TRANSMISSION AND SUBSTATION DESIGN AND OPERATION SYMPOSIUM
UNIVERSITY OF TEXAS ARLINGTON

A Case Study of Geomagnetically Induced Current (GIC) Level from Neighboring System

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LUBBOCK POWER & LIGHT

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Outline

- Background
- Study Methodology & Assumptions
- GIC Study
- Summary of Findings
- Q & A

Study Objectives

- Case study is a Collaboration with Lubbock Power and Light (LP&L)'s system.
- LP&L's Objectives
  - Compliance with NERC TPL 007-1 Requirements R2 and R5
  - Apply NERC TPL-007-1 Application Guide to calculate GIC levels at the LP&L 230 kV Substation.
- To evaluate the impact of the neighboring system on the GIC levels.

Software → GIC Module of Siemens PTI's Power System Simulator for Engineers (PSS®E) software.

Background - NERC

NERC Standards: Develop Operating Procedure (EOP-010-1) and Assessment and Mitigation Strategies(**TPL-007-1**)

January 21, 2015, NERC filed a petition seeking FERC approval of proposed TPL-007-1 Standard.

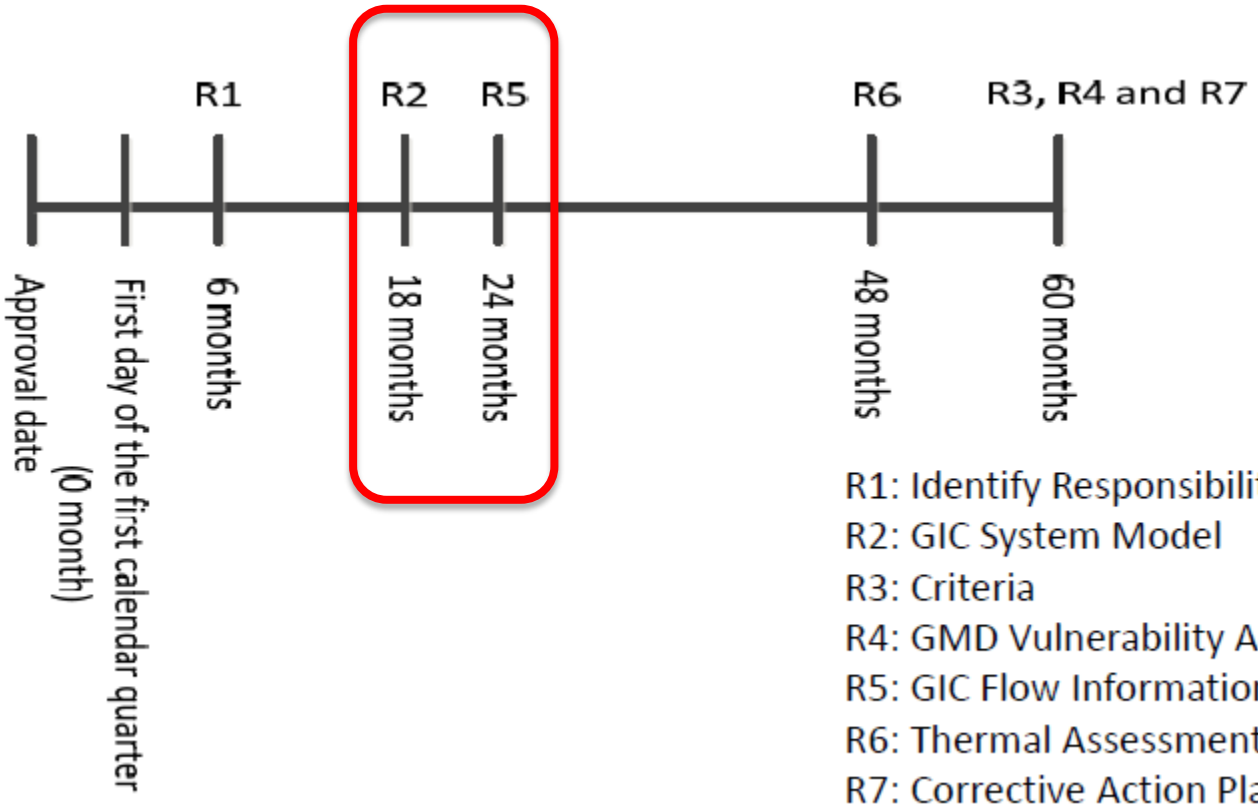
NERC TPL-007-1 Standard

"Purpose: Establish requirements for Transmission system planned performance during geomagnetic disturbance (GMD) events."

