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Power System Toolbox Updates to Enable Long-Term Variable Time-Step Dynamic Simulation

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Background

Among the ways Inverter-Based Resources (IBRs) differ from synchronous generation:

1. Grid interconnection is realized via electronic converters.
2. Injected power from IBRs is often highly variable and intermittent.

1. ➔ Problem of simulating the interface of a fast dynamic component (electronic converter) with a slower system (power grid).

2. ➔ Need to run simulations spanning longer time frames than those associated with typical transient stability simulations.

Combined, 1. and 2. ➔ Simultaneous simulation of fast and slow dynamics.

Numerical integration solvers currently deployed in power system dynamics simulation tools were not designed to study these vastly different dynamics in a single simulation scenario.

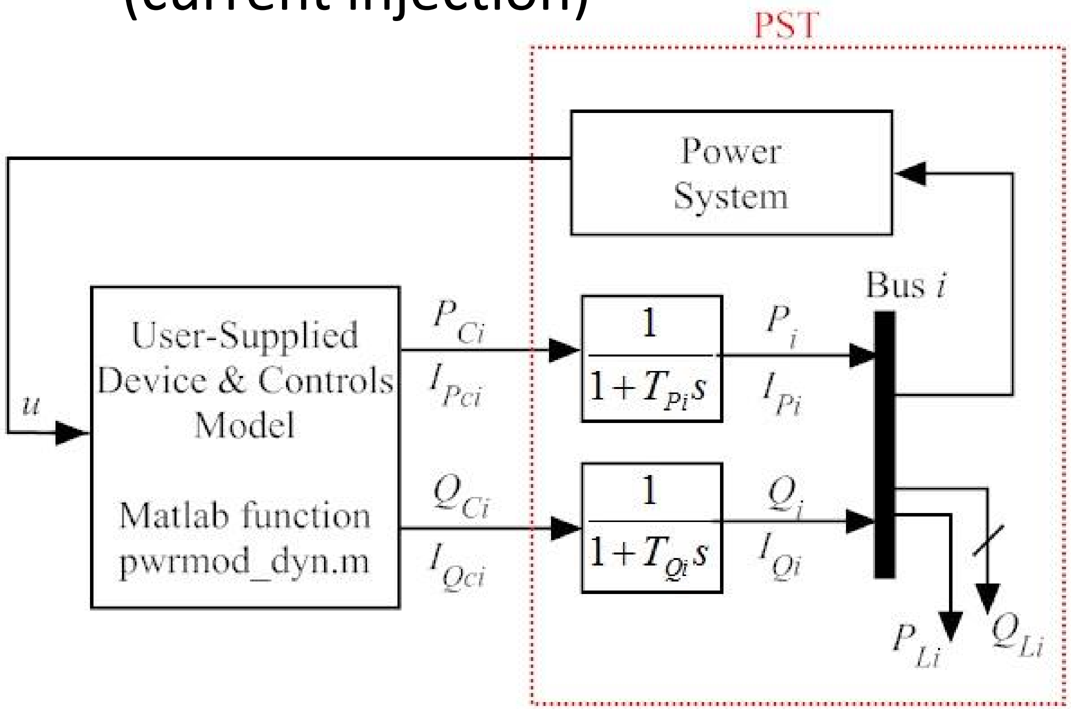
What is needed are:

Improved numerical solvers to simulate fast & slow dynamics on longer time frames.

