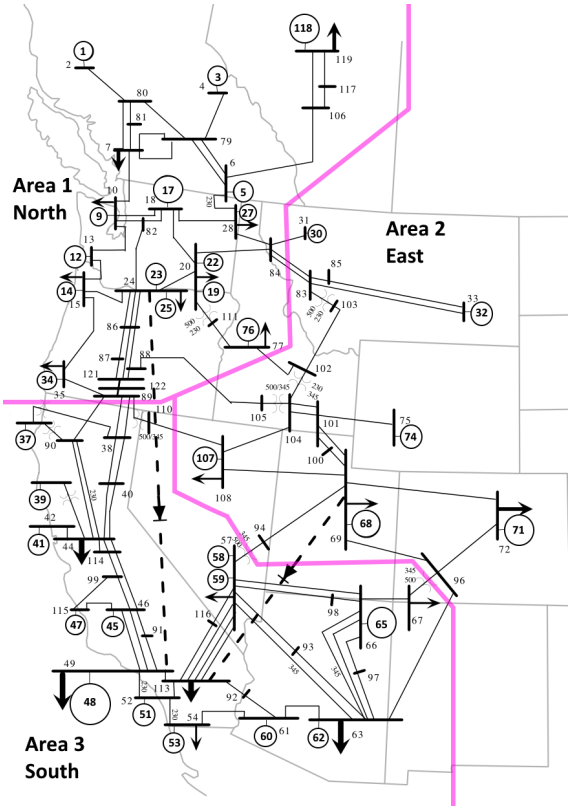
10 Minute AGC Recovery of Mini WECC after 435 MW Load Step

- Mini WECC system:
  - Buses: 122
  - Lines: 171
  - Loads: 88
  - Machines: 34
  - States: 623
- Event: +435 MW load step on Bus 2 in Area 1 at t=1.
- Each area has identical conditional AGC that acts at t=40 and again when t=160, 280, 400, 520 (i.e. 2 minute action time).
- ODE solver tolerances:

  Relative: 1e-5

  Absolute: 1e-7



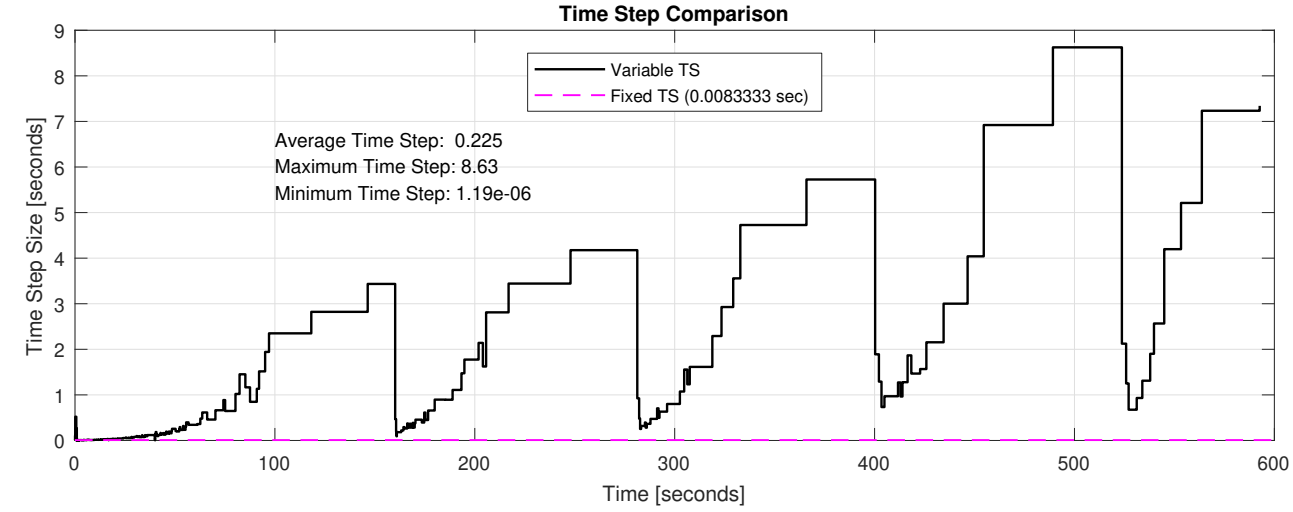
Result Summary:

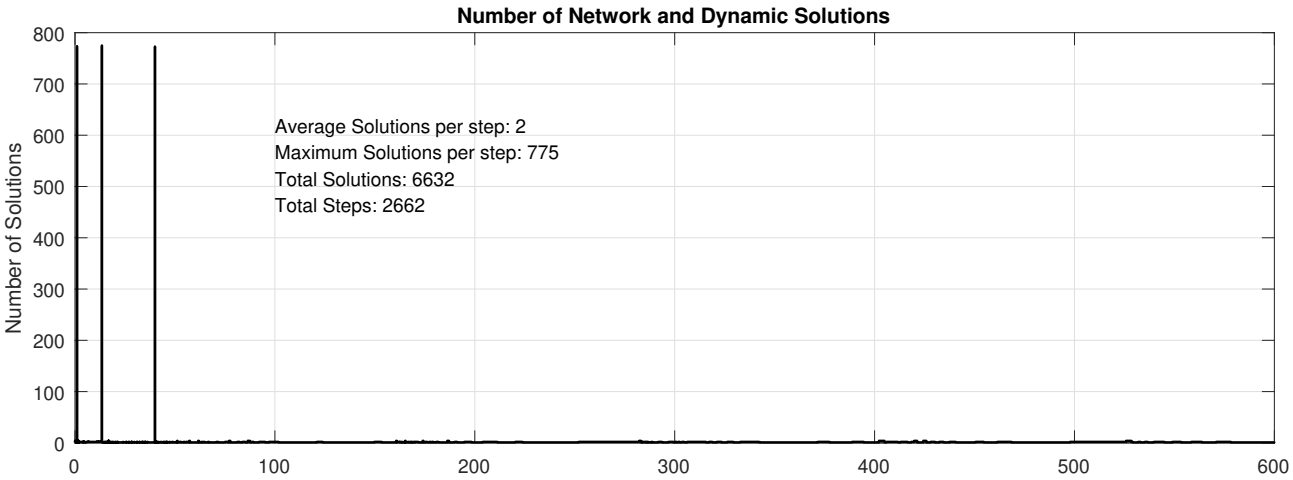
- Using the ode23/ode23t methods provided a 9 times speed up over Huen's 'fixed step' method.
- 27 times fewer steps were taken using VTS which resulted with a saved file size that was approximately 24 times smaller than the Huen's method data file.
- VTS methods appeared to capture fast dynamics well.
- VTS and fixed time step results may 'drift' slightly when time steps become large. Effect can be reduced via ODE solver tolerance settings or additional `sw_con` time blocks.

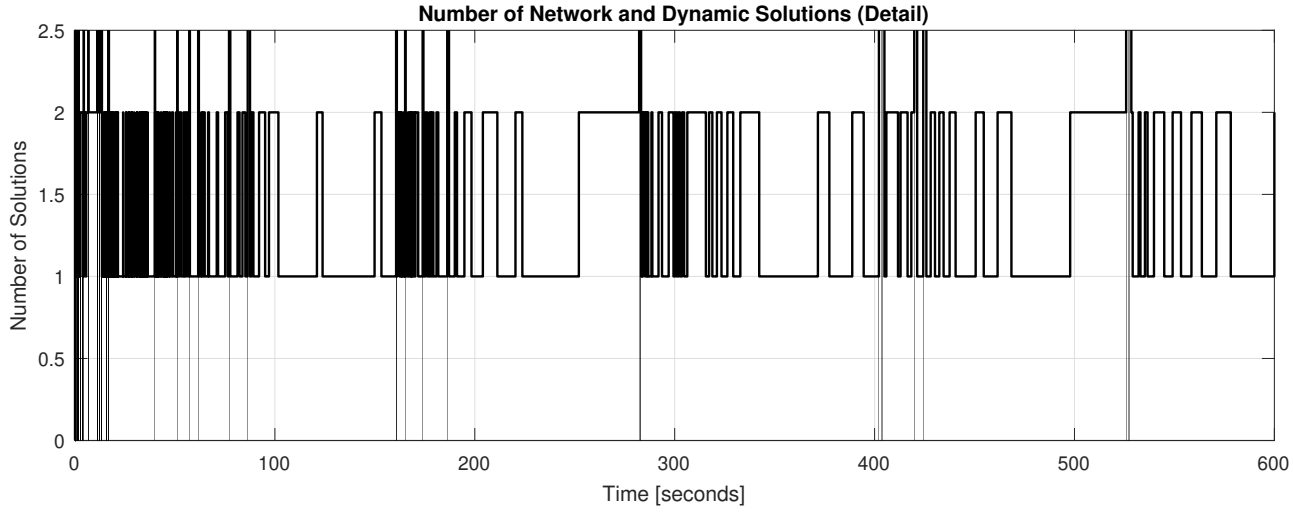
	Step Size [seconds]				Solutions Per Step				
Method	Max	Min	Ave	Total Steps	Ave	Max	Total Slns.	Sim. Time [seconds]	File Size [bytes]
Huen's	0.0083	8.33E-03	0.0083	72,001	2	2	144,002	483.64	778,259,381
ode23/ ode23t	8.6300	1.19E-06	0.0570	2,662	2	775	6,632	53.4	32,772,591
ΔRatio	0.001	7,000	0.146	27.05	1	0.003	21.71	9.06	23.75

Step Size and Solution Count Data

Time blocks were created at: [0:1], [1:40], and [40:600]. Many solutions were executed at beginning of each blocks due to ODE solver method *possibly* creating a Jacobian.

