## Recent Progress:

1. Rework tgov1 model to account for `Pref` completed.

2. MiniWECC step test results re-validated using different time steps.

3. AMQP messages can now handle a non-converging system gracefully.

4. GitHub updated:
   `https://github.com/thadhaines/`

## Current Tasks:

1. Compile Code flowchart to aid in further development.

2. Work to incorporate Matt's *Suggested Use Cases* into simulation.

3. Add logging to Shunt and Branch Agents

4. Add perturbance Agents for Generator/Slack, Shunt, Branch, …

5. Define Agent actions for AGC/LFC (i.e. ACE calculations)

6. Think about Shunt Control / Generic Agent control based on system state(s)

## Current Questions:

1. Does $\Delta\omega = 1 - \omega$ in
   $$\dot{\omega} = \frac{1}{2H_{sys}}\left(\frac{P_{acc}}{\omega} - D_{sys}\Delta\omega\right)\ ?$$

## Goals:

1. Speed⟶ Order of Magnitude faster than PSDS (not met — only ≈3x faster)

## Future Tasks:

1. Formulate an experiment utilizing a multi-area model that can be validated with PSDS.

2. Identify System Slack bus programmatically (currently assumes first slack == global slack if > 1 slack found)

   AND/OR calculate system slack error differently → An average of slack errors?

3. Formulate feasible plan of action for casting all WECC governors to LTD governors (tgov1). Something like:

   (a) Parse models of interest from dyd.

   (b) Create dyd from parsed model.

   (c) Automate Pref step for a one machine infinite bus test in PSDS.

   (d) Generate/Calculate LTD equivalent model parameters from results (this will use MATLAB and `jfind`)

   (e) Export custom dyd for LTD simulation. (PSDS would still use original the dyd, though *could* use modified dyd)

4. Add import mirror / bypass mirror init sequence option to prevent repeated mirror creations.

5. Create an agent for every object: SVD, Transformer, …

## Matt Requests:

1. Enable multiple dyd files to overwrite / replace previously defined agents/parameters

2. Allow for variable time steps.

**Updated Tgov1 model:**  Previous attempt at model revisted to account for $P_{REF}$.
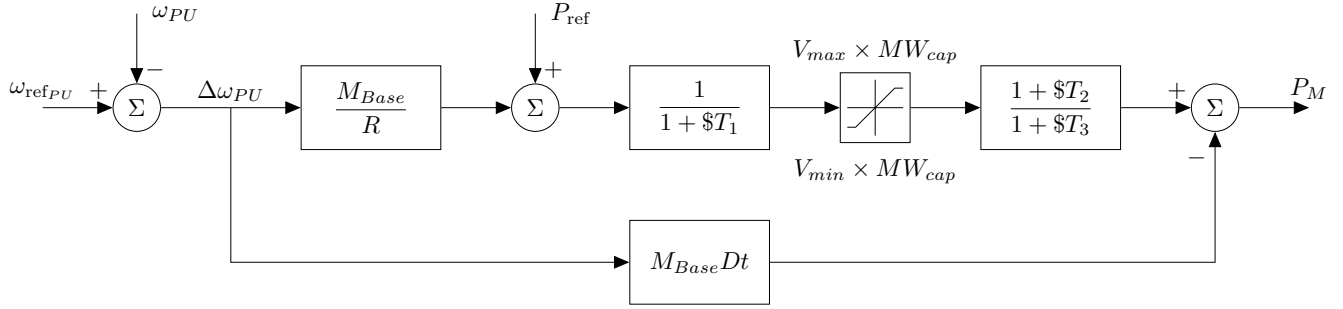


Figure 1: Corrected tgov1 model.

