IEEE P3743: Recommended Practice for Electromagnetic Transient Model Interoperability for Electric Power Transmission Systems

A Consolidation of Presentations Given at:

- IEEE PES General Meeting, Seattle, WA, July 24, 2024 (Meghana Ramesh of PNNL)
- NERC EMT Task Force Meeting, Virtual, June 25, 2025
- ORNL/NERC EMT Workshop, Knoxville, TN, October 8, 2025
- CIM User's Group Meeting, Wendell, NC, October 16, 2025

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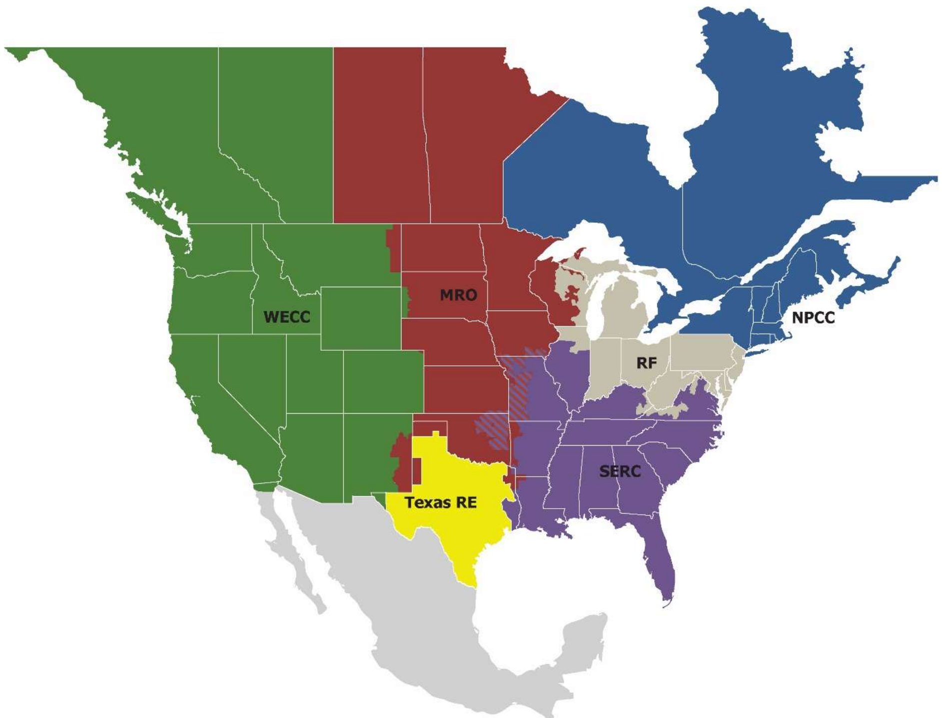
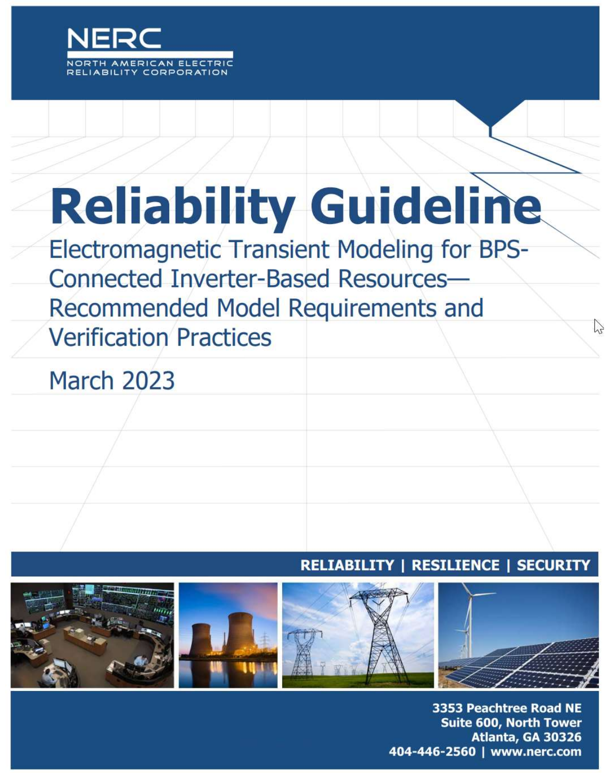
Read PAR and Sign Up at: https://standards.ieee.org/ieee/3743/12233/

The North American Electric Reliability Corporation (NERC) has called for electromagnetic transient (EMT) simulations to help preserve grid reliability in the presence of inverter-based resources (IBRs), which include wind, solar, and storage.




NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Reliability Guideline

Electromagnetic Transient Modeling for BPS-Connected Inverter-Based Resources—Recommended Model Requirements and Verification Practices

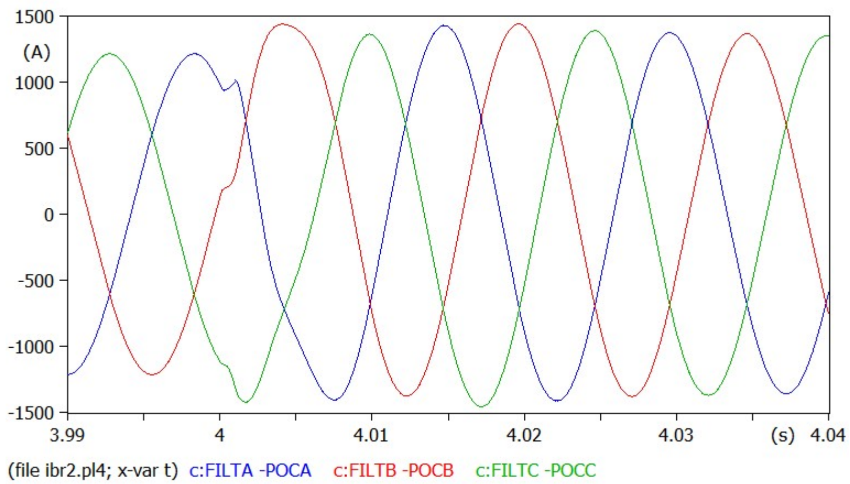
March 2023

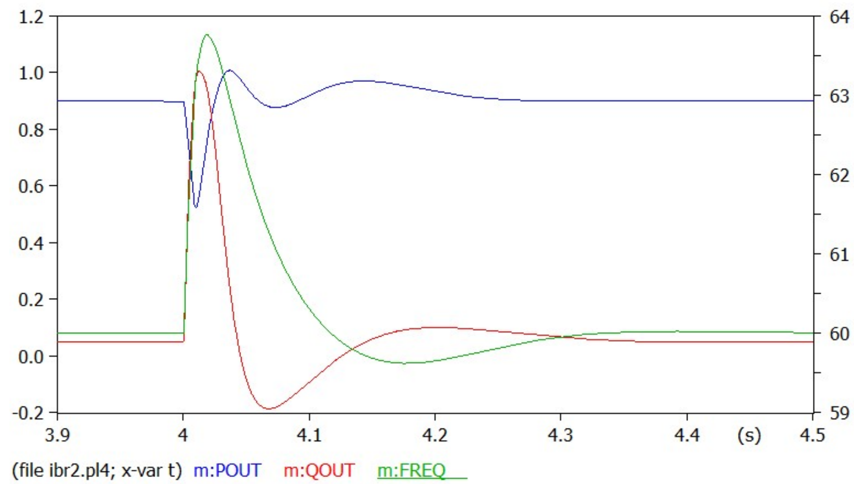
RELIABILITY | RESILIENCE | SECURITY

3353 Peachtree Road NE
Suite 600, North Tower
Atlanta, GA 30326
404-446-2560 | www.nerc.com

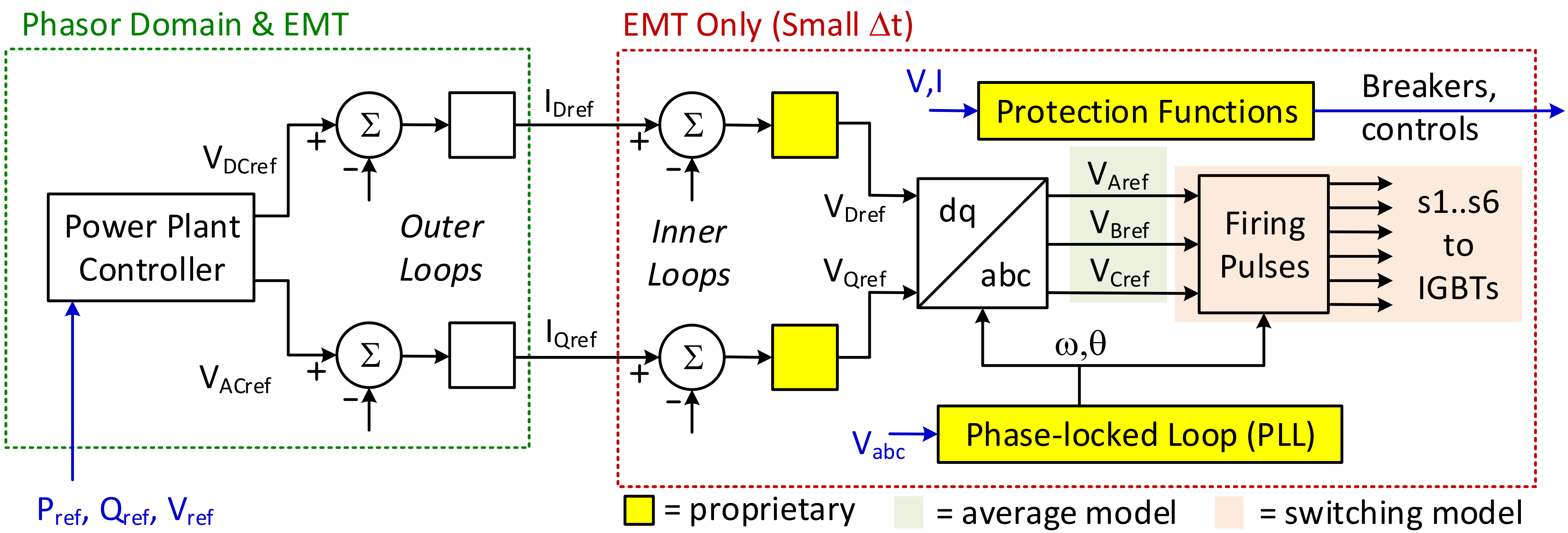
EMT simulation is unbalanced, like distribution power flow, with shorter time step than dynamics.

Application Factors	Shortest Time Simulated, Tmax	Typical Time Step, Δt
Lightning surges	100 – 200 μs	0.1 – 1 μs
Cable switching surges	0.2 – 1 ms	1 – 20 μs
Capacitor switching	1 – 100 ms	10 – 100 μs
Machine dynamics	**0.5 – 5 s**	**100 – 1000 μs**
Inverter-based resources	**0.5 – 45 s**	**1 – 200 μs**





An EMT IBR model adds fast control loops, protection functions, and vendor-proprietary code to the phasor-domain dynamics model.



