2025

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PORTFOLIO

ELECTRICAL ENGINEER

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1. Overview

Fueled by curiosity and a relentless drive to build, my journey in technology merges precision engineering with bold innovation. Holding a BSc in Electrical Engineering from **University of Central Punjab** with a **CGPA of 3.51**, I've developed a strong foundation that thrives not just on theoretical knowledge but on practical implementation and impact. Over the years, I've immersed myself in exploring advanced communication systems, embedded platforms, and intelligent solutions, translating complex concepts into reliable real-world systems.

A significant part of my work revolves around **antenna and communication system** design. I've designed and optimized a range of antennas, including **V-dipole, cross-dipole**, and Quadrifilar Helix Antenna (QFH), specifically targeting satellite communication applications. My exploration also extends into **phased array** systems and Frequency-modulated continuous-wave radar (**FMCW radar**), where I've worked on beam steering techniques, signal processing strategies, and real-time tracking concepts. This work has sharpened my understanding of RF system behavior, high-frequency operation, and advanced communication architectures.

Parallel to this, my expertise in **embedded systems** is grounded in hands-on missions. I've developed complete **CanSat and CubeSat** platforms that consist of onboard sensors transmitting real-time telemetry data to a ground station. These systems use a microcontroller to process data from multiple sensors, including barometers for altitude, accelerometers and gyroscopes for orientation, and GPS for location tracking allowing a clear understanding of the satellite's state during flight. The processed telemetry is then transmitted through a reliable antenna link, ensuring stable communication with the ground. This architecture highlights the practical application of embedded systems, where sensing, processing, and communication work seamlessly together in real-world satellite missions.

What truly defines my approach is **versatility**. I've never confined myself to a **single domain** or technology stack. Whether working on advanced communication systems, embedded robotics, or intelligent autonomous platforms, I quickly adapt, learn fast, and push beyond what I already know. I approach new technologies with focus and practice, rapidly building a deep understanding and applying it to solve real engineering problems. This adaptability allows me to move confidently between RF design, embedded development, system integration, and even software-hardware interfacing.

I believe in engineering that creates **impact solutions** that don't just exist on paper or in simulation but perform in the real world. I thrive on challenging problems, constantly pushing myself to experiment, test, and refine. Every project I take on is an opportunity to learn something new, build something better, and expand what I'm capable of.

This portfolio reflects that journey. It showcases projects where antennas meet embedded intelligence, where communication systems integrate seamlessly with real-time processing, and where bold ideas turn into functional, innovative solutions. It's not just a collection of work—it's a reflection of my mindset: **to build, to adapt**, and to push technology forward for those who are same passionate as I am.

2. Antenna Projects:

2.1. Phased Array Antennas for UWB Applications

Mar 2025-Present

A wideband phased array system is being developed using an antipodal Vivaldi antenna operating from 1–10 GHz. Different Vivaldi and antipodal configurations are being simulated to analyze bandwidth, radiation patterns, and array performance. The implemented UWB array demonstrates stable wideband response with good impedance matching and beam steering capability. This project is funded by Space Agency of Pakistan SUPARCO.

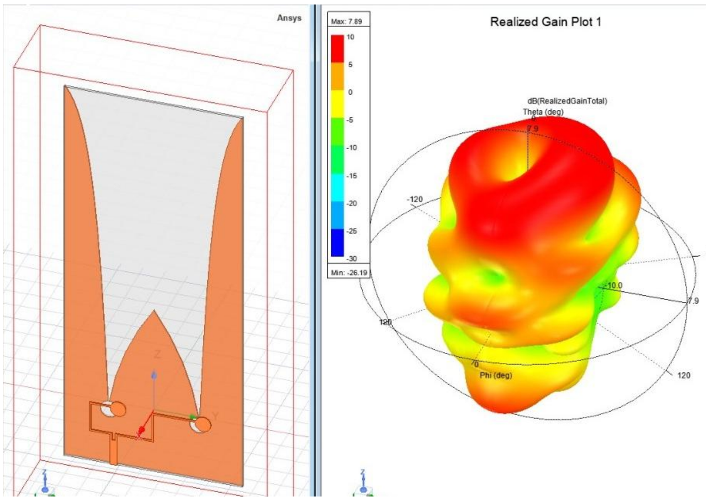


Fig1. Vivaldi Antenna for UWB Applications

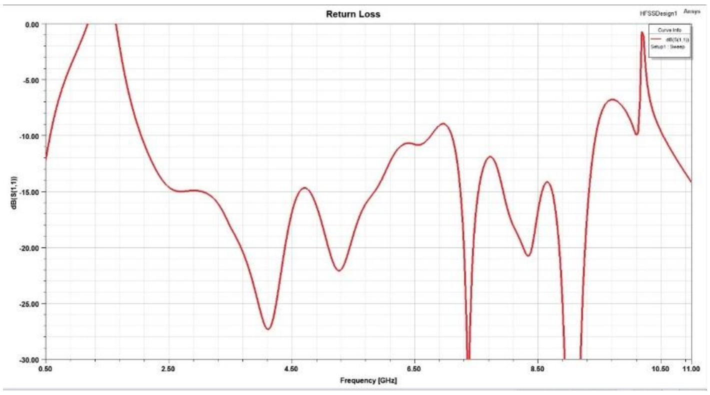


Fig2. Return Loss of Vivaldi Antenna

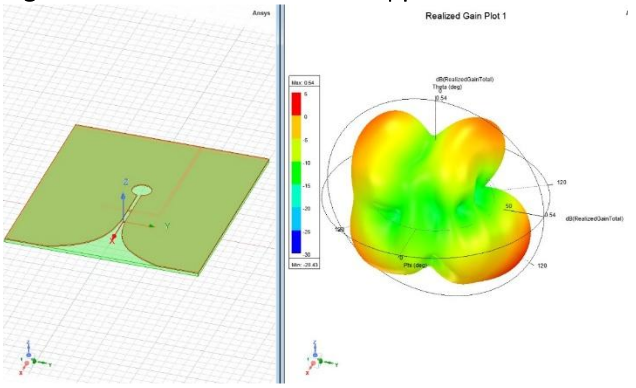


Fig3. Vivaldi Antenna for UWB Applications

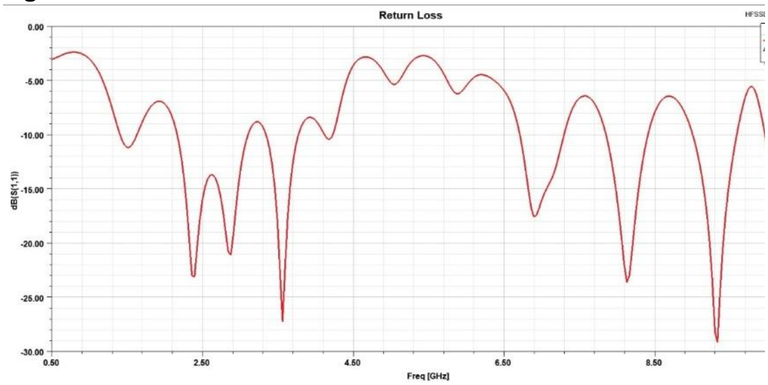


Fig4. Return Loss of Vivaldi Antenna

2.1.1. Antipodal Antenna implemented for Array

A wideband phased array system is being developed using an antipodal Vivaldi antenna operating from 1–10 GHz. The antipodal design has been selected and implemented in 1×2, 1×4, and 1×8 array configurations to study array performance. Mutual coupling effects between the elements are also being analyzed to optimize the overall UWB array efficiency and radiation behavior.

