UWB ANTENNA USING INDIUM TIN OXIDE (ITO)

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ABSTRACT

Recently**,** the need of high data rate communication, enormously fast speed and shorter distance, the engineers and scientists had have decided to work in the larger scale of frequency resulted in the usage of ultra wide band (UWB) frequency which ranged from 3.1 GHz to 10.6 GHz. The patch antennas offer a potential solution for narrowband and with some modifications and researches done before, it does applicable for the ultra-wide band applications. It cost, light weight, easy to feed and their attractive radiation characteristics. In this project, the performance of the UWB antenna characteristics using Indium Tin Oxide (ITO) and AgHT were investigated. Parametric studies were performed to quantify the effect of the ITO and AgHT characteristics as well as the PET (plastic polymer) coating. All those parametric studies are conducted and simulated using CST Microwave Studio. The reflection coefficient, radiation pattern, VSWR and gain values were compared and contrast between the two antennas. It can be concluded that the AgHT coated antenna works better than ITO in terms of the gain and radiation pattern while work as good as ITO in reflection coefficient and VSWR

ABSTRAK

Baru-baru ini , keperluan kepada komunikasi kadar data yang tinggi , sangat laju dan jarak yang lebih pendek , para jurutera dan saintis telah memutuskan untuk bekerja dalam skala frekuensi yang lebih besar menyebabkan penggunaan jalur lebar ultra (UWB) di antara 3.1 GHz sehingga 10.6 GHz. *Antena patch* menawarkan satu penyelesaian berpotensi untuk jalur sempit dan dengan sedikit pengubahsuaian dan penyelidikan dilakukan sebelum ini, ia terpakai bagi permohonan band ultra- lebar. Faktor kos , ringan , *feeding* dan corak radiasi menarik mereka. Dalam projek ini , prestasi ciri-ciri antena UWB menggunakan Indium Timah Oksida (ITO) dan AgHT telah dilihat . Kajian parametrik telah dijalankan untuk melihat kesan ITO dan AgHT ciri-ciri dan juga lapisan PET (polimer plastik). Kajian parametrik dijalankan dan simulasi menggunakan CST Microwave Studio. Pekali pantulan, corak sinaran , VSWR dan gandaan dibandingkan di antara kedua-dua antena. Akhirnya dapat disimpulkan bahawa antena AgHT adalah lebih baik daripada ITO dari segi nilai gandaan dan corak radiasi manakala mempunyai prestasi sama seperti ITO dari segi pekali pantulan dan VSWR

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LIST OF SYMBOLS AND ABBREVIATIONS

W - Width
L - Length
h - Substrate Thickness
ε_r - Permittivity
λ_o - Wavelength in free space
t - Patch Thickness
Γ - Reflection Coefficient
RL - Return Loss
P_{in} - Incident Power
P_{ref} - Reflected Power
ZL - Load Impedance
Z_o - Characteristics Impedance
G - Gain
η - Efficiency
D - Directivity
f_H - Upper frequency
f_L - Lower frequency
f_C - Center frequency
ε_{eff} - Effective dielectric constant
L_{eff} - Effective Length
fr - Resonance Frequency
ΔL - Length extension
BW - Bandwidth
c - Speef of Light
φ - Electromagnetic Field Elevation Angle
θ - Electromagnetic Field Azimuth Angle

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Nowadays the communication technology vastly while the antenna is the most essential components involved. When the need of high data rate communication, enormously fast speed and shorter distance, the engineers and scientists decided to work in the larger scale of frequency. Finally the ultra wide band (UWB) frequency has been chosen with unlicensed use ranged from 3.1 GHz to 10.6 GHz [1, 2]. The allocation of unlicensed spectrum to UWB technology generated a lot of interest in industry and opened the doors for development of numerous daily life applications based on UWB technology [3].

Any system which has an absolute bandwidth of over 500 MHz or relative bandwidth of greater than 25% is said to be an UWB system. Ultra Wideband Radio (UWB) is a potentially revolutionary approach to wireless communication in that it transmits and receives pulse based waveforms compressed in time rather than sinusoidal waveforms compressed in frequency [2]. This is contrary to the traditional convention transmitting over a very narrow bandwidth of frequency, typical of standard narrowband systems such as 802.11a, b, and Bluetooth. This enables transmission over a wide swath of frequencies such that a very low power spectral density can be successfully received [2]. The recent allocation of the 3.1 - 10.6 GHz frequency spectrum by the Federal Communications Commission (FCC) for Ultra Wideband radio applications has presented a myriad of exciting opportunities and challenges for antenna designers [2].

