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Grid Connection Performance of Goldwind Wind Turbines

(GW70-1.5MW、GW77-1.5MW、GW82-1.5MW)

Q/JF 2SJ1500.90SS.1EN-2010

Edition: D0

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Preface

This Standard is compiled in accordance with GB/T1.1-2000 Directives for Standardization – Part 1: Structure and Compiling Rules of Standard and GB/T 1.2-2002 Directives for Standardization – Part 2: Methodology for the Content of Normative Technical Elements in Standards.

This Standard is proposed by and under the centralized management of Xinjiang Goldwind Science & Technology Co., Ltd.

This Standard is drafted by Electrical Technology Center of Xinjiang Goldwind Science & Technology Co., Ltd.

Main drafters: Aisikaer

Historical edition release condition of the Standard replaced by this Standard: This Standard *(Edition: D0, Document Number: Q/JF 2SJ1500.90SS.1EN-2010)* takes place of *Grid Connection Performance of Goldwind 1.5MW Wind Turbines (Edition: C0, Document Number: Q/JF 2SJ1500.90SS.1EN-2010).* Edition C0 is canceled and retained.

This Standard is approved by: Tang Xin

Grid Connection Performance of Goldwind Wind Turbines

1 Scope

This document describes the warranted grid connection performance of the Goldwind 1.5MW wind turbine range configured with connection to the grid via the Goldwind air-cooled converter (It was called Freqcon converter in some of the historical documentations).

Important: the grid connection performance outcomes of the direct drive and gearless wind turbine largely depend on the converter type.

2 System Overview

The Goldwind 1.5MW wind turbine is a direct drive, variable-speed and gearless design with a multi-pole permanent-magnet synchronous generator. As detailed in the document - “Goldwind 1.5MW Wind Turbine Range: Technical Description”.

The generator is decoupled from the grid via the fully-fed IGBT frequency converter - the Goldwind Air-cooled converter. The grid performance and behavior of the wind turbine is only impacted by the grid side of the converter and is not affected by the generator system.

All over/under voltage and over/under frequency trip levels are programmed to be easily customized, and can be adjusted according to the requirements of the network system operator.

The configuration schematics of the main circuit are as shown in Figure 2.1 below.

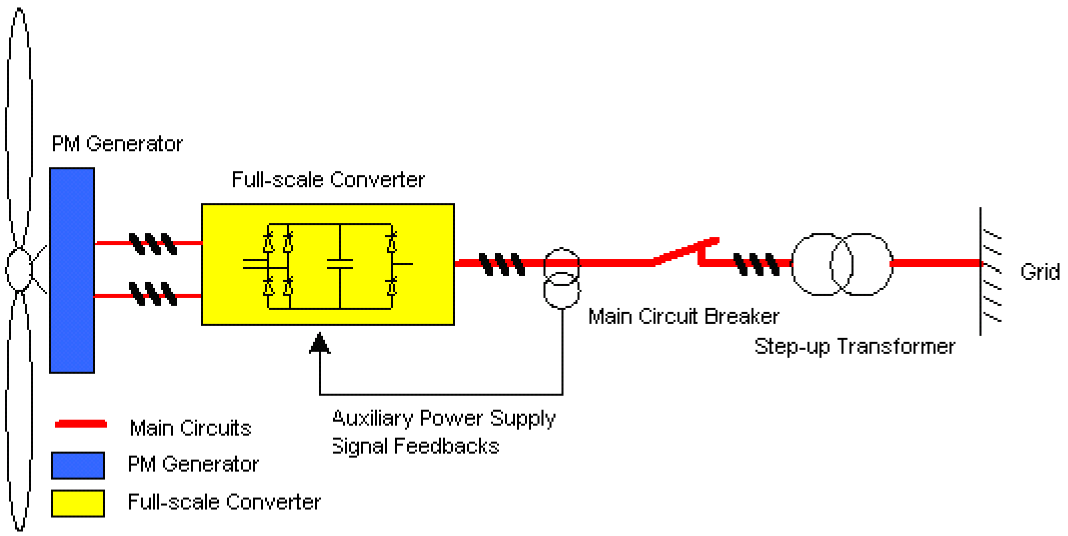

Figure 2.1 System overview

Goldwind 70/77/82-1.5MW wind turbines are pitch regulated; therefore the blades can be pitched to produce the optimum angle for the desired operating conditions (e.g. maximum production, system breaking, etc). Some advantages of this simple and robust design leading to superior technical performance include:

- Low speed generator and gearless design, resulting in high efficiency and high reliability including at low rotational speed;

- Fewer components, resulting in low maintenance;
- Tremendous LVRT capability;
- Grid-friendly active power/frequency control, and reactive power/voltage control;
- Smooth power output for high power quality and low flicker level.

