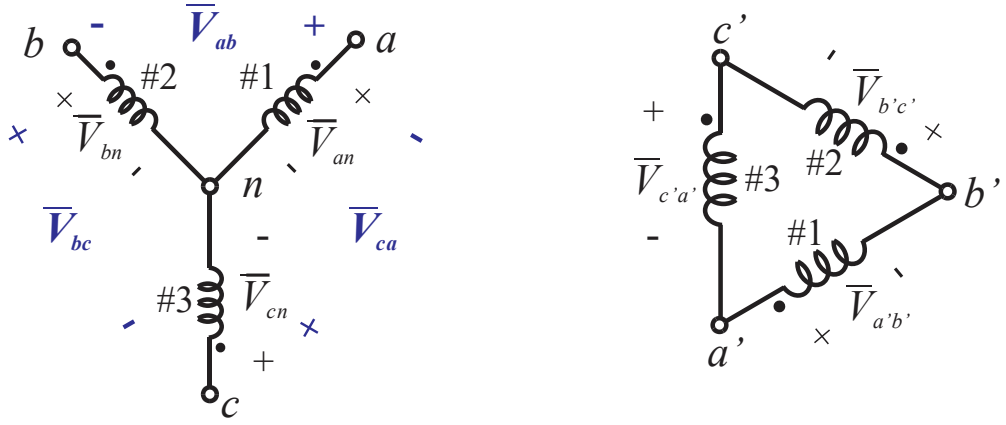
EE 330 Energy Systems (Fall 2026) Quiz #5

Name KEY A

Instructions: Open book & notes (no homework). Place answers in indicated spaces and show all work for credit.

For the Y-Δ connected 3ϕ transformer shown, the primary phase voltages are $\bar{V}_{an} = 360\angle 0°\ \text{V}_{\text{rms}}$, $\bar{V}_{bn} = 360\angle 120°\ \text{V}_{\text{rms}}$, and $\bar{V}_{cn} = 360\angle -120°\ \text{V}_{\text{rms}}$. Find the primary line-to-line voltages $\bar{V}_{ab}$, $\bar{V}_{bc}$, & $\bar{V}_{ca}$ and the corresponding secondary line-to-line voltages $\bar{V}_{a'b'}$, $\bar{V}_{b'c'}$, & $\bar{V}_{c'a'}$. Assume ideal transformers and a turns ratio of $a = 3$ for each pair of coils.



Note that phase sequence is reversed on primary ($c \to b \to a$ rather than $a \to b \to c$). By KVL on the primary transformer circuit-

$$\bar{V}_{ab} = \bar{V}_{an} - \bar{V}_{bn} = 360\angle 0° - 360\angle 120° \quad \Rightarrow \quad \underline{\bar{V}_{ab} = 623.5383\angle -30°\ (\text{V}_{\text{rms}})},$$

$$\bar{V}_{bc} = \bar{V}_{bn} - \bar{V}_{cn} = 360\angle 120° - 360\angle -120° \quad \Rightarrow \quad \underline{\bar{V}_{bc} = 623.5383\angle 90°\ (\text{V}_{\text{rms}})}, \text{ and}$$

$$\bar{V}_{ca} = \bar{V}_{cn} - \bar{V}_{an} = 360\angle -120° - 360\angle 0° \quad \Rightarrow \quad \underline{\bar{V}_{ca} = 623.5383\angle -150°\ (\text{V}_{\text{rms}})}.$$

Per (3-5), each of the coil pair phase voltages are related by the turns ratio $\bar{V}_p / \bar{V}_S = a = 3$ $\Rightarrow \bar{V}_S = \bar{V}_p / 3$. Per (2-14), $V_{LL} = V\phi$ on the secondary Δ-configured side. Therefore,

$$\text{Coil set \#1} \quad \bar{V}_{a'b'} = \bar{V}_{an} / 3 = 360\angle 0° / 3 \quad \Rightarrow \quad \underline{\bar{V}_{a'b'} = 120\angle 0°\ (\text{V}_{\text{rms}})},$$

$$\text{Coil set \#2} \quad \bar{V}_{b'c'} = \bar{V}_{bn} / 3 = 360\angle 120° / 3 \quad \Rightarrow \quad \underline{\bar{V}_{b'c'} = 120\angle 120°\ (\text{V}_{\text{rms}})}, \text{ and}$$

$$\text{Coil set \#3} \quad \bar{V}_{c'a'} = \bar{V}_{cn} / 3 = 360\angle -120° / 3 \quad \Rightarrow \quad \underline{\bar{V}_{c'a'} = 120\angle -120°\ (\text{V}_{\text{rms}})}.$$

Note that the **line-to-line voltages** on either side are offset by 30°.

