BPS Impacts from Behind the Meter DER IEEE 1547-2018 Category II and III

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NERC SPIDER Work Group Meeting

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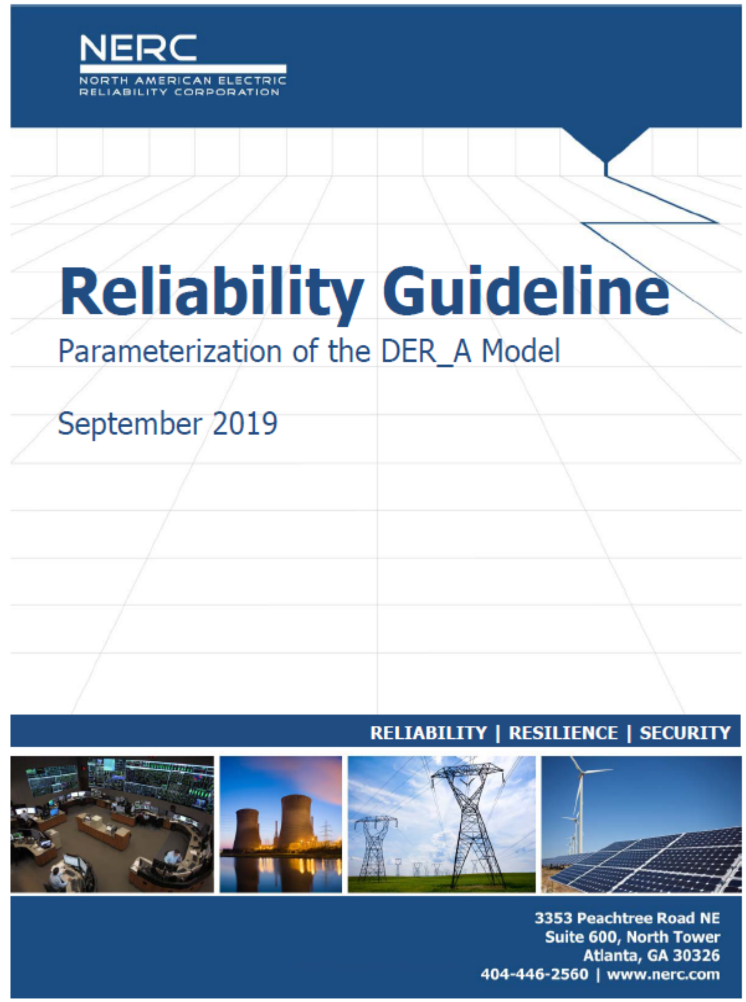
IEEE Std 1547-2018 DER Categories

- Cat. A and B for voltage regulation performance and reactive power capability requirements (Clause 5)
- Cat. I, II, and III for disturbance ride-through requirements (Clause 6)
  - Cat. I with default trip settings in use today. Not consistent with the Bulk Power System (BPS) Standards and may be detrimental for BPS.
  - Cat. II covers all BPS reliability needs and coordinates with the NERC PRC-024-2 developed to avoid adverse tripping. Additional voltage ride-through capability is specified for DERs to account for FIDVR.
  - Cat. III provides the highest disturbance ride-through capabilities, intended to address integration issues such as power quality and system overloads caused by DER tripping very high levels of DER penetration. These requirements are based on the California Rule 21 Smart Inverter requirements.
    - Includes specifications for Momentary Cessation

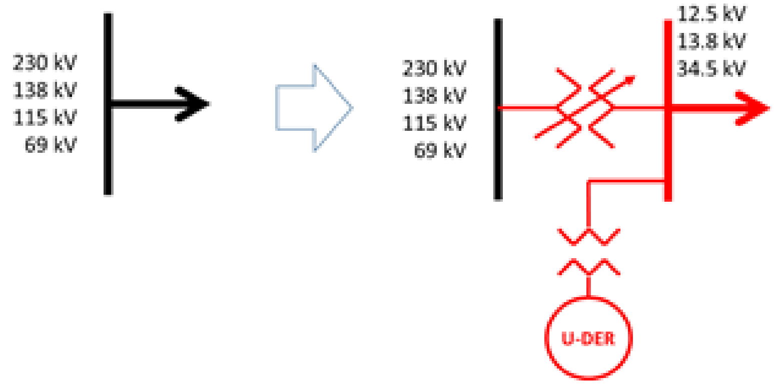
NERC SPIDER (System Planning Impact from DER) WG – DER_A Modeling Guideline

- New DER_A dynamic model now released in all major positive sequence simulation software platforms.
- NERC SPIDERWG developed guideline for how to use the DER_A model, and how to develop its parameter values
- The Guideline is approved by NERC
- Provides detailed understanding of the model
- Provides recommendations for developing parameters for the model and values of DER_A parameters to use

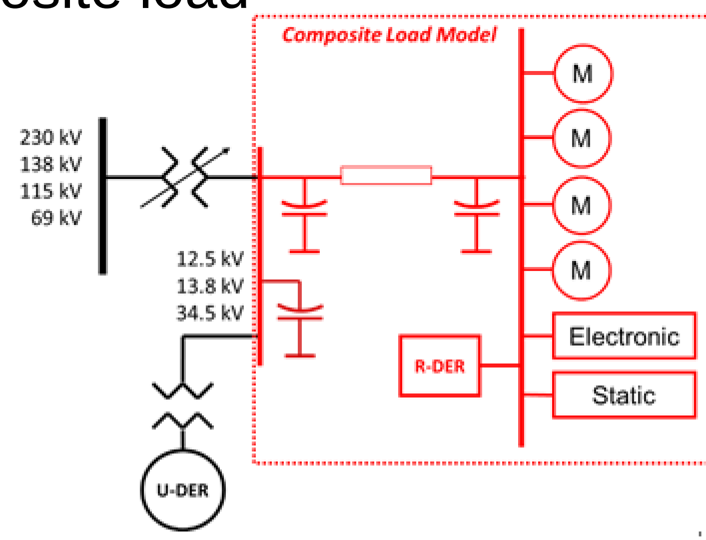


Modeling DER in Power Flow and Dynamic Stability

U-DER transformer and feeder modeled. DER modeled as generator



R-DER is modeled as part of composite load



This study applies only to R-DER

DER Parameters in this Study

- CAISO models behind the meter DER as a part of load for the last two years. Software used was GE PSLF Version 21.07
- 2029 Summer Peak case, modified to increase amount of DER. Assumed hot summer day, DER dispatched at 80% of installed capacity
- The peak case has high load, thus stalling of single-phase air-conditioners with faults
- DER_A parameters as recommended by SPIDER Modeling Guideline for inverters according to IEEE 1547-2018

