THE EASTERN SPECIALTY COMPANY

METER FORMS

Prepared by Tom Lawton, TESCO
The Eastern Specialty Company

For North Carolina Electric Meter School
Polyphase Track
Tuesday June 13, 2023 at 11:00 AM

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AGENDA

Meters 101 - Electro-Mechanical vs Solid-State

Meter Forms

Self-Contained vs Transformer Rated

Blondel's Theorem

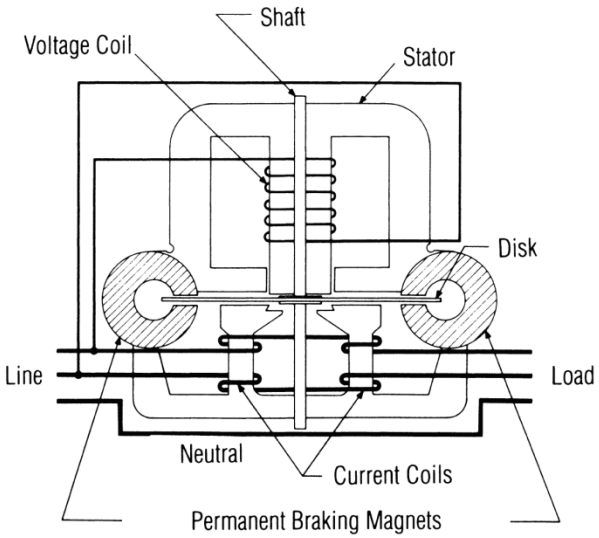
Available References (Hardy's Power Measurement Handbook, UGLY's Elect Ref)

Examples

1S, 2S, 3S, 4S, 5/35S, 8/9S, 16S

INDUCTION METERS

- Two coils and a conducting (usually aluminum) disk. A braking magnet.
- Magnetic field from the first coil generates *eddy currents* in the disk
- Magnetic field from the second coil interacts with the eddy currents to cause motion
- Disk would accelerate without bound except for eddy currents caused by motion through fixed magnetic field which slows the disk
- The end result is that each revolution of the disk measures a constant amount of energy



Basic Energy Formula

- The essential specification of a watthour meter's measurement is given by the value

  K_h [Watthours per disk revolution]

- A Kh of 7.2 is typical. In this example, each full rotation of the disk is equivalent to 7.2Wh of energy.

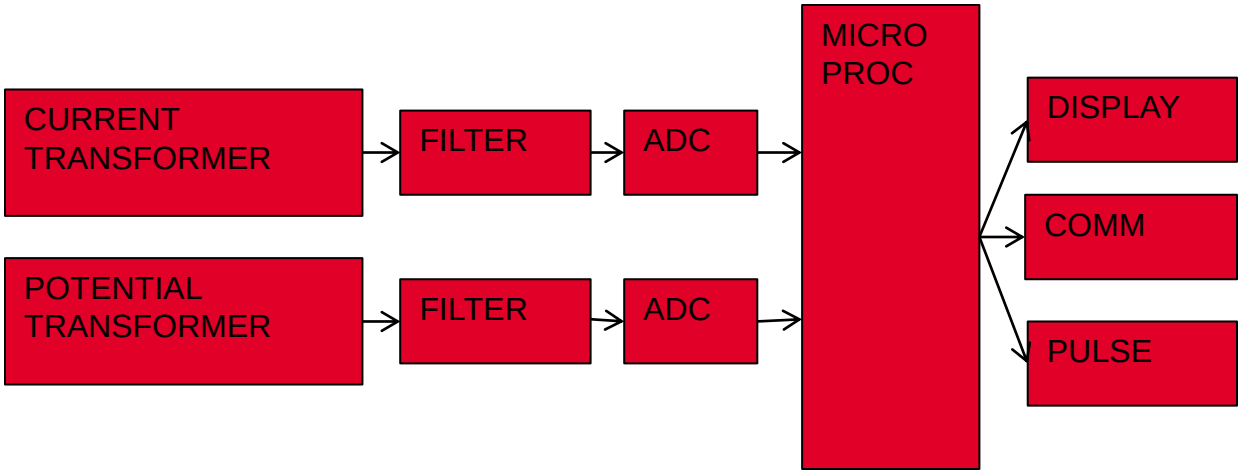
- The watthour meter formula is as follows:

$$E\left[\mathbf{Watthours}\right] = K_h\left[\frac{\mathbf{watthours}}{\mathbf{disk\ revolution}}\right] * n\left[\mathbf{disk\ revolutions}\right]$$

