A Dive into Terahertz Technology

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Discussion

In the world of mass communication, the demand for fast and reliable service is more important than ever.

Our research team specializes in wireless terahertz communication. It has been observed that at lower bandwidths (20 Gbps) atmospheric absorption is the dominant mechanism limiting link distance, while at higher bandwidths it is dispersion. [1].

However, this understanding has been based on simulations, as we could not conduct these experiments with the current equipment in the lab. One missing item was high gain antennae for long distance links.

Our goal is to create a physical antennae capable of transmitting terahertz with a high gain over long distances, that will validate the findings of these simulation results and serve as a reliable tool to conduct future terahertz experiments.

Discussion

Our research was conducted in our state-of-the-art, Ultrafast Terahertz Optoelectronic Lab (UTOL). This lab features new equipment and technology needed for optical and THz communication research.

In this project we decided to construct a Cassegrain antenna to conduct our experiments. This type of antenna features a parabolic dish with a hyperbolic secondary or sub- reflector a certain distance away from the feed.

To determine the expected performance, optimization, and dimensions of the antennae, we programmed optical analysis code in MATLAB. Our resulting design has both benefits and challenges.

Advantages

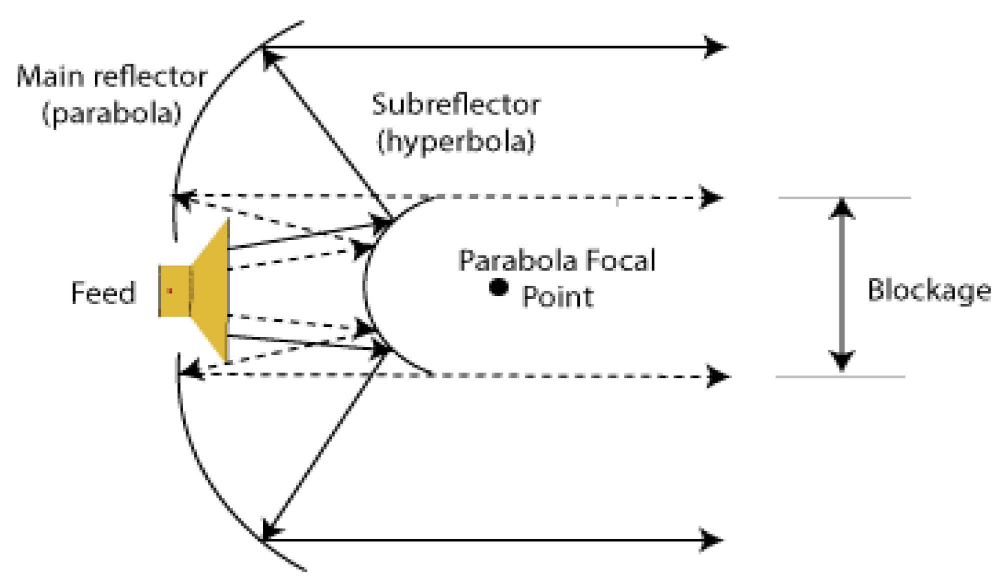
- Large aperture collects more power
- More direct signals
- Easy construction and adjustability

Disadvantages

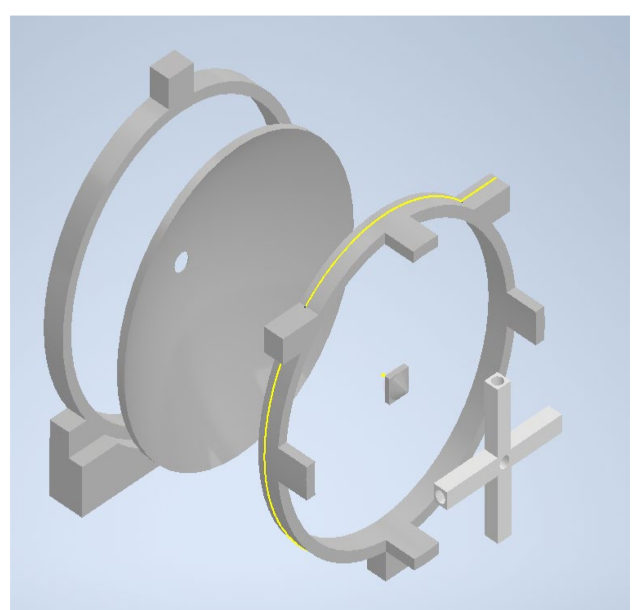
- Some radiation is blocked by the sub-reflector
- Exact calibrations can be troublesome
- Worse side lobes than horn

Design

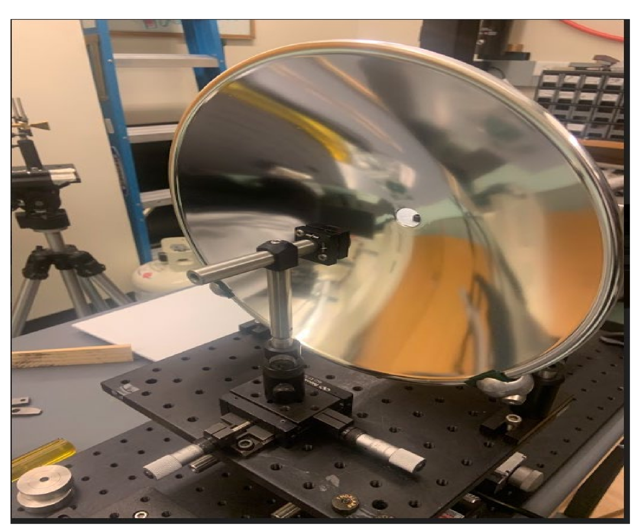
In the beginning, we only had two parabolic dishes and sub-reflectors. To design a Cassegrain antennae to work with, we took two different design routes.



