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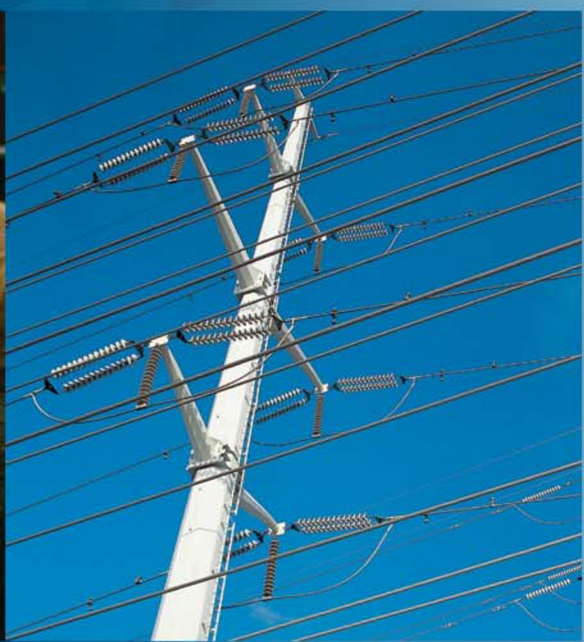
MV-Star Refresh

Background, Issues, and Proposed Requirements



Background

- MVStar is the IESO's meter data repository:
  - Warehousing of all meter data including versions and audit trail
  - Application of loss adjustments to meter data
  - Summation of meters (totalization tables)
  - Compliance aggregation models
  - Contract relationships
  - Interface to MVWeb
  - Process meter data to CRS
- MVStar has been in service since Market Open and is scheduled to be replaced within the next couple of years
  - Hard coding of modules makes it difficult to implement changes
- We have started to do some preliminary analysis to identify future system requirements
  - Focus is on the application of losses

Equation Loss - Power Flow Direction

MVSTAR Application of Method 1 (a, b coefficients) Losses (Background)

Meter attributes are used when V2h and I2h meter values are not available. Attributes include:
CT = current transformer ratio; **VT** = voltage transformer ratio; $\mathbf{V_{nom}}$ = assumed voltage; **PF** = assumed power factor

Method 1 Loss Equation = $a*(V^2hR + V^2hY + V^2hB) + b*(I^2hR + I^2hY + I^2hB)$ per interval
If V^2h, I^2h, kVARh are not available : $V^2hR = V^2hY = V^2hB = \mathbf{V_{nom}}$; $I^2hR = I^2hY = I^2hB = (1000/3)^2*\mathbf{I}*kWh^2/(\mathbf{CT}*\mathbf{VT}*\mathbf{PF}*\mathbf{V_{nom}})^2$

As per MV_STAR Reference Guide (page78)

- If ch1=0 and ch3=0 Losses added to ch1
- If ch1≠0 and ch3=0 Losses added to ch1
- If ch1=0 and ch3≠0 Losses subtracted from ch3
- If ch1≠0 and ch3≠0 Losses added to ch1 and subtracted from ch3

Identified Issue(s):

1. The **CT**, **VT**, $\mathbf{V_{nom}}$, and **PF** attributes are not date referenced . Requires re-registration of a Meter Point each time these parameters are changed; deemed critical change. (ex: CT ratio change)
2. For situations when ch1 ≠0 and ch3≠0, both Load and No-Load Losses are applied to the Delivered (Ch1) and Received (Ch2) meter channels. Net effect is double charge for losses during interval.

Proposed Requirements:

1. **CT, VT, $\mathbf{V_{nom}}$, PF,** and **Service Type** attributes date referenced.
2. Two options:
   a. Losses added to ch1 for all flow conditions (preferred); or
   b. If ch1=0 and ch3=0 Losses added to ch1
      If ch1≠0 and ch3=0 Losses added to ch1
      If ch1=0 and ch3≠0 Losses subtracted from ch3
      If ch1≠0 and ch3≠0 Loss*ch1/(ch1+ch3) add to ch1 and Loss*ch3/(ch1+ch3) subtract from ch3 (used when Load/Gen DP split)

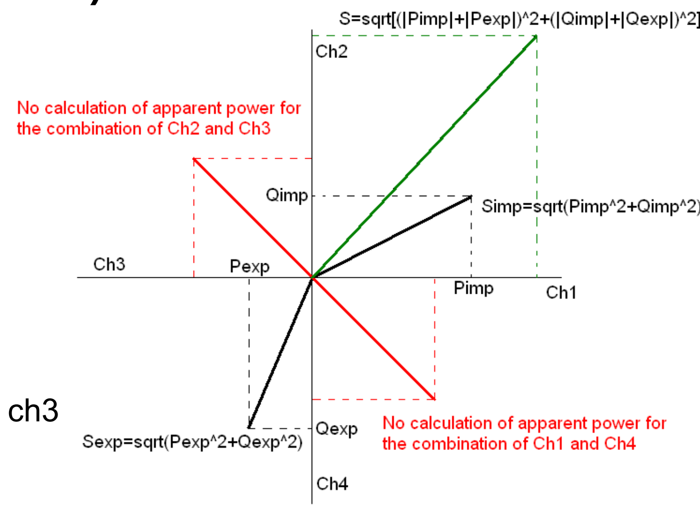
Equation Loss - Power Flow Direction

MVSTAR Application of Method 2 (k1, k2, k3) Losses (Background)

$S_{imp} = sqrt(P_{imp}^2 + Q_{imp}^2) = sqrt(ch1^2 + ch2^2)$
$S_{exp} = sqrt(P_{exp}^2 + Q_{exp}^2) = sqrt(ch3^2 + ch4^2)$
$Loss_{imp} = (k_1/I)*(S_{imp}*I/1000)^2+(k_2/I)(S_{imp}*I/1000)+k_3/I$
$Loss_{exp} = (k_1/I)*(S_{exp}*I/1000)^2+(k_2/I)(S_{exp}*I/1000)+k_3/I$

As per MV_STAR Reference Guide (page78)

If ch1=0 and ch3=0 $Loss_{imp}$ added to ch1
If ch1≠0 and ch3=0 $Loss_{imp}$ added to ch1
If ch1=0 and ch3≠0 $Loss_{exp}$ subtracted from ch3
If ch1≠0 and ch3≠0 $Loss_{imp}$ added to ch1 and $Loss_{exp}$ subtracted from ch3



Identified Issue(s):

1. Combination of ch1ch4 or ch2ch3 are not calculated as an apparent power due the restriction on Simp/Sexp formulas.
2. Method 2 cannot be applied when kVARh channels are missing (non conforming metering issue – using of a VAR virtual meter).
3. For situation when ch1 ≠0 and ch3≠0 both Load and No-Load Losses are applied to the Delivered (Ch1) and Received (Ch2) meter channels. Net effect is double charge for losses during interval.

Proposed Requirements:

1. $S=sqrt[(|P_{imp}|+|P_{exp}|)^2+(|Q_{imp}|+|Q_{exp}|)^2] = sqrt[(|ch1|+|ch3|)^2+(|ch2|+|ch4|)^2]$
2. $S=(|P_{imp}|+|P_{exp}|)/$**PF** when kVAR channels are not available; **PF** assumed power factor (ex. 0.9).
   $Losses = (k_1/I)*(S*I/1000)^2+(k_2/I)(S*I/1000)+(k_3/I)$
3. Two options:
   a) Losses (Load and No-Load) added to ch1 under all flow conditions (preferred); or
   b) If ch1=0 and ch3=0 Losses added to ch1
      If ch1≠0 and ch3=0 Losses added to ch1
      If ch1=0 and ch3≠0 Losses subtracted from ch3
      If ch1≠0 and ch3≠0 Loss*ch1/(ch1+ch3) add to ch1 and Loss*ch3/(ch1+ch3) subtract from ch3 (used when Load/Gen DP split)

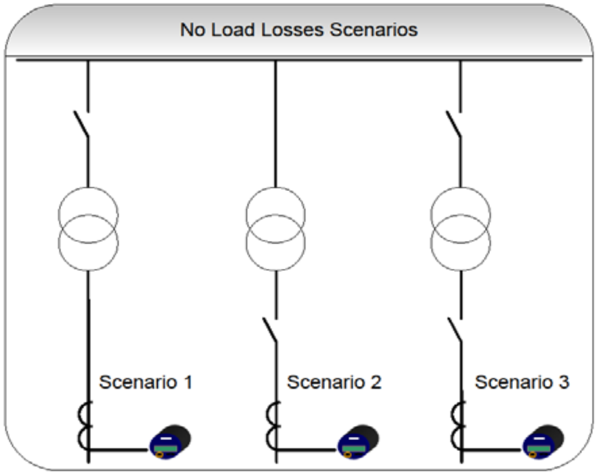
Application of Losses when disconnected from IESO grid

Background

Low side metering under normal circumstances compensates for no-load losses. Some participants as part of their normal day to day operation, frequent disconnect their facility from the IESO controlled grid.