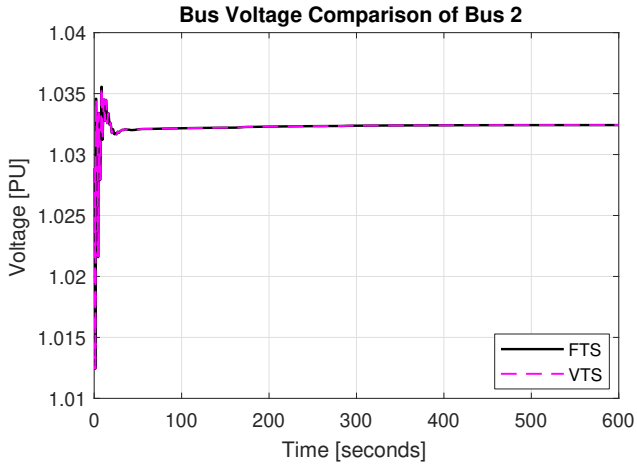


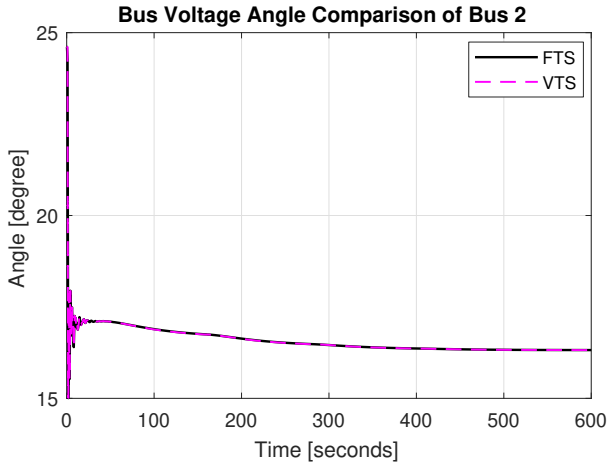


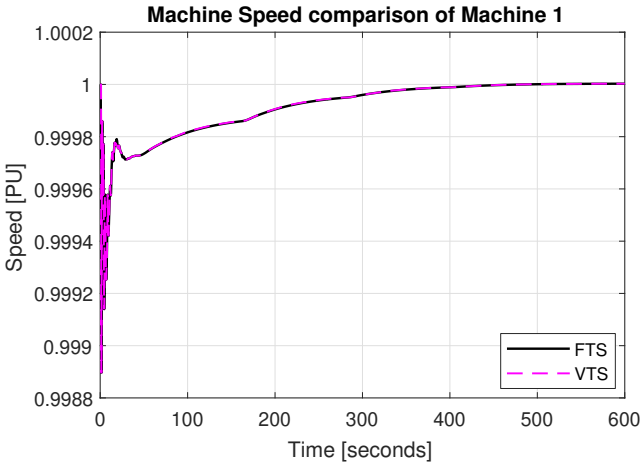


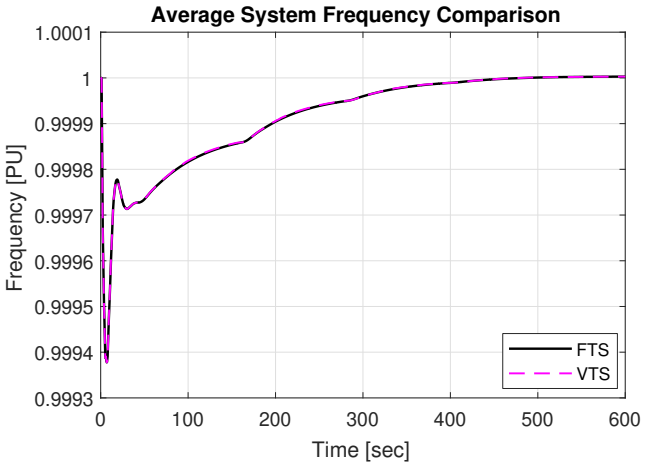
Select Comparisons: t = 0:600 (full simulation)

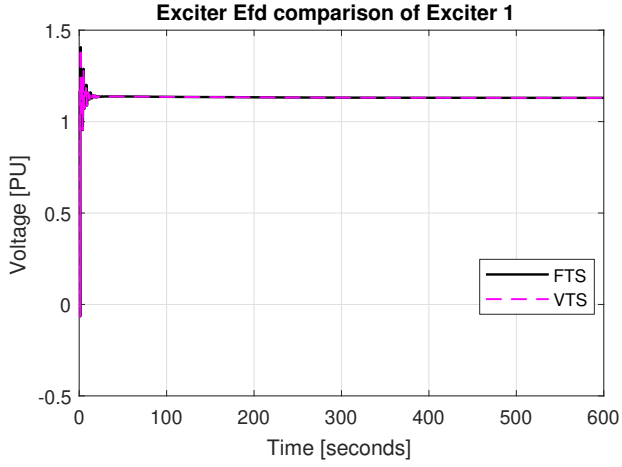
Simulation had a lot of time where not many fast dynamic changes were taking place.

