

## ECE 528 – Understanding Power Quality

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

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### Lecture 14

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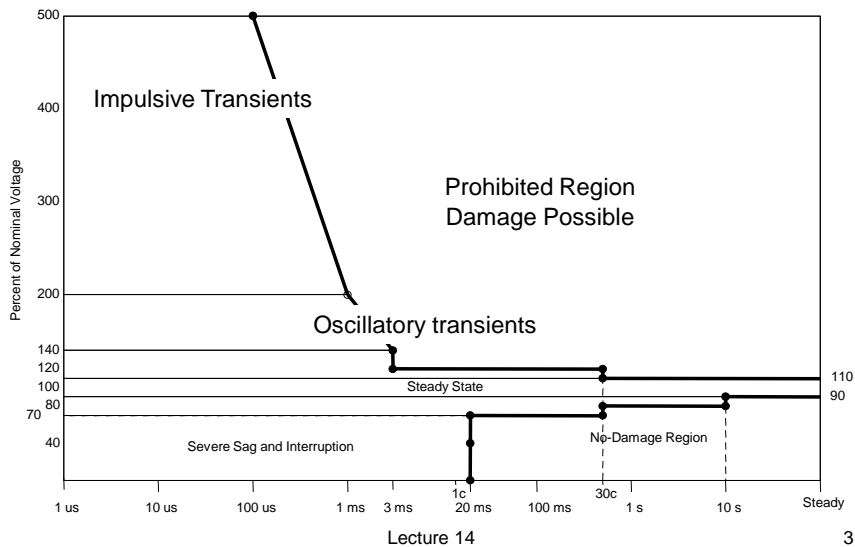
## Today...

- Voltage Transients
  - ITI curve
  - Characterizing voltage transients
  - Collecting data
  - Some sources
  - Some impacts on loads

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## Transient overvoltages and the ITI Curve



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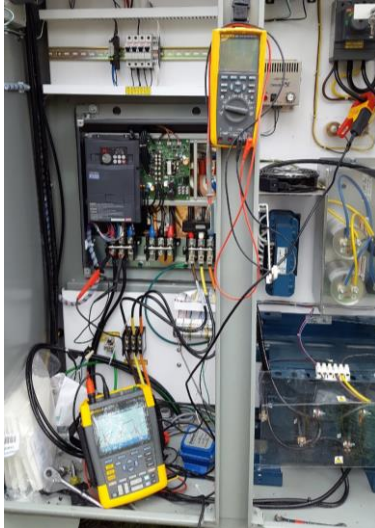
## Analysis of voltage transients

- Transient analysis usually requires waveform data
- Collecting waveforms requires instruments with faster sampling and more data storage
- Typical high-end power quality recorder will detect transients and briefly record at a higher sampling rate
- Oscilloscopes may also be useful for capturing transients

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## Collecting data:



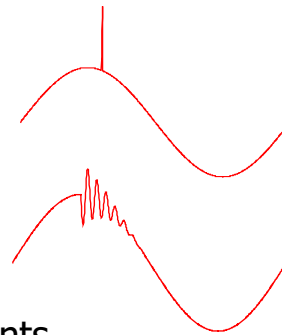
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## Three ways waveforms help us identify sources of voltage transients

- Waveform characteristics
  - Impulsive or oscillatory
  - Frequency of oscillation
  - Rise time, decay time, etc.
- Time-stamp
  - Correlation with known events
- Time-of-arrival
  - Used to determine transient direction



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## Characterizing transient overvoltages

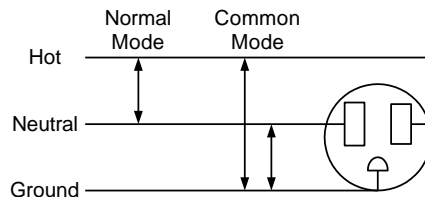
- Impulsive
  - Nanosecond
    - 5ns rise, lasts <50ns
  - Microsecond
    - 1 $\mu$ s rise, lasts 50ns – 1ms
  - Millisecond
    - 0.1ms rise, lasts >1ms
  - Caused by lightning, removal of an inductive load, loose wiring, and other arcing events

## Characterizing transient overvoltages

- Oscillatory
  - Low frequency: <5kHz, 0.3 – 50ms, 0 – 4 pu
    - Capacitor switching, ferroresonance, transformer energization
  - Medium frequency: 5–500 kHz, 20 $\mu$ s, 0 – 8 pu
    - Back-to-back capacitor switching, cable switching, impulse response
  - High frequency: 0.5 – 5 MHz, 5  $\mu$ s, 0 – 4 pu
    - Response of system to an impulsive transient

