Grid Code Workshop
Fault Ride Through – Background

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Background to Fault Ride Through

- Introduced following the introduction of Power Park Modules in June 2005
- Additional clarifications introduced in April 2008
- Why Fault Ride Through performance is required
- Onshore Grid Code Requirements
  - Faults up to 140ms in duration
  - Voltage dips in excess of 140ms in duration
- Issues

Ride Through Capability
Introduction

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- Introduced into the Grid Code in June 2005 following consultation H/04
- Justification and need for the fault ride through covered in Section 5.1 - Appendix 2 of the H/04 Consultation Document available at:-
  - http://www.nationalgrid.com/NR/rdonlyres/3DD7D7C7-6460-4257-BF99-E168D794C13E/7027/aacp_h04.pdf
- Applies to Synchronous and Asynchronous Generating Plant

Ride Through Capability
Introduction

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- Fault Ride Through is a requirement necessary for Generators to remain connected to healthy circuits until the faulted element of plant and Apparatus has been cleared from the Transmission System
- If Fault Ride Through Capability is not installed, Generation would be susceptible to tripping when subject to a voltage dip (below 90% of nominal) even when connected to a healthy circuit for less than normal protection operating times (eg 80ms or 100ms).
- If left unchecked the consequences would be significant loss of Generation, frequency collapse followed by a Blackout.
- Initially identified as an issue with Wind Generation employing Power Electronic Converters but the concept equally applies to all Generation Types

Fault Ride Through Capability
Voltage Dip Propagation - The Wash

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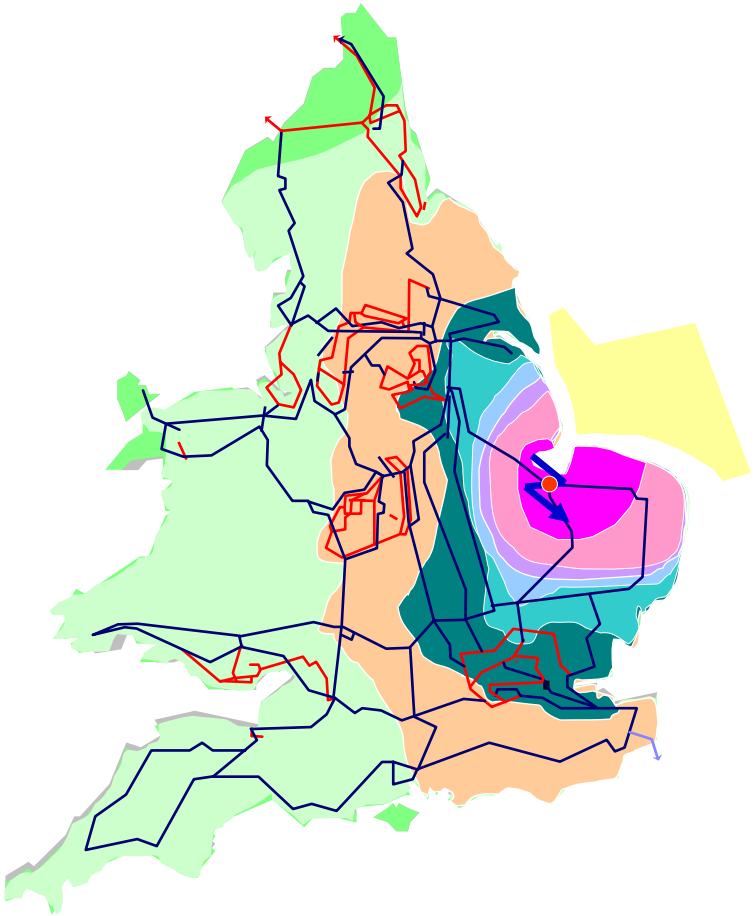

3 phase fault a Walpole 400 kV substation

- Fault Location 0 % Volts
- 0 - 15 % Volts
- 15 - 30 % Volts
- 30 - 40 % Volts
- 40 - 50 % Volts
- 50 - 60 % Volts
- 60 - 70 % Volts
- 70 - 80 % Volts
- 80 - 90 % Volts

Fault Ride Through

Protection Operation under Fault Conditions (1)

