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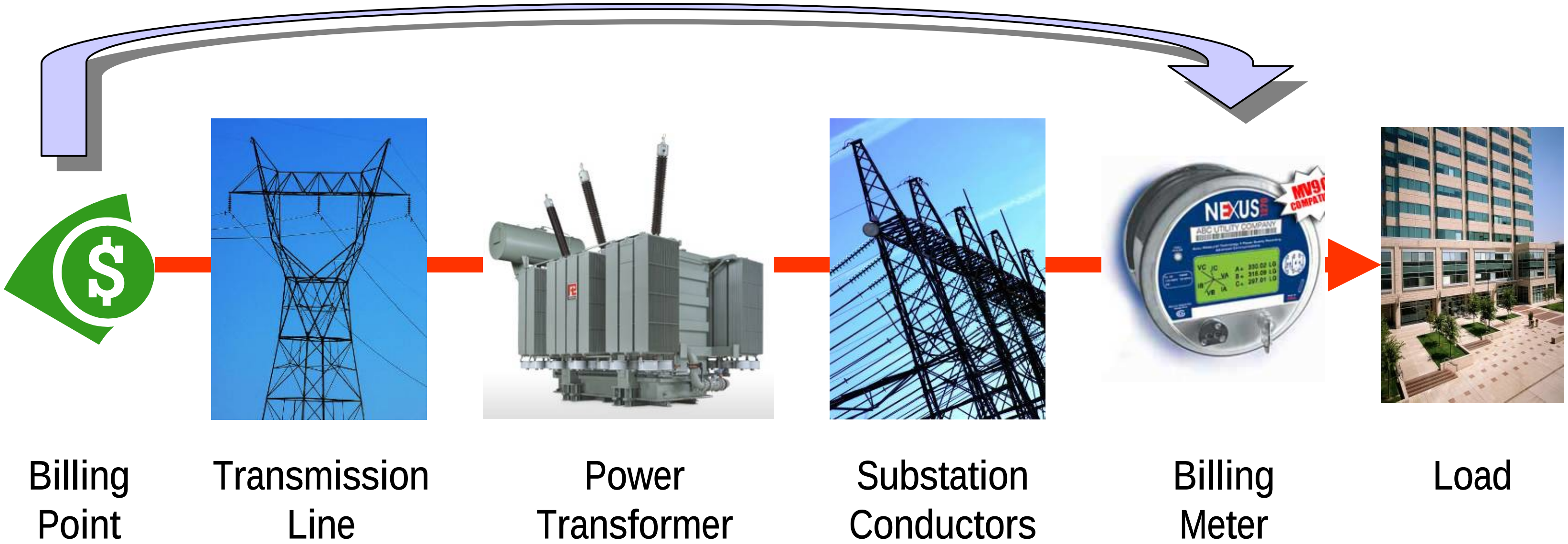
The Leader in Metering Technology Solutions

EIG Loss Calculator Technical Description

The EIG Advantage

What is System Loss Compensation



- Adds or subtracts losses from meter registration
- Allows meter to be placed in most economical location
  - Meters often placed on low side of transformer
  - Significant savings in cost of VT and CT
  - Improves safety and lowers maintenance costs

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Loss Calculation in Meter

Nexus 1260/1270

Nexus 1250

SHARK100
MULTIFUNCTION POWER AND ENERGY METER
Revenue Grade

- Loss Compensation is calculated real-time in Nexus Meters using instantaneous voltage and current measurements
- Demand, Energy, TOU, and Load Profile values are compensated
- Compensation is based on the EEI Model from *The Handbook for Electricity Metering, 10th Edition and IMO MDP_STD_0005*

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EEI/IMO Loss Model in Nexus Meters

The EEI and IMO Loss Model provides a PUC approved and commonly used way to account for the following kinds of losses in revenue metering:

1. Power Transformer Losses
2. Substation Losses
3. Transmission Line Losses

These techniques have a long revenue metering history and are widely used by electric utilities and generally accepted by regulatory bodies.

The EIG Loss Calculator and Nexus Meter implement this model but also allow for Utility Specific customization and extension of the basic Loss Model.

Extensions to include the effects of Transmission Line Capacitance and PF Correction Capacitors are in progress.

