EMT Practices At ISO-NE

ESIG Fall Technical Workshop Session 8A: EMT Practices and Applications

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Presentation Outline

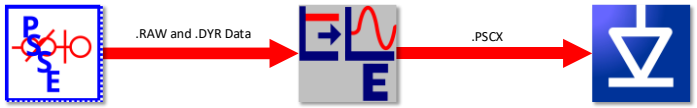
- When does ISO-NE do EMT studies?
- EMT Study practices
- EMT Model Requirements
- EMT Model Verification
- Lessons Learned
- Future EMT Work
- Questions

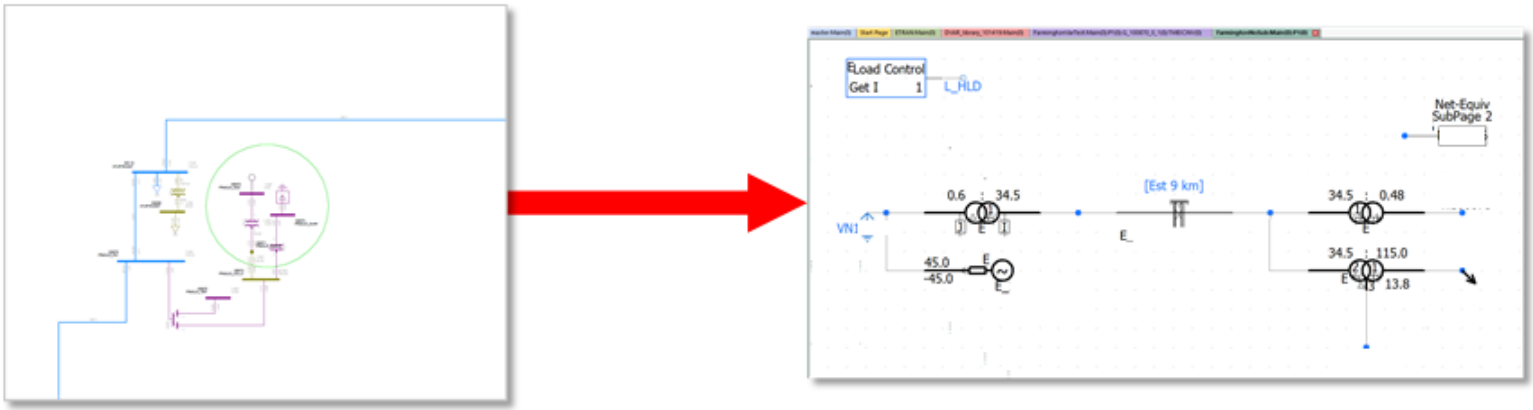
When does ISO-NE do EMT studies?

- ISO-NE requires an EMT study for each inverter-based generating facility interconnection request, or Elective Transmission Upgrade that utilizes power electronics as part of the facility or network upgrade.
  - Type 3 & 4 Wind, PV, BESS, STATCOM, SVC, HVDC, etc.
- Other studies are required when there are concerns about certain grid conditions, interactions, or other high speed phenomena
  - Weak system conditions (low short circuit strength)
  - Sub-synchronous oscillations such as sub-synchronous torsional interactions (SSTI) or sub-synchronous control interactions (SSCI)
  - Control interactions
  - Ride-through or large signal disturbance performance
  - Performance verification
  - Voltage Transients

EMT Study Practices – Study Setup

- ISO-NE uses the Manitoba HVDC Research Centres PSCAD software in conjunction with Electranix E-Tran to accomplish EMT analysis
  - Currently transitioning to PSCAD V5 and E-Tran 6
- Study area includes all electrically relevant transmission and generating facilities
  - Mostly local, PSCAD cases represent portions of the over all system and use voltage sources that represent system strength as boundaries
  - Initial conditions are informed by the steady state and stability cases used in the system impact studies
- E-Tran Provides **PSCAD implementations of non-IBR library models** in the PSSE Standard dynamics model library
  - GENROU, EXAC7B, PSS2A, etc.
  - OEM Specific IBR Models are required



