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Electrical Data

V90 - 3.0 MW

60 Hz

Variable Speed Turbine

Electrical Data, V90 - 3.0 MW (60 Hz)

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1. 3.0 MW Wind Turbine

The Vestas V90 - 3.0 MW is a pitch regulated upwind wind turbine with active yaw and a three-blade rotor.

The Vestas V90 - 3.0 MW has a rotor diameter of 90 m with a generator rated at 3.0 MW.

The turbine utilises the OptiTip® system and variable speed concept. With these features the wind turbine is able to operate the rotor at variable speed (RPM), maintaining the output at rated power even in high wind speeds. At low wind speeds, the OptiTip® and variable speed systems work together to maximise the power output by giving the optimal RPM and pitch angle, which also helps to minimise the sound emission from the turbine.

The variable speed system ensures a steady and stable electric power production from the turbine.

The variable speed system consists of an asynchronous generator with wound rotor and slip rings. A power converter, which is connected to the rotor, enables variable speed operation.

The variable speed and OptiTip® systems ensure energy optimisation, low noise operation and reduction of loads on all vital components.

The system controls the current in the rotor circuit of the generator giving precise control of the reactive power and provides for a smooth connection sequence when the generator is connected to the grid.

The reactive power control is as default set at 0 kVAr export/import at 1000 V.

The advantages of a pitch regulated wind turbine with a variable speed system are e.g.:

- Optimum power production at all wind conditions.
- Output is limited to 3.0 MW.
- Power output is smoothed, resulting in high power quality and low flicker level.
- No motor start.
- The turbine can be stopped without using the mechanical brake.
- Minimising of fluctuations in the mechanical transmission system.

2. The VMP Controller

All functions of the wind turbine are monitored and controlled by microprocessor based control units called VMP (Vestas Multi Processor).

The VMP controller consists of several individual sub-controller systems. Each system has separate operation tasks and communicates via an optical-based network (ArcNet).

The controller enclosures are located in the bottom of the tower, in the nacelle and in the hub.

The processor is based on the Intel® StrongArm processor platform.
The operating system is VxWorks®, which fulfils the demands for stability, flexibility and security that are expected in a modern, intelligent wind turbine.
Digital and analogue input/output functions in the turbine are interfaced via the use of distributed units communicating on the CAN-open protocol.

The VMP controller is equipped with a battery backup system.

The VMP controller serves the following functions:

- Monitoring and supervision of overall operation.
- Synchronising of the generator to the grid during the connection sequence in order to limit the inrush current.
- Operating of the turbine during various fault situations.
- Automatic yawing of the nacelle in accordance to the wind direction.
- OptiTip® - blade pitch control.
- Reactive power control and variable speed operation.
- Noise emission control.
- Monitoring of ambient conditions (wind, temperature etc).
- Monitoring of the grid.
- Monitoring and logging of lightning strikes.
- Supervision of the smoke detection system.
- De-rating in case of critically high temperatures.

3. High voltage Grid Connection

The turbine can be connected to the grid in the range from 10 kV to 34.5 kV, where 36 kV (U_m) is the highest equipment voltage. The high voltage grid cables are led through a tube in the foundation to the high voltage switchgear, which is placed at the bottom of the tower.

The voltage of the high voltage grid should be within +5 / -5 % of nominal voltage. Steady frequency variations within +1 / -3 Hz are acceptable. Intermittent or rapid fluctuations of the grid's frequency may cause serious damage to the turbine. Averaged over the wind turbine's lifetime, grid dropout is to occur no more than once a week.

4. High voltage Switchgear (Option)

The high voltage SF_6 fully insulated switchgear consists of two separate cubicles. The two cubicles are a feeder panel with a load breaker switch and a circuit breaker. The load breaker switch has 3 positions: closed, open and earthed. When the breaker is in earthed position, the grid cable is connected to earth. The circuit breaker cubicle contains a load breaker switch and a circuit breaker with a self-powered relay. The load breaker is also a 3-positioned breaker, which can earth the transformer cable through the circuit breaker. The relay provides the opportunity of tripping the circuit breaker externally (230 V) either by the VMP controller, arc detector, smoke detector or manually from the nacelle.

The high voltage circuit breaker is equipped with an earthing switch on the turbine side (transformer) and an earthing switch on the grid side.

The purpose of the switchgear is to protect the turbine against over-current, short circuit and earth faults.

Both cubicles can be equipped with capacitive voltage indicators, motorization and tank manometers.

