Assessment of a step motor as driver for a swinging mirror Q-switching CO_2 laser

T.J. Fernandes[1], C.A.B. Silveira[2], N.A.S. Rodrigues[2]

1 - Instituto Tecnológico de Aeronáutica – S.J Campos - SP
2 - Instituto de Estudos Avançados – S.J Campos - SP
tiagofer@ieav.cta.br

Abstract

This paper present the main characteristics of a device made of a mirror attached to a step motor developed to be the switch of a Q-switching CO_2 laser, stressing the repetition rate and switching time parameters. A BK-7 mirror aluminum coated was attached to the axis of a step motor; a driver circuit with four independent transistors was used to control the current of each individual step motor winding; a program, written in C language, was used to control the system through the parallel port. This program simulates a PWM controller, generating digital word sequences that promote the sequence for the desired steps. With this device it was possible to control the repetition rate from single pulse until 145 Hz and the switching time from 20 to 250 μs.

Introduction

One of the simplest ways to obtain Q-switching operation in a CO_2 laser is to rotate one of the resonator mirrors [1, 2]. This process, however, presents the drawback of keeping the repetition rate and the switching time dependent to each other, since both parameters are linearly dependent on the angular velocity of the rotating mirror. In principle, a step motor, operating in swinging regime (one step to the left, other step to the right), can be used in order to obtain Q-switching operation in a CO_2 laser, such that repetition rate and switching time can be controlled independently.

This paper presents the experimental results obtained in the assessment of the use of a step motor as the mechanical switch for Q-switching purposes.

Experimental Setup

A program written in C sends digital words to the parallel port; these digital words trigger four individual transistors that control the current of the motor windings. A HeNe laser beam is directed to the mirror attached to the step motor (Applied Motion HT23-397) axis and is reflected towards a screen with two 1 mm diameter holes separated by know distances that can be varied during the experiments. The light that is transmited through the holes is collected and focused into a photodiode by a lens, as shown in Fig.1. The photodiode signal is fed into a digital oscilloscope (Tektronix TDS-3052).

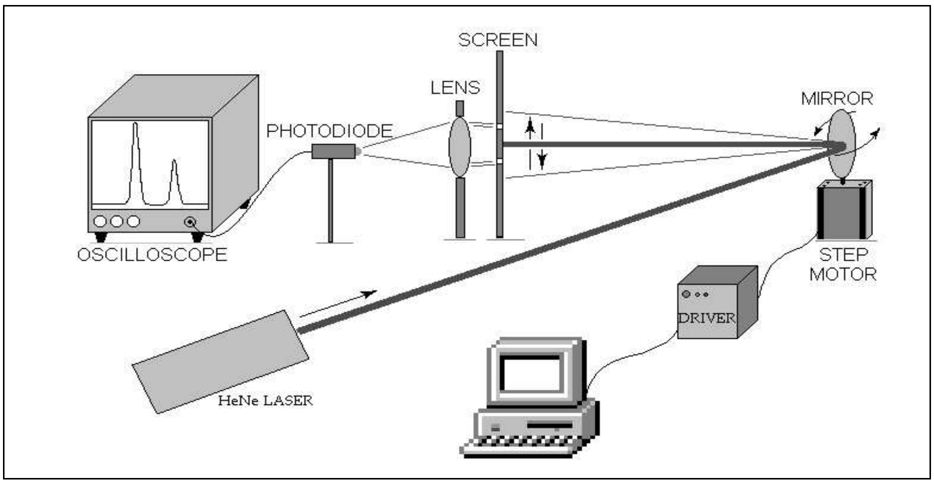

Figure 1: Experimental setup.

Fig. 2 shows a typical photodiode signal; the distance between peaks give the time the laser beam take to go from one screen hole to the other. The mirror angular velocity is calculated considering the distances between holes and between mirror and screen. The switching time is calculated taking the dimensions of the CO2 laser that will use this device (16 mm aperture diameter and 5 m between resonator mirrors).

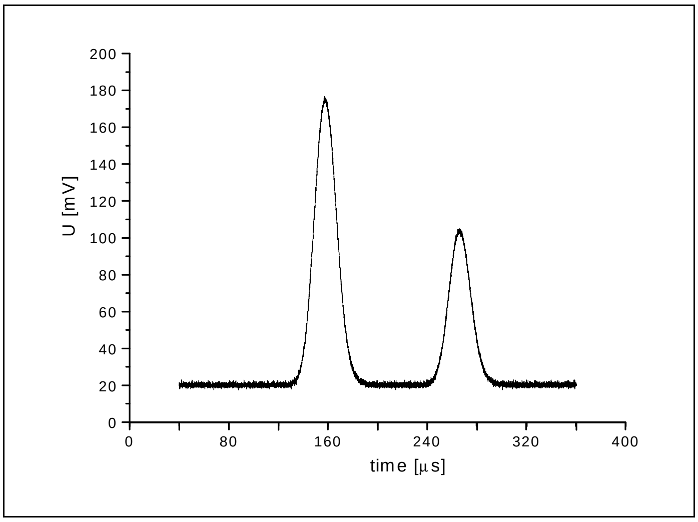

Figure 2: Typical fotodiodo signal.

