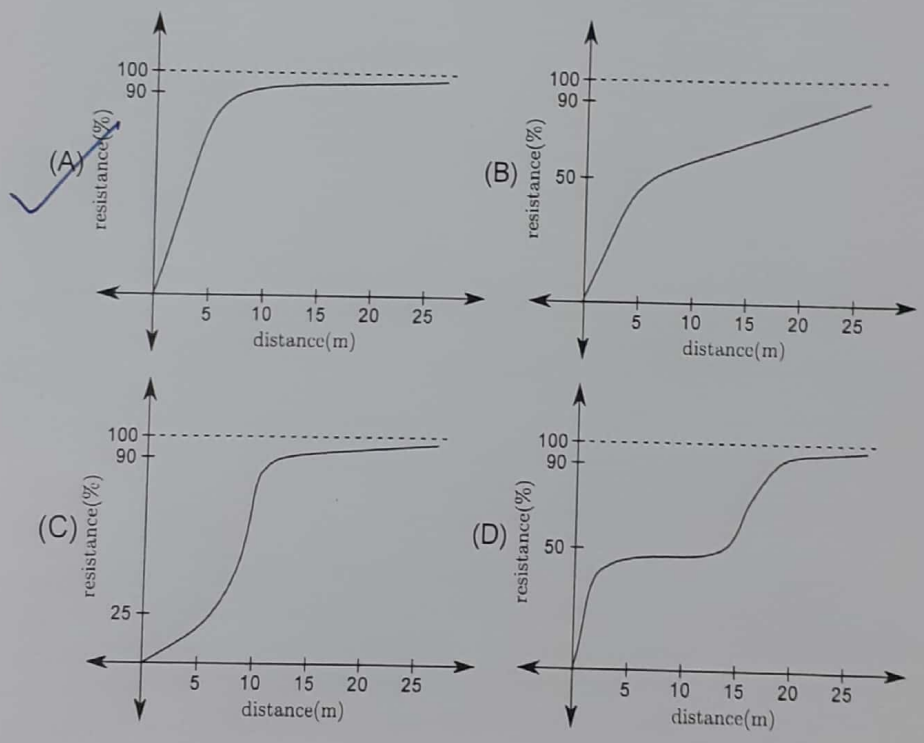
EE 334: Power Systems Quiz 2 February 6, 2020

- You have **50 minutes** to answer the questions.
- Please write your **name** and **roll number** at appropriate places.
- You can solve the problems in the supplementary sheets provided. Please attach the same to this paper.
- For MCQ questions, full credits will be awarded if the right option(s) is/are only marked.
- Total: **25 marks**.

Name: _____ **Roll number**: _____

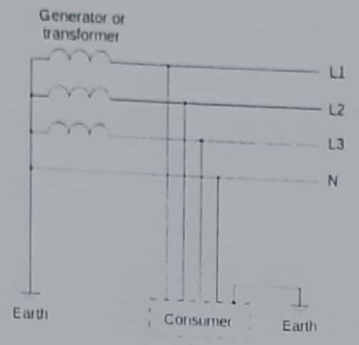
1. Which of the following curves indicates the typical variation of the resistance offered by earth as a function of the distance from the earthing electrode? **1 mark**
   Note: Assume earth is made of a homogeneous material.



2. Which of the following connections is **least safe** for a broken neutral condition? **1 mark**

(PE: protective earth, N: neutral)

A.



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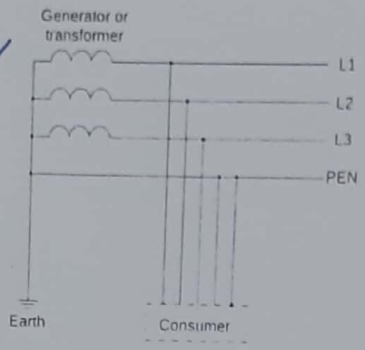

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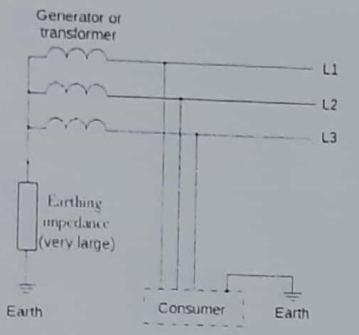
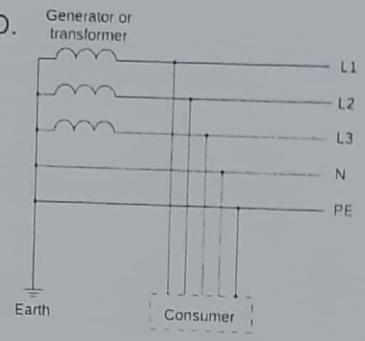


D.