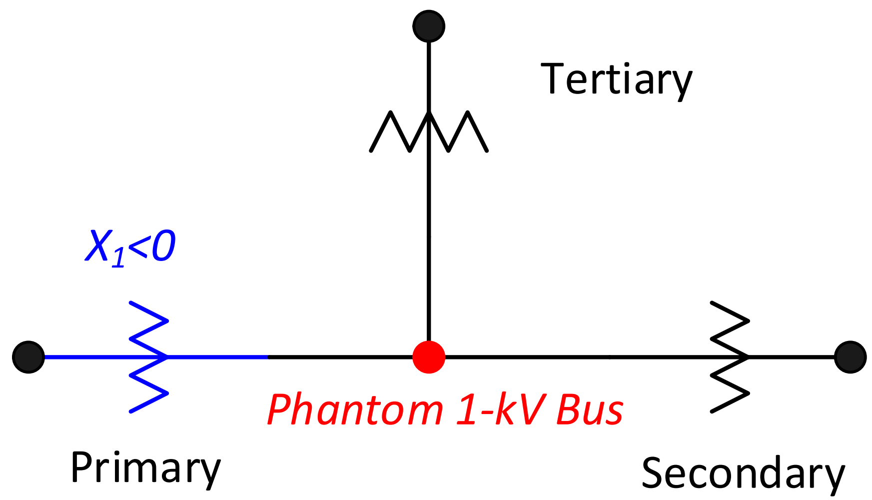
Sources: Andrew L. Isaacs, "EMT Model Intake and Quality Assurance", ESIG Webinar, 5/18/2023. Adapted with permission. Also Tom McDermott, NERC/i2X EMT Bootcamp, 8/3/2023.

Suggested references: https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline-EMT_Modeling_and_Simulations.pdf and https://www.epri.com/research/products/3002014083 for architecture of WECC generic models, now in 61970-302:2024.

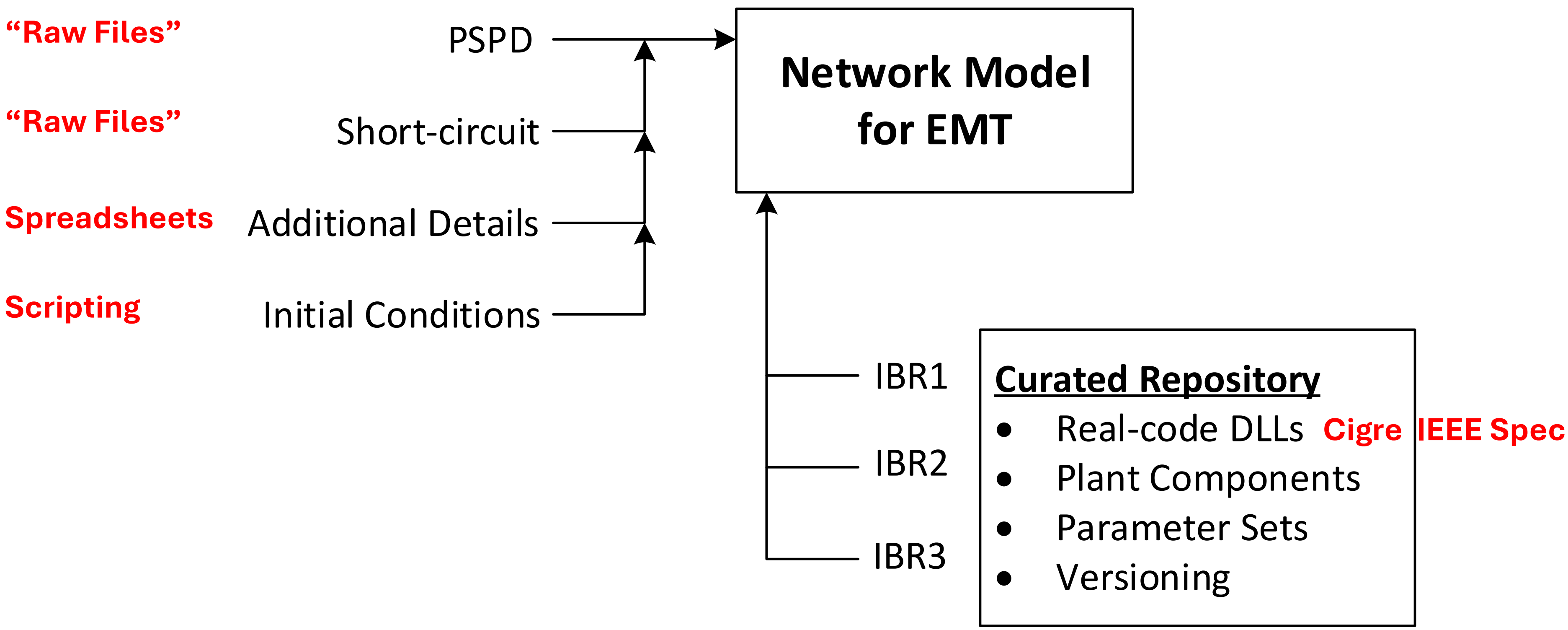
EMT stakeholders in North America presently use “raw files” to build and maintain EMT models.

Some Problems with “raw files” for EMT:

1. Often Missing the Zero Sequence
2. Bus Mismatches, e.g., EMT often uses node-breaker, not bus-branch
3. Legacy Two-Winding Transformers
4. Inconsistencies and Errors that may be tolerable for power flow and positive-sequence dynamics but not for EMT, e.g., $v > c$
5. Reverse-engineering the vendor-controlled format is time-consuming and error-prone



NERC white paper identified “attributes of an EMT network and IBR model repository”, presently an ad hoc process.



Ref: https://www.nerc.com/comm/RSTCReviewItems/1_08_Draft%20Whitepaper_%20EMT%20Analysis%20in%20Operations_v2.0_clean.pdf
Also See: https://doi.org/10.1109/ACCESS.2023.3305394 presented by Thai-Thanh Nguyen at the March 26, 2024, meeting of the NERC EMT TF.

Notes to Slides 6, 8, 10, 12, 20, and 28

6: CGMES uses Modelica equations, MATLAB equations, and FMI components instead of the Cigre/IEEE DLL.

8: The original purpose of CCAPI, see https://doi.org/10.1109/MPE.2015.2481787, reduce the cost of maintaining an EMS. It was taking 3-6 years for implementation and then lasting only 12-14 years. Software and databases often didn't transfer to the next version, even from the same vendor. The EPRI link is https://www.epri.com/research/products/000000000001002130. The first version of 61968 was published around 2003, i.e., earlier than 61970.

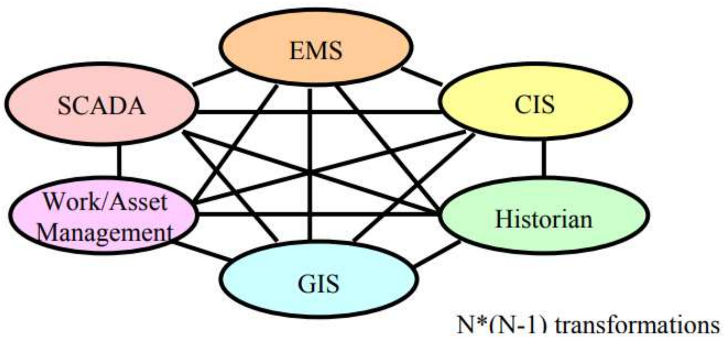
10: EMT simulators have been used since 1969, primarily for 1) design of EHV lines and substations at 500 kV and 765 kV, 2) high voltage direct current (HVDC) designs, 3) sub-synchronous resonance (SSR) studies, and 4) other specialty applications. IBR interconnections are bringing EMT more into the mainstream, because positive sequence phasor domain transients (PSPDT, aka "stability") can't capture all the effects. Just as with SSR in the early 1970s, there have been unexpected IBR trips in recent years. Most utility planning engineers have little or no EMT experience. EMT network models are more complicated to build and validate than PSPDT models. This calls out for automation, standardization, and interoperability to reduce the learning curve, improve quality of results, and optimize the engineering time for each IBR study. The "raw file" vendor has a relatively new extensible JSON format but (as of April 14, 2025) does not wish to contribute it as the basis for an IEEE standard on EMT model interoperability. This led to the focus on CIM.

12: The left-hand link is a 4-page white paper. The right-hand list summarizes the steps used to create results shown on the next slide. Step 4 gives a plausible network layout, because the original test cases didn't have bus locations in the data. Step 6 is important, as it can be a lengthy process to initialize EMT simulations with IBR, and to match those initial conditions with a power flow. The *Steady State Hypothesis* or *State Variable* features of CIM could be used. All output signals were converted to IEEE COMTRADE format. Users will plot results from a variety of EMT tools and event recorders, so a standard output format should be adopted along with CIM.

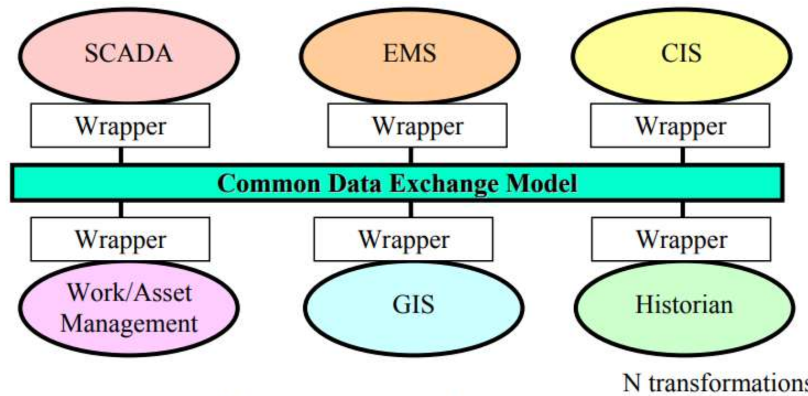
20: This figure shows four EHV lines on the same right of way, two circuits per tower. The phases are numbered 1..6 on each tower, and the ground wires are numbered 7..8. Due to transpositions, the phase assignments usually don't go in numerical order. For example, circuit 1 might assign A=2, B=4, C=6 on the left-most tower, then circuit 2 might assign A=3, B=1, C=5. This approach supports the widest variety of EMT modeling options, and the most accurate. CIM already includes most of it. In 2021, a task force worked on better approaches for lines sharing the same right of way. The existing pair-wise *MutualCoupling* class loses too much information. A proposal was developed for *ParallelLineSegment*, collected into *RightOfWay*. Not sure if that was finally adopted, but it would work for EMT.

28: Relay setting parameters (possibly hundreds or dozens per device) might be supported in a similar pattern.

The Common Information Model (CIM) started around 1990 to support interoperable control center applications.



