Empirical estimation of GICs from the geomagnetic data in Japan

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Pulkkinen et al (2007) proposed the new method of estimating geomagnetically induced currents (GICs) at a transformer station by employing the linear relation between the GICs and the corresponding geomagnetic variations as

$GIC(\omega)=A(\omega)B_y(\omega)+B(\omega)B_x(\omega)$ (1)

By using the two transfer functions in the frequency domain ($A(\omega)$ and $B(\omega)$ in Eq. (1)), we obtain

$GIC(t)=\int A(\tau)B_y(t-\tau)d\tau + \int B(\tau)B_x(t-\tau)d\tau$ (2)

This method (the transfer function method) successfully reproduced the GICs from the geomagnetic variations in Finland [Pulkkinen et al., 2007] and in Hokkaido [Pulkkinen et al., 2010]. However, as the electrical conductivity distributions in both areas are rather uniform, it is important to evaluate how this method is applied to GICs observed at a station in other area of Japan with heterogeneous conductivity distribution. This is the motivation of this research. We employ one-minute values of the GICs observed at a transformer station and those of the geomagnetic data at Kakioka Magnetic Observatory during the Halloween event.

To confirm how this method is effective, we need to investigate how the GICs during one event are reproduced from the geomagnetic data in this event with the transfer function obtained from the other event. Fortunately, the Halloween event has two activities on Oct/30 (the event #1) and on Oct/31 (the event #2), we can calculate separately two transfer functions for the two events. First, we confirm that the transfer functions obtained from the events are essentially identical. This fact indicates that the transfer function method by Pulkkinen et al. (2007) is applicable to the GIC data in Japanese transformer station. Next, the GICs in the event #1/#2 are estimated from the geomagnetic data in the event #2/#1 and the transfer function of the event #2/#1. When calculating GICs in time domain in Eq. (2), we noticed that the integral from t=0 to 50min reproduces sufficiently accurate GICs. This fact is a little bit different from Pulkkinen et al. (2007) who estimated the GICs through the integral only at t=0 and 1min. At last, we confirm that the reproduced GICs are essentially similar to the observed ones.

In the last, we estimate the GICs at the transformer station in the magnetic storm in 1989 which caused the large-scale blackout in Canada and US.

References

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