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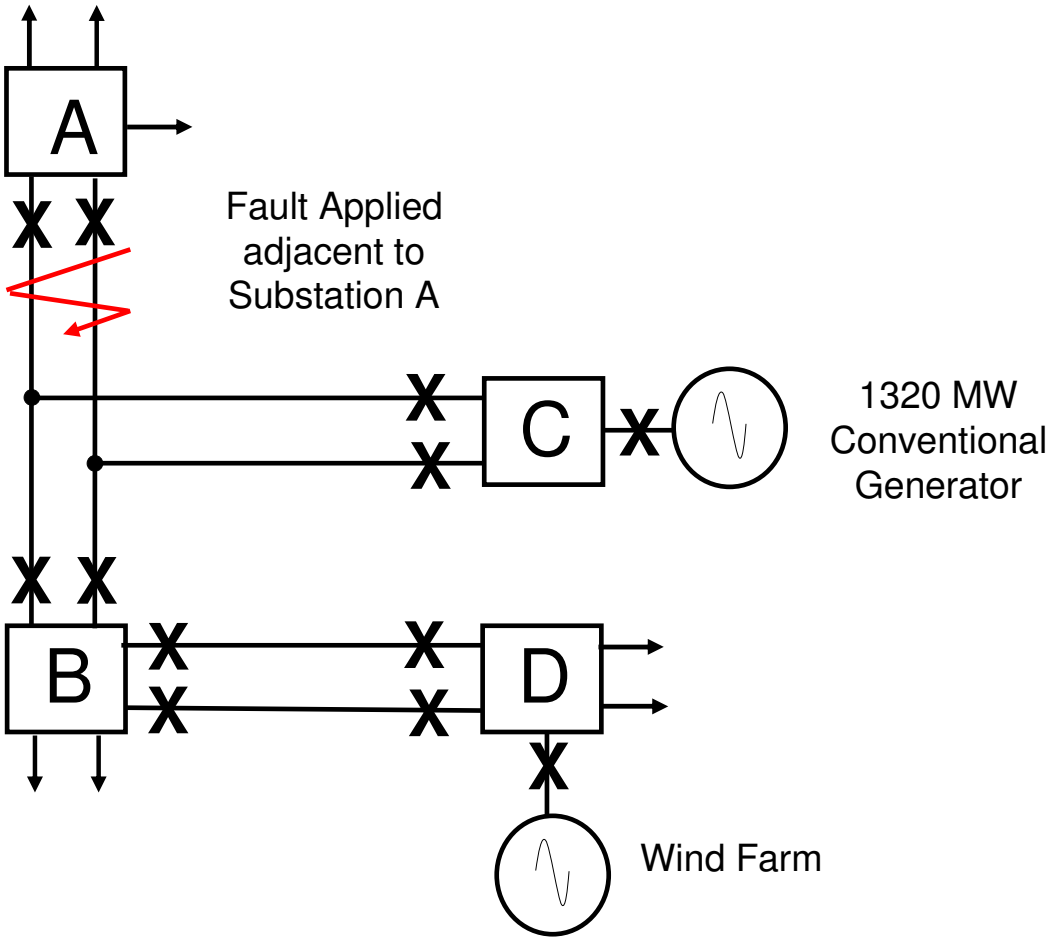
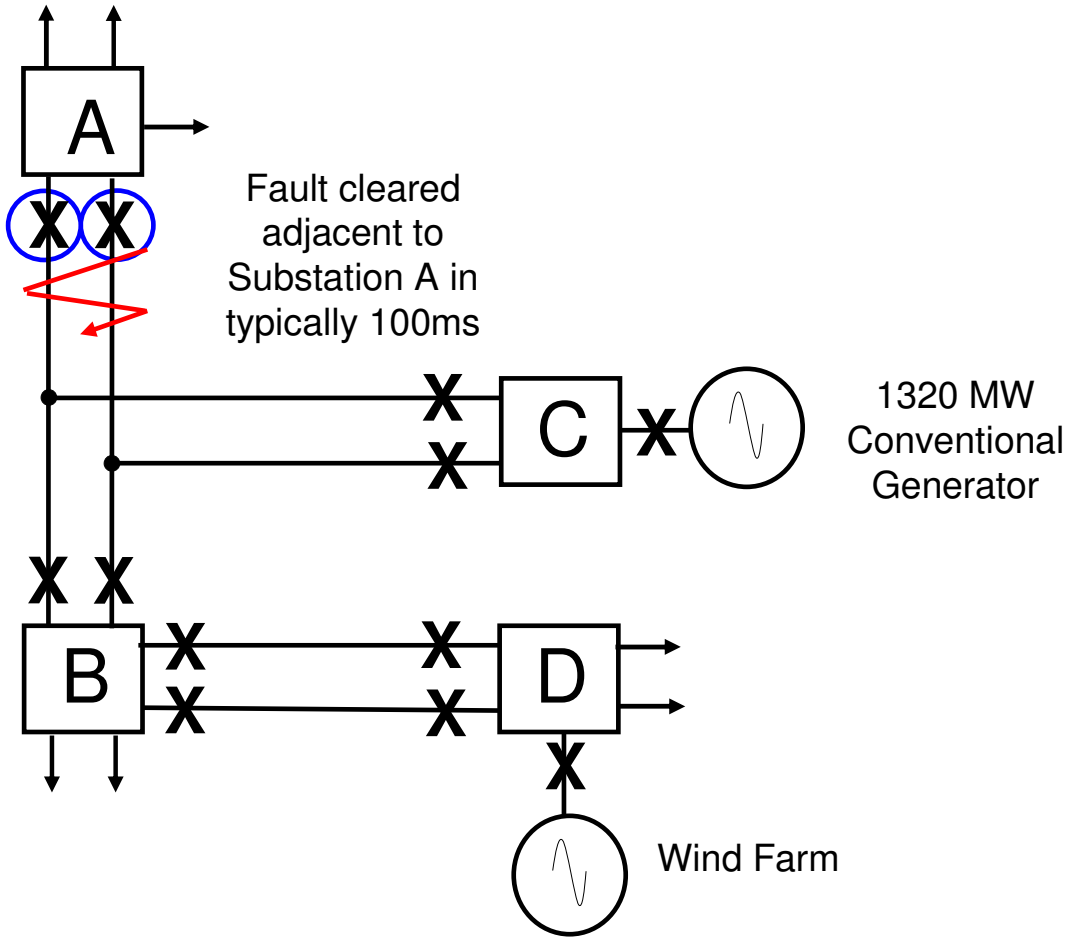
Low voltage seen across all parts of the Network



