

Introduction
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Simulation Model
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EE554 System
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Frequency Validation
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Proof of Concept
o
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Current Conclusions
o

Long-Term Simulation of Power System Dynamics using Time Sequenced Power Flows

Thad Haines

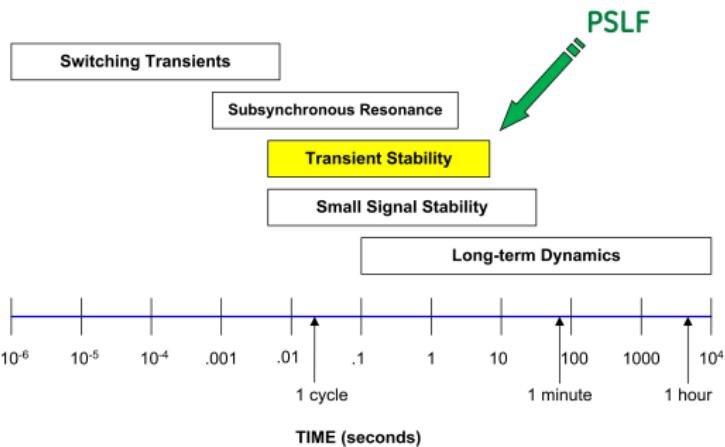
Montana Tech - Master's Thesis Research Project

February 5th, 2019

Overview of Project

What is long-term simulation?

Power System Dynamic Time Scales



imagination at work

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Overview of Project

This long-term simulation assumes:

- ▶ System is stable.
- ▶ System frequency is governed by combined PU swing equation:

$$\dot{\omega}_{sys} = \frac{1}{2H_{sys}} \left(\frac{P_{acc,sys}}{\omega_{sys}(t)} - D_{sys} \Delta\omega_{sys}(t) \right)$$

- ▶ Large time steps (1 second).
- ▶ Fast dynamics are mostly ignored.

Overview of Project

Project Goals:

- ▶ Design simulation framework for long-term dynamic (LTD) simulations using PSLF systems, dynamic data, and modified dynamic models.
- ▶ Investigate system reactions that may be impractical to simulate using other software methods.
- ▶ Write a master's thesis.

TODO:

Overview of parts involved in simulation
(sequence diagram)

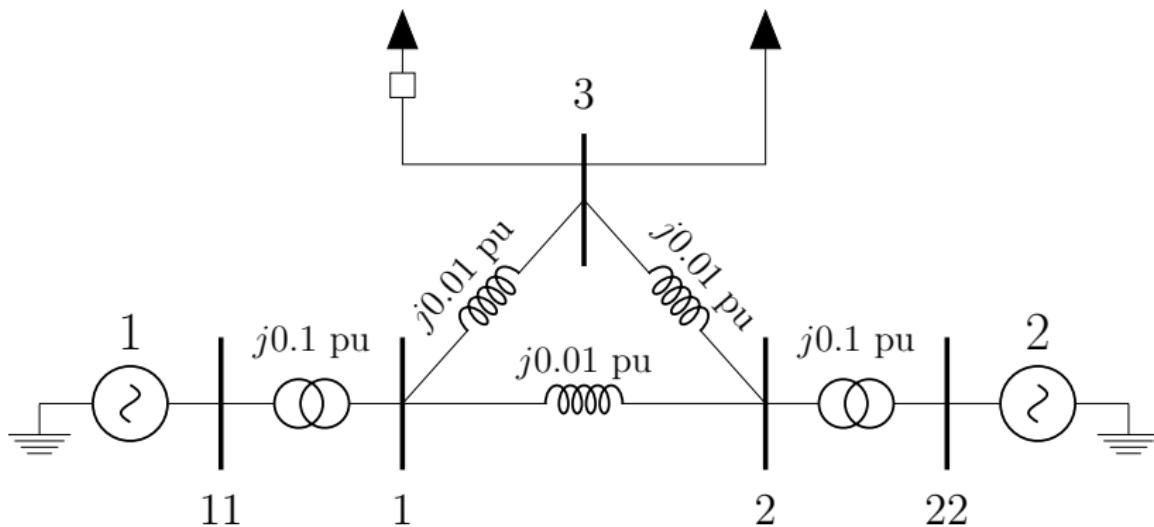
other explanations about computery stuff:

ipy vs py?

flow chart of predicted work flow.