3 Grid Side Nominal Parameters

Table 3.1 Rated Output Parameters

Parameters	Value	Unit
Number of Phases	3	-
Rated Active Power	1500	kW
Rated Apparent Power	1579 (power factor=0.95)	kVA
Rated Voltage (phase to phase)	620	V
Nominal Frequency	50 or 60Hz as required	Hz
Nominal Power Factor	1.0 (default) , controlled (leading 0.95 – lagging 0.95)	-
Reactive Power	0 (Default), Controlled (from 500 (ind) to 500(cap))	kVar

Table 3.2 Short-circuit Current

Parameters	Value	Unit
Short-circuit Current (Maximum)	1600	A

Table 3.3 Protections Parameters

Parameters	Value	Unit	Delay Time (s)
Under Voltage Protection	0.9 U_{rated}	p.u.	0.1
Over Voltage Protection	1.1 U_{rated}	p.u.	0.1
Under Frequency Protection	95% of Nominal Frequency	Hz	0.1
Over Frequency Protection	105% of Nominal Frequency	Hz	0.1
Over Current Protection	1600	A	0.1
Phase Current Unbalance Protection	P*0.05+150 (P: instantaneous active power)	A	1
Active Power Mismatch Protection	90	kW	10
Overload Protection	1600	kW	1
Please Note: Protection settings detailed in Table 3.3 can be reasonably modified based on the local network conditions.			

Table 3.4 Grid Side Transformer Recommendations

Parameters	Value	Unit	Comment
Rated Capacity	1600	kVA	-
Secondary Voltage	620	V	Primary voltage is project specific, customer provides, no recommendation from Goldwind
Positive Sequence Impedance	6	%	Goldwind recommends this value.

Vector Group	Dyn	-	Dyn5 or Dyn11
Number of Windings	2	-	-
Star Point Grounding	Yes	-	-
Tap Changer	±2×2.5	%	Ideally to be ±4×2.5%
Please Note: A single step-up transformer is required for each single wind turbine. The wind turbine and transformer communication requirements will be determined for each project.			

Table 3.5 Grid Side Low Voltage Cable Requirements

Parameters	Value	Unit	Comment
Rated Line Voltage	1	kV	-
Type of Cables	YJV22-0.6/1kV-4(3×240+1×120mm^2)	-	recommended
	There are four parallel connected cables and therefore four core cables are required. That is: 4 parallel connected 1*240 mm^2 cables will be connected to phase bus bar and 4 parallel connected 1*120 mm^2 cables will connected to neutral bus bar		
Installations	Metallic pipe should not be used as cable outside jacket,		
Please Note: Project specific cabling is to be pre-approved by Goldwind Engineers.			

4 Grid Connection Performance of Goldwind 1.5MW Wind Turbine

4.1 Active Power Control

The pitch control system enables control of active power output and its ramp rate.

Goldwind's Energy Management Platform (EMP) controls the wind farm active power output at the PCC (Point of Common Coupling) as described below.

- Functional control of the active power output at PCC.
- Functional control of the ramp rate of the active power output at PCC
- EMP estimating the capability of the active power of wind farm during active power control.

4.2 Reactive Power Control

The capability of the Goldwind 1.5MW wind turbine to perform reactive power control is shown in the Figure 4.2.

The default reactive power control stratagem for independent wind turbine is to export zero kVar at the wind turbine terminals if no reactive power is being required by the EMP.

