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College of Engineering

ECE 528 – Understanding Power Quality

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

Paul Ortmann
portmann@uidaho.edu
208-733-7972 (voice)

Lecture 7

Today…

- Some homework suggestions
- Voltage sags and short interruptions
  - Definitions
  - Causes
  - Fault clearing

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Some homework requests:

- Document your work
- Use appropriate units
- When possible, check your answer
  - Solve the problem another way
  - Work the problem backwards

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Working with variables and units in Mathcad

Define Variables with units: ***(Most units we'll need are built-in.)***

$Cap := 20\mu F \quad f := 60Hz$

Enter equations using defined variables:

$$X_c := \frac{1}{2 \cdot \pi \cdot f \cdot Cap}$$

Then let Mathcad solve it: $X_c = 132.629\,\Omega$

Compare the work above to this:

$$\frac{1}{376.991 \cdot 20 \cdot 10^{-6}} = 132.629$$

The answers are the same, but the answer on the left must be manually transcribed to other portions of the calculation, and if an error was made, it would be difficult to trace.

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Voltage Sags and Interruptions

- Definitions:
  - Magnitude (of nominal voltage)
    - Sag: 0.1 pu - 0.9 pu
    - Interruption: < 0.1 pu
  - Duration
    - Instantaneous: 0.5 cycles - 30 cycles
    - Momentary: 30 cycles - 3 seconds
    - Temporary: 3 seconds - 1 minutes

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Sources:

- From first principles:
  - A sudden increase in load results in a corresponding sudden drop in voltage.
    - Faults
    - Motor starting
    - Switching

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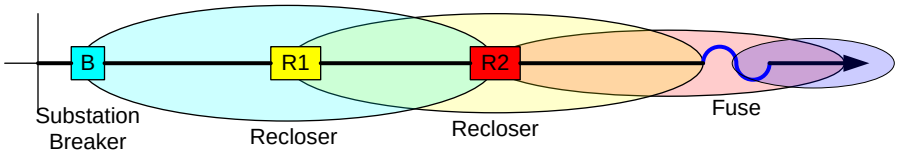
System protection overview

- Typical Objectives:
  - Distinguish fault current from load current
  - Minimize number of customers off
  - Minimize interruption duration
- Issues:
  - Fault current varies – system impedance, fault impedance
  - Coordinating multiple devices can be difficult



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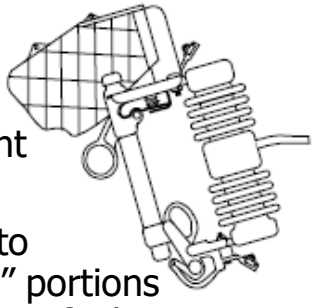
Clearing faults

- Fuses
  - Inexpensive
  - Require manual replacement
  - Help locate faults
  - In general, fuses are used to disconnect, or "sectionalize" portions of the system with permanent faults from the rest of the system.
  - "Current Limiting" fuses can have a PQ benefit.



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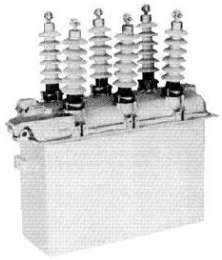
Clearing faults



- Reclosers
  - Automatic circuit breakers
  - Used where faults may be temporary
  - Can be programmed to respond differently to different faults.
  - Can "test" the downstream system to see if a fault is cleared.
  - Generally used to protect larger parts of the system.
  - May protect past downstream fuses.

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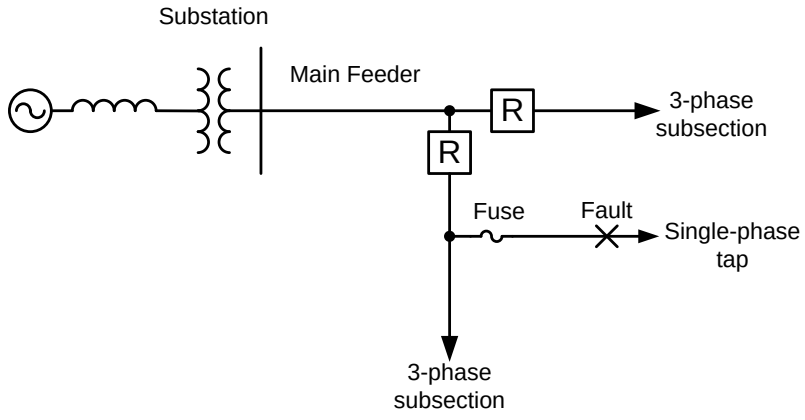
Clearing faults

- Reclosers and fuses can work together
  - Fuse saving
    - Recloser trips very quickly to clear a temporary fault before a fuse can operate.
    - If the fault is still present when the recloser closes, the recloser trips more slowly to allow a downstream fuse to operate.
  - Example…

Clearing faults with and without fuse saving



Distribution voltage sag and interruption

- Fault occurs
  - Voltage sags. Fuses, circuit breakers, and reclosers, start to heat up or time-out.
- Fault is cleared
  - Fuse, circuit breaker, or recloser opens. Voltage returns to normal for upstream loads. Voltage drops to zero for downstream loads.
- Possible reclosing