System Used for Initial Frequency Validation

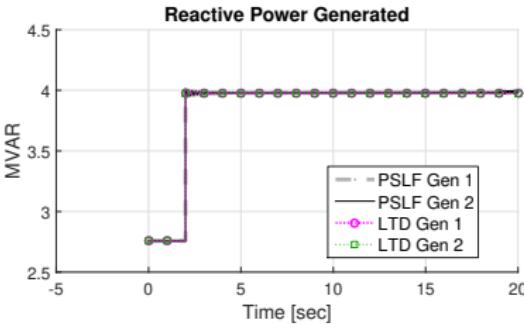
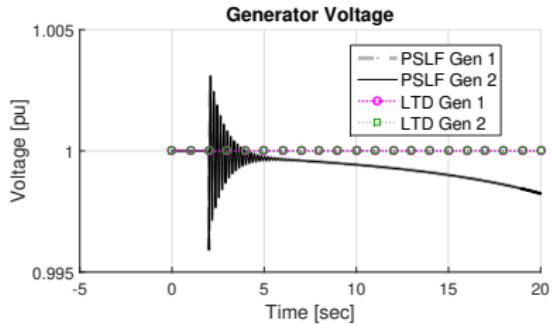
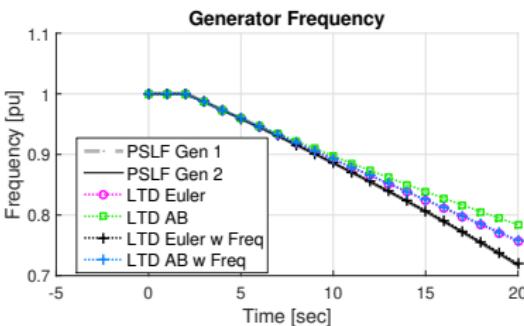
EE554.sav test system:



Generators are identical.
PSLF models have exciters.

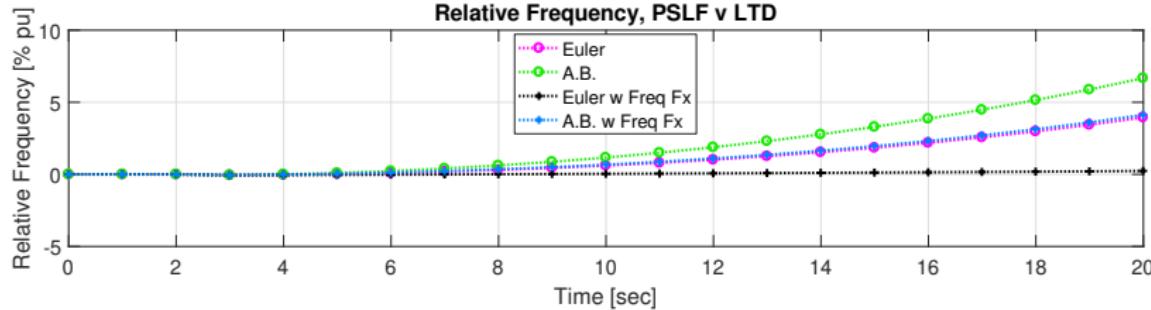
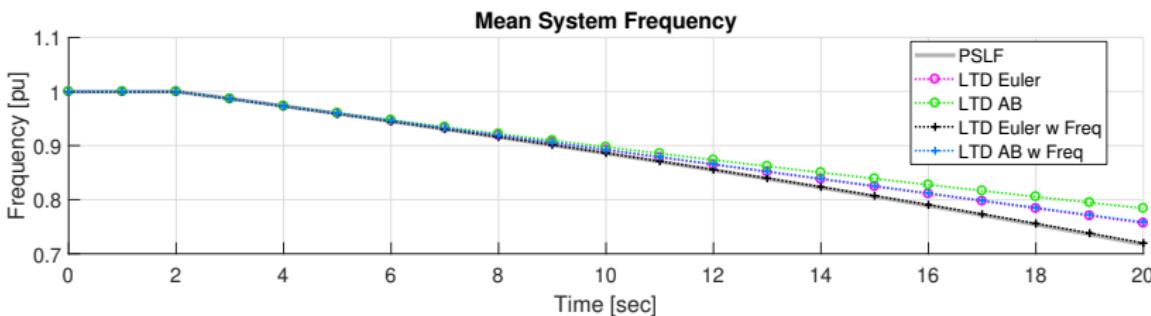
+20 MW Load Step at t=2

