Symmetrical Components Method

1. The method proposes that "N" unbalanced phasors can be decomposed into "N" sets of balanced phasors, with each set having "N" members.

2. Each set of phasors has the same magnitude and successive phases have the same phase angle separation between them.

3. The angle shift between phases in the sequence domain in "α", where $\alpha = 360°/N$

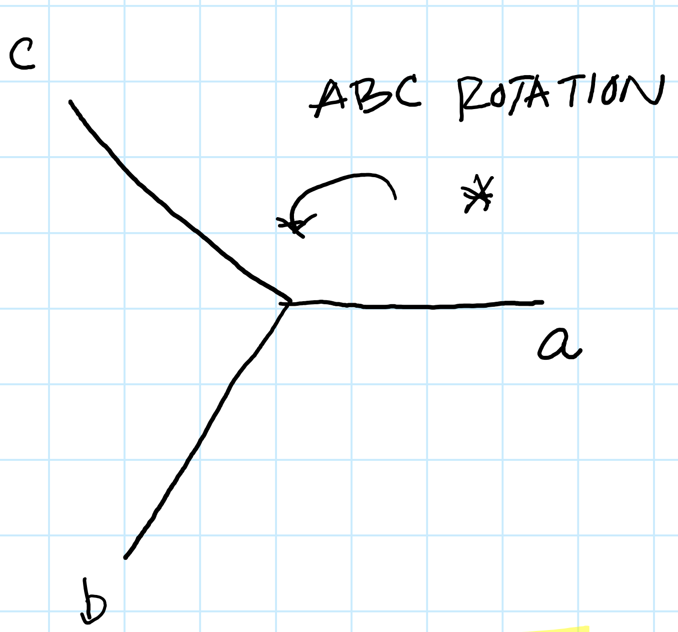
4. The "a" operator is defined as "$a = 1\angle\alpha$". Multiplying a phasor with "a" rotates that phasor by "α" degrees counterclockwise.

5. Within each sequence network, the angular displacement of successive phasors is "$-\alpha \cdot n$", where "n" is the phase sequence network number and where "$n = 0, 1, 2 \ldots N-1$".

Derivation of Sequence Networks for a Three-Phase System

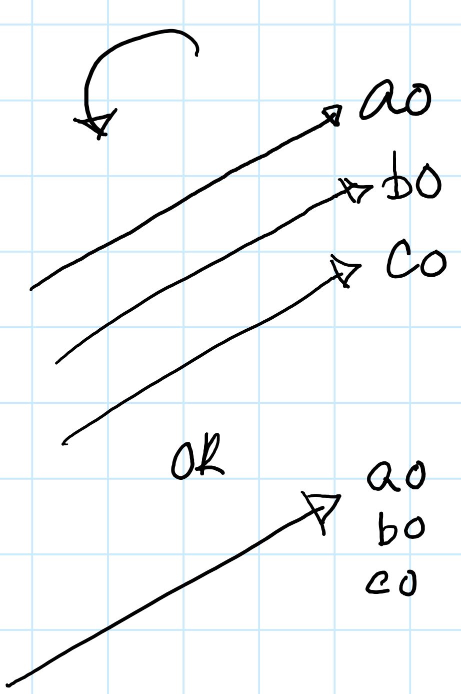
For a 3ϕ system $N = 3$ $\quad \alpha = 360/3 = 120°$ $\quad \boxed{a = 1\angle 120°}$ $\quad n = 0, 1, 2$

