Development of Graphical User Interface (GUI) for Antenna Design

by

Cheow Yeng Peng

16409

Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Engineering (Hons)

(Electrical & Electronics)

JANUARY 2016

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CERTIFICATION OF APPROVAL

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Approved by,

(AP. Dr. Wong Peng Wen)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK.

JANUARY 2016

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

CHEOW YENG PENG

ABSTRACT

This project is to develop a Graphical User Interface (GUI) for the synthesis and analysis of antenna. Antenna design involves electromagnetic wave theory, which takes a tedious process in solving the integral and differential equations. Besides, the introduction of new antenna elements has added to the complexity of antenna, which in turn slower down the antenna design process. Thus, GUI is a crucial tool to speed up the antenna design process, at the same time providing the synthesis and analysis of antenna performance. This project involves four main phases, which is the theoretical modeling of antenna, critical review design of antenna, implementation of synthesis algorithm of antenna and the GUI development. The methodology of this project involved the selection of antenna types to design, computation of antenna parameters, analysis of antenna performance and lastly end with the impedance matching solution. In this project, impedance matching is essential in determining the suitability of an antenna as a matched antenna network, ensuring a maximum power transfer of signal source to the load. In other word, efficiency of an antenna depends on the impedance matching circuit of antenna. This project focused on the impedance matching network based on lumped elements. All the values of antenna input impedance, reflection coefficient, return loss, inductors and capacitors in the impedance matching circuit will be automatically generated by using MATLAB GUI based on the defined design specification. This project can be contributed as a pre-design tool to antenna design tool like ANSOFT HFSS to get the ideal dimension for the desired antenna performance before analyzing the antenna performance.

ACKNOWLEDGEMENT

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LIST OF ABBREVIATION

MAT	MATLAB Antenna Toolbox
FYP	Final Year Project
GUI	Graphical User Interface
IEEE	Institute of Electrical & Electronics
MoM	Method of Moments
FEM	Finite Element Method

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Back in the ancient day, communication between people from two distant point has been a challenge to mankind, until the launched of antenna in wireless communication industry through the recognition of electromagnetic waves theory. [1] In this world of modern wireless communication, designing a small and low- profile antenna together with the multiple antenna system capable of satisfying the strict demands of emergent multifunction wireless devices has become two major trends in RF industry, lead to more prominent role in antenna community. [2]

Based on the BCC Research, [3] the rapid development in wireless communications have made antenna almost indispensable to sectors such as computing application, residential and industrial. Wireless telecommunication has proved to increase the global antennas market from \$1.9 billion in the year of 2009 to \$2.2 billion in year of 2014, a compound annual growth rate (CAGR) of 3.7%. Figure 1 shows the summary figure size of global antenna market, starting from year 2007 to year 2014.

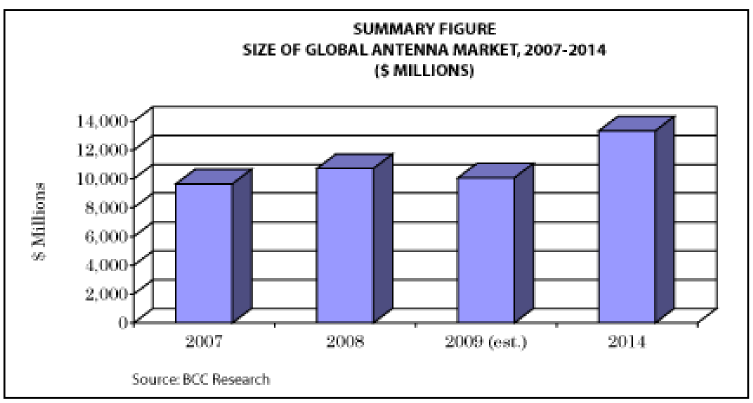


Figure 1: Summary Figure Size of Global Antenna Market

During the 1960's – 1980's, computer aided numerical method that introduced a new era in antenna have had a tremendous impact on the advance of modern antenna technology, which then help in speeding up the antenna modeling and designing process. In addition, asymptotic methods for both low frequencies (e.g. Moment Method (MM), Finite Difference, Finite-Element) and high frequencies (Geometrical and Physical Theories of Diffraction) were introduced, contributing significantly to the maturity of the antenna field. [1] However, the complexity of antenna is continuously increasing, aligning with the growth of the antenna market. In the other word, antenna modeling is getting more complicated with the launched of new elements such as waveguide apertures, horns, reflectors, array and etc. during the World War II.

Numerical and asymptotic method becomes time-consuming while solving complicated antenna array, where more formulas are involved in the antenna design process. Hence in this project, Author will speed up the antenna design process by implementing the synthesis algorithm through MATLAB Graphical User Interface (GUI). MATLAB GUI development helps to accelerate the antenna designing and analysis effort as calculation for different parameters can be done in parallel. Besides, MATLAB GUI provides a user friendly platform for the antenna design process as complicated command or programming will be represented with icons and buttons.

1.2 Problem Statement

New elements such as horns, aperture and etc. are introduced during World War II and these have added the complexity in the designing of an antenna. The tedious process of antenna design has bought to the introduction of various antenna analysis tools to the wireless communication industry. ANSOFT HFSS, a well-known antenna analysis tool, incorporates automated solution process, whereby users only need to specify the antenna geometry and material properties in order to get the corresponding antenna performance. However, each antenna analysis tools has their own limitation, and this same goes to ANSOFT HFSS. For instant, the pre-requisite of simulating the performance of antenna is to draw the dimension of antenna using HFSS or other engineering drawing software like AUTOCAD. It will be time consuming if the user has to continuously draw different dimension of antenna, just to get the desired performance. In addition, ANSOFT HFSS only provides antenna analysis but does not ease the antenna design process, which a lot of trial and error will be needed in the process of getting desired performance. Realizing the problem arise from using ANSOFT HFSS and other antenna analysis tools, this project aims in speeding up the design effort by developing a pre- design tool for these antenna analysis software through the implementation of antenna synthesis and analysis algorithm using MATLAB Graphical User Interface (GUI). A GUI is a user friendly interface where it will prompt the user for the design parameter inputs. Next, calculation and simulation of result will be compute using the computer synthesis tool, which then save time consumed for manual calculation.

1.3 Objectives and Scope of Study

The objectives of the research are aimed:

- To generate a pre-design tool for ANSOFT HFSS
- To synthesis and analyze the behavior of antenna based on the design parameters
- To provide a user friendly platform for antenna synthesis and analysis
- To develop a GUI for antenna design using MATLAB

The scope of study for this project is highly related to MATLAB GUI and the theoretical modeling of antenna, as showed in Figure 2. Author is required to study the function and operations available in MATLAB GUI before start designing an antenna modeling platform. In addition, there is MATLAB Antenna Toolbox (MAT) available in MATLAB, mainly for antenna analysis done by changing the design parameters of antenna. Through MAT, Author can get more understanding on the basic principle of an antenna besides the methodology of conducting antenna design process. Furthermore, Author is required to study the antenna theory involved in different type of antennas in order to develop an antenna design platform more efficiently.

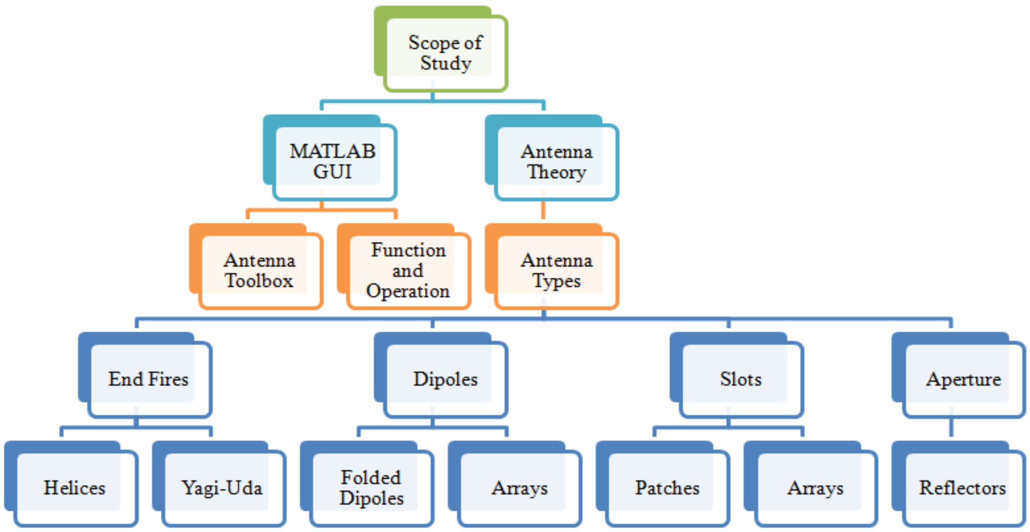


Figure 2: Scope of Study

1.4 Project Feasibility

This project is feasible within the time frame given, which is duration of 2 semesters (FYP 1 and FYP 2). FYP 1 focused more on theoretical study on the antenna and antenna arrays, besides the basic GUI development in order to have a brief idea on how to design a platform for antenna design using MATLAB GUI. Author will be able to gain the basic knowledge about antenna design and analysis through FYP 1 and develop a synthesis algorithm for antenna design to ease the implementation of GUI for antenna design in FYP 2 later. In the other hand, FYP 2 will be emphasize more on the implementation of synthesis algorithm of antenna design in MATLAB GUI as well as troubleshooting of the project for better accuracy of result. Furthermore, this project is feasible as the scope of study is within the capabilities of Author. Author is able to access to online tutorial and books, providing detailed information of antenna design as well as GUI development in MATLAB GUI.

