Meter Forms: Wiring and Uses

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for Pennsylvania Rural Electric Association
XXXXXXXXXXX

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AGENDA

Meters 101 - Electro-Mechanical vs Solid-State

Meter Forms

Self-Contained vs Transformer Rated

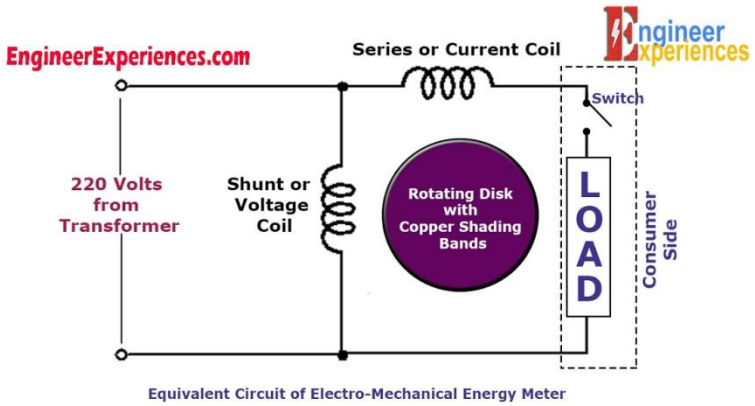
Blondel's Theorem

Available References (Hardy's, UGLY's Elect Ref)

Examples

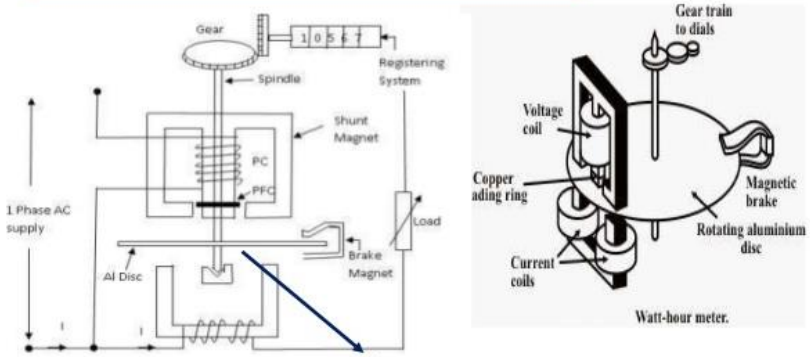
1S, 2S, 3S, 4S, 5/35S, 8/9S, 16S

METERS 101 – ELECTRO-MECHANICAL



Equivalent Circuit of Electro-Mechanical Energy Meter

Electromechanical energy meter continue...



Disk to rotate

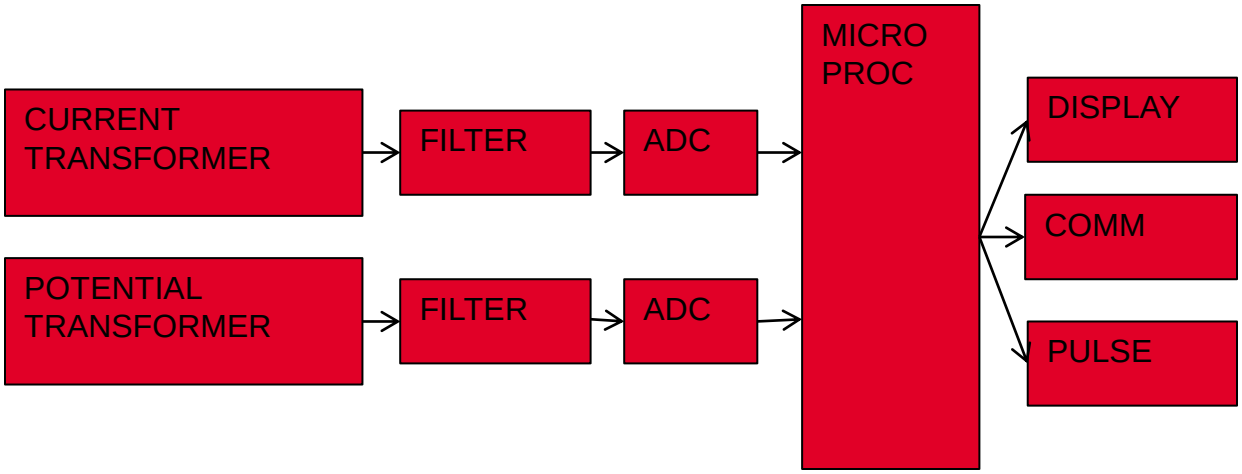
Overview of Functionality

- The electromechanical induction meter operates through electromagnetic induction
- A non-magnetic, but electrically conductive, metal disc which is made to rotate at a speed proportional to the power passing through the meter
- The disc is acted upon by two sets of induction coils, which form, in effect, a two phase linear induction motor.
- One coil is connected in such a way that it produces a magnetic flux in proportion to the voltage
- The other coil produces a magnetic flux in proportion to the current.
- The field of the voltage coil is delayed by 90 degrees, due to the coil's inductive nature, and calibrated using a lag coil
- This produces eddy currents in the disc and the effect is such that a force is exerted on the disc in proportion to the product of the instantaneous current and instantaneous voltage
- A permanent magnet acts as an eddy current brake, exerting an opposing force proportional to the speed of rotation of the disc
- The equilibrium between these two opposing forces results in the disc rotating at a speed proportional to the power or rate of energy usage
- The disc drives a register mechanism which counts revolutions, much like the odometer in a car, in order to render a measurement of the total energy used.
- The amount of energy represented by one revolution of the disc is denoted by the symbol Kh which is given in units of watt-hours per revolution.
- A Kh of 7.2 is typical. In this example, each full rotation of the disk is equivalent to 7.2Wh of energy.

