Wind Turbine Generator System

General Specification
for
HQ1650

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Hyundai Heavy Industries Co., Ltd
Electro Electric Systems
http://www.hyundai-elec.co.kr

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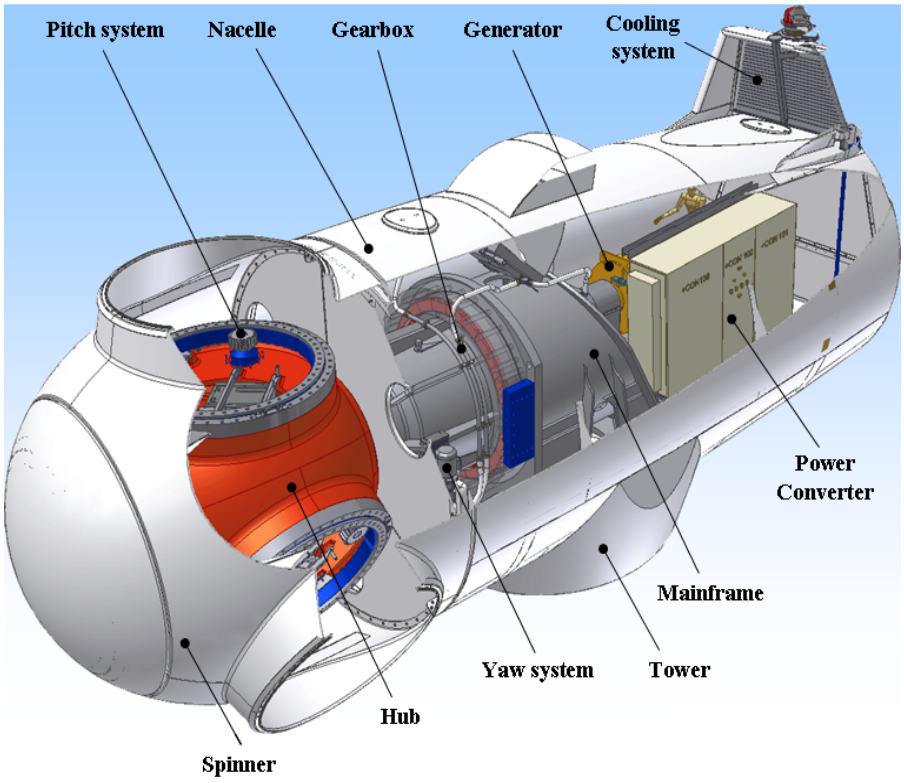
1. General description

The HQ1650 is a pitch regulated upwind wind turbine with active yaw and a three-blade rotor.

The HQ1650 has a rotor diameter of 77m with a generator rated at 1.65MW. With these feathered rated power will be maintained even in high wind speeds, regardless of air temperature and air density, and the wind turbine is able to operate the rotor at variable speed. And variable speed ensures a steady electric power production from the turbine. The variable speed system consists of a doubly fed induction generator with wound rotor, slip rings and power converter. A power converter is connected to the rotor to control the generator at variable speed.

Overview



2. Technical specifications

Rotor

The wind turbine generator HQ1650 has a three-bladed upwind rotor. Its rotational speed is limited by blade pitch control. The advantage of pitch control lies in the lower peak loads at high wind speeds. The wind turbine generator is subject to substantially lower dynamic loads, especially at sites with high turbulence intensity (onshore). The rotor offers high operational reliability and longer service life with minimal maintenance effort due to its enhanced pitch-control system.

Pitch system

The blades can be turned out of the rotor plane by about 90 degrees and therefore act as aerodynamic brakes. During normal operation the pitch motors hold the rotor blades in a defined position via the ring gear (pitch bearing) mounted to the blade root. The aerodynamic brake is applied by varying the rotor blade pitch with the motors. In the event of a fault (e.g. grid loss), the pitch motor is powered by a battery system and can therefore still control the pitch. Consequently, the wind turbine generator is completely safe (“fail safe design”). If one pitch drive cannot be activated (e.g. broken cable, broken power supply to hub), the other two blades can still be turned into feathering position. Furthermore, the Safety Lock system always allows the blades to turn into feathering position in the event of an overall pitch drive fault. The wind turbine generator can therefore be stopped automatically at any time, even without any power supply to the hub.

Hub

The cast iron hub is attached to the integral drive train with a flange. The three pitch drives are easy to maintain as they are mounted within the hub beside the blade root flanges.

