Review Paper on Slot Loaded Patch Antenna for Communication System

Akashdeep Kumar[1], Prof. Manish Sahu[2]

[1]*M. Tech. Scholar,* [2]*Assistant Professor*

[1,2]*Department of Electronics and Communication, SORT, People's University, Bhopal, India*

Abstract: -In this paper a microstrip antenna loading with double U-slot is designed. Here, the shape of patch is rectangular and partial ground plane is used. The antenna designing is done by using HFSS simulation tool. Feeding is done by using microstrip feed line. After designing antenna we see the effect of variation in the dielectric material of substrate, width and length of U-shaped slot, feed position and ground plane variation on antenna bandwidth is analyzed. Due to the very short pulse property of the UWB signal, no cancellation will occur because the direct path signal has passed before the reflected path signal arrives. Therefore, high-speed, mobile wireless applications are particularly well suited for UWB system implementation.

Keywords:-Microstrip Antenna, U-shaped slot, Partial ground plane, Ultra wide band.

I. INTRODUCTION

Antennas are very important component in wireless communication system. There are different types of antennas exit practically which we used for transmit and receive EM waves. Out of these microstrip antenna is one of the most important antenna nowadays due to their attractive features such as low profile, light weight, low cost and ease in fabrication. Therefore, they are compatible with wireless communication integrated circuitry. But it has some disadvantages such as narrow bandwidth, low gain and low efficiency. There are some drawbacks in order to reduce these drawbacks such as slot loading over patch, reduction in length of ground plane etc. [1] [2].

Federal Communication Commission (FCC) allocated a bandwidth of 7.5 GHz i.e. from 3.1 GHz to 10.6. It is generated by very short duration pulses generally in picoseconds therefore it provides very high data rate in the range of Mbps.There are several advantages of short duration pulses like it avoids multipath fading etc. This is widely used in radars and remote sensing applications. UWB antennas having return loss (S11< -10dB) high radiation efficiency over ultra wide band from 3.1 GHz to 10.6 GHz.

In the present paper, a double U-shaped slot loaded rectangular microstrip antenna is designed and analyzed. Two U-shaped slotsreduce the overall impedance of antenna. The slot reduces the area of copper sheet which leads to less value of quality factor hence bandwidth increases. The microstip line is used for feeding because of its ease in fabrication and simple to match by controlling inset positions. A VSWR< 2 and S11< -10 dB is achieved for a frequency range of 6.5-14.8 GHz with stable E- and H-plane radiation patterns.

II. LITERATURE REVIEW

Antara Ghosal et al. [1],this paper described the analysis and design of aslotted square patch microstrip antenna. Slots are introduced in asquare patch to form this slotted design. This slotted squarepatch design is introduced to use a single structure for multiband operations. Using Ansoft HFSS software the antenna ismodeled, designed and simulated. Transmission line modelequation and MATLAB is used to find the design parameters fora rectangular patch antenna. The simulation and modeling of thisconfiguration has been done using Ansoft's HFSS (HighFrequency Structure Simulator) software. For TM010 mode, theresonant frequency and dimensions are computed. The antennaparameters such as return loss, radiation patterns and gain havebeen determined and design is optimized for best results.Network Analyzer is used for experimental results.

Robert Mark et al. [2], a semi curved formed planar microstrip reception apparatus for wideband numerous info different yield (MIMO) remote applications with wideband separation stub is displayed for remote frameworks. The radio wire comprises of two semi curved fix components with edge to edge dispersing of 0.051 λo at 3.1GHz. The stub is embedded between the two components at base of fix and a square shape indent is cut on beneath fix reception apparatus ground plane for separation upgrade and impedance coordinating improvement, separately. The structured reception apparatus has a physical components of 36×28×0.8 mm3 with estimated impedance data transfer capacity (S11<-10dB) from 3.05-7.67GHz. The model of MIMO receiving wire with confinement stub is manufactured and reproduction results for example .Parameters, radiation design, absolute productivity and addition of reception apparatus are approved utilizing test estimations. The envelope connection coefficient (ECC) is inside 0.1, making the plan reasonable for MIMO applications.

Pranav Srinivasan et al. [3], 3x3 reflectarray radio wire in Ku band and its components are planned and broke down in this paper. The Proposed components are titled as hexagonal coincided square shape as a result of its novel shape. The proposed recieving wire is single layered and focus bolstered. The unit cells are indistinguishable in nature what's more, the stage remuneration is accomplished by changing the postpone stubs. The primary 3x3 reflectarray reception apparatus is co-pivotally sustained utilizing a source fix resounding at a similar recurrence as the reception apparatus at 13 GHz, avoided as much as possible of 57.7mm. The return misfortune and the stage execution of the reception apparatus were agreeable and an increase of 25.978 dBi was acquired. The radio wire can discover its applications in DBS, remote getting to furthermore, fiasco the executives.

