



Opportunities for updating the power quality standards following the large scale availability of synchronized measurements

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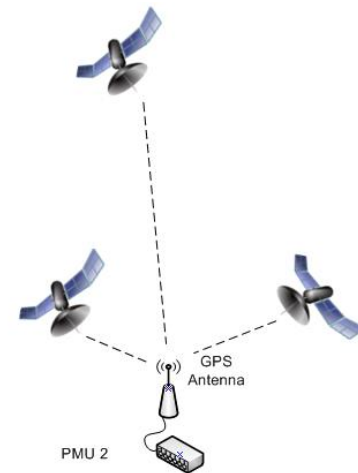
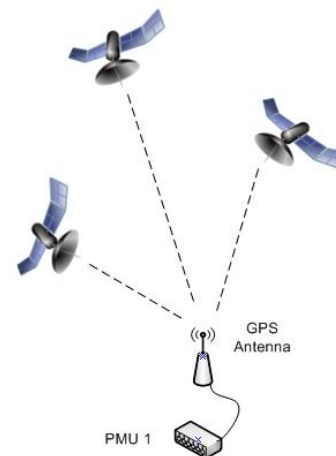
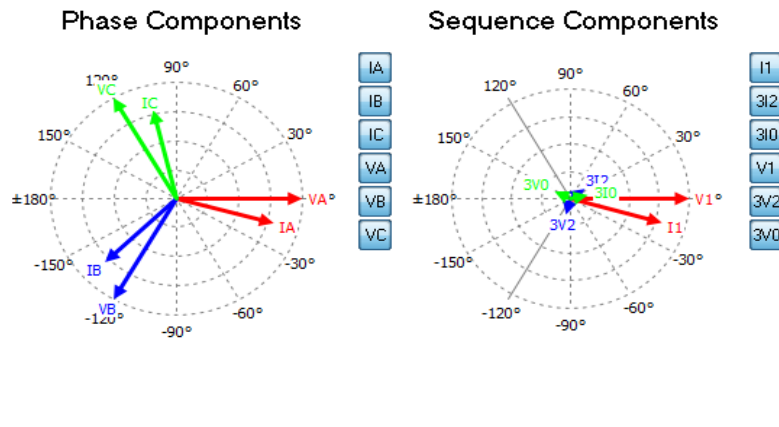


Power Quality Parameters

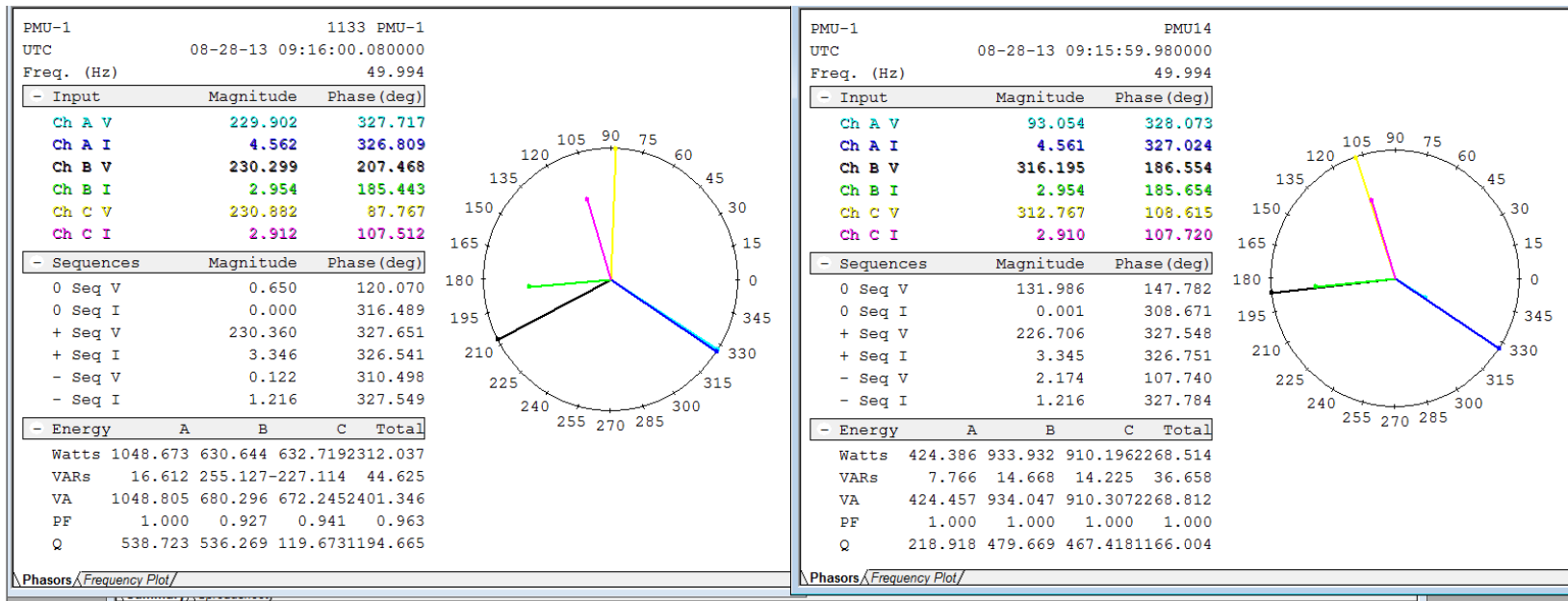
- **Power frequency**
- **Magnitude of the supply voltage**
- **Flicker**
- **Supply voltage dips and swells**
- **Voltage interruptions**
- **Transient voltages**
- **Supply voltage unbalance**
- **Voltage harmonics**
- **Voltage interharmonics**
- **Mains signalling voltage on the supply voltage**
- **Rapid voltage changes**

