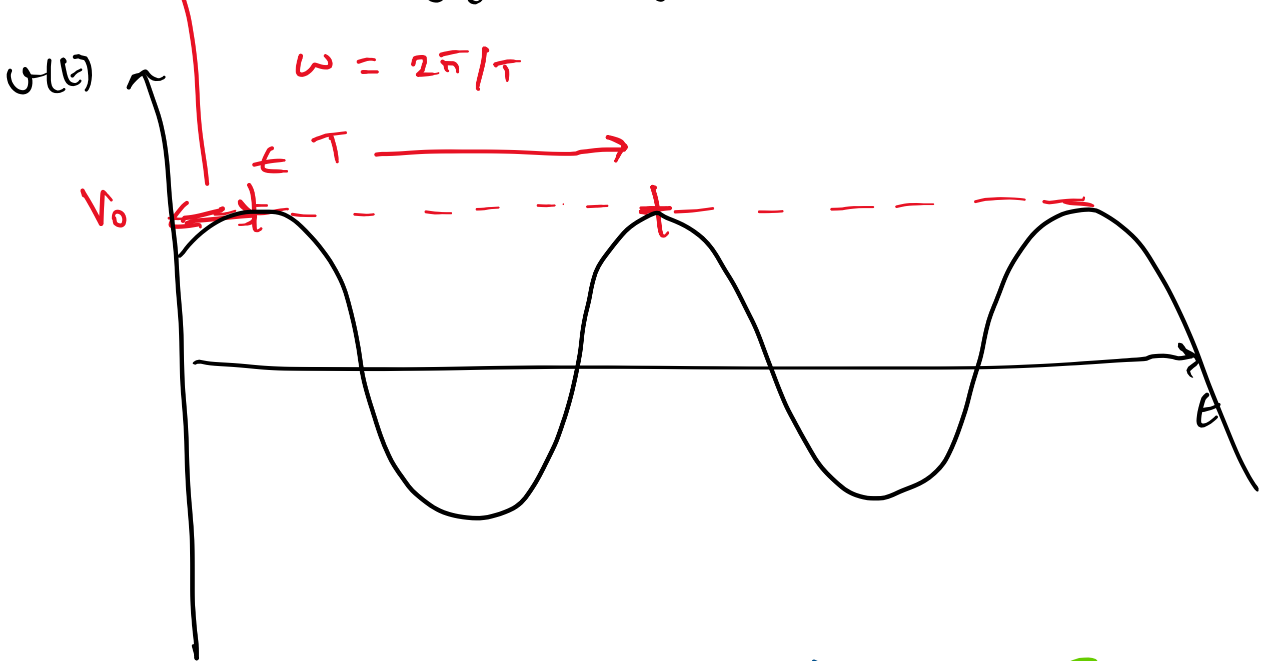
Lecture 4

Polyphase Ckts (Chapter 12)

