



Time Series Simulation for Slow Dynamic Analysis in Distribution Systems with DERs

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Introduction

■ Scope of the “slow dynamics”

- RMS value related, not instantaneous
- Traditional voltage regulation (control of LTC, VR, cap)
- Protection (network protector, DG voltage protection)
- DER voltage support

■ Why need time series simulation

- Single snapshot load-flow based analysis is not enough
- EMTP type simulation is time consuming.

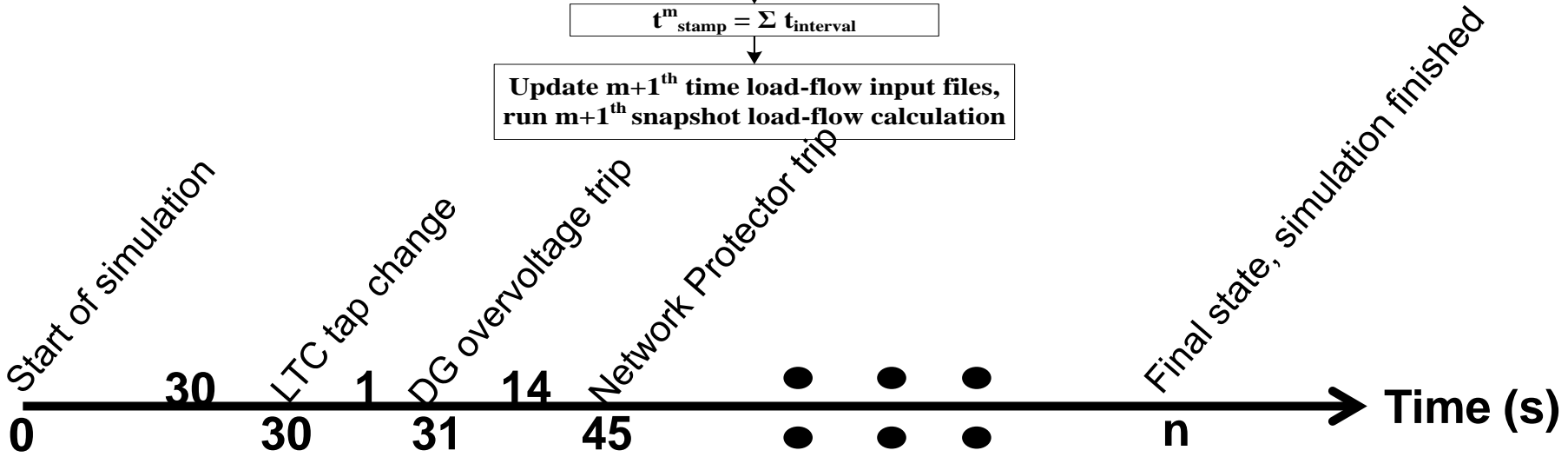
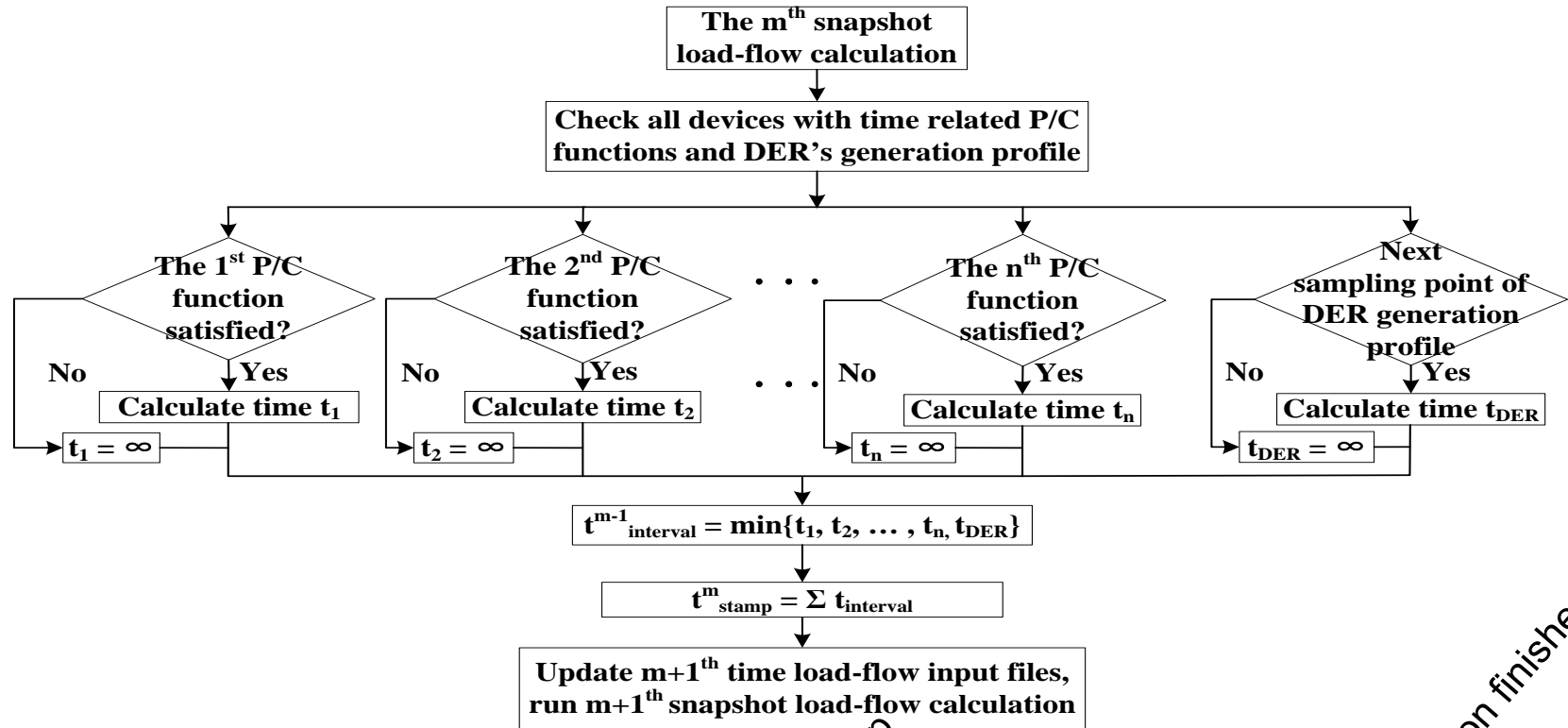
■ Challenges in time series simulation

