NERC SPIDER DER_A Modeling Guideline

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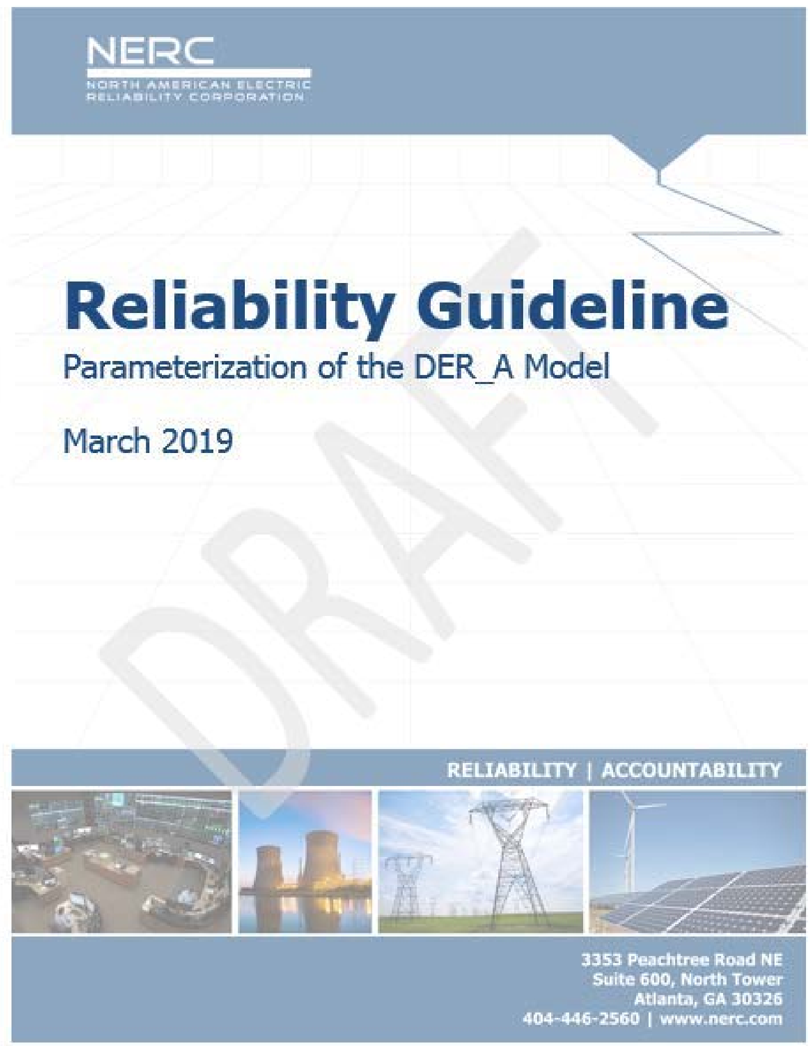
NERC SPIDER (System Planning Impact from DER) WG – DER_A Modeling Guideline

- New DER_A dynamic model now available and is released in all major positive sequence simulation software platforms.
- Industry seeking guidance on how to use and parameterize the model
- NERC SPIDERWG developed guideline for how to use the DER_A model, and how to develop parameter values for the model



NERC SPIDER DER_A Modeling Guideline overview

- Provides detailed understanding of the model and how to use it as stand alone or a part of composite load model
- Provides recommendations for developing parameters values for the model
- Provides guidance for modeling utility-scale DER (U-DER) and retail-scale DER (R-DER)
- Provides values of DER_A parameters to use
- Was developed based on the existing NERC DER modeling guidelines developed by NERC LMTF and published in December 2016 and September 2017

