






PSCAD

Wind and Solar PV – Temporary Overvoltage Studies

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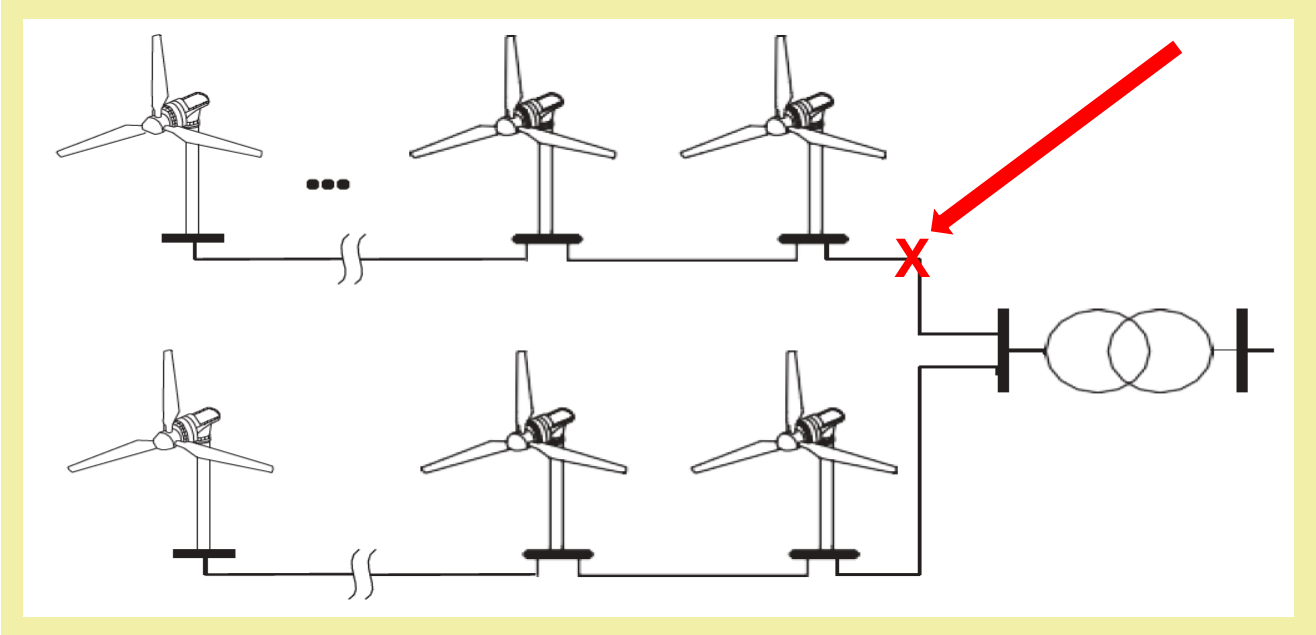
Presentation Outline

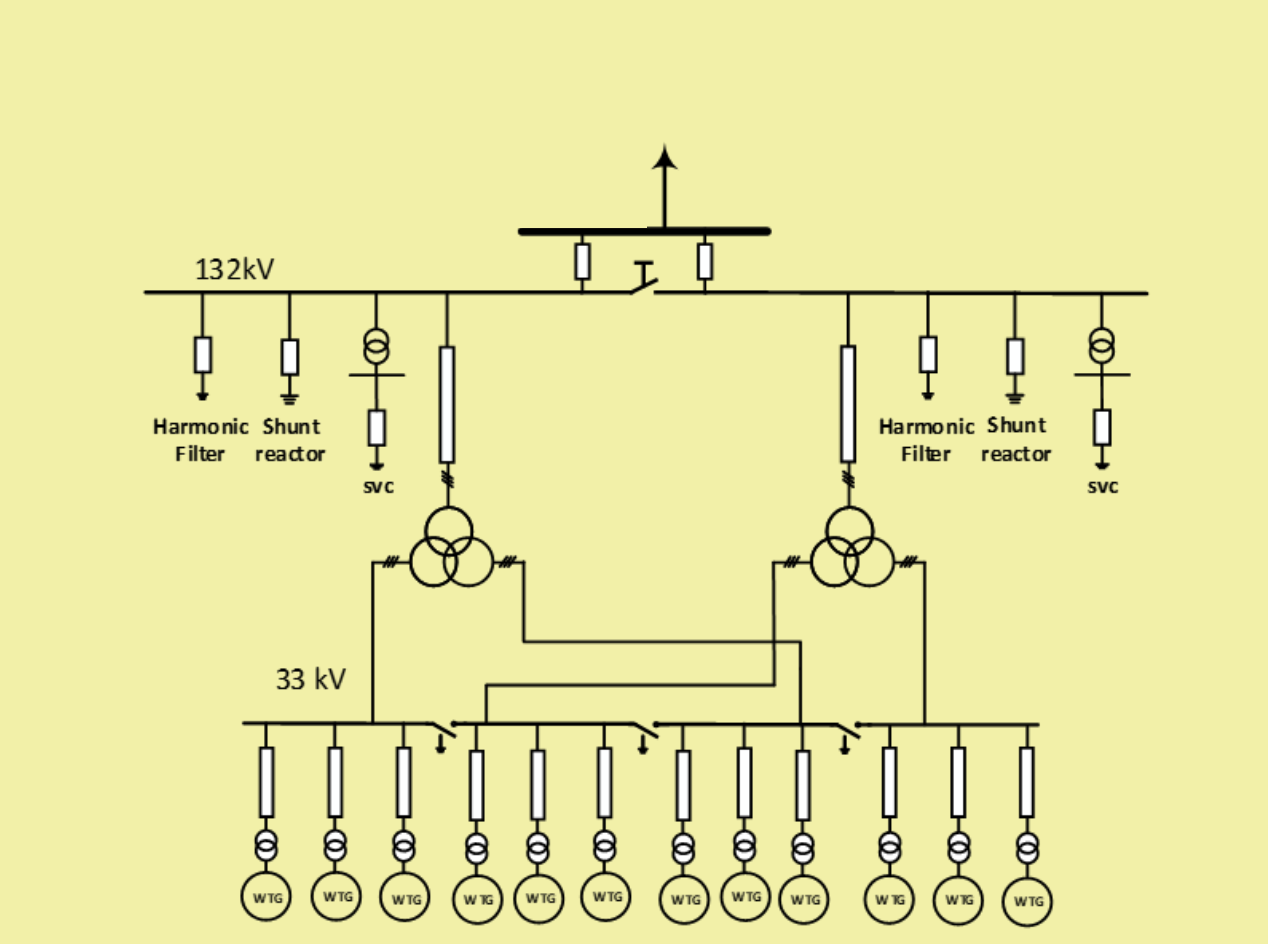
In this webinar, we focus on the key aspects of modeling wind and solar PV plants, in order to study the over-voltages due to isolation of a feeder (tripping) that is connecting a number of wind (or PV) inverters.



