Electrical Description

History of this Document

Rev. no.:	Date:	Description of change
0		First edition
2	2003-10-08	Section 3: "The rated power of the transformer can be increased by 40% if they are equipped with 6 fans for forced cooling (AF - Air Forced)" has been deleted. Section 6: "Neutral earth" changed to "earth". 180 replaced by 180º. Section 9 updated.
3	2003-11-26	Section 9: "AGO" added.
4	2005-06-02	"Medium Voltage" replaced with "High Voltage" Nameplates for V80-1.8MW and V90-2.0MW added in section 7 Page 4: In section title, "50Hz" removed Page 5: In section title, "50Hz" removed Page 6: In section title, "50Hz" removed Added name plates: V66-1.75MW / 60 Hz V66-2.0MW / 60 Hz V80-2.0MW / 60 Hz V80-2.0MW / 50 Hz V90-1.8MW / 60 Hz V90-2.0MW / 60 Hz

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1. High Voltage Grid Connection

The turbine can be connected to the grid in the range from 6 kV to 33 kV, where 36 kV (Um) is the highest equipment voltage. The high voltage grid cables are led through a 200 mm tube in the foundation to the high voltage circuit breaker which is placed at the bottom of the tower.

The voltage of the high-voltage grid shall be within +5 / -5 %. Steady variations within +1 / -3 Hz are acceptable. Intermitted or rapid fluctuations off the grid's frequency may cause serious damage to the turbine. Grid dropouts must only take place once a week as an average over the lifetime of the turbine.

2. Transformer

The transformer is located in the nacelle. The winding is delta connected on the HV-side unless anything else is specified. The winding is connected in star on the LV-side (690V). The 690V system in the nacelle is a TN-system, which means that the star point is connected to earth.

The transformer is a three-phase dry type transformer, which is self-extinguishing.

3. Transformer Data

Three phased transformers for indoor use.
Fittings: 2 pcs. PT100 sensors per phase
Design, manufacturing, routine tests and tolerances according to IEC 76 and IEC 726 standards.

Transformer 10.5 kV.

Rated power 690V:	S_r	=	1902 kVA (AF - Air Forced)
Rated power 480V:	S_r	=	205 kVA (AF - Air Forced)
Frequency:	f	=	50 or 60 Hz
Primary voltage:	U	=	10500 V
Secondary voltage:	U_s	=	690/480 V
No load losses:	P_0	≤	3900 W
Impedance losses at rated load (75°C):	$P_{Cu(75°C)}$	≤	14400 W
Impedance losses at rated load (120°C):	$P_{Cu(120°C)}$	≤	16500 W
Impedance voltage 690V, 1902kVA:	e_k	≥	7 %
Short circuit current 690V, 1902kVA:	$I_{max,3p}$	≤	23 kA
Short circuit current 480V, 205kVA:	$I_{max,3p}$	≤	36 kA
Full load current at 10,5 kV:	$I_{10,5kV}$	=	110/115 A (Cosφ=1/0,96)
Tap changer:	n_{tp}	=	±2x2,5 %
Highest equipment voltage:	U_m	=	12 kV
Power frequency voltage (50 Hz,1 min.):	U_d	=	28 kV (RMS)
Lightning impulse voltage BIL (1,2/50 µs):	U_p	=	75 kV
LV clearance voltage:		=	1,1 kV
LV test voltage (50 Hz, 1 min.):		=	3 kV
Connection:		=	Dyn5 or Dyn11
Weight:		<	5500 kg
Max. ambient temperature:		=	50°C
Max. daily average temperature:		=	40°C
Max. yearly average temperature:		=	30°C
Max. temperature rise (hotspot):	$_{\Delta}T_{(Pt100)}$	=	95 K
Reduction of generator power (hotspot):	$T_{(Pt100)}$	=	145°C
Cut out of generator (hotspot):	$T_{(Pt100)}$	=	150°C
Cut out of HV-grid (hotspot) :	$T_{(Pt100)}$	=	155°C
Temperature class:		=	F
Environment class:		=	E2
Climate class:		=	C2
Fire behavior class:		=	F1

Transformer 20 kV.

