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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 13

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Today…

- Homework/exam suggestions
- Summary of voltage sags
  - Description
  - Causes
  - Effects
  - Mitigation

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Some homework/exam suggestions

- Send Mathcad or Prime files
  - Our grader can open them
  - Makes it easier to find a small mistake
- Turn in professional, annotated work
  - Helpful if you want to refer back to this work later
  - Makes grading easier – you're more likely to get partial credit
- Test your answers
  - It's a necessary engineering skill
  - You'll learn more by experimenting
- Word problem?
  - Be concise but complete
  - Give "most likely" answer(s) and a brief description of your basis

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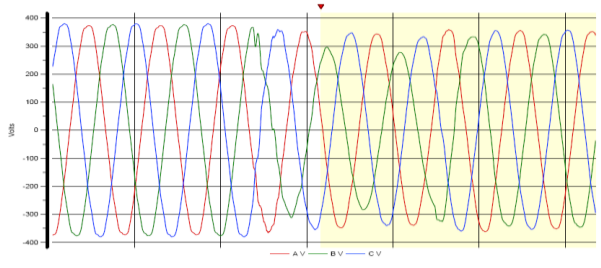
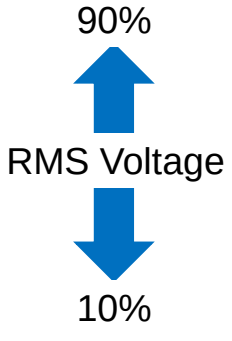
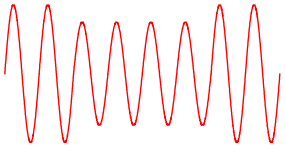
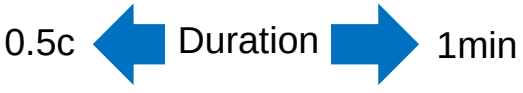
Voltage sags

What are they?









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Voltage Sags - Causes

- Sudden increase in load
  - Some motor starts (FPQ 4.7)
  - Short circuit faults and fault clearing (FPQ 3.4)

Analogy:

Voltage is analogous to water pressure in a home. Turing on water at one faucet may create a noticeable drop in pressure at another faucet.

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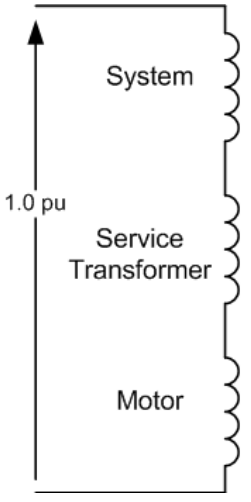
Determining factors - depth

- DEPTH is determined by the relative size of the load or fault compared to the system fault duty.

$$Vmin := \frac{Xm}{Xs + Xt + Xm}$$



What determines system fault duty or capacity?

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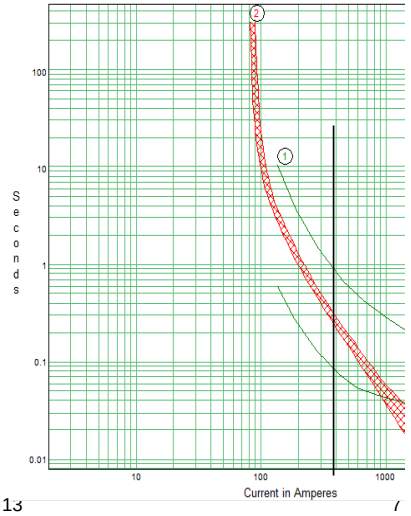
Determining factors - duration

- Duration is determined by the motor start time or the fault clearing time.
- Fault clearing time is determined by the fault current and the corresponding response time of the protective device (fuse, recloser, circuit breaker)
- TCC curves tell us response times



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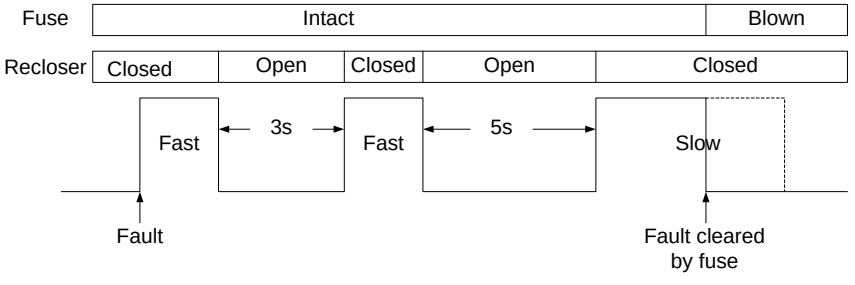
Reclosers: Fuse saving and trip saving

Permanent fault with fuse saving:



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Equipment vulnerability

- What determines vulnerability in common devices?
  - Energy storage versus energy use
    - Inertia – spinning loads
    - Capacitance - power supplies

The term "ride through" is often used when describing voltage sag vulnerability. Ride through describes the depth and duration for voltage sags that some device can withstand and continue operating.

