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Gain Enhancement of Microstrip Patch Antenna for Wi-Fi Augmentation

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Abstract: ***A wideband, compact and low profile microstrip patch antenna (MSPA) design for wireless fidelity and C-band considerations is very advantageous in various applications.***
The antenna proposed in this paper consists of a simple laterally inverted Swastik-shaped patch with the microstrip line fed and a rectangular ground plane.
The antenna has patch dimension of 15mm×12mm, substrate dimension of 20mm×20mm overall size, prototyped on FR4 material of excellent physical and electrical properties, thickness of 0.5 mm and a dielectric constant of 4.4. According to the software simulation results, the proposed MSPA displays remarkable return loss and voltage standing wave ratio (VSWR) and operates at the Wi-Fi frequency of 5 GHz. In addition to this, it may also be operated in the frequency range of 4-8 GHz. The results obtained from the measurements are similar to the fabricated antenna after testing using the vector network analyzer (VNA).
Keywords: Wi-Fi, C-band, MSPA, Swastik, VSWR, Return Loss, Gain, Ansys HFSS

I. INTRODUCTION

Wi-Fi is a family of wireless network protocols based on IEEE 802.11 standards. It has been used for accessing the Internet, exchanging data over long-range communication and for networking purposes for a while now.
It is now being used across the world, in homes and small office networks, linking wireless and wired access points alike to the Internet.
Antennas are unquestionably the most crucial components of a wireless system. Due to the growing mobility and miniaturization of mobile devices, new wireless communication systems require low profile antennas for high mobility as well as wideband antennas for high-speed data transfer with maximum coverage.
Wi-Fi enhancement requires a good negative return loss value (S11 parameter) and nearly ideal VSWR which helps in improving the gain and bandwidth of Microstrip Patch Antenna. As a result, a wideband Wi-Fi antenna design has been determined with extended bandwidth and highly enhanced gain.

II. LITERATURE SURVEY

The proposed antenna design asserts its inquisitive compactness, subsequent augmentation into an embedded Wi-Fi module and portability and enhanced gain.
This has been designed using ANSYS HFSS software. Nowadays, because of advances in integrated technology, engineers are able to fit many diverse applications operating at different frequencies into a single wireless device.
As a result, the demand for various antennas covering different wireless communication bands on the same platform has increased dramatically. [5]
Here, a plain ground structure instead of a defected ground structure (DGS) is implemented within the design. In addition to the aim of this project, achieving a simple, compact and low-profile antenna without DGS would introduce a good amount of radiation on all sides without the radiations getting deflected in the case of a DGS. This way, the slot lobes would not be able to emit some of their radiation towards the back lobes and thus, radiation pattern changes positively. This is one of the main beneficial components that would provide the desired enhanced gain and high radiation.

III. ANTENNA DESIGN

The antenna had been designed following the below procedure as shown in the flowchart.

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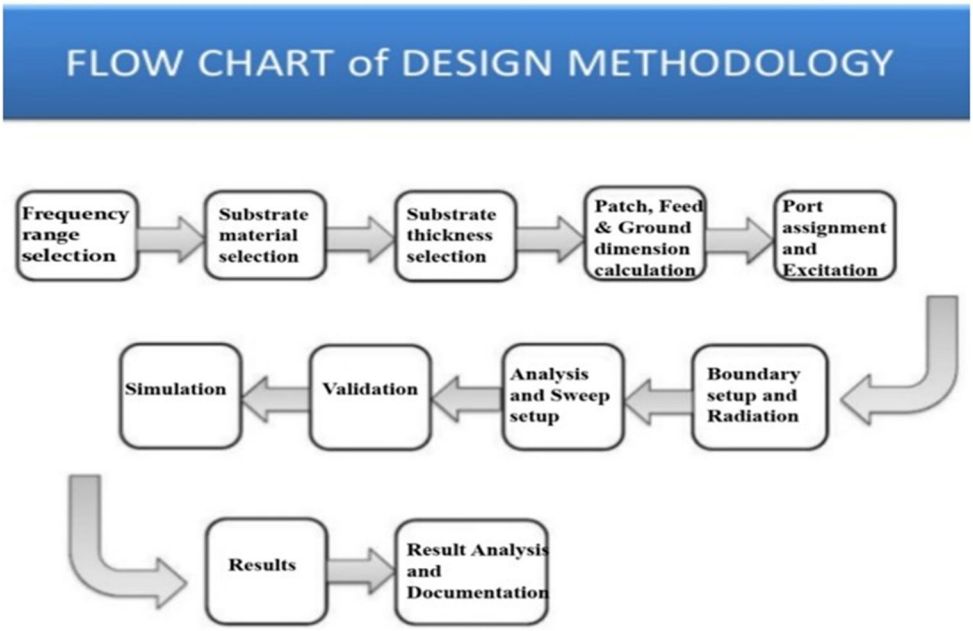


