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"Design and Analysis of L Band Microstrip Patch Antenna for Global Navigation Satellite System"

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Abstract- In this paper the design consideration for the rectangular micro-strip antenna has been presented. In modern wireless communication systems, the micro-strip patch antennas are commonly used in the wireless devices. Therefore, the miniaturization of the antenna has become an important issue in reducing the volume of entire communication system. The various parameters of rectangular micro-strip antenna, input impedance, VSWR, return loss, radiation pattern have been investigated as a function of frequency for proper matching and radiations. It uses L band, X band, C band, Ku band, Ka band for global navigation satellite system (GNSS) communication application. L band frequency range is 1- 2GHz so it can be used in lower frequency range communication. It is proved that this proposed method has better than traditional methods.

Keywords- Antenna, L band VSWR, Microstrip antenna, GNSS.

I. INTRODUCTION

GNSS (Global Navigation Satellite System) is a satellite system that is utilized to pinpoint the geographic area of a client's recipient anyplace on the planet. Two GNSS systems are as of now in operation: the Assembled States' Global Situating System (GPS) and the Russian Federation's Global Circling Navigation Satellite System (GLONASS). A third, Europe's Galileo, is slated to achieve full operational limit in 2008. Every one of the GNSS systems utilizes a group of stars of circling satellites working related to a system of ground stations. Satellite-based navigation systems utilize an adaptation of triangulation to find the client, through computations including data from various satellites.

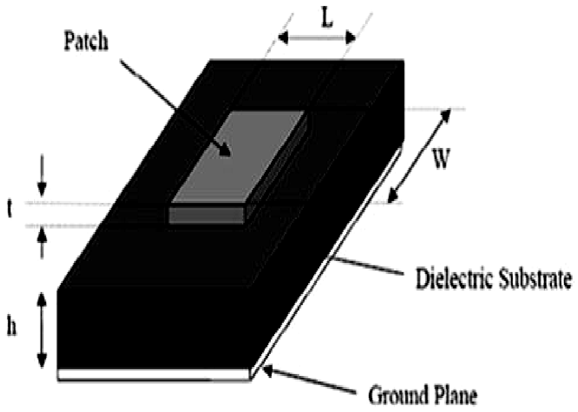

Fig 1. Structure of a microstrip patch antenna.

Microstrip patch antennas have more advantages and better prospects as contrasted with ordinary antennas, for example, lighter in weight, low volume, more affordable, low profile, littler in measurement and simplicity of manufacture and similarity. In addition, the microstrip patch antennas can convey frequency dexterity, more extensive band-width, feed line adaptability and shaft examining omnidirectional designing. Microstrip Patch antenna comprises of a transmitting patch, dielectric substrate and a ground plane.

II. SATELLITE ANTENNA

An assortment of types of antenna can be utilized for transmitting to and getting from satellites. The most widely recognized sort of satellite antenna is the illustrative reflector; anyway this isn't the main kind of antenna that can be utilized. The real sort of antenna will rely on what the general application and the necessities. The separations over which signals travel to a few sate. Geostationary ones are a specific case.

This implies way losses are high and as needs be flag levels are low. Not with standing this the power levels that can be transmitted by satellites are restricted by the way that all the power has been produced from sun oriented boards. Thus the antennas that are utilized are frequently high increase directional assortments. The explanatory reflector is a standout amongst the most well known.

The gain and directivity of the antenna should be addressed the necessities of the satellite. For most geostationary satellites the utilization of directional antennas with gain is obligatory in perspective of the way losses brought about. It has just been referenced that satellite TV antennas utilize allegorical reflector or "dish" antennas. They are likewise fuse what are named a LNB. This is a Low Clamor Square converter.
The satellite transmits signals at frequencies somewhere in the range of 12.2 and 12.7 GHz. Signs at these frequencies

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would be immediately weakened by any coaxial feeder that was utilized.

