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

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***Abstract***

***Antenna design is the primary stage for development of wireless communication technology. In this paper, four element series-fed two dipole antenna array is developed for the WLAN base station applications. The proposed antenna operates at IEEE 802.11b standard 2.4GHz frequency band with reduced size and improved gain for supporting wireless local area network applications. A modified microstrip balun feeding is used for providing impedance matching. This antenna is designed on the FR4 substrate with dielectric permittivity of 4.4 and height of the substrate is 1.6mm and loss tangent of 0.002 to achieve lower return loss. The dimension of the proposed antenna is 160*105*160[mm]^3. This antenna is simulated in an integral based solver simulation software called CST Microwave studio v2018 and obtained results such as VSWR 1.3, Return loss -18dB with Bandwidth of 200MHz, Directivity of 12.5dBi, gain of 11.9dB, Port isolation is -16.5dB Efficiency of 90%. This antenna suitable for WLAN base stations used in larger coverage areas.***

***Keywords:***

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

## 1. INTRODUCTION

The development of wireless communication needs more attention in research towards antennas and to support the entire wireless personal communication the base station antennas needs to be designed at the lowest cost without compromising its performance. The use of 2.4GHz frequency in all WLAN communication devices needs base station antennas with high performance for operating exclusively for this operating band. 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 system 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 selected based on its user interface, which is very simple and has the capability of simulating complex structures.

The organization of this paper includes the introduction section as first part followed by the literature review and design methodology followed in the development of the proposed antenna and the next section consists of results and discussion section and finally conclusion and future works concludes the paper. The next part of this section follows with the literature review.

## 2. LITERATURE REVIEW

The literature review deals with the basics of micro patch antennas [1-3], in [4] fundamental design procedure of single element series-fed two dipole antenna presented for operating in 2.4GHz resonant frequency with 6.73dB of gain. In [5] the using the fundamental antenna array of two element of single element series-fed two dipole antenna is presented for operating in 2.4GHz resonant frequency with 8.68dB improved gain. In [6] a dual band high-gain antenna with beam switching capability presented for wireless local area network and worldwide interoperability for microwave access applications operating over 3.4-3.6GHz and 5-6GHz bands with gain of 10.5dBi still the proposed design is complex. In [7] low-profile dual-band dual polarized antenna with an AMC surface for WLAN applications is presented for operating at 2.4GHz resonant frequency with peak gain of 7.2dBi in lower band and 7.3dBi in upper band. In [8] A dual-band and dual-polarized fractal antenna for WLAN applications is presented for operating in 2.35-2.55GHz and 5.14-5.46GHz with the peak gain of 7.6dB and 5.ldB. In [9] A dual-band folded dipole antenna of 3×2 antenna array for operating in dual bands 2.3~2.56GHz and 3~4.2GHz with a gain 14.3~15.1dBi (2.31~2.51GHz), 16.2~17.3dBi (3.1~4.15GHz) is presented. In [10] a wideband dual-polarized omnidirectional antenna is proposed for mobile communication base station and 2.4GHz wireless local area network applications with the gain of 5.2dB at 2.45GHz is presented. In [11] dual-band base station antenna for WLAN and WiMAX applications which operate at high frequency (3.5-GHz) and the smaller one’s work at low frequency (2.4-GHz) along with gains of near 8.0dBi and 11.0dBi at the low and high working frequencies is presented. In [12] A ±45 polarization diversity antenna with wide bandwidth is presented for IMT2000 (1920–2170MHz), PCS (1850–1990MHz), and DCS (1710–1880MHz) to cover frequency band 1710–2170MHz base station antenna is presented. In [13] a wideband dual-polarized antenna with two independently controllable resonant modes for 2G/3G/4G bands for operating in 1.68～2.94GHz base station application is presented. In [14] a broadband dual-polarized dual-dipole (DPDD) planar antenna for 2G/3G/4G base station application with a gain of about 9dBi is presented. In [15] a novel vector synthetic dipole (VSD) antenna and its array for operating in 690 to 960MHz frequency along with a gain is ranging from 10.1 to 11.4dBi for the lower band, and 12.3 to 14.2dBi for the upper band presented.

