Technical Challenges in the Scottish Hydro Electric (SHE) Transmission System

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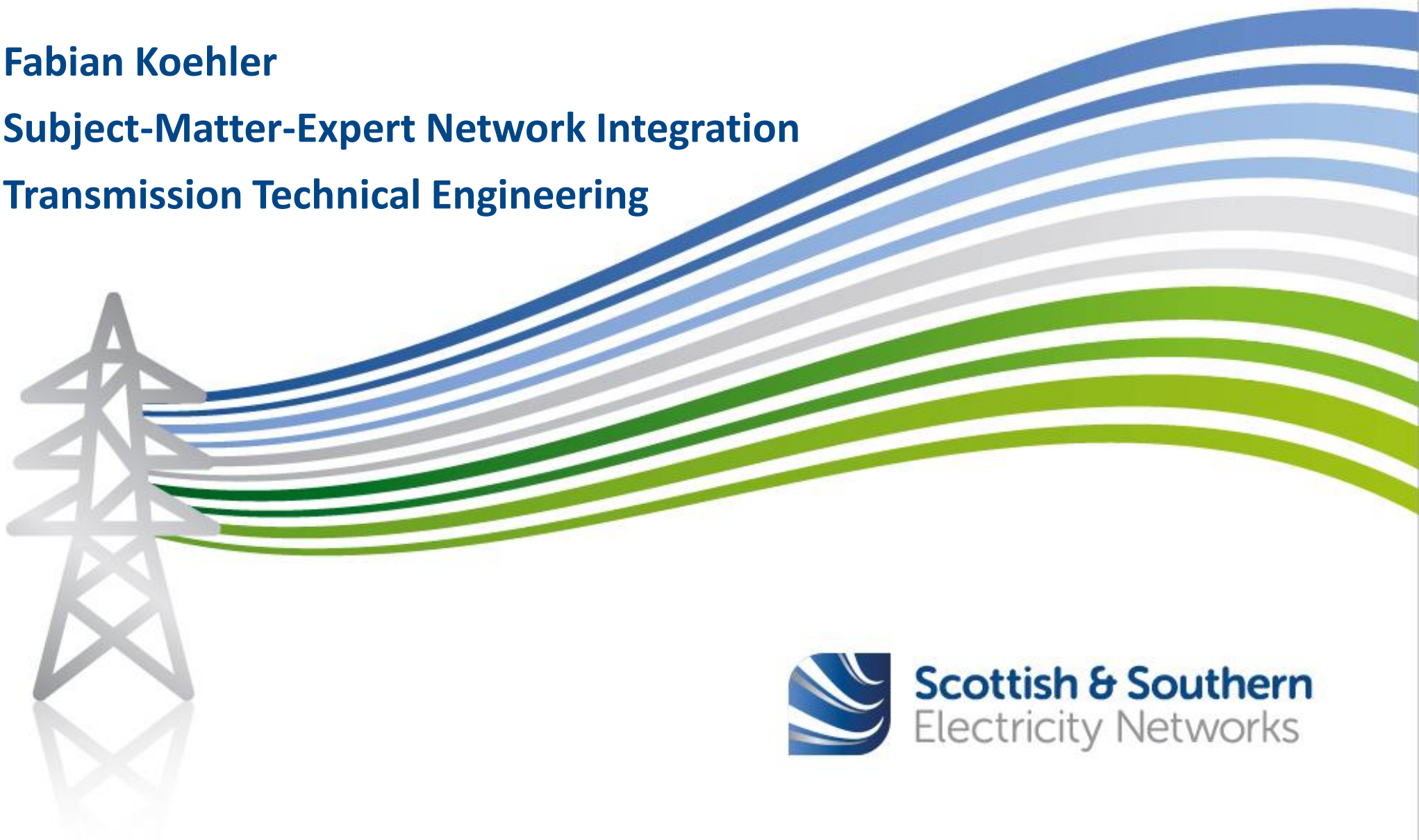
Subject-Matter-Expert Network Integration

Transmission Technical Engineering



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Content

- Why does SHE Transmission face challenges ?
- Challenge in Growth of Network into Remote Areas - Earthing of Transmission Lines
- Challenge in Growth of Network into Remote Areas - Low Short-Circuit Power
- Challenge in Upgrade of the existing transmission system – Reconductoring of OHLs
- Challenge in future-proving of the transmission system – Reactive Compensation

Why does SHE Transmission face challenges ?

