ANALYSIS OF NON UNIFORM SURFACE CURRENT DISTRIBUTION ON THICK AND THIN WIRE ANTENNA

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ABSTRACT

When wires are closely parallel, the surface current distribution becomes non uniform. Normal mode helical antenna is choosing in particular in order to study the effect of surface current distribution along its segmentation from the excitation segments towards the end of the antenna length. Antenna of different wire geometries such as wire thickness, and number of turn is designed to analyze anticipated results. The frequency operating in UHF band frequency spectrum is choose as a contribution towards widely application nowadays. The surface current distribution of thin wire antenna is not uniform as well for thick wire antennas. The difference is that thicker wire antennas results higher amount of current comparing to thin wire antennas. Higher amount of current of the surface wire antenna produce better gain and higher magnetic field strength value.

ABSTRAK

Apabila wayar antenna diletakkan selari, arus pada permukaan menjadi tidak seragam. Mod biasa antena helik dipilih khususnya untuk mengkaji kesan pengagihan permukaan semasa bersama-sama segmentasi dari segmen pengujaan penghujung panjang antena. Antena dengan geometri yang berbeza seperti ketebalan wayar, dan beberapa geometri lain pula direka untuk menganalisis keputusan yang dijangkakan. Frekuensi didalam julat spektrum UHF digunakan diatas faktor sumbangan kepada keperluan masa kini. Pengaliran arus pada permukaan antena wayar nipis adalah tidak seragam begitu juga untuk antena menggunakan wayar yang lebih tebal. Dari segi kuasa penerimaan dan pancaran, perbezaan adalah ketara bahawa antena wayar tebal menghasilkan nisbah kuasa penghantaran yang lebih tinggi jika dibandingkan dengan antena wayar yang lebih nipis. Jumlah yang lebih tinggi semasa antena wayar permukaan menghasilkan keuntungan yang lebih baik dan medan magnet kekuatan nilai yang lebih tinggi. Antena yang mempunyai arus pada permukaan yang lebih tinggi menghasilkan nisbah kuasa penghantaran serta kuasa medan magnet yang lebih tinggi.

CONTENTS

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LIST OF SYMBOLS AND ABBREVIATION

D - Directivity

E - Electric Field Intensity

G - Gain

λ - Wavelength

C - Circumference of a Helix

R_L - Loss Resistance

R_r - Radiation Resistance

Γ - Reflection coefficient

P_a - Radiated Power

E_z - Electric Field in z domain

V_g - Feed Gap

ρ - Wire Radius

I_z - Current Distribution

C_n - Current expansion coefficient

S - Spacing between turns

D - Diameter of base support

Q-factor - Qualitative Behaviour of an Antenna

E-theta - Electromagnetic Field Azimuth Angle

E-phi - Electromagnetic Field Elevation Angle

NEC - Numerical Electromagnetics Code

NMHA - Normal Mode Helical Antenna

CHAPTER 1

INTRODUCTION

An antenna is defined as a “transmitting or receiving system that is designed to radiate or receive electromagnetic waves” [1]. An antenna can be any shape or size. A list of some common types of antennas is wire, aperture, microstrip, reflector, and arrays. Each antenna configuration has a radiation pattern and design parameters, in addition to their benefits and drawbacks. Common antenna types such as wire antenna, microstrip antenna, aperture antenna and others have their own benefits and drawbacks. When we design antennas, it is vital to be able to estimate the current distribution on its surface. From the current distribution, we can calculate the input impedance, gain and the far-field pattern for the antenna.

1.0 Antenna parameters

An antenna or aerial is an electrical device design to transmit or receive radio waves or more generally any electromagnetic waves. Antenna is used in system such as radio and television broadcasting, point to point radio communication, radar, space exploration. Physically an antenna is an arrangement of conductors that generate a radiating electromagnetic field in response to an applied alternating voltage and associated alternating electric current or can be placed in an electromagnetic field so that field will induce an alternating current in the antenna voltage between its terminals.

The input impedance of an antenna is the ratio of the voltage to current at the terminals connecting the transmission line and transmitter or receiver to the antenna.

The impedance can be real for an antenna tuned at one frequency but generally would have a reactive part at another frequency.

The electric field is in a plane orthogonal to the axis of a magnetic dipole. This dependence of the plane of the radiated electromagnetic wave on the orientation and types of antenna in terms polarization. A receiving antenna requires the same polarization as the wave that it is to intercept. By combining field from electric and magnetic dipoles that have common centre, the radiated field can be elliptically polarized.

The operating bandwidth of an antenna may be limited by pattern shape, polarization characteristic and its impedance performance. There are two fundamental types of antenna which with reference to a specific three dimensional usually horizontal or vertical plane are either omni-directions antenna or directional antenna. The omni-directional antenna radiated equally in all directions while directional antenna radiates more in one direction than in the one.

1.1 Radiation Efficiency

Radiation efficiency is the “ratio of total power radiate by an antenna to the net power accepted by the antenna from the connected transmitter. Only 50% of the power supplied through the transmitter network is used to transmit. In the best case scenario, the maximum power accepted by the transmitting antenna is 50% of the total power supplied and occurs when the generator impedance and the antenna are matched, usually to 50Ω. The efficiency of an antenna is given by Equation 1.1

$$E = \frac{Pradiated}{P} = \frac{RrI^2}{(Rr + R\mathrm{L})I^2} = \frac{Rr}{(Rr + RL)} = \frac{1}{1 + \frac{RL}{Rr}} \tag{1.1}$$

R_L is your loss resistance which corresponds to the loss of your antenna and R_r is the radiation resistance.