Indium-tin oxide (ITO) is a most popular transparent semiconducting oxide thin film related to the high optical transmittance in the visible and near infrared regions, and also high reflectance in the infrared region, it has been widely applied in various electronic devices, infrared reflectors, and display devices. Because of its low electrical resistivity and its wide electrochemical window, it has also been extensively used as transparent electrodes. Indium tin oxide products include display electrodes for paper-thin LCD, plasma, and organic electroluminescence (EL) televisions, touch screen monitors on ATMS, ticket vending machines, handheld game consoles and mobile phones. Besides, oxide thin films also has stable characteristics for electrical conductivity and electrical transmissions. Moreover, tin oxide also are applied in AgHT. AgHT basic structure is a 3- layered film made of a Silver (Ag) layer sandwiched between two-layers of tin oxide .AgHT played as a conductive coated film developed for use in EMI/RFI shielding and infrared heat rejection applications. AgHT has less resistivity than ITO which is 4 Ωm and 8 Ωm while ITO resistivity not less than 50 Ω-m on a flexible polymer substrates as the ITO layer which is fragile at a low resistivity he advantage The usage of polymer substrate give AgHT benefits which are conformable, lightweight and easy to replace on window glass and providing easy maintenance at a lower cost. AgHT antenna may provide a double impact as a solar module integrated antenna for green technology and a 3-in-1 solution of sun shielding, wireless communication, and solar energy harvesting for energy provision and storage. AgHT also played a potential use as rectennas on glass windows and panels no matter how the size of the antenna design is as well as in large scale antenna arrays. [1]

1.2 Objective

The objectives of the research are as follows:

1.2.1 Design and simulate the UWB antenna using ITO and AgHT.

1.2.2 Investigate the performance of the UWB in terms of return loss, VSWR, gain and radiation pattern.

1.3 Scope

The scopes of the research are stated below:

1.3.1 Design and simulate the UWB antenna using ITO and AgHT operating at 3.1 up to 10.6 GHz using CST Microwave Studio.

1.3.2 Investigate and observe the performance of these antennas through several parametric studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Basic Concept of Microstrip Patch Antenna

A microstrip patch antenna has been one of the most innovative topics in antenna theory and design. Microstrip antennas are designed to have many geometrical shapes and dimensions but rectangular and circular microstrip patches have been used in many application. They are used in wide range of modern microwave applications because of their simplicity and compatibility with printed-circuit technology.

A microstrip patch antenna in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side as shown in Figure 2.1. The bottom surface of a thin dielectric substrate is completely covered with metallization that serves as a ground plane. The rectangular microstrip patch antenna is made of a rectangular patch with dimensions width (W) and length (L) over a ground plane with a substrate thickness (h) and permittivity (εr). The length (L) of the patch is usually $\lambda_O/3 < L < \lambda_O/2$ and the thick of the patch is very thin ($t << \lambda_O$).

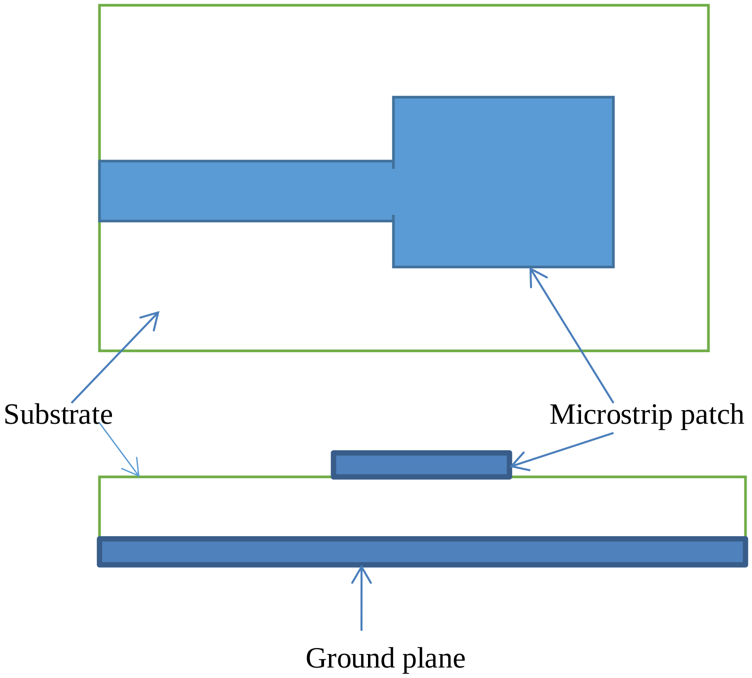


Figure 2.1: The simplest microstrip patch antenna.[2]

The patch is generally made of a conducting material like gold or copper. The radiating patch and the feed lines are commonly photo etched on the dielectric substrate. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edges by variety of methods. The patch is in fact electrically a bit larger than its physical dimensions due to its fringing fields.

Although rectangular microstrip has a very simple geometric structure, the electromagnetic fields involved are actually complex. Accurate and thorough analysis requires mathematical treatment. Some of the disadvantages of microstrip antenna configurations include narrow bandwidth, spurious feed radiation, and poor polarization purity, excitation of surface waves, limited power capacity, and tolerance problem.

2.2 Types of Microstrip Patch Antenna

There are different types of microstrip patch antennas which can be classified based on their physical parameters. The patch may be square, rectangular, dipole, circular, triangular, circular ring, elliptical or any other configuration. These are illustrated in Figure 2.2.

