

**Load Step:** Simulation results with time step = 1.0 second. 1,200 MW Load step at t=2. PSDS must have exciters and PSS models to remain stable.

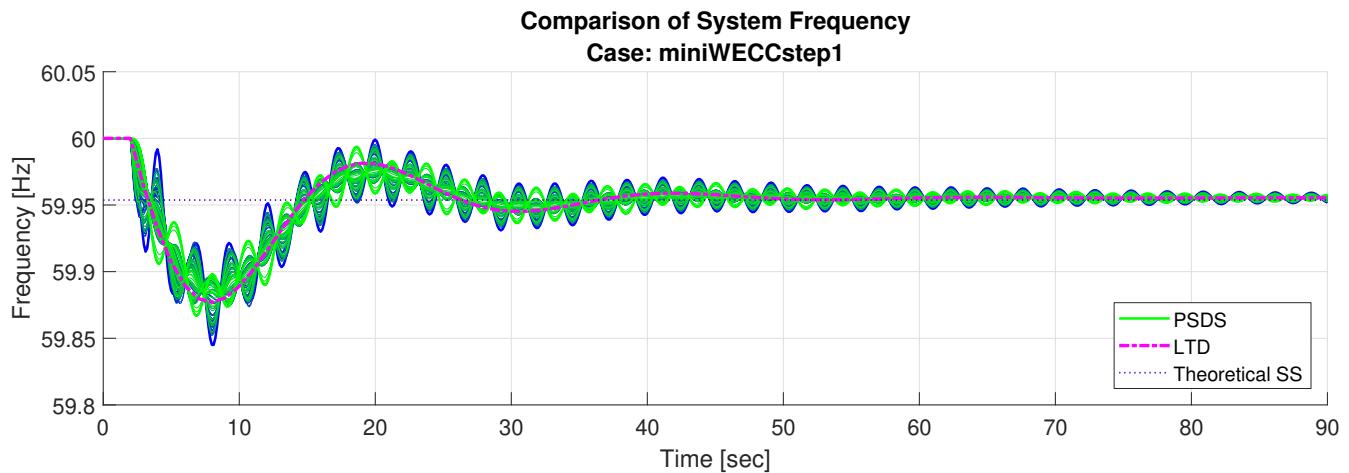


Figure 1: All PSDS bus frequencies and LTD system frequency response.

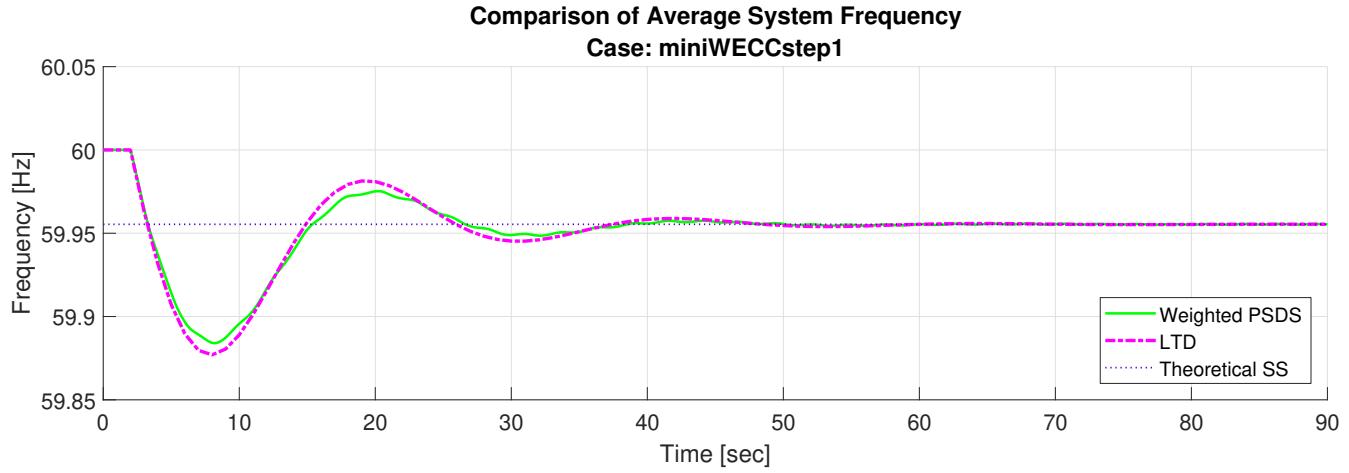


Figure 2: Averaged PSDS system response against LTD frequency.

