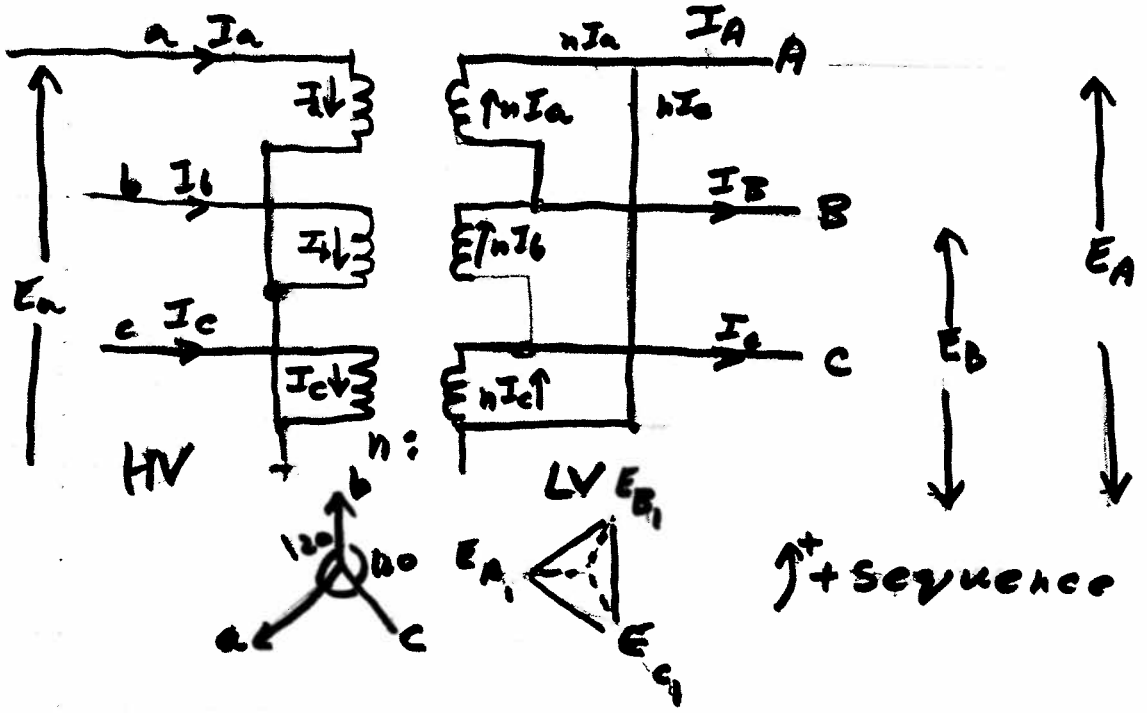
lecture #5 B

Phase shift in Δ-Y or Y-Δ Transformers.



$I_A = n(I_a - I_c)$ line current I_a: LV

$E_a = n(E_A - E_B)$ $\frac{E_a}{n} = E_A - E_B$

For positive sequence designated as "1"

$I_{A1} = n(I_{a1} - I_{c1})$

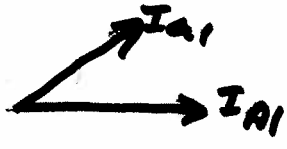
$I_{c1} = \alpha I_{a1}$ $\alpha = 1\angle 120$

