

SHORT COMMUNICATION**DESIGN AND CONSTRUCTION OF A LASER CONTROLLED SWITCH CIRCUIT**

By

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3-Baghdad University – Institute of Laser for Postgraduate Studies**ABSTRACT**

A laser control system is designed and constructed in this work. Diode laser with wavelength 670nm and output power 1mW was used to operate the 555timer and JK flip-flop for a different time intervals. The operation time is calculated and measured through the capacitor value of the circuit. The response of the electronic circuit is tested to work with different lasers. (i.e. He-Ne laser 632.8nm with output power 1mW, diode laser 820nm with output power 75mW, and using the diode laser 670nm, with output power 1mW). The electronic circuit is made to respond for all the lasers with wavelength in the visible portion only.

To operate the circuit by a single laser wavelength, a suitable filter is selected, then the circuit had been operated with the diode laser 670nm only. This means that the electronic circuit was controlled and operated using one laser as switch. The operation of the circuit by using specific laser for different distances is tested. It has shown that the maximum distance for the diode laser (670nm), is 50 meter.

المخلص:

في هذا البحث تم تصميم وتشغيل منظومة تحكم الكترونية تعمل بالليزر. أستخدم ليزر الثنائى ذي الطول الموجى 670 نانومتر وبقدرة 1ملي وات لتشغيل الموقت (555) وكذلك مرجاح JK وبفترات زمنية مختلفة حيث تم حساب وقياس زمن التشغيل من خلال تغيير قيمة المكثف في الدائرة. تم اختبار استجابة الدائرة الالكترونية للعمل مع ليزرات مختلفة مثل ليزر الهليوم نيون (632.8) نانومتر بقدرة 1ملي وات وليزر الثنائى (820) نانومتر بقدرة 75ملي وات وليزر الثنائى (670) نانومتر بقدرة 1ملي وات. استجابت الدائرة الالكترونية لليزرات ذات الأطوال الموجية المرئية فقط.

يهدف جعل الدائرة الالكترونية تعمل بليزر واحد تم اختيار مرشح مناسب حيث استجابت الدائرة لليزر الثنائى (670) نانومتر فقط ولم تستجب لليزرات الأخرى. ووفقا لذلك تم التحكم في تشغيل الدائرة الالكترونية بواسطة ليزر ذي طول موجى واحد.

كما تم اختبار وتشغيل الدائرة بواسطة الليزر المحدد على بعد ولسافات مختلفة حيث أمكن تشغيل الدائرة حتى مسافة (50) متر.

INTRODUCTION

In the information age of the 1900s, light waves are being adapted widely as transmission media for telecommunications and local information networks^[1].

A photonic switch is a device that establishes and releases an optical path of light wave transmission at the command of prescribed control. In its simplest form, it turns the light beam ON and OFF, just as a mechanical toggle switch turns an electrical light bulb operation which the flip of a handle. The command that controls a photonic switch can be made mechanical, electrical, electronic, magnetic, or optical. The type of control depends on the size, power, and speed of transmission system.

Fast response, good reliability, and energy efficiency are common objectives in choosing the type of control.

A simple switch has the dimensions 1×1 , which are, one input line and one output line. Larger communication systems require multidimensional switches of $N \times M$ dimensions^[2].

Experimental Work:

The main purpose of this work is to describe the experimental setup and the function of each component that was used in this work. This is beside the procedure, which was followed in order to build a drive circuit that can be used to operate or control any circuit, to turn it ON OFF through a large distance. Also the switching of this circuit with a certain wavelength will be discussed.

Equipment:

Laser Source: Diode laser with wavelength of 670nm and maximum output power 1mW produced by ASK company was used in this project to operate the circuit.

Photodetector: A silicon pin photodiode (PHYWE Naturwissenschaft und Technik–Germany) was used for detecting light from laser source.

The pin photodiode respond over the approximate spectral range of 0.4 to 0.75 μm covering the visible region^[3].