1.5 Relevancy of the Project

This project is relevant because it helps in minimizing the time consuming antenna modeling and analysis process. It assists in reducing the tedious steps in solving lengthy polynomial equation in electromagnetic theory. Besides, antenna design process involves the knowledge of communication system, which is also within Author’s area of study.

CHAPTER 2

LITERATURE REVIEW AND THEORY

Antennas are any devices that converts electronic signal to electromagnetic waves, by means of using Maxwell Equations theory as stated in [1]. It is crucial to study the operation of an antenna before designing a system of it. Antenna system in transmitting and receiving mode is illustrated in Figure 3 while the Thevenin equivalent of antenna in transmitting and receiving mode is presented in Figure 4. [4]

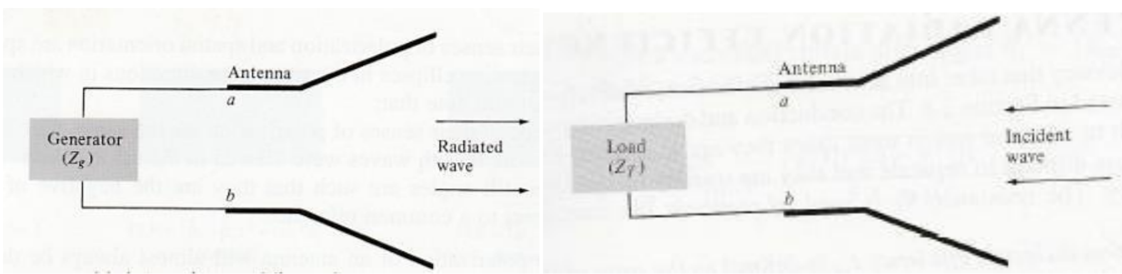


Figure 3: Antenna system in transmitting and receiving mode

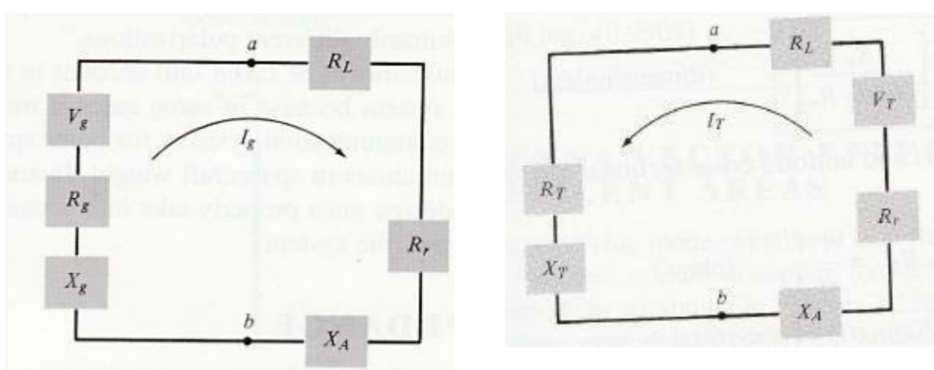


Figure 4: Thevenin equivalent of antenna in transmitting and receiving mode

In this scenario, a half wave dipole is introduced as it is considered as a very basic antenna structure, consisting of a finite length of wire with a length of λ/2. When a time varying voltage or current are applied to the half wave dipole, free electron accelerated. These electrons are able to travel in the spaces between atoms under the influence of exciting voltage or current, applied to the half wave dipole. The acceleration or deceleration of these electrons causes radiation to occur. [5]

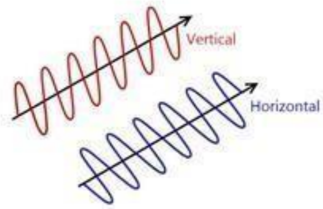
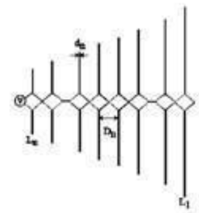
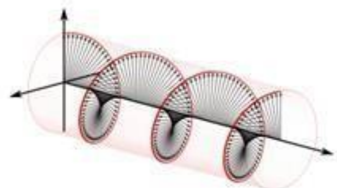
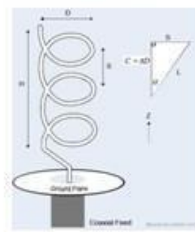
There are varies antenna type introduced, serving in different industries. Antenna can be categorized based on 3 basic parameters, which are the frequency, polarization and radiation. Radio frequency ranges from 3 kHz to 300 GHz and every frequency ranges are usually designated for typical service. Table 1 shows the services designated for particular frequency range. [6]

Table 1: Type of Service and Antenna Type Designated for Frequency:

Frequency Band	**Designation**	**Typical Service**	**Antenna Type**
3 – 30kHz	Very Low Frequency (VLF)	Navigation, SONAR	• Vertical Radiators • Valley span antenna
30 – 300kHz	Low Frequency (LF)	Radio beacons, Navigational Aids	
300 – 3000kHz	Medium Frequency (MF)	AM broadcasting, maritime radio, coast guard communication, direction finding	• Monopoles and Dipoles • Directional Antennas
3 – 30MHz	High Frequency (HF)	Telephone, Telegraph and Facsimile, amateur radio, ship-to-coast and ship-to-aircraft communication	• Log periodic antenna • Conical monopole • Vertical whip antenna
30 – 300MHz	Very High Frequency (VHF)	Television, FM broadcast, air traffic control, police, navigational aids	• Yagi-Uda antennas • Helical antennas • Corner reflector antenna
300 – 3000MHz	Ultra High Frequency (UHF)	Television, Satellite Communication, Surveillance RADAR, navigational aids	
3 – 30GHz	Super High Frequency (SHF)	Airborne RADAR, Microwave Links, Satellite Communication	• Parabolic antenna • Microstrip patch antennas • Pyramidal horn antennas
30 – 300GHz	Extremely High Frequency (EHF)	RADAR, Experimental	

Polarization can be defined as the wave radiated or received by an antenna in a given direction. Polarization can be divided into 2 major categories as stated in Table 2. [6] Each antenna in a system should have the same polarization waves in order to generate maximum signal strength between stations.

Table 2: Type of Polarization Antenna

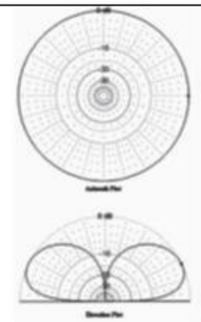
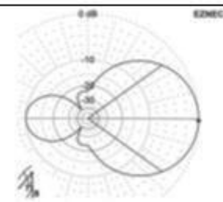
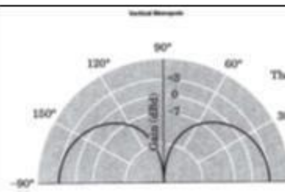
Type	Polarization waves	Type of antenna
Linear Polarization		• Dipole • Yagi-Uda array • Log periodic dipole array 
Circular Polarization		• Helical antenna 

Besides antenna polarization, antenna pattern is also one of the important design considerations. Table 3 illustrates 3 type of basic radiation pattern antenna. [6] Antenna pattern is interrelated to other antenna parameters such as directivity, power density, antenna aperture and height, as stated in [1].

From Figure 3, directional antenna is observed having a main lobe, representing the high directivity (directivity > 1) toward that direction. In the other hand, omnidirectional antenna is having a directivity of 1 as it radiates equally in all direction. The formula for computing directivity of antenna is presented in [1].

In some cases, where high directivity and gain is needed, antenna array is implemented instead of single antenna element. In an array, the mechanical problem of a large single element is traded for the electrical problem associated with the feed network of array. The total field of an array is formed by the vector addition of field radiated by individual antenna element. To achieve high directivity, the field of each single element has to be added together in the desired direction, while field cancelling in other direction.

Table 3: Type of Radiation Pattern Antenna

Radiation Pattern Antenna	Radiation Pattern	Type of antenna
Omnidirectional Antenna		• Whip antenna • Dipole antenna
Directional Antenna		• Yagi-Uda antenna • Log periodic antenna
Hemispherical Antenna		• All monopoles antenna with large plane

In the process of antenna design, complex EM related problems are solved by computer aided numerical and asymptotic methods. These classical methods include Finite Difference Time Domain (FDTD), Method of Moments (MoM) and Finite Element Method (FEM). Based on the research paper in [4], each numerical method owns their pros and cons while solving Maxwell's equation, as showed in Table 4.

In the other hand, MLFMM, which is an accelerated version of MoM has proved to contribute a great reduction in the runtime despite of the electrically large dimension of antenna array. [7] Table 5 shows the computational resources while designing a 4 and 8 element array. MLFMM differs from MoM in the solving of group basis function, instead of solving them individually. Hence, this fact implies the efficiency of MLFMM in solving electrically large antenna array compared to MoM.