Parameter	Cat II	Cat III	Definition
vl0	0.44	0.44	Voltage break-point for low voltage cut-out of the inverter, p.u.
vl1	0.49	0.49	Voltage break-point for low voltage cut-out of the inverter, p.u.
vh0	1.20	1.20	Voltage break-point for high voltage cut-out of the inverter, p.u.
vh1	1.15	1.15	Voltage break-point for high voltage cut-out of the inverter, p.u.
tvl0	0.16	1.00	Low voltage cut-out of timer, sec.
tvl1	0.16	1.00	Low voltage cut-out of timer, sec.
tvh0	0.16	1.00	High voltage cut-out of timer, sec.
tvh1	0.16	1.00	High voltage cut-out of timer, sec.
vrfrac	1.00	1.00	Fraction of device that recovers after voltage returns within vl1 and vh1

DER Modeling and Studies at CAISO. What is CAISO?

ISO AT-A-GLANCE

- 26,000 CIRCUIT MILES OF TRANSMISSION LINES
- 31,208 MARKET TRANSACTIONS PER DAY
- 1,080 POWER PLANTS
- 60% RENEWABLES BY 2030
- 239 MILLION MEGAWATT HOURS PER YEAR
- 9,700 PRICING LOCATIONS (INCLUDES EIM)

BEHIND THE METER DER

Existing as of 2019 – 8,661 MW
2021 – 11,832 MW
2026 – 17,409 MW
2030 – 21,148 MW

Information
http://www.caiso.com/planning/Pages/TransmissionPlanning/2020-2021TransmissionPlanningProcess.aspx

Case Studied – 2029 Summer Peak, Behind the Meter DER at 80% installed capacity

- No DER impact in the peak case studied in Transmission Plan because of its low amount (280 MW in the CAISO).
- Increased amount of behind-the-meter DER to 80% of the installed capacity and increased load 20%, hypothetical case
- Behind the meter DER installed capacity at CAISO 18,600 MW, dispatched 14,880 MW (increased from 280 MW)
- PG&E (Northern California)
  - Load 31,654 MW gross, 24,240 MW net
  - Behind the meter DER installed capacity 9,270 MW
  - Behind the meter DER dispatched 7,416 MW
- Fresno zone,
  - Load MW 2,846 MW gross,1,634 MW net
  - Behind the meter DER installed capacity 1,515 MW
  - Behind the meter DER dispatched 1,212 MW

Contingency Studied, power flow case with 80% Behind-the-Meter DER dispatched

- Fresno area, Gates- Midway 230 kV line outage
- Why 230 kV? Larger difference in DER performance
- 3-ϕ fault on the sending end with normal clearance (6 cycles, 0.1 s)
- DER cases studied:
  - Category II, No voltage control,
  - Category III, No voltage control
  - Category II, Voltage control,
  - Category III, Voltage control
  - No DER, same load, more generation dispatched
- Cases with voltage control, kqv=5, dead-band +0.1/-0.12

. Results Summary for the Cases Studied

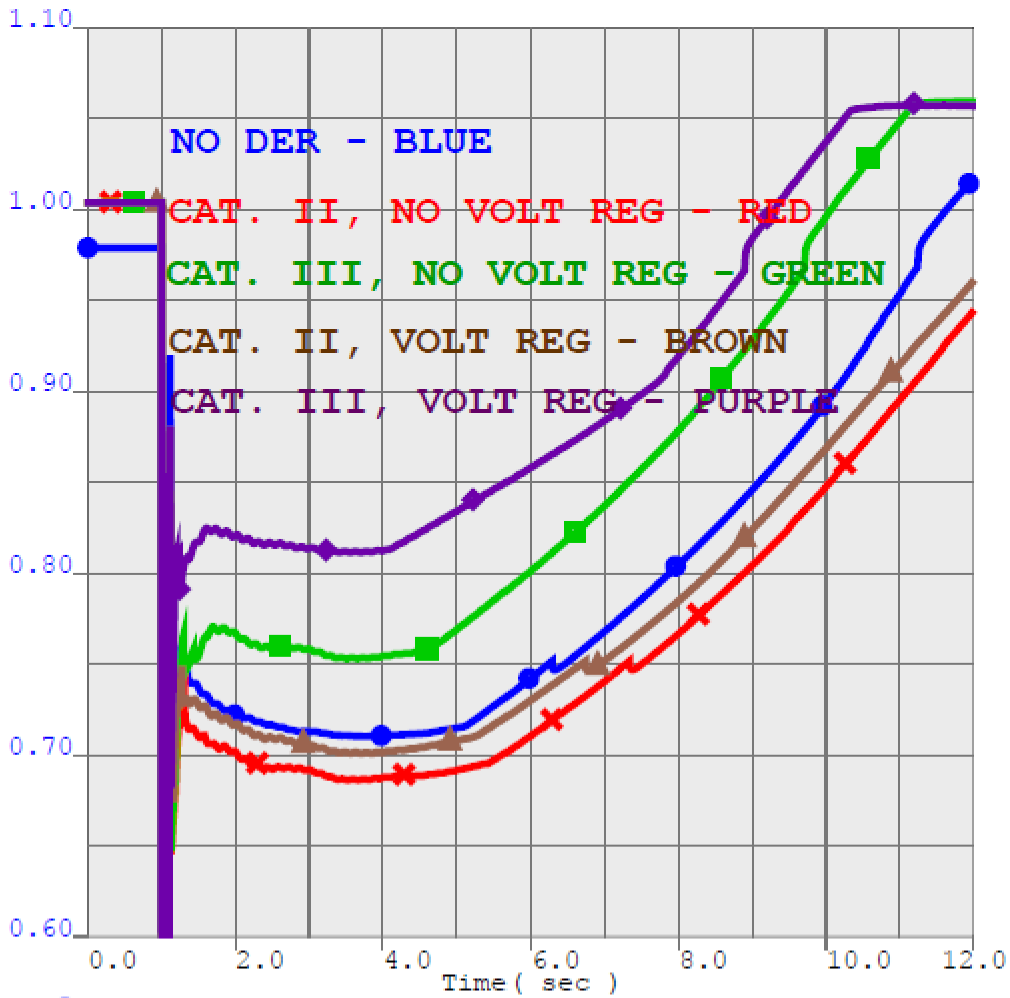
- No criteria violations with this contingency