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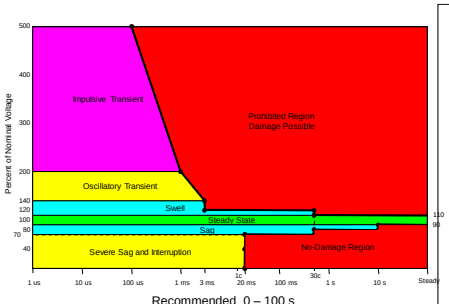
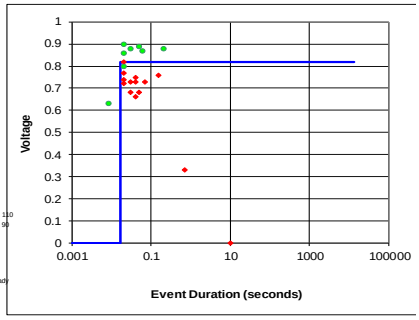
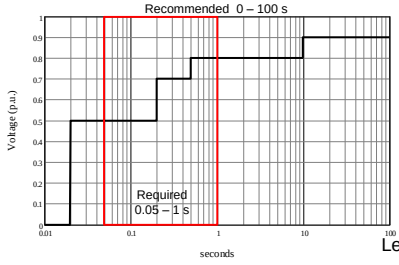
Equipment vulnerability information







Equipment	Upper Range	Average	Lower Range
PLC	20ms, 75%	260ms,60%	620ms, 45%
PLC I/O card	20ms, 80%	40ms, 55%	40ms, 30%
5hp AC drive	30ms, 80%	50ms, 75%	80ms, 60%
ac control relay	10ms, 75%	20ms, 65%	30ms, 60%
Motor starter	20ms, 60%	50ms, 50%	80ms, 40%
PC	30ms, 80%	50ms, 60%	70ms, 50%

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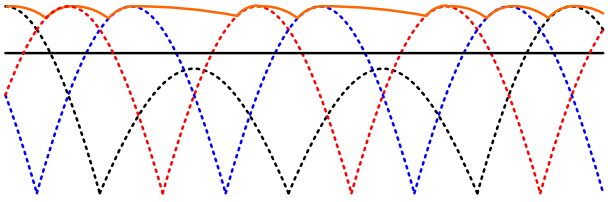
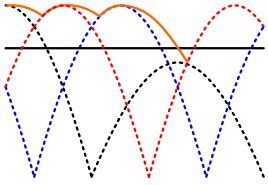
Ride through: Energy storage versus energy use



High energy storage versus energy use: device can "ride through" the single-phase voltage sag.



Low energy storage versus energy use: device cannot "ride through" the single-phase voltage sag.

See lecture 9 for more information.

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Voltage sag mitigation

- Two basic approaches
  - Store more energy
  - Adjust the voltage (quickly)

Electrical Disturbance + Path + Vulnerable Equipment = Power Quality Problem

Stored energy or voltage adjustment is inserted here.

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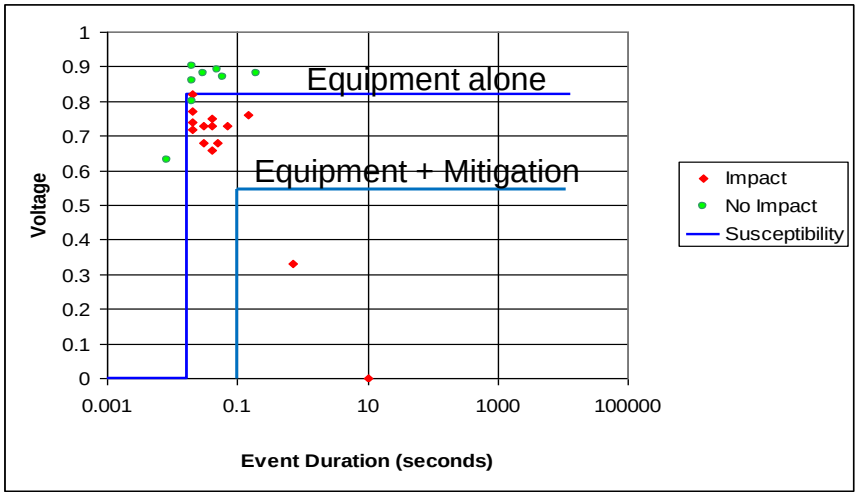
Mitigation objective: lower susceptibility



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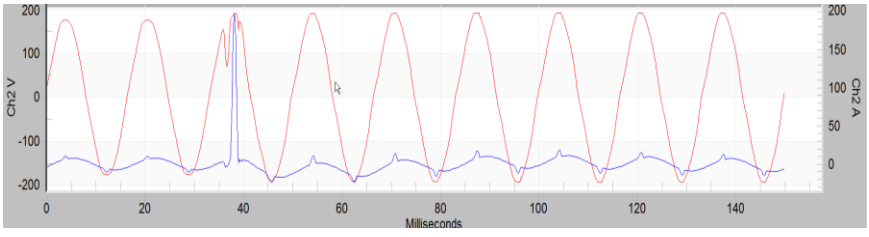
Vulnerability of some rectifier-based loads: I^2t limits and voltage recovery



A large increase in the dV/dt of the voltage applied to a capacitor will cause a large inrush current to flow. This inrush current can damage diodes and similar devices. More on this when we discuss transients.

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Some mitigation options

- UPS
- Motor-generator
- Dynamic voltage restorer
- High speed transfer switch
- Dip proofing inverter
- Voltage dip compensator
- Ferroresonant transformer

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Next time…

- Start transients
  - FPQ – chapter 5
  - PSQ – chapter 4