



Complete, fold and seal
(see note 2 below)

FORENAME(S): Adrian

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

1	Student Number	
2	Title of Examination Paper	Electrical + Electronic principles
3	Module Code	Scot4000
4	Date and Time of Examination	Monday 23.05.22
5	Examination Venue	College Sir Giff -gym (10.00am)
6	Seat Number	4
7	Number of Answer Books handed in	

[illegible]

69%
AGREED.

Question ①.

Q1. draw the equivalent circuit.

$$R_1 = 47k\Omega$$

$$R_2 = 56k\Omega$$

$$V_S = 12V$$

$$C_1 = 10\mu F$$

circuit reduction.

product over sum

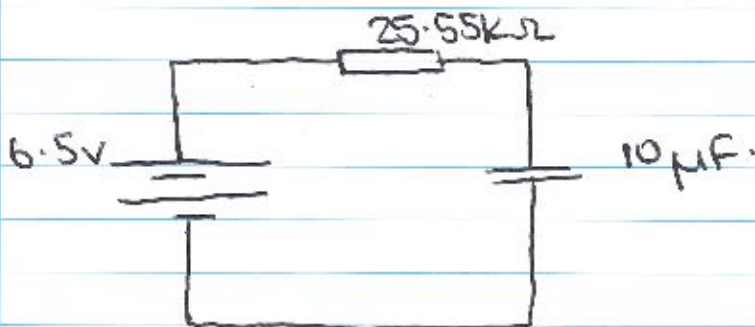
$$\frac{R_1 \times R_2}{R_1 + R_2} = \frac{47k \times 56k}{47k + 56k} = \underline{\underline{25.55k\Omega}}$$

new voltage supply.

potential divider rule

$$\left(\frac{R_2}{R_1 + R_2} \right) V_S = \left(\frac{56k}{47k + 56k} \right) 12$$

$$= \underline{\underline{6.5V}}$$



2

②

$$b) \tau = R \times C$$

$$\tau = 25.55 \text{ k} \times 10 \mu\text{F}$$

$$= \underline{\underline{0.2555 \text{ seconds}}}$$

$$ii) \text{ fully charged} = 5\tau$$

$$5 \times 0.2555 = \underline{\underline{1.28 \text{ seconds}}}$$

$$c) i) \text{ charging} \quad 3v.$$

$$V_c = V_s (1 - e^{-t/\tau})$$

$$3 = 6.5 (1 - e^{-t/0.2555})$$

$$\frac{3}{6.5} = 1 - e^{-t/0.2555}$$

$$e^{-t/0.2555} = 1 - \frac{3}{6.5}$$

take ln of both sides.

$$\frac{-t}{0.2555} = \frac{\ln \left(1 - \frac{3}{6.5} \right)}{\frac{1}{8}}$$

$$\frac{-t}{0.2555} = -0.62$$

$$t = 0.62 \times 0.2555$$

$$= \underline{\underline{0.16 \text{ seconds}}}$$

ii) discharging.

$$V_c = V_s (e^{-t/\tau})$$

$$\frac{3}{6.5} = e^{-t/0.26}$$

$$\frac{3}{6.5} = e^{-t/0.26}$$

take ln of both sides.

$$\ln\left(\frac{3}{6.5}\right) = \frac{-t}{0.26}$$

$$-0.77 = \frac{-t}{0.26}$$

$$t = 0.77 \times 0.26$$

$$t = \underline{\underline{0.2002 \text{ seconds}}}$$

2

d) Time constant for an RL circuit.

$$\tau = \frac{L}{R} = \frac{0.2}{1000}$$

$$L = 200 \text{ mH } (0.2 \text{ H})$$

$$R = 1 \text{ k}\Omega \text{ } (1000 \Omega)$$

$$V = 24 \text{ V}$$

$$= \underline{\underline{200 \times 10^{-6} \text{ seconds}}}$$

2

ii) steady state current

$$V = I \times R$$

$$I = \frac{V}{R} = \frac{24}{1000} = \underline{\underline{0.024 \text{ A}}}$$

2

6

9

iii) current to fall to
(decay).

