DESIGNING AND SIMULATION OF CIRCULARLY POLARIZED MICROSTRIP PATCH AND ARRAY ANTENNAS IN MATLAB

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ABSTARCT

In recent years, the inventions in communication systems require the development of low cost, minimal weight, compact and low profile antennas that are capable of maintaining high performance over a wide spectrum of frequencies. This technological trend has focused much effort in the design of micro strip patch antennas because of its inherent characteristics that fits the requirements of modern communication devices. This project presents the design and simulation of a compact rectangular Micro strip patch antenna for dual frequency operation from 0 GHz to 2 GHz and Impedance from -100 to 300 (Resistance and reactance) Azimuth angle [-180, 180 degrees], Elevation angle [-90°, 90°]. The simulation of the designed antenna was done with the aid of MATLAB which will be used to calculate the parameters. The proposed antenna may find applications in wireless local area network (Wi-Fi) and GNNS, GPS signals according to the frequencies used. The project consists of coming out with a circularly polarized Micro strip patch Antenna designed and simulated in MATLAB based on GPS; GNSS; GALILEO; GLONASS.

Keywords: Circular polarization; GNSS; Microstrip, MATLAB

INTRODUCTION

In the world of modern wireless communication, engineer who wants to specialize in the communication field needs to have a basic understanding of the roles of electromagnetic radiation, antennas, and related propagation phenomena. We use antennas when nothing else is possible, as in communication with a missile or over rugged mountain terrain where cables are expensive and take a long time to install. The performance characteristics of the parent system are heavily influenced by the selection, position and design of the antenna suite. To understand the concept of antenna one should know the behavior of Electromagnetic waves in free space. So I am briefly covering the basics of Electromagnetic waves and its propagation modes in free space. Apart from that I am also covering Antenna classifications (based on Frequency, aperture, polarization and radiation pattern), its performance parameters (Gain, Directivity, Beam area and beam efficiency, radiation pattern, VSWR/Return loss, polarization, Efficiency), measurement techniques (Outdoor and Indoor Testing) and its different applications (Naval antennas, Airborne Antennas and Earth Station Antennas). This project will focus on designing an antenna that is able to operate in all the existing and future GNSS frequencies.

Circular polarization (CP) is commonly adopted in GPS and other satellite communications because of the Faraday rotation when signals travel through the ionosphere. Nowadays, the majority of global positioning system (GPS) receivers only operate at L1 frequency. The design will be done with simulating software MATLAB, Which provides fairly reliable simulations and useful data in designing these kind of antennas. Due to the features of circular polarization, CP antennas have several important advantages compared to antennas using linear polarizations, and are becoming a key technology for various wireless systems including satellite communications, mobile communications, global navigation satellite systems (GNSS) Wireless sensors, Radio Frequency Identification (RFID), wireless power transmission, WLAN,WPAN, WIMAX(Worldwide interoperability for microwave Access and Direct Broadcasting Service(DBS); Lots of progress in research and development has been made during recent years. The challenges include losses during transmission; circular polarized antennas have many performance advantages over linearly polarized (LP) ones. The most important one is less polarization loss, For the receiving antenna to have maximum power reception, it should have the same sense of polarization as that of transmitting one.

The polarization loss depends upon the angle between the transmitting wave and the receiving antenna polarization. If they are orthogonal then no power will be received.

In this paper the authors built a broadband antenna, which main objective is to cover the frequency bands from 1.520-1.5 GHz and 1.660 GHz (Approximately these values can be changed); we can also build a broadband antenna to cover the frequency band from 1.52 to 1.66 GHz, which is a relative bandwidth of about 8.8% centered at 1.59 GHz;

The paper consist of circularly polarized antenna; the polarization of an antenna in a given direction indicates the polarization of the radiated wave of the antenna in that direction; The polarization of a radiated wave is the property of an electromagnetic wave describing the time varying direction and the relative magnitude of the electric field vector at a fixed location in space, and the sense in which it is traced, as observed along the direction of propagation.

In this paper the authors focus on circular polarization: If the electric-field vector at a given point in space, traces a circle as a function of time, we are talking about that the time-harmonic wave is circularly polarized.
The circular polarization antenna has exceptional ability to alleviate the harmful influence caused by multipath effects and to provide insensitivity of signals towards transmitter and receiver antenna orientation.

An antenna

An antenna (or aerial) is an electrical device which converts electric power into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter supplies an oscillating radio frequency electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals that is applied to a receiver to be amplified.

Polarization In General

The polarization of an electromagnetic wave is defined as the orientation of the electric field vector. Recall that the electric field vector is perpendicular to both the direction of travel and the magnetic field vector. The polarization is described by the geometric figure traced by the electric field vector upon a stationary plane perpendicular to the direction of propagation, as the wave travels through that plane. An electromagnetic wave is frequently composed of (or can be broken down into) two orthogonal components. This may be due to the arrangement of power input leads to various points on a flat antenna, or due to an interaction of active elements in an array, or many other reasons.

Circular polarization has a number of benefits for areas such as satellite applications where it helps overcome the effects of propagation anomalies, ground reflections and the effects of the spin that occur on many satellites [4]. Another form of polarization is known as elliptical polarization. It occurs when there is a mix of linear and circular polarization. This can be visualized by the tip of the electric field vector tracing out an elliptically shaped corkscrew.
It is possible for linearly polarized antennas to receive circularly polarized signals and vice versa. But, there is a 3 dB polarization mismatch between linearly and circularly polarized antennas.

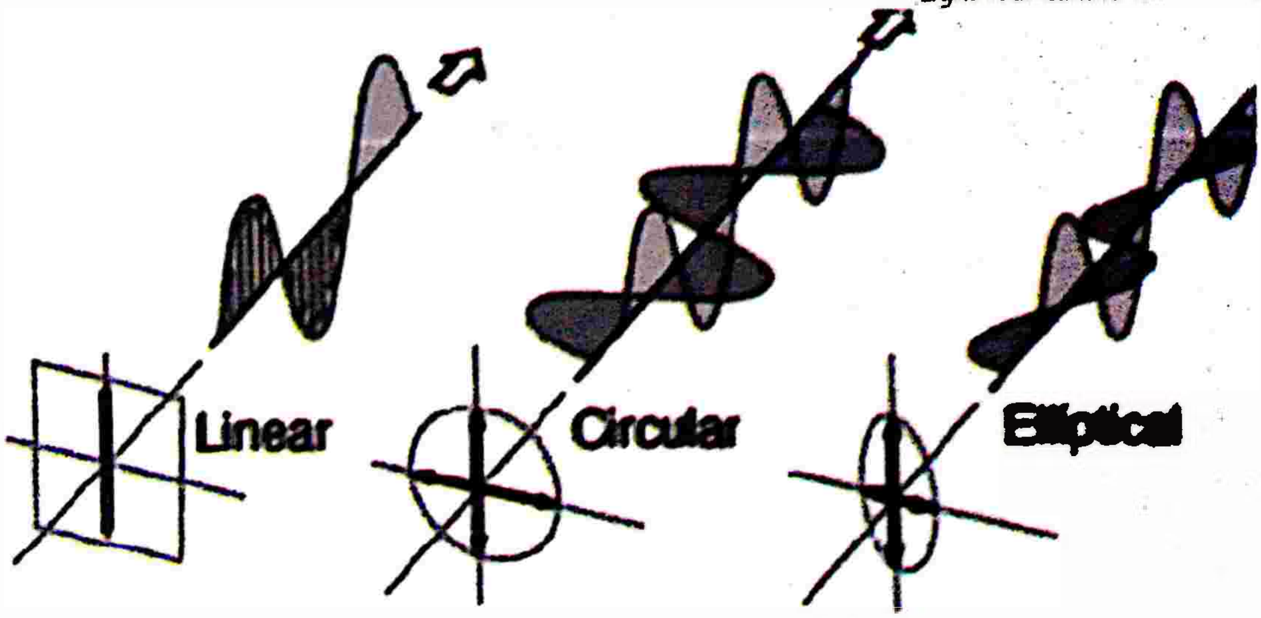


Figure 1: Polarizations (Linear, Circular, And Elliptical) [3]

Polarization types

Polarization of an antenna is defined by the orientation of the electric field component of the electromagnetic plane wave transmitted by the antenna with respect to the earth's surface. Polarization of a plane wave is said to be linear, elliptical, or circular depending on the pattern in which the electric field vector of the wave traces while propagating.

As the electric field of a propagating plane wave is always oriented perpendicular to the propagation direction, the shape of the polarization pattern can be seen when observing the wave from the xy-plane as the wave is travelling along the z-axis.

The electric field has now two perpendicular components, which have equal magnitude and 90° phase difference.

Linear Polarization:

From a technical perspective, linear polarization is defined as polarization of an electromagnetic wave in which the electric vector at a fixed point in space remains pointing in a fixed direction, although varying in magnitude. There are two forms of linear polarization: vertical, where the electric field is perpendicular to the Earth's surface, and horizontal, where the electric field is parallel to the Earth's surface. Both directions can be used simultaneously on the same frequency. Some customers consider linear polarization to be superior, if only because the specific equipment costs are not marginally. Linear polarization can be found in both C-Band and Ku-Band (see Table 1)

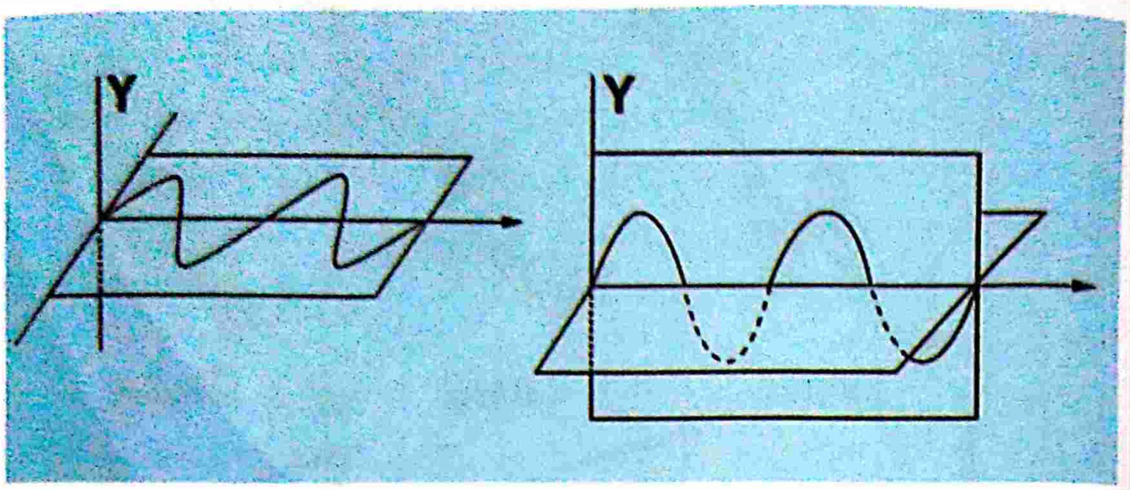


Figure 2: Linear Polarization

Circular Polarization

The circularly polarized wave will radiate energy in the horizontal and vertical plane, as well as every plane in between. There are two directions of propagation that come with circular polarization: Right-Hand-Circular (RHC) which follows a clockwise pattern, and Left- Hand-Circular (LHC) which follows a counterclockwise pattern. As with linear polarization, both directions can be used simultaneously on the same frequency., allowing higher revenue generation through the doubling of capacity on the satellites. Circular polarization can be found on both C-Band and Ku-Band. It is important to note that Intelsat does not have any Ku-Band fleet with circular polarization.

