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The Various Feeding Techniques of microstrip Patch Antenna Using HFSS

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Abstract: *This paper describes the several feeding techniques/methods used for the antenna. These methods can be classified into two categories-contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is used to transfer power between the microstrip line and the radiating patch. The simulation of the antenna is performed using High-Frequency Structure Simulator (HFSS V13.0). Antennas are used for various biomedical diagnosis applications, mobile radio, remote sensing, satellite, and wireless communications. In this manuscript, a comparative study between microstrip feed, inset feed, co-axial feed, aperture couple feed, and proximity couple feed on the rectangular microstrip patch antenna has been shown S-parameter, VSWR, Gain and Radiation Pattern using HFSS software.*

Keywords: *Microstrip Patch Antenna, Feeding Techniques, Return Loss, Gain*

I. INTRODUCTION

The antenna consists of several conductors, and they are connected electrically to transmit or receiver. The antenna is very much an essential component of all equipment that is using radio. Microstrip Patch Antenna has drawn various researchers' attention over the past work because of its many attractive features. They are widely used in different types of communication systems [1].

II. HISTORY OF ANTENNA

The concept of the antenna was first conceived in 1886 by Heinrich Rudolph Hertz, the father of electromagnetic in his Laboratory at the Technical Institute of Karlsruhe. Heinrich Rudolph Hertz proved experimentally that the electrical disturbances could be detected with a secondary circuit of proper resonance dimensions and containing an air gap for sparks to occur. Hertz created, receiving and transmitting electromagnetic energy through an end-loaded half-wave dipole known as Hertz a Dipole as transmitter and a resonant square loop antenna as the receiver. The Indian scientist JagadisChunder Bose (1858-1937) carried out pioneering research paintings with millimeter waves in the 60-GHz range and developed a new sort of antenna referred to as Horn antenna in1897 in the course of his research with millimeter-wave propagation. It's far broadly used as a feed element for radio astronomy and satellite tracking antennas. Furthermore, these shapes are an important part of phased arrays and serve as a conventional widespread calibration and gain measurements.

The tough works with the aid of Bose and Hertz stimulated Guglielmo Marconi (1874-1937), an Italian electric Engineer, to apply the Hertz and waves for communiqué functions [2]. He commenced the scientific network in 1901 through his transatlantic radio conversation hyperlink. The installation was constructed from a transmitting antenna made from a spark transmitter connected between fifty vertical wires and a floor. The antenna utilized in radio can radiate or obtain electromagnetic waves, thereby can switch statistics between unique places with non-intervening systems. Radio has been the first technological product that percolated into the commonplace guy's lifestyles.

III. TYPES OF ANTENNAS

An Antenna is a means of radiating and receiving radio waves. It is a transition structure between the free space and the guiding device. So it can be said as a directional device that guides the device and also probes the signals. It plays a paramount role in wireless communication.

A. Log-periodic Antennas

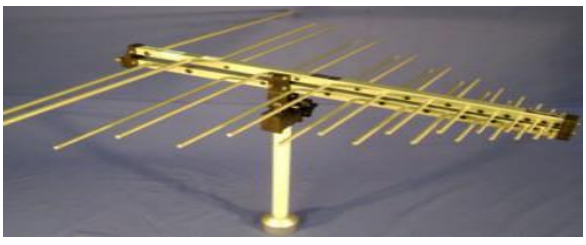


Figure 1: Log Periodic Antennas

A log-periodic antenna is a multi-element called a log-periodic array. It is a directional narrow beam antenna that works on a wide range of frequencies. Therefore used in wideband applications, which is the requirement of today's scenario? It is made of a series of dipoles placed forth the antenna axis at differently spaced intervals of time, derived by a logarithmic function of frequency. The log-periodic antenna is applicable in a wide range when variable bandwidth is our priority with antenna gain and directivity.

B. Wire Antennas

Wire antennas are also known as linear or curved antennas. These antennas are very simple, cheap, and are used in a wide range of applications. These antennas are further available in Dipole antenna and Monopole antenna.

a). *Dipole Antenna*

A dipole antenna is one of the most straightforward antenna alignments. This dipole antenna consists of two thin metal rods with a sinusoidal voltage difference between them.

