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UL RENEWABLES

Presentation GIZ17-132

Testing procedure for the evaluation of grid compliance of power generating units according to the requirements of the Indian Grid Code

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WHO WE ARE

- UL DEWI is one of the leading international performance, measurement, efficiency, research and education providers in the field of wind energy for at least 25 years.
- UL DEWI together with UL India Private Limited are Affiliates of Underwriters Laboratories LLC., USA, and work together to support renewable energy development in India.
- Since 1991, more than 350 power quality measurements worldwide
- UL provides comprehensive Low Voltage Ride Through (LVRT) and Overvoltage Ride Through testing & measurement services for wind, solar and combined heat and power systems
- ISO/IEC 17025 accreditation for measurements according to

International Standards/Guidelines

IEC 61400-21

IEEE 519

ENTSOE

MEASNET

National Guidelines/Procedures

VDE V 0124-100

FGW TR3 TR8

VDE AR N 4120

Spanish Guideline

Italy CEI 0-16, 0-21

CERTIFICATION PROCESS

A Testing of Electrical Characteristics of Wind/PV Stations

PQ Measurements

Testing laboratories accredited according to ISO / IEC 17025

- IEC 61400-21
- IEC 61000-4-7
- MEASNET Procedure
- National Guidelines

Internal validation

YES → Issue of Test Reports

NO → Changes in the electrical subsystem

B Certification and Licensing of Wind/PV Plants

Submission of PQ measurement reports to certification body

Compliance evaluation by the Certification Body

Certification Bodies accredited according to ISO/IEC 17065 (former EN 45011)

- EN 50160
- IEC series 61000 - 3
- IEEE Standard 519
- Special Requirements of National Codes

