ISSN: 2395-1680 (ONLINE)
DOI: 10.21917/ijme.2018.0113

DESIGN AND DEVELOPMENT OF TWO ELEMENT SERIES-FED TWO DIPOLE ANTENNA FOR WLAN BASE STATION APPLICATIONS

G. Geetharamani[1] and T. Aathmanesan[2]
[1]*Department of Mathematics, Anna University, Chennai, India*
[2]*Department of Information and Communication Engineering, Anna University, Chennai, India*

Abstract

Design and development of antenna is the first step in improving overall effective coverage area of wireless communication. In this paper, two element series-fed two dipole antenna is designed for the WLAN base station applications with improved mutual coupling. The proposed antenna operates at IEEE 802.11b standard 2.4 GHz frequency band with reduced size and improved gain for increasing effective access to wireless internet to the end users in wireless communication. A modified balun feeding is used for improving impedance matching. This antenna is designed over the FR4 substrate with dielectric permittivity of 4.4 and height of the substrate is 1.6mm to achieve lower return loss. The dimension of the proposed antenna is 105 mm length 160 mm width. This antenna is simulated in an integral based solver simulation software called CST Microwave studio v2018 and achieved best results such as VSWR 1.3, return loss -16.56dB and bandwidth of 200MHz, directivity of 9.26dBi, gain of 8.68dB and an efficiency of 70%. This antenna suits for WLAN base stations.

Keywords:

WLAN, Series-Fed Two Dipole Antenna, Base Station Antenna, Patch Antenna

1. INTRODUCTION

The expansion of wireless communication helps our daily high-speed data requirements and improves the capacity of professional networking. The data driven industries needs more powerful connections for sustaining the business growth. To meet all these requirements developing new antenna technology is unavoidable in improving the overall efficiency of wireless communication. Wireless Local Area Networks (WLANs) is capable of providing larger range or coverage, with high throughput while providing high power consumption at the lowest cost. The IEEE 802.11 specification was approved in July 1997, since then 2.4GHz is widely driving major WLAN communication. Therefore, this paper focuses on the design of two element series-fed two dipole antenna for providing 2.4GHz base station applications.

The design of single element series-fed two dipole antenna has already been developed and discussed in [4] which performed well. Still to increase its usefulness and coverage area the fundamental design is used for developing two element antenna systems keeping the mutual coupling under control along with the other parameters for developing a new two element series-fed two dipole antenna. The software used in this work is CST Microwave studio v2018. CST microwave studio is an electromagnetic field simulation software which is based on finite integration technique and for analysis of patch antennas time domain solver is used. This CST microwave studio is selected based on its user interface, which is very simple and has the capability of simulating complex structures. The next part of this section follows with the literature review.

The literature review deals with the basics of micro patch antennas [1] - [3], Single element series-fed two dipole antenna with gain of 6.19dBi for 2.4GHz frequency WLAN Base Stations and wireless access points is discussed in [4]. The fundamental design of series-fed two dipole antenna with a bandwidth in the range of 1.68-2.76GHz and a stable gain of 5.57-6.0dBi is presented in [5]. The literature work is further expanded in different base station antennas published in recent times. A modified series-fed two-dipole-array antenna is used to reduce the size along with the bandwidth in the range of 1.68-2.79GHz and a stable gain of 5.86-6.13dBi is discussed in [6]. A bow-tie element is used to enhance gain and front-to-back ratio of series-fed two dipole array antenna covering a frequency band ranging from 1.7 to 2.7GHz and with a gain >5dBi [7]. Compact MIMO antenna covers the Bluetooth (2.4-2.484GHz), Worldwide Interoperability for Microwave Access (WiMAX) (3.4-3.69GHz), Wireless Local Area Network (WLAN) (5.15-5.825GHz), and ultra-wideband (UWB) (3.1-10.6GHz) operating bands is presented in [8]. A double dipole antenna is designed with enhanced usable bandwidth of 84% for wideband phased array applications is discussed in [9]. A Dual-band and Dual-polarized Fractal Antenna for 2.4GHz and 5.2GHz wireless LAN communication with the peak gain of 7.6dB and 5.ldB is presented in [10]. A low profile dual band dual polarized antenna with an AMC Surface which can cover a lower band from 2.36GHz to 2.76GHz and a higher band from 5.12GHz to 5.62GHz is discussed in [11]. A dual band high gain antenna array for WLAN and WiMAX Base Station with operating bands 2.31~2.51GHz and 3.1~4.15GHz are obtained for covering WLAN (2.4~2.48GHz) and WiMAX (3.3~3.8GHz) band is presented in [12]. Wideband two bowtie dipole array antenna integrated with a tapered balun has a -10dB impedance bandwidth of 85.9% from 1.38-3.46GHz is discussed in [13]. A Compact Multiband and Dual-Polarized Mobile Base-Station Antenna Using Optimal Array Structure which supports Band 1: cellular service in 0.824∼0.894GHz, Band 2: PCS, WCDMA, and WiFi in 1.920∼2.170GHz, Band 3: WiBro and WiMAX in 2.300∼2.400GHz, and Band 4: WiMAX in 5.150∼5.850GHz is discussed in [14]. A Triple-Band High-Gain Base-Station Antenna for working frequencies of 2.17, 2.44 and 3.65GHz WLAN and Wi-MAX application is presented in [15].