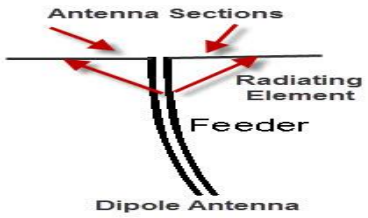


Figure 2: Dipole Antenna

The length of the rods is chosen to have a quarter length of the wavelength at operational frequencies. These antennas are used in designing their antennas or other antennas. They are very simple to construct and use. The dipole antenna consists of two metallic rods through which current and frequency flow. This current and voltage flow makes an electromagnetic wave, and the radio signals get radiated

b). *Monopole Antenna*

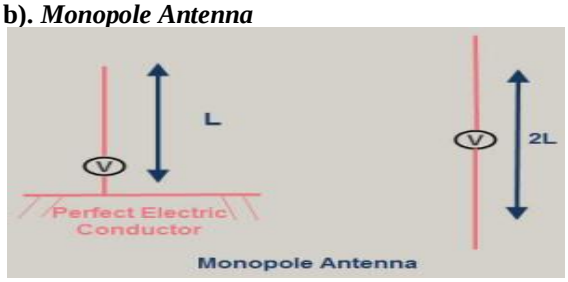


Figure 3: Monopole Antenna

A monopole antenna is half of a simple dipole antenna located over a grounded plane, shown in the figure below. The radiation pattern above the grounded plane will be the same as the half-wave dipole antenna; however, the total power radiated is half that of a dipole; the field gets radiated only in the upper hemisphere region. The directivity of these antennas become double compared to the dipole antennas.

c). *Helical Antennas*

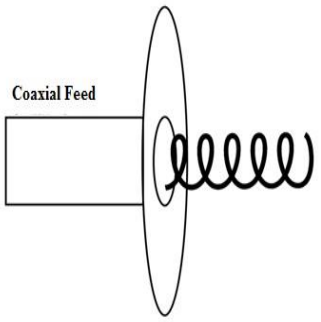


Figure 4: Helical Antenna [23]

Helical antennas are also known as helix antennas. They have relatively simple structures with one, two, or more wires each wound to form a helix, usually backed by a ground plane or shaped reflector and driven by an appropriate feed. The most common design is a single wire backed by the ground and fed with a co-axial line.

d). Yagi-Uda Antenna

Another antenna that makes use of passive elements is the Yagi-Uda antenna. This type of antenna is inexpensive and effective. It can be constructed with one or more reflector elements and one or more director elements. Yagi antennas can be made using an antenna with one reflector, a driven folded-dipole active element, and directors mounted for horizontal polarization in the forward direction.

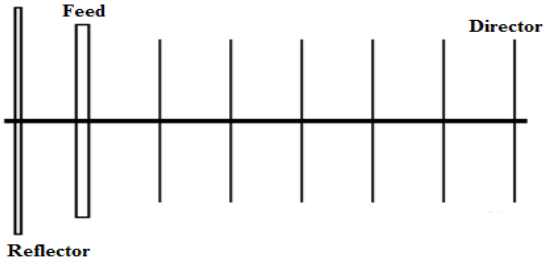


Figure 5: Yagi-Uda antennas [23]

e). Array Antenna

Multi elements form array antenna. This antenna may not give the preferred characteristics. It can be achieved employing multi-elements in the antenna construction. In many applications, it is desired to design the antenna

with very high gain to assemble long-distance communication necessities.

