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Ensemble Estimation of Network Parameters: A Tool to Improve the Real-time Estimation of GICs in the South African Power Network

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Large grounded conducting networks on the surface of Earth, such as power lines or pipelines, have long been known to be affected by solar activity and subsequent geomagnetic storms. With the increased use of electrical technologies, society has become more and more dependent on electrical power and power networks. These power networks form extensive grounded conductors which are susceptible to geomagnetically induced currents (GICs).

GICs at any specific node in a power network are assumed to be linearly related to the horizontal vector components of an induced plane-wave geoelectric field by a pair of network parameters. The network parameters are not easily measured in the network, but may be estimated empirically. In this work, we present a new approach of using an ensemble of network parameters estimates. The ensembles include a huge number of parameter pair estimates calculated from simultaneously solving pairs of time instances of the governing GIC equation. Each individual estimate is not the true state of the system, but a possible state. Taking the ensemble as a whole though gives the most probable parameter estimate. The most probable parameter estimate for both network parameters, as defined by their respective ensembles, is used directly in the modelling of GICs. The ensembles themselves however allow for further analysis into the nature of GICs.

An improvement is seen when comparing the out-of-sample performance of the ensemble estimates with previous GIC modelling in the South African power network during the Halloween Storm of 2003. For the first time, it is shown that errors in the GIC modelling chain are absorbed into the network parameter estimates. Using a range of estimates from the ensemble, a GIC prediction band is produced. This band corresponds to an error estimate for predicted GIC. Furthermore, it has been explicitly shown for the first time that estimated network parameters vary with GIC magnitude during an event. This behaviour is then used to refine the parameter estimation further and allow for real time dynamic network parameter estimation.

Apply to be considered for a student award (Yes / No)?

Yes

Level for award (Hons, MSc, PhD, N/A)?

MSc

Main supervisor (name and email) and his / her institution

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Would you like to submit a short paper for the Conference Proceedings (Yes / No)?

Yes

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