# Introduction to Watthour Meter Testing


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# Focus of this Presentation

- Why do electric meters need to be tested?
- What tests are run on a meter?
- What equipment is needed for testing meters?
- How are the tests run?

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# Why do we test electric meters?

- The meter is the “cash register” – the last stop between the billing department and the customer.

- Meter accuracy must be established to ensure fair billing to the customer and the utility.

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# Who establishes the tests?

- Meter testing guidelines are taken from *ANSI C12.1-2014 American National Standard for Electric Meters – Code for Electricity Metering* (go to www.ansi.org for more information)
- Section 5 of C12.1 covers “Standards for New and In-Service Performance”
- ANSI only provides guidance, but does not enforce standards
- Final testing guidelines are established by the PSC, local government, or the utility

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# What tests are run on a meter?

- In the Lab – ANSI Meter Test

| Test | Voltage | Current | PF |
|---|---|---|---|
| Full Load | Rated V | Rated Test Amps (TA) | 1.0 |
| Power Factor | Rated V | Rated TA | 0.5 |
| Light Load | Rated V | 10% of TA | 1.0 |

- Meter test boards for the lab generate ideal voltage and current to run the meter
- An electric power standard is used to verify the meter's accuracy

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# ANSI Meter Test Example


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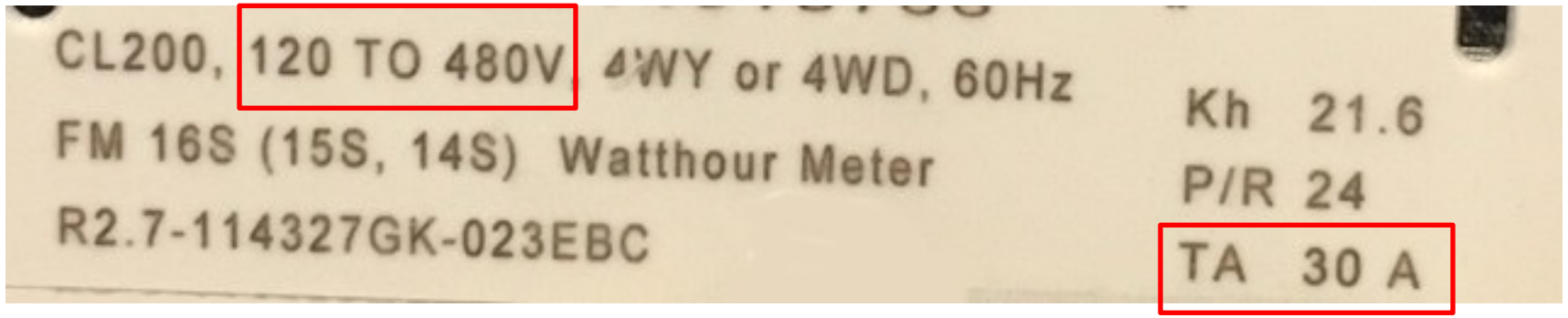
# ANSI Meter Test Example




| Test | Voltage | Current | PF |
|---|---|---|---|
| Full Load | 120V | 30A | 1.0 |
| Power Factor | 120V | 30A | 0.5 |
| Light Load | 120V | 3A | 1.0 |

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# What tests are run on a meter?

- In the Field:
  - Customer load using the customer's actual voltage and current
  - Phantom load using current (and possibly voltage) generated from a load box
  - Phantom load tests are typically based on the ANSI meter test

