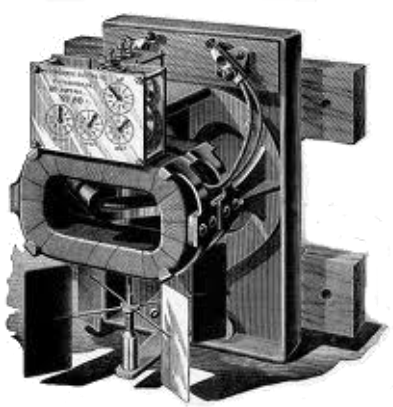
21st Century Power Measurements

Prepared by Bill Hardy, TESCO
The Eastern Specialty Company

For North Carolina Electric Meter School
Advanced Session
Tuesday, June 26, 2018 at 1:45 p.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?

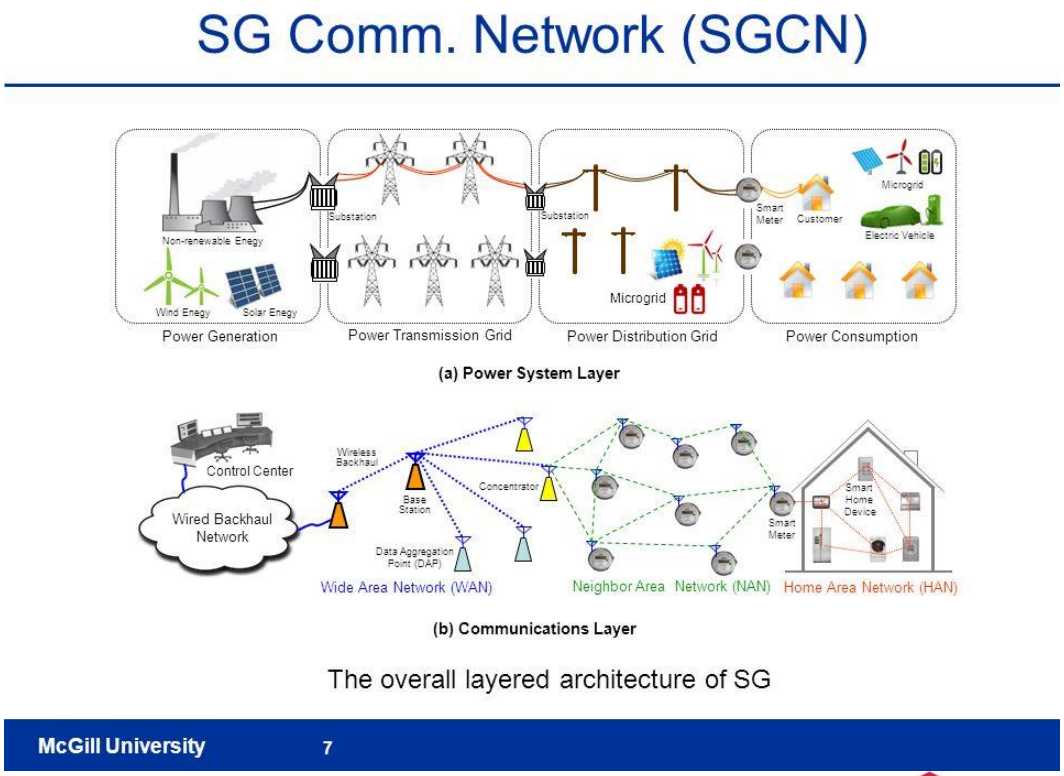
Loads

TODAY

