



International Journal of Innovative Research in Computer and Communication Engineering

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)





A Compact Super Wideband Hexagonal Shaped Monopole Antenna with Reconfigurable

G. Gayathri¹, CH. Kalyan², S. Sai Raju³, J. Naga Siva Krishna⁴, J.S. Deepika⁵

U.G. Student, Department of ECE, SVIET Engineering College, Nandamuru, Pedana, Andhra Pradesh, India^{1,2,3,4}

Assistant Professor, Department of ECE, SVIET Engineering College, Nandamuru, Pedana, Andhra Pradesh, India⁵

ABSTRACT: To reduce interference from other wireless communications, a compact super wideband frequency diversity hexagonal shaped monopole antenna with switchable rejection band capabilities is proposed. The patch consists of hexagonal structure with an open-ended horizontal slot that divides the patch into upper and lower parts. The overall size of the proposed antenna is 36 mmx36 mmx1.6 mm on an FR-4 substrate material with a loss tangent of $\tan \delta = 0.02$. The notch switchable features and the frequency diversity are controlled by changing the length of the resonator through alternating the state of inserted PIN diode inside the horizontal open-ended slot. The upper part of the hexagonal patch is connected to the negative terminal of the diodes and the biasing circuit in the back layer through a conducting via. The lower part is connected to the positive terminal of the diode. When diode is ON, the proposed antenna behaves as a ultrawide band covering a bandwidth from 3.17 GHz to 11.3 GHz. When diode is OFF, antenna behaves as multiband antenna operating at frequencies 3.67GHz, 6.16GHz, 9.91GHz. The antenna's radiation pattern is broadsided directional, the return loss and VSWR are observed for the ON and OFF cases. Hence, the proposed super wideband antenna is well-suited for applications in wireless communications.

KEYWORDS: Super wideband, frequency reconfigurable, notch characteristics, PIN diode, time domain analysis.

I. INTRODUCTION

Antennas play a crucial role in wireless communication systems by transmitting and receiving electromagnetic waves. With the rapid development of wireless technologies such as mobile communication, satellite systems, radar, and wireless local area networks, there is an increasing demand for antennas that can adapt to different operating conditions. Traditional antennas are designed to operate at a fixed frequency and radiation pattern, which limits their flexibility in modern communication systems. To overcome these limitations, reconfigurable antennas have been introduced [1-2]. A reconfigurable antenna is an antenna that can dynamically modify its operating characteristics such as frequency, radiation pattern, or polarization according to the requirements of the communication system. This is achieved by altering the physical structure or electrical properties of the antenna using electronic components such as switches, varactor diodes, MEMS switches, or PIN diodes. These antennas provide flexibility, better spectrum utilization, and improved system performance. Reconfigurable antennas are widely used in modern wireless communication systems where multiple frequency bands and communication standards are required. By using a single antenna that can adapt to different conditions, the need for multiple antennas is reduced, which saves space, cost, and power [3-5]

II. RELATED WORK

Hexagonal shaped monopole antenna is designed, to achieve frequency reconfiguration a switching element is incorporated in the antenna structure. The electrical behaviour of the switching element is modeled using an equivalent circuit consisting of 3 Ω resistance and 0.2 pF capacitance. These parameters represent the conductive and capacitive characteristics of the switching component used in the antenna design[6-8]. The performance of the proposed reconfigurable antenna is analyzed using electromagnetic simulation. The antenna model was designed and simulated using CST Studio Suite. The analysis mainly focuses on important antenna parameters such as return loss (S11), resonant frequency, and Voltage Standing Wave Ratio (VSWR). The antenna performance is evaluated by observing



International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

the S11 characteristics and VSWR curves obtained from the simulation results. Marker points were used on the graphs to identify the resonant frequencies where the antenna shows minimum return loss and proper impedance matching.

III. METHODOLOGY

The proposed compact super wideband frequency diversity hexagonal-shaped monopole antenna with a switchable rejection band is designed and analyzed through a systematic approach. Initially, a hexagonal radiating patch is selected due to its ability to support multiple resonant modes, enabling super wideband performance[8-10]. The antenna is modeled on a FR4 dielectric substrate and a partial ground plane is introduced to enhance impedance bandwidth. Frequency diversity is achieved by incorporating a PIN diode at the open slot. The antenna operates in two modes: with the switch ON (activating the UWB characteristics) and OFF (providing multiband operation). Parametric analysis is carried out using electromagnetic simulation software CST to fine-tune performance metrics such as return loss, VSWR, gain, and radiation pattern.