- Growth of network into remote areas
  - Earthing of transmission lines
  - Cables instead of overhead lines (OHLs)
  - Low short-circuit power
- Upgrade of the existing transmission system
  - Replacement of ‘traditional’ 132kV OHLs
  - Reconductoring of OHLs
  - Introduction of HVDC
- Future-proofing of the transmission system
  - Voltage/frequency/short-circuit support of the transmission system
  - Need for static and dynamic reactive compensation
  - Alternatives for conventional synchronous generation in the transmission system

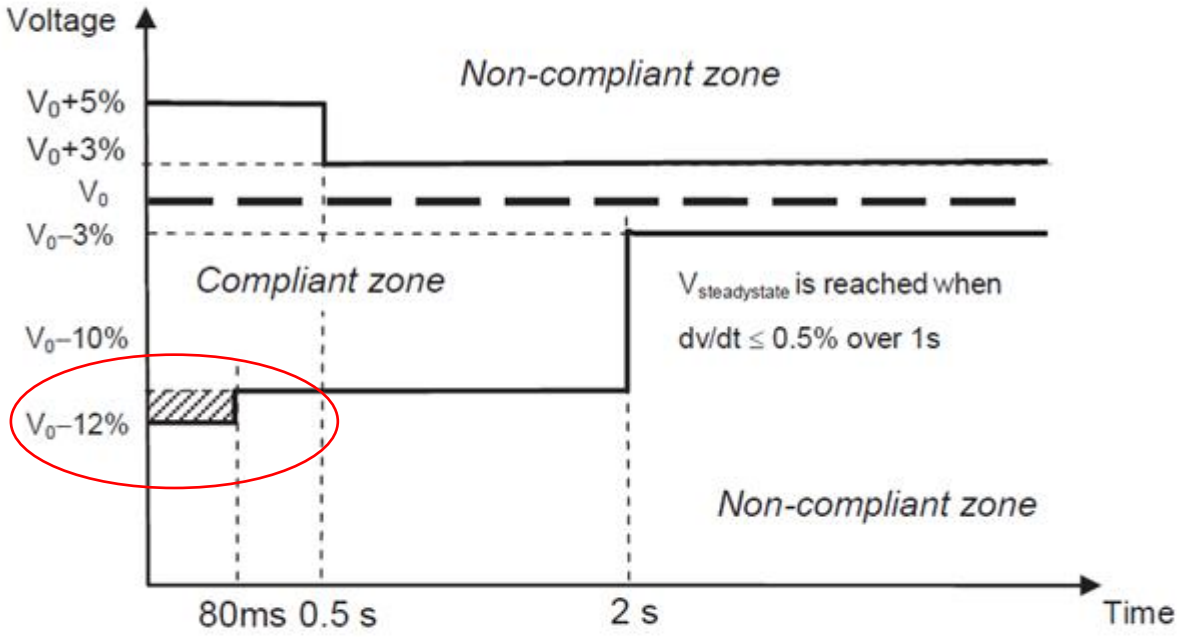
Challenge in Growth of Network into Remote Areas - Earthing of Transmission Lines

- Lightning protection vs ground potential rise (GPR)
- Footing resistance a measure for both?
- Cost-Benefit of specific earthing measures

(more in paper 537 - Analysis of Flashover Mitigation Measures to Improve the Lightning Performance of Transmission Lines)

Challenge in Growth of Network into Remote Areas - Low Short-Circuit Power

- Compliance with SQSS Requirements during transformer energisation



SQSS requirements: Time and magnitude limits for a category 3 rapid voltage change

