INVESTIGATING THE DESIGN AND USE OF APERIODIC ANTENNA ARRAYS FOR ENHANCED PERFORMANCE

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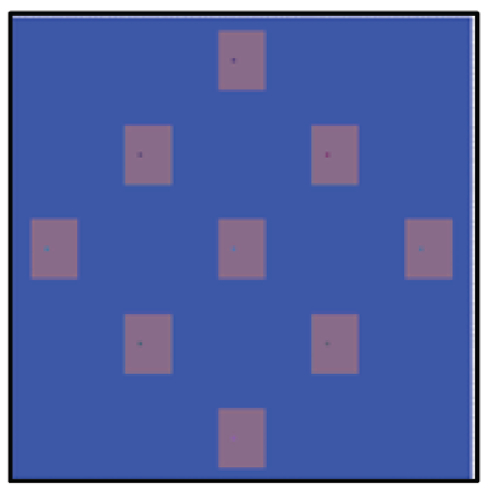
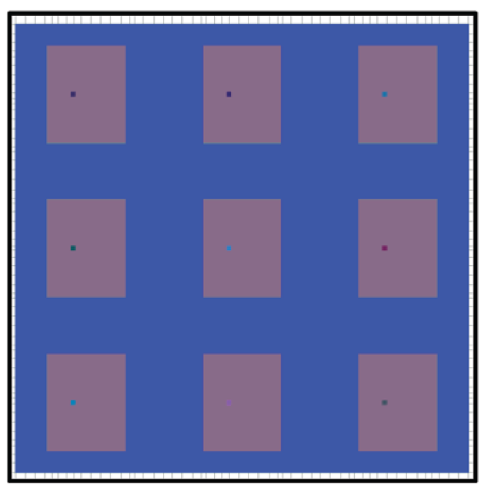
INTRODUCTION

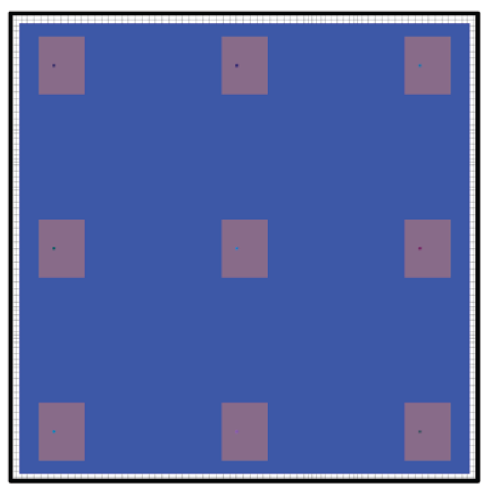
- Periodic antenna arrays are frequently used due to their simplicity.
- However, increasing the gain of the arrays by increasing the spacing of the elements results in increased sidelobe levels.
- Energy radiated to sidelobes is wasted and intercepted by unwanted parties.
- Also, antennas will receive signals from multiple directions, increasing the amount of noise present.
- Therefore, we aimed to create an aperiodic antenna array, where spacing and excitation weightage was varied, that had increased gain and reduced sidelobe levels compared to a periodic antenna array of the same size. This was done for linear arrays in [1]
- We also experimentally verified the properties of linear monopole antenna arrays.

