NuPhotonics

[Approved for public release]

Coming in fall 2023, NuPhotonics is releasing a custom package of our state of the art 35 GHz Photodiode and 25G DFB laser packaged together with an antenna that was optimized by our evolutionary algorithm. This device will operate at various bandwidths, mainly depending on the build configurations. It will be available in both amplified and non-amplified builds. This will encompass a complete transmitter or receiver device; this will allow the user to be able to extend Antenna locations farther away from the central hub at a much easier and more affordable cost. Fiber optics overcome the short comings of RF coaxial cables. We want to offer a complete solution for existing platforms.

At the Drawing board

It was apparent that one of the challenges would be designing an antenna that would fit into a small package while being ultra-wideband, high gain, and maintain circular polarization. Miniature or as often called electrically small antennas pose a difficult problem to overcome due to being limited by physics. Outside of the geometry, it was clear that the antenna will also need to be electrically loaded with a material that can help excite the field by making the small geometry electrically larger for the electromagnetic wave to better couple into the structure. The difficulty of this problem is the optimization of the geometry and material, traditionally an experienced RF engineer would sit behind a computer and design and optimize the structure. This is a slow and expensive process; this becomes exponentially harder as the number of variables increases. This task is must better left to an algorithm to run none stop.

Why Evolutionary Algorithm over Artificial Intelligence

In current news, Artificial Intelligence is everywhere, when have you not heard about companies incorporating artificial intelligence into their daily tasks? Artificial Intelligence was first introduced as a topic in the 1950s, it has had an influx of interests as computers become more powerful, so it seems like this would be an ideal Algorithm to use to solve this problem. The shortcoming of Artificial Intelligence is that it needs a large data set to work off. A problem like this has no data set to work off. Evolutionary Algorithms on the other hand, are well known algorithms to solve complex non-linear problems. This theory is based off what Darwin described as Evolutionary theory. The structure will be broken down into a string of genetic code, where each gene describes the physical geometry, as well as the material properties that will electrically load the structure. The algorithm will use an open-source FEM solver to simulate the structure and emulate what the RF response will be for each genetic sequence. This comes at the expense of it being computationally expensive as it creates the data set it will solve off. The flow cart of this algorithm is shown in Fig 1.

Unlike traditional evolutionary algorithms that start with a random population and breed the population that had desirable attributes, our algorithm starts off with minimal genes and expands out the geometry until the criteria is met. An example of this can be seen in Fig 2. Where the evolutionary algorithm was tasked with solving a planner 5.8 GHz antenna for WiFi applications. This example had the algorithm search for a high return loss at 5.8 GHz and that was the only criteria it was solving for. It solved for 50 generations and after each solve it grew outward keeping some pixels and removing some. This allowed for a more optimized solve in terms of computational expense and while also searching for the smallest geometry.

