Transient Voltage Recovery Criterion -

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NERC TPL 001-4 Standard - Transmission System Planning Performance Requirements

- Performance requirements:
  - No generating unit shall pull out of synchronism for P1.
  - For P2 - P7: When a generator pulls out of synchronism there should be no additional transmission or generation tripping
  - For P1 - P7: Power oscillations shall exhibit acceptable damping
- R5. Each Transmission Planner and Planning Coordinator shall have criteria for acceptable System steady state voltage limits, post-Contingency voltage deviations, and **the transient voltage response for its System. For transient voltage response, the criteria shall at a minimum, specify a low voltage level and a maximum length of time that transient voltages may remain below that level**
- No numbers in the Standard of what levels and times it should be

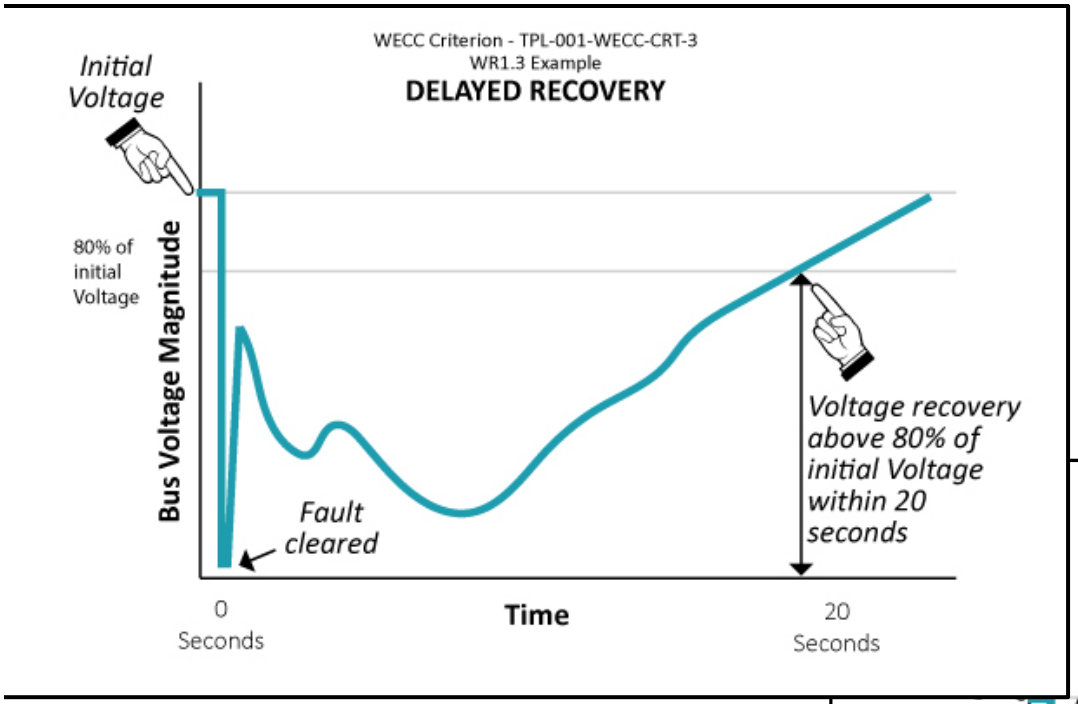
TPL-001-WECC-CRT-3.2.

