THE EASTERN SPECIALTY COMPANY

21ST CENTURY POWER MEASUREMENTS

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The Eastern Specialty Company

For North Carolina Electric Meter School

Advanced/Management/Emerging Technologies Combined Session

Wednesday, June 15, 2022 at 10:30 AM

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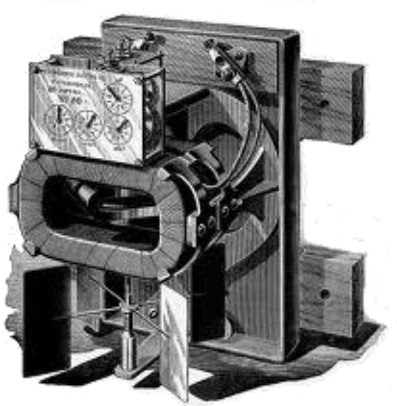
Then – Now – Tomorrow? Meters



First Meters mid-1890s

Westinghouse 1905

2005

2006

2014

2025 ???

Then – Now – Tomorrow? Meters?

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Then – Now – Tomorrow? Loads

YESTERDAY

TODAY

THEN – NOW – TOMORROW? LOADS

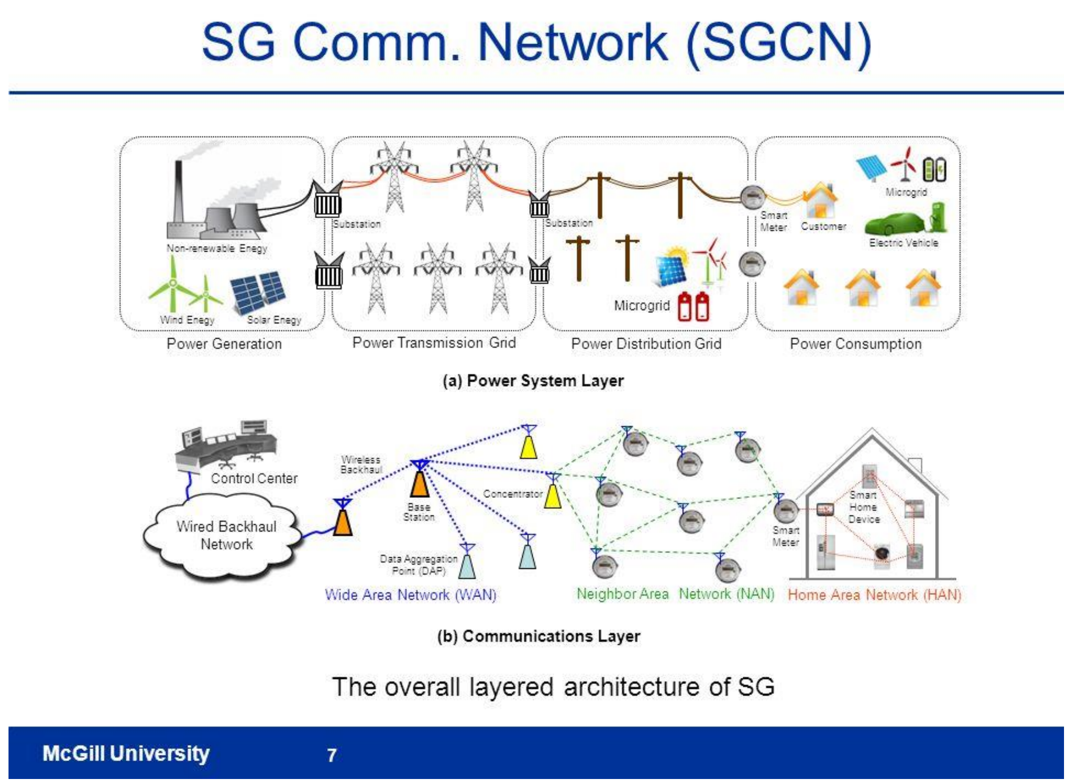
TODAY

Then – Now – Tomorrow?

