

Section A: Overview of the Research Project

1. Title of the research project

Investigating and Characterising the Performance Metrics of an Active Integrated Antenna to be Used on a Mid-Frequency Aperture Array Antenna Receiver System.

2. Broad area of research (Engineering or Science)

Engineering

3. Academic level of research project (Masters or Doctoral)

Masters

4. Abstract of research project

The front end of a receiver chain contains an antenna and a low noise amplifier (LNA). In order to obtain the best power transfer from the antenna to the low noise amplifier, a matching circuit is required between these two elements which matches the output impedance of the antenna (usually 50Ω) to the input impedance of the low noise amplifier (i.e. the transistor within the LNA). This matching circuit may be optimised to provide the best power transfer at a particular operating temperature, but may hinder/compromise the power transfer between the two devices at other operating temperatures (or unideal operation conditions). An Active Integrated Antenna (AIA) is a circuit in which the antenna of the receiver link is directly integrated with an active low noise amplifier circuit without the use of any impedance matching circuit. This avoids the operation requirements of the matching network. This project will investigate and characterise the performance metrics such as, but not limited to, noise figure, power gain, power consumption, system complexity, etc. of a receiver system with an AIA compared to that of a traditional receiver system.

5. Primary supervisor's details:

a. Full name of primary supervisor

Lanche Linden Grootboom

b. Primary supervisor's email address (please note that if this project is approved, this email address will be made available to students to contact the primary supervisor)

llgrootboom@sun.ac.za

c. University where primary supervisor is employed

Stellenbosch University

6. Co-supervisor/Research supervisor's details (if relevant)

N/A

Section B: Details of Research Project

- 1. Scientific/Engineering merit: describe the objectives of the research project, placing them in the context of the current key questions and understanding of the field.**

An Active Integrated Antenna is the direct integration of an antenna with an active LNA circuit without the use of any impedance matching circuit between the two elements. The use of these AIA systems in receiver systems are encouraged due to advantages such as improved weight constraints, cost, overall size of electronic devices, power consumption, power efficiency, etc.

The overall objective of this project is to characterise the performance metrics of an AIA system compared to that of the traditional receiver system which contains an antenna, impedance matching network and a LNA. Various performance metrics can be measured which help to classify a receiver as good or bad. The noise figure, for example, is an important performance metric of a receiver system. This measures the degradation of signal-to-noise ratio caused by components in the receiver chain. The noise figure of the first elements in the receiver system (i.e. the antenna and the LNA) dominates the noise figure of the entire receiver system.

The objectives for the student are to develop an understanding of a receiver system at a component level, specifically with regards to components such as the antenna, LNA, transmission lines and impedance matching, and how to measure and characterise the performance metrics of the receiver system. Another objective is to equip the participant with engineering skills in terms of practical measurements of the devices under test within a lab environment and developing a strong critical engineering/research acumen. This is critical in the field of RF Engineering. In the field of RF engineering, performance metrics are of utmost importance as these give a clear indication of the quality of the receiver system and by designing/optimising these metrics the overall system can be improved.

- 2. Feasibility: outline the methods that will be used to achieve the objectives. Provide details on the availability of required data / access to required equipment / availability of research facilities and other resources required. Include any relevant expected intermediate milestones and associated timeframes towards attaining the overall objectives of the project.**

The infrastructure which is currently available at Stellenbosch University in the Department of Electrical and Electronic Engineering can be used to design, measure and characterise the receiver system. This includes both the software design tools - such as CST, ADS, FEKO, etc. – as well as the hardware devices – such as the anechoic chamber, reverberation chamber, network analysers, etc.

- 3. Link the proposed project to one or more of the SRAO research priority areas for 2021 (refer to Section 5 of the Application Guide), and explain in some detail how the proposed research will contribute to the priority area(s).**

This research project is directly linked to the radio astronomy receiver systems as listed by 5.2.1 of the Engineering focus areas in the SRAO research priority areas for 2022. The receiver system (and the components which make up this receiver chain) is an important part of the Radio Telescope system. By understanding the receiver system at a component level, the student will have an understanding of the overall receiver system and by characterising the performance metrics of the receiver system the student will develop the skills to understand the trade-offs which influence the performance of a receiver system. This will give the student an in depth understanding of the receiver system.

The quality of the received signal which is passed through the receiver system greatly influences the outputs of entire radio telescope system. The signal processing is limited by the type and quality of the data which is received via the receiving system. Thus, an understanding of the receiver system at component level, will assist with the performance improvement of the overall radio telescope system. This research project thus has direct and indirect links to the other SRAO research priority areas such as Real time detection, post processing and classification.

4. If relevant, describe any particular qualifications, academic abilities, skills and/or experience that a student should have in order to successfully deliver on the objectives of the research proposed.

The student should have obtained an Electrical Engineering degree with a focus on electronics, electromagnetics and transmission lines. The student should also have experience in working with measuring devices in a lab such as network analyser (including a vector network analyser), signal generator, power supply, etc. and high frequency measuring devices. A background in receiver design would be advantages.