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AN OPTIMIZED APERTURE ANTENNAS FOR NEAR FIELD SENSING APPLICATIONS

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ABSTRACT

In the world of modern wireless communication, engineer who wants to specialize in the communication field needs to have a basic understanding of the roles of electromagnetic radiation, antennas, and related propagation phenomena. These papers discuss on the performance, characteristic, testing, measurement and application of antennas in modern wireless communication systems. Antenna is an important part of any wireless communication system as it converts the electronic signals (propagating in the RF Transreceiver) into Electromagnetic Waves (Propagating in the free space) efficiently with minimum loss. We use antennas when nothing else is possible, as in communication with a missile or over rugged mountain terrain where cables are expensive and take a long time to install. The performance characteristics of the parent system are heavily influenced by the selection, position and design of the antenna suite. In this paper, among the most punctual sort of receiving wires underway was aperture type. These radio wires were unbending and comprised of an explanatory, paraboloidal, tube shaped, or circular shape. A noteworthy restriction of this kind of receiving wire comes from the reality they could just give one specific radiation design, and on the off chance that one needed to filter the signal starting with one point then onto the next, at that point the entire structure must be moved which implied the satellite must be realigned. This significant weakness prompted the improvement of the all the more expensive staged cluster innovation and different advancements where pillar examining was misused. The aperture is characterized as the zone, arranged opposite to the bearing of an approaching radio wave, which would catch an indistinguishable measure of intensity from that wave from is created by the receiving wire accepting it. Anytime, a light emission waves has an irradiance or power motion thickness which is the measure of radio power going through a unit territory of one square meter.

Keywords: Antenna, wireless communication, Reflector aperture.

1. INTRODUCTION

Antennas are basic components of any electric system and are connecting links between the transmitter and free space or free space and the receiver. Thus antennas play very important role in finding the characteristics of the system in which antennas are employed. Antennas are employed in different systems in different forms. That is, in some systems the operational characteristic of the system are designed around the directional properties of the antennas or in some others systems, the antennas are used simply to radiate electromagnetic energy in an omnidirectional or finally in some systems for point-to-point communication purpose in which increased gain and reduced wave interference are required.

1.1 Antenna Definitions

There are several definitions of antenna, and are as follows:

• The IEEE Standard Definitions of Terms (IEEE Std 145- 1983):

--A means for radiating or receiving radio waves

• “An antenna is any device that converts electronic signals to electromagnetic waves (and vice versa)” effectively with minimum loss of signals as shown in Fig.1.

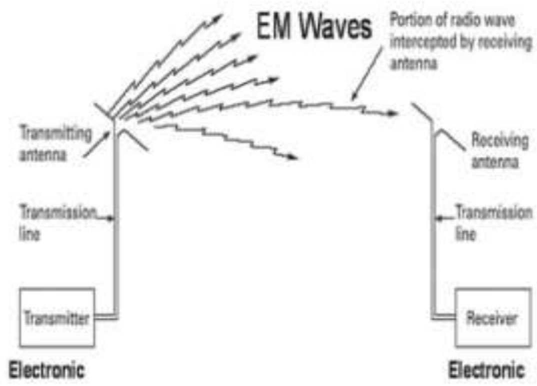


Figure 1. Wireless communication system.

- An antenna is basically a transforming device that will convert impedance of transmitter output (50/75 Ohm) into free space impedance (120pi or 377 Ohm).
- Region of transition between guided and free space propagation
- Concentrates incoming wave onto a sensor (receiving case)
- Launches waves from a guiding structure into space or air (transmitting case)
- Often part of a signal transmitting system over some distance.

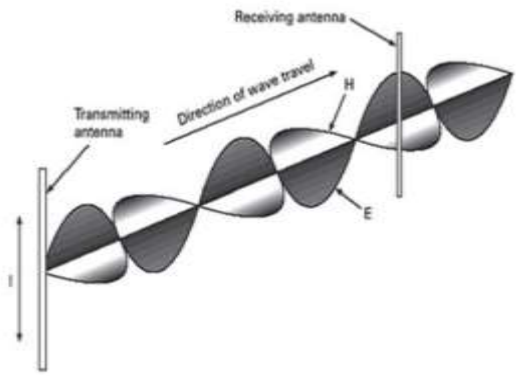


Figure 2. Propagation of EM waves.

1.1.1 Antenna Definitions

• The radiation pattern and radiation resistance of an antenna is the same when it transmits and when it receives, if no non-reciprocal devices are used. So, Same antenna can be used for Transmission and Reception of Electromagnetic Waves

• Does not apply to active antennas.

NB: Antenna is a passive device, it does not amplify the signals, it only directs the signal energy in a particular direction in reference with isotropic antenna.

2. APPLICATIONS OF ANTENNAS

2.1 IMPORTANCE OF ANTENNA IN AIRBORNE APPLICATION:

As shown in Fig.3, different frequency band antennas are placed on aircraft/missile body for different communication.

