Capacitance Sizing for a Load-Management Photovoltaic Electric Vehicle Charging System

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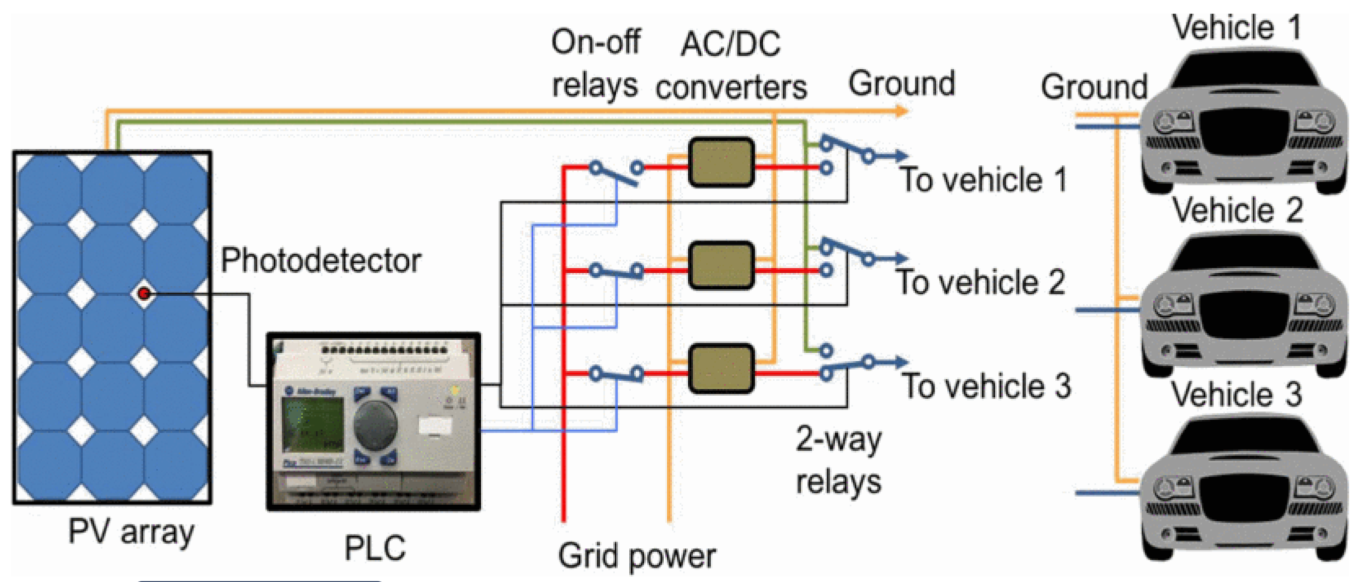
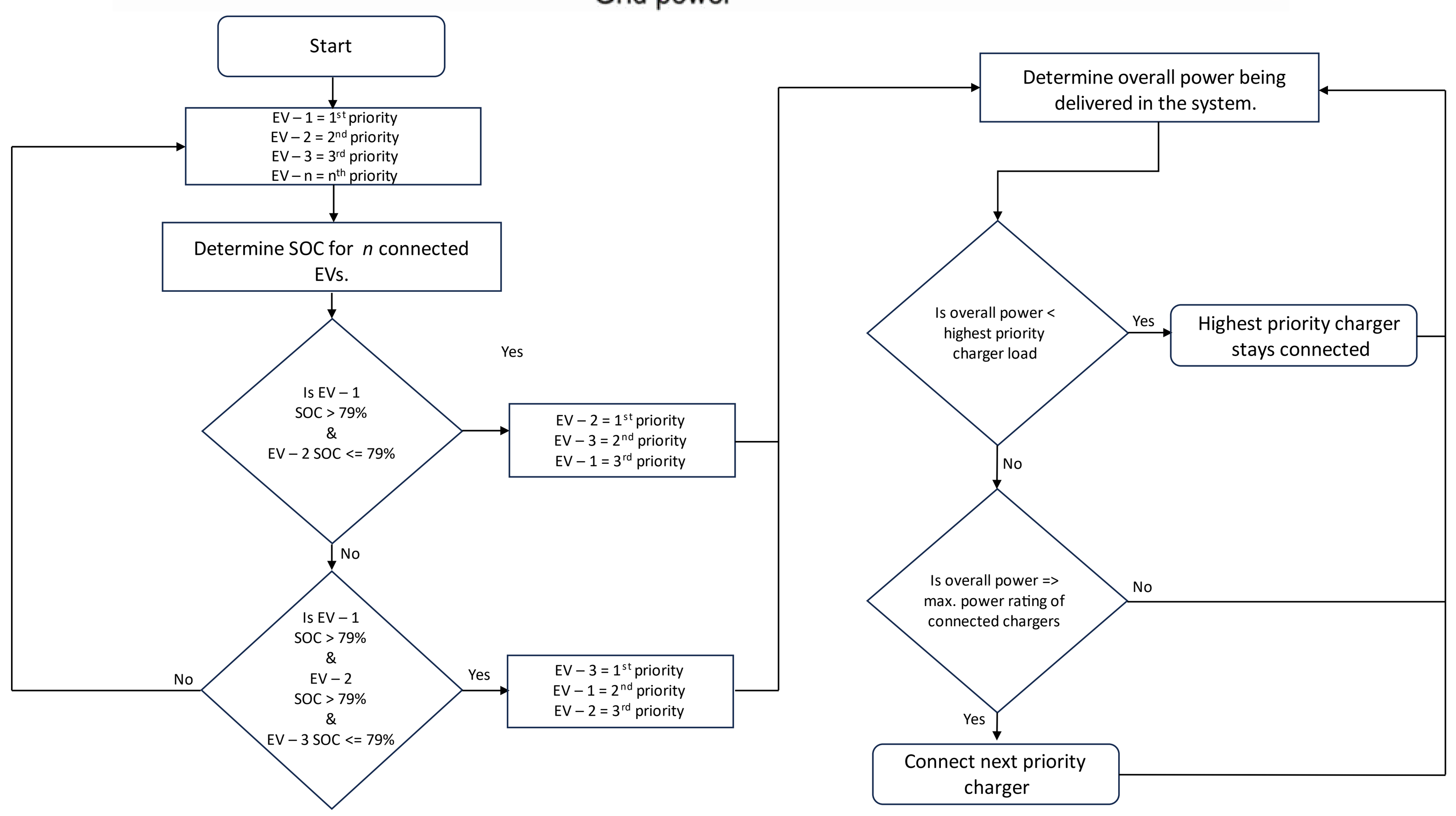
Abstract