Rated power 690V:	S_r	=	1902 kVA (AF - Air Forced)
Rated power 480V:	S_r	=	205 kVA (AF - Air Forced)
Frequency:	f	=	50 or 60 Hz
Primary voltage:	U	=	20000 V
Secondary voltage:	U_s	=	690/480 V
No load losses:	P_0	≤	3900 W
Impedance losses at rated load (75°C):	$P_{Cu(75°C)}$	≤	14400 W
Impedance losses at rated load (120°C):	$P_{Cu(120°C)}$	≤	16500 W
Impedance voltage 690V, 1902kVA:	e_k	≥	7 %
Short circuit current 690V, 1902kVA:	$I_{max,3p}$	≤	23 kA
Short circuit current 480V, 205kVA:	$I_{max,3p}$	≤	36 kA
Full load current at 20 kV:	I_{20kV}	=	58/60 A (Cosφ=1/0,96)
Tap changer:	n_{tp}	=	±2x2,5 %
Highest equipment voltage:	U_m	=	24 kV
Power frequency voltage (50 Hz,1 min.):	U_d	=	50 kV (RMS)
Lightning impulse voltage BIL (1,2/50 μs):	U_p	=	125 kV
LV clearance voltage:		=	1,1 kV
LV test voltage (50 Hz, 1 min.):		=	3 kV
Connection:		=	Dyn5 or Dyn11
Weight:		<	5500 kg
Max. ambient temperature:		=	50°C
Max. daily average temperature:		=	40°C
Max. yearly average temperature:		=	30°C
Max. temperature rise (hotspot):	$\Delta T_{(Pt100)}$	=	95 K
Reduction of generatorpower (hotspot):	$T_{(Pt100)}$	=	145°C
Cut out of generator (hotspot) :	$T_{(Pt100)}$	=	150°C
Cut out of HV-grid (hotspot) :	$T_{(Pt100)}$	=	155°C
Temperature class:		=	F
Environment class:		=	E2
Climate class:		=	C2
Fire behavior class:		=	F1

Transformer 33 kV.

Rated power 690V:	S_r	=	1902 kVA (AF - Air Forced)
Rated power 480V:	S_r	=	205 kVA (AF - Air Forced)
Frequency:	f	=	50 or 60 Hz
Primary voltage:	U	=	33000 V
Secondary voltage:	U_s	=	690/480 V
No load losses:	P_0	≤	3900 W
Impedance losses at rated load (75°C):	$P_{Cu(75°C)}$	≤	14400 W
Impedance losses at rated load (120°C):	$P_{Cu(120°C)}$	≤	16500 W
Impedance voltage 690V, 1902kVA:	e_k	≥	7 %
Short circuit current 690V, 1902kVA:	$I_{max,3p}$	≤	23 kA
Short circuit current 480V, 205kVA:	$I_{max,3p}$	≤	36 kA
Full load current at 33 kV:	I_{33kV}	=	35/36 A (Cosφ=1/0,96)
Tap changer:	n_{tp}	=	±2x2,5 %
Highest equipment voltage:	U_m	=	36 kV
Power frequency voltage (50 Hz,1 min.):	U_d	=	70 kV (RMS)
Lightning impulse voltage BIL (1,2/50 μs):	U_p	=	170 kV
LV clearance voltage:		=	1,1 kV
LV test voltage (50 Hz, 1 min.):		=	3 kV
Connection:		=	Dyn5 or Dyn11
Weight:		<	5500 kg
Max. ambient temperature:		=	50°C
Max. daily average temperature:		=	40°C
Max. yearly average temperature:		=	30°C
Max. temperature rise (hotspot):	$_{\Delta}T_{(Pt100)}$	=	95 K
Reduction of generatorpower (hotspot):	$T_{(Pt100)}$	=	145°C
Cut out of generator (hotspot):	$T_{(Pt100)}$	=	150°C
Cut out of HV-grid (hotspot) :	$T_{(Pt100)}$	=	155°C
Temperature class:		=	F
Environment class:		=	E2
Climate class:		=	C2
Fire behavior class:		=	F1

4. High Voltage-Circuit Breaker

Selection of high voltage-circuit breaker depends on the short circuit level.

1) Circuit breaker.
A circuit breaker is able to protect the transformer cable (3x25+25 mm^2) up to 11 kA.

2) Fuses.
Fuses protect the cable if high short circuit currents occur. However, there might be problems with the selectivity to short circuit protection of the high voltage-grid.

3) Circuit breaker and fuses.
Fuses protect the cable at high short circuit currents, and it is possible to get the selectivity to short circuit protection of the high voltage-grid.

The high voltage-circuit breaker must be equipped with a trip coil (230 V) which can be activated by the VMP-controller and manually from the nacelle.

If the high voltage-circuit breaker is selected as a “ring main unit”, it is possible to loop further on to e.g. other turbines.

5. Earthing

It has to be possible to make an earthing on the grid side and on the turbine side. It is possible to make an earthing in the nacelle. Equipment for the earthing in the nacelle is not supplied from Vestas.

6. The Earthing System of the Wind Turbine/Lightning Protection

The system should be made at the same time as the foundation work.

The earthing system must be accommodated to local soil conditions. The resistance to 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 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 (180º between the earthing rods).

