Electrical System / Grid Connection

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1 GENERAL DESCRIPTION OF THE GRID MANAGEMENT SYSTEM

The electricity generated by the E-66 is fed into the supply system via the novel ENERCON inverter.

The current fed into the system is of sinusoidal shape and harmonics are negligible. Amperage and phase angle can be chosen freely. This degree of freedom makes the new ENERCON grid connection device an ideal generator for feeding power into a supply system.

Most of the complicated conditions for grid connection can be disregarded. the desired current is generated artificially by micro and power electronics according to a specified value. This specified value is compared to the actual current every 100 us and corrected if necessary. The grid connection device is decoupled from the actual generator of the wind energy converter via a direct voltage link. In this way the blade of the E-66 is connected to the electric grid elastically, as with a rubber band. The blade pitch control allows a precise regulation of the power output of the E-66 made operation in parallel with the system much easier. In the following, a few conditions and requirements will be explained.

1.1 Grid Voltage Monitoring

The admissible operating range for operation in parallel with the system is limited by the minimum and maximum grid voltages specified by the local power supply company.

These two limit values, undervoltage and overvoltage, can be set separately from each other. The time required for a measuring interval can also be adjusted in accordance with the power supply company´s regulations.

In addition to these usual standard limits there is a new operating mode: "**Grid-dependent power output**".

The supply system voltage is then measured and monitored continuously. If the voltage rises, for example due to a lack of consumers during the night, the power output is reduced at once. The current fed into the system is regulated by a control loop so quickly that no temporary overvoltage occurs. The active voltage sensor makes it possible to feed the maximum amount of power that the system can take at the time. In other words, the actual power is reduced to match the capacity of the grid. It is no

longer necessary to shut down the wind energy converter altogether. Expensive grid reinforcement measures often required formerly, are also no longer necessary. The E-66 adjusts itself to the weak grid.

1.2 Grid Frequency Monitoring

The minimum and maximum frequencies for operation in parallel with the system can be set as limit values. If the frequency falls below or exceeds these limits, the plant will be disconnected from the grid immediately.

Due to the voltage-controlled operation of the E-66 a stabilization of the grid frequency is achieved.

1.3 Power Gradients

When a wind energy converter or a complete wind farm is started, a temporary overvoltage frequently occurs. This overvoltage has to be corrected by variable transformers or other generators. The E-66 is provided with a data input which allows to pre-set the rate of rise of the power output. This makes it possible for a variable transformer or a diesel generator to follow the new situation.

The power gradient control intervenes automatically for example in case of heavily fluctuating windspeeds or in case of thunder squalls. The E-66 is designed not to bring additional load into the system, but to reduce the load.

1.4 Reactive Power Control

The phase angle ($\cos \varphi$) between the supply system voltage and current can be selected via a data input. If this data input remains unassigned, the E-66 automatically assumes $\cos \varphi = 1$.

In that case, only real power will be fed into the system. The cos φ = 1 remains constant over the whole power range from 0 to 1500 kW/1800kW.

There is also the possibility to choose another cos φ, e. g. 0.95 inductively or -0.95 capacitively, for the whole power range

1.5 Harmonics

The new grid connection device generates a sinusoidal current without harmonics. A high frequency filter ensures that the limit values for the electromagnetic compatibility are observed.

1.6 Flicker (Power swing in the low frequency range)

Due to the elastic coupling of the blades with the grid, low frequency power swings can be compensated by the electronics.

For operation in parallel with the system no relevant flicker coefficients will occur.

1.7 Grid Frequency Resonance

The shape of the current fed into the system is built up artificially to a sinusoidal shape with 50 Hz or 60 Hz. A fluctuating system impedance cannot alter the shape of the current. Actively only current with grid frquency is fed into the system. There are no passive correcting devices (capacitors) with distinct resonances.

1.8 Starting Currents

For starting, the E-66 uses the active control. Power input to the grid starts with 0 up to the respective wind power, controlled via the power gradient. Starting currents in the classical sense are not required. For starting the E-66 a short-time power input of 3 kW for the yaw motor is necessary.

1.9 Short-Circuit Power

In case of a fault, the ENERCON inverter stops within 10 ms. Current spikes above grid current are not possible, not even for a short time.