3. A transformer kept on no load becomes warm mainly due to **1 mark**

(A) Core losses (eddy currents and hysteresis)

(B) Primary side winding losses

(C) Secondary side winding losses

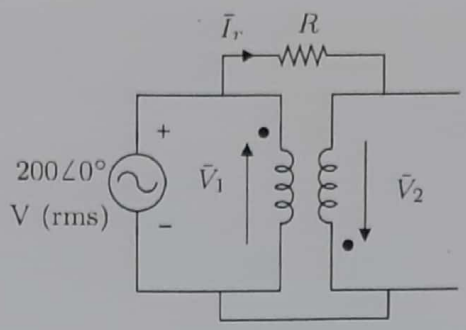
(D) Both primary and secondary side winding losses.

4. The ferromagnetic core of a 2 kV/415 V, 100 kVA, 50 Hz transformer has a *non-linear B-H curve*, but it has negligible hysteresis and core losses. If the transformer is excited with a 2 kV, 50 Hz sinusoidal voltage source and is kept open circuited on the secondary side, it is found that the current drawn by the transformer is non-sinusoidal, but it is periodic in steady state. The fundamental component of the steady state current (drawn by the transformer) lags the input voltage by (approximately) **1 mark**

(A) 180^o (B) 0^o (C) 90^o (D) -90^o (E) -45^o (F) 45^o

Cont.

5. The current $\bar{I}_r$ through the resistor R, whose value is 200 Ω, in the circuit shown is 4 A.
Note: Take $\frac{\bar{V}_1}{\bar{V}_2} = \frac{1}{3}$. **1 mark**



$\bar{V}_2 = 600\angle 0^\circ$ V.

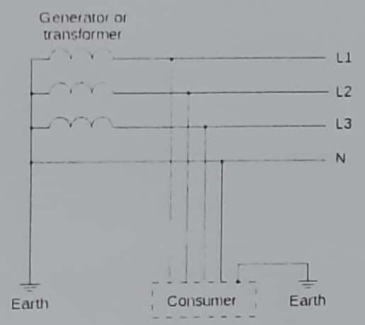
$\bar{I}_r = \frac{\bar{V}_1 + \bar{V}_2}{R}$

$= \frac{800\angle 0}{200} = 4$ A.

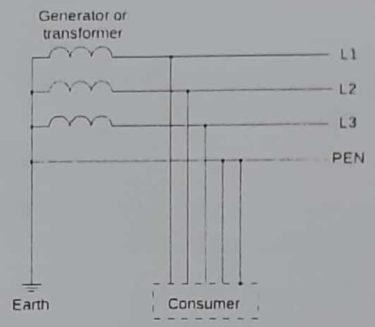
6. Which of the following connections is **best suited** for ensuring service continuity (no disruption to a load) following a single phase to ground fault? **1 mark**

(PE: protective earth, N: neutral)

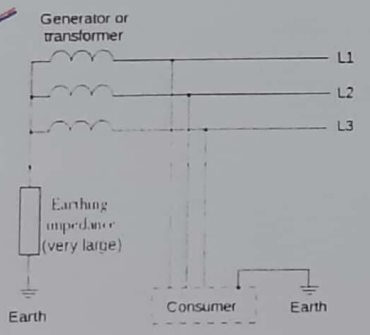
A.



B.



✓ C.