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

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

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

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

7. Nameplate on the Nacelle Controller

1,75 MW

Vestas Wind Systems A/S
Alsvej 21 DK-800 Randers
Tlf.(+45) 97 30 00 00 Fax. (+45) 97 30 00 01

CE 2000

Wind Turbine type:	V66-1.75MW
Controller type:	VMP- 1.75/2.0MW
Voltage:	3x690 V +10/-10%
Voltage:	3x480 V +10/-10%
Frequency:	50 Hz +1/-3 Hz
Current 690V:	1418A
Current 480V:	213A
Max. short circuit current 690V:	I_K = 23kA
Max. short circuit current 480V:	I_K = 36kA
Main wiring diagram:	946471-946478

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CE 2000

Wind Turbine type:	V66-1.75MW
Controller type:	VMP- 1.75/2.0MW
Voltage:	3x690 V +10/-10%
Voltage:	3x480 V +10/-10%
Frequency:	60 Hz +2/-3 Hz
Current 690V:	1418A
Current 480V:	213A
Max. short circuit current 690V:	I_K = 23kA
Max. short circuit current 480V:	I_K = 36kA
Main wiring diagram:	946471-946478

1.8MW

Vestas Wind Systems A/S
Alsvej 21 DK-800 Randers
Tlf.(+45) 97 30 00 00 Fax. (+45) 97 30 00 01

CE 2000

Wind Turbine type:	V90-1.8MW
Controller type:	VMP- 1.75/2.0MW
Voltage:	3x690 V +10/-10%
Voltage:	3x480 V +10/-10%
Frequency:	50 Hz +2/-3 Hz
Current 690V:	1378A
Current 480V:	220A
Max. short circuit current 690V:	I_K = 23kA
Max. short circuit current 480V:	I_K = 36kA
Main wiring diagram:	946471-946478

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CE 2000

Wind Turbine type:	V90-1.8MW
Controller type:	VMP- 1.75/2.0MW
Voltage:	3x690 V +10/-10%
Voltage:	3x480 V +10/-10%
Frequency:	60 Hz +2/-3 Hz
Current 690V:	1378A
Current 480V:	220A
Max. short circuit current 690V:	I_K = 23kA
Max. short circuit current 480V:	I_K = 36kA
Main wiring diagram:	946471-946478

2.0MW

Vestas Wind Systems A/S
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2000

Wind Turbine type:	V66-2.0MW
Controller type:	VMP- 1.75/2.0MW
Voltage:	3x690 V +10/-10%
Voltage:	3x480 V +10/-10%
Frequency:	50 Hz +1/-3 Hz
Current 690V:	1600A
Current 480V:	240A
Max. short circuit current 690V:	I_K = 23kA
Max. short circuit current 480V:	I_K = 36kA
Main wiring diagram:	946471-946478

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2000

Wind Turbine type:	V66-2.0MW
Controller type:	VMP- 1.75/2.0MW
Voltage:	3x690 V +10/-10%
Voltage:	3x480 V +10/-10%
Frequency:	60 Hz +2/-3 Hz
Current 690V:	1600A
Current 480V:	240A
Max. short circuit current 690V:	I_K = 23kA
Max. short circuit current 480V:	I_K = 36kA
Main wiring diagram:	946471-946478

Vestas Wind Systems A/S
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CE 2000

Wind Turbine type:	V80-2.0MW
Controller type:	VMP- 1.75/2.0MW
Voltage:	3x690 V +10/-10%
Voltage:	3x480 V +10/-10%
Frequency:	60 Hz +2/-3 Hz
Current 690V:	1600A
Current 480V:	240A
Max. short circuit current 690V:	I_K = 23kA
Max. short circuit current 480V:	I_K = 36kA
Main wiring diagram:	946471-946478

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CE 2000

Wind Turbine type:	V80-2.0MW
Controller type:	VMP- 1.75/2.0MW
Voltage:	3x690 V +10/-10%
Voltage:	3x480 V +10/-10%
Frequency:	50 Hz +1/-3 Hz
Current 690V:	1600A
Current 480V:	240A
Max. short circuit current 690V:	I_K = 23kA
Max. short circuit current 480V:	I_K = 36kA
Main wiring diagram:	946471-946478

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CE 2000

Wind Turbine type:	V90-2.0MW
Controller type:	VMP- 1.75/2.0MW
Voltage:	3x690 V +10/-10%
Voltage:	3x480 V +10/-10%
Frequency:	50 Hz +1/-3 Hz
Current 690V:	1600A
Current 480V:	240A
Max. short circuit current 690V:	I_K = 23kA
Max. short circuit current 480V:	I_K = 36kA
Main wiring diagram:	946471-946478