Then – Now – Tomorrow?
Communications

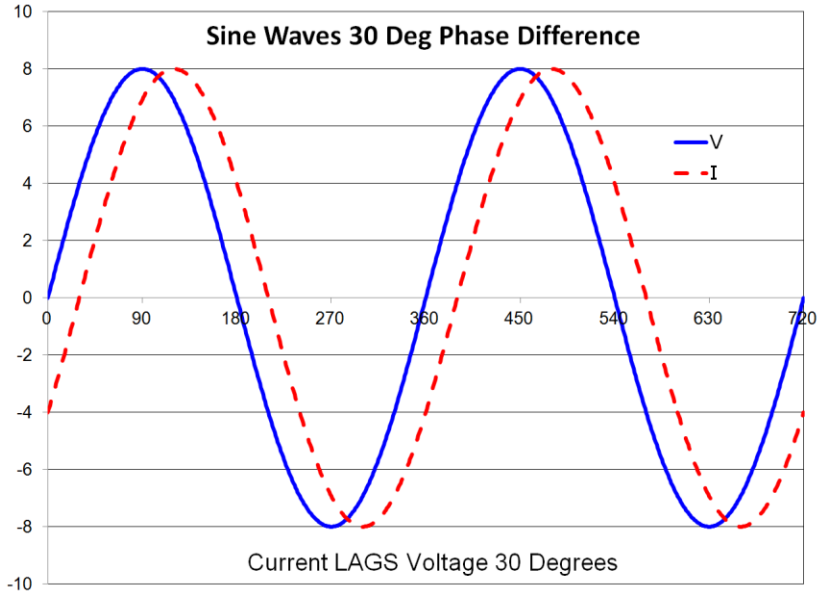
THEN

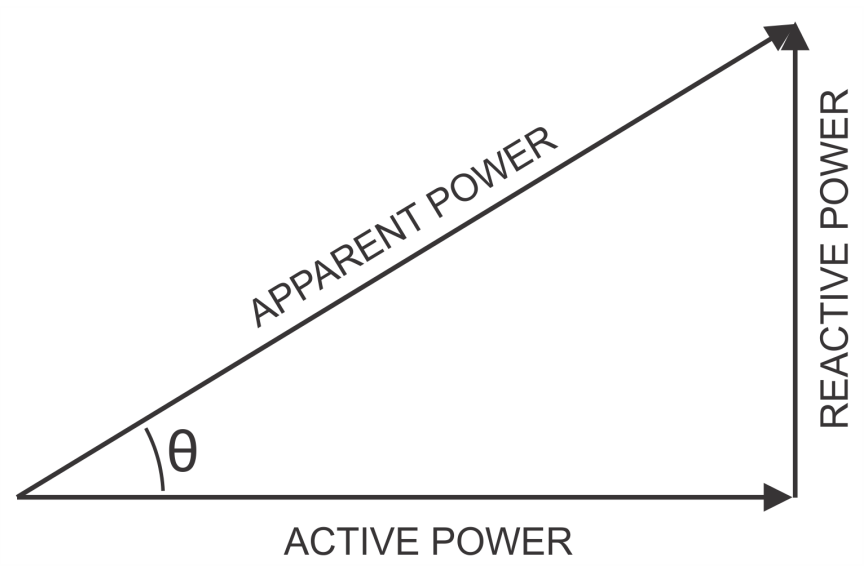
NOW



Why do these changes matter?

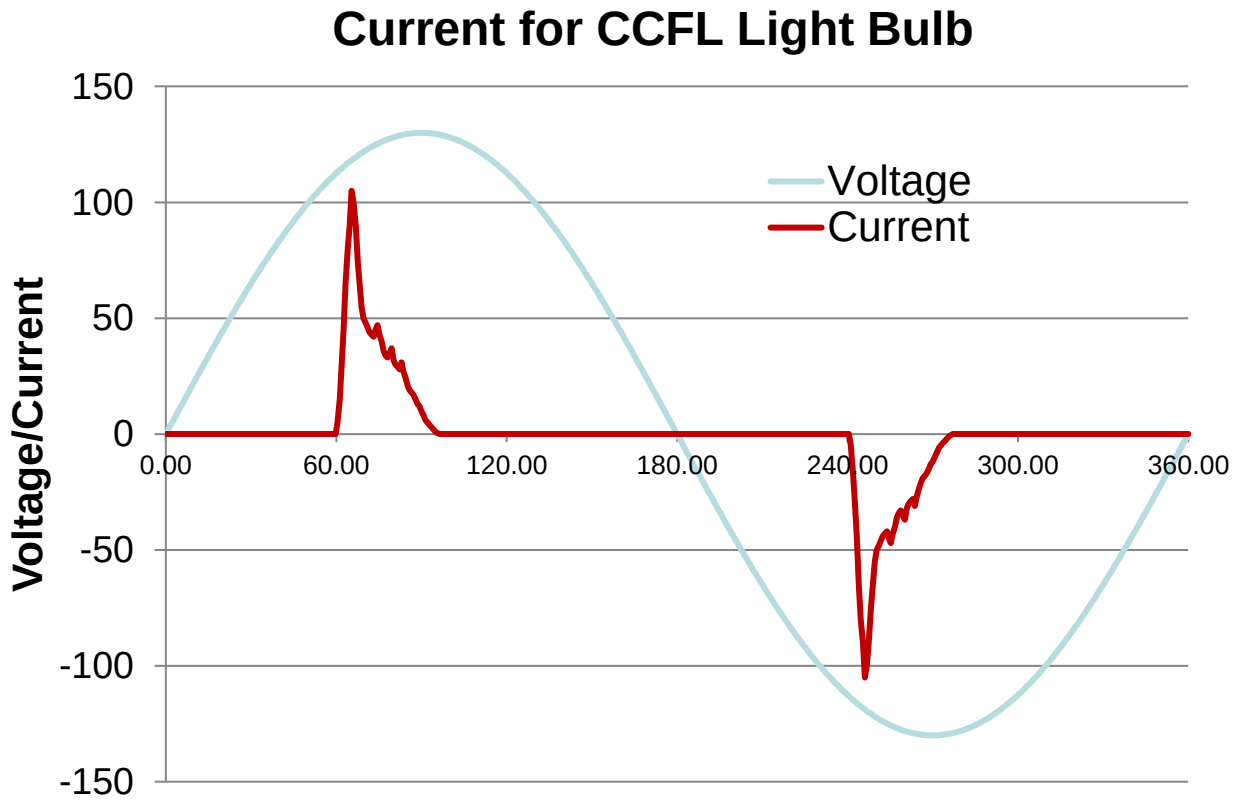
- Changes to our loads have changed the basic computations of metering.
- When loads were linear the power triangle was all we needed to know





