



Complete, fold and seal
(see note 2 below)

FORENAME(S): LIAM ANTHONY

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.**

List the numbers of the questions you have attempted	Office Use
A	27
B2	28
B3	28
Total	83%

83%

A1. ~~$20 \log(90) = 39.1$~~ ~~antilog(90)~~

A1i. $\text{antilog}\left(\frac{90}{20}\right) = 31,623$ ✓

No unit

ii. $\text{antilog}\left(\frac{35}{10}\right) = 31.62$ ✓

3.

A2. $R = 250 \Omega$ $A_v = 36\text{dB}$ $V_{in} = 5\text{mV}$

~~$V_{out} = \frac{V_{in}}{\text{antilog}\left(\frac{36}{20}\right)} = \frac{5 \times 10^{-3}}{63.1} = 7.92 \times 10^{-5}$~~
 ~~$= 79.2 \mu\text{V}$~~

ii. ~~$P_{load} = \frac{V_{out}^2}{R} = \frac{(7.92 \times 10^{-5})^2}{250} = 2.51 \times 10^{-11}$~~
 ~~$= 2.51 \mu\text{W}$~~

i. $V_{out} = V_{in} \times \text{antilog}\left(\frac{36}{20}\right) = 5 \times 10^{-3} \times 63.1 = 0.3155$ ✓

ii. $P_{load} = \frac{V_{out}^2}{R} \therefore \frac{0.3155^2}{250} = 3.98 \times 10^{-4}$
 $= 398 \mu\text{W}$ ✓

4

A3. $A_v = 500$ $m_v = 0.015$

$A_{vf} = \frac{A_v}{1 + A_v m_v} = \frac{500}{1 + (500 \times 0.015)} = 58.8$ ✓

3.

A4. Efficient, stops overheating ✓

0

A5. $L1 = 4 \mu H$ $f = 20 MHz$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$C = \frac{1}{L(2\pi f)^2} = \frac{1}{4 \times 10^{-6} (2 \times \pi \times 20 \times 10^6)^2} = 1.58 \times 10^{-11} = 15.8 \text{ pF}$$

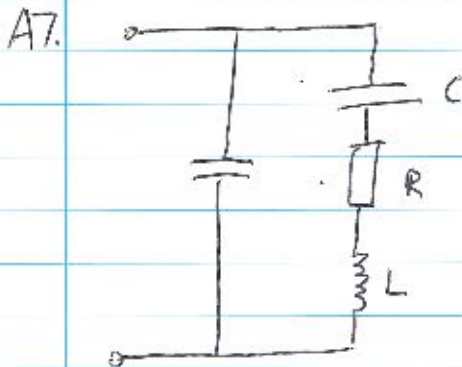
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A6. The Colpitts oscillator consists of 2 capacitors and one inductor. The frequency is found by:

$$f = \frac{1}{2\pi\sqrt{LC_T}}$$

Each capacitor is 180° out of phase with one another. When the circuit is turned on, the charged capacitors release their current to the inductor thus causing oscillation. $C1$ is V_{in} , $C2$ is the feedback.

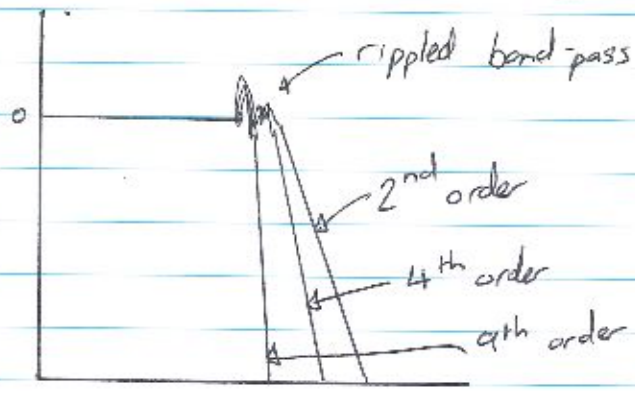
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Similar to an RLC circuit.

