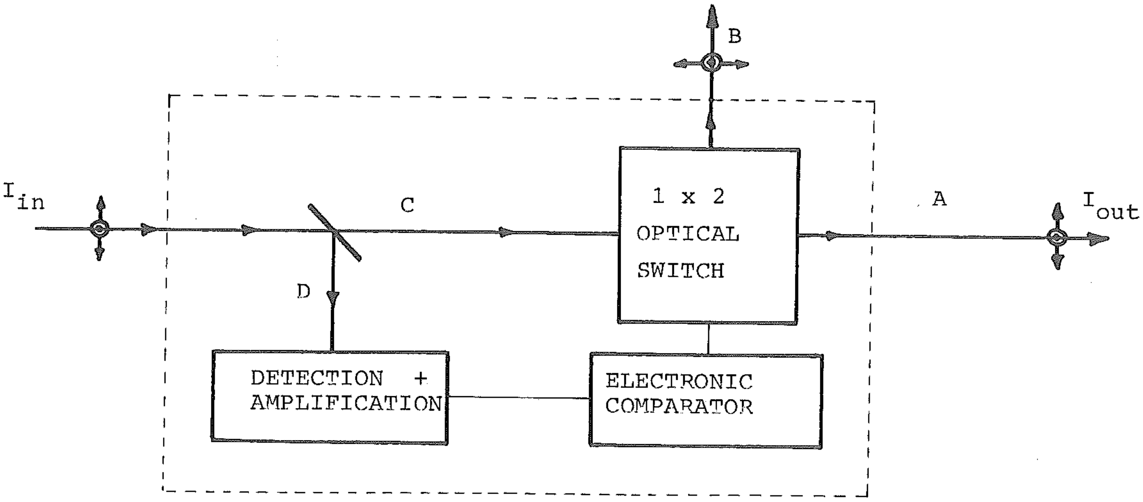

Fig. 2

The employed electronic circuits are shown in Fig. 3. Depending on the electronic comparator characteristics, two possible output laser pulses can be obtained, symmetrical and asymmetrical.

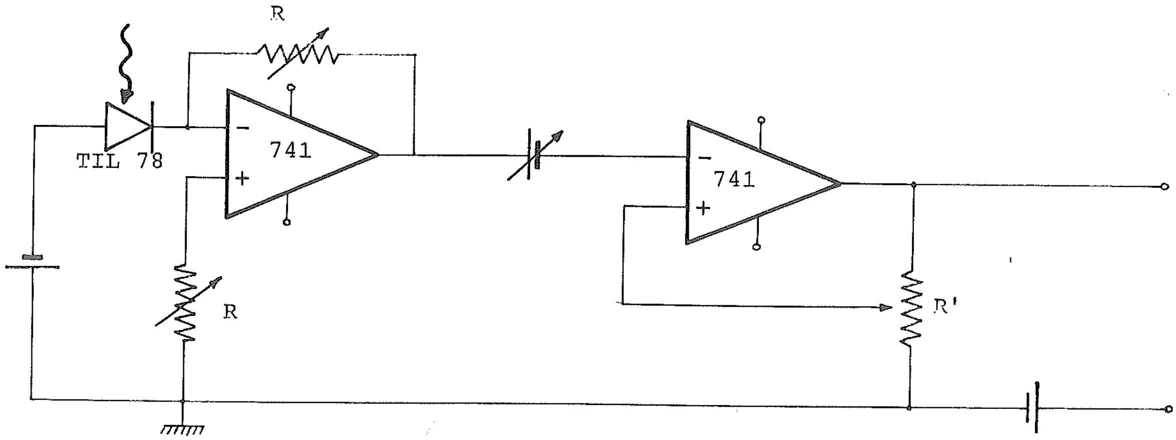

Fig. 3

## Optical behaviour of the system

The experiments were carried out with a modulated input intensity tringularly shaped. Output light pulses through exit A are shown in Fig.4.a. When the electronic comparator is a symmetrical one, $I_1$ and $I_2$ have the same values. In this case, the pulse width is fixed and determined by the value given to $I_2$ by the electronic comparator circuit. This value is fixed by the electronic comparator reference voltage. The resulting output pulses will be symmetrical

