The Effect of Angular velocity of Reticle on the Optical Modulation Transfer Function

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Abstract

In this paper it has been design a Reticle with Dual-Pattern RDP by using Auto-Cad program as. RMP is a circular disc which has a radius R equal to 6 cm, consists of two patterns. The first pattern (r=6 cm) is divided to 60 transparent and 60 opaque sectors (q). The second pattern(r=3 cm) is divided to 15 transparent and 15 opaque sectors.

To explain the impact of changing angular velocity, it has been a set up circuitry for using the photodiode. The results obtained by establishment of a special program named "Reticle with Dual-Patterns RDP "using the language Microsoft Visual Basic 2005 contains many parameters. This paper proposed a new method to generate wide range frequencies by control the angular velocity of reticle RDP by the motor, and it is very important to get the proper frequency detector. The results obtained showed that reticle RDP work with high performance when the value of MTF still maintain fixed rates, also the optimal value of MTF is obtained at low chopping frequency.

Keywords: Reticle, Angular Velocity, Optical Modulator, Chopping frequency, The Modulation Transfer Function MTF

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تأثير السرعة الزاوية للريتكل على التضمين البصري

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الخلاصة

في هذه البحث تم وضع تصميم لريتكل ثنائي النموذج RDP باستخدام برنامج الأوتوكاد. RDP عبارة عن قرص دائري ذو نصف قطر 6 سم ويتألف من نموذجين . الأول (r=6 cm) ينقسم الى من 60 نافذ و 60 مقطع مظلم (q). النموذج الثاني (r=3cm) ينقسم الى من 15 نافذ و 15 مقطع مظلم.

لتوضيح تأثير تغير السرعة الزاوية انشأنا دائرة تستعمل ثنائي ضوئي . النتائج المتحصلة كانت بواسطة انشاء برنامج خاص اسميناه Reticle with Dual-Patterns RDP باستعمال لغة مايكروسوفت فجوال بيسك 2005 يحتوي عدة بارامترات.هذا البحث يقترح طريقة جديدة لإنتاج مدى واسع من الترددات عن طريق التحكم بالسرعة الزاوية للريتكل RDP بواسطة المحرك وهي مهمة جدا للحصول على التردد المناسب للكاشف.النتائج المستحصلة بينت بان الريتكل RDP يعمل بكفاءة عالية عندما تحافظ دالة التضمين البصري MTF على معدلات ثابتة ، كذلك فان افضل قيمة لل MTF تم الحصول عليها عند الترددات الدورانية الواطئة .

كلمات مفتاحية: الريتكل ،السرعة الزاوية،التضمين البصري ، تردد القطع، دالة الانتقال الضمني

Introduction

The main part in the electro- optical tracking systems, which use to determine the target locating is mechanical modulator (Reticle) [1].

Reticle produce forms of modulation that allows various instruments to differentiate objects or targets from their backgrounds and to produce appropriate signals that make possible a variety of applications, from measurement to guidance [2].

Reticle Design

The optical modulation disk is often used in the electro- optical tracking systems as optical filter for background discrimination. The design and movement of the Reticle is to enhance the object and suppress the background. The detect a point source in its environment refers to the efficiency of the Reticle [2,3].

The frequency of the interruption depends upon the angular velocity of the Reticle and the pattern of openings. The Reticle pattern is determined by the requirement of the Reticle system. The Reticle pattern will generate a modulated output detector system signal consisting of square wave with frequency corresponding to the spinning rate times the number of transparent sectors. [4,5].

In this paper, it has been designed a Reticle with Dual-Patterns RDP by using Auto-Cad program as shown in Fig (1). RMP is a circular disc which has a radius R equal to 6 cm, consists of two patterns. The first pattern (r=6 cm) is divided to 60 transparent and 60 opaque sectors (q). The second pattern(r=3 cm) is divided to 15 transparent and 15 opaque sectors. The data of dual patterns are shown in Table 1.

By assuming the incident laser He-Ne is a perpendicular to the modulator which is moveable in a circular form. Hence the laser beam will make discrete circles according to the number of sectors and angular velocity of RDP. To explain the impact of changing angular velocity it has been a set up circuitry for using the photodiode in the photovoltaic mode. Fig.2 shows the location of reticle in optical system. The photodiode operates as a photovoltaic detector. The reticle is mounted on the electric motor. When it rotates, it chops the light. That is, it periodically blocks the He-Ne laser from reaching the detector. The speed of the motor should be adjusted So that the output frequency is within range of the detector. The load resistor should be much smaller than the value of the shunt resistance of the photodiode. The output of the circuit will be hooked to the input of the oscilloscope. Then insert the power meter into the laser beam in front of the photodiode and measure the power in the beam.

