Electrical Power Measurements with LabVIEW

Why Measure Power?

Facilities/Utilities

Machine Health

White Goods Testing

Agenda

1.) The Basics

- Power and Energy
- Voltage and Current

2.) Measuring all the above

3.) Common Power Features

What do we think of when we think of measuring power?

Two Measurements Needed for Power

Voltage Current

$$P = V * I$$

The Electricity / Water Analogy

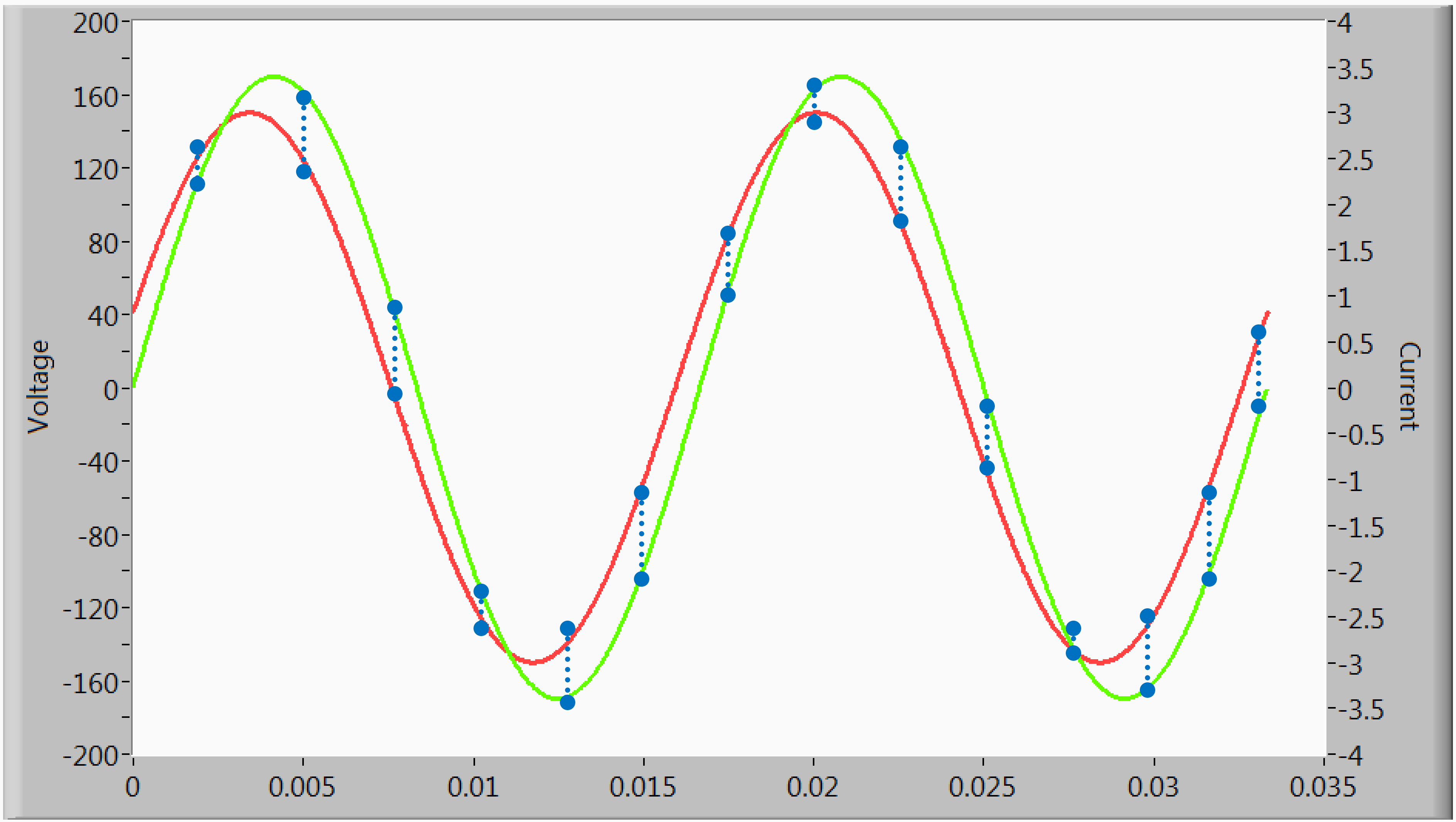
Current = flow rate of water
(Amps)

Voltage = water pressure
(Volts)

