Overview of voltage sag mitigation techniques

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outline

- need for voltage sag mitigation
- mitigation through system improvement
- increasing equipment immunity
- installation of additional equipment
- conclusions
today’s scenario
the need for power quality improvement

Automated factories use sensitive equipment
- power electronics (AC and DC drives)
- process-control electronics (computers, PLCs)

Faults in the power system can cause process interruptions
with associated costs due to loss of production, damaged
product and equipment, and other factors
different faults cause different sags

- voltage
- duration
- local MV network
- remote MV networks
- fuses
- transmission network
- motor starting
- interruptions
from system faults to process interruptions

Faults in the utility power system:
- three-phase
- single-phase-to-ground
- phase-to-phase

Consequences at the PCC:
- voltage sags
- interruptions

Consequences on the process:
- equipment trip
- process interruption
improving power quality for sensitive customers

- System improvement
- Mitigation equipment
- Improvement of equipment immunity
mitigation through system improvement

critical factors:
- frequency of events
- sag duration
- sag magnitude

improvements:
- reducing the number of faults
- reducing the duration of faults
- changing power system layout
equipment sensitivity (1)

low-power electronics

DC drive

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equipment sensitivity (2)

effect of a sag on a single-phase rectifier

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equipment sensitivity (3)

Effect of an unbalanced sag on a three-phase rectifier

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improving equipment immunity

- **low-power electronics**: adding capacitance, improving the dc/dc converter

- **AC drives**: adding capacitance, reducing the setting for the dc bus protection

- **DC drives**: implementing proper control algorithms for adjusting the firing angle of the devices according to changes in the input voltage. Adding capacitance is not a viable option
mitigation devices

- motor-generator set
- ferroresonance transformer
- electronic tap changer
- uninterruptible power supply
- static transfer switch
- series-connected voltage source converter
- shunt-connected back-up source
different sags require different solutions

- Equipment improvement
- System improvement

Voltage vs. Duration
- 100% Voltage
- 80% Voltage
- 50% Voltage
- 0% Voltage
- 0.1 s Duration
- 1 s Duration
- Motor starting
- Remote MV network
- Local MV network
- Transmission network
- Fuses
- Interruptions
conclusions

• mitigation of voltage sags requires careful inspection of the characteristics of the process and of the nature and origin of sag events

• the installation of mitigation devices (normally the only choice for the customer) can be seen as a short-term solution. The mitigation capability of these devices is mainly limited by the energy storage capacity

• only improvement of system performance (for long, deep sags) and of equipment tolerance (for short, shallow sags) can solve the problem in the long term