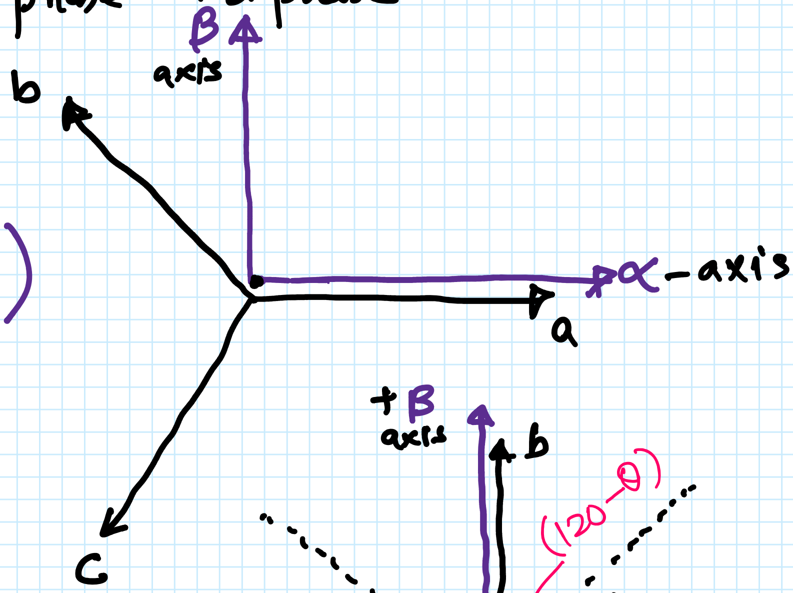
Transformations

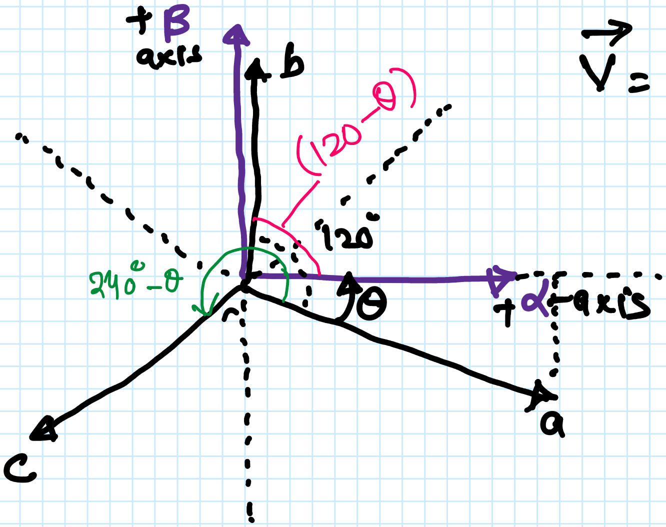
Tuesday, October 22, 2019 5:40 PM

i) 3 phase $\rightarrow$ 2 phase $\rightarrow$ DC

(−ve seq) acb



$V_0 = \dfrac{V_a + V_b + V_c}{3}$



$\vec{V} = \alpha + j\beta$

$$\alpha = a\cos\theta + b\cos(120^\circ - \theta) + c\cos(240^\circ - \theta)$$

$$\beta = a\sin\theta + b\sin(120^\circ - \theta) + c\sin(240^\circ - \theta)$$

$$0 = \frac{a}{3} + \frac{b}{3} + \frac{c}{3}$$

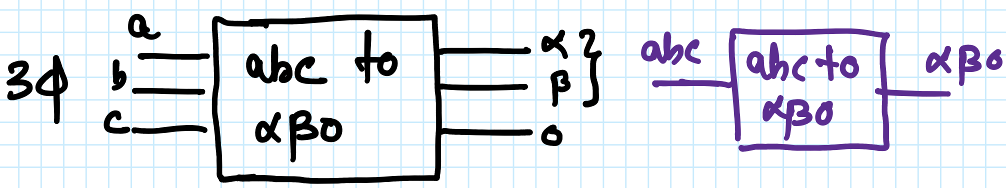
$$\begin{bmatrix} \alpha \\ \beta \\ 0 \end{bmatrix} = \underbrace{K \begin{bmatrix} \cos\theta & \cos(120^\circ - \theta) & \cos(240^\circ - \theta) \\ \sin\theta & \sin(120^\circ - \theta) & \sin(240^\circ - \theta) \\ 1/2 & 1/2 & 1/2 \end{bmatrix}}_{K = 2/3 \quad [\text{Tabe}]} \begin{bmatrix} a \\ b \\ c \end{bmatrix}$$

