TESCO METERING

ANSI METER FORMS

TESCO's Meter School
TESCOOL
July 21-24, 2024

Monday, July 22, 2024
3:15 PM-4:30 PM
Carl Chermak

AGENDA

Meters 101 - Electro-Mechanical vs Solid-State

Self-Contained vs Transformer Rated

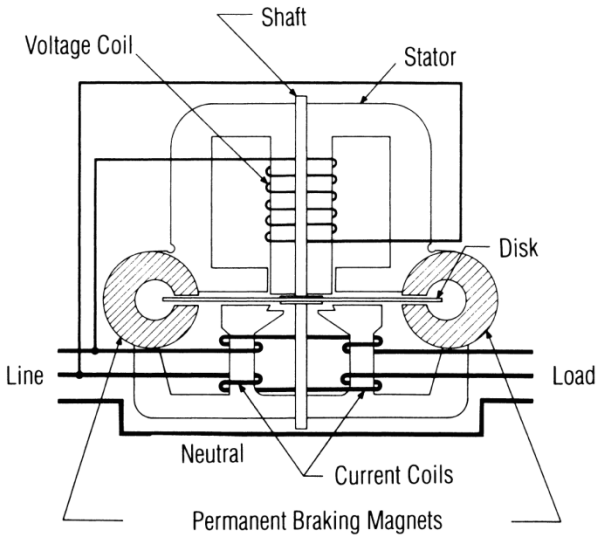
Blondel's Theorem

Meter Forms

Available References

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]

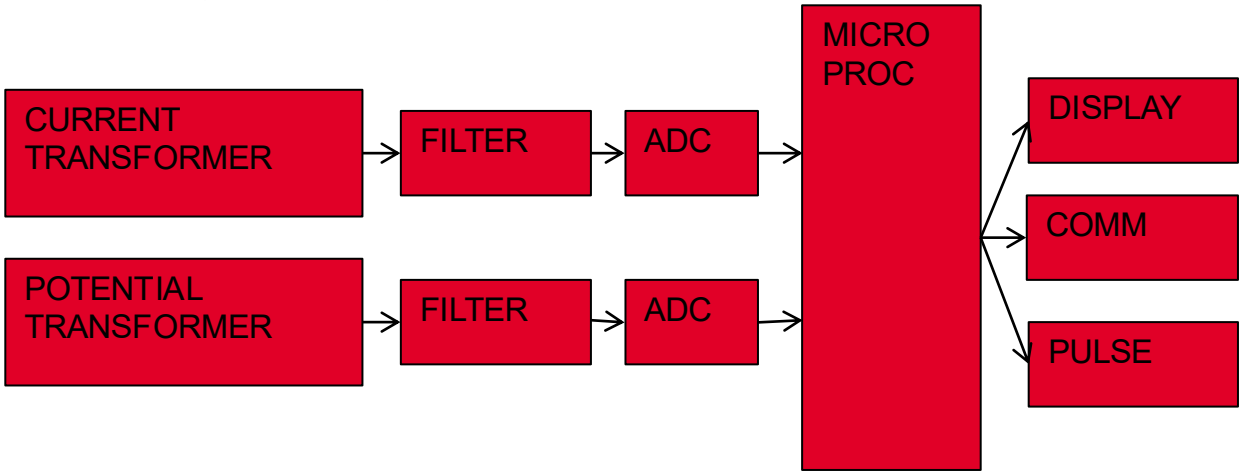
- A Kh of 7.2 is typical. In this example, each full rotation of the disk is equivalent to 7.2Wh of energy.

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

- The watthour meter formula is as follows:

