GET-6498

CT Accuracy Classification

CT ACCURACY CLASSIFICATION – STEADY STATE

The method of classification assumes the CT is supplying 20 times rated current (100 amps). With this secondary current the CT is classified on the basis of the secondary voltage it can maintain at its terminals without its ratio error exceeding a specified 10%.

Standard classifications are shown following:

10T10	10C10
10T20	10C20
10T50	10C50
10T100	10C100
10T200	10C200
10T400	10C400
10T800	10C800

The number before the letter is the maximum specified ratio error in percent.

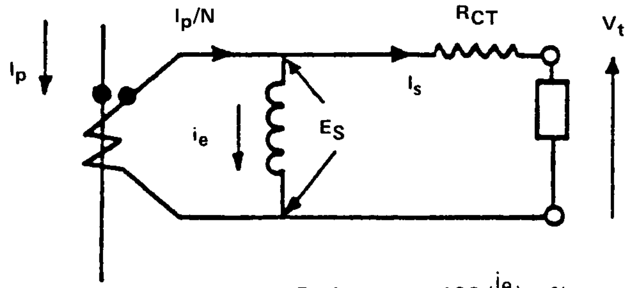
The letter T stands for "test" which means the CT accuracy can only be determined by test. Current transformers with non-distributed windings fit in this category.

The letter C stands for "calculated" which means the CT accuracy can be determined by calculation from given excitation characteristics. CTs with fully distributed windings (bushing CTs for instance) fit in this category.

The number after the letter is the specified terminal voltage the CT will maintain without exceeding the specified 10 percent ratio error with 20 times rated current in the secondary. Furthermore, the ratio error must be limited to 10 percent at any current from 1 to 20 times rated at any lesser burden.

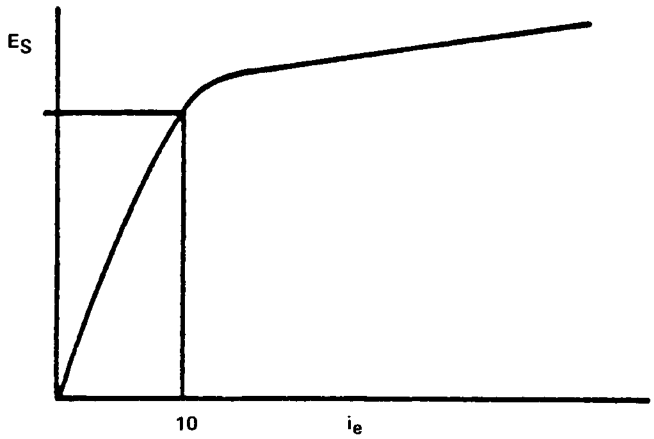
Since there is only one permissible ratio error, the first number is usually omitted in the classification. For example, CTs may be simply specified as a T100 or a C400.

The classification of a "C" type of CT can be determined from the CT equivalent circuit and its excitation characteristic.



$$\text{Ratio error} = 100 \left(\frac{i_e}{I_S}\right) = \%$$

With I_S = 100 amps and assuming 10 percent error, i_e will equal 10 amps. From the excitation characteristic, determine the value of E_S for the magnitude of i_e.



Then determine the terminal voltage

$$V_t = E_S - 100\,(R_{CT})$$

The CT would be classified at the nearest standard voltage below the calculated value of V_t.

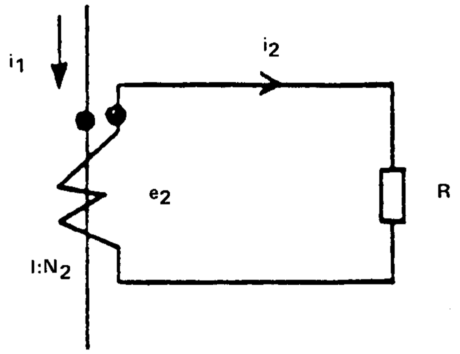
For example, assume that for i_e = 10, E_S = 600 volts and that R_{CT} = 1 ohm.

$$V_t = 600 - 100\,(1) = 500 \text{ volts.}$$

This CT would have to be classified as a C400.

If E_S had been 495 volts, then V_t would be 395 volts and the CT would have to be classified as a C200.

CT TRANSIENT PERFORMANCE



Assume:

Magnetizing impedance very large, or, in other words, magnetizing current i_e is insignificant up to the point of saturation

$$e_2 = N_2 \, 10^{-8} \frac{d\phi}{dt} \text{ volts.}$$

ϕ = flux lines
N_2 = secondary turns

$$\phi = A\beta$$

A = core area - square inches
β = flux density in lines per square inch.

$$e_2 = N_2{}^{-8} A \frac{d\beta}{dt}$$

$$e_2 = i_2 R = (\frac{i_1}{N_2} - i_e) R$$

$i_e \approx 0$

$$\frac{i_1}{N_2} R = N_2 \, 10^{-8} A \frac{d\beta}{dt}$$

or

$$\frac{d\beta}{dt} = \frac{R \, 10^8}{N_2^2 A} i_1$$

assume

$$i_1 = \sqrt{2} \, I_{RMS} (\epsilon^{-\frac{t}{T_{DC}}} - \cos \omega t)$$

This is a fully offset current where the dc component has a time constant = T_{DC} in seconds.

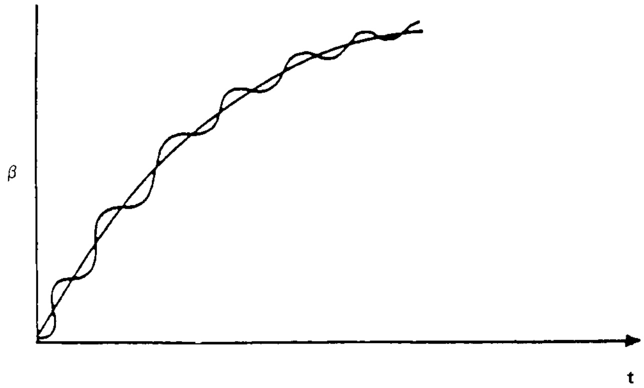
$$\frac{d\beta}{dt} = \frac{R \, 10^8}{N_2^2 A} \sqrt{2} \, I_{RMS} (\epsilon^{-\frac{t}{T_{DC}}} - \cos \omega t)$$

integrating this equation

$$\beta = \frac{10^8 \sqrt{2} \, I_{RMS} R}{A N_2^2} \left[T (1 - \epsilon^{-\frac{t}{T_{DC}}}) \; \frac{1}{\omega} \sin \omega t \right]$$

This is flux density in the CT due to a fully offset primary current.

This flux density as a function of time has the form as shown in next figure.



The sine term is usually small and can be ignored.

$$\boxed{\beta = k \, IRT (1 - \epsilon^{-\frac{t}{T_{DC}}})}$$

$$k = \frac{10^8 \sqrt{2}}{A N_2^2}$$

Solving for t

$$\boxed{t = - T_{DC} \ln (1 - \frac{\beta}{k \, IR \, T_{DC}}) \text{ seconds}}$$

1n = natural log.

This is an approximate equation which gives the time to reach saturation flux density.

saturation $\beta \cong$ 125,000 lines/sq. in.

Knowing the time to saturation, you can determine the number of good cycles a CT will produce before saturating.

NOTE: This is an approximate approach which gives a measure of expected CT performance.

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