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General specification

2.0MW V116/120 50/60Hz
2.2MW V120 50Hz

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Table of contents

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See general reservations, notes, and disclaimers to this general specification in section 8 General reservations, notes, and disclaimers **p. 27**

1 Abbreviations and technical terms

Abbreviation	Explanation
AEP	Annual Energy Production
EMC	Electromagnetic Compatibility
HH	Hub Height
HV	High Voltage
LPS	Lightning Protection System
MASL	Meters Above Sea Level
MW	Megawatt
OH&S	Occupational Health & Safety
OVRT	Over Voltage Ride-Through
pu	Per unit
rpm	Revolutions per minute
SSR-P	Sub Synchronous Resonance Protection
UVRT	Under Voltage Ride-Through

Table 1-1: Abbreviations

Term	Explanation
None	

Table 1-2: Explanation of terms

2 General description

The Vestas 2.0MW/2.2MW series wind turbine is a pitch-regulated upwind turbine with active yaw, gearbox and a three-blade rotor. The turbine is available in two rotor diameters 116m or 120m with a generator rated at 2.0MW 50/60Hz and V120 2.2MW 50Hz. The turbine utilises a microprocessor pitch control system called OptiTip® and the OptiSpeed™ (variable speed) feature. With these features, the wind turbine is able to operate the rotor at variable speed (rpm), helping to maintain output at or near rated power.

Rotor	Hub Height [m]	Region	Wind Class [IEC]	Rotor	Hub Height [m]	Region	Wind Class [IEC]
V116	80	US	IECS	V120	80	US	S
	94		IECS		92		S
	124		IECS		122		S
	80	N/A*	IECS		118	India	S (India specific)
					137		S (India specific)
					95	China	S (China specific)
					141		S (China specific)

Table 2-1: Turbine variants and tower heights

* Tower designed for 50Hz markets in EU

3 Safety

The safety specifications in this safety section provide limited general information about the safety features of the turbine and are not a substitute for Buyer and Buyer's agents taking all appropriate safety precautions, including but not limited to (a) complying with all applicable safety, operation, maintenance, and service agreements, instructions, and requirements, (b) complying with all safety-related laws, regulations, and ordinances, (c) conducting all appropriate safety training and education and (d) reading and understanding all safety-related manuals and instructions. See section 3.11 for additional guidance.

3.1 Access

Access to the turbine from the outside is through the bottom of the tower. The door is equipped with a lock. Access to the top platform in the tower is by a ladder or service lift. Access to the nacelle from the top platform is by ladder. Access to the transformer room in the nacelle is controlled with a lock. Unauthorised access to electrical switchboards and power panels in the turbine is prohibited according to IEC 60204-1 2006.

3.2 Escape

In addition to the normal access routes, alternative escape routes from the nacelle are through the crane hatch.

The hatch in the roof can be opened from both the inside and the outside.

Escape from the service lift is by ladder.

3.3 Rooms/working areas

The tower and nacelle are equipped with connection points for electrical tools for service and maintenance of the turbine.

3.4 Climbing facilities

A ladder with a fall arrest system (rigid rail or wire system) is installed through the tower.

There are anchor points in the tower, nacelle, hub, and on the roof for attaching a full-body harness (fall arrest equipment).

Over the crane hatch there is an anchor point for the emergency descent equipment.

3.5 Moving parts, guards, and blocking devices

Moving parts in the nacelle are shielded.

The turbine is equipped with a rotor lock to block the rotor and drive train.

It is possible to block the pitch of the cylinder with mechanical tools in the hub.

3.6 Lighting

The turbine is equipped with light in tower, nacelle, and hub.

There is emergency light in case of the loss of electrical power.

3.7 Emergency stop buttons

There are emergency stop buttons in the nacelle and in the bottom of the tower.

3.8 Power disconnection

The turbine is designed to allow for disconnection from all its power sources during inspection or maintenance. The switches are marked with signs and are located in the nacelle and in the bottom of the tower.

3.9 Fire protection/first aid

A CO_2 (recommended) or ABC fire extinguisher and first aid kit must be available in the nacelle during all service and maintenance activities. A fire blanket must be available nearby for all those activities for which the respective work instruction requires it.

3.10 Warning signs

Additional warning signs inside or on the turbine must be reviewed before operating or servicing the turbine.

3.11 Manuals and warnings

The Vestas Corporate OH&S Manual and manuals for operation, maintenance, and service of the turbine provide additional safety rules and information for operating, servicing, or maintaining the turbine.

4 Type approvals

The turbine will be type-certified according to the certification standards listed below:

- IEC 61400-22

5 Operational envelope and performance guidelines

Actual climate and site conditions have many variables and must be considered in evaluating actual turbine performance. The design and operating parameters set forth in this section do not constitute warranties, guarantees, or representations as to turbine performance at actual sites.

The turbine can be equipped with different power generation components depending on the region which may influence the performance of the turbine. Consult Vestas Wind Systems for further details.

NOTE As evaluation of climate and site conditions is complex, it is necessary to consult Vestas for every project.

5.1 Climate and site conditions

Values refer to hub height and as determined by the sensors and control system of the turbine.