**Time step resolution re-validation:**  The `distPacc` function was corrected to eliminate a number of power-flow solutions and the new tgov1 model was used for the 90 second 1,200 miniWECC step test. LTD uses no damping, rk45 integration, and 0.5 MW slack tolerance — it is also run from the command line. The PSDS system has exciters and PSS included. Theoretical steady state frequency was calculated as

$$f_{ss} = f_{ref} + \Delta f = f_{ref} + \frac{\Delta P}{S_{base}\beta}$$

$$f_{ss} = 1 \text{ Pu} + \frac{-1200 \text{ MW}}{100 \text{ MW} \times 15,555 \text{ Pu}}$$

$$f_{ss} \approx .9992285 \text{ Pu} = 59.9537126 \text{ Hz}$$

When $R$ is a Pu value, $\beta$ for $N$ governor equipped machines, is calculated as

$$\beta = \sum_{i=1}^{N} \frac{1}{R_i \frac{\text{S}_{\text{Base}}}{\text{M}_{\text{Base}_i}}}$$

In a system with $N$ generators, weighted Pu PSDS system frequency, $f_w$, was calculated as

$$f_w \text{ Pu} = \sum_{i=1}^{N} \frac{f_i}{f_{\text{Base}}} \frac{H_i \text{M}_{\text{Base}_i}}{\text{H}_{\text{sys}}}$$

$$\text{where } \text{H}_{\text{sys}} = \sum_{i=1}^{N} H_i \text{M}_{\text{Base}_i}$$

Table 1: Results from MiniWECC load step.

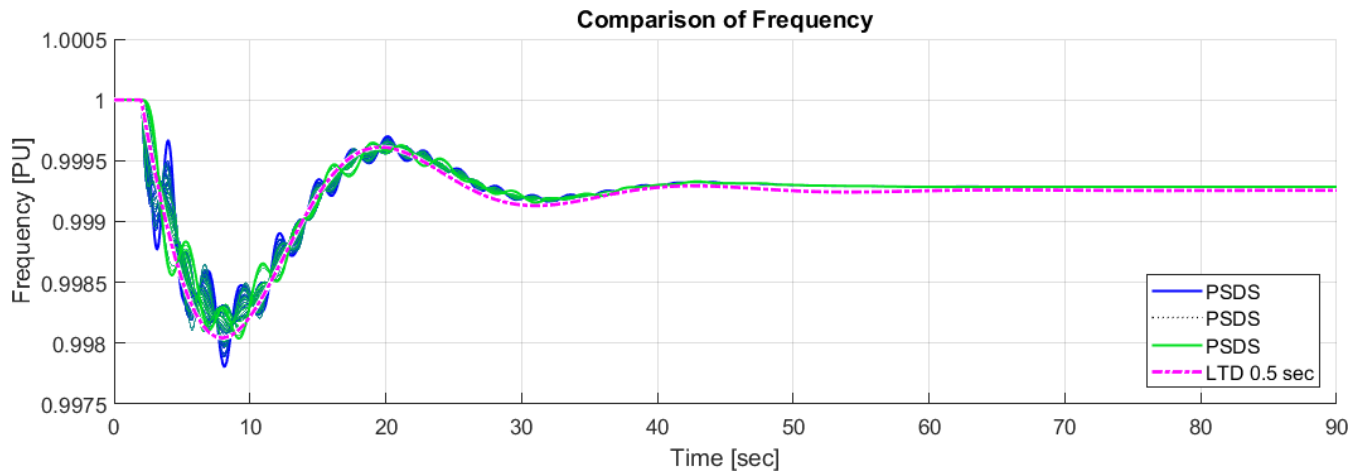| | Time step | Simulation Time [sec] | Data File Size [KB] | Real time Speed up | PSDS Speed up | Reduction of file size | Steady State $f$ error [Hz] |
|---|---|---|---|---|---|---|---|
| PSDS | 4.167 ms | 56.12 | 35,070.00 | 1.60 | 1.00 | 1.00 | 0.0034 |
| LTD | 2 sec | 9.41 | 300.00 | 9.56 | 5.96 | 116.90 | 0.0017 |
| LTD | 1 sec | 17.39 | 496.00 | 5.18 | 3.23 | 70.71 | 0.0017 |
| LTD | 0.5 sec | 33.05 | 888.00 | 2.72 | 1.70 | 39.49 | 0.0017 |
| LTD | 0.25 sec | 63.67 | 1,672.00 | 1.41 | 0.88 | 20.97 | 0.0017 |

