WECC

Inverter-Based Resources Short-Circuit Modeling

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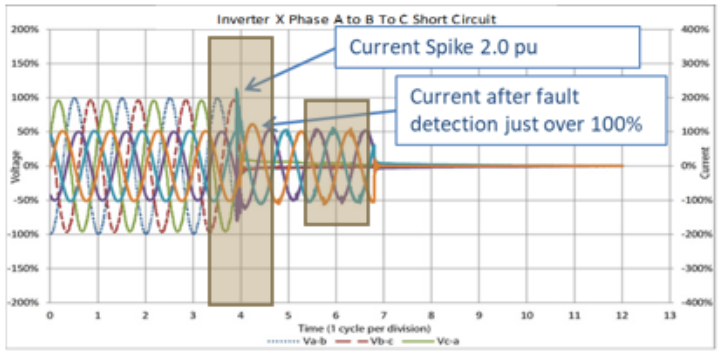
Amos Ang
Senior Power System Planner
Chair of SCMWG

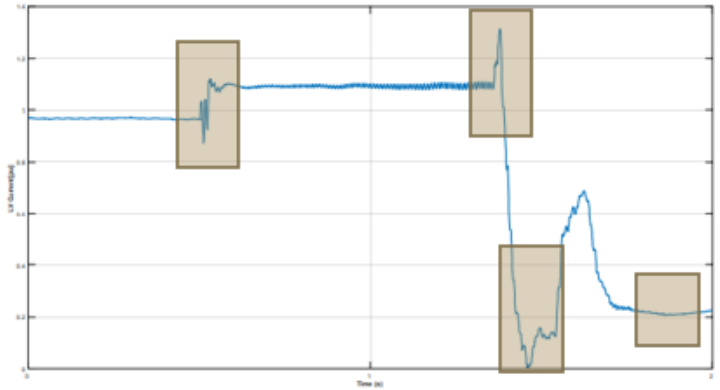
Agenda

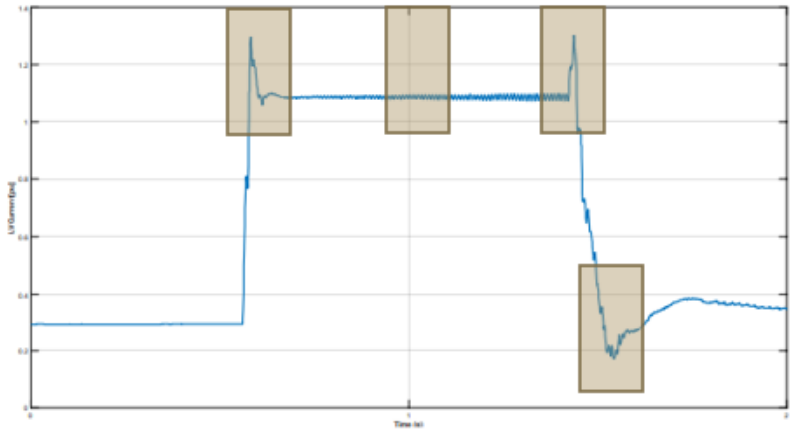
- Goal of IBR Modeling
- Is there an accurate IBR model for calculating faults?
  - State of IBR Modeling
- Clarifying Terms
  - Container Concept
  - DLL Container
- ASPEN's work for DLLs
- WECC Involvement

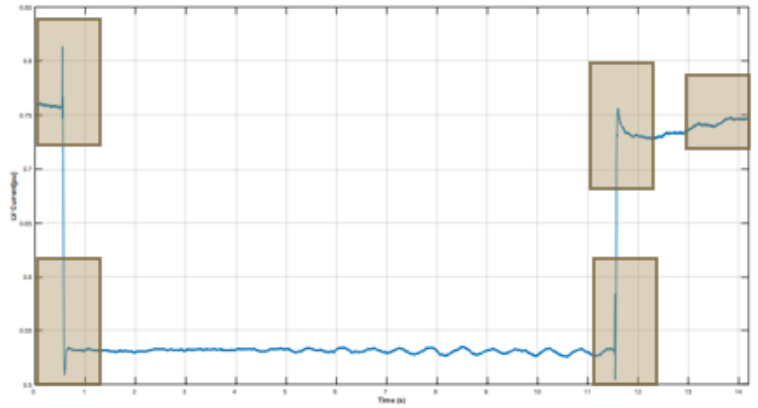
Goal of IBR Modeling

- IBRs are non-liner source
  - Varies output based on settings such as P priority, Q priority or Voltage priority









