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Optimization-based Voltage Dynamics Estimation and Control of Microgrids

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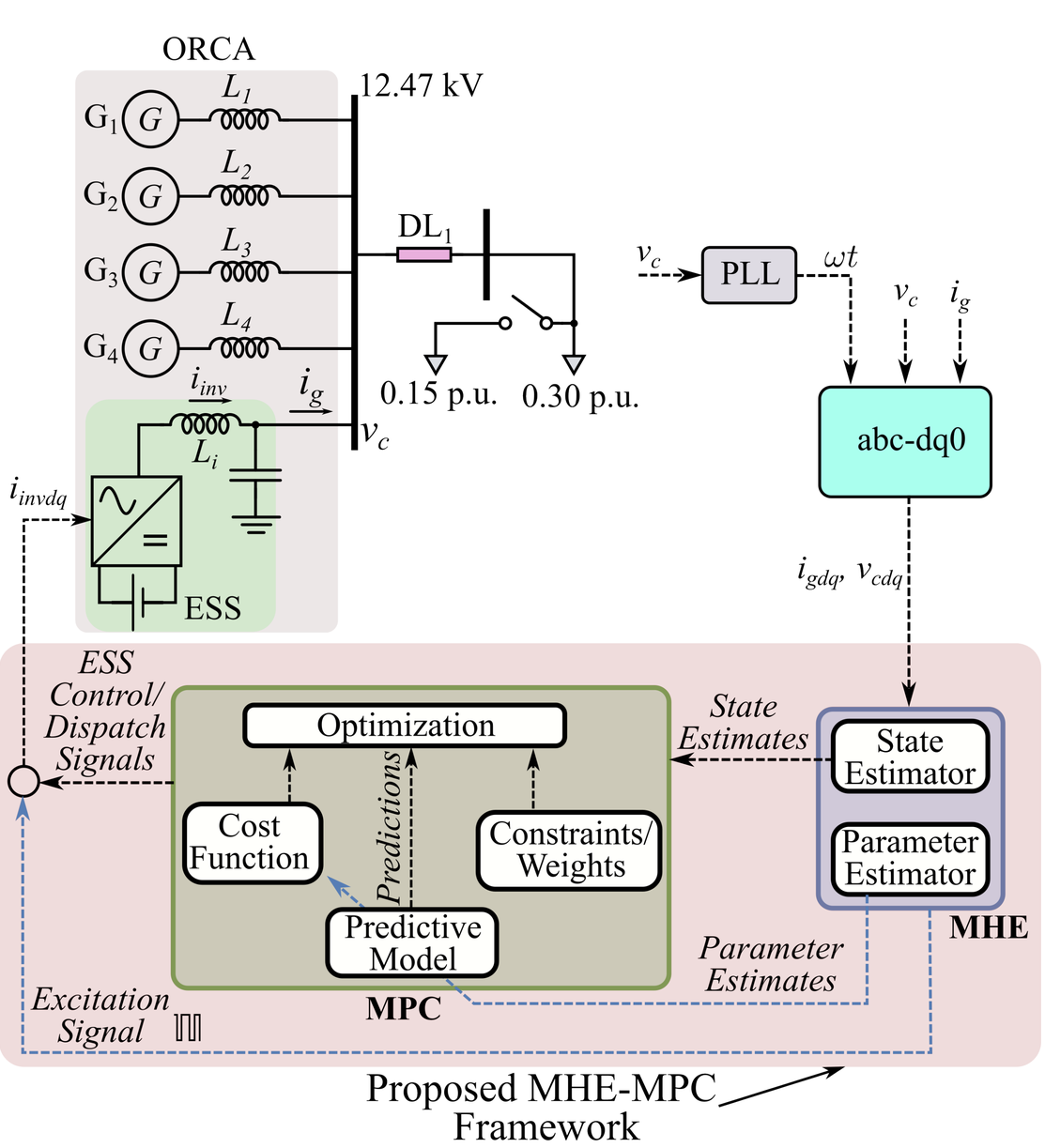
1. Motivation and Objectives

- Microgrids: high R/X ratio
- Both active and reactive power can control voltage
- Different cost of active and reactive power
- Better quality of service -> higher ESS degradation
- Operational Constraints: inverter size
- Controller: to handle operational constraints and flexible
- MPC can handle operational constraints
- Time-varying microgrid parameters
- Noisy measurements -> uncertainty
- Too much filtering -> delays
- Need for the parameter and states estimators that operates under noisy conditions
- MHE can provide estimation of states and parameters under noisy condition

