



VEBKO ONLINE HELP

CT and PT Turns Ratio

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1 Imported Content

Calculation of CT and PT Turns Ratio

The first point to consider when testing the transformation ratio of CT (Current Transformer) and PT (Potential Transformer) is that the accuracy class is defined for the working conditions of nominal burden and nominal current for these transformers. For example, for a CT with a 0.5 accuracy class and a 5 VA burden, the transformation ratio error will be a maximum of 0.5% at 1 A current, assuming a 5 VA load is connected to the CT terminal.

	Cores	Tap No.	Core Type	Class	l _{pn}	l _{sn}	FS/ALF	Burden	Cos Phi	R _{ct} Min	R _{ct} max
▶ 1	1	S1 -S2	Metering	0.5	75.00 A	1.000 A	10.0000	5.000 VA	0.8000	2.000 Ω	2.100 Ω

Figure 1

A common method used for testing in substations is to short-circuit the CT secondary and inject current (typically 20%) into the primary, measure the current flowing through the secondary, and record the transformation ratio. For PT, the usual method involves applying voltage (2-12 kV) to the PT primary and measuring the open-circuit voltage at the PT secondary. As evident from the common testing methods, these transformers are not tested under their actual working conditions, and the tests merely determine the "turns ratio" between the primary and secondary, which may be outside the designed accuracy class. Therefore, to determine the transformation ratio error, the test must be conducted under different conditions.

CT Testing

For testing the transformation ratio and accuracy class of the CT under different loads and currents, voltage is applied to the secondary, and the primary voltage is measured.

Error limits for measuring current transformers												
Accuracy class	Ratio error						Phase displacement					
	± %						± Minutes					
	at current (% of rated)						at current (% of rated)					
	1	5	20	50	100	120	1	5	20	50	100	120
0.1	-	0.4	0.2	-	0.1	0.1	-	15	8	-	5	5
0.2	-	0.75	0.35	-	0.2	0.2	-	30	15	-	10	10
0.2S	0.75	0.35	0.2	-	0.2	0.2	30	15	10	-	10	10
0.5	-	1.5	0.75	-	0.5	0.5	-	90	45	-	30	30
0.5S	1.5	0.75	0.5	-	0.5	0.5	90	45	30	-	30	30
1	-	3	1.5	-	1	1	-	180	90	-	60	60
3	-	-	-	3	-	3	Not specified					
5	-	-	-	5	-	5	Not specified					