Circular polarization (CP) is commonly adopted in GPS and other satellite communications because of the Faraday rotation when signals travel through the ionosphere. Nowadays, the majority of global positioning system (GPS) receivers only operate at L1 frequency (1575:42 § 10:23 MHz) with right hand circular polarization, as the L1 frequency is for civil use. But requiring more precision and reliability, some GPS antennas are requested to cover both L1 and L2 (1227:60 § 10: 23 MHz) bands. Modern Global Positioning System introduces the addition of a new navigation signal located at 1176MHz (L5) with 24.00MHz bandwidth for the use of safety of life in 2007. The circularly-polarized wave can be realized by exciting two linearly polarized modes.

These two modes should be with 90±phase difference, equal amplitude, and orthogonal to each other in polarization. Due to the features of circular polarization, circularly polarized antennas are very useful for various wireless systems such as satellite communications, global navigation satellite systems, mobile communications, wireless sensors, radio frequency identification, wireless power transmission, wireless local area networks, wireless personal area networks, worldwide interoperability for microwave access and direct broadcasting service television reception systems. Recent decades have seen a lot of research and development activities in CP antennas from industries and institutes worldwide.

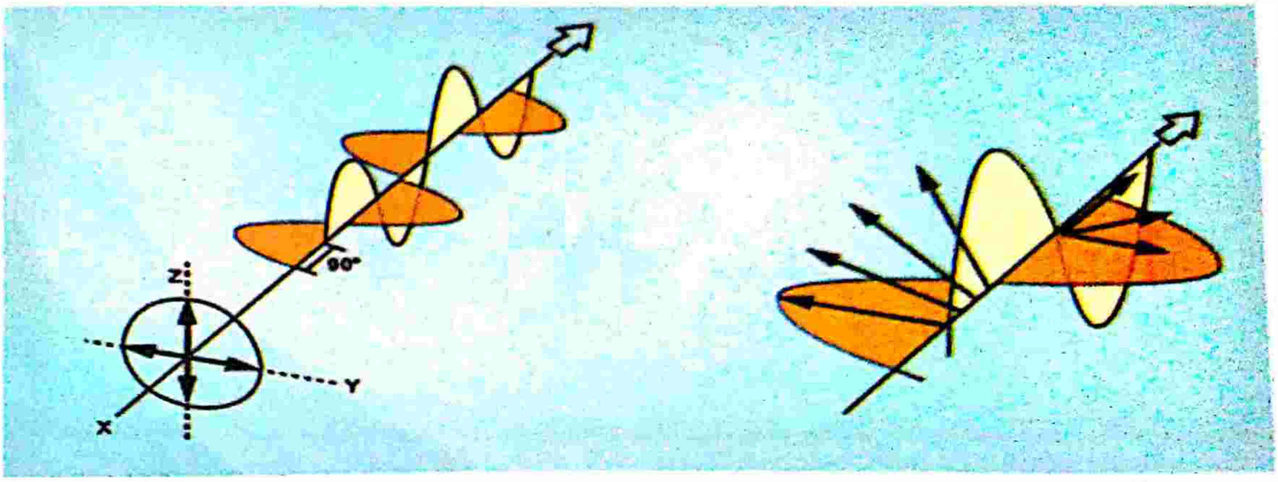


Figure 3: Circular Polarization

If the antenna is able to transmit or receive E field vectors of any orientation, then antenna is said to be circularly polarized antenna.

Advantages of Circular Polarization

There are several key advantages for circular polarization over linear polarization, which make it more appealing:

1. The Faraday Effect

The Faraday effects deals with the interaction between light and magnetic fields. It affects linear, but not circular, polarized signals, and the effects are more severe at lower frequencies, such as C-Band, and not noticeable at higher ones, such as Ku-Band. As signals pass through the atmosphere they become de-polarized, causing undesirable reception of the opposing polarity.

Linear polarized feeds are aligned in such a way to compensate for the Faraday effects, usually with the help of a tracking device; corrections can be made either by rotating the feed system or using adjustable polarizer's within the feed system. This can be very time consuming because the alignment must be exact. One result of incorrect alignment is increased interference. Fortunately, this is not a concern for circular polarization since there is no need for exact signal alignment. Ku-Band is at a high enough frequency that Faraday's effect is not a factor.

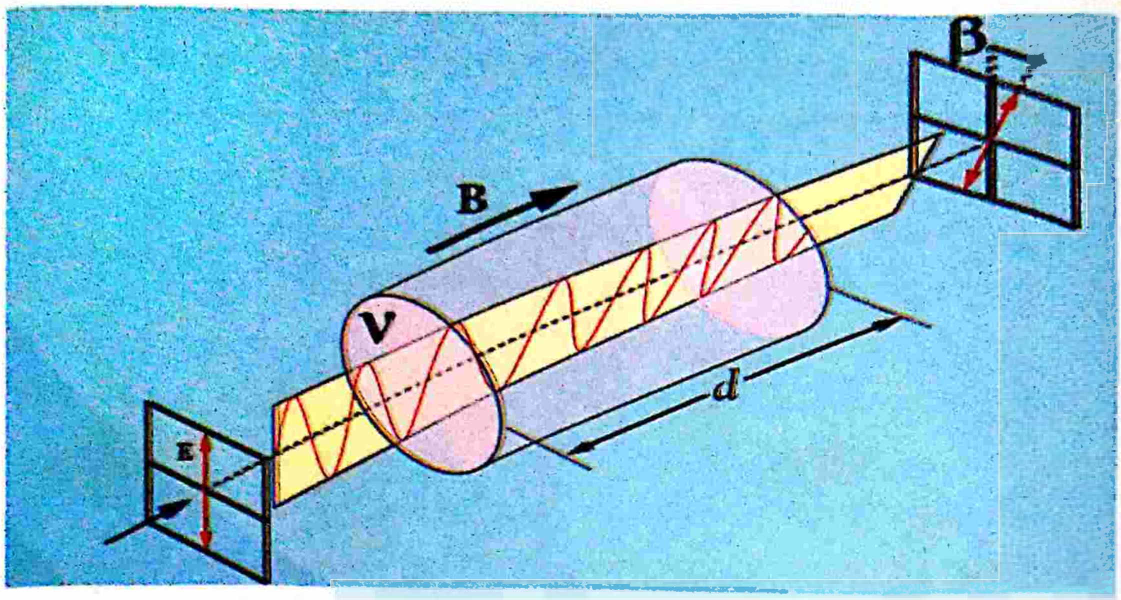


Figure 4: FARADAY effect

1. Atmospheric Conditions

Circular polarization is more resistant to signal degradation due to atmospheric conditions. These conditions can cause changes in the rotation of the signal, and will more adversely affect linear polarization than circular polarization. The effect of a high frequency signal passing through rain can cause signal attenuation and accounts for the majority of the problems with rain fade.

Moisture laden clouds are also a factor; by the time a signal passes through a cloud system it can be attenuated by as much as 1dB. Water droplets on the feed horn may also cause detrimental effects. However, the most important aspect to note is that higher frequencies (like Ku-Band) degrade faster, harder, and longer than their frequency counterparts (C-Band).

2. Easier Installation

The only requirement is ensuring that the antenna is aimed in the correct direction on the satellite; simply point and transmit. This allows for circular feeds to be set up quicker, and there is less of a risk of being misaligned.

3. Higher link reliability

There is higher link reliability since there is a low risk of misalignment, and encountering interference.

Table 1: Breakdown of Polarization on Intelsat satellites

Circular Polarization:	
C-Band	IS-601, IS-602, IS-603, IS-605, IS-701, IS-702, IS-704, IS-705, IS-706, IS-707, IS-709, IS-801, IS-802, IS-901, IS-902, IS-903, IS-904, IS-905, IS-906, IS-907, IS-10-02
Ku-Band	None
Linear Polarization:	
C-Band	G-3C, G-4R, G-9, G-10R, G-11, G-12, G-13, G-14, G-15, G-16, G-23, G-25, G-26, G-27, G-28, Horizons 1, APR-1, IS-1R, IS-2, IS-3R, IS-5, IS-6B, IS-7, IS-8, IS-805, IS-9, IS-10 and IS-12
Ku-Band	All Satellites

Antennas Parameters

1. Antenna Gain

This is the direction in which there is more radiation or this is a measure of the ability of an antenna to direct the input power into radiation in a particular direction and also measured at the peak radiation intensity.

$$G(\theta,\emptyset)=\frac{U(\theta,\emptyset)}{Pin/4\pi}$$

Where
Pin=Input Impedance
U(θ,∅)=Radiation density

Gain is attained by administering the radiation far from different parts of the radiation surface.

2. Input Impedance

This is characterized as, "the impedance exhibited toward an antenna, at its terminals alternately the proportion of the voltage of the present during those combine from claiming terminals or the proportion of the suitable parts of the electric to attractive fields toward a point (magnetic field)". Henceforth those impedance of the antenna might a chance to be composed as provided below.

