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Generalized Approach for Volt-VAr-Control Through Integration of DERs with Traditional Methods

mPrest

David Raz
mPrest Systems
HIT – Holon Institute of Technology Israel

Ariel Daliot
mPrest Systems
Israel

GLOBAL LEADER IN INDUSTRIAL IIOT APPLICATIONS

15 years of mission and life critical production experience

System of Systems

Enabling a best of breed strategy

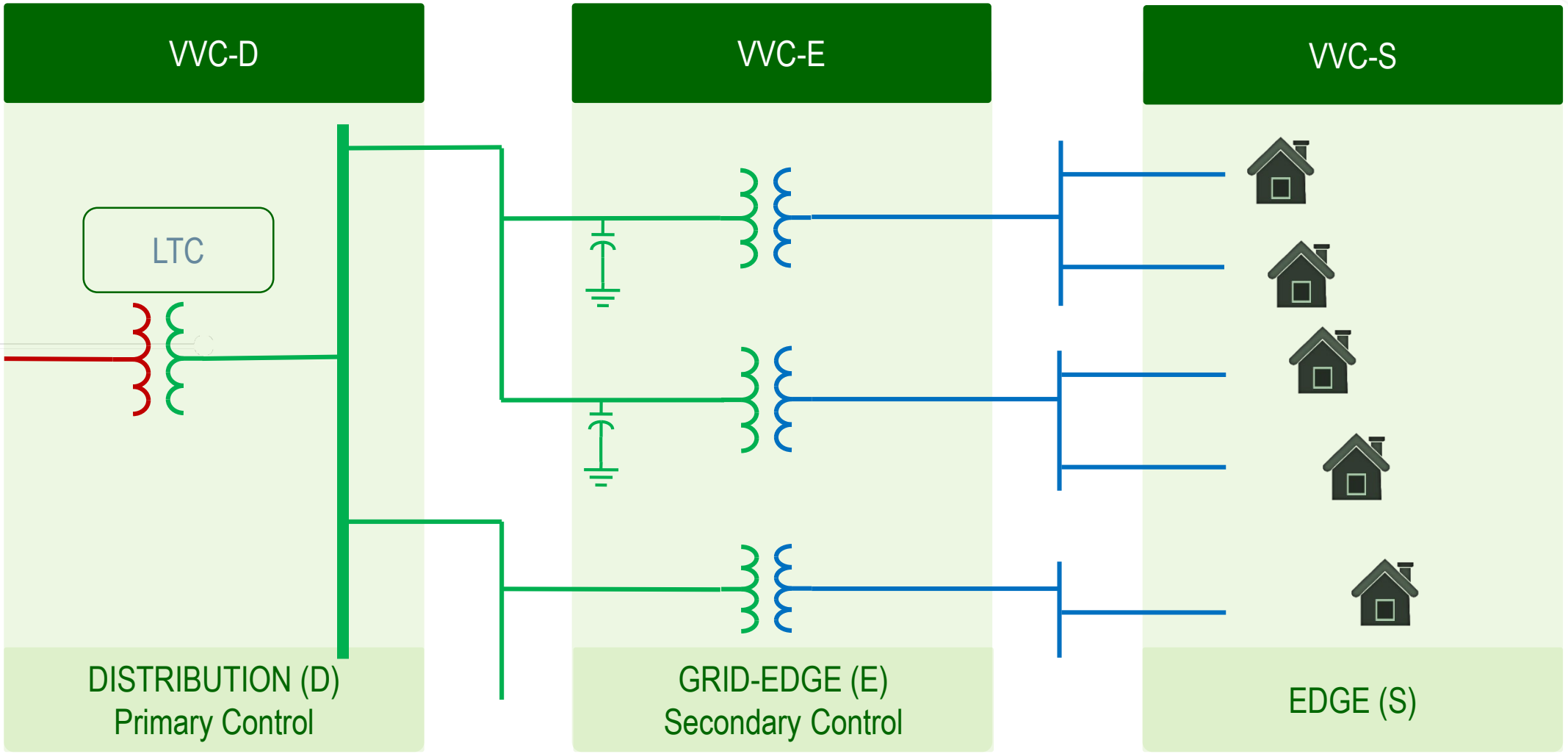
Flexibility

User empowerment

AGENDA

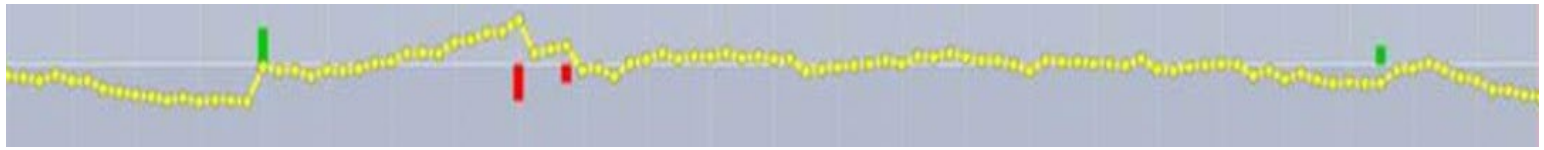
- Existing Solution
- The Challenge
- The “Reduced Diagram” concept
- Stepwise backward-forward algorithm
- Simulation results
- Questions

