21 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Ashwin

Exam.		**Back**	
Level	BE	**Full Marks**	80
Programme	BEX	**Pass Marks**	32
Year / Part	IV / I	**Time**	3 hrs.

Subject: - Filter Design *(EX704)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. What is the importance of scaling in Filter design? Derive element scaling equations. [2+4]
2. Derive the expression to calculate the order n of a Butterworth Low pass filter and use it to find the order for given specification: $\alpha_{max} = 1$ dB, $\alpha_{min} = 20$ dB and $\omega_s/\omega_p = 1.5$. Also determine pole locations and transfer functions. [4+2+4]
3. What is a constant delay filter? Find the transfer function of 3rd order Bessel Thomson response having a constant delay. [2+4]
4. What is the importance of frequency transformation? Obtain a bandpass filter having $\omega_0 = 2000$ rad/s and B = 400 rad/s from fourth order Butterworth lowpass filter. [Refer table 2] [1+4]
5. Which of the following is LC lossless functions and why? Pick one of the valid LC lossless functions and realise it using Foster-I and Cauer-I form. [2+3+3]

   i) $Z_1(s) = \frac{s(s^2+4)(s^2+6)}{(s^2+3)(s^2+9)}$

   ii) $Z_2(s) = \frac{(s^2+3)(s^2+6)}{s(s^2+4)(s^2+9)}$

   iii) $Z_3(s) = \frac{(s^2+4)(s^2+6)}{s(s^2+3)(s^2+9)}$

   iv) $Z_4(s) = \frac{(s^2+3)(s^2+6)}{(s^2+4)(s^2+9)}$

6. What is transmission zeros in two port network? What is zero shifting by partial removal of pole? Explain with suitable example. [1+3]
7. Design a third order Butterworth low pass filter using resistively terminated lossless ladder with unequal termination. $R_1 = 1\ \Omega$ and $R_2 = 4\ \Omega$. [Refer table 1] [7]
8. Derive transfer function of Sallen Key low pass filter. Design second order Butterworth low pass filter using Sallen Key biquad. In your final design the values of capacitor must be 0.01μF and feedback resisters should also be equal. [Use Table 1] [4+4]
9. What is RC-CR transformation? How can you convert a Sallen Key low pass filter into the Sallen Key High pass filter using RC-CR transformation? [4]
10. What information do you get when sensitivity of x with respect to y is -3. Perform sensitivity analysis for ω_o of Sallen Key low pass filter with respect to all the resisters and capacitors present in the circuit. [1+4]
11. What is GIC? How a GIC can be used to simulate grounded inductor? Explain with necessary figures and expression. [5]
12. Simulate the Butterworth 4th order low pass filter in resistively – terminated lossless network using FDNR. (Refer table 2) [6]
13. What is a switched capacitor filter? How resistor, summing integrator and inverting lossy integrator can be realized using switched capacitor filter? Explain with necessary derivations. [1+5]

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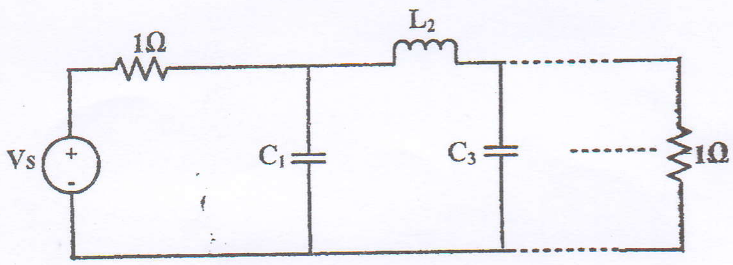
Table 1:
Pole Location for Butterworth Responses

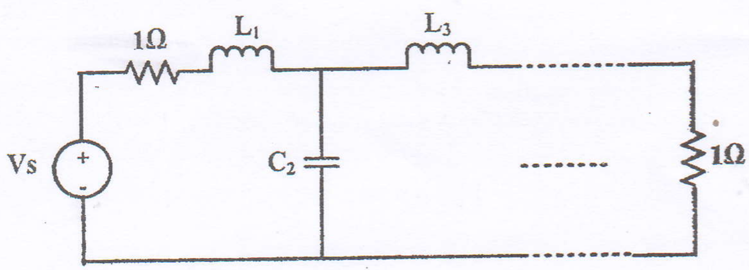
n=2	n=3	n=4	n=5
- 0.7071068 ± j 0.7071068	- 0.50 ± j 0.86603	- 0.3826834 ± j 0.9238795	- 0.809017 ± j 0.5877852
	- 1.0	- 0.9238795 ± j 0. 3826834	- 0.309017 ± j 0. 9510565
			-1.0

Table 2:

Elements values for doubly terminated Butterworth filter normalized to half power frequency of 1 rad/s



n	C_1	L_2	C_3	L_4	C_5
2	1.414	1.414			
3	1	2	1		
4	0.7654	1.848	1.848	0.7654	
5	0.618	1.618	2	1.618	0.618
n	L_1	C_2	L_3	C_4	L_5



21 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2074 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Filter Design *(EX704)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ ***__Necessary tables are attached herewith.__***
- ✓ *Assume suitable data if necessary.*

1. What is a filter? What is its importance in communication? Explain ideal response and response of practical filter. [1+2+3]

2. Derive an expression to calculate the order of Chebyshev low pass filter. Use this formula to find the order of Chebyshev low pass filter having following specification; [3+3]

   a) For pass band extending from f = 0 Hz to f = 3.2 KHz, the attenuation should not exceed 0.4dB

   b) For stop band extending from f = 9.8 KHz to f = ∞, the attenuation should not be less than 52 dB

3. What is an all pass filter? What is its importance? Derive the transfer function of second order constant delay filter. [1+1+4]

4. What is frequency transformation? How can you convert a low pass filter into a band stop filter using frequency transformation? Explain with suitable example. [2+4]

5. What are the properties of RC impedance function? Which of the following is valid RC impedance function? State with reason. Pick a valid RC impedance function and realize it using foster I and cauer I method. [2+2+3+3]

$$z(s) = \frac{s(s^2+2)}{(s^2+1)}$$

$$z(s) = \frac{(s+1)(s+5)}{(s+3)(s+7)}$$

$$z(s) = \frac{(s+3)(s+7)}{(s+1)(s+5)}$$

$$z(s) = \frac{(s+1)(s+3)}{(s+4)(s+5)}$$

6. Define zeros of transmission. How zeros of transmission can be realized? Explain with suitable example. [4]

7. What information do you get from reflection coefficient? Design a third order Butterworth low pass filter using Resistively terminated lossless ladder with equal termination of 1Ω. (Use table 1) [1+5]

8. Draw the circuit diagram of Tow-Thomas low pass biqaud circuit and derive its transfer function. Design a second order low pass filter using Tow-Thomas biqùad poles at -450± j893.03 and dc gain of 1.5. The final circuit should consist practically realizable elements. [4+4]

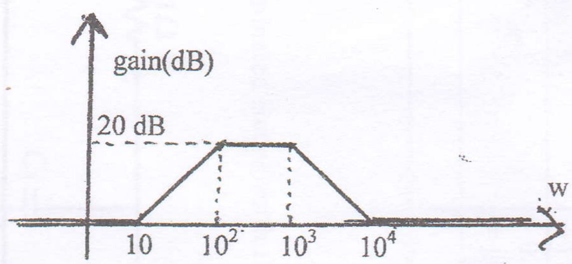
9. How excess gain can be compensated in sallen key filter? Explain. [5]

10. Define sensitivity Perform sensitivity analysis of Tow-Thomas biquad low pass filter. [1+4]

11. What is ideal gyrator? How can you simulate inductor using gyrator? Explain with necessary deriation. [1+4]

12. Design the fourth order Butterworth low pass filter using leapfrag simulation. In your final design the half power frequency should be 10000 rad/s and practically realizable elements. [Refer table 2] [7]

13. What are the applications of switched capacitor filter? Design a switched capacitor filter for following requirements. [6]



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21 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2074 Ashwin

Exam.		Back	
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Filter Design *(EX704)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

