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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

NASPI-NERC Workshop PPMV Tools

Calibration Session Overview

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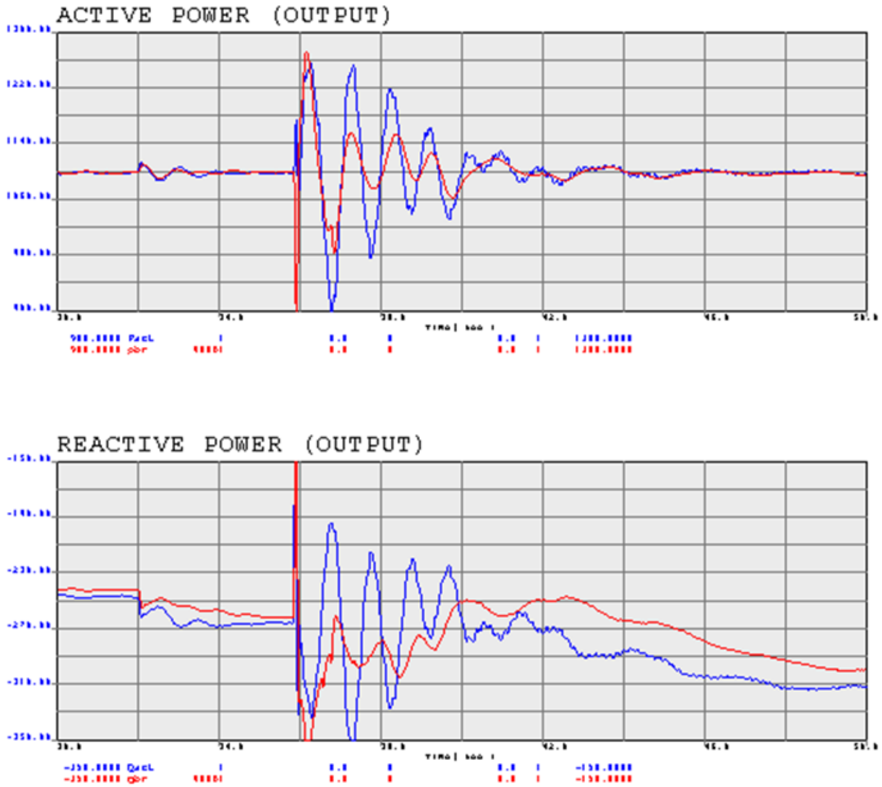
RELIABILITY | ACCOUNTABILITY




Model (In)Validation

- Model verification studies do not match historical responses.



Blue = actual

Red = simulated

Model (In)Validation

- What do you do next?

- Before you hire consultant to do baseline model development or model calibration, do basic checking first:
  - Verification studies over multiple events
  - Confirm that you are using the most recent dynamic models
  - Check powerflow data, particularly transformer impedances and tap position
  - Make sure operating conditions modeled correctly (e.g. head on hydro power plant, frequency response mode, temperature limits, etc.)