Synchronized phasor measurements

- The Phasor Measurement Unit (PMU) is the key element of the synchronized phasor measurement technology
- Dispersed PMUs are synchronized using a GPS signal, enabling the PMU to provide voltage and current phasor measurements



Synchronized phasor measurements



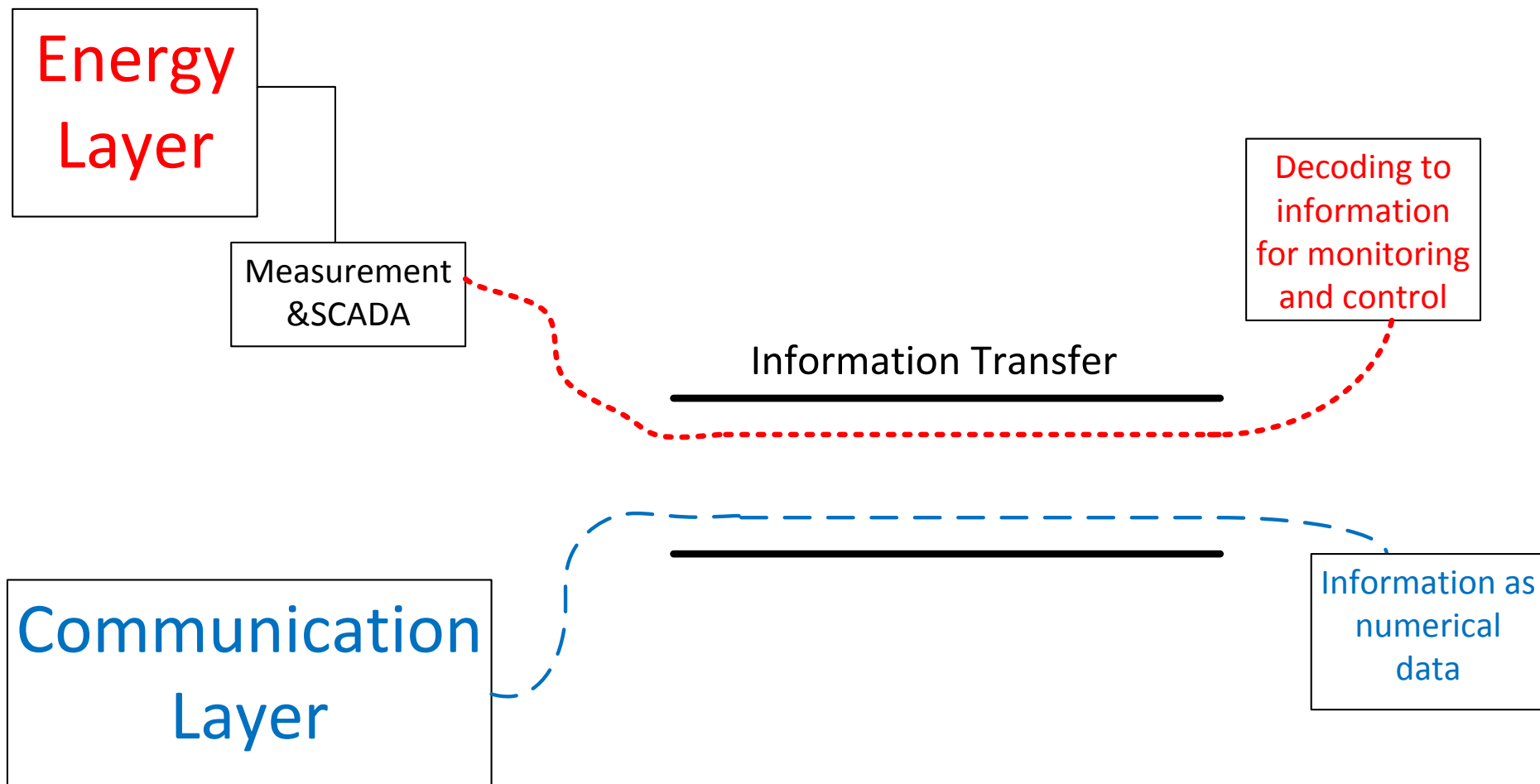
Synchronized phasor measurements

Data Type	Description	No. Items	Rate
Basic	Voltage, Current, Power, Frequency, Time Deviation, Flicker	55	1/sec.
Energy	Watt-hours, VAR-hours, Volt-Amp-hours, Q-hours	40	1/sec.
Harmonics	Voltage and Current, magnitude and phase, up to 50th harmonic	600	1/sec.
HarmonicSummary	Voltage and Current, RMS, THD, RMS-K, THD-F, THD-T and K-Factor	30	1/sec.
Waveform	Voltages and Currents, mag. and phase	6	20/sec.
Phasor PMU-1	Many data types according to C37.118 Synchrophasor Spec.	50	varies
Phasor PMU-2	Many data types according to C37.118 Synchrophasor Spec.	50	varies
Relative Phase	Voltage and Current, all phases and sequences	24	1/sec.

