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Modulation In Frequency of A Laser Diode With A Low Power Bipolar Transistor

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***Abstract:* -** For industrial applications is necessary that the test systems are portable, for example measuring the concentration of pollutants in water or characterization of processes that occur in plants or other organisms be developed in situ and in vivo. The need to make the system portable, leads us to develop a driver that automatically controls the intensity of power and modulation in frequency of the Laser, measuring the temperature of the respective material to be analyzed. Presents the implementation of the characteristics of a low power bipolar transistor as a tool for modulating in frequency the Laser Diode. The result is a hardware and free software of the cost effective that can be used in various photothermal phenomena**.**

***Keywords:* -** *Driver, Frequency, Laser Diode, Modulation, Portable*

I. INTRODUCTION

Photothermal techniques have demonstrated their potential for measuring thermal properties of materials. In particular technique fotopiroeléctrica (FPE) offers the advantage of facilitating the realization of measurements at different temperatures in a relatively easy and inexpensive.

Due to the good thermal contact takes place between the pyroelectric sensor and liquid sample or semi-liquid, the FPE technique has become a very useful tool for the detection of phase transitions in these systems and for the study of phenomena that can take place near so-called critical points. This opens many expectations for use on an industrial scale, so that the proposed experimental systems compact, inexpensive, and portable is impetuous.

Regarding the modulated light source to excite the signal FT is scanned using laser diodes (LD) and light emitting diodes (LED) of moderate power available at low cost in a wide spectral region and which can be modulated in a wide range of frequency. It is increasingly common for its practicality, the use of photoacoustic techniques for identification of specific substances.

The use of these techniques, involves among other things the modulation of a radiation source which exposes the sample to obtain this characterization [1]. In most cases the choose powerful lamps that can be modulated with external devices. All of this gives robustness to the experiment, besides it became more expensive [2].

Find modulated radiation sources that involve a lower cost and also remain practical is the objective of this work. A diode laser with a suitable modulation in frequency can be a viable substitute for this kind of sources. The diode laser it's going to use a TTL signal, which will be generated by a medium scale microcontroller the PIC16F876, using software developed in Java to control the frequency modulation.

The uses of a driver will carry out, the correct modulation of the Laser Diode to obtain the desired modulation results in a wide frequency range, through the feed current.

II. DEVELOPMENT

To implement a useful radiation source is necessary to take various considerations. One of them is the type of sample that is looking to characterize, But mostly observe the behavior of the sample frequency variation in Laser Diode, since most of the cases in photothermal techniques do this kind of experiments by varying the laser intensity.

Another factor very important, is the **Potency of the power of source** to generate the optimal photoacustic signals [3] .

Also relevant is determinate the configuration in this experiment, in some cases, the space is limited, and it seek an arrangement with small dimensions. For this work, where considered biological type samples and a small space for the development of the experiment.

For the stage of the control modulation in frequency and conditioning in our system. We using the circuit show in figure 1 and the interface show figure 2, where shows the schematic of the control stage to take care of handling the Transistors, is very important to mention that the light emitting diodes are polarize to different voltages, because is necessary to use voltage regulators as the case of the diode light emitting to will be polarize.

