Multi-Inverter Interaction with Advanced Grid Support Function

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Overview

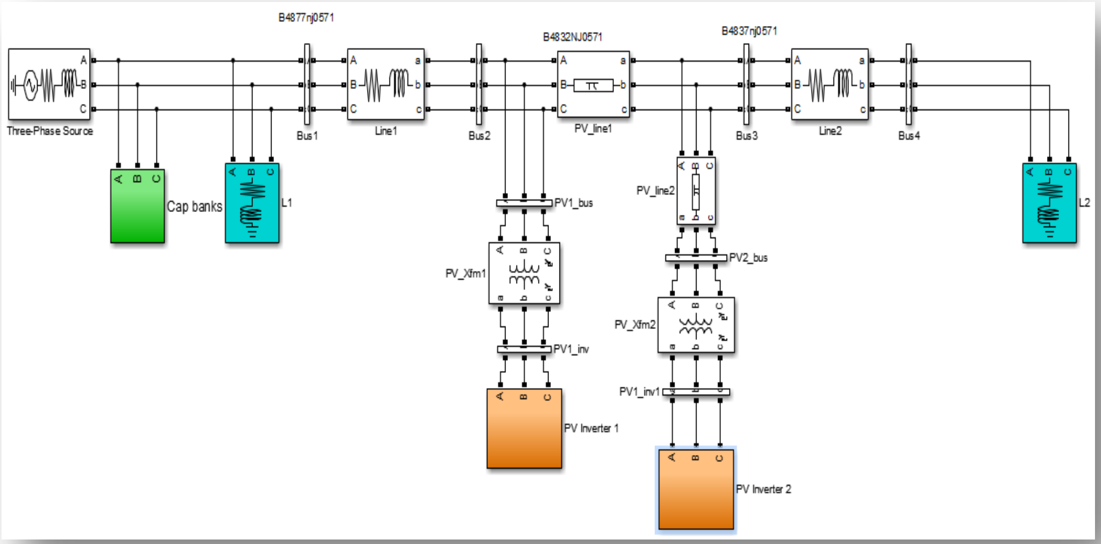
Objective	Approach
Raise awareness on potential inverter interactions resulting from smart inverter control on multiple DER systems	Simulation based study conducted in Matlab/Simulink to investigate possible inverter interaction

Assumption	Next Step
Generic PV inverter and control model Stable PV dc output Volt-var function Voltage perturbation generated by cap banks switch	On-site PQ meters to monitor and capture potential inverter interactions

Overall Approach

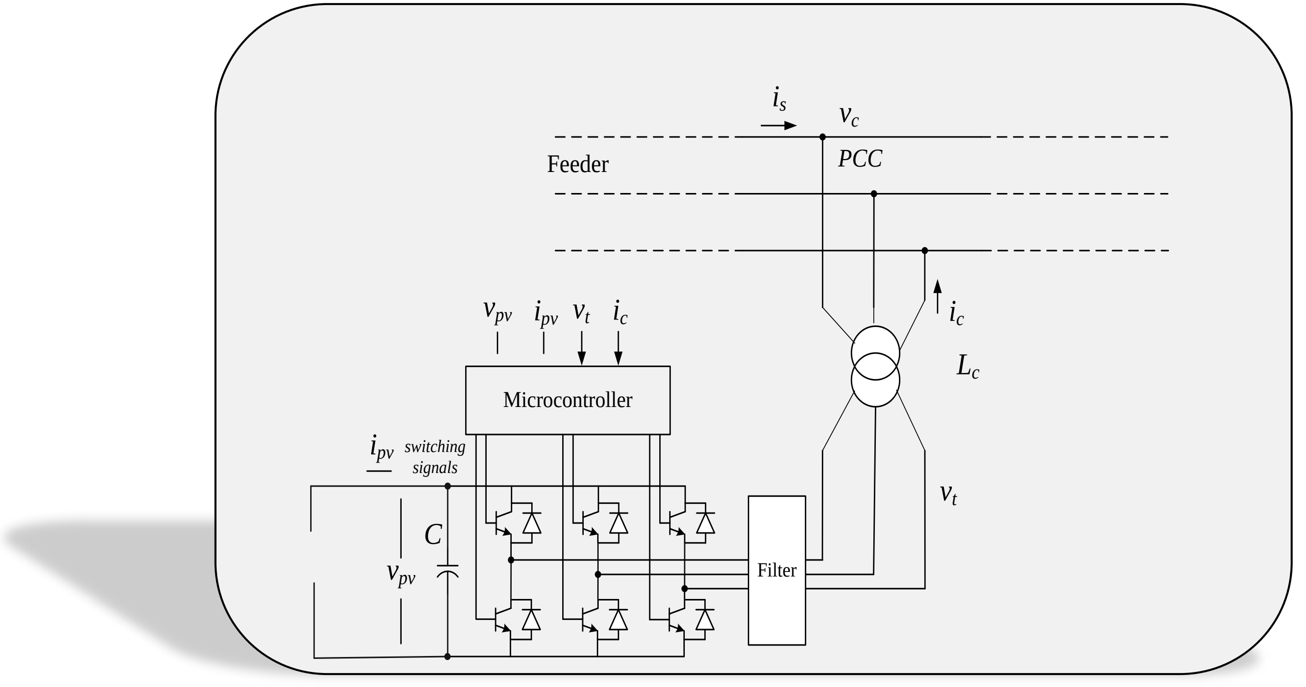
- Simplified distribution feeder model
- Two close, three-phase PV inverters
- Volt-var function
- Simulations with varying volt-var settings and controller settings for potential interactions

