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College of Engineering

ECE 528 – Understanding Power Quality

http://www.ece.uidaho.edu/ee/power/ECE528/

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Lecture 12

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Today…

- HW2 clarifications
- Sags and short interruptions
  - Whole facility and utility-system mitigation options
  - Summary and a few more important points

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Power Quality Mitigation Philosophy

Electrical Disturbance + Path + Vulnerable Equipment = Power Quality Problem

What we know:
Eliminating any of the three components eliminates the problem.

It often makes sense to install some mitigation device here.

Why?

Why mitigate at the vulnerable equipment:
- Maximizes the disturbances that can be mitigated - most benefit
- Minimizes the capacity of mitigation - least cost

What other advantages can we think of?
Are there disadvantages to this approach?

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Whole facility mitigation

- Why install whole-facility mitigation?
  - Time constraints
  - Convenient – can turn project over to utility or third party
  - Utility may provide this service for an additional fee
  - Minimal impact to facility's existing electrical system.

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A few options

- "Giant" battery-based UPS
- Motor generator
- Dynamic voltage restorer
- High speed transfer switch

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The giant UPS

- Simply a much larger version of a traditional, off-line, battery-based UPS.
  - Advantages
    - Can mitigate sags, interruptions, and swells
    - Generally sized for approximately 60 seconds of ride-through at rated load
    - May be installed to work with a generator and will smooth the transition to and from a generator
    - Convenience – one device – external monitoring

The giant UPS

- Disadvantages
  - Battery maintenance – typically require replacement at 5 years.
  - Must be sized to carry the entire downstream load.*
  - Cost: approximately $400/kVA – hardware only.
  - Distortion – power electronics are used to convert stored energy (DC) to AC.

* Control system may simultaneously disconnect non-essential load.

Motor-Generator

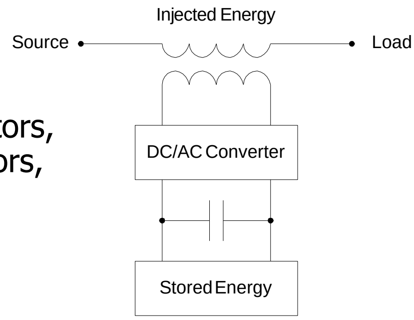
- Motor – turns flywheel – turns generator
  - Advantages
    - Isolation from utility system – protects from transients and harmonics
    - Protection from interruptions
    - May synchronize with a diesel generator
    - Seamless transitions between utility and generator
    - No inherent harmonic generation

Motor-Generator

- Disadvantages
  - Losses – system is always running
  - Must be sized for entire load
  - May limit future load growth
  - Frequency variations as system slows
  - Stored energy in a conventional system may be much higher than useful energy.
    - Frequency variation and energy storage may be addressed with power electronics.

Dynamic Voltage Restorer

- Uses series connected transformer to "inject" the missing energy during a voltage sag
- Advantages
  - Energy storage options include batteries, capacitors, flywheels, superconductors, etc.
  - Only the missing energy needs to be stored
  - May also be used for harmonic filtering



Based on figure 7.27 in "Understanding Power Quality Problems" by Math Bollen

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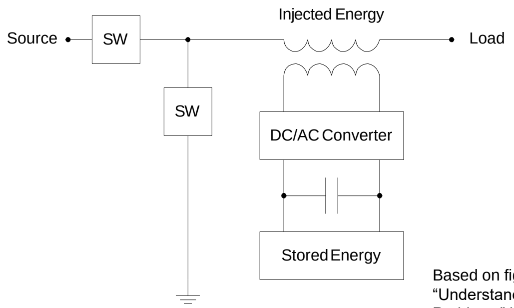
Dynamic Voltage Restorer

- Disadvantages
  - Cannot (usually) mitigate interruptions



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High speed transfer switch

- Solid-state switches used to make or break connections between the load and alternate sources.
  - Advantages
    - No energy storage required
    - Minimal losses
    - Fast response time

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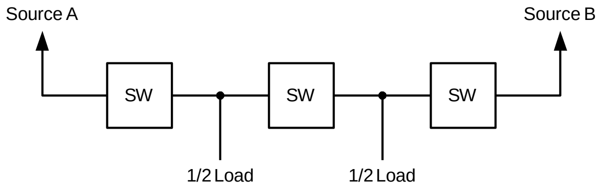
High speed transfer switch

- Disadvantages
  - Requires two independent sources (with respect to the typical voltage sags.)
  - No local energy storage
  - Underutilized system capacity and capacity charges



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Other utility/whole facility options

- Protection scheme issues
  - Minimize fuse saving to minimize interruptions
  - Fuse taps to minimize unnecessary interruptions
  - Current-limiting fuses may shorten fault clearing times and reduce the depth of the corresponding voltage sag
  - Prevent the faults in the first place!
    - Line clearing, bird guards, enclosed "dead-front" switchgear, etc.

Summary and a few more important points

- Addressing voltage sags and interruptions:
  - Start at the equipment or component and work upstream (slowly).
  - Only protect necessary equipment.
  - Before adding equipment, (UPSs, etc.) evaluate changes to existing equipment.
    - Line-to-line connected control power transformers minimize the impact of SLG faults.
    - Operate equipment near the top of any available voltage ranges.

Next time…

- Summarize Voltage sags
  - Causes
  - Vulnerabilities
  - Mitigation
- To do:
  - Start reading transient information:
    - FPQ – chapter 5
    - PSQ – chapter 4