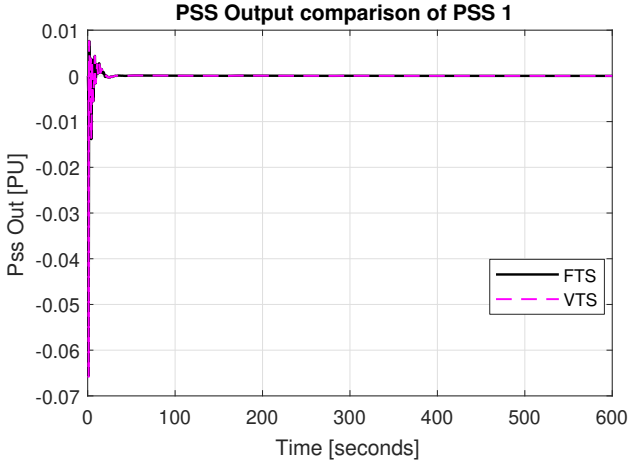






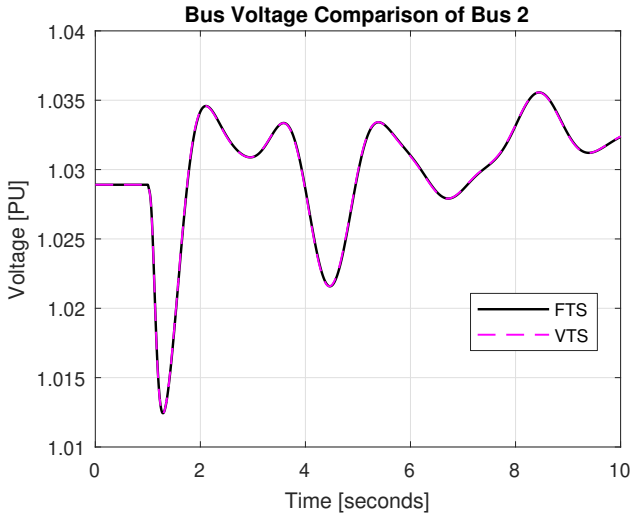


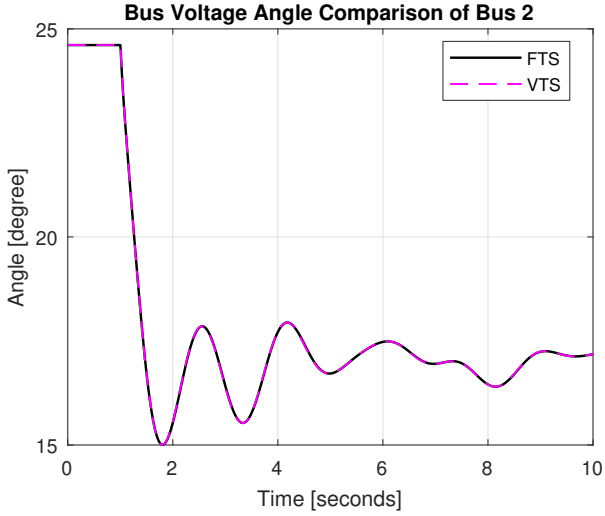


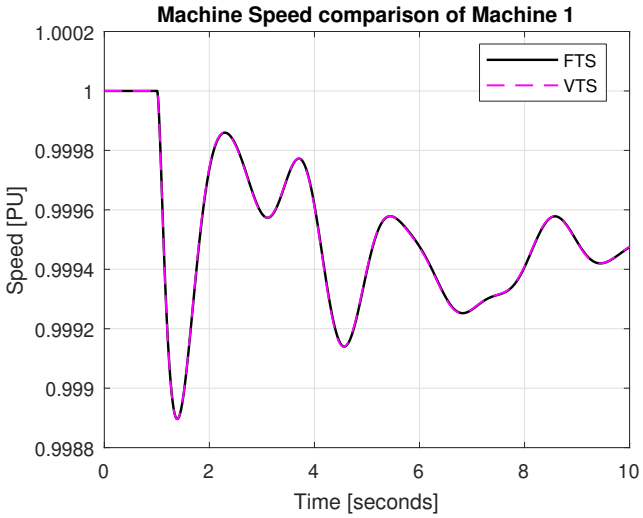


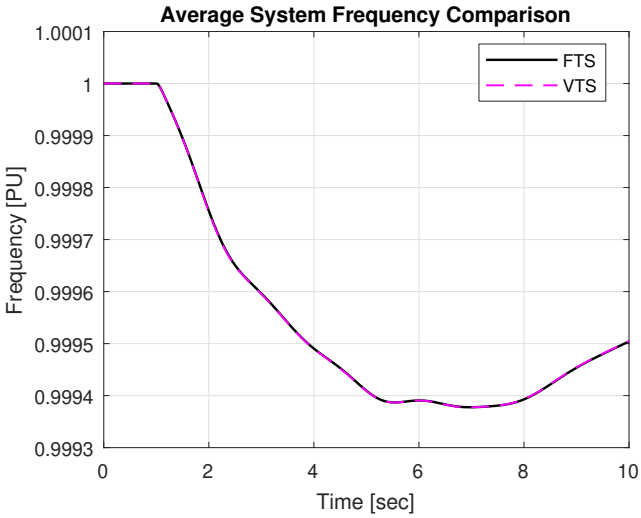
Select Comparisons: t = 0:10

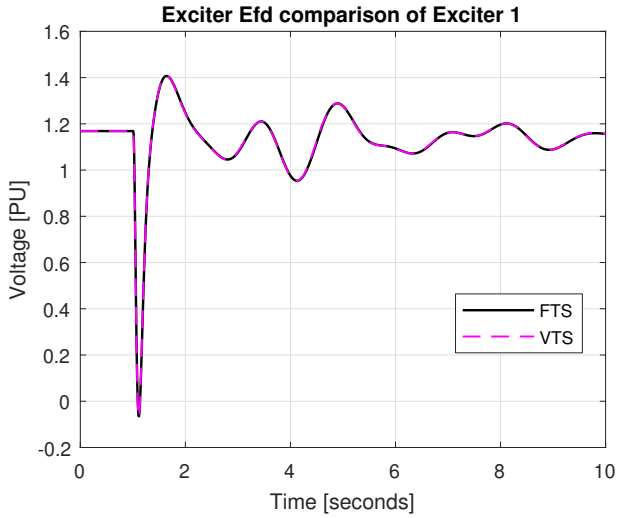
Initial transients were captured well.

