Fault Ride Through Issues for Inclusion in Working Group Report Pending outcome of voltage against time curve issues

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Recap of Issues for inclusion in Working Group Report

- Issue initially raised in GCRP Paper Ref PP12/04 relating to the ability of synchronous Generators to ride through longer duration faults (ie in excess of 140ms), whether or not a site specific requirement should be introduced and further clarifications as to how Compliance should be assessed.
- Three workshops were held in September and November 2012 and January 2013 to address the issues raised in GCRP Paper Reference PP12/04.
- Issues identified to be mainly associated with Synchronous Plant
- Workshop participants acknowledged that whilst there were still issues with Asynchronous Generation, they were broadly happy with the GB fault ride through requirements and would not wish to undergo a full set of additional research and type tests ahead of the European ENTSO-E requirements
  - *The Workshops identified issues with Asynchronous Plant but these do not fall within the scope of this Workgroup*
- The workshops proposed a formal Grid Code Work Group to be established to examine the implications of early adoption of the ENTSO-E (RfG) fault ride through requirements for Synchronous Generation including specification of the GB Parameters.
- *Fault Ride Through Terms of Reference approved at July 2013 GCRP Meeting (Modification GC0062)*
- The background to Fault Ride Through and why it is required will be covered as an appendix within the Fault Ride Through Report.

Terms of Reference (1)

- Understand the implications and interpretation of the Fault Ride Through requirements as defined in the ENTSO-E Requirements for Generators
- Assess the ENTSO-E RfG fault ride through requirement and develop GB specific requirements and parameters which would provide clarity to Generators and ensure consistency with the ENTSO-E RfG Code. *The output of this work will feed into the ENTSO-E RfG pilot programme which is specifically aimed at implementing the ENTSO-E RfG and National Code in addition to selection of National parameters.*
- Asses the impact to all Stakeholders of early adoption of the ENTSO-E RfG fault ride through requirements and the implications to existing Generators. In addition, the Workgroup will inform GCRP and JESG Members of the progress of the work in particular the options for integration of the ENTSO-E RfG with the National Code and the developments of the ENTSO-E pilot programme.
- Consider the impact on Embedded Synchronous Generators in adopting the ENTSO-E Fault Ride Through requirements.

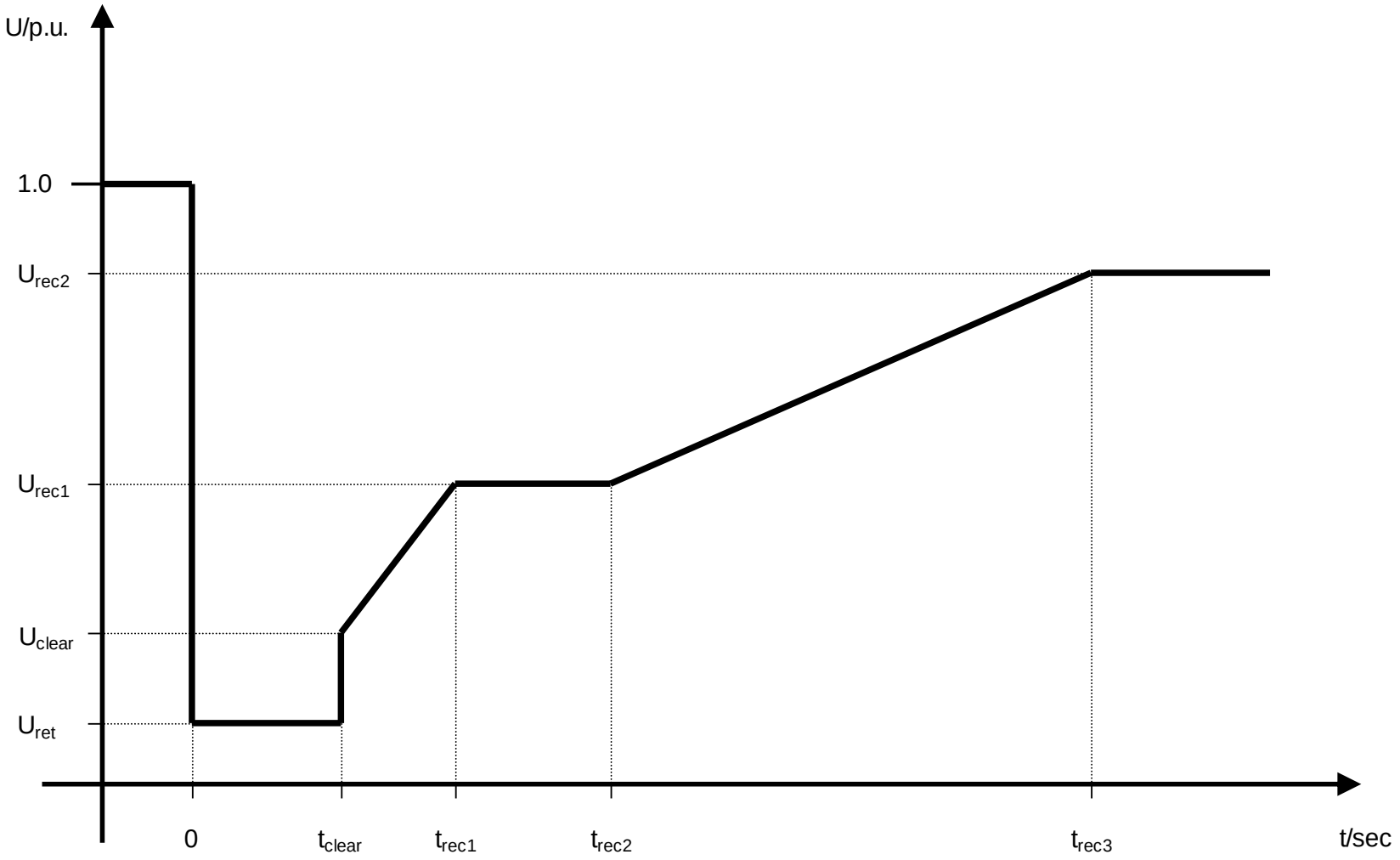
Terms of Reference (2)