Requirements	Modeling	Neighboring Systems
• Seven Requirements • ***R2*** – GIC System Model • ***R5*** – GIC Flow Calculation	• Equivalent DC Model • Separate from AC Model • *PSS/E GIC Module*	• GIC Model Should Include Neighboring System • ***Impact of the Neighboring System?***

NERC TPL-007-1 Standard

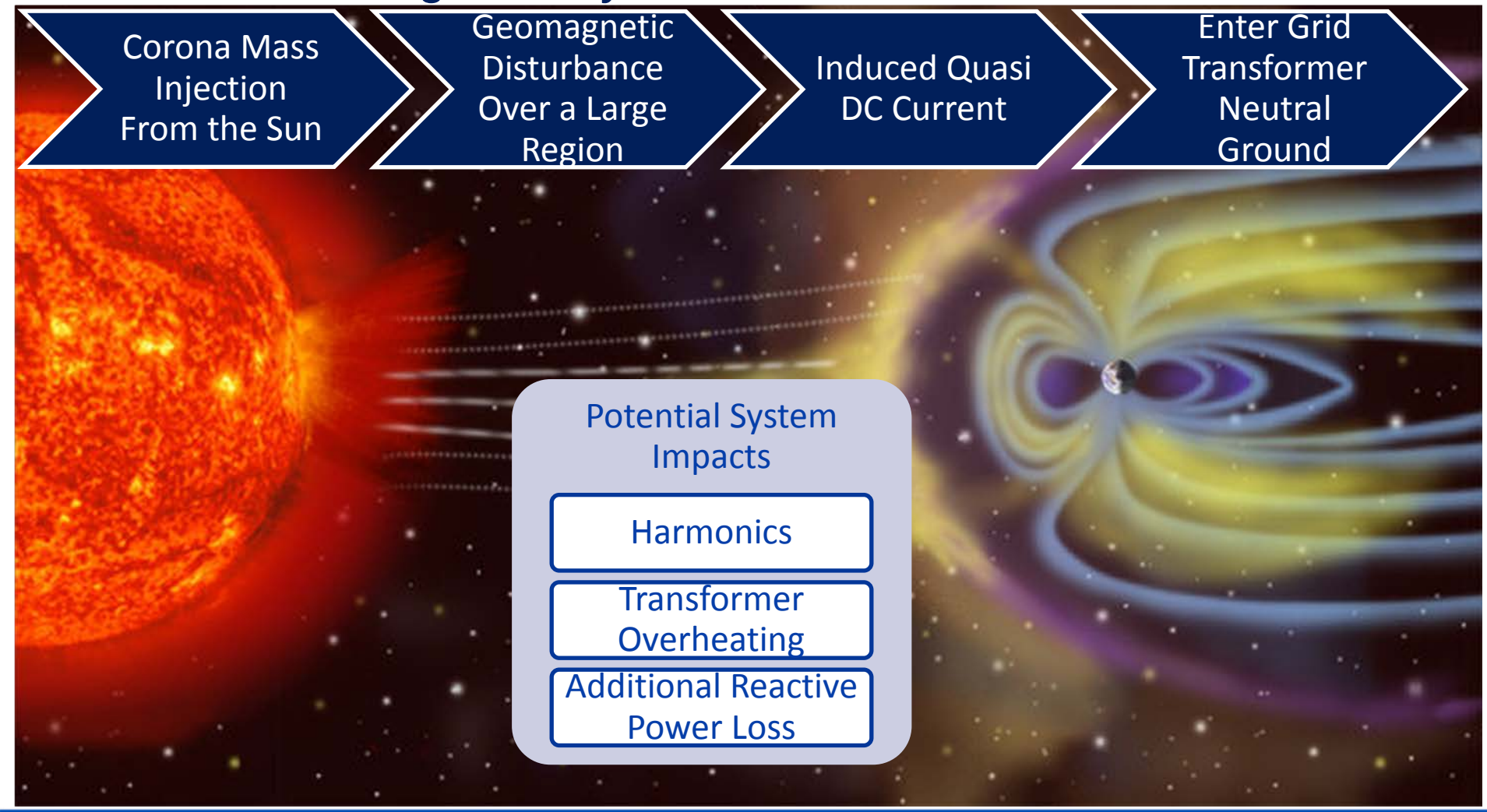
Summary of the Requirements



R1: Identify Responsibilities
R2: GIC System Model
R3: Criteria
R4: GMD Vulnerability Assessment
R5: GIC Flow Information
R6: Thermal Assessment
R7: Corrective Action Plan

Background – What is GIC?

