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# Technical Documentation
# Wind Turbine Generator Systems
# Cypress 158 - 50/60Hz

# Technical Description and Data

Rev. 07 - Doc-0075288 - EN 2021-06-17

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# Table of Contents



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## Document Revision Table

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| Rev. | Date (YYYY/MM/DD) | Affected Pages | Change Description |
|---|---|---|---|
| 06 | 2020-08-10 | 7 | ADDED new HHs. |
| | | 11 | EDITED section 2.11. |
| | | 13 | ADDED Cypress 158m rotor the dimensional details in Section 4. |
| | | 14 | EDITED section 3.1. |
| | | 15 | MODIFIED section 4. |
| 07 | 2021-06-17 | 5, 10, 12 | ADDED information on 5.8/6.1 uprate |
| | | 8 | UPDATED Section 2.12 Nacelle |
| | | 5, 12, 13 | ADDED 117 m tower information |

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# 1 Introduction

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This document summarizes the technical description and specifications of the Cypress 158 wind turbine.

# 2 Technical Description of the Wind Turbine and Major Components

The Cypress -158 is a three-bladed, upwind, horizontal-axis wind turbine with a rotor diameter of 158 meters. The turbine rotor and nacelle are mounted on top of:

- a tubular steel tower with a hub height of 96 m
- a tubular steel tower with a hub height of 101 m (config supports 5.8/6.1 50/60 Hz)
- a tubular steel tower with a hub height of 107.4 m
- a tubular steel tower with a hub height of 117 m (config supports 5.8/6.1 60 Hz)
- a tubular steel tower with a hub height of 120.9 m (config supports 5.8/6.1 50 Hz)
- a tubular steel tower with a hub height of 125.4 m (config supports 5.8/6.1 60 Hz)
- a tubular steel tower with a hub height of 141 m
- a concrete hybrid tower with a hub height of 150 m
- a tubular steel tower with a hub height of 151 m
- a concrete hybrid tower with a hub height of 161 m

The Cypress 158 turbine, available with these ratings: 4.2/4.5/4.8/5.0/5.2/5.3/ 5.5/5.8/6.1 employs active yaw control (designed to steer the wind turbine with respect to the wind direction), active blade pitch control (to regulate turbine rotor speed) and a variable speed generator with a power electronic converter system.

The Cypress -158 turbine features a modular drive train design where the major drive train components, including main shaft bearing, gearbox, generator and yaw drives, are attached to a bedplate.

The increased ratings 5.8 and 6.1 are available for the listed configurations others may be added on demand.

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## 2.1 Rotor

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Rotor speed is regulated by a combination of blade pitch angle adjustment and generator/converter torque control. The rotor spins in a clockwise direction under normal operating conditions when viewed from an upwind location.

Full blade pitch angle range is approximately 90 degrees, with the zero degree position being with the blade flat to the prevailing wind. Pitching the blades to a full feather pitch angle of approximately 90 degrees accomplishes aerodynamic braking of the rotor, thus reduces the rotor speed.

## 2.2 Blades

There are three logistics optimized rotor blades used on the Cypress -158 wind turbine. Optional the blades can be equipped with Leading Edge Protection. Values below are typically needed to perform shadow casting calculations.

| | **Rotor Diameter** |
|---|---|
| | **158 m** |
| **Longest chord** | 4.0 m |
| **Chord at 0.9 x rotor radius** | 1.35 m |

In order to optimize noise emissions, the rotor blades are equipped with Low-Noise-Trailing-Edges (LNTEs) at the pressure side of the blade's rear edge. LNTEs are thin jagged plastic strips. The rotor blades of the Cypress -158 are equipped with these strips at the factory.

Fig. 1: LNTEs at the wind turbine rotor blade

### Blade Split

To ease transportation of blade, GE developed a solution using a split blade which has transportation requirements comparable to 137 m product. The two parts of the blade are connected using a mechanical connection which has been extensively tested.

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## 2.3 Blade Pitch Control System

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The rotor utilizes a pitch system to provide adjustment of the blade pitch angle during operation.

The active pitch controller enables the wind turbine rotor to regulate speed, when above rated wind speed, by allowing the blade to “spill” excess aerodynamic lift. Energy from wind gusts below rated wind speed is captured by allowing the rotor to speed up.

Independent back up is provided to drive each blade in order to feather the blades and shut down the wind turbine in the event of a grid line outage or other fault. By having all three blades outfitted with independent pitch systems, redundancy of individual blade aerodynamic braking capability is provided.

