

ECE 528 – Understanding Power Quality

<https://webpages.uidaho.edu/ECE/power/ECE528/>

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Today...

- Final exam discussion
- Power quality instruments and analyzers
 - Issues associated with instrument location
 - Identifying the direction to a fault
 - General instrument and analyzer discussion

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Final discussion

- Due – May 12, 11:59 pacific time.
- Same rules as homework and midterm.
- Drafts accepted up to 48hrs before deadline.
- Show your work, cite your sources, state your assumptions if necessary, clearly identify your answers, and use appropriate units.

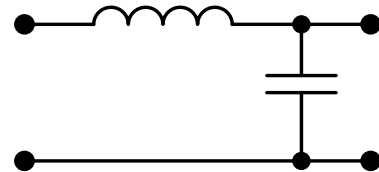
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How instrument location affects what is recorded

- Transients
 - System acts like an LC low-pass filter – attenuating high frequency signals
- Voltage sags
 - Current change can indicate if cause is upstream or downstream
 - Instantaneous power may make the sag direction more apparent

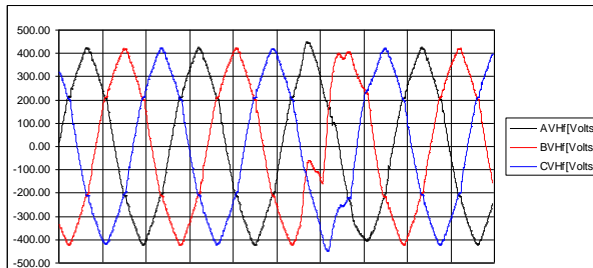


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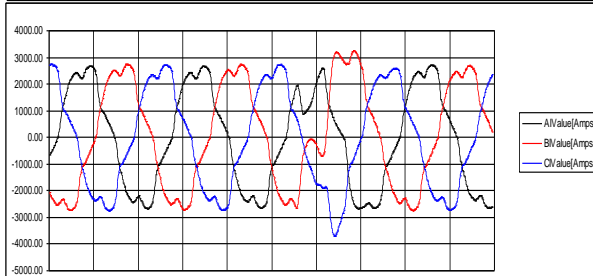
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Event direction?



Voltage

Did the voltage disturbance cause the current disturbance, or did the current disturbance (a change in the load) cause the voltage disturbance?



Current

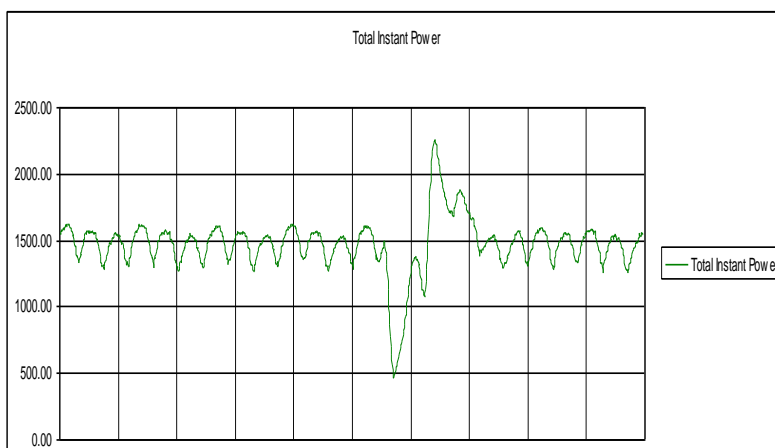
It's hard to tell.

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Event direction: Instantaneous total apparent power



Same event from previous slide.

The initial large drop in apparent power indicates an upstream event.