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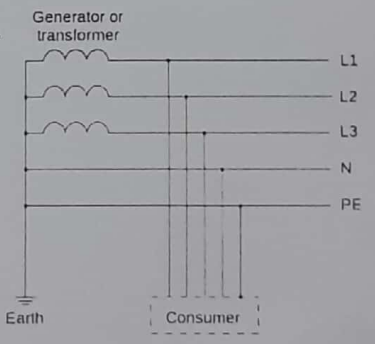

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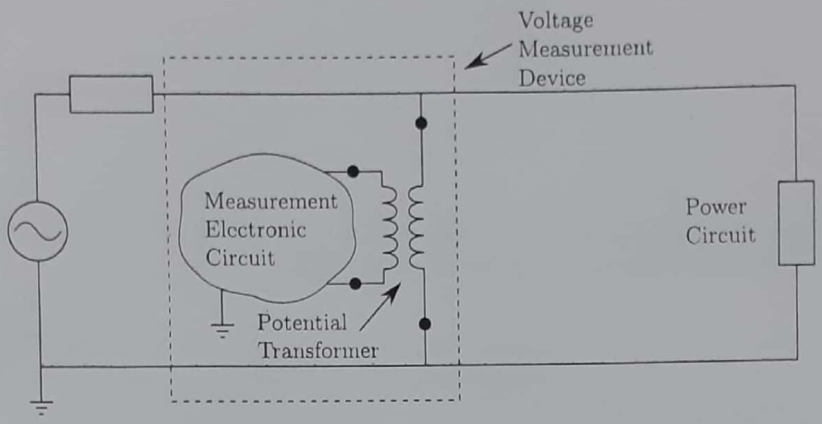
7. A transformer is also used as a part of a voltage measuring device (also called a "potential transformer"). It is connected in shunt (as shown in the figure) and it can step down voltages to measurable levels, besides providing isolation to the measurement electronic circuits. Which of the following statements is/are **TRUE**? **1 mark**



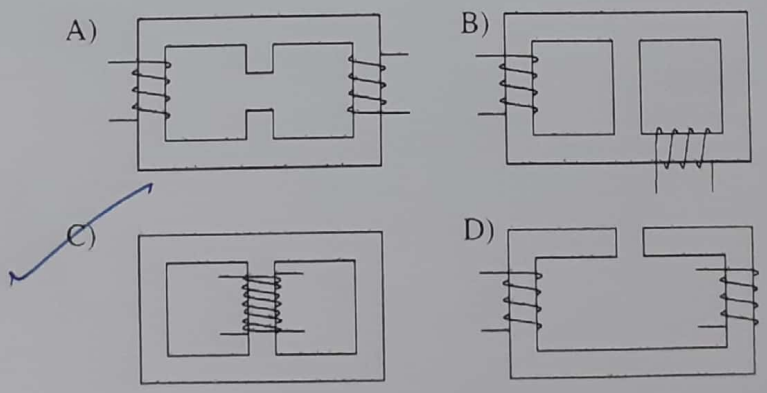
(A) The load impedance offered by the measurement electronic circuit on the transformer should be very large

(B) The transformer should practically be short circuited on the measurement circuit side

(C) Open circuiting the winding on the measurement side will damage the power circuit and the potential transformer

(D) The resistance and leakage reactance of the potential transformer are designed to be very large as compared to a power transformer.

8. The behavior of which of the following magnetically coupled circuits is closest to an **ideal**[1] transformer? **1 mark**
Note: The core material on which the windings are shown to be wound on is ferromagnetic.



[1]For an ideal transformer, winding losses, core losses, and leakage inductance are neglected. The primary current when the secondary is kept open-circuited ($\bar{I}_{oc}$) is negligible compared to the currents under loaded condition.

Cont.