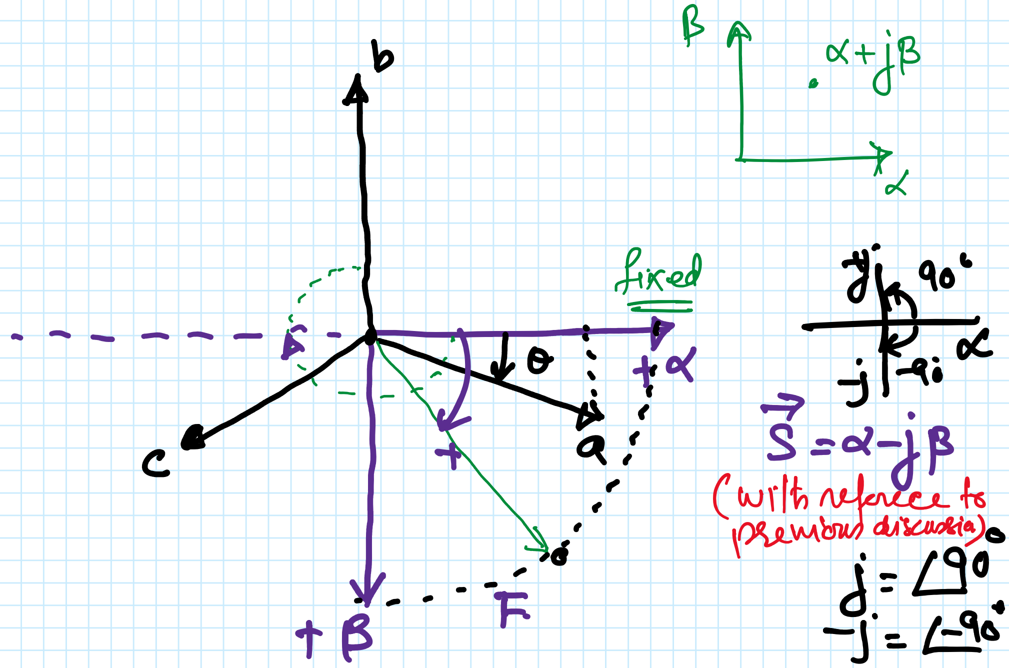
$$\begin{bmatrix} \alpha \\ \beta \\ 0 \end{bmatrix} = \frac{2}{3} \begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\frac{\sqrt{3}}{2} \\ 1/2 & 1/2 & 1/2 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix}$$

$$\begin{bmatrix} 0 \end{bmatrix} \quad \begin{bmatrix} 1/2 & 1/2 & 1/2 \end{bmatrix} \begin{bmatrix} c \end{bmatrix}$$

$$\begin{bmatrix} \alpha \\ \beta \\ 0 \end{bmatrix} = \underbrace{\begin{bmatrix} 2/3 & -1/3 & -1/3 \\ 0 & \frac{1}{\sqrt{3}} & -1/\sqrt{3} \\ 1/3 & 1/3 & 1/3 \end{bmatrix}}_{T_{abc}|_{\theta=0}} \begin{bmatrix} a \\ b \\ c \end{bmatrix}$$

$T_{abc}|_{\theta=0} \implies$ α-axis is aligned with phase a



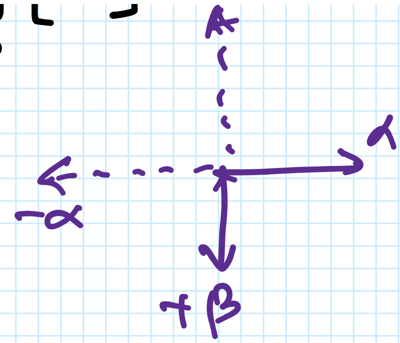


$$\alpha = a\cos\theta + b\cos(\theta + 240°) + c\cos(\theta + 120°)$$

$$\beta = a\sin\theta + b\sin(\theta + 240°) + c\sin(\theta + 120°)$$

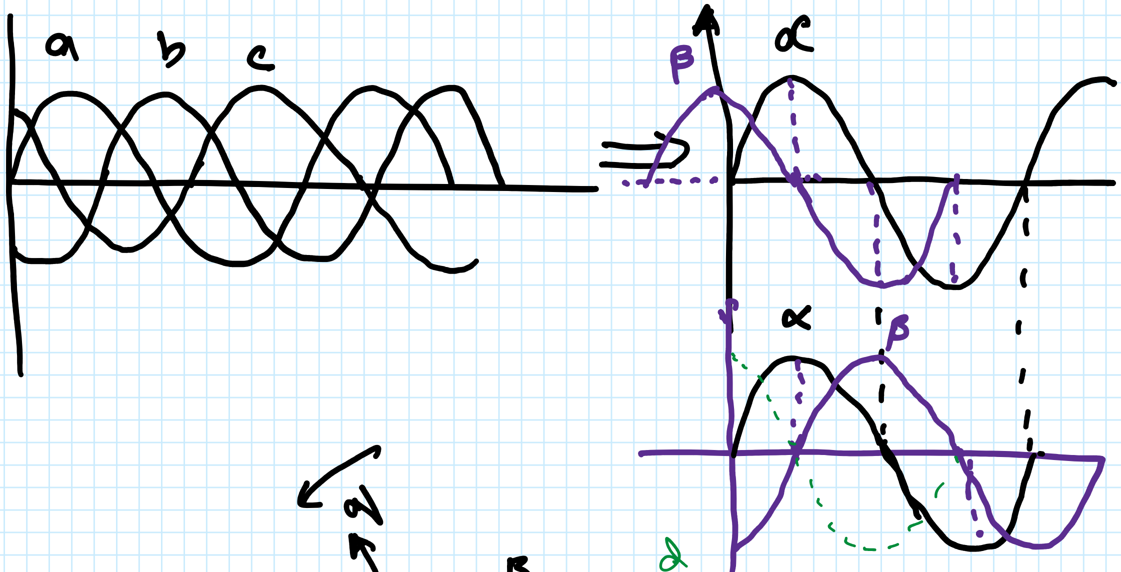
$$\begin{bmatrix} \alpha \\ \beta \\ 0 \end{bmatrix} = \frac{2}{3}\underbrace{\begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & -\frac{\sqrt{3}}{2} & +\frac{\sqrt{3}}{2} \\ 1/2 & 1/2 & 1/2 \end{bmatrix}}_{} \begin{bmatrix} a \\ b \\ c \end{bmatrix}$$

