High Gain Yagi-Uda Antenna Using Microstrip Configuration

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Abstract : The paper proposes designing of high gain, multilayered microstrip Yagi-Uda antenna. The proposed antenna is designed to operate over 5.725 to 5.875 GHz, ISM frequency band. The proposed antenna consists of, a metal plated MSA with parasitic patches placed above it. These parasitic patches are also called as directors. The gain of the antenna increases with increase in number of directors. The gain of the antenna has increased further by printing director on a high permittivity superstrate. Parametric study is carried out to optimize the antenna. Yagi-Uda antenna is designed on IE3D mentor graphics software for Linear Polarization (LP). The proposed antenna provides a peak gain of 13.29 dBi and impedance BW corresponding to R.L <-10 dB is 398 MHz. The overall dimensions of the antenna are 23mm × 29mm × 2mm. The proposed antenna can be used for long distance terrestrial communication.

***IndexTerms* - MSA; High gain antenna Yagi-Uda antenna, multi layered structure, λ_0, ISM frequency band, dielectric; Linear Polarization.**

I. INTRODUCTION

Wire Antenna, linear or curved, are some of the oldest, simplest, cheapest, and in many cases the most versatile for many application. The numerical models for wire antennas are much simpler than plate (2D) or aperture (3D) antenna models. Therefore, even large wire antenna structures can be simulated in a matter of seconds or minutes on an ordinary PC. Wires are often used to model simple linearly polarize antennas like monopoles and dipoles placed on large platforms, Wires are also used to build circularly polarized helix antenna.

A Yagi-Uda antenna consists of linear array of dipole elements with one driven element, one reflector and one or more director elements [1]. Earlier, Yagi-Uda antennas were designed using cylindrical metallic dipoles, which have large weight such as television reception mounted on the roof of home and buildings etc. To reduce its weight, a microstrip based planar Yagi-Uda antennas were introduced as microstrip based planar antennas have advantages of low profile, light weight, compact size, low cost, simple to fabricate and easy to integrate with other RF components etc. which significantly increases its applications in modern wireless communication system [2]. Planar Yagi-Uda antennas are widely used in various applications such as wireless communication system, phased arrays, radar systems, RFID reader, portable direction finding systems, etc. First planar Yagi-Uda antenna was proposed by Qian in 1998 [3]. After that, many researchers proposed new configurations based on different feed structures and element shapes to make the design broadband [4-7,13].

Yagi-Uda antenna is designed for ISM band to achieve high gain using stripline structure [12]. Proposed antenna is the Yagi-Uda array antenna with multiple directors and different dielectrics. High gain is achieved using tapered shaped antenna than the normal rectangular micro strip antenna. A microstrip balun structure is used to miniaturize the Yagi and to improve the characteristics of the antenna [13].

Planar Yagi-Uda antenna mimetized for TDT reception, balun structure matches the TDT operating band. The planar antenna reduces the visual impact of classical antenna used for TDT reception [15]. Stub and milled cavities helps to improve the gain of Yagi-Uda antenna, they can be placed on top of the very thin bendable substrate. Coaxial probe is replaced with microstrip line for better impedance matching and high gain with reduced return loss at resonant frequency [14,16].

In this paper Yagi-Uda Antenna is designed for linear polarization. The proposed system is designed on IE3D Mentor graphics software to obtain optimized antenna done parametric study depends upon the various parameter. Different dielectric layers are used to designed the structure.

II. ANTENNA GEOMETRY AND DESIGN THEORY

The geometry of proposed antenna structure is shown in Figure 1. To increase antenna efficiency metal plated linearly polarized MSA is designed using air as a dielectric substrate and the patch is placed at h_1 = 2 mm from ground plane. This antenna is designed using a square ground plane of 80mm ×80mm, to operate over 5.725 GHz to 5.875 GHz ISM, frequency band. This antenna is termed as ‘ Ant1’ and its optimized patch dimensions are 23mm × 29mm and MSA is fed through a coaxial probe of 50 Ω. The structure is simulated on finite ground plane and optimized using method of moment based IE3D Mentor Graphics software. ‘Ant1’ provides, a peak gain of 10.51 dBi, antenna efficiency> 90%, impedance BW of 348 MHz, which covers 5.65 GHz to 5.99 GHz, frequency band.

Now to increase the gain of ‘ Ant1’ , a parasitic patch, so called director-1 is placed above the ‘ Ant1’ . The size of the director-1 is a square patch of 18 mm×18mm.

