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Aim: To design a Low-Profile Monopole Antenna Design with Dual Notch Bands and Ultra-Wide Impedance Bandwidth.

ABSTRACT

In this project our group designed an ultra-wideband (UWB) monopole antenna with dual band-notched characteristics in HFSS which would be used for future wireless communications. In this structure we implemented modified circular radiation patch with an embedded rectangular stub and also a pair of modified slits. From the results and proper analysis, we got to know that our antenna operates at frequencies (3-11) GHz, covering the UWB spectrum (3.1−10.6 GHz). We were supposed to achieve two notched bands at 3.5GHz (3.3−3.7 GHz) and 5.5GHz (5-6 GHz) but we achieved that at 4GHz and 5.2GHz. We tried using modified radiation stub resonators to suppress the interfaces from the wireless local area network (WLAN) and worldwide interoperability for microwave access (WiMAX). The final structured designed by our group is examined in terms of its fundamental characteristics. It has been observed that the results which we have obtained has sufficient frequency response, radiation patterns, efficiency, and gain are all achievable with the planned UWB antenna design. The Final designed antenna has all the viable parameters present and thus this UWB antenna is suitable for Practical usage.

Literature Survey

It is a well-known fact that planar monopole antennas present really appealing physical features, such as simple structure, small size, and low cost. Designing a low-profile monopole antenna with dual-notch bands and an ultra-wide impedance bandwidth is a challenging yet important task in the field of antenna engineering. Such antennas find applications in wireless communication, RFID systems, and various other wireless devices, where space and performance constraints are critical. To provide a literature survey on this topic:

1. "Design of a Low-Profile Dual-Band Monopole Antenna with Dual Notch Bands" by T. Yu et al. (IEEE Transactions on Antennas and Propagation, 2015):

- This paper presents a novel design of a low-profile monopole antenna capable of dual-band operation with dual-notch bands. The antenna's impedance bandwidth is significantly enhanced using a stub-loaded technique. The design is optimized for wireless communication applications.

2. "A Compact Low-Profile Monopole Antenna with Dual-Band and Wide Impedance Bandwidth" by Y. Yang et al. (IEEE Antennas and Wireless Propagation Letters, 2017):

- This work introduces a compact monopole antenna that achieves dual-band operation and a wide impedance bandwidth by employing a combination of notching and meandering techniques. The antenna's low profile makes it suitable for various applications.

3. "Ultra-Wideband (UWB) Monopole Antenna with Dual Notch Bands" by S. Wang et al. (Progress in Electromagnetics Research C, 2014):

- This research focuses on the design of an ultra-wideband monopole antenna featuring dual-notch bands. The antenna achieves UWB performance while effectively suppressing interference in specific frequency bands, making it suitable for cognitive radio and UWB applications.

4. "Low-Profile Monopole Antenna Design for RFID Applications with Dual Band and Ultra-Wide Impedance Bandwidth" by H. Liu et al. (IEEE Transactions on Antennas and Propagation, 2019):

- This paper presents a low-profile monopole antenna design tailored for RFID applications. The antenna achieves dual-band operation and an ultra-wide impedance bandwidth, ensuring reliable communication and identification in RFID systems.

5. "Design and Analysis of Dual-Band and Wideband Monopole Antenna with Notch Function for Wireless Communication Applications" by Y. Chen et al. (Electronics, 2018):

- This paper discusses the design and analysis of a dual-band monopole antenna with wideband performance for wireless communication applications. The antenna incorporates a notch function to suppress unwanted frequency bands effectively.

Brief Theory About UWB Antenna

UWB antenna design focuses on making antennas that can work across a wide range of frequencies, from 3.1 GHz to 10.6 GHz. UWB antennas stand out because they can send really short pulses of signals, which only last for a tiny fraction of a second. These antennas are super versatile and are used in things like radar, where they can precisely measure distances, communication systems where they send data really fast with low power, and positioning systems, which locate things very accurately.

