

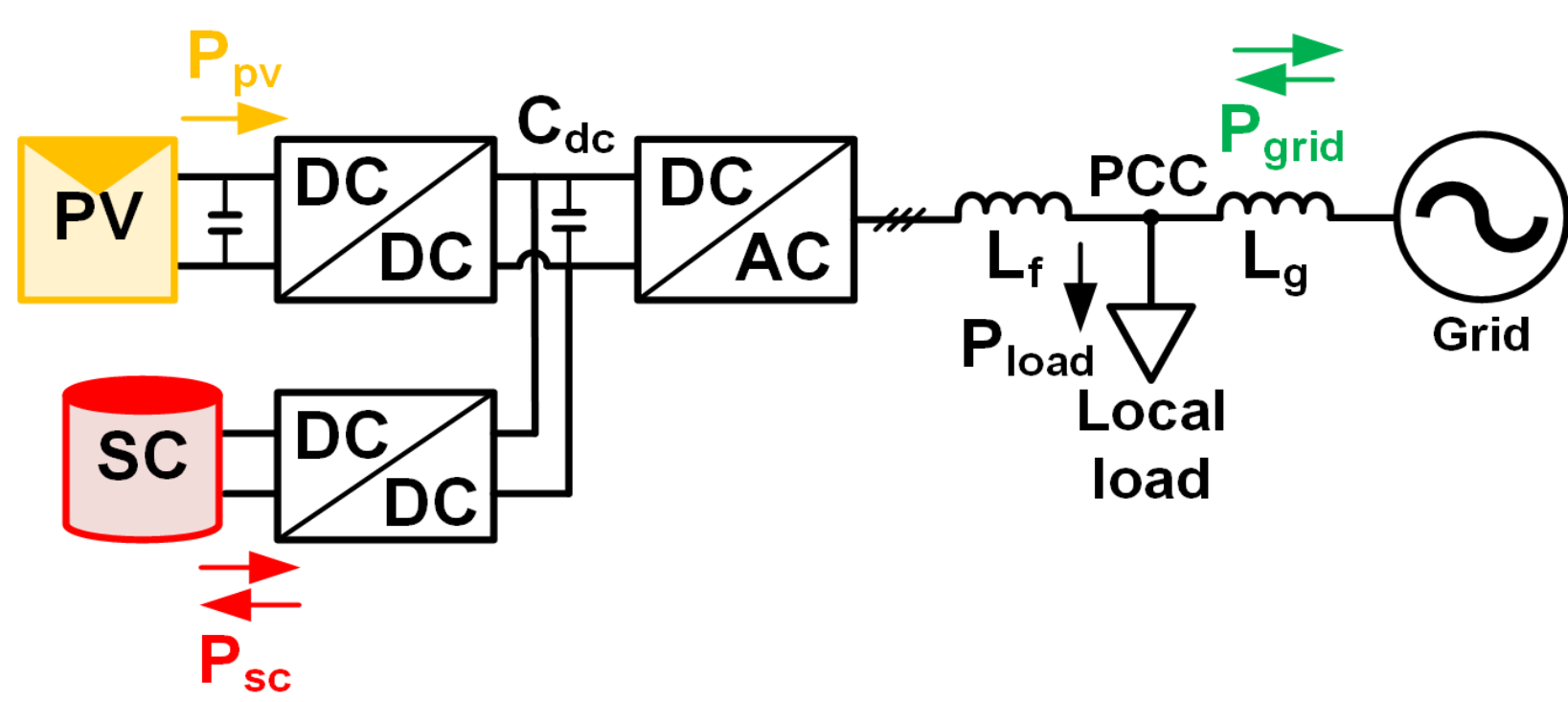
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## BACKGROUND AND MOTIVATION

- Supercapacitor (SC) has gained more use in power system applications due to its superior characteristics in terms of high power density, ability to undergo numerous charge and discharge cycles, and long service life.
- A real-time reconfigurable hardware testbed (HTB) lacks an SC emulator.
- SC emulator eliminates the limitation of grid studies offered by distributed energy storage resources.
- SC emulator is developed on the HTB for a grid-connected photovoltaic (PV) system.
- SC emulator is compared to MATLAB/Simulink to verify its accuracy.