Communications

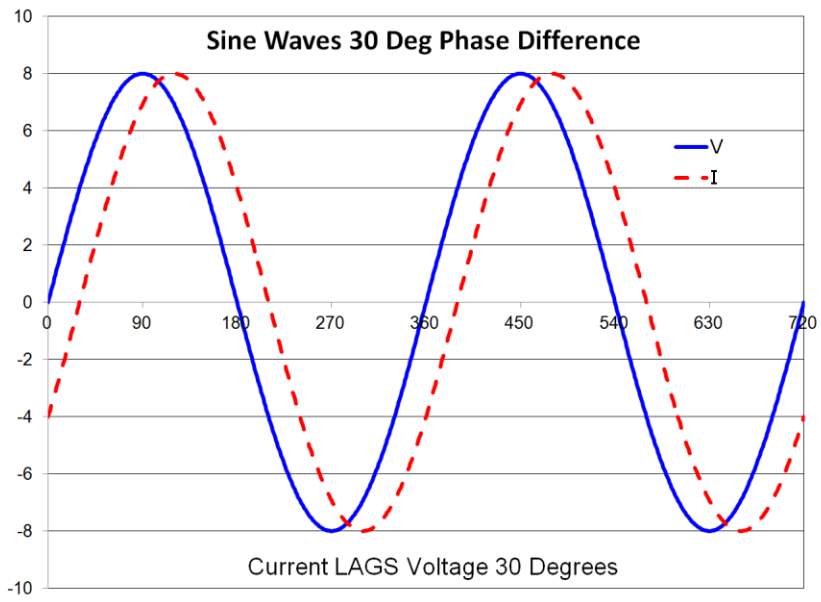
THEN

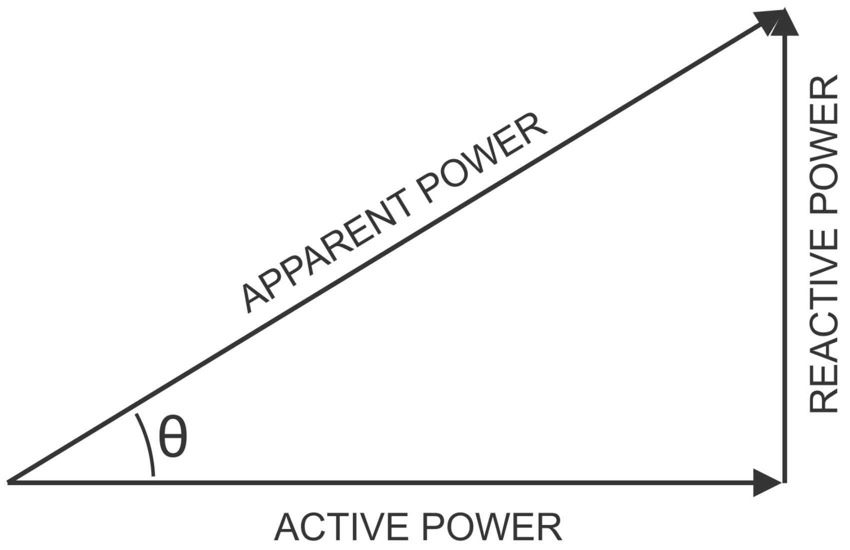
NOW



WHY DO THESE CHANGES MATTER?