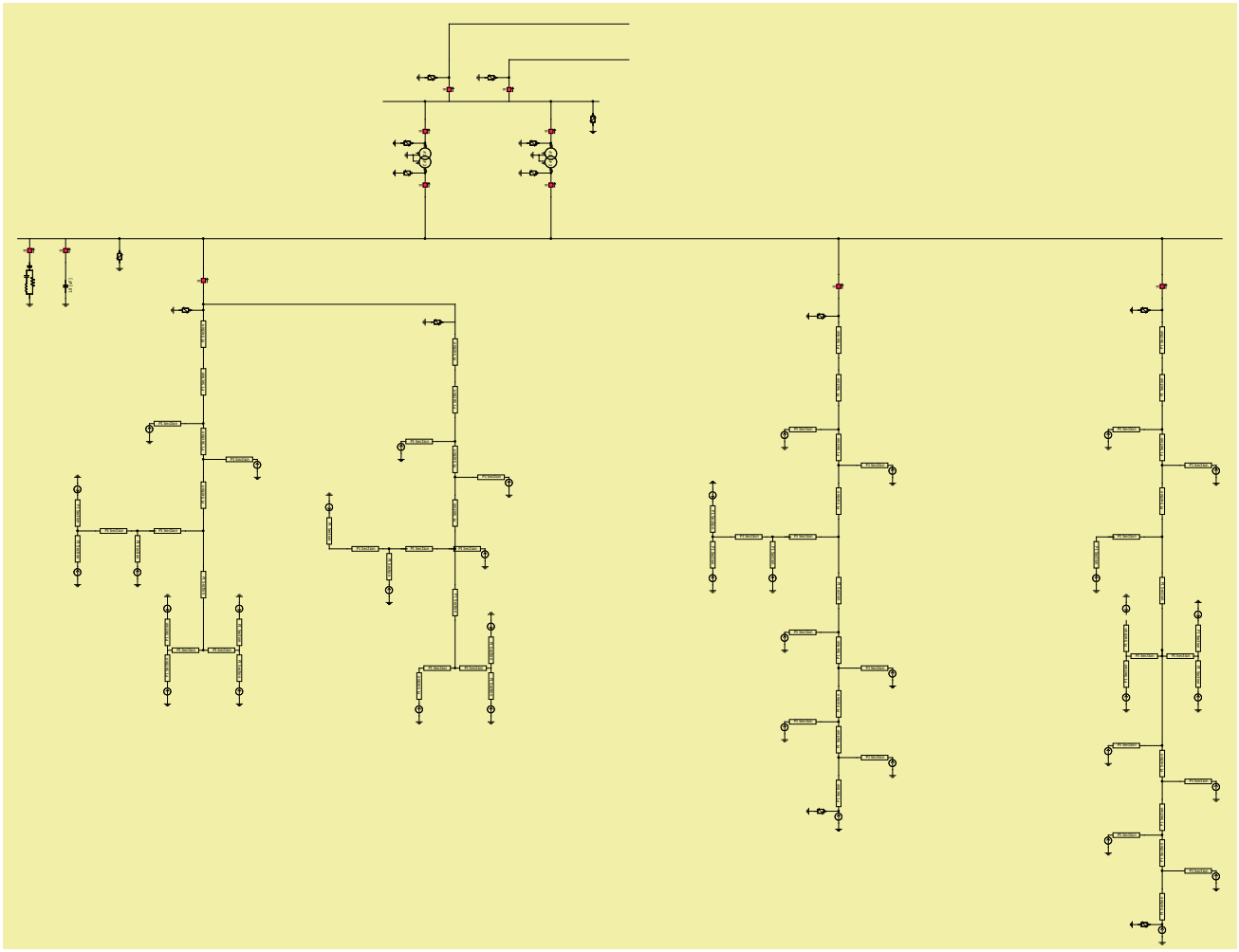
Presentation Outline

- General background
- Wind and Solar PV collector system layout
- The TOV concern
- Modeling Details
  - Transmission system, transformers, surge arresters, filters, capacitor banks
  - Collector system model
  - Collector network aggregate representation (equivalent collector network model)
  - WTG (Solar PV) model
- PCAD Implementation
  - Parallel Network Interface (PNI)
  - WTG (Solar PV) model ‘scaling’ (aggregation)
- Typical results
- PSCAD Simulation example

