



Calculation Methods for Metering System Accuracy

Metering Task Force, Session 1
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- The overall accuracy of the metering system is dependent on the accuracy of the different instruments, such as CTs, PTs, and the meter.
- The overall metering accuracy is a combination of all these instruments, and improving the accuracy of one of these components can improve overall accuracy significantly.

- Instrumentation transformers are not 100% accurate, therefore they contribute to the overall metering system error.
- If we assume a Gaussian distribution (a bell curve), the instrumentation transformer error is:

$$\epsilon_{IT} = \sqrt{\epsilon_{CT}^2 + \epsilon_{PT}^2}$$

ϵ_{IT} is instrumentation transformer error

ϵ_{CT} is the current transformer error

ϵ_{PT} is voltage transformer error

- Therefore, if we consider a typical meter installation where both CT and PT error rate is 0.1%, the overall instrumentation error becomes:

$$\varepsilon_{IT} = \sqrt{(0.2\%)^2 + (0.2\%)^2} = 0.283\%$$

$$\left. \begin{array}{l} \varepsilon_{CT} = 0.2\% \\ \varepsilon_{PT} = 0.2\% \end{array} \right\} \varepsilon_{IT} = 0.283\%$$

- The same principal can be applied to take into account the measurement error of the meter while calculating the total system error of the metering.

$$\epsilon S = \sqrt{\epsilon IT^2 + \epsilon M^2}$$

ϵS is total system error

ϵIT is the instrumentation transformer error

ϵM is the measurement error of the meter

- Consider a 0.3% error on the metering device added to the previous instrumentation transformer:

$$\varepsilon_S = \sqrt{(0.3\%)^2 + (0.283\%)^2} = 0.412\%$$

$$\left. \begin{array}{l} \varepsilon_{CT} = 0.2\% \\ \varepsilon_{PT} = 0.2\% \\ \varepsilon_M = 0.3\% \end{array} \right\} \varepsilon_S = 0.412\%$$

- Note that the total system error is worse than the each component's error, but better than the sum of the error of all components.
- If there are other known factors that might impact total error after the meter, it can be incorporated in the total error using the same method.
 - RTU error
 - Analog to Digital Conversion error

- For example, NERC BAL-005-0.2b R17 states the following requirements for devices that enter into the PJM ACE calculation (such as external Tie Lines):

MW, MVAR, and voltage transducer $\leq 0.25\%$ of full scale

Remote terminal unit $\leq 0.25\%$ of full scale

Potential transformer $\leq 0.30\%$ of full scale

Current transformer $\leq 0.50\%$ of full scale

$$\Rightarrow \varepsilon_{IT} = \sqrt{0.3\%^2 + 0.5\%^2} = 0.583\%$$

$$\varepsilon_S = \sqrt{(0.583\%)^2 + (0.25\%)^2 + (0.25\%)^2} = \mathbf{0.683\%}$$

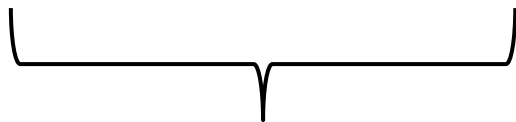
- Even using a relay CT instead of a meter CT significantly diminishes total accuracy:

System with Meter CT

$$\varepsilon_{CT_1} = 0.50\%$$

$$\varepsilon_{PT_1} = 0.30\%$$

$$\varepsilon_{M_1} = 0.25\%$$



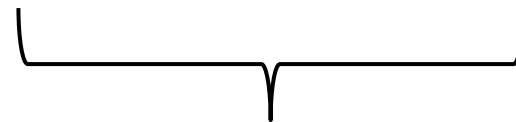
$$\varepsilon_{S_1} = \mathbf{0.634\%}$$

System with Relay CT

$$\varepsilon_{CT_2} = 3.00\%$$

$$\varepsilon_{PT_2} = 0.30\%$$

$$\varepsilon_{M_2} = 0.25\%$$



$$\varepsilon_{S_2} = \mathbf{3.025\%}$$

- Depending on the amount of MW associated with the measurement point, the inaccuracy of the metering system may represent a significant or insignificant amount of money.
- Let's consider 2 systems, one with high accuracy and one with low accuracy:

$$\begin{aligned} \varepsilon CT_{HA} &= 0.20\% \\ \varepsilon PT_{HA} &= 0.20\% \\ \varepsilon M_{HA} &= 0.50\% \\ \underbrace{\hspace{10em}} & \\ \varepsilon S_{HA} &= \mathbf{0.574\%} \end{aligned}$$

$$\begin{aligned} \varepsilon CT_{LA} &= 1.20\% \\ \varepsilon PT_{LA} &= 1.20\% \\ \varepsilon M_{LA} &= 0.50\% \\ \underbrace{\hspace{10em}} & \\ \varepsilon S_{LA} &= \mathbf{1.769\%} \end{aligned}$$

- If we assume \$0.03/kWh price, then the equivalent dollar value of the system error per MW for a year becomes:

- High Accuracy System:

$$0.574\% \times \frac{\$0.03}{kWh} \times 1 \text{ MW} = +/\- \frac{\$1508}{\text{year}}$$

- Low Accuracy System:

$$1.769\% \times \frac{\$0.03}{kWh} \times 1 \text{ MW} = +/\- \frac{\$4649}{\text{year}}$$

- Total \$ Transacted: \$262,800/year

- For low capacity power applications, the expense of very accurate equipment may not have a good payoff, but for high capacity power applications, the potential payoff of more accurate system is significant.
- For 100 MW system, the potential transaction error for both systems is:
 - High Accuracy: +/- \$150,800/year
 - Low Accuracy: +/- \$464,900/year
- Total Amount Transacted=\$26,280,000

\$314,100/year

- In conclusion, the accuracy of the system is not only dependent on the meter itself, but also the other equipment supporting the metering, from CT/PTs to the RTU.
- The total system error is worse than the each component's error, but better than the sum of the error of all components.
- Having one component with low accuracy impacts the overall accuracy significantly.
- Higher accuracy metering does cost more in equipment and maintenance, but the costs can be easily measured against the resulting level of uncertainty of \$ equivalent of the power.

