# 21st Century Power Measurements

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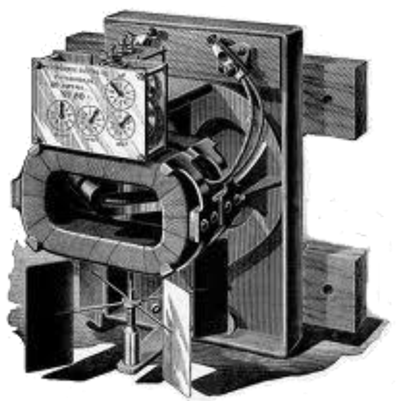
The Eastern Specialty Company

*For North Carolina Electric Meter School*
*General Session*
*Monday, June 24, 2018 at 11:15 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

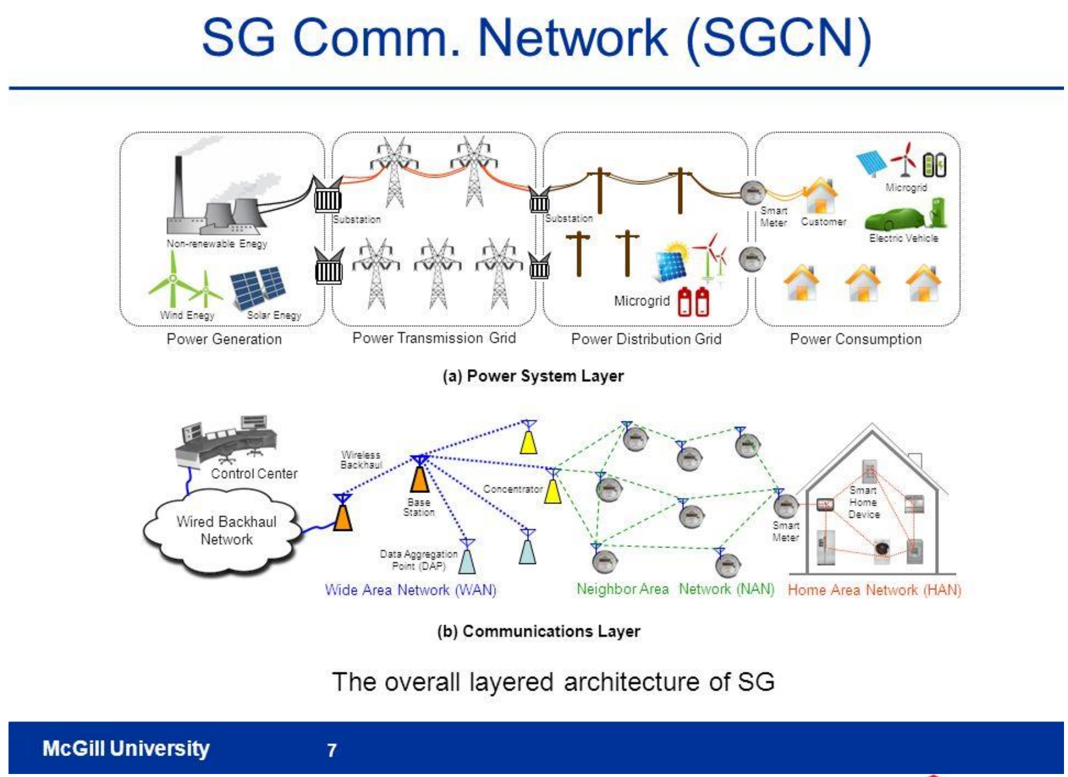
# Then – Now – Tomorrow?
## Loads

**TODAY**

# Then – Now – Tomorrow?
## Communications

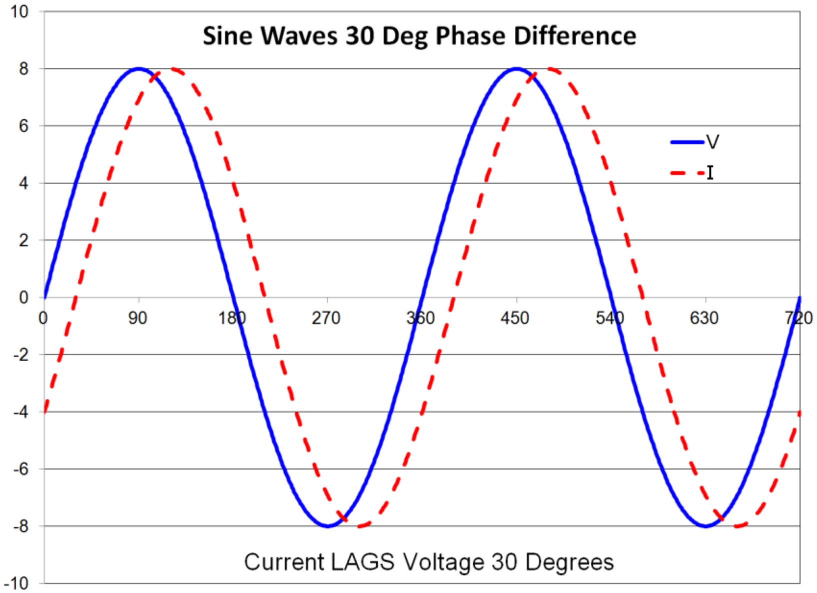
**THEN**

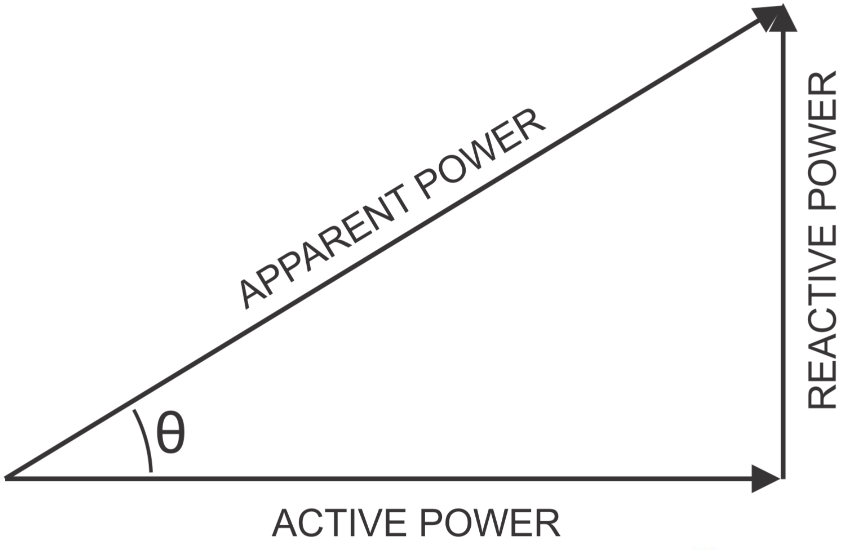