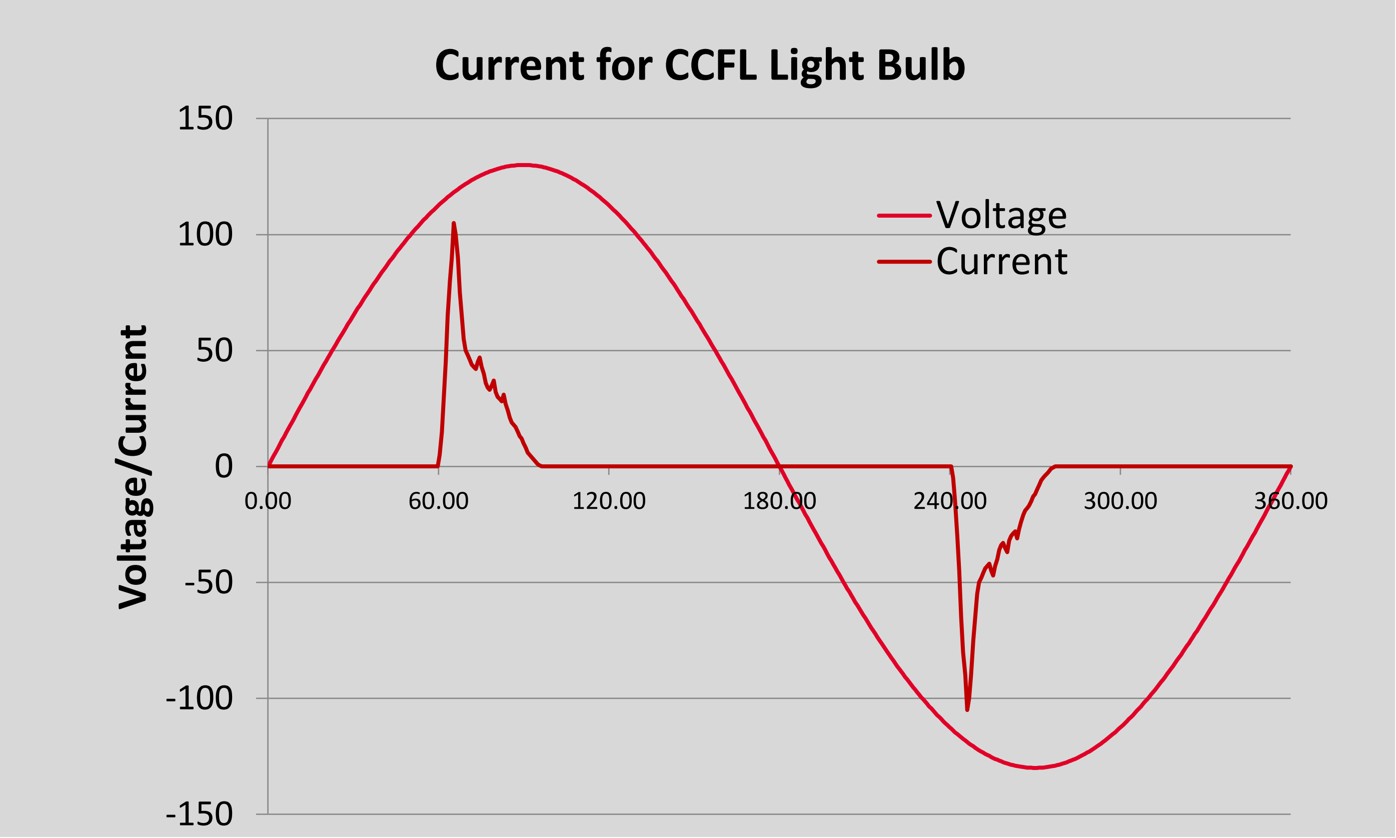
- Changes to our loads have changed the basic computations of metering.
- When loads were linear the power triangle was all we needed to know





WHY DO THESE CHANGES MATTER?