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



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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 24S 56S

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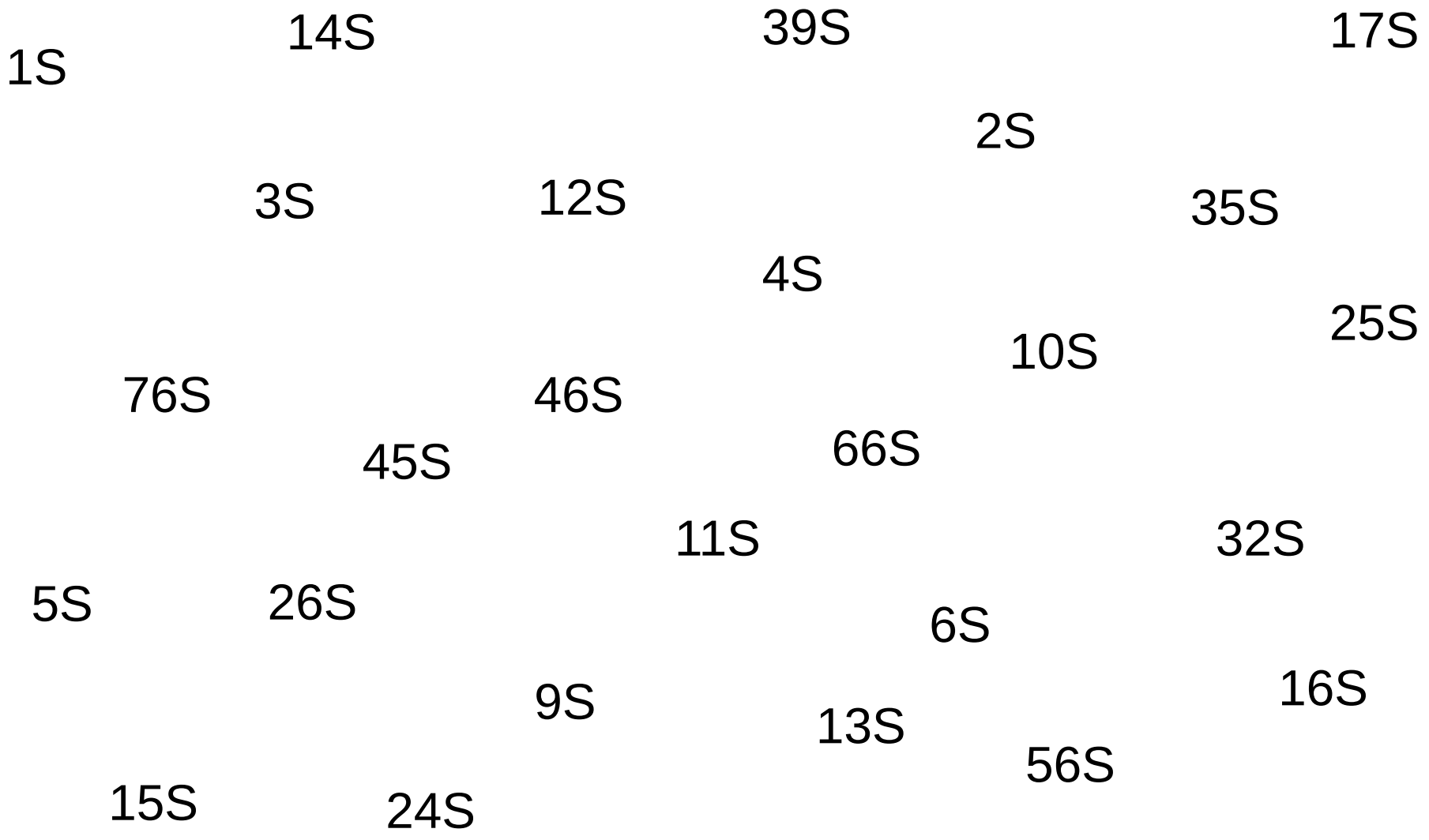
METER FORMS

