Mathcad Solutions to Assessment Problems from Nilsson and Riedel
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Chapter 11

$\angle(\text{mag}, \text{ang}) := \text{mag}\cdot(\cos(\text{ang}\cdot\text{deg}) + i\cdot\sin($

$/\angle(\text{cval}) := \left(|\text{cval}| \quad \frac{\arg(\text{cval})}{\text{deg}} \right)$

AP 11.1 The voltage from A to N in a balanced threephase circuit is 240∠-30° V. If the phase sequence is positive, what is the value of VBC?

$\sqrt{3}\cdot 240 = 415.69$ $\quad V_b := 240 \angle (-30 - 120)$ $\quad V_c := 240 \angle (-30 + 120)$

$V_{bc} := V_b - V_c = (\,415.69 \quad -120\,)\angle$

AP 11.2 The c-phase voltage of a balanced three-phase Y-connected system is 450∠-25° V. If the phase sequence is negative, what is the value of V_{AB}?

$V_c := 450 \angle -25$ $\quad V_a := 450 \angle (-25 + 120)$ $\quad V_b := 450 \angle (-25 - 120)$

$V_{ab} := V_a - V_b = (\,779.42 \quad 65\,)\angle$

AP 11.3 The phase voltage at the terminals of a balanced three-phase Y-connected load is 2400 V. The load has an impedance of 16 + j12 Ω/ϕ and is fed from a line having an impedance of 0.10 + j0.80 Ω/ϕ). The Y-connected source at the sending end of the line has a phase sequence of acb and an internal impedance of 0.02 + j0.16 Ω/ϕ. Use the a-phase voltage at the load as the reference and calculate (a) the line currents $\mathbf{I}_{aA}$, $\mathbf{I}_{bB}$, and $\mathbf{I}_{cC}$; (b) the line voltages at the source, $\mathbf{V}_{ab}$, $\mathbf{V}_{bc}$, and $\mathbf{V}_{ca}$; and (c) the internal phase-to-neutral voltages at the source, $\mathbf{V}_{a'n}$, $\mathbf{V}_{b'n}$, and $\mathbf{V}_{c'n}$.

$V_a := 2400 \angle 0 \qquad V_c := 2400 \angle -120$

$V_b := 2400 \angle 120 \qquad \text{Load} := (16 + 12j)$

a)

$$I_{aA} := \frac{V_a}{\text{Load}} = (120 \quad -36.87)\angle$$

$$I_{bB} := \frac{V_b}{\text{Load}} = (120 \quad 83.13)\angle$$

$$I_{cC} := \frac{V_c}{\text{Load}} = (120 \quad -156.87)\angle$$

$\text{Line} := 0.1 + j\cdot 0.8 \qquad \text{Line} = (0.81 \quad 82.87)\angle$

$Z := 0.02 + j\cdot 0.16 \qquad Z = (0.16 \quad 82.87)\angle$

$$V_A := V_a + I_{aA}\cdot\text{Line} = (2468.18 \quad 1.62)\angle$$

$$V_B := V_b + I_{bB}\cdot\text{Line} = (2468.18 \quad 121.62)\angle$$

$$V_C := V_c + I_{cC}\cdot\text{Line} = (2468.18 \quad -118.38)\angle$$

b)

$$V_{AB} := V_A - V_B = (4275.02 \quad -28.38)\angle$$

$$V_{BC} := V_B - V_C = (4275.02 \quad 91.62)\angle$$

$$V_{CA} := V_C - V_A = (4275.02 \quad -148.38)\angle$$

c)

$$V_{a'n} := V_A + I_{aA}\cdot Z = (2482.05 \quad 1.93)\angle$$

$$V_{b'n} := V_B + I_{bB}\cdot Z = (2482.05 \quad 121.93)\angle$$

$$V_{c'n} := V_C + I_{cC}\cdot Z = (2482.05 \quad -118.07)\angle$$

AP 11.4 The current $\mathbf{I}_{CA}$ in a balanced three-phase Δ-connected load is 8 ∠-15° A. If the phase sequence is positive, what is the value of $\mathbf{I}_{cC}$?

