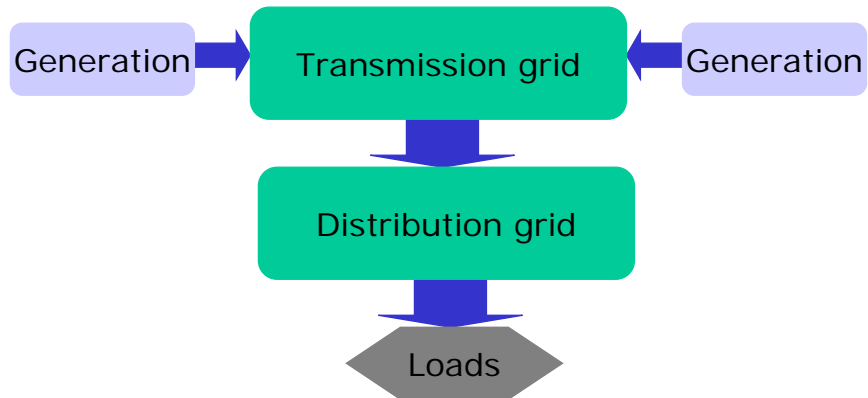




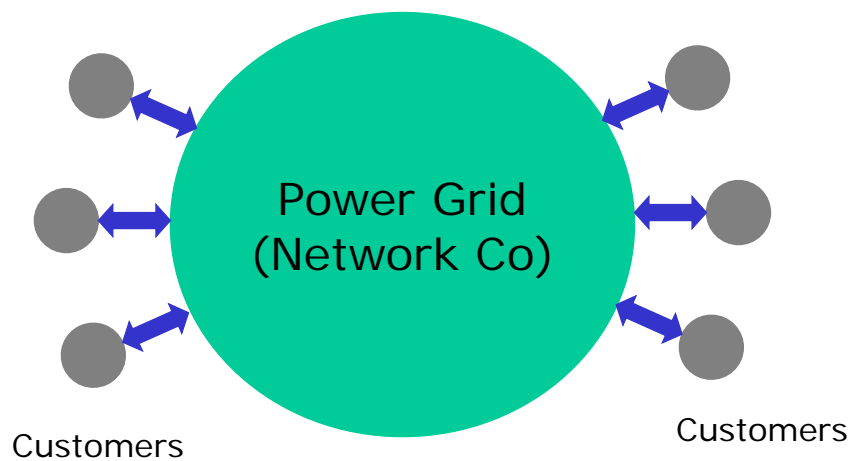
Voltage quality monitoring

- Voltage, current or power quality?
- Variations and events
- Processing of variations
- Processing of events
- Measurement and interpretation issues
- Conclusions

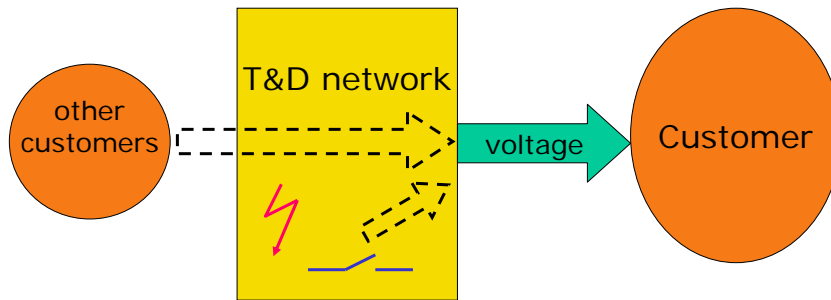
Classical Power System View



Modern Power System View

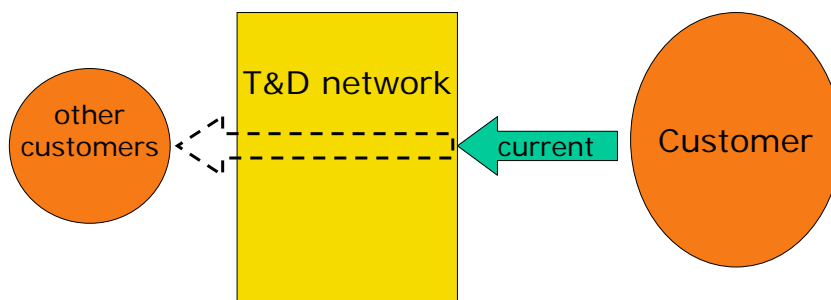


Voltage Quality



STRI

Current Quality



STRI

Voltage quality monitoring

- Voltage, current or power quality?
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Power quality disturbances

- A **power quality disturbance** is any deviation from the ideal voltage or current waveform, magnitude or frequency.
- **Interference**: when a disturbance adversely impacts equipment.
- **Power quality monitoring** is the observation of the disturbances.

Variations and Events

- **Variations:** slow and small deviations.
 - Can be measured continuously and at pre-defined instants.
 - Fixed performance objectives are appropriate.
 - Framework for standards and regulations is available.
- **Events:** sudden and large deviations.
 - Require a triggering mechanism.
 - Performance objectives to differ between countries and locations.
 - Standards and regulations still under development.