1.1.2 Directivity and Gain

Directivity is defined as “the ratio of radiation intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna where radiating isotropic ally [5]. In other words it’s the ratio of the radiation intensity of an antenna to one that radiates equally in all direction. This is similar to that of antenna gain but antenna gain takes into account the efficiency of the antenna while directivity is the losses gain of an antenna. Directivity can be calculated using the Poynting Vector, P, which tells you the average real power per unit area radiated by an antenna in free space [6]. The equation for the directivity of an antenna is given by Equation 2.

$$D = \frac{P}{P_0}, \qquad D|_{dB} = 10log_{10}\frac{P}{P_0}, \quad P_0 = \frac{P_a}{4\pi r^2} \tag{1.2}$$

Pa is the total power radiated by the antenna and r is the distance between the two antennas. The antenna gain takes into account loss so the gain of an antenna will always be less than the directivity. Knowing the directivity of the antenna, the total power radiated by the antenna, and the received power which takes into account loss, the antenna gain can be calculated using Equation 1.3.

$$G = D\frac{P_a}{P_{accepted\ by\ the\ antenna}} \leq D \tag{1.3}$$

1.1.3 Antenna Bandwidth

Antenna bandwidth is the range of frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard [5]. The bandwidth can be viewed as the frequencies left and right of the center frequency in which the antenna performance meets the specified values. The impedance bandwidth of an antenna is commonly agreed upon as the power delivered to the antenna greater than or equal to 90% of the available power [6]. Another way to interpret the antenna bandwidth is in terms of the reflection coefficient Γ. Γ is usually plotted in as the power reflection coefficient by using Equation 1.4.

$$|\Gamma|_{dB} = 20log_{10}|\Gamma| = 10log|\Gamma|^2 \qquad (1.4)$$

Figure 1 displays an example of a power reflection coefficient graphed in terms of frequency.

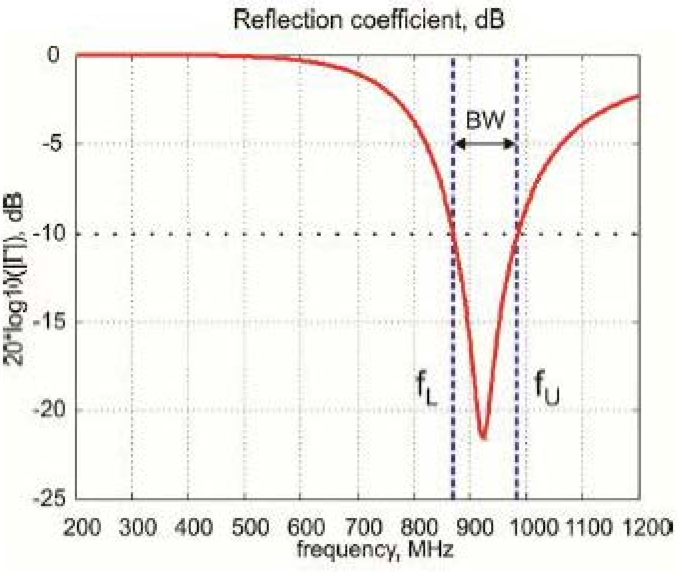

Figure 1.0: Power Reflection Coefficients

f_L represents the lowest frequency that satisfies the 90% power, and f U represents the highest frequency that follows the criteria. The average of f_L and f_c will give you the center frequency fc and the bandwidth or commonly referred to as fractional bandwidth.

1.2 Surface Current Distribution

When wires are closely parallel, the surface current distribution become non-uniform. This effect has been investigated previously subject to certain approximations. Smith and Olaefe assumed that the average current flowing in a set of parallel wires was equal, which means that the cross sectional distribution of surface current remain constant along the wires [3]. These earlier studies were restricted to simple geometries. Tuluyathan used a more general treatment but still neglected the possibility of a circumferential component in the surface current [5]. It is intuitively obvious that such component must be present when there is significant displacement current flow in the inter wire capacitance.

Most of the methods used for analysis of wire antenna of arbitrary shape including the possibility of closely parallel wire assume a uniform surface current distribution across the cross section [8]. Hence, surface resistive losses and reactive effects that may be augmented by the non-uniform surface current will not be correctly predicted.

1.3 Background of Study

The analysis of radiation and scattering from the straight thin wire antenna is one of the most important problems in antenna theory. The excitation of the straight thin wire can be regarded as a standard canonical problem. Furthermore, this configuration itself is one the practical interest in the design of the antenna arrays same as in wire grid modeling. In a numerical sense, this relatively simple geometry is very convenient for testing newly developed numerical techniques.

1.4 Statement of Problem

This problem is particularly significant for resonant coiled electrically smaal antennas, such as normal mode helical antenna, spiral antennas and other closely space antennas, in which the surface current distribution has a critical effect on the efficiency, Q-factor and resonant frequency. A new moment of method is developed which solves this problem.

1.5 Objective of the Study

The principle objectives of the research are depicted as follows.

1.5.1 To design a helix antenna using NEC Software Simulation with matching feeding network in the UHF-Band frequency spectrum.
1.5.2 Analyze the different of thin and thick wire antennas to its surface current distribution.
1.5.3 To optimize the performance of the helix antenna in term of surface current distribution between antennas of different antenna thin and thick dimensions.

1.6 Scope Of The Study

The study will focus on wires that are closely parallel to each other, in particular the normal-mode helical antenna and spiral antenna. The investigation will consider the surface current distribution which has a vital part in contribution to the efficiency, Q-factor and resonant frequency of an antenna.

1.7 Significant of Study

The analysis of non-uniform surface current distribution on wire antennas may improve the understanding of complex coupling processes between surface resistive losses and reactive effects. The design and analysis developed by the end of the research is hoped to determine the surface current distribution for different antenna wire geometries. Results of study might be of interests to related field of study and industry.