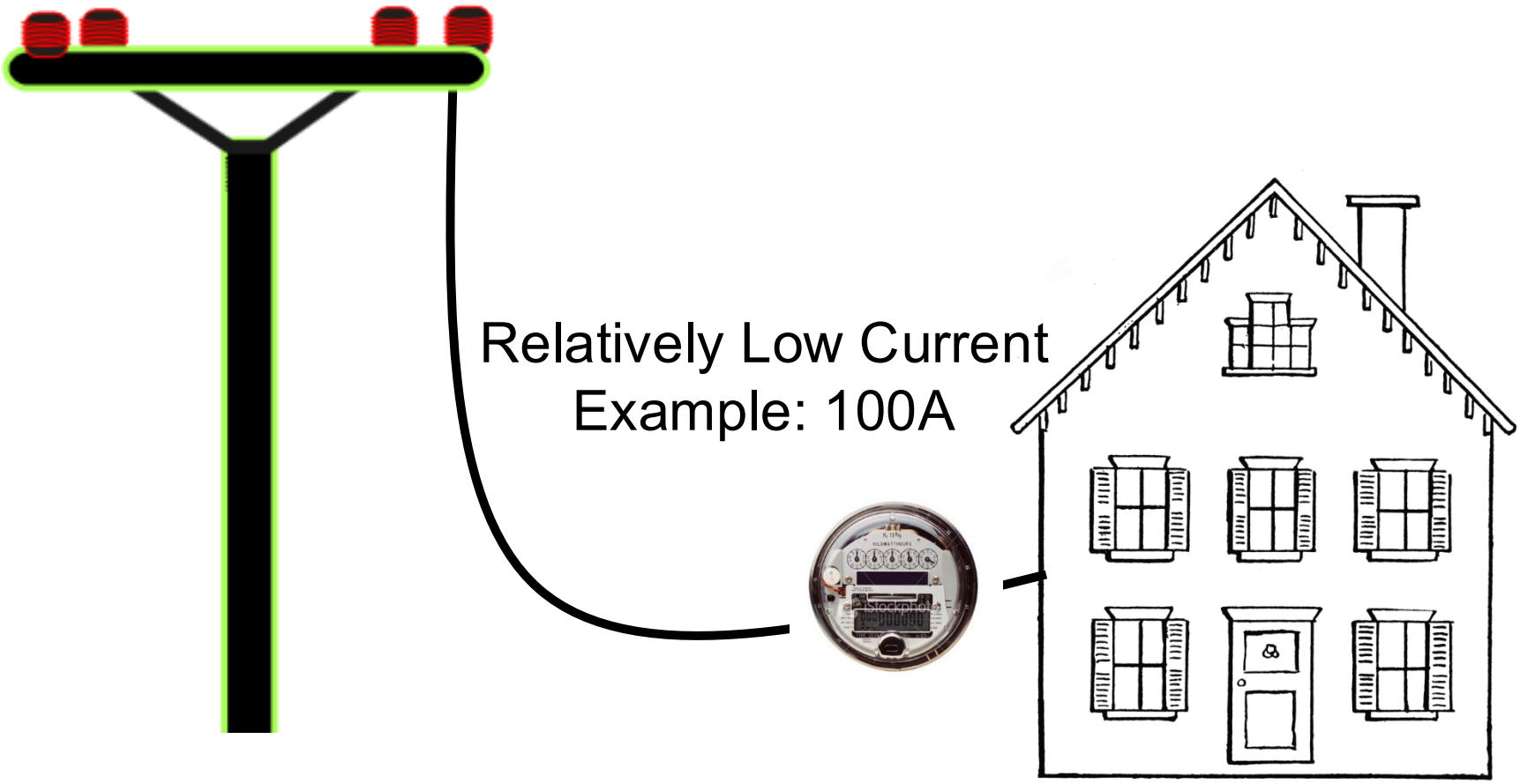
Overview of Functionality

- 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

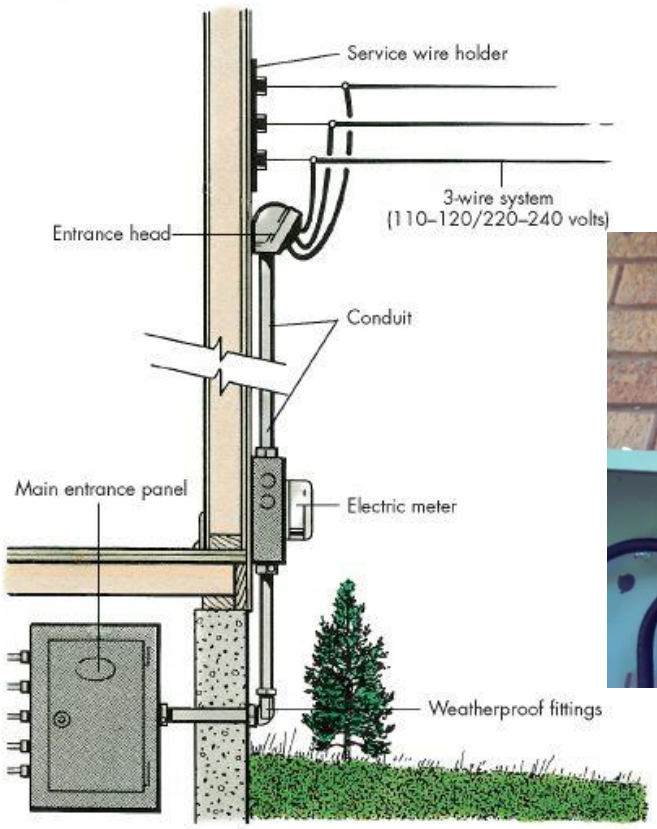


SELF-CONTAINED METERS

Primarily Residential



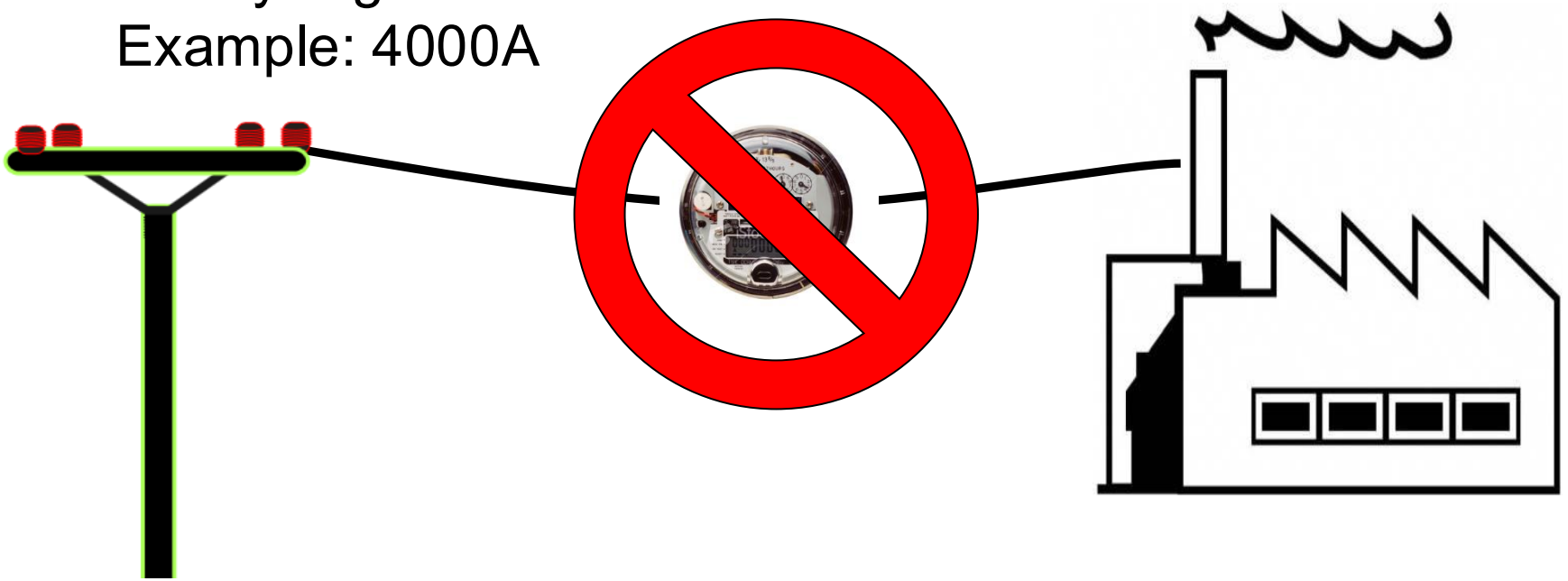
Primarily Residential



TRANSFORMER-RATED METERS

Primarily Commercial/Industrial

Relatively High Current
Example: 4000A



TRANSFORMER-RATED METERS

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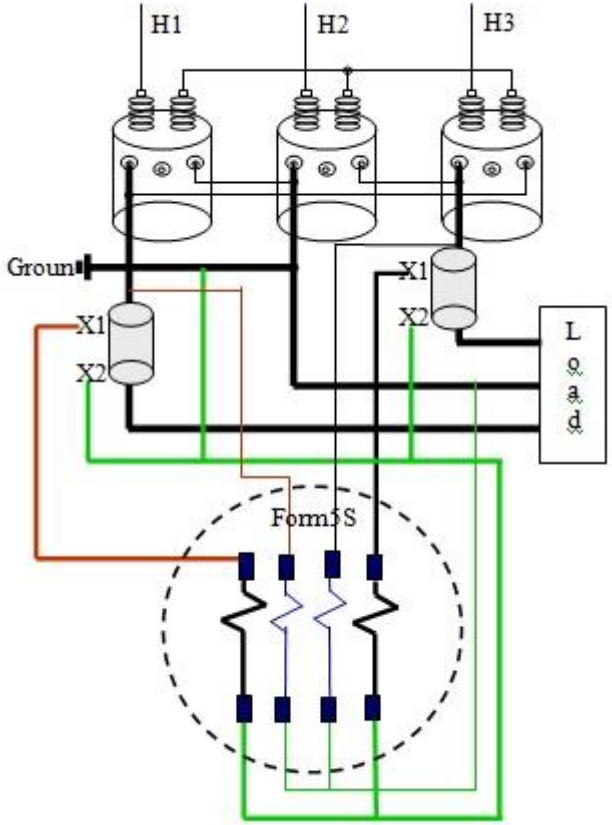
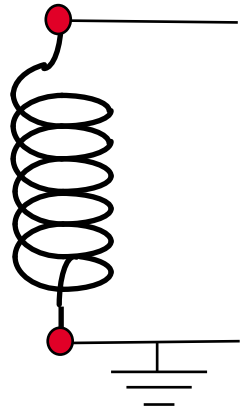
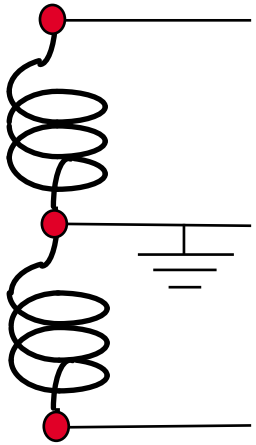