EN50160 - Voltage variations

- Power frequency
- Supply voltage variations
- Rapid voltage changes (flicker)
- Supply voltage unbalance
- Harmonic voltage
- Interharmonic voltages
- Mains signalling voltages

EN50160 - Voltage events

- Interruptions of the supply voltage
- Supply voltage dips
- Supply voltage swells
- Rapid voltage changes (steps)
- Transient overvoltages

Voltage quality monitoring

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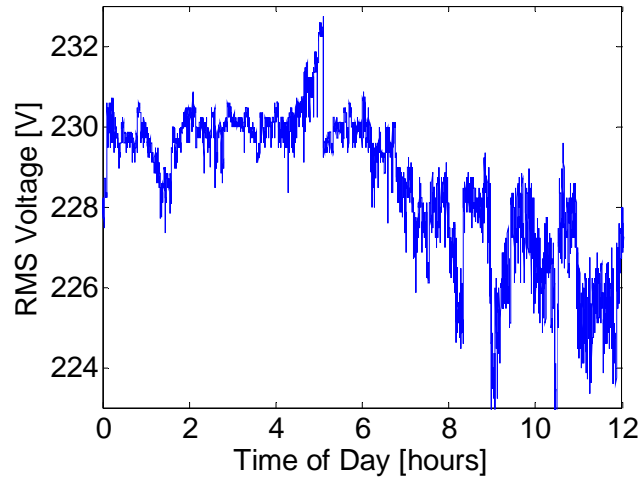
The road to variation statistics

- Sampled voltages
- Basic characteristics (features)
 - IEC 61000-4-30: 200-ms window
- Aggregated characteristics
 - IEC 61000-4-30: 3-sec, 10-min
- Site indices
 - 95, 99 or 100% of time
- System indices

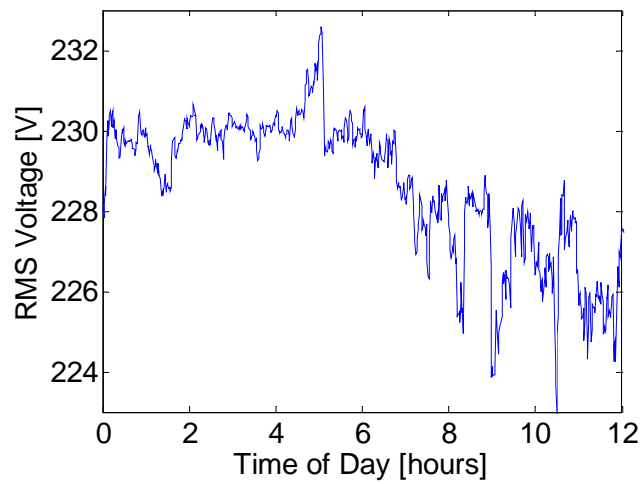
Window and percentile

	3-sec	1-min	10-min	2-hour
100%	IEC (harmonics)	NVE	IEC (harmonics)	IEC (flicker)
99%	CIGRE (harmonics)			
95%	IEC/CIGRE (harmonics)		EN 50160	EN 50160 (flicker)