3.1 Antenna design analysis:

The suggested patch antenna schematic diagram for the top, back, and side views are shown in Figure The simulations and optimizations have been supported by high-frequency structure simulator software. The antenna was built using a low-cost substrate known as FR-4 with a relative permittivity of 4.4 and loss tangent of 0.02, having an overall size of $36 \times 36 \times 1.6 \text{ mm}^3$. The patch has a hexagonal shape and is fed by a feedline for better impedance matching between the $50\text{-}\Omega$ coaxial cable connected to the SMA connector and the high impedance at the patch edge. A horizontal slot in the patch center with a width of 1 mm is introduced to insert anode PIN diode with a footprint of $1 \text{ mm} \times 0.8 \text{ mm}$, placed at the center of the horizontal slot for frequency diversity analysis.

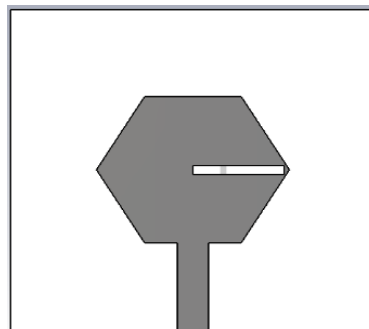


Fig:1 Antenna structure front view

Antenna consists of a simple hexagonal patch, partial ground plane, and feedline. The hexagonal shape was chosen because the bandwidth of a circular patch antenna is higher than any other geometry, and the hexagonal geometry is almost identical to a circular patch. The dimensions of the hexagonal antenna are calculated by adjusting the planar disc formula as explained in. The tapered feed line is a matching transformer between the point of feeding and the hexagonal patch which will provide a smooth impedance transition, reduce the reflection of the incident wave, and enhance the antenna bandwidth.

3.2 Return Loss Characteristics:

Return loss is an important parameter used to determine the efficiency of an antenna. It indicates the amount of power that is reflected back from the antenna due to impedance mismatch between the antenna and the feeding transmission line. The reflection coefficient is represented by the parameter S11 and is expressed in decibels (dB). For most practical antenna designs, a return loss value below -10 dB indicates good impedance matching and efficient radiation performance. The S11 graph obtained from the simulation results shows several dips in the curve. These dips correspond to the resonant frequencies where antenna radiates electromagnetic energy efficiently.

3.3 Resonant Frequency Analysis:

A resonance is observed near 3.6713 GHz , where the return loss reaches approximately -15.97 dB . This indicates good impedance matching and efficient radiation at this frequency. Another strong resonance occurs at 6.1939 GHz ,



International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

where the return loss decreases significantly to -22.88 dB. This deep null in the S_{11} graph indicates excellent impedance matching between the antenna and the transmission line. A third resonance appears around 9.9145 GHz, where the return loss reaches approximately -23.10 dB. This represents one of the strongest resonance points of the antenna, indicating very efficient radiation. When the switching configuration changes, additional resonant frequencies appear. The antenna exhibits resonance near 3.1739 GHz, where the return loss is approximately -9.91 dB. Another resonance occurs at 3.7291 GHz, where the return loss decreases to approximately -16.03 dB. A strong resonance is also observed at 9.8384 GHz, where the return loss reaches -21.93 dB, indicating efficient radiation performance. At higher frequencies, the antenna shows another resonance near 11.395 GHz, where the return loss value is approximately -10.06 dB, which still satisfies the acceptable condition for antenna operation. The presence of these multiple resonance points confirms that the antenna is capable of operating across several frequency bands.

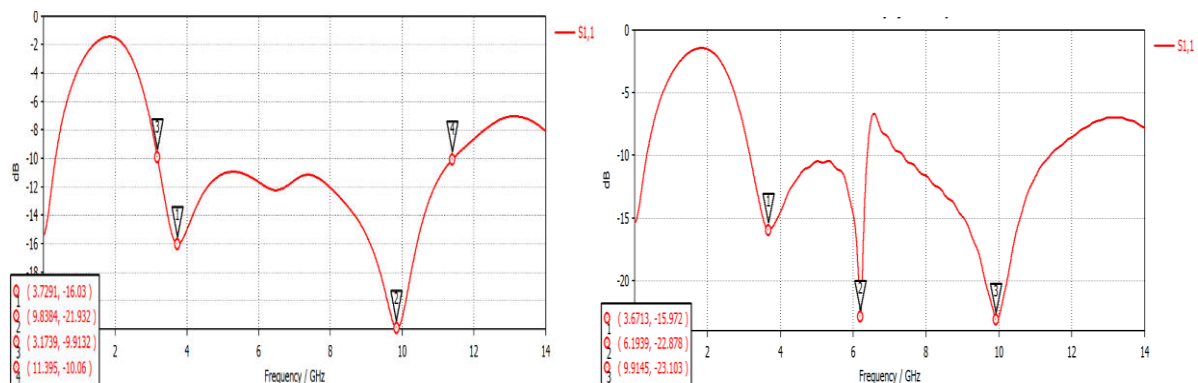
3.4 Impedance Matching Behaviour:

Impedance matching plays a crucial role in antenna performance because it determines how effectively power is transferred from the feed line to the antenna. When the antenna impedance matches the characteristic impedance of the transmission line, maximum power transfer occurs and reflections are minimized. From the S_{11} graph, it can be observed that the return loss values fall below -10 dB at several frequencies. This indicates that the antenna maintains good impedance matching across multiple frequency bands. The strongest impedance matching occurs near 6.1939 GHz and 9.9145 GHz, where the return loss values reach approximately -22.88 dB and -23.10 dB, respectively. These deep nulls in the return loss curve confirm that the antenna radiates electromagnetic energy efficiently with minimal reflection. Voltage Standing Wave Ratio (VSWR) is another important parameter used to evaluate antenna performance. VSWR indicates the ratio between the maximum voltage and minimum voltage along the transmission line. A VSWR value of 1 indicates perfect impedance matching, while values less than 2 are generally considered acceptable for practical antenna systems. The VSWR curve obtained from the simulation results shows minimum values at the same frequencies where the S_{11} graph exhibits resonance. At frequencies such as 3.6713 GHz, 6.1939 GHz, and 9.9145 GHz, the VSWR values approach values close to 1, indicating strong impedance matching and efficient power transfer. Similarly, the resonances observed at 3.7291 GHz, 9.8384 GHz, and 11.395 GHz also exhibit VSWR values. The close relationship between the S_{11} dips and VSWR minima confirms the accuracy and reliability of the antenna simulation results.

IV. EXPERIMENTAL RESULTS

In the ON state, the antenna acts as an ultra-wideband (UWB) antenna covering approximately 3.7 GHz to 11.9 GHz, exhibiting good impedance matching over a wide frequency range. It shows multiple resonant frequencies around 3.72 GHz, 3.73 GHz, 9.83 GHz, and 11.39 GHz with satisfactory return loss, indicating efficient radiation performance. In the OFF state, the antenna operates as a multiband antenna with distinct resonant frequencies around 3.67 GHz, 6.13 GHz, and 9.91 GHz, showing good return loss at these frequencies [10-12]. This indicates efficient radiation and proper impedance matching across the selected bands.

Fig 2:



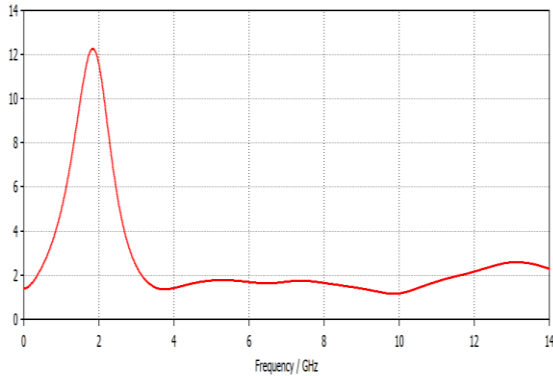
(a) s-parameter for diode on state

(b) s-parameter for diode off state

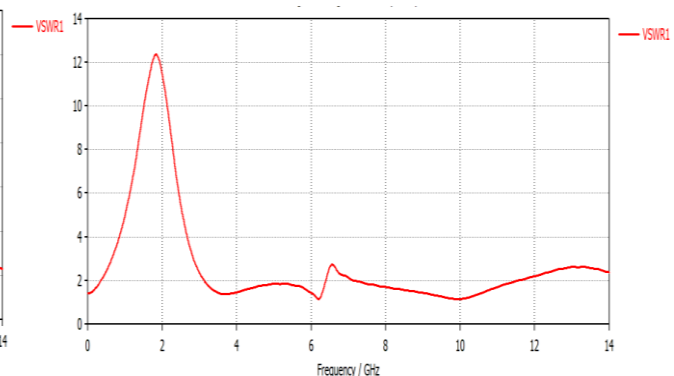


International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCCE)

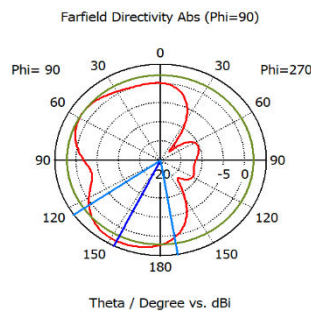
(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



