



**POWER**  
MEASUREMENTS

# 21<sup>st</sup> Century Power Measurements



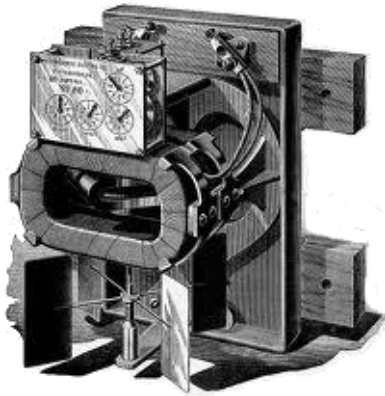
Prepared by Bill Hardy, TESCO

*For North Carolina Electric Meter School  
Thursday, June 29, 2017 at 9:00 a.m.*



# Then – Now – Tomorrow?

## Meters



First Meters mid-1890s



Westinghouse 1905



2005



2006



2014



2025 ???



# Then – Now – Tomorrow?

## Meters??





# Then – Now – Tomorrow?

## Loads



**YESTERDAY**



**TODAY**



# Then – Now – Tomorrow?

## Loads

**TODAY**



# Then – Now – Tomorrow?

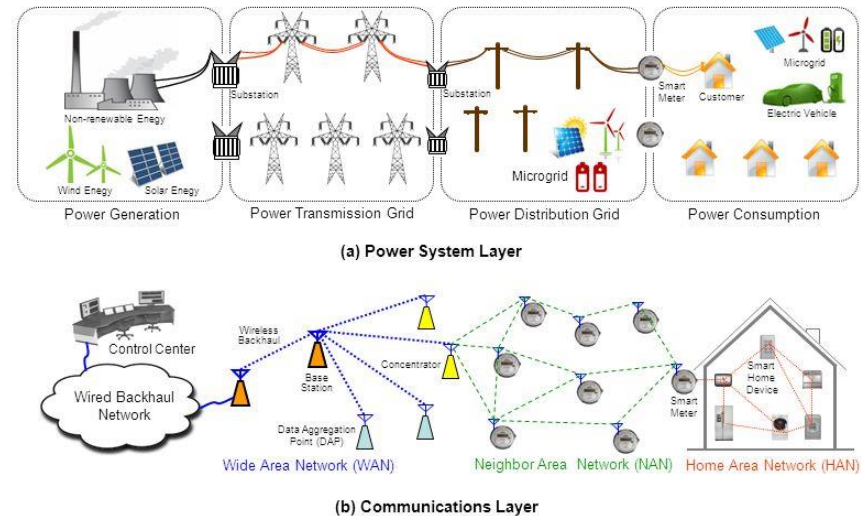
## Communications

**THEN**



**NOW**

### SG Comm. Network (SGCN)

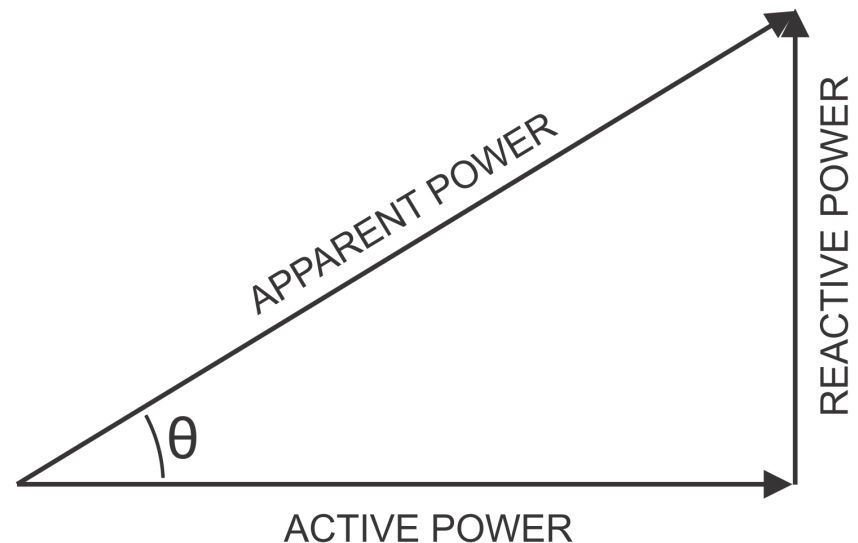
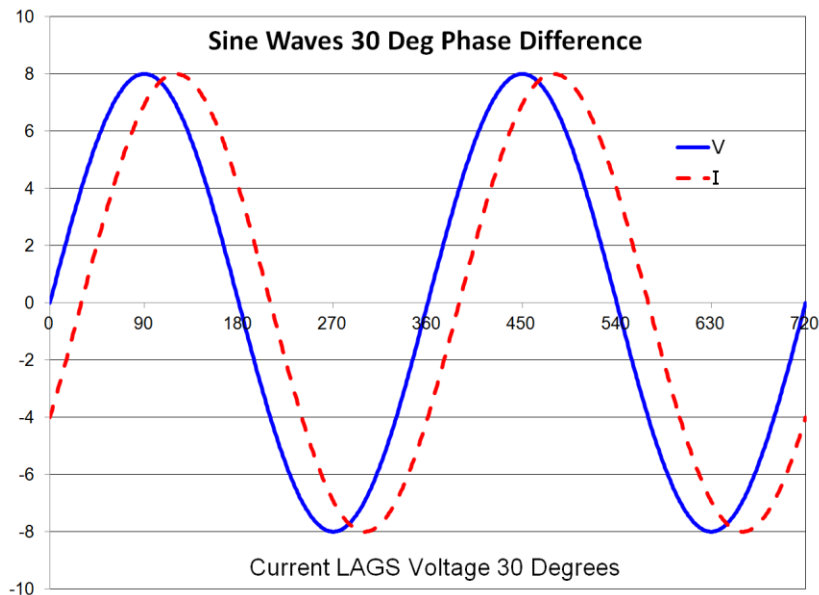


The overall layered architecture of SG



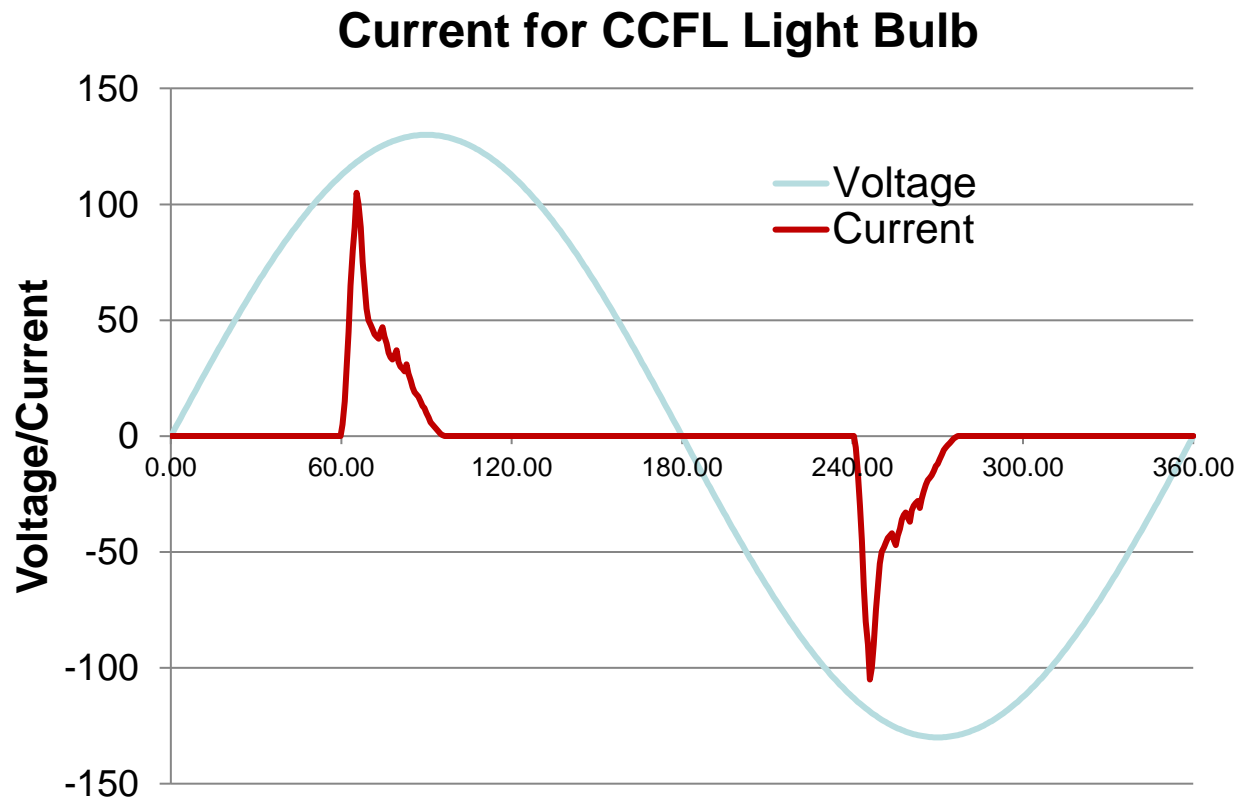
# Why do these changes matter?