Point-to-point Model Transformations



Use of a common exchange model

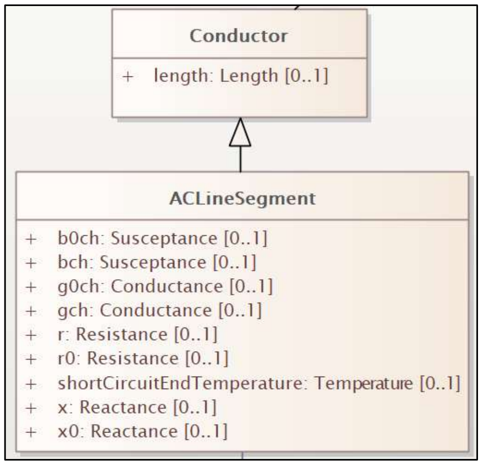
Source: EPRI Report #1002130, “Standards for Transmission and Distribution System Data Integration”, 9/30/2003

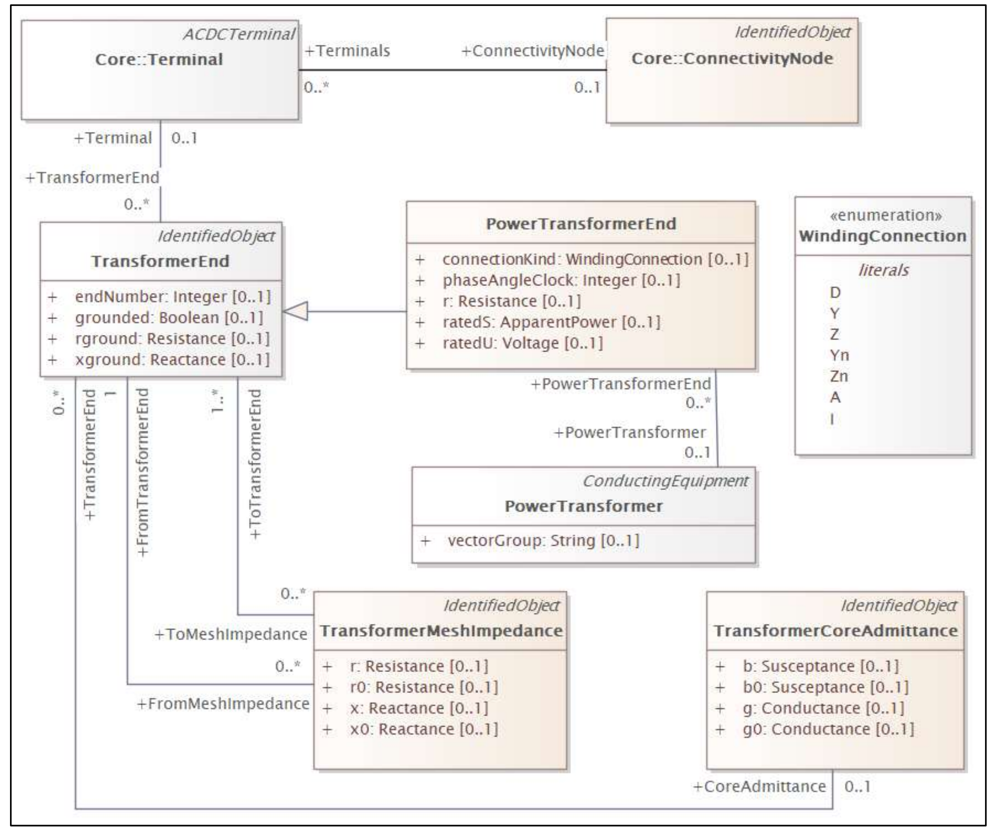
<u>Timeline of Some Adoptions and Use Cases</u>:

- ≈1990: EPRI Control Center API Project
- ≈2004: First IEC Std. 61970 Published
- ≈2009: Common Grid Model Exchange Spec. (CGMES) in Europe
- ≈2009: ERCOT Nodal Market uses CIM in Texas
- 2023: NERC Reliability Guideline w/ IBR EMT
- 2025: IEEE P3743, a “Simplified CIM for IBR EMT”

U.S. Dept. of State, Public Domain, 10/5/2022

The CIM uses a Universal Modeling Language (UML) to Represent Power Systems for Interoperable Applications





CIM Getting-Started References (in suggested reading order):

https://www.epri.com/research/programs/062333/results/3002026852

https://www.osti.gov/biblio/1922947

https://www.osti.gov/biblio/2007843

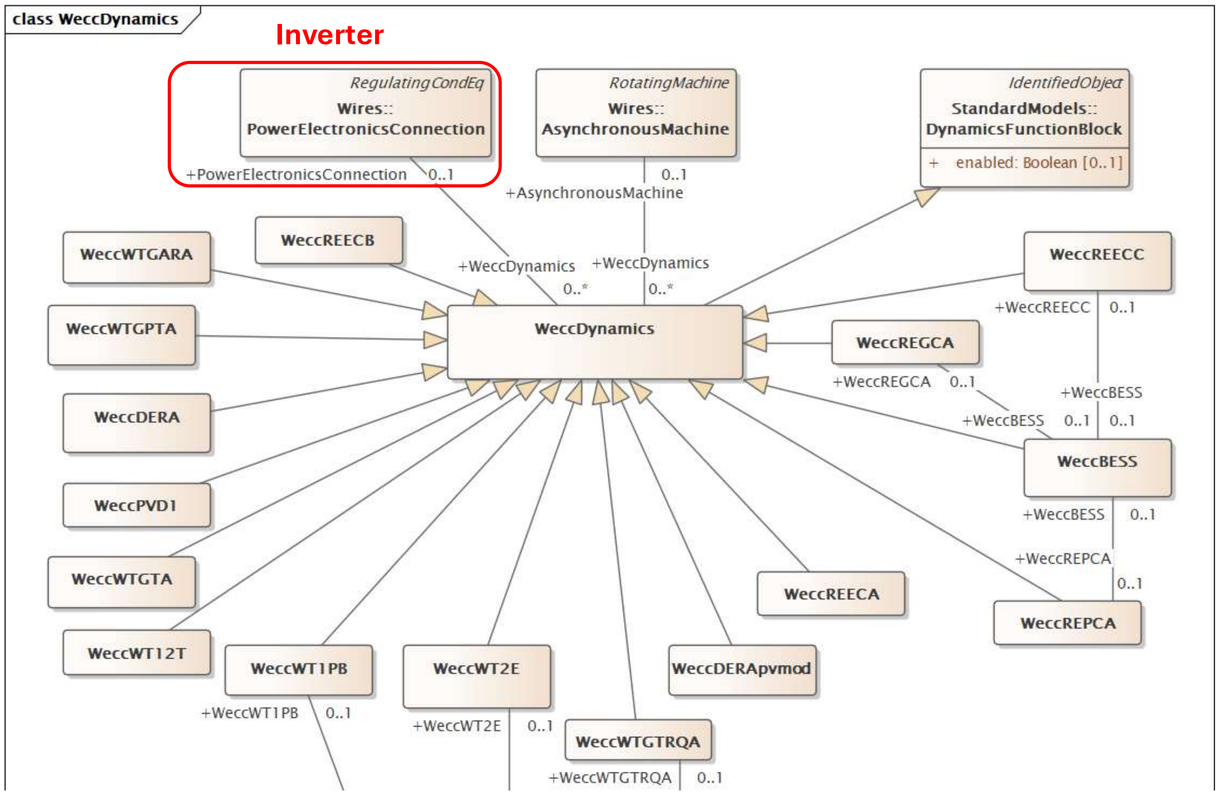
https://cim-mg.ucaiug.io/latest/

UML: https://cimug.org/cimdocs/standards-artifacts/

EMT model management is a new utility workflow requirement, and CIM can help. (from 2024 IEEE PES Meeting in Seattle, WA)

- North American Electric Reliability Corporation (NERC) requires EMT modeling of inverter-based resources (IBR) to maintain grid reliability.
- Existing network models may have baked-in deficiencies for EMT usage, e.g., artificial two-winding transformer equivalents, no zero sequence.
- Interconnection queues for new solar, wind, and storage IBR are years long in many regions; new EMT studies will only worsen this problem.
- EMT is still a niche specialty at most utilities; there is a shortage of staff trained to build, validate, maintain, and run EMT network and IBR models.
- **<u>CIM is the only practical option</u>** for standards-based, multi-vendor, multi-simulator management of EMT network and IBR models.
- CIM already works for unbalanced distribution network model management.
- CIM-based Common Grid Model Exchange Standard (CGMES) already works for transmission dynamics network and machine model management in Europe.

The CIM can do most of the EMT repository now. But how many North American utilities are using CIM?

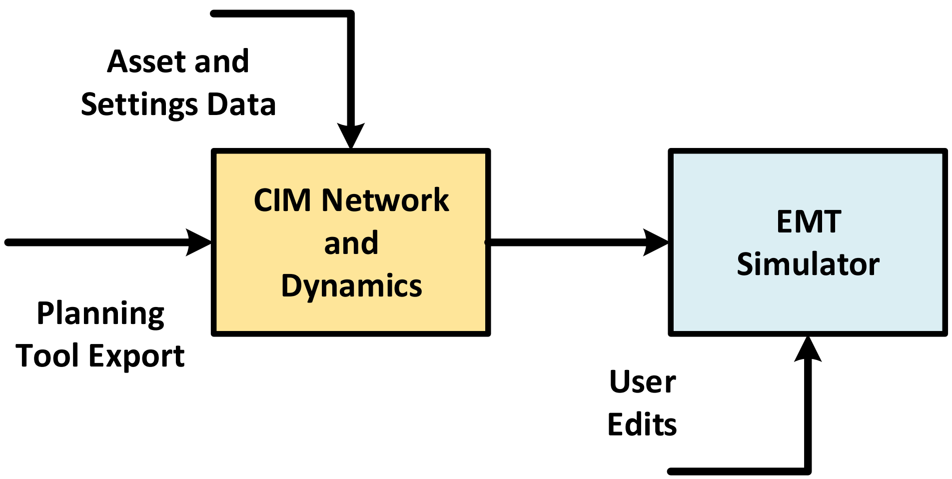


Some CIM Features

- Globally unique identifiers
- SI units, i.e., no per-unit
- Zero sequence, or Z_{phase}
- Equipment terminals: bus-branch and node-breaker
- Substation modeling
- Geographic and one-line
- Transformer winding model
- **“Complete” dynamic models**
- Incremental data updates
- Data sheets for transformer tests, line, and cable parameters
- **Regular interoperability tests**

See: https://www.ipstconf.org/papers/Proc_IPST2017/17IPST099.pdf and https://doi.org/10.1109/ISGTEUROPE62998.2024.10863427

Model conversion process starts with PSSE models, adding some heuristics for CIM, then exporting to ATP netlists.



