Section A: Overview of the Research Project Proposal

1. PhD
2. Engineering
3. A broadband cooled radio astronomy receiver
4. Dr Tinus Stander
5. University of Pretoria

Section B: Research Project Proposal

1. Scientific merit:

The 8 – 16 GHz spectrum contains numerous spectral lines of interest to radio astronomy, including methanol (12.178 GHz) and formaldehyde (14.488 GHz). In addition, it is an important band for VLBI, as well as for geodetic observations and geodetic VLBI. The traditional approach to receiver design has been narrowband, single-purpose instruments; a design choice motivated in part by limited capacity in data processing. This has left many observatories, including the SARAO station at HartRAO, with receiver cabins containing numerous receivers for co-located narrow bands.

However, with increased computational capacity available in the digital back-end, modern receivers are predominantly designed for wider bands, thereby serving multiple observational purposes. In terms of architecture and integration, there are many approaches to follow. In state-of-the-art lithography nodes, it is a simple matter to integrate full receivers (even full systems) on a single MMIC, but this approach has not seen much application in radio astronomy. The suitable application of monolithic integration, and hybrid modularized / connectorized co-design, with appropriate approach to use of available cooling stages, would seem to be an open-ended research question at X-band.

Another factor to consider in operating an X-band receiver is mitigating interfering sources from satellite and terrestrial communication, as well as RADARs.

This project will develop a concept broadband cooled receiver, covering the X- and Ku-bands, as a step toward replacing several legacy receivers currently operating on the 26m dish at HartRAO. This will include studies into suitable receiver architectures, approaches to switching calibration and cooling, selection of suitable semiconductor processes and devices, integration media, appropriate use of available cooling stages, and IF output.

2. Feasibility:

The M4 lab at the University of Pretoria has significant experience in RF system and MMIC design. The lab is further equipped with all the necessary laboratory facilities for measurement (including wafer-probed microelectronic measurements), as well as software for circuit and system modelling. Semiconductor prototyping is also in place, with access to various suitable foundries and processes. Although cryo-coolers are available on campus, it is anticipated that most of these measurements will be taken at HartRAO, about an hour's drive from Hatfield campus.

Potential objectives for this project would be:

Y1: Literature review. Training in microelectronic design. System architecture design and simulation. Detail component design using discrete semiconductors.

Y2: Integration and evaluation of uncooled broadband RF front-end. Monolithic design stages and prototyping.

Y3: Integration and evaluation. Design of a basic digital back-end. Dissemination. Conclude study.

3. The project relates to "Radio astronomy antennas and receiver systems (including digitisation) associated with supported and hosted instruments.". The proposed techniques, if successful, will lead to the availability of new receivers to an SARAO station.

4. The preferred candidate would have, if not a postgraduate, than at least a firm undergraduate background in high frequency electronics and / or electromagnetics. Prior knowledge of microelectronic design would will be beneficial.