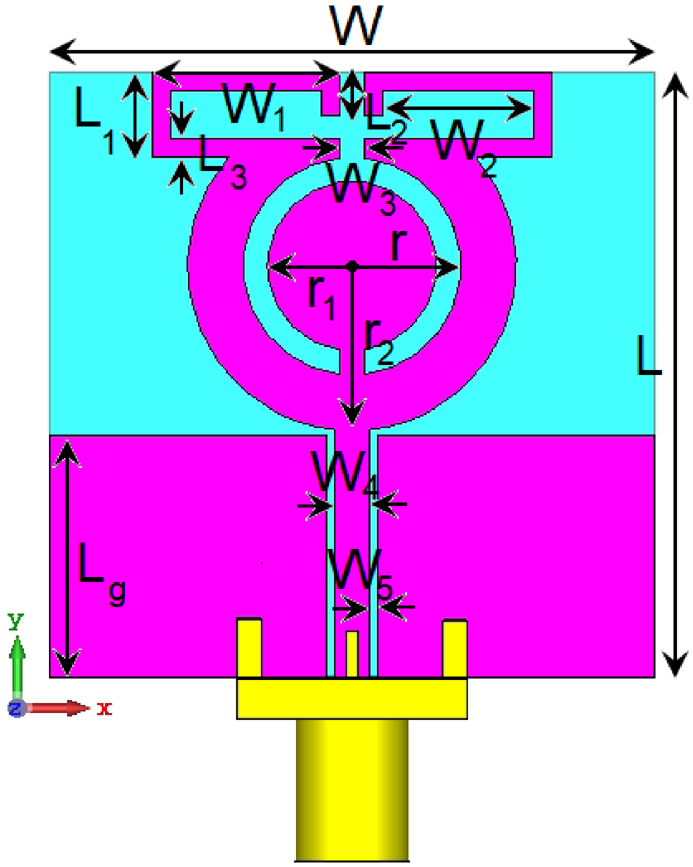
UWB's special ability to cover this huge frequency range and send out ultra-short pulses is what makes it so useful. For example, in radar, UWB helps measure distances with incredible accuracy. In communication, UWB antennas can send data at high speeds without using too much power, which is important for devices with limited battery life. Plus, UWB is handy in positioning systems, where it can pinpoint objects even in crowded, obstacle-filled spaces. This precision is especially helpful in new technologies like the Internet of Things (IoT) and tracking things like assets.

In short, UWB antennas are designed to handle a wide range of frequencies and create super short pulses, making them valuable for various applications and emerging technologies.

Calculations of UWB Antenna

• Basic Configurations of Antenna

The below UWB Antenna depicts how the introduced dual-notched UWB antenna is manufactured. The UWB design involves a modified circular radiation patch with an embedded rectangular stub. A pair of modified slits with the hook and T shapes are inserted to generate the filtering bands . The antenna is compact in size and constructed in a planar form on a 1.6 mm FR-4 substrate.

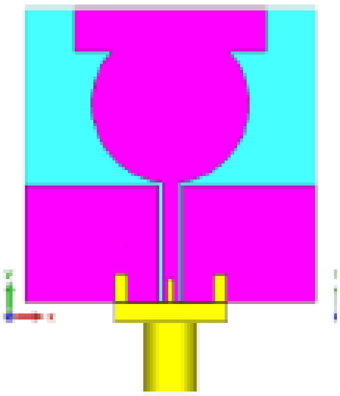


Below Table provides the Dimensions for Antenna.

Param.	W	L	W_1	L_1	W_2
Value, mm	25	25	7.75	3.5	6.25
Param.	L_2	W_3	L_3	W_4	W_5
Value, mm	1.8	1	0.75	1.5	0.25
Param.	r	r_1	r_2	L_g	h
Value, mm	4.25	3.25	7	10	1.6

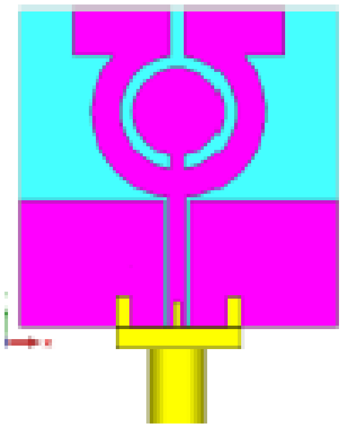
The Antenna was designed in three parts and each part was considered as a separate project return loss for each project (partwise) was calculated and graphs were obtained accordingly.

(a) Basic structure with a modified radiation patch.

