المضمن السمعي البصري

أ . مبروكة مسعود مفتاح ذبان - كلية التربية- قصر بن غشير- جامعة طرابلس
MSc of Nanotechnology and Microsystems
Heriot-Watt University
UK
Email:mabroukadeban@googlemail.com

ملخص البحث :

يوضح هذا البحث كيفية عمل المضمن السمعي البصري (خلية براج), وكيفية تعديل شدة شعاع الليزر مع مرور الوقت, ويوضح الخصائص الأساسية للمعدل الذي يتم قياسه والتي تشمل زاوية براج(θ_B) وسرعة الصوت و دالة نقل قياس الطور واستجابة التردد. يستخدم المضمن الذي يسمى أيضا بخلية براج أو منحرف التأثير لنشر وتحويل تردد الضوء باستخدام الموجات الصوتية (عادة عند التردد الراديوي). وهي تستخدم في الليزر للتبديل Q(مفتاحQ)، والاتصالات السلكية واللاسلكية لتعديل الإشارات، وفي التحليل الطيفي للتحكم في التردد. يتم إرفاق محول كهرومغناطيسي ضوئي إلى مادة مثل الزجاج. تدفع الإشارة الكهربائية المتذبذبة المحول إلى الاهتزاز ، مما يخلق موجات صوتية في المادة. يمكن اعتبار هذه المستويات الدورية المتحركة للتوسع والضغط التي تغير مؤشر الانكسار. ينثر الضوء الوارد قبالة تعديل المؤشر الدوري الناتج والتداخل يحدث مماثل لحيود براج. يمكن اعتبار التفاعل كعملية خلط ثلاثية الموجات مما يؤدي إلى توليد تردد الفرق بين الفونونات والفوتونات.

تقاس سرعة الصوت في المضمن السمعي البصري لتكون (1035.5 ± 26.04)متر/ثانية, وزاوية براج هي (8.15 ± 7.23) ° والتي تحتوي على نسبة خطأ تبلغ حوالي 7.23% مقارنة بزاوية براج في دليل المضمن السمعي البصري و قياس الطور الذي وجد أن عمق التشكيل فيه (93٪).

تم العثور على دالة النقل لتكون مربعة الجيب وهي مطابقة لدالة النقل النظري.

Acoustio- Optic Modulator(AOM)

Abstract

This research investigates how (AOM) work. It is to provide experience in aligning of (AOM), and it is investigates how the intensity of laser beam modulated in time, and it is illustrates the basic properties of the modulator that is measured which include Bragg angle(θ_B), speed of sound, phase measurement transfer function, and frequency response.[1]

The key results which is investigated in this research .

The speed of sound in the (AOM) medium is measured to be (1035.5±26.04) m/s, and Bragg angle is $(8.15\pm7.23)^{\circ}$ which has error percentage about 7.23% error compared with (θ_B) in AOM manual, and the phase measurement which modulation depth is found to be (93%). The transfer function is found to be sine squared which is identical with theoretical transfer function, and the frequency response of AOM in it is -3dB is found to be ≈99kHz.

1- INTRODUCTION:

Acousto-optic modulator (AOM) is useful device that allow the frequency, intensity and direction of a laser beam to be modulated. Within this device incoming light Bragg diffracts off acoustic wave fronts which propagate through a crystal. Modulation of this incoming light can be achieved by varying the amplitude and frequency of the acoustic waves travelling through the crystal.[6]

Acousto-optic modulator (AOM) allow the intensity of light to be controlled and modulated at rates that far exceed mechanical shutters, even up to 70 MHz..