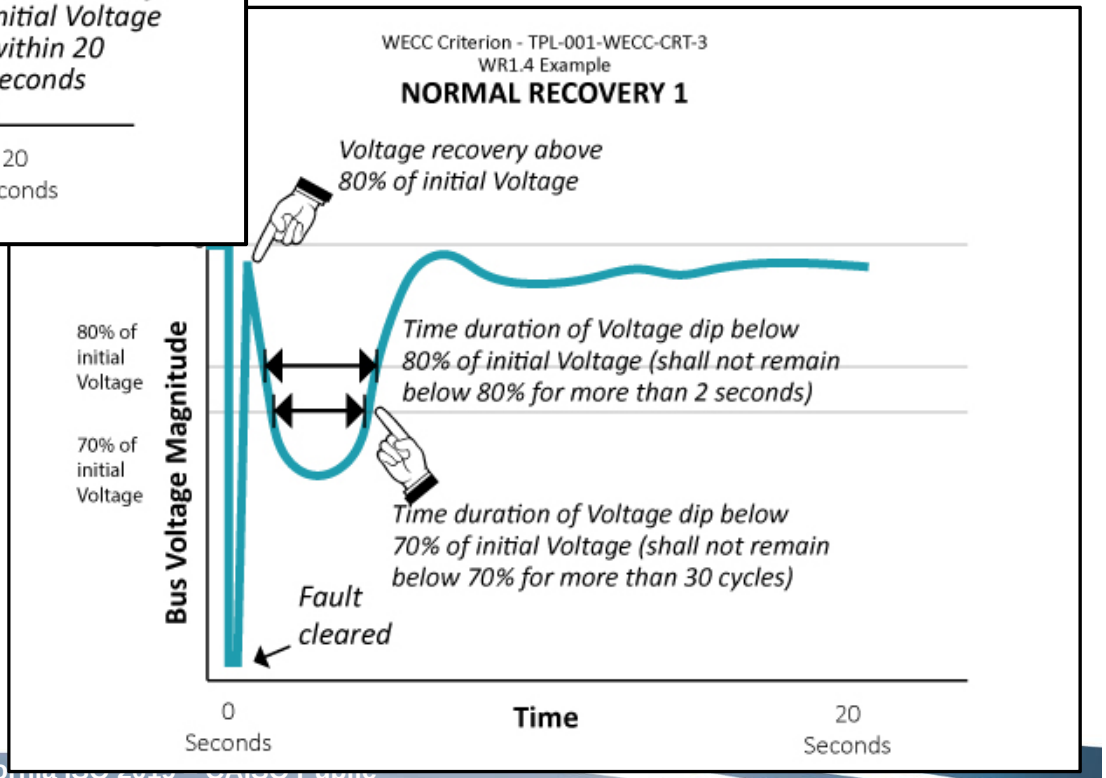
1.3. Following fault clearing, the voltage shall recover to 80% of the pre-contingency voltage within 20 seconds of the initiating event for all P1 through P7 events, for each applicable BES bus serving load.

1.4. Following fault clearing and voltage recovery above 80%, voltage at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds, for all P1 through P7 events.

These requirements apply to the BES Facilities and do not apply to the buses at the low sides of distribution transformers and at the ends of the feeders that are added to the system model by composite load model.

