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Pulse Width Modulation Generation Based on Laser Using Ultrasonic Frequency

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Abstract
In this work, a Wien Bridge Oscillator and a Triangle Wave Oscillator were used to obtain a 40 KHz sine wave and a 400 KHz triangular wave respectively. A modified pulse using a comparator circuit was obtained to control the laser transmission circuit and to send the modified laser pulse to the photodiode receiving circuit in any distance. The original sine wave (40 KHz) was then retrieved to be used in medical, industrial, physical and military applications.

Keywords: ultrasound Frequency, laser, Modulation ,Transmitter circuit.

1-Introduction
Ultrasound cannot move through the space vacuum without a physical medium, while visible light and other forms of electromagnetic radiation can propagate through the vacuum. However, by creating an electronic circuit that modulates the laser ultrasound, it become possible to transmit ultrasonic frequencies in space and for long distances which can be used in various applications. Ultrasonic Mechanical waves are longitudinal compression waves refer to frequencies greater than 20 kHz. The limit of human hearing it continues up into the MHz range up to around 1 GHz, goes over into what is conventionally called the hypersonic regime. In Medical imaging typically 100 Times higher frequency than audible by human 2 to 20 MHz, which use ultrasound waves to echo back an image of a fetus or internal organ, as well as to administer therapy to various parts of the body using a probe.Ultrasonic wave have characteristic properties such as a slow speed of about 100,000 times less than the electromagnetic wave. The possibility of penetrating the opaque material gave it the possibility of using it to load information and detect the opaque properties of materials can penetrate [1, 2].

2- Circuits Design

The process of laser generation and modification of ultrasonic waves passed through three main stages represented by the electronic circuits described below.

2-1. Wien Bridge Oscillator

A Wein bridge oscillator circuit shown in figure 1 is built with two capacitor - resistor connection with operational amplifier. The two inputs of the amplifier is the operational amplifier output feedback. The first input (inverting input) was fed by resistor divider network R_3, R_4. The other input was fed (non-inverting input) by RC series and RC parallel combinations, which produces the frequency of the Wien Bridge Oscillator [3, 4].

The following two conditions should be satisfied to operate the Wien Bridge Oscillator:

1. The phase shift of the positive feedback loop must be 0°

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2. The amplifier gain should be unity using resistors network (so : $A_v \geq 3$).

If (C1=C2 , R1= R2) is taken, then the frequency of the circuit can be calculated by equation (1).

$$f_r = \frac{1}{2\pi RC} \qquad (1)$$

And the amplifier voltage gain (A_v) can be calculated by equation 2 [5].

$$A_v = 1 + \frac{R_3}{R_2} \qquad (2)$$

2-2. Triangular Wave Oscillator

The Triangular Wave Oscillator circuit is consisting of two parts; the first part is the comparator and the second part is the integrator as shown in figure 2.

In this figure, the two resistors R_2, R_3 are set the output amplitude of the circuit. The upper trigger point UTP and the lower trigger point LTP voltages can be calculated as in the following equations:

$$V_{UTP} = +V_{max}\left(\frac{R_3}{R_2}\right) \qquad (3)$$

$$V_{LTP} = -V_{max}\left(\frac{R_3}{R_2}\right) \qquad (4)$$

The time constant and the frequency of the triangular wave oscillator can be produced based on the R_1, C_1 network waveforms as shown in figure 3. The oscillation frequency was adjusted by varying R1 without changing the output amplitude as illustrated in equation 5 [5, 6].

$$f = \frac{1}{4R_1C_1}\left(\frac{R_2}{R_3}\right) \qquad (5)$$

2-3 comparator circuit

Pulse Width Modulation PWM Generation based on comparator circuit is generally used to compare two currents or voltages. Given two inputs to the comparator, returns a differential output voltage, which is either high level signal 1 (the voltage at the plus side) or low level signal 0 (the voltage at the negative side) to indicate the largest one. As shown in figure 4, it is easy to create a voltage comparator from an op - amp, because the polarity of the op-amp's output circuit depends on the polarity of the difference between the two input voltages. The comparator circuit receive the two signals in both inputs A, B as sine wave or triangle wave to produce the PWM which can drive MOSFET (as a switch) to fed the laser to the comparator circuit [7].