Simplified distribution feeder in Matlab/Simulink



Modeling Assumption
- PV Inverter

- Generic single-stage voltage source inverter configuration



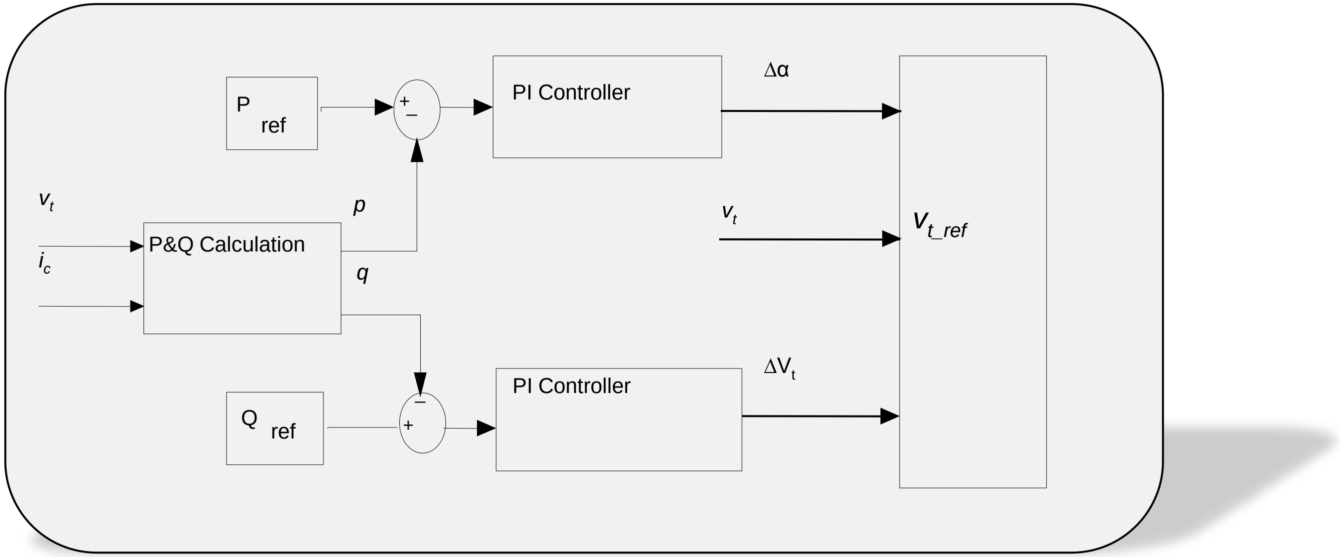
$$P = \frac{V_t V_c}{X_l} \sin \alpha \approx \frac{V_t V_c}{X_l} \alpha$$

$$Q = \frac{V_t}{X_l}(V_t - V_c \cos \alpha) \approx \frac{V_t}{X_l}(V_t - V_c)$$

