A micro-scaled graphene-based wideband (0.57–1.02 THz) patch antenna

Group No-C10
Group Members-

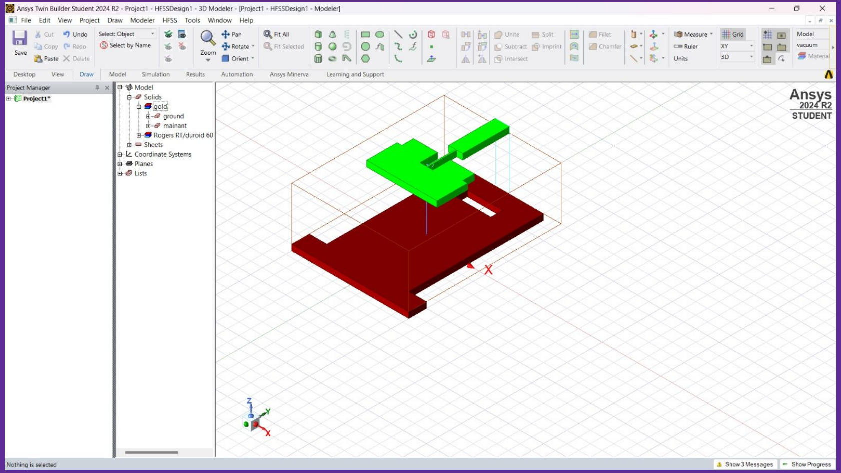
Nachiket Mahajan	202301060047
Hrushabh Shendokar	202301060054
Piyush Raundal	202301060043
Sahil Raichurkar	202301060051

Proposed Antenna

1. E shaped antenna – Graphene
2. T-shaped ground - Graphene
3. Substrate - Rogers RT/Duroid 6010

Application

High-speed short-distance communication, medical, imaging and sensing applications are key uses in the terahertz (THz) region.



Antenna properties

E-Shaped Patch

It improves the Fractional Bandwidth (FBW)

T-Shaped Ground

Band Width Ratio (BDR) improves because of T-shaped ground

S11 and VSWR

Max reflection coefficient(S11) :- 19.48dB

VSWR : <2

Why Graphene?

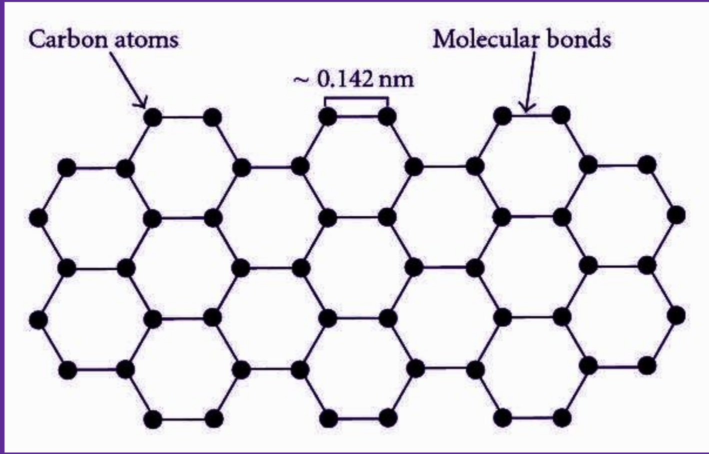
- Single-layer, honeycomb-shaped, carbon-bonded structure.

- Outperforms traditional materials like gold, silver, and copper in terahertz (THz) applications.

-Lightweight and mechanically flexible, advantageous for portable or flexible devices.

-Enables operation in high-temperature conditions

-Provides high efficiency and wide bandwidth.



Why did we choose the said substrate?

Substrate	**Radiating Element : Graphene**
Rogers RT/Duroid 6010	0.57–1.02 THz = 450 GHz
Polyamide	0.95–1.05 THz = 100 GHz
SiO_2	0.96–1.06 THz = 100 GHz
Arlon CE 1000	0.67–0.93 THz = 260 GHz