Identified issue(s):

MVSTAR calculates no-load losses even when the transformer is de-energized.
Current tools cannot differentiate between scenarios 1, 2 and 3



Proposed Requirements:

Must meet certain conditions/requirements:

- Scenario 1 power system configuration
- Disconnection from grid part of normal operations

More flexibility applied to the Summary Meter module of proposed system:

- Start and stop time for CT, VT ratio, assumed voltage and power factor, service type
- Voltage code applied individually for each channel
- Requires mathematical (multiplication, division, exponentiation) and logical (IF, AND, OR) functions to Loss module

ex: Loss added on ch1 = if (ch5+ch6+ch7>0, $(k_1/I)*\{sqrt[(|ch1|+|ch3|)^2+(|ch2|+|ch4|)^2]*I/1000\}^2$
$+(k_2/I)*\{sqrt[(|ch1|+|ch3|)^2+(|ch2|+|ch4|)^2]*I/1000\}+k_3/I$, 0)

MEC, TLF applications

Background

Total Loss Factors (TLF) take into account distribution losses for an embedded RWM up to the Defined Meter Point. As approved by the Ontario Energy Board, the TLF can be applied to a physical or summary meter as a fixed factor. Both fixed factors MEC and TLF are applied only on active energy channels (UOM=1) regardless the power flow. For a MEC the application of a fix factor is correct for active channels regardless power flow.

Identified issue(s)

1. MEC

Form 1039 MEC submission provides a MEC value for reactive energy but MVSTAR is unable to adjust the reactive values. When method 2 is used, the apparent power is calculated using an MEC adjusted active power but not MEC adjusted reactive power.

2. TLF

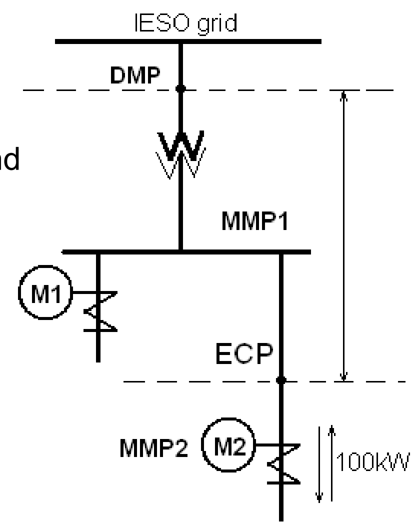
When an embedded RWM records energy exported to the Host Distributor, this energy will have applied the same TLF as for energy withdrawn. For Distributed Generators TLF are applied to Del channels +LF applied to Rec Channels

Proposed requirements

Voltage code applied individually to each channel:

1. MEC_a fix factor applied to active channels and MEC_r fix factor applied to reactive channels
2. TLF_i fix factor applied to import active channels and TLF_e fix factor applied to export active channels

Physical meter	Ch1	Ch2	Ch3	Ch4
Precedence 1	MEC_a	MEC_r	MEC_a	MEC_r
Precedence 2	TLF_i	0	TLF_e	0
Total	= ch1 + MEC_a + TLF_i	= ch2 + MEC_r	= ch3 + MEC_a + TLF_e	Ch4 + MEC_r



MVSTAR

TLF=1.034
MMP2 = ch1*TLF = 103.4kW
MMP2 = ch3*TLF = 103.4kW

Proposed

TLFi=1.034
TLFe=1.000 or as agree between MMP1 and MMP2

MMP2 = ch1*TLFi = 103.4kW correct
MMP2 = ch3*TLFe = 100kw correct

Static vs. Dynamic Loss Apportioning Allocation

Background

As per Market Manual 3.7: Totalization Table Registration Section 2.3.3: Apportioning Transformation Losses**,** when an agreement is reached between all MMPs, the MSPs must submit the apportioning in the "Totalization Table Form" as follows:
Method 1 – the A coefficient must be multiplied by the ratio (ex: 3/10), while the B coefficient must be multiplied by the inverse ratio, 10/3;
Method 2 - K1 coefficient must be multiplied by the inverse ratio, 10/3, while K3 coefficient must be multiplied by the ratio, 3/10; K2 coefficient remains unchanged.
This apportioning, the **ratio**, is determined usually based on feeders ratio or average load ratio.

Identified issue(s)

The total No_Load Loss is allocated correctly regardless of the load distribution between MMPs.
The total Load Loss is allocated correctly only when the load distribution matches the ratio agreed between MMPs; otherwise the calculated total Load Loss is higher than the actual total Load Loss – in favour of the market (see attached Allocation of Power Transformer SSLA).
In the MVSTAR Method 1 a,b + Method 2 k_1, k_2, k_3 are fixed and not variable factors.

Proposed requirements

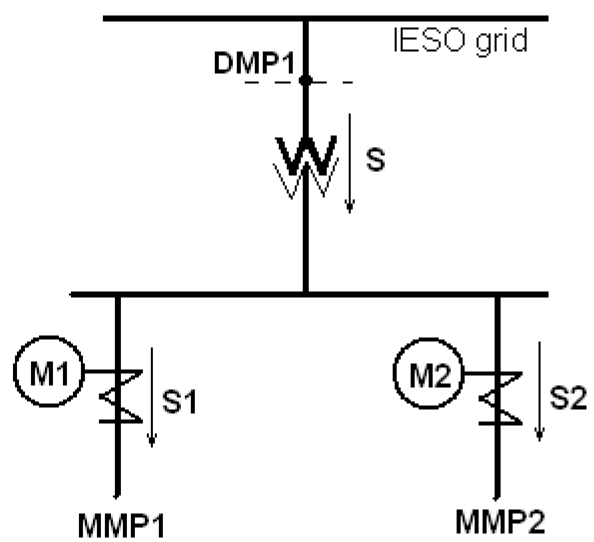
If the apportion could be recalculated for each time interval, based on MMPs loads ratio, the total Load Loss will be allocated correctly .
For that the loss module must permit mathematical (multiplication, division, exponentiation) and logical (IF, AND, OR) functions.

Ex: $S = S_1+S_2$
for MMP_1 the ratio will be S_1/S
for MMP_2 the ratio will be S_2/S

$Loss_1 = [(S/S_1)*k_1/I]*(S_1*I/1000)^2 +(k_2/I)*(S_1*I/1000)+(S_1/S)*k_3/I$
$Loss_2 = [(S/S_2)*k_1/I]*(S_2*I/1000)^2 +(k_2/I)*(S_2*I/1000)+(S_2/S)*k_3/I$

Total Loss = $Loss_1+Loss_2 = (k_1/I)*(S*I/1000)^2 +(k_2/I)*(S*I/1000)+k_3/I$

Issue: Require agreement between MMP's for data confidentiality purposes – needs market rules clarification



Netting of Losses – Actual vs. Metered flow

Background

Two MMPs, a generator and a load, could be metered on the low voltage side in a transformer station, with no bus meter above. For this scenario the loss allocation and calculation is a complex process.

Identified issue(s)

The losses will be calculated for the total metered load (50MW +100MW)

$MMP_1 = -S + (3/1)k_1S^2+k_2S+1/3k_3$

$MMP_2 = 2S + (3/2)k_1(2S)^2+k_2(2S)+2/3k_3$

Total: $MMP_1+ MMP_2= S+ k_1(3S)^2+k_2(3S) +k_3$

The losses can be calculated for the actual load flowing through power transformer S=50MW

Loss allocation ratio is a fix factor(see attached Allocation of Power Transformer SSLA)

Proposed requirements

If the apportion could be recalculated for each time interval, based on MMPs loads ratio, the apportioned Net_Load_Losses will be correct distributed.

For that the ratio module must permit mathematical (multiplication, division, exponentiation) and logical (IF, AND, OR) functions.

It will calculate the Net_Load (50MW), the Net_Load_Losses, and distribute these losses between MMPs based on dynamic ratio – apportioned factors (see **Static vs. Dynamic Loss Apportioning Allocation** slide).