Cable connection on the switchgear is standard 630 A elbow cone connectors. Loop in and out option is available.

Feeder Function:

Rated voltage [kV] (Max. system voltage)	24	36
Rated current [A]	400/630	400/630
Short time withstand current (1 or 3 s) [kA]	16/20	16/20
Insulation level		
Power frequency (1 min) [kV]	50	70
Lightning impulse [kV_{peak}]	125	170
Making capacity [kA_{peak}]	40/50	40/50
Breaking capacity:		
Mainly active current [A]	400/630	400/630
Capacitive current [A]	31.5	31.5
Inductive current [A]	16	16

Circuit Breaker Function:

Rated voltage [kV] (Max. system voltage)	24	36
Rated current [A]	400/630	400/630
Short time withstand current (1 or 3 s) [kA]	12.5/16/20	12.5/16/20
Insulation level		
Power frequency (1 min) [kV]	50	70
Lightning impulse [kV_{peak}]	125	170
Making capacity [kA_{peak}]	31/40/50	31/40/50
Breaking capacity [kA]	12.5/16/20	12.5/16/20

5. Transformer

The transformer is located in the nacelle. The transformer is a three-phase dry-type transformer, which is self-extinguishing. The windings are delta-connected on the high voltage side unless otherwise specified. The windings are star-connected on the low voltage side (1000 V and 400 V). The 1000 V and 400 V systems in the nacelle are a TN-system, which means that the star point is connected to earth. In the transformer room, surge arresters are mounted on the high voltage side of the transformer.

It is important to specify the nominal grid voltage at which the transformer is connected (10-34.5 kV).

Type:	Cast resin
Rated power:	3160 kVA
High voltage:	10 – 34.5 kV
Frequency:	60 Hz
Vector group:	Dyn / Option YNyn
HV - tappings:	±2 x 2.5%
Low voltage:	1000 V
Power at 1000 V:	3326 kVA
Low voltage:	400 V
Power at 400 V:	168 kVA

6. Earthing System / Lightning Protection

The earthing system must be accommodated to local soil conditions. The resistance to neutral earth must be according to the requirements of the local authorities, but no more than 10 Ω.

The earthing system must be made as a closed ring conductor with earthing rods providing the following advantages:

1. **Personnel safety**
   The ring conductor limits step and contact voltage for persons staying near the tower foundation in case of a lightning stroke.

2. **Operational safety**
   The earthing rods ensure a steady and low resistance to neutral earth for the whole earthing system.

The earthing system is made as follows:

1. Ring conductor in 50 mm^2 Cu is established at a distance of 1 m from the foundation and approx. 1 m below ground level.

2. The ring conductor is equipped with 2 copper-coated earthing rods, each of 6 m (Ø14). The earthing rods are rammed down on each side of the tower (180° between the earthing rods).

3. The ring conductor is connected to two opposite points on the tubular tower. The top controller is connected to one of these points.

If the resistance to neutral earth is not sufficiently low, the earthing system can be improved.