Figure 2

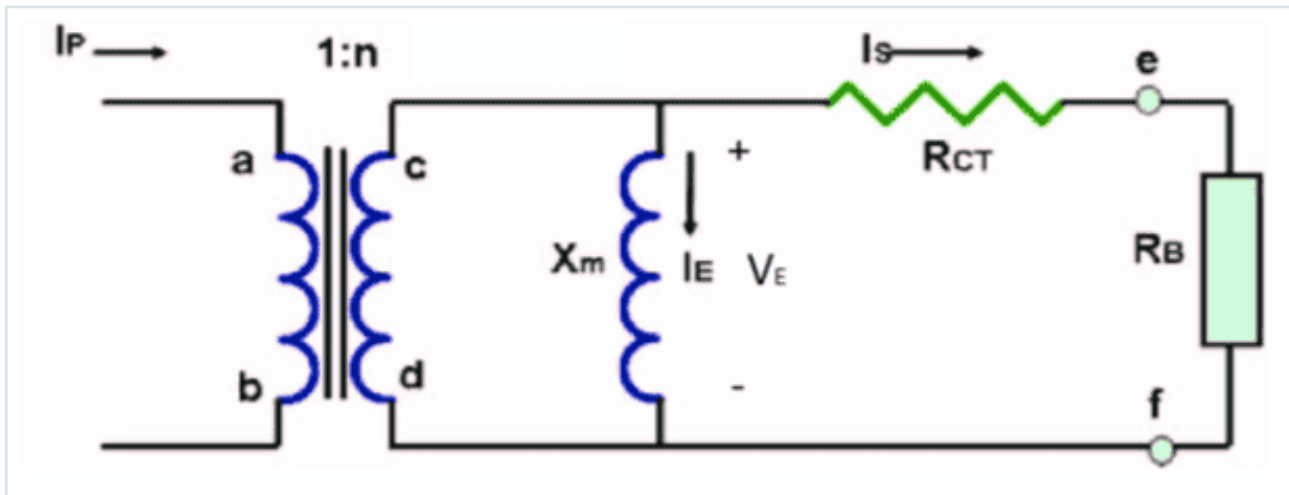


Figure 3

In the first stage of this test, the "turns ratio" between the primary and secondary is obtained. The voltage for this stage of the test is calculated by dividing the nominal burden by the nominal secondary current. In addition to this voltage, half and double of it are also applied to achieve better measurement accuracy.

Nominal Burden = 5VA

Secondary Nominal Current = 1A

$$\text{Test Voltage} = \frac{5}{1} = 5\text{v}$$

$$V_{\text{test1}} = 2.5\text{v}$$

$$V_{\text{test2}} = 5\text{v}$$

$$V_{\text{test3}} = 10\text{v}$$

Figure 4

By applying higher voltages, the CT turns ratio is obtained. At this stage, the transformation ratio error must be calculated at various burdens and currents (based on nominal current). For example, transformation ratio error calculations are provided for three different scenarios:

1) 100% current and nominal burden.



Figure 5

$$\begin{aligned}
 N_{tm} &= 74.6255 \\
 \left\{ \begin{aligned} \%100I_n &= 1A \\ VA_n &= 5VA \\ Z &= \frac{VA}{I_n^2} = 5\Omega \end{aligned} \right. \\
 V_E &= Z * I = 5 * 1 = 5v \\
 I_{E_Based\ on\ saturation\ curve} &= 5.154mA \\
 I_{T_In\ secondary} &= 1 + 0.005154 = 1.005154 \\
 I_{primary} &= 74.6255 * 1.005154 = 75.0101 \\
 Turns\ Ratio\ Error &= \left(\frac{75.0101}{75} - 1 \right) * 100 = 0.013\%
 \end{aligned}$$

Figure 6

2) 100% current and 50% nominal burden.

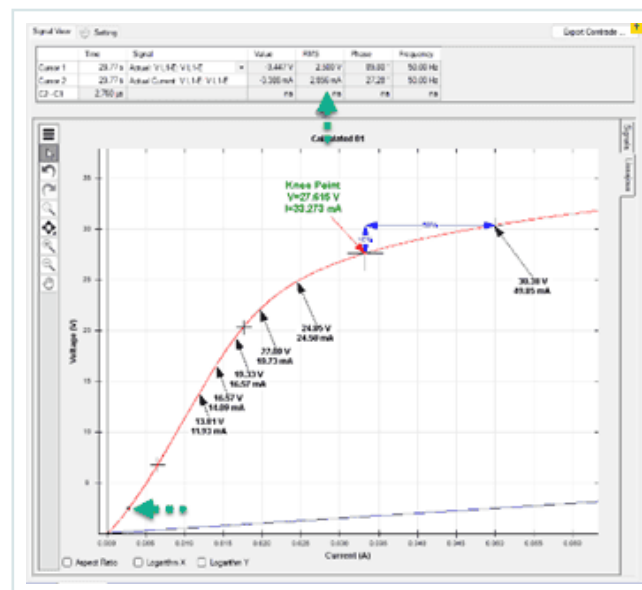


Figure 7

$$\begin{aligned}
 N_{tm} &= 74.6255 \\
 \left\{ \begin{aligned} \%100I_n &= 1A \\ 0.5*VA_n &= 2.5VA \\ Z &= \frac{0.5*VA_n}{I_n^2} = 2.5\Omega \end{aligned} \right. \\
 V_E &= Z * I = 2.5 * 1 = 2.5v \\
 I_{E_Based\ on\ saturation\ curve} &= 2.857mA \\
 I_{T_In\ secondary} &= 1 + 0.002857 = 1.002857 \\
 I_{primary} &= 74.6255 * 1.002857 = 74.8387 \\
 Turns\ Ratio\ Error &= \left(\frac{74.8387}{75} - 1 \right) * 100 = -0.215\%
 \end{aligned}$$