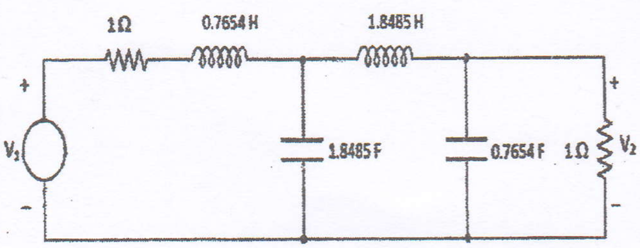
1. Define and explain the following terms with necessary diagrams: α_p, α_s, ω_p, ω_s. What is scaling? Derive element scaling equations. [4+4]

2. What are the characteristics of Inverse Chebyshev response? Derive the expression to calculate the required order of Inverse Chebyshev lowpass filter. Using your expression calculate the required order of Inverse Chebyshev filter for following lowpass filter specifications. [2+4+2]

   $\omega_p = 10000$, $\omega_s = 20000$ rad/s $\qquad \alpha_{max} = 0.4$, $\alpha_{min} = 16$ dB

3. What is constant delay filter? Obtain the transfer function of second order constant delay filter. Also mention the importance of delay equalization. [8]

4. What is frequency transformation in filter design? How can you obtain a bandpass filter from given lowpass filter at normalized frequency? Obtain a bandpass filter having ω_1=100 rad/s and ω_2=10000 rad/s from following lowpass filter at normalized frequency. [1+3+4]



5. What are the properties of lossless one port function? Realize the following function using Cauer I and Foster II method. [2+3+3]

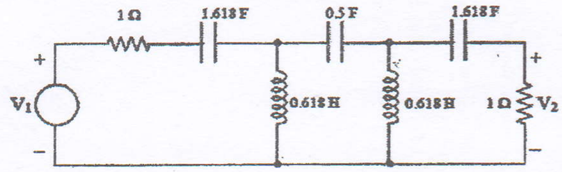
   $$Z(s) = \frac{s(s^2+4)}{(s^2+2)(s^2+6)}$$

6. Define transmission and reflection coefficient. Synthesize $t(s) = 1/(s^3+2s^2+2s+1)$ in LC ladder circuit terminated with $R_1=R_2=1\Omega$. [3+5]

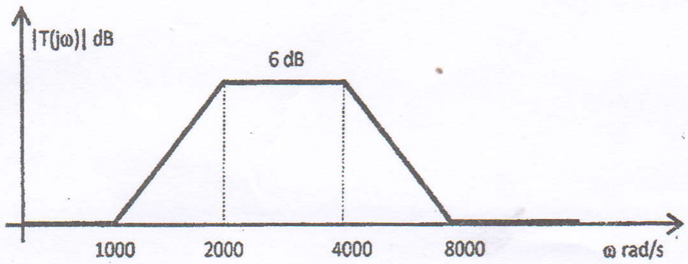
7. Draw the circuit diagram of Sallen-Key lowpass biquad circuit and derive the transfer function. How can you obtain highpass filter from lowpass one? Design the second order lowpass Butterworth filter having half power frequency of 12 KHz using Sallen-Key biquad circuit. $T_2(s) = 1/(s^2+\sqrt{2}\,s+1)$ [4+2+4]

8. What is the importance of sensitivity analysis in filter design? Perform the sensitivity analysis of Tow Thomas lowpass filter. [2+4]

9. What is generalized impedance converter (GIC)? Explain how inductors can be simulated using GIC? Simulate the following highpass filter by active simulation of grounded inductors such that ω_0 is 4000 rad/s and practically realizable elements. [4+4]



10. What is switched capacitor filter? What are its applications? Design a switched capacitor filter for following requirement. [3+5]



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26 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2073 Shrawan

Exam.	**New Back (2066 & Later Batch)**		
Level	BE	**Full Marks**	80
Programme	BEX	**Pass Marks**	32
Year / Part	IV / I	**Time**	3 hrs.

Subject: - Filter Design *(EX704)*

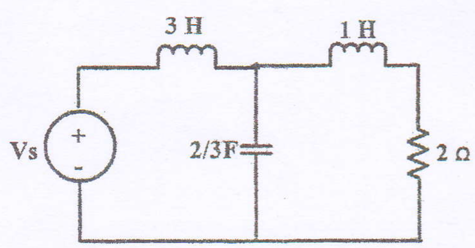
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. What is Normalization and De-normalization? A low pass filter has half power frequency of w_0 rad/s. Derive formula to calculate the new value of the resisters, capacitors and inductors present in the low pass filter if you want to change its half power frequency to w_n rad/s. [2+5]

2. What are the characteristics of Elliptical Response? Compare it with Chebyshev and Inverse Chebyshev response. [3+2+2]

3. What is a constant delay filter? Obtain the transfer function of second order constant delay filter. [4]

4. The following low pass filter has passband frequency w_p of 1 rad/s. Transform it into a highpass filter having passband frequency of 2KHz. [4]



5. Which of the following functions are LC driving point impedance function and why? [2+3+3]

$$Z(s) = \frac{s^4 + 10s^2 + 9}{s^3 + 4s}$$

$$Z(s) = \frac{s^3 + 4s}{s^4 + 5s^2 + 6}$$

Also find the Foster parallel and cauer I form of the valid LC driving point impedance function.

6. What is zero shifting by partial removal of pole? How can two-port passive circuits be synthesized using zero-shifting by partial pole removal? Explain. [1+4]

7. What is Transmission and Reflection Coefficient? How resistively terminated ladder network can be realized with finite transmission zeroes? Explain. [2+4]

8. Draw the circuit diagram of Tow Thomas low pass filter and derives its transfer function. Realize following low pass filter using Tow Thomas biquad circuit. [4+4]

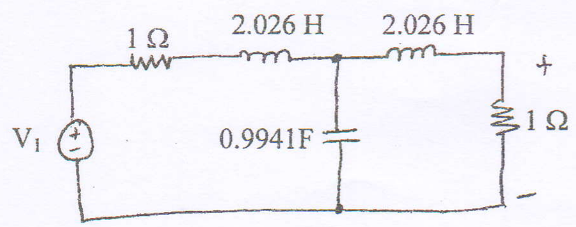
$$T(s) = \frac{-2000}{s^2 + 500s + 1000000}$$

9. How can the gain enhancement be performed in a Sallen-Key circuit? Explain with necessary diagram. [5]

10. What is sensitivity? Describe it's importance in filter design? Perform sensitivity analysis of quality factor in Tow Thomas Low Pass Filter. [6]

11. What is GIC? How a GIC can be used to simulate a grounded inductor? Explain with necessary figures and derivations. [5]

12. The following circuit is a third-order Chebyshev lowpass filter. Simulate it using the leap-frog method. The final design should have w_0 = 4000 rad/s and practically realizable element values. [8]



13. Why resistors are replaced by switched capacitor in IC technology? How can you simulate a resistor using a switched capacitor? Explain with necessary derivations. Also draw the switched capacitor equivalent circuit for inverting summer lossy integration and non inverting integrator. [7]

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21 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2072 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Filter Design *(EX704)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
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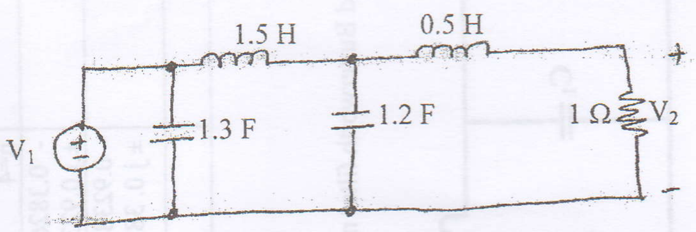
1. What is the significance of normalization and de-normalization in filter design? The following is a pass filter with $\omega_p = 1$ rad/sec. Modify the circuit so that it becomes a low pass filter with a pass band of 1000 rad/sec and a load resistance of 75 Ω. [2+3]



2. Derive an expression to calculate the order of Inverse Chebyshev low pass filter. Use this formula to estimate the order of Inverse Chevyshev low pass filter having following specification: [5+3]

$$\alpha_{max} = 0.25\,\text{dB}, \quad w_p = 1000\,\text{rad/s}$$

$$\alpha_{min} = 18\,\text{dB}, \quad w_s = 1400\,\text{rad/s}$$

3. What is delay equalization? How can it be done? Explain with necessary figures. [5]

4. What are the applications of Frequency Transformation in Filter Design. How can you obtain a high pass filter from a given low pass filter? Explain with a suitable example. [6]