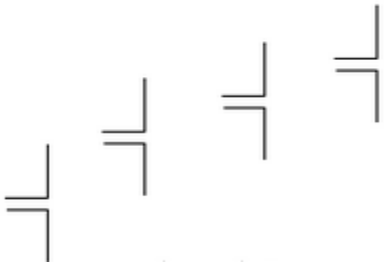


Figure 6: Array Aperture antennas

IV. MICROSTRIP PATCH ANTENNA

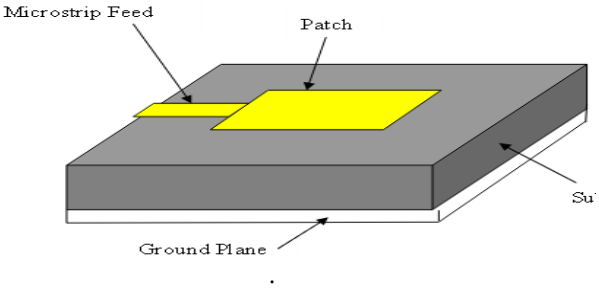
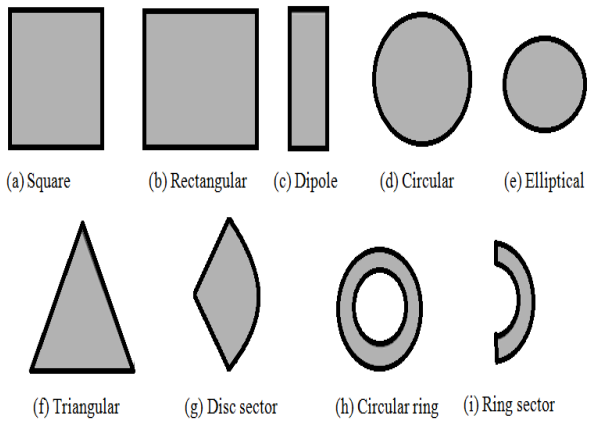


Figure 7: Structure of Microstrip Patch Antenna[23]

A Microstrip Patch Antenna is a low-profile antenna with many advantages over other antennas in that it is lightweight, inexpensive, and easy to integrate with accompanying electronics. Microstrip Patch Antenna consists of a Conducting rectangular patch of width "W" and "L" on the side of the dielectric substrate of thickness "h" and dielectric constant. "ε_r". With a high permittivity substrate, the antenna's size can be reduced up to a great extent, but these techniques reduce the radiation efficiency of the antenna, and the impedance bandwidth of the antenna is also reduced [2].

The radiating patch has different shapes such as Rectangular, Square, Circular, triangular, dipole, and Elliptical, but any continuous shape is possible. The role of feeding is very important in the efficient operation of an antenna to improve the antenna input impedance matching [3,4]. The input impedance of these antennas depends on their geometric shape, dimensions, the properties of substrate material used, feeding type, and feeding location[6]. With a high permittivity substrate, the antenna's size can be reduced up to a great extent, but these techniques reduce the radiation efficiency of the antenna, and the impedance bandwidth of the antenna is also reduced. The typical bandwidth of a microstrip antenna is between 1% to 3%. To overcome these limitations, many optimization techniques have been introduced. The radiating patch has different shapes such as square, rectangular, circular, elliptical, triangular, dipole, ring. The shape of the patch is very important to analyze the performance and different parameters of the antenna [5,6].



These methods are divided into two categories, i.e., contacting and non-contacting. In general, contacting methods are microstrip line feed and co-axial plane feed. On the other hand, non-contacting techniques are aperture coupled feed and proximity coupled feed.

V. FEEDING TECHNIQUES

A variety of methods can feed microstrip Patch Antenna. These methods can be classified into two categories: contacting and non-contacting. In the contacting methods, the RF power is fed directly to the radiating patch using connecting elements such as a microstrip line [7]. In a non-contacting scheme, the patch is not directly fed with the RF power, but instead, power is transferred to the path from the feed line through electromagnetic coupling. The most commonly used non- contacting feed methods are aperture and proximity coupled feed.

A. Microstrip Line Feed

In this type of feed technique, a conducting strip is connected directly to the microstrip patch's edge, as shown in figure 2. The conducting strip is smaller in width than the patch, and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure [3,8].

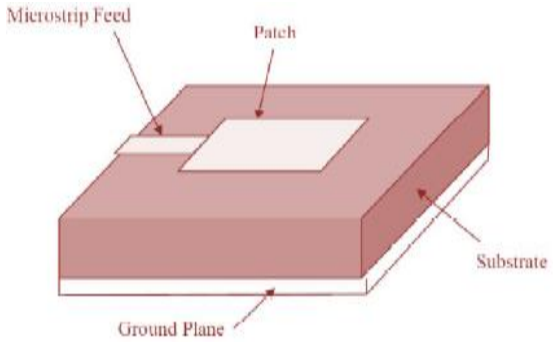


Figure 8: Microstrip Line Feed

The purpose of the inset cut in the patch is to match the feed line's impedance to the patch without the need for any additional matching element, as in figure 3.