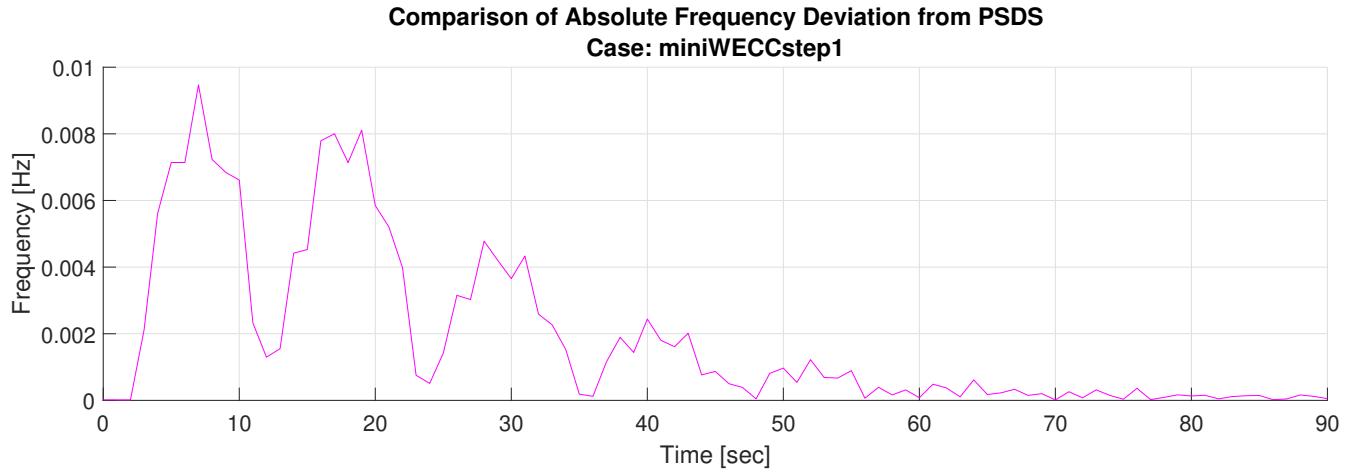


Figure 3: Relative Hz difference of PSDS - LTD (i.e.  $\left| \frac{f_{PSDS}(t) - f_{LTD}(t)}{f_{PSDS}(t)} \right| \times 60\text{Hz}$ ).

Improvement from previous results. Load model in dyd changed from `alwscc` with Q as a constant impedance and P as a constant current to `wlwscc` where both P and Q are constant Power.

$P_e$ ,  $P_m$ , and  $Q$  all match well (reactive power example on last page), however, a number of system voltages don't match at  $t=0$ . Additionally, PSDS angles missing (around  $t= 8, 25, 45, 70$ ) are shifted up near 5 and 6 degrees. Could be an issue with the selected reference bus angle.

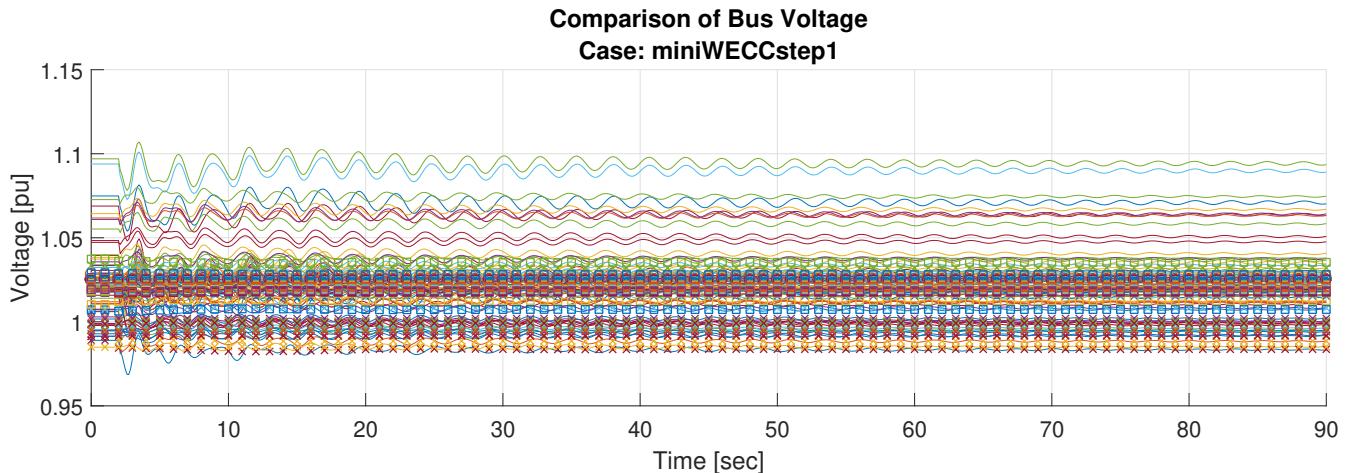


Figure 4: Voltage Magnitude Comparison.