- Changes to our loads have changed the basic computations of metering.
- When loads were linear the power triangle was all we needed to know



# Why do these changes matter?

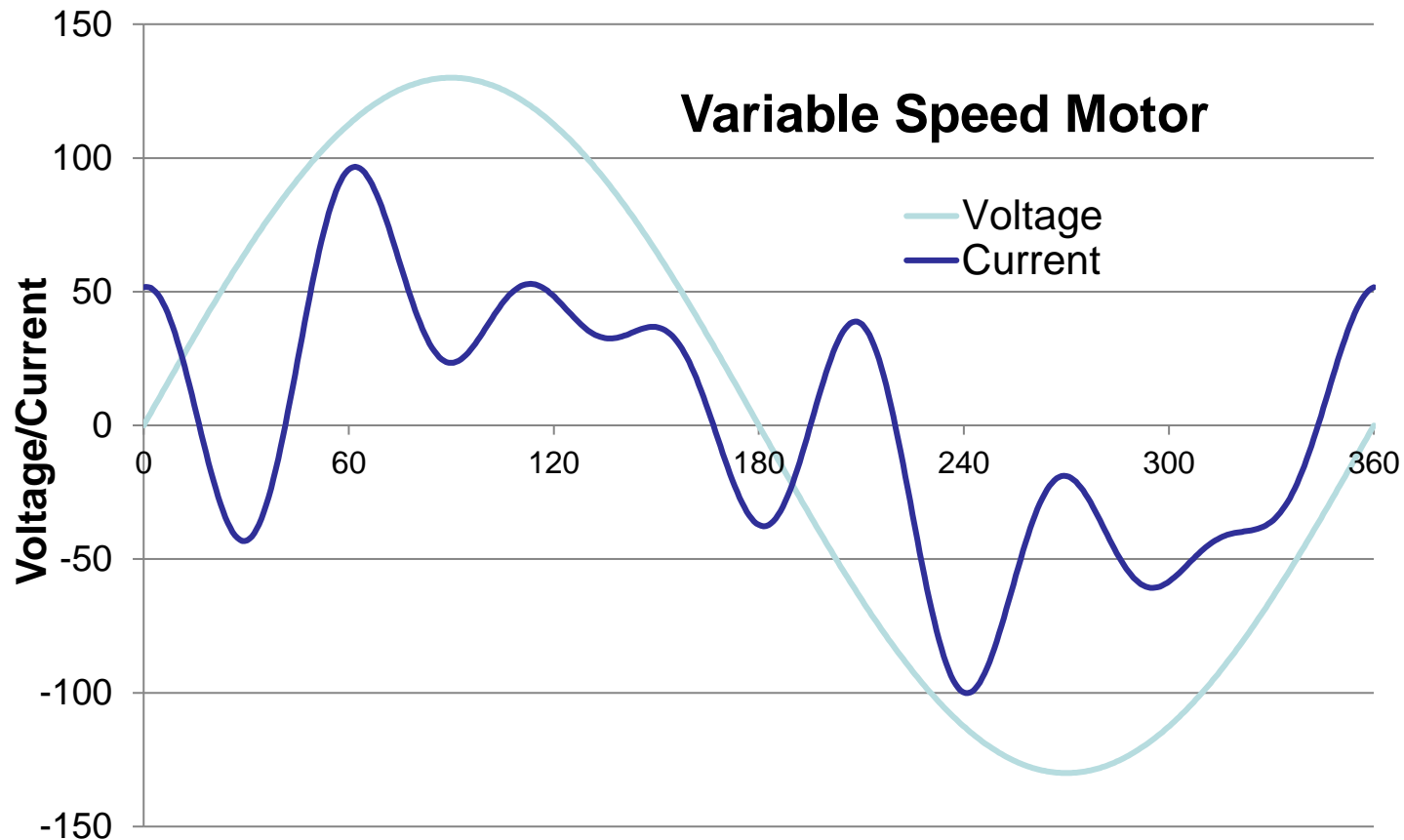
- Today's loads look more like these





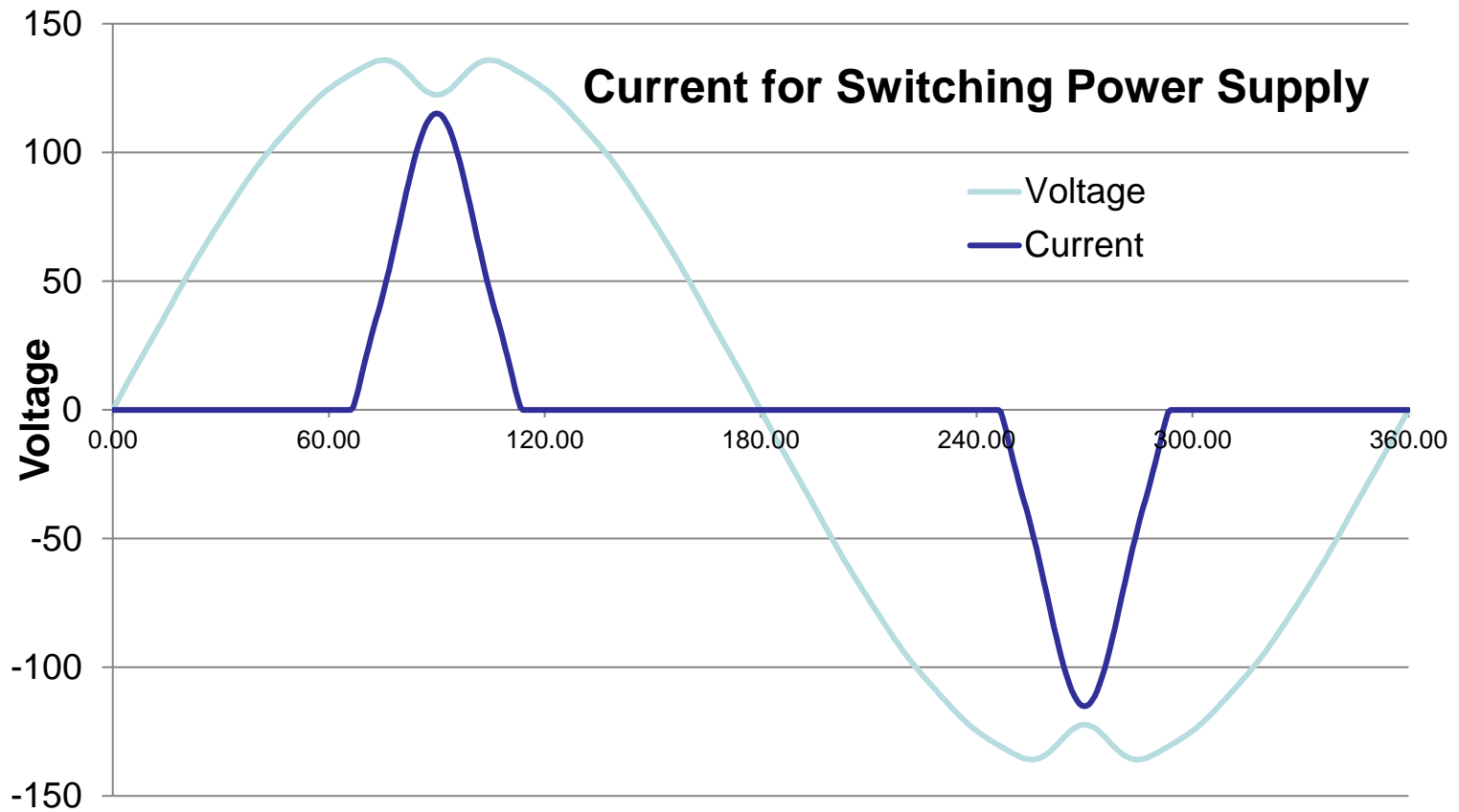
# Why do these changes matter?

