Modeling, Protection, Application of Advanced Grid Services from IBRs

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Session 3A
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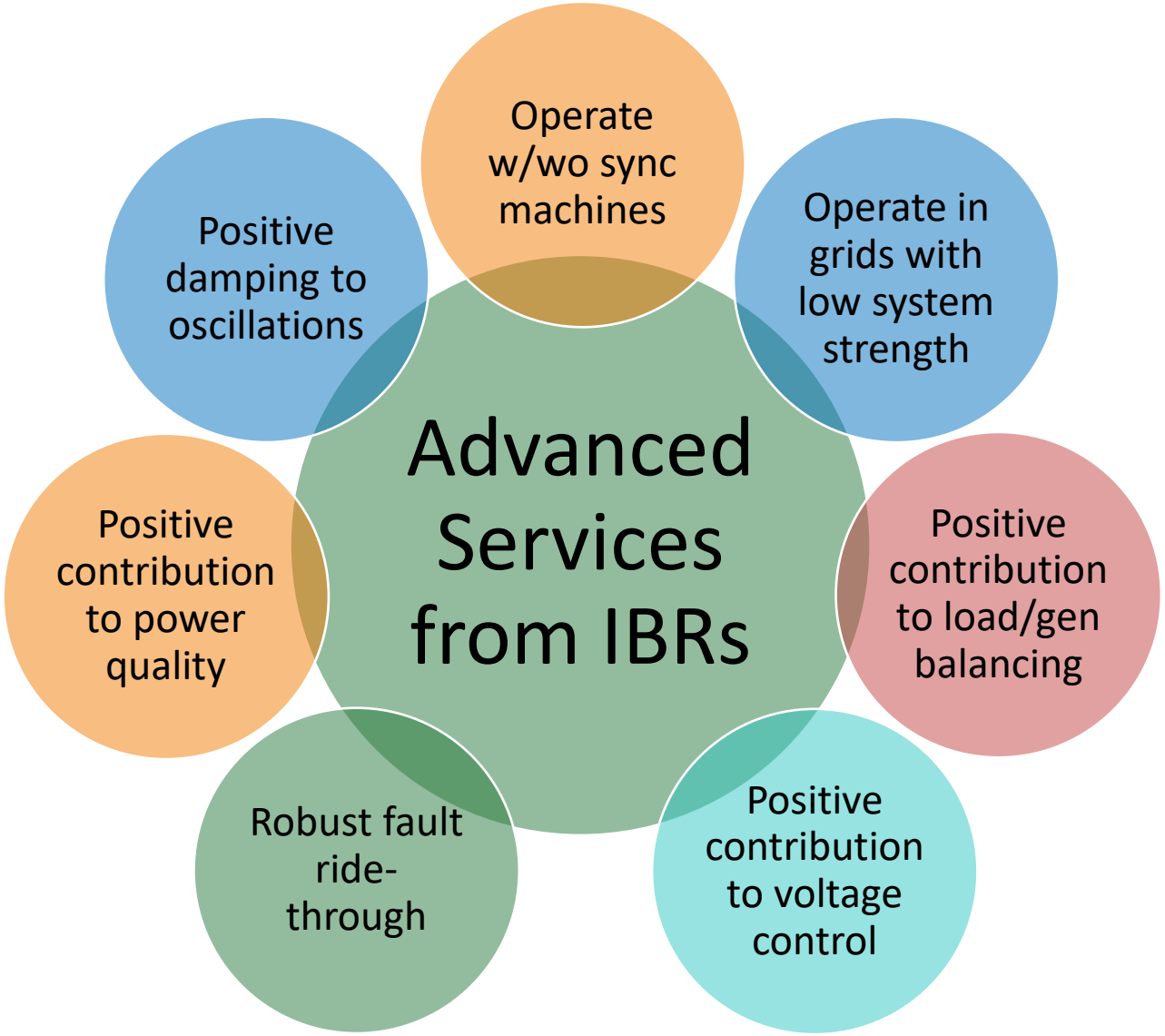
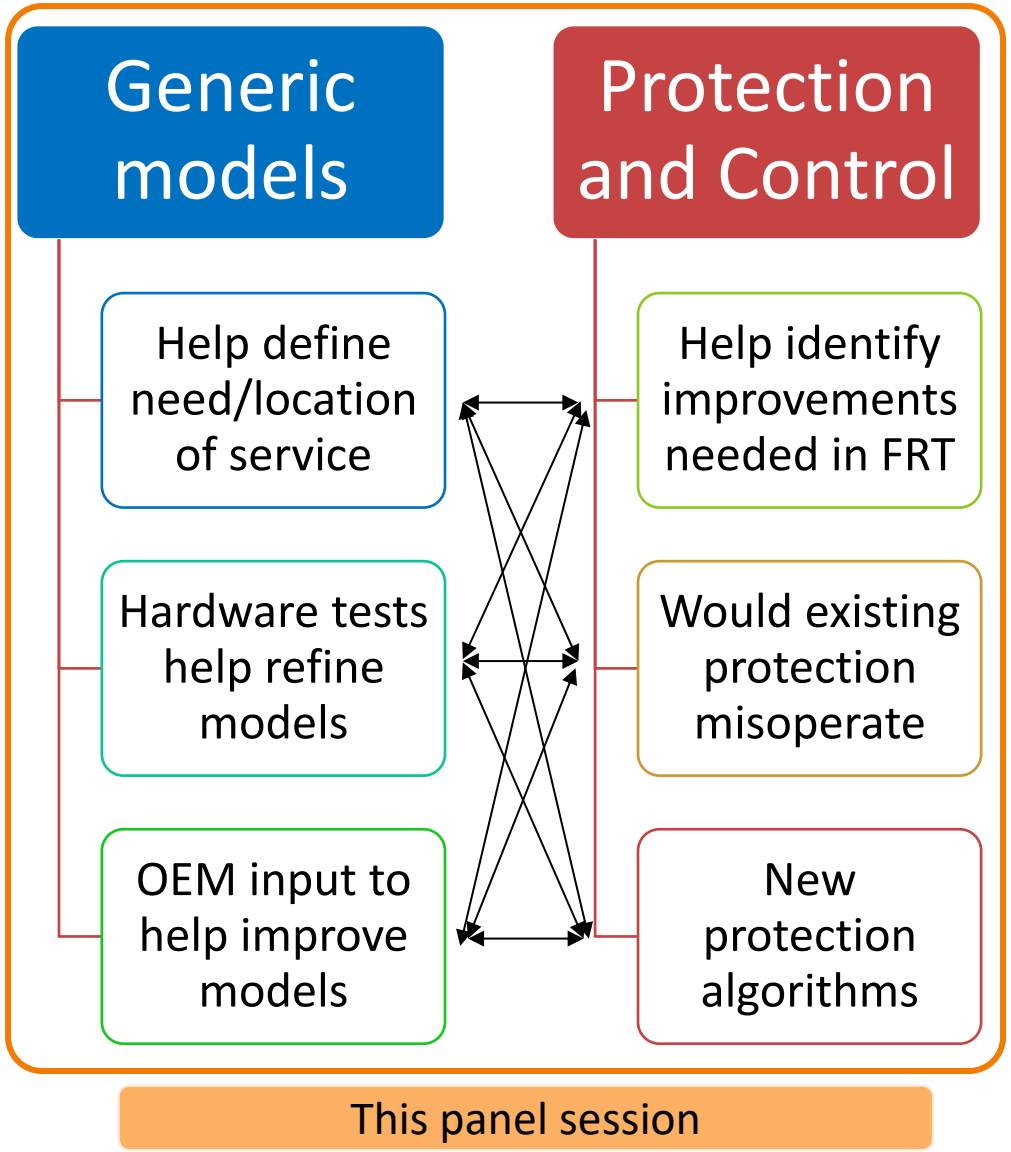
What does power system need inverters to do and how?