- Example of file dimension:

17MB for 13min of data from 1 PMU (50 frames/sec)

2GB for aprox 20 hours (50 frames/sec)





Electromagnetic compatibility (CEM)

Standards 61000 Series

- **CEI (EN) 61000-1-1: Part 1: General**
(Section 1: Application and interpretation of fundamental definitions and terms)
- **CEI (EN) 61000-1-2: Part 2: Environment**
(Sections 1-14)
- **CEI (EN) 61000-1-3: Part 3 – Limits**
(Sections 1-12)
- **CEI (EN) 61000-1-4: Part 4: Testing and measurement techniques**
(Sections 1-35)

61000-2

- Section 8: Voltage dips and short interruptions on public electric power supply systems with statistical measurement results
- Section 14: Overvoltages on public electricity distribution networks

61000-3

- Sections 2&4: Limits for harmonic emissions
- Sections 3&5: Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems

61000-4

- Section 7: General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto
- Section 11: Voltage dips, short interruptions and voltage variations immunity tests

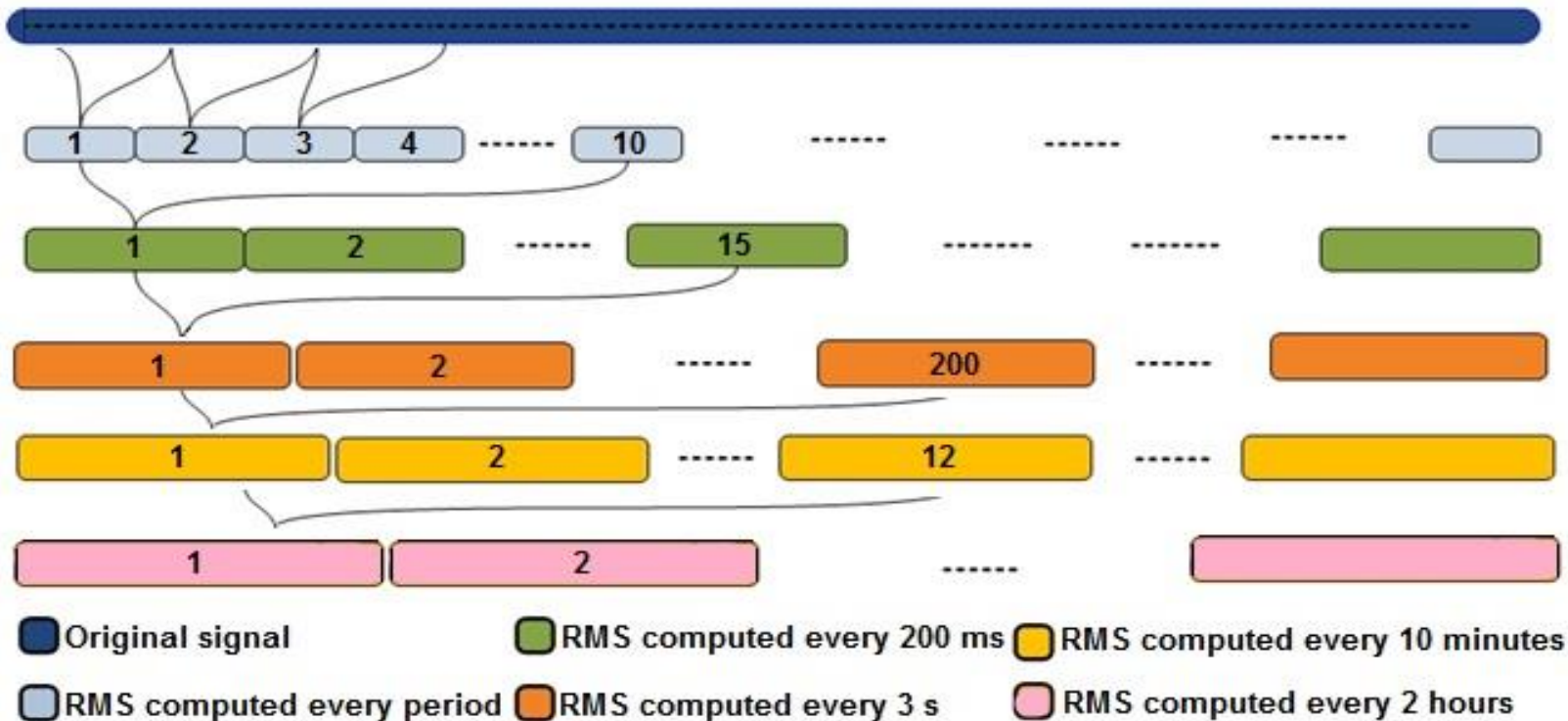
61000-4

- Section 27: Unbalance, immunity test for equipment with input current not exceeding 16 A per phase
- Section 28: Variation of power frequency, immunity test for equipment with input current not exceeding 16 A per phase
- Section 29: Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests

61000-4

- **Section 30: Power quality measurement methods**
- Section 34: Voltage dips, short interruptions and voltage variations immunity tests for equipment with mains current more than 16 A per phase

Time aggregation process



IEC 61000-4-30 ed2.0, Electromagnetic compatibility (EMC) Part 4-30: Testing and measurement techniques - Power quality measurement methods, 2008

Mihai Calin, Ana Maria Dumitrescu, Markos Asprou, Elias Kyriakides, Mihaela Albu, **2013**, Measurement Data Aggregation for Active Distribution Networks, *Proc. of IEEE Applied Measurements for Power Systems AMPS2013, Aachen, 25-27 Sept. 2013*

Time aggregation process

The basic measurement time interval for parameter magnitudes (supply voltage, harmonics, interharmonics and unbalance) shall be a 10-cycle time interval for 50 Hz power system. Measurement time intervals are aggregated over 3 different time intervals. The aggregation time intervals are 3-s interval (150 cycles), 10-min interval, 2-h interval

$$v_{(0.2s)} = \sqrt{\sum_{k=1}^{10} \frac{v_k^2}{10}}$$

$$v_{(10\min)} = \sqrt{\sum_{p=1}^{200} \frac{v_{(3s)p}^2}{200}}$$

$$v_{(3s)} = \sqrt{\sum_{m=1}^{15} \frac{v_{(0.2s)m}^2}{15}}$$

$$v_{(2h)} = \sqrt{\sum_{p=1}^{12} \frac{v_{(10\min)p}^2}{12}}$$

The data for the 150 cycle time interval shall be aggregated from fifteen 10 cycle time intervals

The data for the “2-h interval” shall be aggregated from twelve 10-min intervals



Time aggregation process

Frequency and rocof

The frequency reading shall be obtained every 10-s. As power frequency may not be exactly 50 Hz within the 10-s time clock interval, the number of cycles may not be an integer number. The fundamental frequency output is the ratio of the number of integral cycles counted during the 10-s time clock interval, divided by the cumulative duration of the integer cycles.

No other mention of aggregation of data for frequency or rocof (rate of change of frequency)



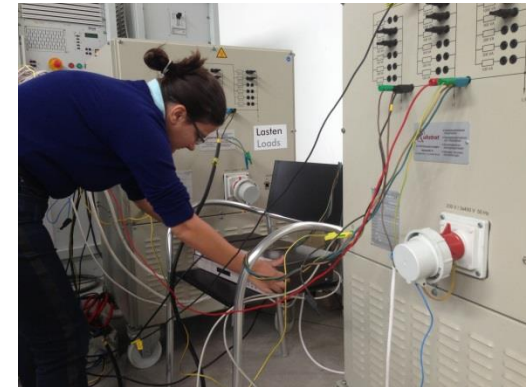
Highlighting asymmetries in LV grids



MicroDERLab Group @ DERLAB

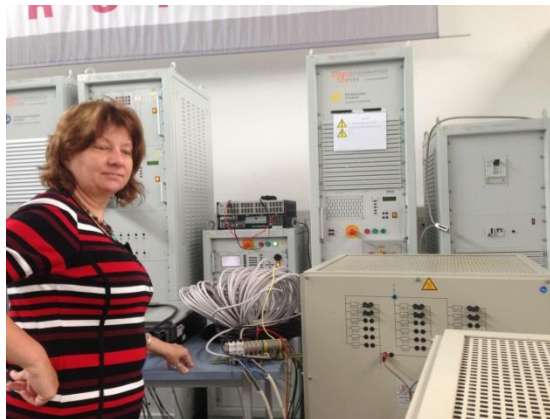
DERlab

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DERri - Distributed Energy Resources Research Infrastructure

