



GMD Phenomena & the NYSRC Reliability Rule

NYSRC Executive Committee Meeting #208

Action Item 206-4

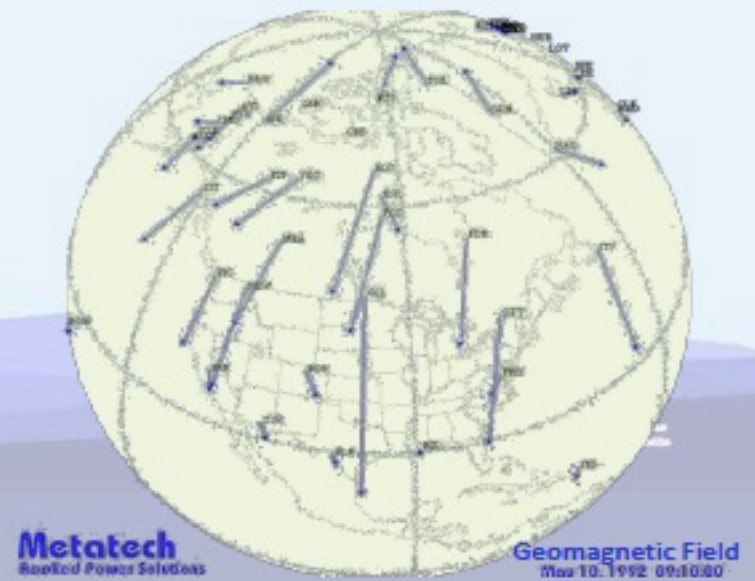
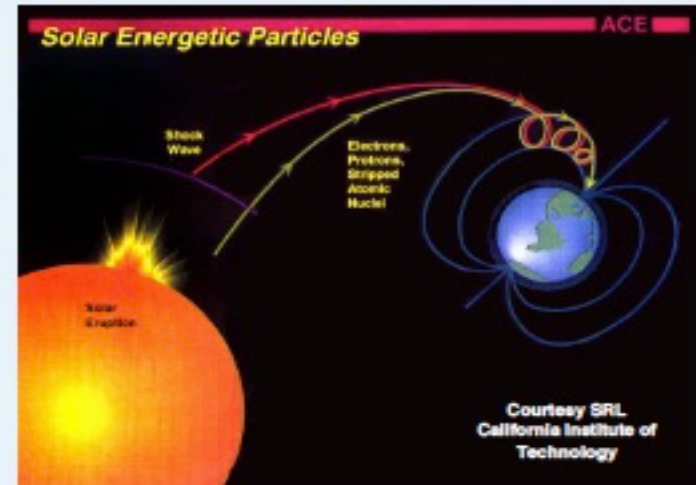
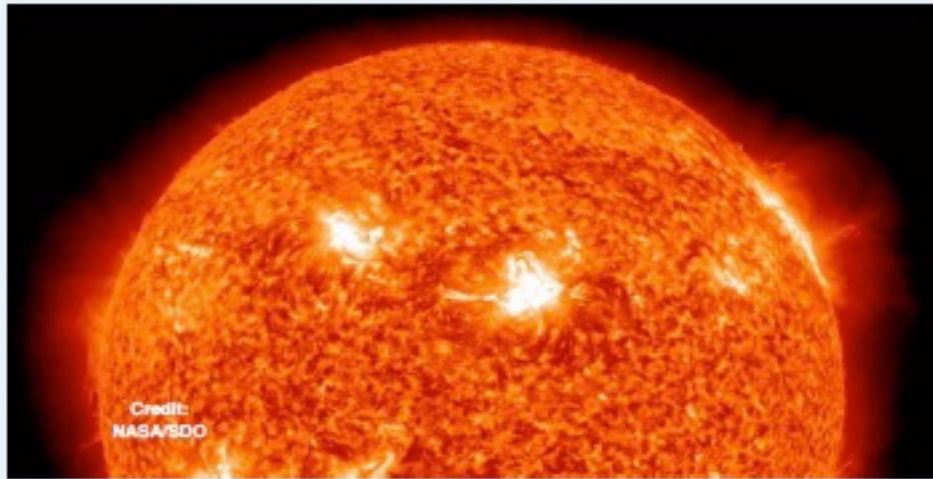
8/12/16