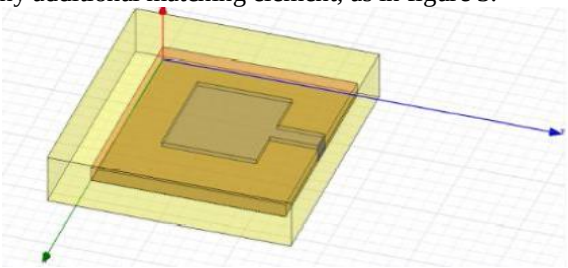


Figure 9: Design using Microstrip line feed

B. Co-axial Feed

The co-axial feed is a non-planar feeding technique in which z co-axial cable is used to feed the patch. The inner conductor of the co-axial connector extends through the dielectric, making a metal contact with the patch, and the outer conductor of the cable is connected to the ground plane, as shown in figure 4. The probe is in direct contact with the antenna, and it is located at the point where the antenna input is 50 ohms.

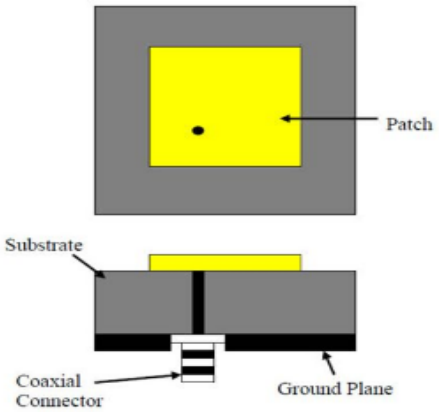


Figure 10: Co-axial feed line

This feed method is easy to fabricate and has low spurious radiation. However, its major disadvantage is that it connected to Ground Plane Connector, as shown in figure 5.

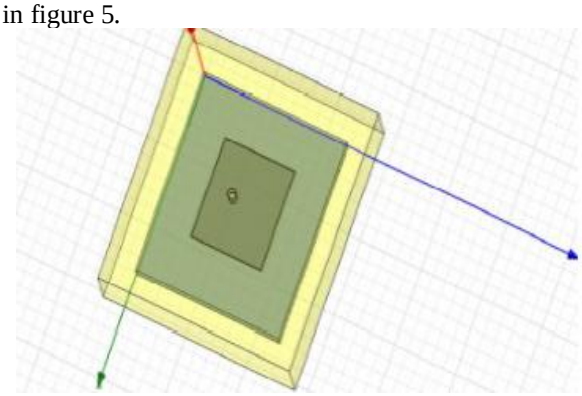


Figure 11: Design using Co-axial Feed

C. Aperture Coupled Feed

The aperture feed technique consists of two dielectric substrates, namely antenna dielectric substrate, and feed dielectric substrate. These dielectric substrates are separated by a ground plane, which has a slot at its center. The metal patch is placed on top of the antenna substrate is shown in figure 5. The ground plane is placed on the other side of the antenna dielectric. The feed dielectric and feed line are placed on the other side of the ground plane to provide isolation. Aperture feed provides excellent polarization purity, which is something unattainable with other feed techniques [9]. Aperture fed antenna offers higher bandwidth. It is very useful in applications in which we don't want to use wires from one layer to another. The disadvantage with this feed is that it requires multilayer fabrication.

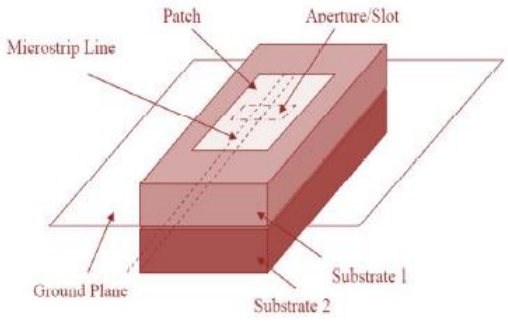


Figure 12: Aperture coupling line feed

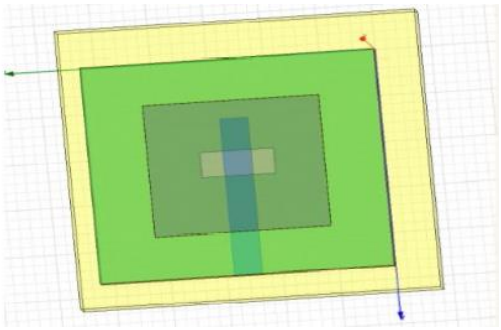


Figure 13: Design using aperture Coupled feed

D. Proximity Coupled Feed

In proximity feed, the feed line is placed between two dielectric substrates. In the edge fed technique, it is impossible to choose a 50 ohms feed point since the impedance at the edges will be very high. To overcome this, the feed line is moved to a lower level below the patch. The edge of the feed line is located at a point where the antenna input impedance is 50 ohms. Here the power transfer from the feed to the patch takes place through electromagnetic field coupling. Since the feed line has been moved to a lower level, feed line radiation has been reduced to a great extent, and also, this technique allows planar feeding [6]. Also, it has an improved bandwidth efficiency compared to the other techniques. The disadvantage with this method is that multilayer fabrication has to be done, and it offers poor polarization purity [8,10].

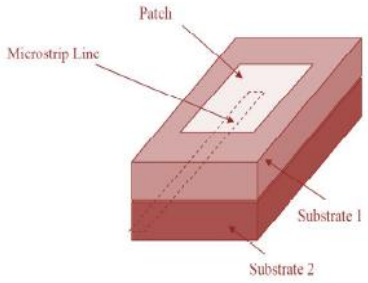


Figure 14: Proximity Coupled line feed

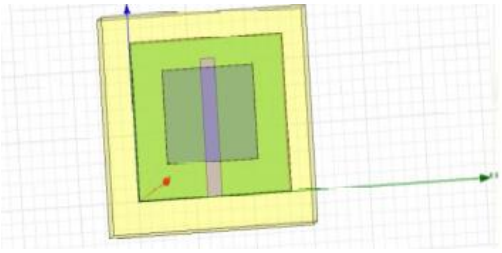


Figure 15: Design using Proximity Coupled feed

E. Branch Line Feed

In this type of feed technique, a conducting strip is connected directly to the microstrip patch's edge, as shown in the figure. The conducting strip is smaller in width as compared to the patch. This kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. An inset cut can be incorporated into the patch to obtain good impedance matching without the need for any additional matching element. This is achieved by properly controlling the inset position, or we can cut the slot and etch it from the patch with an appropriate size, as shown in the figure. Moreover, this technique is used nowadays and named branch feed microstrip line feed technique.

