Yagi Uda Antenna with Integrated Balun for WLAN Application

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ABSTRACT

In this paper, a printed Yagi-Uda antenna with an integrated balun is presented for WLAN applications. The planar directive antenna is designed to operate at 2.4 GHz and 5 GHz frequency bands. An integrated balun in the form of microstrip-to-coplanar strips (CPS) transition is used to feed the antenna. The substrate material used is FR4 of dielectric constant 4.4 and thickness 1.6mm.The proposed antenna design presents measured bandwidths (RL≤ -10 dB) of 2.37 – 2.42 GHz and 4.78 – 6.17 GHz for VSWR < 2 and with moderate gain of 4 – 4.5 dBi.

Keywords- Printed Yagi antenna, directive antenna, integrated balun, wireless local area network (WLAN).

1. INTRODUCTION

For wireless local area networks (WLAN) communication standards, frequencies of 2.4GHz and 5GHz have been widely used. A large number of access points (APs) is needed inside high buildings, due to the presence of shadowing areas, to achieve ubiquitous coverage of WLAN systems. An AP is commonly attached on the wall or ceiling to provide coverage in a specified area. Therefore, the antenna for WLAN AP requires not only dual band operation but also an insignificant back-radiation. For dual-band applications, several antennas including the printed dipole antennas [1], [2] or slot-monopole antenna [3] were reported. However, these antennas have omni-directional radiation patterns, hence cannot prevent the radiated wave from propagating to undesired directions. For WLAN APs, directional and end fire antennas are promisingly suitable.

The Yagi–Uda antenna [4], has been used extensively as an end-fire antenna. However, only limited success has been achieved at adapting this antenna to microwave/millimetre wave operation. Several interesting approaches for this are a microstrip Yagi array based on the Microstrip patch antenna, and a coplanar-stripline fed printed Yagi–Uda antenna with the reflector element printed on the back of a thick, low-permittivity slab at 60 GHz [5].

In this paper, we report a new type of planar Yagi–Uda antenna that is well suited to microwave and millimetre wave frequencies. The planar Yagi antenna has several advantages over more traditional wire antennas radiating in free space. The presence of the substrate provides mechanical support for the antenna and planar transmission-line compatibility. Wire-type antennas in free space are extremely fragile at high frequencies and difficult to feed. The planar Yagi antenna can be fed by alternative feeding lines, including Microstrip line [6], coplanar waveguide [7], coplanar stripline [8], and slotline [9].

In the proposed paper, printed Yagi antenna is fed by a simply integrated balun in the form of microstrip-to-coplanar strips (CPS) transition. The antenna structure is designed to operate at 2.4GHz and 5GHz bands of WLAN. The proposed antenna is realised on FR4 substrate of dielectric constant 4.4 and thickness 1.6mm.We have achieved good bandwidth for VSWR < 2 and moderate gain of 4 – 4.5 dBi.

2. SIMULATED ANTENNA STRUCTURE

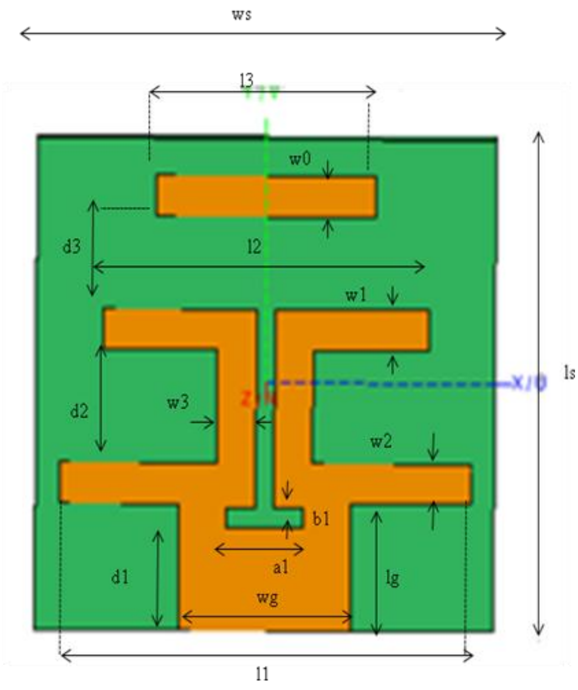
The printed Yagi Uda antenna with an integrated balun was designed on both sides of 24mm x 24mm FR4 (Flame Resistant 4) with a dielectric constant 4.4 and thickness of 1.6mm as shown in figure1.The antenna comprises of an integrated balun feeding, two printed dipoles, a parasitic strip and a ground plane. The two printed dipoles, the larger dipole and the smaller dipole, act as a reflector and driver respectively. The parasitic strip in the proposed structure act as a director.

