Answers

1.1

(a) $1.732\angle -150°$ (b) $2\angle 0°$ (c) $1\angle 0°$ (d) $1\angle -30°$

1.3

(i) $I_1 = 43.2$ A, $I_2 = 30.5$ A, $I_4 = 28.4$ A

(ii) 190.75 V

1.4

(i) 19.74 μF (ii) 796 J

1.6

(a) 7.9 kW, -197.3 kvar

(b) (i) 11.66 kΩ (ii) 5.92 kW, 197.3 kvar (iii) 13.81 kW (iv) 3.36 kV

1.7

Machine 1 receives 1 kW (motoring) and supplies 268 vars.

Machine 2 supplies 1 kW and 268 vars.

The inductor receives 536 vars.

1.8

$12.87 + j6.16$ VA

1.9

13.52 kV, 610.2 kW, 72.3 kvar, 614.5 kVA

1.10

205 MW, -25.8 Mvar, 214.7 kV

1.11

A in: $15.6 + j11.7$ MVA A out: $15.6 + j9.5$ MVA

B in: $8.4 + j6.3$ MVA B out: $8.4 + j5.1$ MVA

1.12

(a) $\sqrt{3}$ (b) There are two possible answers, can you find both?

2.1

$P = 2.05$, $Q = -0.258$, $|V| = 0.976$

2.2

$0.049 + j0.42$ p.u.

2.3

(a) $\theta_{12} = 26.08°$, $Q_{12} = 40.66$ Mvar, $Q_{12} = -6.91$ Mvar

(b) $S_{12} = 245 + j245$ MVA, $S_{12} = 245 - j245$ MVA, half-way voltage = 99 kV

2.4

-6%

2.5

(a) $V_0 = 9.36 \angle 17.1°$ kV, $V_1 = 9.36 \angle 22.3°$ kV, $V_2 = 6.31 \angle -86.5°$ kV

(b) $1.94 \angle 46.3°$ kV

(c) 5.48 MW

2.6

(a) $Z_0 = 0.020 + j0.220\,\Omega$, $Z_1 = Z_2 = 0.020 + j0.1257\,\Omega$

(b) $Z_0 = 0.0165 + j0.1818$ p.u., $Z_1 = Z_2 = 0.0165 + j0.104$ p.u.

2.7

$V_A = 0$ p.u., $V_B = 1.418 \angle -137.8°$ p.u., $V_C = 1.418 \angle 137.8°$ p.u.

3.1

(a) 0.5 p.u. (b) 0.866 p.u.

3.2

(a) $I_{HV} = 38.46 \angle 90°$ A, $I_{LV} = 660.7 \angle 76°$ A, $I_{TV} = 80 \angle 0°$ A

(b) $|S_{HV}| = 384.6$ kVA, $|S_{LV}| = 396.4$ kVA, $|S_{TV}| = 96$ kVA.

3.3

(a) 250 kVA (b) $(0.24 + j0.4)\%$

3.4

$Z_1 = (0.50 + j2.82)\%$, $Z_2 = (0.50 + j2.18)\%$, $Z_3 = (0.58 + j2.70)\%$

Note: It is unusual for the reactances to be so similar. It is more common to have one of the reactances turn out negative.

3.5

(a) Fault current $= 16.3 \angle -86.4°$ p.u.

(c) (i) 83.8 kVA (ii) $(0.39 + j5.1)\%$

3.9

(a) 288.7 kVA

(b) (i) 2.13% (ii) 0.37%

4.2

$(298.4 + j265.5)$kVA and $(151.6 + j131.3)$kVA

4.3

HV $24.9\angle -90°$ A into transformer 1

LV $63.6\angle -90°$ A from transformer 1

TV $15.9\angle 60°$ A from transformer 1

4.4

(a) $13.91\angle 0°$ A , $13.91\angle -120°$ A , $13.91\angle 120°$ A

(b) 0 A, $12.05\angle -90°$ A , $12.05\angle 90°$ A

(c) $13.91\angle 0°$ A , $6.955\angle 180°$ A , $6.955\angle 180°$ A

5.1

(a) 7.54 pF/m (b) 12.70 pF/m (c) 12.14 pF/m

5.2

(a) 1.146 μH/m (b) 0.54 μH/m (c) 0.587 μH/m

5.3

$L = 1.098\ \mu\text{Hm}^{-1}$, $C = 10.76\ \text{pFm}^{-1}$ with earth, $C = 10.61\ \text{pFm}^{-1}$ without

5.4

1220 V using standard formulae. No.

5.5

0.44 V/km

5.6

200.6 pF/m 0.424 μH/m

6.2

(a) $\frac{1}{y_{12}} = 20.08 + j87.2\,\Omega$, $y_{10} = 0.995 + j518.2\ \mu\text{S}$

(b) (i) $124.58\angle 5.9°$ kV/phase, $180.3\angle 46.2°$ A, $51.4 - j43.6$ MVA

(ii) $130.46\angle 5.3°$ kV/phase or 226 kV line-to-line

(c) 165 MW

6.3

(a) 2406 Mvar (b) 974 Mvar (c) 835 kV line-to-line

(d) 466 Mvar each end and 932 Mvar at mid-point

7.1

(a) 2.1 A (b) 59.3 A