88/1001/CD

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IEC TC 88: WIND ENERGY GENERATION SYSTEMS	
SECRETARIAT:	SECRETARY:
Denmark	Mrs Christine Weibøl Bertelsen
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD:
CIS/H	☐
	Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☒ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY

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TITLE:

Wind energy generation systems – Part 40: Electromagnetic Compatibility (EMC) – Requirements and test methods

NOTE FROM TC/SC OFFICERS:

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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WIND ENERGY GENERATION SYSTEMS – Part 40: Electromagnetic compatibility (EMC) – Requirements and test method

FOREWORD

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International Standard IEC 61400-40 has been prepared by IEC technical committee 88: Wind energy generation systems.

The text of this International Standard is based on the following documents:

Enquiry draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The National Committees are requested to note that for this document the stability date is 20XX.

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

CONTENTS

INTRODUCTION

The purpose of this part of IEC 61400 is to provide the EMC requirements and test methods that are applicable to all the equipment within its scope.
The current document applies to measurements on individual wind turbines and not multiple turbines or wind power plants.

1 Scope

This part of IEC 61400 applies to all type of wind turbine plants.

This standard defines the requirements and test methods for the verification of the wind turbine performance against emissions and their immunity against conducted and radiated phenomena.

The requirements and test methods are defined for the wind turbine and all the sub systems.

Compliance with this standard is given if the single wind turbine complies with all clauses of the main body of this standard.

2 This standard is applicable to both wind turbine plants to be installed in offshore and onshore locations.Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CISPR 11: 2015/AMD1:2016, Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement.

IEC 61000-4-2:2008, Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test.

IEC 61000-4-3:2020, Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test.

IEC 61000-4-4:2012RLV, Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test.

IEC 61000-4-5:2014+AMD1:2017CSV, Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test.

IEC 61000-4-6:2023, Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields.

IEC 61000-4-8:2009 RLV, Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test.

IEC 61000-4-11:2020-COR 2022, Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests.

IEC61000-4-34:2005+AMD1:2009CSV, Electromagnetic compatibility (EMC) - Part 4-34: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with mains current more than 16 A per phase.

CISPR 16-2-3: 2016, Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-3: Methods of measurement of disturbances and immunity - Radiated disturbance measurements

IEC 61400-1: 2019, Wind turbines - Part 1: Design requirements

IEC 61400-2: 2013, Wind turbines - Part 2: Small wind turbines.

IEC 61400-24 ed.2, Wind turbines - Part 24: Lightning protection.

CISPR TR 16-2-5: 2008, Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-5: In situ measurements for disturbing emissions produced by physically large equipment

CISPR 16-4-2: 2011+amd:2014, Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-2: Uncertainties, statistics and limit modelling - Measurement instrumentation uncertainty

IEC 61400-21-1:2019, Wind energy generation systems - Part 21-1: Measurement and assessment of electrical characteristics – Wind turbines

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

For the purposes of this document, the terms and definitions are given in IEC 61400-1, IEC 61400-2 and CISPR 11.

4 Symbols and units

See IEC 61400-1, IEC 61400-2, CISPR11 and the other referenced standards.

5 Abbreviations

See IEC 61400-1, IEC 61400-2, CISPR11 and the other referenced standards.

6 Operating conditions during testing.

Operating conditions specific for this standard are included in the relevant clauses.

7 Emission requirements

7.1 General

The entire turbine shall comply with the requirements of this standard.
All subsystems shall fulfil the emission requirements of their product standard, product family standards or the relevant generic standard.

7.2 Conducted Emissions

Conducted emissions requirements do not apply for wind turbines.