A printed Yagi-Uda antenna has been presented in [10] where a broadband microstrip-to-coplanar strips (CPS) transition is employed. The ground plane below the transition acts also as the Yagi-Uda reflector. Here we construct different microstrip-to-CPS transition with a shaped ground for optimization of the reflector element. The shaped ground also allows reduction of the metallization near the feeding point. We excite the entire structure by proximity coupling, using an open ended microstrip above a rectangular hole in the ground plane. We used a 50Ω impedance microstrip line on a substrate. The antenna was simulated using CADFEKO software.

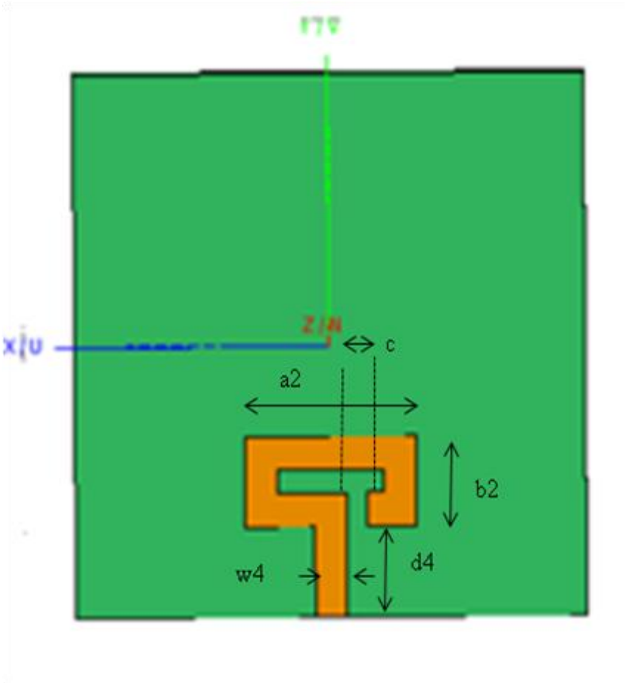
The Proposed antenna dimensions are chosen as -the length and width of substrate is 24 mm each, the length of driver is 21.5 mm, while the length of driver is 17 mm, while the width of each is select 2 mm. The ratio of transition is maintained at 0.5 mm .The design of patch, shaped ground plane and feeding mechanism guarantees WLAN response of the sensing antenna. [11-12].

3. SIMULATION AND RESULTS

The proposed antenna is simulated using CADFEKO 6.0 software. The various parameters like - Return loss, Impedance, VSWR, Bandwidth, Radiation pattern, Gain, Directivity are studied.



Top View



Back View

Fig.1. Proposed antenna design

Return loss is a convenient way to characterize the input and output signal sources. It should be below -10 dB for proper matching and good efficiency of an antenna. The input impedance of an antenna is ratio of input voltage to the input current at the input terminals. It should match to 50 ohm to make antenna more perfect. At each interface, depending on the impedance match, some fraction of the wave's energy will reflect back to the source, forming a standing wave in the feed line which decides the antenna efficiency. The VSWR is a ratio of maximum voltage to the minimum voltage along the line which expresses the degree of match between the transmission line and the antenna. When the VSWR is 1 the match is perfect and all the energy is transferred to the antenna prior to be radiated. The directivity is used to characterize the relative radiation intensity in a specific direction with respect to the average radiation intensity over all directions. Antenna gain is defined as antenna directivity times a factor representing the radiation efficiency. This efficiency is defined as the ratio of the radiated power to the input power. The gain of an antenna is defined based on the power delivered to the antenna.The bandwidth of an antenna is the range of frequencies over which it is effective usually centered on the resonant frequency. The Radiation pattern_of an antenna is the geometric pattern of the relative field strengths of the field emitted by the antenna which indicates the direction of the power transmission or reception of antenna.

