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ANALYSIS OF DIPOLE ANTENNA RADIATION PATTERNS USING LOW FREQUENCY MODEL

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Abstract: Antennas are an extremely vital element of communication systems and radar technologies. The antenna will produce radiation dispersed in space in a definite way when a signal is feed into an antenna, which called a "radiation pattern". Most pervious literatures concentrates on studying the effect of an EM filed on communication systems that have high frequency and its radiation pattern on far filed. The main aim of this paper is in order to investigate the effect of the electromagnetic EM-field in communication systems that have low frequency, and using the MATLAB software simulation in order to show this effectto describe the radiation pattern for an antenna on far field for different low frequencies due to the lack literatures that focus on this field. A dipole antenna is analyzed using the radiation pattern on far field for different low frequencies model within the frequency band of 1-5 KHz, to make the final design realizable.

Keywords: *Antennas Radiation Patterns; Gain; Frequency; near-Field; main and minor lobs; Directivity; Beam Width.*

تحليل أنماط الإشعاع لهوائي ثنائي القطب باستخدام نموذج التردد الواطئ

الخلاصة: الهوائيات عنصر حيوى للغاية من انظمة الاتصالات وتكنولوجيا الرادار. ينتج الهوائى الاشعاع فى الفضاء بشكل محدد عند تغذية اشارة الى هوائى ما ويدعى "نمط الاشعاع". وتركز معظم االدراسات السابقة بشان دراسة اثر الاشعاع الكهرومغناطيسي في انظمة الاتصالات ذات الترددات العالية و التي تكون بنمط اشعاع المجال البعيد. الهدف الرئيسي من هذا البحث هو من اجل التحقيق فى تاثير التداخل الكهرومغناطيسى فى انظمة الاتصالات ذات التردد المنخفض واستخدام برامج المحاكاة ماتلاب لاظهار ذلك لوصف نمط الاشعاع للهوائى فى المجال البعيد ذات الترددات المنخفضة بسبب الافتقار الى الدراسات التى تركز على هذا المجال .باستخدام وتحليل هوائى نوع الدايبول بنمط اشعاع المجال البعيد لمختلف الترددات المنخفضة داخل نطاق التردد من 1 الى 5 كيلوهرتز لجعل التصميم النهائى يمكن تحقيقه عمليا.

1. Introduction

The antenna or radiation pattern illustrates the comparative strength of the emitted field in diverse ways from the transmitter, at an invariable space. The "radiation pattern" is a getting model in addition, as it also illustrates the reception assets for an antenna. The "radiation pattern" is (3D) three-dimensional, other than generally the evaluated "radiation patterns" are a (2D) two dimensional segment of the three dimensional pattern,

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in the perpendicular and parallel planes. These pattern quantities exist in either a polar or a rectangular configure [1]. The following subsection gives an appropriate background about low frequency effect of an EM filed on communication systems and its radiation pattern.

Antennas show a property recognized as "reciprocity", which denotes that an antenna will keep the similar attributes in spite of if it is broadcasting or accepted. The majority of aerials are "resonant-Booming" mechanisms that work professionally more a comparatively constricted frequency range. An aerial have to be adjusted to similar frequency range of a broadcasting scheme to that it is linked, if not, broadcasting with the reception will be damaged [1].There are two types of radiation pattern:

a. Relative “Radiation or Emission Patterns”: This is referenced within comparative elements for field power and strength.
b. Absolute “Radiation or Emission patterns”: This is existing within absolute elements for field power and strength.

The difficulty of low frequency spreading in (bi) isotropic surroundings becomes magnetizing rising attention in modern years due to its clear submissions for approximating EM- electromagnetic features of element loaded medium such as reproduction dielectrics, sea ice, and polymer compounds. For a little ellipsoidal and circular scattered, locked form terms of an interior area in addition, the polarize-ability dyads become computed. An instantaneous alter of area changeable and spatial coordinates becomes formulated to alternate an innovative quasi stationary difficulty for an an-isotropic ellipsoid in an an-isotropic intermediate by an easier one concerning an an-isotropic ellipsoid located in a space [2].