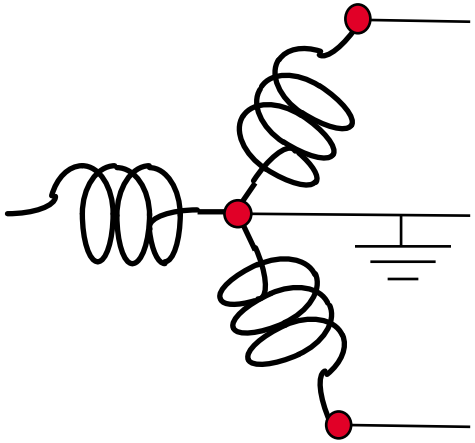
SERVICES COMMONLY METERED



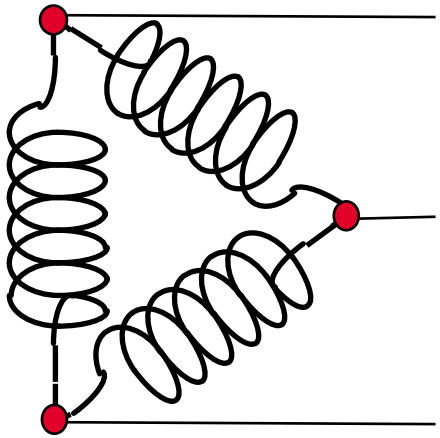
2 wire, 1 ϕ



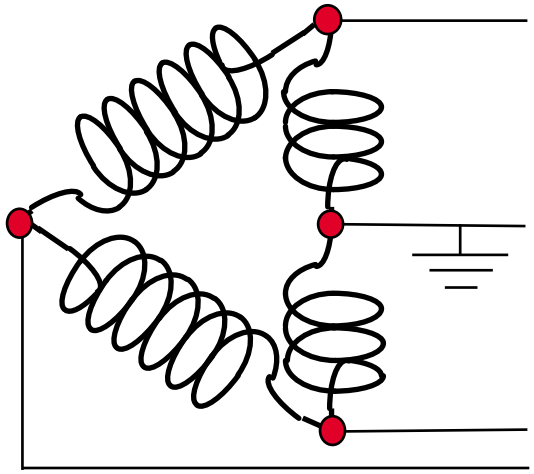
3 wire, 1 ϕ



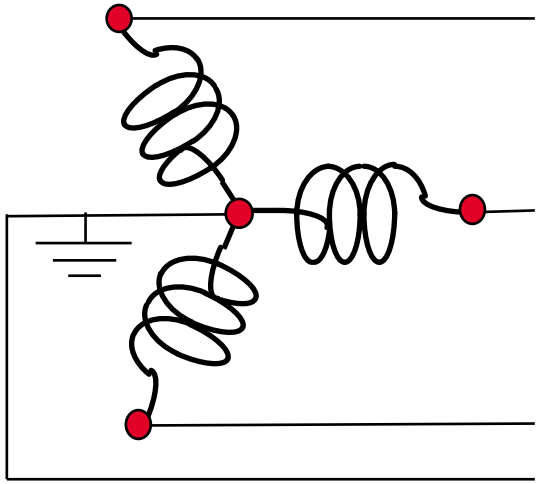
3 wire, network



3 wire, delta



4 wire, delta



4 wire, wye

BLONDEL'S THEOREM

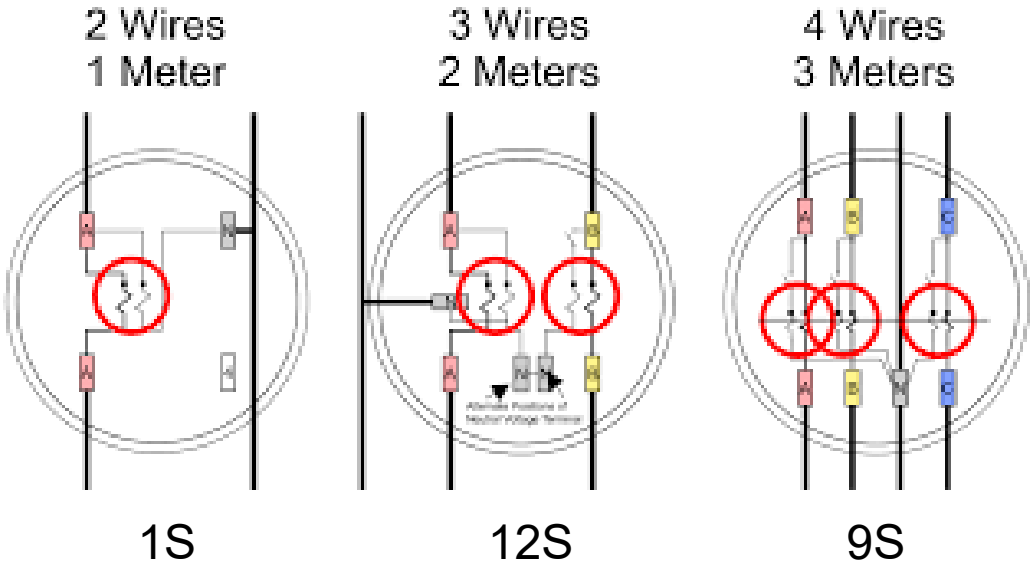
- French Electrical Engineer Andre Blondel
- Attempt to simplify electrical measurements and validation of the results
- Paper submitted to the International Electric Congress in Chicago in 1893.