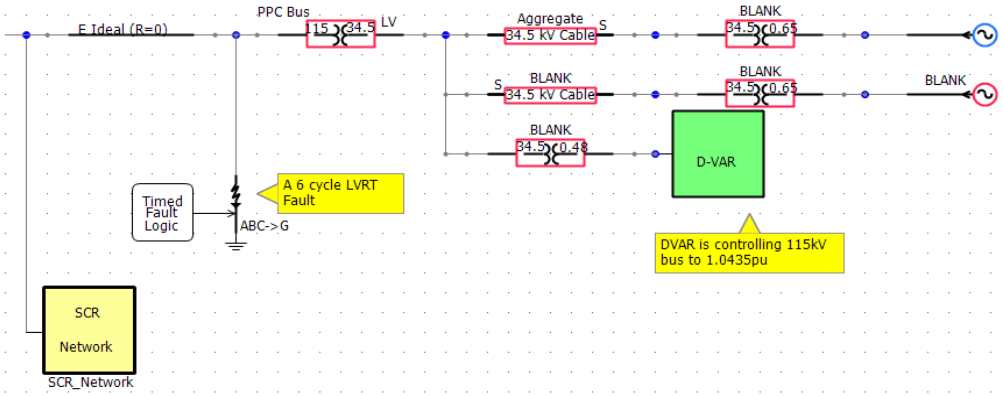


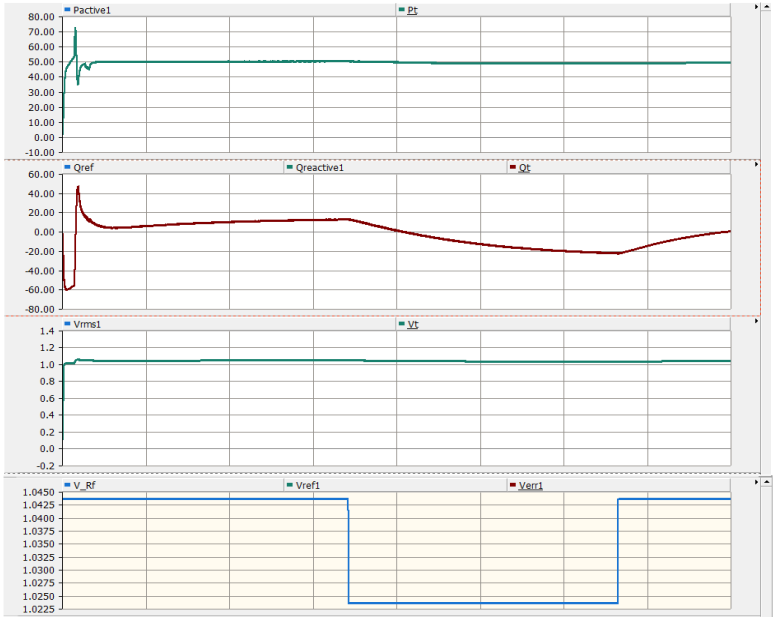
EMT Study Practices – Methodologies

- Interconnection System Impact Studies require full N-1 and N-1-1 fault testing along with any other EMT analyses identified during scoping
  - Which faults to run are decided on using engineering judgement
    - Focus on contingencies that cause the system to weaken and that have longer clearing times
- Boundaries are set up to include as many relevant projects as possible
  - May include Transmission, Sub-Transmission, and Distribution connected resources
  - Can result in large amounts of EMT models
- Studies are almost always run using parallel processing

EMT Model Requirements

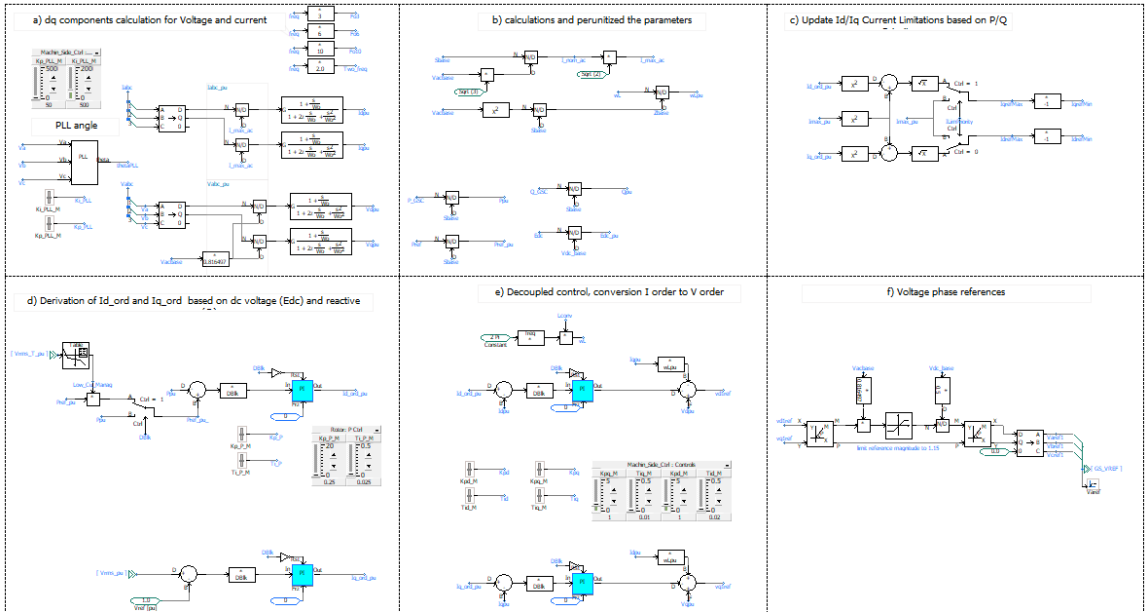
- Models are required to be provided as part of the interconnection request for all IBRs and ETUs utilizing power electronics
- Models are vetted for accuracy, usability, and efficiency as part of the interconnection request review process.
  - Model Quality Attestation
  - Model Quality Checklist
  - Benchmarking
  - SMIB testing
  - Playback Testing
- Full requirements can be found in ISO-NE [Planning Procedure 5-6]