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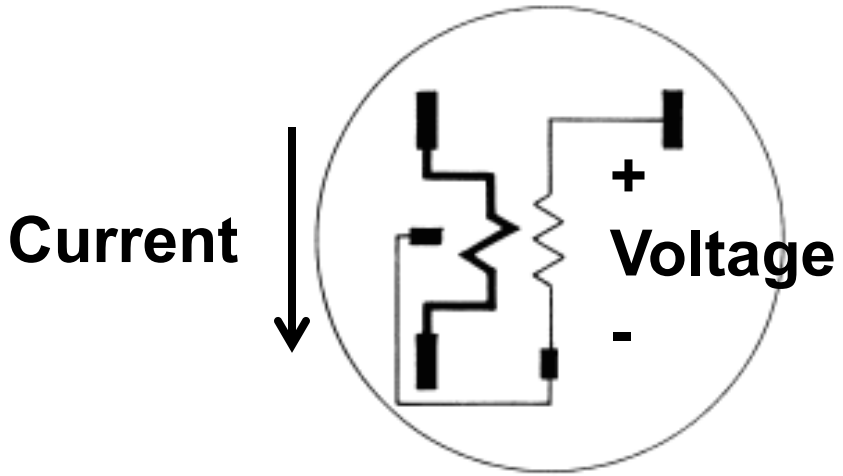
# How does a meter measure power?

The meter has two stators – a voltage stator and a current stator.
Power = Voltage x Current x Power Factor
Power Factor = cos θ

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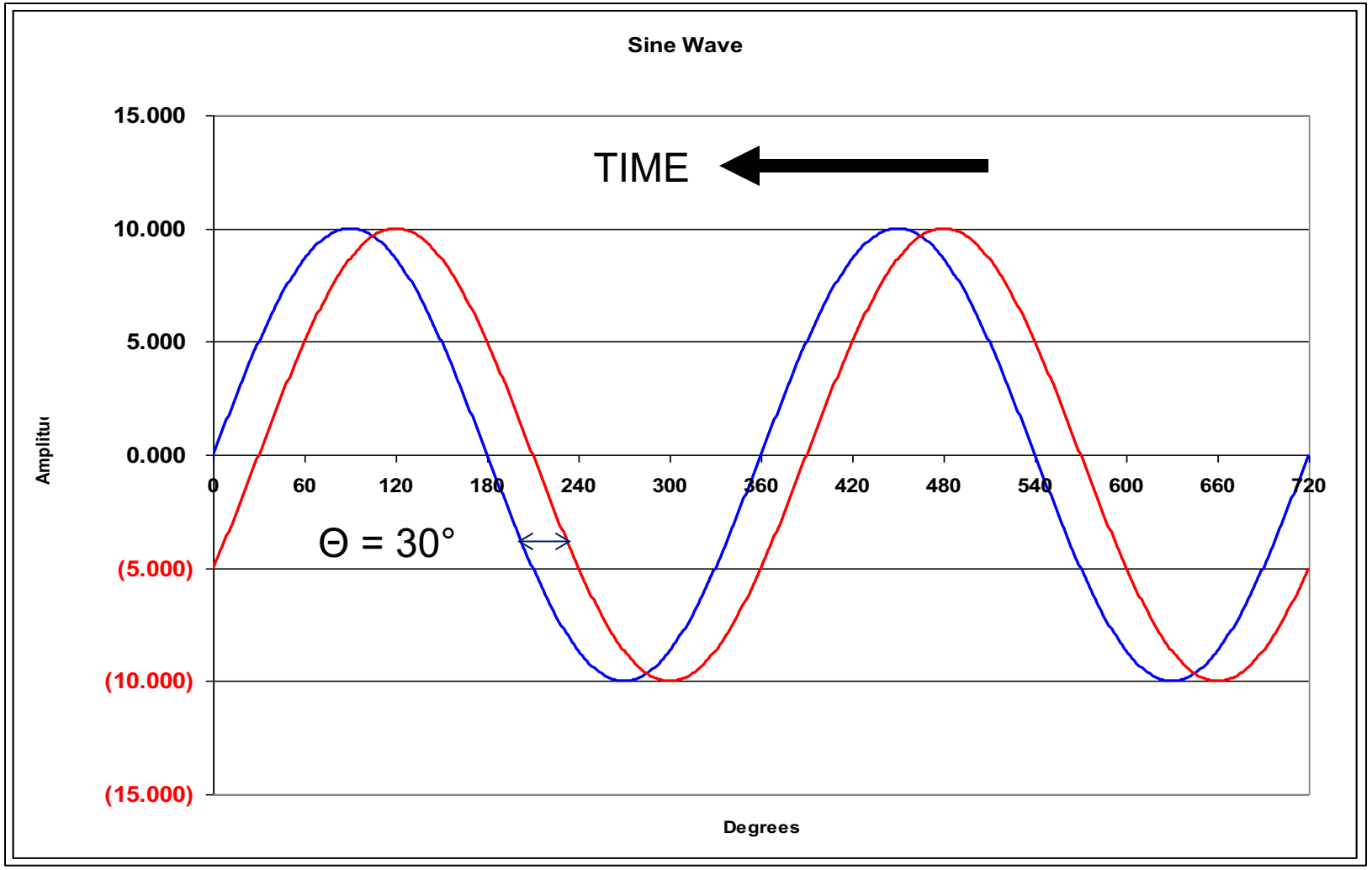
# Phase and Power Factor