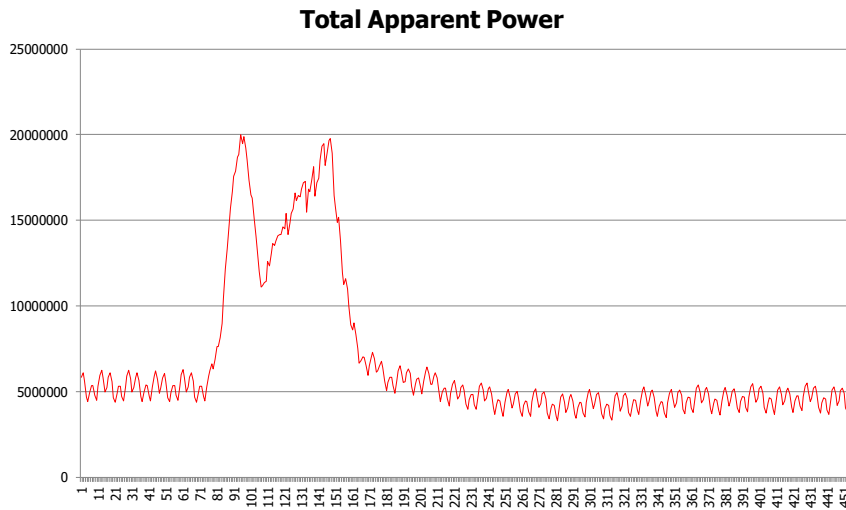
Instantaneous power climbs shortly afterwards as motors accelerate, and power supplies and drives recharge.

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Event direction?



Using what you know now, which direction is this event; upstream or downstream of the recorder?

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Choosing instruments and analyzers

- What do you need to know?
 - Basic electrical parameters
 - RMS voltage and/or current
 - Single-phase or three-phase
 - Waveforms of voltage and/or current
 - Waveforms of transient events – frequency?
 - Calculated parameters
 - Power
 - Imbalance
 - Harmonics / Voltage distortion

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Choosing instruments and analyzers

- How much do you want (or need) to know?
 - Spot measurements
 - Logging at specific intervals
 - Triggered events
 - Customizable triggers? – different parameters, magnitudes
 - Continuous recording
 - Memory issues – how long before data is lost
 - Usually, continuous monitoring (not recording) with periodic logging and triggering is used

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Basic instruments DMM: Digital Multimeter



- Single-phase, single parameter instrument
- **True RMS**
- May include built-in current clamp, or use external clamps
- Some models may have recording capability
- May measure other parameters
 - Frequency
 - Capacitance
 - Resistance
 - Crest Factor

Picture from Fluke Inc.

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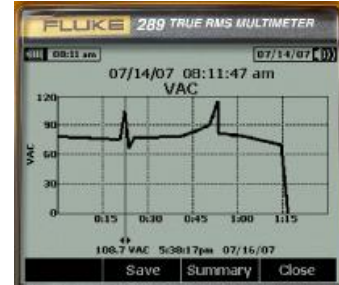
DMMs: More advanced functions



On-screen menus
and help



Recording



Plotting of recorded data

Data can be downloaded to a computer for
analysis and reporting

Pictures from Fluke Inc.

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The next step up: Handheld power quality analyzers

- Measures voltage and current simultaneously
 - Necessary for power values (W, VA, VAR, PF, etc.)
- Additional functions
 - Sags, swells
 - Transients
 - Inrush current
 - Harmonics - THD, individual harmonic magnitudes, etc.
 - Basic oscilloscope functions
- Some triggering and recording capabilities
- Will save data for analysis and reporting

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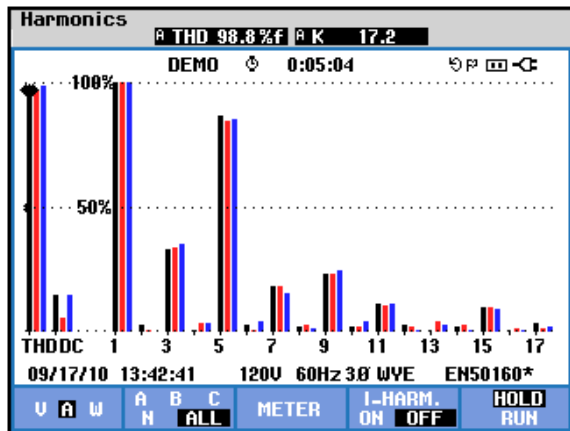
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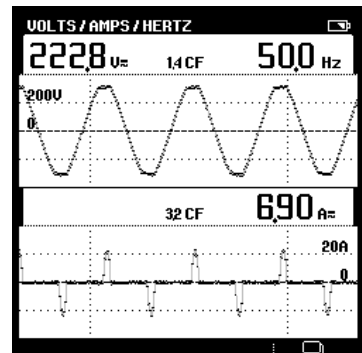
Handheld power quality analyzers