Zin=Rin+jXin

Where Z in is the antenna impedance, Xin is the antenna reactance, which impedance is the coefficient of the power stored in the near field of the antenna and Rin is the antenna resistance about two components, those radiation resistance Rr and the loss resistance RL in. All is found at the terminals of the antenna. The power associated with the radiation resistance is the power actually radiated by the antenna, while the power dissipated in the loss resistance is lost as heat in the antenna itself due to dielectric or conducting losses.

3. Radiation Pattern

Radiation pattern could be characterized in distinctive routes like it can be a mathematical, procedure, alternately it might make a graphical representational of the antenna as a function of space coordinates. The radiation pattern of an antenna is a plot of the far-field radiation properties of an antenna as a function of the spatial co-ordinates, which are specified by the elevation angle (θ) and the azimuth angle (φ). Radiation properties include power flux densi ty, radiation intensity, field strength, directivity, phase or polarization." The radiation property of most concern is the two- or three-dimensional spatial distribution of radiated energy as a function of the observer's position along a path or surface of constant radius. More specifically it is a plot of the power radiated from an antenna per unit solid angle which is nothing but the radiation intensity. It can be plotted as a 3D graph or as a 2D polar or Cartesian slice of this 3D graph, all is summarized by the following diagram below.

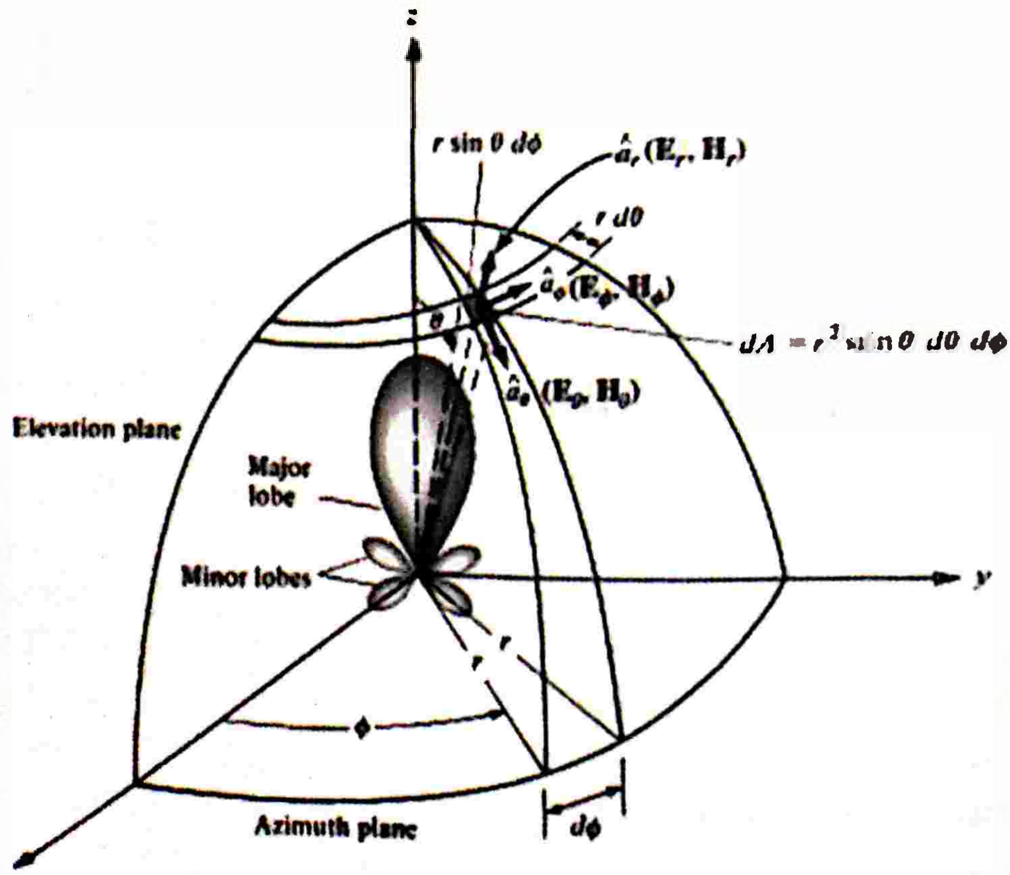


Figure 5: COORDINATE system for antenna analysis [?]

4. Radiation Intensity

Radiation intensity in a given direction is defined as the power radiated from an antenna per unit solid angle. The radiation intensity is a far-field parameter, and it can be obtained by multiplying the radiation density by the square of the distance. In a mathematical form, it is expressed as:

$$U = r^2 W_{rad}$$

Where:
U =Radiation intensity (W/unit solid angle)
Wrad =Radiation density (W/m^2)
r = Distance (m)

5. Directivity

The Directivity of an antenna is defined as the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. The average radiation intensity is equal to the total power radiated by the antenna divided by 4π. If the direction is not specified, the direction of maximum radiation intensity is implied. The directivity of a non-isotropic source is equal to the ratio of its radiation intensity in a given direction over that of an isotropic source. In a mathematical form, it can be written as

$$D=\frac{U}{U_0}=\frac{4\pi U}{P_{rad}}$$

Where
D = directivity (dimensionless)
U = radiation intensity (W/unit solid angle)
Uo = radiation intensity of isotropic source (W/unit solid angle)

6. Antenna Efficiency

Related with an antenna, there are a number of efficiencies. The total efficiency., takes into account losses at the input terminals and with the structure of the antenna. Such losses may be due to reflections because of the mismatch between the transmission line and the antenna, and I2R losses (conduction and dielectric). The overall efficiency can be written as

$$e_o = e_r e_c e_d$$

Where:
e_0=total efficiency (dimensionless)

e_r = reflection (mismatch) efficiency = $(1 - |\Gamma|^2)$ (dimensionless)

e_c = conduction efficiency (dimensionless)

e_d = dielectric efficiency (dimensionless)

Γ = voltage reflection coefficient at the input terminals of the antenna

$\Gamma = (Z_{in} - Z_0)/(Z_{in} + Z_0)$

Where:
Z_{in} = anten ninput impedance, Z_0 = characteristic impedance of the transmission line.

$$\text{VSWR= Voltage Standing Wave Ratio=} \frac{1+|\Gamma|}{1+|\Gamma|}$$

7.Bandwidth

The bandwidth of an antenna is defined as the range of frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard. The bandwidth can be considered to be the range of frequencies, on either side ofa center frequency, usually the resonance frequency. In this range, the antenna characteristics such as input impedance, pattern, beamwidth, polarization, side lobe level, gain, and radiation efficiency are within an acceptable value of those at the center frequency. For broadband antennas, the bandwidth is usually expressed as the ratio of the upper-to-lower frequencies of acceptable operation. For example, a 10:1 bandwidth indicates the upper frequency is 10 times greater than the lower. For narrowband antennas, the bandwidth is expressed as a percentage of the frequency difference (upper minus lower) over the center frequency of the bandwidth. For example, a 5 percent bandwidth indicates that the frequency difference of acceptable operation is 5 percent of the center frequency of the bandwidth.

8. Axial Ratio

The axial ratio is a very important parameter that helps to quantify the polarization of an antenna. The axial ratio of a wave elliptically polarized, is the relationship between major and minor axes of the ellipse, and it can take values among one and infinity.

For an antenna that has a purely linear polarization, the axial ratio tends to infinity because one of the components of electric field is zero.

For antennas that have perfect circular polarization, the axial ratio is 1 (or 0 dB), because you have electric field components of the same magnitude, if it is an antenna with elliptical polarization, the axial ratio is greater than 1.

9. Satellite

Orbiting system in space that receives communications radio signals from ground bases on earth and then retransmits them to distant locations.

A TV station licensed to rebroadcast the programming of apparent station. It differs from a translator in that satellite power limits are much higher, and satellites may also originate some programming. Satellite communication systems-A remote communications technique using a satellite in orbit to receive signals from one location and then retransmit them to another location.

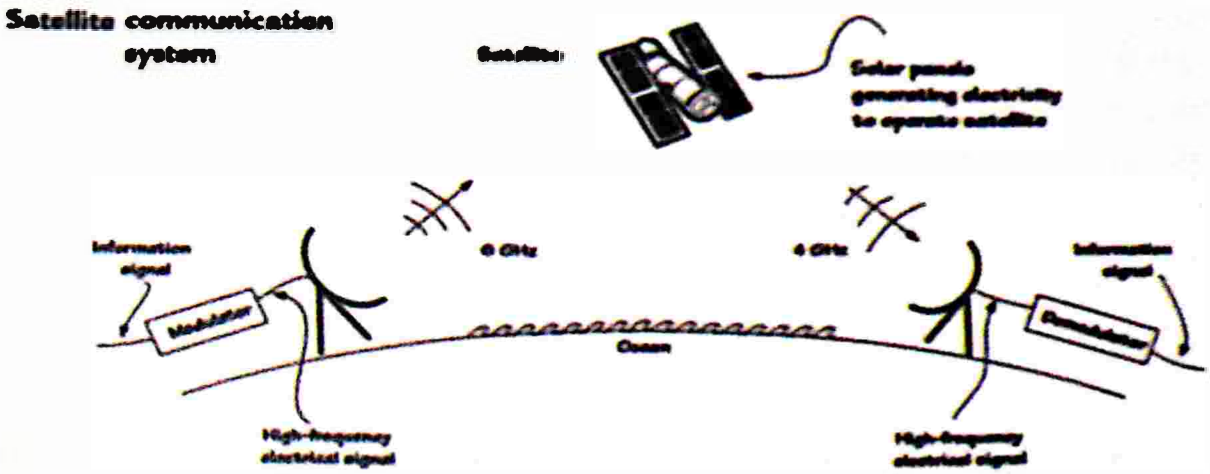


Figure 6: satellite communication

Fundamentals of satellite communication

Satellites are specifically made for telecommunication purpose. They are used for mobile applications such as communication to ships, vehicles, planes, hand-held terminals and for TV and radio broadcasting.

They are responsible for providing these services to an assigned region (area) on the earth. The power and bandwidth of these satellites depend upon the preferred size of the footprint, complexity of the traffic control protocol schemes and the cost of ground stations.

A satellite works most efficiently when the transmissions are focused with a desired area. When the area is focused, then the emissions don't go outside that designated area and thus minimizing the interference to the other systems. This leads more efficient spectrum usage.