GIC → Geomagnetically Induced Current

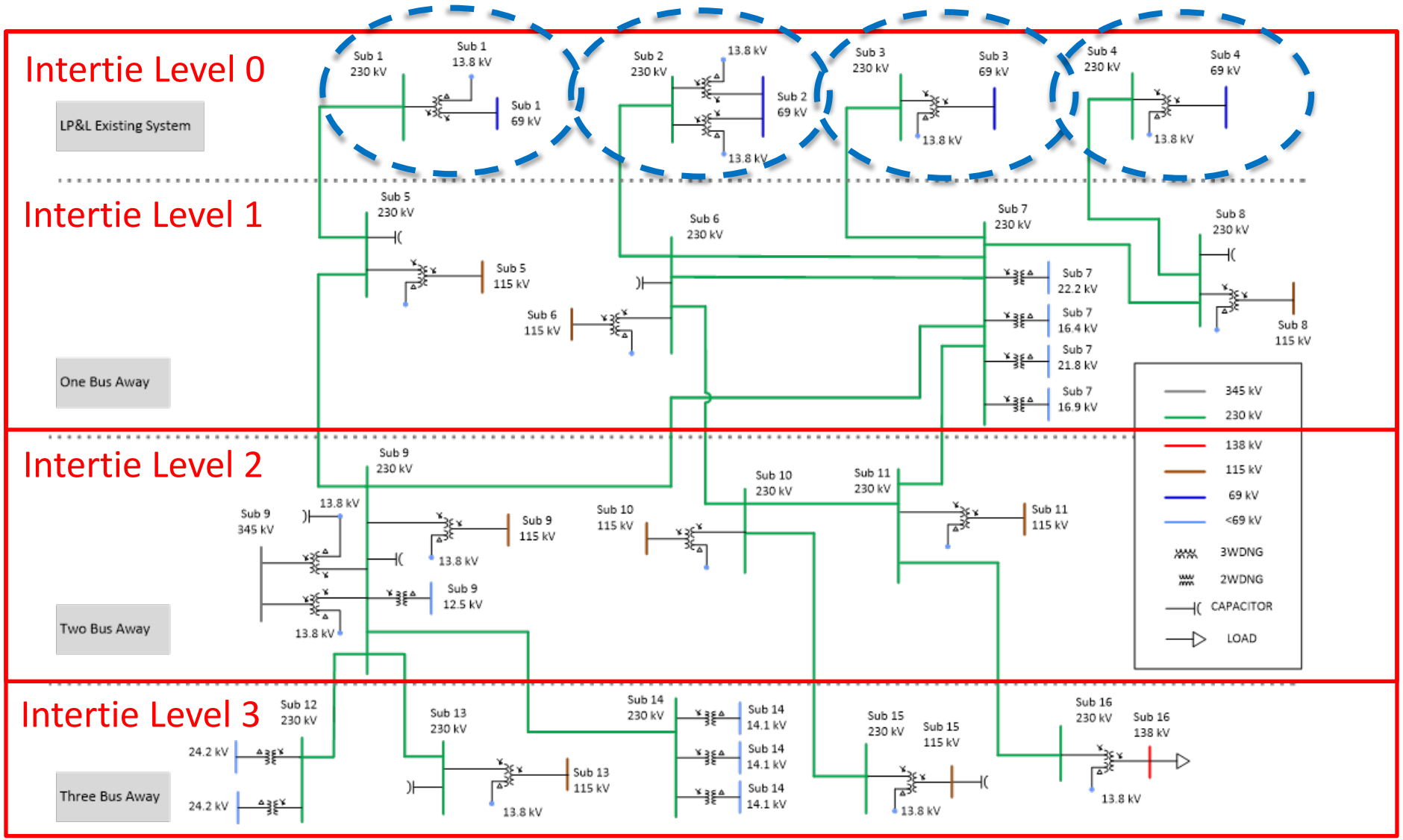


Study Methodology and Assumption

- *Definition: Intertie Level is the level up from subsystem tie buses.*
- Different boundaries of neighboring system (Intertie Levels 1, 2 and 3) were evaluated for GIC equivalent model and GIC calculation.
- PSS®E GIC Module assumes an open circuit beyond Intertie Level.
- Equivalent DC Model Data Assumptions

Data Item	LP&L System	Neighboring System
Transformer Winding	Test Report	PSS®E Load Flow Data
Transformer DC Resistance	Test Report	PSS®E Load Flow Data
Substation Grounding	Calculated	Assumed
Geographic Data	Public Information	Public Information