$$E = n - 1$$

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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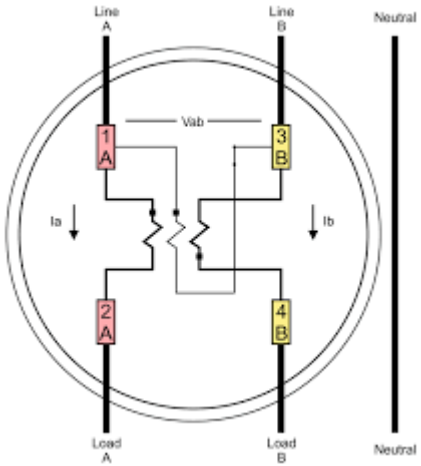
BLONDEL'S THEOREM

Non-Blondel Compliant



2S

$$E = n - 1$$

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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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METER FORMS

METER STANDARDIZATION (BACKGROUND)

1928 First detachable meter produced in US

- Forerunner of today's Socket Meter
- Provides outside mountable meter

1933 Introduction of a true "socket system"

- Type "S" socket and Type "CS" meter
- Wide spread acceptance

1934 Parameters for "socket" meters standardized

- Interchangeable mounting was developed
- Participation by all manufacturers okayed

Meter Standardization (Background)

1934 Metering committees establish guidelines

- Edison Electric Institute
- Association of Edison Illuminating Companies

1940 Standard dimensions & wiring documented

- Published in “Electrical Metermen’s Handbook
- Reference numbers look like forms but are not

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"FORM" STANDARDS ESTABLISHED

1958 - 1960 First Standards Published

- MSJ-10 Standard established (includes Forms)
- Published jointly by AEIC, EEI, & NEMA

1978 *New* ANSI Standard Introduced

- MSJ-10 replaced by ANSI C12.10 Standard
- No change to established "Forms"

What is a meter Form Number?

IEEE Standard Dictionary of Electrical and Electronic Terms defines a watthour meter “form designation” as:

- An alphanumeric designation denoting the circuit arrangement for which the meter is applicable and it’s specific terminal arrangement.
- The same designation is applicable to equivalent meters of all manufactures.

What is a meter Form Number?

A Form designation tells us:

- The Physical Configuration of the meter
  - Socket (S)
  - Bottom Connected (A)
- The number and arrangement of meter terminals
- The number of voltage circuits within the meter
- The number of current circuits within the meter
- The number and arrangement of meter elements (stators)

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"Form" Describes the Meter

The Form designation describes the meter, not the electrical service.

- **Same Form is applicable to equivalent meters of all manufacturers**
- **With modern electronic meters, Form consolidation is possible thus reducing variety while improving measurement accuracy**
- **Form does not change with current or voltage rating**
- **Form does not necessarily identify meter as Self-contained or Transformer-rated**
- **Form does not change with addition of meter accessories**
- **More than one meter Form could be used with a particular service, depending on the connection of Instrument Transformers.**

NEW ELECTRONIC METER FORMS

New Forms were added (1994 - 1999) to accommodate modern electronic meter construction

- **Broad voltage range meter designs require different internal connections**
  - **–Typically affects transformer rated applications**
  - **–Cannot support isolated voltage circuits**
- **In most popular services, “broad range” meters are compatible with existing socket wiring**
- **Special applications need to be verified for compatibility**

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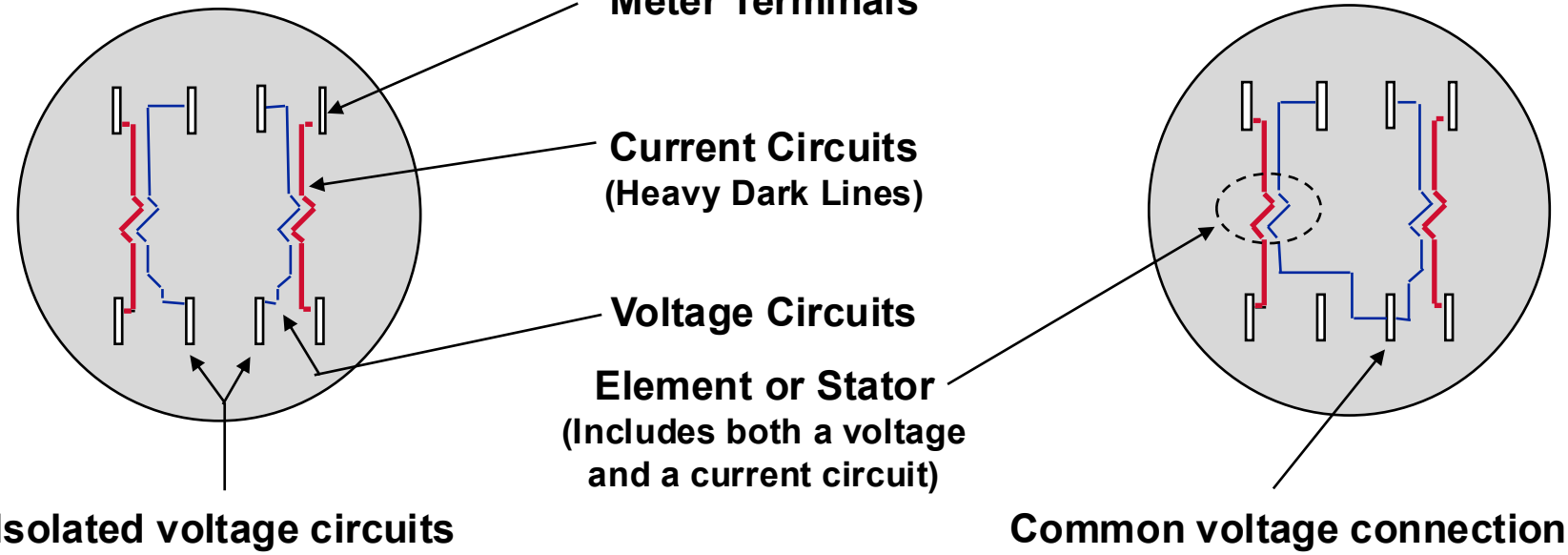
NEW ELECTRONIC METER FORMS

New Meter FORMS (Electronic Meter)	Replacement for existing FORM	*Typical* Service Application
45S (or 35S)	5S	3W-3Ø
36S (or 46S)	6S	4W-Y
56S (or 66S)	26S	3W-3Ø
45A (or 35A)	5A	3W-3Ø
36A (or 46A)	6A	4W-Y
48A	10A (alternate)	4W-Yor△

