Designing And Implementation of Broadband Microstrip Patch Antenna For Space Applications

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Abstract- *In this research paper we have developed a new study concerning the broad-band microstrip patch antenna by using several types of slots in patch using microstrip line feeding technique which providing broadband (consisting bandwidth of many wireless bands). The goal from this work was to get wider bandwidth to design a better wideband antenna. A wideband microstrip patch antenna has been developed, analyzed and validated for K-Band applications. So in this research paper, a Rook shaped slotted patch microstrip line fed antenna providing wideband of many bands for many microwave bands application is designed in HFSS. Loading slots at the non-resonating sides of the patch of single band antenna make its band broad for Ku-Band Applications (12-18 GHz), K-Band (18-26 GHz) and Ku-Band (26-40 GHz). The parametric study of the designed antenna has been attempted in this thesis. The antenna parameters like operating frequency, input impedance, VSWR, Smith Chart, Radiation pattern, Bandwidth and Return loss (S-Parameter) determined for each antenna configuration.*

Keywords- C-shaped Slot, Single ultra wide band rectangular antenna, Return Loss, Impedance Matching, VSWR, resonant frequency, High Frequency Structure Simulator.

I. INTRODUCTION

Since technology is updating gradually, the demand of the miniaturization device is being increased to control the performance of the device. This concept is the same in case of antenna technology. Now a day, the demand of low profile antenna design is very high. The communicating device should be smaller in wireless communication. As a result, the antenna used in such devices should be small also but the cost should not be increased. Similarly if we want to place an antenna in space, any aircraft, parabolic reflector antenna or Yagi antenna that have high bandwidth and gain can be placed in that place but, it will affect highly on the space and aircraft because of their 3D structure, hence it becomes inefficient to plant those antenna structure on the space and aircraft. Microstrip patch antennas can be easily mounted on the surface of any such equipment. In this case, the microstrip patch antenna plays an important role.

Microstrip patch antennas are used in extensive range of applications such as in wireless communication and biomedical diagnosis. In recent years, the widespread proliferation of wireless communication has augmented the demand for compact broadband antennas for handheld devices, satellite systems, etc. But it has a disadvantage of producing narrow bandwidth and low gain. To overcome the inherent limitation, many techniques such as probe fed antenna, stacked shorted patches, patch antenna with thick substrate electrically and slotted patch antenna have been planned and investigated. In general, there are different shapes for Microstrip Patch Antenna is available, such as Disc sector, Square, Rectangular, Elliptical, Dipole, Circular, Triangular, Circular ring and Ring sector. Each design has its own merits and demerits.

Knowing that the patch size is inversely dependent to the substrate permittivity, thus, substrate with higher permittivity is needed to ensure the patch compactness. Fiber Reinforced (FR4) is good in this regard; also its low cost is another benefit. Nevertheless, more permittivity is increased, more the patch suffers from losses inherent the substrate due to the surface waves that propagate along the substrate. These waves, will also lead to increased coupling between adjacent elements and can cause ripples in the radiation pattern

II. WIRELESS NETWORK

Advances in wireless communications have introduced tremendous demands in the antenna technology. It also paved the way for wide usage of mobile phones in modern society resulting in mounting concerns surrounding its harmful radiation [1-6]. Microstrip patch antenna has attractive features such as low profile, low cost, light weight, easy integration with integrated circuits and ease of fabrication. There are varieties of techniques to enhance the bandwidth of patch antenna such as using of a foam or a thick substrate material, cutting rectangular and circular slots or notches like U slot, M-shaped, H-shaped, Z- shaped, E-shaped patch antenna, initiating the parasitic elements either in stack configuration or coplanar and changing the shape of the radiating patch by setting up the slots. In [7-10], a wide-slot antenna with a microstrip line is proposed to enhance the bandwidth using a fork-like tuning stub.

The vision of the wireless communication supporting information exchange between people and devices is the communication frontier of the next few decades. This vision will allow multimedia communication from anywhere in the world. In the last few years, the development of wireless local area networks and Worldwide Interoperability for Microwave Access represented one of the principal interests in the information and communication field. Also, in the today's environment, technology demands antennas which can operate on different wireless bands and should have different features like low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a chromatic spectrum of frequencies. This technological trend has much focused in the design of Microstrip patch antennas. Wireless Communication is the process of transmitting radio waves or micro waves over a distance between the two points without any physical wire attachment. It encompasses various types of devices such as Bluetooth, remote control, Hand-held walkie-talkies, personal digital assistant, wireless computer mice and so on. Worldwide Interoperability for Microwave Access is a wireless communications standard designed to provide a high speed data rates. Its capability to deliver high-speed Internet access and telephone services to subscribers enables new operators to compete in a number of different markets. In urban areas already covered by DSL (Digital Subscriber Line) and high-speed wireless Internet access, WiMAX allows new entrants in the telecommunication sector to compete with established fixed-line and wireless operators. The increased competition can result in cheaper broadband Internet access and telephony services for subscribers. In rural areas with limited access to DSL or cable Internet.