PHYSICAL DOMAIN



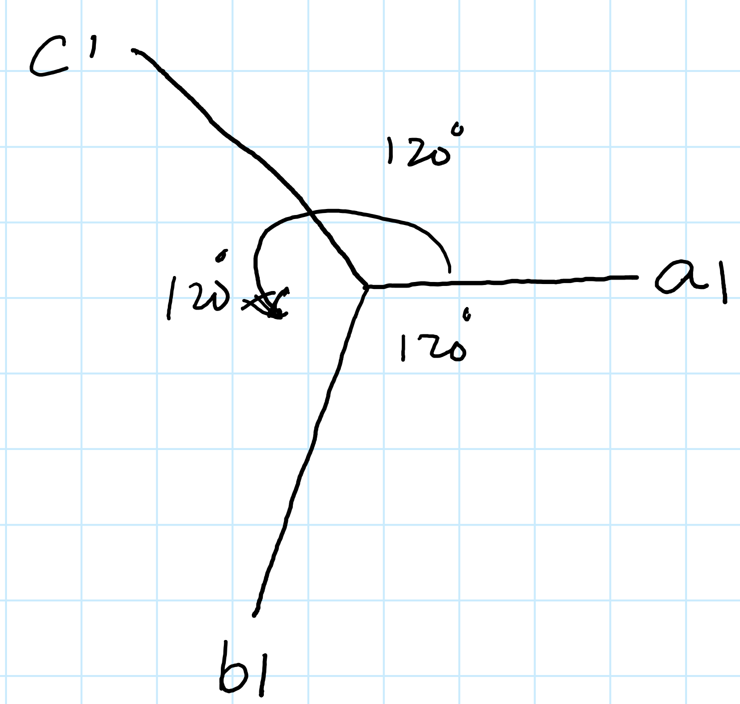
SEQUENCE #0 DOMAIN

$n = 0$; "$-\alpha \cdot n = -120 \times 0 = 0$"



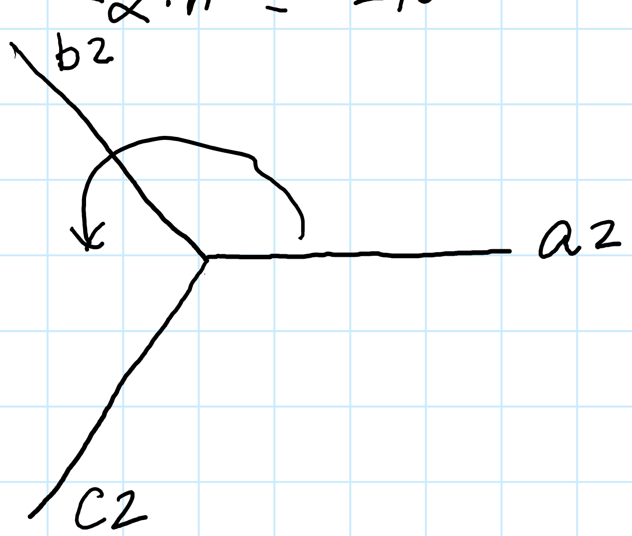
SEQUENCE #1 DOMAIN

$n = 1$; "$-\alpha \cdot n = -120°$"



SEQUENCE #2 DOMAIN

$n = 2$; "$-\alpha \cdot n = -240°$"

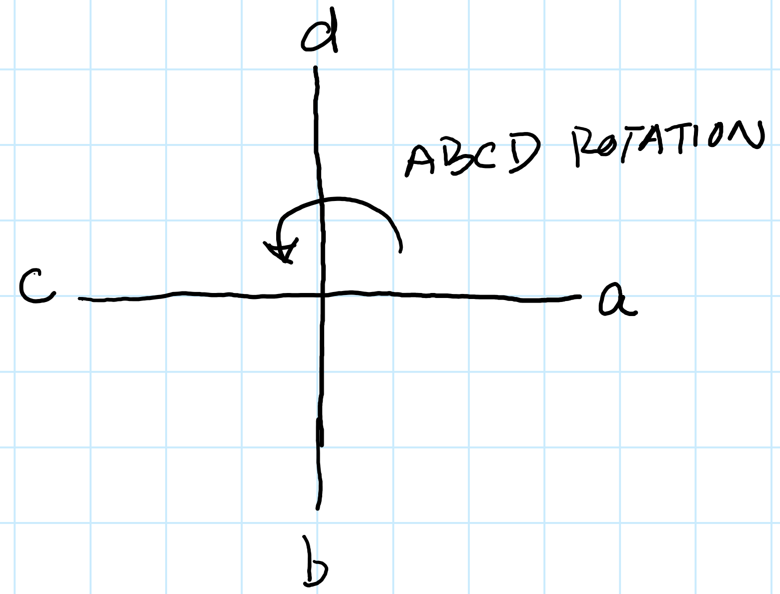


Derivation of Sequence Network Phasors for a Four Phase System

$N = 4$

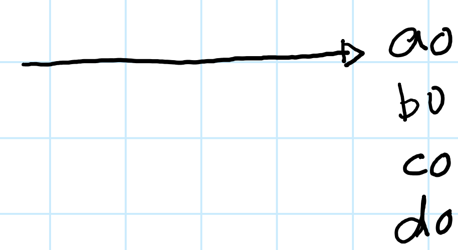
$\alpha = 360/4 = 90^\circ$ $\quad$ $a = 1\angle 90^\circ$ $\quad$ $n = 0, 1, 2, 3$