## Characterizing transient overvoltages

- **Common Mode (N-G)**
  - caused by lightning, utility switching, ground potential differences in a network, and radio and T.V. transmitters
- **Normal Mode**
  - caused by power electronics, switching power supplies, and arcing loads



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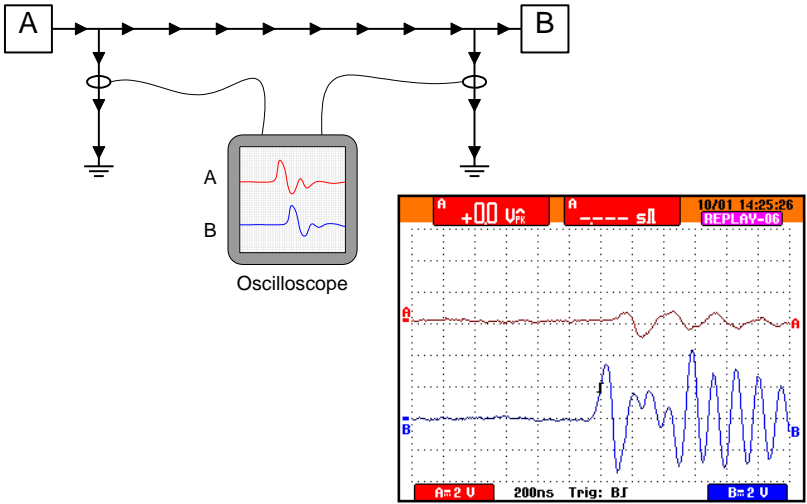
## Time-of-arrival test

- Used to determine a transient's direction of travel.
- Transients travel away from their source, at (nearly) the speed of light.
- We can monitor two locations and determine the direction to a transient source.

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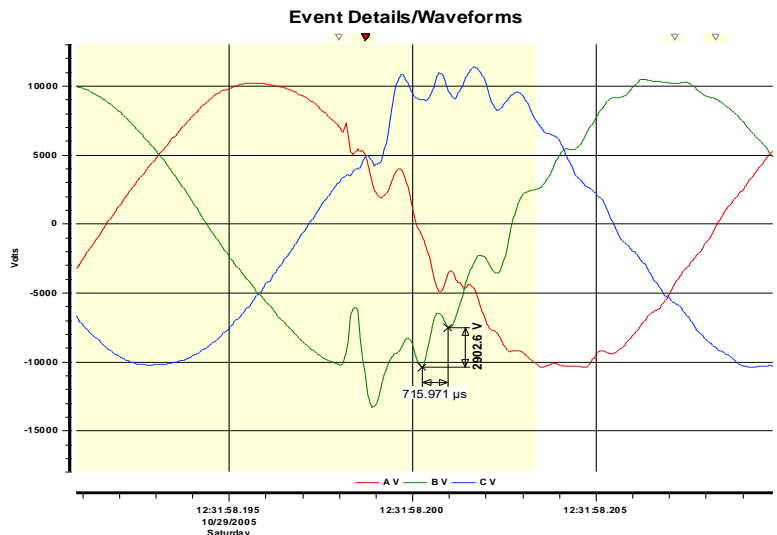
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# Time of arrival test



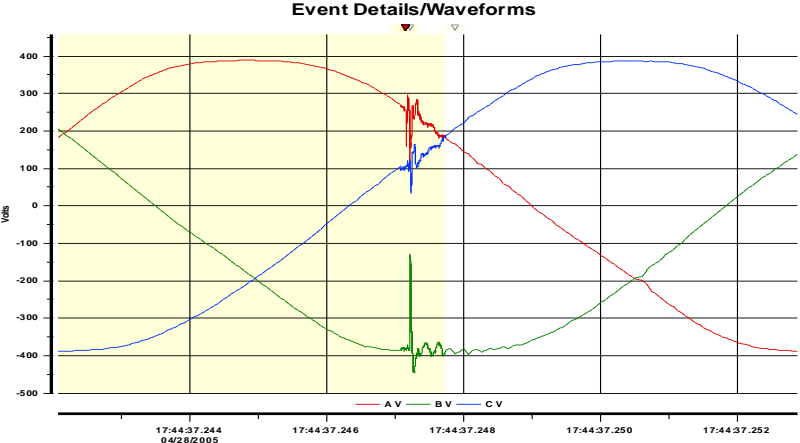
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# Some real transient waveforms