Disclaimer: the concepts on this slide may not map one – one to IBR plants that are already built/commissioned

Generic models for IBRs

Modular that do not necessarily represent the exact control algorithm of any particular IBR vendor.

Appropriately parameterized models can provide the expected trend of dynamic behavior.

Characteristics of a single model do not represent the characteristics of the entire IBR plant.

Advantages

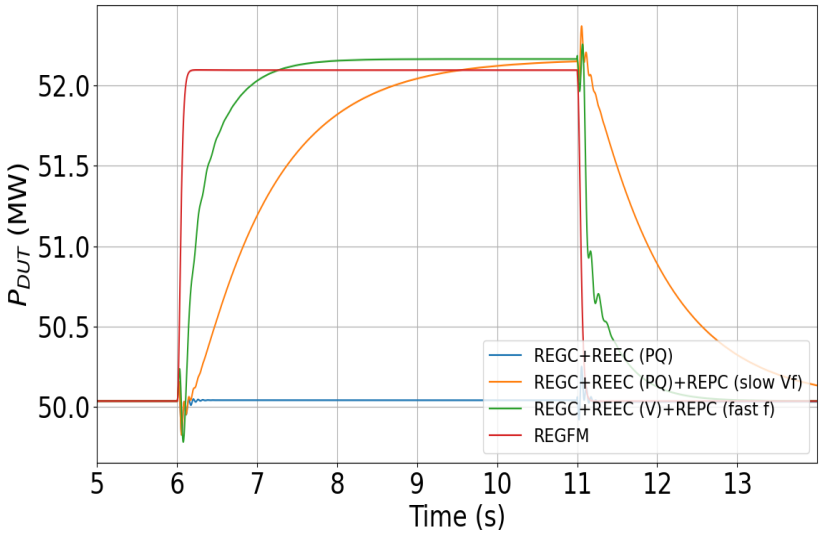
- Software portability
- Open documentation
- Publicly available
- Designing the future system
- Interconnection wide application

