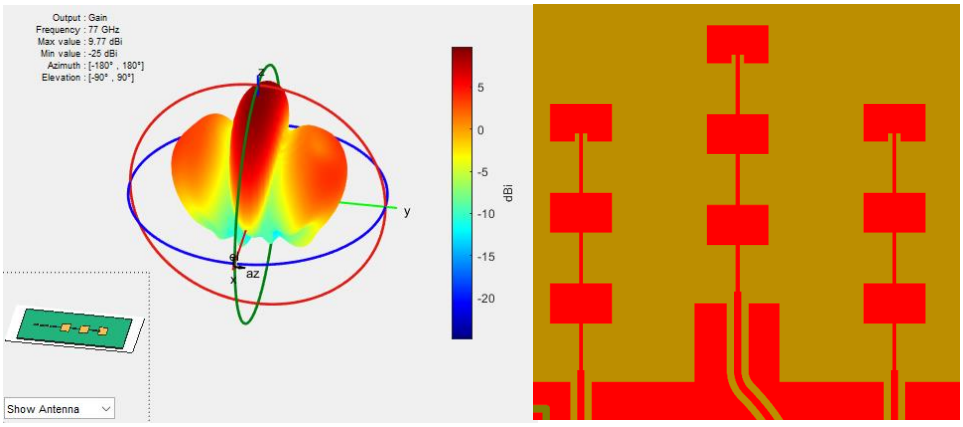
Radar antenna design changes. Project 53

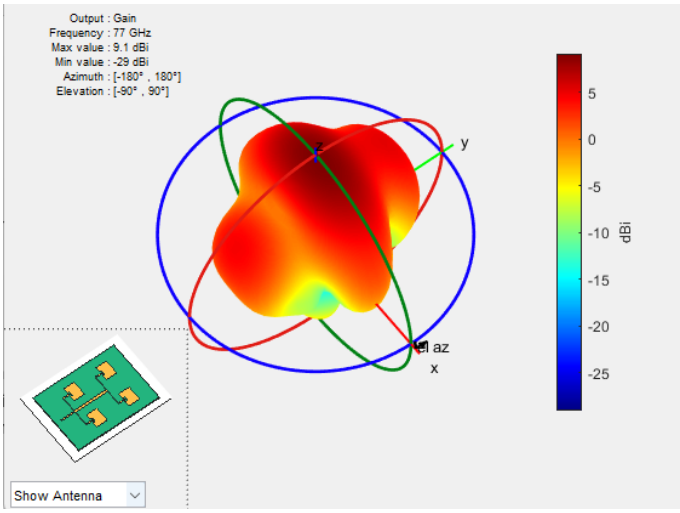
Primer:

Our project involves us using an automotive radar antenna and repurposing it for two uses: imaging radar and general use radar for object detection and detecting the speed of approach of an object, as well as its speed and whether it is likely a drone or not based off the doppler map. We are doing this using an automotive radar module the AWR2243BOOST board, a 77Ghz, 3Tx 4Rx antenna and are going to use MIMO radar techniques (specifically TDM) to increase the angle resolution for better results for both the angle resolution and imaging.



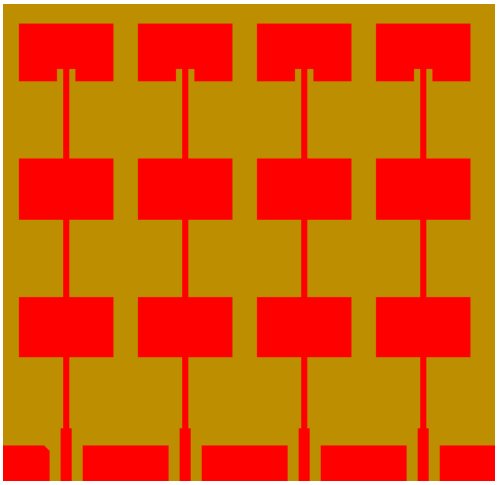
Changes to the original radar design (above) were done with the intention of increasing the vertical resolution and gain of the radar, while reducing the directionality and gain along the horizontal direction so that it is more even.

