UWB Circular Slot Antenna using CPW Feed

by

Name	Roll No.	Registration No:
Sayak Banerjee	*11700314087*	141170110269 of 2014-2015
Prasanna Mallick	*11700314058*	141170110240 of 2014-2015
Shivdutt Kumar	*11700314093*	141170110275 of 2014-2015
Suman Das Sarkar	*11700314113*	141170110295 of 2014-2015

A comprehensive project report has been submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology

in

ELECTRONICS & COMMUNICATION ENGINEERING

Under the supervision of

Mr. Nandan Bhattacharya
Assistant professor of RCCIIT,ECE Department

श्रमम् बिना न किमपि साध्यम्

Department of Electronics & Communication Engineering
RCC INSTITUTE OF INFORMATION TECHNOLOGY
Affiliated to Maulana Abul Kalam Azad University of Technology, WestBengal
CANAL SOUTH ROAD, BELIAGHATA, KOLKATA – 700015

May, 2018

CERTIFICATE OF APPROVAL

This is to certify that the project titled "**UWB Slot Antenna**" " carried out by

Name	Roll No.	Registration No:
Sayak Banerjee	*11700314087*	141170110269 of 2014-2015
Prasanna Mallick	*11700314058*	141170110240 of 2014-2015
Shivdutt Kumar	*11700314093*	141170110275 of 2014-2015
Suman Das Sarkar	*11700314113*	141170110295 of 2014-2015

for the partial fulfillment of the requirements for B.Tech degree in **Electronics and Communication Engineering** from **Maulana Abul Kalam Azad University of Technology, West Bengal**is absolutely based on his own work under the supervision of Mr. Nandan Bhattacharya Assistant professor. The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

Optional in case of External Supervisor

....

....
Mr. Nandan Bhattacharya
Assistant Professor , Dept. of ECE
RCC Institute of Information Technology

....

Dr. Abhishek Basu
Head of the Department (ECE)
RCC Institute of Information Technology

DECLARATION

"We Do hereby declare that this submission is our own work conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute and that, to the best of our knowledge and belief, it contains no material previously written by another neither person nor material (data, theoretical analysis, figures, and text) which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgement has been made in the text."

.............SayakBanerjee................................ ....
Registration No: 141170110269 OF 2014-2015
Roll No: 11700314087

..........PrasannaMallick.................................. ....
Registration No:141170110240 OF 2014-2015
Roll No: 11700314058

........................ShivduttKumar................... ....
Registration No: 141170110275 OF 2014-2015
Roll No: 11700314093

....SumanDasSarkar....................................... ....
Registration No:141170110295 OF 2014-2015
Roll No: 11700314113

Date: 10/05/2018

Place: Beliaghata, Kolkata

CERTIFICATE of ACCEPTANCE

This is to certify that the project titled "**UWB Slot Antenna**" carried out by

Name	Roll No.	Registration No:
Sayak Banerjee	*11700314087*	141170110269 of 2014-2015
Prasanna Mallick	*11700314058*	141170110240 of 2014-2015
Shivdutt Kumar	*11700314093*	141170110275 of 2014-2015
Suman Das Sarkar	*11700314113*	141170110295 of 2014-2015

is hereby recommended to be accepted for the partial fulfillment of the requirements for B.Tech degree in **Electronics and Communication Engineering** from **Maulana Abul Kalam Azad University of Technology, West Bengal**

Name of the Examiner Signature with Date

1. ………………………………………………………………………

2.……………………………………   ..………………………………..

3.…………………………………… ………………………………

4. ……………………………………. ………………………………

ABSTRACT

Since the release by the Federal Communications Commission (FCC) of a bandwidth of 7.5GHz (from 3.1GHz to 10.6GHz) for ultra-wideband (UWB) wireless communications, UWB is rapidly advancing as a high data rate wireless communication technology.

As is the case in conventional wireless communication systems, an antenna also plays a very crucial role in UWB systems. However, there are more challenges in designing a UWB antenna than a narrow band one. A suitable UWB antenna should be capable of operating over an ultra-wide bandwidth as allocated by the FCC. At the same time, satisfactory radiation properties over the entire frequency range are also necessary. Another primary requirement of the UWB antenna is a good time domain performance, i.e. a good impulse response with minimal distortion.

This report focuses on UWB antenna design and analysis. Studies have been undertaken covering the areas of UWB fundamentals and antenna theory.
The type of UWB antenna is circular slot antenna, which can also be fed by either micro-strip line or CPW.

The performances and characteristics of UWB circular slot antenna are investigated in both frequency domain and time domain. The design parameters for achieving optimal operation of the antennas are also analyzed extensively in order to understand the antenna operations.

It has been demonstrated numerically and experimentally that both types of antennas are suitable for UWB applications.

CONTENTS

LIST OF SYMBOLS

- η - intrinsic impedance of free space
- Z_s - impedance of the slot antenna
- Z_c - impedance of its dipole antenna
- J*s* - electric source density
- Ms - magnetic current density
- E - electric field
- H - magnetic field
- ˆn - normal vector

List of Abbreviations

UWB	**Ultra Wide Band**
WAPN	**Wireless personal area network consumer electronics**
CE	**Consumer Electronics**
GTD	**Geometric Theory of Diffraction**
SATCOM	**Satellite Communication**
MBOFDM	**Multiband Orthogonal frequency division multiplex**

LIST OF FIGURES

LIST OF TABLES

Introduction

Nowadays, wireless communication systems, which use antennas to radiate or receive electromagnetic waves, have been grown very fast wherever in mobile communications, warehouse manufacturing systems, industrial communications, medical services, and etc. Also, many wireless communication systems require antennas responding to multiband operation with low profile.