2-4 Adjustable Voltage Regulator

Figure 5 shows an Adjustable Voltage Regulator is a regulator that can produce an adjustable current or voltage in the range that the voltage regulator is designed to. This voltage is used to derive the laser and it can be calculated as in equation 5 [8].

$$V_{out} = \frac{R_1 + R_2}{R_1} * V_{ref} + I_{adj}R_2 \quad (5)$$

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3- Experimental Test

Figure 6 shows the designed of an electronic transmission circuit. It consists of several parts to modulate the ultrasound signal with the distances emitted laser depends on the emitted laser energy.

The Multisim ver. 14.1 simulation programs was used to obtain the 40 kHz sine wave and the triangle wave of 400 KHz frequency as shown in Figures 7, 9.

In experimental test, the obtained output sine wave of 40 KHz frequency and triangle wave of 400 KHz frequency forums were explained in the figures 8, 10. Comparing the experiment results shown in figures 7, 9 with that of the simulation results of the two waves frequency and amplitude shown in figures 7, 9 respectively. It is clear that the waves are approximately similar.

After using the Pulse Width Modulation (PWM) Generation based on the comparator circuit to obtain the modulated wave shown in figure 11. Again the Multisim ver. 14.1 software simulation programs was used to obtain the digital triangle modulation (PWM) wave of 400 kHz, and the digital sine modulation wave of 40 kHz as shown in figure 12. These waves were compared with that of figure 11.

The square wave represents the opening and closing of the MOSFET transistor to the laser emission as shown in figures 12 and 13.

Conclusions

Due to the various applications of the ultrasound and the laser, this electronic circuit was designed to allow the ultrasonic waves transfer to long distances based on the laser energy used and which can be developed to be used for a wide range of ultrasonic frequencies. Pulse Width Modulation (PWM) Generation was used to drive the laser through the MOSFET. The laser light is sent for any distance then it is received using the receiving circuit, and get the origin ultrasonic wave (40 KHz) through detector, amplifier, and low pass filter circuits. It can be used in the application which the ultrasound wave has been transmitted to. Our next step is built receiving circuit to detect and pass the origin ultrasonic wave to use it at any application for ultrasonic wave.

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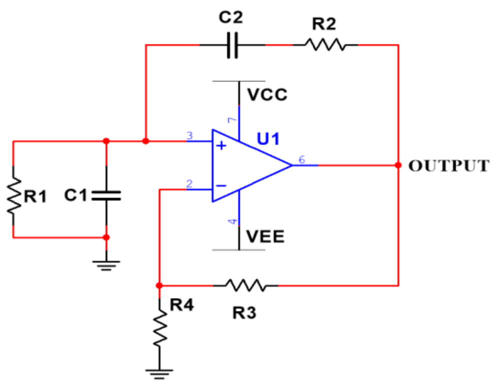

Figure (1): electronic circuit of Wien Bridge Oscillator.

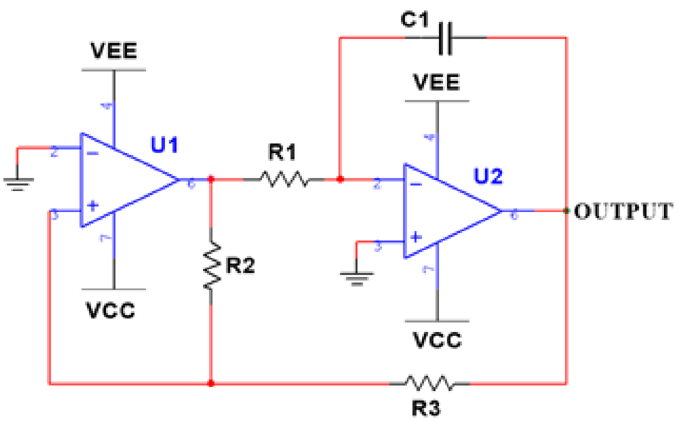

Figure (2): electronic circuit of Triangular Wave Oscillator.