The Implementation Result and Discussion

Obtained the results of this work through the establishment of a special program named " Reticle with Dual-Patterns RDP " using the language visual basic 6 contains many parameters and as shown in Fig (3). 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

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

$$fc = qfr \qquad \qquad \text{.……… (2)}$$

Where f_c chopping Frequency, f_r rotation Frequency and q number of sectors.

The modulation transfer function MTF is a measure of the transfer of modulation from the subject to the image. In other words, it measures how faithfully the modulator reproduces (or transfers) detail from the object to the image. MTF is calculated for each pattern by using the equation to describe the performance of reticle [6, 7,8,9]:-

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

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 the results of the angular velocity *w, fc, f₀* and MTF when changing the periodic time T are shown in Table 2.

First, draw a relation between the angular velocity *w* and Chopping frequency *fc* with Periodic Time depending on data in Table(1), we got the curve shows the inverse relation between angular velocity and periodic time as shown in Fig*(4).* Where the values of the angular velocity of the first model is greater than the second pattern about 7133 when T=0.01 sec (due to different radius), that's lead to generate a wide range of rotation frequency. Since the reticle RDP consist of multi pattern with different sectors , therefore, the maximum value

of chopping frequency greater than the maximum value of the rotation frequency of q times and that is identical with the e*q(2)*.Fig(5) shows directly relation between chopping frequency and angular velocity.

In other words, could generate wide range frequencies by control the angular velocity of the disk by the motor, and it is very important to get the proper frequency detector. Thus we were able to detect laser signals, taking into consideration the cutoff frequency of laser source.

Finally, we evaluate the modulation transfer function MTF by using   eq (3). By drawing the relationship between MTF and chopping frequency fc, we got the behavior of MTF. Fig(6) shows that the MTF curve is decreased with increasing frequency, but still maintain fixed rates, this means that the reticle RDP work with high performance.

Conclusions

1. It possible to generate a wide range frequencies by control the angular velocity of the disk by the motor, and it is very important to get the proper frequency detector

2. If $f_c \leq f_0$, the reticle RDP work with High-performance work to produce a wide range of frequencies that are within the limits of the response of detector

3. The reticle RDP work with high performance when the value of MTF still maintain fixed rates.

4. The optimal value of MTF is obtained at low Chopping frequency.

5. It possible to design multi propos of modulator depending on multi- patterns.

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Table (1): The data of Reticle with Dual-Patterns RDP

state	Pattern 1	Pattern 2
Radius of Pattern cm	6	3
Number of sector	120	30
Angle of sector	3^0	12^0
Circumference of pattern cm	37.68	18.84
Circumference of sector (q) cm	0.314	0.628
Area of pattern cm^2	113.04	28.26
Area of sector(q) cm^2	0.942	0.942
cutoff frequency f_0(Hz)	113207	
Wavelength of laser λ (μm)	1.06	
Radius of Spot size laser (cm)	0.6	

Table (2): The results of the angular velocity _w_, fc, f_0 and MTF when changing the Periodic Time T.