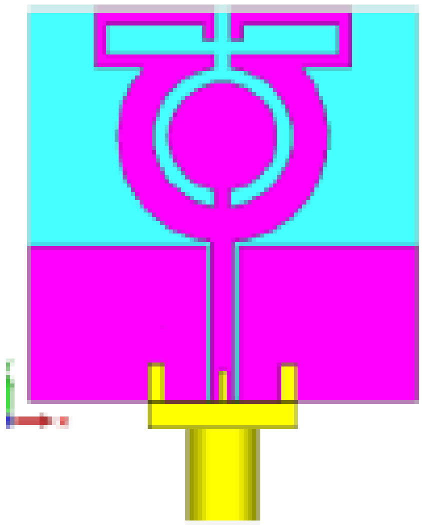


(a)

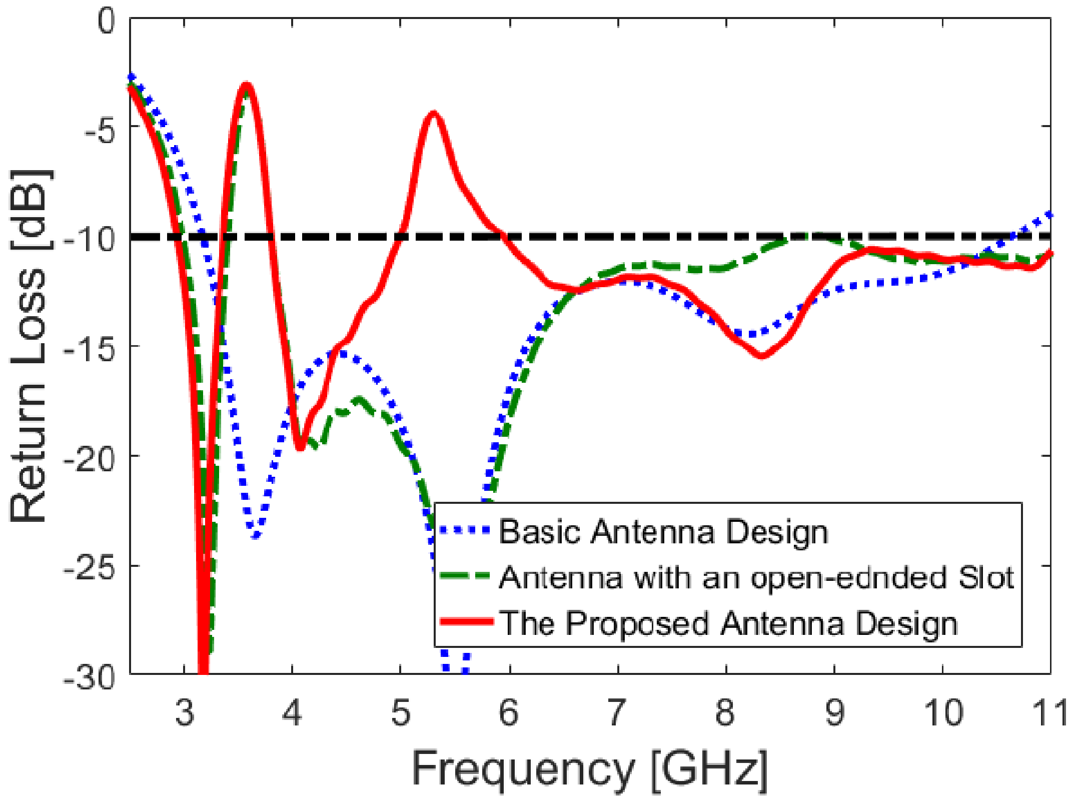
(b) The modified antenna with a single inverted slit