Structure of Antenna

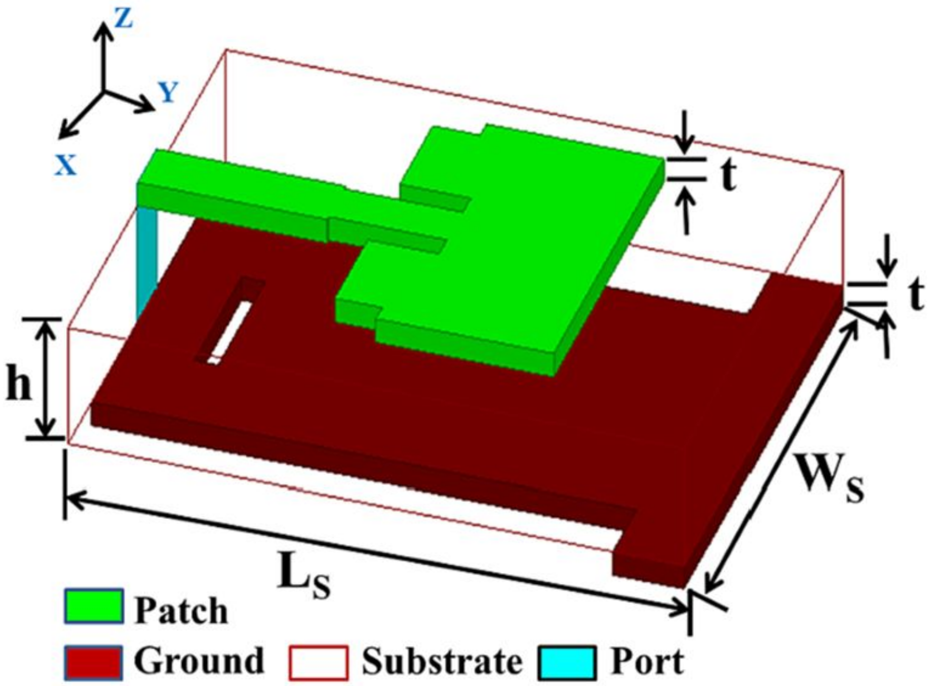
E-shaped Graphene antenna with 50 ohm transmission line on top of substrate Rogers RT/Duroid 6010 and bottom side is ground made of Graphene

Properties of graphene

Good Conductor: Transmits signals well at high frequencies.

Flexible: Can be used in small, lightweight designs.

Adjustable: Frequency can be changed with voltage.



How making cuts in the antenna changes the results

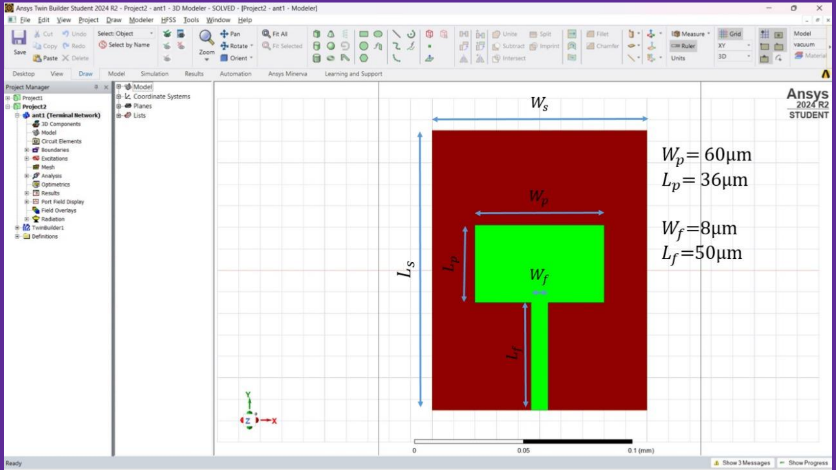
Stage 1 : Antenna 1

In design step – 1 (Ant 1), a rectangular microstrip patch antenna (Lp ×Wp) with full ground doped with the graphene material is designed.

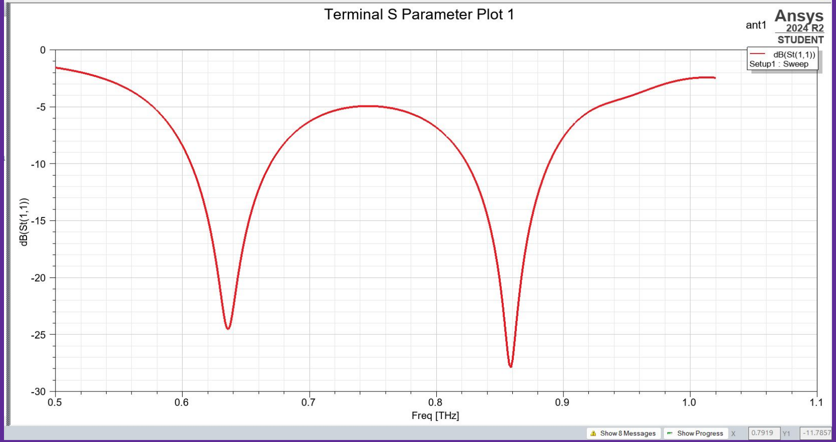
On resonating at 0.867 THz :-

Expected:
S11 :- -17.34 dB
(Using Graphene)