5. Which of the following is LC lossless function and why? Pick one of the valid LC lossless functions and synthesize it using Foster and Cauer methods. [2+3+3]

i) $Z_1(s) = \dfrac{s(s^2+4)(s^2+9)}{(s^2+2)(s^2+10)}$

ii) $Z_2(s) = \dfrac{(s^2+2)(s^2+10)}{s(s^2+5)}$

iii) $Z_3(s) = \dfrac{s^2+25}{s(s^2+5)(s^2+50)}$

6. Define transmission zeros. How zeros of transmission be realized? Explain with suitable example. [5]

7. Design a third order Butterworth low pass filter using resistively terminated lossless ladder with unequal termination. $R_1 = 1\Omega$ and $R_2 = 4\Omega$ (Refer table 1) [7]

8. Realize the following transfer function by cascading two first-order sections using inverting op-amp configuration. [5]

$$T(s) = \frac{12}{s^2 + 8s + 12}$$

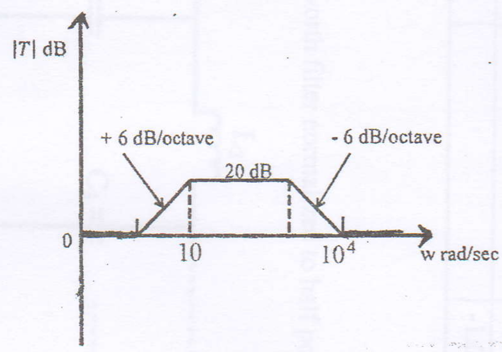
9. Design Sallen key lowpass filter for fourth order Butter worth filter. The final circuit should have $w_0 = 10{,}000$ rad/s have and practically realizable elements. (Refer table 1). [8]

10. What information do you get when the sensitivity of x with respect to y is -5? Perform sensitivity analysis for center frequency (w_0) of the Sallen Key low pass filter with respect to all the resistors and capacitors present in the circuit. [1+4]

11. Draw the circuit diagram of an generalized impedance converter. Derive the relationship between input and output current. How can it be used to simulate a grounded FDNR? Explain. [5]

12. Design a Fourth order Butterworth low pass filter having half power frequency of 4000 rad/s using Frequency dependent negative resister (FDNR). (Use table 2) [6]

13. What is switched capacitor filter? Design a switched capacitor filter to realize the magnitude response given below: [1+6]



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21 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
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Year / Part	IV / I	Time	3 hrs.

Subject: - Filter Design *(EX704)*

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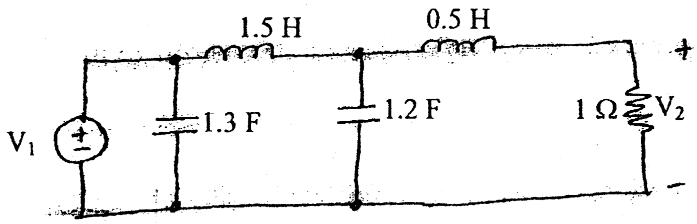
1. What is the significance of normalization and de-normalization in filter design? The following is a pass filter with ω_p = 1 rad/sec. Modify the circuit so that it becomes a low pass filter with a pass band of 1000 rad/sec and a load resistance of 75 Ω. [2+3]



2. Derive an expression to calculate the order of Inverse Chebyshev low pass filter. Use this formula to estimate the order of Inverse Chevyshev low pass filter having following specification: [5+3]

   $\alpha_{max} = 0.25\,\text{dB}$, $w_p = 1000\,\text{rad/s}$

   $\alpha_{min} = 18\,\text{dB}$, $w_s = 1400\,\text{rad/s}$

3. What is delay equalization? How can it be done? Explain with necessary figures. [5]

4. What are the applications of Frequency Transformation in Filter Design. How can you obtain a high pass filter from a given low pass filter? Explain with a suitable example. [6]

5. Which of the following is LC lossless function and why? Pick one of the valid LC lossless functions and synthesize it using Foster and Cauer methods. [2+3+3]

   i) $Z_1(s) = \dfrac{s(s^2+4)(s^2+9)}{(s^2+2)(s^2+10)}$

   ii) $Z_2(s) = \dfrac{(s^2+2)(s^2+10)}{s(s^2+5)}$

   iii) $Z_3(s) = \dfrac{s^2+25}{s(s^2+5)(s^2+50)}$

6. Define transmission zeros. How zeros of transmission be realized? Explain with suitable example. [5]

7. Design a third order Butterworth low pass filter using resistively terminated lossless ladder with unequal termination. $R_1 = 1\Omega$ and $R_2 = 4\Omega$ (Refer table 1) [7]

8. Realize the following transfer function by cascading two first-order sections using inverting op-amp configuration. [5]

$$T(s) = \frac{12}{s^2 + 8s + 12}$$

9. Design Sallen key lowpass filter for fourth order Butter worth filter. The final circuit should have $w_0 = 10{,}000$ rad/s have and practically realizable elements. (Refer table 1). [8]

10. What information do you get when the sensitivity of x with respect to y is -5? Perform sensitivity analysis for center frequency (w_0) of the Sallen Key low pass filter with respect to all the resistors and capacitors present in the circuit. [1+4]

11. Draw the circuit diagram of an generalized impedance converter. Derive the relationship between input and output current. How can it be used to simulate a grounded FDNR? Explain. [5]

12. Design a Fourth order Butterworth low pass filter having half power frequency of 4000 rad/s using Frequency dependent negative resister (FDNR). (Use table 2) [6]

13. What is switched capacitor filter? Design a switched capacitor filter to realize the magnitude response given below: [1+6]

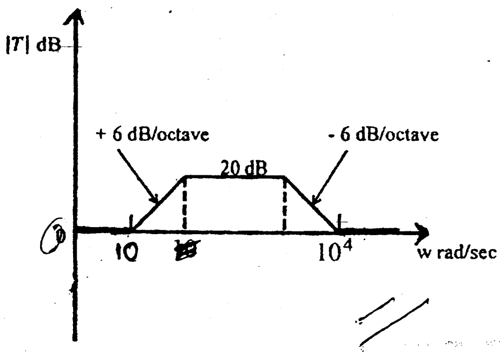


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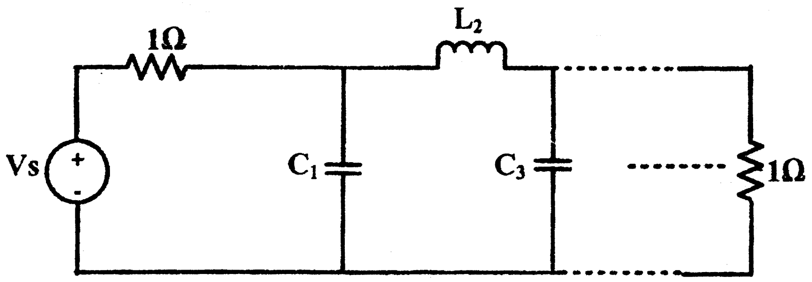
Table 1:
Pole Location for Butterworth Responses

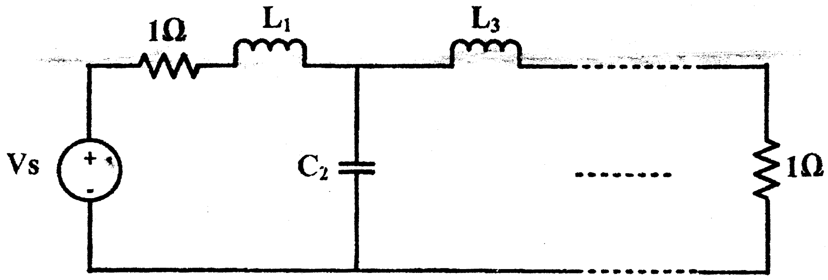
n=2	n=3	n=4	n=5
- 0.7071068 ± j 0.7071068	- 0.50 ± j 0.86603	- 0.3826834 ± j 0.9238795	- 0.809017 ± j 0.5877852
	- 1.0	- 0.9238795 ± j 0. 3826834	- 0.309017 ± j 0. 9510565
			-1.0

Table 2:

Elements values for doubly terminated Butterworth filter normalized to half power frequency of 1 rad/s



n	C_1	L_2	C_3	L_4	C_5
2	1.414	1.414			
3	1	2	1		
4	0.7654	1.848	1.848	0.7654	
5	0.618	1.618	2	1.618	0.618
n	L_1	C_2	L_3	C_4	L_5



27 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Chaitra

Exam.	Regular		
Level	BE	**Full Marks**	80
Programme	BEX	**Pass Marks**	32
Year / Part	IV / I	**Time**	3 hrs.