 **Fraunhofer**
IWES

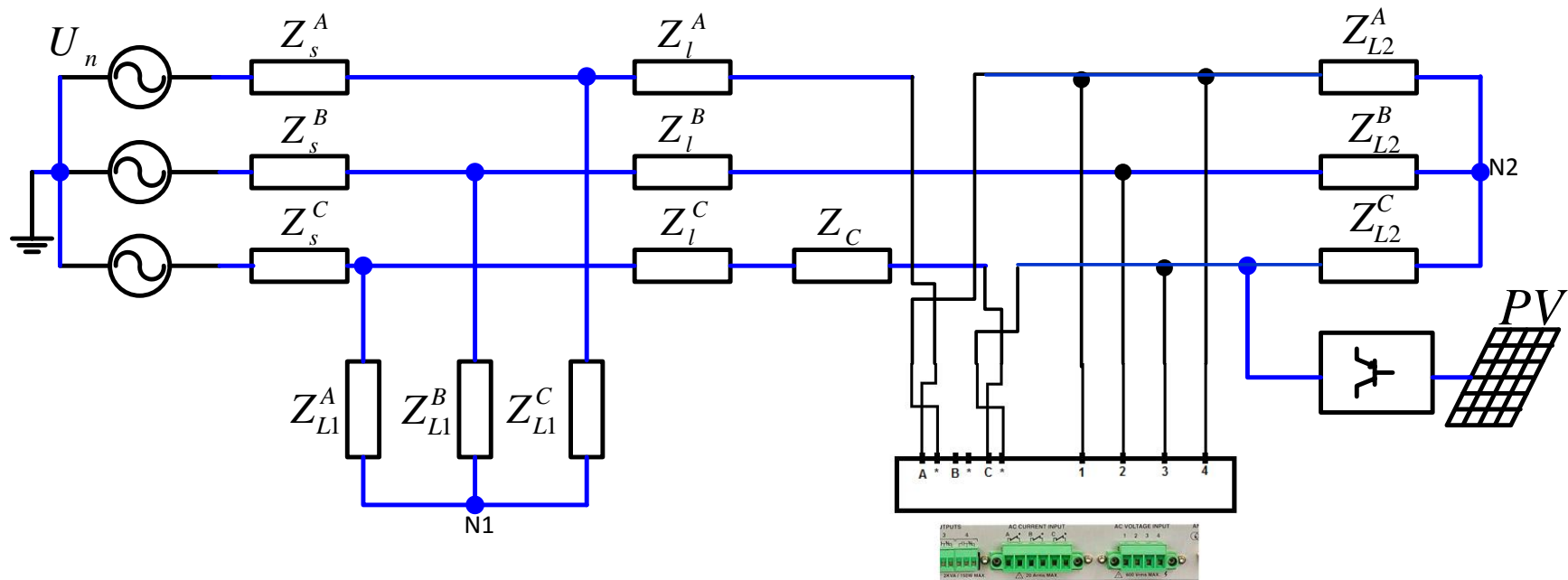


Fraunhofer Institute for Wind Energy and Energy System Technology
IWES

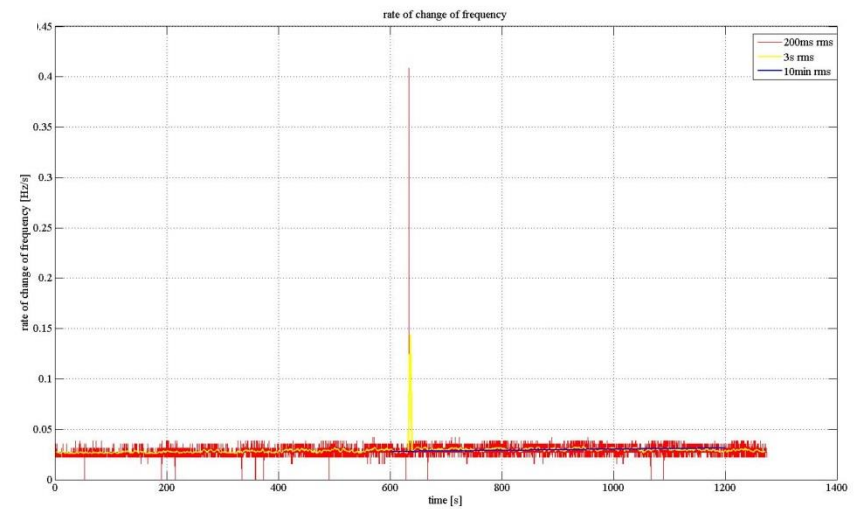
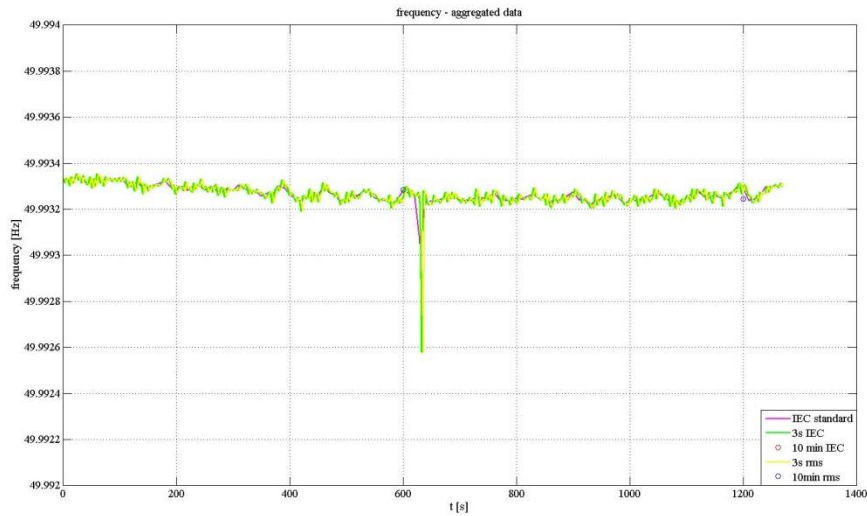
SMART GRID:
GLOBAL STANDARDS for GLOBAL MARKET