- Review the parameters (including the voltage against time curves) that National Grid will need to define in developing the fault ride through requirements for Synchronous Generators which are consistent with those defined in the ENTSO-E RfG.
- Define the scope and remit to which the new fault ride through requirements apply
- Ensure the proposals adopted:-
  - Address the issues raised in paper PP12/04
  - Are in the best interests of all Stakeholders
  - Are fully consistent with the ENTSO-E RfG and do not cause any conflicts when the ENTSO-E European Network Codes are all fully implemented in 2016.
  - Provide clarity to all affected User's
- Determine an appropriate implementation timescale for any new requirements.

Background to RfG Fault Ride Through Requirements

- The report will outline the background to the Fault Ride Through RfG requirements
- Voltage against time curves
- National Parameter range
- Active Power Recovery
- Balanced and unbalanced faults
- Operating Conditions under which the Generator is expected to remain connected and stable
  - Pre and post fault short circuit level
  - Generator operating point (ie MW and MVAr)

ENTSO-E RfG - Fault Ride Through Requirements – Voltage Against Time Profile – Figure 3 (Types B and C)



ENTSO-E RfG - Voltage Against Time Parameters – Table 7.1 – Type D Synchronous Power Generating Units

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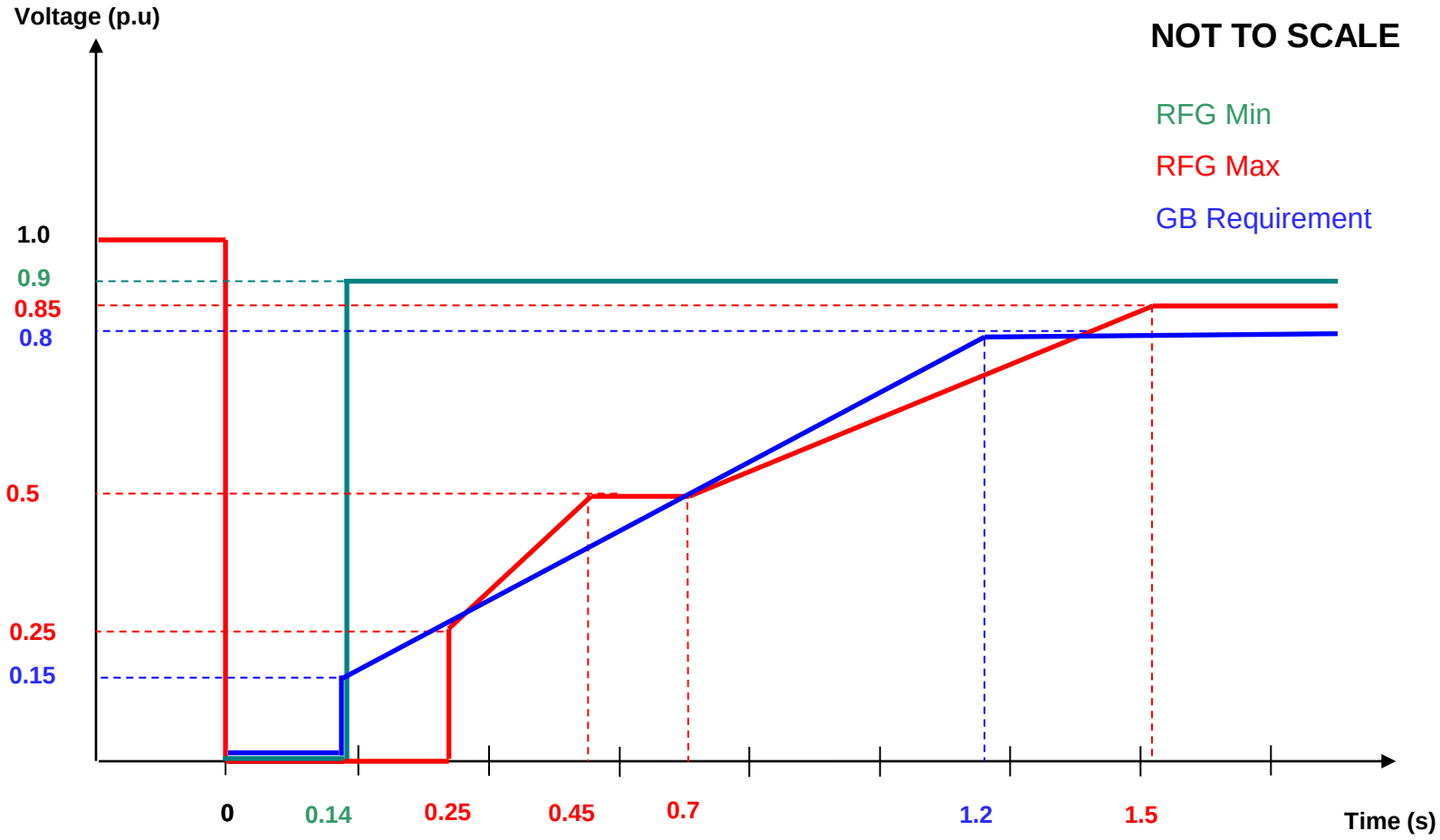
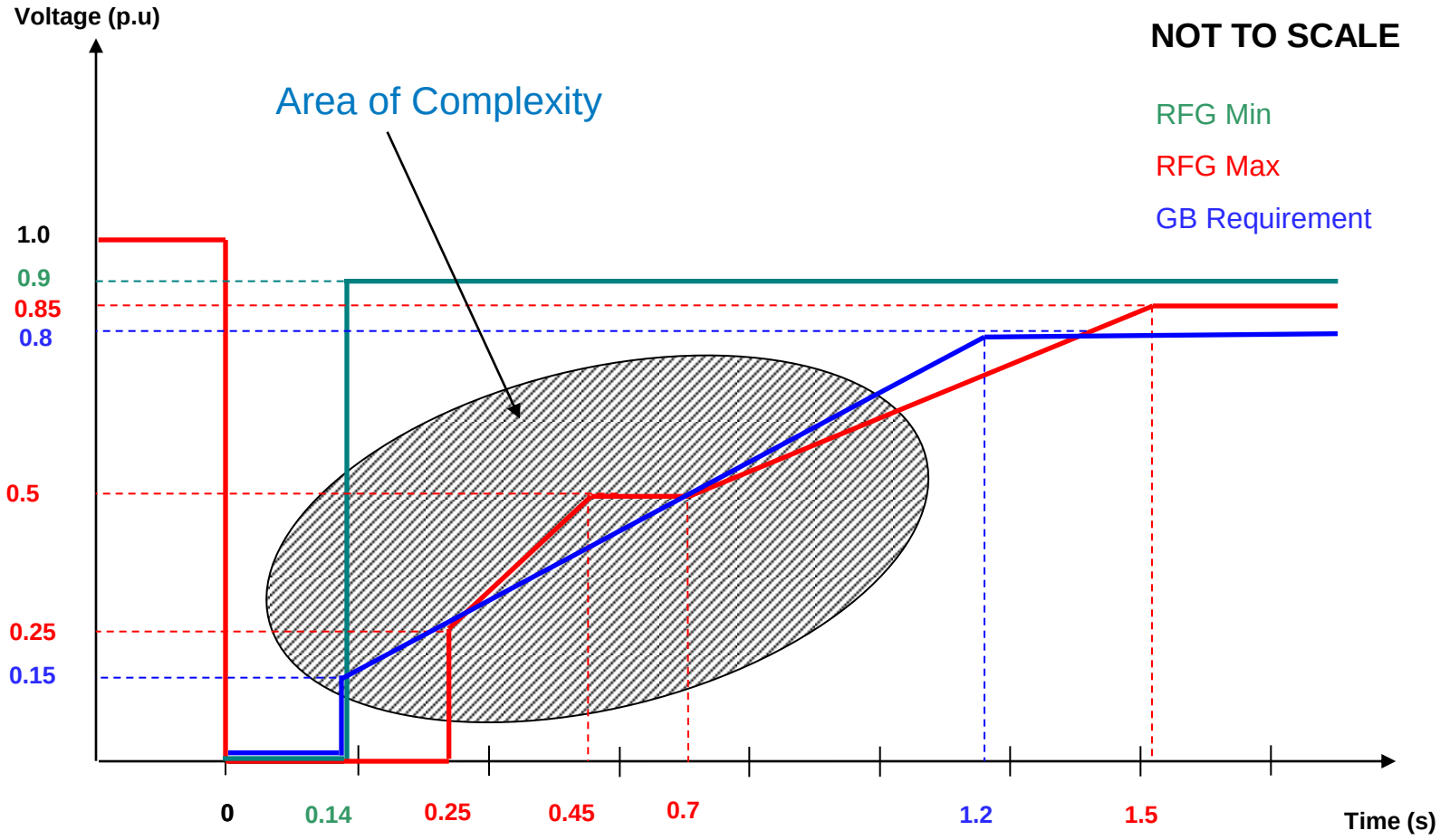
Voltage parameters [pu]		Time parameters [seconds]	
Uret:	0	tclear:	0.14 – 0.25
Uclear:	0.25	trec1:	tclear
Urec1:	0.5 – 0.7	trec2:	trec1 – 0.7
Urec2:	0.85 – 0.9 and ≥ Uclear	trec3:	trec2 – 1.5