Subject: - Filter Design *(EX704)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. What is the significance of scaling in filter design? Derive the necessary expressions to determine the new values of circuit elements in the case of magnitude and frequency scaling. [6]

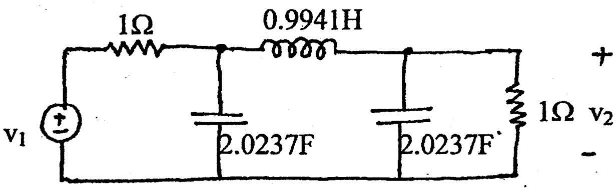
2. Derive an expression to calculate the order of Inverse Chebyshev low pass filter. Use this formula to estimate the order of Chebyshev low pass filter having following specifications: [5+3]

$\alpha_{max} = 0.25\,dB, \qquad \omega_p = 1000 rad/s$

$\alpha_{min} = 18\,dB, \qquad \omega_s = 1400 rad/s$

3. Explain the importance of all pass filters in delay equalization. Find the transfer function of fourth order Bessel-Thomson low pass filter. [3+3]

4. What is the importance of frequency transformation in filter design? The circuit given in figure below is a lawpass filter having passband frequency of 1 rad/s. Obtain a band pass filter having $\omega_o = 2000$ rad/s and B = 400 rad/s. [2+3]



5. Which of the following functions are LC driving point impedance function and why? [2+3+3]

$$Z(s) = 2\frac{s(s^2+4)(s^2+16)}{(s^2+1)(s^2+9)}$$

$$Z(s) = 4\frac{(s+2)(s+5)}{(s+1)(s+4)}$$

Also find the Faster series and Cauer II Realization of the valid LC driving point impedance function.

6. What is transmission zeros? Explain "zero shifting by partial removal of pole" with example. [1+4]

7. What is transmission coefficient? What information do we get from it? Derive expression for reflection coefficient for a resistively terminated LC ladder circuit. [2+5]

8. Realize a system using inverting op-amp configuration with zero at s = -2 and pole at s = -5 and having high frequency gain of 2. [3]

9. Perform sensitivity analysis for center frequency (W_o) and quality factor (Q) of the Tow Thomas low pass filter with respect to all the resistors and capacitors present in the circuit. [5]

10. What is Frequency Dependent Negative Resistor? How can it be used to avoid bulky inductors in the design of your circuits? Explain with suitable examples. [5]

11. Using heapfrag method simulate the LC ladder circuit given in question number 4 to obtain a low pass filter having passband of 6KHz and suitable element values. [6]

12. What is switched capacitor filter? How inverting lossy integrator, integrator and non-inverting integrator can be realized using switched capacitor? Explain with necessary diagrams and transfer functions. [7]

13. Draw a neat and clean circuit diagram of Tow-Thomas Low Pass Biquad filter and derive it's transfer function. Design a low pass filter using Tow-Thomas Biquad circuit which has poles at 1000±8994.03j and DC gain of 1.89. Use 0.01μF capacitor in your design. [9]

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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Chaitra

Exam.		Regular	
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Filter Design *(EX704)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ ***__Necessary tables are attached herewith.__***
- ✓ *Assume suitable data if necessary.*

1. Define α_{max}, α_{min} and half power bandwidth with necessary diagrams. At frequency f = 20 KHz and f = 30 KHz a filter is designed to attenuate the input signal by 78 dB and 90 dB respectively. Find the amplitude of the output signal if the 30 KHz input signal has amplitude of 1V. [3+4]

2. Derive an expression to calculate the order of Chebyshev low pass filter. Use this formula to estimate the order of Chebyshev low pass filter having following specification: [5+3]
   $\alpha_{max} = 0.1$ dB, $w_p = 1000$ rad/s
   $\alpha_{min} = 20$ dB, $w_s = 2500$ rad/s

3. What is constant delay filter? What are the steps involved in designing constant delay filter? Explain with necessary example. [6]

4. What is the significance of frequency transformation in filter design? How band pass filter can be obtained from prototype low pass filter? Explain with example. [1+3]

5. Which of the following functions are LC driving point impedance function and why? Pick one of the valid LC driving point impedance and synthesize it in Foster-I and Caver-I form: [2+3+3]

   $Z_1(s) = \dfrac{(s^2+1)(s^2+5)}{(s^2+2)(s^2+10)}$ $\quad Z_2(s) = \dfrac{5s(s^2+4)}{(s^2+1)(s^2+3)}$

   $Z_3(s) = \dfrac{2(s^2+1)(s^2+9)}{s(s^2+4)}$ $\quad Z_4(s) = 4\dfrac{(s+2)(s+5)}{(s+1)(s+4)}$

6. What is transmission zeros? What are the steps involved in realizing transmission zeros of a lossless two port network? Explain with suitable example. [5]

7. What is reflection coefficient? Design a third order Butterworth high pass filter using resistively terminated lossless ladder with equal termination of 1Ω. (Refer following table). [1+6]

   Pole Location for Butterworth Responses

n=2	n=3	n=4	n=5
- 0.7071068 ± j 0.7071068	- 0.50 ± j 0.86603	- 0.3826834 ± j 0.9238795	- 0.809017 ± j 0.5877852
	- 1.0	- 0.9238795 ± j 0. 3826834	- 0.309017 ± j 0. 9510565
			-1.0

8. Draw the circuit diagram and derive transfer function of Tow Thomas Biquad circuit. Design a low pass filter using Tow-Thomas Biquad circuit with poles at -500 ± j 2449.49 and dc gain of 2. The final circuit should consist capacitors of value 0.1μF. [3+5]

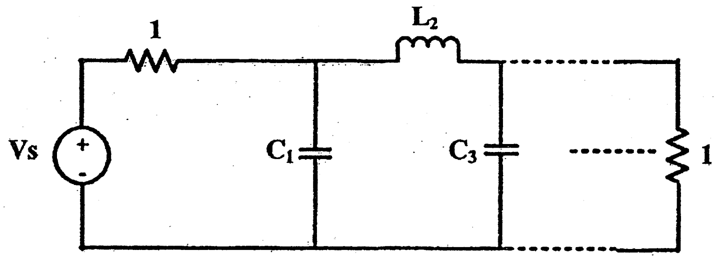
9. What is RC-CR transformation? Draw the circuit diagram of high pass sallen-key biquad obtained by RC-CR transformation of its low pass counterpart. [4]

10. What is signal parameter sensitivity? Perform sensitivity analysis for center frequency (w_o) of Sallen-Key biquad with respect to all resistors and capacitors present in the circuit. [1+4]

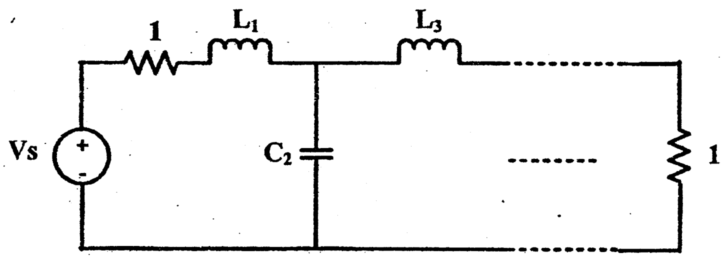
11. What is GIC? How a GIC can be used to simulate grounded inductor? Explain with necessary figures and expression. [5]

12. Simulate third order Butterworth low pass filter using Leapfrog simulation. (Refer following table) [6]

Elements values for doubly terminated Butterworth filter normalized to half power frequency of 1 rad/s



n	C_1	L_2	C_3	L_4	C_5
2	1.414	1.414			
3	1	2	1		
4	0.7654	1.848	1.848	0.7654	
5	0.618	1.618	2	1.618	0.618
n	L_1	C_2	L_3	C_4	L_5



13. What is switched capacitor filter? What are its applications? Design a switched capacitor filter to realize the magnitude response given below: [2+5]