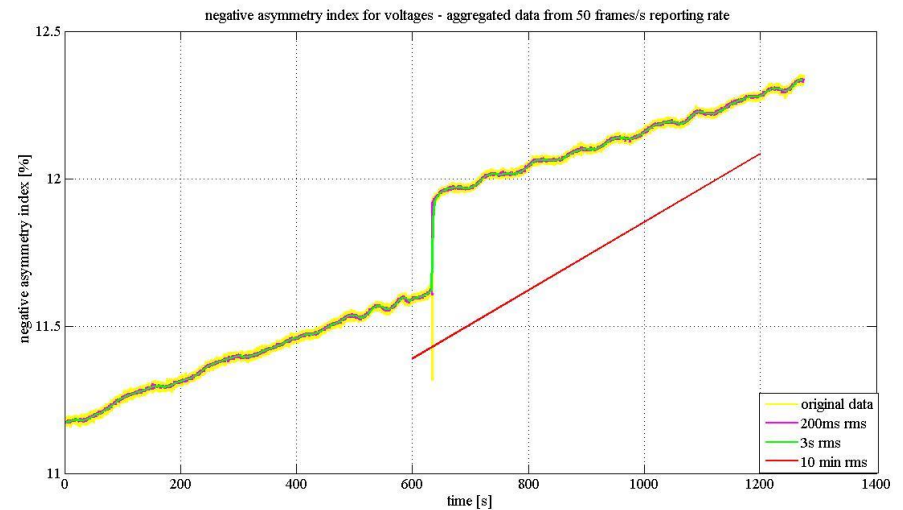
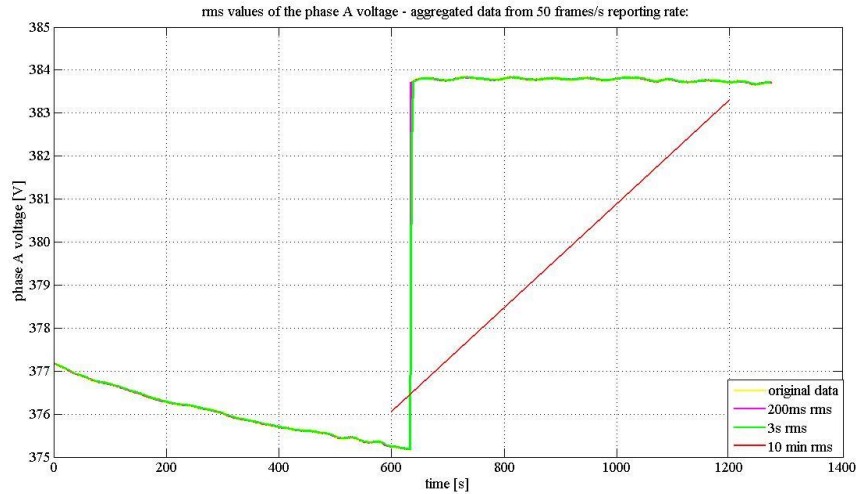
Connection Diagram



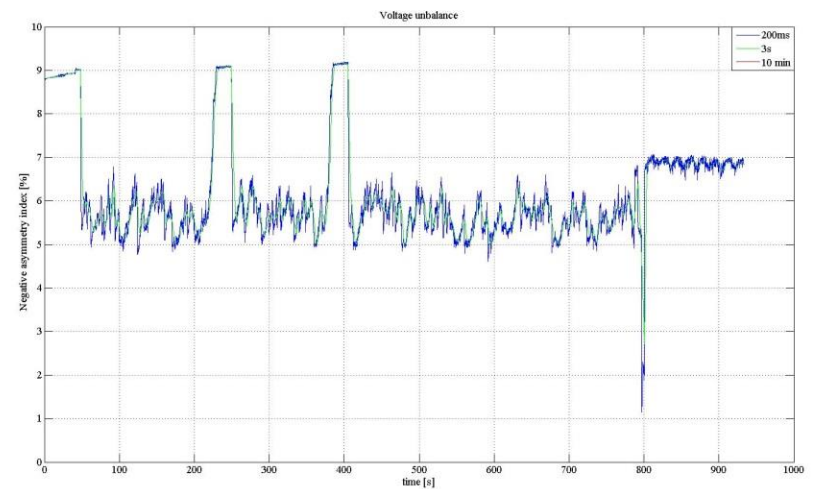
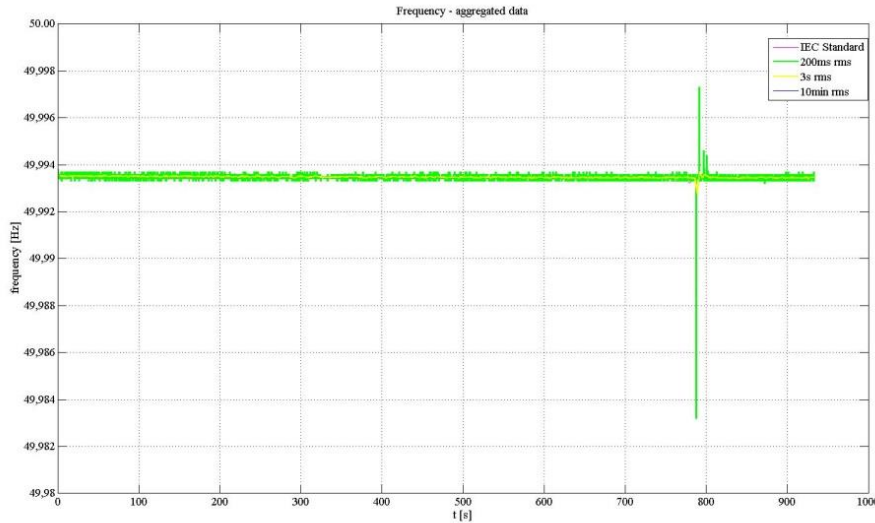
Results



