Section A: Overview of the Research Project

1. A tuneable X-band notch filter for interferer suppression in radio astronomy
2. Engineering
3. Masters
4. The X-band (8 – 12 GHz) is an important observation band for SARAO's critical geodetic observations. It is, however, also a popular band for other applications (eg. communications and RADAR) generating interferers that may degrade receiver sensitivity. An appropriate front-end notch filter may suppress such an interferer, provided that it has minimal impact on the receiver chain (and, subsequently, does not degrade sensitivity in the observation bands). In addition, it would be advantageous to have these filters reconfigurable, such that it can deployed at different sites with different dominant interfering sources. This project will develop such a filter.
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Section B: Details of Research Project

1. Scientific merit:

The X-band (8 – 12 GHz) is an important observation band for radio astronomy, but especially so for SARAO's critical geodetic observations. X-band is, however, also a popular band for point-to-point terrestrial communications, satellite communications, and RADAR. Such an interferer, if not properly suppressed, could potentially degrade (or completely saturate) a highly sensitive radio astronomy receiver. This task may be achieved with the natural selectivity (both in frequency and spatially) of the receiver, but for particularly strong interferers, a specific front-end band-stop or notch filter may be required.

A wide range of circuit design techniques and implementation technologies have been proposed to address this problem. Conventional approaches are expected to yield 1-2% notch fractional bandwidth, which leaves a fair amount of spectrum unavailable for radio astronomy observation. One particularly interesting one is the use of dual phase path filtering, where the depth of the suppressing notch is determined not by resonator Q-factor, but by accurate phase path cancellation. Making these filters returnable in a medium suitably low-loss for radio astronomy is, however, an open research question. Another option would be to implement a multi-band filter with transmission zeros placed at interfering frequencies, but again, making these both tuneable and low-loss presents a significant challenge in published literature.

2. Feasibility:

There have been numerous studies published on notch and dual phase path filtering; the application of any of these approaches would, therefore, feasibly lead to the development of a working prototype.

The M4 lab at the University of Pretoria has significant experience in the design of RF and microwave components. The lab is further equipped with all the necessary laboratory facilities for measurement, as well as software for circuit, EM, and system modelling. Cryo-cooling and RF measurement facilities are available both at UP and at HartRAO, about an hour's drive from campus.

Potential objectives for this project would be:

Y1: Literature review. Network and circuit synthesis. EM design. Prototyping and measurement (both at room temperature and cryo-cooled).

Y2: Investigation into tuning capability. Circuit design of a tunable notch filter. EM and circuit co-design. Prototyping and testing.

3. The project relates to Priority Area 1. It is designed to address a specific, existing receiver problem at a SARAO geodesy site.

4. The preferred candidate would have a firm undergraduate background in electromagnetics and microwave theory, having completed (preferably) a related final year B.Eng project.