Table 4: Comparison of the main numerical techniques in term of storage requirement, CPU time, Versatility and Preprocessing

Numerical Methods	Storage requirement	CPU Time	Versatility	Preprocessing
FDTD	L	L	E	-
FEM	L	M/L	E	S
MoM	S/M	S/M	G	M

E – Excellent, G – Good, L – Large, Ma – Marginal, M – Moderate, S – Small

Table 5: Computational Resources while Designing a 4 and 8 Element Array

Method	4-element array		8-element array	
	Memory	Runtime	Memory	Runtime
FDTD	1.3GB	5 hours	2.6GB	10 hours
FEM	11.4GB	1 hours	35.7GB	4 hours
MoM	37GB	7.3 hours		
MLFMM			15.8GB	4.3 hours

In MATLAB 2015 version, MATLAB Antenna Toolbox (MAT) [8] is introduced, providing the ability to design, analyze and antenna visualizations. MAT utilizes Method of Moments (MoM) for the computation of antenna parameters. Antenna pattern, current and charge distribution of the selected antenna can be defined by simulating MAT functions with the desired parameters specified by users. MAT is providing reasonably accurate analysis for simple antennas. In addition, MAT introduced examples of antenna design, accompanied by related commercial antenna analysis software - ANSOFT HFSS FEM solution. Figure 5 and 6 illustrate a slight difference in the antenna analysis results such as return loss and directivity, which seperately simulated under MAT and ANSOFT HFSS. The offset results obtained from both simulation tools is mainly due to the difference in numerical methods used besides the less consideration of material properties in MAT. [10]

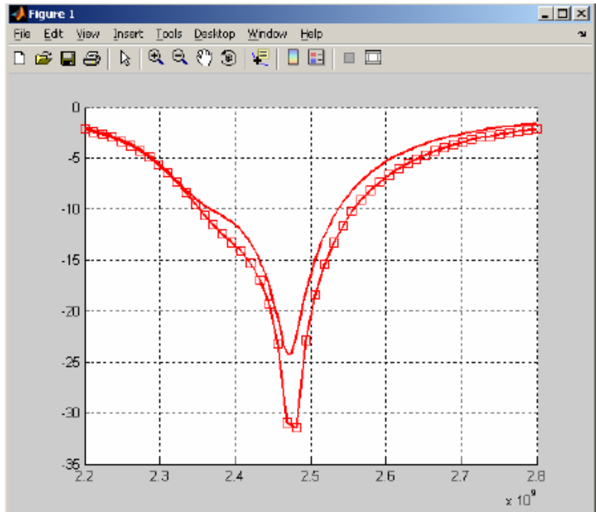


Figure 5: Result of antenna return loss simulated by MAT (squared curve) and return loss predicted by ANSOFT HFSS (solid curve)

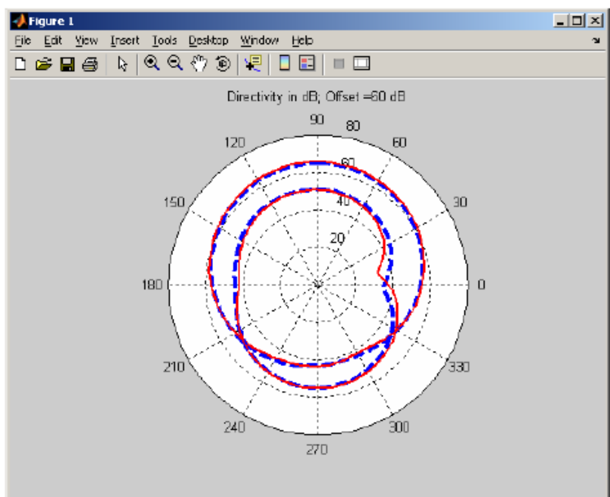


Figure 6: Result of directivity simulated by MAT (solid curve) and directivity predicted by ANSOFT HFSS (dashed curve)

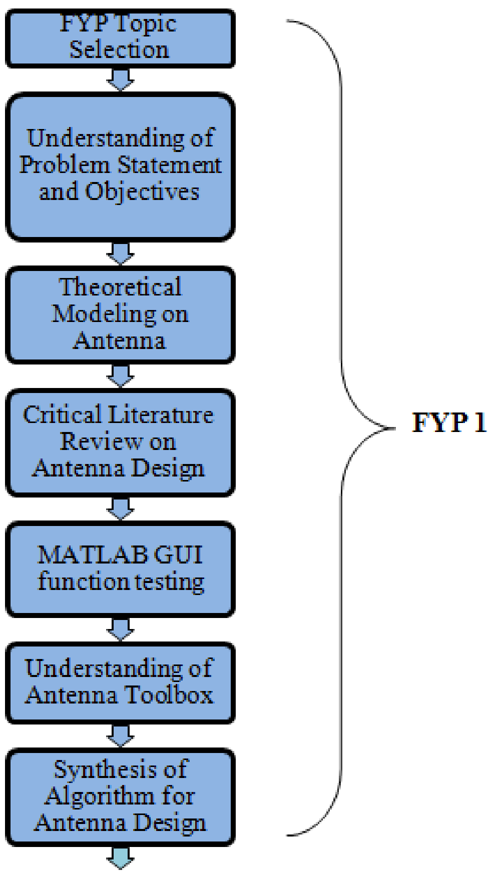
In this paper, development of Graphical User Interface (GUI) for antenna design will be done. MATLAB GUI serves as a user friendly platform, by representing all the complicated command or programming with icons and buttons. Besides, functions available in MAT are used in the GUI development for antenna synthesis and analysis. Computational process will become more efficient as different parameters design process can be done in parallel by implementing all the related command under the same operating system.

CHAPTER 3

METHODOLOGY AND PROJECT WORK

3.1 Research Methodology

Research methodology illustrates the process of planning throughout the whole project. This project will be carried out throughout the 28 weeks, which is 2 semesters. With a well planning methodology, the objective to develop a GUI for the synthesis of antenna can be achieved within the given timeline. The general flow of research methodology is shown in the flow chart in Figure 7.



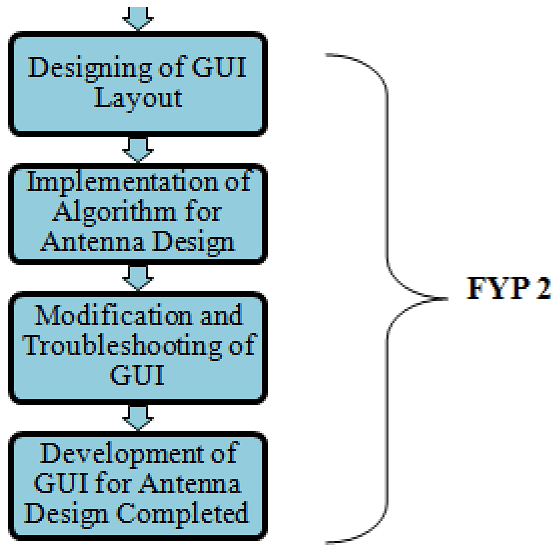


Figure 7: General flow of Research Methodology

3.2 Project Activities

This project involves four main phases, which will be carried out throughout two semesters (September 2015 till April 2016). These four main phases involves theoretical modeling of antenna, critical design review on antenna design, the development of synthesis algorithm for antenna design as well as the implementation of antenna synthesis algorithm on MATLAB GUI. FYP 1 focuses on the theoretical modeling as well as critical design review of antenna. Several techniques like Method of Moments and Finite Element Method (FEM) are commonly used to solve the complex polynomial equations involved in antenna design. Different techniques used is studied and analyzed before deciding the method used for antenna design in this project. Furthermore, the antenna design procedure is studied and a synthesis algorithm for antenna design has developed during FYP 1, in order to ensure smooth progress flow during FYP 2. For FYP 2, the implementation of antenna synthesis algorithm in MATLAB GUI as well as troubleshooting of result will proceed throughout the final semester in order to achieve the goal of this project.

3.3 Gantt Chart

No.	Activities / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Final Year Project Title Selection														
2	Approval of Proposed Topic														
3	Understanding of Problem Statement & Objectives of Proposed Topic - Identify the market demand of this project - Study how this project aids in accelerating the antenna design process														
4	Theoretical Modeling on Antenna - Study the theory of electromagnetic waves and radiation - Understand how antenna works - In-depth understanding of the theory involved (Maxwell's Equation)														
5	Critical Literature Review on Antenna Design - Identify the methods (eg. Method of Moments) to solve complicated differential and integral equation involved in antenna design - Comparison between methods - Comparison between existing antenna design software and current project														
6	Methodology formation for Project - Planning of the methodology for FYP 1														
7	In depth study on the theoretical modeling of antenna - Identify the type of antenna selection in GUI - Study the theory and formula involved in each antenna - Study on the optimization of antenna														
8	Testing on Matlab GUI														
9	Study on Antenna Toolbox build in function														
10	Synthesis of Algorithm for Antenna Design														

Figure 8: Gantt Chart for FYP I

No.	Activities / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Development of GUI Layout - Create panels for 4 main functions (Type of Antenna, Design Parameters, Radiation Pattern and Port Analysis)														
2	Study on Antenna Toolbox build in function														
3	Implementation of Algorithm for Antenna Design - Calling function from Antenna Toolbox - Provide user friendly button to ease antenna design process														
4	Troubleshooting of GUI for antenna design														
5	Development of GUI for antenna design completed														

Figure 9: Gantt Chart for FYP II

3.4 Project Key Milestone

Figure 10: Project Key Milestone for FYP I and FYP II

CHAPTER 4

RESULT AND DISCUSSION

4.1 Theoretical Modelling of Antenna

In this project, Author has studied the theoretical modeling of different antenna type not only from [1], but also from MATLAB Antenna Toolbox (MAT), by running the function in command window. Author used the existing function in MAT to generate a GUI for antenna design besides adding an impedance matching network for maximum power transfer purpose. MATLAB Antenna Toolbox allows users to identify the radiation pattern of antenna and its directivity in specific azimuth as well as elevation. In addition, port analysis can be simulated based on defined parameters such as frequency range and dimension of antenna.