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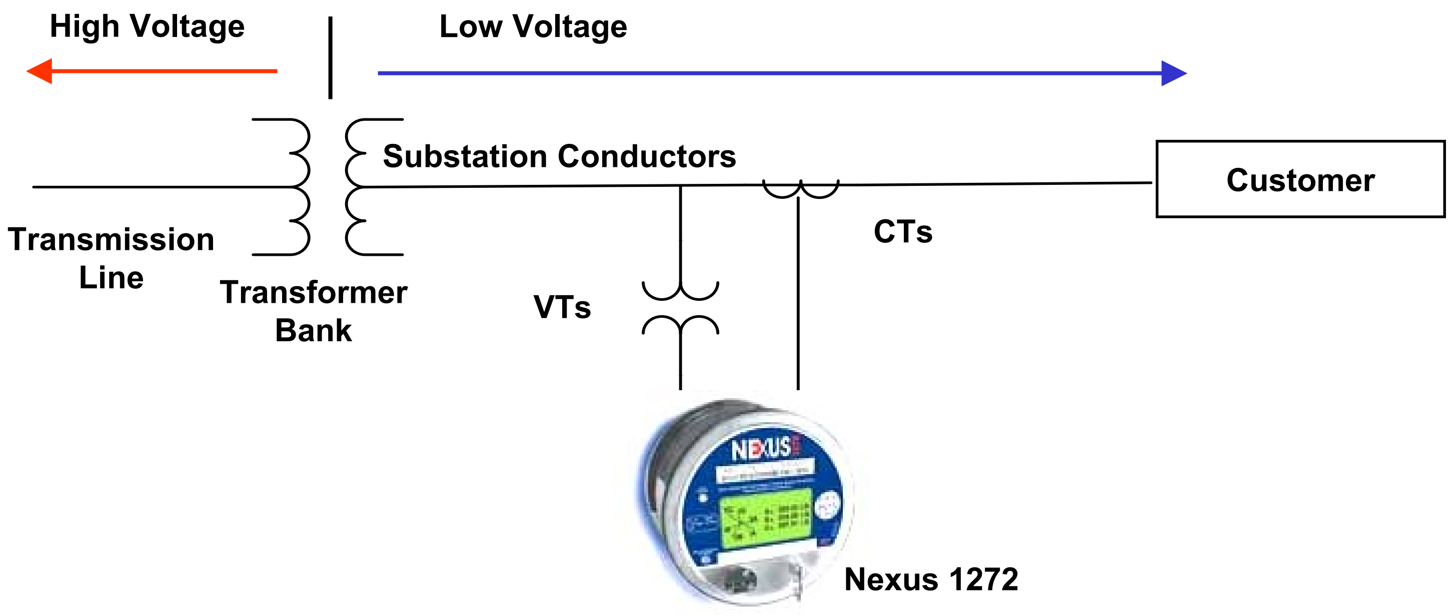
Basics of EEI/IMO Loss Model



The EEI/IMO Loss Model is intended to account for losses that would have been metered if the meter was placed somewhere along the Transmission Line.

The Model may be extended to provide credits for off setting effects of PF Correction Capacitors or Transmission Line Capacitance but these are not part of the EEI/IMO Loss Model

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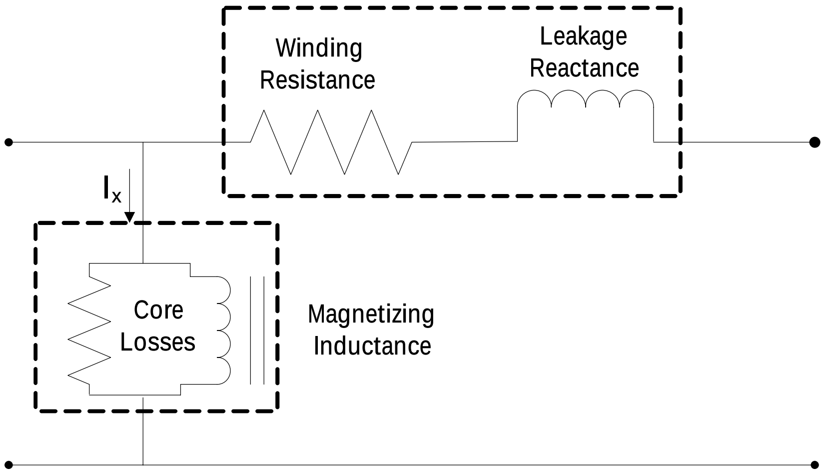
EEI/IMO Transformer Loss Model