K. Vijayachandra et al. [4], subjective radio frameworks required recurrence reconfiguration, which is a basic necessity for the present remote correspondence. In this proposed work a square fix is structured at a recurrence of 4.26 GHz with two spaces on the substrate of Rogers RT/duriod 5880(tm) fix. The size of the fix is 18x18mm. Two PIN diodes are associated between the spaces for adjusting the present circulation on the fix surface what's more, it prompts re-configurability. In this investigation The planned reconfigurable fix radio wire works in nine unique recurrence groups with resounding frequencies of 2.3GHz, 3.8GHz, 4.3GHz, 6.8GHz, 8.8GHz, 12.8GHz, 13.2GHz, 14.6GHz and 16GHz. This reception apparatus reconfiguration groups are reasonable for Wi-Fi, Radio Alternatives, GSM, WLAN, RADAR and Satellite interchanges applications. Diverse recurrence groups can be stipulated by utilizing PIN diode switches. Ansoft HFSS 16 is utilized for the proposed receiving wire reproduction.

Abhinav Bhargava et al. [5], a multi rectangular opened radio wire is dissected and recreated by FEKO reproduction programming. Two columns of rectangular openings are presented in the rectangular geometry upgrade radiation. Many bolstering system are accessible out of them Micro-strip feed system is utilized for this plan. Hexa represents six full frequencies created by this plan. Due to idea of fractal reception apparatus comparable spaces are presented in square shape builds the present length and brokenness. This configuration is helpful for six band applications. The estimation of return misfortune is under −10 dB in every one of the six groups with satisfactory data transfer capacity. Frequencies of reverberation are 0.27GHz, 1.7GHz, 3.3GHz, 2.7GHz, 3.5GHz and 4.3GHz their individual return misfortune are - 53dB, - 31dB, - 36dB, - 16dB, - 31dB and - 25dB. Measurements of reception apparatus are 40mm*50mm because of this size of receiving wire is little which makes it compact. The estimations of VSWR are near two for separate frequencies which are helpful for working recurrence go. FR4 substrate is utilized for the structure and investigation for this receiving wire with dielectric 4.4 and thickness of 1.3 mm. The structure is broke down by FEKO programming dependent on Method of Moment.

For the improvement in remote correspondence numerous proficient planned have been created by numerous approaches, by which generally speaking execution of the correspondence framework just as the size of the framework have been improved. Even with standard advancement can improve the IC that is incorporated circuit innovation has insubordinately decreased size and weight of the correspondence framework. Execution of the radio wire improvement must be goes on time to time by various and special innovation.

GuipinJin et al. [6], a differential-sustained double band directional reception apparatus is proposed for WLAN and WiMAX applications. The differential-sustained double band directional reception apparatus is made out of a couple of dualband dipole. Each double band dipole component comprises of a couple of curve arms, and an isosceles trapezoid fix for 3.5-GHz band, and a square shape branch for 2.4-GHz band. The deliberate outcomes show that two working groups of the reception apparatus is from 2.38 to 2.58 GHz and from 3.18 to 4.18 GHz. The acquired directional radiation designs are steady at both recurrence groups with an increase of 7.4 dBi for the low band, 8 dBi for the high band.

III. MICROSTRIP ANTENNA

Microstrip antennas received considerable attention starting in the 1970s, although the idea of a microstrip antenna can be traced to 1953 and a patent in 1955. Microstrip antennas, as shown in figure (2.1). It consist of a very thin metallic strip (patch) placed above ground plane. The patch and the ground plane are separated by a dielectric sheet (referred to as the substrate). There are numerous substrates that can be used for the design of microstrip antennas, and their dielectric constants are usually in the range of $2.2 \leq \epsilon_r \leq 12$.

The ones that are most desirable for good antenna performance are thick substrates whose dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space, but at the expense of larger element size. Thin substrates with higher dielectric constants are desirable for microwave circuitry because they require tightly bound fields to minimize undesired radiation and coupling, and lead to smaller element sizes; however, because of their greater losses, they are less efficient and have relatively smaller bandwidths.Often microstrip antennas are also referred to as patchantennas. The radiating patch may be square, rectangular, thin strip (dipole), circular, elliptical, triangular, or any other configuration.

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.