Earth Model	U.S. Geological Survey	U.S. Geological Survey

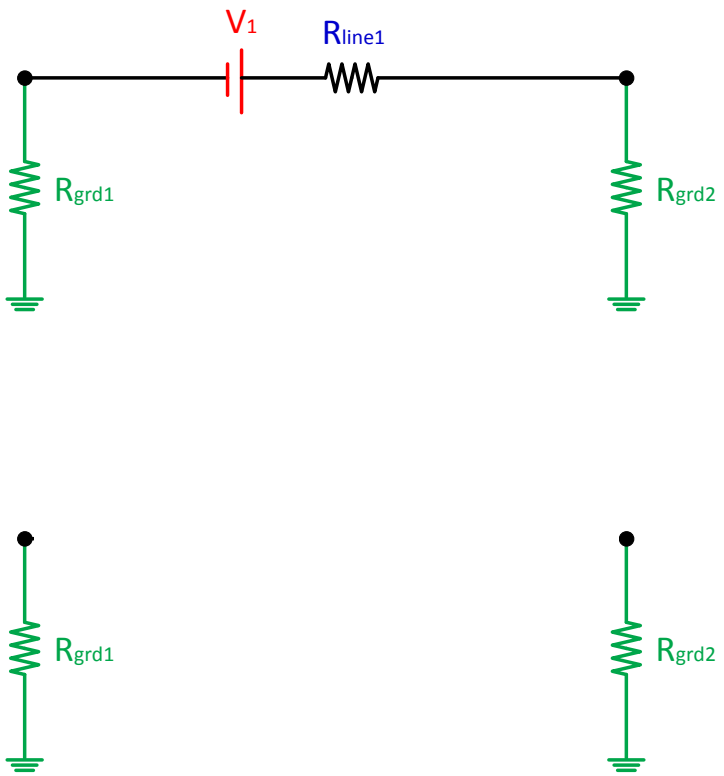
Study Area Diagram



GIC Study – Intertie Level 0

Intertie Level 0 refers to the subsystem being studied *without any external neighboring system* modeled.

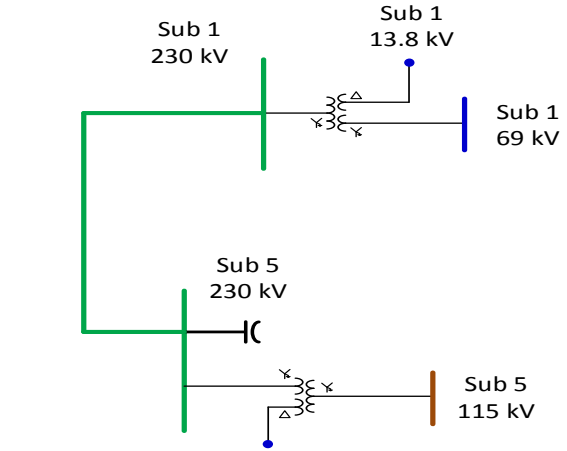
- The figure at right is a simplified model of the DC circuit used for GIC calculation.
- A voltage is applied on the transmission line which connects the two ground grid connections
- In this case study since there are *no transmission lines* connecting the substations in the study area, there will be *no GIC calculated.*

