Interconnection and Reliability Studies with GFM

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ELECTRANIX
SPECIALISTS IN POWER SYSTEM STUDIES

Interconnection and Reliability Studies with GFM

- How do interconnection studies (primarily PSCAD) change with GFM?
  - If already following NERC / IEEE guidance (ATC, ISONE, ERCOT, HECO and others), potentially not much change needed!
- What determines success / failure of studies with GFM?
  - Analysis becomes more difficult due to increased complexity and potentially requirements with GFM compared to GFL
- Need to review process of GFM battery evaluation following RFP

Step 1: Publish specification of tests

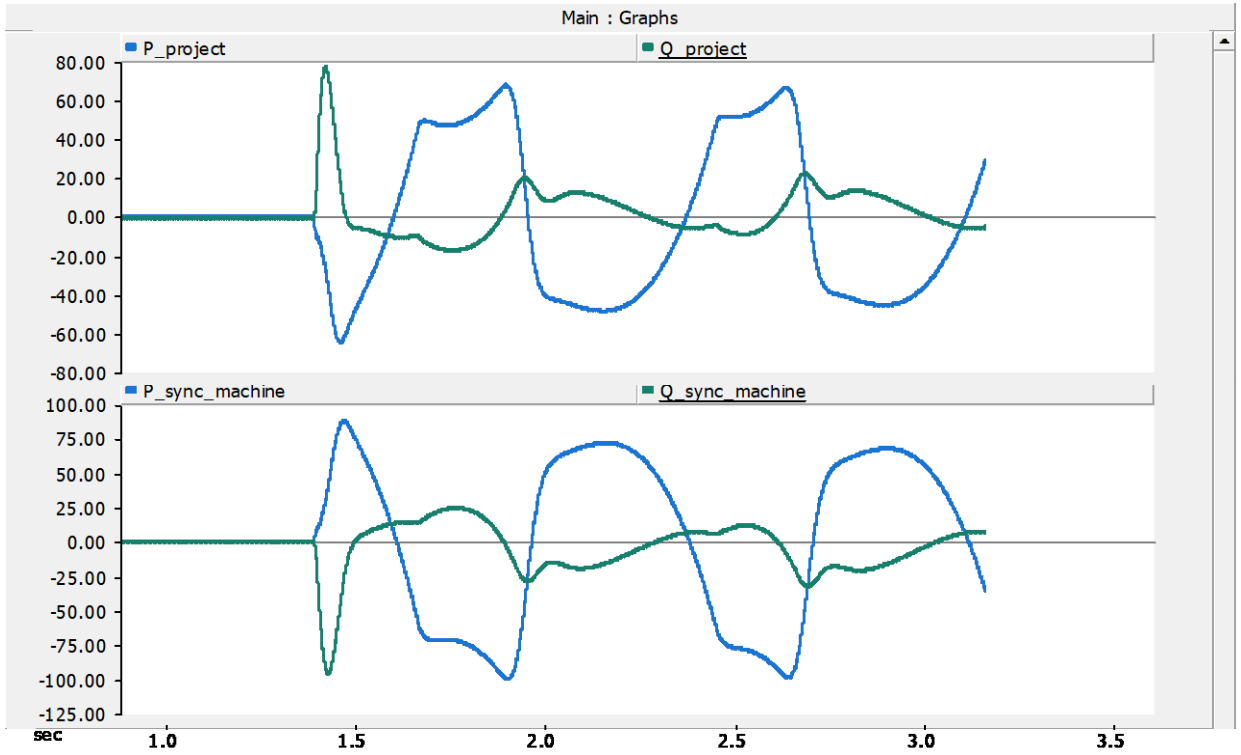
- GFM requirements include relevant GFL requirements, plus additional GFM-only tests
- Tests should be functional specifications of the desired GFM capability, such as:
  1. Survival of the loss of last synchronous machine
  2. Able to operate in GFM while grid-connected
  3. ‘Play nice’ with other GFMs / GFLs / synchronous machines
  4. Load step up/down
  5. Topology / system specific needs (overcurrent capability? FFR?)
- Clearly define test procedure and terminology to avoid confusion
- HECO Modeling requirements: https://www.hawaiianelectric.com/documents/clean_energy_hawaii/selling_power_to_the_utility/competitive_bidding/20210901_cbre_rfp/20210825_redline_lanai_appxb_att3.pdf