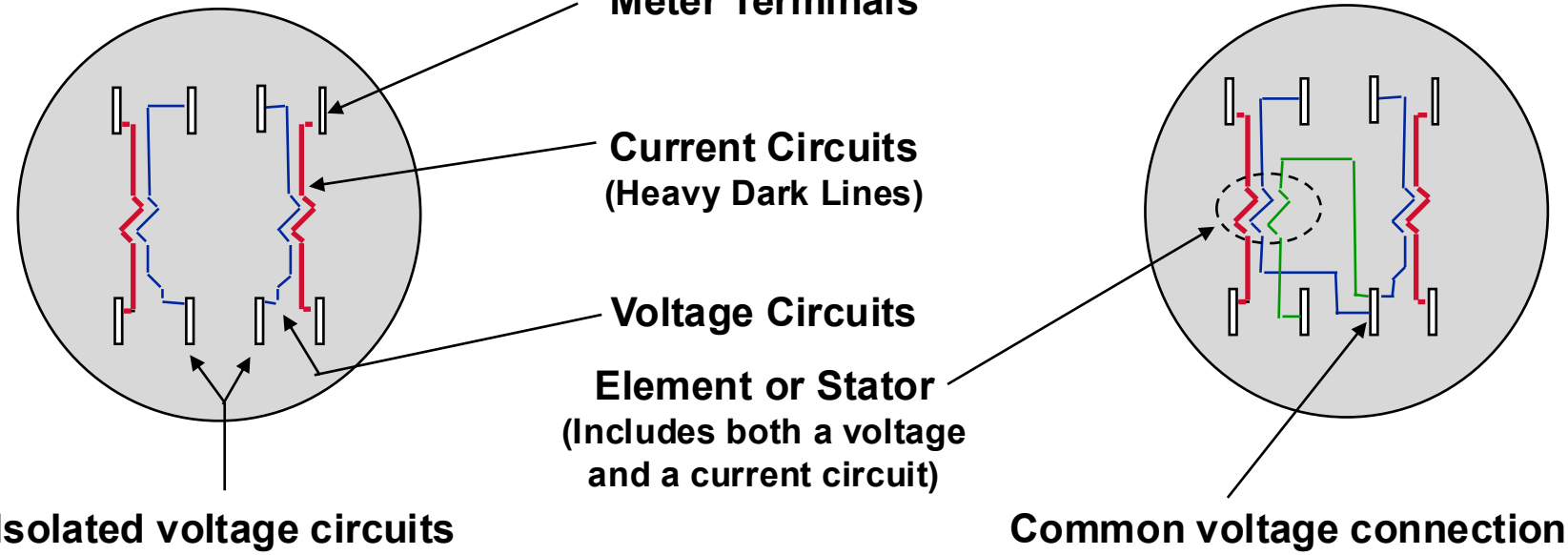
DISSECTING THE DIAGRAM



Electromechanical
or
Electronic
with voltage transformers

Electronic
with
broad range voltage

DISSECTING THE DIAGRAM



Electromechanical
or
Electronic
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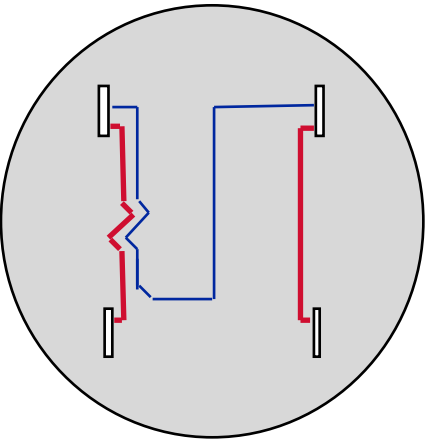
Electronic
with
broad range voltage

Single Phase Forms

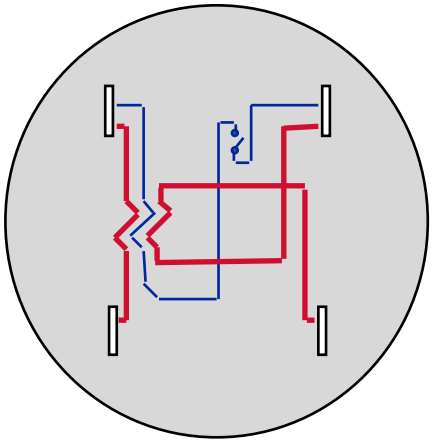


Form 1S*

1 Element,

Self Contained

2 wire, single phase

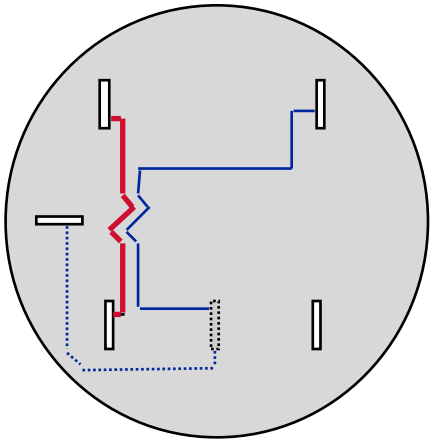


Form 2S*

1 Element,

Self Contained

3 wire, single phase



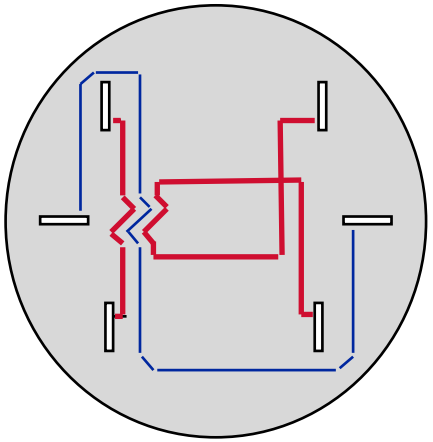
Form 3S*

1 Element,

Transformer Rated

2 wire, single phase,

3 wire, single phase



Form 4S*

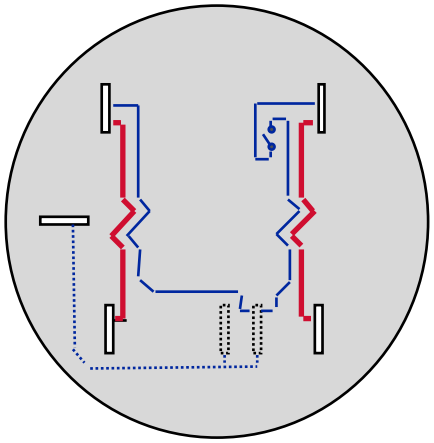
1 Element,

Transformer Rated

3 wire, single phase

- ANSI Forms looking from the front of the meter.

