Fault Ride Through

Antony Johnson / Richard Ierna
National Grid – TNS Technical Policy

Summary

- Review Fault Ride Through Report
  - **NOTE:- Aim to Present to November GCRP – 2 week commenting Period!**
- Summarise of the contents of the report
  - Background to Fault Ride Through
  - Summary of the Issue – PP12/04
  - Process undertaken
  - Discussion of the Terms of Reference
  - Scope
  - Review of ENTSO-E RfG Fault Ride Through Requirements
  - Suggested GB Parameters / Demonstration of Compliance
  - Review of GB Mode B requirements
  - Revised Voltage Duration Curve
  - Demonstration of Compliance
  - Proposed Legal text for Mode B Synchronous Generating Units

Proposal in EDF's GCRP Paper 12/04

- To permit the developer to request a location specific FRT voltage duration curve where the generic profile cannot be met.
- Alternatively the developer could submit the FRT capability declared by manufacturer for NGET to assess taking account of the point of connection
- Facilitates the adoption of standard generator designs without impacting security supply
- Could remove uncertainty for the developer prior to awarding contracts

Summary of Process

- Three Workshops held in September 2012, November 2012 and January 2013 covering industry representatives from the synchronous and asynchronous sectors
- It was agreed the issue should be referred to the GCRP with the aim to set up a Working Group for Synchronous Generating Units.
- At this stage, early adoption of the ENTSO-E RfG requirements was considered the best approach
- Terms of Reference with the GCRP finalised in July 2013
- Initial view was to consider the requirements for directly connected synchronous plant and then extend the group for Embedded Synchronous Plant
- First Workgroup Meeting held December 2013

Grid Code Deficiency

- A significant volume of Synchronous Generators, particularly larger units, struggle to meet the Mode B requirements.

- The Compliance process for Synchronous Plant is unclear and not well documented.

Terms of Reference

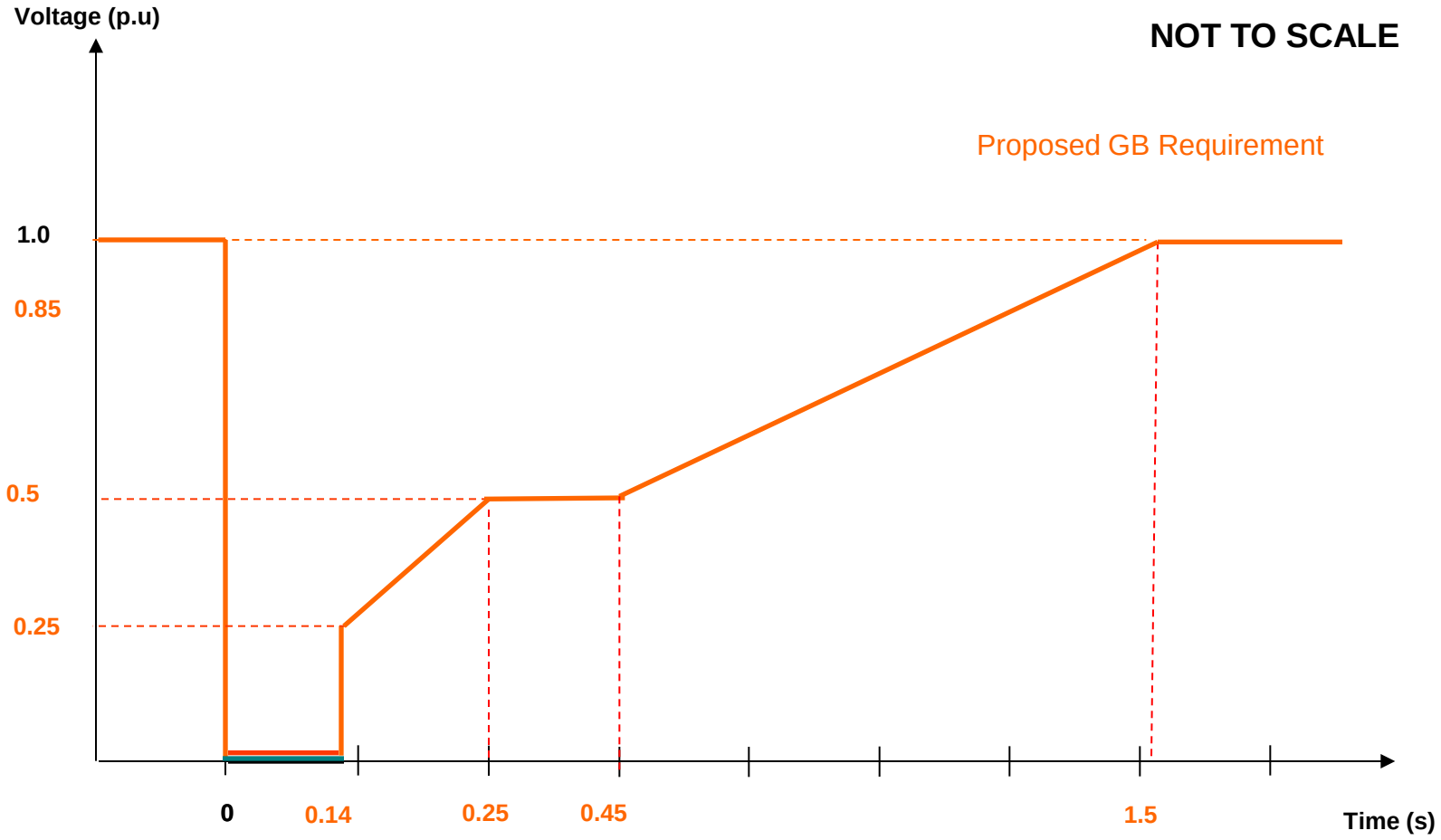
- During the Workgroup discussions and following extensive studies, it was realised that early adoption of the ENTSO-E RfG Requirements would not address the Grid Code deficiencies
- The ENTSO-E Fault Ride Through Requirements apply only to secured faults (ie Mode A faults) and not Mode B faults.
- The Workgroup therefore agreed to detail its findings and interpretation of the ENTSO-E RfG Fault Ride through requirements including recommended GB Parameters and demonstration of compliance. This information will be invaluable for the GC0048 Workgroup but the report will **NOT** include proposed legal text for these Mode A requirements.
- The workgroup also undertook detailed studies to investigate and revise the Mode B fault ride through requirements in addition to demonstrating compliance.
- The Report proposes legal text for amendments to the GB Mode B Fault Ride Through requirements.