Step 2: Evaluation of GFM models in isolation

1. Does the model meet requirements expected of GFL models? (model accuracy / usability, fault ride-through, voltage/frequency control)
2. Are GFM functional tests handled gracefully?
    1. Does current magnitude and duration seem reasonable?
    2. What happens when current limits are hit?
    3. Poorly damped oscillations?

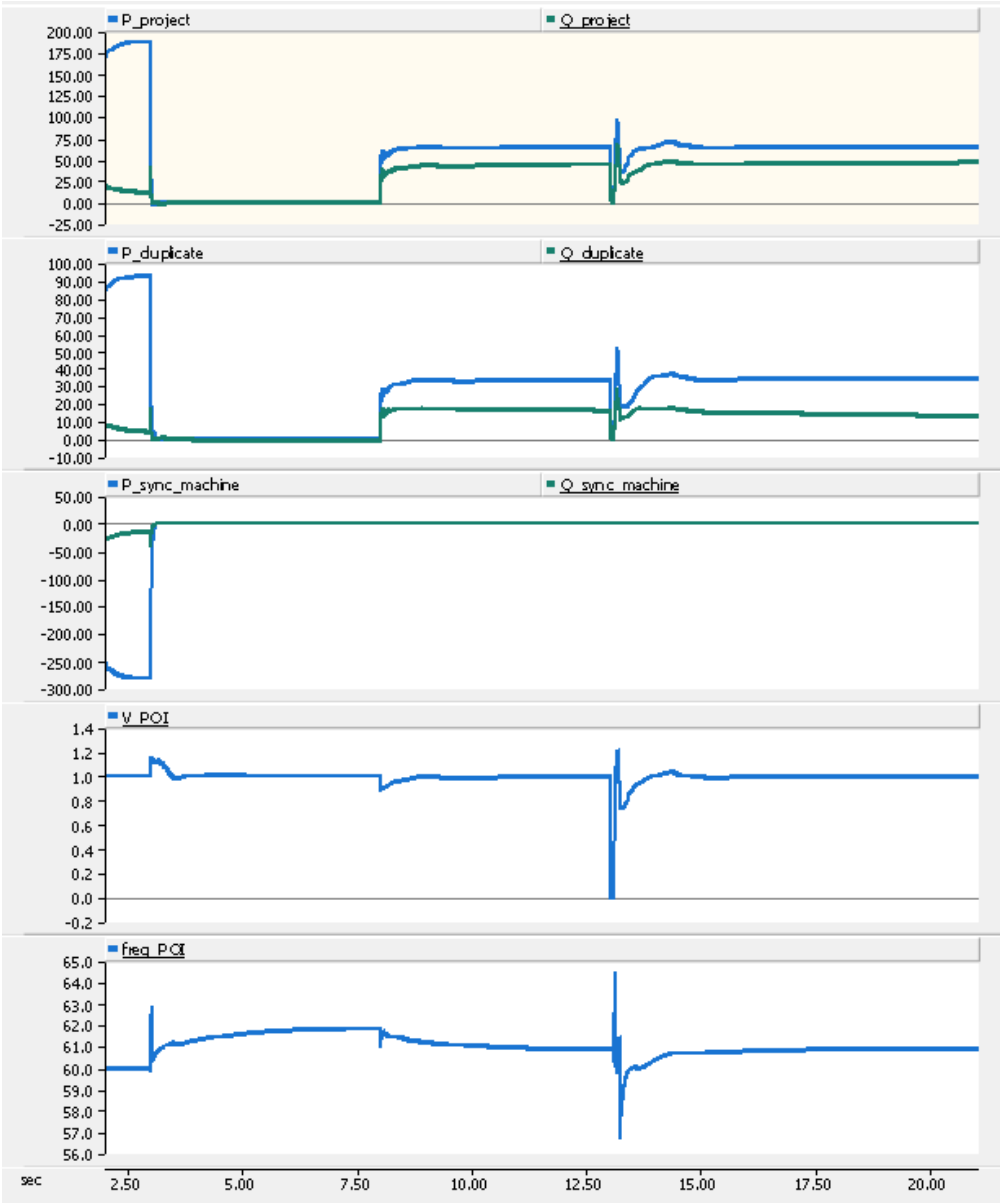
Step 2: Evaluation of GFM models in isolation

