JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

DESIGN AND ANALYSIS OF MICROSTRIP PATCH ANTENNA OF 7.5 GHZ FOR X-BAND VSAT APPLICATION

[1] Chandipriya D, [2]Anjani K, [3]Rachel A. V, [4]Tejaswini G,[5] Sudheer V

[1]UGScholar, [2]UGScholar, [3]Scholar, [4]UGScholar, [5]Assistant Professor
[1] Department of Electronics and Communication Engineering (ECE),
[1]Narayana Engineering College, Nellore, India

Abstract: Antenna is a necessary element in radio broadcasting domain like T.V, Two manner radio, radar, cell phones etc. Micro-strip patch antenna has very planar profile which can incorporate into the surface of consumer products aircrafts and missiles. There is an increasing demand for miniaturized and cost effective antenna for both commercial and personal applications. In the proposed method, micro strip patch antenna operates at frequency of 7.5GHz. The frequency is chosen based on the x-band frequency, which is applicable for satellite communications. The designs are developed in Ansys HFSS software. The antenna is fabricated using RT/ duroid 5880 substrate with a dielectric constant of r=2.2.

***Key words* - Microstrip Patch Antenna, HFSS, VSAT.**

I. INTRODUCTION

As technology evolves at a very fast pace, antennas have become extremely important in the world of communication technology. Antennas play a major role in transmitting and/or receiving electromagnetic waves with respect to their specific direction and properties for the intended application. There are various forms of antennas available in the market for instances wires, apertures, arrays, parabolic reflectors, lenses, and micro-strip patches. The micro-strip patch antenna is one of the most used antennas nowadays due to its excellent properties such as having a low profile and lightweight structure, having low cost, ease of fabrication and ease of integration with circuits. A compact and lightweight antenna is always opted for VSAT, very small aperture terminal, satellite applications so that it can be easily carried around or accommodated on moving stations, especially for military communication services. In high-performance aircraft, spacecraft, satellite, and missile applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints, low-profile antennas may be required. Presently there are many other government and commercial applications, such as mobile radio and wireless communications, that have similar specifications. To meet these requirements, microstrip antennas can be used.

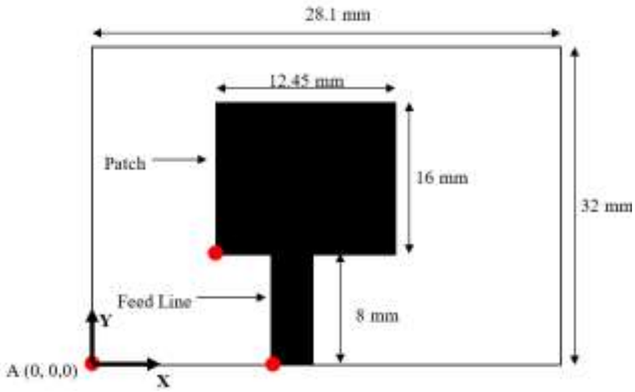

Fig.1 Antenna

II. DESIGN OF THE MICROSTRIP PATCH ANTENNA

The theoretical dimensions of the microstrip patch antenna proposed in this paper are determined using equations (1) to (5).

$$Patch\ Width = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad ...1$$

$$Patch\ Length = L_{eff} - 2\Delta L \qquad ...2$$

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} \qquad ...3$$

$$\Delta L = \frac{(\varepsilon_{eff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{W}{h}+0.8)} \qquad ...4$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{W}}}\right) \qquad ...5$$

By using equations (1) to (5), the length, L and the width, W of the 7.5 GHz rectangular micro-strip antenna is calculated to be L = 12.45 mm and W = 16 mm. Nevertheless, these equations are just the basic step to determine the initial dimension of the antenna for use at 7.5 GHz, and the performance results may slightly differ from the target research's demand. Thus, a huge number of recent studies and designs are referred in order to support the finding of the optimum dimensions. Moreover, the antenna is designed using RT/duroid ® High Frequency 5880 substrate with a dielectric constant of εr = 2.2, loss tangent of δ = 0.0009 and thickness of t = 1.574 mm. The substrate is chosen due to its exceptional dielectric constant uniformity over a wide frequency range. Fig. 1 and Table 1 depict the final dimensions of the proposed antenna.