## SUPERCAPACITOR SYSTEM EMULATOR FOR PV APPLICATIONS



Schematic of a grid-connected photovoltaic with supercapacitor system (PVSS).

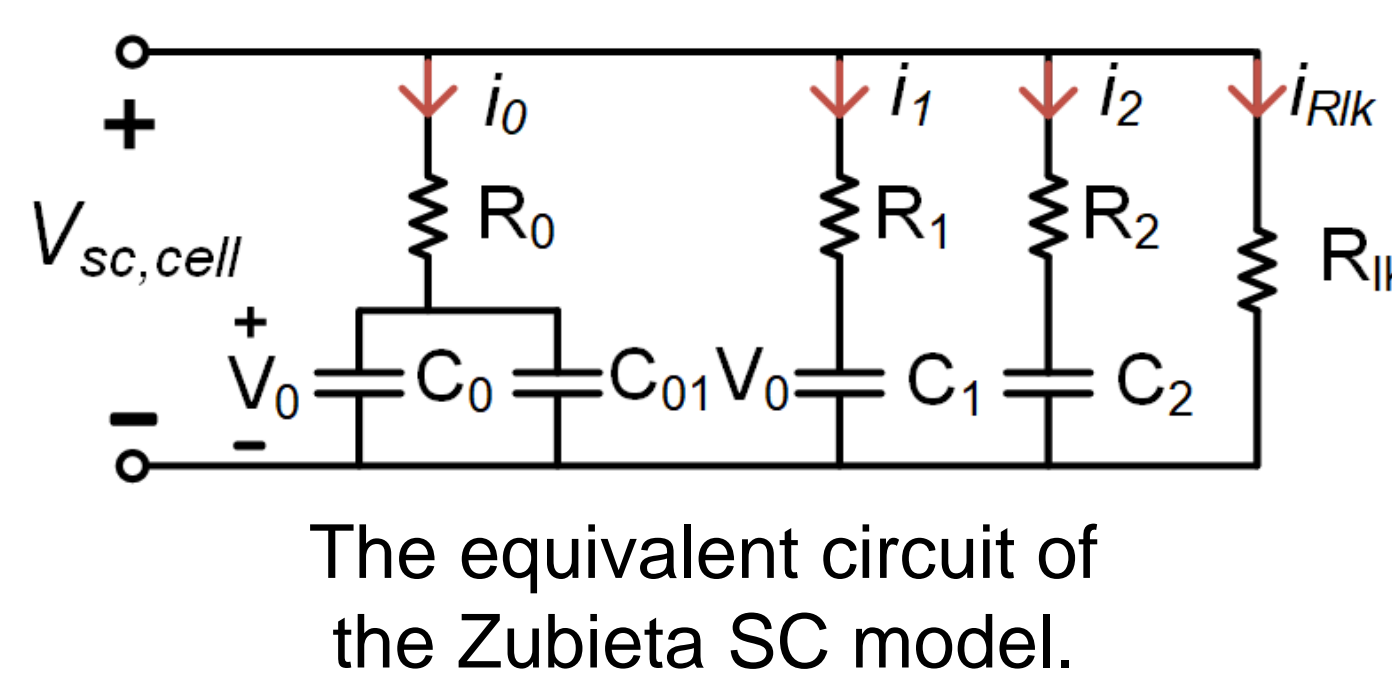


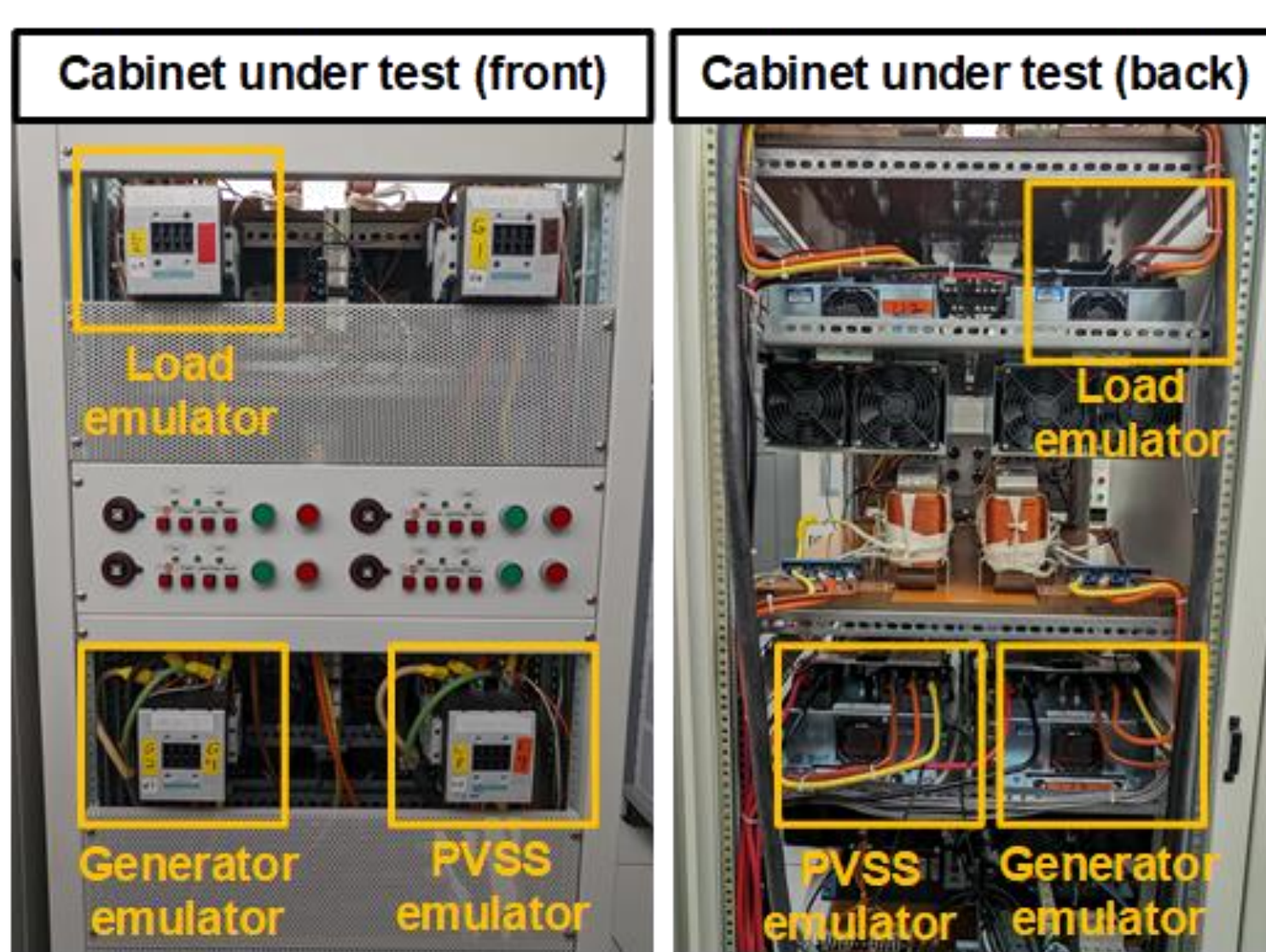
Table I. Supercapacitor's Parameters.

Parameters	Values
Usable energy capacity	0.35 kWh
Usable power capacity	63.18 kW
Number of series (Ns)	180
Number of parallel (Np)	1
Voltage rating (V)	480 V