CHAPTER 2

LITERATURE REVIEW

2.0 Chapter Overview

In this chapter, several topics on core theories behind the research will be discussed. Section 2.1 provides information on mathematical foundation on method of moments in antenna fundamental design which has been used in the research. Later, a Pocklington Iintegral Equation is discussed in section 2.2 in more details. In section 2.3, researches that have been done previously by others which closely related to this research are revealed and discussed.

2.1 Mathematical Foundations

Moment's technic, as applied to problems in electromagnetic theory, was introduced by Roger F. Harrington (Harrington 1967). Throughout the history of physical science, natural behaviors have been represented in terms of integral-differential equations. In many instances, behaviors are described in terms of simple differential equations.

$$\frac{dy}{dt} = v \tag{2.1}$$

where the function *x(t)* is defined over the domain or *t.* The differential operator then yields the function *x(t)* which also defined over the domain of *t.* In other instances, where the function *v(t)* is known over the domain of *(t)*, specific values of x may be derived from representatives expressions given by:

$$\int_0^{t_1} v(t)dt \tag{2.2}$$

For example, if v(t) = k, then x = kt1. A special case arises when the function v(t) is unknown and values of x are known at only discrete values of t. this type of problem is generally referred to as an integral equation problem where the task is to determine the function v(t) with boundary conditions described by values of x at specific values of t. the task of determining the current distribution on a wire antenna resulting from an arbitrary excitation may be readily stated in terms of an integral equation problem. The formulation begins with the development of an integral expression which defines the electric field resulting from an arbitrary current distribution on the wire. This integral expression will employ a function which relates the electric field at an arbitrary observation point to the current at an arbitrary source point. The integral equation problem then employs the integral expression to relate known electric field boundary conditions to an unknown current distribution on the wire.

The method of moments applies orthogonal expansions to translate the integral equation statement into a system of circuit like simultaneous linear equations. Basic functions are used to expand the current distribution. Testing functions are used to invoke the electric field boundary conditions. Matrix methods are then used to solve for the expansions coefficients associated with the basic functions. The current distribution solution is the constructed from the expansion coefficients. The antenna’s radiation characteristics and feed point impedance are then derived from the calculated current distribution [10].

2.2 Pocklington integral Equation

A well-known formulation for simple wire antennas is Pocklington Integral Equation. The Pocklington integral equation use time domain processing model. Figure 2, depicts a representatives geometry from which Pocklington equation can be derived. A simple wire antenna is positioned along the z axis in a Cartesian coordinate system. The current is restricted to the centerline of the wire and directed along the z axis. Elemental current segments are located at coordinate z’. Field observation pointsb are located at coordinate’s z. A feed gap is positioned at z=0. The electric field along the surface of the wire and in the feed gap, which establishes the boundary conditions for the problem, is defined as follows:

$$E_z = 0 \tag{2.3}$$

On the surface of the wire.

$$E_z = \frac{V_g}{\Delta z} \tag{2.4}$$

At the feed gap, V_g, the antenna excitation, is normally set to 1.0V for input impedance calculations. Δz is commonly set equal to the diameter of the wire. However, it is possible to study the impact of the feed gap dimensions on antenna input impedance by varying the value of Δz.

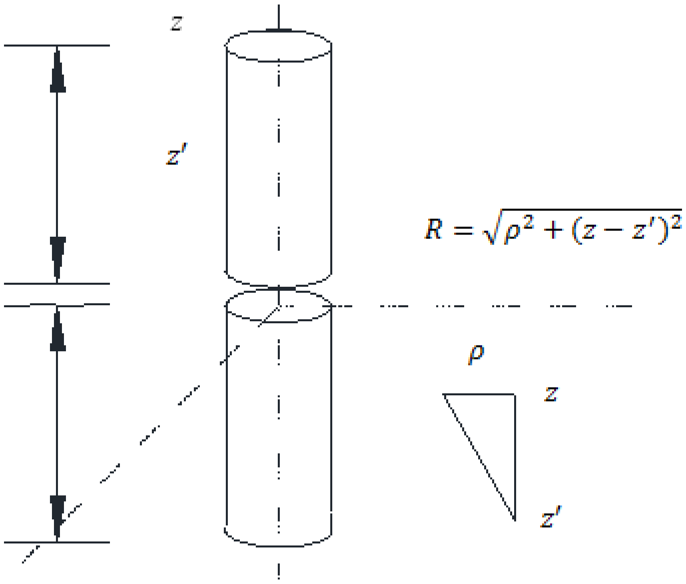

Figure 2.0: Integral Equation Formulation

With the conditions presented in Figure 1, Pocklington's equation may be written as:

$$\int_{-l/2}^{l/2} I_z(z')\left[\frac{\partial^2}{\partial z^2} + k^2\right]\frac{\varrho^{-jkR}}{4\pi R}\,dz' = j\omega\varepsilon E_z(z) \tag{2.5}$$

Where,

$$R = \sqrt{\rho^2 + (z - z')^2} \tag{2.6}$$

The variable R represents the distance between the current source and field observation points. The variable ρ specifies the radius of the wire. The current distribution $I_z(z')$ is defined along the length of the wire from $z = \frac{l}{2}$ to $z = \frac{-l}{2}$. The kernel $\frac{\partial^2}{\partial z^2} + k^2$ denotes the wave equation differential operator on the free space function. The constant k specifies the free space wave number. $E_z(z)$ represents the electric field generated by the current on the wire. With the specific excitation applied, as modeled through the appropriate boundary conditions, radiation characteristics and feed point impedances are determined from knowledge of the antenna's current distribution$I_z(z')$. Of the many techniques available to solve such integral equations problems, the method of moments is one of the related filed popular approaches.