Extreme design parameters			
	V116 50/60Hz	**V120 50/60Hz**	**V120 50 Hz**
	2.0MW	**2.0MW**	**2.2MW**
	IECS	**IECS**	**IECS**
Ambient temperature range (standard turbine)	-30° to +50°C	-30° to +50°C	-30° to +50°C
Ambient temperature interval (low temperature turbine)	-40° to +50°C	-40° to +50°C	-40° to +50°C
1 year mean wind speed $V_{1,10min}$	29,0 m/s	29,0 m/s	29,0 m/s
1 year extreme wind speed $V_{e1,3s}$	40,6 m/s	40,6 m/s	40,6 m/s
50 year mean wind speed $V_{50,10min}$	36,25 m/s	36,25 m/s	36,25 m/s
50 year extreme wind speed $V_{e50,3s}$	50,8 m/s	50,8 m/s	50,8 m/s

Table 5-1: Extreme design parameters

Inflow angle (vertical)			
	V116 50/60Hz	**V120 50/60Hz**	**V120 50Hz**
	2MW	**2.0MW**	**2.2MW**
	IECS	**IECS**	**IECS**
Annual average wind speed	8.5 m/s	7.2 m/s	7.0 m/s
Form factor, c	2.0	2.5	2.5
Turbulence intensity according to IEC 61400-1:2005, including wind farm turbulence (@15 m/s – 90% quartile)	16%	16%	16%
Wind shear	0.20	0.20	0.20

Table 5-2: Average design parameters

5.1.1 Complex terrain

Classification of complex terrain according to IEC 61400-1:2005 Chapter 11.2.

For sites classified as complex, appropriate measures are to be included in the site assessment.

5.1.2 Altitude

The 2.0MW/2.2MW variants of the turbine are designed for use at altitudes up to 1.500 metres above sea level as standard.

With altitudes above 1.500 metres, special considerations must be taken regarding for example HV installations and cooling performance. Consult Vestas for further information.

5.1.3 Wind farm layout

Turbine spacing is to be evaluated site-specifically. Spacing below two rotor diameters (2D) may require sector-wise curtailment.

5.2 Operational envelope (temperature and wind)

Values refer to hub height and are determined by the sensors and control system of the turbine.

Operational envelope (temperature and wind)			
	V116 50/60Hz	**V120 50/60Hz**	**V120 50Hz**
	2.0MW	**2.0MW**	**2.2MW**
	IECS	**IECS**	**IECS**
Ambient temperature interval (standard temperature turbine)	-20° to +45°C	-20° to +45°C	-20° to +45°C
Ambient temperature interval (low temperature turbine)[1]	-30° to +45°C	-30° to +45°C	-30° to +45°C
Cut-in (10 minute average)	3 m/s	3 m/s	3 m/s
Cut-out (10 minute average)	20 m/s	18 m/s	18 m/s
Re-cut in (10 minute average)	18 m/s	16 m/s	16 m/s

Table 5-3: Operational envelope (temperature and wind)

NOTE Turbines will de-rate the power according to the cooling system selected for the specific product. See Figure 5-2 and Figure 5-3

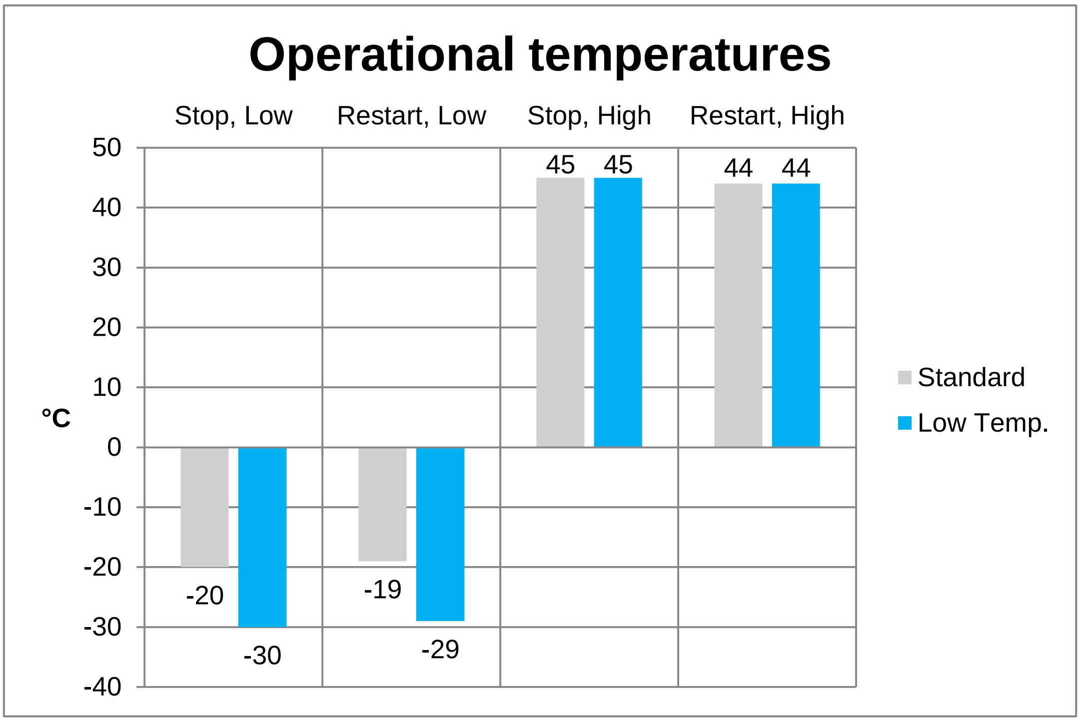

Figure 5-1: Temperature variants

NOTE Restart temperature is where the turbine will initiate the start-up; not resume production.

The turbine can be equipped with different Coolertop variants which are suited for different climate conditions:

Coolertop 30 is suited for turbines sited in relative low temperature areas or where there is no or a limited correlation between high temperature and high wind speeds.

Coolertop 40 is suited for turbines sited in high temperature areas where there is a correlation between high temperatures and high wind speed.

