DESIGN OF DUAL-BAND PATCH ANTENNA FOR WLAN APPLICATIONS

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Abstract-
This Research paper discusses about the Design of dual band Patch antenna for WLAN applications using HFSS software. The proposed design consists of four elements of square shaped inset fed microstrip antennas to cover the frequency band for WLAN application, in which two elements of inset feed antenna were used for each frequency band. The design is created using the FR-4 Epoxy material, which has a 1.6mm thickness and a dielectric constant of 4.4. The measured reflection coefficients below -10dB covers 4.69-5.15 GHz and 5.84-7.23GHz. The present research derives the performance parameters Gain, radiation pattern, and Return loss. The designed antenna that is suggested in this study is compatible for WLAN applications. By using HFSS, we were able to fine-tune the antenna's shape and size to ensure it performs well in both frequency bands.

Introduction :

Antennas are essential for effective data transmission and reception in wireless communication systems like WLAN(Wireless Local Area Network), Bluetooth, ZigBee e.t.c. The quality, range, and reliability of wireless communication are substantially influenced by an antenna's performance. Since they enable wireless access for a variety of devices, WLANs have become a crucial element of our daily life. Due to their adaptability and capacity for handling high data rates, dual-band antennas that can operate at both 2.4GHz and 5GHz frequencies are crucial for WLAN applications. Microstrip antennas (MSA), also known as patch antennas, that consist of a radiating patch element on one side and a ground plane on the other, with a dielectric substrate fitted in between them. Because it is simple to manufacture and has numerous uses in wireless communication, Microstrip Antennas are among the most popular antenna structures. Since they are currently physically printed onto the circuit boards, they are quite helpful. FR-4 Epoxy has been used as the substrate in this paper. The MSA is used extensively in modern times due to a variety of benefits. It also has certain drawbacks, but they are overcome by the benefits. Some benefits of MSA include : Lightweight, inexpensive & low profile and capable of operating at dual and triple frequencies with ease. It also has some disadvantages like : Low gain, narrow bandwidth, low efficiency [2,3].
Due to the swift advancement of wireless communication systems and expansion of their applications, multiband rectangular patch antenna in a variety of forms—such as square, circular, triangular, elliptical, etc.—have grown in popularity and demand for use in a wide range of wireless applications. This has led to the development of numerous different types of antennas that can handle these variations in antenna characteristics. To achieve dual band and multiband functioning, a variety of techniques can be used, such as slot cutting with various dimension and form variations. There have been numerous studies of dual-band microstrip antennas used in WLAN recently, and many different dual-band antenna types have been proposed. Innovative strategies including meta materials and compact geometries have been explored recently in antenna design developments to further improve dual-band performance.[1,4,5,6,7].
However, there are several challenges in designing dual-band patch antennas for WLAN applications. It can be challenging to achieve the required separation between 2.4 GHz and 5.8 GHz bands while optimizing patch dimensions and using suitable substrate materials. It is difficult to decide on the best feeding method, manage radiation patterns in both bands, and balance efficiency and gain. Furthermore, it is difficult to move from simulation to actual implementation while maintaining excellent antenna efficiency in both bands. To design successful dual-band WLAN antennas, researchers and engineers must overcome these challenges. As a result, research into multiband and

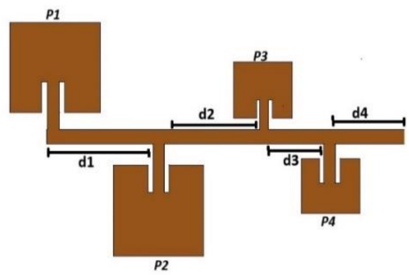
miniature antennas becomes crucial for the field of antennas. This paper presents a comprehensive study on the design, simulation, and method to create a multiband antenna using a two-element square-patch antenna with an inset feed configuration for every frequency band at 2.4 GHz and 5.4 GHz. Our research aims to address the challenges in achieving optimal performance in both bands while maintaining a compact/small and practical antenna design, which requires careful selection of dielectric substrates, patch sizes, and feeding strategies. The physical size of antenna is frequently reduced by using substrate materials with high dielectric constants.