Fig 3.1 Flowchart of Design Methodology of the Proposed Antenna

The antenna has been designed after numerous levels of trial and error in determining the various parameters that include position coordinates, size, shape etc to design it. Here are the formulae that have been involved in calculating the length and width of the patch.

$$Width = \frac{c}{2f_o\sqrt{\frac{\varepsilon_R+1}{2}}}; \quad \varepsilon_{eff} = \frac{\varepsilon_R+1}{2} + \frac{\varepsilon_R-1}{2}\left[\frac{1}{\sqrt{1+12\left(\frac{h}{W}\right)}}\right] \longrightarrow (1)$$

$$Length = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}\right) \longrightarrow (2)$$

The length of the patch has been calculated as 11.82 mm and its width 15.2 mm at the operating frequency of 5 GHz (the Wi-Fi frequency). The tabulated version of all the dimensions is shown in this paper.

IV. PROCEDURE OF ANTENNA DESIGN

The antenna is designed as follows. Open Ansys Electronic Desktop application installed in the PC. Go to project and insert a new HFSS 3D Design. Click the Box Icon on the toolbar above, name it as “Substrate”, create box under Substrate, provide the material as FR-4 Epoxy (relative permittivity=4.4) and give the required coordinates. For Patch, repeat the procedure but by taking a rectangle instead of a box, name it as “patch”. Take a rectangle and name it as “Slot”. Click create rectangle under the slot and create multiple rectangles and give proper position coordinates in order to get swastik shape. Create new rectangle, name it as “Feed” and provide coordinates with respect to patch and slot.

Create new Box, name it as “Boundary” and create a box, give position coordinates such that entire substrate must be inside of it but without colliding. Click Apply and OK. For the ground plane, take a rectangle and name it as “ground”. Create a rectangle and assign position coordinates. In the toolbar above, change the axis from XY to YZ. Take another rectangle for the port, name it. Create a rectangle under the port and assign position coordinates. Subtract patch and slot of multiple by clicking the subtract option available in the toolbar above.

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Before this step, unite the multiple rectangles of the slot into the Swastik shape. Similarly, add patch and feed by clicking unite option in the toolbar. To give an excitation port, under project, Click HFSS design and right click on port. Click assign excitation and then lumped port. Click next and take a new line and click at the center of the port and drag it to any corner of the port. It must display as defined. Click next and finish. Assigning excitation to the port is mandatory in order to establish good impedance matching so that a wide range of signals or large data transmission and receiving takes place which is required.

To get plots, right click on patch, then assign boundary as perfect E. Right click on boundary (under vacuum), then assign boundary as radiation. Right click on radiation and insert far field setup and select as infinite sphere. Right click on analysis and add solution setup. Enter frequency as 5 GHz. Click on Analysis setup and add frequency sweep. Go to HFSS on above toolbar, click validation check and green ticks must be obtained. Right click on analysis, click analyze all and save the project. Right click on the result and create a modal solution data report. Select the rectangular plot and click the new report to get each plot. Similarly, for VSWR , repeat the above procedure in the new report window. In the result, click the far field report to obtain radiation patterns and new report likewise, select 3D polar plot and new report.

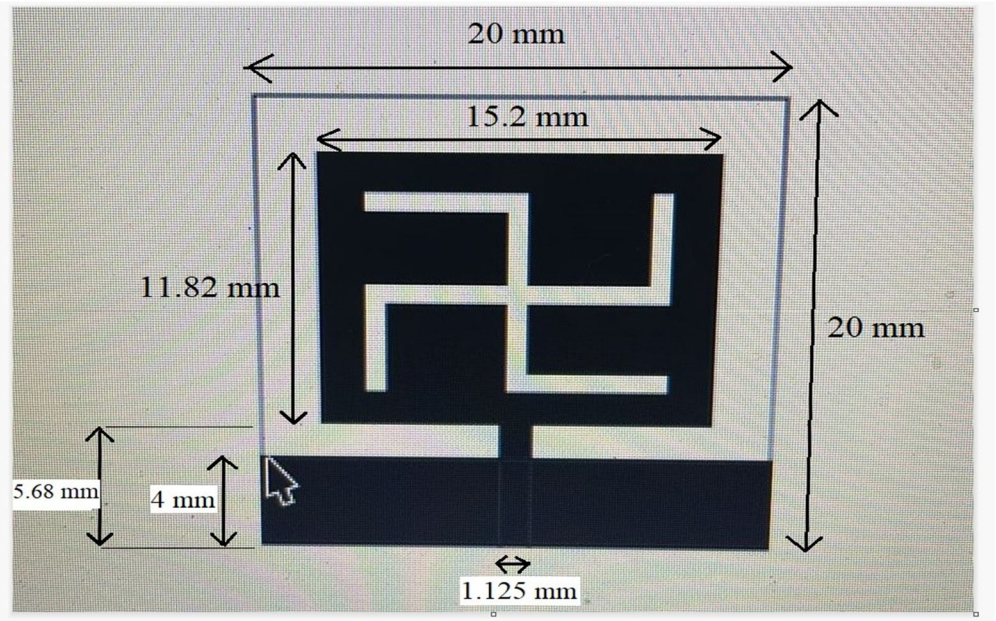


Fig 4.1 Dimensions of Inverted Swastik Shaped Slot Microstrip Patch Antenna

V. RESULTS

The results of the software simulation are as follows:

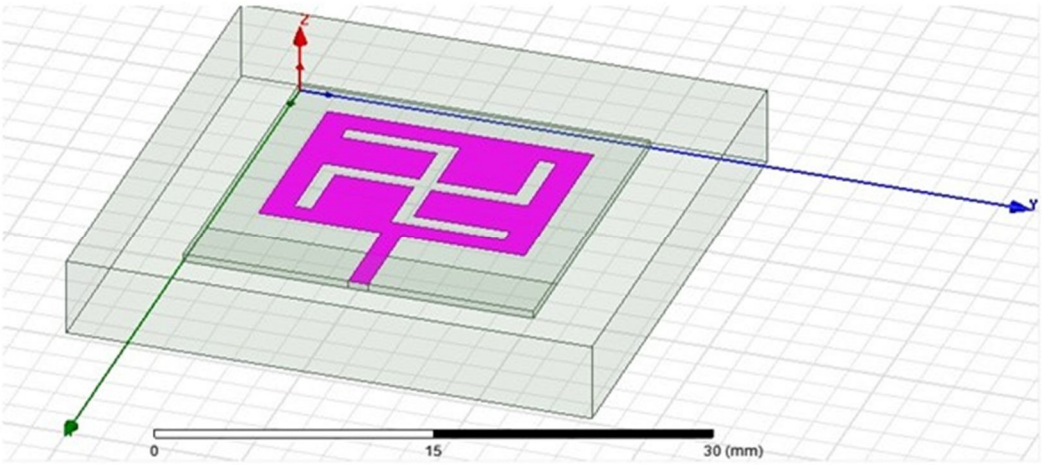


Fig 5.1 Trimetric View of Inverted Swastik-shaped Slot of Proposed Antenna

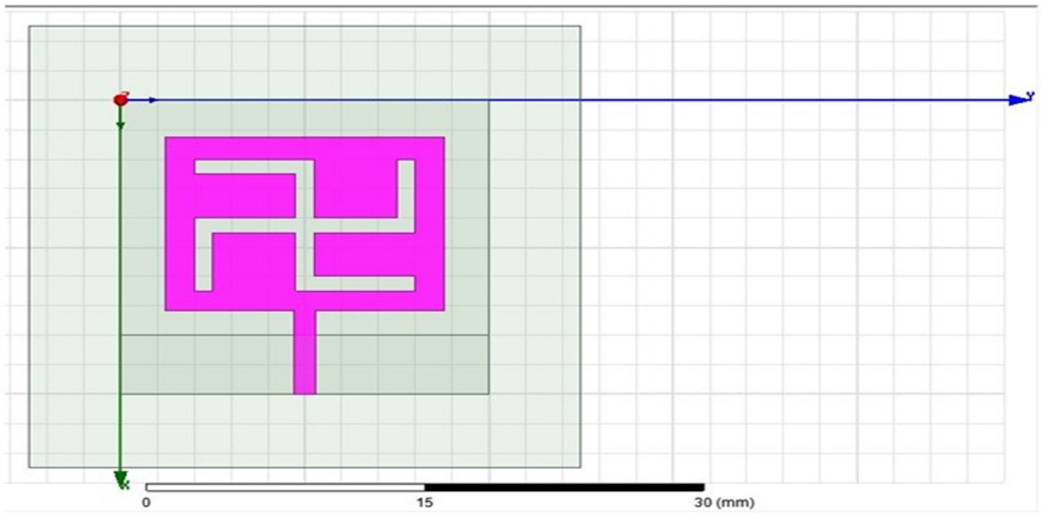


Fig 5.2 Top View of Inverted Swastik-shaped Slot of Proposed Antenna

It has been observed in the ANSYS HFSS that the return loss for the proposed design at 5.09 GHz is -33.6895 dB. This return loss indicates relatively less power is reflected from the load. This is a desirable outcome for proper functioning of the antenna.