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State of IBR Modeling

Model	Pros	Cons
Impedance	• Current contribution from IBR(s) can be converted to an equivalent without loss of detail. • No convergence issues	• Not the highest current that could be seen by the relay • IBR output is dependent on starting voltage and operational priority settings which are not translated in this model • IBRS with negative sequence output would not be correctly modeled • Corresponding voltage and angles will be incorrect during the faults because the starting state dictates the results
Current Limited Current Source	• Highest Current seen by relay and equipment. • Easy to enter data	• Cannot be reduced into an equivalent generator • Output of IBR is inconsistent compared to detailed models that depends on starting voltage and operation priority settings • Convergence issues for solution • Not recommended by Aspen any more
Voltage Control Current Source	• More Accurate IBR output • Use this model for STATCOM modeling	• Need power flow solution as a starting case for accurate results • Negative Sequence output is not represented if IBR is capable of output • Table need to filled out with generator owner/manufacturer • Convergence issues for solution • Phase angle output (without “tweaking”) would result in SCD lower with generation online instead of being higher • Cannot be reduced into an equivalent

State of IBR Modeling

Model	Pros	Cons
Converter-Interfaced Resource Model	• Most accurate IBR output • Capable of negative sequence output • Less data setting compared to VCCS	• Accurate IBR output for only one type of IBR • **Not supported in CAPE*** • Convergence issue for solution • Cannot be reduced into an equivalent • Data might be difficult to get from generator owner • For faults near the generator, current is set to zero due to undervoltage • Phase angle output (without "tweaking") would result in SCD lower with generation online instead of being higher
Type IV Model	• More accurate IBR output • Less data setting compared to VCCS	• Need power flow solution as a starting case for accurate results • Negative sequence output is not represented if IBR is capable of output • Convergence issues for solution • Phase angle output (without "tweaking") would result in SCD lower with generation online instead of being higher • Cannot be reduce into an equivalent • **Not Supported in OneLiner**