- Single-phase (2 – channel)
 - (1 voltage and 1 current channel)
- Three-phase (6-8 – channel)
 - (3-4 voltage and 3-4 current channels)
 - Adds automatic calculation of three phase parameters
 - Voltage imbalance, three-phase power, etc.
 - Connections become important
 - On-screen connection diagrams are helpful

Handheld power quality analyzers - Some function examples



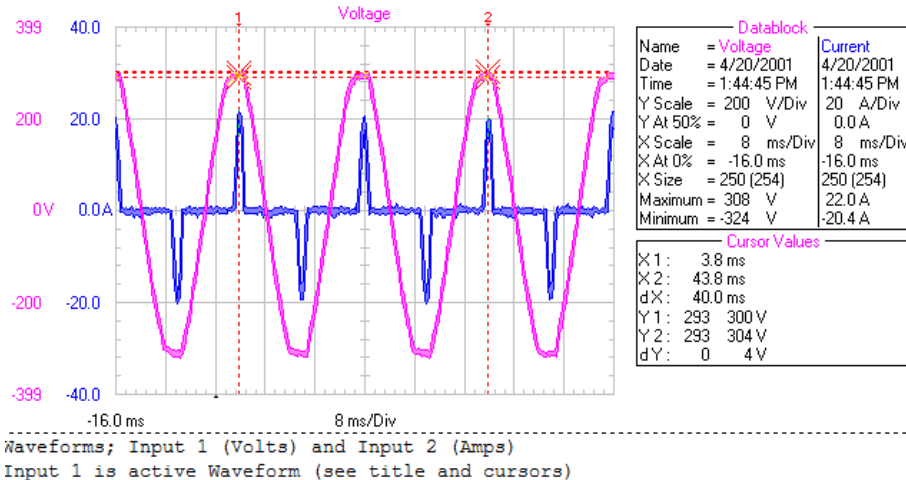
Three-phase harmonic current with THD and K factor



RMS voltage and current with waveforms

Pictures from Fluke Inc.

Handheld power quality analyzers Looking at the data with a computer



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Monitors and recorders - From basic to advanced

- Power Quality Monitoring (from the class PSQ text):
 - *The process of gathering, analyzing, and interpreting raw measurement data into useful information.*
- Unconventional power quality monitors
 - Any device or condition that changes in an observable way as a result of some power quality issue can provide useful data
 - Digital clocks, analog clocks, incandescent lamps, variable speed drives, computers, UPSs, irrigation control systems, etc., could all be considered basic power quality monitors

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Recorder features

- Basic recorder features
 - Logging of RMS voltage or current at specified intervals
 - No triggers – essentially just a digital strip-chart recorder
 - May record minimum and maximum values within an interval, but not specific duration data



Picture from AEMC.com

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Intermediate features

- Simple RMS voltage magnitude triggers
 - Record the time the RMS voltage left the normal bandwidth
- Automatic, internal triggers
 - Reduces installation time
 - Usually voltage triggering only
- Combined voltage channels
 - N-G, A-N, B-N, C-N
- These characteristics usually reduce the time it takes to install the recorder, but may also reduce the operator's options in conducting the investigation