2.3 The Method of Moments

The fundamental concept behind the methods of moments employs orthogonal expansions and linear algebra to reduce the integral equation problem to a system of simultaneous linear equations. This is accomplished by defining the unknown current distribution $I_z(z')$ in terms of an orthogonal set of basic functions and invoking the boundary conditions; the values of the electric field on the surface of the wire, and in the feed gap. Moving the currents expansions coefficients to the outside of the integral differential operator permits the evaluation of known functions, yielding values which are loosely defined as impedances. The current expansions coefficients, the orthogonal projections of the electric field boundary conditions, and these impedances are gathered into a system of simultaneous linear equations. This system of equations is solved to yield the current expansion coefficients. The original current distribution is then determined by the introducing these coefficients back into the basic function expansion.

The solution procedure begins by defining the unknown current distribution $I_z(z')$ in terms of an orthogonal set of basic functions. Two categories of basic functions exist. Sub domain basic functions, significantly more popular in industry, subdivide the wire into small segments and model the current distribution on each segment by a simple geometrical construct, such as a rectangle, triangle or sinusoidal arc. The amplitudes of these construct represent the expansion function coefficients. These simple constructs, illustrated in Figure 2.1, often overlap to maintain continuity of the current distribution along the wire.

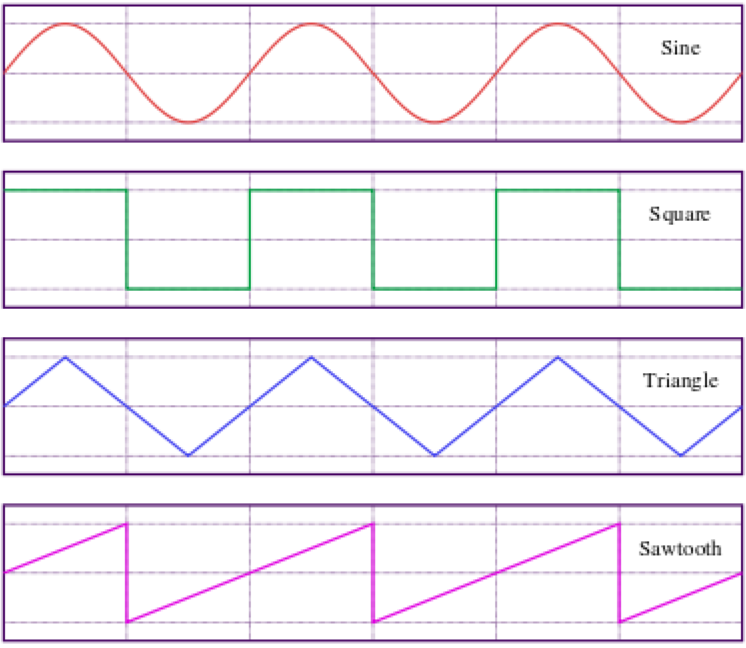

Figure 2.1: Basic Function of Current distribution Construction (en.wikipedia.org)

Entire domain basic functions employ a more formal orthogonal expansion, such as a Fourier Series to represent the current distribution along the entire wire. Entire domain basic functions tend to yield more complicated calculations for the impedances, therefore impractical. The introduction of the redefined current distribution reduces the integral equation to the form:

$$\sum_{n=1}^{N} C_n G_n(z) = E_z(z) \qquad 2.6$$

Where

$$G_n(z) = \frac{1}{j4\pi\omega\varepsilon} \int_{-l/2}^{l/2} F_n(z') \left[\frac{\partial^2}{\partial z^2} + k^2\right] \frac{e^{-jkR}}{R} dz' \qquad 2.7$$

C_n = current's expansion coefficient
$F_n(z')$ = basic function

The boundary conditions are now enforced through the use of an inner product operator with a set of orthogonal testing function. Each testing function is applied to both sides of the integral equation, the inner product then enforces the boundary condition at the location described by the testing function. This operation may be thought of as simply enforcing the boundary condition at a single point on the wire. After each testing function operation, the integral equation will be stated as:

$$\sum_{n=1}^{N} C_n \langle H_m(z), G_n(z)\rangle = \langle H_m(z), E_z(z)\rangle \qquad 2.8$$

where the fractional equation represent the inner product operator,

$$\langle H_m(z), G_z(z)\rangle = \int_{-l/2}^{l/2} H_m(z) G_n(z) dz \qquad 2.9$$

Where $H_m(z)$ is a testing function which has a non-zero value for only a small segment of wire located at z = Z_m. There are two common approaches to formulating the orthogonal set of testing functions. The first approach, the point matching or location technique, defines the testing function in terms Dirac delta function given by:

$$H_m(z) = \partial)z - z_m \qquad 2.10$$

Where z_m are specific points on the wire which the boundary conditions are enforced. z_m are usually selected to correspond with the midpoint of each basis function. The second approach, Galerkin's technique, although more complicated from a computational perspective, enforces the boundary condition more rigorously than the point matching technique. However, this more difficult approach is required for simple wire antenna problems. The entire boundary condition is enforced by applying the complete set of testing functions. This operation yields a set of integral equations.

$$[z_{mn} I I_n] = [V_m] \qquad 2.11$$

Where

$$z_{mn} = \int_{-l/2}^{l/2} H_m(z) G_n(z) dz \qquad 2.12$$

$$I_n = C_n \qquad 2.13$$

$$V_m = \int_{-l/2}^{l/2} H_m(z) E_{nz}(z) dz \qquad 2.14$$

This circuit like set of simultaneous linear equations will yield the value of C_n.

$$[I_n] = [Z_{mn}]^{-1}[V_m] \qquad 2.15$$

The software that had been tested to carry out the codes using method of moments is the Numerical Electromagnetics Code (NEC), which had been used to solve problems that can be defined as sets of one or more than wire.