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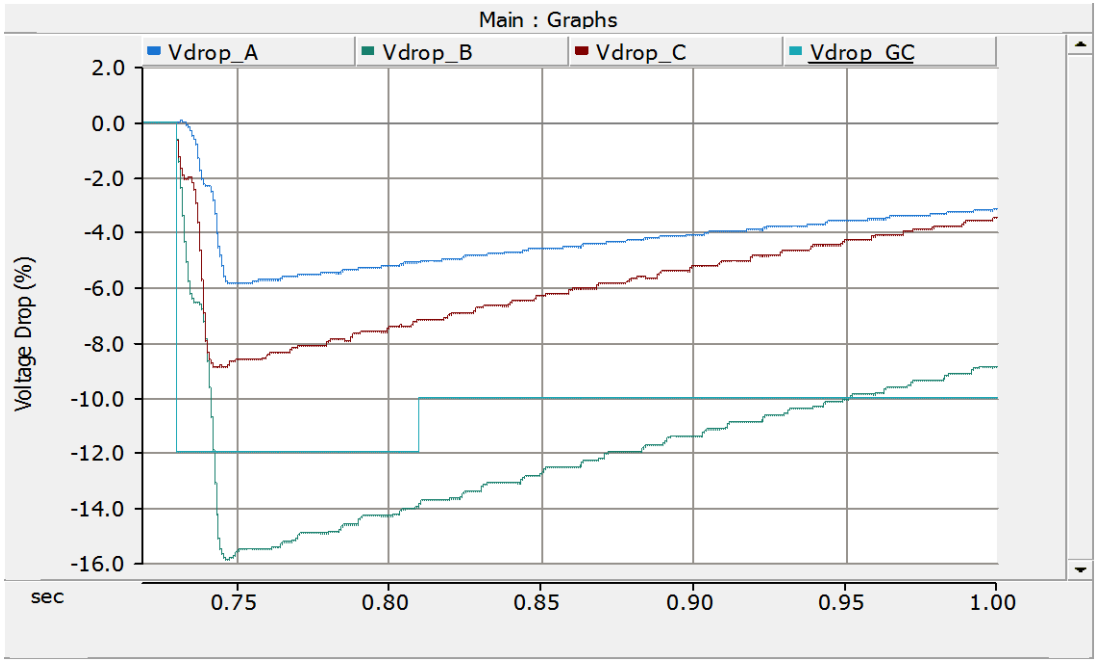
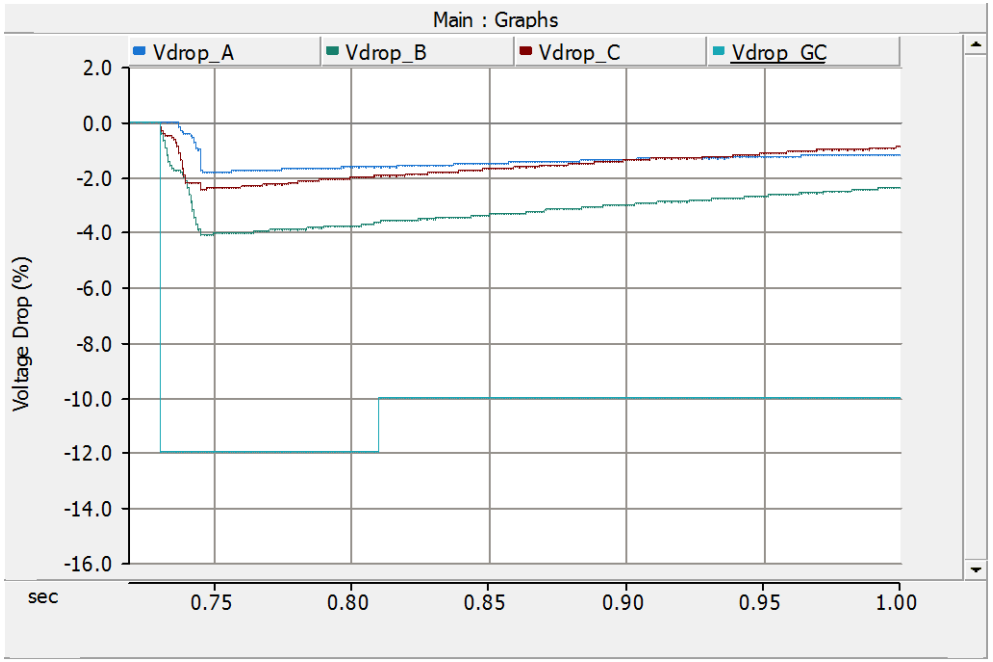
Challenge in Growth of Network into Remote Areas - Low Short-Circuit Power