Antenna design and analysis start off with the selection of antenna type, defining of antenna dimension, followed by radiation pattern identification and finally end with port analysis like return loss, reflection coefficient and etc.

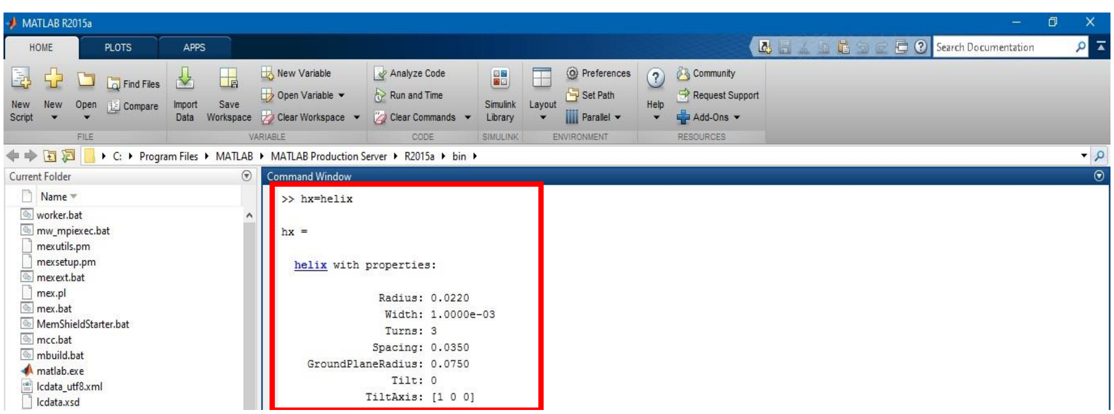


Figure 11: Default antenna dimension is displayed after selection of antenna is made

Users can define their desired antenna to design in the command window and the antenna dimension will be displayed, as shown in Figure 11. Figure 12 illustrates the easy modification of antenna dimension based on the users' input.

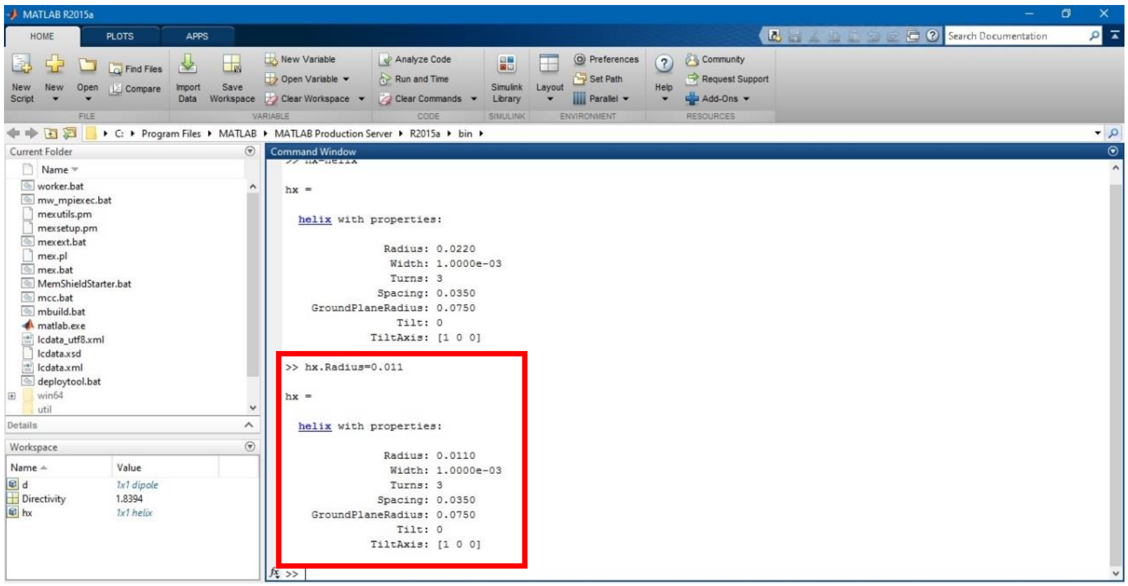


Figure 12: Properties of antenna can be modify easily

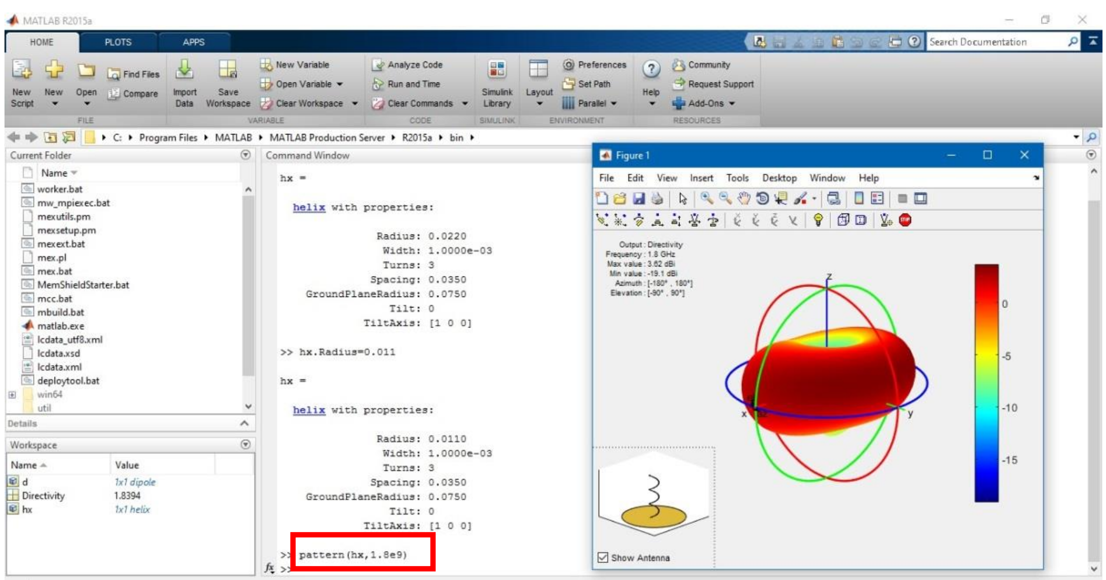


Figure 13: Radiation Pattern of Antenna with Frequency Input by User

Next, to analyze the antenna performance, radiation pattern of antenna can be observed easily by defining the frequency and the antenna element to design in the command window, using the function 'pattern'. From Figure 13, a 3D radiation pattern of the design antenna is observed, with an azimuth of -180 degree to 180 degree and with an elevation of -90 degree to 90 degree. The dark red shaded region symbolizes the highest directivity, whereas the dark blue shaded region indicates the lowest directivity at the specific azimuth and elevation.

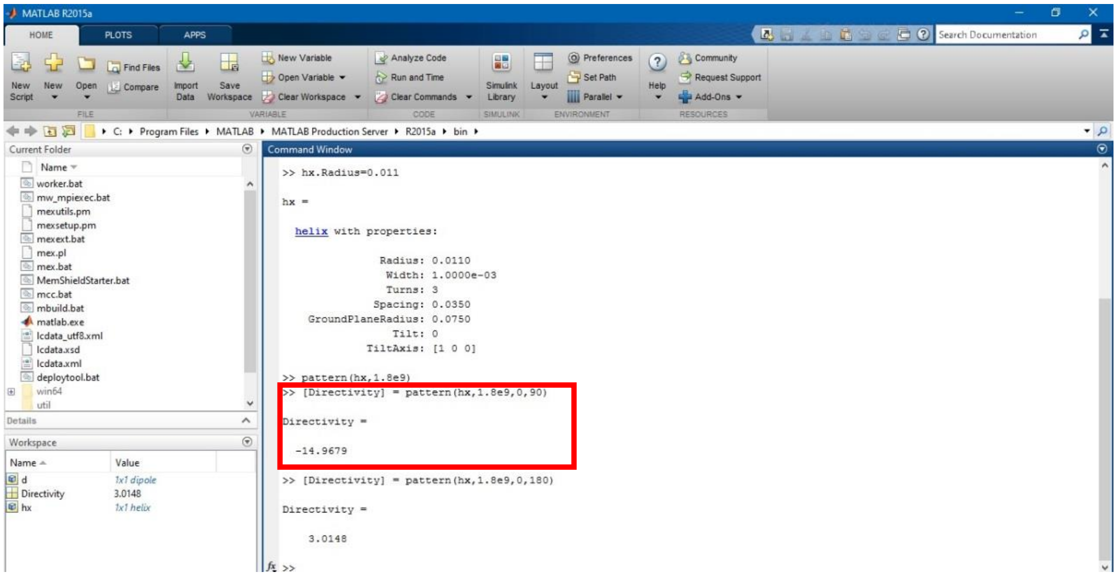
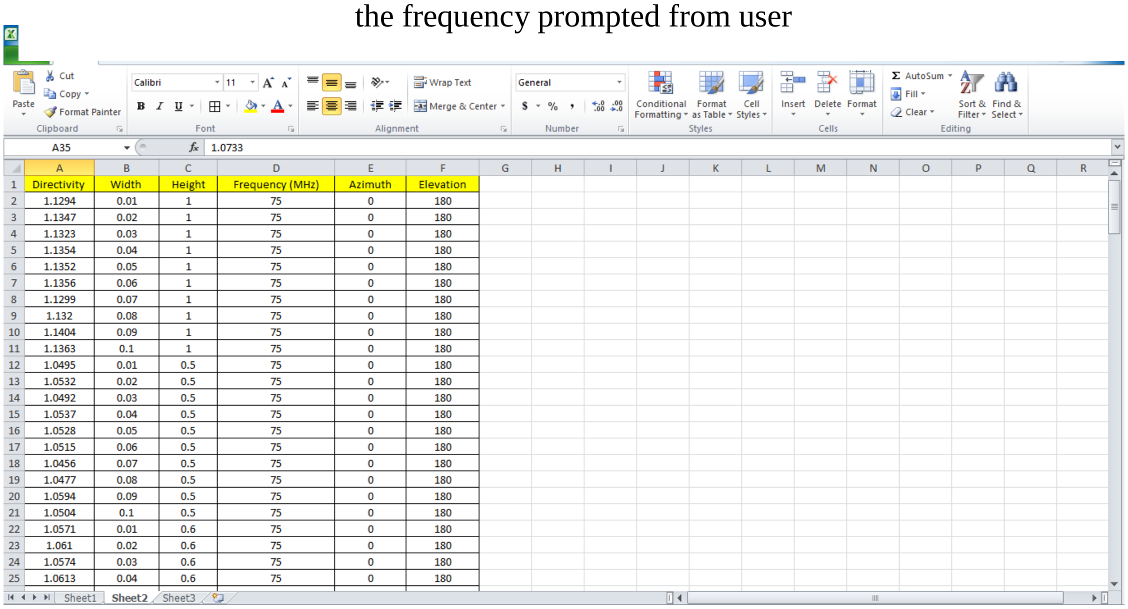


