Modeling of Electronic Loads for Planning Studies

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WECC MVS Meeting
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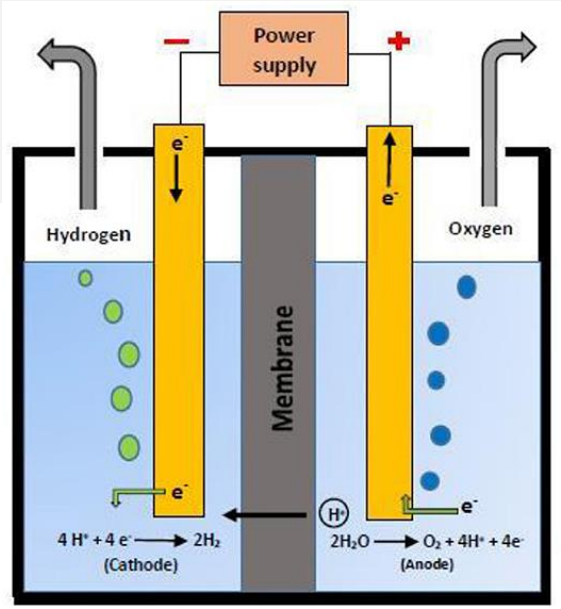
New Electric Loads in Power Systems

Hydrogen Electrolyzers



In 1000s of MW

Crypto Mining

Few kW to ~1000s MW

Data Centers

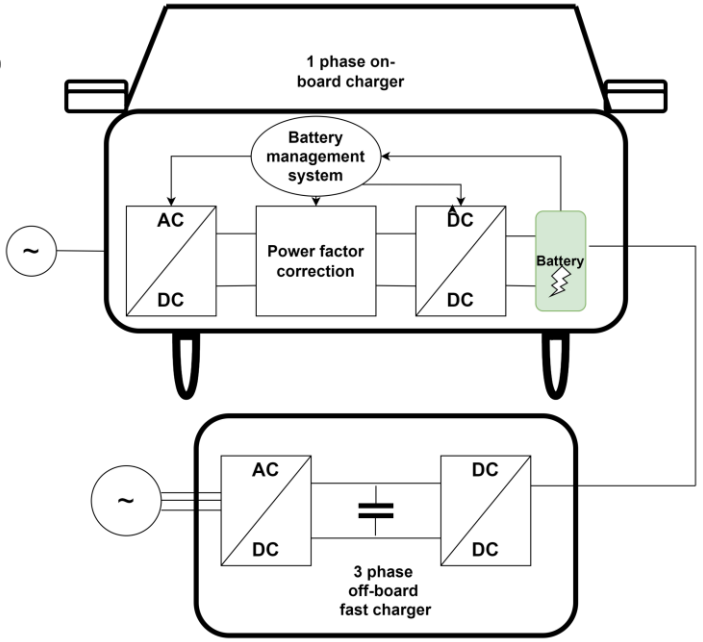
Few kW to ~1000s MW

EV Charging

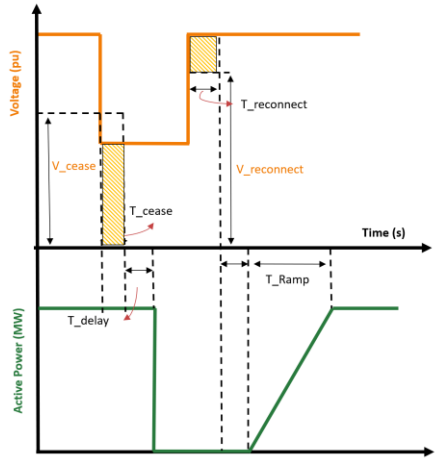
Up to 50 MW

EV charger technologies

- Currently, EV chargers make up 1% of the total load and in the future are expected to rise to 30%[1].
- Wide variety of EV chargers in market with different characteristics
- Understand the key differences in their responses
- Identify relevant characteristics that need to be captured in transmission planning studies



Temporary disconnection characteristics



Chargers	I/p voltage	Power range	Location
Level 1	120V (1Φ)	~2.6kW	Residential
Level 2	240V (1Φ)	~7.4kW	Commercial
Level 3	480V (3Φ)	60-350 kW	Charging hubs

Improve modeling of EV chargers through test results and comparison with electromagnetic transient (EMT) models

