Application Note: Space Weather Monitoring

OVERVIEW

Space Weather describes the effect that solar activity has on the solar system and more particularly on spacecraft or on man-made networks on Earth.

Solar activity will generate flux of charged particles at varying degrees of intensity, speed and directions, called solar wind. When these events reaches satellite or Earth, they can cause havoc with electronics and electrical systems. A common example being the March 1989 storm which affected the Hydro Quebec Network causing power network failures and blackouts.

Since then, a number of measures have been put in place, from satellite monitoring the solar activity, to the deployment of ground magnetometers monitoring the field changes and being part of a response system from the power network operators.

Revised August 2020

Equipment

- Three-axis Fluxgate Magnetometer

Applications

- Monitoring magnetic field variations associated with Solar activity
- Monitor the presence of DC or near DC current within power lines

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Application of Fluxgate sensors to Space Weather and Geomagnetically Induced Currents

The effect that space weather, that is the various particle emissions from the Sun, has on electric and electronic systems is well known. When the flux of particles is directed to Earth, they will interact with the magnetosphere and the upper layers of the atmosphere and lead to events such as auroras. They can also cause rapid and sometimes high amplitude magnetic field variations called Geomagnetic Disturbances (GMD).

As a direct result of these magnetic field variations, area of higher ground conductivity will see electric currents, GICs (Geomagnetically Induced Currents), generated which couple with long man-made conductors, whether this is a pipeline, railway line or power lines. Whilst the effect on pipeline and railway rarely has a direct immediate effect, the effect on power lines on the other hand can be immediate.

The circulation of GICs through the transmission lines and into transformers, can cause the transformers to saturate and lead to power failures. Examples include the March 1989 blackout on the Hydro Quebec network where a failure in domino effect took multiple transformers offline.

Increasing our understanding of ground conductivity can help identify the parts of the networks which are most at risks from higher levels GICs. Additionally, the monitoring of the magnetic field is equally important along the more susceptible networks. This allow for a user to have information in real-time to determine whether a particular event can cause sufficient GICs to damage their network.

Fluxgate sensors are ideal for this type of monitoring, where the field variations dB/dt are critical in comparison to the absolute accuracy. For the purpose of space weather monitoring, the sensors need to be deployed remote from electrical substations, roads, power lines and other man-made features in order to avoid interferences.

The magnetic data collected can then be integrated to models which will include ground conductivity information and network structure to predict the amplitude of GICs and take necessary actions. Example of sensors deployed for this purpose include the Mag-03, Mag-13 and some of the low power Mag648/Mag649.

In addition to space weather monitoring, fluxgate can also be deployed alongside power lines, in a gradient setup so as to monitor the field generated by any GICs running through the power lines. Due to the remote nature of these deployments, low power sensors such as the Mag648 and Mag649 are typically implemented.

For further fluxgate sensor information please refer to:

https://gmw.com/product/mag-03-mag-13/

https://gmw.com/product/other-probes/