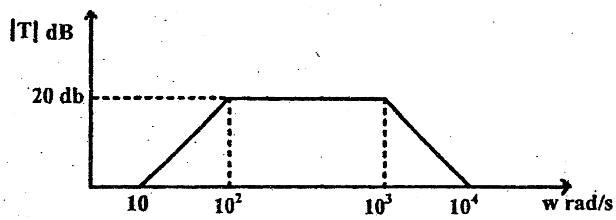


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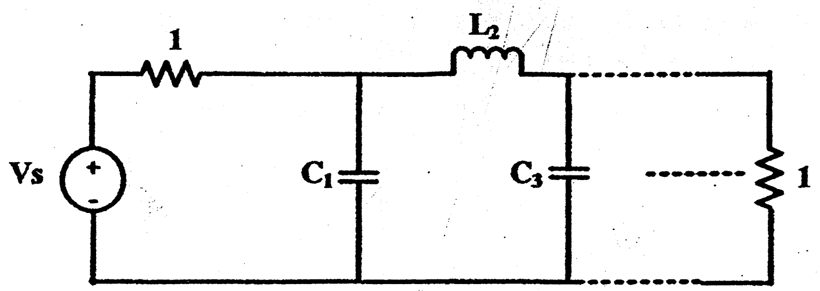
Table 1:

Pole Location for Butterworth Responses

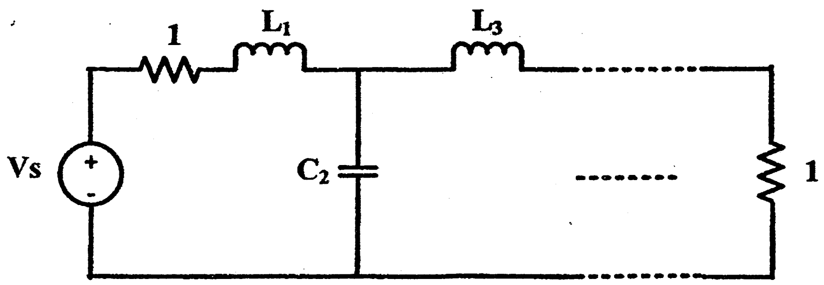
n=2	n=3	n=4	n=5
- 0.7071068 ± j 0.7071068	- 0.50 ± j 0.86603	- 0.3826834 ± j 0.9238795	- 0.809017 ± j 0.5877852
	- 1.0	- 0.9238795 ± j 0. 3826834	- 0.309017 ± j 0. 9510565
			-1.0

Table 2:

Elements values for doubly terminated Butterworth filter normalized to half power frequency of 1 rad/s



n	C_1	L_2	C_3	L_4	C_5
2	1.414	1.414			
3	1	2	1		
4	0.7654	1.848	1.848	0.7654	
5	0.618	1.618	2	1.618	0.618
n	L_1	C_2	L_3	C_4	L_5



filter design _ To Chaitra.

Bex IV / I

page-③

26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Filter Design *(EX704)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ *Assume suitable data if necessary.*

1. What is the importance of Normalization and Denormalization in filter design? Derive element scaling equations. [2+5]

2. Derive the expression to calculate the order of Butterworth appronimation for given lowpass filter specifications. Calculate the order of Butterworth low pass filter having following specification; [5+3]

   i) Passband extends from $\omega = 0$ to $\omega = 200$ rad/s and the attenuation in the passband should not exceed 0.1 dB.

   ii) Stopband extends from $\omega = 2000$ rad/s to $\omega = \infty$ and the attenuation in the stopband should not be less than 30 dB

3. What is a constant delay filter? Find the transfer function of a third order Bessel Thomson response having constant delay. [2+4]

4. What is frequency transformation? Describe the frequency transformation from low pass to band stop filter with example. [4]

5. Which of the following functions are LC driving point impedance function and why? [4+3]

   $$Z(s) = \frac{s(s^2+4)}{(s^2+9)(s^2+16)},\quad Z(s) = \frac{s(s^2+1)(s^2+9)}{(s^2+4)(s^2+16)},$$

   $$Z(s) = \frac{s(s^2+4)}{2(s^2+1)(s^2+9)},\quad Z(s) = \frac{2(s+1)(s+3)}{(s+2)(s+4)}$$

   Also find the Cauer II realization of the valid LC driving point impedance function.

6. What is "zero shifting by partial removal of pole"? Explain with example. Also mention its importance in two port network synthesis. [4+2]

7. What is transmission coefficient? What information do you get from the transmission coefficient? Design a second order Butterworth low pass filter using lossless ladder with equal termination of 1Ω i.e. $R_1 = 1\Omega$ and $R_2 = 1\Omega$ (Refer Table 1) [1+1+5]

8. Draw the circuit diagram of Tow thomas biqual low pass filter and derive its transfer function. Design a second order low pass filter using Tow Thomas biquad circuit having poles at $-750 \pm j\,661.44$ and dc gain of 2. Use capacitor of value $0.01\mu F$ in your design. [8]

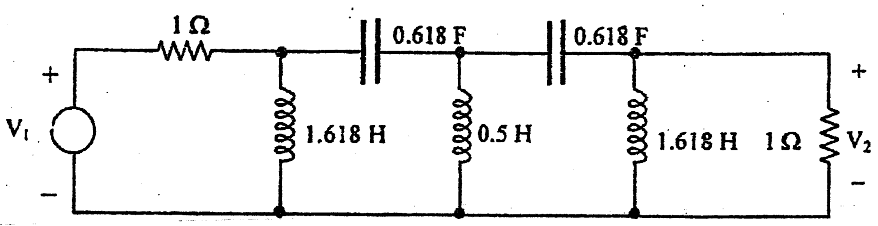
9. Design the following transfer function using inverting op-amp configuration. [4]

$$T(s) = 7\,\frac{S+400}{S+200}$$

You are not allowed to use inductors in the design.

10. What do you understand when the sensitivity of y with respect to x is equal to -3? Perform sensitivity analysis for Quality factor Q of the Tow Thomas low pass filter with respect to all the resistors and capacitors present in the circuit. [1+4]

11. What is generalized impendance converter (GIC)? How can you simulate the grounded incuctor in the passive filter using GIC? Explain The following circuit is a high pass filter having half power frequency of 1 rad/sec. Design a high pass filter having half power frequency of 4.5 kHz by active simulation of inductors. In your final circuit the largest capacitance should be 0.1 μF. [2+4+6]



12. What is a switched capacitor filter? What are its applications? How can you simulate a resistor using switched capacitor? Explain with necessary derivation. [3+3]

Table 1: Pole Location for Butterworth Responses

n = 2	n = 3	n = 4	n = 5
-0.7071068 ±j 0.7071068	-0.50 ±j 0.86603	-0.382684 ±j 0.9238795	-0.809017 ±j 0.5877852
	-1.0	-0.9238795 ±j 0.3826834	-0.309017 ±j 0.9510565
			-1.0

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31 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2064 Poush

Exam.	Regular/Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary figures and tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. The magnitude squared function of Chebyshev approximation is given as: [4+2+4]

$$|T_n(j\omega)|^2 = \frac{1}{1+\varepsilon^2 C_n^2(\omega)}$$

   a) Derive an expression to calculate the required order for given low pass filter specifications.
   b) Calculate the required order for following low pass specifications.
   $\alpha_{max} = 0.5$ dB, $\alpha_{min} = 14$ dB, $\omega_p = 1200$ rad/s, $\omega_s = 1800$ rad/s
   c) Prove that the locus of poles of Chebyshev approximation is ellipse.