$\text{Net\_Load} = S = \sum(\text{ch1-ch3})$

$\text{Net\_Load\_Losses} = k_1\text{Net\_Load}^2+k_2\text{Net\_Load} +k_3$

$MMP_1 = -S + 1/3\ \text{Net\_Load\_Losses}$

$MMP_2 = 2S + 2/3\ \text{Net\_Load\_Losses}$

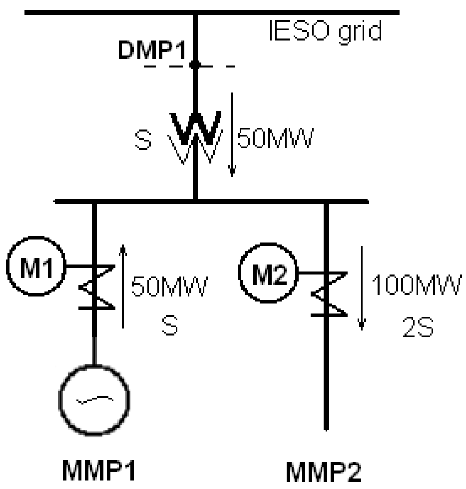
Total: $MMP_1+ MMP_2 = S+ k_1S^2+k_2S +k_3$

$S = S_1+S_2$; for MMP_1 the ratio will be S_1/S; for MMP_2 the ratio will be S_2/S

$MMP_1 = -S + (S_1/S)\text{Net\_Load\_Losses}$

$MMP_2 = 2S + (S_2/S)\text{Net\_Load\_Losses}$

Issue: Require agreement between MMP's for data confidentiality purposes – needs market rules clarification



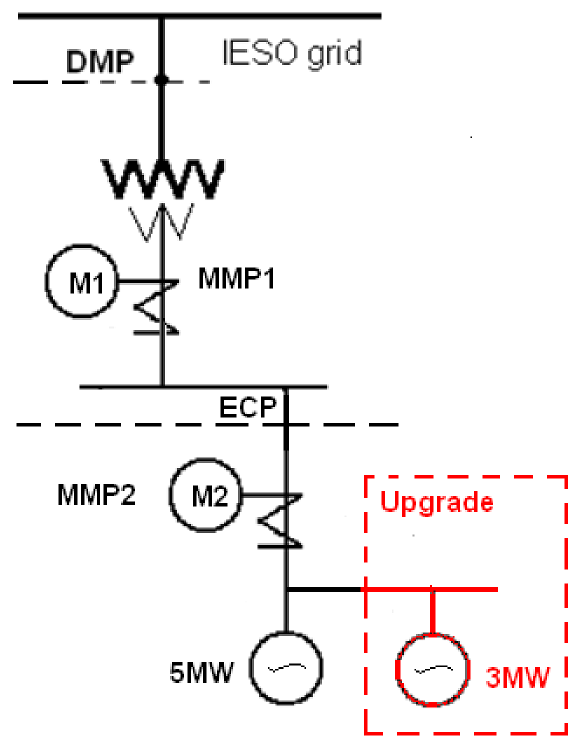
Settlements Principles
Incremental Generation Capacity

Background

Actually many transmission customers have embedded generation facilities which as per Ontario Uniform Transmission Rate Schedule don't attract Transmission Connection Service Charges (approved prior 1998 or less than 1MW).
Most of these generation facilities plan to increase their output capacity (upgrades, FIT programs) which in most cases will attract Transmission Connection Service Charges.
The charges should be applied to the positive difference between the total generation and the previous maximum continuous rating excepted from Transmission Connection Service Charges.

Identified issue(s)

The Transmission Connection Service charges are applied only using the Alternative Metering Installation Standards for Embedded Generation Facilities.
It is done outside of MVSTAR, once per year, as an annual adjustment using IESO form 1563.



Proposed requirements

Only the positive difference between the total generation output and the exempted (legacy) generation quantity will be added to the Connection DP of the transmission customer MMP1.
For that the channel module must permit mathematical (multiplication, division, exponentiation) and logical (IF, AND, OR) functions.

The settlements equation would be
MMP1
- Energy DP = M1- M2
- Network DP = M1
- Connection DP = M1 +(if(M2-5MW>0, M2-5MW, 0)

MMP2
- Energy DP = M2

Summary

- Following requirements would address known issues:
  - **CT, VT, V_{nom}, PF,** and **Service Type** meter attributes to be date referenced
  - Flexibility to apply losses by using mathematical (multiplication, division, exponentiation) and logical (IF, AND, OR) functions
    - Losses applied to delivered channel (regardless of power flow)
    - Option to apportion losses based on power flow
    - Calculation of system apparent power
    - Apportioning of dynamic losses
    - Netting of losses
    - Determining incremental capacity
  - Application of voltage code/loss factor to meter channel level
    - MEC per channel (active, reactive, del, rec)
    - TLF/LF per channel (del, rec)
- Any changes to current loss application principles will require update to SSLA and MEC standards

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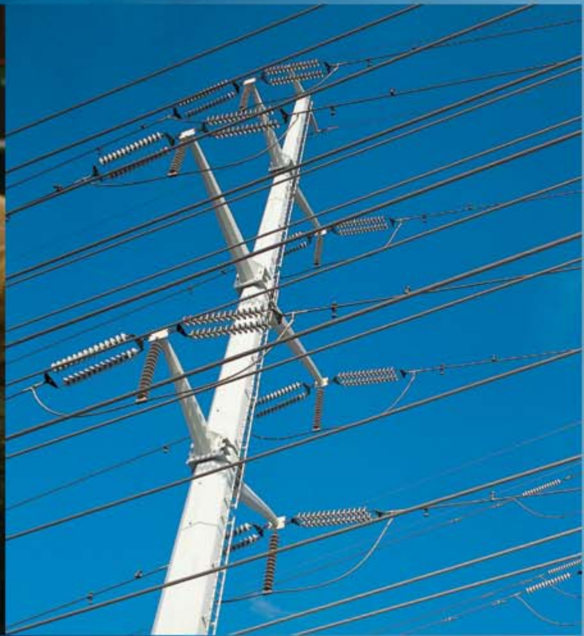
Allocation of Power Transformer SSLA



Introduction

As per Market Manual 3.5: **Site-Specific Loss Adjustments** the power transformer losses can be calculated using one of the two methods:

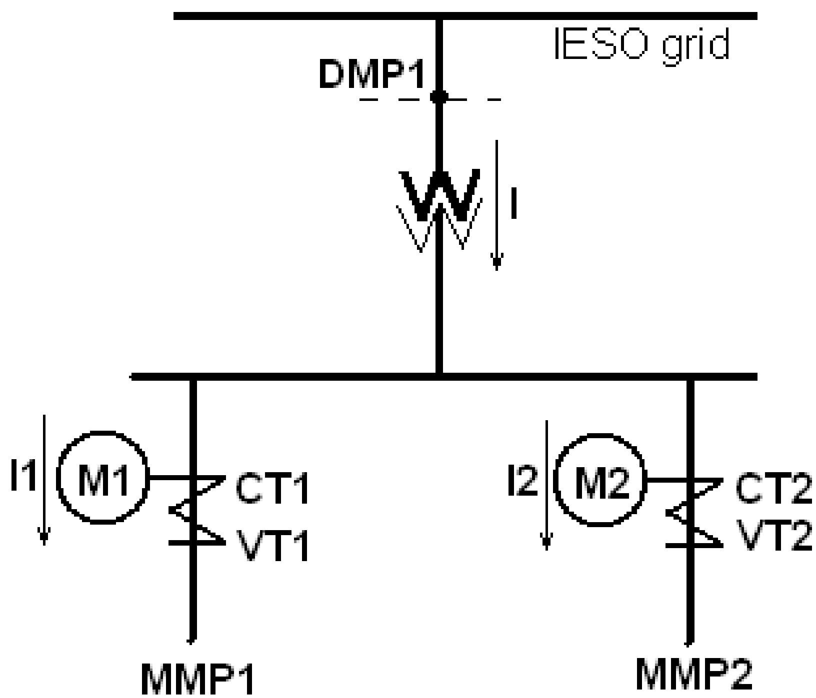
Method 1 – Volt and Amp Squared coefficients (A, B) - P_{loss} = A(V2R+V2Y+V2B) +B(I2R+I2Y+I2B)

Method 2 – Equation Coefficients (k_1, K_2, K_3) - $P_{loss} = K_1 S_{total}^2 + K_2 S_{total} + K_3$

As per Market Manual 3.7: **Totalization Table Registration** art 2.3.3: **Apportioning Transformation Losses,** when an agreement is reached between all MMPs, the MSPs must submit this apportioning in the "Totalization Table Form" as follows:

> **Method 1 –** the A coefficient must be multiplied by the ratio (ex: 3/10), while the B coefficient must be multiplied by the inverse ratio, 10/3;
>
> **Method 2** - K1 coefficient must be multiplied by the inverse ratio, 10/3, while K3 coefficient must be multiplied by the ratio, 3/10; K2 coefficient remains unchanged.