Table 7.1 – Fault Ride Through Capability of Synchronous Power Generating Modules

ENTSO-E RfG - Voltage Duration Profile – Range compared with GB Requirement



ENTSO-E RfG - Voltage Duration Profile – Range compared with GB Requirement



Criteria for Fault Ride Through Assessment

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- The ability of Generators to remain connected and Stable for faults cleared in normal protection operating times (up to 140ms)
- The ability of remote Generators to remain connected and stable for faults cleared in backup operating times. It is accepted that Generation adjacent to the fault which is cleared in backup operating times may trip and more than 1800MW may be lost but the intention is to maintain overall integrity of the Transmission System.
- Any requirements specified need to be achievable from a Generator perspective
- The requirements are highly dependent upon fault level.
- There is a key requirement to ensure that during the fault period the Generator injects maximum reactive current (required to sustain System voltage) – A natural phenomena of Synchronous Generators
- Active Power Recovery on fault clearance – required to prevent frequency collapse – This would not be expected to change from the current CC.6.3.15 Grid Code requirement.

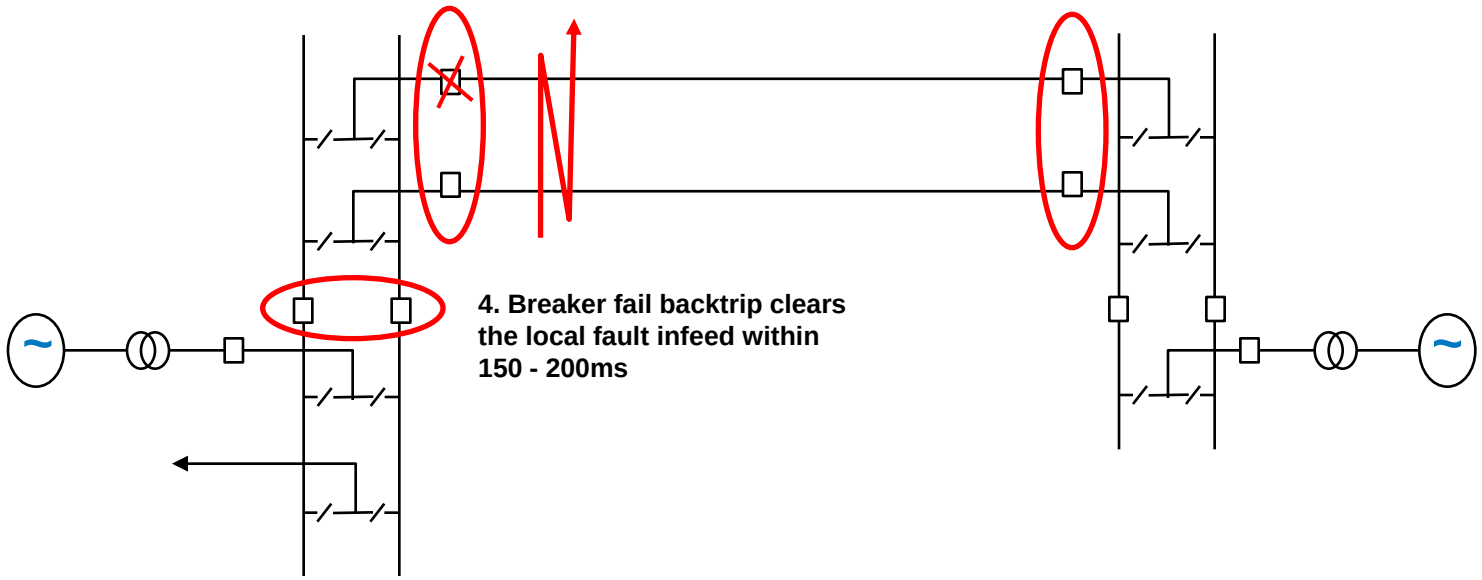
Criteria for Fault Ride Through Assessment (Example 1)

A double circuit fault, with a failure of a local breaker

3. Remote protection receives an intertrip and clears within 140ms

2. Local protection operates within 80ms, but a breaker fails

1. Double Circuit Fault



4. Breaker fail backtrip clears the local fault infeed within 150 - 200ms

Criteria for Fault Ride Through Assessment (Example 2)

