

Designing of a Slotted Rook Shaped Novel Wide-band Microstrip Patch Antenna for Radar Altimeter and C-band Satellite Downlink Applications

Rimpi Devi¹, Neeraj Kumari², Amit Kumar³

^{1,2} Research Scholar, ECE Department, G.I.T.M, Karnal

³ Assistant Professor, ECE Department, K.I.T.M. Karnal

Abstract- In this paper we have developed a new study concerning the wideband microstrip patch antenna by using rook shaped slot loaded patch resonating at frequencies 5.3 GHz which providing wideband (consisting bandwidth of many wireless bands). The goal from this work was to get more number of bands to design a better wideband antenna. A wideband microstrip patch antenna has been developed, analyzed and validated for C-Band and Radar altimeter 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 C-Band Applications (4-8 GHz), Radar altimeter Band Applications (4.2-4.4 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, Return loss (S-Parameter) and gain are determined for each antenna configuration.

Keywords- Rook-shaped Slot, Single-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. The solution is to use planner or 2D antenna configuration to this type of difficulties. These 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

1.1 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.

2. 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 ϵ_{eff} is introduced to account for fringing and the wave propagation in the line.

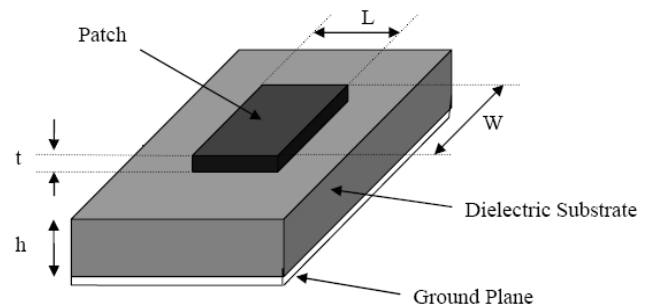


Figure 1 Basic Geometry of Microstrip Patch Antenna

1.4.1 MICROSTRIP 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.

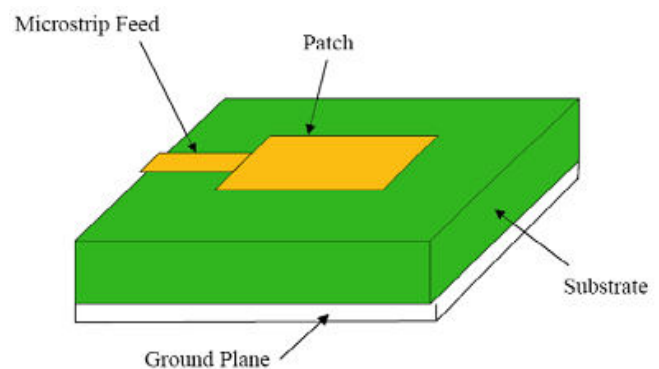


Figure 2 Microstrip line feed

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.

3. DESIGNING OF WIDE-BAND ANTENNA:

The geometry of proposed antenna which is MSL fed for Radar altimeter and C-Band applications is depicted in figure 3

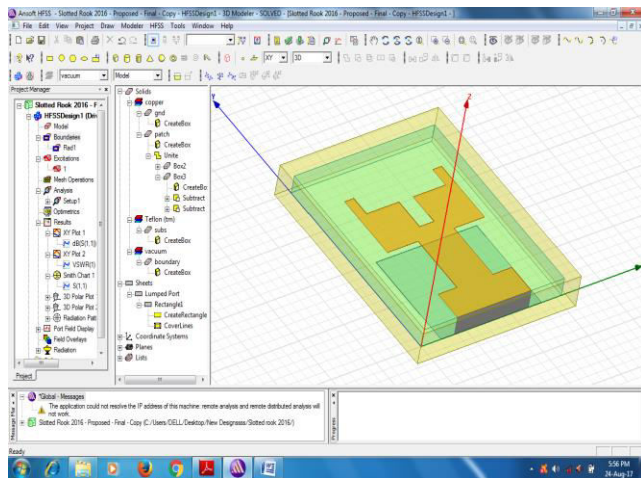


Figure 3 Proposed Slotted Rook Shape Design

3.1 Result

a) Observation from -10dB return loss

- Resonant frequency = 5.3639 GHz at -25.71 dB
- Band width= $f_2 - f_1 = 6.4044 - 3.8505 = 2.5539$ GHz = 2553.9 MHz

