International Journal of Engineering and Applied Physics (IJEAP)
Vol. 3, No. 2, May 2023, pp. 736~742
ISSN: 2737-8071

Pentagon Patch Antenna for WLAN at 2.6 GHz

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Article Info

Article history:

Received Feb 21, 2023
Revised May 02, 2023
Accepted May 10, 2023

Keywords:

Microstrip Patch Antenna
FR-4 substrate,
Pentagonal Shape Microstrip Antenna
Hexagonal Patches

ABSTRACT

In this paper an antenna with a pentagonal patch design is being prototype on FR-4 epoxy material fed by a microstrip line with a hexagonal parasitic element for bandwidth enhancement. A pentagon microstrip antenna with hexagonal parasitic elements is designed and analyzed its properties for WLAN application at 2.52 GHz. The pentagon microstrip antenna with hexagonal parasitic element is being analyzed in terms of return loss, gain in dB and VSWR, etc. The experimental result shows a patch antenna is operating frequency at 2.52 GHz, with the return loss parameter is observed as -9.84 dB, and the VSWR ratio is < 2 respectively.

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1. INTRODUCTION

For communication antennas are the easiest alternativeto use now-a-days. In wireless communication systems, antenna is one of the important elements. An antenna is defined as an electric inducer which is used to convert electrical waves into electromagnetic waves and vice-versa.Also, antennas act as an interface for electromagnetic energy, propagating between free space and guided medium. For antenna to work in microwave frequency region, microstrip antenna comes into use. They are used in this region because of their simplicity and compatibility and the ease of printed circuitry technology. Microstrip antennas were first established in the 1950's. However, this idea had to wait nearly 20 years to be realized after the development of the printed circuit board (PCB) technology in the 1970's. Microstrip patch antennas have a number of advantages such as light weight, less cost, low profile, easy to fabricate and many more,which makes it best suitable for many applications. Due to lot of advantages and with easy fabrication methods, it has become favorite among antenna designers and have been used in wireless communication i.e., in military and commercial sectors. Due to their compact size and planar structure microstrip they are used in number of applications such as radars,telemetry, navigation, radio frequency identification (RFID), biomedical systems, mobile and satellite communications, missile systems, global positioning system (GPS) [1]-[5]. In this paper we are operating our MSA at 2.4Ghz which falls under the ISM frequency band.

The industrial, scientific and medicalradio band (ISM) refers to a group of radio bands or parts of the radio spectrum that are internationally reserved for the use of radio frequency (RF) energy intended for industrial, scientific and medical requirements rather than communications. The most common everyday uses of ISM bands are for low- power and short-range telecommunications. Many are familiar with the 2.4GHz ISM band, as most Wi-Fi and Bluetooth communications operate in these bands. For an antenna to perform well, it should have a thick dielectric constant which isdesirable which will provide better efficiency, large bandwidthand better radiation. There are many shapes available for an MSA such as circle, rectangle, elliptical, dipole, square, triangle, circular ring, pentagon, hexagon, etc. In our design we have chosen pentagon as a base shape for our antenna. Pentagonal patch antenna gives better performance than the regular shapes like circle and rectangle. It supports two types of polarization namely, circular and linear which requires only one feed. Also, according to a literature review [6]-[12], it was found that pentagon shape gives the best results in terms of antenna parameters such as return loss, gain and bandwidth. These are the above validations which helped us to choosethis as our base shape of antenna design. Also, hexagon shaped patches are used which enhance the parameters ofthe antenna. The basic structure of MSA consists of three main components i.e., ground plane, a dielectric substrate and a patch of desired shape. For a microstrip patch antenna there are four feeding techniques or methods, they are coaxial probe feed, microstrip line feed, aperture-coupled feed and proximity feed. A microstrip patch can be connected directly to a microstrip transmission line. With the microstrip-line feed approach, an array of patch elements and their microstrip power division lines can all be designed and chemically etched on the same substrate with relatively low fabrication cost per element [13]-[20].