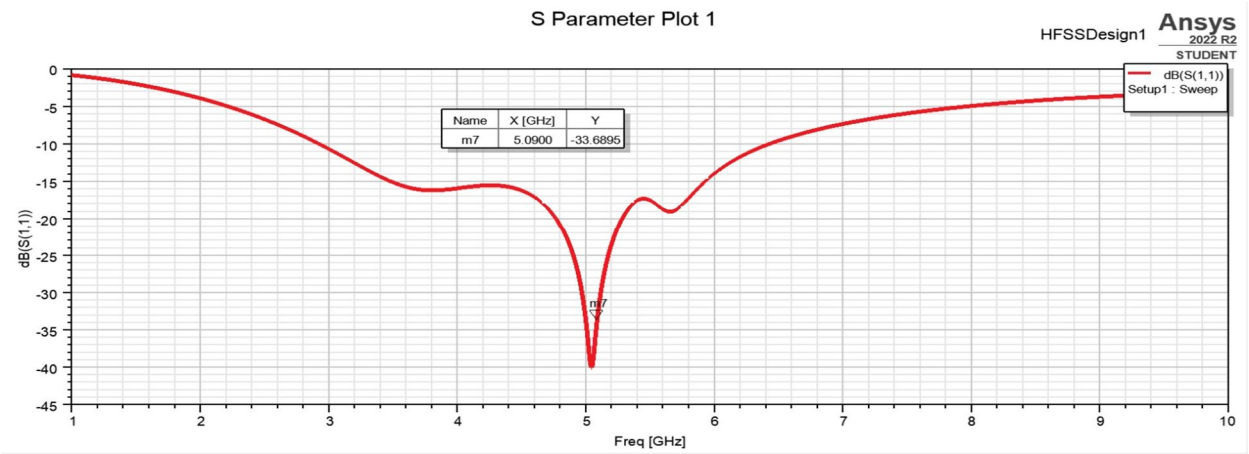


Fig 5.3 Return Loss vs Frequency Plot of Inverted Swastik-shaped Slot of Proposed Antenna

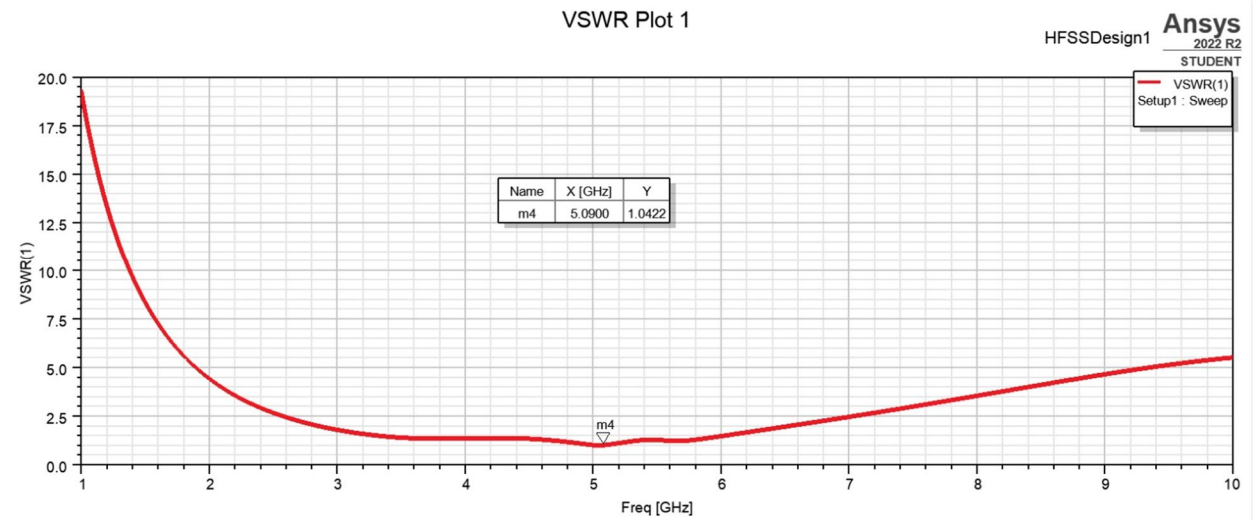


Fig 5.4 VSWR vs Frequency Plot of Inverted Swastik-shaped Slot of Proposed Antenna

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For the proposed design, it has been observed that at 5.09 GHz, the VSWR value is 1.0422, which is close to the ideal value and highly desirable.