| Periodic Time T(sec)	Pattern 1				Pattern 2			
	w(rev/sec)	fr(Hz)	fc(Hz)	MTF	w(rev/sec)	fr(Hz)	fc(Hz)	MTF
0.01	10466	1666	100000	0.9912	20933	3333	50000	0.9818
0.02	5233	833	50000	0.9959	10466	1666	25000	0.9912
0.03	3488	555	33333	0.9974	6977	1111	16666	0.9943
0.04	2616	416	25000	0.9982	5233	833	12500	0.9959
0.05	2093	333	20000	0.9987	4186	666	10000	0.9968
0.06	1744	277	16666	0.9990	3488	555	8333	0.9974
0.07	1495	238	14285	0.9992	2990	476	7142	0.9979
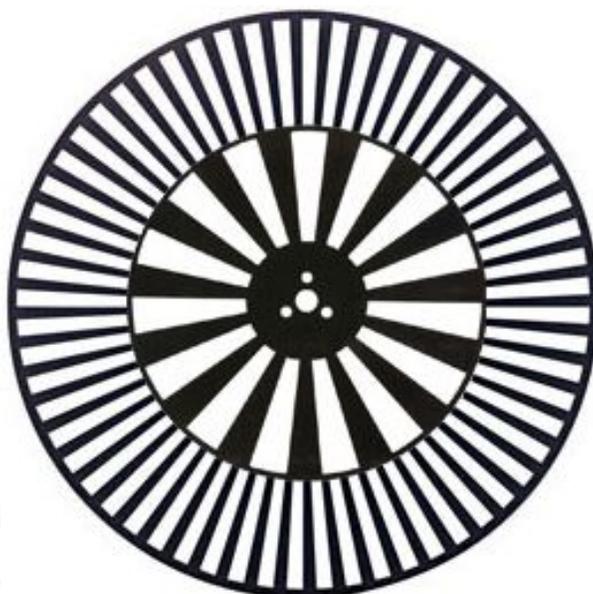
Fig(1): The Reticle with Dual-Patterns RDP.
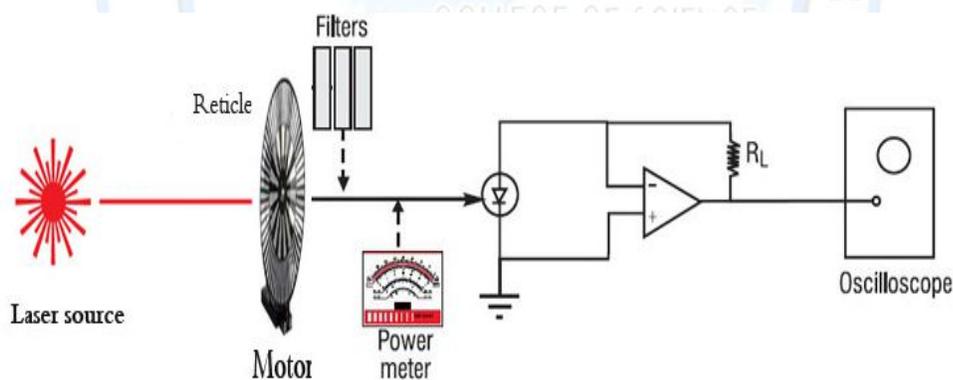
Fig (2): The location of reticle in the optical system

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Transfer Function

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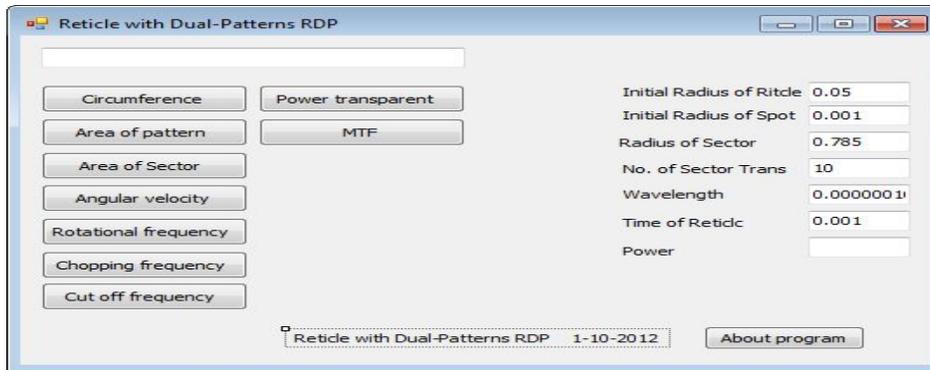