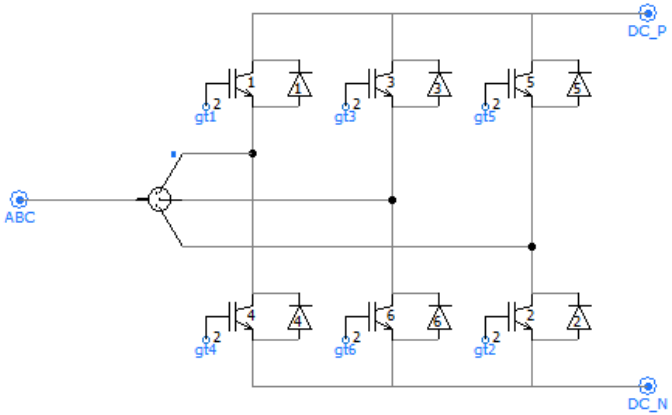




EMT Model Requirements (cont.)

- Models must represent the full detailed inner control loops of the power electronics.
  - Any approximations must be non-consequential
  - Best practice is to embed actual hardware code

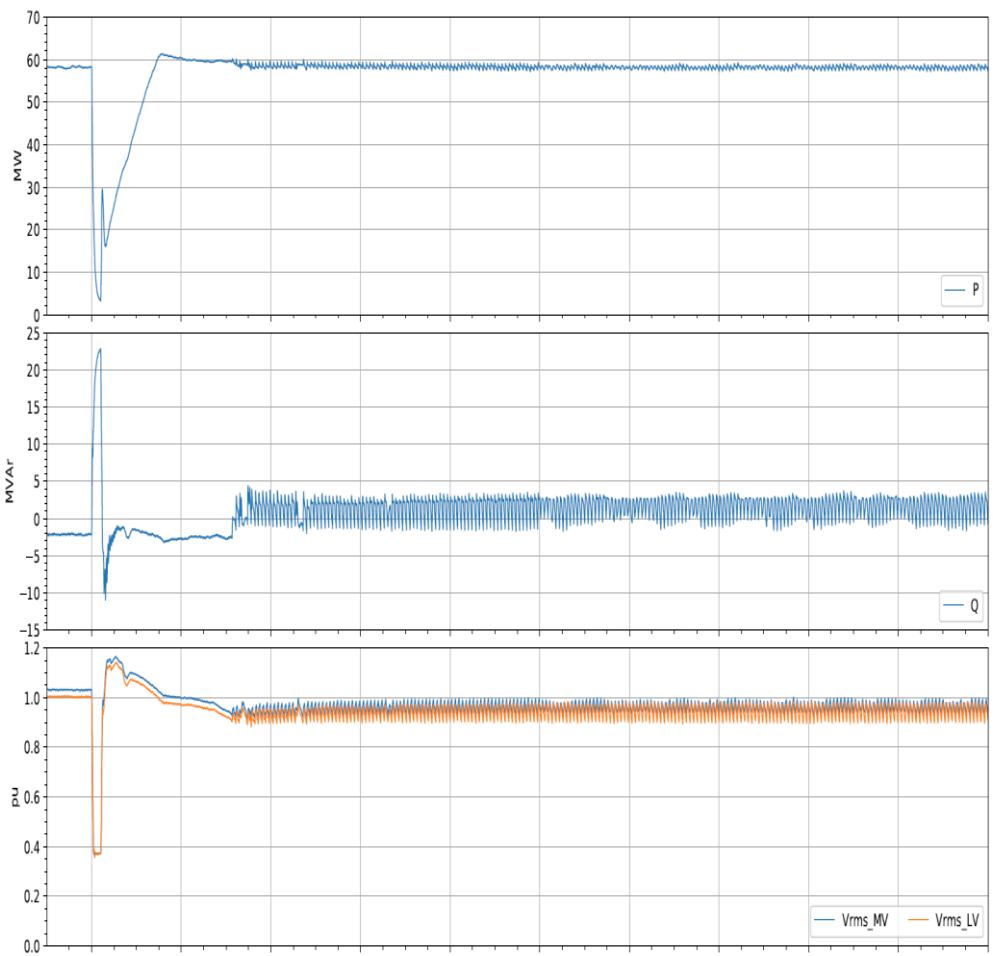


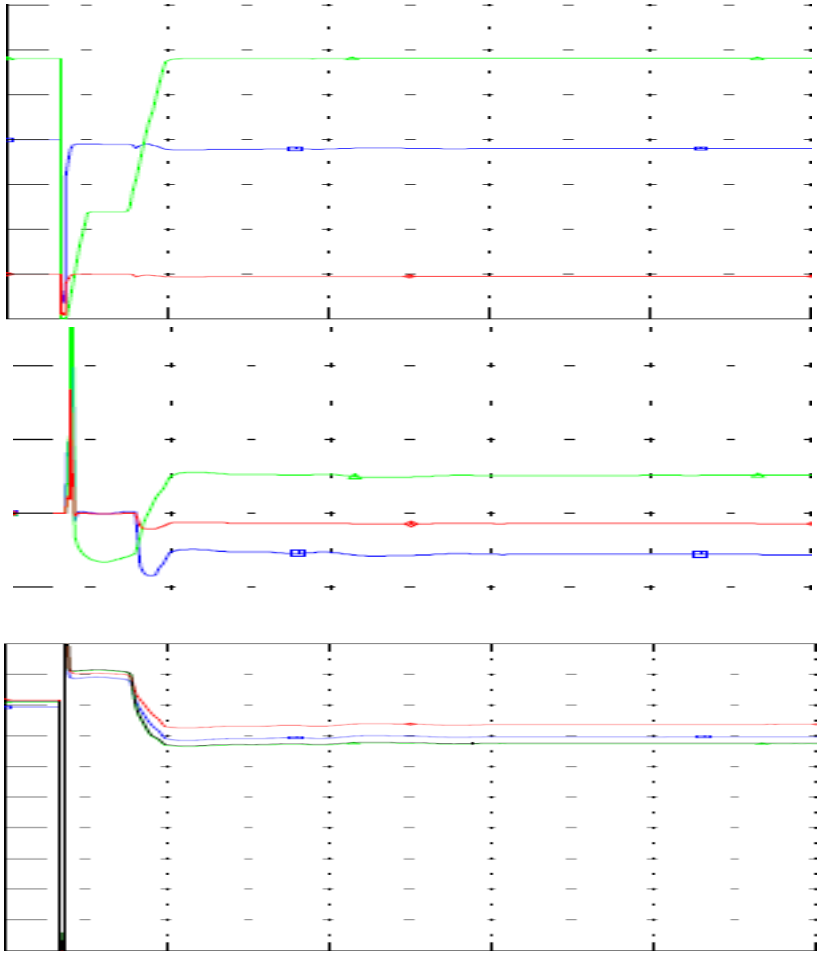


EMT Model Verification – Comparison of PSCAD to PSS/e Model

