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BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

RAVE
Measurement Channels Description
AV04 Wind Turbine

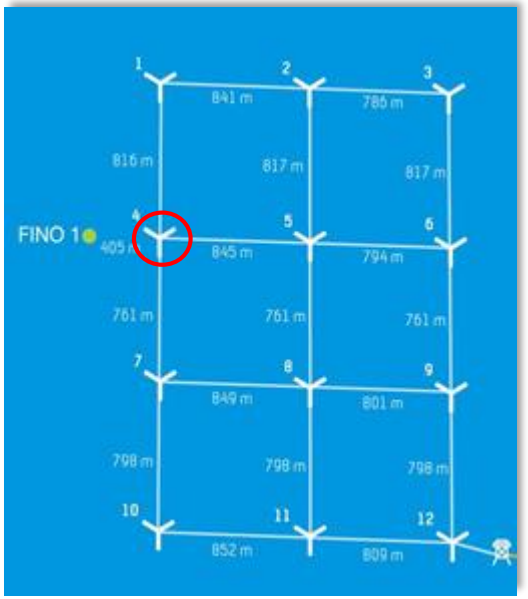
Period: from 2018-08-17 to …

CONTENT

- Introduction
- Coordinate system and reference points at tower
- Measurement channels
- Tower channels
- Hub-blade connection channels
- Nacelle channels
- Rotor shaft channels
- Jacket channels

INTRODUCTION

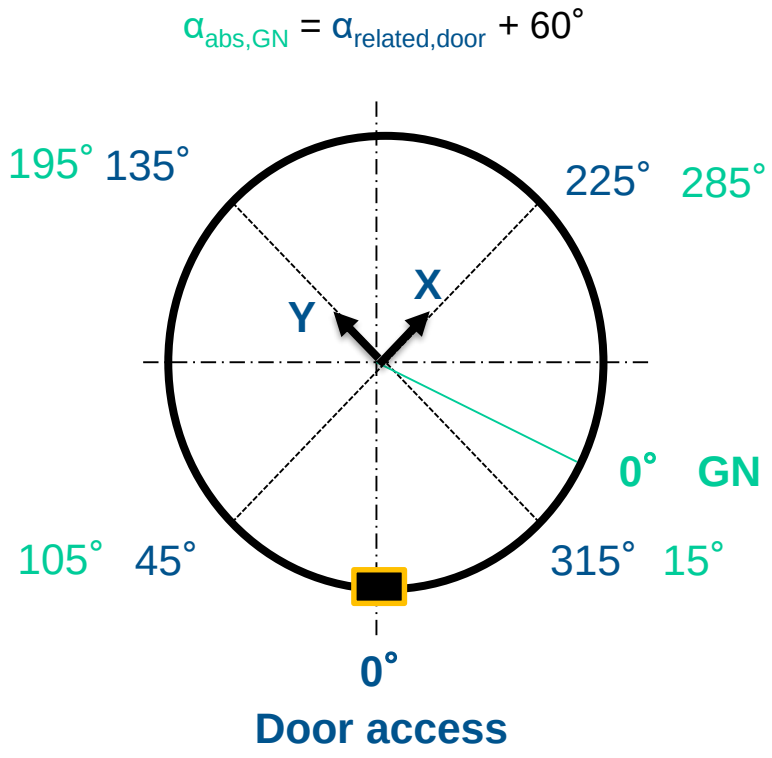
- In this presentation, you will find information about the measurement channel on the following parts of the AV04 Wind Turbine (WT):
  - Tower
  - Blades
  - Nacelle
  - Rotor shaft
  - Jacket
- Please refer to the attached excel file for further details about the sensors and its location.
- Mind the coordinate system presented in the next slide for the tower and in the attached sketches for the rest of the parts.
- The location of the AV04 WT in the Alpha Ventus Offshore wind farm is shown in the figure on the right.



COORDINATE SYSTEM AND REFERENCES TOWER (1/2)

The coordinate system of the measurements taken on the tower is presented on the figure on the right:

- The sensors were located considering the door access as the 0° coordinate. This coordinate system origin can be found in the sketches of the sensors.
- The Geographical North (GN) is shifted 60° from the door access. The measurement names and descriptions are based on this coordinate system.



