



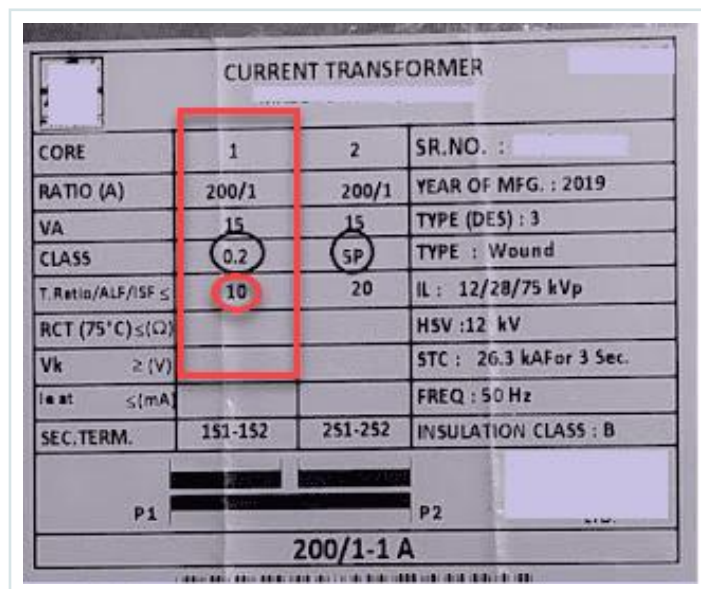
VEBKO ONLINE HELP

Estimating FS and ALF for Various CTs

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1 Imported Content

In measurement CTs (Current Transformers), a parameter called F_s (Security Factor) exists, which is used to describe the CT and its accuracy class. According to the IEC60044-1 standard, F_s is defined such that at a current of F_s times the rated current, the composite error in the secondary is 10%. For example, for a CT with a class of $0.5F_s10$, at 10 times the rated current, the composite error is 10%. On the CT nameplate provided in this example, Core number one is a measurement type and its class is $0.2F_s10$. This means that at 10 times the rated current, the composite error at the output is 10%. The 0.2 figure before F_s represents the accuracy class of the CT at the rated current. This means that at 100% and 120% of the rated current on the primary side, the ratio error at the secondary terminal is less than 0.2%.



CURRENT TRANSFORMER			
CORE	1	2	SR.NO. :
RATIO (A)	200/1	200/1	YEAR OF MFG. : 2019
VA	15	15	TYPE (DES) : 3
CLASS	0.2	5P	TYPE : Wound
T.Ratio/ALF/ISF ≤	10	20	IL : 12/28/75 kVp
RCT (75°C) ≤ (Ω)			H5V : 12 kV
Vk ≥ (V)			STC : 26.3 kA For 3 Sec.
I _{sat} ≤ (mA)			FREQ : 50 Hz
SEC. TERM.	151-152	251-252	INSULATION CLASS : B
P1 P2			
200/1-1 A			

Figure 1

For protective CTs, a similar concept exists known as ALF (Accuracy Limit Factor). To explain this parameter, consider the previous example. Core number 2 is a protective core with a class of 5P20. In this example, ALF = 20, and according to the definition provided by IEC60044-1, at 20 times the rated current, the composite error is 5%. For a more detailed explanation, consider a protective CT with a class of 10P5. In this case, ALF = 5, and according to the definition, at 5 times the rated current, the composite error is 10%.

One key point about these two parameters is that for measurement CTs, the actual F_s is less than the value indicated on the nameplate, whereas for protective CTs, the actual ALF is greater than the value shown on the nameplate

Ratio Error and Composite Error

According to the definition provided in the IEC60044-1 standard, the ratio error is represented as follows:

$$RatioError = \frac{N_{measured} - \left(\frac{I_{pn}}{I_{sn}}\right)}{\left(\frac{I_{pn}}{I_{sn}}\right)} \cdot 100$$

$$CompositeError = \frac{I_c}{\frac{I_{pn}}{N} \cdot Fs} \cdot 100$$

Figure 2

$$I_c = \sqrt{I_s^2 + \left(\frac{I_p}{N}\right)^2 - \left(2 \cdot I_s \cdot \frac{I_p}{N} \cdot \cos \alpha\right)}$$

I_{sn} : rated secondary current

I_s : secondary rms current

I_c : calculated composite current

I_{pn} : nominal primary current

Fs : instrument security factor

N : rated transformer winding ratio

α : Phase deviation between primary and secondary current

Figure 3

ALF or Fs is where the composite error is 5% or 10%.