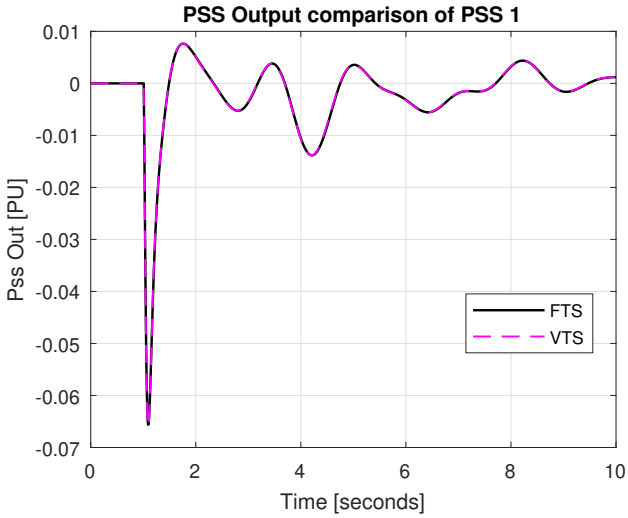






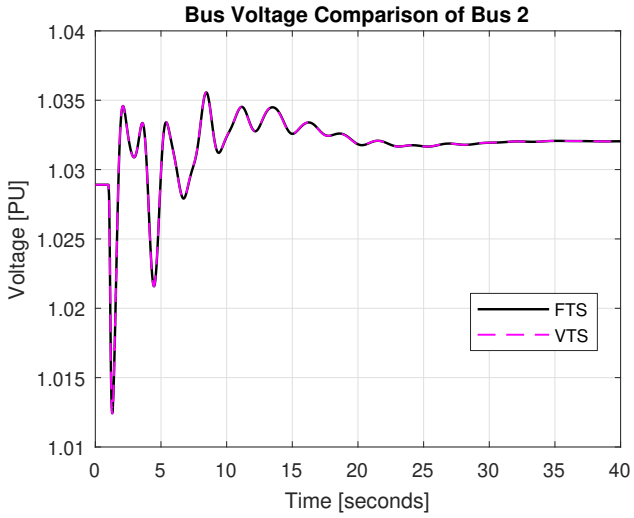


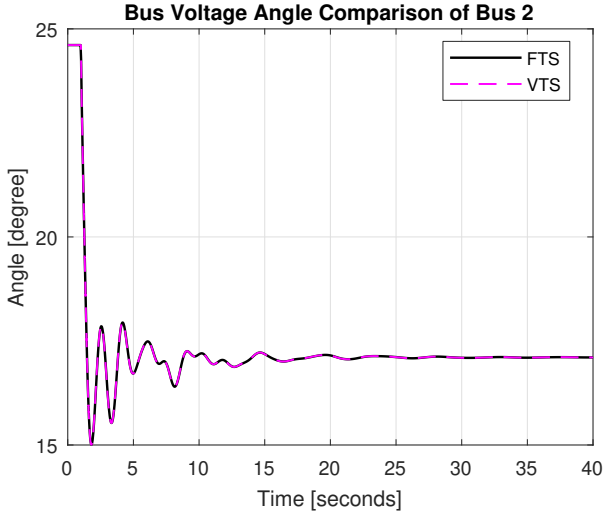


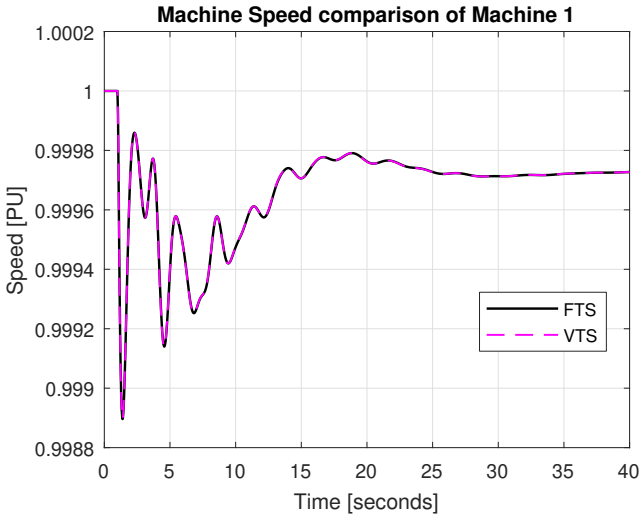