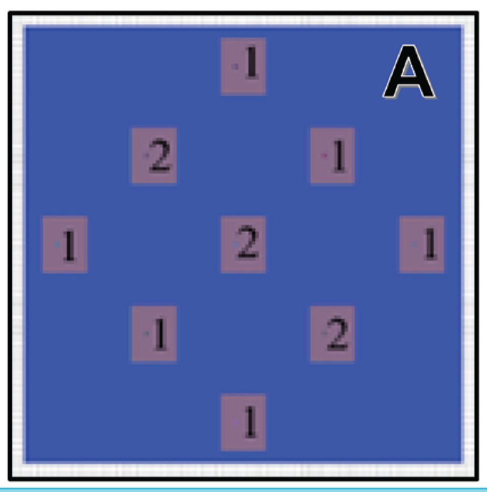
METHODOLOGY – 2D ARRAY

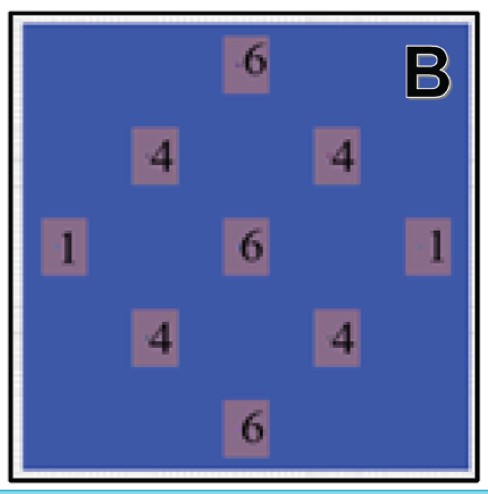
- We carried out simulations in openEMS to generate gain plots
- The patch antennas simulated were 32.86mm x 41.37mm in size
- They were generated on a substrate with a dielectric constant of 4.2
- Below are the various arrays we simulated:





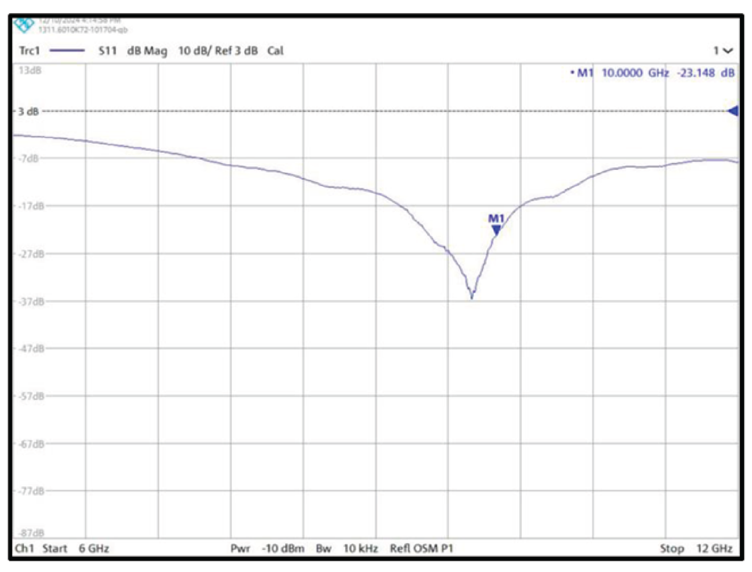


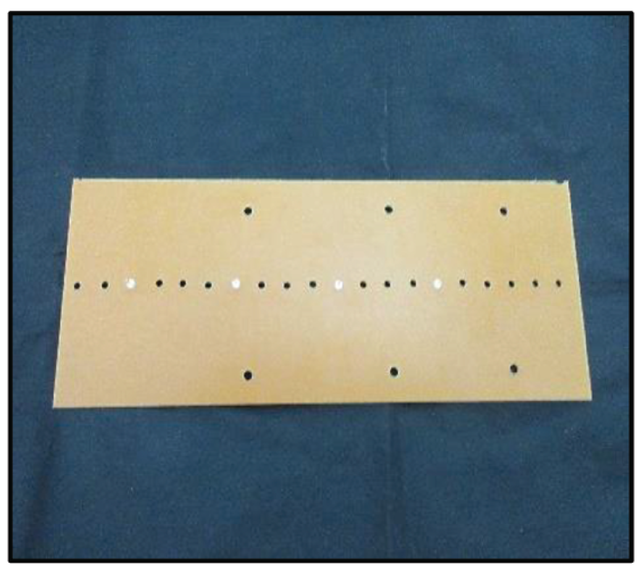




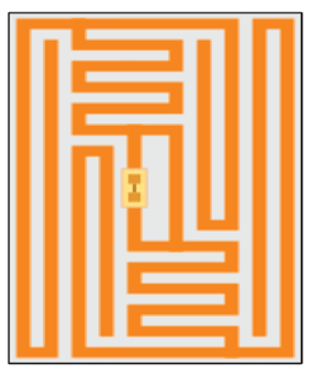
METHODOLOGY – 1D ARRAY

- 7.5mm tall monopole antennas used in accordance with quarter wavelength principle
- Each separation on the substrate is 15mm (half wavelength)
- S11 and gain measured at 10GHz
- We varied the spacing between 8 elements to create three different linear arrays with half wavelength, full wavelength and double wavelength spacing
- We used a Vector Network Analyser to plot the S11 graph of each individual antenna to ensure the antenna would operate at the desired frequency of 10GHz
- The gain of the arrays was measured in an anechoic chamber for us to observe the difference in the arrays' distribution patterns