From the literature it is found that the antenna is designed widely for the mobile communication base stations to cover different range of frequencies and single and double element STDA [4-5] is proposed and there is a serious problem of lower gain using the design methodology in the previous models therefore in this work the four-element series-fed two dipole antenna arrays is developed for WLAN base station applications for covering larger coverage area along with the improved gain. In the next section the design methodology is presented.

## 3. ANTENNA DESIGN

This section presents the detailed design methodology of the proposed four element series-fed two dipole antenna for WLAN base station applications. The design of the proposed antenna is given in Fig.1. The overall dimension of the proposed four-element series-fed two dipole antenna array consists of length *a*, which is 105mm and width *b* is 160mm dimension.

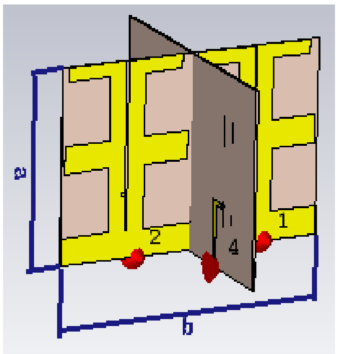


Fig.1. Proposed Antenna Array

Here is the evolution of design process presented in Fig.2. In this Fig.2(a) represents the front view of the single element. The Fig.2(b) represents the back view of the single element. This single element has been designed and its results were discussed in [4]. Then two element antennae are designed which is given in Fig.2(c) front side and Fig.2(d) back side of the two-element antenna. The design of four-element series-fed two dipole antenna arrays is discussed in further part of this section.

The proposed four element antenna array is made by joining a pair of two element antenna in cross alignment for developing the proposed antenna. The fundamental 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 proposed antenna developed on 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 balun feed is modified at the joint as bending curve to provide perfect impedance matching. In further section the results and discussion are presented.

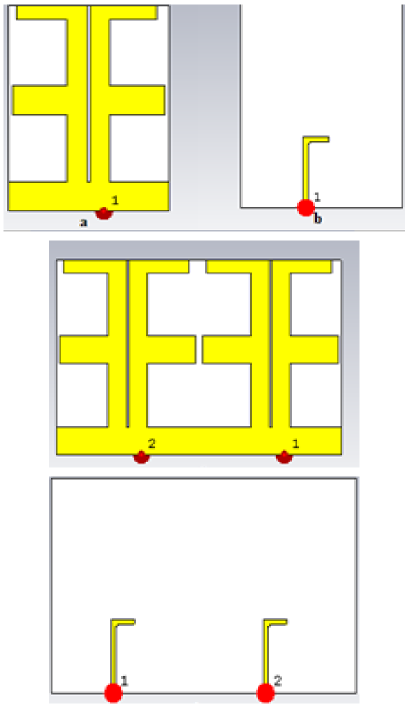


Fig.2. Design Evolution

## 4. 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, far field radiation, surface current, gain and efficiency front to back ratio were discussed below.

### 4.1 RETURN LOSS

The minimum return loss obtained at 2.4GHz is -18dB 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 elements are found to be -16.5dB isolation this shows that the proposed four-element series-fed two dipole antenna arrays will not get affected by the mutual coupling between the four input ports and the antenna performance will be stable.

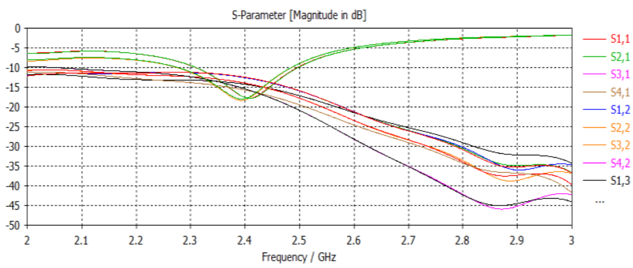


Fig.3. Return loss

### 4.2 VSWR

The minimum VSWR (Voltage Standing Wave Ratio) obtained at 2.4GHz is 1.29 for the proposed antenna array 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 1.29 is close to the perfect value.

