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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 25

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Today…

- Conclude Harmonics
  - Neutral loading
  - Interharmonics
  - Standards

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Harmonic filter tuned frequency

- Why pick 4.7 for a 5th harmonic filter?
  - Parallel resonant frequency will be slightly lower; around the 4th, an uncommon harmonic.
  - Component and system parameters may vary slightly without resulting in a short circuit at the 5th harmonic
  - Additional series inductance lowers both notch and parallel resonant frequencies; reduces harmonic current flow into filter from loads served through other transformers.

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Neutral conductor loading

- Triplen harmonics add in the neutral (PSQ p303)
  - Example: Assume 3rd harmonic current is 50% of the fundamental.
  - Three-phase system is perfectly balanced
  - Fundamental current is 100A.
  - RMS current based on fundamental and 3rd harmonic?
  - Neutral current due to 3rd harmonic?

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Interharmonics: Definitions (PSQ pg. 250)

- Harmonic: Integer multiple of the fundamental frequency
- Interharmonic: Non-integer multiple of the fundamental frequency
  - Sub-harmonic: frequency less than the fundamental frequency

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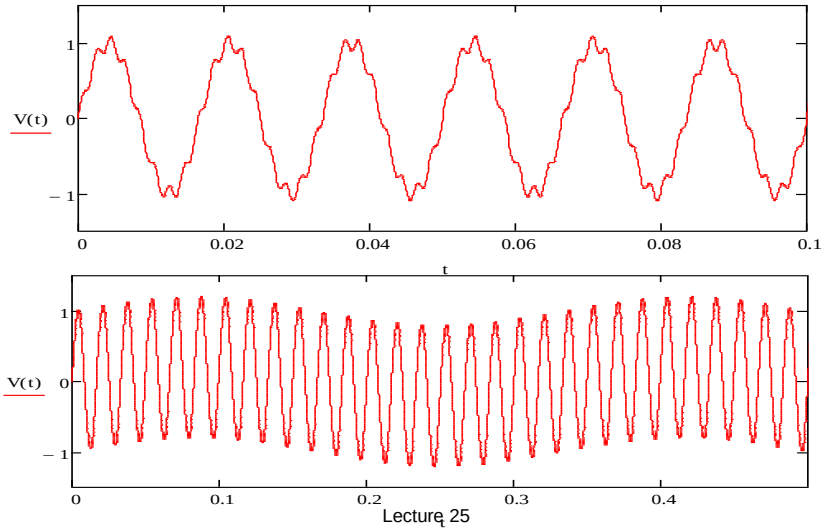
Interharmonics examples:



Sources of interharmonics

- Power-line-carrier signals
- Frequency converters
  - Drives
  - Cycloconverters
  - Induction furnaces
- Arcing loads
- Load variations

Interharmonics issues

- Analysis
  - Power quality instruments may not accurately measure them
- Impacts
  - Same heating and distortion issues as regular harmonics
  - Oscillations in mechanical systems
  - Interference with power-line-carrier systems
  - Tuned filters may not work because of the variability of the harmonic spectrum

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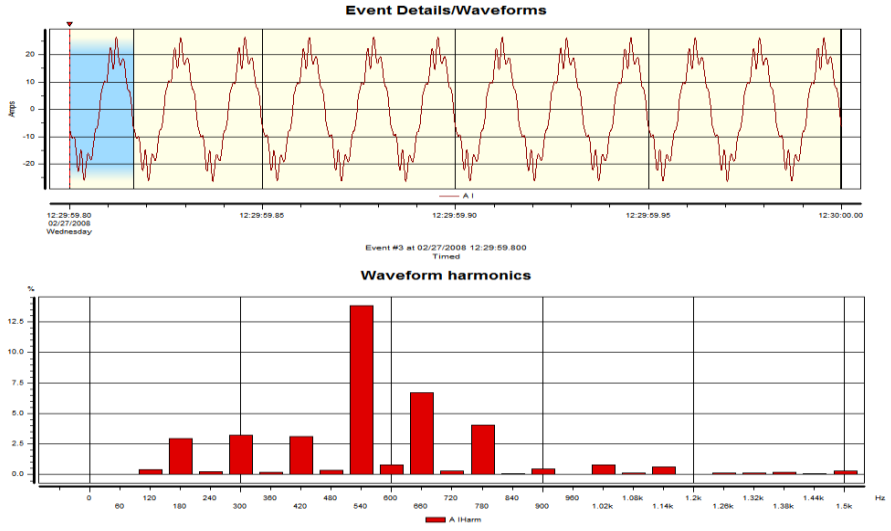
Interharmonics – data analysis issue, 1-60Hz cycle