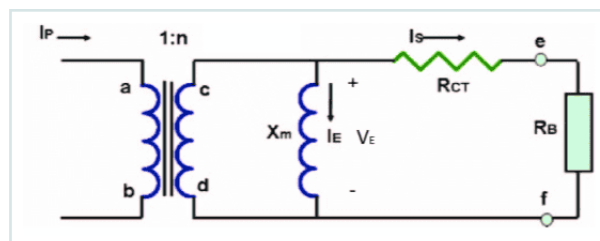


Figure 4

According to the definition, ALF or FS is where

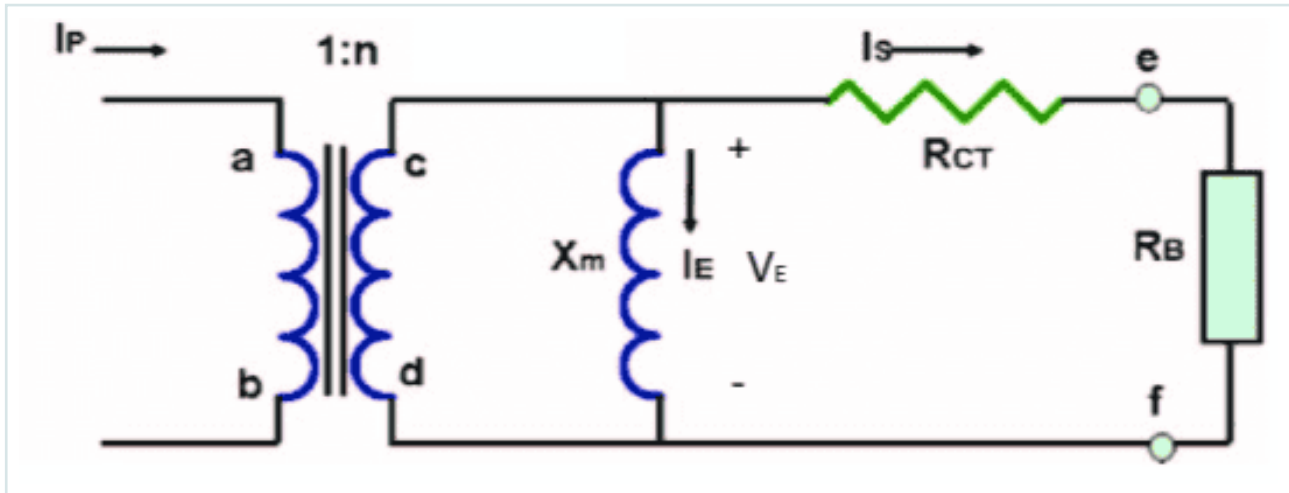


Figure 5

$$I_E = 0.1 * F_S * I_n$$

Figure 6

To calculate the composite error using the indirect method (disregarding the ratio error), it can be said that the parallel branch current is the cause of the composite error between the primary and secondary sides. Therefore, to ensure that the composite error at F_S times the rated current is 10%, the parallel branch current must be 10% of the output current.

$$I_E = 0.1 * F_S * I_n$$

Figure 7

$$I_n = \frac{V_{En}}{R_{CT} + R_B} \Rightarrow FS * I_n = FS \cdot \frac{V_{En}}{R_{CT} + R_B}$$

$$V_E = F_s \cdot V_{En}$$

$$FS = \frac{V_E}{V_{En}}$$

$$I_E = 0.1 * FS * I_n \Rightarrow I_E = 0.1 * \frac{V_E}{V_{En}} * I_n \Rightarrow * \frac{I_n}{I_n}$$

$$I_E = 0.1 * \frac{V_E}{V_{En} * I_n} * I_n^2 \Rightarrow I_E = 0.1 \frac{I_n^2}{VA_n} V_E$$