However, multiband antennas could be designed by using either multi-resonators or wideband notch technique to produce multiple band operation .Slot antennas have been extensively investigated in the last two decades .This type of antennas are suitable for radar and satellite communications applications. The advantages of the slot antennas are low profile, lightweight, easy integration with monolithic microwave integrated circuits (MMICs) and stable radiation patterns.

This type of antenna can take various configurations such as rectangle, circle, arc-shape, triangle, annular-ring and others. These printed slot antennas have been realized by using either micro strip line, or CPW feeding structure. Various techniques have been proposed to broaden the bandwidth of printed slot antennas and improve their performances. In, a micro strip line fed circular slot can operate over the entire UWB band, i.e. from 3.1GHz to 10.6GHz. However, the antenna size is big and the slot diameter is 65.2mm.

In this report we have used slot antenna having CPW feed and the shape of the slot antenna is circular. Ultra-Wide Band (UWB) is a communication method, used in wireless networking. UWB, ultra wide band technology, is a form of transmission that occupies a very wide bandwidth. It will be many Gigahertzes', and it enables to carry data rates of Gigabits per second. Due to the high data transmission, it also uses in currently deployed technologies such as 802.11a, b, g, WiMax and many more. It's also called as pulse radio or digital pulse wireless.

LITERATURE REVIEW

In this literature review I am going to discuss about the previous works that have been done in this field of work. For this purpose I am going to take some references from some of the thesis written earlier.

In the past there have been two designs which were implemented. They were designs of planar elliptical slot antennas. They were printed on a dielectric substrate and the feed was given by either micro stripline or coplanar waveguide with a U –shaped tuning stub. It is known that both circular and elliptical exhibit ultra-wideband characteristics. Based on the performance and several analyses some empirical formulas were introduced to determine operating bandwidth.

It should be noted that printed slot antennas were used in the designs because of their low profile, light weight, ease of fabrication and also because it supports a wide bandwidth.

In that design rectangular slot antenna was used and it was etched on a substrate. A fork - like tuning stub was used to enhance the bandwidth and a gain was achieved. A CPW feed square slot antenna with a widened tuning stub is able to produce a bandwidth of 60%. It was also noted that the achieved bandwidth of the antennas cannot cover the whole FCC defined frequency band.

In the paper that I am discussing two novel designs of printed elliptical and circular slot antenna for UWB technology. To use UWB technology it is necessary to broaden the bandwidth of the antenna so U-shaped tuning stub was used to enhance the coupling between slot and the feed line. Both the antennas had shown that they both can UWB characteristics with nearly omnidirectional radiation patterns which cover the entire bandwidth. **[1]**

UWB Technology

Regular Aspect/Summary

Wireless connectivity has enabled a new lifestyle with conveniences for mobile computing users. There are several electronics devices to connect each other in WAPN (wireless personal area network). Today's wireless LAN and WPAN technologies cannot meet the needs of future's connectivity because the devices will require high bandwidth. UWB Technology is one of the solutions of this problem.

Ultra-wideband (UWB) technology offers a solution for the band-width, cost, power consumption, and physical size requirements of future consumer electronic devices. UWB enables wireless connectivity with high data rates across multiple devices and PCs within the home and the office. This emerging technology provides the high bandwidth.

Many technologies used in the digital home, such as digital video and audio streaming, require high-bandwidth connections. This wireless technologies developed for wirelessly connecting PCs, such as Wi-Fi* and Bluetooth Technology, are not optimize for multiple high-bandwidth, basically data rates can reach 54 Mbps for Wi-Fi. .But when it connecting multiple consumer electronics devices in a short-range network a wireless technology needs to support multiple high data rate streams, with very little power, and maintain low cost, The UWB wireless technology and silicon developed for UWB applications offer a great solution.