- Today's loads look more like these



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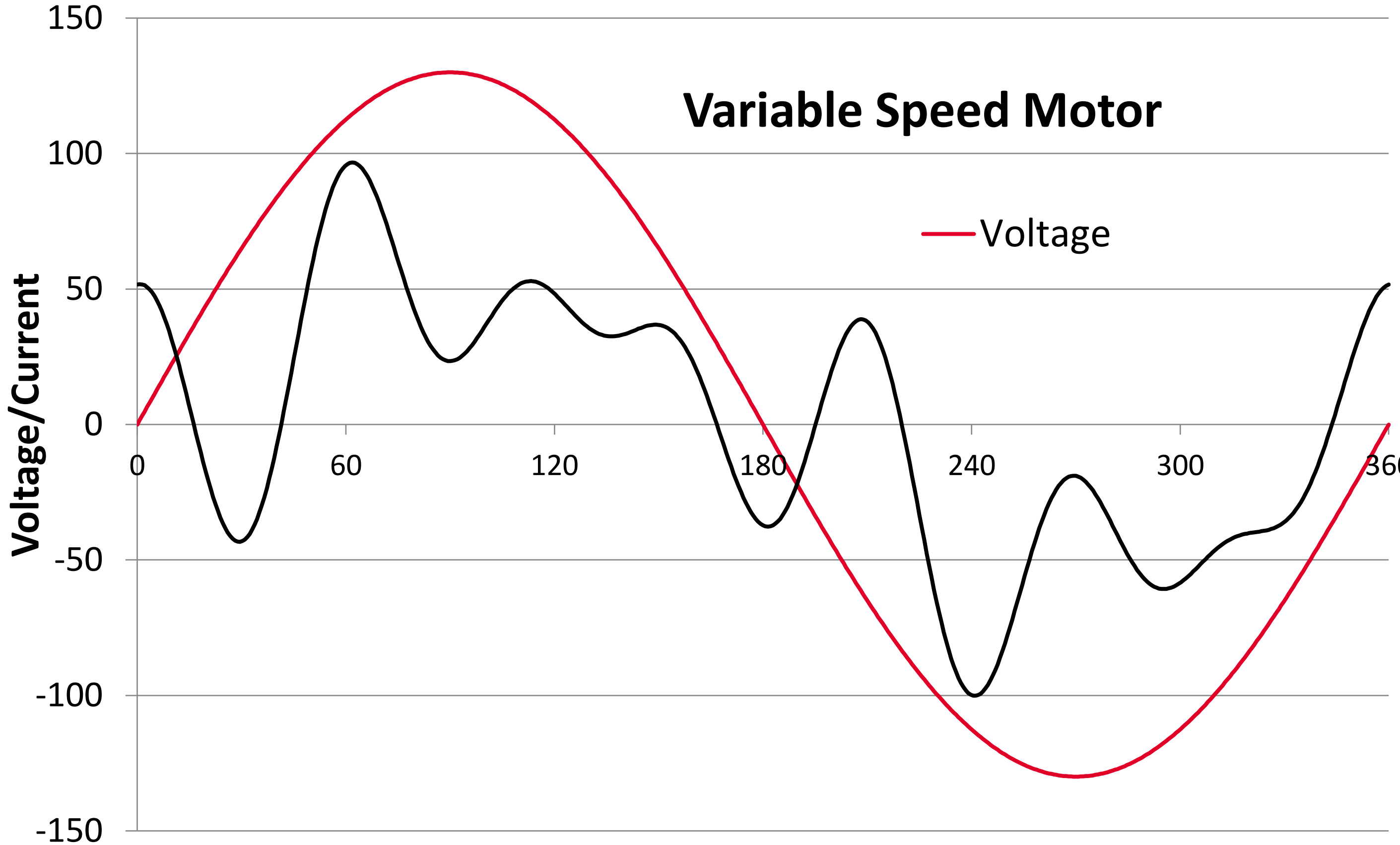