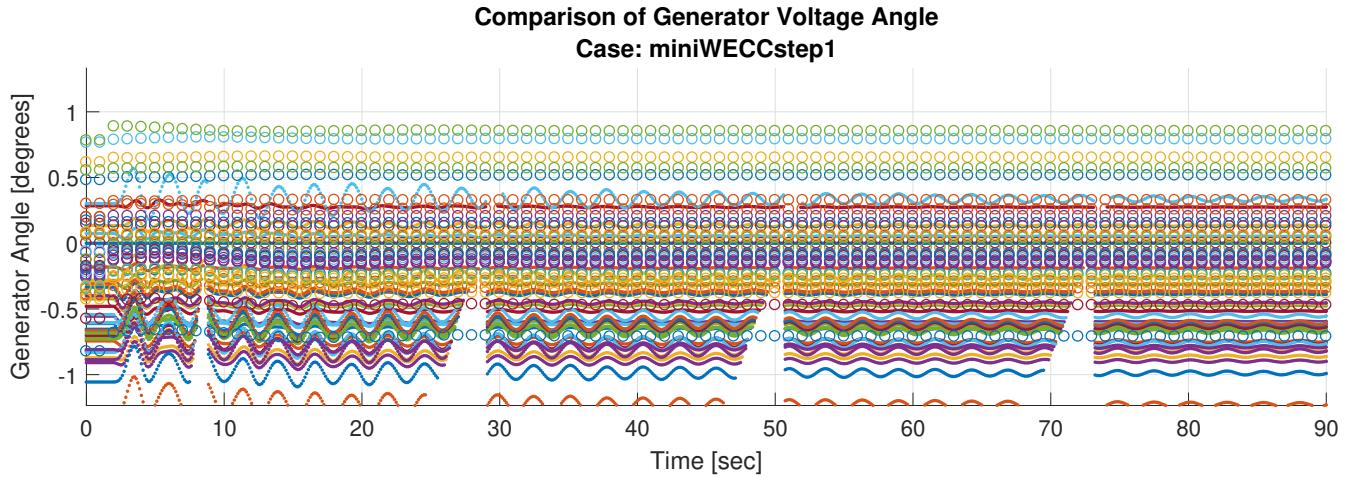


Figure 5: Voltage Angle Comparison.

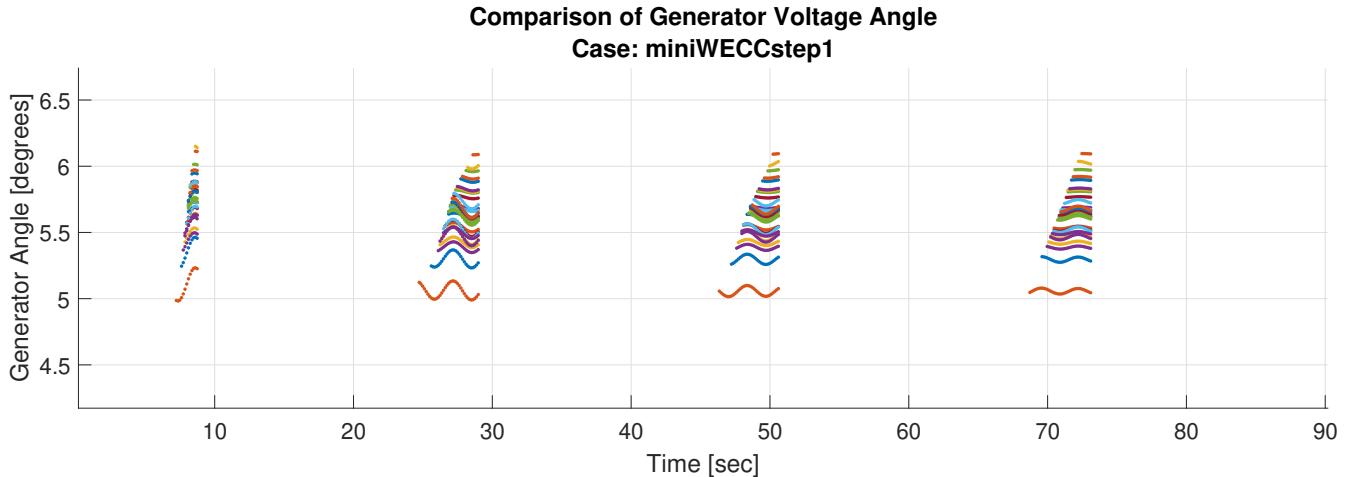


Figure 6: Voltage Angle Wrapping.

**Generator Trip:** Simulation results with time step = 1.0 second. Generator producing 212.5 MW tripped at t=2 (smallest generator in MiniWECC). PSDS must have exciters and PSS models to remain stable. Calculated theoretical SS requires knowing MW tripped and  $\Delta P_{losses}$ .

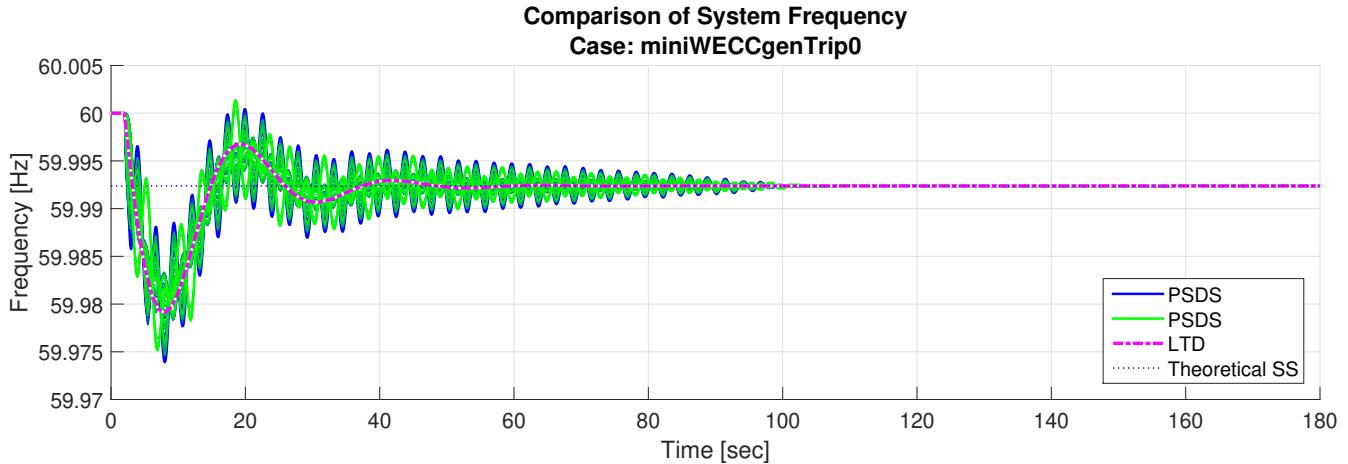


Figure 7: All PSDS bus frequencies and LTD system frequency response.