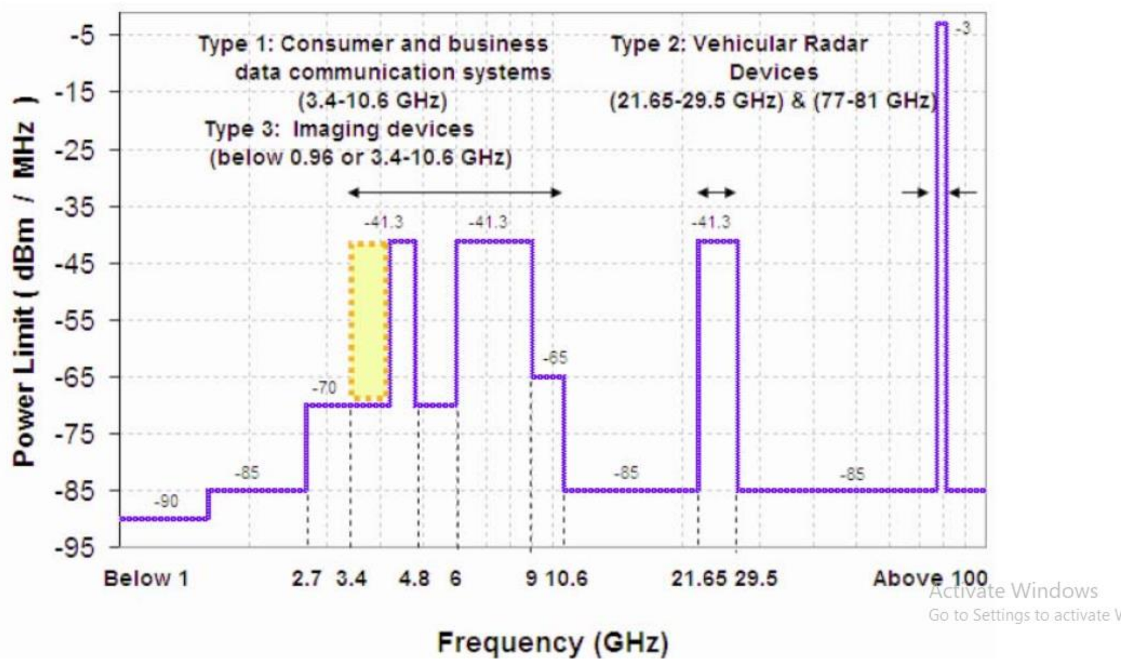


Fig-1

Properties:-

- UWB transmission has wide bandwidth that will cross the boundary of much currently licensed based carrier transmission.
- Its power spectral density is low.
- It provides a new technology for short-range ultra-high speed communication, frequency range: 3.1-10.6 GHz.
- It supports bit rate 100mbps within a 10 meter radius range.
- The advantages of UWB technology are low-power transmission and low power dissipation.
- It does not interfere with conventional narrowband and carrier wave transmission in the same frequency band.
- Ultra-wideband is a technology for transmitting information spread over a large bandwidth (>500 MHz).

Basic Concept

UWB technology is a form of transmission. It occupies a very wide bandwidth. Typically this will be many Gigahertzes'. It is this aspect that enables it to carry data rates of Gigabits per second. The fact is UWB transmissions have a wide bandwidth that will cross the boundaries of many of the licensed carrier based transmissions.

UWB transmissions transmit information by generating radio energy at specific time intervals with a large bandwidth, thus enabling pulse-position or time modulation. The information can also be modulated on UWB signals (pulses), its amplitude and by using orthogonal pulses. UWB pulses can be sent sporadically at relatively low pulse rates to support time or position modulation,

And a feature of pulse-based UWB is that the pulses are very short (less than 60 cm for a 500 MHz-wide pulse) .so most signal reflections do not overlap the original pulse. And there is no multipath fading of narrowband signals.

Types:-

Despite the single named used for the ultra-wideband (UWB) transmissions, there are two very different technologies being developed.

- **Carrier free direct sequence ultra-wideband technology**:- This type of ultra-wideband technology transmits a series of impulses. In view of the very short duration of the pulses, it occupies a very wide bandwidth.

- **<u>MBOFDM, Multi-Band OFDM ultra wideband technology:-</u>** This type of ultra-wide band technology uses wide band/multiband orthogonal frequency division multiplex (MBOFDM) signal that is effectively a 500 MHz wide signal.

  This is 500 MHz signal is hopped in frequency to enable it for occupy a sufficiently high bandwidth.

- **<u>FCC UWB definition:-</u>**According to USA, UWB, ultra wideband technology for indoor and short range outdoor communication, but there are some restrictions on the frequencies over which the transmission can spread and power limits. This will go to the UWB ultra wideband transmissions to communicate successfully. FCC has mandated that UWB technology can legally operate in the range from 3.1 GHz up to 10.6 GHz, and a limited transmit power of -41dBm/MHz's with addition the transmissions occupy a bandwidth at least 500 MHz, as well having a bandwidth of at least 20% of the center frequency of the bandwidth.

Pulse Radio

Ultra-wideband was formerly known as pulse radio. FCC is defined UWB as an antenna transmission for which emitted signal bandwidth exceeds the lesser of 500 MHz or 20% of the arithmetic center frequency. Thus, pulse-based systems—where each transmitted pulse occupy the UWB bandwidth or an aggregate of at least 500 MHz of narrow-band carrier. Pulse repetition rates may be either low or very high. Pulse-based UWB radars and imaging systems tend to use low repetition rates .It is typically in the range of 1 to 100 mega pulses per second.

On the other hand, communications systems favor high repetition rates; each pulse in a UWB system occupies the entire UWB bandwidth. This allows UWB to reap the benefits of relative immunity to multipath fading,

Development &Applications

Like many wireless technologies is to be moving into high volume production and becoming established a new technology to turn the industry upside down. One of the technologies name is Ultra Wide Band (UWB). This new technology has much offer both in the performance and data rates and the wide number of application. Currently ultra-wideband (UWB) technology has been proposed for or is being used in applications from radar and sensing applications right to high band width communications. Furthermore ultra-wide band, UWB can be used in both commercial and military applications also.

Unlike other wireless technologies of today, ultra wideband (UWB) has developed a totally different method of transmission. Using a specified frequency with a carrier, the technique that is used by traditional transmissions, UWB uses what may be termed "time domain" electromagnetic. UWB uses pulses that spread over a wide bandwidth;

It is one of the fact that UWB technology uses different approach to wireless as well as radio transmissions is part of the reason UWB development. With wireless transmissions using traditional techniques filling the airwaves, care has to be taken when establishing UWB.

Development

The development of UWB technology is undertaken by the US military into defining the behavior of microwave networks to impulse or transients. This works which was started in 1962. These networks had been characterized according to their response in the frequency domain parameters such as amplitude and phase with respect to frequency are important. However the new approach of about ultra- wide band or UWB technology looked at the impulse response.

At the time measurements were difficult to test equipment with a high bandwidth was not available. The facts that this research was investigating an area where supporting other technologies were not sufficiently developed placed restraints on the research, but investigations into the technology continued still today.

Having looked at the response of microwave networks to impulses, the next major step forward occurred when the techniques were applied to radiating systems. Once this work commenced in 1968 it soon became obvious that UWB technology could be used for radar and communications applications.

The rate of work was undertaken and increased in the 1970s as the supporting technologies became available. That period was termed *carrier free* or *impulse* technology. The term ultra-wide band or UWB was named in the later 1980s by the US Department of Defense.

Development of this UWB technology was intended military applications and it was classified on that time. As a result little development took place in the commercial arena. In the years following 2000, commercial wireless communications became established. Technologies such as (Wi-Fi), Bluetooth and others technologies became established. These showed the flexibility offered by wireless communications for a big wide variety of applications from connectivity for mobility and connectivity for laptops.