PSCAD

PSS/e

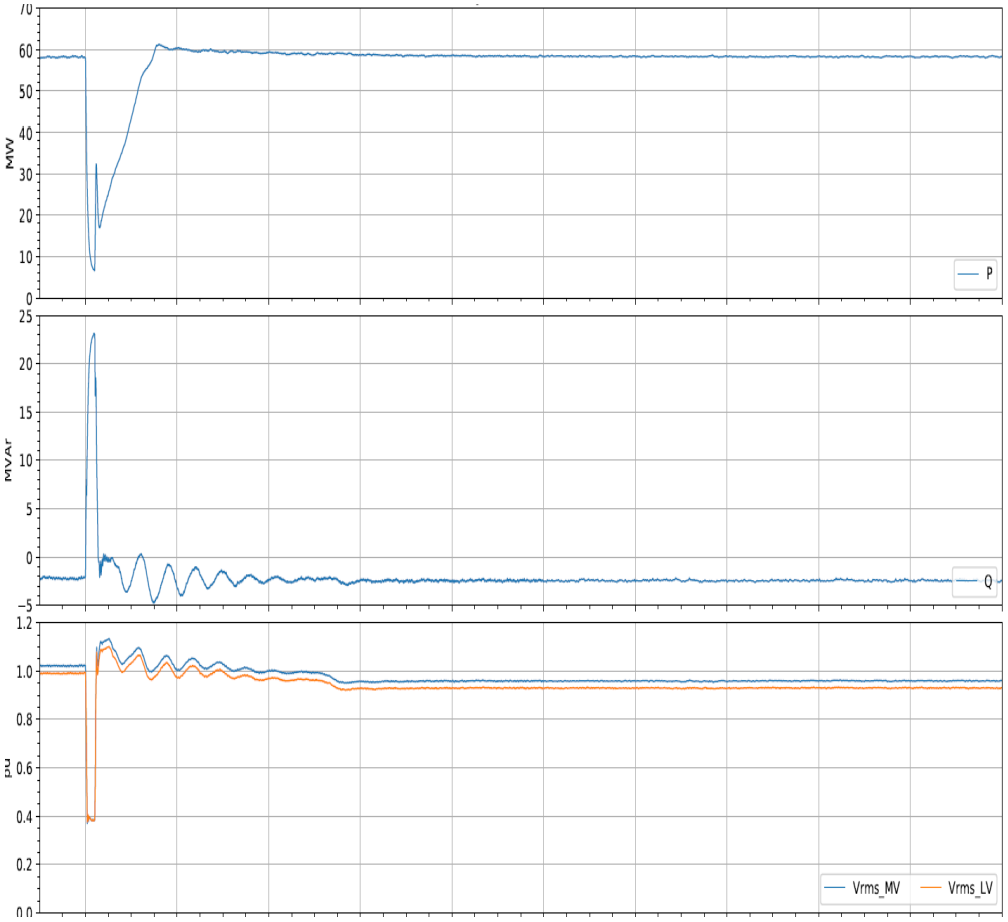


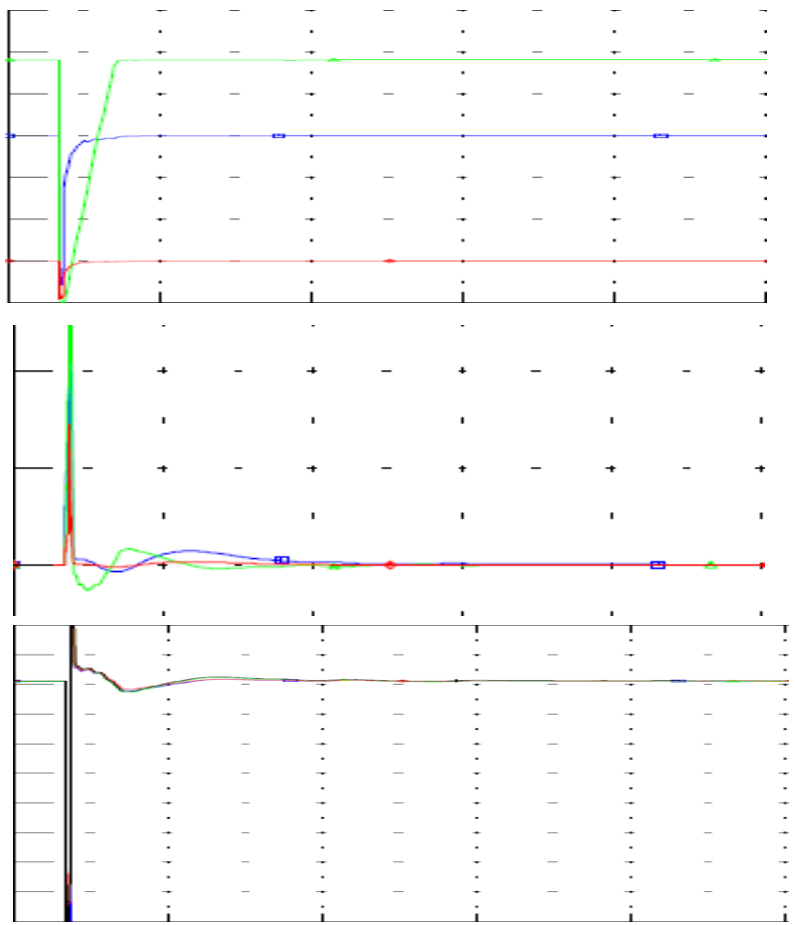


EMT Model Verification – Comparison of PSCAD to PSS/e Model (Cont.)