## 2.4 Hub

The hub is used to connect the three rotor blades to the turbine main shaft. The hub also houses the blade pitch system and is mounted directly to the main shaft. To carry out maintenance work, the hub can be entered through one of three hatches at the area close to the nacelle roof.

## 2.5 Gearbox

The gearbox in the wind turbine is designed to transmit torsional power between the low-rpm turbine rotor and high-rpm electric generator. The gearbox is a multi-stage planetary/helical design. The gearbox is mounted to the wind turbine bedplate. The gearbox mounting is designed to reduce vibration and noise transfer to the bedplate. The gearbox is lubricated by a forced, cooled lubrication system and a filter assist to maintain oil cleanliness.

## 2.6 Bearings

The blade pitch bearing is designed to allow the blade to pitch about a span-wise pitch axis. The inner race of the blade pitch bearing is outfitted with a blade drive gear that enables the blade to pitch.

The spherical roller main bearing supports and aligns the main shaft to the main gearbox and is absorbing radial and axial loads from the rotor.

## 2.7 Brake System

The blade pitch system acts as the main braking system for the wind turbine. Braking under normal operating conditions is accomplished by feathering the blades out of the wind. Only two feathered rotor blades are required to decelerate the rotor safely into idling mode, and each rotor blade has its own backup to drive the blade in the event of a grid line loss.

## 2.8 Generator

The generator is a doubly fed induction generator. It is mounted to the generator frame with a mounting designed to reduce vibration and noise transfer to machine.

## 2.9 Gearbox/Generator Coupling

To protect the drive train from excessive torque loads, a special coupling including a torque-limiting device is provided between the generator and gearbox output shaft.

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## 2.10 Yaw System

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A bearing positioned between the nacelle and tower facilitates yaw motion. Yaw drives mesh with the gear of the yaw bearing and steer the wind turbine to track the wind in yaw. The yaw drive system contains an automatic yaw brake. This brake engages when the yaw drive is not operating and prevents the yaw drives from being loaded due to turbulent wind conditions.

The controller activates the yaw drives to align the nacelle to the wind direction based on the wind vane sensor mounted on the top of the nacelle.

The wind turbine records nacelle yaw position following excessive rotation in one direction, the controller automatically brings the rotor to a complete stop, untwists the internal cables, and restarts the wind turbine.

## 2.11 Tower

The wind turbine is mounted on top of a tubular steel tower (or a hybrid tower). Access to the turbine is through a door at the base of the tower. Internal service platforms and interior lighting is included. A ladder provides access to the nacelle and also supports a fall arrest safety system.

Optional climb assist or service lifts are available upon request.

## 2.12 Nacelle

The nacelle houses the main components of the wind turbine generator. Access from the tower into the nacelle is through the bottom of the nacelle. The nacelle is ventilated and illuminated by electric lights. A hatch provides access to the blades and hub. The nacelle enclosure floor is designed to collect liquids (e.g. oil, grease) in cases of leakage with a safety factor of 1.5. Such capability has been proven by a test.

## 2.13 Wind Sensor and Lightning Rod

An ultrasonic wind sensor and lightning rod are mounted on top of the nacelle housing. Access is accomplished through the hatch in the nacelle.

## 2.14 Lightning Protection (according to IEC 61400-24 Level I)

The rotor blades are equipped with lightning receptors mounted in the blade. The turbine is grounded and shielded to protect against lightning; however, lightning is an unpredictable force of nature and it is possible that a lightning strike could damage various components notwithstanding the lightning protection employed in the wind turbine.

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## 2.15 Wind Turbine Control System

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The wind turbine can be controlled locally. Control signals can also be sent from a remote computer via a Supervisory Control and Data Acquisition System (SCADA), with local lockout capability provided at the turbine controller.

Service switches at the tower top prevent service personnel at the bottom of the tower from operating certain systems of the turbine while service personnel are in the nacelle. To override any wind turbine operation, emergency-stop buttons located in the tower base and in the nacelle can be activated to stop the turbine in the event of an emergency.

## 2.16 Power Converter

The wind turbine uses a power converter system that consists of a converter on the rotor side, a DC intermediate circuit, and a power inverter on the grid side.

The converter system consists of a power module and the associated electrical equipment.