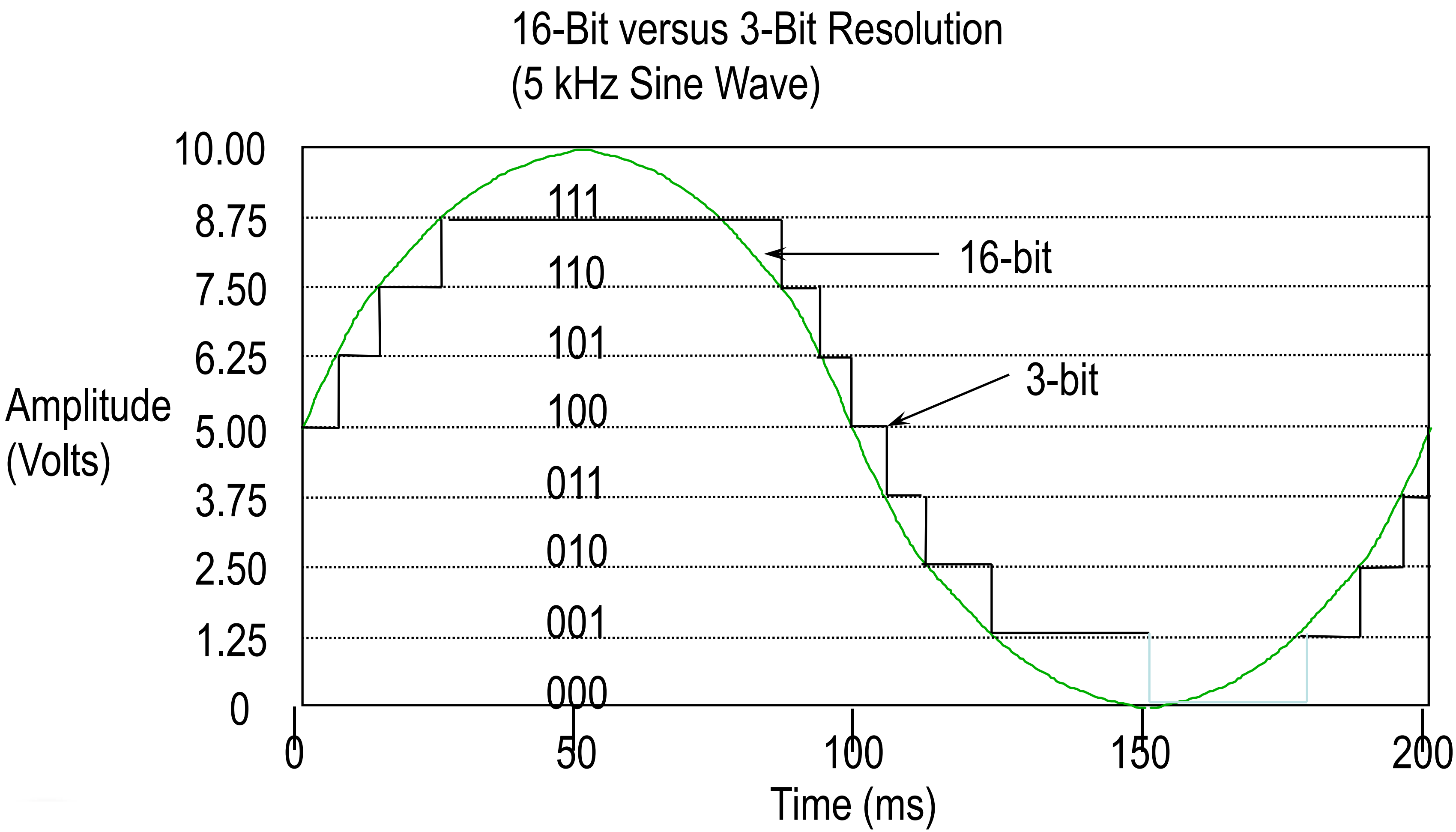
Instrumentation Considerations

- Simultaneous acquisition
- Resolution
- Sample rate

Synchronization



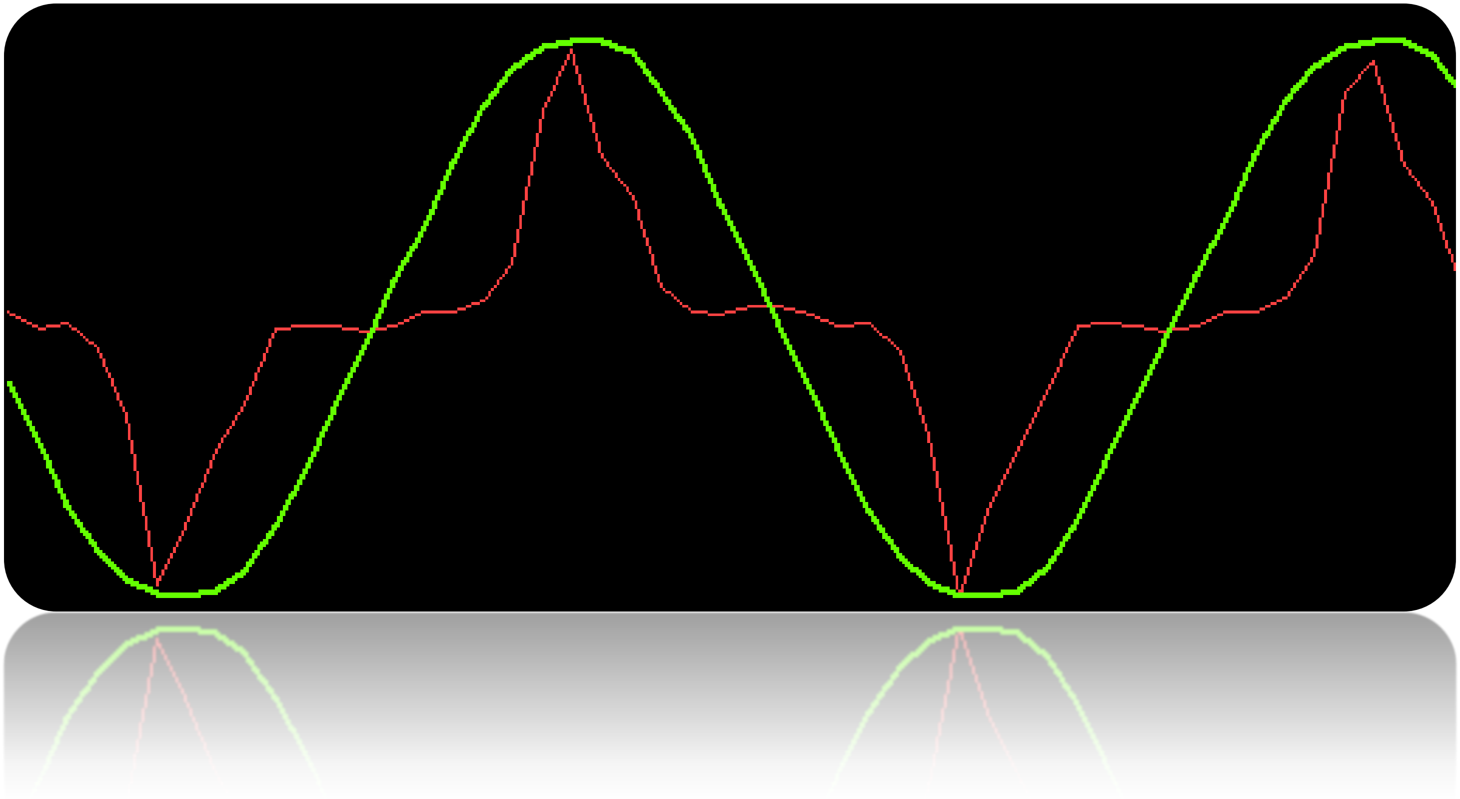
Resolution



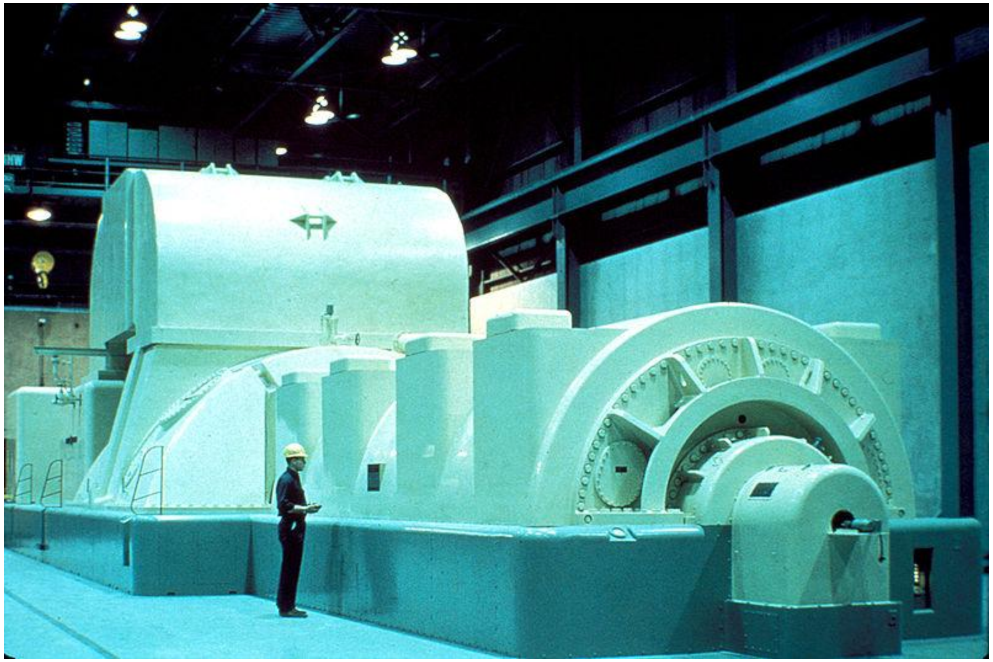
16-Bit versus 3-Bit Resolution
(5 kHz Sine Wave)
Amplitude
(Volts)
10.00
8.75
7.50
6.25
5.00
3.75
2.50
1.25
0
111
110
101
100
011
010
001
000
16-bit
3-bit
0
50
100
150
200
Time (ms)