System Response



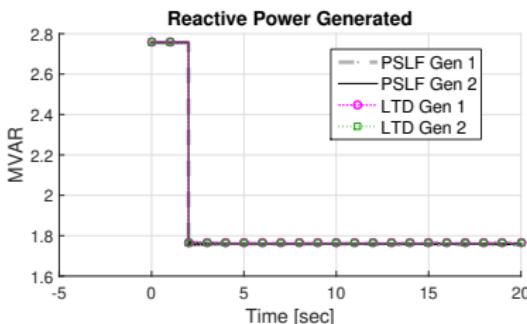
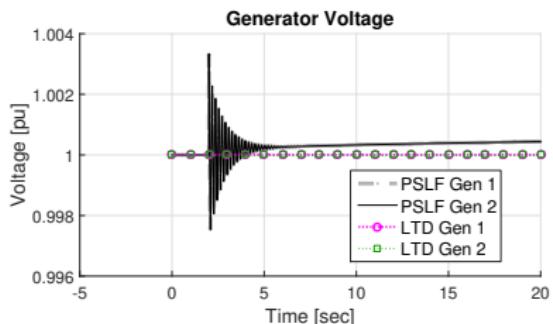
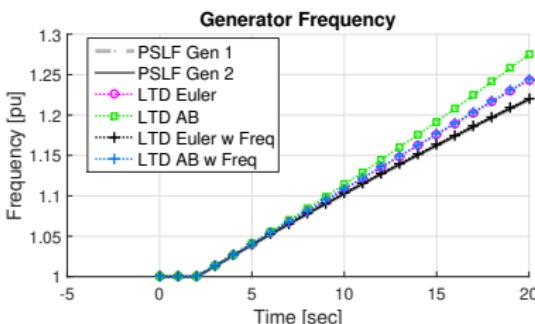
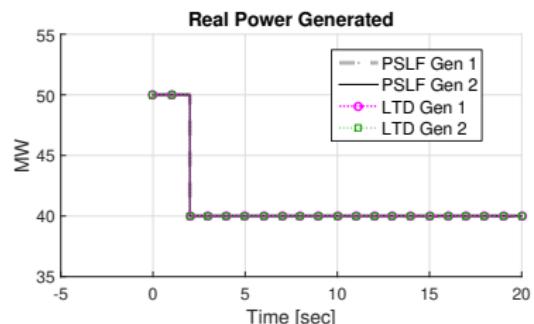
+20 MW Load Step at t=2