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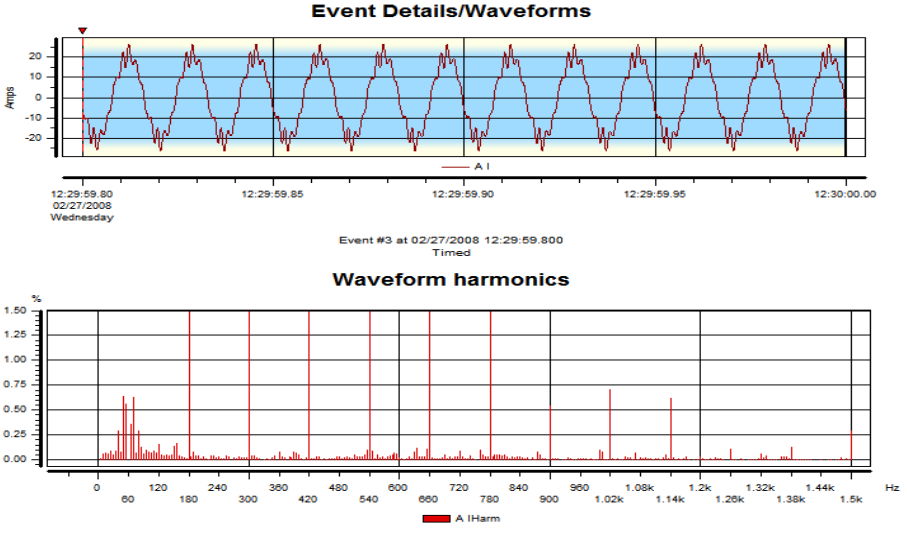
Interharmonics – data analysis issue



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Interharmonics – addressing issues

- Not all power quality instruments can measure interharmonics – check documentation
- Broadband low-pass filters or active filters are both effective at mitigating interharmonic distortion

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Why have harmonic (and other) standards?

- Compatibility between the power system and end-user equipment
- For utilities
  - Provides measurable limits that can be used as the basis for system design
- For equipment manufacturers
  - Describes the electrical environment the equipment may be expected to operate in
  - Helps manufacturers design equipment to operate acceptably

Harmonic standards

- IEEE 519-2014
- Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems
  - Requirements
    - Limits harmonic current produced by loads
    - Limits voltage distortion on the utility system
  - Reference material
    - Describes harmonic sources and impacts
    - Provides a list of other useful references
    - Describes interharmonic limits to to help control lamp flicker

Harmonic standards

- IEEE 519-2014/1992
  - Practices
    - Covers analysis methods for –
      - System frequency response
      - System modeling
      - Telephone interference
      - And more…
    - Covers measurements
    - Describes a methodology for evaluating new harmonic sources
    - Includes examples

The IEC standards (See PSQ pg. 313+)

- IEC – International Electrotechnical Commission
  - Main organization developing power quality standards for the international community
  - Standards may be adopted in individual countries

General IEC standard overview

- Six parts:
  1. General – definitions, terms
  2. Environment – description and characteristics
  3. Limits – Allowable disturbances caused by equipment
  4. Testing and measurement techniques – guidelines for measurement equipment and test procedures
  5. Installation and mitigation guidelines – application of filters, surge suppressors, etc.
  6. Generic and product standards – define equipment immunity levels

Other standards and standards-related work

- EN 50160 – "Voltage Characteristics Of Electricity Supplied By Public Distribution Systems"
  - Voltage at the PCC only
  - Addresses harmonics, sags, swells, etc.
  - Incorporated in newer power quality recorders
  - Describes 95% conditions
  - Operation at minimum requirements is not likely to be acceptable to customers.

Standards

- Standards are becoming more international – several IEEE standards reference IEC standards.
- IEEE Power Engineering Society Power Quality Subcommittee
  - Works to coordinate international power quality standards including harmonic standards
  - In some cases identical standards are issued from multiple organizations now
    - ANSI/ISA-61010-1 is practically identical to IEC 61010-1, CSA C22.2 No. 1010.1, and UL 61010-1

Next time…

- Start long-duration voltage variations