7.3 Radiated Emissions

7.3.1 General

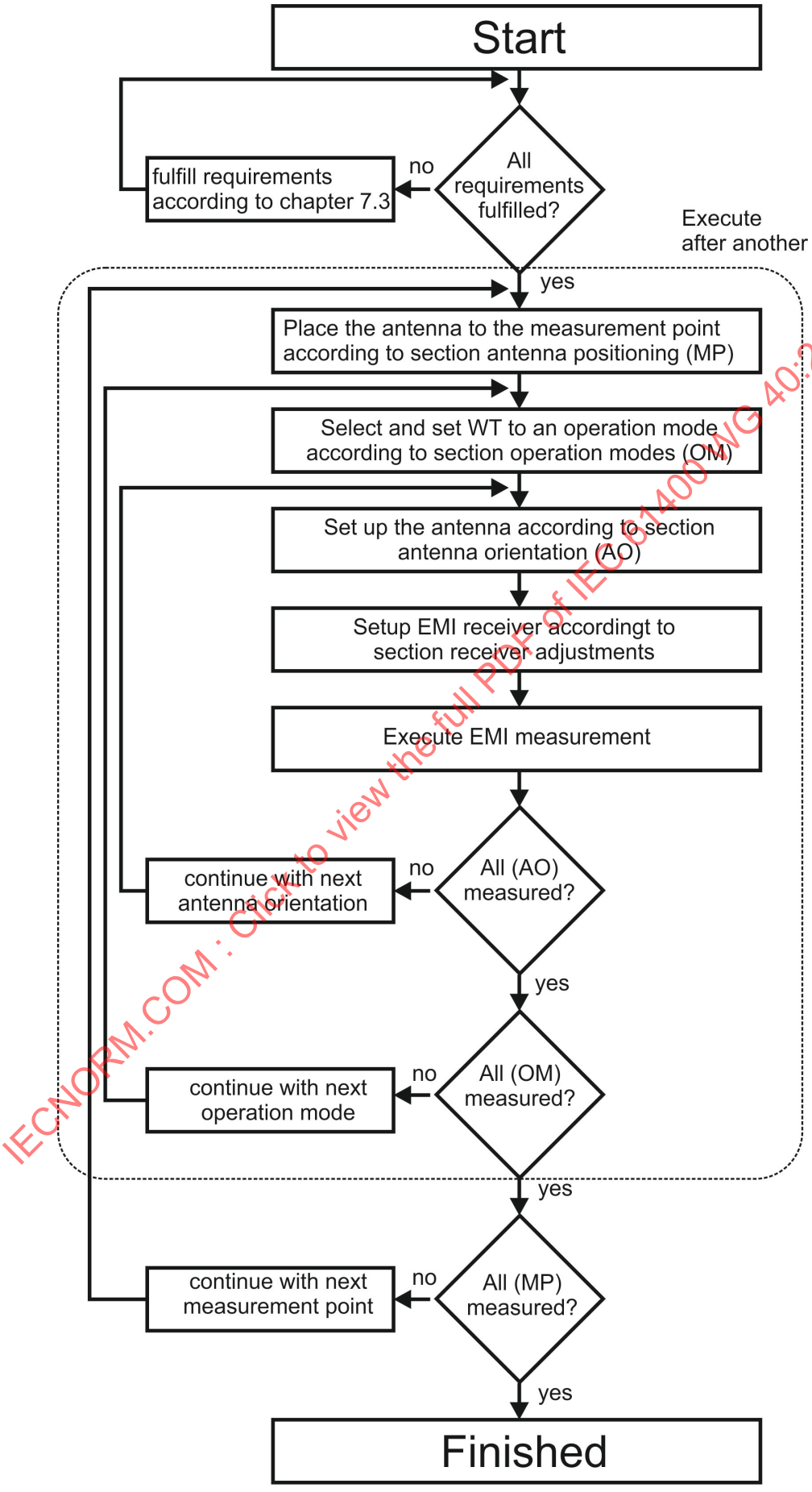
Due to continuous variation of wind speed and other external influences the emissions of wind turbines may vary during the measurements. Ambient signals and noise shall be distinguished from emissions of the wind turbine.

An overview of a recommended test sequence is given in Figure 1 and Table 1.

Description of Figure 1:

The measurements shall be executed under the following conditions:

- The antenna positions and orientations are given in subclause 7.3.7.
- The adjustments of the EMI-Receiver is given in clause 7.3.7
- The operation modes of the wind turbine are given in clause 7.3.8.
- To distinguish the emission of the wind turbine from prevailing ambient emissions, all measurements on one measurement point shall be executed in sequence in one (time) block. The assessment for ambient emission detection given in CISPR 16-2-3 Annex A4.3 to A5 shall be used.
- Discontinuous disturbances which occur sporadically shall be disregarded.
- All measurements can be repeated multiple times.



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97 **Figure 1: Flow chart of EMI measurement**

Id	Operating mode	Type of measurement	Frequency range	Antenna elevation	Antenna Polarization
1	Disconnected from the grid	Magnetic field	150 kHz-30 MHz	-	Radial
2	Disconnected from the grid	Electric field	30 MHz-1 GHz	Tower base	Vertical
3	Disconnected from the grid	Electric field	30 MHz-1 GHz	Tower base	Horizontal
4	Disconnected from the grid	Electric field	30 MHz-1 GHz	Nacelle	Vertical
5	Disconnected from the grid	Electric field	30 MHz-1 GHz	Nacelle	Horizontal
6	Standby mode	Magnetic field	150 kHz-30 MHz	-	Radial
7	Standby mode	Electric field	30 MHz-1 GHz	Tower base	Vertical
8	Standby mode	Electric field	30 MHz-1 GHz	Tower base	Horizontal
9	Standby mode	Electric field	30 MHz-1 GHz	Nacelle	Vertical
10	Standby mode	Electric field	30 MHz-1 GHz	Nacelle	Horizontal
11	Medium load operation	Magnetic field	150 kHz-30 MHz	-	Radial
12	Medium load operation	Electric field	30 MHz-1 GHz	Tower base	Vertical
13	Medium load operation	Electric field	30 MHz-1 GHz	Tower base	Horizontal
14	Medium load operation	Electric field	30 MHz-1 GHz	Nacelle	Vertical
15	Medium load operation	Electric field	30 MHz-1 GHz	Nacelle	Horizontal
16	Increased load operation	Magnetic field	150 kHz-30 MHz	-	Radial
17	Increased load operation	Electric field	30 MHz-1 GHz	Tower base	Vertical
18	Increased load operation	Electric field	30 MHz-1 GHz	Tower base	Horizontal
19	Increased load operation	Electric field	30 MHz-1 GHz	Nacelle	Vertical
20	Increased load operation	Electric field	30 MHz-1 GHz	Nacelle	Horizontal