Fig.(3) The Reticle with Dual-Patterns RDP Program
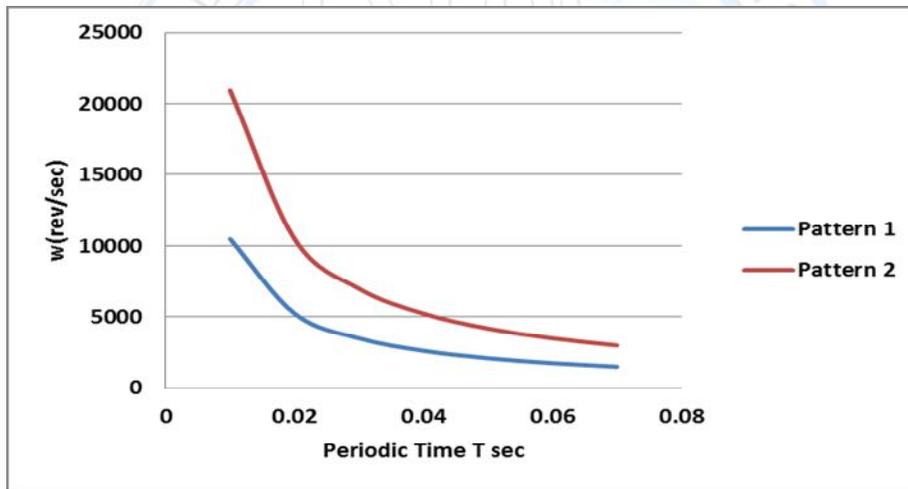
Fig(4) :The relation between angular velocity *w* versus Periodic Time T(sec)
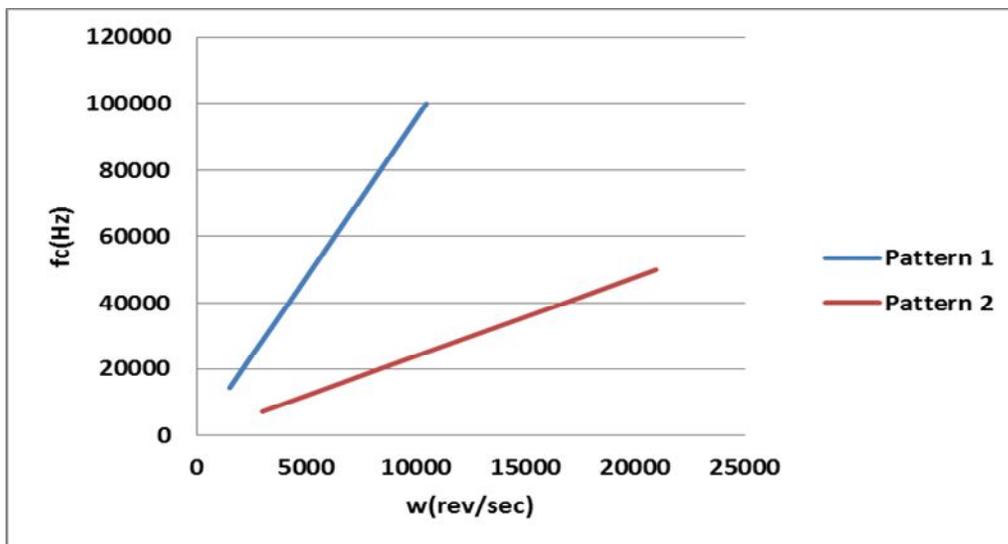
Fig(5) :The relation between Chopping frequency fc versus angular velocity
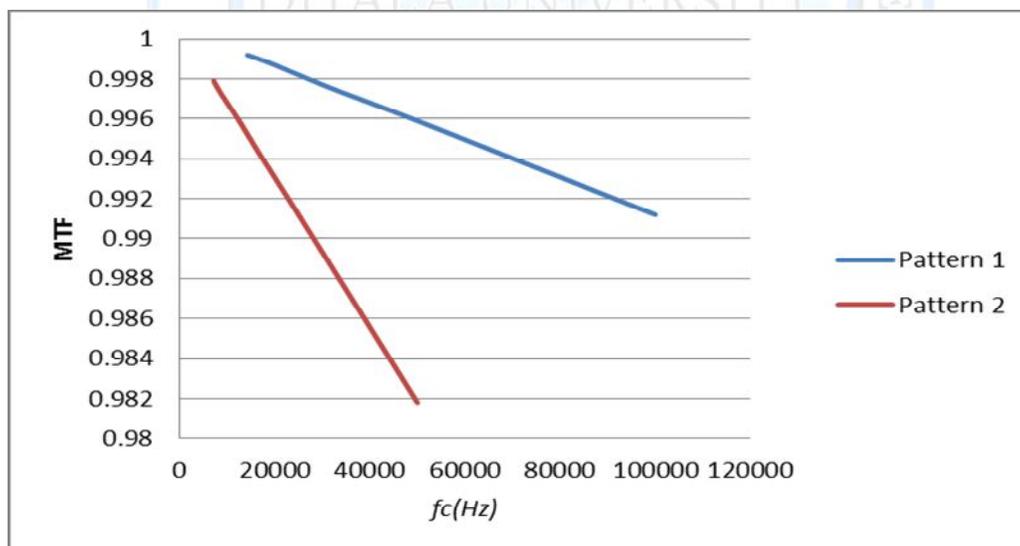
Fig(6) :The relation between MTF versus Chopping frequency fc