2. ANTENNA CONFIGURATION

In the fig. 1, the pentagonal Microstrip patch antenna has three components namely, the ground, dielectric substrate FR4 epoxy with height of 1.6 mm, and the radiating patch.The material used for ground and the patch is copper. Here, we have subtracted three hexagons from our pentagonal patch out of which two (halves) of hexagon are subtracted from the upper two edges of the pentagon and the remaining one is subtracted from the center of the patch.

Table 1. A Pentagonal Patch Design Parameters.

Parameters and symbol	Value in mm
W_s (Width of substrate)	60
L_s (Length of substrate)	60
R_p (Radius of patch)	18.5
W_f (Width of microstrip feedline)	3
L_f (Length of microstrip feedline)	23.5
h (Height of substrate)	1.6
R_e (Radius of the hexagon subtracted from the edges of the patch)	5.4
R_c (Radius of the hexagon subtracted from the center of the patch)	4

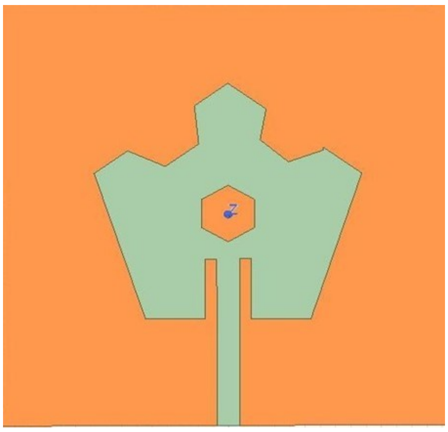

Figure 1. Proposed Pentagonal Patch Design.

3. MEASUREMENT SETUP OF PROPOSED PATCH ANTENNA

3.1. Reflection Coefficient or Return Loss (S11)

An antenna's return loss is a figure that indicates the proportion of radio waves arriving at the antenna input that are rejected as a ratio against those that are accepted it is expressed in decibels. The performance of antenna generally depends upon a good reflection coefficient or return loss ofat least -10 dB or greater than -15 dB because return loss in antenna is a ratio of incident power to that of reflected power [8]. If S11= 0 dB, then all power is reflected from the antenna and nothing is radiated. The return loss obtained in our antennais -12.0145 dB at 2.5 GHz which is shown in Fig. 2.

