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Design, Construction and Testing A Laser Power Comparator

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Abstract

A laser power comparator prototype that can be utilized in laboratories has been designed constructed and tested. The system consists of three main electronic circuits: the laser comparator electronic circuit, sign detector and phase inverting circuit, and an analog-to-digital readout display circuit. The comparator has two detectors each receives a particular input signal. Two input signals will be compared and the output will be displayed on a digital readout (or on an oscilloscope). Power difference up to 0.1mW is achieved.

تصميم وبناء واختبار مقارن قدرة ليزر

الخلاصة

تم تصميم وبناء واختبار نموذج لمقارن قدرة الليزر حيث يمكن الاستفادة منه في المختبرات. تتألف المنظومة قيد البحث من ثلاثة دوائر الكترونية رئيسية وهي : الدائرة الالكترونية للمقارن الليزري، دائرة كاشف الاشارة ودائرة عكس الطور ودائرة تحويل الاشارة من تماثلي الى رقمي وعرض القراءة رقمياً.

للمقارن كاشفين كلاهما يستقبل اشارة داخلة مستقلة عن الاخرى. سوف تقارن الاشارتين الداخلتين مع بعضهما ويتم عرض الاشارة الخارجة على شكل قراءة رقمية أو على اوسلوسكوب. ولقد تحقق فرق بالقدرة وصل الى(0.1mW).

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Introduction

Some basic applications of comparators are (ADC), function generation, signal detection and neural networks etc [1]. Examples of circuits functioning as comparators are:

QSC Audio Products.(1998), designed an ABX comparator. The ABX comparator which is a measuring device that permits simple and accurate comparative listening tests of two or more power amplifiers or even line-level audio components [2]. Z.Huichenga, et al. (1999), presented a three-dimensional laser comparator for dimensional inspection [3].

D. Y. Duose.(2005), introduced a phase detector which is a device that compares two input frequencies and generates an output that is a measure of their phase difference [4].

Many applications and experiments in optics encounter the necessity of estimating and comparing two levels of optical powers in situ. Examples are interferometry, diffraction, polarization, beam splitting, holography and sun sensors to mention but a few.

The work herein aims at designing and building a laser comparator capable of detecting two input laser signals and comparing their powers.

Theory

A comparator can be thought of as a fast, high-gain op-amp. This basic idea is shown in Figure (1). The comparator has large open-loop gain A. The function of a comparator is to decide which of the two inputs has larger voltage. We have in the limit of very large A:

$$v_{out} = A(v_+ - v_-) = \begin{Bmatrix} +V\max \\ -V\min \end{Bmatrix} \text{......(1)},$$

where Vmax and Vmin are approximately the power supply voltages. Therefore, the comparator converts an analog input signal into an output with two possible states. Hence, this can be thought of as a 1-bit analog to digital converter (A/D or ADC).[5]

Comparators require one to three power supplies. Comparators requiring multiple power supplies use dual voltages to obtain maximum input dynamic range in a manner similar to that of an op-amp input stage. And these comparators use ground and a third voltage to level-shift the output voltage to a compatible logic voltage. Engineers often configure comparators with ±15V analog supplies and 5V and ground for the TTL interface [6].

Depending on the type and architecture of the comparator, the comparator can have significant impact on the performance of the target application. The speed and resolution of an analog-to-digital converter (ADC) is directly affected by the comparator input offset voltage, the delay and input signal range [7].Depending on the nature, functionality and inputs, comparators are classified into different types i.e. voltage and current comparators, continuous and discrete time comparators etc [1].

Electronic Circuits Description

The circuit , used in this work ,is called comparator .The purpose of this comparator is to compare the power of two input laser signals of the same wavelength.