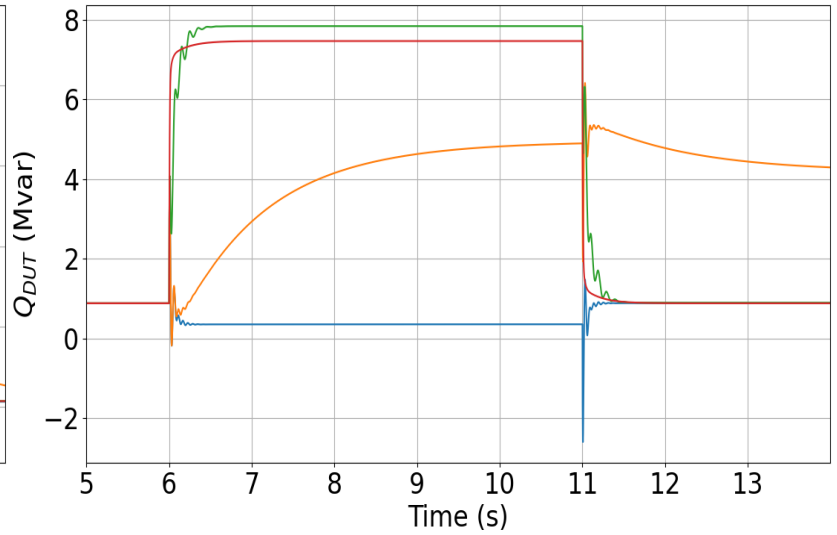
Disadvantages

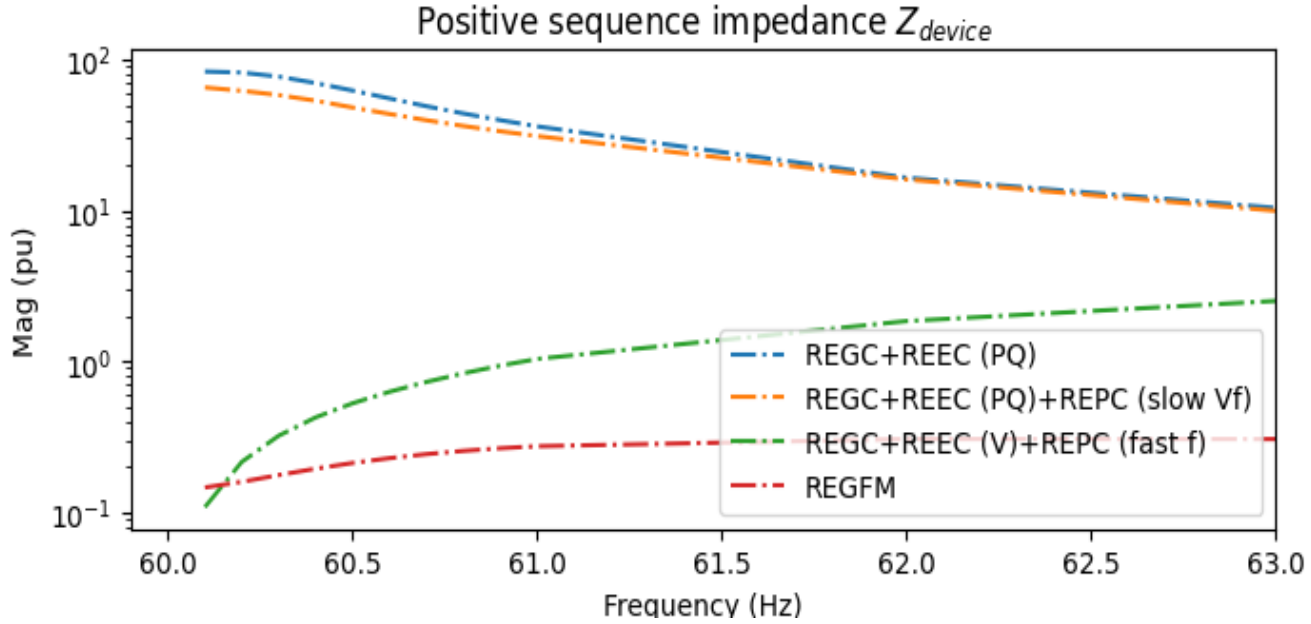
- Cannot represent every detail of operation at limits and fault ride through
- Should not be used to identify mitigation measures for oscillations
- May have longer time lines for improvement
- Requires adequate knowledge of the models to ensure appropriate parameterization

	Lower than 3.0 Hz	3.0 Hz – 10.0 Hz	Greater than 10.0 Hz
+SEQ domain	Applicable	Applicable with care	Out of software domain design
EMT domain	Applicable but potentially overkill	Applicable	Applicable

Overall performance of an IBR plant



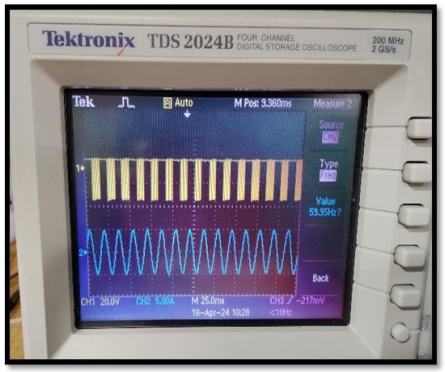


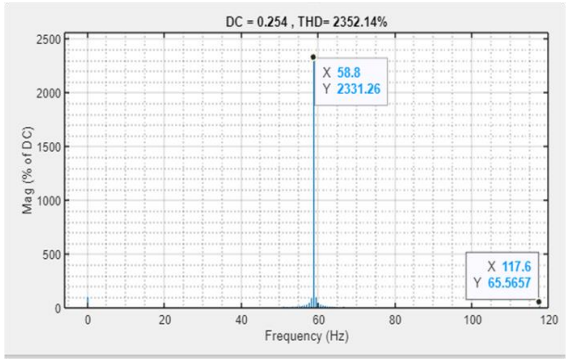


- A plant's dynamic characteristics and ability to provide services is defined by every control loop within the plant
- Same plant level characteristics can be obtained with various combinations of control designs
- Especially important when using generic models to determine system performance requirements

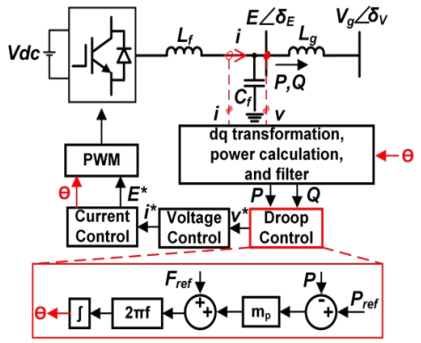
Hardware and interoperability testing of inverters

