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Design and Analysis of a Compact Microstrip Patch Antenna with BPF for Wi-Fi Applications

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Abstract— Emerging new communication systems have increased the demand for multi- band antennas. Microstrip patch antenna is preferred over other antennas in today's modern world scenario for their compatibility to be fit in Mobile, Aircraft, Satellites owing to very small sizes. In the majority of microwave receiving and transmitting systems, a requirement is to have a filter immediately adjacent to the antenna or antenna array. Conventionally the filter and antenna are designed as separate components and a matching circuit is used in order to get maximum power transfer between them. In this work, single antenna with a bandpass filter which are simulated to cover Wi-Fi (4.2 GHz) is designed. Also proximity coupling is used because of its larger bandwidth and low spurious radiation. The proposed microstrip patch antenna with a bandpass filter is used to allow the required frequency with reduced noise. The proposed configuration is simulated and analyzed using CST (Computer Simulation Technology) software package. Results have been shown for the parameters of return loss, VSWR, bandwidth and radiation pattern and comparison were analyzed.

Index Terms— Microstrip Patch Antenna, Wi-Fi, Return loss, Gain, S-Parameter, Bandwidth, VSWR.

1 Introduction

Wireless communications and sensing systems have experienced enormous development over the past two decades. They are bringing information to us with convenience and flexibility at low cost. There are many wireless communication systems in our daily lives such as cellular radio systems, mobile satellite systems, wireless local area networks, etc. Although it is hard to predict precisely how systems will appear in the future, it is clear that there will be a need for new solutions in the field of antennas [5]. The antenna is a vital part of any wireless communication system. It is used for coupling between the guided medium and free-space.

For wireless communication system microstrip patch antenna is highly used because this antenna has several advantages like small size, light weight, low cost and low power consumption. But a major drawback of this antenna is the narrow bandwidth. Microstrip patch antenna consists of a conducting rectangular patch of width 'W' and length 'L' on one side of dielectric substrate of thickness 'h' and dielectric constant 'ε_r'. Most popular methods to feed the microstrip patch antenna are microstrip line feed, coaxial probe feed, aperture coupled feed and proximity coupled feed. Desired bandwidth is necessary to enhance the performance of the antenna. There are numerous and well-known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, slotted patch antenna, the use of various impedance matching and feeding techniques [14]. By choosing the suitable filter shape, selecting a proper feed and tuning their dimensions, a large operating bandwidth is obtained. The antenna is simulated using CST software package. The results show that the impedance bandwidth has achieved a good match.

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2 Antenna Structure

The proposed geometry of the microstrip patch antenna is shown in Fig.1 (a). It consists of a rectangular patch with finite-size ground plane. The rectangular patch, filter with microstrip feed line are situated top of the substrate and the ground plane is situated bottom of the substrate. Here 'L' shaped filters are used. Compared to the other antennas, the proposed antenna has a rather simple structure that is easy to fabricate. Meanwhile, the measured results represent that the antenna shows a good multiband characteristics to satisfy the requirement of Bluetooth and WLAN in the 2.4/5.2/5.8-GHz bands. Table 1 shows the dimensions of our proposed antenna.

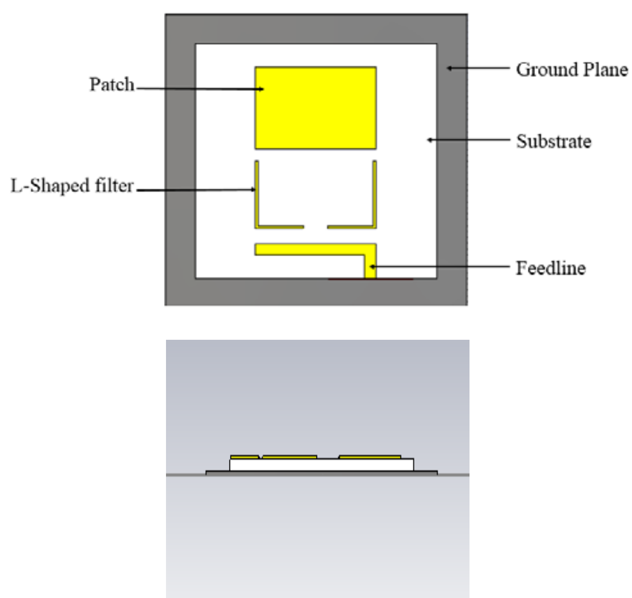


Fig. 1 Structure of 4.2 GHz antenna (Top and Side view)