- Stable PV dc power
- Inverter kVA>kW for var generation

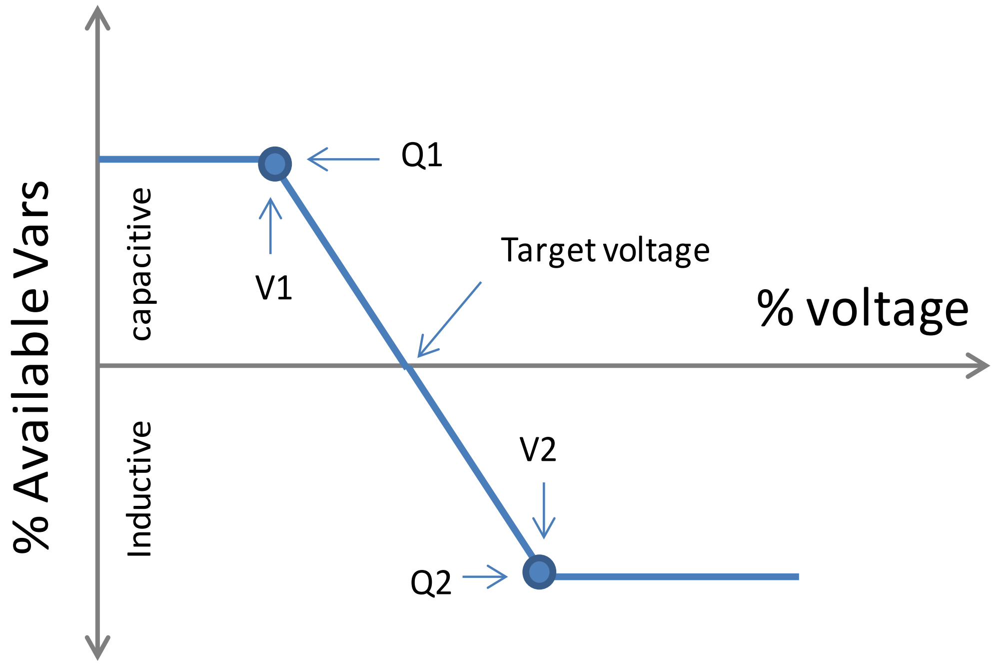
Modeling Assumption
- Inverter Control

- PI feedback control for active and reactive power control

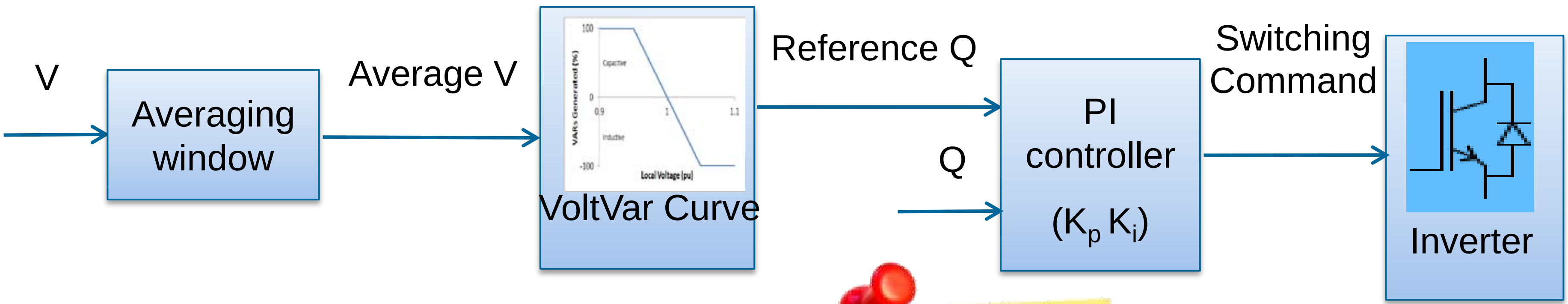


Volt-var Grid Support Function

- Var generation based on local voltage and volt-var curve definition



Var Control Flow

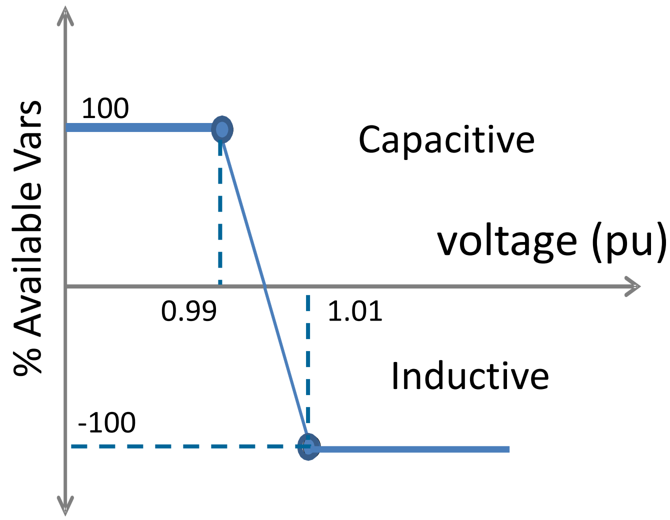


<u>Factors Involved in Var Control</u>

- Volt-var curve setting
- Inverter controller parameters
- Voltage averaging time

