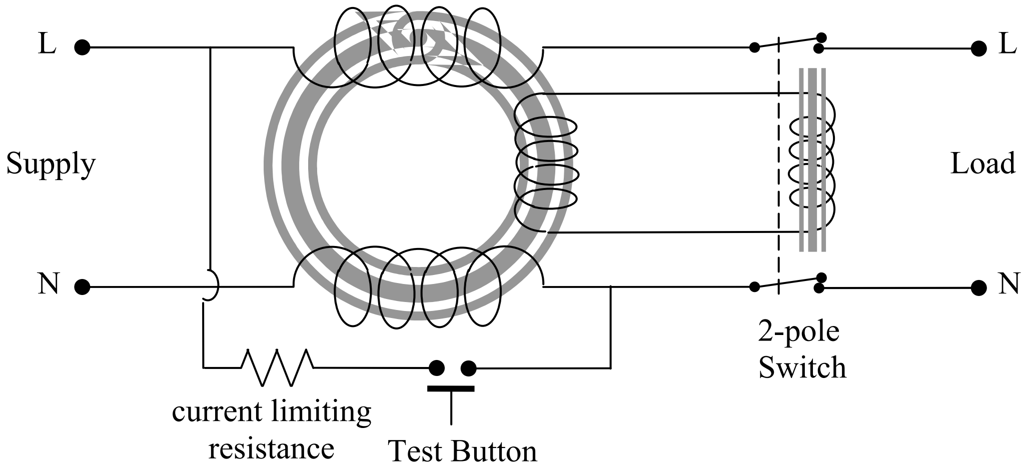
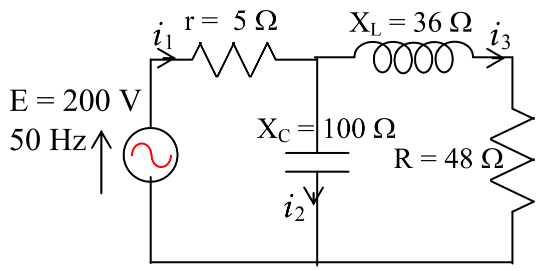
EE 201 - THEORY OF ELECTRICITY – Short Answers

Level 2 Examination - December 2002

1. (a)





(b) $-jX_c // (R + jX_L)$

$$= \frac{-j100(48 + j36)}{48 + j36 - j100}$$

$$= \frac{100\angle -90^0 \times 60\angle 36.87^0}{80\angle -53.13^0} = 75\Omega$$

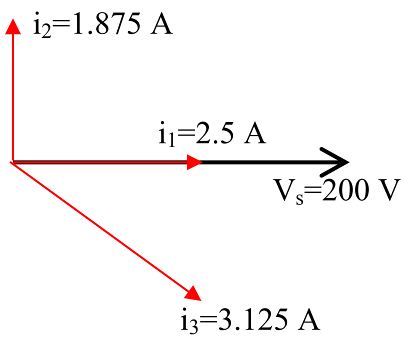
Total impedance = 5 + 75 = 80 Ω

$\mathbf{i_1}$ = $200\angle 0^0/80$ = $\mathbf{2.5\angle 0^0}$ **A**,

$\mathbf{i_2 = 1.875\angle 90^0}$ **A**,

$\mathbf{i_3 = 3.125\angle -36.9^0}$ **A**

(c)



2. (a) **Z =** $1/j\omega C + j\omega(L_1+L_2+2M) + R$

$= \mathbf{-j\ 2\times10^5/\omega + j\omega\ 0.032 + 10}$ Ω

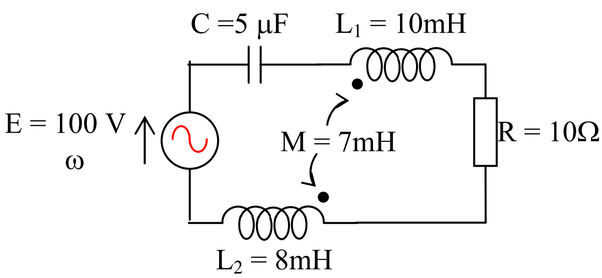
(b) At resonance, power factor=1

ω = 2500 rad/s, **f = 397.9 Hz**

Q = 8 at resonance

I = 10∠0⁰ A at resonance

(c) $\mathbf{V_L = 425\angle 90^0}$ **V** at resonance



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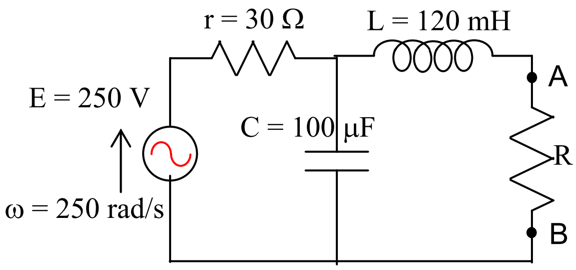
3. (a) 120 mH →j 30 Ω, 100 μF→ – j40 Ω