Integral drive train

The integral drive train is composed of rotor shaft and gearbox as a unit.
The hub is bolted with the rotor flange.
The gearbox is a three-stage gear with two planetary reduction stages and one parallel shaft gear stage. The helical-tooth planetary stages and the

helical-tooth parallel-shaft stage are optimized with shape and tooth trace compensation. To compensate for internal loads, the planetary stage sun wheels are self adjusting.

The gearbox is forced lubricated. The gear oil temperature is monitored by a sensor and automatically cooled by a separate oil-air cooler and a filter unit in the nacelle if the permissible oil temperature is exceeded. Mechanical seals ensure a perfect seal and are wear-resistant.

The rotor controller cables are fed through the stationary hollow shaft into the hub. A rotor lock device at the input shaft enables the drive train to be mechanically locked for maintenance purposes.

Coupling

The gearbox and the generator are linked by a flexible shaft which compensates for alignment tolerances.

Generator and power electronics

The wind turbine generator is equipped with a double-fed three-phase induction generator. The advanced power electronics (IGBT converter) ensure that the generator works with high efficiency over the entire speed range.

A heating winding is installed to prevent damage to the generator due to damp. In addition, there are sensors to monitor the temperature in the generator. The generator and the power electronics are cooled by a water-air heat exchanger.

Mechanical brake

The mechanical brake is a disc brake fitted with one caliper and mounted on the high-speed shaft of the gearbox. The hydraulic system is pressurized. To apply the brake, solenoid valves are activated and the brake pads pressed against the disc. An intelligent braking system controls the braking sequence. The brake can be released by pressurizing the hydraulic circuit.

Main frame

The welded main frame transfers the loads from the integral drive train to the yaw drive system and holds the generator and control cabinet over the bolted cantilever.

Yaw drive system

The yaw drive system consists of an external ring gear which is bolted to the top flange of the tower plus a slide bearing. It is system is driven by four converter-fed electrical motors with a gearbox and a pinion mounted on the base plate of the main frame. Additional yaw brakes keep the wind energy converter in a fixed position until it has to be realigned with the actual wind direction. The motor brakes are released when the nacelle is turned. The yaw actuators also keep the nacelle in a fixed position, even at high eccentric wind loads.

Control system

The wind turbine generator control system is based on an industrial type PLC system. The wind turbine generator status can be checked on the display in the nacelle cabinet. The wind turbine generator control system is located in special cabinets located in the nacelle and tower base. The nacelle cabinet has the control function of pitch, yaw, generator and converter. It also controls the variants for power production by specific algorithm. The tower base cabinet has the function of the monitoring and remote control for the nacelle cabinet and inter-communicates the status of wind farm with SCADA system.

Tower and foundation

A conical tubular steel tower with internally screwed top flange for high maintenance safety has been designed for this wind turbine generator. Inside the tower is a ladder for accessing the nacelle, equipped with a climbing protection system to prevent a fall down. The tower contains also working platforms at the flange connections, resting platforms in each tower section and is equipped with working and emergency lightning. The steel door at the tower base is burglar-proofed.

Foundation will be designed site-specific as flat or pile foundation depending on the soil conditions and other local requirements..

3. Technical Data

Operating data

- Type model ..... HQ 1650
- Cut-in wind speed ..... 3.5 m/s
- Rated wind speed ..... 12.0 m/s
- Cut-out wind speed ..... 20.0 m/s
- Survival wind speed ..... 59.5 m/s
- Calculation guideline ..... Germanischer Lloyd
- Type class ..... TC ⅡA
- System life ..... 20 years

Temperature range

- Ambient temperature out of operation ..... -20 to 40℃
- Ambient temperature in operation ..... -15 to 40℃
- Survival temperature ..... -30 to 40℃

Blade

- Blade type ..... LM37.3 / AB37/ ZN37.5
- Manufacturer ..... LM / Aeroblade / CEW
- Blade length ..... 37 / 37.3 / 37.5 m
- Diameter of blade root connection ..... 1800 mm
- Material ..... epoxy, glass fiber
- Lightning conductor ..... integrated

Rotor

- Number of rotor blades 3
- Rotor axis ..... horizontal
- Position relative to tower ..... upwind
- Speed range ..... 11.3 ~ 20 rpm
- Rated speed ..... 18.23 rpm
- Direction of rotation (looking downwind) ..... clockwise
- Power control method ..... Pitch control
- Rotor axis tilt angle ..... 4.5 deg
- Rotor diameter ..... 77 m
- Rotor area ..... 4647 / 4659 m^2
- Sweep angle ..... 0.6 deg
- Cone angle ..... 0 deg
- Aerodynamic brake ..... full feathering