$$v(t) = V_0 \cos(\omega t + \theta)$$

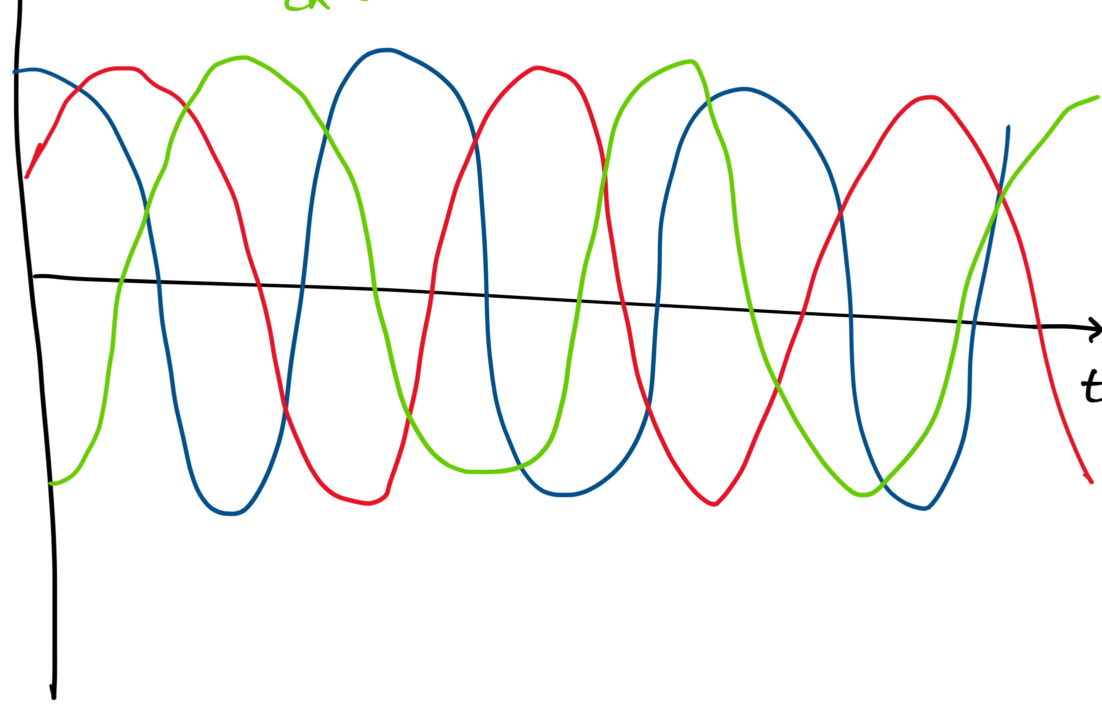


$v_{an}(t) = V_0 \cos(\omega t)$

$v_{bn}(t) = V_0 \cos(\omega t - 120^\circ)$

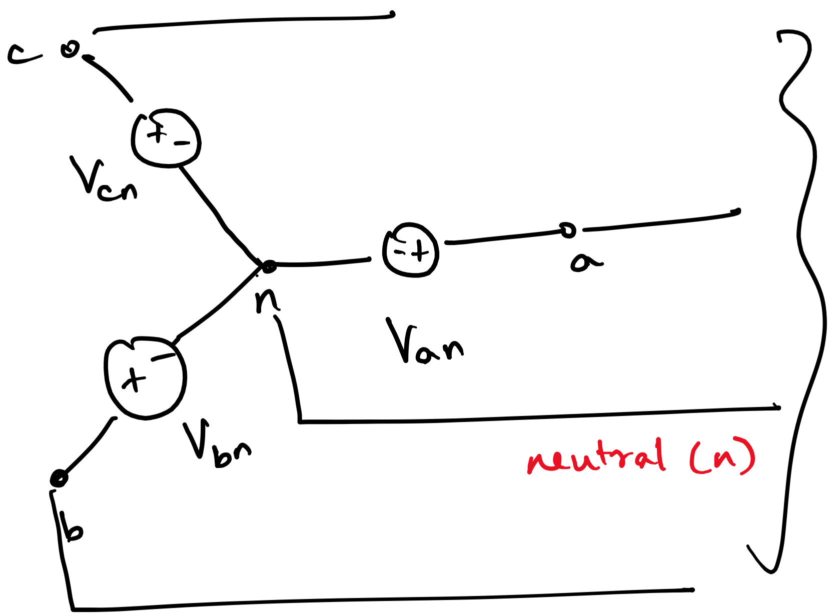
$v_{cn}(t) = V_0 \cos(\omega t - 240^\circ)$