The dimensions taken to design above the rectangular patch antenna are shown in Table.1

PARAMETERS	PARAMETERS
Substrate length	40 mm
Substrate width	40 mm
Substrate thickness	1.6 mm
Patch length	14 mm
Patch width	20 mm
Patch thickness	0.6 mm
Dielectric constant	4.4
Feed length	6 mm
Feed width	2 mm
Feed thickness	0.6 mm
Filter length	11.5 mm
Filter width	0.5 mm

Table.1 Dimensions of the proposed antenna at 15 Hz

3 Results

A. Return loss

From the s-parameter graph we can infer that whether the antenna is radiating or not, and also graph tells that how much power is reflected from the antenna.This is called return loss or reflection coefficient.

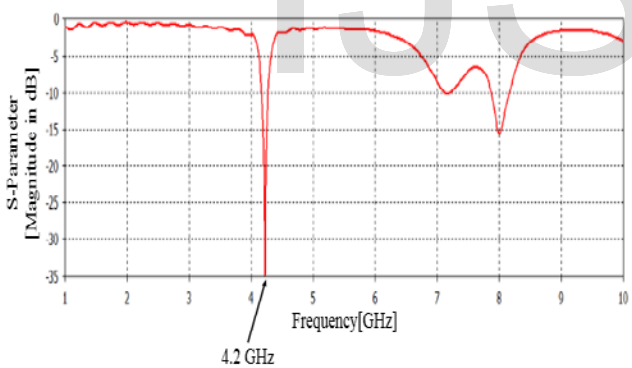


Fig.3 Return loss of proposed antenna at 4.2 GHz

Fig.3 shows the return loss of microstrip patch, it is resonating frequency at 4.2GHZ and reflection coefficient is increasing with increasing frequency. The return loss of the microstrip patch antenna is obtained about -35dB, also it offers good impedance matching.

B. Bandwidth

The bandwidth of the antenna describes the range of frequency over which the antenna can properly radiate or receive energy. For microstrip patch antenna bandwidth obtained is about 0.104 GHz. Bandwidth the rate of data transfer, bit rate or throughput, measured in bits per second.

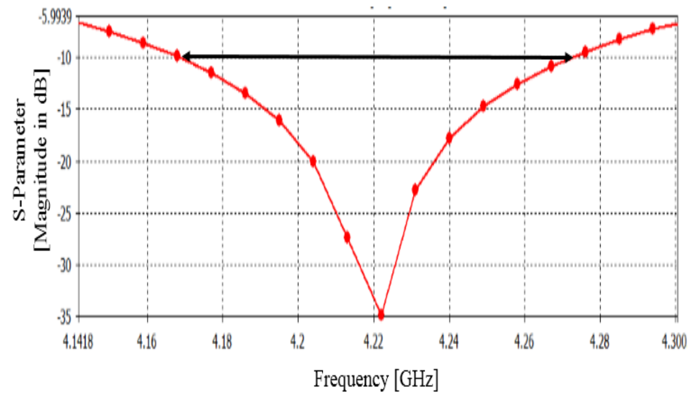


Fig 4 Bandwidth calculation

From graph as shown in figure 4 after identifying -10dB line we get two points i.e. low and high frequency of band.
Here we get,

Low frequency = 4.168 GHz
High frequency = 4.272 GHz
Bandwidth = 1040 MHz

C. Gain

Radiation pattern of the antenna shows the graphical representation of radiation properties of the antenna. The 3D radiation pattern of antenna is shown in the fig.5. For microstrip patch antenna it has directional radiation pattern. That is this antenna radiates power in omni-direction.