Potential Interactions
- Base case simulation settings

- Voltage deviation caused by capacitor banks switch at 10 *s*
- Volt-var curve



- Controller parameters

Kp	Ki
0.3	3

- Averaging window: 0.05 *s*

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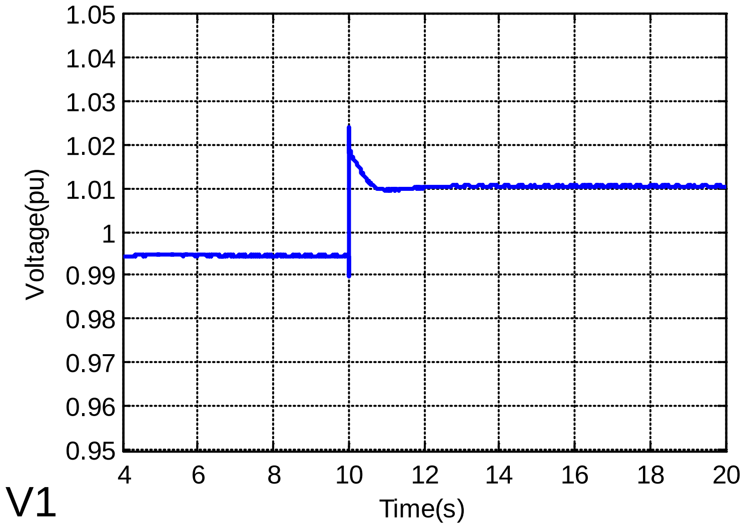
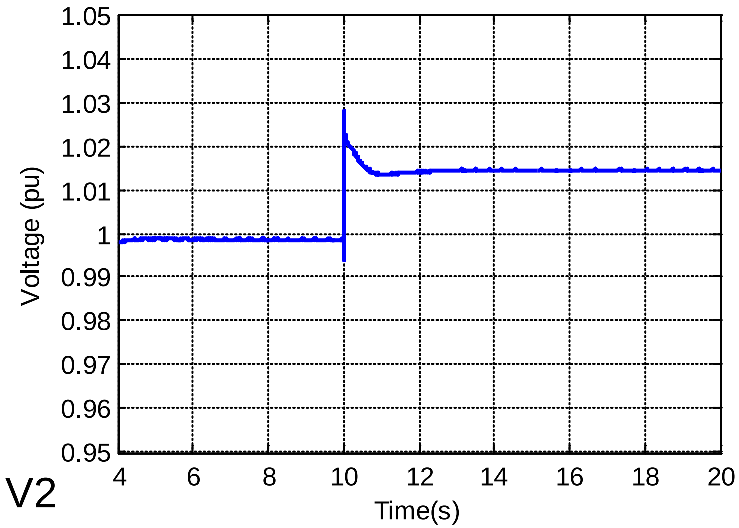
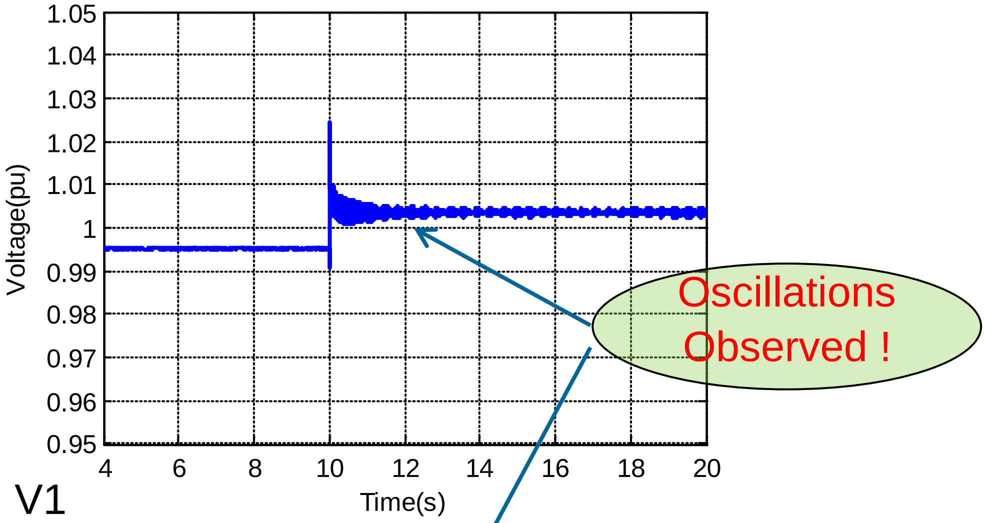
Potential Interactions
- Single inverter vs. Two inverters