Pictures from powermonitors.com

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Advanced features

Standard Distortion UserFreq Unbalance Advanced			
Basic		Volts	Amps
Comp Basic	A	120.3	30.07
Power	B	120.3	30.07
Demand	C	120.3	30.07
Energy	D	9.986	10.02
Harmonics	A-B	209.3	*
Flicker	B-C	209.3	*
	C-A	206.3	*

* Derived values

Exit



Pictures from dranetz.com

- Highly customizable triggers
 - Triggering on multiple parameters
 - Triggering on parameters besides voltage or current
- Fully-independent voltage channels with individual ranges
 - Monitor multiple voltages simultaneously including DC
- On-board display and controls with real-time data display while recording continues
 - Allows the recorder to also serve as a meter or handheld analyzer

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Permanent recorders

- Recorders can be installed permanently as stand-alone devices or incorporated in revenue metering.
- Permanent recorders provide continuous, year-round monitoring of the power system at multiple locations
- Data is automatically uploaded to a server and can be viewed via the network or internet.



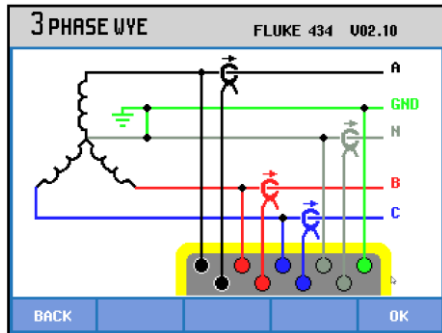
Picture from Schneider Electric – ION8650

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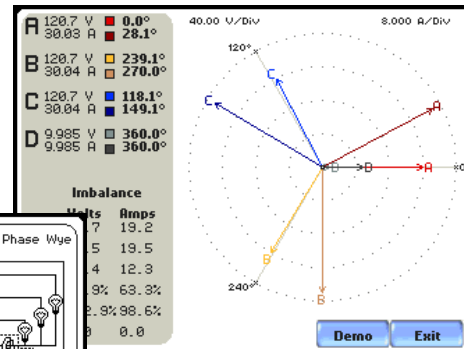
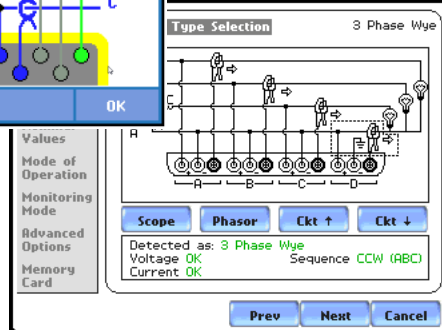
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A few other useful features



Connection diagrams



Phasor display

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What does your instructor use?

Note, this is not a recommendation or testimonial; these are just tools I use and am familiar with. There are other options.

- DMMs
 - Fluke 87V, 189, 289
 - An assortment of current probes
- Current clamp meters
 - AEMC 512
 - Fluke 360
- Oscilloscopes
 - Fluke 190-204 (4-channel, 200MHz)
- Ground Impedance tester
 - AEMC 6417
- Handheld PQ Analyzers
 - Fluke 43B, 434
- PQ Recorders
 - Power Monitors Inc. Eagle-440, Socket recorders, Eagle 120, "Revolution" with cell-modem, "Guardian" with cell modem
 - Dranetz PX5
 - PowerLogic ION 8650 permanent meters at large customers and similar at substations
- Infrared Camera
 - Flir E60 with 15mm lens (for overhead connections from the ground)

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Some less common tools:

- UV camera
 - Corona
 - Arcing connections
- Radio Frequency Interference tools
 - Receiver – Radar Engineers 243
 - Parabolic dish w/ultrasonic mic
 - Flir Ultrasonic Imager
 - Assorted antennas
- Sound meter
 - TSI Quest SP-DL-2
- Stray and contact voltage tools
 - An assortment of long leads, shunt resistors, copper plates, and probes
 - SVM-10 Stray voltage recorder (Power Monitors Inc.)

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Next time

- More on instruments
 - Deciding what to record and where
- Safety

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