- Need coordinate all devices in the simulation but not only LTC, VR and Cap.

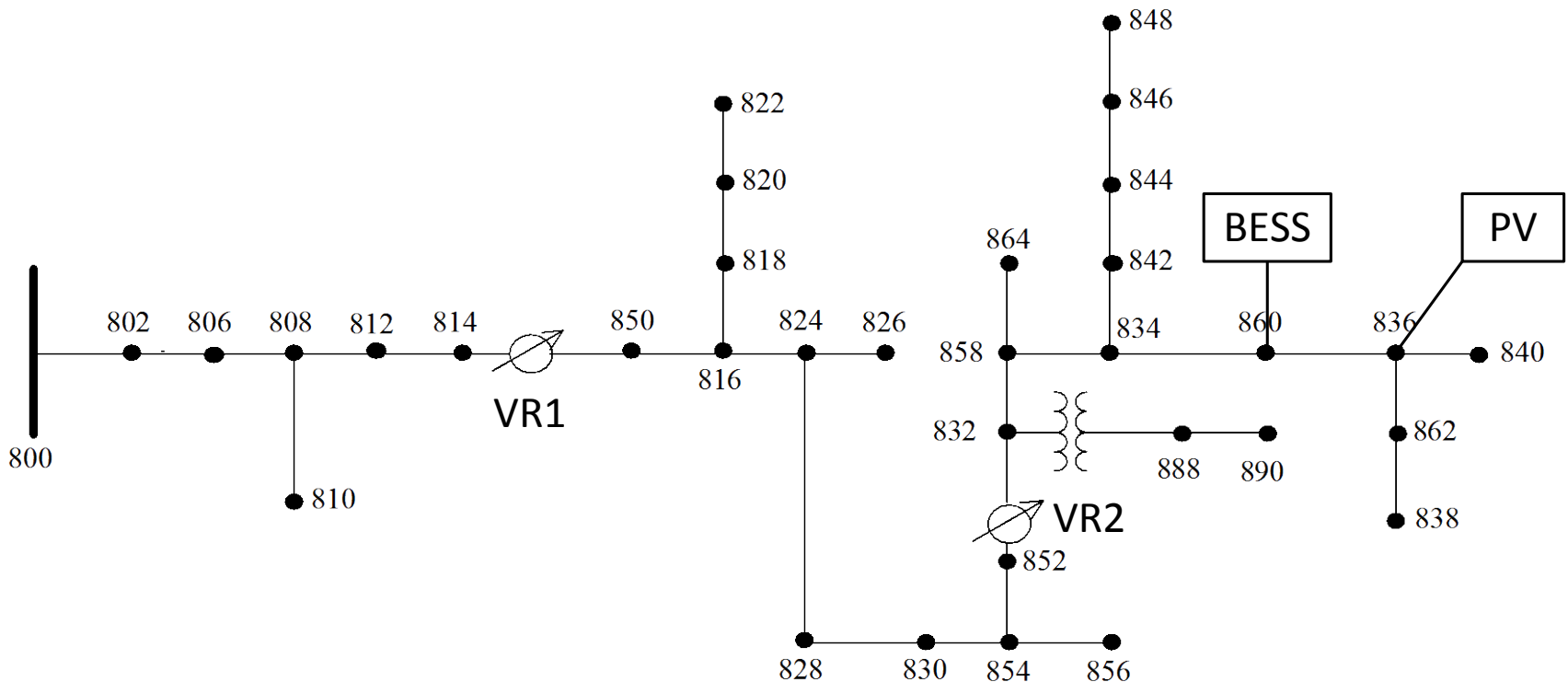
Proposed Simulation Method

- Multiple snapshot load-flow calculation
- Procedures of the simulation technology
 - Initialization (the first snapshot load-flow calculation)
 - Prepare next snapshot of load-flow calculation
 - End of simulation (the final snapshot load-flow calculation)

Proposed Simulation Technology (Cont.)



Simulations and Results

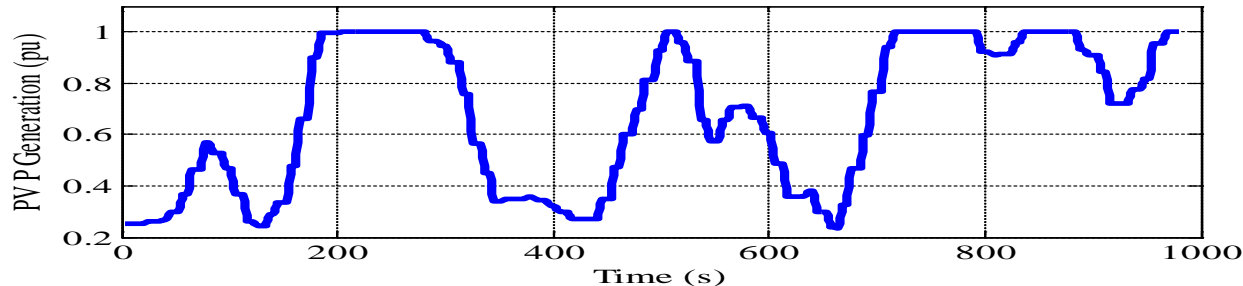


Modified IEEE 34-bus test feeder
Modeled in both proposed method and PSCAD

Simulations and Results (Cont.)

■ Case 1- Simulation of PV dynamic voltage support

➤ 500 kW PV 1000s generation profile



➤ PV voltage support function

- ❑ Assume PV var control is very fast
- ❑ Use load-flow iteration to simulate PV var generation control