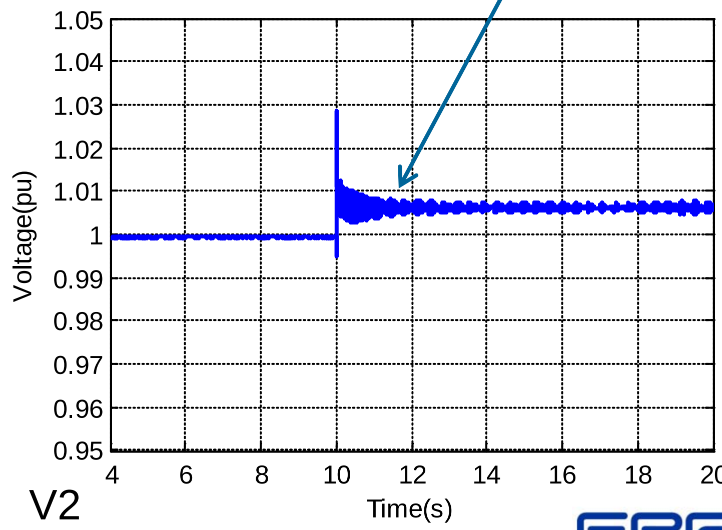
Single PV providing vars





Both PVs providing vars





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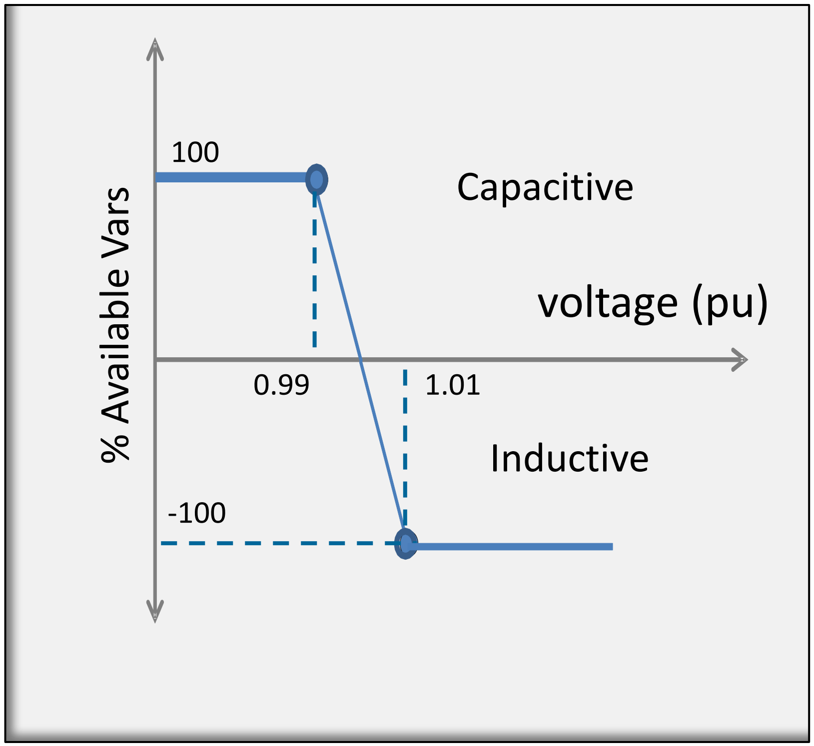
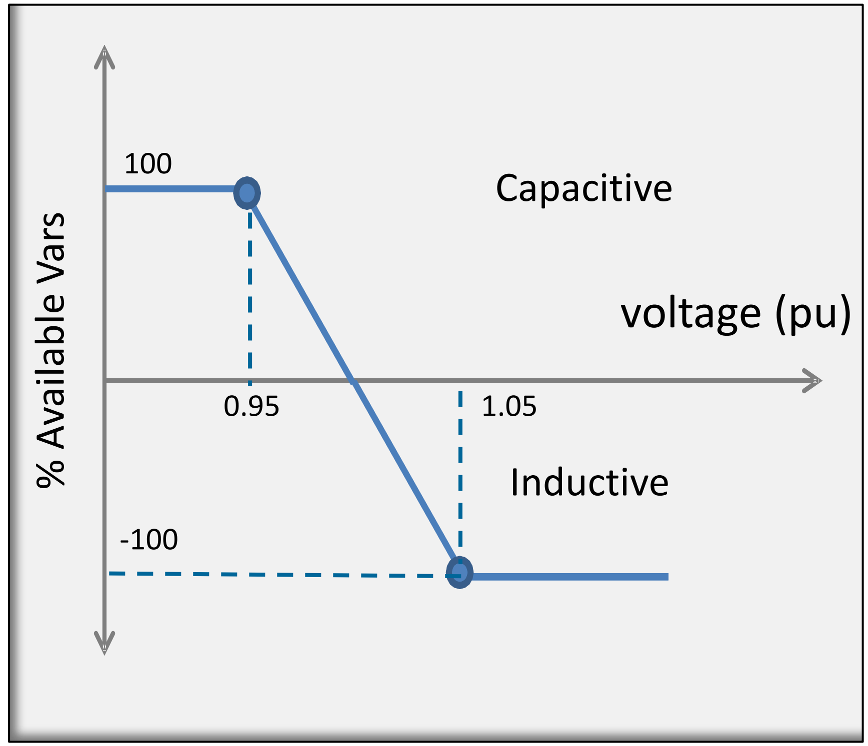
Impact of Volt-var Setting

