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Design Implementation of Multi Band Antenna Array for Wireless Applications

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Abstract:

This paper provides the improvement and characterization of twin band and 1×4 twin band antenna array on a bendy polymide substrate. In this paper we have introduced the plan of a twin band microstrip antenna which will be running in the wi-fi LAN band and IEEE 802.11 a/b/g. Dual-band antenna factors that help dual-polarization furnish perfect performance for applications including space-based platforms, multifunction radar, wi-fi communications, and private electronic devices. In many communications and radar applications, a dual-band, dual-polarization antenna array becomes a requirement in order to produce an electronically steerable, directional beam capable of aiding a couple of functions. In this paper a twin band microstrip antenna is designed and its dimension outcomes in phrases of S(1,1) parameters and radiation patterns are studied. Microstrip layout equations are introduced and validated by way of simulated results. This antenna is carried out on polymide substrate with = 4.3, h=1.6mm and running frequency 5.25GHZ. By this format it is additionally proven that twin band operation is feasible with appropriate role of the feed line and appropriate willpower of inset size. Designed antennas is simulated by using Ansoft High Frequency Structural Simulator (HFSS) via the use of the FEM (Finite Element method).

Keywords **— Beem steering, Dual band array antenna, IEEE802.11a/b/g, WLAN..**

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I. INTRODUCTION

Micro Strip Antenna Array has been proposed with excessive efficiency for wi-fi communication. Micro strip antenna arrays are broadly used in a number of applications like wi-fi communication system, satellite tv for pc communication, Radar systems, Global positioning systems, Radio Frequency Identification (RFID), Worldwide interoperability for microwave access (WiMax), Medicinal applications of patch [1]. Communication performs an essential position in the global society now days and the communication structs are swiftly switching from "wired to wireless".Wireless technology presents much less high-priced choice and a bendy way for communication. Antenna is one of the essential factors of the wi-fi communications systems. Thus, antenna sketch has become one of the most active fields in the communication studies. Antenna is a radiating factor which radiate electromagnetic strength uniformly in Omni direction or eventually in some structs for factor to factor communication motive in which increased reap and reduced wave interference is required. Antenna is a transducer designed to transmit or receive electromagnetic waves. One of the kind of antenna is the Micro strip patch antenna. Microstrip antennas have numerous benefits over conventional microwave antenna and consequently are broadly used in many practical applications [1].Microstrip patches are one of the most versatile, conformal and handy to fabricate antennas.The recent boom in the ambit of contemporary wi-fi communication has the increased demand of multiband antennas that can fulfill the necessities pertaining to Wireless Local Area Network(WLAN).The improvement of twin band antenna that can cover the 5.25 GHZ (5.15-5.85GHZ) band and 9.25 GHZ (9-9.5 GHZ) band for IEEE802.11a and IEEE802.11g requirements respectively, are accordingly fantastically suited [2].

Wi-Fi local location community (WLAN) has received much interest for the flexibility of community reconfiguration in office room, cell web connection and so on. A WLAN presents all the advantages of standard LAN technologies barring the obstacles of being tethered to a cable. This offers extensively increased freedom and flexibility.Antennas capable of running at a couple of frequency bands are fantastic to many applications ranging from space-based radar to non-public wi-fi communications. Synthetic apert radar (SAR) typically operates in L- and C-bands.

For space-based SAR applications the place minimizing the mass and weight of the radar device is necessary to reducing the typical weight of the payload and cost of the mission, antennas capable of running in more than one frequency bands with more than one polarizations are beneficial. Dual-band antenna factors are additionally proper in radar applications because of their capability to enhance information collection rates, whilst additionally permitting for actual multifunction radar (MFR) operation. Wireless communications networks have proven an increased wide variety of subscribers as properly as an increased demand for multi-band gear [3]. Wireless access factors and laptops are each turning in the direction of antennas capable of running in more than one frequency bands in order to aid a couple of protocol.

II. DESIGN PROCED AND EQUATIONS

A microstrip antenna consists of conducting patch and a floor airplane separated by means of dielectric substrate. This concept was once undeveloped till the revolution in electronic circuit miniaturization and large-scale integration in 1970. The early work of Munson on microstrip antennas for use as a low profile flush established antennas on rockets and missiles confirmed that this was once a practical concept for use in many antenna machine problems. Various mathematical fashions had been developed for this antenna and its applications have been prolonged to many different fields. The wide variety of papers, articles posted in the journals for the closing ten years.