One of the major is the speed at which UWB could enter the commercial marketplace. In view of the fact that UWB occupies a wide bandwidth, it has to exist alongside traditional transmissions without causing any undue interference.

Applications of UWB Technology

Commercial:-

- High speed LAN / WAN (>20 Mbps)
- Avoidance radar
- Altimeter (aviation)
- Tags for intelligent transport systems
- Intrusion detection
- Reallocation

Military:

- Radar
- Covert communications
- Intrusion detection
- Precision geo-location
- Data links

Slot Antenna

Slot antennas are commonly used at microwave frequencies. There are a number of geometrical configurations of a slot antenna . They can take the form of a waveguide or a horn whose aperture may be square, rectangular, circular, elliptical, or any other configuration. Slot Antennas are very practical for space applications, because they can be flush mounted on the surface of the spacecraft or aircraft. Their opening can be covered with a dielectric material to protect them from environmental conditions.

The most practical, configurations are the rectangular and circular configurations.
But the mathematical calculations are very complex, therefore the observations are taken with respect to the far-field region. There is a technique called Geometrical Theory of Diffraction (GTD) to determine the edge effects which occurs due to the finite size of the ground plane on which the aperture is mounted.

We can determine the radiation characteristics of wire antennas once the current distribution on the wire is known. But there are complications in case of many configurations, and the current distribution cannot be determined exactly and only experimental measurements can provide the desired results. This problem becomes more prominent in case of slot antennas, therefore to compute the radiation characteristics approximation of field is used and one such technique is the Field Equivalence Principle.

FIELD EQUIVALENCE PRINCIPLE: HUYGENS' PRINCIPLE

In the field equivalence principle actual sources, like as an antenna and transmitter, are replaced by equivalent sources. The fictitious sources are assumed to be equivalent within a region because they produce the same fields within that region as produced by the original sources.

This principle is based on the uniqueness theorem which states that "a field in a lossy region is uniquely specified by the sources within the region plus the tangential components of the electric field over the boundary, or the tangential components of the magnetic field over the boundary, or the former over part of the boundary and the latter over the rest of the boundary".

Using this principle, the fields outside a closed surface which is actually imaginary is obtained by placing on the closed surface certain electric- and magnetic-current densities which satisfies certain predefined conditions. The current densities are selected in such a way that the fields inside the closed surface are zero and on the outside they are equal to the radiation produced by the actual sources. So the technique can be used to obtain the fields radiated outside a closed surface by sources enclosed within it. The technique is exact but requires integration over the closed surface.

The equations supporting the theorem are as follows:-

$\mathbf{J}_s = \hat{\mathbf{n}} \times [\mathbf{H}_1 - \mathbf{H}]$

$\mathbf{M}_s = -\hat{\mathbf{n}} \times [\mathbf{E}_1 - \mathbf{E}]$, where E1 and H1 are the original sources and are replaced by E and H. Since the fields **E, H** within *S* can be anything it can be taken that they are zero. In such a case the above equations can be written as

$\mathbf{J}_s = \hat{\mathbf{n}} \times (\mathbf{H}_1 - \mathbf{H})|_{\mathbf{H}=0} = \hat{\mathbf{n}} \times \mathbf{H}_1$

$\mathbf{M}_s = -\hat{\mathbf{n}} \times (\mathbf{E}_1 - \mathbf{E})|_{\mathbf{E}=0} = -\hat{\mathbf{n}} \times \mathbf{E}_1$, This form of the field equivalence principle is known as Love's Equivalence Principle.

RADIATION PATTERN

The fields that are radiated by sources $\mathbf{J}_s$ and $\mathbf{M}_s$ in a medium which is not bounded are calculated using integration over the entire surface covered by $\mathbf{J}_s$ and $\mathbf{M}_s$.

Now we must take into account that for far-field observations, the formulas are complex but they can be simplified.

For far-field observations *R* can be approximated by the formulae's

$R = r - r' \cos\psi$ *for* phase variations
$R = r$ *for* amplitude variations
Now using integration and the above formulas E and H fields can be determined and the fields will give us an idea of the radiation pattern of the antenna.
The radiation pattern of an slot antenna is basically omnidirectional an dit is very similar to a half dipole antenna.

Working of a slot antenna

The principle of optics can be applied to electromagnetic waves for the waves to start radiating.
It has been proven that when we apply a HF field across a narrow slot in a conducting plane, the energy is radiated.
To properly explain the and understand and relate it with Babinet's principle we can try a little experiment. At first take an infinite plane conducting screen with apertures of desired shapes and this will serve as screen of the slot antenna. Next we need to take another screen for interchanging the planes of aperture and screen areas which is a complimentary screen. The above mentioned two screens are called as complimentary as they result in complete infinite metal screen and this makes our slot antenna.

Working Principle

The working principle of a slot antenna can be explained by only establishing a relation between wire and slot antenna, for this purpose we first have to get an understanding of Babinet's Principle.

Babinet's Principle

Babinet's principle states that "when the field behind a screen with an opening is added to the field of a complementary structure, the sum is equal to the field when there is no screen". Babinet's principle in optics does not consider polarization, which is so vital in antenna theory.
Slot antenna is c $\lambda/2$celongated slots and they are cut in a conductive plate and excited along the centre. The slot behaves as a resonator as explained by the Babinet's Principle. This principle also relates the radiated fields and impedance of a slot antenna and a dipole antenna. It is known that polarization of a slot antenna is linear. We can see that the fields of a slot antenna are almost the same as that of a dipole antenna but there is a difference, i.e. the field's components are interchanged.

Now a voltage source is applied across the short end of the slot antenna. This will induce an E-field distribution within the slot antenna, and currents travelling around the slot perimeter, contributes to radiation the voltage source is specifically applied at the center of the dipole, so that the voltage source is rotated.