Base case



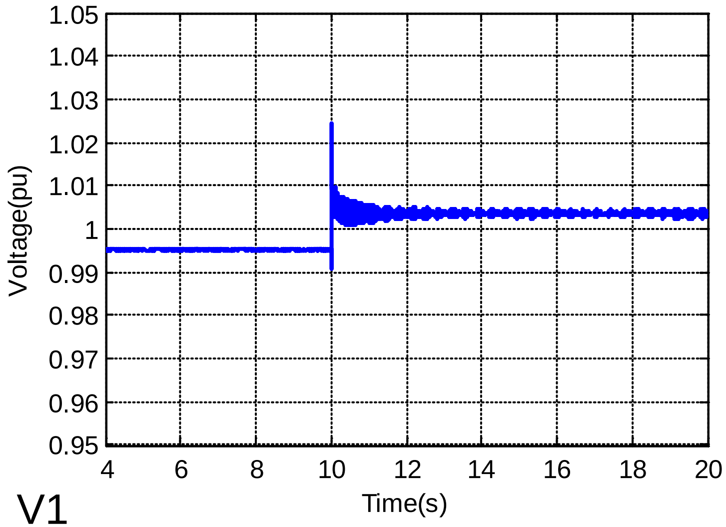
Compared Case



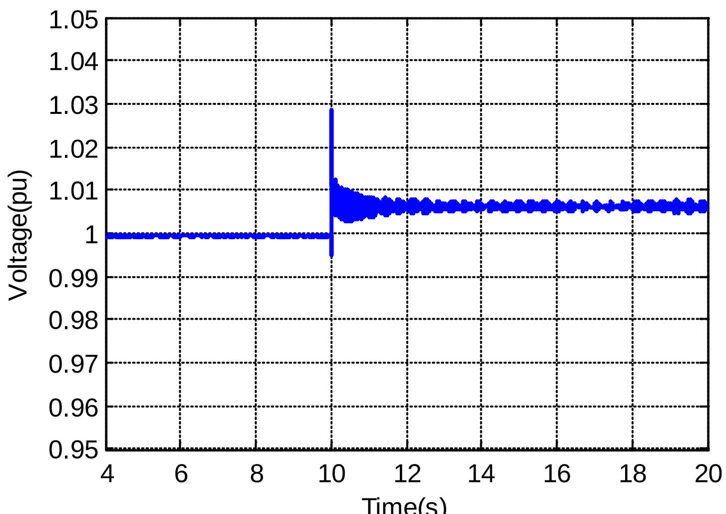
Voltage

Observation
Higher sensitivity of var/volt cause more visible interactions

Base Case

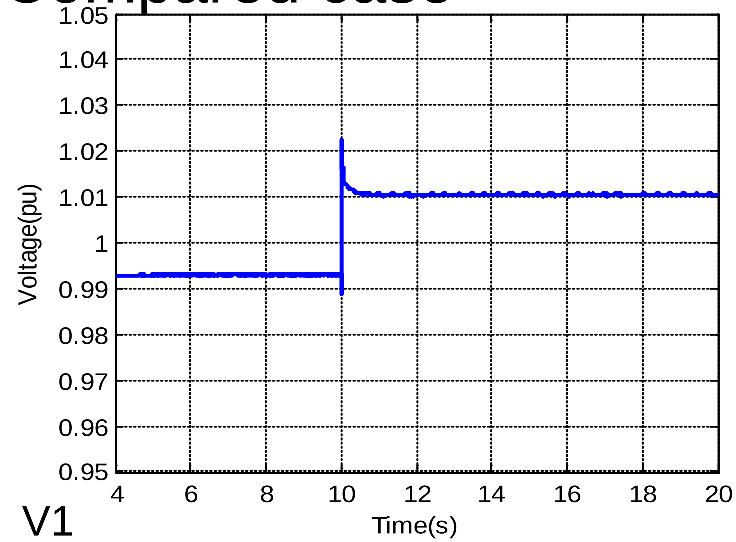


V1

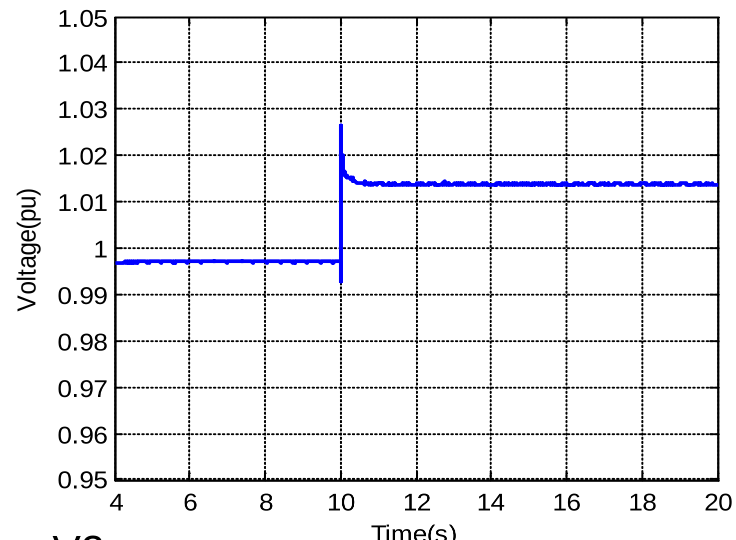


V2

Compared case



V1



V2

Impact of Controller Parameters

Base Case

Kp	Ki
0.3	3

Compared Case

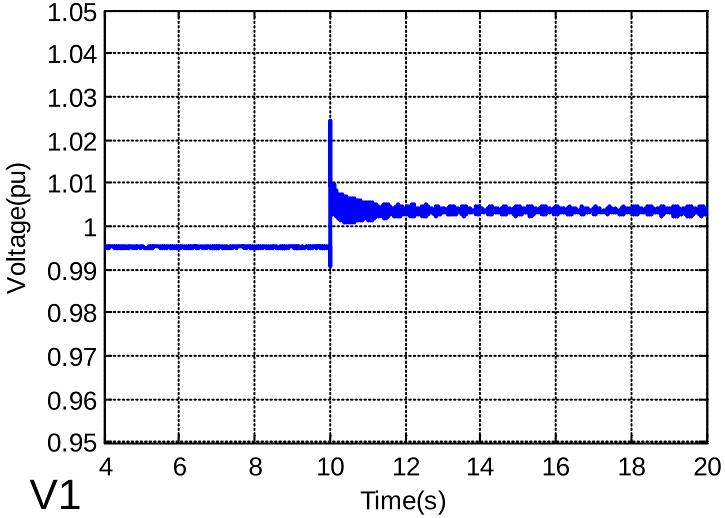
Kp	Ki
0.1	1

Voltages

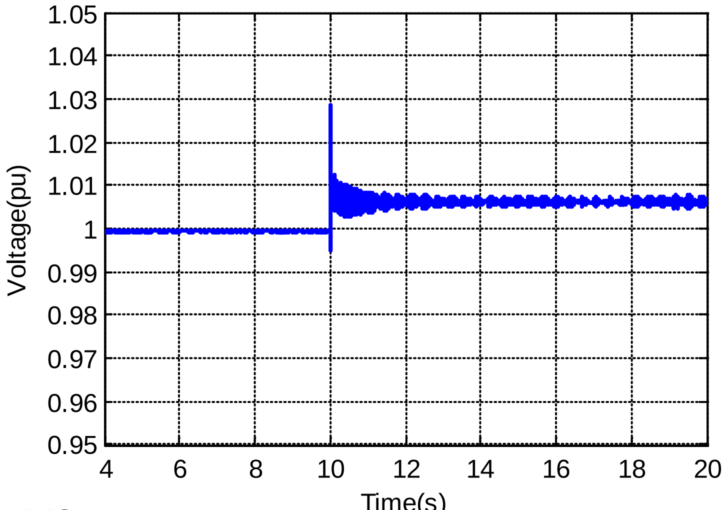
Observation

Smaller control parameters, which means smaller adjustments at each step, reduce the oscillations