Table 1: Summary of measurements for each measurement point

7.3.2 Measuring system

7.3.2.1 General

Antenna calibration at 10 m distance is acceptable for the testing.

7.3.2.2 Auxiliary measurement equipment

Auxiliary measurement equipment does not have to be calibrated as values are informative.

Note: Non-exhaustive list of equipment: distance meter, clock, compass, sensors of wind turbine data and sensor of meteorological data.

The sensor of meteorological data shall be placed in close vicinity from the selected measurement points.

7.3.3 Data recording

Recorded data shall show evidence of synchronisation or time referencing.

Operation data of the wind turbine that are helpful to replicate the measurement shall be recorded. At least the active power values shall be documented in the test report.

Other required operation data of the wind turbine shall be recorded at least in 10 min average values with a time stamp as defined in IEC 61400-1.

Radiated emissions levels which are measured shall be recorded and documented.

At least every 10 minutes, one set of meteorological data shall be recorded.

7.3.4 Requirements for the wind turbine

During the measurement the power output of the turbine should be controlled to get the operation modes according to subclause 7.3.8.

If such function is not available, the measurements shall be done while the required measurement conditions are reached by the available windspeed according to clause 7.3.8.

7.3.5 Requirements for the test site

For all the measurement points around the wind turbine, the site should be as flat and level as possible, easily accessible and free from obstacles in direction towards the wind turbine.

The foundation mound belongs to the wind turbine and not to the measuring environment.

Deviation from these requirements are possible and shall be documented.

7.3.6 Weather conditions

The weather conditions shall be free from precipitation, fog, upcoming thunder storms and higher elevated field strength conditions or significant weather changes.

7.3.7 Measurement setup

The measurement setup is defined by the following procedure:

Adjustments of the EMI-Receiver:

At least the following EMI Receiver settings shall be used:

- Quasi-Peak Detector
- Observation time for each frequency step is 1 full round of the rotor at medium load as defined in clause 7.3.8.
- 150kHz – 30MHz: Resolution bandwidth 9kHz
- 30MHz – 1000MHz: Resolution bandwidth 120kHz
- Stepsize of the EMI Receiver maximal half of resolution bandwidth

Antenna positioning

- The measurement positions shall be aligned with respect to the wind turbine hub, in four orthogonal directions, aligned with the 4 sides of the nacelle seen from the top (see Fig. 4).
- Measurements shall be performed in alignment and directed to the tower door (see Fig. 4). If the wind turbine has no door in the tower base, this measurement point does not apply. If there are any additional openings in the lower 30 m of the tower, it must be evaluated if these openings can cause additional emissions and additional measurement points shall be set.
- The horizontal distance between the outer boundary of the tower at ground level of the wind turbine and the reference point of the measurement antenna shall be 30 m with an accuracy of ±5%.
- Additionally, two more measurement positions shall be defined where no power supply cables are detected. Those two positions shall have a horizontal distance of 65 m and 100 m with an accuracy of ±5%.
- The measurement distances are defined as the horizontal distance from wind turbine, as a deviation from CISPR 11 Ed. 6 clause 10 in conjunction with CISPR TR 16-2-5 clause 6.1 explicitly for wind turbines.
- The measurement position in relation to the hub shall be noted into the test report. In case the wind turbine yaw angle varies more than ±15º at one measurement point, the measurement point shall be moved and the measurements of the last operation mode shall be repeated.
- For detection of underground power cables, the measurement position may be shifted by ±15º or by changing the measurement height. If a power cable was positively detected at a measurement position, those results shall be void and replaced by a new measurement at a position, which is at least 30° away from any existing valid measurement position.

If another electrical system is part of the EUT, such as an external transformer, other measurement positions are required. The orthogonal system of axes as described above, is copied and shifted so that the origin of the new axis systems are positioned on the additional electrical system (see figure 5 for orientation). A new measurement position is defined at a horizontal distance of 30 m from the system in the opposite direction to the wind turbine. The other measurement positions shall be adjusted to positions like shown in Figure 5. Two overlapping circles with a radius of 30 m, centred at the mid point of the wind turbine and the electrical system outside of the wind turbine, shall be used as shown in figure 5. The measurement points should be placed on the perimeter of the constructed overlapping circles with an accuracy of ±5% with respect to the measurement distance.
Note: In presence of radio systems at measurement site, like described in CISPR 11 clause 10, the procedure of CISPR 11 shall be taken in consideration.