Loss of Composite Load and DER with Contingency

Load and DER in Northern California	80% DER, Cat II, No voltage control		80% DER, Cat III, No voltage control		80% DER, Cat II, with voltage control		80% DER, Cat III, with voltage control		No DER	
	MW	%	MW	%	MW	%	MW	%	MW	%
Reduction in net load	364	1.5%	383	1.6%	219	0.9%	283	1.2%	427	1.3%
Reduction in gross load	456	1.4%	440	1.4%	296	0.9%	291	0.9%	427	1.3%
Reduction in DER output	92	1.2%	57	0.8%	77	1.0%	8	0.1%	N/A	N/A

Load and DER in Fresno area	80% DER, Cat II, No voltage control		80% DER, Cat III, No voltage control		80% DER, Cat II, with voltage control		80% DER, Cat III, with voltage control		No DER	
	MW	%	MW	%	MW	%	MW	%	MW	%
Reduction in net load	147	9.8%	159	10.6%	76	5.1%	147	9.8%	223	8.2%
Reduction in gross load	230	8.5%	207	7.6%	148	5.5%	149	5.5%	223	8.2%
Reduction in DER output	83	6.8%	48	4.0%	72	5.9%	2	0.2%	N/A	N/A

Comparison of the five cases Voltage at feeder end

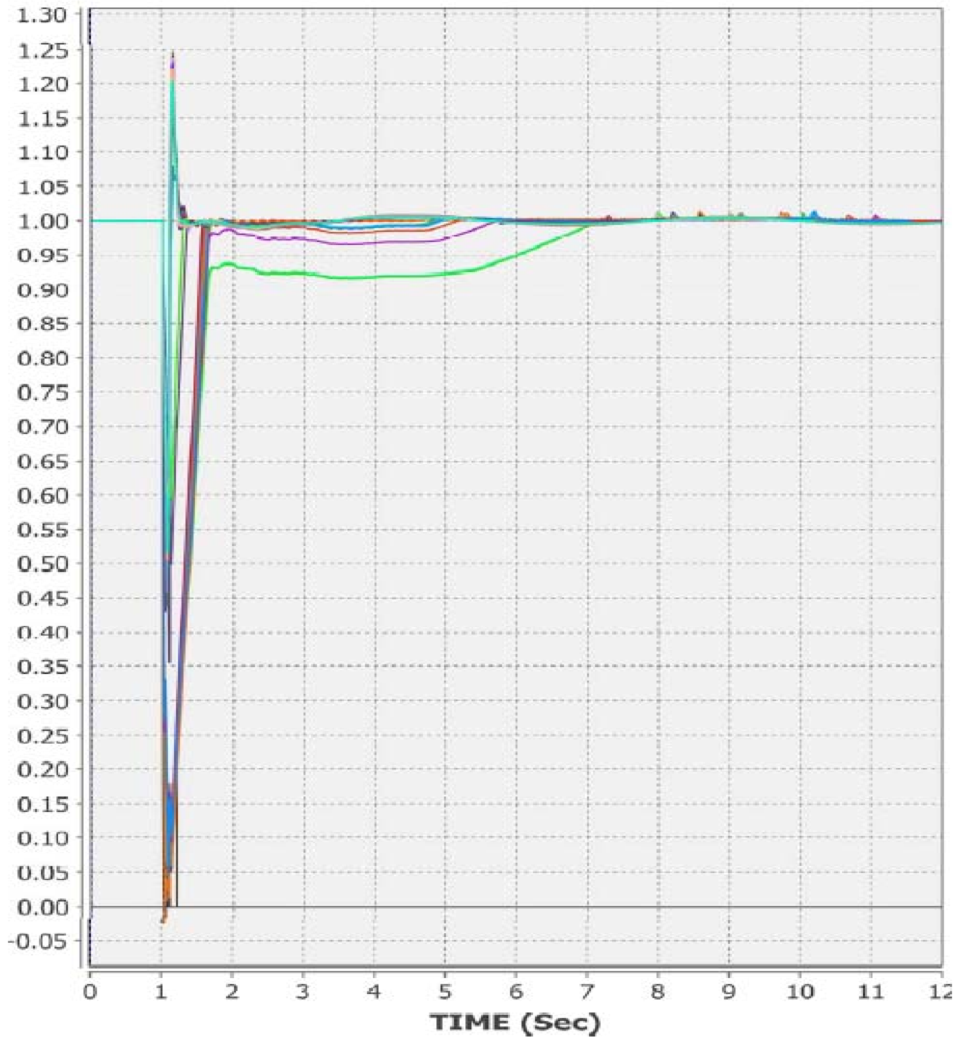


- Higher recovery voltage with Cat III and voltage control
- Lowest voltage with Cat II and no voltage control
- Without DER appeared to be similar to Cat II with voltage control because of voltage support from power plants
- Significantly better performance with Cat III