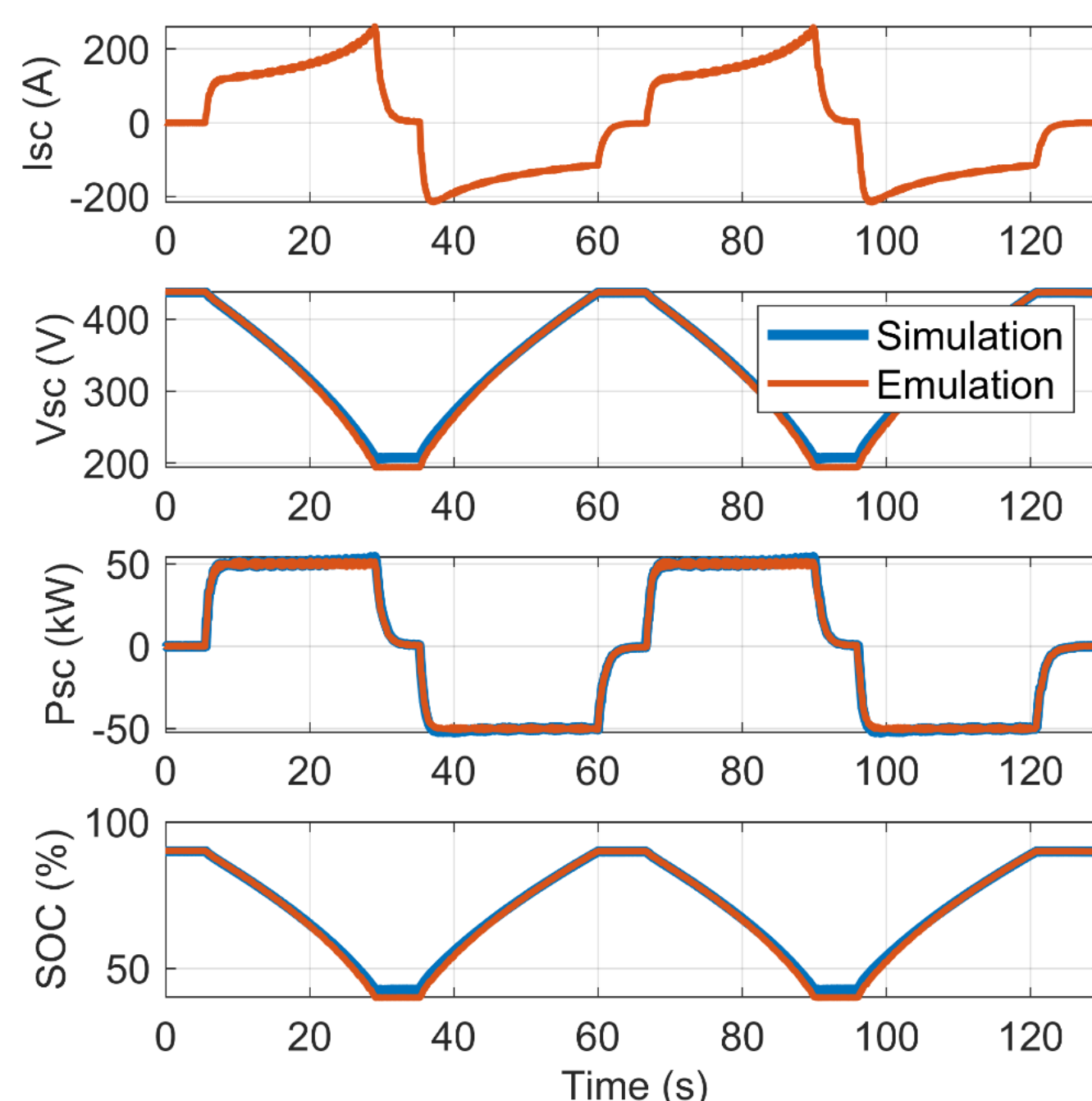
- A grid-connected photovoltaic with supercapacitor system (PVSS) is emulated.
- Adopt the Zubieta SC model in this work.
- Mimic the SC behaviors in short-term and long-term with moderate computation burden.