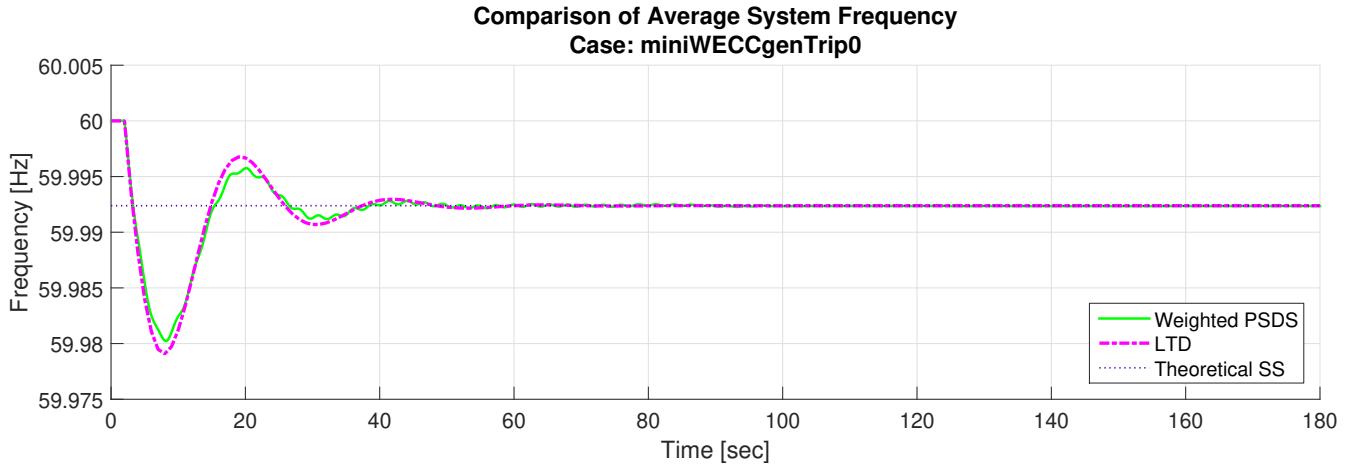


Figure 8: Averaged PSDS system response against LTD frequency.

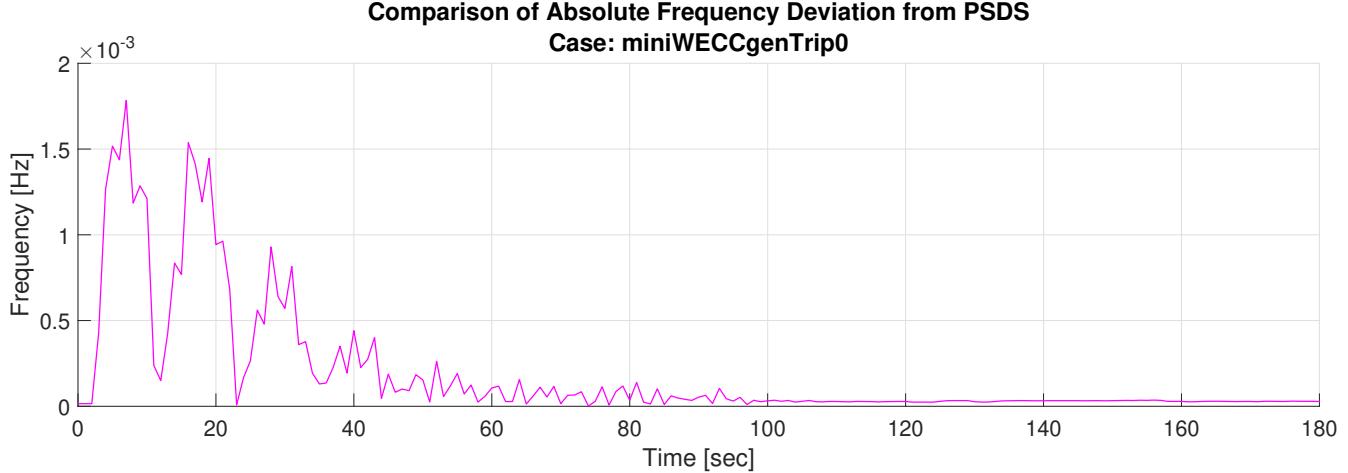


Figure 9: Relative Hz difference of PSDS - LTD (i.e.  $\left| \frac{f_{PSDS}(t) - f_{LTD}(t)}{f_{PSDS}(t)} \right| \times 60\text{Hz} \right).$

Weighted PSDS average frequency adjusted by  $\frac{H_i M_{BASE_i}}{H_{sys}}$  where the  $i$ th generator is tripped.

Again  $P_e$ ,  $P_m$ , and  $Q$  all match well, but a number of system voltages don't match at t=0.