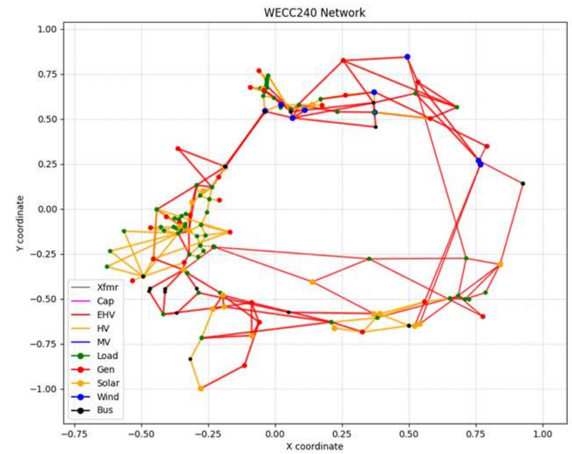
1. Obtain PSSE Raw Files for Test Case
2. Add Controls for Machines and IBR (Solar, Wind)
3. Transform to CIM XML with Python and SPARQL Queries
   a) Use heuristics for line x0, b0
4. Add Bus Locations using length-weighted Networkx package Kamada & Kawaii layout
5. Store CIM XML in Blazegraph Triple Store
6. Export CIM to Matpower to Solve for Initial Conditions
7. Export for Alternative Transients Program (ATP)
   a) Check line travel time vs. Δt
   b) ATP has license requirements, but $0.
8. Solve EMT network in ATP
9. Plot EMT Output Variables and Network Topology with Python and Matplotlib

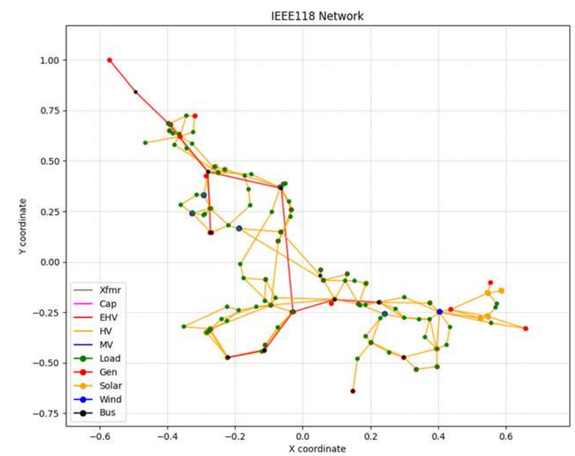
Ref: https://openei.org/wiki/File:CIM_EMT_Article.pdf

BPS/EMT test cases for full CIM are medium-scale, generally representing WECC, the Midwest, and New England.

Medium-Scale Test Systems Augmented with IBR

	WECC 240	IEEE 118	IEEE 39
Buses	243	193 *	39
Machines	49 **	56 **	10
Solar	25	14	1
Wind	10	5	1
Notes	w/ Series Capacitors 2 aggregate DER By NREL, circa 2020	AEP System circa 1962	New England circa 1979

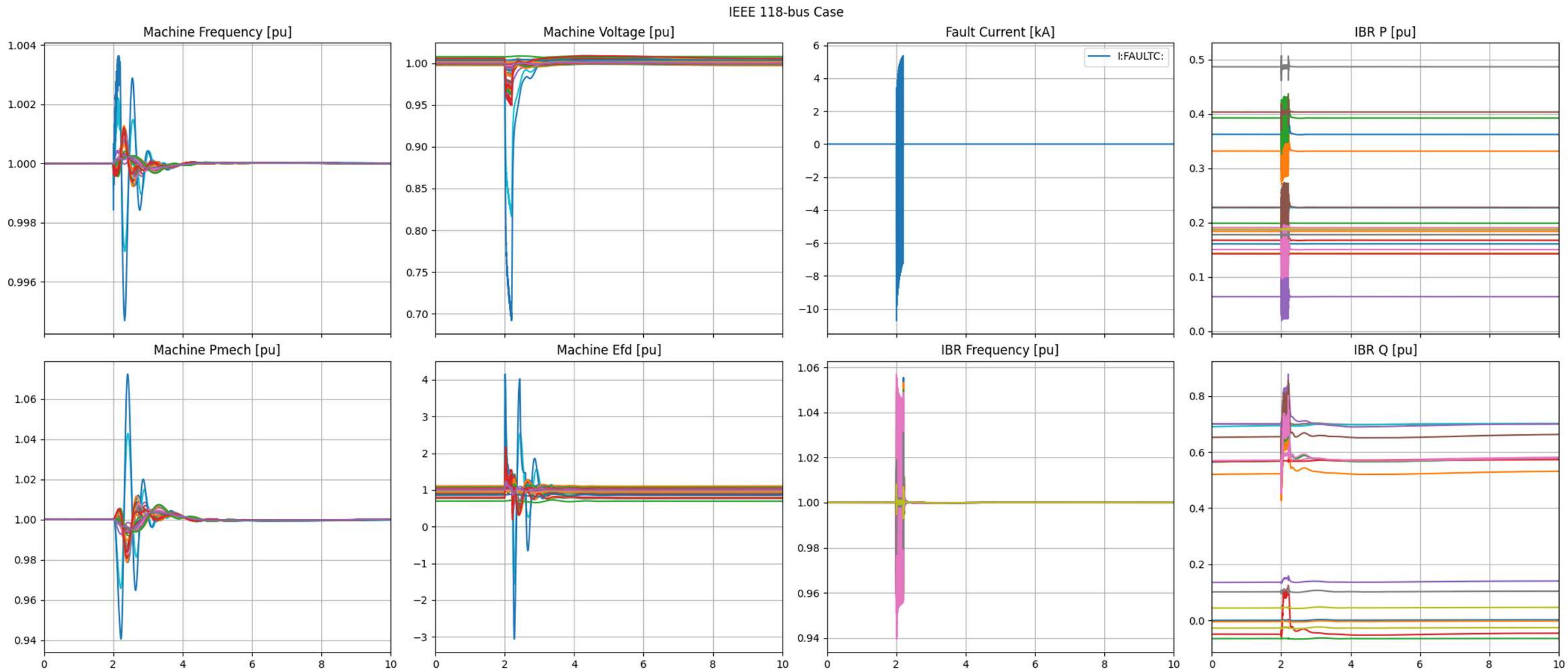




* Extra buses for generator step-up (GSU) transformers.
** Reflects aggregation of steam and hydro units at same bus.

Data: https://github.com/GRIDAPPSD/CIMHub/tree/feature/SETO/BES and https://github.com/pnnl/i2x/tree/develop/bes

Sample results for the IEEE 118-bus system include machine and IBR responses to a SLGF with 12% IBR generation.



Ref: Ramesh & McDermott, 2024 IEEE PES GM, https://emthub.readthedocs.io/en/latest/_static/24PESGM2411.pdf

Notes to Slide 14

This case took 352 seconds to run in ATP at $\Delta t = 50\ \mu s$.

- There is a model initialization phase, 40s not plotted, not fully complete at time zero.
- Single-line-to-ground fault occurs at 2.0 seconds and clears at 2.2 seconds. This initiates fault-response dynamics in the machines and IBRs.
- Machine field voltage, Efd, tries to compensate for voltage drop. Small power and frequency swings also occur at the machines.
- The nineteen IBR were all dispatched at different levels in pu of rating to make up 12% of the system load and be distinguishable on the plot.
- IBR reactive power, Q, also tries to compensate for local voltage drops at the IBRs. Short term effects on P, and some measurement errors on frequency, also occur at the IBRs. This IBR implementation uses a synchronous reference frame phase-locked loop (SRF-PLL) to measure frequency; a real implementation might work better.

The WECC240 system needed more work to alleviate line and transformer overloads. Some of these adjustments were done for the i2X project, not yet integrated into CIM-for-EMT.

Lessons Learnt: find a middle ground between the full CIM and vendor-controlled “raw files”.

Full CIM, as in Europe/CGMES

—Complex for **many** use cases

—Low adoption in North America

—Suited for graph databases

—Needs extensions for IBR EMT

—IEC IP concerns with code

—Document cost is ≈$2700

+Interoperability testing

+Broad applicability

Lightweight CIM Profile

+Purpose-built for EMT

+Build on the *raw files*

+Relational Database (**SQL**)

+Include IBR EMT from the start

+IEEE and CIM User’s Group open-source licenses

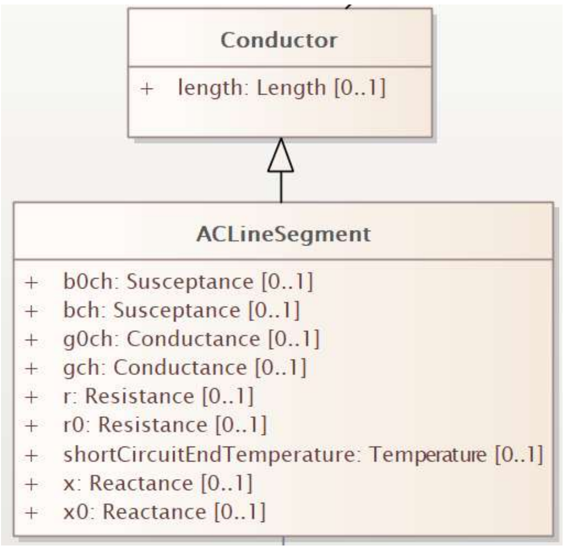
+Document cost is ≈$300

—Build tests and converters

—May not displace *raw files*

Ref: https://github.com/pnnl/i2x/blob/develop/emt-tf-repo/EMT_Model_Portability.pdf

Transmission line zero-sequence data is required for EMT; may use network short-circuit models or heuristics.



Start: $L = x/(length * \omega)$

If $bch > 0$: $C = bch/(length * \omega)$

$Z = \sqrt{L/C}$

Else: $Z = 400$

$C = L/Z^2$

$bch = C * length * \omega$

Check: $v = 1/\sqrt{LC} \leq 3e8$

If $Z < 100$: $r0 = r$

$x0 = x$

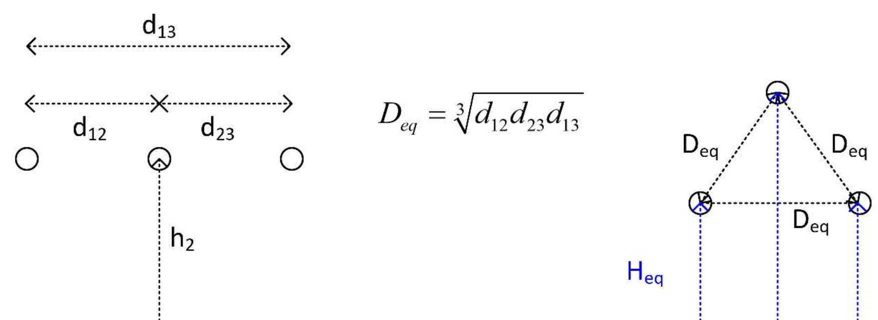
$b0ch = bch$

Else: $r0 = 2r$

$x0 = 3x$

$b0ch = 0.6 * bch$

To do the square roots just once, legacy data may retain D_{eq} for positive sequence, losing H_{eq} for zero sequence.



Notes to Slide 17

Steps delineated by the green lines:

1 – find inductance per unit length
2 – if line charging provided, estimate the surge impedance from capacitance per unit length. If not provided, assume overhead line with Z=400, back calculate capacitance per unit length and then the line charging.
2a – if X is about 0.8 ohms per mile, Z=400 is a good assumption. If X is about 0.6 ohms per mile, or the line conductors are known to be bundled (EHV lines), then Z=280 is a better assumption.
3 – positive sequence wave velocity should not exceed the speed of light. If so, that indicates an error in *bch*. Some well-known load flow test cases have this problem.
4 – if the surge impedance is low, assume a cable and zero sequence about equal to positive sequence. Otherwise, use some heuristics to estimate the zero sequence for overhead lines.
4a – Using just the surge impedance it's hard to tell the difference between a cable, and multiple overhead lines in parallel.
At the bottom – some legacy databases don't have the information needed to calculate zero sequence impedance.

Example: estimating traveling wave (✓) line parameters from the "raw file" line data of an IEEE 118-bus test system.