2

A8. The Tschhebyscheff filter has a sharp roll-off but a rippling effect on the magnitude. The sharper the roll-off, the more the magnitude ripples.



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A9. $Q = 105$ $f_0 = 2.1 \text{ MHz}$

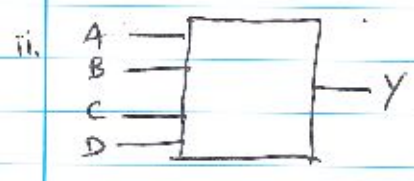
$$BW = \frac{f_0}{Q} = \frac{2.1 \times 10^6}{105} = 20,000$$

$$\text{Lower cut-off} = f_0 - \frac{1}{2} BW \therefore 2.1 \text{ MHz} - 20,000 = 2.08 \text{ MHz}$$

$$\text{Higher cut-off} = f_0 + \frac{1}{2} BW \therefore 2.1 \text{ MHz} + 20,000 = 2.12 \text{ MHz}$$

2

A10. Inputs are A, B, C, D, Output is Y



4

iii. 4 input AND gate

Inputs				Output
A	B	C	D	Y
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

B2 a. $C_1 = 470 \text{ pF}$ $f_c = 75 \text{ kHz}$

i. $a_1 = 0.6656$

$a_2 = 1.1402$

$b_2 = 0.4128$

$a_3 = 0.6216$

$b_3 = 0.3245$

i. Stage 1

$$R1 = \frac{a_1}{2\pi f_c C_1} \therefore \frac{0.6656}{2 \times \pi \times 75 \times 10^3 \times 470 \times 10^{-12}} = 3005 \Omega$$

ii. $C_2 > \frac{C_1 \times 4b_2}{a_2^2} \quad \frac{470 \times 10^{-12} \times 4(0.4128)}{1.1402^2} = 5.97 \times 10^{-12} = 597 \text{ pF}$

$\therefore C_2 = 600 \text{ pF}$ ✓

$$C_2 > \frac{C_1 \times 4b_3}{a_3^2} \quad \frac{470 \times 10^{-12} \times 4(0.3245)}{0.6216^2} = 1.58 \times 10^{-9} = 1.58 \text{ nF}$$

$$\therefore C_2 = 1.6 \text{ nF} \checkmark$$

2

iii. Stage 2

$$R_2, R_3 = \frac{a_2 C_2 \pm \sqrt{a_2^2 C_2^2 - 4b_2 C_1 C_2}}{4\pi f_c C_1 C_2}$$

$$= \frac{1.1402 \times 600_p \pm \sqrt{1.1402^2 \times 600_p^2 - 4 \times 0.4128 \times 470_p \times 600_p}}{4 \times \pi \times 75,000 \times 470_p \times 600_p}$$

$$R_2 = 2758 \Omega \checkmark$$

$$R_3 = 2390 \Omega \checkmark$$

6

Stage 3

$$R_4, R_5 = \frac{a_3 C_2 \pm \sqrt{a_3^2 C_2^2 - 4b_3 C_1 C_2}}{4\pi f_c C_1 C_2}$$

$$= \frac{0.6216 \times 1.6_n \pm \sqrt{0.6216^2 \times 1.6_n^2 - 4 \times 0.3245 \times 470_p \times 1.6_n}}{4 \times \pi \times 75,000 \times 470_p \times 1.6_n}$$

$$R_4 = 1564 \Omega \checkmark$$

$$R_5 = 1242 \Omega \checkmark$$

4

$$b. f = 5 \text{ MHz} \quad m_v = 0.2 \quad C = 2.2 \text{ pF}$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$L = \frac{1}{C(2\pi f)^2} \quad \therefore \frac{1}{2.2 \times 10^{-12} (2 \times \pi \times 5 \times 10^6)^2} = 4.61 \times 10^{-4} = 461 \mu\text{H} \checkmark$$