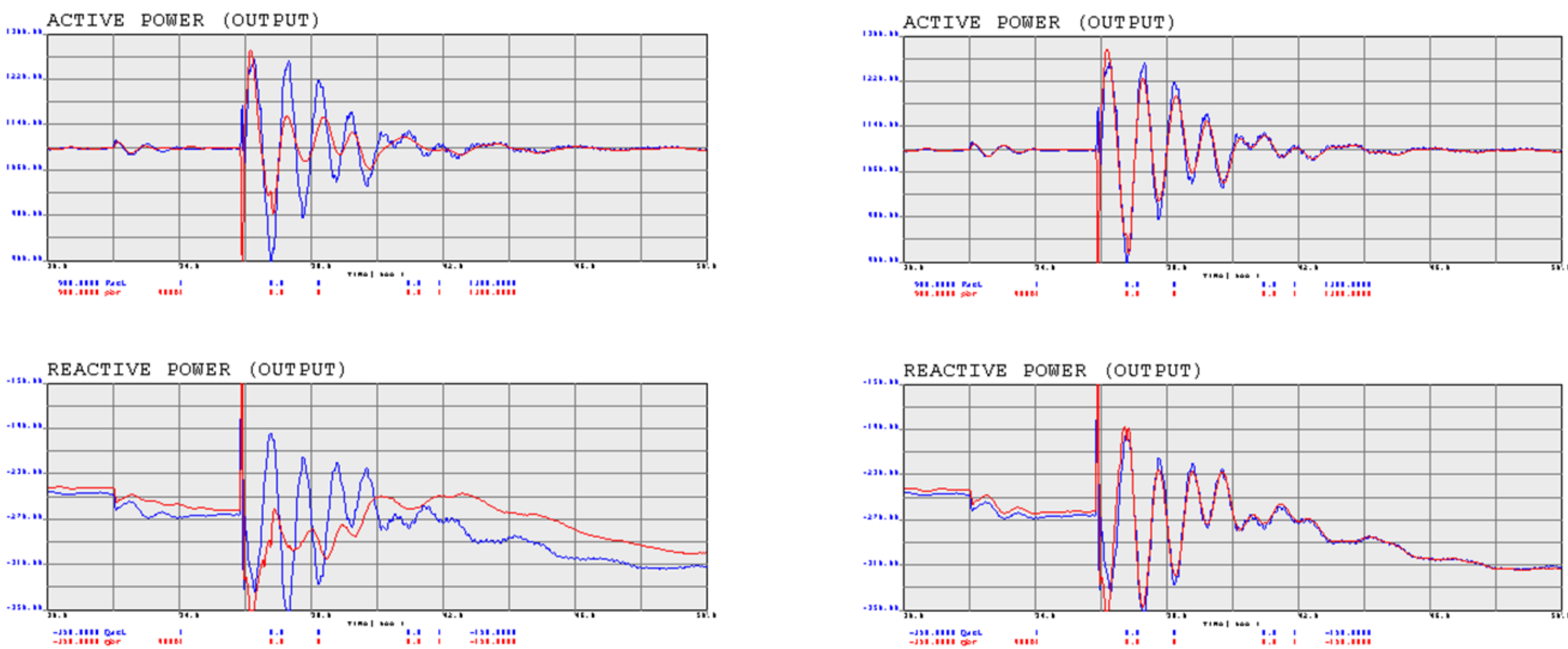
- If all options are exhausted, can disturbance data be used for model calibration?

Model (In)Validation

- Essential elements of disturbance-based model verification:
  - First and foremost, you must know that the model structure is correct
  - Engineering knowledge of the plant controls is essential
  - Measurements at generator terminals are strongly preferred, including both stator and field quantities
  - Large number of events, including voltage and frequency deviations
  - Model calibration vs. curve-fitting
- Some success stories using disturbance-based calibration
  - EPRI Power Plant Parameter Derivation application - user’s group

Model (In)Validation

- Successful model calibration for large thermal plant
  - Subsequent verification successful over dozens of events



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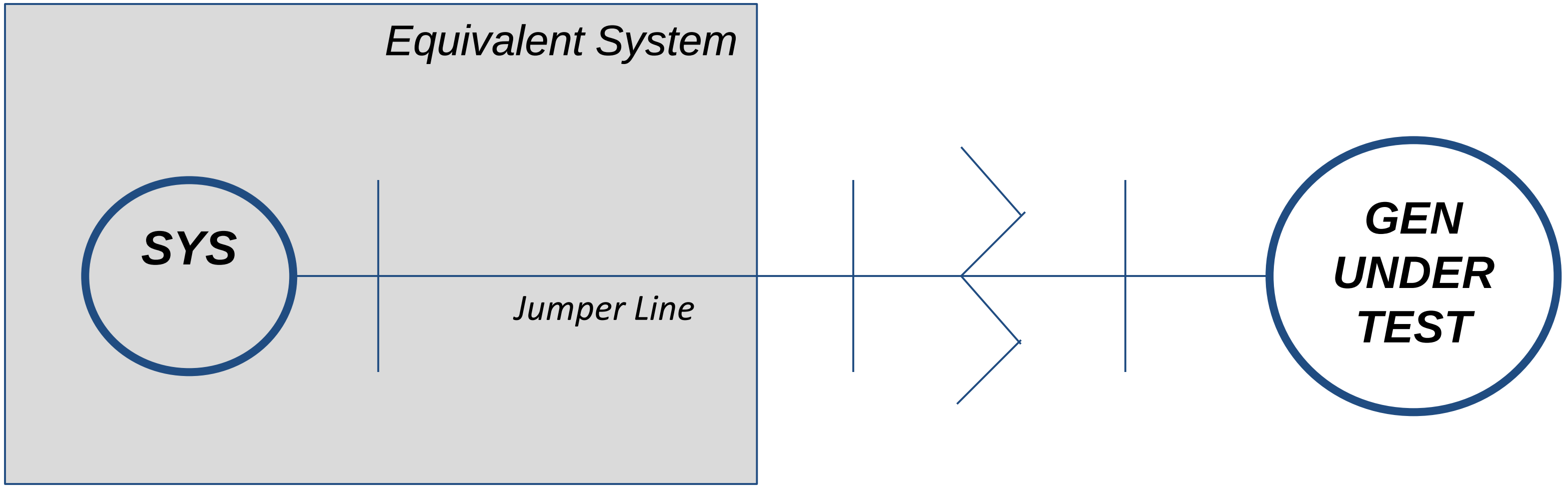
Session Structure

