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The SKA Radio Telescope: a Global Project for a Better Understanding of the Universe

UNIVERSITEIT STELLENBOSCH UNIVERSITY

Key Highlights

Industry:
Aerospace, Radio Science

Challenge:
Studying RFI mitigation

Altair Solution:
FEKO – Essential in the SKA project

Benefits:
- Simulation used to study MeerKAT
- RFI calculations can be achieved
- Rigorous analysis can be conducted successfully with FEKO

Background

Challenging Einstein's seminal theory of relativity to the limits, how the very first stars and galaxies formed just after the Big Bang, the study of dark energy and the vast magnetic fields in the cosmos, and the age old question "Are we alone in the Universe?" These are some of the key scientific goals of the Square Kilometer Array (SKA) project, led by the SKA Organization from Jodrell Bank Observatory in the UK, supported by 11 member countries - South Africa, Australia, Canada, China, Germany, India, Italy, New Zealand, Sweden, The Netherlands and the United Kingdom.

The SKA will be a collection of various types of antennas, ranging from large dish reflectors to aperture antennas. Spread over large distances, they work together as an interferometric array. When completed, the SKA will be 10,000 times faster and 50 times more sensitive than any existing radio telescope. It will be constructed in two phases: Phase 1 (SKA1) is estimated to be completed in 2023 and is being built in South Africa and Australia; Phase 2 (SKA2) will be started after SKA1 and will take the project into other African countries, with the Australian component also being expanded. For Phase 1 the 64-dish MeerKAT precursor array, which is currently under construction and expected to come online in a few years' time, will be integrated into SKA1 MID, with the construction of another 190 dishes.

On completion, the SKA will be so sensitive that it will be able to detect an airport radar on a planet tens of light years away.
Its central computer will have the processing power of about one hundred million PCs and the dishes of the SKA will produce 10 times the global internet traffic. The SKA will use enough optical fibre to wrap twice around

Keywords: SKA, Square Kilometer Array, MeerKAT Telescope, Gregorian Dish, University of Stellenbosch, FEKO

University of Stellenbosch Success Story

"FEKO modelling on the Cape Town CHPC has been pivotal in our RFI mitigation research. We have successfully validated dish scale models with measurement and continue to use FEKO to study EM induced current paths and provide RFI mitigation recommendations to SKA South Africa."

Dr Gideon Wiid,
Lecturer, E & E Engineering
University of Stellenbosch, South Africa

the Earth and the aperture arrays in the SKA will be able to produce more than 100 times the global internet traffic.

The Research Chair at the University of Stellenbosch focuses on the analysis of both electromagnetic systems and mitigation of radio frequency interference (RFI) between systems. Dr Gideon Wiid and Mr Kuja Stanley Okoth from the EMC Metrology Research and Innovation (EMRIN) group have been working on Electromagnetic compatibility (EMC) metrology issues for the SKA. (EMC) issues are anticipated and considered throughout the planning and design phase and measurements are made on prototypes as thoroughly as possible. With this approach EMC becomes an integral part of the electrical and mechanical design of the finished product.

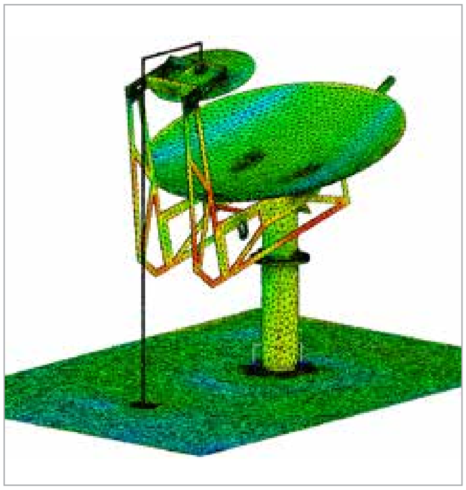
RFI mitigation for the SKA EM Environment

The proximity of adjacent antennas and other systems can result in unwanted inter-coupling, even from low-level emissions, due to currents on cables. This inter-coupling needs to be minimized by first identifying the coupling mechanisms, either through simulations or measurements, and then applying measures to improve isolation, for example shielding or re-routing of cables.