2. Proposed Moving Horizon Estimation (MHE)-Model Predictive Control (MPC) Approach

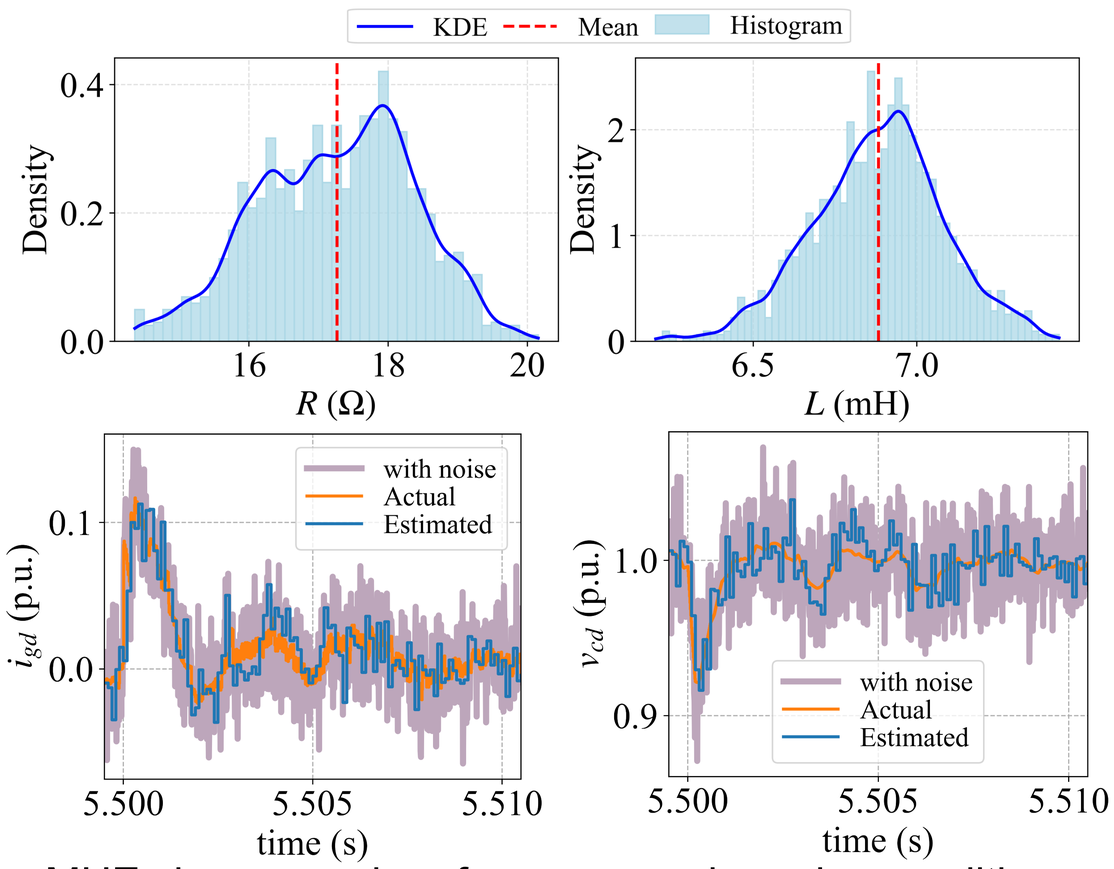
- MHE: estimates states and parameters online
- MPC: generates control signal using MHE estimates