- Most onerous conditions with Super-Grid-Transformers (SGT) of higher rating (240/360/480 MVA)





Transformer Energisation with various short-circuit power, no controlled switching

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Challenge in Growth of Network into Remote Areas - Low Short-Circuit Power

- Solution: Point-on-Wave relay to control switching
- Most onerous conditions with SGTs during commissioning at network states with minimum short-circuit power
- Co-ordination between Transmission Planning/Engineering/Operations to reduce impact on network

ABB Buyer's and Application Guide

Challenge in Upgrade of the existing transmission system – Reconductoring of OHLs

- Standards not applicable to OHL arrangements, E.g. "*IEC 62271-102 for High-voltage switchgear and control gear — Part 102: Alternating current disconnectors and earthing switches*"

Table C.1 – Standardized values of rated induced currents and voltages for earthing switches

Rated voltage U_r kV	Electromagnetic coupling				Electrostatic coupling			
	Rated induced current A (r.m.s.)		Rated induced voltage kV (r.m.s.)		Rated induced current A (r.m.s.)		Rated induced voltage kV (r.m.s.)	
	Class		Class		Class		Class	
	A	B	A	B	A	B	A	B
145	50	80	1	2	0,4	2	3	6
300	80	160	1,4	10	1,25	10	5	15
420	80	160	2	10	1,25	18	5	20

Excerpt of Table C1. IEC 62271-102

Challenge in Upgrade of the existing transmission system – Reconductoring of OHLs

Higher earthing switch duty at maximum line capacity

- Increased wear of contacts
- Reduced number of operations

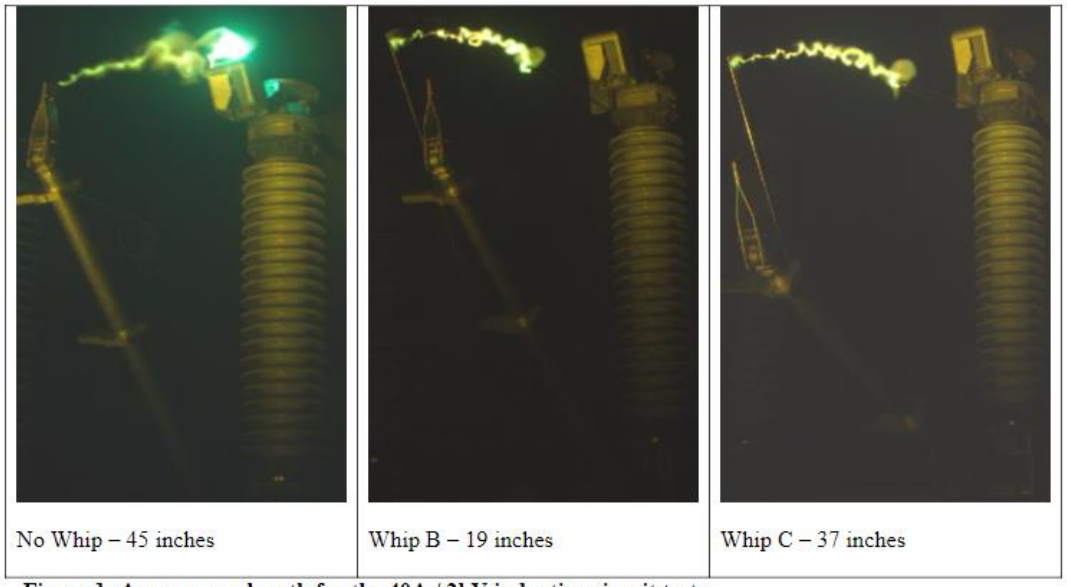

Figure 1: Average arc length for the 40A / 2kV inductive circuit tests

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Challenge in Upgrade of the existing transmission system – Reconductoring of OHLs

- SHE Transmission Specification for Disconnectors, Earth Switches and the Provision for Portable Earthing within Substations at 66kV and, "*SP-PS-401*"