NERC SPIDER DER_A Modeling Guideline Content

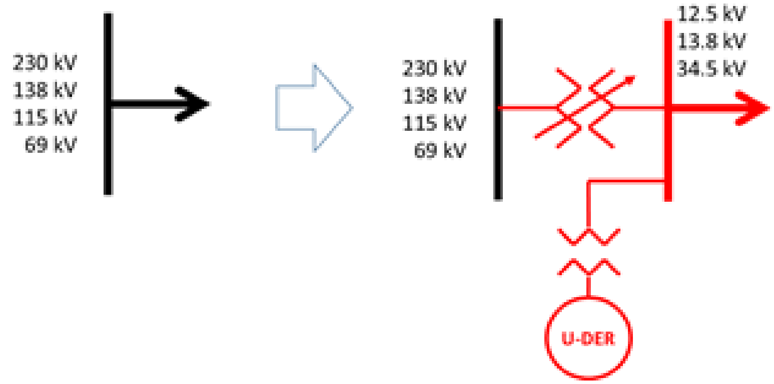
- Introduction
  - DER Modeling Framework, Utility-scale and Retail-Scale DER
- Background and Overview of DER_A Model
- Annotated DER_A Block Diagram
  - Description of blocks in model
- Parameterization of the DER_A Model
  - Relation to specific interconnection requirements/standards (e.g., IEEE 1547-2003, IEEE 1547-2018, CA Rule 21)
- Practical DER_A Model Implementation
  - Based on mix of different vintages of IEEE 1547
- Appendix: References
- Appendix: DER_A Block Diagram

DER Modeling Framework

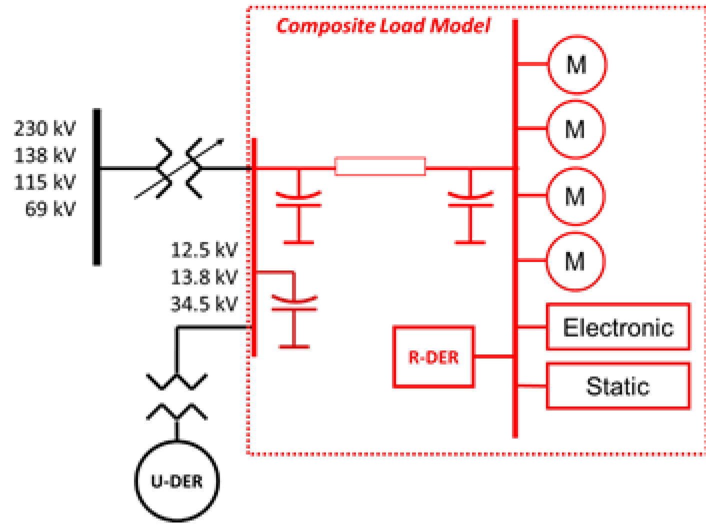
- **Utility-Scale Distributed Energy Resources (U-DER):** DER directly or through a dedicated, non-load serving feeder. connected to the distribution bus. Typically three-phase interconnections, and can range in capacity (e.g., 0.5 to 20 MW).
- **Retail-Scale Distributed Energy Resources (R-DER):** DER that offsets customer load, including residential, commercial, and industrial customers. Typically, residential are single-phase while the commercial and industrial units can be single- or three-phase facilities.
- Transmission Planners (TPs) and Planning Coordinators (PCs), in conjunction with their Distribution Providers (DPs), should identify thresholds for U-DER and R-DER modeling based on either the individual or aggregate impact of DER on the BPS.

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



DER_A Model in Dynamic Stability

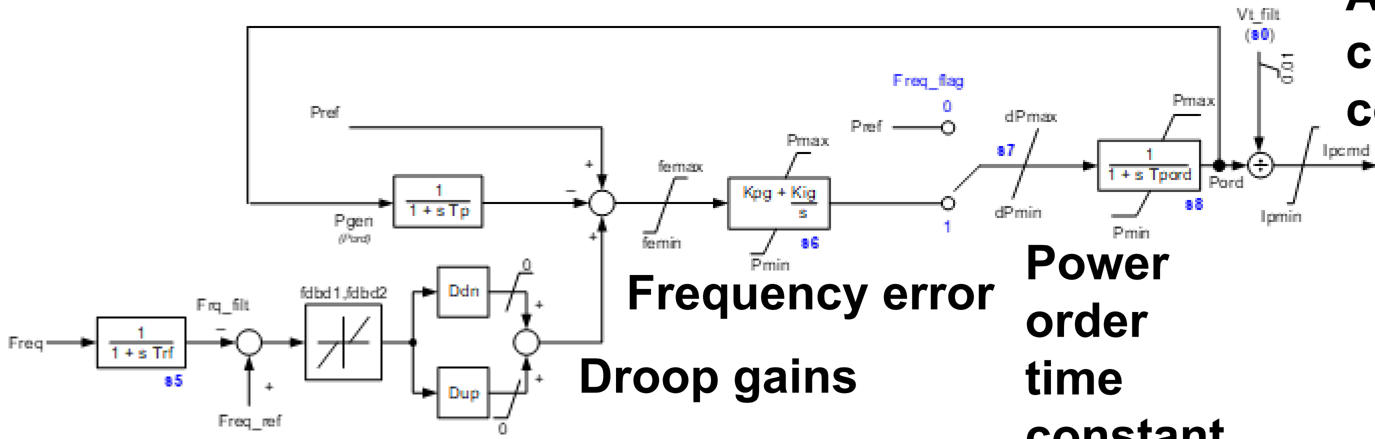
- Simplified version of the second generation generic renewable energy system models (i.e., *regc_a*, *reec_b*, *repc_a*, *lhvrt*, *lhfrt*)
- More detailed and flexible than PVD1 model
- Currently, may represent only aggregated solar PV
- Standalone or part of composite load model
- These two models are identical

DER_A Features

- Constant power factor and constant reactive power control modes. Allows voltage control to be active along with PF/Q control
- Active power-frequency control with droop and asymmetric dead-band
- Voltage control with proportional control and asymmetric dead-band
- Fraction of resources tripping or entering momentary cessation at low and high voltage, includes a timer feature
- Fraction of resources restoring output following a low or high voltage or frequency condition
- Active power ramp rate limits during return to service after trip or enter service following a fault or during frequency response
- Active-reactive current priority options
- Capability to represent generating or energy storage resources.

DER_A Block Diagram – Active Power-Frequency Control

- Freq_flag = 1 – frequency control enabled

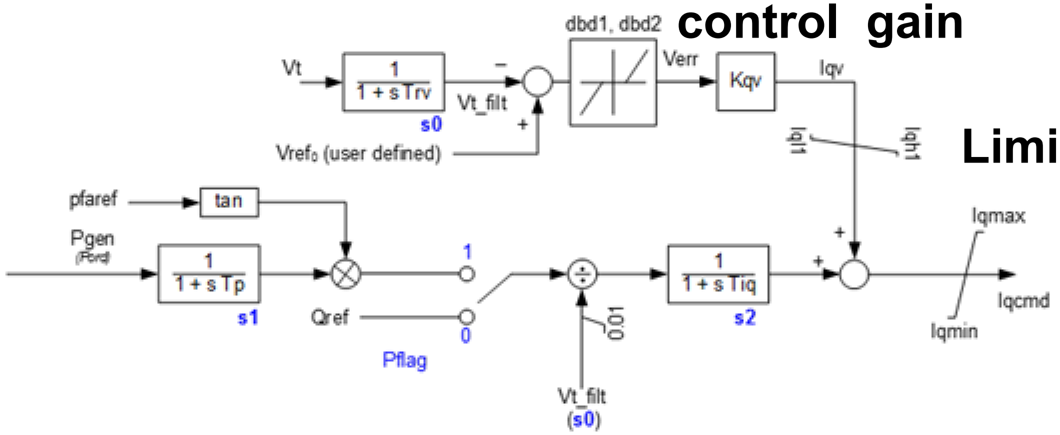


Frequency signal, dead-band

Reactive Power-Voltage Controls

- Pf Flag = 0 constant Q control, = 1 – constant power factor control

Proportional control gain



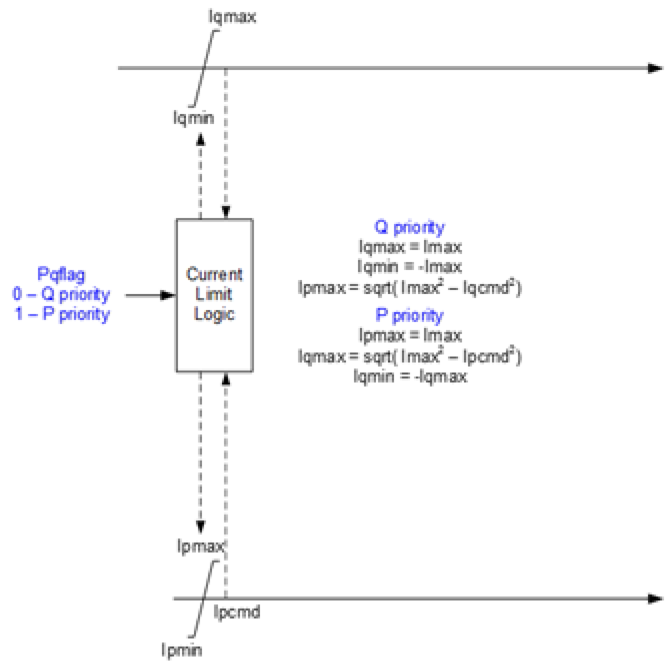
Limits on Iq injection

Reactive current command

- If Kqv=0, no voltage control

Active –Reactive Priority Logic

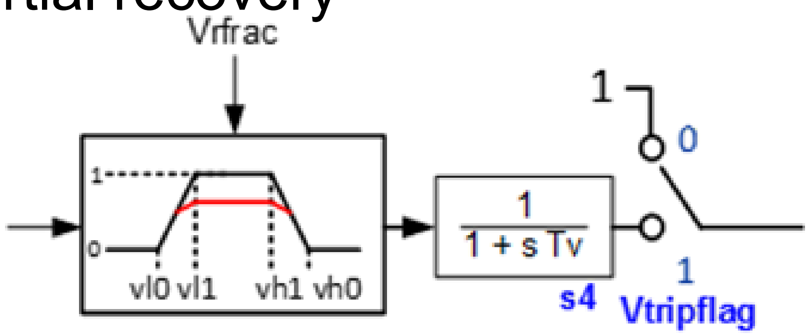
- Type flag =1, generator (Ipmin=0) or =0, storage (I pmin=- Ipmax)
- Pq flag = 0, Q priority, = 1, P priority



- Inverters prior to IEEE 1547-2018 not required to have voltage control, thus P priority
- After the approval of IEEE 1547-2018 – voltage control, Q priority

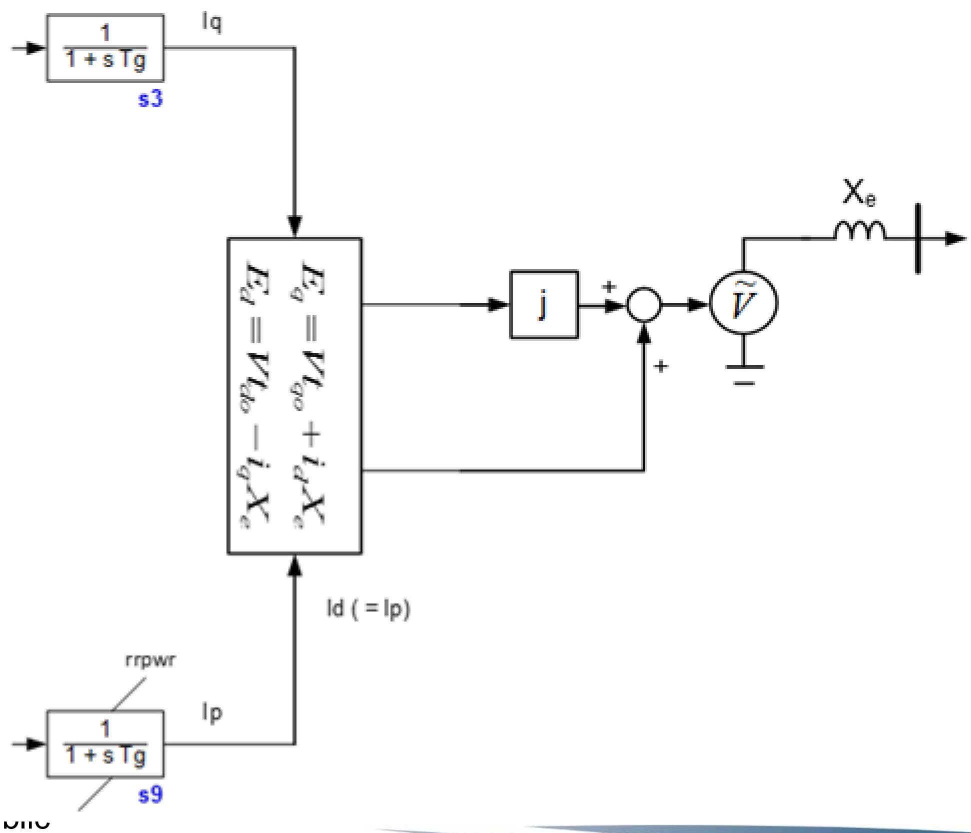
Fractional Tripping

- Portion of DER tripped for low or high voltage, not all at the same time
- Vfrac – portion of DER that recover after voltage returns
- Frequency tripping – single low and high cut-out points, no partial tripping
- Tv – time constant for tripping delay
- Vl0, Vl1, Vh0, Vh1 – cut-out points for voltage
- If voltage falls outside the thresholds for the pre-defined amount of time (below *tvl0* or *tvl1* or above *tvh0* or *tvh1*), then the recovery of resources changes from the black line to the red line to represent partial recovery



Voltage Source Representation

- Modern inverters use a voltage source converter (VSC)
- The current through the VSC is controlled by the controls of the inverter. This can be represented as a voltage source behind an impedance
- *ipcmd* and *iqcmd* are used to evaluate the voltage drop across the impedance Xe



DER_A Default Parameters (SPIDER Modeling Guideline)

Param	IEEE 1547-2003 Default	IEEE 1547a-2014 Default	CA Rule 21 Default	IEEE Std 1547-2018 Category II Default
trv	0.02	0.02	0.02	0.02
dbd1	-99	-99	-99	-99
dbd2	99	99	99	99
kqv	0	0	0	0
vref0	0	0	0	0
tp	0.02	0.02	0.02	0.02
tiq	0.02	0.02	0.02	0.02
ddn	0	0	20	20
dup	0	0	20	20
fdbd1	-99	-99	-0.0006	-0.0006
fdbd2	99	99	0.0006	0.0006
femax	0	0	99	99
femin	0	0	-99	-99
pmax	1	1	1	1
pmin	0	0	0	0
dpmax	99	99	99	99
dpmin	-99	-99	-99	-99
tpord	0.02	0.02	5	5
imax	1.2	1.2	1.2	1.2
vl0	0.44	0.44	0.49	0.44
vl1	$0.44+V_{DROP}$	$0.44+V_{DROP}$	$0.49+V_{DROP}$	$0.44+V_{DROP}$

Param	IEEE 1547-2003 Default	IEEE 1547a-2014 Default	CA Rule 21 Default	IEEE Std 1547-2018 Category II Default
vh0	1.2	1.2	1.2	1.2
vh1	$1.2–V_{DROP}$	$1.2–V_{DROP}$	$1.2–V_{DROP}$	$1.2–V_{DROP}$
tvl0	0.16	0.16	1.5	0.16
tvl1	0.16	0.16	1.5	0.16
tvh0	0.16	0.16	0.16	0.16
tvh1	0.16	0.16	0.16	0.16
vrfrac	0	0	1	1
fltrp	59.3	59.5 OR 57.0	58.5 OR 56.5	58.5 OR 56.5
fhtrp	60.5	60.5 OR 62.0	61.2 OR 62.0	61.2 OR 62.0
tfl	0.16	2.0 OR 0.16	300.0 OR 0.16	300.0 OR 0.16
tfh	0.16	2.0 OR 0.16	300.0 OR 0.16	300.0 OR 0.16
tg	0.02	0.02	0.02	0.02
rrpwr	0.1	0.1	2.0	2.0
tv	0.02	0.02	0.02	0.02
kpg	0	0	0.1	0.1
kig	0	0	10	10
xe	0.25	0.25	0.25	0.25
vpr	0.8	0.8	0.3	0.3
iqh1	0	0	1	1
iql1	0	0	-1	-1
pflag	1	1	1	1
frqflag	0	0	1	1
pqflag	P priority	P priority	Q priority	Q priority
typeflag	1	1	0 OR 1	0 OR 1

Default Parameters that Typically Don't Change

Parameter name	Param	Typical Value
Tranducer time constant, sec	trv	0.02
Voltage reference setpoint, p.u.	vref0	0
Transducer time constant, sec	tp	0.02
Q control time constant, sec	tiq	0.02
Maximum power, p.u.	pmax	1
Maximum converter current, p.u.	imax	1.2
Current control time constant, sec	tg	0.02
Time constant for voltage and frequency cut-out, sec	tv	0.02
Voltage source reactance, p.u.	xe	0.25

Comparison of CA Rule 21, Newer (IEEE1547-2018) and Early (IEEE1547-2003) Vintage DER Systems

Difference in parameters

Parameter name	Param	CA Rule 21 Default	Newer Vintage DER IEEE Std. 1547-2018	Early Vintage DER System IEEE Std. 1547-2003
Frequency control droop gain, down and up	ddn	20	20	0
	dup	20	0	0
Lower and upper frequency deadband, p.u.	fdbd1	-0.0006	-0.0006	-99
	fdbd2	0.0006	0.0006	99
Frequency control maximum error, p.u.	femax	99	99	0
	femin	-99	-99	0
Power order time constant, sec	tpord	5	1	0.02
Voltage breakpoints for low voltage inverter cut-out, p.u.	vl0	0.49	0.44	0.44
	vl1	0.54	0.49	0.49
Low and High voltage cut-out 2nd timer, sec	tvl1	1.5	0.16	0.16
	tvh1	1.5	0.16	0.16
Fraction of DER that recovers	vrfrac	0.5	1	0
Low and High frequency thresholds for inverter cut-out, HZ	fltrp	58.5	56.5	59.3
	fhtrp	61.2	62	60.5
Low and high frequency cut-out timers	tfl	300	0.16	0.16
	tfh	300	0.16	0.16

Parameter name	Param	CA Rule 21 Default	Newer Vintage DER IEEE Std. 1547-2018	Early Vintage DER System IEEE Std. 1547-2003
Power rise ramp after a fault, p.u./sec	rrpwr	2	2	0.1
Proportional and integral gains, real power controller, p.u/p.u, p.u/p.u/sec	kpg	0.1	0.1	0
	kig	10	10	0
Voltage threshold when frequency set to 1	vfth	0.3	0.3	0.8
Upper and lower limits on reactive current injection, p.u.	iqh1	1	1	0
	iql1	-1	-1	0
0- no frequency control, 1 - freq. control	frqflag	1	1	0
0- Q priority, 1 - P priority	pqflag	0	0	1

NERC SPIDER DER_A Modeling Guideline Approval

In March, 2019, the Guideline was presented to the NERC Planning Committee for approval and for posting for the industry comments

- So far the Guideline wasn't approved due to a wrong notion that there was something wrong with the DER_A model in PSSE when the user observed a crash when running a case with standalone DER_A model
- Siemens PTI investigated the issue very extensively and determined that there was no issue with the DER_A model or with PSS/E. The issue that the user had was related to momentary cessation. The way the DER_A model behaves is exactly per the design specification of this model.
- The Guideline will be presented for approval again in the nearest future after the examples and explanations are added.

QUESTIONS?

COMMENTS?

Please send your comments to Irina Green

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