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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 18

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Today…

- Transient overvoltages
  - Reflected and damped transients
  - Finish types of capacitor switching transients
  - Mitigating capacitor switching transients
  - Other switching transients
  - Transient protection summary

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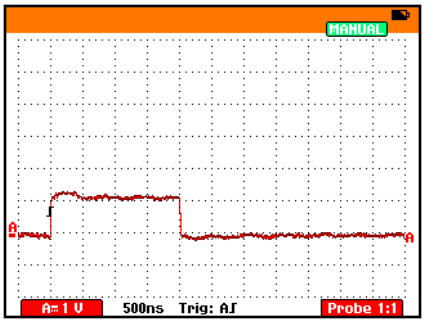
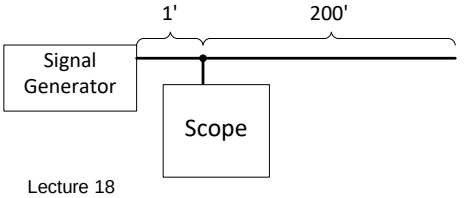
Transient reflections

- The source signal
  - 200μs, 1V pulse
- Setup
  - Signal generator to oscilloscope, to 200' of 50-ohm coax with 50-ohm terminator





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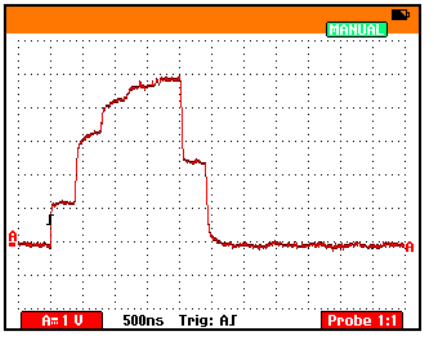
Reflected transients

- Same source signal
- 50-ohm terminator removed
- Notice:
  - Reflections at both far and near ends
  - Gradual damping



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Other switching transients

- Issues:
  - High voltages
    - Sometimes several p.u.
  - Higher frequencies
    - Compared to capacitor switching
  - Multiple sources
    - Any switched load may cause a transient

Reference: (Get a copy – it's a good resource)

IEEE Std. 62.41.1-2002 - IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits

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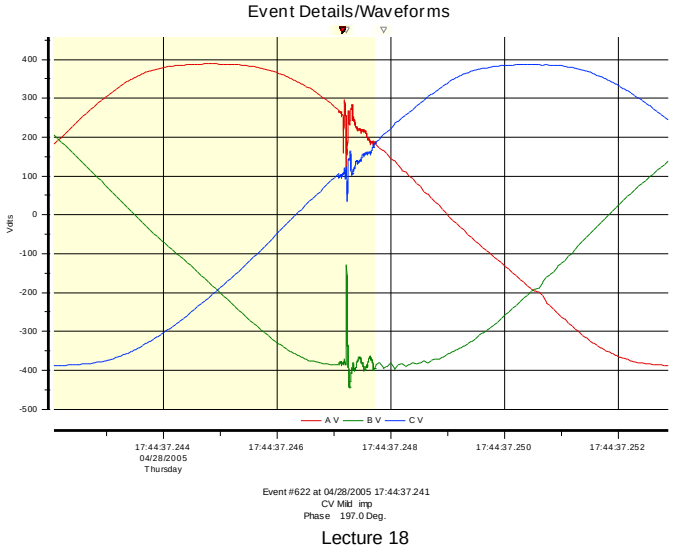
Other switching transients



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Switching transient sources (besides capacitors)

- Normal switching:
  - Load switching – turning equipment on and off
  - Voltage notching – due to commutation in electronic power converters
  - Switching on the power system
    - Transformer energizing – PSQ pg. 194.
- Abnormal switching:
  - Arcing faults
  - Fault clearing – current limiting fuses or fast breakers – current chopping