Workgroup Report Scope

- Background
- Grid Code Deficiencies
- Interpretation of ENTSO-E RfG Requirements and proposed GB Parameters.
- Compliance demonstration for Mode A faults under RfG
- The report does **NOT** propose legal text changes for Mode A faults.
- Amendments to the Voltage Duration curve in respect of Mode B voltage dips and proposed legal text
- Methods to demonstrate compliance for Mode B faults.
- Note:- This Workgroup report does not propose any legal text changes to demonstrate compliance. This additional guidance has been included only in this workgroup report and will be introduced as part of the GC0048 work.
- There is no effective date (ie it is retrospective) as these proposals are considered a relaxation to existing requirements. In summary if a Generator can meet the current proposals they will have no issue in satisfying the proposed requirements.

Proposed GB Mode A Requirement

Voltage Against Time Curve



GB Parameters – Consistent with Table 7.1

nationalgrid

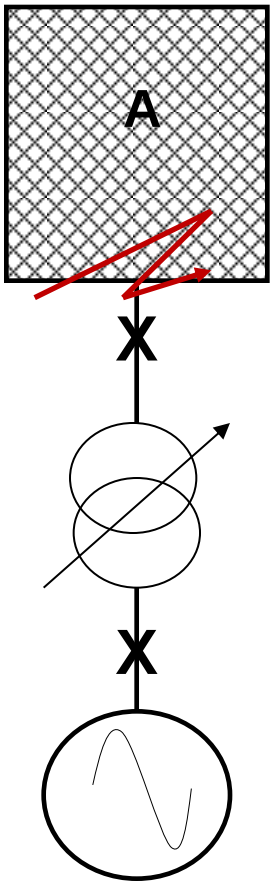
Voltage parameters [pu]		Time parameters [seconds]	
Uret:	0	tclear:	0.14
Uclear:	0.25	trec1:	0.25
Urec1:	0.5	trec2:	0.45
Urec2:	1.0	trec3:	1.5

Table 7.1 – Parameters for Figure 3 for fault ride through capability of synchronous power generating modules.

Assessment of Compliance Design / Operational Requirements

- NGET will run initial stability studies at the application stage with the appropriate pre and post fault short circuit level.
- Results should demonstrate a stable system with the appropriate excitation system
- Generator to run detailed studies using the equivalent model supplied – see slide 16
- In cases of non compliance discussions will need to be held with NGET on appropriate actions
  - Enhanced Excitation
  - Faster fault clearing times
  - Others

Mode A Fault Ride Through Suggested Model



1) Solid (zero impedance) three phase short circuit fault applied at Substation A for 140ms
2) Pre fault Short Circuit Level = 15,000 MVA
3) Post Fault Short Circuit Level = 10,000 MVA
4) Maximum Reactive current to be injected during the period of the fault
5) Active power to be restored to 90% of the pre-fault active power within 0.5 seconds of fault clearance

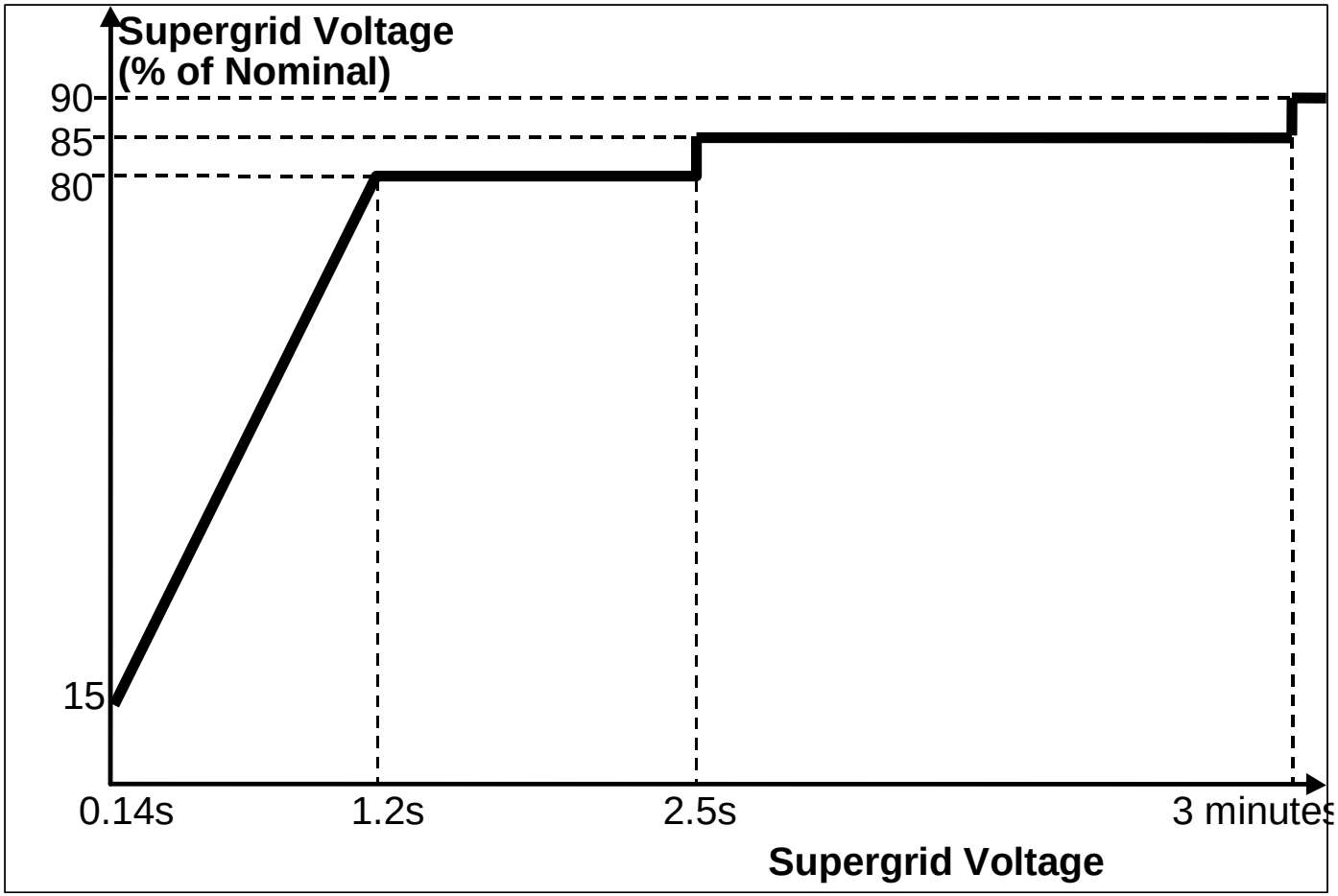
Operating Conditions of Generator (all Values quoted at the terminals)