Fault Ride Through

Protection Operation under Fault Conditions (2)



Fault Ride Through

Protection Operation under Fault Conditions (3)

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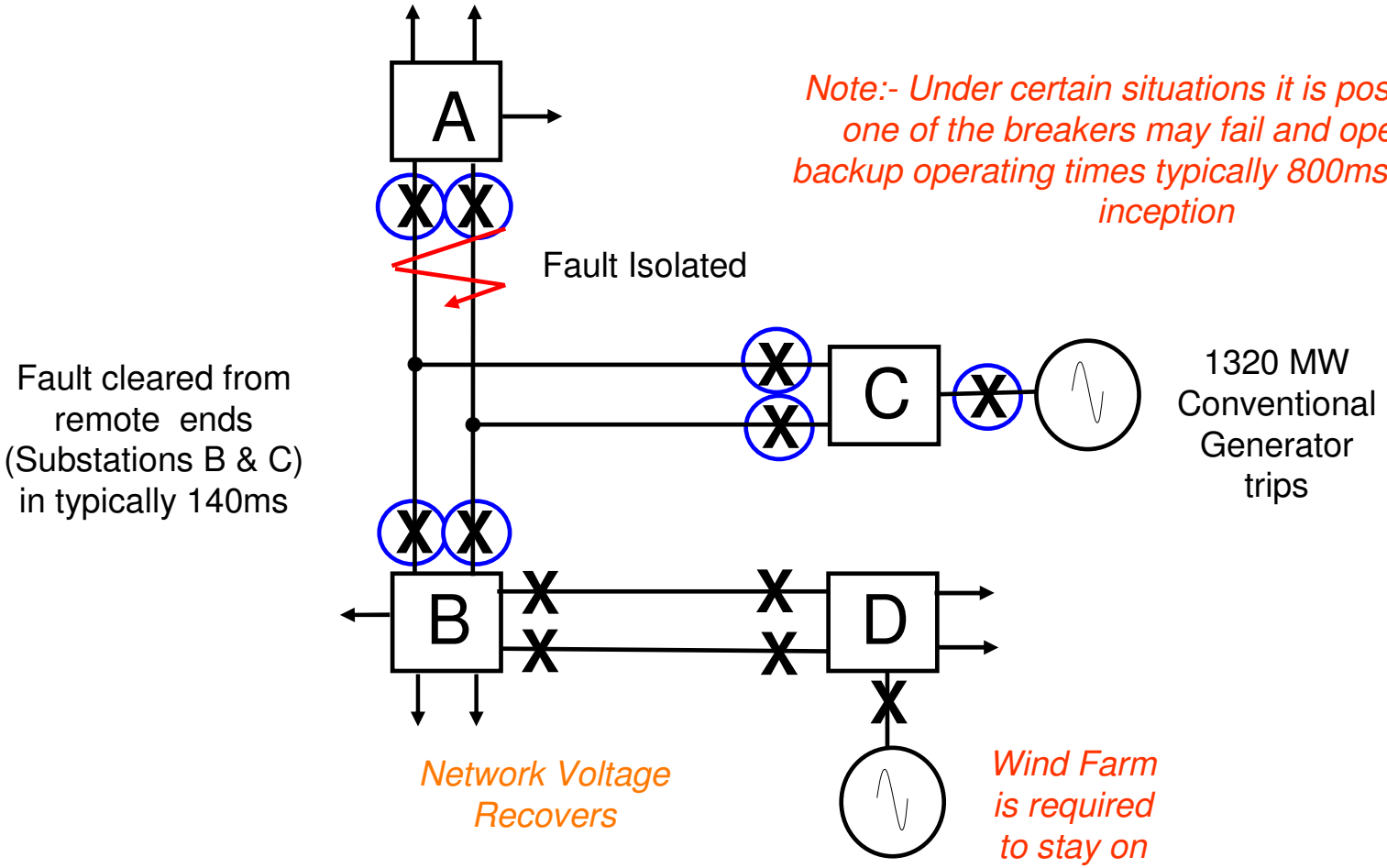

Note:- Under certain situations it is possible that one of the breakers may fail and operate in backup operating times typically 800ms after fault inception

Retained Voltage in a Wind farm during a Transmission System Fault

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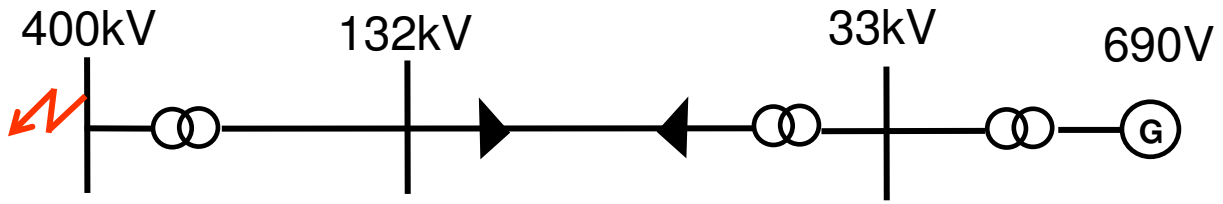