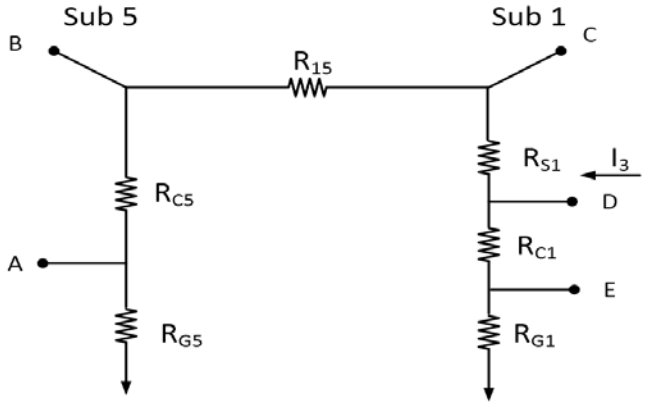


GIC Study – Intertie Level 1 (Sub 1)

Intertie Level 1 refers to the subsystem plus one bus level of the *external neighboring system*.

- The figure at right illustrates the Intertie Level 1 for Sub 1 and its full DC circuit model
- Since this circuit only connects Sub 1 to Sub 5, it exhibits a radial characteristic
- The ground currents shown represent the radial system

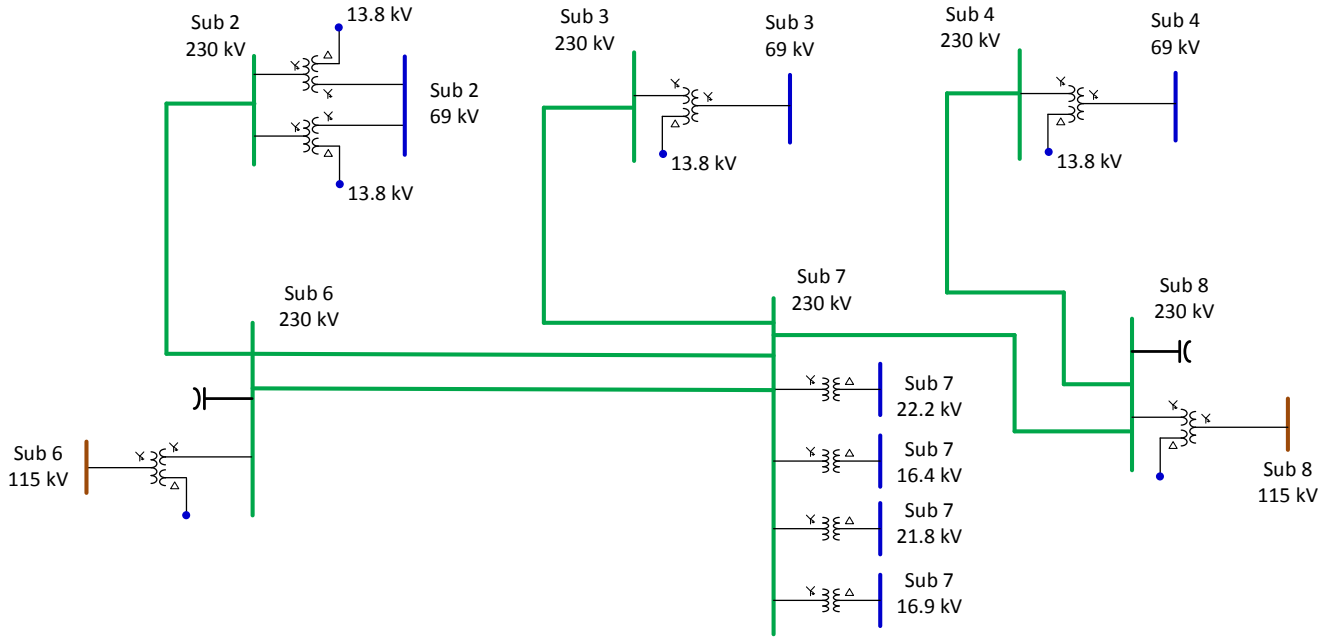




Substation	Current (A)
1	-0.1419
5	0.1419

GIC Study – Intertie Level 1 (Sub 2, 3 and 4)

- The figure below illustrates the Intertie Level 1 for Sub 2, 3 and 4.