VOLTCRAFT®
M-3850
0.385
V
ON/OFF
FUNCTION
SET/RESET
UP
DOWN
FREQ
CAP
hFE
TEMP
TEMP (ROOM)
LOGIC
AUTORANGE DMM
FUSED
20A
mA
VOLTCRAFT®

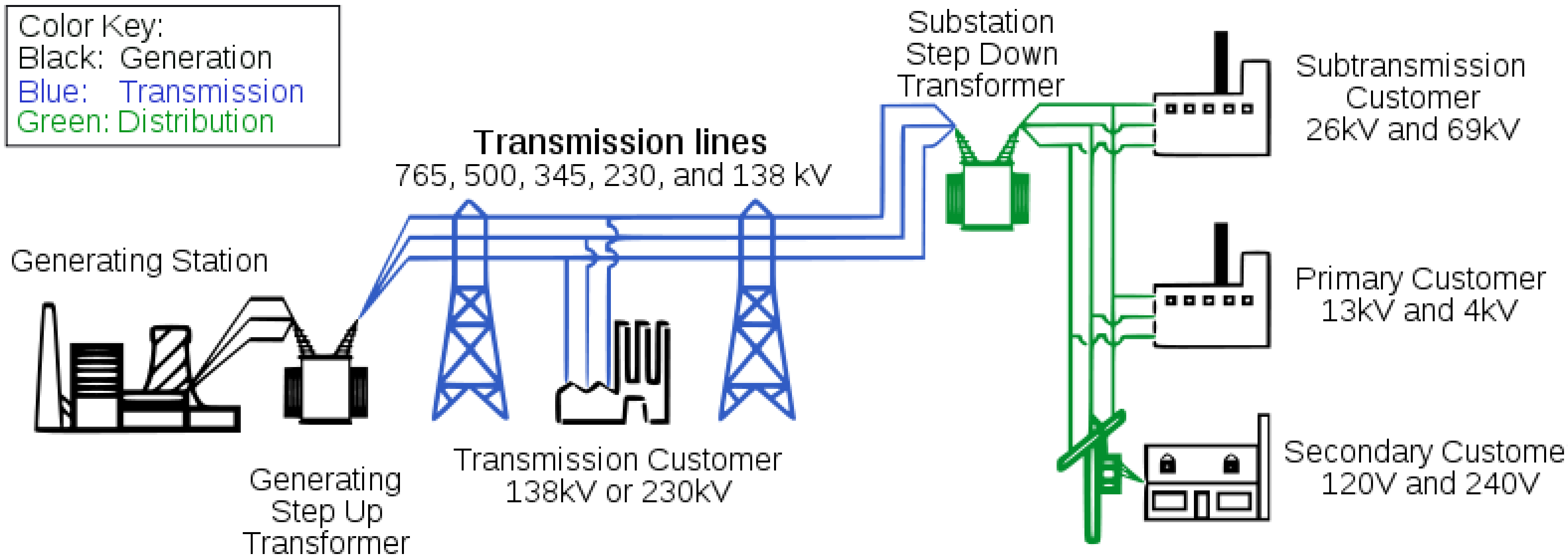
Measuring Waveform Data



Turbine Generators



Power Transmission



Power Quality Demo

The Grid

The power strip represents a small grid.

Power Measurement System

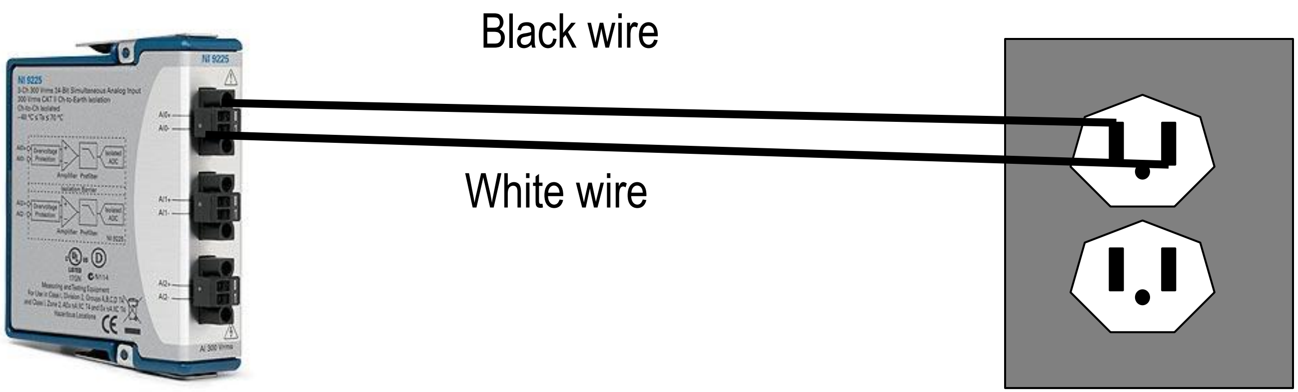
NI 9225
(300 V_{rms})

NI 9227
(Amps)

