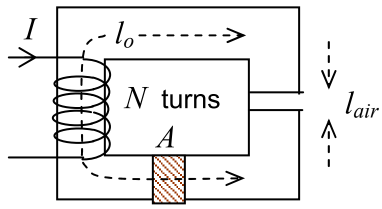
# UEE 201 - THEORY OF ELECTRICITY - Answers

## Final Part I Examination Repeat - July 2002

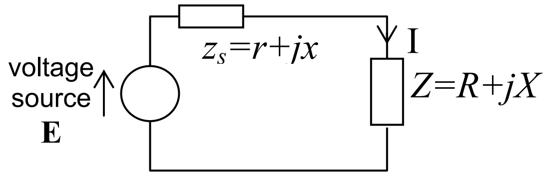
A1 (a) Effective reluctance $S = \dfrac{l_0}{\mu A} + \dfrac{l_{air}}{\mu_0 A}$




Inductance $= \dfrac{N^2}{\dfrac{l_0}{\mu A} + \dfrac{l_{air}}{\mu_0 A}}$

(b) $I = \sqrt{\dfrac{P}{R}}$

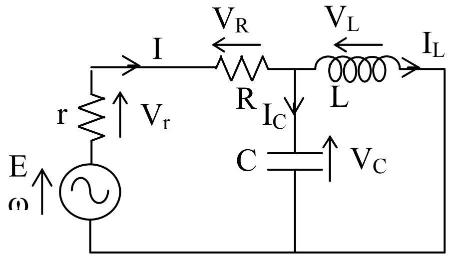
$E = \sqrt{\dfrac{(R+r)^2 + (X+x)^2}{R} \cdot P}$




(c) at resonance $L\omega = 1/C\omega$

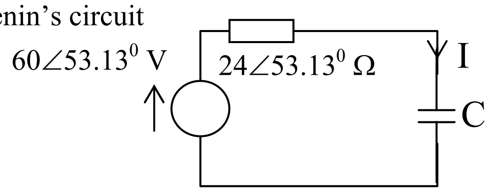
$L = 2.533$ mH

$Q = (R+r)/L\omega = 1.005$




(d) $V_{oc} = 60\angle 53.13^0$ V, $Z_{th} = 24\angle 53.13^0\ \Omega = 14.4 + j19.2$

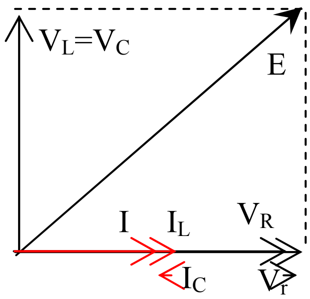
Thevenin's circuit



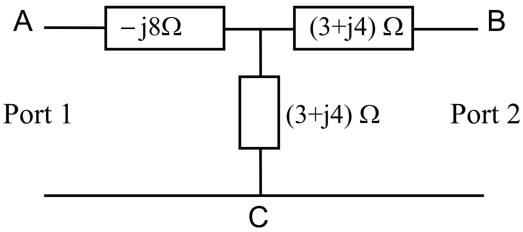

(e) $C \to -j\,333.3\ \Omega$, $L \to j\,30\ \Omega$

Taking $V_C$ as vertical,

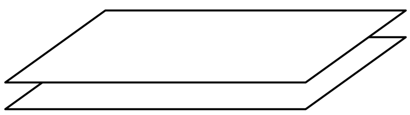
Phasor diagram




(f) $Z_{AB} = 3 - j\,12\ \Omega$




(g)



C = 50 pF

thickness d = 15.5 μm

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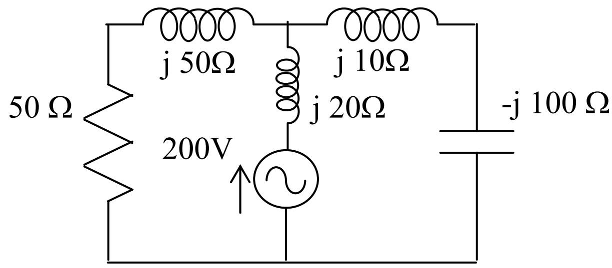
A2. Uncoupled equivalent circuit

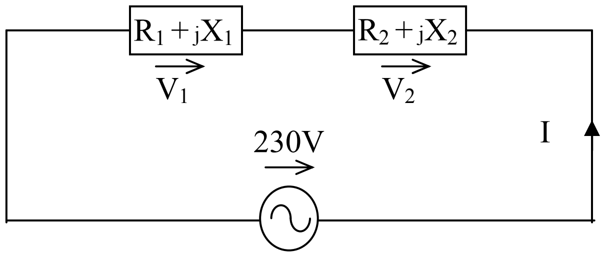



Current supplied = $2.016\angle{-5.22^0}$ A

Power supplied = 401.6 W

Supply power factor = 0.996 lag

A3. $R_1+R_2 = 123.46\ \Omega$

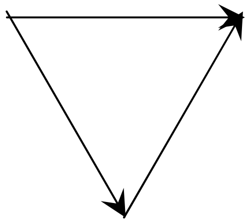



$|Z_1| = |Z_2| = |Z| = 127.78\ \Omega$

$X_1+X_2 = \pm\ 32.94\ \Omega$

$\cos\phi = 0.9662,\ \phi = \pm\ 14.94^0$

One solution



E $= 230\angle 0^0$ V, $V_1 = 230\angle{-60^0}$ V, $V_2 = 230\angle 60^0$ V,

$Z_1$ $= 127.78\angle{-74.94^0}$ or $127.78\angle{-45.06^0}\ \Omega$

$= 33.20 - j123.39$, or $90.26 - j\ 90.45$

$Z_2$ $= 90.26 + j90.45$, or ....

