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Study and Analyzing the Circular Dish Radar Antennas Pattern

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Abstract: In this paper we discuss analysis and synthesis techniques for planar circular arrays usable in passive HF target ranging. The elements geometries are assumed and analyzed for the array. The frequencies of the bands are taken as; S-band (2 and 4) GHz, C-band (5 and 8) GHz and X-band (9 and 12.4) GHz. The frequencies are taken for the initial and terminal of the specified bands. The circular dish array antenna was used to study the three - dimensional array radiation pattern for circular aperture with diameter (0.3m) at a given wavelength. Linear and polar array radiation patterns were analyzed. It was noted that the number of side lobes increases either by increasing element spacing or by increasing operating frequency. In array design, the positions of sparse array elements is an important concern for optimal performance A new and very fast low-side lobe pattern synthesis method for planar array antennas with periodic element spacing is described.

Keywrods: Radar Antenna Frequencies, Matlab Computer Program

I. INTRODUCTION

The word RADAR is an abbreviation for Radio Detection and Ranging which tends to suggest that it is a piece of equipment that can be used to detect and locate a target. Radar's function is intimately related to properties and characteristics of electromagnetic waves as they interface with the targets, then it reflect waves back by an obstacle in its path. The words antenna and aerial are used interchangeably; but usually a rigid metallic structure is termed an antenna and a wire format is called an aerial [1].

II. MATERIAL AND MEATHOD

A: Array Antenna

Study the basic principle of array antenna synthesis techniques and show the radiation patterns of several array antennas. An array antenna may be linear, circular, or elliptical (rectangular). The array antenna may consist of fewer than ten elementary radiating sources arranged in a line or tens to thousands arranged on a planar grid. These elementary radiating sources can be arranged in a linear array, a circular aperture, or an elliptical (or rectangular) aperture [2].

B: Circular Dish Antenna Pattern

Figure (1) shows the geometry associated with a circular aperture. Denote the aperture radius as r. A far field observation point p is defined by range R and angular position (β, φ). Due to the circular nature of the aperture, it is more convenient to adopt cylindrical coordinates. It follows that [3]:

$$E(\beta,\emptyset) = \int^{r} \rho d\rho \int^{2\pi} e^{jk\rho \sin\beta \cos(\emptyset-\acute{\emptyset})} d\acute{\emptyset}$$

(1)

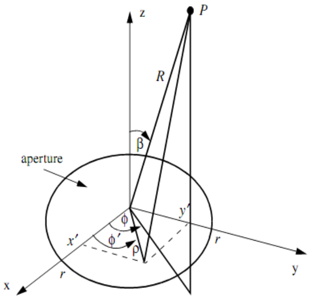

Figure (1): Circular aperture geometry [4].

Where the current distribution over the aperture is assumed to be unity. The second integral in Equation (1) is of the form

$$\int_0^{2\pi} e^{jz\cos\zeta} d\zeta = 2\pi J_0(z) \qquad (2)$$

Where J_0 is the Bessel function of the first kind of order zero. Because of the circular symmetry over the aperture, the electric field is independent of φ. Hence, E (β, φ) = E (β) and Equation (1) can now be rewritten as [5]:

$$E(\beta) = 2\pi \int_0^r \rho J_0(k\rho \sin\beta) d\rho \qquad (3)$$

Using the Bessel function identity

$$\int_0^r \rho J_0(q\rho)\, d\rho = \frac{r}{q} J_1(qr) \qquad (4)$$

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Equation (3) leads to the following expression for the aperture factor [6].

$$E(\beta) = \pi r^2 \frac{2J_1(kr\sin\beta)}{kr\sin\beta} \qquad (5)$$

The far field circular dish antenna pattern is computed as the modulus of the aperture factor defined in the below Equation . The first null occurs when the Bessel function is zero. More precisely,

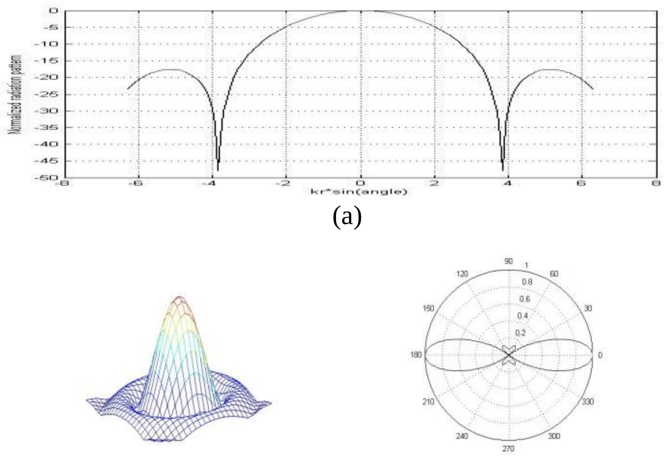
$$\frac{2\pi r}{\lambda}\sin\beta_{n1} = 1.22\pi \Rightarrow \beta_{n1} \approx 1.22\frac{\lambda}{2r}$$