The laser comparator device consists of three parts : part (1) laser comparator electronic circuit , part (2) sign detector and phase inverting circuit , part (3) represents the analog to digital readout display circuit as shown in Figure (2):

Before the comparison stage there is a detection stage (D1 and D2) which has the function of converting the power of the two laser signals into electrical signals. After that, the comparison stage will be applied. The circuit can be divided in to three stages as shown in Figure (3) :

1-The first stage A (short circuit resistance) produces the output current hence an equivalent voltage.

2-The second stage B produces two opposite sign voltage.

3- The third stage C sums up the signals from the two stages A and B.

Readout Circuit:

The output of the comparator electronic circuit is passed through the : sign detectors , phase inverting , relay drive , and A/D converter circuits .

If the sign detectors circuit shows NEGATIVE on the sign digital display that means the difference value between two inputs laser signals is negative signal; A case where the input of detector D1 is greater than the input of detector D2. A positive is otherwise.

This negative signal is passed through the phase inverting circuit and converted to positive signal then applied to the relay; in this case the relay drive circuit receives the NEGATIVE sign from the output of detectors sign circuit, the relay is non-activated and remains in case NORMALLY OPEN .

The positive signal which is passed through the relay will be applied to the A/D converter circuits.

If the detectors sign circuit shows the POSITIVE sign digital display that means the difference value between two inputs laser signals is positive signal .This positive signal is passed through the relay and dose not pass through the phase shifter circuit.

In this case the relay drive circuit received the POSITIVE sign from the output of sign detectors circuit. The relay is activated and compressed on NORMALLY CLOSED to allow the positive signal passed through it and applied to A/D converter circuits.

In A/D converter circuits, which is the readout of this work displays the difference value for two analog inputs in digital logic display.

Testing And Results

Testing a laser comparator device is quite elaborate work. Most important is to a achieve an alignment between the laser light and detectors, and to prevent the external electrical and light noise. The optical arrangement is shown in Figure (4).

The output power P_{out} can be found by using the following equation :

$$P_{out} = (P_{D1} - P_{D2}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

where P_{D1} and P_{D2} represent the input powers for detectors D1 and D2 respectively.

CASE (1)

Detector (D1) is allowed to receive a fixed power at 0.8 mW and detector (D2) is allowed to receive varying powers from 0.1 to 0.8 mW. Optical attenuators are used for attenuating laser power. Table (1) presents the output power values.

CASE (2)

In this case detector (D2) is set at fixed power 0.8 mW and detector (D1) is allowed to receive varying powers from 0.1 to 0.8 mW. Table (2) summarizes the results.

In both cases the laser comparator is tested at laboratory condition .

Conclusions

A laser comparator prototype based on a comparison between two input laser signals with different values of powers from (0.1 to 0.8 mW) is implemented. The experiment results presented in Tables (1) and (2) showed that the laser comparator performance is encouraging. It can be developed to accept powers other than those mentioned above.

The device can help to solve the problems that are encountered in experiments where the measurement of the difference between two laser signals in situ are required.

References

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Electronics System at Linköping Institute of Technology, 2007.

Table (1) The output power values, (positive when $P_{D1} > P_{D2}$)

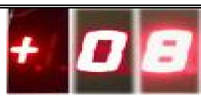
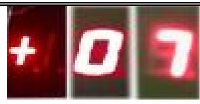
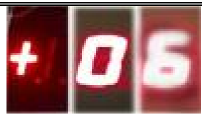
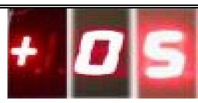
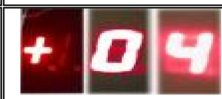
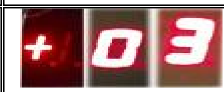
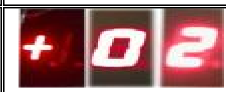
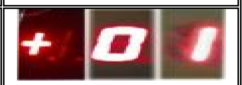
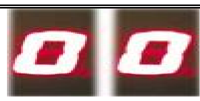
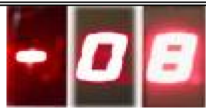
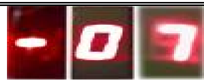
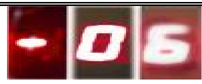
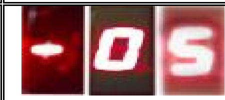
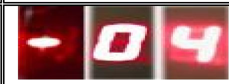
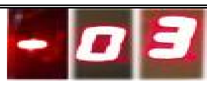
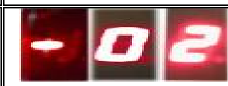
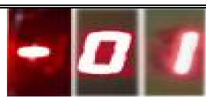
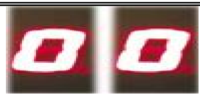
D_1 Input power(mW)	D_2Input powers(mW)	$P_{out}(mW)=P_{D1}-P_{D2}$
0.8	0	
0.8	0.1	
0.8	0.2	
0.8	0.3	
0.8	0.4	
0.8	0.5	
0.8	0.6	
0.8	0.7	
0.8	0.8	