178 **Measurement Antenna**

179 Because of the expected radiation pattern of a Wind Turbine, the antennas shall only be
180 positioned as described below.

181 • In the frequency range 150 kHz to 30 MHz an H-field antenna shall be used as referenced in
182 CISPR 11. The lowest point of the antenna shall be 1 m above ground. The antenna shall be
183 mounted in radial direction, so that a minimum of loop area is presented towards the surface
184 of the turbine. The configuration is shown in **Fig. 2**.

185 • In the frequency range 30 MHz to 1000 MHz an E-field antenna shall be used as referenced in
186 CISPR 11. The configuration is shown in **Fig. 3**.

187 • The elevation angle of the E-field antenna shall be zero degree for one measurement and
188 additionally being pointed towards the nacelle for another measurement as shown in Fig. 3.

189 • The distance between the lowest point of the E-field-antenna and the ground shall be 0.2 m or
190 more as described in CISPR11. Its centre point height shall be 2.0 m ±0.2 m and all
191 measurements shall be carried out in horizontal and vertical polarisation. This shall be
192 followed since a height scan is not practical for a Wind Turbine.

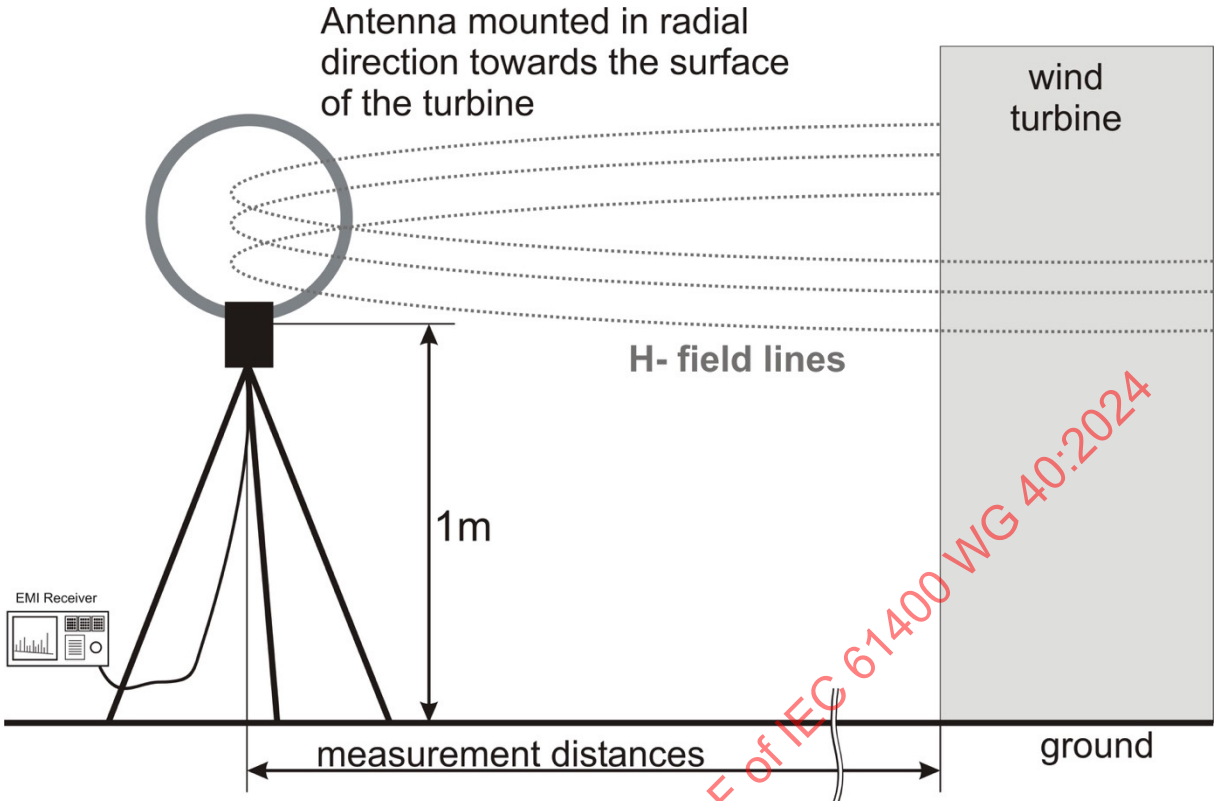


Fig. 2: **Example of a test setup of a magnetic field strength measurement**

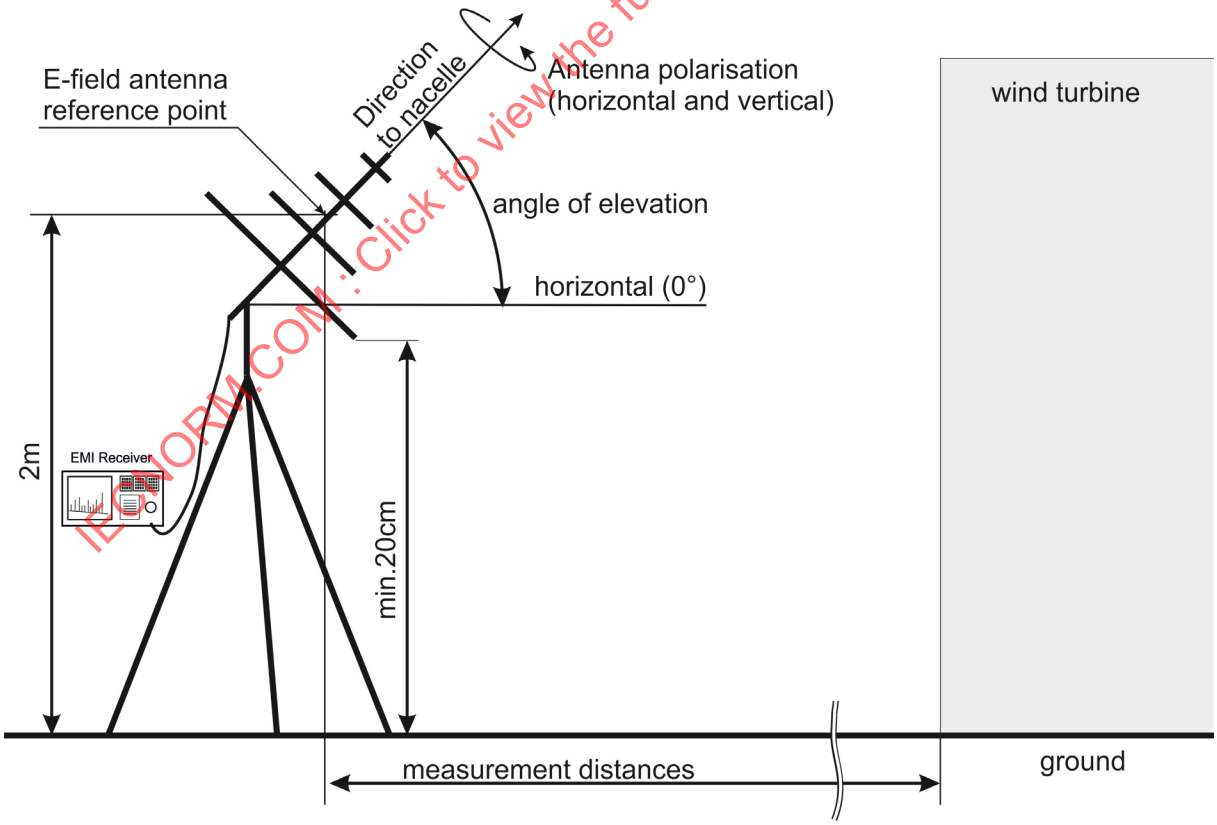
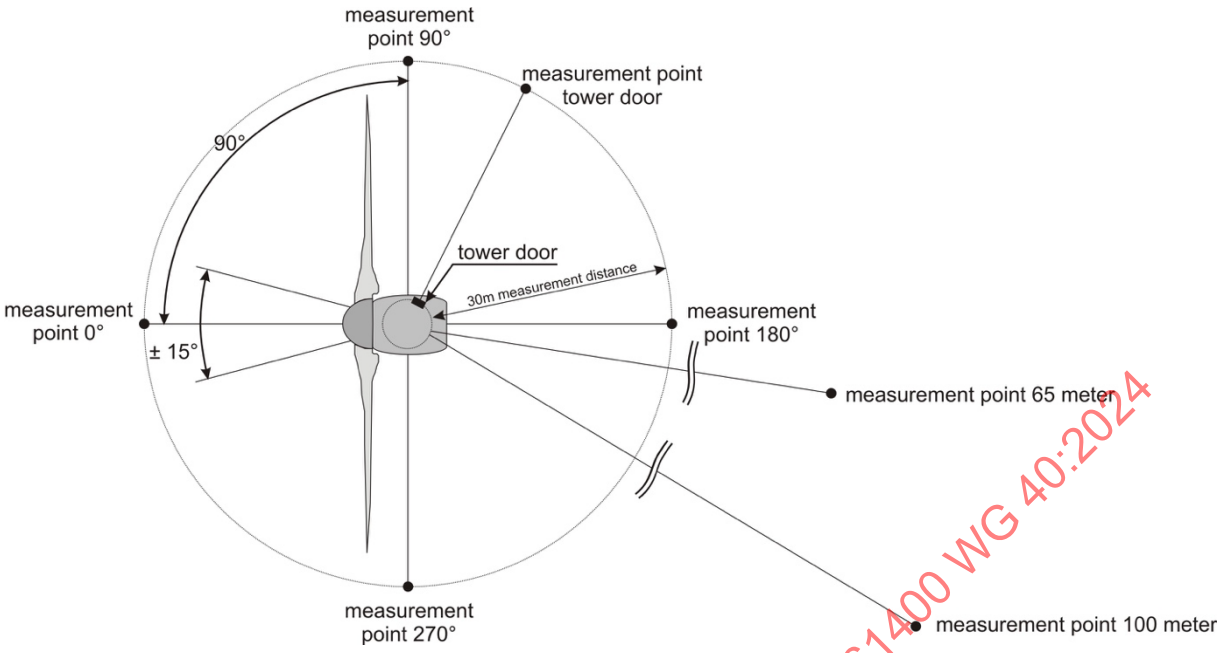