(6)

III. RESULTS AND DISCUSSION

The antenna pattern distribution of the aperture previously described for a one-dimension. In this section, the antenna pattern produced by a two-dimensional circular aperture will be discussed. The polar coordinates were used to describe the pattern distribution produced by circular aperture. Radar signal was analyzed and processed using MATLAB as introduced numerous programs and functions to study and evaluate the Radar circular array antennas.

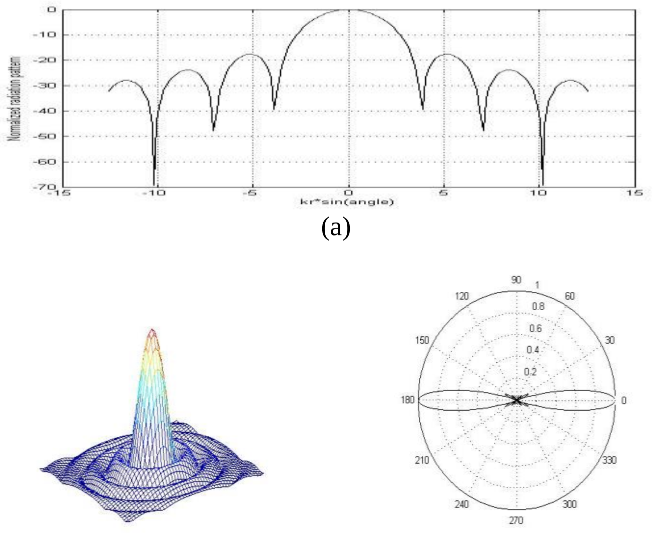
The program "circ_aperture" was used to analyze and plot the antenna pattern distribution produced by circular aperture of diameter d=0.3m and wavelengths associated with the central band frequencies. The wavelength (given by the speed of light divided by the frequency) Wavelength are: (0.15)m, (0.075)m, (0.06)m, (0.0375)m, (0.0333)m and (0.0241)m .the normalized radiation patterns produced by a circular aperture as a function of [kr sin(θ)] are shown in figures (2) - (7). Where k is a wave number and r is the radius of the circular aperture.



(a)

(b) (c)

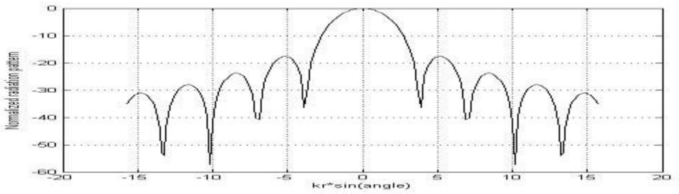
Figure (2): (a): The normalized radiation pattern versus (kr*sinθ) produced by circular aperture. (b): Three dimensional array pattern corresponding to fig.(a). (c): polar plot of radiation pattern for a circular .Here (d=0.3m and λ=0.15m).



(a)

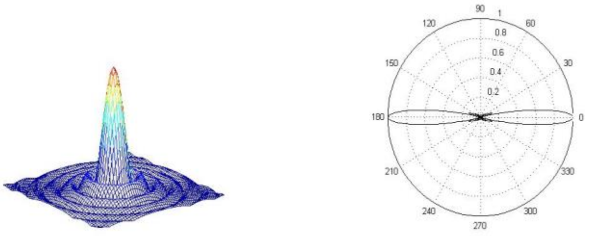
(b) (c)

Figure (3): (a): The normalized radiation pattern versus (kr*sinθ) produced by circular aperture. (b): Three dimensional array pattern corresponding to fig.(a). (c): polar plot of radiation pattern for a circular aperture corresponding to fig.(a). Here (d=0.3m and λ=0.075m).



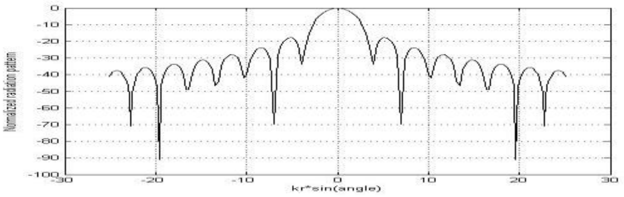
(a)

Figure (4): (a): The normalized radiation pattern versus (kr*sinθ) produced by circular aperture. (b): Three dimensional array pattern corresponding to fig.(a). (c): polar plot of radiation pattern for a circular aperture corresponding to fig.(a). Here (d=0.3m and λ=0.06m).