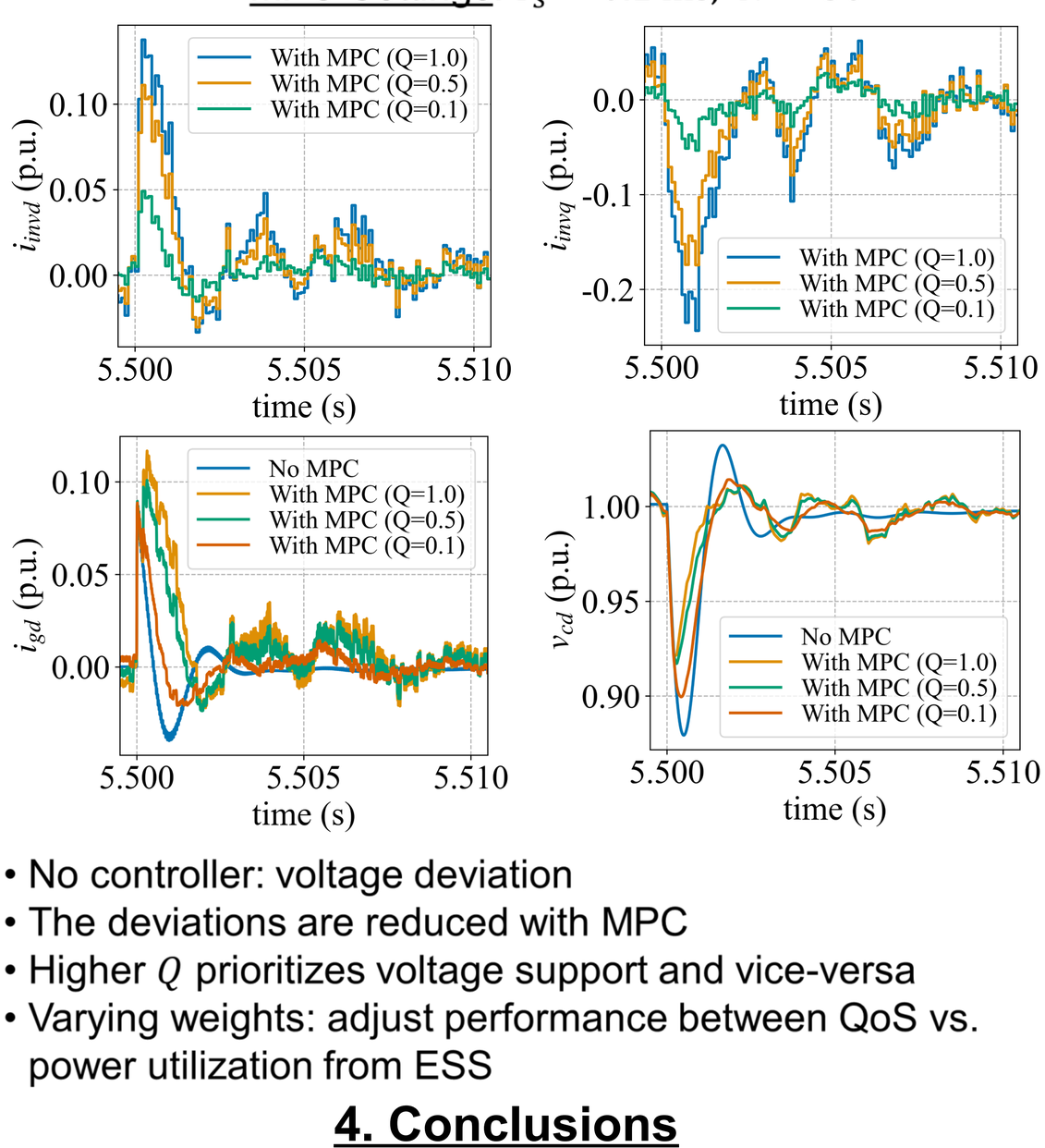
- Modified remote microgrid test system from Cordova, Alaska
- Simplified Thevenin equivalent model used as prediction model in MHE/MPC
- Measurements through phase locked loop (PLL)
- Square wave excitation signal used

3. Simulation Results and Analysis

- MHE Settings: $T_s = 0.1$ ms, $L = 10$



- MHE shows good performance under noise condition
- MPC Settings: $T_s = 0.1$ ms, $N = 50$



- No controller: voltage deviation
- The deviations are reduced with MPC
- Higher Q prioritizes voltage support and vice-versa
- Varying weights: adjust performance between QoS vs. power utilization from ESS

4. Conclusions

- Dynamic voltage support using MPC
- Flexibility to tune performance: balance between QoS and power utilization from ESS

5. Acknowledgements

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6. References

[1] N. Bhujel, T. M. Hansen, R. Tonkoski, U. Tamrakar and R. H. Byrne, "Model Predictive Integrated Voltage and Frequency Support in Microgrids," 2020 52nd North American Power Symposium (NAPS), 2021, pp. 1-6, doi: 10.1109/NAPS50074.2021.9449640.
[2] N. Bhujel, T. M. Hansen, R. Tonkoski, U. Tamrakar and R. H. Byrne, "Optimization-Based Estimation of Microgrid Equivalent Parameters for Voltage and Frequency Dynamics," 2021 IEEE Madrid PowerTech, 2021, pp. 1-6, doi: 10.1109/PowerTech46648.2021.9494858.