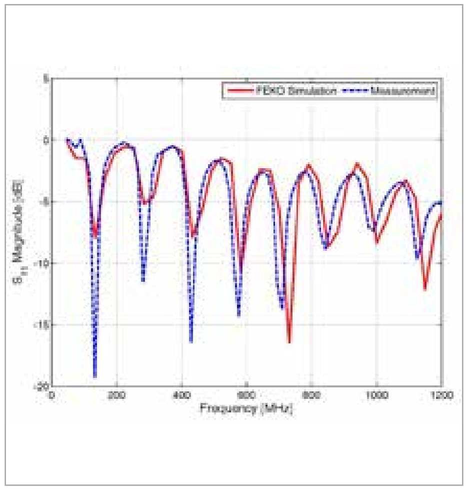
Although on-site radio frequency (RF) coupling investigations are required, they can only be done after installation. During the design, planning and installation stages such characterization of the electromagnetic (EM) environment has to be done on scale models and through simulations.

The actual 13.5m diameter MeerKAT antenna

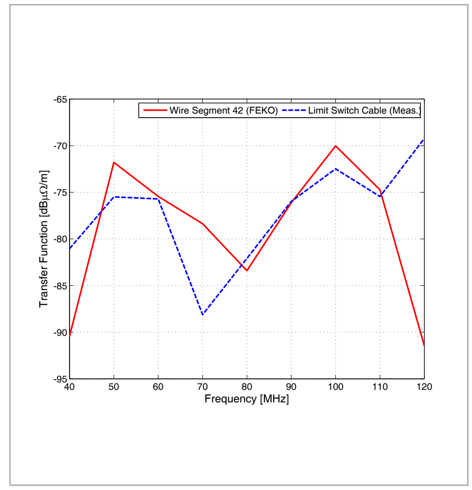
Core of the MeerKAT site



FEKO model of a single antenna



Comparison of the reflection coefficient at an input port as measured on a scale model and simulated with FEKO



Measurement results on the actual on-site MeerKAT antenna compared to FEKO simulations

Characterization of EM environment for the SKA through simulation

Simulation was, and still is, the only viable option to study the interference characteristics in detail. This requires extensive verification of the computational electromagnetic (CEM) model and measurements on a scale model in an anechoic chamber.

The electrical size of the structure and the broad spectrum covered requires significant computational resource requirements. FEKO's state of the art parallel method of moments (MoM) solver was run at the Centre for High Performance Computing (CHPC) in Cape Town and the simulations were completed in a matter of days.

Comparing simulation with measurements

For the actual MeerKAT telescope, on-site RFI measurements were conducted using an emission reference source (ERS) that operates from 30-1000 MHz. The ERS was placed 30 meters from the dish to represent any possible RF coupling from a future nearby telescope. The measured and simulated results of the transfer function, a measure of the coupling between RF source and a receiver, agrees very well. This validated FEKO model can then be used to do rigorous RFI studies and make design, layout, shielding and bonding recommendations to mitigate the interference between these extremely sensitive telescopes.

"FEKO modelling on the Cape Town CHPC has been pivotal in our RFI mitigation research at Stellenbosch University for the MeerKAT Telescope. We have successfully validated dish scale models with measurement and continue to use FEKO to study EM induced current paths and provide RFI mitigation recommendations to SKA South Africa" said Dr Gideon Wiid, Lecturer, E & E Engineering, University of Stellenbosch, South Africa.

New solvers are continually being added or improved in order to solve future challenges posed by this massive project. In particular at the low frequency limits, where traditional asymptotic methods such as physical optics (PO), physical theory of diffraction (PTD) and the geometrical theory of diffraction (GTD) are at their least reliable. Improvements to different solvers and specifically the hybridisation of these are essential for the efficient simulation of such electrically large structures operating over a broad frequency spectrum. Not only has FEKO shown to be invaluable for (RFI) mitigation and lightning protection but also for the design of the receiver, placed at the focus of reflector, and the overall gain calculation of the antenna, taking into consideration effects such as aperture blockage, support struts and deformation of the large structure.

EMC measurements inside anechoic chamber on scaled model

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