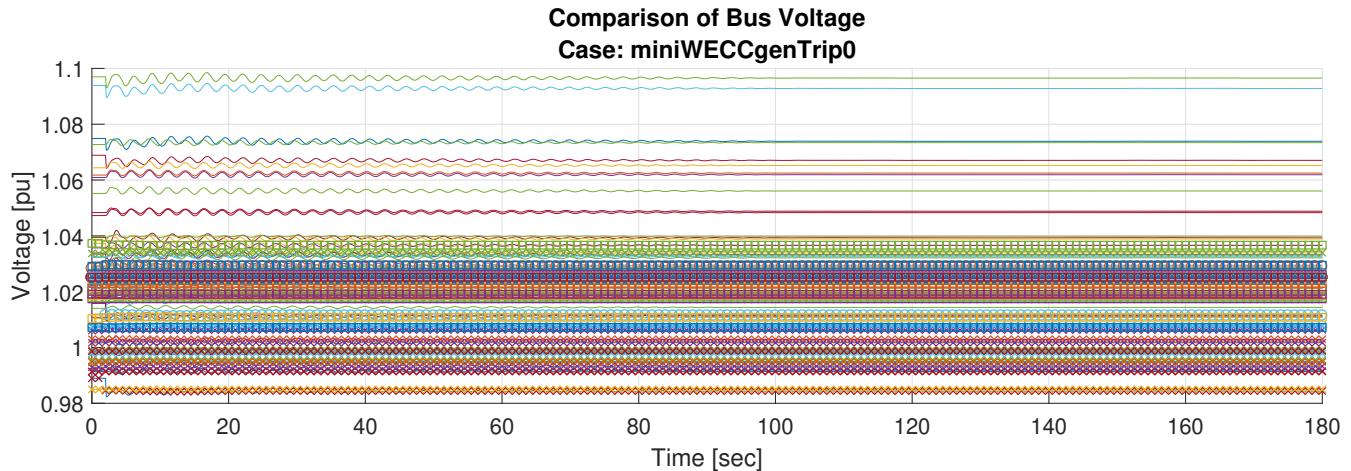


Figure 10: Voltage Magnitude Comparison.

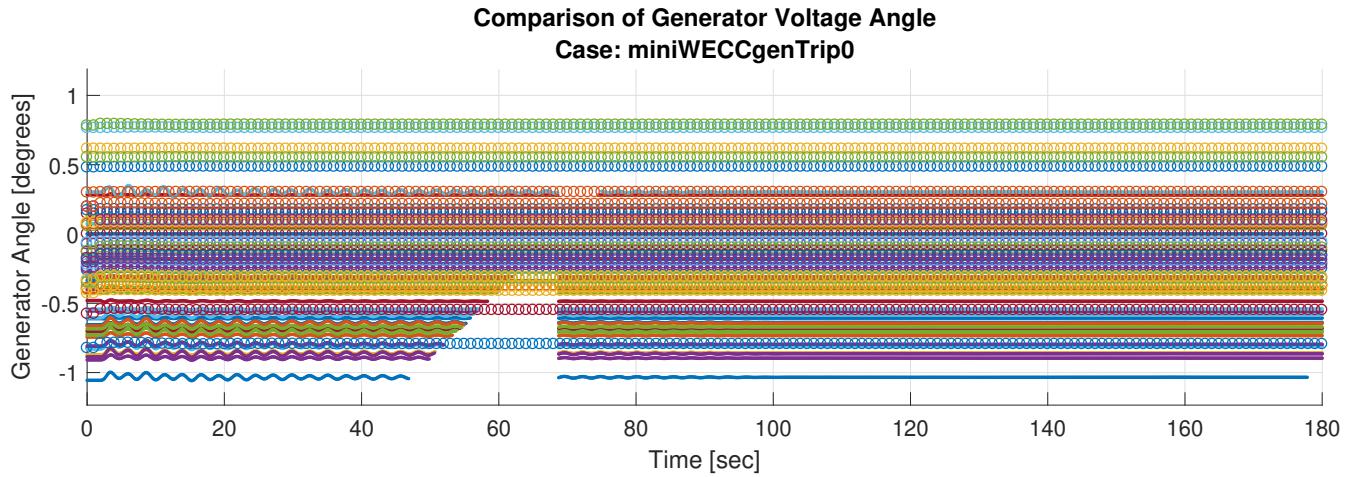


Figure 11: Voltage Angle Comparison.