Expansion

Synchronize with:
- Temperature
- Control/Output
- Vibration
- Rotational Speed

Voltage Measurement

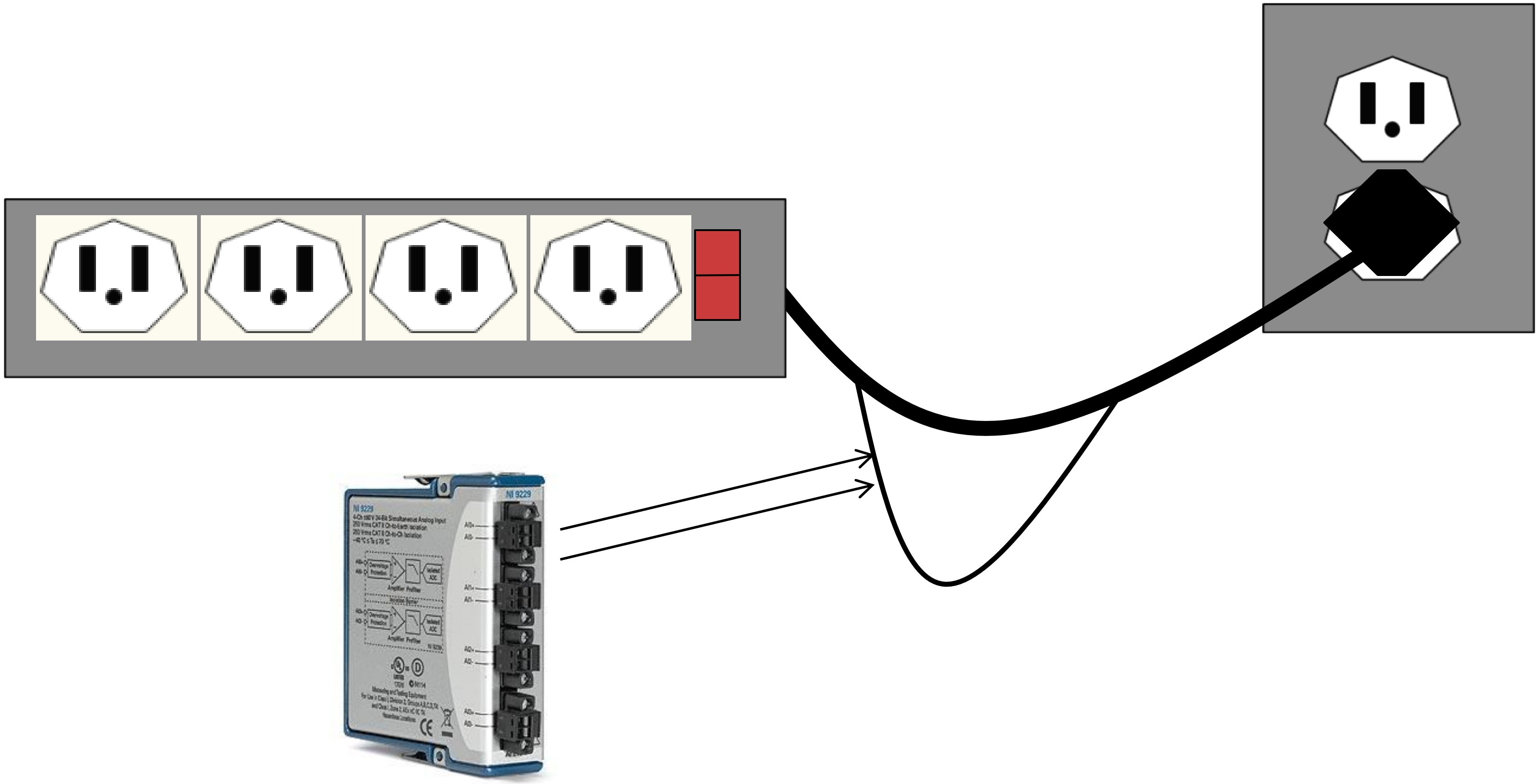


NI 9225

"Grid"

Connection made using spliced power cord

Current Measurement

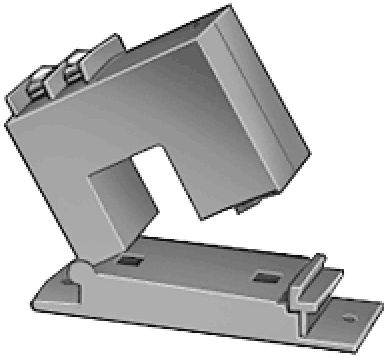


NI 9227*

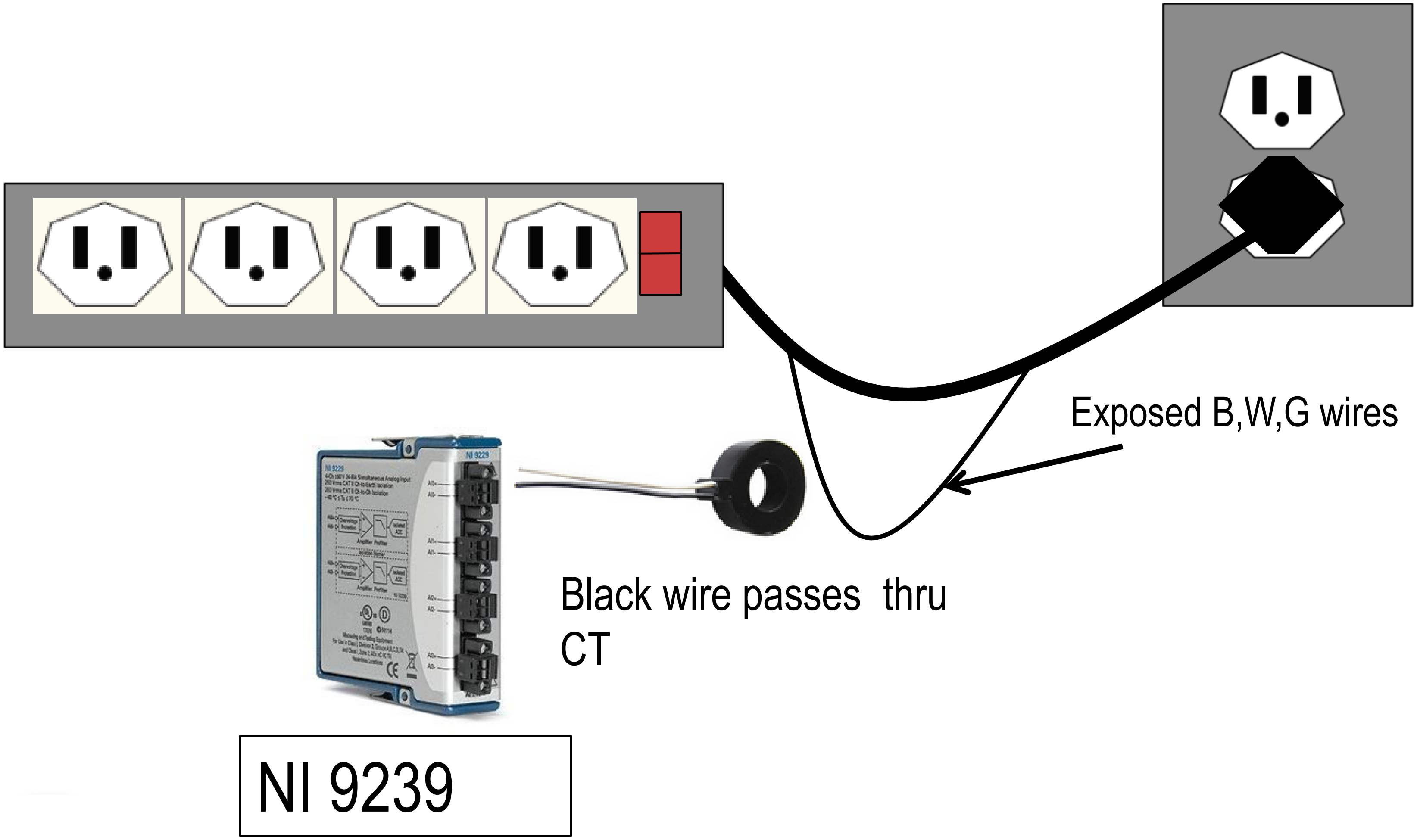
Transformers & Transducers

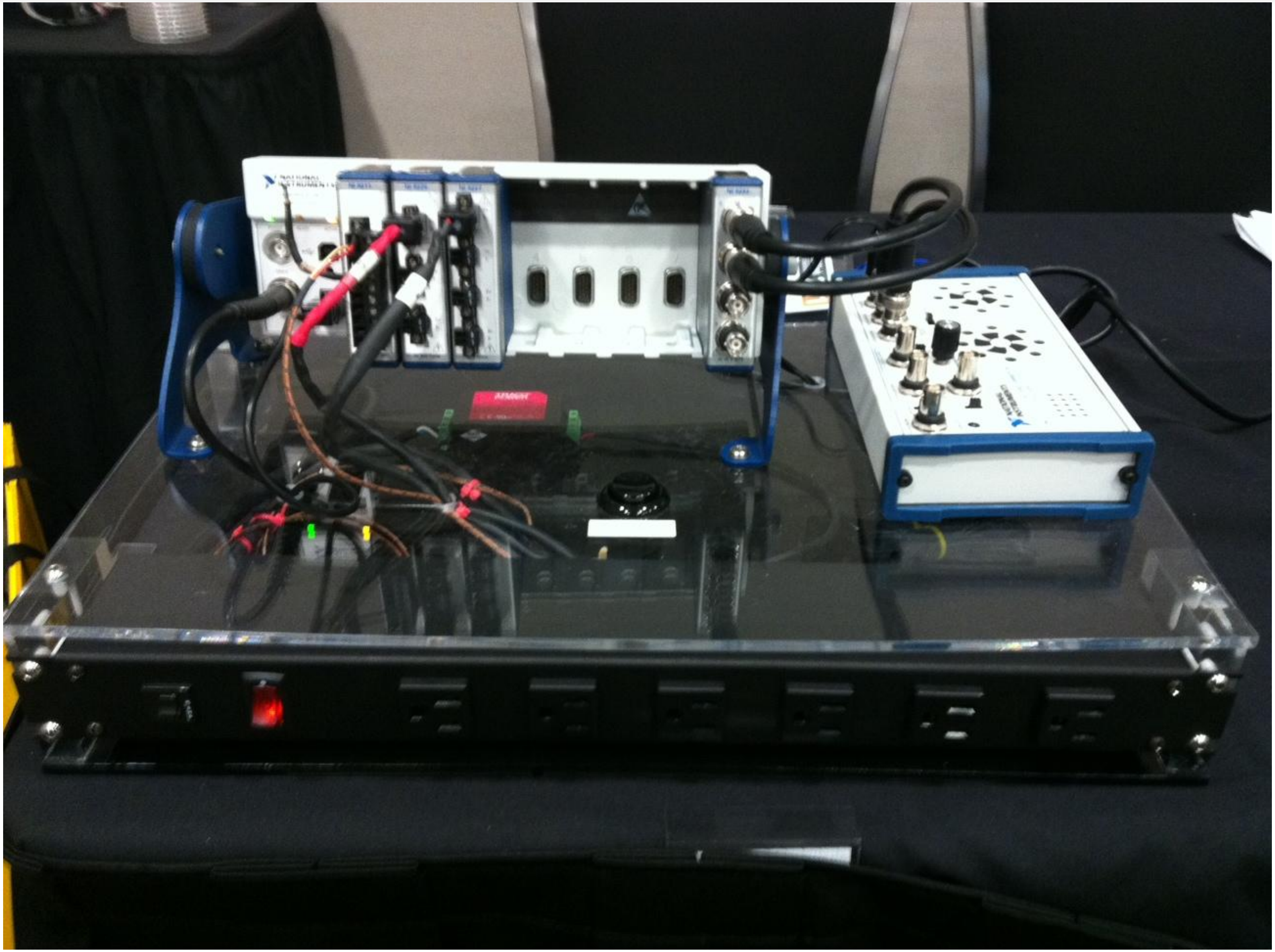
Current or Voltage

- Output voltage or current
- DC or high frequency
- Split or solid core
- Mount or handheld

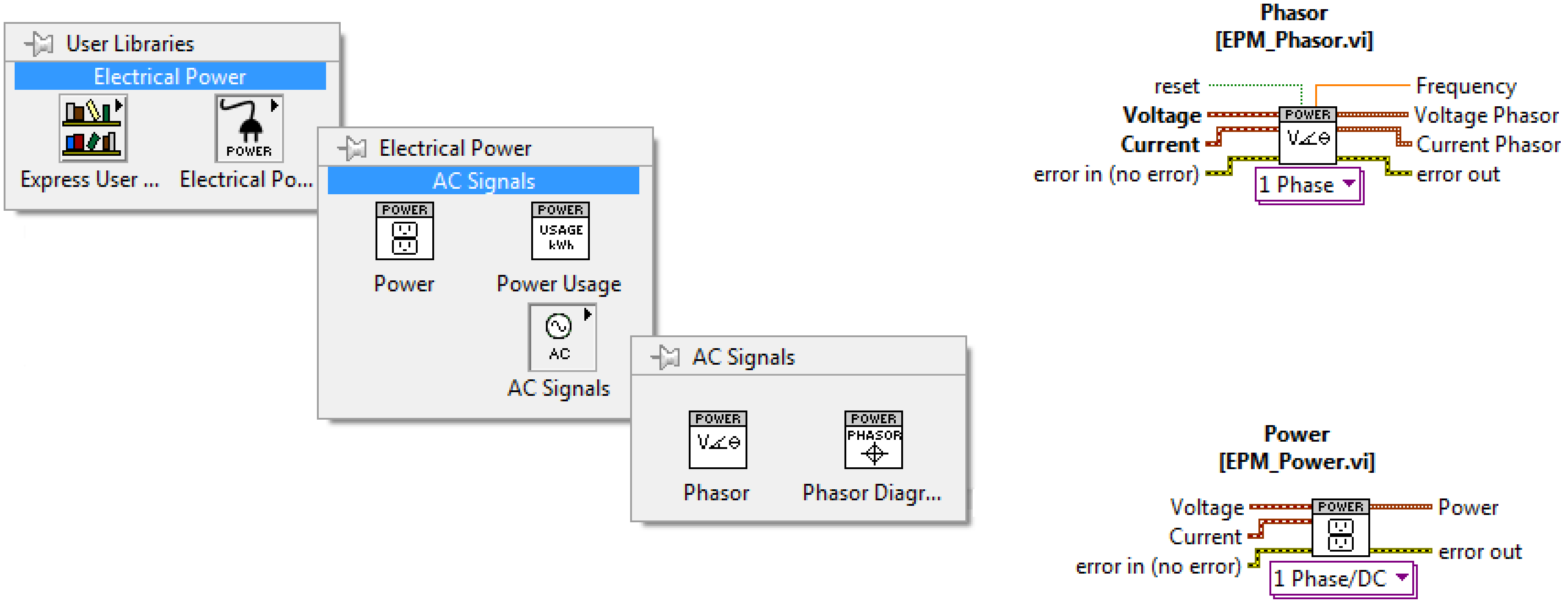


Current Measurement





EPM Palette for LabVIEW



CompactRIO Getting Started

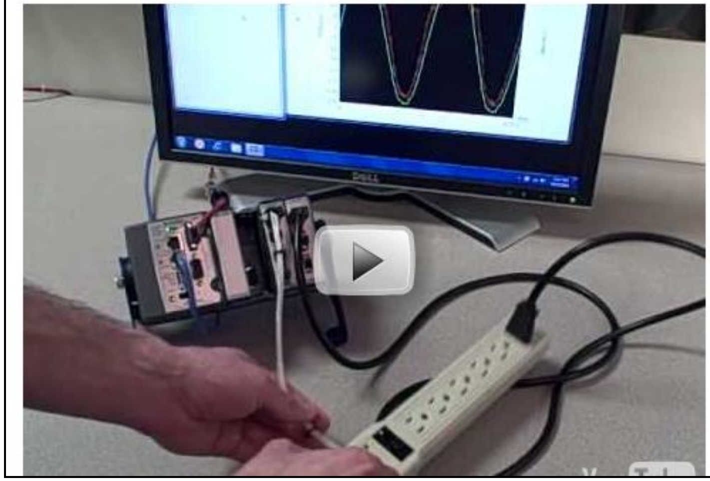
How to Get Started with the Power Monitoring Starter Kit for NI CompactRIO

Print | PDF　　6 ratings | **5.00** out of 5

Overview

This how to guide will walk you through the hardware and software setup of the Power Monitoring Starter Kit for NI CompactRIO. This starter kit uses LabVIEW 2009, and the LabVIEW Real-Time and LabVIEW FPGA modules. The parts list below contains the complete list of hardware used in this starter kit.

Table of Contents



Parts List

Go to My Lists　　Print/Export List

Power Quality Monitor Starter Kit for CompactRIO

Save a copy of this list so that you can edit and fully customize it to meet your own needs.

Selected Items: Instant Quote

Product	Qty	Line Total
cRIO-9024, Real-Time PowerPC Controller for cRIO, 800 MHz 781174-01 | $ 3,999 | Ships in 1 - 2 days.	1	$ 3,999
cRIO-9111, 4-slot Virtex-5 LX 30 Reconfigurable Chassis for cRIO 780915-01 | $ 999 | Ships in 1 - 2 days.	1	$ 999
NI 9225 3-Ch +/-300V Analog Input 780159-01 | $ 1,499 | Ships in 1 - 2 days.	1	$ 1,499
NI 9227 4 ch current input, 5Amp, ISO, 50k, 24bit 781099-01 | $ 999 | Ships in 1 - 2 days.	1	$ 999

NATIONAL INSTRUMENTS

You have waveforms, now what?

Features

- Voltage, Current, Power
  - Instantaneous
  - RMS
- Peak-Peak
- Crest Factor
- Fundamental Frequency
- Power Factor
- Power (reactive, apparent, real)

Events

- Sag
- Swell
- Interruption
- Flicker


VOLTCRAFT®
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FUNCTION
SET/RESET
UP
DOWN
FREQ
CAP
hFE
TEMP
TEMP (ROOM)
LOGIC
AUTORANGE DMM
FUSED
20A
mA
VOLTCRAFT®

RMS (Root Mean Square)

AC Equivalent of DC

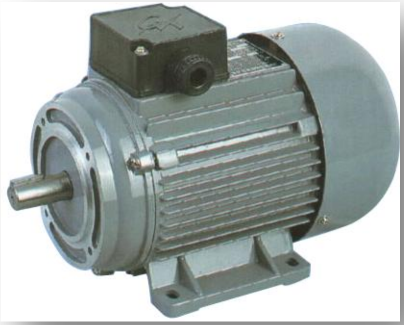
3 Common Ways to Calculate

- True RMS
- Peak
- Average

Equation (True)

$$x_{\mathrm{rms}} = \sqrt{\frac{{x_1}^2 + {x_2}^2 + \cdots + {x_n}^2}{n}}.$$

Types of Electrical Loads

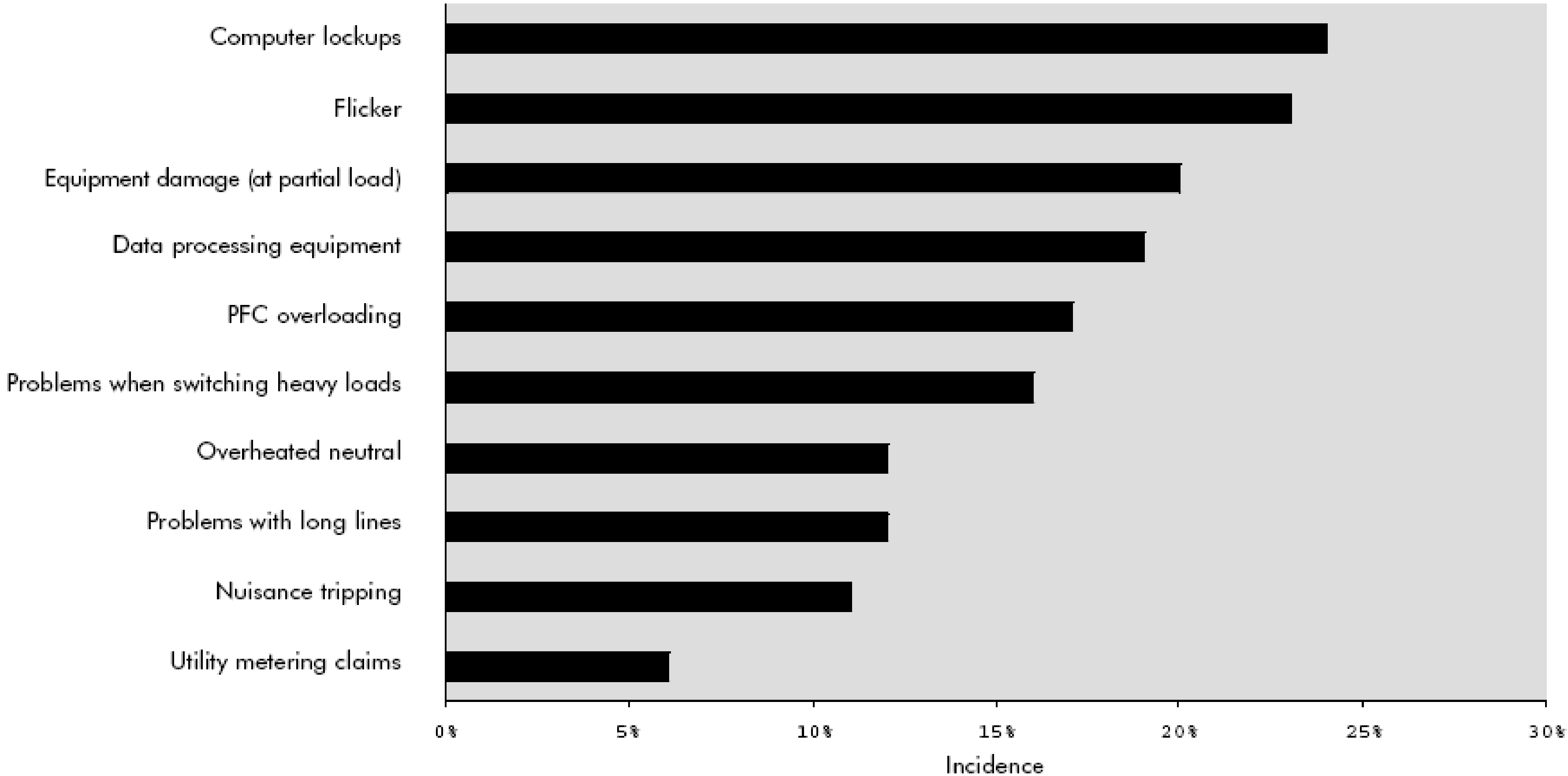
Resistive	Inductive	Capacitive
		
In Phase	Lagging Phase	Leading Phase

Power Quality Events

phenomena defined in IEEE 1159:1995

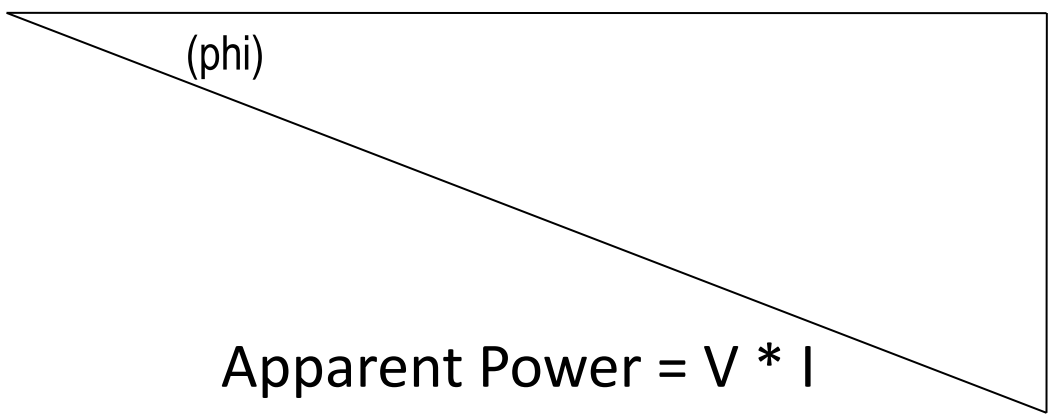
Categories	Typical spectral content	Typical duration	Typical voltage magnitude
1. Transients			
1.1. Impulsive			
1.1.1. Nanosecond	5 ns rise	<50 ns	
1.1.2. Microsecond	1 µs rise	50 ns–1 ms	
1.1.3. Millisecond	0.1 ms rise	>1 ms	
1.2. Oscillatory			
1.2.1. Low frequency	<5 kHz	0.3–50 ms	0–4 p.u.
1.2.2. Medium frequency	5–500 kHz	20 µs	0–8 p.u.
1.2.3. High frequency	0.5–5 MHz	5 µs	0–4 p.u.
2. Short-duration variations			
2.1. Instantaneous			
2.1.1. Sag		0.5–30 cycles	0.1–0.9 p.u.
2.1.2. Swell		0.5–30 cycles	1.1–1.8 p.u.
2.2. Momentary			
2.2.1. Interruption		0.5 cycles–3 s	<0.1 p.u.
2.2.2. Sag		30 cycles–3 s	0.1–0.9 p.u.
2.2.3. Swell		30 cycles–3 s	1.1–1.4 p.u.
2.3. Temporary			
2.3.1. Interruption		3 s–1 min	<0.1 p.u.
2.3.2. Sag		3 s–1 min	0.1–0.9 p.u.
2.3.3. Swell		3 s–1 min	1.1–1.2 p.u.

Typical PQ problems



The Power Triangle
Mathematical Analogy

Real Power = V * I cos (ϕ)
[Watts]

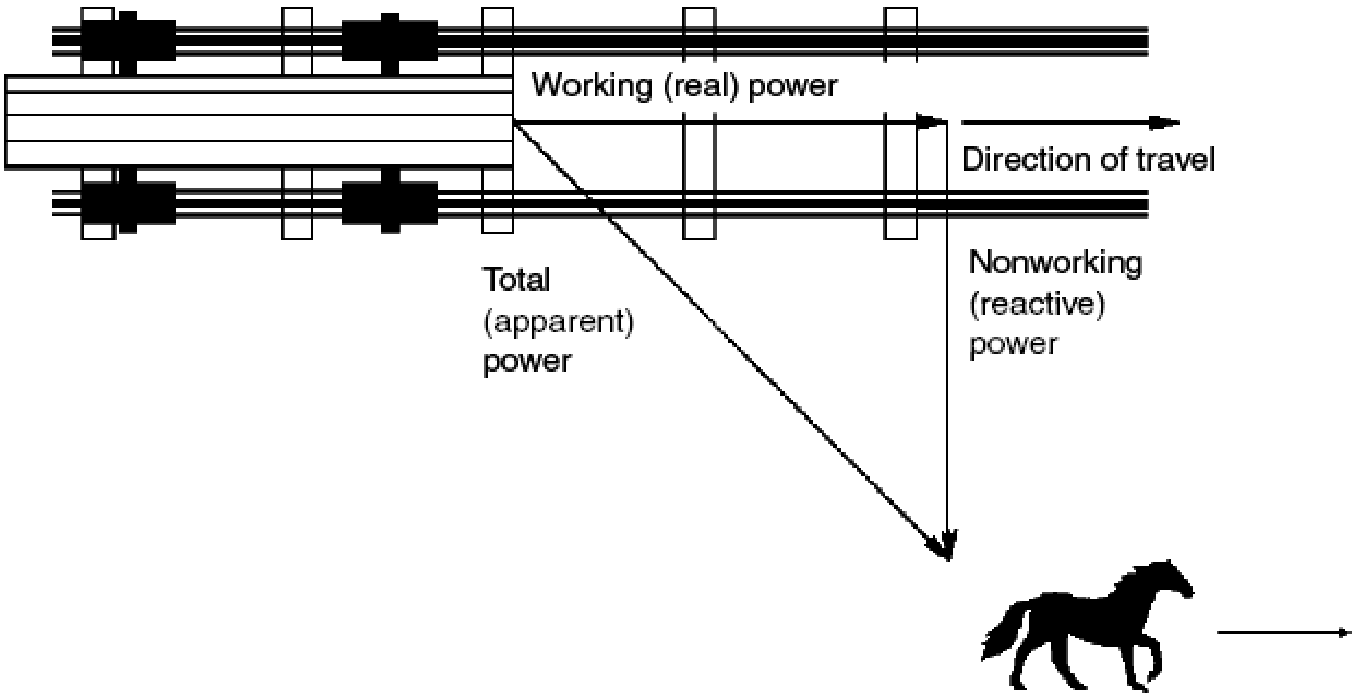


Reactive Power
[Var]