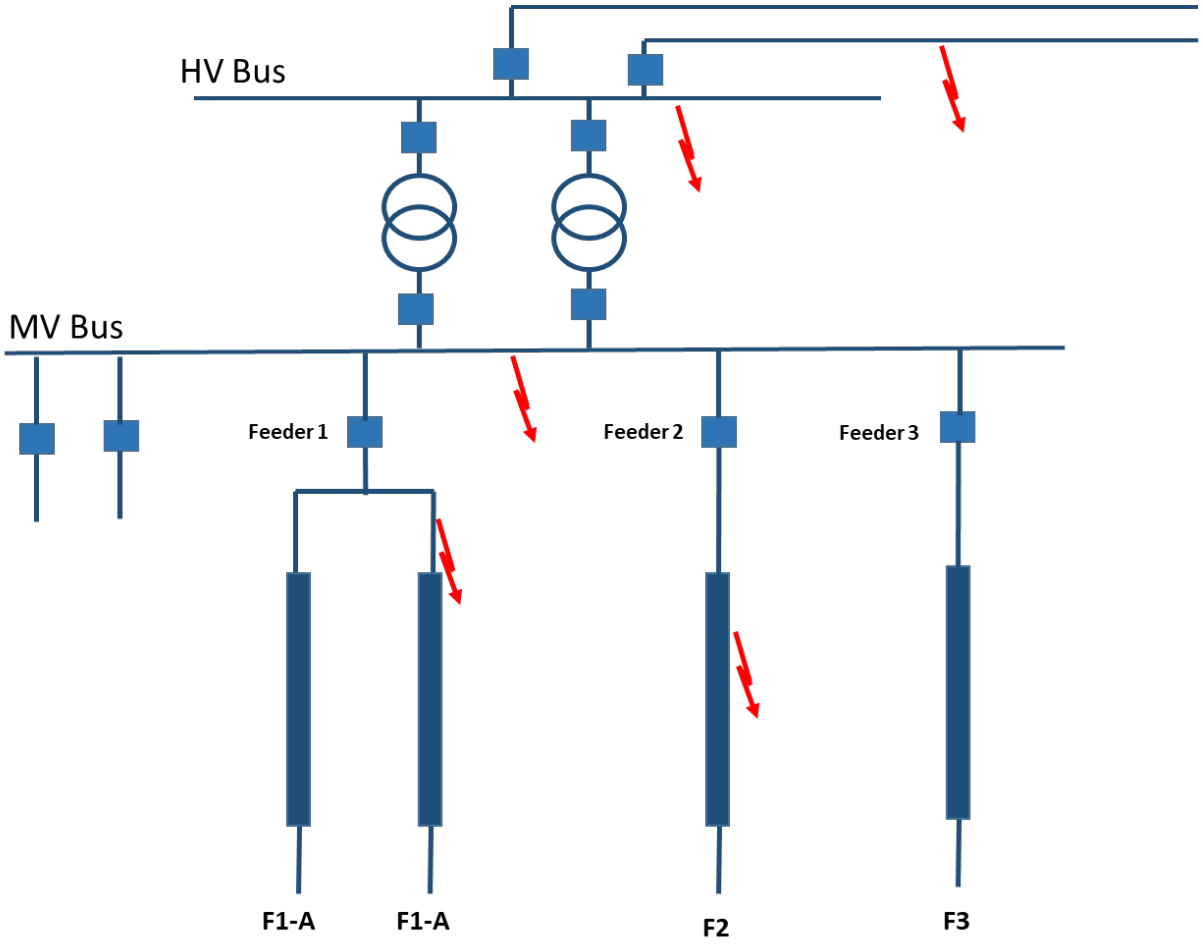
Typical Wind Farm Layout



Typical Wind Farm Layout



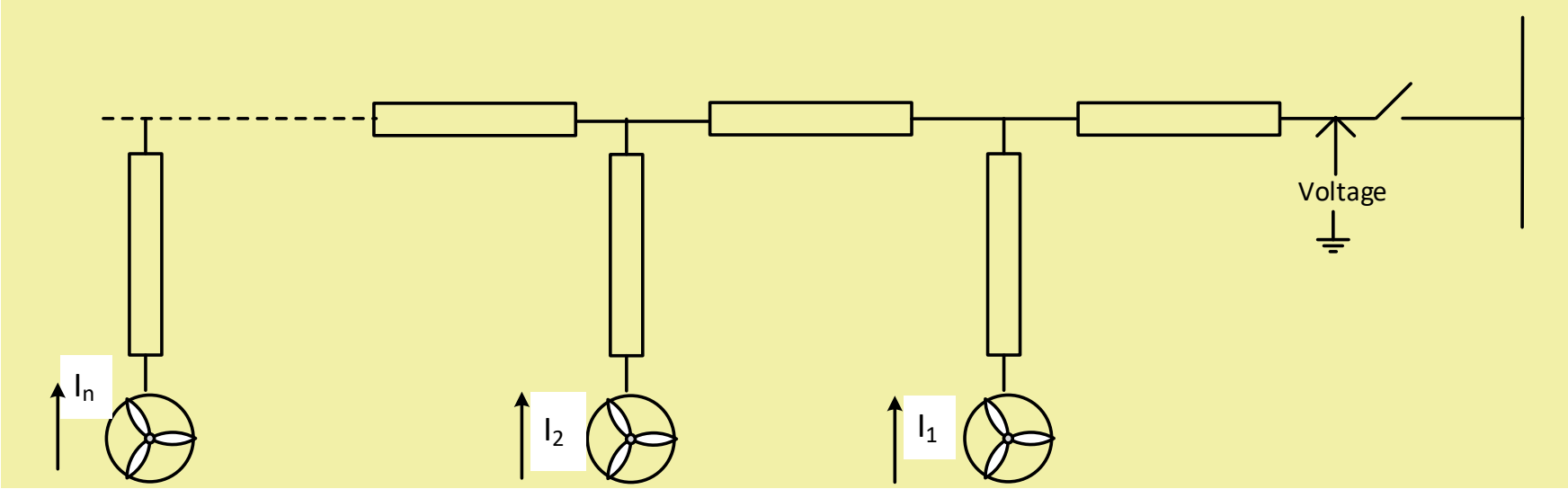
Faults on feeders or inside the windfarm substation



The Temporary Overvoltage (TOV) concern

Current injection to an open feeder – can cause the feeder voltage to rise rapidly