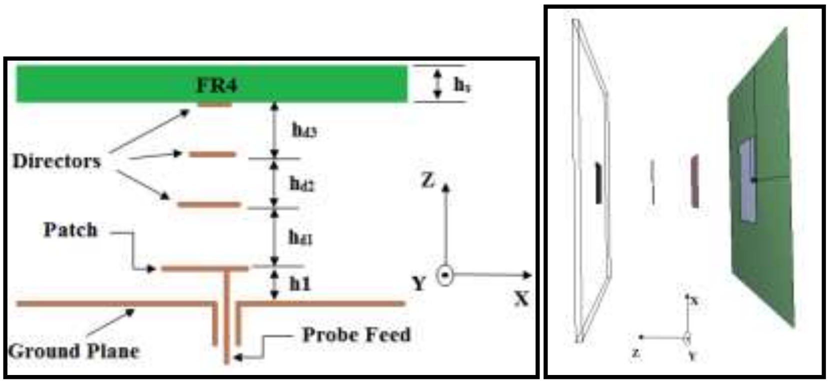


Figure 1. geometry of proposed antenna

These square patches act as a shunt capacitors while the dielectric loaded short circuit transmission line act as shunt inductor in parallel with shunt capacitors. The value of the capacitance and inductance varies with frequency and therefore MSA or parallel L-C circuit behaves as inductive, resonant or capacitive circuit depending on the frequency. Yagi-Uda Antenna with uniform MSA layer provides 12.78 dBi gain at 5.75 GHz with bandwidth of 383 MHz (5.715 GHz to5.865 GHz) the geometry is called as 'Ant2' it has efficiency > 90% over the total BW.

By Yagi theory after placing more director at proper height the gain of the antenna should be increased. To enhance the gain of the antenna further, two more directors are placed above the 'Ant2'. The antenna designed with three directors is having the gain of 12.8 dBi with BW of 183 MHz. The geometry is called as 'Ant3'. To increase the gain of Ant3 the patch i.e. parasitic element is placed under the FR4 superstrate.

The superstrate is designed by snell's law to confine wave over a narrow region so that gain will be increased with increase in BW. Snell's law states that whenever wave passes from rare medium to denser medium there is tendency of wave to bend towards normal axis of the interface. Gain has improved to 13.29 dBi by placing third director on the FR4 superstrate. The BW enhanced to 398 MHz with efficiency >80% over the complete band. FR4 superstrate enhances the gain and BW over a complete ISM band which can be evaluated from Fig .2-4. The geometry is called as 'Ant4'.

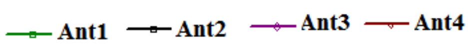
The parametric study was carried out for better the antenna geometry and to enhance the gain of the antenna. Parameters of the antenna are length,width, distance between parasitic elements, feed position and effect of changing dielectric. Basic parameteric study was carried out with FR4 antenna such that the effective changes in AIR dielectric are observed in gain and RL. The BW of the free space antnna is observed more compared to FR4 antenna. To reduced the height of the antenna distance between each parasitic element is changed and observed the changes. The design shown in this paper is optimized with less height and free space dielectric which constant gain over the ISM band.

III. Simulation results and Analysis

The analysis of the proposed antenna is shown in Table.1. The comparison of patch antenna to three layer Yagi-Uda antenna with FR4 superstrate is shown. The same illustrated with Figure.2-4.

Antenna	R.L (dB)	BW (MHz)	Gain (dBi)	F/B ratio	Efficiency (%)
Ant1	-30	348	10.51	-0.76	99.41
Ant2	-23	383	12.78	-2.13	99.25
Ant3	-41	183	12.8	-1.07	98.8
Ant4	-13	398	13.29	-7.95	80.19