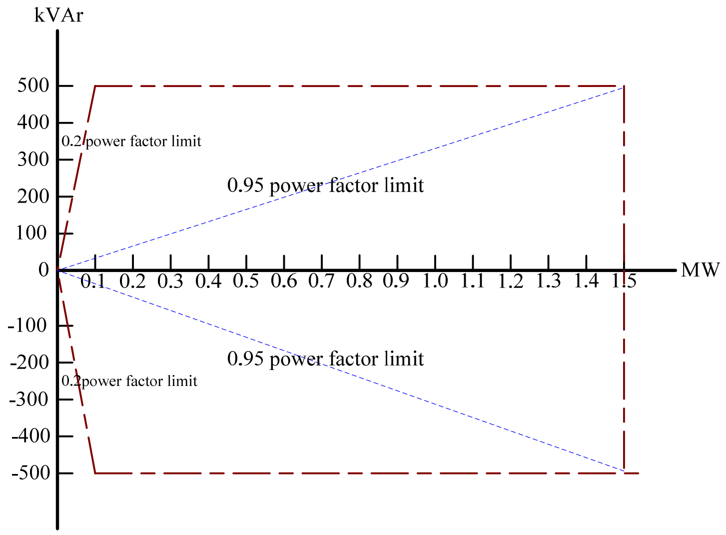

Figure 4.2 the capability of the Goldwind 1.5MW wind turbine to perform reactive power control

Wind farm level dynamic, on-line and continuous control based on a voltage setpoint and a reactive power setpoint are available with the application of Goldwind EMP. Default information as per Table 4.2.

Table 4.2 Wind Farm Level Control

Control Model	**Response Time**	**Conditions**	**Reactive power Range(kVar/unit)**	**Remote Control**
Reactive power	≤2s	|△U|≤ ±5%	-500 ~500	Yes
Voltage level	≤2s	|△U|≤ ±10%	-500 ~500	Yes
|△U|>10%	EMP stopping, but the voltage ride through mode (HVRT or LVRT) of wind turbine is activated.			
Please note: the voltage level control of the wind farm not only depend on reactive power capability of wind turbines, but also grid side network structure and substation central reactive power compensator of wind farm. △U= (rated voltage)-(measuring voltage).				

4.3 Voltage Operating Range

The Goldwind 1.5MW wind turbines stay in the ‘Normal Operation state’ if the terminal voltage is within the range of 90-110%.

The protection settings for the terminal voltage will be selected based on the results of relevant simulations if it exceeds “‘Normal Operation range’”, but the set point for extreme voltage operating range should be within the shaded areas as shown in Figure 4.3.

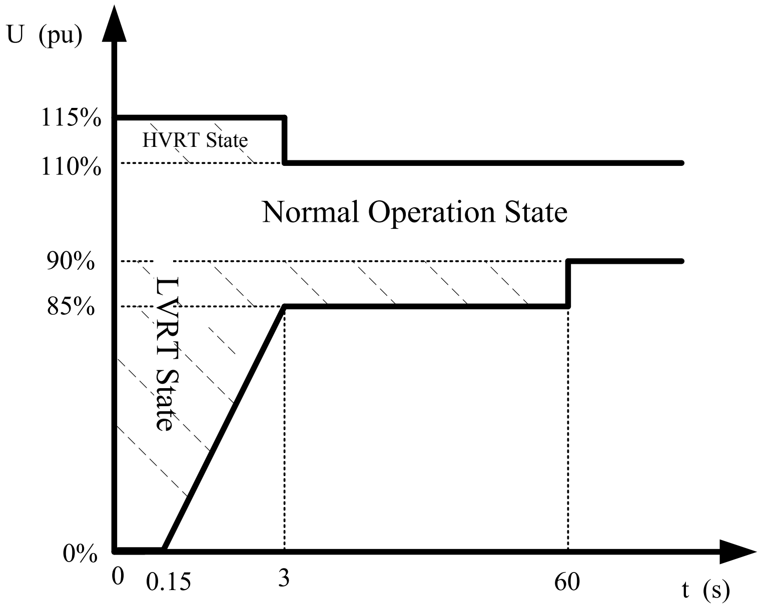

Figure 4.3 Operating voltage range of the wind turbine

4.4 Frequency Operating Range

The frequency operating range for continuous operation is within the range of 95%～105% of nominal value.

4.5 Fault Ride Through

4.5.1 Low Voltage Ride Through and High Voltage Ride Through

A wind turbine has an independent protective response to high or low voltage conditions during grid fault. Both high voltage ride through (HVRT) and low voltage ride through (LVRT) are shown in Figure 4.3.