4

$$m_v = \frac{L_2}{L_1} \quad m_v = 0.2 \quad \therefore m_v = \frac{1}{5} \quad \text{or} \quad L_1 = 5L_2$$

$$L_T = 4.61 \times 10^{-4} = \frac{L_1 \times L_2}{L_1 + L_2}$$

Divide by L_2

$$4.61 \times 10^{-4} = \frac{L_1}{\frac{L_1}{L_2} + 1} \quad \text{being that } \frac{L_1}{L_2} = 5$$

$$4.61 \times 10^{-4} = \frac{L_1}{5 + 1} = \frac{L_1}{6}$$

$$4.61 \times 10^{-4} = \frac{L_1}{6} \quad \therefore L_1 = \frac{4.61 \times 10^{-4} \times 6}{6} = 2.77 \times 10^{-3} \text{ or } 2.77 \text{ mH}$$

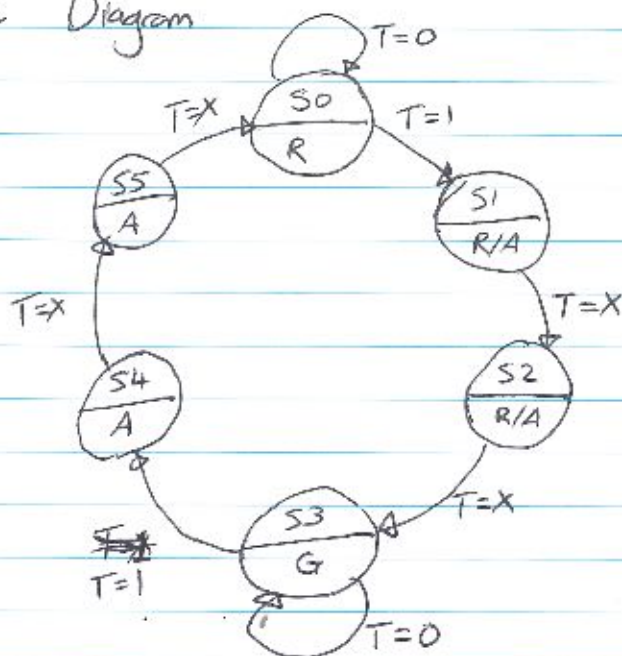
$$L_2 = m_v \times L_1 \quad \therefore 0.2 \times 2.77 \times 10^{-3} = 5.54 \times 10^{-4} \text{ or } 554 \mu\text{H}$$

c. $C = 68 \text{ pF} \quad f = 500 \text{ kHz}$

$$f_0 = \frac{1}{2\pi CR\sqrt{6}}$$

$$R = \frac{1}{2\pi C f_0 \sqrt{6}} \quad \therefore \frac{1}{2 \times \pi \times 68 \times 10^{-12} \times 500,000 \times \sqrt{6}} = 1911.52$$

B3a. State Diagram



State Table

Current	Current			NEXT		T=0 NEXT			T=1 NEXT			OUTPUT		
	QA	QB	QC	T=0	T=1	QA+	QB+	QC+	QA+	QB+	QC+	R	A	G
S0	0	0	0	S0	S1	0	0	0	0	0	1	1	0	0
S1	0	0	1	S2	S2	0	1	0	0	1	0	1	1	0
S2	0	1	0	S3	S3	0	1	1	0	1	1	1	1	0
S3	0	1	1	S3	S4	0	1	1	1	0	0	0	0	1
S4	1	0	0	S5	S5	1	0	1	1	0	1	0	1	0
S5	1	0	1	S0	S0	0	0	0	0	0	0	0	1	0