## 2.17 Transformer and Medium Voltage Switch Gear

### Transformer

The 3 winding transformer is located at the rear of the nacelle. The transformer is a dry type transformer supporting medium voltage range of 10 - 33 kV range. The transformer is completely separated from the rest of machine head. The transformer is in GE scope, a pad mounted variant is not available.

### Medium Voltage Switchgear

The medium voltage switchgear is mounted in the tower entry area.

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# 3 Technical Data for the Cypress-158

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| Turbine | 4.2/4.5/4.8/5.0/5.2/5.3/5.5/5.8/6.1 158 |
|---|---|
| Rated output [MW] | 4.2/4.5/4.8/5.0/5.2/5.3/5.5/5.8/6.1 |
| Rotor diameter [m] | 158 |
| Number of blades | 3 |
| Swept area [$m^2$] | 19607 |
| Rotational direction (viewed from an upwind location) | Clockwise |
| Maximum speed of the blade tips [m/s] | 4.2-4.8MW 50Hz - 74.5 m/s<br>5.0-5.5MW 50Hz - 80.3 m/s<br>4.8-6.1MW 50Hz - 82.0 m/s<br>4.8-6.1MW 60Hz - 83.6 m/s |
| Orientation | Upwind |
| Speed regulation | Pitch control |
| Aerodynamic brake | Full feathering |
| Color of outer components | RAL 7035 (light grey) and<br>RAL 7023 (concrete grey, for concrete sections of hybrid tower only) |
| Reflection degree/Gloss degree Steel tower | 30 - 60 gloss units measured at 60° as per ISO 2813 |
| Reflection degree/Gloss degree Rotor blades, Nacelle, Hub | 60 - 80 gloss units measured at 60° as per ISO 2813 |
| Reflection degree/Gloss degree Hybrid Tower | Concrete gray (similar RAL 7023); gloss matte |

Table 1: Technical data Cypress-158 wind turbine

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| Atmospheric corrosion protection (corrosion categories as defined by ISO 12944 2:1998) | |
|---|---|
| Corrosion protection - Tower Shell Coating<br>internal/external | C-2/C-3 (standard)<br>C-4/C-5 (enhanced) |
| Corrosion protection - Tower Flange Bolts (TFB)<br>internal/external | C-4/C-4 (standard)<br>C-4/C-4 (enhanced) |
| Corrosion protection - Tower Mechanical Fasteners and internals<br>internal/external | C-3/C-3 (standard)<br>C-3/C-5 (enhanced) |
| Corrosion protection - Hub<br>internal/external | C-5/C-5 |
| Corrosion protection - Nacelle & Hub Fasteners<br>internal/external | C-3/C-5 |
| Corrosion protection - Automatic Lubrication System, Yaw Drive Bolts<br>internal | C-3 |
| Corrosion protection - Pitch Motor, Pitch Gearbox<br>internal | C-4 |
| Corrosion protection - Main Shaft, Pillow Block, Gearbox<br>internal | C-4 |
| Corrosion protection - Bedplate, Generator Frame<br>internal | C-5 |

Table 2: Atmospheric corrosion protection

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## 3.1 Operational Limits

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| Turbine | 4.2/4.5/4.8/5.0/5.2/5.3/5.5/5.8/6.1-158 |
|---|---|
| Hub height | 96 m tubular steel tower (only 50Hz)<br>101 m tubular steel tower (50/60Hz)<br>107.4 m tubular steel tower (only 60Hz)<br>117 m tubular steel tower (only 60Hz)<br>120.9 m tubular steel tower (only 50Hz)<br>125.4 m tubular steel (only 60Hz)<br>141 m tubular steel tower (only 50Hz)<br>150 m hybrid tower (only 50Hz)<br>151 tubular steel tower (only 50Hz)<br>161 m hybrid tower (only 50Hz) |
| Wind turbine design standard | * IEC 61400-1, Ed. 3<br>** DIBt 2012 |
| Height above sea level | Maximum 1000 m with the maximum standard operational temperature of up to +40 °C. Above 1000 m, the maximum operational temperature is reduced per DIN IEC 60034 1 (e.g., maximum operational temperature reduced up to +30 °C at 2000 m). For installations above 1000 m isolation distances of medium voltage terminals must also be re-evaluated. De-rated operation additionally driven by ambient temperature, power rating or specific grid requirements and conditions may occur. Details on these can be found in Hot Weather High Altitude. |
| Standard Weather Option (STW) | Operation from -15 °C up to +40 °C. De-rated operation driven by ambient temperature, power rating or specific grid requirements and conditions may occur. Details on these can be found in Hot Weather High Altitude and Grid Interconnection documentation.<br>Survival temperature of -20 °C to +50 °C without the grid.<br>Survival means turbine not in operation including the heat transfer system due to lack of energy supply by the grid. |
| Cold Weather Option (CW) | Operation from -15 °C up to +34 °C. De-rated operation driven by ambient temperature, power rating or specific grid requirements and conditions may occur. Details on these can be found in Hot Weather High Altitude and Grid Interconnection documentation.<br>Survive extreme temperature of -40 °C to +50 °C without the grid.<br>Survive means: turbine not in operation including the heat transfer system due to lack of energy supply by the grid. |
| Wind class | IEC S + WZ (S) |