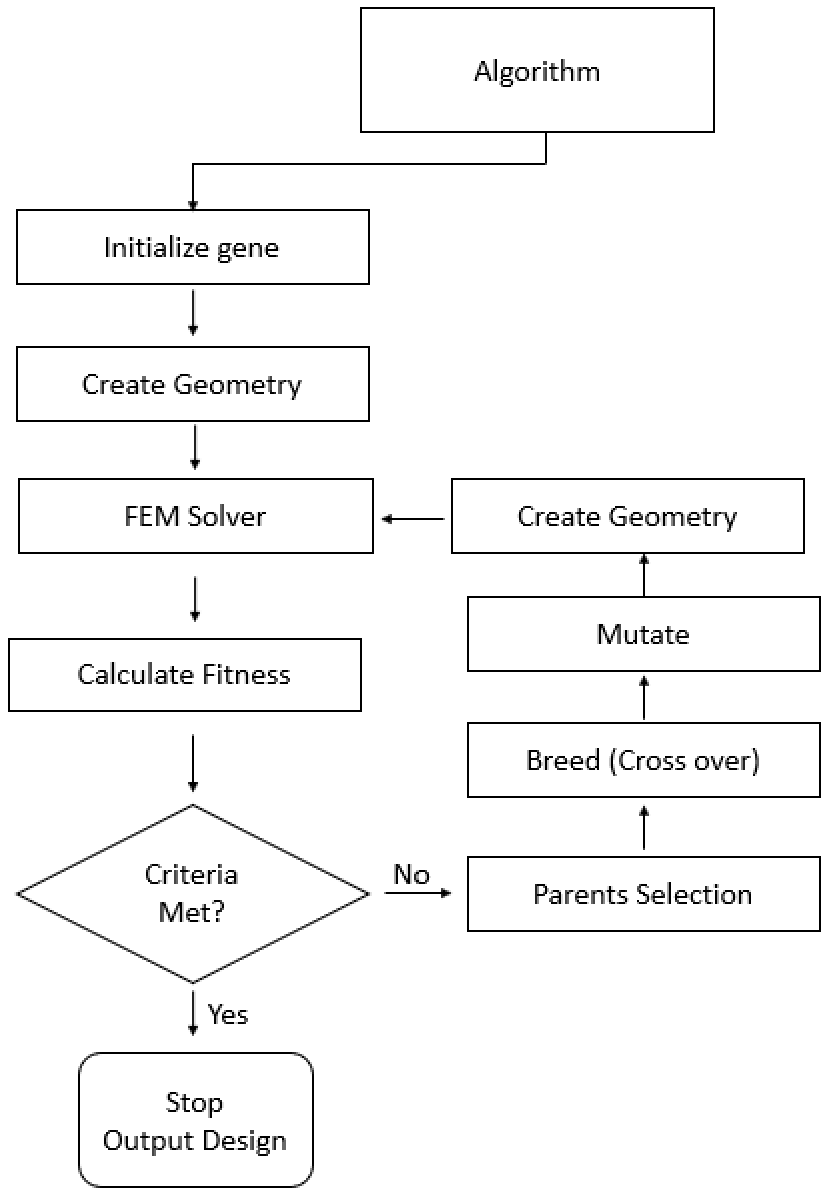


Fig 1. Evolutionary Algorithm Flow chat

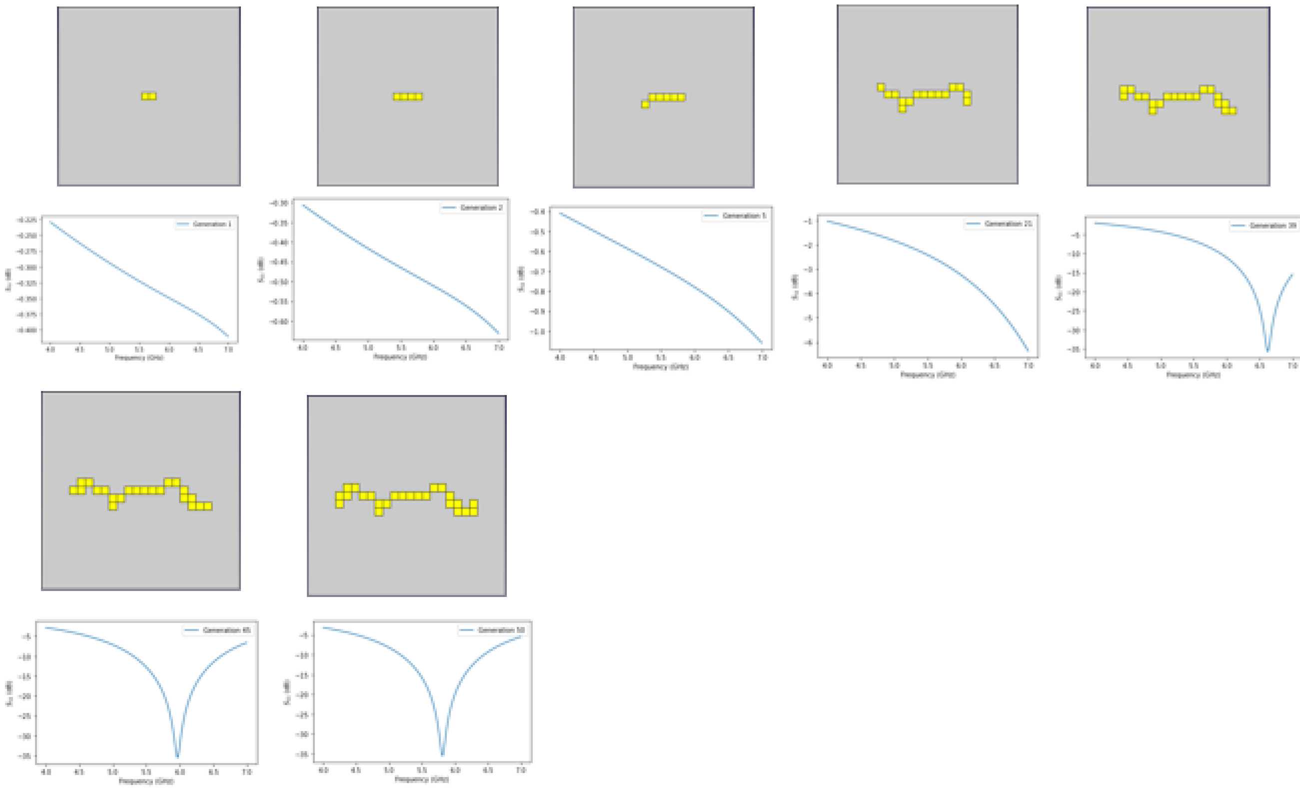


Fig 2. Pixelated Antenna example of the Evolutionary Algorithm growing the antenna to meet criteria.