MVA_{base}

0,   100.00, 33, 0, 0, 60.00   / October 01, 2013 18:46:48
08/25/93 UW ARCHIVE   100.0 1961 W IEEE 118 Bus
Test Case
0 / END OF SYSTEM-WIDE DATA, BEGIN BUS DATA
1,'Riversde   ', 138.0000,2, 1, 1, 1,0.95500, 10.9828
2,'Pokagon   ', 138.0000,1, 1, 1, 1,0.97139, 11.5228
#, Name, kV_{base}, Area, Zone, ?, ?, V_{mag}, V_{ang}

0 / END OF GENERATOR DATA, BEGIN BRANCH DATA
1,   2,'1 ', 0.03030, 0.09990,0.02540,
From, To, Circuit #, R_{pu}, X_{pu}, B_{pu}

*We don't have length or zero sequence, so work with **total RLC**, not RLC per unit length.*

$$Z_{base} = \frac{kV_{base}^2}{MVA_{base}} = \frac{138^2}{100} = 190.44\,\Omega$$

✓ $R_1 = R_{pu} Z_{base} = 0.0303 * 190.44 = 5.7703\,\Omega$

$X_1 = X_{pu} Z_{base} = 0.03990 * 190.44 = 18.8536\,\Omega$

$L_1 = X_1/377 = 18.8536/377 = 50.01\,mH$

$C_1 = B_{pu}/377 Z_{base} = 0.0254/(377 * 190.44)$
$= 0.3538\ \mu\text{F}$

✓ $Z_1 = \sqrt{L_1/C_1} = 376\,\Omega$ *Overhead line!*

✓ $\tau_1 = \sqrt{L_1 C_1} = 133\ \mu s$

Next, estimate length and check wave velocity

$len \approx X_1/0.8 = 23.57$ miles   *(no bundling)*

$v_1 = len/\tau_1 = 177{,}195\ miles/s$ *(okay, 95% of speed of light)*

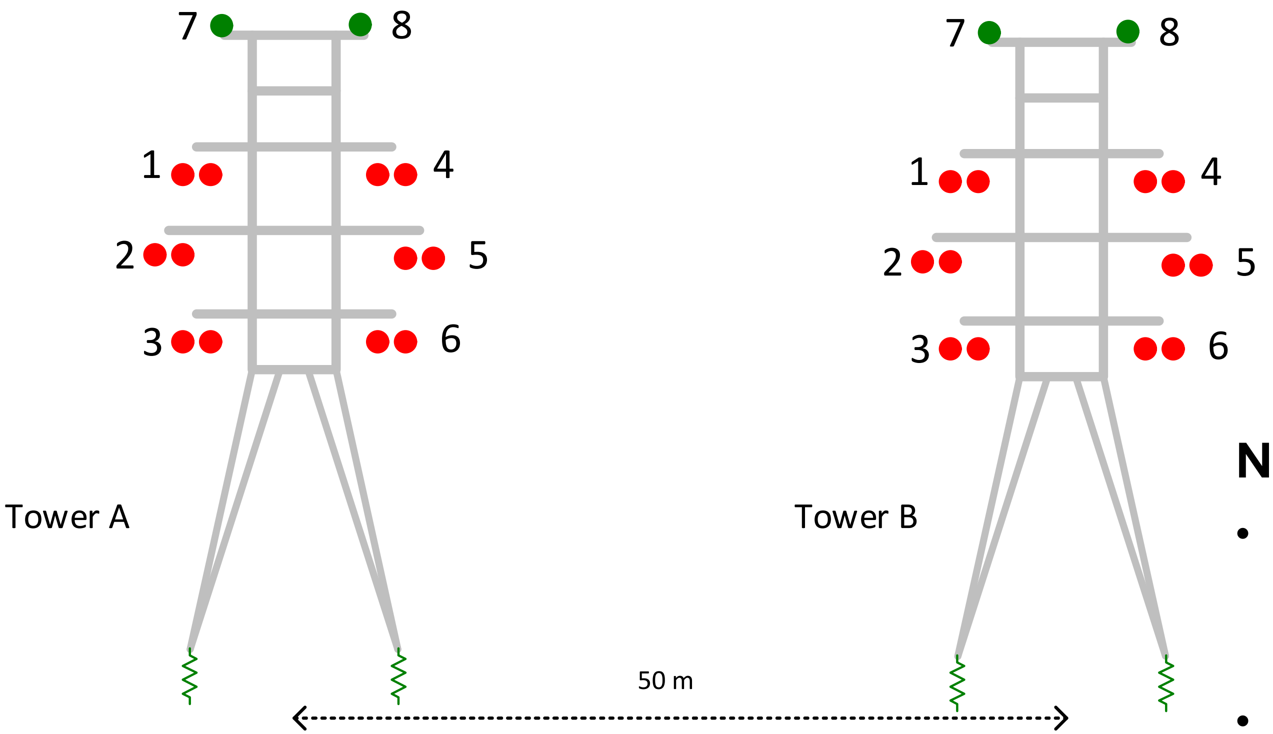
Finally, estimate zero sequence

✓ $R_0 = 2R_1 = 11.54\,\Omega$

✓ $Z_0 = \sqrt{3/0.6}\,Z_1 = 841\,\Omega$

✓ $\tau_0 = \sqrt{3 * 0.6}\,\tau_1 = 178.4\ \mu s$

Line models in CIM can use tower and conductor data to represent unbalance and frequency dependence.



Ref: i2X EMT Bootcamp: https://github.com/pnnl/i2x/tree/master/emt-bootcamp

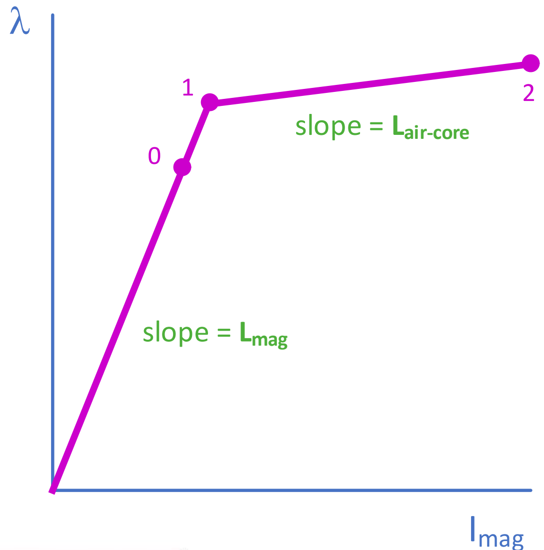
Existing CIM Classes:

- ACLineSegment
- ACLineSegmentPhase
- WireSpacingInfo
- WireInfo
- WirePosition

New CIM Classes:

- WireAssemblyInfo – to support a "catalog" of tower/conductor construction types
- ParallelLineSegment and RightOfWay – to generalize pairwise MutualCouplings

A CIM extension is required for transformer saturation, which influences dynamics in voltage and reactive power.



$L_{mag} = b / \omega$ TransformerMeshImpedance.x

$L_{air\text{-}core} = 2\,x / \omega$

$\lambda = u / \omega$

<u>Points</u>:

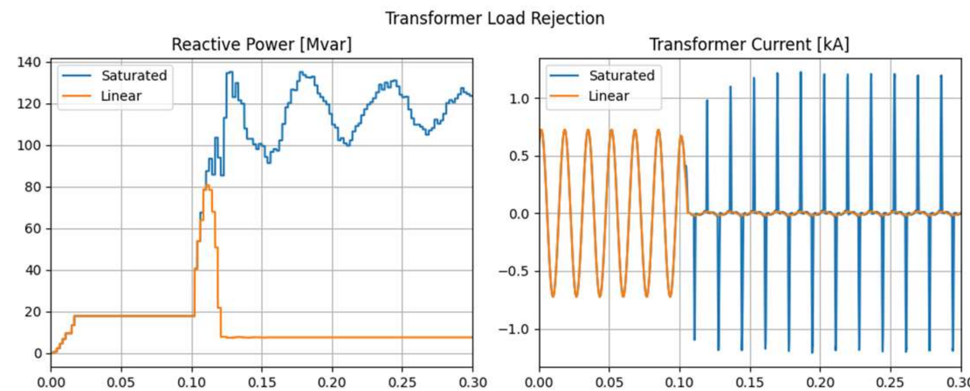
0 @ 1 pu voltage

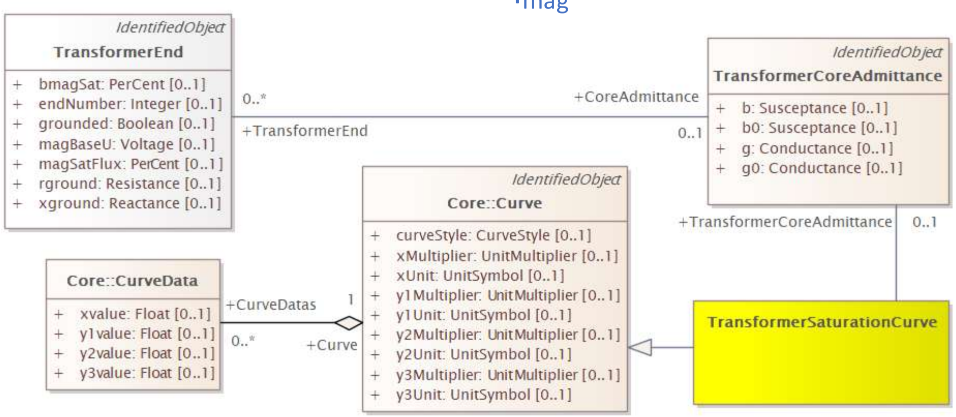
1 @ saturation 1.1pu

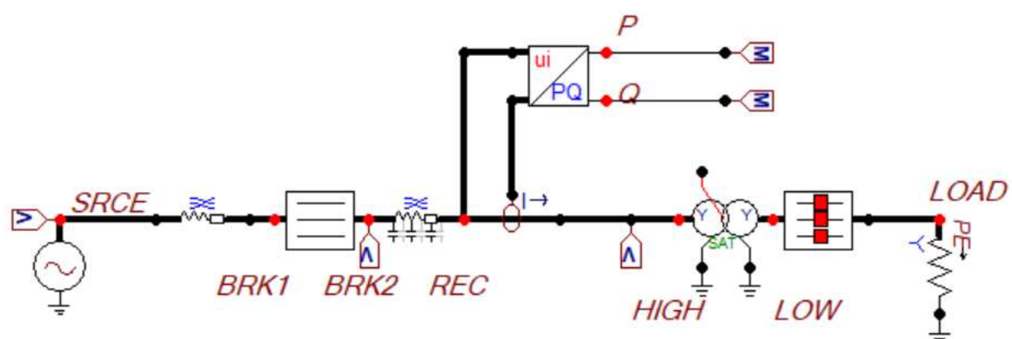
2 by choosing ΔI:

$I_2 = I_1 + \Delta I$

$\lambda_2 = \lambda_1 + L_{air\text{-}core} * \Delta I$







Notes to Slide 21

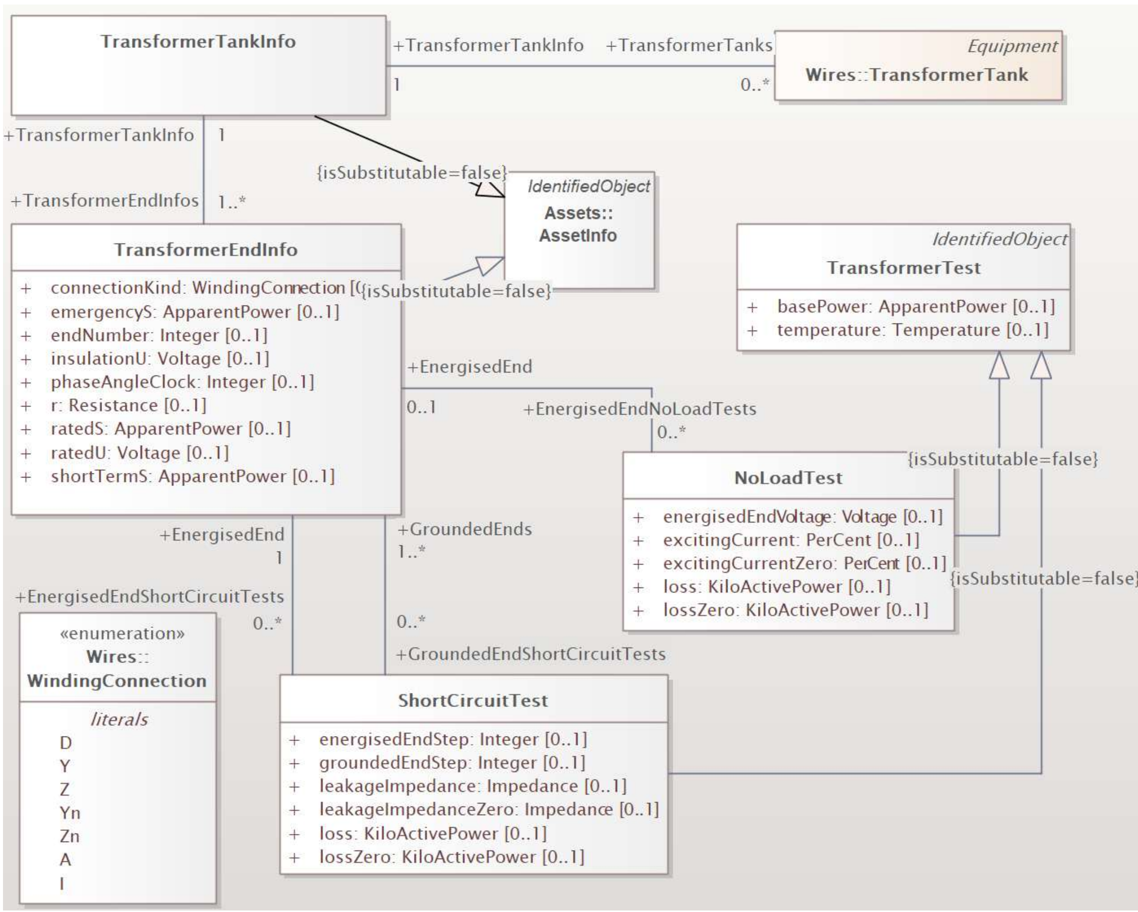
The saturation characteristic is instantaneous flux vs. instantaneous current in the magnetizing branch. If point 1 is supplied, point 0 is not required because they are co-linear. Either one may be calculated from TransformerCoreAdmittance.b and the transformer ratings.

The saturation characteristic could have many points, but usually two are sufficient. The air core reactance is 2 to 4 times the leakage reactance (assume 2 in this example). Given an assumed knee point on the saturation curve, 1.1 pu in this example, a reasonable 2-slope saturation curve may be inferred.

The right-hand side shows a severe example of transformer load rejection at the end of a long 345-kV line. Without saturation, Q drops to zero but with saturation, the magnetizing current is high due to overvoltage, and the measured Q is high. Notes a) Q is ill-defined under these non-linear conditions, but there is still an effect on machines and IBR, and 2) the P/Q meter takes a couple of cycles to wake up at the beginning of the simulation.

The UML at lower left is one idea. A different proposal would apply to the transformer test sheet pattern. Those tests record V and I at different voltage levels.

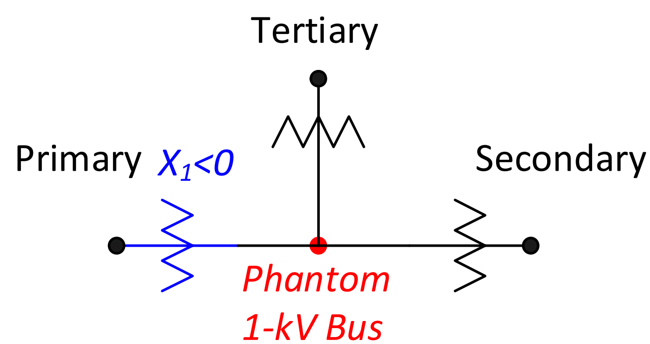
Transformer data for EMT may eventually come from test sheets; if not available, multi-winding connections (YΔ) are required.



← IEC 61970 Modeling is good for EMT

Include *TransformerTankEnd.OrderedPhases* from the June 2022 EPRI Grid Model Data Management interoperability tests.

***TransformerMeshImpedance* (preferred) and *TransformerStarImpedance* also work. Beware of assumptions made in legacy power flow models.**

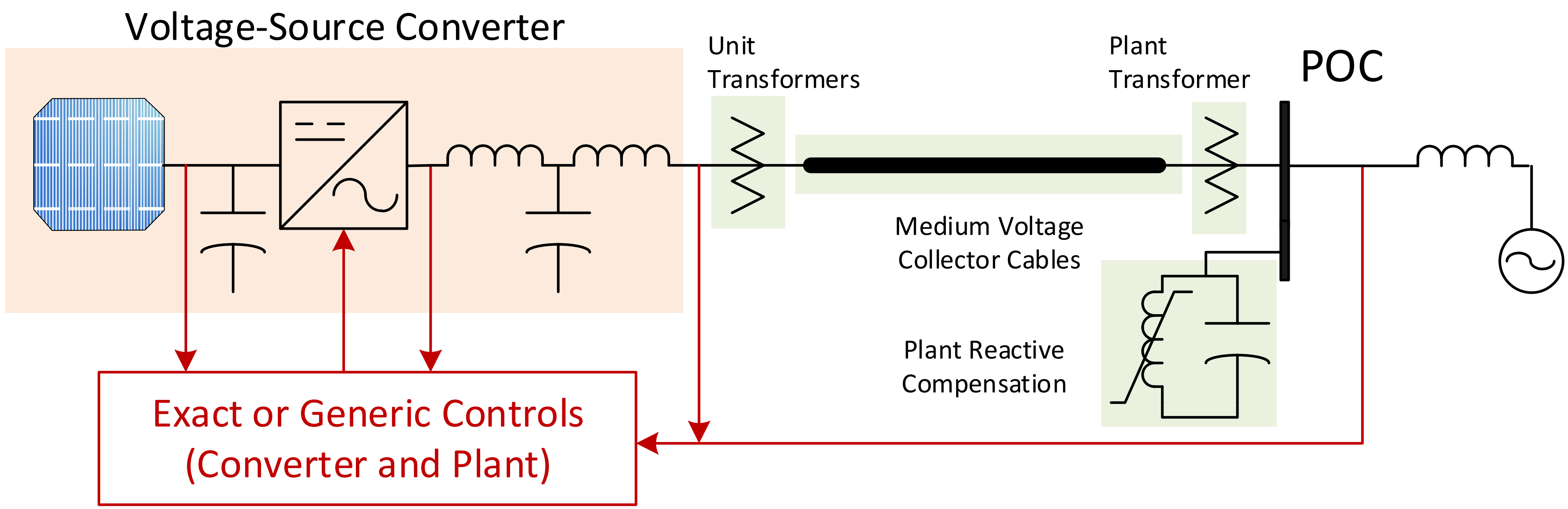


Notes to Slide 23

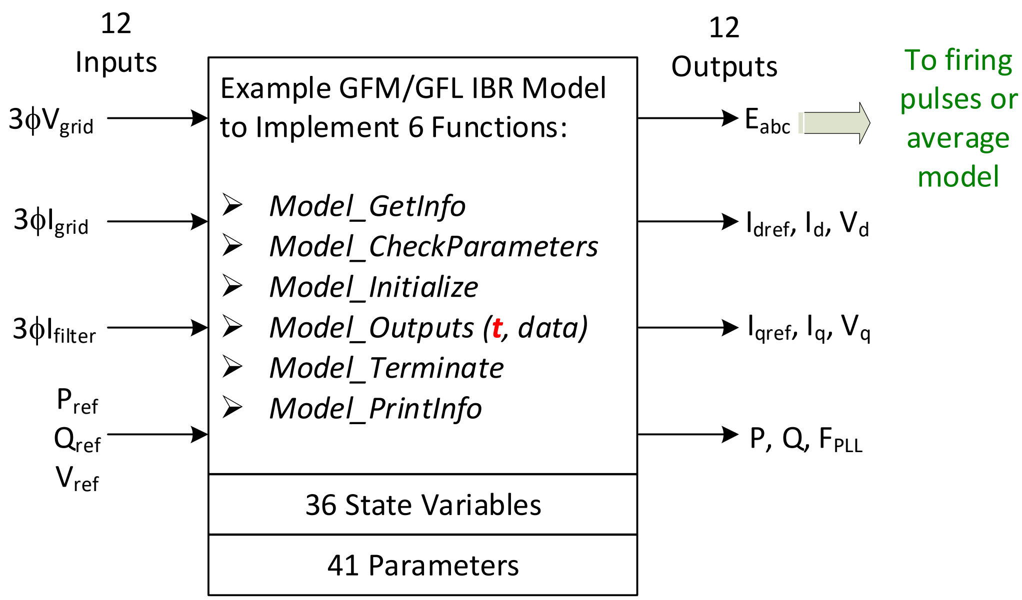
The “data sheet” pattern for transformers was developed for unbalanced distribution networks. These models have much in common with EMT transformer models. In the Wires package, a *TransformerTankEnd* will associate to a *TransformerEndInfo*, which then provides access to *ShortCircuitTest* and *NoLoadTest*. Those test results define the transformer impedances and admittances, which EMT tools usually prepare with internal processing of the data sheet attributes. In the SETO OEDI project, this pattern was tested on several distribution feeders to create ATP models of them, including all the single-phase, center-tap secondary and other transformers.

The lower right shows a “star equivalent” embedded into many legacy power flow network models. The original software tools only modeled two-winding transformers, so three-winding transformers were artificially broken into three two-winding transformers as show. The star point was a new bus of rating 1 kV or even 0.1 kV. Typically, one transformer has X<0, which may not be acceptable to an EMT simulator. So, it’s recommended to re-aggregate such transformer models before using them for EMT.

IBR Plant models include real-code DLLs along with other components behind the Point of Connection (POC).



IEEE/Cigre Task Force B4.82 developed a "real code" dynamic link library (DLL) specification that supports user-defined models.