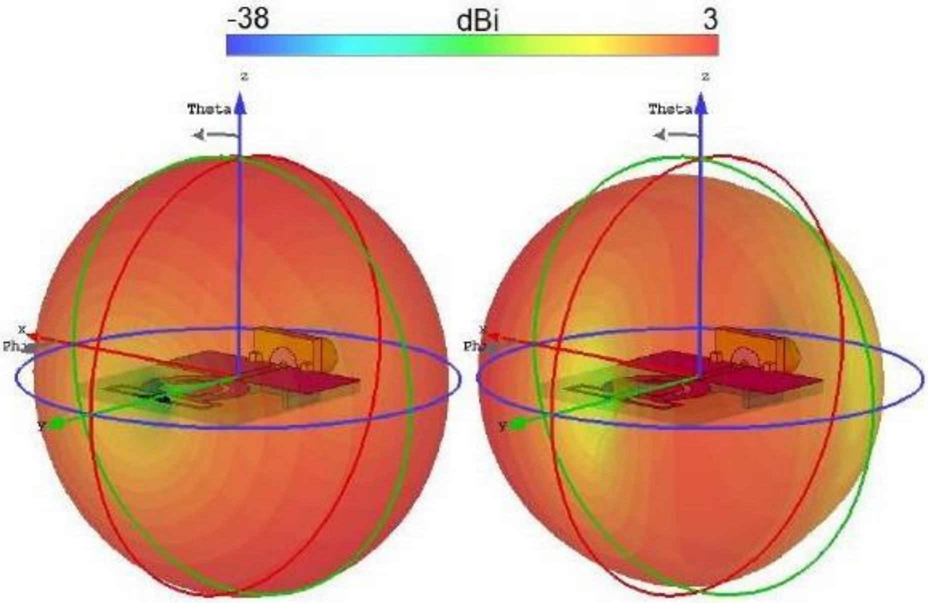
(c) The final suggested structure.



Ideal Return Loss Graph



Ideal Radiation Pattern of UWB antenna



(a) (b)

Fig. 6. 3D antenna radiations at the middle frequency (7 GHz).

Explanation of Proposed antenna

The Design and functionality which is obtained due to this following antenna is:

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1. Wide impedance bandwidth:

Achieving a wide impedance bandwidth is the main goal. This means that the antenna can maintain an acceptable impeda nce match (usually close to 50 ohms) over a wide frequency r ange. This is important for the antenna to effectively transmit or receive signals on multiple frequencies without the need f or coordination.

2. Slim Design:

Slim design is all about making the antenna size as compact a nd inconspicuous as possible. This is important for restricted areas such as mobile devices, RFID systems or connected syst ems.

3. Impedance Matching Technology:

Many types can be used to achieve a wide impedance bandw idth. These may include the use of reactive devices such as ca pacitors or inductors, stubs or antenna structures. This input helps adjust the impedance response of the antenna at multi ple frequencies.

4. Double Notch Bands:
Some designs also use double notch bands to limit some unwanted frequencies. These warnings are provided to detect interference or signals that may interfere with antenna performance in certain applications. Stripes are often made using parasitic or specially designed lines or gaps in the antenna structure.

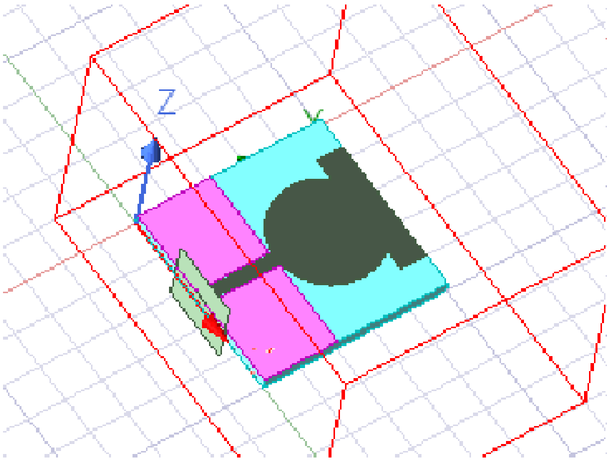
5. Electromagnetic simulation and optimization:
Antenna design strategy usually includes a process of electromagnetic simulation and optimization using software such as HFSS, CST Microwave Studio or FEKO. Designers use these tests to adjust antenna geometry and measurements to meet desired targets.

6. Prototyping and Testing:
After the design phase, the physical model of the antenna will be created and tested in the test environment. The test is designed to measure the antenna's impedance bandwidth, power model, gain, and other factors to ensure the antenna is operating as intended.

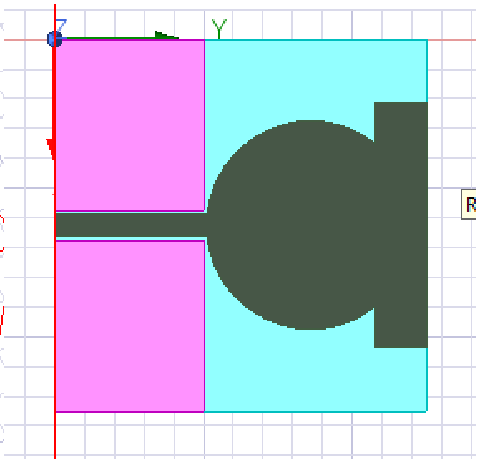
7. Practical application:
Ultrawide impedance and thin monopole antenna can be widely used in various wireless communications, including wireless LAN (Wi-fi).