Fig. 3: **Example of a test setup of a electric field strength measurement**



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199 Fig. 4: **Example of a test configuration for an EMC measurement on a wind turbine.**
200 **Measurement points relative to the wind turbine hub.**
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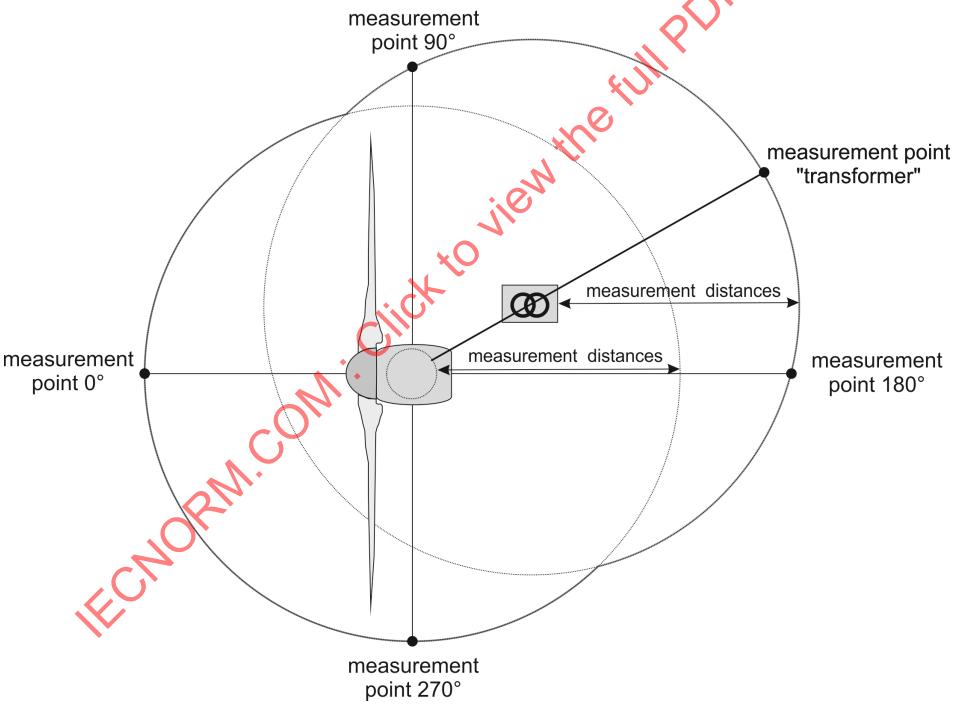

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204 Fig. 5: **Example of a test configuration with a transformer**

7.3.8 Description of the operating modes

In accordance with CISPR11 the wind turbine under test shall be measured under conditions at which the maximum interference emission occurs.

To capture the maximum interference emissions of the Wind Turbine it is sufficient to execute the measurements in the following operation modes of the wind turbine:

- Mode 1: Disconnected from the grid

  Equipment which is not allowed to switch off according to regulations and laws in the area of the measurement site shall not be disabled in this mode.

- Mode 2: Standby mode

  Standby mode should be declared and documented in the test report.

  Electric and electronic systems are energized, and the light shall be on. The power conversion system is inactive.

- Mode 3: Medium load operation

  The wind turbine shall produce active power in the range from 0% to 49% of rated power.

  Derating may be applied and shall be documented in the test report.

- Mode 4: Increased load operation

  The wind turbine shall produce active power in the range from 50% to 100% of rated power.

The internal light shall be off during medium load and increased load operation.

The Power of the Wind Turbine during the 2 ranges shall differ at least 20%.

These ranges are displayed graphically in **Fig. 6**.

7.3.9 Declaration of the worst case by the manufacturer

In established cases the worst case of radiated emission can be declared by the manufacturer. In this case only the background noise (wind turbine disconnected from the grid) and worst-case mode shall be measured.