"10.2 As specified in IEC 62271 – 102, depending upon the severity of the switching duty, earth switches may require induced current and voltage ratings and are divided into class A and B. Deviating from current ratings specified in IEC 62271 – 102, class B earth switches shall be rated for an electromagnetic coupling current of

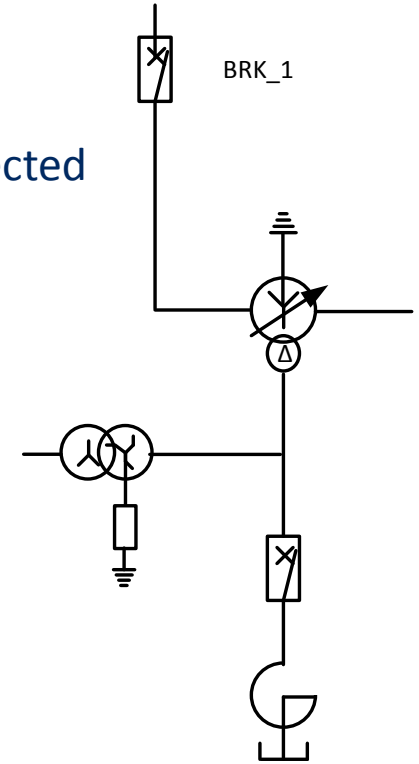
- 100A rms, rated for a voltage of 132kV,
- 200A rms, rated for a voltage of 275kV,
- 400A rms, rated for a voltage of 400kV.

10.3 All line earth switches shall be class B with deviations listed in section 10.2. All other switches may be class A."

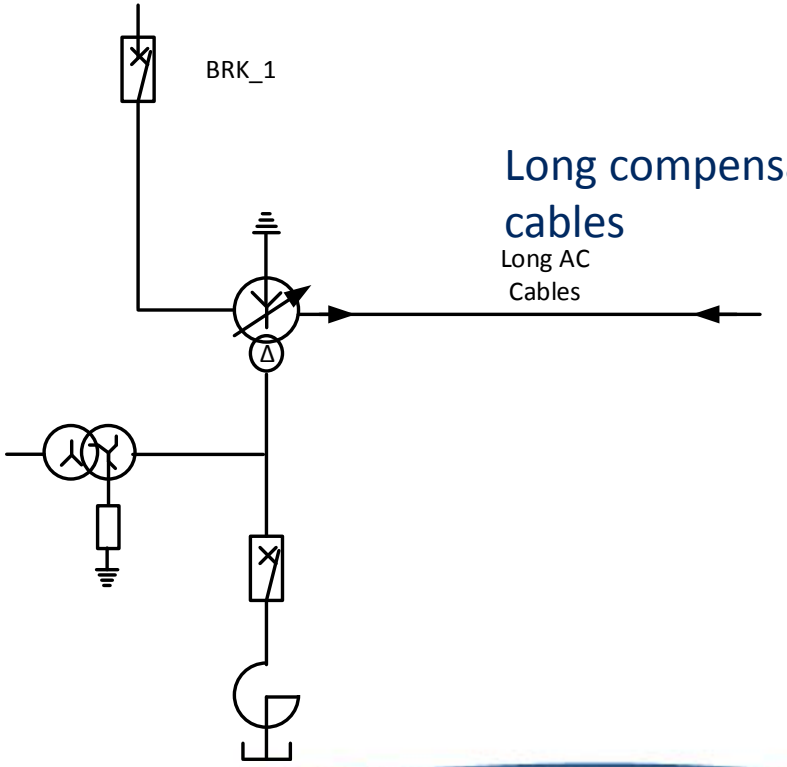
Challenge in future-proving of the transmission system – Reactive Compensation