DISTRIBUTION VVC – EXISTING SOLUTION



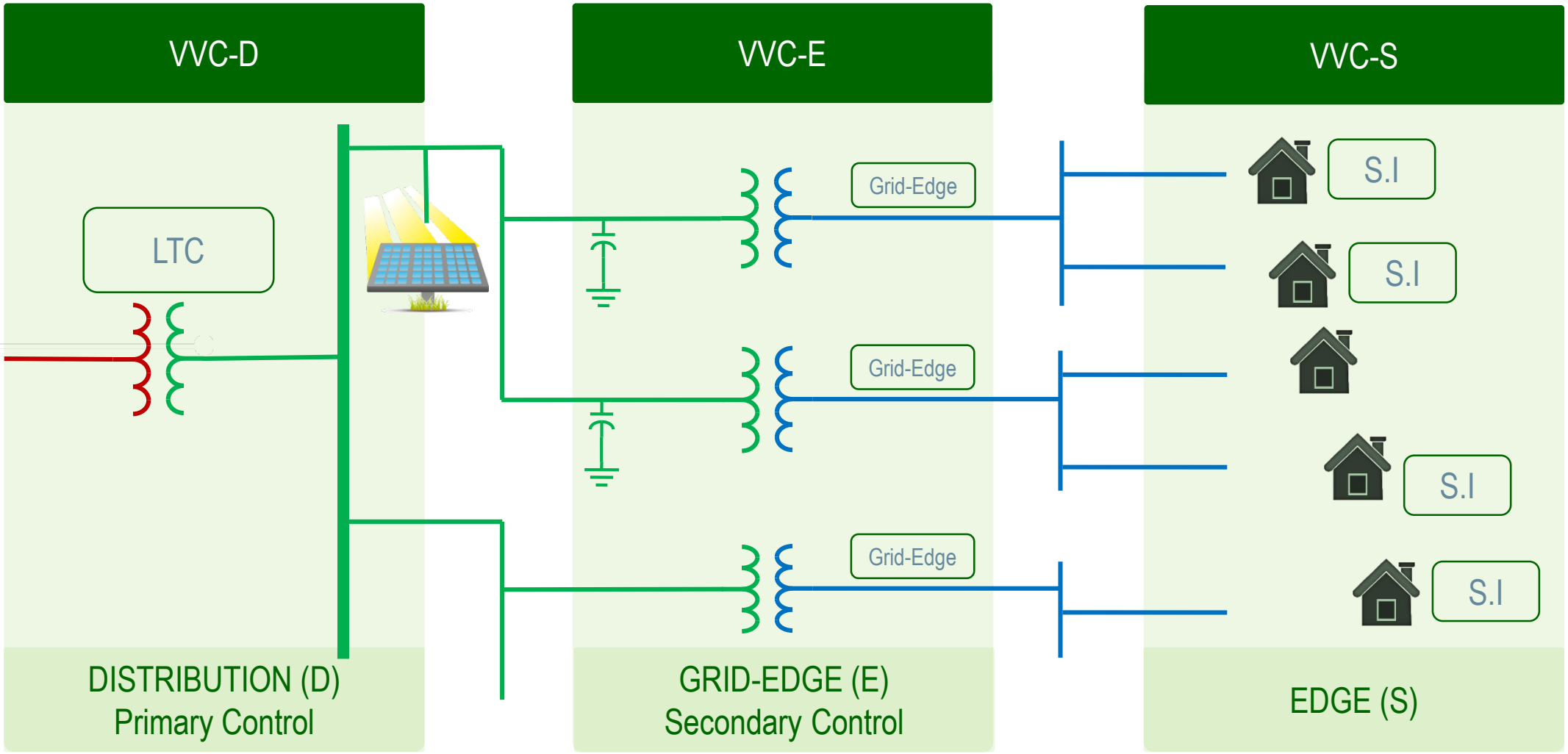
EXISTING SOLUTION – TYPICAL CONTROL SCHEME

- Local control of capacitor banks
  - Measure voltage/VAr
  - Engage capacitor when voltage below threshold/VAr above threshold
  - Trip when back above/below