Acousto-optic modulator AOM is widely used to accomplish the frequency control in laser cooling experiments. When the laser frequency is scanned with an AOM, the angle of the first-order diffracted beam shifts as well, since the beam diffraction angle is a function of modulation frequency[2], [3]

Sound waves travelling through a crystal can be modelled as crests of increased refractive index alternating with troughs of decreased refractive index. Light incident on gradients in refractive index is scattered, therefore the light scatters from the acoustic wave fronts. In an AOM the light scattered from successive wave fronts interferes constructively. Note that only some of the light is scattered from these wavefronts. The optical and acoustic wavelengths are denoted by λL and Λ respectively, while θi and θd are the angles the incident and scattered light rays make with the acoustic wavefronts respectively. The condition for constructive interference of the scattered light is

$n\lambda L = \Lambda(\sin\theta i + \sin\theta d)$, (1) where n is an integer [5]

Fig(1) below shows an acousto-optic modulator:

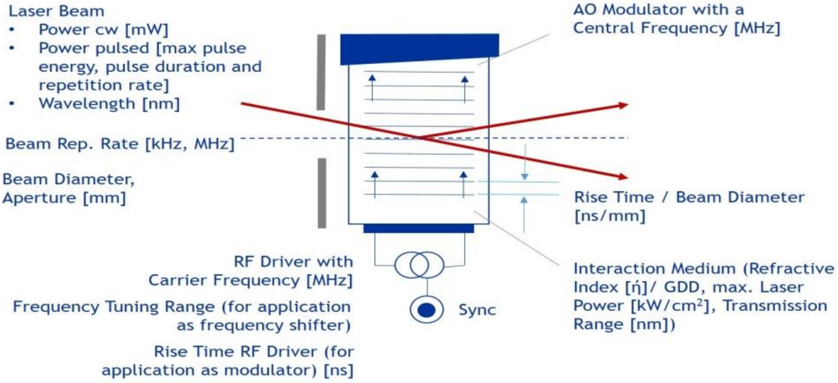

Fig.1 acousto- optic modulator.

2-Research results, and Discussion:

2-1-Aligning the Acoustic-Optic Modulator:

Acoustic – optic modulator is aligned by maximising the laser power that is different into first order m=+1, and by using large area photo diode to measure diffraction efficiency into first order with adjustment the laser.

It is found to be (0.68v)→0.2x2.4=0.68v

And by setting the carrier balance to maximum, and signal generator output to zero.

The first order diffraction is (0.56v)→0.2x2.8=0.56v.

The diffractions efficiency of the first order is

$$\text{1st order efficiency} = \frac{0.56}{0.68} = 0.82 = 82\% \text{ at } 633nm$$

By optimising the angle of AOM include the control of AOM itself, and position of detector, and pinhole.

The diffraction efficiency (0.58volt)

1st order efficiency $=\frac{0.58}{0.68} = 0.85 = 85\%\ at\ 633nm$

Which is identical with value that is given in the coherent (304A°) operating manual which illustrated that the maximum diffraction efficiency is 85%.

This value is compared with second order which is found to be 0.01v

Second order efficiency = $\frac{0.01}{0.68}$ x 100 = 1.47%

The proportion of the original beam that remains un diffracted is 0.09VP_{cB}

$$0.01+0.58 = 0.59v$$

$$\frac{0.09}{0.68} x\ 100 = 13.5\%$$

The effect of reducing (c_B) is that leads to decrease in output power which coupled into the first order diffraction because the output power contains term that dependence only on (c_B) setting which according to transfer function.

$$P = P_{CB} + P_{max}\sin^2(\frac{\pi v}{2})[1]$$

3- Calculations:

3-1- Measurement of sound speed in AOM:

$\sin \theta B = \frac{\lambda}{2An} = \frac{\lambda \omega Rf}{4\pi nv}$

Where ω= 2πf→f= 40MHz, λ= 633nm, n= 1.5

$\tan x/y$ →y = 49cm→ = 490mm, x= 4mm

$\Theta = \tan^{-1}\frac{4}{490} = 0.46$

$\frac{0.46x3.14}{180} = 8.15mrad.$

Due to operation manual of an AOM the value of θ_B is (7.6±0.1)mrad

Error calculation percentage:

Error% $= \frac{thoretical-expermental}{thoretical}$ x100

Error $= \frac{7.6-8.15}{7.6} x100 = 7.23\%$

The speed of sound:

$\Theta_s = \frac{2\lambda f\pi}{4n\theta B\pi} = \frac{\lambda f}{2n\theta B}$=1035.5m/sec

Error calculation

$$\sin\theta \approx \theta = \frac{x}{y}$$

$$\frac{\Delta\theta B}{\theta B} = \frac{\Delta x}{x} + \frac{\Delta y}{y}$$

$$\frac{0.1}{4} + \frac{0.1}{490} \rightarrow \Delta\theta B = 0.205mrad$$

$$\frac{\Delta v}{v} = \frac{\Delta\theta B}{\theta B} \rightarrow \Delta v = \frac{vx\Delta\theta B}{\theta B} = 26.04m/sec$$

$$v = 1035.5 \pm 26.04m/sec$$

3-2-AOM transfer function:

By setting an oscilloscope photo diode input to Dc coupling, and signal generator output to zero, and c_B adjusted then the diffraction power 50%of maximum value.