2.4 Helix Antenna

A helix antenna is defined as an antenna whose configuration relates to a helix [1]. The helix antenna is relatively light weight because it is constructed using a metal conductor wire, a center support the helix structure, and is usually attached to a ground plane at the base. An example of a helix antenna is seen in Figure 2.2. The lossless gain of a Helix Antenna is given by

$$G = 15N\left(\frac{C}{\lambda}\right)^2\left(\frac{S}{\lambda}\right)^2 \qquad 2.16$$

Where, C is the circumference of helix. Circumference is the linear distance around the outside of a closed curve or circular object. S is the spacing between turns and N is the number of turns of a helical antenna.

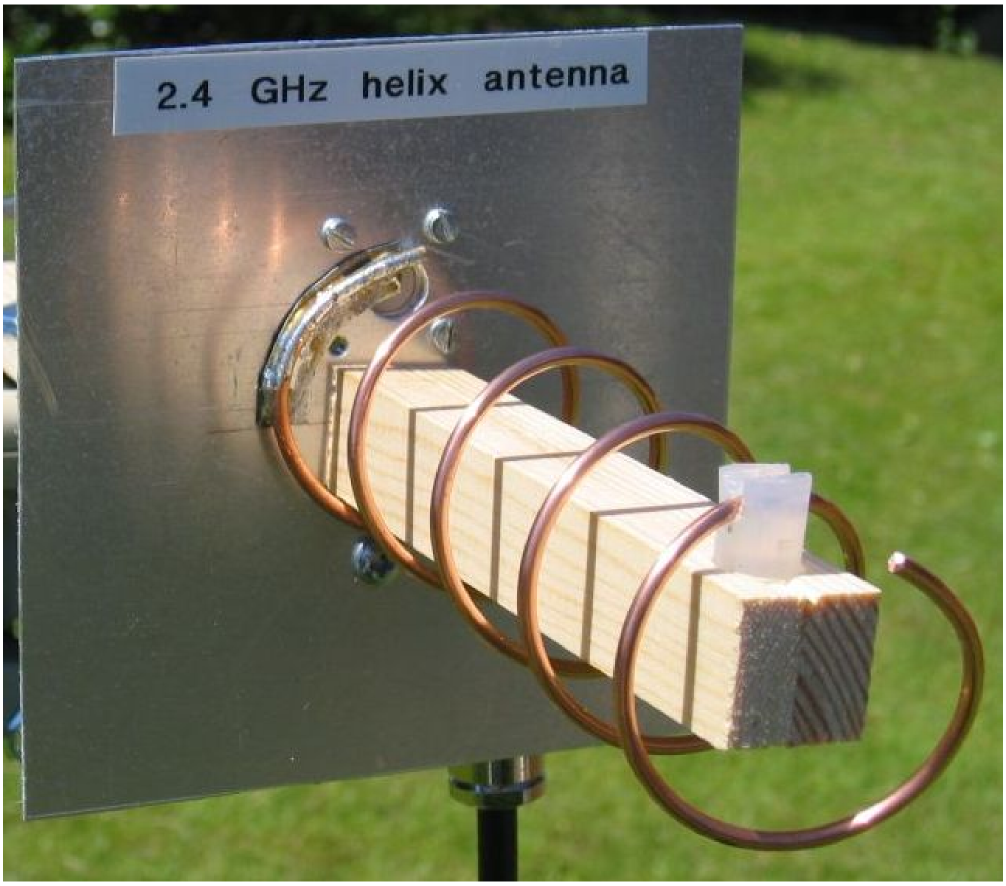

Figure 2.2 Basic Helix Antenna Configurations (Chung Fuk, 2011)

The gain is dependent of the number of turns, the circumference of the helix, the spacing between turns, and the wavelength. Designers can increase the gain of the antenna by adding additional turns which will increase the length of the antenna. Another key characteristic is the input impedance of the antenna. This can be obtained using,

$$R = 140\frac{C}{\lambda} \qquad 2.17$$

The resistance of the antenna is dependent of the circumference of the helix and the wavelength. By making the circumference smaller and closer to the wavelength, the antenna will have a smaller input resistance but a smaller achievable gain. By changing the circumference, designers can match the impedance of the transmitter to the generator resistance. Figure 2.3 shows a basic configuration of a helix antenna.

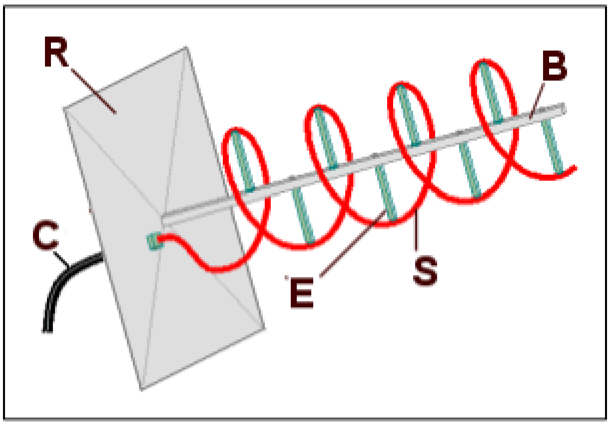

Figure 2.3 Basic Helix Antenna Configurations (Sergey Makarov, 2011)

The coaxial cable is connected to the feed is label as C, R is the reflector base, B is the center support, E is the support for the helix, and S is the wire of the helix antenna that is radiating or receiving electromagnetic waves. Other design parameters that needs to be consider when designing a helix antenna are the pitch angle:

$$\text{pitch } \Theta = \tan^{-1}\frac{S}{\pi D} \qquad 2.18$$

$$Antenna\ Length = NS \qquad 2.19$$

$$Total\ wire\ Length = N\ x\ Length\ of\ 1\ turn \qquad 2.20$$

There are two operational modes for a helix antenna that is axial mode, and normal mode. In normal mode the spacing between helixes and the diameter of the helixes are small in comparison with the wavelength. The radiation pattern is along the helical direction and it is similar to that of a dipole. In axial mode, the antenna functions like a directional antenna and the spacing between elements is λ/4. The antenna radiates at the top of the helix along the axis of the antenna. The radiation pattern of both operation modes can be seen in Figure 2.4.

