A Reduced RCS Antenna

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Introduction

The ability to be detected by radar can be directly related to the radar cross section (RCS) of an object [1]. In typical radar design, the RCS of an antenna mounted on a vehicle (missile, aircraft etc.) is often greater than the RCS of the object itself [2]. The design of reduced RCS antennas are therefore important to reduce the chance of detection. The current methods of RCS reduction methods are often complicated to design and implement as well as expensive.

A research gap was identified for an antenna with reduced RCS that is relatively simple to design and cheap to implement. One possible antenna configuration is presented below.

Understanding RCS

RCS can be seen as the potential that a target possesses to reflect radar signals back towards the source of the radar signals. With the above definition it stands to reason that with an increase in RCS an increase in the ability to detect an object can also be expected.

RCS can be visualised at the product of three factors: reflectivity, directivity and the cross sectional area as seen by the radar transmitter [2]. There are four commonly exploited methods for reducing the effect of these factors and consequently the RCS of the object itself: shaping, passive cancellation, active cancellation and the use of radar absorbing material (RAM).

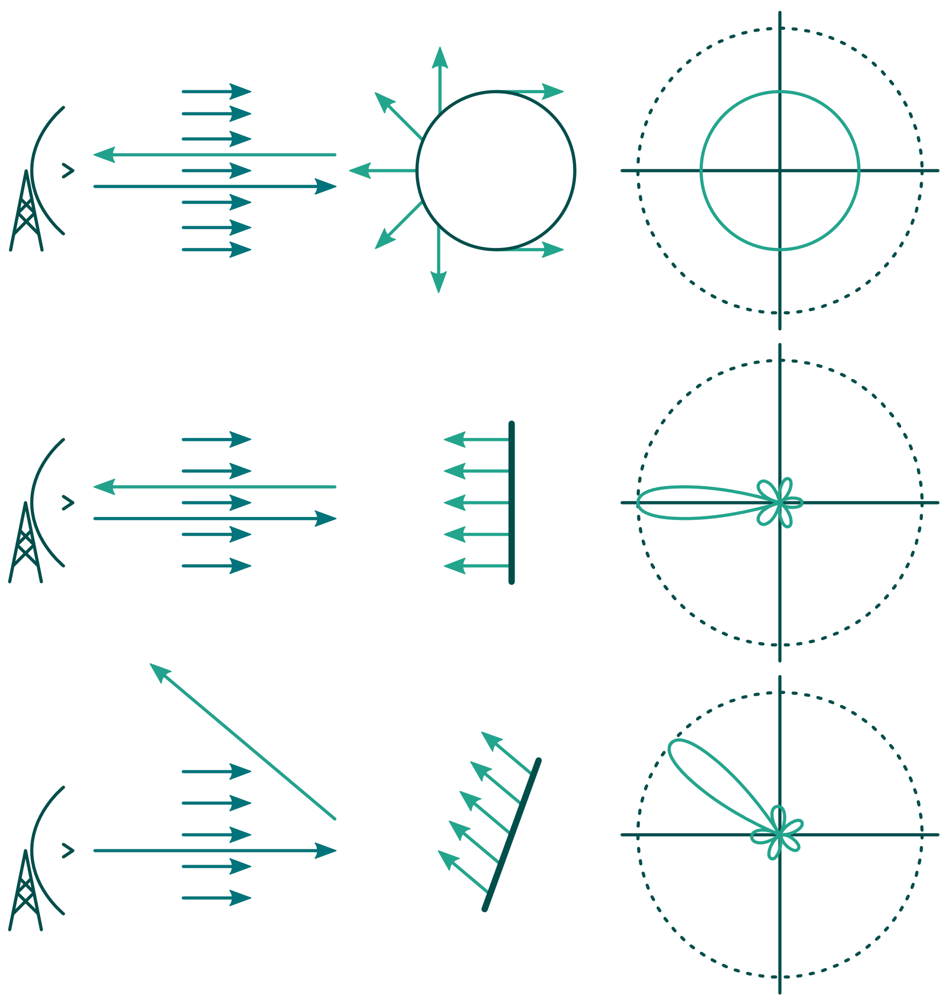

Figure 1. Effect of directivity on backscatter from objects with different shapes and orientations and the relative magnitude of backscatter of these shapes. [1].

Shaping aims to reduce the RCS of an object by reducing the directivity of the reflected radiation. Basic shaping is elaborated on below and in Figure 1. An ideal sphere radiates equally in all directions whilst a flat plate has almost no RCS (as seen from the direction of the transmitting radar) except when lying perpendicular to the direction of the incident ray. This limited RCS inherent with an oblique flat plate is exploited in the reduction of the proposed antennas RCS.