- The current will charge the cable capacitances



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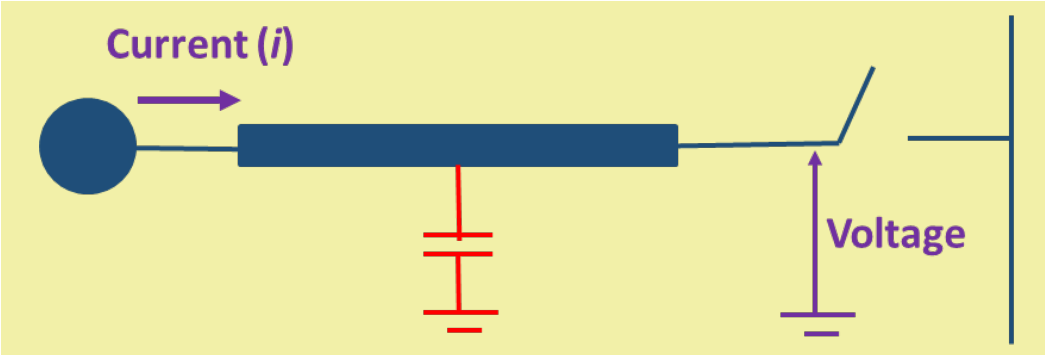
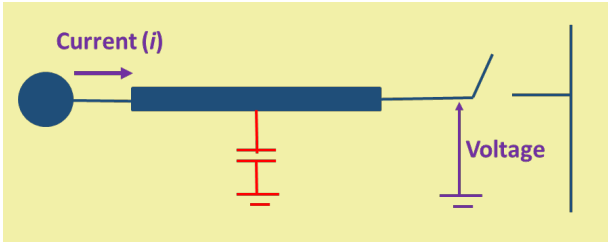


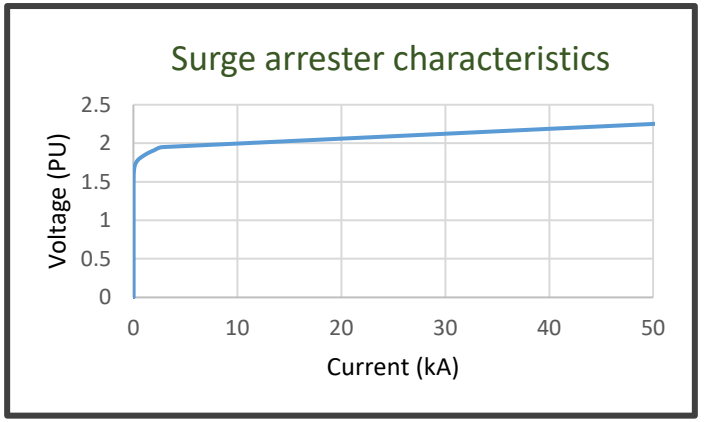
Collector network Cable (OH line) capacitance

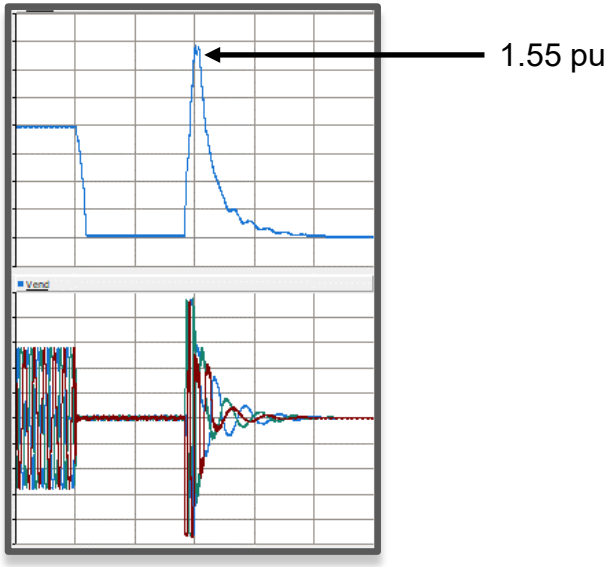
TOV impact on surge arresters and wind farm equipment

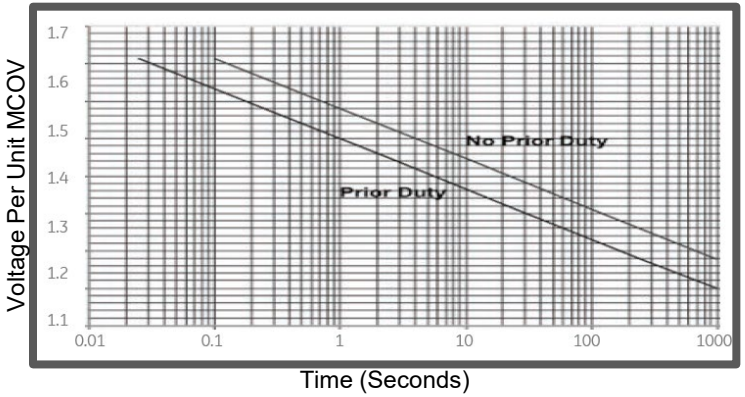
Current injection to an open feeder – can cause the feeder voltage to rise rapidly

- The surge arresters typically do not limit TOV
- Arresters (and other collector network equipment) can fail due to TOV