2. Which o the following functions are LC-driving point impedances? Explain with reason. [4]

$$Z_1(s) = \frac{s^2+20s^3+64s}{s^4+34s^2+225}, \quad Z_2(s) = \frac{s^4+9s^2+8}{s^3+4s}$$

   Synthesize one of the realizable impedance using Cauer-I and Cauer-II method. [3+3]

3. For $R_1 = R_2 = 1\Omega$, obtain a lossless ladder to realize the following transmission coefficient: [10]

$$t(s) = \frac{2(s^2+1)}{3s^3+4s^2+3s+2}$$

4. Draw the neat diagram of Sallen-Key low pass filter and derive the transfer function. Design a fourth order Butterworth filter (refer Table 1) using cascade of two Sallen-Key circuits using design-1 and design-2 respectively. Your final circuit must have cutoff frequency of $\omega_0 = 4000$ rad/s and capacitances of 0.1 μF to 0.001 μF. [10]

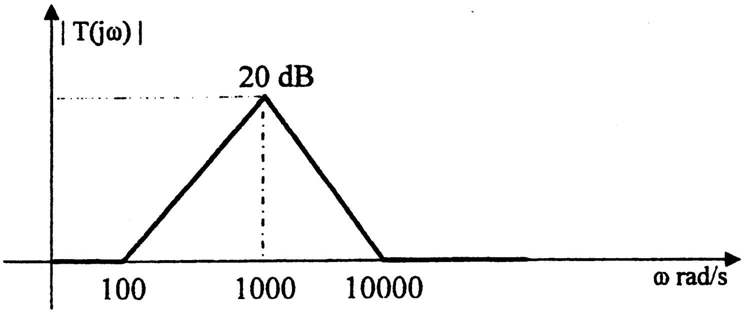
5. Define bandwidth, α_{max}, α_{min} and roll of with necessary diagram. At frequency f = 15 kHz and f = 20 kHz a filter is designed to attenuate the input signal by 78 dB and 90 dB respectively. Find the amplitude of the output signal if the 15 kHz input has amplitude of 500 mV. [8]

6. What is the importance of frequency transformation in filter design? Use frequency transformation to find the bandstop filter assuming suitable lowpass prototype. [8]

7. Discuss single parameter and multiparameter sensitivities. Perform the sensitivity analysis of Sallen-Key lowpass filter. [8]

8. What is frequency dependent negative resistor (FDNR)? How FDNR helps us to avoid the use of inductor in filter design? Explain with suitable example. [8]

9. What is switched capacitor filter and what are the limitations? Design a switched capacitor MOS filter to realize the magnitude response given in attached figure. [8]



Use suitable clock frequency for your design.

Table 1:
Pole Locations for Butterworth Responses

$n = 2$	$n = 3$	$n = 4$	$n = 5$
- 0.7071068 ± j 0.7071068	- 0.50 ± j 0.86603	- 0.3826834 ± j 0.9238795	- 0.809017 ± j 0.5877852
	- 1.0	- 0.9238795 ± j 0.3826834	- 0.309017 ± j 0.9510565
			- 1.0

***** The End *****

31 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2064 Shrawan

Exam.		Back	
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary table is attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. Define bandwidth, transition width, α_{max}, α_{min} and roll off. [6]

2. What are the major properties of RC driving point impedance functions? [4+2+3+3]

$$Z_1(s) = \frac{s^2+4s+3}{s^2+8s+12}, \text{ and } Z_2(s) = \frac{s^2+8s+12}{s^2+4s+3}$$

Determine which of the above impedance function is valid RC driving point impedance? Then realize it in Foster series and RC ladder form.

3. Explain zero shifting by partial removal of pole with a suitable example. [6]

4. Derive relation to estimate the order n of inverse Chebyshev approximation. Use this formula to estimate the order of inverse Chebyshev for following specifications: [4+3+5]

$\alpha_{max} = \alpha_p = 1$ dB $\alpha_{min} = \alpha_s = 16$ dB

$\omega_p = 1000$ rad/s $\omega_s = 1600$ rad/s

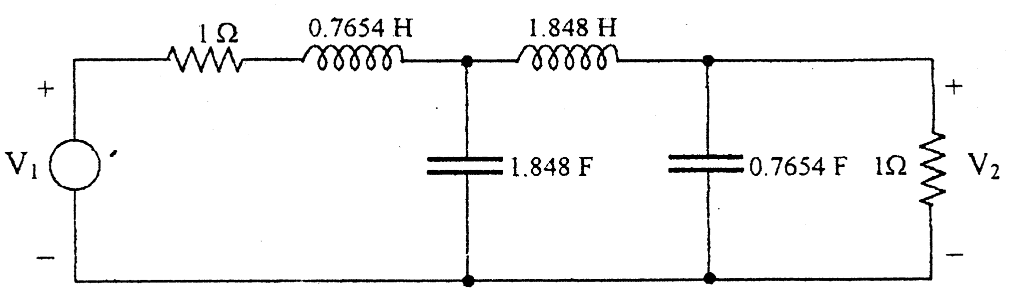
Determine the pole locations and plot it.

5. Starting from a second order all pole transfer function $t(s) = \dfrac{a_0}{s^2 + a_1 s + a_0}$, derive the constant delay second order filter. [8]

6. How can you transform given low pass filter into a bandpass filter? Explain with example. [6]

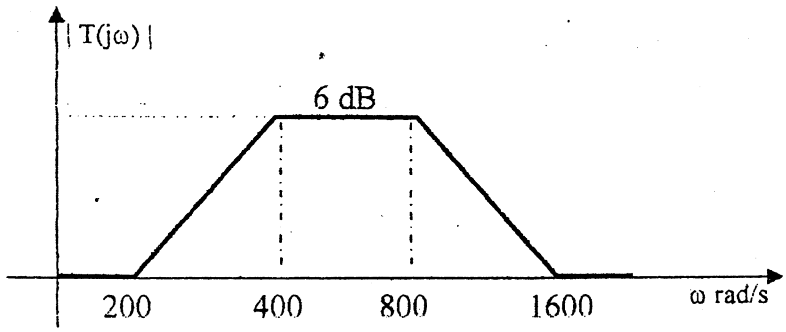
7. Draw the complete circuit of Sallen Key low pass biquad filter and derive the transfer function. Design third order lowpass Butterworth filter at $f_0 = 3$ kHz using Sallen and Key circuit. Your final circuit must contain practically realizable values. Perform gain compensation if necessary. [6+6]

8. Design a lowpass filter using the Leapfrog simulation method. The prototype is given in figure below, having half-power frequency of 1.0 rad/s. [10]



In your final design the half-power frequency is to be 1.6 kHz, and all elements should be in a practical range of values.

9. Design a switched capacitor MOS filter to realize the magnitude response given below: [8]



Use suitable clock frequency for your design.

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Table 1:
Pole Locations for Butterworth Responses

$n = 2$	$n = 3$	$n = 4$	$n = 5$
- 0.7071068 ± j 0.7071068	- 0.50 ± j 0.86603	- 0.3826834 ± j 0.9238795	- 0.809017 ± j 0.5877852
	- 1.0	- 0.9238795 ± j 0.3826834	- 0.309017 ± j 0.9510565
			- 1.0

31 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Magh

Exam.	Old Back (2065 & Earlier Batch)		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Filter Design ***(EG675EX)***

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) What are the differences between ideals and practical filter? Describe the concept of α_p and α_s with diagrams. [2+2]

   b) Derive element scaling equations. What is the importance of scaling? Explain. [6]

2. a) What are the properties of Butterworth approximation? What are its advantages and disadvantages compared with other approximation methods? Explain. [2+2]

   b) Find the order of Butterworth low pass filter and plot its pole-zero locations which satisfies the following specifications: α_{max} = 1 dB, α_{min} = 12 dB, ω_p = 1000 rad/s, ω_s = 2000 rad / s [6]

3. a) Define positive real function. What are the properties of RC impedance function? Explain. [6]

   b) Realize the given function below using faster I method [5]

$$Y(S)=\frac{(S^2+1)(S^2+5)(S^2+20)}{s(S^2+2)(S^2+10)}$$

4. What is zero-shifting by partial pole removal? Explain with example. [4]

5. a) Find the relationship between transmission coefficient and reflection coefficient in case of doubly terminated lossless two port network. [4]

   b) Give the reflection coefficient, ρ(s) below, relaize the doubly terminated lossless two port with resistances of 1 Ohm each. $\rho(S)=\frac{S^3}{S^3+2s^2+2s+1}$. [5]

6. Draw the circuit diagram of low Thomas biquad circuit and derive its transfer function. Design a second order lowpass filter using Tow Thomas biquad circuit with poles $-2000\pi \pm j4852.58$ and a dc gain of 2. In your final design, use capacitor of 0.01μF. [4+6]

7. a) Define single parameter and multi-parameter sensitivity. Why sensitivity analysis is important in filter design? [2+2]

   b) Perform the sensitivity analysis of Tow Thomas Biquad circuit. [5]

8. What is Generalized Impedance Converter (GIC)? Discuss the active simulation of grounded inductor with example. [2+8]

9. What is switched capacitor filter? Realize the switched capacitor circuit of integrator, investing summer, lossy integrator and inverting integrator. [7]

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31 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2067 Mangsir

Exam.	**Regular / Back**		
Level	BE	**Full Marks**	80
Programme	BEX	**Pass Marks**	32
Year / Part	III / II	**Time**	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ *Assume suitable data if necessary.*

1. What are the properties of RC admittance function? Determine whether the following functions are RC admittance functions or not? [12]

$$Y(s) = \frac{s^3+3s}{s^4+5s^2+4} \qquad Y(s) = \frac{s^2+4s+3}{s^2+2s} \qquad Y(s) = \frac{(s+1)(s+3)}{(s+2)(s+4)}$$

Realize one of the valid RC admittance function using Foster parallel and Cauer II method.