Allocation of Tx SSLA calculated with method 1 (A B coefficients)
case1 - No Bus Meter



Note:

a1, b1 are calculated using CT1, VT1 ratios
a2, b2 are calculated using CT2, VT2 ratios

Assumption

$$a_1' = \frac{3}{10} \times a_1 \quad b_1' = \frac{10}{3} \times b_1 \qquad a_1 = \frac{P_{noload}}{3} \div \left(\frac{V}{VT_{rat1}}\right)^2 \quad b_1 = \frac{P_{load}}{3} \div \left(\frac{I}{CT_{rat1}}\right)^2$$

$$a_2' = \frac{7}{10} \times a_2 \quad b_2' = \frac{10}{7} \times b_2 \qquad a_2 = \frac{P_{noload}}{3} \div \left(\frac{V}{VT_{rat2}}\right)^2 \quad b_2 = \frac{P_{load}}{3} \div \left(\frac{I}{CT_{rat2}}\right)^2$$

Allocation of Tx SSLA calculated with method 1 (A B coefficients) case1 - No Bus Meter

Verification

$$P_{load1} = 3\times b_1' \times\left(\frac{I_1}{CT_{rat1}}\right)^2 = 3\times\frac{10}{3}\times b_1 \times\left(\frac{\frac{3}{10}\times I}{CT_{rat1}}\right)^2 \qquad P_{load2} = 3\times b_2' \times\left(\frac{I_2}{CT_{rat2}}\right)^2 = 3\times\frac{10}{7}\times b_2 \times\left(\frac{\frac{7}{10}\times I}{CT_{rat2}}\right)^2$$

$$P_{load} = P_{load1} + P_{load2} = 3\times\left[b_1\times\frac{I^2}{CT_{rat1}^{\ 2}}\times\frac{3}{10} + b_2\times\frac{I^2}{CT_{rat2}^{\ 2}}\times\frac{7}{10}\right] = 3\times I^2\times\left[\frac{3}{10}\times\frac{b_1}{CT_{rat1}^{\ 2}} + \frac{7}{10}\times\frac{b_2}{CT_{rat2}^{\ 2}}\right] =$$

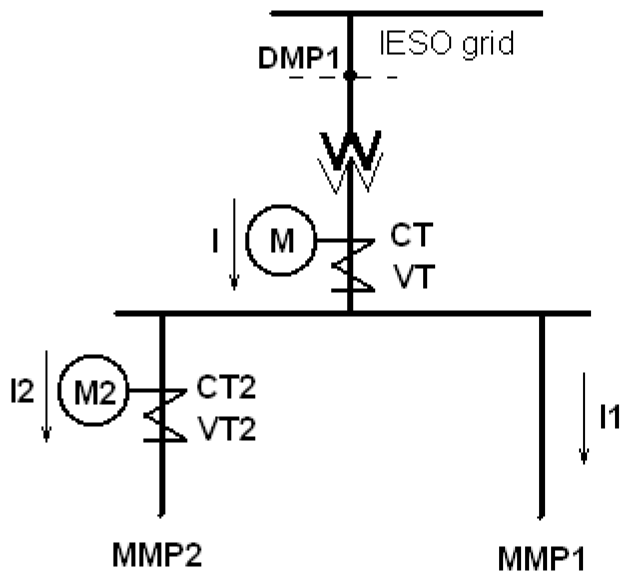
$$= 3\times I^2\times\left[\frac{3}{10}\times\frac{1}{CT_{rat1}^{\ 2}}\times\left(\frac{P_{load}}{3}\times\frac{CT_{rat1}^{\ 2}}{I^2}\right) + \frac{7}{10}\times\frac{1}{CT_{rat2}^{\ 2}}\times\left(\frac{P_{load}}{3}\times\frac{CT_{rat2}^{\ 2}}{I^2}\right)\right] = 3\times I^2\times\left[\frac{3+7}{10}\times\left(\frac{P_{load}}{3\times I^2}\right)\right] = P_{load}$$

$$P_{noload1} = 3\times a_1' \times\left(\frac{V}{VT_{rat1}}\right)^2 = 3\times\frac{3}{10}\times a_1\times\left(\frac{V}{VT_{rat1}}\right)^2 \qquad P_{noload2} = 3\times a_2' \times\left(\frac{V}{VT_{rat2}}\right)^2 = 3\times\frac{7}{10}\times a_2\times\left(\frac{V}{VT_{rat2}}\right)^2$$

$$P_{noload} = P_{noload1} + P_{noload2} = 3\times\left(\frac{3}{10}\times a_1\times\left(\frac{V}{VT_{rat1}}\right)^2 + \frac{7}{10}\times a_2\times\left(\frac{V}{VT_{rat2}}\right)^2\right) =$$

$$= 3\times\left(\frac{3}{10}\times\frac{\frac{P_{noload}}{3}}{\left(\frac{V}{VT_{rat1}}\right)^2}\times\left(\frac{V}{VT_{rat1}}\right)^2 + \frac{7}{10}\times\frac{\frac{P_{noload}}{3}}{\left(\frac{V}{VT_{rat2}}\right)^2}\times\left(\frac{V}{VT_{rat2}}\right)^2\right) = 3\times\frac{P_{noload}}{3}\times\left(\frac{3+7}{10}\right) = P_{noload}$$

Allocation of Tx SSLA calculated with method 1 (A B coefficients) case2 - Bus Meter



Note:

a, b are calculated using CT, VT ratios
a2, b2 are calculated using CT2, VT2 ratios

Assumption

a b

$$a = \frac{P_{noload}}{3} \div \left(\frac{V}{VT_{rat}}\right)^2 \quad b = \frac{P_{load}}{3} \div \left(\frac{I}{CT_{rat}}\right)^2$$

$$a_2' = \frac{3}{10} \times a_2 \quad b_2' = \frac{10}{3} \times b_2$$

$$a_2 = \frac{P_{noload}}{3} \div \left(\frac{V}{VT_{rat2}}\right)^2 \quad b_2 = \frac{P_{load}}{3} \div \left(\frac{I}{CT_{rat2}}\right)^2$$

Allocation of Tx SSLA calculated with method 1 (A B coefficients) case2 - Bus Meter

Verification

$$P_{load} = 3 \times b \times \left(\frac{I}{CT_{rat}}\right)^2 \quad P_{load2} = 3 \times b_2{}' \times \left(\frac{I_2}{CT_{rat2}}\right)^2 = 3 \times \frac{10}{3} \times b_2 \times \left(\frac{\frac{3}{10} \times I}{CT_{rat2}}\right)^2$$

$$P_{load1} = P_{load} - P_{load2} = 3 \times b \times \left(\frac{I}{CT_{rat}}\right)^2 - 3 \times \frac{10}{3} \times b_2 \times \left(\frac{\frac{3}{10} \times I}{CT_{rat2}}\right)^2 =$$

$$= 3 \times \frac{\frac{P_{load}}{3}}{\left(\frac{I}{CT_{rat}}\right)^2} \times \left(\frac{I}{CT_{rat}}\right)^2 - 3 \times \frac{10}{3} \times \frac{\frac{P_{load}}{3}}{\left(\frac{I}{CT_{rat2}}\right)^2} \times \left(\frac{\frac{3}{10} \times I}{CT_{rat2}}\right)^2 = P_{load} - \frac{3}{10} \times P_{load} = \frac{7}{10} \times P_{load}$$