Simulation results and measurement results

Firstly, we replicated basic Basic structure with a modified radiation patch. We have shown this structure in two views.

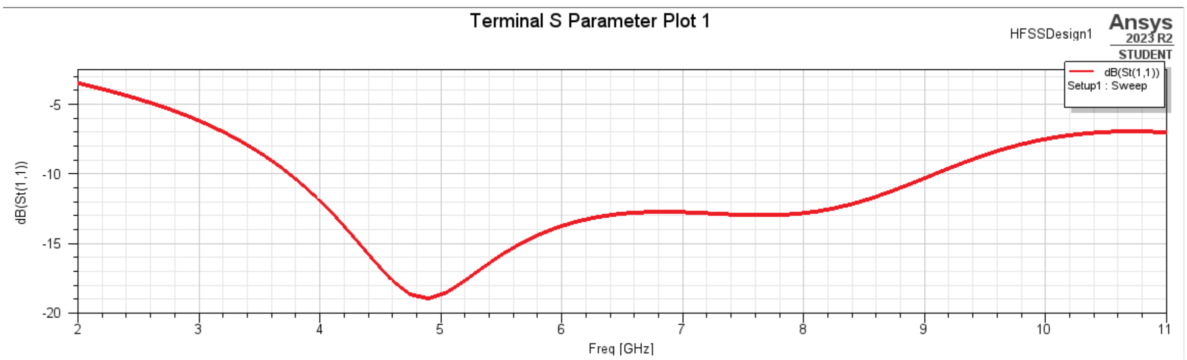


Side View

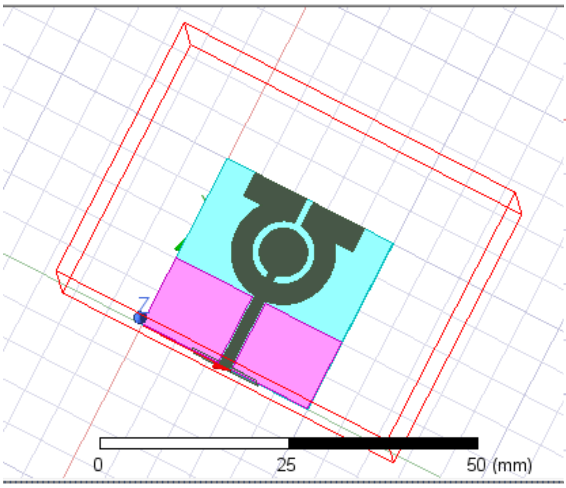


Top View

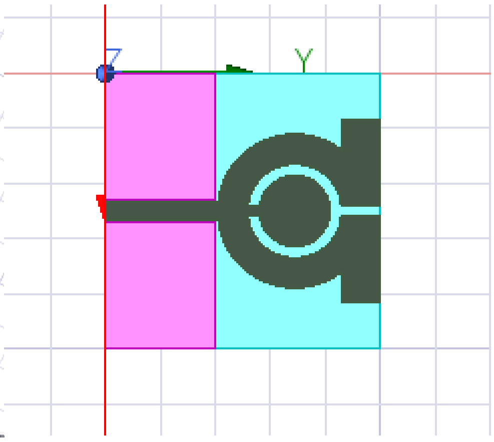
We have considered 3-11 GHz as our solution frequency and tried to generate S parameter plot. For creating open region (radiation region) we have considered operating frequency as 8 GHz.



Secondly, we replicated modified antenna with inverted slit. This structure is also shown in two views.