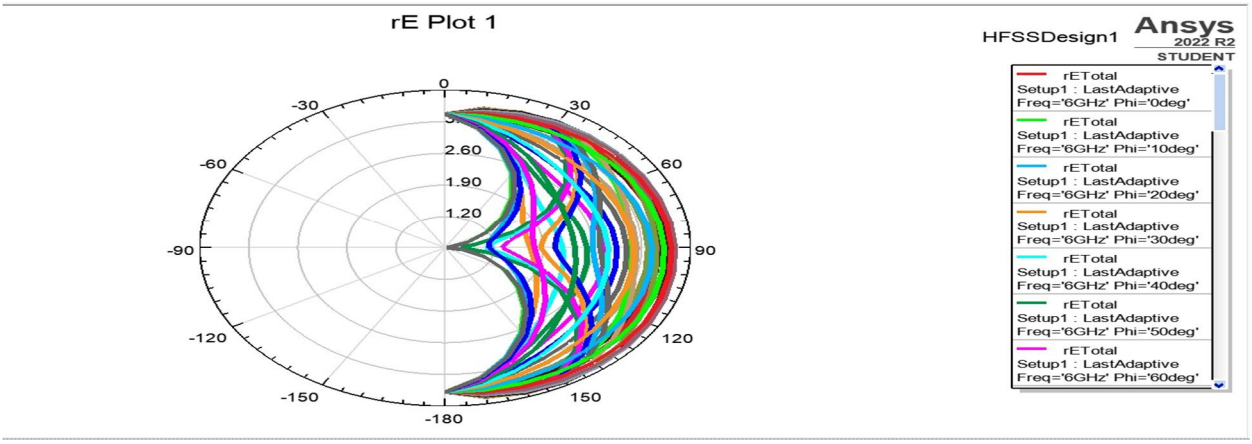


Fig 5.5 Radiation Pattern of Inverted Swastik-shaped Slot of Proposed Antenna

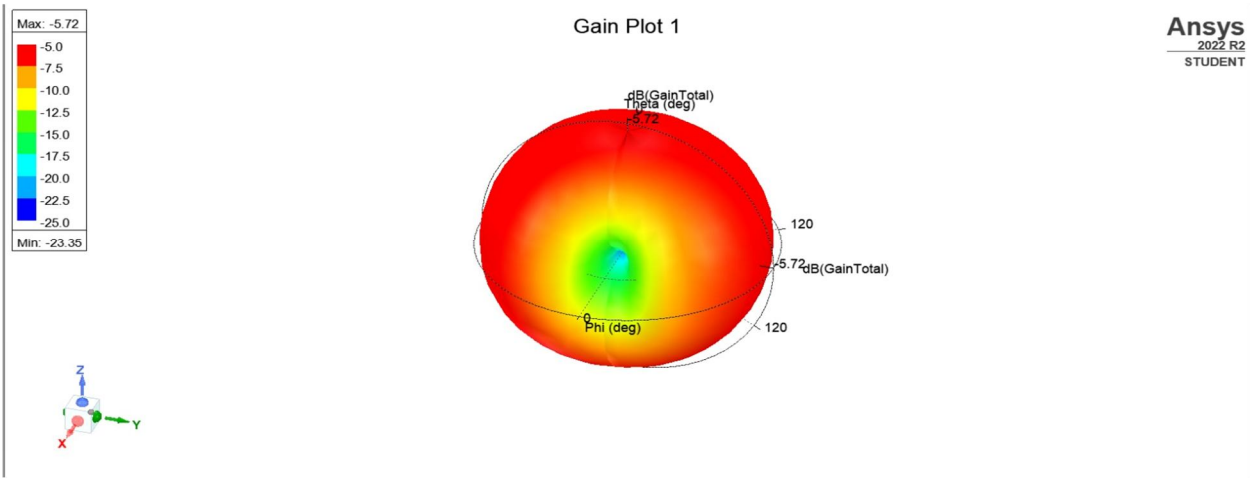


Fig 5.6 Gain vs Theta of Inverted Swastik-shaped Slot of Proposed Antenna

For the proposed design, it has been observed that at 5.09 GHz, the Gain value is -5.72 dB, which shows the maximum radiation in z-direction.The gain of the antenna is highly associated with the directivity. While the directivity shows complete dependency on the radiation pattern offered by the antenna. The proposed antenna shows maximum radiation in the z-direction by the color coding of red.