Satellites antenna patterns play an important role and must be designed to best cover the designated geographical area (which is generally irregular in shape). Satellites should be designed by keeping in mind its usability for short and long term effects throughout its life time.

An inclination angle of 0 degrees means that the satellite is exactly above the equator. If the satellite does not have a circular orbit, the closest point to the earth is called the perigee.

Antenna Look Angles

The look angles for the ground station antenna are Azimuth and Elevation angles. They are required at the antenna so that it points directly at the satellite. Look angles are calculated by considering the elliptical orbit. These angles change in order to track the satellite.

For geostationary orbit, these angles values does not change as the satellites are stationary with respect to earth. Thus large earth stations are used for commercial communications, these antennas beamwidth is very narrow and the tracking mechanism is required to compensate for the movement of the satellite about the nominal geostationary position. For home antennas, antenna beamwidth is quite broad and hence no tracking is essential. This leads to a fixed position for these antennas.

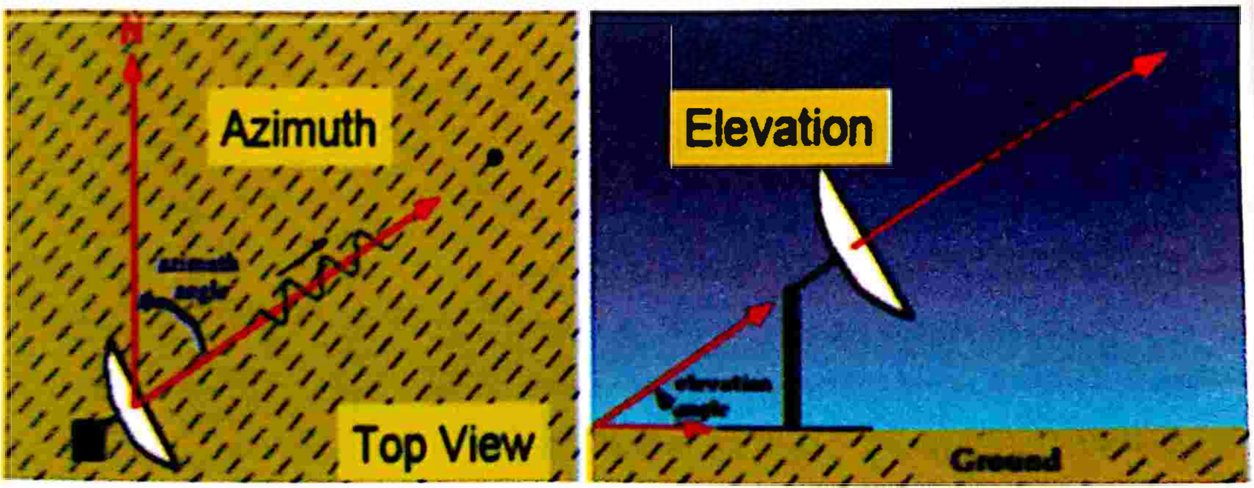


Figure 7. Azimuth and elevation

Polarization of electromagnetic waves

The waves transmitted by satellite are polarized. That is, the transmitted electromagnetic vibrations are parallel to a fixed direction, in this case the polarization is vertical or horizontal, or else it rotates while moving, in this case the polarization is circular right or left following the direction of rotation.

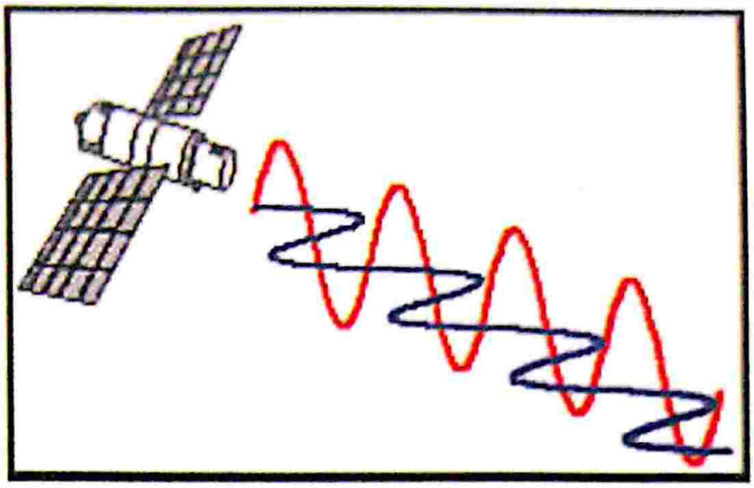


Figure 8: Electromagnetic waves

Frequency bands used

The need for a high channel capacity, and hence large bandwidths, makes it necessary to choose high frequencies, generally in the centimeter wave range

Table 2: Summary of the frequency bands used in the fixed-satellite service.

Band	Frequencies	Services
L	1-2 GHz	mobile communications
S	2-3 GHz	mobile communications
C	4-6GHz	International and Domestic Civil Communications
X	7-8 GHz	military communications
Ku	11-14 GHz	international and national civil communications
Ka	20-30 GHz	new broadband network access systems
EHF	21-45 GHz	military communications

GNSS System

The term Global Navigation Satellite System (GNSS) refers to a constellation of satellites providing signals from space, transmitting positioning and timing data. A GNSS receiver computes its position (latitude, longitude and altitude) and time based on the data received from four or more GNSS satellites. The satellites broadcast a signal that contains orbital data and the exact time the signal is transmitted. The orbital data is transmitted in a data message that is superimposed on a code that serves as a timing reference. Global coverage for each system is generally achieved by a satellite constellation of 20–30 medium Earth orbit (MEO) satellites spread between several orbital planes. The actual systems vary, but use orbital inclinations of >50° and orbital periods of roughly twelve hours (at an altitude of about 20,000 kilometers).

Basic GNSS Concepts

The basic GNSS concept is shown in Figure 3, which illustrates the steps involved in using GNSS to determine time and position then applying this information.

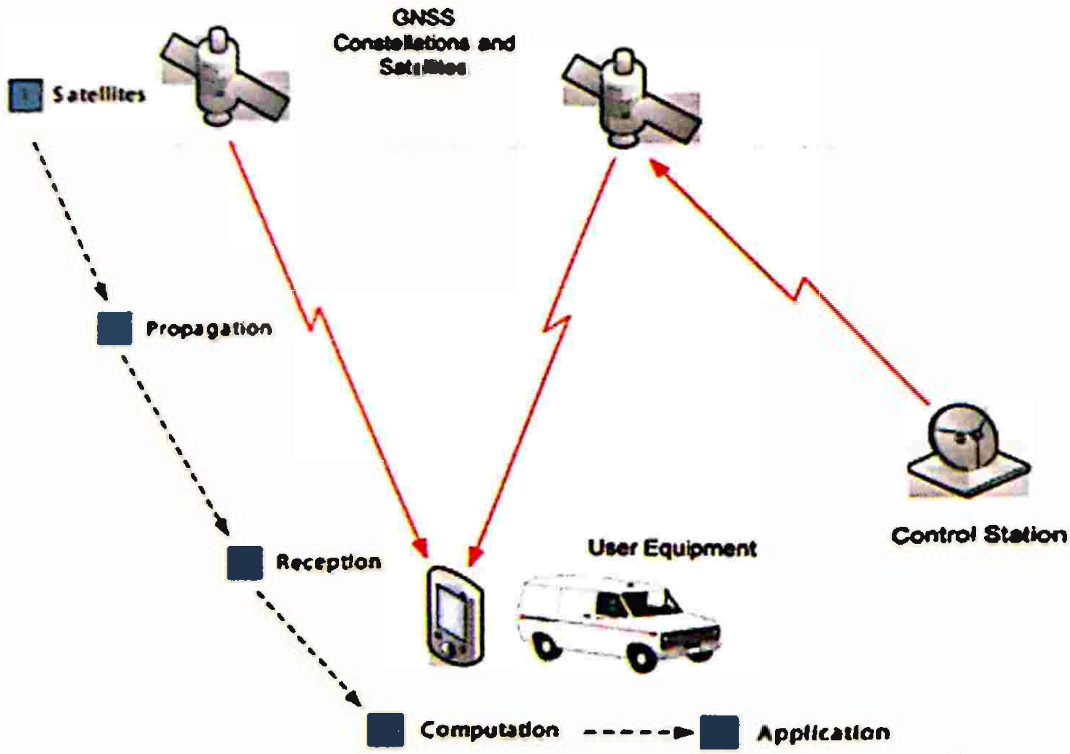


Figure 9: BASIC GNSS concept [1]

GNSS Satellites

There are multiple constellations of GNSS satellites orbiting the earth. A constellation is simply an orderly grouping of satellites, typically 20- 30, in orbits that have been designed to provide a desired coverage, for example, regional or global. GNSS satellites orbit well above the atmosphere, about 20,000 km above the earth's surface.

They are moving very fast, several kilometers per second. The latest generation of GPS satellites weighs over 1000 kg, the first generation of Galileo satellites will weigh about 700 kg. In the relative vacuum of space, satellite trajectories are very stable and predictable. As mentioned, GNSS satellites know their time and orbit ephemerides very, very accurately.

Global Positioning System (GPS)

The NAVSTAR GPS system is composed of 24 satellites, and was created by the U.S. Department of Defense. It can be accessed anywhere on or near the Earth where there is an unobstructed line-of-sight to four or more GPS satellites.

The system provides critical capabilities to military, civil and commercial users worldwide and is freely accessible to anyone with a GPS receiver.

GPS Signals

Table 3: Provides further information on GPS signals. GPS signals are based on CDMA (Code Division Multiple Access) technology.

Designation	Frequency	Description
L1	1575.42 MHz	L1 is modulated by the C/A code (Coarse/Acquisition) and the P-code (Precision) which is encrypted for military and other authorized users.
L2	1227.60 MHz	L2 is modulated by the P-code and, beginning with the Block IIRM satellites, the L2C (civilian) code.L2C will ensure the accessibility of two civilian codes
L5	1176.45 MHz	L5 Safety of Life.

