



EMT Studies At ISO-NE

ESIG/NAGF/NERC/EPRI Generation Interconnection Workshop

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Purpose

- What is an EMT study?
- Why do an EMT study?
- When does ISO-NE do EMT studies?
- EMT Study practices
- EMT Models

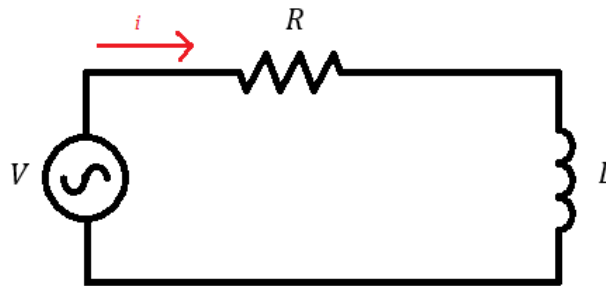
What is an EMT study?

- 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.

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

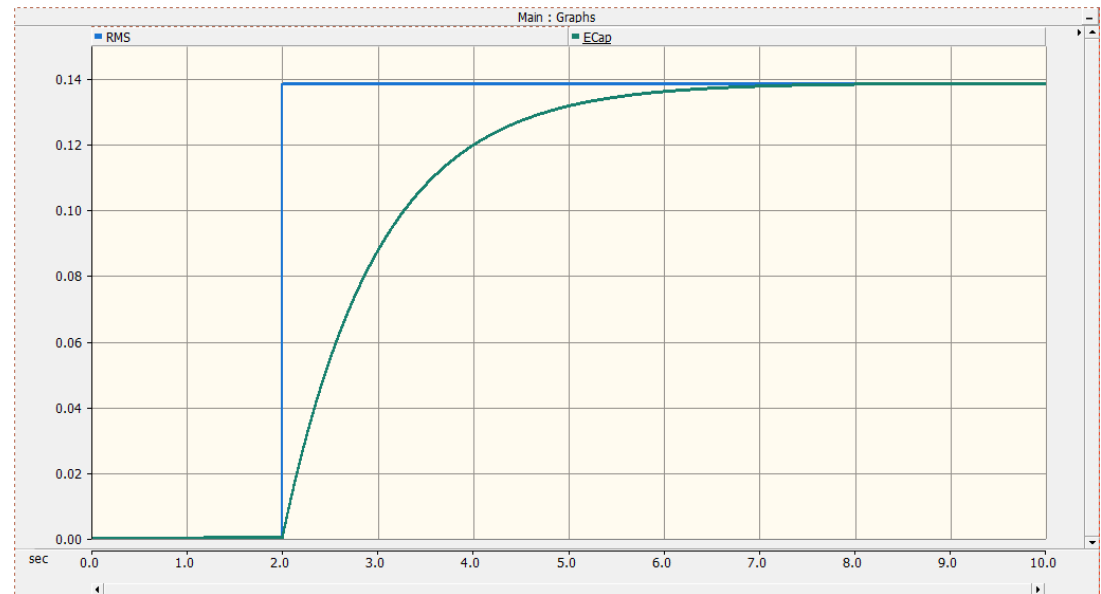
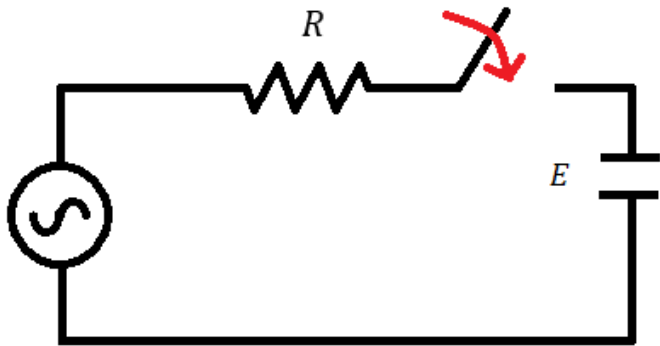
- This is as opposed to traditional transient stability studies that are solved based on phasor calculations and are normally run at quarter cycle (millisecond) time frame.