The first result states that the impedance of the slot antenna (Z_S) is related to the impedance of its dipole antenna (Z_C) by the relation:

$$Z_C Z_S = \frac{\eta^2}{4}$$

, (product of slot and dual antenna impedances equal to square of free space impedance over 4).

The next important thing is the feeding of the slot antenna ,it can be done easily using ordinary two-wire line and it should also be taken into account that the impedance is dependent on the feeding point.

Now coming back to the above equation, (η) is the intrinsic impedance of free space .

The next and major result of Babinet's principle is that the fields of the dipole antennas are almost the same as the slot antenna like we have already mentioned before but this is a major result of the principle. The fields of the slot antenna can be given using the following

$$E_{\theta S} = H_{\theta C}$$
$$E_{\phi S} = H_{\phi C}$$

$$H_{\theta S} = \frac{-E_{\theta C}}{\eta^2}$$

$$H_{\phi S} = \frac{-E_{\phi C}}{\eta^2}$$

equations:-

Hence, if we know the fields from one antenna we can determine the fields of the other antenna. Thus, if we understand Babinet's principle then we can easily determine the fields and impedance of a slot antenna.

UWB Slot Antenna

For UWB technology we need far field and slot antennas have relatively large magnetic near-fields that tend not to couple strongly with near-by objects .Thus, slot antennas are well suited for applications wherein near-field coupling is required to be minimized.

CIRCULAR SLOT ANTENNA

Circular slot antenna make out of a couple of planar, generally circular, conductive members which are substantially coaxial with and parallel to each other and spaced apart to define a slot there between and input means comprising a conductive pillar which extends between and electrically interconnects the conductive members, a first input at a selected point along the length of said pillar, and a second input on one of said conductive members.

The antenna works as a slot antenna, with one conductive part filling in as a ground member and the other conductive part filling in as a drive member, the position of the first input along the length of said pillar being selected to provide impedance matching with the output from the transmitter, typically a 50 ohm coaxial cable. Furthermore, when the antenna is used in its intended orientation, in which the common axis of the conductive members is oriented vertically as will be described hereinafter, it creates a vertically polarized transmission, with a radiation pattern similar to that of a vertical dipole but with a slight gain (of the order of 1 dB) in azimuth, which we have observed to be especially favorable in remote metering applications.

The space between the conductive members might be loaded with a dielectric material, eg polystyrene.

Favorably, a variable tuning capacitor is associated between the conductive members, to tune the antenna to the desired operating frequency. On the other hand, a varactor might be associated between the conductive members to allow tuning. Tuning may also be controlled by use of a variable air gap. For each situation, the tuning device is ideally associated connected between the conductive members at a position diametrically opposite said pillar. As a further option, tuning might be accomplished by changing the spacing between the conductive members.

Advantageously, both conductive members are shaped, e.g. from copper or aluminum, on particular insulating substrates using printed circuit techniques. On the other hand, the members can be produced using tin foil or solid metal, e.g. aluminum.

Preferably, the input comprises a coaxial radio frequency connector mounted on the face of said one conductive member remote from said other conductive member, said connector having an inner conductor passing in an insulated manner through an aperture in said one conductive member and connected to said first input terminal, and an outer conductor connected to said one conductive member.

In a advancement of the aforementioned preferred embodiment of the invention, in which said other conductive member comprises an annular conductive member, the antenna may include a second annular conductive member concentrically nested within the first mentioned annular conductive member.

This second annular conductive member may have an outside diameter just marginally littler than the within diameter of the first annular conductive member, so defining with said one conductive member a slot which mutually couples with that defined by the first annular conductive member with said one conductive member. The second annular member is tuned by implies like that portrayed for the first annular member. This course of action gives an expansion in bandwidth, which may be required, for instance, for task on two different frequencies where duplex channel spacing is being utilized, e.g. on an 8 or 45 MHz duplex split or a 3 MHz split at lower frequencies.

Applications of Circular Slot Antennas

Circular Slot antennas are as often as possible utilized for microwave and UHF frequencies, though they were originally invented for VHF television broadcasting. Most slot antennas are utilized for frequencies between 300 MHz and 25 GHz.

Aperture antenna is extremely prominent for aviation applications since it can be flush-mounted on aircraft surface. Its aperture opening can be covered with an electromagnetic (dielectric) window material that is straightforward to the RF energy to protect the antenna from the environmental conditions. This is known as a random, and it is executed so as not to disturb the aerodynamic profile of the vehicle, which is of extraordinary significance to rapid flying machine or rockets.

Circular Slot antenna provide easy and inexpensive antenna which is particularly suitable for use with radio transmitter which is associated with a utility meter, particularly a water meter, for the purpose of transmitting the readings of the meter to a remote receiver.

Study of Printed Circular Slot Antennas for Ultra wideband Applications

- DUE to the attractive merits, such as low profile, lightweight, ease of fabrication and wide frequency bandwidth, printed slot antennas are currently under consideration for use in ultra wideband (UWB) systems. This type of antenna has been realized by using either micro strip line or coplanar waveguide (CPW) feeding structure.
- The proposed printed circular slot antennas with two different feeding structures are illustrated in respectively. For the micro strip line fed elliptical/circular slot antenna, the slot and the feeding line are printed on different sides of the dielectric substrate; for the CPW fed one, they are printed on the same side of the substrate.

ANTENNA GEOMETRY

In both designs, the elliptical/circular radiating slot has a long axis radius and a short axis radius (for circular slot,) and is etched on a rectangular FR4 substrate with a thickness and a relative dielectric constant. The feed line is tapered with a slant angle for a length to connect with the U-shaped tuning stub which is all positioned within the elliptical/circular slot and symmetrical with respect to the short axis of the elliptical/circular slot. The U-shaped tuning stub consists of three sections: the semi-circle ring section with an outer radius and an inner radius, and two identical branch sections with equal heights and equal widths, represents the distance between the bottom of the tuning stub and the lower edge of the circular slot.