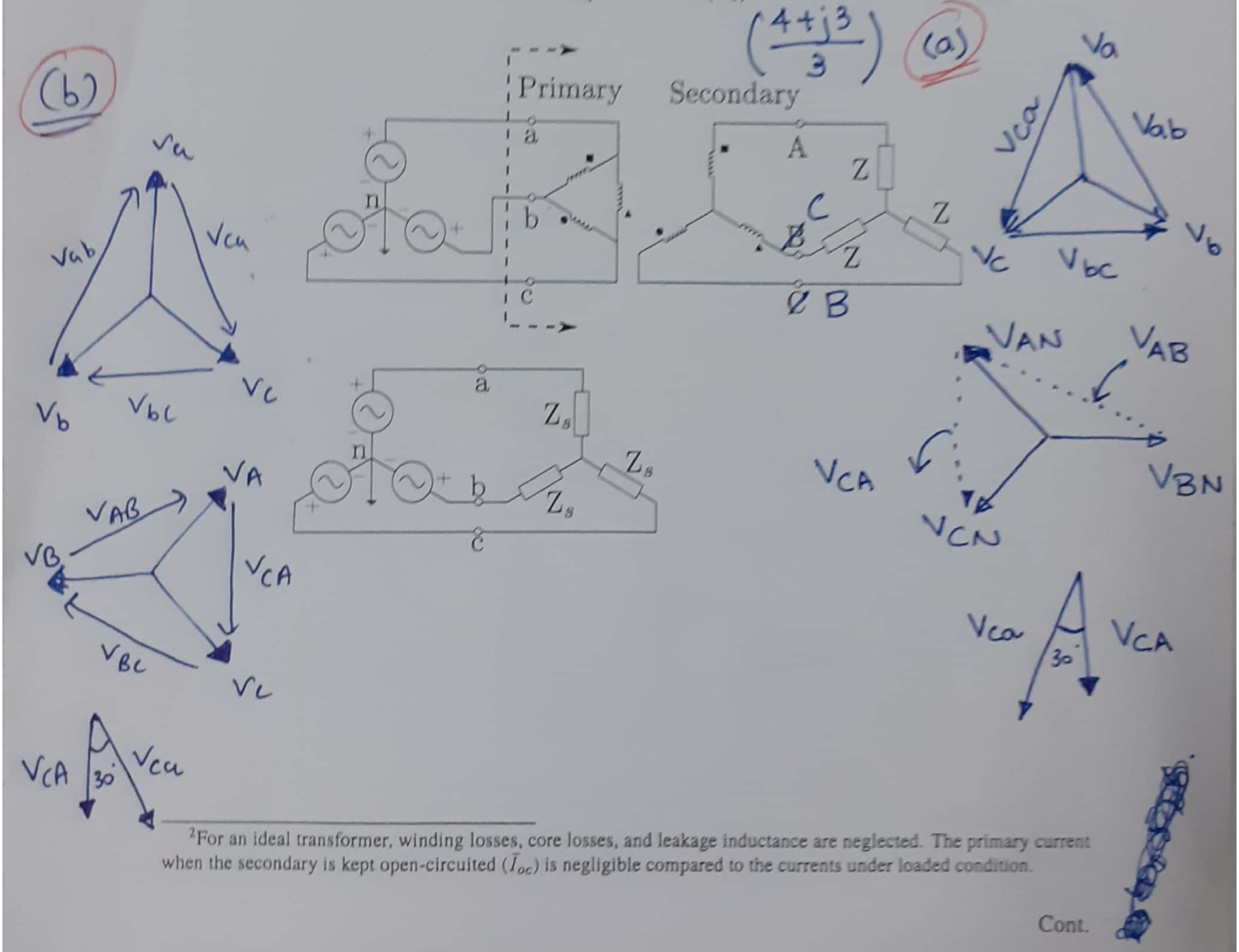
9. Consider a delta-star connected three-phase transformer as shown in the figure. The transformer is made of three identical **ideal**[2] single phase transformers of turns ratio 1:1 (i.e. equal number of turns on both primary and secondary windings). **Total: 7 marks**

(i) If a balanced, three phase voltage source is applied to the delta winding with phase sequence a-b-c (b lags a, and c lags b), then the line-line voltages on the star side will lag the corresponding line-line voltages on the delta side by $-30°$ (degree) **2 marks**

(ii) If a balanced, three phase voltage source is applied to the delta winding with phase sequence a-c-b (c lags a, and b lags c), then the line-line voltages on the star side will lag the corresponding line-line voltages on the delta side by $30°$ (degree) **2 marks**

(iii) The ratio of the line-to-line rms voltage on the primary side to that of the secondary side is $1 : \sqrt{3}$ **1 mark**

(iv) If the load impedance (Z) connected per phase is $(4 + j3)\ \Omega$, then the effective load impedance (per phase) as seen by the source (Z_s) is _____ Ω. **2 marks**



[2]For an ideal transformer, winding losses, core losses, and leakage inductance are neglected. The primary current when the secondary is kept open-circuited ($\bar{I}_{oc}$) is negligible compared to the currents under loaded condition.