Table 1 Measurements

Component	Position	X Size	Y Size	Z Size
Substrate	(0, 0, 0)	28.1	32	-0.794
Patch	(7.825, 8, 0)	12.45	16	0.05
Feed	(10.9375, 0, 0)	2.46	8	0.05
Ground Plane	(0, 0, -0.794)	28.1	32	-0.05
Boundary Box	(-5, -5, -5.794)	40	45	10.794
Excitation Sheet	(10.9375, 0, 0.05)	2.46	-	-0.794

III. PATCH ANTENNA DESIGN IN HFSS

3.1. Microstrip Patch Antenna

Microstrip antennas became very popular in the 1970s primarily for space borne applications. Today they are used for government and commercial applications. These antennas consist of a metallic patch on a grounded substrate. The metallic patch can take many different configurations.

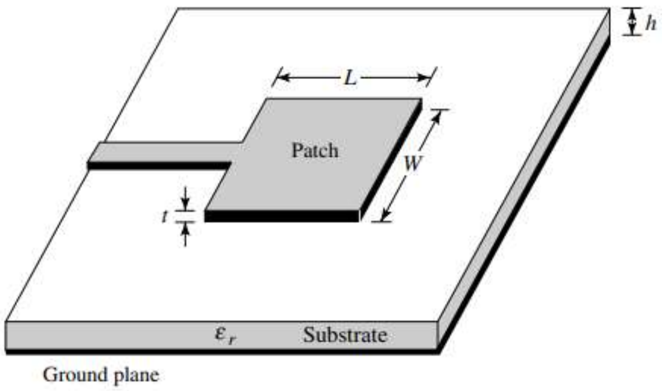

Fig 2 Microstrip Patch Antenna Key Components

These antennas are low profile, conformable to planar and nonplanar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs, and when the particular patch shape and mode are selected, they are very versatile in terms of resonant frequency, polarization, pattern, and impedance. Microstrip antennas are very small, less in weight, fabrication process is very simple and provides a high amount of robustness.

3.2 Microstrip Patch Antenna Key Components:

A. Radiating patch

The radiating patch is the most crucial element of the antenna. It is typically made of a conductive material, such as copper or gold, and shaped in a specific geometric pattern. Common patch shapes include square, rectangular, circular, or elliptical. The dimensions of the patch, including its length, width, and shape, determine the operating frequency and radiation characteristics of the antenna.

B. Dielectric Substrate

The radiating patch is mounted on a dielectric substrate, which provides mechanical support and electrical insulation. The substrate is typically made of low-loss materials with a high dielectric constant, such as fiberglass-reinforced epoxy or ceramic. The choice of substrate material affects the antenna's performance, bandwidth, and efficiency.

C. Ground Plane

Beneath the substrate lies a conductive ground plane. It acts as a reflector and improves the antenna's radiation efficiency by providing a return path for the electromagnetic waves. The ground plane is usually larger than the radiating patch to reduce radiation losses.

D. Transmission Line

The radiating patch is fed by a transmission line, typically in the form of a micro-strip or coaxial cable. The feeding mechanism connects the patch to the RF signal source and determines the polarization and radiation pattern of the antenna.

3.3 HFSS:

Ansys HFSS software is used by engineers all over the world to develop high-frequency, high-speed electronics that can be found in communications networks, advanced driver assistance systems, satellites, and internet-of-things devices. There are six main steps to creating and solving a proper HFSS simulation. They are:

A. Create model/geometry:

The initial task in creating an HFSS model consists of the creation of the physical model that a user wishes to analyse. This model creation can be done within HFSS using the 3D modeller.

B. Assign boundaries:

The assignment of "boundaries" generally is done next. Boundaries are applied to specifically created 2D objects or specific surfaces of 3D objects. Boundaries have a direct impact on the solutions that HFSS provides.

C. Assign excitations:

After the boundaries have been assigned, the excitations should be applied. As with boundaries, the excitations have a direct impact on the quality of the results that HFSS will yield for a given model.

D. Set up the solution:

Once boundaries and excitations have been created, the next step is to create a solution setup.