Current is lagging Voltage by 30˚

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# Power Factor Definition:

Power Factor represents the ratio of active power (Watts) to the total power (VA) in a system. It is also equal to the cosine of the phase angle for a sinusoidal system.

It is a representation of the percentage of useful work being done.

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# How does a meter measure power?

- Mechanical meters – Voltage and current generate a magnetic field that turns a gear
- Solid-state meters – Voltage and current are digitized and processed by a microprocessor

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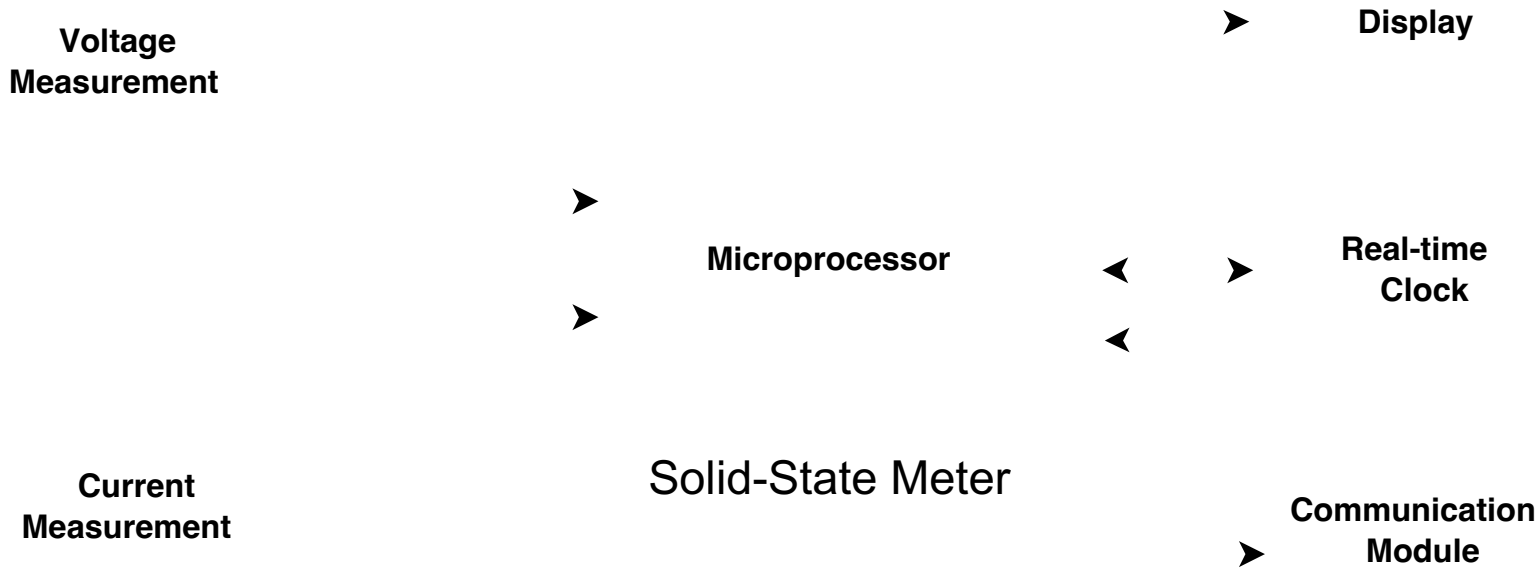
# How does a meter measure power?