Antenna Results

Our RF engineer created the basic geometry of the Antenna for this application, and it was plugged into the algorithm, the search criteria for this antenna was both return loss as well as gain, which makes it a much more difficult problem then the example shown. It was chosen that a circular horn antenna would be the base for this structure. The Evolutionary Algorithm gene pool was made up of 9 geometrical points to optimize, as well as the material infill for the antenna. A few limitations were set for the search criteria, 1: the opening of the antenna could not exceed 22 mms as well as the material was limited to commercially available glass. The glass limitation was for specific CTE matching with the device body as well as hermetic sealing criteria. The algorithm ran for 136 hours continuously on 28 CPU cores, and it generated 8 TB of data. After completing a solve, the algorithm processed all the data and created the next gene pool and started simulating the structure within 3 seconds. This was significantly faster than any human would be able to do. The antenna design and subsequently the antenna 3D printed in conductive resin as can be seen in Fig 3. The algorithm optimized an antenna that was just under 23mm long.

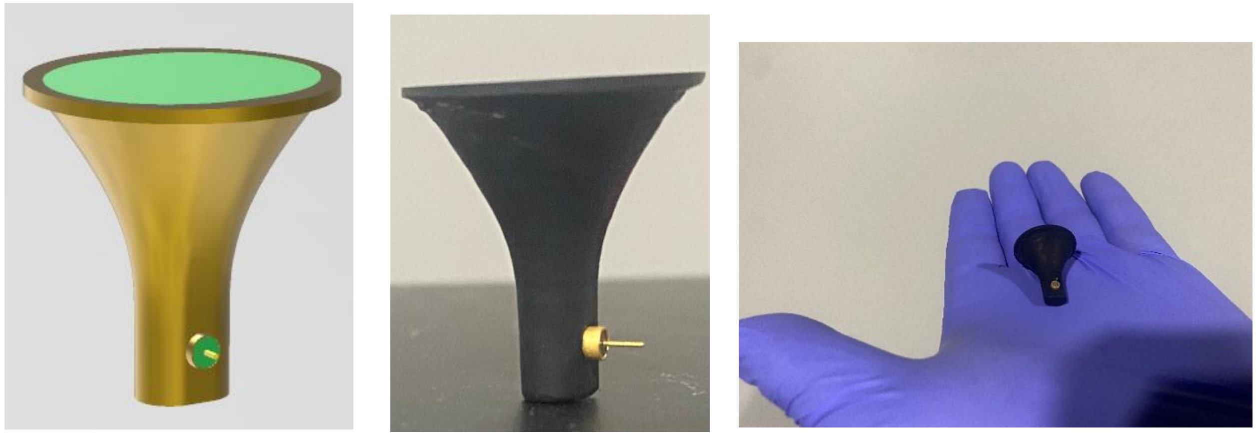
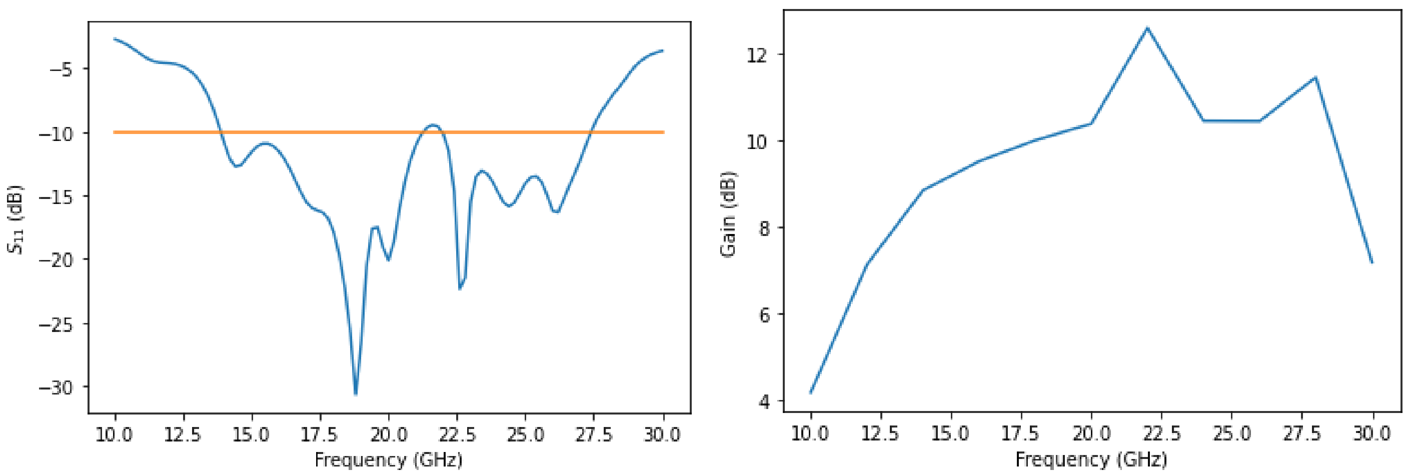