The edge fed brick wall antenna

The brick wall antenna (or originally coined "backward angle-fire array antenna") was first investigated in 1964 by Kraus [3]. Further research has been conducted into design techniques for the brick wall antenna over the years but is in the original paper by Kraus that an interesting observation was made.

Kraus observed that if the brick wall antenna consisted of individual bricks of one effective wavelength by half an effective wavelength, as in Figure 2, the horizontal segments of the antenna would act as transmission lines whilst the vertical segments would radiate. This would cause the antenna to act as a single fed array. Krause further observed that if the frequency of operation was varied from the original design frequency the main beam of the antenna would start to scan. By mastering the parameters affecting the scanning of the beam the antenna can be angled obliquely to the target whilst still focussing the main beam towards the target. This would in turn reduce the structural reflections towards the target and in turn the RCS of the antenna.

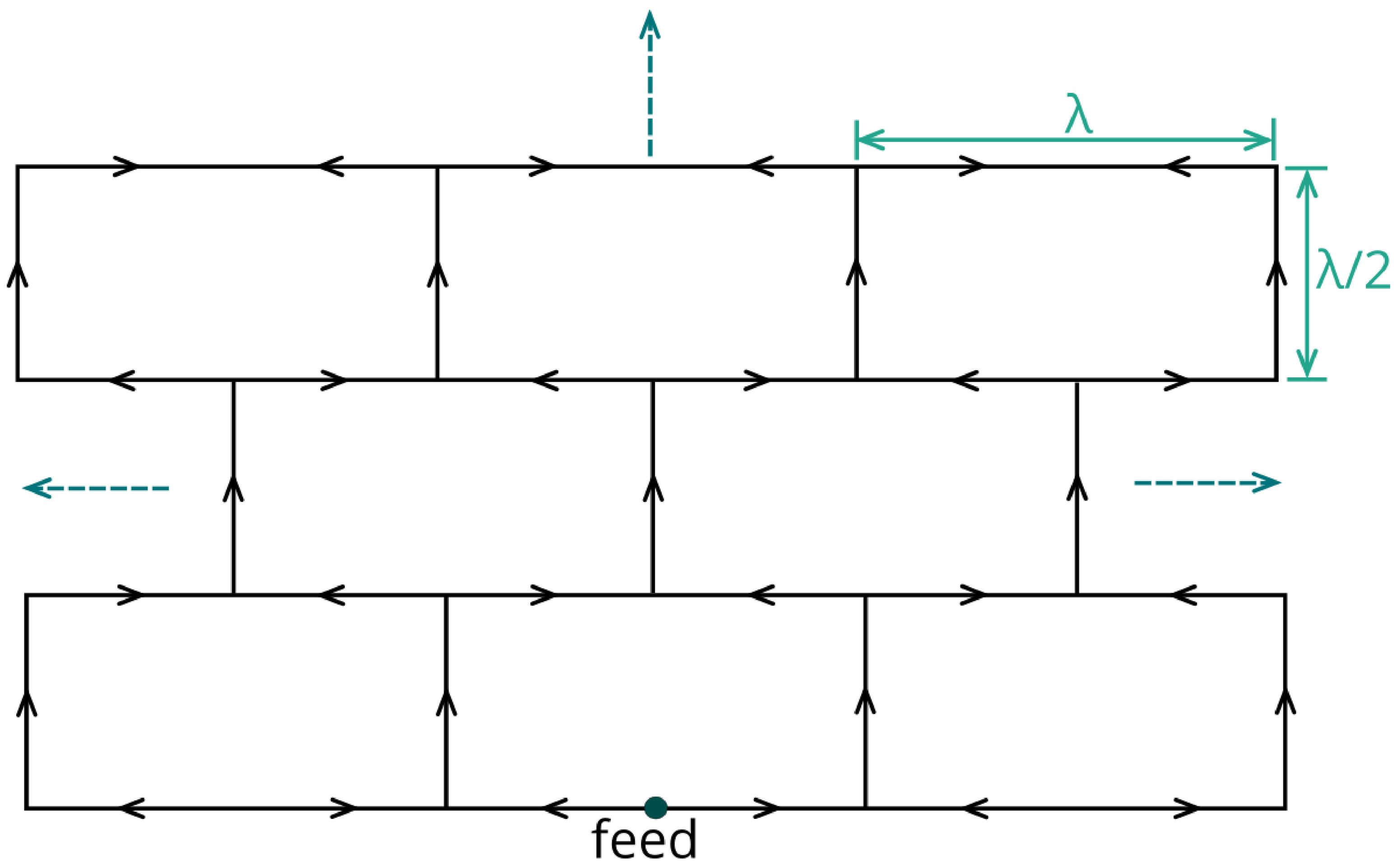

Figure 2. The basic brick wall antenna.

