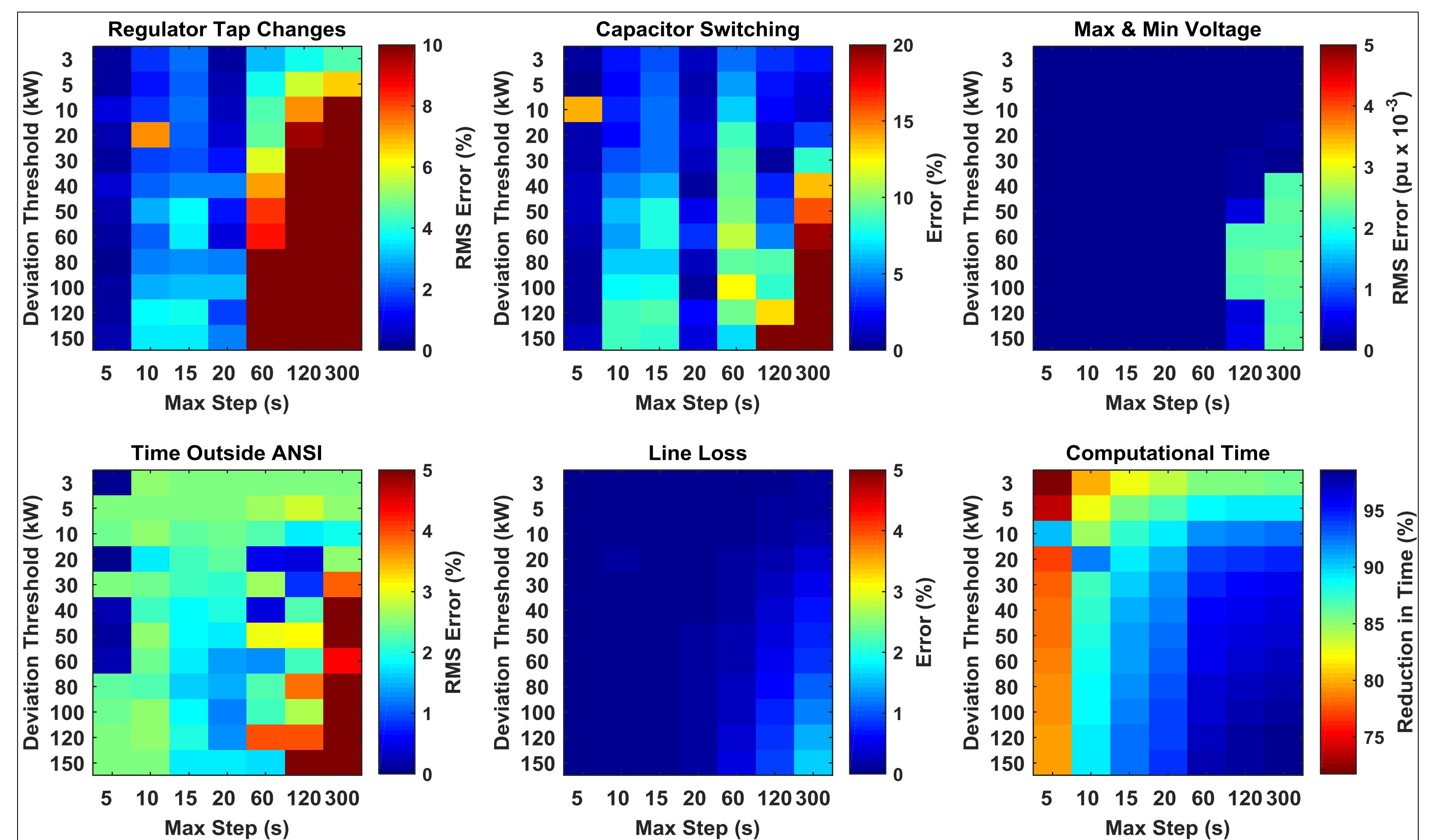


Predetermined Time-Step Solver for Rapid Quasi-Static Time Series (QSTS) of Distribution Systems

Matthew J. Reno and Robert J. Broderick
Sandia National Laboratories, Albuquerque, NM, USA