PHYSICAL DOMAIN



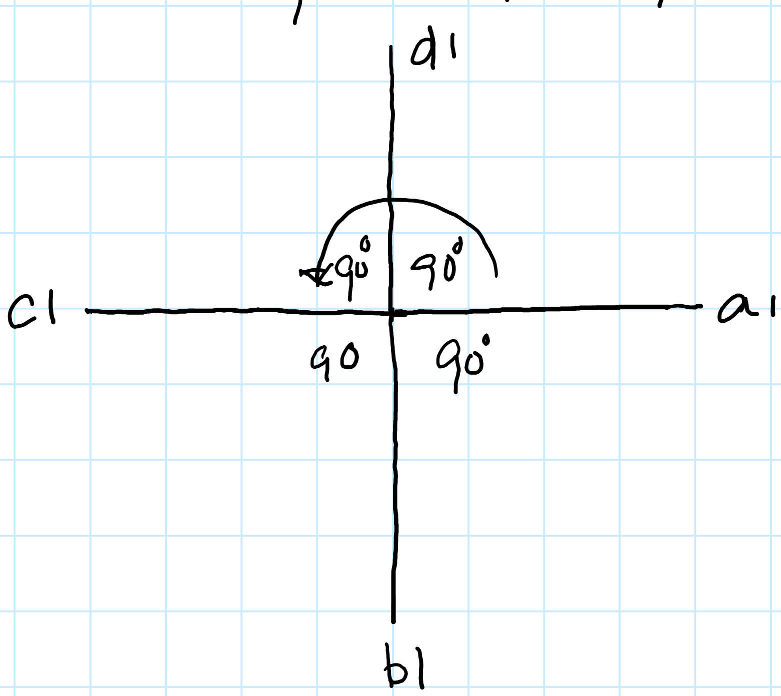
SEQUENCE #0 DOMAINCE

$n = 0$; "$-\alpha \cdot n = 0$"



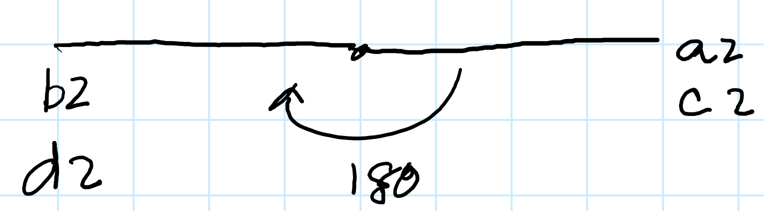
SEQUENCE #1 DOMAIN

$n = 1$; "$-\alpha \cdot n = -90^\circ$"



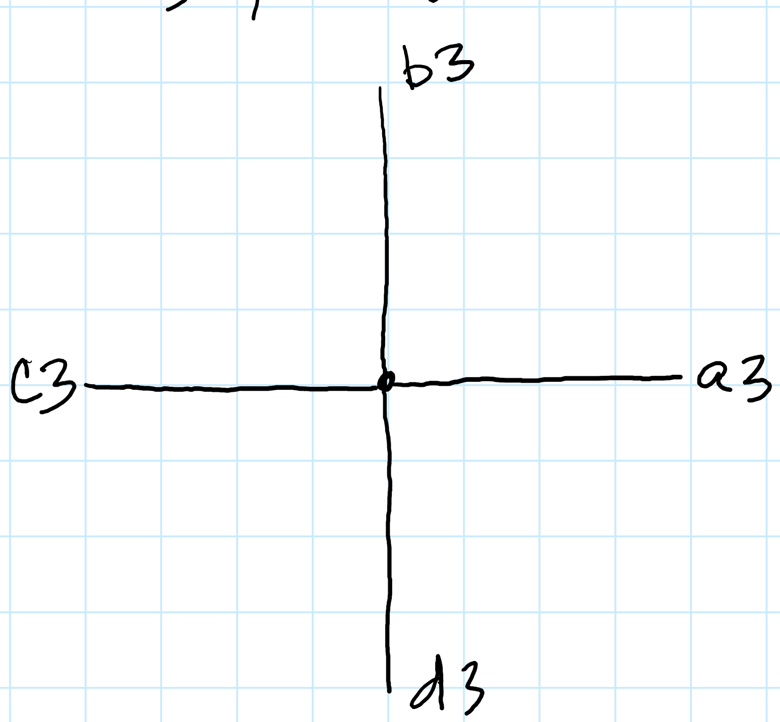
SEQUENCE #2 DOMAIN

$n = 2$ "$-\alpha \cdot n = -180^\circ$"