E. Solve:

When the initial four steps have been completed by an HFSS user, the model is now ready to be analysed. The time required for an analysis is highly dependent upon the model geometry, the solution frequency, and available computer resources.

F. Post-process the results:

Once the solution has finished, a user can post-process the results. Post processing of results can be as simple as examining the S-parameters of the device modelled or plotting the fields in and around the structure.

IV. SIMULATED RESULTS

The simulated and measured results of the antenna performances are presented and discussed in this section. The Fig 3 shows the design of the antenna generated in HFSS and Fig 4 shows simulated and measured return loss of the proposed antenna.

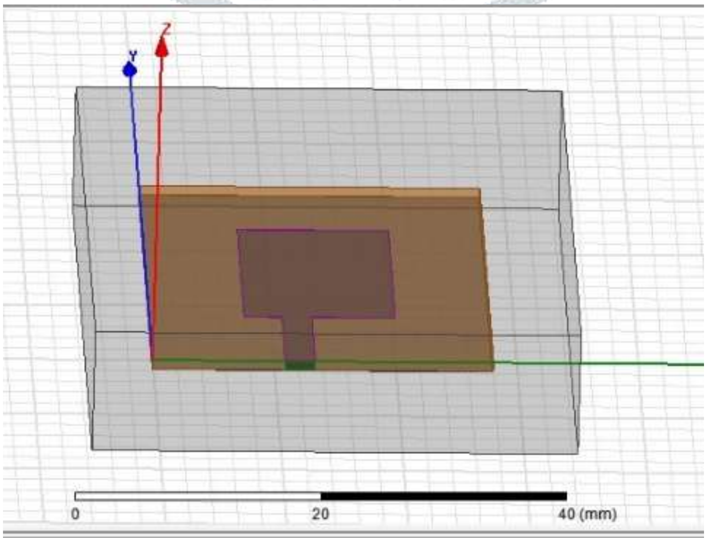

Fig 3 Antenna Design in HFSS

A. Return Loss:

These Parameters play a crucial role in the design of microstrip patch antennas by providing insights into the antenna's performance characteristics. These parameters, such as return loss and impedance matching, directly impact the antenna's efficiency, gain, and directivity. it can be observed that the micro strip patch antenna is resonating at the targeted frequency of 7.5 GHz with return loss, -12.96 dB, which proved that the designed antenna is well-matched to the 50ohm reference impedance.

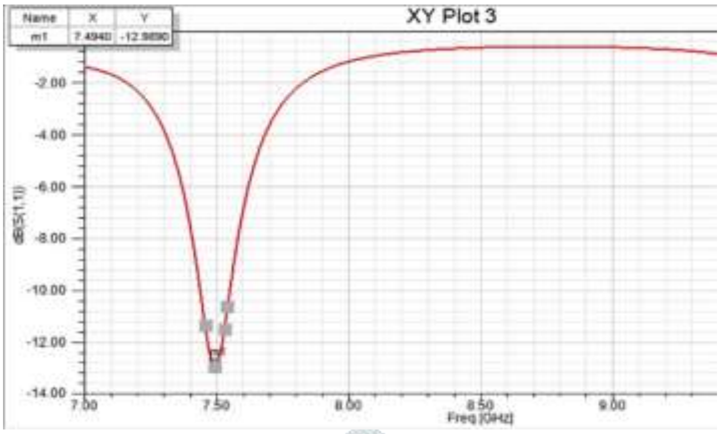

Fig 4 Return loss

B. ***Gain:***

Antenna gain is closely related to the directivity, but it is also a measure that takes into account the efficiency of the antenna. The gain of an antenna in a given direction is defined as the ratio of the intensity, in a given direction, and the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically. it can be observed when we fix the Category to Gain, Quantity to GainTotal, and Function to dB. A perfect gain of 7.5 is shown that means the antenna is in good condition.