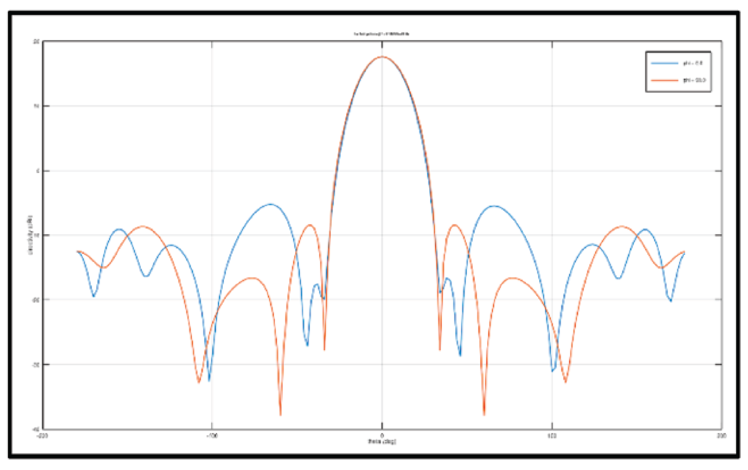


DISCUSSION & CONCLUSION



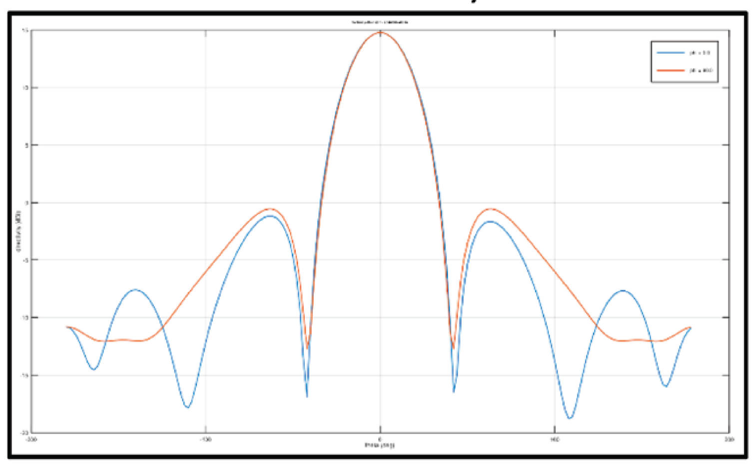
- Diamond array with design A has lower sidelobes (up to 10dB), narrower HPBW & higher gain (up to 3dB)
- Applications in ground stations [2] & RFID tags [3] to reduce noise and interference
- Half wavelength principle verified experimentally
- Discrepancies due to human error such as unequal antenna height
- Further work includes S11 and gain measurement of diamond array