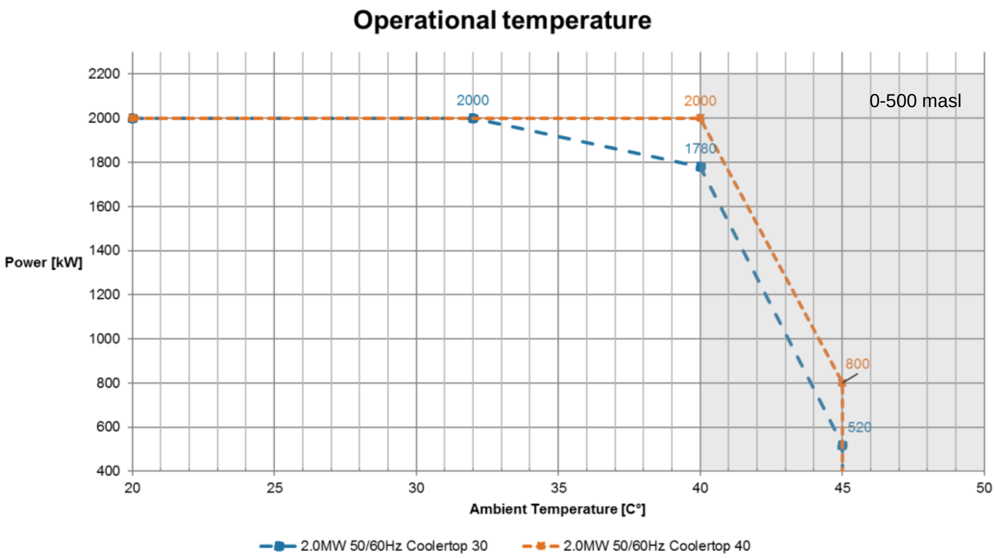

Figure 5-2: Temperature and de-rate curves 2.0MW. 0 to 1.000masl and 0 to 500masl

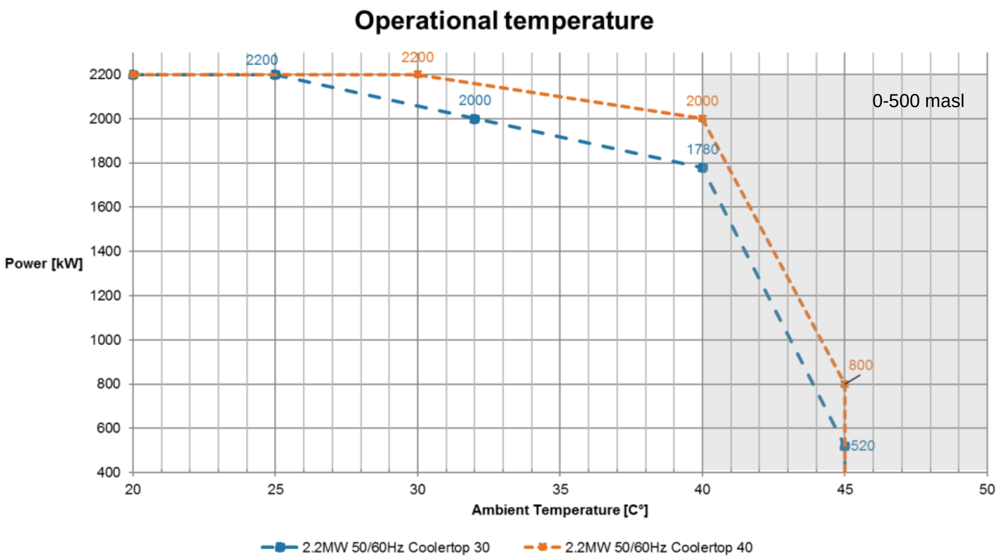

Figure 5-3: Temperature and de-rate curves 2.2MW. 0 to 1.000masl and 0 to 500masl

NOTE Turbines in altitudes below 500masl will be able to continue operation up to 45°C. For altitudes above 500masl the turbine will stop production at 40°C.

5.3 Operational envelope (grid connection)

Operational envelope (grid connection)		
Nominal phase voltage	[U_{NP}]	480 V (Grid inverter) 690 V (Stator)
Nominal frequency	[f_N]	50 / 60Hz
Maximum frequency gradient	±4 Hz/sec.	
Maximum negative sequence voltage	3% *(connection)* 2% *(operation)*	
Minimum required short circuit ratio at turbine HV connection	3[1]	
Maximum short circuit current contribution	4.0 pu *(peak short-circuit current)* 1.5 pu *(steady-state short-circuit current)*	

Table 5-4: Operational envelope (grid connection)

[1] SCR of 3 is depending on site specific constraints. For SCR below 3 the WTG default parameter settings may need modifications. Consult Vestas for further information.

Generator and converter disconnecting values		
	50Hz	**60Hz**
Frequency is above [Hz] for 0.2 Seconds	53 Hz	63,6Hz
Frequency is below [Hz] for 0.2 Seconds	47 Hz	56,4Hz

Table 5-5: Generator and converter disconnecting values

NOTE Over the turbine lifetime, grid drop-outs are to occur at an average of no more than 50 times a year.

5.4 Reactive power capability

5.4.1 P/Q Charts

The turbine has a reactive power capability dependent on power rating as illustrated in Figure 5-4 and Figure 5-5

The P/Q chart will always follow the temperature de-rate profile enabled for the specific turbine. When turbines are de-rating power due to temperature the reactive power level cannot exceed the levels given at 2.0MW rating for the corresponding voltage level.

In addition, following conditions applies:

- The Q capability is only applicable for turbines running in Voltage control mode. For Q controller operation consult Vestas for further information.
- For optimum operation the turbines are expected to have Vpu 1.0 as an average for normal operation i.e. adequate substations equipment is expected, WTG transformers tap-adjusted.