Established cases require previous measurements and a documentation according to the requirements of this standard for determining the worst case of a wind turbine. If the worst-case condition shall also be applicable for other wind turbines, the documentation shall also contain the technical reasons for this.

The test report shall refer to the document where the worst case has been determined.

Note: At this moment there is, for determine the worst case for a wind turbine, no experience or any state of the art. So, it is now not possible to work with the worst case like this. When a determining procedure has been developed and validated it can be included in this standard and the worst case, determined according to it can be used for compliance of a wind turbine according to this standard.

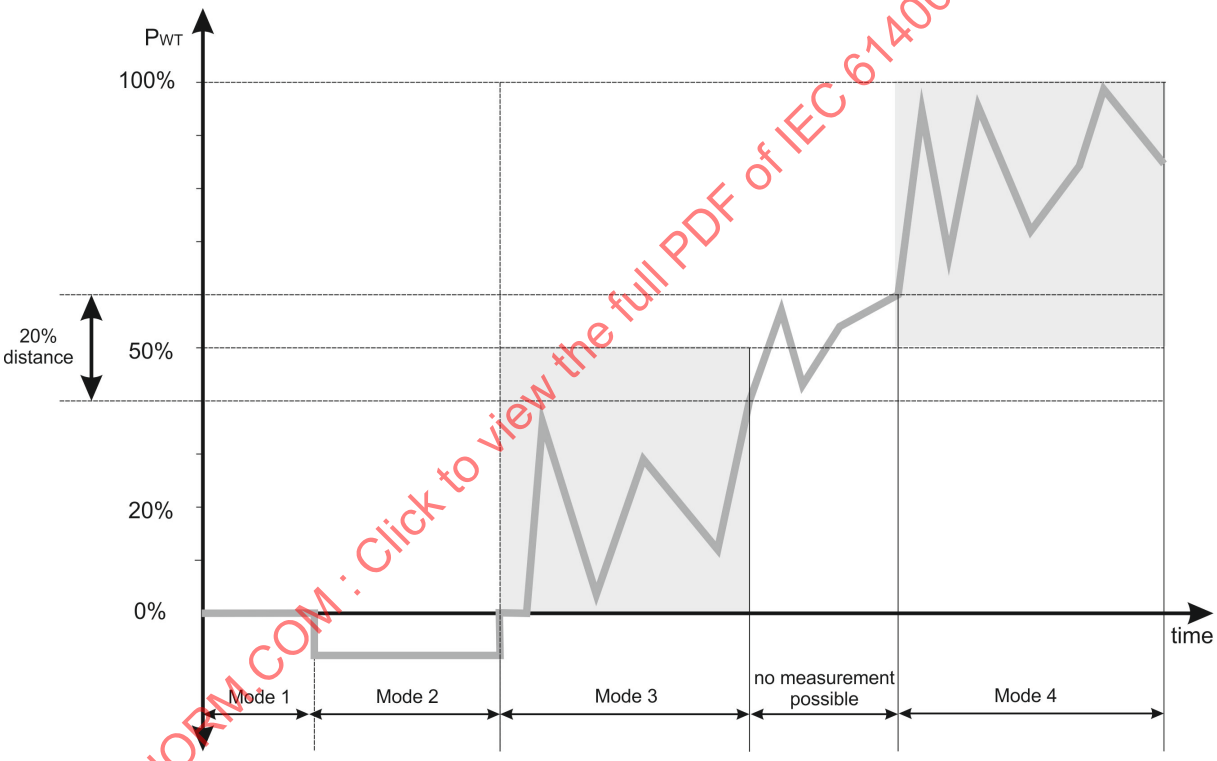

Fig. 6: **Overview of operating modes of a wind turbine**

7.3.10 Limit values

According to CISPR 11 classification the following allocation applies for wind turbines: group 1, class A. Therefore, for onshore wind turbines which are measured in situ, the limit values in Table 16 of the CISPR11 apply. The table in Annex C gives an extract from the CISPR11 with the limit values to be applied.

Correction factor for offshore wind turbines:

If offshore wind turbines are measured onshore the limits below 30 MHz are lowered by x dB. For the frequency range 30 MHz up to 1 GHz there is no limit correction.

Note: Official request to CISPR H is sent to give the correct correction factor for the measurement of offshore turbines onshore. (x dB)

Criteria for 65 and 100m measurements:

If compliance with the limits for the measurements at 65 and 100m is not possible because of wide band ambient noise levels at certain frequencies, alternative methods (e.g. change of location, time slot, additional pre amplifier) shall be considered. Only if no alternatives can be found with reasonable effort and the procedure of CISPR 16-2-3 annex A is not applicable, the measurements at 65 and 100 m do not need to be considered for the evaluation according to this standard. In this case all efforts to fulfil the required measurements shall be documented in detail (including spectra of the alternatives considered) in the test report.