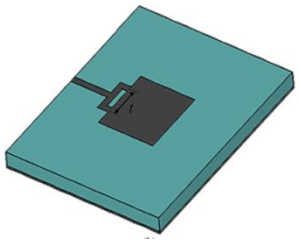


Figure 16: Branch line feed

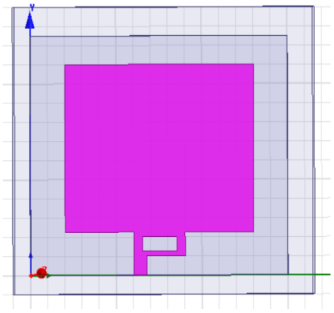


Figure 17: Design using branch feed

VI. COMPARISON OF DIFFERENT FEEDING TECHNIQUES

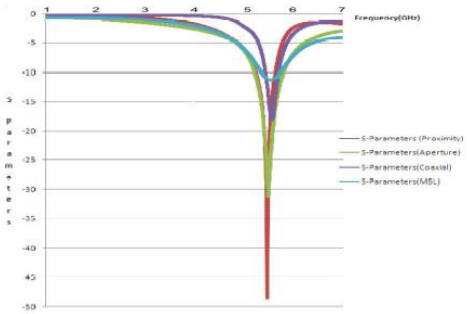


Figure 18: comparison of different feeding technique

Comparisons between different techniques are that the Aperture-coupled feed has more bandwidth but less directivity. The co-axial feed provides high beam-width but less bandwidth. We can observe that the Proximity fed antenna has poor radiation performance. Inset feed has the highest directivity [11]. Aperture feed has the lowest reflection loss. The co-axial feed has the highest beam-width. Aperture feed has the lowest VSWR value. Comparing the four antennas, we infer that aperture fed antenna has better radiation performance than all the four antennas. Inset fed antenna has a moderate radiation performance but has the simplest structure making it easier to fabricate.

VI. CHALLENGES

Antenna size is kept large for the lower frequency spectrum to meet the requirements of the application. Many challenges for antenna design have been used to reduce the size of the antenna, such as:

- Using dielectric substrates with high permittivity applying resistive or reactive loading
- Increasing the electrical length of the antenna by optimizing its shape
- Utilization of strategically positioned notches on the patch antenna.
- Various shapes of slots and slits have been embedded on patch antennas to reduce their size.

VII. CONCLUSION

In this paper, there are the five feeding techniques for the Rectangular MPA is compiled and compared in terms of return loss, VSWR, Gain, and Bandwidth. The following conclusions are made from the comparative study of the different feeding techniques of the patch antenna:

1. The proper selection of a feeding technique for a microstrip patch antenna is important because it affects the bandwidth, S11, VSWR, patch size, radiation efficiency, and impedance matching.
2. Inset fed antenna has the highest directivity, and co-axial fed antenna has the lowest directivity. Aperture antenna has a moderate directivity. Since inset fed antennas have high directivity, they can be used as a coupler in MRI applications and long-distance communications.

REFERENCES

[1] Indrasen Singh, Dr. V.S. Tripathi "Microstrip Patch Antenna and its Applications: a Survey" Indrasen Singh et al., International J. Comp. Tech. Appl., Vol 2 (5), 1595-1599.

[2] C.A. Balanis, Antenna theory: analysis and design, 2nd ed., John Willey and & Son, Inc., 1997

[3] ParwinderKaur, "Gain Enhancement of Microstrip Patch Antenna with Slotting Techniques" International Journal Of Advanced Research in Engineering & Management (IJAREM)- Volume 03, issue 01, PP.13-19, ISSN:2456-2033, Feb 2017.

[4] SourabhBisht, ShwetaSaini, DrVedPrakash, BhaskarNautiyal" Study The Various Feeding Techniques of Microstrip Antenna Using Design and Simulation Using CST Microwave Studio." International Journal of Emerging Technology and Advanced Engineering Volume 4, Issue 9, September 2014.

[5] Liton Chandra Paul, Nahid Sultan "DESIGN, SIMULATION AND PERFORMANCE ANALYSIS OF A LINE FEED RECTANGULAR MICRO-STRIP PATCH ANTENNA," International Journal of Engineering Sciences & Emerging Technologies, Feb. 2013. ISSN: 2231 – 6604 Volume 4, Issue 2, pp: 117-126 ©IJESET.

[6] Navneet Kaur, Narinder Sharma &Navdeep Singh, "A Study Of Different Feeding Mechanisms In Microstrip Patch Antenna", International Journal of Microwaves Applications, Volume 6, No. 1, January – February 2017.

[7] AlakMajumder," Rectangular Microstrip Patch Antenna Using Coaxial Probe Feeding Technique to Operate in SBand", International Journal of Engineering Trends and Technology (IJETT) - Volume4, Issue4- April 2013.

[8] M. Singh, A. Basu; S. K. Koul, "Design of Aperture Coupled Fed Micro-Strip Patch Antenna for Wireless Communication", India Conference, 2006 Annual IEEE, DOI: 10.1109/INDCON.2006.302848.

[9] M.Arulaalanand, L.Nithyanandan "Analysis of Microstrip Line Feed Triangular Patch Antenna for WLAN (2.4GHz)," Proc. of Int. Conf. on Advances in Communication, Network, and Computing, CNC 2014.

