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Thermal Analysis of a Dense Dipole Array for the SKA Mid-Frequency Aperture Array

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The Square Kilometer Array (SKA) is a collaborative effort between countries from all over the world to build the next generation radio telescope. A key component of the final telescope is the Mid-Frequency Aperture Array (MFAA) developed to realise the aperture array concept in the mid-frequency range [1]. A dual-polarized Dense Dipole Array (DDA) has been designed as a candidate element for the MFAA and is planned to be situated in the Karoo of Africa.

The DDA is a ground planar structure with tightly coupled dipole elements and is fed differentially through a specially designed common-mode suppressing feed. The planar nature of the DDA structure will aid in simplifying mass-production and maintenance as many are to be deployed in the field [2]. The purpose of this work is to thermally analyse the element through modelled simulation to ensure its fully intended operation can be achieved in the climate of the Karoo. The DDA is modeled using finite element analysis software that incorporates standard thermal analysis equations to model the conduction, convection and radiation heat transfer. The model is built with multiple elements to represent the different components of the DDA and their corresponding thermal properties.

Two different simulations are necessary for a conclusive thermal analysis of the DDA. The first models the heat transfer that the DDA might experience in the Karoo under two extreme conditions on either side of the temperature scale. The second is a multi-physics simulation to develop a relationship between the temperatures of the DDA and its electromagnetic performance.

With the first simulation a worst-case hot day and a worst-case cold day are created. These days represent the highest and lowest ambient temperature and solar flux respectively that the DDA might experience during operation. The values for the ambient temperature and solar flux are taken from data recorded at the SKA site where the MFAA is to be situated. As the hot day represents a potentially critical case this simulation is repeated in a multi-day transient analysis to provide the most extreme environmental conditions potentially seen during operation. The simulation applies these worst-case days to determine the thermal patterns the DDA will experience, providing its operating temperatures and the heat transfer of the element with its surroundings. As this is a modelled simulation the accuracy of the simulated results will need to be tested by comparison with physical measurements. This is intended to be done with a similar working model/prototype of the DDA.

A multi-physics simulation is necessary to determine the effect the Karoo's environmental conditions have on the electromagnetic performance of the DDA and therefore its operation. The second phase of this work involves developing a relationship between the temperature and the electromagnetic performance of the DDA with focus on the main beam to finally determine if whether the DDA will be suitable in the climate of the Karoo.

1. "SKA Telescope – Square Kilometre Array Radio Telescope (SKA)." *Square Kilometre Array Radio Telescope*, [ONLINE] Available at: http://www. Skatelscope.org/MFAA/. [Accessed 18 December 2017].

2. J. Gilmore, "Design of a Dual-Polarized Dense Dipole Array for the SKA Mid-Frequency Aperture Array – Stellenbosch University," *Stellenbosch*, 18, December 2017.