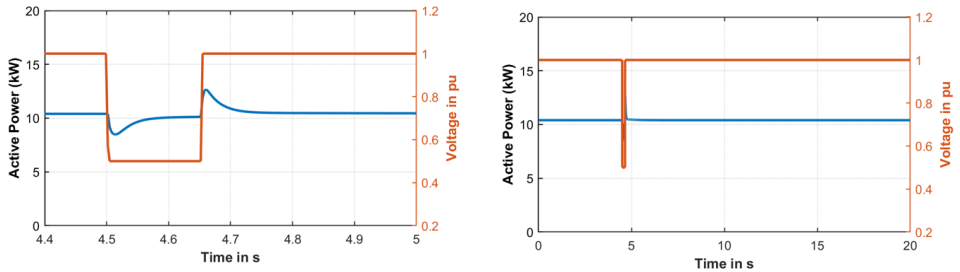
1. https://www.nerc.com/comm/RSTC_Reliability_Guidelines/NERC_Potential_Bulk_Power_System_Impact_of_Vehicle_Chargers_2024.pdf

EV charger test results (2021)

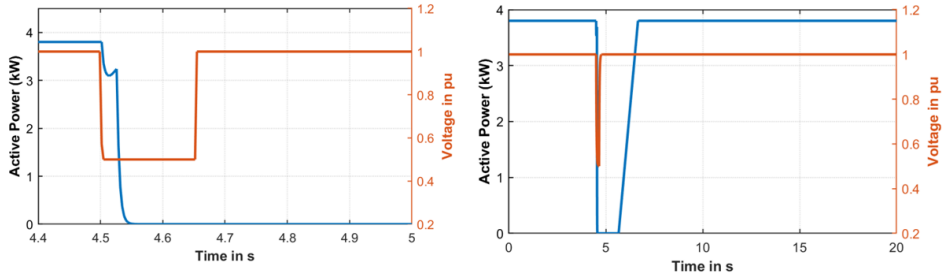
- A voltage dip of 50% for 9-cycles was applied and the responses were recorded
- The three key responses observed were:
  - The charger remained connected
  - The charger disconnected and did not reconnect
  - The charger disconnected temporarily and reconnected with a ramp after a time delay

EV charger testing[1] (2021)