RESULTS – 2D ARRAY

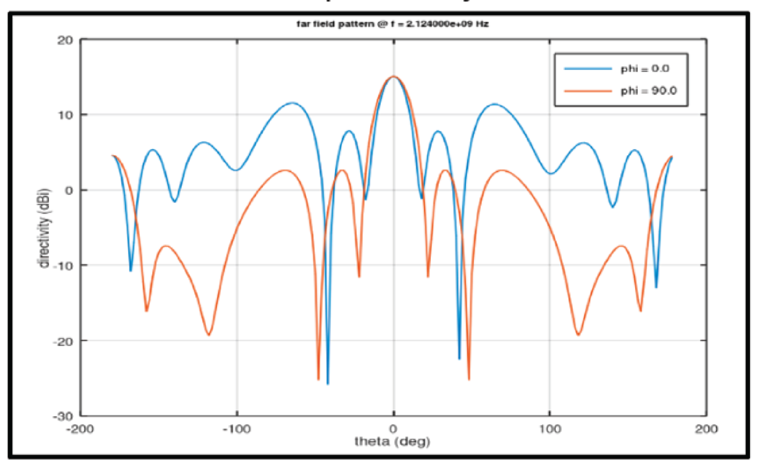


Diamond Array

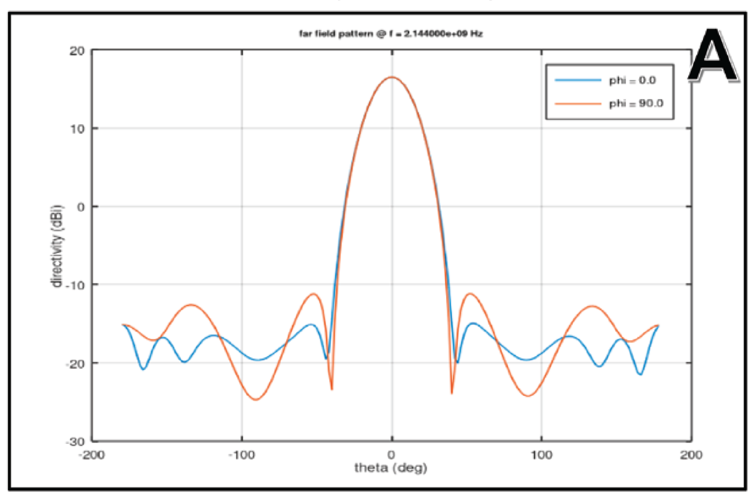
- Generally, increasing the area of an antenna array will increase its gain. However, sidelobes also increase significantly, leading to energy wastage and noise.
- The diamond array's gain is comparable to the enlarged square (~3dB higher than normal square).
- Its sidelobe level difference is 18dB and 14.9dB higher than the enlarged square when φ = 0° & 90°; i.e. sidelobes are smaller compared to mainlobe.
- Half power beamwidth (HPBW) of diamond array 8° narrower than square array.