GFM model unable to operate in parallel with synchronous machine (incorrect interpretation of GFM requirement) - Fail



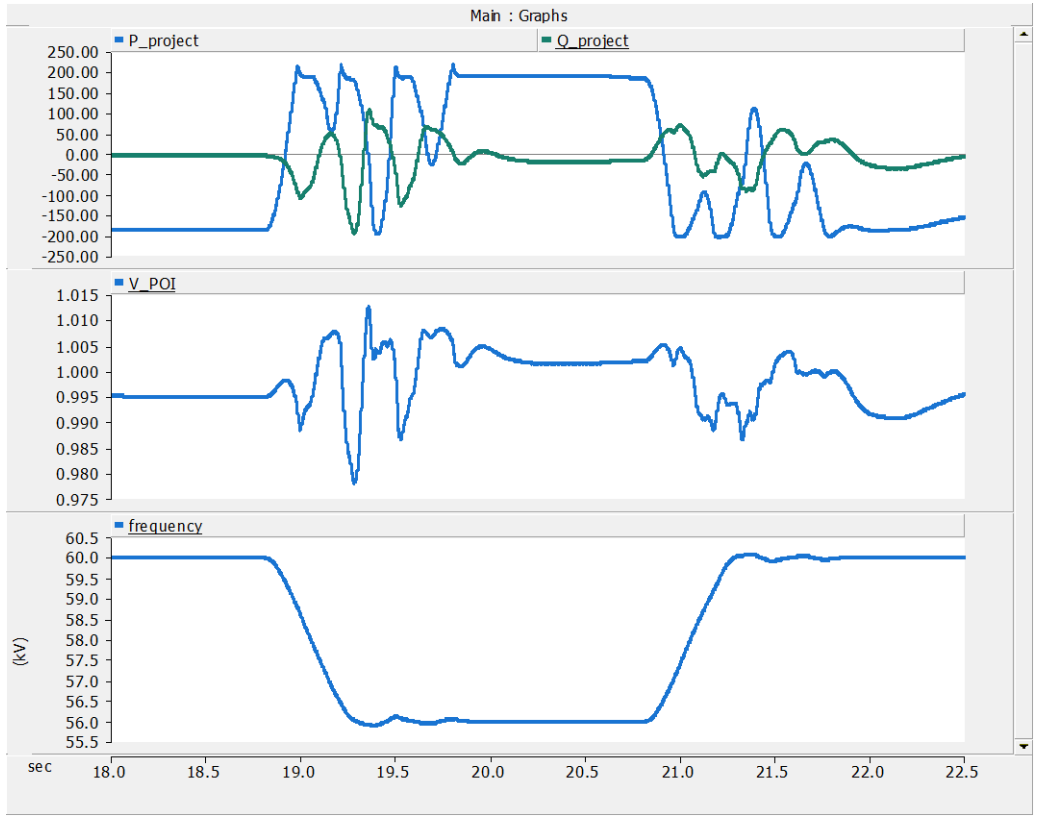
Step 2: Evaluation of GFM models in isolation

- Survives loss of last synchronous machine (3s)
- Shares load step-up with project duplicate (8s)
- Rides-through fault (13s)
- Success!



