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FAEE – resolution for
Technical guideline
TG 3 Rev. 25

Berlin, 22.01.2019

FGW Technical committee for Electrical Characteristics (FAEE) – resolution of 22.01.2019:

The Technical committee for for Electrical Characteristics votes for alterations of revision 25 of the TG 3. The alteration is needed to clarify the intended procedure.

In the following section chapters 4.1.3.3, 4.5.1, 4.5.2, 4.6.1, 4.6.3 and I.3.2.2.4.2 are presented with visible track changes.

On behalf of FGW TC

Marko Mühlberg

4.1.3.3 Carrying out the test

Testing the behaviour of the PGU when the rated frequency is exceeded:

The frequency steps are given and illustrated in Table 4-7 and Fig. 4-4.

The test begins at an active power greater than 100% of P_n.

To enable the desired response during the measurement the PGU's active power is reduced to 50 % Pn by specifying a setpoint before measurement begins.

The measurement begins and the specified frequency steps are adopted in sequence. 60 s at the earliest after reaching the stationary active power value forAt frequency step 53 or 4, the power reduction of the PGU must be cancelled, so that it is possible to demonstrate that the PGU targets the maximum possible power with a gradient $\Delta P/\Delta t$ of maximum 10% of P_n/min when the frequency drops below 50.2 Hz.

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4.5.1 CONNECTION WITHOUT PREVIOUS PROTECTION TRIGGER

4.5.1.1 Aim

The aim of this test is to demonstrate that a connection and reconnection of the PGU at the voltage and frequency values described below is possible. This measurement is optional.

The cut-in of the PGU must be possible in the following voltage and frequency ranges:

- VDE-AR-N 4110 and 4120:
  Grid voltage in the range from 90% U_n ±2% U_n and 110% U_n ±2% U_n
  Grid frequency in the range from 47.5 Hz ±0.1 Hz and at 50.2 Hz ±0.1 Hz

1.• VDE-AR-N 4120:
  Grid voltage in the range from 90% U_n ±2% U_n and 110% U_n ±2% U_n
  Grid frequency in the range from 47.5 Hz ±0.1 Hz and at 51.0 Hz ±0.1 Hz

- VDE-AR-N 4130:
  Grid voltage in the range from 85% U_n ±2% U_n and 110% U_n ±2% U_n
  Grid frequency in the range from Netzfrequenz 47.5 Hz ±0.1 Hz and at 51.0 Hz ±0.1 Hz

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4.5.2 CONNECTION AFTER TRIGGERING OF THE UNCOUPLING PROTECTION

4.5.2.1 Aim

The aim of the test is to demonstrate that the PGU does not connect at the voltage and frequency values tested below. The limit values for the reconnecting only apply after the PGU has been disconnected from the grid (e.g. due to triggering of the uncoupling protection).

Connection conditions according to VDE-AR-N 4110/20/30 are defined as follows:

- ~~VDE-AR-N 4110 and 4120:~~
  ~~grid voltage of at least 95% U_n~~
  ~~grid frequency in a range from 48.5 Hz and 50.1 Hz~~
- ~~VDE-AR-N 4130:~~
  grid voltage of at least 95% U_n
  grid frequency in a range from 49.9 Hz and 50.1 Hz

4.5.2.2 Testing method

The test is done with simulated grid frequency and grid voltage with the PGU at standstill. The evidence can be provided with the help of a grid simulator or a test stand test.

- The undervoltage test is carried out in steps of 1% of Un beginning at 94% to 96% of Un.
- The underfrequency test is carried out in steps of 0.1 Hz beginning at ~~48.3 (or~~ 49.7~~)~~ Hz to ~~48.7 (or~~ 50.0~~)~~ Hz.
- The overfrequency test is carried out in steps of 0.02 Hz beginning at 50.14 Hz to 50.06 Hz.
- Each step must be set for a duration of at least 5 min.
- A test can be stopped as soon as the PGU is able to be connected for the first time, or that the control system signals that the PGU has the release to connect.
- To demonstrate that the requirements compliant with VDE-AR-N 4120 and 4130 have been met, it must also be demonstrated that reconnection is not possible within the allowable voltage and frequency range without a release signal.

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4.6.1.2 General testing method

The PGU is connected to a grid with downstream testing equipment. This testing equipment must be capable of producing the relevant voltage drop or voltage increase as described in the procedure. The correct setting for the relevant voltage drops and and the voltage increases is checked using an idle test. Here, the curve form of the voltage in the positive phase sequence system and (to the extent present) the negative phase sequence system during the tests must lie within Fig. 4-26 for voltage drop tests or Fig. 4-27 for overvoltage tests, respectively. ~~For overvoltage tests, the increase here is related to U_{pre}, the pre-fault voltage from the averaging of the fundamental oscillation for the last 50 periods.~~ During the idle test, the PGU transformer may remain connected.