Credit:
NASA/SDO

Outline

- What is a Geomagnetic Disturbance (GMD)?
 - Slides 3 through 8 from NOAA’s “Geomagnetic Storms and the US Power Grid”, January 2010
<http://www.swpc.noaa.gov/sites/default/files/images/u33/finalBoulderPresentation042611%20%281%29.pdf>
- NERC Standards
 - Slides 9 & 10 from “Benchmark GMD Event Description”, May 12, 2016.
[http://www.nerc.com/pa/Stand/Project201303GeomagneticDisturbanceMitigation/Benchmark Clean May12 complete.pdf](http://www.nerc.com/pa/Stand/Project201303GeomagneticDisturbanceMitigation/Benchmark%20Clean%20May12%20complete.pdf)
 - Slide 11 from EOP-010-1 – Geomagnetic Disturbance Operations
- NYSRC Rules
 - Slides 12 & 13 from NYSRC RR&CM V37 – “C.4 Operation Prior to and During Extreme Weather Conditions and Solar Magnetic Disturbances”, June, 2016
[http://www.nysrc.org/pdf/Reliability Rules Manuals/RRC Manual V37 6-10-16.pdf](http://www.nysrc.org/pdf/Reliability%20Rules%20Manuals/RRC%20Manual%20V37%206-10-16.pdf)

What is a Geomagnetic Disturbance (GMD)?



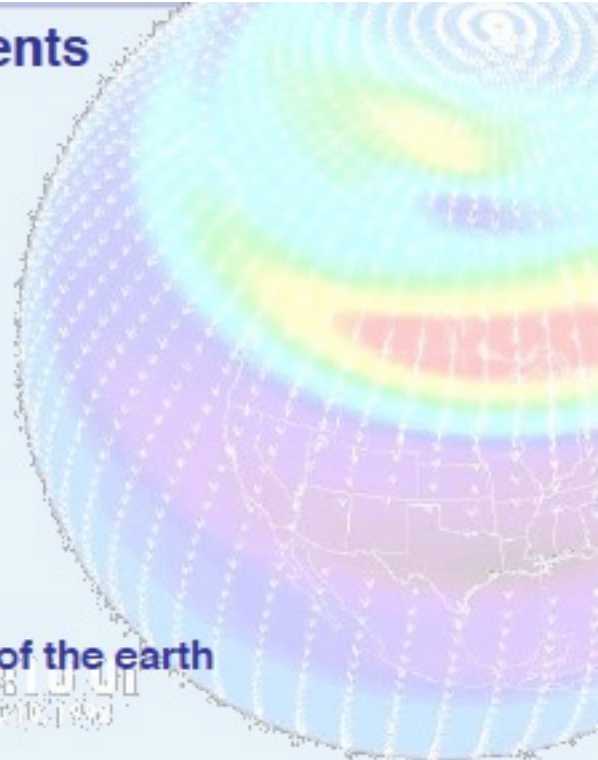
What is a Geomagnetic Disturbance (GMD)?