Simple High Side Transformer Loss Model

Assumptions:

1. **No-load loss watts are proportional to V squared**
2. **Load loss watts are proportional to I squared**
3. **No-load loss VArs are proportional to V to the 4th power**
4. **Load loss VArs are proportional to I squared**

- The Simple High Side Transformer Model is used
- This model is the basic Loss Model used in Revenue Metering.
- The primary source for this model is the "Handbook for Electricity Metering".
- V, V^2, I^2, and V^4 effects are compensated for real time in the Nexus meter
- However, if your business uses a different model, the Spreadsheet can be easily modified to use your model.

See EEI Handbook for Electricity Metering Chapter 10 – Special Metering

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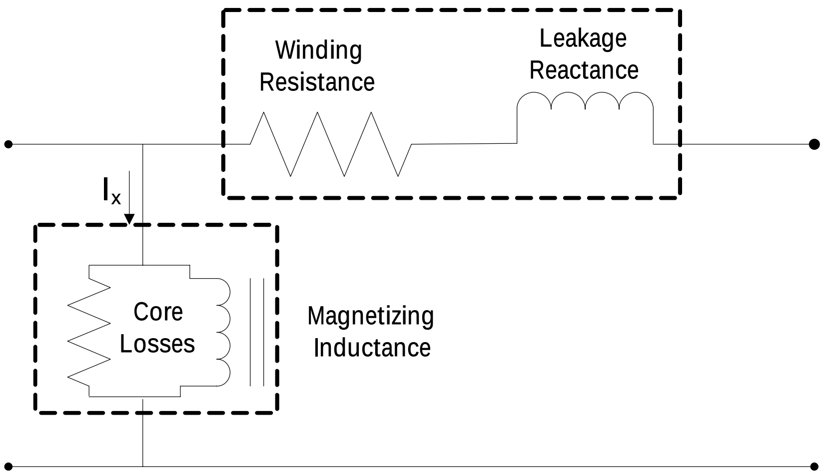
Transformer Loss Data



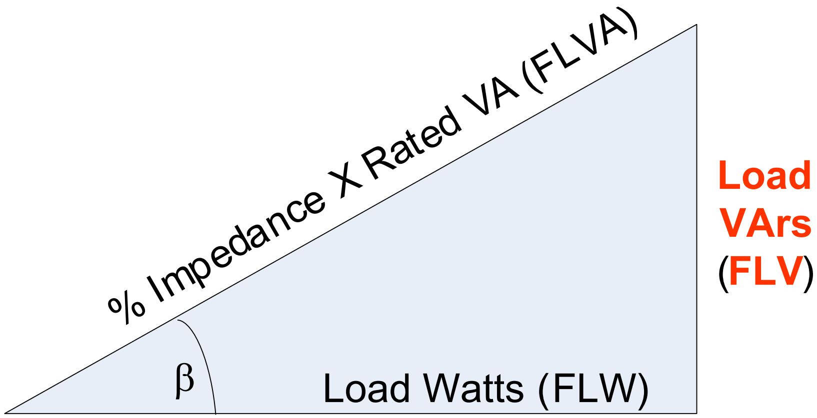
Information supplied by the transformer manufacturer includes:

- The kVA rating of the transformer bank
- Rated primary and secondary voltages
- No-load watts at rated voltage
- Load watts at rated current and at 75 C
- Percent exciting current at rated voltage
- Percent impedance at rated load.

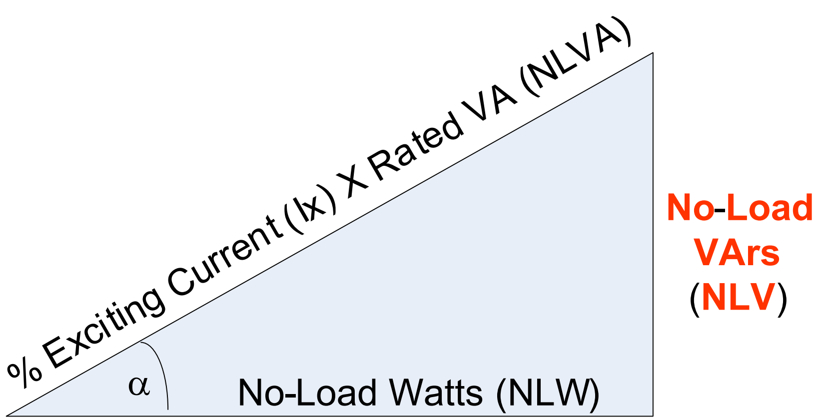
Note: These values can be measured or values from similar transformers used if data is not available

The watt losses are given for both no-load and full-load, but the VAr losses have to be calculated.