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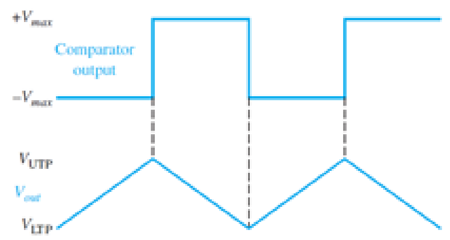

Figure (3): time constant and the frequency of the triangular wave oscillator based on the (R_1,C_1) network waveforms.

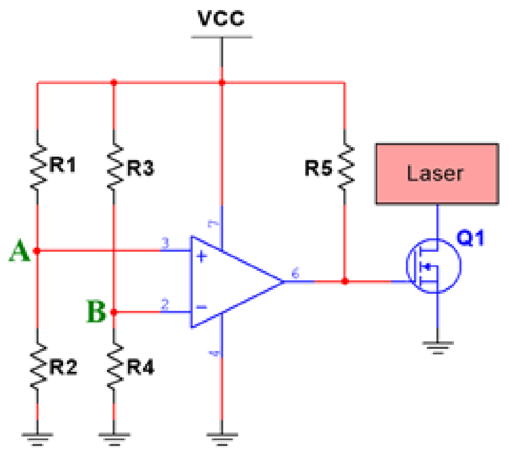

Figure (4): comparator circuit.

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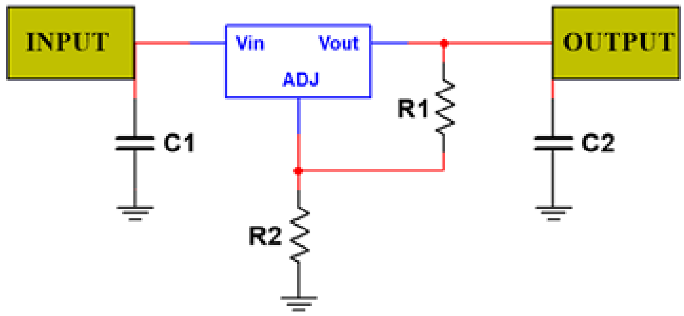

Figure (5): electronic circuit of Adjustable Voltage Regulator.