1.10 Short-time disconnection from grid

The E-66 is immediately diconnected whenever the grid voltage or frequency falls below or exeeds the specified minimum or maximum values, respectively. As there are no correction capacitors, the frequency will collapse at once, and the E-66 is separated from the grid within 10 ms.

2 TECHNICAL DATA FOR GRID CONNECTION E-66

2.1 Grid Voltage Control

Overvoltage:	
100 % = 230 V	(minimum control value)
106 % = 245 V	(normal control value)
115 % = 265 V	(maximum control value)
Step width 1 V	
Undervoltage:	
100 % = 230 V	(maximum control value)
91 % = 207 V	(normal control value)
70 % = 160 V	(minimum control value)
Step width 1 V	
Switch off time:	100 ms

2.2 Frequency Control

Increase of frequency:	
50.0 Hz	(minimum control value)
50.4 Hz	(normal control value)
57.0 Hz	(maximum control value)
Step width 0.05 Hz	
Decrease of frequency:	
50.0 Hz	(maximum control value)
49.6 Hz	(normal control value)
43.0 Hz	(minimum control value)
Step width 0.05 Hz	
Switch off time:	100 ms

2.3 Control Values for cos j

Firm

e. g. 1.0 valid for the entire range of capacity

Preset Range

from 0.94 cap. to 0.94 ind. valid	for the entire range of capacity

2.4 Stand up power consumption

12 kVA	maximum for 20 s

2.5 Other Electrical Data:

Rated power:	1500 kW/1800 kW
Maximum output:	1530 kW/1850 kW
Connection type:	3 x 400 / 230 V
Rated current:	2165 A/2598 A

2.6 Special Function

Automatical voltage and power adjustment

Adjustment of the power if needed according to the voltage directives of the local utility

3 TECHNICAL GRID CONNECTION

For safe transmission of the 1500 kW/1800 kW power produced by the E-66 it is necessary to have a medium voltage grid in the vicinity of the wind energy converter or the windfarm. The pulse-controlled inverter developed by ENERCON, which is housed in the steel tower, feeds a sinusoidal alternating current of 3 x 400V/50 Hz into the adjacent packaged substation of the plant.

As shown in the grid connection survey diagram, a 1,600 kVA/2000 kVA transformer of vector group DYN5 is installed in the packaged substation. Here the input voltage room an SF6 switchgear is installed. With these medium-voltage circuit breakers each individual wind energy converter can be directly separated from the grid. It is also possible to connect another wind energy converter, to the medium-voltage circuit-breaker. In this way several wind energy converters can be series-connected, like a string of pearls, to form a windfarm.

In individual plants the low voltage is measured in the packaged substation, whereas in windfarms it may be necessary to have a main substation. This example is shown in the „Electric Connection Concept for Windfarms“. The exact details of a main substation and the necessary measuring system are to be discussed with the local power supply company. An example of a low voltage measuring system is shown in the equivalent circuit diagram of the E-66.

The low-voltage cable of the ENERCON-66 is protected by a fuse disconnector, behind which the incoming supply meter and, if required, an imported energy meter are installed. After transformation to medium voltage the transformer itself is protected in the SF6 switch gear by a medium voltage panel with fuses. Thus the overall concept of a wind energy converter with integrated substation and SF6 switchgear offers the best prerequisites for a simple solution when planning a windfarm.

4 GENERAL DIRECTIVES FOR THE WIND ENERGY CONVERTER

4.1 Corrosion protection of the control cabinets

The control cabinets are provided with a corrosion protection couch and an immersion paint.

In order to protect the control cabinets from condensation humidity they can be provided with an additional heating system.

4.2 Cabling

Cabling is carried out according to VDE and VBG 4 regulation. All requirements regarding this regulation namely electrical safety and passenger protection are observed.

4.3 Protective class

Protective class for all motors inside the machine are > IP43.

4.4 Electrical diagrams

Please refer to section 12 "Drawings".

5 POWER REGULATION OF THE E-66

At wind speeds above rated power, the power generated works constantly without power spikes. At wind speeds below rated power the power oscillates corresponding to the windspeed.

Furthermore it is possible to feed any power below the rated power to the grid in case the windspeed is above rated windspeed. This is described in the chapter of Grid Voltage Monitoring.

6 THE GRID COMPATIBILITY OF THE E-66

As the grid certificate Windtest WT 1502/00 (see section 5, "Certificates") shows, the quality of the power output is very high. The current fed into the grid has almost no harmonics.