$I_{A1} = n(I_{a1} - \alpha I_{a1}) = n(1-\alpha) I_{a1} = n(1.5 - j.866)$

$I_{A1} = n\sqrt{3}\angle -30\ I_{a1}$

OR

$I_{a1} = \frac{I_{A1}}{n\sqrt{3}}\angle 30$



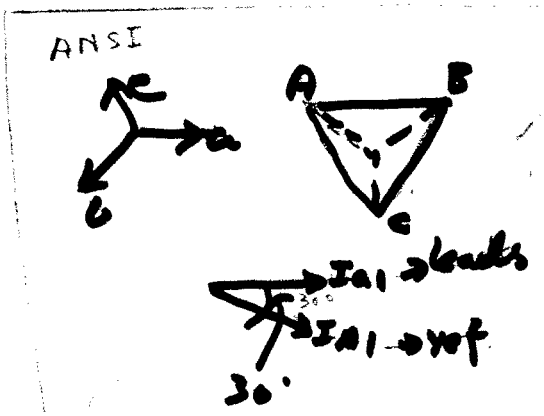
~~ANSI standard (U.S.A.)~~

$$E_{a1} = n(E_{A1} - E_{B1})$$

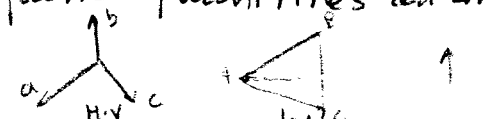
$$E_{B1} = a^2 E_{A1} \qquad a^2 = 1\angle 240$$

$$E_{a1} = n(E_{A1} - a^2 E_{A1})$$
$$E_{a1} = n(1 - a^2) E_{A1}$$

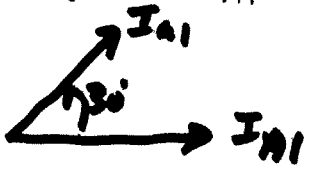
$$E_{a1} = n(1 - a^2) E_{A1}$$
$$= n(1 + .5 + j.866) E_{A1}$$
$$E_{a1} = n\sqrt{3}\angle 30 \, E_{A1}$$



1) **ANSI standard U.S.A.** For either wye-delta or delta-wye connections, phases shall be labled in such a way that positive sequence quantities on the high voltage side lead their corresponding positive sequence quantities on the low voltage side by 30°



- Choose Low voltage side as a reference (i.e. I_{A1}
- High voltage side should lead by 30°

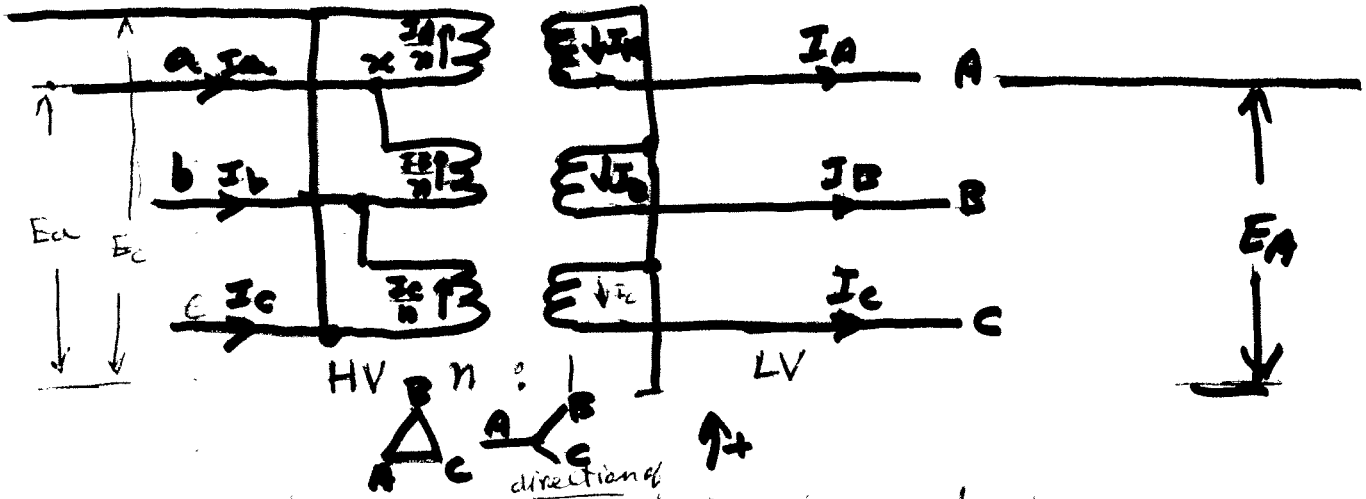


$$I_{a_1} = \frac{I_{A1}}{n\sqrt{3}} \angle 30^\circ$$

2) ANSI Standard U.S.A. The effect of wye-delta or delta wye connections on negative sequence quantities is the reverse, that is, HV values Lag LV values by 30°

For $\underset{HV}{\curlyvee}\ \underset{LV}{\Delta}$ then $I_{a2} = \frac{I_{A2}}{n\sqrt{3}} \angle -30^\circ$, $E_{A2} = \frac{E_{a2}}{\sqrt{3}\,n} \angle 30^\circ$ "2" negative.