Global Orbiting Navigation Satellite System (GLONASS)

GLONASS is a global satellite navigation system operated by the Russian Federation. The first GLONASS satellite was launched in October 1982. The GLONASS constellation nominally consists of 24 satellites in three orbital planes, with an inclination angle of 64.8 degrees and an altitude of 19,100 km. This system is the only other satellite navigation system in operation with global coverage and of comparable precision to GPS. Table 2 summarizes the GLONASS signals. GLONASS satellites each transmit on slightly different L1 and L2 frequencies, with the P-code (HP code) on both L1 and L2, and the C/A code (SP code), on L1 (all satellites) and L2 (most satellites). GLONASS satellites transmit the same code at different frequencies, a technique known as FDMA, for frequency division multiple access. GLONASS signals have the same polarization (orientation of the electromagnetic waves) as GPS signals, and have comparable signal strength.

The GLONASS system is based on 24 satellites using 12 frequencies. It achieves this by having antipodal satellites transmitting on the same frequency. Antipodal satellites are in the same orbital plane but are separated by 180 degrees. The paired satellites can transmit on the same frequency because they will never appear at the same time in view of a receiver on the Earth's surface.

New generation of GLONASS satellites broadcast navigation signals on L1, L2 and in additional sub-band, the L3 sub band (1198-1213 MHz). These new satellites introduce CDMA in addition to previously used FDMA.

Galileo

Galileo is the European satellite navigation system. Galileo is still being implemented, it is specifically designed for civil and commercial purposes and it will be interoperable with the other radio-navigation systems. This will be beneficial to all users as they will be able to use more satellites for redundancy and higher accuracy. Galileo will offer four distinct navigation services and one service to support search and rescue.

The Galileo system consists of 27 operational satellites in three Medium Earth Orbit (MEO) orbital planes, at about 23 000km altitude and inclined at 56 ° to the equatorial plane. It has three spare satellites (one in each orbital plane) where each satellite is able to cover for any failed satellite in that plane. The Galileo navigation signals are transmitted in four frequency bands. CDMA is used within each frequency band and as we can note, the frequency bands are overlapping or contiguous to frequency bands used by others GNSS constellations. This will allow the combined use of several constellations (GPS, COMPASS and GLONASS) to increase performance and robustness of the navigation services.

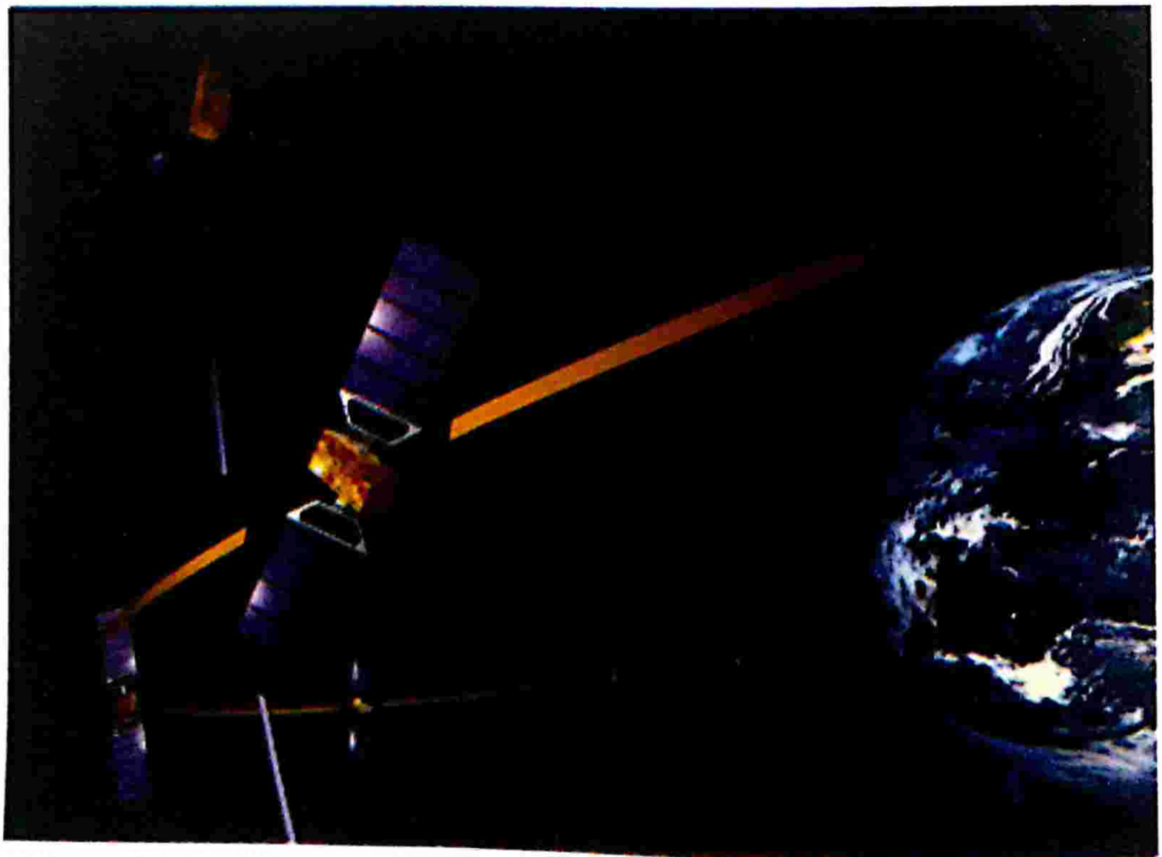


Figure 10: Galileo satellite

Compass

The Compass/ BeiDou Navigation Satellite System (CNSS), better known as COMPASS, is a satellite navigation system developed by China. The space segment of CNSS will consist of 30 MEO satellites at an altitude of 21 490 km and five geostationary satellites. It will offer two services, the Open Service that will provide accuracies of 10m positioning, 0.2m/s in velocity, and 50 ns in time dissemination; and the Authorized Service, which is only intended for entities authorized by the Chinese government.

Quasi-Zenith Satellite System (QZSS)

The Quasi-Zenith Satellite System (QZSS) is a proposed three-satellite regional time transfer system and Satellite Based Augmentation System for the Global Positioning System that would be receivable within Japan and Australia. QZSS is targeted at mobile applications to provide communications-based services and positioning information. Its three satellites, each 120° apart, are in highly-inclined, slightly elliptical, geosynchronous orbits. Because of this, they do not remain in the same place in the sky. Their ground traces are asymmetrical figure-8 patterns, created to ensure that one is almost directly over Japan at all times.

Beidou Navigation Satellite System (BDS)

The BeiDou Navigation Satellite System (BDS) consists of two separate satellite constellations. The first is a limited test system that has been operating since 2000 known as BeiDou-1. The BeiDou-1 consists of three satellites and offers limited coverage and applications. Its navigation services have been mainly for customers in China and neighboring regions. As mentioned previously, the second generation is a full-scale global navigation system that is currently under construction and will be known as Compass, or BeiDou-2.

Indian Regional Navigational Satellite System (IRNSS)

The Indian Regional Navigational Satellite System (IRNSS) is a regional satellite navigation system being developed by the Indian Space Research Organization. When complete, it will be under control of the Indian government. IRNSS will provide standard service for civilian use and an encrypted restricted service for authorized users (military).

METHODS AND MATERIALS

The steps and process for designing A CIRCULARLY POLARIZED Micro strip Patch ANTENNA based on GPS; GNSS; GALILEO; GLONASS. We are aiming to design an antenna which is circularly polarized, it will be shown that sending a signal using circular polarization have much benefits than using vertical or

System design steps and explanation

The project is completed using Matlab which stands for MATrixLaboratory, is a state-of-the-art mathematical software package, which is used extensively in both academia and industry. It is an interactive program for numerical computation and data visualization, which along with its programming capabilities provides a very useful tool for almost all areas of science and engineering.

Unlike other mathematical packages, such as MAPLE or MATHEMATICA, MATLAB cannot perform symbolic manipulations without the use of additional Toolboxes. It remains however, one of the leading software packages for numerical computation.

Auto mode

The Auto mode works with already compiled Matlab files, which are placed in a special library. Organizing the Matlab-files in this way makes it significantly easier for Ptolemy to parse them. Hence, the simulation speed is increased to be 20 times faster compared to the Script mode. One inconvenience is the requirement of recompiling the Matlab-files whenever a change is made to the code.

Compile Mode

In the Compile mode, there is no need to pre-compile the scripts since ADS would call on the Matlab compiler itself and therefore simulations with Matlab files would be greatly simplified. However, this last feature does not yet work in ADS 2004A. Due to different reasons, the

Communication between ADS and the Matlab compiler somehow cannot be established. Thus, the Auto mode is a natural choice.

Software Requirements:

Note: Release 2015a is the last release supporting Windows XP and Windows Vista.

Table 4: System Requirements.

32-Bit and 64-Bit MATLAB and Simulink Product Families				
Operating Systems	**Processors**	**Disk Space**	**RAM**	**Graphics**
Windows 10 Windows8.1 Windows 8 Windows 7 Service Pack 1 Windows Vista Service Pack 2 Windows XP Service Pack 3 Windows XP x64 Edition Service Pack 2 Windows Server 2012 Windows Server 2008 R2 Service Pack 1 Windows Server 2008 Service Pack 2 Windows Server 2003 R2 Service Pack 2	Any Intel or AMD x86 processor supporting SSE2 instruction set*	1 GB for MATLAB only 3–4 GB for a typical installation	2 GB	No specific graphics card is required Hardware accelerated graphics card supporting OpenGL 3.3 with 1GB GPU memory recommended

* You can find more information in Solution 1-B3MR75

Main body of the paper with results sections based on you research objectives In this section, the procedure for designing a patch antenna using Matlab is discussed. The simulated and measured results are discussed in terms of reflection coefficient, radiation patterns, impedance, Azimuth and Elevation angles.

Table 5 Design specifications

GNSS	POLARIZATION	BANDs	CARRIERs(MHz)	F_{min}(MHz)	F_{max}(MHz)
GPS	CP	L1	1575.42	1563	1587
		L2	1227.6	1215	1237
		LS	1176.45	1164	1191
GLONASS	CP	G1	1602	1593	1612
		G2	1246	1238	1255
		G3	1204.704	1198	1213
GALILEO	CP	E1	1575.42	1559	1591
		E6	1278.75	1260	1300
		E5a	1176.45	1164	1191
		E5b	1207.14	1191	1214

The designed antenna must be able to operate in all the required GNSS frequency bands. Reflection coefficient must be less than -10dB, axial ratio must be less than 3dB for circular polarization.

