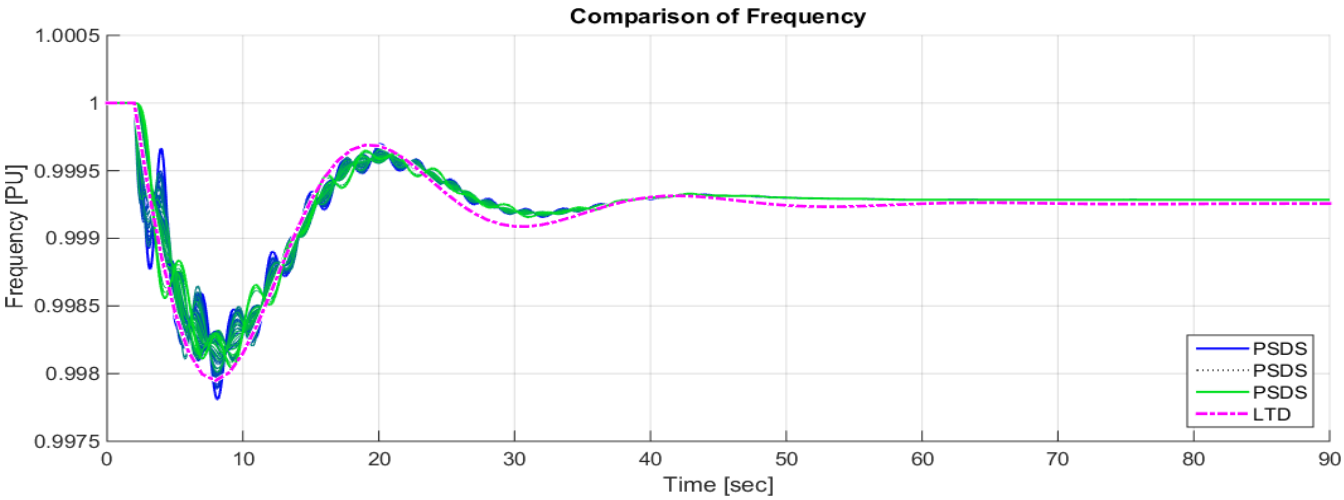

Figure 1: All PSDS bus frequencies and LTD system frequency response.

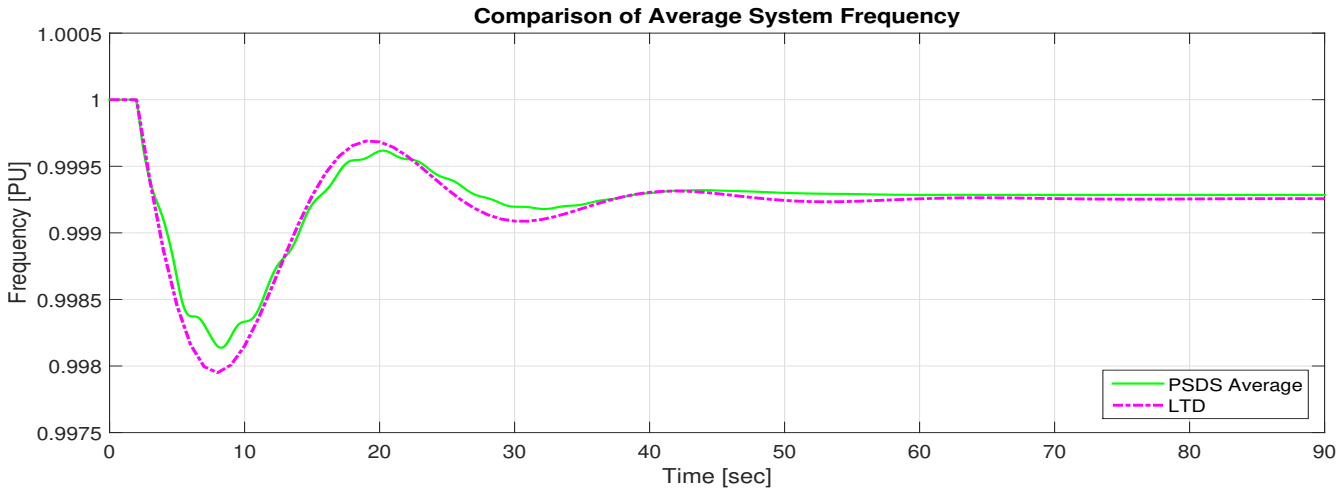

Figure 2: Averaged PSDS system response against LTD frequency. (Difference at $t(90) \approx$ 2.84E-5).