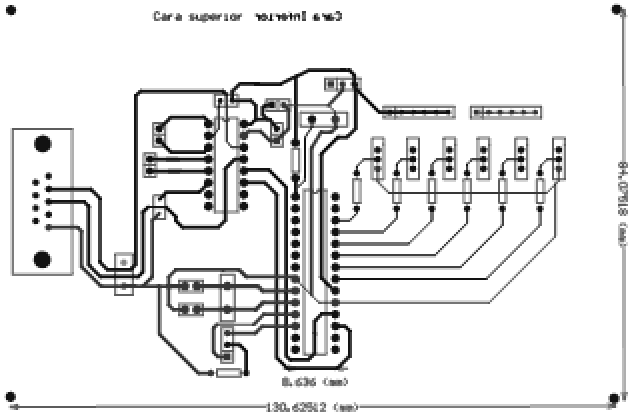

Figure 1. PCB of the circuit of control for modulation

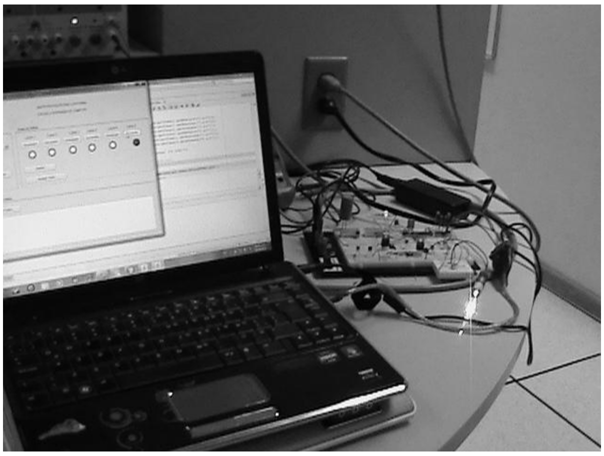

Figure 2. Interface of the Systems for Modulation in Frequency

III. SPECIFICATIONS OF THE LASER DIODE USED

One of the advantages of laser diodes is their versatility. It can easily find diodes with different wavelengths and power, depending on the application that seeks to give [4]. For this case is necessary to irradiate biological samples, which means that to get a proper insight into these, the use of a diode laser with a wavelength between 405nm -780nm can perform this task [5]. Regarding the potency diode relates, whereas the samples are small, the potency should not be higher than 10 mW.

In our project we used infrared AlGaAs laser diodes EGISMOS brand with a wavelength of 780nm and a potency output of 5mW. One of the important characteristics, is the active medium is a p-n junction in which by passing a current greater than a given threshold occurs the inversion through recombination of charge carriers at the junction releasing energy as photons, which are reflected in the polished faces to the junction again and it provokes the retro-causing optical power necessary to sustain the emission. It can operate in CW (continuous way or continuous duty) with efficiency in excess of 50%.

In total six Laser Diodes were used at different wavelengths, also with different bias. Among the specifications of each laser diode is detailed electrical characteristics of each of them. The following describes the electrical properties more important for our case which is pulse width modulation of the laser diode.

Figure 3 shows the variation of the potency emitted by the laser diode EGISMO that is used which was employed in this work, based on the applied current.

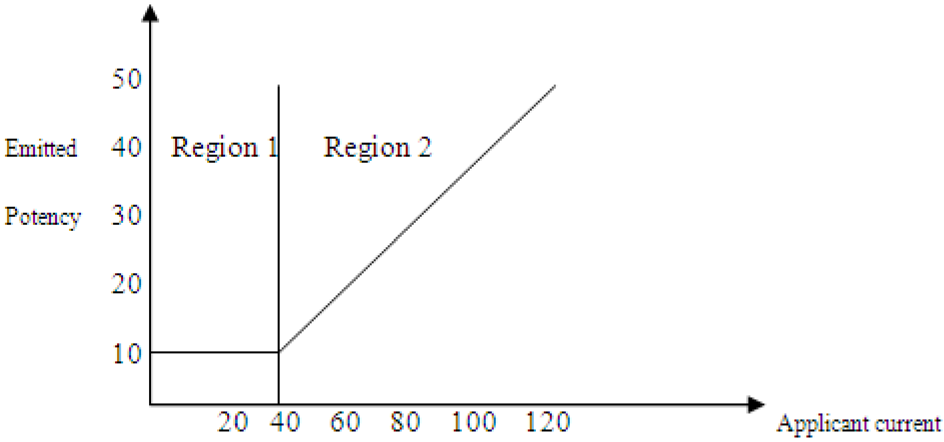

Figure 3. Diagram of Potency emitted vs Applicant current.

In it can be observed two regions: in the first one the behavior is linear and correspond to low currents where the LED acts as a common, the second region corresponds to the currents in which the diode behaves as a laser but still retains the linear behavior. This behavior is typical of laser diode when operating in free mode, without any feedback.

The two regions are separated by a zone of inflection, this indicates that the current has become a value large enough to achieve the inversion and start the laser emission. Since the observed behavior is linear in these regions is possible to find the value of current setting where lines intersect, this value is known as the threshold current and this value correspond to the current emission in which the laser is stabilized.

Also we present in the figure 4, samples of the response of the transistor bipolar a high frequency, we show that in display of the digital oscilloscope.