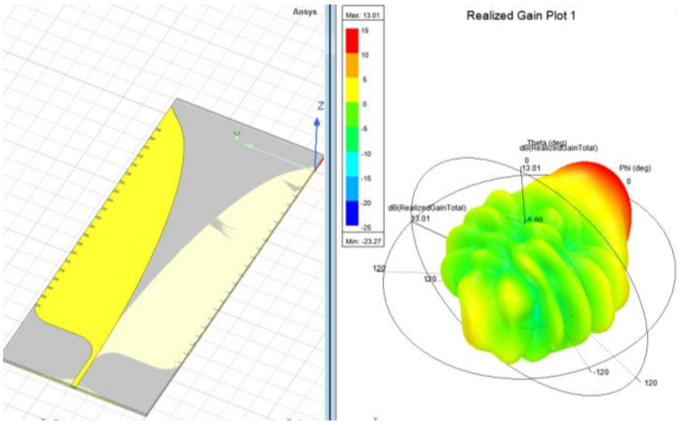


Fig. Single Element Antipodal Antenna

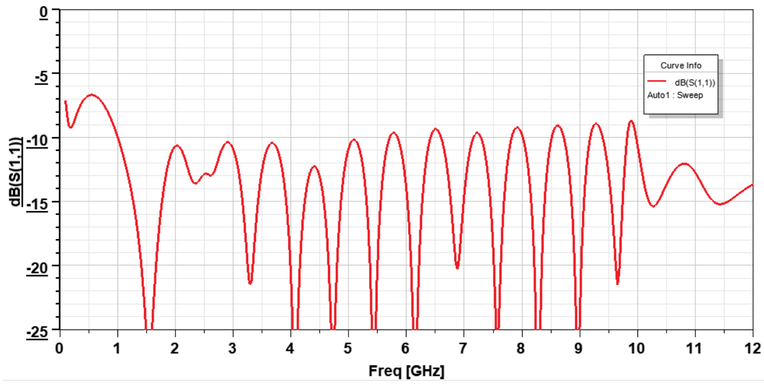


Fig. Return Loss of Antenna from 1 to 10GHz

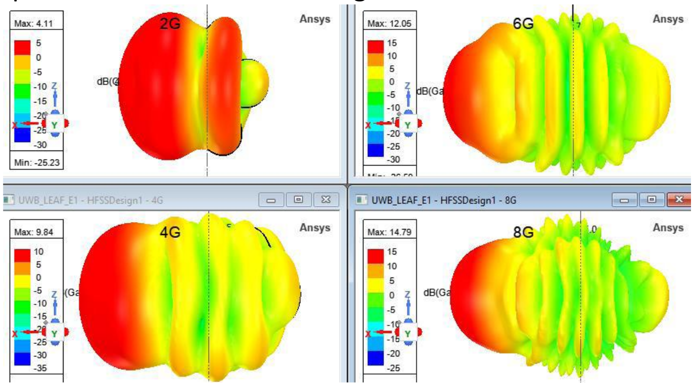


Fig. Single Element Antipodal Antenna Realized gain at different frequencies

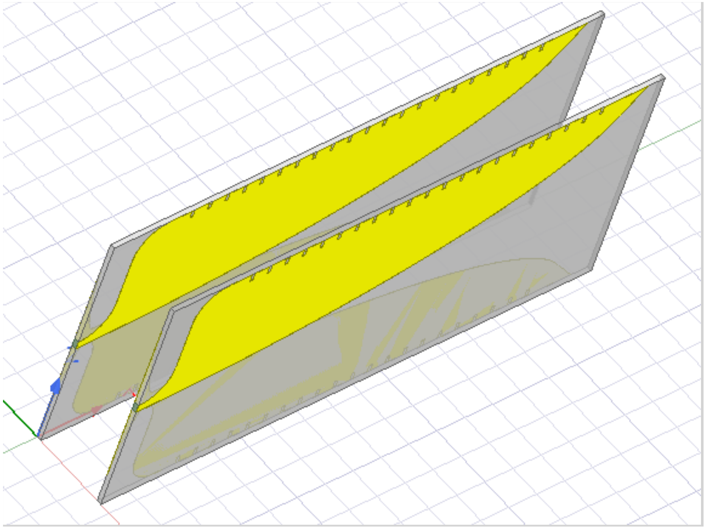


Fig. 1x2 Antipodal Antenna Array

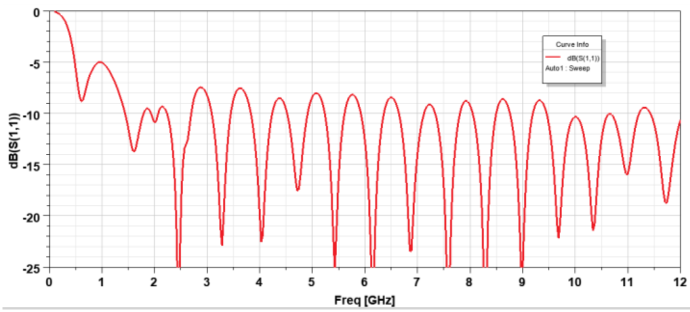


Fig. Return Loss of Antenna from 1 to 10GHz

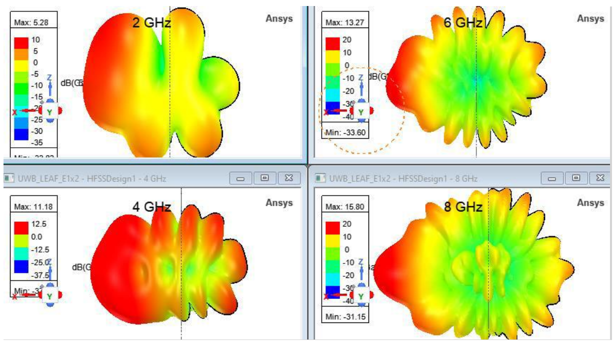


Fig. 1x2 Antipodal Antenna Array Realized gain at different frequencies

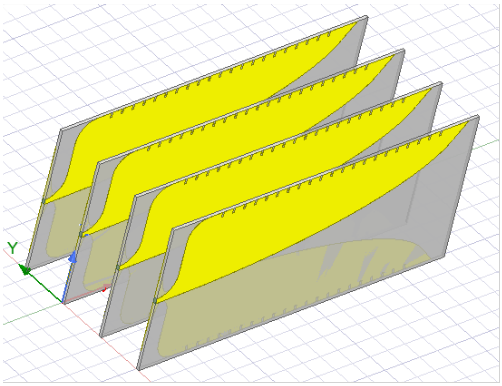


Fig. 1x4 Antipodal Antenna Array

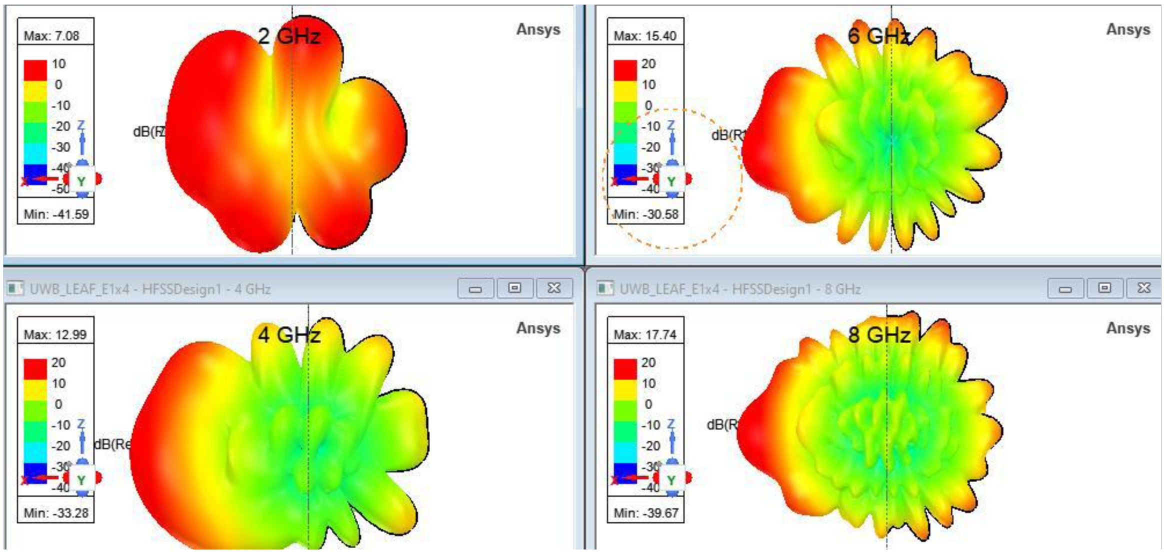


Fig. 1x4 Antipodal Antenna Array Realized gain at different frequencies

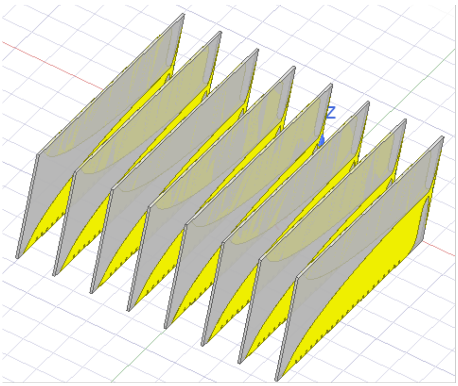


Fig. 1x8 Antipodal Antenna Array

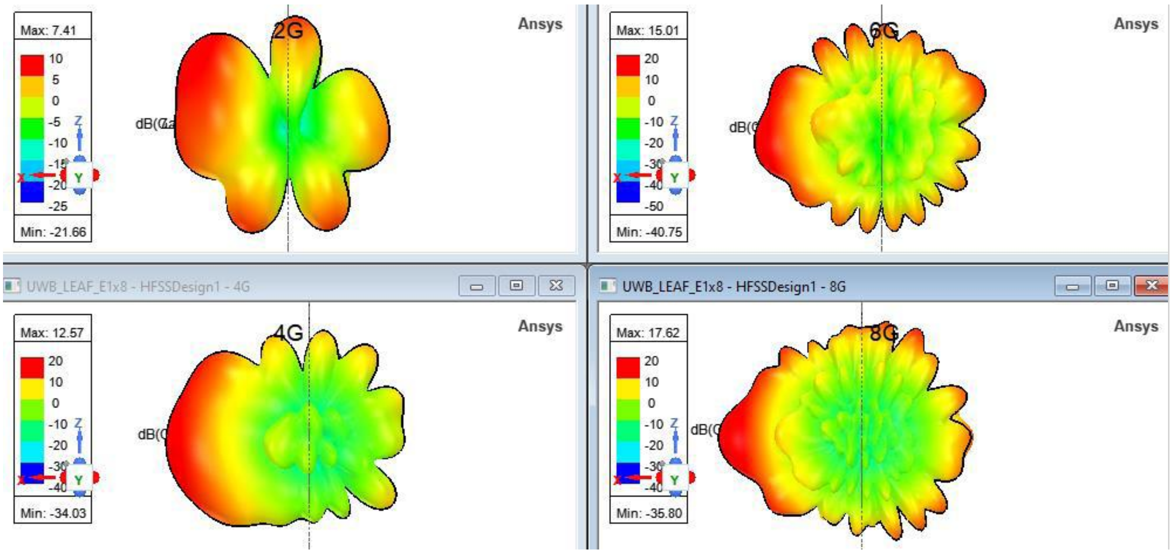


Fig. 1x8 Antipodal Antenna Array Realized gain at different frequencies

2.1.2. Power Dividers for 1x2 and 1x4 Antenna Arrays