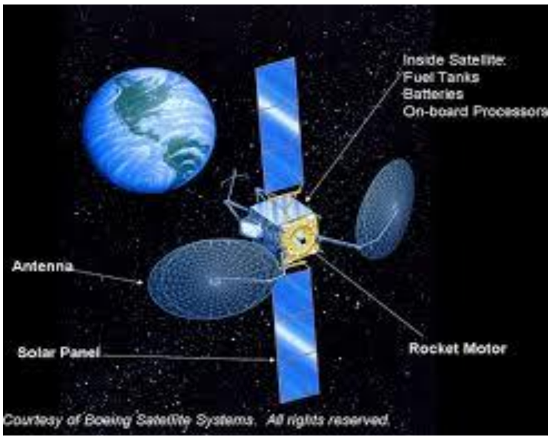


Fig 2. Antenna for satellite communication.

1. Microstrip Antenna for Satellite Communications:
As a new sort of microwave antenna, smaller scale strip antenna appreciates the accompanying preferences over allegorical antenna: little segment plane, light weight and minimal effort. It tends to be made into the structure relates with conveys, for example, correspondence vehicles, etc. However the regular small scale strip antenna component is hard to adjust the requests of satellite correspondence system in the accompanying regards: bandwidth, double frequency and twofold polarization, etc.

2. Satellite Frequency Bands:
Because of lower frequencies, L-Band is most effortless to execute for marine satellite balanced out systems. There isn't much L-Band bandwidth accessible. The higher you go in frequency, the more bandwidth is accessible; however the hardware should be progressively modern. The frequency band ranges are L-Band (1-2 GHz) | C-Band (4-8 GHz) | Ku-Band (12-18 GHz) | Ka-Band (26.5-40 GHz)|

III. PROPOSED METHODOLOGY

At the point when the transmitter supplies an electric flow swaying at radio frequency (i.e. a high frequency exchanging current (air conditioning)) to the antenna's terminals, and the antenna transmits the vitality from the present as electromagnetic waves (radio waves). At gathering, an antenna catches a portion of the intensity of an electromagnetic wave so as to deliver a small voltage at its terminals.

The attractive field that the antenna puts out will create an electric flow on any metal surface that it strikes, notwithstanding if the metal surface that the flag strikes has a length connection to itself the initiated flow will be especially more grounded on the article. As we expressed before that as a flag goes through the air, finishes a cycle in around 36 feet. In the structure strategy of round patch antenna, fundamental parameters are Dielectric steady of the substrate (εr) and Stature of dielectric substrate (h)

IV. DESIGN EQUATIONS OF MICROSTRIP ANTENNA

An antenna is a gadget that gives a way to transmitting or accepting radio waves. At the end of the day, it gives a progress from guided waves on a transmission line to a "free space" wave (and the other way around in the accepting case). In this manner data can be exchanged between various areas with no interceding structure. The various focal points of microstrip antenna, for example, its low weight, little volume and simple of manufacture utilizing printed-circuit innovation prompted the plan of a few configurations for different applications. With expanding prerequisites for individual and versatile correspondences, the interest for littler and low-profile antennas has conveyed the microstrip antenna to the front line.

1. Theoretical Considerations:
Resonant frequency (f_r) can be found using equations, $h<\lambda_o$; E_z= Constant; k_z=0; f_r for TM^z_{mn} mode is given by [4],

$$(f_r)_{mn0} = \frac{1}{2\pi\sqrt{\mu\varepsilon}}\left(\frac{X'_{mn}}{a}\right) \qquad \text{………….. (1)}$$

Where X'_{mn}= 3614essel's function for circular waveguide, a is the radius of the patch.

TM_{11} mode is dominant mode. Thus using,

$$(K_\rho)^2 + (K_z)^2 = K_r^2 = \omega_r^2\mu\epsilon \ \ (K_z{=}0 \text{ and } K_\rho{=}X'_{mn}/a) \qquad \text{……(2)}$$

This is known as Bessel's Differential Equation .