Thus by setting the signal generator to KHz.

The measurement of compared with theoretical transfer function.

$$P = P_{CB} + P_{max}\sin^2(\frac{\pi v}{2})$$

The fig(2) below shows theoretical measurement of output which is a function of $\sin^2(x)$.

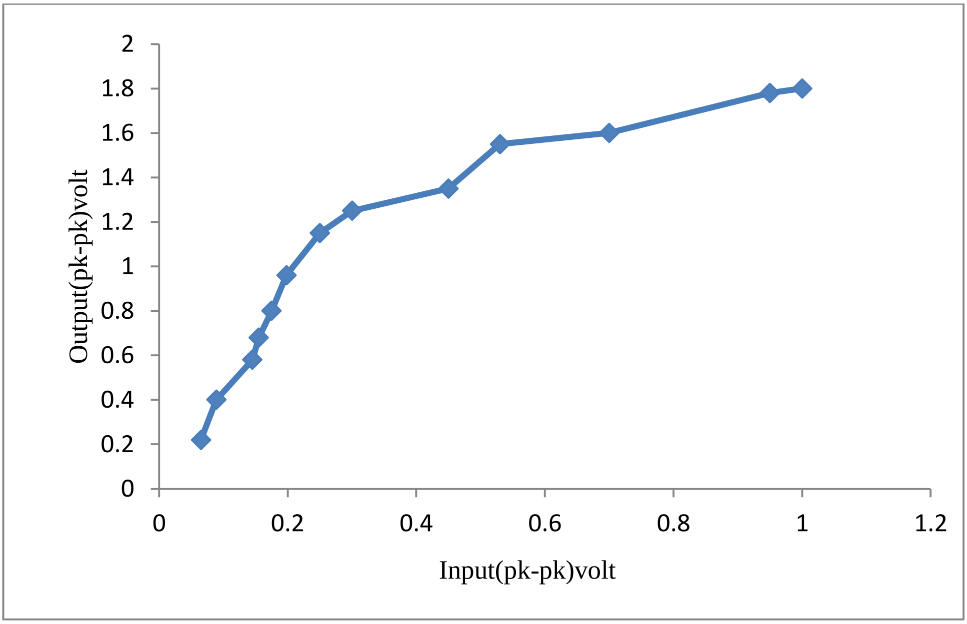

Fig.2 theoretical transfer function.

The fig(3) below shows an experimental measurement of output which approximately like $\sin^2(x)$ function.

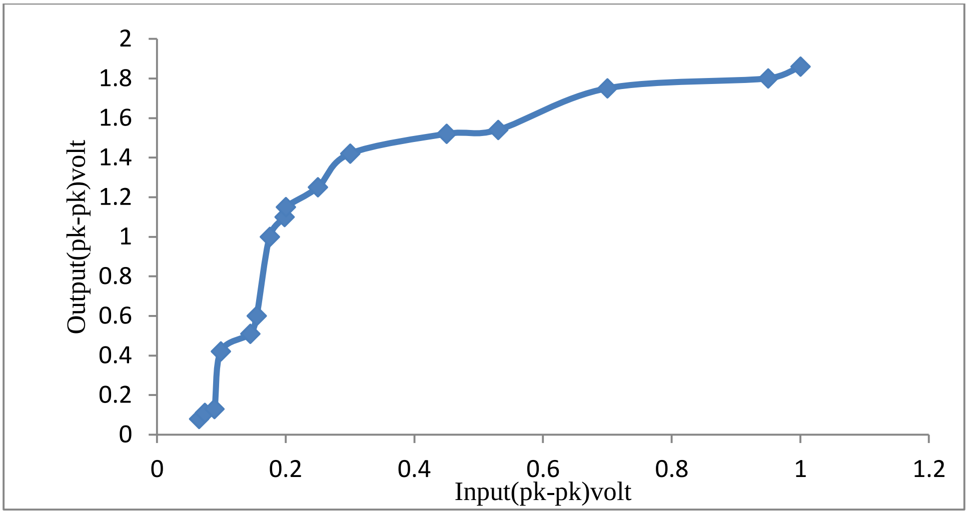

Fig.3 transfer function.

