Workshop Smart Grid
Standardisation
May 16th 2013

Connection of micro-generators to the grid: current status of standardization

Session : voltage control and DG integration

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International normative activity

- *Presently being reviewed:*
- **Requirements for micro-generating plants to be connected in parallel with public low-voltage distribution networks**

What is a micro-generating plant?

- Rated currents up to and including 16 A per phase, single or multi phase 230/400 V.

Requirements for micro-generating plants…

- Apply irrespectively of the primary energy source
- The following aspects (i.a.) are excluded from the scope:
  - *multiple units which, in aggregate, exceed 16 A;*
  - *metering or other commercial matters;*
  - *island operation of generating plants, whether intentional or unintentional, where no part of the public distribution network is involved;*
  - *safety of DSO personnel or their contracted parties.*

Requirements for micro-generating plants…

- **inform and fit**

- process of installing and commissioning a micro-generator with prior notification of the DSO;

- commencement of operation with no need of prior formal approval of the DSO.

Requirements for micro-generating plants…

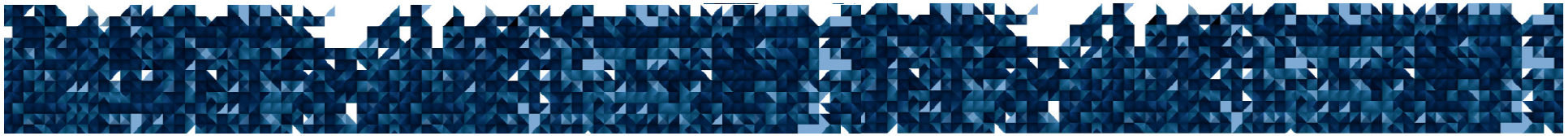
- **Distribution system operator (DSO)**

- Party responsible for operating, maintaining and developing the distribution network in an area.

Requirements for micro-generating plants…

- **interface protection**

- electrical protection ensuring that the micro-generator is disconnected in case of any event that could impair the integrity or degrade the safety of the distribution network.



Requirements for micro-generating plants…

- The generating plant shall be capable not to disconnect due to voltage when the voltage at the point of connection is “normal”(e.g., 0,85 U_n to 1,1 U_n)

Requirements for micro-generating plants…

- The generating plant shall be capable to operate continuously when the frequency at the point of connection is “normal” (e.g., 49 Hz to 51 Hz).

- Possible exceptions (disconnection permitted below 49,5 Hz and above 50,5 Hz):
  - generators coupled directly and synchronously to the grid
  - free piston stirling engines.

Response to under-frequencies

- A generating plant must be resilient to reductions of frequency at the point of connection;

- power should be reduced as little as possible;
- Minimum time period for operation in under-frequency situation: 30 minutes if frequency is within the range 47,5 Hz – 49 Hz;

- more stringent requirement may be required by the DSO in coordination with the TSO.

Response to over-frequencies

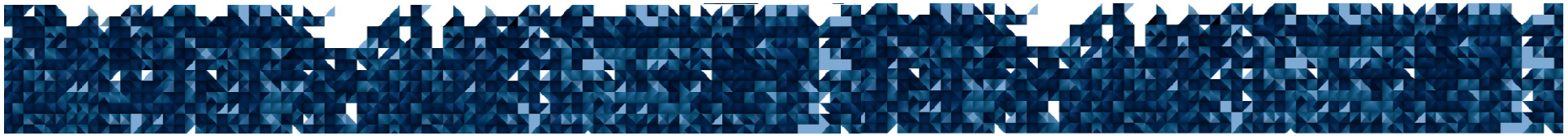
- A generating plant must be resilient to over-frequency at the point of connection.
- Minimum time periods for over-frequency operation: 30 minutes if frequency is within 51 Hz – 51,5 Hz.
- More stringent requirements may be required by the DSO in coordination with the TSO.