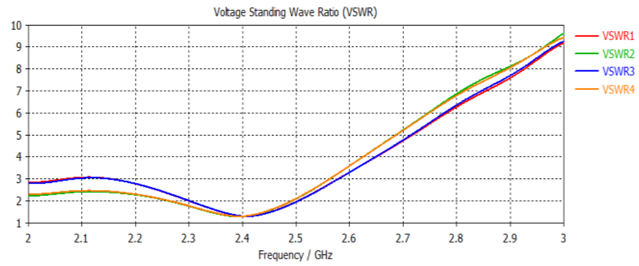


Fig.4. VSWR

## 4.3 SURFACE CURRENT DISTRIBUTION

The surface current distribution is a 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 in which the current flow starts from the feeding point through the balun designed from the bottom to the top surface of the STDA. The red region indicates the maximum surface current waves generated at the frequency 2.4GHz. From the above portrayed surface current distribution, it is clear that the proposed four-element series-fed two dipole antenna array achieved maximum performance at the required resonant frequency 2.4GHz.

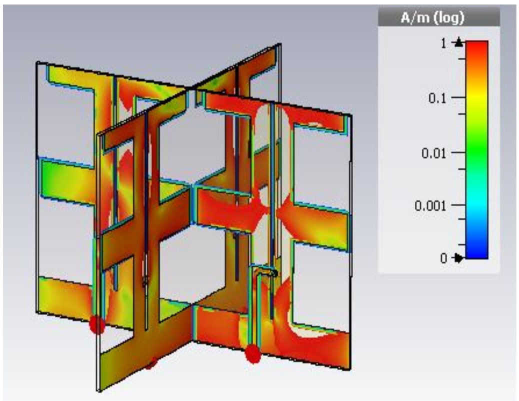


Fig.5. Surface Current Distribution

## 4.4 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 directivity obtained ad 12.5dB. The Maximum Efficiency obtained at 2.4GHz is 85.64% and the total Efficiency from 2 to 3GHz frequency range is 90% for the proposed antenna. The 2D farfield plot is given in Fig.7, which shows the radiation characteristics of the proposed antenna with Phi=0 and Theta=0 is similar to circular polarization therefore very much useful for the base station application.