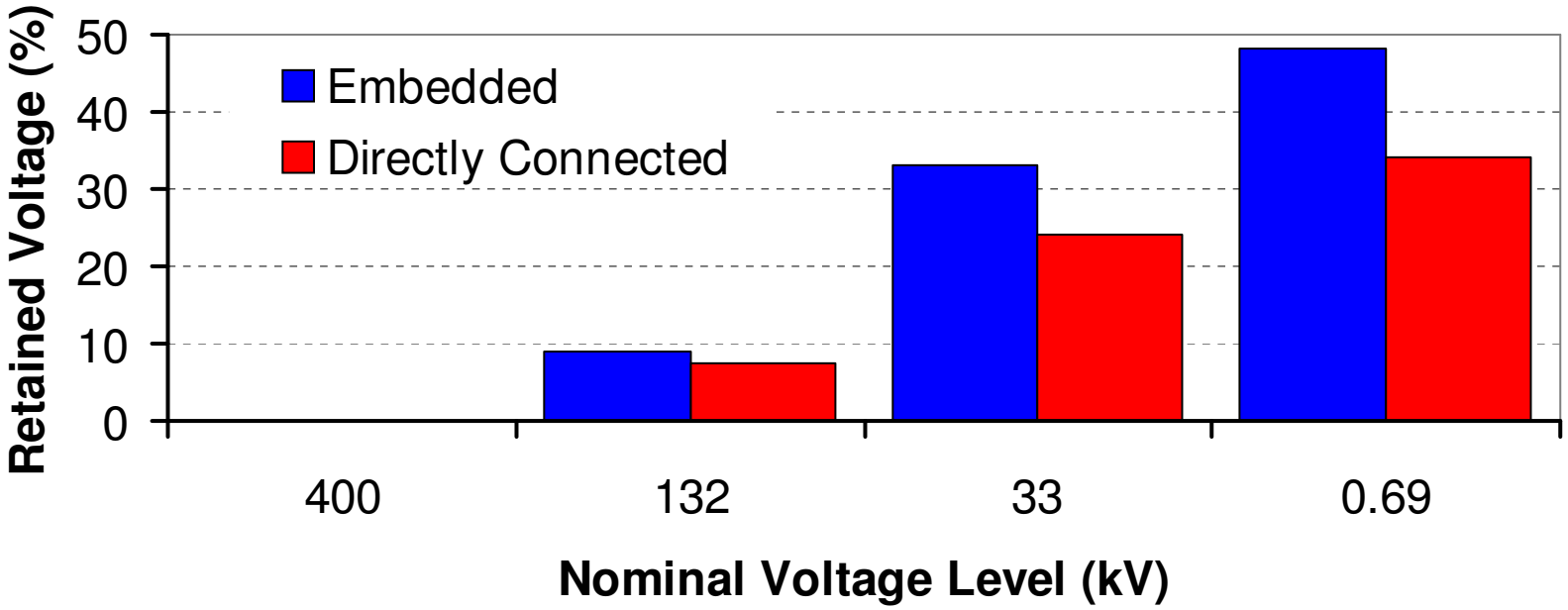

Ride Through Capability (CC.6.3.15)

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- Under the Grid Code fault ride through defines:
  - The requirements for Generating Plant to remain connected and stable for balanced and unbalanced faults up to 140ms in duration (CC.6.3.15.1(a)).
  - The requirements for Generating Plant to remain connected and stable for balanced voltage dips in excess of 140ms (CC.6.3.15.1(b)).

Ride Through Capability
Faults up to 140ms in duration (CC.6.3.15.1(a))