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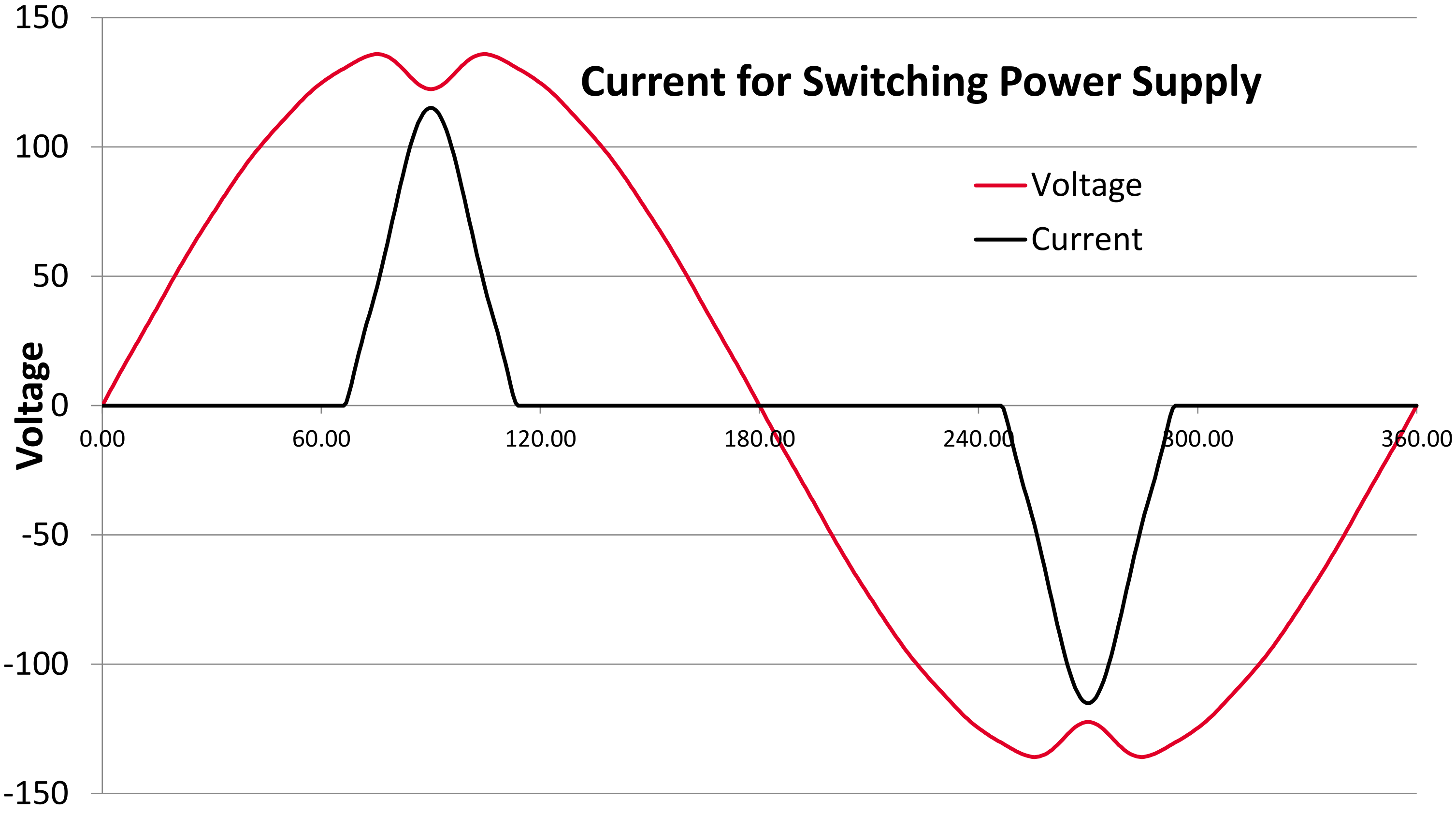

Standards Changes

- **C12.1-2021 American National Standard for Electric Meters—Code for Electricity Metering**
  - Combines C12.1 and C12.20 into a single modernized document
  - Polyphase meters tested using polyphase
  - Unbalanced load testing required
  - Full harmonic testing required
  - Bidirectional energy flow testing required.

Standards Changes

- Testing with Auxiliary Communications Devices for accuracy required
- Testing for each service type for which the meter is applicable is required
- Blondel vs non-Blondel meter forms and applications are called out.
- An appendix on inherent non-Blondel errors and the governing assumptions is included.
- Many tests were updated to make them more applicable to 21st century applications