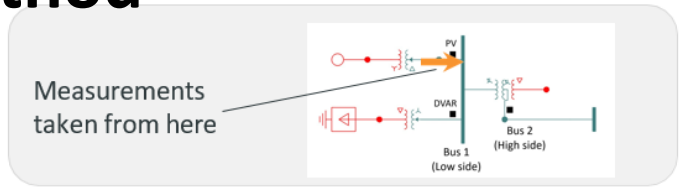
PSCAD

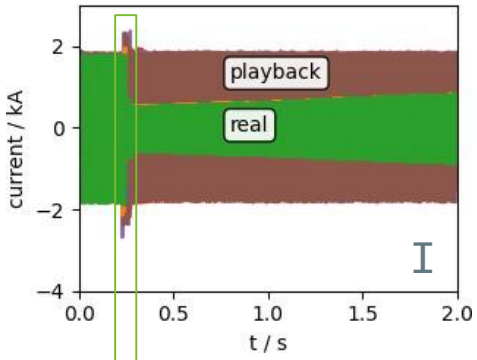
PSS/e

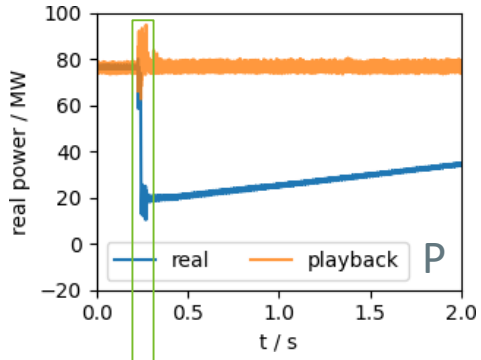


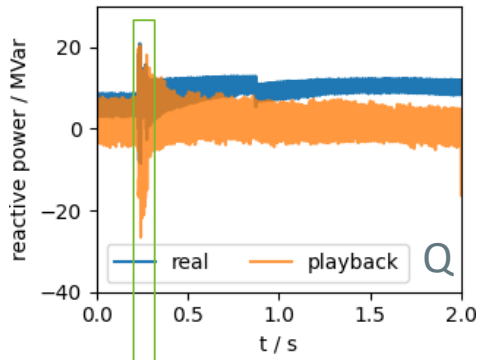


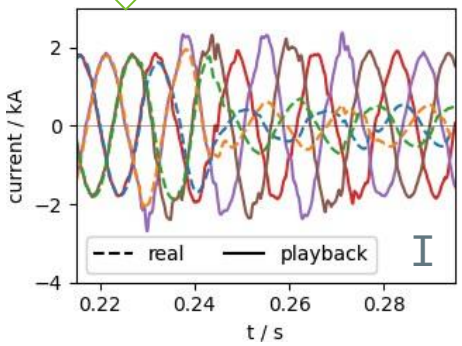
EMT Model Verification – Comparison of EMT model to measured DFR Data – Playback Method

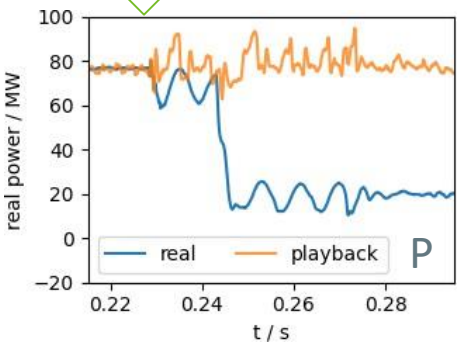


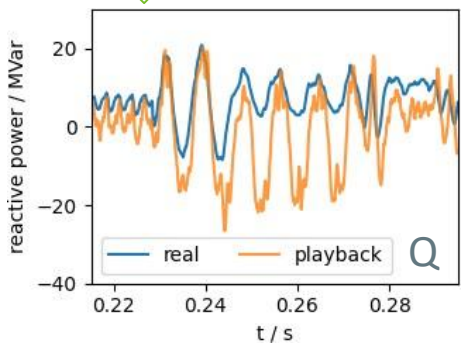












Lessons Learned

- EMT Studies are much more time intensive than traditional transient stability studies
  - Models are much more complicated
  - Computationally expensive
- EMT studies can show things that may have been missed in stability studies
  - Due to higher fidelity models (ie: tripping due to PLL)
- Starting early and doing studies in parallel can help keep timelines on track
- Investing in more powerful hardware will be crucial as the clean energy transition puts more IBR's onto the grid
  - NERC activities are pointing towards EMT studies becoming required

Future EMT Work

- Development of an EMT Model Repository
  - Single source of up-to-date EMT models that are plug and play
- Investigating which hardware setup is most beneficial
  - Currently weighing costs and benefits of in house hardware or use of cloud services
- Designing automated testing and verification tools for EMT models
  - Automated testing and event playback to validate EMT models
  - IEEE 2800 conformity assessments
- Researching viability of hybrid simulations
  - Using PSPD models for area network and EMT models for project under study

Questions

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APPENDIX: WHAT IS AN EMT STUDY?

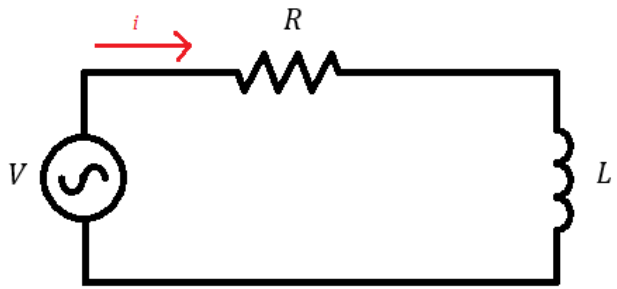
What is an EMT study?