Cont.

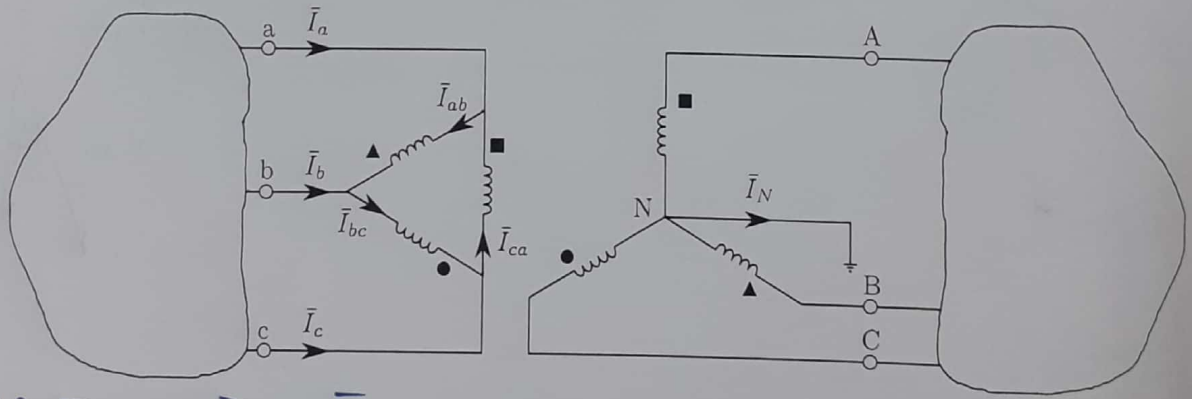
10. Match the materials shown in the Table with their resistivities (at 20° C). **2 marks**

Material	Resistivity(Ω-m)
(1) Copper	(I) 10^{9} to 10^{15}
(2) Air	(II) 1.7×10^{-8}
(3) Iron	(III) $10 - 50$
(4) Soft clay	(IV) 9.7×10^{-8}

(1) II (2) I (3) IV (4) III

11. A three-phase transformer is made by connecting three single-phase **ideal**[3] transformers as shown in the figure. The single-phase transformers have turns ratio of 1:1 i.e. identical number of turns in both primary and secondary windings. The three-phase transformer is connected between two parts of an ac network as shown in the figure. Under a certain loading condition, the neutral current $\bar{I}_N$ is found to be $3\angle 0^o$ A. It has been observed that the line currents $\bar{I}_a$ and $\bar{I}_b$ are $2\angle 0^o$ A and $3\angle 120^o$ A respectively. On the star side, the phase to neutral voltages $\bar{V}_{AN}$ and $\bar{V}_{CN}$ are $45\angle 50^o$ kV and $50\angle -60^o$ kV respectively. Find the following quantities.
(Hint: Apply KVL and KCL, and **ideal** transformer equations.) **1+1+1+1+1 = 5 marks**

(A) $\bar{I}_c$ = 2.6458∠−100.89°, −0.5 − j 2.598 A
(B) $\bar{I}_{ab}$ = 2.167 − j0.866, 2.3333∠−21.787 A
(C) $\bar{I}_{bc}$ = 0.667 + j1.732, 1.8559∠68.948 A
(D) $\bar{I}_{ca}$ = 0.1667 − j0.866, 0.88192∠−79.107 A
(E) $\bar{V}_{BN}$ = 54.643∠170.7°, −53.925 + j8.829 kV



(A) $\bar{I}_c = -\bar{I}_a - \bar{I}_b$ (E) $\bar{V}_{BN} = -\bar{V}_{AN} - \bar{V}_{CN}$