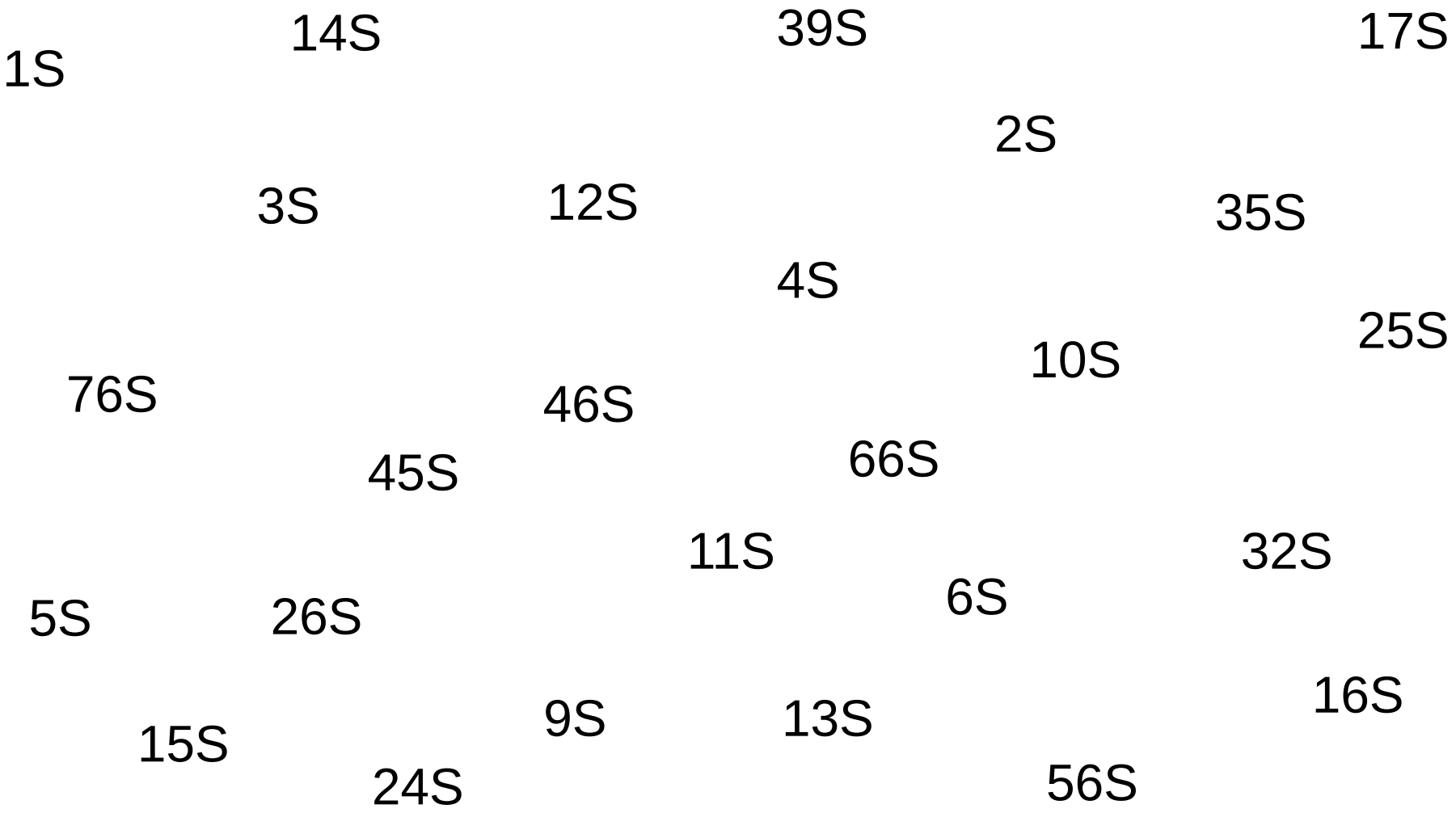
METERS 101 – SOLID-STATE

Overview of Functionality

- Potential and Current is scaled down and conditioned with transformers and filters
- ADC's (analog to digital converters) digitize the signals
- A micro-processor or DSP executes the calculations
- Resulting data is displayed, sent externally via the communication circuits, and used for the calibrated pulse output



METER FORMS


1S
14S
39S
17S
2S
3S
12S
35S
4S
25S
10S
76S
46S
66S
45S
11S
32S
6S
5S
26S
16S
9S
13S
15S
56S
24S

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METER FORMS

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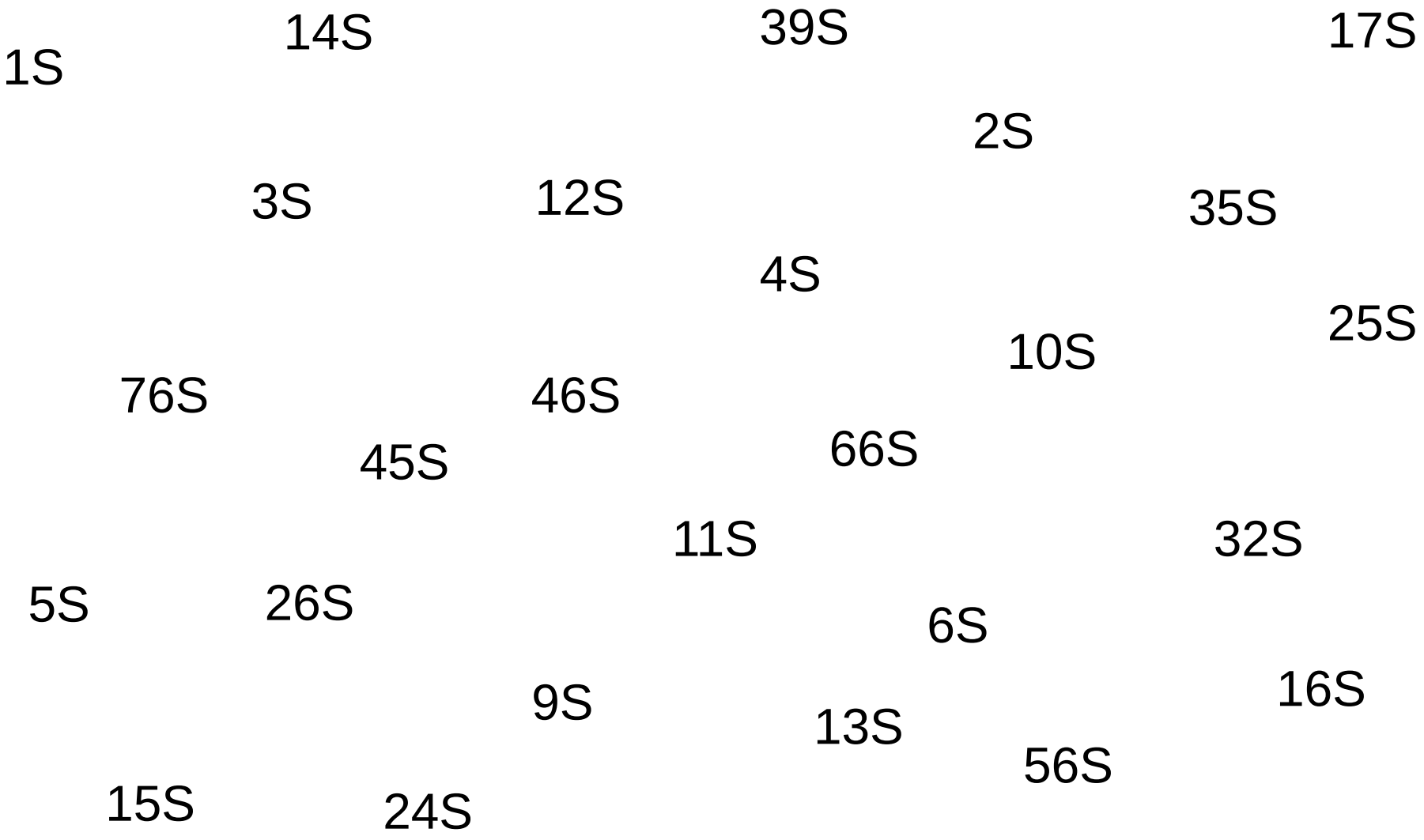
1S
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METER FORMS