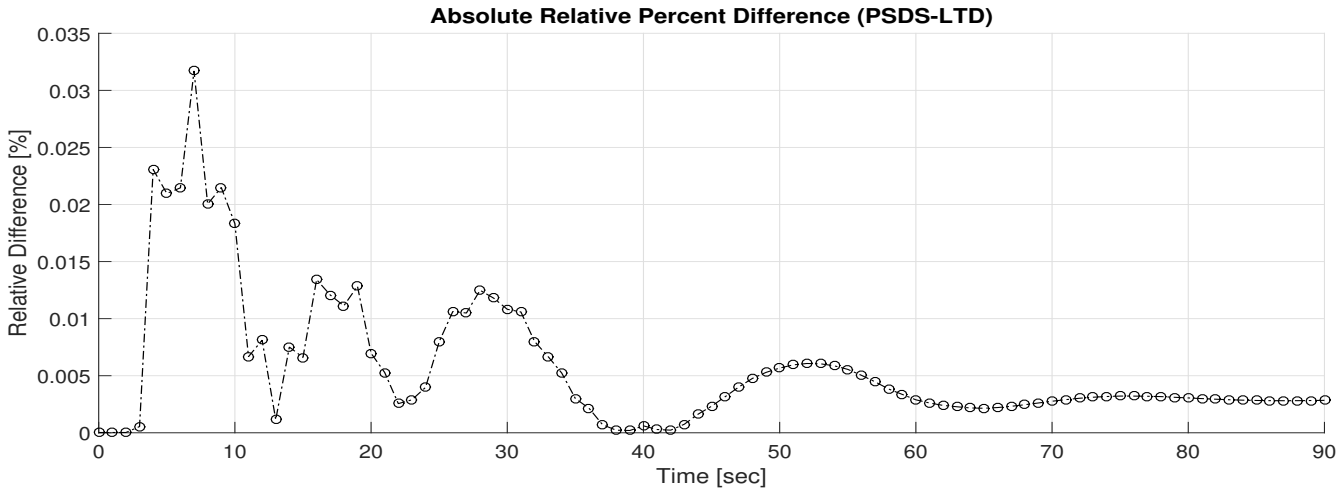

Figure 3: Relative difference of PSDS - LTD as a percent $\left(\text{i.e. } \left|\frac{f_{PSDS}(t) - f_{LTD}(t)}{f_{PSDS}(t)}\right| \times 100\%\right)$.

MiniWECC Model:

Buses 120

Generators 34

Loads 23

Generation 107,509 MW

Load 105,985 MW

Simulation Results (60 Second Run):

	PSDS	LTD
Timestep	4.167 ms	1 sec
Produced Data File Size	35,492 KB	423 KB
Simulation Run Time	41.42 sec	11.75 sec
Speed up from PSDS	1	3.52

Possible reasons for Steady State Variance

1. Mishandled Machine Parameters: PSDS and LTD Generator H and MWcap were verified as being the same for all machines in system.

2. AMQP JSON message behavior: The coded AMQP procedure sends data as a json message and as shown below, a value with many decimals is rounded to be represented as a floating point (Line 6), and then truncated when added to a dictionary (Line 9). This rounded and truncated value is what is sent as the AMQP message (Line 11). Note that Python reports these values as the same (Lines 12-17). The `numpy` (numerical python) package may have an alternate approach to this rounding / truncation behavior.

```
1  >>> import json
2  >>> lval = 123.123456789012345678901234567890
3  >>> lval
4  123.12345678901235
5  >>> print('%.30f' % lval)
6  123.123456789012351464407402090728
7  >>> msg = {'mval': lval}
8  >>> msg
9  {'mval': 123.12345678901235}
10 >>> print(json.dumps(msg))
11 {"mval": 123.12345678901235}
12 >>> 123.123456789012345678901234567890-123.123456789012351464407402090728
13 0.0
14 >>> print('%.30e' % (123.123456789012345678901234567890 -  lval))
15 0.000000000000000000000000000000e+00
16 >>> 123.123456789012345678901234567890 ==  123.12345678901235
17 True
```

3. Slack Tolerance: Decreasing the slack tolerance to 0.001 MW (from 1 MW) had no effect on relative difference - though did increase simulation time by ≈7x due to the number of power flows required to solve each time step.

4. Simulation Length: The simulation was run for 120 seconds and relative difference was found to vary slightly over time but stay between 3.3E-3% and 2.1E-3%.