For Δ (HV) – Y (LV) connection



- determine the direction of current in each coupled coil.
- Algebraic $\sum I$ for $x = 0$

$$I_a + \frac{I_B}{n} - \frac{I_A}{n} = 0$$

$$I_a = \frac{1}{n}(I_A - I_B)$$

$$\frac{E_A}{1} = \frac{E_a - E_c}{n}$$

$$E_A = \frac{1}{n}(E_a - E_c)$$

For positive sequence "1"

$$I_{a1} = \frac{1}{n}(I_{A1} - I_{B1})$$

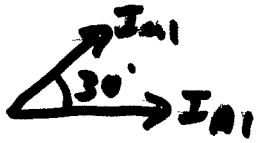
$$I_{B1} = \alpha I_{A1} \qquad \alpha = 1\angle 240^\circ$$

$$I_{a1} = \frac{1}{n}(I_{A1} - \alpha I_{A1})$$

$$I_{a1} = \frac{1}{n}(1-\alpha)(I_{A1}) = \frac{\sqrt{3}}{n} I_{A1}\angle 30^\circ$$

let $N = \frac{n}{\sqrt{3}}$

$$I_{a1} = \frac{I_{A1}}{N}\angle 30$$



- Choose low voltage side as a reference (i.e I_{A1})
- High voltage side should lead by 30°

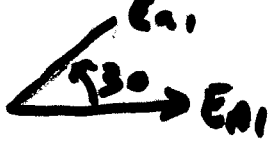
$$E_{A1} = \frac{1}{n}(E_{a1} - E_{c1}) = \frac{1}{n}(E_{a1} - \alpha E_{a1})$$

$$E_{c1} = \alpha E_{a1}$$

$$E_{A1} = \frac{1}{n}(1-\alpha) E_{a1} = \frac{\sqrt{3}}{n} E_{a1} \angle -30^\circ$$

$$E_{A1} = \frac{E_{a1}}{N} \angle -30^\circ \qquad \text{where } N = \frac{\sqrt{3}}{n}$$

$$E_{a1} = N E_{A1} \angle 30$$



- choose Low voltage side (variable) as a reference (like E_{A1})
- High voltage side variable should lead by 30°

For negative sequence Δ — Y we have:

$$I_{a2} = \frac{I_{A2}}{N} \angle -30$$

$$E_{a2} = N E_{A2} \angle -30$$

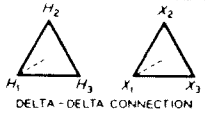
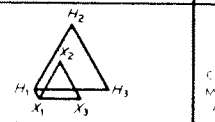
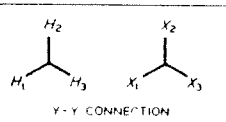
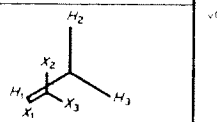
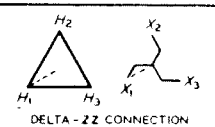
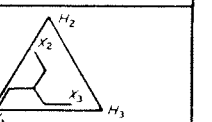
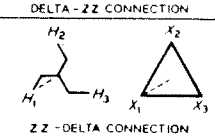
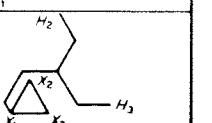
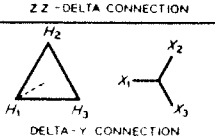
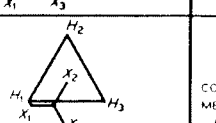
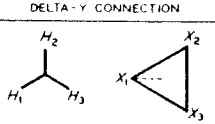
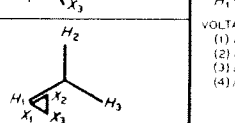
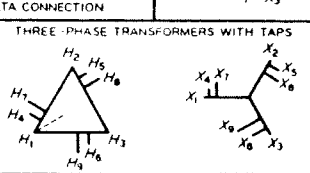
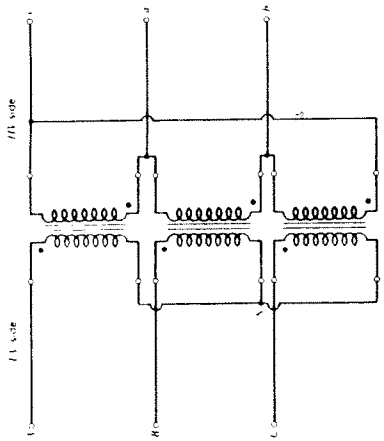
	ANGULAR DISPLACEMENT	DIAGRAM FOR CHECK MEASUREMENT	CHECK MEASUREMENTS
GROUP 1 ANGULAR DISPLACEMENT 0 DEGREES	 DELTA - DELTA CONNECTION		CONNECT H_1 TO X_1 MEASURE H_2-X_2, H_3-X_2, H_1-H_2, H_2-X_3, H_3-X_3 VOLTAGE RELATIONS (1) $H_2-X_3 = H_3-X_2$ (2) $H_2-X_2 < H_1-H_2$ (3) $H_2-X_2 < H_2-X_3$ (4) $H_2-X_2 < H_3-X_3$
	 Y - Y CONNECTION		
	 DELTA - ZZ CONNECTION		
	 ZZ - DELTA CONNECTION		
GROUP 2 ANGULAR DISPLACEMENT 30 DEGREES	 DELTA - Y CONNECTION		CONNECT H_1 TO X_1 MEASURE H_3-X_2, H_3-X_3, H_1-H_3, H_2-X_2, H_2-X_3 VOLTAGE RELATIONS (1) $H_3-X_2 = H_3-X_3$ (2) $H_3-X_2 < H_1-H_3$ (3) $H_2-X_2 < H_2-X_3$ (4) $H_2-X_2 < H_1-H_3$
	 Y - DELTA CONNECTION		
	THREE - PHASE TRANSFORMERS WITH TAPS 		

Fig 22a
Transformer Lead Markings and Voltage-Phasor Diagrams for Three-Phase Transformer Connections

For either wye-delta or delta-wye connections, phases shall be labeled in such a way that positive sequence quantities on the high voltage side lead their corresponding positive sequence quantities on the low voltage side by 30°. The effect on negative sequence quantities is the reverse, that is, HV values lag LV values by 30°.



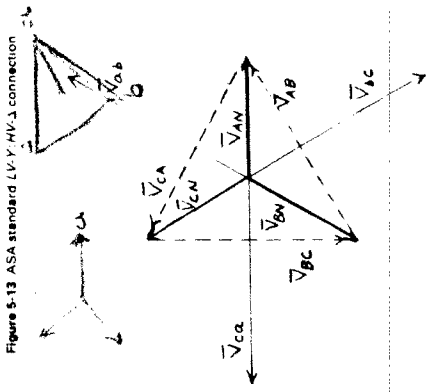
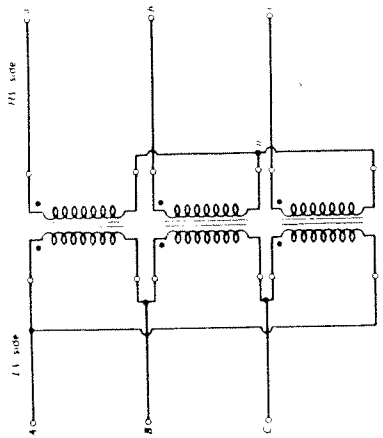


Figure 5-13 ASA standard LV-Y HV-Δ connection



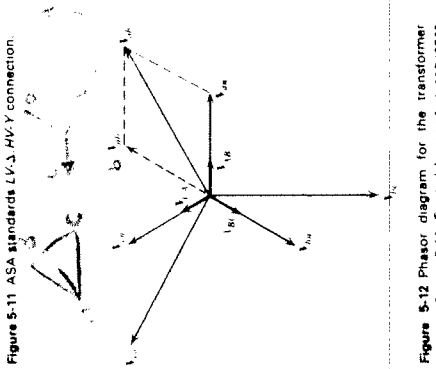


Figure 5-11 ASA standards LV-Δ HV-Y connection

Figure 5-12 Phasor diagram for the transformer bank of Figure 5-11. Excited by positive sequence voltages