DER output, normalized (p.u) no voltage control. Fresno

Category II

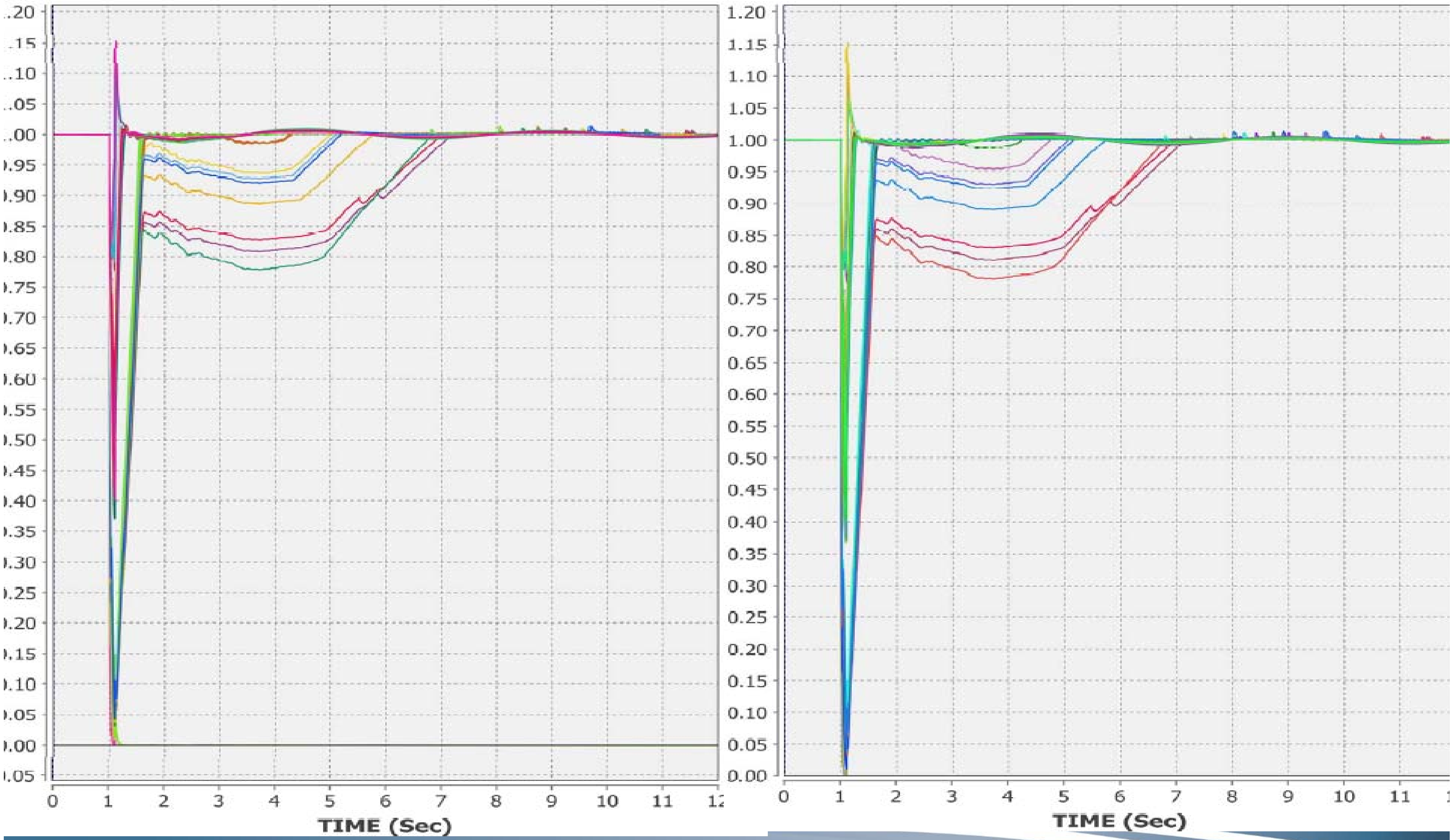
Category III



DER output, normalized (p.u) with voltage control. Fresno