CMEs affect the Auroral Electrojet currents

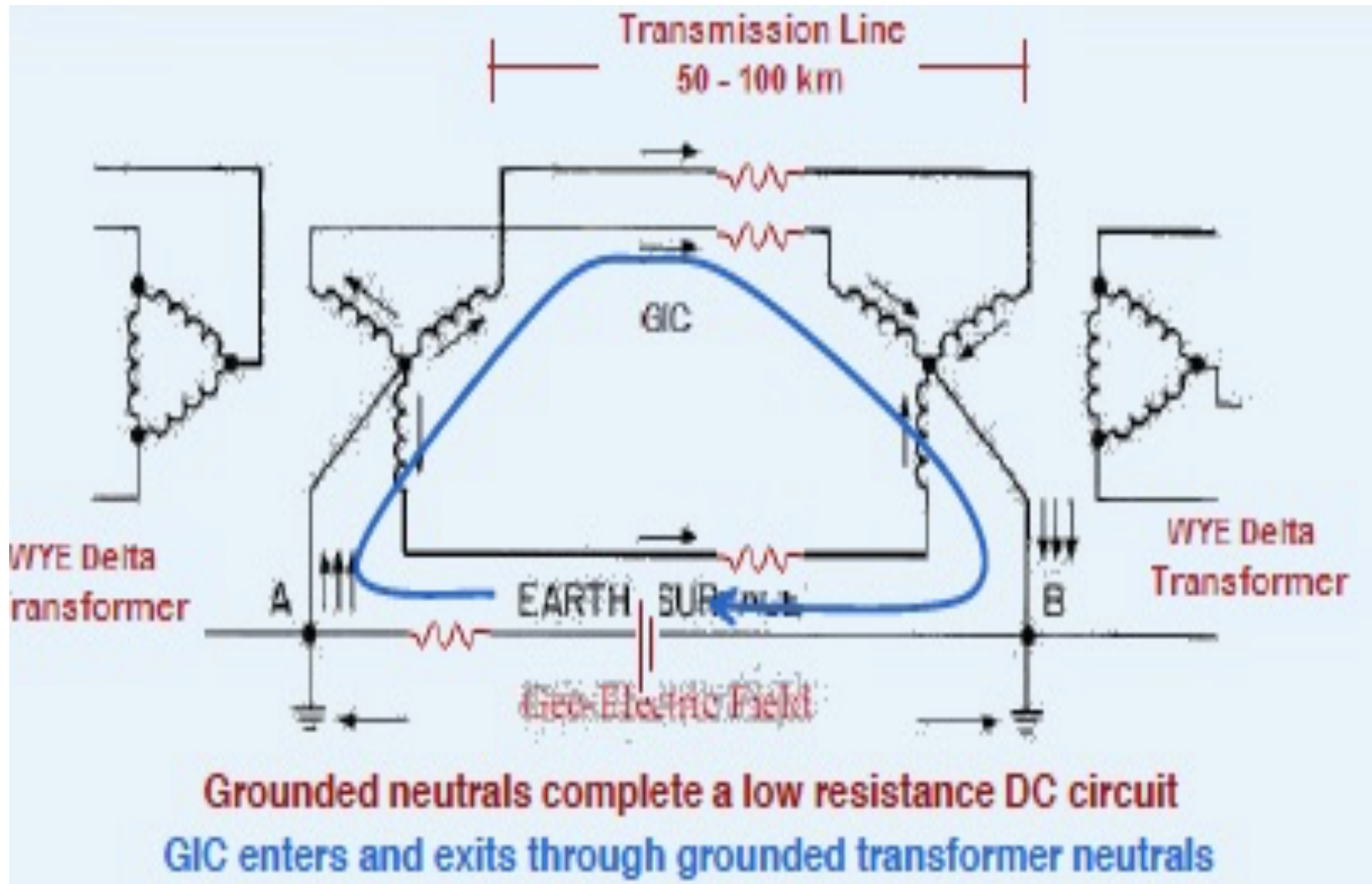
- Normally confined to far north
- Expand southward as intensity of storm increases

Currents

- Reach millions of Amperes
- Affect Earth's Magnetic Field
- The induce electric fields along surface of the earth are the principle drivers of GIC
 - Create Earth Surface Potentials
 - affected by earth resistivity
- Variations in field is slow compared to system frequency
 - GIC are Quasi DC currents
- Moderate Storm - Electric Field at Earth's Surface 1-5 V/km
 - Largest recorded 20 V/km



What is a Geomagnetic Disturbance (GMD)?

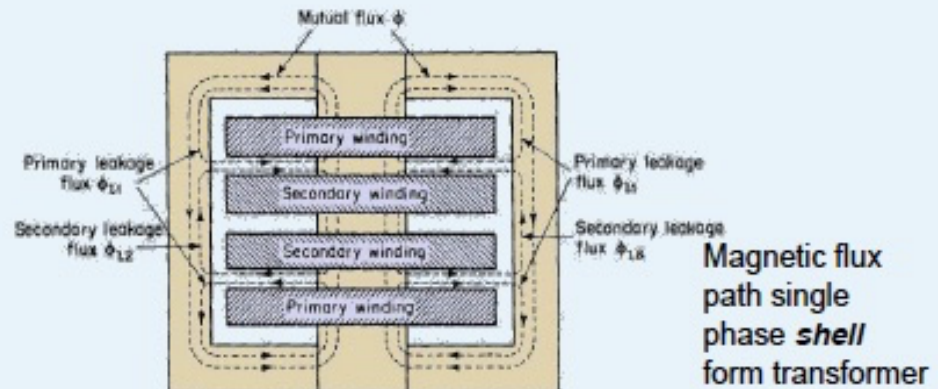


What is a Geomagnetic Disturbance (GMD)?