A wideband phased array system is being developed using an antipodal Vivaldi antenna operating from 1–10 GHz. The design includes ultra wideband power dividers implemented in 1×2 and 1×4 configurations for efficient signal distribution. These are fabricated on a Rogers 5880 substrate with a thickness of 1.575 mm and 35 µm copper cladding, ensuring low loss and wideband performance.

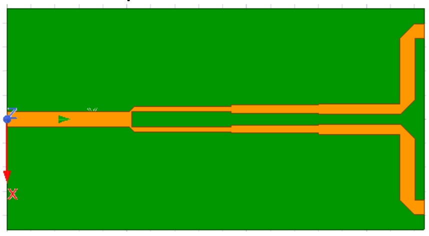


Fig. 1x2 Power divider

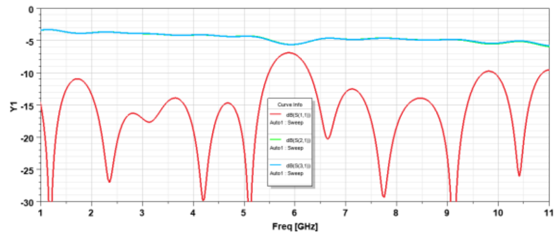


Fig. S-Parameters of Power Divider

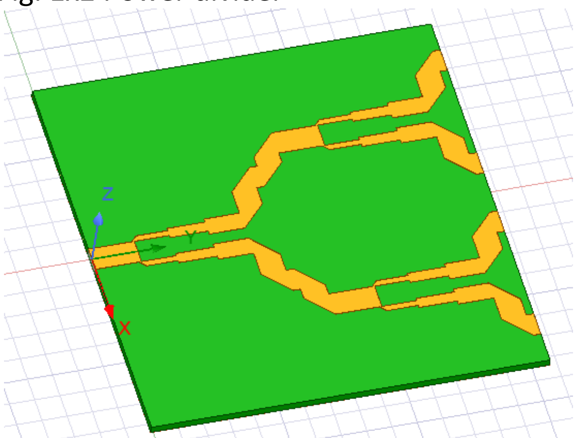


Fig. 1x4 Power Divider

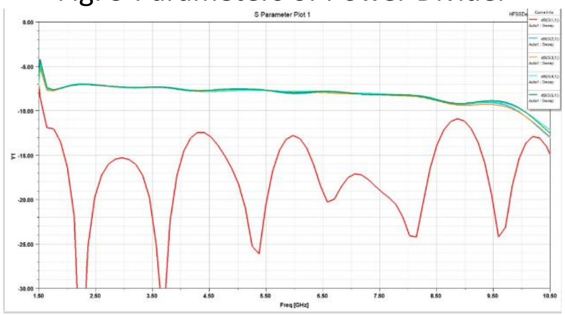
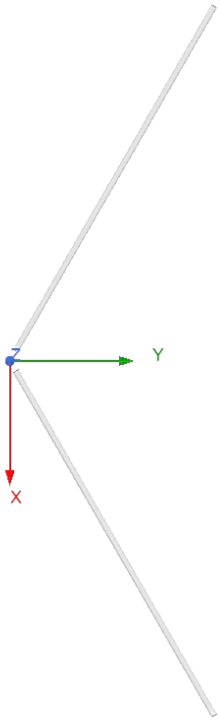


Fig. S-Parameter of 1x4 Power Divider

2.2. Ground Station Development for Satellite Communications **Feb 2025-Jul 2025**

Antennas are being designed for ground station development to receive signals from NOAA satellites. V-dipole, cross-dipole, and quadrifilar helical (QFH) antennas are implemented and tested for optimal signal reception. Each configuration is analyzed for gain, polarization, and coverage to ensure reliable satellite communication performance.

2.2.1. V-Dipole



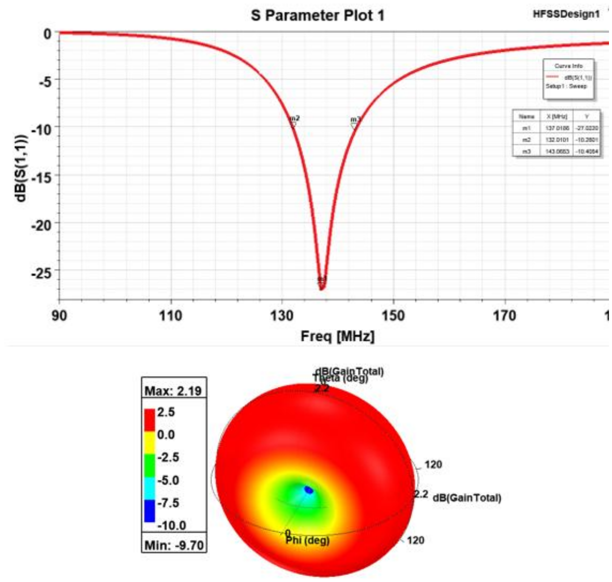
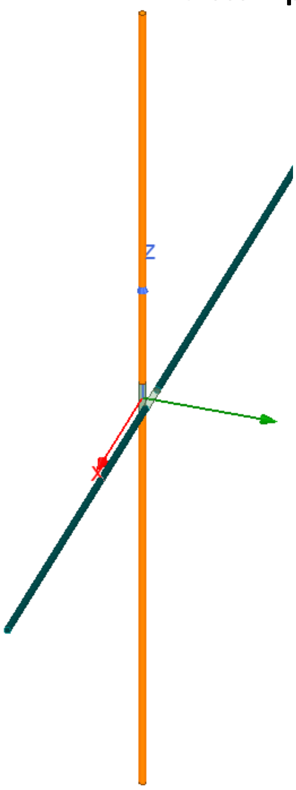