The microstrip antennas are the existing day antenna designer's choice. Low dielectric constant substrates are usually desired for most radiation. The conducting patch can take any struct however rectangular and circular configurations are the most commonly used configuration. A microstrip antenna is characterized by way of its length, width, enter impedance; obtain and radiation patterns.Various parameters, associated calculation and feeding technique will be discussed similarly thru this section. The size of the antenna is about 1/2 wavelength of its operational frequency. The size of the patch is very critical and necessary that end result to the frequency radiated [2].

The blessings of the microstrip antennas are small size, low profile, and lightweight, conformable to planar and non planar surfaces. It needs a very little quantity of the struct when mounting. They are easy and cheap to manufact the use of cutting-edge printed circuit technology. However, patch antennas have disadvantages. The fundamental hazards of the microstrip antennas are: low efficiency, slim bandwidth of much less than 5%, low RF electricity due to the small separation between the radiation patch and the floor plane(not appropriate for high-power applications) [4].

A. Microstrip Line Feed Technique

This method of feeding is very widely used because it is very simple to design and analyze, and very easy to manufact [2].

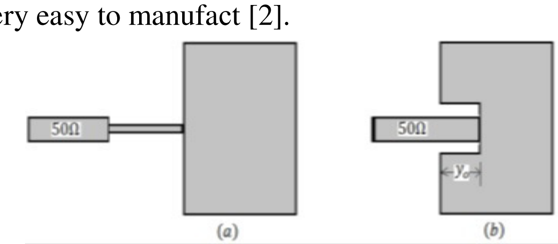

Fig 1 microstrip patch antenna with feed fom side

The position of the feed point (y_0) of the patch in fig (1b) has been discussed in detail in the section of Impedance Matching.

The impedance of the patch is given by [3]:

$$Za = 90\frac{\epsilon_r^2}{\epsilon_r - 1}\left(\frac{L_T}{W_T}\right)^2 \quad (1)$$

where, ϵ_r =dielectric constant, L_T =length of transmission line,

W_T =width of transmission line

The characteristic impedance of the transition section should be:

$$Z_T = \sqrt{50 + Za} \quad (2)$$

The width of transmission line is calculated by [3]:

$$Z_T = \frac{60}{\sqrt{\epsilon_r}}\ln\left(\frac{8h}{W_T} + \frac{W_T}{4h}\right) \quad \text{for } \frac{W_T}{h} > 1 \quad (3)$$

where, h = height of substrate

The width of the 50Ω microstrip feed can be found using the equation given below [4]:

$$Z_O = \frac{120\pi}{\sqrt{\epsilon reff}\left(1.393 + \frac{W}{h} + \frac{2}{3}\ln\left(\frac{W}{h} + 1.444\right)\right)} \quad \text{for } \frac{W_T}{h} < 1 \quad (4)$$

where, Z_O=50 Ω

The length of the strip can be found by [4]:

$$Rin(x = 0) = \cos^2\left(\frac{\pi}{2}x_o\right)$$

The length of the transition line is quarter the wavelength:

$$l = \frac{\lambda o}{4\sqrt{\epsilon reff}}$$

where, λo = free space wave length

ϵ_{reff}= efective dielectric constant

B. Design Equations of Proposed Dual Band Antenna

- Thickness of the substrate, h ranges between [7] $0.003\lambda o \leq h \leq 0.05\lambda o$

where,λo = free space wave length

- Guide wave length[7] $\lambda g = \lambda o/\sqrt{\epsilon_r}$

where ϵ_r= permittivity of substrate

- Width of the patch[4] $W_P = \frac{c}{2f_r\sqrt{\frac{\epsilon_r + 1}{2}}}$

where, f_r=center frequency

- Length of the patch[4] $L_P = L_{eff} - 2\Delta L$

where, $\Delta L = 0.412\frac{(\epsilon_{reff} + 0.3)\left(\frac{W_P}{h} + 0.264\right)}{(\epsilon_{reff} - 0.258)\left(\frac{W_P}{h} + 0.8\right)}$

- Effective length of patch [3] $L_{eff} = \frac{c}{2f_r\sqrt{\epsilon_{reff}}}$

c= Velocity of light=3×10^{11}mm/sec

- Effective dielectric constant

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left(\frac{1}{\sqrt{1 + \frac{12h}{W_P}}}\right)$$

where, h= thickness of substrate and W_T = width of patch

- Length of substrate[4] $L_S = L_P + 6h$
- Width of substrate[4] $W_S = W_P + 6h$

where, h = Thickness of substrate

- Length of notch H=$0.822\times\frac{L_P}{2}$
- where, L_P =Length of patch
- Width of notch $Y = \frac{W_P}{5}$
- where, W_P=width of patch

Based on above equations the design dimensions of the antenna are calculated and are shown in Table I.