Fig 12.1



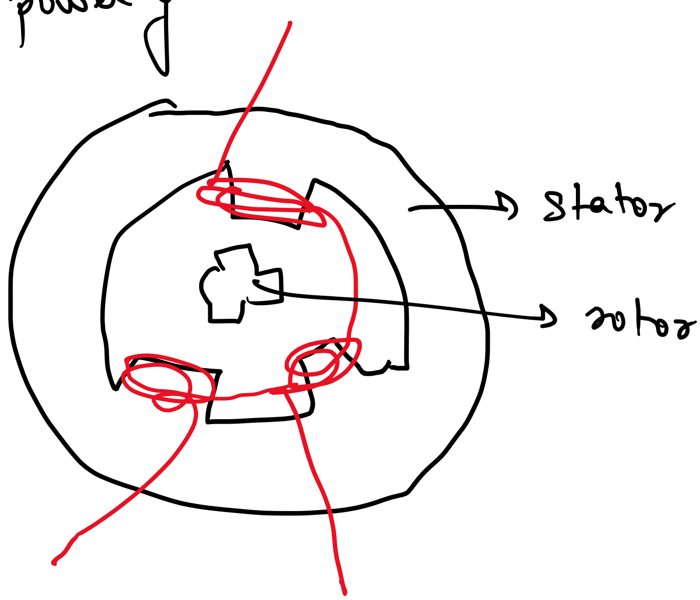
Time Domain	Phasor / Freq Domain
$v_{an}(t) = V_0 \cos(\omega t + \theta)$	$V_{an} = V_0 \angle \theta$
$v_{bn}(t) = V_0 \cos(\omega t + \theta - 120^\circ)$	$V_{bn} = V_0 \angle \theta - 120^\circ$
$v_{cn}(t) = V_0 \cos(\omega t + \theta - 240^\circ)$	$V_{cn} = V_0 \angle \theta - 240^\circ$

"Balanced Three-Phase Source"