Detailed Frequency Response



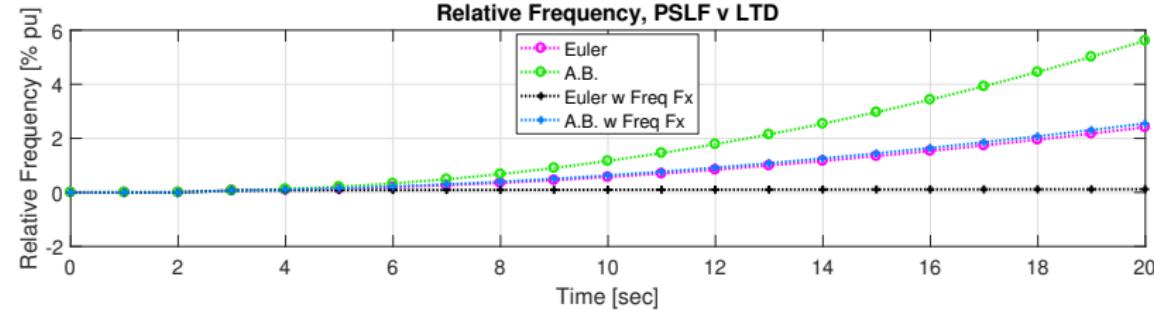
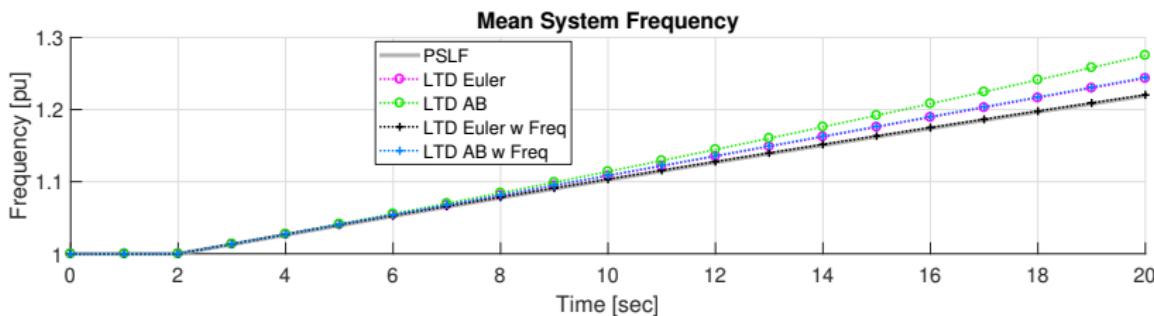
-20 MW Load Step at t=2