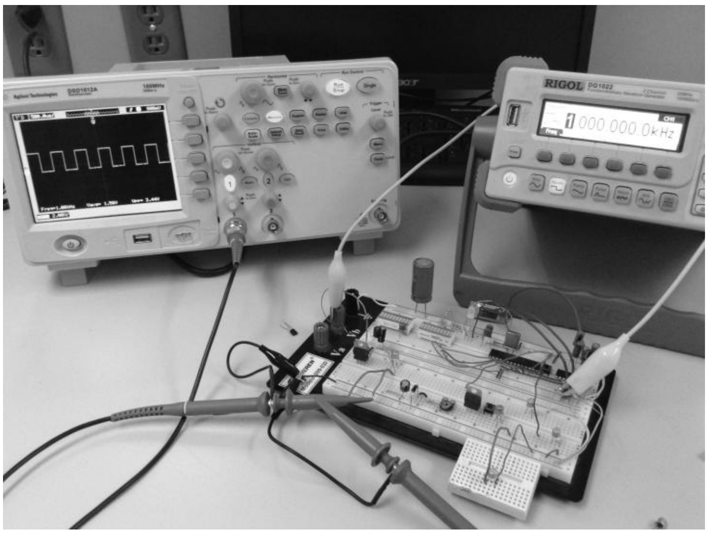

Figure 4. Frequency response of the bipolar transistor

IV. DRIVER DESIGN FOR LASER DIODE MODULATION

In this chapter we present the design of the tool electronic, in the first case we have to know that specs of the several diode lasers, because this point is very important for the design of the tool. The modulation of the diode laser is required to obtain a different exposure in each of the experiments involving different results[6]. The sample exposure to radiation source ranging from 10 to hundreds of nanoseconds, but the principal idea is to make a frequency sweep controlled by software, that because in research results are known only by exposure the sample to the laser diode modulation in intensity but in our case we will make the modulation frequency is the novelty of our system, so we have presentation the design of the hardware used of the lineal model, shown in figure 5.

Assuming a saturation BJT:

$$V_o = V_{CEQ} = V_{CEsat.}, V_{BEQ} = V_{BEsat}, \qquad (1)$$

$$I_{BQsat} = \frac{V_{CC} - V_{BEsat}}{R_b} \qquad (2)$$

$$I_{CQ} = I_{Csat.} = \frac{V_{CC} - V_{CEsat.}}{R_C} \leq \beta I_{Bsat} \Rightarrow Q \qquad (3) \text{ in saturation}$$

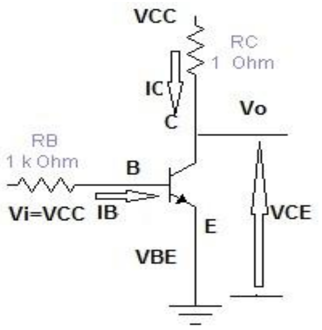

Figure 5. transistor npn in saturation

Solving for equations (2) and (3), R_B and R_C respectively, we obtain the values of resistors, these are shown in Driver obtained see Fig. 6.

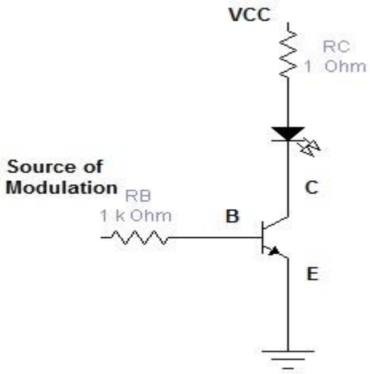

Figure 6. Design Driver

With this simple configuration shown we can make a sweep in frequency[7], for the modulation of the each diode laser, to control a sweep is used a microcontroller (PIC16F876), That through the interface shown in Figure 7 has the sweep control.

Figure 7. Interface for the control of laser diode modulation and the frequency

V. CONCLUSION

The implementation of a BJT device for modulating a laser diode can be replaced with complex arrangements of gas lamps or lasers coupled to other devices, for sample radiation photoacoustic techniques. Reducing the cost and space required for these experiments.

Photothermal techniques (FT) are based on measuring the temperature variations induced in a material by absorption modulated or pulsed light radiation. Although simple and inexpensive, test systems based on them can be further simplified for specific applications. For industrial applications, for example, it is necessary that the test systems are portable, for example measuring the concentration of pollutants in water or characterization of processes that occur in plants or other organisms be developed in-situ and in-alive.

The need to make the system portable, leads us to develop a Driver which automatically controls power and intensity modulation of the laser, to measure the temperature of the respective material to be analyzed.

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