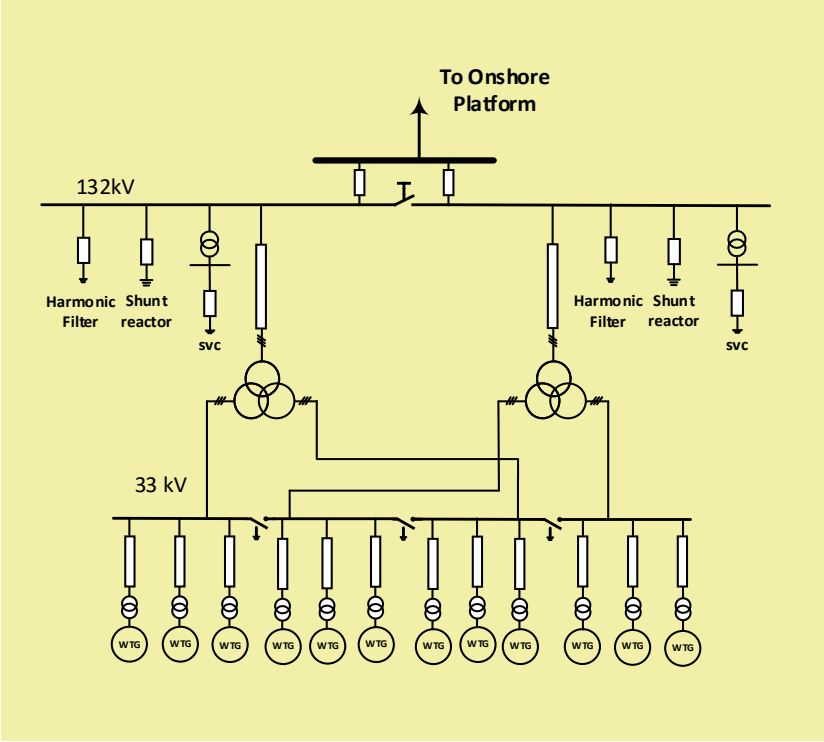






Modeling – Transformers , surge arresters, capacitor banks and filters

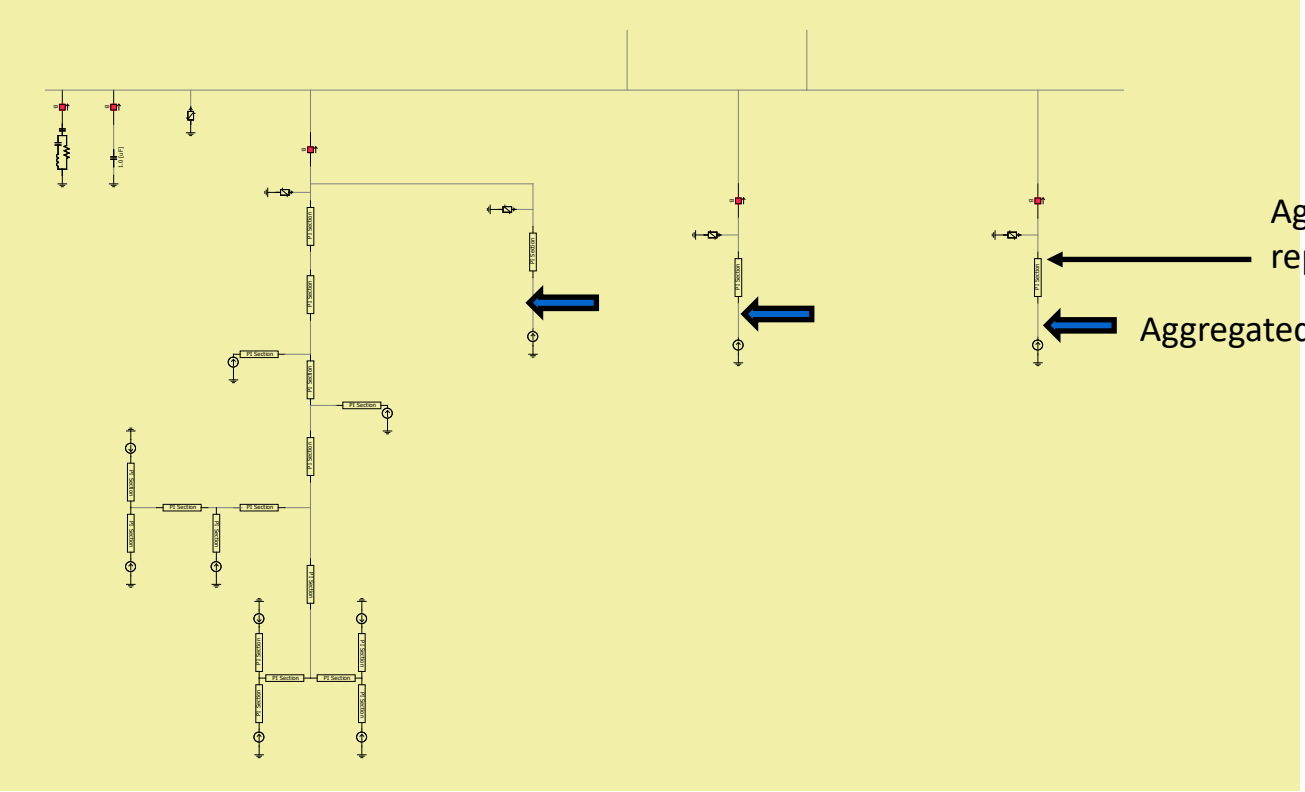
- External transmission system – 1-2 buses away from POC
- SVCs, STATCOMs – use specific models provided by vendor
- Transformers – standard data (impedance, ratings), Saturation characteristics
- Capacitor banks – standard passive models in PSCAD
- Filters – Standard models in PSCAD



Modeling – Collector Network

Typical study methodology

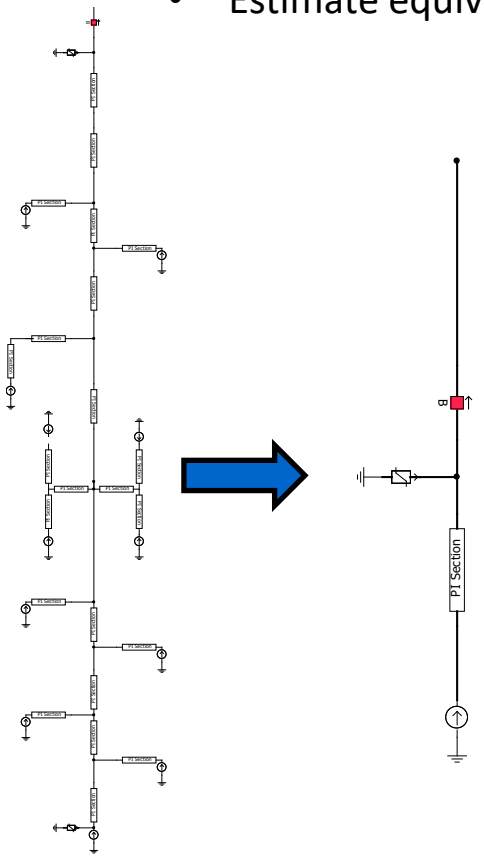
- Detailed Representation of one feeder (PSCAD Demonstration)
- Aggregated representation of the rest of feeders



