EPSRC CENTRE for Doctoral Training in Embedded Intelligence

Compact, Wideband Antenna Optimisation

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Motivation

The project investigated capabilities of Koshelev antenna, to create an antenna and its array that operate over high range of frequencies.

- Radio frequency (RF) antennas are widely used but antennas require space. i.e., real estate. That means single antenna array covering a wide range of frequencies is advantageous as it can replace all other antennas.
- Antenna arrays are very established across some frequencies but there are mutual coupling problems
- Koshelev antenna was used because it covers a wide range of frequencies
- Project main goal was to build it, test it and study the characteristics of its array

Second loop positioning

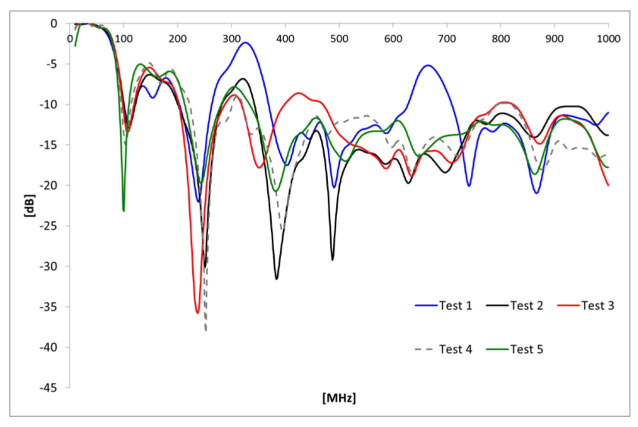
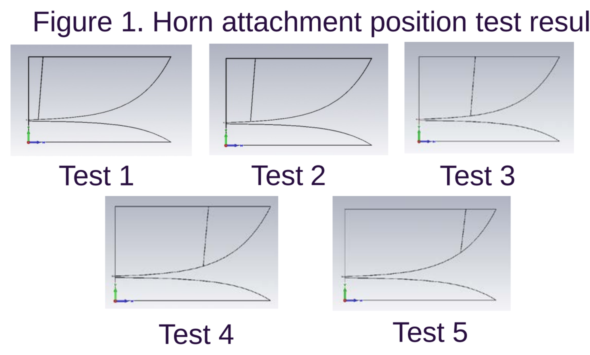