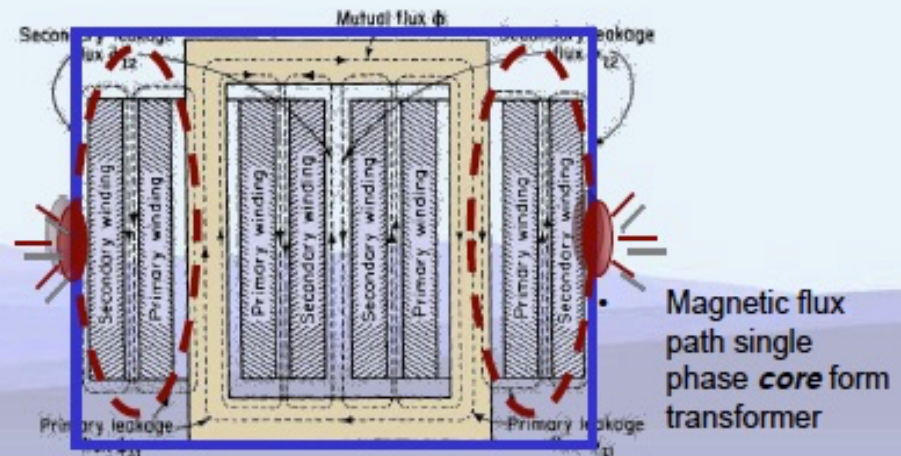
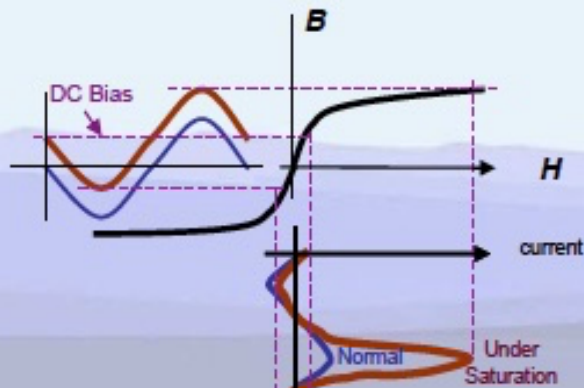
Saturation is when the iron core can no longer effectively contain the magnetic flux

Leakage flux is forced into the surrounding space where it can flow through structural members including the tank wall

Eddy currents produced by the intense magnetic field can heat ferrous structural members of the transformer



Winding arrangement in shell type transformer showing approximate paths taken by mutual flux and primary and secondary leakage fluxes.



What is a Geomagnetic Disturbance (GMD)?

Effects of stray flux and eddy current heating in transformer tank and structural members

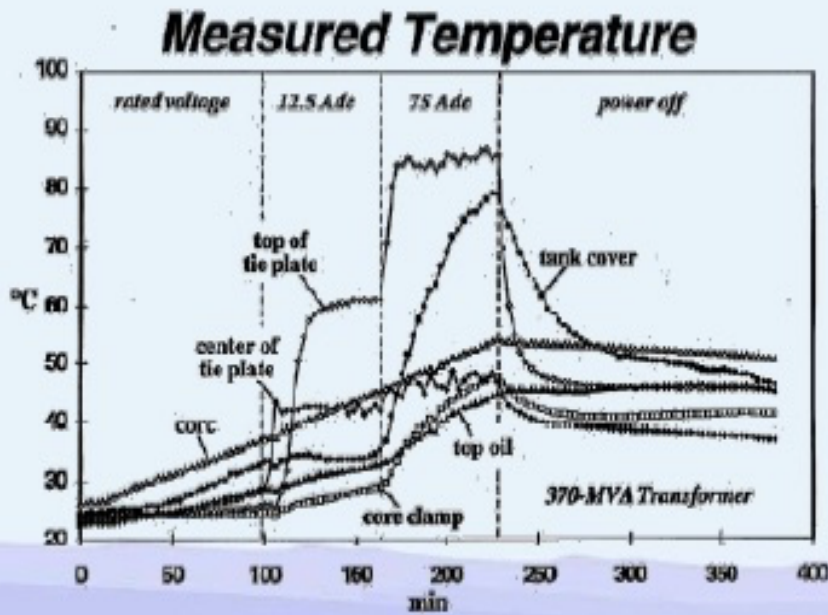
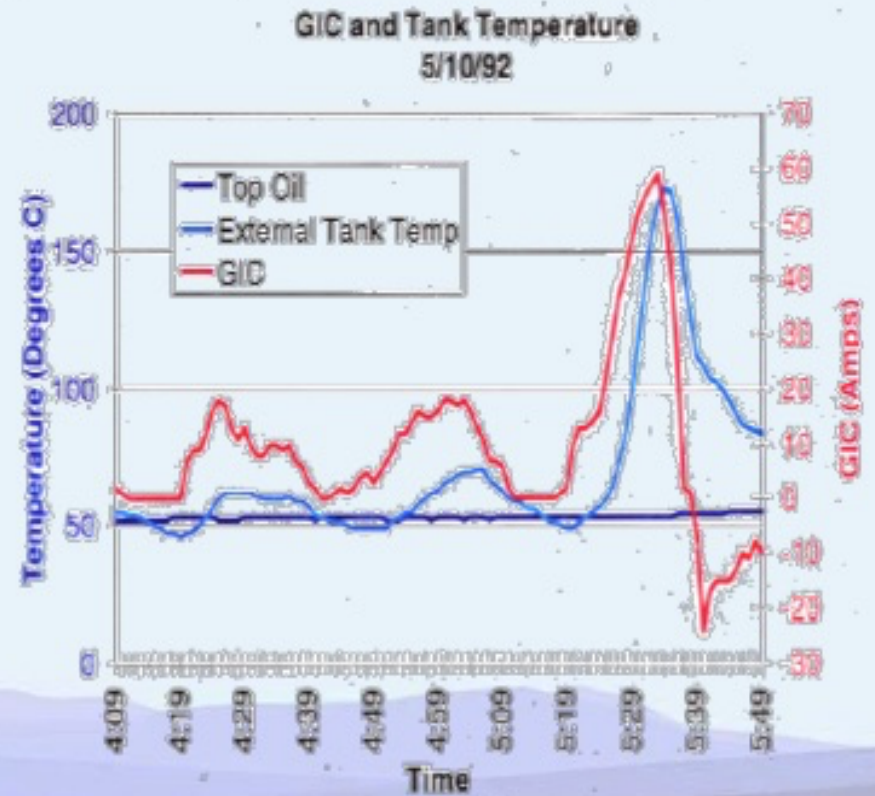