**NOW**



# Why do these changes matter?

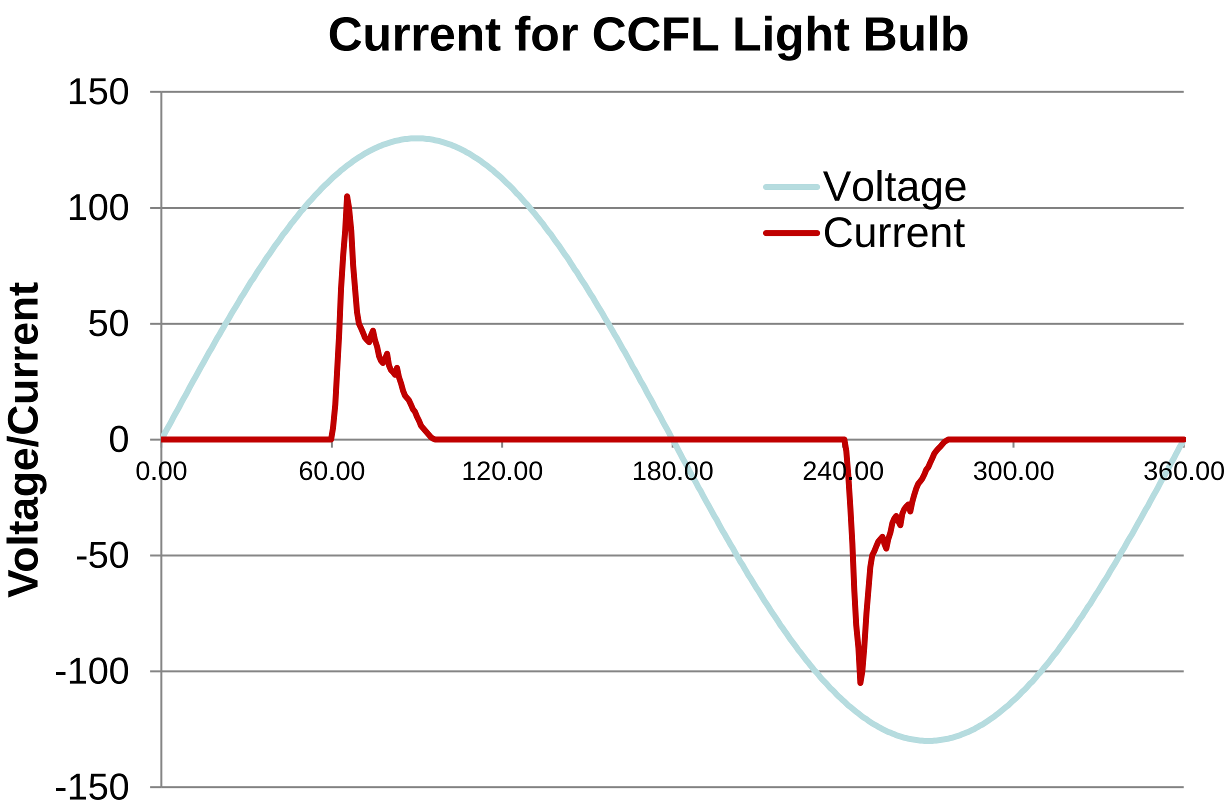
- Changes to our loads have changed the basic computations of metering.
- When loads were linear the power triangle was all we needed to know