Results



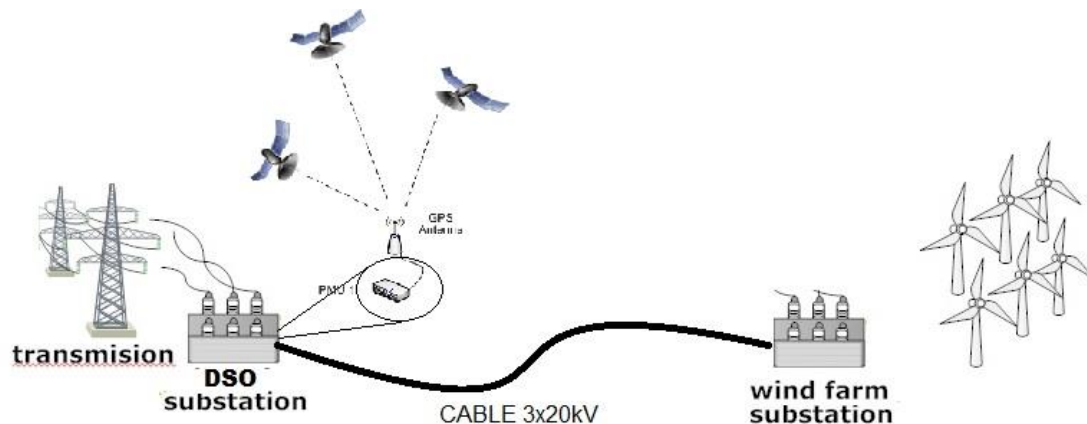
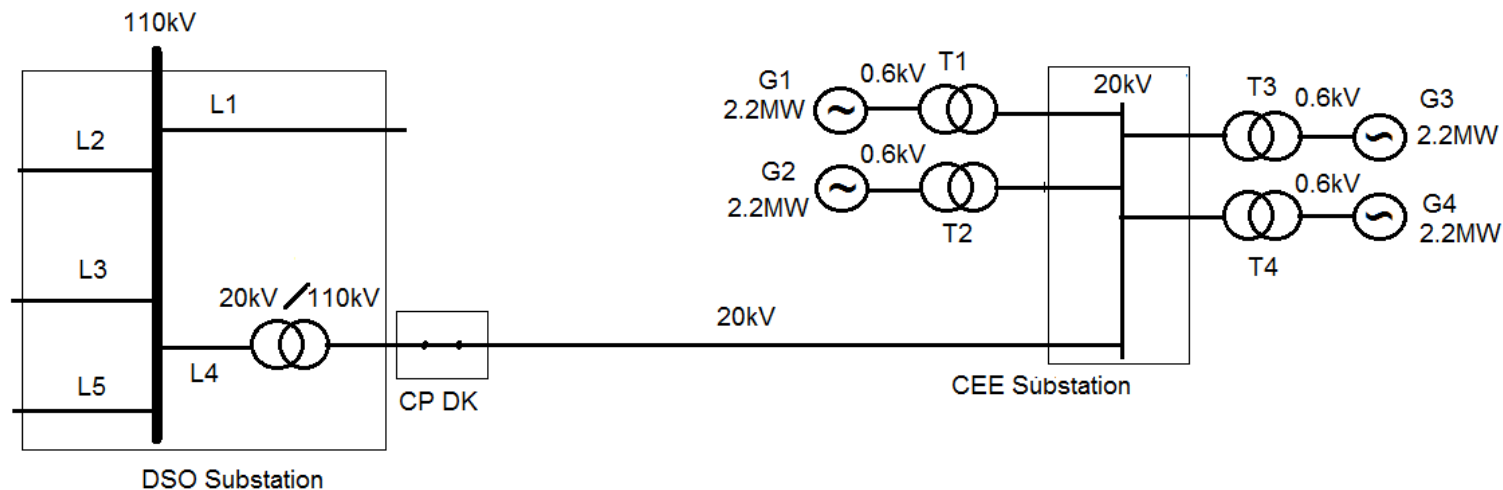
Results