Figure 8

In such conditions, the parallel branch voltage is also equal to Fs times the parallel branch voltage under conditions where the rated current passes through the CT terminal at the nominal load:

$$I_n = \frac{V_{En}}{R_{CT} + R_B} \Rightarrow FS * I_n = FS \cdot \frac{V_{En}}{R_{CT} + R_B}$$

$$V_E = F_s \cdot V_{En}$$

$$FS = \frac{V_E}{V_{En}}$$

$$I_E = 0.1 * FS * I_n \Rightarrow I_E = 0.1 * \frac{V_E}{V_{En}} * I_n \Rightarrow * \frac{I_n}{I_n}$$

$$I_E = 0.1 * \frac{V_E}{V_{En} * I_n} * I_n^2 \Rightarrow I_E = 0.1 \frac{I_n^2}{VA_n} V_E$$

Figure 9

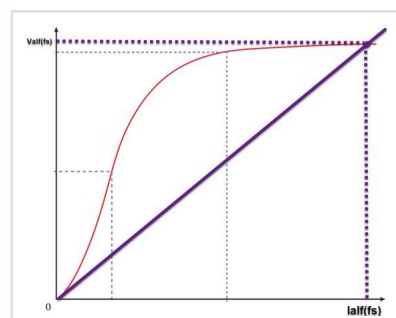


Figure 10

According to the provided relationship, for a specified ALF (Fs), there is a line with a constant slope. The intersection of this line with the saturation curve indicates the point where the CT's composite error is 10%.

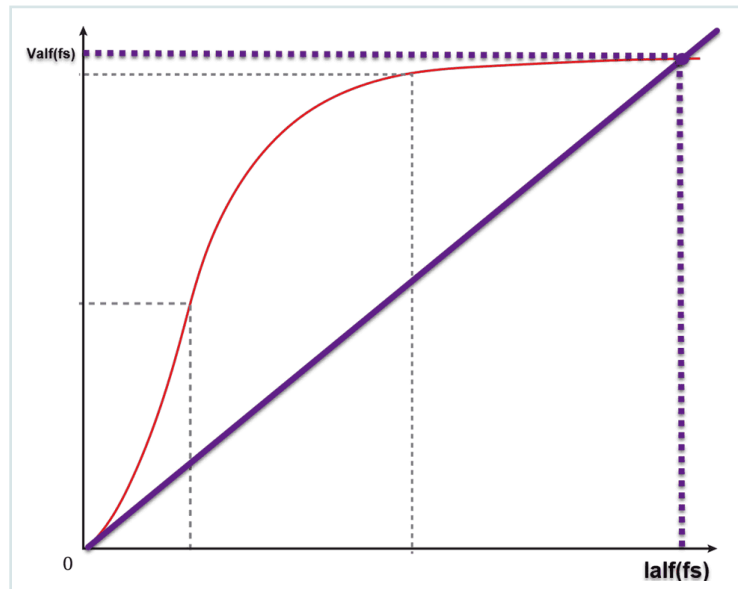


Figure 11

$$I_{\text{out}} = \frac{V_{\text{ALF}}}{Z_n}, \quad Z_n = \frac{V A_n}{I_n}$$

$$\text{ALF}(F_s) = \frac{I_{\text{out}}}{I_n}$$

Figure 12

By dividing the obtained voltage by the nominal impedance, the output current is obtained, and its ratio to the rated current will correspond to ALF (Fs)

$$\frac{V_{\text{ALF}}}{Z_n} = \frac{V A_n}{I_n} \cdot \frac{I_{\text{out}}}{I_n}$$

Figure 13

[jg1]Fs_and_ALF_Calculation