Response to over-frequencies

- Unless otherwise required by the DSO, the micro-generating plant shall be capable of activating active power frequency response at a programmable frequency threshold f_1 .
- The threshold shall be adjustable at least between 50,2 Hz and 52 Hz .
- The droop shall be programmable in the range of at least 2 – 12% (droop is relative to P_M, the actual AC output power at the instant when the frequency reaches the threshold f_1)

Response to over-frequencies

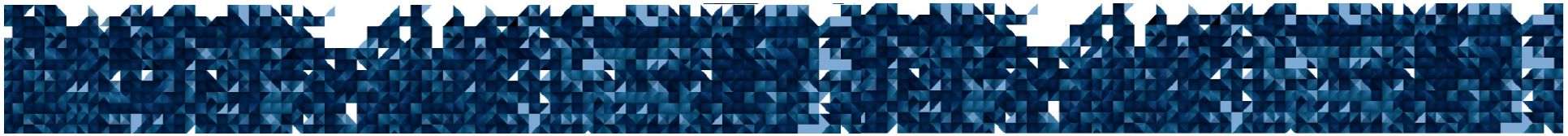
- Resolution of the frequency measurement: +/- 10 mHz or less.
- After a programmable, intentional delay, the active power frequency response shall be delivered with an accuracy of ± 10% P_n and with a settling time less than 2 seconds.
- Initial delay: as short as possible with a maximum of 2 seconds.



Response to over-frequencies

- If the initial delay is below 2 seconds an intentional delay shall be programmable to adjust the total response time to a value between the initial response time and 2 seconds.

- If the initial delay is greater than 2 seconds it shall be reasonably justified by the manufacturer to the DSO.



Response to over-frequencies

- The settings for the threshold frequency f_1, the droop and the intentional delay are provided by the DSO and shall be field adjustable. If no settings are provided, default settings shall be applied.

- The frequency threshold f_1 should be set to a value from 50,2 Hz up to 50,5 Hz. Setting the frequency threshold $f_{1,}$ to 52 Hz is considered as deactivating this function.

Response to over-frequencies

- **Default settings**
- Threshold frequency: 50,2 Hz
- Droop: 5%
- Intentional delay: 0 s

Response to over-frequencies

- Once the frequency drops below threshold frequency f_1 the micro-generating plant is allowed to rise the power above P_M.
- The specified gradient shall not be exceeded. If no gradient is specified by the DSO, the default setting is 10% P_n/min.
- Non-adjustable or partly adjustable generating plant that have been disconnected shall reconnect.

Reactive power: inverter based micro-generators

- The micro-generator shall be capable to operate with the following reactive power exchange:

- following a characteristic curve provided by the DSO within the active factors $\cos \varphi = 0{,}90_{\text{under-excited}}$ to $0{,}90_{\text{over-excited}}$ when the active power is 20% of nominal active power or more;

- exchanging no more reactive power than 10% of nominal active power when the active power output is less than 20%.

Reactive power: directly coupled micro-generator (no inverter)

- The power factor shall be above 0,95, provided the output active power of the micro-generator is above 20% the nominal output power of the unit.

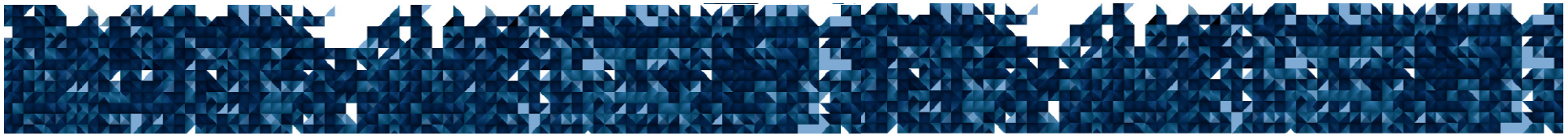
- Below 20% nominal output power the micro-generator shall not exchange more reactive power than 10% of its nominal active output power.

Reactive power control modes

- When a reactive power exchange capability following a characteristic curve is required, following requirements shall apply.
- The control shall be delivered at the terminals of the micro-generator.
- The micro-generator shall be capable of operating in the following control modes: Q (U); cos ϕ fix; cos ϕ (P).

Reactive power control modes

- The configuration of the control modes shall be field adjustable.
- The activation and deactivation of the control modes shall be field adjustable.
- The type of contribution to voltage control by reactive power shall be specified by the DSO. If no characteristic curve is specified by the DSO, the micro-generator shall operate with an active factor = 1.