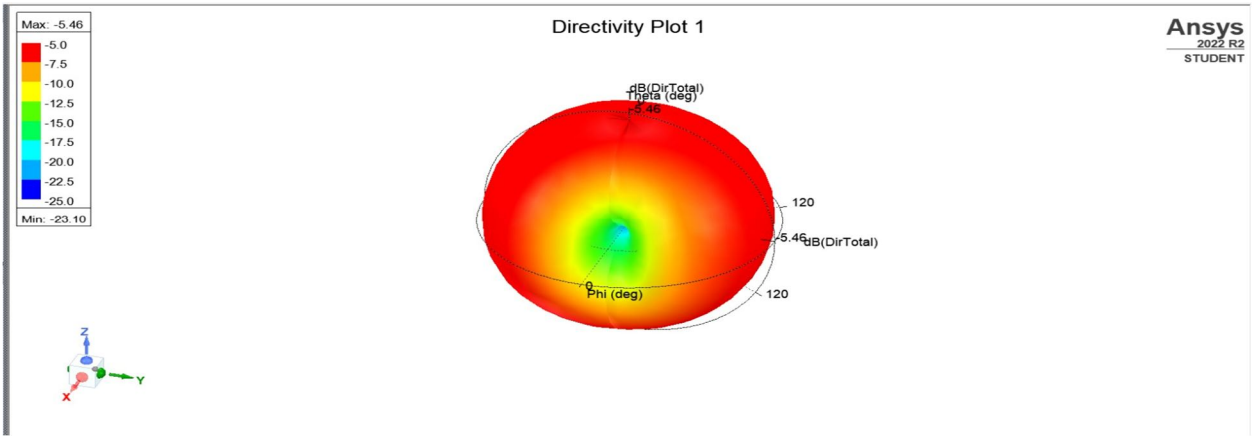


Fig 5.7 Directivity vs Theta of Inverted Swastik-shaped Slot of Proposed Antenna

Conversely, the hardware simulations are as shown below.

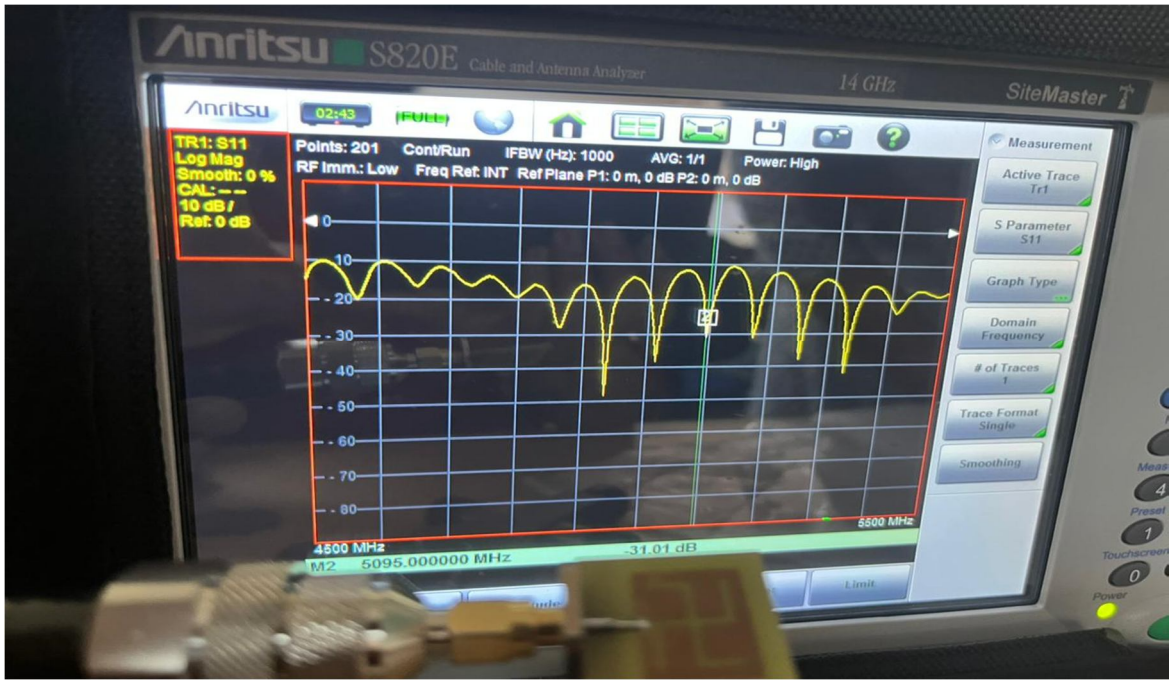


Fig 5.8 Return Loss vs Frequency Plot of Inverted Swastik-shaped Slot Fabricated Antenna on VNA