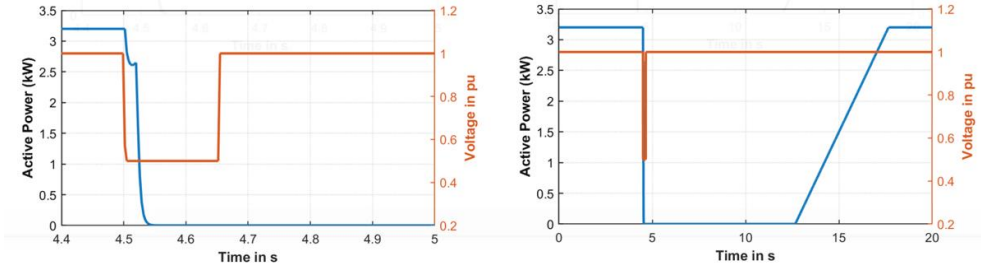
Type A



Type B



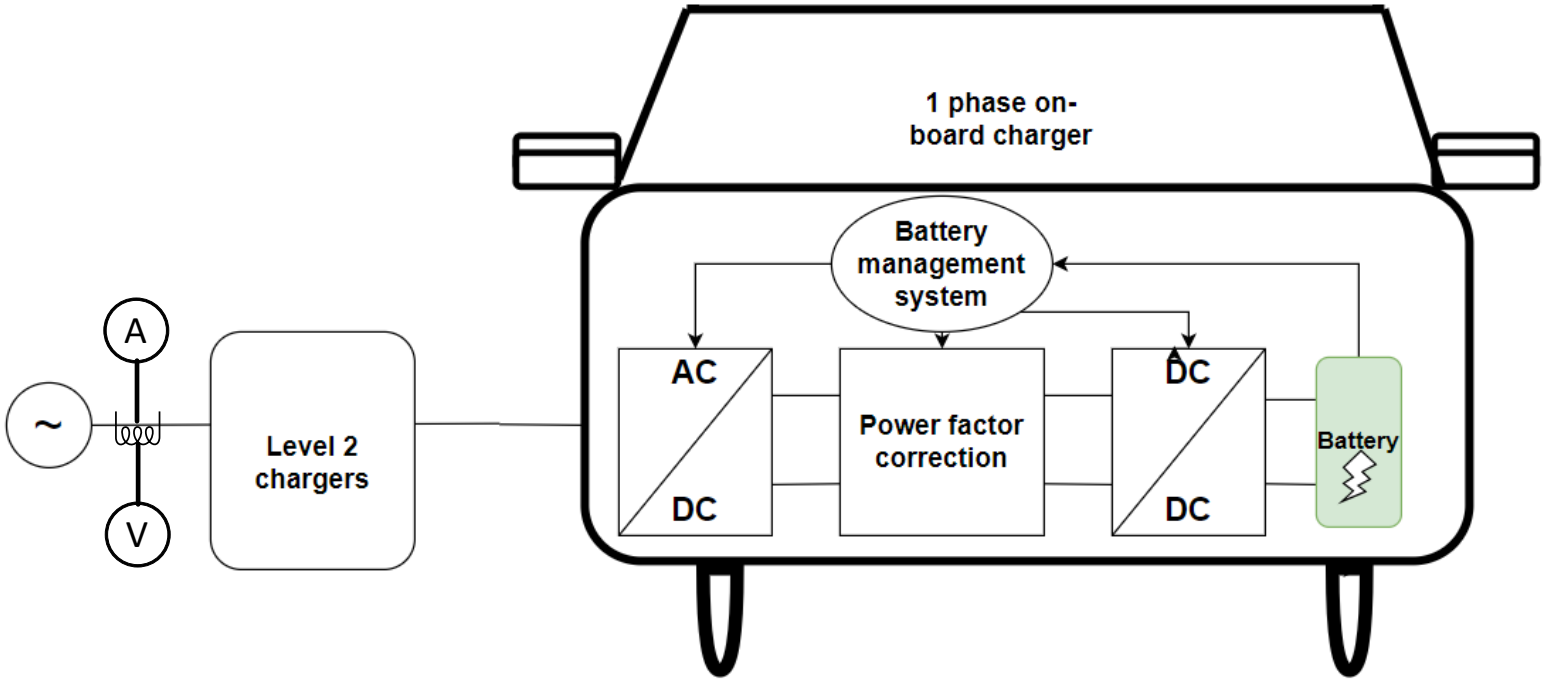
Type C

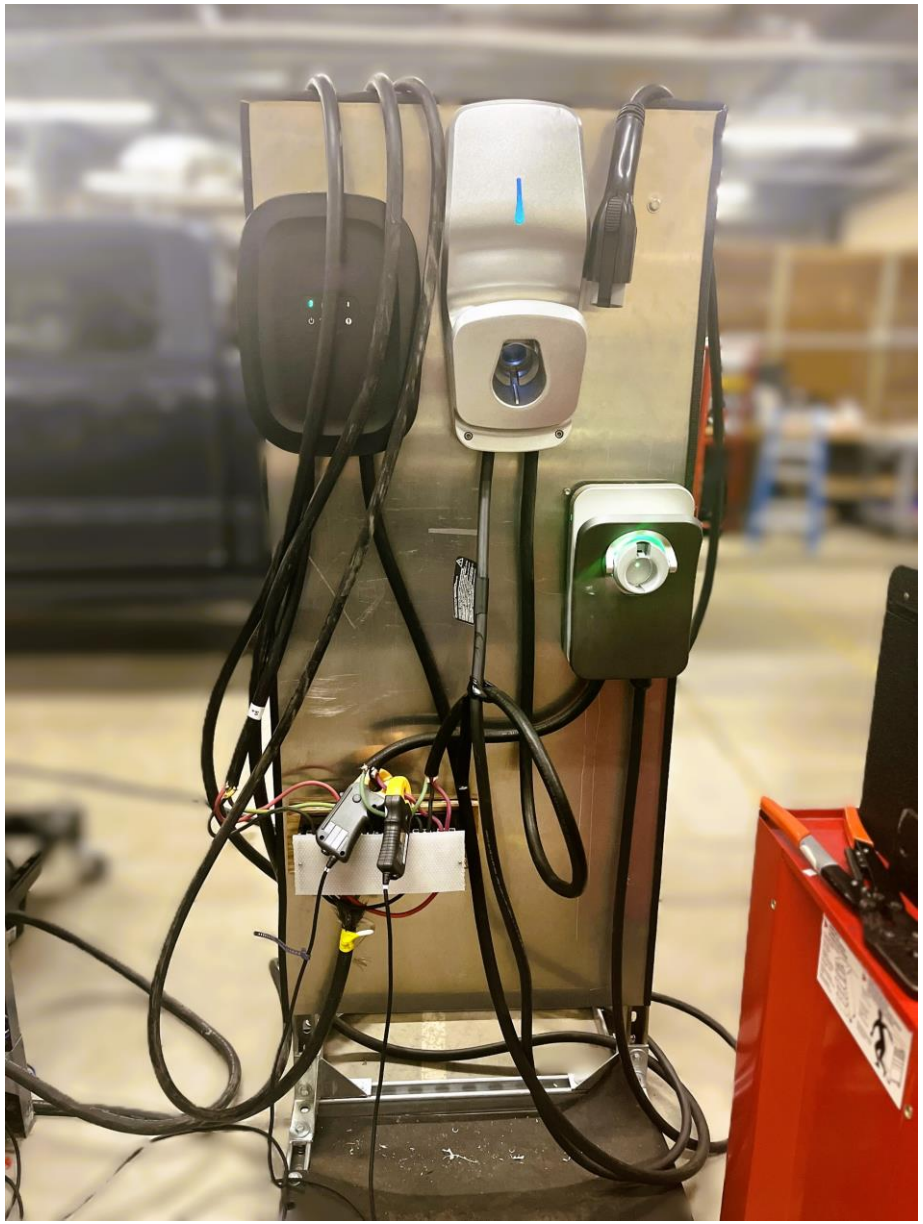


1. Tuffner, Francis K., Undrill, John, Scoffield, Don, Eto, Joseph H., Kosterev, Dmitry, and Quint, Ryan D. Distribution-Level Impacts of Plug-in Electric Vehicle Charging on the Transmission System during Fault Conditions. United States: N. p., 2021. Web. doi:10.2172/1832905.