7.3.11 Measurement uncertainty

The uncertainty of the measuring equipment shall be handled in accordance with the specifications of the CISPR 16-4-2.

The contribution of the uncertainty due to the site itself is excluded from the uncertainty calculation.

7.4 Harmonics, interharmonics and higher frequency components

The current emission of harmonics, interharmonics and higher frequency components of the wind turbine shall be measured and reported according to the respective procedure given in IEC 61400-21-1.

Note: Limits shall be in accordance with the local requirements of each country.

7.5 Flicker

The voltage fluctuations caused by the wind turbine during continuous operation and switching operations shall be measured and reported according to the respective procedure given in IEC 61400-21-1.

Note: Limits shall be in accordance with the local requirements of each country.

8 Immunity requirements

8.1 General

Immunity requirements are applicable for subsystems and not for the whole wind turbine.

Note: Detailed analyses might be necessary as a result of the EMC risk analyses.

8.2 Electrostatic Discharge

All components shall as minimum follow the requirements of IEC 61000-6-2. For the below described phenomena tests shall be carried out according to IEC 61000-4-2, test level 4 or X depending on the local EMC environment of the component placed in the wind turbine. Additional tests might be necessary which are not standardized.

Consideration should also be given to the operation of a wind turbine as a source of ESD. The blades of a wind turbine are able to charge electrostatically due to the air friction of the rotating rotor blades. This happens in all operation modes including standby. Weather conditions will also influence the level of electrostatic charge build up. If the earth connection of the blades or the hub is not adequate, an ESD impulse can occur from the hub to the nacelle. This impulse can disturb devices and systems in the nacelle and should be considered by testing for the effect of indirect discharges.

8.3 Immunity to radiated electromagnetic fields

Test method shall be in accordance with the IEC 61000-4-3 or alternative methods referenced in IEC 61000-6-2. Levels and requirements shall be in accordance with the IEC 61000-6-2.

8.4 Immunity to Burst EFT

Test method shall be in accordance with the IEC 61000-4-4. Levels and requirements shall be in accordance with the IEC 61000-6-2.

In case of elevated levels from the application (found by verification) the test levels shall be accordingly, or mitigations need to be implemented to reduce the levels from the application.

8.5 Surge tests

Test method shall be in accordance with the IEC 61000-4-5. Levels and requirements shall be in accordance with the IEC 61400-24 clause 8.5.3.

Note: Other waveforms and levels are to be expected inside and outside the wind turbine.

8.6 Conducted Immunity

The test method shall be in accordance with the IEC 61000-4-6. Levels and requirements shall be in accordance with the IEC 61000-6-2.

8.7 Immunity to power frequency magnetic field

The test method shall be in accordance with the IEC 61000-4-8. Levels and requirements shall be in accordance with the IEC 61000-6-2.
Detailed analyses might be necessary as a result of the EMC risk analyses.

A wind turbine generates power frequency electromagnetic fields, which shall be considered as phenomena for this standard.

The power frequency electromagnetic fields are identified as a continuous phenomena.

8.8 Voltage dips, short interruptions and voltage variations

The test method shall be in accordance with the IEC 61000-4-34 or 61000-4-11. Levels and requirements shall be in accordance with the IEC 61000-6-2.

9 Test results and test report

9.1. Emission measurements of the wind turbine

The test report for emission measurements shall include all information of this standard that is needed to reproduce the measurement:

Turbine:

- GPS coordinates of the wind turbine.
- Photo of the wind turbine.
- Active Power plot.
- YAW angle plot.
- Standy mode declaration
- Derating mode declaration at medium load operation.
- If available: Worst case operation mode declaration.
- Data of the identification of the wind turbine as described below in point “Machine parameters”.

Antenna orientation for each measurement point:

- Antenna position.
- Antenna orientation (H-Field).
- Antenna polarization (E-Field).
- Antenna elevation (E-Field).
- Minimum one representative photo of the H-Field and minimum one E-Field measurement.

Site description:

- Air humidity.
- Air temperature.
- Soil conditions (e.g. stony, sandy, mud, overgrown / dry, humid, wet).
- Weather conditions (e.g. sunny, cloudy, thundery, sporadically rainy, etc.).
- If applicable: Radio service antenna in the vicinity.
- If applicable: Reasons not to execute the measurements at 65 m and 100 m.
- If applicable: Photos and description of all obstacles higher than approx. 1 m in between the antenna and the wind turbine (e.g. mounds, trees, bushes, cargo containers, etc.).
- If applicable: Passive electrically conducting structures in the vicinity (e.g. metallic fences).
- If applicable: Active electrically conducting structures in the vicinity (e.g. electric fences).

Description of the test setup:

- Manufacturer of all measurement devices.
- Model of all measurement devices.
- Serial Number of all measurement devices.
- Calibration references of all measurement devices.

The following minimum information shall be provided and be included as an annex of the test report: