Low-cost and power-efficient DC-biasing system for reconfigurable reflective surfaces in the terahertz spectrum

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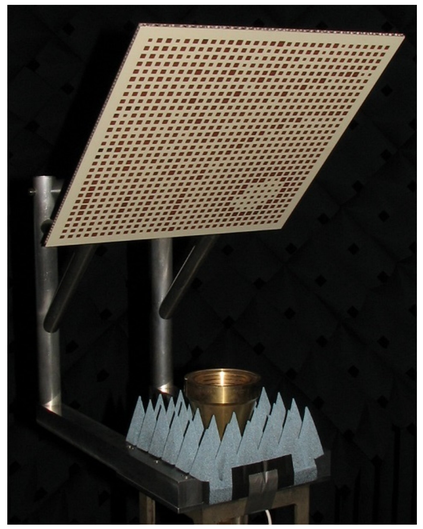
Abstract and Project Overview

Abstract

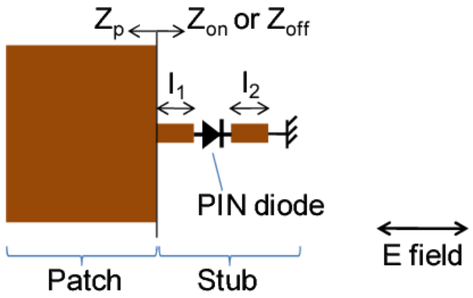
Reconfigurable reflectarrays aim to mitigate connection issues with wireless sensing, target tracing, artificial intelligence, and many other capabilities. Being able to establish and replicate an effective, low-cost DC biasing circuit for many types of reflectarrays would improve the process of implementing such devices in a wide range of orientations, configurations, and locations. This would allow for a stronger, more reliable, and direct signal for the end user.

Motivation Behind the Design

- Reconfigurable intelligent surfaces are optimal for dynamic beam forming in dense, urban areas
- Other applications include remote sensing and satellite communications
- Similar to RADAR technology but incorporates a narrow-band signal for receiving and transmitting with fine accuracy and fast data-rates



A flat-panel reflectarray antenna designed by the ESA

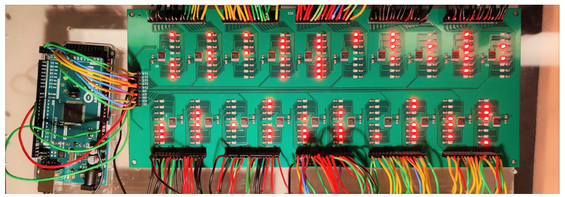


An illustration of the PIN diode in conjunction with a unit-cell

Roles of Biasing in the Reflectarray

- PIN diodes unique internal architecture allows for fast switching at high frequencies
- To switch the signal path on or off, a steady DC-voltage can be applied to the unit cell provided by the biasing PCB
- When the cell is biased properly, a 180° phase shift is induced on the reflected signal which allows the formed beam to be precisely controlled
- Optimized code can be pushed to the microcontroller to control the beam steering however desired

Solution and Next Steps



The newly fabricated PCB to replace the prototyped circuit

Design Goals and Solution

The new solution and design emphasizes focus on how a large system can be condensed to a small PCB board. The challenges involve optimal component placement for clean route tracing, as well as finding a neat solution to the modular aspects for this build. The final design shares the same set-up as the prototype but will account for the intended ability to scale the usable shift register memory for a larger reflectarray. This will allow for the user to choose the specific number of biasing boards they would like for their build without reworking the original layout fitted for a single design.

Final design of the THz lab reflectarray with the completed bias PCB on the back

Current Design and Next Steps

The next step in finalizing the build is to establish design methods so the implementation of the system is easy integratabtle with the current and newer revisions. Some goals include:

- Scaling the size of the reflectarray from 160 to 400 elements
- Incorporating alternative methods to tune the phase shift in between 0° and 180°
- Increase the operating frequency from sub-6GHz to -28GHz
- Move towards a FPGA based design to allow for higher switching speeds and maximal computation strength in regards to beam-forming

Such design choices will allow for more ubiquitous uses of reflectarrays, highlighting their potential strengths in solving communication and imaging issues across a wide range of frequencies

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