Design of Antenna:

The Design of Dual-band antenna is shown in Figure.2. This above design consists four elements of square patches of inset configuration, in which two elements of the antenna were used for each frequency band. Proposed antenna is designed over a 1.6-mm thickness FR4 epoxy substrate with 140×100mm surface dimension. The loss tangent and relative permittivity of the substrate is 4.4 and 0.02, respectively. The Ground plane is inserted with a thickness of 0.2 mm and a dimensions same as that of the substrate. The finalized dimensions of the patch are detailed as shown in Table 1.

Patch	L=W (mm)	d_n (mm)	Lm (mm)	Rin (mm)
P1	28.981	28.36	15.746	9.447
P2	27.948	18.75	15.185	9.091
P3	13.444	21.59	7.304	4.610
P4	12.803	27.63	6.956	6.956

Figure -1 : Layout of the Antenna



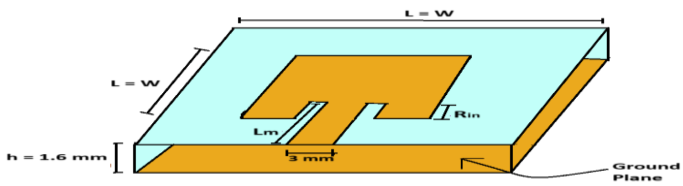


Figure -2 : 3D view of a single element

Where,
P1, P2, P3, P4 are the respective Patches.
d_n = distance between the corresponding patches.
Lm = length of the inset feed from the feed line to the patch.
Rin = length of the inset feed from Patch.
The High Frequency Structure Simulator (HFSS) Software is used to design and simulate the suggested antenna. In order to maintain the return loss, (S11 ≤ -10 dB), over the appropriate frequency range, the antenna structure is improved.

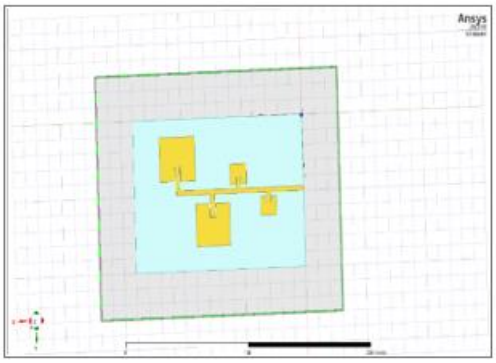


Figure -3 : Design of Dual-band antenna in HFSS

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As previously mentioned, the patch with inset feed configuration has four elements, with two of them designed to operate on the 2.4 GHz band (28.98 mm and 27.94 mm) and two other elements (13.44 mm and 12.08 mm) designed to operate on the 5 GHz band (to achieve good return loss for desired dual-band operation).

Simulation and Results :

Several factors affect how well the dual-band antenna performs when it is designed, such as thickness of substrate (1.6mm), length of the square radiating patch F1=28.98 mm, F2=27.94 mm , F3=13.44, F4=12.08 mm slots inserted in patch with a feed line of (105.33 mm). Due to its function as a matching network, the substrate thickness might have an impact on the impedance bandwidth. In addition to this it also depends on ground plane size of length = 140mm, width = 100mm and thickness = 0.2 mm (140×100×0.2 mm), these elements all have an impact on performance of the dual-band antenna.
The S-parameter S11 or Return Loss result is simulated and measured that is represented in Figure 4. It is observed the frequencies that cover 2.73-4.58GHz and 5.22-7.42GHz, with return loss of -21.74dB at 6.0769GHz and -17.78 dB at 7.23GHz respectively.

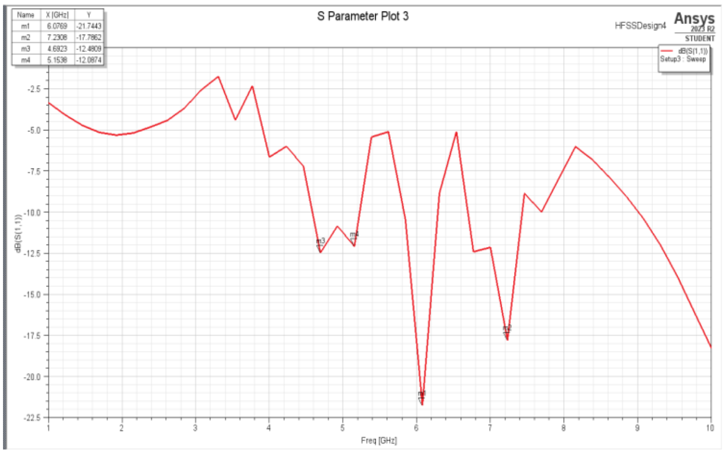

Figure -4 : Return Loss(S- parameter plot)