Here we measure power using the decibel scale. Decibel (dB) is a logarithmic style of power measurement, scaled similarly to how humans perceive sound.



Design one: We first designed a Cassegrain antennae using the Inventor 3D modeling software. Once the sketches were completed, we would later 3D print them.



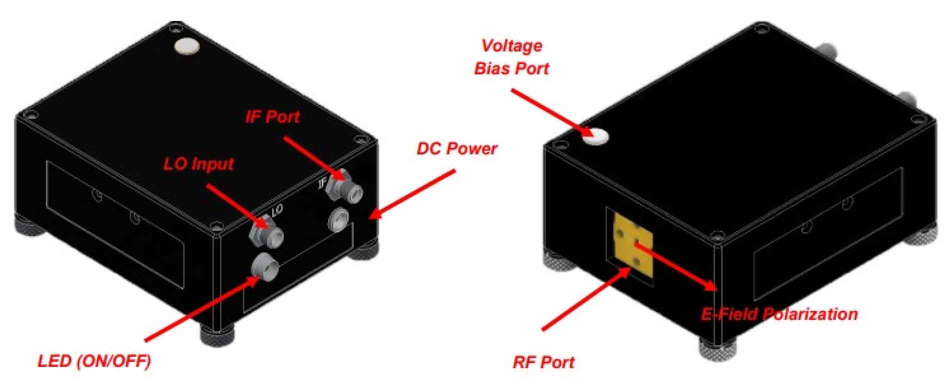
Design two: We made a Cassegrain antennae out of multiple pre-built components. We attached it to a breadboard with translation stages. This would be the first design we would test.

- Gain: Strength of antenna radiation in the peak direction, compared to isotropic radiated power (in DBm)

Testing

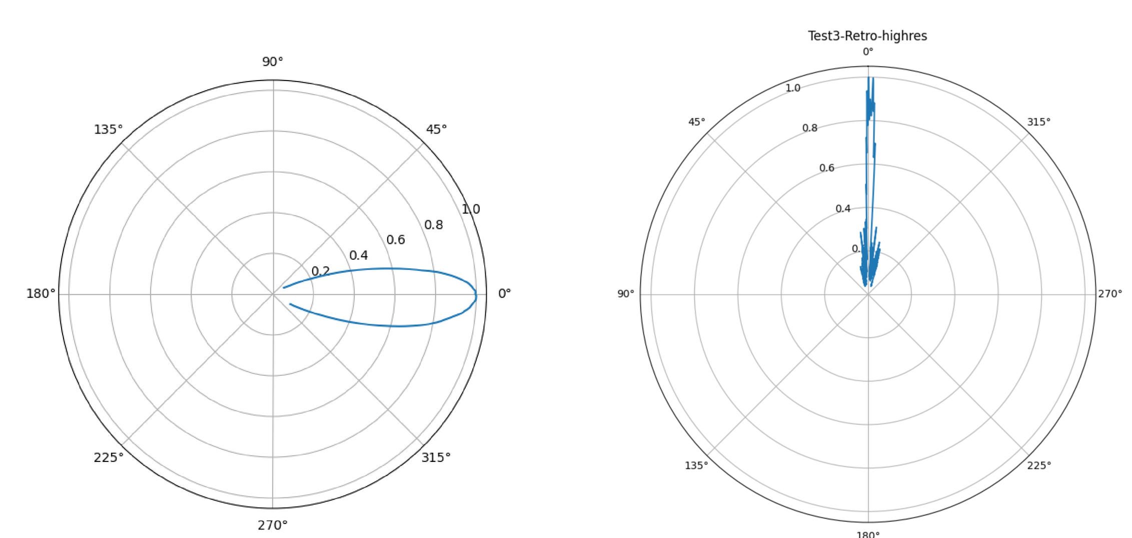
Testing occurred in our lab where equipment is capable of measuring and creating various terahertz signals for our experimentation.

The lab equipment includes: an Analog Signal Generator, Arbitrary Waveform Generator, and a Digital Storage Oscilloscope which can measure up to 25 GHz.
We also have a Compact Up and Compact Down Converter (CCU and CCD) which will serve as feeds for our antennae.



For our test in design 2, we first aligned the antennae with a laser calibrator. Then we attached our converters in the aperture of our dish to serve as the feed for the antennae.

A program was written using MATLAB and Python to control a programmable rotation stage, so the antennae can shift directions slightly and record received power at each angular position. This forms antenna patterns that describe the antenna gain.



Above are the antenna patterns of the horn measured in the far field (Left) and the horn-fed Cassegrain antenna mid field(Right).
Some of the advantages and disadvantages are present in these 2D patterns

Discussion

From our recorded results. We have both favorable results and results that need to be improved. Through experimentation, the antenna functions as expected, having much higher gain. We also learned how to better calibrate certain parameters, like the axial distance of the sub reflector.

Upcoming work will include constructing more efficient bases to produce a better Cassegrain antennae (one where there aren't as much obstructions and unnecessary reflections). We will also need to recheck our data as our antennae might be stronger (more gain, higher directionality) then previously anticipated.

Our future experiments include measuring our antennae's radiation in the far-field. Lastly, we plan on characterizing the phase pattern as well as the power pattern.

We have the equipment and ideas to continue testing. With a few more adjustments this antennae will be a vital piece for our lab.

References

[1] Karl Strecker, Dr. Sabit Ekin, Dr.John O'Hara
"Fundamental Performance Limits on Terahertz Wireless Links Imposed by Group Velocity Dispersion," IEEE Transactions on Terahertz Science and Technology 12(1), 87-97 (2021)

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