- Today's loads look more like these



# Why do these changes matter?

- Today's loads look more like these



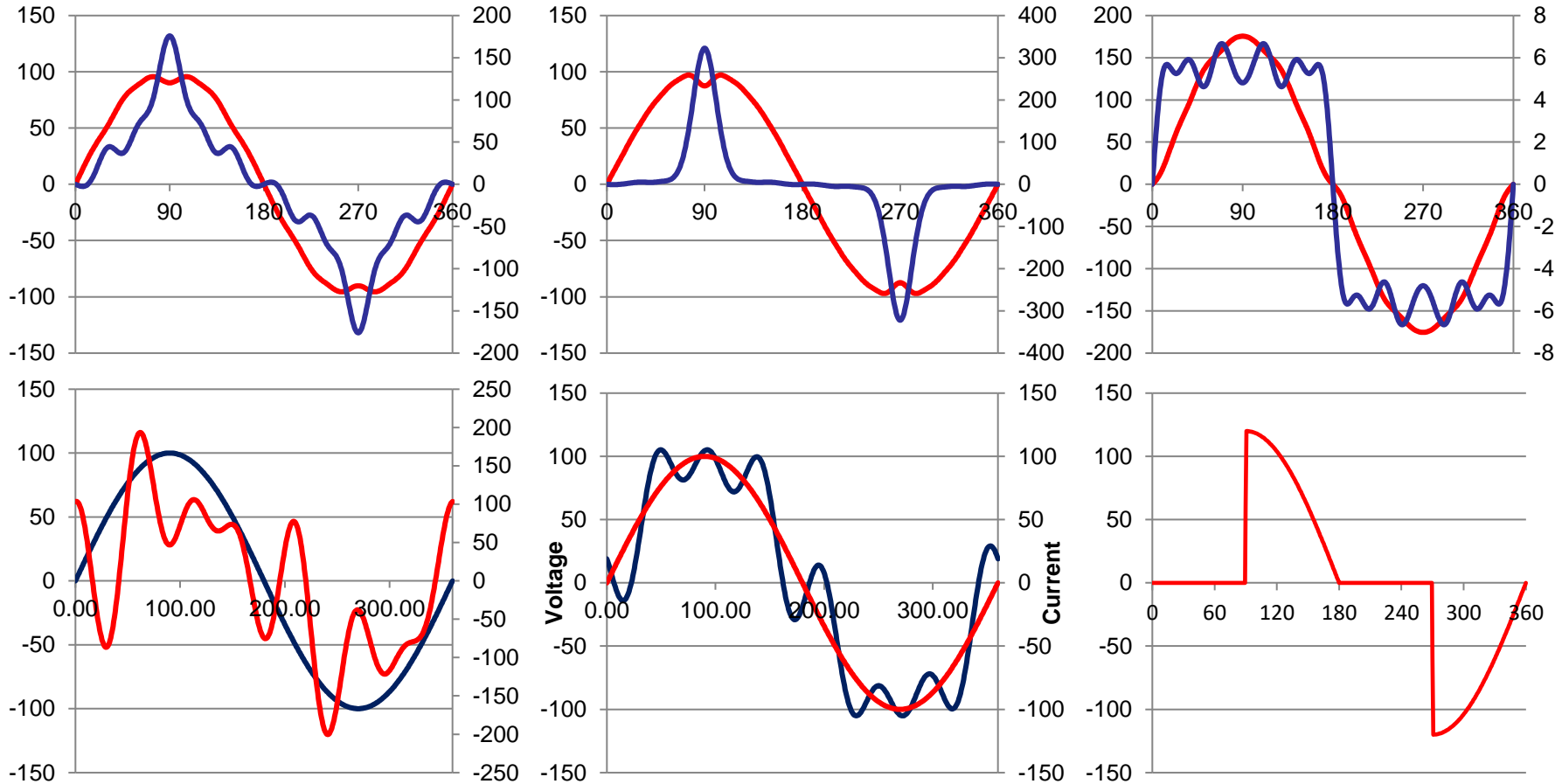
# Standards Changes

- **New Revision of C12.20 just Published**
  - Polyphase meters tested using polyphase
    - Recommended now, required 2020
  - Unbalanced load testing required
  - Full harmonic testing required
  - 0.1% Accuracy Class added
  - Specific call out of Non-Blondel applications where C12.20 does not apply
  - Detailed requirements and specs for test outputs added



# Harmonic Load Waveforms

ANSI C12.20 now addresses harmonic waveforms





# Standards Changes

- **New Revision of C12.20 just Released**
  - Tighter reference condition performance specifications
  - When using polyphase loading meters must be tested in **each configuration** used



# Standards Changes

- **New Revision of C12.1**
  - 0.5% Accuracy Class added
  - Testing required for unbalanced loads
  - Testing required under unbalanced conditions
  - Tighter reference performance requirements
  - Bi-directional energy flow testing
  - Extensive update on in service testing



# Standards Changes

- **New Revision of C12.10 in 2015**
  - Accuracy tests moved here from C12.1
  - Much broader safety requirements