Meter Forms


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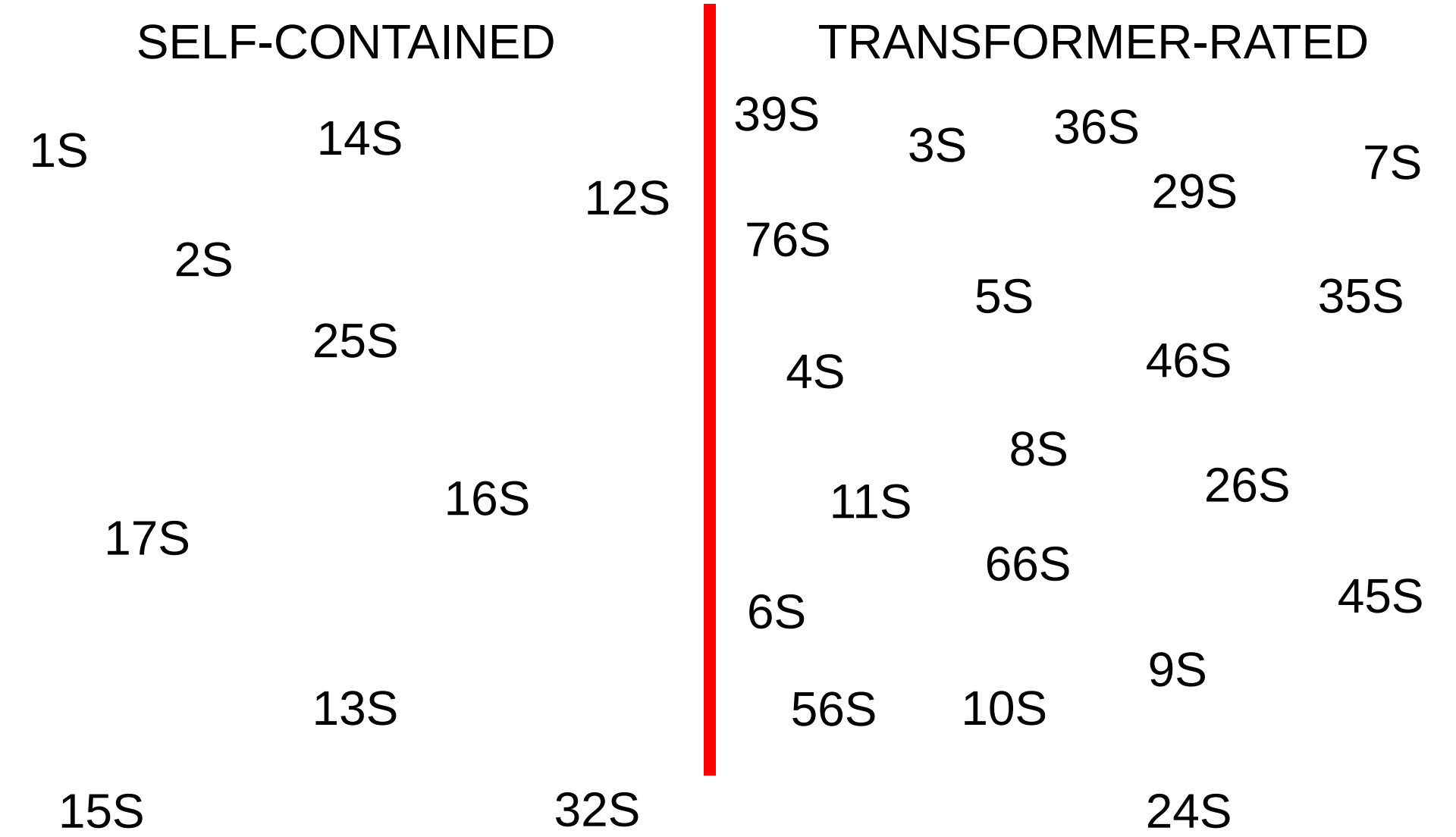
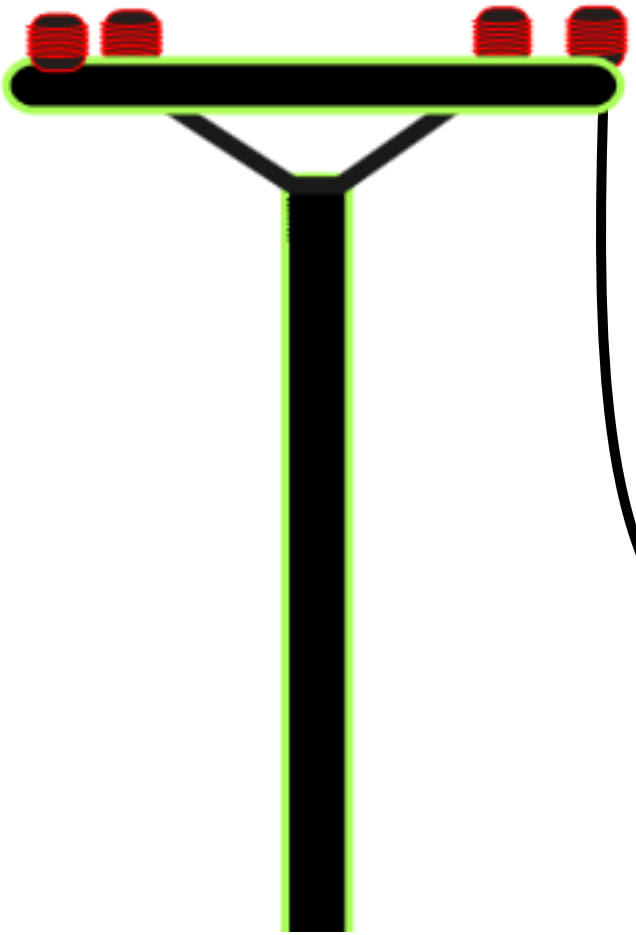
26S
6S
16S
9S
13S
56S
15S
24S

