Characteristics and Propagation of Short-duration Voltage Events


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Outline

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**Introduction**

**Power quality (PQ)** - any power problem manifested in voltage, current and/or frequency deviations resulting in

- Damage of customer devices, processes, systems, installations, or
- Mis-operation of customer equipment
- Stoppage or slowing down of processes
- Economic damage of customers

- PQ includes
  - Transients
  - Short-duration voltage variations
  - Long-duration voltage variations
  - Voltage imbalance
  - Waveform distortion
  - Voltage fluctuations
  - Power frequency variations
Introduction

PQ responsibility sharing

Grid operators
- Responsible for defining minimum quality of supply in standards and regulations
- State requirements in contract agreement

Customers
- have processes, installation& equipment
- Responsible for choosing the robustness of processes, installation and equipment
- Responsible for impact of voltage disturbances expected from their installations, and quality of current withdrawals on other customers.

Manufacturers
- develop and supply equipment with adequate voltage quality and cost-effective power conditioning devices.
Introduction

- **Short-duration voltage events** – the temporary increase/reduction in RMS voltage outside a specified limit (or value) followed by quick recovery to the acceptable voltage level.
Introduction

Short-duration voltage events – include voltage dips, voltage swells and short-interruption.

- **Voltage dip** – when remaining voltage is between 90 – 5% of nominal voltage for a duration between ½ cycle to 1 minute.
- **Short-interruption** – when remaining voltage is falls below 5% of nominal voltage for a duration between ½ cycle to 1 minute.
- **Voltage swell** – when voltage rises above 110% for a duration between ½ cycle to 1 minute.

**Cause:** mainly (unpredictable) faults  
**Effects:** financial & technical impacts to industrial customers
Objectives

• Study the characteristics of short-duration voltage events
• Identify the causes of short-duration events by the characteristics
• Study the propagation of short-duration voltage events on the same voltage level
• Study the transfer of short-duration volatge events in different voltage levels
Methodology

Network Under Study

- HV, MV and LV network
- Disturbances by short-circuit faults, connection of loads and transformer excitation
- Characteristics, propagation and transfer
- Depends on cable types and length, system grounding, fault types, protection, fault location and point of observation
Results

Characteristics of short-duration voltage events

(a) Caused by short-circuit faults

Typical characteristics
- at least two-transition
- a during-event segment
Results (2)

Characteristics of short-duration voltage events
(b) Caused by transformer excitation

Typical characteristics
• One–transition segment when slowly recovering
• Don’t include clear during-event segment
Results (3)

Characteristics of short-duration voltage events
(c) Caused by connection of heavy loads

![Graph showing voltage (pu) over time](image)

Typical characteristics
- One –transition segment when slowly recovering
- Don’t include clear during-event segment
Results (4)

Propagation of voltage events

Faults | Voltage (pu) at POO\text{s} | BB5 | BB6 | BB3 | BB1
---|---|---|---|---|---
SPGF at BB4 | 0 | 0 | 0.32 | 0.96
DPGF at BB4 | 0 | 0 | 0.58 | 0.98
DPF at BB4 | 0 | 0 | 0.61 | 0.98
3PF at BB4 | 0 | 0 | 0.63 | 0.99
Transfer of voltage events

Example:
Transfer of voltage events due to LG fault in the HV to MV and LV network
Conclusion

• By analyzing the shape of RMS voltages at the PCC, DSOs can get quick estimation about the source of voltage events for finding solutions.

• Looking into the characteristics of voltage events provides better and detailed information about the occurring events for describing the event in more descriptive parameters.

• Effects of fault location and transformer between voltage levels on the propagation and transfer voltage events are studied.
  ✓ Line-line voltage characteristics in MV become phase-ground voltage characteristics after Dyn transformer in LV network
  ✓ The closer the fault location to the point of connection (POC), the most severe its impact on the customers connected to that POC.
  ✓ Effects of disturbances in lower voltage networks reduces as they propagate to higher voltage networks
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Thank you

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