Transient Evaluation of an Intermeshed Medium Voltage AC / Medium Voltage DC Distribution Architecture Utilizing Distributed Energy Storage

University of Pittsburgh Swanson School of Engineering – Power & Energy Initiative

7th Annual Pitt Electric Power Industry Conference

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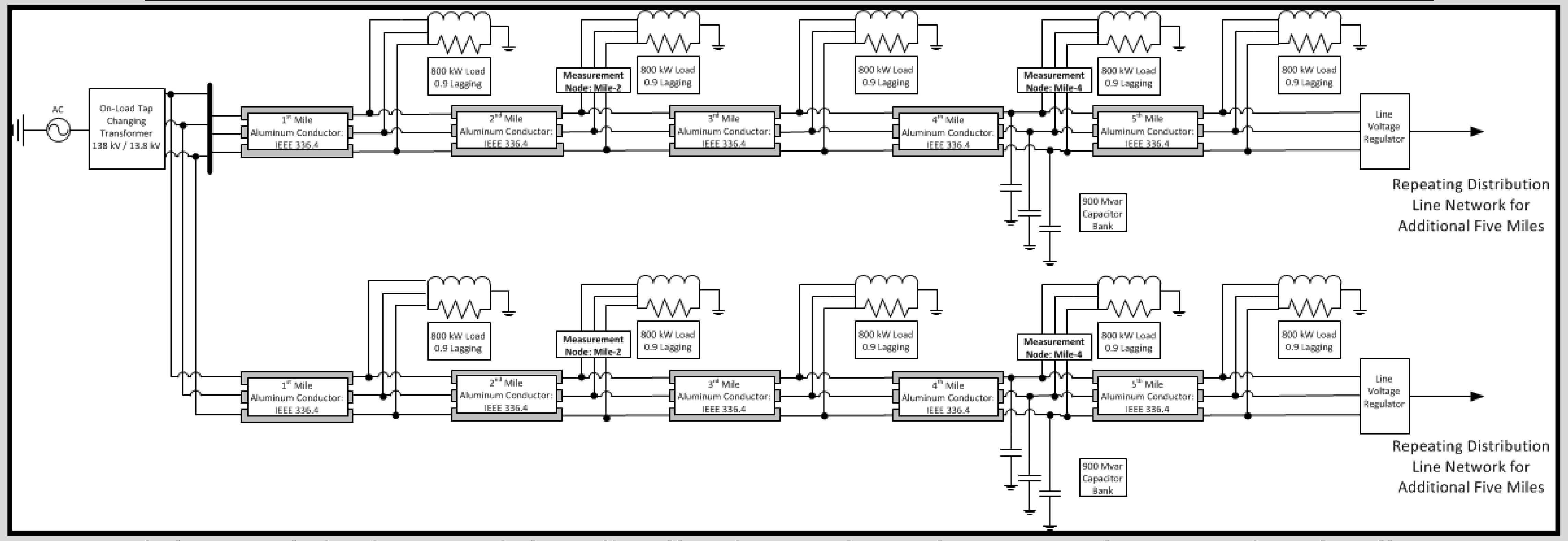
Medium Voltage DC Potential

- **DC system research** is drawing the attention of the smart grid community, including many power equipment vendors, utilities, end-users, universities and other market participants.
- **Power electronics technologies** continue to advance, and an emerging portfolio of generation resources and DC-based loads either utilize a DC link or produce/consume DC power, such as battery energy storage systems.
- **However, the legacy** of a reliable and robust AC system will remain as the base supply for many loads.
- **For this reason**, methods will need to be established for intermeshing and integrating AC systems with future DC systems.

Simulink Model of Distribution Architecture (In-Progress)



Note: Last Five Miles Identical to First Five Miles for Each Feeder, But Uses Aluminum Conductor Type: IEEE #1/0

Visio model of one of the distribution substations serving two feeder lines

Description:

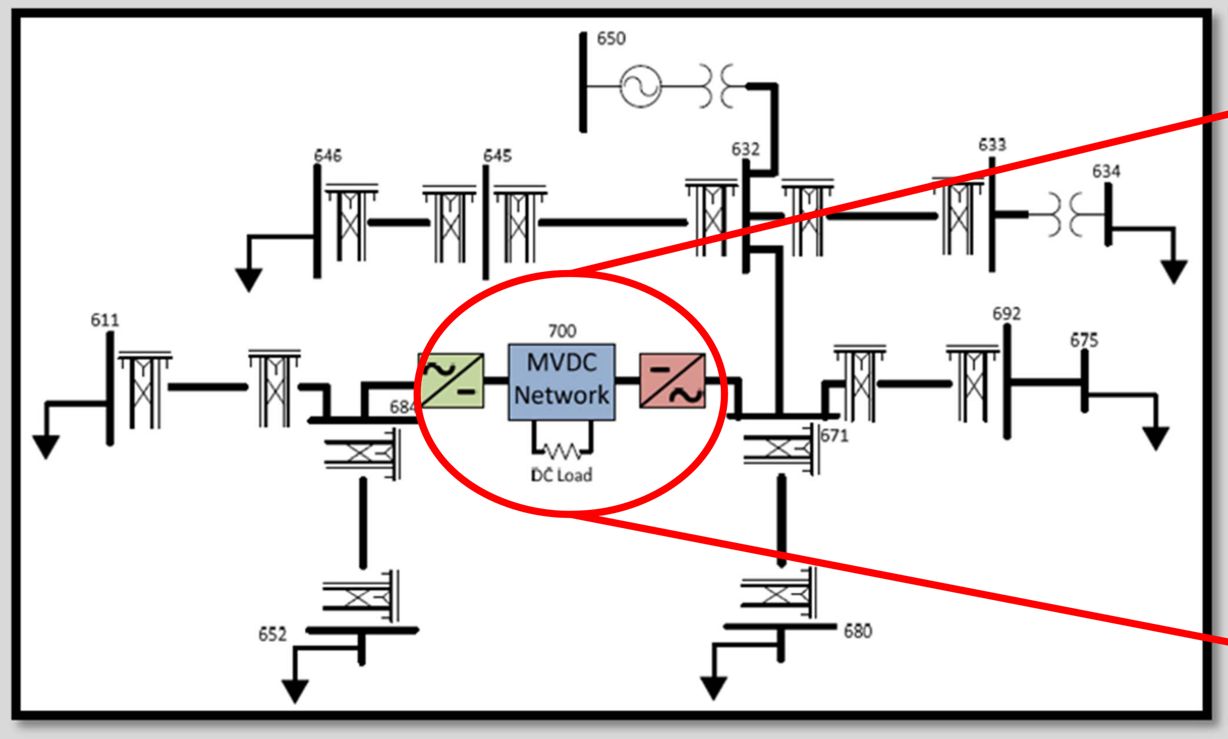
- A custom distribution model is being created using MATLAB® Simulink based off the IEEE 13-Bus network shown below
- The model will contain two tied substations with two feeders per substation
- One of the substation's feeders will integrate an MVDC architecture