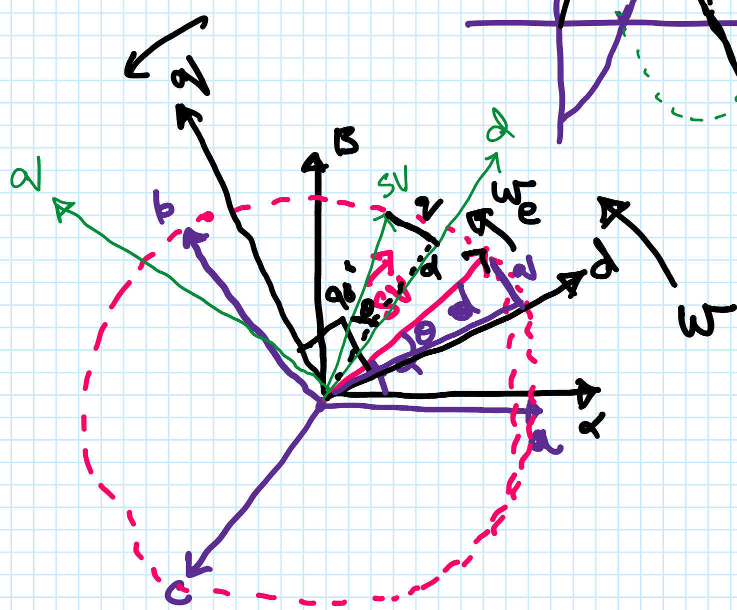
$$\underbrace{\qquad\qquad\qquad}_{[T_{abc}]}$$

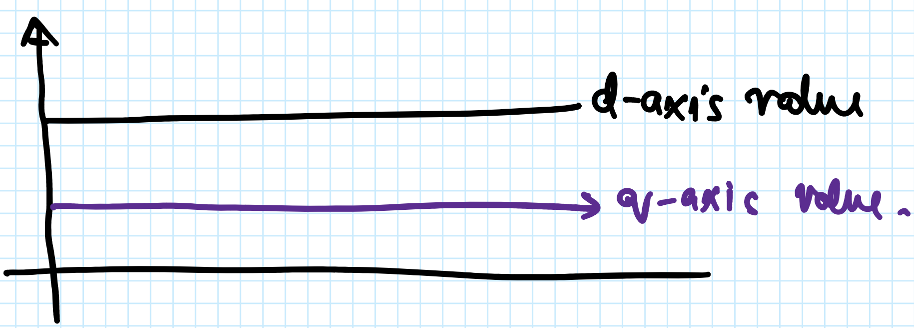


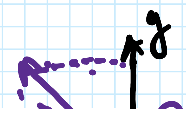
$$[\alpha\beta 0] = [T_{abc}][abc]$$

$$[abc] = [T_{abc}]^{-1}[\alpha\beta 0]$$

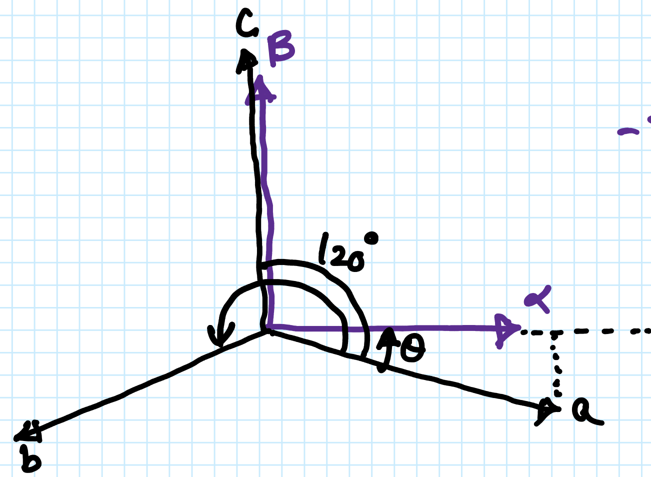


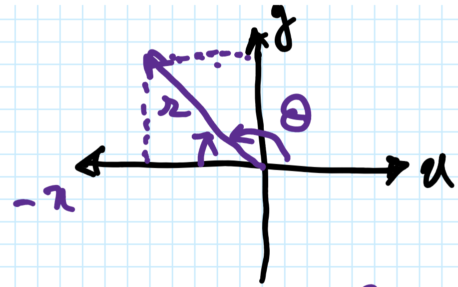






[+ve seq abc]





$x = r\cos\theta$

$y = r\sin\theta$

$x = -r\cos(180 - \theta)$

$$\alpha = a\cos\theta + b\cos(240^\circ - \theta) + c\cos(120^\circ - \theta)$$

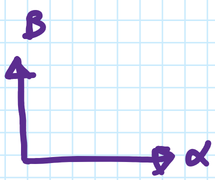
$$\beta = a\sin\theta + b\sin(240^\circ - \theta) + c\sin(120^\circ - \theta)$$

$$\begin{bmatrix}\alpha \\ \beta \\ 0\end{bmatrix} = \frac{2}{3}\begin{bmatrix}\cos\theta & \cos(240^\circ - \theta) & \cos(120^\circ - \theta) \\ \sin\theta & \sin(240^\circ - \theta) & \sin(120^\circ - \theta) \\ 1/2 & 1/2 & 1/2\end{bmatrix}\begin{bmatrix}a \\ b \\ c\end{bmatrix}$$

$\theta = 0 \implies$ α-axis & a-axis are aligned.

$$\begin{bmatrix}\alpha \\ \beta \\ 0\end{bmatrix} = \underbrace{\frac{2}{3}\begin{bmatrix}1 & -1/2 & -1/2 \\ 0 & -\sqrt{3}/2 & +\sqrt{3}/2 \\ 1/2 & 1/2 & 1/2\end{bmatrix}}_{\text{+ve seq abc}}\begin{bmatrix}a \\ b \\ c\end{bmatrix}$$