Table 3: Operational limits

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## 3.2 Cypress Overview Drawing and Dimensions

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This document presents an overview of the relevant dimensions for the wind energy turbine with 158 m rotor diameter.

The table shown below fits to the GE drawing 450W1333.

| Description | | Dimension for hub height in [m] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 96 m (tubular steel tower) | 101 m (tubular steel tower) | 107.4 m (tubular steel tower 60Hz only) | 117m (tubular steel tower 60Hz only) | 120.9 m (tubular steel tower) | 125.4 m (tubular steel tower 60Hz only) | 141 m (tubular steel tower) | 150 m (hybrid tower) | 151 m (tubular steel tower) | 161 m (hybrid tower) |
| Hub height [m] | A2 | 96 | 101 | 107.4 | 117 | 120.9 | 125.4 | 141 | 150 | 151 | 161 |
| Total height [m] | A3 | 175 | 180 | 186.4 | 196 | 199.9 | 204.4 | 220 | 229 | 230 | 240 |
| Height upper daylight identification (only when required) [m] | A4 | - | 60 | 60 m | - | 60 | 60 m | 60 | 60 | - | 60 |
| Height lower daylight identification (only when required) [m] | A5 | - | 40 | 40 m | - | 40 | 40 m | 40 | 40 | - | 40 |
| Top of soil to top of foundation EU [m] | A6 | 1.3 | 1.3 | | - | 1.3 | | | 1.51 | | 1.31 |
| Top of soil to top of foundation Australia [m] | A6 | 0.2 | 0.2 | | - | 0.2 | | | - | | - |
| Top of soil to top of foundation Australia & North America [m] | A6 | 0.745 | 0.745 | 0.745 | 0.745 | - | 0.745 | - | - | | - |
| Height aviation light [m] | A7 | 100 ∓1 | 105 ∓1 | 111.7 ∓1 m | - | 125 ∓1 | 129 ∓1 m | 145 ∓1 | 154 ∓1 | | 165 ∓1 |
| Foundation diameter [m] | B2 | 22 | 22 | 20-25 m | 20-25 m | 25.8 | 20-25 m | 25.8 | 23.5 and 25 | | 23.5 and 25 |
| Distance aviation lights (only when required) [m] | C1 | | 52.5 ∓4 | 52.5 ∓4 m | - | 62.5 ∓4 | 62.5 ∓4 m | 72.5 ∓4 | 77 ∓4 | | 82.5 ∓4 |
| Tower bottom diameter [m] | C7 | 4.3 | 4.3 | 4.3 m | 4.56 | 4.3 | 4.3 m | 5.0 | 7.9 | 5.3 | 8.5 |

Table 4: Description


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| General information for all hub heights | | |
|---|---|---|
| **Description** | **Parameter** | **Dimension** |
| Rotor diameter | A1 | 158 m |
| Longest chord | A8 | 4.0 m |
| Chord at 90% rotor radius | A9 | 1.35 m |
| Aviation light spacing on machine head | B1 | Min 3.9 m |
| Blade tip distance in ideal position | C2 | 9.55 m |
| Blade tip distance in operation position | C3 | 5.55 m |
| Blade tip distance in ideal position | C4 | 20.48 m |
| Blade tip distance in operation position | C5 | 16.53 m |
| Tower top diameter | C6 | 3.7 m |
| Nacelle length | D1 | 12.8 m (max 14.3 m) |
| Distance from Yaw Bearing to Centre line crossing | D2 | 1.38 m |
| Aviation marking stripe width | D3 | 2 m |
| Nacelle height | D4 | 4.3 m (max 4.56 m) |
| Distance tower center - hub center | D5 | 4.17 m |
| Overhang | D6 | 4.18 m |
| Distance tower top - hub center | D7 | 1.92 m |
| Tilt drivetrain | D8 | 4° |
| Blade direction | D9 | 85° |
| Eccentricity area in idle | B3 | 20.562 $m^2$ |
| Eccentricity area in operation | B4 | 19.910 $m^2$ |