Step 2: Evaluation of GFM models in isolation

GFM model sensitive to high RoCoF
– Further discussion with OEM needed



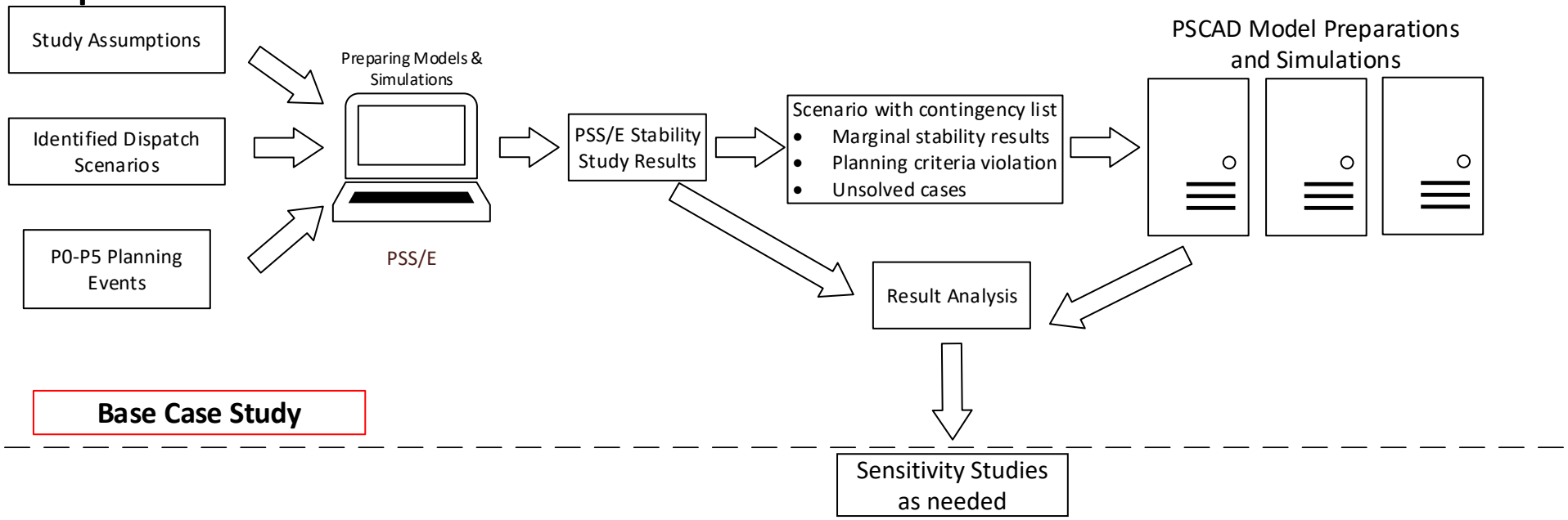
Step 3: System Model Development

- Gather dynamic models for IBRs and synchronous machines
- Prepare databases of dynamic models with initialization, automation and re-usability in mind
  - No special initialization/automation needed for GFM. Both GFM and GFL have plant controllers which should accept references from a solved loadflow
- Prepare database with fault automation, frequency dependent T-lines, monitoring, etc.
- For islanded systems:
  - No fixed-frequency voltage source models allowed
  - If relevant, model frequency dependent load and UFLS schemes
- Use tool such as E-Tran to create full PSCAD case from solved powerflow

NOTE: this is a big topic… no time for it now!!

Step 4: Interface between planning studies in PSS/E and PSCAD

- PSCAD simulation and analysis is very time consuming
- PSSE may be used to identify PSCAD contingency list
- Example from HECO:



Step 5: Performance testing and system analysis in composite model

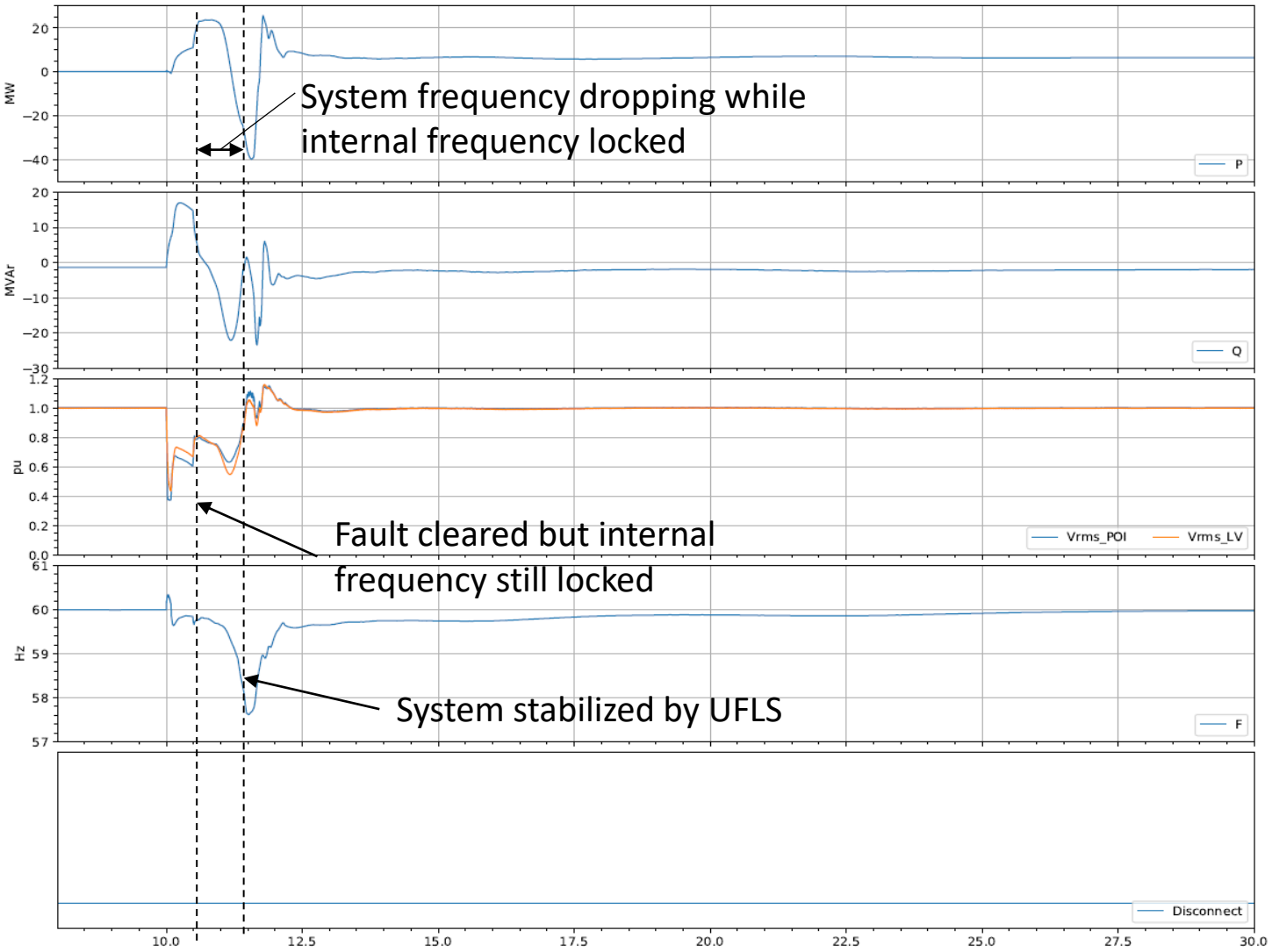
- Objective is to create high-level pass/fail results summary

Dispatch	Contingency	Acceptable System Impact?	Specific Issues / Concerns
…	…	…	…
…	…	…	…

- How to determine success / failure?
  - System stability (loss of load, undamped oscillations, excess generation tripping)
  - Device performance issues (ride-through, voltage/frequency control)
  - Additional criteria (damping, TOV, harmonics, etc.)
  - System dependent!