Features:

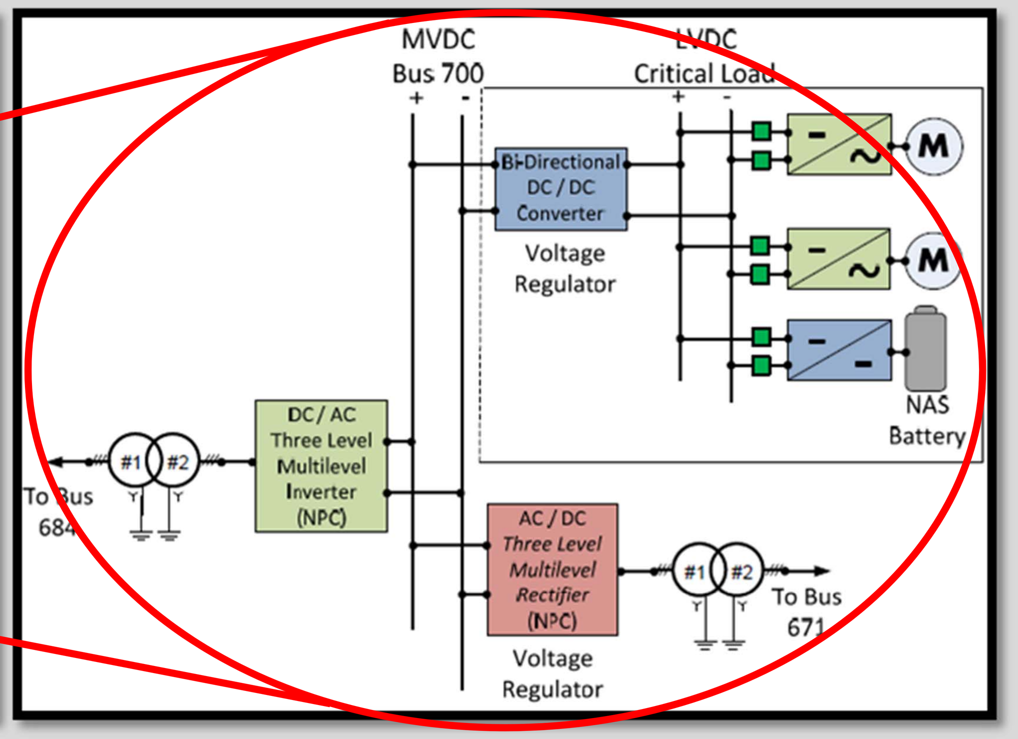
- Substations distribute a 138 kV source which is stepped down to 13.8 kV
- Ten-mile long feeder lines with 800 kW loads placed at each mile
- Two different types of aluminum conductor lines modeled:
  - 1st five miles - IEEE 336.4; 2nd five miles - IEEE #1/0
- On-load tap changing transformers to regulate voltage flow between substation and feeder lines
- Line voltage regulators after mile-five for voltage optimization
- Capacitor banks placed every four miles to assist power quality
- Voltage and current monitored every two miles

Conceptual Distribution Network Framework

IEEE 13-Bus Network with Integrated MVDC Architecture



Subsystem Architecture of MVDC Network with Battery Storage



Left: IEEE 13-Bus distribution model used as reference for simulation model development. *Right*: More detailed look at some of the components of the MVDC intermeshed network incorporating a Low Voltage DC (LVDC) subsystem with battery energy storage technologies connected using bi-directional DC-DC converters.

Benefits of an Intermeshed MVAC / MVDC Network

- The MVDC network can be used to interconnect and supply various DC loads:
  - Adjustable/variable speed drives, batteries, data centers, and LED lighting
  - Renewable energy resources
- A LVDC bus will be connected to the MVDC bus via a bidirectional DC-DC converter allowing for the LVDC bus to act as a load or as a source of generation.
  - Important for battery energy storage systems (BESS) in the form of distributed energy storage systems (DESS)
  - Converter provides the LVDC bus with a regulated current and voltage
    - Useful when dealing with non-ideal input power.
- Tightly regulated bus power is important for handling critical loads such as hospitals and data centers, as well as sensitive loads such as semiconductor manufacturing processes.
- The inclusion of the distributed energy storage system (DESS) allows for the system to be self-sustaining, avoid power quality issues, more efficiently integrate renewable sources of generation, and help support grid health by sending power out to the MVDC bus and the larger AC grid when needed.

Battery Energy Storage Example