System Response



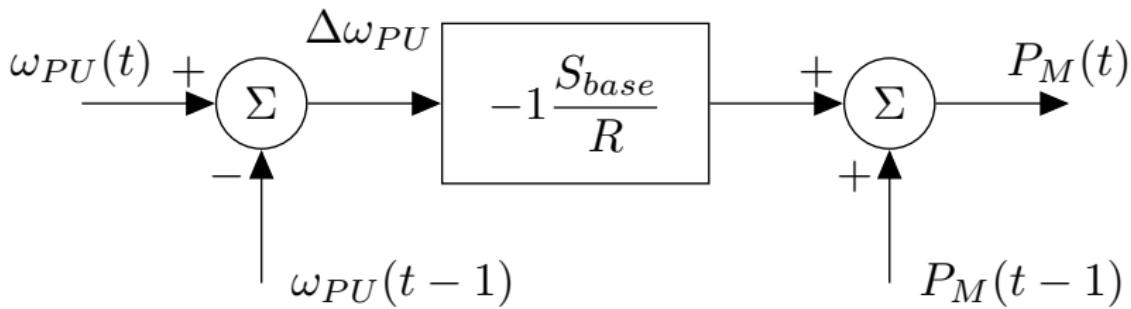
-20 MW Load Step at t=2

Detailed Frequency Response



Dynamic model 'pgov1' defined

pgov1 : Proportional gain control of P_M

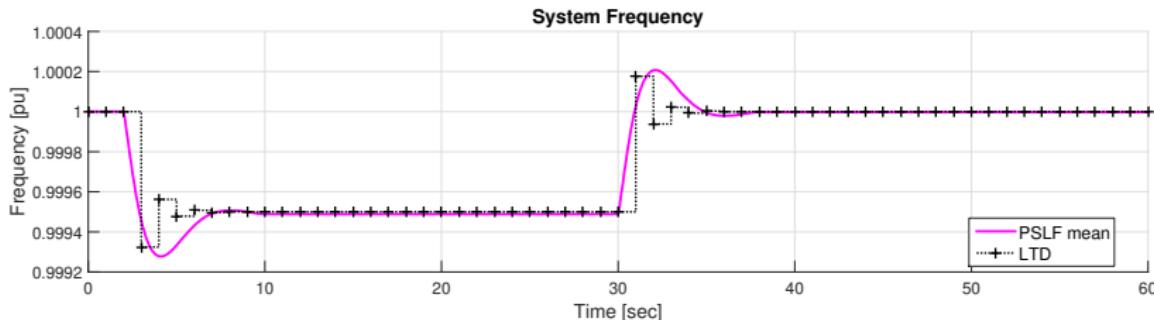
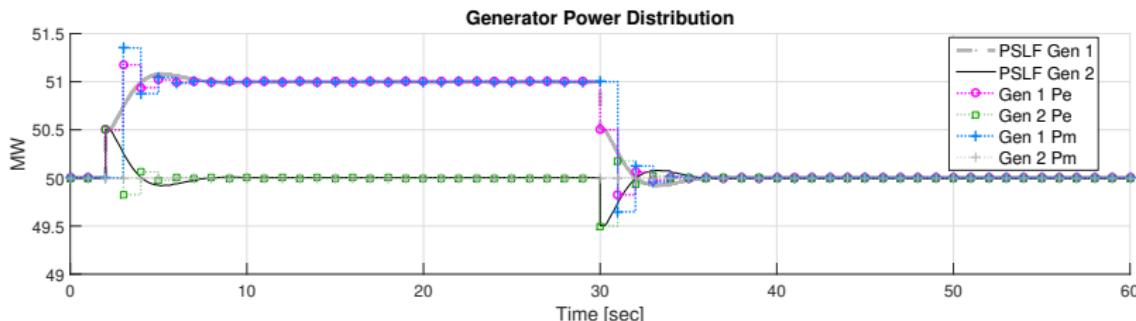


Entered into system via parsed text file:

```
# model busnum busnam basekv id : #9 mwcap droop
#!pgov1 11 "11" 22.00 "1" : #9 mwcap=100.0 0.05
```

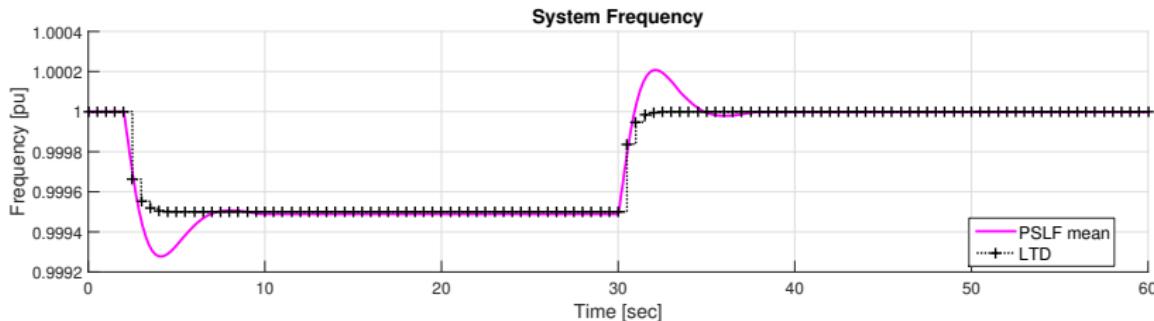
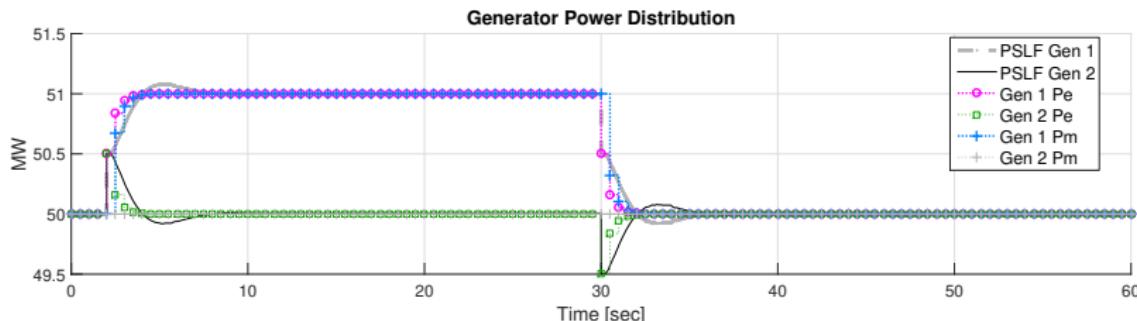
Dynamic model 'pgov1' experiment: +1 MW t=2, -1 MW t=30