It has been viewed that a full wave depend on the resolution of Maxwell’s formulas fails downward at low frequencies. Such a difficulty is particularly harsh in digital and assorted signal incorporated circuit submissions in which signals have a broad bandwidth from DC to a propos the third vocal frequency. In these submissions, the break frequency is correct in the variety of circuit working frequencies [2].

Electronic tool takes an enormous expediency, while "low frequency electromagnetic" emission risk to human is worried regarding by a growing numeral of people. The "lowfrequency electromagnetic" emission quantities are significant to the defense of human strength. The status of electromagnetic surroundings has to be systematically examined and sensibly observed to obtain defensive measures. Currently the electromagnetic emission is perceived via handheld tools such as "China made 701" or further three dimensional-3D field tools. Contrasted to the preceding discovery technique [2].

1.1 Literature Review

Most pervious literatures concentrates on studying the effect of an EM filed on communication systems that have high frequency and its radiation pattern on far filed. The main aim of this paper is in order to investigate the effect of an electromagnetic EM-field in communication systems that have low frequency, and using the MATLAB software simulation in order to show this effect to describe the radiation pattern for an antenna on near field for different low frequencies due to the lack literatures that focus on this field. And to illustrate the performance of the radiation pattern when changing the operating frequency under low frequency range. The importance of this work can appear by studying the measurement of the low frequency of the systems which can be called near band and it almost represented as side loop compared with main loop of the radiation pattern.

This paper is divided into the following subsections; theoretical part, and design and analysis. Theoretical part (Methodology) section describes the obtainable approaches for low frequency fail difficulty, and explicates the relationship amide the near-filed and far-field of the emission or radiation pattern. Results in addition to brief discussion section demonstrates the analysis of the low frequency fail difficulty, and shows all the numerical results of the analysis. Finally, we conclude the obtained results.

2. Background

Obtainable advances for defeating the low frequency fail difficulty can be classified into two groups. First one is to point a fixed or quasi fixed depend on EM electromagnetic resolver in the midest of a filled wave depend on electromagnetic resolver. This advance is imprecise because fixed/quasi-fixed resolvers entail basic estimates like a decoupled H and E [3]. Furthermore, at which frequency to control among diverse resolvers is a subject. In observe, engineers frequently have to utilize an estimate depend on model to accomplish a soft alteration among fixed, quasi-fixed, and filled wave resolvers, which establishes a further level of imprecision. The further group of techniques for resolving the low frequency break difficulty is to expand the strength of filled wave resolvers to low frequencies. The techniques that belong to this group further or fewer rely on low frequency estimates. For instance, a loop-star and loop-tree base purposes be utilized in order to accomplish the normal Helmholtz [4].

The main basic parameters of an antenna can be classified as follow [5]:

1. Radiation pattern: it's a graphical representation of EM power distribution in free space. Adding to that it is able to consider being delegate of the comparative field power of the field emitted by the antenna. It is (3D) three dimensional, but generally the evaluated "radiation patterns" are a (2D) two dimensional segment of the three dimensional pattern, in the perpendicular and parallel planes.
2. Isotropic pattern: Equivalent power is emitted in all directions, No actual antenna consists this pattern, other than the isotropic radiator is imperative an indication pattern with which to contrast further antenna radiation patterns to describe directivity [6].
3. Omnidirectional pattern: the pattern is autonomous of azimuthal angle.
4. Pattern lobes: Limited maxima in the radiation pattern. The "main lobe" is the lobe which accomplishes f_{max} , but Side lobes are lesser lobes. A back lobe is a pattern lobe close to the opposed way of the major lobe [7]. Side lobe and Nulls is a region in which the effectual emitted power is at a minimum. A null frequently has a constricted directivity angel evaluated to that of the major beam.
5. Beam-width: There are numerous means to identify the angular width of the major lobe. The mainly general max is the "Half-Power- Beam-width" (HPBW) and

"Null-to-Null Beam-width". The Half-Power-Half Beam-width (HPBW/2) is in addition utilized. Beam-Width of the antenna is typically considered to be the angular width of the half power emitted in a confident cut during the major beam of the antenna where most of power emitting.