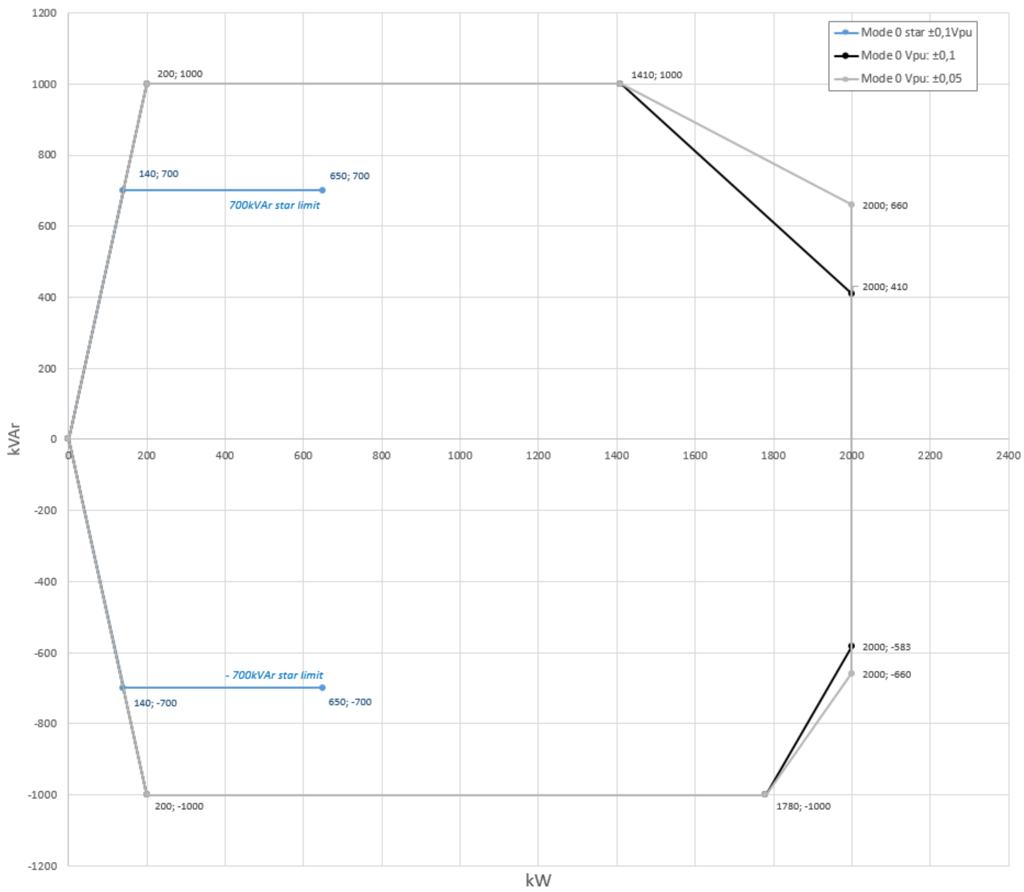

Figure 5-4: Reactive power capability for 2.0MW 50/60Hz – PQ Mode 0. For temperatures up to 40ºC and up to 1500masl

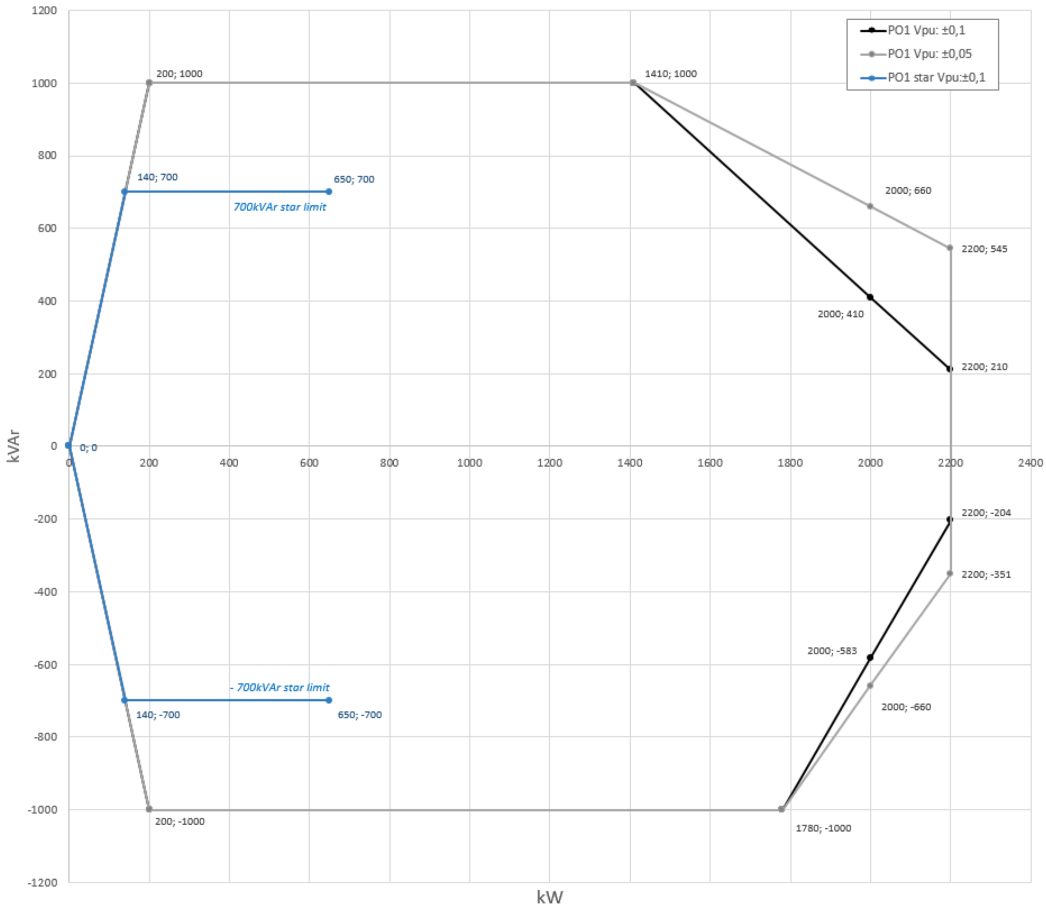

Figure 5-5: Reactive power capability for 2.2MW 50/60Hz – PQ Mode PO1. For temperatures up to 30ºC and up to 1500masl

NOTE

The reactive power capability charts apply to the low-voltage side of the HV transformer. The turbine maximises active power or reactive power depending selected settings.