# Why do these changes matter?

- Today's loads look more like these



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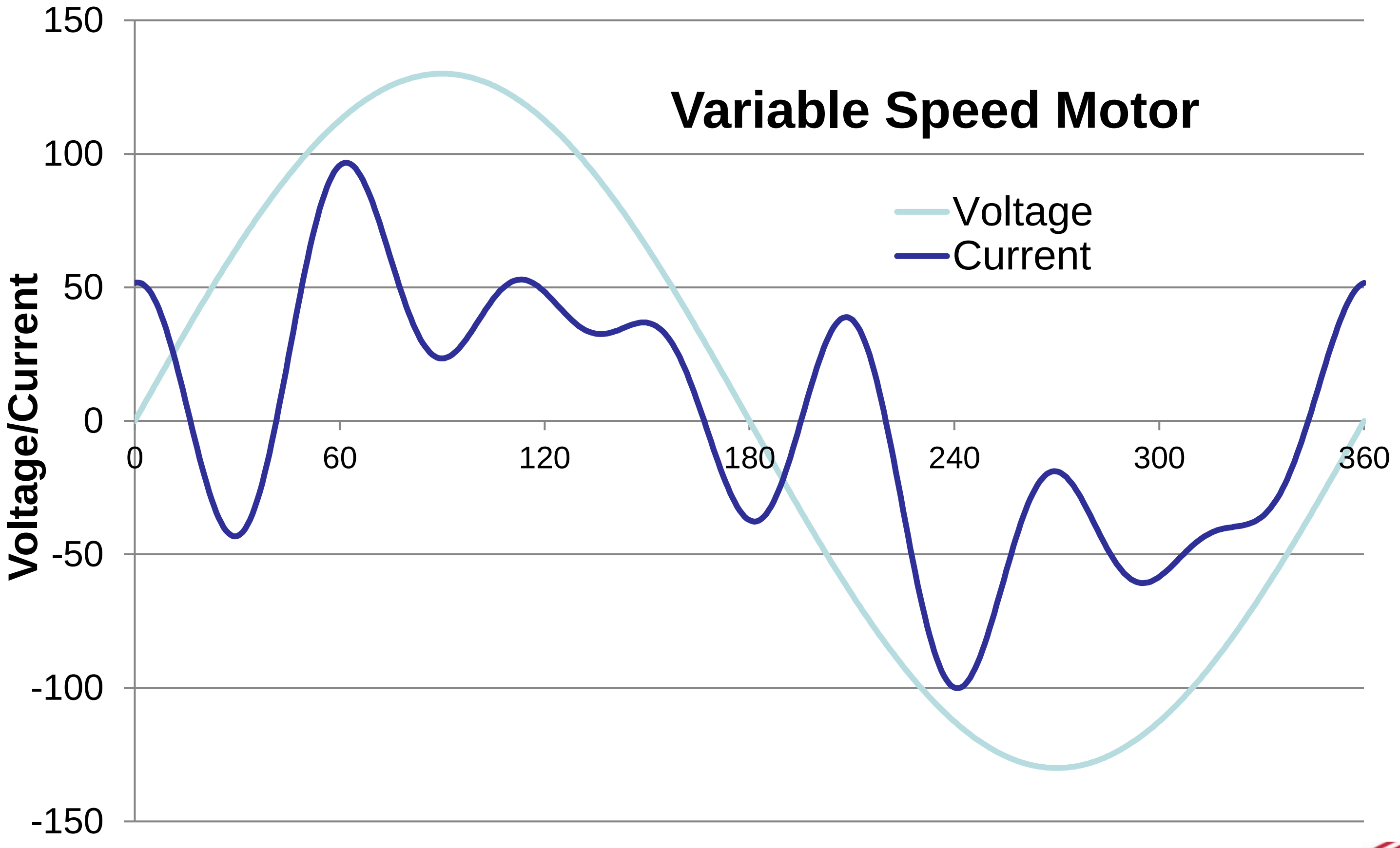