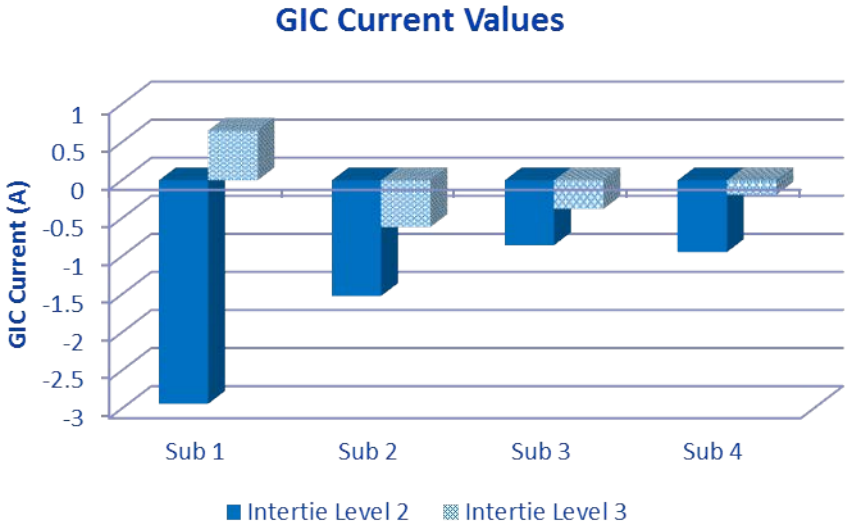


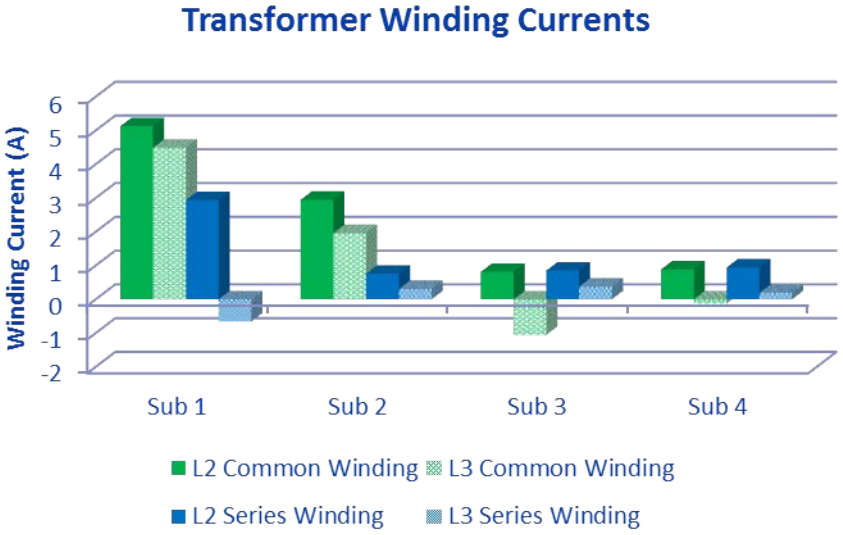
- At Intertie Level 1, the DC equivalent circuit is more complex than that of Intertie Level 0 and exhibits a highly meshed characteristic
- The ground currents shown represent the meshed system

Substation	Current (A)
2	8.285
3	-4.522
4	-1.072
6	-0.453
7	0
8	-2.239

GIC Study – Intertie Level 2 & 3

Intertie Levels 2 and 3 refer to the subsystem plus two and three levels of the *external neighboring system, respectively*.