Key feature needed: User defined cease/ reconnect response

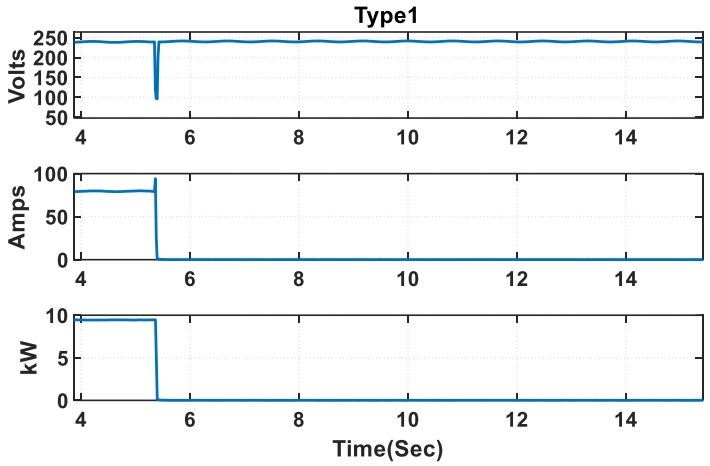
Level 2 Charger Test Set Up



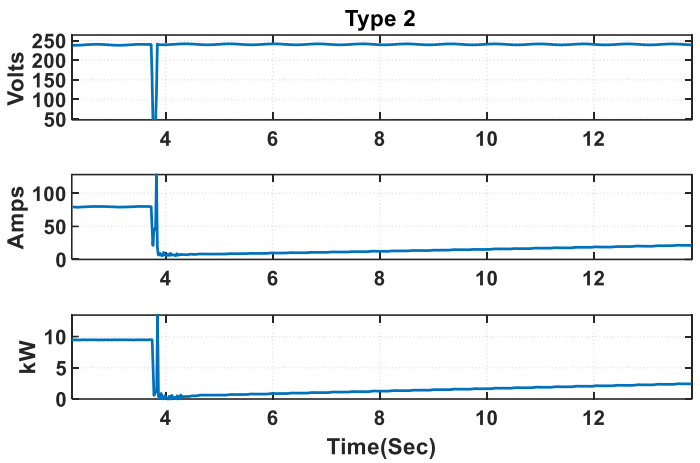


Ride-through responses

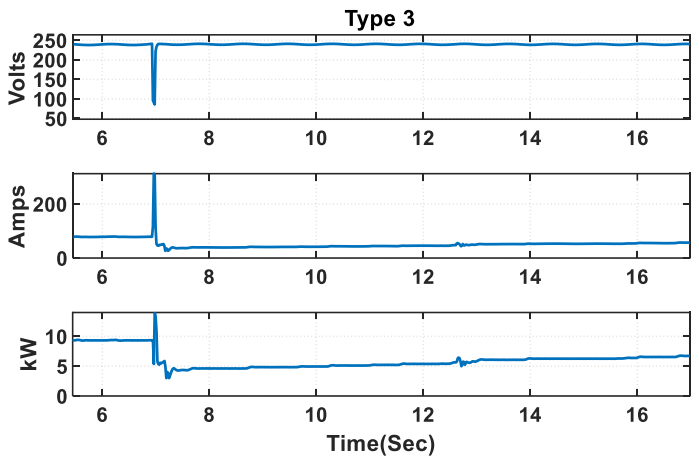
Disconnected & manual reconnect



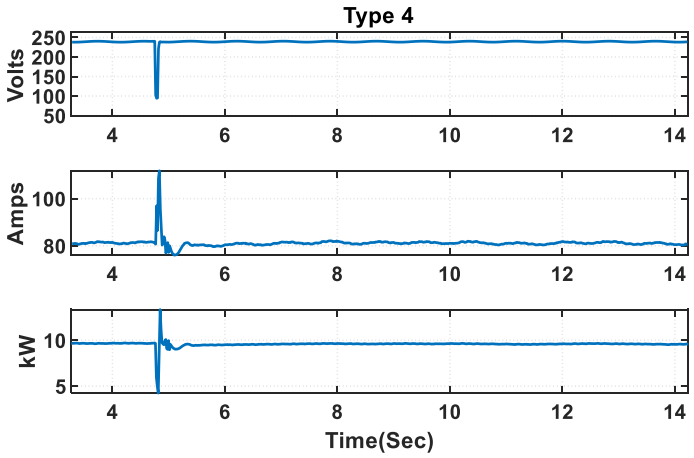
Zero power with ramped reconnect



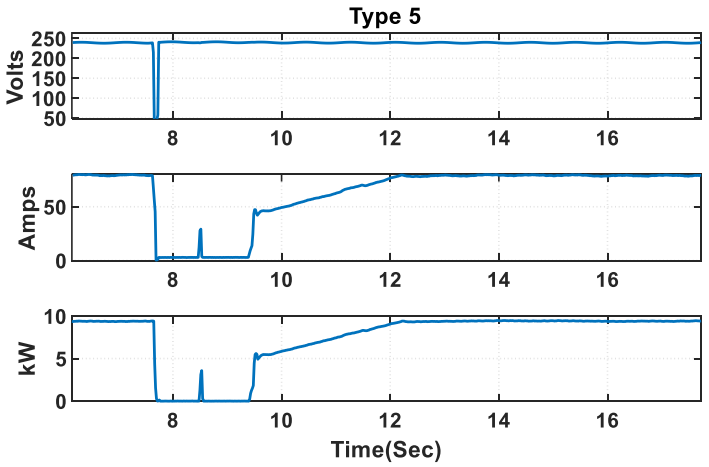
Reduced power with ramped reconnect



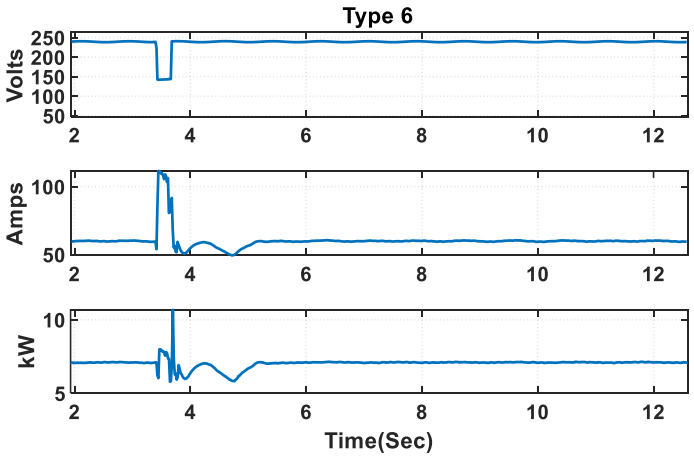
Fast transients



Ramped reconnect after time delay



Slow transients



EV Truck 1

	Disconnected & manually reconnect
	Zero power with ramped reconnect
	Reduced power with ramped reconnect
	Fast transient