Illustration of Normal and Delayed Voltage Recovery

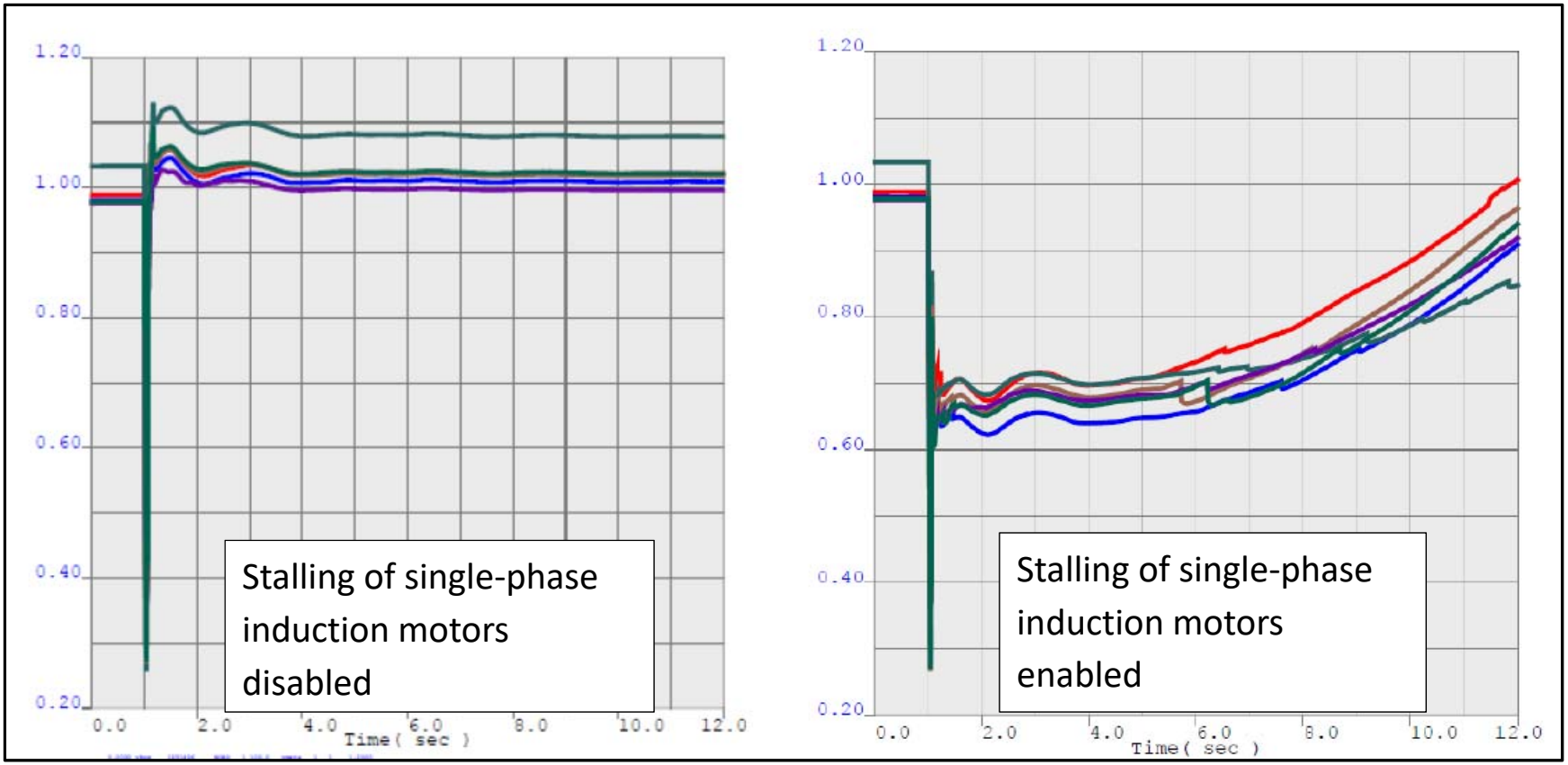




Reason for Delayed Voltage Recovery and Uncertainty

- In 2016, WECC approved Phase II of the composite load model that had stalling of single phase induction motors (air-conditioners) enabled.
- Stalling of these induction motors may cause depression of voltage
- Requirement 1.3 is clear – voltage should recover in less than 20 seconds
- Requirement 1.4 is intended for voltage dip in the areas where are no stalled induction motors
- How to distinguish voltage dip due to power swings from depressed voltage due to stalling of induction motors?