SELF-CONTAINED

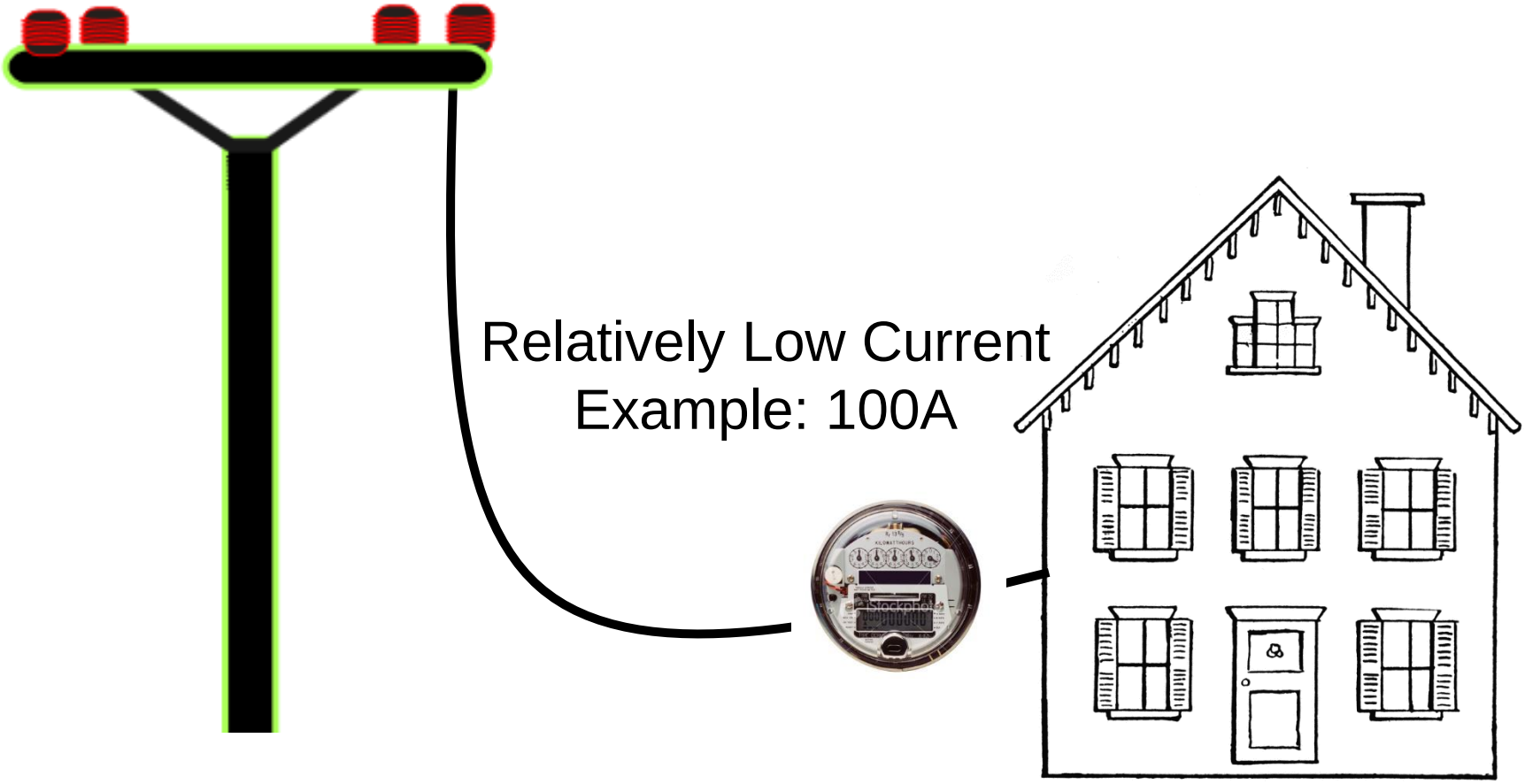
1S
14S
12S
2S
25S
16S
17S
13S
15S
32S

TRANSFORMER-RATED

39S
3S
36S
7S
29S
76S
5S
35S
4S
46S
8S
26S
11S
66S
9S
45S
6S
24S
56S
10S