Meter Forms

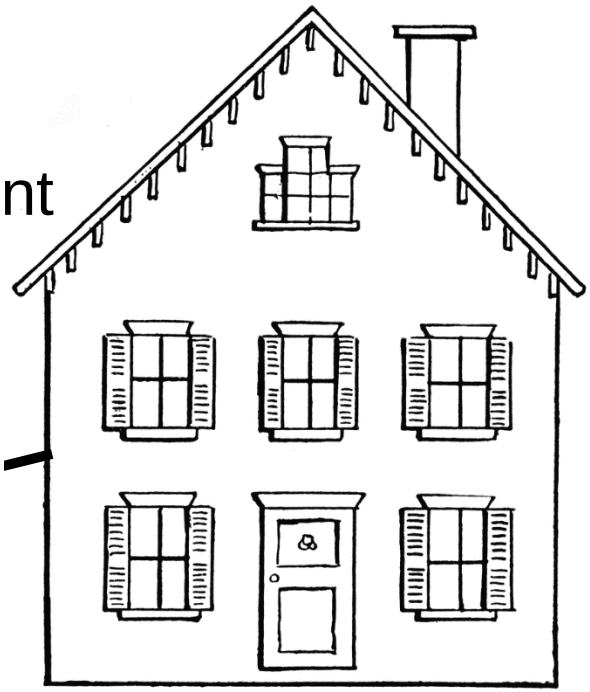

SELF-CONTAINED
1S
14S
12S
2S
25S
16S
17S
13S
15S
32S
TRANSFORMER-RATED
39S
3S
36S
7S
29S
76S
5S
35S
4S
46S
8S
26S
11S
66S
45S
6S
9S
56S
10S
24S

Self-Contained Meters

Primarily Residential



Relatively Low Current
Example: 100A



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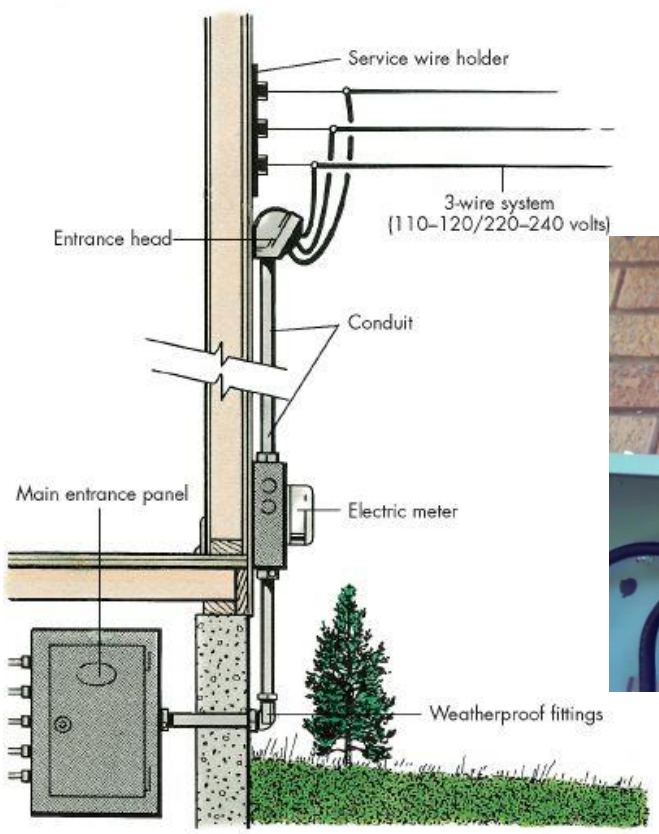
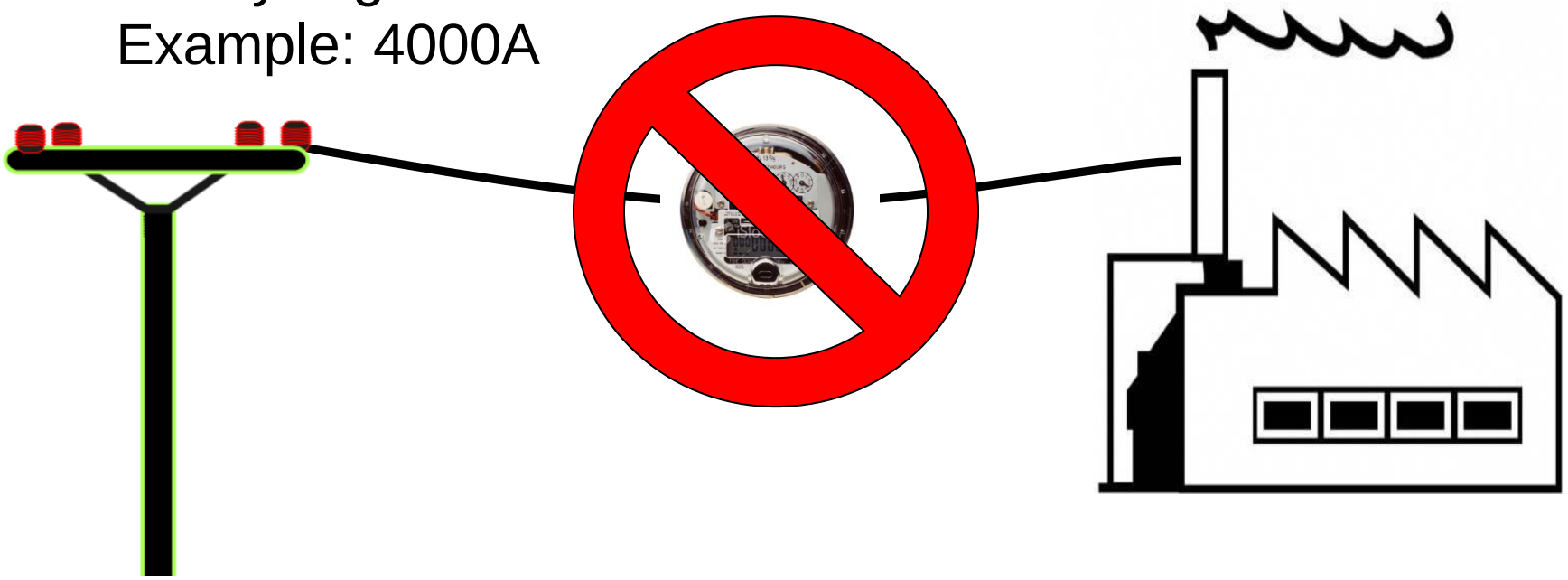