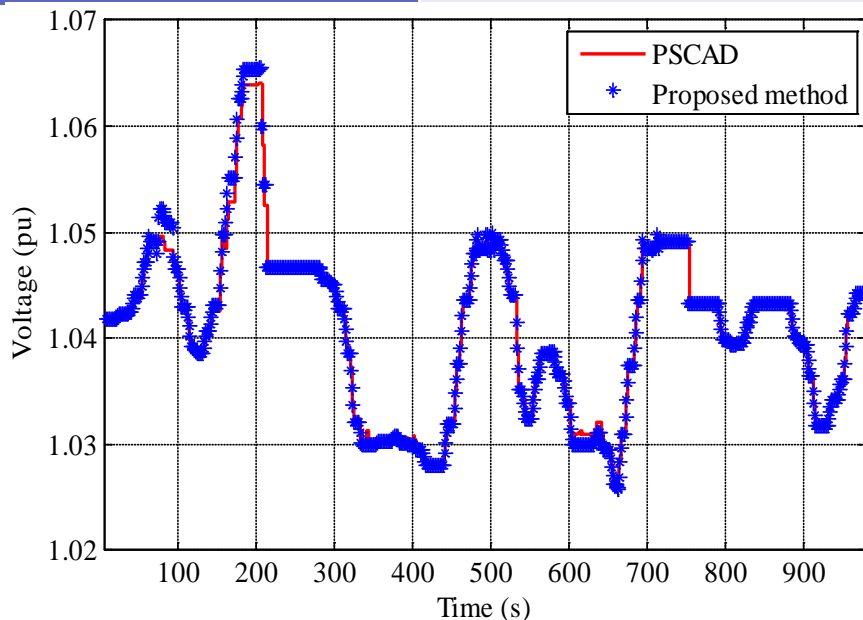
➤ Involved “P/C devices” in this case

- ❑ PV voltage support; control of VR1 and VR2

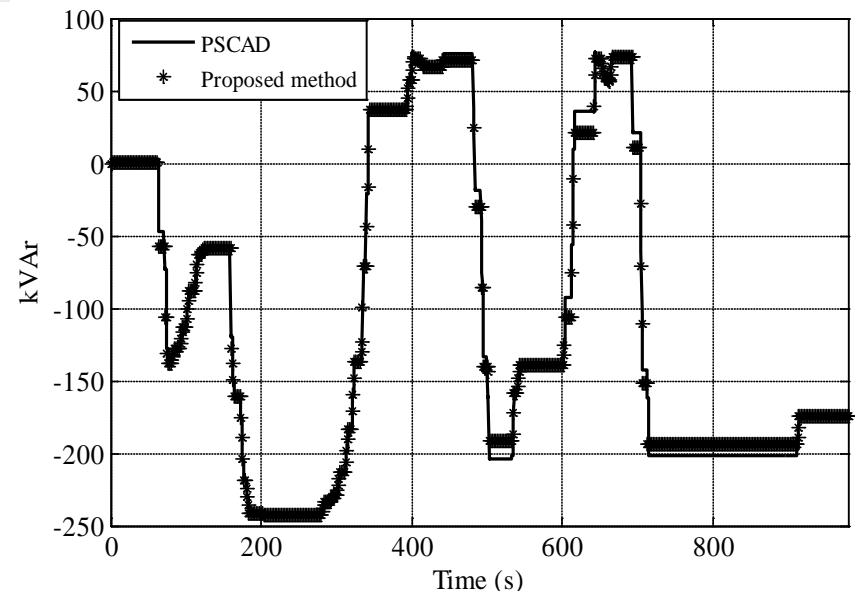
Simulations and Results (Cont.)

Comparison of voltage regulators tap position change

Voltage regulator	Tap position change		Tap changing time	
	Proposed method	PSCAD	Proposed method	PSCAD
VR1	From 10 to 9	From 10 to 9	209s	208s
	From 9 to 8	From 9 to 8	211s	210s
VR2	From 10 to 9	From 10 to 9	215s	214s
	From 9 to 8	From 9 to 8	754s	754s



Comparison of voltage at bus 836



Comparison of PV Q generation

Simulations and Results (Cont.)

- Case 2- Simulation of system with PV and BESS
 - Modeling of BESS
 - ❑ SOC is controlled within 5% (2.25 kWh) to 95% (42.75 kWh).
 - ❑ Bus voltage >1.06 , charge; bus voltage <1.035 , discharge
 - ❑ Bus voltage between 1.035 pu and 1.06 pu, BESS keeps status of charging or discharging or idling. PV voltage support function
 - Involved “P/C devices” in this case
 - ❑ PV voltage support; BESS control, control of VR1 and VR2

Simulations and Results (Cont.)

