Scenario

A 14 ms 3 Phase Fault in the New England 39 Bus, 10 Machine Benchmark System was simulated using the standard PST fixed time step method (Huen's Method) and five of the standard MATLAB ODE solvers that employ variable time step (VTS) methods. The simulation was only 20 seconds to verify transient dynamics could be captured, and confirm if the VTS methods increased the time step in a desirable way.

Summary

- Variable time step (VTS) simulation works in PST.
- Bus Voltage and Angle, Machine Speed, Average System Frequency, Exciter Efd, and PSS out dynamics from the VTS simulations seem to match fixed results well.
- Some methods do not work (ODE45, ODE23s)
- For this relatively short simulation (20 Seconds), all VTS simulations took ≈3 times longer than the standard PST fixed method.
- The VTS methods rely on tolerances to change the time step (no minimum step size option).
- Some steps require hundreds of network and dynamic solutions before being accepted.

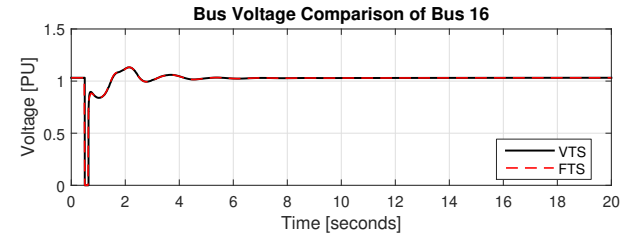
	Step Size [seconds]				Solutions Per Step				
Method	Max	Min	Ave	Total Steps	Ave.	Max.	Total Slns	Sim time	Speed Up
Fixed	0.020	0.02	0.0200	1000	2	2	2000	8.1207	1
ODE113	0.133	5.16E-05	0.0148	1350	2	7	2937	19.849	0.409
ODE15s	0.110	1.37E-05	0.0276	725	8	382	5715	25.6757	0.316
ODE23	0.185	1.27E-05	0.0216	925	3	15	3023	17.6041	0.461
ODE23t	0.372	3.73E-05	0.0266	753	6	382	4817	23.178	0.350
ODE23tb	0.546	1.51E-05	0.0327	612	9	383	5645	26.278	0.309

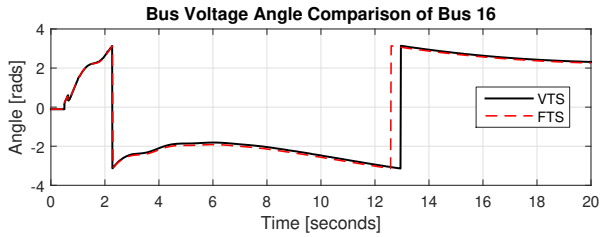
Observations of Note

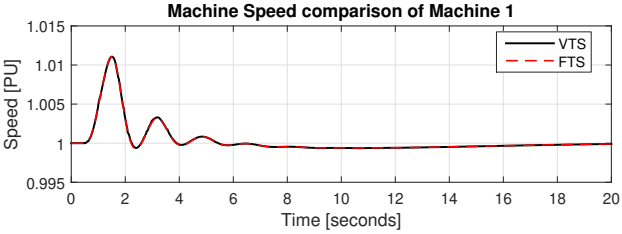
1. A smaller initial step 'may' reduce the number of solutions required at the beginning of 'time blocks'. Alternatively, tolerances may be adjust to further 'tune' simulation operation.
2. It should be possible to change the solution method and/or ODE solver during simulation.
3. A longer simulation will probably highlight the benefits of VTS better.

