SOLAR ENERGY
TECHNOLOGIES OFFICE
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Rapid QSTS Simulations for High-Resolution Comprehensive Assessment of Distributed PV

SETO Portfolio Review

Integration of Solar in the Distribution System

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Quasi-Static Time-Series (QSTS)

What is QSTS?

Quasi-static time series (QSTS) analysis captures time-dependent aspects of power flow, including the interaction between the daily changes in load and PV output and control actions by feeder devices and advanced inverters.

What is the problem with today's tools?

Snapshot analyses and other methods that only investigate specific and limited time periods can be overly pessimistic about PV impacts. They do not include the geographic and temporal diversity in PV production and load and the interaction with control systems may not be adequately analyzed.

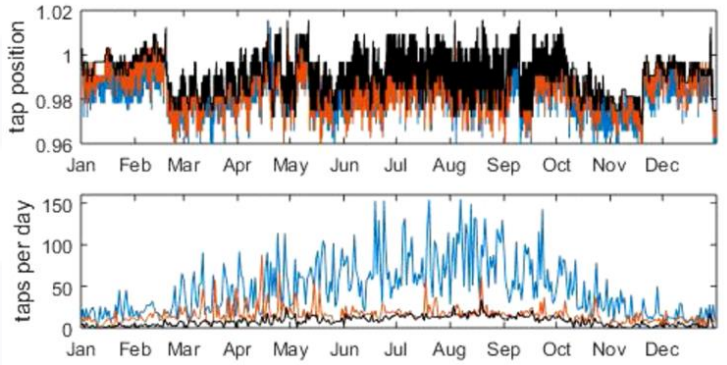
Why do we need QSTS?

QSTS simulations are needed today to understand:

- Rapid fluctuations due to high variable PV
- Impact to voltage regulators and switch capacitors
- Temporary extreme conditions before controls react

The need will continue to increase in the future:

- Study interactions between advanced inverters with volt-var
- Simulate fast operating FACTS devices
- Research new distribution control strategies



Yearlong QSTS for Regulator Tap Position

"You can't manage what you can't measure"

-P. Drucker

Progression of Impact Study Methods and Tools

	Extreme Voltages	Thermal Loading	Regulators Tap Changes	Capacitor Switching	Time outside ANSI	Losses	Computation Time[1]
Snapshot	Good	Good	-	-	-	-	<1 sec
Hourly Timeseries	Great	Great	-	-	Good	Great	5 sec
1 day QSTS	Poor	Poor	Decent	Decent	Poor	Poor	5 minutes
1 year QSTS	Great	Great	Great	Great	Great	Great	36 hours
New Rapid QSTS Algorithms	Great	Great	Great	Great	Great	Great	30 sec

Our new rapid QSTS algorithms maintain the accuracy of high-resolution yearlong QSTS simulations

…..while solving in a fraction of the time

Results of the QSTS Project for PY 1 & PY 2

- We have developed a portfolio of rapid QSTS algorithms, each demonstrating significant speed improvements
- Algorithms can be combined for additional speed
  - For example: a reduced circuit can be simulated with a variable time-step separated onto several parallel cores
- The project was targeting 1400x speed improvement:

$$\frac{120\ \text{hours}}{\underbrace{10}_{\text{Fast Timeseries}} \times \underbrace{2}_{\text{Improved Power Flow Solution}} \times \underbrace{10}_{\text{Circuit Reduction}} \times \underbrace{7}_{\text{Parallelization}}} = 5\ \text{minutes}$$

- Project has been extremely successful and in research settings we may be able to achieve even faster speeds reaching greater than **100,000x faster**

$$\underbrace{200}_{\text{Fast Timeseries}} \times \underbrace{5}_{\text{Improved Power Flow Solution}} \times \underbrace{20}_{\text{Circuit Reduction}} \times \underbrace{7}_{\text{Parallelization}}$$

Innovation in QSTS >> greater amounts of Solar with better grid performance

- Our proposal is addressing key challenges in Grid Performance and Reliability for the integration of ever increasing amounts of PV into the distribution system.
- We are making great progress to dramatically increase the computational speed of QSTS analyses for evaluating the impact of PV.

Key Outcomes

- Integrate rapid QSTS capability into utility distribution planning and operations solving complex integration problems in minutes verses days
- Allow penetrations of 100% or more of peak load by 2020 by accurately determining the expected impact of a PV system's requesting interconnection
- Speed up the interconnection approval time by speeding up the key analysis required for determining the impact of PV.
- Accelerate a decrease in study costs for interconnections by reducing the amount of labor hours required per interconnection study.

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