

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 Balanced Harmonic Distortion

1 1/2 h

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

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

Q&A session

DAY 2

Exercise: Assessment of Unbalanced Harmonic Distortion

3/4 h

Definition of unbalanced harmonic sources in a test network.

Analysis of the differences of using a balanced or unbalanced network representation for the harmonic load flow.

MODULE 3: Impedance Frequency Sweep

Presentation: Frequency Dependency of the Network Impedance

3/4 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 Part 1

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.

Q&A session

DAY 3

Exercise: Frequency Sweep Part 2

3/4 h

Repetition of the result presentation and modeling for the frequency sweep.

Investigating the self and mutual network impedance's using the frequency sweep.

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

MODULE 4: Harmonic Filters

Presentation: Harmonic Filters

3/4 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

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.

Definition of operational dependent harmonic sources.

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

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: Background Harmonics and Envelope Curve

1 h

Adding background harmonics based on measured values to *PowerFactory*.

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

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

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



DIGSILENT GmbH
Heinrich-Hertz-Str. 9
72810 Gomaringen
Germany

T +49 7072 9186-0
F +49 7072 9168-88
mail@digsilent.de

www.digsilent.de