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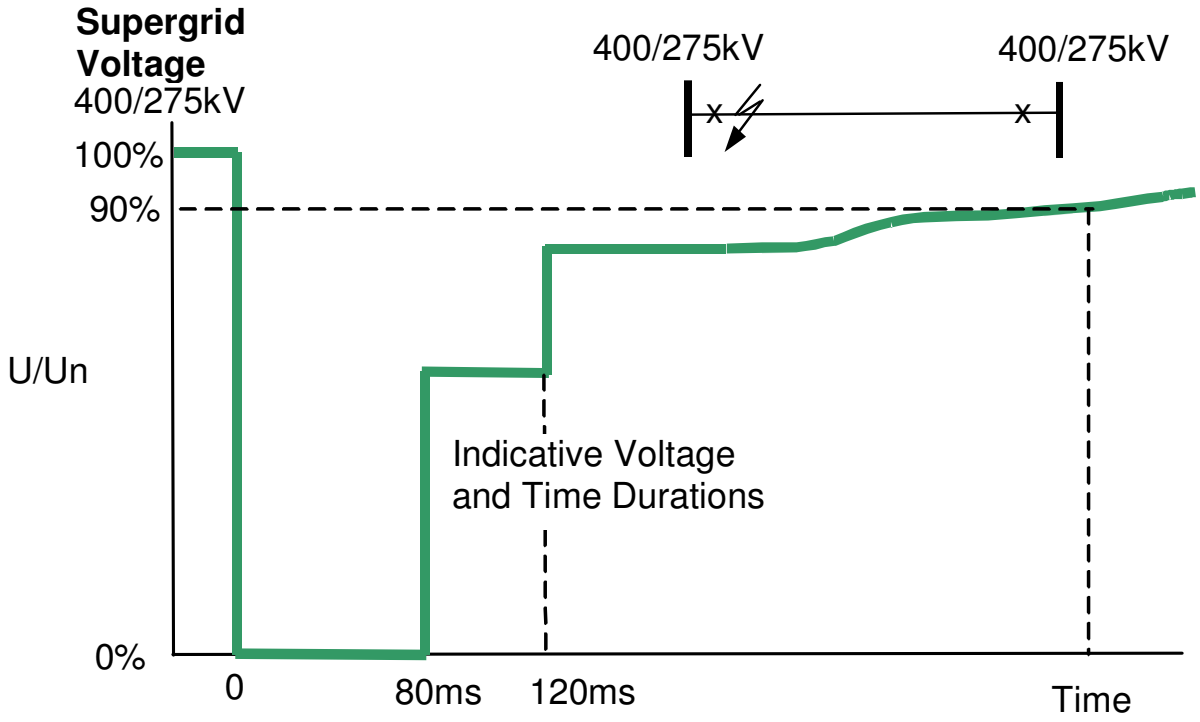
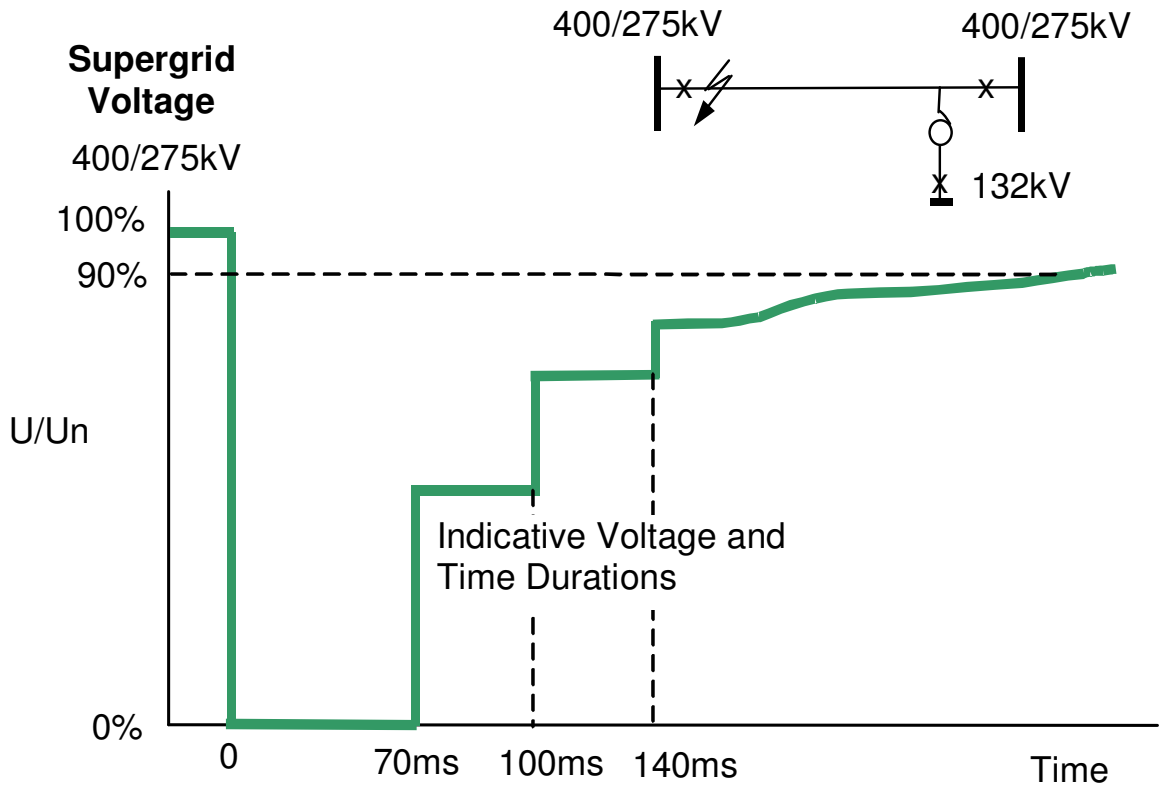
- Generating Units and Power Park Modules are required to remain stable and connected for any balanced or unbalanced fault on the Transmission System operating at 200kV or above and lasting for up to 140ms.
- Each Generating Unit and Power Park Module is required to generate maximum reactive power without exceeding its transient rating limit.
- Active Power output should be restored to at least 90% of the level available immediately before the fault and within 0.5 seconds of restoration of the voltage at the Connection Point
- Active Power Oscillations are acceptable provided:-
  - The total energy delivered during the period of the oscillations is at least that if the Active Energy was constant and
  - The Oscillations are adequately damped
- Examples provided in Connection Conditions – Appendix 4.