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



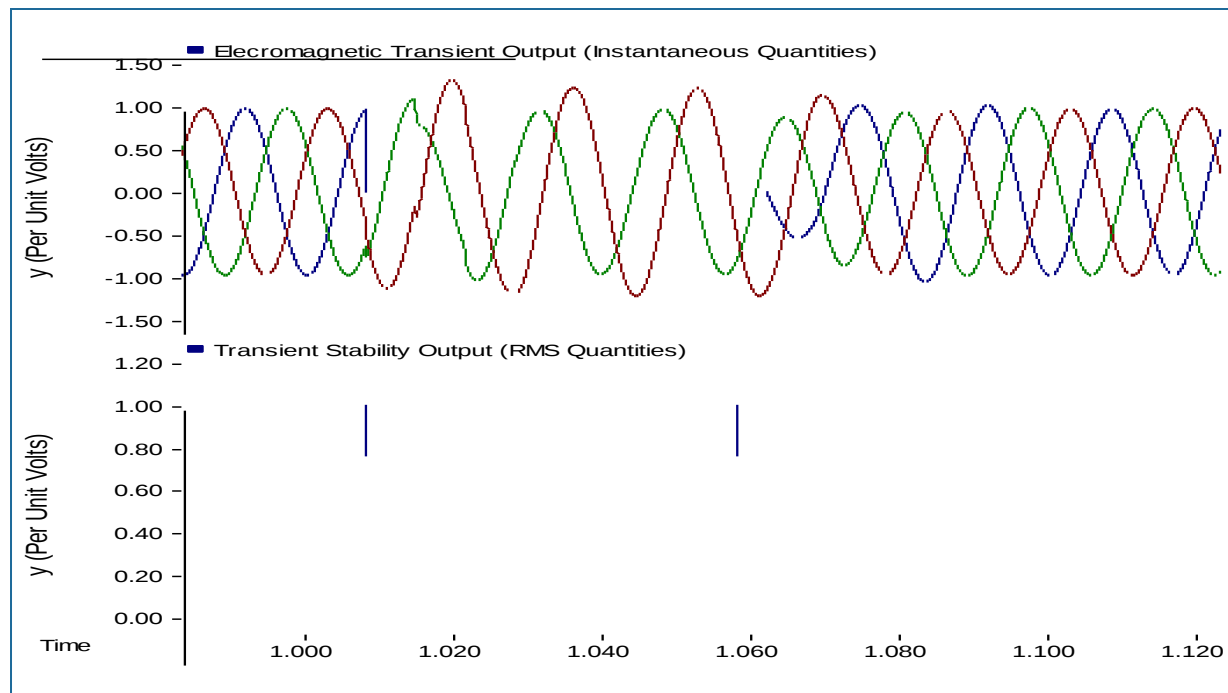
Why do an EMT study?

- 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.)

- 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 Electronix Corp.