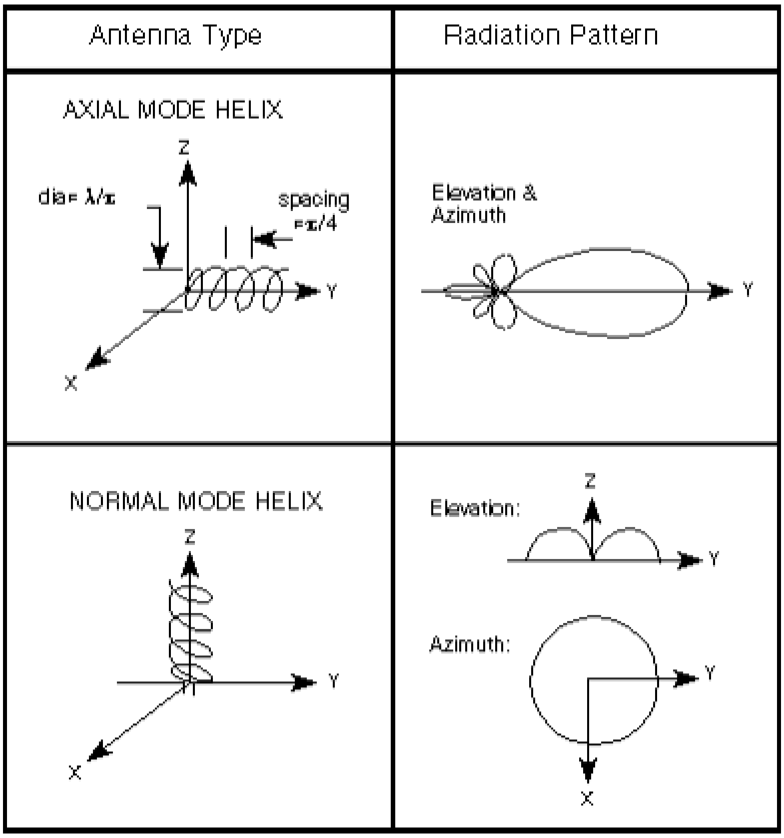

Figure 2.4 Radiation Pattern of Helix Antenna (Michael Gauthier 2005)

2.5 Previous Research

2.5.1 Effect of Wire End, In Thin Wire Analysis.

Most of the methods for thin wire analysis are based on the solving integral equation by using method of moments. In connection with that, special care is devoted to the effect of wire ends. Improper treatment of wire ends results in a very large total electric field in the vicinity of these discontinuities .In the case of electrical thin wire this large electric field usually has little effect on the current distribution away from the wire ends, as well as on the radiation characteristics. However, neglecting the end effect in the case of electrically thicker resonant structures can lead to significant numerical instabilities. A rigorous treatment of the end effect must include precise approximation of the surface current and charge distribution at the wire ends, taking into account the exact shape of the ends. Such treatment requires a number of extra terms in order to approximate these currents and charges and evaluation of a new type of quasisingular integrals. This implies an increase in the computer storage requirements and execution time presents a new, simple and almost rigorous treatment of effect of rationally symmetrical end, which can be easily included into algorithms developed without introducing additional unknowns. Further, it shows how the ends of the simple shape can be successfully modeled by conical (flat) ends, in which case evaluation of a new type of quasisingular integral for each particular end is avoided. Extensive numerical results confirm the suggested treatment and show some less known properties of errors of thin-wire analysis performed by various methods. The quality and efficiency of thin-wire analysis can be significantly improved by including simple and almost rigorous treatment of effect of conical (flat) end, which can be successfully used for modeling of ends of simple shapes.

2.5.2 Analysis of Coil-Loaded Thin-Wire

The technique of coil loading has been applied to a wire antenna to improve its radiation characteristics. On the analysis of this antenna, the coil was treated as a lumped circuit, and the voltage drop on the coil was expressed by the delta-function generator in the integral equation for the current distribution. When the coil is of finite length, however, the correct current distribution may not be obtained. Recently, the contribution from the coil was expressed by two deltas function generators located at coil ends and the current on the coil was approximated by a linear function. Although this method gives better result than the former approximate method does. The deviation of the calculated current distribution from the measured one is observed as the number of turns and length of coil increase. Pocklington's integral equation with the more accurate expression for the electric field on the surface of coil is formulated and its numerical solutions are compared with the measured results. The coil-loaded wire antenna is numerically analyzed and the good agreements between the numerical and measured current distribution and input impedance are obtained for the different numbers of turns in the coil. The application of the integral equation formulated here to an arbitrary wire-antenna structure is almost straightforward. Therefore the method suggested here is useful for the analysis and design of the coil-loaded wire antenna.

2.5.3 Approximate Surface-Current Distributions of Rectangular Dipole Antennas

Fractal-shaped wire antennas have been shown to exhibit resonance compression and multi-band behavior that has primarily, been attributed to the space-filling properties of the fractal geometry. Exhibiting a lower resonant frequency than a same-sized Euclidean antenna, fractal-shaped antennas can be made smaller than a Euclidean antenna that is resonant at time same frequency. While numerous fractal-shaped antennas such as Minkowski Island fractal loops and Koch fractal monopoles have been described in the literature, most discussions regarding these antennas have primarily focused on comparing their resonant behavior to those of simple Euclidean antennas. To understand the significance of any fractal geometry in determining the resonant behavior of the fractal-shaped antenna, it is also necessary to consider the other physical properties of the antenna. For the wire-loop antenna, these physical properties include the loop area, the total wire length, and the wire diameter. For the wire monopole antenna, these physical properties include the monopole height, the total wire length, and the wire diameter. While the antennas would have different geometries, they would have the same physical area or height, the same total wire length, and the same wire diameter. The performance properties of the, Minkowski Island fractal loop and the Koch fractal monopole are compared with those of other non-Euclidean geometry antennas.