Base Case

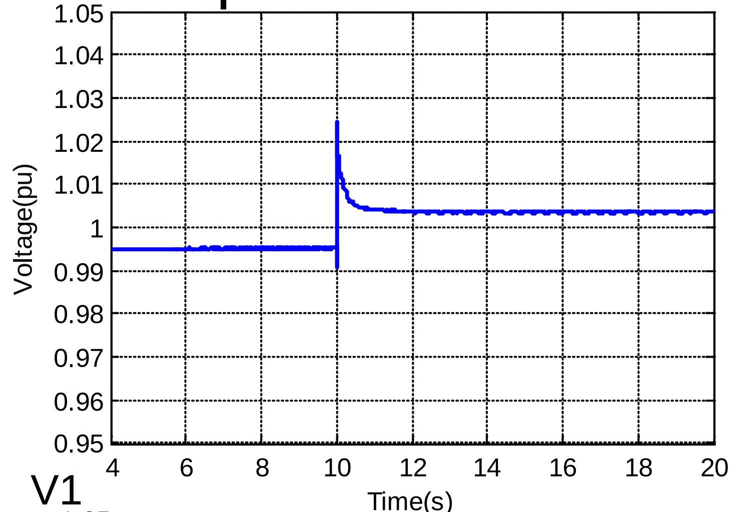


V1

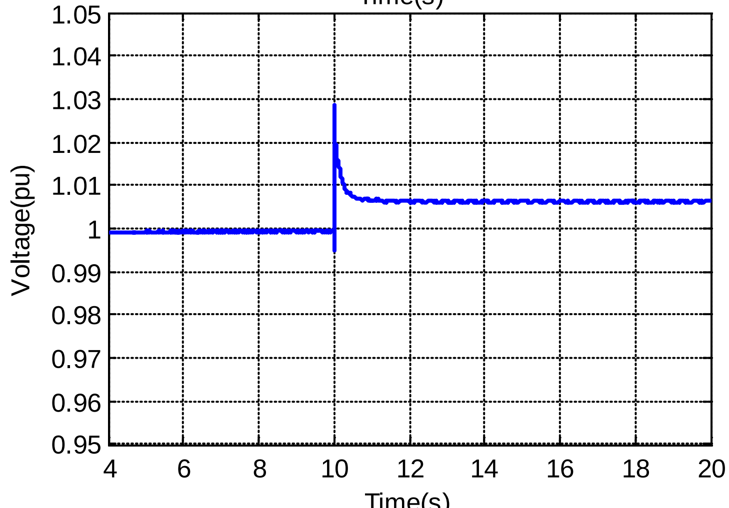


V2

Compared Case



V1



V2

Impact of Voltage Averaging Time

Base Case	→	Compared Case
Moving average window = 0.05 *s*		Moving average window = 1 s

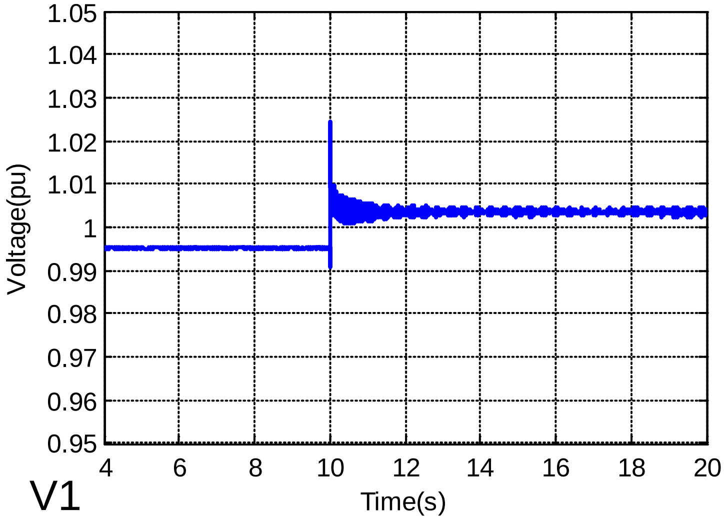
Voltage

Observation

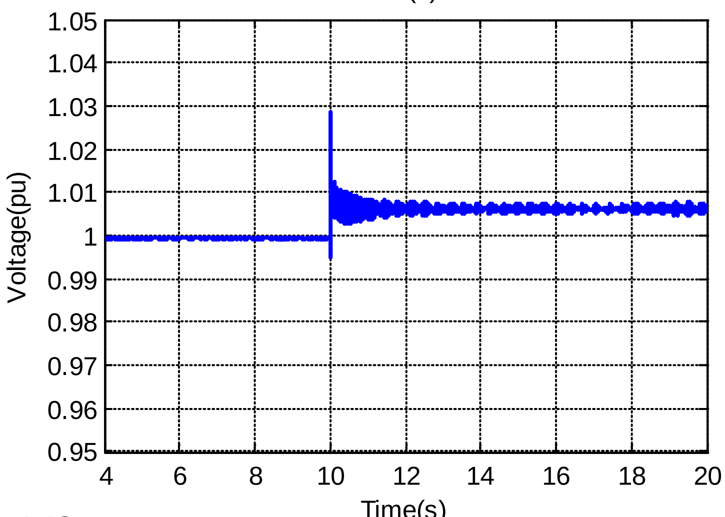
Two sides of longer averaging time

Slowing response could cause large oscillation initially but smoother var as a result of long averaging time helps dampen out the oscillation eventually