From the literature available it is found that the series-fed two dipole antenna is designed mostly for the mobile communication base stations to cover different range of frequencies and using the design methodology in this work the WLAN base station antenna is developed. In the next section the design methodology is presented.

2. ANTENNA DESIGN

This section presents the detailed design methodology of the proposed two element series-fed two dipole antenna for WLAN base station applications. The front view of the proposed antenna is given in Fig.1 and the back view of the proposed antenna is given in Fig.2.

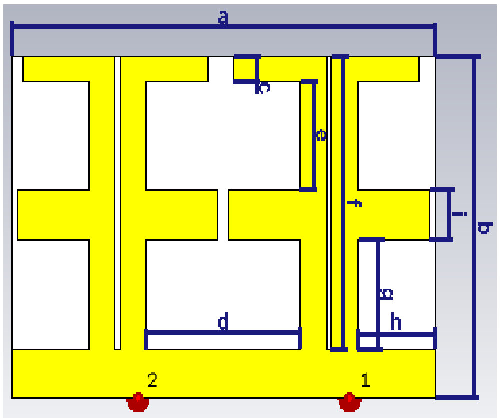


Fig.1. Front View of the Proposed Antenna

The proposed to two element series-fed two dipole antenna consists of pair of two dipoles and a ground structure at the top side. The modified balun feeding is used to provide a better impedance matching the balun structure [6] at the bottom side. The gap of 1.6mm is made in the middle of the structure which gives enough isolation between the radiations from the side lobes, and the gap of 58.40mm is given in between the two dipole antenna elements. The size of the ground plane and the distance between the dipoles and the size of the dipoles and the gap in between the side lobes determines the frequency range of operation therefore these parameters are optimized for the WLAN applications in this work.

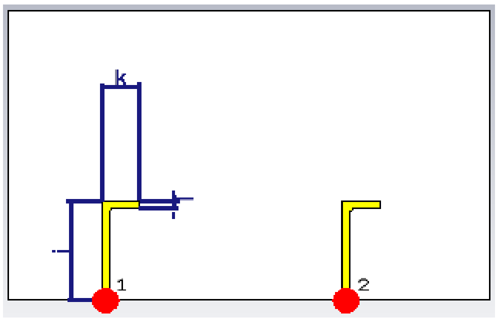


Fig.2. Back View of the Proposed Antenna

The antenna is designed in FR4 Substrate with permittivity of 4.3 and thickness 1.6mm. The patch is designed in copper material having electrical conductivity of $5.8e^7$ with a thickness of 0.035mm. The gap is introduced in the middle of the patch of 1.6mm is also designed in the patch structure for the dipole elements. The position of feeding point is found to 35.50mm above the ground after iterations to achieve required performance of the antenna. The shorting pin of 1mm radius copper via is used to connect the feeing element with the series dipole elements is attached at the end of the balun feeding. The balun feed is modified at the joint as bending curve to provide perfect impedance matching. The design parameters were given in Table.1. In CST Simulation, the discrete port is used for both port 1 and port 2 which are represented as red color dots in the Fig.1 and Fig.2 with 50Ω as a reference impedance. The overall size of the antenna is 160×105mm. The next section of this paper discusses the results obtained from the proposed two element series-fed two dipole antenna.