We have the value of X'_{mn} for m=1 and n=1 is equal to X'_{11}=1.8412 (from Bessel's chart for circular waveguide) [4].

$$(f_r)_{11} = \frac{1.8412}{2\pi a\sqrt{\mu\varepsilon}}$$

$$\text{or } (f_r)_{11} = \frac{1.8412c}{2\pi a\sqrt{\varepsilon_r}} \qquad \text{………………….. (3)}$$

Where c is the speed of light. The effective radius a_e is used in place of actual radius (due to fringing effect).

$$a_e = a\left\{1+\frac{2h}{\pi a\varepsilon_r}\left[\ln\left(\frac{\pi a}{2h}\right)+1.7726\right]\right\}^{\frac{1}{2}} \quad \text{....... (4)}$$

Thus,

$$(f_r)_{110} = \frac{1.8412c}{2\pi a_e\sqrt{\varepsilon_r}} \quad \text{.................. (5)}$$

2. Calculations:

2.1 Resonant Frequency:

The resonance frequency of a CMSA is obtained using the given formula [3].

$$f_o = \frac{K_{mn}c}{2\pi a_e\sqrt{\varepsilon_e}} \quad \text{..................... (6)}$$

Where K_{mn} is the m^{th} root of the derivative of the Bessel function of order n . For the fundamental TM_{11} mode, the value of K_{mn} is 1.84118. The a_e and ε_e are the effective radius and the effective dielectric constant of the CMSA, respectively. The fringing fields along the circumference of the given MSA are taken into account by replacing the patch radius a by the effective radius a_e.

$$a_e = a\left[1+\frac{2h}{\pi a\varepsilon_r}\left\{\ln\left(\frac{a}{2h}\right)+1.41\varepsilon_r+1.77+\frac{h}{a}\left(0.268\varepsilon_r+1.65\right)\right\}\right]^{\frac{1}{2}} \quad \text{... (7)}$$

2.2 Actual radius of the Patch:

Using above equations and taking the values of different parameters as follows,

K_{mn}=1.84118; c=3x10^8 m/s;

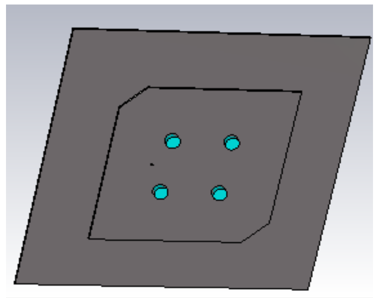
ε_o= 8.86x10^{-12}F/m; ε_r=4.4;

h=1.6 mm; Frequency(f_o)=1.7GHz

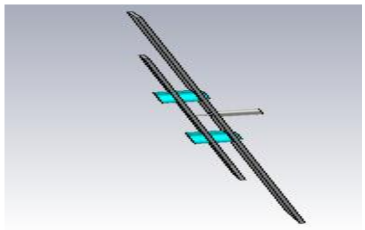
And effective radius a_e followed by the value of the actual radius 'a' which come out to be 25.4 mm.

V. PROPOSED MICROSTRIP ANTENNA VIEW

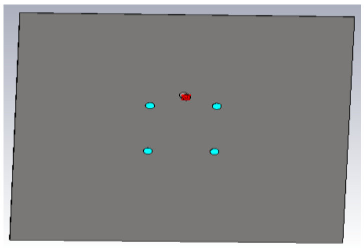
In figure 3, showing top view of proposed microstrip patch antenna, one side of a dielectric substrate acts as a radiating patch and other side of substrate acts as ground plane. Top view of a rectangular patch antenna with coaxial feed has. Patch and ground plane together creates fringing fields and this field is responsible for creating the radiation from the antenna.



(a)



(b)



(c)

Fig 3. (a)Top view of proposed antenna Figure 4.2 (b) Side view (c) Back view of proposed antenna

VI. SIMULATION AND RESULT DISCUSSION OF PROPOSED ANTENNA

Figure 4 indicating recreated antenna in CST microwave studio, it is a specific apparatus for the quick and exact 3D EM reenactment of high frequency issues. It is a particular apparatus for the quick and exact structure and examination of 3D electron firearms.

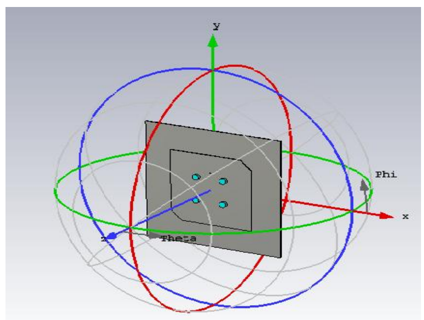


Fig 4. Simulation and field.