Operation Amplifier: The basic function of the operation amplifier is to multiply a voltage or current level by the gain of the amplifier. D.C level of +1 volt couple into the (+) input of the operation amplifier then the output voltage would be $1\text{V} \times 1000000$ or one million volts. The output voltage, however, cannot exceed the supply voltage so the output will be +20V DC. A D.C level of +1 volt couple into the (-) input of the operation amplifier then the output voltage would be $-1\text{V} \times 1000000$ or minus one million volts. And also, the output voltage, however, still cannot exceed the supply voltage, so the output will be -20V DC. A D.C level +1v couple into both (-, +) inputs of the operation amplifier then the output voltage would be zero volt. This is a good test for an operation amplifier^[4].

In this work, the transistor BC182L was used to work as switch in the circuit, and it was connected at the output of comparator. The range of voltage to activate the transistor extends from +5 to 15 volts^[5].

A 555-timer was used to precision timing, pulse generation, sequential timing, time delay generation and pulse width modulation^[4].

(GaAsP) light emitting diode, which has a peak wavelength at 700nm, and energy gap 1.8 eV, connected to the output of the timer, was used as a display unit. The maximum operation voltage and current of LED is 3V, and 100mA respectively, and the threshold voltage and current are 0.7 volt and 20mA respectively^[6].

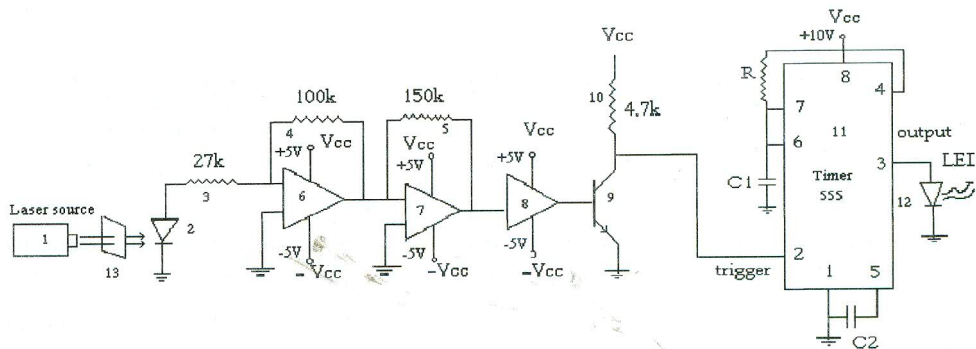
The Experimental Procedure:

- The circuit was connected as shown in (Fig. 1).
- The light beam from the laser diode had been received at a photodiode which converts the light signal to electrical signal (0.4V).

The electrical signal passed through the operation amplifier (UA741) to amplify the weak signal (from 0.4 to 1.4V) under process of feedback at the input resistance 20k Ω , and 100k Ω as a feedback resistance. A second operation amplifier (UA741), with 150k Ω resistance connected as feedback, was used to amplify the signal too, and then the output voltages from two

stages become 4.6V. The signal output was connected to the base of transistor (npn BC182L), to work as a switch, through the comparator.

- The signal from the collector of the transistor was sufficient to trigger the 555 timer, and then the light emitting diode operates according to the adjustment of the circuit.
- Plastic plate filter (680nm cutoff, 1*1cm square shape) is inserted between the laser source and the photodetector to prevent any wavelength to pass except $680 \pm 20\text{nm}$.
- The laser source was used to operate the circuit for different distances from the photodetector, and the proper operation result was registered at 50m away from the detector.



- 1- Laser source 2- Photodetector 3- Resistance 27k Ω 4- Resistance 100k Ω 5- Resistance 150k Ω
 6- Operational Amplifier 7- Operational Amplifier 8- Comparator 9- Transistor BC 182L
 10- Resistance 4.7k Ω 11-555 Timer 12- Light Emitting Diode 13-Filter

Fig. (1): The circuit diagram of laser switching

RESULTS AND DISCUSION

Calculations: the timer circuit consists of a-555-IC integrated circuit resistance, and variable capacitor. The output time changed at 555 timer according to the change in the capacitance value according to the equation.

$$T = 1.1 RC \dots\dots\dots (1)$$

Where C is capacitance value, R is resistance value, and T high the values of the time high for different capacitance values.

Then, when the value of the capacitor change from $10\mu\text{f}$ to $20\mu\text{f}$, the output voltage time high (the light emitting diode remains ON) change from 1.1sec to 2.2sec with $R=100\text{k}\Omega$. The values of T high for different values of the capacitance used in this work are listed in (Table 1).