5.4.2 Reactive power in standstill

The turbine can as an option provide reactive power supply when it is not producing active power to the grid due to low wind speeds.

Reactive power support below cut-in wind speeds		
	Reactive power [±kVAr]	**Max ambient temperature [°C]**
Coolertop 30°C	150	35
Coolertop 40°C	200	43

Table 5-6: Reactive power supply below cut-in wind speed.

NOTE The reactive power capability in standstill/idle will not follow the ramp rates specified Figure 5-6 and Figure 5-7.

The turbines will not supply reactive power when switching between standstill/idle and operation.

5.5 Fault ride through

The turbine is equipped with a reinforced converter system in order to gain better control of the generator during grid faults. The turbine control system continues to run during grid faults.

The pitch system is optimised to keep the turbine within normal speed conditions, and the generator speed is accelerated in order to store rotational energy and be able to resume normal power production faster after a fault and keep mechanical stress on the turbine at a minimum.

The turbine is designed to stay connected during grid disturbances within the UVRT curve in Figure 5-6.

Power recovery time	
Power recovery to 90% of pre-fault level	Maximum 2 seconds

Table 5-7: Power recovery time

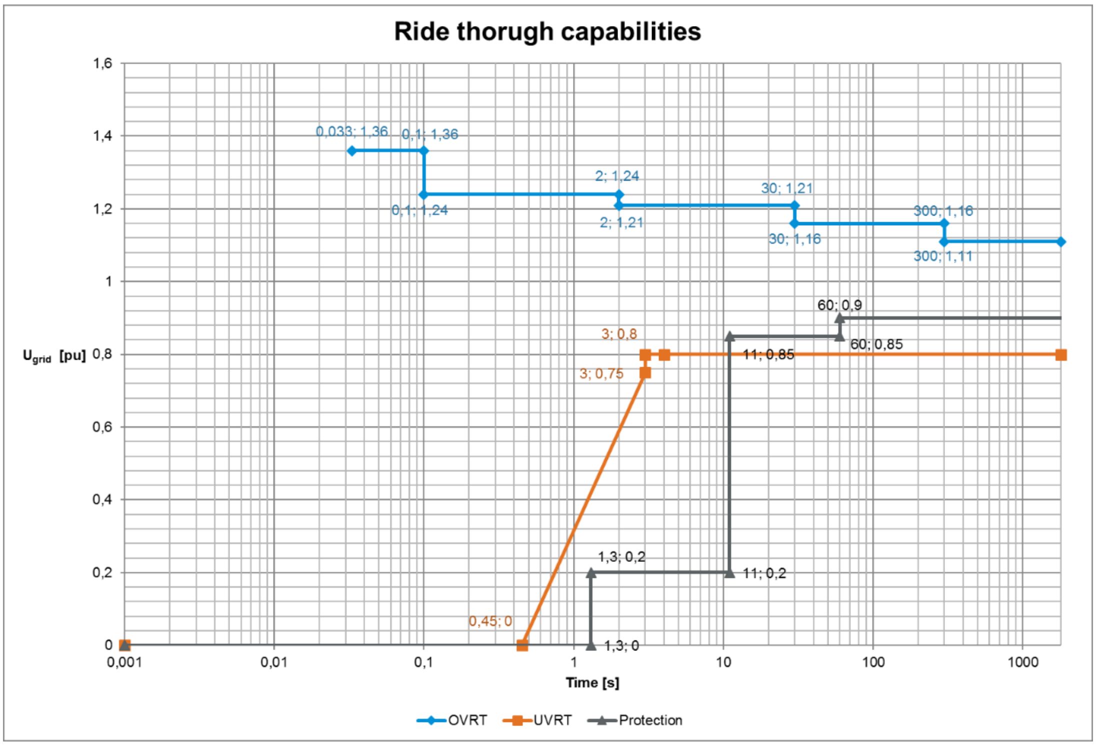

Figure 5-6: *OVRT, UVRT and Protection curves for symmetrical and asymmetrical faults where U_{grid} represents grid voltage values. Linear interpolation can be assumed between all points in the UVRT curve.*

The turbine stays connected when the values are above UVRT (and protection) and below OVRT. The UVRT curve is only active when the turbine is supplying power.

5.5.1 OVRT

The turbine is able to run with voltage levels above nominal within restricted time intervals.

The generator and the converter will be disconnected if the voltage level exceeds the OVRT curve shown in Figure 5-6.

5.6 Reactive current contribution

The reactive current contribution depends on whether the fault applied to the turbine is symmetrical or asymmetrical.

5.6.1 Symmetrical reactive current contribution

During symmetrical voltage dips the wind farm will inject reactive current to support the grid voltage. The reactive current injected is a function of the voltage measured at the low voltage side of the WTG transformer.

The default value gives a reactive current part of 1 p.u. of the nominal WTG current. Figure 5-7 indicates the reactive current contribution as a function of the voltage. The reactive current contribution is independent from the actual wind conditions and pre-fault power level.