  - Coordinated effort with UL2735
    - Utilities exempt from UL2735 but only if they own and install the equipment



# Standards Changes

- **New Revision of C12.9 in 2014**
  - Full specifications for test plugs included in standard
    - Ensures safe operation between all switches and all plugs
    - previously some combinations produced safety hazards
  - New barrier requirements between switch elements





# Standards Changes

- **Communications Standards**
  - New C12.19 which replaces C12.18 and C12.19 is in ballot process
    - Major changes – major controversy has held up approval for two years
    - Standard will still not guarantee inter-operability



# ANSI C12.31

- At the moment there is no non-sinusoidal definition for VA
- New ANSI Standard coming very soon

## C12.31

**American National Standard**

**for Electricity Meters—  
Measurement of VA and Power Factor**



# New Definitions

## RMS Voltage

Eq. 4.1.4.1	$V(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty} (a_n \cos(n\omega_0 t) + b_n \sin(n\omega_0 t))$	Waveform
Eq. 4.2.4.1	$V = \frac{1}{T} \int_0^T V^2(t) dt$	Basic Definition
Eq. 4.2.4.2	$V = \sqrt{\frac{1}{N} \sum_n V_n^2}$	Time Domain
Eq. 4.2.4.3	$V = \frac{1}{\sqrt{2}} \left[ \sum_n (a_{vn}^2 + b_{vn}^2) \right]^{1/2}$	Frequency Domain