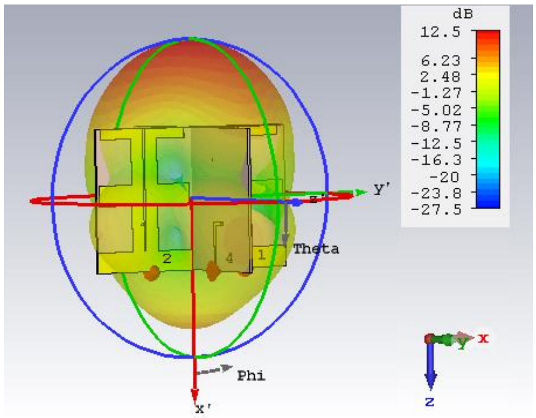


Fig.6. Farfield at 2.4GHz

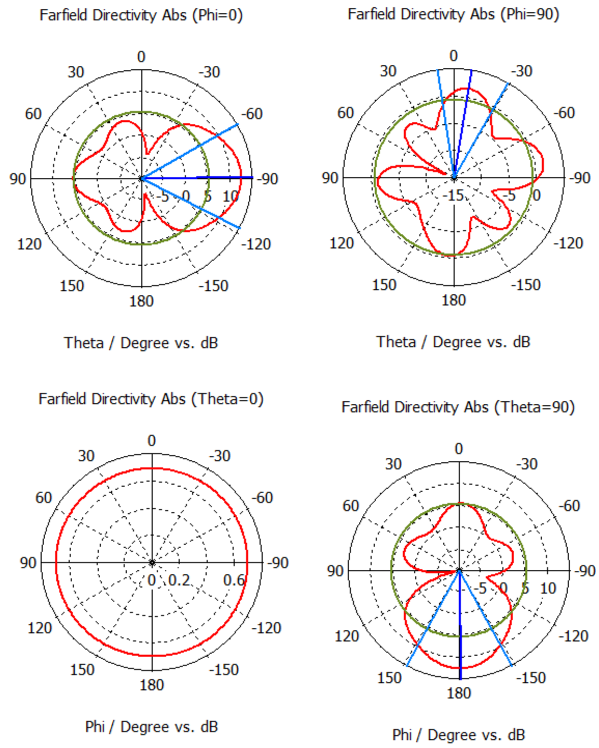


Fig.7. 2D Farfield Plot

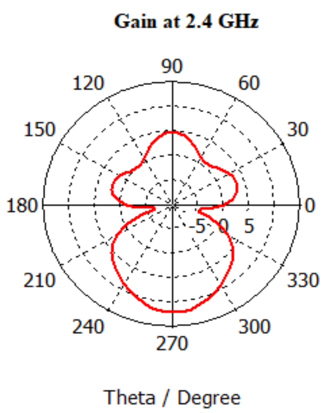


Fig.8. Gain Plot

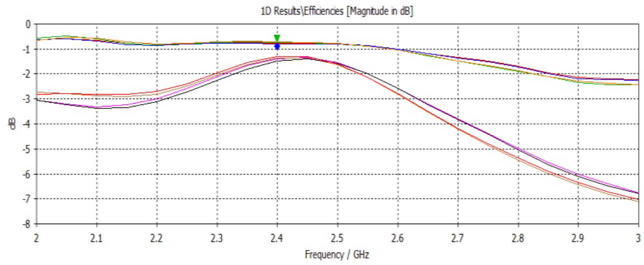


Fig.9. Efficiency Plot

### 4.5 GAIN AND EFFICIENCY

The gain plot at frequency 2.4GHz is given in Fig.8. The efficiency plot is presented in Fig.9, which shows the proposed antenna achieves 11.9dB of gain and 90% efficiency at 2.4GHz resonant frequency. Also, the front to back ratio is the ratio of power gain between the front and rear of a directional antenna which is 3.592 for the proposed antenna. The overall result are tabulated in Table.1.

Table.1. Overall Results

| Parameter | Value |
|---|---|
| Frequency | 2.4GHz |
| Return Loss | -18dB |
| VSWR | 1.29 |
| Gain | 11.9dB |
| Efficiency | 90% |
| Directivity | 12.5dBi |
| Bandwidth | 200MHz |
| Front-to-back ratio | 3.592 |

While comparing this four-element series-fed two dipole antenna array with the existing single element antenna system [5] the gain is improved from 6.73 to 11.9dB and the directivity also increased from 6.72 to 12.5dBi without affecting the 200MHz bandwidth and the mutual coupling between the ports has been reduced to below -15dB. The value of front to back ratio is reduced from 6.74 to 3.592 which confirms that this proposed four-element series-fed two dipole antenna arrays can be suitable to cover larger wireless local area networks in which a high capacity data can be successfully communicated between the base station and the users are the major significance of the proposed antenna.

## 5. CONCLUSIONS AND FUTURE WORK

The proposed four element series-fed two dipole antenna array is developed and simulated using CST Microwave studio and obtained results such as return loss -18dB, VSWR 1.29, gain 11.9dB and bandwidth 200MHz are following the IEEE 802.11b guidelines for operating WLAN applications in ISM Band frequency. This four-element series-fed two dipole antenna arrays can be used in the WLAN base station applications for large coverage areas with high capacity data rate transmission. 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.

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