i) 20 mA
 0.02 A

$$i = I (e^{-t/\tau})$$

$$0.02 = 0.024 (e^{-t/200\mu\text{s}})$$

$$\frac{0.02}{0.024} = e^{-t/200\mu\text{s}}$$

take ln of both sides.

$$\ln \left(\frac{0.02}{0.024} \right) = \frac{-t}{200\mu}$$

$$-0.18 = \frac{-t}{200\mu}$$

$$t = 0.18 \times (200 \times 10^{-6})$$

$$t = \underline{\underline{36 \times 10^{-6} \text{ seconds}}}$$



6

ii) 5 mA
 $5 \times 10^{-3} \text{ A}$

$$i = I (e^{-t/\tau})$$

$$5 \times 10^{-3} = 0.024 (e^{-t/200\mu})$$

$$\frac{5 \times 10^{-3}}{0.024} = e^{-t/200\mu}$$

take ln of both sides.

6

6

$$\ln \left(\frac{5 \times 10^{-3}}{0.024} \right) = \frac{-t}{200 \times 10^{-6}}$$

$$-1.57 = \frac{-t}{200 \times 10^{-6}}$$

$$t = 1.57 \times (200 \times 10^{-6})$$
$$t = \underline{\underline{314 \times 10^{-6} \text{ seconds}}}$$

✓ (25)

6

Q2) Question (2)

$$Z_T = \left(\frac{Z_1 \times Z_2}{Z_1 + Z_2} \right) + Z_3$$

$$Z_1 = 3 - j4$$

$$Z_2 = 6 + j7$$

$$Z_3 = 2.5 - j6.5$$

$$Z_1 \times Z_2 = (3 - j4)(6 + j7)$$
$$= 18 + j21 - j24 - j^2 28$$
$$= 18 + j21 - j24 - (-1) 28$$
$$= 18 - j3 + 28$$
$$= \underline{\underline{46 - j3}}$$

(for) $j^2 = -1$

$$Z_1 + Z_2 = (3 - j4) + (6 + j7)$$
$$= 9 + j3$$

$$\frac{46 - j3}{9 + j3} \times \frac{9 - j3}{9 - j3}$$

(6)

6

$$\frac{46 - j3}{9 + j3} \times \frac{9 - j3}{9 - j3}$$

Top of fraction $j = \cancel{414 - j138 - j27 + j^2 9}$
 $414 - j138 - j27 + j^2 9$
 $414 - j165 + (-1)9$
 $414 - j165 - 9$
 $405 - j165$ ✓

bottom ; $\cancel{81 + j27 + j27 + j^2 9}$
 $81 + j27 + j27 + j^2 9$
 $81 + j54 - 9$
 $72 + j54$

$$\frac{405 - j165}{72 + j54} = \underline{\underline{5 - j186}}$$

add $Z_3 = (5 - j186) + (2.5 - j6.5)$
 $= \underline{\underline{7.5 - j192.5}}$ ✗

b)

c) impedance in the circuit.

$$Z = \sqrt{R^2 + X_L^2}$$

$$= \sqrt{40^2 + X_L^2}$$

$$= \sqrt{40^2 + 150.8^2} = \underline{\underline{156.02 \Omega}}$$
 ✓

$$R = 40 \Omega$$

$$L = 0.4 \text{ H } \angle 90^\circ$$

$$V = 200 \text{ V } \angle 0^\circ$$

$$60 \text{ Hz}$$

$$X_L = 2\pi fL$$

$$= 2\pi(60)(0.4)$$

$$= \underline{\underline{150.8}}$$
 ✓

$$\tan \phi = \frac{X_L}{R}$$

$$\phi = \tan^{-1} \left(\frac{X_L}{R} \right)$$

$$Z = \underline{\underline{156.02 \angle 75.14^\circ}}$$
 ✓

$$\phi = \underline{\underline{75.14^\circ}}$$

ii) The current in the circuit.