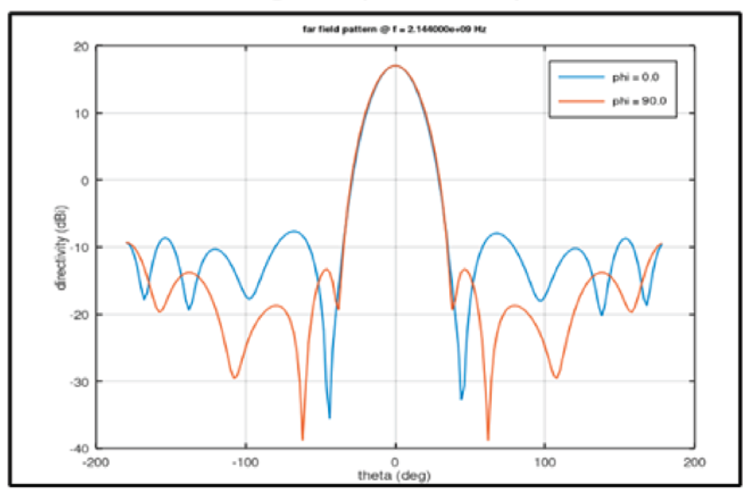


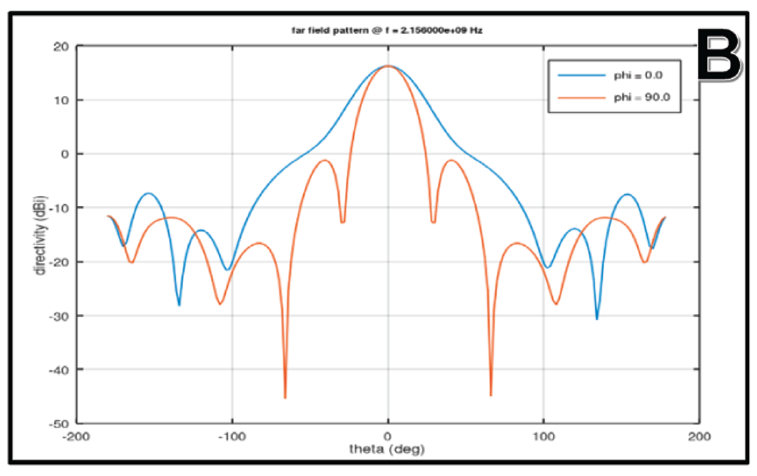
3x3 Square Array

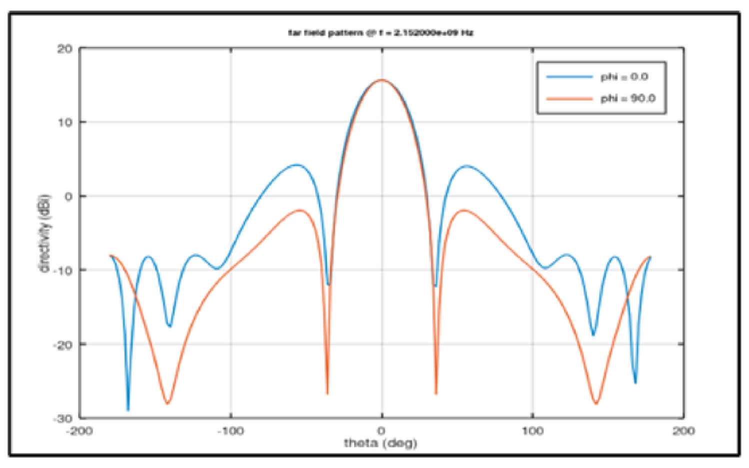


Enlarged Square Array



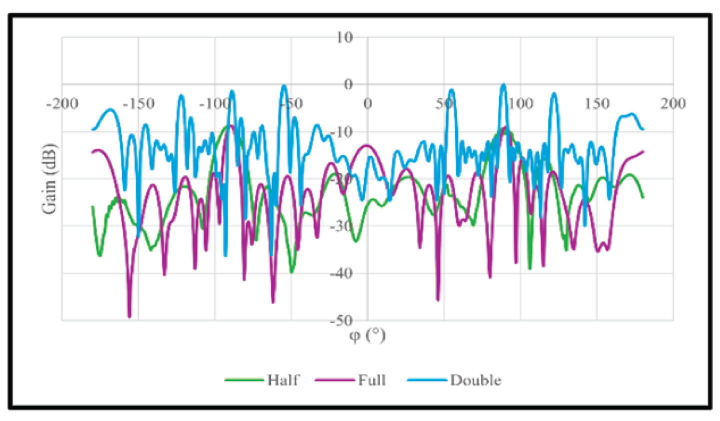


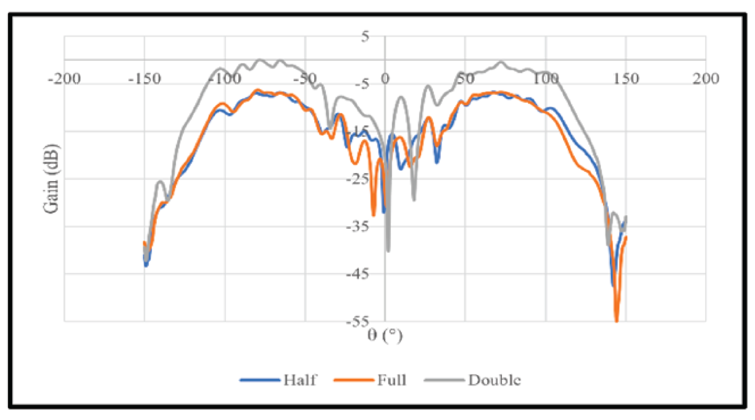




- Comparison between unequal excitation and equal excitation with total power input kept the same
- Top and bottom right have 1.3 and 4V/m for each individual element respectively
- For design A, the HPBW is comparable; sidelobe level difference is 7.9dB & 1.3dB higher than equal excitation array when φ = 0° & 90°
- Design A is a suitable weightage method
- Design B's has a similar performance to the equal excitation array when φ = 90°; sidelobe level difference is 17.5dB
- When φ = 0°, Design B has a greater sidelobe level difference by 13.4dB
- However, its HPBW is much wider which makes it unsuitable for applications requiring directivity

RESULTS – 1D ARRAY





- In the azimuth plot, the number of sidelobes increases with inter-element spacing.
- When spacing is half wavelength, the sidelobes occur at φ = ±90°, which is the ideal direction.

- In the elevation plot, the pattern resembles a single monopole antenna, which verifies that our array was constructed correctly with all the antennas lying in a straight line.

References
1) Mahmood, A. S., & Ibrahim, D. A. (2016). Study of the Binomial Excitation of a Linear Broadside 10-Element Dipole Antenna Array. International Journal of Electronics Communication and Computer Engineering, 7(3), 147–155.
2) Maini, A., & Agrawal, V. (2011). Satellite Technology principles and applications (2nd ed.). Wiley.
3) Weinstein, R. (2005). RFID: A technical overview and its application to the Enterprise. IT Professional, 7(3), 27-33. https://doi.org/10.1109/mitp.2005.69