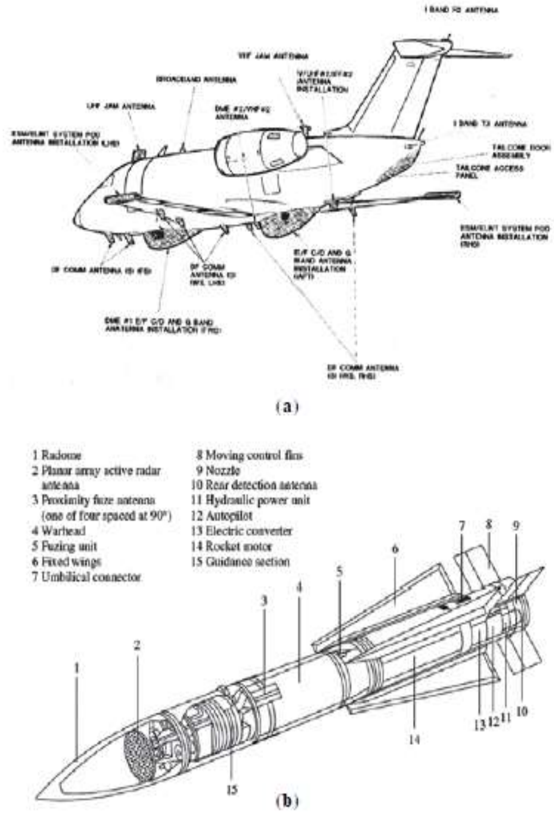
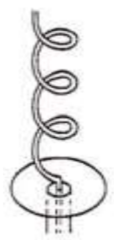


Figure 3. Application of airborne antennas.

Antenna placed at nose of the aircraft is a part of guidance RADAR system, which will guide the aircraft. Various jamming antenna are placed on different parts of aircraft for jamming the enemy signals. Antenna placed at the belly of the aircraft for data link application. All these antennas are operated on different frequency bands, so care should be taken that to avoid the interference of radiation pattern of all these antennas. Also when these antennas are placed on the aircraft body, its radiation pattern gets distorted, so one should design an antenna such that it will meet our application.

Astronomical Antenna:



Helical Antenna

1. Highly Directional Antenna
2. Circularly Polarized Antenna
3. Use in Radio Astronomy

3. CLASSSIFICATION AND CHARACTERISTICS OF ANTENNA

3.1 CLASSSIFICATION OF ANTENNA:

Antenna can be classified on the basis of:

1 Frequency - VLF, LF, HF, VHF, UHF, Microwave, Millimeter wave antenna

2 Aperture - Wire, Parabolic Dish, Microstrip Patch antenna

3. Polarization - Linear (Vertical/Horizontal), Circular polarization antenna

4. Radiation - Isotropic, Omnidirectional, Directional, Hemispherical antenna

3.2. ANTENNA CHARACTERISTICS

Before designing an antenna one should know its performance parameters or characteristics of antenna for particular applications. The beam pattern of any antenna is shown below in Fig.4 and 5.

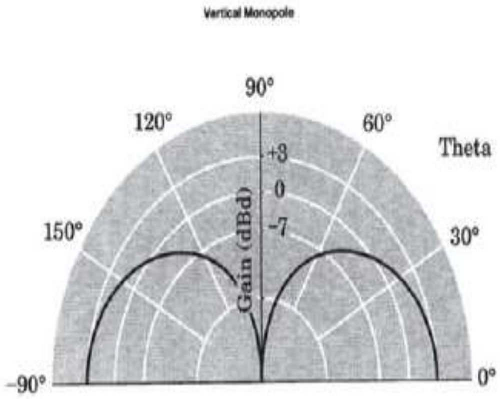


Figure 4. Upper hemispherical radiation pattern.

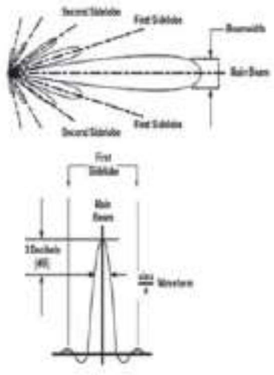


Figure 5. Antenna pattern showing main beam and side lobes.

4. DESIRED APERTURE DISTRIBUTION

For a more general case, the optimal aperture (in terms of both the size and the distribution) for the maximum penetration is investigated by two approaches: optimization and direct solving.