2. Draw the neat and clean circuit diagram of Tow Thomas biquad circuit and derive the low-pass transfer function. How can you obtain highpass response from Tow Thomas biquad circuit? Explain with necessary derivations. Using Tow Thomas biquad circuit realize the following transfer function [12]

$$T(s) = \frac{2000}{s^2+500s+1000000}$$

3. Derive the expression to estimate the order (n) of Inverse Chebyshev approximation. Use this formula to estimate the order of Chebyshev filter for following specifications: [8]

$$\omega_p = 1000 \quad rad/s \qquad \omega_s = 1500 \quad rad/s$$
$$\alpha_p = 1.0 \quad dB \qquad \alpha_s = 15.0 \quad dB$$

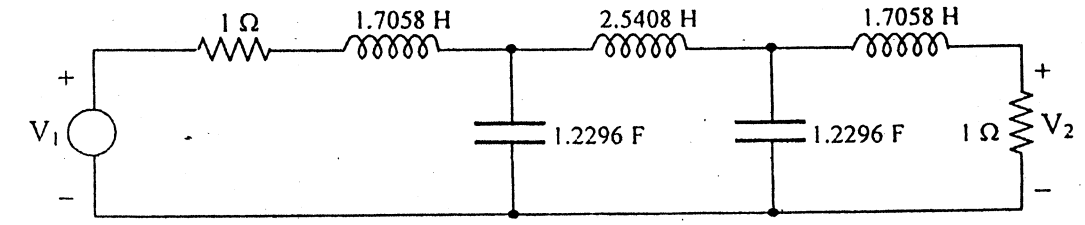
4. Define the terms: pass-band, stop-band, half-power point, roll-off, insertion-loss and insertion-gain with necessary diagrams. [8]

5. What are the properties of lossless two port network? If a pole is removed partially from given impedance function, what is the effect on all poles and zeros in given impedance function? Explain with example. [8]

6. What are the characteristics of active filter? Realize an active filter using inverting op-amp configuration with zero at 8, pole at 4 and dc gain of 2. [8]

7. What is sensitivity? Compare the sensitivity of active vs. passive filter. Perform sensitivity analysis of Tow Thomas biquad lowpass filter. [8]

8. Following circuit shows the passive lowpass filter having normalized bandwidth. Design a lowpass filter using FDNR having bandwidth of 4 kHz. In your final design all elements should be in practical range. [8]



9. What is switched capacitor filter? How a resistor can be simulated using switched capacitor? Explain. Also draw the switched capacitor equivalent circuit of the Summing inverter and Non-inverting integrator. [8]

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31 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2066 Magh

Exam.	Regular/Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. What are the advantages of active filter over passive filter? Realize a bilinear transfer function with zero at 3, pole at 9 and high frequency gain of unity using inverting op-amp configuration. [8]

2. Derive the element scaling equations. What is the importance of normalization in filter design? Explain with example. [8]

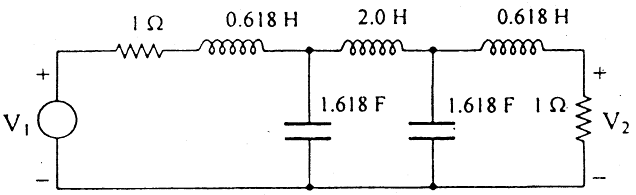
3. Synthesize the following impedance function in Foster parallel and Cauer II form. [8]

$$Z(c) = \frac{6s^4 + 54s^2 + 48}{s^5 + 19s^3 + 48s}$$

4. Realize a two port LC ladder circuit which is defined by following impedances: [12]

$$Z_{21} = \frac{s^2}{s(s^2 + 10)} \text{ and } Z_{11} = \frac{s^2 + 5}{s(s^2 + 10)}$$

5. Following circuit is a fifth order Butterworth lowpass filter at normalized frequency. From given circuit obtain a highpass filter having half power frequency of 10 KHz using simulated inductors. [8]



6. Draw the circuit diagram of multiple feed-back (MFB) lowpass biquad filter, and derive its transfer function. Design the second order Butterworth lowpass filter having half power frequency of 10 KHz using MFB biquad circuit. In your final circuit, the largest capacitance should be 0.1 μF. [12]

7. Define sensitivity? What is single parameter and multiparameter sensitivity? Why passive filters are less sensitive than active filters? Explain. Perform sensitivity analysis of RLC lowpass filter. [8]

8. From a doulby terminated fourth order Butterworth lowpass filter, design a lowpass filter having half power frequency of 4000 rad/sec using active simulation of inductors. [8]

9. What is switched capacitor filter? How can you simulate a resistor and invert a signal using switched capacitor? Explain with necessary derivations. [8]

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Table 1: Pole locations for Butterworth Response

$n = 2$	$n = 3$	$n = 4$
$-0.7071068 \pm j\,0.7071068$	$-0.50 \pm j\,0.86603$	$-0.3826834 \pm j\,0.9238795$
	-1.0	$-0.9238795 \pm j\,0.3826834$

Table 2: Elements of 4th order Butterworth lowpass ladder circuit

$R_1 = 1\,\Omega$	$L_1 = 0.7654$ H	$C_2 = 1.848$ F	$L_3 = 1.848$ H	$C_4 = 0.7654$ F	$R_2 = 1\,\Omega$

31 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2065 Chaitra

Exam.	Regular/Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III/II	Time	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. What is scaling in filter design? Why is it necessary? Derive the expression to determine the new value of circuit elements while applying magnitude and frequency scaling. [8]

2. Derive an expression to calculate the required order for given low pass specifications using inverse Chebyshev approximation. Using your expression calculate the order of inverse Chebyshev filter for following specifications: [12]

   $\alpha_{max} = 0.5$ dB, $\alpha_{min} = 15$ dB

   $\omega_p = 1000$ rad/s, $\omega_s = 2000$ rad/s

   Also show pole, zero locations.

3. Which of the following functions are LC driving point impedance function and why? Explain. [8]

   $$Z_1(s) = \frac{s^4 + 20s^2 + 64}{s^5 + 34s^3 + 225s} \text{ and } Z_2(s) = \frac{s^5 + 20s^3 + 64s}{s^4 + 10s^2 + 9}$$

   Pick one of the valid LC impedance and synthesize it in foster parallel form.

4. What is the importance of frequency transformation in filter design? How bandstop filter can be obtained from suitable low pass prototype? Explain. [8]

5. Design an active filter to realize the bilinear transfer function with zero at 1kHz, pole at 12kHz and high frequency gain of 20dB. [8]

6. Draw the neat and clean diagram of Tow-Thomas lowpass biquad filter, and derive the transfer function. Design a low pass filter using Tow-Thomas biquad which has poles at -450±893.03j and dc gain of 1.5. Your final circuit should contain practically realizable elements. [12]

7. Define sensitivity, and explain the importance of sensitivity analysis in filter design. Perform sensitivity analysis of Tow Thomas lowpass biquad filter. [8]

8. What is Frequency Dependent Negative Resistor? How can it be used to avoid use of inductor in filter circuit? Explain with suitable example. [8]

9. What is switched capacitor filter? Design a switched capacitor filter to realize the transfer function: [8]

   $$T(S) = \frac{(s+200)(s+800)}{(s+400)^2}$$

31 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2065 Kartik

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ *Assume suitable data if necessary.*

1. The magnitude squared function of Butterworth filter is given as: (5+3+2+4+6) [20]

$$|T_n(j\omega)|^2 = \frac{1}{1+(\omega/\omega_0)^{2n}}$$

a. Derive an expression to calculate the required order for given low pass filter specifications.

b. Using this expression calculate the required order for following low pass specifications.

$\alpha_{max} = 1$ dB, $\alpha_{min} = 10$ dB $\omega_p = 1000$ rad/s $\omega_s = 2000$ rad/s

c. Calculate half power frequency.

d. Plot pole-zero location and determine the transfer function.

e. Realize the transfer function using Sallen-Key circuit.

