Section A: Overview of the Research Project Proposal

1. Academic level of research project

Masters

2. Broad field of research

Engineering

3. Title of the research project

Highly Integrated Quad-Ridge Horn Feed for Reflector Antennas

4. Supervisor:

Prof Petrie Meyer

5. University:

Stellenbosch University

Section B: Research project Proposal

1. Scientific Merit

Quad-Ridge horns are the most widely used wideband feeds for reflector antennas, but due to the complexity of design, and especially the scope of the electromagnetic problem that needs to be solved, they offer substantial design challenges. The current state of research focuses mostly on optimisation of the ridge profiles, in order to achieve certain beam characteristics and good input matching, over very large bandwidths. These optimisation phases can take extremely long to perform, with a recent design for a below-GHz horn taking 6 months.

The fundamental issues with these horns are the transition between the horn ridges and the first stage of electronics, i.e. the Low-Noise Amplifiers (LNA's), and the transition from a ridge guide with very narrow ridge gaps, to an open waveguide radiator. In both cases, the point of transition is the focus point of design, as it typically requires very narrow gaps between the ridges to effect a good impedance match, which in turn calls for a very large impedance transformation to the radiating aperture. These transitions are mostly still designed in the same way as they have been for many years, and most of the design effort effectively goes into compensating for the transition.

A few advances in recent years have however opened up a number of unexplored possibilities in the design of these horns. Firstly, 3D-printing of metal structures have developed at a staggering pace. This allows for completely non-traditional structures being possible, and thus exciting new electrical options. Secondly, the advances in optimisation techniques and electromagnetic analysis software have been huge. Finally, recent work at Stellenbosch University by SKA-funded student Dr Theunis Beukman, proposed a way of designing horns not primarily through optimisation, but through careful control of the modal content in the Quad-Ridge horn.

This project aims to build on the work by Dr Beukman, with a specific focus of deeply integrating the LNA subsystems with the ridge horns, in this way removing the requirements for very small ridge gaps. This, in turn, will make the impedance transformation problem to the radiating aperture significantly smaller, and allow a very high level of control over the modal content in the horn. Removing the requirement for a 50 ohm transition impedance, and rather design the horn input to optimally match the LNA inputs (normally the other way around), has the potential of offering good performance over a much wider bandwidth.

The approach proposed here is very much in line with the newest trends towards very high levels of integration between subsystems in high-frequency design. Such levels of integration can only be made possible by exploiting the freedom offered by new manufacturing techniques, and very powerful analysis and optimisation software.

2. Feasibility:
High levels of integration in receiver design have already been proven to work extremely well, for a range of systems. It is therefore eminently feasible to use this for the design of antenna horns. The group at Stellenbosch University has all the necessary modelling software, computing hardware, and state-of-the-art measurement facilities to support this project, and many years of demonstrated expertise in modelling and numerical electromagnetic analysis amongst its staff members. In addition, Prof Meyer has an ongoing cooperation with Ghent University in Belgium, probably the leading institution in Europe on the use of optimisation in microwave design, and with the antenna group at Chalmers University, a leading group in the design of integrated antenna systems. The research is also highly publishable, as it forms part of a current wave of design algorithms making use of integrated design.

The project is fully aligned with the area of radio astronomy antennas and receivers.

3. SARAO research priority area:
Radio astronomy antennas and receivers.

4. Qualifications, academic abilities, skills and/or experience required:
The successful candidate for this project needs a BEng degree in electronic engineering – with specific capabilities in electromagnetics and mathematics. A strong interest in advanced mathematical techniques is certainly required.