For a proposed antenna we got dual band operation. At lower band of frequencies ranging from 2.37 GHz to 2.42 GHz the operating frequency is 2.39 GHz and return loss is below -10dB for complete band of 43 MHz. At the operating or resonant frequency the impedance is 45.5 ohm and VSWR is 1.28.The directivity of antenna at lower band is around 6 to 6.5 dBi and gain around 4 to 4.5 dBi.

Similarly for upper band of frequencies ranging from 4.78 GHz to 6.17 GHz the operating frequency is 5.02 GHz and return loss is below -10dB for complete band of 1.39 GHz. At the operating frequency the impedance is 47 ohm and VSWR is 1.15.The directivity of antenna at upper band is around 6 to 6.5 dBi and gain around 4 to 4.5 dBi.

Thus the proposed antenna is designed and simulated for dual band WLAN application. Simulated parameters are visualized in the following figures. Figure 2 shows the return loss plot where two deep notches are found at 2.39 and 5.02 GHz. These both frequencies are useful in wireless application.

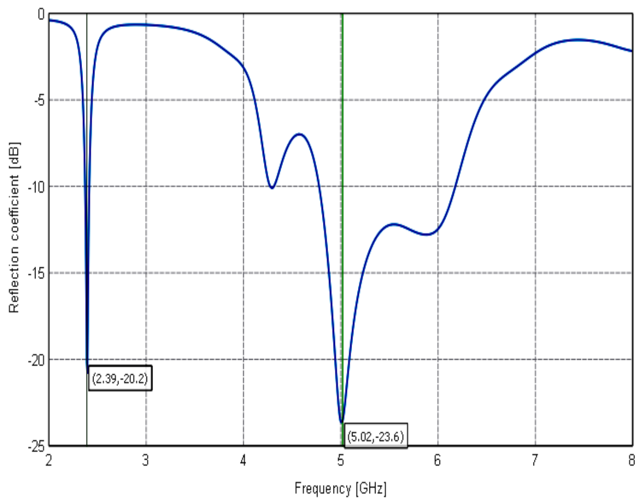


Fig.2. Return loss plot

The bandwidth is found to be 45 MHz at resonance frequency 2.39 GHz. while at higher band i.e. resonance frequency at 5.02 GHz, we get wide bandwidth of 1.39 GHz.

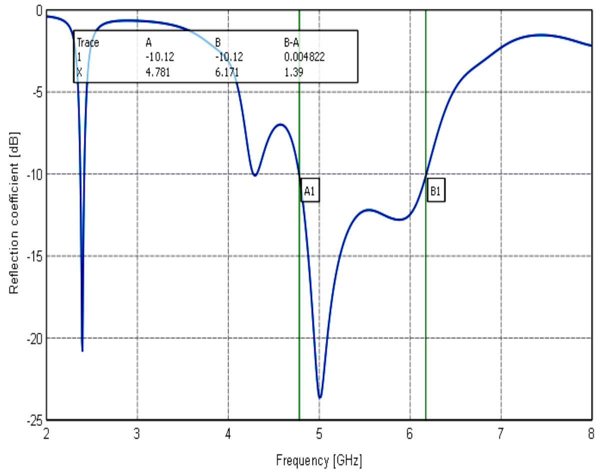


Fig.3. Return loss plot showing bandwidth at 5GHz

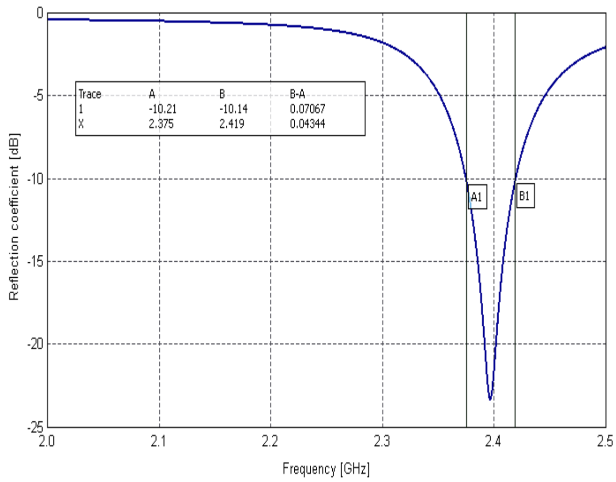


Fig.4. Return loss plot showing bandwidth at 2.4GHz

The value of VSWR is found to be in between 1 and 2 in both band i.e. lower as well as higher band. The impedance of antenna is quite closer to the 50 Ω.