Fig. V dipole Fig. Simulation Results Fig. Manufactured Antenna

2.2.2. Cross Dipole



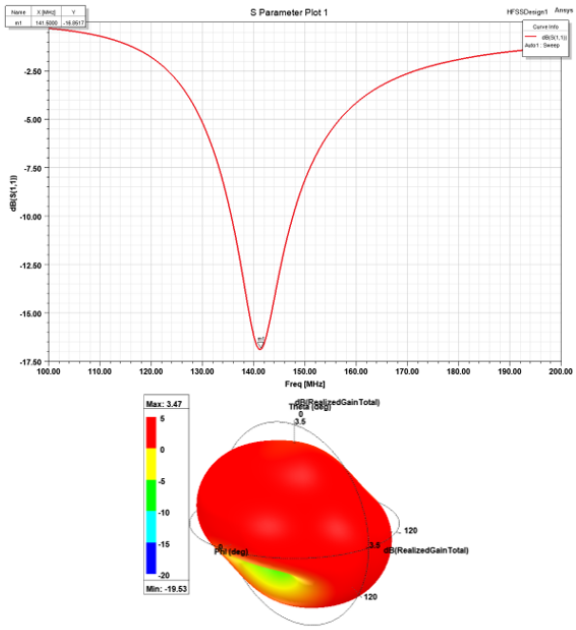


Fig. Cross Dipole Fig. Simulation Results Fig. Manufactured Antenna

2.2.3. Quadrifilar Helical Antenna (QFH)

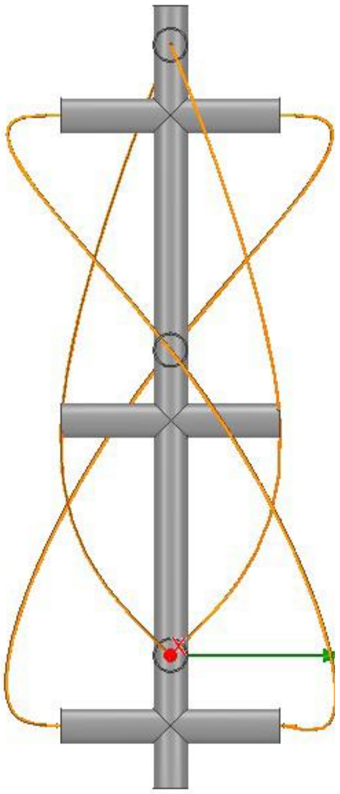


Fig. QFH Antenna

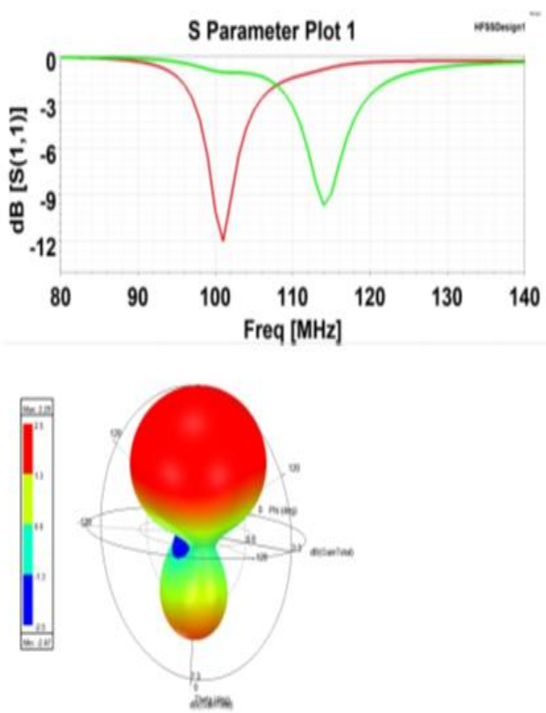


Fig. Simulation Results

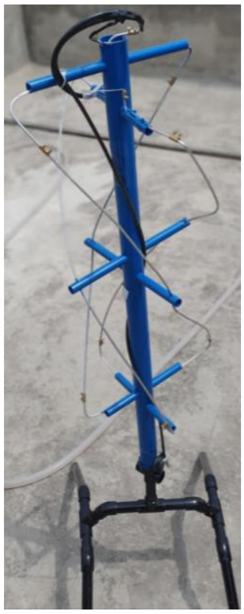


Fig. Manufactured Antenna

2.3. Yagi Antennas for CANSAT Range Extension **Feb 2025-Jul 2025**

Yagi antennas are being developed for 2.4 GHz to extend the communication range of student satellites such as CanSat and CubeSat. The designs aim to enhance signal strength and link reliability between the satellite and the ground station. Different Yagi configurations are analyzed to achieve optimal gain and directional performance for long-range data transmission.

2.3.1. Yagi Antenna

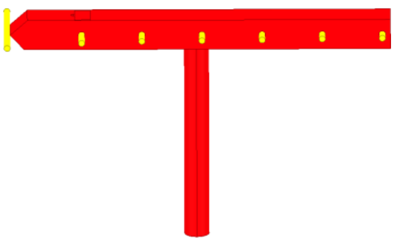


Fig1. Yagi Antenna at 2.4 GHz

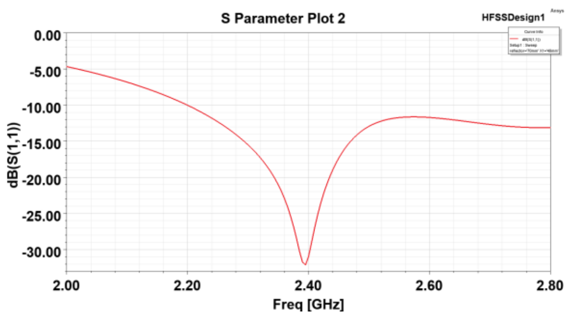


Fig2. S-Parameter Plot

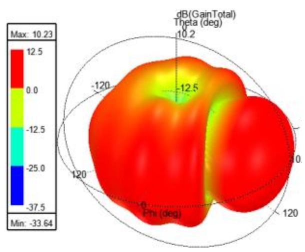
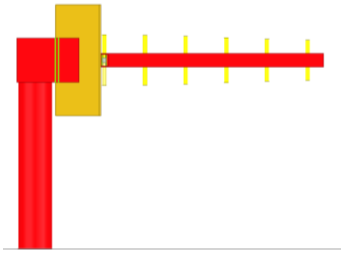
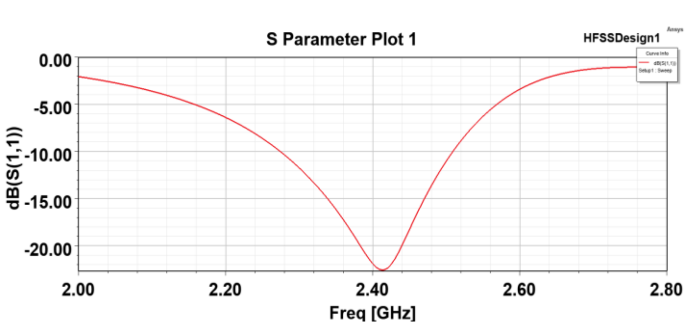


Fig3. Gain Plot of antenna

2.3.2. Corner Reflector Yagi





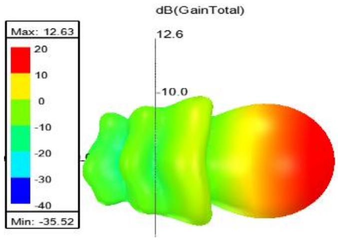
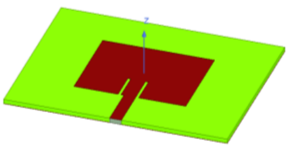
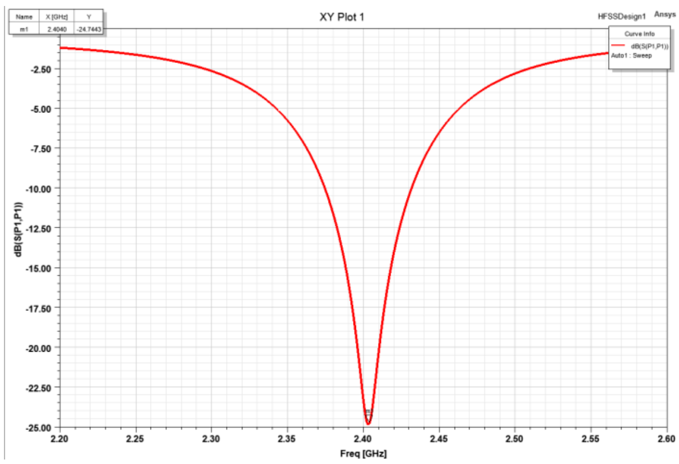


Fig1. Yagi Antenna at 2.4 GHz Fig2. S-Parameter Plot Fig3. Gain Plot of antenna

2.4. Patch Antenna and Array

A patch antenna is a low-profile, planar antenna that radiates primarily in the broadside direction, commonly used for wireless and satellite communication. It offers ease of fabrication, lightweight structure, and compatibility with printed circuit technology. A phased array of patch antennas combines multiple elements with controlled phase shifts to achieve beam steering, enhanced gain, and directional radiation without physically moving the array.