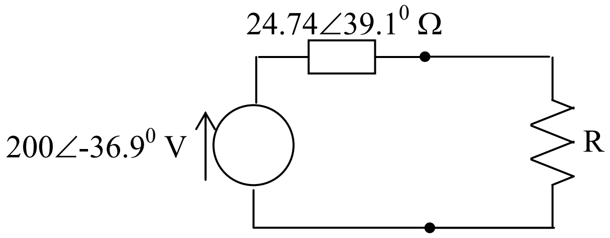
with AB open, $i = 5\angle{-36.9^0}$ A

$V_{th} = 200\angle{-36.9^0}$ V

$Z_{th} = 19.2+j15.6 = 24.74\angle 39.1^0$ Ω

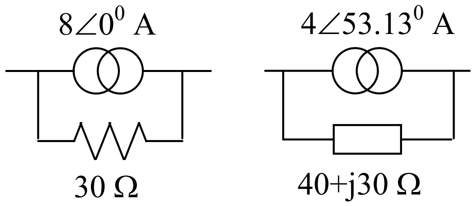


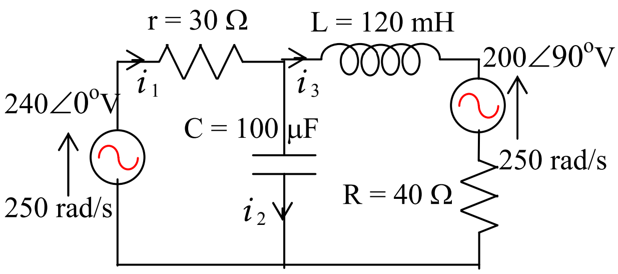
Thevenin's equivalent circuit



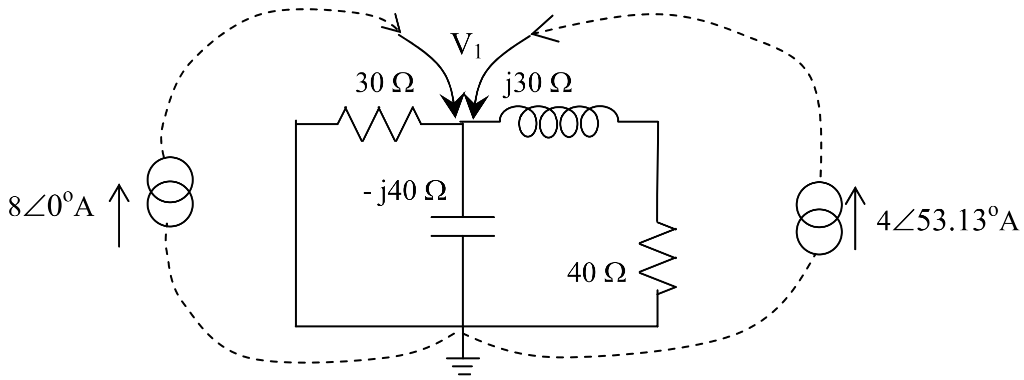
(b) $P = \dfrac{200^2 \cdot R}{(R+19.2)^2 + 15.6^2}$, for maximum power **R = 24.74 Ω, P_{max} = 455 W**

4. (a) **Equivalent current sources**





(b)



nodal admittance matrix $[\mathbf{Y_N}] = \left[\dfrac{1}{30} + \dfrac{1}{-j40} + \dfrac{1}{40+j30}\right] = [0.0510\angle 14.76^0]$

nodal injected current source $\mathbf{I_N} = 8\angle 0^0$ A $+ 4\angle 53.13^0 =$ **$10.88\angle 17.10^0$ A**

(c) $\mathbf{i_1} = 0.897 - j\,0.290$ = **$0.94\angle{-17.90}$ A**

$\mathbf{i_2} = -0.214 + j\,5.329$ = **$5.33\angle 92.30$ A**

$\mathbf{i_3} = 1.111 - j\,5.619$ = **$5.73\angle{-78.80}$ A**

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5. (a) Phase voltage = 400/√3 = 230.9∠0^0 V, 200 mH → j 62.83 Ω

