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Review Paper

Evaluate the Effective of Annular Aperture on the OTF for Fractal Optical Modulator

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The fractal optical modulator is the optical modulator design by using the fractal function. As well known there is an effect of aperture's shape on the OTF signal for optical modulator. In present paper an aberration-free single annular aperture has used and the MTF characteristics responses investigate for fractal optical modulator of IR-Seeker .The annular aperture provide several frequency transmission bands within the region up to cut-off frequency. The result compared with the spatial frequency for circular shape of fractal optical modulator aperture.

Keywords: Annular Aperture, OTF, Fractal Optical Modulator,

INTRODUCTION

The optical modulator is an important device in optical system for guide and control .This device create a frequency which depend on type ,pattern and area (size) of the modulator.

The optical transfer function (OTF) curve has a relation with area of an aperture. If we have full aperture the broad frequency response peak will be near the cut-off frequency (Rteel, 1953).

The literature view of using annular aperture as follow:

1-The OTF for an annular aperture with a spherical aberration was treated by (Barakat and Houston, 1965)].

2- (Welford, 1960)], investigated the effect of increasing the depth of focus in such a type of aperture.

3-The single annular aperture is probability the simplest modified aperture. Kyung Hee Hong was found the characteristics of the OTF of Double annular aperture (Kyung Hee Hong And Sang Soo Lee, 1980), he studied the amplitude distribution the image field is given by the amplitude due to the full aperture minus

the amplitude due to the inner circular aperture.

Define the Shape of Annular Aperture

The annular aperture (AA) defined by using the reduced parameters r_0 , r_1 & r_2 the radii of the circles on the aperture. $r_1=3.5\text{cm}$ the radius of the full circle of aperture. $r_0 =1.4\text{cm}$ the radius of annular area (the oblique area 42.8%) and $r_2=2.1\text{cm}$ is the radius of transmuted area of the aperture (57.2%) as shown if fig.(4-A) .

Fractal Optical Modulator

It is an optical modulator (disk) design by using a fractal function . There are different type of fractal modulator , we choose one of them whose designed by the reference (Jebbar, 2007) which is single pattern of AM modulation ,