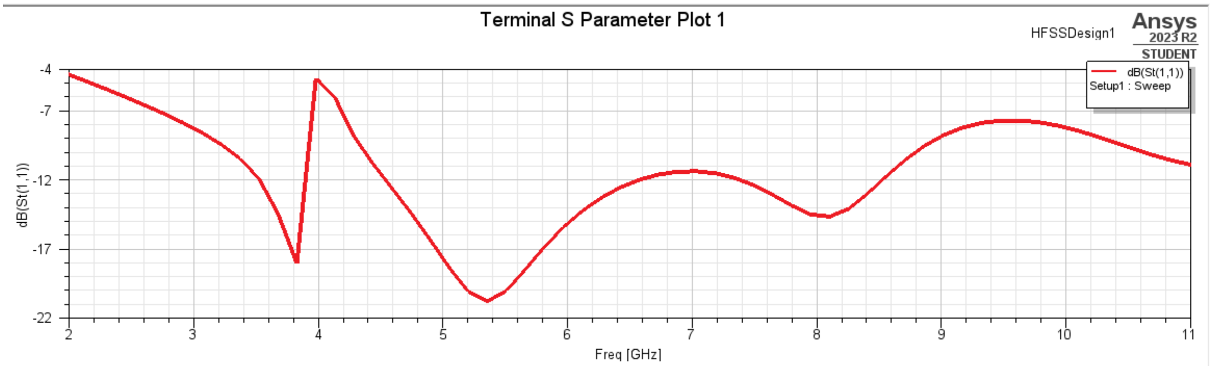


Side View

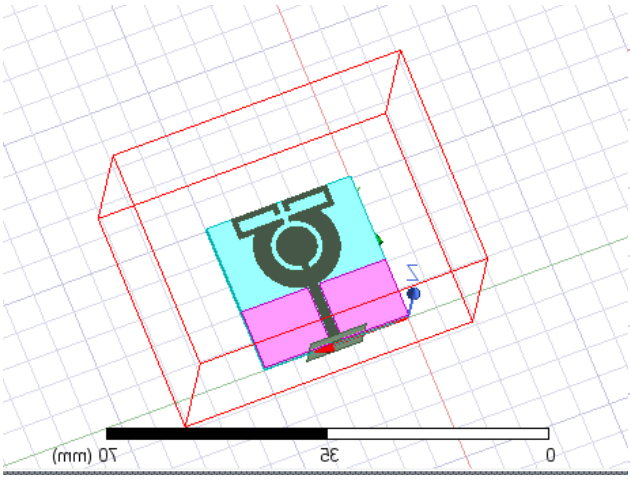


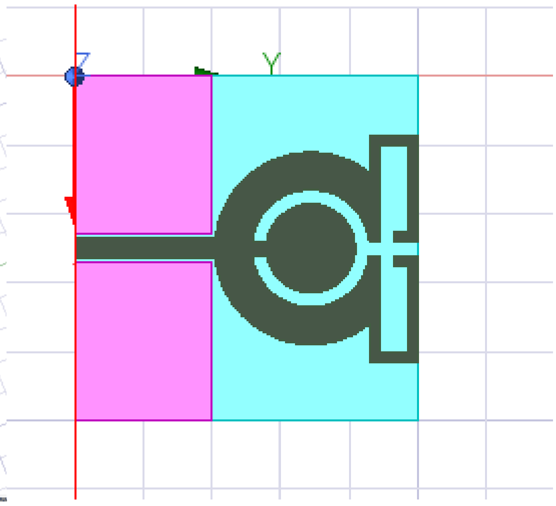
Top View

S Parameter plot which we obtained for this structure: -



At last, we replicated the final structure which is shown below.