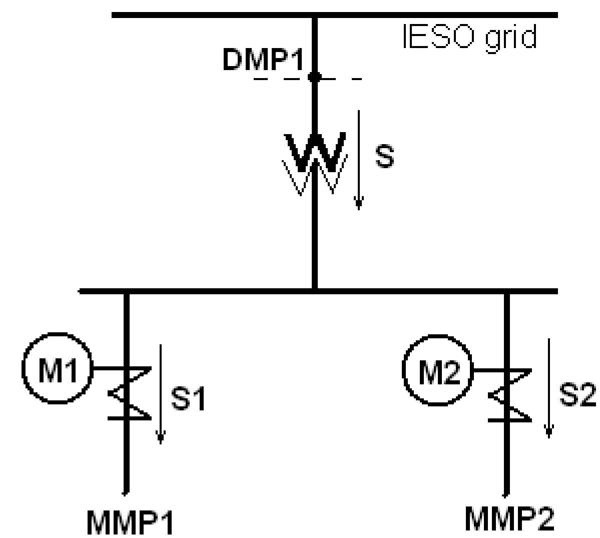
$$P_{noload} = 3 \times a \times \left(\frac{V}{VT_{rat}}\right)^2 \quad P_{noload2} = 3 \times a_2{}' \times \left(\frac{V}{VT_{rat2}}\right)^2 = 3 \times \frac{3}{10} \times a_2 \times \left(\frac{V}{VT_{rat2}}\right)^2$$

$$P_{noload1} = P_{noload} - P_{noload2} = 3 \times a \times \left(\frac{V}{VT_{rat}}\right)^2 - 3 \times \frac{3}{10} \times a_2 \times \left(\frac{V}{VT_{rat2}}\right)^2 =$$

$$= 3 \times \frac{\frac{P_{noload}}{3}}{\left(\frac{V}{VT_{rat}}\right)^2} \times \left(\frac{V}{VT_{rat}}\right)^2 - 3 \times \frac{3}{10} \times \frac{\frac{P_{noload}}{3}}{\left(\frac{V}{VT_{rat2}}\right)^2} \times \left(\frac{V}{VT_{rat2}}\right)^2 = P_{noload} - \frac{3}{10} \times P_{noload} = \frac{7}{10} \times P_{noload}$$

Allocation of Tx SSLA calculated with method 2 (K_1, k_2, k_3 coefficients)

Note:
k1, k2, k3 are not depending by the CT, VT ratio of MI



Assumption

$$MMP_1 \quad S_1 = \frac{1}{4}\times S \quad k_1' = \frac{4}{1}\times k_1, \quad k_2' = k_2, \quad k_3' = \frac{1}{4}\times k_3$$

$$MMP_2 \quad S_2 = \frac{3}{4}\times S \quad k_1'' = \frac{4}{3}\times k_1, \quad k_2'' = k_2, \quad k_3'' = \frac{3}{4}\times k_3$$

Verification

$$Losses_{MMP1} = k_1' \times S_1^2 + k_2' \times S_1 + k_3'$$

$$Losses_{MMP2} = k_1'' \times S_2^2 + k_2'' \times S_2 + k_3''$$

$$Losses_{MMP1} + Losses_{MMP2} = k_1' \times S_1^2 + k_2' \times S_1 + k_3' + k_1'' \times S_2^2 + k_2'' \times S_2 + k_3'' =$$

$$= \frac{4}{1}\times k_1 \times \left(\frac{1}{4}\times S\right)^2 + k_2 \times \left(\frac{1}{4}\times S\right) + \frac{1}{4}\times k_3 + \frac{4}{3}\times k_1 \times \left(\frac{3}{4}\times S\right)^2 + k_2 \times \frac{3}{4}\times S + \frac{3}{4}\times k_3 =$$

$$= k_1 \times S^2 \times \left(\frac{1+3}{4}\right) + k_2 \times S \times \left(\frac{1+3}{4}\right) + k_3 \times \left(\frac{1+3}{4}\right) = k_1 \times S^2 + k_2 \times S + k_3 = Losses\ Total$$

Tx Losses Error as a function of Load Allocation
-SSLA method 1 (A B coefficients)

Method 1

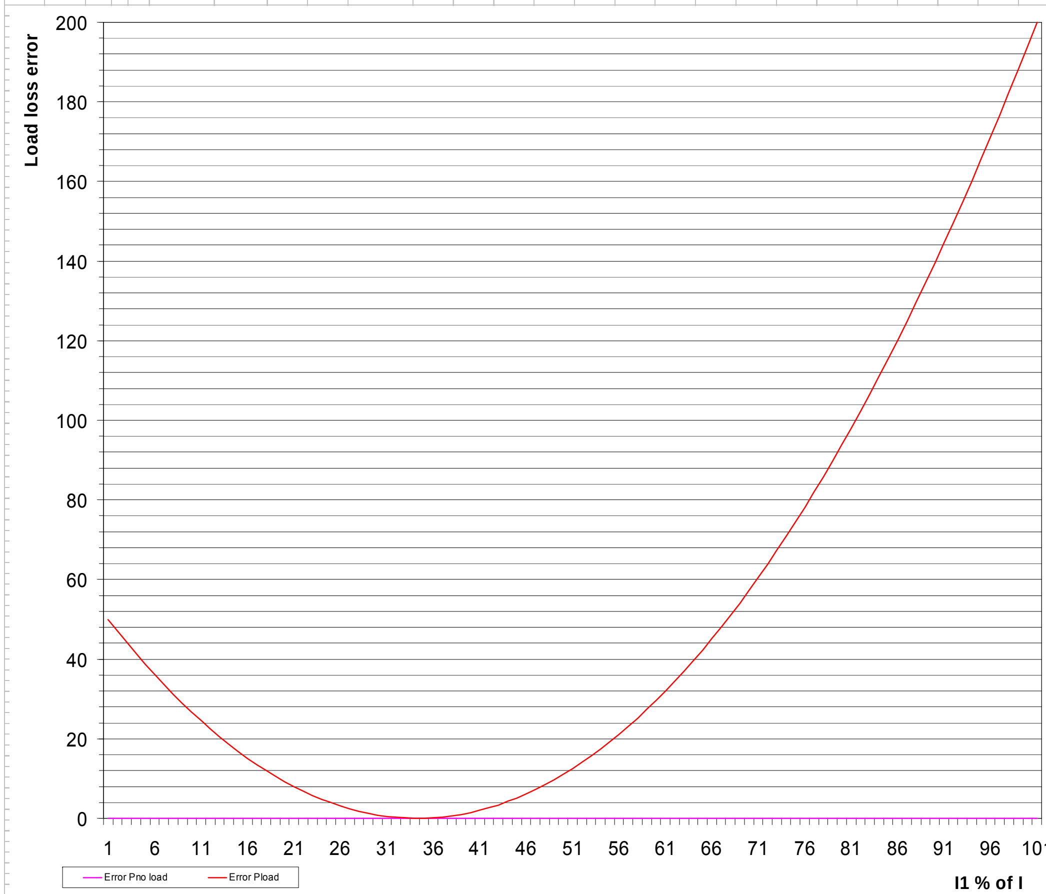
S rated	1000	kVA
V rated	600	V
Pnoload	3.585	kW
Iex	1.93	%
Pload	9.693	kW
z	5.72	%

Vitp	346.4101615	V
Iitp	962.2504486	A

VT1	3
CT1	160
VT2	3
CT2	40

a1	0.000089625	kW/V2
b1	0.089330688	kW/A2
a2	0.000089625	kW/V2
b2	0.005583168	kW/A2

a1'=1/3a1	0.000029875
b1'=3/1b1	0.267992064
a2'=2/3a2	0.00005975
b2'=3/2b2	0.008374752