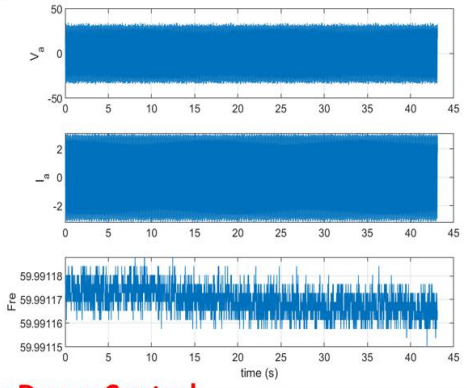
- Nuances in hardware that cannot always be captured by models





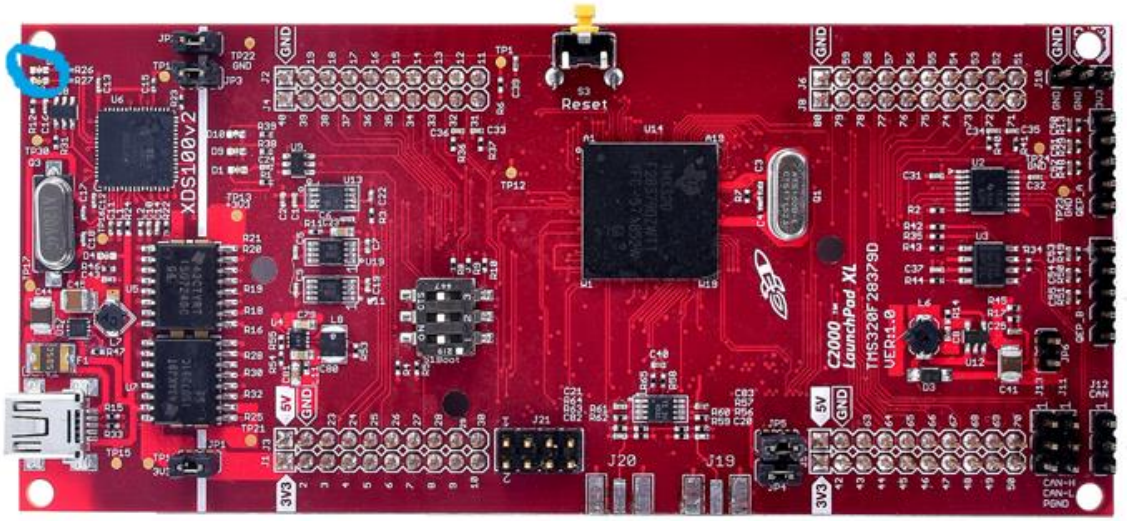
Hardware Measured Frequency





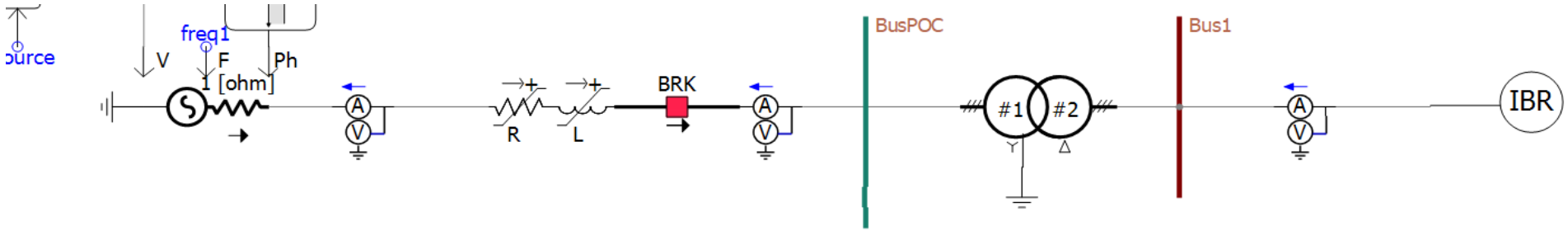
Frequency Generated from Droop Control