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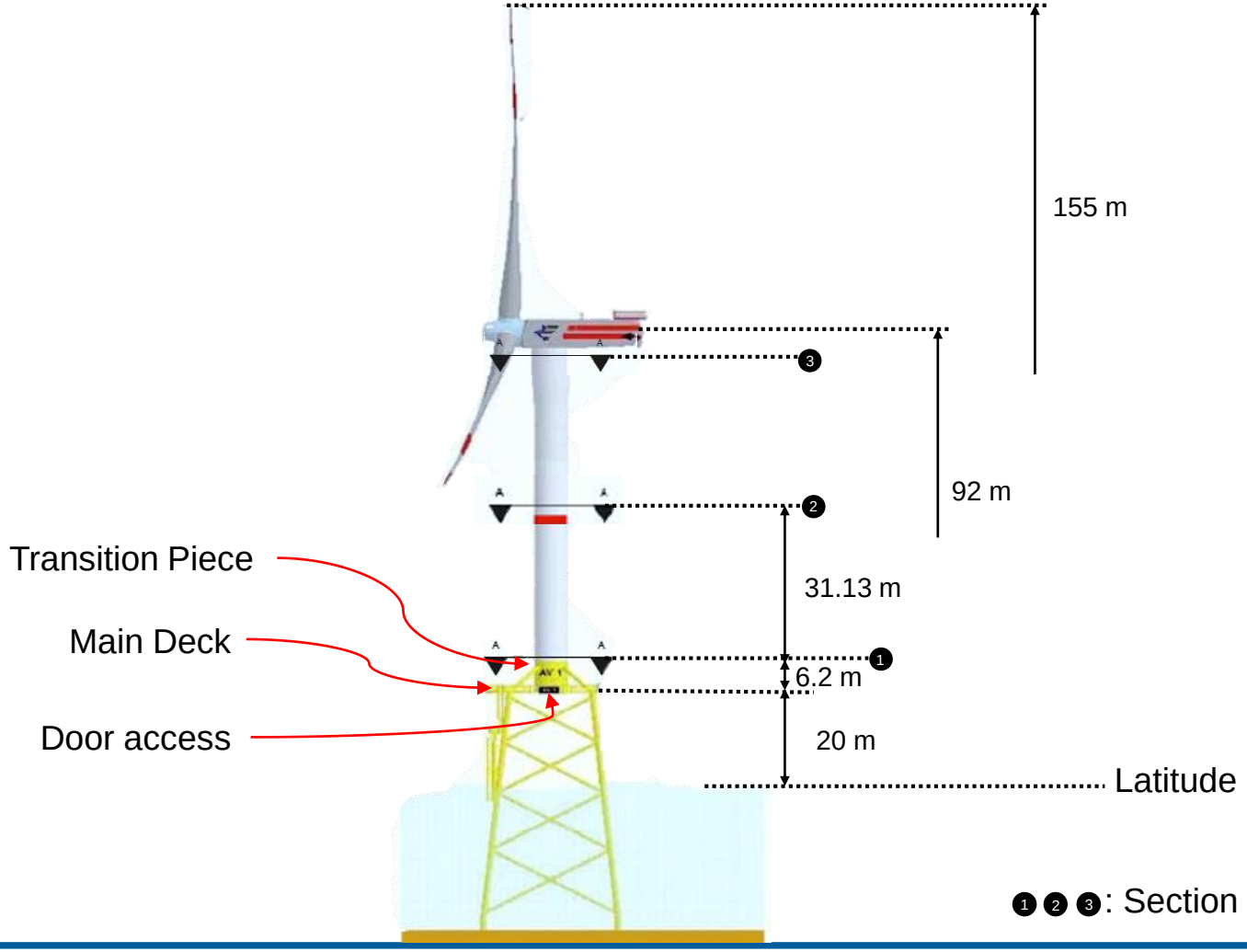
COORDINATE SYSTEM AND REFERENCES TOWER (2/2)