Table.1. Design Parameters

Parameter	Value in mm
A	105
B	160
C	7.50
D	58.40
E	33.50
F	90
G	34
H	29.20
I	15
j	36
k	12.50
l	2.50

3. RESULTS AND DISCUSSION

In this section the results and discussion are presented. The design and simulation are done in CST microwave studio v2018 and its results such as return loss, VSWR, farfield radiation, surface current, gain and efficiency front to back ratio were discussed below.

3.1 RETURN LOSS

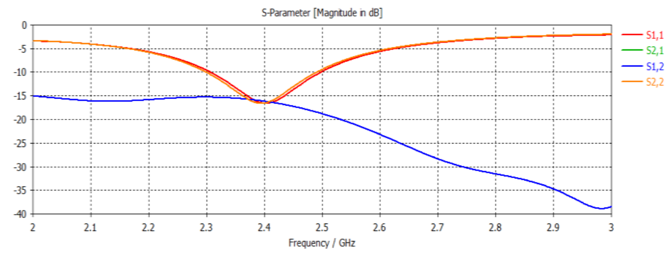


Fig.3. Return loss

The minimum return loss obtained at 2.4GHz is -16.50dB for the proposed antenna which is given in Fig.3. The -10dB Bandwidth obtained at 2.4GHz is 200MHz for the proposed antenna. The mutual coupling between the element 1 and element 2 was found to be -15dB isolation which is the major factor to be considered for the validation of a multi element antenna system. This validates that the proposed design is well suitable for the WLAN applications.

3.2 VSWR

The minimum VSWR (Voltage Standing Wave Ratio) obtained at 2.4GHz is 1.34 for the proposed antenna which is given in Fig.4.The VSWR value must be from 1 to 1.5 for the perfect antenna and the proposed design achieves the value of 1.34 which validates the proposed design will serve for better purpose.

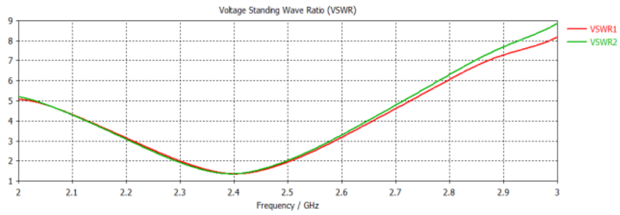
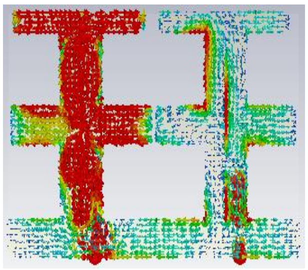


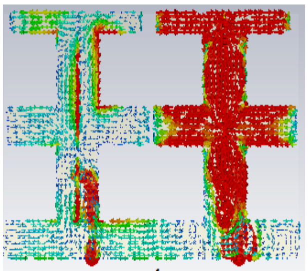
Fig.4. VSWR

3.3 SURFACE CURRENT DISTRIBUTION

The surface current distribution can be a very useful plot for the analysis of design. The surface current distribution plot is given in Fig.5 obtained from the simulation shows the current distribution is starting from the feeding point through the balun designed from the bottom to the top surface of the STDA. The Fig.5(a) represents the surface current distribution when the port 1 is excited and the Fig.5(b) represents the surface current distribution when the port 2 is excited. The green color represents the minimum current generation, and the red indicates the maximum surface current waves generated at the frequency 2.4GHz.



(a)



(b)

Fig.5. Surface Current Distribution (a) Port 1 Excited (b) Port 2 Excited

3.4 FARFIELD ANALYSIS

The radiation pattern defines the variation of the power radiated by an antenna as a function of the direction away from the antenna. The 3D far field radiation is given in Fig.6. The Maximum Efficiency obtained at 2.4GHz is 83.79% and the total Efficiency from 2 to 3GHz frequency range is 76.74% for the proposed antenna. The 2D farfield directivity plots were given in Fig.7.