Self Contained - 3 Wire Polyphase

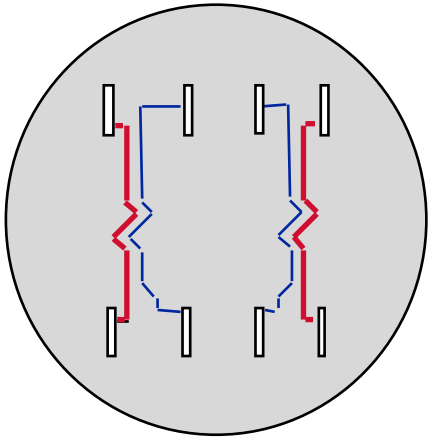


Form 12S*

2 Element,

Self Contained

3 wire delta, network



Form 13S

2 Element,

Self Contained

3 wire delta

- ANSI Forms looking from the front of the meter.

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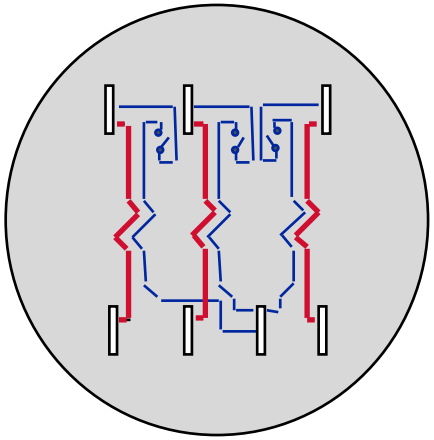
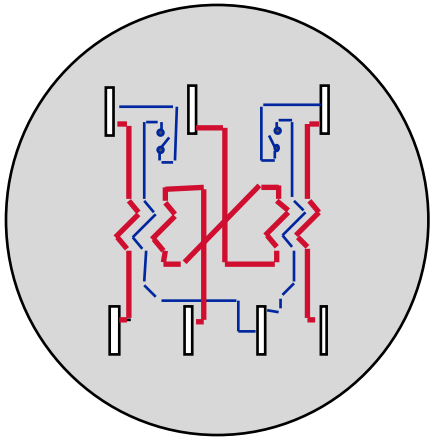
SELF CONTAINED - 4 WIRE



Form 16S*

3 Element,

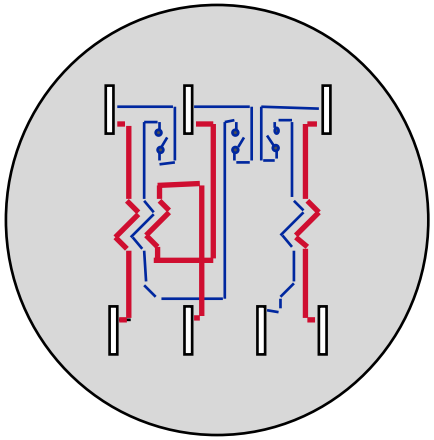
4 wire, wye



Form 14S

2½ Element,

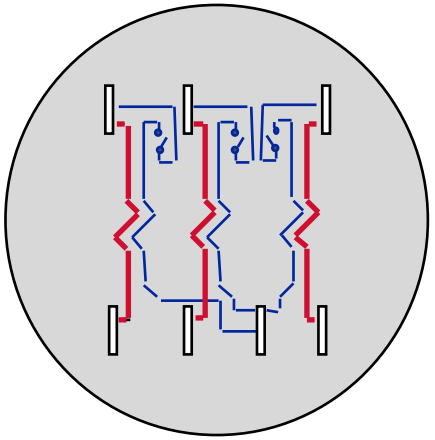
4 wire, wye



Form 15S

2 Element,

4 wire, delta



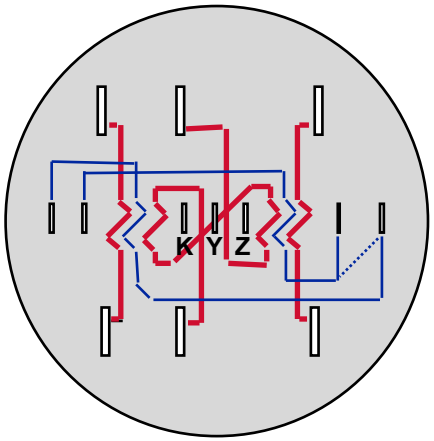
Form 17S

3 Element,

4 wire, delta

- **Meterman's view of ANSI Forms looking from the front of the meter.**

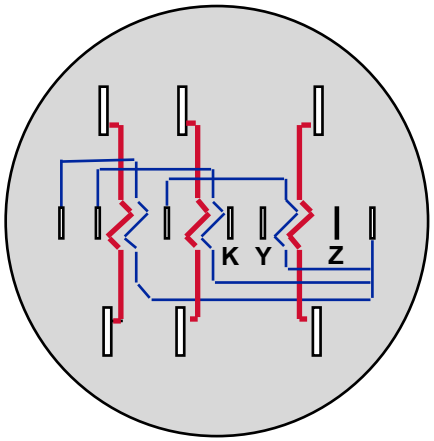
TRANSFORMER RATED - 4 WIRE



Form 6S, (36S*)

2½ Element,

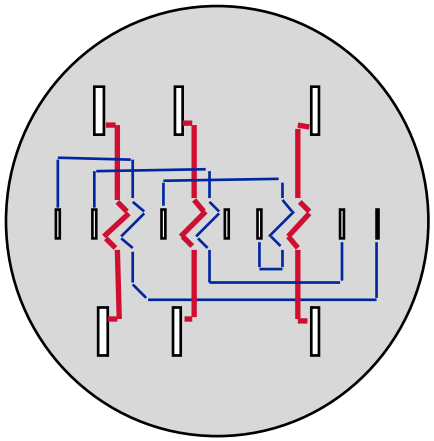
4 wire, wye



Form 9S*

3 Element,

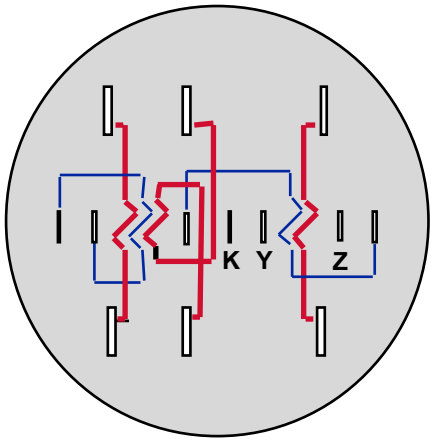
4 wire, wye



Form 10S

3 Element,

4 wire, wye



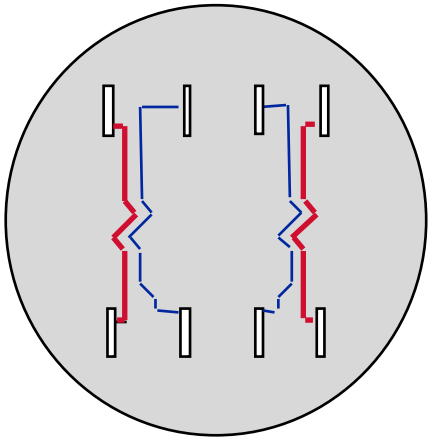
Form 8S

2 Element,

4 wire, delta

- Meterman's view of ANSI Forms looking from the front of the meter.