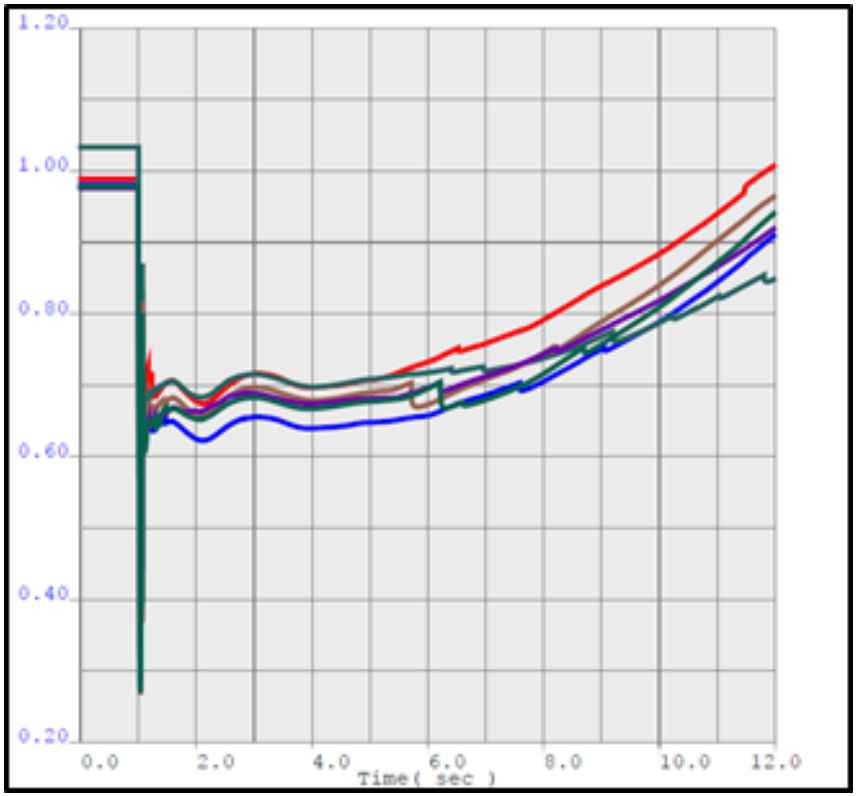
How voltage recovers after a fault?



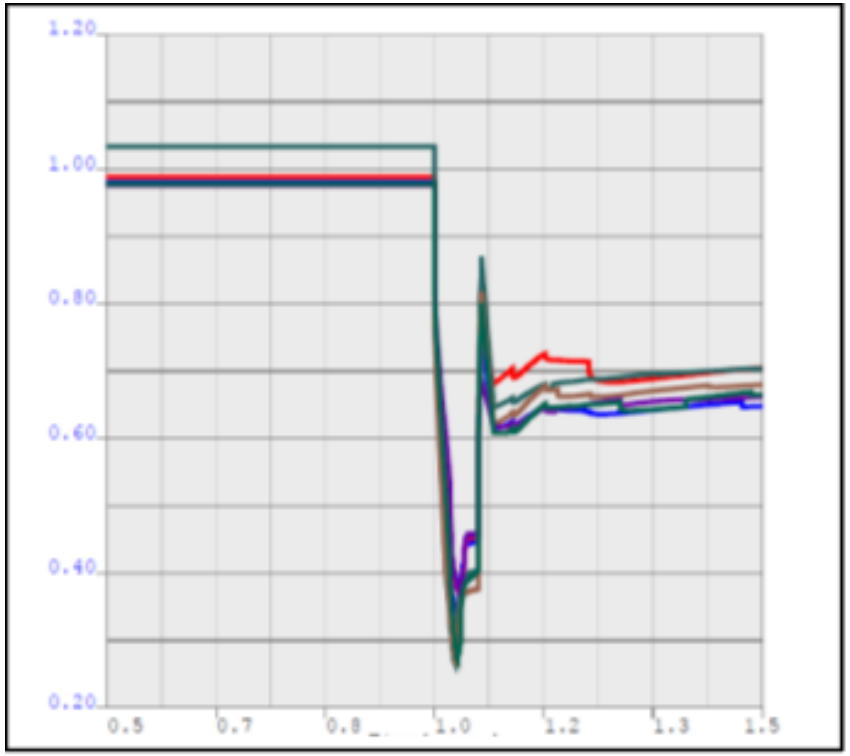
Issues with Staling of Induction Motors

- From the study results it may be problematic to distinguish whether voltage dips were caused by power swings or by stalling of single-phase induction motors following faults.
- With delayed voltage recovery, voltage not necessarily stays below 80% of the initial pre-contingency voltage. In many cases, voltage recovers above 80% right after the fault and then falls below that due to stalling of induction motors.