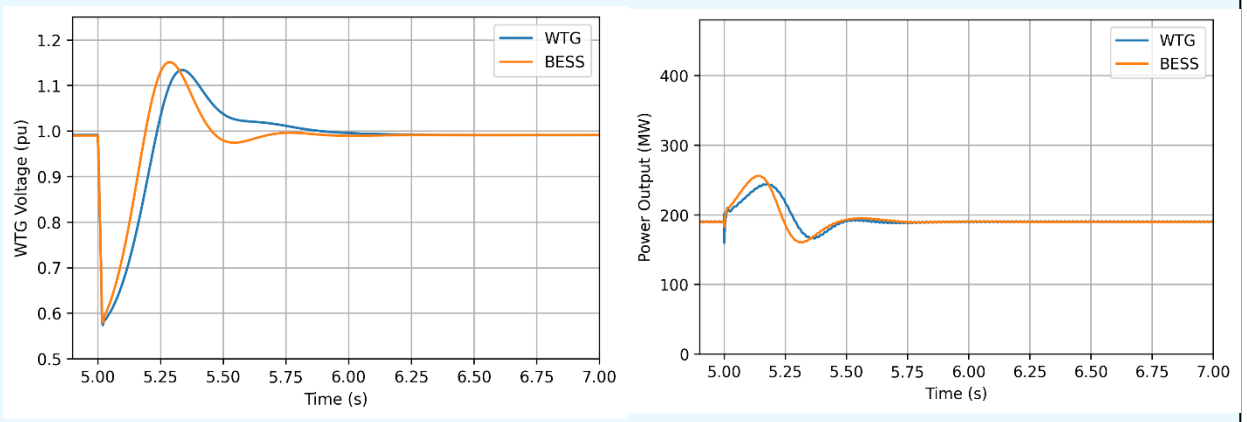
- Higher numerical precision = higher cost



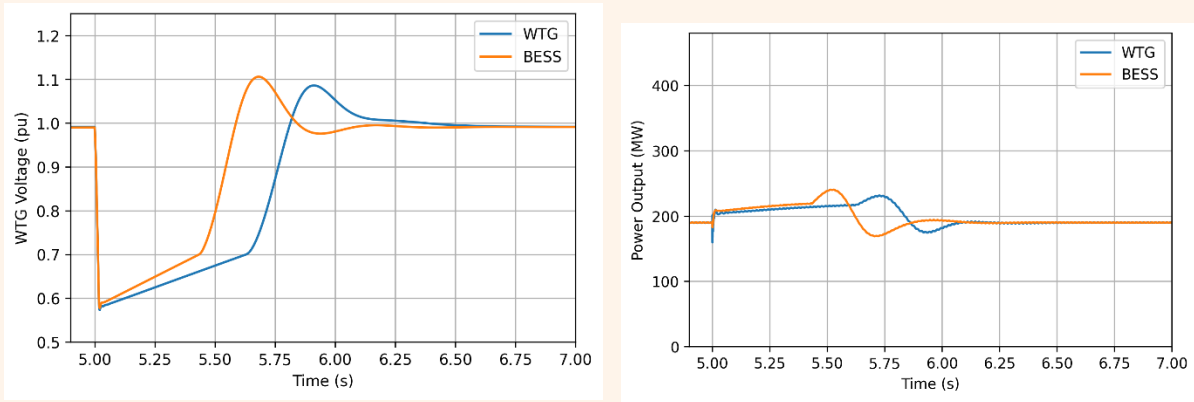
- Hardware testing is important to understand many such nuances

Dynamics of source behind inverter important to consider when delivering advances grid services