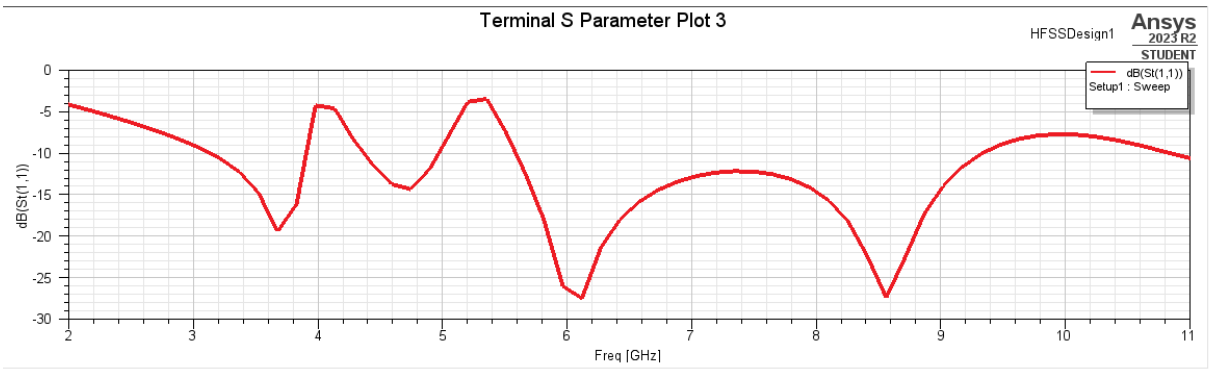




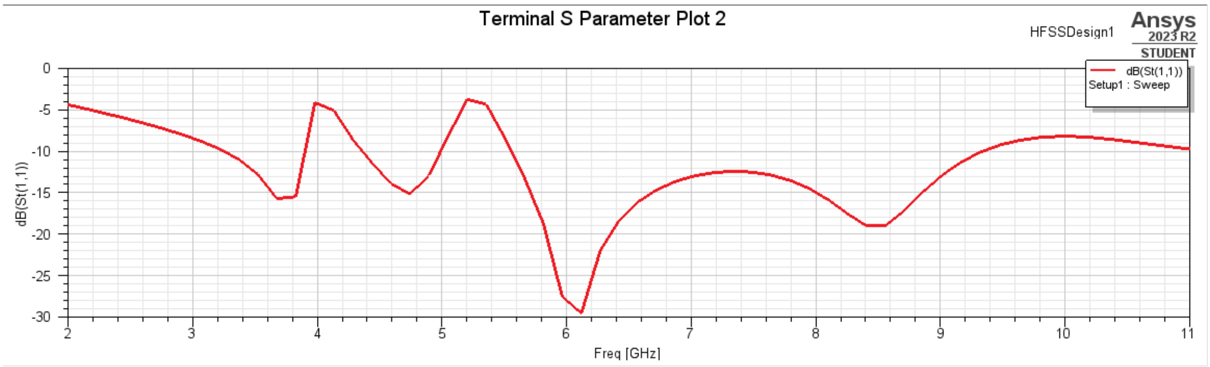
Side View   Top View

For the final structure we did the analysis at two different frequencies 4.5 GHz and 8.5 GHz. We have also generated far field 3D report for these frequencies. It is shown below.

Return Loss Obtained

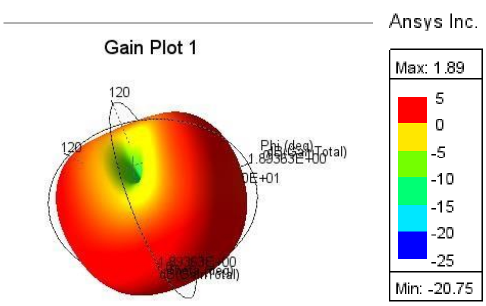


S Parameter plot at 4.5 GHz

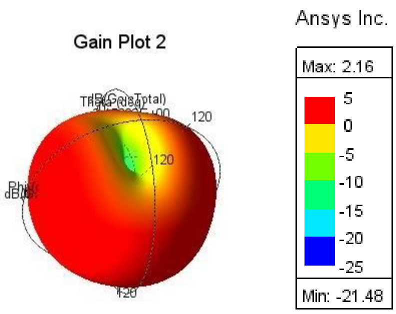


S Parameter plot at 8 GHz

Radiation pattern obtained



Far field 3D polar report at 4.5 GHz



Far field 3D polar report at 8 GHz

Conclusion

From this antenna designing project we got the knowledge and working of UWB antenna. Firstly, we considered two rectangular sheets on both side of slit line as antenna only but after doing simulation we came to know that both sheets were ground. In that case we have to add connector but due we were not aware about how to model transmission line so we did this using wave port though it is not practically possible. We ran various simulations to calculate return loss of antenna and study the radiation pattern of the antenna. We understood the working and functioning of the antenna and where are the practical use and application be done in today's society. We read various articles and refer various books to understand its working and functioning. With proper team work and individual efforts we resolved various problems faced during the constructions and simulation of the antenna and we also arrived at the conclusion that the antenna exhibits favourable characteristics, providing coverage across the frequency range of (3-11GHz) while incorporating two notched frequency bands at 4GHz and 5.2GHz.

References

A. J. Sharath Kumar, and T. P. Surekha, “Antennas for Ultra-Wide Band Communication Applications: A Survey,” 2017 International Conference on Current Trends in Computer, Electrical, Electronics and Communication (CTCEEC), Mysore, India, 2017, pp. 486–489.

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