Self-Contained Meters

Primarily Residential



SELF-CONTAINED

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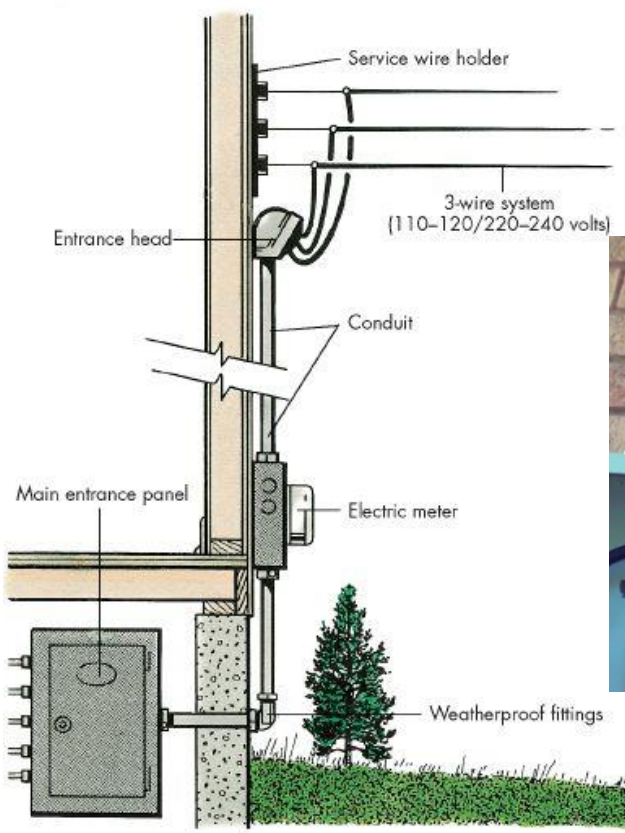
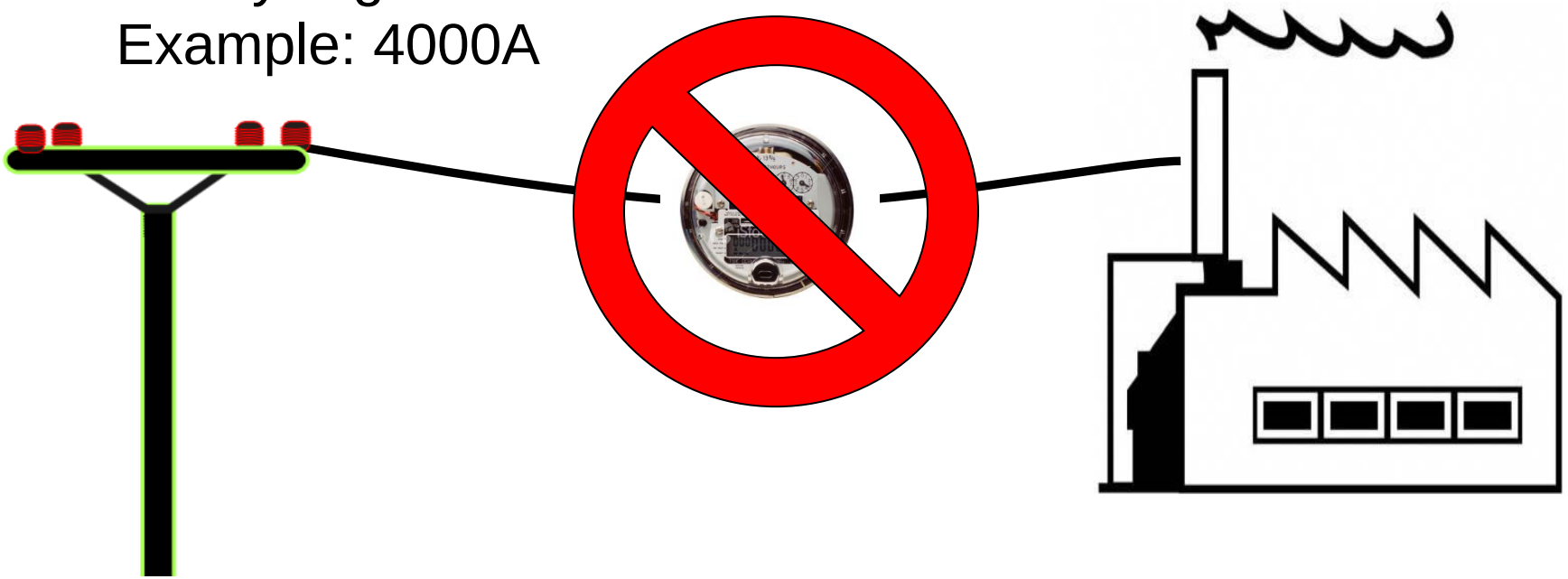