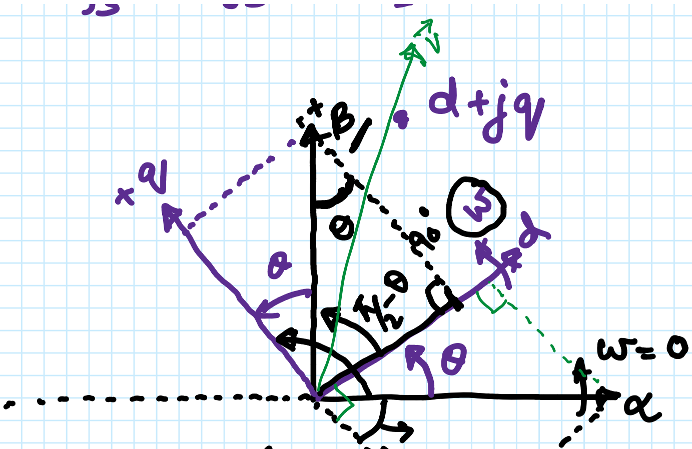
[Tabc]

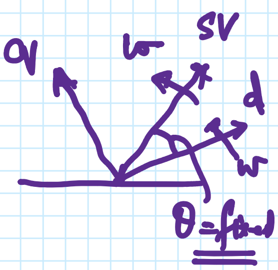


$$V_\alpha = \frac{2}{3}\left[a - \frac{1}{2}b - \frac{1}{2}c\right] = \frac{2}{3}a - \frac{1}{3}b - \frac{1}{3}c$$

$$V_\beta = \frac{-1}{\sqrt{3}}b + \frac{1}{\sqrt{3}}c = \frac{1}{\sqrt{3}}[c - b]$$ +ve seq. abc

$$V_\beta = \frac{1}{\sqrt{3}}b - \frac{1}{\sqrt{3}}c = \frac{1}{\sqrt{3}}[b - c]$$ -ve seq abc





$$d = \alpha \cos\theta + \beta \cos(\pi/2 - \theta)$$

$$d = \alpha \cos\theta + \beta \sin\theta$$

$$q = -\alpha \cos\left(\frac{\pi}{2} - \theta\right) + \beta \cos\theta$$

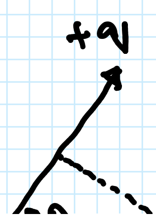
$$q = -\alpha \sin\theta + \beta \cos\theta$$

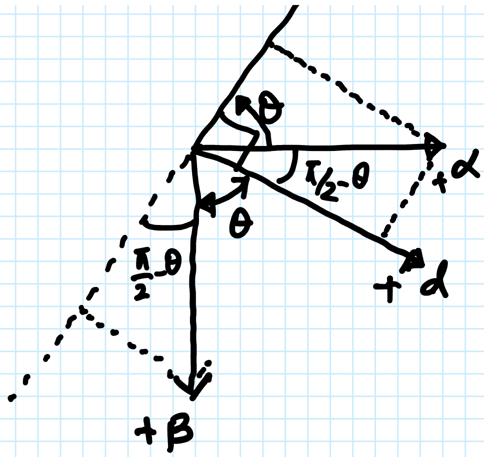
$$\begin{bmatrix} d \\ q \end{bmatrix} = \underbrace{\begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}}_{\alpha\beta \to dq} \begin{bmatrix} \alpha \\ \beta \end{bmatrix} \Rightarrow \begin{bmatrix} \alpha \\ \beta \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}^{-1} \begin{bmatrix} d \\ q \end{bmatrix}$$

$$\begin{aligned} d + jq &= (\alpha \cos\theta + \beta \sin\theta) + j(-\alpha \sin\theta + \beta \cos\theta) \\ &= \alpha(\cos\theta - j\sin\theta) + \beta(\sin\theta + j\cos\theta) \\ &= \alpha(\cos\theta - j\sin\theta) + j\beta(\cos\theta - j\sin\theta) \\ &= (\alpha + j\beta)(\cos\theta - j\sin\theta) \end{aligned}$$

$$\underbrace{d + jq}_{R.F} = \underbrace{(\alpha + j\beta)}_{S.F} e^{-j\theta} \qquad e^{-j\omega t}$$

$$\underbrace{(\alpha + j\beta)}_{S.F} = \underbrace{(d + jq)}_{R.F} e^{j\theta} \qquad e^{j\theta} = e^{j\omega t}$$





$$d = \alpha \sin\theta + \beta \cos\theta$$

$$q = \alpha \cos\theta - \beta \sin\theta$$

$$\begin{bmatrix} d \\ q \end{bmatrix} = \begin{bmatrix} \sin\theta & \cos\theta \\ \cos\theta & -\sin\theta \end{bmatrix} \begin{bmatrix} \alpha \\ \beta \end{bmatrix}$$

$$d + jq = \alpha(\sin\theta + j\cos\theta) + \beta(\cos\theta - j\sin\theta)$$

$$= j\alpha(\cos\theta - j\sin\theta) + \beta(\cos\theta - j\sin\theta)$$

$$\underbrace{d + jq}_{R.F} = \underbrace{(j\alpha + \beta)}_{S.F}\, e^{-j\theta}$$

Example:

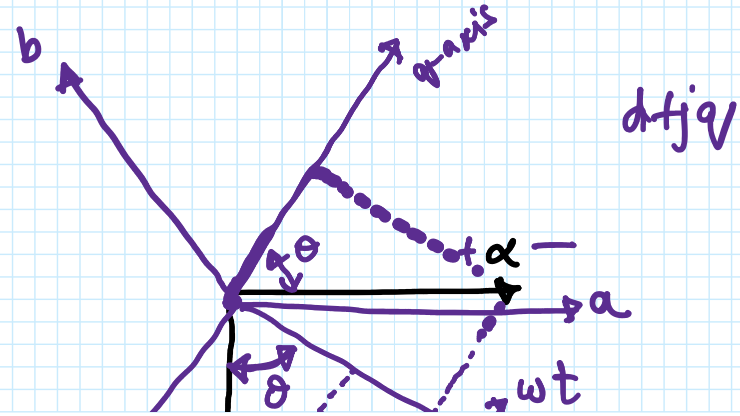
$$V_a = V_m \cos(\omega t + \phi)$$

$$V_b = V_m \cos(\omega t + \phi - 2\pi/3)$$

$$V_c = V_m \cos(\omega t + \phi + 2\pi/3)$$

$\phi = 30°$

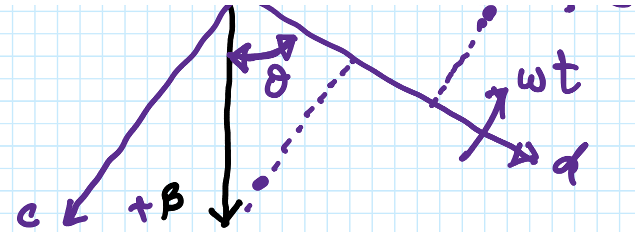
$\phi = 0°$



$V_a + V_b + V_c = 0$

$V_a + V_b + V_c = 0$

$V_b + V_c = -V_a$



$$V_\alpha = \frac{2}{3}\left[V_a - \frac{1}{2}V_b - \frac{1}{2}V_c\right] = V_a$$

$$= \frac{2}{3}\left[V_a - \frac{1}{2}(V_b + V_c)\right] = \frac{2}{3}\left[V_a - \frac{1}{2}(-V_a)\right]$$

$$= \frac{2}{3}\left[V_a + \frac{V_a}{2}\right] = V_a$$

$$\boxed{V_\alpha = V_m \cos(\omega t + \phi)}$$

$\cos A - \cos B = 2\sin\frac{A+B}{2} \cdot \sin\frac{(B-A)}{2}$

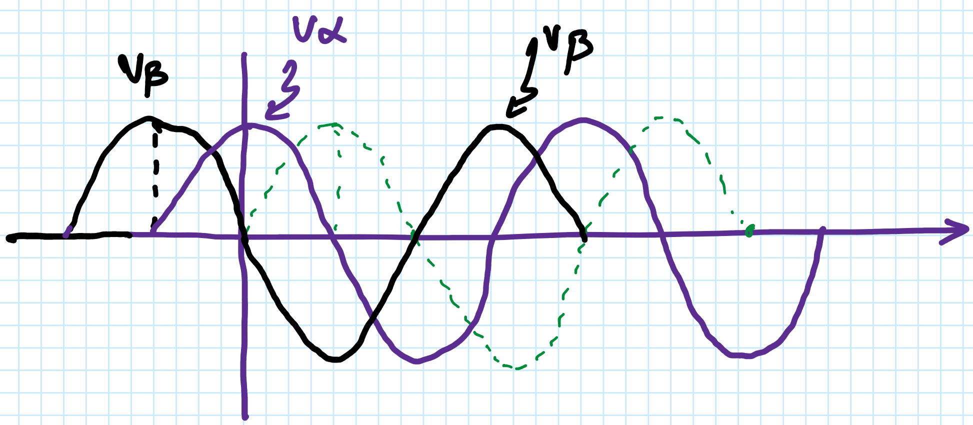
$$V_\beta = \frac{1}{\sqrt{3}}\left[V_c - V_\beta\right]$$

$$= \frac{1}{\sqrt{3}}\left[V_m \cos\left(\omega t + \phi + \frac{2\pi}{3}\right) - V_m \cos\left(\omega t + \phi - \frac{2\pi}{3}\right)\right]$$

$$= \frac{1}{\sqrt{3}}\left[2\sin(\omega t + \phi)\sin(-2\pi/3)\right]$$

$$= \frac{1}{\sqrt{3}}\left[-\frac{\sqrt{3}}{2} \cdot 2\sin(\omega t + \phi)\right]$$

$$\boxed{V_\beta = -V_m \sin(\omega t + \phi)}$$



$$V_\alpha - jV_\beta = V_m \cos(\omega t + \phi) + jV_m \sin(\omega t + \phi)$$

$$= V_m e^{j(\omega t + \phi)}$$

$$v_\alpha - jv_\beta = V_m \cos(\omega t+\phi) + jV_m \sin(\omega t+\phi)$$

$$= V_m e^{j(\omega t+\phi)}$$

$$v_\alpha - jv_\beta = V_m e^{j\omega_e t} \cdot e^{j\phi}$$

$$v_d + jv_q = V_m \cdot e^{j\omega_e t} \cdot e^{j\phi} \cdot e^{-j\omega t}$$

$$V_q = V_\alpha \cos\theta - V_\beta \sin\theta$$

$$V_q = V_m \cos(\omega t+\phi) \cdot \cos\theta + V_m \sin(\omega t+\phi) \cdot \sin\theta$$

$$\boxed{V_q = V_m \cos\phi}$$

$$\omega t = \theta$$

$$V_d = V_\alpha \sin\theta + V_\beta \cos\theta$$

$$= V_m \cos(\omega t+\phi) \sin\theta - V_m \sin(\omega t+\phi) \cdot \cos\theta$$