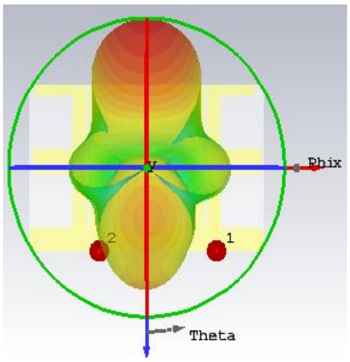


Fig.6. Farfield at 2.4GHz

The 2D farfield directivity plots at Phi=0 and Theta=0 degrees were given in Fig.7, which shows that the radiation characteristics of the proposed antenna is adequate to support WLAN application.

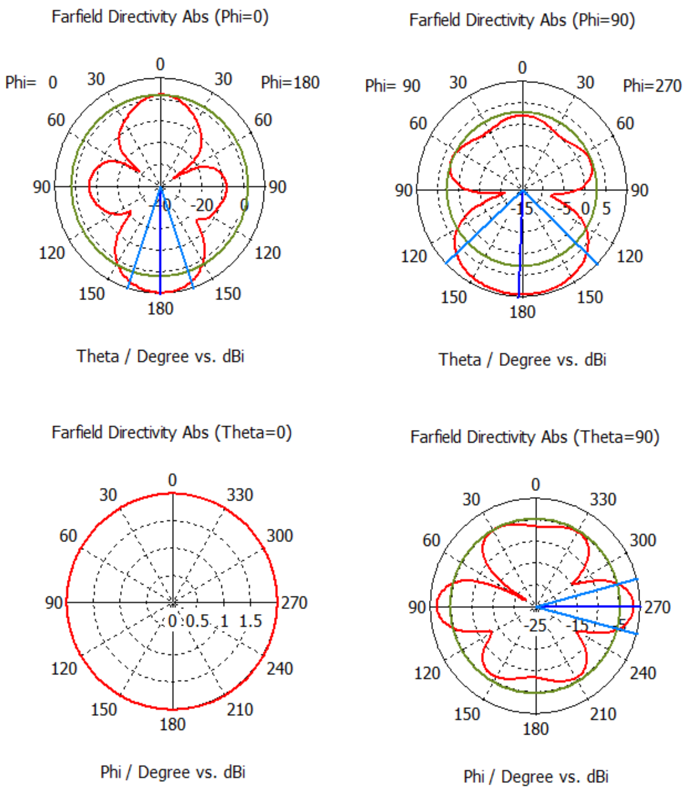


Fig.7. 2D Directivity Plots

3.5 GAIN

The gain plot at frequency 2.4GHz is given in Fig.8, which shows the proposed antenna achieves 8.68dB. Also, the front to back ratio is the ratio of power gain between the front and rear of a directional antenna which is 3.65 for the proposed antenna.

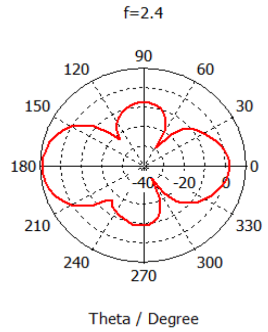


Fig.8. Gain Plot

3.6 EFFICIENCY

The efficiency plot at frequency 2 to 3GHz is given in Fig.9, which shows the proposed antenna achieved radiation efficiency of 67% and total efficiency of 70% at 2.4GHz. The overall results were given in Table.2.

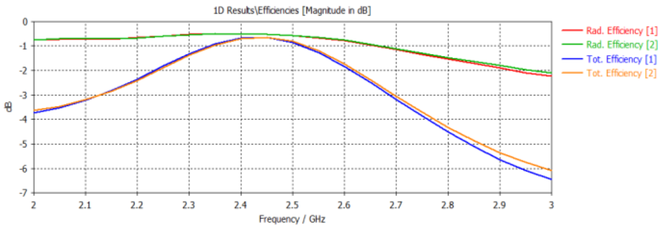


Fig.9. Efficiency Plot

Table.2. Overall Results

Parameter	Value
Frequency	2.4GHz
Return Loss	-16.56dB
VSWR	1.34
Gain	8.68dB
Efficiency	70%
Directivity	9.26dBi
Bandwidth	200MHz
Front-to-back ratio	3.65

4. CONCLUSION AND FUTURE WORKS

The proposed two element series-fed two dipole antenna is performing well in the simulation environment and the major parameters such as return loss -16.56dB, VSWR 1.34, gain 8.68dB and bandwidth 200MHz with 70% efficiency are following the IEEE 802.11b guidelines for operating WLAN Applications in ISM Band frequency. This two-element series-fed two dipole antenna can be used in the WLAN base station applications for larger coverage areas. Future work in this work will be focusing on developing an array of multiple elements series-fed two dipole antennas and design of feeding networks for the improvement of its performance and applications.

