Complex Permittivity Measurements of Karoo Soil for the Square Kilometre Array

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Abstract

MeerKAT is the pathfinder to support the South African bid to host the Square Kilometre Array and will be situated in the Northern Karoo region of South Africa [1], [2]. The SKA will ultimately be orders of magnitude more sensitive than existing radio telescope systems and much attention is being devoted to the issue of self-generated radio frequency interference (RFI) and its management. This paper considers the use of the Karoo soil to further assist in the RFI mitigation by looking at its electromagnetic shielding properties. The level of unwanted signal attenuation, by burying cables and bunkers containing "noisy" electronic equipment under ground, is investigated. The soil would not only help attenuate these noisy signals, but also give a level of protection to the equipment from radiated environmental interference like lightning. This is examined by measuring the attenuation of induced common mode currents on cables buried at various depths under ground on-site in the Karoo. The complex permittivity of a soil sample, taken from the core-site, is furthermore extracted by measuring S-parameters and applying the iterative *Baker-Jarvis* extraction method [3]. These values are then used in both computational models and experimental arrangements to derive the attenuation level of the Karoo soil sample as a function of frequency. They were also used in the analytical expression, given by equation 1, to predict the attenuation level in [dB/m] over a frequency range covering both S and X-band [4], [5]. It is important to be confident of the complex permittivity values of surrounding soil at the radio telescope sites to use the most suitable values in the computational models. Good agreement between analytically predicted, numerically computed and site, as well as laboratory-measured attenuation results for the Karoo soil, are shown in figure 2. Permittivity extracted values were $\epsilon_r' \approx 3.8$ and $\epsilon_r'' \approx 0.29$ $(\tan\delta \approx 0.076)$.

$$\alpha = 8.686 \times \frac{2\pi f}{c} \sqrt{\frac{\epsilon_r'}{2}\left(\sqrt{1+\left(\frac{\epsilon_r''}{\epsilon_r'}\right)^2}-1\right)} \tag{1}$$

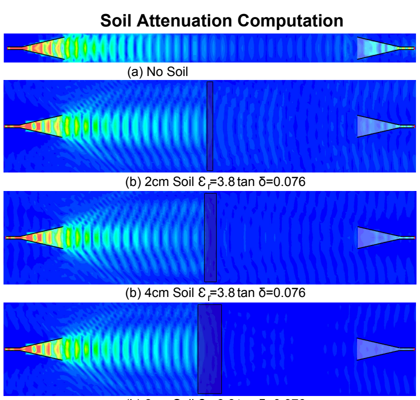

Fig. 1. CST computational model of two X-band horn antennas with various soil sample depths

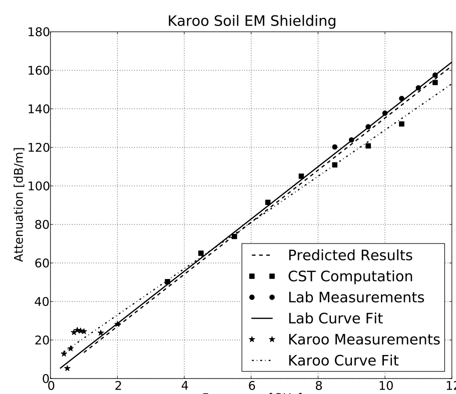

Fig. 2. Measured, computed and predicts attenuation values in [dB/m] versus frequency [GHz] for Karoo soil

References

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