2.5.4 Complete Surface Current Distribution In A Normal mode helical Antenna Using A Galerkin Solution With Sinusoidal Basis Functions.

An investigation of the surface current distribution in a normal-mode helical antenna (NMHA) is reported. This enables precise prediction of the performance of NMHAs, since traditional wire-antenna simulations ignore important details, such as non-uniform and transverse current distributions. A moment-method formulation is developed, using two-dimensional basis functions to represent the total non-uniform surface current distribution over the surface of the wire of the helix. Piecewise-sinusoidal basis functions are employed in two normal directions, with an exact kernel formulation and application of Galerkiu's solution method. The numerical solution of the singular integrals associated with self-impedance terms was computed with a very low relative error. The surface current distribution was computed for different helix geometries. It was found that the axially-directed component of the current distribution around the surface of the wire was highly non-uniform and that there was also a significant circumferential current flow due to inter-turn capacitance, both effects that are overlooked by standard filamentary current representations.

CHAPTER 3

METHODOLOGY

3.0 Chapter Overview

Milestones for the project completion are discussed in this chapter. Figure 3.0 illustrates the project methodology flowchart. Regardless of the literature, the methodology involves modeling, simulation, and experimental work. The diagram in Figure 3.0 clarifies that the methodology is mainly divided into two main tasks; first the modeling and testing different antenna wire geometries and derive current distributions for different antenna wire geometries.

3.1 Software Simulation

The project is started with the research project background and problem statement definition. Theories and previous research have been the basic reference in order to define the logic specification to achieve for the analysis of the wire antenna with difference wire thickness. 4NEC Antenna Simulation will be used to as a design simulation for performance results analysis. There are several soft wares that had been used nowadays especially in designing antenna such as CST Microwave Studio, and AN-SOF antenna simulation, but for wire antennas 4NEC has the edge because it use frequency domain solution, and it is easier to analyze surface current distribution on the antennas because of the extracted data of the results.

3.2 Research Work Stages

The research work will be carried out in throughout a few stages. The stages include review and establish the requirements and importance of the subject that is the surface current distribution on thick and thin wire antennas. In order to learn how to apply two orthogonal basis functions on curved surfaces, the best numerical techniques should be explore and established so it can offer the solution for the simulation.

The application of the approximated kernel and improvement of efficiency of integral equation method will be investigated throughout the development of the research. Before modeling process is introduced, the mathematical model of the surface resistive losses will be estimated. In order to discuss the effect of surface current distribution bring a critical contribution towards antenna performance, Q-factor, and efficiency, the variations of the non-uniform currents subject to antenna size is predicted.

The next stages that is the most important stages that is build and test several antenna geometries includes frequency operation as control parameter and the number of turns and antenna wire thickness as variable parameter. All obtained results will be discussed to its significance towards the antenna performance and resonant frequency.