Design of the circularly polarized patch antenna

The antenna is based on the design of the figure (10). The said antenna is a wideband micro strip antenna which covers all the frequencies in the GNSS system (freq. from 1.1558 – 1.8395 GHz). Our aim is to redesign the antenna for circular polarization using Matlab.

1 Agenda

Introducing antenna design in MATLAB using full wave EM simulation
Designing and analyzing your own custom antennas
Addressing realistic antenna array modeling by including edge and coupling effects.

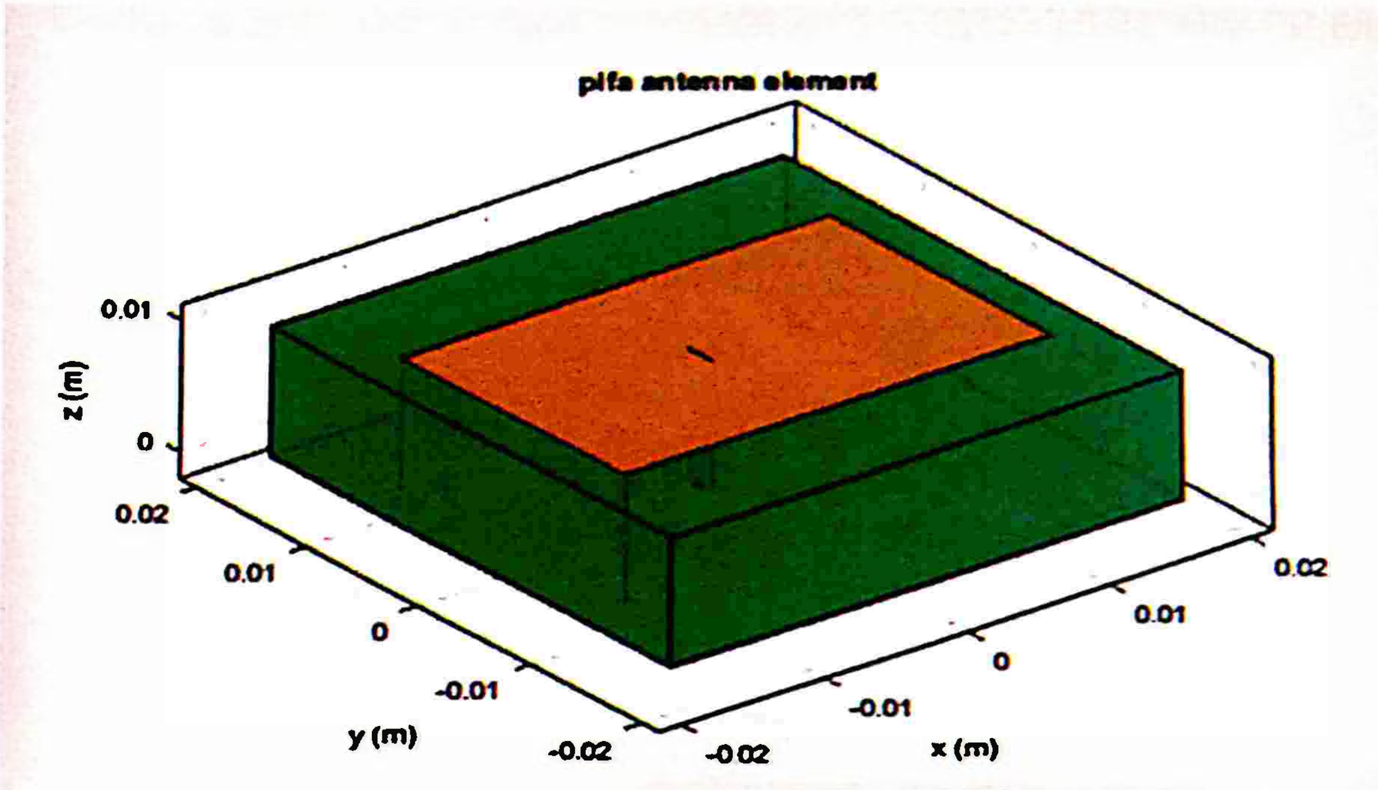


Figure 11: Micro strip patch antenna

Factors to be considered when designing a patch antenna are like what might be required for antenna great performance and this may be the thickness of the dielectric substrate with low dielectric constant and this provides exceptional efficiency, bigger data transfer capacity and also superior radiation.

Antenna Toolbox

```
>> p = patchMicrostrip
>>p.Height= 0.01;
>>impedance(p, (500e6:10e6:2e9));
>>current(p, 1.66e9);
>>pattern(p, 1.66e9);
```