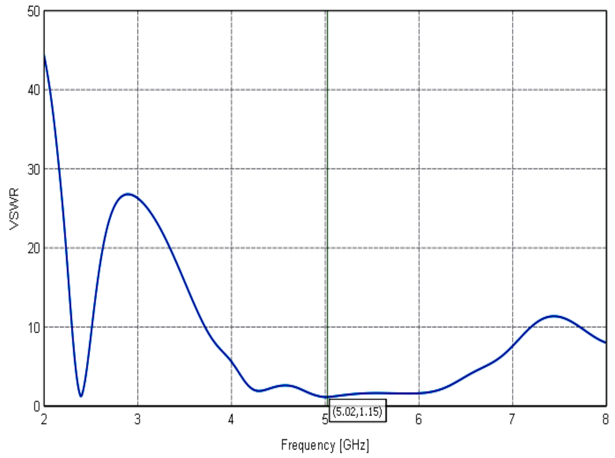


Fig.5. VSWR plot

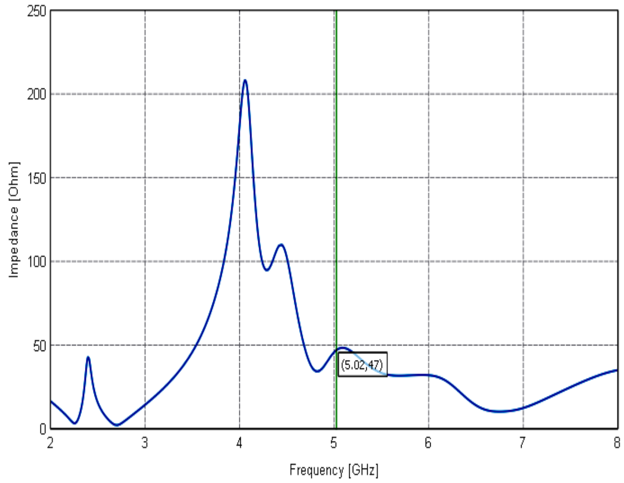


Fig.5. Impedance plot

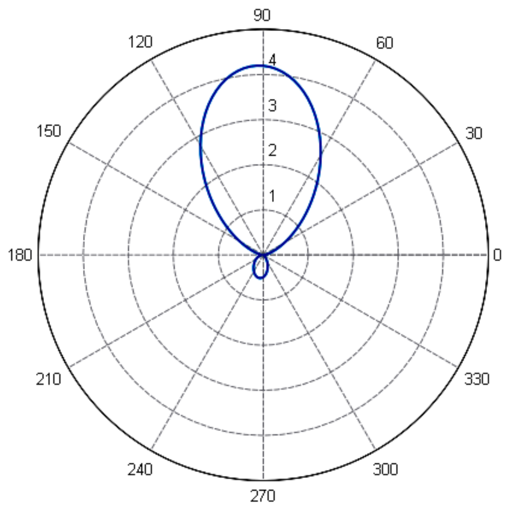


Fig.6. Polar plot showing directivity

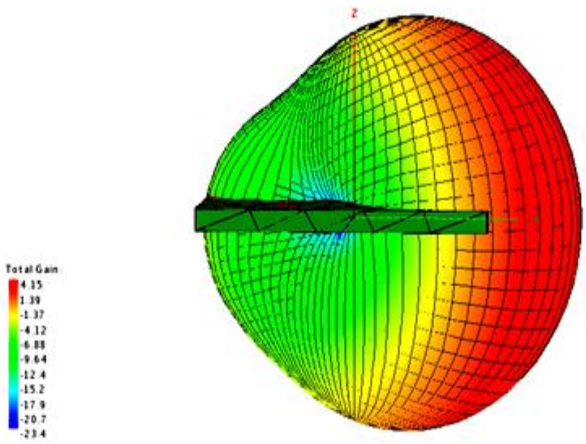


Fig.7. The radiation pattern showing gain of antenna at upper band

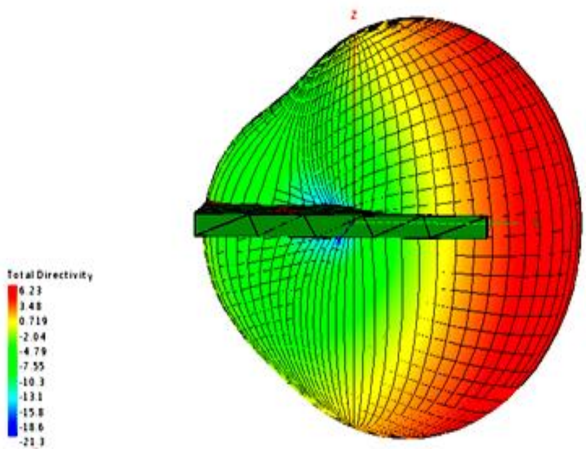


Fig.8. The radiation pattern showing directivity of antenna at upper band

4. CONCLUSION

The printed Yagi Uda antenna with an integrated balun has been designed for WLAN applications. The antenna is designed to operate at 2.4 GHz and 5 GHz frequency bands. The antenna has bandwidth of 43 MHz at 2.39 GHz and 1.39 GHz at 5.02 GHz. The gain of antenna is around 4-4.5 dBi and directivity of 6-6.5 dBi. The proposed antenna is used for indoor applications due to compact size. Also it can be extended to arrays having a large number of antennas due to compact size of antenna.

5. REFERENCES

[1] E. Avila-Navarro, C. Cayuelas, and C. Reig, "Dual-band printed dipole antenna for Wi-Fi 802.11n applications," *Electronics Letters,* vol. 46, no. 21, pp. 1421–1422, 2010.

[2] N. Zhang, P. Li, B. Liu, X.W. Shi, and Y. J.Wang, "Dual-band and low cross-polarisation printed dipole antenna with L-slot and tapered structure for WLAN applications," *Electronics Letters*, vol. 47, no. 6, pp. 360–361, 2011.

[3] C.-Y. Huang and E.-Z. Yu, "A slot-monopole antenna for dualband WLAN applications," *IEEE Antennas and Wireless Propagation Letters,* vol. 10, pp. 500–502, 2011.

[4] J.Huang and A. C. Densmore, "MicrostripYagi array antenna for mobile satellite vehicle application," *IEEE Trans. Antennas Propagat.*, vol. 39,pp. 1024–1030, July 1991.