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# Energy – What we sell!

Electricity meters measure energy in Watt-hours

Energy = Power x Time

For test purposes, meters output a pulse to indicate how much energy how been measured

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# Energy Pulse Output

- On a solid state meter, a pulse (IR or visible light) is emitted to indicate how much energy has been consumed
- The light pickup is used by meter test equipment to make precise accuracy measurements



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# What is Kh?

- The “Kh” on the meter indicates how much energy is indicated per pulse

- On a mechanical meter, the “Kh” is the energy in Watt-hours equal to one revolution of the disc

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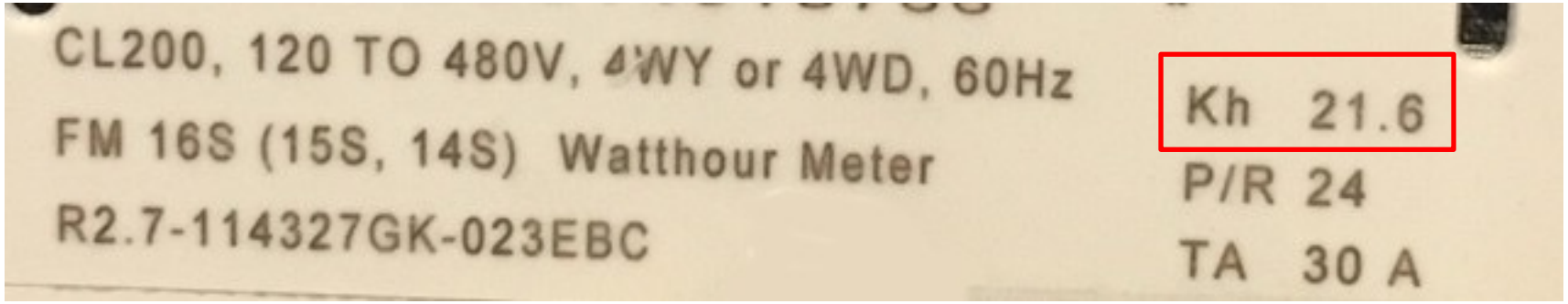
# What is Kh?

- Example: Kh = 21.6 means one pulse per 21.6 Watt-hours

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# How is a meter test run?

The Meter's Energy is given as

$E_m = K_h$ x (# of meter pulses or disk revolutions)

Example: $K_h = 21.6$

# of pulses = 3

$E_m = 21.6 * 3 = 64.8$ Wh

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# How is a meter test run?

- A meter is tested against an electric power standard
- The standard measures power the same way as the meter, but has an accuracy 4 to 10 times greater than the meter
- The power standard measures the same voltage, current, and phase as the meter

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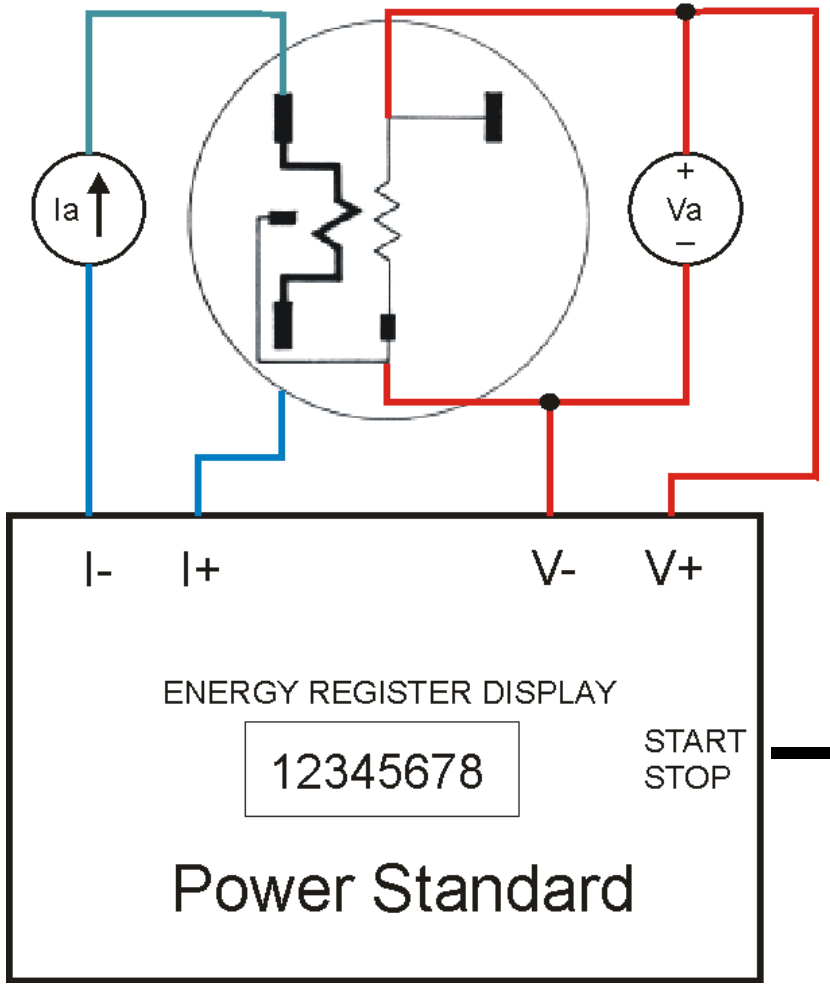
# How is a meter test run?