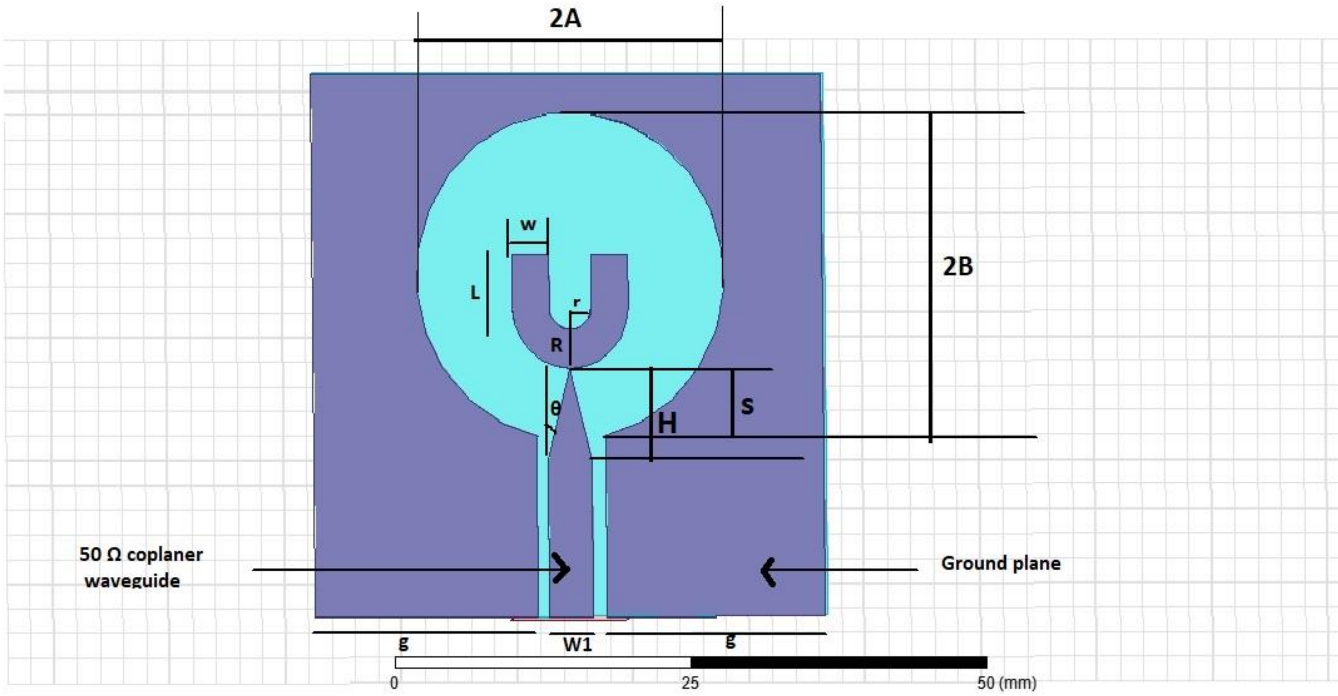


Fig-2

Design Considerations

Table I: - THE OPTIMAL DIMENSIONS OF THE CPW FED CIRCULAR SLOT ANTENNAS

DIMENSIONS	CPW FED CIRCULAR SLOT
A(mm)	13.3
B(mm)	13.3
S(mm)	0.4
R(mm)	5
r(mm)	1.8
H(mm)	3.1
W(mm)	3.2
L(mm)	4.3
Substrate size(mm^2)	44*44

TABLE II: - MEASURED AND SIMULATED BANDWIDTHS OF CPW FED CIRCULAR SLOT ANTENNAS

	Simulated -10dB bandwidth(GHz)	Measured -10dB bandwidth(GHz)
CPW FED CIRCULAR SLOT	3.5-12.3	3.75-10.3

From what we have seen so far the ultra wide bandwidth of the slot antenna results from the overlapping of the multiple resonances introduced by the combination of the circular slot and the CPW feed line. Thus the most important parameters that we have to consider for designing the antenna are slot dimension, distance S and slant angle θ.

- **Dimensions of Circular Slot Antenna:**

It is well known from experiments that the dimension of the slot antenna is directly related to the lower edge of the impedance bandwidth. The formula to determine the above is given as below