Figure 4-3. Observed temperature from Hydro Quebec tests showing response between two levels of neutral GIC (12.5 amps and 75 amps) and measured temperatures in the transformer in easy-to-access spots.

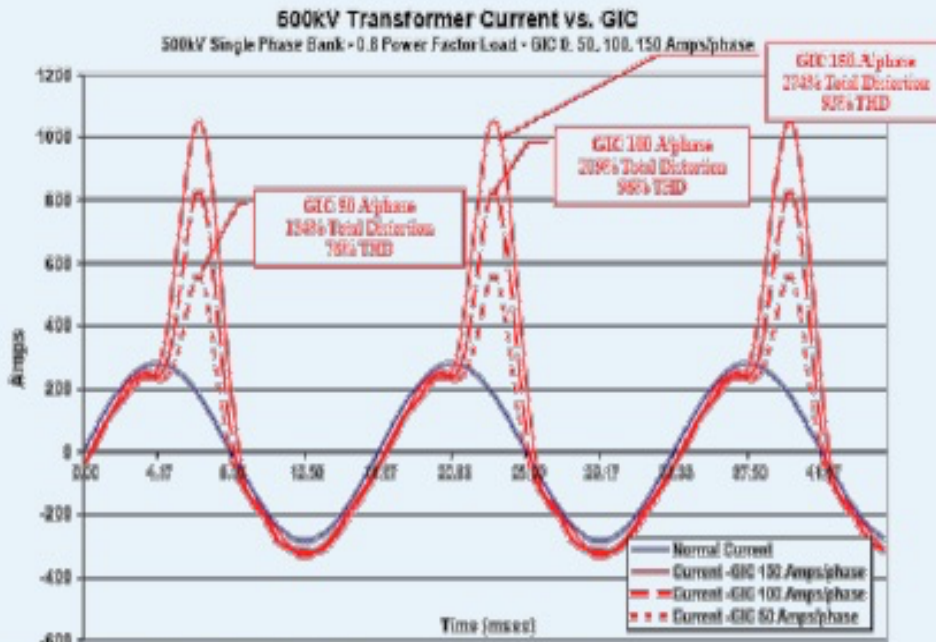


GIC and transformer tank temperature for May 10, 1992 geomagnetic storm.

What is a Geomagnetic Disturbance (GMD)?