Manual Meter
Test with
Stop/Start Switch

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# Power Standard Pulse Constant

- The standard has a “pulse constant”, $K_s$.
- The “pulse constant” is given in Watt-hours per pulse
- The energy measured by the standard is

$$E_s = K_s \times (\#\ \text{of pulses})$$

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# Meter Registration Test

$$\%\ Registration = \frac{E_M}{E_s} x100\%$$

where

$E_M$ is the energy measured by the meter

$E_S$ is the energy measured by the standard

Registration is given as a percentage:

- 100% is perfect registration
- <100% is in the customer's favor
- >100% is in the utility's favor

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# Meter Registration Test

*Example:*

$K_S = 0.00001\ Wh/pulse$

$\#\ of\ standard\ pulses = 6{,}475{,}000$

$E_S = 0.00001\ x\ 6{,}475{,}000 = 64.75\ Wh$

$K_M = 21.6\ Wh/pulse$

$\#\ of\ meter\ pulses = 3$

$E_M = 21.6\ x\ 3 = 64.8\ Wh$

$$\%\ Registration = \frac{E_M}{E_s} x100\%$$

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# Meter Registration Test

*Example:*

$$E_S = 0.00001\ x\ 6{,}475{,}000 = 64.75\,Wh$$

$$E_M = 21.6\ x\ 3 = 64.8\,Wh$$

$$\%\ Registration = \frac{64.8}{64.75}\ x\ 100\%$$

$$\%\ Registration = 100.08\%$$

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# Lab Meter Testing

Equipment Required:

- Load Box
- Electric Power Standard
- Meter Socket

- Lab testing often use ideal conditions
- Modern load boxes can simulate real-world conditions (harmonics)

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# Lab Meter Testing


Bench Top Tester

- Zero-insertion force socket
- Load Box
- Integrated Standard
- Automatic meter registration calculation