- Use LTC for rough control of bus voltage

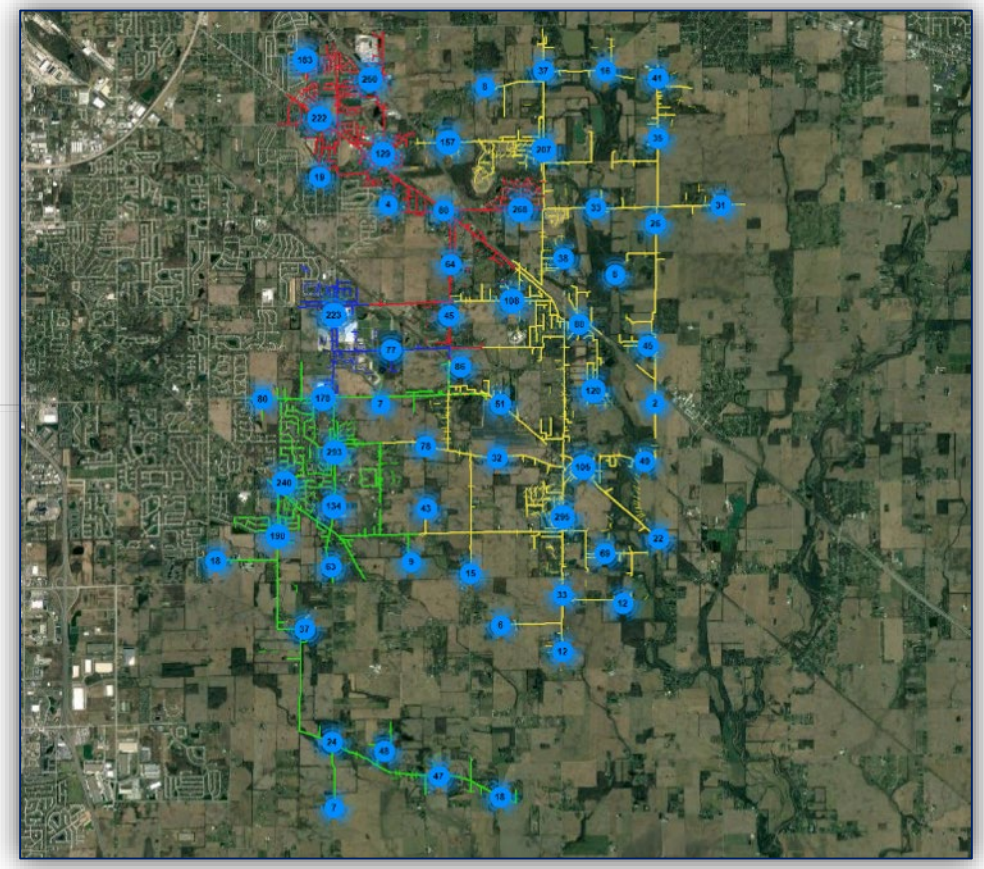
DISTRIBUTION VVC – INTRODUCING DERMS

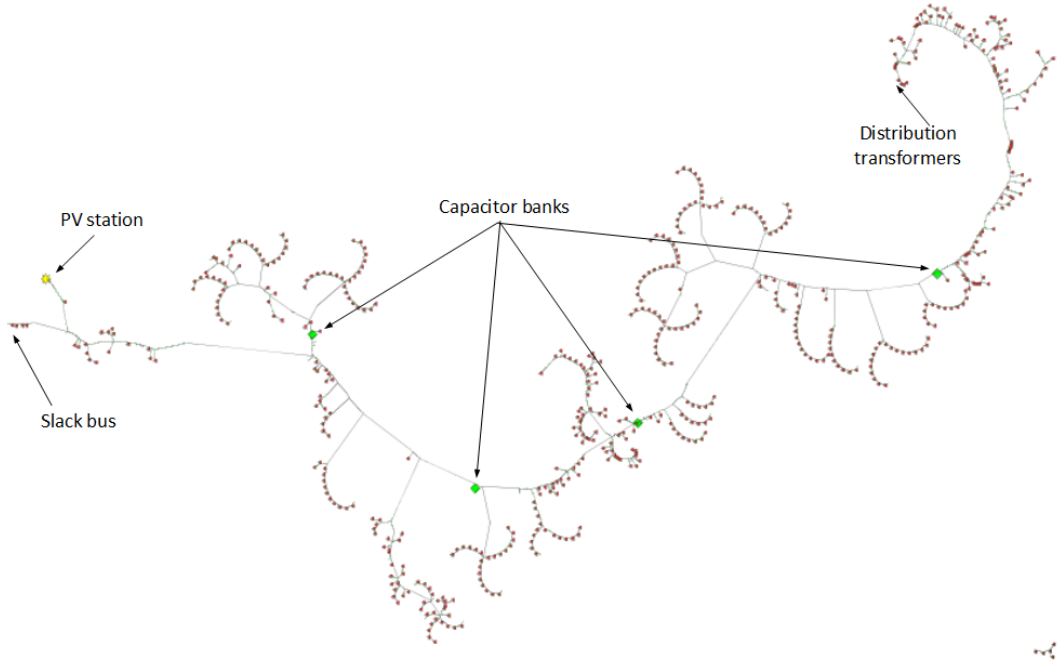


THE CHALLENGE – TARGET FUNCTIONS

- Multiple target functions
  - Flat voltage profile
  - Conservation Voltage Reduction (CVR)
  - Minimum asset operations
  - Zero VAr flow
  - Designated VAr flow
  - Predefined power factor