The wind turbines would stay connected when the voltage deviations are within the limited area of 0-90% or within the limited area of 110-115% of the rated voltage as shown in Figure 4.3, the required reactive current supplied to the grid during grid disturbance are shown in Figure 4.5. After the fault, the active power output would recover to pre-fault active power output level at the speed of 30% of pre-fault active power output level per second (minimum speed).

Please note：LVRT is equipped to the wind turbine as a standard but HVRT (as shown in Figure 4.3 and Figure 4.5) is an optional extra if required.

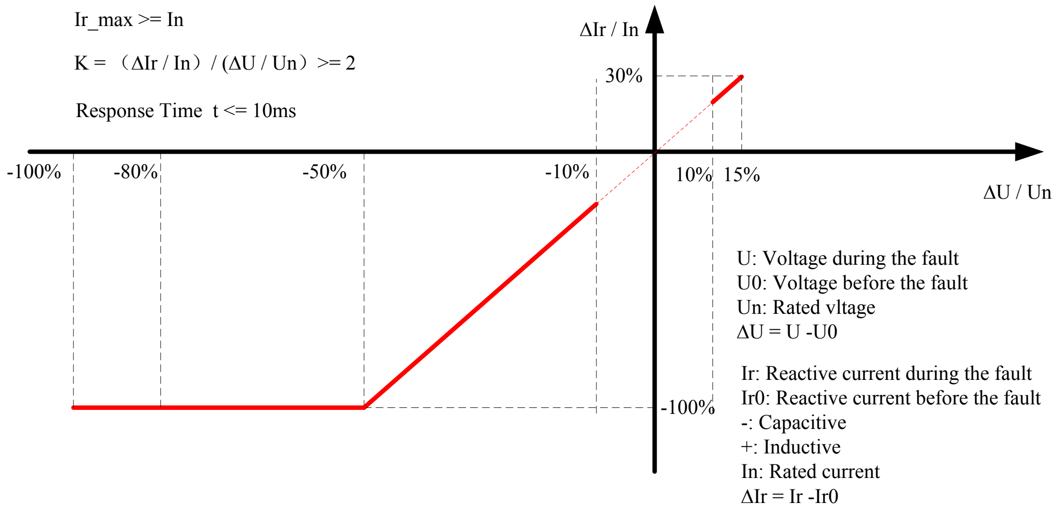

Figure 4.5 Reactive current controls during voltage ride through

4.5.2 Frequency Ride Through

By means of the full-fed IGBT frequency converter, wind turbines have the frequency ride through capabilities within the range of 95%-105% of the rated frequency.

4.6 Harmonics and Flicker

The harmonics and flicker has been measured for the Goldwind 70/1500 (The harmonic results for the GW70/1500 with Freqcon GmbH converter represent the results for the whole Goldwind 1.5MW range with air-cooled converters. This specifically includes the Goldwind Air-Cooled Converter) by WINDTEST KWK Germany according to IEC 61400-21 standard; the measured harmonics and flicker given in Table 4.6.1 and Table 4.6.2 (refer to the certificate of the tests if the related data requested in detail).

Table 4.6.1 Harmonics

order	Output power	Harmonic current	order	Output power	Harmonic current	order	Output power	Harmonic current
	[kW]	[% from I_n]		[kW]	[% from I_n]		[kW]	[% from I_n]
2	1544	2.8	11	14.2	0.6	--	--	--
3	1544	0.6	13	14.2	0.4	--	--	--
4	1544	0.2	17	14.2	0.5	--	--	--
5	1531.4	0.4	19	19.4	0.5	--	--	--
7	1124.4	0.8	23	19.4	0.2	--	--	--
8	1540	0.3	29	19.4	0.1	--	--	--
9	186.2	0.6	--	--	--	--	--	--
10	1531.4	0.1	--	--	--	--	--	--

Maximum THD [% from rated current]	2.98
Power at maximum THD [kW]	1544
Please note: the values below than 0.1% of rated current were not mentioned in the table 4.6.1	

Table 4.6.2 Flicker coefficient

Network impedance phase angle	30°	50°	70°	85°
Annual average wind speed v_a (m/s)	Flicker coefficient $c(\psi_k, v_a)$			
v_a =6.0m/s	1.83	1.81	1.93	2.04
v_a =7.5m/s	2.01	1.91	2.11	2.31
v_a =8.5m/s	2.03	2.08	2.22	2.36
v_a =10.0m/s	2.06	2.59	3.13	3.41

4.7 Modeling of Wind Turbines

Dynamic model for PSS/E versions 29 to 32 and DIgSILENT 14.0 are available.

