

*Welcome To:*

# **AEMC® Instruments**

Understanding & Logging  
Electrical Power & Energy

We'll start at 11:00 AM EST

**AEMC ONE SOURCE®**  
For All Your Electrical Test & Measurement Instruments

# AEMC<sup>®</sup> Instruments

## Understanding & Logging Electrical Power & Energy

Mark Gutekunst, Mid Atlantic Sales Engineer

# AEMC® Instruments

## Training Webinars

- Bi-monthly webinar subjects include;
  - Testing Insulation Resistance
  - Remote Power Monitoring and NEC 220.87
  - Introduction to Power Quality
- In-person & On-line Understanding Ground Resistance Testing training – see AEMC website for times and costs
- Private training seminars – ask your AEMC Sales Engineer for more information.

## What is Electrical Energy

- Electrical Energy is what powers all our electrical devices. The use of this energy is metered by electrical utilities and measured in Watt-hours (Wh), This is what you get billed for.

## Power vs. Energy

- Power and Energy are related, but different
- Power – measured in Watts and is rate of how much electrical energy a device instantaneously consumes.
- Energy – measured in Watt-hours, is the accumulated use of power over time



## Power vs. Energy

- When a 100 watt light is turned on:
- It begins to draw current from the utility.
- If the light stays on for an hour, the utility bills you for 100 Watt-hours
- If the light only stayed on for  $\frac{1}{2}$  an hour, the utility bills you for 50 Watt-hours.

## Power vs. Energy

- In a Single Phase System, a pair of voltage leads (L1 and Neutral) are used to monitor the voltage and 1 CT (Current Transducer) is used to monitor the current.
- In Split phase systems, 3 voltage leads are used (L1, L2, Neutral) to monitor the voltage and 2 CT's are used to monitor the currents.
- In 3 phase / 3 wire systems, 3 voltage leads (L1, L2, L3) and used to monitor voltages and 1 or 2 CT's are used to monitor currents.
- In 3 phase / 4 wire systems, 4 voltage leads (L1, L2, L3, & Neutral) are used to monitor voltages and 3 or 4 CT's are used to monitor currents.

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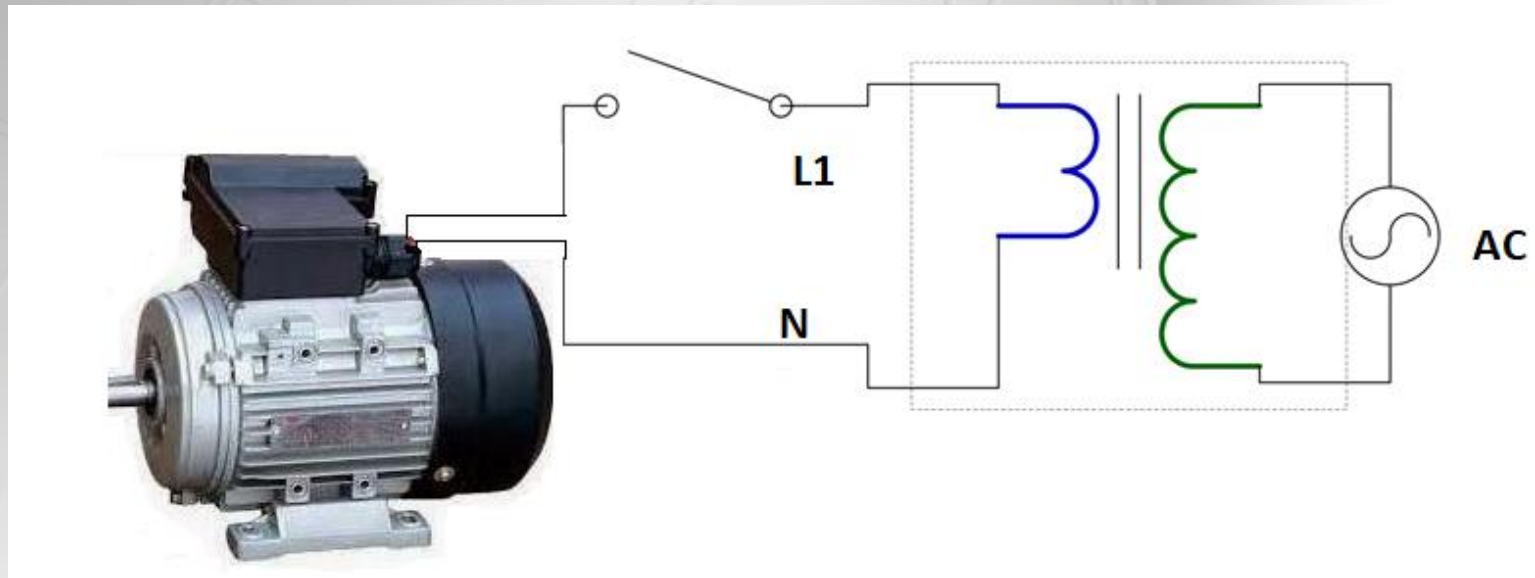
## Why Would You Want To Record Energy

- Energy is what our utility bills us for (in addition to other things such as PF, Peak Demand, Harmonics, etc.)
- Energy is always one of the most significant operational costs of any facility.
- Lowering Energy usage reduces operating expenses.
- Using energy efficient devices or turning off unused devices can significantly reduce energy usage and therefore operating costs.
- **KEY: YOU NEED TO KNOW WHAT IS BEING USED BEFORE YOU CAN PLAN WHAT TO DO**

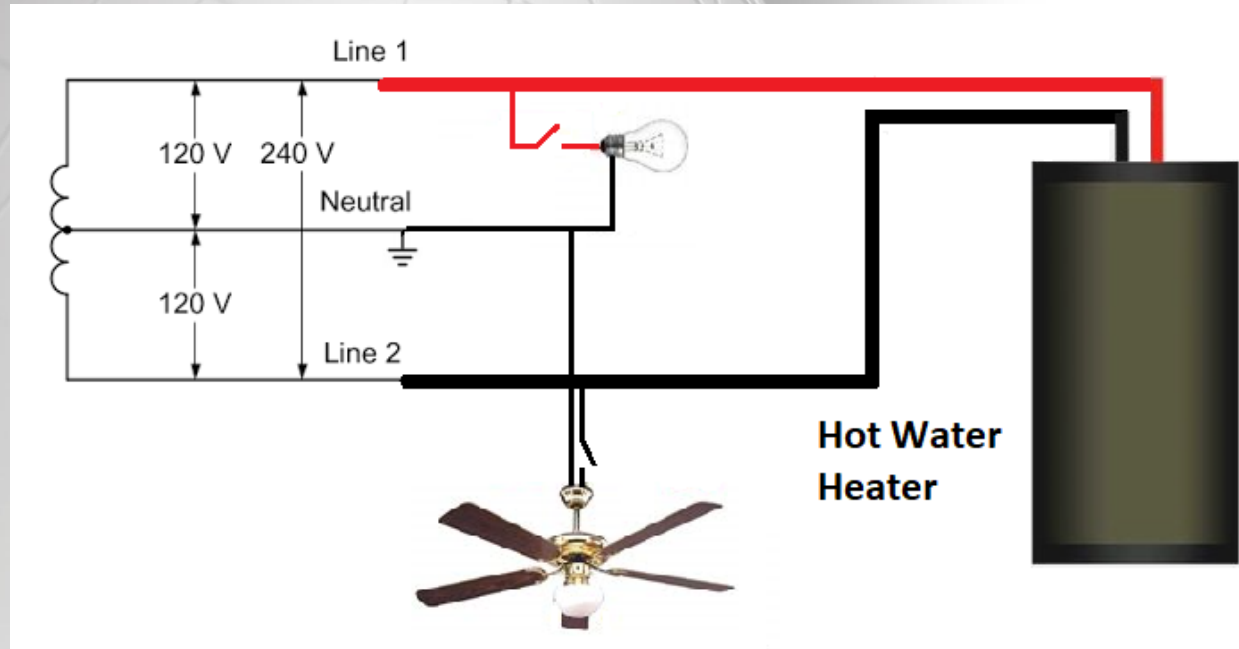
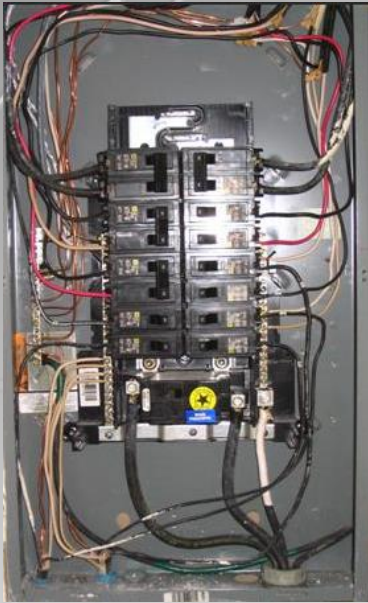


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## Let's Look a Single-Phase System



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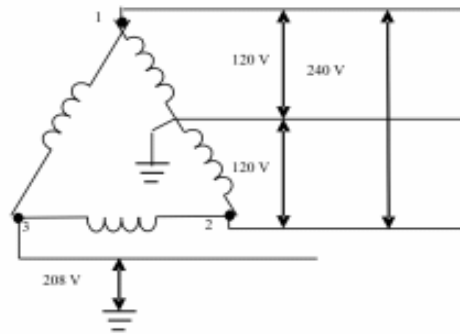
This is the type of power system used in residential structures

## Split Phase System

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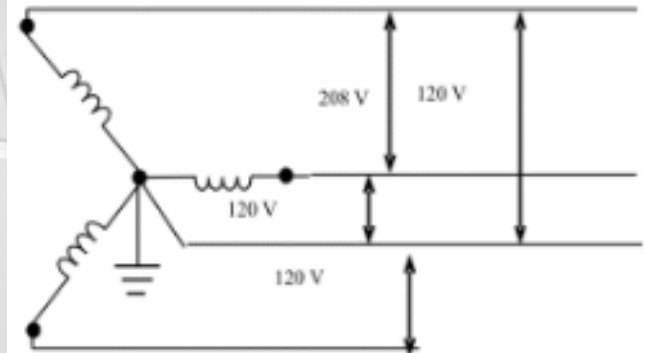


Figure 3. Three-Phase 120/240V Delta

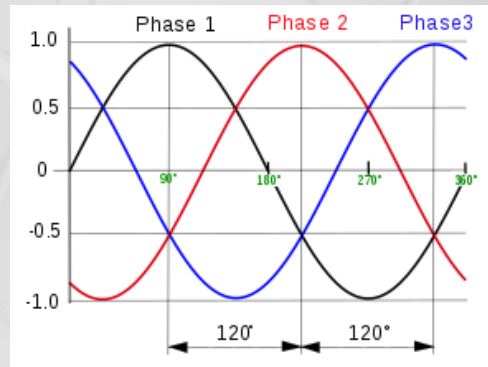


DELTA

Figure 1. Three-Phase 120/208Y



WYE



## 3 Phase Systems

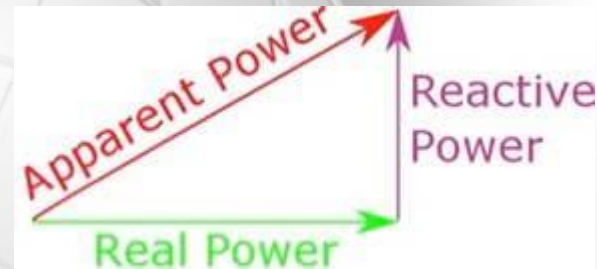
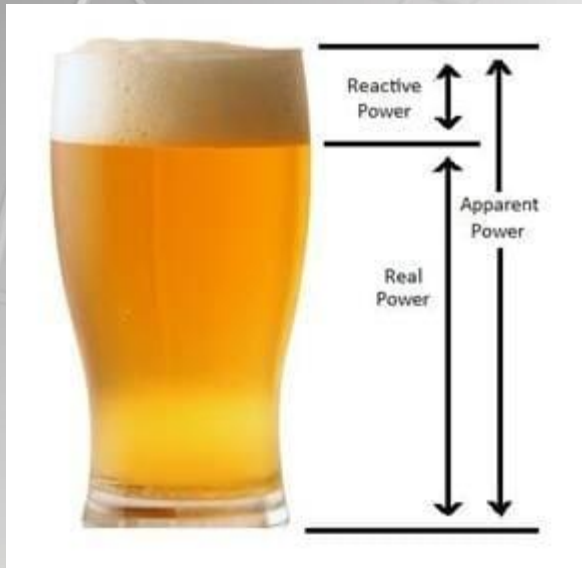
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## Types of Power

- **Apparent Power** - VA - Volts x Amps, power grid must be able to supply
- **Real Power** - Watts - Volts x Amps x  $\cos \theta$ , energy consumed by resistive load
- **Reactive Power** - VARS - Volts x Amps x  $\sin \theta$ , energy stored in the inductor or capacitor



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A famous analogy is made with the glass of beer and the froth of the beer. Real power is what you end up drinking. The glass is the apparent power and must be large enough to contain liquid and froth.



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## When The Load is Resistive

- Devices like incandescent light bulbs
- Phase angle  $\Theta$  is 0 degrees and  $VA = \text{Watts}$ ,
- **Real Power equals Apparent Power**
- Power Factor = 1
- All energy is converted to work

## When The Load is Inductive

- Devices like Motors, Transformers
- Phase Angle  $\Theta$  increases from 0 to as much as 90 degrees
- Real Power, Watts will drop while Apparent Power, VA stays constant.
- As Phase Angle  $\Theta$  increases so does Reactive Power, VARs
- In Inductive devices, the current lags the voltage, and which causes a lagging Power Factor

*...Which many utilities bill you extra for*

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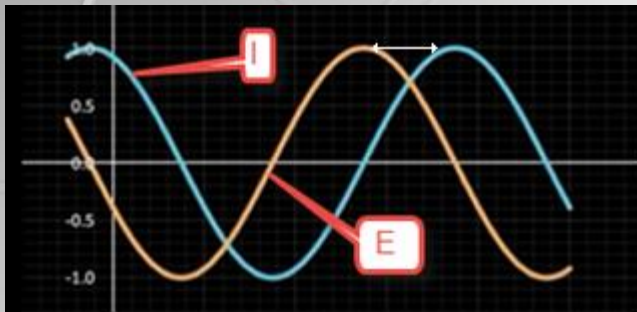
## When The load is Capacitive

- Devices like Computers, LED lights
- Phase Angle  $\Theta$  increases from 0 to as much as 90 degrees
- Real Power, Watts will drop while Apparent Power, VA stays constant
- As Phase Angle  $\Theta$  increases, so does Reactive Power, VARs
- In this case, the current leads the voltage, and we would have a leading Power Factor

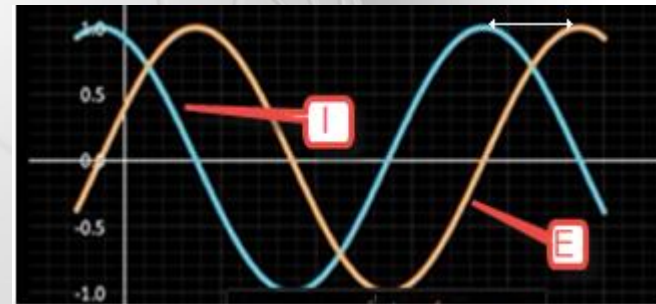
*...Which many utilities bill you extra for*

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## The Electricians' Friend ELI the ICE Man



In an inductive circuit the  
Voltage leads the Current (ELI)



In a capacitive circuit the  
Current leads the Voltage (ICE)



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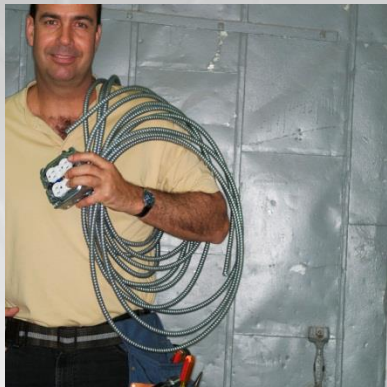
## How do I measure & log power, what do I need?

- Device capable of measuring required phase voltages and phase currents: single to 3 phase
- Capable of measuring True RMS
- Memory to record Power over time frame required
- Real time clock to record Time of Day (TOD)
- Report Generation capability included
- Suitable for required CAT (voltage impulse) rating
- Weather consideration: interior or exterior



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## Who Uses Energy Loggers



- **Electrical Contractors**
- **Design Engineers**
- **Electric Utility Technicians**
- **Plant Maintenance Staff**
- **Field Service Technicians**
- **Consultants**

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## Why is CAT Rating so important???

Category	Description
CAT I	At the signal level parts of electronic equipment
CAT II	At local level environment, Portable equipment appliances
CAT III	At an interior, fixed installation distribution level of AC main power
CAT IV	Outside of a building, main power line at service level

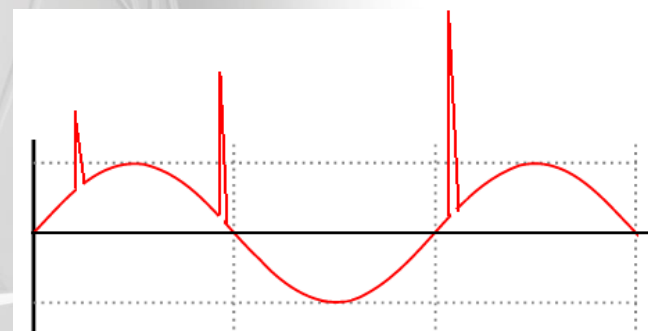
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## WHAT IS CAT IV Rating???

Test instruments are rated on their ability to withstand a voltage impulse, which is applied through a specified level of resistance (See table).

The ratings are broken down by categories — CAT I, II, III, and IV.

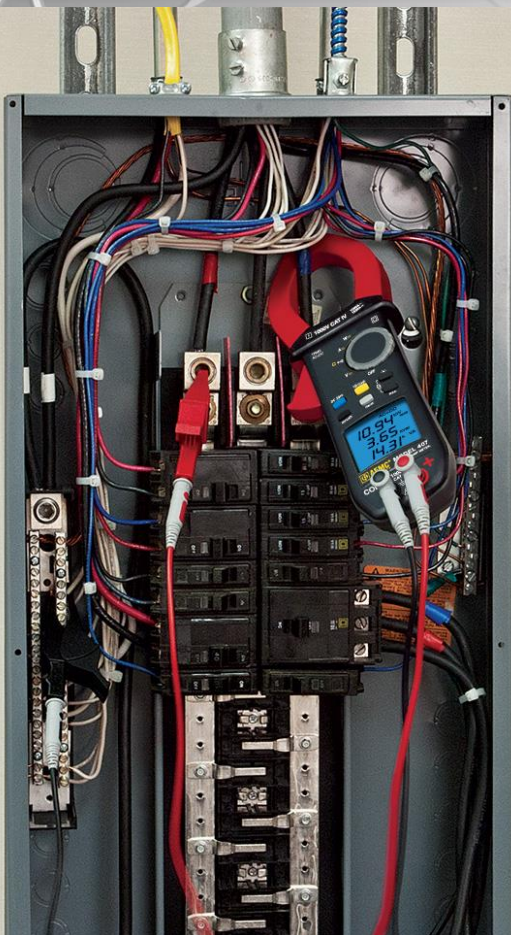
Rated voltage	IEC 61010-1 2nd Edition			UL 61010B-1 (UL 3111-1)		
	CAT IV	CAT III	CAT II	CAT III	CAT II	CAT I
150V	4,000V	2,500V	1,500V	2,500V	1,500V	800V
300V	6,000V	4,000V	2,500V	4,000V	2,500V	1,500V
600V	8,000V	6,000V	4,000V	6,000V	4,000V	2,500V
1,000V	12,000V	8,000V	6,000V	8,000V	6,000V	4,000V
Resistance	2 ohms	2 ohms	12 ohms	2 ohms	12 ohms	30 ohms



CAT IV-rated test instruments are designed for testing on the primary supply source, which also includes 120V or 240V overhead or underground lines that power detached buildings or underground lines that power well pumps. The CAT IV rating covers the highest and most dangerous level of transient overvoltage electricians encounter when working on utility service equipment like exterior transformers

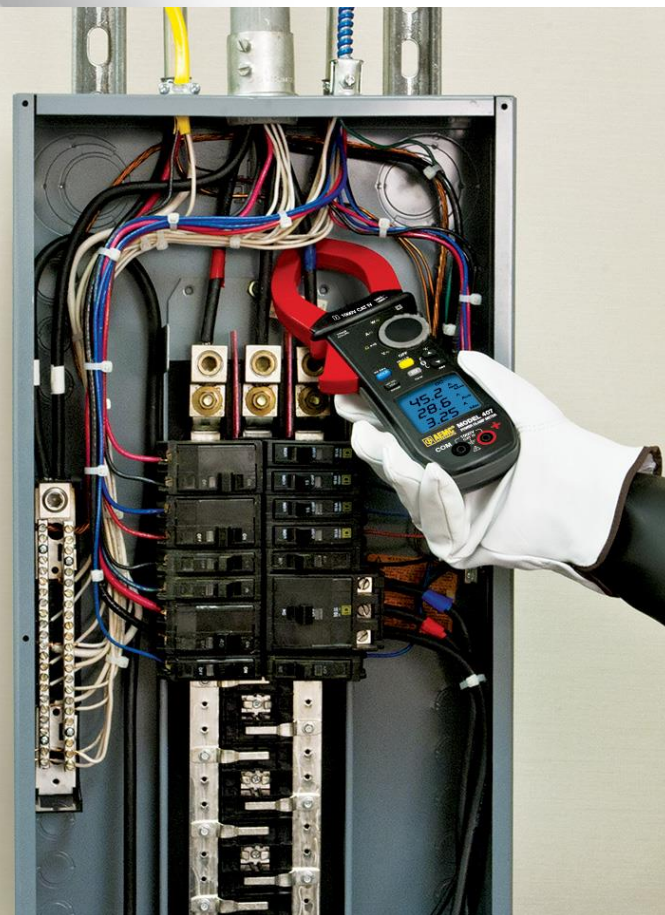


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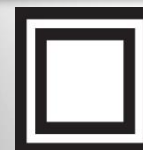
Use as a traditional  
clamp meter

Use as a wireless  
communicating  
power meter



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## Models Series



### 400 series

Models 401 and 403 are general purpose measures to 1000VAC/1400VDC and 1000AAC/(model 403)1500ADC  
Models 405 and 407 also measures Power and Harmonics

MSRP: \$309 to \$489

### 600 series

Models 601 and 603 are general purpose measures to 1000VAC/1400VDC and 2000AAC/(model 603)3000ADC  
Models 605 and 607 also measures Power and Harmonics

MSRP: \$411 to \$560

The models 407 and 607 can record and employ Bluetooth communication for Report Generation

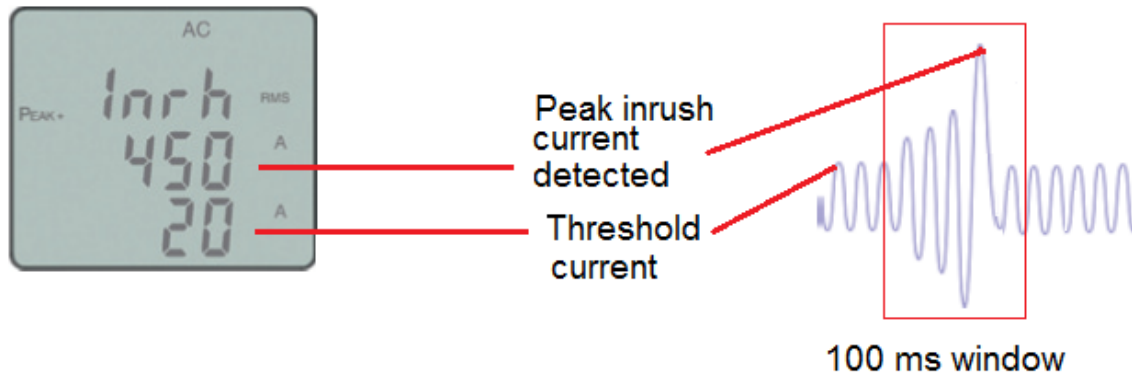
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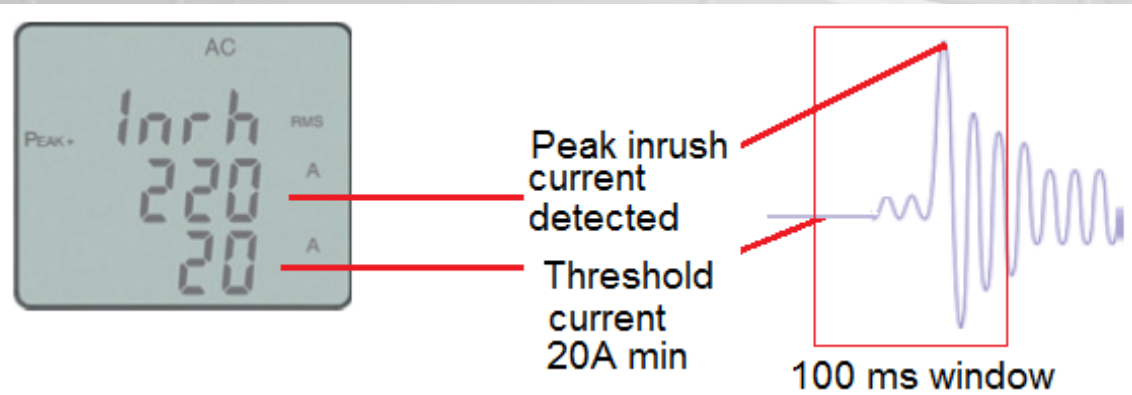


Inrush captured on an operational circuit




- Automatic threshold detection (20A minimum)
- Programmable deviation detection from 5 to 200%
- 100 ms sample duration for calculation

Inrush captured on start up



# AEMC® Instruments

## AEMC Clamp-On Overview

- ✓ Up to 1000V CAT IV rated
- ✓ 2000 Amp AC 3000 ADC
- ✓ AC+DC measurement (can measure ripple on a DC signal)
- ✓ IP54 rated
- ✓ Measures real, apparent and reactive power to 3 MW with 1W resolution with 1 and 3 phase display
- ✓ 40 to 70 and 400Hz fundamental reference for harmonic measurements
- ✓ Bluetooth communication (model 407, 607)
- ✓ Stores up to 1,000 measurements with user programmable storage rates
- ✓ InRush measurement with 1mS response time and 100 ms sample duration periods 
- ✓ Phase rotation measurement
- ✓ Agency approvals UL, CSA, VDE, GS and TUV
- ✓ UL 94VO flame retardant/self extinguishing plastic
- ✓ RoHS (Lead Free) compliance pending

# AEMC® Instruments

## What is Included?

**Model** 401,403, 405, 601,603, 605

- Meter
- Cat IV 1000V rated Silicone lead set
- K Thermocouple (excluding 405, 605)
- Set of 4 AA 1.5 V Batteries
- Soft case
- User Manual



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# AEMC® Instruments

## What is Included?

**Model** 407 and 607

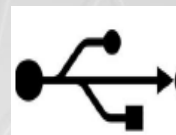
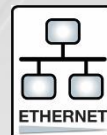
- Meter
- Cat IV 1000V rated Silicone lead set
- Bluetooth adaptor
- Set of 4 AA 1.5V Batteries
- Hard shell case
- DataView® Thumb Drive
- User Manual



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# AEMC® Instruments

## PEL 102/103/105 Power & Energy Loggers



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## PEL 105



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## PEL Phase Power Adapter for Models 102 and 103



- Powers the PEL 102/103 from phase power
- Powers from phase to neutral or phase to phase
- Provides isolation between measurement and instrument power
- Range of use: Phase-to-neutral voltage: 110 to 277VAC  
Phase-to-phase voltage: 110 to 480VAC
- Max. input voltage: Permanent: 530Vac; Transient: 550VAC
- Min. input voltage: 85VAC (-20%)
- Max. output voltage: 360V peak
- Frequency: 50/60Hz
- Consumption: 100VA max at 50/60Hz

Phase  
Powered

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## PEL102/103/105 capabilities

- Simple to use, minimal set up, records everything
- Offers all the necessary functions for Power/Energy data logging for most of the 50Hz, 60Hz, 400Hz and DC distribution systems worldwide
- User configurable for single phase to 3 phase Delta, Wye electrical systems, 17 electrical distribution system hook-ups supported
- Direct current measurements from 200mA up to 10,000A with MA193 external current sensors
- Energy measurements VAh, Wh (source/load indication) and varh (including quadrant indication)
- Power Factor (PF), Cos ( $\varphi$ ), and Tan ( $\varphi$ ), Crest Factor and DPF measurements
- Harmonics up to the 50th order for 50/60 Hz voltages and currents
- RMS and DC measurements @ 128 samples/cycle – all phases simultaneously (16/cycle @ 400Hz)
- Storage of measured and calculated values on a removable SD-Card or SDHC-Card up to 32GB
- Automatic recognition of the connected current sensors/probes
- Configuration of current and voltage ratios to external PT and CT ratios
- USB, LAN, and *Bluetooth* (class 1 300 ft) communication
- DataView® software for data download, real-time communication with a PC and report generation with pre-written or custom templates, included with system.
- **Complies with NEC 220.87 monitoring requirements: Determining Existing Loads** which requires monitoring 15-minute demand periods for 30 days with a recording power meter when 1 year's historical data is not available before upgrading the service.



# AEMC® Instruments

## Distribution Systems Supported

### Single-Phase Power Networks

- ▶ .Single-Phase 2-Wire
- ▶ .Single-Phase 3-Wire (Split-phase)

### Three-Phase 3-Wire Power Networks

- ▶ .Three-phase 3-wire  $\Delta$  (with two current sensors)
- ▶ .Three-phase 3-wire  $\Delta$  (with three current sensors)
- ▶ .Three-phase 3-wire Open  $\Delta$  (with two current sensors)
- ▶ .Three-phase 3-wire Open  $\Delta$  (with three current sensors)
- ▶ .Three-phase 3-wire Y (with two current sensors)
- ▶ .Three-phase 3-wire Y (with three current sensors)
- ▶ .Three-phase 3-wire  $\Delta$  Balanced (with one current sensors)

### Three-phase 4-Wire Y Power Networks

- ▶ .Three-phase 4-wire Y (with three current sensors)
- ▶ .Three-phase 4-wire Y Balanced
- ▶ .Three-phase 4-wire Y 2½ Element
- ▶ .Three-phase 4-wire  $\Delta$
- ▶ .Three-phase 4-wire Open  $\Delta$

### DC Power Networks

- ▶ .DC 2-wire
- ▶ .DC 3-wire
- ▶ .DC 3-wire



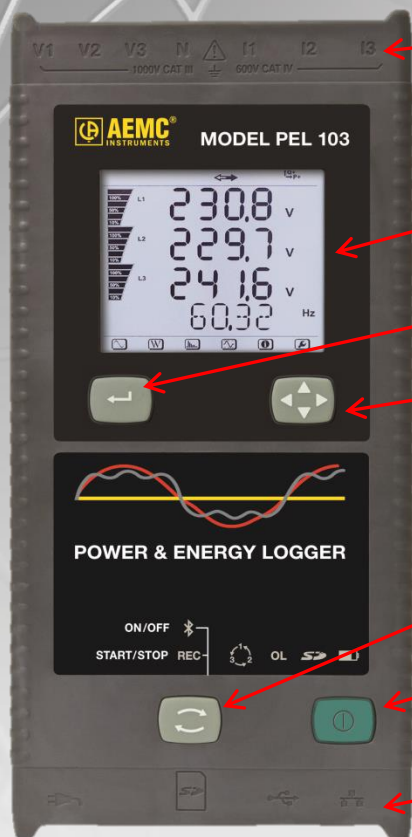
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# AEMC® Instruments

## PEL Physical Features – Front Panel

PEL 103



Input Indicators

Backlit LCD

Enter Button

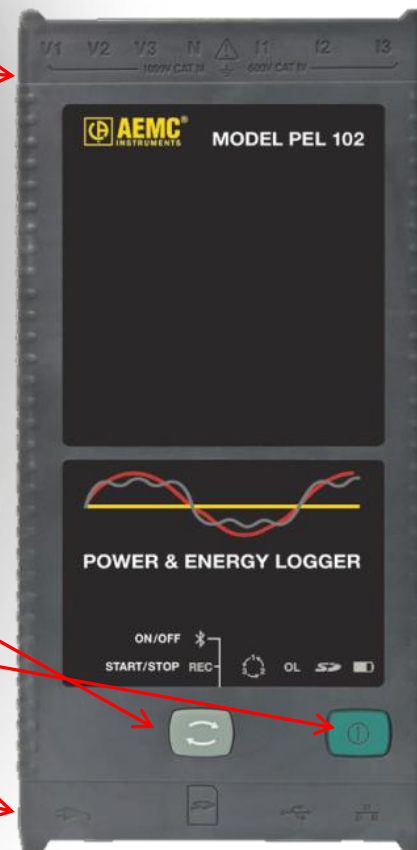
Navigation Button

Selection Button

Power Button

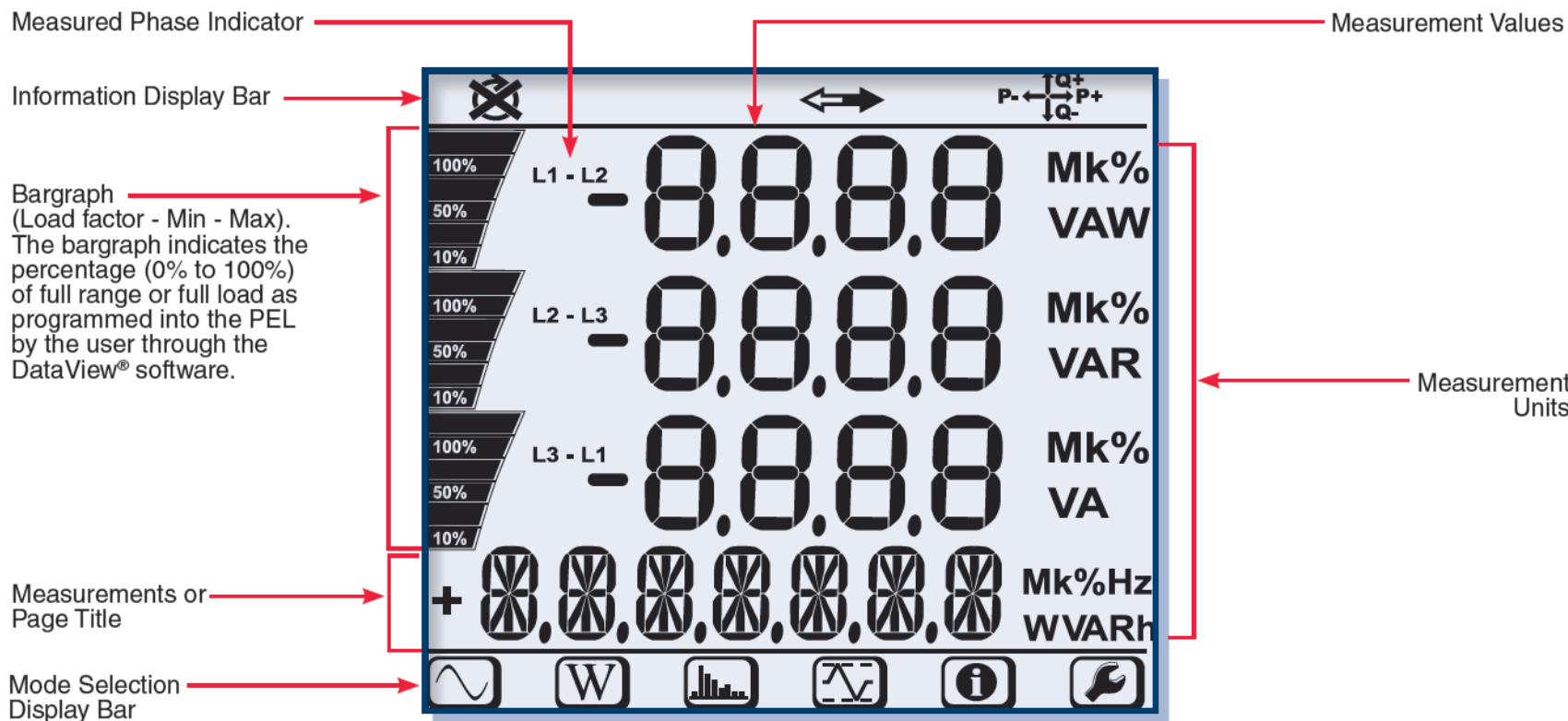
Port Indicators

PEL 102



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## PEL Display





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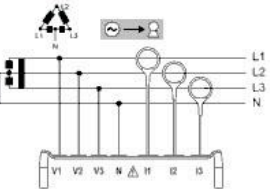
## DataView PEL Control Panel

Configure Instrument

General Communication Measurement Recording Meters

Distribution system

- 3-phase 3-wire open Δ (I2 missing)
- 3-phase 3-wire open Δ
- 3-phase 3-wire Y (I2 missing)
- 3-phase 3-wire Y
- 3-phase 3-wire Δ balanced
- 3-phase 4-wire Y
- 3-phase 4-wire Δ balanced
- 3-phase 4-wire Y 2½
- 3-phase 4-wire Δ**
- 3-phase 4-wire open Δ



Nominal voltage and voltage ratios

☒ Set a Voltage Transformer Ratio

Primary: 100 V (50...650000) ☐ Phase-to-phase ☒ Phase-to-neutral

Secondary: 100 V (50...650000) ☐ Phase-to-phase ☒ Phase-to-neutral

Nominal frequency

☒ Auto ☐ 50 Hz ☐ 60 Hz ☐ 400 Hz

Current measurement

AmpFLEX / MiniFLEX

Range: ☒ 100 A ☐ 2000 A ☐ 400 A ☐ 10000 A

Number of primary wraps: 1 (1, 2 or 3)

Multiple primary wraps will increase the sensitivity of the AmpFLEX/MiniFLEX, however the nominal current will be divided by the number of primary wraps.

For example, with 2 primary wraps for a 2000 A range, the nominal current will be 1000 A instead of 2000 A.

MN93A clamp (5 A)

☒ An external CT is used

Primary: 10000 A (5...25000)

Secondary: 5 A

5 A adapter box

☒ An external CT is used

Primary: 10000 A (5...25000)

Secondary: 5 A

Current sensor with BNC adapter

Nominal current: 1000 A (1...25000)

Output voltage: 1 V

Sensor output voltage must not exceed 1.7 V peak

OK Cancel Help

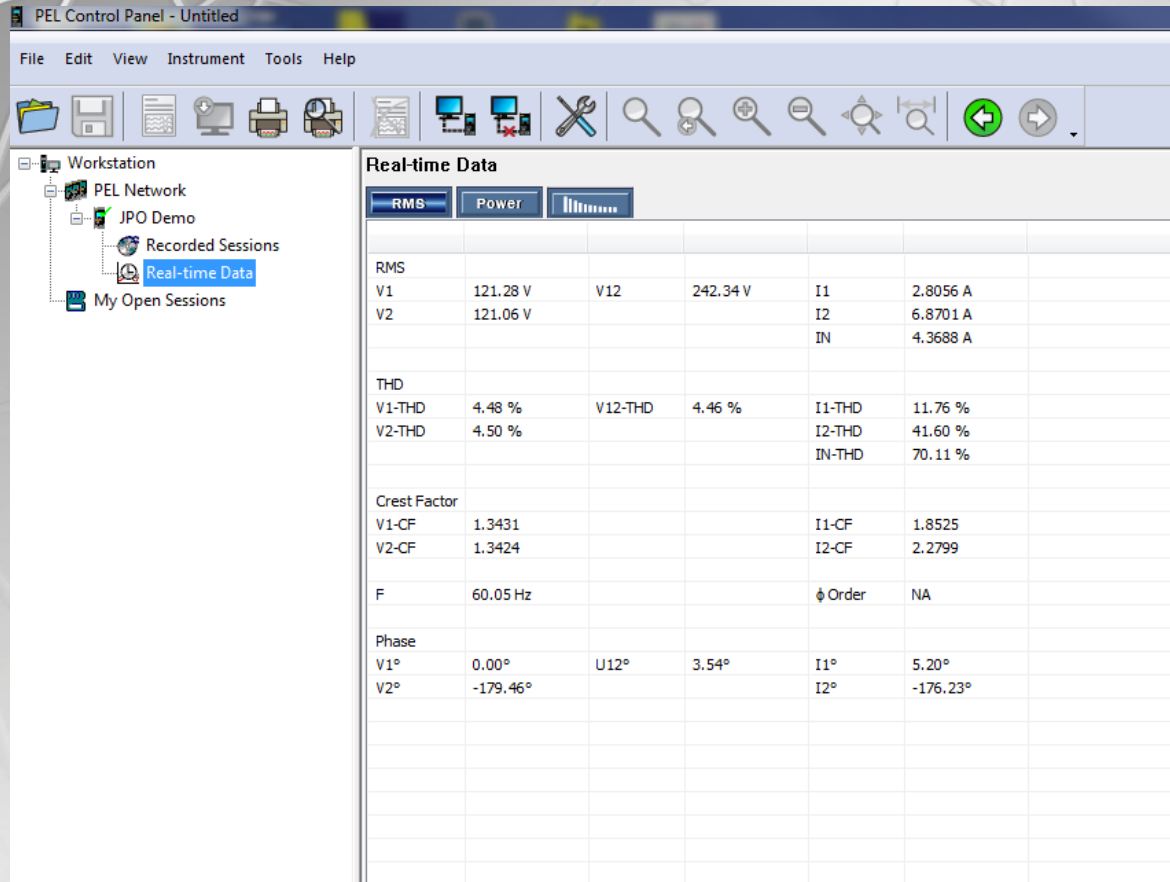
## Measurement Tab

- Select network type
- Set PT ratio
- Select flexible probe range and number of wraps
- Select CT ratios for specific probes and adapters
- Select frequency/detection



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## DataView PEL Control Panel – Real Time Display

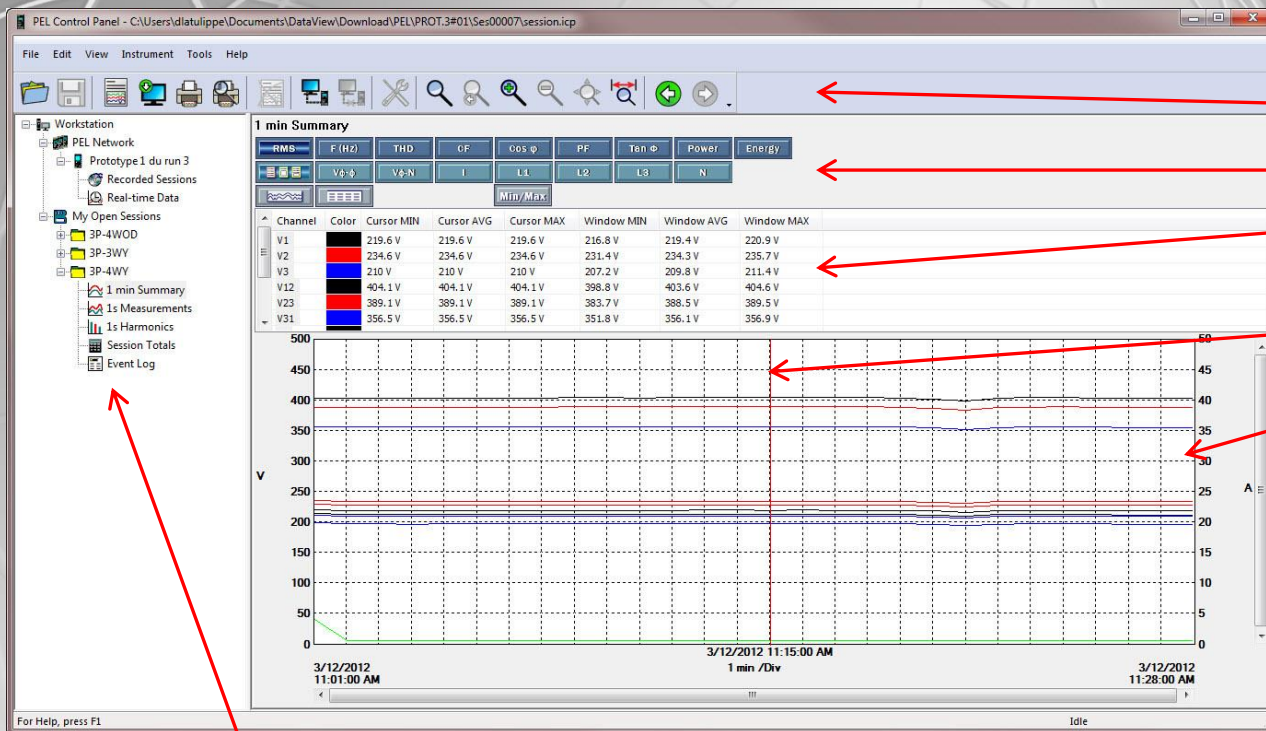


Displays all measurements and calculations for:

- **RMS measurements**
- **Power**
- **Harmonics**

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## DataView PEL Control Panel – Recorded Data



Tool Bar

Selection Buttons

Tabular listing @

Cursor position

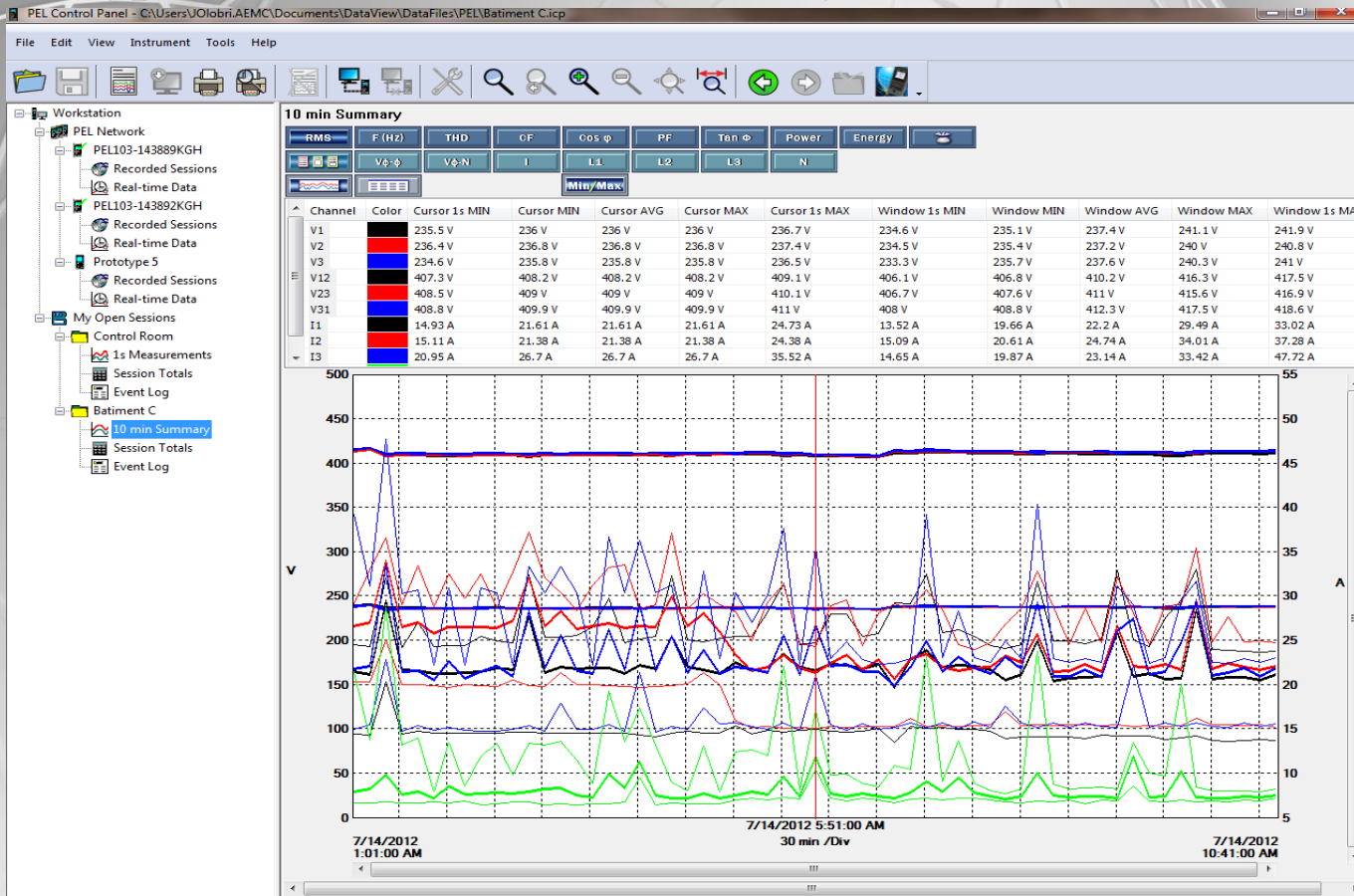
Movable cursor

Plot/List area

Logger Tree

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## Typical Demand Period Summary



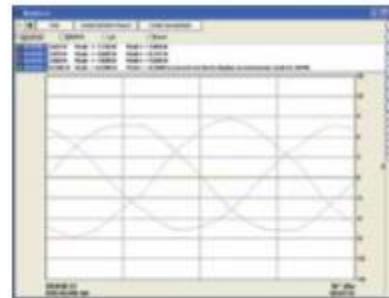
Stores and plots measurements based on user programmable demand aggregation periods from 1 to 60 minutes

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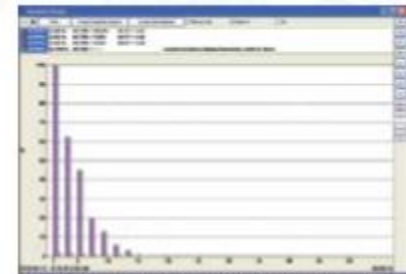
## Here is a typical output



*Clear and easy setup of all functions from one tabular display here*



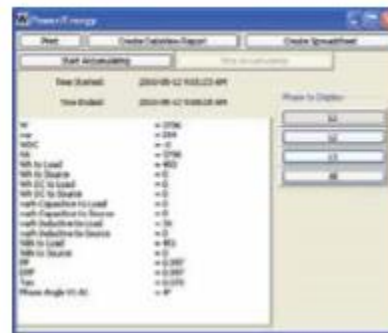
*Display real-time waveforms by phase, parameter or total*



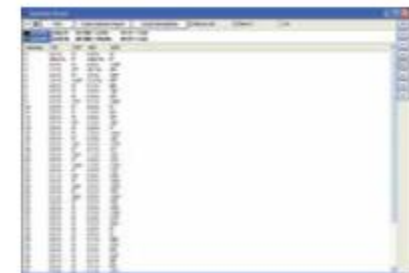
*Display all harmonics from 1<sup>st</sup> to 50<sup>th</sup> in bargraph form for voltage, current and power.*



*Display real-time Phasor diagrams. Includes unbalance for both voltage and current.*



*Display power and energy parameters – both instantaneous and total.*

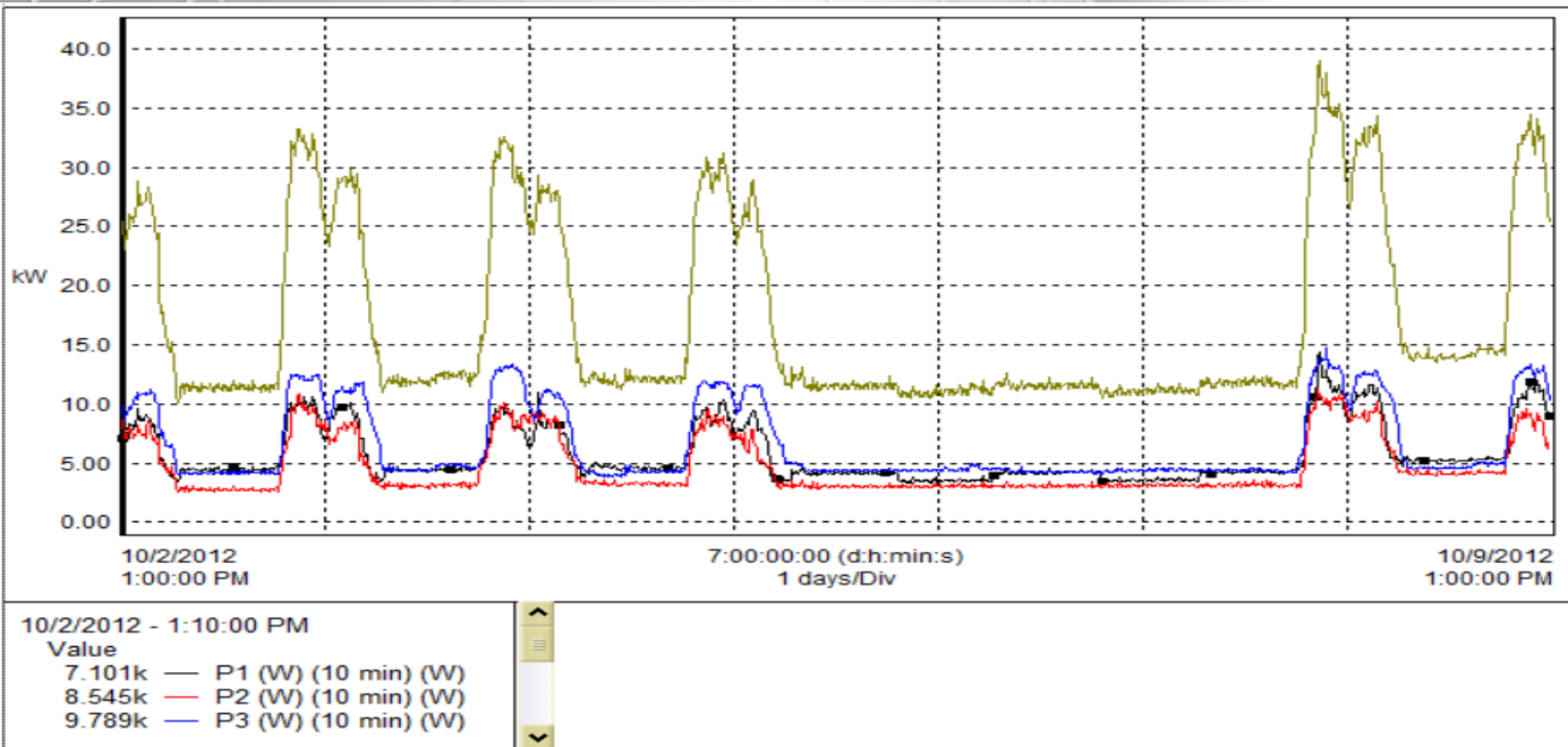


*Display harmonics in a text table from harmonic 0 (DC) through the 50<sup>th</sup>.*