4 wires for 3 phase system

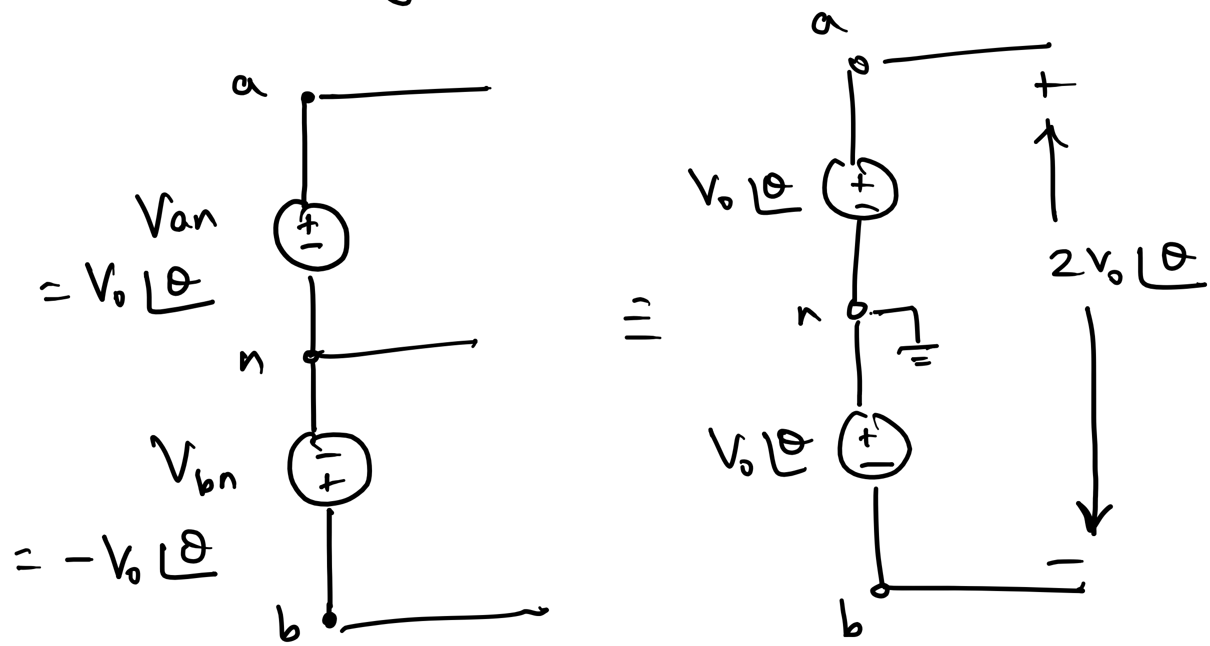
Three phase power generation



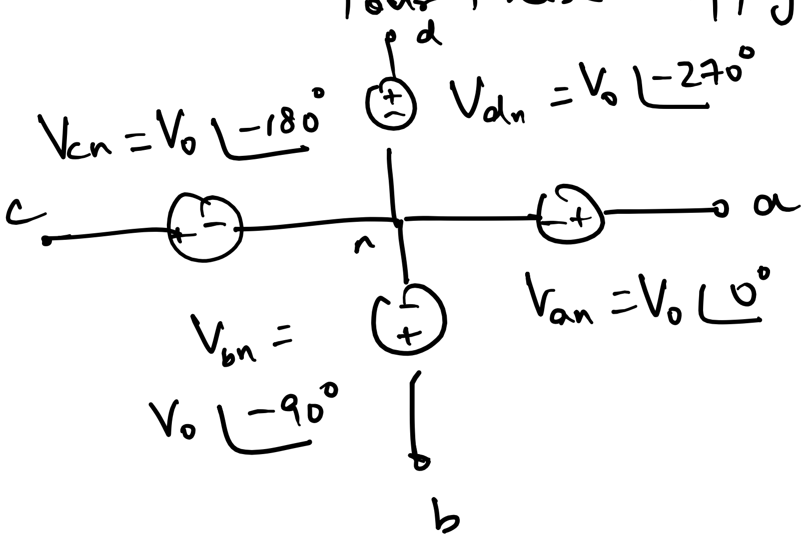
Time Domain	Frequency Domain
$v_{an} = V_0 \cos(\omega t + \theta)$	$V_{an} = V_0 \angle \theta$
$v_{bn} = V_0 \cos(\omega t + \theta - 180^\circ)$	$V_{bn} = V_0 \angle \theta - 180^\circ$
	$= -V_{an}$

Balanced Two Phase System or

Single Phase Differential System



Four Phase Supply

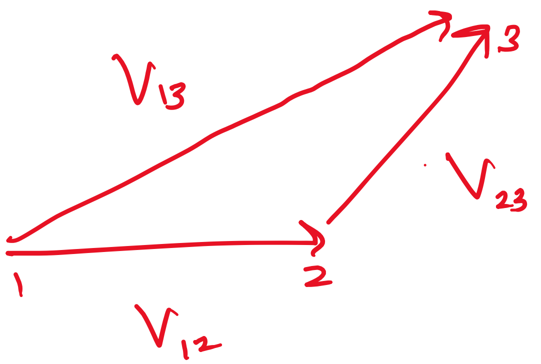


- Voltages associated with a circuit are given by $V_{12} = 9\angle 30°$ V, $V_{32} = 3\angle 130°$ V, and $V_{14} = 2\angle 10°$ V. Determine V_{21}, V_{13}, V_{34} and V_{24}.