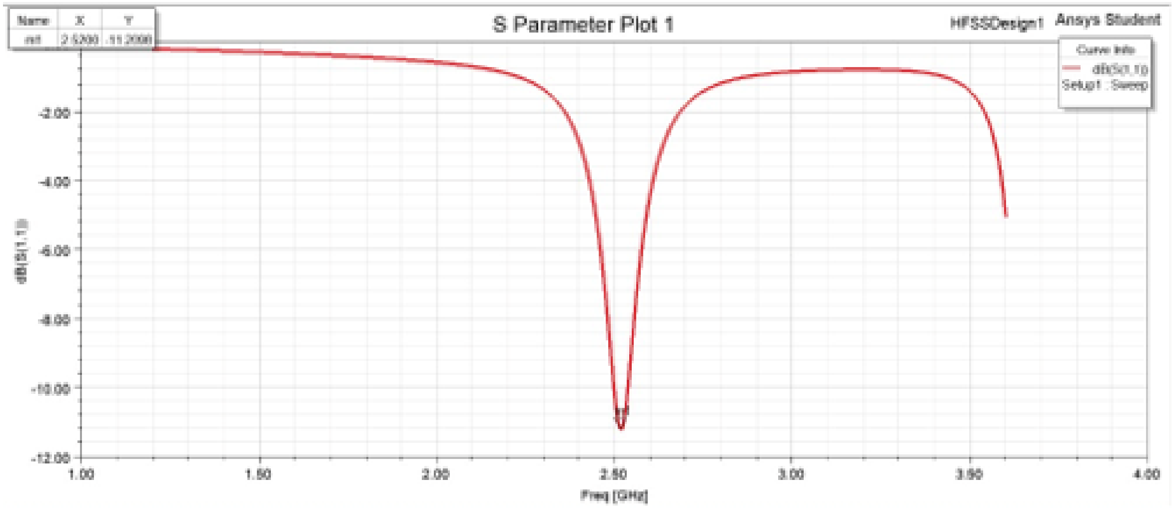

Fig. 2. Proposed Pentagonal Patch S11 parameters.

3.2. Voltage Standing Wave Ratio

Voltage Standing Wave Ratio is the measure of how efficiently RF power is transmitted and is expressed as the ratio ofmaximum to minimum amplitude (or voltage or current) of the corresponding field component appearing on the line that feedsan antenna. The VSWR is always a real and positive number for antennas. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. For microstrip patch antenna design to be used, this ratio should be in the range 1 VSWR 2 which is shown in Fig. 3.

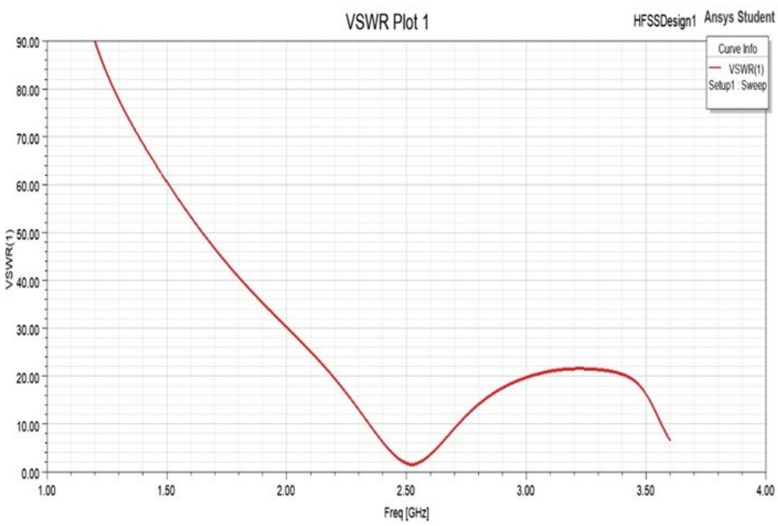

Fig. 3. VSWR of a Proposed Patch.

Table 2. Simulated result of proposed pentagaon patch.

Frequency in GHz	Return Loss in dB	VSWR
2.5	-11.2	1.7

3.3. Directivity

Directivity of an antenna is defined as the ratio of the radiation intensity in a given direction from the antenna tothe radiation intensity averaged over all directions. Figures and tables at the top and bottom of columns. The directivity of patch antennas is approximately 5-7 dB. The obtained directivity is 6.7 dB from Fig 4 (a).