A. Optimization

Global optimization algorithms (such as Genetic Algorithm, Particle Swarm, Pattern Search, etc.) are widely used in electromagnetic problems. Genetic algorithm (GA) is applied to find the optimal aperture distribution in this work. To find the optimal aperture in this case, it is assumed that the aperture radius is fixed and only the distribution is optimized. For different aperture distributions of the same radius, 3dB near-field beam radius is calculated at a range of distances. This range is selected around expected best focus distance from the case of uniform aperture. Then, the minimum 3dB near-field beam radius in this range is selected as the fitness function which will be minimized by the means of GA. As for parameter to be tuned, low-order Fourier coefficients of current distribution are chosen. The purpose of this choice is to ensure the continuity and smoothness of resulting distribution. A sample of GA results, by using the above assumptions is presented here, for an aperture of radius equal to one wavelength (i.e. a = λ) in free space.

In this case a population of 20 genes is used and the algorithm converges after 51 generations. The amplitude and phase of resulting current distribution is shown in Fig. 6. Near-field co-polar component produced by such distribution is demonstrated in Fig. 7 at distances between 0.4λ and 0.8λ, also the 3dB near-field beam radius of this current distribution is plotted in Fig. 8.

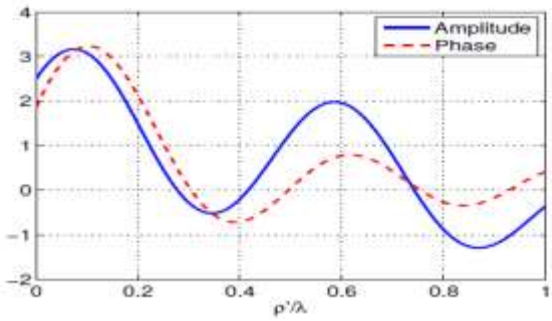


Fig. 6: Amplitude and phase of current distribution from GA.

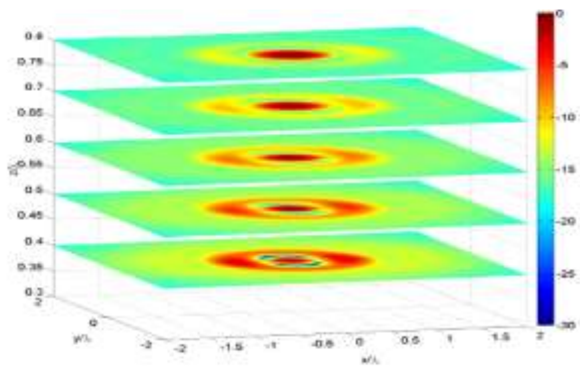


Fig. 7: Near-field co-polar component of GA optimized aperture.

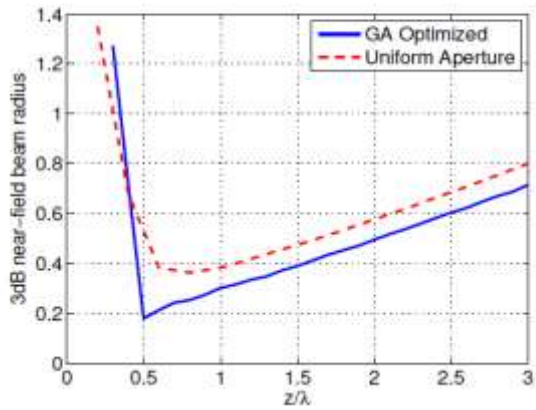


Fig. 8: 3dB near-field beam radius of GA optimized aperture.

B. Direct Solving

Due to the linear nature of the problem, it is also possible to solve directly for the aperture distribution to have a desired field distribution at one or more z-cuts in the space. In order to do this, following approach is adopted. First, a discrete aperture distribution Jdis(ρ) and a desired field **E**goal are selected.

$$J(\rho') \approx J_{dis}(\rho') = \sum_{n=1}^{N} J_n \psi_n(\rho')$$

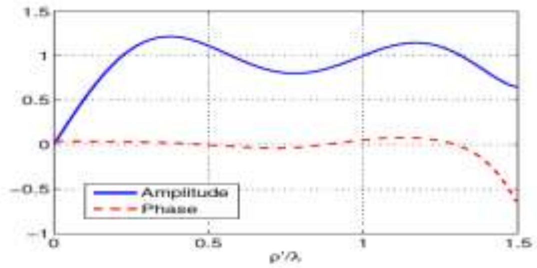


Fig. 9: Calculated amplitude and phase of current distribution by using the direct solving method.

CONCLUSION

In this paper, an optimized aperture is explored to accomplish the most extreme end fire directivity for a persistent line source with a uniform stage movement. It has been shown that the optimal aperture size for near field sensing applications depends on the spacing between the transmit and the receive antennas and the material properties of the medium between the two, as the minimum near-field beam radius varies with both aperture size and loss for a uniform aperture distribution. For a more general case, the optimal aperture can be determined by two approaches: optimization algorithms and direct solving. The optimization algorithms are more useful when just the 3dB near-field beam radius is required to be small and there is no restriction on the actual field distribution. On the other hand, direct solving method can be used in cases where the field distribution also matters for the specific application.

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