Figures

Through the varying of certain parameters the main beam is scanned as expected. This is shown in a rudimentary form in Figure 3 below. During the beam scanning the far field radiation pattern maintains a:

- main beam gain of above 19.5 dBi.
- HPBW of below 30°.
- side lobe attenuation of at least 11 dB.

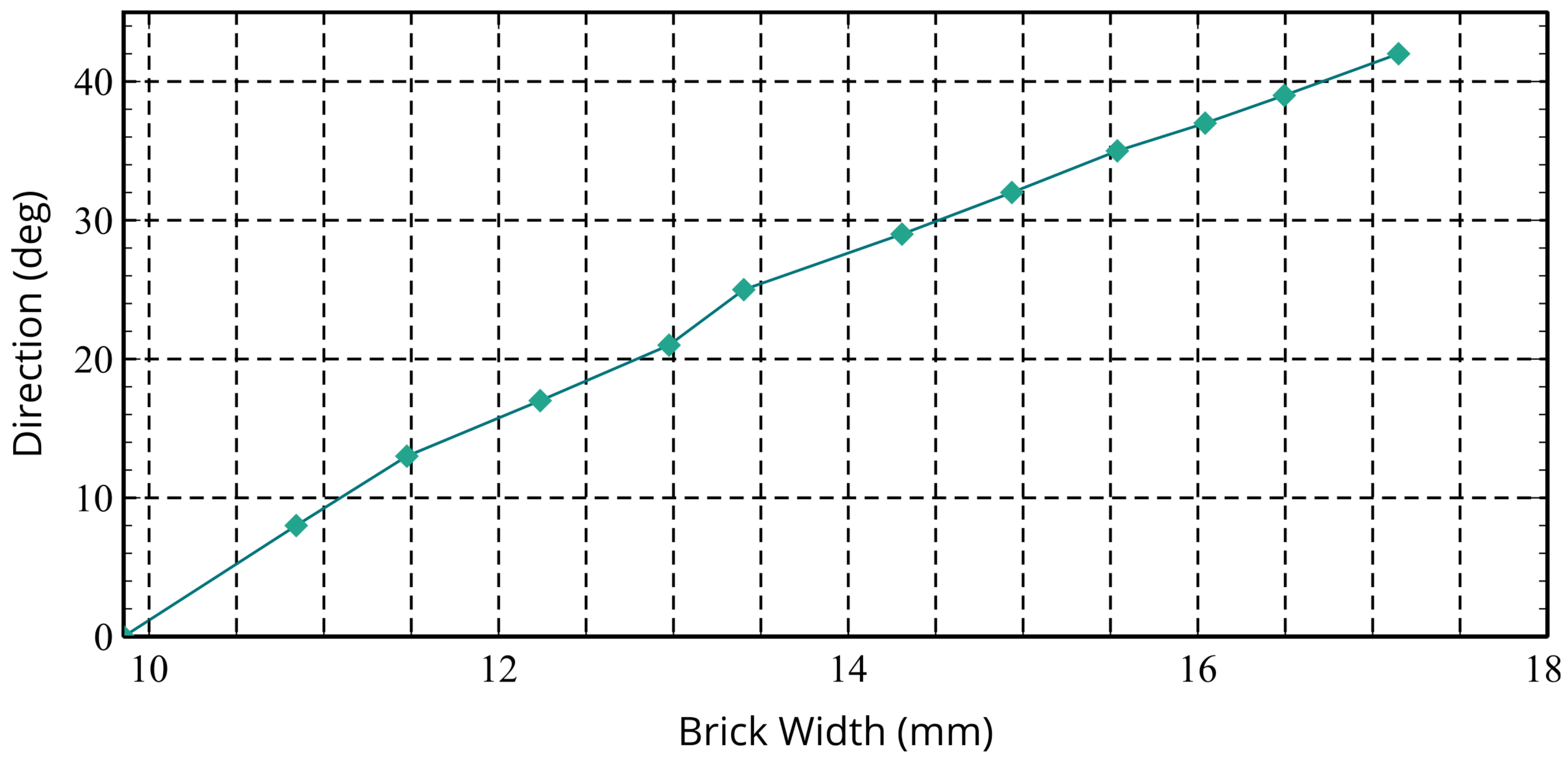

Figure 3. Antenna main beam scanning.

Conclusion

The scanning of the antenna has been understood and can be controlled in a largely linear manner whilst maintaining acceptable performance. This would enable the antenna to be angled away from the target, reducing structural reflections and subsequently reducing the antennas RCS.

References

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[2] Black, A. A., 1991. Pulse Doppler for Missile Approach Warning. *Journal of Electronic Defense (JED),* vol. 14, no. 1, pp. 45-56.

[3] Kraus, J. D., 1964. A backward angle-fire array antenna. *IEEE Transactions on Antennas and Propogation,* vol. 6, no. 2, pp. 48-50.

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