6. Polarization of an antenna: it is a direction of the emotional field- E plan, for a broadcasting signal in the midst of regard to the earth's plane, in addition to, it is indomitable by the physical arrangement of the direction of an antenna.
7. Antenna efficiency: it is appraise of antenna's ability to broadcast the participation power into emission. Antenna efficiency is the ratio between the emitted powers to the input power [8].
8. Directivity: Directivity of an antenna is identified as the proportion of the emission intensity to a specified orientation from antenna to the emission intensity standard on the whole orientations [9].
9. Gain: is a parameter determines the directionality of a specified antenna. An antenna with little gain radiates radiation power in the midst of concerning the comparable power in all orientations, while an elevated gain antenna will preferentially emit in particular orientations [10].
10. Intermediation: an antenna is considered a passive linear device, when a device is animated by elevated sufficient power. It acts faintly as a nonlinear device.
11. Input impedance: it is the frequency reaction of an antenna at its port. It is the ratio amid the voltage and currents at the antenna port.
12. Bandwidth: it is the antenna working frequency range inside which the antenna executes as preferred. The bandwidth is able to relate to the antenna corresponding range if it is radiation pattern don't alter inside this range.

Figure 1illustrates "a rectangular plot appearance" of a typical ten element Yagi. The aspect is excellent but it is hard to imagine the antenna performance at diverse directions Ease of Use.

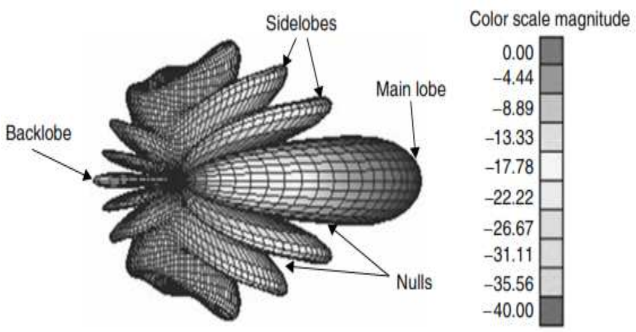

Figure 1. 3D Radiation pattern [11]

The following figures demonstrate the main parameters of an antenna.

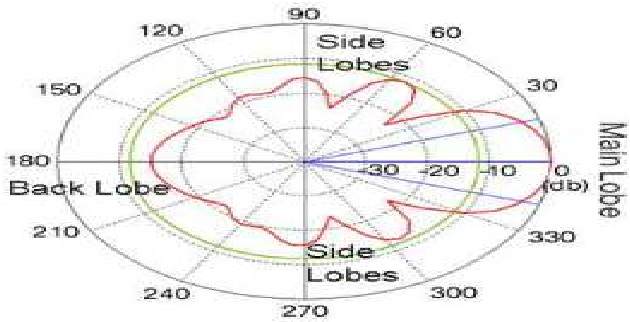

Figure 2. Polar Plot radiation [12]

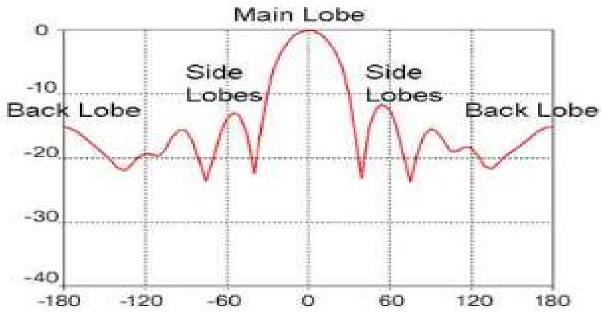

Figure 3. Rectangular Polar Plot [12]