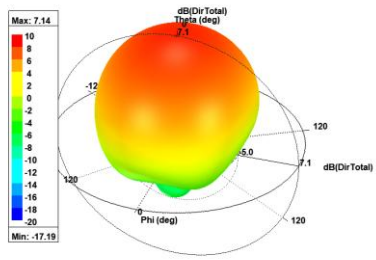


Fig1. Dipole Antenna at 2.4 GHz Fig2. S-Parameter Plot for Dipole Antenna Fig3. Gain and Radiation Plot of antenna

2.4.1. Phased Array

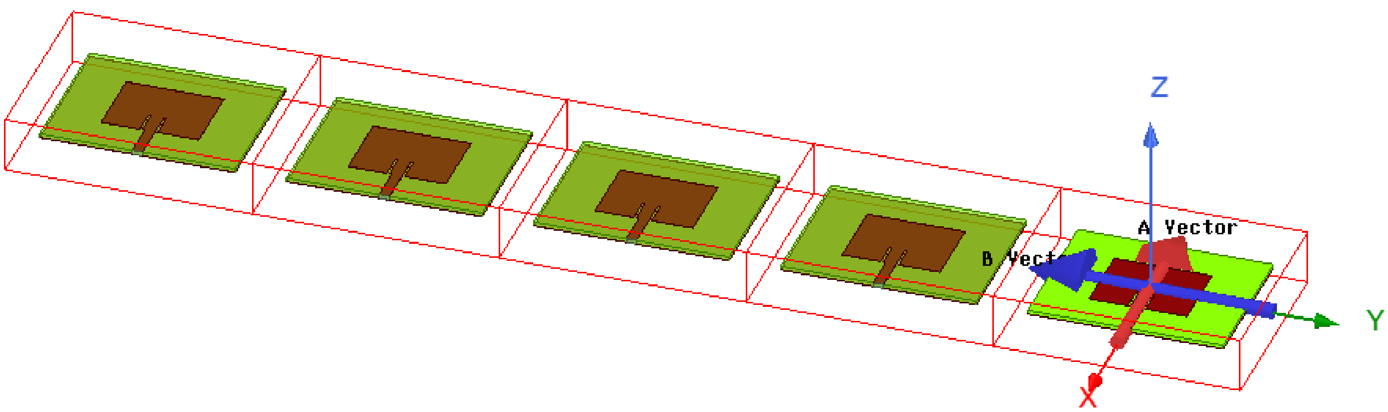


Fig. 1x5 Patch Antenna Array at 2.4 GHz

2.5. Parabolic Reflector Antenna

A parabolic reflector antenna uses a parabolic-shaped surface to focus incoming radio waves onto a feed point or to direct outgoing waves into a narrow beam. It provides very high gain and directivity, making it ideal for satellite communication, radar, and deep-space applications. The design ensures efficient energy concentration and minimal signal loss over long distances.

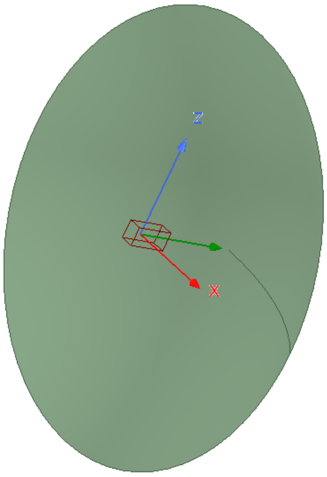


Fig. Parabolic reflector with Horn antenna previous discussed.

2.6. Automotive Radar Applications

An antenna mounted on a vehicle is used to develop an automotive radar system, with simulations performed in ANSYS SBR+. The model captures real-world multipath and vehicle scattering to evaluate target detection, range, and angular resolution. Simulation results guide antenna placement, beamforming, and signal-processing choices to optimize radar performance and minimize interference.

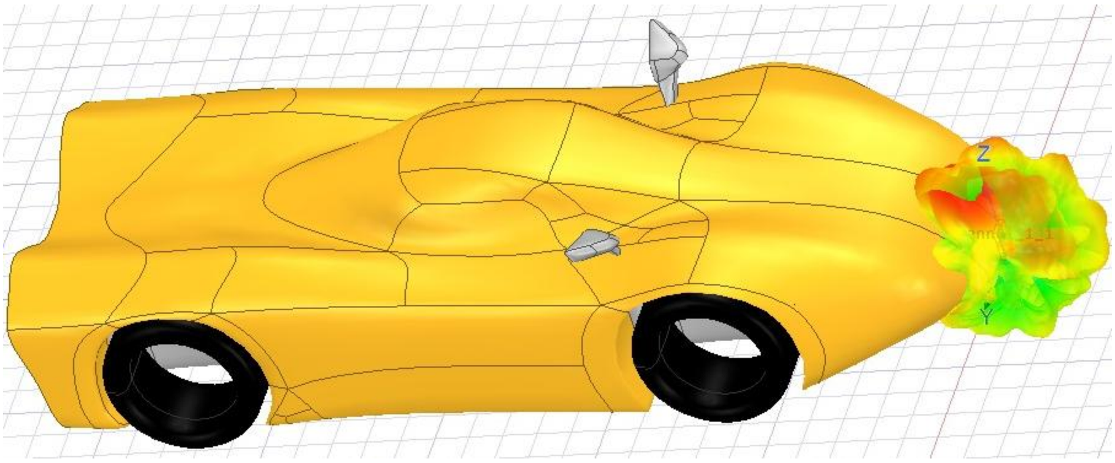


Fig. Antenna on automotive vehicle for radar applications

3. FMCW RADAR

The FMCW is designed and manufactured using the substrate FR4 with dielectric constant of 4.4 and thickness of 1.6mm. The operating frequency of radar is 1GHz. The LNA amplifies the signal. The coupler is designed at -16dB. A small portion of power is transmitted from coupled port to the branchline mixer which basically get the signal from receiver antenna and compares it to the coupled signal and process the signal to power amplifier then to the receiver.

3.1. Low Noise Amplifier

In a Frequency-modulated continuous-wave radar (FMCW) system, a low-noise amplifier (LNA) is placed at the receiver front end to amplify weak echo signals with minimal added noise. It improves the overall sensitivity and detection range of the radar. By maintaining a high gain and low noise figure, the LNA ensures accurate signal processing and reliable target detection.

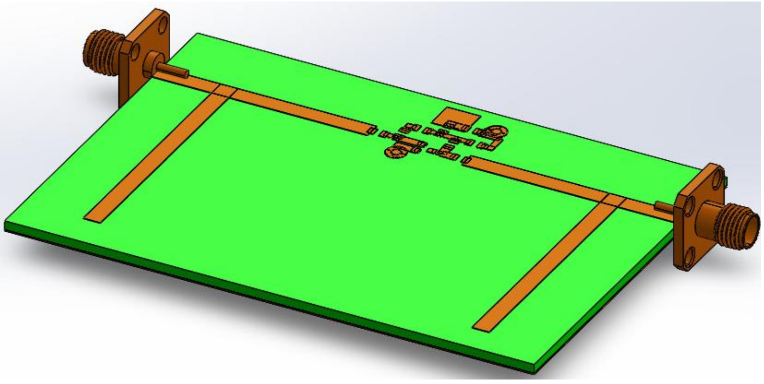


Fig. Low Noise Amplifier

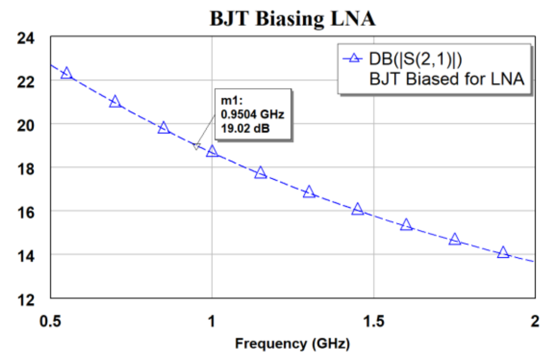
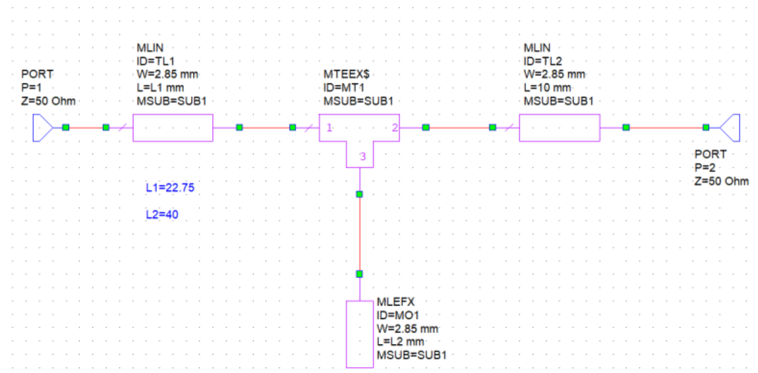


Fig. Biasing of LNA using transistor



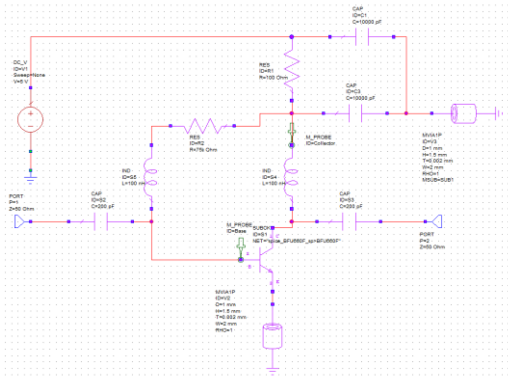


Fig. Schematic Diagram of LNA Stub and LNA circuit used for bjt biasing

3.2. Coupler

A coupler is a passive RF/microwave component used to split or combine signals in a controlled way. It allows a certain portion of power from an input signal to be “coupled” out to another port while the main signal continues through the transmission line.