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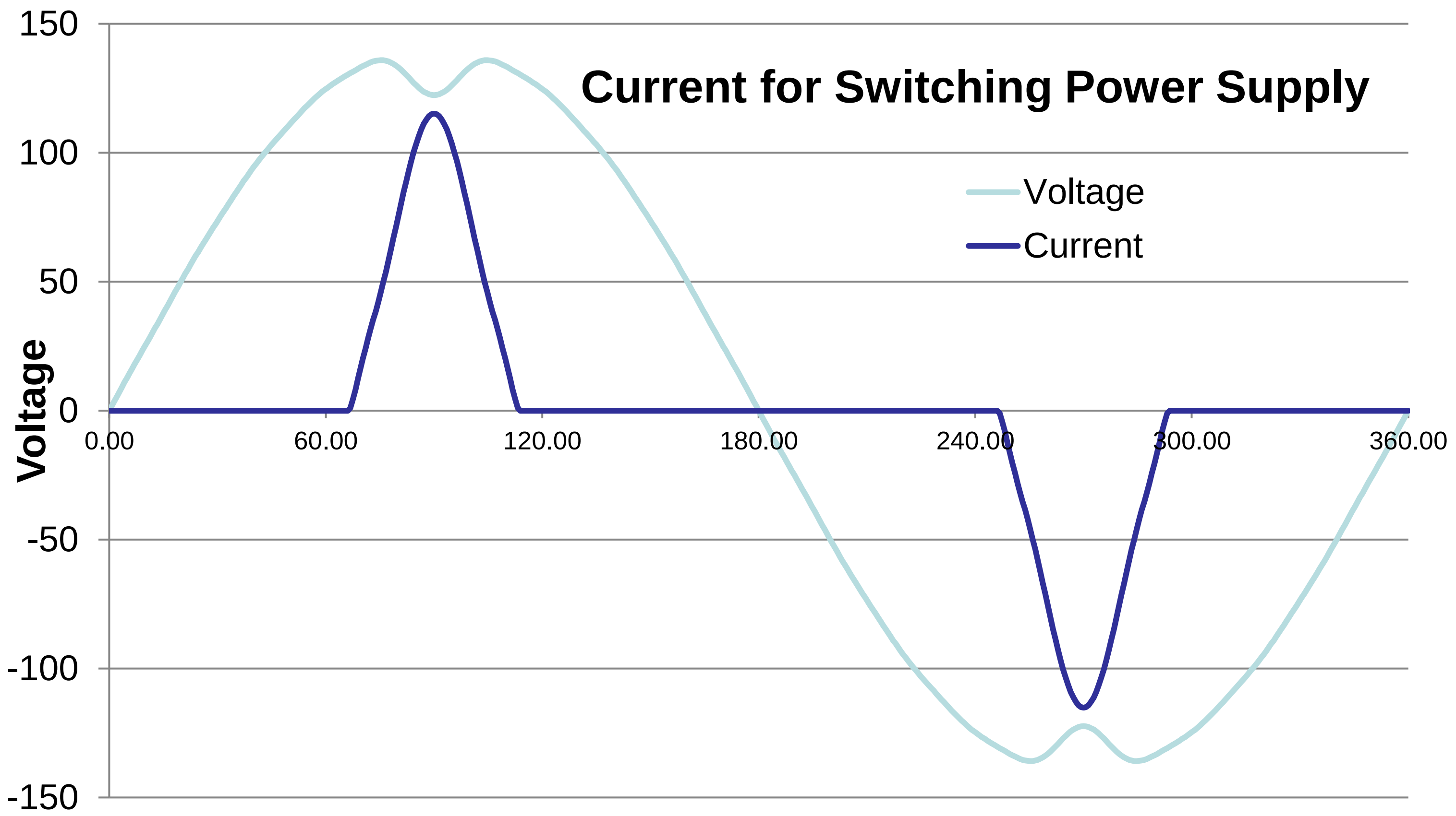

# Standards Changes

- **C12.20-2015**
  - **American National Standard for Electricity Meters—0.1, 0.2, and 0.5 Accuracy Classes**
  - Polyphase meters tested using polyphase
    - Recommended now, required **Jan 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