MEASUREMENT CHANNELS

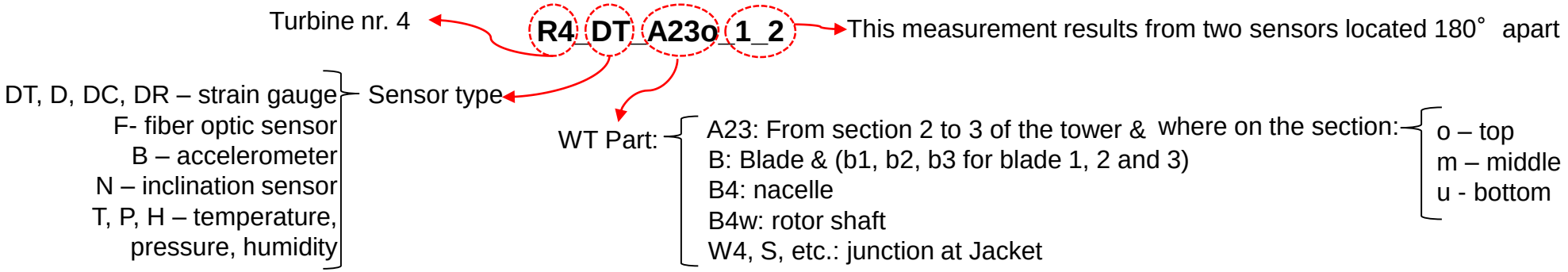
- The measurement channels are going to be presented by three aspects:

Channel Name | Description | Sensor Type

- The sensors are generally of the type:

Sensor Type	Description	Physical unit
DMS	Strain gauge	kNm
FOS	Fiber Optic Sensor	λ (wave length)
Environmental	Temperature, humidity, pressure	°C, %, hPa
Inclinometer	Inclination angle	°
Control	Various	rpm, °, kW, m/s
ICP	Accelerometer	m/s^2

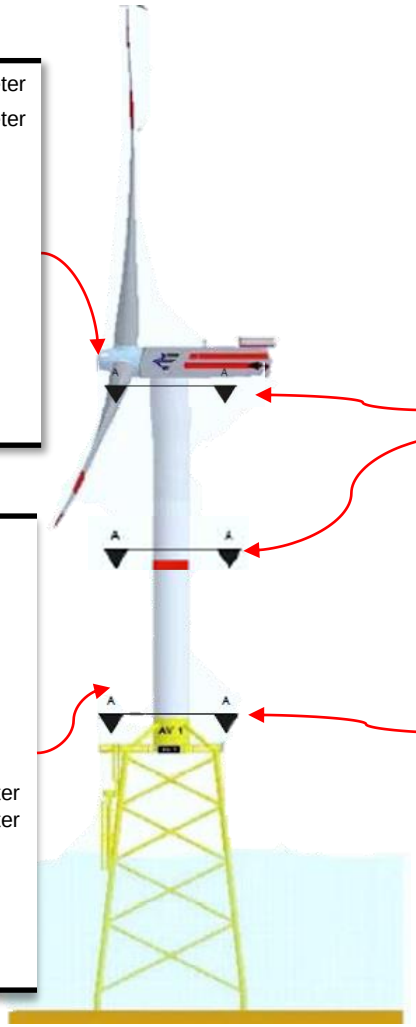
- A general rule to understand the measurement channels name with an example:



TOWER CHANNELS

R4_N-A23o(x)	Inclination angle x-direction (294° and 114°)	Inclinometer
R4_N-A23o(y)	Inclination angle y-direction (24° and 204°)	Inclinometer
R4_B-A23o(x)	Acceleration x-direction 105°	ICP
R4_B-A23m(y)	Acceleration y-direction 105°	ICP
R4_B-A23m(x)	Acceleration x-direction 105°	ICP
R4_B-A23o(y)	Acceleration y-direction 105°	ICP
R4_B-A23o(x)_135	Acceleration x-direction	ICP
R4_B-A23o(y)_135	Acceleration y-direction	ICP
R4_T_A23o	Temperature	
R4_P_A23o	Air-Pressure	
R4_H_A23o	Humidity	

R4_B-A12u(x)	Acceleration x-direction 105°	ICP
R4_B-A12u(y)	Acceleration y-direction 105°	ICP
R4_B-A12u(x)_135	Acceleration x-direction 135°	ICP
R4_B-A12u(y)_135	Acceleration y-direction 135°	ICP
R4_B-A12m(x)	Acceleration y-direction 105°	ICP
R4_B-A12m(y)	Acceleration y-direction 105°	ICP
R4_B-A12o(x)	Acceleration x-direction 105°	ICP
R4_B-A12o(y)	Acceleration y-direction 105°	ICP
R4_B-A12o(x)_135	Acceleration y-direction 135°	ICP
R4_B-A12o(y)_135	Acceleration y-direction 135°	ICP
R4_N-A12u(x)	Inclination angle x-direction (105° and 330°)	Inclinometer
R4_N-A12u(y)	Inclination angle y-direction (60° and 240°)	Inclinometer
R4_T_A12u	Temerature	
R4_P_A12u	Air-Pressure	
R4_H_A12u	Humidity	
R4_T_A12o	Temerature	
R4_P_A12o	Air-Pressure	
R4_H_A12o	Humidity	