Submission of compliance certificate to System operator

Approval of the Unit-Plant for the specific PCC

YES → Next Step of the Licensing Procedure

NO → Rejection of the Specific Plant

CURRENT STATUS WORLDWIDE

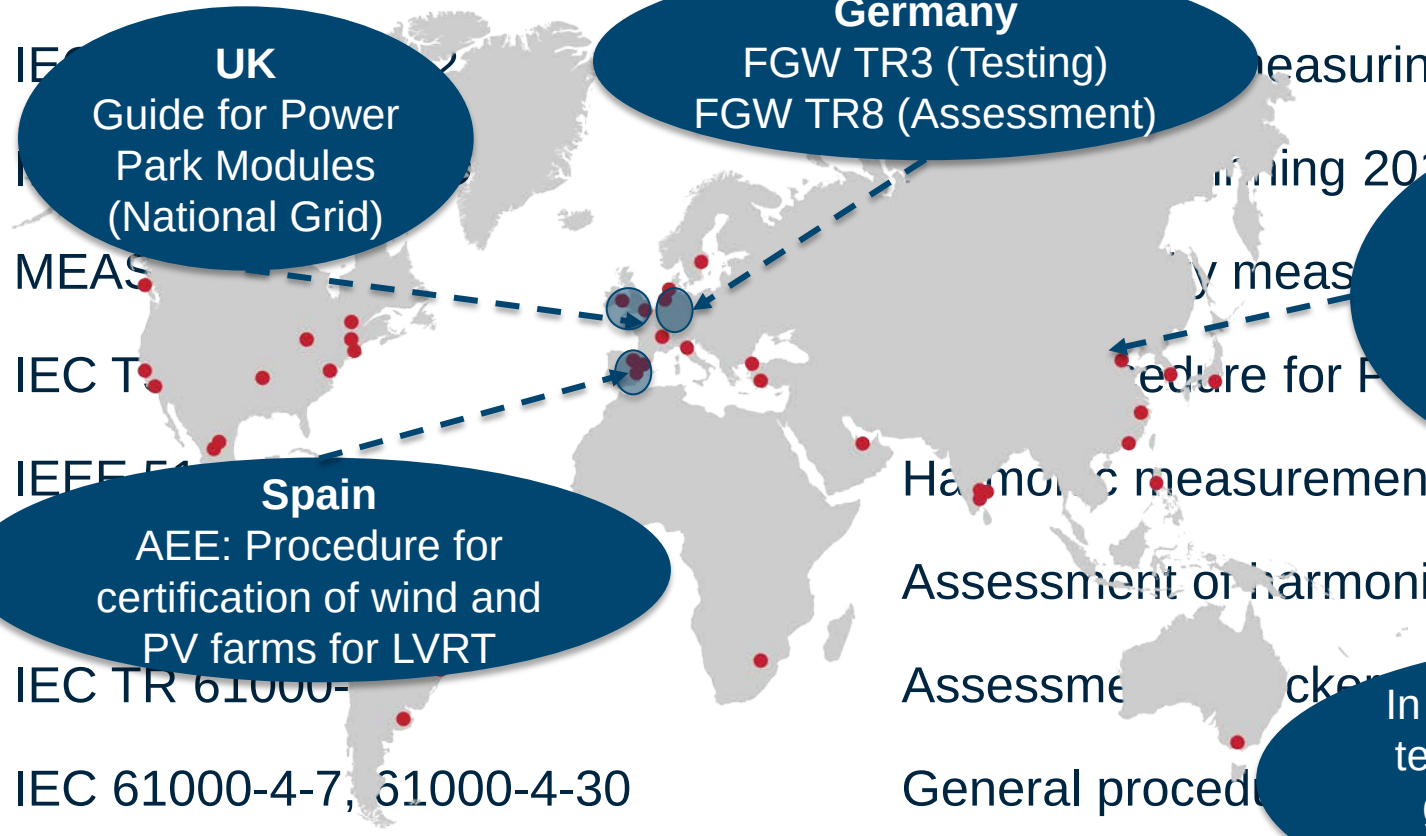
National Procedures/Guidelines

UK
Guide for Power Park Modules (National Grid)

Germany
FGW TR3 (Testing)
FGW TR8 (Assessment)

China
Chinese version of IEC 61400-21 and additional procedure for the acceptance of grid adaptability

Spain
AEE: Procedure for certification of wind and PV farms for LVRT



- IE… easuring wind turbine power quality parameters
- I… ning 201…
- MEAS… y meas… d turbines
- IEC T… edure for P…
- IEEE 5… Ha…c measurement and limits assessment of all types of units
- … Assessment of harmonic emission limits
- IEC TR 61000-… Assessme… cke…
- IEC 61000-4-7, 61000-4-30 General proced… for any type of equipment

In countries where no special testing procedure exists, the general rule is to use IEC 61400-21 as a guide