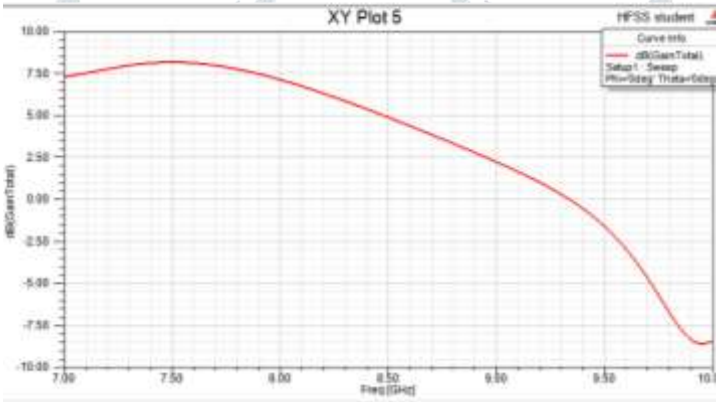

Fig 5 Gain

c. VSWR:

The Voltage Standing Wave Ratio (VSWR) is a measure of the impedance mismatch between a transmission line and an antenna. It is often used to evaluate the performance of an antenna in terms of how well it can transmit and receive signals.

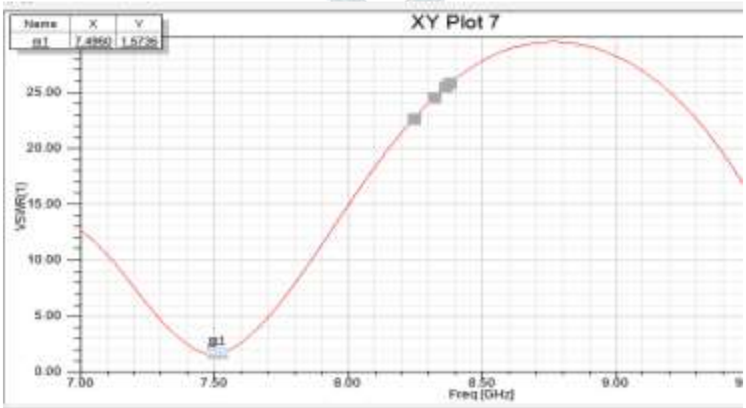

Fig 6 VSWR

it can be observed when we fix the Category to Gain, Quantity to GainTotal, and Function to dB. A perfect gain of 7.5 is shown that means the antenna is in good condition. The simulated result of the antenna VSWR is shown in the fig 6. it can be observed the value is 1.57dB as VSWR.

D. Magnitude of Electric and magnetic fields of the antenna:

Electric and Magnetic field strengths of the simple patch antenna structure show that the maximum radiated strength. The electric field strength of the rectangular patch antenna is 2.3748e+004 V/m. The maximum radiated magnetic field strength is that 1.9736e+002A/m.

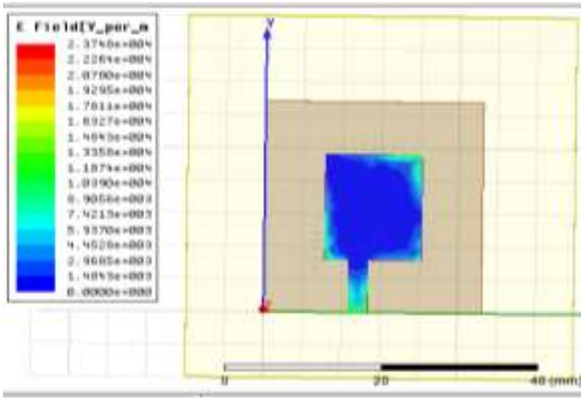

Fig 7 Electric field Magnitude

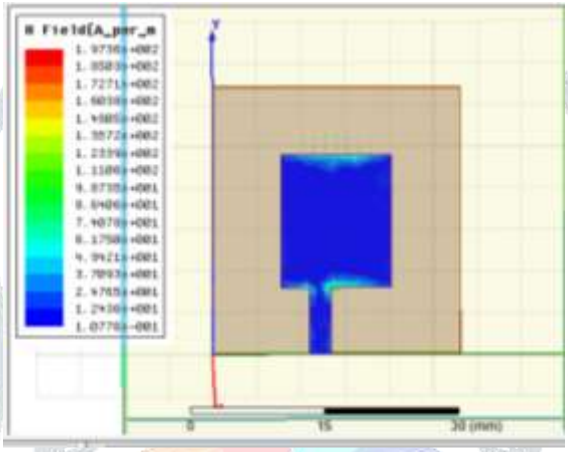

Fig 8 Magnetic field Magnitude

E. Vectors of Electric and magnetic fields of the antenna:

These vectors represent the distribution and orientation of electromagnetic fields around the antenna. Then the above two outputs Figure 9 shows the vector directions of Electric field and Figure 10 shows vectors of Magnetic field.