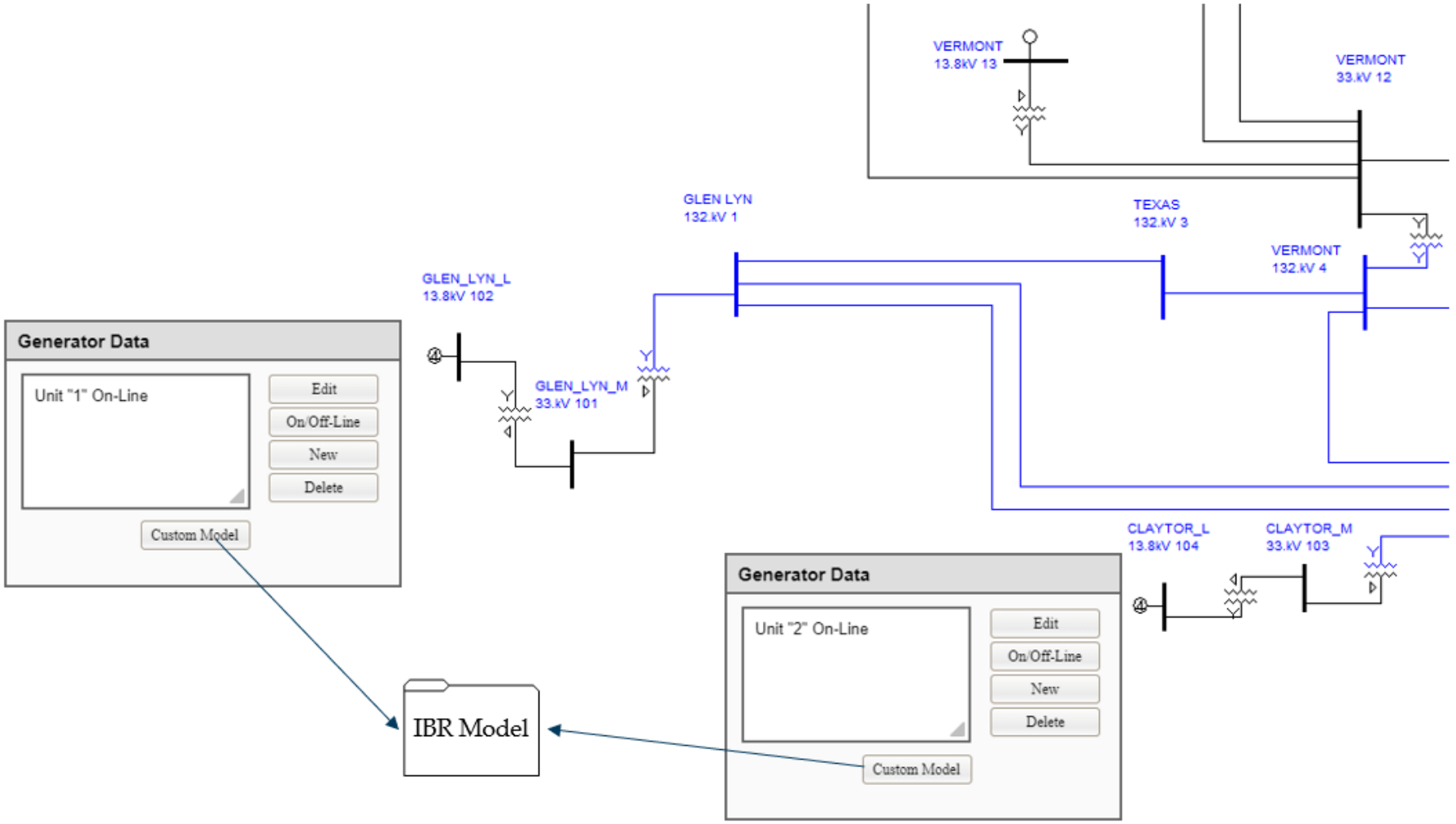
Clarifying Terms

- Container Concept
- Dynamic Link Library
  - Defining DLL
  - DLL “Container”: Pros and Cons

Container Concept

- File to “contain” the IBR SCD model
- Multiple generators in programs, such as OneLiner or CAPE, can use the same container for the IBR model
- Containers should be developed by the IBR manufacturers to ensure accuracy
- Each container from each IBR manufacturer can cover manufacturers’ multiple IBR models (preferred by users)
- Container can be a DLL or an XML table