[5] K. Uehara, K. Miyashita, K. I. Matsume, K. H. Hatakeyama, and K.Mizuno, "Lens-coupled imaging arrays for the millimeter and submillimeter-wave regions," *IEEE Trans. Microwave Theory Technol.*, vol.40, pp. 806–811, May 1992.

[6] Y. Qian, W. R. Deal, N. Kaneda, and T. Itoh, "Microstrip-fed quasi-Yagi antenna with broadband characteristics," *Electronics Letters,* vol. 34, no. 23, pp. 2194–2196, 1998.

[7] L. H. Truong, Y.-H. Baek, M.-K. Lee, S.-W. Park, S.-J. Lee, and J.-K. Rhee, "A high-performance 94 GHz planar Quasi-Yagi antenna on GaAs substrate," *Microwave and Optical Technology Letters,* vol. 51, no. 10, pp. 2396–2400, 2009.

[8] K. Han, Y. Park, H. Choo, and I. Park, "Broadband CPS-fed Yagi- Uda antenna," *Electronics Letters,* vol. 45, no. 24, pp. 1207–1209, 2009.

[9] S. X. Ta, B. Kim, H. Choo, and I. Park, "Slot-line-fed Quasi Yagi Antenna," *in the 9th International Symposium on Antennas, Propagation, and EM Theory*, Guangzhou, China 2010.

[10] N.Kaneda,W.R.Deal,Y.Qian,R.Waterhouse,and T. Itoh, "A Broadband Planar Quasi Yagi Uda Antenna,"*IEEE Trans.Antennas Propag*.,vol50,pp.1158-1160,Aug.2002.

[11] Son Xuat Ta , Ikmo Park , Chien Dao-Ngoc, ,"A Hybrid of T-Dipole and Quasi Yagi Antenna for Dual-band WLAN Access Point,"*REV Journal on electronics and communications*,vol.2,No.1-2,January-June,2012.

[12] Antonio-Daniele, Capobianco, Filippo Maria Pigozzo, Antonio Assalini, Michele Midrio, Stefano Boscolo ,and Francesco Sacchetto,"A Compact MIMO Array of Planar End-Fire Antennas for WLAN Applications,"*IEEE Trans. Antennas Propag.*, vol. 59, no.9,September,20