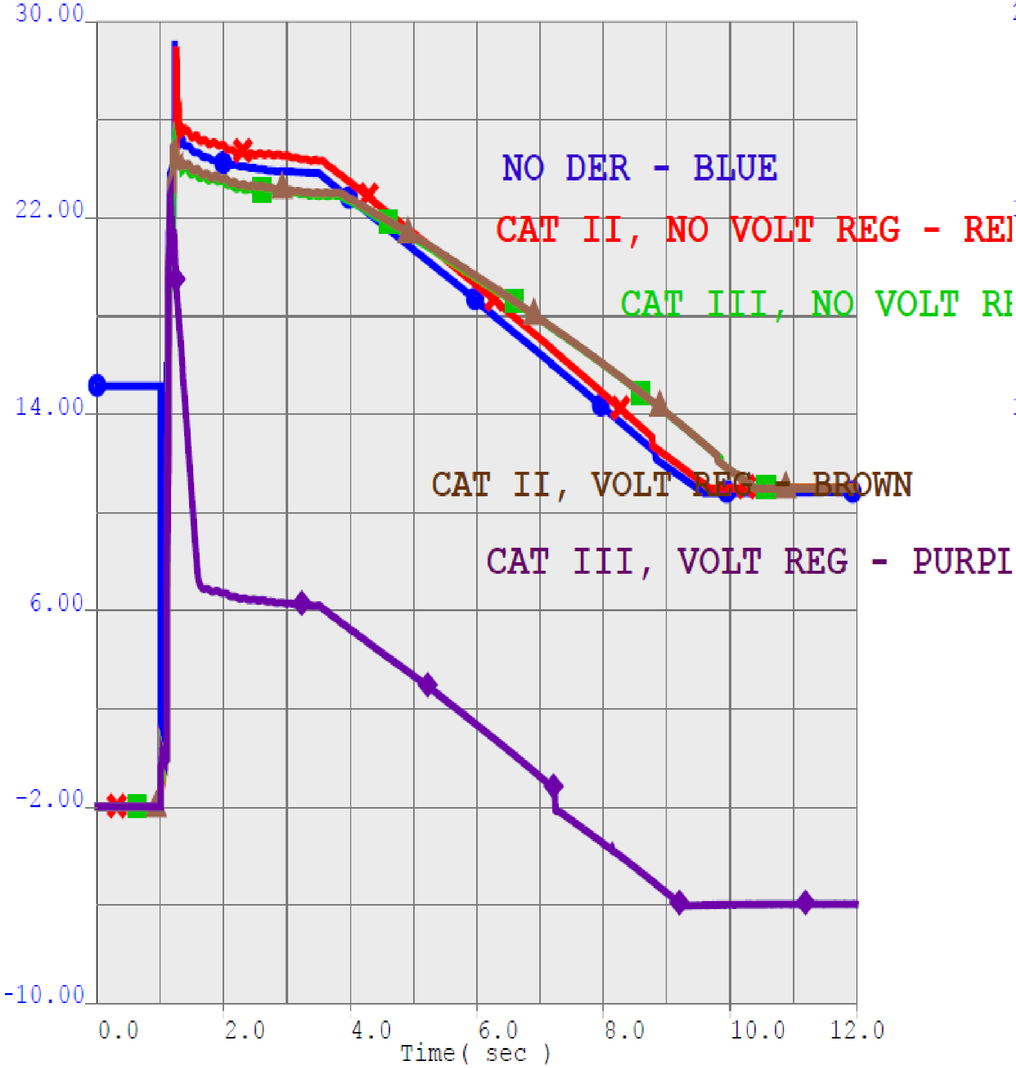
Category II

Category III

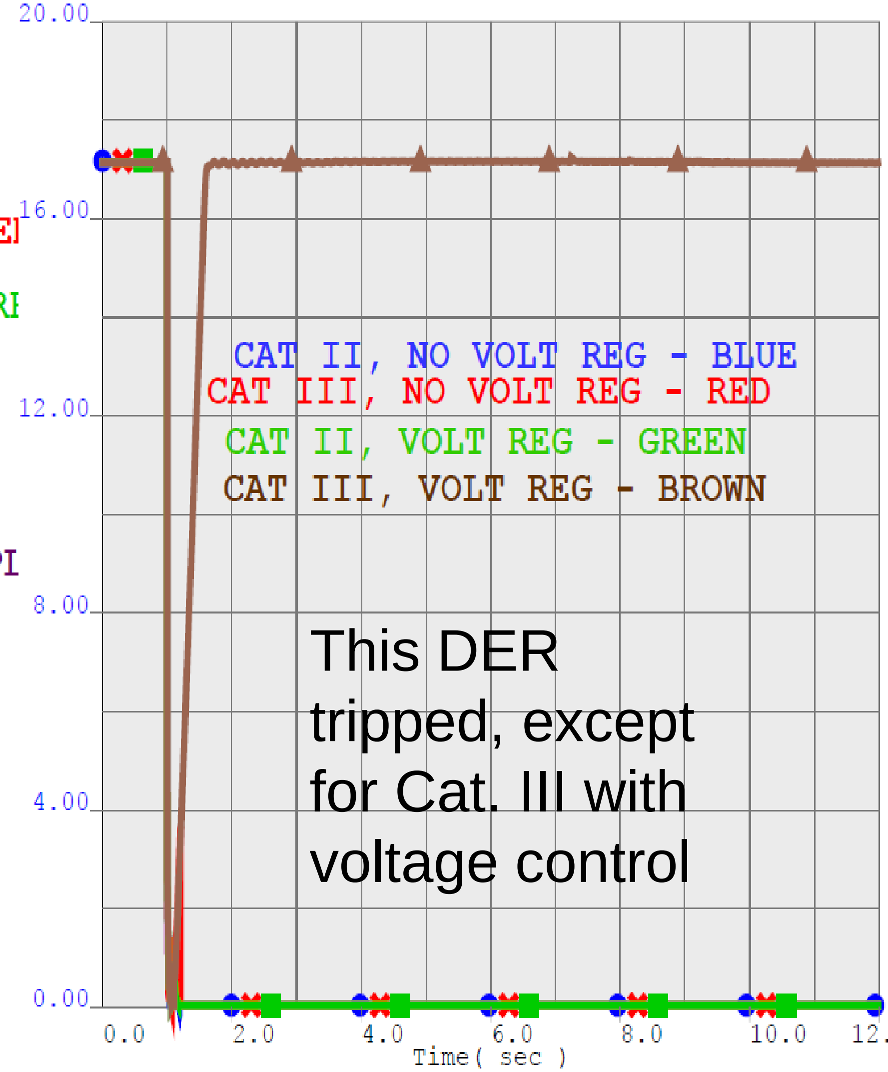


Comparison of load and DER on a 70 kV bus close to fault