III. ANALYSIS OF ANTENNA

The length of the patch is denoted by L and width of the patch is denoted by W. Because the dimensions of the patch are finite along the length and width, the fields at the edges of the patch undergo fringing. Since some of the waves travel in the substrate and some in air, an effective dielectric constant $\varepsilon reff$ is introduced to account for fringing and the wave propagation in the line.

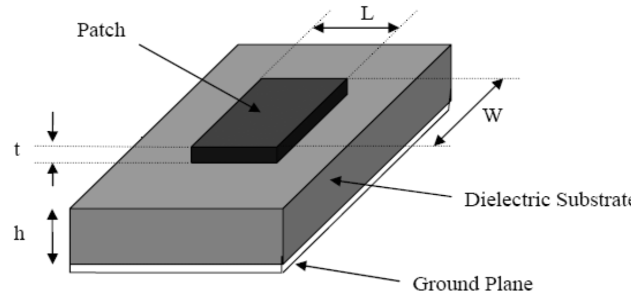

Figure 1 Basic Geometry of Microstrip Patch Antenna

Microstip Line Feed

A Microstrip Feed uses a transmission line to connect the radiating patch to receive or transmit circuitry. Electromagnetic field lines are focused between the microstrip line and ground plane to excite only guided waves as opposed to radiated or surface waves. Guided waves dominate in electrically thin dielectrics with relatively large permittivities[2]. For the patch antenna, radiated waves at the patch edges are maximized using electrically thick dielectric substrates with relatively low permittivities.

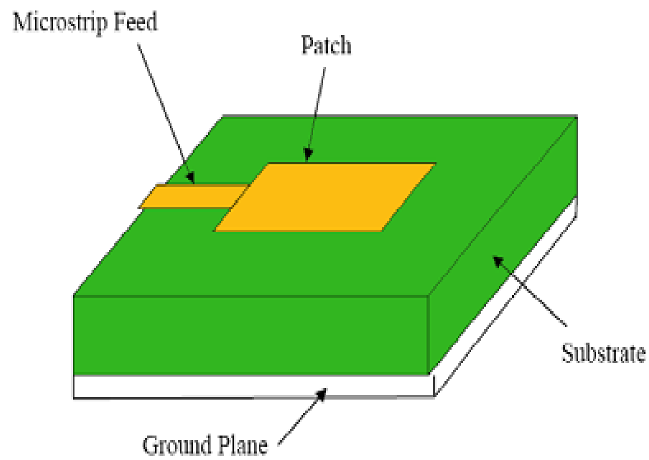

Figure 2 Microstrip line feed

Hence, it is difficult to meet substrate height and permittivity requirements for both the microstrip transmission line and patch antenna. Dielectric substrates selected to satisfy the two conflicting criteria increase surface waves, reduce radiation efficiency due to increased guided waves below the patch, and increase side- lobes and cross- polarization levels from spurious feed line radiation [9,10]. A microstrip line feed is generally used in two configurations namely directly fed and Inset feed.

IV. DESIGNING OF BROADBAND ANTENNA

Further, to increase the overall performance of the former antenna, a compact size microstrip antenna is presented that have its applications in UWB frequency range. The main difference in this proposed antenna comparatively to previous one is that the size of ground plane and substrate is reduced by 10 mm from both side that is length and width. The antenna is fed by a microstrip feeding technique and printed on a dielectric FR4 substrate of dimension **(22 mm X 27 mm X 1.6 mm)** permittivity εr =4.4 and height h = 1.60 mm. The return losses are observed at -10 dB of the microstrip patch antenna. Moreover, in comparison with base paper dimensions, the dimensions of proposed antenna are reduced so that the proposed design enhances (increases) the bandwidth and improves the value of return loss.

Antenna Design Geometry

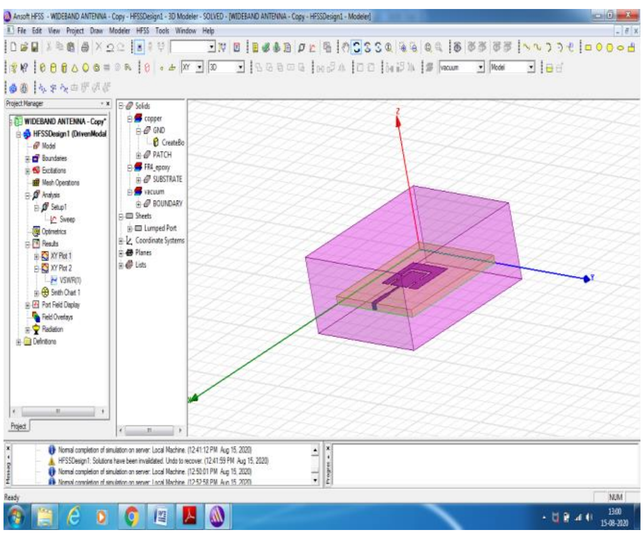

Figure 3 Proposed UWB Antenna Design (Top View)

Microstrip fed UWB antenna is designed which is a modified structure of base paper antenna as designed and studied in previous section. UWB antenna consists of modified rectangular patch with reduced size of ground and substrate. In this proposed design of antenna the bandwidth of antenna is observed **1.5711 GHz**.