TRANSFORMER-RATED METERS

Primarily Commercial/Industrial

Relatively High Current
Example: 4000A



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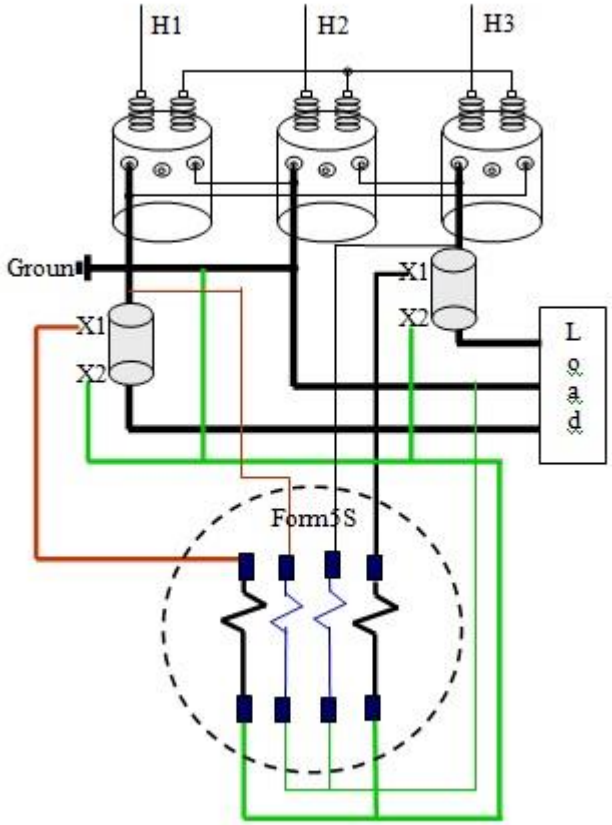
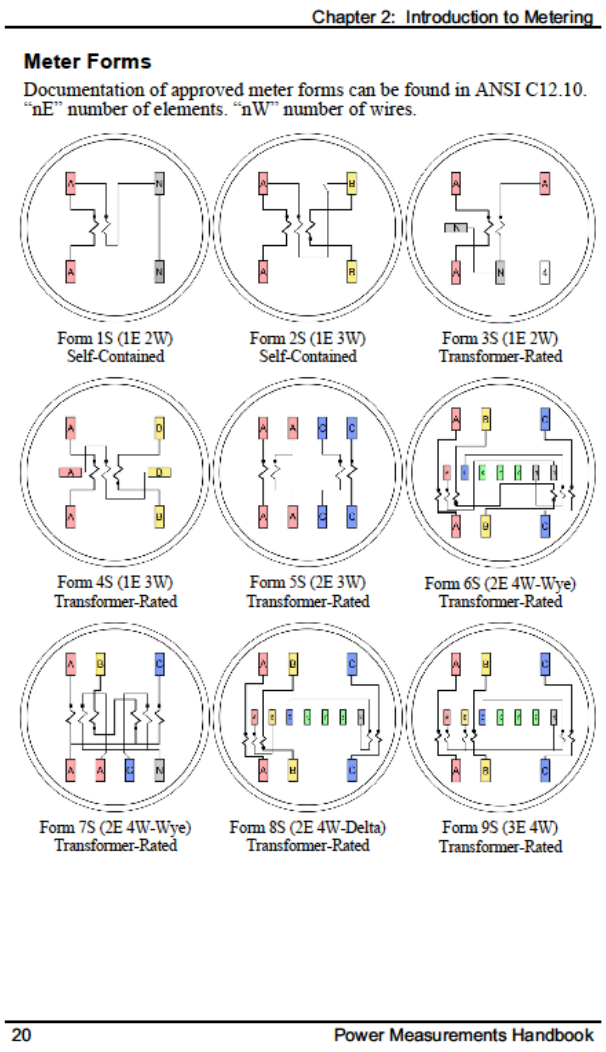


DIAGRAM EXAMPLE



Chapter 2: Introduction to Metering

Meter Forms

Documentation of approved meter forms can be found in ANSI C12.10. "nE" number of elements. "nW" number of wires.

Form 1S (1E 2W) Self-Contained

Form 2S (1E 3W) Self-Contained

Form 3S (1E 2W) Transformer-Rated

Form 4S (1E 3W) Transformer-Rated

Form 5S (2E 3W) Transformer-Rated

Form 6S (2E 4W-Wye) Transformer-Rated

Form 7S (2E 4W-Wye) Transformer-Rated

Form 8S (2E 4W-Delta) Transformer-Rated

Form 9S (3E 4W) Transformer-Rated

20 Power Measurements Handbook

References

- Power Measurements Handbook, Dr. Bill Hardy
- UGLY's Electrical References
- Meterman's Handbook
- Manufacturer's websites

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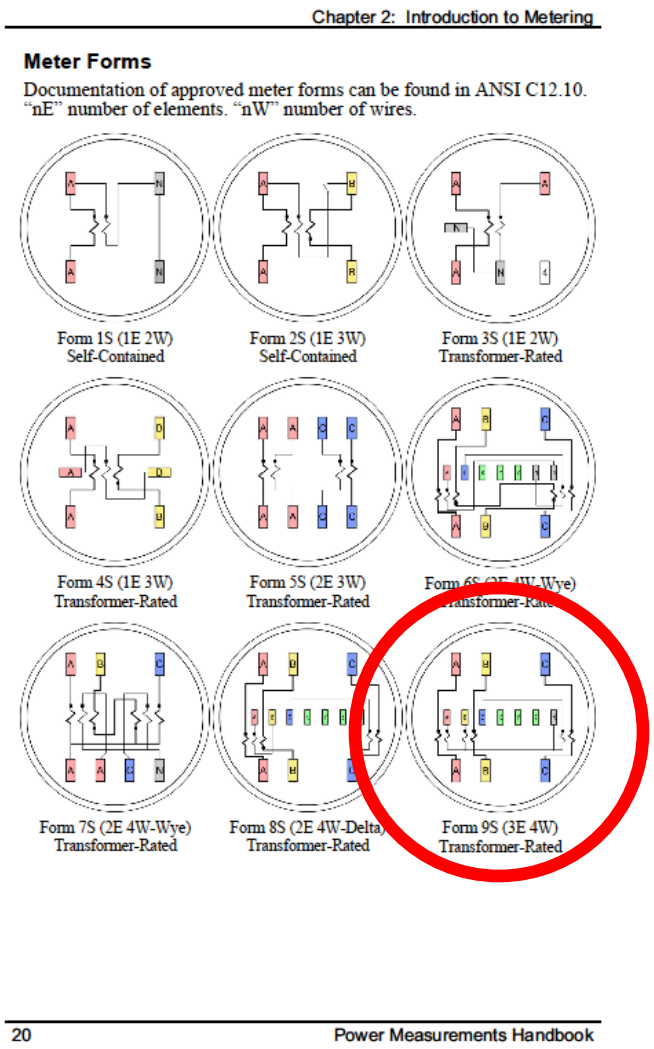