Line current = 230.9∠0^0 / (100 + j 62.83) = **1.955∠-32.10 A**

Load power factor = cos32.1^0 = **0.847 lag**

Active power supplied = √3 × 400 × 1.955 × 0.847 = **1.147 kW**

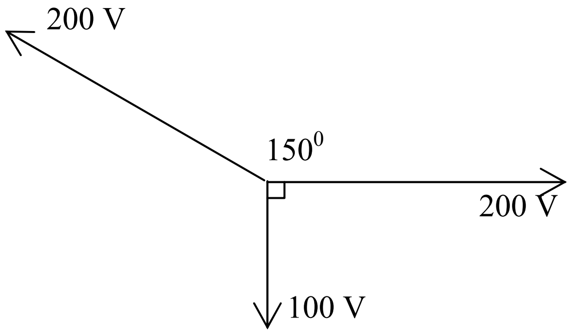
(b) Q = √3 × 400 × 1.955 × sin 32.1^0 = 720.6 var

Q_{new} = 1147 × tan 18.19^0 = 377.0 var

Rating of each capacitor = (720.6 – 377.0)/3 = 114.5 var

for delta connected capacitors (V = 400 V), **C = 2.28 μF**

(c)



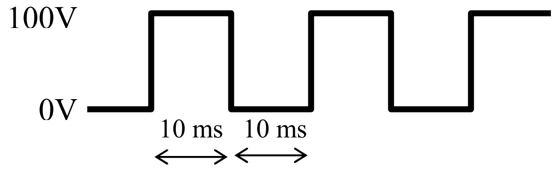
V_{A0} = 8.9∠0^0 V

V_{A1} = 161.2∠18.1^0 V

V_{A0} = 62.7∠-52.9^0 V

6. (a) mean value = $a_0/2$ = 100/2 = 50 V

Shift axis by 50 V as shown.



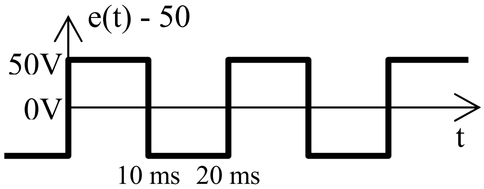
T = 20 ms

e(t) – 50 is an odd function.

∴ a_n= 0 for all n ≠ 0

b_n is the same for e(t) and for e(t) – 50

b_n = 200/nπ

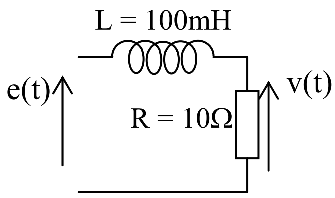


∴ e(t) = 50 + 200/π [sin 100πt + ⅓ sin 300πt + ...]

(b) **Peak value = 100 V**

average value = 50 V (rectified)

mean value = 50 V



rms value = $\sqrt{\frac{1}{T}\int_0^{\frac{1}{2}T} 100^2\,dt + \frac{1}{T}\int_{\frac{1}{2}T}^{T} 0^2\,dt}$ **= 70.7 V**

form factor = 70.7/50 **= 1.414**

(c) $v(t) = \dfrac{10}{10 + j100n\pi \times 0.1} \cdot e(t)$

v(t) = 50+19.31 sin (100πt-72.34^0) + 2.24 sin (300πt – 83.94^0) + ...

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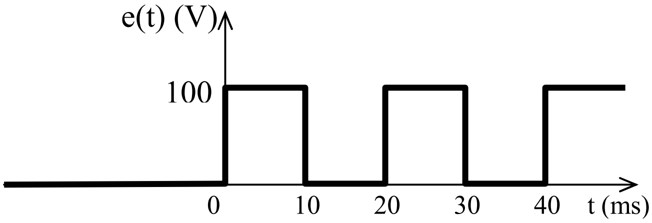
7. (a) $E(s) = \frac{100}{s} \times \frac{1}{1+e^{-0.01s}}$



(b) $\mathcal{L}\,[Ae^{-\alpha t}] = A/(s+\alpha)$

(c) $V(s) = \frac{100}{s} \times \frac{10}{10+0.1s}$

$v(t) = 100\,(1 - e^{-100t})$ or $200\,e^{-50t}\sinh 50t$

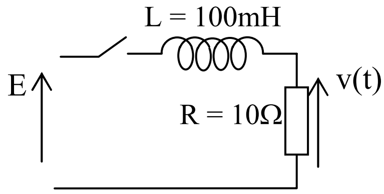


Figure Q7b