Pitch drive system

- Maximum pitch control speed limit ..... 9 deg/s
- Type of pitch bearing ..... 4 point ball bearing

Hub

- Hub type ..... rigid
- Material ..... steel iron

Mainframe

- Mainframe type ..... welded structure
- Material ..... steel iron

Gearbox unit

- Type description ..... 1^{st}, 2^{nd} step planetary
  3^{rd} step parallel
- Transmission ratio (50/60Hz) ..... 1:98.74 / 1:115
- Mechanical power ..... 1650 kW
- Bending strength ..... $S_F > 1.4$
- Surface durability ..... $S_H > 1.0$
- Application factor 1.3
- Shaft sealing ..... Labyrinth seals
- Rated drive torque ..... 930 kNm
- Maximum static torque ..... 3300 kNm
- Lubrication ..... oil pump
- Oil capacity ..... 600 liter
- Connection gear with generator ..... flexible coupling

Parking brake system

- Type of construction ..... hydraulic
- Mechanical brake ..... disc brake
- Activation ..... passive

Convertor

- Converter type ..... IGBT, 4 quadrants
- Rated power ..... 1650 kW
- Rated voltage ..... 3Φ / 690 VAC
- Power factor ..... standard 1.0
- Torque control ..... field vector control

Control system

- Control device ..... PLC
- Remote monitoring ..... yes
- SCADA system ..... yes

Generator

- Generator type ..... Double Fed Induction
- Rated power ..... 1650 kW
- Poles ..... 4 - pole
- Power factor 0.9
- Frequency ..... 50/60 Hz
- Stator voltage ..... 690 VAC
- Cooling ..... water cooled
- Protection grade IP54

Yaw drive system

- Type of wind direction alignment ..... active
- Type of yaw bearing ..... slide bearing
- Drive unit ..... planetary gear motor
- Voltage ..... 3Φ / 480/690 VAC
- Number of drive units 4
- Gear ratio of yaw gear unit ..... 1 : 1812.6
- Brake ..... friction / motor brake

Nacelle cover

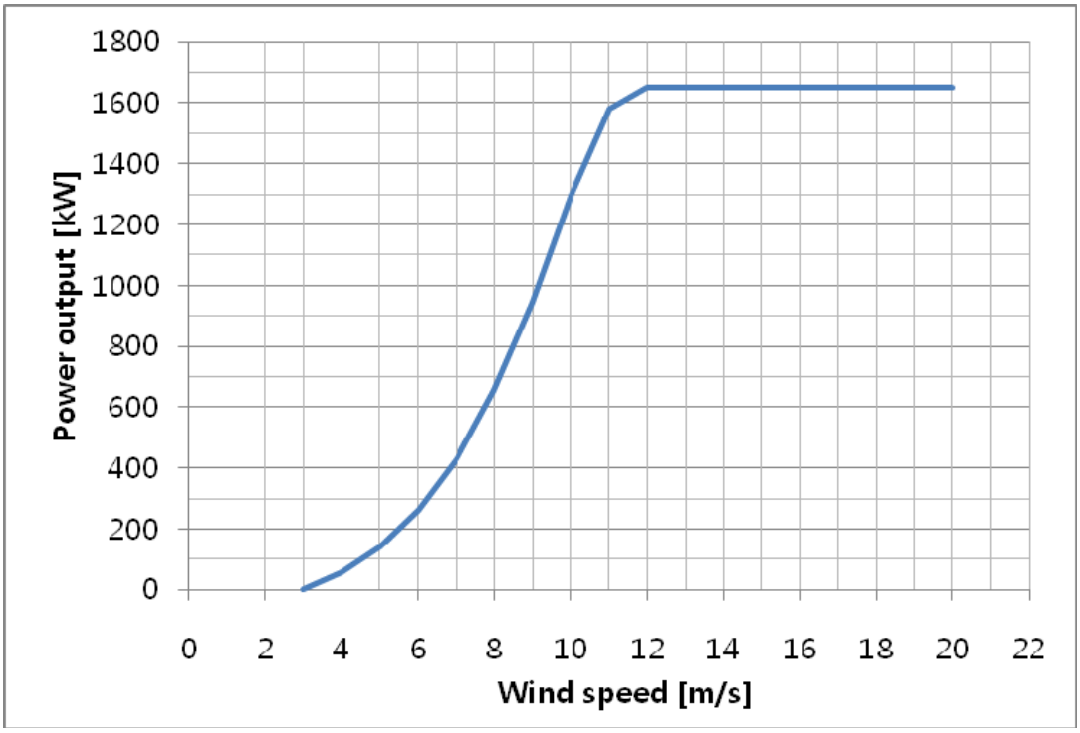
- Type of construction ..... closed
- Material ..... polyester, glass fiber