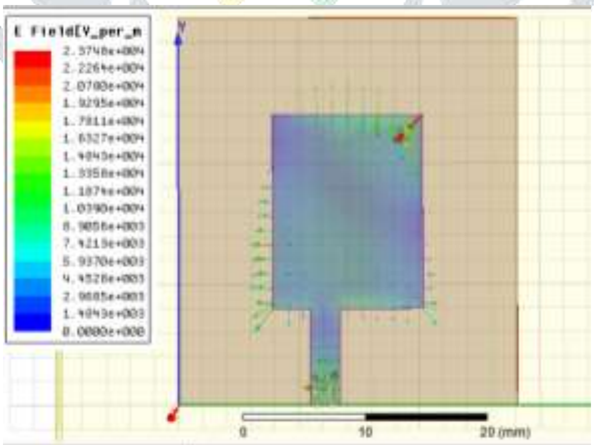

Fig 9 Electric field Vectors

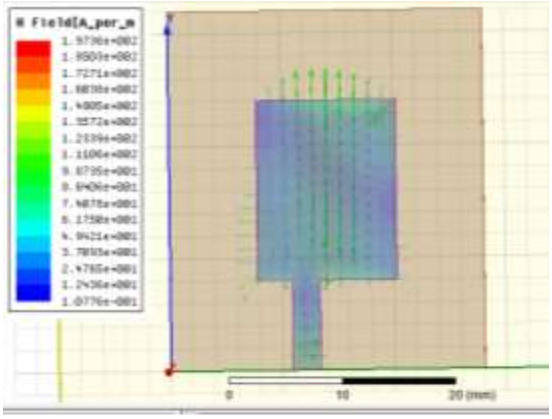

Fig 10 Magnetic field Vectors

V. CONCLUSION

A Micro-strip patch antenna for X-band VSAT application at 7.5 GHz has been designed, simulated, and tested. The antenna has a compact and lightweight structure. The antenna depicted a good simulated performance with a return loss of -12.98 dB and gain of 7.63dB. The proposed antenna can be a good replacement and a solution for the massive and bulkier parabolic reflector antenna for X-band VSAT application at 7.5 GHz and will also be suitable for use on a moving vehicle or station.

REFERENCES

[1]"Design and analysis of aperture coupled micro strip patch antenna for radar applications " by D. Anandkumar, R.G. Sangeetha.
[2] “Optimization of micro-strip patch antenna for X- Ku band application” by A. Khare, R. Nema.
[3] “Design of microstrip patch antenna for x-band applications” by A.A.Vahora, Jay Suthar.
[4] “Design of a Micro-Strip Patch antenna at for x-band vsat application” by Sarah Mohamad, Noralya Fatin Muzamil, Norun Abdul Malek, and Nurain Izzati Shuhaimi.
[5] Balanis, C. A. (2005). "Antenna Theory: Analysis and Design, 3rd Edition".
[6] Kumar, G., & Ray, K. P. (2003). "Broadband Microstrip Antennas"
- Google Books: Broadband Microstrip Antennas by Girish Kumar and K. P. Ray
[7] Ali, M., et al. (2017). "Design and Fabrication of a 7.5 GHz Microstrip Patch Antenna for VSAT Applications"
[8] Mandal, K., & Das, S. (2018). "Design of a Dual-band Microstrip Patch Antenna for X and Ku-band Applications"
- IEEE Xplore: Design of a Dual-band Microstrip Patch Antenna for X and Ku band Applications
[9] James, J. R., & Hall, P. S. (1989). "Handbook of Microstrip Antennas"
- IET Digital Library: Handbook of Microstrip Antennas.
[10] Micro strip Antenna Design by David M. Pozar. This comprehensive book covers the fundamentals and design techniques for micro strip antennas, including various feeding methods and optimization approaches.