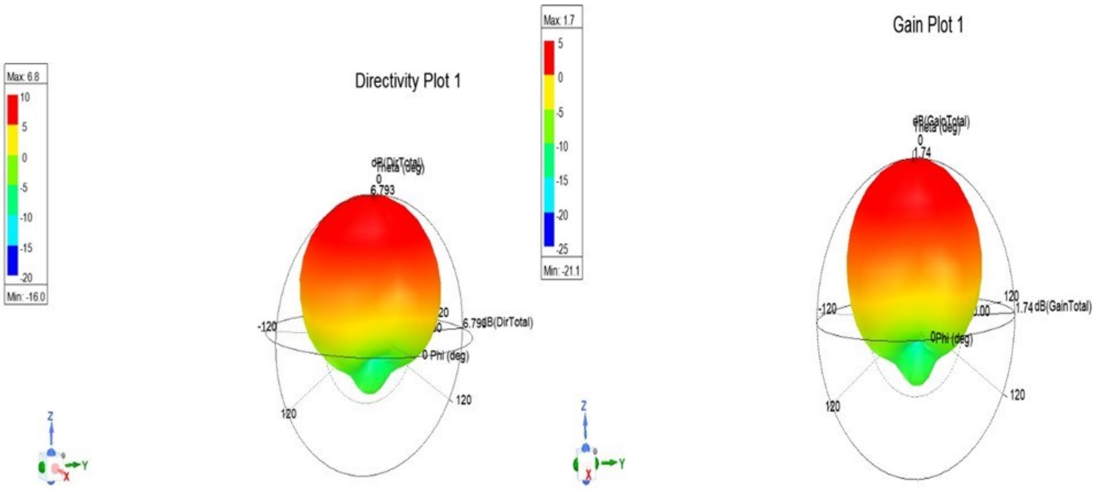

Fig. 4. Proposed patch (a) Directivity (b) Gain

3.4. Gain

Gain is one of the realized quantities in antenna theory. In general, gain is less than directivity and it introduces ohmic and other losses. A single patch antenna provides a maximum directive gain of around 6–9 dBi. The obtained gain is 1.74 dB Fig. 4 (b).

3.5. Vector Network Analyzer (VNA)

The VNA network analyzer is a more useful form of RF network analyzer than the SNA as it is able to measure more parameters about the device under test. Although mainly focused on research and development, RF network analyzers are able to provide vital insights into the operation and performance of RF networks of all types. The experimental resultof the proposed pentagonal shaped antenna VNA measurement setup is shown in Fig. 5 (a) and measurement result from VNA in 5 (b), respectively.

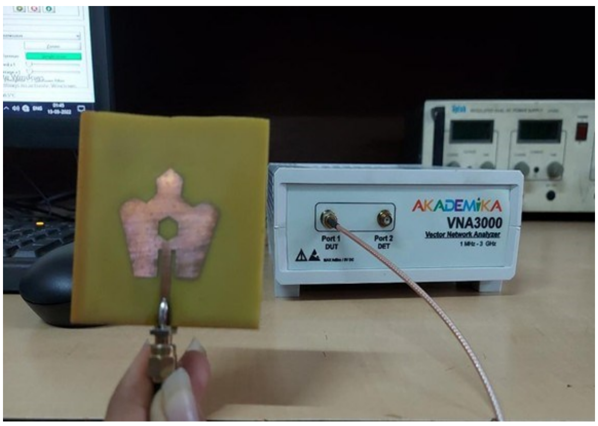

Fig. 5.a. Experimental results of the pentagonal shaped antenna Setup on the Vector Network Analyzer.