	Ramped reconnect with time delay

Charger 1

	3 cycles	5 cycles	10 cycles	15 cycles
20%				
30%				
40%				
50%				
60%				

Charger 2

	3 cycles	5 cycles	10 cycles	15 cycles
20%				
30%				
40%				
50%				
60%				

Charger 3

	3 cycles	5 cycles	10 cycles	15 cycles
20%				
30%				
40%				
50%				
60%				

EV Truck 2

	Disconnected Manually reconnect
	Zero power with ramped reconnect
	Reduced power with ramped reconnect

	Fast transient
	Ramped reconnect with time delay

Charger 1

	3 cycles	5 cycles	10 cycles	15 cycles
20%				
30%				
40%				
50%				
60%				

Charger 2

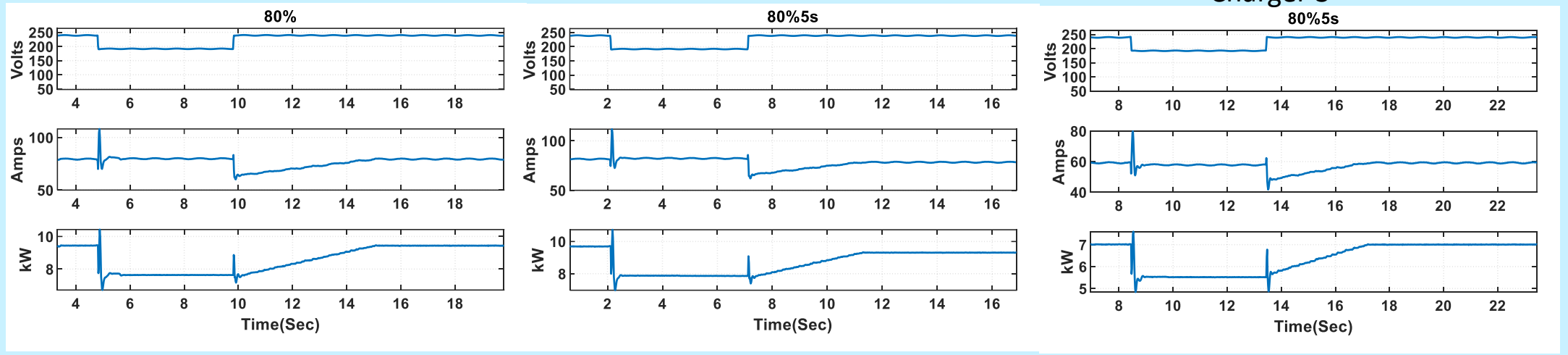
	3 cycles	5 cycles	10 cycles	15 cycles
20%				
30%				
40%				
50%				
60%				