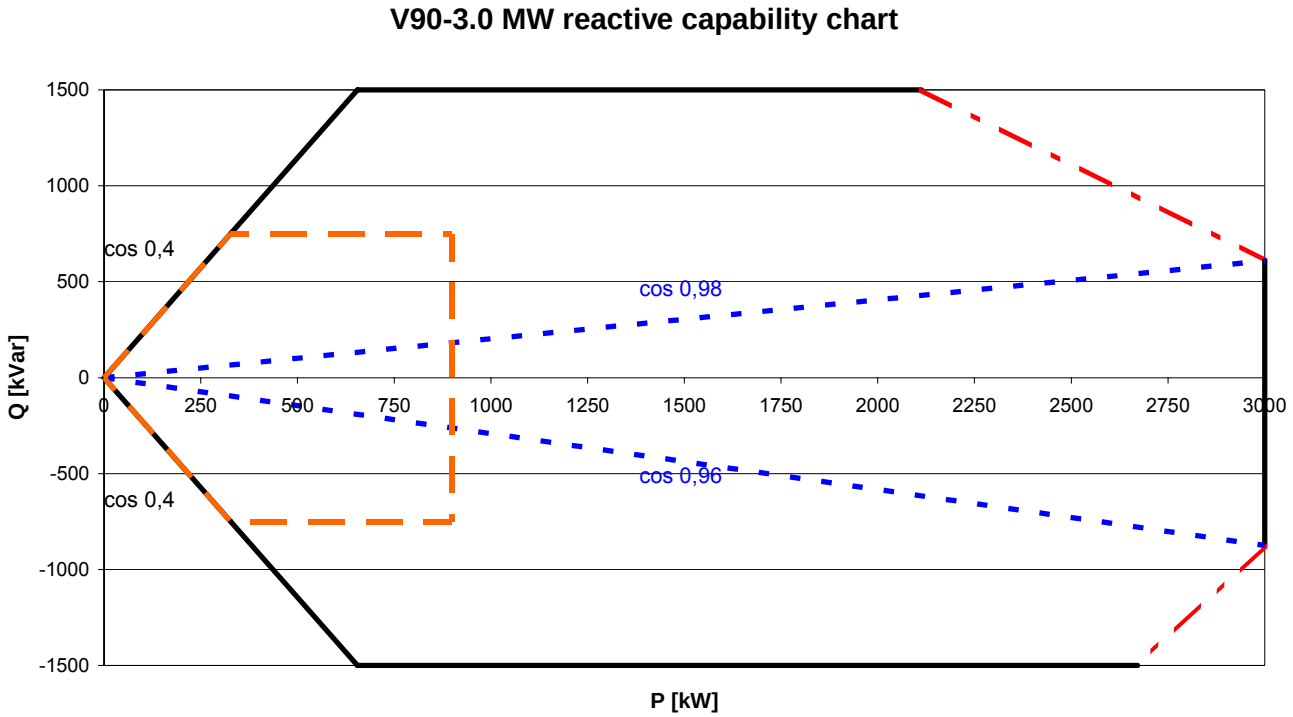
1. The two earthing rods can be extended to 10 m.

2. Two extra earthing rods, each of a length of 10 m, can be added (90^0 between the 4 earthing rods).

7. Nominal Generator Data

Rated power	:	**3000 kW**
Total power	:	3400 kVA (Cosφ = 0.96)
Generator type	:	Asynchronous with wound rotor, slip rings and VCRS
Building size	:	560
Degree of protection (Gen)	:	IP54
Voltage, generator	:	1000 Vac
converter	:	400Vac
Frequency	:	60 Hz
Number of poles	:	4
Winding connection, stator	:	Star/delta
Rated efficiency with converter	:	96 %
Power factor, default (cos)	:	1.0
Possible cos Φ regulation, capacitive/inductive	:	0.98/0.96
Full load current at 10.5 kV	:	165/172 (cosΦ = 1/0.96)
Full load current at 20.0 kV	:	87/91 (cosΦ = 1/0.96)
Full load current at 33.0 kV	:	53/55 (cosΦ = 1/0.96)

7.1 V90-3.0 MW Reactive Capability Chart



The capability of the V90-3.0 MW wind turbine to perform reactive power control is shown in the above chart. Note that the above chart only applies at nominal voltage.

Reactive power is produced by the rotor converter, therefore traditional capacitors are not used.

The V90-3.0 MW wind turbine is able to operate in fixed power factor mode with a power factor range in the interval of 0.98 capacitive to 0.96 inductive, measured on the 1000 V generator side and with 100% of rated active power. It is possible to choose other power factor values, however with reduced active power.

The V90-3.0 MW wind turbine is also able to operate in fixed reactive power mode. In the fixed reactive power mode and when the generator stator winding is coupled in delta, the wind turbine will generate or absorb reactive power up to 1500 kVAr, though with decreased reactive power close to the rated power output (see the red dashed line in the above chart). When the stator winding is in star connection, the maximum reactive power is 750 kVAr. During this operation, it is possible to have priority on either active or reactive power.

The turbine will automatically change the generator stator connection from star to delta and vice versa, depending on the actual active power production.
The criteria are as follows:

- From star to delta: Active power must be above 900 kW for more than 30 seconds.
- From delta to star: Active power must be below 400 kW for more than 15 seconds.

This means that if the turbine is adjusted to generate e.g. 1000 kVAr, the turbine will automatically decrease the reactive power to 750 kVAr when the generator is in star connection.

Please note that the area marked with orange dashed line, indicates that the generator can be in either star or delta, depending on the actual conditions.

Please note that the generator can be in star connection, producing active power above 900 kW, if the wind speed increases rapidly during the 30 second time delay. The active power in star is limited to 1400 kW.
The same can happen at low wind speed, so that the generator can be in delta below 400 kW if the wind speed is decreasing rapidly (faster than the 15 second time delay).