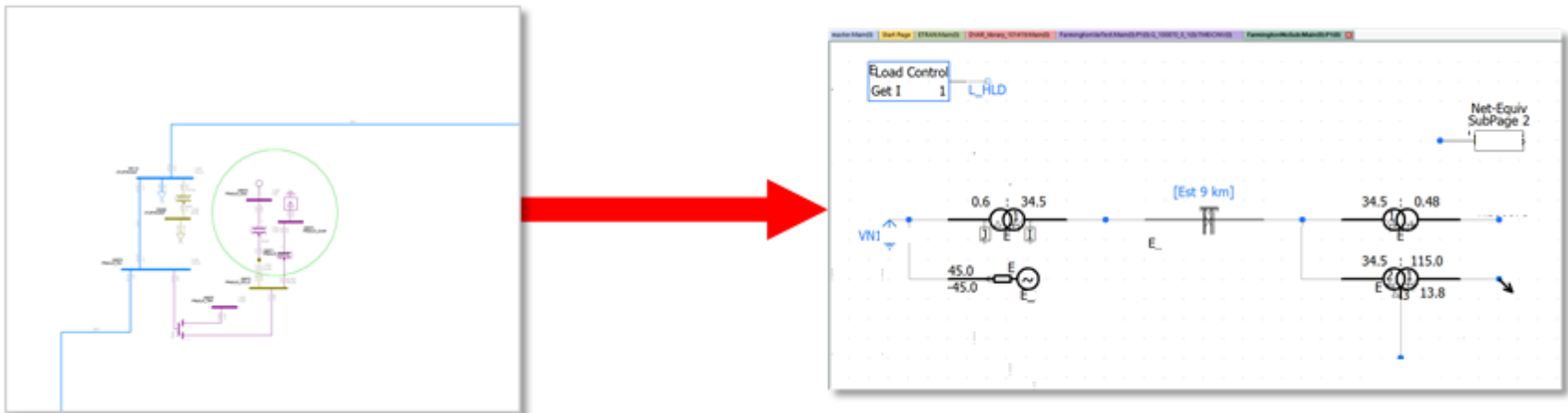
When does ISO-NE do EMT studies?

- Studies are required when there are concerns about certain grid conditions, interactions, or 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
- ISO-NE requires an EMT study for each inverter-based generating facility, or Elective Transmission Upgrade that utilizes power electronics as part of the facility or network upgrade.



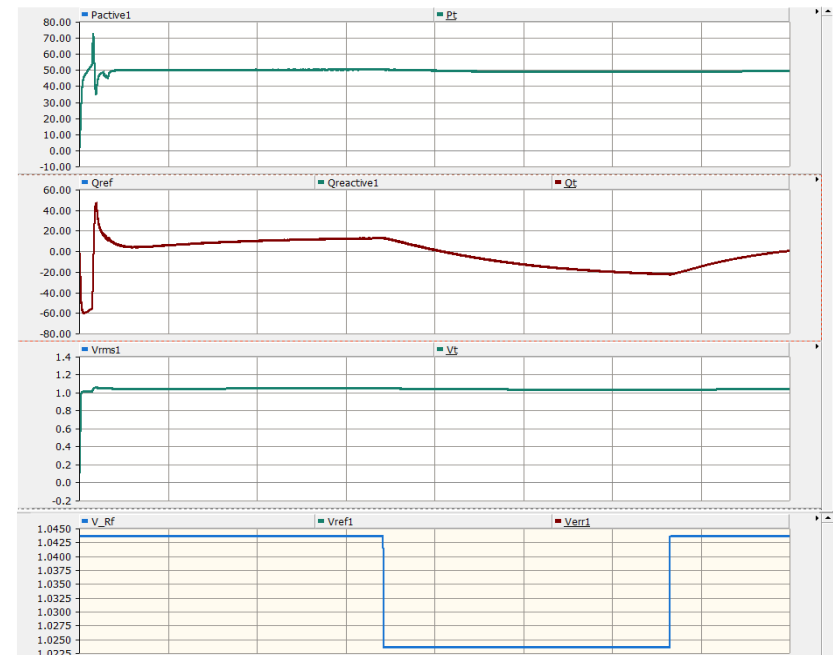
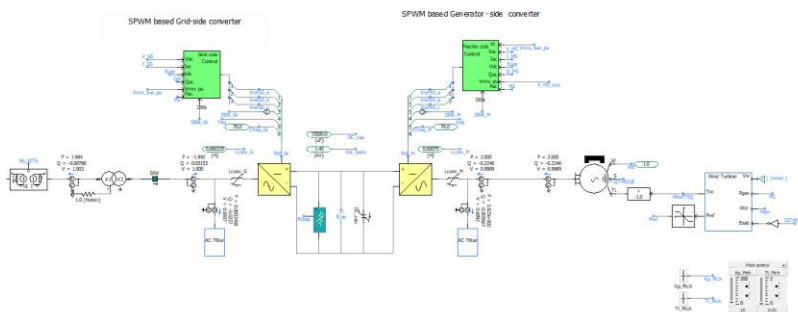
EMT Study Requirements