THE CHALLENGE – COMPLEXITY

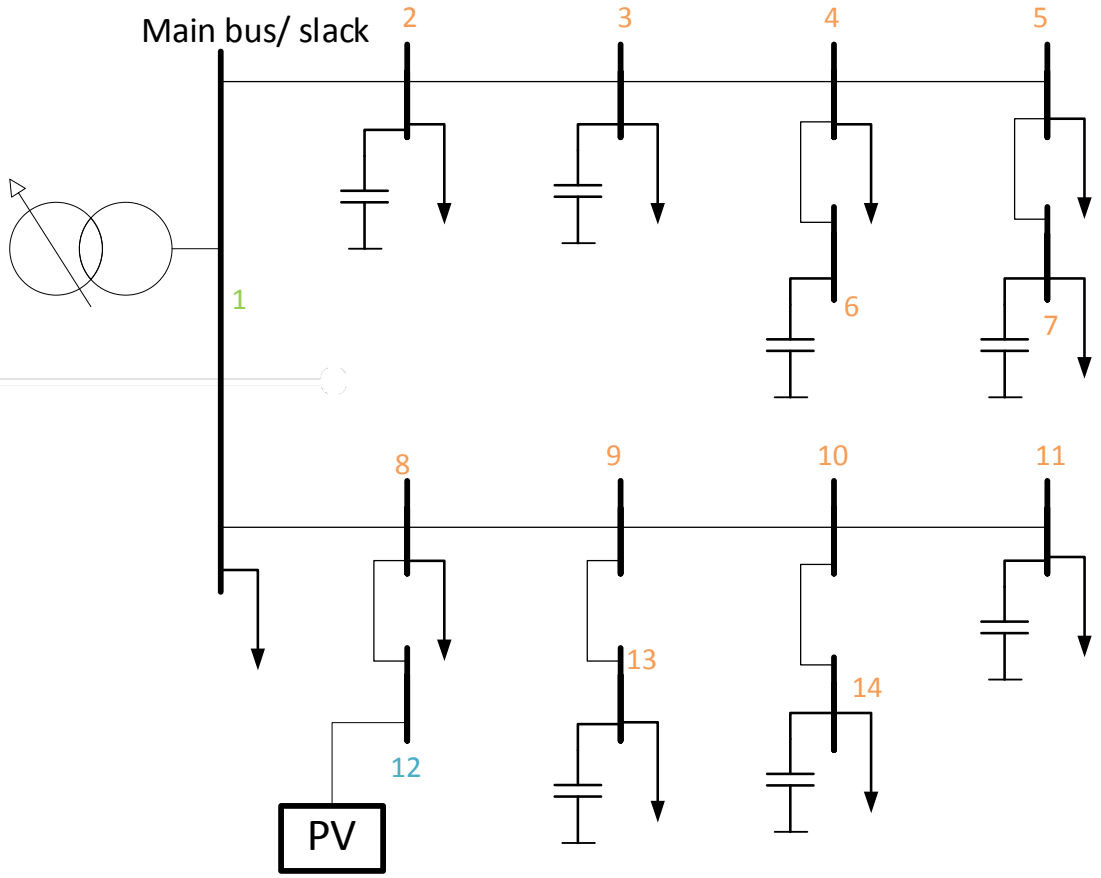


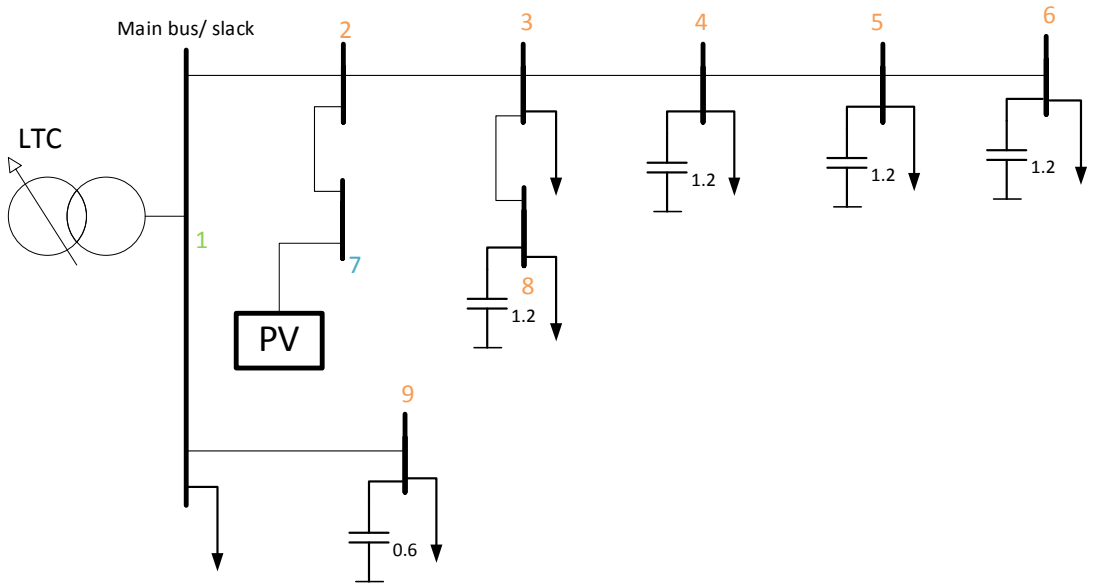


REDUCED DIAGRAMS

- Model only the information required for optimization
- Model feeders as main and branches
- “Bunch” elements
- Create diagrams semi-automatically based on identification of critical elements and operator hints