TABLE I

DESIGN DIMENSIONS FOR DUAL BAND ANTENNA

Dimensions	**Length(mm)**	**Width(mm)**
Substrate and ground	22.9	27.2
Patch	13.33	17.6
Notch	5.478	3.52
Feed line	7.904	1.85
Wave port	1.85	1.6
Slot	1.25	3.52

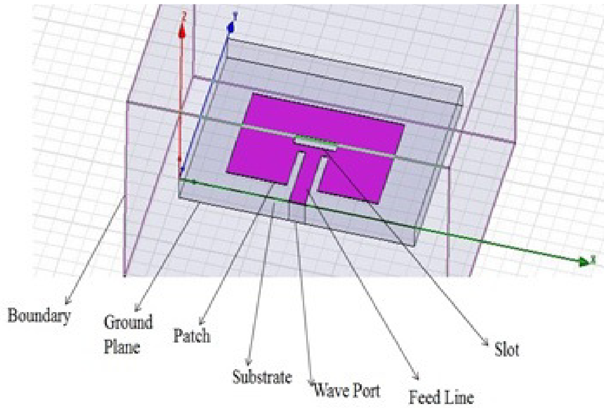

Fig 2 Simulated geometry of dual band antenna design

The twin band microstrip antenna (MSA) is realized by means of cutting the slots of exclusive shapes. The geometry of twin band rectangular microstrip antenna is proven in determine two It is constructed on the substrate having dielectric constant and thickness h=1.6 mm. For microstrip antennas, the dielectric constants are commonly in the vary of 2.2 .Dielectric constants in the decrease cease of the vary can supply us higher efficiency, massive bandwidth, loosely certain electric area for radiation into space, however at the cost of massive issue size. In microwave circuit that requires tightly certain fields to decrease undesired radiation and coupling, and lead to smaller component size. In some application we want small measment antennas, substrate with excessive dielectric constant is a higher choice in this application. High dielectric constants have higher losses so they are much less efficient and have incredibly small bandwidth.The proposed struct is simulated the usage of HFSS simulation software. The sketch is for a resonant frequency of round 5.25 GHz.The first stage includes the creation of extra TMoδ resonant modes at a resonant frequency above that of the crucial TM01 mode, with the equal polarization experience [3]. The subsequent stage is to concurrently deliver the enter impedance of all modes to 50Ω at resonances thru the use of an inset feed function control.

C. Proposed Dualband Array Antenna Design in HFSS

Microstrip antennas are used in arrays as properly as single elements. By the usage of array in communication structs we enhance the performance of the antenna like increasing gain, directivity scanning the beam of an antenna system, and different functions which are difficult to do with the single element. An antenna array consists of identical antenna factors with identical orientation disbursed in space. The person antennas radiate and their radiation is coherently introduced in space to shape the antenna beam. For a linear array, the antennas are placed alongside a line called the axis of the array [6].

The corporate-feed network is used to grant strength splits of (i.e., n = 2; 4; 8; 16; 32, etc.). This is accomplished via the usage of both tapered strains or the use of quarter wavelength impedance transformers [5]. In a uniform array the antennas are equi-spaced and are excited with uniform current with constant modern section shift.

Spacing between any two adjacent factors of the array is (d) [6]:

$\lambda/2 \leq d \leq \lambda$ where, λ=Wavelength and d= spacing between two antennas

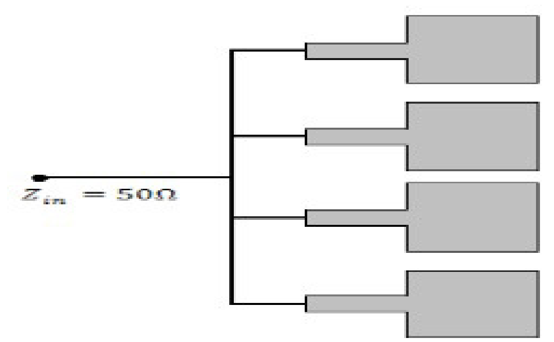

Fig 3 Four element micro strip array

combination of 4-elements array as shown in fig 3, By using equations (1),(2) and (3) we calculate the dimensions of 200Ω transmission line .Length and width of feed line for different impedances are shown in Table II.