$$= V_m \sin(-\phi)$$

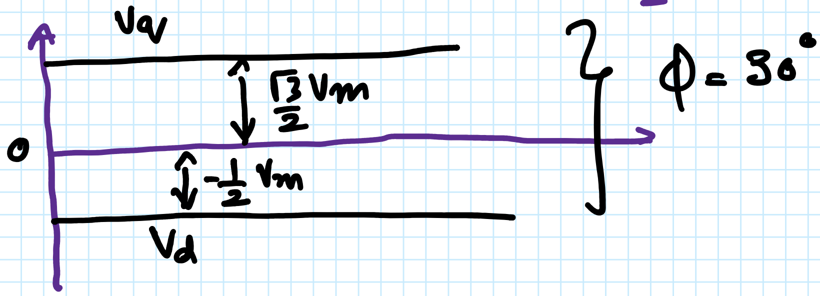
$$V_d = -V_m \sin\phi$$

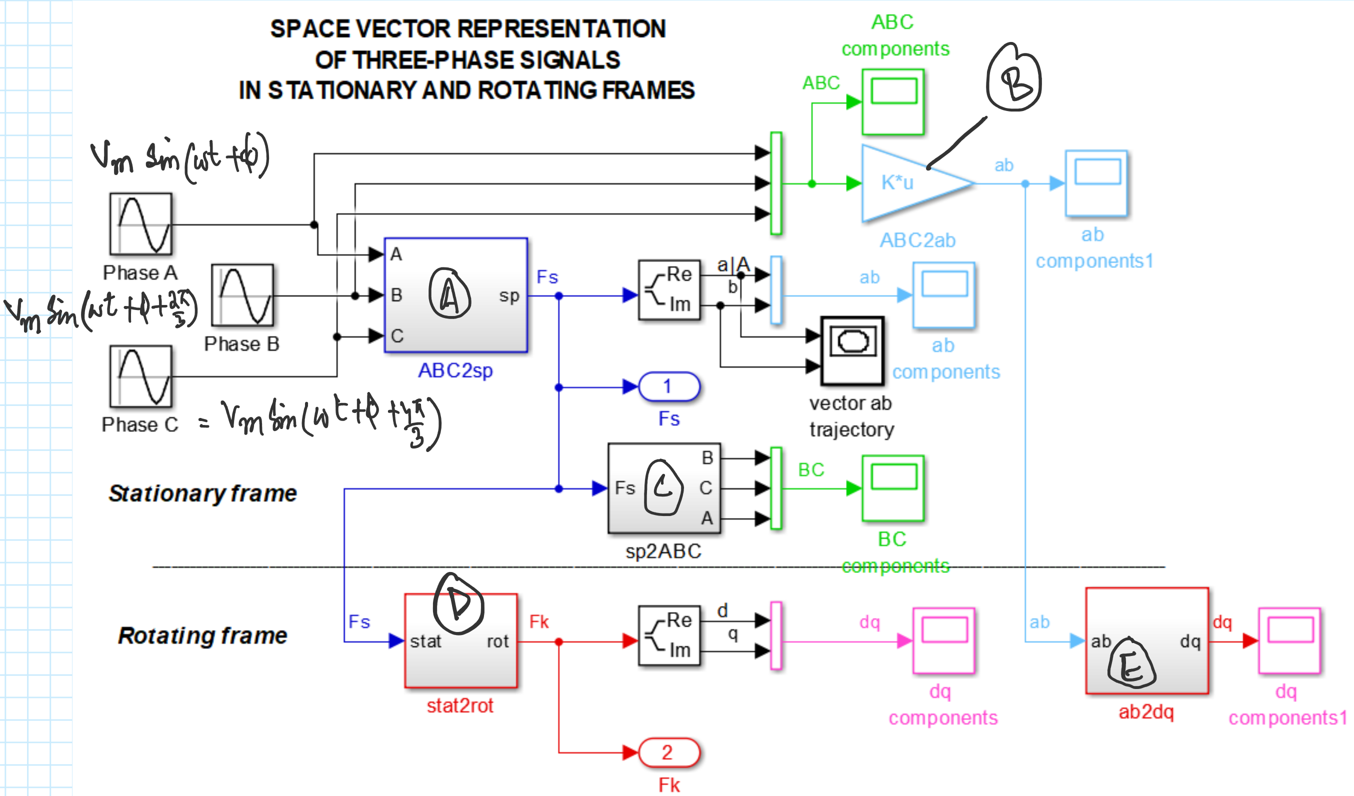
$\phi = 0^\circ$ $\quad V_q = V_m$

$\quad\quad\quad\; V_d = 0$

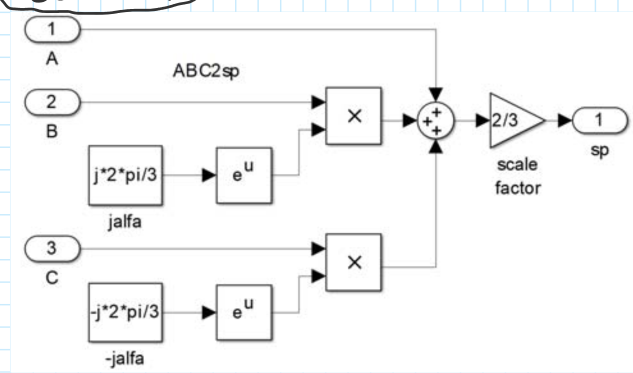
$\phi = 30^\circ$ $\quad V_q = V_m \cos 30^\circ = V_m \frac{\sqrt{3}}{2}$