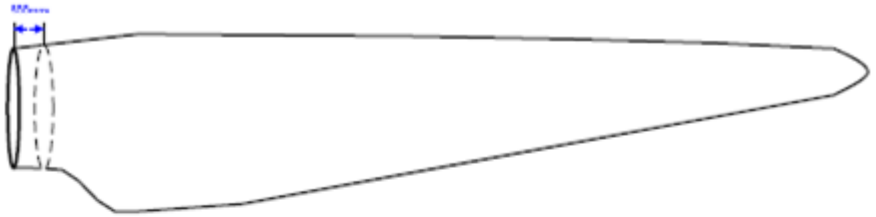


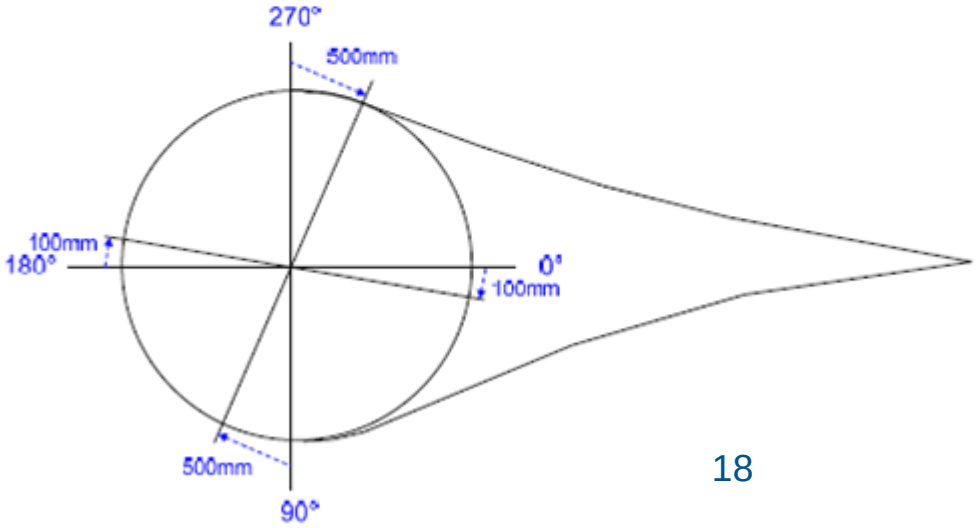
R4_DT_A23o_1_2	Tower Bending Moment (15° and 195°)	DMS
R4_DT_A23o_3_4	Tower Bending Moment (105° and 285°)	DMS
R4_DT-A23o2_1_2	Tower Bending Moment (0° and 180°)	DMS
R4_DT-A23o2_3_4	Tower Bending Moment (90° and 270°)	DMS
R4_DT-A23ot	Torsion (138° and 318°)	DMS
R4_F_A23o1_strain	Strain 105°	FOS
R4_F_A23o1_temp	Temperature 105°	FOS
R4_F_A23o2_strain	Strain 195°	FOS
R4_F_A23o2_temp	Temperature 195°	FOS
R4_F_A23o3_strain	Strain 285°	FOS
R4_F_A23o3_temp	Temperature 285°	FOS
R4_F_A23o4_strain	Strain 15°	FOS
R4_F_A23o4_temp	Temperature 15°	FOS

R4_D_A12o_1_2	Tower Bending Moment (105° and 285°)	DMS
R4_D_A12o_3_4	Tower Bending Moment (15° and 195°)	DMS
R4_F_A12o1_strain	Strain 105°	FOS
R4_F_A12o1_temp	Temperature 105°	FOS
R4_F_A12o2_strain	Strain 195°	FOS
R4_F_A12o2_temp	Temperature 195°	FOS
R4_F_A12o3_strain	Strain 285°	FOS
R4_F_A12o3_temp	Temperature 285°	FOS
R4_F_A12o4_strain	Strain 15°	FOS
R4_F_A12o4_temp	Temperature 15°	FOS