I1% of Iitp	I1	I2	Pnoload1	Pnoload2	Pnoload	Pload1	Pload2	Pload	Error Pload	Error Pno
0	0	962.2504	1.195	2.39	3.585	0	14.5395	14.5395	50.00	0
0.01	9.622504	952.6279	1.195	2.39	3.585	0.002908	14.25016	14.25307	47.05	0
0.02	19.24501	943.0054	1.195	2.39	3.585	0.011632	13.96374	13.97537	44.18	0
0.03	28.86751	933.3829	1.195	2.39	3.585	0.026171	13.68022	13.70639	41.41	0
0.04	38.49002	923.7604	1.195	2.39	3.585	0.046526	13.3996	13.44613	38.72	0
0.05	48.11252	914.1379	1.195	2.39	3.585	0.072698	13.1219	13.1946	36.13	0
0.06	57.73503	904.5154	1.195	2.39	3.585	0.104684	12.8471	12.95179	33.62	0
0.07	67.35753	894.8929	1.195	2.39	3.585	0.142487	12.57521	12.7177	31.21	0
0.08	76.98004	885.2704	1.195	2.39	3.585	0.186106	12.30623	12.49234	28.88	0
0.09	86.60254	875.6479	1.195	2.39	3.585	0.23554	12.04016	12.2757	26.65	0
0.1	96.22504	866.0254	1.195	2.39	3.585	0.29079	11.777	12.06779	24.50	0
0.11	105.8475	856.4029	1.195	2.39	3.585	0.351856	11.51674	11.86859	22.45	0
0.12	115.4701	846.7804	1.195	2.39	3.585	0.418738	11.25939	11.67813	20.48	0
0.13	125.0926	837.1579	1.195	2.39	3.585	0.491435	11.00495	11.49638	18.61	0
0.14	134.7151	827.5354	1.195	2.39	3.585	0.569948	10.75341	11.32336	16.82	0
0.15	144.3376	817.9129	1.195	2.39	3.585	0.654278	10.50479	11.15907	15.13	0
0.16	153.9601	808.2904	1.195	2.39	3.585	0.744422	10.25907	11.00349	13.52	0
0.17	163.5826	798.6679	1.195	2.39	3.585	0.840383	10.01626	10.85664	12.01	0
0.18	173.2051	789.0454	1.195	2.39	3.585	0.94216	9.77636	10.71852	10.58	0
0.19	182.8276	779.4229	1.195	2.39	3.585	1.049752	9.539366	10.58912	9.25	0
0.2	192.4501	769.8004	1.195	2.39	3.585	1.16316	9.30528	10.46844	8.00	0
0.21	202.0726	760.1779	1.195	2.39	3.585	1.282384	9.074102	10.35649	6.84	0
0.22	211.6951	750.5553	1.195	2.39	3.585	1.407424	8.845832	10.25326	5.78	0
0.23	221.3176	740.9328	1.195	2.39	3.585	1.538279	8.62047	10.15875	4.80	0
0.24	230.9401	731.3103	1.195	2.39	3.585	1.67495	8.398015	10.07297	3.92	0
0.25	240.5626	721.6878	1.195	2.39	3.585	1.817438	8.178469	9.995906	3.13	0
0.26	250.1851	712.0653	1.195	2.39	3.585	1.96574	7.96183	9.927571	2.42	0
0.27	259.8076	702.4428	1.195	2.39	3.585	2.119859	7.7481	9.867959	1.80	0
0.28	269.4301	692.8203	1.195	2.39	3.585	2.279794	7.537277	9.81707	1.28	0
0.29	279.0526	683.1978	1.195	2.39	3.585	2.445544	7.329362	9.774906	0.84	0
0.3	288.6751	673.5753	1.195	2.39	3.585	2.61711	7.124355	9.741465	0.50	0
0.31	298.2976	663.9528	1.195	2.39	3.585	2.794492	6.922256	9.716748	0.24	0
0.32	307.9201	654.3303	1.195	2.39	3.585	2.97769	6.723065	9.700754	0.08	0
0.33	317.5426	644.7078	1.195	2.39	3.585	3.166703	6.526782	9.693485	0.00	0
0.34	327.1652	635.0853	1.195	2.39	3.585	3.361532	6.333406	9.694939	0.02	0
0.35	336.7877	625.4628	1.195	2.39	3.585	3.562178	6.142939	9.705116	0.12	0
0.36	346.4102	615.8403	1.195	2.39	3.585	3.768638	5.955379	9.724018	0.32	0
0.37	356.0327	606.2178	1.195	2.39	3.585	3.980915	5.770728	9.751643	0.60	0
0.38	365.6552	596.5953	1.195	2.39	3.585	4.199008	5.588984	9.787991	0.98	0
0.39	375.2777	586.9728	1.195	2.39	3.585	4.422916	5.410148	9.833064	1.44	0
0.4	384.9002	577.3503	1.195	2.39	3.585	4.65264	5.23422	9.88686	2.00	0
0.41	394.5227	567.7278	1.195	2.39	3.585	4.88818	5.0612	9.94938	2.65	0
0.42	404.1452	558.1053	1.195	2.39	3.585	5.129536	4.891088	10.02062	3.38	0
0.43	413.7677	548.4828	1.195	2.39	3.585	5.376707	4.723884	10.10059	4.20	0
0.44	423.3902	538.8603	1.195	2.39	3.585	5.629694	4.559587	10.18928	5.12	0
0.45	433.0127	529.2377	1.195	2.39	3.585	5.888498	4.398199	10.2867	6.12	0
0.46	442.6352	519.6152	1.195	2.39	3.585	6.153116	4.239718	10.39283	7.22	0
0.47	452.2577	509.9927	1.195	2.39	3.585	6.423551	4.084146	10.5077	8.40	0
0.48	461.8802	500.3702	1.195	2.39	3.585	6.699802	3.931481	10.63128	9.68	0
0.49	471.5027	490.7477	1.195	2.39	3.585	6.981868	3.781724	10.76359	11.05	0
0.5	481.1252	481.1252	1.195	2.39	3.585	7.26975	3.634875	10.90463	12.50	0
0.51	490.7477	471.5027	1.195	2.39	3.585	7.563448	3.490934	11.05438	14.05	0
0.52	500.3702	461.8802	1.195	2.39	3.585	7.862962	3.349901	11.21286	15.68	0
0.53	509.9927	452.2577	1.195	2.39	3.585	8.168291	3.211776	11.38007	17.41	0
0.54	519.6152	442.6352	1.195	2.39	3.585	8.479436	3.076558	11.55599	19.22	0
0.55	529.2377	433.0127	1.195	2.39	3.585	8.796398	2.944249	11.74065	21.13	0
0.56	538.8603	423.3902	1.195	2.39	3.585	9.119174	2.814847	11.93402	23.12	0
0.57	548.4828	413.7677	1.195	2.39	3.585	9.447767	2.688354	12.13612	25.21	0
0.58	558.1053	404.1452	1.195	2.39	3.585	9.782176	2.564768	12.34694	27.38	0
0.59	567.7278	394.5227	1.195	2.39	3.585	10.1224	2.44409	12.56649	29.64	0
0.6	577.3503	384.9002	1.195	2.39	3.585	10.46844	2.32632	12.79476	32.00	0
0.61	586.9728	375.2777	1.195	2.39	3.585	10.8203	2.211458	13.03175	34.45	0
0.62	596.5953	365.6552	1.195	2.39	3.585	11.17797	2.099504	13.27747	36.98	0
0.63	606.2178	356.0327	1.195	2.39	3.585	11.54146	1.990458	13.53191	39.61	0
0.64	615.8403	346.4102	1.195	2.39	3.585	11.91076	1.884319	13.79508	42.32	0
0.65	625.4628	336.7877	1.195	2.39	3.585	12.28588	1.781089	14.06697	45.13	0
0.66	635.0853	327.1652	1.195	2.39	3.585	12.66681	1.680766	14.34758	48.02	0
0.67	644.7078	317.5426	1.195	2.39	3.585	13.05356	1.583352	14.63691	51.01	0
0.68	654.3303	307.9201	1.195	2.39	3.585	13.44613	1.488845	14.93497	54.08	0
0.69	663.9528	298.2976	1.195	2.39	3.585	13.84451	1.397246	15.24176	57.25	0
0.7	673.5753	288.6751	1.195	2.39	3.585	14.24871	1.308555	15.55727	60.50	0
0.71	683.1978	279.0526	1.195	2.39	3.585	14.65872	1.222772	15.8815	63.85	0
0.72	692.8203	269.4301	1.195	2.39	3.585	15.07455	1.139897	16.21445	67.28	0
0.73	702.4428	259.8076	1.195	2.39	3.585	15.4962	1.05993	16.55613	70.81	0
0.74	712.0653	250.1851	1.195	2.39	3.585	15.92366	0.98287	16.90653	74.42	0
0.75	721.6878	240.5626	1.195	2.39	3.585	16.35694	0.908719	17.26566	78.13	0
0.76	731.3103	230.9401	1.195	2.39	3.585	16.79603	0.837475	17.63351	81.92	0
0.77	740.9328	221.3176	1.195	2.39	3.585	17.24094	0.76914	18.01008	85.80	0
0.78	750.5553	211.6951	1.195	2.39	3.585	17.69166	0.703712	18.39538	89.78	0
0.79	760.1779	202.0726	1.195	2.39	3.585	18.1482	0.641192	18.7894	93.85	0
0.8	769.8004	192.4501	1.195	2.39	3.585	18.61056	0.58158	19.19214	98.00	0
0.81	779.4229	182.8276	1.195	2.39	3.585	19.07873	0.524876	19.60361	102.25	0
0.82	789.0454	173.2051	1.195	2.39	3.585	19.55272	0.47108	20.0238	106.58	0
0.83	798.6679	163.5826	1.195	2.39	3.585	20.03252	0.420192	20.45271	111.01	0
0.84	808.2904	153.9601	1.195	2.39	3.585	20.51814	0.372211	20.89035	115.52	0
0.85	817.9129	144.3376	1.195	2.39	3.585	21.00958	0.327139	21.33672	120.13	0
0.86	827.5354	134.7151	1.195	2.39	3.585	21.50683	0.284974	21.7918	124.82	0
0.87	837.1579	125.0926	1.195	2.39	3.585	22.0099	0.245718	22.25561	129.61	0
0.88	846.7804	115.4701	1.195	2.39	3.585	22.51878	0.209369	22.72815	134.48	0
0.89	856.4029	105.8475	1.195	2.39	3.585	23.03348	0.175928	23.2094	139.45	0
0.9	866.0254	96.22504	1.195	2.39	3.585	23.55399	0.145395	23.69939	144.50	0
0.91	875.6479	86.60254	1.195	2.39	3.585	24.08032	0.11777	24.19809	149.65	0
0.92	885.2704	76.98004	1.195	2.39	3.585	24.61247	0.093053	24.70552	154.88	0
0.93	894.8929	67.35753	1.195	2.39	3.585	25.15043	0.071244	25.22167	160.21	0
0.94	904.5154	57.73503	1.195	2.39	3.585	25.6942	0.052342	25.74655	165.62	0
0.95	914.1379	48.11252	1.195	2.39	3.585	26.2438	0.036349	26.28015	171.13	0
0.96	923.7604	38.49002	1.195	2.39	3.585	26.79921	0.023263	26.82247	176.72	0
0.97	933.3829	28.86751	1.195	2.39	3.585	27.36043	0.013086	27.37352	182.41	0
0.98	943.0054	19.24501	1.195	2.39	3.585	27.92747	0.005816	27.93329	188.18	0
0.99	952.6279	9.622504	1.195	2.39	3.585	28.50033	0.001454	28.50178	194.05	0
1	962.2504	0	1.195	2.39	3.585	29.079	0	29.079	200.00	0

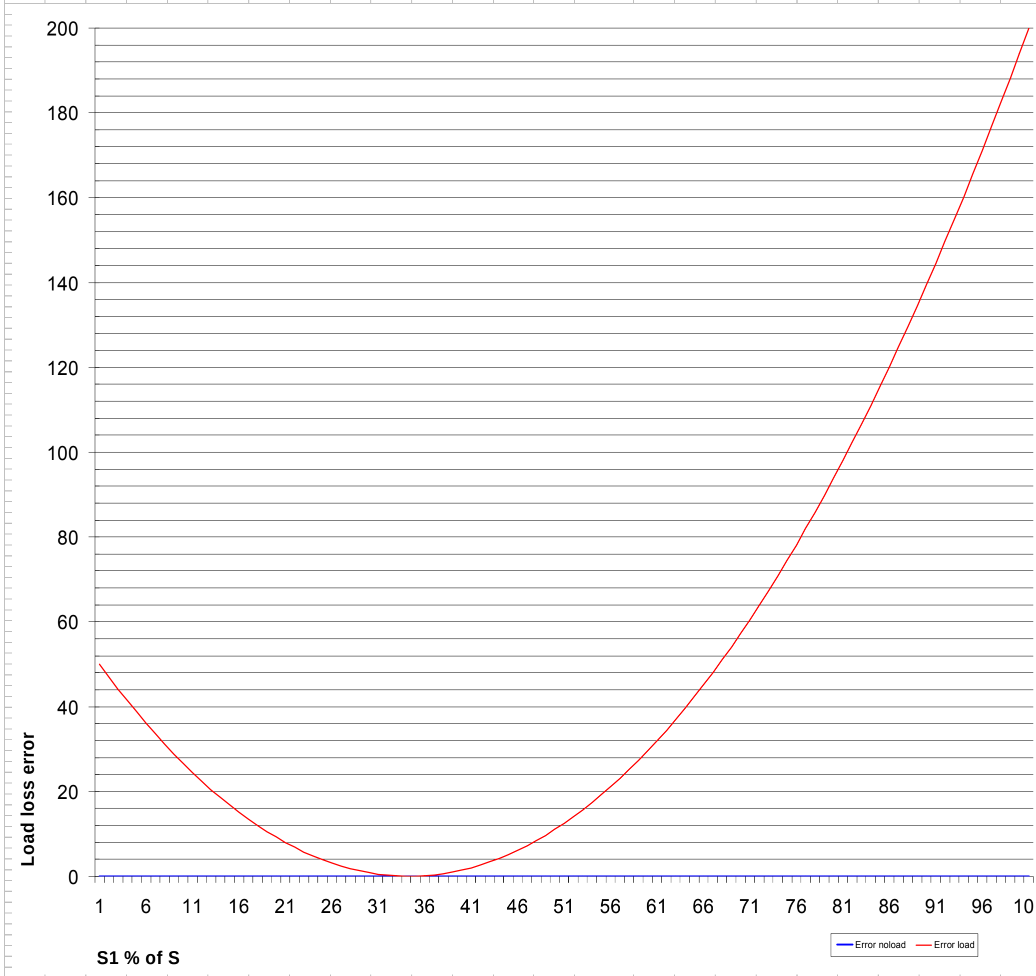
Tx Losses Error as a function of Load Allocation -SSLA method 2 (k1, k2, k3 coefficients)

Method 2

S rated	1000	kVA
V rated	600	V
Pnoload	3.585	kW
Iex	1.93	%
Pload	9.693	kW
z	5.72	%

Vitp	346.4102	V
Iitp	962.2504	A

k1	9.693	k1'=3/1*k1	29.079	k1"=3/2*k1	14.5395
k2	0	k2'=k2	0	k2"=k2	0
k3	3.585	k3'=1/3*k3	1.195	k3"=2/3*k3	2.39