pgov1 on Gen 1, 1 second time step



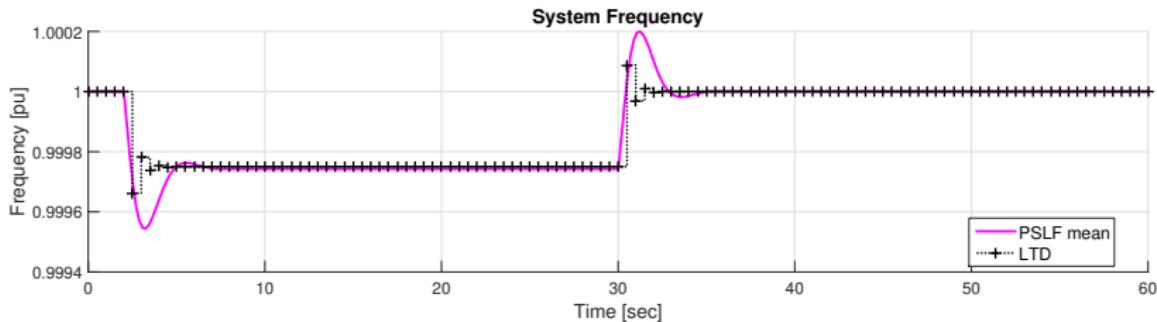
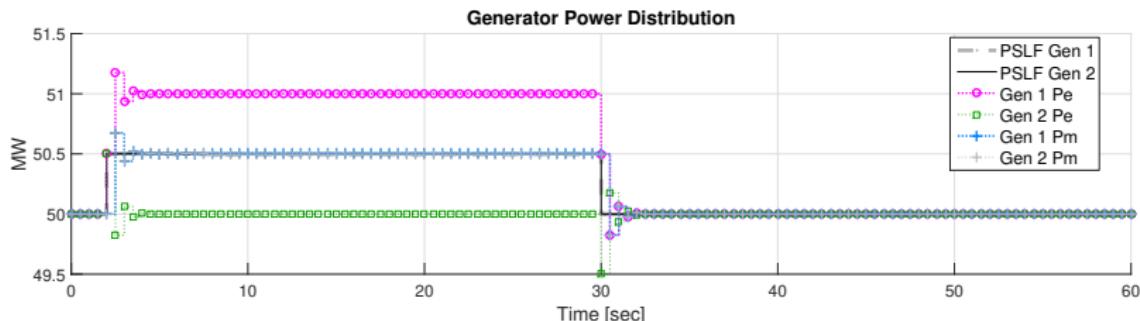
Dynamic model 'pgov1' experiment: +1 MW t=2, -1 MW t=30

pgov1 on Gen 1, 0.5 second time step



Dynamic model 'pgov1' experiment: +1 MW t=2, -1 MW t=30

pgov1 on both Gens, 0.5 second time step



- ▶ Much more work to do.
- ▶ Frequency effects should be accounted for in swing equation.
- ▶ Euler Integration tracks PSLF mean frequency well.
- ▶ Custom dynamic model implementation seems realizable.