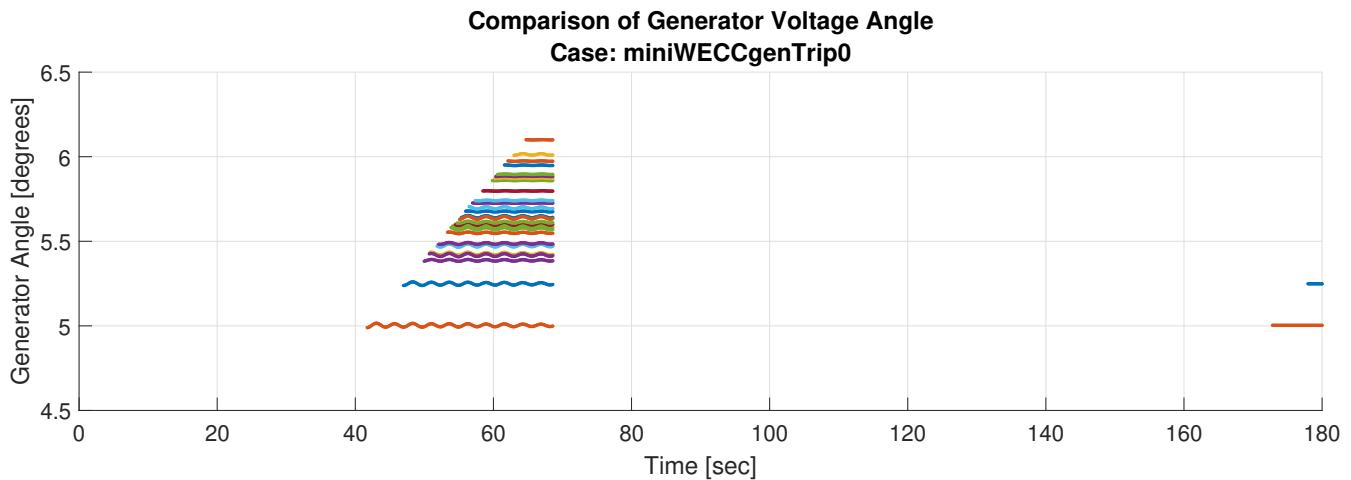


Figure 12: Voltage Angle Wrapping.

**Generator Trips that Crash:** Tripping anything but the smallest generator in the miniWECC results in the PSLF load flow not solving. Attempting to trip Colstrip:

In IPY redirect...

```
{'HandoffType': 'PY3toIPY', 'Pacc': -1429.5000000000146, 'msgType': 'Handoff',
'Pert_Pdelta': 0.0}
* PY3toIPY handoff
prev P load: 105985.000000
current P load: 105985.000000
Pert delta : 0.000000  Pacc -1429.500000
expected: 0.000000      -1429.500000
Perturbation P delta Match
Pacc Match
*** LTD: Distributing -1429.50 MW of Pacc, Iteration 1
Beginning solution
You can interrupt SOLN with <Cntl-c>
```

It -P-error- --Bus-- ----Name---- --Kv-- area -Q-error- --Bus-- ----Name---- --Kv-- area  
-delta-A- --Bus-- ----Name---- --Kv-- area -delta-V- --Bus-- ----Name---- --Kv-- area

0	13.8461	32 COLS-GEN	20.00	1	-71.4250	49 SC-49	500.00	1
	87.4744	32 COLS-GEN	20.00	1	0.946379	33 COLSTRP	500.00	1
1	-93.0123	32 COLS-GEN	20.00	1	51.9179	33 COLSTRP	500.00	1
	97.4184	32 COLS-GEN	20.00	1	0.671771	32 COLS-GEN	20.00	1
2	334.4607	32 COLS-GEN	20.00	1	143.2892	33 COLSTRP	500.00	1
	17.8952	30 MNT-GEN	20.00	1	1.147258	30 MNT-GEN	20.00	1
3	87.2405	32 COLS-GEN	20.00	1	37.7330	33 COLSTRP	500.00	1
	8330.6761	76 IDA-76	20.00	1	62.766499	77 IDA-77	230.00	1

Excessive mismatch, aborting iteration

4	468.0493	77 IDA-77	230.00	1	1163.3152	77 IDA-77	230.00	1
	8330.6761	76 IDA-76	20.00	1	62.766499	77 IDA-77	230.00	1

Stopped on divergence check, CASE NOT SOLVED

Stopped on divergence check, CASE NOT SOLVED

Power Flow Solution returns: -1

\*\*\* Error Caught, Simulation Stopping...

\*\*\* PSLF power flow solution did not converge.

Tripping the 2nd smallest generator in the system (gen on bus 53) hit the maximum iteration count before trying to redistribute remaining  $P_{acc}$  and attempting to solve again but not before running into voltage issues. System diverges on 2nd iteration in second attempt at a solution.

In IPY redirect...

```
{'HandoffType': 'PY3toIPY', 'Pacc': -435.0000000001455, 'msgType': 'Handoff',
'Pert_Pdelta': 0.0}
* PY3toIPY handoff
prev P load: 105985.000000
current P load: 105985.000000
Pert delta : 0.000000  Pacc -435.000000
expected: 0.000000      -435.000000
Perturbation P delta Match
Pacc Match
*** LTD: Distributing -435.00 MW of Pacc, Iteration 1
Beginning solution
You can interrupt SOLN with <Cntl-c>
```

It -P-error- --Bus-- ----Name---- --Kv-- area -Q-error- --Bus-- ----Name---- --Kv-- area  
-delta-A- --Bus-- ----Name---- --Kv-- area -delta-V- --Bus-- ----Name---- --Kv-- area

0	4.2633	53 SDG-GEN	20.00	1	-71.4250	49 SC-49	500.00	1
	10.2709	55 SDG-55	110.00	1	0.104277	103 MNT-103	230.00	1
1	-0.7020	54 SDG-54	500.00	1	1.9695	49 SC-49	500.00	1
	4.7730	55 SDG-55	110.00	1	0.103712	55 SDG-55	110.00	1
2	1.0767	55 SDG-55	110.00	1	0.1826	55 SDG-55	110.00	1
	82.1392	55 SDG-55	110.00	1	1.748695	55 SDG-55	110.00	1
3	101.3166	54 SDG-54	500.00	1	52.7344	55 SDG-55	110.00	1
	278.2173	55 SDG-55	110.00	1	2.740665	53 SDG-GEN	20.00	1
4	-193.2022	54 SDG-54	500.00	1	810.8662	55 SDG-55	110.00	1
	42.3168	52 SC-52	230.00	1	0.547776	55 SDG-55	110.00	1
5	52.6068	55 SDG-55	110.00	1	200.6331	55 SDG-55	110.00	1
	65.1522	53 SDG-GEN	20.00	1	0.563170	55 SDG-55	110.00	1
6	30.9338	55 SDG-55	110.00	1	49.5185	55 SDG-55	110.00	1
	149.7914	54 SDG-54	500.00	1	0.870878	54 SDG-54	500.00	1
7	33.0169	55 SDG-55	110.00	1	-65.0312	57 LASVEGAS	500.00	1
	2880.5991	55 SDG-55	110.00	1	18.117615	54 SDG-54	500.00	1
8	245.0757	54 SDG-54	500.00	1	223.9316	54 SDG-54	500.00	1
	70.2058	55 SDG-55	110.00	1	0.378723	54 SDG-54	500.00	1
9	64.5537	54 SDG-54	500.00	1	60.4908	54 SDG-54	500.00	1

