

ECE 525: Homework #2

Due Session 11 (September 25)

1. Recommend an appropriate CTR ratio for CT's connected at the terminals of a synchronous generator rated as follows: $P_{\text{rated}} = 500 \text{ MW}$, $pf_{\text{rated}} = 0.8$, $V_{\text{ratedLL}} = 22 \text{ kV}$, $X/R = 40$. **The maximum available fault current is for a three phase fault, with a current level of 250 kA.** Assume 5A secondary currents, and steps in primary side CT current ratings of 500 A for the range in question (so for example, ratios go up as 3000/5, 3500/5, on up).

2. You need to determine the C-class rating for 2000/5 CTs applied on a transmission system. The X/R ratio for the fault impedance for the worst case fault seen by the CTs is 8. The CTs have a winding resistance of 0.0030 ohms/turn, relay is connected to the CT by 2500 feet of number 10 AWG, and the relay burden is 50m Ω . The magnitude of the impedance of the lead wire can be calculated using the formula below. A typical angle of the impedance of the lead wire is about 12-15 degrees (so highly resistive). For this problem you just need to use the magnitude.

- Recall that for 3 phase faults, you only need one length of lead wire, but for SLG and LL faults you need to include two lengths in lead resistance calculations

$$R_{\text{AWG_wire}} = e^{0.232 \cdot \text{Gauge} - 2.32} \quad \text{in ohm/1000ft}$$

(a) Determine the C-class to never saturate if the decaying DC offset is neglected and the maximum fault current is 21000A (assume the worst case fault is SLG). Verify with the Mathcad CT model from class.

(b) Determine the C-class to never saturate with the decaying DC offset included and the maximum fault current is 21000A (assume you can go up to very high knee voltages). Again, verify with the Mathcad CT model from class.

(c) You are limited to using a C800 CT. Determine how long it will take the CT to saturate under the conditions of part (b). Again, verify with the Mathcad CT model.

(d) Repeat parts (a)-(c) for a 3 phase fault of 27000 A with the same burden and X/R ratio.

3. Repeat problem 2. except with an X/R ratio of 35, and a fault current of 12000 A for a SLG fault and a 3 phase fault of 15000 A.

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4. Suppose the CT with the characteristic described below is carrying 1128 A primary and is using a 1200/5 secondary tap and a resistive burden of 4 ohms. Neglecting the core loss resistance of the CT, (1) calculate the approximate initial voltage that would result across the CT secondaries if the CT secondary is accidentally opened (2) calculate the approximate final voltage it would reach if the insulation survives the initial overvoltage. Explain where the current is flowing.

ORIGIN := 1

CT Data: C600 class, 1200/5 Full ratio: $N_{full} := \frac{1200}{5}$ $N_{full} = 240$

CT Excitation Curve	TAPS
$\text{excitation} := \begin{pmatrix} .001 & 0.09 \\ .04 & 90 \\ .1 & 428 \\ .12 & 520 \\ .14 & 600 \\ .2 & 700 \\ .3 & 780 \\ .4 & 800 \\ 40 & 927 \end{pmatrix}$	$t := \begin{pmatrix} 240 \\ 200 \\ 180 \\ 160 \\ 120 \\ 100 \\ 80 \\ 60 \\ 40 \\ 20 \end{pmatrix}$