Transformer Loss Calculations



Load Losses



No-Load Losses

Loss Triangles can be used to compute Loss values not supplied by the Transformer manufacturer

- These relationships gives us a few simple formulas:

$$FLV = \sqrt{FLVA^2 - FLW^2}$$

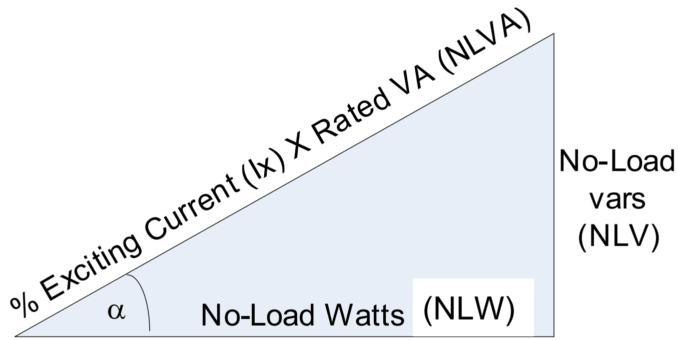
$$NLV = \sqrt{NLVA^2 - NLW^2}$$

Related Terms:

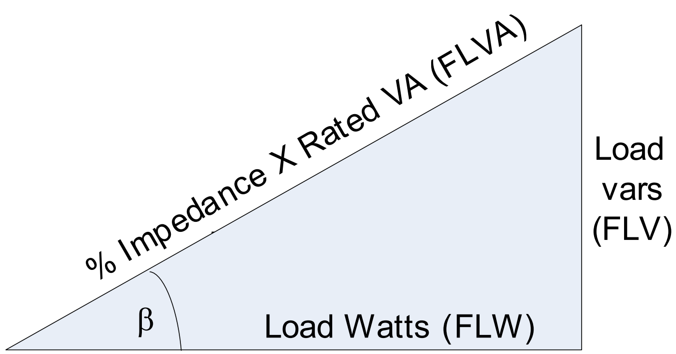
- Load Losses = Copper (Cu) Losses
- No-Load Losses = Core or Iron (Fe) Losses

Values in Red not supplied by Transformer manufacturer

Transformer VAr Calculations



No-Load Losses



Load Losses

No-Load VArs

NLVA = %Ix ● kVA Rated

NLV = sqrt($NLVA^2$-NLW^2)

Full-Load VArs

FLVA = %Z ● kVA Rated

FLV = sqrt($FLVA^2$-FLW^2)

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Transmission Line Losses

Transmission Line Losses are assumed to be is I^2r Losses

Information Needed:

r = Resistance per unit of distance typically ohms/mile or ohms/km

x= Inductive reactance per unit of distance typically ohms/m or ohms/km

LL= Total length of line = 3 ● length of single conductor

So,

Transmission Line Current at primary-rated current of transformer is

Ip = kVA Rated/(Vp●sqrt(3)) where **Vp** = Rated primary Voltage Line-Line

Transmission Line Losses can then be calculated as

$$\text{Line Loss Watts (LLW)} = Ip^2 \bullet r \bullet LL$$

$$\text{Line Loss VArs (LLV)} = Ip^2 \bullet x \bullet LL$$

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Substation Conductor Losses

Substation Conductor Losses are also assumed to be I^2r Losses

Information Needed:

r = resistance per unit of distance typically ohms/foot or ohms/meter

x = inductive reactance per unit of distance typically ohms/ft or ohms/m

LC = Total length of conductor = 3 ● length of single conductor

The Secondary Current at Transformer Bank Rating is:

Ir = kVA Rated/(3●Vr) where Vr = Rated Secondary Voltage Line-Neural

So Losses can be calculated as:

Conductor Loss Watts (CLW) = Ir^2 • r ● LC

Conductor Loss VArs (CLV) = Ir^2 • x ● LC

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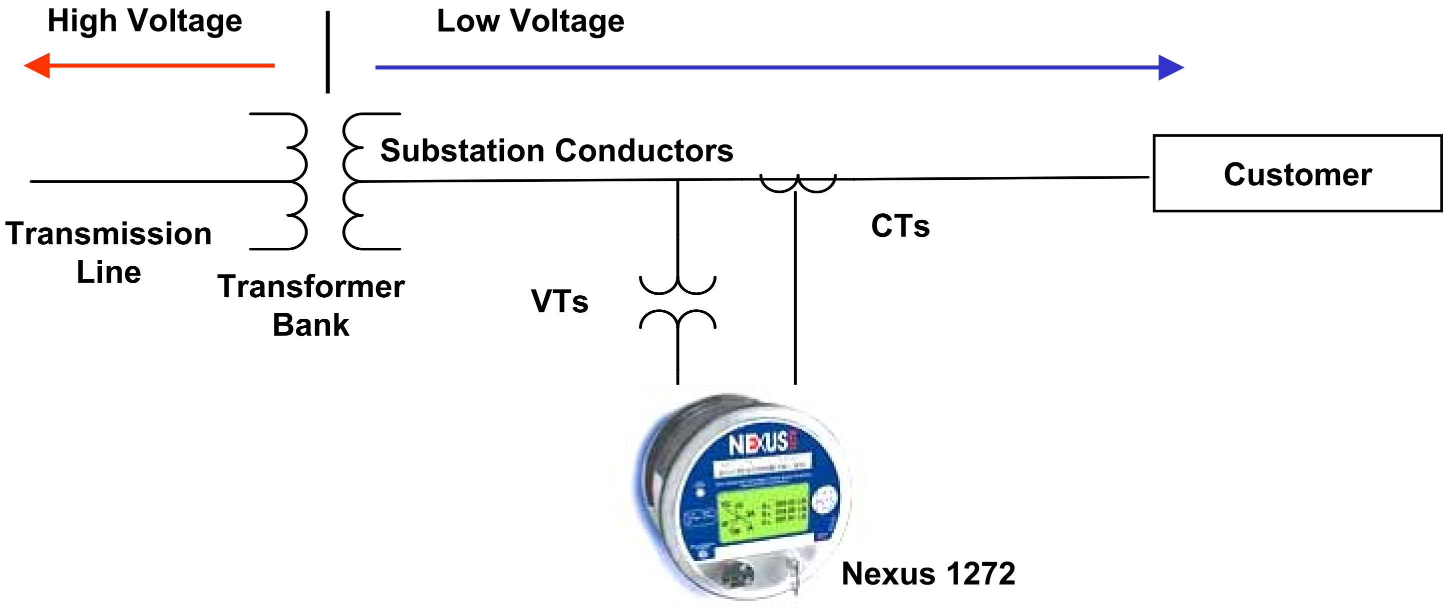
Loss Relationships:

Empirically Derived Assumptions:

1. No-load loss watts are proportional to V squared
2. Load loss watts are proportional to I squared
3. No-load loss VArs are proportional to V to the 4th power
4. Load loss VArs are proportional to I squared

- These assumptions are used in the Meter to calculate Real-Time Loss Compensation
- They are also used in the Model as we adjust Power Transformer Loss Values to the Primary Side of the Instrument Transformers and to the Meter

Moving Losses



- Using the Loss Assumptions, High Side Losses can be moved to the Primary side of the Instrument transformers

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Total System Losses

Type	Source	Watts	VAr
No-Load Losses	Transformer Core	NLW	NLV
Load Losses	Transformer Windings	FLW	FLV
	Transmission Line	LLW	LLV
	Substation Conductors	CLW	CLV
	Total Load Losses	TLW	TLV

Summary of Losses Table
EIG Loss Calculator

Where:

- **TLW = FLW + LLW + CLW**
- **TLV= FLV + LLV + CLV**

Total System Losses are Calculated by summing the Loss Components.

The Loss components are shown on the First Sheet of the EIG Loss Calculator

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Meter Loss Coefficients

Meter Loss Coefficients are used to adjust the meter for the effect of the Losses shown in the System Loss Table

Losses are scaled by the meter rating to compute Meter Loss Coefficients.