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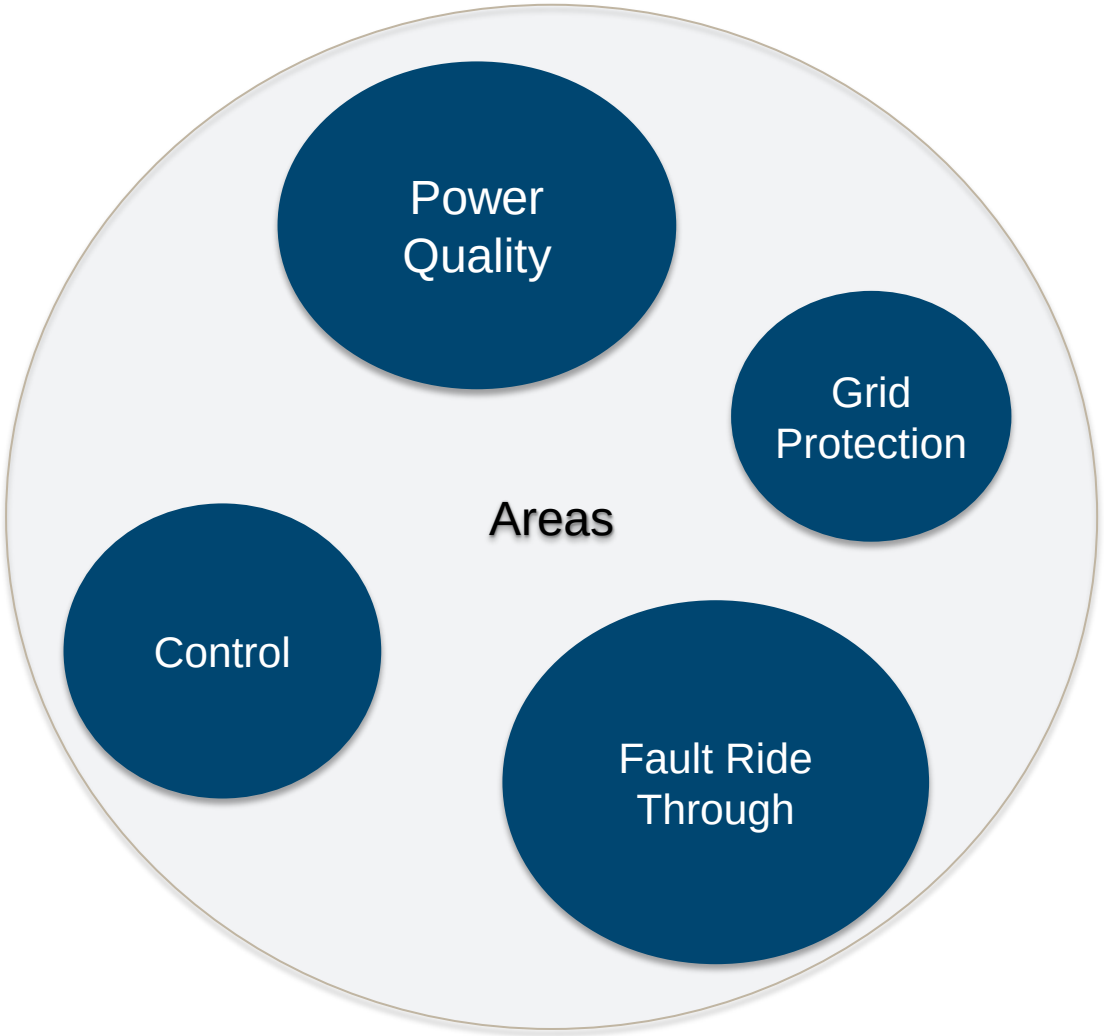
CENTRAL ELECTRICITY AUTHORITY REQUIREMENTS



Power Quality

- Harmonics acc. to IEEE 519
- Flicker acc. to IEC 61000 (TR 61000-3-7)
- DC current injection ≤ 0.5% of rated

Control

- Power factor within the limits of 0.95 lagging and 0.95 leading
- Operational frequency range between 47.5 and 52 Hz – Production of rated power with frequencies between 49.5 to 50.5 Hz
- Set-point control of active power

Fault Ride Through

- Remain connected
- Generate active power in proportion to the retained voltage
- Maximize reactive current

Grid protection

Reliable fault detection

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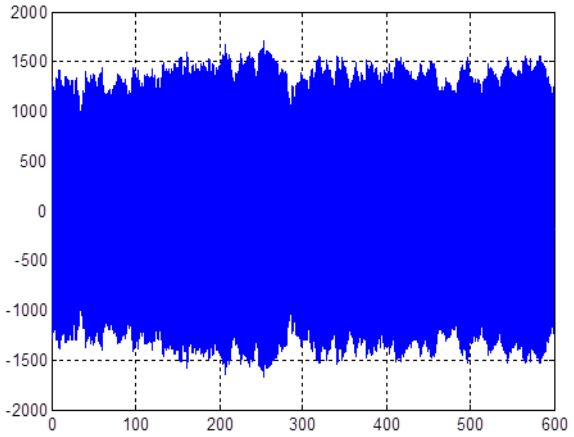
POWER QUALITY

Flicker

- Flickermeter according to IEC 61000-4-15
- According to IEC TR 61000-3-7, flicker shall be measured on long term basis (at least one week)
- Measurement and evaluation procedure and according to IEC 61400-21, Ed.2 is addressing the effect of the operating point and thus it is more suitable. According to this:

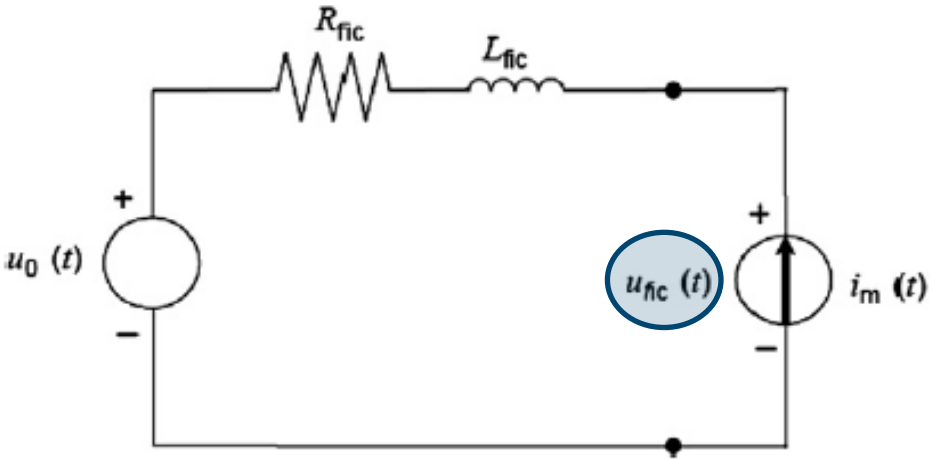
  At least fifteen 10 min time series of instantaneous voltage and current measurements shall be collected for each 1 m/s wind speed bin between cut-in wind speed and 15 m/s

STEP 1



Measurement of 10min WT Currents

STEP 2



Simulation of a fictitious grid and calculation of voltage flicker at the terminals of the tested unit for 4 different Grid Impedance Angles ψ_k =30, 50, 70, 85 deg

STEP 3

Statistical Analysis
99% percentile

Filling of Flicker Coefficient Table

Network impedance phase angle, ψ_k (deg.)	30	50	70	85
Annual average wind speed, v_a (m/s)	Flicker coefficient, $c(\psi_k, v_a)$			
6,0	3.0	3.7	4.3	4.5
7,5	3.1	3.7	4.4	4.6
8,5	3.1	3.8	4.4	4.6
10,0	3.1	3.8	4.5	4.7

POWER QUALITY

Flicker

- Changes in the new IEC 61400-21-1, CDV

  The wind turbine flicker coefficient for continuous operation, c(ψk) shall be stated as the **95th percentile** for the network impedance phase angles ψ_k = 30°, 50°, 70° and 85° in tables for operation of the wind turbine **within the active power bins 0, 10, 20, … , 100 % of Pn**. 0, 10, 20, … , 100 % are the bin midpoints. The measurements shall be based on **at least twenty-one**, 10 minutes for each data set.

Conclusions

- ✓ IEC 61400-21 is sufficient to cover CEA requirement

- ✓ New edition of IEC will facilitate measurement campaings because it will be not required to measure for wind speeds up to 15 m/s

POWER QUALITY

Standard harmonic measurements

- IEC 61400-21

  The values of individual current components (harmonics, interharmonics and higher frequency components) and the total harmonic current distortion (THC) shall be given in tables in percentage of nominal current and for operation of the wind turbine within the active power bins 0, 10, 20, …, 100% of Pn (bin midpoints) (Nominal Power).

- IEEE 519

  Measurement method is mainly oriented to loads operating at constant power and thus not convenient for fluctuating loads (like wind turbines or PVs).

Conclusions

✓ Measurement according to IEC 61400-21 and evaluation according to IEEE 519 is suggested

More details will be given in the special presentation for harmonics

POWER QUALITY

DC Current Injection

- Option 1

  the raw data derived from the standard harmonic measurements can be used for the evaluation of the zero-Hz component. This will be extracted through the Fast Fourier Transform (FFT) and can be averaged for example over 10 min, like in the normal IEC harmonic evaluations. In the final report, either the maximum or the 95th percentile for each power bin can be presented