# New Definitions

## RMS Current

Eq. 4.1.4.2 
$$I(t) = \frac{c_0}{2} + \sum_{n=1}^{\infty} (c_n \cos(n\omega_0 t) + d_n \sin(n\omega_0 t))$$
 Waveform

Eq. 4.2.2.1 
$$I = \frac{1}{T} \int_0^T I^2(t) dt$$
 Basic Definition

Eq. 4.2.2.2 
$$I = \sqrt{\frac{1}{N} \sum_n I_n^2}$$
 Time Domain

Eq. 4.2.2.3 
$$I = \frac{1}{\sqrt{2}} \left[ \sum_n (c_{vn}^2 + d_{vn}^2) \right]^{1/2}$$
 Frequency Domain





# New Definitions

## Active Power

Eq. 4.2.3.1 
$$P = \frac{1}{T} \int_0^T V(t)I(t)dt$$
 Basic Definition

Eq. 4.2.3.2 
$$P = \frac{1}{N} \sum_{i=0}^{i=N-1} V_i I_i$$
 Time Domain

Eq. 4.2.3.3 
$$P = \frac{1}{2} \sum_n |\vec{V}_n \bullet \vec{I}_n| = \frac{1}{2} \sum_n (a_n c_n + b_n d_v)$$
  
$$= \frac{1}{2} \sum_n V_n I_n \cos(\theta_n)$$
 Frequency Domain



# New Definitions

## Apparent Power

Eq. 4.2.3.1 
$$S = \sqrt{\frac{1}{T} \int_0^T V^2(t) dt} \sqrt{\frac{1}{T} \int_0^T I^2(t) dt}$$
 Basic Definition

Eq. 4.2.3.2 
$$S = VA = \sqrt{\frac{1}{N} \sum_{i=0}^{i=N-1} V_i^2 \cdot \frac{1}{N} \sum_{i=0}^{i=N-1} I_i^2}$$
 Time Domain

Eq. 4.2.3.3 
$$S = \frac{1}{2} \left[ \sum_n (a_n^2 + b_n^2) \sum_n (c_n^2 + d_n^2) \right]^{1/2}$$
 Frequency Domain



# Next Generation Standards

- **ANSI C12.46**

- New standard in development to **replace C12.1 and C12.20**
- Structured like OIML IR-46
- A true digital age standard
- Applies to ALL energy measurements
  - Watts, VA and VAR
  - Contains precise definitions for the quantities based on digitally sampled waveforms



# Next Generation Standards

- **ANSI C12.46**

- Covers ALL waveform types
  - sinusoidal, harmonic, time varying
- Defines the meter as everything under the cover
  - If there is auxiliary functions in the meter they must be fully operational during accuracy testing
  - If a option is added to a meter, it must be tested with the option running to remain qualified





# Next Generation Standards

- **ANSI C12.46**

- View of accuracy changes
  - Currently changes with respect to reference
  - New approach is absolute error

**Philosophy of C12.46** – When a meter is claimed to be of a specific accuracy class, for example , AC 0.2%, then it's accuracy under all commonly ocuring conditions should be within  $\pm 0.2\%$  maximum error.



# What does the Future Hold

- Over the next FEW years metering may have a whole new meaning
- Do these look like meters to you?



# What does the Future Hold

- Each has an embedded revenue meter
- They may NOT be regulated by the PSC's.



# Questions and Discussion



Bill Hardy, CTO

TESCO – The Eastern Specialty Company

Bristol, PA

1-215-785-2338

This presentation can also be found under Meter Conferences and Schools on the TESCO web site: [www.tesco-advent.com](http://www.tesco-advent.com)