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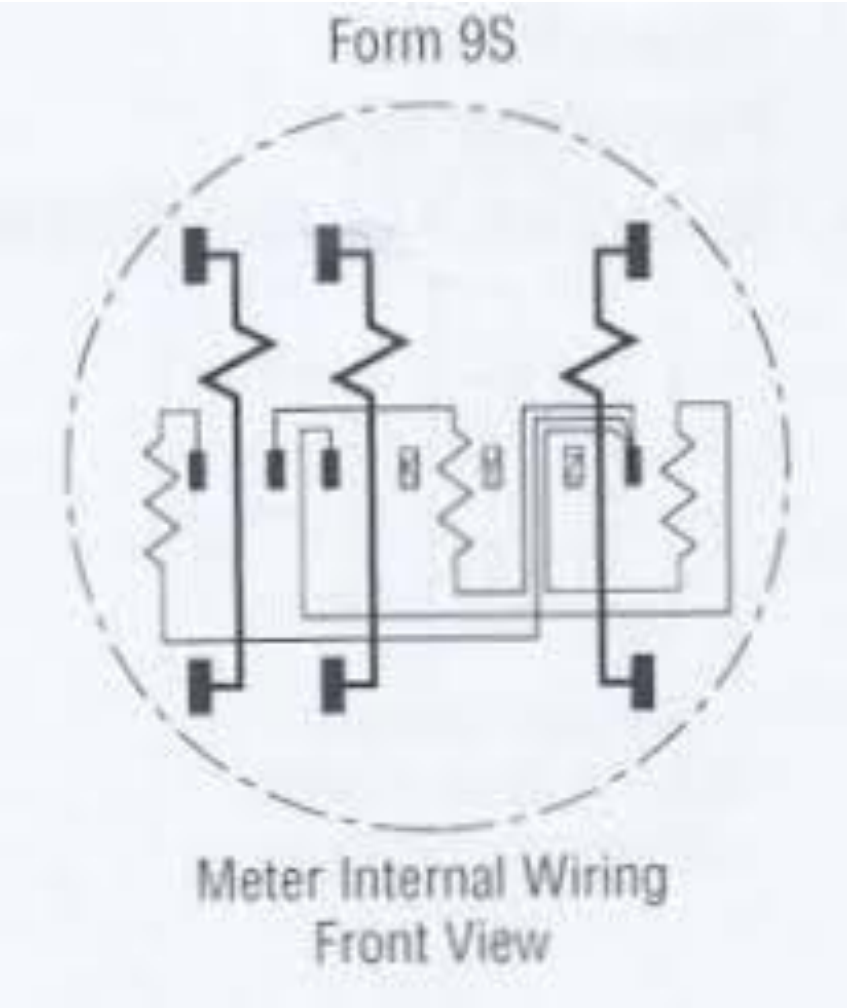
Diagram Example



- 3 Current Coils
- 3 Potential Coils

BLONDEL'S THEOREM

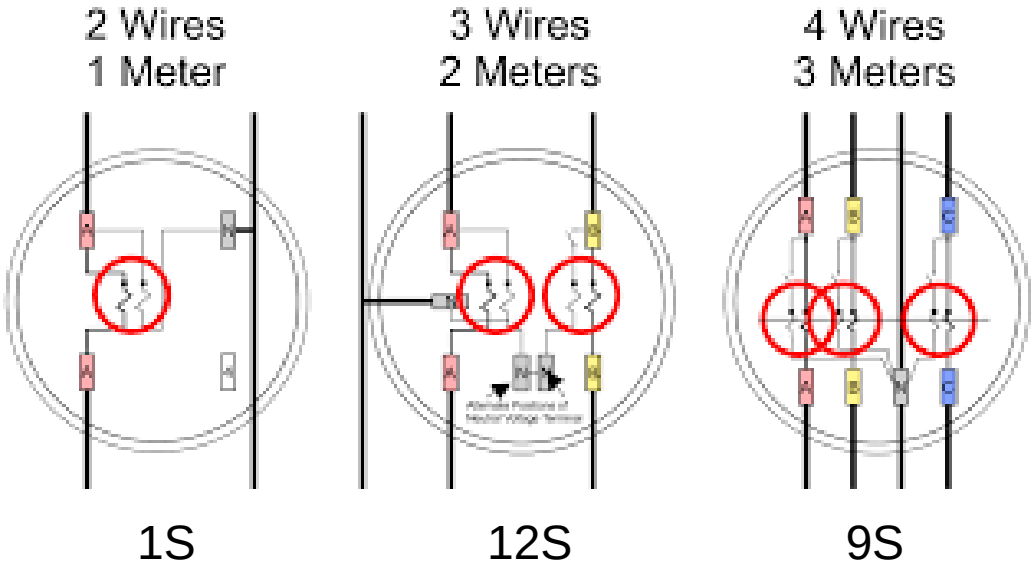
- French Electrical Engineer Andre Blondel
- Attempt to simplify electrical measurements and validation of the results
- Paper submitted to the International Electric Congress in Chicago in 1893.

$$E = n - 1$$

The theorem states that the power provided to a system of N conductors is equal to the algebraic sum of the power measured by N watt-meters. The N watt-meters are separately connected such that each one measures the current level in one of the N conductors and the potential level between that conductor and a common point. In a further simplification, if that common point is located on one of the conductors, that conductor's meter can be removed and only N-1 meters are required.