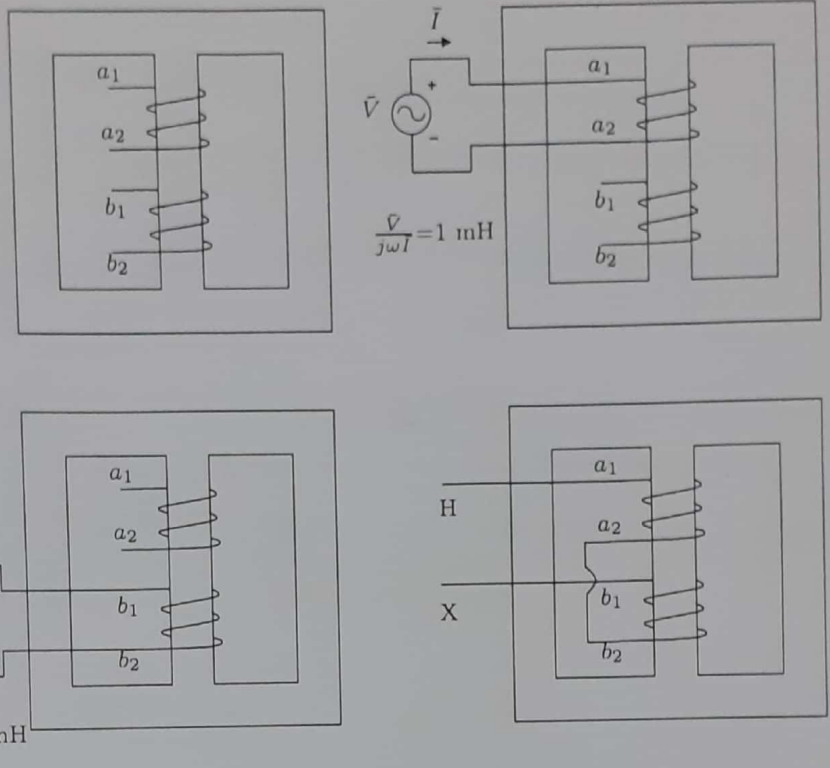
[3]For an ideal transformer, winding losses, core losses, and leakage inductance are neglected. The primary current when the secondary is kept open-circuited ($\bar{I}_{oc}$) is negligible compared to the currents under loaded condition.

(B, C, D) $\bar{I}_{ab} - \bar{I}_{ca} = \bar{I}_a$
$\bar{I}_{bc} - \bar{I}_{ab} = \bar{I}_b$
$\bar{I}_{ab} + \bar{I}_{bc} + \bar{I}_{ca} = \bar{I}_N$
$\Rightarrow \bar{I}_{ab} = (\bar{I}_a - \bar{I}_b + \bar{I}_N)/3$
$\bar{I}_{bc} = (\bar{I}_a + 2\bar{I}_b + \bar{I}_N)/3$
$\bar{I}_{ca} = (-2\bar{I}_a - \bar{I}_b + \bar{I}_N)/3$

Cont.

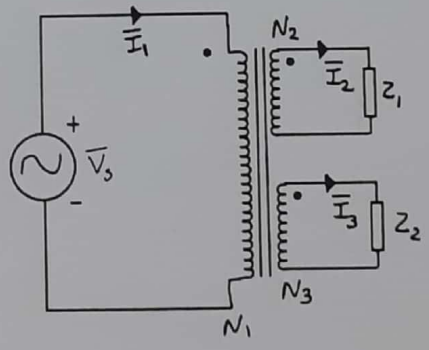
12. The inductance of each winding in the figure when excited individually (with the other winding kept open) is found to be 1 mH. If the leakage flux is negligible, the effective inductance as seen from the terminals HX (as indicated in the figure) is ___0___ mH. **2 marks**

$L_1 + L_2 - 2M$



13. A single-phase, three-winding **ideal**[4] transformer is connected to an ac voltage source as shown in the figure. The number of turns are as follows: $N_1 = 100$, $N_2 = 50$ and $N_3 = 50$. If the magnetizing current is neglected, and the currents in the two windings are $\bar{I}_2 = 2\angle 30^\circ$ A and $\bar{I}_3 = 2\angle 150^\circ$ A, then the primary current $\bar{I}_1$ is ___$1\angle 90^\circ$___ A. **1 mark**

$$\bar{I}_1 = \frac{N_2\bar{I}_2 + N_3\bar{I}_3}{N_1}$$
$$= 0 + 1i \text{ A}$$
$$= 1\angle 90^\circ \text{ A}$$



[4]For an ideal transformer, winding losses, core losses, and leakage inductance are neglected. The primary current when the secondary is kept open-circuited ($\bar{I}_{oc}$) is negligible compared to the currents under loaded condition.

The End.