	93.5233	55 SDG-55	110.00	1	0.094997	53 SDG-GEN	20.00	1
<hr/>								
	It -P-error- --Bus-- ----Name---- --Kv-- area -Q-error- --Bus-- ----Name---- --Kv-- area -delta-A- --Bus-- ----Name---- --Kv-- area -delta-V- --Bus-- ----Name---- --Kv-- area							
10	24.3688	55 SDG-55	110.00	1	17.0381	55 SDG-55	110.00	1
	59.4342	54 SDG-54	500.00	1	0.417368	55 SDG-55	110.00	1
11	17.5804	55 SDG-55	110.00	1	7.8905	61 PV-61	500.00	1
	42.2959	55 SDG-55	110.00	1	0.901168	55 SDG-55	110.00	1
12	22.0870	55 SDG-55	110.00	1	73.4881	63 PHX-63	500.00	1
	16.0814	55 SDG-55	110.00	1	0.148651	55 SDG-55	110.00	1
13	-4.5591	55 SDG-55	110.00	1	17.7221	63 PHX-63	500.00	1
	10.5828	55 SDG-55	110.00	1	0.121005	55 SDG-55	110.00	1
14	3.0140	55 SDG-55	110.00	1	3.0016	63 PHX-63	500.00	1
	5.5029	55 SDG-55	110.00	1	0.130526	55 SDG-55	110.00	1
15	0.8028	55 SDG-55	110.00	1	0.6315	52 SC-52	230.00	1
	75.3235	55 SDG-55	110.00	1	1.607296	55 SDG-55	110.00	1
16	67.6170	54 SDG-54	500.00	1	39.1311	55 SDG-55	110.00	1
	266.4972	55 SDG-55	110.00	1	2.920609	53 SDG-GEN	20.00	1
17	-133.4454	54 SDG-54	500.00	1	558.1630	55 SDG-55	110.00	1
	56.1306	53 SDG-GEN	20.00	1	0.526573	55 SDG-55	110.00	1
18	49.4588	55 SDG-55	110.00	1	138.0932	55 SDG-55	110.00	1
	104.3050	54 SDG-54	500.00	1	0.705451	54 SDG-54	500.00	1
19	32.3658	55 SDG-55	110.00	1	33.1036	55 SDG-55	110.00	1
	452.8957	55 SDG-55	110.00	1	0.716826	55 SDG-55	110.00	1
<hr/>								
	It -P-error- --Bus-- ----Name---- --Kv-- area -Q-error- --Bus-- ----Name---- --Kv-- area -delta-A- --Bus-- ----Name---- --Kv-- area -delta-V- --Bus-- ----Name---- --Kv-- area							
20	38.0448	55 SDG-55	110.00	1	16.5559	52 SC-52	230.00	1
	326.6619	54 SDG-54	500.00	1	4.108809	55 SDG-55	110.00	1
21	66.6867	55 SDG-55	110.00	1	137.3597	54 SDG-54	500.00	1
	149.7430	55 SDG-55	110.00	1	1.326245	55 SDG-55	110.00	1
22	118.4120	112 SC-112	110.00	1	47.3383	54 SDG-54	500.00	1
	102.6142	55 SDG-55	110.00	1	5.550318	55 SDG-55	110.00	1
23	28.1265	55 SDG-55	110.00	1	118.6632	57 LASVEGAS	500.00	1

Research  
July 1st, 2019

MiniWECC  
Step and Trip Results

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1342.8722	55 SDG-55	110.00	1	5.420668	53 SDG-GEN	20.00	1
24 35.9450	55 SDG-55	110.00	1	60.8100	52 SC-52	230.00	1
632.1847	54 SDG-54	500.00	1	4.213779	53 SDG-GEN	20.00	1
25 -312.4132	54 SDG-54	500.00	1	341.8130	55 SDG-55	110.00	1
92.0843	52 SC-52	230.00	1	0.717109	54 SDG-54	500.00	1

WARNING: SOLUTION stopped due to maximum number of iterations or CONTROL-C hit

Stopped after 26 iterations

Estimated solution error 31241.3203 MW, 34181.3047 MVAR

at buses 54 SDG-54 500.00 55 SDG-55 110.00

Power Flow Solution returns: -2

expected: 478.86 actual: 883.03 error: -404.16

\*\*\* LTD: Distributing -404.16 MW of Pacc, Iteration 2

Beginning solution

You can interrupt SOLN with <Ctrl-c>

Initial voltage magnitude [ 0.49] at bus 55 outside of range [0.5, 2.0] p.u  
Resetting it to schedule value of [ 1.00]

