South African Square Kilometre Array Project Postgraduate Bursary Programme

PhD Eng Research Project Proposal to be considered for Bursary Funding to Commence in 2020

1. Title of Research Project: Modelling Aggregate Effect of Multiple Radiators inside Electrically Large Shielded Enclosures

2. Academic Level: PhD Eng

3. Supervisor's Title and Full Name: Dr Pieter Gideon Wiid

4. Co-supervisor's title and full name:

5. Supervisor's University: Stellenbosch University

6. Overview and Aims of the Research Project:
This investigation is applicable to the processing instrumentation hosted inside the shielded correlation room of the Square Kilometre Array (SKA) central processing facility. In order to effectively and accurately model the required shielding levels for the facility, multiples of similar complex radiating sources inside the electrically large conductive enclosures will be investigated. Radiated and conducted emissions as well as absorption of a single source module will be measured and the electromagnetic (EM) software modelling will be developed to duplicate the source realistically and investigate both the aggregate effect as well as absorption. With the developed software modelling, recommendations can be provided for future layout changes or additions to the enclosure to minimize the aggregate effect of the radiators inside these enclosures. Mitigation methods will include the investigations of careful placement of absorbing material to reduce the aggregate effect from the multiple radiators. Heat-flow simulations can be coupled to the electromagnetic solvers to do a multi-physics analysis of optimal layout inside the enclosure without compromising the cooling requirements.

7. Relevance of the research proposed to the priority areas of MeerKAT / SKA:
Shielding of equipment to levels complying with the SARAS and SKA Threshold levels are imperative to the SKA project. This project will assist in quantifying the required shielding levels of the processing facility and provide advice in mitigation solutions.
This falls in priority area 4.2.3 Hardware and data analysis systems for detecting, monitoring and identifying Radio Frequency Interference (RFI), including the use of telescope data (e.g. using MeerKAT visibilities to locate RFI sources).

8. Research work breakdown:

a. Year 1

The student will conduct an in-depth literature study in the first semester on: shielding of enclosures, modelling of electrically large enclosures, modelling of multiple radiators inside an enclosure with similar and dissimilar characteristics as well as antenna array theory linked to this, absorption and microwave absorbing materials. The second semester will include test methodologies to evaluate radiated and conducted emissions from a typical processing rack used inside the processing facility of MeerKAT, as well as the representation options to include the measured results in simulation of multiple radiators inside an electrically large enclosure.

b. Year 2

The first semester of year 2 will involve the development of numerous CEM models of the processing racks in different software using the measured values of radiation and conducted noise. The effects of absorbing material will also be investigated in simulation, testing done in a reverberation chamber to confirm the absorption characteristics. During the second semester, multiples of these models will be used in simulation inside an electrically large enclosure to investigate the aggregate effect with different layouts. Current layouts and practical changes to current layouts will be investigated together with multi-physics studies of heat-flow to ensure that the changes do not negatively affect the cooling requirements inside the enclosure. This will lead to an optimal layout of racks within practical limits of the chamber.

c. Year 3

In semester 1 of the third year, critical analysis of the investigation results will lead to practical recommendations of mitigation methods on the aggregate effect of the multiple radiators, including optimal placement of absorber material, in order to accurately quantify the levels of shielding required from the processing facility to comply to SARAS and SKA Threshold levels. The dissertation writing will be done during this time as well, where the second semester will be used for finalising the dissertation.

9. Availability of required data / access to required equipment /availability of research facilities and other resources required:

The Stellenbosch University has a shielded reverberation chamber, an anechoic chamber, a Rohde and Schwarz 8 GHz network analyser, as well as a Rohde and Schwarz 40 GHz Spectrum Analyser and soon a Tektronix 2.5 GHz oscilloscope for testing purposes. There are common mode current probes which range up to 3 GHz which are usually used together with a Rohde and Scwarz FSH4 handheld spectrum analyser. The university has licenses for several computational electromagnetic (CEM) software programs to enable the simulation models to be developed and simulated, including ANSYS, Altair FEKO and DSS CST. An additional license for EMCoS EMC simulation software is planned. Access to the CHPC is available with an Altair FEKO license for any larger scale intensive modelling.