The majority of radiation pattern quantities are comparative to the "Isotropic Antenna", and after that the gain transport way be after that utilized in order to institute a totality gain of an aerial. The "radiation or emission pattern" in the area near to the aerial isn't identical as the model at huge expanses. [13] The expression "near-field" submits to field- pattern, which survives near to an aerial, whilst the term "far field" submits to the field pattern at distant distances. Adding to that the "far-field" is named the emission field, and is what is mainly generally of attention.
Normally, it can identify as the emitted power, which is of attention, and consequently aerial patterns are typically considered within the "far-field" area. Pattern quantity can identify as a significant to select a expanse adequately great chosen within the "far-field", well out of the "near field" [14].
The lowest allowable distance depends on the proportions of the antenna in relative to the wavelength. The traditional principle for this distance is [15]:

$$r_{min} = \frac{2d^2}{\lambda} \text{(1).[15]}$$

Where r_{min} the lowest expanse starting from the aerial, d is the major measurement of an aerial, and λ is the wave-length. There is no antenna capable to emit the entire energy in one favorite direction. Various are unavoidably emitted in other directions. The peaks are submitted to as "side lobes", generally identified in dB downward from the "main lobe" [16].

The following subsection focuses on studying the effect of EM filed on communication systems that have low frequency on near filed, and demonstrates the radiation pattern of a dipole antenna for different frequencies using the MATLAB simulation software.

3. Results and Discussion

The low frequency fail difficulty in EFIE- "Electric Field Integral Equation" is well documented and becomes expansively considered. Conversely, obtainable plans have not carefully resolved the difficulty yet as they depend on low frequency estimates. In this subsection, an accurate technique is presented to basically remove the difficulty. MATLAB software simulation is used in order to illustrate the main parameter of a dipole antenna at different frequencies, and concentrates on the low frequency to investigate the impact of EM filed for this antenna and to describe the radiation pattern for the different frequencies [17].

The resolution of the suggested technique becomes authorized at low frequencies. As the primary exact resolution to "Electric-Field-Integral-Equation" (EFIE) at little frequencies, the suggested method is able to be utilized to standard the accuracy of obtainable low frequency EFIE- depend resolvers [18].To examine the low frequency fail difficulty, a dipole antenna is used in order to show the effect of EM filed at different frequencies and demonstrates the radiation pattern for these frequencies using MATLAB software simulation.

A "dipole-aerial" can identify as an instantly electrical-conductor determining half of the wave-length from end-to-end, and attached at the middle to a broadcasting frequency (RF) feed-line. This aerial, also named a “doublet-antenna”, is solitary of the easiest sorts of aerial, and comprises the major radio frequency receiving and radiating component in a variety of complicated sorts of aerials. The dipole is intrinsically an impartial aerial, because it is bilaterally regular [19].

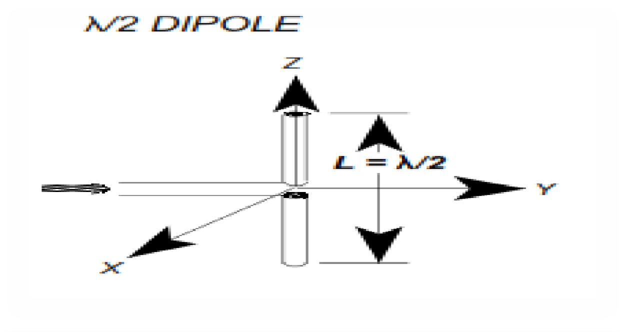

Figure 4. Geometry of "a dipole antenna"[20]

In order to confirm the suggested technique, we imitated "dipole antenna", the geometrical data that shows in Figure 4, (L) is the length and equals to 6 cms. The first frequency that taken equals to 1 KHz according to the following equation [20];

$$\lambda = \frac{c}{f} \quad (2)$$

Where λ the wavelength, c is is the velocity of light and equals to $3*10^8$ m/sec, f is the frequency.At this frequency; 1 KHz, λ is equal to $3*10^5\ m$,Far-field emission pattern of a dipole-antenna is calculated at low frequency, which is equal to 1KHz, Figure 5 shows this radiation pattern; the following figures are taken from the simulation of the MATLAB codes.