TABLE II
IMPEDANCE MATCHING TABLE

Impedance(Ω)	**Length(mm)**	**Width(mm)**
50	7.804	3.10
100	8.205	0.71
200	8.632	0.49

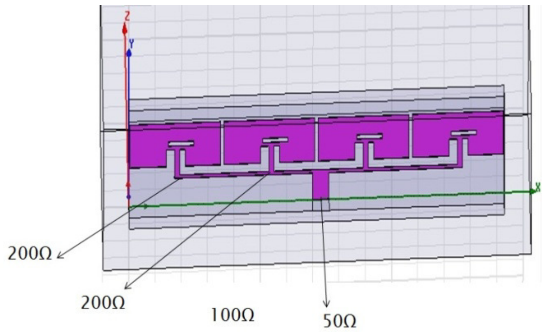

Fig 4 Simulated dual band array antenna design

III. SIMULATION RESULT FOR DUAL BAND ANTENNA

The microstrip single band antenna is designed using HFSS simulator. The performance of the antenna has been studied by comparing the Return loss, VSWR, S parameter, Gain, azimuthal and elevation patterns.

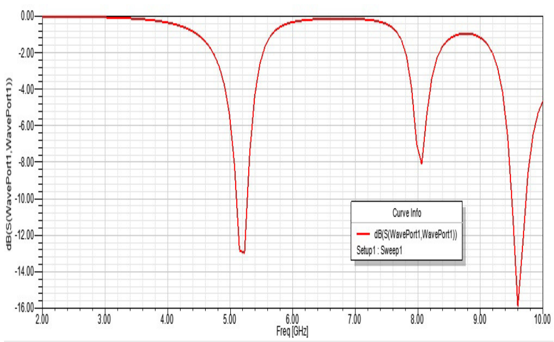

Fig 5 Return loss graph for dual band antenna

Fig 5 shows the return loss graph for frequency 5.25 GHZ and 9.5 GHZ. S parameter display at operating frequency 5.25GHZ ,S(1,1)=-13.01 dB and for 9.5GHZ, S(1,1)=-15.8dB.

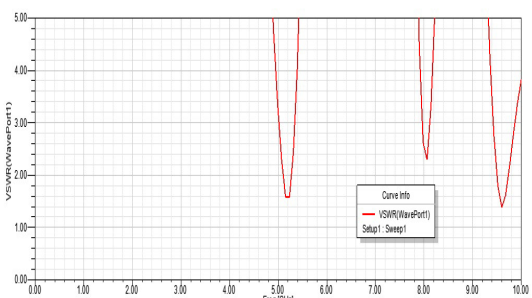

Fig 6 VSWR plot for the dual band antenna

The simulation results for VSWR for the frequency of 5.25 GHz and 9.25GHZ is shown in the fig 6. VSWR for 5.25 GHZ frequency is 1.5 and for 9.25GHZ is1.40 for better performance of antenna VSWR value should be in range 1 to 2 [7].

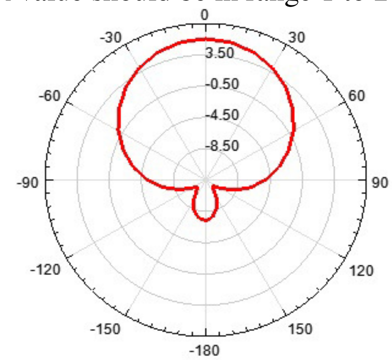

Fig 7 Elevation pattern (E-Plane) gain display (for θ=all values and φ = 0degree)

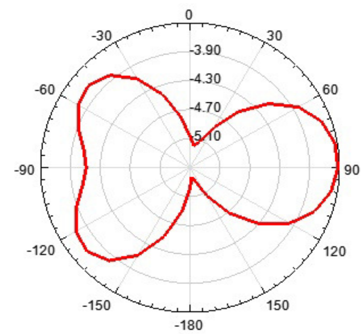

Fig 8 Azimuthal pattern (H-plane) gain display (for φ = all values and θ = 90degree)