VAm = 3*Vm * TA * CTR *VTR (Meter VA Rating)

where, TA = Test Amps CTR= CT Ratio VTR = VT Ratio

These are the four Loss Coefficients programmed into the meter:

%LWFE = LWFE / VAm (% No-Load Loss Watts)
%LVFE = LVFE / VAm (% No-Load Loss VARs)
%LWCu = LWCu / VAm (% Full-Load Loss Watts)
%LVCu = LVCu / VAm (% Full-Load Loss VARs)

The Meter Loss Coefficients are used by the meter to compensate instantaneous calculations.

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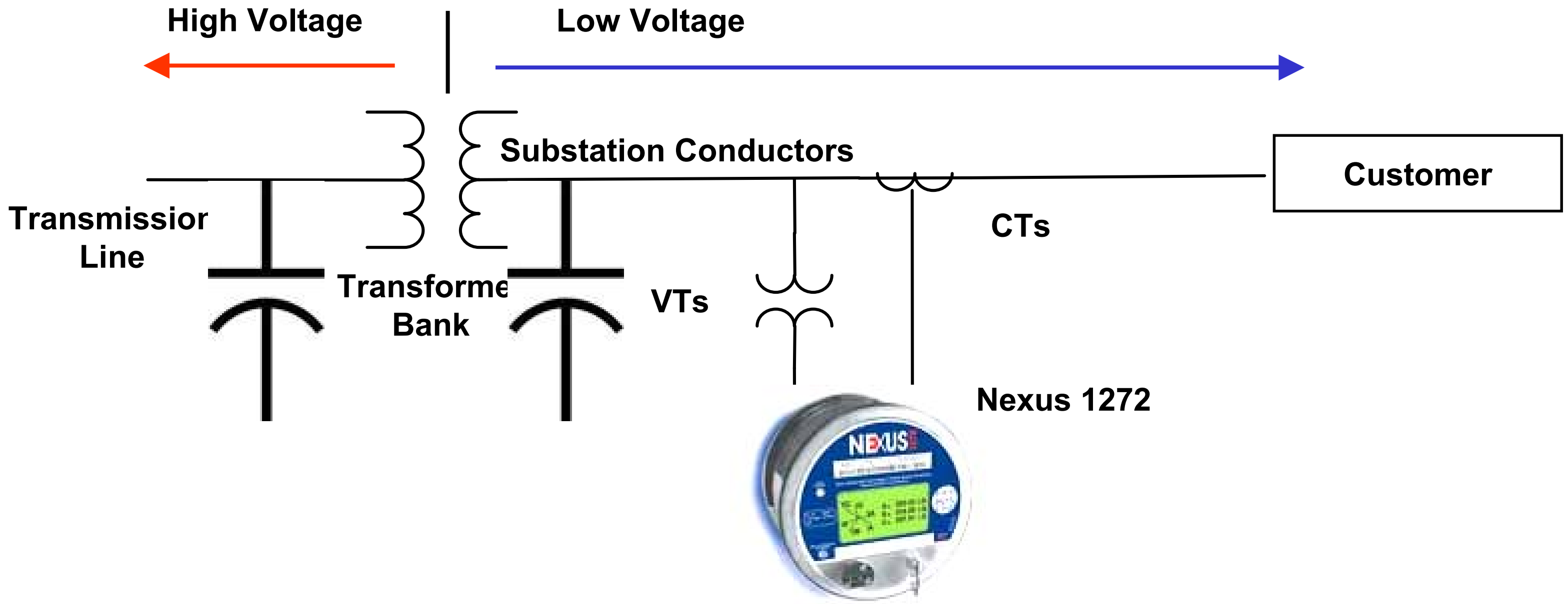
Dynamic Compensation

The Nexus Meter dynamically computes system losses instantaneously using the Meter Loss Coefficients and the assumed voltage and current relationships for Watts and VARs.

1. No-load loss watts are proportional to V squared
2. Load loss watts are proportional to I squared
3. No-load loss VArs are proportional to V to the 4th power
4. Load loss VArs are proportional to I squared

Demand, Energy, TOU, and Load Profile values are compensated instantaneously.

Extending the Loss Model



- Capacitance grouped or ungrouped can be added at the Transmission or Distribution Level of the model. They can be added to the table shown on Total System Losses slide but with a negative sign.
- Alternatively, any or all losses can be reduced by a fixed % by applying a Correction Factor to the Individual Loss Type or to Total Losses

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