Fig 3. Designed Antenna, 3D Printed Antenna with Kovar-Glass RF Pin, In comparison to a hand.



(Averages 4, 1% Smoothing)

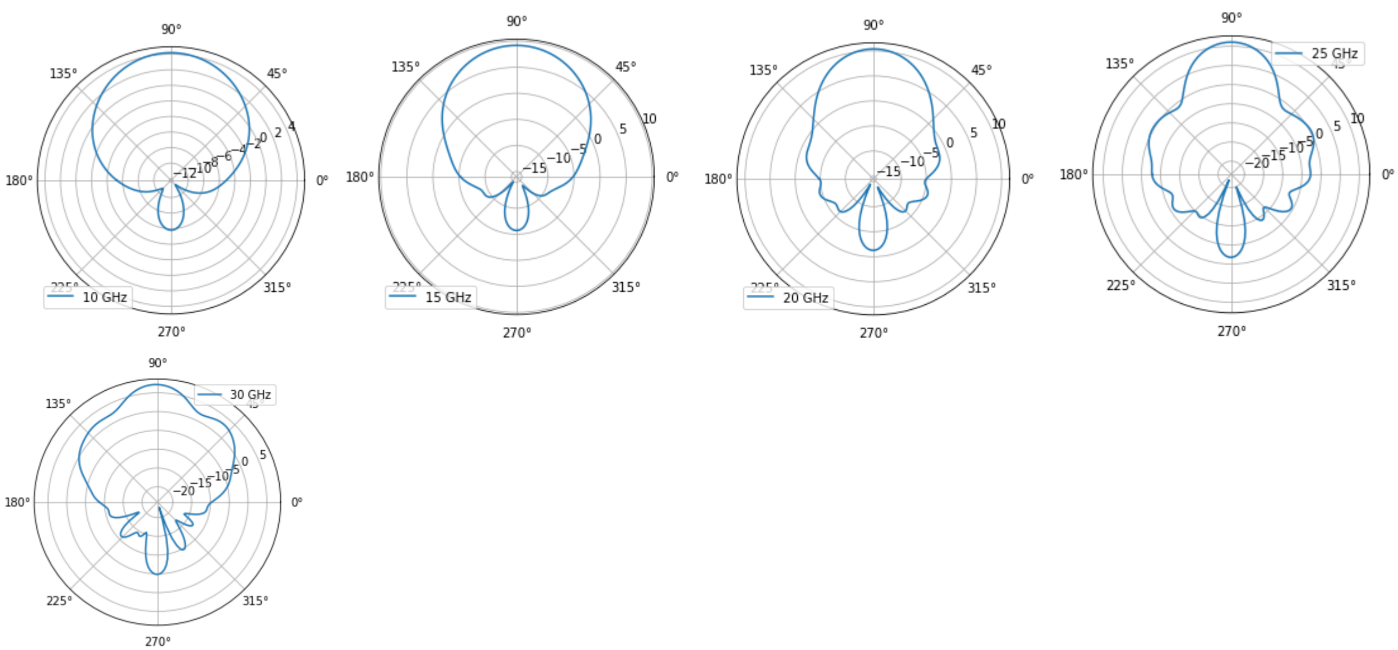


Fig 4. Antenna Results

Device

We are excited about the possibilities this will enable for consumers. When this device is paired with our Opto-electronic devices it will allow users to be able to transmit signals over kilometers with ease. It will be a hermetically sealed device. Device datasheet will be released in the coming months (exp. August 2023).