Results and Discussion

The antenna design was simulated in the HFSS software to obtain the following results:

- Return Loss
- Smith chart
- Voltage Standing Wave Ratio (VSWR)

Return Losses

S-parameters describe the input-output relationship between ports (or terminals) in an electrical system. The S-parameter of above designed is shown in figure 4. The antenna is resonating at 19.12 GHz which covers many bands of wide-band. In this proposed design of antenna the bandwidth of antenna is wider **1.5711 GHz** than previous simple designed antenna (having band-width 2.29 GHz) whereas 1.1 GHz in base paper and the return losses of antenna is also improved at **-45 dB**.

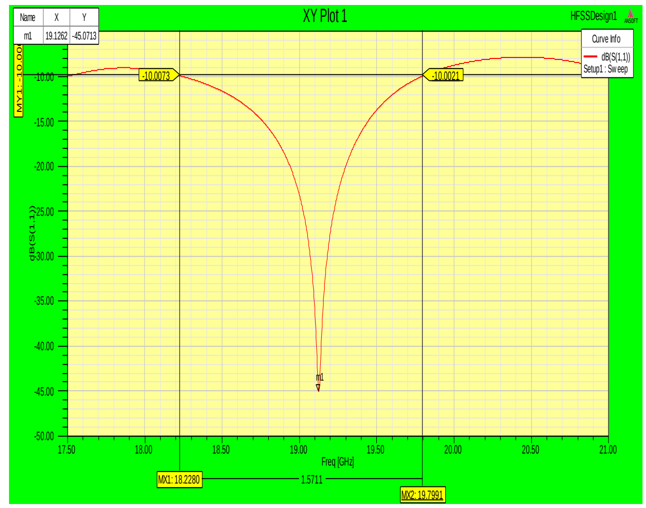

Figure 4 S-Parameter

VSWR

The measured value of VSWR from the graph is 1.011 which is good as near to ideal value 1.

Figure 5 VSWR Plot

Smith Chart:

In the proposed design the impedance matching is measured as 1.0098 × 50 = 50.49 ohm which is very good as so near or matched to characteristic impedance of 50 Ω as the

Smith Chart is a graph or tool for observing the impedance of a transmission line and antenna system as a function of frequency.

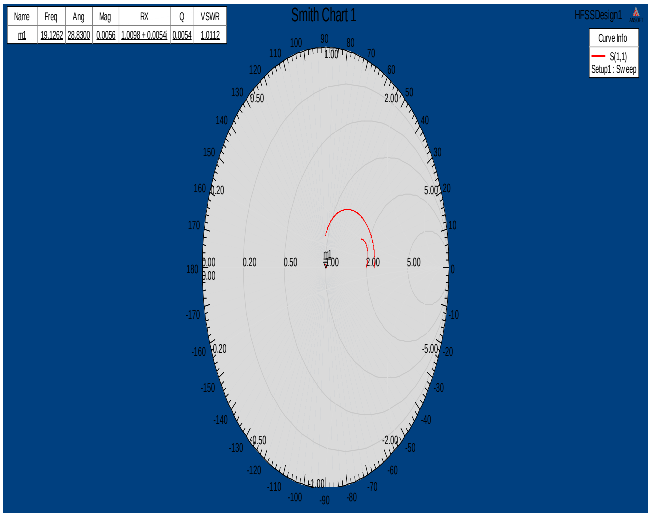

Figure 6 Smith Chart

4.6 Comparison of Proposed Results with Reference Paper

Table 4.2 Comparison of Result

SR.NO	Frequency (GHz)	RETURN LOSS (dB)	VSWR	Band width (GHz)
1. Reference Antenna	19	-31.9	1.05	1.10
2. Proposed antenna with small size	19	-45.06	1.01	1.57

V. CONCLUSION

First on the basic antenna with simple rectangular patch is designed and their band properties are studied. Then some rectangular slots cut out from patch onto the primitive antenna. While integrating all the elements utmost care has been taken to minimize the cross-coupling among them; so that their operation doesn't get hampered by the presence of other cut out elements from patch in designing antenna. Minimizing the potential interferences between the broadband system and the narrow band systems, a compact microstrip fed planar broadband antenna with single band rejection features was designed. The proposed antenna operates with 1.57 GHz bandwidth and resonates at 19 GHz.

The simulation results and other measurement results of the designed antenna show a good agreement in terms of the return loss, VSWR and impedance matching.

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