Post-Grad Bursaries within EMACS group:
Dept of E&E Engineering; Stellenbosch University

A number of bursaries are offered each year for post-graduate students wishing to pursue MEng or PhD degrees within the Electromagnetics, Microwave, Antennas and Computational System (EMACS) group at Stellenbosch University. For the MEng degree, the requirements are a BEng in electronic (or electrical and electronic) engineering, or an appropriate BSc (Hons) with appropriate subjects, typically physics, mathematics/applied mathematics and/or computer science. Candidates with a BEng Mechatronics may also be considered. For the PhD degree, an appropriate Master's degree is required. The bursaries offer generous levels of support (> R150k per annum) and, in some cases, include travel and equipment grants. Applications are open to all South African citizens and permanent residents; applications from students from previously disadvantaged groups are particularly encouraged, and demographic targets are strictly enforced selection criteria in some of our funding instruments.

In addition to bursaries offered through the National Research Foundation (NRF) from the South African Radio Astronomy Observatory (SARAO), in both freestanding and grant-linked to the SARChI Chair in Antenna Systems for SKA forms, some bursaries are also available annually from a number of industry grants.

The first round of applications for the 2023 academic year is now open, with **application deadline of 30 June 2022.** This allows time to coordinate NRF bursary applications before the internal deadline of 8 July 2022.

All applications, **to be sent to Prof Dirk de Villiers (ddv@sun.ac.za)**, should include:

1. Study record (if BEng not obtained from Stellenbosch University)
2. Short CV (especially important if there were breaks in your study career)
3. Motivation letter (maximum 1 page) – why do you want to study in this field and with our group?
4. A list of the top 3 topics of interest to you from the list below

A list of past and possible future topics is given below, which can be used to guide candidates to a suitable supervisor and study direction. Not all these topics will be offered, and the final assigned topic will be finalised through consultation and may be different from the list provided below as it will depend on student interest, supervisor availability, and grant conditions.

Octave bandwidth orthomode transducer design for radio telescope antenna feeds An orthomode transducer (OMT) is a device that splits to orthogonal waveguide modes into two separate ports. These are widely used to feed symmetric antennas that are required to operate in dual-polarization mode. In short, the antenna can receive both orthogonal polarizations equally well, and the OMT then splits these two modes into different ports. In this project an OMT must be developed to operate over about an octave of bandwidth to feed radio telescope reflector antennas operating above 2 GHz (and up to more than 20 GHz).	Prof Dirk de Villiers	MEng
Development of a low cost analog receiver chain for MFAA demonstrators The Mid-Frequency Aperture Array system is envisaged to form part of SKA-phase 2. It will operate around the 500-1500 MHz frequency band, and the final version will be fully-digital in all channels. During development, several demonstrator antennas need to be prototyped and tested. This project will design an analog receiver chain for such demonstrator antennas. It must be able to mix a chunk of bandwidth to baseband, from anywhere in the operating band of the system. Furthermore, large numbers of these receivers must be connected coherently and in a small form factor. The final system must be packaged and mass-producible.	Prof Dirk de Villiers	MEng
Design and optimization of antennas for single element radio telescopes Single element radio telescopes are typically much cheaper to build and operate than array-based systems (like interferometers), but they come with substantial difficulty in modelling the antenna characteristics to estimate the efficacy of the final sensor for the specific science goals of the antenna. This project will investigate methods to speed up the accurate modelling of the antenna characteristics in order to include more information in the figure of merit used during the design optimization phase. We will work on specific examples currently in development including the REACH and X-BASS telescopes.	Prof Dirk de Villiers	PhD
Solver integration for large-scale radio astronomy antenna array analysis Array antennas are an important component of the SKA, for the mid-frequency aperture array (MFAA) stations of SKA Phase 2, and for phased array feeds. The Stellenbosch University (SU) research group is part of the international MFAA consortium. Designing such arrays require extensive numerical modelling. The analysis of a single candidate geometry at a single frequency is very expensive with conventional methods. Thus, analysis is a major bottleneck in the design process. The implication is that design spaces are restricted by the computational capabilities of commercial field solvers, leading to sub-optimal designs. The objective of this work is to integrate the various new solver techniques being developed at Stellenbosch University for efficient array analysis. Approaches which are in development for disjoint array elements include fast macro basis function (MBF) methods, hp-adaptive analysis and global solutions based on collections of localized solutions. It is envisaged that the integrated solver should be suitable for execution on large-scale computing facilities. The final goal is to use this industrial-grade solver to analyse real-world array antennas of interest to the SKA.	Prof Matthys Botha	MEng
Domain decomposition methods for efficient electromagnetic simulation of large antennas/scatterers This topic involves devising and implementing a new domain decomposition method for EM analysis of electrically large structures, to yield faster solutions than with conventional solvers. It fits in with the ongoing SKA research, but has much broader applications as well. It combines EM theory, applied math and programming. This is a challenging problem of substantial industrial relevance.	Prof Matthys Botha	PhD