REFERENCES

[1] C. A. Balanis, "*Antenna Theory: Analysis and Design*", 2nd Edition, John Wiley and Sons, 1997.

[2] D.M. Pozar and D.H. Schaubert, "*Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays*", Wiley-IEEE Press, 1995.

[3] Yi Huang and Kevin Boyle. "*Antennas from Theory to Practice*", John Wiley and Sons, 2008.

[4] G. Geetharamani and T. Aathmanesan, "Design and Development of Series Fed Two Dipole Antenna for WLAN Base Station Applications", *ICTACT Journal on Microelectronics*, Vol. 4, No. 1, pp. 515-518, 2018.

[5] Junho Yeo and Jong-Ig Lee, "Design of Compact Broadband Series-Fed Two Dipole Array Antenna with Top Loading", *IEEE Antennas and Propagation Society International Symposium*, pp. 892-893, 2013.

[6] J. Yeo and J.I. Lee, "Modified Series-Fed Two-Dipole-Array Antenna with Reduced Size", *IEEE Antennas and Wireless Propagation Letters*, Vol. 12, pp. 214-217, 2013.

[7] J. Yeo and J.I. Lee, "Series-Fed Two Dipole Array Antenna using Bow-Tie Elements with Enhanced Gain and front-to-Back Ratio", *IETE Journal of Electromagnetic Waves and Applications*, Vol. 26, No. 11-12, pp. 1641-1649, 2012.

[8] H.F. Huang and S.G. Xiao, "Compact MIMO Antenna for Bluetooth, WiMAX, WLAN, and UWB Applications", *Microwave Optical Technology Letters*, Vol. 58, No. 4, pp. 783-787, 2016.

[9] A. Eldek, "Design of Double Dipole Antenna with Enhanced Usable Bandwidth for Wideband Phased Array Applications", *Progress in Electromagnetics Research*, Vol. 59, pp. 1-15, 2006.

[10] L. Xi, D. Yang, D. Feng and H. Zhai, "A Dual-band and Dual-polarized Fractal Antenna for WLAN Applications", *Proceedings of 7th Asia Pacific International Symposium on Electromagnetic Compatibility*, pp. 17-21, 2016.

[11] H. Zhai, K. Zhang, S. Yang and D. Feng, "A Low-Profile Dual-Band Dual-Polarized Antenna with an AMC Surface for WLAN Applications", *IEEE Antennas and Wireless Propagation Letters*, Vol. 16, pp. 2692-2695, 2018.

[12] Zedong Wang, Guan-Xi Zhang, Yingzeng Yin and Jianjun Wu, "Design of a Dual -Band High Gain Antenna Array for WLAN and WiMAX Base Station", *IEEE Antennas and Wireless Propagation Letters*, Vol. 16, pp. 1123-1189, 2018.

[13] Jianxing Li, Lumei Li, Anxue Zhang, Jiangang Liu and Qing Huo Liu, "Wideband Two Bowtie Dipole Array Antenna Integrated with a Tapered Balun", *Proceedings of 11th International Symposium on Antennas, Propagation and EM Theory*, pp. 1-7, 2016.

[14] Young-Bae Jung and Soon-Young Eom, "A Compact Multiband and Dual-Polarized Mobile Base-Station Antenna using Optimal Array Structure", *International Journal of Antennas and Propagation*, Vol. 2015, pp. 1-11, 2015.

[15] Anjali Kumari and Ritesh Kumar Badhai, "A Triple-Band High-Gain Base-Station Antenna for WLAN and Wi-MAX Applications", *Proceedings of International Conference on Inventive Systems and* Control, pp. 19-23, 2017.