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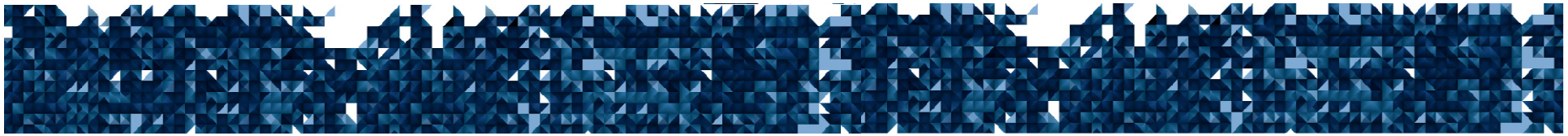


Reactive power control modes

- New set values due to a change of the active power output have to be adjusted within a settling time of 10 seconds.

- The rate of change of reactive power should be in the same time range as, and synchronized with, the rate of change of active power.

Reactive power control modes

Fix control mode cos ϕ fix

- controls the active factor cos ϕ of the micro-generator's output according to a setpoint .

  - **Voltage related control mode Q(U)**

- controls the reactive power output as a function of the voltage. A characteristic curve shall be configurable.
-

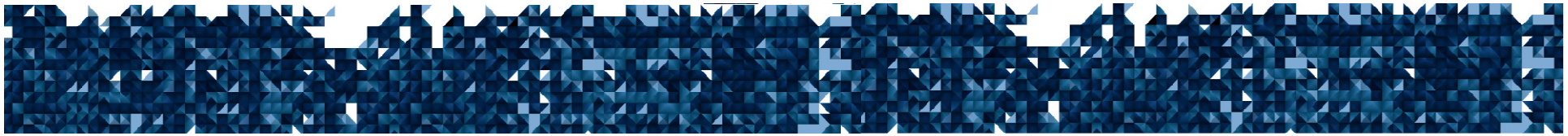
  - **Power related control mode cos ϕ (P)**

- controls the active factor cos φ of the micro-generator's output as a function of its active power output.
- A characteristic curve shall be configurable.

Interface protection

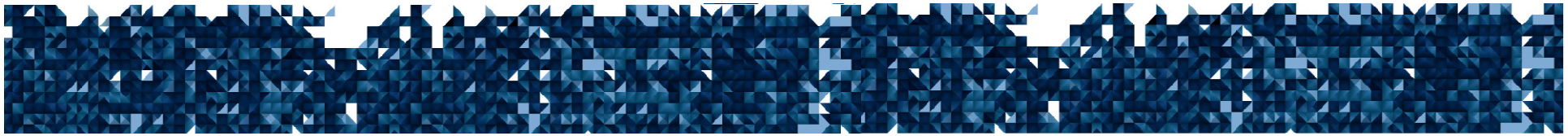
- Purpose: to ensure that the connection of a micro-generator will not impair the integrity or degrade the safety of the distribution network.

- The interface protection shall be insensitive to voltage and frequency variations in the distribution network (within the voltage and frequency settings).



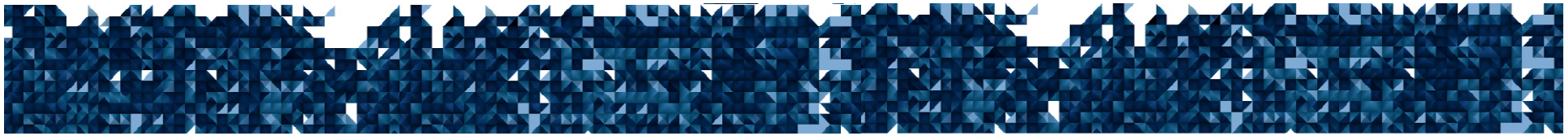
Interface protection

- The settings shall be field adjustable.
- The protection functions have to evaluate all phases.
- The output of each evaluation shall be OR connected.
- The frequency has to be evaluated on at least one of the supply voltages.



Interface protection

- The measurement point can be inside the micro-generator or anywhere between the micro-generator terminals and the point of connection.
- If the interface protection system is external to the generating unit it should measure as close as possible to the point of connection.
- The interface protection settings may only be altered with the written agreement of the DSO, and only in accordance with the manufacturer instructions.



Interface protection: default settings

- Over-voltage – stage 1 (disconnection within 3 s; trip value: 230 V + 10%).
- Over-voltage – stage 2 (0,2 s; 230 V + 15%).
- Under-voltage (1,5 s; 230 V - 15%).
- Over-frequency (0,5 s; 52 Hz).
- Under-frequency (0,5 s; 47,5 Hz).