R4_DT_A12u_1_2	Tower Bending Moment (15° and 195°)	DMS
R4_DT_A12u_3_4	Tower Bending Moment (105° and 285°)	DMS
R4_DT_A12ut	Tower Torsion	DMS
R4_F_A12u1_strain	Strain 105°	FOS
R4_F_A12u1_temp	Temperature 105°	FOS
R4_F_A12u2_strain	Strain 195°	FOS
R4_F_A12u2_temp	Temperature 195°	FOS
R4_F_A12u3_strain	Strain 285°	FOS
R4_F_A12u3_temp	Temperature 285°	FOS
R4_F_A12u4_strain	Strain 15°	FOS
R4_F_A12u4_temp	Temperature 15°	FOS

HUB-BLADE CONNECTION CHANNELS





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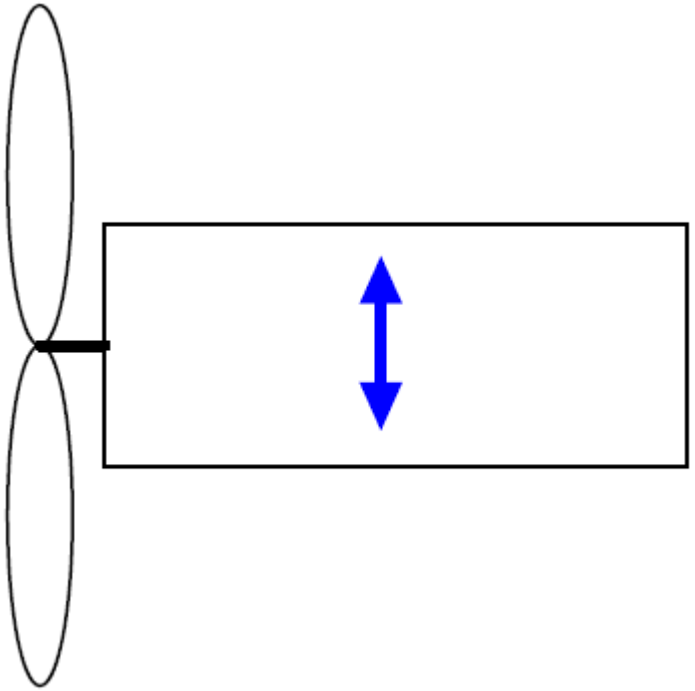
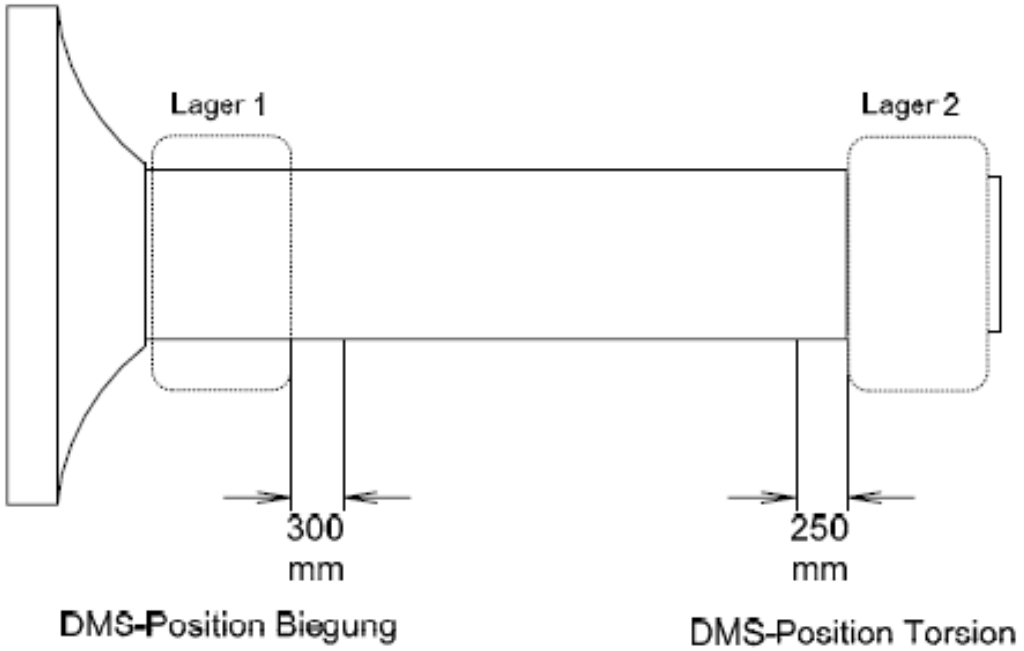
R4_D-B5b1a1	Blade1-Edgewise bending moment 0°	DMS
R4_D-B5b1a2	Blade1-Flapwise bending moment 90°	DMS
R4_D-B5b1_Edge_0	Blade1-Edgewise bending moment 0°	FOS
R4_D-B5b1_Flap_90	Blade1-Flpawise bending moment 90°	FOS
R4_D-B5b1_Edge_180	Blade1-Edgewise bending moment 180°	FOS
R4_D-B5b1_Flap_270	Blade1-Flpawise bending moment 270°	FOS
R4_D-B5b2_Edge_0	Blade2-Edgewise bending moment 0°	FOS
R4_D-B5b2_Flap_90	Blade2-Flpawise bending moment 90°	FOS
R4_D-B5b2_Edge_180	Blade2-Edgewise bending moment 180°	FOS
R4_D-B5b2_Flap_270	Blade2-Flpawise bending moment 270°	FOS
R4_D-B5b3_Edge_0	Blade3-Edgewise bending moment 0°	FOS
R4_D-B5b3_Flap_90	Blade3-Flpawise bending moment 90°	FOS
R4_D-B5b3_Edge_180	Blade3-Edgewise bending moment 180°	FOS
R4_D-B5b3_Flap_270	Blade3-Flpawise bending moment 270°	FOS
R4_D-B5b1_Temp_0	Temperatur_0_Grad	PT-100
R4_D-B5b1_Temp_90	Temperatur_90_Grad	PT-100
R4_D-B5b1_Temp_180	Temperatur_180_Grad	PT-100
R4_D-B5b1_Temp_270	Temperatur_270_Grad	PT-100