1. Workshop organizers developed event dataset suite
2. Each participant given
    1. Complete set of twelve (12) grid disturbances measured by PMUs
    2. Powerflow model for arbitrary conditions
    3. Dynamics models known to have issues
3. Participants performed calibration on dynamics models using datasets and root models provided
4. Participants will provided dynamics data of calibrated models
5. Workshop organizers reviewed results and tested on additional dataset

Test Cases

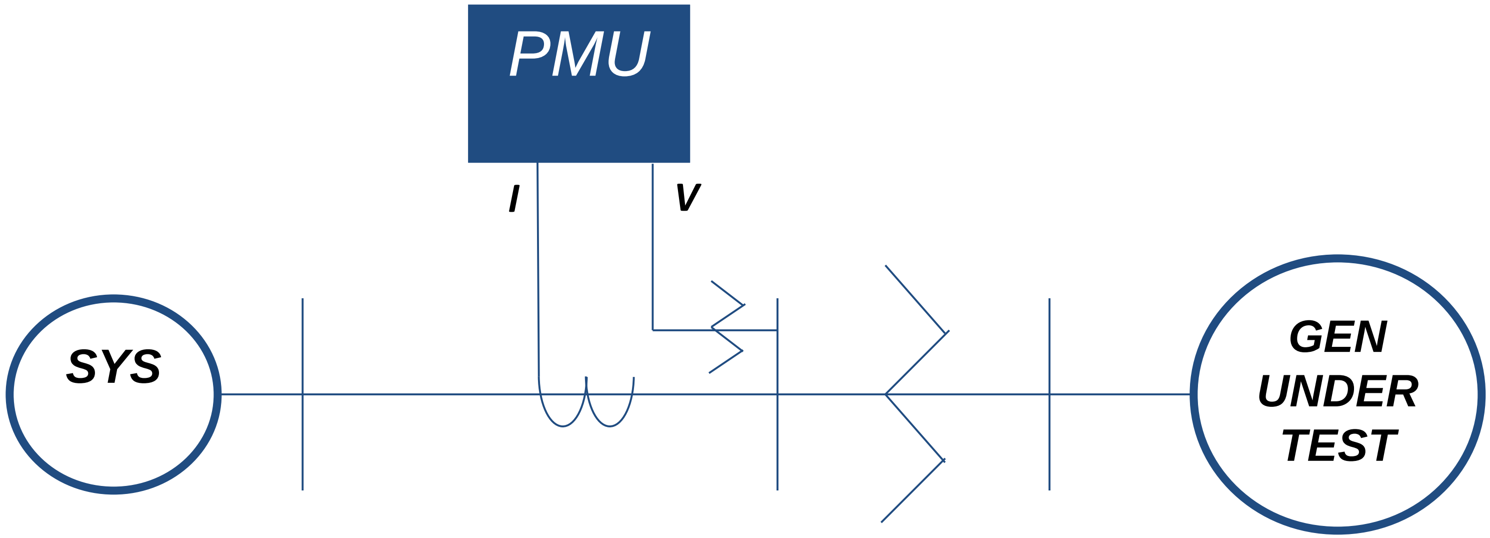
- Steam Turbine Generator
- Gas Turbine Generator
- Hydroelectric Generator