TRANSFORMER RATED - 2 ELEMENT



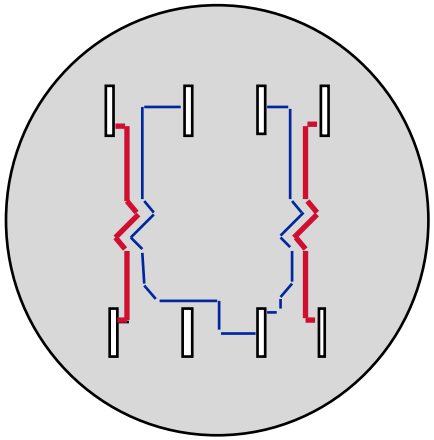
Form 5S

2 Element,

3 wire

4 wire, wye

4 wire, delta

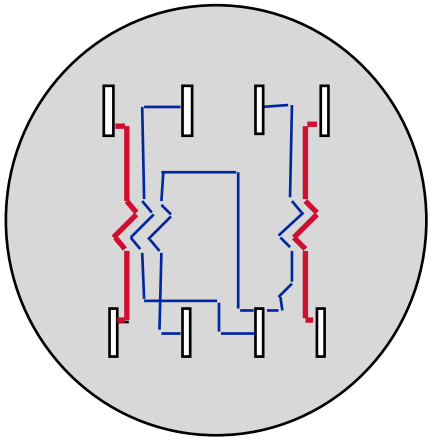


Form 35S

2 Element,

3 wire

4 wire, wye



Form 45S*

2 Element,

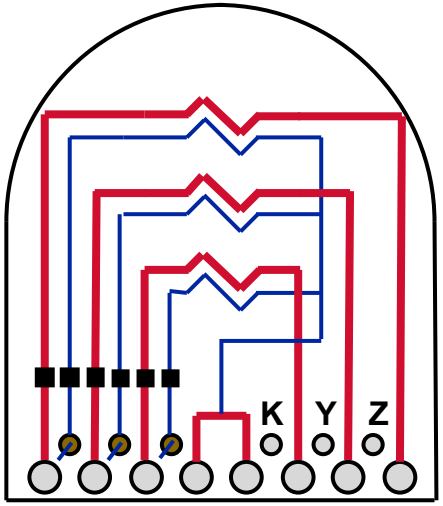
3 wire

4 wire, wye

4 wire, delta

- ANSI Forms looking from the front of the meter.