# Some real transient waveforms

## Load switching

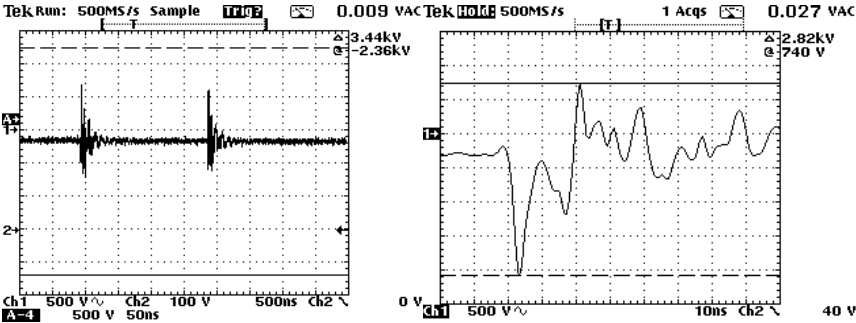


# Some real transient waveforms

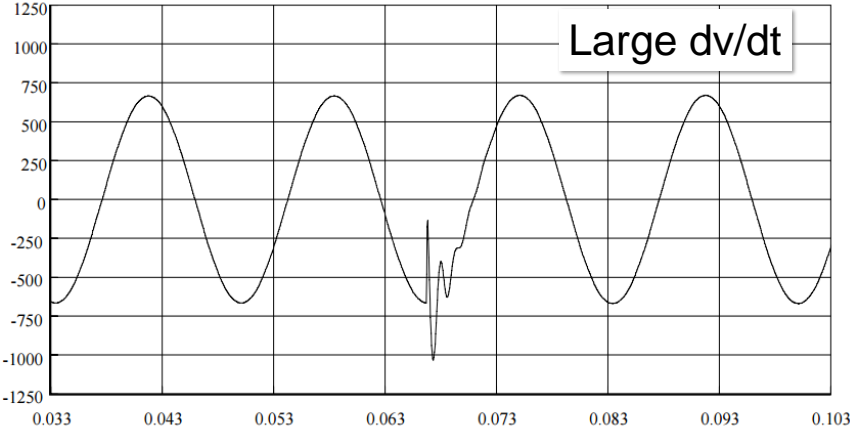
## Load switching

First try with oscilloscope

Adjusted oscilloscope and caught another transient

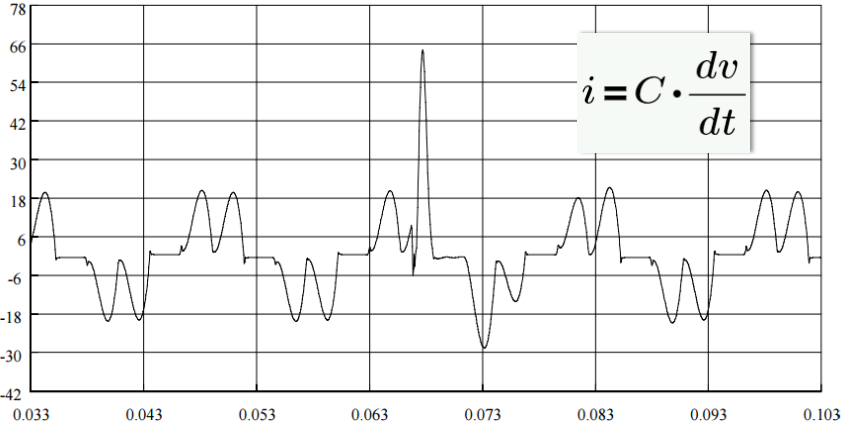


# Impact on loads Capacitor switching and ASDs



From: *Effects of Capacitor Switching and Load Switching on Power Quality* – Doug Dorr, EPRI 2009 Power Quality Workshop

# Impact on loads Capacitor switching and ASDs

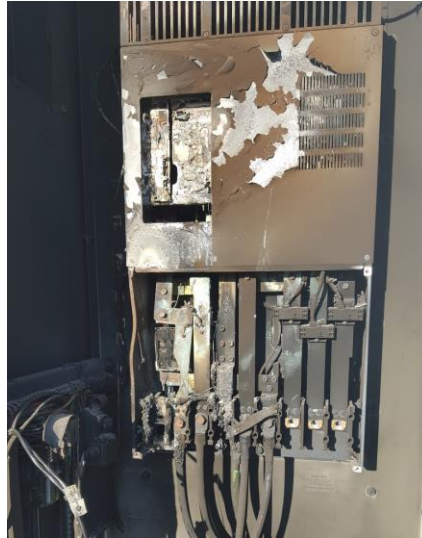


From: *Effects of Capacitor Switching and Load Switching on Power Quality* – Doug Dorr, EPRI 2009 Power Quality Workshop



## Impact on loads

- A few “symptoms”
  - Hard disk crash
  - Power supply failure
  - Component failure
  - SCR failure
  - Circuit board failures
  - Process interruptions
  - “letting the smoke out”



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## Next time

- Homework 3
- How transients travel
- Principles of protection

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