The shape of the antennas was changed from the 1x3 patch layout above to a 2x2 patch, which has a wider beamwidth which should be beneficial for our purposes, and a gain of 9.1 dB when simulated in MATLAB (as seen below)



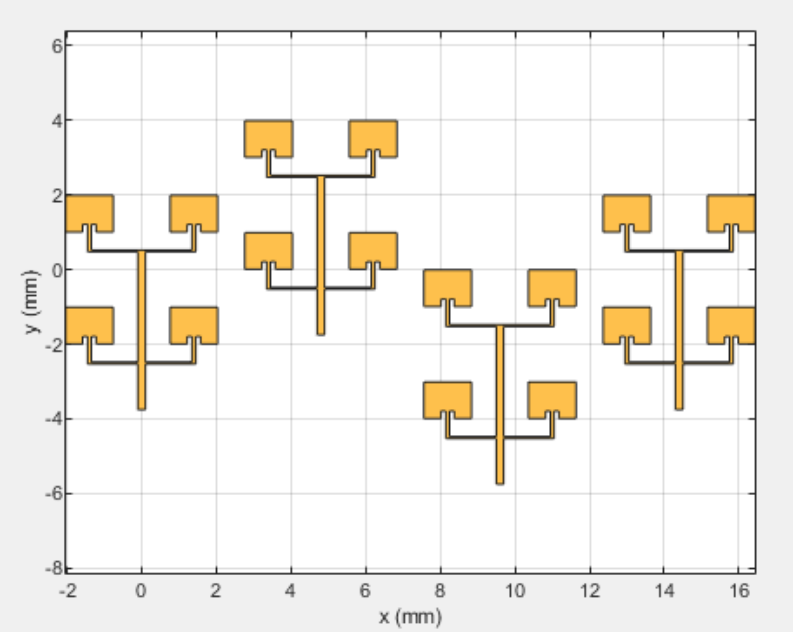
Separation of the patches within a singular antenna was set as 2.8mm horizontally and 3mm vertically After simulating many different separations less than 1 full wavelength, as that lead to the tallest and widest beamwidth as seen in the figure on the right. This was chosen as other separations either had highly directional gain which is useful for the original use of automotive radar sensing, but less useful for our intended use of position sensing in 3D space, or they had large dead zones from antenna interference. Notably, as we are still using the same radar module and frequencies, the antenna shape has been kept mostly the same, only

minorly modified, from 0.97x1.5mm, to 0.9825x1.2744mm as based off of calculations made that was a more optimal design, and the notch size of 02mm x 0.3577mm was maintained and used for all 4 patches instead of just the last antenna.

