Section A: Overview of the Research Project

1. Dual-band LNB for Nooitgedacht interferometer
2. Engineering
3. Masters

4. An perennial trend in radio astronomy is increasing instantaneous bandwidth and concurrent observation at multiple bands. The four-element Nooitgedact interferometer at North-West University is currently equipped with single-band low-noise block downconverters, routing data from the four dishes to a receiver over buried coaxial cables. The observatory has expressed the desire to improve the capabilities of the interferometer by, among other things, simultaneous observation of two bands. This project aims to deliver and qualify such an LNB.

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Section B: Details of Research Project

1. Scientific merit:

Dual-band concurrent VLBI observations are often used in radio astronomy, most notably for S-X band astrometry [10.3847/1538-3881/aca012]. The current paradigm in designing these multi-band instruments is to use beam-splitting optics that direct the beam to several independent receivers [10.1007/s10762-007-9296-7]. This increases the complexity of the receiver layout, as well as the required size in the cabin. A much simpler approach may result from having multi-band receivers with shared aperture feed horns [10.1109/APS/URSI47566.2021.9704114]. The challenge, now, becomes designing front-end electronics that is simultaneously sensitive to two independent bands.

The NWU Nooitgedact interferometer is currently designed to observe methanol masers at 6.7 GHz, using four 3.7 m prime focus dishes. Each dish is equipped with a single low-noise block downconverter (LNB) covering a single 300 MHz band. It has, however, been proposed that the dishes could support concurrent observation in multiple bands, given a suitable LNB and dual-band feed horn. Further improvements would involve the introduction of a calibrated noise source at each dish, as well as the means to phase-lock the LNBs of the four interferometers using a common reference (which is currently absent).

One interesting design choice to explore, would be the use of a sideband-separating mixer (SSB), which naturally allows for dual-band observations [10.1109/ICEAA49419.2022.9899886]. The challenge, here, would be the extent to which a low-cost PCB implementation can minimize phase imbalance in the branches, which would result in reduced sideband isolation. On the other hand, the project could experiment with finer-resolution lithography in e.g. alumina, using an MCM integration approach.

The interface to the LNB would complicate this design considerably, as each dish has a single coaxial cable between the centrally located receiver and the four LNBs. This gives a single cable to supply DC and a reference tone, as well as control for noise calibration, whilst leaving enough cable bandwidth available for two downconverted IF bands. While preliminary designs have made some progress to achieving some of these goals, the full LNB has not yet been developed or demonstrated.

This study will develop a new dual-band LNB for the Nooitgedact interferometer, and demonstrate its use in observation. This would include the development of a dual-polarized, dual-band feed horn.

2. Feasibility:

The M4 lab at the University of Pretoria has significant experience in RF circuit design. The lab is further equipped with all the necessary laboratory facilities for patterning, packaging and measurement of RF devices, as well as software for circuit and system modelling. Anechoic antenna measurements can also be made on campus.

Potential objectives for this project would be:

Y1: Literature review. Research proposal development. LNB architecture design and simulation. Modular prototyping and testing, followed by integration and testing.

Y2: Dual-band, dual-polarized feed horn design, prototyping and characterization. Integration on site and qualification observations. Final dissemination.

3. The project relates to “Antenna, receiver, (analogue and digital) signal processing, data analysis and data recording systems associated with radio telescopes and geodesy instruments supported and hosted by SARAO”. While Nooitgedact is not a SARAO facility, this project provides a unique, low-complexity opportunity for an RF engineer to see an end-to-end development of a low-noise receiver, from feed optics and RF design to participating in observations.

4. The preferred candidate would have completed a final year B.Eng project with some element of circuit design, RF, or electromagnetics design.

Section C: CV of primary supervisor

Prof Tinus Stander, *Pr.Eng, PhD(Eng)(SU), SMIEEE*

Education

- **PhD, Electronic Engineering**
  Stellenbosch University, South Africa, 2009.
- **B.Eng, Electrical and Electronic Engineering with Computer Science**
  Stellenbosch University, South Africa, 2005

Awards, Distinctions and Fellowships

- Coimbra Staff Exchange Fellowship (2014)
- Erasmus Mundus EUROSA III scholarship (2013)
- Awarded NRF C-rating (2020)
- Awarded SANRAL B-category researcher rating (2020)
- IEEE MTTSAT Challenge Phase 2 participant (2020)

Leadership positions

- Project Leader, SANRAL Research Project 1.2a, "Sensors".
- Co-PI, SA-Mexico Bilateral Programme on Water Vapour Radiometry (2018 – 2021)

Professional Activities

- Registered as Professional Engineer with the Engineering Council of South Africa
- Consultant to South African National Roads Agency (SANRAL), leader of Project 1.2s: "Sensors"
- Scientific advisor to Multifractal Semiconductors (Pty) Ltd.
- Senior member of the IEEE (2005 – present)