REDUCED DIAGRAMS EXAMPLES

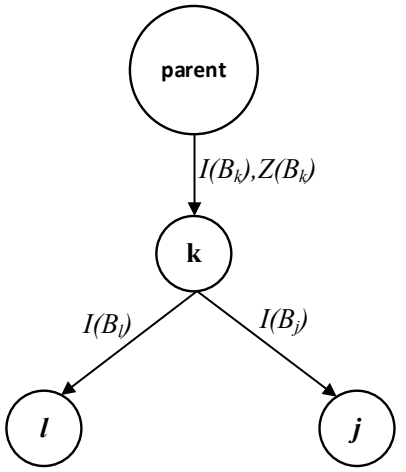




THE BACKWARD-FORWARD ALGORITHM

- Proposed by Luo & Semlyen (1990)
- Suited for distribution system (more stable than gradient based PF)
- Backward step: calculate branch current as the sum of the currents in leading branches

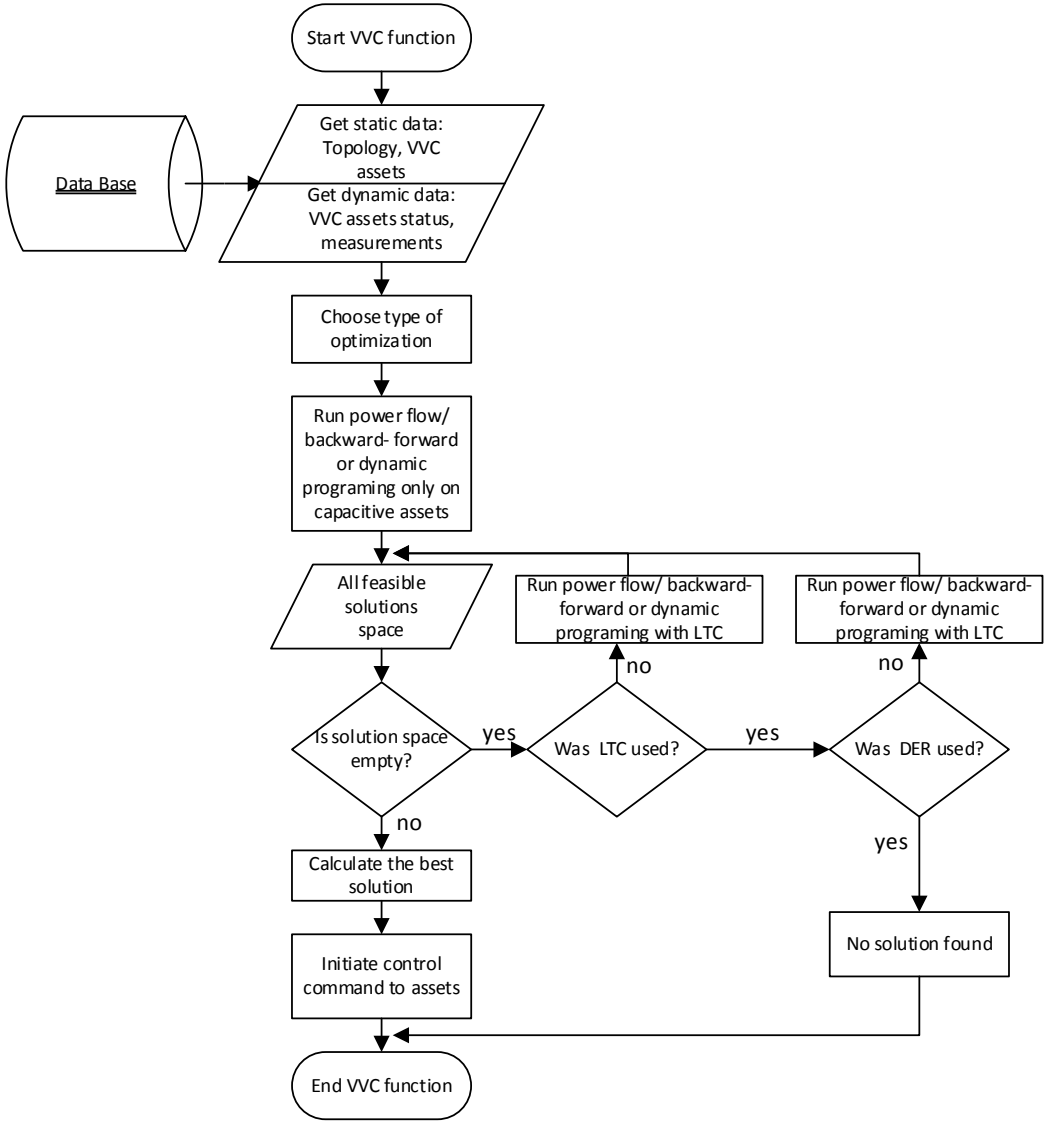
$$I(B_k) = \sum_{V_j} \frac{S_j}{v_j} \cdot U(k-j) \Big| U(k-j) = \begin{cases} 0 & if \ \ j > k \\ 1 & otherwise \end{cases}$$