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# Field Test Connections


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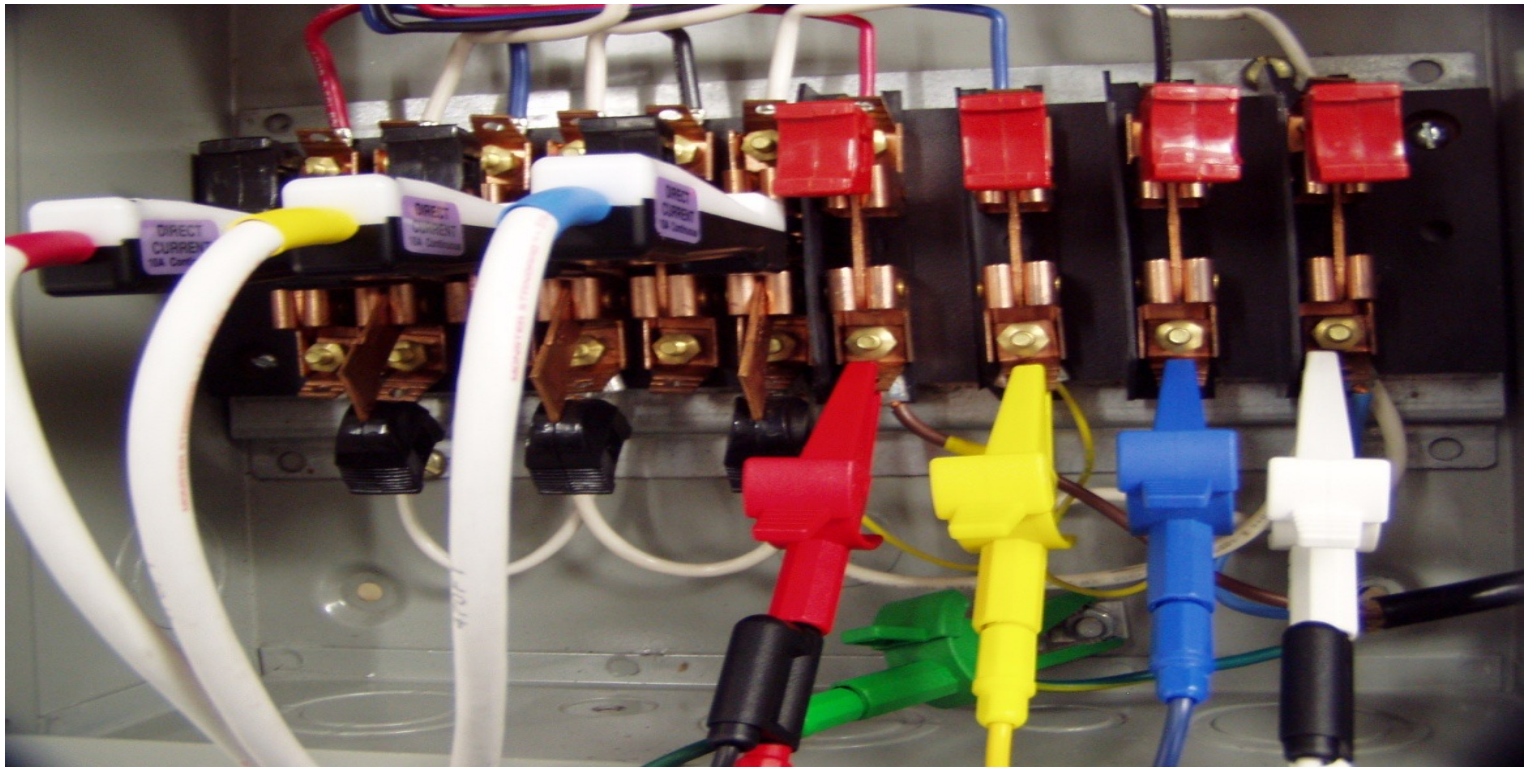
# Field Test Connections



Current Connections
Duckbill Connectors

Voltage Connection
Alligator Connectors

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# Types of Field Meter Tests

## Customer Load Test

Real - World Conditions
Voltage and Current Harmonics
Current and Phase Angle Balance

## Phantom Load Test

Ideal Current and Voltage Waveforms
ANSI Full Load, Power Factor & Light Load
Custom Test Sequences for Special Applications