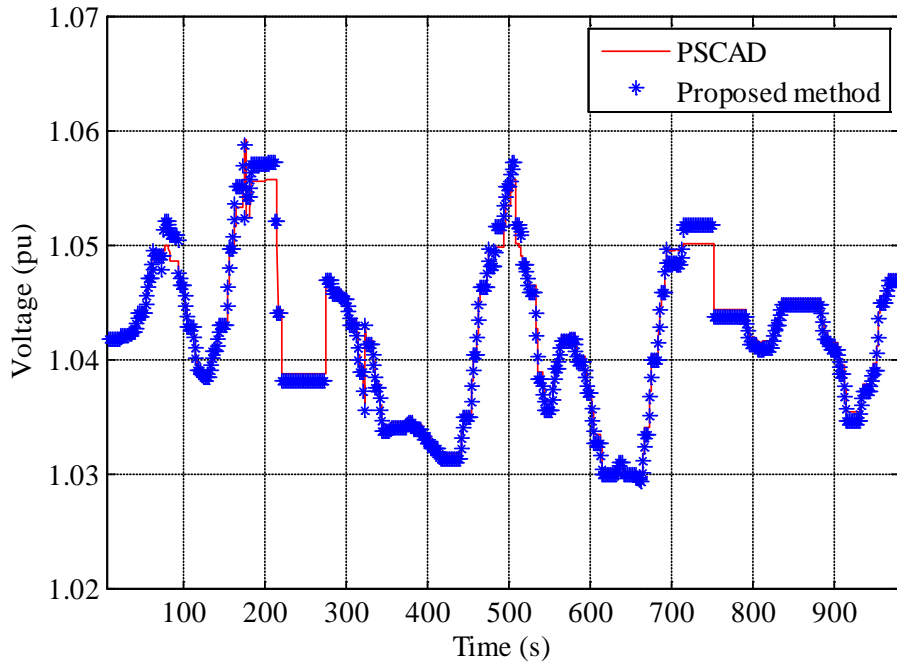
Comparison of voltage regulators tap position change

Voltage regulator	Tap position change		Tap changing time	
	Proposed method	PSCAD	Proposed method	PSCAD
VR1	From 10 to 9	From 10 to 9	222s	221s
	From 9 to 8	From 9 to 8	510s	508s
VR2	From 10 to 9	From 10 to 9	215s	214s
	From 9 to 8	From 9 to 8	217s	216s
	From 8 to 7	From 8 to 7	753s	752s

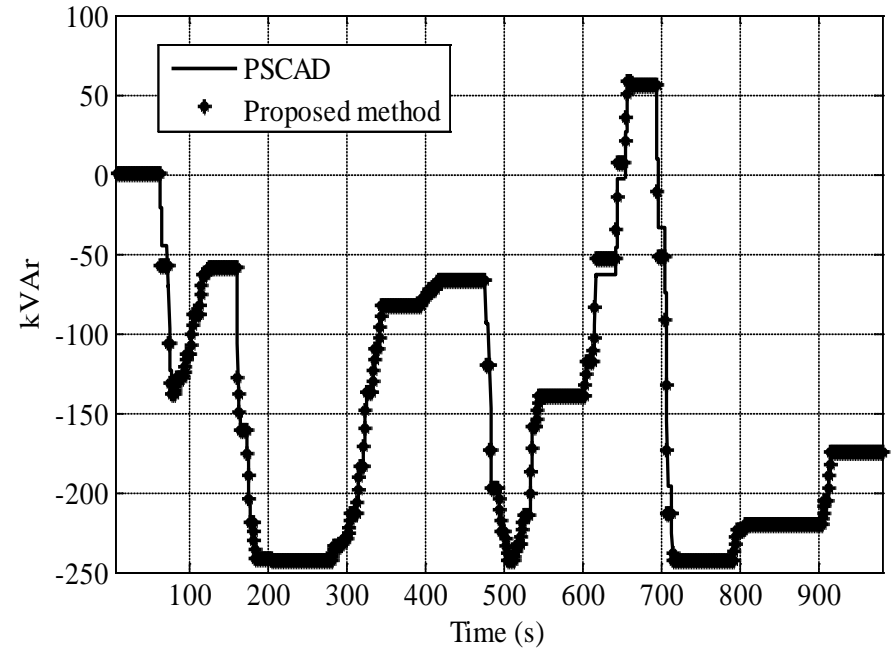
Comparison of BESS operations

Proposed method		PSCAD	
BESS SOC (kWh)	Duration time	BESS SOC (kWh)	Duration time
40	0-174s	40	0-176s
From 40 to 42.75	174-273s	From 40 to 42.75	176-275s
42.75	273-322s	42.75	275-323s
From 42.75 to 24.5	322-980s	From 42.75 to 24.5	323-980s

Simulations and Results (Cont.)



Comparison of voltage at bus 836



Comparison of PV Q generation

Conclusions

- Multiple snapshot load-flow calculation based simulation method for slow dynamic analysis for distribution system with DER is proposed
- Coordinate all P/C device in the network, “take picture” of critical stages of long term simulation.
- Showed high precision and efficiency by comparing with EMTP type simulation.



Thank you!
Questions?

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