A new design of Reticle with multi-patterns RMP

Thair Abdulkareem K Al-Aish
University of Baghdad / College of Education Ibn Al-Haitham
Department of Physics

Abstract

In this paper, it has been a new design of Reticle with multi-patterns RMP to detect the laser signals that emitting from targets. The RMP is design using Auto CAD program, which consists of four patterns, each Pattern consists of twenty sectors, ten sectors are opaque and the other ten sectors are transparent for the laser. The number of sectors depends on several factors as chopping frequency of RMP, cutoff frequency of spot laser and modulation transfer function.

All results obtained by design a special program named a "Reticle with Multi-Patterns RMP" which contains many parameters. To explain the impact of changing spot size of laser (As a result of the approaching target), we will change the radius of spot size between (0.1 to 0.6) cm, and then evaluate the best value of MTF which obtained when radius of spot size laser is equal 0.6 cm.

Keywords: Optical Modulator, Chopping frequency of RMP, Spot size laser, cutoff frequency of spot laser, Modulation Transfer Function MTF

Introduction

Disk optical modulator (Reticle) is a mechanical method of repetitively switching electromagnetic EM wave of target on and off. The disc is placed in the path of EM wave which will cause the wave to be periodically interrupted by the blocking part sectors of the disc. Reticle used to modify any characteristic of an EM wave for the purpose of conveying information [1, 2].

In practice it must not exceed the size of Reticle sector at three times the size of spot size of target. The ideal situation, in fact, occur when the dimensions of object image is equal to the dimensions sectors Reticle, but the increase in the volume of object image as a result of the approaching electro- optical system is the real motive behind the reduced dimensions of its image in order to start a third remove sections of Reticle, should not exceeding the dimensions spot dimensions of disk sectors [1,2].

Design of Reticle

The proposed model is used to detect laser signals directed towards specific targets. Theoretically, the best detection are occurs when sectors of the disk is determined periodically when the forms and dimensions similar to the form and dimensions of spot laser, this lead to complete the modulation continues process and reduce the frequency bandwidth occupied by the optical signal to the lowest extent possible, or in other words, reduce the impact of noise to a minimum [1,3]

By using the Auto-Cad program, we have designed a reticle with multi-patterns RMP as shown in Fig (1). RMP is a circular disc which has a radius R equal to 5 cm, consists of 4 patterns. Each pattern is divided to ten transparent and ten opaque sectors (q). The sector is a circle with different radius r as shown in Table 1.

To explain the impact of changing spot size of laser, we will change the radius of spot size between 0.1 cm to 0.6 cm (In order to unify the values of radius for all models) and then evaluate the best value of MTF depending on Eq.3

Result and Discussion

To get work it has been established a special program named a “Reticle with Multi-Patterns RMP " using the Microsoft Visual Basic 2005 contains many parameters as shown in Fig.2 .When calculating the frequency has been converted to units (Rev / s), as well as for angular velocity *w,* The Law of frequency is given by[4,5]:

$$f_r = w / 2\pi \qquad \text{..... (1)}$$

$$f_c = q f_r \qquad \text{..... (2)}$$

Where fc chopping Frequency, fr rotation Frequency and q number of sectors.

The modulation transfer function MTF is calculated for each pattern by using the equation to describe the performance of reticle [6, 7,8,9]:-

$$MTF = \frac{2}{\pi}\left[\arccos\left(\frac{f_c}{f_0}\right) - \left(\frac{f_c}{f_0}\right)\sqrt{1-\left(\frac{f_c}{f_0}\right)^2}\right] \qquad \text{.....(3)}$$

Where: f_0 : is cutoff frequency and defined by $f_0 = \frac{D}{\lambda}$ where D is the diameter of spot laser .

The results that were obtained based on a number of information assumed as shown in Table (1) and By assuming the wavelength of laser emission from source λ=1.06 μm and beginning radius of spot is r = 0.1 cm.

The movement of any section in a circular motion takes approximately 0.0005 seconds that would lead to cut the signal on an ongoing basis every 0.0005 seconds as shown Fig.(3), which represents the relationship between Chopping frequency (for four patterns) and the time.