- Electromagnetic Transient Studies are studies that use time domain solutions of the differential equations that govern an elements response. Normally solved in the microsecond time frame.

$$v(t) = R * i(t) + L\frac{d}{dt}i(t)$$

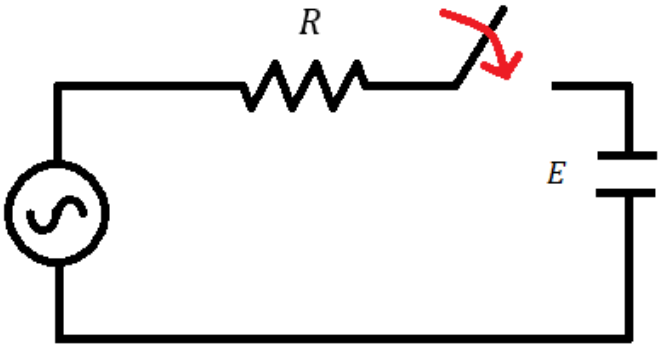
- This is as opposed to traditional transient stability studies that are solved based on phasor calculations and are normally run at quarter cycle (millisecond) time frame.

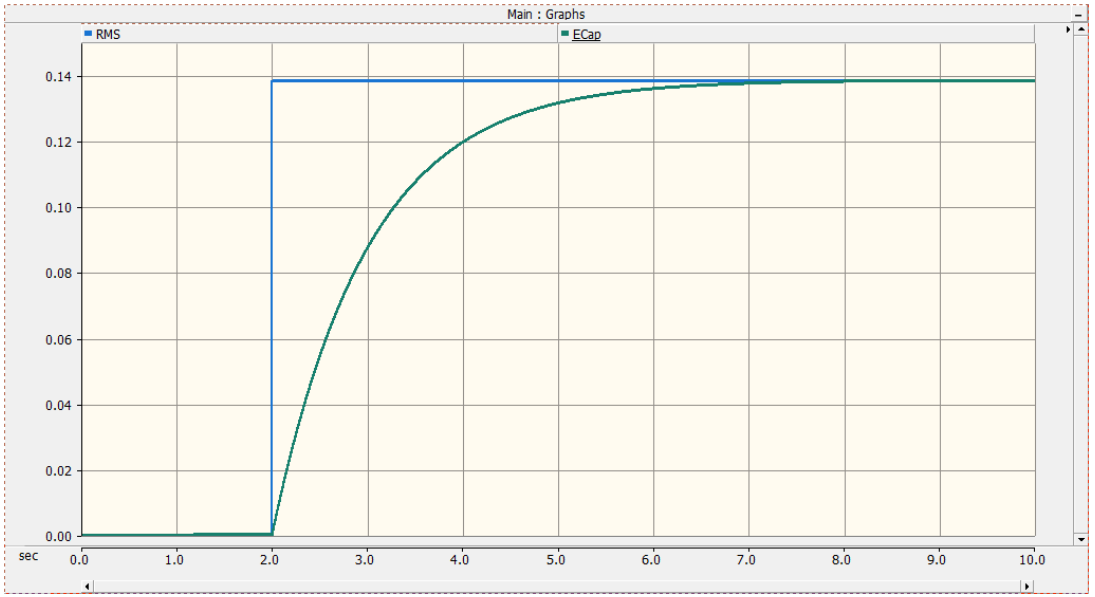
$$V(\omega) = R * I(\omega) + j(L\omega) * I(\omega)$$



Why do an EMT study?

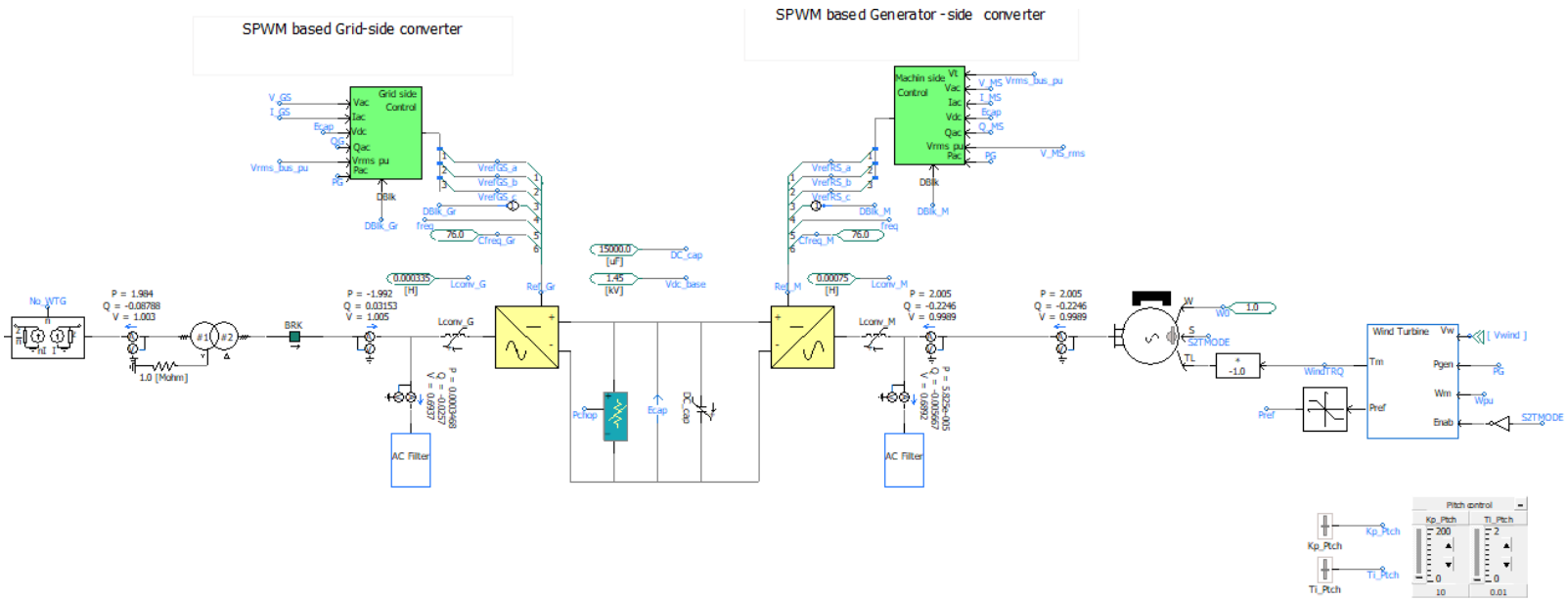
- EMT Studies can show you phenomena that are non-existent, or act differently in RMS, fundamental frequency, positive seq. dynamics.
- Fast transients can be studied since models are generally higher fidelity and solved at smaller time-steps.





