Derivation of the voltage v_{d1} for the generalised Kron primitive machine voltage matrix, followed by the full KP voltage matrix and the simplified KP voltage matrix......

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In summary:-

Transformer EMF's: d_1d_2, d_2d_1, q_1q_2, q_2q_1

Rotational EMF's: d_1q_1, d_1q_2, q_1d_1, q_2d_2

Instantaneous coil voltages may be written in matrix form:- $[v] = [Z][i]$ where $[Z] = [R + Lp + G\omega]$

e.g. determination of v_{d1}

$$v = iR + \underbrace{L\frac{di}{dt}}_{\text{SELF INDUCED}} + \underbrace{M\frac{di}{dt}}_{\text{ONLY BETWEEN } d_1 \,\&\, d_2} + \left[\underbrace{i\frac{dL}{d\theta}}_{=0,\ \text{since rotor field fixed in space}} + \underbrace{i\frac{dM}{d\theta}}_{q_1 \,\&\, q_2 \text{ both } \perp\text{'r to } d_1}\right]\omega$$

$$\Rightarrow v_{d_1} = i_{d_1}R_{d_1} + L_{d_1}\frac{di_{d_1}}{dt} + M_{d_1d_2}\frac{di_{d_2}}{dt} + \omega i_{q_1}\frac{dM_{d_1q_1}}{d\theta}$$

$$+ \omega i_{q_2}\frac{dM_{d_1q_2}}{d\theta}$$

using p to denote d/dt & $G = \frac{dM}{d\theta} + \frac{dL}{d\theta}$ $= 0.$

$$\Rightarrow v_{d_1} = (R_{d_1} + L_{d_1}p)i_{d_1} + \underbrace{G_{d_1q_1}\omega i_{q_1}}_{\text{Rot. Volts induced in } d_1 \text{ due to current in } q_1} + M_{d_1d_2}p\,i_{d_2} + \underbrace{G_{d_1q_2}\omega i_{q_2}}_{\text{Rot. Volts induced in } d_1 \text{ due to current in } q_2}$$

SUMMERISING:-

The G coefficient is POSITIVE when the FLUX axis LEADS the induced VOLTAGES in the direction of rotation.

e.g. $G_{\underbrace{q_1}_{\text{INDUCED VOLTS}}\underbrace{d_1}_{\text{FLUX AXIS}}}$ d leads q axis $\Rightarrow$ POSITIVE

$\Rightarrow$ Matrix reduces from ....

$$\begin{bmatrix} V_{d_1} \\ V_{q_1} \\ V_{d_2} \\ V_{q_2} \end{bmatrix} = \begin{bmatrix} (R_{d_1}+L_{d_1}p) & G_{d_1q_1}\omega & M_{d_1d_2}p & G_{d_1q_2}\omega \\ G_{q_1d_1}\omega & (R_{q_1}+L_{q_1}p) & G_{q_1d_2}\omega & M_{q_1q_2}\omega \\ M_{d_2d_1}p & 0 & (R_{d_2}+L_{d_2}p) & 0 \\ 0 & M_{q_2q_1}p & 0 & (R_{q_2}+L_{q_2}p) \end{bmatrix} \begin{bmatrix} i_{d_1} \\ i_{q_1} \\ i_{d_2} \\ i_{q_2} \end{bmatrix}$$

...... to .....

$$\begin{bmatrix} V_{d_1} \\ V_{q_1} \\ V_{d_2} \\ V_{q_2} \end{bmatrix} = \begin{bmatrix} (R_{d_1}+L_{d_1}p) & -L_{q_1}\omega & M_d p & -M_q\omega \\ L_{d_1}\omega & (R_{q_1}+L_{q_1}p) & M_d\omega & M_q p \\ M_d p & 0 & (R_{d_2}+L_{d_2}p) & 0 \\ 0 & M_q p & 0 & (R_{q_2}+L_{q_2}p) \end{bmatrix} \begin{bmatrix} i_{d_1} \\ i_{q_1} \\ i_{d_2} \\ i_{q_2} \end{bmatrix}$$