- Current Zero-Missing Phenomenon

Tertiary connected shunt reactor



Long compensated cables



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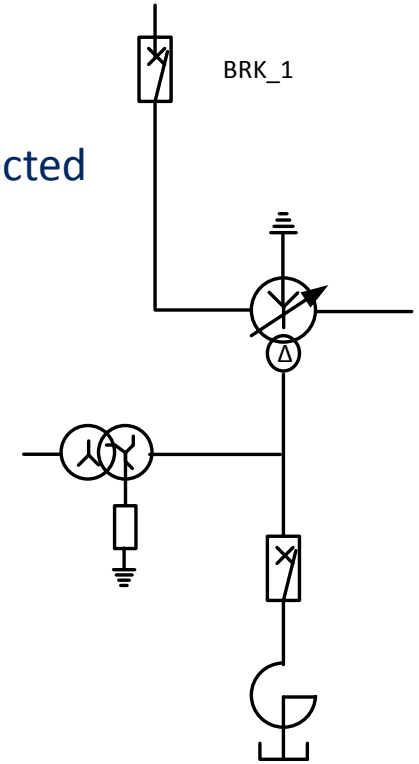
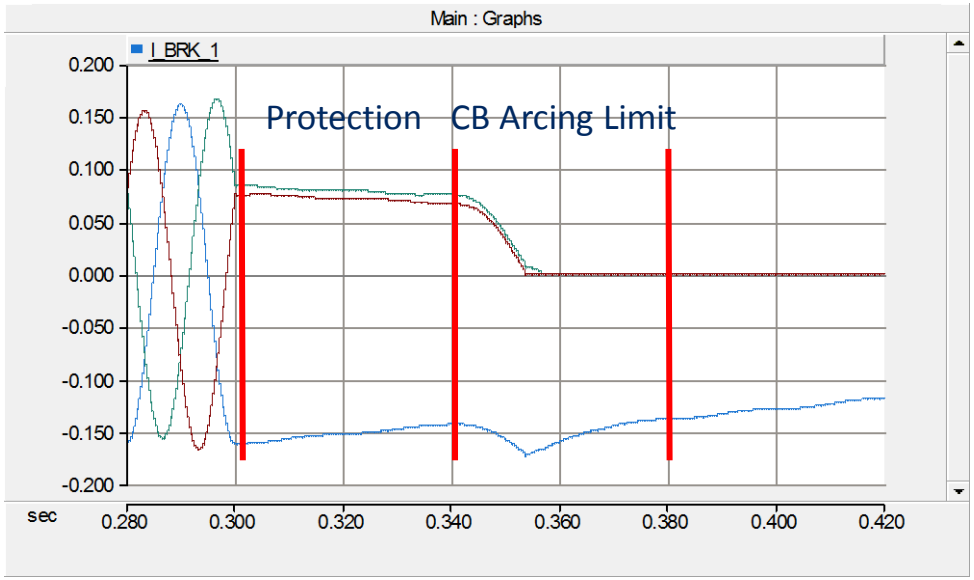
Challenge in future-proving of the transmission system – Reactive Compensation

- Current Zero-Missing Phenomenon

Tertiary connected shunt reactor





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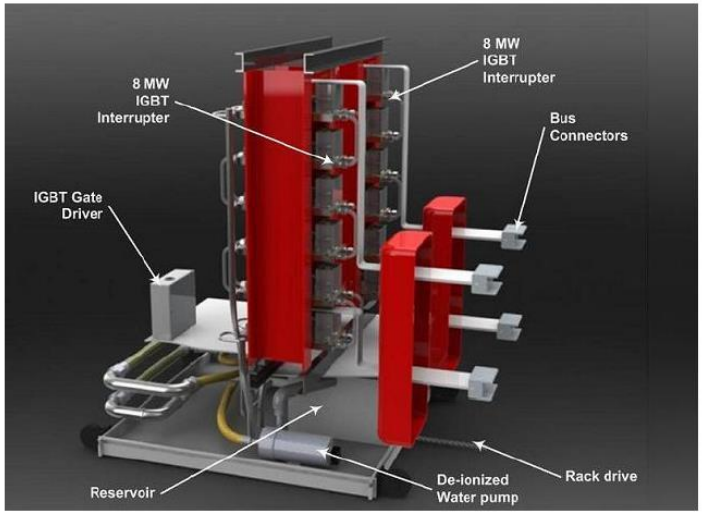
Challenge in future-proving of the transmission system – Reactive Compensation

- Current Zero-Missing Phenomenon Solutions
  - CB open delay
  - Provide AC short-circuit contribution
  - New CB technology



"Solid-State circuit Breaker for Medium Voltage DC Power, DivTecs

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Any Additional Questions?

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