Table 5: General information for all hub heights

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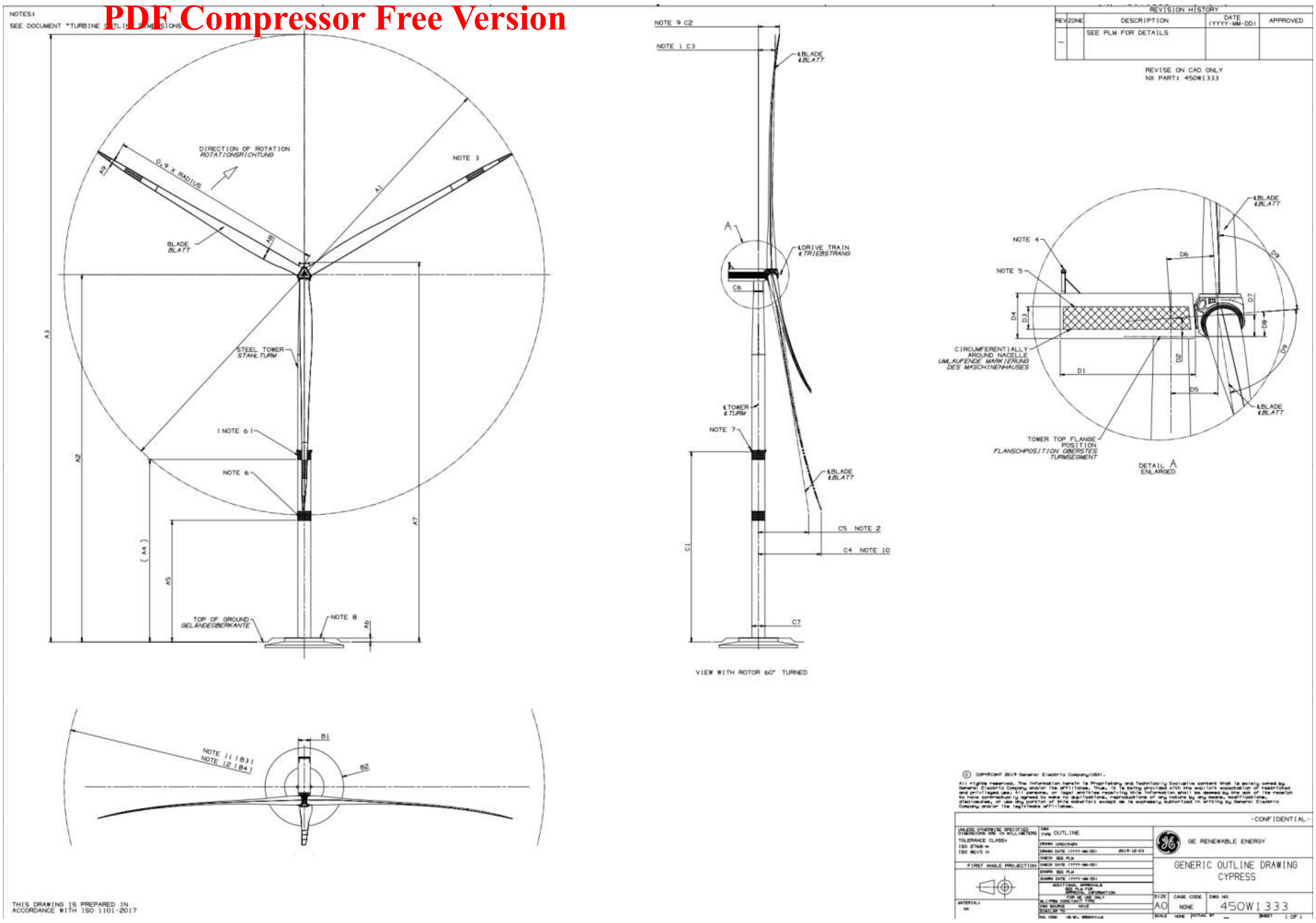


Figure 2: Generic outline drawing Cypress 450W1333

Please note that generic outline drawing 450W1333 is attached to this file as a separate document.


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