4.8 Tests for Certification

Overall tests and analysis including LVRT, Power Quality and etc have been completed by WINDTEST Germany for the Goldwind 1.5MW wind turbine generators.

5 Earth System on Grid Terminal of Wind Turbines

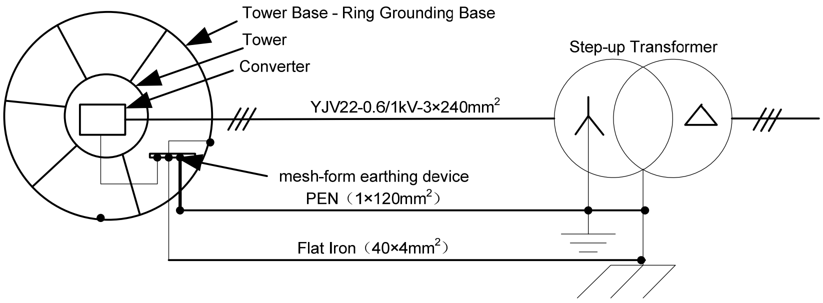

Figure 5.1 Earth systems on grid terminal of wind turbine

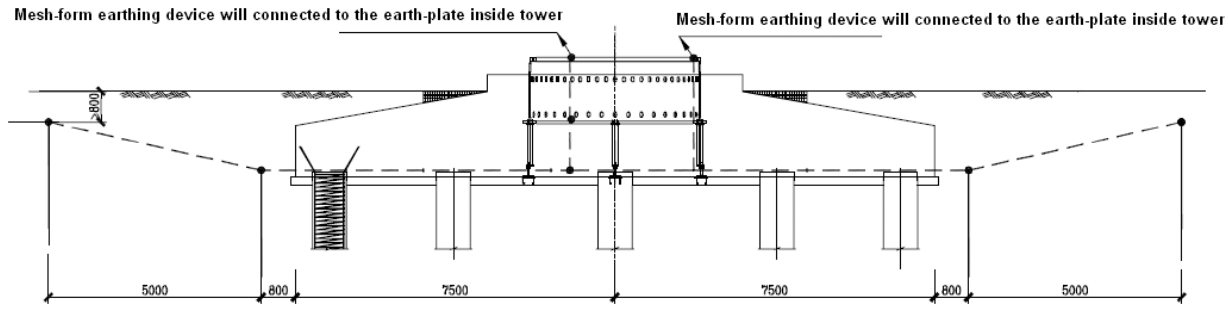

Figure 5.2 Earthing devices of wind turbine

6 Standards

The Goldwind design discussed in this document complies with accepted international standards and technical regulations. Concerning wind turbines, the latest IEC regulations (especially IEC 61400-1 to -21) and publications or the respective national regulations are of particular interest. The latest GL wind turbine guideline “Guideline for the Certification of wind turbines, Edition 2003”, should also be referred to, especially where the grid codes for the wind turbines in European countries must be complied with.

Concerning the generator, the following standards are of special importance:

- EN 60034-1 Rotating electrical machines - Part 1: Rating and performance
- EN 60034-2 Rotating electrical machines - Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)
- EN 60034-5 Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code)
- EN 60034-6 Rotating electrical machines - Part 6: Methods of cooling (IC Code)
- EN 60034-9 Rotating electrical machines - Part 9: Noise limits
- EN 60034-14 Rotating electrical machines - Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity
- EN 60034-15 Rotating electrical machines - Part 15: Impulse voltage withstand levels of rotating a.c. machines with form-wound stator coils
- EN 60034-18-1 Rotating electrical machines - Part 18: Functional evaluation of insulation systems - Section 1: General guidelines
- EN 60034-18-31 Rotating electrical machines - Part 18: Functional evaluation of insulation systems - Section 31: Test procedures for form-wound windings

Concerning the frequency converter, the following standards are of special importance:

- Fundamental standard EN 50178 “Electronic equipment for use in power installations”:
- IEC 61800-1 and IEC 61800-1 “Adjustable speed electrical power drive systems”