After simulation of proposed antenna by using applied monitor with different condition, following parameters result calculated.

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1. Return Loss:

Figure 5, demonstrates the Return Loss (S11) parameters for the proposed antenna, which speaks to the multiband bands of frequency for which the antenna planned is upgraded i.e. frequencies going from 1 GHz to 2 GHz with S11 esteem past - 10 dB and the scope of frequencies according to the outcomes demonstrates that it has a decent bandwidth when contrasted with other microstrip antenna. The got estimation of S11 for 1.567 GHz is -12.08db dB.

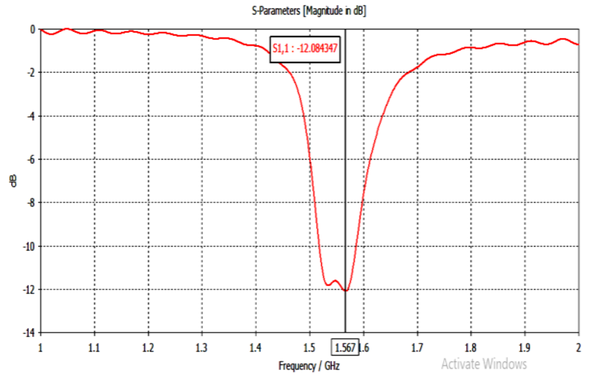


Fig 5. Return loss.

2. Bandwidth:

The bandwidth of an antenna is characterized as "the scope of frequencies inside which the execution of the antenna, as for some trademark, fits in with a predetermined standard." The bandwidth of proposed antenna is 70.2 MHz, (1.5877GHz-1.5175GHz).

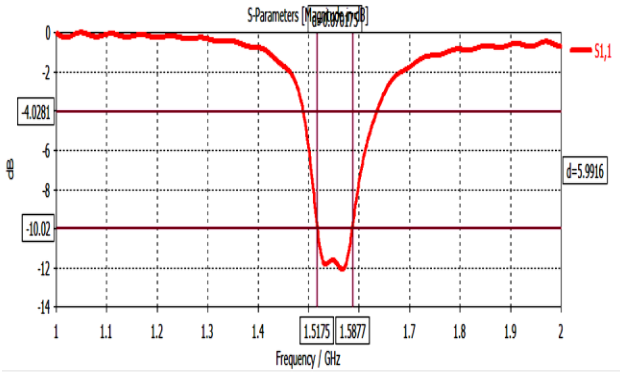


Fig 6. Bandwidth calculation.

3. S11 Parameter:

S11 speaks to how much power is reflected from the antenna, and henceforth is known as the reflection coefficient (now and then composed as gamma: or return loss. In the event that S11=0 dB, all the power is reflected from the antenna and nothing is emanated. So here s11 parameter is -12.08db.

4. Voltage Standing Wave Ratio (VSWR):

The most widely recognized case for estimating and looking at VSWR is when introducing and tuning transmitting antennas. At the point when a transmitter is associated with an antenna by a feed line, the impedance of the antenna and feed line must match precisely for most extreme vitality exchange from the feed line to the antenna to be conceivable. At the point when an antenna and feed line don't have coordinating impedances, a portion of the electrical vitality can't be exchanged from the feed line to the antenna. Vitality not exchanged to the antenna is reflected back towards the transmitter. It is the communication of these reflected waves with forward waves which causes standing wave designs.

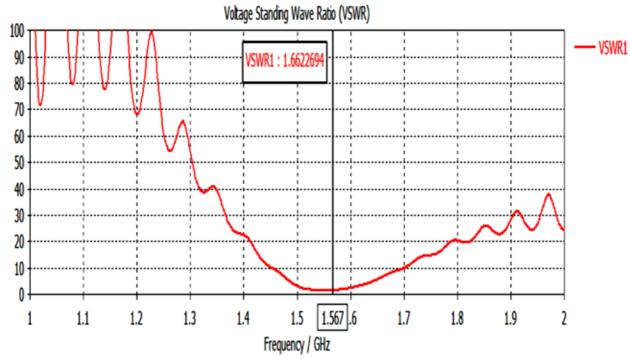
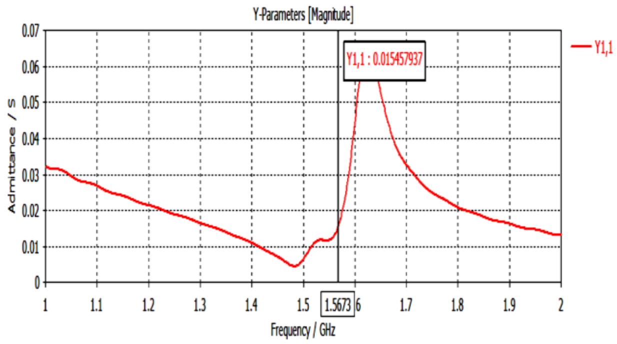