Charger 3

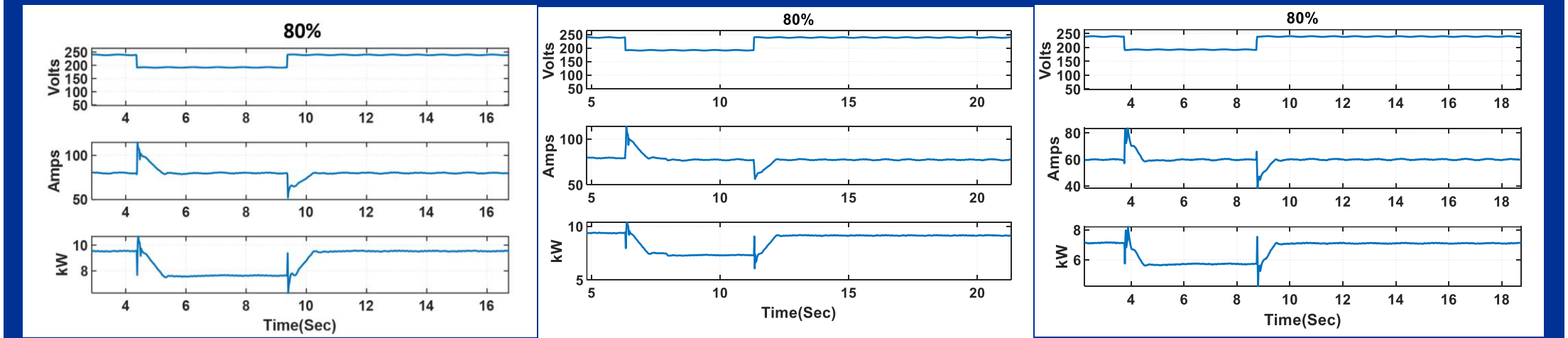
	3 cycles	5 cycles	10 cycles	15 cycles
20%				
30%				
40%				
50%				
60%				