Initial voltage magnitude [ 0.17] at bus 54 outside of range [0.5, 2.0] p.u  
Resetting it to schedule value of [ 1.00]

Initial voltage magnitude [ 0.29] at bus 53 outside of range [0.5, 2.0] p.u  
Resetting it to schedule value of [ 1.02]

It -P-error- --Bus-- ----Name---- --Kv-- area -Q-error- --Bus-- ----Name---- --Kv-- area  
-delta-A- --Bus-- ----Name---- --Kv-- area -delta-V- --Bus-- ----Name---- --Kv-- area

0 -53.9367	49 SC-49	500.00	1	-347.7013	49 SC-49	500.00	1
232.9004	55 SDG-55	110.00	1	4.540574	54 SDG-54	500.00	1

Excessive mismatch, aborting iteration

1 -1029.5880	55 SDG-55	110.00	1	-170.3492	53 SDG-GEN	20.00	1
232.9004	55 SDG-55	110.00	1	4.540574	54 SDG-54	500.00	1

Stopped on divergence check, CASE NOT SOLVED

Stopped on divergence check, CASE NOT SOLVED

Power Flow Solution returns: -1

\*\*\* Error Caught, Simulation Stopping...

\*\*\* PSLF power flow solution did not converge.

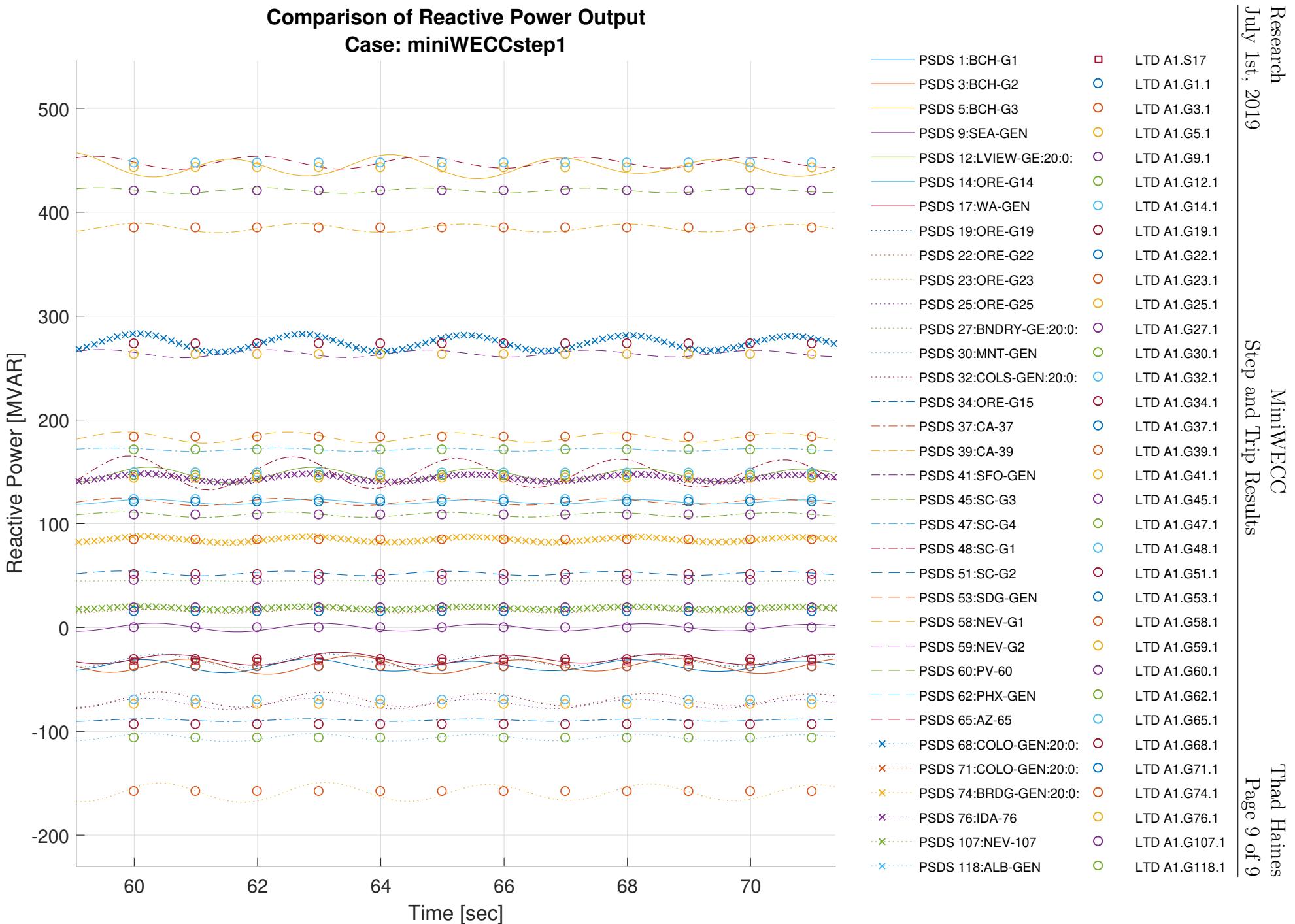


Figure 13: Detail Reactive Power Comparison. Not all Generators shown.