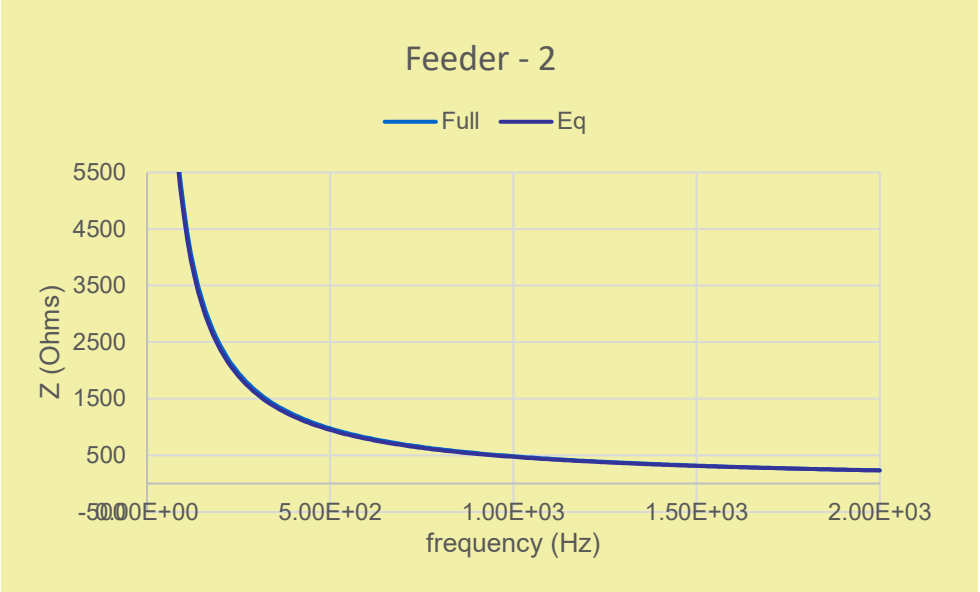
Modeling – Collector Network

Aggregation: Based on IEEE publication (Equivalencing the collector system of a large wind power plant – Muljadi et.el.)

- Estimate an equivalent cable inductance and resistance
- Estimate equivalent capacitance to maintain the total cable charging MVAR



Comparison of frequency scans



Modeling – Collector cables (OH lines)

Represent the equivalent cable section as ‘Bergeron Type’ (travelling wave type) model

- Travel time determines the smallest time step that can be used in the simulation

Bergeron type line/cable representation in PSCAD

Definition Canvas (F1_2)

Segment Name: F1_2

Steady State Frequency: 60.0 [Hz]

Length of Line: 1 [ft]

Number of Conductors: 3

Bergeron Model Options

Travel Time Interpolation: On
Reflectionless Line (ie Infinite Length): No

Manual Entry of Y,Z

+ve Sequence R: 9.9E-01 [ohm/ft]
+ve Sequence XL: 7.6E-01 [ohm/ft]
+ve Sequence XC: 0.004 [Mohm*ft]
0 Sequence R: 3.7 [ohm/ft]
0 Sequence XL: 2.9 [ohm/ft]
0 Sequence XC: 0.004 [Mohm*ft]

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MODAL IMPEDANCE MATRIX [ohms/m]:
   0.122047244E+02,0.938320210E+01   0.000000000E+00,0.000000000E+00   0.000000000E+00,0.000000000E+00
   0.000000000E+00,0.000000000E+00   0.325787402E+01,0.249671916E+01   0.000000000E+00,0.000000000E+00
   0.000000000E+00,0.000000000E+00   0.000000000E+00,0.000000000E+00   0.325787402E+01,0.249671916E+01

MODAL ADMITTANCE MATRIX [mhos/m]:
   0.000000000E+00,0.796320363E-03   0.000000000E+00,0.000000000E+00   0.000000000E+00,0.000000000E+00
   0.000000000E+00,0.000000000E+00   0.000000000E+00,0.796320363E-03   0.000000000E+00,0.000000000E+00
   0.000000000E+00,0.000000000E+00   0.000000000E+00,0.000000000E+00   0.000000000E+00,0.796320363E-03

MODAL CHARACTERISTIC IMPEDANCE VECTOR (Z0) [ohms]:
   0.124730944E+03,-.614378417E+02   0.643805805E+02,-.317732457E+02   0.643805805E+02,-.317732457E+02