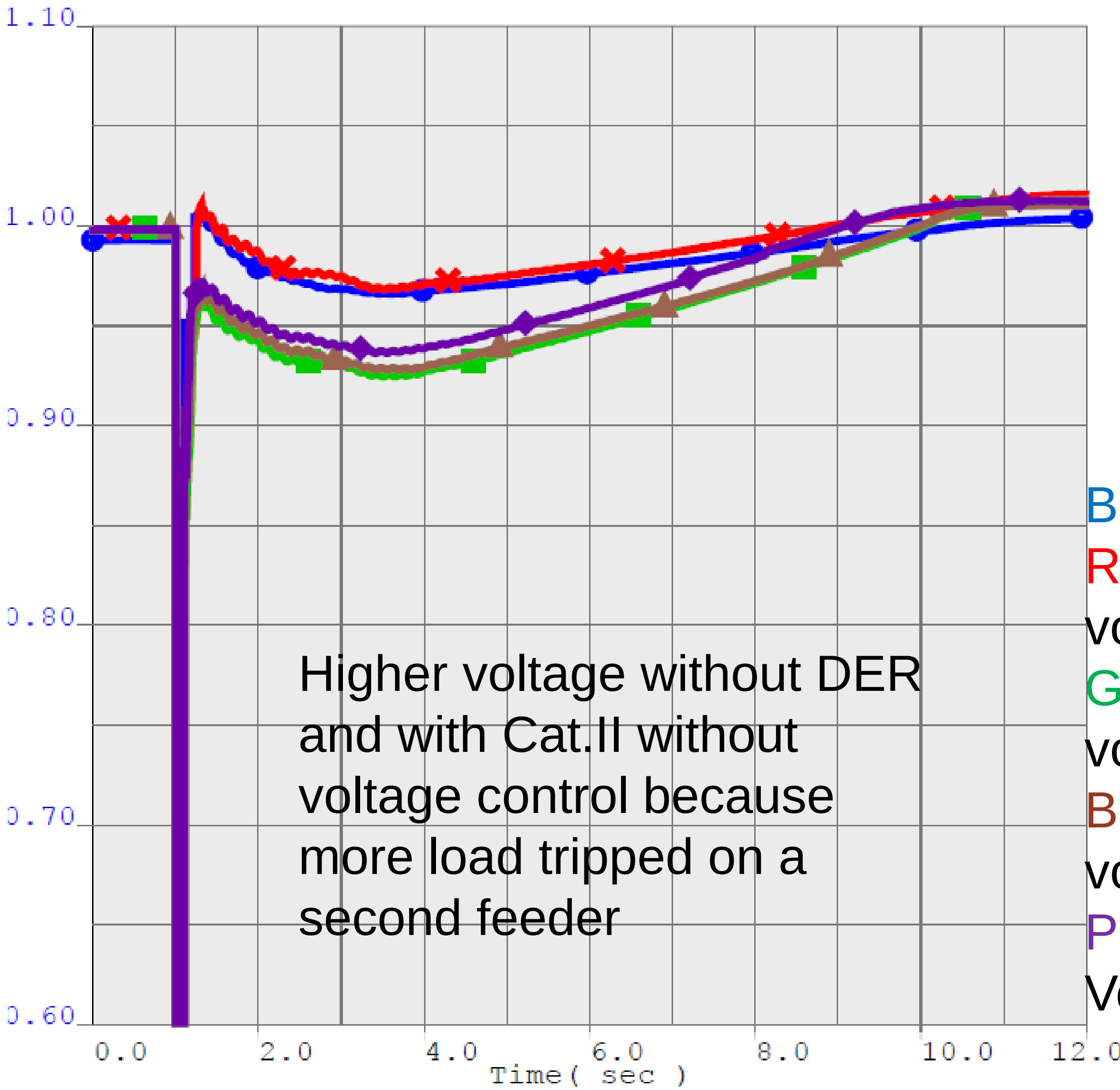
NET LOAD



DER OUTPUT



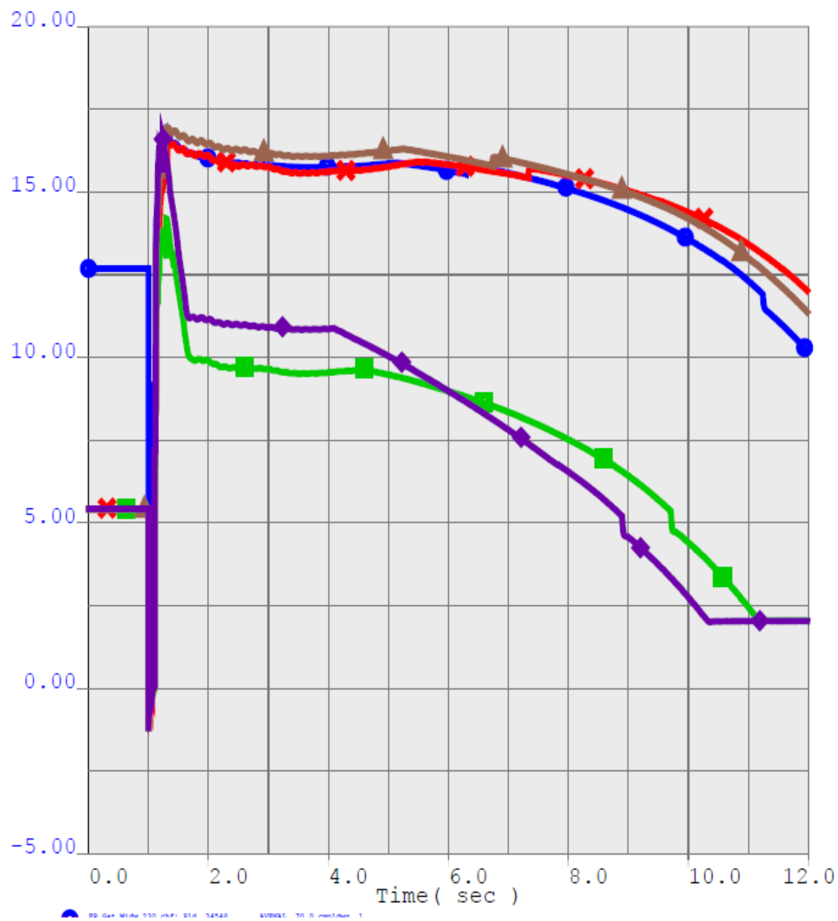
Comparison of voltage on this 70 kV bus close to fault

