

SAARC Training Workshop 'Power System Studies for Synchronization of Multiple Systems'

Generator Models

Day-3-B

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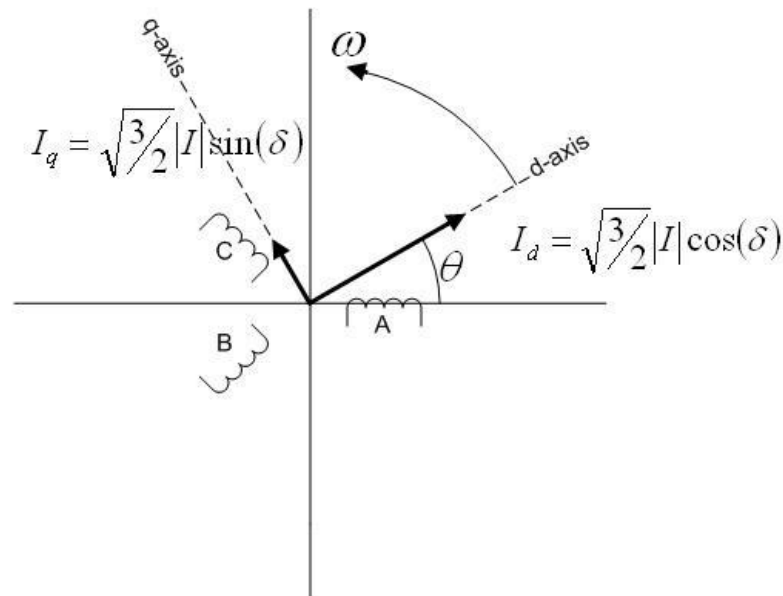
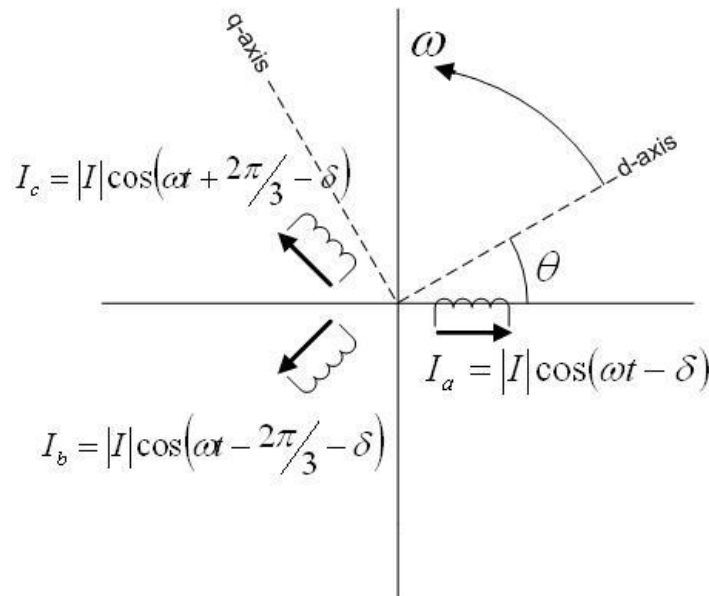
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Transforming Phase Currents to dq axis

The dqo transformation can be thought of in geometric terms as the projection of the three separate sinusoidal phase quantities onto two axes rotating with the same angular velocity as the sinusoidal phase quantities. The two axes are called the direct, or d, axis and the quadrature, or q, axis. Not surprisingly the q-axis is at an angle of 90 degrees to (in quadrature with) the direct axis.



Transforming Phase Currents to dq axis: Contd

➤ The dqo transform applied to three-phase currents is shown below in matrix form

$$I_{dqo} = T I_{abc} = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos(\theta) & \cos(\theta - \frac{2\pi}{3}) & \cos(\theta + \frac{2\pi}{3}) \\ \sin(\theta) & \sin(\theta - \frac{2\pi}{3}) & \sin(\theta + \frac{2\pi}{3}) \\ \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$

➤ The inverse transform is:

$$I_{abc} = T^{-1} I_{dqo} = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos(\theta) & \sin(\theta) & \frac{\sqrt{2}}{2} \\ \cos(\theta - \frac{2\pi}{3}) & \sin(\theta - \frac{2\pi}{3}) & \frac{\sqrt{2}}{2} \\ \cos(\theta + \frac{2\pi}{3}) & \sin(\theta + \frac{2\pi}{3}) & \frac{\sqrt{2}}{2} \end{bmatrix} \begin{bmatrix} I_d \\ I_q \\ I_o \end{bmatrix}$$

➤ Zero Sequence current is:

$$I_0 = \frac{1}{3} (I_a + I_b + I_c)$$

Standard dq-Parameters of Generators

➤ Generators are modeled by parameters resolved across dq-axes as follows:

Parameter	d-axis	q-axis
Synchronous Reactance	X_d	X_q
Transient Reactance	X'_d	X'_q
Sub-Transient Reactance	X''_d	X''_q
Transient OC Time Constant	T'_{do}	T'_{qo}
Sub Transient OC Time Constant	T''_{do}	T''_{qo}
Stator leakage Reactance	X_l	

dq-Parameter of Generator for Round Rotor Machine GENROU

CONs	#	Value	Description
J			$T'_{do} (>0)$ (sec)
J+1			$T''_{do} (>0)$ (sec)
J+2			$T'_{qo} (>0)$ (sec)
J+3			$T''_{qo} (>0)$ (sec)
J+4			H, Inertia
J+5			D, Speed damping
J+6			X_d
J+7			X_q
J+8			X'_d
J+9			X'_q
J+10			$X''_d = X''_q$
J+11			X_l
J+12			S(1.0)
J+13			S(1.2)

Note: X_d , X_q , X'_d , X'_q , X''_d , X''_q , X_l , H, and D are in pu, machine MVA base.

X''_q must be equal to X''_d .

Inertia Constant of Generating Unit (Generator + Turbine)

$$H = \frac{\text{stored energy at rated speed in MWs}}{\text{MVA rating}}$$

$$\text{Stored Energy} = \frac{1}{2} J \omega^2_{0m} \quad \text{W-s}$$

$$\text{Stored Energy} = \frac{1}{2} J \omega^2_{0m} \times 10^6 \quad \text{MW-s}$$

J = moment of inertia in kg.m^2

ω^2_{0m} = rated speed in mech. rad/s

$$\begin{aligned} H &= \frac{1}{2} \frac{J \omega^2_{0m} \times 10^6}{\text{MVA Rating}} \\ &= 5.48 \times 10^{-9} \frac{J (\text{RPM})^2}{\text{MVA rating}} \end{aligned}$$