Table (2) The output power values, (negative when $P_{D1}<P_{D2}$)

D_1 Input power(mW)	**D_2 Input powers(mW)**	**$P_{out}(mW)=P_{D1}-P_{D2}$**
0	0.8	
0.1	0.8	
0.2	0.8	
0.3	0.8	
0.4	0.8	
0.5	0.8	
0.6	0.8	
0.7	0.8	
0.8	0.8	

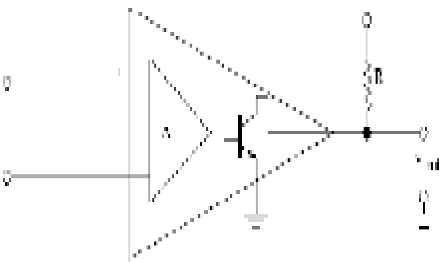


Figure (1) Simple comparator .[5]

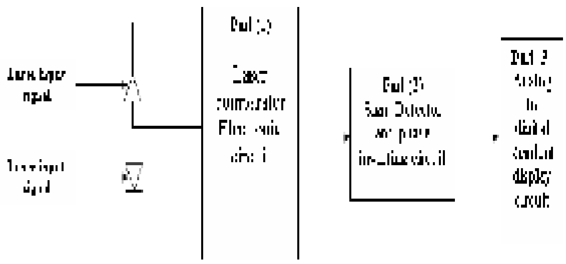


Figure (2) Laser power comparator main units.

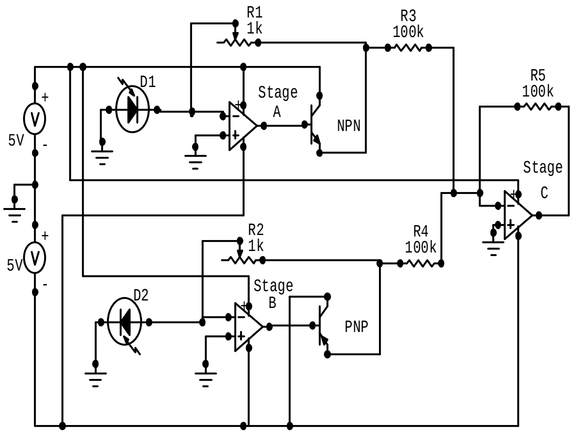


Figure (3) Electronic circuit of laser power comparator.

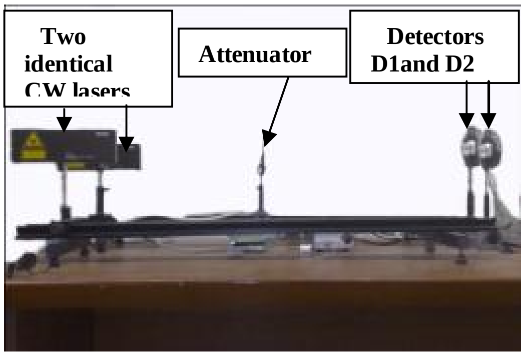


Figure (4) Optical arrangement of the laser power comparator.