Table.1. comparison of patch antenna to three layer antenna



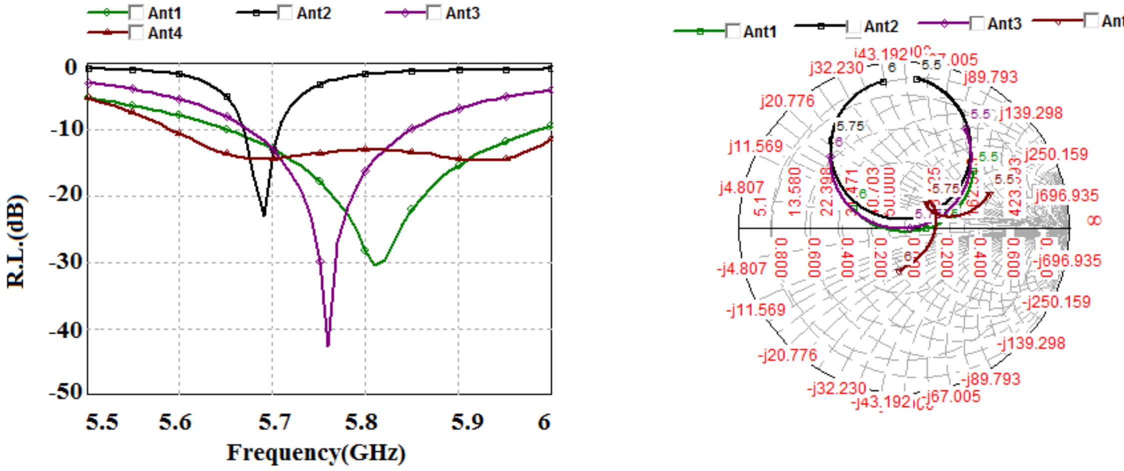


Figure 2. rl and impedance variation vs. frequency

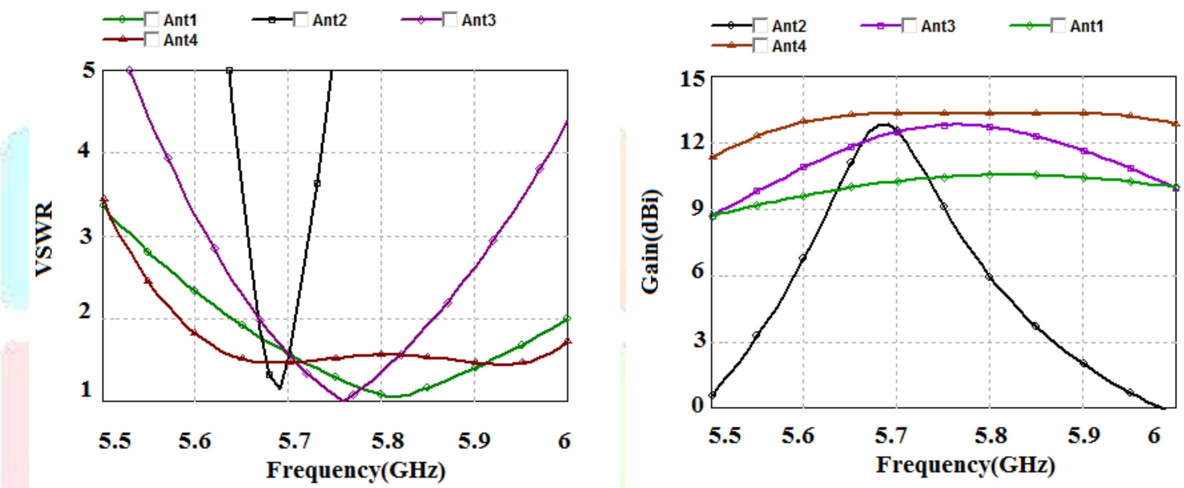


Figure 3. vswr and gain vs. frequency

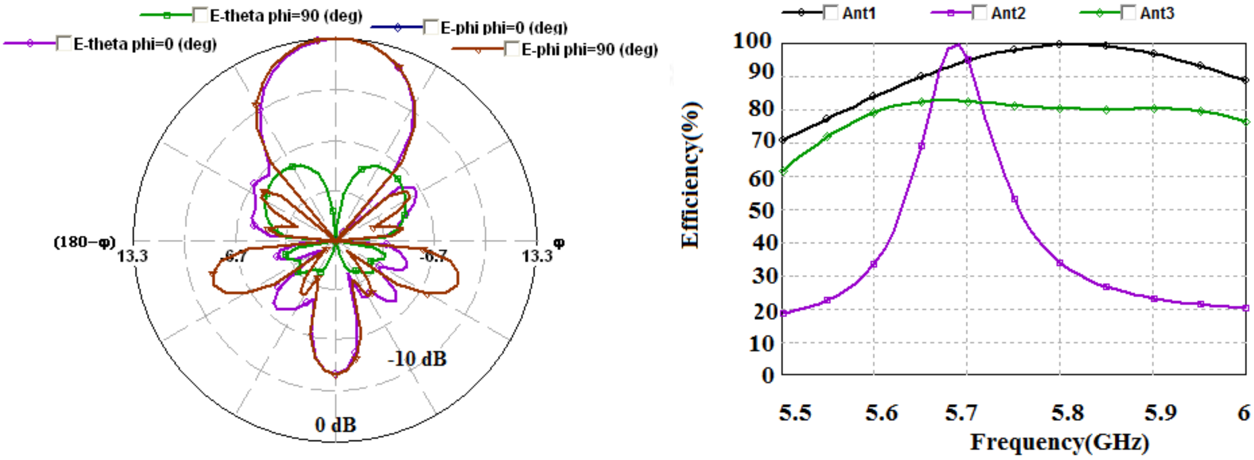


Figure 4. radiation pattern and efficiency

IV. ANTENNA FABRICATION AND MEASUREMENT RESULTS

The fabricated structure is shown in Figure 5.