Table (1): Calculated results of Time high (sec) according to the change in capacitance value (μf).

Capacitance value (μf)	T high (sec)
0	0
10	1.1
20	2.2
30	3.3
40	4.4
50	5.5

Experimental Measurement of T High:

In this section the circuit had been operated by using diode laser (wavelength 670nm, maximum output power 1mW). At that moment the laser beam incident on the photodetector the light emitting diode, which used as a display unit connected at pin3 output of the 555 timer, will go ON at a period of time depending on the capacitor value.

In the experimental measurements, the capacitor takes different values, which lead to different T high at the output of timer, these changes in T high (sec) due to the changes in capacitor value (μf) are given in (Table 2), and the relation between these two quantities are plotted in (Fig. 2) for both calculated and measured T high.

Table (2) Experimental results of T high (sec) according to changes in the capacitance value

Capacitance value (μf)	T high (sec)
0	0
10	1.01
20	2.26
30	3.01
40	4.34
50	5.98

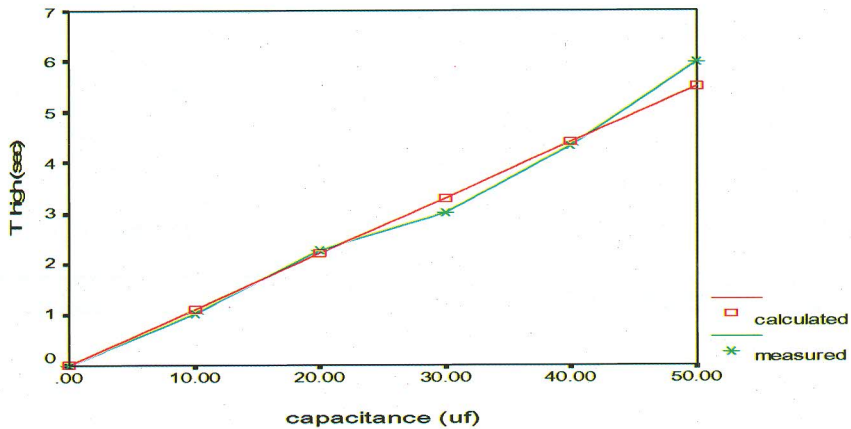


Fig. (2): The T high as a function of the capacitor values

It is shown that there is a good agreement between the calculated and the experimental results.

Performance of circuit operation with different lasers: The circuit designed to operate by using optical source to which the light beam is incident on the photodetector. Diode laser (670nm, 1mW), and He-Ne laser (632.8nm, 1mW), were applied to operate the circuit, as shown in (Fig. 3, 4), respectively.

In both cases the lasers operate the circuit properly. To insure the range of wavelengths that can be used to operate the circuit, another diode laser in the IR region (820nm) was used, and in this case the circuit has no response to these wavelengths, as shown in (Fig. 5).

The results of using different lasers to operate the circuit proved that the photodetector is sensitive to all wavelengths in the visible region.

Then, if the circuit needs to be operated for single wavelength a suitable filter must be used to allow narrow line width to pass through it and to prevent the others.

A suitable filter (plastic plate) was used to select a certain wave-length or make the band of the operation of the circuit very narrow. The transmittance of the filter is very high for the $680 \pm 20\text{nm}$, and then other wavelengths can not operate the circuit. That is clear in (Fig. 6) when the He-Ne laser (632.8nm) was

applied to operate the circuit, the light emitting diode which used as a display unit stay at the level 0 or OFF state.