The Radiation pattern is observed as shown in Figure 5; where at phi is 0^0 and frequency operated at 6.0769 GHz by varying all the parameters of theta from 0^0 to 360^0 . The highest gain achieved in radiation pattern is -2.4 dB at an angle of 180^0 .

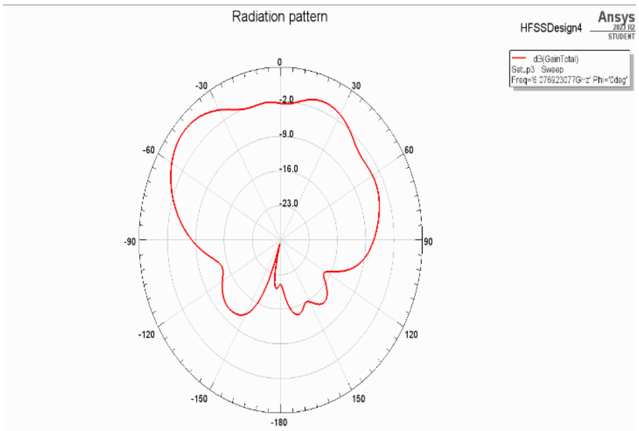

Figure -5 : Radiation Pattern

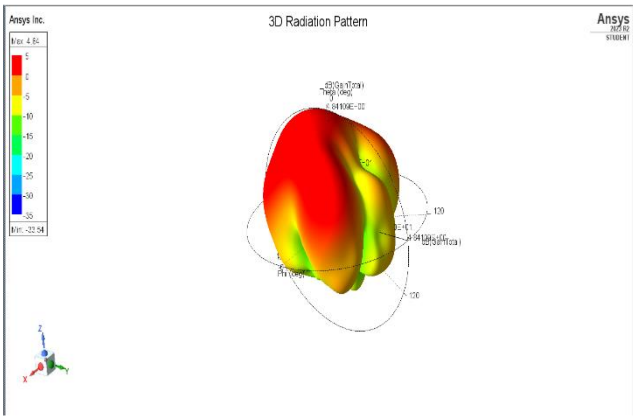

Figure -7 : Current Distribution

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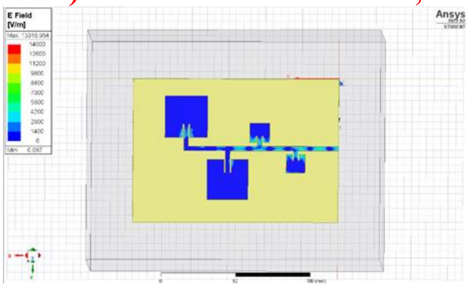
Figure -6 : 3D- Radiation Pattern

Conclusion:

In this study, the HFSS tool is used to build a dual-band antenna for WLAN applications. The design process involved careful selection of substrate material, compact patch dimensions, feeding technique, and ground plane size. This antenna design consists of four antenna elements square shaped with inset fed configuration antenna elements in which two elements are used to operate on each frequency band and a ground plane of thickness 0.2mm on a 140 x 100 x 1.6 mm substrate of material FR4 epoxy. Hence, the suggested antenna offers efficient control. over the both of its operating frequency bands. The simulation results confirm the antenna's performance in terms of radiation patterns, Return loss & S- parameters and gain. Therefore, the results confirm the Dual-Band operation of the antenna which is suitable for WLAN Applications.

Future Scope:

In order to ensure that the measured observations closely match the results of the simulation, it is important for future work to adjust for the frequency shift while constructing the antenna and to improve the antenna model. The design can possibly include additional feeding methods to boost bandwidth while requiring fewer components to span the wireless LAN frequency bands.

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