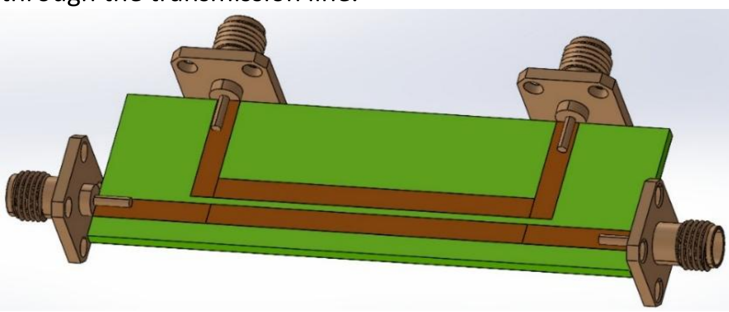


Fig. Coupler

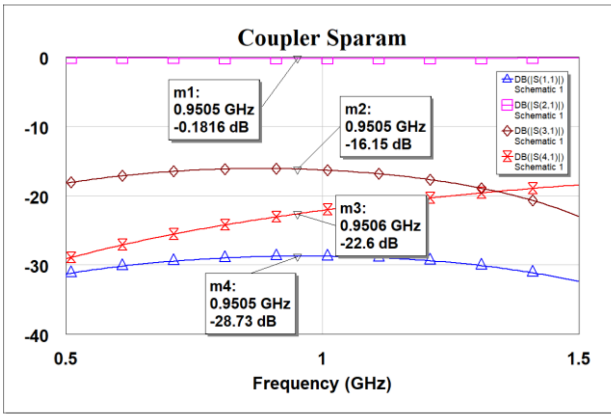


Fig. S-Param of Coupler

3.3. Power Amplifier

In an Frequency-modulated continuous-wave radar (FMCW) system, a power amplifier (PA) is used at the transmitter side to boost the signal power before it's radiated through the antenna. This ensures the radar signal can travel longer distances and reflect clearly from targets. A well-designed PA provides high gain and efficiency while maintaining linearity, which is crucial to avoid signal distortion and ensure accurate range and velocity measurements.

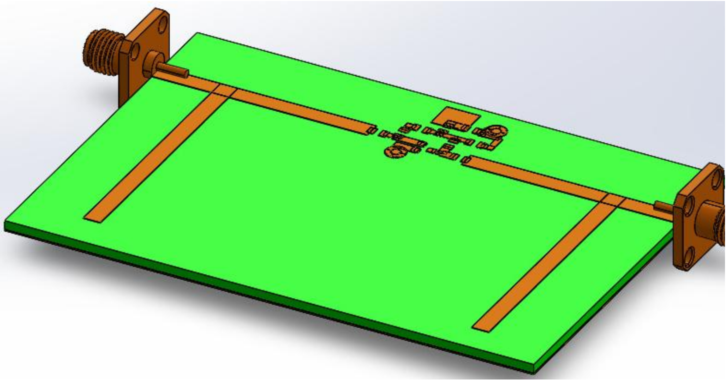


Fig. Power Amplifier

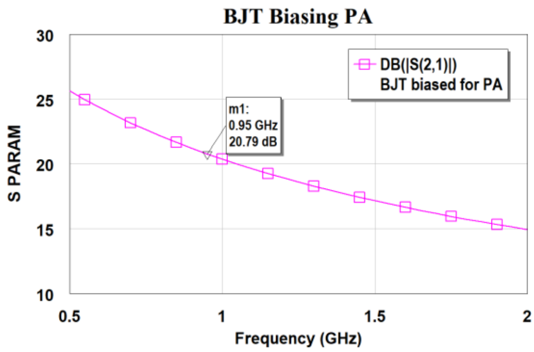
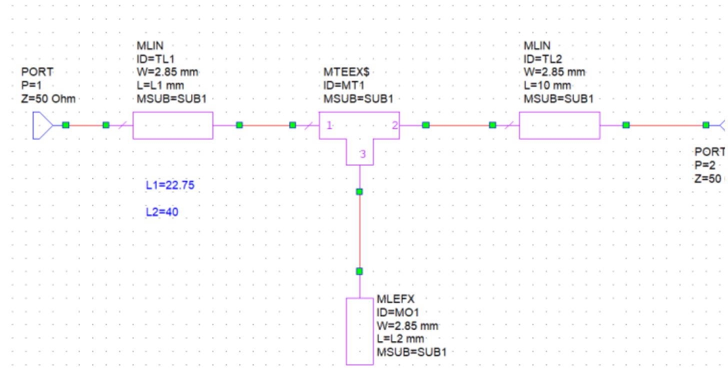


Fig. Biasing of PA using transistor



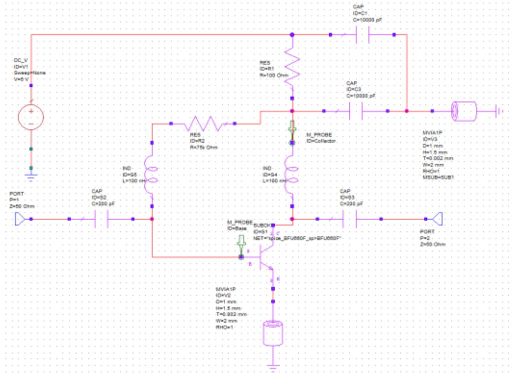


Fig. Schematic Diagram of PA Stub and PA circuit used for bjt biasing

3.4. Branchline Mixer

A coupler is a passive RF/microwave component used to split or combine signals in a controlled way. It allows a certain portion of power from an input signal to be "coupled" out to another port while the main signal continues through the transmission line.

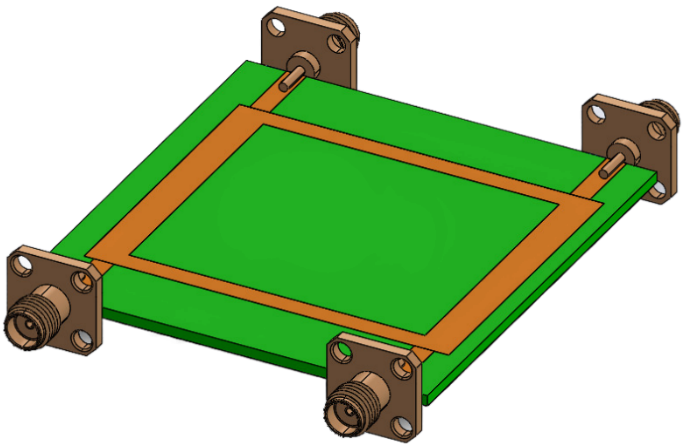


Fig. Coupler

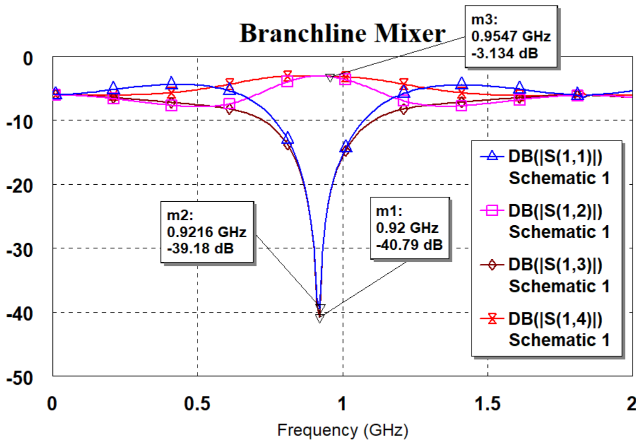


Fig. S-Param of Coupler

3.5. Antipodal Antenna

In an Frequency-modulated continuous-wave radar (FMCW) system, a power amplifier (PA) is used at the transmitter side to boost the signal power before it's radiated through the antenna. This ensures the radar signal can travel longer distances and reflect clearly from targets. A well-designed PA provides high gain and efficiency while maintaining linearity, which is crucial to avoid signal distortion and ensure accurate range and velocity measurements.