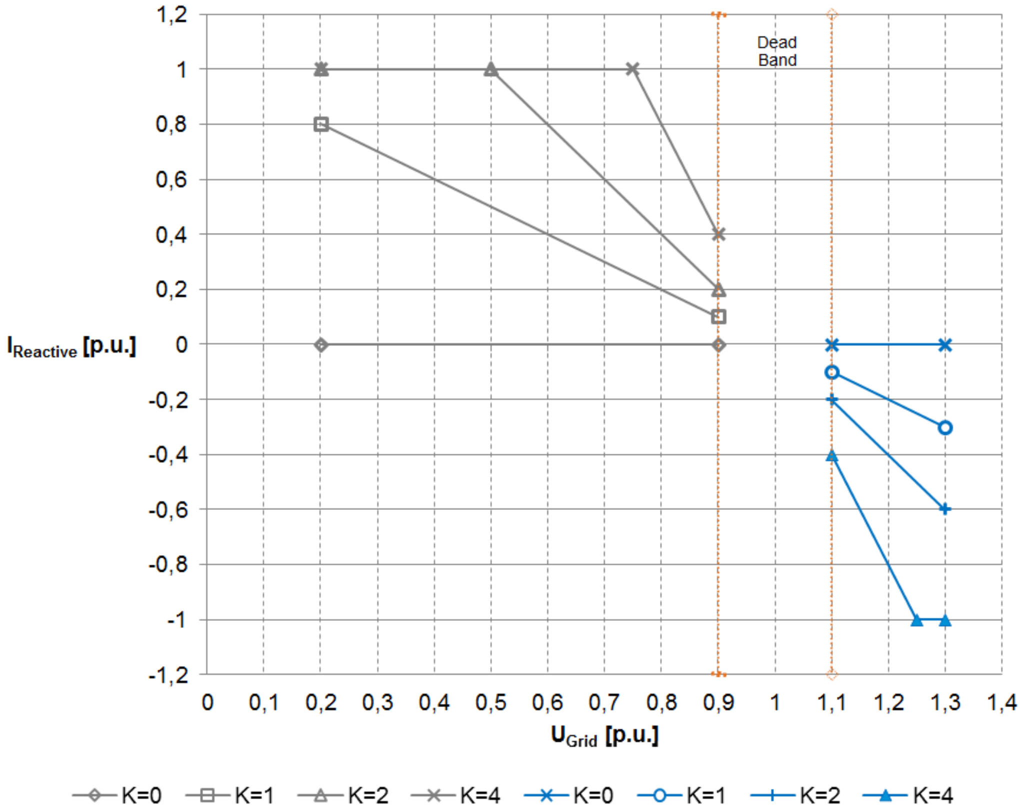

Figure 5-7: Reactive current contribution

Slope (K-factor), offset and dead band can be set freely to fulfil requirements to UVRT current injection.

5.6.2 Asymmetrical reactive current contribution

Current reference values are controlled during asymmetrical faults to ensure ride through.

5.6.3 Sub synchronous Control Interaction

The turbine is designed to mitigate Sub-Synchronous Control Interaction (SSCI) due to interaction between the turbine and series-capacitor-compensated transmission lines. The generator and converter will mitigate power, voltage or current oscillations in the frequency range listed in Table 5-7.

SSCI Frequency range	
Minimum frequency	10 Hz
Maximum frequency	35 Hz

Table 5-8: SSCI frequency range

SSR mitigation (SSCI) capability and performance is depending on the grid conditions at the specific sites. In case that the turbines SSCI capability is not sufficient to mitigate then the SSR protection will protect the turbine from harm full sub-synchronous oscillations (see section 5.5.4). Vestas should be contacted for proper setting of the SSR mitigation function, if the SSCI frequency range is outside the numbers given in above table.

5.6.4 Sub synchronous resonance protection

Turbine is equipped with fast-acting protection to shield the converter, generator and drivetrain from excessive voltages, currents and torques due to sub-synchronous resonance (SSR) caused by interaction between the turbine and the series-capacitor-compensated transmission lines. The generator and converter will be disconnected upon SSR detection by the turbine controller, according to Table 5-9. SSR protections availability is depending on grid conditions at the specific sites.

SSR protection time	
Generator and converter disconnect	Maximum 100ms (including breaker response time)

Table 5-9: SSR protection time

5.7 Active and reactive power control

The turbine is designed for control of active and reactive power by means of the VestasOnline® SCADA system.

Maximum ramp rates for external control	
Active power[2]	0.1 pu/sec
Reactive power[2]	2.5 pu/sec

Table 5-10: Maximum ramp rates for external control data

Active power restriction	
Technical minimum	400kW

Table 5-11: Minimum active power output

[2] Limitations in duration of a power ramp may apply.

5.8 Voltage control

The turbine is designed for integration with VestasOnline® voltage control by utilising the turbine reactive power capability.

5.9 Frequency control

The turbine can be configured to perform frequency control by decreasing the output power as a linear function of the grid frequency (over frequency).

Dead band and slope for the frequency control function are configurable.

5.10 High voltage connection

5.10.1 Transformer

The step-up HV transformer is located in a separate locked room in the back of the nacelle.

The transformer is a three-phase, two-winding, dry-type transformer that is self-extinguishing. The windings are delta-connected on the high-voltage side unless otherwise specified.

The transformer comes in different versions depending on the market where it is intended to be installed.

- The transformer is as default designed according to IEC standards for both 50 Hz and 60Hz versions.
- For turbines installed in Member States of the European Union, it is required to fulfil the Eco design regulation No 548/2014 set by the European Commission.

5.10.2 HV Switchgear

Vestas delivers a gas insulated switchgear which is installed in the bottom of the tower as an integrated part of the turbine. Its controls are integrated with the turbine safety system which monitors the condition of the switchgear and high voltage safety related devices in the turbine. This ensures all protection devices are fully operational whenever high voltage components in the turbine are energised. The earthing switch of the circuit breaker contains a trapped-key interlock system with its counterpart installed on the access door to the transformer room in order to avoid unauthorized access to the transformer room during live condition.

The switchgear is available in two variants with increasing features – see Table 5-12. Beside the increase in features, the switchgear can be configured depending on the number of grid cables planned to enter the individual turbine. The design of the switchgear solution is optimized such grid cables can be connected to the switchgear even before the tower is installed and still maintain its protection toward weather conditions and internal condensation due to a gas tight packing.

The switchgear is available in an IEC version and in an IEEE version. The IEEE version is however only available in the highest voltage class.