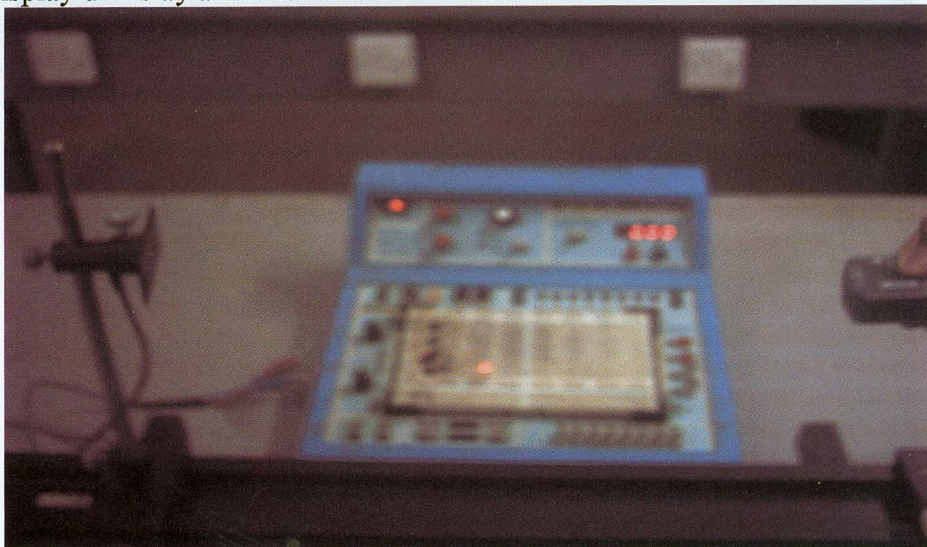


Fig. (3): Circuit operation by diode laser(670nm) without filter

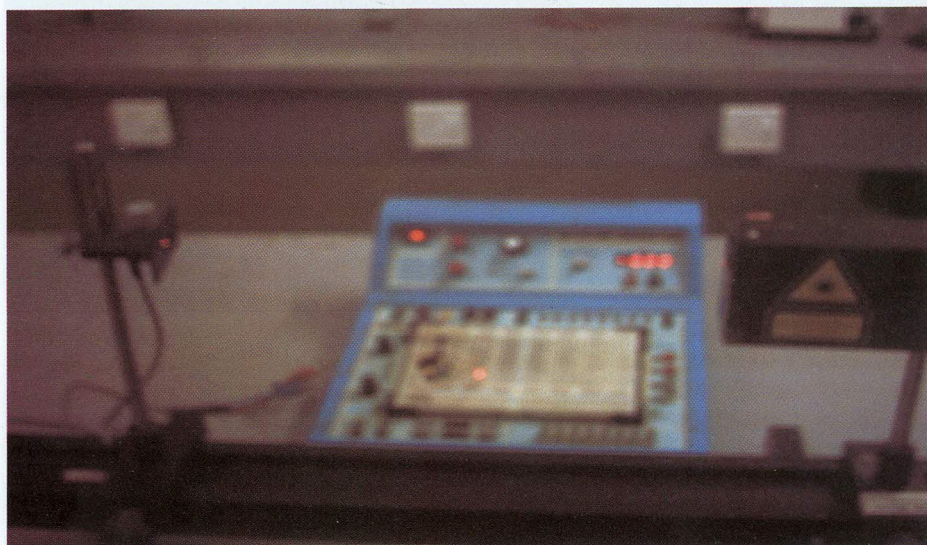


Fig. (4): Circuit operate by He-Ne laser (632.8nm) without filter



Fig. (5): Circuit operation by diode laser (820nm) without filter

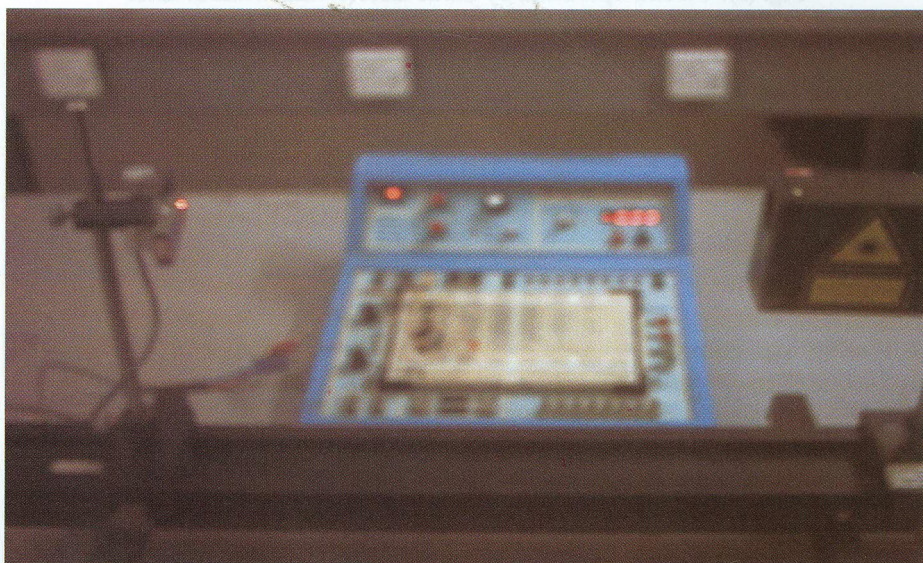


Fig. (6): Circuit did not operate by He-Ne laser with the filter usage

From (Fig .7) one can see that, when the diode laser (670nm) was incident on the photodetector, the light emitting diode will go to level 1 or ON state according to the time high while adjusted.