Figure 8

3) 50% current and 50% nominal burden.

$$\begin{aligned}
 N_{\text{turn}} &= 74.6255 \\
 \left\{ \begin{aligned} \%50I_n &= 0.5A \\ 50\%VA_n &= 2.5VA \\ Z &= \frac{50\%VA_n}{I_n^2} = 2.5\Omega \end{aligned} \right. \\
 V_E &= Z * I = 2.5 * 0.5 = 1.25v \\
 I_{E_Based \text{ on saturation curve}} &= 1.2825mA \\
 I_{T_InS_econdary} &= 0.5 + 0.001282 = 0.501282 \\
 I_{primary} &= 74.6255 * 0.50128 = 37.4084 \\
 \text{Turns Ratio Error} &= \left(\frac{37.4084}{37.5} - 1 \right) * 100 = -0.2442\%
 \end{aligned}$$

Figure 9

Using this calculation method, the CT transformation ratio error can be obtained under various current and burden conditions.

PT Testing

For PT testing, the turns ratio between the PT primary and secondary must first be determined. To do this, apply 450V to the PT primary, and measure the open-circuit voltage at the PT secondary. In this way, the "turns ratio" between the primary and secondary is obtained.

Core No.	Tap No.	Vprim.	Primary Factor	Vsec.	Secondary Factor	VA	CLP	CLM
1	1	20.00 kV	1/√3	100.0 V	1/√3	150.0 VA	3P	0.5

Figure 10

In the next step, the transformation ratio error at different burdens must be determined. For example, transformation ratio error calculations are provided for two different scenarios, assuming a secondary resistance of 0.1 ohms:

1) 100% nominal burden.

$$\begin{aligned}
 N_{\text{turn}} &= 100.000 \\
 R_p &= 0.1\Omega \\
 \text{Secondary Burden} &= 100VA \\
 I_n^2 &= \frac{100}{Z} = \frac{100}{\frac{100}{I_n^2}} = 100 \Rightarrow I_n = 10A \\
 Z &= \frac{100}{I_n^2} = \frac{100}{10^2} = 1\Omega \\
 R_p &= 0.1\Omega \\
 V_E &= I_n * R_p = 10A * 0.1\Omega = 1V \\
 I_{E_Based \text{ on saturation curve}} &= 1.2825mA \\
 I_{T_InS_econdary} &= 10A + 0.001282A = 10.001282A \\
 I_{primary} &= 100.000 * 10.001282 = 1000.1282A \\
 \text{Turns Ratio Error} &= \left(\frac{1000.1282}{1000} - 1 \right) * 100 = 0.01282\%
 \end{aligned}$$

Figure 11

2) 50% nominal burden.

$$\begin{aligned}
 N_{\text{nom}} &= 199.5784 \\
 \Delta\phi &= 0.1^\circ \\
 \text{Burden} &= 75\text{VA} \\
 \frac{100^2}{\sqrt{3}} &= 75 \Rightarrow \frac{\left(\frac{100}{\sqrt{3}}\right)^2}{75} = Z \Rightarrow Z = 44.444 \Rightarrow 44.444 * I^2 = 75 \Rightarrow I = 1.299\text{A} \\
 \text{PF} = 0.8 &\Rightarrow \phi = -36^\circ \\
 V_E &= \frac{100}{\sqrt{3}} + R_{\text{pt}} * I = \left(\frac{100}{\sqrt{3}} \angle 0\right) + 0.1 * (1.299 \angle -36) = 57.8401 \angle -0.0075 \\
 V_p &= 57.8401 * 199.5784 = 11543.6346 \\
 \Rightarrow \text{Turns Ratio Error} &= \left(\frac{11543.6346}{\frac{20000}{\sqrt{3}}} - 1 \right) * 100 = -0.0292 \\
 \Rightarrow \text{Phase displacement} &= 0.1 - (-0.0075) = -0.1075^\circ
 \end{aligned}$$

Figure 12

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