Transformer-Rated Meters

Primarily Commercial/Industrial

Relatively High Current
Example: 4000A



TRANSFORMER-RATED METERS

Primarily Commercial/Industrial

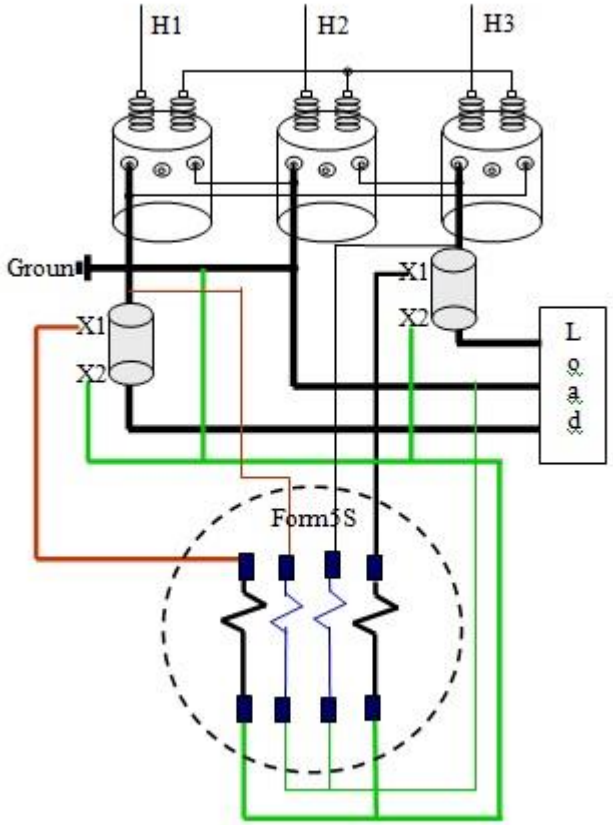
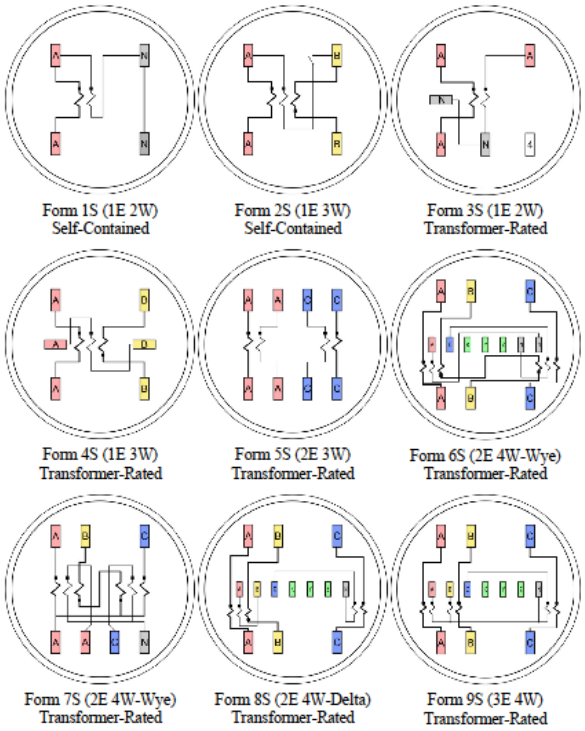