Apparent Power = V * I
[VA]

The Power Triangle

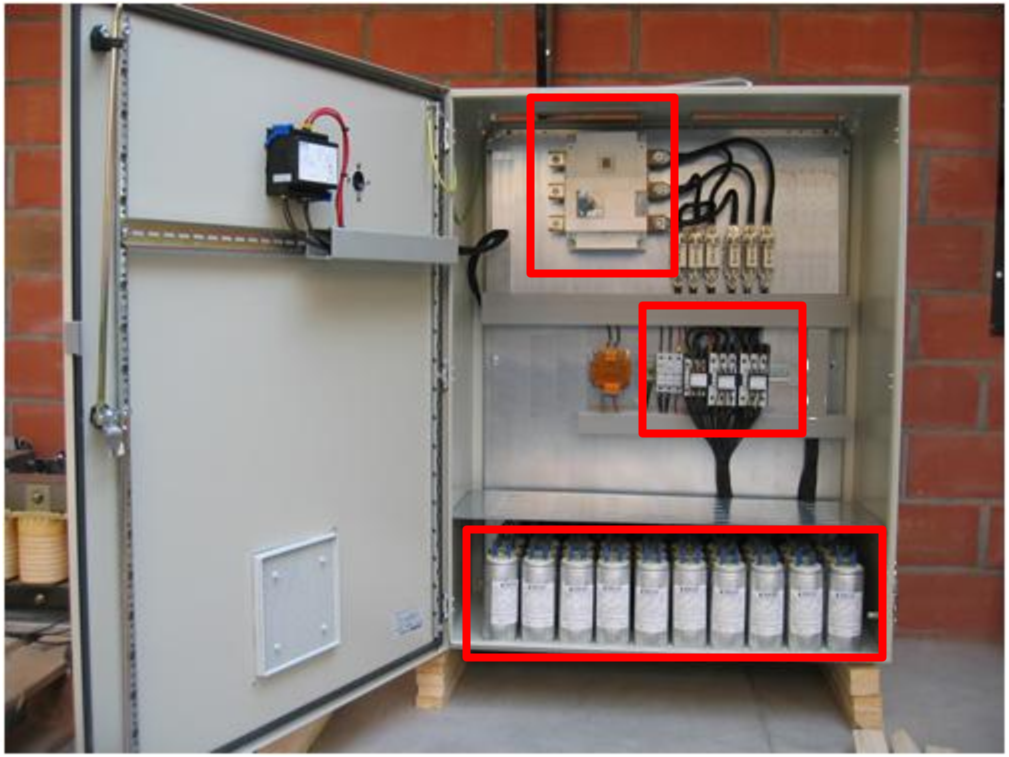
Mechanical Analogy



$$\text{Power Factor} = \frac{\text{Real Power}}{\text{Apparent Power}}$$

PFC

Circuit Connection



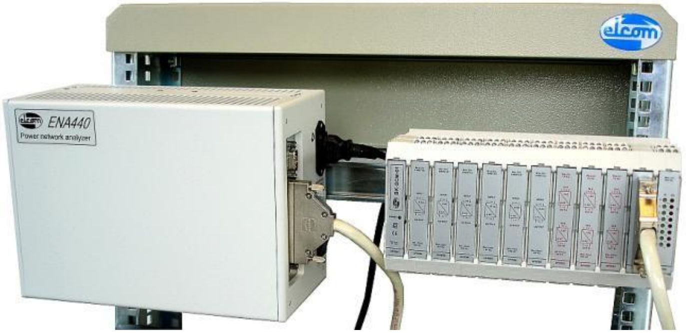
Contactors “Relays”

Bank of Capacitors

Example Power Monitors

ENA450

ENA460



ENA440

All PQA are compliant wit IEC 61000-4-30 class A

Up to Date Portable PQ Analyzers

ENA330

ENA500

All PQA are compliant wit IEC 61000-4-30 class A

Power Monitoring Software

ENA-Touch, ENA450 User Interface

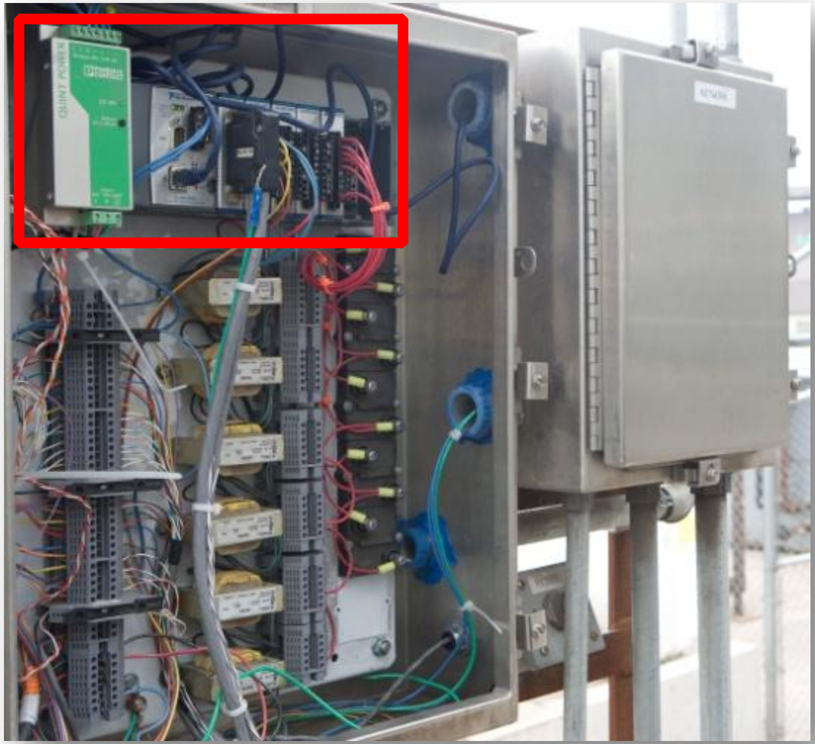
Single Board RIO Technology

Case Study: Nucor Steel Corporation

- One of the largest steel producers in the US, and the largest recycler
- Implemented grid power monitoring
  - Acted on grid power information
  - Saved money and pollution

Monetary fines can be significant.

Nucor Power Monitoring Station



Questions