The radiation pattern can be obtained from the Azimuthal and Elevation pattern gain displays in dB.The Elevation pattern (E-plane) gain display is shown in fig 7, for any value of θ, φ=0 degree and the Azimuthal pattern (H-plane) gain display is shown in fig 8, for any value of φ, θ=90 degree [7]. For dual band antenna gain is 3.58 db and directivity is 3.9dB

IV. SIMULATION RESULTS FOR DUAL BAND ARRAY ANTENNA

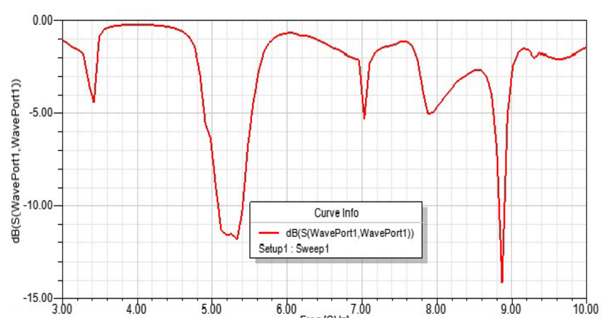

Fig 9 Return loss graph for dual band array antenna

Fig 9, shows the return loss graph for the dual band array antenna. S parameter display at operating frequency 5.25 GHZ, S(1,1) = -13 dB and for 9.25GHZ, S(1,1) = -14.88dB.

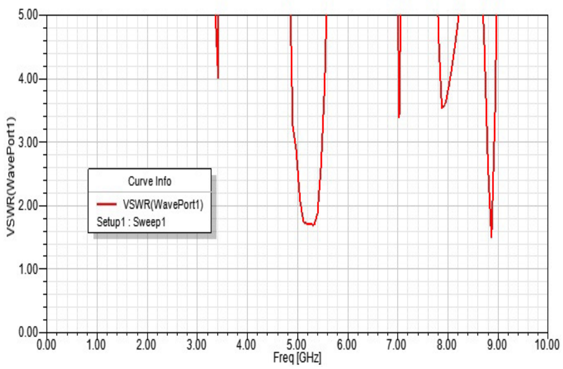

Fig 10 VSWR plot for the dual band array antenna

Fig 10, shows the VSWR plot dual band array antenna. VSWR for 5.25 GHZ frequency is 1.70 and for 9.25 GHZ is 1.50. Fig 11 and Fig 12 shows the E-plane and H-plane respectively,

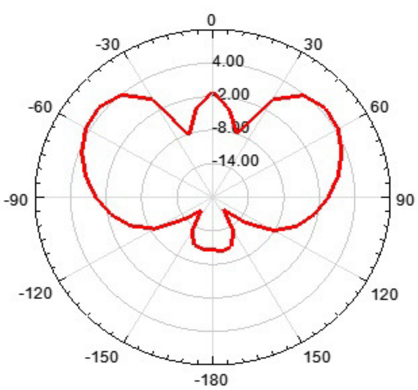

Fig 11 Elevation pattern (E-Plane) gain display (for θ=all values and φ = 0degree)

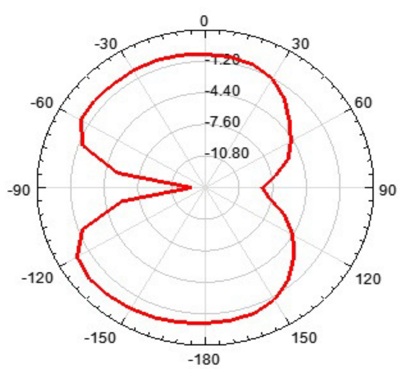

Fig 12 Elevation pattern (E-Plane) gain display (for θ=all values and φ = 0degree)

The gain of dual band array antenna is 5.08 dB and directivity is 5.5 dB.

V. CONCLUSION

Dual band microstrip antenna is designed via the use of HFSS and their parameters are analysed.To enhance the performance in achieve and bandwidth of antenna, a 1×4 twin band microstrip array antenna is designed and its parameters are studied. The performance of the designed antenna in phrases of their parameter is compared. Dual band array antenna is extra efficient as compared to twin band antenna. In fut through introducing active devices such as pin diode or varactor diode, a phased antenna array with beam steerage can be achieved with enchancment in acquire and bandwidth.

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