## EXPERIMENTAL EMULATION

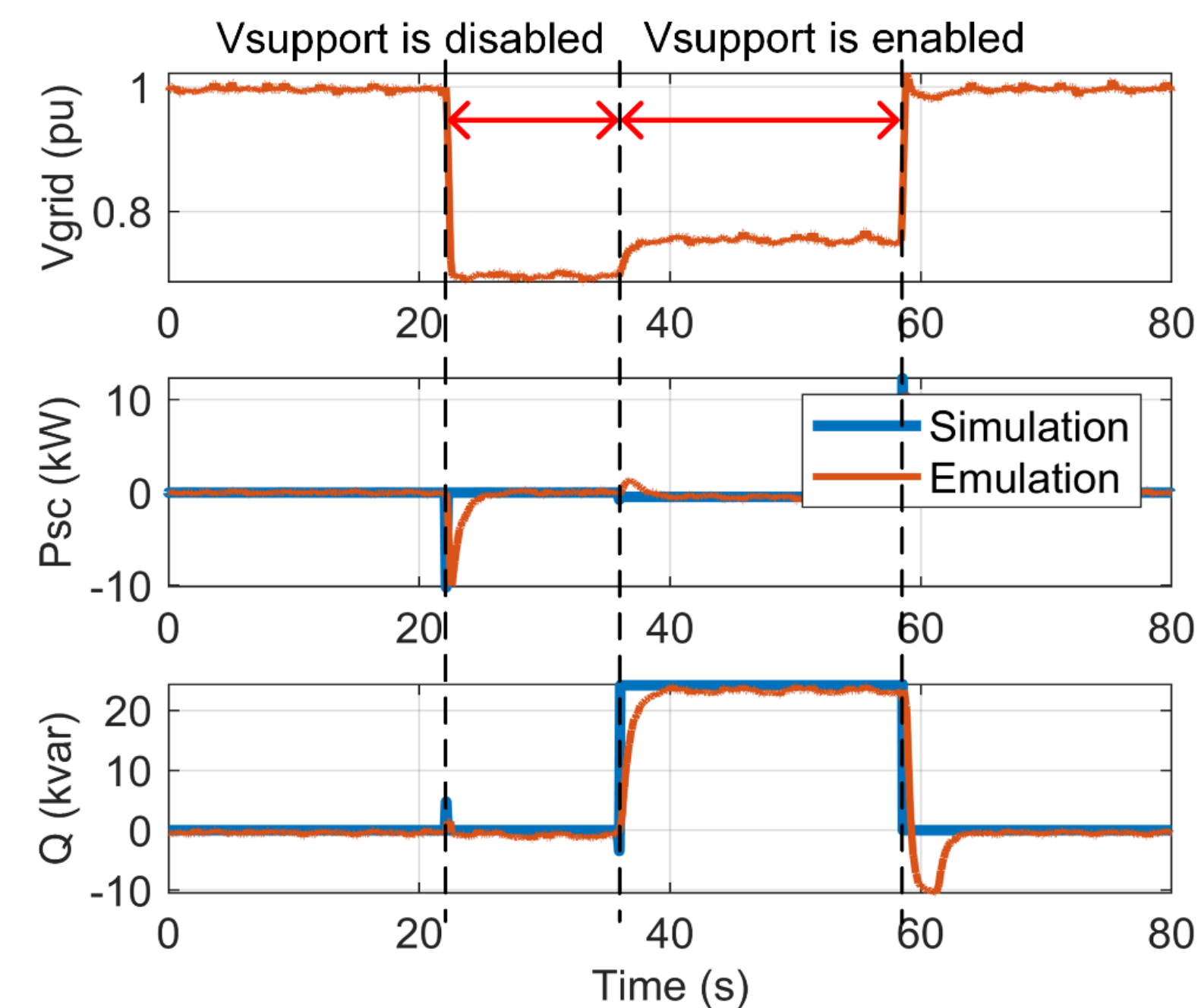
- Three voltage source converters are used to emulate the PVSS including generator emulator, load emulator, and PV combined with SC emulator.
- Embed the digitalized PVSS model in the digital signal processor (DSP) of the power converter.
- Conduct test scenarios to demonstrate the accuracy of the emulator.
  - Constant power charge - discharge.
  - Grid voltage support under voltage sag event.
- Good match between the experimental results and the simulation results.



Experimental test setup on the HTB.



Constant power charge - discharge profiles.



Grid voltage support test scenario.

## CONCLUSION AND FUTURE WORK

- The SC emulator has been developed on the HTB, and verified with the developed model in MATLAB/Simulink.
- The developed SC emulator can operate as a single emulator or integrated with other emulators such as PV, wind, and battery.
- The SC emulator on the HTB provides flexibility to test various power system scenarios to represent a large-scale system.
- Dynamic behaviors of the SC emulator under other grid scenarios i.e., grid frequency support, inertia emulation and fault ride through will be further investigated and discussed.