Container Concept



Defining Dynamic Link Library

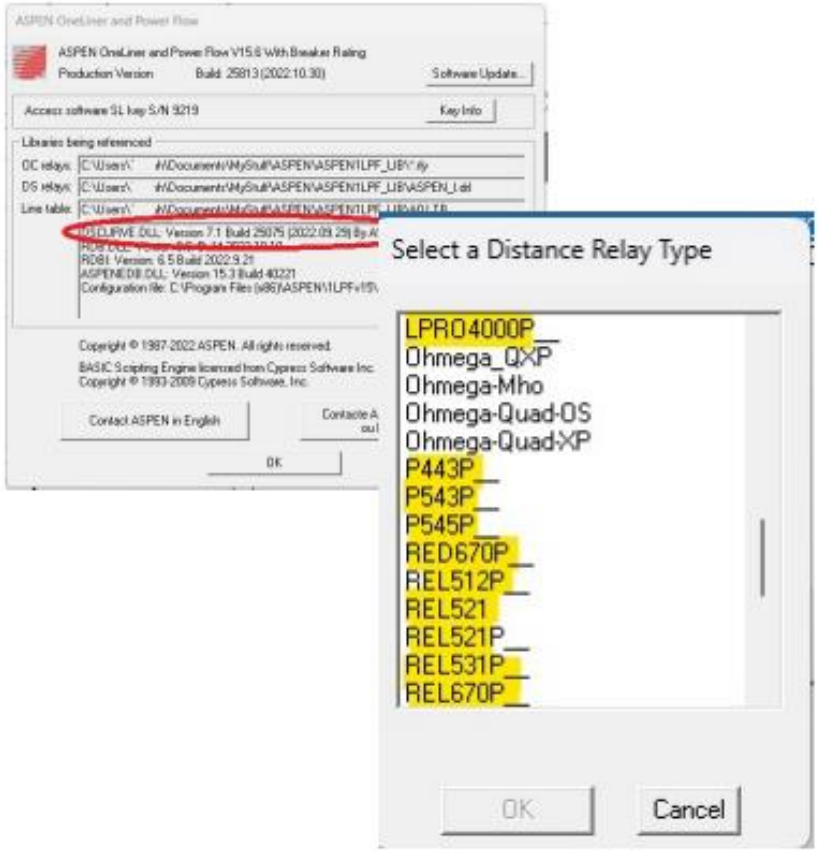
- A collection of small programs that larger programs can load when needed to complete specific tasks
- Contains bits of code and data, like classes variable, or other resources such as images that the larger program can use
- The “container” for the needed pieces of logic/data for the larger program (e.g., OneLiner/Cape)
- The “container” can have equations/control schemes/look-up tables coded into the DLL
- https://www.techtarget.com/searchwindowsserver/definition/dynamic-link-library-DLL

DLL Container: Pros and Cons

Pros	Cons
Save on memory	More complex to develop
Potential “faster” computing time	Need to be rewritten every time software packages have major updates
Potentially useable by multiple programs	Longer to implement
Can contain equations, control logic, and/or look-up tables that can “masked” intellectual property protection “black box”	New “variables” can potentially break model and need to be rewritten from both the IBR manufacturers and sequence software vendor’s side
	Potential malware issues
	IBR manufacturers need to work with software vendors for the compilation of a DLL for it to work correctly

Aspen Example for Distance Relays

- Can be built by a third party
- Accessed automatically by the short-circuit program at run time
- In the screenshots on the right are:
  - Distance relay models in the form of DLLS



Author of DLLS

- Converter-Interface Resource (IBR for everyone else) manufactures such as Siemens, SMA, GE, Vesta
- EPRI, University researchers, etc.
- ASPEN to provide “prototype” DLL source code and software for testing and demonstration purposes

ASPEN CIR Model DLL Prototype

- "Starter" source code in Visual Studio C++ 2019
- Freely downloadable OneLiner working model software for testing
- Must publish application program interface (API):
  - CIR current output calculation
  - Model data management

CIR Model Data Management API

- Supply model specific parameter template
  - Parameter name
  - Parameter value range
- Validate user-entered CIR model data

What are ASPEN and Siemens Gamesa Going to Do?

- Establish the input and output data type and format for the DLLs
- Test the DLL's data type/format for completeness using OneLiner and CAPE

Approximate Time Line

- Pilot project with Siemens Gamesa starting in Q1 2023
- Data-format and parameter list for the DLLs with be made available by Q3 2023
- DLLs for wind and solar plants with available as built-in component of ASPEN OneLiner releases starting in late 2023

WECC

- Models can be stored at WECC as part of base case system
- Data can be accessed accordingly—Can be opened to the software vendors and IBR manufacturers to upload the latest and great models

Reminder of Goal

Model IBRs well enough to satisfy:

- Ensure safety
  - Reliability–relay operated as intended
  - Equipment sizing
- Ensure security
  - Lessen relay misoperations
- Meet compliance obligations
- Avoid FERC investigations for causing blackouts due to misoperations

Feedback

- Questions
- Comments
- Discussions

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