Our result :
S11 :- -28db
(Using Gold)



Results : S11 characteristics

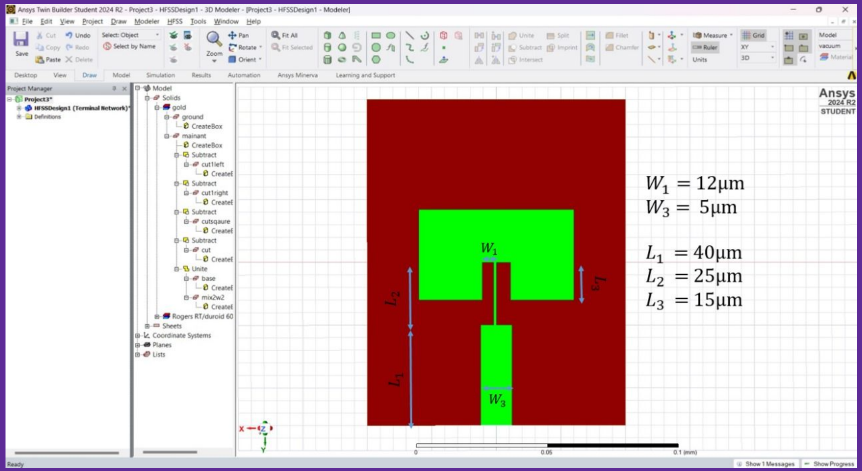


Stage 2 : Antenna 2

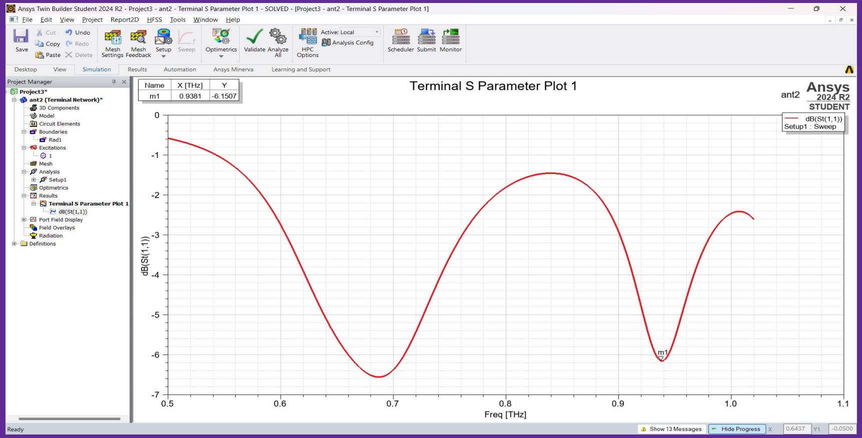
After making cuts near the 50 ohm Transmission line :-

Improvements :
Impedance Bandwidth upto 60 Ghz due to incorporation of rectangular slot of the patch

Change in Results :
S11 : -6.1 dB



Results : S11 characteristics



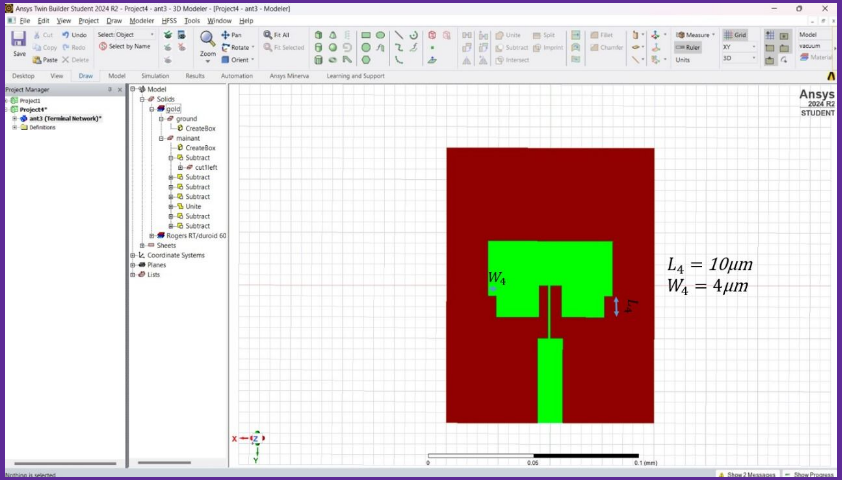
Stage 3 : Antenna 3

After the cut around the transmission line, we have made 2 more cuts on the main antenna of (4 x 10) µm on the far left and right bottom side.