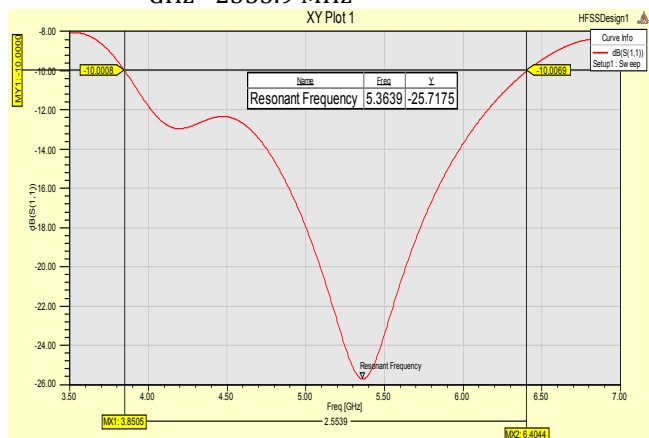


Figure 4 Return Loss curve for Proposed Antenna

b) Observation from VSWR

VSWR at resonant frequency 5.36 GHz=1.10

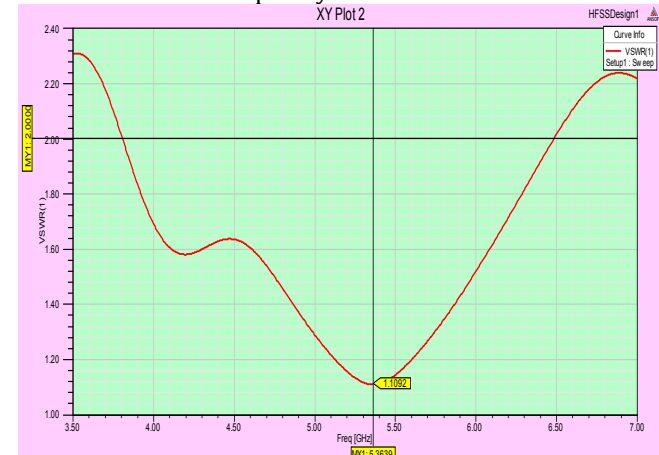


Figure 5 VSWR curve for Proposed Antenna
d) Smith Chart

It is observed from the smith chart that the value of impedance in this smith chart is 1.1080×50 (characteristic impedance) = 55.40 ohm at resonant frequency.

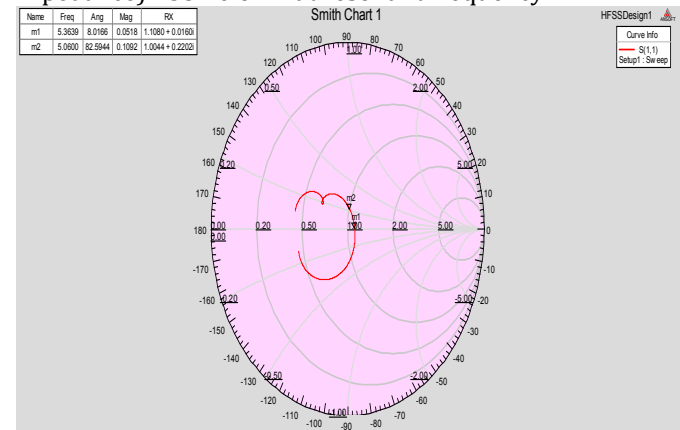


Figure 6 Smith chart curve

Hence I have designed a slotted rook shaped antenna for wireless applications & thus a compact microstrip patch antenna has been designed for full filling the requirements of Radar altimeter and C-Band applications at 3.85- 6.40 GHz freq. The measured and simulated results are in good match. To meet the miniaturization requirement microstrip patch antennas has been designed.

3.2 Conclusion with difference between Reference Antenna and Proposed Wideband Antenna:

ANTENNA	DIFFERENCE IN DESIGN	IN RESONANT FREQUENCY (GHz)	BANDWIDTH (GHz)
Reference Antenna	Using Slotted Rook Shape Patch and Teflon Substrate	4.3	$4.600 - 3.181 = 1.419$
Proposed Antenna	Using comparatively wide slot in Rook Shape Patch, Duroid Substrate and changes the Ground and substrate.	5.3	$6.4044 - 3.8505 = 2.5339$

Table 1 Difference result of reference and proposed antenna of wide band

4. CONCLUSION

In this research paper, a typical wideband microstrip patch antenna with slotted rook patch shape forming a simple and efficient technique of design has been introduced for the betterment of bandwidth, also, giving the better performance at the desired resonant frequency. In this the

Wide band microstrip patch antenna is proposed for the radar altimeter and C-Band applications. This antenna bands is designed for different wireless bands.

Hence from the designing of a slotted rook shaped antenna for full filling the requirements of Radar altimeter and C-Band applications at 3.85- 6.40 GHz frequency. It is observed that the value of wideband in proposed antenna is 2.5339 GHz (2553.9 MHz) which is very wide with respect to wideband of reference antenna which has 1.419 GHz (1419 MHz) value. So the difference between Proposed antenna and reference antenna is 2553-1419=1134 MHz, so the value of wideband is about 179.9% more than the reference antenna.

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BIOGRAPHIES



Ms Rimpi Devi is a Research Scholar. She has completed her M.Tech & B.Tech in ECE from G.I.T.M, Karnal affiliated to KUK.



Mrs. Neeraj Kumari is a Research Scholar. She has completed her M.Tech & B.Tech in ECE from G.I.T.M, Karnal affiliated to KUK. She was an Asst. Professor in G.I.T.M also. She has published many research papers in international journal.



Mr. Amit Kumar is an Assistant Professor in ECE Department in KITM college. He has completed his M.Tech & B.Tech in ECE from KUK. He has more than 8 years teaching experience. He has published more than 20 research papers in National & international conferences and in international journals.