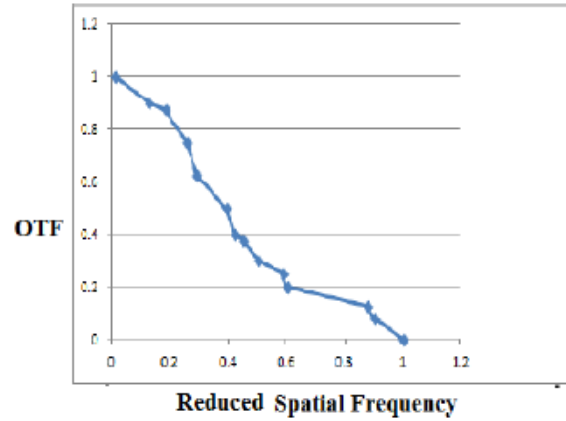


Fig.(1) OTF for full area of aperture

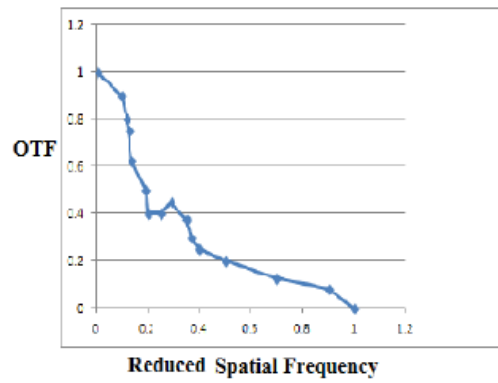


Fig.(2) OTF for Annular aperture 42.8% area from full aperture

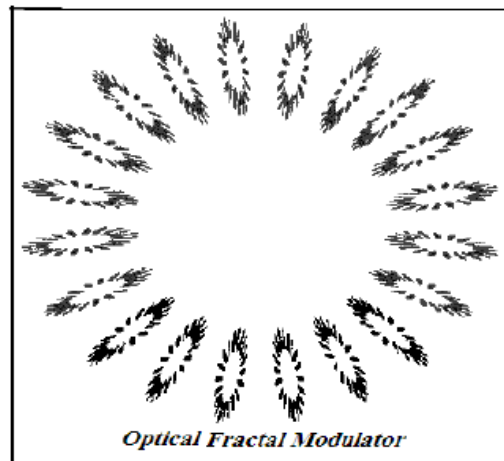
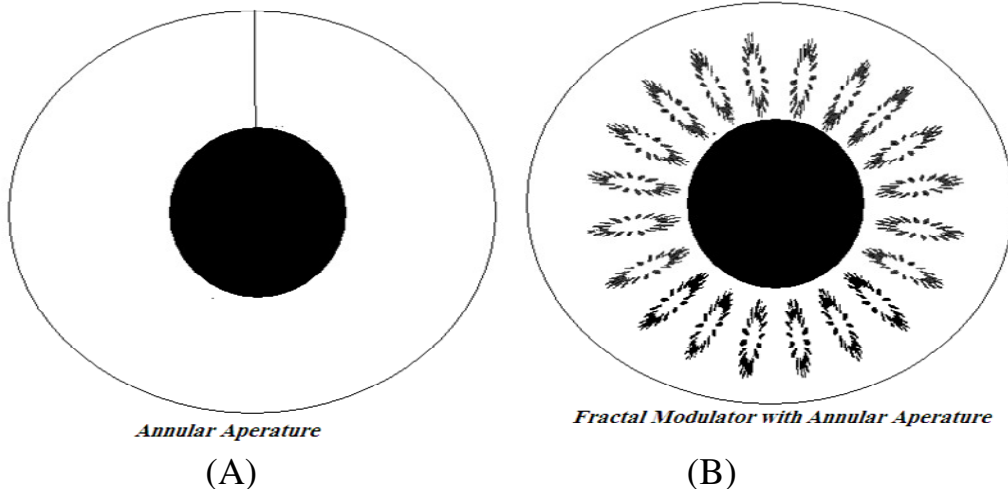


Fig. (3) Optical Fractal Modulator

it assumed the size of the modulator is same size of full annular aperture (7cm diameter, it means 3.5 cm radius).The radius of inner oblique area is 1.5cm and outer radius (transmitter area) is 2cm as shown in fig.(3).

In fig.(4-B) shows the fractal modulator with annular aperture in front of it.

Some time there will be a condensing lenses between the aperture and the modulator.



Fig(4) A- Annular aperture B-Fractal modulator with annular aperture

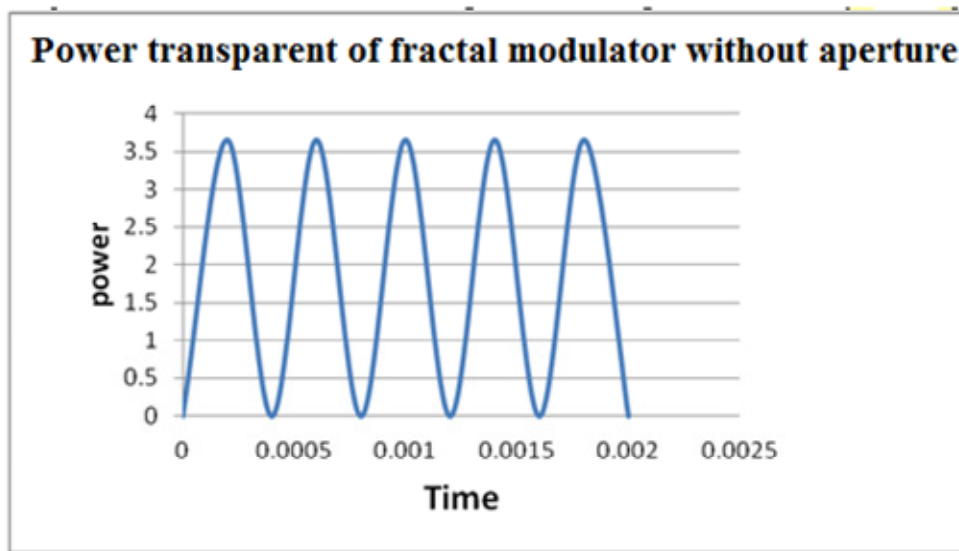


Fig (5). Power transparent of fractal modulator without annular aperture

A short idea about fractal design is let we have an element (single line) it's length (L) divided in to (N) pieces, each piece has a length (K), so The Fractal dimension (D) equal (Razak and Ahammed, 2008) to :

$$D = \frac{\log(N)}{\log(L/K)} \dots\dots\dots(1)$$

By using Iterated Function System (IFS) "it is a method of constructing fractals" for the dimension of the element