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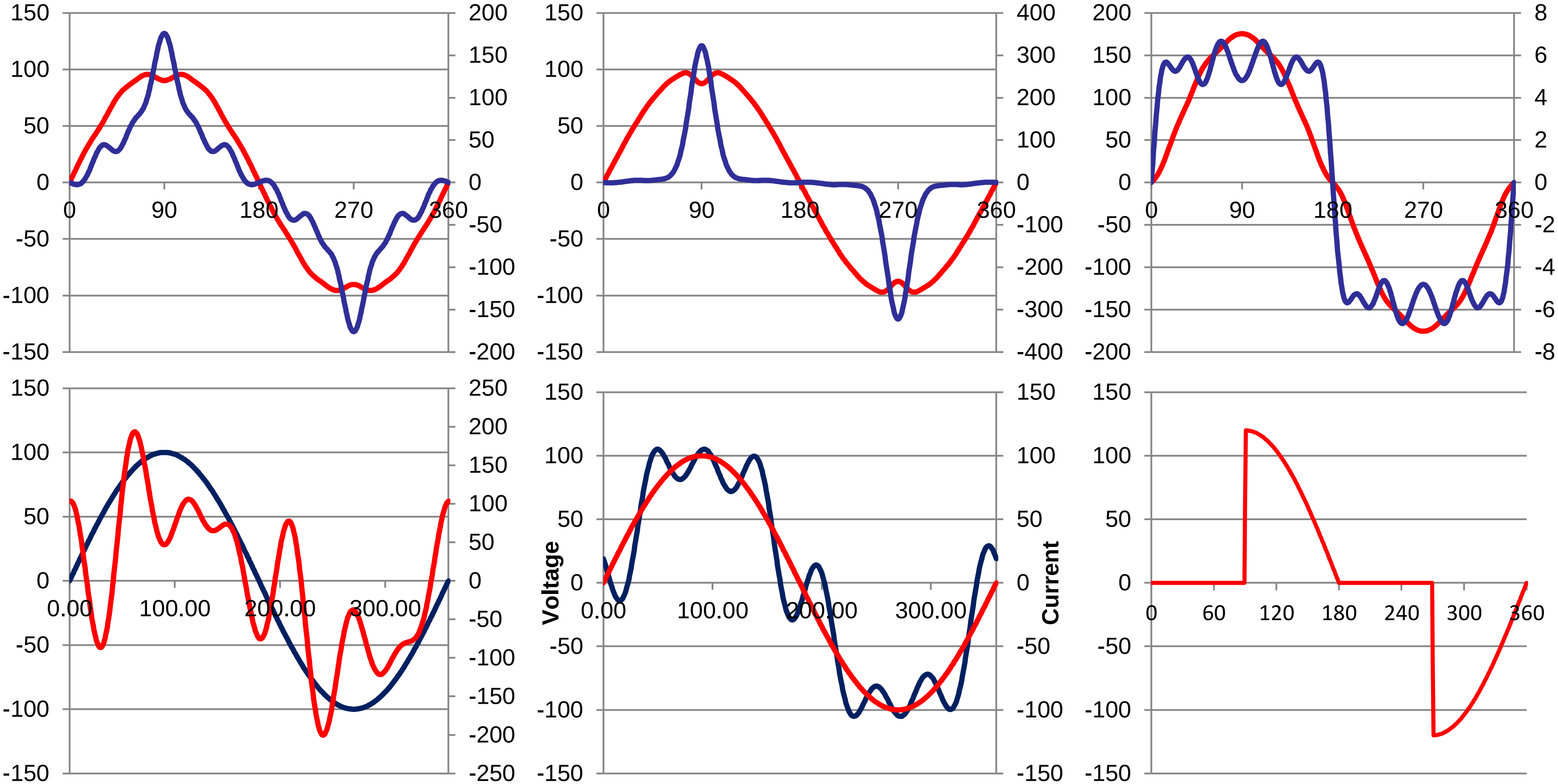
# Harmonic Load Waveforms

ANSI C12.20 now addresses harmonic waveforms



# Standards Changes

- **C12.20-2015**
  - 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

- **C12.20 and C12.1 are in the process of being combined**

- **New Revision of C12.10**
- Safety 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**
  - COSEM has been recommended for adoption as an ANSI standard

# ANSI C12.31

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

C12.31

# ANSI C12.31

## RMS Voltage

Eq. 4.1.4.1

$$V(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty} \left( a_n \cos(n\omega_0 t) + b_n \sin(n\omega_0 t) \right)$$

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

# ANSI C12.31

## RMS Current

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

# ANSI C12.31

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

# ANSI C12.31

## 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 $$S = VA = \sqrt{\frac{1}{N}\sum_{i=0}^{i=N-1} V_i^2 \bullet \frac{1}{N}\sum_{i=0}^{i=N-1} I_i^2}$$ 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

# ANSI C12.31

- **OPEN ISSUE – Polyphase VA**
  - New approach suggested by John Voisine (Landis+Gyr)
    - Tries to better represent VA seen by the transformer
  - In general the issue of how to compute polyphase VA is unresolved
  - Issue is the meter can neither know the real load configuration not the transformer configuration

# Next Generation Standards

- **ANSI C12.46**
  - New standard in development to **replace C12.1** and **C12.20**
  - Structured like OIML R-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 occurring conditions should be within ±0.2% maximum error.

# Next Generation Standards

- **OIML R-46 REVISION**
  - Expanding to cover VA and VAR
  - Adding harmonic performance tests
  - Adding new (non-utility) applications
    - Sub-metering
    - Point of load (Streetlights for example)
    - Electric vehicle chargers

# What does the Future Hold

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




METER

# Questions?

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This presentation can also be found under Meter Conferences and Schools on the TESCO website: www.tescometering.com