$$V_{12} = 9\angle 30°$$

$$V_{21} = -V_{12} = 9\angle 30° - 180°$$
$$= 9\angle -150°$$

$$V_{13} = V_{12} + V_{23}$$



$$\Rightarrow V_{13} = V_{12} - V_{32} = 9\angle 30° - 3\angle 130°$$

$$\neq 6\angle -100°$$

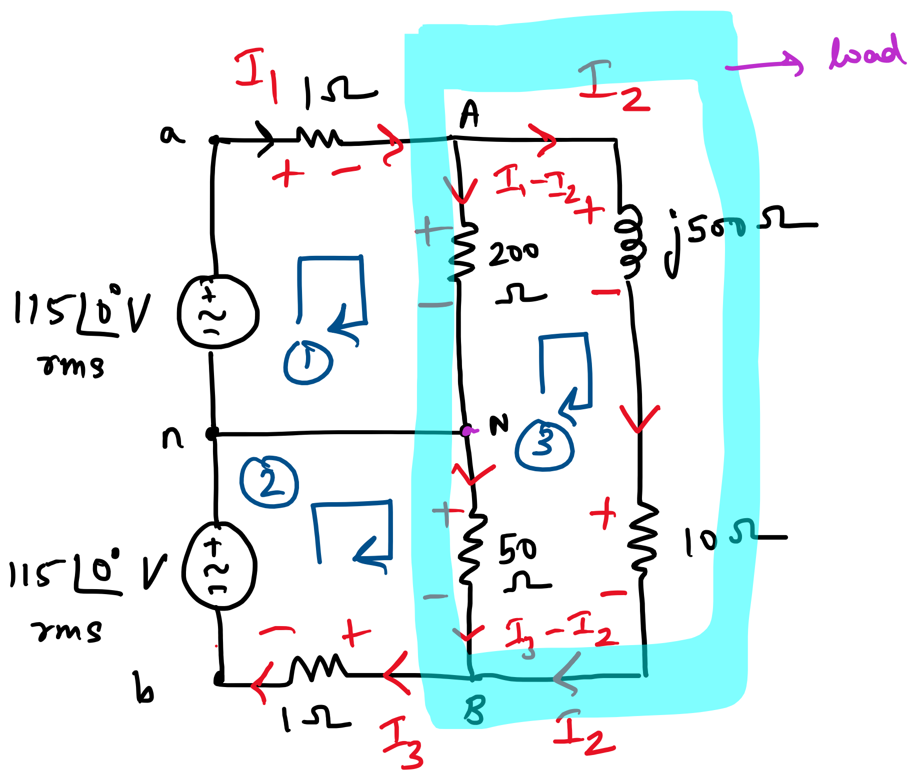
(No subtraction in polar format)

$$= (9\cos 30° - 3\cos 130°) + j(9\sin 30° - 3\sin 130°)$$
$$= 9.7226 + j2.201 \text{ V}$$

$$V_{34} = V_{31} + V_{14} = -V_{13} + V_{14} =$$
$$-7.75 - j1.85 \text{ V}$$

$$V_{24} = V_{21} + V_{14} = -5.82 - j4.15 \text{ V}$$

3. For the system represented below, the ohmic losses in the neutral wire are so small they can neglected and it can be adequately modeled as a short circuit. (a) Calculate the power lost in the two lines as a result of their nonzero resistance. (b) Compute the average power delivered to the load. (c) Determine the power factor of the total load.



Loop 1

$$+115 - I_1 \times 1 - (I_1 - I_2) \times 200 = 0$$

$$\Rightarrow \quad 201 I_1 - 200 I_2 + 0 \times I_3 = 115 \quad — ①$$

Loop 2

$$+115 - 50 \times (I_3 - I_2) - I_3 \times 1 = 0$$

$$0 \times I_1 + 50 I_2 - 51 I_3 = -115 \quad — ②$$

Loop 3 $\quad +(I_1 - I_2) \times 200 - I_2 \times (j500 + 10) + 50 \times (I_3 - I_2) = 0$

$$I_1(200) + I_2(-260 - j500) + I_3(50) = 0 \quad \text{—— ③}$$

$$201\, I_1 - 200 I_2 + 0\, I_3 = 115$$

$$0 + 50 I_2 - 51 I_3 = -115$$

$$200 I_1 + (-260 - j500) I_2 + 50 I_3 = 0$$

$I_1 = 0.7376 \angle -37.8^\circ$ A , $I_2 = 0.454 \angle -88.6^\circ$, $I_3 = 2.31 \angle -11.1^\circ$ A

(a) Power lost in line aA $= Re\{\underbrace{I_1 \times R_w}_{V} \times \underbrace{I_1^*}_{I^*}\}$

$= |I_1|^2 R_w$ (omitted $\frac{1}{2}$ due to rms)

$= 0.5440$ Watts

(b) Power lost in line bB $= Re\{I_3 \times R_w \times I_3^*\}$

$= |I_3|^2 R_w = 5.3310$ Watts

(c) Time averaged Power lost in load =

$|I_1 - I_2|^2 \times 200 + |I_3 - I_2|^2 \times 50 + |I_2|^2 \times 10$ Watts

$= 65.4573 + 254.185 + 2.0631$

$= 321.7055$ Watts