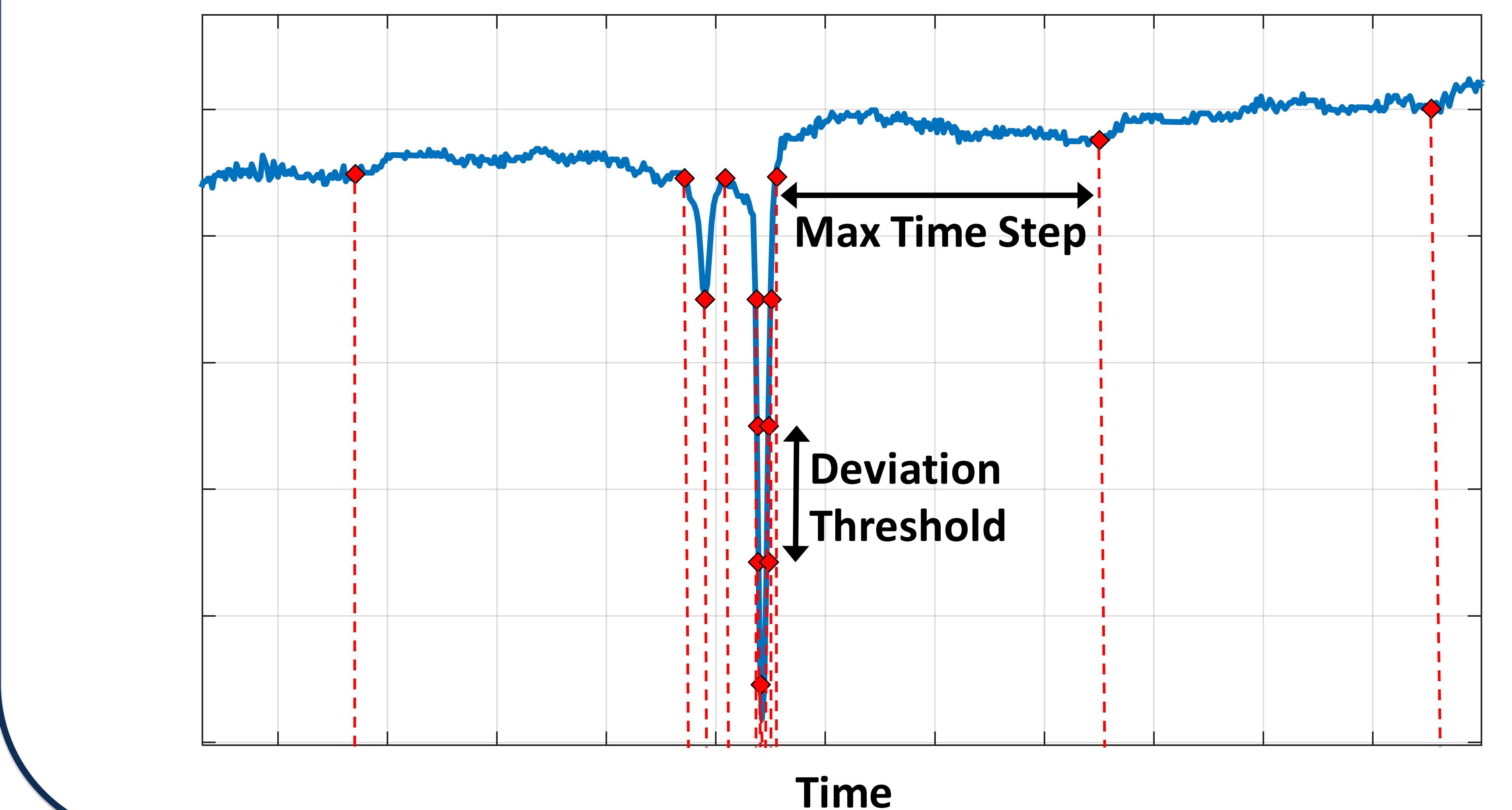
Abstract

Distribution system analysis with high penetrations of distributed energy resources (DER) requires quasi-static time-series (QSTS) analysis to capture the time-varying and time-dependent aspects of the system, but current QSTS algorithms are prohibitively burdensome and computationally intensive. This paper proposes a deviation-based algorithm to calculate the critical time periods when QSTS simulations should be solved at higher or lower time-resolution. This predetermined time-step (PT) solver is a new method of performing variable time-step simulations based solely on the input data. The PT solver demonstrates high accuracy while performing the simulation up to 20 times faster.