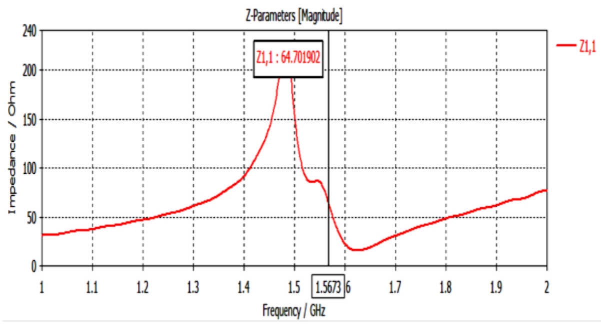
Fig 7. VSWR.

The VSWR plot for L-band antenna with customary ground plane is appeared in Figure 7. In a perfect world, VSWR must lie in the scope of 1-2 which has been accomplished for the frequencies 1.567GHz. The incentive for VSWR is 1.66.

5. Admittance and Impedance:



(a)



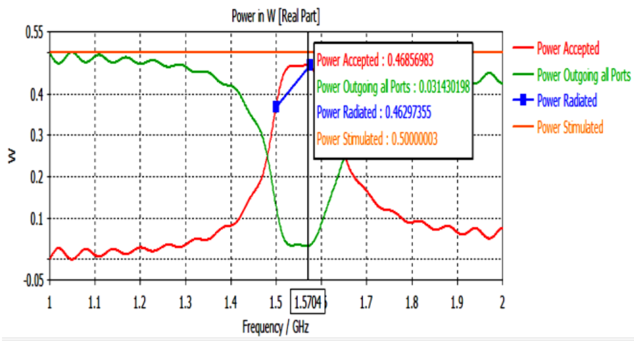
(b)

Fig 8. (a) Y parameter (b) Z- parameter.

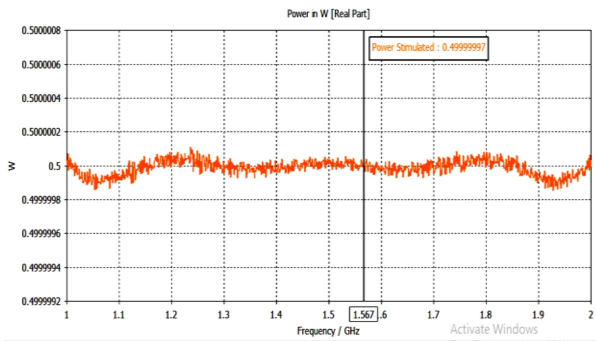
Figure 8 appearing of induction of antenna and impendence of proposed antenna. A Y-parameter lattice portrays the conduct of any straight electrical system that can be viewed as a black box with various ports. Z parameter is utilized to decide the quality factor of an antenna which can give an understanding about the feasible bandwidth.

Z(ant)=R+jX, where R=R(rad)+R(Loss), so ie can anticipated in some way or another the losses and the effectiveness. So estimations of induction and impedance of antenna is- Y parameter= 0.0154s (siemens), perfect esteem lies on approx zero in this way is huge documented. Z parameter= 68.70 ohm, basic esteem approx 50 to 70 ohm.

6. Power:
Figure 9 showing result of accepted power, power outgoing all ports power radiated and power stimulated.Therefore results of power is following-
Accepted power- 0.4685 W, Power outgoing All ports - 0.0314 W, Radiated power- 0.4629 W and Power stimulated. - 0.5 W.