In this case the only way to operate the circuit is to use high intensity light with wavelength equals 680 ± 20 nm as a trigger for the detector.

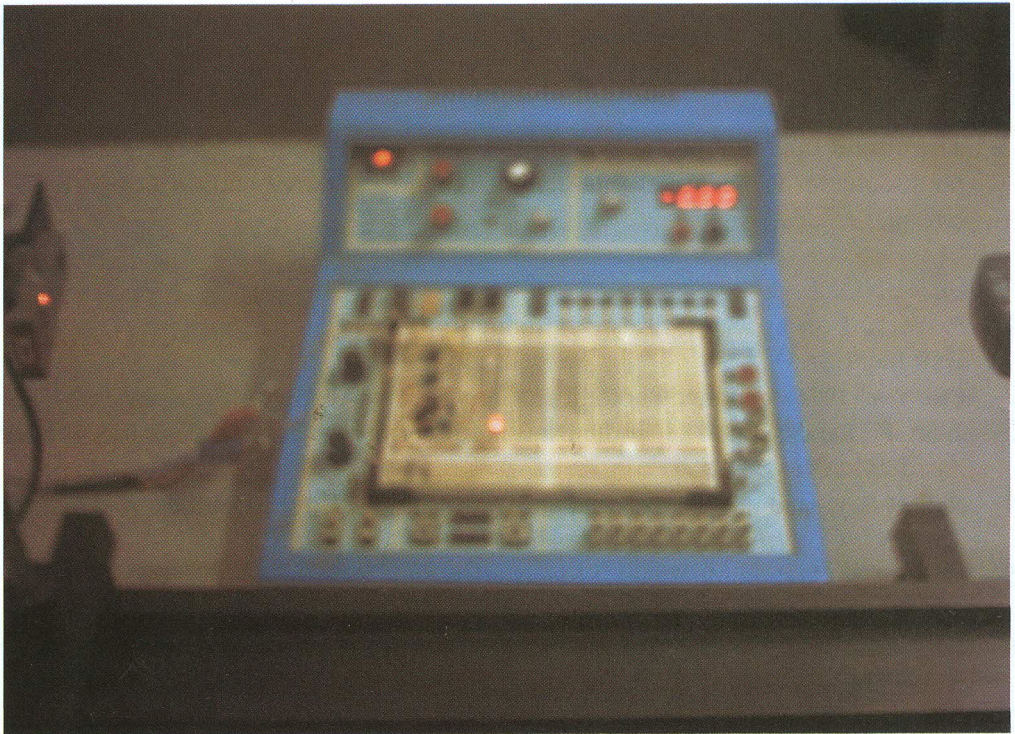


Fig. (7): Circuit operates by diode laser (670nm) with the filter usage

The result of the present work was similar to that previously reported by (Liu, *et al.*, 2001)^[7], who studied "all-optical switching of packets for all-optical buffering Purposes", laser switch is Argon ion laser. And also similar to that reported by (Hill, *et al.*, 2002)^[8] who studied 1X2 all optical packet switch of Mstandford University, (2002), the laser switch is diode laser 1550nm.

CONCLUSIONS

From above, the previous notes, one given concludes that:

- 1- The circuit which was designed prove the possibility of operation at different loads, by using the laser as a switch.
- 2- Different laser wavelengths can be used to turn ON or OFF the circuit at the visible region and near infrared, or at certain laser wavelengths according to the filter used.
- 3- Electronic circuit does not need high energy to operate.
- 4- The circuit operation time (ON or OFF) can be controlled through controlling the 555 timer.
- 5- The circuit operated properly until the distance between the laser source and photodetector is 50m, over this distance the laser source couldn't operate the circuit.

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