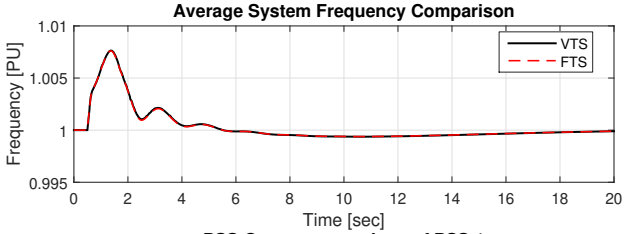
ode113 Results

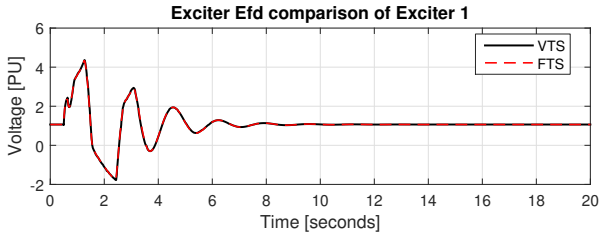
ode113

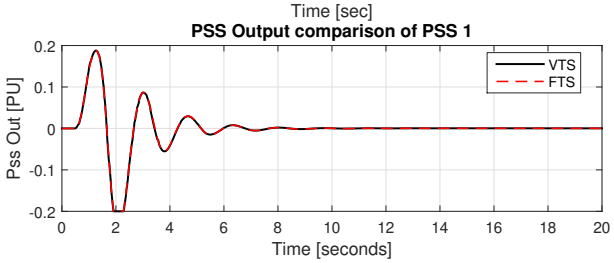


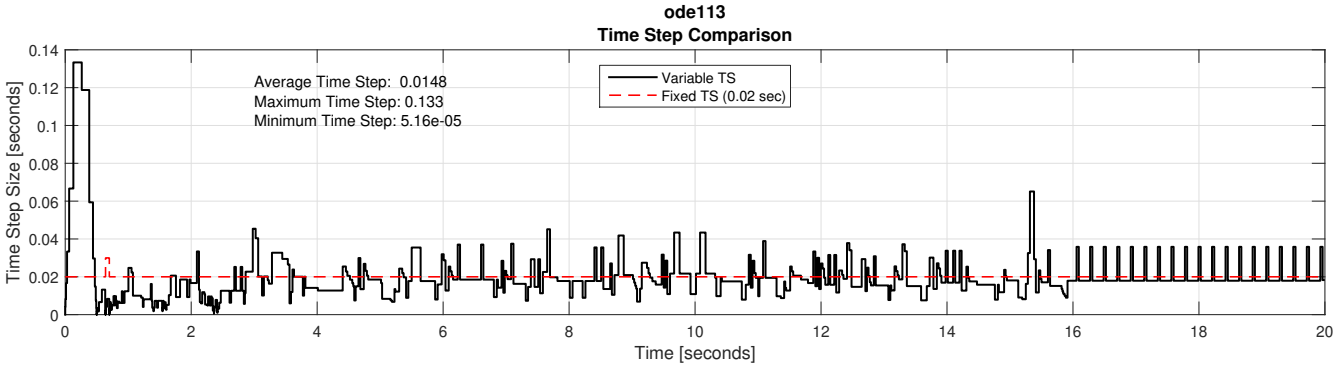


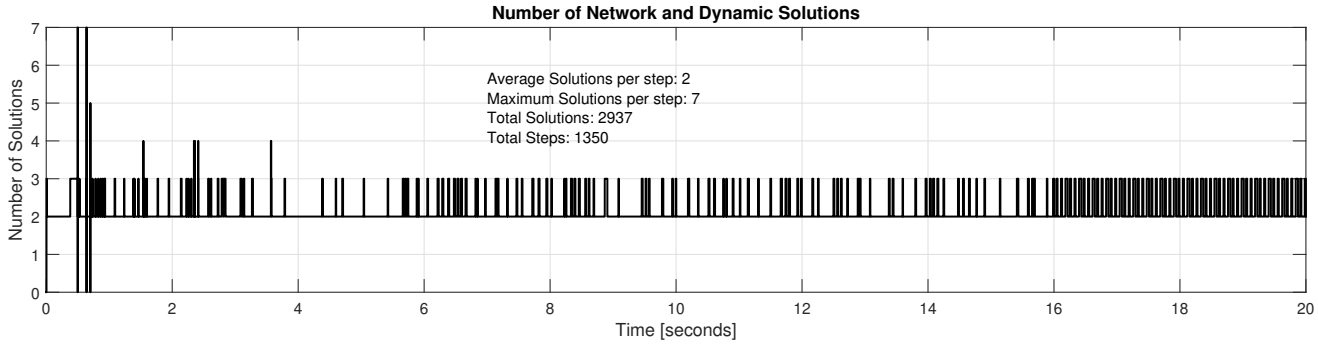






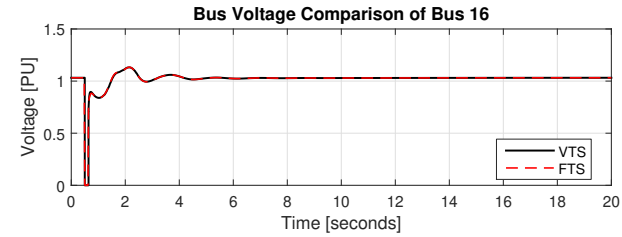


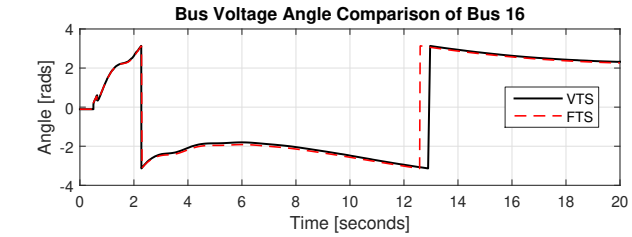


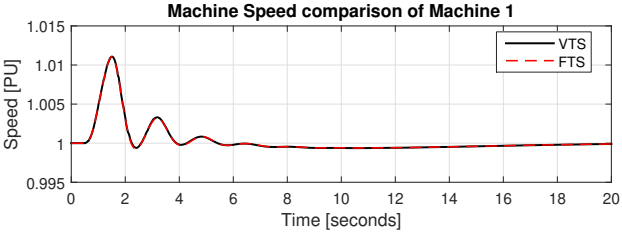


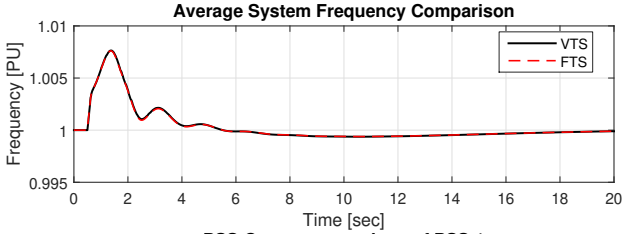
ode15s Results

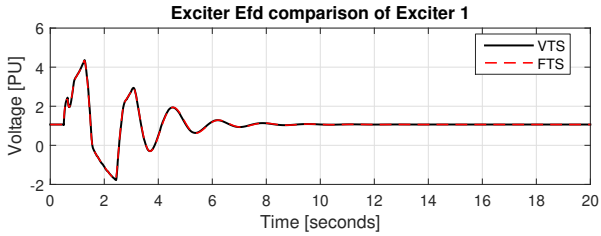
ode15s

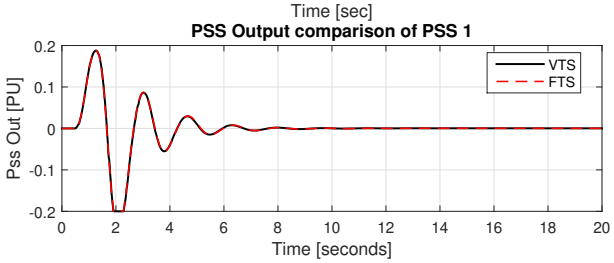


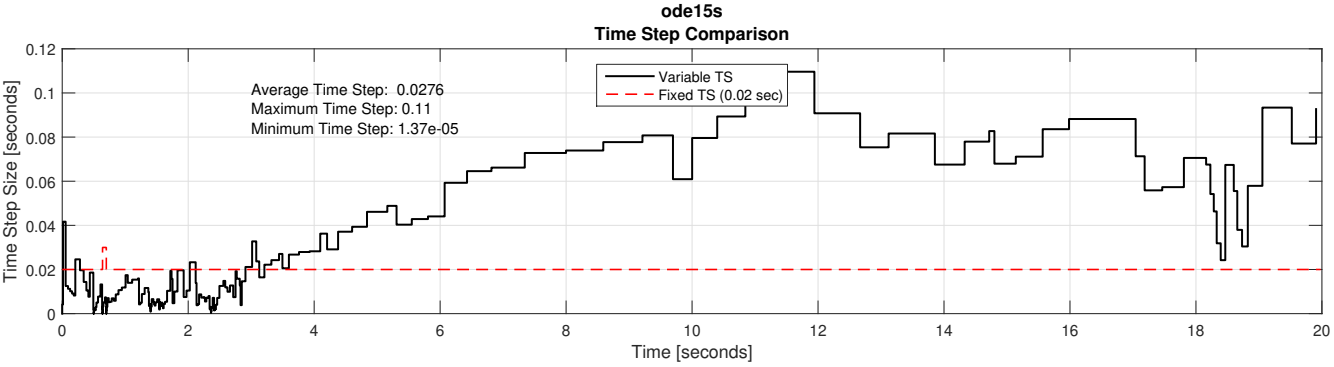


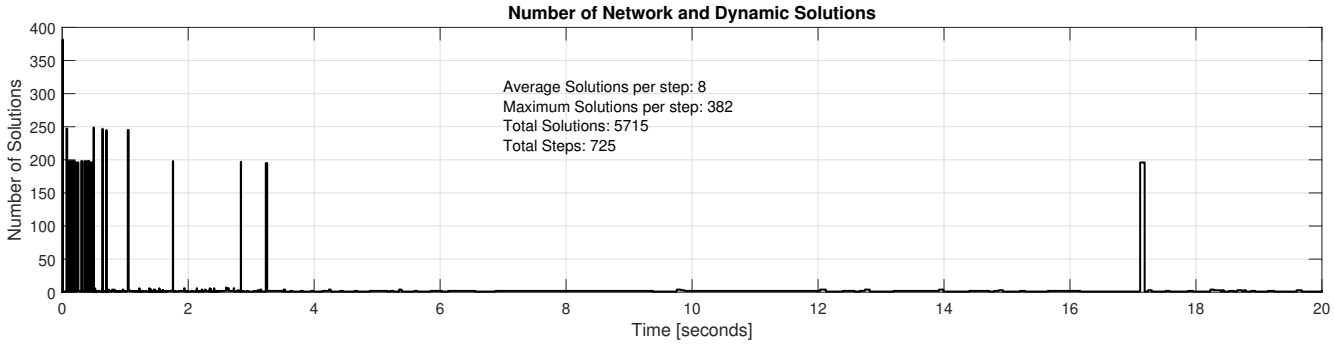






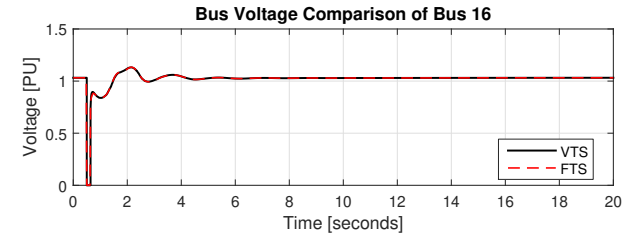


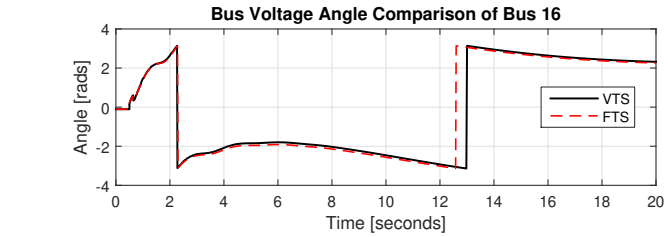


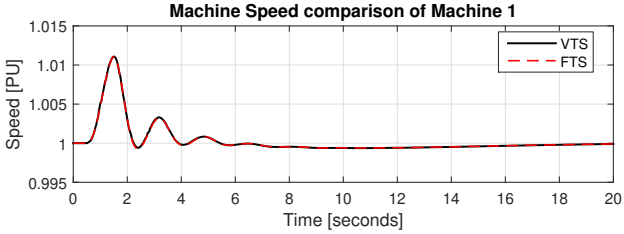


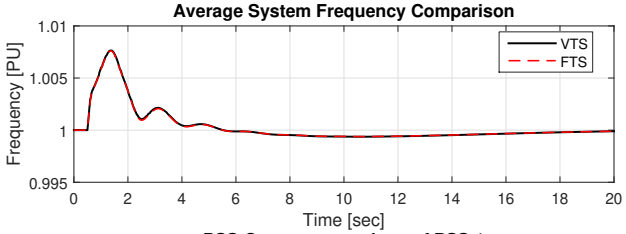
ode23 Results

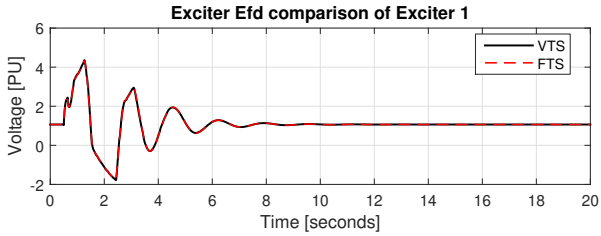
ode23

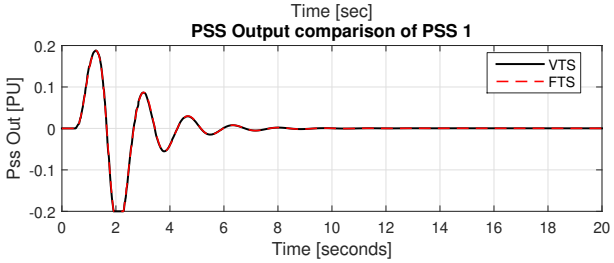


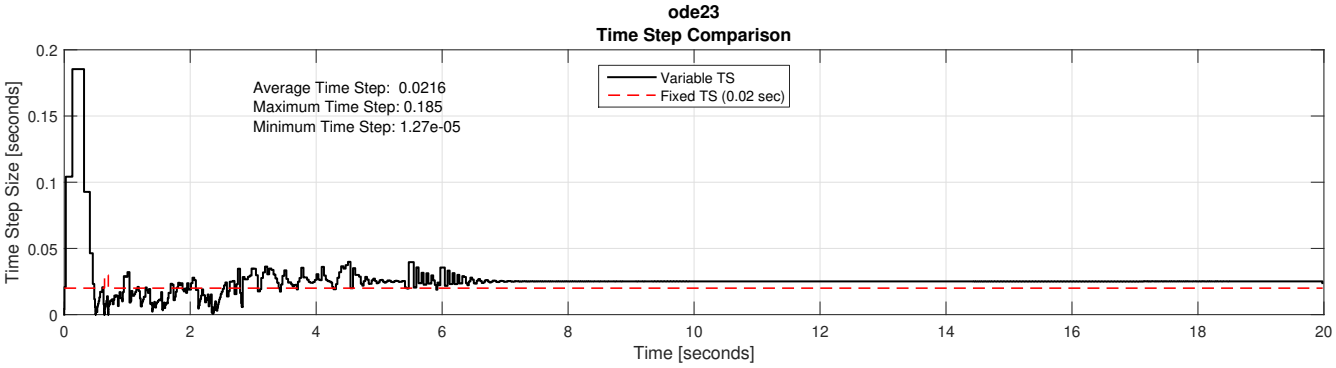


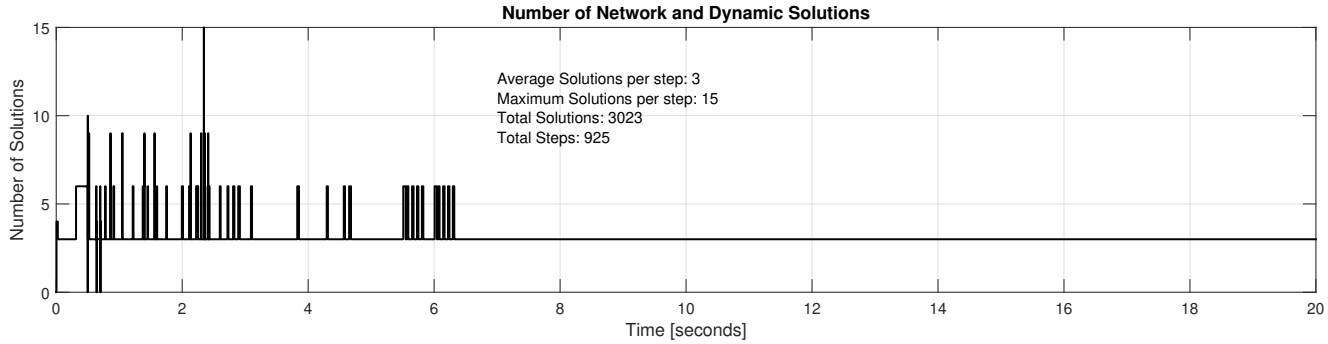






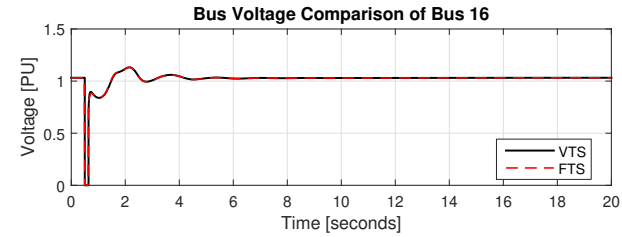


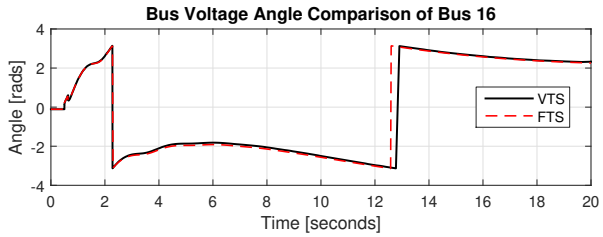


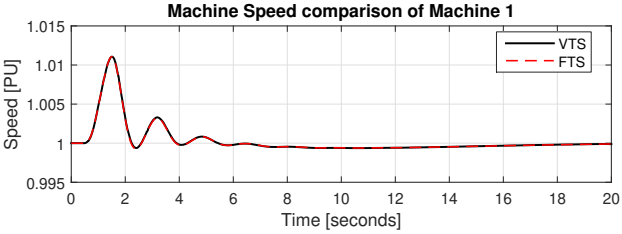


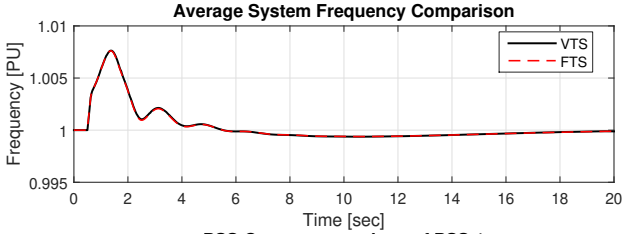
ode23t Results

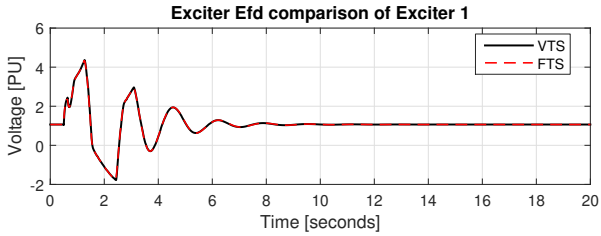
ode23t

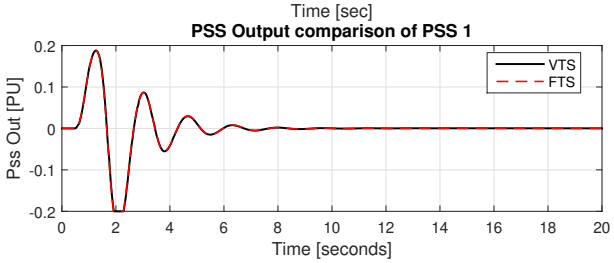


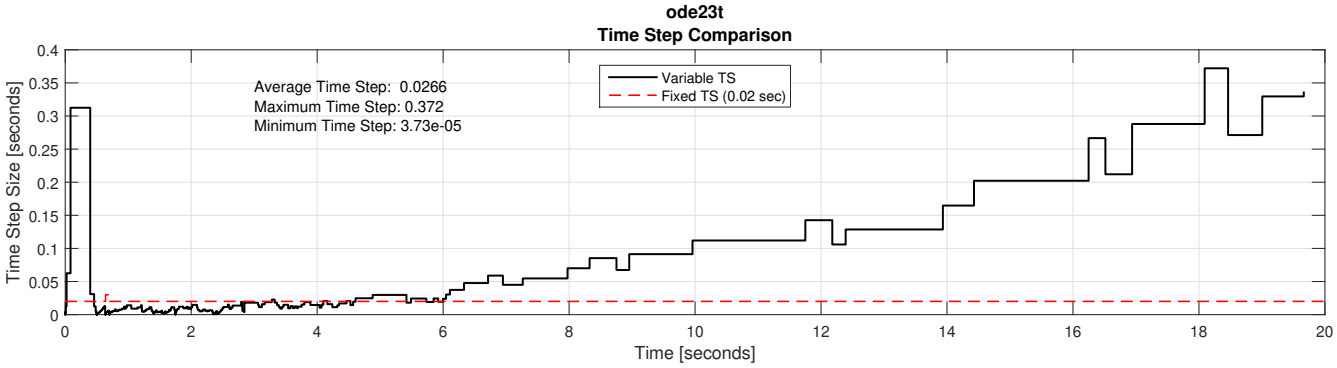


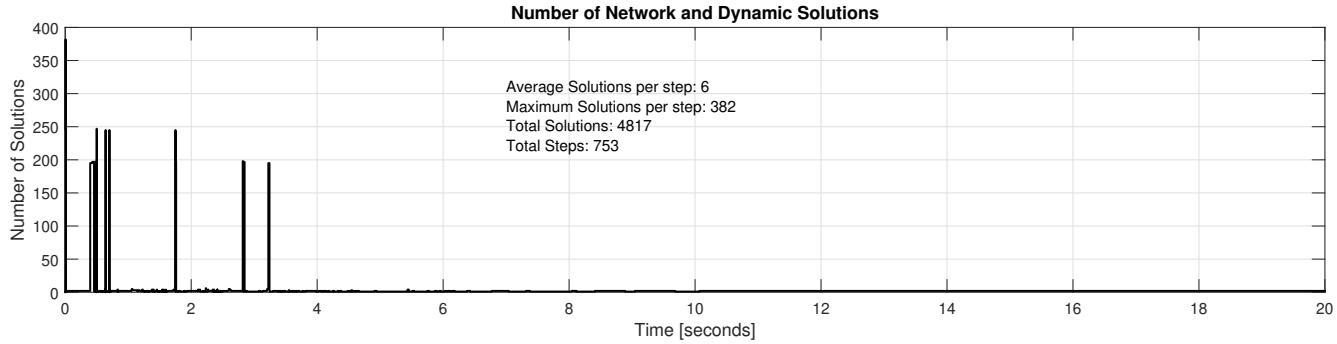












ode23tb Results

ode23tb