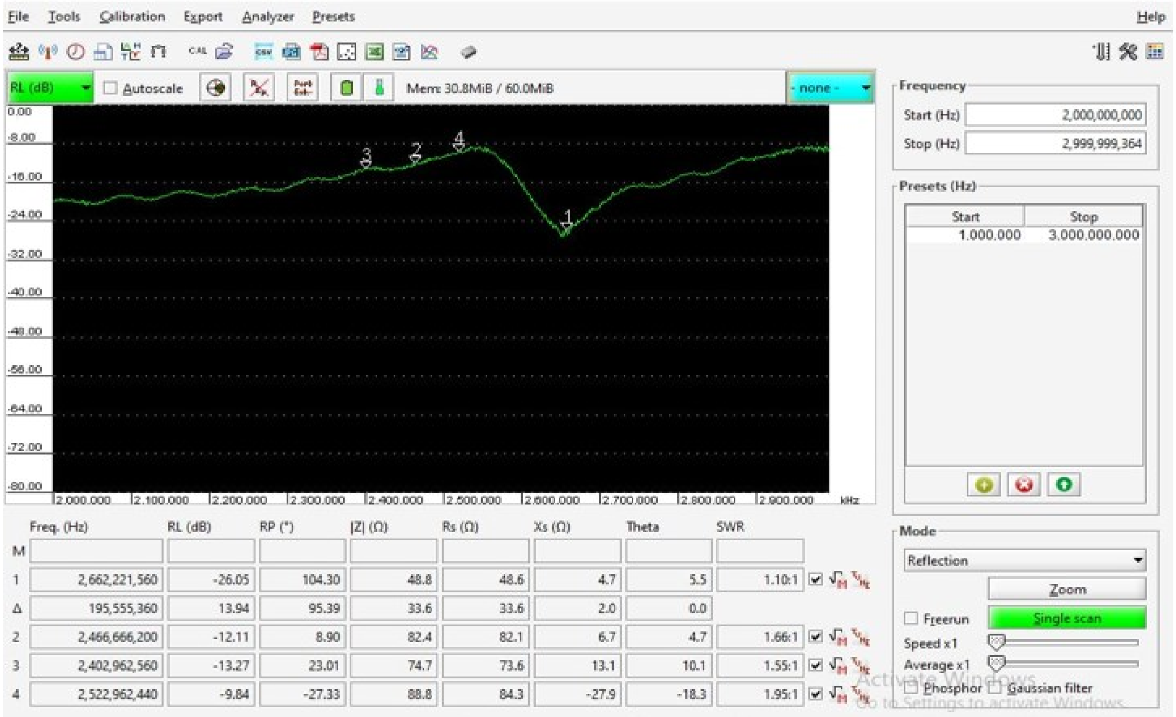

Fig. 5.b. Experimental results of the pentagonal shaped antenna measurement result from VNA.

4. RESULT AND DISCUSSION

Fig.2, shows the simulated and measured return loss is analyzed at 2.52 GHz frequency with the value of -11.2 dB respectively. The VSWR shown in Fig. 3, has a value of 1.7at 2.5 GHz. The gain and directivity value for the proposed design is 1.7 dB and 6.7 dB at 2.52 GHz frequency, which can cover WLAN and WiMAX applications in the 4G mobile phones. Table. 2 and 3. shows a simulated and measured antenna parameters for the pentagon microstrip patch antenna. The discrepancy between the measured and simulated results is due to fabrication tolerance and small air gap between dielectric layers. Fig. 5, illustrates the experimental set-up using vector network analyzer and the measured return loss -9.84 dB, impedance 88.8 Ω, and VSWR is 1.95 at 2.52 GHz. Fig. 6, shows a fabricated prototype of a proposed pentagonal antenna.

Table. 3. Experimental Result of a Proposed Pentagonal Patch.

Frequency in GHz	Return Loss in dB	Impedance in Ω	VSWR
0.19	13.94	33.6	-
2.4	-13.27	74.7	1.55
2.46	-12.11	82.4	1.66
2.52	-9.84	88.8	1.95
2.6	-26.06	48.8	1.1

Fig. 6. Fabricated prototype of a Proposed Patch.

5. CONCLUSION

According to the results observed in the Vector Network Analyzer we can see that at a frequency of 2.46 GHz and 2.66 GHz we are getting the desired results for antenna after implementing the hardware. Also, it is observed that there is only a slight change of in the parameter values after comparing the simulation and hardware results. Here, a pentagonal microstrip patch antenna is designed which is operating at a frequency of 2.52 GHz and has a return loss as less as -12.0145dB. Along with that this antenna gives a great directivity of 6.7dB and the VSWR values lies between 1 and 2. The proposed system of antenna can be used for WLAN applications after overcoming the problem of the gain parameter as it's slightly less than expected value.

ACKNOWLEDGEMENTS

We would like to thank our Dr. Dipak Marathe (HOD, Electronics and Telecommunication Engineering Department) A. C. Patil College of Engineering for being supportive and understanding throughout the course of this project. His guidance really helped us tackle various obstacles during simulation and hardware implementation of the project.

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