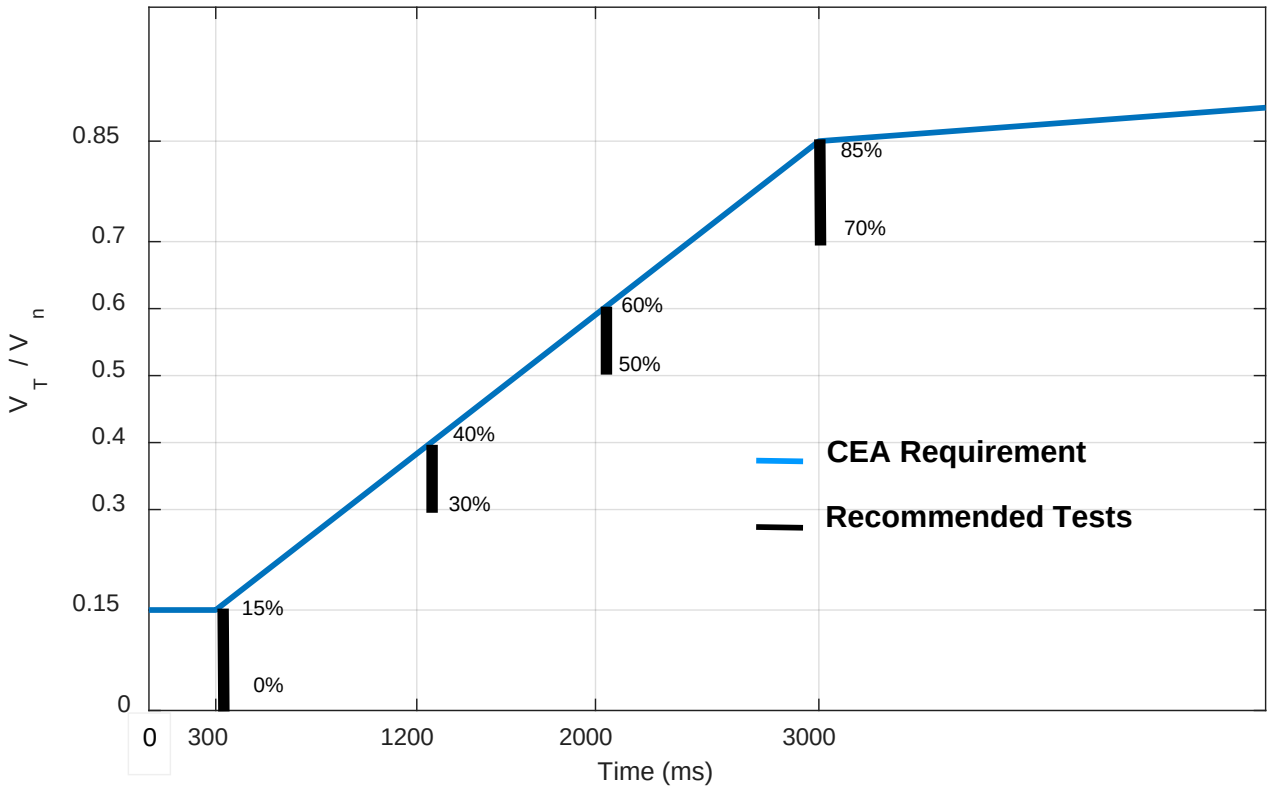
- Option 2

  According to IEEE standard 1547.1, measurement of harmonics for a 5-min period at three different power levels (33%, 66% and as close to 100% of Pn as possible) is foreseen and then calculation of the dc component. Use of set-point power is acceptable for this test.

Important Note

Current sensors used in either of these approaches should be capable of measuring the zero Hz component correctly