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4.6.3.1 Testing method (Table 4-69)

Remaining phase-to-phase voltage [p.u.]	Fault type	Fault duration compliant with			Load	Reactive power Q/P_n	K	Test no.
		AR-N-4110 [ms]	AR-N-4130 [ms]	AR-N-4130 [ms]				
Increase by ≥0.1 to a value > 1.10	Three-phase	≥ 5000			Full load	0 to ±10%	K=2	115.1
					Partial load			115.2
Rise by ≥0.1 to a value ≥ 1.10 as largest external conductor voltage	Two-phase	≥ 5000			Full load	0 to ±10%	K=2	110.1
					Partial load			110.2
≥ 1.10	Three-phase	≥ 60000			P>0.1P_n	0 to ±10%	K=2	110.3
~~From around 1.05 to ≥ 1.10~~	~~Two-phase~~	~~--~~	~~--~~	~~≥ 5000~~	~~P>0.1P_n~~	~~0 to ±10%~~	~~K=4~~	~~110.4~~
~~From around 1.05 to ≥ 1.15~~	~~Three-phase~~	~~--~~	~~--~~	~~≥ 5000~~	~~P>0.1P_n~~	~~0 to ±10%~~	~~K=4~~	~~115.1~~

Table 4-69: Minimum requirements for overvoltage tests

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4.6.3.2 Analysis method

The following time series must be calculated from the measured data at least once per millisecond:

- 1-period rms currents and voltages
- Calculation of the positive and negative phase sequence system values according to Annex F
- Positive and negative sequence current (1-period value)
- Positive and negative sequence voltage (1-period value)
- Positive and negative sequence active and reactive power (1-period value)
- Positive and negative sequence active and reactive current (1-period value)

The short-circuit current is determined from the tests for three-pole faults from the following data:

- When the fault occurs (first 20 ms): highest instantaneous value of the measured current, including any decaying DC current portion which may be present; is equivalent to the peak short-circuit current ip;
- Rms value of the short-circuit current as 1-period rms value of the fundamental oscillation portion of the current at the following points in time after the fault occurrence:
  - 20 ms
  - 100 ms
  - 150 ms
  - 300 ms
  - 500 ms
  - 1000 ms

If measurement of the short-circuit current with DC component is technically not possible on the LV side, the measurement of the short-circuit current on the LV side can also be done without DC component and verified if req. by a measurement on the MV side including DC component.

Tolerance band calculation and reactive current evaluation

For voltage drops <=0.15 U_n (test number 0.x in Table 4-68), instead of the reactive current, the apparent current of the positive phase sequence system should be determined.

For calculating the K-factors and the rise and settling times, the voltage drop depth for two-phase faults and three-phase faults is shall be determined from the voltages in the positive and negative phase sequence systems over a period of 100 ms following fault occurrence until 20 ms before fault clearance. The voltage U_{1min} and the reactive current I_{B1min} prior to the fault are determined as mean values of the fundamental frequency over one minute immediately before fault occurrence. Here, the voltage U_{1min} can either be determined as a positive and negative phase sequence system value or as an rms value, since a virtually symmetrical voltage can be expected before the fault, therefore the negative phase sequence system voltage will be virtually zero. The reactive current I_{B1min} should be determined as positive and negative phase sequence system values.

~~The pre-fault voltage and the pre-fault reactive current are determined as mean values of the fundamental frequency over 50 periods immediately before fault occurrence. Here, the pre-fault voltage can either be determined as a positive and negative phase sequence system value or as an rms value, since a virtually symmetrical voltage can be expected before the fault, therefore the negative phase sequence system voltage will be virtually zero. The pre-fault reactive current should be determined as positive and negative phase sequence system values.~~

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4.6.3.2 Analysis method (Extract)

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Limited dynamic grid support

In order to evaluate the limited dynamic grid support, the fundamental oscillation rms values of the three currents according to Annex F are used as a basis.
To determine the settling time, an upper tolerance limit of +10% of the rated current I_n is taken into account on the setpoint value of the apparent current. The time measurement starts at the moment of the fault occurrence and must not exceed 80 ms.

Exceptions for double-fed asynchronous machines

For test number ~~25.8 and 25.9~~50.5, 50.6, 80.1 and 80.2 the evaluation of the positive phase sequence system current takes place in the fault condition. This must be a maximum of 10% I_n. The negative phase sequence system should be identified accordingly and must be below the tolerance limit according to Figure 4-28 and/or Figure 4-29.

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I.3.2.2.4.2 Measuring method

The measurements are performed on a PGU operated in the grid. During measurements high reactive power feed-in may occur, meaning that the respective characteristics of the measured PGU or the entire PGS must be taken into account. In particular, these include the effects of high reactive power fed into the grid, including the associated stability aspects and feedback from nearby power stations and other voltage regulation devices. Alternatively, in the case that the measurements cannot be performed at the specified operating points and/or not using the defined changes in setpoint, measurements may be performed at different operating points and an adapted change in the setpoint. The selected alternative operating conditions and values must be explained. Examination of the impacts on the grid by means of prior simulation is recommended to facilitate suitable adaptation of the subsequent measurements.

1. The PGU is operated synchronous to the grid. The measurements are carried out for operating conditions with an active power output of 50–75%.
2. Based on a steady-state condition and a defined voltage regulator setpoint of 1 p. u., the measured voltage is stepped down to ~~no less~~a value not lower than 0.3 p. u. by means of a voltage divider for a duration to be determined. The duration of the reduction is selected such that the exciter device achieves its maximum excitation voltage. Appropriate simulations may also be used to tentatively determine the duration of the necessary reduction. Once the duration of the reduction has been defined, the measurement must be performed in its entirety, whereby the voltage measured after the reduction is returned in a step to the original measured value by bypassing the voltage divider.
3. The overexcitation protection (OEL) must be adjusted such that the maximum allowable reactive power output at the PCC cannot be exceeded. The necessary excitation current can be determined either by simulation or by a measurement. Here, the voltage setpoint is continuously increased until the maximum reactive power is achieved. The excitation current identified here is adopted as the OEL limit value.
4. During measurements, the active and reactive power fed in, the generator speed, the voltage regulator output signal, and the excitation voltage and excitation current must be recorded. The respective measurements must cover a steady-state range from 10–20 s before applying the stepped setpoint change and the voltage regulator's steady-state condition.