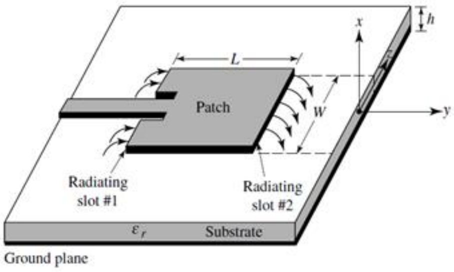

Figure 1: Microstrip Antenna

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.

Major operational disadvantages of microstrip antennas are their low efficiency, low power, high *Q* poor polarization purity, poor scan performance, spurious feed radiationand very narrow frequency bandwidth, which is typically only a fraction of a percent or at most a few percent.However, there are methods, such as increasing the height of the substrate that can be used to extend the efficiency (to as large as 90 percent if surface waves are not included) and bandwidth (up to about 35 percent). However, as the height increases, surface waves are introduced which usually are not desirable because they extract power from the total available for direct radiation.

IV. SHAPES OF MICROSTRIP ANTENNA

The radiating patch may be square, rectangular, thin strip (dipole), elliptical, circular, triangular, or any other configuration as shown in figure 2. Rectangular patches are probably the most utilized patch geometry. It has the largest impedance bandwidth compared to other types of geometries. Rectangular and circular patch configurations have received enormous attention of researchers for their convenient analysis and design concept.

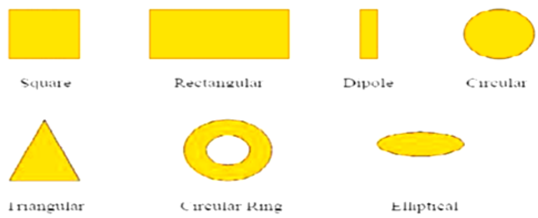

Figure 2: Common shapes of microstrip patch element

But there are certain sophisticated applications which require the analysis of other shapes such as pentagonal, triangular, patch ring, etc. But researchers paid least attention toward the analysis of the above mentioned shapes due to their structural complexity.

Circular and elliptical shapes are slightly smaller than of rectangular patches. Thus it will have smaller bandwidth and gain. This circular geometry patches were difficult to analyze due to its inherent geometry. Microstrip dipoles are attractive because they inherently possess a large bandwidth and occupy less space, which makes them attractive for arrays.

Triangular patch is even smaller than both rectangular and circular geometries. However, this will produce even lower gain and smaller bandwidth. It will also produce higher cross-polarization due to its unsymmetrical geometry. Dual polarized patch could be generated from these geometries.

V. ANTENNA DESIGN

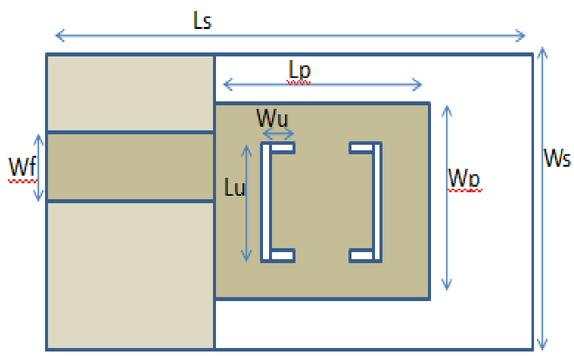

Fig. 1 Design of Double U-slot loaded Microstrip Antenna

Mathematical Formulation

Width of microstrip antenna is simply given as

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}} \quad (1)$$

Where,

W= Width of Patch

ε_r = Dielectric constant of the substrate

Actual length of microstrip antenna is given as

$L_{actual} = L_{eff} - \Delta L (2)$

Where,

L_{eff} = Effective length of the patch.

ΔL = Extended electrical length

Effective length of the patch is simply given by

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad (3)$$

Where,

ε_{reff} = Effective dielectric constant

For low frequencies the effective dielectric constant is essentially constant. At intermediate frequencies its values begin to monotonically increase and eventually approach the values of dielectric constant of the substrate. Its value is given by,

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}} (4)$$

h = thickness of the substrate

In microstrip antenna, radiation occurs due to the fringing effects. Due to fringing effects electrical length of patch is greater than its physical length. This fringing depends on the width of patch and height of substrate [2].Now the extended electric length is given by

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.8)} \quad (5)$$

The width of microstrip line in microstrip antenna is given as follows:

For

$$\frac{W_{eff}}{h} \geq 2$$

$$W_{eff} = \frac{2h}{\pi}\left\{\frac{\varepsilon_r-1}{2\varepsilon_r}\left[\ln(B-1)+0.39-0.\frac{61}{\varepsilon_r}\right]+B-1-\ln(2B-1)\right\}$$

and for

$$\frac{W_{eff}}{h} \leq 2$$

$$W_{eff} = \frac{8he^{A}}{e^{2A}-2}$$

$$W_f = W_{eff} - \frac{t}{\pi\left[1+\ln\left(\frac{2h}{t}\right)\right]}$$

Where, A and B are given as follows

$$A = \frac{Z_{ol}}{60}\left(\frac{\varepsilon_r+1}{2}\right)^{0.5} + \frac{\varepsilon_r-1}{\varepsilon_r+1}(0.23+0.11/\varepsilon_r)$$

$$B = \frac{377\pi}{2Z_{ol}\sqrt{\varepsilon_r}}$$

VI. CONCLUSION

It is observed that double U-slot loaded microstrip antenna provided optimum bandwidth when length of partial ground plane is 8mm (6.5-13.7 GHz i.e 7.2 GHz), U-slot width is 1mm (6.5-14.8 GHz i.e. 8.3GHz), and feeding position is 2.5mm from symmetrical position (6.5-14.8 GHz i.e. 8.3 GHz). Finally, we saw the effect of dielectric material on bandwidth and got optimum bandwidth by using FR-4 epoxy substrate (6.5-14.8GHz i.e. 8.3 GHz), and when length of U-slot is 12mm (6.5-14.8 GHz i.e. 8.3 GHz).

REFERENCES

[1] Antara Ghosal, AnurimaMajumdar and Sisir Kumar Das, “A Multiband Microstrip Antenna for Communication System”, IEEE 2018.

[2] Robert Mark, Neha Rajak, Kaushik Mandal and Soma Das, “Semi Elliptical Two Port MIMO antennas for wideband Wireless Application”, International Microwave and RF Conference (IMaRC), IEEE 2018.

[3] Pranav Srinivasan ; LaxmanSethuraman ; Rahul Bhaskaran ; H. UmmaHabiba, “Hexagonal Meshed Rectangular Reflectarray Antenna in Ku Band for Satellite Communication”, 9th IEEE Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON), IEEE 2018.

[4] K. Vijayachandra ; M. Satyanarayana ; B.T. Krishna, “Compact frequency Reconfigurable rectangle patch with double slot Antenna for Cognitive Radio Applications”, Indian Conference on Antennas and Propogation (InCAP), IEEE 2018.

[5] Abhinav Bhargava and Dr. Poonam Sinha, “Multi Rectangular Slotted Hexa Band Micro-strip Patch Antenna for Multiple Wireless Applications”, Proceedings of the International Conference on Communication and Electronics Systems (ICCES 2018), IEEE 2018.

[6] GuipinJin ; Guangjie Zeng ; Miaolan Li, “A Differential-fed Dual-Band Directional Antenna for WLAN and WiMAX Applications”, International Applied Computational Electromagnetics Society Symposium China, IEEE 2018.

[7] SuchitraJeenawong, PatchadapornSangpet, PichetMoeikham and PrayootAkkaraekthalin, “A Compact Modified E-Shaped Monopole Antenna for USB Dongle Applications”, International Symposium on Antennas and Propagation (ISAP), IEEE 2018.

[8] H. Q. Ngo A. Ashikhmin H. Yang E. G. Larsson T. L. Marzetta "Cell-free massive MIMO versus small cells" IEEE Trans. Wireless Communication vol. 16 no. 3 pp. 1834-1850 Mar. 2017.

[9] Huang A. Burr "Compute-and-forward in cell-free massive MIMO: Great performance with low backhaul load" Proc. IEEE Int. Conf. Communication (ICC) pp. 601-606 May 2017.

[10] H. Al-Hraishawi, G. Amarasuriya, and R. F. Schaefer, “Secure communication in underlay cognitive massive MIMO systems with pilot contamination,” in In Proc. IEEE Global Communication Conf. (Globecom), pp. 1–7, Dec. 2017.

[11] V. D. Nguyen et al., “Enhancing PHY security of cooperative cognitive radio multicast communications,” IEEE Trans. Cognitive Communication and Networking, vol. 3, no. 4, pp. 599–613, Dec. 2017.

[12] R. Zhao, Y. Yuan, L. Fan, and Y. C. He, “Secrecy performance analysis of cognitive decode-and-forward relay networks in Nakagami-m fading channels,” IEEE Trans. Communication, vol. 65, no. 2, pp. 549–563, Feb. 2017.

[13] N. O. Parchin, M. Shen and G. F. Pedersen, “End-fire phased array 5G antenna design using leaf-shaped bow-tie elements for 28/38 GHz MIMO applications,” 2016 IEEE International Conference on Ubiquitous Wireless Broadband (ICUWB), Nanjing, 2016, pp. 1-4.