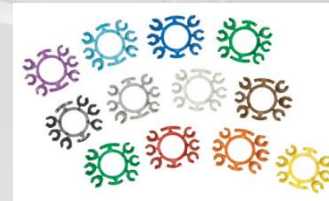
# AEMC® Instruments

Here's another look



# AEMC® Instruments

## What is Included?



MSRP PEL102: \$1795  
MSRP PEL103: \$1995  
Phase Power Adapter MSRP: \$200  
MSRP PEL105: \$3050

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# AEMC® Instruments

## Android App Available



ANDROID APP ON  
Google play



3-Phase 3-Wire Δ

V01

V02

V03

U01 442.0 V

U02 436.7 V

U03 382.2 V

F 63.80 Hz

I 0.75 A

I 1.00 A

I 0.67 A

2W 4.10k W Load

PF 0.985 Load Inductive

97 4.00k W



**POWER & ENERGY LOGGER**  
AEMC

- Configure
- Display data in real-time
- For use on most devices with an Android platform



# AEMC® Instruments








## Glossary of Terms

- Volt.....** True RMS AC, DC, AC + DC (Ripple).
- Amps.....** AC only (C.T.) AC/DC, AC+DC (Hall effect device).
- Ripple.....** The quality of rectified AC voltage expressed in a percentage. (AC+DC)
- W.....** (S) Apparent Power (Volts X Amps).  
(P) Real Power ( Volts X Amps X COS  $\theta$ ).  
(Q) Reactive Power (Volts X Amps Reactive).
- Min/Max.....** Highest & Lowest RMS Voltage or Current.
- Peak.....** Instantaneous (1ms) maximum Voltage or current.
- Harmonics....** Multiple frequencies within 50 or 60Hz fundamental (400Hz selectable).
- THD.....** Total Harmonic Distortion as expressed as a  $\sqrt{\Sigma^2 H_m}$ / Fundamental  $^2 = \%$ .
- True Inrush...** Several types: (Motor and Load)  
Start up (Motor start and End).  
Maximum instantaneous (RMS  $\frac{1}{2}$  Cycle)  
Maximum due to load changes.
- Recording.....** Stores the Max, Min and present value of switch position parameter.
- Auto Shut-off.** Selectable, Automatic after 10 minutes inactivity with 5 “Beep” warning



# AEMC® Instruments

## Optional Accessories

Sensor Type		I nominal	RMS or DC Current	Accuracy	Typical Error on $\phi$ at 50/60Hz	Maximum Error on $\phi$ at 50/60Hz	Typical Error on $\phi$ at 400Hz	Max Conductor Size
<b>MiniFlex® MA193</b> <i>(Included with instrument)</i>  10" Sensor		100AAC	5A to 120A	$\pm 1\% \pm 50\text{mA}$	0°	$\pm 0.5^\circ$	-0.5°	2.75" (70mm)
		400AAC	20A to 500A	$\pm 1\% \pm 0.2\text{A}$	0°	$\pm 0.5^\circ$	-0.5°	
		2000AAC	100A to 2400A	$\pm 1\% \pm 15\text{A}$	0°	$\pm 0.5^\circ$	-0.5°	
		10,000AAC	500A to 12000A	$\pm 1\%$	0°	$\pm 0.5^\circ$	-0.5°	
<b>MR193</b> 	1000ADc	50A to 100A	$\pm 1.5\% \pm 1\text{A}$	-1°	$\pm 2.5^\circ$	-4.5° @ 100A	1.6" (41mm)	
		100A to 800A	$\pm 2.5\%$	-0.7°				
		800A to 1200A	$\pm 4\%$					
<b>SR193</b> 	1000AAC	50A to 100A	$\pm 0.5\%$	+0.25°	$\pm 1^\circ$	+0.1°@ 1000A	2.05" (52mm)	
		100A to 1200A	$\pm 0.3\%$	+0.2°	$\pm 0.7^\circ$			
<b>AmpFlex® 193</b>  24" Sensor      36" Sensor	100AAC	5A to 120A	$\pm 1\% \pm 50\text{mA}$	0°	$\pm 0.5^\circ$	-0.5°	7.64" (190mm)	
	400AAC	20A to 500A	$\pm 1\% \pm 0.2\text{mA}$	0°	$\pm 0.5^\circ$	-0.5°	11.46" (290mm)	
	2000AAC	100A to 2400A	$\pm 1\% \pm 15\text{A}$	0°	$\pm 0.5^\circ$	-0.5°		
	10,000AAC	500A to 12000A	$\pm 1\%$	0°	$\pm 0.5^\circ$	-0.5°		
<b>MN93</b> 	200AAC	5A to 40A	$\pm 2.5\% \pm 1\text{A}$	+2°	$\pm 5^\circ$	-1.5°@ 40A	0.78" (20mm)	
		40A to 100A	$\pm 2\% \pm 1\text{A}$	+1.2°	$\pm 3^\circ$	-0.8°@ 100A		
		100A to 240A	$\pm 1\% \pm 1\text{A}$	+0.8°	$\pm 2.5^\circ$	-1°@ 200A		
<b>MN193</b> 	100A	100AAC	5A to 120A	$\pm 1\%$	+0.75°	$\pm 2.5^\circ$	-0.5°@100A	0.78" (20mm)
	5A	5AAC	250mA to 6A	$\pm 1\%$	+1.7°	$\pm 5^\circ$	-0.5°@ 5A	
<b>SL261 *</b> 	10A	100AAC/bc	5A to 40A	$\pm 4\% \pm 50\text{mA}$	—	$\pm 1^\circ$	—	0.46" (11.8mm)
			40A to 100A	$\pm 15\%$	—	$\pm 1^\circ$	—	
	100A	10AAC/bc	50mA to 10A	$\pm 3\% \pm 50\text{mA}$	—	$\pm 1.5^\circ$	—	

\*  AC/DC Current Probe BNC Adapter for Model SL261 only  
Use with Catalog #2140.40

← MA193 included in base price

# AEMC® Instruments

## For More Information

Free Technical Support: Call 800-343-1391

E-mail: [TechnicalSupport@aemc.com](mailto:TechnicalSupport@aemc.com)

Call me - Mark Gutekunst: 508.698.5655, email:  
[MPG@aemc.com](mailto:MPG@aemc.com)

Checkout our website: [www.AEMC.com](http://www.AEMC.com)

# AEMC® Instruments

## For More Information

SE US: Chad Dugas, [cdugas@aemc.com](mailto:cdugas@aemc.com), 508.698. 5655

Central US: Brent McKinley, [bmckinley@aemc.com](mailto:bmckinley@aemc.com), 508.698.5649

N. Central, NE US: George Vlachos, [gtv@aemc.com](mailto:gtv@aemc.com), 508.698.5651

Central South USA: Gregg Wong: [gwong@aemc.com](mailto:gwong@aemc.com), 508.698.5652

Western US: Tim Cowgill, [tcowgill@aemc.com](mailto:tcowgill@aemc.com), 508.698.5618

CA, OR, WA: Mark Van Til, [mvantil@aemc.com](mailto:mvantil@aemc.com), 508.698.5654