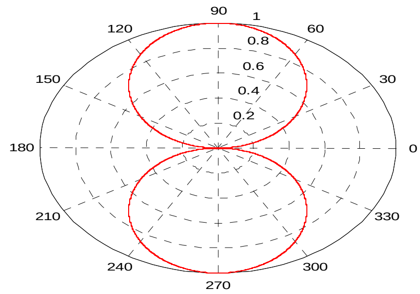

Figure 5. Far Field Radiation pattern- 1 KHz

Figure 6 shows that at this low frequency the radiation pattern of an antenna is omnidirectional. This antenna sends or receives signals equally in all directions at this frequency. From this Figure; elevation plane pattern; it can see that the dipole antenna has an elevation plane beam-width of 78-degrees as shown on the far filed Radiation pattern. The elevation plane beam-width is the totality angular width amid the two 3-dB points on the curvature.

Also, the near-field emission pattern is calculated at the same frequency for the same antenna, Figure 6 shows this radiation pattern.

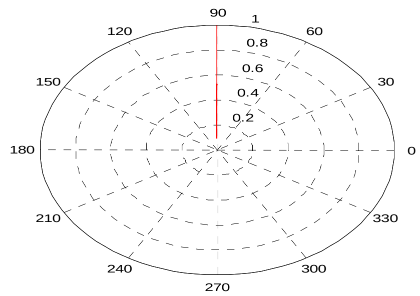

Figure 6. Near Field Radiation Pattern-1KHz

The second frequency that taken is 2 KHz, at this low frequency λ is equals to 1.5 $*10^5\ m$, Figure 7 shows the far field radiation pattern at this frequency.

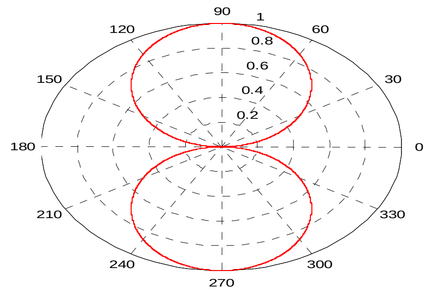

Figure 7. Far-Field Radaiation pattern- 2 KHz

Another frequency that taken is 5 KHz, at this low frequency λ is equals to 6 $*10^4$ m, Figure 8 shows the far field radiation pattern at this frequency.

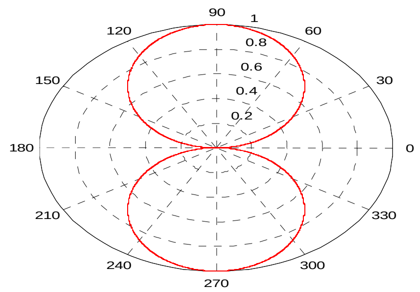

Figure 8. Far Field Radaiation pattern- 5 KHz

4. Conclusion

An antenna is fundamentally a transmission line that transforms electrical energy into electromagnetic energy. The length of this line is inversely proportional to the transmission frequency. Therefore, as new wireless applications move up in frequency, their antennas correspondingly shrink in size. The concept dipole antenna has been studied. A MATLAB code is written to analyze the radiation patterns of dipole antenna. The results so obtained from MATLAB for different low frequencies model within the frequency band of 1 KHz, 2 KHz and 5 KHz and its radiation pattern on far filed. It is observed that the results replicate each other. It does not create utilize of low frequency estimates, and is similarly suitable at elevated frequencies.

An exact resolution is developed in order to basically remove the "low frequency" fail difficulty in the "RWG" depend on EFIE resolution of EM difficulties. The technique avoids switching diverse resolvers or base purposes. It does not create utilize of low frequency estimates, and is similarly suitable at elevated frequencies. The frequency reliance of the resolution to "Maxwell’s equation" is logically exposed. The suggested tool can be used to quantitatively review the truth of presenting EFIE resolvers at low frequencies. As future work, this work can be extended to study the performance of polarization fluctuations in the same scenario especially when apply it in wavelength medium.

The suggested tool can be used to quantitatively review the truth of presenting EFIE resolvers at low frequencies. As future work, this work can be extended to study the performance of polarization fluctuations in the same scenario especially when apply it in wavelength medium.

Abbreviations

2D	Two Dimensional
EM	Electro Magnetic
EFIE	Electric-Field-Integral-Equation
HPBW	Half-Power-Half Beam-width
RF	Radio Frequency

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