FAULT RIDE THROUGH TESTING

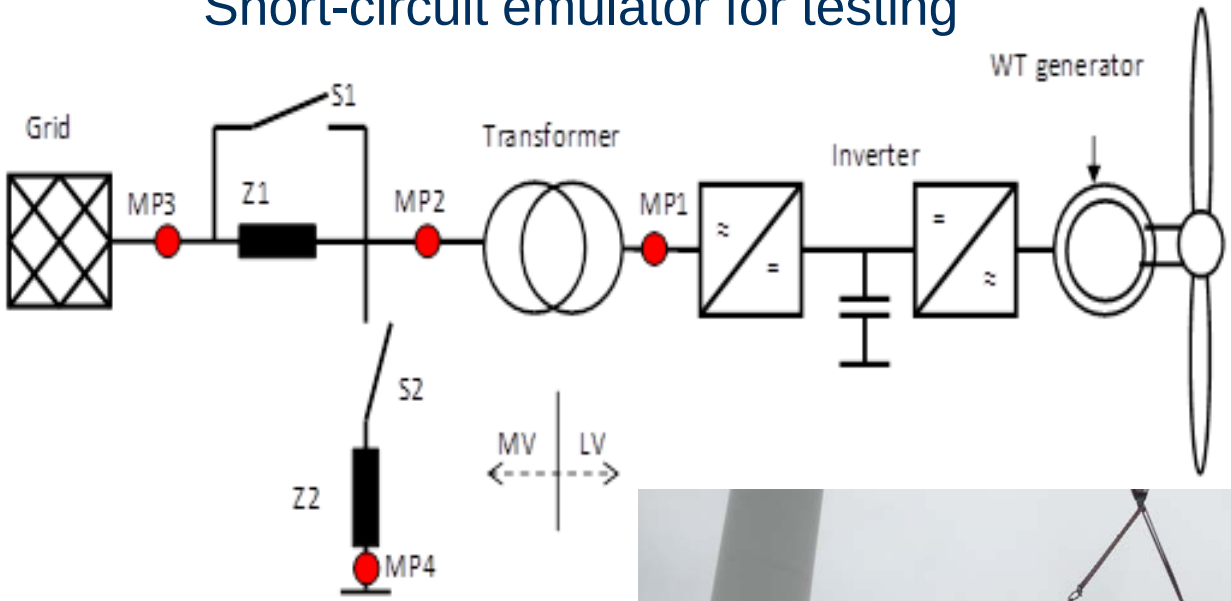


Testing procedure

- ➢ According to IEC 61400-21
- ➢ IEC TS 62910: LVRT procedure for PV inverters – This procedure is based on IEC 61400-21
- ✓ At least three different voltage levels to be tested
- ✓ The on-site test is performed on the complete unit
- ✓ A test bench test is permissible for PV units

FAULT RIDE THROUGH TESTING

Short-circuit emulator for testing



Testing procedure

- Two power levels
- Two and Three phase faults
- Single phase faults raise safety issues and are not recommended
- Two consecutive tests per case
- No load test for each fault type to be performed closely to the faults under load

CONTROL AND GRID PROTECTION

Control

- Based on the current CEA requirements, testing of set-point active power and reactive power capability are mandatory. However, it is recommended that the full scope of IEC 61400-21 is followed, especially considering the expected release of IEC 61400-21-1
- To test the sensitivity of reactive power on the voltage in the range of ±5% of Un increases the complexity of the testing procedure
- For the frequency range test, grid protection tests according to IEC 61400-21 should be requested as a minimum. Further functionality tests using a grid simulator can be also performed on a non-mandatory basis.

Grid protection

- The current procedure of IEC 61400-21 is sufficient, especially considering the improvements in the expected IEC 61400-21-1

SUMMARY OF THE SUGGESTED TESTS

No	Current CEA Requirement	Proposed test procedure	Covered by IEC 61400-21
1	Harmonics according to IEEE 519	Measurement according to IEC 61400-21 and evaluation according to IEEE 519	No
2	DC current > 0.5% of I_n	Evaluation with FFT transform and reporting according to IEC	No
3	Flicker according to IEC 61000	According to IEC 61400-21	Yes
4	Reactive power support	Reactive power capability according to IEC 61400-21	Yes
5	Operation within specific frequency range	- Grid protection test acc. to IEC - Use of grid simulator (optional)	Yes
6	Fault Ride Through Capability	Acc. to IEC 61400-21	Yes
7	Active power set-point control	Acc. to IEC 61400-21	Yes
8	Functionality of grid protection system	Acc. to IEC 61400-21	Yes