Tower

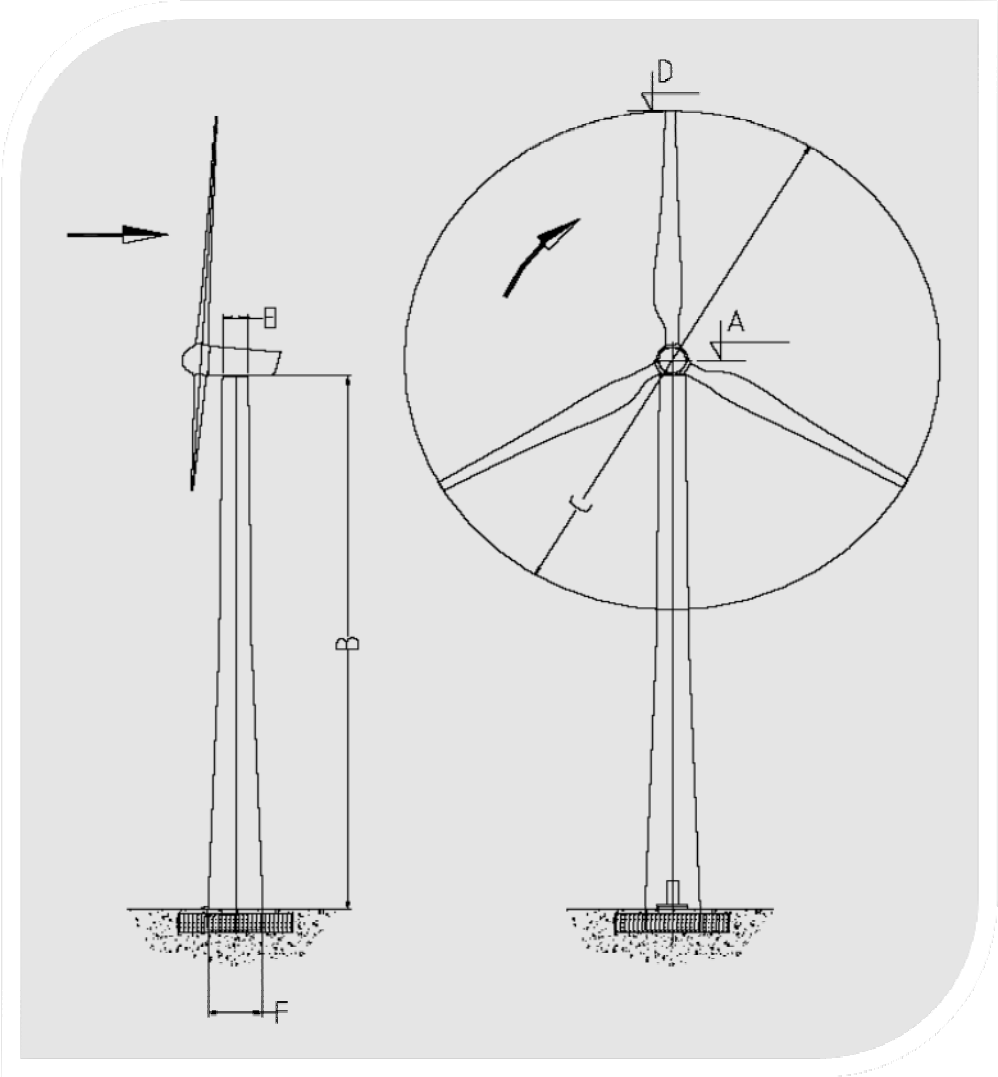
- Type of construction ..... conical tubular
- Hub height ..... 70 / 80 m
  (refer to wind condition in the site)
- Material ..... high tension steel
- Surface treatment ..... anti-corrosion painted
- Access condition ..... internal, ladder
  electric lift(option)

4. Calculated Power Curve

The power data presented in this document are based on simulation data. That is, the power data are calculated using model information of the wind turbine generator. Power curves are acquired by static calculations at an air density of 1.225 kg/m³.



5. Outline dimension



Dimensions [m]					
A	**B**	**C**	**D**	**E**	**F**
70 / 80	68 / 78	77	108 / 119	2.66	4.0

Assembled construction