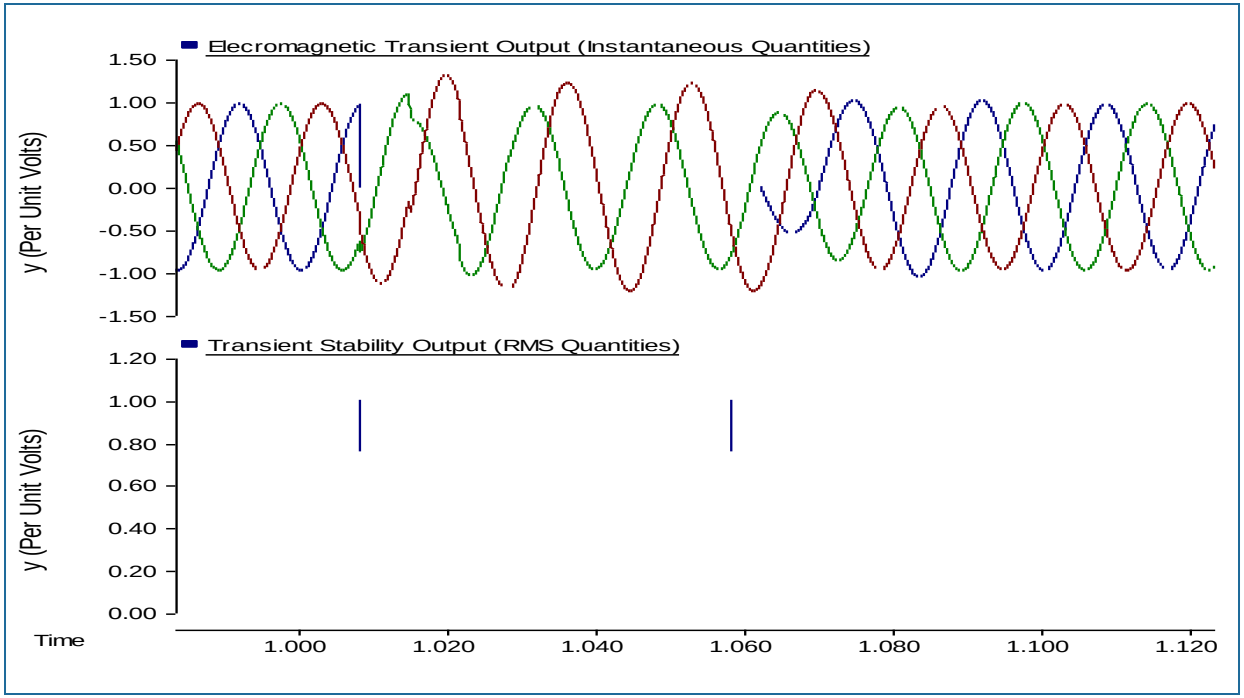
Why do an EMT study? (cont.)

- EMT models generally have higher fidelity than PSPD models
  - Full PLL representation
  - DC side dynamics and protections
  - OEM specific controls and logic



Why do an EMT study? (cont.)

- Full three phase power system behavior is represented at all frequencies.
- Each individual instantaneous phase quantity is calculated allowing for unbalanced faults, harmonics, transients, and other phenomena to be modeled



*plot provided by Electranix Corp.