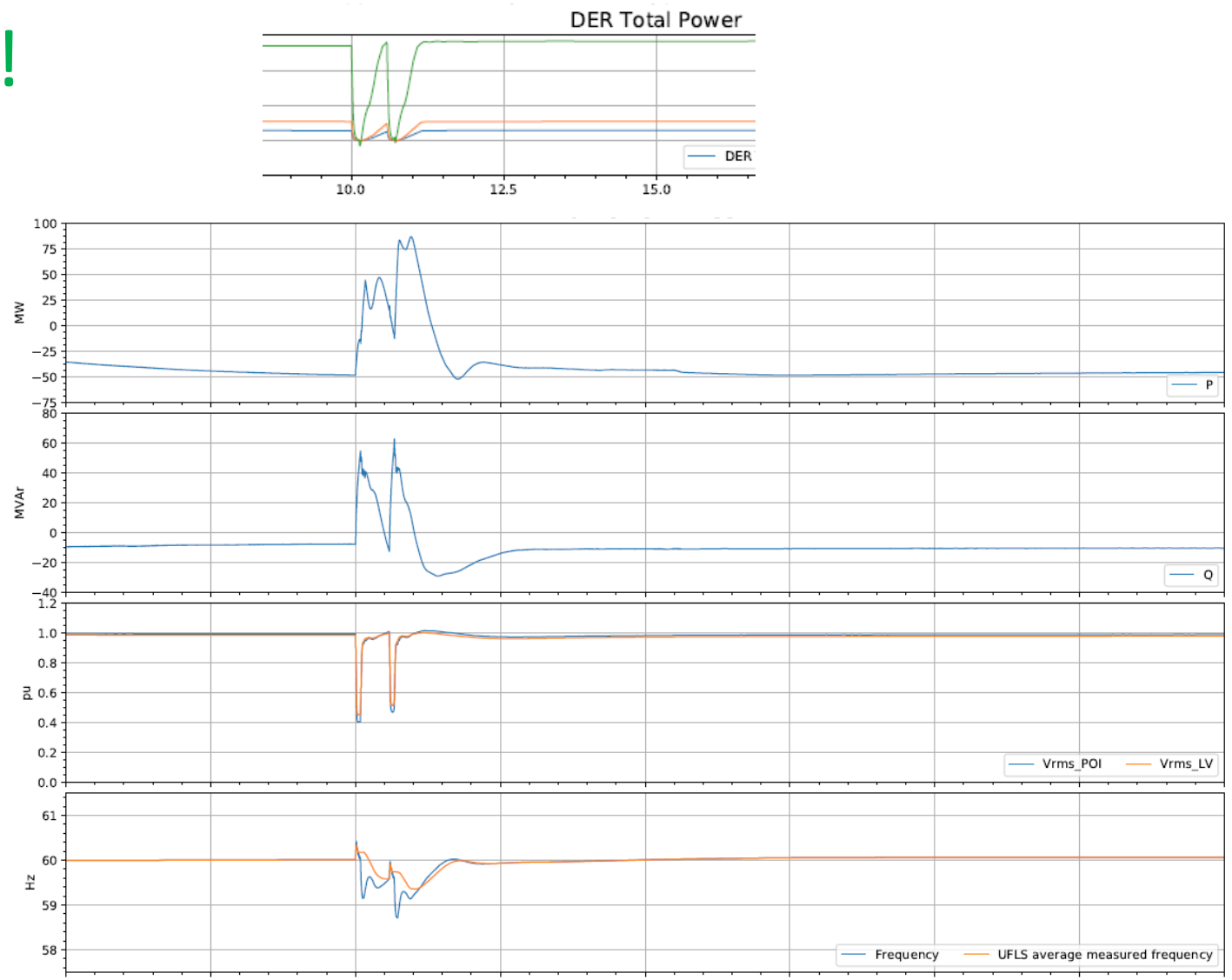
GFM Analysis - Fail

- GFM control design not optimized for delayed voltage recovery, resulting in system failure
- Interaction between current control and GFM power synchronization loop
- Analysis can become more complex!