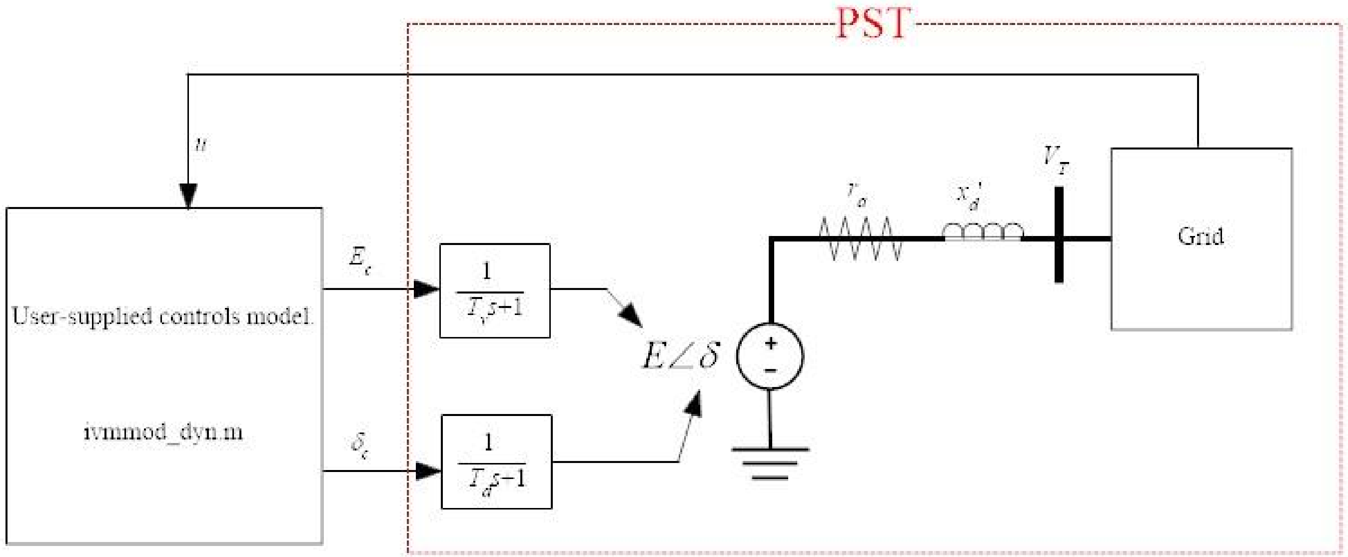
Results

Improved AGC, grid forming and grid following inverter models in PST

Grid following inverter model (current injection)

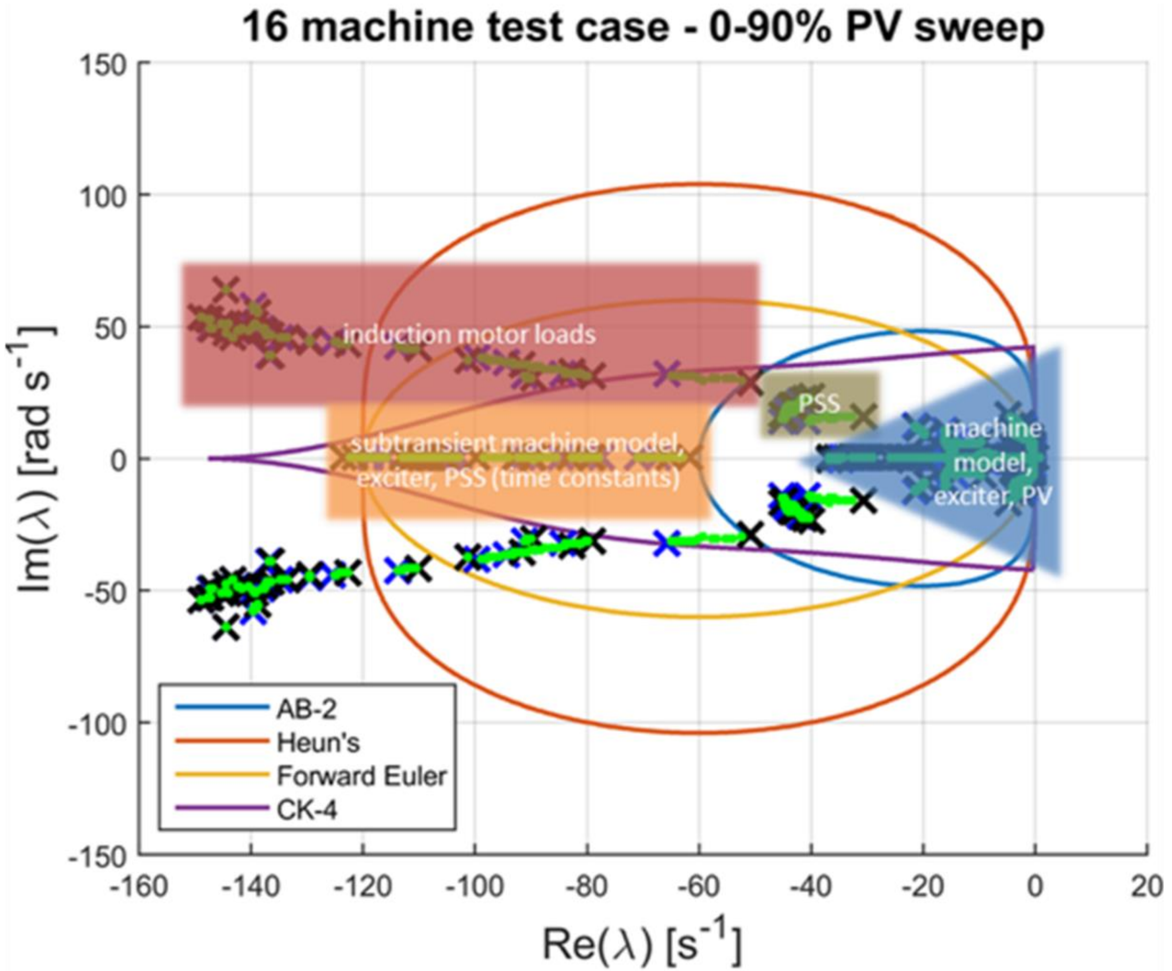


Grid forming inverter model (voltage injection)