Employment History

- **Professor**
  Department of Electrical, Electronic and Computer Engineering, University of Pretoria, South Africa, 2023 – present.
- **Associate Professor**
  Department of Electrical, Electronic and Computer Engineering, University of Pretoria, South Africa, 2022 – 2022.
- **Senior Lecturer**
  Department of Electrical, Electronic and Computer Engineering, University of Pretoria, South Africa, 2013 – 2019.
- **Radio frequency and microwave engineer**, Denel Dynamics, Centurion, South Africa, 2010 – 2012

Teaching Activities

- Postgraduate Communications Electronics EMK732, UP, 2017 – current.
- Electronic engineering design ELO320, UP, 2014-current.
- Advanced Electronics ENE410, UP, 2014-current.
- Digital Electronics ERS 220, UP, 2013.
- Postgraduate Analogue Electronic Design EME 732, UP, 2013-2014.
- Analogue Electronics ENE310, UP, 2013.
- Microwave Filters for RADAR, UCT, 2013.
- Microwave Engineering EMW040, CPUT, 2008.

Research Interests

- mm-Wave microelectronics for terrestrial communications.
- Built-in self-testing of RF and mm-wave electronics
- mm-Wave radiometry for radio astronomy
- mm-Wave remote sensing for transportation applications
- Additive manufacturing for microwave and mm-wave components and packaging.

Research Activities

Completed Postgraduate Supervision

- M.Eng (Electronic and Microelectronic Engineering): 9
- PhD (Electronic Engineering): 6

Current Student Supervision

Supervisor or co-supervisor to 9 postgraduate students (M.Eng and PhD)

Current Research Grants

- NRF Competitive Support for Rated Researchers (2022 – 2024), "OBT for RF electronics"
- SANRAL Project 1.2a, "Remote sensing of road texture"

Current Facilities Management

- mm-Wave coaxial and waveguide lab
- mm-Wave microelectronic wafer probe lab
- mm-Wave anechoic chamber
- Micron-precision 2.5D patterning and assembly lab
- Class 6 cleanroom

Publication Metrics

- Total journal papers: 25
- Total international conference papers: 57
- Total patents: 3
- Total citations in Scopus: 207
- h-index in Scopus: 7

Top Publications

1. J. J. P. Venter, T. Stander and P. Ferrari, "X-band Reflection-Type Phase Shifters Using Coupled Line Couplers on Single Layer RF PCB", IEEE Microwave and Wireless Components, Vol. 28, no. 9, pp. 807 – 809, 2018.
2. H. P. Nel, F. C Dualibe, T. Stander, "Influence of PVT Variation and Threshold Selection on OBT and OBIST Fault Detection in RFCMOS Amplifiers", IEEE Open Journal of Circuits and Systems, Vol. 4, pp. 1 – 15, 2023.
3. P. J. Osuch, T. Stander, "A Millimeter-Wave Second-Order All-Pass Delay Network in BiCMOS", IEEE Microwave and Wireless Components Letters, Vol. 28, no. 10, pp. 912 – 914, 2018.
4. J. B. Cloete, T. Stander, D. N. Wilke, "Parametric Circuit Fault Diagnosis Through Oscillation-Based Testing in Analogue Circuits: Statistical and Deep Learning Approaches", IEEE Access, Vol. 10, pp. 15671 - 15680
5. N. Singh, T. Stander, "E-band Active Q-enhanced pseudo-combline E-band resonator 130nm SiGe BiCMOS", Journal of Infrared, Millimeter, and Terahertz Waves, Vol. 39, No. 10, pp 949–953, 2018.
6. F. Sagouo Minko, T. Stander, "Effect of TID Electron Radiation on SiGe BiCMOS LNAs at V-band", Microelectronics Reliability, Vol. 112, e113750, 2020.
7. J. J. P. Venter, T. Stander, "Phase Shifters with Multiple Independently Controllable Bands Utilizing Frequency-Selective Variable Gain Networks", IET Microwaves, Antennas and Propagation, Vol. 15, no. 2, pp. 143-153, 2021.
8. P. J. Osuch, T. Stander, "High-Q second-order all-pass delay network in CMOS", IET Circuits, Devices and Systems, Vol. 13, no. 2, pp. 153 – 162, 2019.
9. J. J. P. Venter, R. Maharaj, T. Stander, "Additive Manufacturing of Interdigital Filters with Arbitrary Line Cross Section", IEEE Transactions on Components, Packaging and Manufacturing Technology, Vol. 10, no. 4, pp. 686–693, 2020.
10. F. Sagouo Minko, T. Stander, "A comparison of three-dimensional electromagnetic and RC parasitic extraction analysis of mm-wave on-chip passives in SiGe BiCMOS low-noise amplifiers", International Journal of RF and Microwave Computer-Aided Engineering, vol. 30, no. 2, e22019, 2020.