MVA Rating = 1500MVA
Pmax = 1275 MW
Full lead = -419 MVAr (ie 0.95 PF lead at the Generating Unit Terminals)
Pre Fault Operating Voltage at Substation A = 1.0p.u
Post Fault Operating Voltage at Substation A = 1.0 p.u

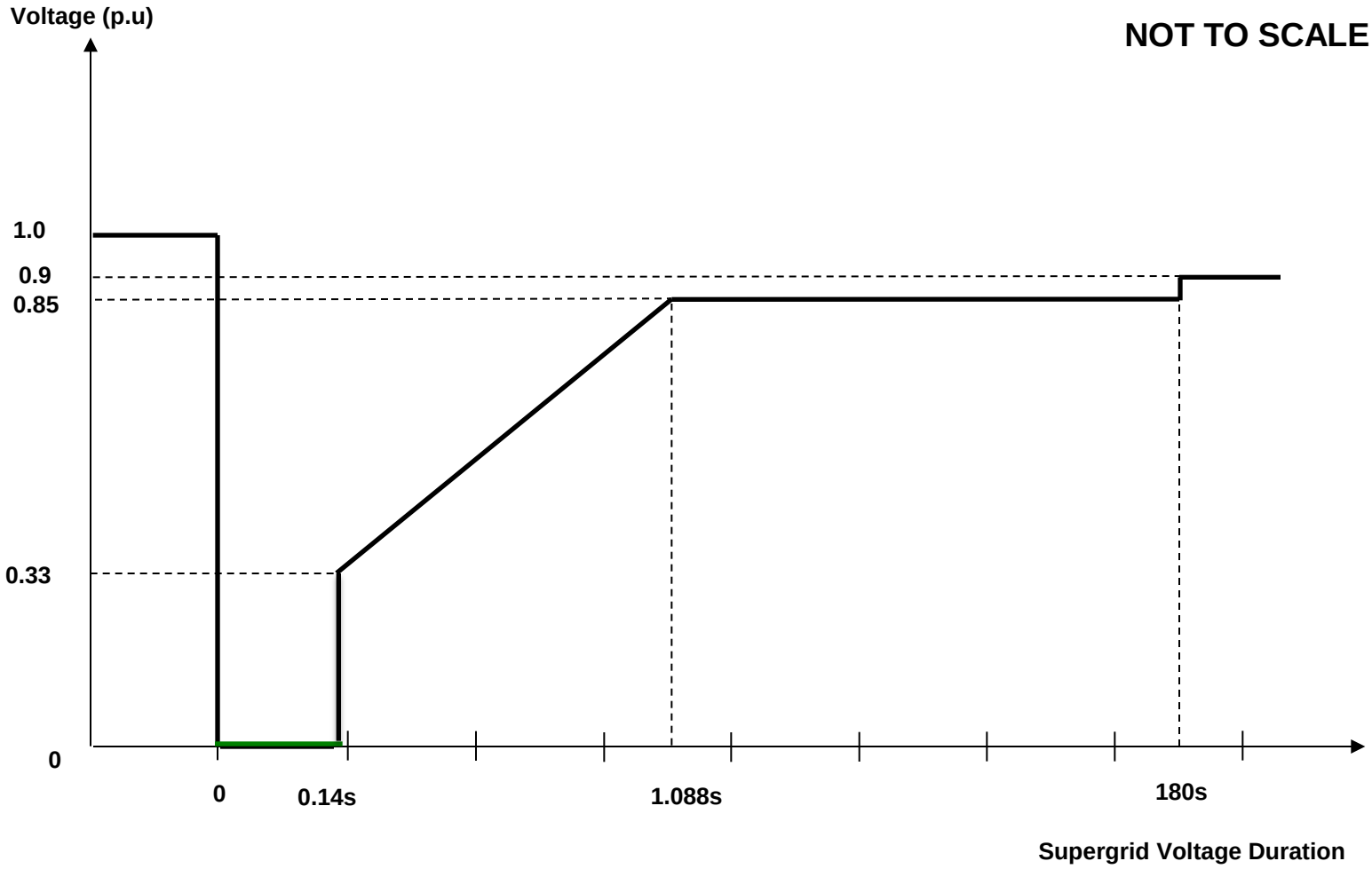
Mode B Faults

- As per current GB fault ride through requirements defined in CC.6.3.15.1(b) with a revised voltage duration curve – see next slide.
- Would apply specifically to Synchronous Generating Units only
- The existing Figure 5 would be changed to reflect the study work completed as part of this working group (Option 3)*.
- Note – this requirement would remain as a voltage duration curve – (ie each point on the profile represents a voltage level and an associated time duration).
  - * NOTE:- Voltage duration curve amended back to Option 3 based on further analysis work