MODAL TRAVEL TIME VECTOR [ms]:
   0.803056080E-01                   0.414501926E-01                   0.414501926E-01

MODAL VELOCITY VECTOR [m/s]:
   0.379550081E+04                   0.735340370E+04                   0.735340370E+04
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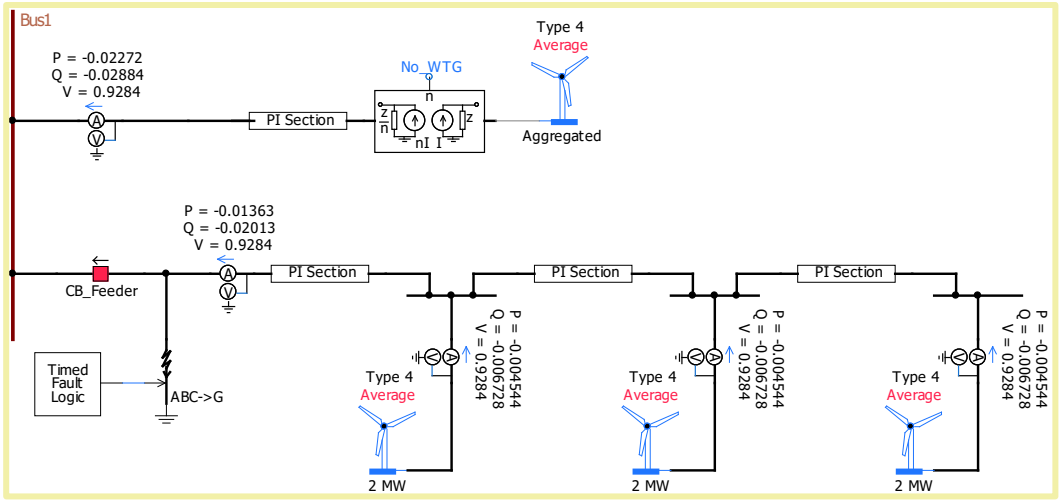
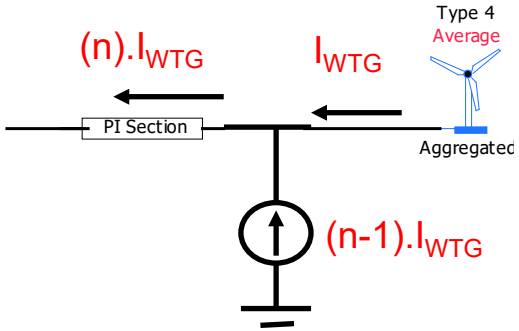
Modeling – WTGs (or Solar PV inverters)

WTG Model ‘Scaling’ (aggregation)





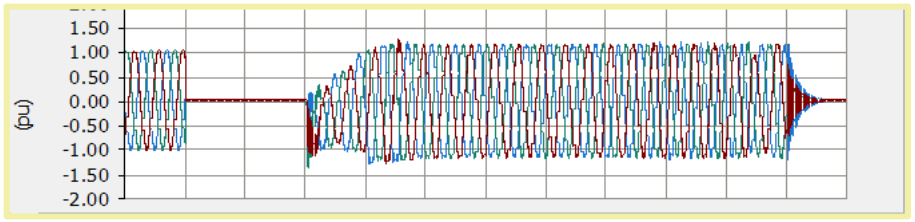
Typical results – Voltage at open feeder section

Example 1: Acceptable response

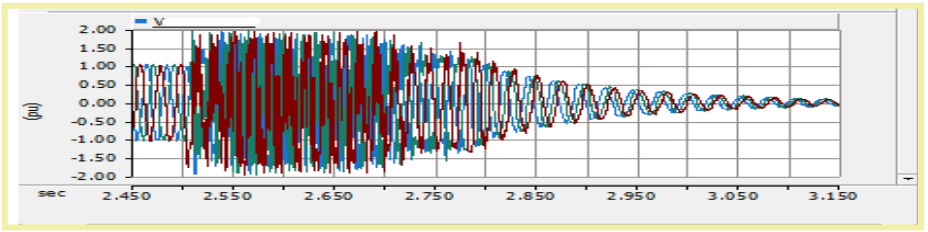
Voltage (rms)

Voltage

Example 2: Acceptable response (WTG controls have maintained the voltage close to 1 pu for a set period before ramping the voltage down)