Thus for this solution

$R_1 = 33.20\ \Omega$, $X_1 = 123.29\ \Omega$ inductive, $R_2 = 90.26\ \Omega$, $X_2 = 90.45\ \Omega$ capacitive,

A4. (i) Current supplied to Load = $4.62\angle{-36.87^0}$ A

(ii) Active power supplied to load = 2.56 kW

(iii) Line voltage at supply = $413.9\angle 0.73^0$ V

(iv) Power factor at supply = 0.792 lag

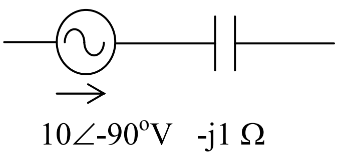
Reactive power at load = 1.92 k var, new power factor = 0.95 giving $\phi_{new} = 18.19^0$

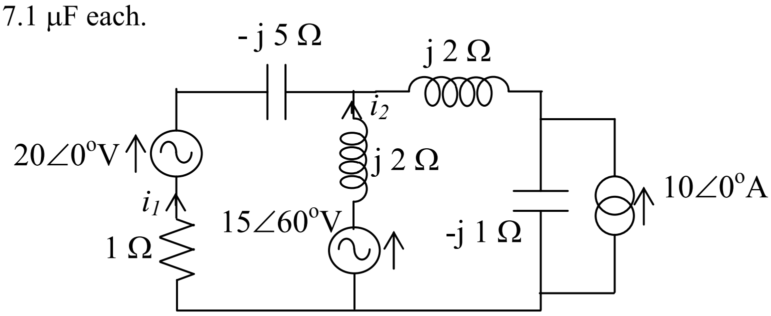
New reactive power required = 0.841 k var

Thus reactive power supplied by each capacitor = (1.92 – 0.841)/3 = 0.36 k var

Value of each capacitor = 7.1 μF each.

A5. (a) Equivalent voltage source




(b) Mesh impedance matrix

$$[Z_m] = \begin{bmatrix} 1-j3 & -j2 \\ -j2 & j3 \end{bmatrix}$$

(c) Mesh voltage source vector

$$E_{gm} = \begin{bmatrix} 18.02\angle -46.10^0 \\ 24.18\angle 71.93^0 \end{bmatrix}$$

(d) $i_1 = 3.97\angle 84.6^0$ A

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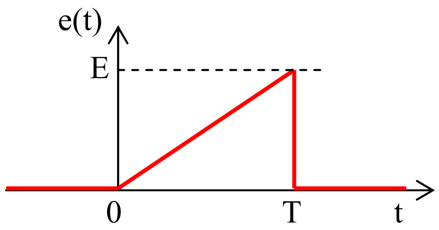
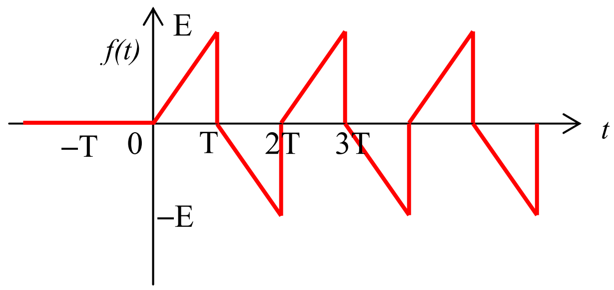
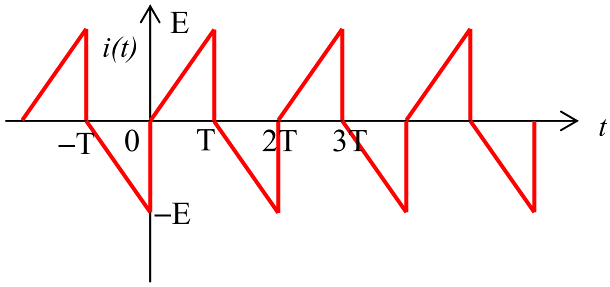
A6.




$$E(s) = -\frac{E}{s}\cdot e^{-sT} - \frac{E}{s^2T}\cdot(e^{-sT}-1)\,, \qquad F(s) = \frac{1}{1+e^{-sT}}\left[-\frac{E}{s}\cdot e^{-sT} - \frac{E}{s^2T}\cdot(e^{-sT}-1)\right]$$

A7. (a)

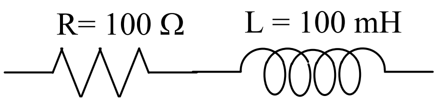



mean = $a_0/2$ = 0, half wave symmetry → no even harmonics, period = 2T

$$a_n = -\frac{4E}{n^2\pi^2}, \quad b_n = \frac{2E}{n\pi}$$

$$i(t) = \left(-\frac{4E}{\pi^2}\cos\omega_0 t + \frac{2E}{\pi}\sin\omega_0 t\right) + \left(-\frac{4E}{9\pi^2}\cos 3\omega_0 t + \frac{2E}{3\pi}\sin\omega_0 t\right) + \left(-\frac{4E}{25\pi^2}\cos 5\omega_0 t + \frac{2E}{5\pi}\sin 5\omega_0 t\right) + \left(-\frac{4E}{49\pi^2}\cos 7\omega_0 t + \frac{2E}{7\pi}\sin 7\omega_0 t\right) + \ldots\ldots$$

(b)




v = R i + L p i

fundamental term of voltage

$$v(t) = 100\times\left(-\frac{4E}{\pi^2}\cos\omega_0 t + \frac{2E}{\pi}\sin\omega_0 t\right) + 100\times10^{-3}\times\left(\frac{4E}{\pi^2}\omega_0\sin\omega_0 t + \frac{2E}{\pi}\omega_0\cos\omega_0 t\right)$$