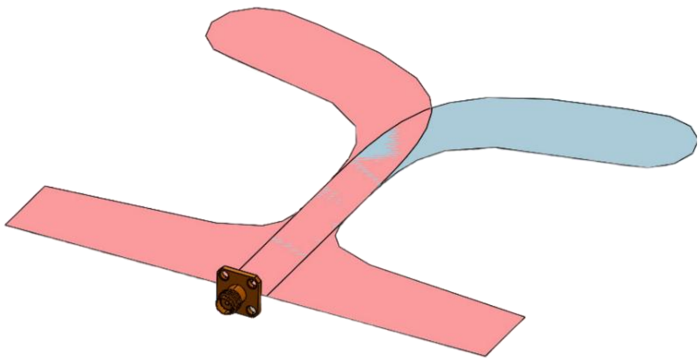


Fig. Antipodal Antenna at 1GHz

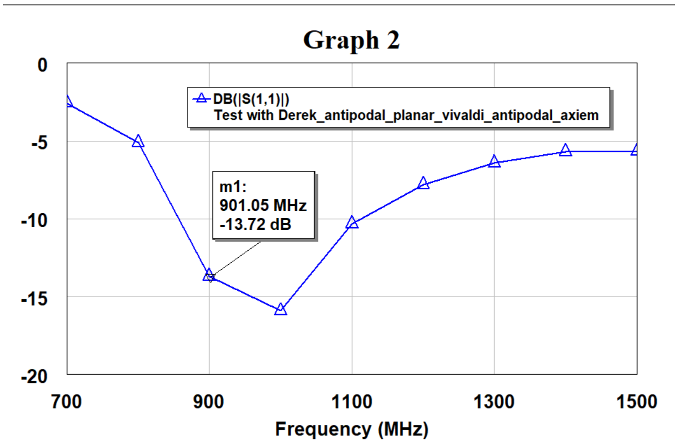
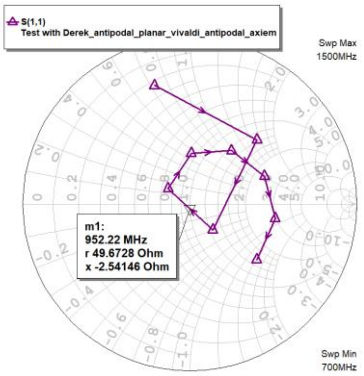


Fig. Antenna S-Parameter



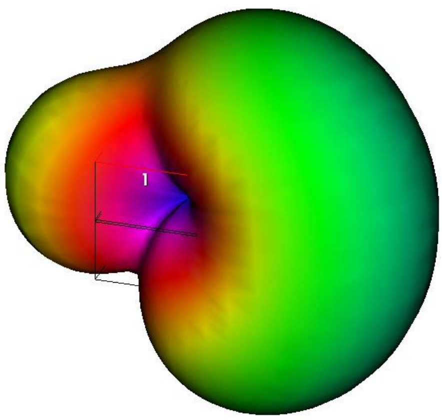
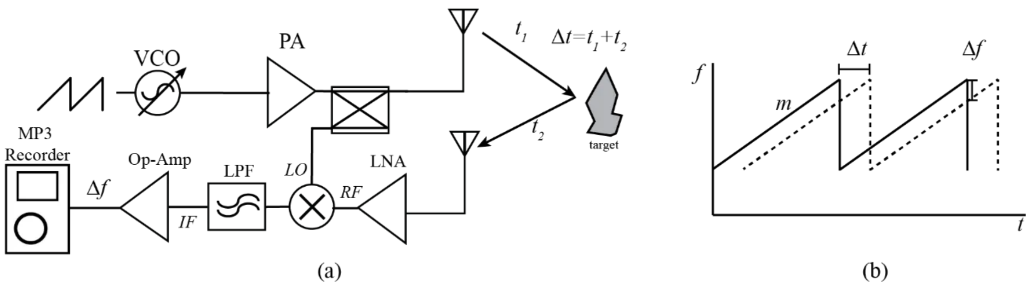


Fig. Gain of Antipodal Antenna

3.6. Manufactured FMCW RADAR



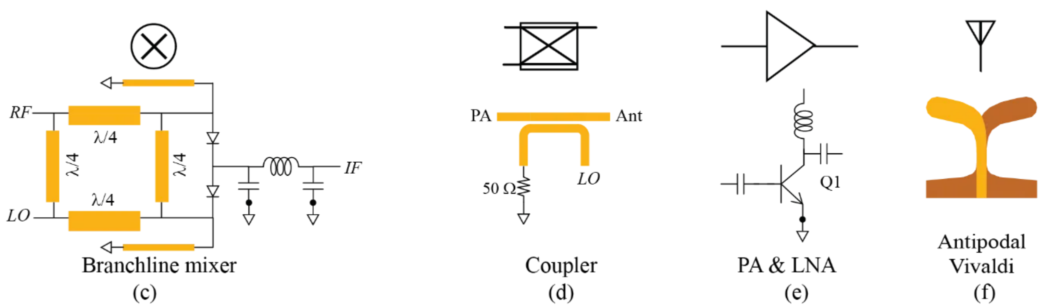


Fig. Block Diagram of FMCW Radar

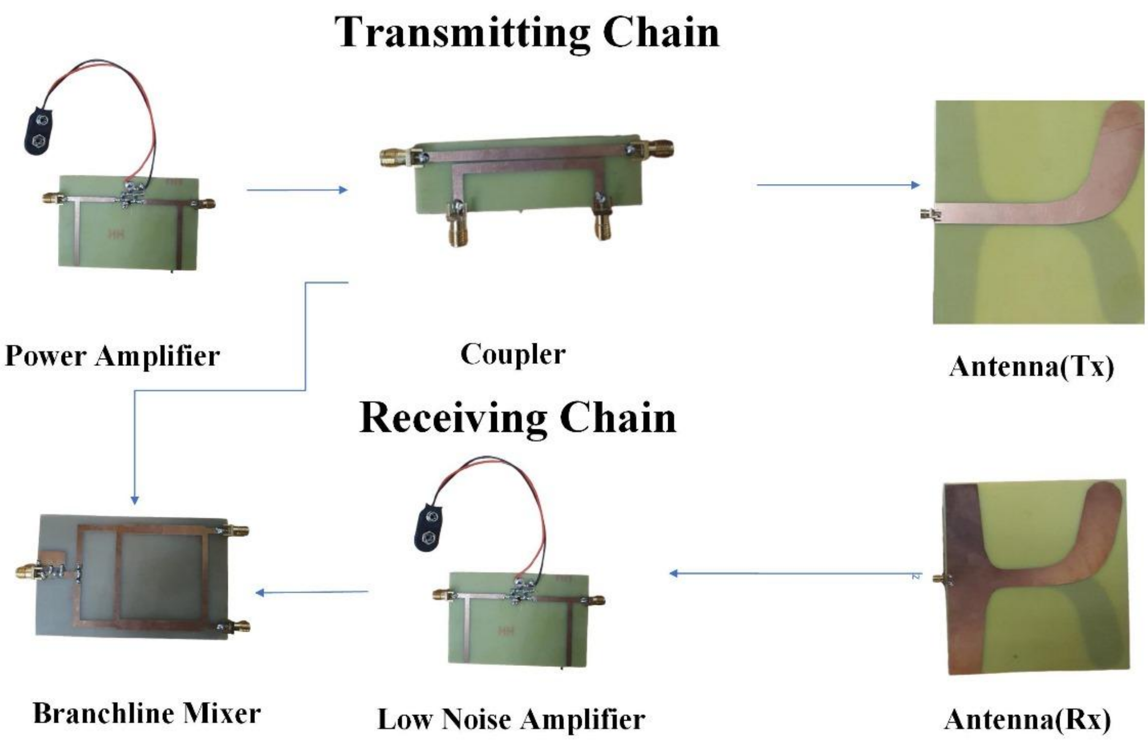


Fig. Manufactured FMCW Radar at 1 GHz

4. RF COMPONENTS

4.1. Low Pass Filter

A low-pass filter allows signals with frequencies below a certain cutoff frequency to pass while attenuating higher frequencies. It is used to remove unwanted high-frequency noise or harmonics from a signal. Such filters are commonly implemented in RF, audio, and communication systems to ensure clean and stable signal transmission.