Figure 2: System frequency response to a 1,200 MW load step.
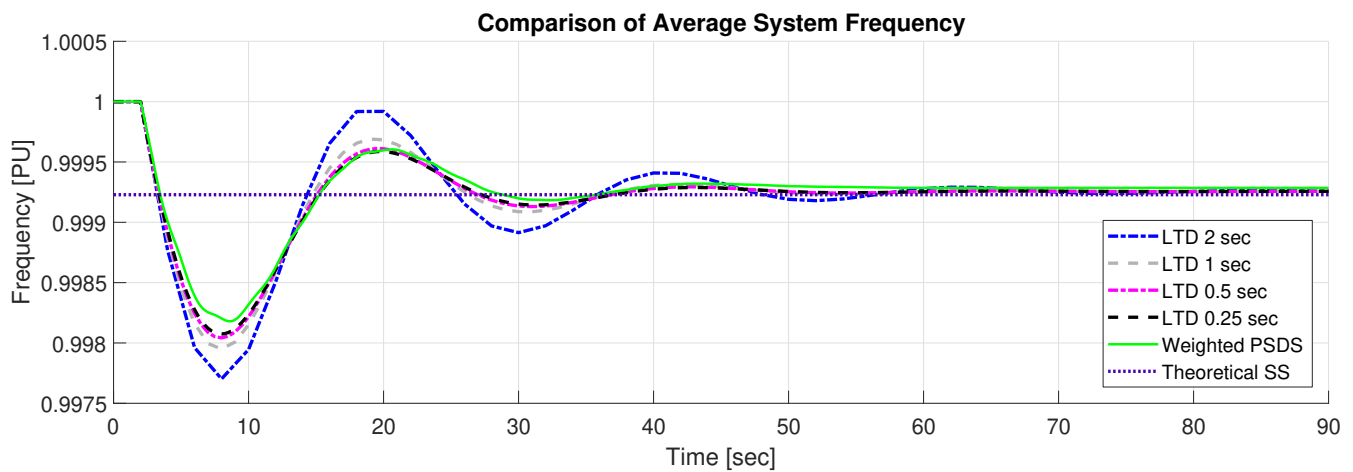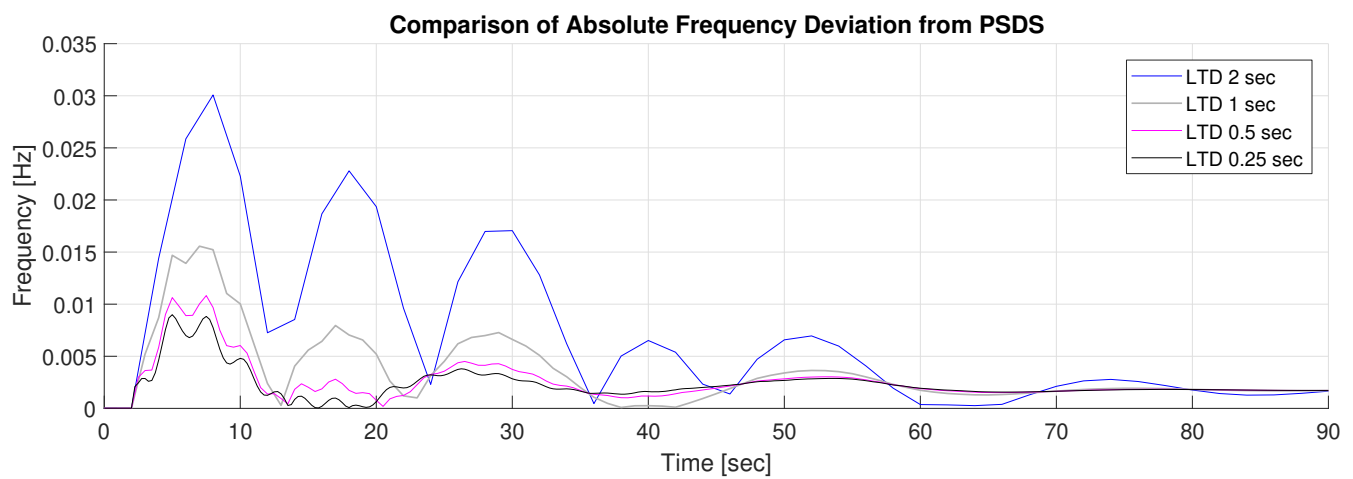


Figure 3: Average frequency of different time steps during a 1,200 MW load step.



Figure 4: Relative Hz difference of PSDS - LTD $\left(\text{i.e. } \left|f_{PSDS}(t) - f_{LTD}(t)\right| \times 60\text{Hz}\right)$.