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FNSNF

GECN: Primary Voltage Control for Active Distribution Networks via Real-Time Demand-Response

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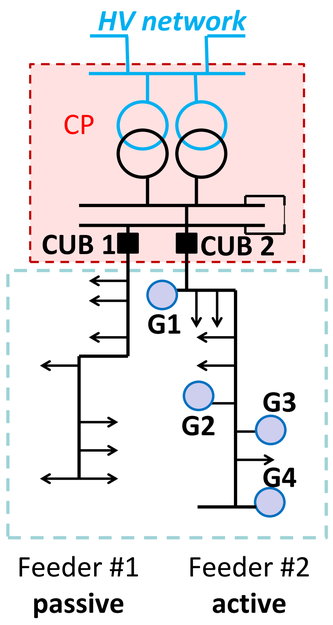
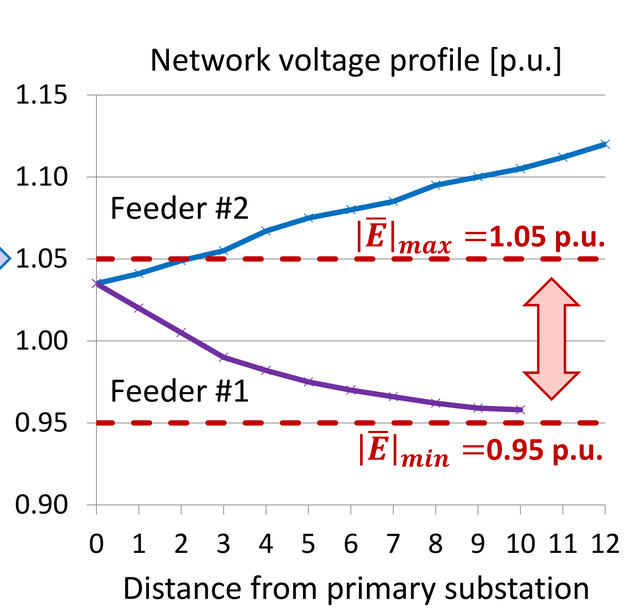
Voltage Problem in ADNs





Voltage Control via Demand-Response

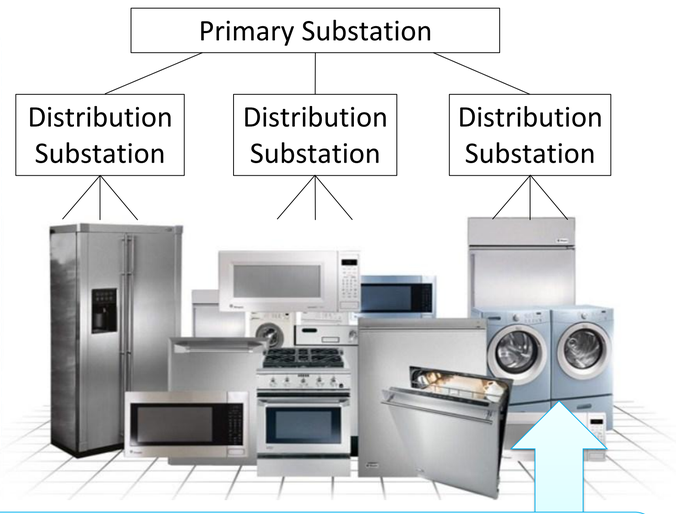
Why?

- PQ variations can control voltage

$$\Delta|\bar{E}| \approx K_P \Delta P + K_Q \, \Delta Q$$

Benefits

- Increased **availability** (small residential loads)
- **Flexibility** of control (Spatially distributed resources)



Problem: Point-to-point communication not tractable
Solution: Design of **control schemes based on broadcast signals**

The Grid Explicit Congestion Notification Mechanism

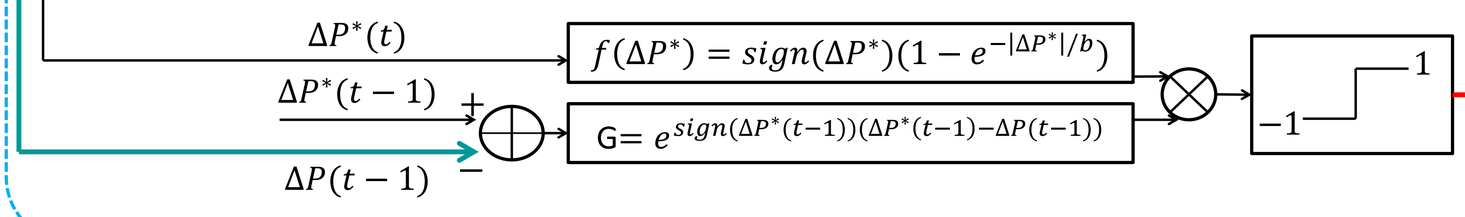
Network Controller (Generic)