Example of Voltage, in Different Scales



- Voltage stays below 70% for over 30 cycles or 80% for over 2 sec
- Some voltages recover above 80%, some don't
- It may be numerical issue



- If voltage doesn't recover above 80% after the fault, it is not a violation
- If voltage recovers after the fault – it is a violation

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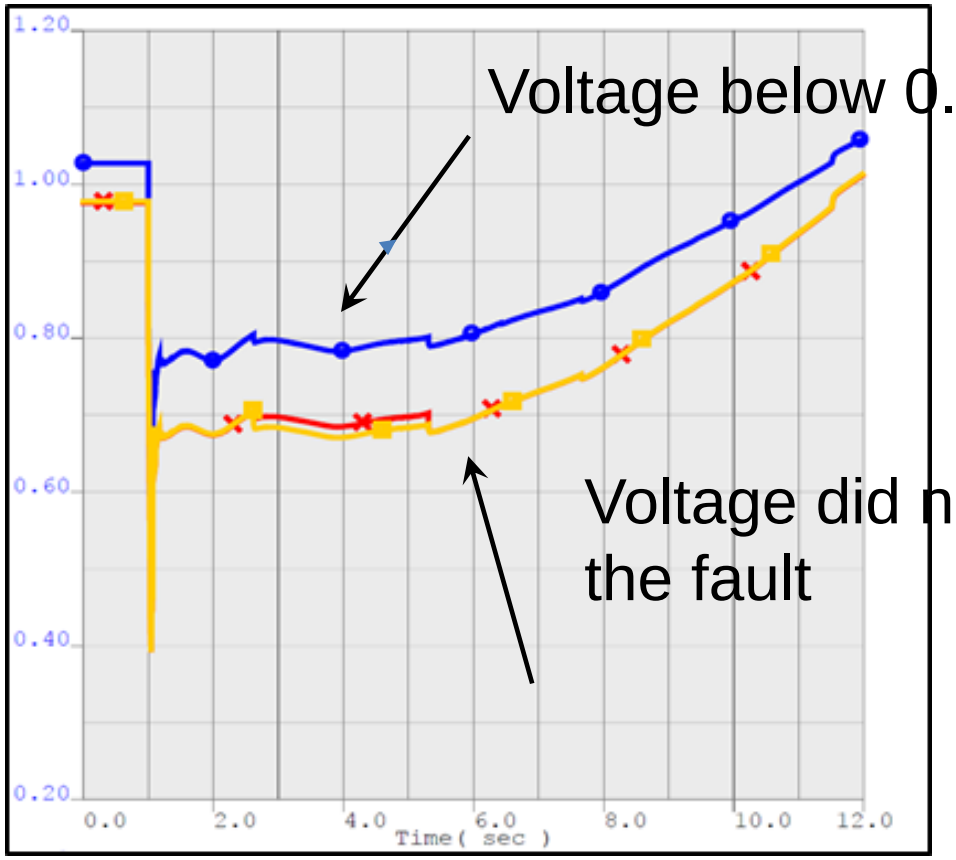
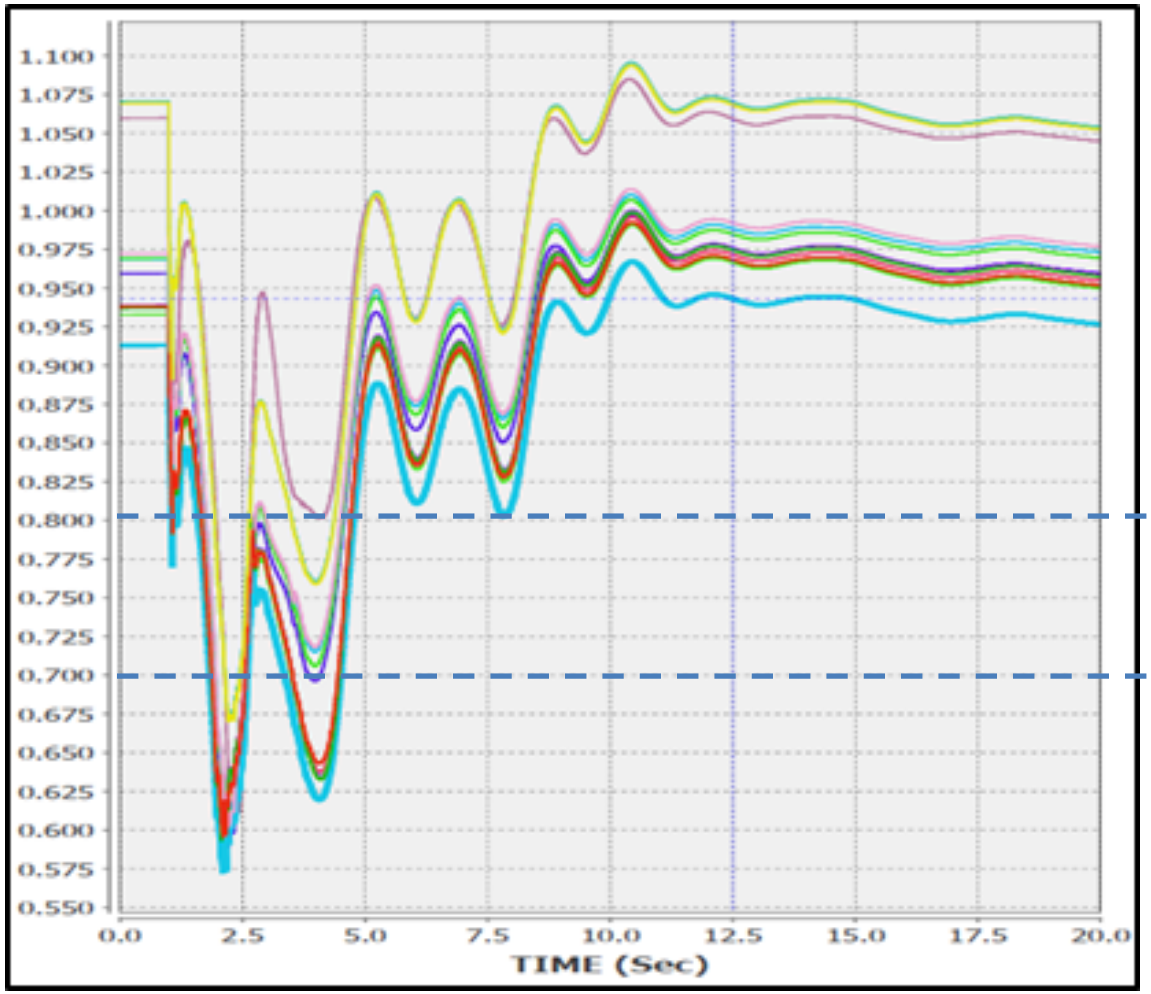
Should it count as a criteria violation?