Why do these changes matter?

- Today's loads look more like these



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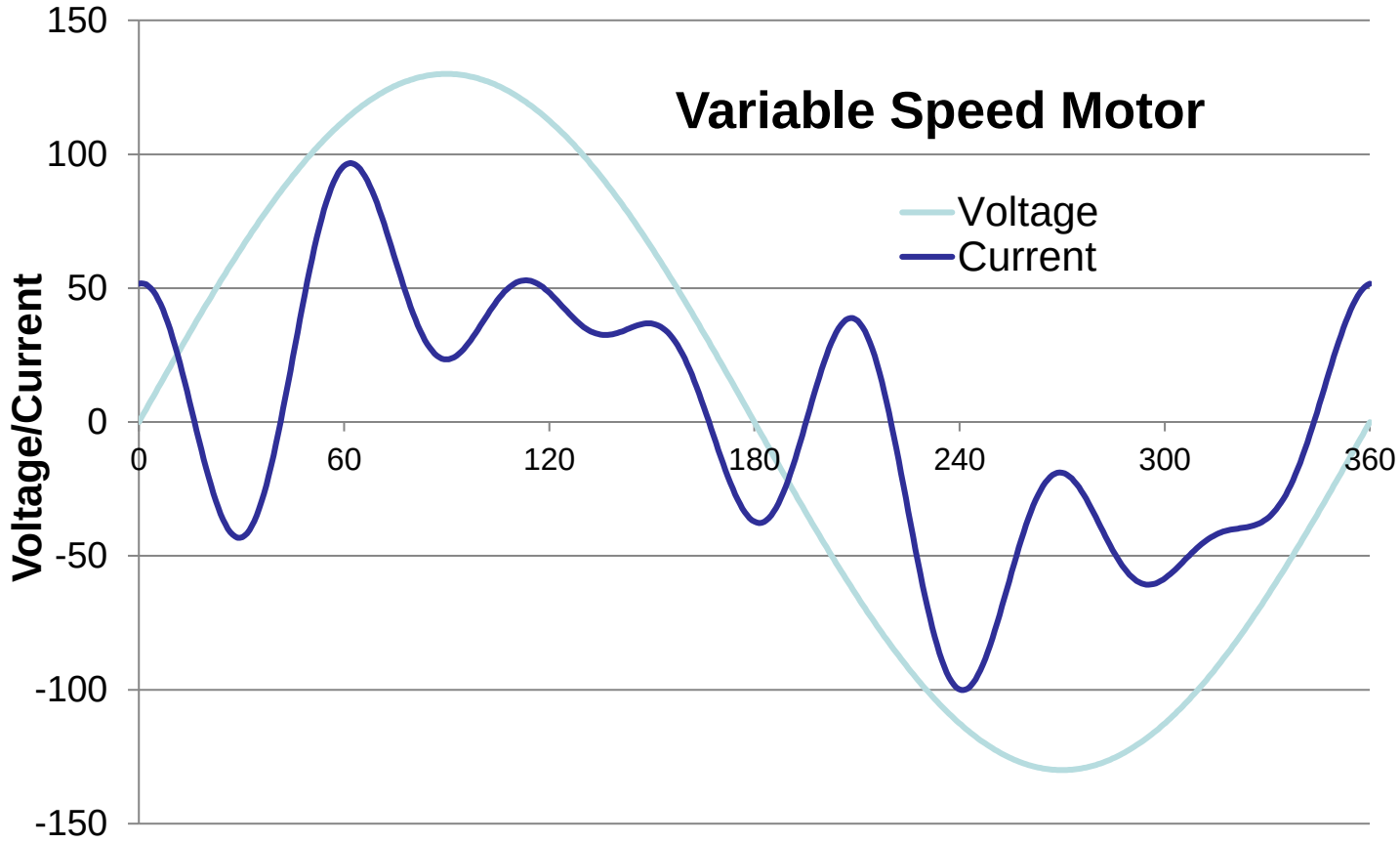

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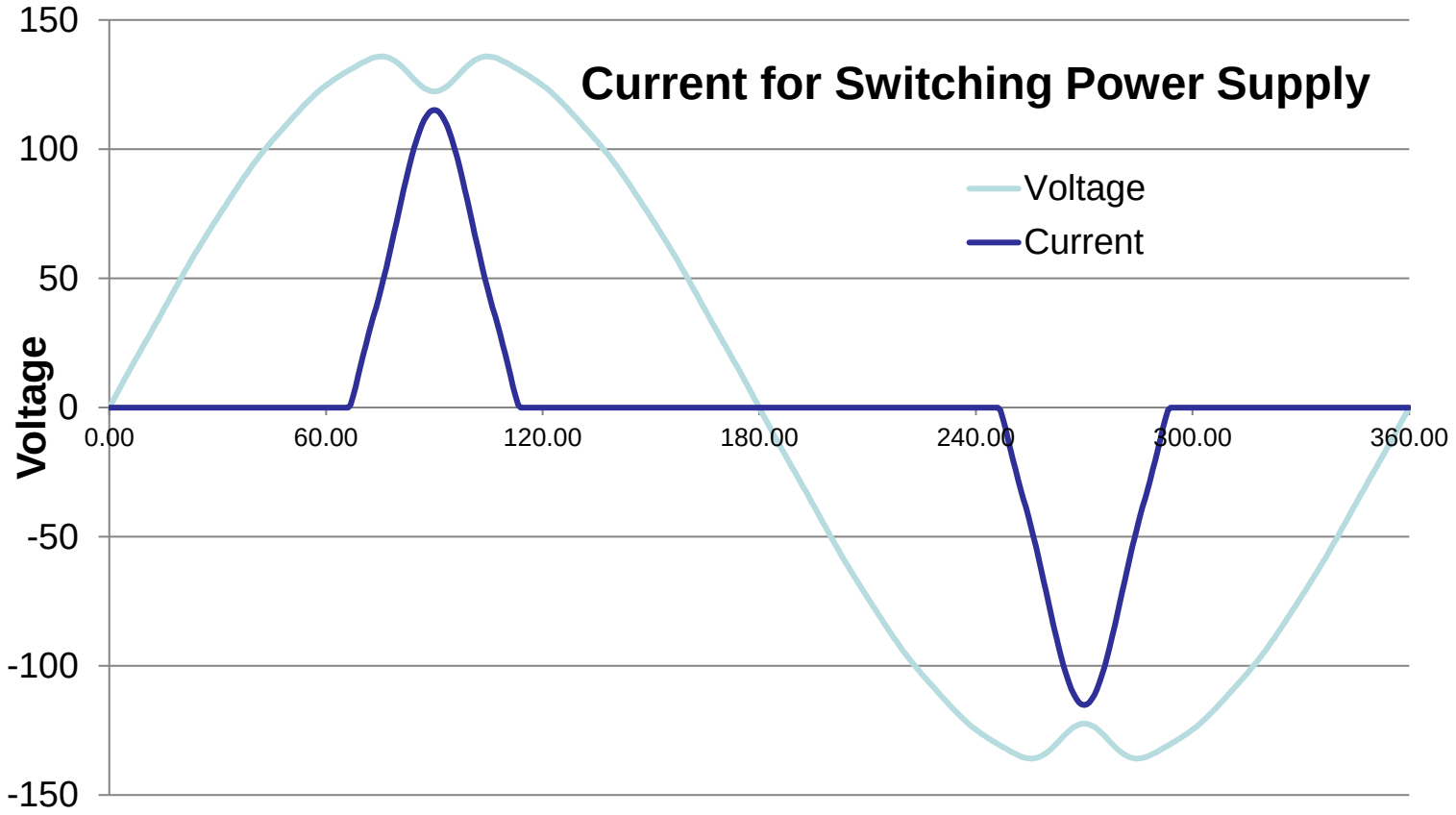
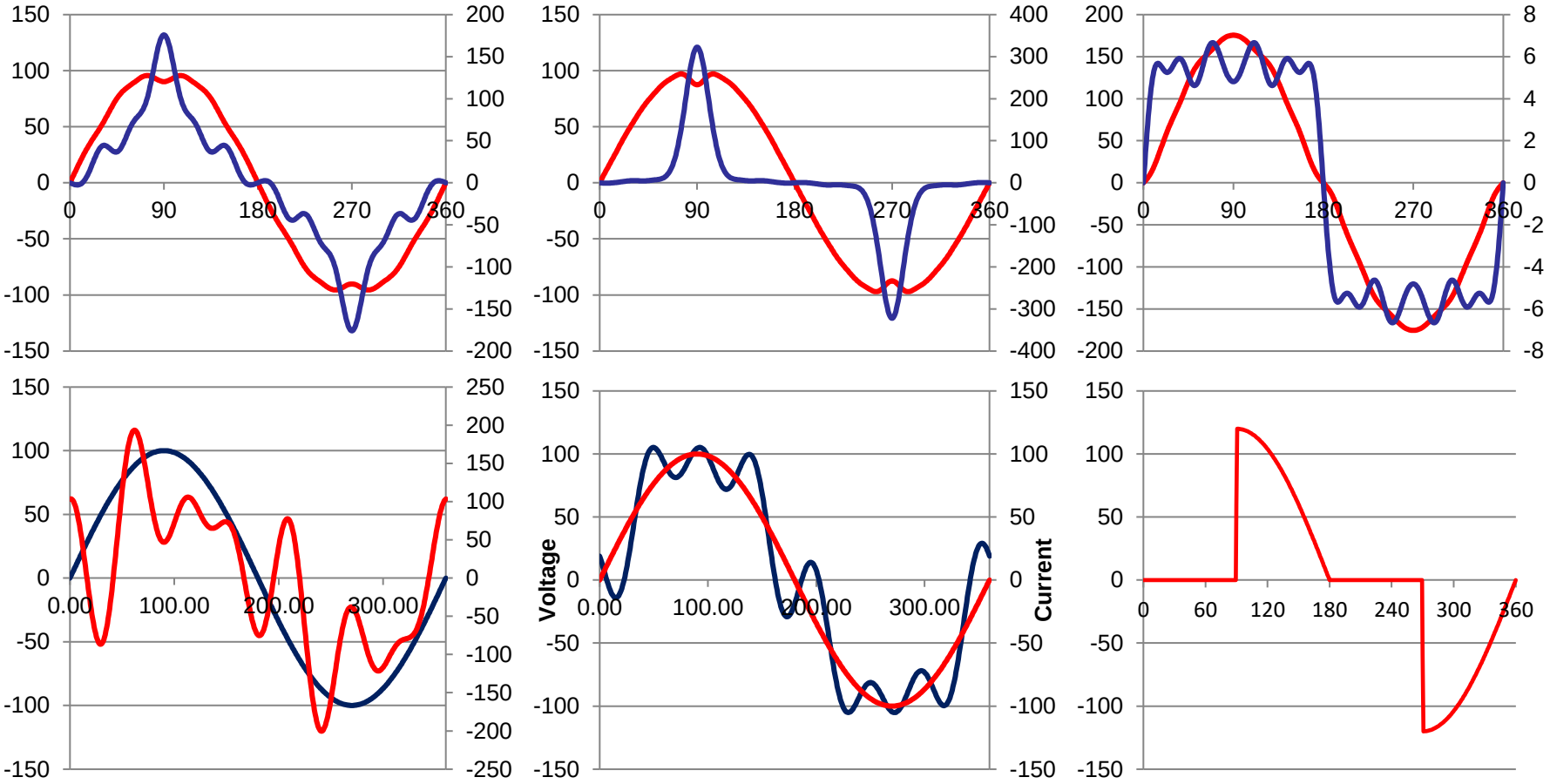


Standards Changes

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

New Definitions

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

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

$$P = \frac{1}{2}\sum_n \left|\vec{V}_n \bullet \vec{I}_n\right| = \frac{1}{2}\sum_n (a_n c_n + b_n d_v)$$

Eq. 4.2.3.3

$$= \frac{1}{2}\sum_n V_n I_n \cos(\theta_n)$$

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

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 occurring conditions should be within ±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?

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