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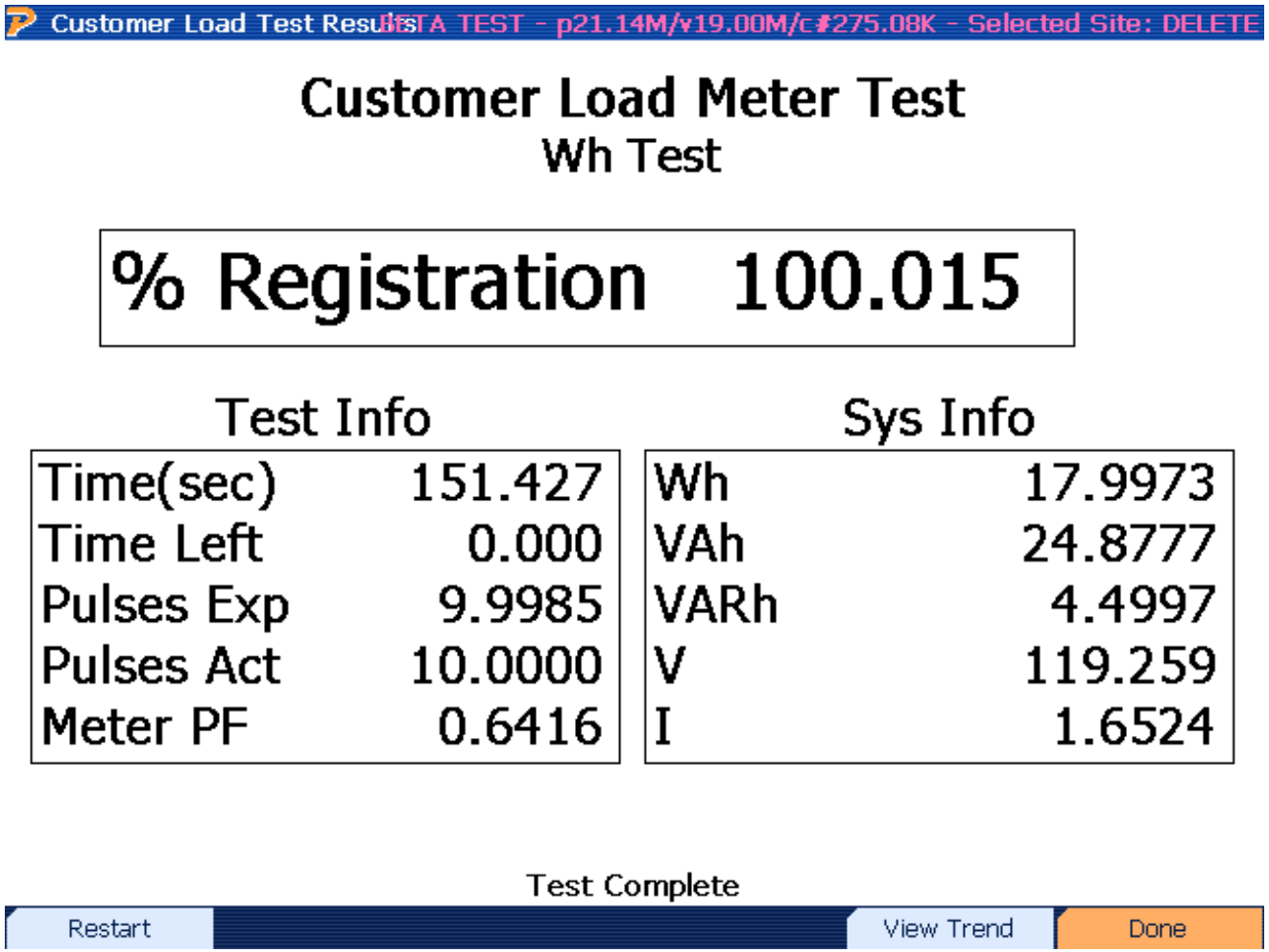
# Customer Load Meter Test

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# Phantom Load Meter Test

Phantom Load Results — Selected Site: TEST

## FL 99.954

| Phase | Voltage | Current | PF | Time | Pulses |
|---|---|---|---|---|---|
| All | 238.54 | 4.995 | 0.868 | 4.18 | 2 |

## PF 99.913

| Phase | Voltage | Current | PF | Time | Pulses |
|---|---|---|---|---|---|
| All | 238.54 | 4.995 | 0.441 | 8.24 | 2 |

## LL 99.966

| Phase | Voltage | Current | PF | Time | Pulses |
|---|---|---|---|---|---|
| All | 238.51 | 0.497 | 0.868 | 42.03 | 2 |

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Retest | Retest All | Done

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# Stick around for a Live Meter Test Demonstration!


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