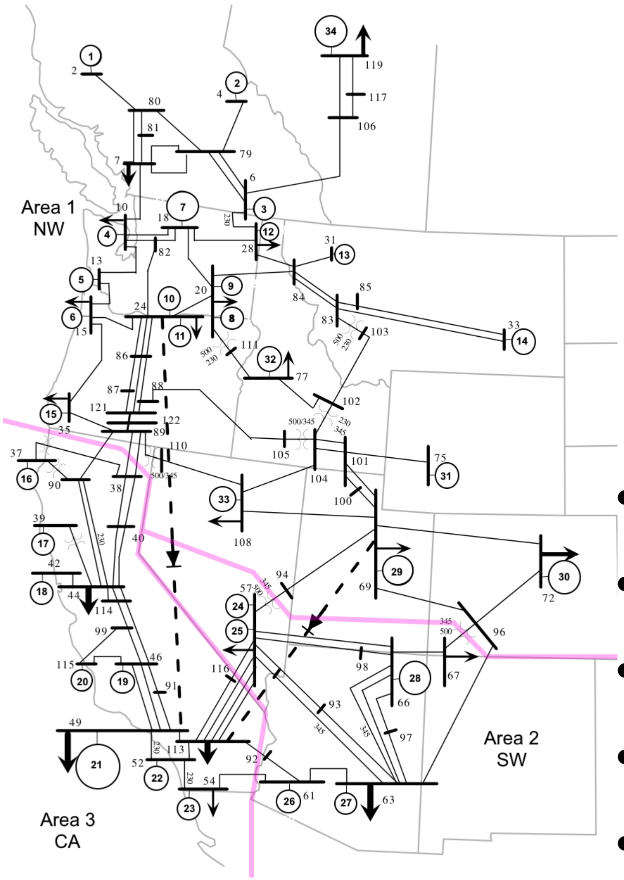
Results

- In the **variable time step** method, the time step can increase as fast transients subside.
- Conversely, the time step can be reduced to capture fast transients.
- This permits a reduction in the number of necessary iterations.
- Therefore, more complex integration schemes can be supported.



Regions of stability for four candidate integrators for a given step size. The poles of a representative power system are shown for reference.