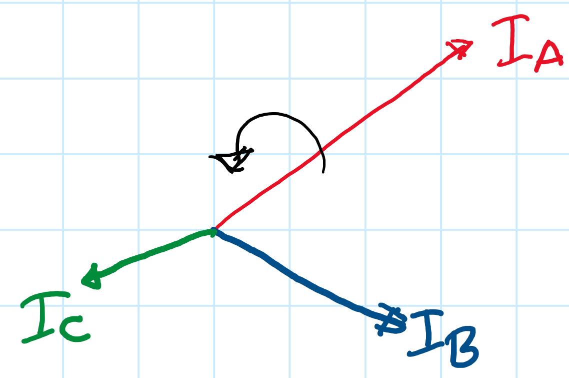
SEQUENCE #3 DOMAIN

$n = 3$; "$-\alpha \cdot n = -270^\circ$"

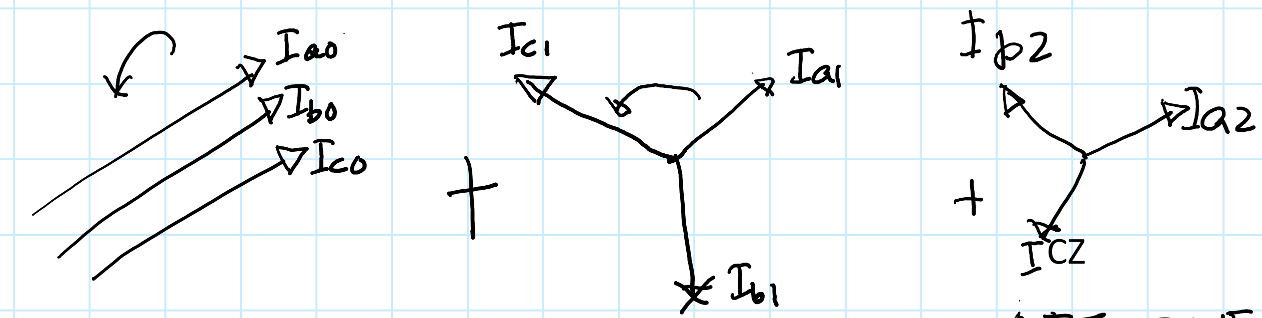


DECOMPOSITION OF AN UNBALANCED SET PHASORS

$a = 1\angle 120°$



$\Rightarrow$



ZERO-SEQUENCE

POSTIVE SEQUENCE

$I_{c1} = a I_{a1}$

$I_{b1} = a^2 I_{a1}$

NEGATIVE SEQUENCE

$I_{b2} = a\, I_{a2}$

$I_{c2} = a^2 I_{a2}$

Phase To Sequence Currents Transformation

$$I_A = I_{A0} + I_{A1} + I_{A2} = I_{A0} + I_{A1} + I_{A2} = I_0 + I_1 + I_2$$

$$I_B = I_{B0} + I_{B1} + I_{B2} = I_{A0} + a^2 I_{A1} + a I_{A2} = I_0 + a^2 I_1 + a I_2$$

$$I_C = I_{C0} + I_{C1} + I_{C2} = I_{A0} + a I_{A1} + a^2 I_{A2} = \underbrace{I_0 + a I_1 + a^2 I_2}$$

We dropped the "A" subscript since we know that they are all referenced to phase "A"

$$I_A = I_0 + I_1 + I_2$$
$$I_B = I_0 + a^2 I_1 + a I_2$$
$$I_C = I_0 + a I_1 + a^2 I_2$$

$1 + a + a^2 = 0$

$$I_A + I_B + I_C = 3I_0 + I_1\,\cancelto{0}{(1 + a^2 + a)} + I_2\,\cancelto{0}{(1 + a + a^2)}$$

$$\boxed{3I_0 = I_A + I_B + I_C}$$

$$I_A = I_0 + I_1 + I_2$$
$$(I_B = I_0 + a^2 I_1 + a I_2)\, a$$
$$(I_C = I_0 + a I_1 + a^2 I_2)\, a^2$$

$$I_A + a I_B + a^2 I_C = I_0\,\cancelto{0}{(1 + a + a^2)} + I_1\,\cancelto{3}{(1 + a^3 + a^3)} + I_2\,\cancelto{0}{(1 + a^2 + a^4)}$$

$$\boxed{3I_1 = I_A + a I_B + a^2 I_C}$$

$$I_A = I_0 + I_1 + I_2$$
$$(I_B = I_0 + a^2 I_1 + a I_2)\, a^2$$
$$(I_C = I_0 + a I_1 + a^2 I_2)\, a$$