$$V = I \times Z$$

$$I = \frac{V}{Z}$$

$$I = \frac{200 \angle 0^\circ}{156.02 \angle 75.14^\circ} = \underline{\underline{1.28 \angle -75.14^\circ \text{ A}}}$$

2

iii). Pd across the resistor (40 Ω).

$$V_r = I \times R$$

$$V_r = 1.28 \angle -75.14^\circ \times 40 \angle 0^\circ$$

$$V_r = \underline{\underline{51.2 \angle -75.14^\circ \text{ V}}}$$

Cartesian form =

$$13.13 - j49.49$$

3

iv) Pd across the coil

$$V_L = I \times X_L$$

$$V_L = 1.28 \angle -75.14^\circ \times 150.8 \angle 90^\circ$$

$$V_L = \underline{\underline{193.024 \angle 14.86^\circ}}$$

Cartesian form =

$$186 + j49.5$$

3

c) Prove that;

$$V_S = V_R + V_L$$

$$= 51.2 (13.13 - j49.49) + (186 + j49.5)$$

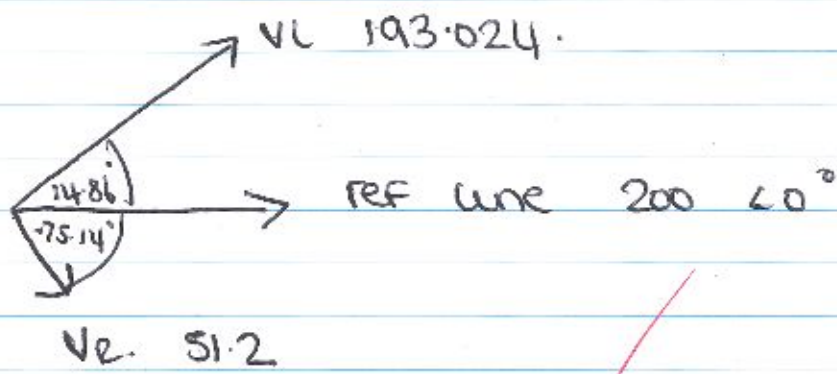
$$= \underline{\underline{199.13 + j0.01 \text{ V}}}$$

3

as you can see that the answer is very close to the supply voltage of 200V, slightly off due to roundings.

11

d)



3

3

3

question ④.

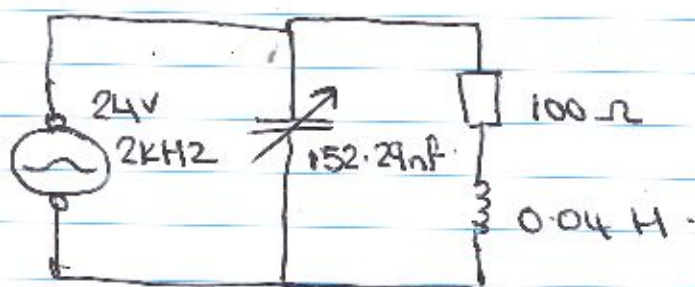
$$L = 0.04$$

$$R = 100 \Omega$$

$$V_L = ? \quad \text{on parallel}$$

$$V = 24V \quad 2 \text{ kHz supply.}$$

circuit arrangement.



a) capacitance of the capacitor.

$$f_r = \frac{1}{2\pi} \sqrt{\left(\frac{1}{LC} - \frac{R^2}{L^2}\right)}$$

$$2\pi f_r^2 = \frac{1}{LC} - \frac{R^2}{L^2}$$

$$C = \frac{1}{L(2\pi f_r)^2 + \frac{R^2}{L^2}}$$

$$C = \frac{1}{0.04 \left((2\pi \times 2000)^2 + \frac{100^2}{0.04^2} \right)}$$

$$C = \underline{\underline{152.29 \text{ nF}}}$$

6

⑥

6

b) dynamic resistance.