Every S seconds

1. Obtain network state (e.g., via state estimation) → $|\bar{E}_i|, P_i, Q_i \quad \forall\, bus\ i$
2. Compute optimal **PQ** and **OLTC** variations that lead to the desired operating point

$$\min_{\Delta(\mathbf{P},\mathbf{Q},\mathbf{n})} \sum_i \mu_i \left(\Delta(\mathbf{P},\mathbf{Q})_i - \Delta(\mathbf{P},\mathbf{Q})_{f_i}\right)^2 + \sum_i \lambda_i \left[\left(|\bar{E}_i| + (K_{\mathbf{P},\mathbf{Q},\mathbf{n}}(t)\Delta(\mathbf{P},\mathbf{Q},\mathbf{n}))_i - |\bar{E}|\right)^2 - a^2\right]^+ + \psi\Delta\mathbf{n}^2$$

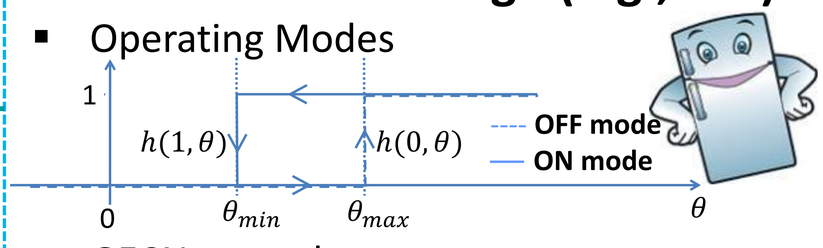
3. Map $\Delta P^*(t)$ to GECN signal $g(t)\epsilon$[-1,1]
   (+ inhibits consumption, - encourages consumption)



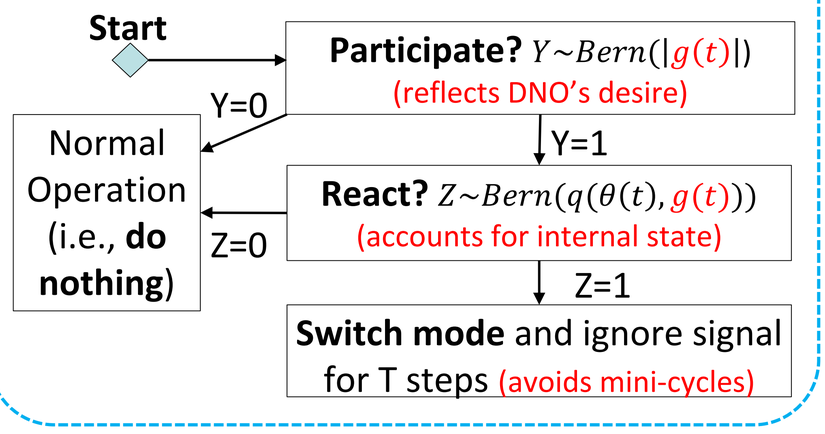
Measure

Local Controller Design (e.g., TCL)

- Operating Modes



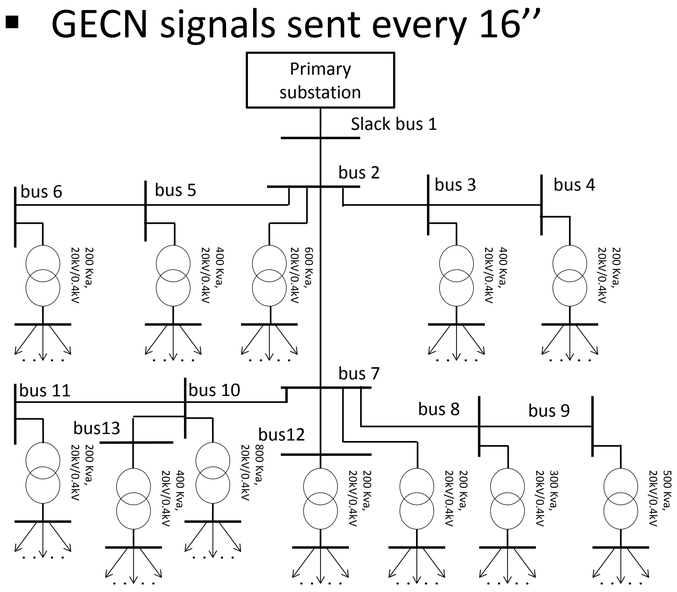
- GECN control



Simulation Results

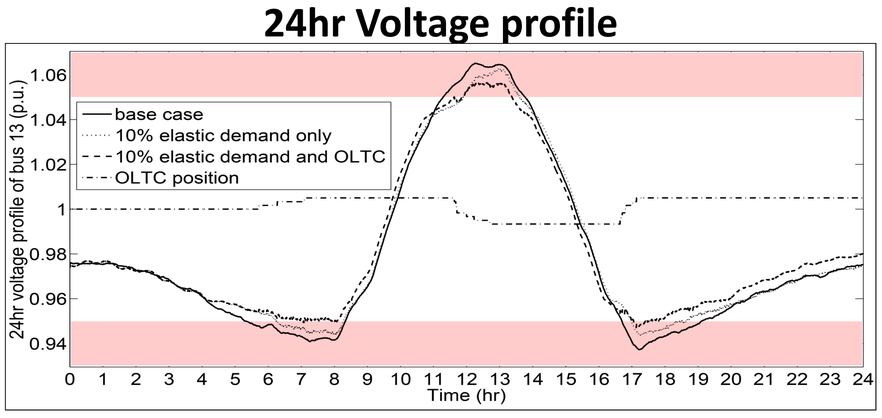
Setting

- IEEE 13-Node Test Feeder
- Non dispatchable PV production
- 10% and 30% of elastic demand
- GECN signals sent every 16''