BLONDEL'S THEOREM

Blondel Compliant



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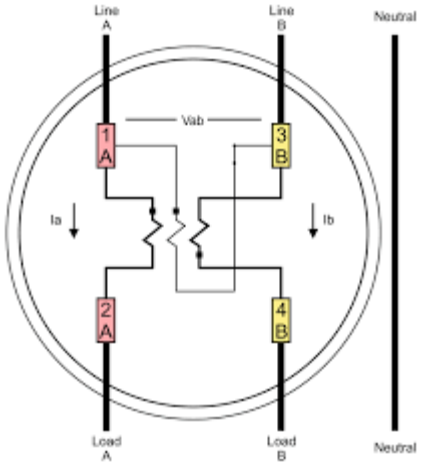
BLONDEL'S THEOREM

Non-Blondel Compliant



2S

$$E = n - 1$$

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BLONDEL'S THEOREM

Why is non-Blondel metering bad?

- Makes assumptions about the service
- Example: balanced voltages
- Assumptions might not be true
- When these assumptions are not true, then there are power measurement errors even if the meter is working perfectly.

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BLONDEL'S THEOREM

Why are non-Blondel meters used?

- Fewer elements (meters) = lower cost
- Especially true for electro-mechanical meters
- Fewer CT's and PT's = lower cost
- Less wiring and cheaper sockets

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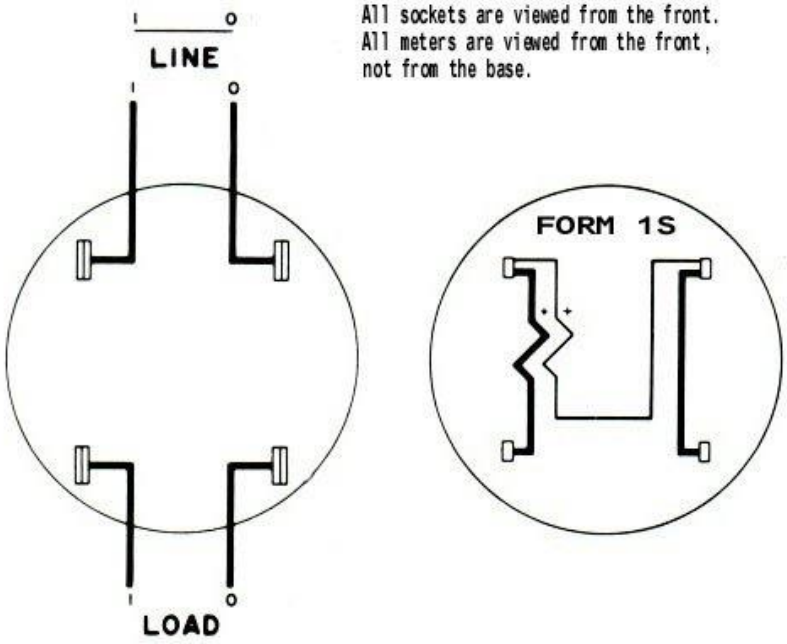
METERING EXAMPLES



FORM 1S

1ø, 2 W CIRCUIT

1 Stator, 2 W Meter, Self-Contained

BCM
Bay City Metering
P: 212-575-0785

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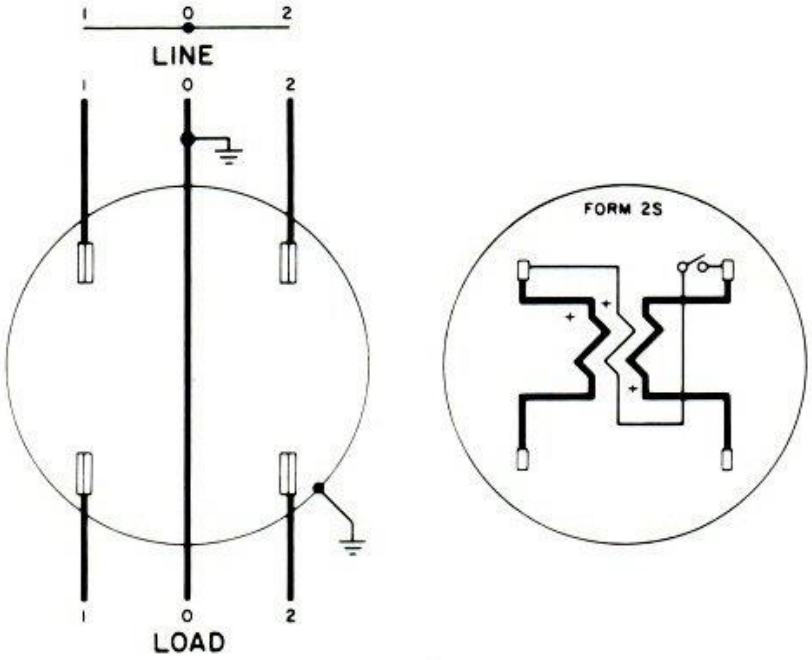
METERING EXAMPLES