$$Z_0 = \frac{L}{CR} = \frac{0.04}{(152.29 \times 10^{-9})(100 \Omega)}$$

$$= \underline{\underline{2626.57 \Omega}}$$



2

c) supply current.

$$V = I \times R_p$$

$$I = \frac{V}{R_0} = \frac{24}{2626.57} = \underline{\underline{9.14 \times 10^{-3} A}}$$



2

d) Q factor

$$Q = \frac{2\pi f_r L}{R}$$

$$= \frac{2\pi(2000)(0.04)}{100}$$

$$= \underline{\underline{5.03}}$$



1

e) bandwidth.

$$BW = f_2 - f_1 \quad f_2 - f_1 = \frac{2000}{5.03} = \frac{BW}{5.03} = \underline{\underline{397.61 Hz}}$$

$$Q = \frac{f_r}{f_2 - f_1}$$



2

$$5.03 = \frac{2000}{f_2 - f_1}$$

7

7

f) upper and lower frequencies.

$$\text{so } f_r = \sqrt{f_2 f_1}$$

$$\therefore f_r^2 = f_2 \times f_1$$

$$2000^2 = f_2 f_1$$

$$4 \times 10^6 = f_2 f_1$$

~~$$f_2 = \frac{4 \times 10^6}{f_1}$$~~

so find expression for f_1 .

$$\frac{4 \times 10^6}{f_2} = f_1$$

so substitute back in to B_{LO}

$$B_{LO} = f_2 - f_1$$

$$397.61 = f_2 - \frac{4 \times 10^6}{f_2}$$

multiply everything by f_2 to remove fraction.

$$397.61 f_2 = f_2^2 - 4 \times 10^6$$

turn into quadratic

A B C

$$f_2^2 - 397.61 f_2 - 4 \times 10^6 = 0$$

$$= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-(-397.61) \pm \sqrt{(-397.61)^2 - 4(1)(-4 \times 10^6)}}{2(1)}$$

$$= 1791.29 \quad \text{neglect the negative.}$$

$$f_1 = 1791.29 \text{ Hz.} \quad \checkmark$$

rounding errors
method ok

now sub back into equation to find f_2 .

$$BW = f_2 - f_1$$

$$f_r^2 = f_2 f_1$$

$$\frac{4 \times 10^6}{1791.29} = f_2$$

$$f_2 = \underline{\underline{2233.03 \text{ Hz}}} \quad \checkmark$$

g) ~~Calculate~~ Circuit Impedance.

$$\begin{aligned} Z &= \sqrt{R^2 + X_L^2} \\ &= \sqrt{100^2 + 502.65^2} \\ &= 512.5 \Omega \end{aligned}$$

$$X_L = 2\pi fL$$

$$X_L = 2\pi(2000)(0.04)$$

$$X_L = 502.65$$

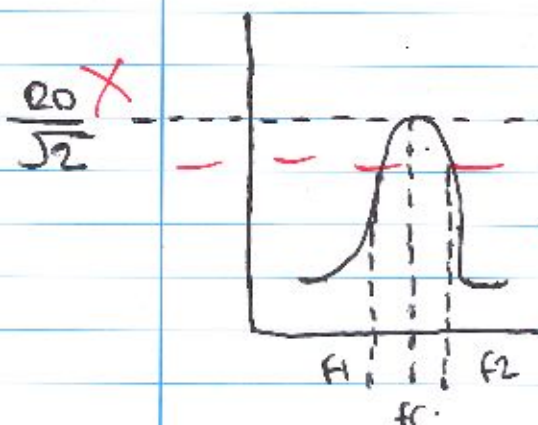
$$Z = \underline{\underline{512.5 \angle 44.4^\circ}}$$

$$\phi = \tan^{-1} \left(\frac{502.65}{512.5} \right) \quad \times$$

h) graph below

$$\phi = 44.4^\circ$$

$$\frac{Z_R}{\sqrt{2}}$$



$$f_1 = 1791.29 \text{ Hz}$$

$$f_2 = 2233.03 \text{ Hz}$$

$$f_r = 2000 \text{ Hz.}$$