**Section A: Overview of the Research Project**

1. Dual-band LNAs for concurrent K-Q band observations
2. Engineering
3. Masters

4. Concurrent multi-band observations are commonly required for astrometry and geodesy. The state-of-the-art currently relies on beam splitting optics and separate receivers in each band. Aperture sharing or broadband feed horns could eliminate the need for this optics, but would require low noise amplifiers (LNAs) operating at both bands. This project will design a dual-band K-Q LNA to match the lower two bands of the KVN receivers at 22 and 43 GHz, investigation research questions of dual-band matching network synthesis and integration.

5a. Prof Tinus Stander
5b. tinus.stander@up.ac.za
5c. University of Pretoria

**Section B: Details of Research Project**

1. Scientific merit:

Dual-band concurrent VLBI observations of active galactic nuclei (AGNs) have been used since ICRF-1 for astrometry. While ICRF-1 used dual S-X band observations, this was augmented by K-band and dual X/Ka observations since ICRF-3 [10.3847/1538-3881/aca012]. The addition of higher frequencies circumvents weaknesses in low frequency observations (such as a spatially extended intrinsic structure that may vary over time and frequency). The current trend is to incorporate even higher frequency observations, with K-Q band used in the VERA survey and multi-band K-Q-W receivers used by several observatories such as the Thai National Radio Telescope [10.23919/URSIGASS49373.2020.9232235] and the Korea VLBI network [10.1007/s10762-007-9296-7].

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 cabin 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. Concurrent dual-band LNAs have been demonstrated in literature [10.1109/LMWC.2022.3201087], which shows the approach feasible in principle, but these have some shortcomings that should be addressed prior to application in radio astronomy. The most important issue is that these networks tend to be of fairly high order, which means increased susceptibility to the low-Q passives environment in MMICs. Hybrid integration of LNAs in a cooled ceramic substrate (substituting the low-Q BiCMOS or GaAs matching network with high-Q alumina substrate components) might eliminate some of these performance constraints, but at the risk of manufacturing reliability. Furthermore, it should be asked whether the traditional workhorse technologies in radio astronomy LNAs (GaAs and InP) outperform cryogenic SiGe HBT amplifiers [10.1109/LMWC.2019.2911919] to an extent that justifies the increased prototyping cost.

This study will seek to make two contributions. Firstly, it will investigate the relative value of on-chip vs hybrid matching of dual-band LNAs; secondly, it will evaluate the relative performance of SiGe vs GaAs pHEMT for the application.

2. Feasibility:

The M4 lab at the University of Pretoria has significant experience in RF circuit and MMIC design. The lab is further equipped with all the necessary laboratory facilities for patterning, packaging and measurement, as well as software for circuit and system modelling.

Potential objectives for this project would be:

Y1: Literature review. Research proposal development. Circuit design. Hybrid prototyping using off-the-shelf SiGe HBT and GaAs pHEMT or mHEMT transistors. Measurement and performance comparison.

Y2: Port hybrid designs to MMIC and verify. Prototype, measure. 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”. This project is of particular importance to developing dual-band astrometry receivers, to enable joint observations with the KVN.

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.