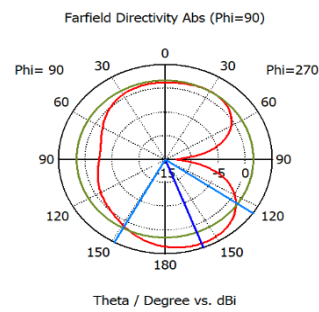
(c) VSWR for diode on state



(d) VSWR for diode off state



(e) Radiation pattern for diode on state



(f) Radiation pattern for diode off state

Fig 1 shows the results of compact super wideband frequency diversity hexagonal shaped monopole antenna with switchable rejection band. fig (a) s-parameter for diode on state. (b) s-parameter for diode off state. (c) VSWR analysis for diode on state. (d) VSWR analysis for diode off state. (e) radiation pattern for diode on state. (f) radiation pattern for diode off state

V. CONCLUSION

In this project, a reconfigurable antenna capable of operating in both ultra-wideband and multiband modes was successfully designed and analyzed. The antenna was modeled and simulated using CST Studio Suite to evaluate its performance characteristics such as S-parameters and VSWR.

The simulation results show that in the diode ON state, the antenna operates at resonant frequencies around 3.17 GHz, 3.72 GHz, 9.83 GHz, and 11.39 GHz, demonstrating ultra-wideband behaviour. In the diode OFF state, the antenna exhibits multiband operation at approximately 3.6 GHz, 6.1 GHz, and 9.9 GHz. The obtained S11 values are below -10 dB and the VSWR values are less than 2, which indicate good impedance matching and efficient radiation performance.

Therefore, the proposed antenna design is suitable for various wireless communication, radar, and satellite communication applications. The reconfigurable capability of the antenna makes it useful for modern communication systems that require flexible and efficient antenna performance

REFERENCES

1. Federal Communication Commissions (FCC) (First Report and Order), Revision of Part15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, document ET Docket 98—153, Washington, DC, USA, 2002.
2. W. Balani, M. Sarvagya, T. Ali, M. Pai M. M., J. Anguera, A. Andujar, and S. Das, "Design techniques of super-wideband Antenna—Existing and future prospective," IEEE Access, vol. 7, pp. 141241–141257, 2019.



International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

3. B. Yeboah-Akouwah, E. T. Tehao, M. Ur-Rehman, M. M. Khan, and S. Ahmad, "Study of a printed split-ring monopole for dual-spectrum communications"
4. T. Okan, "A compact octagonal-ring monopole antenna for super wideband applications," *Microw. Opt. Technol. Lett.*, vol. 62, no. 3, pp. 1237–1244, Mar. 2020.
5. S. Ahmad, S. Khan, B. Manzoor, M. Soruri, M. Alibakhshikenari, M. Dalarsson, and F. Falcone, "A compact CPW-fed ultra-wideband multi-input-multi-output (MIMO) antenna for wireless communication networks," *IEEE Access*, vol. 10, pp. 25278–25289, 2022
6. M. A. Dorostkar, M. T. Islam, and R. Azim, "Design of a novel super wide band circular-hexagonal fractal antenna," *Prog. Electromagn. Res.*, vol. 139, pp. 229–245, 2013.
7. I. Raviteja, C. Padmanjali, D. V. S. Kalyan, B. Alekhya, G. Chakravarthy, and M. V. Ramya, "Analysis and design of hexagonal patch antenna with fractals for wide band applications," *Int. J. Innov. Technol. Exploring Eng. (IJITEE)*, vol. 8, no. 8, pp. 583–587, 2019.
8. R. Kumar, N. Kushwaha, and R. V. S. Ram Krishna, "Design of ultra-wide-band hexagonal patch slot antenna for high-gain wireless applications," *J. Electromagn. Waves Appl.*, vol. 28, no. 16, pp. 2034–2048, Nov. 2014.
9. R. Boopathi Rani and S. K. Pandey, "A parasitic hexagonal patch antenna surrounded by same shaped slot for WLAN, UWB applications with notch at vanet frequency band," *Microw. Opt. Technol. Lett.*, vol. 58, no. 12, pp. 2996–3000, Dec. 2016.
10. Chandrabhan and A. Kumar, "Triple band notch loaded hexagonal patch stacked antenna," *Int. J. Eng. Technol. (IJET)*, vol. 9, no. 3, pp. 2485–2490, Jun. 2017
11. M. Abdelazeez and A. Sharif, "Enhanced UWB printed monopole antenna based on ground plane modifications," *Jordanian J. Comput. Inf. Technol. (JJCIT)*, vol. 4, no. 1, pp. 25–33, 2018.
12. Y. S. Al-Faouri, N. M. Awad, and M. K. Abdelazeez, "Enhanced ultra-wide band hexagonal patch antenna," *Jordanian J. Comput. Inf. Technol.*, vol. 4, no. 3, pp. 150–158, 2018.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

 9940 572 462  6381 907 438  ijircce@gmail.com



www.ijircce.com

Scan to save the contact details