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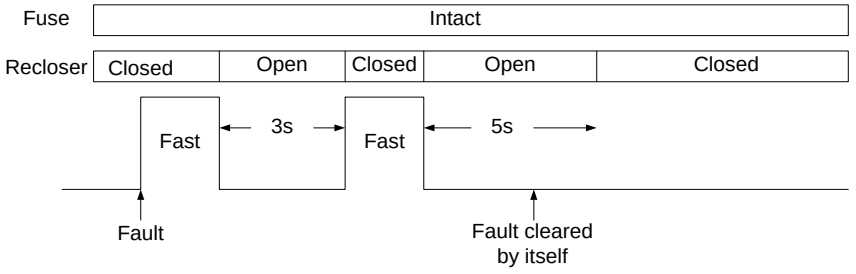
Recloser with fuse saving

- Temporary fault with fuse saving



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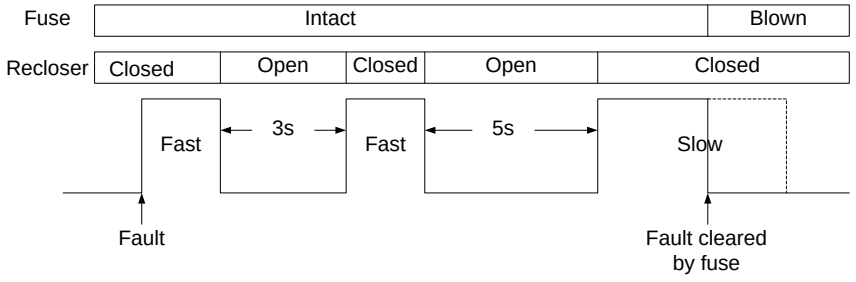
Recloser with fuse saving

- Permanent fault with fuse saving



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Recloser operation

Log of recloser operations during a temporary fault.

Can you tell where the recloser tested to see if the fault was cleared? Was it? What did customers see during the test?

Call Type	Date	Time	Duration
ON	8/24/2006	13:34:34.961	CONTINUING
OFF	8/24/2006	13:34:25.039	09.935
ON	8/24/2006	13:34:24.707	00.316
OFF	8/24/2006	13:34:19.457	05.266

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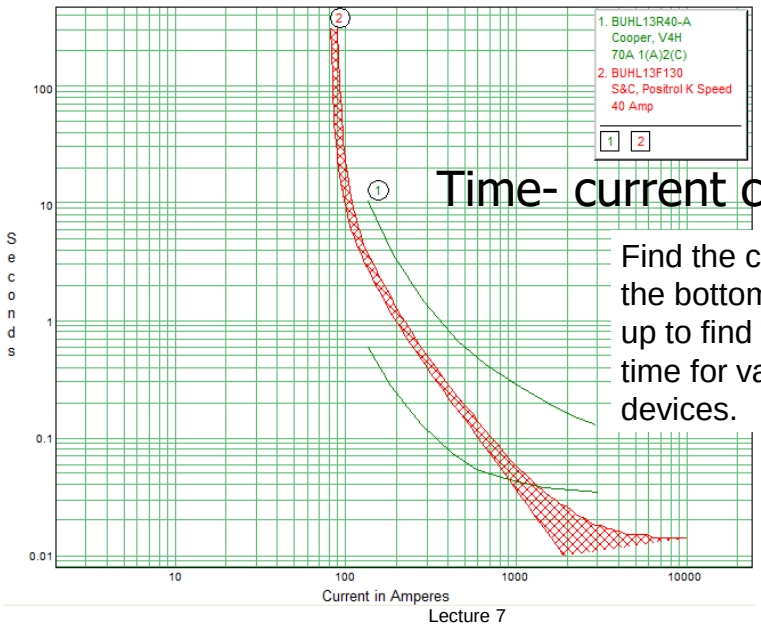
Fuse saving tradeoffs

- What are the advantages of using fuse saving?

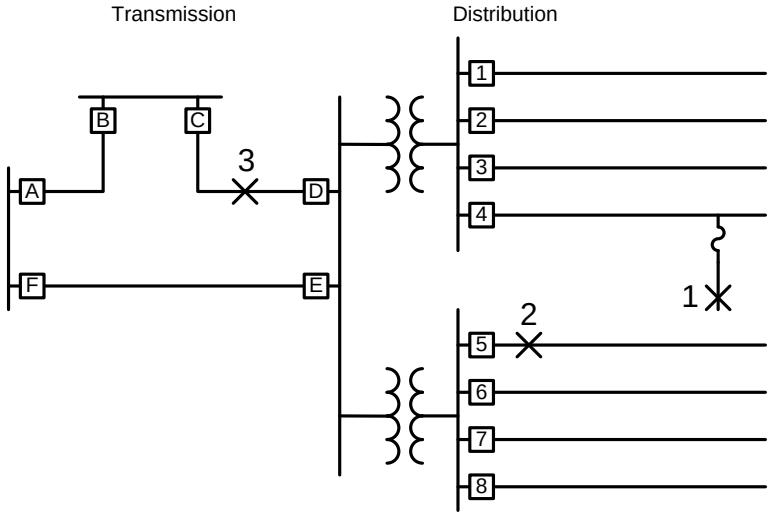
- What are the disadvantages?



Time- current curves

Find the current at the bottom, then go up to find the trip time for various devices.

Voltage Sag Impacts



Next time…

- Motor starting