Figure 1. Horn attachment position test results



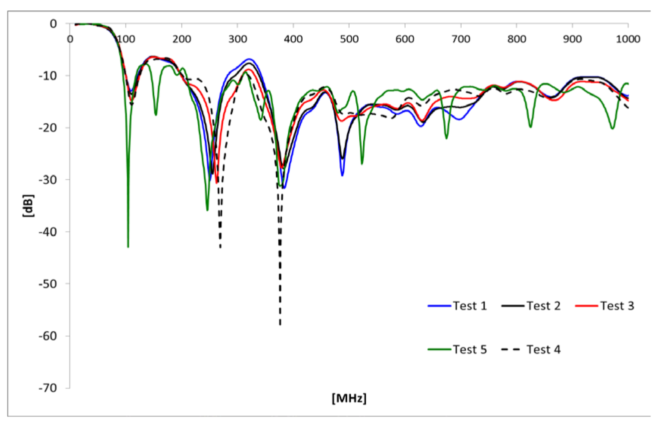
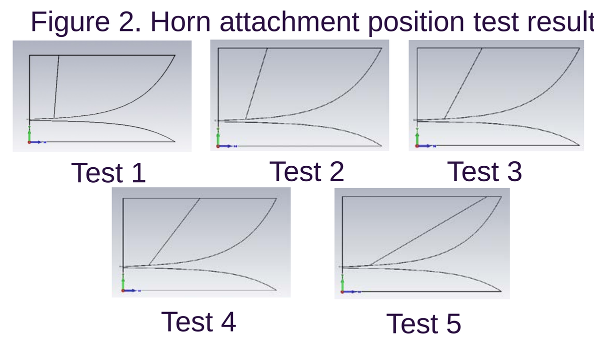
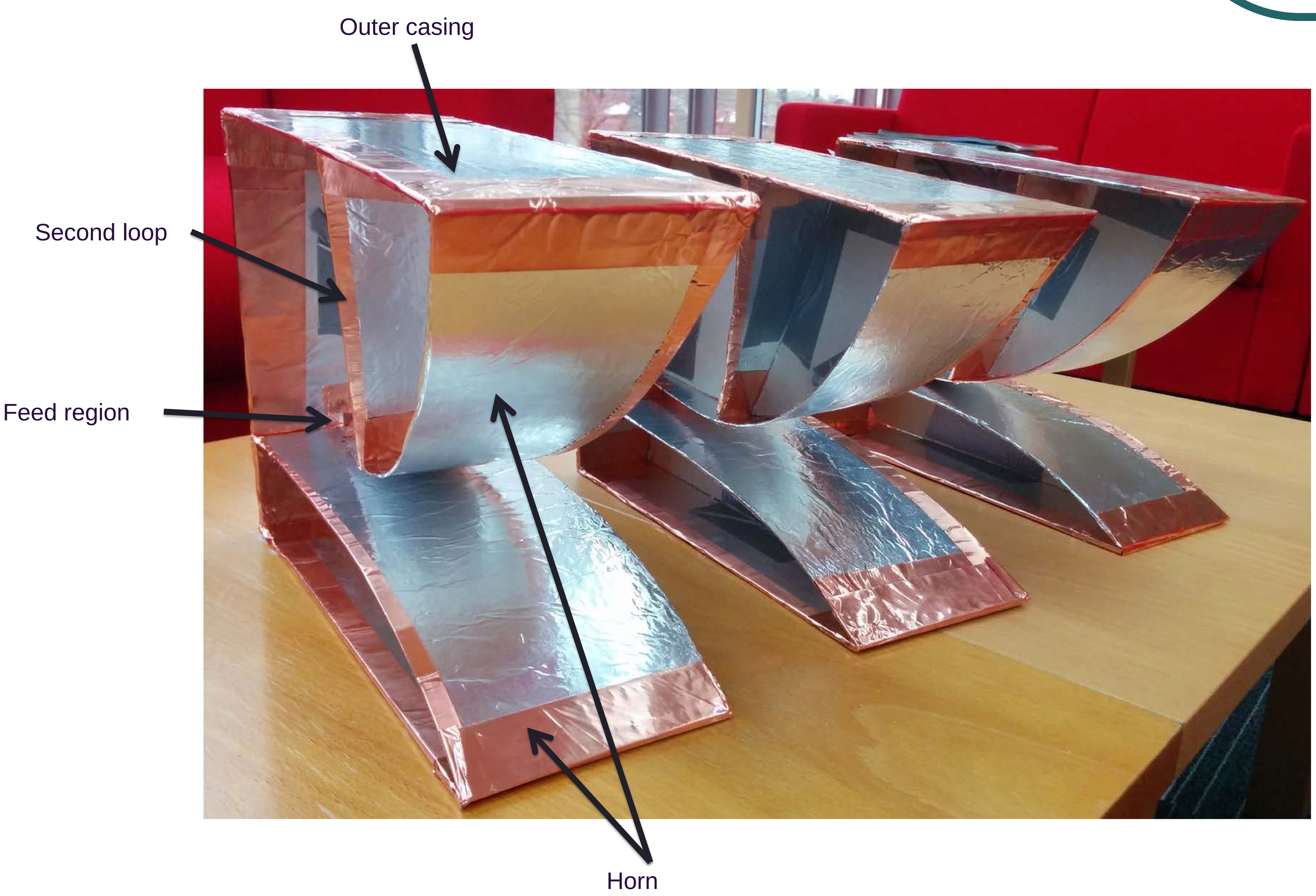


Figure 2. Horn attachment position test results



Different loop positions were simulated to find the most effective solution. It can be Seen that test 2 has the best attachment position at the horn, while test 5 shows the best attachment point to the outer casing.



Antenna sizing

Initial antenna's width and height were based on work from Goddard. In course of this work the dimensions were changed in order to improve antenna's low Frequency performance. Once height and length were fixed, width was adjusted so that the antenna provided best matching between 50 Ω of coaxial cable and 377 Ω of air. This process was repeated until satisfactory results were obtained. Equation (1) was used in order to model the Impedance of the horn. Figure 3 shows how impedance for fixed height and length varies with width. It is clear that width of 200 mm provided the best matching.

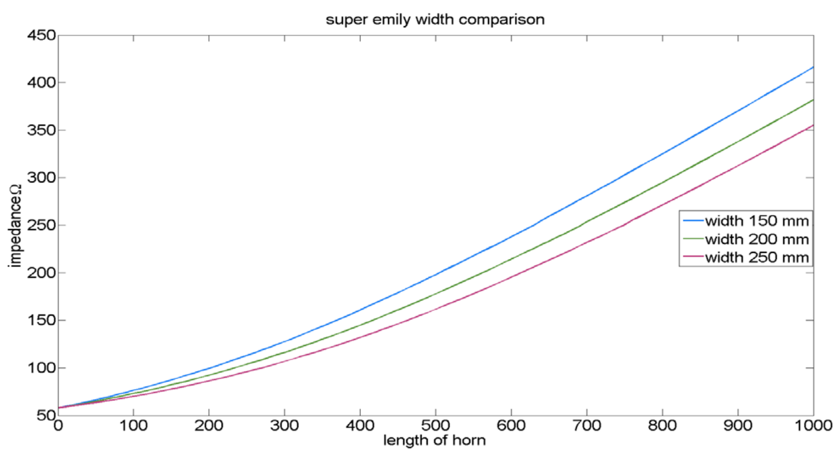


Figure 3. Variance of impedance across the horn

$$\begin{cases} Z_0 = 59.95\frac{2}{\sqrt{\varepsilon_r}}\ln\left(\frac{8h}{w}+\frac{w}{4h}\right) \; for\; 0 \le \frac{w}{h} \le 1 \\ Z_0 = \frac{2}{\sqrt{\varepsilon_r}}\frac{376.69}{\left[\frac{w}{h}+2.42-0.44\frac{h}{w}+\left(1-\left(\frac{h}{w}\right)^6\right)\right]} \; for\; 1 \le \frac{w}{h} \le 10 \end{cases} \quad (1), \text{Grosvenor (2007)}$$

Array

We tested five different antenna configurations (figure 4). Using antenna analyser, s11, s21 and s22 were measured for each antenna, in each configuration. This was then used to determine which of the 5 configurations was the best.