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Equipment Impact

- Nuisance tripping of ASDs
- Power supply failure
- I/O board failures
- Turn-to-turn faults in motors and transformers

Special considerations for transients

- High frequency
  - Increases capacitive and inductive coupling
  - Conductor lengths become important
    - Reflections/voltage magnification
    - Voltage differences at equipment based on conductor route
- May cause extra zero-crossings
  - Some timing circuits use zero-crossings
- Multiple sources
  - Eliminating all sources is unlikely

Transient overvoltage mitigation

- Standard transient overvoltage protection
  - "Crowbars" – arc gaps or electronic devices
    - May arc through air or other gasses
  - "Clamps" – MOVs
  - Filters
  - Combined devices

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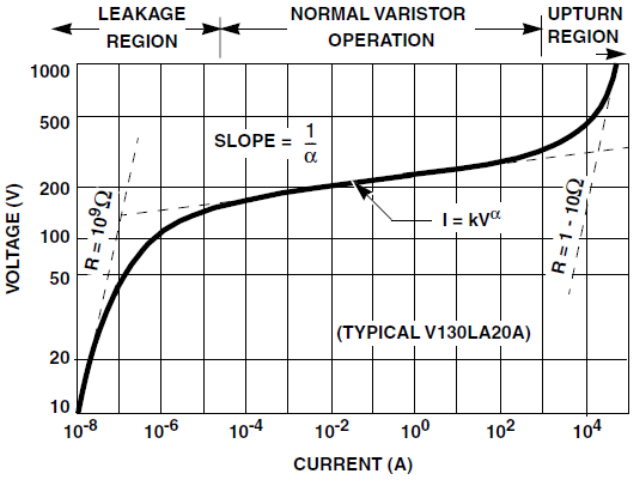
Typical MOV operating characteristic



From Littlefuse Application Note AN9767.1, www.littelfuse.com

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Transient overvoltage mitigation

- Some switching transients can be stopped at the source:
  - Shunt-connected devices cannot "tell" which direction the transient is coming from.
  - A "surge capacitor" near a motor contactor can limit the voltage transients associated with motor switching and help suppress high frequency transients from other sources.
  - A "snubber" across the motor contactor contacts can reduce or eliminate arcing when the contactor opens.

Surge Capacitor

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Summary of transient overvoltages and mitigation

- Sources
  - Lightning
  - Switching (Capacitors, loads)
  - Faults
- Mitigation
  - Clamping devices (MOVs)
  - Crowbar devices (Arc gaps)
  - Filters (low-pass)

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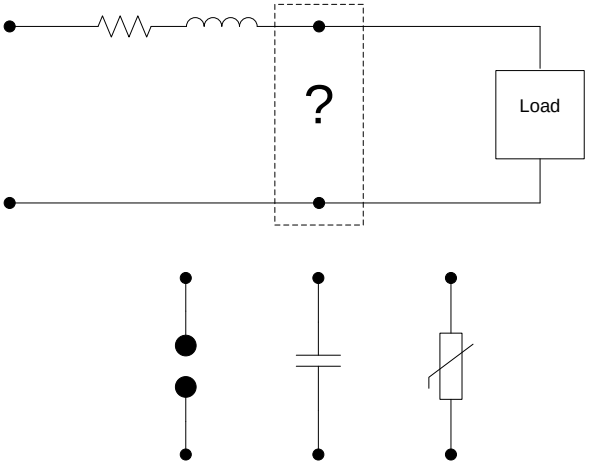
Transient overvoltage mitigation methods



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Summary of transient overvoltages and mitigation

- Mitigation continued:
  - Establish common ground reference for power and communication circuits
  - Minimize coupling to communication and control circuits
    - Use twisted, shielded communication conductors
    - Separate communication and power circuits
    - Use optical isolation for communications between devices on different power systems

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Next time…

- Harmonics fundamentals
  - PSQ Ch. 5
  - FPQ Ch. 6
- Definitions and terms
  - Standards