DIAGRAM EXAMPLE

Meter Forms

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

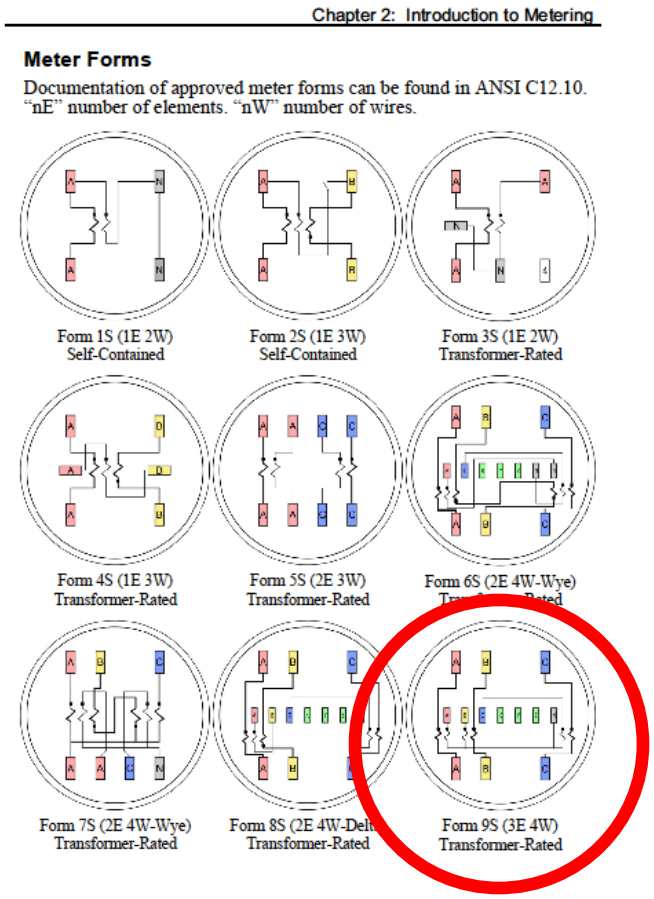


Form 1S (1E 2W) Self-Contained
Form 2S (1E 3W) Self-Contained
Form 3S (1E 2W) Transformer-Rated
Form 4S (1E 3W) Transformer-Rated
Form 5S (2E 3W) Transformer-Rated
Form 6S (2E 4W-Wye) Transformer-Rated
Form 7S (2E 4W-Wye) Transformer-Rated
Form 8S (2E 4W-Delta) Transformer-Rated
Form 9S (3E 4W) Transformer-Rated

References

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

Diagram Example



Chapter 2: Introduction to Metering

Meter Forms

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20 Power Measurements Handbook

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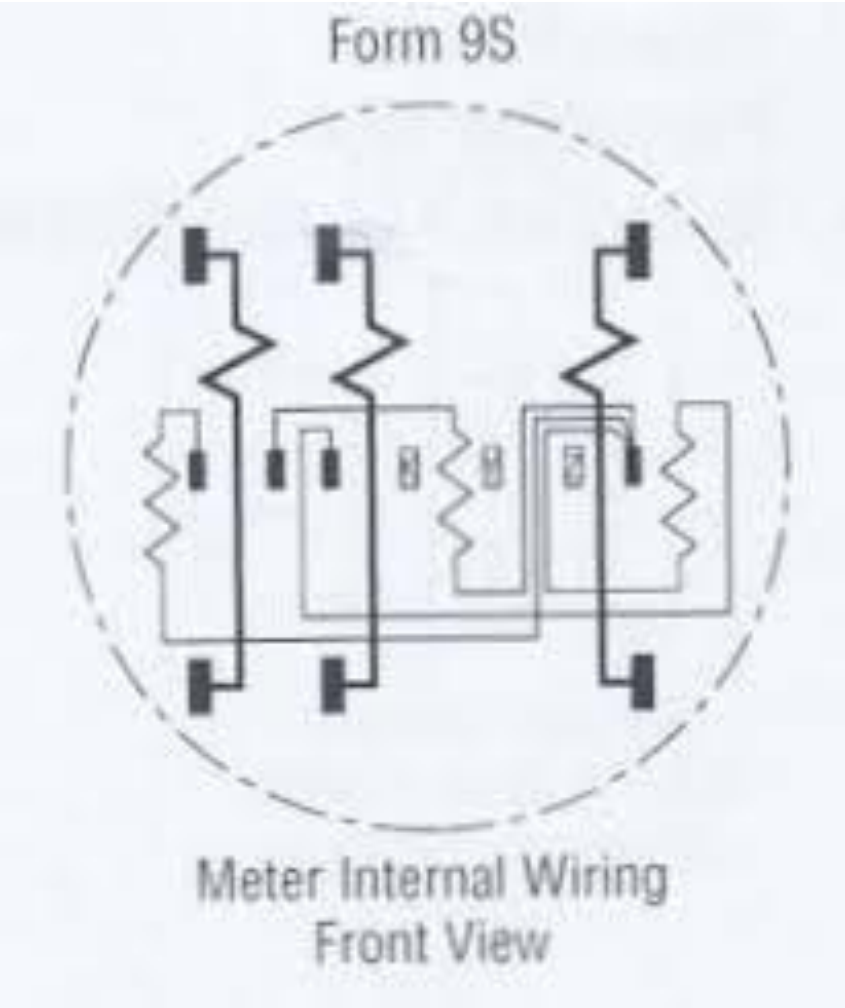
DIAGRAM EXAMPLE



- 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.