HARMONIC LOAD WAVEFORMS

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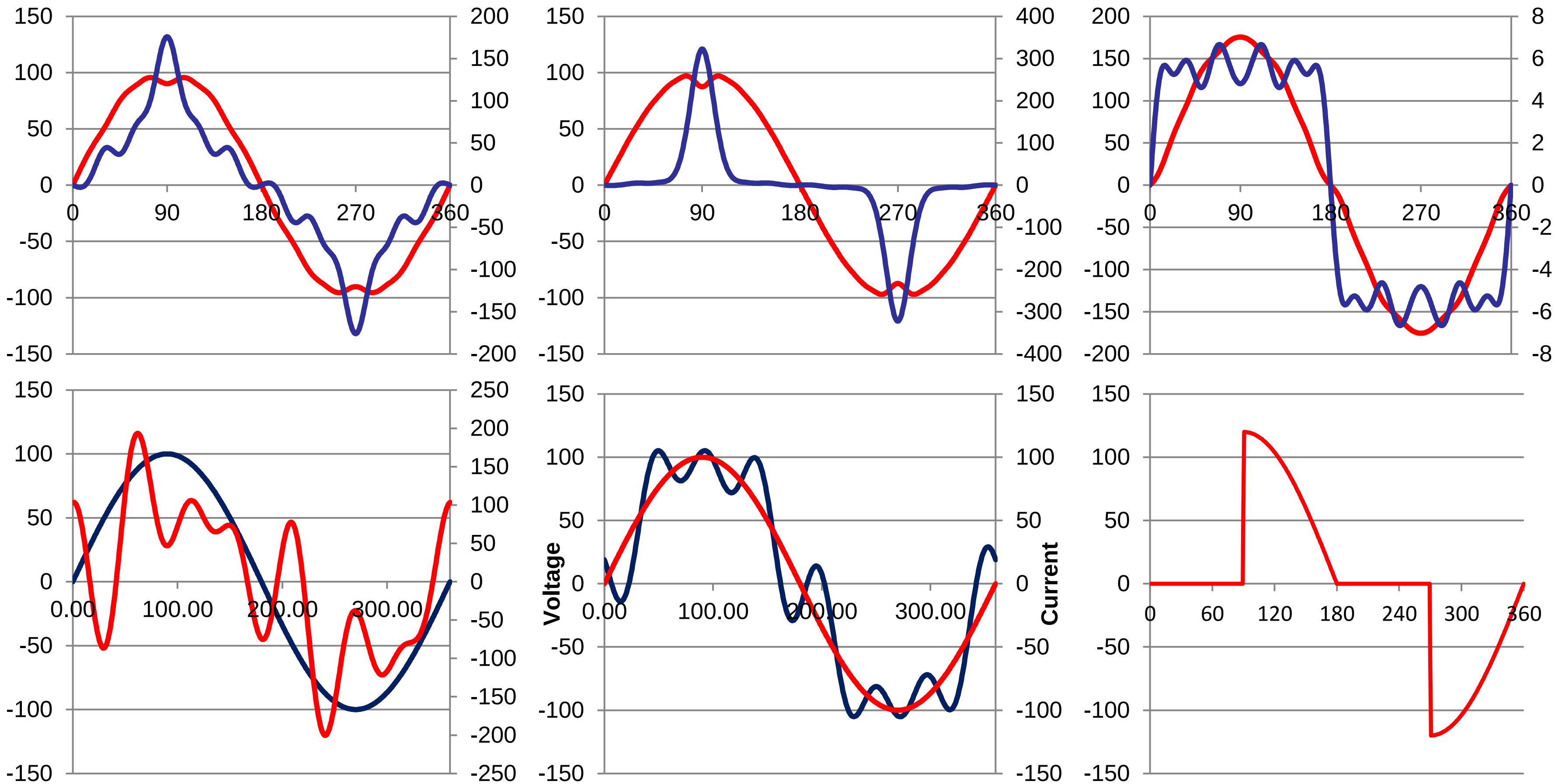
ANSI C12.1/C12.20 now addresses harmonic waveforms



STANDARDS CHANGES

- **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

- **Communications Standards**
  - COSEM has been approved for adoption as an ANSI standard

ANSI C12.31

- There was no non-sinusoidal definition for VA or VAR or Power Factor
- New ANSI Standard C12.31 defines these mathematically so every meter manufacturer can use the same calculations
- Addresses the issue of non-sinusoidal waveforms
- Addresses the issue of polyphase measurements for VA

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

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

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

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
  - The issue of how to compute polyphase VA is presently unresolved but is being actively worked on
  - The Issue is the meter can neither know the real load configuration nor the transformer configuration

Next Generation Standards

- **ANSI C12.46**
  - New standard in development to eventually replace C12.1-2021
  - Structured to be inline with OIML R-46
  - New C12.1 has moved much closer to the actual requirements of IR-46.
  - Applies to ALL energy measurements
    - Watts, VA and VAR
    - Uses C12.31 definitions for all quantities

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 an option is added to a meter, the meter must be tested with the option running to remain qualified

NEXT GENERATION STANDARDS

- **OIML TC12 now working on expanded recommendation**
  - 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

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WHAT DOES THE FUTURE HOLD?