Faults up to 140ms in duration
Two Ended Circuit *(CC – Appendix 4A)*



Typical fault cleared in less than 140ms: 2 ended circuit

Faults up to 140ms in duration
Three Ended Circuit *(CC – Appendix 4A)*



Typical fault cleared in 140ms:- 3 ended circuit

Voltage Dips in excess of 140ms in duration (CC.6.3.15.1(b))

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- Generating Units and Power Park Modules are required to remain stable and connected for any balanced Supergrid voltage dips on the Onshore Transmission System anywhere on or above the heavy black line shown in Figure 5 of the Grid Code (see next slide).
- Each Generating Unit and Power Park Module is required to generate maximum reactive power without exceeding its transient rating limit.
- Active Power output should be supplied at least in proportion to the retained balanced voltage at the Connection Point
- Restore Active Power output following Supergrid Voltage dips on the Onshore Transmission System within 1 second of restoration of the voltage at the Connection Point to at least 90% of the Active Power available before the voltage dip unless there has been reduction in the intermittent power source, during the period of the voltage dip.
- Active Power Oscillations are acceptable provided:-
  - The total energy delivered during the period of the oscillations is at least that if the Active Energy was constant and
  - The Oscillations are adequately damped

Voltage Duration Curve

Post 140ms Faults – CC.6.3.15 Figure 5

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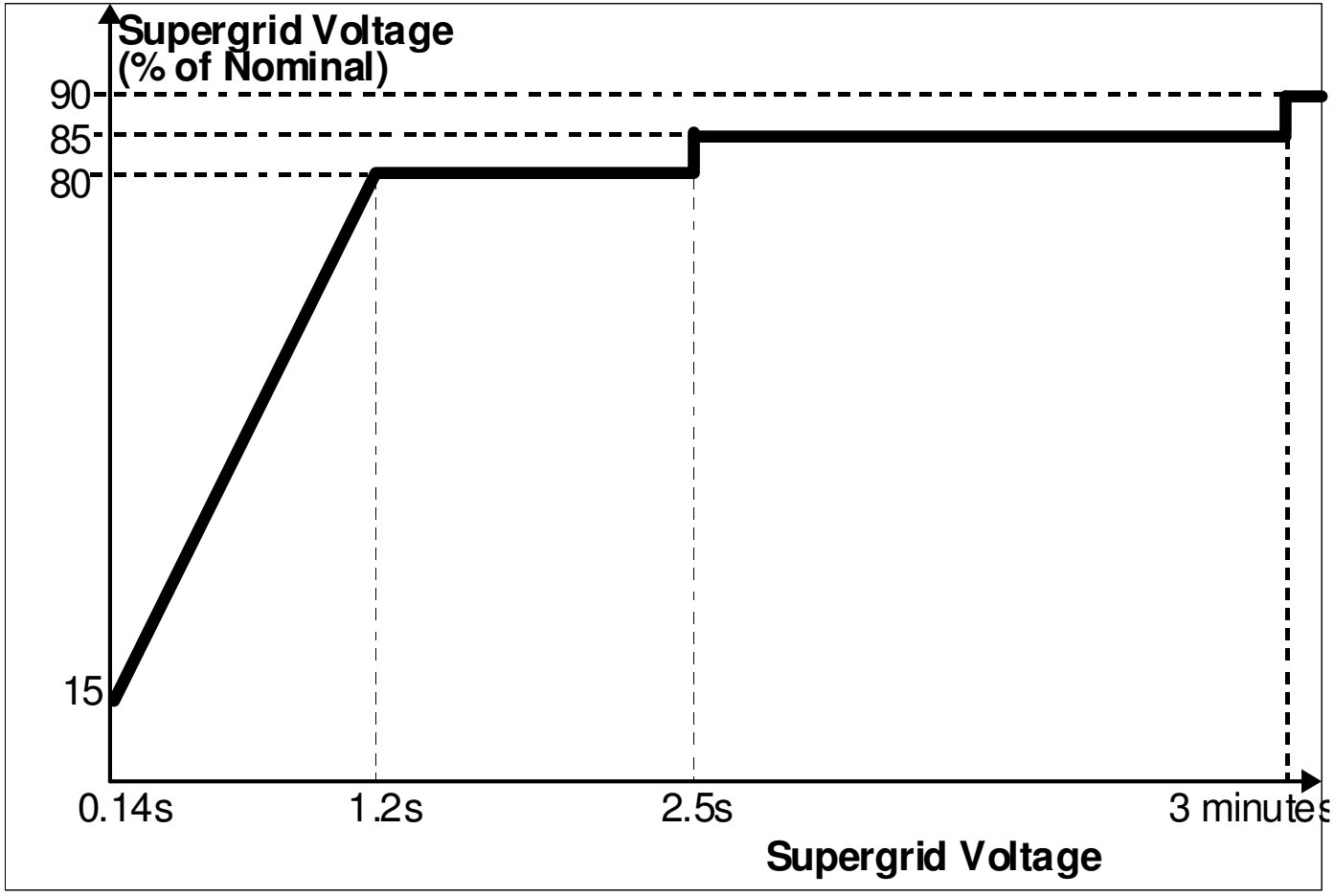
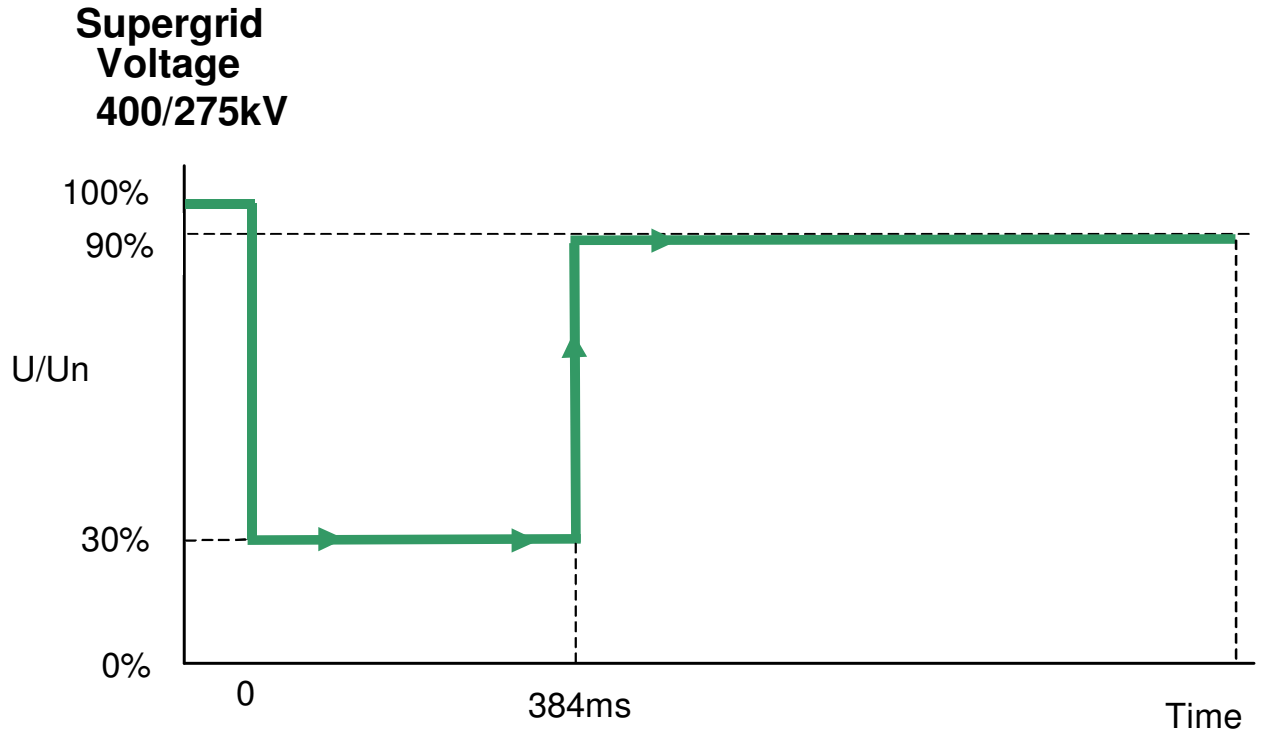