$I_{CA} := 8 \angle -15 \qquad I_{BC} := 8 \angle 105 \qquad 8\cdot\sqrt{3} = 13.86$

$I_{cC} := I_{CA} - I_{BC} = (\, 13.86 \quad -45 \,) \angle$

AP 11.5 A balanced three-phase Δ-connected load is fed from a balanced three-phase circuit. The reference for the b-phase line current is toward the load. The value of the current in the b-phase is 12∠65° A. If the phase sequence is negative, what is the value of $\mathbf{I}_{AB}$?

$I_b := 12 \angle 65 \qquad I_a := 12 \angle (65 - 120) = (\, 12 \quad -55 \,) \angle$

$\frac{I_a - I_b}{3} = (\, 6.93 \quad -85 \,) \angle$

$I_{AB} := \left(\frac{12}{\sqrt{3}}\right) \angle -85 = (\, 6.93 \quad -85 \,) \angle$

AP 11.6 The line voltage $\mathbf{V}_{AB}$ at the terminals of a balanced three-phase Δ-connected load is $4160\angle 0°$ V. The line current $\mathbf{I}_{aA}$ is $69.28\angle -10°$ A.

a) Calculate the per-phase impedance of the load if the phase sequence is positive.

b) Repeat (a) for a negative phase sequence.

$$V_{AB} := 4160 \angle 0$$

a)

$$I_{aA} := 69.28 \angle -10 \qquad I_{bB} := 69.28 \angle -130 \qquad I_{AB} := \frac{I_{aA} - I_{bB}}{3} = (40 \quad 20)\angle$$

$$Z := \frac{V_{AB}}{I_{AB}} = (104 \quad -20)\angle\Omega$$

b)

$$I_{bB} := 69.28 \angle 110 \qquad I_{AB} := \frac{I_{aA} - I_{bB}}{3} = (40 \quad -40)\angle$$

$$Z := \frac{V_{AB}}{I_{AB}} = (104 \quad 40)\angle\,\Omega$$

AP 11.7 The line voltage at the terminals of a balanced Δ-connected load is 110 V. Each phase of the load consists of a 3.667 Ω resistor in parallel with a 2.75 Ω inductive impedance. What is the magnitude of the current in the line feeding the load?

$$\|(a,b) := \frac{a \cdot b}{a + b}$$

$$Z := (3.667\Omega)\,\|\,(j\cdot 2.75\Omega) \qquad I_{ab} := \frac{110V}{Z} \qquad \frac{I_{ab}}{A} = (50 \quad -53.13)\angle$$

$$I_{aA} := 50\cdot\sqrt{3} = 86.6$$

AP 11.8 The three-phase average power rating of the central processing unit (CPU) on a mainframe digital computer is 22,659 W. The three-phase line supplying the computer has a line voltage rating of 208 V (rms). The line current is 73.8 A (rms). The computer absorbs magnetizing VARs.

a) Calculate the total magnetizing reactive power absorbed by the CPU.

b) Calculate the power factor.

$$VA \equiv W$$

$$VAR \equiv W$$

$$P := 22659W$$

$$V_a := 208V \qquad I_a := 73.8A$$

$$p := \sqrt{3} \cdot V_a \cdot I_a = 26587.67\,VA$$

a) $$Q := \sqrt{p^2 - P^2} = 13909.5\,VAR$$

b) $$\frac{P}{p} = 0.85$$ lagging

AP 11.9 The complex power associated with each phase of a balanced load is 144 + j192 kVA. The line voltage at the terminals of the load is 2450 V.
a) What is the magnitude of the line current feeding the load?
b) The load is delta connected, and the impedance of each phase consists of a resistance in parallel with a reactance. Calculate R and X.
c) The load is wye connected, and the impedance of each phase consists of a resistance in series with a reactance. Calculate R and X.

$$P := (144 + 192j)\cdot 1000$$

$$V_{an} := \frac{2450}{\sqrt{3}}$$

$$I' := \frac{P}{V_{an}} = 101.8 + 135.74j$$

$$I_{aA} := \overline{I'} = (169.67 \quad -53.13)\angle$$

$$|I_{aA}| = 169.67$$

b) $$R := \frac{(2450V)^2}{144000W} = 41.68\,\Omega$$

$$X := \frac{(2450V)^2}{192000\cdot VAR} = 31.26\,\Omega$$

c) $$\frac{V_{an}}{I_{aA}} = 5 + 6.67j \qquad R := 5\Omega \qquad X := 6.67\Omega$$