1ø, 3 W CIRCUIT
1 Stator, 1ø, 3 W Meter, Self-Contained

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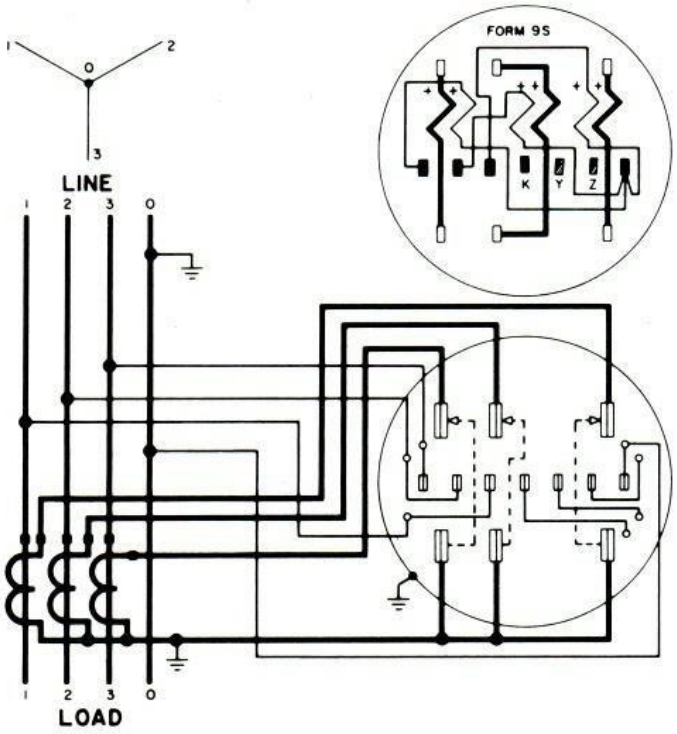
METERING EXAMPLES



3ø, 4 W, Y CIRCUIT
3 Stator, 3ø, 4 W, Y Meter with 3-2 W CT's

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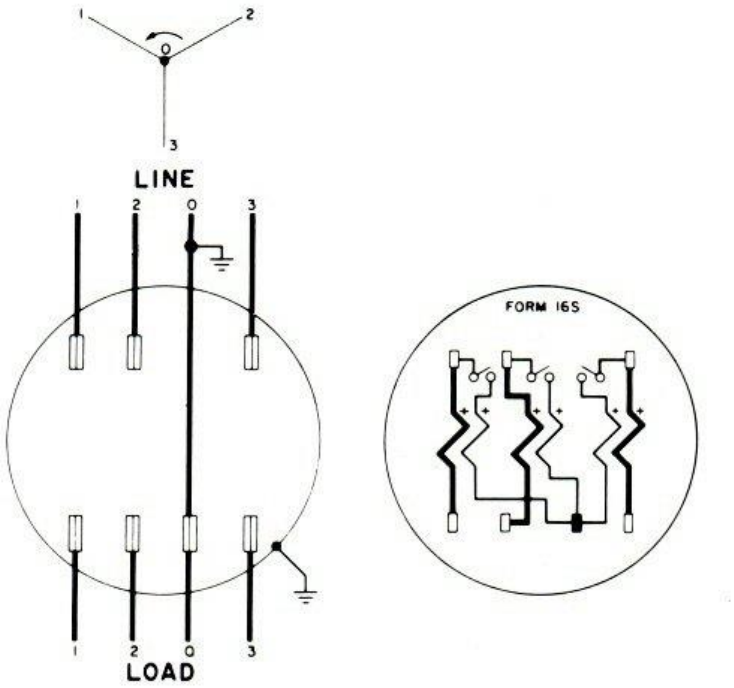

3ø, 4 W, Y CIRCUIT
3 Stator, 3ø, 4 W, Y Meter, Self-Contained

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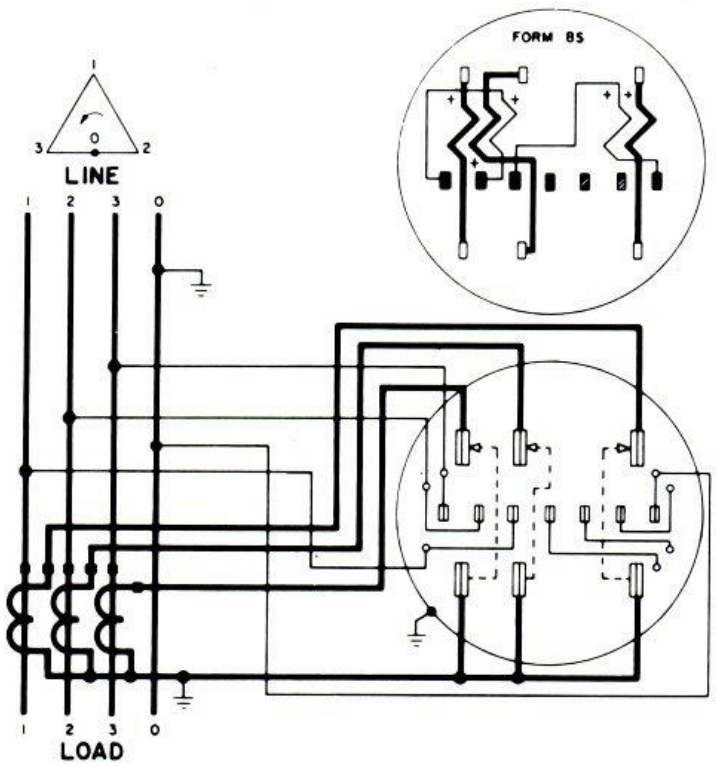

3ø, 4 W, Δ CIRCUIT

2 Stator, 3ø, 4 W, Δ Meter with 3-2 W CT's

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REFERENCES

- Wikipedia – of course
- https://en.wikipedia.org/wiki/Blondel%27s_theorem

- Power Measurement Handbook – Dr. Bill Hardy – TESCO CTO Emeritus
- http://www.powermeasurements.org/library/Presentations/NCMS%202013%20-%20Non-Blondel%20Metering.pdf

- Third Party meter sites
- https://www.baycitymetering.com/

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AGENDA

Meters 101 - Electro-Mechanical vs Solid-State

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Available References

Questions and Discussion

Tom Lawton
President
tom.lawton@tescometering.com

TESCO – The Eastern Specialty Company

Bristol, PA

215-228-0500

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