$\quad\quad\quad\;\; V_d = V_m \sin 30^\circ = \frac{-V_m}{2}$

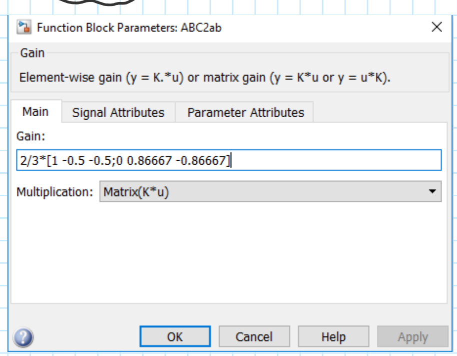




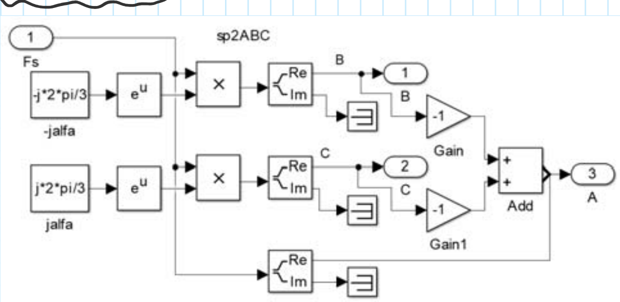
Block A



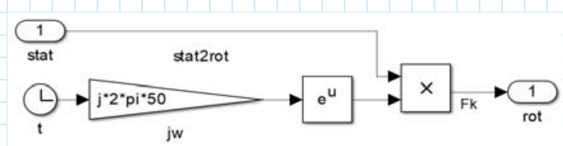
Block B

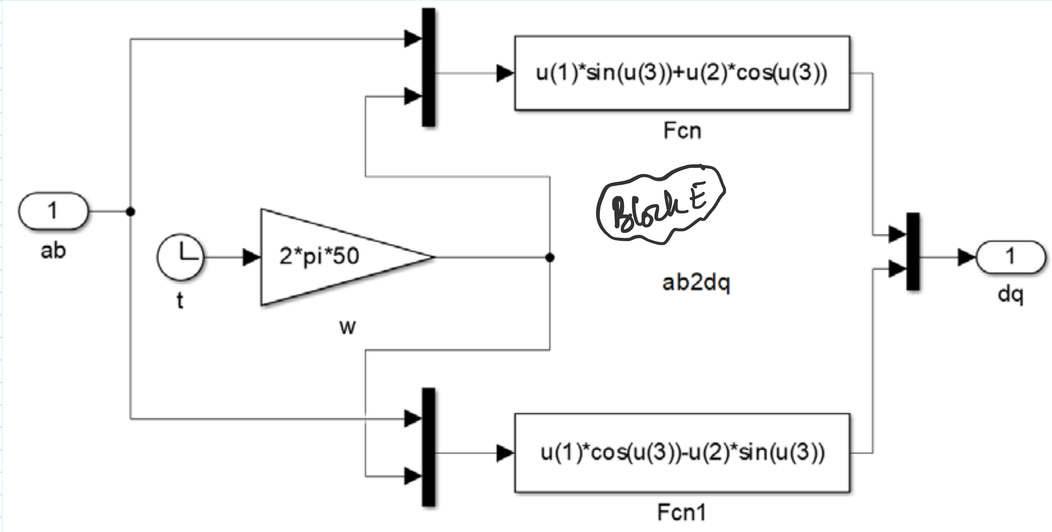


Block C

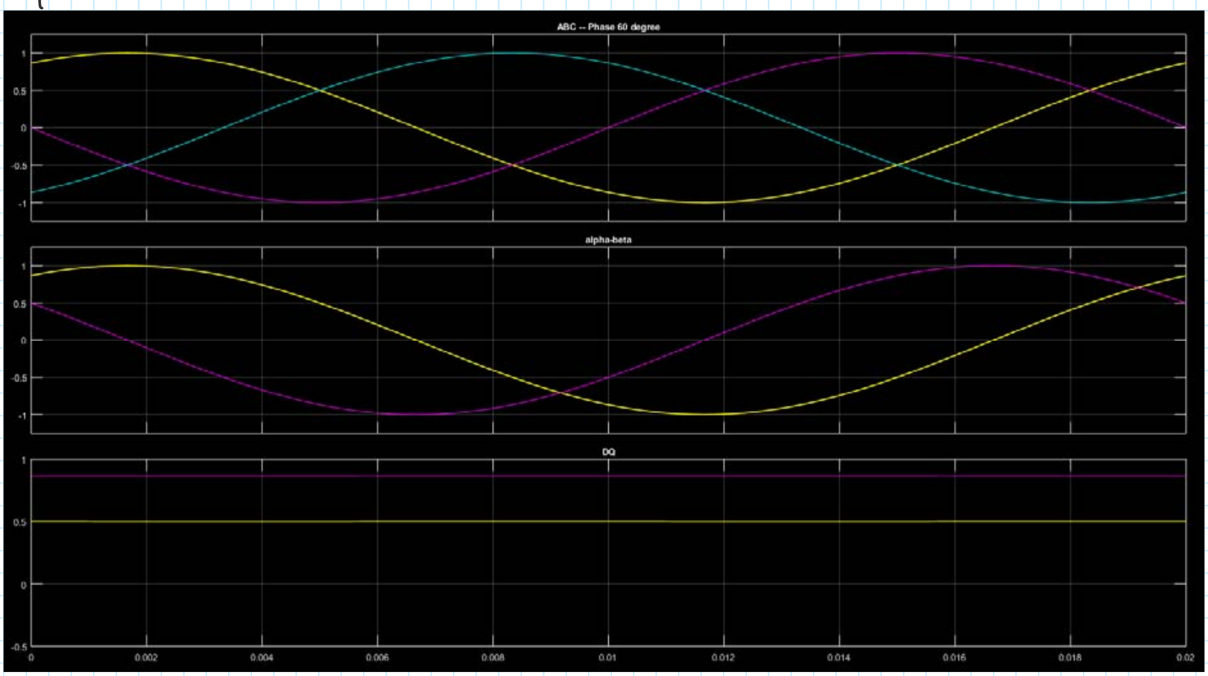


Block D

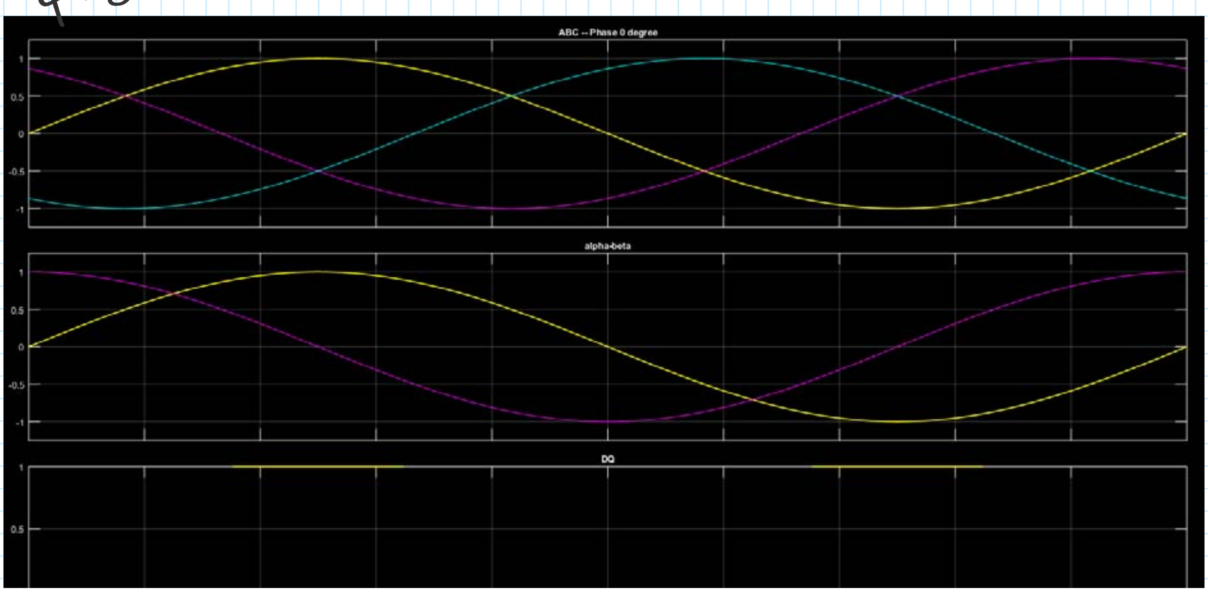