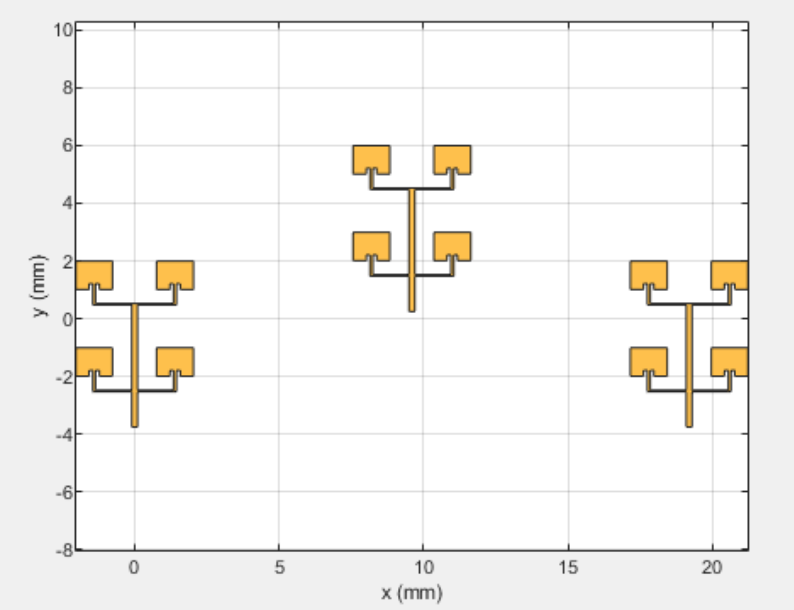


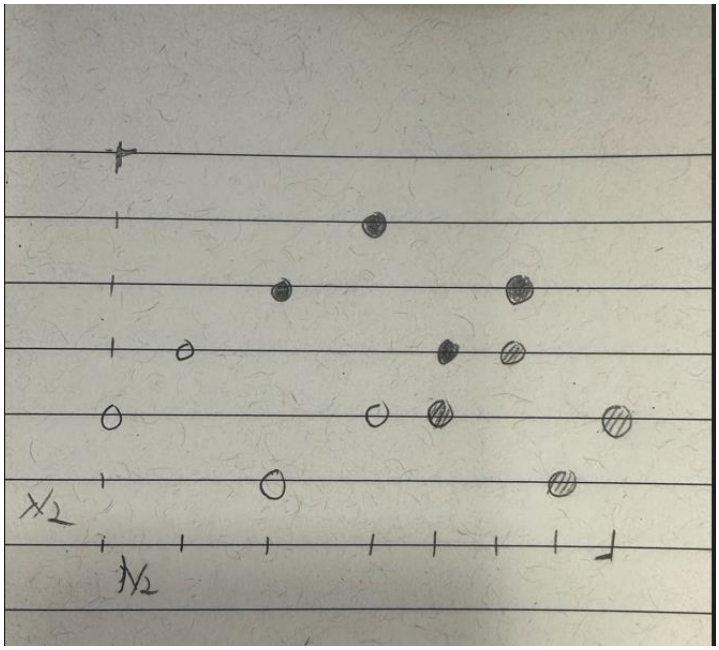
We also plan to change the separation of successive antenna elements, to adjust the position of the virtual array to for better vertical resolution. The original receiver array can be seen to the right, with each antenna offset by 1.9mm - roughly equal to 0.475 wavelengths. While the transmit array has individual elements horizontally offset by 3.8mm and the middle antenna vertically offset by 1.9mm. This leads to a very long virtual antenna array, with poor vertical resolution. Part of the antenna redesign is improving the vertical resolution by changing the virtual array, the simplest way to implement this would be to simply have the transmit array at a right angle to the receive array, creating a wider 3x5 virtual array in comparison to the 2x12 of the current design. One other method I have been considering is offsetting the middle two receive antenna to further increase the vertical resolution, the design I came up with can be seen below, however I am not sure how effective it would prove as the virtual array it creates would have a lot of gaps between the antennas.

The antenna separation for the receive array, the distances were calculated from the nearest antenna elements, so the top left antenna was offset from the top right antenna of the next antenna by ½ wavelength (2mm) I'm assuming this is the intended method as any other way would cause the antenna design as I've made it to overlap and so would not work. See below the intended transmit and receive antenna layouts



Receive array (top) and transmit array (bottom)





Intended virtual array (above) with ½ wavelength spacing and receivers colour coded from each transmitter from the chosen layout of transmit and receive antenna, If this ends up not being viable or useful, instead we will have the transmit array at a right angle to the original receive array layout for a simpler 3x5 virtual array

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Questions that would be useful answering / clarifying:

2x2 receiver layout measures offset from the adjacent sides of the antenna, but still measures vertically from the same antenna (vertical offset by ½ wavelength is looking at the top patches) should that be changed to match the horizontal offsets?

I assume the 2x2 antenna array will have worse horizontal resolution as each antenna is effectively getting two sets of angle data horizontally and vertically – is this a negative? And if so, does it outweigh the benefits?

And the obvious: are there any glaring issues with the design that I have not noticed or overlooked?

thank you for taking the time looking through this, please also find the Matlab file used to develop this design " AntennaDesignFinal" for if you need any further details.