Mode B Existing Voltage Duration Curve



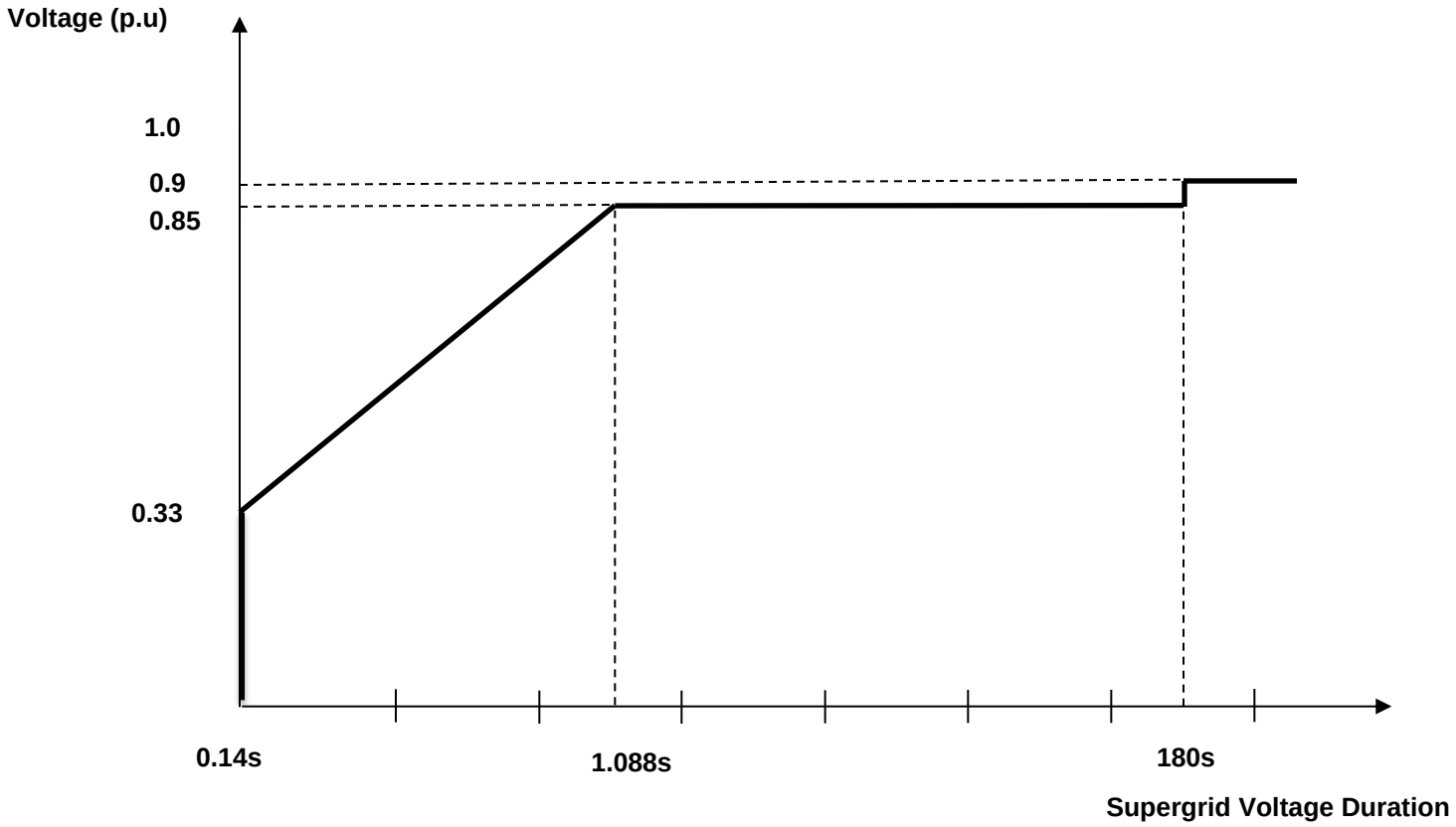
Revised Mode B Voltage Duration Curve



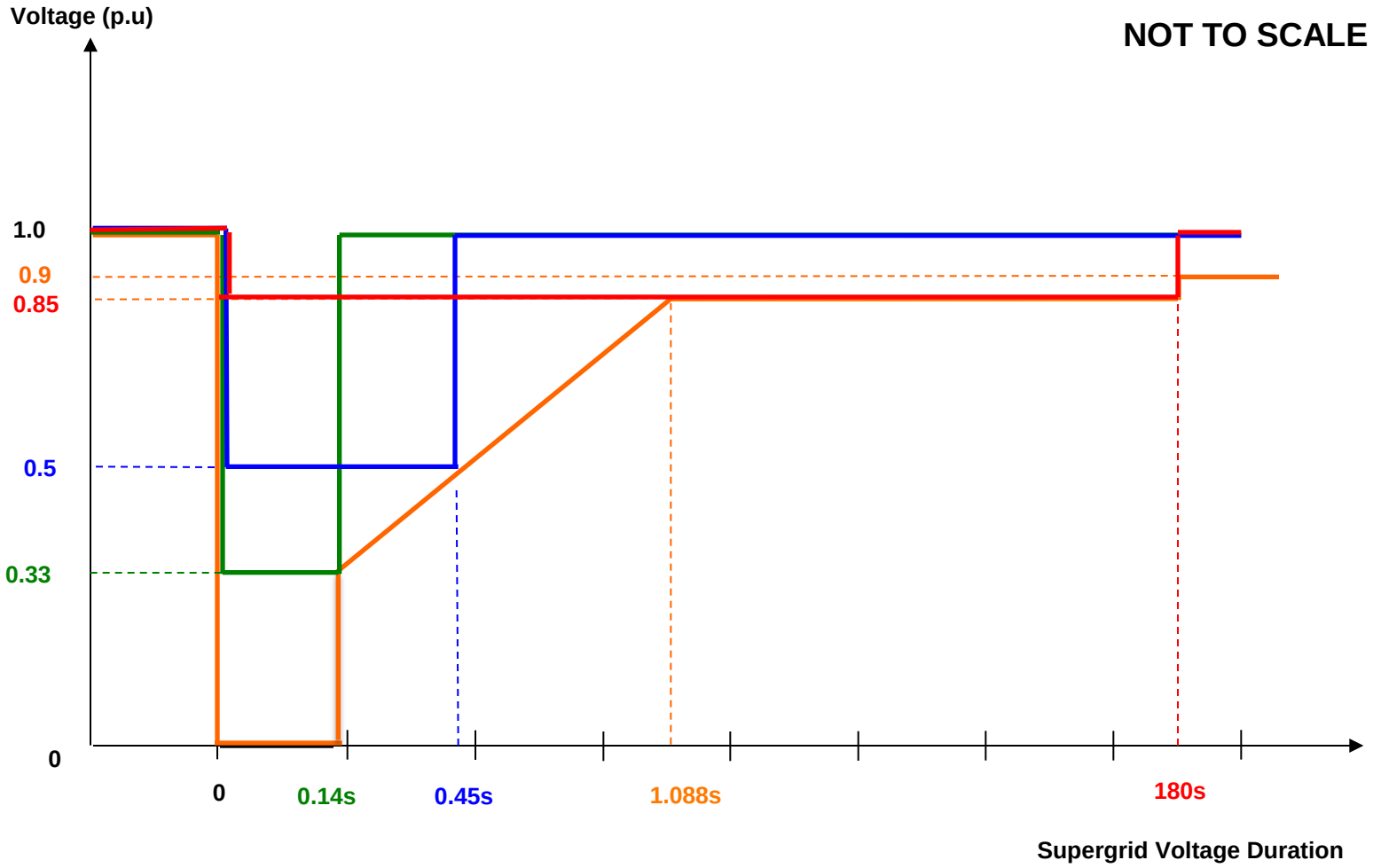
Revised Mode B Voltage Duration Curve - Final