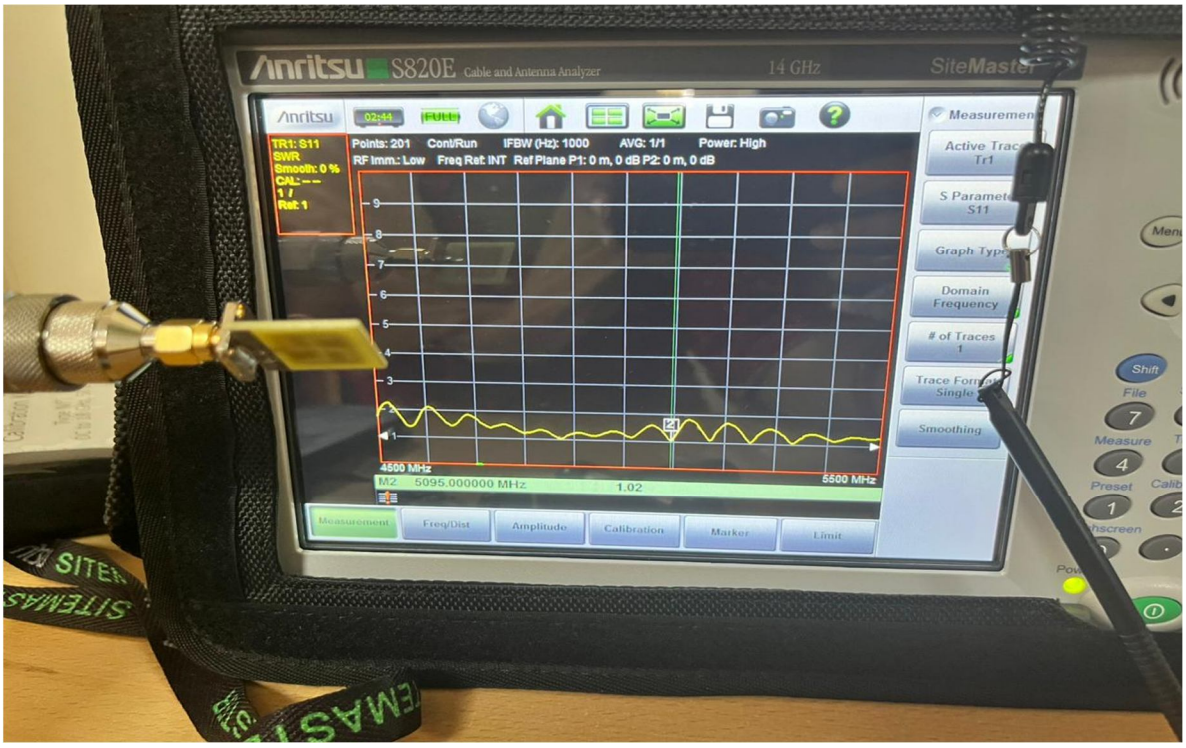


Fig 5.9 VSWR vs Frequency Plot of Inverted Swastik-shaped Slot Fabricated Antenna on VNA

The fabricated antenna is connected to vector network analyzer in order to get antenna parameters such as S11 parameter and VSWR. The above pictures show the hardware results of S11 parameter and VSWR which have been yielded by testing the fabricated antenna using vector network analyzer.

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S. No	Antenna Parameters	Operating Frequency	Software Simulation	Hardware Testing
1.	Return Loss	5.09 GHz	-33.6895 dB	-31.01 dB
2.	VSWR	5.09 GHz	1.0422	1.02

Fig 5.10 Comparison of software simulation and hardware testing results of inverted swastika patch antenna

VI. CONCLUSIONS AND FUTURE SCOPE

The proposed antenna witnesses a possibility of extensive 5G network coverage. Wi-Fi connectivity in C band is essential for various types of satellite communication and its divergence into the aviation industry. The antenna parameters such as VSWR, return loss, gain, radiation patterns and directivity have been obtained using Ansys HFSS Software. A high return loss is advantageous as it will result in a lower insertion loss. This will also lead to VSWR nearer to 1 which implies that most of the power from source is absorbed by the load which is highly crucial for Wi-Fi applications. This proposed design obtains a better throughput owing to comparatively larger bandwidth range. The compact antenna size with maximum gain and radiation contributes to broad geographic reach. It is also robust and compatible with other embedded systems and devices when mounted on rigid surfaces and within them.

Adverse weather connections invariably result in poor network connectivity, necessitating the establishment of continuous communication, specifically Wi-Fi. Wi-Fi augmentation is something that is extremely advantageous. By improving the gain, shape of the slot, and bandwidth of microstrip patch antennas, long-range wireless communication may be achieved. Some Wi-Fi systems use C-band frequencies to provide wireless connectivity in high-density areas like airports, satellite communications sites, and shopping malls and to render mobile broadband services.

REFERENCES

[1] S. Kumar, S. K. Palaniswamy, S. Saxena, R. Tiwari and S. Sah, "Dual-Band Low Profile Notched Printed UWB Monopole Antenna with Enhanced Bandwidth," *2018 5th International Conference on Signal Processing and Integrated Networks (SPIN)*, Noida, India, 2018, pp. 39-42, doi: 10.1109/SPIN.2018.8474146.

[2] H. Zhang and A. Shamim, "Gain and Efficiency Enhancement of a 77 GHz On-Chip Antenna through AMC and Superstrate Package," *2018 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting*, Boston, MA, USA, 2018, pp. 363-364, doi: 10.1109/APUSNCURSINRSM.2018.8608189.

[3] Arora, Ayush & Rana, Arpit & Yadav, Abhimanyu & Yadava, R.L. (2021). Design of microstrip patch antenna at 2.4 GHz for Wi-Fi and Bluetooth applications. Journal of Physics: Conference Series. 1921. 012023. 10.1088/1742-6596/1921/1/012023.