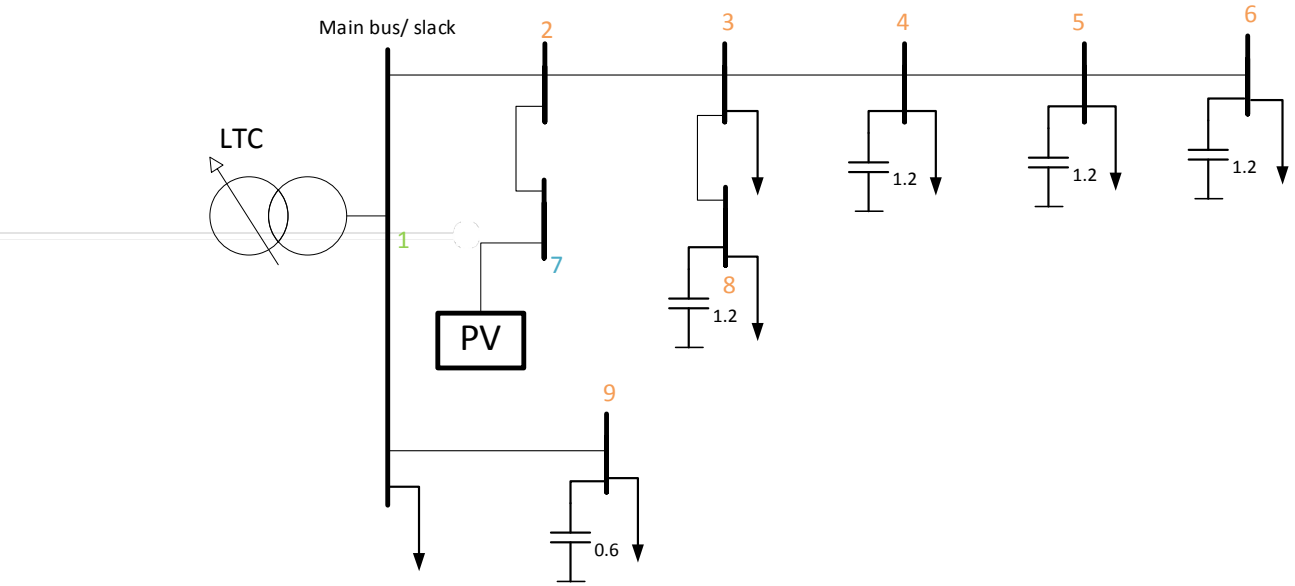
- Forward step: calculate node voltage using the parent vertex voltage drop

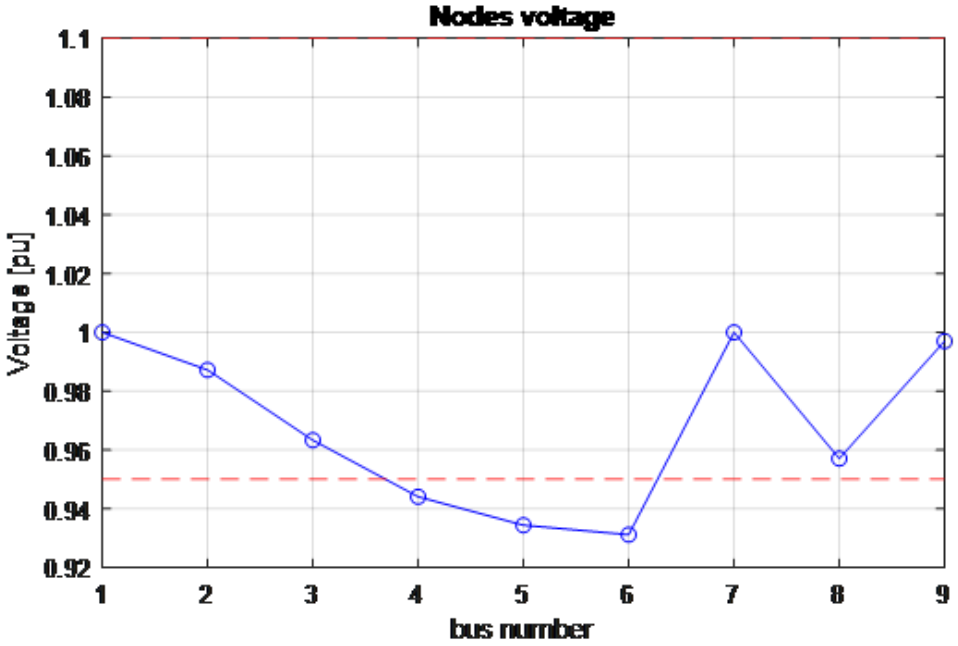
$$v_k = v_{parent} - I(B_k) \cdot Z(B_k)$$