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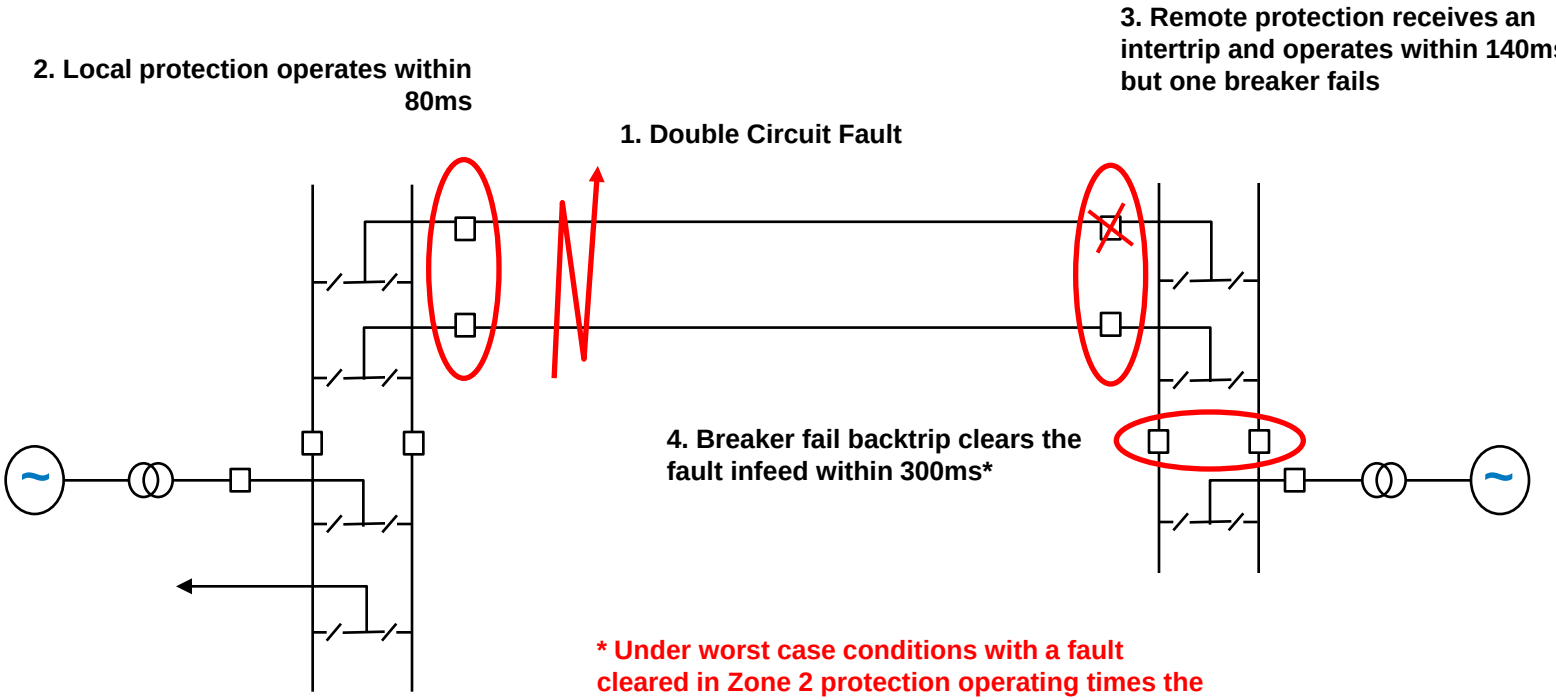
A double circuit fault, with a failure of a remote breaker