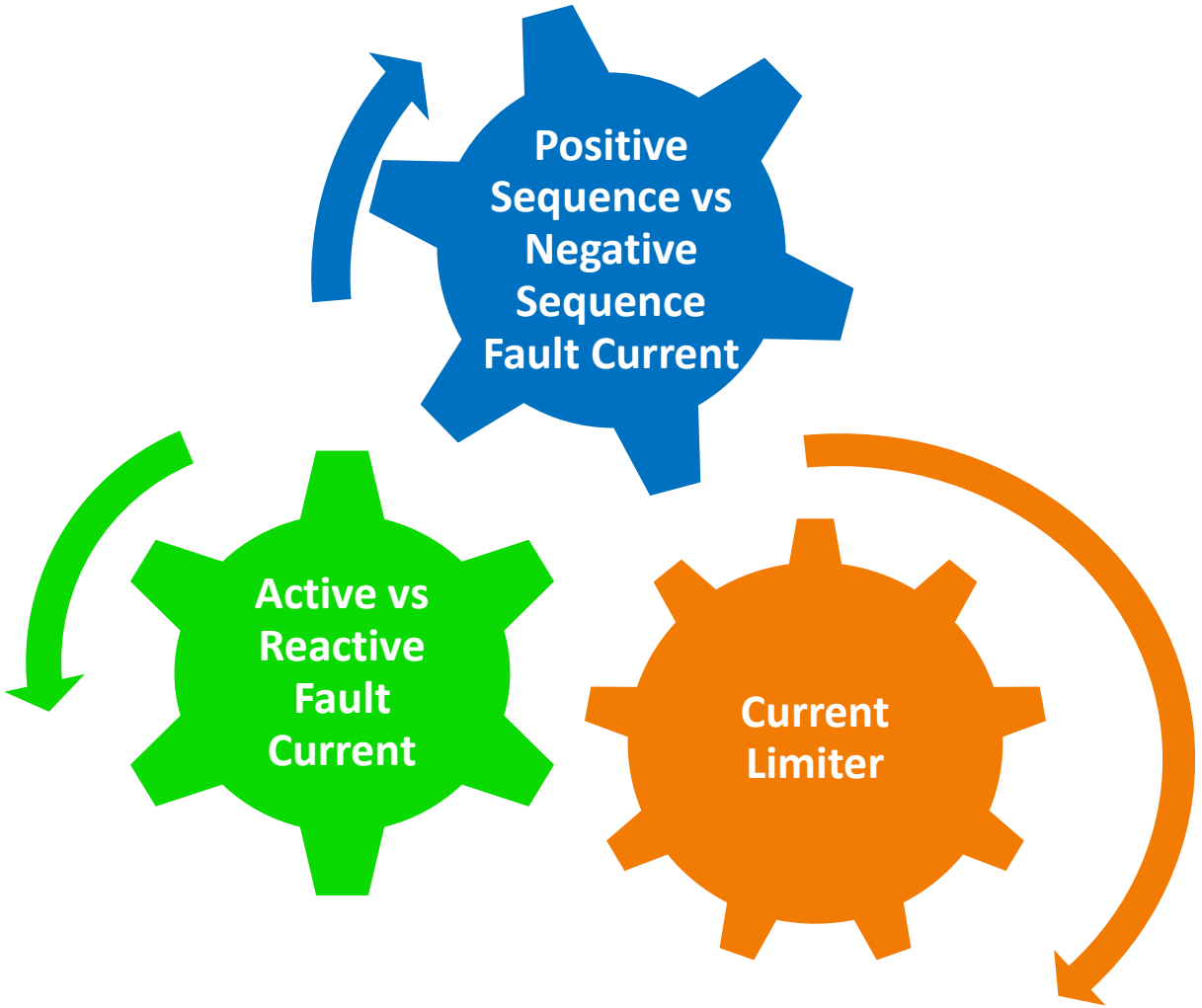
No FRT Freeze



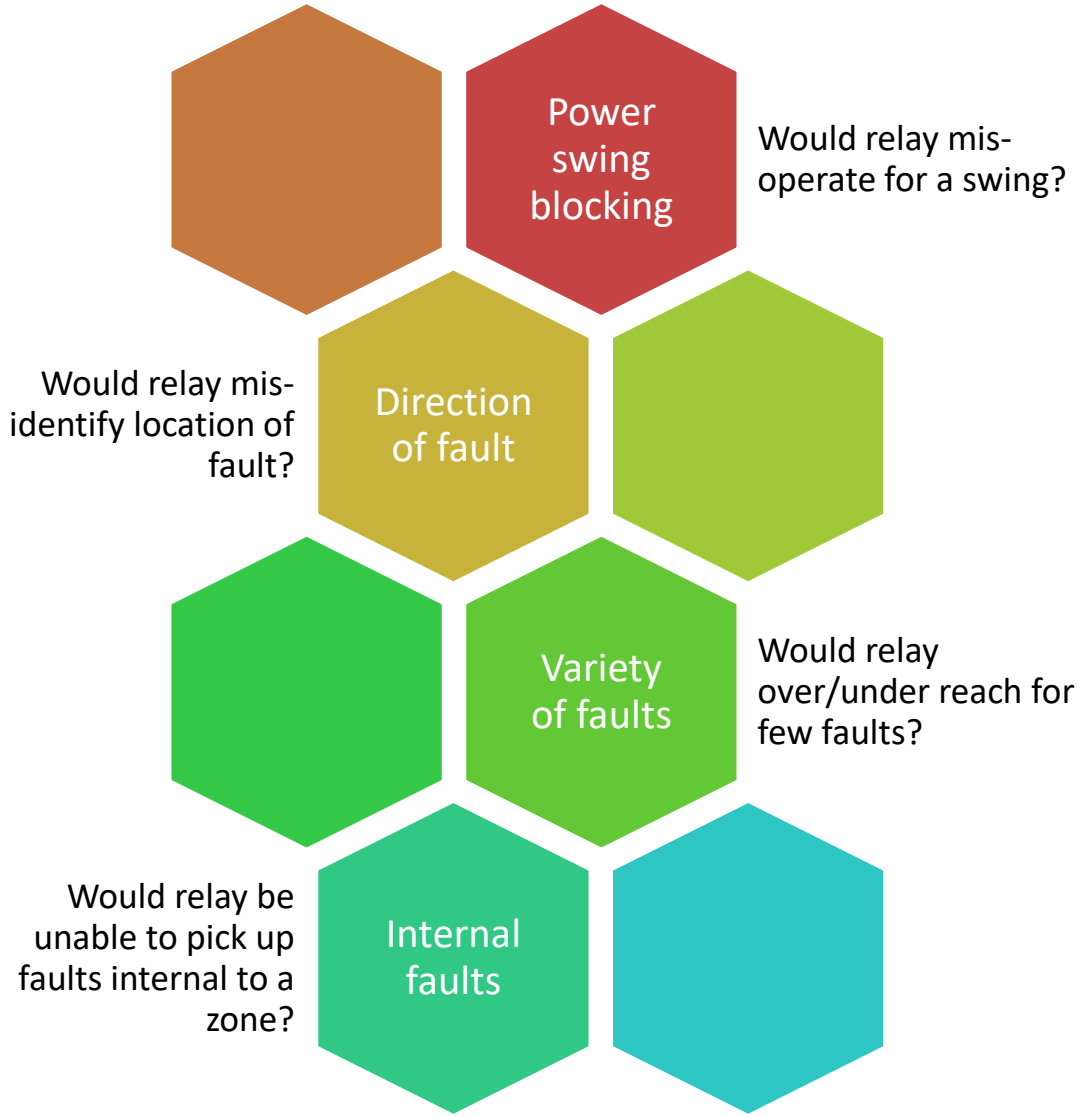
FRT Freeze below 0.7 pu voltage

Modeling source/DC control and FRT dynamics may be important to accurately capture transients

Protection in IBR dominated grids



How should an IBR respond?



How should protection be set/designed?

Panelists

Introduction of WECC-Approved Dynamic GFM Models

Wei Du, Solar Subsector Manager, PNNL

Deepak Ramasubramanian, Senior Technical Leader, EPRI

GFM Inverter Interoperability Through Hardware Testing

Jing Wang, Researcher, NREL

Technology Updates Associated with GFM Wind Testing

Ignacio Vieto, Senior Engineer, GE Vernova

Protection of Inverter-dominated Power Systems

Ulrich Muenz, Principal Research Scientist, Siemens

Each panelist: 20 minutes presentation followed by 5 minutes Q&A