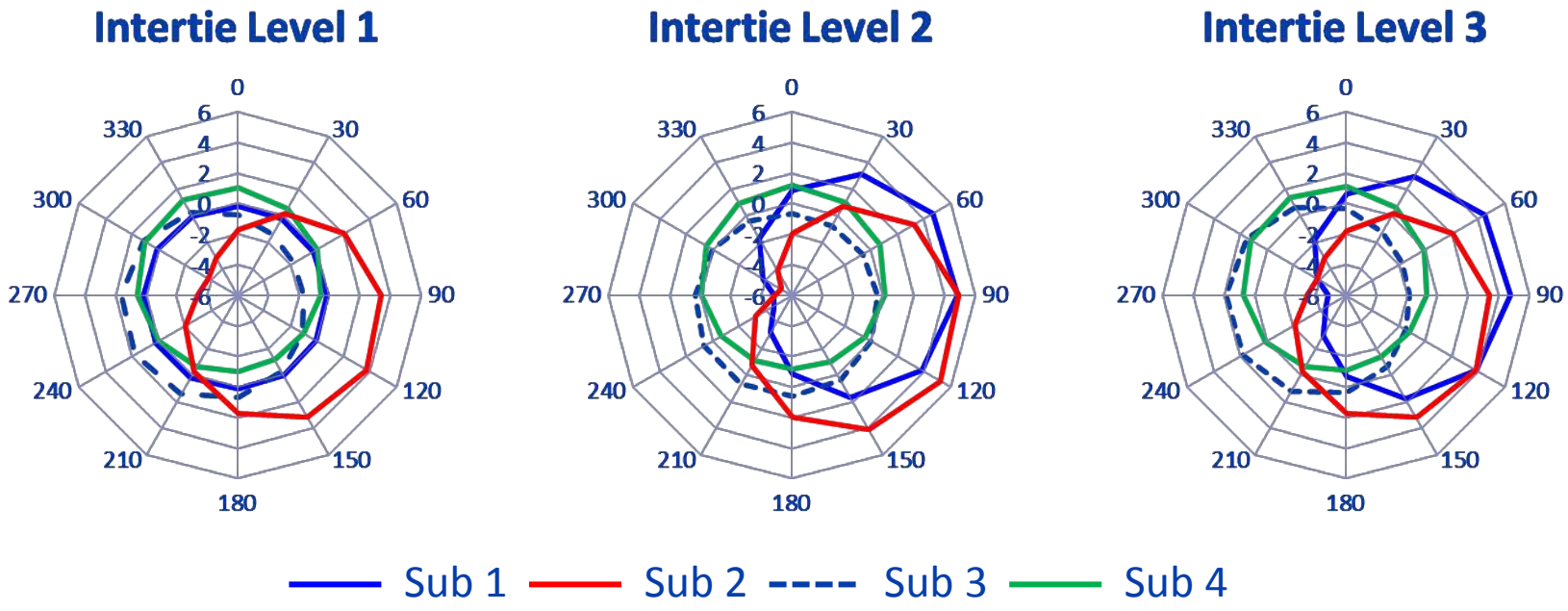




- As intertie levels are added the GIC values are seen leveling
- A more meshed characteristic of the equivalent DC circuit contributes to leveling
- This is most noticeable in the values for Sub 1

GIC Study – Effects of Intertie Level

Intertie Levels impact the characteristic of the DC equivalent model and this characteristic impacts the GIC response to the GMD event angle.

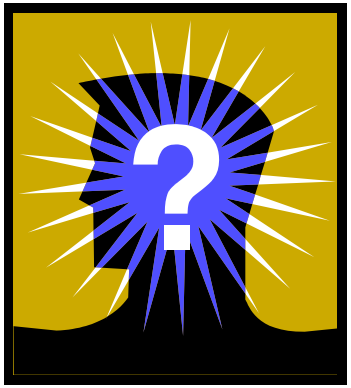


- *GIC responses* to GMD event angles begin *to settle as intertie levels increase.*
- The reason for this is that the *added intertie levels* are creating a *more meshed system* which has a *lower sensitivity* to the GMD event angle.

Summary of Findings

- Results show that the ***GIC will change*** when the equivalent DC model's ***characteristic changes from radial to meshed***.
- The impact on GIC is ***dependent*** on the transmission line orientation and the GIC flow from the neighboring substation when the ***DC model has a radial characteristic***.
- If the system is connected to a ***mesh network***, the ***sensitivity*** to each neighboring substation ***decreases***.
- Therefore, it ***is recommended*** that when setting the boundary of the neighboring system, ***the characteristic of the neighboring system*** (radial or meshed network) should be considered instead of setting a fixed boundary assumption.

Q & A



REFERENCES & ACKNOWLEDGEMENTS

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