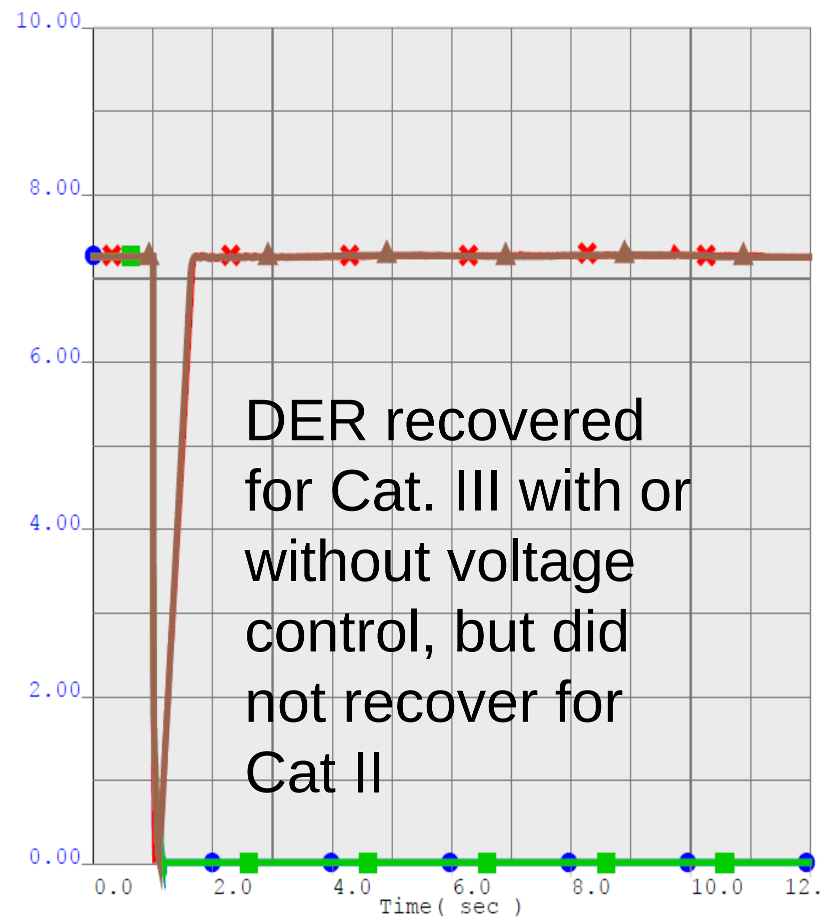


Voltage recovered, but DER was tripped and not recovered, except for Cat. III with voltage control

BLUE – no DER
RED – Category II, no voltage control
GREEN – Category III, no voltage control,
BROWN – Category II, voltage control
PURPLE – Category III, Voltage control