- None of the buses in this example had voltage dips caused by power swings.
- The observed transient voltage performance was due to stalling of induction motors, even if the study results indicated criteria violations caused by unacceptable voltage dips for the buses where voltage recovered to above 80% right after the fault.
- More examples?

Example of Transient Voltage

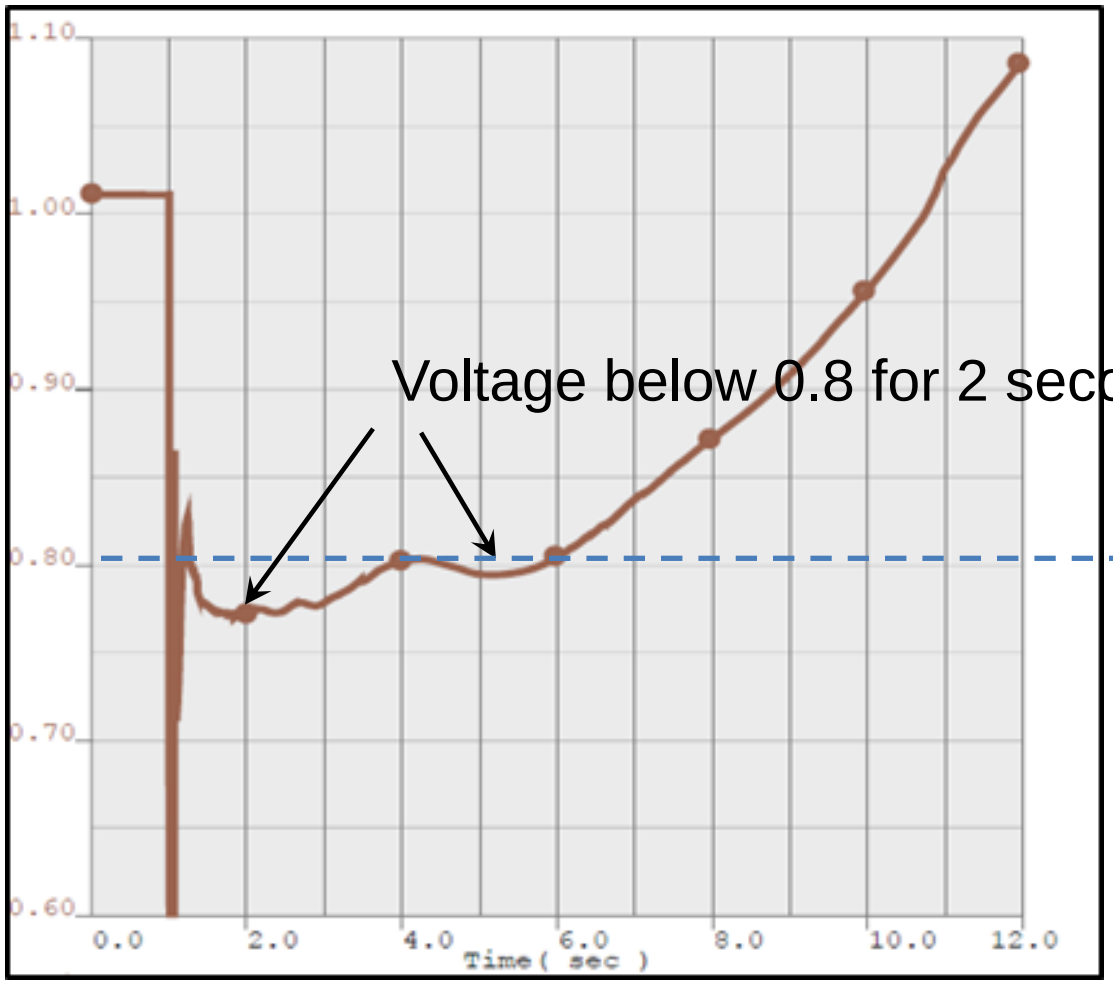
- 

Violations of Transient Voltage Criteria with Contingency



This is obvious violation of voltage dip requirement

Is it a violation of the criteria? What caused second dip?



WECC-CRT-3.2 Criteria – Voltage Recovery

- For the faults not resulting in motor stalling, the intention of the criteria was to specify a voltage dip that would give a reasonable expectation of loss of load subsequent to the initial recovery above 80% after fault clearing.
- However, from these examples loss of load is not clear.
- There may be different interpretations of Requirement 1.4 by different entities. What is considered to be a criteria violation by one company, may not be considered a violation, but just an example of the slow voltage recovery which is within the criteria, by another one.
- May lead to additional investments in fixing voltage dip, which are actually unnecessary, or to not implementing necessary upgrades.

Questions to Ask

- How does meeting this criteria help BES reliability?
- Is the criteria a proxy for early-warning of BES instability? If so, which one– voltage, angular, both?
- Is the criteria intended to flag unacceptable FIDVR when applied at load buses? Then, what's the adverse reliability impact of unacceptable FIDVR?
- Is it loss of load? But, loss of voltage-sensitive load is not a non-consequential load loss and is allowed by the NERC TPL criteria
- How does FIDVR driven load loss equate to unacceptable system performance specified in NERC TPL 001-4 Table 1? If we cannot map the FIDVR load loss to Table 1 performance, then how is unacceptable FIDVR (and hence transient voltage criteria) a useful metric for BES reliability?

Does Criterion need to be re-written? If yes, how?