$\bar{V}_{ab} =$ $\underline{623.54\angle -30°\ (\text{V}_{\text{rms}})}$ $\bar{V}_{bc} =$ $\underline{623.54\angle 90°\ (\text{V}_{\text{rms}})}$ $\bar{V}_{ca} =$ $\underline{623.54\angle -150°\ (\text{V}_{\text{rms}})}$

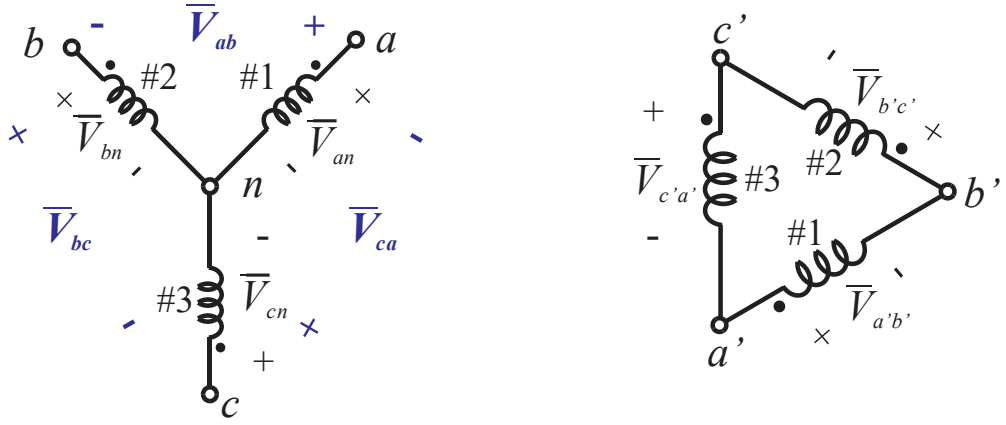
$\bar{V}_{a'b'} =$ $\underline{120\angle 0°\ (\text{V}_{\text{rms}})}$ $\bar{V}_{b'c'} =$ $\underline{120\angle 120°\ (\text{V}_{\text{rms}})}$ $\bar{V}_{c'a'} =$ $\underline{120\angle -120°\ (\text{V}_{\text{rms}})}$

EE 330 Energy Systems (Fall 2026) Quiz #5

Name KEY B

Instructions: Open book & notes (no homework). Place answers in indicated spaces and show all work for credit.

For the Y-Δ connected 3ϕ transformer shown, the primary phase voltages are $\bar{V}_{an} = 540\angle 0°\ \text{V}_{\text{rms}}$, $\bar{V}_{bn} = 540\angle 120°\ \text{V}_{\text{rms}}$, and $\bar{V}_{cn} = 540\angle -120°\ \text{V}_{\text{rms}}$. Find the primary line-to-line voltages $\bar{V}_{ab}$, $\bar{V}_{bc}$, & $\bar{V}_{ca}$ and the corresponding secondary line-to-line voltages $\bar{V}_{a'b'}$, $\bar{V}_{b'c'}$, & $\bar{V}_{c'a'}$. Assume ideal transformers and a turns ratio of $a = 4$ for each pair of coils.



Note that phase sequence is reversed on primary ($c \to b \to a$ rather than $a \to b \to c$). By KVL on the primary transformer circuit-

$$\bar{V}_{ab} = \bar{V}_{an} - \bar{V}_{bn} = 540\angle 0° - 540\angle 120° \quad \Rightarrow \quad \underline{\bar{V}_{ab} = 935.3074\angle -30°\ (\text{V}_{\text{rms}})},$$

$$\bar{V}_{bc} = \bar{V}_{bn} - \bar{V}_{cn} = 540\angle 120° - 540\angle -120° \quad \Rightarrow \quad \underline{\bar{V}_{bc} = 935.3074\angle 90°\ (\text{V}_{\text{rms}})}, \text{ and}$$

$$\bar{V}_{ca} = \bar{V}_{cn} - \bar{V}_{an} = 540\angle -120° - 540\angle 0° \quad \Rightarrow \quad \underline{\bar{V}_{ca} = 935.3074\angle -150°\ (\text{V}_{\text{rms}})}.$$

Per (3-5), each of the coil pair phase voltages are related by the turns ratio $\bar{V}_p / \bar{V}_S = a = 4$ $\Rightarrow \bar{V}_S = \bar{V}_p / 4$. Per (2-14), $V_{LL} = V\phi$ on the secondary Δ-configured side. Therefore,

Coil set #1 $\bar{V}_{a'b'} = \bar{V}_{an} / 4 = 540\angle 0° / 4 \quad \Rightarrow \quad \underline{\bar{V}_{a'b'} = 135\angle 0°\ (\text{V}_{\text{rms}})},$

Coil set #2 $\bar{V}_{b'c'} = \bar{V}_{bn} / 4 = 540\angle 120° / 4 \quad \Rightarrow \quad \underline{\bar{V}_{b'c'} = 135\angle 120°\ (\text{V}_{\text{rms}})}, \text{ and}$

Coil set #3 $\bar{V}_{c'a'} = \bar{V}_{cn} / 4 = 540\angle -120° / 4 \quad \Rightarrow \quad \underline{\bar{V}_{c'a'} = 135\angle -120°\ (\text{V}_{\text{rms}})}.$

Note that the **line-to-line voltages** on either side are offset by 30°.

$\bar{V}_{ab} =$ 935.31∠−30° (V_{rms}) $\quad \bar{V}_{bc} =$ 935.31∠90° (V_{rms}) $\quad \bar{V}_{ca} =$ 935.31∠−150° (V_{rms})

$\bar{V}_{a'b'} =$ 135∠0° (V_{rms}) $\quad \bar{V}_{b'c'} =$ 135∠120° (V_{rms}) $\quad \bar{V}_{c'a'} =$ 135∠−120° (V_{rms})