Primary effects

Winding Overheating : Insulation Damage

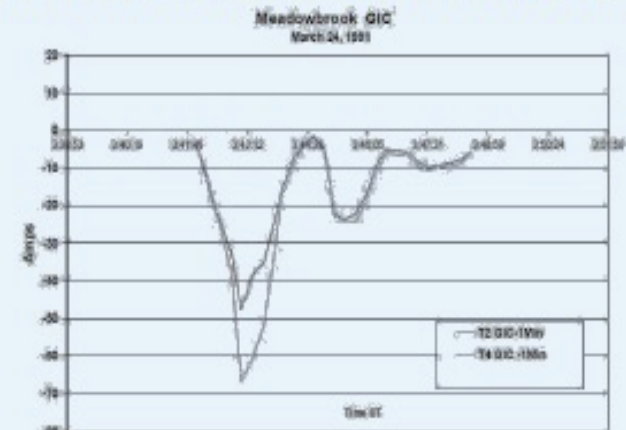


Transformer total load current – normal conditions and with 50, 100 and 150 amps/phase of GIC.

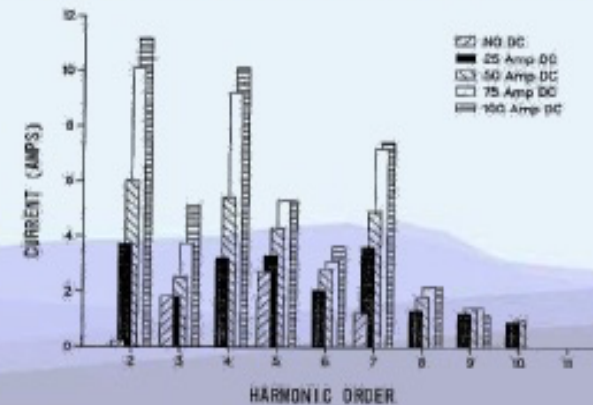
Transformer load current under core saturation

Secondary effects

Harmonics : VAR Consumption : Voltage Problems



GIC flow measured in transformer neutral



The test results (230/115 KV, 3-phase, shell form auto-transformer).