[10] M.Susila.T.R.Rao and A.Gupta, "A novel fractal antenna design for UWBwirelesscommunications," IEEE, International Microwave and RF Conference (IMaRC), pp.118- 120, 2014.

[11] R. K. Pandey and T. Shanmuganantham, "Miniaturization and Bandwidth Enhancement of a wideband Slotted Microstrip Patch Antenna", International Conference on Circuit, Power computing Technologies (ICCPCT), pp. 1- 4, 2016, DOI:10.1109/ICCPCT.2016.7530263.

[12] Y. P. Saputra, Y. Wahyu and A.Munir, "Slot Utilization for Altering Polarization of X-band microstrip Patch Antenna", 13th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON 2016), Chiang Mai, Thailand, 28 June – 1 July 2016, IEEE Catalog Number: CFP1606E-POD, ISBN: 978-1-4673-9750-6.

[13] X. Liu, Y. Li, Z. Liang, and S. Zheng, "A Triple-Band Microstrip Antenna Using a 1/8 Annular SectorPatch with Slots and Vias", IEEE International Conference on Computational Electromagnetics(ICCEM), pp. 81 – 83, 2016, DOI: 10.1109/COMPEM.2016.7588642.

[14] S. Mishra, P. Wankhade and A. Sahu, "Design and Analysis of T and U shaped slots with TruncatedCorner Rectangular MicrostripPatchn Antenna for Return Loss Enhancement", Symposium on colossal Data Analysis and Networking (CDAN), pp. 1 – 7, 2016, DOI:10.1109/CDAN.2016.7570902.

[15] H. Barapatre, A. Gour, K. Solanki, and P. Gadkari, "Design of UWB circular monopole antenna with enhanced bandwidth", 2nd International Conference on Advances in Electrical, Electronics, Information, Communication, and Bio-Informatics (AEEICB), pp. 275 – 277, Feb. 2016, DOI:10.1109/AEEICB.2016.7538288.

[16] Dinesh B Ganure , S L Mallikarjun , P M Hadalgi , P V Hunagund, "Proximity Coupled Rectangular Microstrip Patch Antenna for S-band applications", IJRET: International Journal of Research in EngineeringandTechnologyeISSN: 2319-1163 | pISSN: 2321-7308.

[17] M. A. Matin, A. I. Sayeed," A Design Rule for Inset-fed Rectangular Microstrip Patch Antenna", WSEAS Transactions Communications.

[18] KJ Vinoy, K.A. Jose, V.K.Varadan, and V.V. Varadan, "Hilbert curve fractal Antenna: a small resonant antenna for VHF/UHF applications," Microwave &Optical Technology Letters, vol. 29, pp. 215-219,2001.

[19] H.-O. Peitgen, J.M. Henriques, L.F. Penedo(Eds.), Fractals in the Fundamental and Applied Sciences, Amsterdam: North-Holland,1991.

[20] CTP Song, P.S. Hall, H. Ghafouri-Shiraz andD.Wake,"SierpinskimonopoleAntenna with controlled band spacing and input impedance," Electron. Lett., vol. 35, pp. 1036-1037, 1999.

[21] J. Yeo and R. Mittra, "Modified Sierpinskigasket patch antenna for multi-band Applications," IEEE AP-S Inter. Conf. 2001, Vol. 3, pp. 134-147,2001.

[22] V.K. Varadan, K.A. Jose, V.V. Varadan, R. Hughes, and J.F. Keley, "Novel Microwave planar phase shifter," Microwave J., vol38,1995.

[23] N. Sharma and V. Sharma, "A journey of Antenna from Dipole to Fractal: A Review", Journal of Engineering Technology, pp. 317-351, Vol. 6, Issue 2, July 2017.

[24] R.Anbu and A.Jayakumar, "Design and Analysis of Array Microstrip Patch Antenna with Frequency Reconfiguration" SSRG International Journal of Electronics and Communication Engineering 4.4 (2017): 1-4.

[25] Sudarshan Kumar Jain, "Design and Analysis of Multilayer Substrate Structure Microstrip Patch Antenna" SSRG International Journal of Electronics and Communication Engineering 2.11 (2015): 27-31.