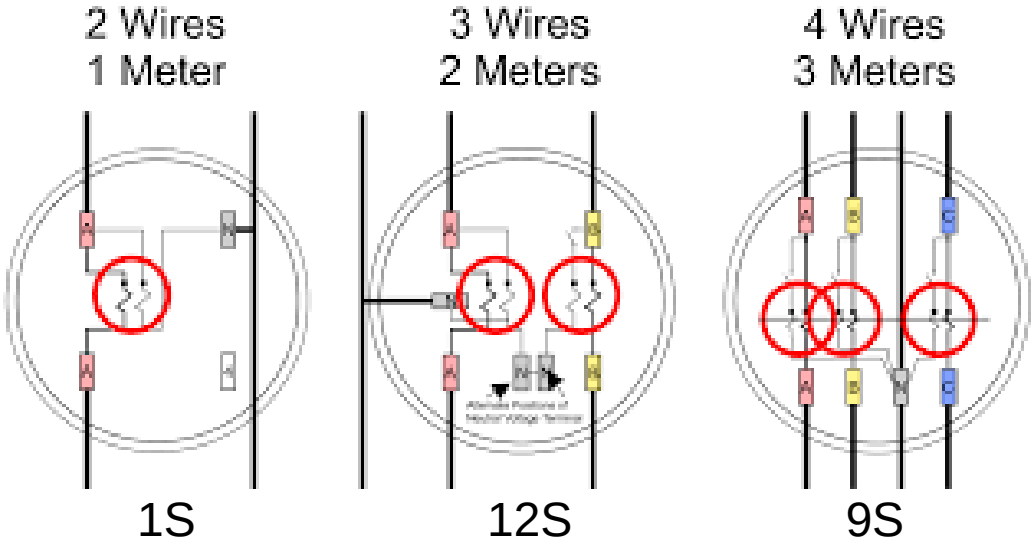
$$E = n - 1$$

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

$$E = n - 1$$



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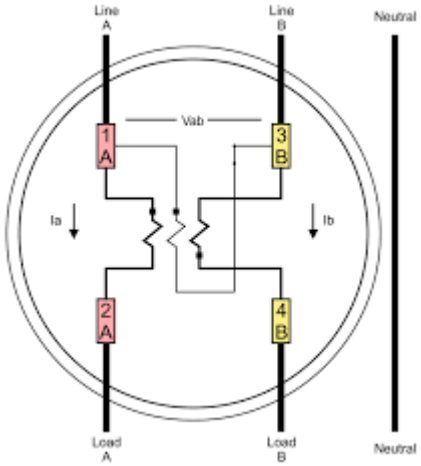
BLONDEL'S THEOREM

Non-Blondel Compliant

$$E = n - 1$$



2S

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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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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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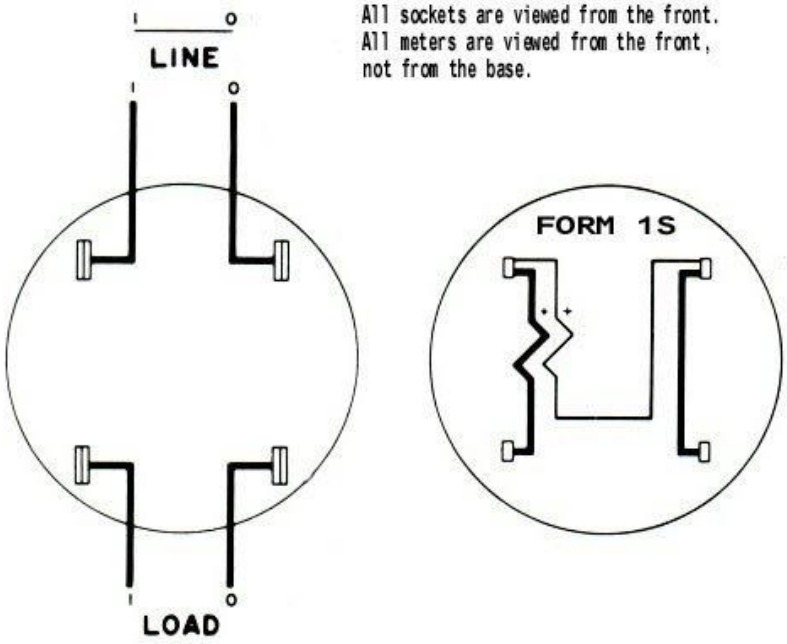
METERING EXAMPLES