NACELLE CHANNELS



R4_B-B4(x)	Acceleration in x-direction	ICP
R4_B-B4(y)	Acceleration in y-direction	ICP
R4_B-B4(z)	Acceleration in z-direction	ICP
R4_Generatordrehzahl_B4_50Hz	Generator revolutions	Control
R4_Pitchwinkel_Ist_B4_50Hz	Pitch angle	Control
R4_elektrische_Leistung_B4_50Hz	Electrical power	Control
R4_Windgeschwindigkeit_B4_50Hz	Wind speed	Control
R4_T-B4_Ansaug-Entfeuchter	Air temperature (Lufttemperatur)	Temperature & Humidity sensor
R4_H-B4_Ansaug-Entfeuchter	Humidity (Luftfeuchtigkeit)	Temperature & Humidity sensor
R4_P-B4_Ansaug_Entfeuchter	Air Pressure	Barometer
R4_T-B4_Umgebung-Umrichter	Air temperature (Lufttemperatur)	Temperature & Humidity sensor
R4_H-B4_Umgebung-Umrichter	Relative humidity	Temperature & Humidity sensor
R4_P-B4_Umgebung-Umrichter	Absolute pressure	Barometer
R4_T-B4_Ansaug_Gondelkuehler	Air temperature (Lufttemperatur)	Temperature & Humidity sensor
R4_H-B4_Ansaug-Gondelkuehler	Relative humidity	Temperature & Humidity sensor
R4_P-B4_Ansaug_Gondelkuehler	Absolute pressure	Barometer
R4_Azimutwinkel_B4_50Hz	Azimut angle	Control
R4_T-B4_außen	Temperature outside nacelle	
R4_P-B4_außen	Airpressure outside nacelle	
R4_H-B4_außen	Humidity outside nacelle	

ROTOR SHAFT CHANNELS



R4_DT-B4w_1_2	Bending moment 0° and 180°	DMS
R4_DT-B4w_3_4	Bending moment 90° and 270°	DMS
R4_DT-B4wt	Torsion	DMS
R4_Rotorposition_B4	Angle	Inductive sensor