Tables (2) shows the results of the fc, cutoff frequency f_0 and modulation transfer function MTF which was obtained as a result of changing the radius of spot size from 0.1 cm to 0.6 cm as shown in Fig (3).

Fig (4) shows the best values for the MTF was obtained when the radius of spot size of laser and is equal to 0. 6 cm for all patterns. This is achieved when the radius of the RMP is equal to 0.05 cm, so we will use the first Pattern to detect targets that have low frequencies (about 1000 Hz) while the use of the three patterns to detect targets that have higher frequencies of 1000 Hz and up to cutoff frequency f_0 =113207 Hz.

Conclusion

1- The detectability of RMP realized only for all targets move with chopping frequencies $f_c \leq f_0$.

2- For $f_c > f_0$ the MTF= 0, that means the detectability equal to zero.

3- Complete the modulation continues process and this leads to reduce the impact of noise to a minimum.

4- Access to the regular signal and nearly constant frequency.

5- When approaching the targets from the RMP, the Spot size increases (that means a change in radius of spot) and this leads to improved values of MTF.

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Table (1): The data of Reticle Multi-Patterns RMP

State	Pattern 1	Pattern 2	Pattern 3	Pattern 4
Radius of Pattern cm	5	3.5	2.5	1.7
Radius of Circle(q) cm	0.785	0.549	0.392	0.256
Time sec	0.01	0.01	0.01	0.01
Number of sector	20	20	20	20
Angle of sector	18^0	18^0	18^0	18^0
Circumference of pattern cm	31.4	21.98	15.7	10.6
Circumference of circle (q) cm	4.929	3,447	2.46	1.6
Area of pattern cm^2	78.5	38.46	19.62	9.07
Area of Circle(q) cm^2	1.934	0.946	0.48	0.205
Angular velocity rad/sec	628	897.1	1256	1847.05
Rotational frequency Hz	100	142.85	200	294.11
Chopping frequency Hz	1000	1428.5	2000	2941.1

(2): The results of the fc, cutoff f_0 frequency and modulation transfer function MTF when changing the radius of spot.

Radius of Spot (cm)			0.1	0.2	0.3	0.4	0.5	0.6
f_0(Hz)			18867	37735	56603	75471	94339	113207
Pattern	*R(cm)*	Fc(Hz)	MTF1	MTF2	MTF3	MTF4	MTF5	MTF6
1	5	1000	0.933	0.966	0.978	0.983	0.987	0.989
	4.7	1063	0.928	0.964	0.976	0.982	0.986	0.988
	4.4	1136	0.923	0.962	0.975	0.981	0.985	0.987
	4.1	1219	0.918	0.959	0.973	0.980	0.984	0.986
	3.8	1315	0.911	0.956	0.970	0.978	0.982	0.985
2	3.5	1428	0.904	0.952	0.968	0.976	0.981	0.984
	3.3	1515	0.898	0.949	0.966	0.975	0.980	0.983

	3.1	1612	0.891	0.946	0.964	0.973	0.978	0.982
	2.9	1724	0.884	0.942	0.961	0.971	0.977	0.981
	2.7	1851	0.875	0.938	0.958	0.969	0.975	0.979
3	2.5	2000	0.865	0.933	0.955	0.966	0.973	0.978
	2.3	2173	0.854	0.927	0.951	0.963	0.971	0.976
	2.1	2380	0.840	0.920	0.947	0.960	0.968	0.973
	1.9	2631	0.823	0.911	0.941	0.956	0.965	0.970
4	1.7	2941	0.802	0.901	0.934	0.950	0.960	0.967
	1.5	3333	0.776	0.888	0.925	0.944	0.955	0.963
	1.3	3846	0.742	0.870	0.914	0.935	0.948	0.957
	1.1	4545	0.696	0.847	0.898	0.923	0.939	0.949