- ISO-NE uses the Manitoba HVDC Research Centres PSCAD software to accomplish EMT analysis
- System Impact Studies require full N-1 and N-1-1 fault testing along with any other EMT analyses identified during scoping
- 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 studies



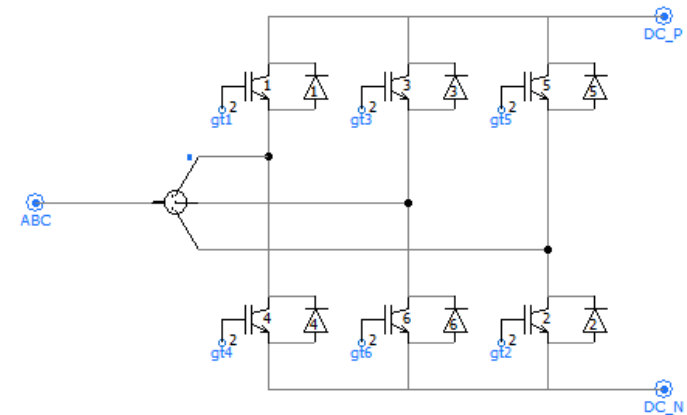
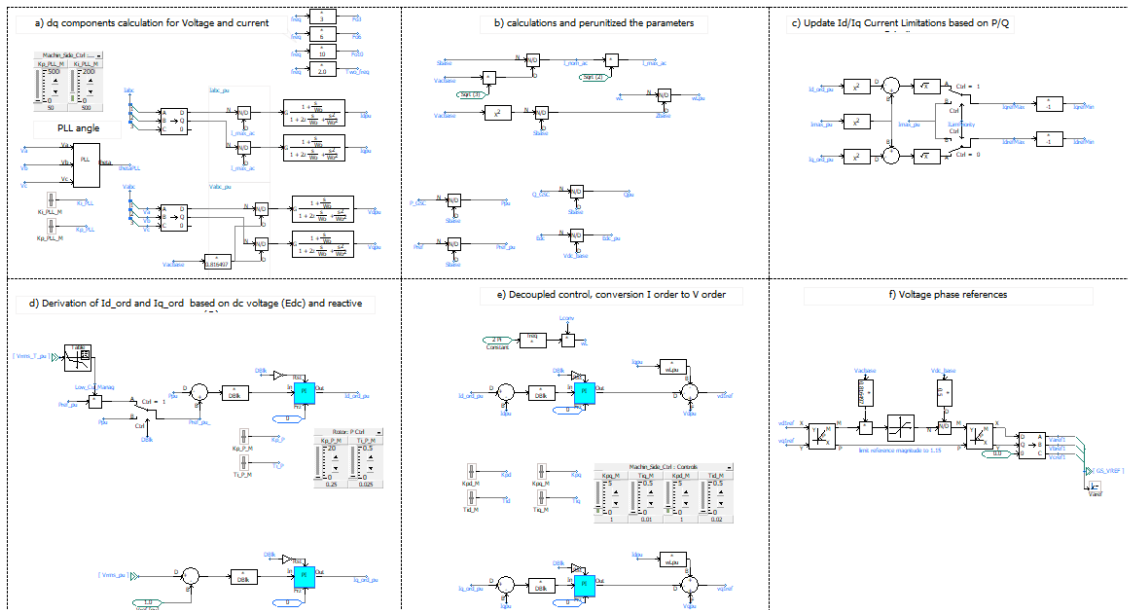
PSCAD Models

- 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, useability, and efficiency as part of the interconnection request review process.
 - Benchmarking
 - SMIB testing
 - Playback Testing



PSCAD Models (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



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 clean transition puts more IBR's onto the grid
 - NERC activities are pointing towards EMT studies becoming required



Questions

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