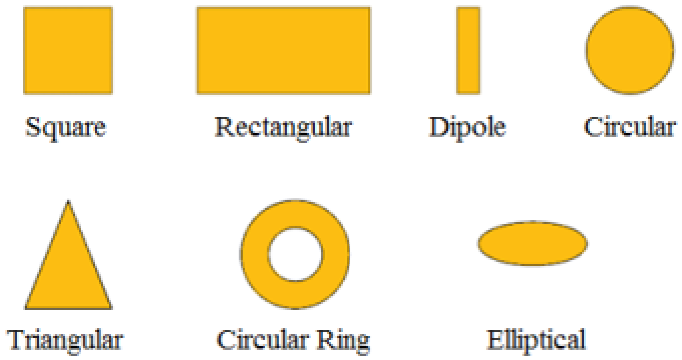


Figure 2.2: Common shapes of microstrip patch antenna.[2]

The rectangular microstrip patch antenna is widely used because of ease of fabrication and analysis. This type is also robust design and very eases to handle.

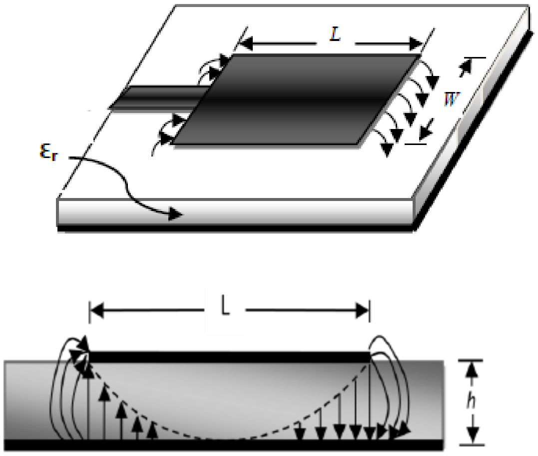
2.3 Feeding Techniques

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories, contacting and non-contacting. To obtain a desirable return loss at the resonant frequency, a microstrip patch antenna must be matched to the transmission line feeding it.

The microstrip line is also a conducting strip. It is easy to fabricate and simple to match by controlling the feed position and rather simple to model. This conducting strip is directly connected to the edge of the microstrip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. This conducting strip and the patch are also made from the same material [2].

2.4 Fringing Effects

Fringing fields have a great effect on the performance of a microstrip antenna. In microstrip patch antennas, the electric field in the center of the patch is zero. The radiation is due to the fringing field between the periphery of the patch and the ground plane. Figure 2.3 shows there is no field variation along the width and thickness. The amount of the fringing field is a function of the dimensions of the patch and the height of the substrate. Higher the substrate, the greater is the fringing field [7] [2].



(a) Electric field lines (top view)　　(b) Electric field lines (side view)

Figure 2.3: Electric field lines for rectangular microstrip patch antenna. [2]

Due to the fringing effect, the microstrip patch antenna looks greater than its physical dimension. Thus, an effective dielectric constant is to be introduced. The effective dielectric contstant takes in account both the fringing and the propagation in the line. Hence, when designing a patch antenna it is typically trimmed by 2-4% to achieve at the desired resonance frequency.

2.5 Radiation Pattern

The power radiated or received by an antenna is a function of the angular position and radial distance from the antenna. The radiation pattern is good represented in the form of a three dimensional graph of power versus elevation and azimuth angles but more commonly represented by E-plane or H-plane where one angle is held fixed while the other is varied [2]

The microstrip patch antenna has radiation pattern that can be calculated easily. The source of the radiation of the electric field at the gap of the edge of the microstrip element and the ground plane is the key factor to the accurate calculation of the patch antenna.

2.6 Return Loss

Return loss is an important parameter when connecting an antenna. It is a way to characterize the input and output of signal sources. The return loss is related to impedance matching and the maximum transfer of power theory. When the load is mismatched, not all the available power from generator is delivered to the load. This return loss is also a measure of the effectiveness of an antenna to deliver power from the source to the antenna [2].

The return loss, RL shows the level of the reflected signal with respect to the incident signal in dB. It is defined by the ratio of the incident power of the antenna P_{in} to the power reflected back from the antenna of the source P_{ref}. The mathematical expression is:

$$RL = -20\log_{10}|\Gamma|(dB) \qquad (2.1)$$

Where $|\Gamma|$ is determined by:

$$|\Gamma| = \frac{P_{in}}{P_{ref}} = \frac{Z_L - Z_O}{Z_L + Z_O} \qquad (2.2)$$

The Z_L and Z_O are the load and characteristic impedance.

For good power transfer, the ratio P_{in}/P_{ref} shall be high. If the return loss is low, the standing wave phenomena's or resonances might occur, and it will end up in the frequency ripple or gain. During the process of the design of microstrip patch antenna there is a response taken from the magnitude of S_{11} versus the frequency which known as the return loss. In most practical circuits a return loss value of -10 dB is good enough [2].