Voltage dips in excess of 140ms

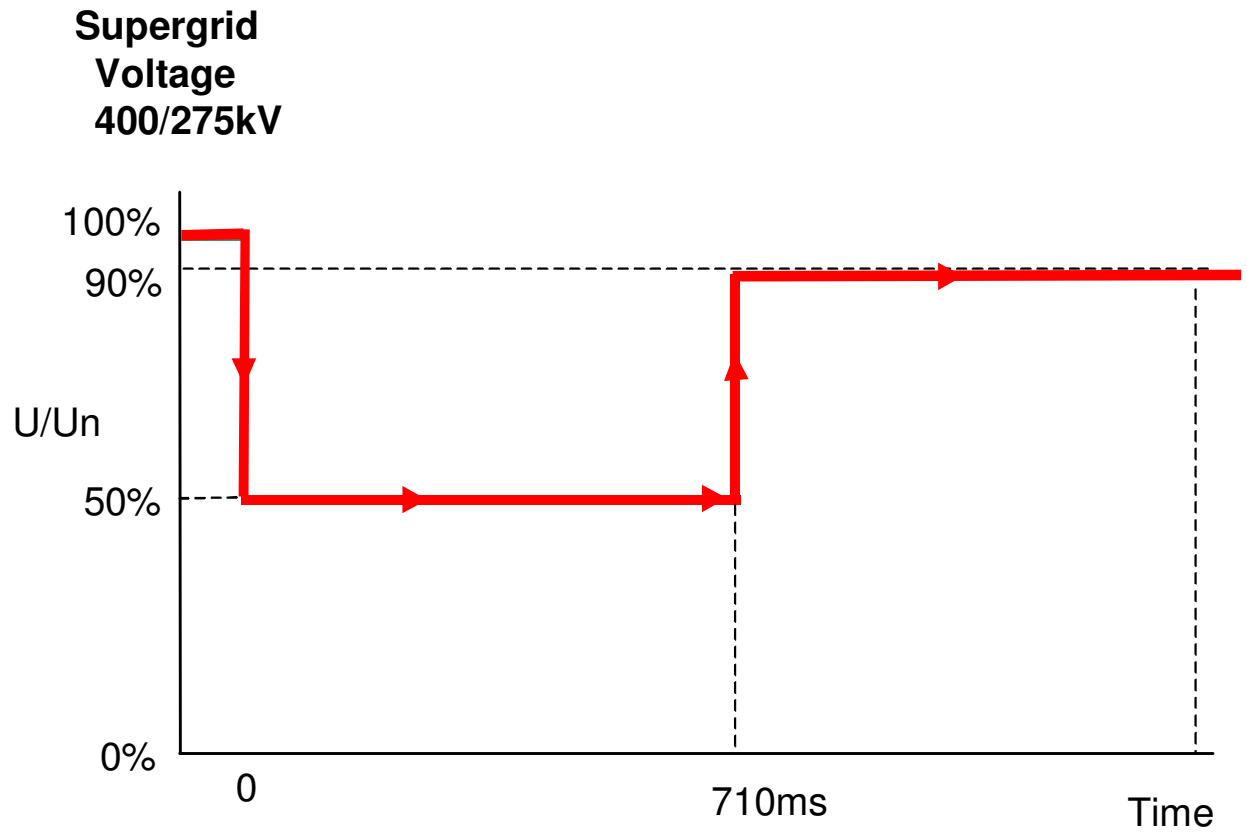
30% Retained Voltage (CC – Appendix 4A)