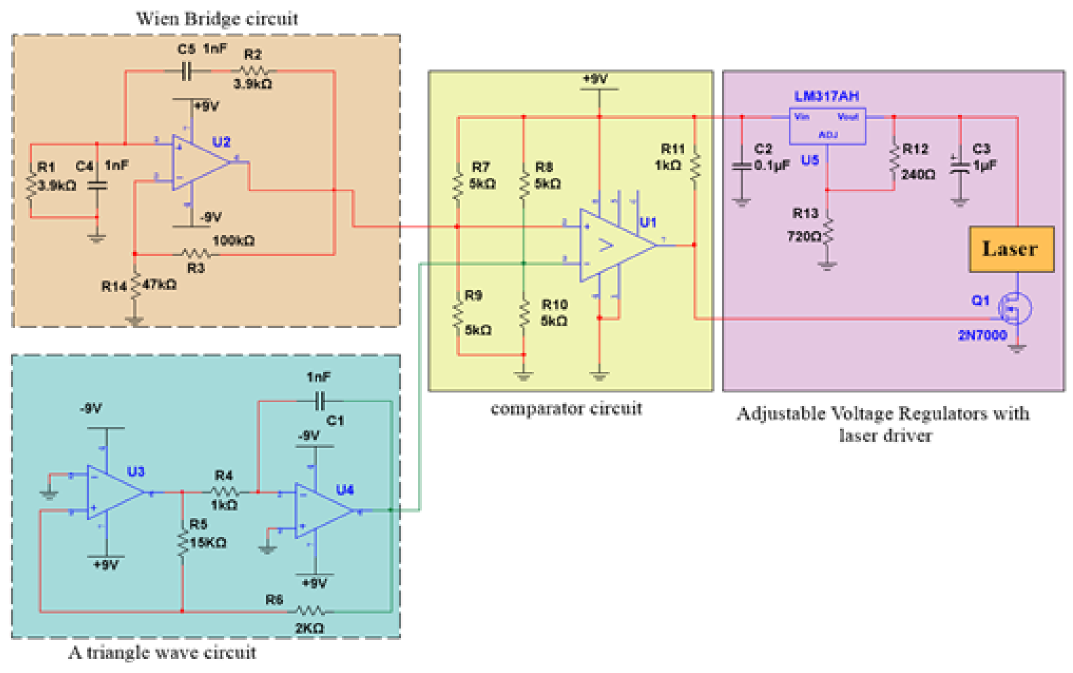

Figure (6): Transmitter circuit of Pulse Width Modulation Generation Based on Laser Using Ultrasonic Frequency.

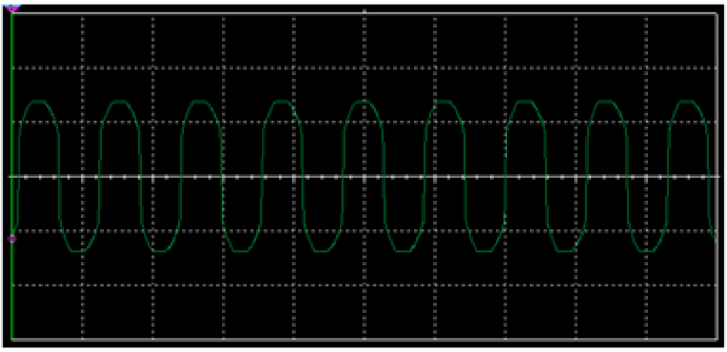

Figure (7): The Multisim ver.14.1simulation program was used.

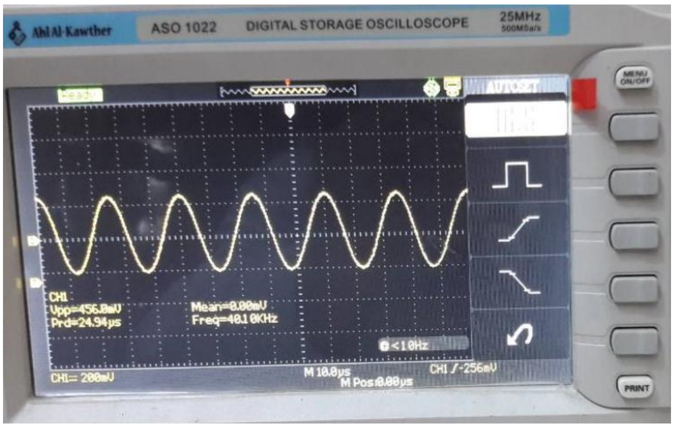

Figure (8): The experiment result 40KHZ of sine wave output.

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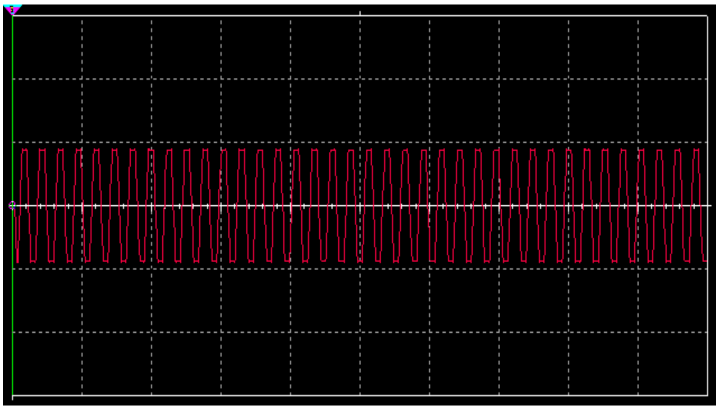

Figure (9): The Multisim ver.14.1 simulation program was used to obtain the 400KHZ output of triangle wave.