HV Switchgear		
Variant	**Basic**	**Streamline**
IEC standards	○	⦿
IEEE standards	⦿	○
Vacuum circuit breaker panel	⦿	⦿
Overcurrent, short-circuit and earth fault protection	⦿	⦿
Disconnector / earthing switch in circuit breaker panel	⦿	⦿
Voltage Presence Indicator System for circuit breaker	⦿	⦿
Voltage Presence Indicator System for grid cables	⦿	⦿
Double grid cable connection	⦿	⦿
Triple grid cable connection	⦿	○
Preconfigured relay settings	⦿	⦿
Turbine safety system integration	⦿	⦿
Redundant trip coil circuits	⦿	⦿
Trip coil supervision	⦿	⦿
Pendant remote control from outside of tower (Option via ground controller)	⦿	⦿
Sequential energisation	⦿	⦿
Reclose blocking function	⦿	⦿
Heating elements	⦿	⦿
Trapped-key interlock system for circuit breaker panel	⦿	⦿
UPS power back-up for protection circuits	⦿	⦿
Motor operation of circuit breaker	⦿	⦿
Cable panel for grid cables (configurable)	○	⦿
Switch disconnector panels for grid cables – max three panels (configurable)	○	⦿
Earthing switch for grid cables	○	⦿
Internal arc classification	○	⦿
Supervision on MCB’s	○	⦿

Table 5-12 - HV switchgear variants and features

5.11 Main contributors to own consumption

The consumption of electrical power by the wind turbine is defined as consumption when the wind turbine is not producing energy (generator is not connected to the grid). This is defined in the control system as Production Generator (zero).

The following components have the largest influence on the power consumption of the wind turbine:

Main contributors to own consumption	
Hydraulic motor	20 kW
Yaw motors 6 x 1.75 kW	10.5 kW
Oil heating 3 x 0.76 kW	2.3 kW
Air heaters (2 x 6 kW)	12 kW
Oil pump for gearbox lubrication	5.0 kW
Generator fan (included in generator efficiency)	7.5 kW
Average of measured no-load loss of the HV transformer	4.0 kW

Table 5-13: Own consumption data

6 Drawings

6.1 Structural design – illustration of outer dimensions

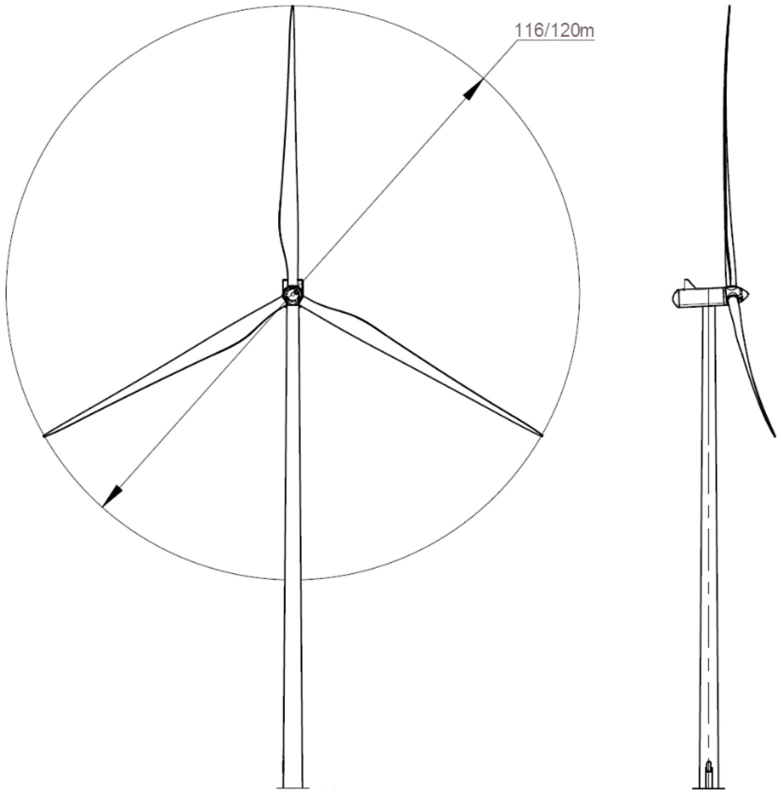

Figure 6-1: Illustration of outer dimensions for a V116/V120 turbine

6.2 Structural design (side-view drawing)

Figure 6-2: Side-view drawing

6.3 Turbine protection systems

6.3.1 Braking concept

The main brake on the turbine is aerodynamic. Braking the turbine is done by feathering the three blades. During emergency stop all three blades will feather simultaneously to full end stop, thereby slowing the rotor speed.

In addition there is a mechanical disc brake on the high-speed shaft of the gearbox. The mechanical brake is only used as a parking brake and when activating the emergency stop push buttons.

6.4 Overspeed protection

The generator rpm and the main shaft rpm are registered by inductive sensors and calculated by the wind turbine controller to protect against overspeed and rotating errors.

In addition, the turbine is equipped with a safety PLC, an independent computer module that measures the rotor rpm. In case of an overspeed situation, the safety PLC activates the emergency feathered position (full feathering) of the three blades independently of the turbine controller.

6.5 EMC system

The turbine and related equipment must fulfil the EU EMC-directive with later amendments:

- European Parliament Council directive 2004/108/EC of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility.
- The EMC-directive with later amendments.

6.6 Lightning protection system

The LPS consists of three main parts.

- Lightning receptors.
- Down conducting system.
- Earthing system.

NOTE The LPS is designed according to IEC standards.

6.7 Earthing

The Vestas Earthing System is based on foundation earthing.

Document 0000-3388 ‘Vestas Earthing System’ contains the list of documents pertaining to the Vestas Earthing System.

Requirements in the Vestas Earthing System specifications and work descriptions are minimum requirements from Vestas and IEC. Local and national requirements may require additional measures.

7 Environment

7.1 Chemicals

Chemicals used in the turbine are evaluated according to the Vestas Wind Systems A/S Environmental System certified according to ISO 14001:2004.

- Anti-freeze liquid to help prevent the cooling system from freezing.
- Gear oil for lubricating the gearbox.
- Hydraulic oil to pitch the blades and operate the brake.
- Grease to lubricate bearings.
- Various cleaning agents and chemicals for maintenance of the turbine.