- Traditional meters will have many more integrated features and take on a wider operational role and will become a primary source of system data
- Many more devices will have a non-traditional embedded revenue meter
- Some will NOT be regulated by the PSC's

What does the Future Hold?

- The Meter Tech of the future will be
  - dealing with these embedded meters
  - working with all of these new features
  - addressing communications issues
  - working across departments at the Utility to provide information and accomplish wider ranging initiatives (e.g. DER)
  - Work with a new set of primarily private commercial customers who do not own buildings but own assets piggy backed onto the network

What about DC?

- There are still a number of DC meters out on our systems, primarily in the larger, older urban areas such as San Francisco and New York City.
- There has been no effective way to test these legacy meters for some time. This is shortcoming was highlighted as new DC metering applications have begun to make an appearance on the grid and are demanding we find a solution (e.g. DC superchargers)
- Using labs with traceable Voltage sources and measurement capabilities and traceable Current sources and measurement capabilities we are now starting to do this.

DC Theory?

No need for new definitions. Power is simply VA. If we can measure the fundamental Volt and the fundamental Amp then we can create a Standard to measure against and can effectively test our DC meter.

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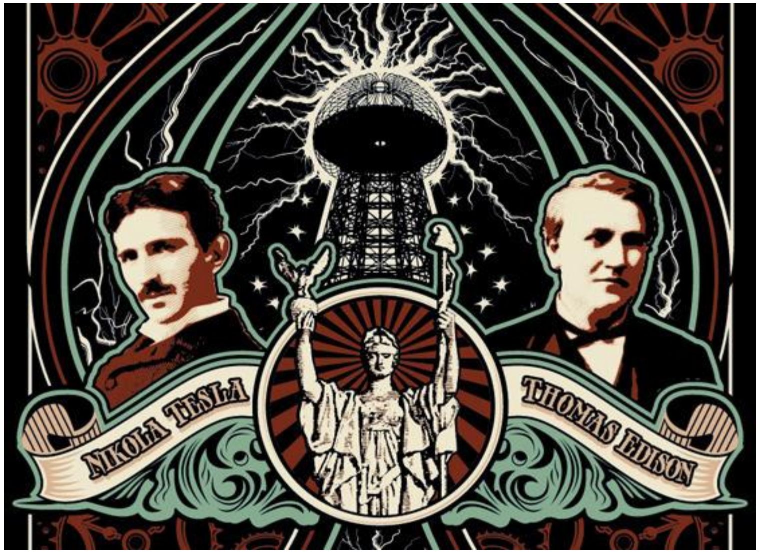
ANSI C12.32

- As always, the theory is only the start. We now need to take this theory and create a practical process. For AC Meters we have been using ANSI C12.1 for many years to guide us on how to move from theory to practice.
- We have never had a comparable Standard for DC Metering
- ANSI Standard ANSI C12.32 for Electricity Meters for the Measurement of DC Energy has been developed over the past several years and is actively being balloted and is expected to be released in 2022.
- This Standard lays out the tests, the definitions, the acceptable performance levels for accuracy as well as functional testing.
- Definitions are given and the practical means of type testing as well as acceptance testing are given.

2S to 12S to DC Residential?

- Are 2S Meters suitable for the need of the residential customer in 2021?
- Should we start the transition to all 12S metering for residential if 2S is no longer applicable or desirable?
- Should we consider DC metering at the residence and eliminate all inverters other than between the home and grid.
  - Should the meter include this inverter?



Questions and Discussion

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