Test results for 80% voltage dip for 5s

Truck 1

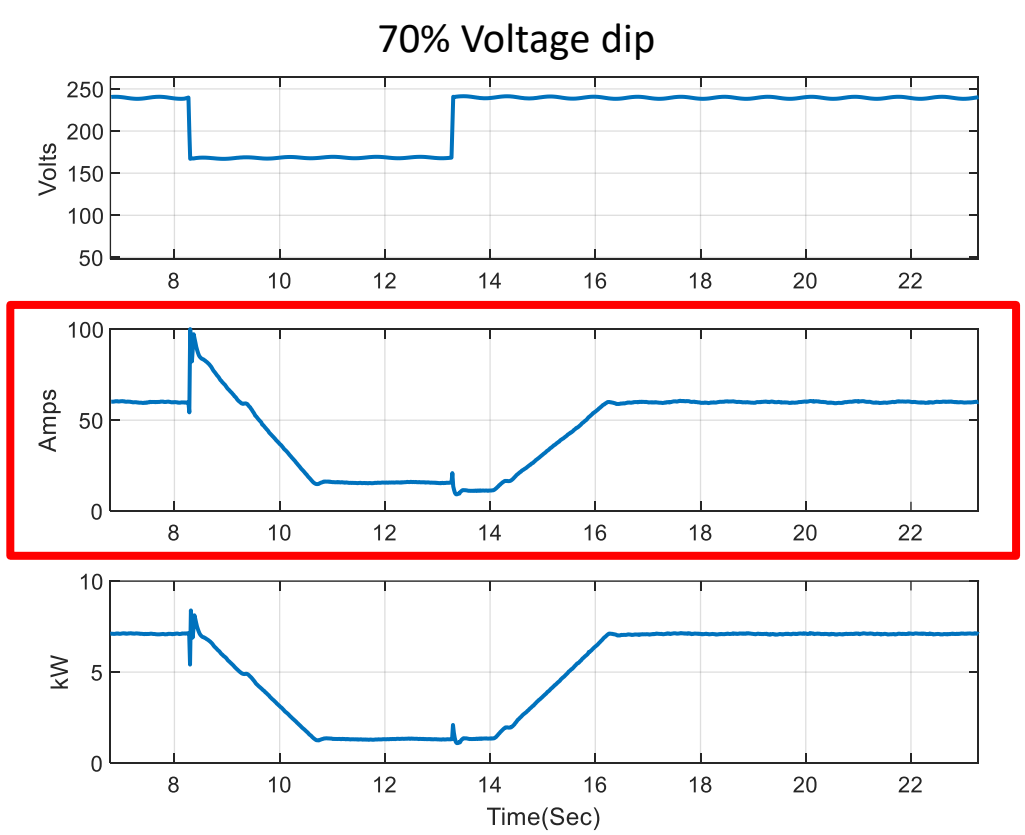


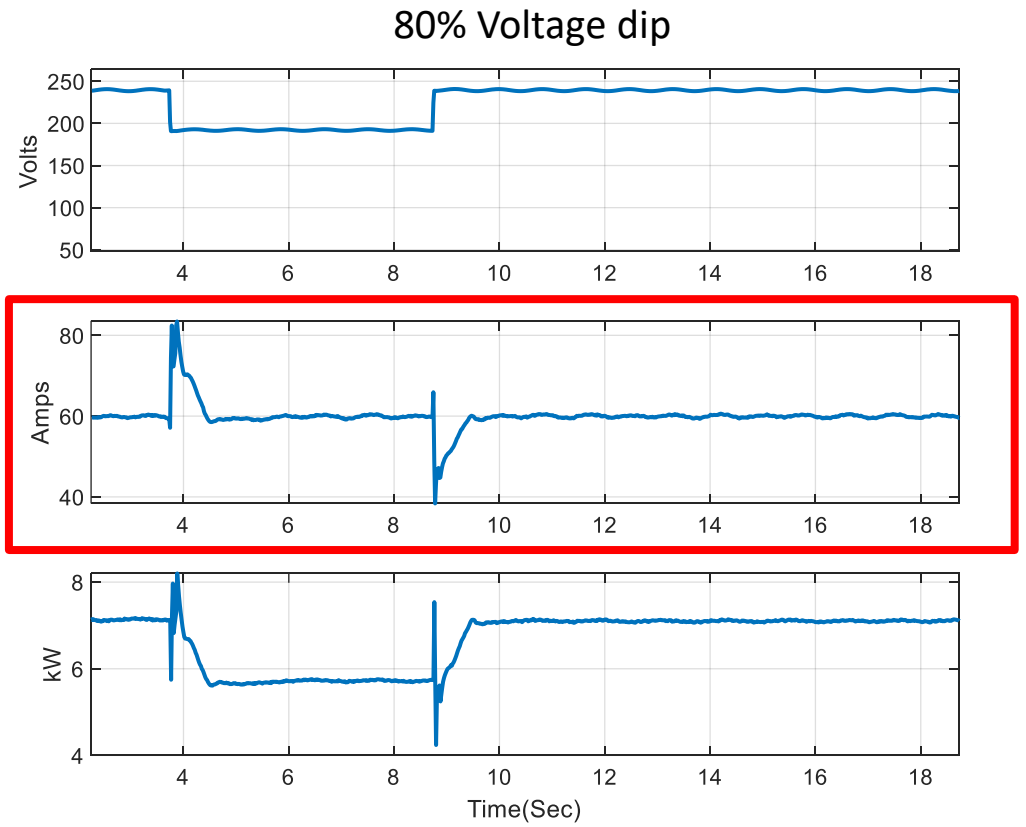
Truck 2



Same charger with a different vehicle will perform differently

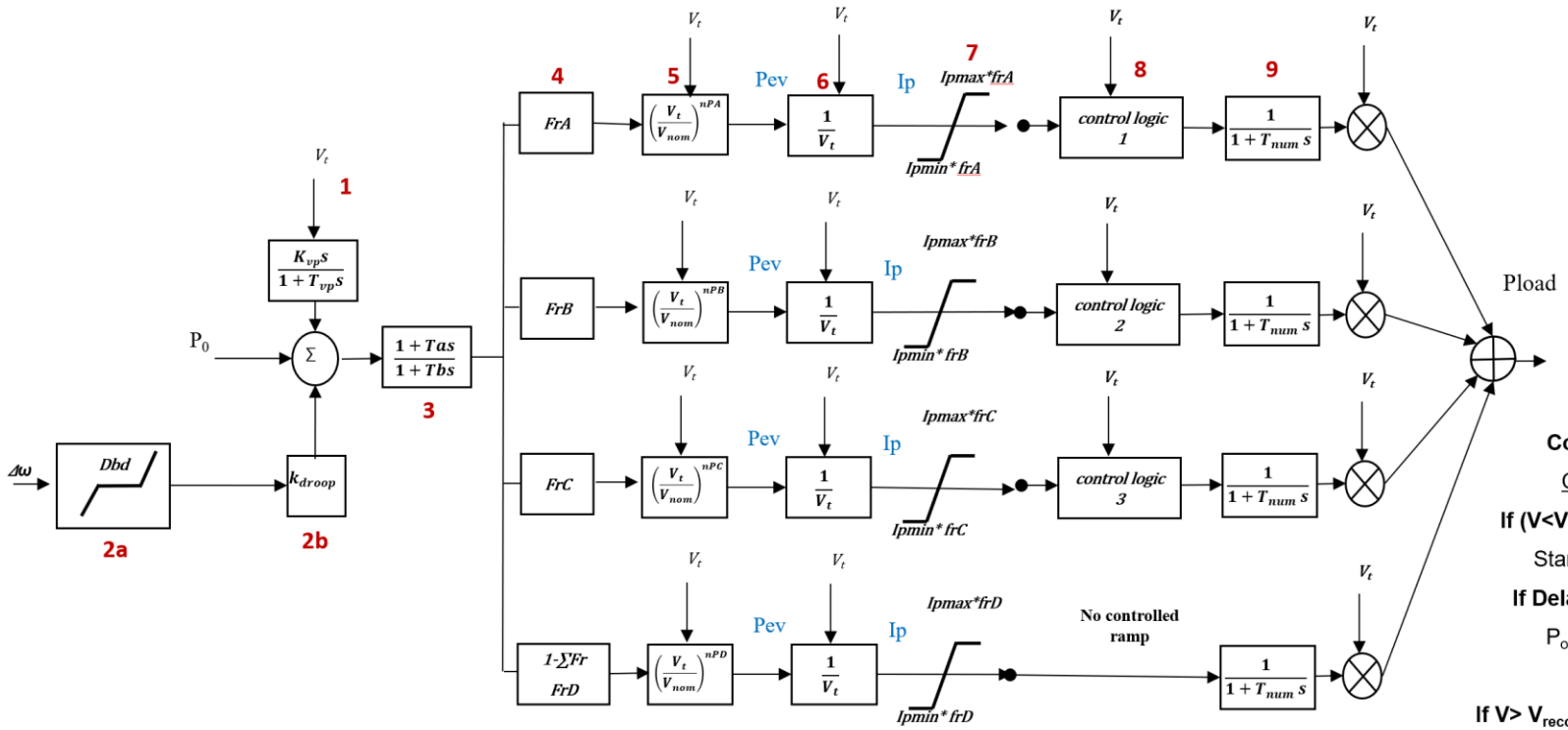
Ride-through responses (EPRI testing 2024)

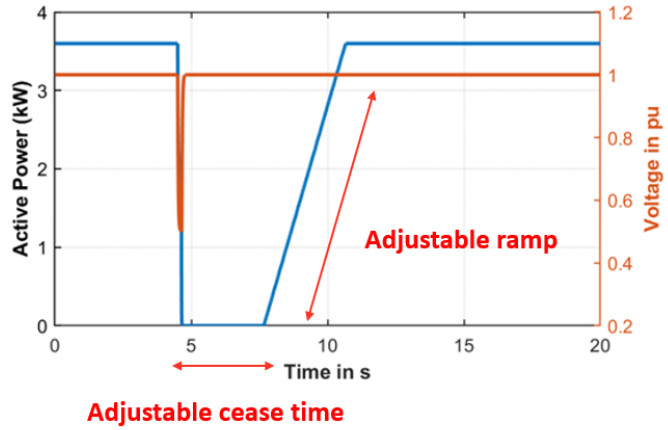




For shallow sags, current limiting response was observed

Existing positive sequence model





Control Block

Cease logic

If ($V<V_{cease}$ for $T>T_{cease}$)

Start Delay Timer

If Delay Timer $>T_{delay}$

$P_{out} = P_{ev}*(1-fr)$

Start logic

If $V> V_{reconnect}$ for $T>T_{reconnect}$

$P_{out} = P_{out} + P_{ev}*delt/T_{ramp}$

where T_{ramp} is the ramp time

Cease logic is applied to the power output of the model

Positive sequence model can replicate the slow dynamics in the measurements to a great extent

Next steps

- Current positive sequence model replicate slow dynamics observed to a large extent
- The need for limiting current in place of power is currently being evaluated
- There is a big need for testing more EVSEs
  - *Not a simple task logistically, and quite expensive*
- Dc-Dc fast charging equipment need to be tested
  - *Planning to test at least one non-Tesla equipment this year*
- Test results are not just dependent on the car or the charger, its dependent upon both

www.epri.com