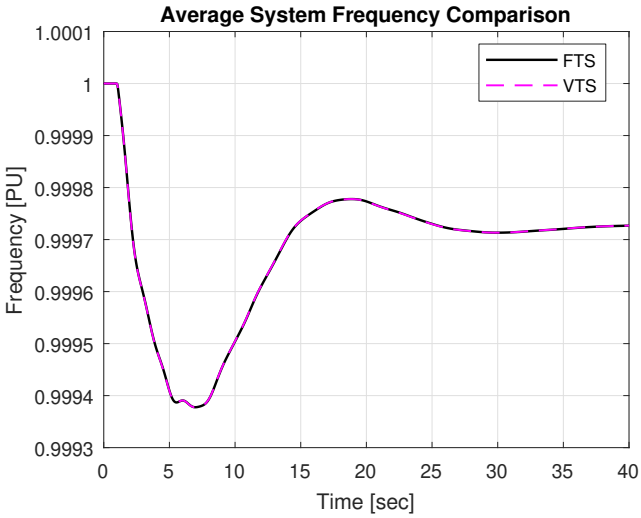
Select Comparisons: t = 0:40

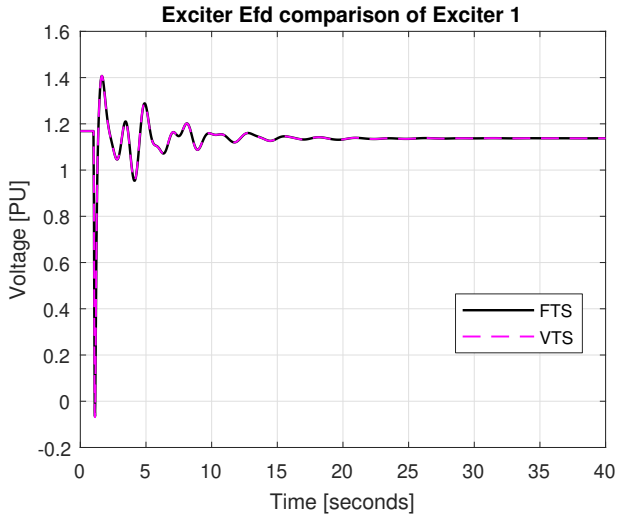
Simulation methods continued to match as system stabilized.