%	S1	S2	Pnoload1	Pnoload2	Pnoload	Pload1	Pload 2	Pload	Error noload	Error load
0	0	1000	1.195	2.39	3.585	0	14.5395	14.5395	0	50.00
0.01	10	990	1.195	2.39	3.585	0.002908	14.25016	14.25307	0	47.05
0.02	20	980	1.195	2.39	3.585	0.011632	13.96374	13.97537	0	44.18
0.03	30	970	1.195	2.39	3.585	0.026171	13.68022	13.70639	0	41.41
0.04	40	960	1.195	2.39	3.585	0.046526	13.3996	13.44613	0	38.72
0.05	50	950	1.195	2.39	3.585	0.072698	13.1219	13.1946	0	36.13
0.06	60	940	1.195	2.39	3.585	0.104684	12.8471	12.95179	0	33.62
0.07	70	930	1.195	2.39	3.585	0.142487	12.57521	12.7177	0	31.21
0.08	80	920	1.195	2.39	3.585	0.186106	12.30623	12.49234	0	28.88
0.09	90	910	1.195	2.39	3.585	0.23554	12.04016	12.2757	0	26.65
0.1	100	900	1.195	2.39	3.585	0.29079	11.777	12.06779	0	24.50
0.11	110	890	1.195	2.39	3.585	0.351856	11.51674	11.86859	0	22.45
0.12	120	880	1.195	2.39	3.585	0.418738	11.25939	11.67813	0	20.48
0.13	130	870	1.195	2.39	3.585	0.491435	11.00495	11.49638	0	18.61
0.14	140	860	1.195	2.39	3.585	0.569948	10.75341	11.32336	0	16.82
0.15	150	850	1.195	2.39	3.585	0.654278	10.50479	11.15907	0	15.13
0.16	160	840	1.195	2.39	3.585	0.744422	10.25907	11.00349	0	13.52
0.17	170	830	1.195	2.39	3.585	0.840383	10.01626	10.85664	0	12.01
0.18	180	820	1.195	2.39	3.585	0.94216	9.77636	10.71852	0	10.58
0.19	190	810	1.195	2.39	3.585	1.049752	9.539366	10.58912	0	9.25
0.2	200	800	1.195	2.39	3.585	1.16316	9.30528	10.46844	0	8.00
0.21	210	790	1.195	2.39	3.585	1.282384	9.074102	10.35649	0	6.85
0.22	220	780	1.195	2.39	3.585	1.407424	8.845832	10.25326	0	5.78
0.23	230	770	1.195	2.39	3.585	1.538279	8.62047	10.15875	0	4.81
0.24	240	760	1.195	2.39	3.585	1.67495	8.398015	10.07297	0	3.92
0.25	250	750	1.195	2.39	3.585	1.817438	8.178469	9.995906	0	3.13
0.26	260	740	1.195	2.39	3.585	1.96574	7.96183	9.927571	0	2.42
0.27	270	730	1.195	2.39	3.585	2.119859	7.7481	9.867959	0	1.80
0.28	280	720	1.195	2.39	3.585	2.279794	7.537277	9.81707	0	1.28
0.29	290	710	1.195	2.39	3.585	2.445544	7.329362	9.774906	0	0.85
0.3	300	700	1.195	2.39	3.585	2.61711	7.124355	9.741465	0	0.50
0.31	310	690	1.195	2.39	3.585	2.794492	6.922256	9.716748	0	0.24
0.32	320	680	1.195	2.39	3.585	2.97769	6.723065	9.700754	0	0.08
0.33	330	670	1.195	2.39	3.585	3.166703	6.526782	9.693485	0	0.01
0.34	340	660	1.195	2.39	3.585	3.361532	6.333406	9.694939	0	0.02
0.35	350	650	1.195	2.39	3.585	3.562178	6.142939	9.705116	0	0.13
0.36	360	640	1.195	2.39	3.585	3.768638	5.955379	9.724018	0	0.32
0.37	370	630	1.195	2.39	3.585	3.980915	5.770728	9.751643	0	0.61
0.38	380	620	1.195	2.39	3.585	4.199008	5.588984	9.787991	0	0.98
0.39	390	610	1.195	2.39	3.585	4.422916	5.410148	9.833064	0	1.45
0.4	400	600	1.195	2.39	3.585	4.65264	5.23422	9.88686	0	2.00
0.41	410	590	1.195	2.39	3.585	4.88818	5.0612	9.94938	0	2.65
0.42	420	580	1.195	2.39	3.585	5.129536	4.891088	10.02062	0	3.38
0.43	430	570	1.195	2.39	3.585	5.376707	4.723884	10.10059	0	4.21
0.44	440	560	1.195	2.39	3.585	5.629694	4.559587	10.18928	0	5.12
0.45	450	550	1.195	2.39	3.585	5.888498	4.398199	10.2867	0	6.13
0.46	460	540	1.195	2.39	3.585	6.153116	4.239718	10.39283	0	7.22
0.47	470	530	1.195	2.39	3.585	6.423551	4.084146	10.5077	0	8.41
0.48	480	520	1.195	2.39	3.585	6.699802	3.931481	10.63128	0	9.68
0.49	490	510	1.195	2.39	3.585	6.981868	3.781724	10.76359	0	11.05
0.5	500	500	1.195	2.39	3.585	7.26975	3.634875	10.90463	0	12.50
0.51	510	490	1.195	2.39	3.585	7.563448	3.490934	11.05438	0	14.05
0.52	520	480	1.195	2.39	3.585	7.862962	3.349901	11.21286	0	15.68
0.53	530	470	1.195	2.39	3.585	8.168291	3.211776	11.38007	0	17.41
0.54	540	460	1.195	2.39	3.585	8.479436	3.076558	11.55599	0	19.22
0.55	550	450	1.195	2.39	3.585	8.796398	2.944249	11.74065	0	21.13
0.56	560	440	1.195	2.39	3.585	9.119174	2.814847	11.93402	0	23.12
0.57	570	430	1.195	2.39	3.585	9.447767	2.688354	12.13612	0	25.21
0.58	580	420	1.195	2.39	3.585	9.782176	2.564768	12.34694	0	27.38
0.59	590	410	1.195	2.39	3.585	10.1224	2.44409	12.56649	0	29.65
0.6	600	400	1.195	2.39	3.585	10.46844	2.32632	12.79476	0	32.00
0.61	610	390	1.195	2.39	3.585	10.8203	2.211458	13.03175	0	34.45
0.62	620	380	1.195	2.39	3.585	11.17797	2.099504	13.27747	0	36.98
0.63	630	370	1.195	2.39	3.585	11.54146	1.990458	13.53191	0	39.61
0.64	640	360	1.195	2.39	3.585	11.91076	1.884319	13.79508	0	42.32
0.65	650	350	1.195	2.39	3.585	12.28588	1.781089	14.06697	0	45.13
0.66	660	340	1.195	2.39	3.585	12.66681	1.680766	14.34758	0	48.02
0.67	670	330	1.195	2.39	3.585	13.05356	1.583352	14.63691	0	51.01
0.68	680	320	1.195	2.39	3.585	13.44613	1.488845	14.93497	0	54.08
0.69	690	310	1.195	2.39	3.585	13.84451	1.397246	15.24176	0	57.25
0.7	700	300	1.195	2.39	3.585	14.24871	1.308555	15.55727	0	60.50
0.71	710	290	1.195	2.39	3.585	14.65872	1.222772	15.8815	0	63.85
0.72	720	280	1.195	2.39	3.585	15.07455	1.139897	16.21445	0	67.28
0.73	730	270	1.195	2.39	3.585	15.4962	1.05993	16.55613	0	70.81
0.74	740	260	1.195	2.39	3.585	15.92366	0.98287	16.90653	0	74.42
0.75	750	250	1.195	2.39	3.585	16.35694	0.908719	17.26566	0	78.13
0.76	760	240	1.195	2.39	3.585	16.79603	0.837475	17.63351	0	81.92
0.77	770	230	1.195	2.39	3.585	17.24094	0.76914	18.01008	0	85.81
0.78	780	220	1.195	2.39	3.585	17.69166	0.703712	18.39538	0	89.78
0.79	790	210	1.195	2.39	3.585	18.1482	0.641192	18.7894	0	93.85
0.8	800	200	1.195	2.39	3.585	18.61056	0.58158	19.19214	0	98.00
0.81	810	190	1.195	2.39	3.585	19.07873	0.524876	19.60361	0	102.25
0.82	820	180	1.195	2.39	3.585	19.55272	0.47108	20.0238	0	106.58
0.83	830	170	1.195	2.39	3.585	20.03252	0.420192	20.45271	0	111.01
0.84	840	160	1.195	2.39	3.585	20.51814	0.372211	20.89035	0	115.52
0.85	850	150	1.195	2.39	3.585	21.00958	0.327139	21.33672	0	120.13
0.86	860	140	1.195	2.39	3.585	21.50683	0.284974	21.7918	0	124.82
0.87	870	130	1.195	2.39	3.585	22.0099	0.245718	22.25561	0	129.61
0.88	880	120	1.195	2.39	3.585	22.51878	0.209369	22.72815	0	134.48
0.89	890	110	1.195	2.39	3.585	23.03348	0.175928	23.2094	0	139.45
0.9	900	100	1.195	2.39	3.585	23.55399	0.145395	23.69939	0	144.50
0.91	910	90	1.195	2.39	3.585	24.08032	0.11777	24.19809	0	149.65
0.92	920	80	1.195	2.39	3.585	24.61247	0.093053	24.70552	0	154.88
0.93	930	70	1.195	2.39	3.585	25.15043	0.071244	25.22167	0	160.21
0.94	940	60	1.195	2.39	3.585	25.6942	0.052342	25.74655	0	165.62
0.95	950	50	1.195	2.39	3.585	26.2438	0.036349	26.28015	0	171.13
0.96	960	40	1.195	2.39	3.585	26.79921	0.023263	26.82247	0	176.72
0.97	970	30	1.195	2.39	3.585	27.36043	0.013086	27.37352	0	182.41
0.98	980	20	1.195	2.39	3.585	27.92747	0.005816	27.93329	0	188.18
0.99	990	10	1.195	2.39	3.585	28.50033	0.001454	28.50178	0	194.05
1	1000	0	1.195	2.39	3.585	29.079	0	29.079	0	200.00

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Conclusions

The total No_Load Loss is correct regardless the load distribution between MMPs. (the No_Load Loss Error = 0)

The total Load Loss is correctly calculated only when the load distribution match the ratio agreed between MMPs. (otherwise the Load Loss Error > 0)

When a bus meter exists the total Load Loss is correct regardless the load distribution, the MMPs would be charged based on the ratio agreed.

If the apportion could be recalculated on each time interval (MMPs loads ratio) the total Load Loss will be correct all the time. The actual MVSTAR cannot use a Dynamic Load Allocation, A, B, k_1, k_2, k_3 being fix factors.