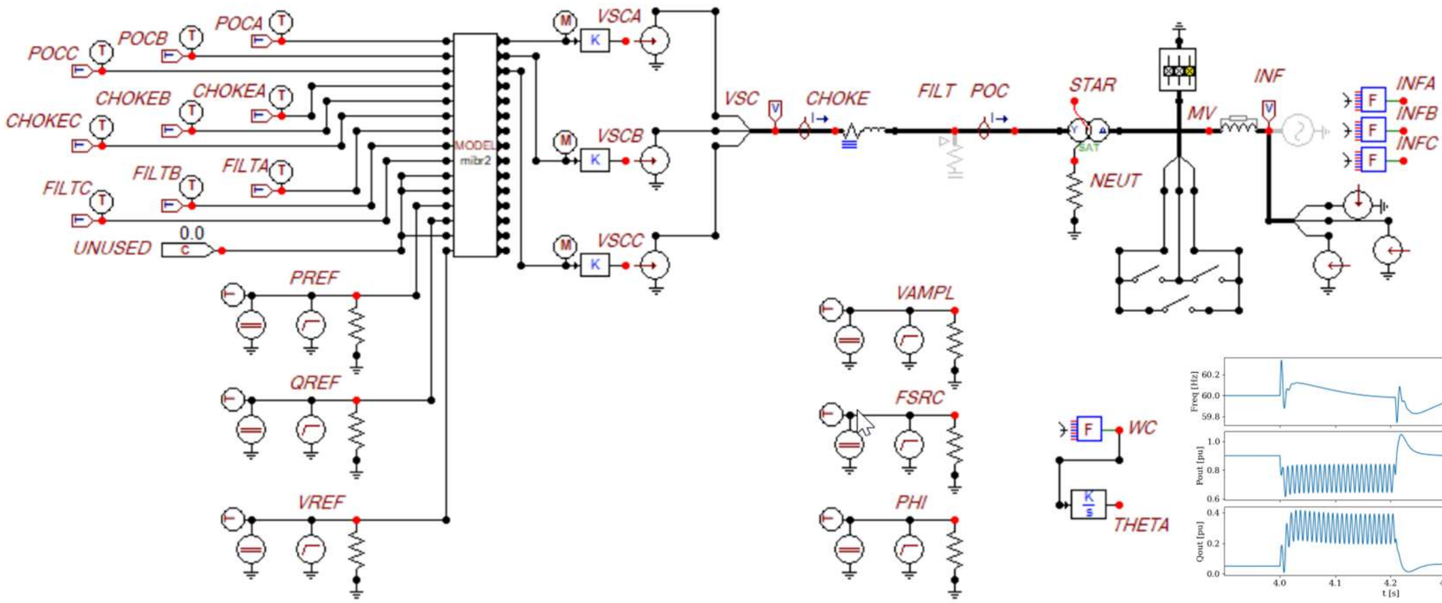


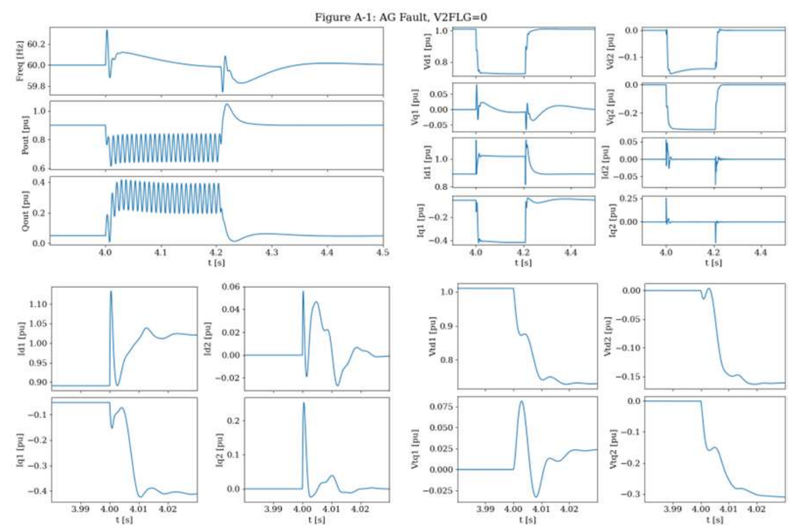
Ref: i2X EMT Bootcamp: **https://github.com/pnnl/i2x/tree/master/emt-bootcamp**

Cigre Technical Brochure: https://www.e-cigre.org/publications/detail/958-guidelines-for-use-of-real-code-in-emt-models-for-hvdc-facts-and-inverter-based-generators-in-power-systems-analysis.html

IEEE P3597, "Standard for Interfacing of Controls and Protection to Power System Simulation Tools", PAR approved, work expected to start in 2026, Garth Irwin, Chair. https://standards.ieee.org/ieee/3597/12053/

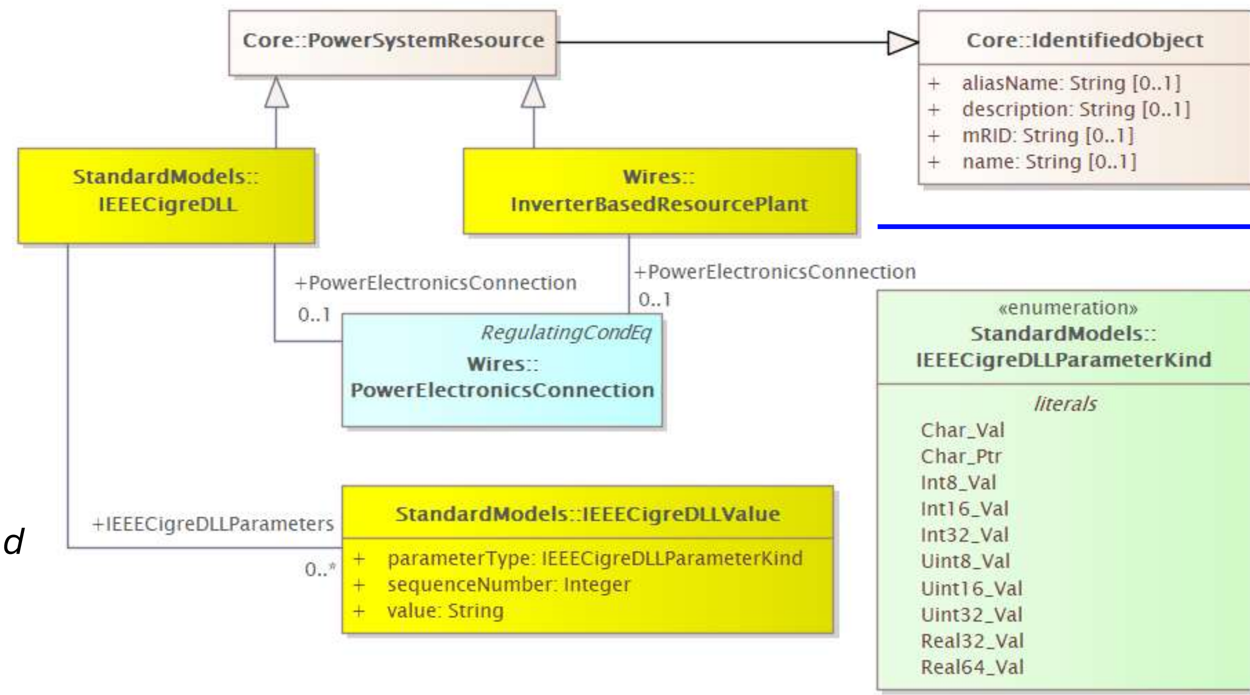
Examples of DLL interface to include in an IEEE open-source project; this is EPRI's generic grid-forming inverter model in ATP.





For Everyone: https://github.com/temcdrm/emthub and
https://emthub.readthedocs.io/en/latest/
For Licensed ATP Users: https://github.com/temcdrm/emthubsupport
Model Description: https://www.epri.com/research/products/3002028322
(Supported by DOE/SETO in the EOS-2 Project)

New CIM extension classes (yellow) and enumeration (green) would incorporate real-code DLLs and IBR plant parameters in the network.

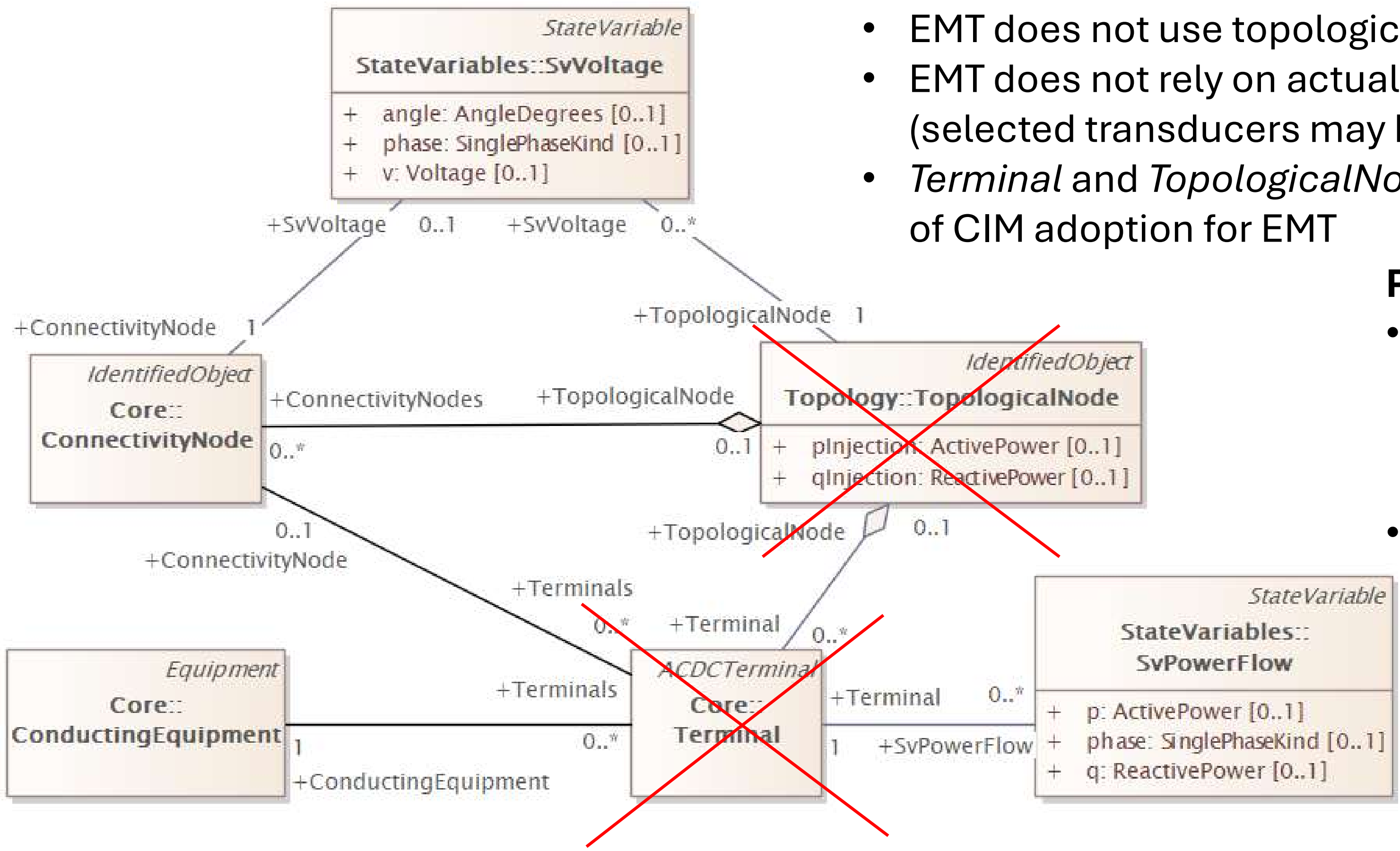


Attributes:
dcLinkVoltage
dcLinkCapacitance
acFilterRgrid
acFilterLgrid
acFilterCapacitance
acFilterRbridge
acFilterLbridge
switchingFrequency

Attributes:
vendorName
firmwareVersion
firmwareInstalled
uri
timestep
supportsEMT
supportsRMS

Ref: NERC White Paper: "Model Portability for EMT Studies of IBR: A Lightweight Common Information Model Profile", Draft 0.5, August 2025.