Build configurations:

- Electric only – Paired with an Amplifier, it will have a 27 GHz RF connector available.
- Laser Device- Antenna paired with a Laser, it will be a receive antenna. (1310 & 1550 nm available)
- Laser + Amplifier – Antenna paired with an amplified laser build. (1310 & 1550 nm available)
- Photodiode Device – Transit antenna build. (900 – 1660 nm spectrum)

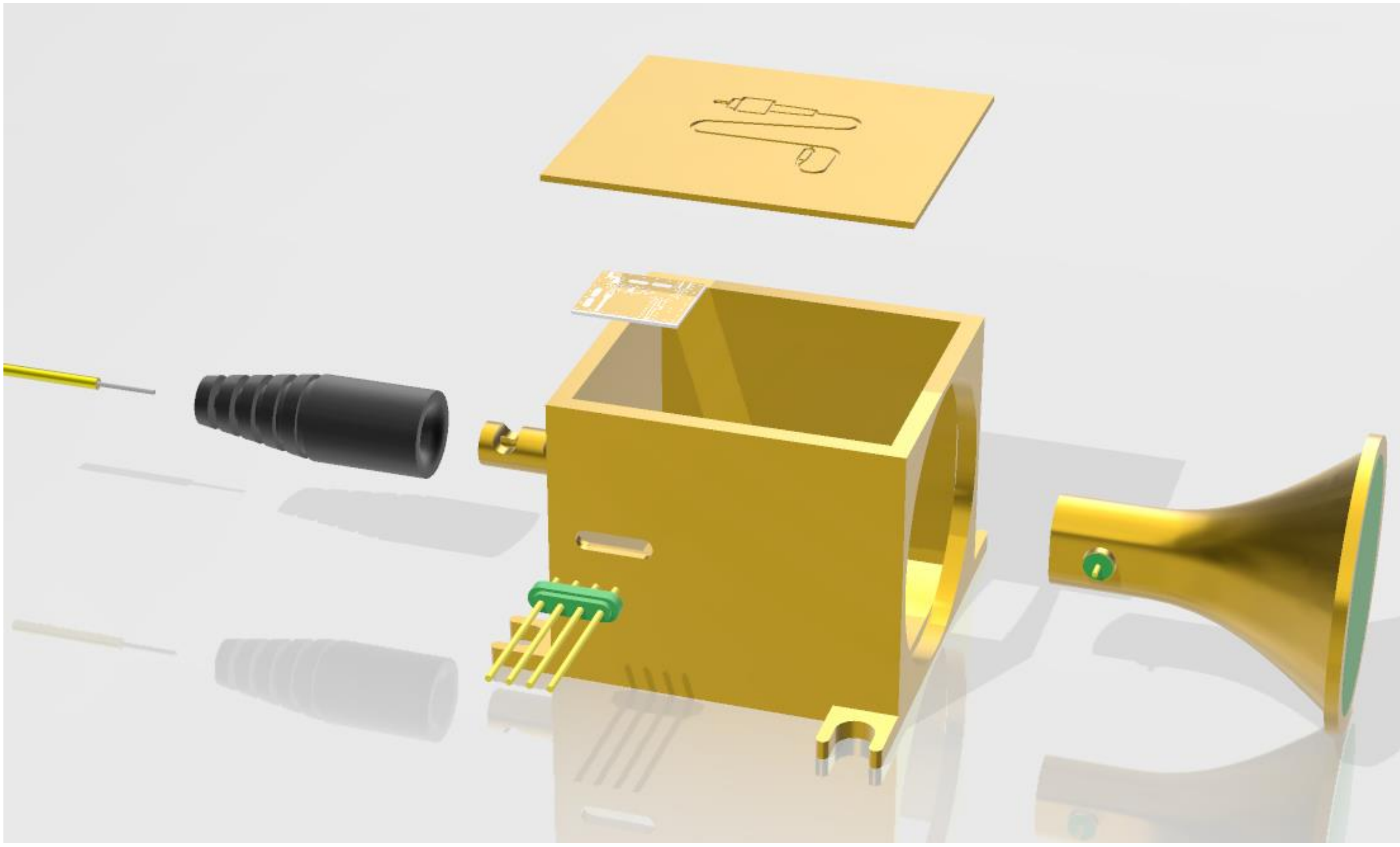


Fig 5. Designed Device (Photodiode Build) exploded view.