3.3 Methodology Flow Chart

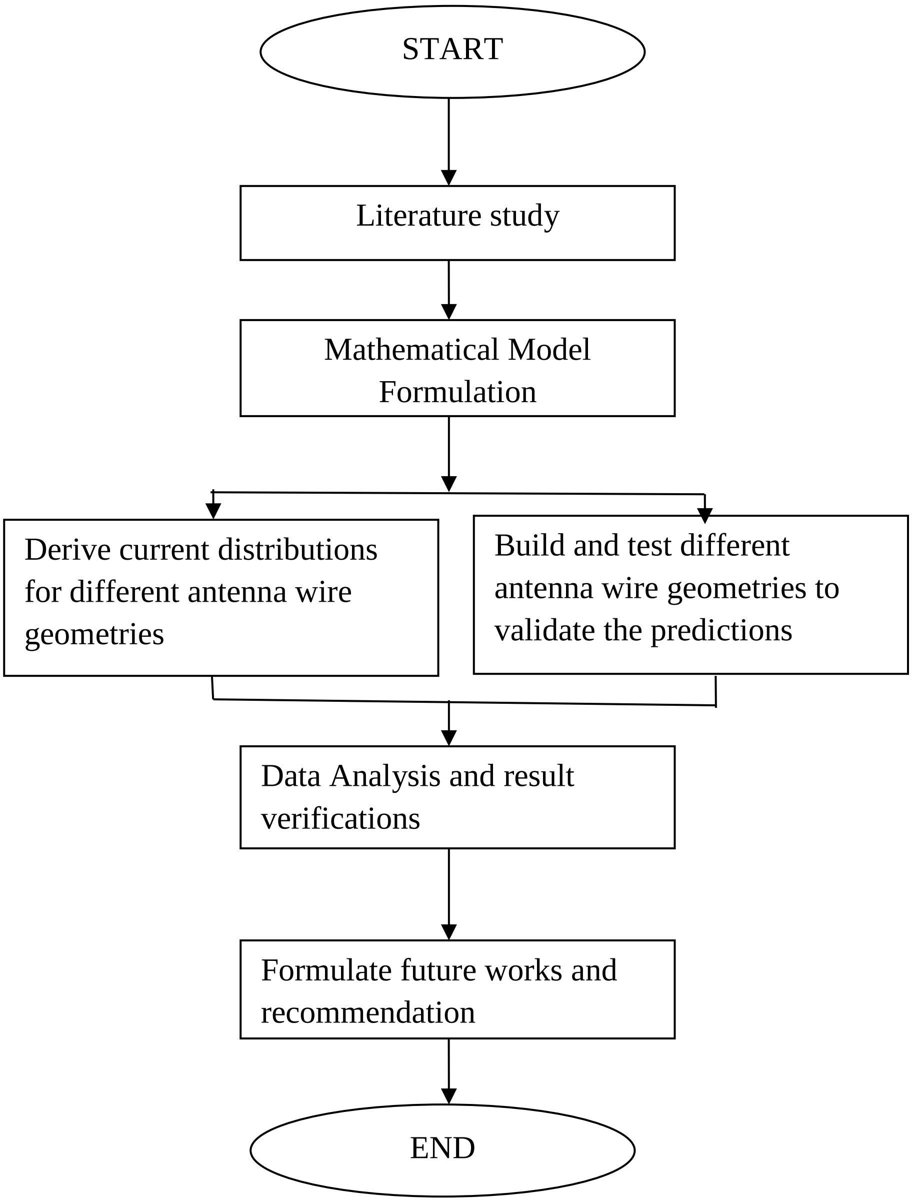

Figure 3.0: Methodology Flow Chart

CHAPTER 4

RESULTS AND ANALYSIS

4.0 Chapter Overview

In order to investigate the surface current distribution on different wire thickness, a helical antenna is designed using 4NEC simulation software. As stated in chapter three, the control parameter is frequency resonant. The variable parameters are helical antenna turn and wire thickness. Section 4.1 provides results and analysis on two turn helical antenna resonate at 300MHZ with three different wire thickness that is 1.0mm, 1.5mm, and 2.0mm wire thickness. Section 4.2 provide results and analysis on three turn helical antenna resonate at 300MHZ with three different wire thickness that is 1.0mm, 1.5mm, and 2.0mm wire thickness. Section 4.3 provide results and analysis on four turn helical antenna resonate at 300MHZ with three different wire thickness that is 1.0mm, 1.5mm, and 2.0mm wire thickness. Section 4.4 provide results and analysis on two turn helical antenna resonate at 900MHZ with three different wire thickness that is 1.0mm, 1.5mm, and 2.0mm wire thickness. Section 4.5 provide results and analysis on three turn helical antenna resonate at 900MHZ with three different wire thickness that is 1.0mm, 2.0mm, and 3.0mm wire thickness. The last experiment in Section 4.6 provide the results and analysis on four turn helical antenna resonate at 900MHZ with three different wire thickness that is 2.0mm, 4.0mm, and 6.0mm wire thickness.

4.1 Two Turn Helical Antenna at 300MHZ

Figure 4.0 shows the current distributions of two turn helical antenna resonate at 300MHz. Graph are plotted from NEC simulation results analysis from currents and locations section. From the figure we could clearly see that the current at surface are not uniform from the initial segments towards the end of the design. At wire thickness of 1mm, the peak current is 0.0160mA and approaching zero towards the end of the segments. At wire thickness of 1.5mm, the peak current is 0.0404mA and a relatively higher than 1mm antenna thickness. The current distribution of 2.0mm wire thickness antenna is the highest recorded peak value at 0.1086mA. Clearly here, the higher amount of wire thickness will result in the higher current distributions. Throughout along the wire antenna, the current on its surface are approaching zero, similar to all the three wire antenna of different thickness.

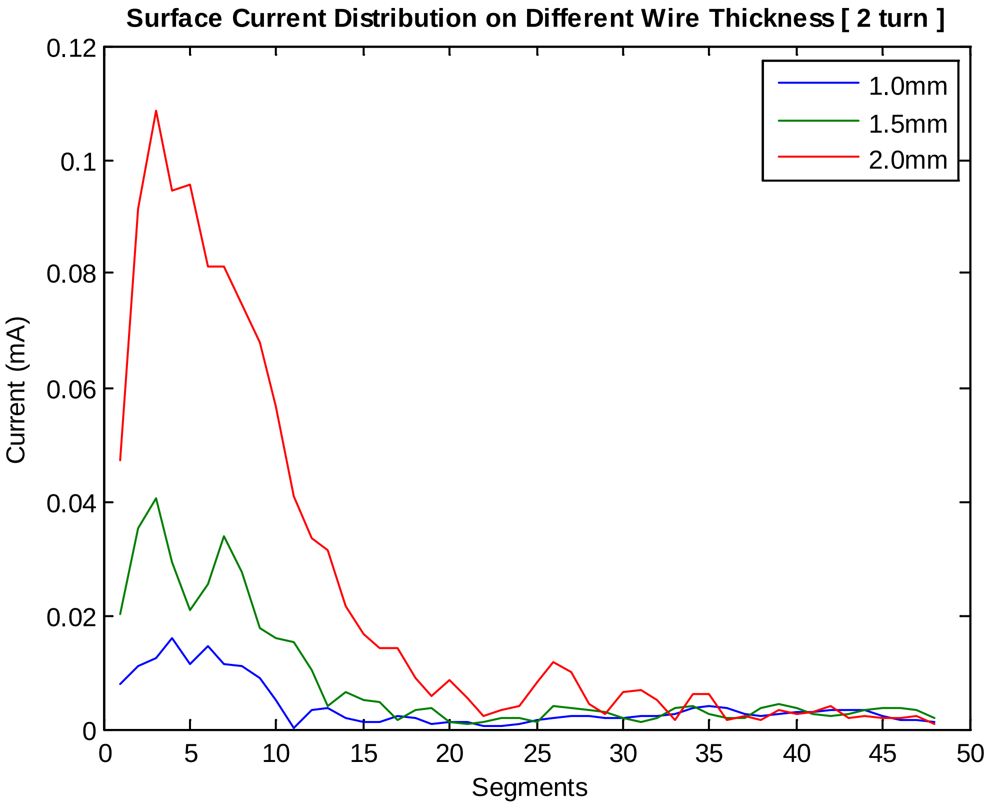

Figure 4.0: Surface Current Distribution of two turn Helical Antenna at 300MHZ

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