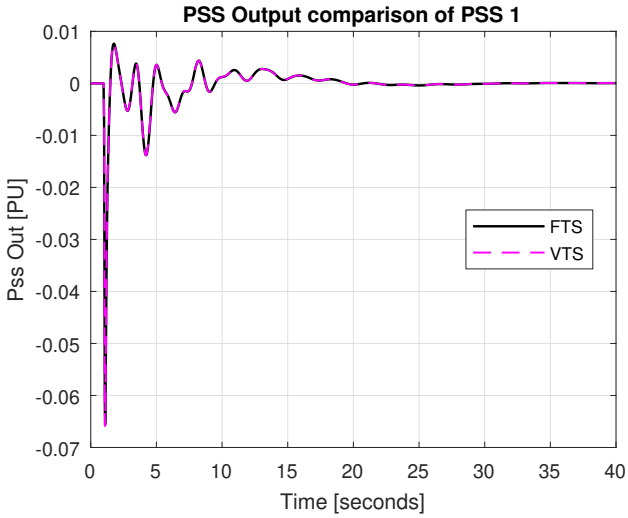






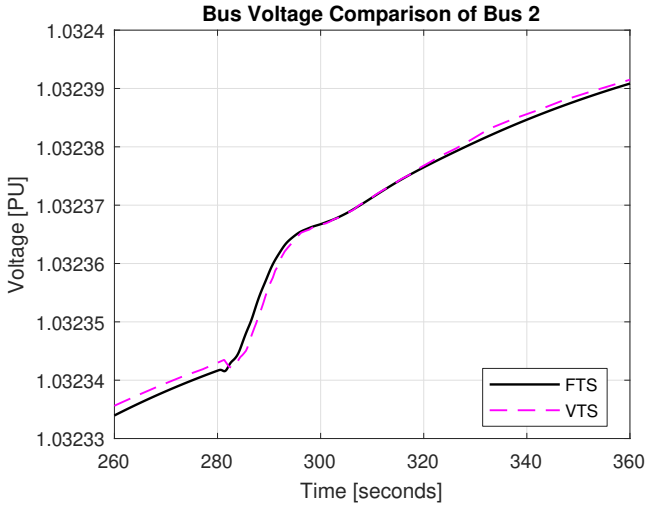


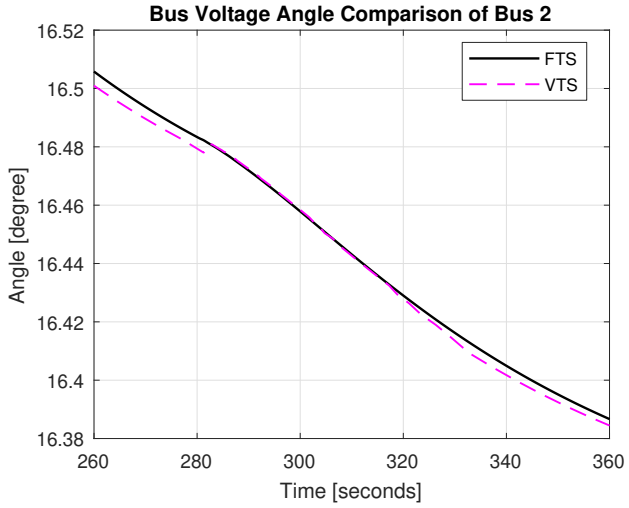


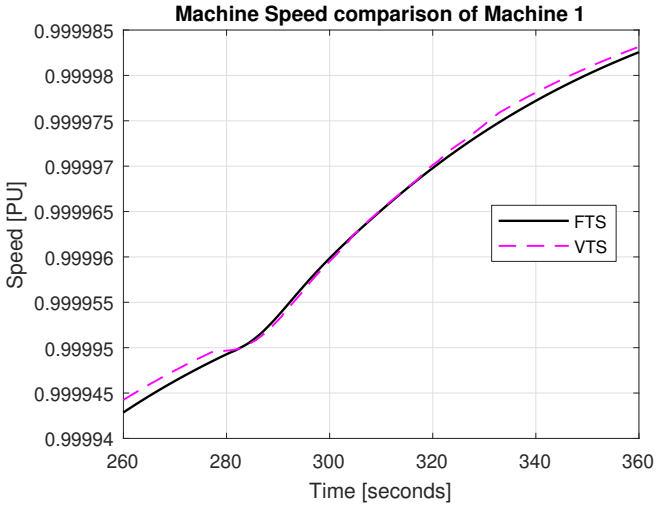


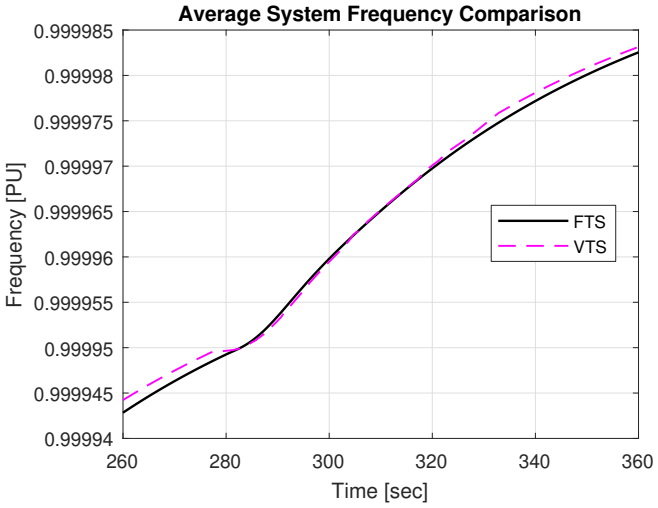
Select Comparisons: t = 260:360 (Result 'Drift' - Scale should be noted)

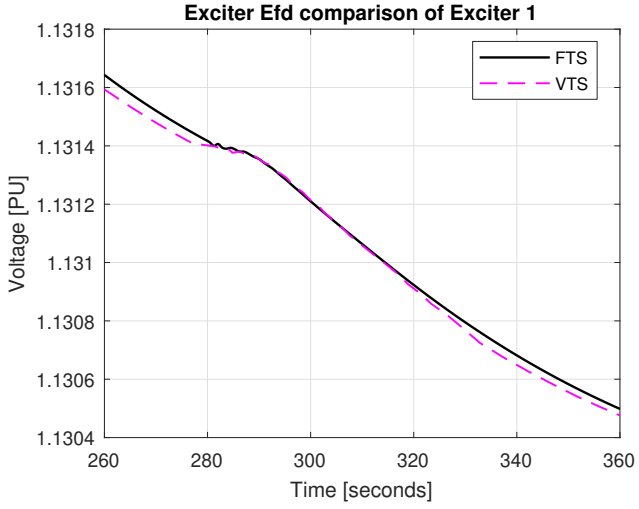
As individual time blocks were not created for each AGC action, dispatches may not be synchronized between simulations and add to state drift.

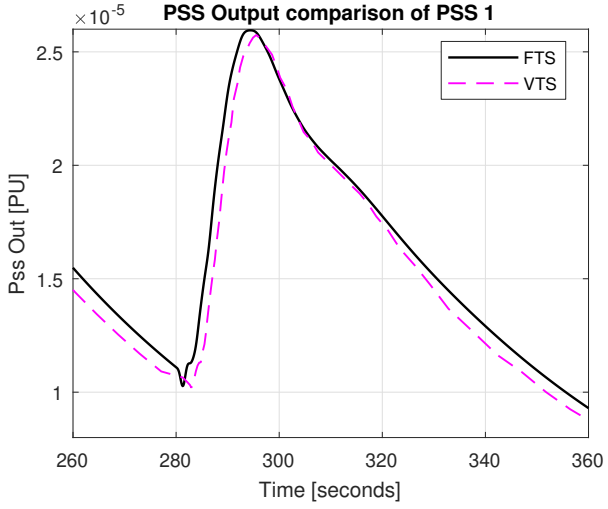












AGC Settings

```
%{
Each agc(x) has following fields:
    area        - Area number / controlled area
    startTime   - Time of first AGC signal to send
    actionTime  - Interval of time between all following AGC signals
    gain        - Gain of output ACE signal
    Btype       - Fixed frequency bias type (abs, percent of max capacity...)
        0 - absolute - Input B value is set as Frequency bias (positive MW/0.1Hz)
        1 - percent of max area capacity
    B           - Fixed frequency bias Value
    Kbv         - Varaible frequency bias gain used to gain B as B(1+kBv*abs(delta_w))
    condAce     - Conditional ACE flag
        0 - Conditional ACE not considered
        1 - ace2dist updated only if sign matches delta_w (i.e. in area event)

    (PI Filter Values)
    Kp          - Proportional gain
    a           - ratio between integral and proportional gain (placement of zero)
    ctrlGen_con - col 1 = generator bus,
                  col 2 = participation factor,
                  col 3 = low pass filter time constant [seconds]
%}
agc(1).area = 1;
agc(1).startTime = 40;
agc(1).actionTime = 120;
agc(1).gain = 1; % gain of output signal
agc(1).Btype = 1; % per max area capacity
agc(1).B = 1;
agc(1).Kbv = 0; % no variable bias
agc(1).condAce = 1; % conditional ACE
agc(1).Kp = 0.015;
agc(1).a = 0.0001;
agc(1).ctrlGen_con = [ 23, 1.0, 60 ];

agc(2) = agc(1); % duplicate most settings from AGC 1 to AGC 2
agc(2).area = 2;
agc(2).ctrlGen_con = [ 32, 1.0, 60 ];

agc(3)=agc(1); % duplicate most settings from AGC 1 to AGC 3
agc(3).area = 3;
agc(3).ctrlGen_con = [...
    45, 0.75, 60;
    53, 0.25, 60;
    ];
```