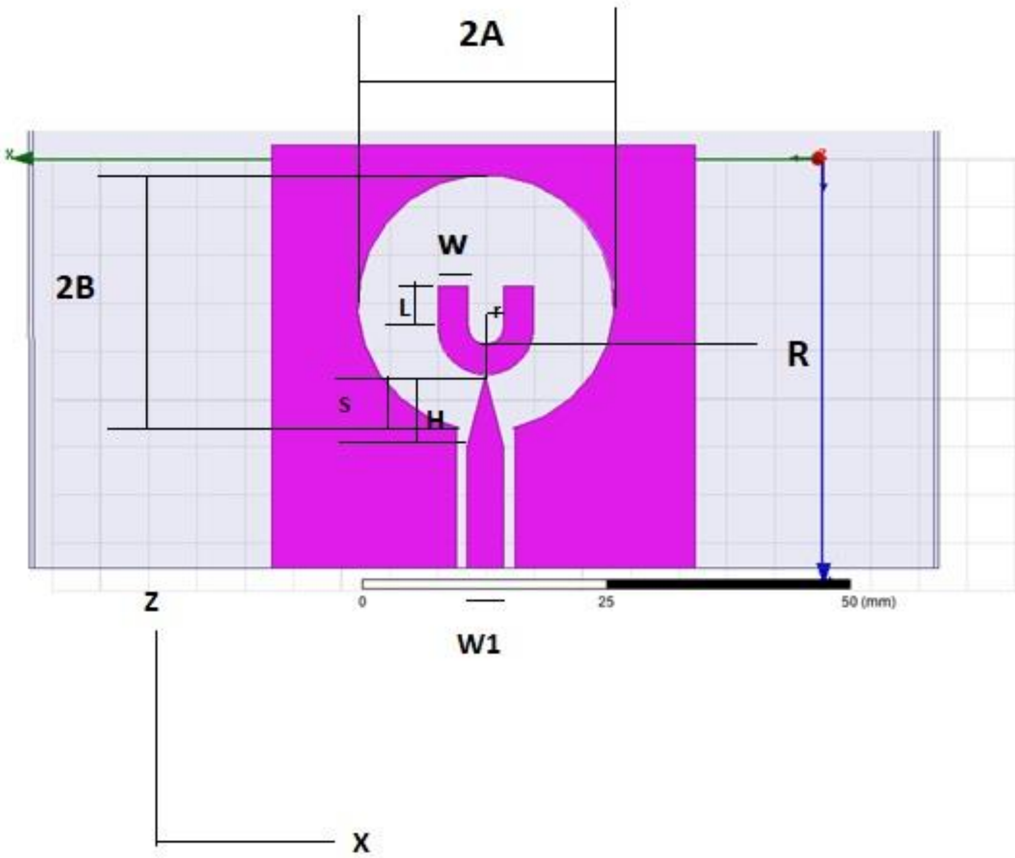
fL= (30*0.24)/ (L+r), where fL is in GHz and r is in centimeters. L is the disc height, r is equivalent radius .

In order to implement circular slot antenna the above equation is modified as;

fL= (30*C)/ (L+r), where C is the element factor and C=0.35.

- **Distance(S):**

  Here in this report we have taken the distance to be optimal in order to ensure proper output and the value assigned is 0.4mm. The values of the long axis (A) and short axis (B) is taken as 13.3mm. It should be noted that as we are using circular slot antenna so both the values are same.



CPW FED Slot Antenna(Without substrate)

Fig-3

ANSOFT HFSS

HFSS is a commercial finite element method solver for electromagnetic structures from Ansys. The acronym stands for High Frequency Structure Simulator. It is one of several commercial tools used for antenna design, and the design of complex RF electronic circuit elements including filters, transmission lines, and packaging. It was originally developed by Professor Zoltan Cendes and his students at Carnegie Mellon University. Prof. Cendes and his brother Nicholas Cendes founded Ansoft and sold HFSS stand-alone under a 1989 marketing relationship with Hewlett-Packard, and bundled into Ansoft products.

[1] In 1997 Hewlett-Packard acquired Optimization Systems Associates Inc. (OSA), a company John Bandler founded in 1983.

DESIGN MADE BY HFSS

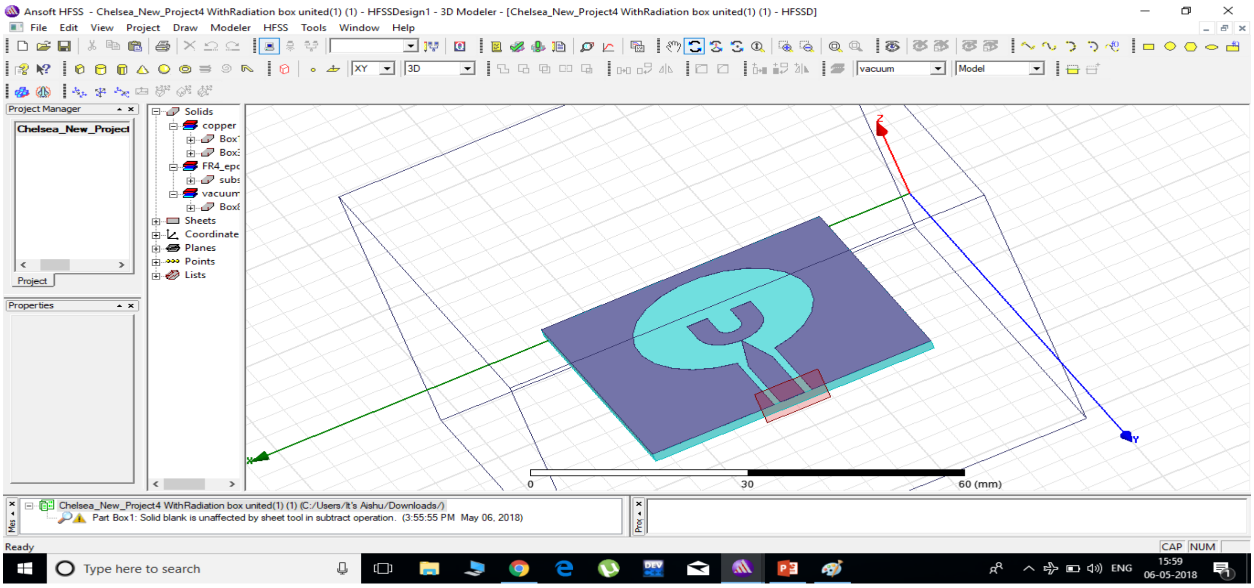


Fig-4

Simulation Part

Definition: Simulation is the imitation of the operation of a real-world process or system. Simulation is used in many contexts, such as simulation of technology for performance optimization, safety engineering, testing, training, education, and videogames. Often, computer experiments are used to study simulation models

Simulation is also used when the real system cannot be engaged, because it may not be accessible, or it may be dangerous or unacceptable to engage, or it is being designed but not yet built, or it may simply no.

After design the antenna fabrication part, now it's time to simulate. Simulation is the important part of this project. Basically, in this part, we want to study the return loss, bandwidth, and gain of the UWB Slot antenna.