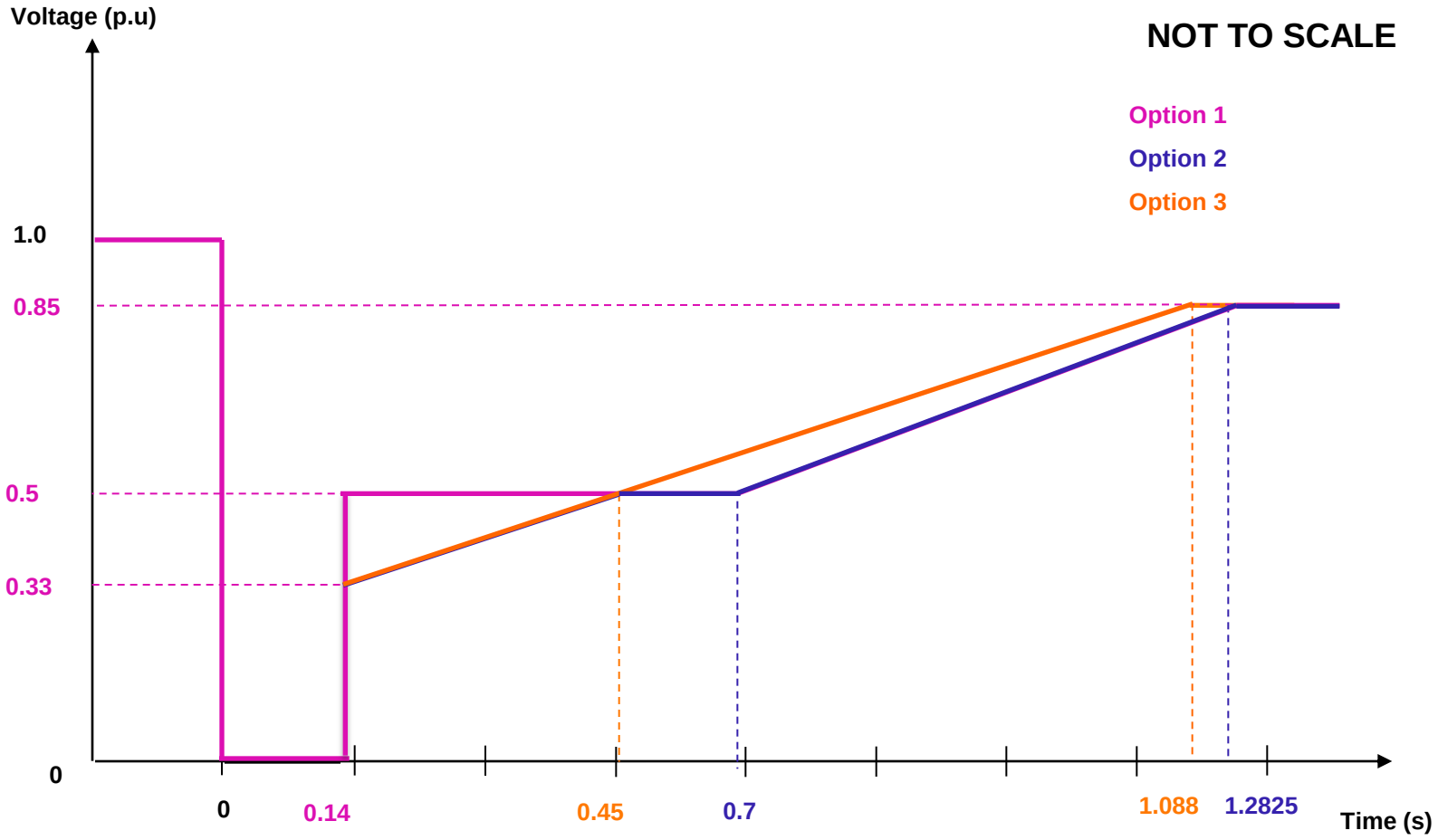


*** Under worst case conditions with a fault cleared in Zone 2 protection operating times the remote end would not be cleared until 500ms after fault inception**

Study Work Undertaken

- Extensive Study work has been undertaken
- A range of scenario's examined
- Multi Machine Studies – Drax, Eggborough and Seabank
- Single machine studies – Full range of machine size from very Small to very Large (eg 2000MVA) over a range of different fault level conditions and machine operating points (eg full MW output and full MVAr import was observed)
- Variations observed in respect of fault level and machine excitation performance. Machines with both rotating and static excitation systems modelled.
- Models provided to Working Group members for them to establish the impact on their Station Auxiliaries.
- Studies run to establish the minimum needs of the Transmission System and the capability of the Synchronous machines under test.

Options for Voltage Against Time Curves



Voltage against Time Curves / Performance Requirements

- Based on System Study work three options have been developed for a Voltage against time curve
- Options 1 and 2 were developed based on initial study work using the criteria outlined above
- Option 3 was further developed further based on more extensive study work using both single an multi machine studies. This is the recommended option. – NOTE:- Further analysis and research now needs to be undertaken in view of issues identified with the parameters specified in Table 7.1 of RfG.
- The machine would be expected to be operated at full output under maximum MVAr leading conditions
- The minimum post fault short circuit level under pre and post fault conditions would be specified in the Bilateral Agreement. Further discussion is required on this point.
- Compliance would need to be demonstrated through simulation studies and clarification would be required to the Grid Code on this issue.

High Level Grid Code Amendments

- Amendments to CC.3.15 of the Grid Code to cover the fault ride through requirements for Synchronous Generators.
- Inclusion of voltage against time curve
- Requirements for minimum pre and post fault short circuit level – to be specified on a Bilateral level but further discussion required
- Requirements for Generator pre fault operating conditions (ie Full MW output under full MVAr leading conditions)
- Amendments to Appendix 4 of the Connection Conditions on examples of Fault Ride Through Performance
- Amendments to Grid Code Compliance Processes

Next Steps

- Address potential anomalies in RfG Parameter Table 7.1
- Review proposals and ensure they are consistent with RfG
- Develop Grid Code Legal Text
- Consider changes on other documents – eg Guidance Notes for Synchronous Generators?
- Extend the remit and representation of the Working Group to consider the Fault Ride Through requirements for Embedded Synchronous Generators