Middle vertical configuration showed the best results of all alignments due to the waves being polarized in different directions, causing very low coupling between electro-magnetic fields

Figure 4. Tested arrays configurations

Feed region optimisation

Feed region dimensions were optimised to match 50 Ω from coaxial cable. Simplified model of antenna was created in order to quicken optimisation procedure. Genetic optimiser built into CST microwave studio was used for optimisation.

Figure 6 shows comparison of initial feed region to optimised one. It can be seen that Voltage Standing Wave Ratio (VSWR) is more consistent across spectrum of interest in optimised region. Maximum achieved VSWR of 2.3 means that about 85% of energy send via the coaxial cable is being sent to antenna for emitting. This was deemed appropriate For this project.

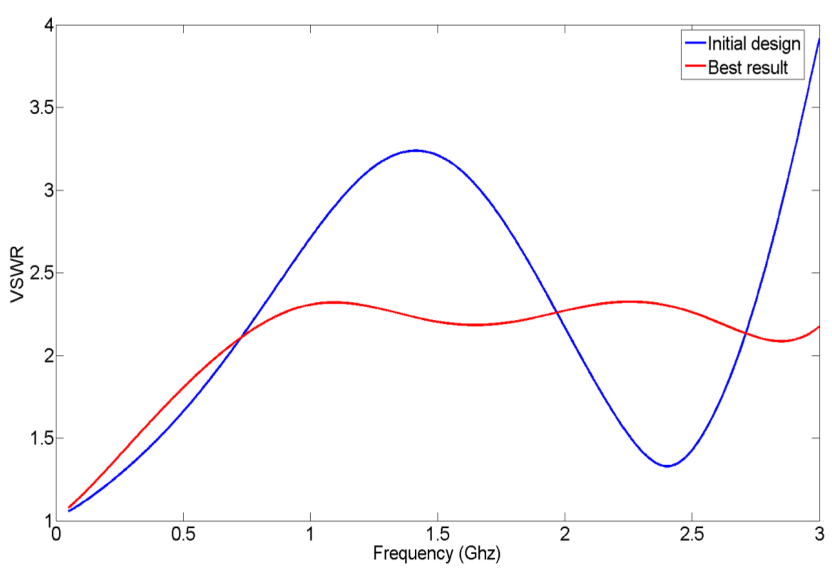


Figure 6. Feed region comparison graph

Manufacturing

Card board was used. Thin card boards were used for horn and second loop and thick ones for outer casing and support.

We covered cardboard skeleton with 0.8 millimetre thick aluminium foil to provide conductive material. Conductive tape was used to connect separate aluminium covered surfaces.

Super glue was employed to firmly attach the connector to the antenna.

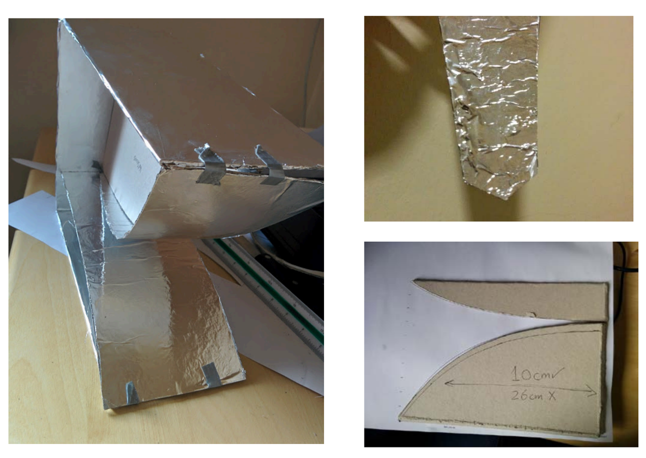


Figure 5. Manufacturing overview

Conclusion

Designed antenna proved to work on an ultra wide range of frequencies with good performance.

The aperture of the antenna drives the fundamental frequency.

In array arrangement, the higher the distance, the lower the coupling.

REFERENCES

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Koshelev, Vladimir, "Ultrawideband array antennas for radars," in Antennas and Propagation, 2006. EuCAP 2006. First European Conference on , vol., no., pp.1-6, 6-10 Nov. 2006 doi: 10.1109/EUCAP.2006.4584500

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