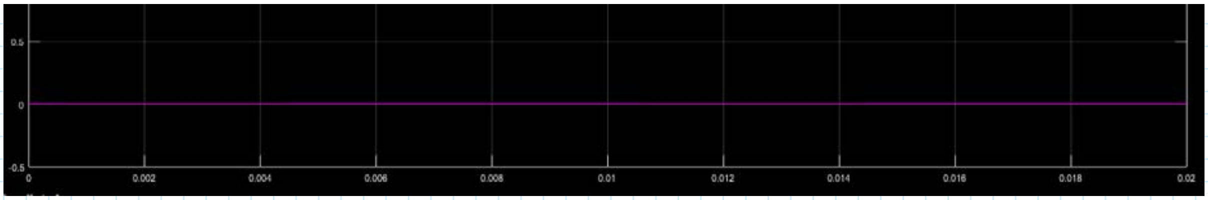


$\phi = 60^0$

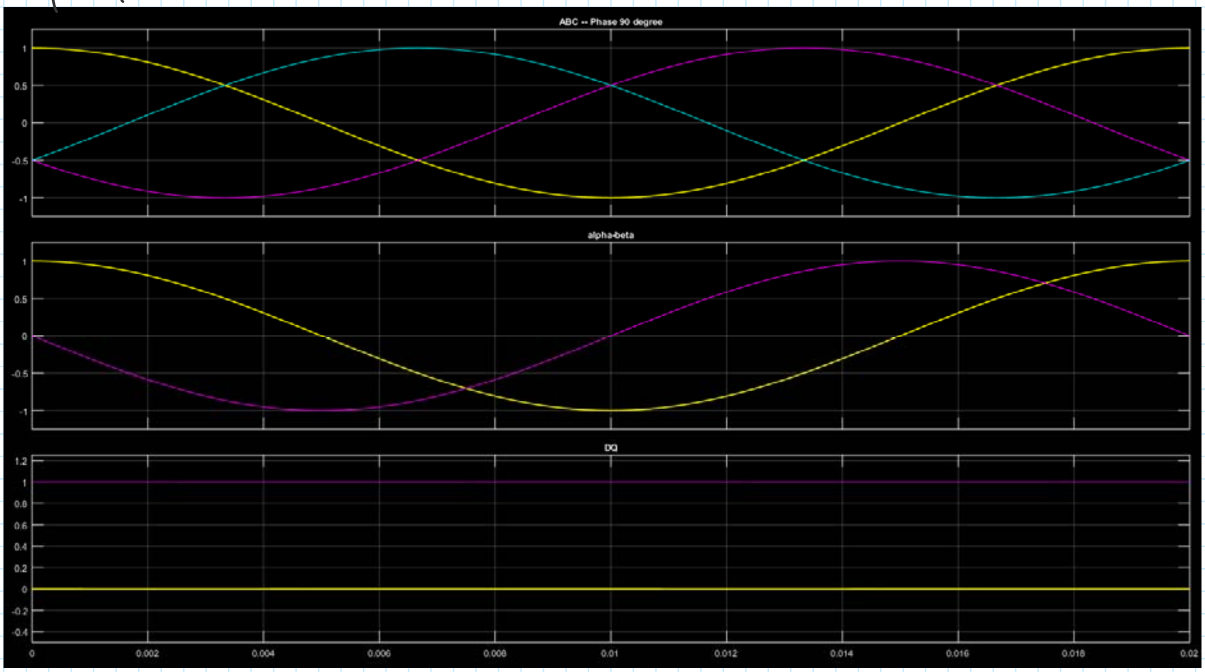


$\phi = 0^0$




0.5
0
-0.5
0
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
0.018
0.02

$\phi = 90^\circ$


ABC -- Phase 90 degree
alpha-beta
DQ
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0.5
-0.5
-1
0
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
0.018
0.02