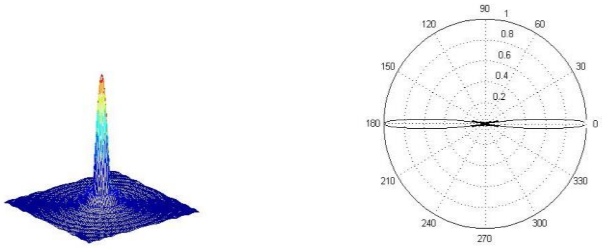


(b) (c)

Figure (4): (a): Continue at: (d=0.3m and λ=0.06m).

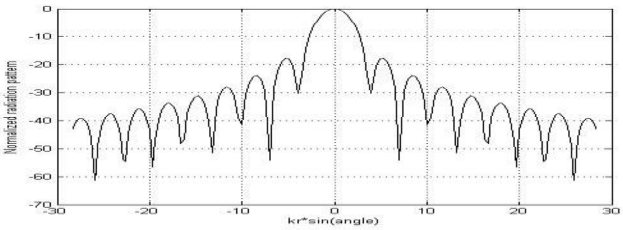


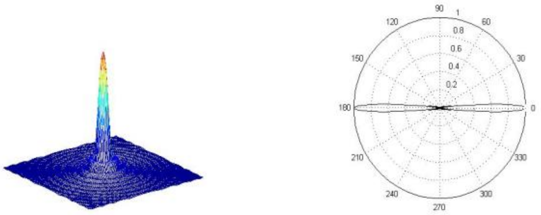
(a)



(b) (c)

Figure (5): (a): The normalized radiation pattern versus (kr*sinθ) produced by circular aperture. (b): Three dimensional array pattern corresponding to fig.(a). (c): polar plot of radiation pattern for a circular aperture corresponding to fig.(a). Here (d=0.3m and λ=0.0375m).

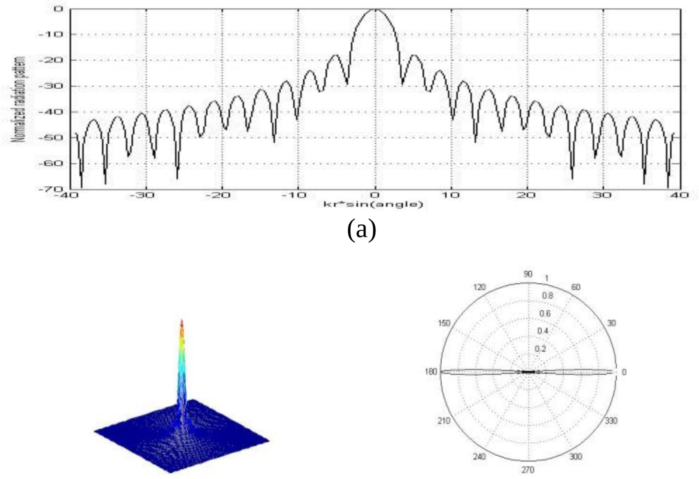




(a)

(b) (c)

Figure (6): (a): The normalized radiation pattern versus (kr*sinθ) produced by circular aperture. (b): Three dimensional array pattern corresponding to fig.(a). (c): polar plot of radiation pattern for a circular aperture corresponding to fig.(a). Here (d=0.3m and λ=0.0333m).



(a)

(b) (c)

Figure (7): (a): The normalized radiation pattern versus (kr*sinθ) produced by circular aperture. (b): Three dimensional array pattern corresponding to fig.(a). (c): polar plot of radiation pattern for a circular aperture corresponding to fig.(a). Here (d=0.3m and λ=0.0241m).

I. CONCLUSION

According to the present analysis procedures and the computed results of Radar-systems, by using matlab program for each shapes of radar's antenna (Circular array), the following important conclusions can be noticed:

1- Polar plot of radiation patterns as produced by a linear array was shown in figures. It can be noticed that the radiation pattern depends upon element spacing and frequency of bands. The number of side lobes of the radiation was increased with decreasing frequency and increasing element spacing. The maximum peak of radiation occurred at steering angle β= 30 degree.

2- Three dimensional radiation patterns for circular aperture were drawn in figures. The number of main and side lobes of the pattern was decreased by increasing the frequency of bands. However, the maximum value of the radiation power occurred at θ equals (0 degree and 180 degree).

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