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Voltage:	3x690 V +10/-10%
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Frequency:	60 Hz +1/-3 Hz
Current 690V:	1600A
Current 480V:	240A
Max. short circuit current 690V:	I_K = 23kA
Max. short circuit current 480V:	I_K = 36kA
Main wiring diagram:	946471-946478

8. Short Curcuit Protection of the Nacelle Controller

Breakers 690V	Generator / Q8 ABB S7H 1600	Controller / Q15 ABB S3X	VCS / Q7 ABB S5H 400
Breaking capacity, I_{cu}, I_{cs}	23 kA	75 kA	40 kA
Making capacity, I_{cm}	52 kA	440 kA	40 kA
Thermo release, I_{th}	1600A	100 A	400 A
Magnetic release, I_m	9.6 kA	1.0 kA	1600 A

9. Monitoring of the Grid

The generator will be disconnected if the voltage or the frequency exceeds the following limits (measured at the 690 V side):

Nominal phase voltage:	$U_{P,nom}$ = 400 V.
Phase voltage:	U_P
Grid voltage:	U_N

<u>The generator and the converter will be disconnected if:</u>

	U_P	U_N
The voltage is 10 % above the nominal voltage for 60 s.	440 V	762 V
The voltage is 10 % below the nominal voltage for 60 s.	360 V	624 V
The voltage is 13.5 % above the nominal voltage for 0.2 s.	454 V	786 V
The frequency is above 51 Hz for 0.2 s.		
The frequency is below 47 Hz for 0.2 s.		

If a fault on the grid interrupts and the voltage supply to the VMP-controller, the emergency stop circuit will be opened immediately, and the generator will be disconnected simultaneously. In case the turbine has an Advanced Grid Option (AGO) the control system is supplied from an UPS system and the generator is kept connected until the voltage tolerance curve for the specific AGO solution is exceeded.

10. Component Prefix

This chapter explains the rules for stating the name of the components used in the controller.

Components, in- and output are named with the following letter prefix:

Prefix	Subject
A	Group of components, e.g. top and ground controller
B	Electronical signal ground controller, e.g. windvane, thermostat, sensor
D	Auxiliary Relay
E	Heating element/fan
F	Thermo relay/circuit breaker/fuse
G	Generator
H	Signal lamp
K	Contactor, relay
L	Coil, discharge coil
M	Motor
Q	Circuit breaker for main current circuit
R	Resistance (temperature sensors)
S	Switch function
T	Transformer
U	Rectifier
V	Thyristor
W	Cable
X	Terminal
Y	Magnetic valve

11. Component Numbers

Components, in- and output are named with the following number:

Component number	Number group	
0.. 99	Electric installation	
100..199	Yaw System	
200..299	Hydraulic System	
300..399	Ambient	
400..499	Transmission System/VOG	
500..599	Generator/VCS	
600..699	Control System/VCS	
700..799	Control System	
800..899	Control System - Hub	
900..999	Emergency Stop	

In- and output have the same number, if these have connection with the same component (e.g. control signal and feedback from contactor). The distinction is made by means of the signal's letter prefix.

Two components with a complete parallel function have the same number, but they can be distinguished by means of a subsequent letter (E.g.: K100A, K100B).

The auxiliary relays are defined as a component, which exclusively functions as a connecting link between e.g. a computer output and a contactor coil. The auxiliary relays have the letter prefix D and the same number as the component, which they serve.

12. Assembly and Terminal Designation

VMP-1,75/2,0MW controller include the following assemblys:

A1	:	Busbar section.
A2	:	Hub controller.
A3	:	VCS section.
A4	:	Control section..
A5	:	Ground controller.
A6A	:	Box for ultrasonic sensor.
A6B	:	Box for ultrasonic sensor.
A7	:	Box on rotating transformer.
A8	:	Box on gear (sensors).
A9	:	Box for sensors at the main shaft.
A10	:	Box on generator.
A11	:	Box for sensors for the yaw system.
A14	:	Box for heating elements on the gear box.
A15	:	Box for transformer ventilation (trafo wall).
A16	:	Box for termistor on transformer vent. motors.
A18	:	Box for LT Heating systems in systems
A32	:	Box for Hydraulic systems
A33	:	Box on sliprings champer – generator
A34	:	Box on sliprings champer – Gear
A35	:	Box on offline filter gear

Example of designation of terminals:

Nacelle controller (A1), terminal block X4, terminal 8:	A1.X4:8
Hub controller (A2), terminal block X1, terminal 4:	A2.X1:4
Component K44, terminal 3:	K44:3
Component K903, terminal 5:	K903:5