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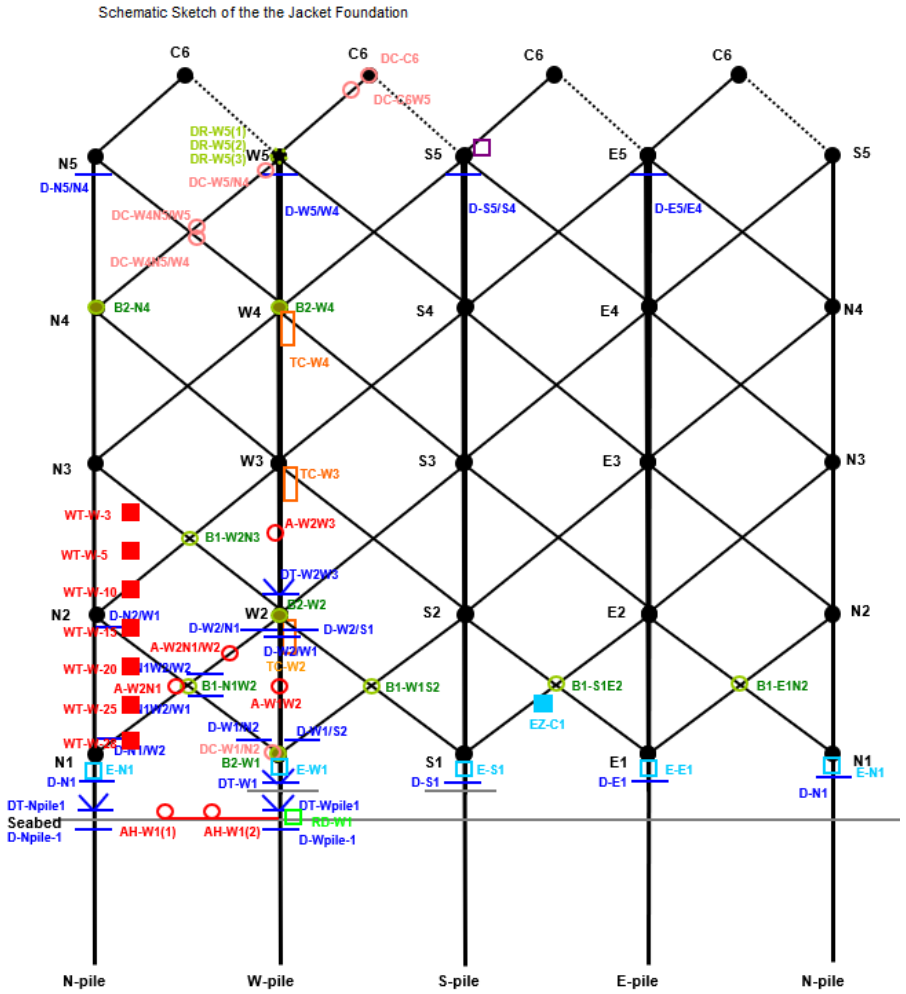
JACKET (AT HOTSPOT) CHANNELS



Symbols for Sensors
(Definition of Measurements)

- DT
- D
- B1
- B2
- DC
- DR
- TC
- A and AH
- RD
- E
- EZ
- WC/WL
- WT

R4_DC-W4N5/W5_3	Bending Moment	DMS
R4_DC-W4N5/W5_4	Bending Moment	DMS
R4_DC-W4N5/W5_5	Bending Moment	DMS
R4_DC-W4N5/W4_1	Bending Moment	DMS
R4_DC-W4N5/W4_2	Bending Moment	DMS
R4_DC-W4N5/W4_3	Bending Moment	DMS
R4_DC-C6_5	Bending Moment	DMS
R4_DR-W5(1)_1	Bending Moment 135°	DMS
R4_DR-W5(1)_2	Bending Moment 135°	DMS
R4_DR-W5(1)_3	Bending Moment 135°	DMS
R4_DR-W5(2)_1	Bending Moment 15°	DMS
R4_DR-W5(3)_1	Bending Moment 255°	DMS
R4_DR-W5(3)_2	Bending Moment 255°	DMS
R4_DR-W5(3)_3	Bending Moment 255°	DMS

R4_B-W4(x)	Acceleration x-direction	ICP
R4_B-W4(y)	Acceleration y-direction	ICP
R4_B-W2(x)	Acceleration x-direction	ICP
R4_B-W2(y)	Acceleration y-direction	ICP
R4_B-W1(x)	Acceleration x-direction	ICP
R4_B-W1(y)	Acceleration y-direction	ICP
R4_B-S1E2(x)	Acceleration x-direction	ICP
R4_B-N4(x)	Acceleration x-direction	ICP
R4_B-N4(y)	Acceleration y-direction	ICP