(a)



(b)
Fig 9. (a) Power in different port (b) Real power for stimulated (For working).

7. Radiation Pattern:
An antenna radiation example or antenna design is characterized as "a scientific capacity or a graphical portrayal of the radiation properties of the antenna as a component of room facilitates. By and large, the radiation design is resolved in the far field area and is spoken to as an element of the directional directions. Radiation properties incorporate power transition thickness, radiation force, field quality, directivity, stage or polarization."

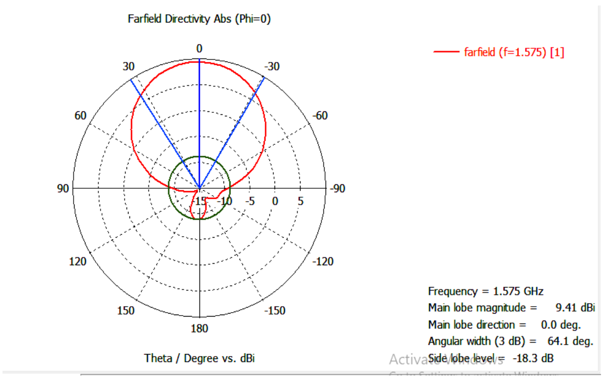


Fig 10. Far field.

The reenacted radiation designs for the proposed microstrip antenna are plotted in Figure. 10, Figure.11 and Figure 12. With the acquired gain design for E plane, the antenna has radiation example of omnidirectional which has wide assortment of use in satellite correspondence.

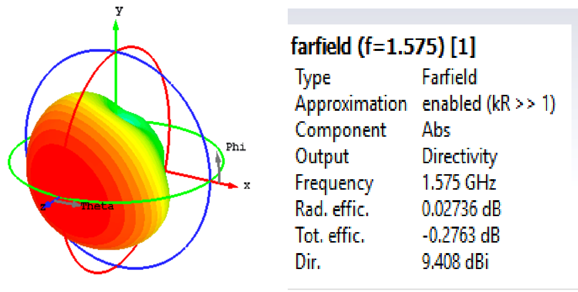


Fig 11. Specific absorption rate (SAR).

The deliberate radiation designs for the two frequencies incorporating the polarization the azimuthal way (xy-plane) and the rise bearing (xz and yz-planes) while working at 1.567 frequencie for GNSS/GPS/GSM, WiMax, Bluetooth and WLAN/Wi-Fi applications.

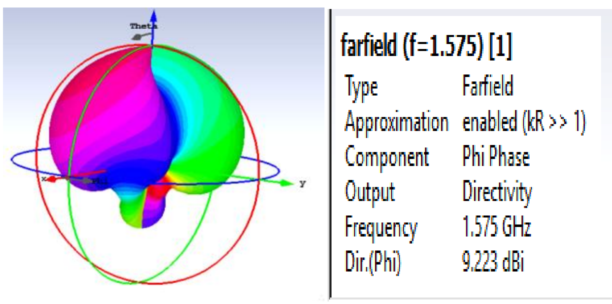


Fig 12. Specific absorption rate (SAR) pattern.

since surface waves add to common coupling between components in a cluster, and furthermore cause unfortunate edge diffraction at the edges of the ground plane or substrate, which regularly adds to twists in the example and to back radiation. For an air (or froth) substrate there is no surface-wave excitation.

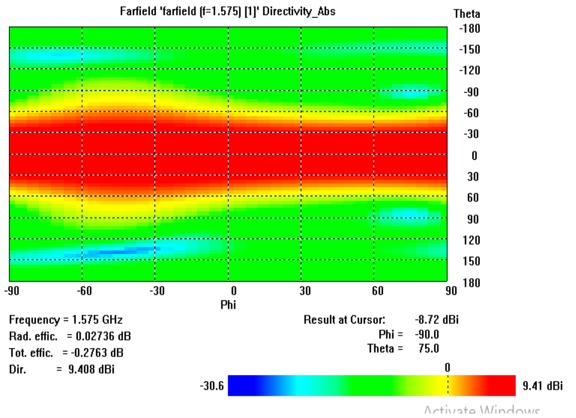


Fig 13. Far field.