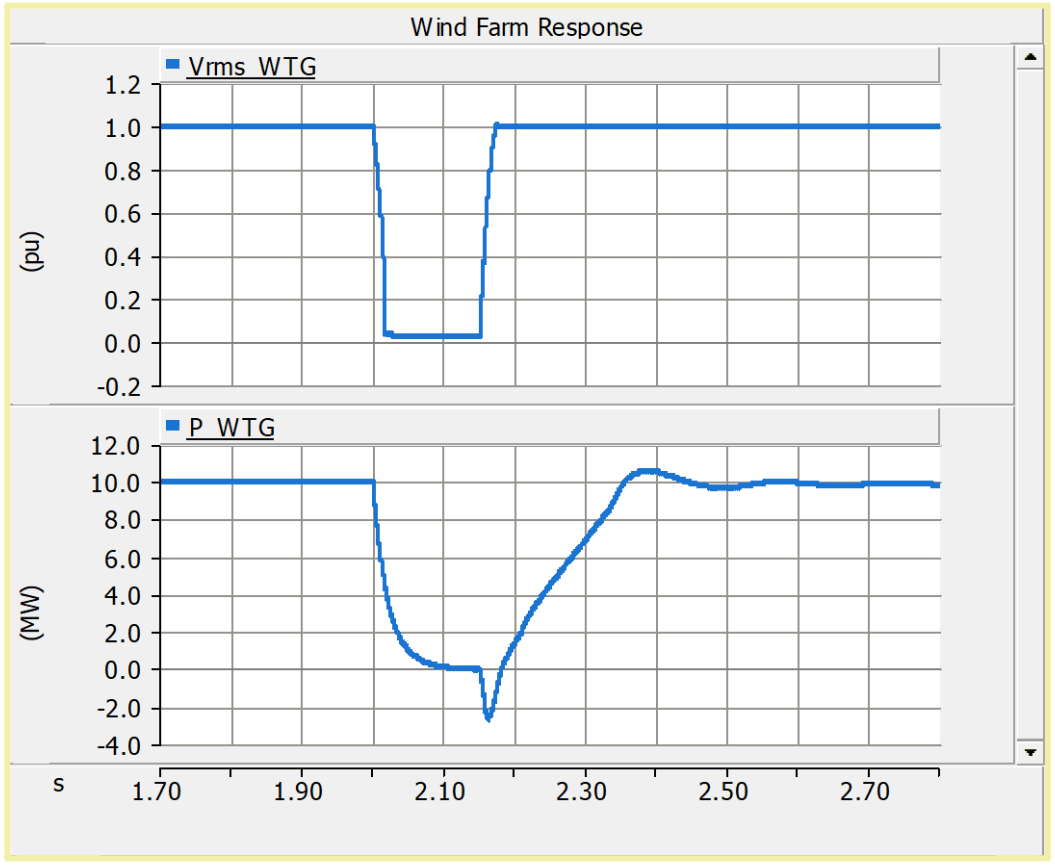


Example 3: Unacceptable response



Typical results – Response of WTGs on connected feeders

Successful fault recovery



PSCAD Simulation Example

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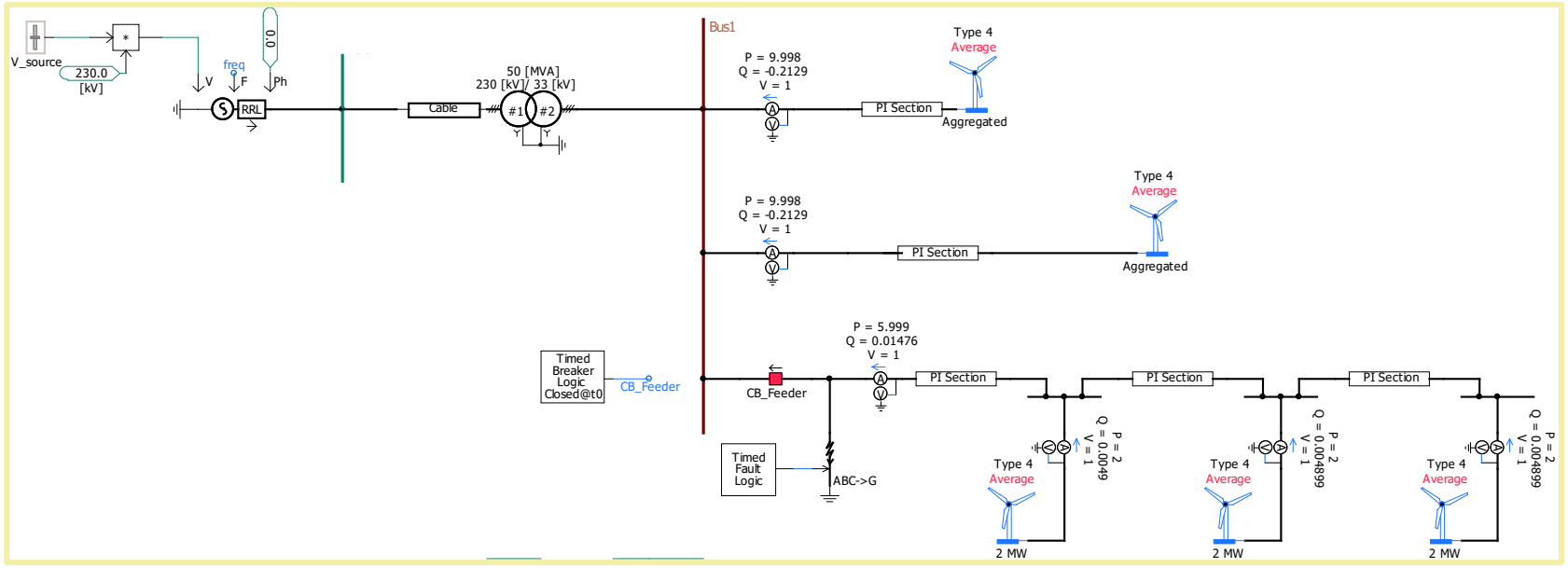

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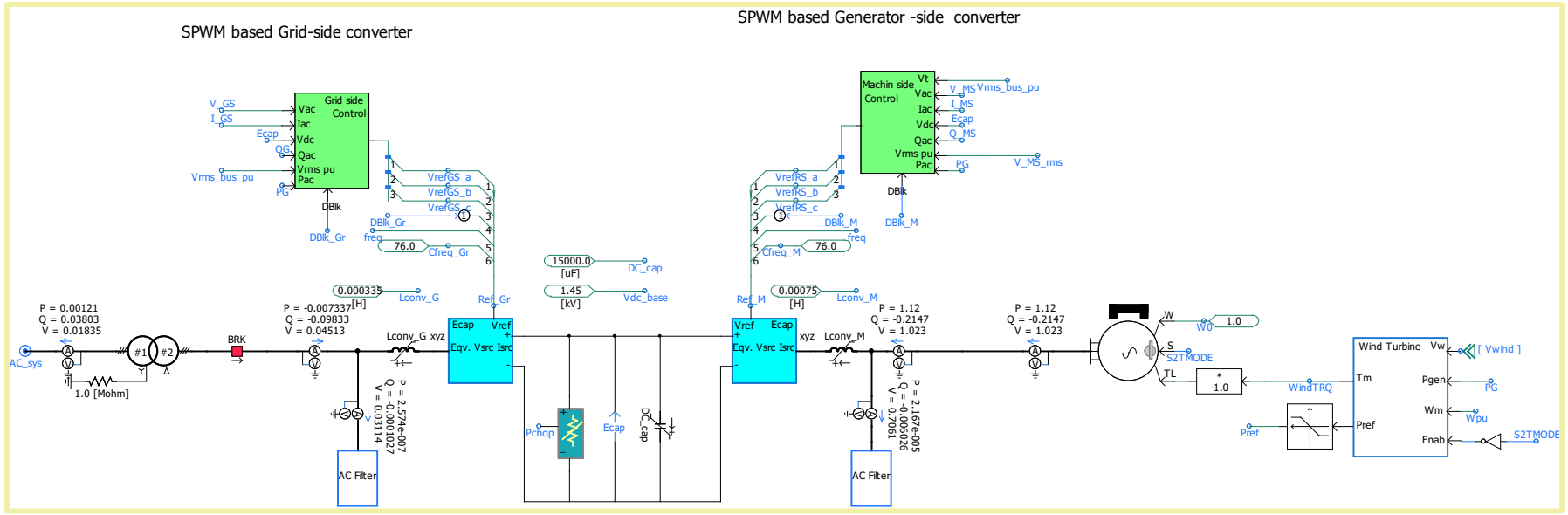

Thank you