3-3- Phase measurement:

By setting the amplitude of signal generator, and with c_B adjusted to maximum, and by using the fast Bp x 65potodiode then:

Modulation depth = $\frac{vmax-vmin}{vmax+vmin} = \frac{6.2-0.2}{6.2+0.2} = 0.93 \rightarrow 93\%$

3-4-Freqancy response of AOM:

The fig(4) below shows the log of frequency response of AOM.

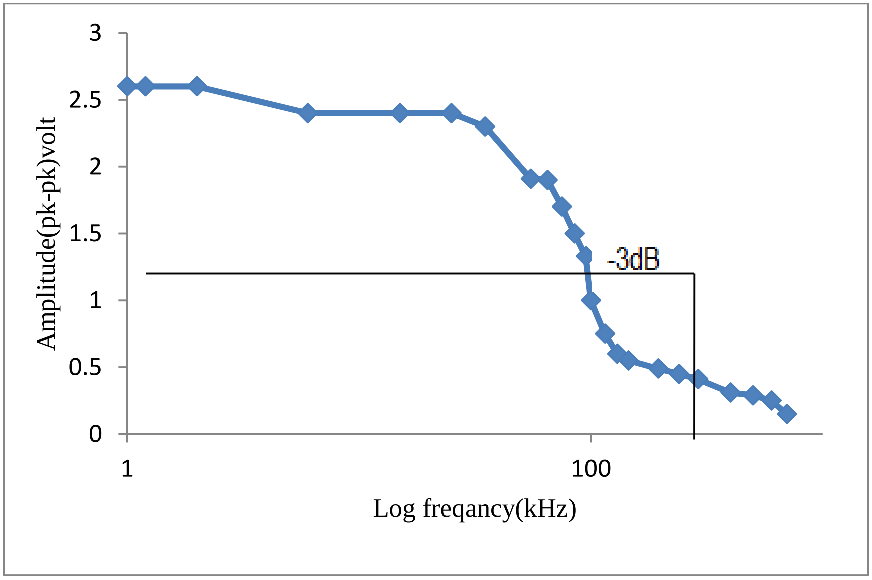

Fig.4 frequency response.

4- Conclusion:

At the end of a research we can conclude that the research illustrated how does an AOM work and, It provided an experience in aligning of (AOM), and it investigated how the intensity of laser beam modulated in time, and it is illustrated the basic properties of the modulator that is measured which include Bragg angle(θ_B), speed of sound, phase measurement transfer function, and frequency response.

The speed of sound in the (AOM) medium is measured to be (1035.5±26.04) m/s, and Bragg angle is $(8.15\pm7.23)^{\circ}$ which has error percentage about 7.23% error compared with (θ_B) in AOM manual, and the phase measurement which modulation depth is found to be (93%). The transfer function is found to be sine squared which is identical with theoretical transfer function, and the frequency response of AOM in it is -3dB is found to be ≈99kHz.

Reference:

[1]-S.D,Smith, Optoelectronic Devices, pp.247-252(prentice- Hall 1995).

[2] Xu J and Stroud R 1992 Acousto-Optic Devices (New York:Wiley).

[3] Handbook of optics. CHAPTER 12 ACOUSTO-OPTIC DEVICES AND APPLICATIONS I. C. Chang.

[4] Goutzoulis A and Pape D 1994 Design and Fabrication of Acousto-Optic Devices (New York: Dekker.

[5] E. I. Gordon. Appl. Opt., 5:1629, 1966.

[6] D. J. McCarron December, 2007 A Guide to Acousto-Optic Modulators.