Answers – Exam 2014. Esbjerg.

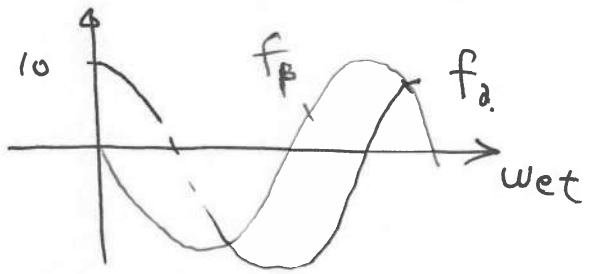
Dynamic modeling of El. machines.

Problem 1.

(1) knowing $\bar{f}_{\alpha\beta} = f_\alpha + j f_\beta$ (the definition).

Now $\bar{f} = 10 e^{j\omega_e t_1} = \bar{f}_{\alpha\beta}$

therefore: $\bar{f}_{\alpha\beta} = 10 e^{j\omega_e t} = 10[\cos(\omega_e t_1) - j\sin(\omega_e t_1)]$



(2) Using the "vector projection method"

$$f_a = \text{Re}\left(\frac{\bar{f}_{\alpha\beta}}{e^{j0^\circ}}\right) = 10 \cdot \cos \omega_e t_1$$

(take the real part) location of phas-a axis

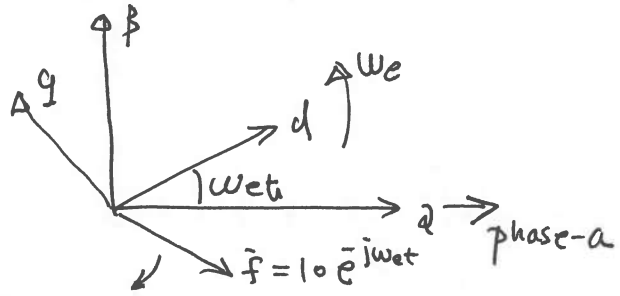
$$f_b = \text{Re}\left(\frac{\bar{f}_{\alpha\beta}}{e^{j120^\circ}}\right) = 10 \cdot \cos(\omega_e t_1 + 120^\circ)$$

location of phase-b axis

$$f_c = \text{Re}\left(\frac{\bar{f}_{\alpha\beta}}{e^{j120^\circ}}\right) = 10 \cdot \cos(\omega_e t_1 - 120^\circ).$$

What we find is that compared to a normal abc sequence, here, phase-b and phase-c are exchanged.

(3)



this is how the reference frames may be defined.

You can see that at $t=0$, $\omega et = 0$, and d-axis is aligned with phase-a axis (and the a-axis).

We use the same vector projection method. Note. for $\bar{f} = 10\,e^{-j\omega et}$, when t increases, it is rotating in a clock-wise (negative) direction.

According to the vector projection method.

$$f_d = Re\left(\frac{\bar{f}_{\alpha\beta}}{e^{j\omega et}}\right) = 10\cdot\cos(2\omega et) \quad \left(\text{Note. } \bar{f}_{\alpha\beta} = \bar{f} = 10\,e^{-j\omega et},\right.$$

↑ location of the d-axis

$$f_q = Re\left(\frac{\bar{f}_{\alpha\beta}}{e^{j(\omega et + 90^\circ)}}\right) = -10\sin(2\omega et).$$

You can now sketch their waveforms. The frequency is 100 Hz.

(4) We use the equation.

$$\bar{f}_{\alpha\beta} = \bar{f}_{abc} = \frac{2}{3}\left(v_a + v_b \cdot e^{j\frac{2\pi}{3}} + V_c e^{-j\frac{2\pi}{3}}\right)$$

$$= \frac{2}{3} \cdot V_{pk}\left[\sin(\omega et) + \sin\left(\omega et + \frac{2\pi}{3}\right) e^{j\frac{2\pi}{3}} + \sin\left(\omega et - \frac{2\pi}{3}\right) e^{-j\frac{2\pi}{3}}\right]$$

The real part. of this term

$$= \sin(\omega et) + \sin\left(\omega et + \frac{2\pi}{3}\right) \cdot \cos\frac{2\pi}{3} + \sin\left(\omega et - \frac{2\pi}{3}\right)\cos\frac{2\pi}{3}$$

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

$$= \sin(\omega et) - \sin(\omega et) \cdot \cos\frac{2\pi}{3} = \frac{3}{2}\sin(\omega et)$$

The imaginary ~~part~~ part.

$$= \sin\left(\omega et + \frac{2\pi}{3}\right) \cdot \sin\frac{2\pi}{3} - \sin\left(\omega et - \frac{2\pi}{3}\right) \cdot \sin\frac{2\pi}{3}$$

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

$$= \sqrt{3} \cdot \cos(\omega et) \cdot \sin\frac{2\pi}{3} = \frac{3}{2}\cos(\omega et)$$

Therefore.

$$\bar{f}_{\alpha\beta} = V_{pk} \cdot \frac{2}{3} \cdot \frac{3}{2} \cdot \left[\sin(\omega et) + j\cos(\omega et)\right]$$

$$= V_{pk} e^{j(\omega et - \frac{\pi}{2})}$$

Then you can do the transformation. to other reference frames using the vector projection method.