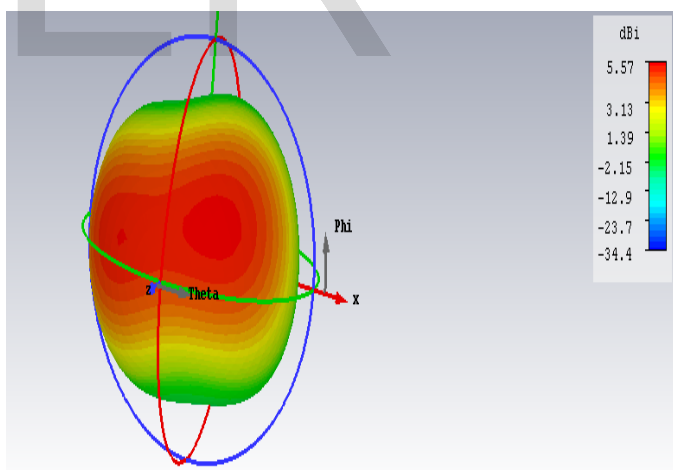
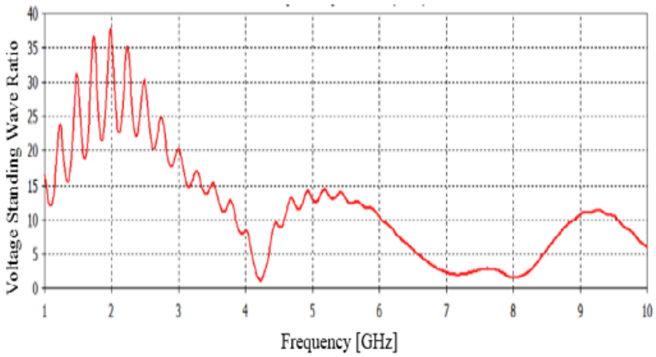


Fig.5 3D plot of gain at 4.2 GHz

D. VSWR

Voltage Standing Wave Ratio (VSWR) is a way to measure transmission line imperfections. Always VSWR value should be less than or equal to 2. The calculated value of VSWR is shown in Fig.4.



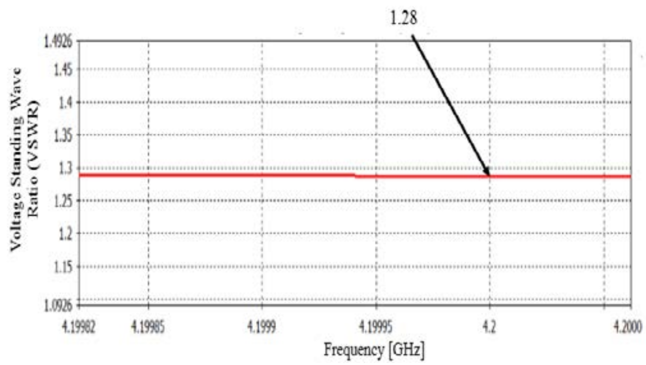


Fig.6 VSWR of the proposed antenna at 15 GHz

4 Conclusion

The purpose of this work is to identify where or if a single antenna works for Wi-Fi bands. In this paper the microstrip patch antenna using proximity coupled technique is discussed for Wi-Fi applications. Compared to many antennas proposed earlier, this antenna is designed based on a rather simple structure with filter inbuilt. This design has various applications in electronic devices, mobile phones and Satellite communication. At these frequency bands, the antenna demonstrates good radiation performance for mobile device applications. The antenna is fabricated using a substrate FR4 of thickness 1.6mm and dielectric constant 4.4. The antenna is designed for 4.2 GHz bands with enhanced bandwidth. The filter-antenna provides good selectivity and rejection in out of band regions. In addition, the proposed antenna shows enhanced parameters in the operating bands. These antennas might replace existing antennas in different products in future.

During the next phase of study, our goal is to design a single antenna which operates at three band of frequencies. The goal is to design a miniaturized antenna using filter. So further we can design an antenna with various shapes of band pass filter. For antenna optimization more work could be done on fine tuning the antenna geometrics. For example, feed techniques, length and width. This tuning gives the overall performance of the antenna extensively and exclusively focusing on the area of different design methods especially in enhancing the impedance bandwidth and the efficiency.

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