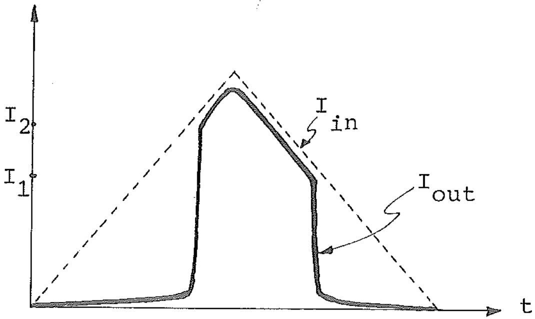

Fig. 4.a

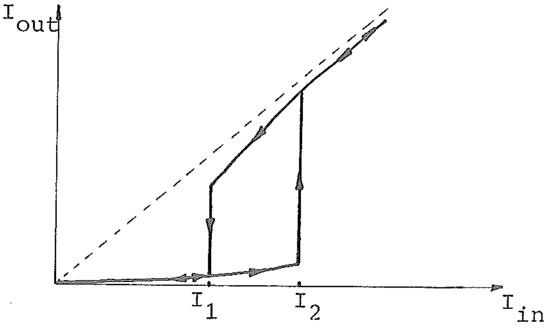

Fig. 4.b

If an asymmetrical electronic comparator is employed, an asymmetrical output pulse can be obtained. In this case, $I_1$ and $I_2$ will have different values. The values for $I_2$ and pulse width are controled by the electronic comparator circuit .

If output light versus input light is represented, an hysteresis cycle is obtained in the asymmetrical case (Fig. 4.b). This hysteresis cycle has a zero area for the symmetrical operation mode. In both cases, its position with respect to the $I_{in}$ axis can be varied. Two are the possibilities: a change on its width or a change on its possition keeping width constant. This hysteresis cycle is similar to the one obtained by conventional hybrid optical bistability methods.

The input intensity can have any waveform and no just the triangular one employed by us in our experiments.

If the intensity going through output B is taken, the removed input pulse intensity is obtained. As a consequence, two pulses are obtained for every input pulse.

## Applications

The main applications of this system is pulse regeneration, When an optical signal is immersed in noise, this system can suppress a noisy background and extract from it the optical signal pulses. The basis is shown in Fig. 5. The first results obtained by us in this field and with this method have given an improvement in the signal to noise ratio of 3 dBs.

Another application of this system is the cw to pulsed laser radiation conversion. In this case, the continuous input wave crossesthrough an hybrid optical bistable device simmilar to the one previously reported by us[3]. As it has been shown, it is possible to obtain an intensity modulated waveform from a c.w. laser radiation. Signals up to frequencies near 150 kHz have been obtained.

Obviously, because the optical behaviour of this system is equivalent to a certain type of optical bistability, every one of the conventional applications reported in the literature for Optical Bistable Devices, can be obtained here.

## Results

When the system has been employed as laser pulse shaper, pulse widths smaller than 0.1 msec. have been achieved. This time is the result of the nonlinear material employed by us, namely, nematic liquid crystals. Other materials with faster response times, should give smaller widths. But because the use of nematic liquid crystals, the employed voltages have been much smaller than the voltages needed for other materials. Our voltages have been in any case smaller than 8 volts. Obtained switching times are samller than 0.05 msec.

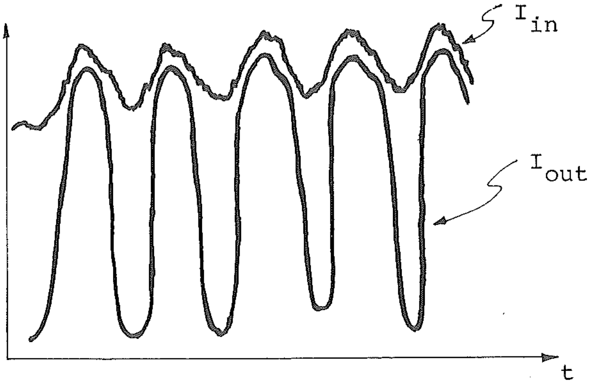

Fig. 5

## Acknowledgments

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2. Wagner, R.E. et al., Appl. Opt., 19, 2921, 1980.
3. Martín-Pereda, J.A. et al., Appl. Phys. B, 28, 138, 1982.