Consensus-Based Distributed Voltage Regulation

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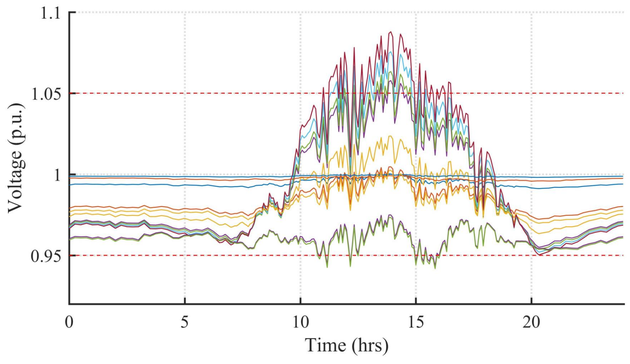
Introduction

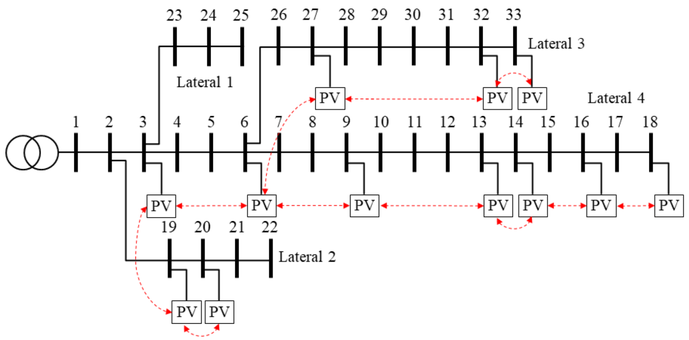
Rooftop photovoltaic (PV) are causing voltage problems:

Overvoltage; Fluctuation; Nodal magnitude difference



Distribution system voltage regulation requirements:

Distributed; Coordinated; Real-time;



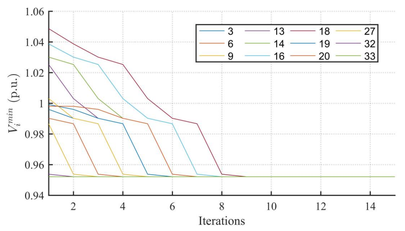
Distribution system voltage regulation objective:

Voltage range: $\underline{V} \leq V \leq \overline{V}$;

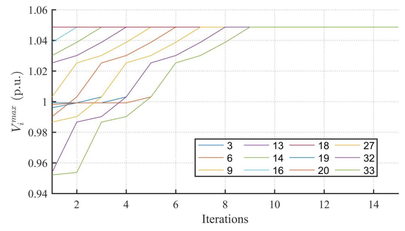
PV inverter reactive power range: $\underline{Q} \leq Q \leq \overline{Q}$;

***Fair utilization of PV inverter:** $Q_i/\overline{Q_i} = Q_j/\overline{Q_j} = u$

Voltage Regulation Group (when to cooperate?)

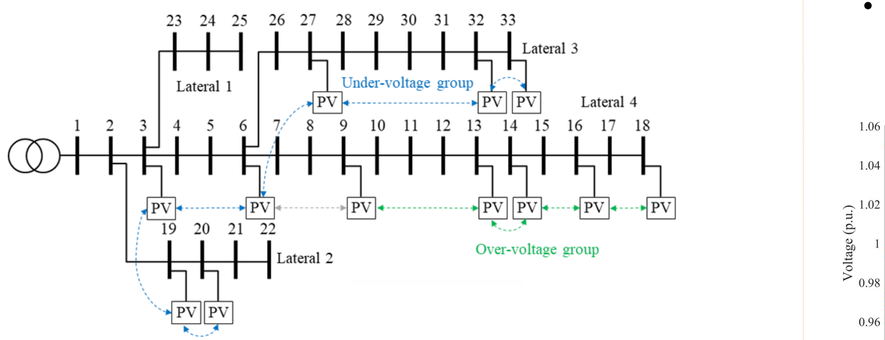


(a) Max-consensus: assess highest voltage



(b) Min-consensus: assess lowest voltage

- Assess global voltage status through peer-to-peer communication
- Separate into different groups when regulation objectives conflict



Within Group Coordination (how to cooperate?)

- Achieve fair-allocation based on capacity within each group

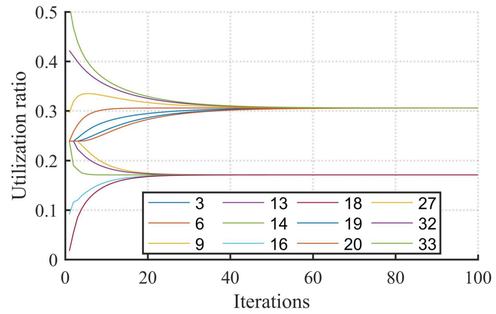
Local droop:

Excessive use of few PVs

Early saturation

After consensus:

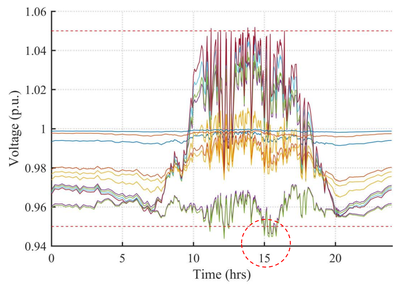
Fair allocation of voltage regulation burden

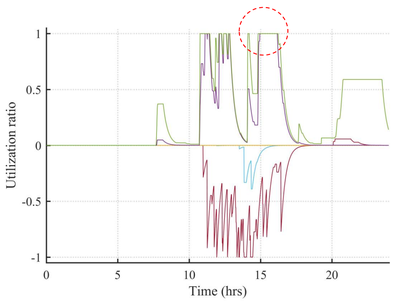


Control Performance

- Local control:

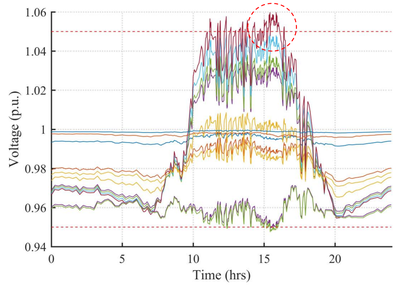
Undervoltage exists due to the saturation of certain local PV inverter

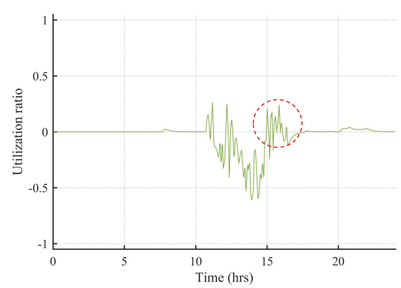




- Common consensus algorithm without group separation:

Overvoltage exists when conflicting objectives coexist, and all PV inverters choose to support the undervoltage at certain nodes





- Proposed control:

Effective voltage regulation and fair utilization of PV inverter capacity