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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 15

Today…

- Transient voltages
  - Homework 3 discussion
  - How transients travel through, and between electrical systems
  - Principles of protection

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Homework 3 discussion

- 1 – Covered well in FPQ 5.3-5.5
- 2 – From the lectures, the reading in PSQ, and an application note on PQ Links page
- 3 – Low-side surge – will be covered in lectures

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How transients travel through and between electrical systems

- Transients may travel via:
  - Conduction ("Resistive coupling")
  - Inductive coupling
  - Capacitive coupling
  - Far-field coupling

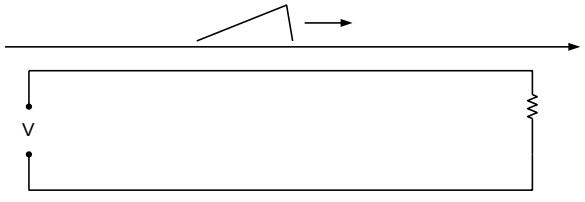
Electrical Disturbance + **Path** + **Vulnerable Equipment** = **Power Quality Problem**

How transients travel…

- Conduction - Using any and all conductor paths available
  - Power circuits
  - Communication circuits
  - Grounding systems - Water pipes – structural steel

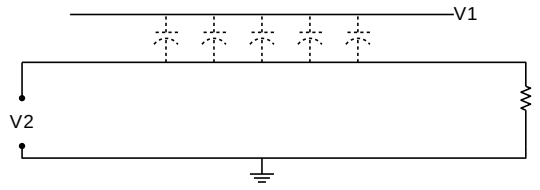
How transients travel…

- Inductive coupling
  - Current in a conductor may induce currents and voltages in nearby circuits
  - May be thought of as a transformer
  - Function of di/dt



How transients travel…

- Capacitive coupling
  - Parallel conductors act like a capacitor
  - Voltage can be induced on nearby conductors
  - Function of dV/dt



Capacitive and Inductive coupling issues

- Voltages and currents can be capacitively and inductively coupled in any conductor
  - Fencing
  - Piping
  - Building materials
- Can you see why we twist conductors in communication circuits?

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Far field coupling

- Circuit components may act like a receiving antenna for radiated electromagnetic energy
  - Far field starts beyond $\lambda/2\pi$ (approximately wavelength/6)
  - With increasing distance, electric and magnetic fields each start to produce their complementary field
  - Capacitive and inductive coupling are no longer separate effects in the far field
  - Absorption of EM radiation in the far field has no impact on the transmitter
  - Examples: Radio and television, Lightning

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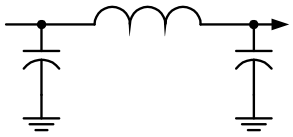
Principles of protection (PSQ pg. 157)

- Limit voltage at device terminals
  - Turn transient voltage into transient current
- Divert transient current
- Block transient current
- Bond grounds together at devices
- Reduce or prevent transient current flowing between grounds

What the protective devices do

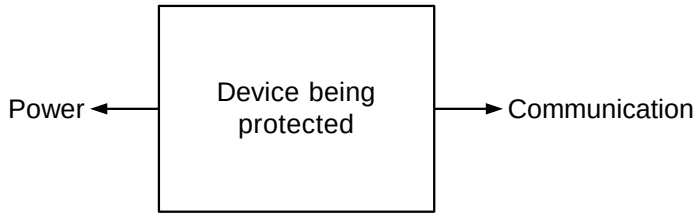
- Increase impedance as frequency increases
  - Low pass filters
  - Isolation transformers
  - Low impedance power conditioners



- Reduce impedance as voltage increases
  - MOVs (clamping)
  - Arc gap or electronic (crowbar)

Limit voltages at (and between) terminals

- This means excessive voltages on power circuits, on signal circuits, AND between power and signal circuits.



Diverted transients are still transients

- Diverting transient currents with clamping or crowbar devices "reroutes" them to other conductors
- Ohm's Law still applies: I*Z=V
- May lead to voltage differences on grounding system

Blocked transients are still transients

- Remember reflections and refractions
  - At an impedance change in the system, the transient may be reflected back into the "upstream" system.
  - Other nearby devices may be subjected to transient voltage magnification

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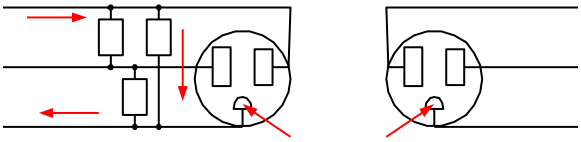
Grounding system voltage differences

- A transient on the left receptacle could result in voltage between the grounds at these two receptacles



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Next time…

- Lightning
- More examples

For a brief introduction to near- and far-field, read the first 2 pages of the paper *Near-Field Methods of Locating EMI Sources*, by Vladimir Kraz, Credence Technologies, Inc., 1995 Available here:
http://www.bestesd.com/library/NEARFIELD.pdf

Also interesting is this paper on EOS – electric overstress:
http://www.bestesd.com/library/Origins-of-EOS.pdf