nationalgrid

NOT TO SCALE

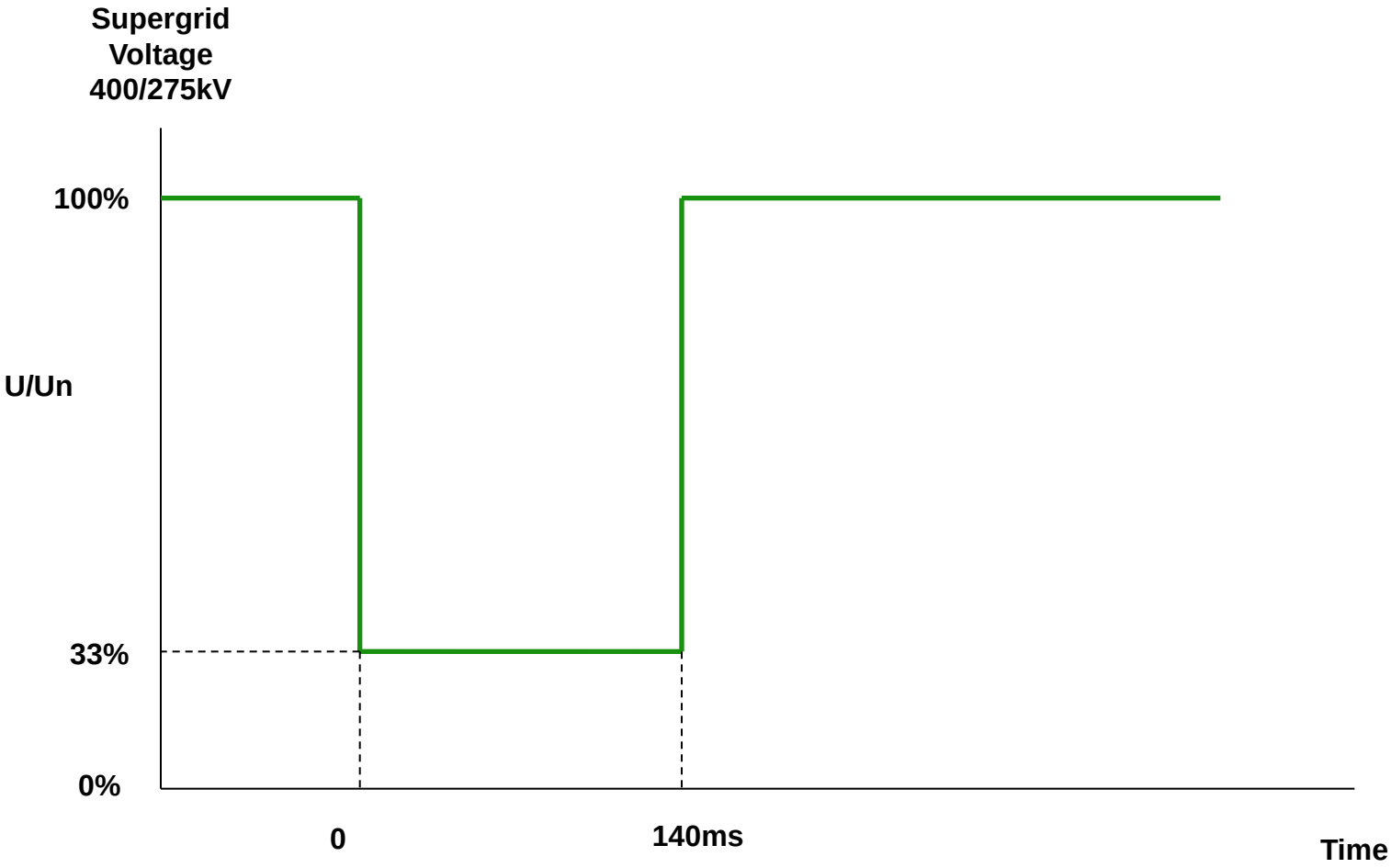


Mode B Voltage Duration Curve



Voltage dips in excess of 140ms

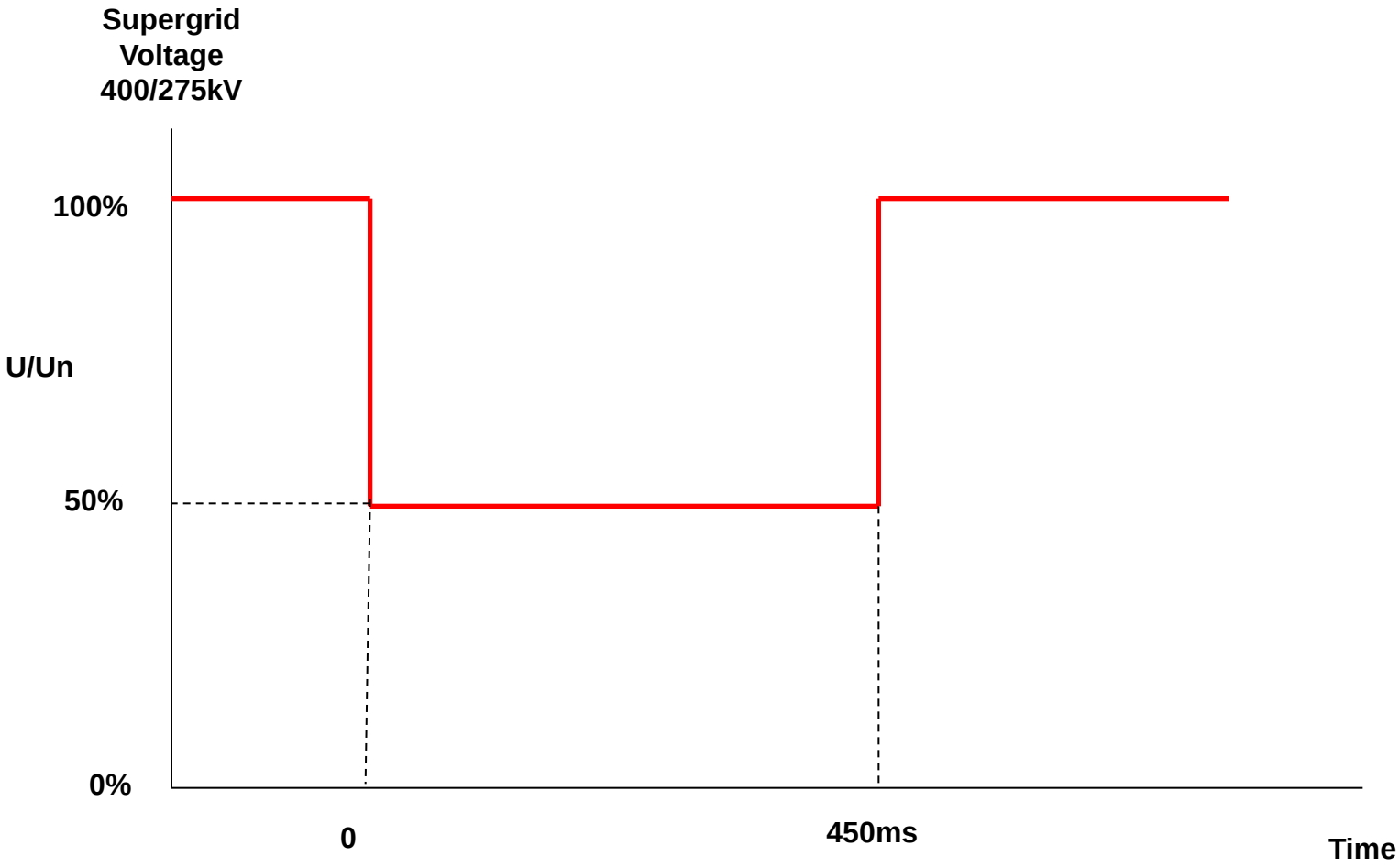
33% Retained Voltage



33% retained voltage, 140ms duration

Voltage dips in excess of 140ms