Karnaugh Maps

QA+ TA	BC	00	01	11	10
00		0	0	0	0
01		1	0	X	X
11		1	0	X	X
10		0	0	1	0

QB+ TA	BC	00	01	11	10
00		0	1	1	1
01		0	0	X	X
11		0	0	X	X
10		0	1	0	1

QC+ TA	BC	00	01	11	10
00		0	0	1	1
01		1	0	X	X
11		1	0	X	X
10		1	0	0	1

RED A	BC	00	01	11	10
0		1	1	0	1
1		0	0	X	X

AMBER A	BC	00	01	11	10
0		0	1	0	1
1		1	1	X	X

GREEN A	BC	00	01	11	10
0		0	0	1	0
1		0	0	X	X

Boolean Equations

$$QA+ = A \cdot \bar{C} + \bar{T} \cdot BC$$

$$QB+ = \bar{T} \cdot B + B \cdot \bar{C} + \bar{A} \cdot \bar{B} \cdot C$$

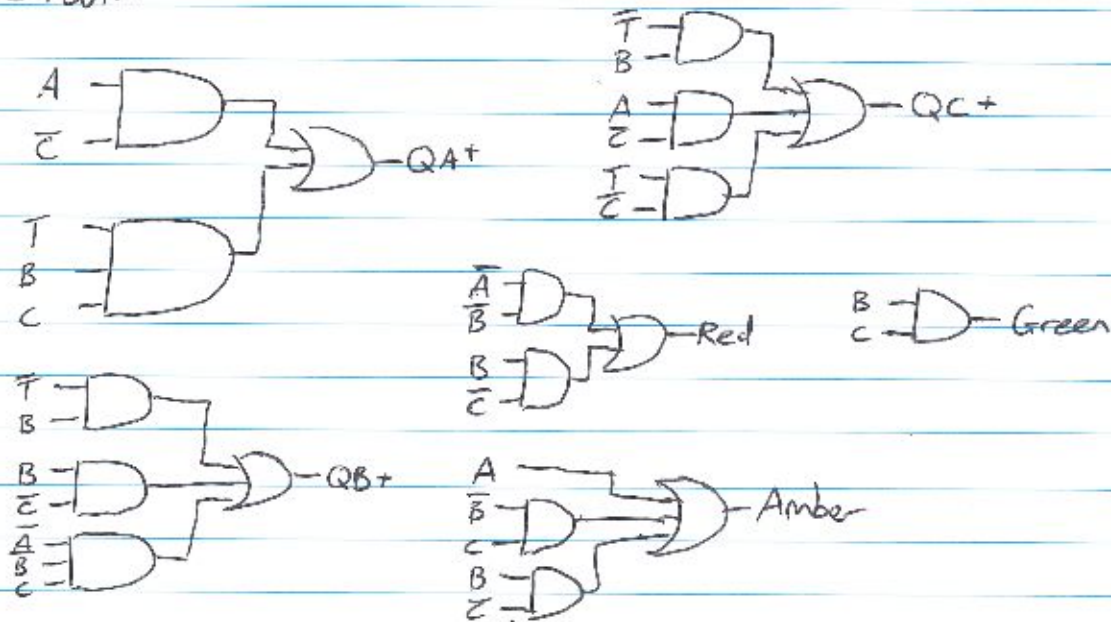
$$QC+ = \bar{T} \cdot B + \bar{A} \cdot \bar{B} \cdot C + T \cdot \bar{C}$$

$$Red = \bar{A} \cdot \bar{B} + B \cdot \bar{C}$$

$$Amber = A + \bar{B} \cdot C + B \cdot \bar{C}$$

$$Green = B \cdot C$$

Circuits



b.i Inputs are D, PR, CLK, CLR ✓
Outputs are Q and Qneg ✓



iii. When PR is high and CLR is low, then Q will go low and Qneg will go high.
When PR is low and CLR is high, then Q will go high and Qneg will go low.
When D is high then Q will go high, Qneg will go low, otherwise, Q will go low and Qneg will go high.
CLOCK.

CLK	CLR	Q	Qneg
0	0	0	1
0	1	1	0
1	0	0	1
1	1	1	0

6