Base Case

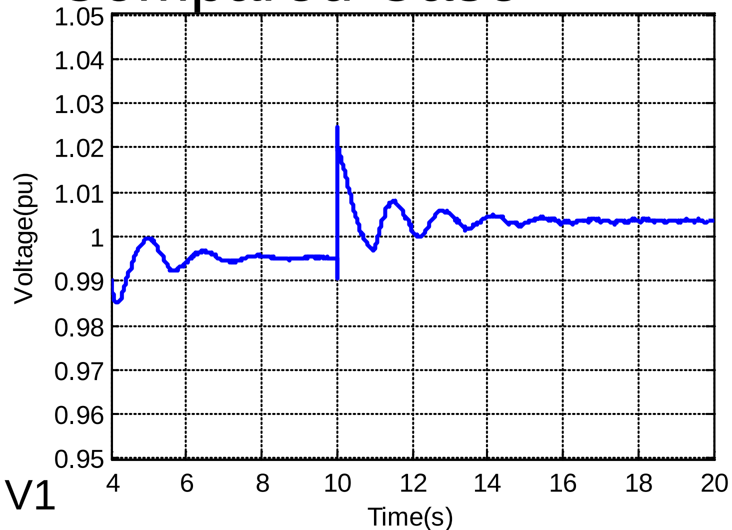


V1

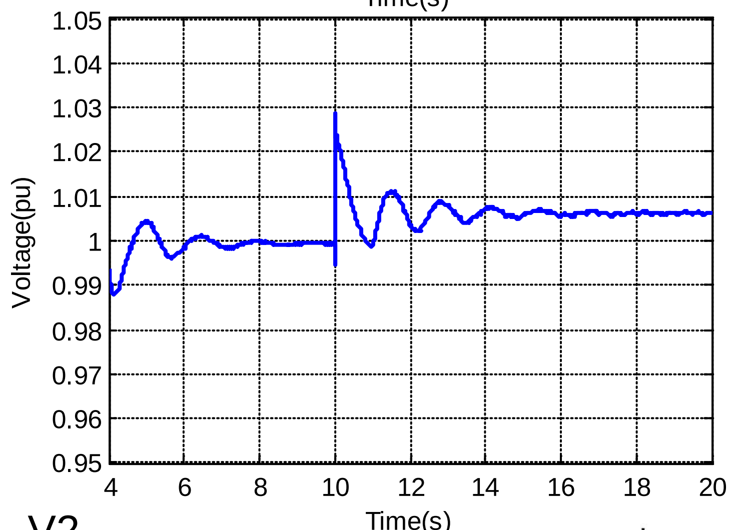


V2

Compared Case



V1



V2

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Collusions & Next Step

- Interactions potentially exist between the two close inverters and could pose challenges on system.
- Settings of the factors involved in the control flow have impacts on potential interactions.
- Further studies and field demonstration/measurement are needed to better understand the interactions and to provide insights on how to prevent possible adverse impacts.

Acknowledgement

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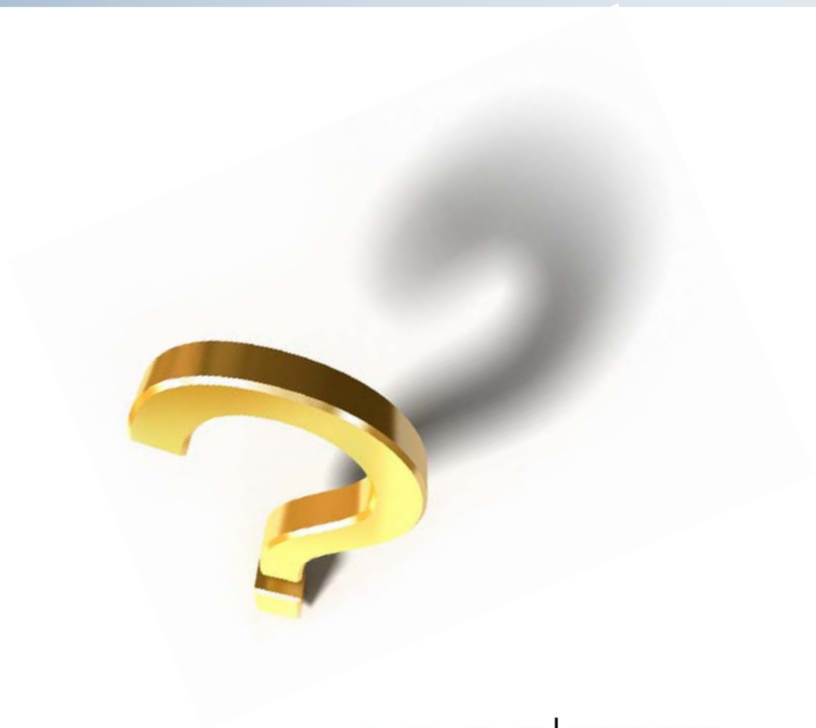
Questions and Interactive Discussion



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