5. Integration method Euler and RK-45 were found to have similar results and did not change relative difference.

6. Differences in load distribution: As shown in Figure 4, the steady state mechanical output does not change by the same amount in the two simulation environments. How this may affect steady state frequency is not entirely clear at the moment.

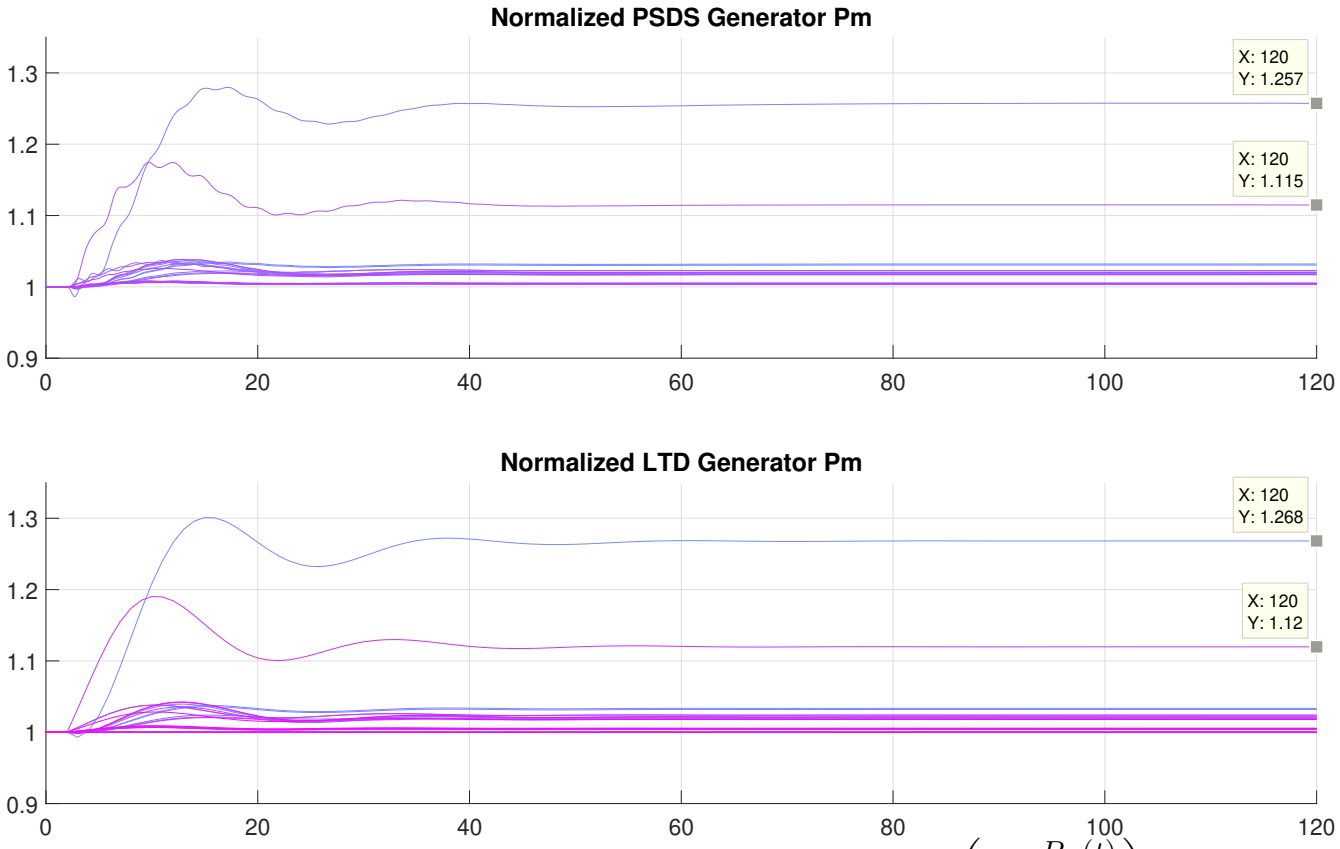

Figure 4: Normalized P_M from all machines in system. $\left(\text{i.e. } \frac{P_m(t)}{P_m(0)}\right)$

The table below quantified this difference for the two generators that had the largest % change from $t(0)$.

Generator	PSDS	LTD	Difference
WA-GEN (slack top line)	1.257	1.115	0.011
SDG GEN (lower line)	1.115	1.12	0.005