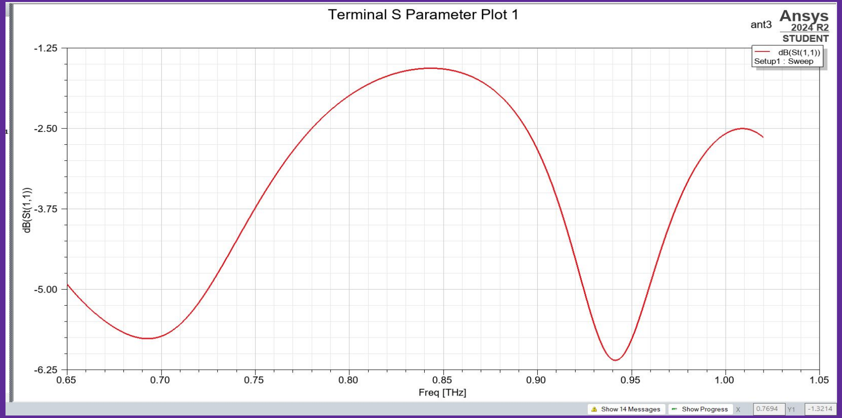
Due to this addition of corner shorten rectangular slots :-

Expected Result :
S11: m > -10dB
Bandwidth: 60 GHz

Obtained Result:
S11: -6.1
Bandwidth: 50 GHz



Results : S11 characteristics



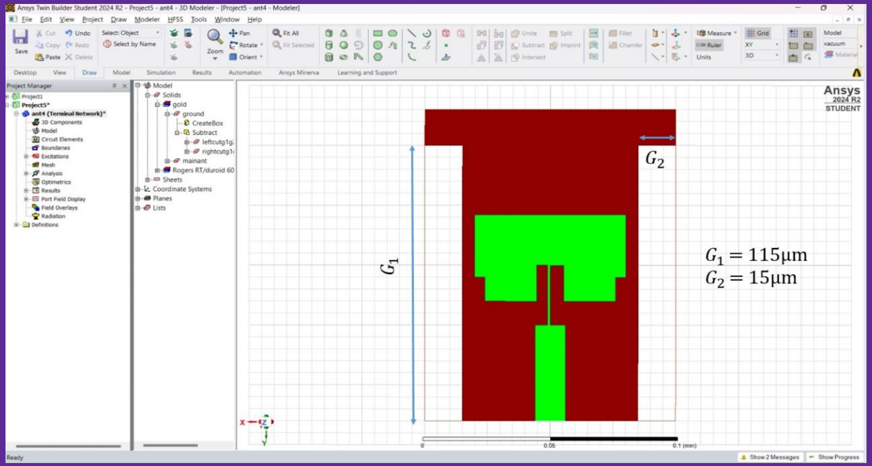
Stage 4 : Antenna 4

Now the ground is modified to a T-shape. For this T-shape we have made two cuts on both the right and left side of the ground of (15 X 115)µm.

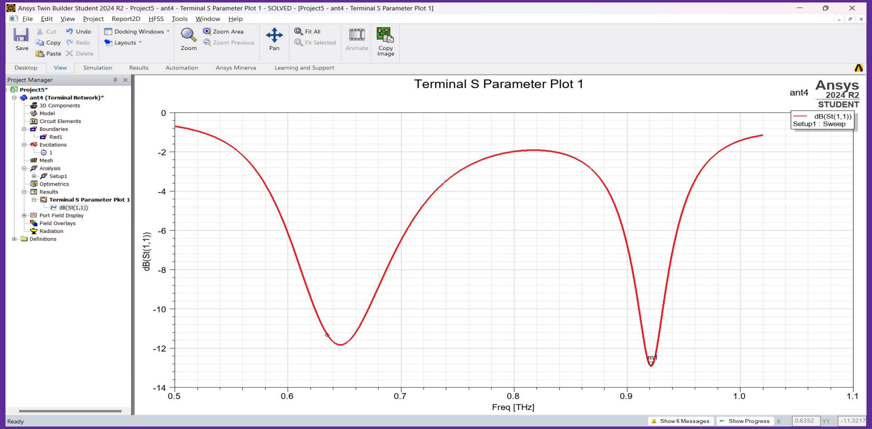
Improvements after cutting:
Less reflection coefficient over operating Band and Obtained Band.