Harmonic current generation under saturation

NERC Standards - Benchmark GMD

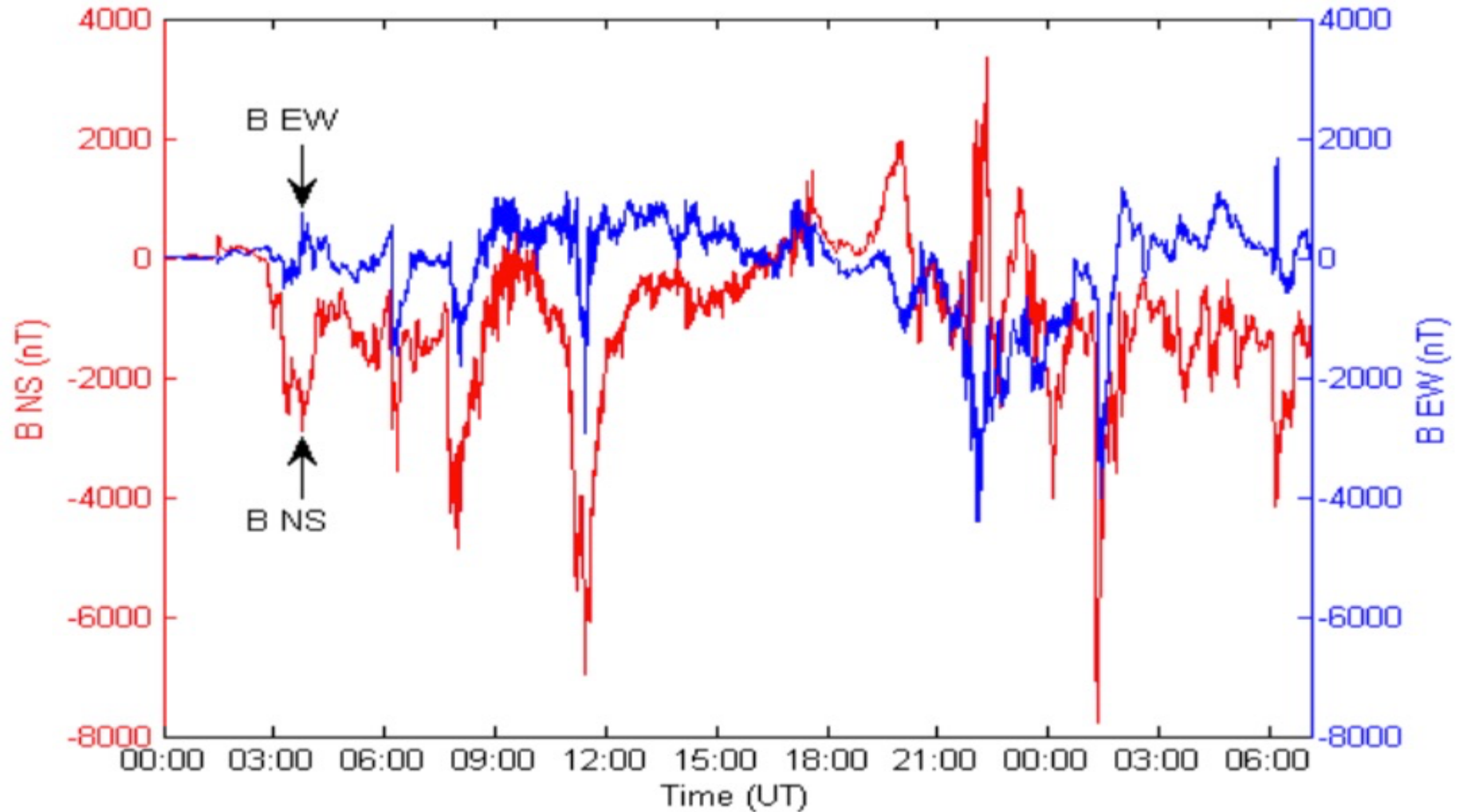


Figure 1: Benchmark Geomagnetic Field Waveshape
Red Bn (Northward), Blue Be (Eastward)