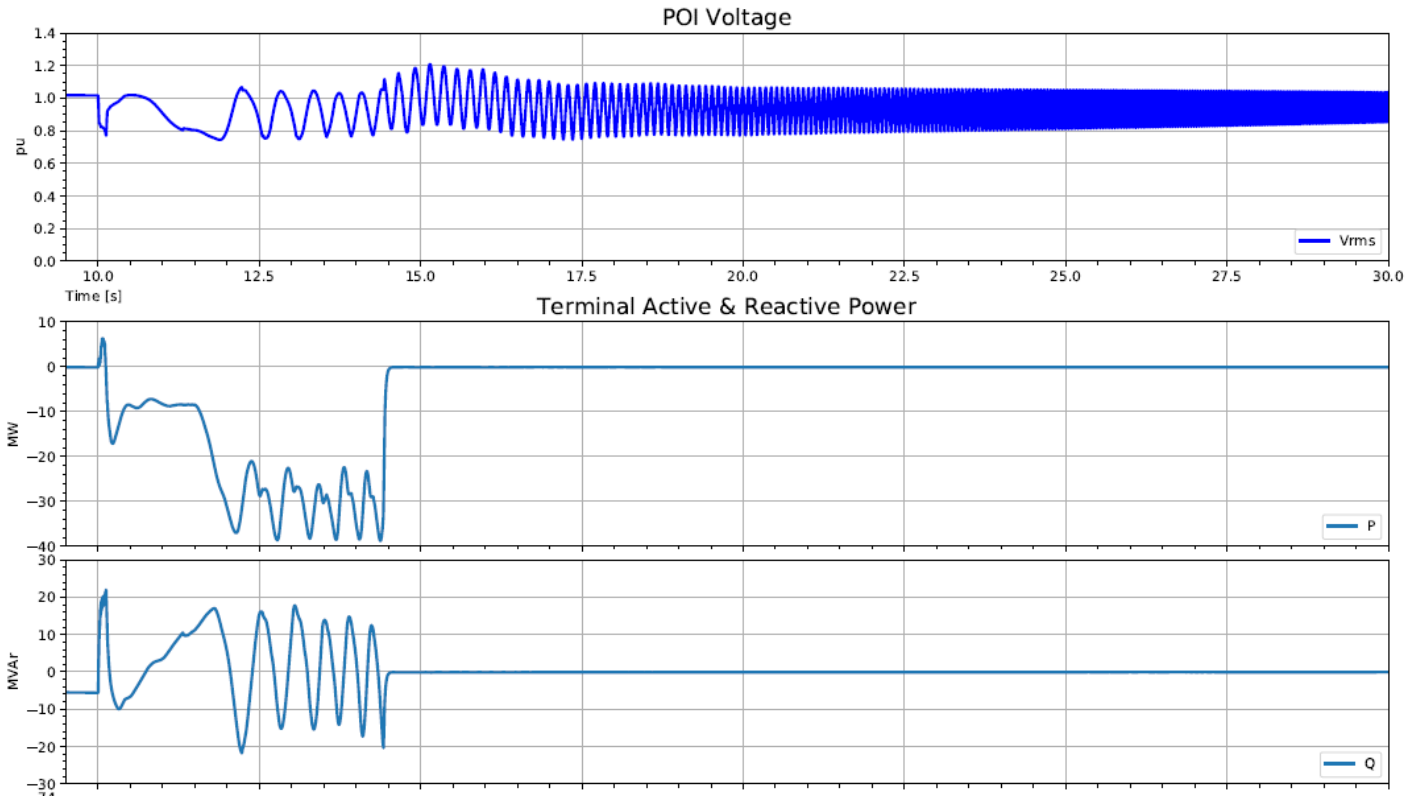
GFM Analysis – Success!

- Strong response to fault and DER momentary-cessation energy deficit
- Post event, active power pulls back to pre-fault as frequency returns to 60 Hz



GFM Analysis – physics still applies!

- GFM BESS attempts to return to pre-fault power (0 MW) after fault
- Results in voltage collapse, transient instability



In summary…

- Interconnection studies process may not require substantial change if following NERC / IEEE guidance on EMT studies and modelling
- Areas which will require change:
  - Performance requirements for GFM batteries (GFM test specifications)
  - Additional testing to evaluate GFM in isolation
  - Additional analysis to ensure GFM control operating appropriately

Future Considerations – GFM STATCOM?

- Multiple manufacturers working this product
- May be able to provide multiple seconds of power at full rating, then operate as normal STATCOM
- For short term, strong potential technical and cost advantages of supercapacitors over batteries.

Questions?

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