RESEARCH RESULTS

SIMULATION RESULTS

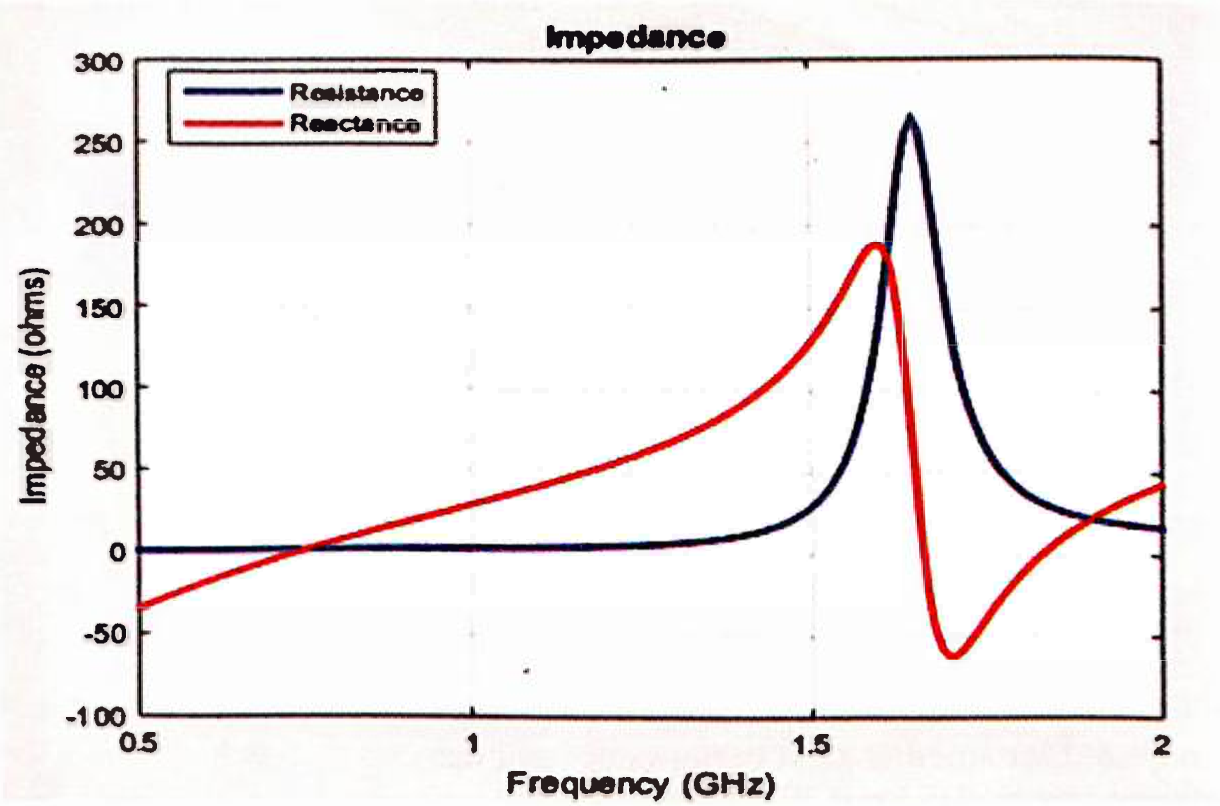


Figure 12: the impedance curve

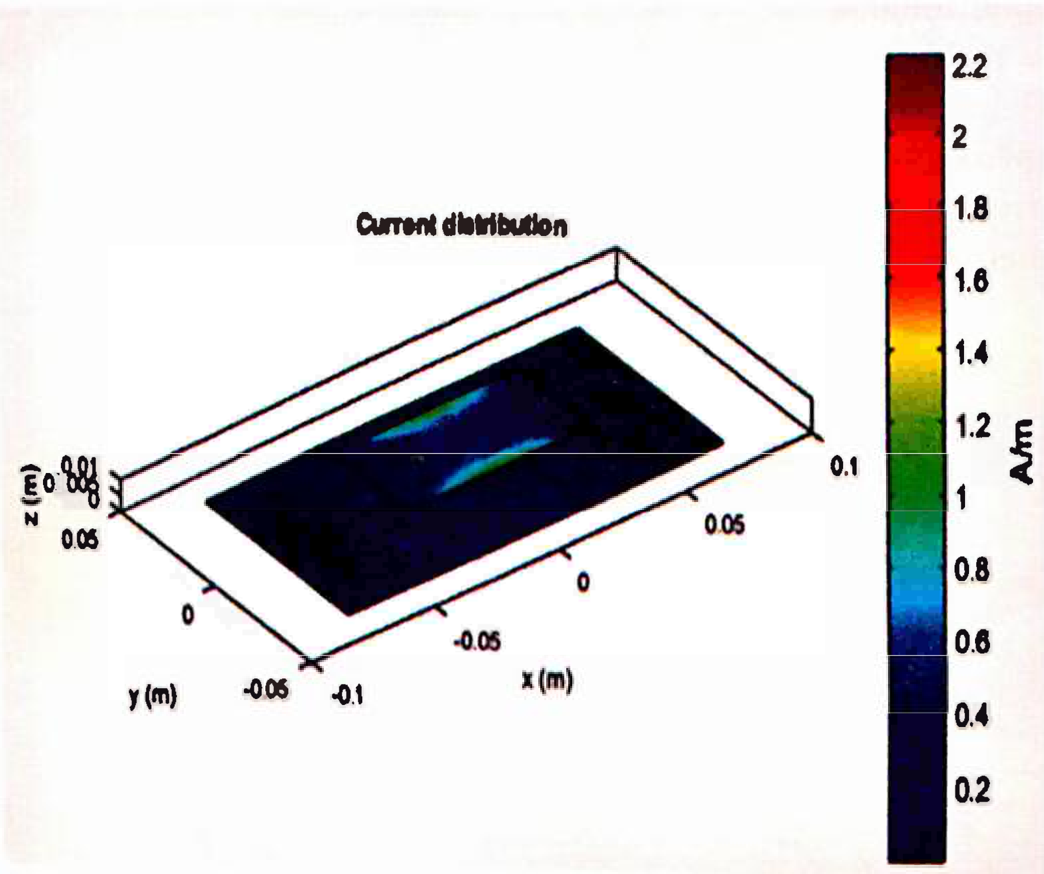


Figure 13: current distribution

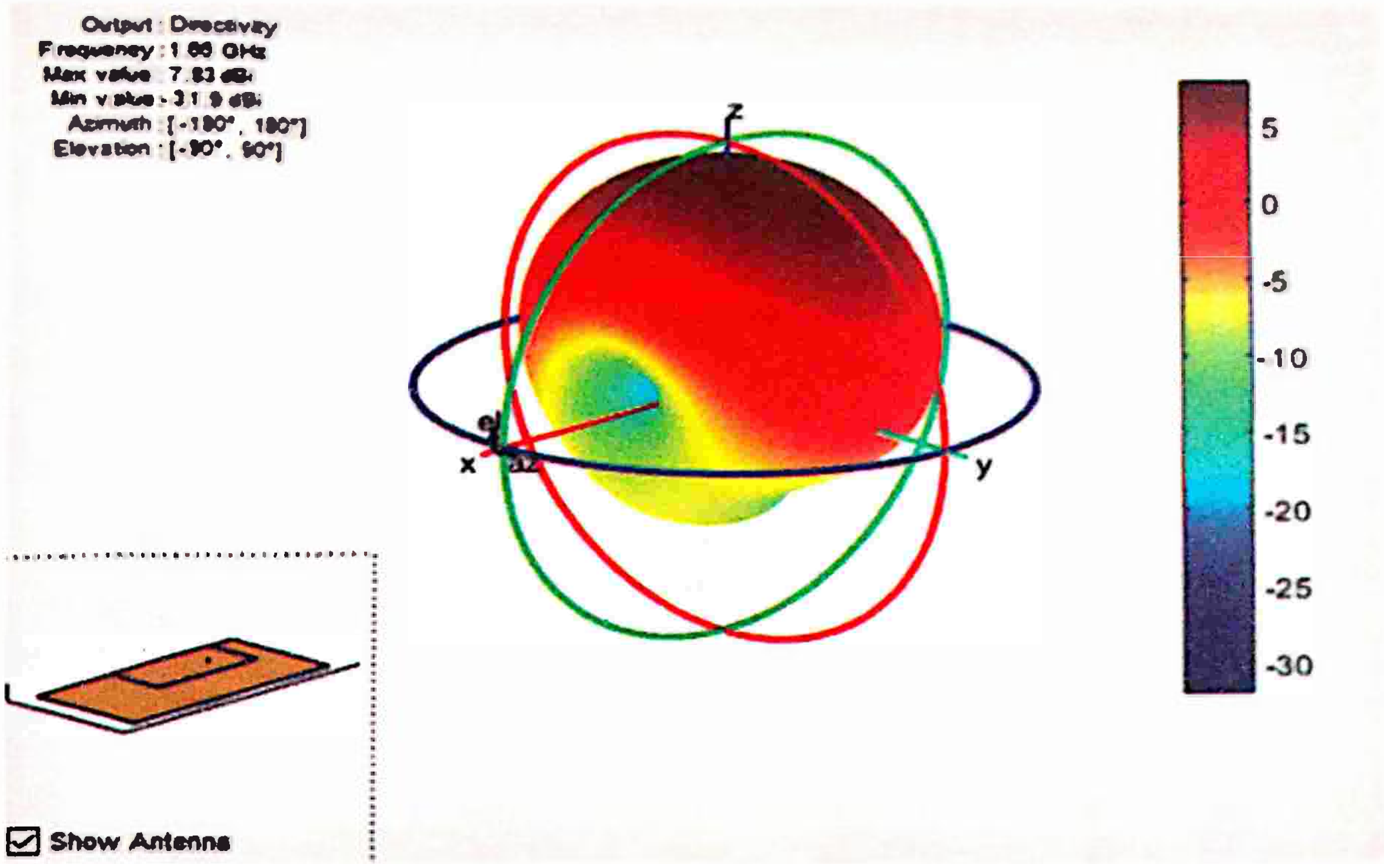
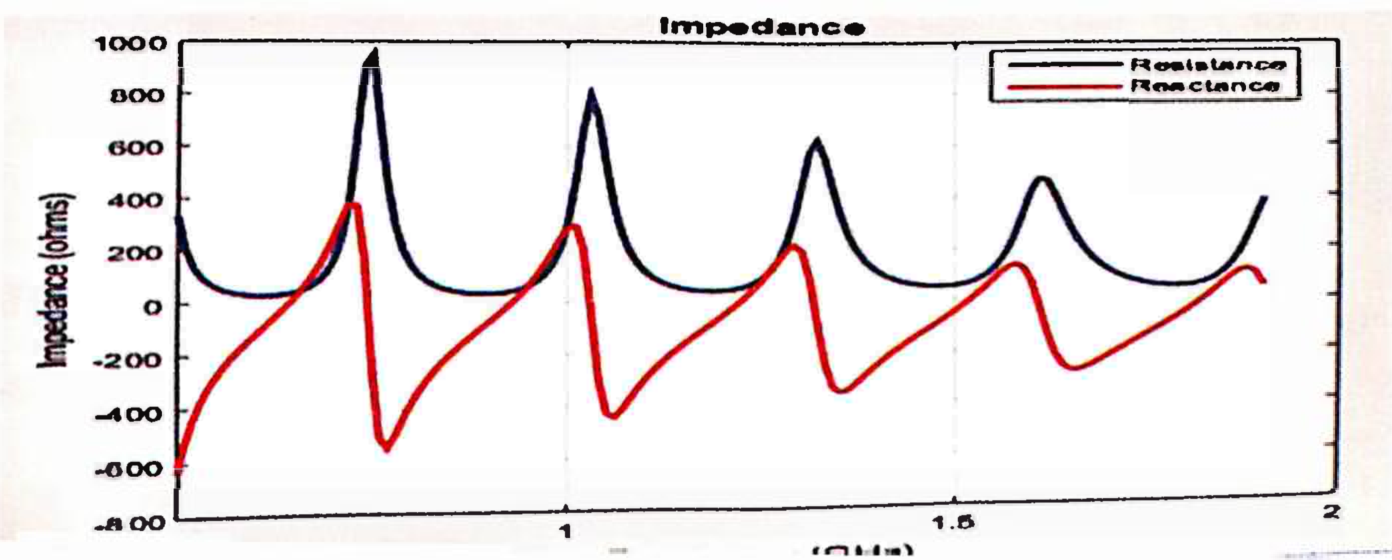


Figure 13: The general output of the antenna

Output: Directivity
Frequency: 1.660GHz
Maximum value:7.83dBi
Minimum value:-31.9dBi
Azimuth: [-180, 180 degrees]
Elevation: [-90, 90 degrees]

FAILED TRIAL DURING THE DESIGN



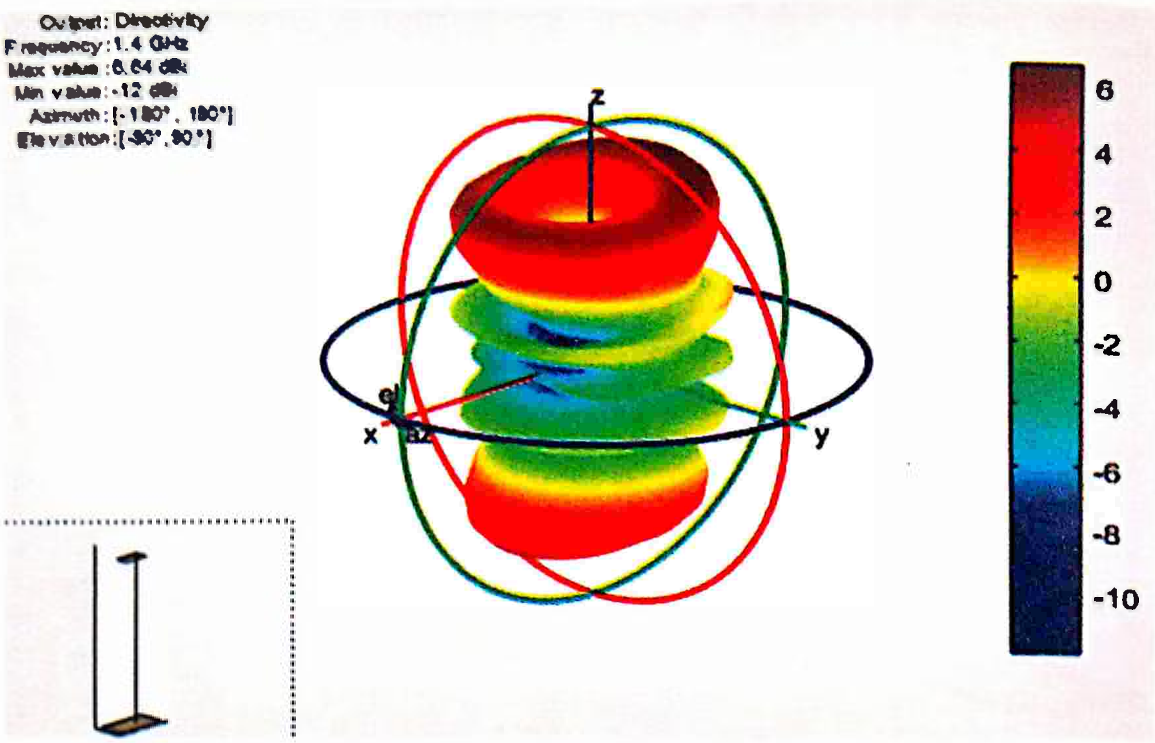


Figure 14 Failed trial   P. HEIGHT: 0.5;

IMPEDANCE (p, (500e6:10e6:9e9));
PATTERN (p, 1.40e9);
Designed Array antenna:

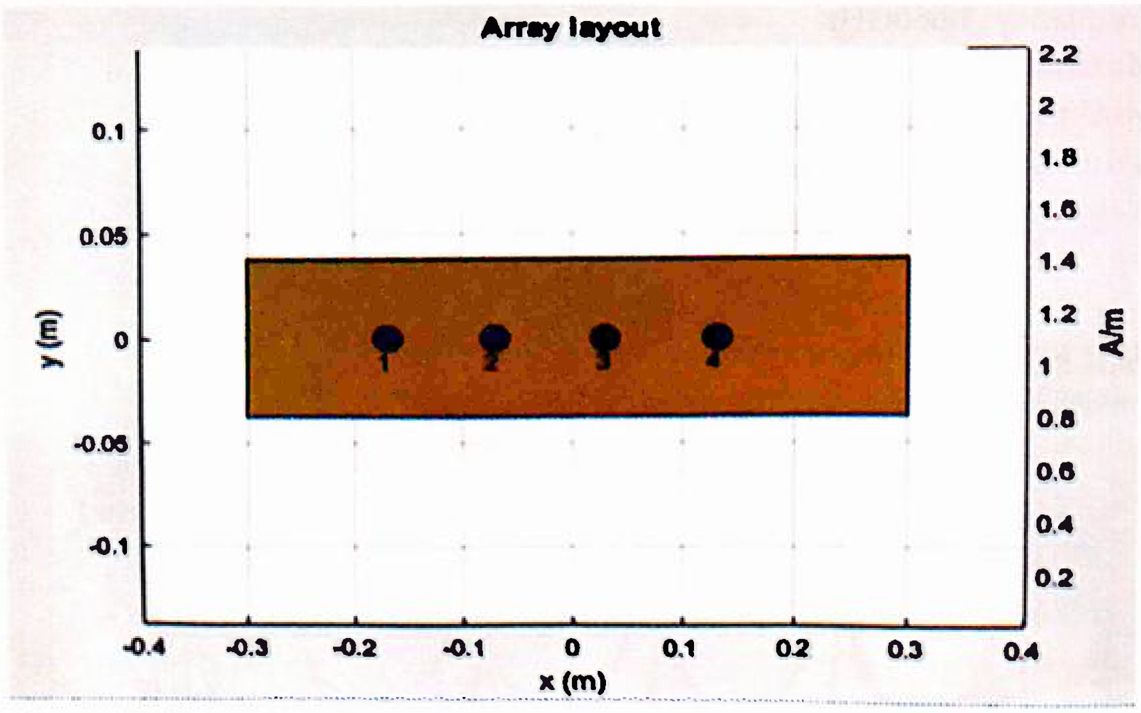


Figure 15: Microstrip array antenna

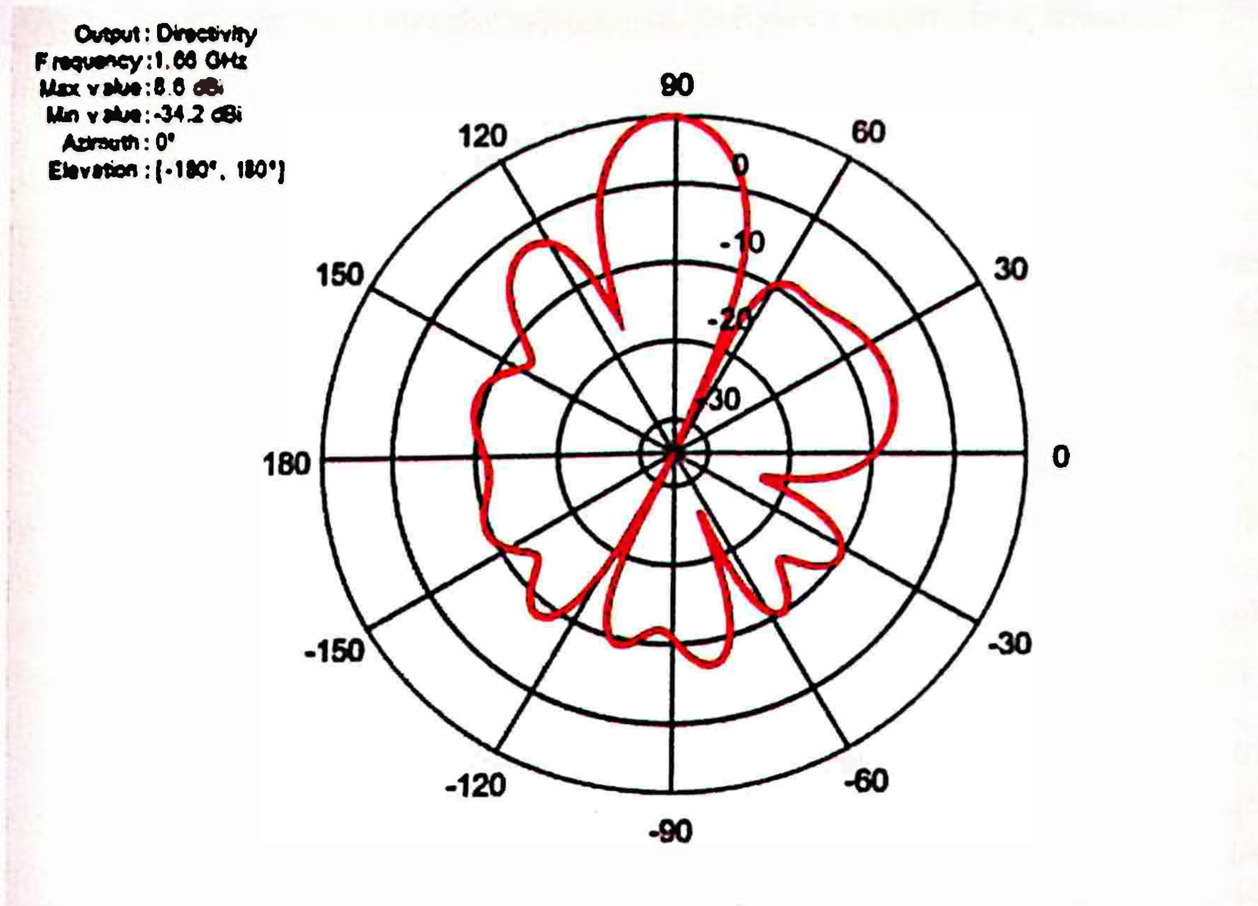


Figure16: Output pattern

```
>> a =linearArray
>>a.Element = p;
>>a.ElementSpacing = 0.1;
>>a.NumElements = 4;
>>layout(a);
>>patternElevation(a, 1.66e9,0);
```

DISCUSSION

Advantages and disadvantages

Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc. The telemetry and communication antennas on missiles need to be thin and conformal and are often Microstrip antennas. Another area where they have been used successfully is in Satellite communication. The principal advantages are as follow:

- Light weight and low volume.
- Low profile planar configuration which can be easily made conformal to host surface.
- Low fabrication cost, hence can be manufactured in large quantities.

- Supports both, linear as well as circular polarization.
- Can be easily integrated with microwave integrated circuits (MICs).
- Capable of multiple frequency operations.
- Mechanically robust when mounted on rigid surfaces.

Microstrip patch antennas suffer from a number of disadvantages as compared to conventional antennas. Some of their major disadvantages are given below:

- Narrow bandwidth
- Low efficiency
- Low Gain
- Extraneous radiation from feeds and junctions
- Poor end fire radiator except tapered slot antennas
- Low power handling capacity.
- Surface wave excitation

Microstrip patch antennas have a very high antenna quality factor (Q). Q represents the losses associated with the antenna and a large Q leads to narrow bandwidth and low efficiency.. Q can be reduced by increasing the thickness of the dielectric substrate. But as the thickness increases, an increasing fraction of the total power delivered by the source goes into a surface wave. This surface wave contribution can be counted as an unwanted power loss since it is ultimately scattered at the dielectric bends and causes degradation of the antenna characteristics. However, surface waves can be minimized by use of photonic band gap structures. Other problems such as lower gain and lower power handling capacity can be overcome by using an array configuration for the elements.

TABLE 6: Final Results

FREQUENCY	AXIAL RATIO	REFLECTION COEFFICIENT
1.66	7.83 dB	-31.9 dB
1.66	8.6 dB	-34.2 dB

CONCLUSION

In this paper the author designed two types of antenna, Microstrip patch antenna and Array antenna. Although the author wanted them to be fully circularly polarized there is some parameters which are not perfect as it has to be, it is mentioned in the table above.

The circularly polarized antenna must be able to operate in all the required GNSS frequency bands. Reflection coefficient must be less than -10dB, axial ratio must be less than 3dB for circular polarization.

In this paper, the authors have presented a way to design and simulate a circularly polarized micro strip antenna that is compatible with all the available and future GNSS systems including GPS, GLONASS and GALILEO using Momentum. The design of such antenna provides a receiver to better cope in an area where one of this signals may not be sufficient.

Normal antennas, the ones we see every day on rooftops, routers and antenna towers are linear polarized. Meaning that they radiate in only one plane, either vertically or horizontally. Whenever you take a linear polarized antenna and turn it 90degrees it changes its polarization, If it's in line with the horizon it's horizontally polarized, hence the name. The trouble is that when a vertically polarized antenna tries to communicate with a horizontally polarized antenna this called cross-polarization), and vice-versa, you get a 30dB loss in signal strength (which is a lot!);

This where circular polarization comes into the picture, instead of transmitting in just one plane a circular polarized antenna transmits in both planes at once, with 90 degrees phase shift between the two planes; However if a circular polarized antenna and a linear polarized antenna tries to talk to each other there is only a 3dB loss regardless of the orientation of the two antennas.

RECOMMENDATION

Some customers feel that circular polarization is not as desirable as linear polarization. The reasons for this view are not clear; one possible reason is due to the customer not being fully educated on the benefits or the price sensitivity towards equipment. Some customers may also feel that since Intelsat is the only satellite provider offering C-Band, the availability of antennas could become an issue. However, it is important to realize that the increased reliability in signal strength, resistance to weather conditions, and ease of installation outweigh the expense of the feed horn. Technically speaking, circular polarization involves the plane of polarization rotating in a corkscrew pattern, making one complete revolution during each wavelength.

The circularly polarized wave will radiate energy in the horizontal and vertical plane, as well as every plane in between.

The author recommends using other simulation software like ADS (advanced design system) and CST (computer simulation technology). The author recommends also the fabrication of these two antenna so that they can be in use.

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