Result:

- S11: -12.91dB
- Bandwidth: 70 GHz (0.88THz - 0.95THz)



Results : S11 characteristics



Stage 5 : Antenna 5

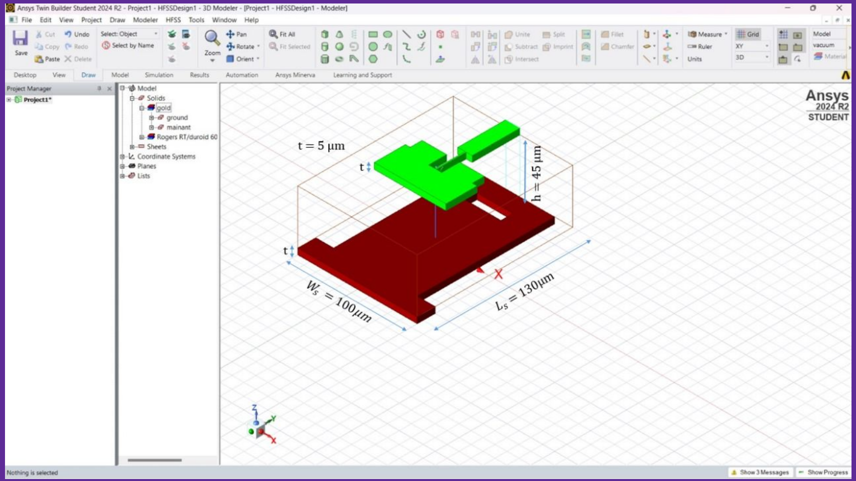
To create the final antenna, we have made one cut on the ground plane of (30 X 5)µm just below the 50 ohm transmission line

After making this cut the change in results are:
Bandwidth Enhancement as well as impedance matching due to existence of optimised rectangular slot.

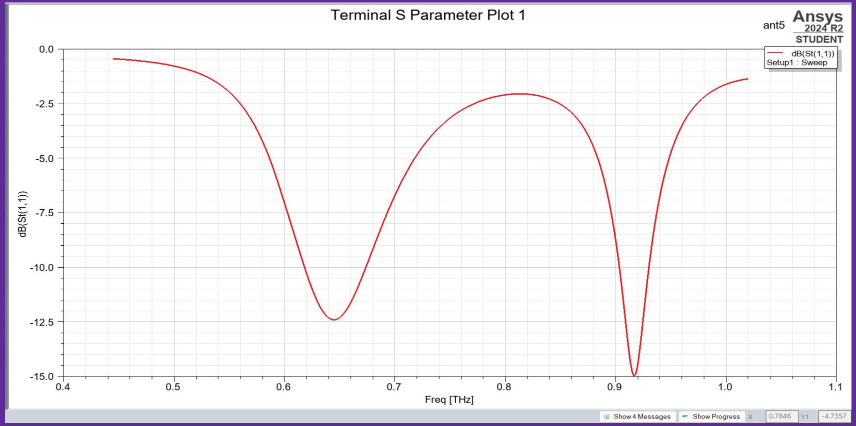
Operating on 0.57 THz to 1.02THz

Result:

- S11: -14.9 db at 0.91 THz
- Bandwidth: 0.96THz−0.86THz = 100 GHz



Results : S11 characteristics



Applications

1. Short-Range Communication: Ideal for indoor or device-to-device communications.
2. Used in imaging systems for cancer detection, wound monitoring, and dental health assessments.
3. Used in airport security to detect concealed objects like weapons or explosives without harmful radiation.
4. THz waves can identify and analyze chemicals and biological samples through their spectral fingerprints.
5. Supports ultra-fast file sharing between devices

Conclusion

Using ANSYS HFSS, we analyzed important parameters like return loss (S11), VSWR, and radiation patterns to improve the antenna performance. The effects of substrate material (εr=10.02) and feeding techniques were studied to ensure good efficiency.The simulation results matched well with theoretical expectations, and any issues were fixed through adjustments. This project helped us improve both technical skills in antenna design and teamwork for solving complex problems in THz communication.

References

1. Ch, M. K., Islam, T., Suguna, N., Kumari, S. V., Devi, R. D. H., and Das, S., "A micro-scaled graphene-based wideband (0.57–1.02 THz) patch antenna for terahertz applications," *International Conference on Communication Computing and Security*, 666-9501, © 2023, Published by Elsevier B.V.

2. J. Rajendran, R. Peter, and K. P. Soman, "Design of Trapezoidal Monopole Antenna with truncated ground plane for 2.5 GHz Band," *International Conference on Communication Computing and Security*, 666-9501, © 2023, Published by Elsevier B.V.

Thank You