SELF CONTAINED - A BASE

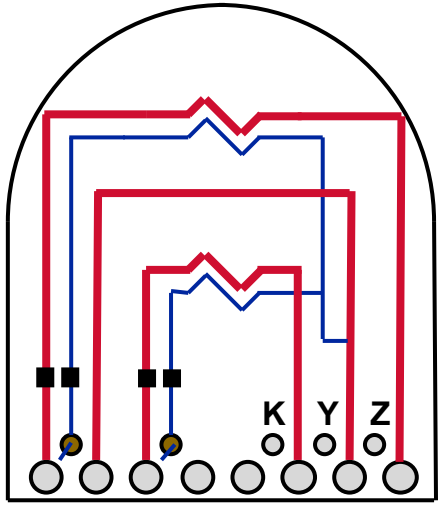


Form 16A*

3 Element,

4 wire, wye

4 wire, delta



Form 13A*

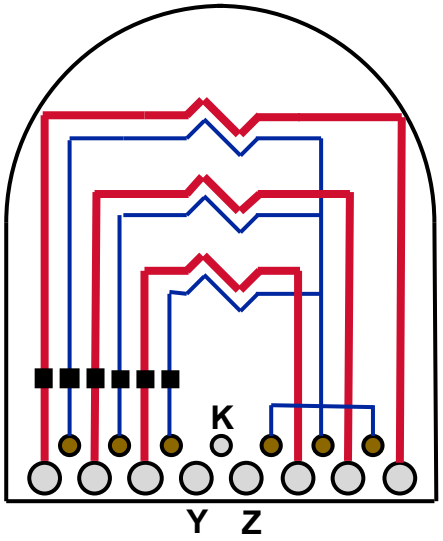
2 Element,

3 wire, delta

3 wire, network

- **ANSI Forms looking from the front of the meter.**

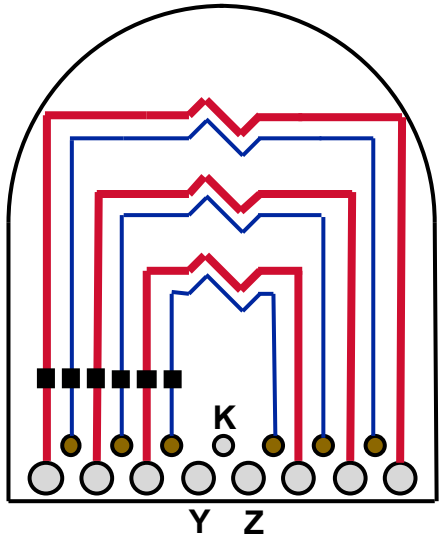
TRANSFORMER RATED - A BASE 4 WIRE



Form 10A*

3 Element,

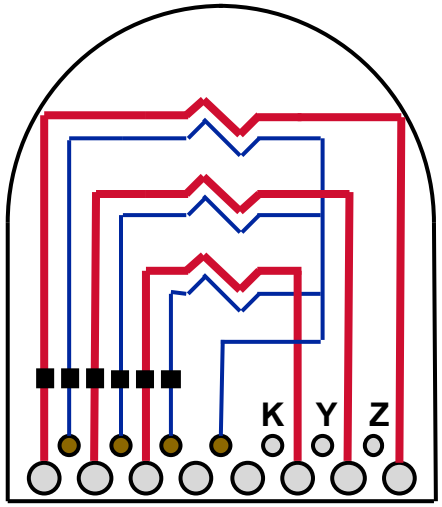
4 wire, wye



Form 9A

3 Element,

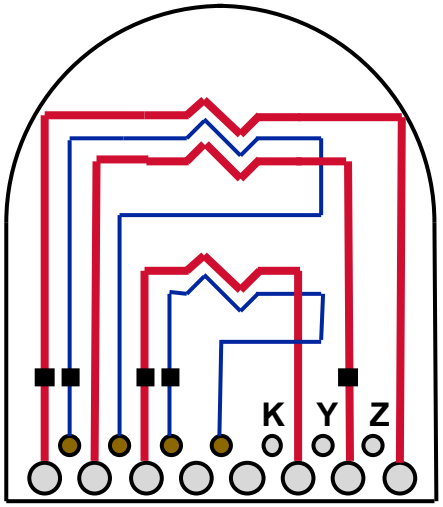
4 wire, wye



Form 48A*

3 Element,

4 wire, wye



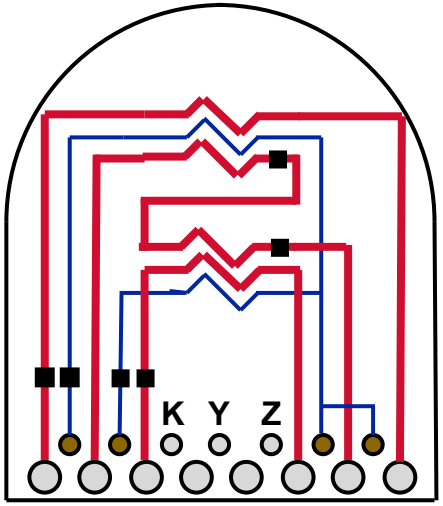
Form 8A

3 Element,

4 wire, delta

- **ANSI Forms looking from the front of the meter.**

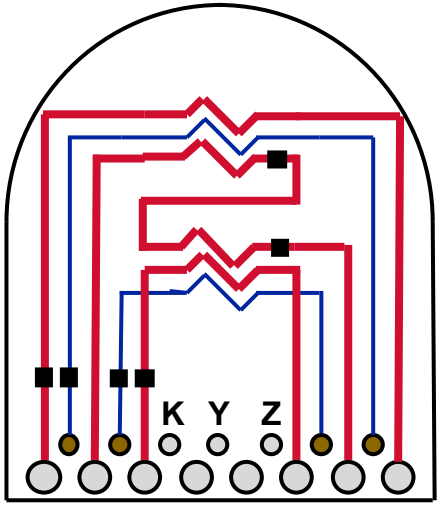
TRANSFORMER RATED - A BASE 2½ ELEMENT



Form 36A*

2½ Element,

4 wire, wye



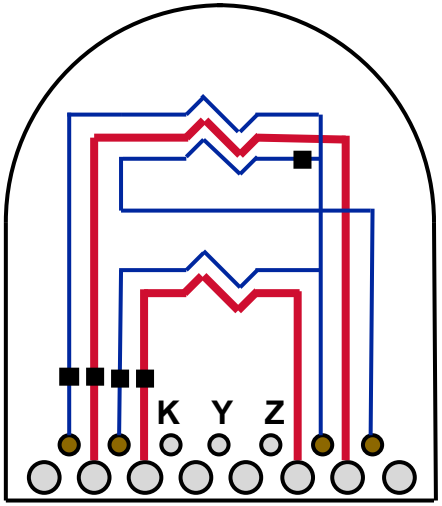
Form 6A

2½ Element,

4 wire, wye

- **ANSI Forms looking from the front of the meter.**

TRANSFORMER RATED - A BASE 2 ELEMENT



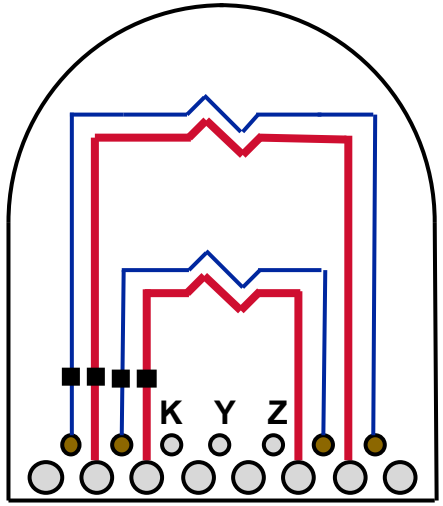
Form 45A*

2 Element,

3 wire

4 wire, wye

4 wire, delta



Form 5A

2 Element,

3 wire

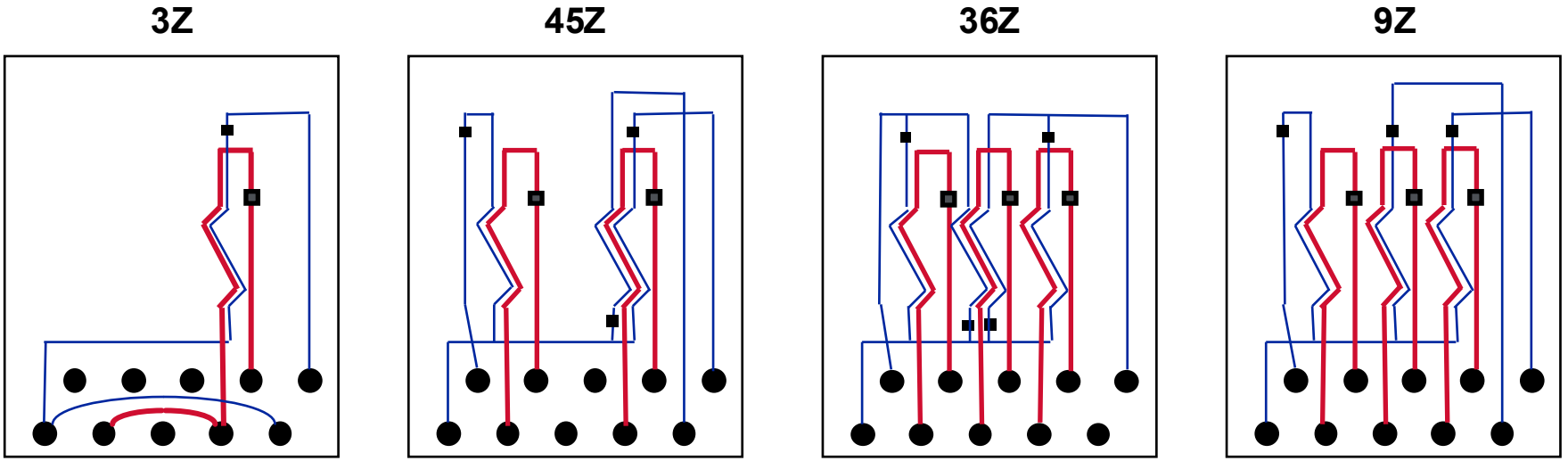
4 wire, wye

4 wire, delta

- **ANSI Forms looking from the front of the meter.**

Switchboard Meters

- Switchboard Connection Designations
  - Wide voltage range electronic meter - voltage windings are not isolated
  - GE Connection Designations similar to S-Base & A-Base meters
  - Switchboard Connection Designations are not covered by ANSI standards
  - These connections are retrofit compatible with GE DS-60* and ES meters
  - DS-64 (3-stator) retrofit uses existing “tall” case
  - Actual construction may vary from diagrams shown (for Mfg. convenience)



* 9Z connection shown in short case, DS-64 was built in tall case.

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/

Questions and Discussion

Carl Chermak

July 22, 2024

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

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