Electric vehicles (EVs) chargers currently rely on power conversion infrastructure to transform grid supply to usable power for a vehicle battery. However, these existing power converters lose power at each required conversion step. Professor Tao's research team has previously worked on a load-management photovoltaic (LMPV) algorithm to cut out these power conversion steps and link power supplies directly to vehicles' batteries. This project aimed to iterate on the previous design by investigating the role of a capacitor in limiting the voltage output variance.

System Overview





Figures 1 and 2: Framework for LMPV EV Charger System and the block diagram of the control algorithm that connects additional EV over time.

Improvement Strategies

Our research used MATLAB Simulink to simulate a 120kW load management EV charging system with varied capacitance. We sought to determine the smallest capacitance required to limit our voltage oscillation drop to 5% or lower.

Results

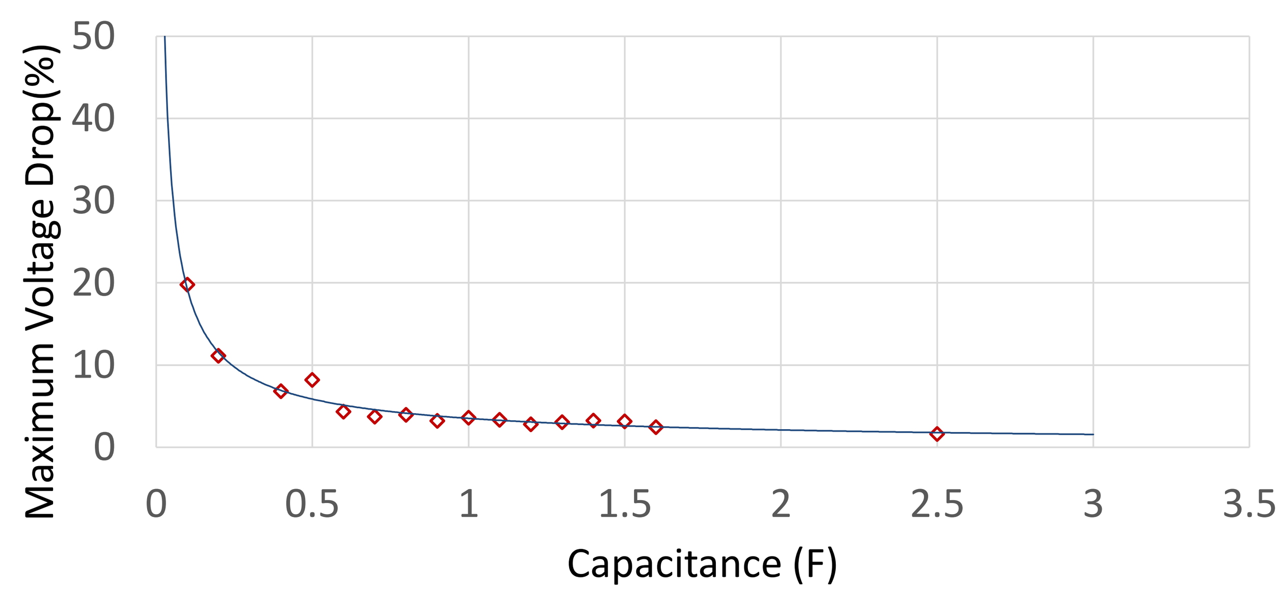


Figure 2: Maximum Percent Voltage Drop vs Capacitance

Simulation testing of the LMPV EV System derives the following:

- An Exponential relationship between voltage oscillation magnitude and capacitor size.
- A capacitor under 0.6F is sufficient to retain a 5% oscillation limit in a 120kW LMPV EV Charging System.

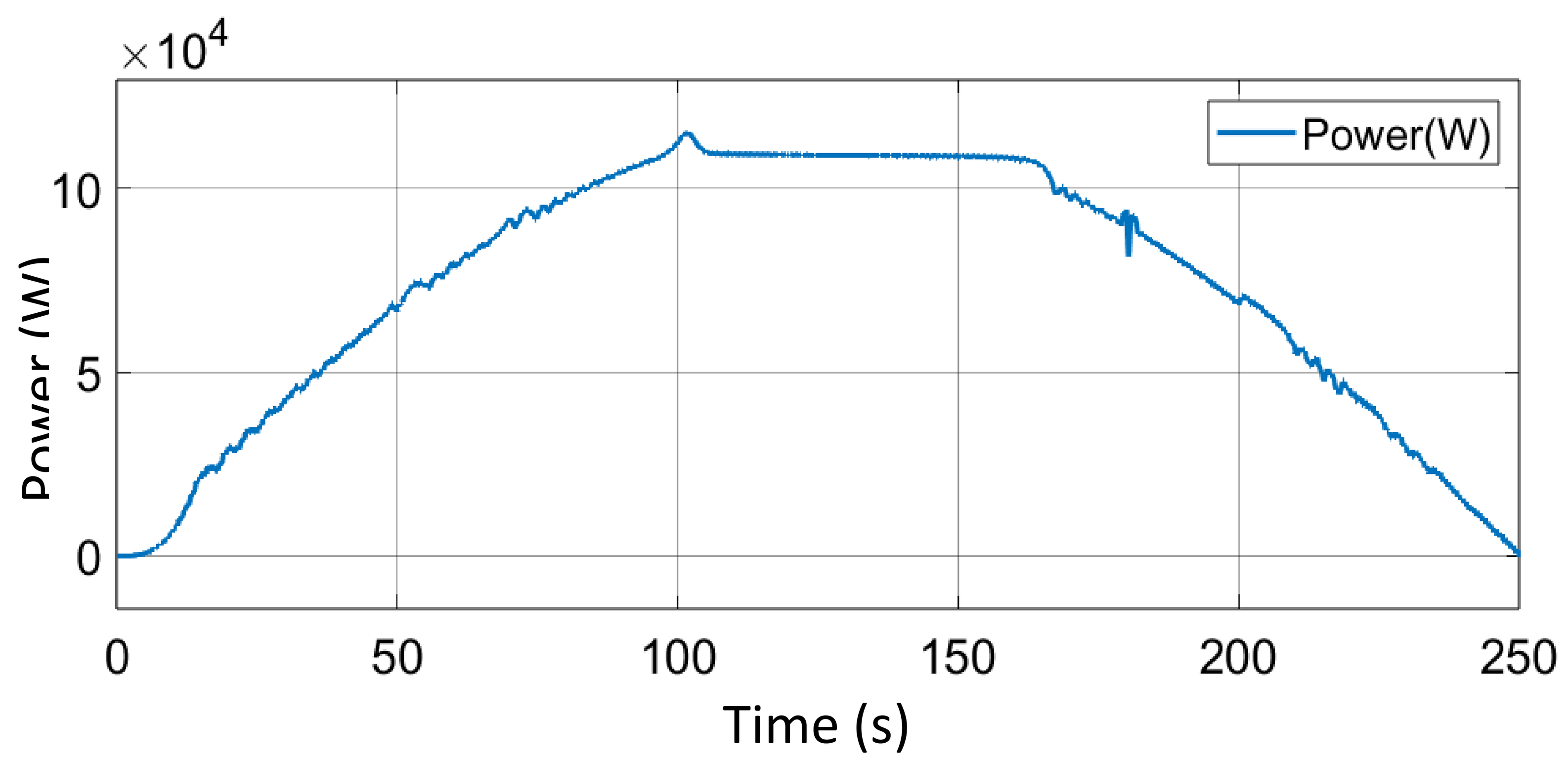


Figure 3: Load-matching Photovoltaic Power Curve with EV Loads.