Figure 14: Directivity of antenna calculated with the azimuth and elevation as well as the frequency prompted from user



Directivity	Width	Height	Frequency (MHz)	Azimuth	Elevation
1.1294	0.01	1	75	0	180
1.1347	0.02	1	75	0	180
1.1323	0.03	1	75	0	180
1.1354	0.04	1	75	0	180
1.1352	0.05	1	75	0	180
1.1356	0.06	1	75	0	180
1.1299	0.07	1	75	0	180
1.132	0.08	1	75	0	180
1.1404	0.09	1	75	0	180
1.1363	0.1	1	75	0	180
1.0495	0.01	0.5	75	0	180
1.0532	0.02	0.5	75	0	180
1.0492	0.03	0.5	75	0	180
1.0537	0.04	0.5	75	0	180
1.0528	0.05	0.5	75	0	180
1.0515	0.06	0.5	75	0	180
1.0456	0.07	0.5	75	0	180
1.0477	0.08	0.5	75	0	180
1.0594	0.09	0.5	75	0	180
1.0504	0.1	0.5	75	0	180
1.0571	0.01	0.6	75	0	180
1.061	0.02	0.6	75	0	180
1.0574	0.03	0.6	75	0	180
1.0613	0.04	0.6	75	0	180

Figure 15: Database of monopole antenna

To get an exact value of the directivity in specific direction, function 'Directivity' is called from the command window by defining the antenna element, frequency as well as the azimuth and elevation of the antenna. The more positive the value of calculated directivity, the more the antenna radiates, in other word, more power transferred in that direction. Since MAT permits the calculation of directivity only after the definition of antenna dimension, but not in the other way round, Author has collected sheets of database for each antennas, simulated from the Antenna Toolbox function, which allows the GUI to look up from the excel file for the suitable antenna dimension after desired directivity is defined by users. Figure 15 shows the example sheet of database for monopole antenna.

Return loss, reflection coefficient and VSWR are generally used to analyze the performance of antenna, making sure of maximum transfer of power from the source to the load. Figure 16, 17, 18 illustrate the return loss, reflection coefficient and VSWR graph simulated from MAT based on the parameters input by users. In telecommunication, reflection coefficient measures the amplitude of the reflected wave versus the amplitudes of the incident wave. The expression for calculating the reflection coefficient is as ***Equation (1).***

$$\boxed{\Gamma = \frac{Z_L - Z_S}{Z_L + Z_S}}$$ …. **Equation (1)**

$Z_L = load\ impedance$;

$Z_s = source\ impedance$;

In addition, VSWR measurement describes the voltage standing wave pattern that is present in the transmission line due to the phase addition and subtraction of the incident and reflected waves. The ratio is defined by the maximum standing wave amplitude versus the minimum standing wave amplitude. The VSWR can be calculated from the reflection coefficient with the ***Equation (2).***

$$\boxed{VSWR = \frac{1 + \Gamma}{1 - \Gamma}}$$ ….**Equation (2)**

Besides, return loss measurement describes the ratio of the power in the reflected wave to the power in the incident wave in units of decibels. The standard output for the return loss is a positive value, so a large return loss value actually means that the power in the reflected wave is small compared to the power in the incident wave and thus indicating a better impedance matching. The return loss can be calculated from the reflection coefficient with ***Equation 3***.