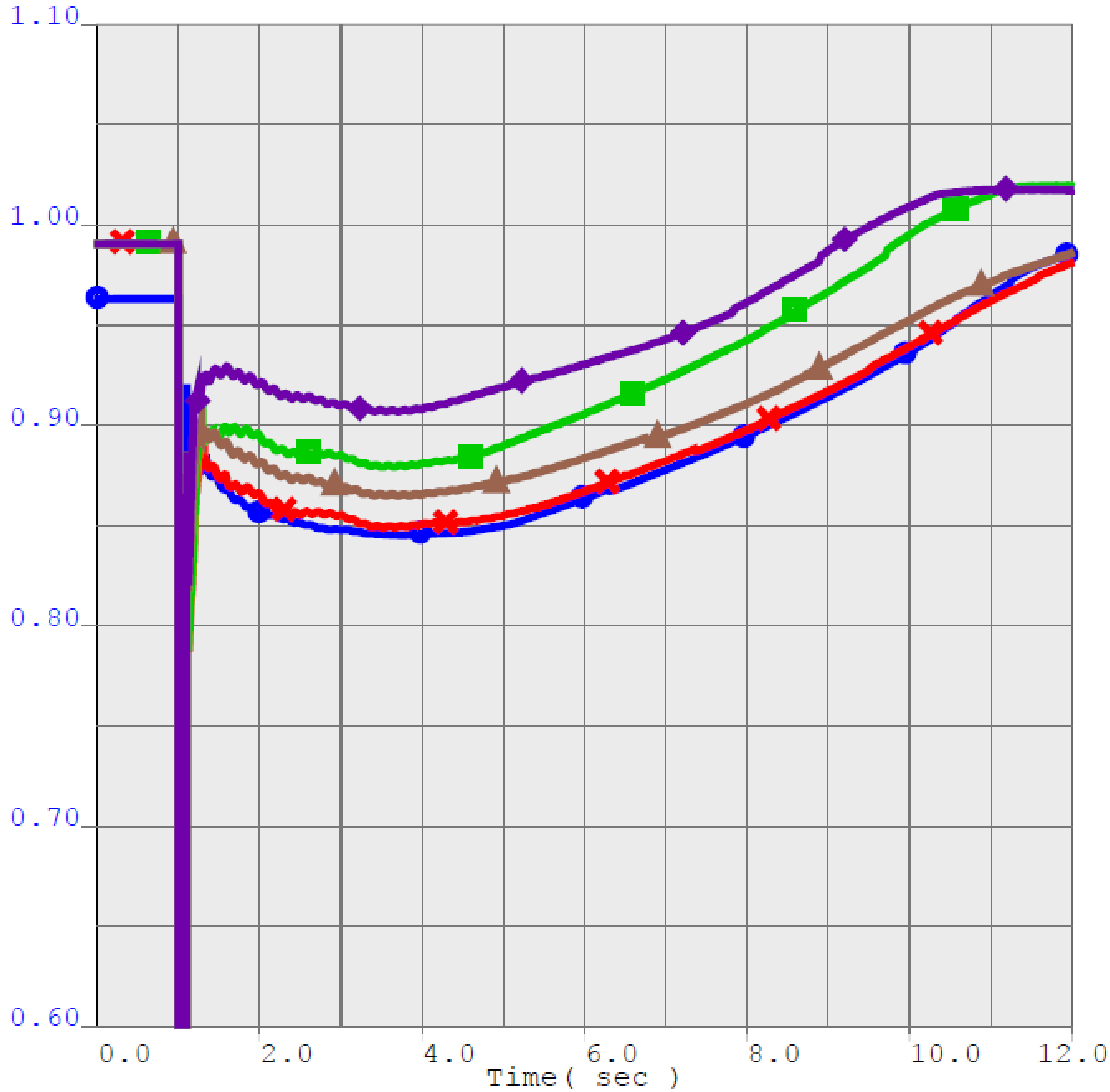
Load and DER on another bus





Net load: blue –no DER, red and brown Cat II, green and purple Cat III

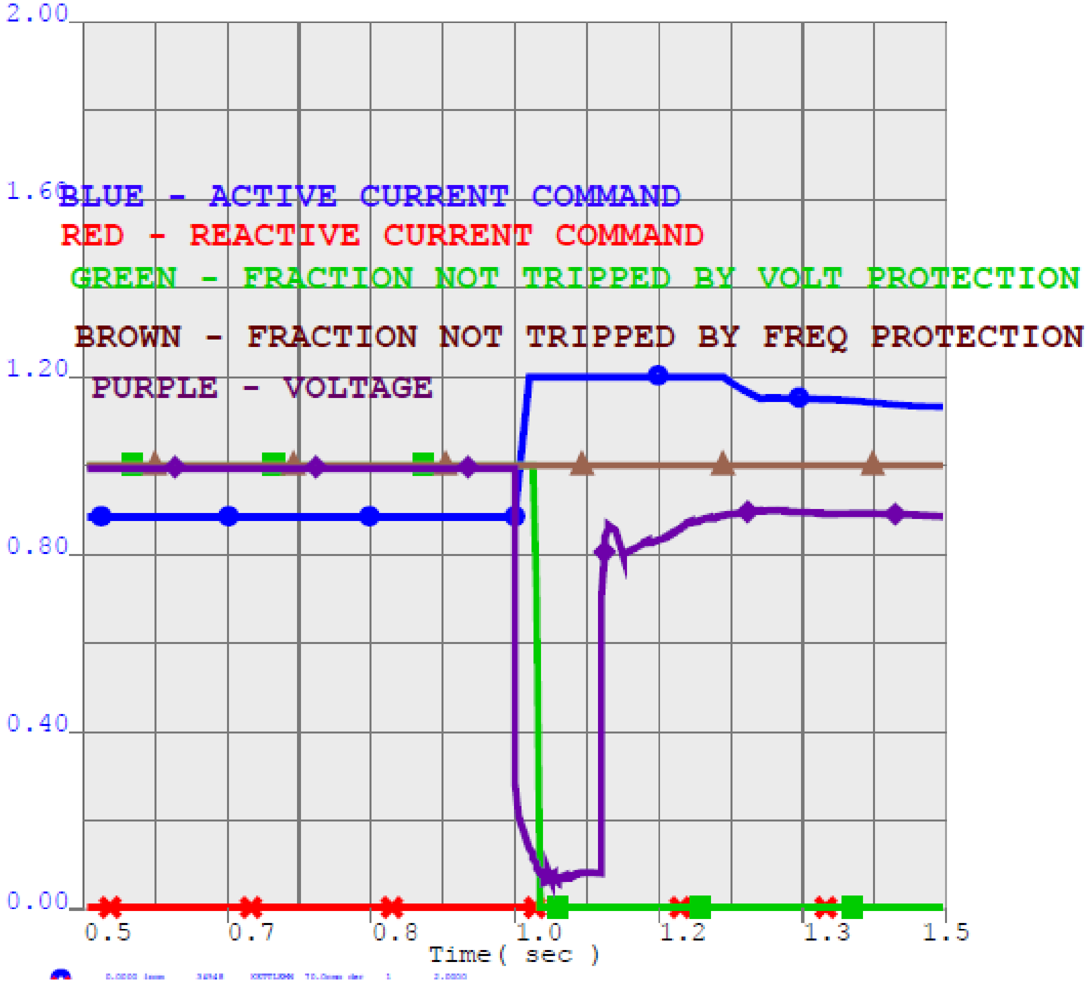
Voltage on this bus



Voltage recovered, but DER was tripped and not recovered, except for Cat. III with and without voltage control

BLUE – no DER
RED – Category II, no voltage control
GREEN – Category III, no voltage control,
BROWN – Category II, voltage control
PURPLE – Category III, Voltage control

Why DER were tripped – Example, Category II, no voltage control



- Voltage was below 0.44 per unit for over 0.16 seconds
- 100% DER on this bus was tripped

Conclusions from the studies

- DER ride-through capability and adequate trip settings lead to a significant reduction of DER trip
  - There is less load reduction if DER have Category III requirements and settings, than with Category II
  - If DER have Category III requirements and settings, system performance is significantly better than with Category II.
  - Some DER trip for low voltage with faults and don't recover when voltage recovers.
  - There are fewer DER that trip and don't recover with Category III.
- In addition, voltage regulation on the Behind the Meter DER can provide some additional help with faults ride through and may allow the induction motors not to stall.
  - There is less load reduction if DER have voltage control
  - If DER have voltage control, their active power output during transient period will be lower because of the reactive current priority

QUESTIONS?

COMMENTS?

Please send your comments to Irina Green

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