(D) to get the new design of fractal function modulator pattern .in order to generate the fractal pattern , let we have (x,y) mapping space of a matrix , so the f(x) will represents all the points of the space . If the matrix (W_i for i=1,2,3,...m) then :

$$W_i(x) = w \begin{pmatrix} x_i \\ y_i \end{pmatrix} = \begin{pmatrix} a_i & b_i \\ c_i & d_i \end{pmatrix} \begin{pmatrix} x_i \\ y_i \end{pmatrix} + \begin{pmatrix} e_i \\ f_i \end{pmatrix} \dots\dots(2)$$

$$\therefore W_i = A_i X_i + T_i \dots\dots\dots(3)$$

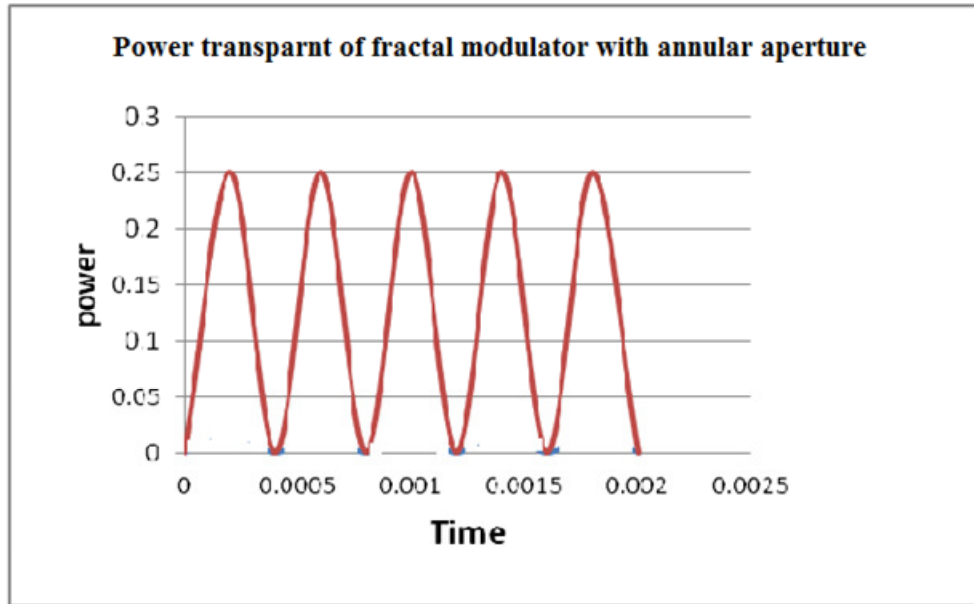


Fig 6. Power transparent of fractal modulator with annular aperture

By these sets production operation can be obtain of all points in sum operation of two linear transformation.

Evaluation of OTF and MTF (Kyung Hee Hong And Sang Soo Lee, 1980)

The OTF or it's modulus the modulation transfer function (MTF) is used as an objective means for assessing and specifying the imaging quality of optical & electro-optical system.(thermal or visible) .

For a given distribution of intensity in the object plane of modulator can be considered as series of superimposed sine wave grating distribution of intensity of different periodicities , phases and amplitudes

This defined as the Fourier transform of the point spread function or impulse response of the optics and it give the criteria, such as contrast, sensitivity and resolution .

If the optical transfer function of the system is real and non-negative, the optical transfer function is equal to modulation transfer function (MTF) by definition . Also the relative contrast is given by the absolute value of the OTF, a function referred to as the (MTF). On other hand when the pattern translation is also important .

We consider intensity distribution $f(u)$ where (u) is a distance in object plane , and this can be expressed as:

$$f(u) = \int_{-\infty}^{\infty} F(v) e^{2\pi i v u} dv \dots\dots\dots(4)$$

Where $F(v)$ is a complex function which gives the amplitude and phase of sine wave component of spatial frequency (v) .

The distribution of intensity in the image plane $f'(u)$ can be built up from sine wave in the same way as a function $F'(v)$

The complex valued optical transfer function can be seamed as a combination of these valued function

$$OTF (v) = MTF (v) e^{iPhTR(v)} \dots\dots\dots (6)$$

where $MTF (v) = | OTF(v) |$

The definition of transfer function, should indicate the fraction of light that was detected from the point source object. However, typically the contrast relative to the total amount of detected light is most important. It is thus common practice to normalize the optical transfer function to the detected intensity, hence

$$MTF(\nu) \equiv 1.$$

$$MTF = \int f(u) e^{2\pi \nu u} du \dots\dots\dots(7)$$

The MTF is then plotted against spatial frequency and all relevant data concerning , can be determined from that graph.

DISCUSSION AND CONCLUSION

By using annular aperture with optical fractal modulation we found:

- 1-The case give us more accuracy result especial the optical modulator which has a centre oblique area, (such as our case).
- 2-The difference between OTF of full aperture fig(1) and annular aperture fig (2) is in the behavior of OTF curve for full aperture is more smoothly than annular one, (for same reduced spatial frequency) because of the central oblique area .
- 3-In fig (5 &6) the power transparent has been evaluated for both cases (Fractal modulator without annular aperture and with it respectively), for same interval time. We note that the different between them is in annular aperture the power is limited but more specific (because less aberration) .

4-The advantage of using annular aperture with optical modulator is avoided the noise that generated in the centre of the modulator and it applied in some optical system (guide and control system) such as Laser & IR Seeker.

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