$$\boxed{Return\ Loss = -20log(\Gamma)}$$ ……**Equation (3)**

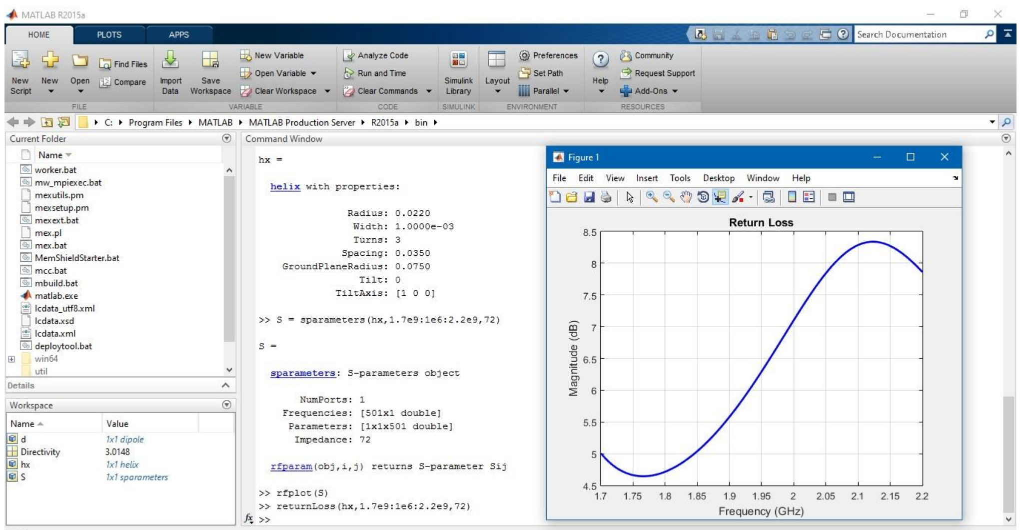


Figure 16: Return Loss Graph

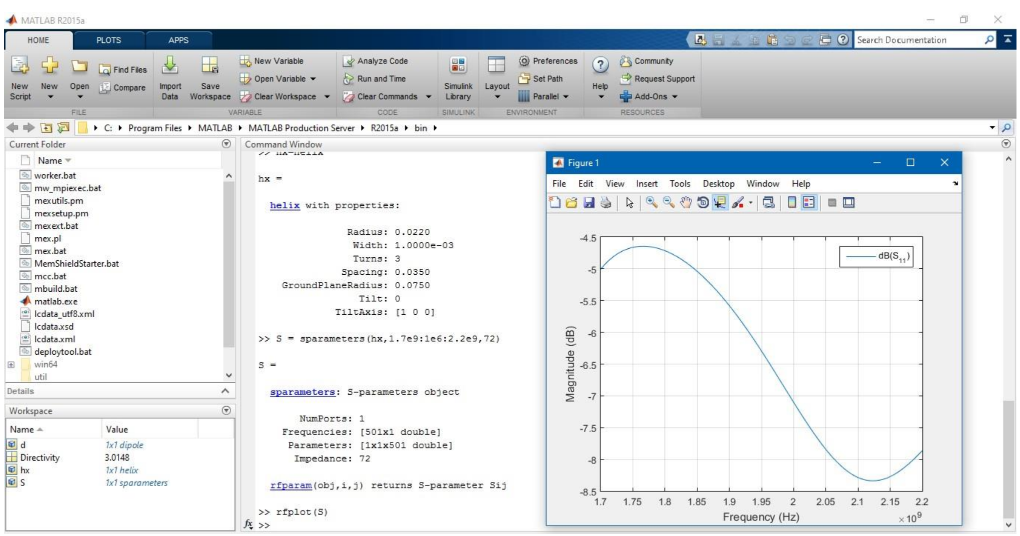


Figure 17: Reflection Coefficient Graph

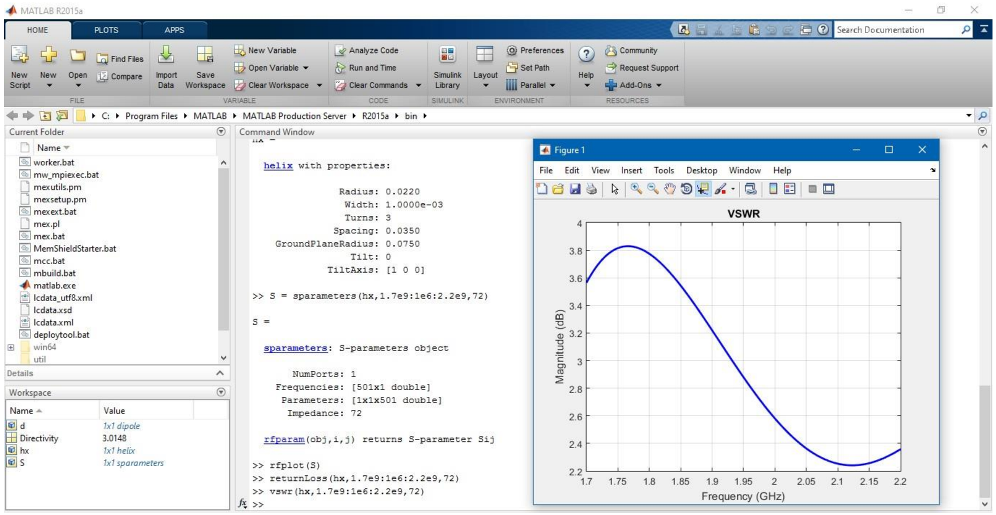


Figure 18: VSWR Graph

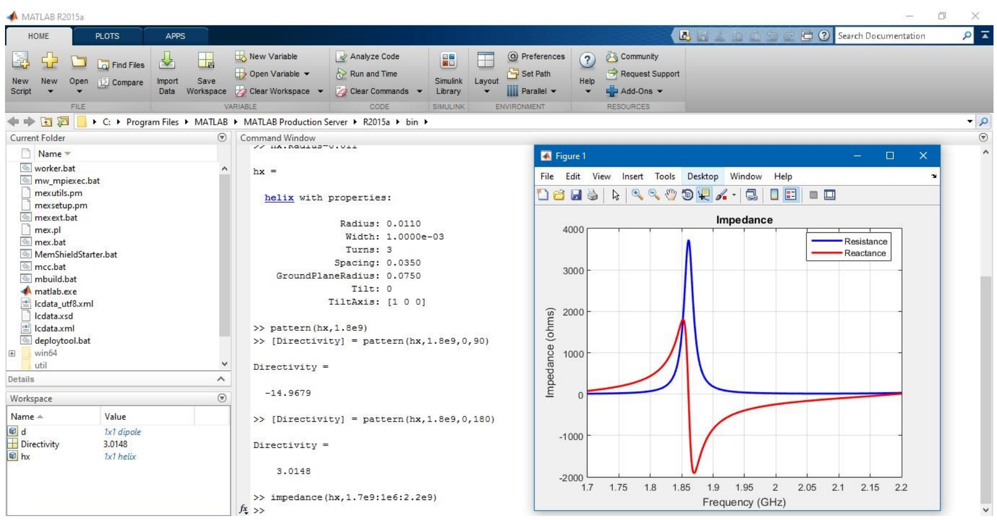
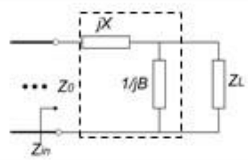
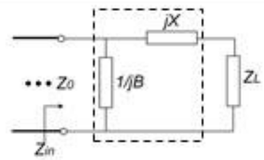
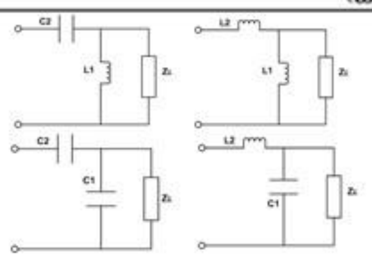
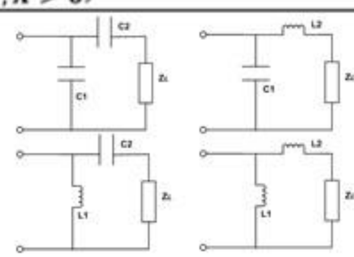


Figure 19: Input impedance of antenna calculated with the frequency range prompted from user

Other than that, impedance matching is also implemented in this project to ensure maximum power transfer from source to load. Despite of the utilization of different impedance matching network introduced nowadays, Author utilize lumped element L network matching in this GUI implementation. Table 6 shows the graphical representation of L network matching network under two different conditions. There are 8 possible L networks matching network, depending on the value of source and load impedance. Load impedance of antenna can be easily obtained by simulating the antenna impedance graph, as shown in Figure 19 and get the respective resistance and reactance at the specific frequency, whereas source impedance is prompted from the user with a default value of 50Ω.

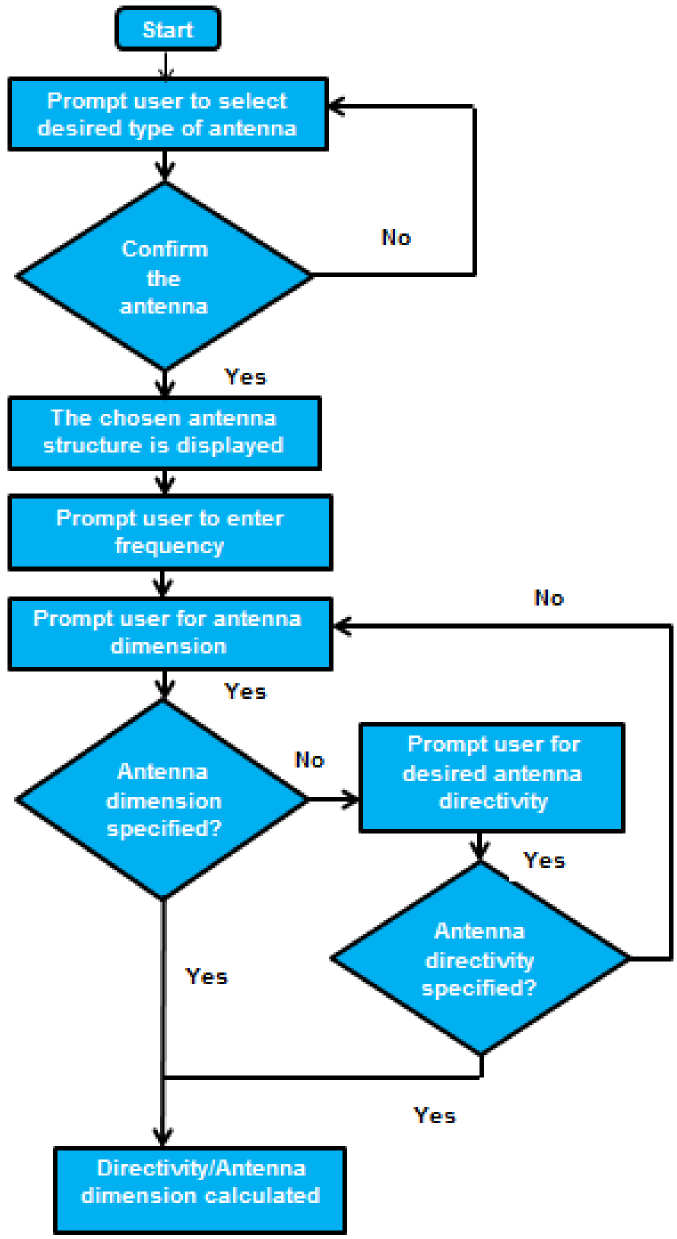
Table 6: Lumped element L Network Impedance Matching

$R_L > Z_0$	$R_L < Z_0$
	
$B = \frac{X_L \pm \sqrt{\frac{R_L}{Z_0}}\sqrt{R_L(R_L - Z_0) + X_L^2}}{R_L^2 + X_L^2}$	$B = \pm\frac{1}{Z_0}\sqrt{\frac{Z_0 - R_L}{R_L}}$
$X = \frac{1}{B} + \frac{X_L Z_0}{R_L} - \frac{Z_0}{BR_L}$	$X = \pm\sqrt{R_L(Z_0 - R_L)} - X_L$
$B = \begin{cases} \frac{-1}{\omega L} & ; B < 0 \\ \omega C & ; B > 0 \end{cases}$ $X = \begin{cases} \frac{-1}{\omega C} & ; X < 0 \\ \omega L & ; X > 0 \end{cases}$	
	

B is the admittance while X is the reactance in the lumped element L matching network. Inductance and capacitance of the L network is then calculated based on the equations stated in Table 6.

4.2 Synthesis Algorithm for Antenna Design

A synthesis algorithm for antenna design is generated as shown in Figure 20. It is necessary to develop a synthesis algorithm before the implementation of formula in MATLAB GUI as this algorithm allows Author to have a wise planning on the step-by step coding on antenna design, especially when implementing GUI on different type of antenna design.



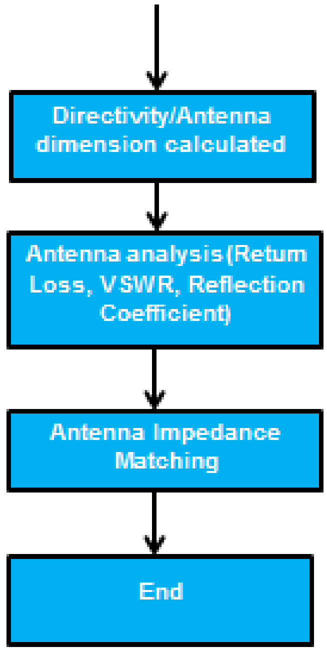


Figure 20: Synthesis Algorithm for Antenna Design

4.3 GUI Development for Antenna Design

To access the antenna design GUI, user has to first call the 'PosterPresentationLayout.m' file from the command window as shown in Figure 21. Next, a pop out window with the antenna design interface will be appeared. There are panels created in the GUI in order to make the interface look more organized in term of functions.

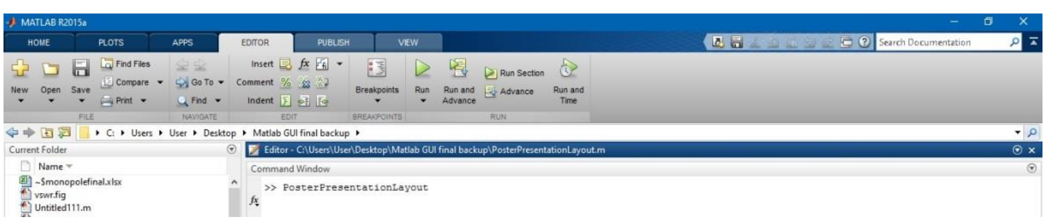


Figure 21: Antenna design GUI file calling from command window

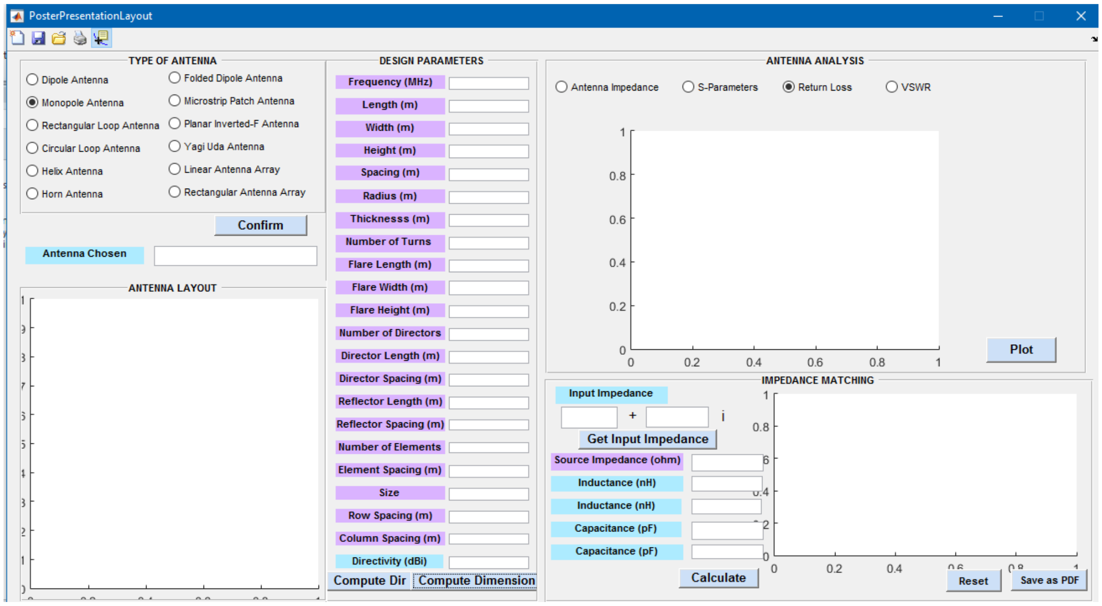


Figure 22: GUI for antenna design

The antenna modelling starts off with the selection of antenna. A total of 12 types of antenna and array are available for design. Figure 23 shows the type of antenna is first prompt from the user and the antenna structure is appeared right after the selection of antenna is completed and confirmed.

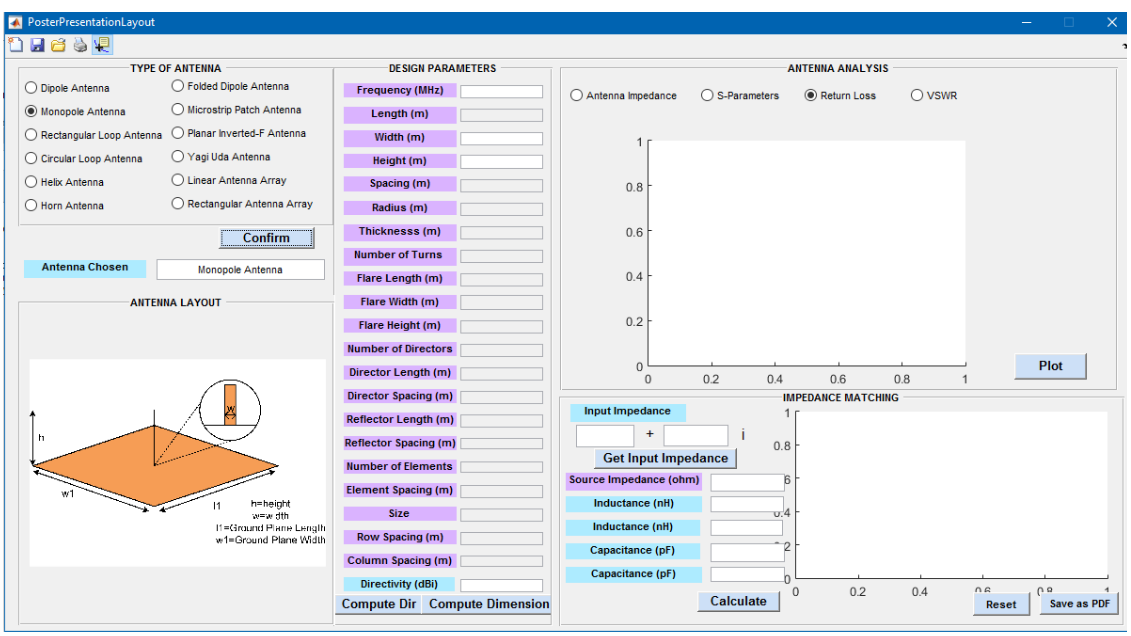


Figure 23: Selection of antenna type

Next, antenna modeling proceeds with the two ways calculation, which is the calculation of directivity based on the given antenna dimension, or vice versa. However, the frequency used has to be first input by the user before proceeds further.

Case 1: Calculation of Directivity

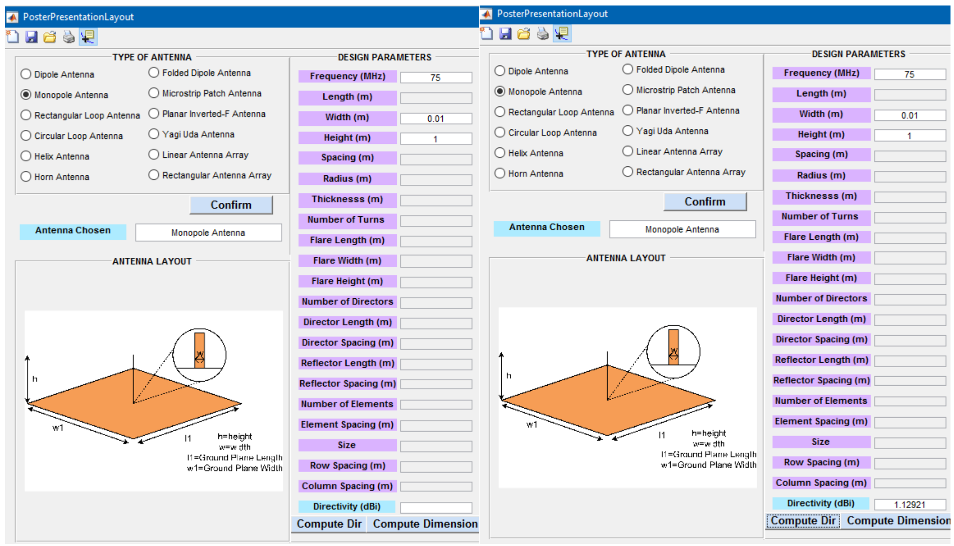


Figure 24: (a) Antenna dimension is define (b) Directivity of antenna is calculated

Case 2: Calculation of Antenna Dimension

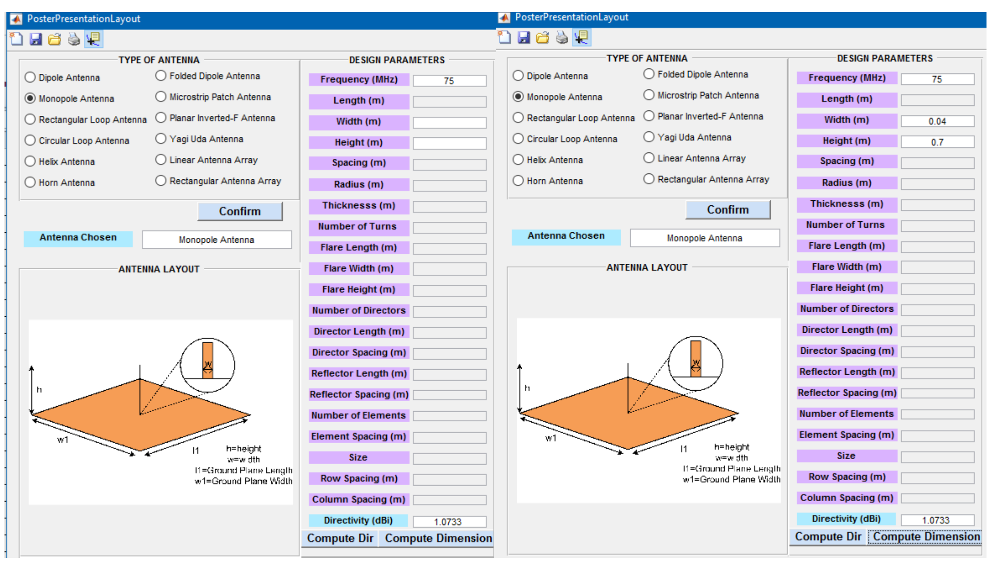


Figure 25: (a) Directivity is defined. (b) Antenna dimension is calculated.

After the calculation of directivity and antenna dimension, the program proceeds to the antenna analysis. Antenna impedance is identified and the resistance and reactance of antenna input impedance, at desired frequency can be easily obtained from the plot. Figure 26 shows the antenna impedance graph whereas Figure 27 shows the return loss graph obtained from the panel Antenna Analysis.

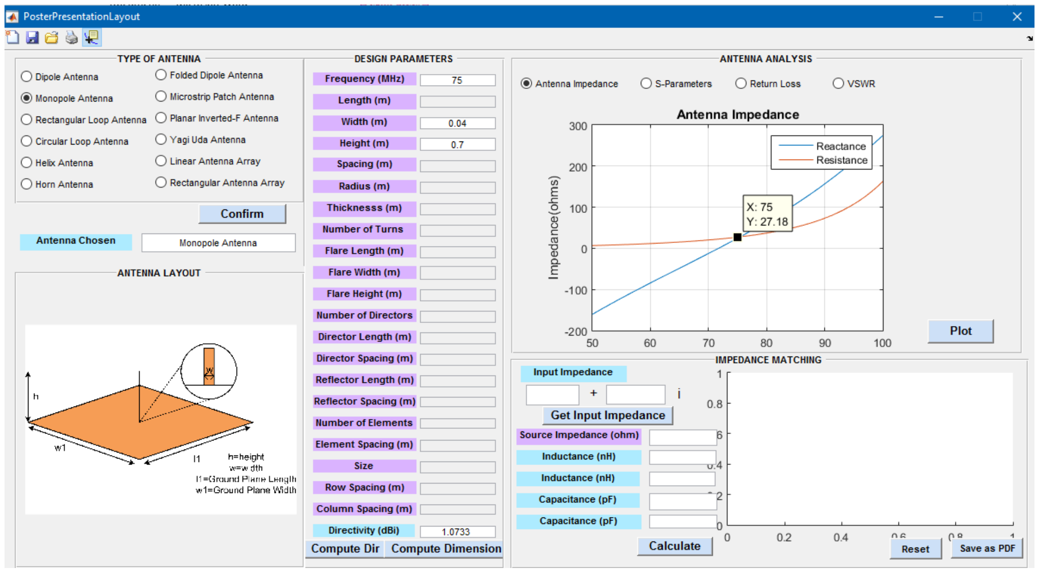


Figure 26: Antenna Impedance graph is plotted

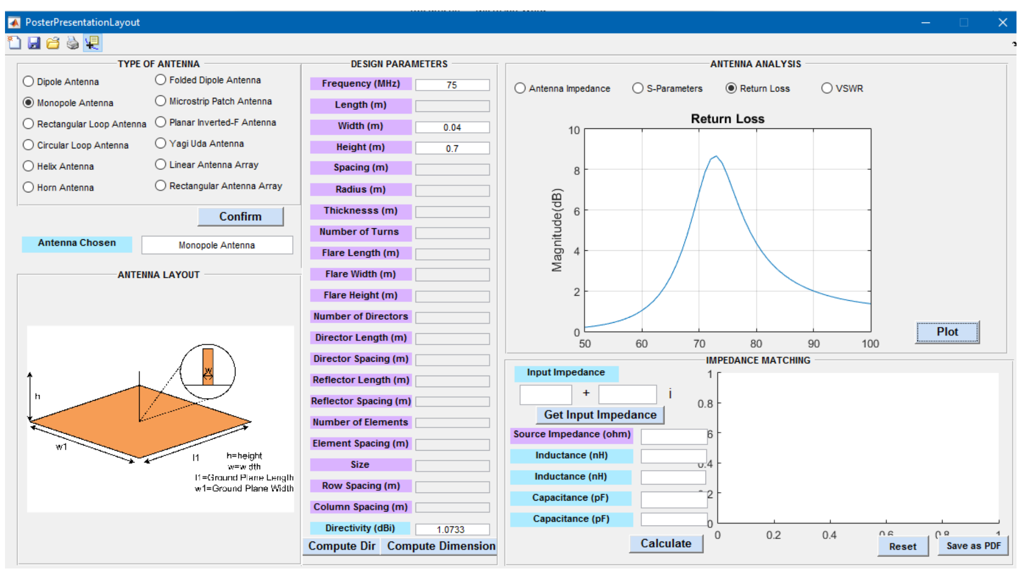


Figure 27: Return loss graph is plotted

Lastly, the impedance matching network is designed. The capacitance and inductance used is computed based on the antenna impedance as well as the source impedance prompted from user.

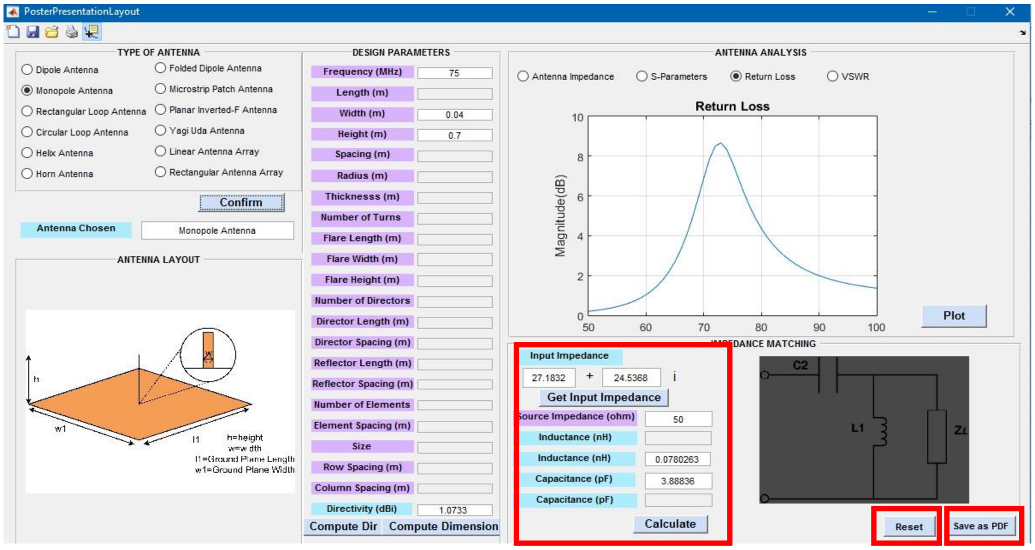


Figure 28: Impedance matching network is designed

To ease for future documentation, the GUI can be saved as PDF file. After saving the file, a new antenna design process can be started over again by clicking on the ‘Reset’ button in the bottom left of the GUI. The data in the GUI will be cleared as shown in Figure 22 after a reset button is triggered.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Antenna design process begins with antenna type selection, followed by design parameter specification, antenna analysis and lastly end with impedance matching network. It will be a lengthy and tedious process if an automated antenna design platform is not provided. This project, which is the implementation of MATLAB GUI for antenna synthesis and analysis, will not only assist in handling time consuming polynomial calculation of EM equations, but also serving as a user-friendly platform for antenna design. In addition, with the automated calculation and functions available in MAT, accuracy of antenna design is guaranteed. This project is feasible as the scope of study involves EM theory which is within the area of Author's study. Besides, it is also achievable as Author's progress is aligned with the progress stated in Gantt Chart throughout these 8 months. In this project, design parameters of antenna are auto generated. Simulated result can be saved in PDF form for future reference. A reset button is also used to clear the previous data before proceeding to the next antenna design without reinitializing of program. In short, the main objective of this project is achieved as the development of GUI for antenna synthesis and analysis is completed. Antenna dimension can be computed based on the desired directivity input by user, and vice versa. In addition, it is proven that the accuracy of the MAT function used is almost the same as the simulation result through ANSOFT HFSS [9], a well-known commercial antenna analysis tool. Thus, this project can serve as a pre-design tool for ANSOFT HFSS to reduce the frequency of trials and errors before getting the desired antenna performance. This project can be contributed to software developer and also will assist in the work of antenna designer in the future.

5.2 Recommendation

Graphical User Interface (GUI) is an useful tool that help in reducing the time needed to design an antenna. The antenna analysis tool can be strengthened and enhanced by adding current distribution graph and etc. Besides, new antenna elements like antenna array can be designed further using MATLAB GUI for future improvement since antenna array are widely used nowadays in wireless communication industry. Furthermore, a link between the engineering drawing tools such as AUTOCAD or HFSS and antenna design GUI can be developed for automated drawing based on the antenna dimension calculated. This can assist in new users of HFSS by drawing the dimension of antenna automatically without going through user manuals or tutorial.

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