30% retained voltage, 384ms duration

Voltage dips in excess of 140ms

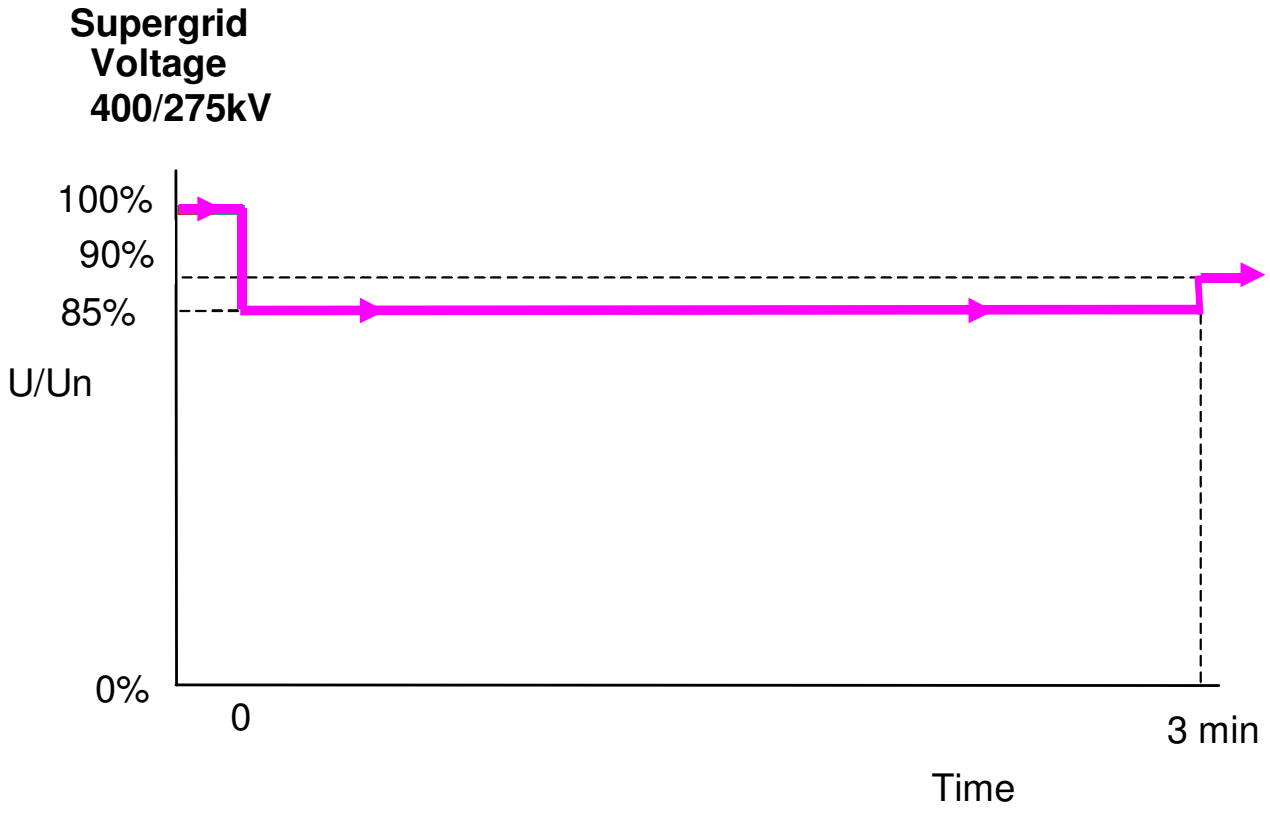
50% Retained Voltage (CC – Appendix 4A)



50% retained voltage, 710ms duration

Voltage dips in excess of 140ms

85% Retained Voltage (CC – Appendix 4A)



85% retained voltage, 3 minutes duration

Issues

- Fault Ride Through is equally applicable to Synchronous Generation and Power Park Modules
- Synchronous Generating Units have struggled to meet the requirements especially for longer duration voltage dips
  - Grid Code Review Panel Paper Ref PP12/04
  - New Connection Applications?
  - Compliance?
- The introduction of the ENTSO-E Requirements for Generators (RfG) proposes new requirements which are believed will address these issues

Summary

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- Background to Fault Ride Through
- Why fault ride through is required
- Faults up to 140ms in duration
- Voltage dips in excess of 140ms in duration
- Issues