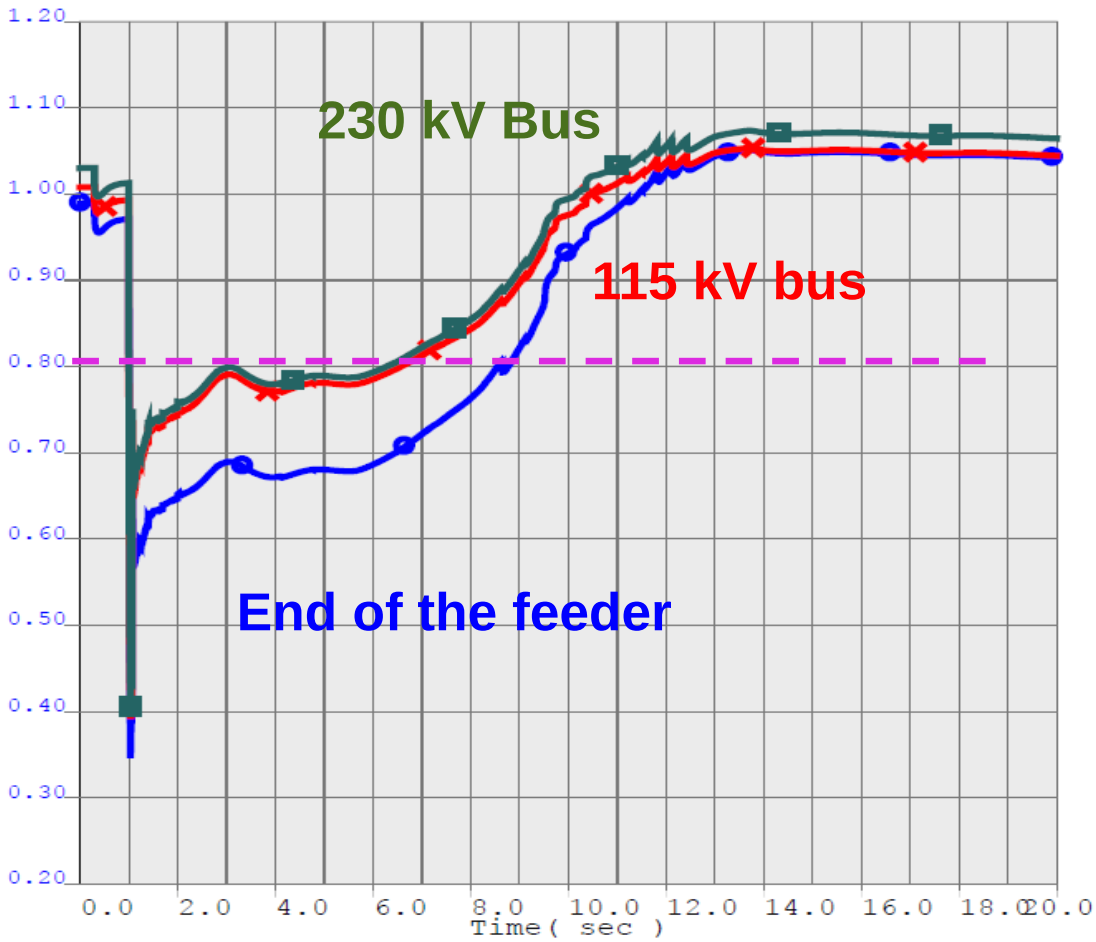
- Specify the duration of time when voltage should stay above 80% after the fault prior to decreasing.
- Add the magnitude of voltage dip from the time when it starts that is considered to be the criteria violation.
- Add limitations on how much load may be lost, or to what magnitude voltage may raise after the transient period.
- Will criterion improve if this is added?

Conclusions after Discussions with WECC

- Even if the Criteria may be confusing, it doesn't need to be re-written
- It is up to TP and PC to decide how to apply the Criteria to their systems
- In each specific case, engineering judgement needs to be used.

Application of the WECC Transient Recovery Criteria at the California ISO

- Criteria is applied only to the BES system. Distribution feeders and fictitious load buses created by composite load model are excluded.
- We distinguish between voltage dip and slow voltage recovery based on the output channel plots



Recovered in less than 20 seconds
Voltage dip is not a violation

QUESTIONS?

COMMENTS?

SUGGESTIONS?

Please send your comments to Irina Green

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