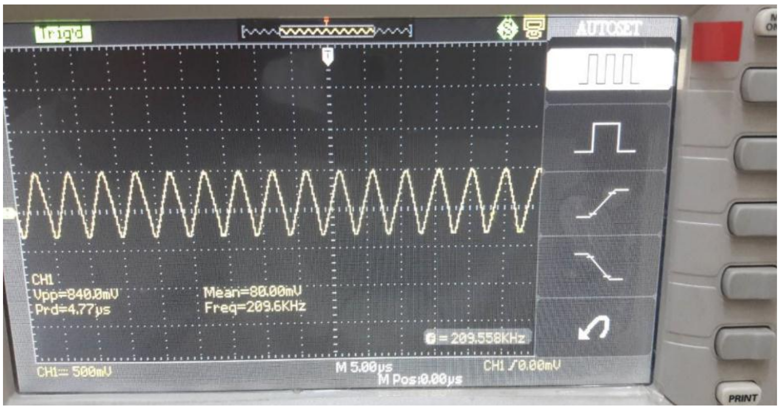

Figure (10): The experiment result of 400KHZ triangle wave output.

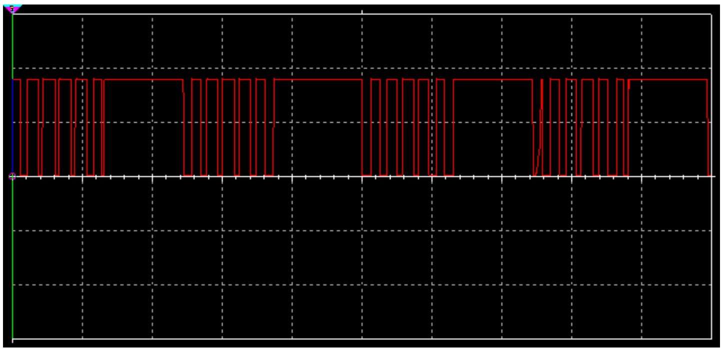

Figure (11): The Multisim ver.14.1 simulation program was used. to obtain the (PWM) wave output.

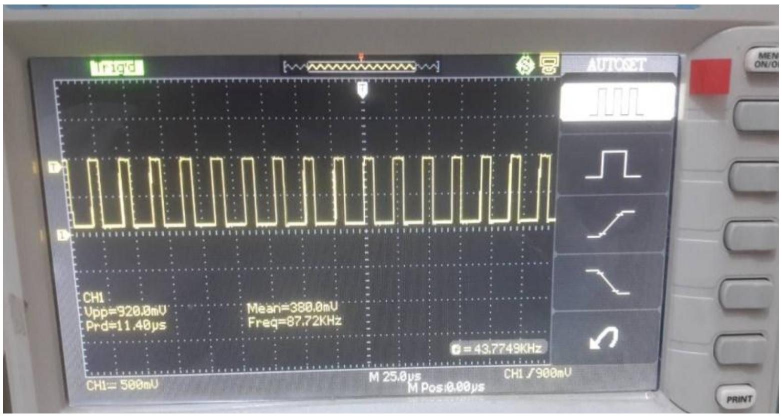

Figure (12): The experiment result of (PWM) wave output.

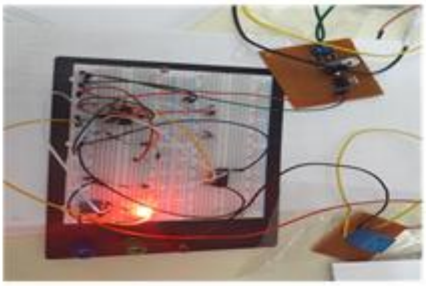

Figure (13): Experiment circuit of Pulse Width Modulation Generation Based on Laser Using Ultrasonic Frequency.