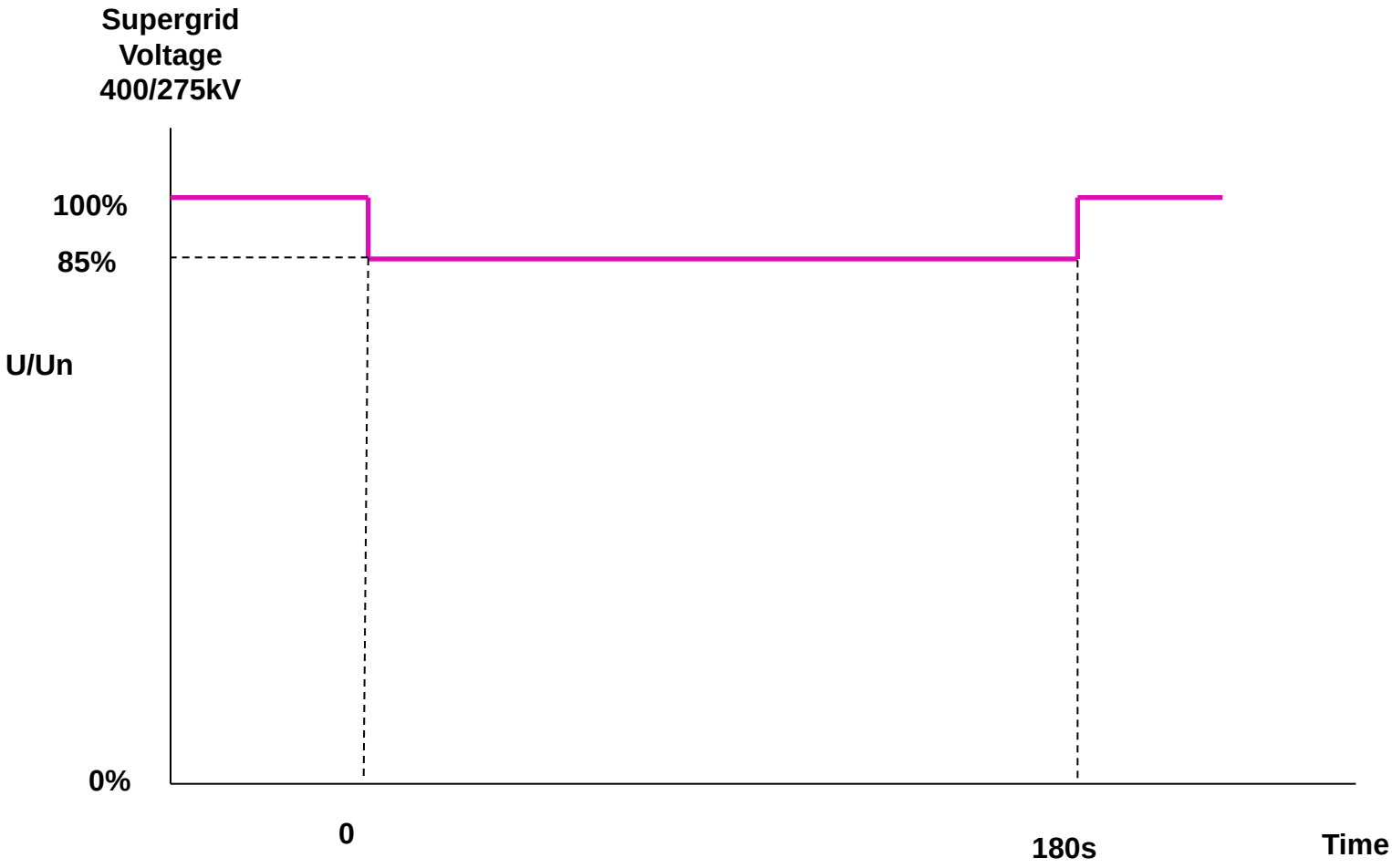
50% Retained Voltage



50% retained voltage, 450ms duration

Voltage dips in excess of 140ms

85% Retained Voltage



85% retained voltage, 180s duration

Fault Ride Through Studies Mode B – Method 1

Model built as shown below:

Pre Fault conditions:

- 0.95PF Leading at rated MW Load
- 1pu at Gen Terminals and TX HT Terminals
- Line Z to achieve Fault Level in Table 2
- External Grid Voltage determined by balance

During Fault:

- Fault of appropriate impedance applied to TX HT to achieve voltage & time duration in Table 1

Post Fault Conditions

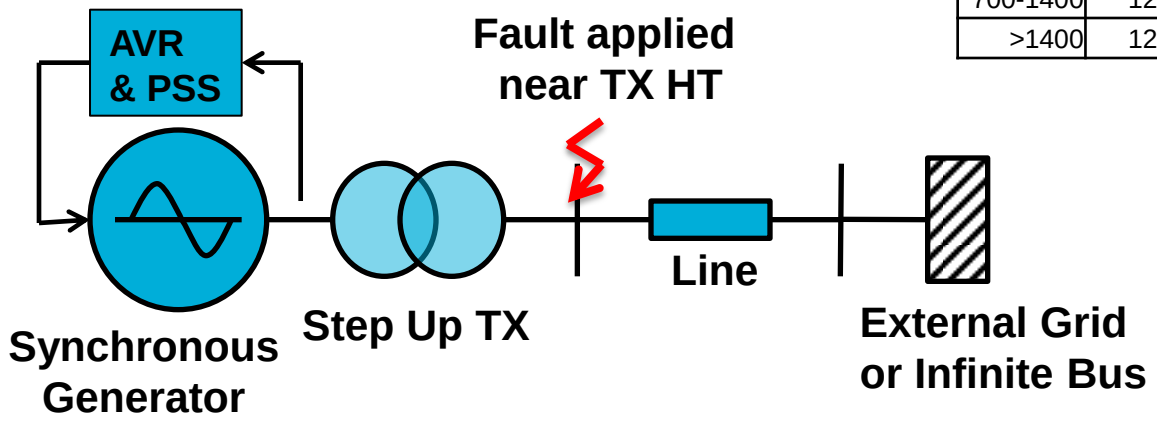
- Fault removed
- Generator must remain stable, connected and not pole slip

Retained Volts (pu)	Duration (s)
0.14	0
0.25	0.39
0.45	0.5
0.514	0.535
0.7	0.637
1.088	0.85
180	0.85

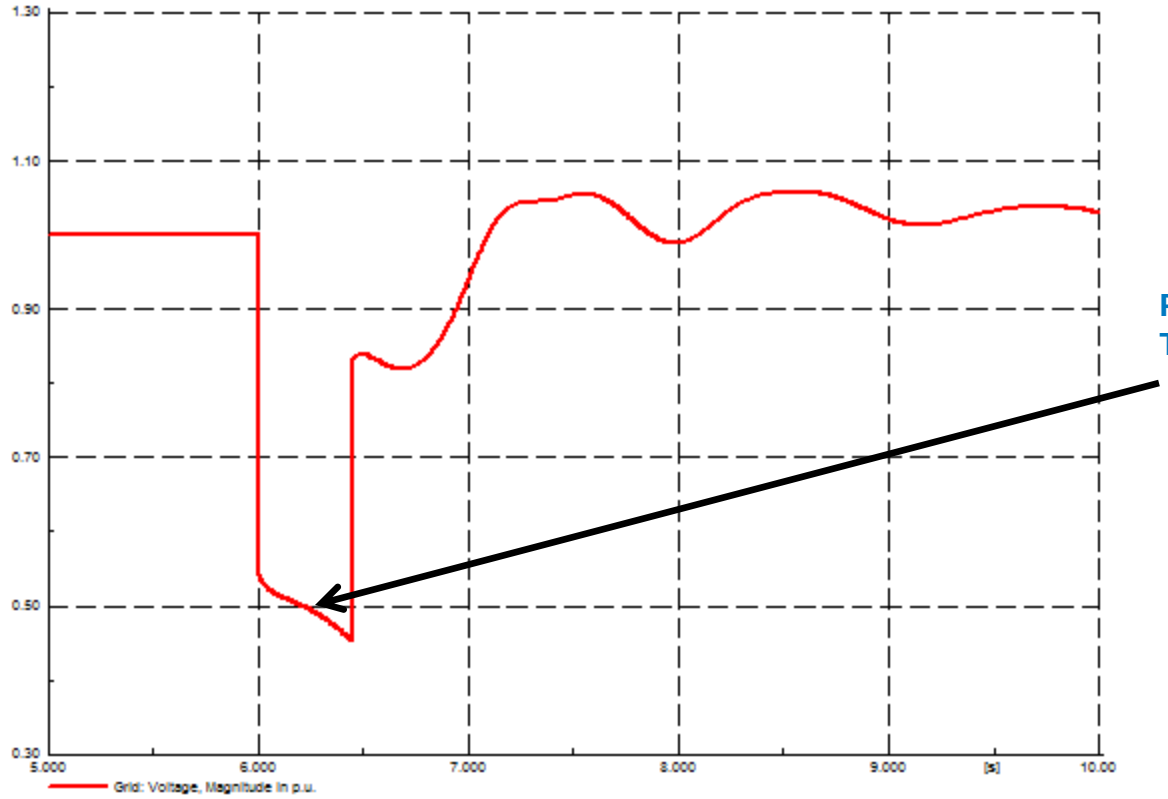
Table 1

Table 2

MW	X/R	Fault MVA
0-200	12	2300
200-450	12	4500
450-700	12	7000
700-1400	12	10000
>1400	12	15000



1800MW M/C 450ms Fault at 0.5pu Retained Volts – Method 1



Fault impedance selected
To give an average of 0.5pu

Fault Ride Through Studies Mode B – Method 2

Model built as shown below:

Pre Fault conditions:

- 0.95PF Leading at rated MW Load
- 1pu at Gen Terminals and TX HT Terminals
- Line Z to achieve Fault Level in Table 2 for 3ph S/C
- External Grid Voltage determined by balance

During Fault:

- Simulation TX connected with taps set to achieve appropriate voltage depression & time in Table 1

Post Fault Conditions

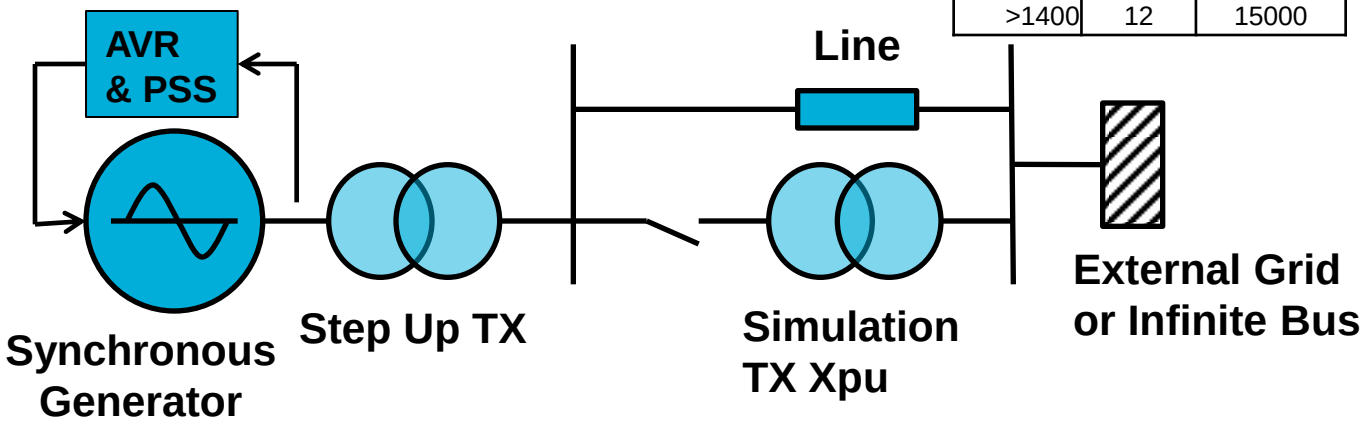
- Simulation TX removed from circuit
- Generator must remain stable, connected and not pole slip

Table 1

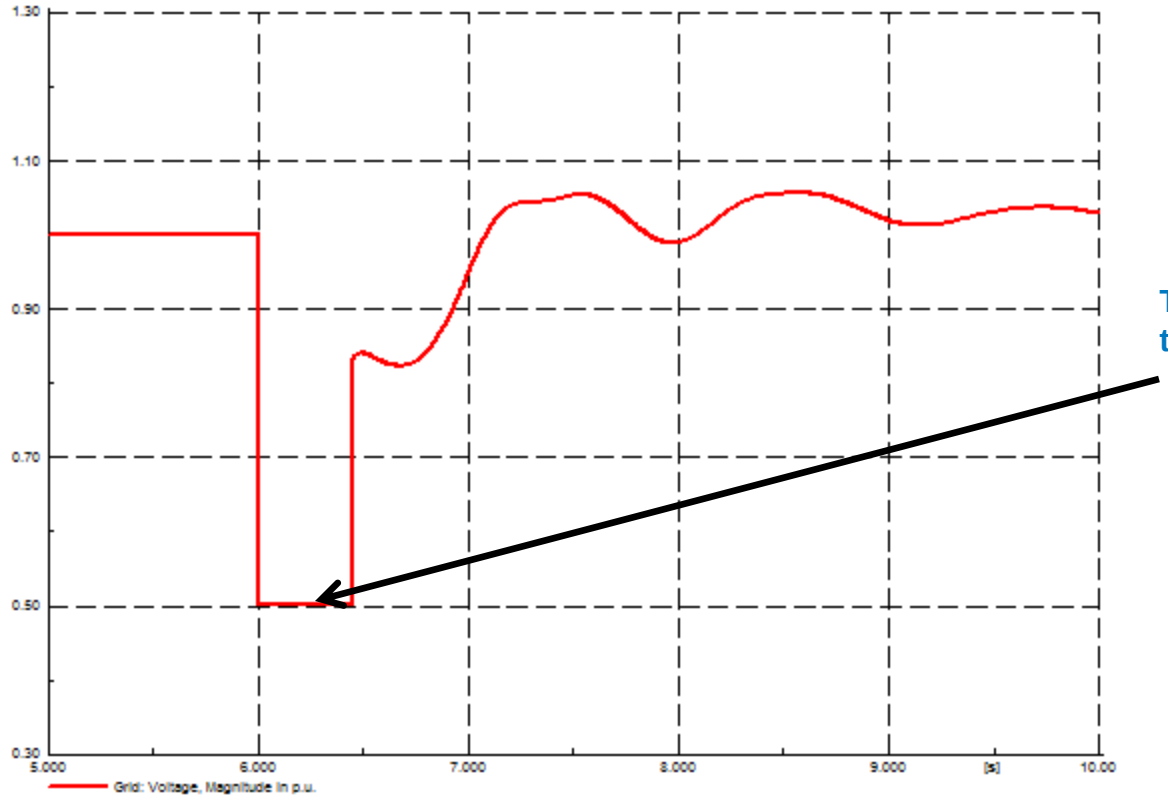
Retained Volts (pu)	Duration (s)
0.14	0
0.25	0.39
0.45	0.5
0.514	0.535
0.7	0.637
1.088	0.85
180	0.85

Table 2

MW	X/R	Fault MVA
0-200	12	2300
200-450	12	4500
450-700	12	7000
700-1400	12	10000
>1400	12	15000



1800MW M/C 450ms Fault at 0.5pu Retained Volts – Method 2



Transformer tap selected to give constant 0.5pu

Next Steps

- Work Group Members to consider Workgroup report
- Presentation to GCRP November 2015 GCRP
- Comments required within the next couple of weeks ahead of the November GCRP
- Industry Consultation
- Report to the Authority