The control program

The computer program was written in order to simulate a PWM control driver, allowing, this way, the independent control of repetition rate and electric current. The control is made by applying to the motor voltage bursts, as shown in Fig. 3, with variable duty cycle and variable number of pulses in each burst. The number of individual pulses in the burst controls the repetition rate and the electric current controls the motor torque (and, thus, the switching time).

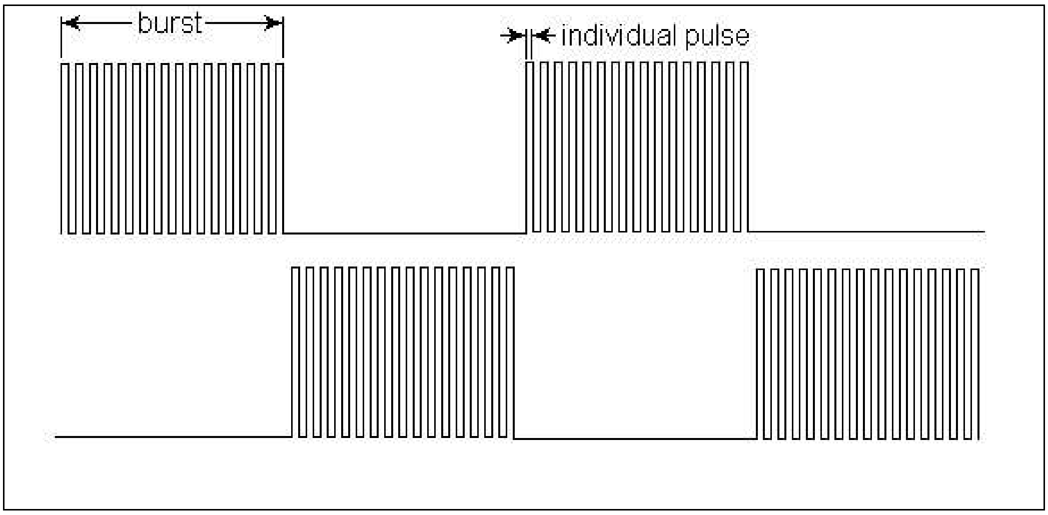

Figure 3: Signals from program.

Results and Discussions

With this setup it was possible to vary the repetition rate from single pulso until 145 Hz and the switching time from 20 until 250 μs. The tables ahead show some typical results. In Table 1, for instance, there are some different switching time for a repetition rate of 36 Hz, while in Table 2, the switching time is varied while the repetition rate is kept unchanged.

Oscilation frequency (36,00 ± 0,34) Hz										
Switching time [μs]	83,73	89,60	105,60	123,73	124,00	132,27	140,80	158,00	164,27	166,40

Tabel 1 – Different switching time for a single frequency.

Switching time (35,00 ± 0,94) µs										
Frequency [Hz]	104,17	106,38	110,13	111,11	116,28	117,37	119,05	120,19	121,36	122,55

Tabel 2 – Different frequencies for a fixed switching time.

Conclusions

The experiments shown in this paper confirmed that it is possible to control repetition rate and switching time independently by using a setp motor. Previously, it was found that a switching time of about 20 – 40 µs is necessary to actually have Q-switching in a CO_2 laser and, thus, it is possible to control switching time in this range by using a step motor.

The next step of this work is to attach this device to a commercial CW CO_2 laser and to observe the pulse formation. This study will be also extended to other models of step motors and other mechanical designs of mirror support in order to change de moving masses and, consequently, the resonance frequencies.

Acknowledgements

The authors thank to the CAPES for partially supporting this project.

References.

[1] - U. Nundy and U.K. Chatterjee, Theory Of Rotating Mirror Q-Switching in a Helical Transversely Excited CO_2-Laser J Appl Phys 53 (12): 8501-8507, 1982 .

[2] - A.D. Devir and O. Kafri, Doppler Q-Switching In A Single-Mode CO_2-Laser by a Rotating Mirror, J Appl Phys 43 (8): 3397, 1972

[3] - Cook, G. Forest. Pulse width modulator [online]. Available in Internet via URL: http://www.humboldt1.com/~michael.welch/extras/pwmhp75.pdf. File downloaded in July,07, 2002

[4] – Data obtained by the authors with a numerical model not published yet.