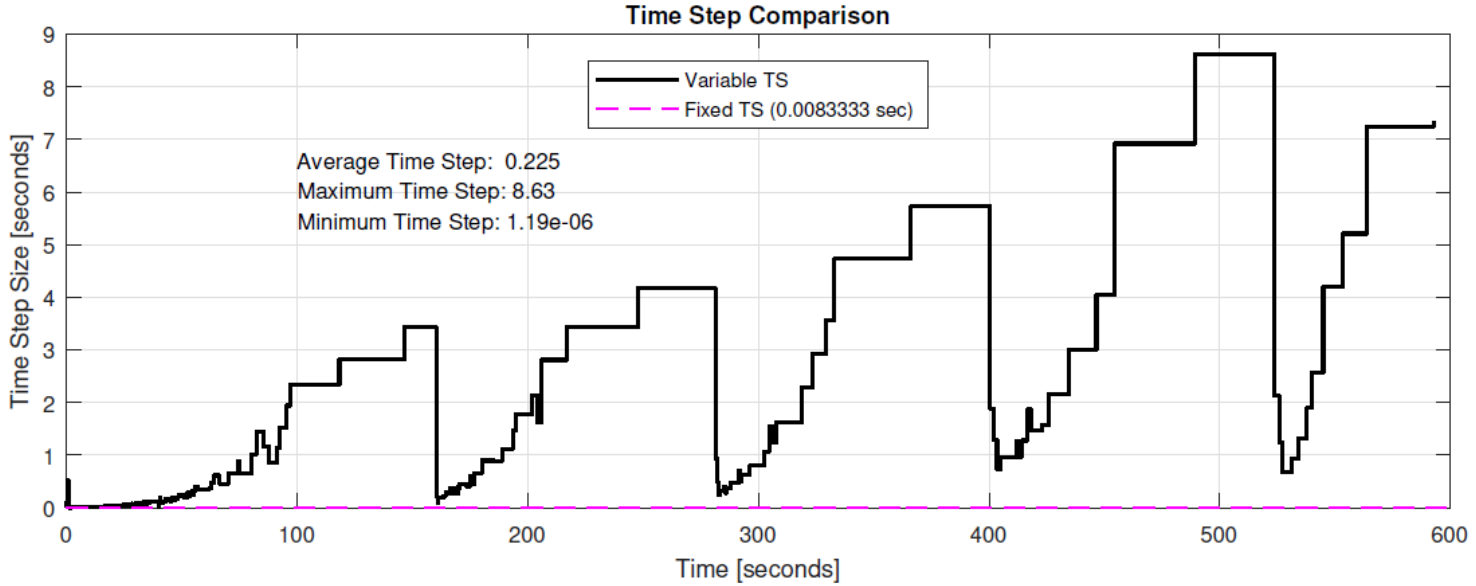
Results



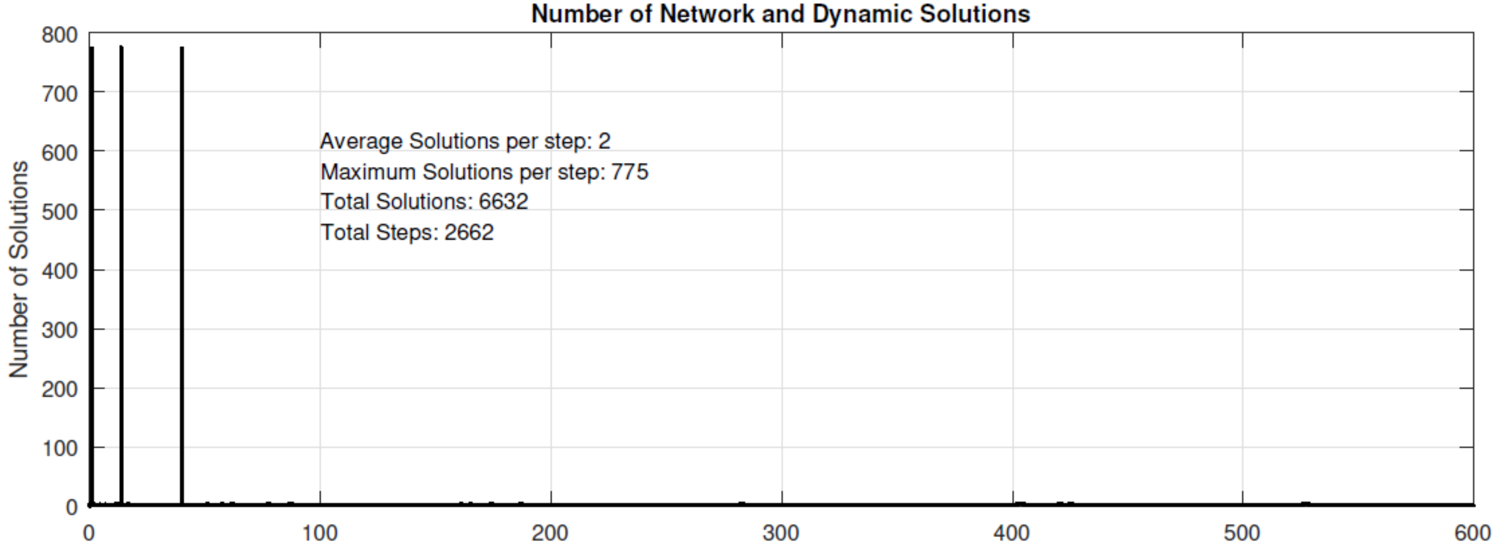
	Step Size [seconds]				Solutions Per Step				
Method	Max	Min	Ave	Total Steps	Ave	Max	Total Slns.	Sim. Time [seconds]	File Size [bytes]
Huen's	0.0083	8.33E-03	0.0083	72,001	2	2	144,002	483.64	778,259,381
ode23/ ode23t	8.6300	1.19E-06	0.0570	2,662	2	775	6,632	53.4	32,772,591
ΔRatio	0.001	7,000	0.146	27.05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

- VTS method is labeled ode23/ode23t. Fixed Time Step (FTS) method is Huen's.
- Model is MiniWECC: 122 buses, 171 lines, 88 loads, 34 generators, 623 states.
- Event is a +435 MW load step on Bus 2 at t=1 sec.
- Each area has identical AGC acting at t=40 sec and every 2 minutes thereafter.
- Simulation is run for 10 mins (600 secs).
- Results: VTS runs 9 times faster than FTS and 24 times smaller output file size.

Results



Comparison of time step size for variable time step and fixed time step methods.



Plot of number of network (algebraic) and dynamic (ODE) solutions for VTS method.

Conclusions/Recommendations

- New numerical methods and improved models have been developed to address the need for longer simulation times of systems with dynamics on widely varying time scales.
- These methods and models have been implemented on large-scale grid examples using PST.
- PST repository link: https://github.com/thadhaines/MT-Tech-SETO
- PST repository contents: Datasets, Models, PST/Matlab Code, Documentation of results
- Manual available at: https://github.com/thadhaines/MT-Tech-SETO/blob/master/PST/literature/PST4UserManual-1.0.0.pdf

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