- Each case includes single unit, generator step-up (GSU) transformer, and equivalent system model



Measurement Location

- PMU measures the following quantities at the high-side of the generator step-up (GSU) transformer
  - Bus Voltage Magnitude and Angle
  - Bus Frequency
  - Active and Reactive Power



Sequence of Events

- 12 **sequential** events provided for each unit
  - Certain events might consider different generator operating modes

5					
Time Vact Fact Pact Qact //Head					
1 500 60 1 1 // Scale					
0 0 0 0 0 // Offset					
0 0 0 0 0 // Tf					
0 0.8 0.99 0 -200 // min					
0 1.2 0.99 1000 200 // max					
75 1 1 1 1 // Plot					
0	547.4673	60.00002	79.98307	-1.99037	-143.67
0.033333	547.456	60.00002	79.97124	-1.98633	-142.766
0.066667	547.4365	60.00003	79.96841	-1.9858	-141.842
0.1	547.4334	60.00004	79.96796	-1.98537	-141.828
0.133333	547.4307	60.00001	79.98277	-1.94515	-141.442
0.166667	547.4285	59.99997	79.98241	-1.94654	-140.981
0.2	547.4281	59.99995	79.99251	-1.9517	-140.636
0.233333	547.4366	59.99995	79.99373	-1.95304	-140.151
0.266667	547.4298	59.99993	79.97747	-1.9955	-139.327
0.3	547.4276	59.9999	80.0025	-1.96091	-138.379
Time	*V_{mag}*	*Freq*	*P*	*Q*	*Ang*

Event #
01
02
03
04
05
06
07
08
09
10
11
12

Test Units

- Steam Turbine Generator
  - genrou – Round Rotor Machine
  - esst4b – Digital Static Rectifier Excitation System
  - ggov1 – General Purpose Turbine-Governor
  - pss2b – Digital Dual-Input Stabilizer
- Gas Turbine Generator
  - genrou – Round Rotor Machine
  - rexs – General Purpose Rotating Exciter
  - ggov1 – General Purpose Turbine-Governor
  - pss2a – Analog Double-Input Stabilizer
- Hydroelectric Generator
  - gentpj – Synchronous Generator Model
  - esst1a – Bus-Fed Static Excitation System
  - ieeeg3 – IEEE Type 3 Turbine-Governor
  - pss1a – Analog Single-Input Stabilizer

STEAM TURBINE PLANT MODEL

GENROU		ESST4B		GGOV1		PSS2B	
Param	Value	Param	Value	Param	Value	Param	Value
Xd	2.3	Tr	0	R	0	J1	1
X'd	0.3	Kpr	5	Rselect	1	K1	0
X''d	0.3	Kir	5	Tpelec	0.01	J2	3
Xq	2.07	Ta	0.02	Maxerr	9.05	K2	0
X'q	0.53	Vrmax	1	Minerr	-9.05	Vsi1max	2
X''q	0.3	Vrmin	-0.85	Kpgov	20	Vsi1min	-2
Xl	0.25	Kpm	1	Kigov	0	Tw1	2
Ra	0.004	Kim	0	Kdgov	0	Tw2	2
T'd0	6.5	Vmmax	1	Tdgov	0.05	Vsi2max	2
T''d0	0.05	Vmmin	-0.85	Vmax	1	Vsi2min	-2
T'q0	0.55	Kg	0	Vmin	0.1	Tw3	2
T''q0	0.07	Kp	10.25	Tact	0.5	Tw4	0
S(1.0)	0.14	Ang p	0	Kturb	1	T6	0
S(1.2)	0.4	Ki	0	Wfnl	0.01	T7	2
H	2.3	Kc	0.15	Tb	10	Ks2	0.46
D	0	Xl	0	Tc	0.3	Ks3	1
Rcomp	0	Vbmax	12.8	Flag	0	T8	0.5
Xcomp	0	Vgmax	999	Teng	0	T9	0.1
Accel	0			Tfload	0.3	N	1
Kis	0			Kpload	1	M	5
Pfd	0			Kiload	3.3	Ks1	50
Pkd	0			Ldref	1	T1	0.5

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Questions?