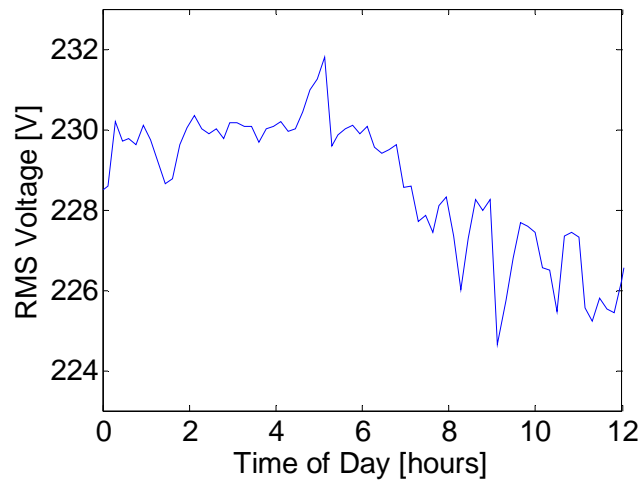
3-second rms voltages



1-min rms voltages



10-min rms voltages

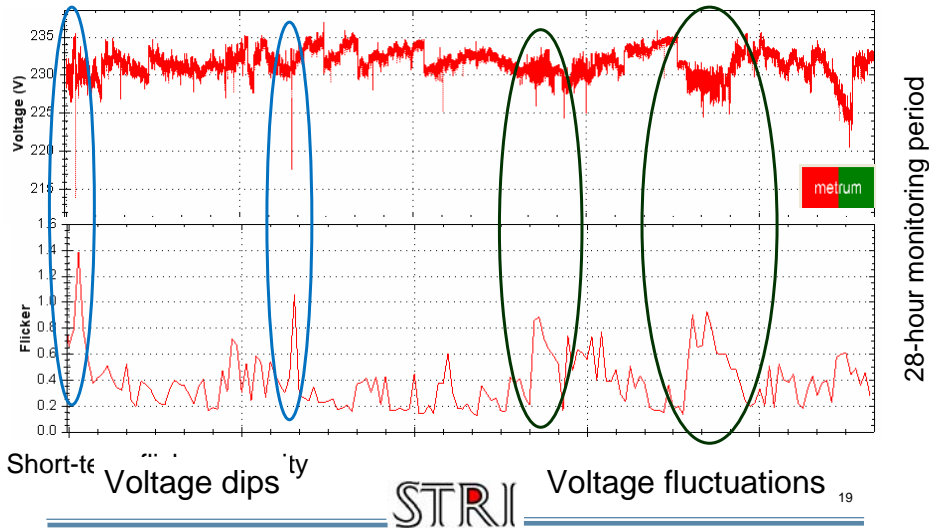


Flagging!

- Borderline between variations and events!
- When an event occurs the variation measurement should be flagged
 - To prevent double counting
 - To remove unrealistic values
- Treatment of flagged data to be decided case-by-case

Example: Pst and dips

Highest, lowest and average voltage every second



Fast Voltage Fluctuations

- Traditionally: flicker
 - Pst=1 is the limit
 - Annoying flicker for the standard 60-W incandescent lamp and most observers
- Future: nobody knows
 - A revised Pst definition
 - Higher compatibility levels
 - Emphasis on 1 sec – 1 min
 - Combine with "voltage steps"

Interharmonics

- Still a **future issue!**
 - Standard mention interharmonics but rarely give any limits.
- **Windpower** converters could be a source.
 - More of a broadband spectrum
- **Measurement and analysis** is not easy.
 - Measurement window; aliasing; broadband versus narrowband
- Don't forget frequencies **above 2 kHz.**
 - Modern power-electronics is emitting here

Voltage quality monitoring

- Voltage, current or power quality?
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- Processing of variations
- **Processing of events**
- Measurement and interpretation issues
- Conclusions

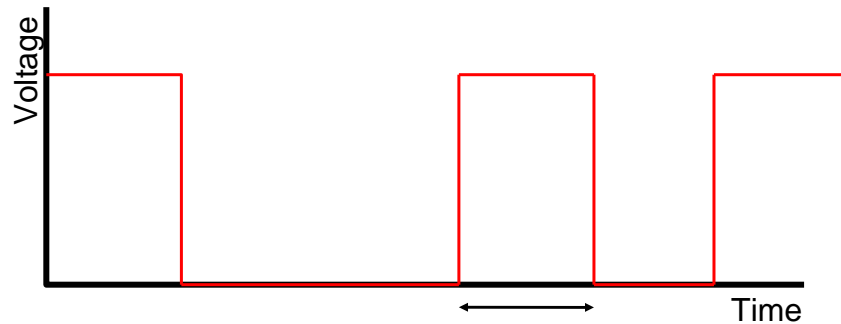
The road to event statistics

- **Event triggering**
 - IEC 61000-4-30: rms voltage
- **Characteristics versus time**
 - IEC 61000-4-30: rms voltage
- **Single-event characteristics**
 - Interruptions: duration
 - Dips and swells: voltage and duration
- **Site indices**
 - Number of events
- **System indices**
 - Average number of events

Interruptions

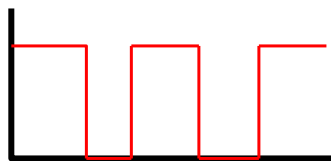
- **Single-event characteristics**
 - Duration of the event
- **Site indices**
 - Rarely obtained from monitoring
- **System indices**
 - Number of events (SAIFI)
 - Average duration (CAIDI, SAIDI)
 - Number versus duration

One and one is one?

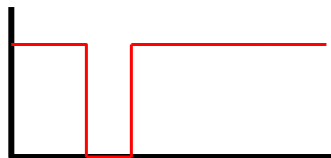


- When do two interruptions become one interruption?
 - Depends on the customer
 - Different routines in different countries

Short Interruptions



Multiple short interruptions are reported to cause damage to end-user equipment



Transient interruptions are also suspected of doing this



Longer short interruptions only cause equipment tripping

Voltage dips

- **Characteristics**
 - Voltage, duration and unbalance type
- **Site indices**
 - SARFI
 - Voltage-dip table
 - Contour chart
- **System indices**
 - Similar to site indices
- **Recommendations by JWG C4.110**

Voltage quality monitoring

- Voltage, current or power quality?
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- Processing of events
- **Measurement and interpretation issues**
- Conclusions

Be careful!

- A simple comparison with objectives (standard limits) can easily result in wrong conclusions!
- Flagging!
- Consider the three phases!
- Consider voltages and currents!
- A disturbance is not an interference!

Voltage quality monitoring

- Voltage, current or power quality?
- Variations and events
- Processing of variations
- Processing of events
- Measurement and interpretation issues
- **Conclusions**

Conclusions

- Measurement equipment is available for wide-scale permanent monitoring of the supply.
- Data and signal processing still needs some further developments but is overall in good shape.
- Interpretation of the results is not always easy.