Figure 5. fabricated structure

A high gain linearly polarized Yagi-Uda antenna with an substrate of FR4 layer is proposed. The gain of the antenna is improved by placing a Patch on FR4 above a metal plated linearly polarized antenna. The proposed antenna provides more than 90% efficiency and a peak gain of 13.21 dBi. The antenna offers SLL< -20 dB, cross polarization<-19 dB and F/B lobe ratio > 20dB. The proposed antenna can be a good candidate as a access point for WLAN, Wimax, RFID and it can be made suitable for long distance communication by increasing number of directors on it.

Abbreviations

dB	Decibel
ISM	Industrial-Scientific-Medical
RL	Return Loss
VSWR	Voltage Standing Wave Ratio
MSA	Microstrip Antenna
PCB	Printed Circuit Board

Table.2. Abbreviations

REFERENCES

[1] C.A.Balanis, " Antenna Theory: Analysis and Design," *Wiley-Interscience*, 2005.
[2] G. Kumar and K. P. Ray, Broadband Microstrip Antennas, *Artech House*, USA, 2003.
[3] Y. Qian, W. R. Deal, N. Kaneda et al., "Microstrip-fed quasi-Yagi antenna with broadband characteristics," *Electronics Letters, vol. 34*, no. 23, pp. 2194-2196, 12 Nov 1998.
[4] N. Kaneda, W. R. Deal, Yongxi Qian, et al., "A broadband planar quasi-Yagi antenna," *IEEE Transactions on Antennas and Propagation, vol. 50*, no. 8, pp. 1158-1160, Aug 2002.
[5] G. S. Shiroma and W. A. Shiroma,"A Two-Element L-Band Quasi-Yagi Antenna Array With Omnidirectional Coverage," *IEEE Transactions on Antennas and Propagation, vol. 55*, no.12, pp. 3713-3716, Dec. 2007.
[6] T. G. Ma, C. W. Wang, R. C. Hua et al.,"A Modified Quasi- Yagi Antenna With a New Compact Microstrip-to-Coplanar Strip Transition Using Artificial Transmission Lines," *in IEEE Transactions on Antennas and Propagation, vol. 57, no. 8, pp. 2469-2474, Aug. 2009*.
[7] H. Karbalaee, M. R. Salehifar and S. Soleimany,"Designing Yagi-Uda antenna fed by microstrip line and simulated by HFSS," *Application of Information and Communication Technologies (AICT), 2012 6th International Conference on, Tbilisi, 2012, pp. 1-5.*
[8] R. D. Javor, X.D. Wu, and K. Chang, "Design and performance of a microstrip reflect array antenna*", IEEE Trans. Antennas Prop., Vol. AP-43, 1995*
[9] D.M.Pozar, S.D.Targonski and H. Syrigos, "Design of millimeter wave mi-crostrip reflec tarrays", *IEEE Trans. Antennas Propagat., vol. AP-45 no.2, pp.287-295, Feb. 1997*.
[10] D. M. Pozar and D. H. Schaubert, Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays", *John Wiley and sons Inc. USA, 1995*.
[11] John D Kraus, Antenna for all application", *TATA McGraw-Hill edition,2nd edition.*

[12] Alper alkan and Filiz Gne, Mehmet A. Belen, " Coplanar Stripline-Fed Mi- crostrip Yagi-Uda Antenna",*Department of Electronics and Communica- tion Engineering Yldz Technical University Istanbul, Turkey, in 2017*

[13] Hemant Kumar and Girish Kumar, " Compact Planar Yagi-Uda Antenna with Improved Characteristics", *11th Euro-pean Conference, in 2017*

[14] F.Vavrik, "Testing of Three element Printed Yagi-Uda Antenna", *11th international conference, Measurement 2017*

[15] Jorge Gmez-Yuste, Marta Cabedo-Fabrs, Eva Antonino-Daviu, Miguel Ferrando-Bataller, "Mimetized Printed Yagi-Uda Antenna Array for TDT Reception", *11th European Conference on Antennas and Propagation (EUCAP), 2017*

[16] Pablo Rodriguez-Ulibarri and Thomas Bertuch, " Microstrip-fed complementary Yagi-Uda antenna, IET Microwaves", *Antennas Propagation, 2016, Vol. 10, Iss.9*