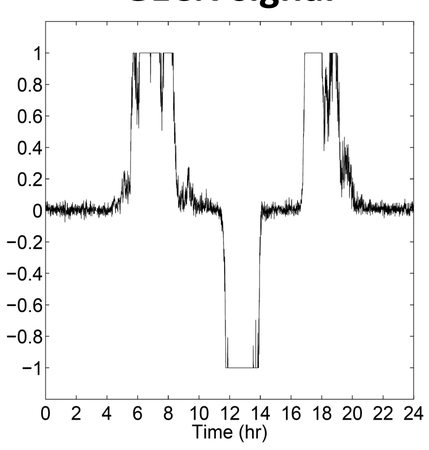


10% of elastic demand

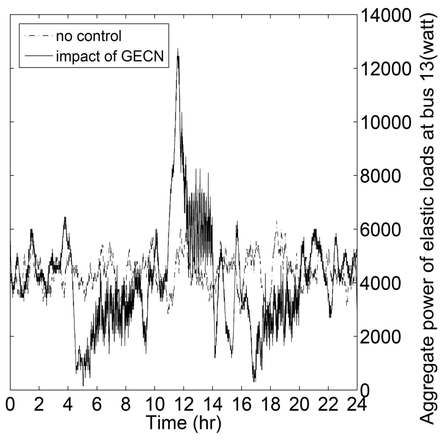
24hr Voltage profile



GECN signal

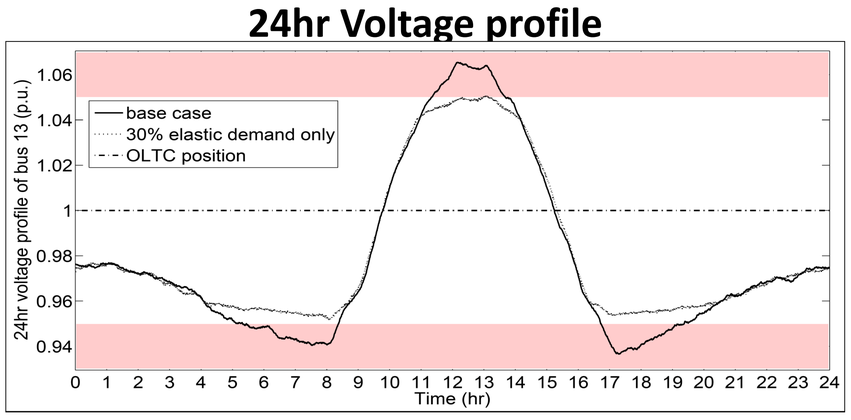


TCL Power

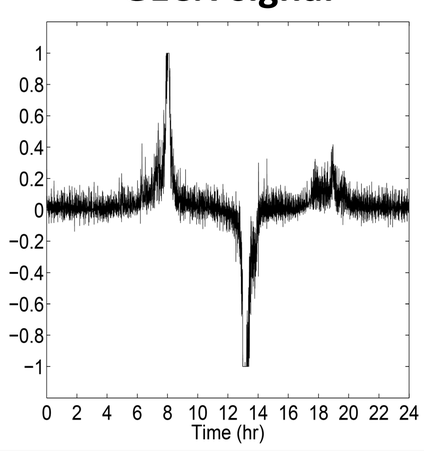


30% of elastic demand

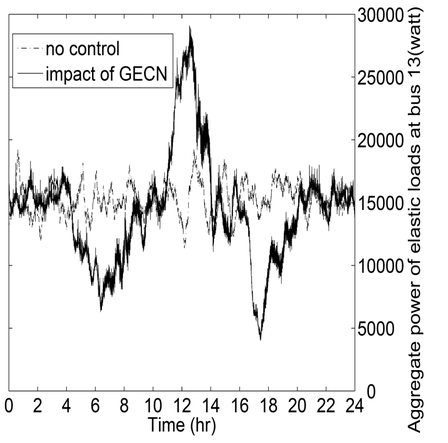
24hr Voltage profile



GECN signal



TCL Power



Further Applications

- Aggregated response of mixed populations under the same signal (e.g., storage/loads)
- Inclusion of different ancillary services (e.g., lines congestion)

References

1. K. Christakou, D.-C. Tomozei, J.-Y. Le Boudec, and M. Paolone, *GECN: Primary Voltage Control for Active Distribution Networks via Real-Time Demand-Response*, IEEE Trans. on Smart Grids, vol.5, no.2, pp.622-631, March 2014
2. K. Christakou, D.-C. Tomozei, M. Bahramipanah, J.-Y. Le Boudec and M. Paolone, *Primary Voltage Control in Active Distribution Networks via Broadcast Signals: The Case of Distributed Storage*, in press, IEEE Transactions on Smart Grids, 2014