Seeking to flatten this EMT profile for relational databases; will consider breaking changes if they can preserve an upgrade path to full CIM.



Motivations:
- EMT does not use topological nodes
- EMT does not rely on actual sensor locations (selected transducers may be modeled in detail)
- *Terminal* and *TopologicalNode* increase the burden of CIM adoption for EMT

Possible Simplification:
- Add two sequenced associations (0..1) from *ConductingEquipment* to *ConnectivityNode*
- Add association from *SvPowerFlow* to *ConductingEquipment*, with polarity attribute.

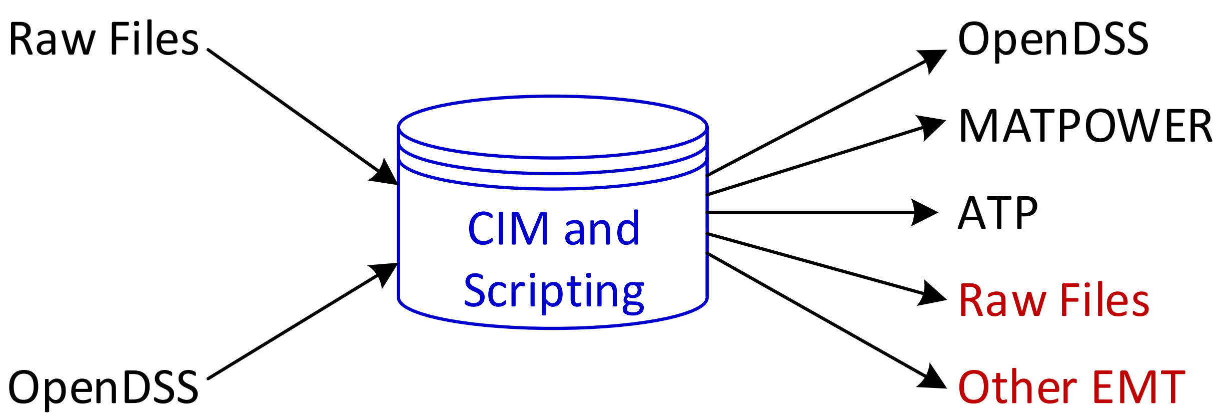
Notes to Slide 29

EMT tools allow the users to collect (many) outputs from any point in the network. It's not necessary to have CIM Terminals for these outputs. Sometimes it's desirable to model physical characteristics of a voltage transformer (VT), current transformer (CT), metering algorithms (rms, reactive power, filtering), etc. In those use cases, the CIM Terminal supports the physical location of real VTs and CTs in the network. This isn't needed for the immediate need to support IBR EMT studies. A real-code DLL typically incorporates filtering and other signal processing algorithms for the IBR.

TopologicalNode is important in state estimator applications, but not for EMT.

What can the CIM User's Group and CIM Experts do to help?

1. Participate in the IEEE Working Group developing P3743
2. Update the Public UML with WECC Dynamic and DER Models in IEC 61970-302:2024
3. Organize EMT Model Interoperability Tests



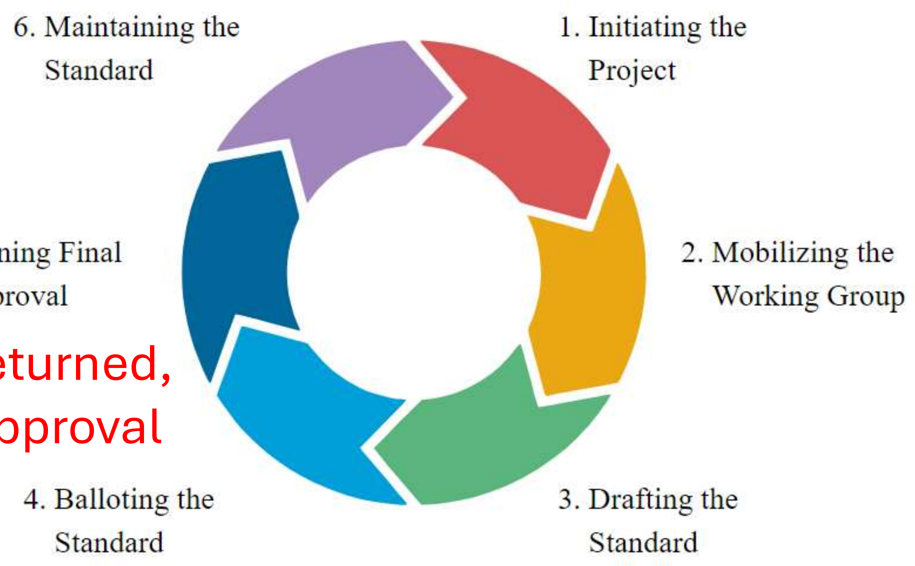
Gaps, Challenges, and Open Questions for Discussion

1. How quickly would EMT and other tool vendors adopt the full CIM?
2. What are barriers to EMT tool vendors adopting a lightweight CIM profile?
3. Should we migrate from per-unit to SI units for EMT data repositories?
4. Should we adopt (or support) node-breaker instead of bus-branch?
5. What about geographic coordinates or one-line diagram layouts?
6. How should the schema support EMT network equivalents?
7. Status of “CIM Fragments” and protection systems?
8. How will the full-CIM community view proposed “breaking changes”?
    a. Removing the *Terminal* class, in favor of bus foreign keys
    b. Removing *TopologicalNode*; EMT just needs *ConnectivityNode*
9. What other extensions or features would be important to IBR studies?
10. How much effort on IBR unit models, HVDC, FACTS, data centers, etc.?

Next Step 1: Develop IEEE Standards P3597 and P3743 using the individual process; update every ten years.

Revise or Withdraw every 10 years

Project Authorization Request (PAR)



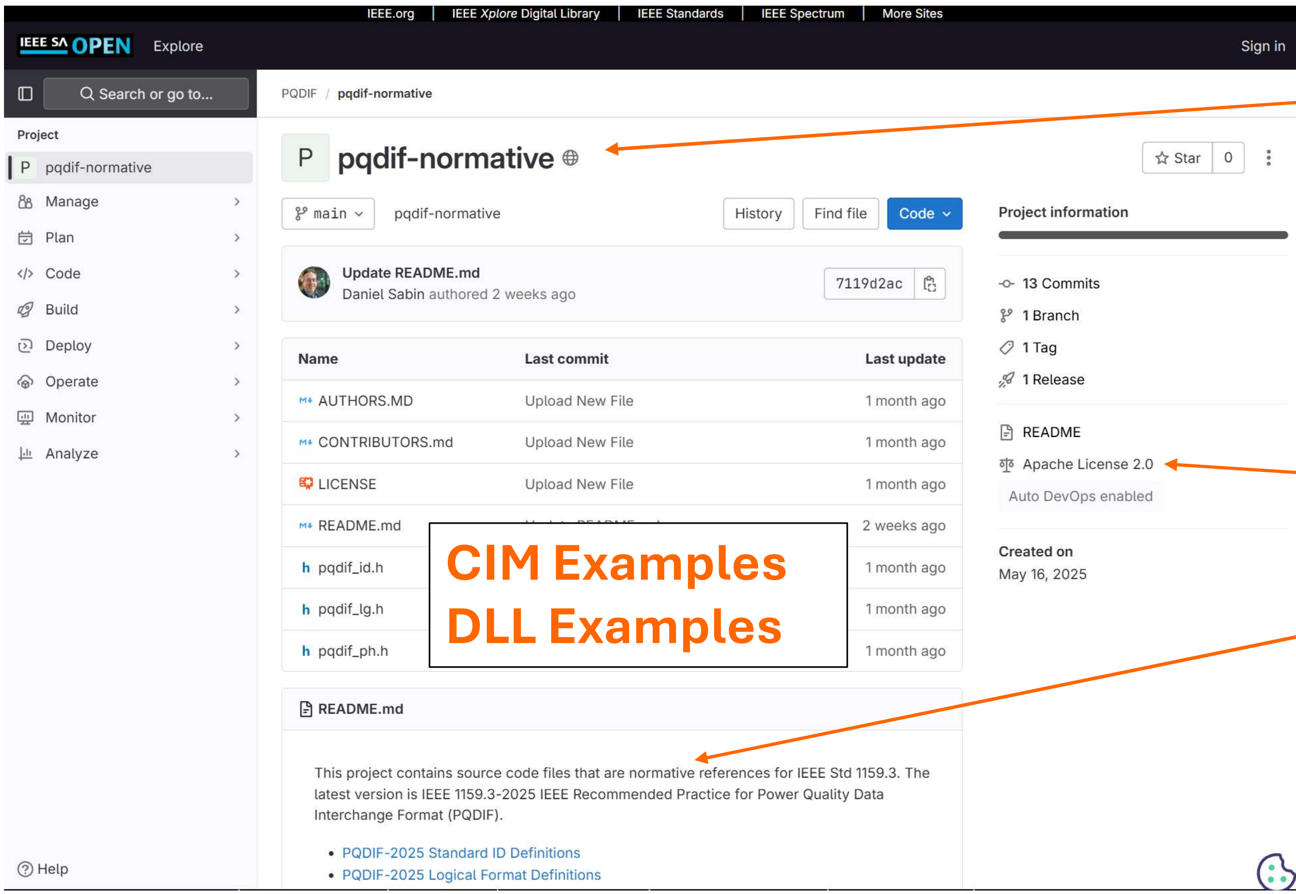
75% returned, 75% approval

- Three strength levels:
  - Standard, "shall"
  - Recommended Practice, "should"
  - Guide, "may"
- Join IEEE SA to vote
  - Formal comment process
- Examples in grid space:
  - 421.x for excitation systems
  - 1547.x for DER
  - 2030.x for smart grid / microgrid
  - 2800.x for bulk system IBR
  - P3597 for real-code DLLs

https://standards.ieee.org/develop/index.html

NERC may then mention 3597 and 3743 in the Technical Rationale for MODs 26, 32, and 33.

Next Step 2: develop a Tier 4 IEEE open-source project in conjunction with P3597 and P3743.



Approved by IEEE Open Source Committee in parallel with the IEEE NesCom's PAR approval. The same Working Group develops both under controlled processes. Individuals would sign Contributor License Agreements.

Use the **Apache License** to enable commercialization.

Pairs with an IEEE standard. The code may be "locked" to a version of the standard, or it may evolve between versions of the standard.

Examples: https://opensource.ieee.org/pqdif/pqdif-normative and https://opensource.ieee.org/pes-testfeeders