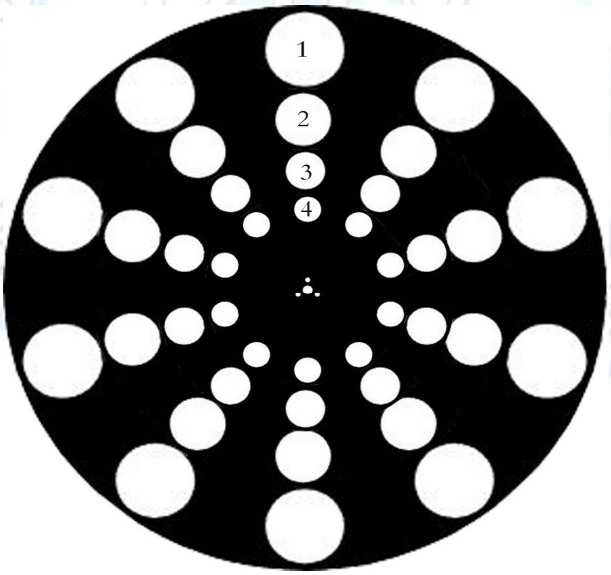

Fig (1): The Reticle with Multi-Patterns RMP

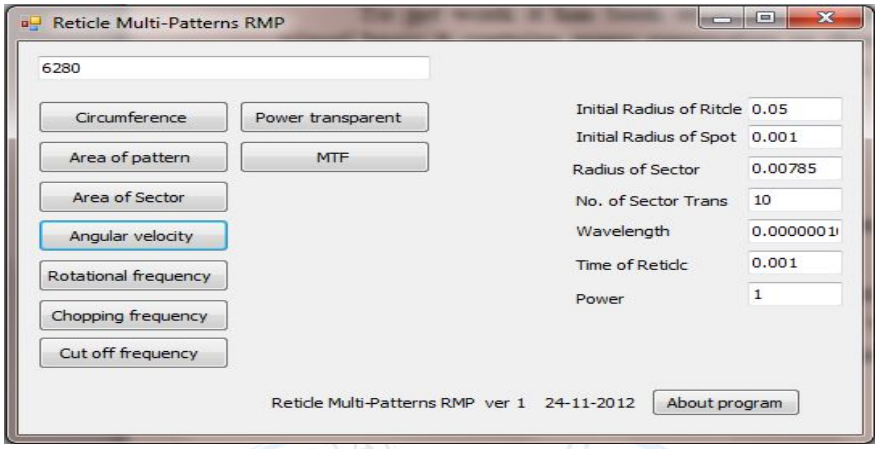

Fig. (2) The interface of Reticle with Multi-Patterns RMP program

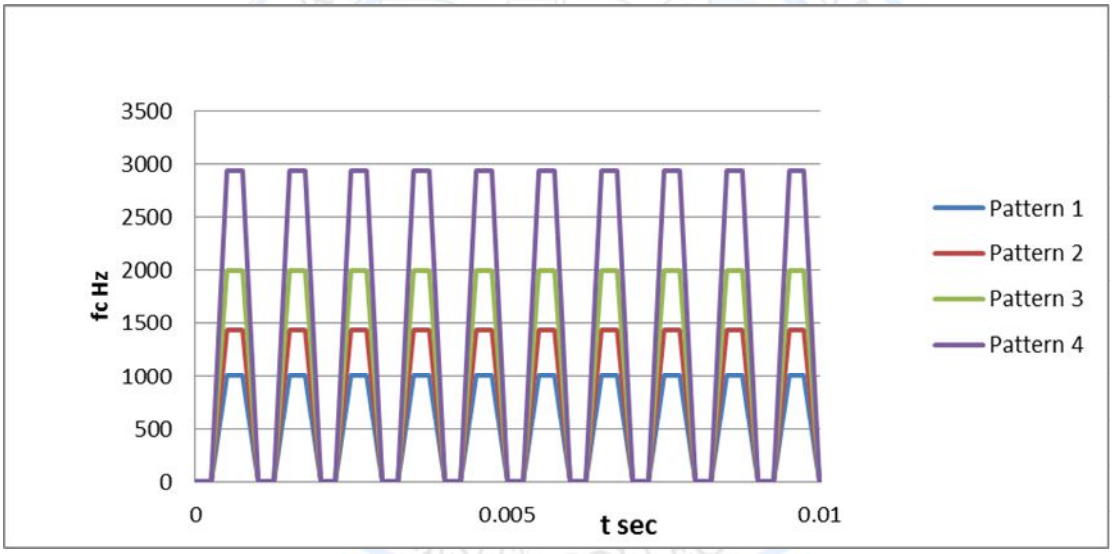

Fig (3): The relation between chopping frequency versus time

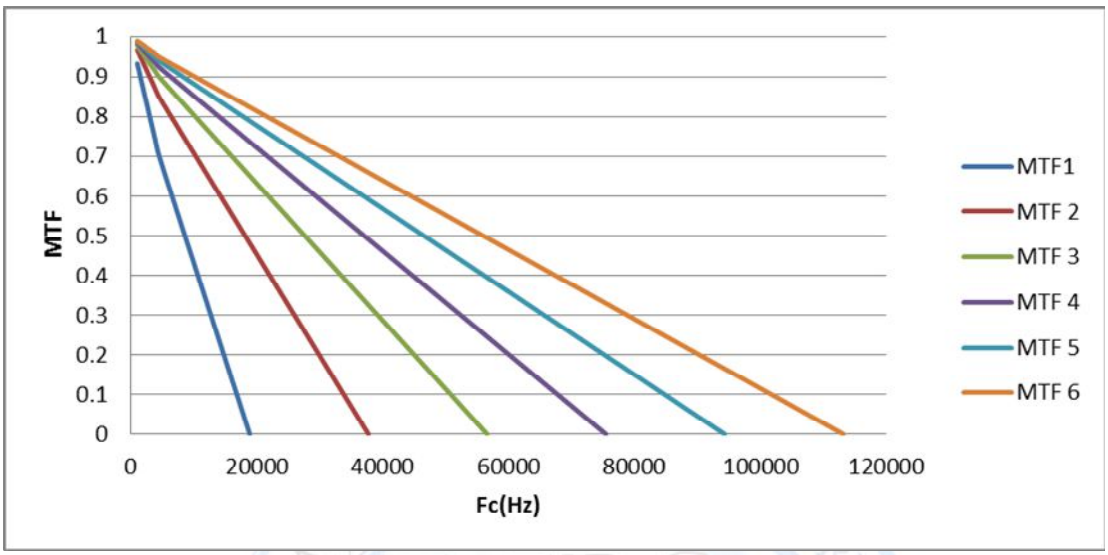

Fig (4): The MTF versus f_c with changing spot size laser

تصميم جديد للمضمن المتعدد الأنماط RMP

ثائر عبد الكريم خليل العايش

قسم الفيزياء -كلية التربية ابن الهيثم – جامعة بغداد

الخلاصة

في هذا البحث وضعنا تصميم جديد للمضمن (الريتكل) المتعدد الانماط RMP للكشف عن الاشارات الليزرية المنبعثة من الاهداف.الـ RMP صمم باستعمال برنامج الأوتوكاد ، الذي يتألف من اربعة نماذج ، وكل نموذج يتألف من 20 مقطع ,عشرة منها معتمة والاخرى نافذة لضوء الليزر. ان عدد المقاطع يعتمد على عدة عوامل مثل تردد القطع للمضمن والبقعة الليزرية ، ودالة الانتقال الضمني.

جميع النتائج استحصلت بواسطة انشاء برنامج خاص اسميناه برنامج المضمن المتعدد الانماط RMP والذي يحتوي العديد من البارامترات. ولتوضيح تأثير تغير حجم بقعة الليزر (نتيجة اقتراب الاهداف) سنقوم بتغيير نصف قطر بقعة الليزر بين (0.1 - 0.6) سم ومن ثم حساب افضل قيمة لدالة الانتقال الضمني والتي تم الحصول عليها عندما يكون نصف قطر بقعة الليزر 0.6 سم.

كلمات مفتاحية: التضمين البصري ، تردد القطع للريتكل، تردد القطع لبقعة الليزر، حجم بقعة الليزر ، دالة الانتقال الضمني