New methods for efficient modelling of large-scale antenna arrays with tightly coupled elements Tightly coupled array antennas (i.e. arrays with elements which are electrically connected and in close proximity to each other) are an important component of the SKA, for the mid-frequency aperture array (MFAA) stations of SKA Phase 2, and for phased array feeds. The Stellenbosch University (SU) research group is part of the international MFAA consortium. Designing such arrays require extensive numerical modelling. The analysis of a single candidate geometry at a single frequency is very expensive with conventional methods. Thus, analysis is a major bottleneck in the design process. The implication is that design spaces are restricted by the computational capabilities of commercial field solvers, leading to sub-optimal designs. The objective of this work is to develop new integral-equation based methods for fast and accurate analysis of array antennas with tightly coupled elements. Significant groundwork has already been done at SU. Approaches which have already been developed for disjoint array elements, must be extended to tightly coupled elements.	Prof Matthys Botha	PhD
Higher-order basis modelling for fast analysis and optimisation of ridged horn feeds Ridged horn feed antennas are important to the SKA, forming a crucial part of the reflector antenna array. The Stellenbosch University (SU) research group is part of the international single pixel feed consortium. Such antennas are designed through optimisation. This entails exploring large parameter spaces, which relies on full-wave analysis of candidate designs in combination with surrogate-based modelling. Reduction of the full-wave analysis cost is directly proportional to reduction of the design optimisation cost. This project will entail the development of novel higher-order basis functions and macro basis functions for constructing full-wave solutions with the fewest possible unknown coefficients to solve for, and hence, reduce the cost of such solutions. The developed solver technology must further be integrated into the latest optimisation schemes for ridged horn feeds, which are currently under development within the SU research group. Such leading-edge analysis and optimisation capabilities for ridged horn antennas would constitute a valuable contribution by South Africa to the international radio astronomy engineering community.	Prof Matthys Botha	PhD
Efficient modelling of large-scale radio astronomy antenna arrays with interconnected elements A variety of array antenna systems are currently being developed for future expansions to the SKA (e.g. MFAA and phased array feeds). Designing these complex arrays with the property of electrically interconnected elements, require extensive numerical modelling. This is very challenging, not so much because a single analysis (i.e. fixed geometry, frequency and excitation configuration) of such antennas is unachievable, but because such a single analysis is expensive. The many required analyses altogether are a major bottleneck in the design process. Design spaces are thus restricted by the computational capabilities of commercial electromagnetic field solvers. This generally leads to sub-optimal designs. In radio astronomy, even a small improvement to antenna performance may be crucial. The main objective of this work is to develop an industrial-grade, optimized solver for large-scale radio astronomy antennas with electrically interconnected elements. A customized, integral equation based approach is required. Past work from the literature and at SU must be combined and modified for interconnected elements, to yield a solver to analyse real-world interconnected-element array antennas of interest to the SKA.	Prof Matthys Botha	MEng
Wideband antenna design for time-domain measurements in a reverberation chamber Currently, the antenna being used in the reverberation chamber at SARAO for RFI qualification is a Log-periodic Dipole Array (LPDA). While this design is very well suited	Dr Jacki Gilmore	MEng

for use in frequency-domain measurements, the group delay of LPDA's render them unsuitable for use in time-domain measurements. This project aims to design a wide-band antenna that can efficiently handle pulsed signals as that will simplify time-domain measurements for RFI qualification.		
Non-uniform Feeding Scheme for Regular Aperture Arrays Recent studies have concluded that while a fully digital dense aperture array would be a formidable instrument in the SKA mid-frequency range, the total cost of such a system would be astronomical. This study aims to investigate to what extent an increased use of dummy elements (array elements of which the antennas are present, but not connected to a receiver chain) could help contain the cost of such a system.	Dr Jacki Gilmore	MEng or PhD
SLM 3D-printed Wideband Balun The excitation of a large subgroup of antennas require the transformations between balanced and unbalances transmission lines. These transformations are usually done using a so-called balun. This project endeavours to harness the versatility offered by metal 3D-printing in order to design a low-loss, wideband balun.	Dr Jacki Gilmore	MEng
Radio astronomy receiver system with integrated, adaptable RFI mitigation A well-known problem at the SKA Karoo site is the interference from other radio signals, such as air traffic communication, that results in a reduced signal-to-interference ratio and problems with amplifier linearity for specific frequencies. Therefore, this project aims to yield a system design that can suppress various sources of RFI by integrating an adaptable notch filtering stage into the antenna before the first amplification stage.	Dr Jacki Gilmore Dr Elmine Meyer (TU/e)	PhD
Development of Metamaterial surfaces to improve isolation between antenna elements Mutual coupling between elements in an array is often the limiting factor in the performance of the array. Due to the close proximity of other integrated circuits such as filters and LNA's, these components might also influence the antenna parameters. Metamaterials (MTMs) are artificial composite structures that exhibit a homogeneous effective permittivity and permeability that are not normally found in PCB-based transmission lines and components. It has been shown recently that Metamaterials could be used to improve the isolation between antenna elements by reducing the mutual coupling and near-field radiation. This research will investigate and analyse the performance of various Metamaterial structures.	Dr Werner Steyn	MEng
Development of a wideband antenna for an FMCW GPR Ground Penetrating Radar (GPR) is used for underground imaging in many applications. The majority of such systems use Ultra Wideband (UWB) pulses or Stepped FM waveforms. While Linear Frequency Modulated Continuous Wave (LFMCW) is a viable alternative, very little research has been done on wideband antenna designs for FMCW GPR and the effects of antenna characteristics on the GPR system.	Dr Werner Steyn	MEng
Development of harmonic filter structures for automotive radar applications Automotive radars currently operate at frequencies of up to 81 GHz. These radars must also comply with international regulations in terms of spectral purity, including the levels of harmonics that are generated by the transmitters. While simple lowpass filters can be used at lower frequencies, this becomes increasingly difficult at high frequencies where the normal TEM modes are not the only propagating modes on planar transmission lines. This project will investigate the development of harmonic filters for systems that operate at frequencies of commercial automotive radar sensors.	Dr Werner Steyn	MEng