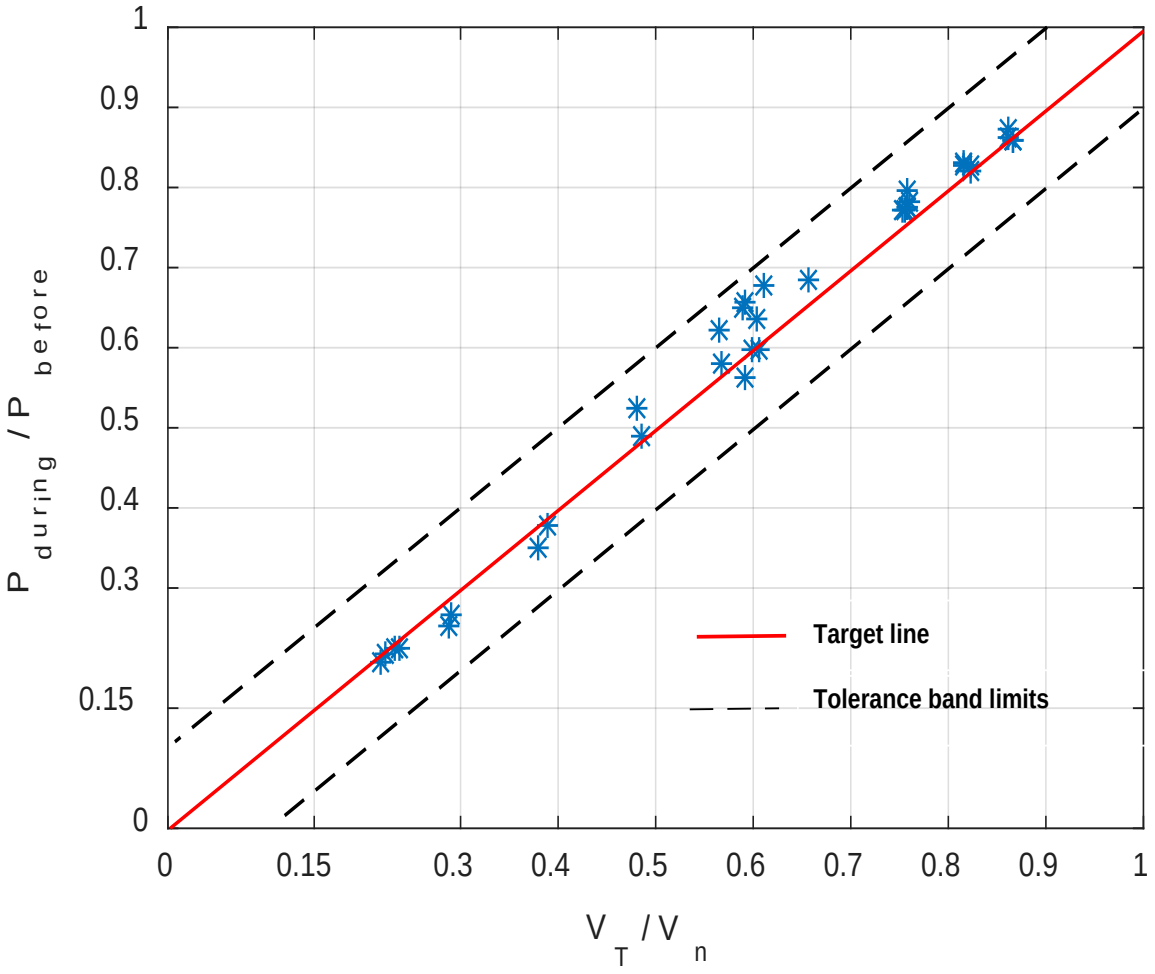
ASSESSMENT OF COMPLIANCE

Main requirements

- Testing has to be performed by laboratories accredited according to ISO/IEC 17025
- A full report according to IEC 61400-21 should be submitted for assessment to the Certification Bodies, including detailed results and graphs
- A special results table with the desirable parameters according to the requirements of the Indian Grid Code is necessary
- The tested unit should remain connected in the event of voltage dips for two consecutive tests
- Testing on single wind/PV units in terms of LVRT should be accepted

ASSESSMENT OF COMPLIANCE

Example of graphical representation of the results



Generation of active power during the dip

- Actual field measurements do not necessarily lie on the target line of 1:1 proportion between active power and voltage, as required by CEA. To facilitate certification phase, a tolerance band of 0.1 p.u. is proposed to be introduced and displayed together with the measurement results

CONCLUSIONS

1. Many countries with large renewable energy penetration have developed specific testing procedures to support compliance assessment with their grid codes

2. For most CEA requirements, the testing procedure of the IEC 61400-21 is sufficient. Special evaluation for harmonics is required according to IEEE 519

3. The proposed new amendement of the CEA Regulation is also covered by the IEC, especially the new edition IEC 61400-21-1, CDV

4. Uniform reporting requirements are suggested to ensure comparability for the Certification process

5. Testing needs to be performed by accreddited laboratories to ensure same level of quality

THANK YOU!

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