2.7 Gain

Gain is a useful measurement describing the antenna performance. Although the gain of the antenna is closely related to directivity, it is a measure that takes into account the efficiency of the antenna as well as its directional capabilities. Antenna gain usually expressed in dB, simply refers to the direction of maximum radiation. Mathematically the maximum gain, G is obtained by using equation 3[2]

$$G = \eta D \qquad (2.3)$$

Where, η = efficiency and D = directivity

2.8 Directivity

It is desirable to maximize the radiation pattern of the antenna response in a fixed direction to transmit or receive power. Likewise, the directivity is dependent only on the shape of radiation pattern. It is always referenced to an isotropic point source as in Figure 2.5. A quantitative measure of this response is the directive gain of the antenna for a given direction.

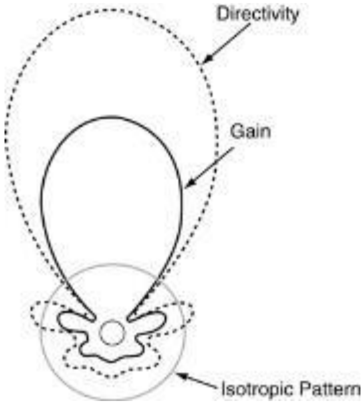


Figure 2.4: Directivity of an antenna [2]

2.9 Bandwidth

The bandwidth of an antenna is defined as the range of usable frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard [1]. The bandwidth can be defined as the ratio of the upper to lower frequencies of acceptable operation. The bandwidth of a narrowband antenna can be defined as the percentage of the frequency difference over the center frequency. The bandwidth is given by the expression:

$$Bandwidth_{narrowband}(\%) = \left[\frac{f_H - f_L}{f_C}\right] \times 100\% \qquad (2.\ 4)$$

Where,

f_H = upper frequency
f_L = lower frequency
f_C = center frequency

2.10 Antenna Efficiency

The antenna efficiency is defined as the ratio of total power radiated by the antenna to the input of the antenna. The total antenna efficiency is used to take into account losses at the input terminals and within the structure of the antenna. An antenna may dissipate power due to conductor loss or dielectric loss. A high efficiency antenna has most of the power present at the antenna's input radiated away. A low efficiency antenna has most of the power absorbed as losses within the antenna, or reflected away due to impedance mismatch [2].

2.11 Polarization

The polarization of an antenna is defined as the polarization of the wave transmitted or radiated by the antenna. Whenever, the direction is not stated, the polarization of the antenna will be following the direction of the maximum gain. It is known that a rectangular patch with a conventional feeding will radiate linearly. However, with some modifications on the feeding techniques or the patch itself can turns to a circular polarization. The main advantage of using circular polarization is because of it as a receiver orientation so that it can always receive a signal even from different axis of transmission [2].

2.12 Substrate

There are numerous substrates that can be used for the design of microstrip patch antenna. Their dielectric constants are usually in the range of $2.2 < \varepsilon r < 12$ [7]. The microstrip patch antenna radiate primarily because of the fringing fields between the patch edge and the ground plane. Therefore, the effective dielectric constant (ε_{reff}) must be obtained. The dielectric constants play a major role in the overall performance of the antenna. When a dielectric substrate is selected, one is interested in a material with the lowest tangent ($\tan \delta$) available. The loss tangent is a metric of the quantity of electrical energy, which is converted to heat by a dielectric. The lowest possible loss tangent maximizes the antenna efficiency.

Thin substrate with higher dielectric constants is desirable for microwave circuitry because they require tightly bound fields to minimize undesired radiation and coupling, and lead to smaller element sizes. However, they are less efficient and have relatively smaller bandwidth because of their greater losses. Since microstrip antennas are often integrated with other microwave circuitry, a compromise has to be reached between good antenna performance and circuit design [2]

2.13 Antenna Design Calculation

The most important parameters needed for the design of this antenna are the width and length of the rectangular patch antenna. An accurate value of the width and length affects the result very much. The following design equations are the basic calculation according to the microstrip patch antenna design procedure [1]. Refer to Figure 2.6.

The patch width (W) for efficient radiation is given by:

$$W = \frac{c}{2fr}\sqrt{\frac{2}{\varepsilon_r + 1}} \tag{2.5}$$

where, W is the patch width, c is the speed of light, f_r is the resonant frequency, and ε_r is the dielectric constant of the substrate.

Due to the fringing and the wave propagation in the field line, an effective dielectric constant (ε_{reff}) must be obtained. The effective dielectric constant (ε_{reff}) is calculated as follows:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(\frac{1}{\sqrt{1 + 12\left(\frac{h}{w}\right)}}\right) \tag{2.6}$$

where, ε_{reff} is the effective dielectric constant, h is the height of the dielectric substrate. The effective length (L_{reff}) for a given resonance frequency, fr is given as:

$$L_{eff} = \frac{c}{2 f_r \sqrt{\varepsilon_{eff}}} \tag{2.7}$$

The length extension (ΔL) is given by the expression:

$$\Delta L = 0.412h \frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)} \tag{2.8}$$

The actual patch length (L) now becomes:

$$L = L_{eff} - 2\Delta L \tag{2.9}$$

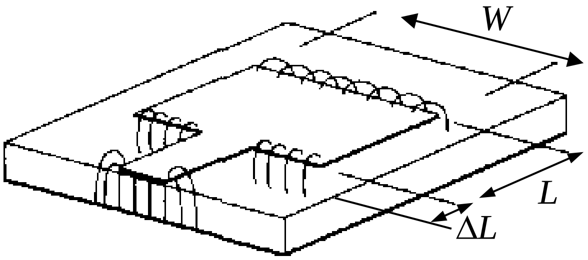


Figure 2.5: Elementary rectangular microstrip antenna and electric field distribution.

The bandwidth (BW) is calculated as:

$$BW\% = 3.77\left(\frac{\varepsilon_r - 1}{\varepsilon_r^{\,2}}\right)\left(\frac{W}{L}\right)\left(\frac{h}{\lambda_0}\right) \times 100\% \qquad (2.10)$$

where, λ_0 is the wavelength in free space.

2.14 Previous Project

By referring to previous projects, it will describe about microstrip patch antenna design, the software used to simulate the circuit and the parameters. These previous projects are very useful to design the UWB antenna.

2.14.1 Optically Transparent UWB Antenna for Wireless Application & Energy Harvesting

The project was done by Peter, T. [1]. The aim of the research presented in the research was to develop optically transparent UWB antennas for wireless applications and energy harvesting. There are three objectives that are to be emphasized such as to study the characteristics of the commercially available transparent conductive polymers such as

AgHT from Solutia Inc. and how to apply the knowledge in transparent antenna design, to develop a transparent UWB antenna with good gain and efficiency for UWB wireless applications through different geometries and improved feed connection and to see the integration of transparent UWB antennas with solar panels for solar energy. This thesis report is mainly inspired from here. As we know that AgHt is costly than ITO. So that the trial to get the antenna performance as good as before with low cost as well as to find variety of material that are able to produce UWB antenna is done.

2.14.2 Antenna Made of Transparent Conductive Film

The project was proposed by Guan,N., Furuya, H., Delaune D. and Ito,K [3]. In this paper, a monopole antenna that consists of one-half of a bow-tie dipole antenna, made of optically transparent conductive thin film and mounted above a ground plane, is investigated. The antenna is designed to work at 2.4 GHz and the radiation element of the antenna is made of several transparent conductive films with different sheet resistivities. This project inspired with many transparent conductive films. However, it does not cover the uwb frequency as focused in this thesis.

2.14.3 The Transparent Monopole Antenna for WCDMA and WLAN

The project was done by Chen-Tin Lee, Cheng-Ming Lee, Ching-Hsing Luo [4]. In this paper, the transparent antenna is fabricated with ITO film on the plastic. Transparent conductive indium tin oxide (ITO) films have are usually used on electrodes for many optoelectronic devices, electrochromic cells and solar cells because of the diaphaneity in the visible range and high electrical conductivity. ITO films are widely deposited on glass substrate. In this paper, the films deposited on plastics substrates have such excellence as light weight, thin volume, limpidity and flexibility that the proposed antenna can be more easily integrated with any products everywhere in the world. A novel design is introduced for a planar transparent monopole antenna consisting of a rectangular patch with two rectangular notches and a square ground plane. A prototype of the proposed antenna was fabricated on a polyethylene terephalate (PET) plastic; on which ITO film is deposited by magnetic sputter. This project contributed many information on PET and ITO which originated from magnetic sputter process.

2.14.4 Challenges with Optically Transparent Antennas for Small Satellite

This project was done by Saberin, J.R. and Furse, C., [7]. This paper looks at transparent conductors in such a way to study the importance of these material-science constraints and how they affect the antenna design. Many issues involving thin-antenna design using thin-film transparent conductors, including skin depth losses, ground losses, and surface losses are investigated. Skin-depth losses are introduced because of high optical transparency, which requires thin transparent-conducting-oxide depositions, reducing antenna efficiency. Ground-effect losses in the ground plane of patch antennas further reduce efficiency. These issues, related with the low conductivity of transparent conducting oxides, (approximately 8×10^5 S/m for indium tin oxide, ITO) can cause significant increases in the surface resistance of the microstrip patch, and resultant lower efficiency. From this project, the researcher introduced many issues in producing the perfect antenna for satellite applications.

2.14.5 A Study on the Efficiency of Transparent Patch Antenna Designed from Conductive Oxide Films

This project was done by Yassin, T. and Baktur, R. [8]. This project presents an analysis on the efficiency of patch antennas made from ITO films and to predict design guidelines for a 90% ITO antenna. A patch antenna's efficiency performance is represented by the conductivity of the patch and substrate. Electrical conductivity and optical transparency of an ITO film are highly dependent on the material properties, which are mostly decided during doping and deposition process. It is found that high conductivity is balanced against high transparency in the visible spectrum. The operating frequency is 2.5GHz which does not cover uwb frequency.

2.14.6 A Simple UWB Microstrip-Fed Planar Rectangular Slot Monopole Antenna

This project was described by Nasser-Moghadasi, M. and Koohestani, M. [9]. This project presents a new printed rectangular slot antenna with enhanced impedance bandwidth. The slot is to maximize the bandwidth of the antenna with simple configuration and low fabrication cost. The proposed antenna is introduced from conventional rectangular monopole and added by stubs and slots for patch radiator. The proposed antenna is a rectangular slot etched on ground plane and fed by a microstrip corner truncated rectangular patch combined with two tuning stubs. The measured return loss and that obtained from simulation indicate that the presented structure exhibits an ultra wide impedance bandwidth more than FCC defined frequency range which is 148%. This project mainly contribute to enhance the knowledge of the uwb antenna as it is not a transparent or TCO antenna material based.

2.14.7 Design of UWB Planar Antenna With Improved Cut-Off and Out-of-Band Frequencies.

This project was designed by Bialkowski, M.E. and Abbosh A.M. [10]. This project highlighted the designing of a UWB antenna with sharp cutoffs at the low frequency band (below 3.1 GHz) and the high frequency band (above 10.6 GHz). The presented design relies on the use of a meandered slot which is made in the radiating planar monopole. In order to generate an efficient frequency cutoff, the slot requires a certain length, which is calculated using a simple formula. Also, it requires a suitable shape. This is to ensure the limited area of the monopole and to prevent rejecting frequencies within the passband of UWB. The effectiveness of the proposed method is demonstrated via full-wave simulations and measurements on two UWB antennas: one without a slot and the other with a slot. This thesis also help to improve the knowledge of uwb slot monopole antenna but not the patches antenna.

2.14.8 A Simple Design Approach for Planar UWB Antenna

This project was done by Gholipour, A., Askarpour, A.N., and Faraji-Dana, R. [10]. This research is completed by introducing a monopole tulip antenna. It is said that this antenna help to cover the problem of high input impedances produced by the patches antennas. The antennas are built according to two major steps. First, is to design the planar radiating element in a monopole configuration with the goal of good impulse response. Secondly is to put this radiating element in front of a truncated ground plate and optimize it for the best matching. This is also a monopole designed antenna which cover uwb frequency. It help to understand more about the matching techniques for monopole antenna.

2.15 Indium Tin Oxide

Indium-tin oxide (ITO) is a well-known transparent semiconducting oxide thin film. Due to its high optical transmittance in the visible and near infrared regions, and high reflectance in the infrared region, it has been widely applied in various opto-electronic devices, infrared reflectors and display devices [11]. Besides its applications in the above-mentioned areas, recent studies show how ITO can be as patches on the antennas. There are various methods to grow semiconducting and conducting thin films. The specific techniques for the growth of thin ITO film includes chemical vapor deposition (CVD), magnetron sputtering, vacuum evaporation, spray pyrolysis, electron-beam evaporation and ion-beam sputtering, etc. Each of the processes has its own advantages and disadvantages. [20]

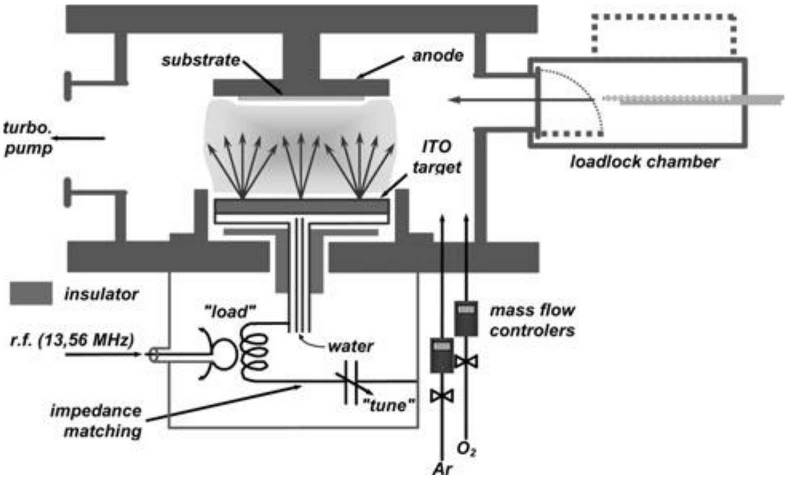
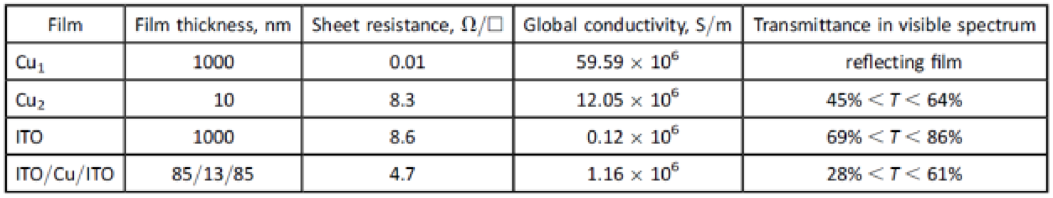


Figure 2.6 : Diagram of the r.f. sputtering machine [20]

Table 2.1 : Physical Characteristics of ITO [20]

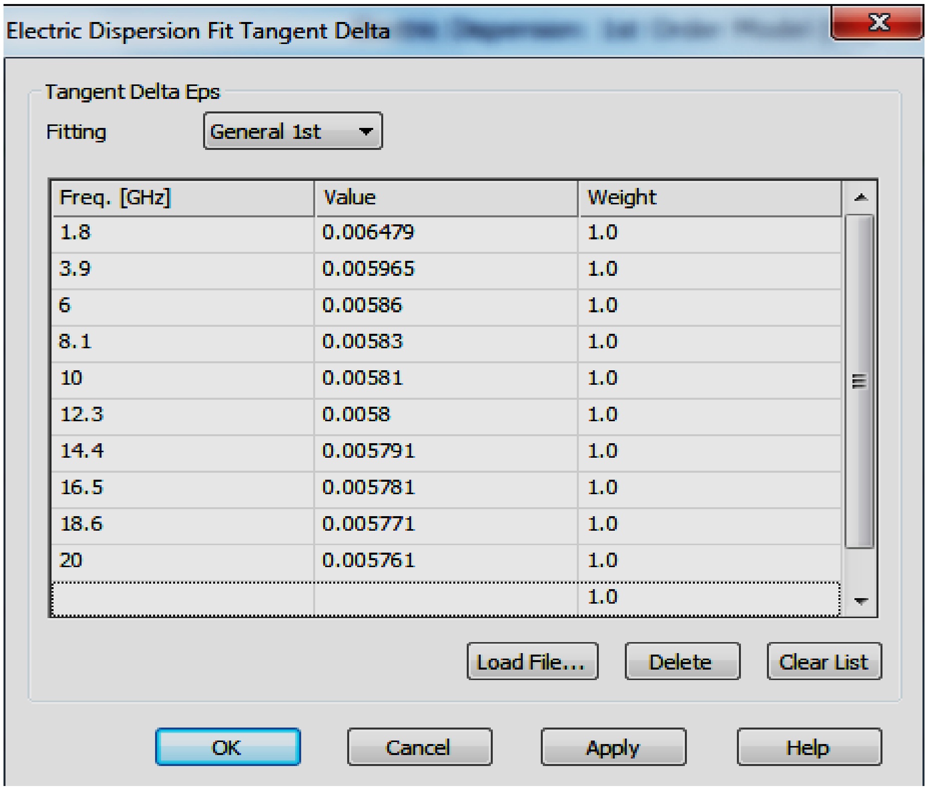


Film	Film thickness, nm	Sheet resistance, Ω/□	Global conductivity, S/m	Transmittance in visible spectrum
Cu_1	1000	0.01	59.59×10^6	reflecting film
Cu_2	10	8.3	12.05×10^6	$45\% < T < 64\%$
ITO	1000	8.6	0.12×10^6	$69\% < T < 86\%$
ITO/Cu/ITO	85/13/85	4.7	1.16×10^6	$28\% < T < 61\%$

The ITO parameter of r.f sputtering technique is chose as they are a common physical method in the manufacturing environment for ITO films mass production, an easy method for thin film metal elaboration, and offers multilayer deposition advantage when deposition chamber includes several targets.[20]

2.16 Polymer Substrate (PET)

Polyethylene terephthalate (sometimes written poly(ethylene terephthalate)), commonly abbreviated PET. The permittivity is defined by including a dispersion fit of the loss tangent to describe the losses of the PET material. The measurements were done at the National Physics Laboratory (NPL) at Teddington, UK. Fig. 2.9 shows the dispersion list. [1]



Electric Dispersion Fit Tangent Delta

Tangent Delta Eps

Fitting: General 1st

Freq. [GHz]	Value	Weight
1.8	0.006479	1.0
3.9	0.005965	1.0
6	0.00586	1.0
8.1	0.00583	1.0
10	0.00581	1.0
12.3	0.0058	1.0
14.4	0.005791	1.0
16.5	0.005781	1.0
18.6	0.005771	1.0
20	0.005761	1.0
		1.0

Figure 2.7 : Dispersion List of PET [1]

2.17 AgHT

AgHT is a 3-layered film made of a Silver (Ag) layer sandwiched between two-layers of tin oxide. Figure 2.9 show the AgHT structure. The electrical conductivity of AgHT-4 and AgHT-8 are 250,000 S/m and 125,000 S/m respectively. AgHT is made of a 3-layered conductive coating on a polymer base. This 3-layered coating on a transparent polyethylene terephthalate (PET) or polymer, comprises of a silver layer sandwiched between 2 layers of tin oxide. The coating is electrically conductive and transparent with a VBLT of 75-82%. The AgHT film has an approximate thickness of 0.175mm. About 40% of this thickness is the coating and the balance PET [1].