8 General reservations, notes, and disclaimers

- The general specification document here described applies to the present design of the 2.0MW/2.2MW wind turbine series. Updated versions of the wind turbine, which may be manufactured in the future, may have a general specification document that differs from these general specifications. In the event that Vestas supplies an updated version of the wind turbine, Vestas will provide updated general specification applicable to the updated version.
- Vestas recommends that the grid be as close to nominal as possible with little variation in frequency.
- A certain time allowance for turbine warm-up must be expected following grid dropout and/or periods of very low ambient temperature.
- The estimated power curve for the different estimated noise levels (sound power levels) is for wind speeds at 10 minute average value at hub height and perpendicular to the rotor plane.
- All listed start/stop parameters (for example wind speeds and temperatures) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
- The earthing system must comply with the minimum requirements from Vestas, and be in accordance with local and national requirements, and codes of standards.
- This document, ‘General Specifications’, is not an offer for sale, and does not contain any guarantee, warranty, and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method). Any guarantee, warranty, and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method) must be agreed to separately in writing.

9 Appendices

9.1 Design codes – structural design

The structural design has been developed and tested with regard to, but not limited to, the following main standards:

Design codes – structural design	
Nacelle and hub	IEC 61400-1:2005 EN 50308 ANSI/ASSE Z359.1-2007
Bed frame	IEC 61400-1:2005
Tower	IEC 61400-1:2005 Eurocode 3

Table 9-1: Structural design codes

9.2 Design codes – mechanical equipment

The mechanical equipment has been developed and tested with regard to, but not limited to, the following main standards:

Design codes – mechanical equipment	
Gear	Designed in accordance with rules in ISO 81400-4
Blades	DNV-OS-J102 IEC 1024-1 IEC 60721-2-4 IEC 61400 (Part 1, 12, 22 and 23) DEFU R25 ISO 2813

Table 9-2: Mechanical equipment design codes

9.3 Design codes – electrical equipment

The electrical equipment has been developed and tested with regard to, but not limited to, the following main standards:

Design codes – electrical equipment	
High-voltage AC circuit breakers	IEC 60056
High-voltage testing techniques	IEC 60060
Power capacitors	IEC 60831
Insulating bushings for AC voltage above 1 kV	IEC 60137

Design codes – electrical equipment	
Insulation coordination	BS EN 60071
AC disconnectors and earth switches	BS EN 60129
Current transformers	IEC 60185
Voltage transformers	IEC 60186
High-voltage switches	IEC 60265
Disconnectors and fuses	IEC 60269
Flame retardant standard for MV cables	IEC 60332
Transformer	IEC 60076-11
Generator	IEC 60034
Specification for sulphur hexafluoride for electrical equipment	IEC 60376
Rotating electrical machines	IEC 34
Dimensions and output ratings for rotating electrical machines	IEC 72 and IEC 72A
Classification of insulation, materials for electrical machinery	IEC 85
Safety of machinery – electrical equipment of machines	IEC 60204-1

Table 9-3: Electrical equipment design codes

9.4 Design codes – I/O network system

The distributed I/O network system has been developed and tested with regard to, but not limited to, the following main standards:

Design codes – I/O network system	
Salt mist test	IEC 60068-2-52
Damp head, cyclic	IEC 60068-2-30
Vibration sinus	IEC 60068-2-6
Cold	IEC 60068-2-1
Enclosure	IEC 60529
Damp head, steady state	IEC 60068-2-56
Vibration random	IEC 60068-2-64
Dry heat	IEC 60068-2-2
Temperature shock	IEC 60068-2-14
Free fall	IEC 60068-2-32

Table 9-4: I/O network system design codes

9.5 Design codes – EMC system

To fulfil EMC requirements the design must be as recommended for lightning protection. See Table 9-6

Design codes – EMC system	
Designed according to	IEC 61400-1: 2005
Further robustness requirements according to	TPS 901795

Table 9-5: EMC system design codes

9.6 Design codes – lightning protection

The LPS is designed according to lightning protection level I:

Design codes – lightning protection	
Designed according to	IEC 62305-1: 2006 IEC 62305-3: 2006 IEC 62305-4: 2006
Non-harmonized standard and technically normative documents	IEC/TR 61400-24:2010

Table 9-6: Lightning protection design codes

9.7 Design codes – earthing

The Vestas Earthing System design is based on and complies with the following international standards and guidelines:

- IEC 62305-1 Ed. 1.0: Protection against lightning – Part 1: General principles.
- IEC 62305-3 Ed. 1.0: Protection against lightning – Part 3: Physical damage to structures and life hazard.
- IEC 62305-4 Ed. 1.0: Protection against lightning – Part 4: Electrical and electronic systems within structures.
- IEC/TR 61400-24. First edition. 2002-07. Wind turbine generator systems – Part 24: Lightning protection.
- IEC 60364-5-54. Second edition 2002-06. Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors.

9.8 Operational envelope conditions for power curve (at hub height)

Conditions for power curve (at hub height)	
Wind shear	0.00-0.30 (10 minute average)
Turbulence intensity	6-12% (10 minute average)
Blades	Clean
Rain	No
Ice/snow on blades	No
Leading edge	No damage
Terrain	IEC 61400-12-1
Inflow angle (vertical)	0 ±2°

Table 9-7: Conditions for power curve

9.9 Power curves, C_t values, and sound power levels

Power curve, C_t values and sound power levels for noise modes are defined in separate performance specifications for each variant. The documents will reference this General Specification to ensure correct traceability between performance data sheet and the General Specification.

The turbine can be equipped with different power generation components depending on the region which may influence the performance of the turbine. Consult Vestas Wind Systems for further details.

The Performance Specifications are listed below:

Performance specifications	Number
V116-2.0MW 50/60Hz	0063-8370
V120-2.0/2.2MW 50/60Hz	0063-8371

Table 9-8: Performance specifications