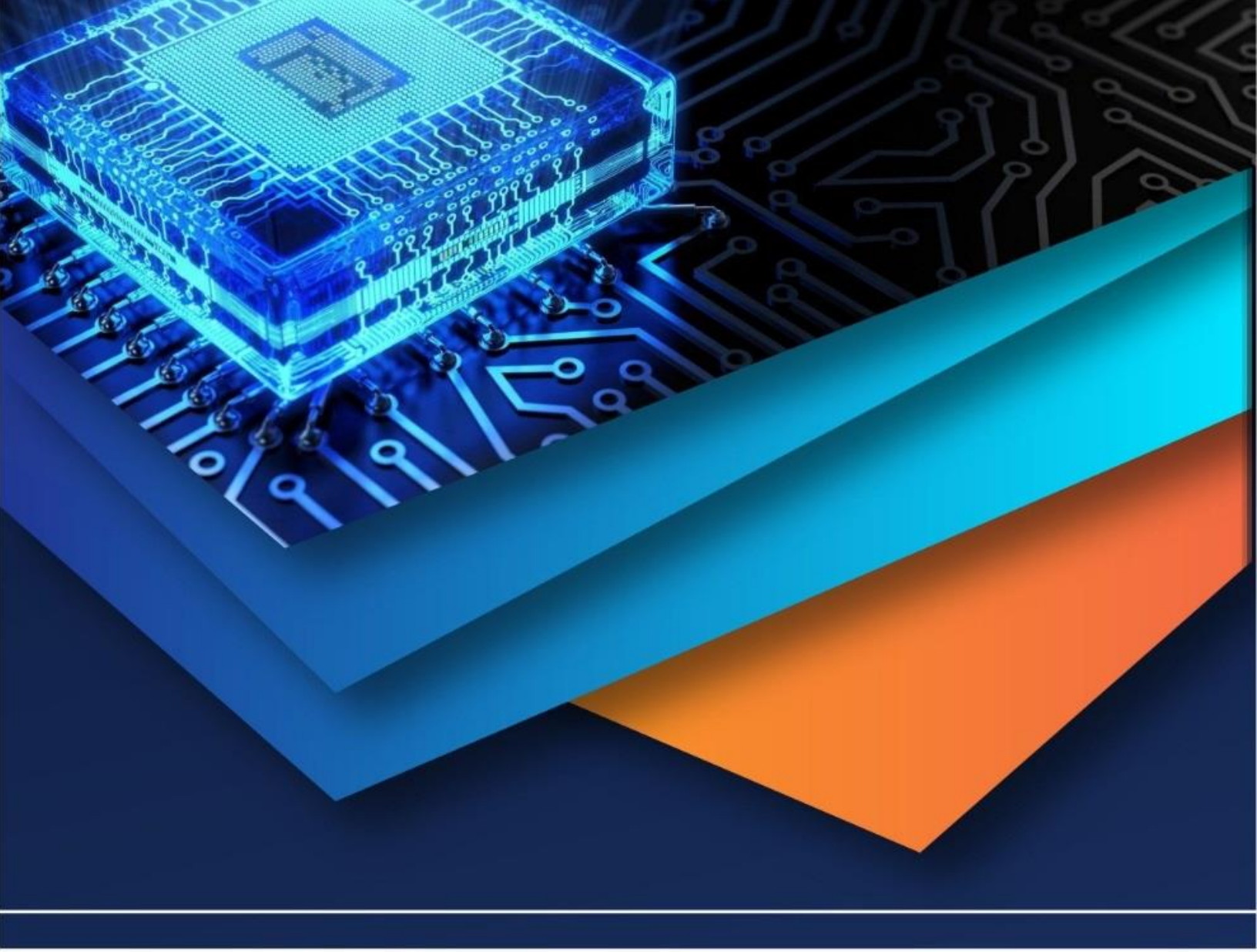
[4] M. Yerlikaya, S. S. Gültekin, and D. Uzer, "A Low Profile Wideband Log Periodic Microstrip Antenna Design for C-Band Applications", AEM, vol. 8, no. 2, pp. 48–52, Mar. 2019.

[5] Nagaraju P, Imran Khan, H V Kumaraswamy, Sachina D H, K R Sudhindra,Analysis of SWASTIK-shaped slotted MSPA antenna for 5G sub band applications,Global Transitions Proceedings,Volume 3, Issue 1,2022,

[6] Imran Khan, Geetha D Devanagavi, Sudhindra K R, Tanweer Ali, Rashmitha R K, Raksha Gunjal, A Hepta-band Antenna Loaded with E-shaped Slot for S/C/X-band Applications, INTL JOURNAL OF ELECTRONICS AND TELECOMMUNICATIONS, 2019, VOL. 65, NO.2, PP. 167-174 Manuscript received October 23, 2018; revised April, 2019.

[7] Al-Gburi, Ahmed & Ibrahim, Imran & Zakaria, Zahriladha. (2020). Gain Enhancement for Whole Ultra-Wideband Frequencies of a Microstrip Patch Antenna. Journal of Computational and Theoretical Nanoscience. 1469-1473.

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