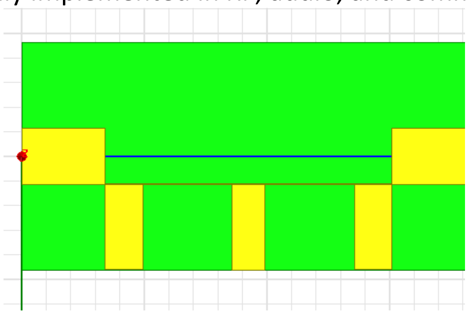


Fig. Low Pass stub Filter

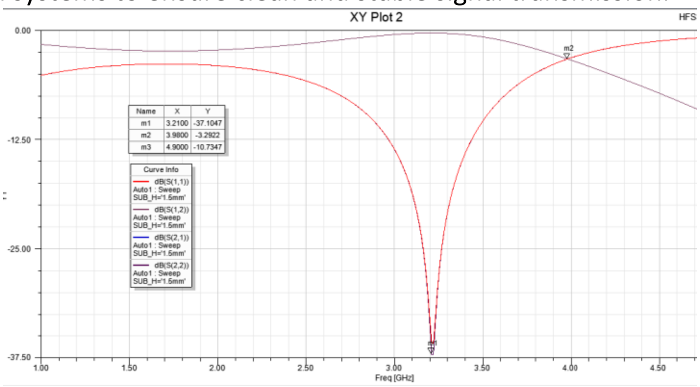


Fig. Return Loss of the filter

4.2. Waveguide Filter

A waveguide filter is a high-frequency filter that uses sections of waveguide to control signal propagation based on frequency. It allows desired frequency bands to pass while rejecting others through resonant cavities or irises. These filters are widely used in microwave and satellite communication systems due to their low loss and high power-handling capability.

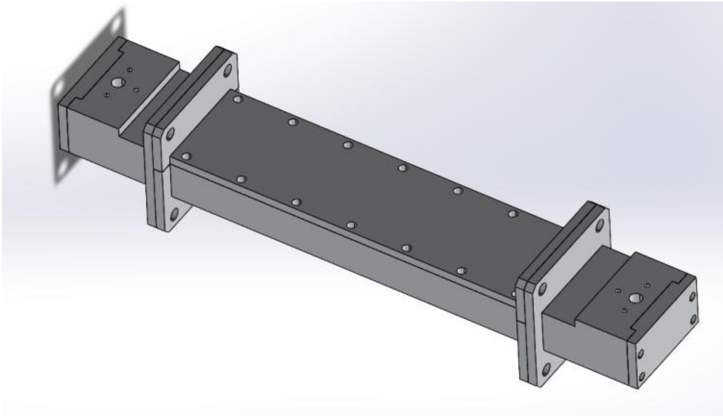


Fig. Complete Assembly of X-Band Waveguide Filter using WR-90

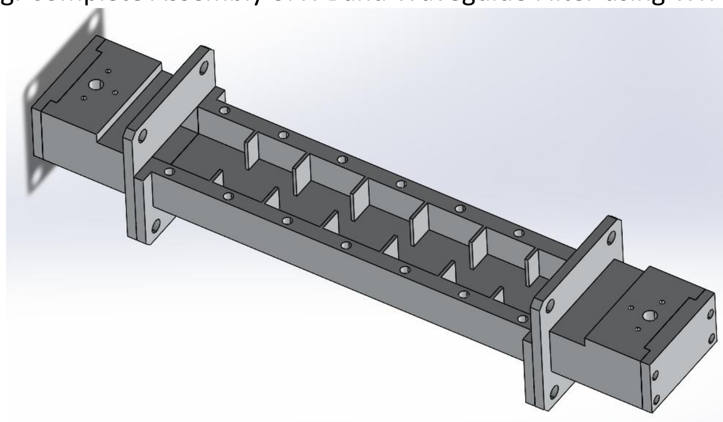


Fig. Waveguide filter designed using the irises and optimizing its widths for best optimization

5. Hardware for testing

5.1. Vector Network Analyzer

For RF component testing and characterization, a PocketVNA is used to measure parameters such as S_{11}, S_{21}, and impedance across a wide frequency range. It enables accurate analysis of filters, antennas, and couplers in both magnitude and phase. This portable VNA setup provides a convenient solution for on-site and laboratory RF measurements.

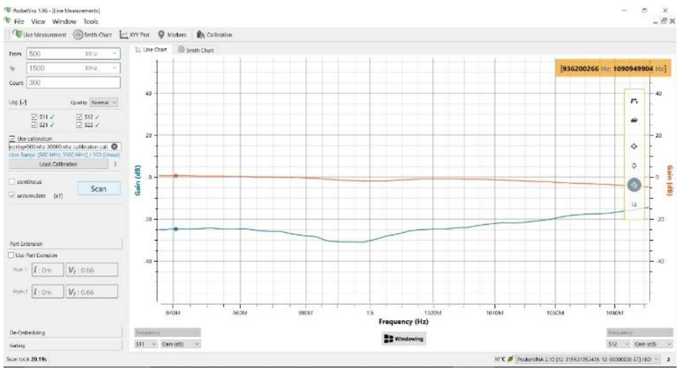


Fig. S-Parameter testing using pocket VNA

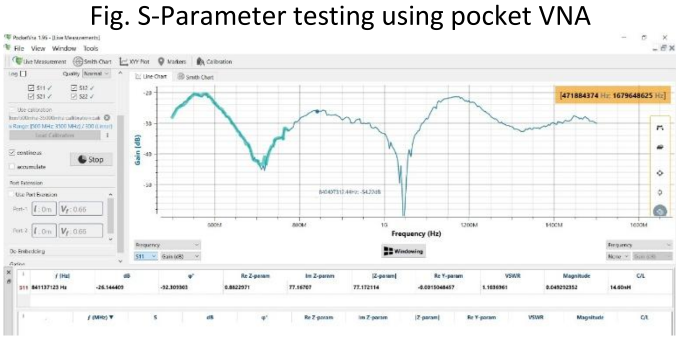


Fig. Measured Return loss of Antennas discussed above, using pocket VNA

5.2. SDR PLUTO

SDR++ software is used with the ADALM-Pluto SDR for real-time signal reception, analysis, and demodulation. This setup allows monitoring of various frequency bands, including satellite and communication signals. The combination provides a flexible and low-cost platform for experimentation in RF, signal processing, and wireless system development.

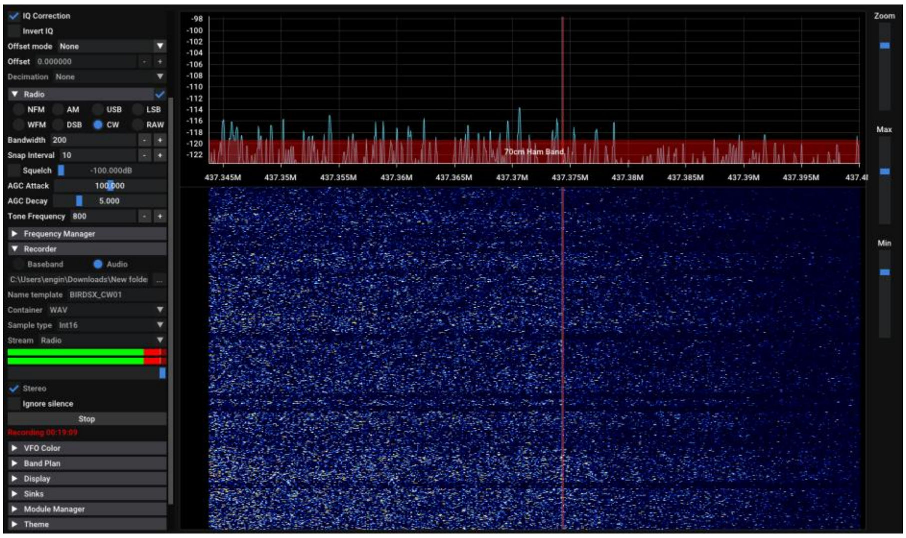


Fig. SDR++ Software Interface and signal reception

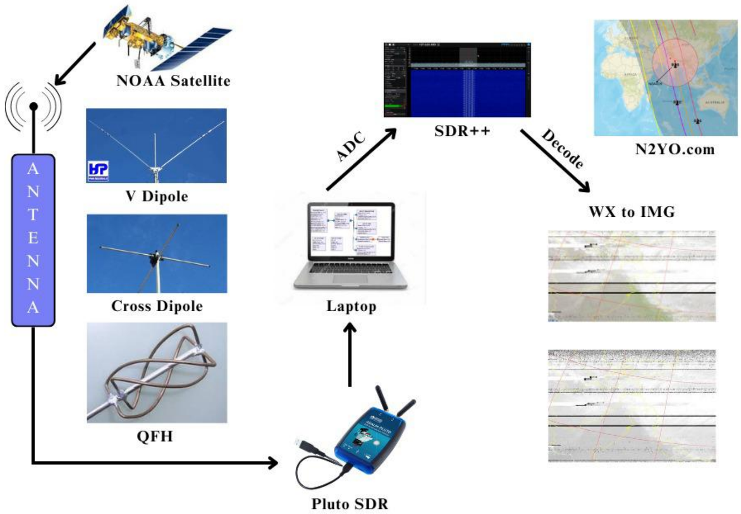


Fig. SDR Pluto signal reception and decoding audio to image from NOAA Satellite

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THANK YOU

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