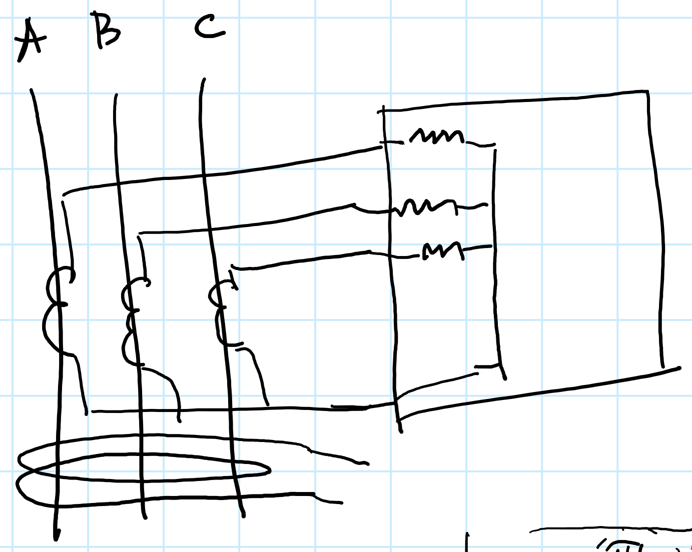
$$I_A + a^2 I_B + a I_C = I_0\,\cancelto{0}{(1 + a^2 + a)} + I_1\,\cancelto{0}{(1 + a^4 + a^2)} + I_2\,\cancelto{3}{(1 + a^3 + a^3)}$$

$$\boxed{3I_2 = I_A + a^2 I_B + a I_C}$$

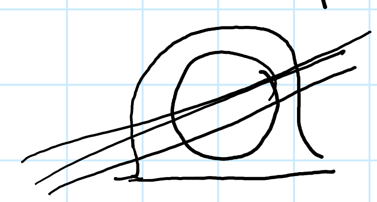
$$I_A = I_0 + I_1 + I_2$$
$$I_B = I_0 + a^2 I_1 + a I_2$$
$$I_C = I_0 + a I_1 + a^2 I_2$$

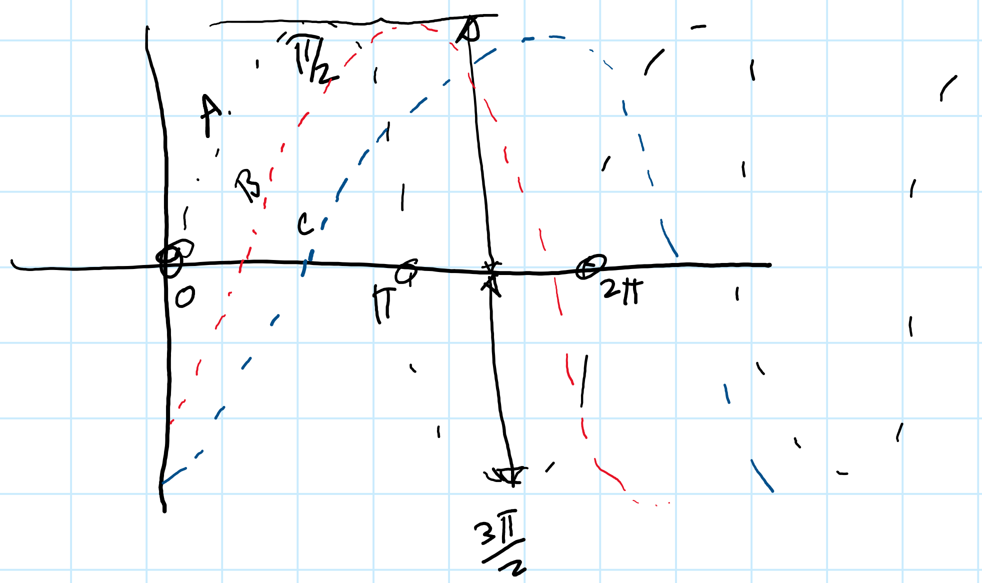
$$\longrightarrow \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} I_0 \\ I_1 \\ I_2 \end{bmatrix}$$

$$[I_P] = [A][I_S]$$



Define $[A] = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix}$





$$I_{RMS} = \frac{I_{MAX}}{\sqrt{2}}$$

RAM = Random Access Memory

$$3I_0 = I_A + I_B + I_C$$
$$3I_1 = I_A + a I_B + a^2 I_C$$
$$3I_2 = I_A + a^2 I_B + a I_C$$

$$\longrightarrow \begin{bmatrix} I_0 \\ I_1 \\ I_2 \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix} \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix}$$