AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Electricity Rule change proposal

May 2018

Generator technical requirements: Supplementary material to Rule change proposal

Important notice

PURPOSE

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1. Purpose

The Australian Energy Market Operator (AEMO) provides the following information to specify active current injection requirements during fault conditions, as Supplementary Material to AEMO's Electricity Rule Change Proposal: Generator Technical Requirements.

AEMO thanks stakeholders for the feedback provided to date on AEMO's Rule change proposal and will continue to work with the Australian Energy Market Commission (AEMC) and stakeholders during the AEMC's consultation process.

2. Background

AEMO's proposed rule change under S5.2.5.5 proposes:

- Reactive current injection with specific speed and amount of injection during faults.
- Active current injection between 100-1000 ms after fault clearance.
- The proposed requirement does not specify active current injection during faults.
- Examples of actual projects exist where the generating system drops the active current to zero during faults even for shallow voltage disturbances resulting in 10-20% voltage dip at the connection point.

3. Methodology

To understand and define expected active current response of asynchronous generation technology during faults AEMO has completed a range of studies. The following have been applied to the studies:

(1) Four site specific EMT models of non-synchronous generating systems are used for these studies, including three wind farms and one solar farm.

(2) Active current and reactive current have been measured at the solar inverter/wind turbine low voltage (LV) terminal.

(3) Three residual voltage levels have been investigated, including 0.7 pu point of connection (POC) residual voltage, 0.5 pu POC residual voltage, and 0 pu POC residual voltage.

(4) Current injection are calculated in per unit based on nominal plant current rating at the generating unit low voltage terminals.

(5) Active current and reactive current are measured separately (in per unit), and total current injection is calculated using the following equation:

$$I_{total} = \sqrt{I_{active}^2 + I_{reactive}^2}\ \text{(pu)}$$

4. Results and findings

The current injection during LVRT are listed in the following table for different OEMs:

POC Volt Scenario	OEM	Wind OEM 1	Wind OEM 2	Wind OEM 3	Solar OEM 1
0.7 pu POC residual voltage	Iq - Active current (pu)	1.370	1.010	1.108	1.039
	Id – reactive current (pu)	0.544	0.452	0.367	0.366
	Itotal (pu)	1.474	1.106	1.168	1.102
	LV terminal voltage (pu)[1]	0.784	0.800	0.825	0.787
	K factor[A]	4.688	4.518	4.898	3.241
0.5 pu POC residual voltage	Iq - Active current (pu)	1.087	0.835	0.876	0.996
	Id – reactive current (pu)	0.751	0.734	0.605	0.764
	Itotal (pu)	1.321	1.112	1.064	1.255
	LV terminal voltage (pu)	0.687	0.664	0.711	0.708
	K factor	3.526	3.111	3.210	3.976
0.0 pu POC residual voltage	Iq - Active current (pu)	0.169	0.054	0.084	0.083
	Id – reactive current (pu)	1.120	1.110	1.055	1.394
	Itotal (pu)	1.133	1.112	1.058	1.397
	LV terminal voltage (pu)	0.374	0.165	0.197	0.221
	K factor	2.130	1.511	1.500	2.053

1. This table indicates that the voltage dip at the low voltage terminals of the generating units during a fault vary in different generating systems for the same voltage dip at the connection point. This is due to a difference in the reticulation system impedance of different generating systems considered.

A. K factor is the reactive current injection (in percentage of the generating unit nominal current), for every 1% voltage drop from 0.9 pu nominal voltage, at the generating unit's low voltage terminals.

It can be observed from the results that:

(1) For Wind OEM 1, the maximum current injection can be 147% of nominal plant rating, and the total current injection is reduced with deeper voltage drop due to active current reduction.

(2) For Wind OEM 2, the total current injection is around 110% of nominal plant rating, and is not affected by voltage dip.

(3) For Wind OEM 3, the maximum current injection can be 117% of nominal plant rating, and is reduced with deeper voltage drop due to active current reduction.

(4) For Solar OEM 1, the maximum current injection can be 140% of nominal plant rating. The total current injection is increased with deeper voltage drop, with reactive current injection up to 140% of nominal plant current.

(5) With shallow faults, all designs can provide a total current of at least 100% of nominal plant current.

Results obtained from vendors-specific EMT models of wind and solar farm demonstrate that the voltage dips experienced at the generating units' low voltage terminals are smaller than the voltage dips at the generating systems' connection points. For all generation technologies considered, the amount of reactive current injected by the generating units during faults are proportional to the voltage dip measured at the generating unit's low voltage terminals. The calculations of K factor is therefore performed based on the voltage at the LV terminals of the generating units.

5. Results and findings

Detailed simulation studies indicate that a range of OEM technologies, are capable of injecting a total current of greater than their nominal current during fault conditions.

It is therefore recommended that the proposed S5.2.5.5 general requirements is amended to account for active power injection requirements during the fault along the line of:

(vii) Notwithstanding the amount of *reactive current* injected/absorbed during *voltage* disturbances, the maximum continuous current of the *generating system* including all operating *generating units* (in the absence of a disturbance) must be available at all times.