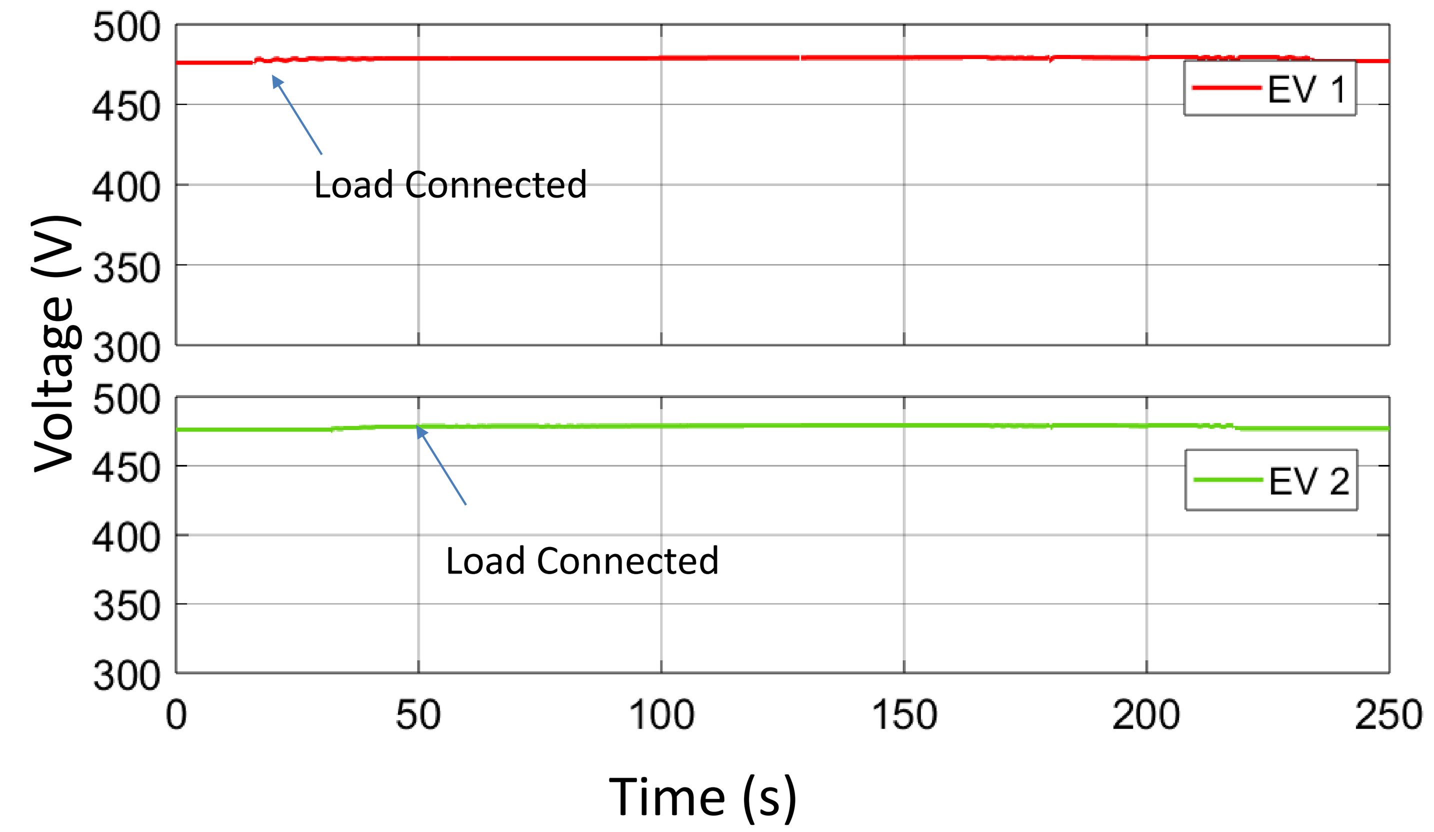


Figure 4: Electric Vehicle Voltages for EV 1 and 2 with a 0.6F Capacitor.

With PV voltage variation kept under 5%, there is little to no voltage deviation within the EV chargers (<1%).
This ensures safe practices and promotes battery health in LMPV.

Conclusion

Our findings indicate the optimal capacitance for our load management system is 0.6F. At this capacitance, the overall voltage output was only 4.35%, below the 5% recommended limit. Overall, our work also demonstrates the effectiveness of a capacitor in reducing voltage variance.

Future Work and Acknowledgement

Future work on this project includes:

- Iterating the load management algorithm to smooth out load-switching.
- Investigating the switching frequency within the EV battery loads to reduce voltage variance further.

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