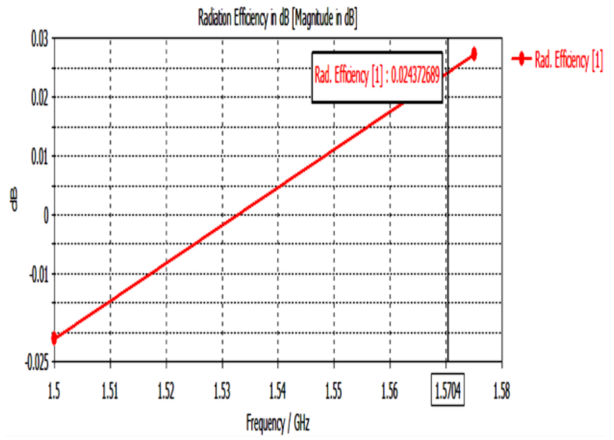


Fig 14. Radiation Efficiency.

The efficiency is set by the substrate material and thickness.

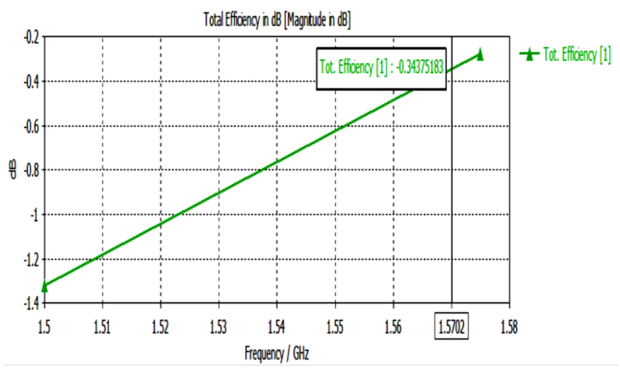


Fig 15. Total Efficiency.

The effectiveness of an antenna is a ratio of the power conveyed to the antenna with respect to the power emanated from the antenna. Being a ratio, antenna productivity is a number somewhere in the range of 0 and 1. In this antenna productivity is 0.343 along these lines we have accomplished great effectiveness of proposed antenna.

Table I shows the simulated results of return loss, VSWR, gain, impedance and bandwidth.

Table 1. Result summary of proposed Antenna.

Sr. No.	Parameter	Value
1	S11	< -10 db
2	Return Loss	-12.08db
3	Band Width	70.2MHz
4	VSWR	1.662
5	Total Efficiency	0.343
6	Resonant Frequency	1.567GHz
7	Y parameter	0.0154s (siemens)
8	Z parameter	68.70 ohm
9	Accepted power	- 0.4685 W
10	Radiated power	- 0.4629 W
11	Power stimulated.	0.5 W

Table 2. Design parameters for proposed frequency.

Frequency(f_r)	1.7 GHz
Dielectric constant(ε_r)	4.4 / Air
Substrate Height(h)	1.6 mm
Line Impedance	50 Ω
Ground Plane	Upto 140 x 180 mm^2
Tangent Loss	0.06

Table 3. Comparison of proposed design result with previous design result.

Parameter	Previous work	Proposed Work
Bandwidth	25MHz	70.2MHz
Return Loss	-11db	-12.08db
Resonant Frequency	1.35GHz	1.567GHz
VSWR	>1	1.662
No of Band	Single	Single
Application	GNSS	GNSS

Table III showing comparison of proposed antenna results with previous design result in terms of bandwidth, return loss, resonant frequency and VSWR etc.Therefore above result shows, designed proposed antenna give significant improved result.

VII. CONCLUSION

In this exposition, we proposed an adjusted single band microstrip antenna which works proficiently in GNSS and remote application. As an outcome a proposed antenna was recreated with fitting parameters for better working antenna. The cutting of rectangular opening brought about wide multiband microstrip antenna for GNSS/GSM/GPS applications. The S11 (return loss), VSWR, Impedance, Gain and Bandwidth for frequencies is gotten amid reproduction for the planned antenna which works at 1.567GHz.

In the proposed structure we have accomplished a colossal increment in frequency when contrasted with base paper with decrease in the tallness of the antenna also. In view of accumulated perceptions while finishing this theory themes were distinguished which would profit for further examination.

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