

# Training Content

## Harmonics Analysis

### DAY 1

#### MODULE 1: Introduction into Harmonics

##### **Presentation: Introduction into Harmonics Calculation**

1/2 h

Principles of harmonic analysis. Harmonic sources and their impact on a power system. Harmonic Analysis Tools in *PowerFactory*.

#### MODULE 2: Assessment of Harmonics

##### **Presentation: Introduction into Harmonics Calculation**

1 h

Definition of harmonic sources in a test network. Assessment of voltage distortion. Verification of distortion limits. Harmonic currents. Bar and distortion diagrams. Waveform plots.

Modelling of balanced and unbalanced spectrums. Source models in *PowerFactory*.

Calculation options in the Harmonic Load Flow. Power quality indices like HD and THD. Result analysis with harmonic distortion diagrams considering harmonic distortion limits (IEC, IEEE, etc.) and waveform plots.

#### Coffee break

##### **Exercise: Assessment of Harmonic Distortion**

1 1/2 h

Definition of harmonic sources in a test network. Assessment of voltage distortion and verification of distortion limits.

Analysis of harmonic currents and the impact of different sources in the network. Analysis of balanced and unbalanced operation of a twelve pulse system.

#### Q&A session

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### DAY 2

#### MODULE 3: Impedance Frequency Sweep

##### **Presentation: Frequency Dependency of the Network Impedance**

1 1/2 h

Definition of self and mutual impedance. Impact of resonances on the network impedance.

Frequency response of relevant network components: Cable and overhead lines, network equivalent impedance, loads, transformers.

User defined frequency characteristics.

## Coffee break

### Exercise: Frequency Sweep

1 1/2 h

Determining the frequency dependency of the network impedance with the frequency sweep tool in *PowerFactory*: handling, results, calculation options.

Assessment of series and parallel resonances with impedance plots over frequency and build-in tabular reports. Self and mutual network impedances.

Determine the n-1 impedance with the contingency analysis (optional)

## Q&A session

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## DAY 3

### Recapitulation of Harmonic Load Flow and Impedance Frequency Sweep

1/2 h

## MODULE 4: Harmonic Filters

### Presentation: Harmonic Filters

1 h

Overview of harmonic filters: single-tuned band pass filter, damped high pass filter, C-type filter. Design criteria and filter reports.

## Coffee break

### Exercise: Filter Design

1 1/2 h

Filter sizing for grid connection compliance. Layout and design parameters. Verification of filter ratings. Filter design and layout report.

Verify filter design for n-1 contingency cases (optional).

Active filter design (optional).

## Q&A session

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## DAY 4

## MODULE 5: Harmonics Assessment according to IEC 61000-3-6

### Harmonics Assessment acc. to IEC 61000-3-6

1/2 h

Harmonic load flow calculation according to IEC 61000-3-6. Integer harmonics and non-integer harmonics (interharmonics). Summation laws for harmonics in networks with multiple sources.

### Exercise: Harmonics Assessment of a Wind Farm with IEC-Sources

1 h

Comparison of Harmonic load flow results of IEC sources and sources with unbalanced spectrum.

Assessment of harmonic voltage distortion under different network conditions.  
Analysis of multiple Study Cases using Task Automation.  
Filter design for all network conditions (optional).

### Coffee break

## MODULE 6: Flicker Assessment according to IEC 61400-21

**Presentation: Flicker Assessment acc. to IEC 61400-21** 1/2 h

Introduction into flicker and their calculation in *PowerFactory*. Short and long term flicker severity for continuous and switching operation including voltage change.

**Exercise: Flicker Assessment of a Wind Farm** 1 h

Definition of Flicker Coefficients and assignment to wind generators. Calculation of Flicker severity level of a wind farm acc. to IEC 61400-21.

### Q&A session

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## DAY 5

## MODULE 7: Envelope Curve of the Network Impedance

**Presentation: Envelope Curve of the Network Impedance** 1/2 h

Simplified representation of the network impedance by an envelope curve to model the first parallel resonance of the network. This is an approach of IEC 61000-3-6.

**Exercise: Envelope Curve** 1 h

Definition of the frequency characteristic of a network harmonic impedance. Application of this approach to model the envelope curve of the network impedance.

### Coffee break

## MODULE 8: Network Impedance Loci

**Presentation: Network Impedance Loci** 1/2 h

Consideration of possible network behaviour in the frequency domain with respect to resistance and reactance of the network impedance for various system states using impedance loci.

**Exercise: Impedance Loci** 1 h

Verification of power quality compliance under consideration of network impedance loci for various frequency ranges.

### Q&A session

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## Time Schedule (Central European Time)

Half-Day	Time
First 90 minutes block	9:00
Coffee break	10:30
Second 90 minutes block	10:45
Q&A session	12:15
End of the training day	12:30



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