At maximum active and reactive power, the turbine degrades either active or reactive power depending on which type of power has priority (red dashed line). E.g. if reactive power has priority, the active power is degraded.

The minimum reactive power is limited to a power factor of 0.4.

8. Short Circuit Protection of the Top Controller

Breakers	Generator / Q8 ABB E2N E-2000 1000 V	Controller / Q22 ABB S3X125 400 V	VCS / Q7 ABB S6H 630 400 V
Breaking capacity, I_{cu}, I_{cs}	30 kA	200 kA	65 kA
Making capacity, I_{cm}	143 kA	440 kA	143 kA
Thermo release, I_{th}	2 kA	0.125 kA	0.63 kA
Magnetic release, I_m	- kA	1.25 kA	8.19 kA

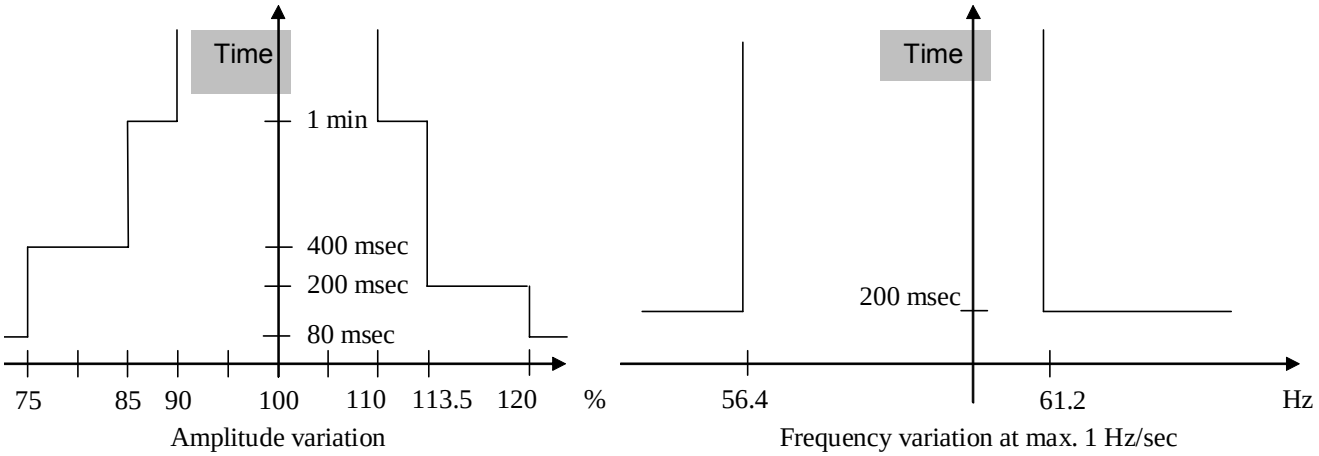
9. Monitoring of the Grid

The generator will be disconnected if the voltage or the frequency exceeds the following limits (measured at the 1000 V side):

Nominal phase voltage : $U_{P,nom}$ = 577 V
Phase voltage : U_P
Grid voltage : U_N

The generator and the converter will be disconnected if:

	U_P	U_N
The voltage is above 110 % of the nominal voltage for 60 s.	635 V	1100 V
The voltage is above 113.5 % of the nominal voltage for 0.2 s.	655 V	1135 V
The voltage is above 120 % of the nominal voltage for 0.08 s.	692 V	1200 V
The voltage is below 90 % of the nominal voltage for 60 s.	519 V	900 V
The voltage is below 85 % of the nominal voltage for 0.4 s.	490 V	850 V
The voltage is below 75 % of the nominal voltage for 0.08 s.	433 V	750 V
The frequency is above 61,2 Hz for 0.2 s.		
The frequency is below 56.4 Hz for 0.2 s.		



Amplitude variation

Frequency variation at max. 1 Hz/sec

If a fault on the grid disconnects the power supply to the VMP controller, the emergency stop circuit will open immediately and the generator will be disconnected simultaneously.

10. Options

Remember to specify:

- Nominal grid voltage and the transformer winding connection on the high voltage side.
- Ring main unit (circuit breaker)
- Remote control
- Lift

11. Electrical Protection

The turbine is protected by hardware and software. The hardware protection must be able to disconnect any electrical short circuits and earth faults. The software protection is mainly for protection against thermal overload, asymmetrical voltages and/or currents. The software must also protect against current and voltage deviations outside the limitations as well as frequency deviations etc.
The protection diagrams are created in accordance to IEEE C37.3-1996.

12. Drawings