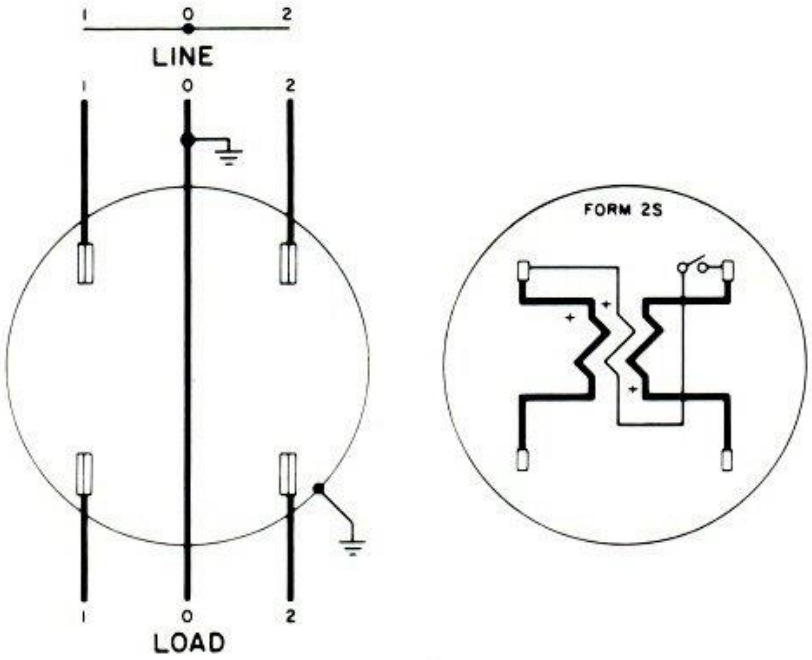
FORM 1S

1ø, 2 W CIRCUIT

1 Stator, 2 W Meter, Self-Contained

BCM
Bay City Metering
P: 212-575-0785

METERING EXAMPLES



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

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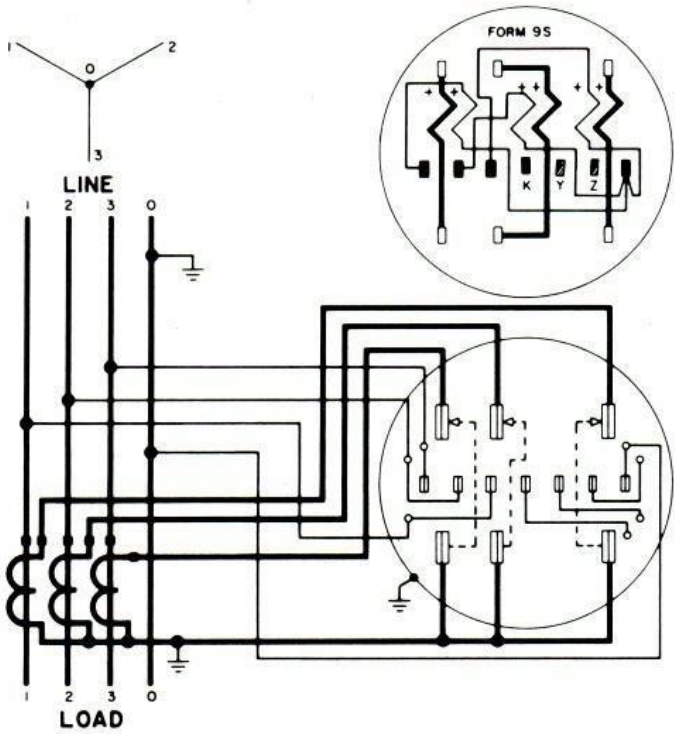
METERING EXAMPLES



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

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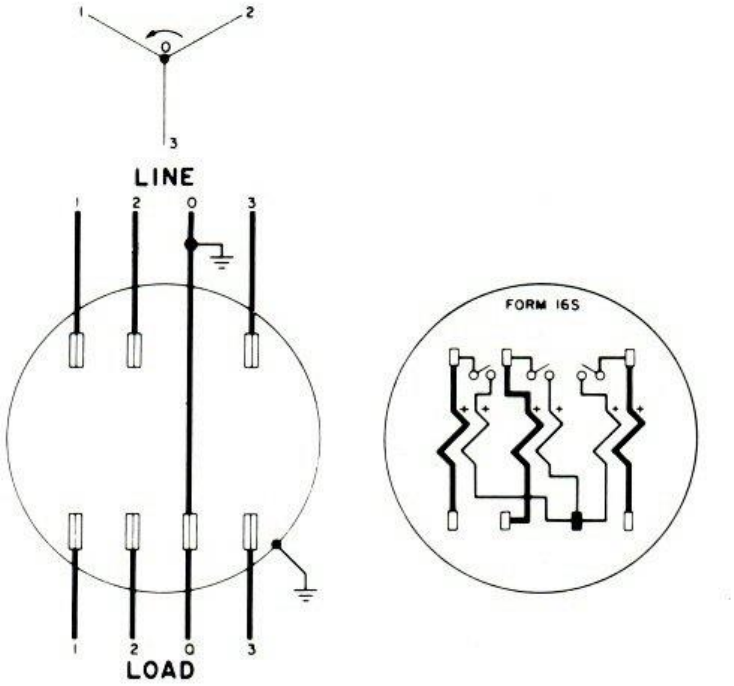
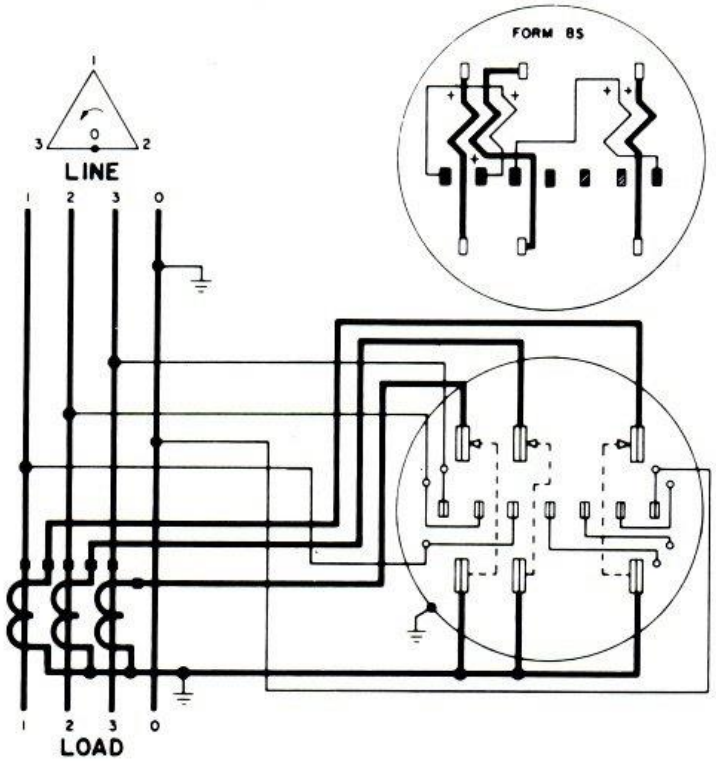
METERING EXAMPLES



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

METERING EXAMPLES



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

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References

- https://en.wikipedia.org/wiki/Blondel%27s_theorem
- http://www.powermeasurements.org/library/Presentations/NCMS%202013%20-%20Non-Blondel%20Metering.pdf
- https://www.baycitymetering.com/

QUESTIONS AND DISCUSSI

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