Highlighting aggregation in MV grids

Babadag set-up

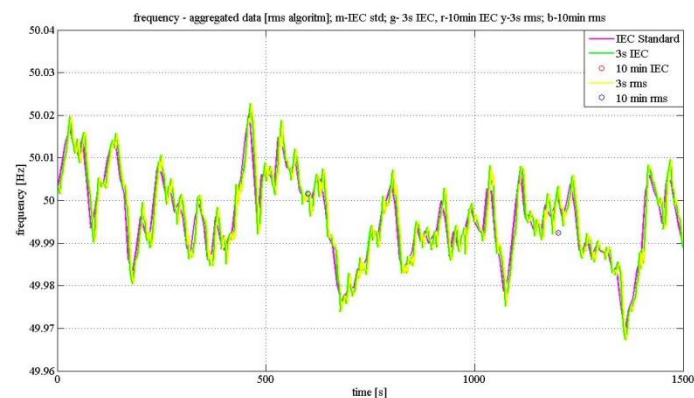
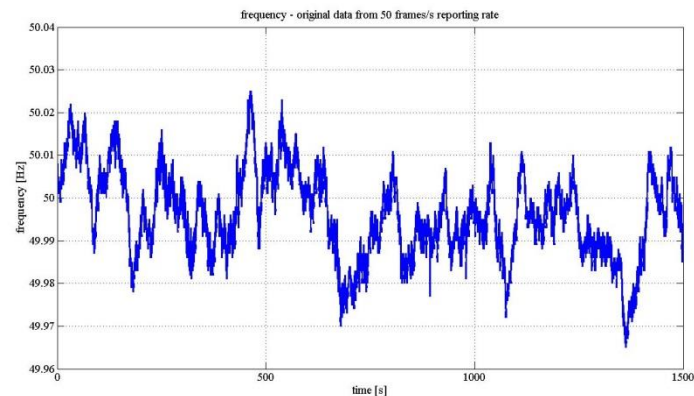


Babadag power station with wind generators in-feed, 110kV busbar, July 2013

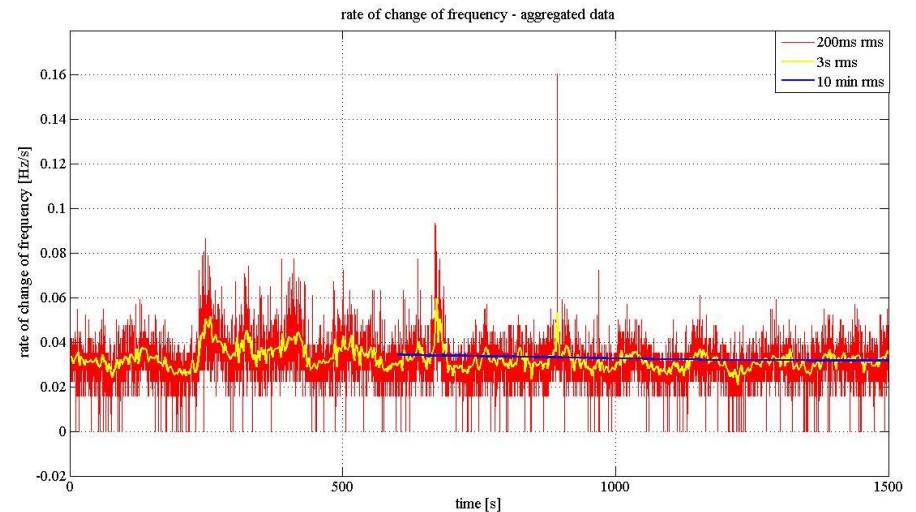
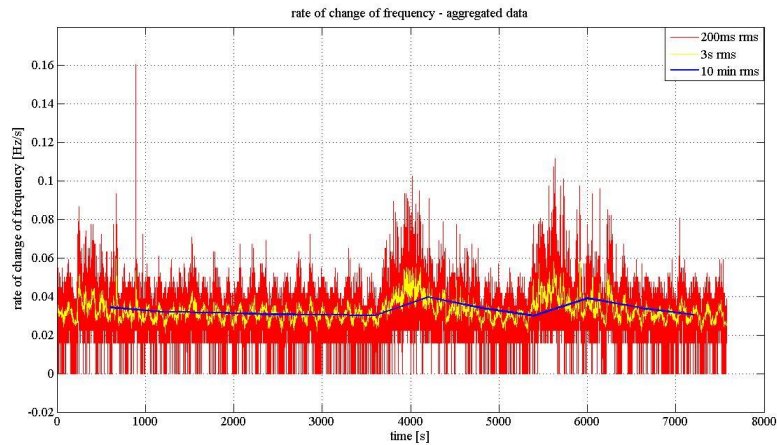
Aggregation of frequency

		Mean [Hz]	Std [Hz]
original data		49.9981	0.015
aggregation	IEC over 10s	49.9981	0.015
	rms over 200 ms	49.9981	0.015
	IEC-average over 200 ms	49.9981	0.015
	rms over 3 s	49.9981	0.015
	IEC-average over 3s	49.9981	0.015
	rms over 10 min	49.9987	0.013
	IEC-average over 10 min	49.9986	0.033

Mihai Calin, Ana Maria Dumitrescu, Markos Asprou, Elias Kyriakides, Mihaela Albu, **2013**, Measurement Data Aggregation for Active Distribution Networks, *Proc. of IEEE Applied Measurements for Power Systems AMPS2013, Aachen*, 25-27 Sept. 2013



Rocof aggregation





Thank you for your attention!

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