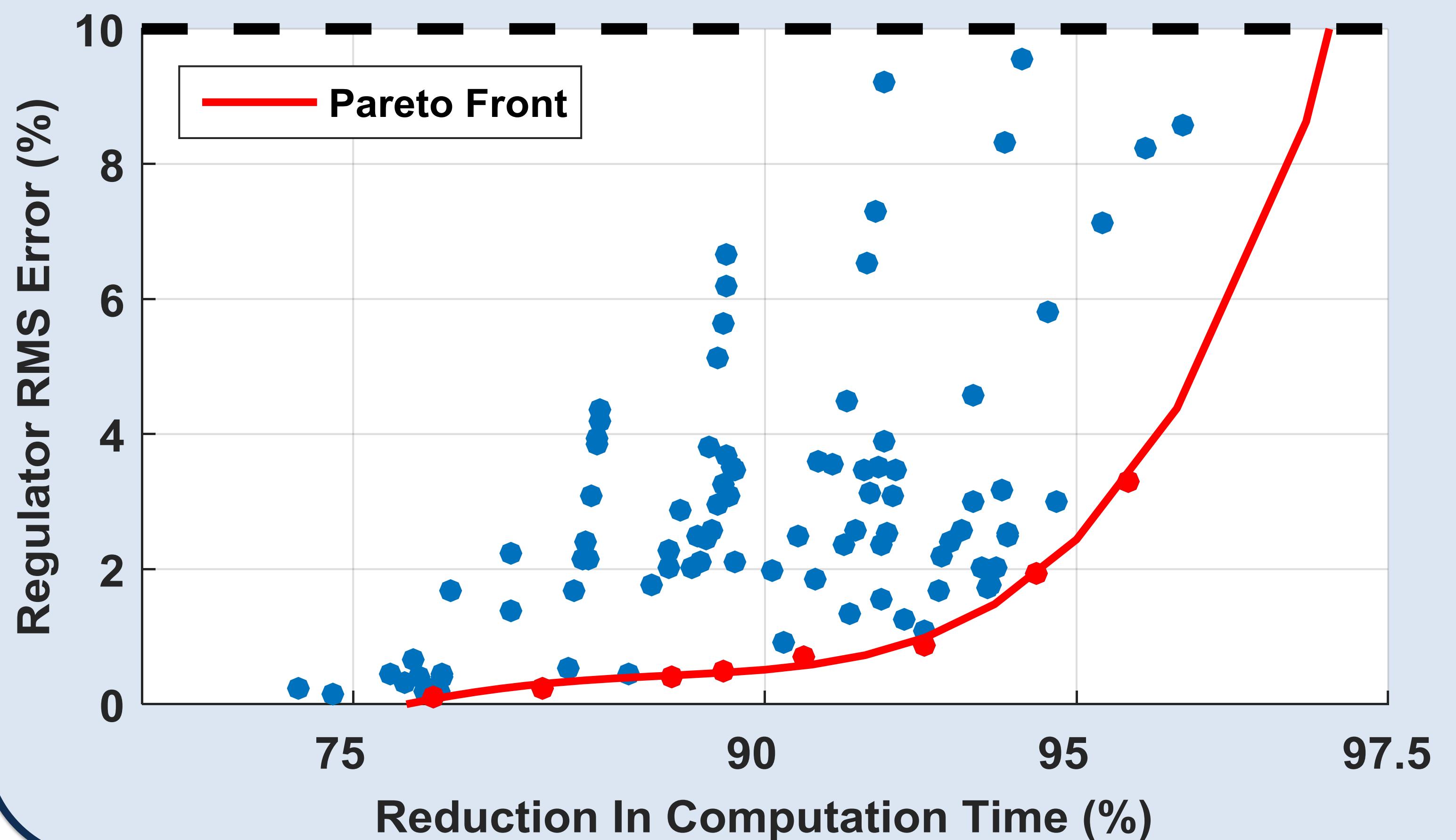


Predetermined Time-Step Algorithm

- Traditionally QSTS solves the time-series power flow simulation at fixed time-steps
- The proposed predetermined time-step algorithm is a type of variable time-step solver that does not solve every time-step by skipping forward to time points of interest
- The computational burden for QSTS is dramatically reduced by solving fewer load flows
- Preprocessing the load and generation time-series data in order to define the time-steps without any interaction with the power flow engine
- PT solver has two tuning parameters (max time-step and deviation threshold)



Optimal PT Solver Settings



Deviation Threshold (kW)	Max Time Step (s)	Tap Changes Per Regulator	Capacitor Switches	Max Voltage	Min Voltage	Hours Above ANSI	Hours Below ANSI	Total Line Losses	Percent Reduction
Base Case		7048,7222,8449	2504	1.0607pu	0.9673pu	22.1h	11.5h	146.0 MWh	
90	5	0.1%,0.1%,-0.2%	0.6%	-0.0000pu	0.0000pu	-0.1%	3.3%	-0.04%	79.1%
3	20	-0.0%,0.2%,-0.4%	1.0%	-0.0000pu	0.0000pu	0.0%	3.5%	-0.03%	83.6%
5	30	0.2%,0.7%,0.0%	11.7%	-0.0000pu	0.0001pu	0.0%	3.4%	0.01%	87.7%
10	20	-0.2%,-0.2%,-0.8%	1.1%	-0.0000pu	0.0000pu	0.0%	3.4%	-0.03%	89.0%
20	20	-0.6%,-0.5%,-0.9%	1.4%	-0.0000pu	-0.0000pu	0.0%	3.3%	-0.04%	90.8%
60	20	-0.2%,-0.1%,-1.5%	3.2%	-0.0000pu	0.0000pu	-0.6%	1.8%	-0.11%	93.0%
40	40	-1.6%,-1.4%,-2.6%	17.4%	-0.0000pu	-0.0000pu	-0.2%	2.9%	-0.03%	94.5%
60	45	-3.2%,-2.7%,-3.9%	18.8%	-0.0000pu	0.0000pu	-0.7%	2.2%	-0.11%	95.5%