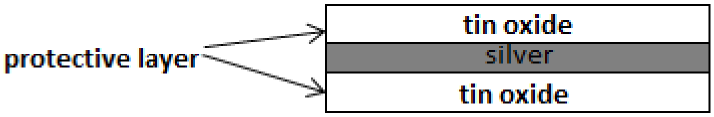


Figure 2.8 AgHT structure

Figure 2.8 above shows the 3-layered film made of silver (Ag) sandwiched between two layers of tin oxide. This sandwich is known as AgHT[1]

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter explains the methodology of project in detail. The project starts with the research project background and problem statement definition. Theories and previous research have been the basic references in order to define the specification for the microstrip patch antenna. The define specification will also be considered at the application, particularly for the UWB application. Figure 3.1 shows the flow of steps required in designing the microstrip patch antenna.

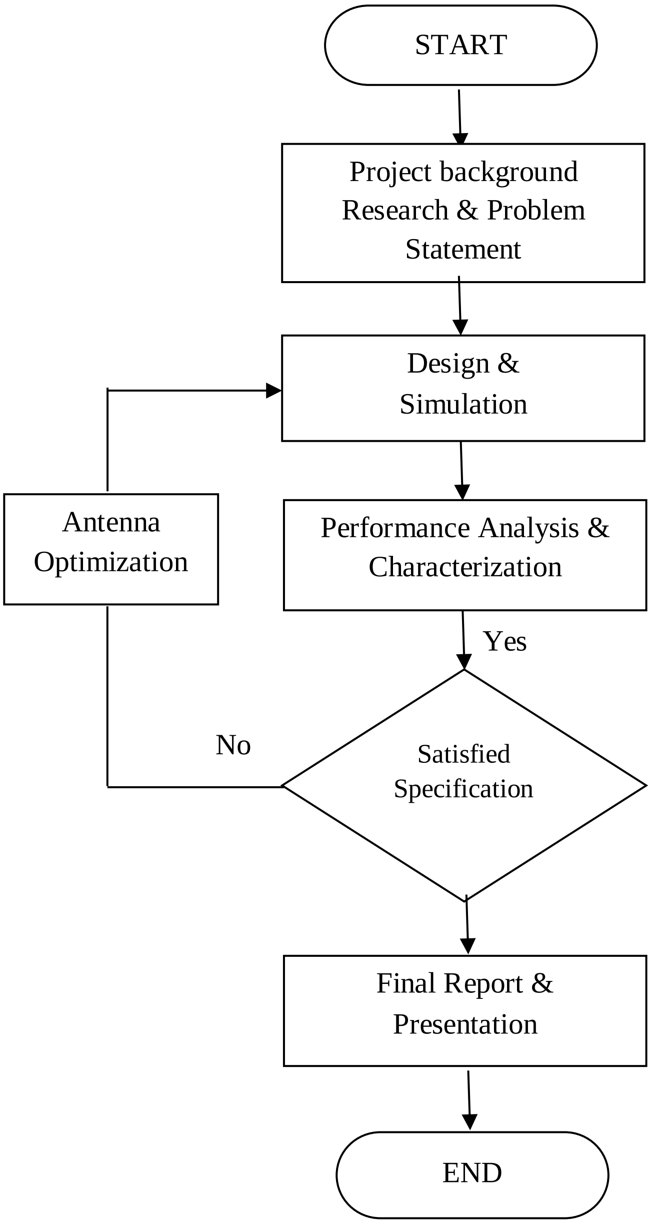


Figure 3.1: Project flow chart.

3.2 Antenna Specification

Basically, the performance of the antenna depends on its resonant frequency, dimension, operating frequency, radiation efficiency, directivity, and return loss. The characteristics of the antenna are defined mainly by their geometries and the material properties. The design of patch antenna requires precise physical dimensions and power feeding method for the antenna.

The microstrip patch antenna is designed based on three parameters. The substrate used is ITO with electrical conductivity of 120000 S/m, permeability and permittivity is unity and height, h = 0.175 mm. The define specification is as shown in Table 3.1

Table 3.1: Defined Antenna Specification

Parameters	Specification
Operating Frequency	3.1 – 10.6 GHz
Gain	> 3 dB
Return Loss	< -10 dB
-10dB Bandwidth	3% - 5%

A low dielectric constant of the substrate material is used in the prototype design because it gives better efficiency and higher bandwidth. The low value of the dielectric constant will increases the radiated power. The design has a patch size independent of the dielectric constant. Therefore, the reduction in the patch size is accomplished by using higher dielectric constant. Thus, ITO is good in this agreement. Another important design parameter is the substrate thickness, *h*. The thickness of the substrate increases the fringing field at the patch periphery. Therefore, the substrate height of 0.175 mm has been chosen [1].

Typically, gain is a useful measurement describing the performance of the antenna. Although the gain of the antenna is closely related to the directivity, it is

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