- Repeat until stable
- Stepwise solution


Start VVC function
Data Base
Get static data: Topology, VVC assets
Get dynamic data: VVC assets status, measurements
Choose type of optimization
Run power flow/ backward- forward or dynamic programing only on capacitive assets
All feasible solutions space
Run power flow/ backward- forward or dynamic programing with LTC
Run power flow/ backward- forward or dynamic programing with LTC
no
no
Is solution space empty?
yes
Was LTC used?
yes
Was DER used?
no
yes
Calculate the best solution
Initiate control command to assets
No solution found
End VVC function

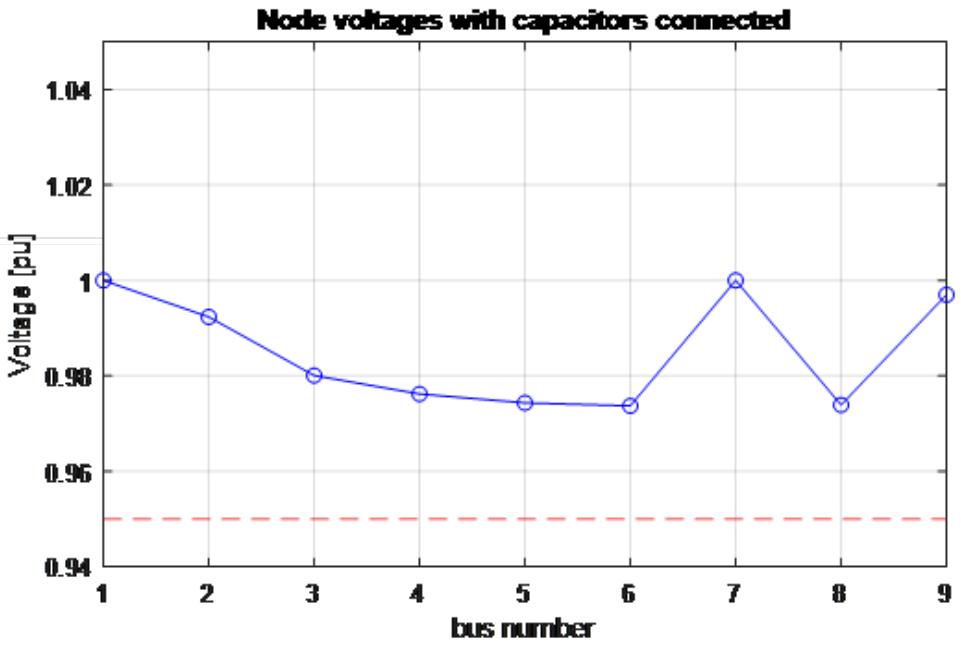
SIMULATION RESULTS I



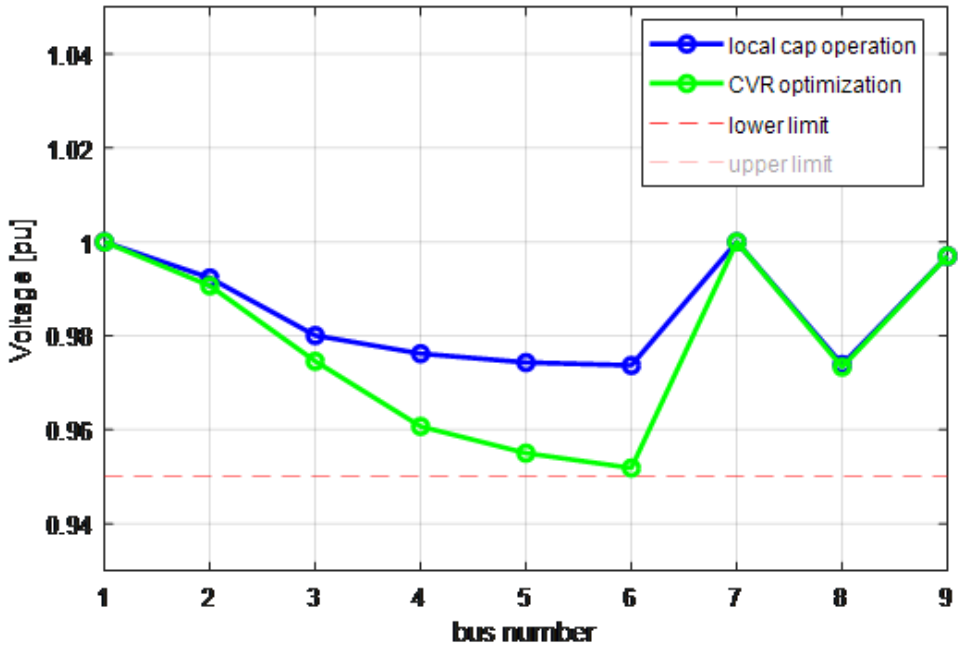


SIMULATION RESULTS I CNTD

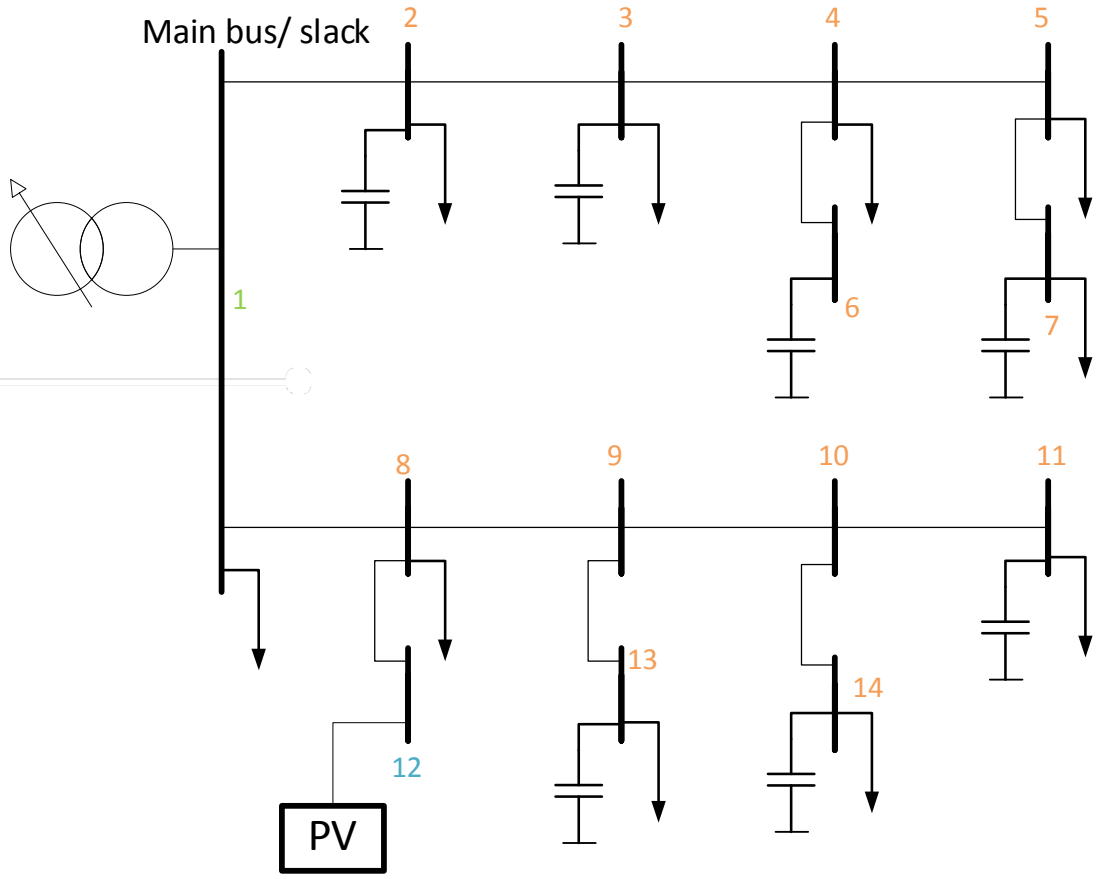
Activate 4, 5, 6

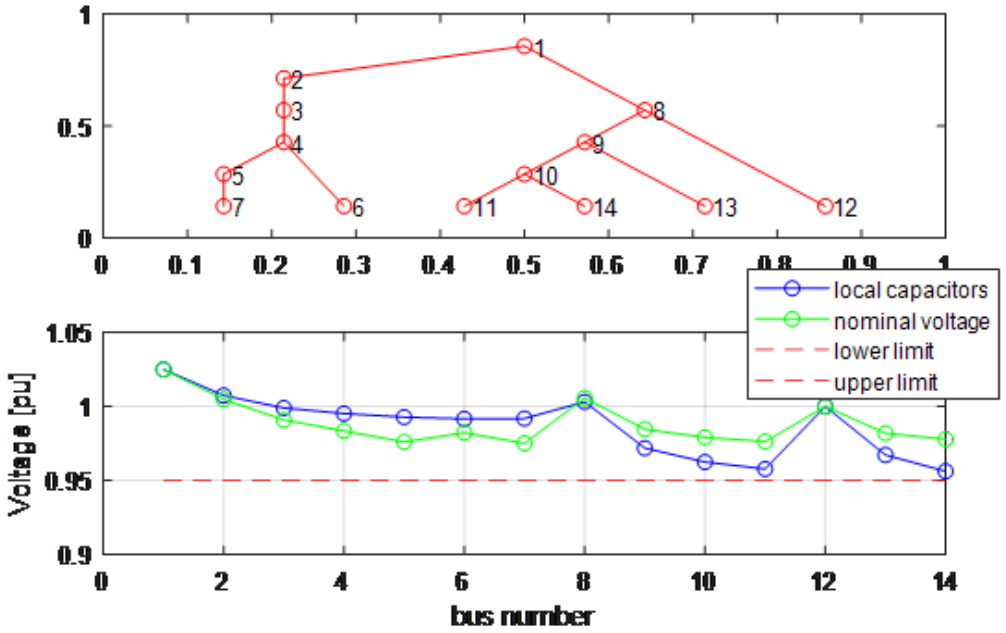


Activate 5, 8



SIMULATION RESULTS II





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THANK YOU