NERC Standards – Benchmark GMD

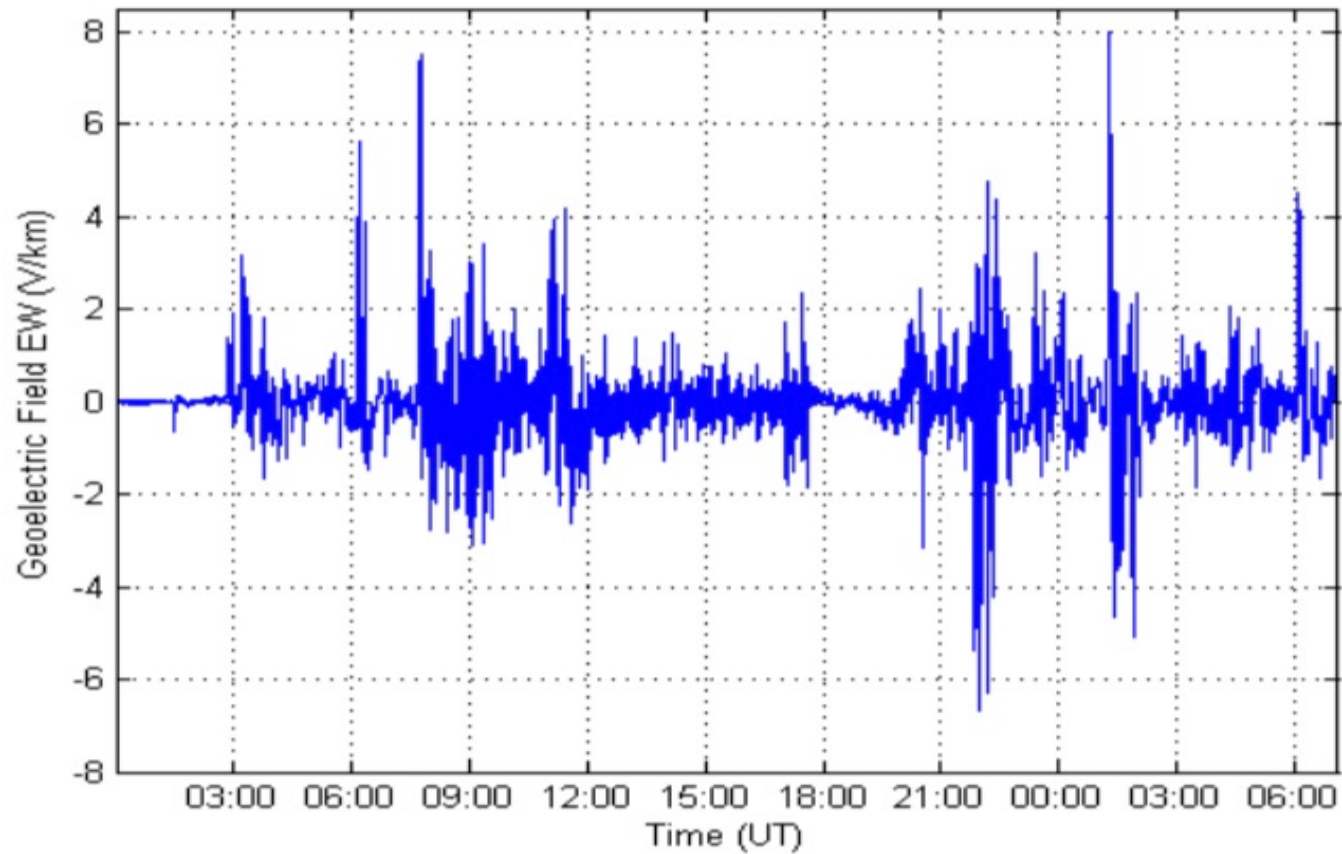


Figure 2: Benchmark Geoelectric Field Waveshape (E_E Eastward)

NERC Standards – EOP-010-1 GMD Operations

EOP-010-1 — Geomagnetic Disturbance Operations

A. Introduction

- 1. Title: Geomagnetic Disturbance Operations**
- 2. Number:** EOP-010-1
- 3. Purpose:** To mitigate the effects of geomagnetic disturbance (GMD) events by implementing Operating Plans, Processes, and Procedures.
- 4. Applicability:**
 - 4.1. Functional Entities:**
 - 4.1.1** Reliability Coordinator
 - 4.1.2** Transmission Operator with a Transmission Operator Area that includes a power transformer with a high side wye-grounded winding with terminal voltage greater than 200 kV
- 5. Background:**

Geomagnetic disturbance (GMD) events have the potential to adversely impact the reliable operation of interconnected transmission systems. During a GMD event, geomagnetically-induced currents (GIC) may cause transformer hot-spot heating or damage, loss of Reactive Power sources, increased Reactive Power demand, and Protection System Misoperation, the combination of which may result in voltage collapse and blackout.

NYSRC RR&CM C.4 Operation Prior to and During Extreme Weather Conditions and Solar

A. Reliability Rule

The *NYISO* shall maintain procedures and systems which allow for more stringent than normal operating restrictions prior to, and during severe weather conditions and solar magnetic *disturbances*.

1. Associated NERC and NPCC Standards and Criteria:

NERC EOP-001

NPCC Directory 2

2. Applicability: *NYISO*

B. Requirements

R1. Operation during Impending Severe Weather

During periods when severe weather (such as, but not limited to, tornadoes or hurricanes) exists or is forecast to occur, it may be necessary to take steps in addition to those procedures normally followed, to maintain system *security*. The *NYISO* shall enter this mode of operation for those portions of the *NYS Bulk Power System* affected by actual or impending severe weather when requested to do so by the affected *Transmission Owners*, or at any other times when it deems necessary to preserve the *security and reliability* of the *NYS Bulk Power System*.

R1.1 When a situation exists in which the effects of impending severe weather could severely jeopardize the *security* of the *NYS Bulk Power System*, corrective actions, which would be necessary to protect for one transmission *contingency* greater than the normal criteria within the affected area, shall be implemented.

R1.2 *Generation* may be ordered to full operating *capacity* and transmission facilities out of service for maintenance may be ordered restored to service.

NYSRC RR&CM C.4 Operation Prior to and During Extreme Weather Conditions and Solar Magnetic Disturbances

R2. Operation during a Severe Solar Magnetic Disturbance

During periods when a severe solar magnetic *disturbance* ("SMD") exists or is forecast to occur, it may be necessary for the *NYISO* and *Transmission Owners* to take steps in addition to those procedures normally followed to maintain system *security*. Such steps may include, but are not limited to, restoration of transmission facilities that are out of service, cancellation of scheduled outages, and adjustment of *reactive power* dispatch.

The *NYISO* shall enter this mode of operation for those portions of the *NYS Bulk Power System* affected by an SMD when requested to do so by the affected *Transmission Owners*, or at any other times when it deems necessary to preserve the *security* and *reliability* of the *NYS Bulk Power System*.

R3. The *NYISO* shall maintain procedures and systems which allow for more stringent operating restrictions prior to, and during, severe weather conditions and solar magnetic *disturbances*. The *NYISO* shall notify the *NYSRC* of any changes to these procedures and systems.