Procedure:

To produce the results of the circular UWB slot antenna, execute the result and add the frequency sweep (3.1-20GHz). Update the setup and go for the result. According to the result, we will find important parameters.

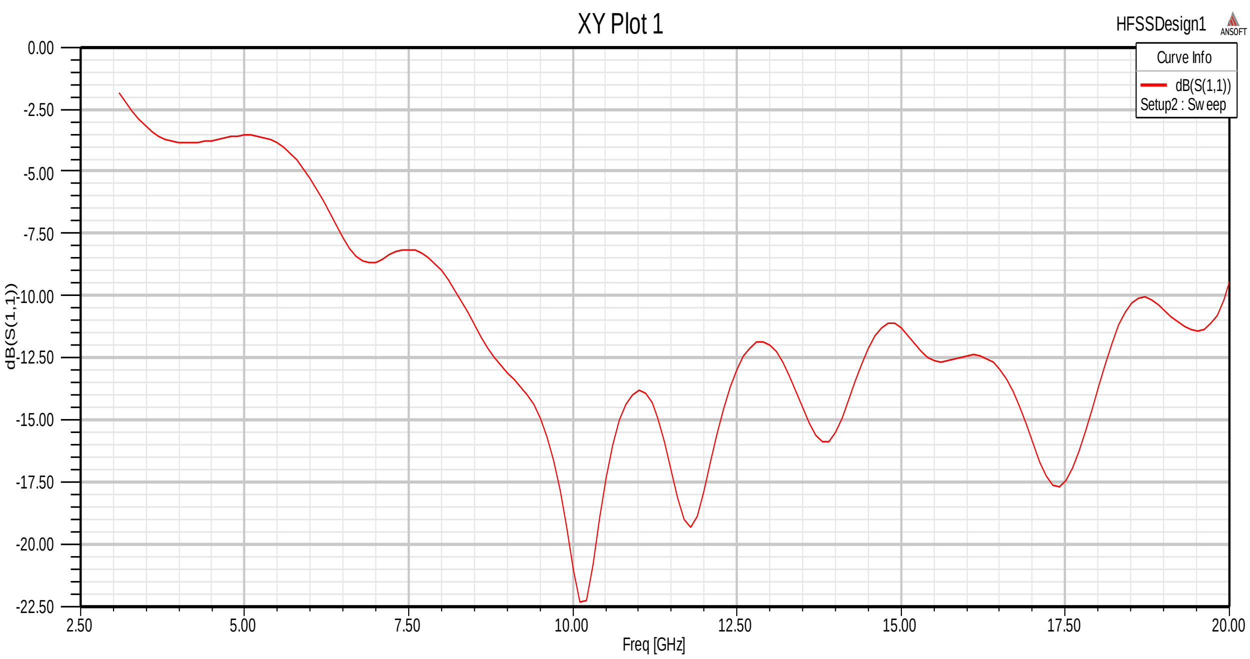
In this section, we will find out a total five parameters.

1. Return loss
2. VSWR
3. Gain Polar plot
4. 3D Polar Plot
5. Vector film animated file

1. **Return Loss:** After selecting the rectangular plot, a box will open.Here selects the parameters, quality, and the function. Here we select the category: S Parameter, Quality: S (1, 1), and Function: dB. And just click on new report. You will see the graph.

2. **VSWR:** To find out the VSWR of the antenna follow the steps:
Like a previous procedure, select result, right click->Add frequency setup->rectangular plot. Open a box. Then select the category, quality and function.

Outcome



This is the graph of circular UWB slot antenna.
Sweep type: Interpolating
Start frequency: 3.1GHz
Stop frequency: 20 GHz
Step size: 0.1 GHz

Time domain calculation:
Max solution: 250
Error tolerance: 0.5%

SCOPE FOR FUTURE WORK

Based on the conclusion and limitation in the research work discussed in this thesis, the following future work can be further investigated.

- UWB antennas would be embedded in wireless devices, so the effects of antenna performance and the human body impact on antennas mounted on portable devices need to be studied.

- Further research may be focused on reducing the interference from other sources rather WiMax and WLAN band services.

- Studies should be carried out to find new technique for further size reduction of the antenna to hold it into the compact wireless UWB devices.

- The thesis only focuses on the research of single UWB antenna element. The research on antenna array can also be carried out wherever highly directional and gain is required.

ACKNOWLEDGEMENT

Somebody has correctly said “Rome was not built in a day”. Behind the creation of many great things, the blessings of many are showered directly or indirectly, The same also happened with our dissertation and many blessed us too. We will be failing in our duty if we fail to acknowledge some of the contributions personally.

At the very outset our hands bow in gratitude to our project guide Prof. Nandan Bhattacharya under whose brilliant guidance we were able to complete our project. We are wholeheartedly thankful to him for giving us his valuable time and attention and for providing us a systematic way for completing our project on time.

And finally our deepest gratitude to our parents and well-wishers for their unfailing emotional support for the project. Lastly we owe greatly to GREAT ALMIGHTY GOD who is always there as a guiding force behind all the creations of the world and, without whose wish not a leaf can flutter.

SAYAK BANERJEE

PRASANNA MALLICK

SHIVDUTT KUMAR

SUMAN DAS SARKAR

References

[1] H. L. Lee, H. J. Lee, J. G. Yook, and H. K. Park, “Broadband planar antenna having round corner rectangular wide slot,” in *Proc. IEEE Antennas and Propagation Society Int. Symp.*, Jun. 16–21, 2002, vol. 2,

[2] H.-D. Chen, “Broadband CPW-fed square slot antennas with a widened tuning stub,” *IEEE Trans. Antennas Propag.*, vol. 51, no. 8, pp. 1982–1986, Aug. 2003.

[3] Antenna Theory by Balanis.

[4] Thesis by Liang Jianxin.