2. Find an LC ladder to realize the following impedances simultaneously. [10]

$$Z_{11} = \frac{s^2+5}{s(s^2+10)}, \quad \text{and } Z_{21} = \frac{Ks^2}{s(s^2+10)}$$

3. To obtain higher order active filters in filter design, instead of using cascaded biquads, why is it necessary to simulate LC ladder circuits? Explain leapfrog simulation of LC ladders with suitable example. [10]

4. Define passband, stopband and transition band with necessary diagram. A wide-band input signal of amplitude 100 mV is applied to the filter. In the stopband, the signal components at output of filter must be no larger than 50 μV. Determine the required stopband attenuation α of the filter in dB. [8]

5. What is positive real function? Discuss the properties of LC driving point impedance function with suitable example. [8]

6. Compare active filter with passive filter. Design an active filter using non-inverting op-amp configuration with following transfer function: [8]

$$T(s) = \frac{s+8}{s+2}$$

7. Draw the neat and clean diagram of multiple feedback (MFB) lowpass biquad circuit and derive the transfer function. Design a MFB biquad for the following transfer function: [8]

$$T(s) = \frac{1}{s^2+1.2s+1}$$

8. Define sensitivity. What is its importance in filter design? Compute the sensitivity expression for cutoff frequency and quality factor of RLC lowpass filter. [8]

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INSTITUTE OF ENGINEERING

Examination Control Division

2063 Kartik

Exam.	Regular/Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Derive the relation to calculate the order n of low-pass Butterworth approximation. Using this formula calculate the order for following low-pass specifications: [4+3+3+2]

   $\alpha_{max} = \alpha_p = 1$ dB $\alpha_{min} = \alpha_s = 12$ dB

   $\omega_p = 1000$ rad/s $\omega_s = 2000$ rad/s

   Also determine transfer function and plot pole locations.

2. Draw the complete circuit of Tow Thomas biquad low-pass filter and derive its transfer function. Using this circuit realize the second order low pass filter with poles $-2000 \pm j3464.102$ and dc gain of 2.5. In your final circuit capacitor should be 0.01 μF. [6+6]

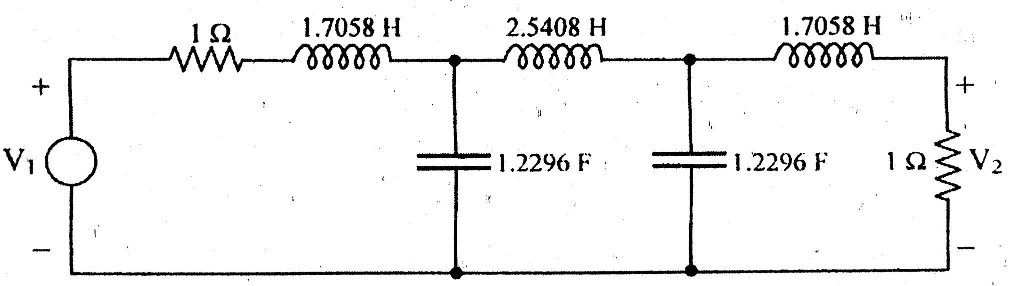
3. Which of the following functions are LC driving point impedance function and why? [4+3+3]

   $$Z_1(s)\frac{s^5+20s^3+64s}{s^4+34s^2+225},\quad Z_2(s)=\frac{s^4+9s^2+8}{s^3+4s},\quad \text{and}\quad Z_3(s)=\frac{s^3+13s^2+44s+32}{s^3+8s^2+12s}$$

   Pick one of the valid LC impedance and synthesize it in foster parallel, as well as LC ladder form.

4. What are the properties of lossless two-port networks? How zeroes of transmission can be realized in two port network? Show with suitable example. [3+5]

5. The following circuit is a fifth order Chebyshev lowpass filter with a 0.5 dB ripple, normalized so that the 3-dB bandwidth is 1.0 rad/s. [8]



   Realize this using FDNR such that the half power bandwidth is 1432.5 Hz. Your final circuit should contain practically realizable elements.

6. What are the characteristics of ideal filter? Compare the characteristics of ideal filter with that of practical filter. [6]

7. What do you mean by frequency transformation? Why it is necessary? Explain with example. [6]

8. What are the properties of Bessel Thomson response? How can you design constant delay filter? [6]

9. Why sensitivity analysis is important in filter design? Show how changes in each capacitors C_i affect the filer parameters ω_0 and Q in Tow Thomas biquad circuit. [6]

10. What is switched capacitor filter, and where it is used? How inverting lossy integrators and non-inverting can be realized using switched capacitor? [6]

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31/5-19 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2062 Bhadra

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ *Assume suitable data if necessary.*

1. Derive element scaling equations. Explain the importance of scaling in filter design. [6]
2. Discuss the properties of positive real function with suitable examples. [6]
3. Determine whether the following functions are RC driving point admittance functions or not, state with reason. [10]

   $$Y(s) = \frac{(s+1)(s+4)}{s(s+2)} \text{ and } Y(s) = \frac{3(s+1)(s+4)}{(s+3)(s+6)}$$

   Pick one of the valid RC admittance function and realize it in parallel Foster form, as well as RC ladder form.
4. Synthesize the two port network whose parameters are defined as: [8]

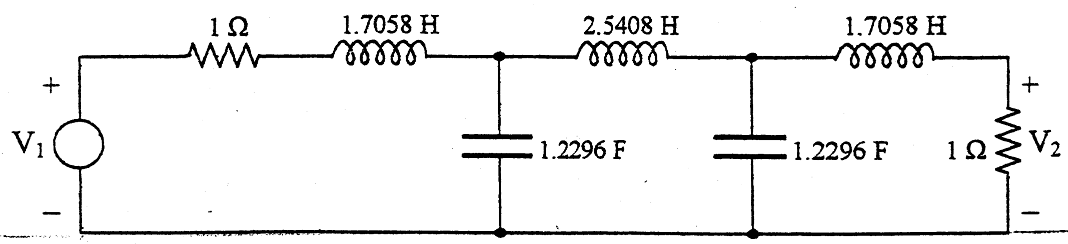
   $$Z_{22} = \frac{2s^2+1}{s(s^2+2)}, \quad \text{and} \quad Z_{21} = K\frac{s^2+4}{s(s^2+2)}$$

5. Compare Butterworth approximation with inverse Chebyshev approximation. [6]
6. Derive the expression to calculate the order (n) of Butterworth approximation. And using this expression, calculate the order of Butterworth filter for following low pass specifications: [12]

   $\alpha_{max} = \alpha_p = 1 \quad dB$ $\qquad \alpha_{min} = \alpha_s = 20 \quad dB$

   $\omega_p = 1000 \quad rad/s$ $\qquad \omega_s = 2000 \quad rad/s$

   Show the pole locations, and determine the transfer function.
7. Derive the transfer function of Tow Thomas biquad circuit (lowpass). Then design a second order lowpass filter using Tow Thomas biquad with poles – 4000 ± j 9165.1514 and a dc gain of 2. In your final circuit capacitor value should be within 0.1 μF to 0.001 μF. [10]
8. Define sensitivity. Perform the sensitivity analysis of Tow Thomas biquad lowpass filter. [8]
9. What is switched capacitor filter? How can you realize summing integrator and lossy integrator using switched capacitor? Explain with necessary diagrams. [6]
10. The following circuit is the lowpass filter having half power bandwidth of 1.0 rad/s. [8]



Realize above filter using FDNR, such that the half power bandwidth is 5 kHz. Your final circuit should contain practically realizable values.

31/2-17 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2062 Jestha

Exam.		Back	
Level	B.E.	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Define half-power point, bandwidth, roll-off, pass-band and stop-band with necessary diagrams. [5]

   b) What are the properties of lossless driving point impedance function? Explain with examples. [6]

2. a) Identify the following driving point impedance. Then synthesize using foster series and foster parallel method. [8]

$$Z(s) = \frac{s^5 + 6s^3 + 8s}{s^4 + 4s + 3}$$

   b) Express impedance parameters in terms of admittance parameters. [5]

3. a) Distinguish between Butterworth approximation and Elliptic approximation. [6]

   b) Derive the expression to estimate the order (n) of Inverse Chebyshev approximation. Use this formula to extimate the order of Inverse Chebyshev for following specifications: [12]

   $\omega p = 1000$ rad/s $\quad \omega_s = 1500$ rad/s

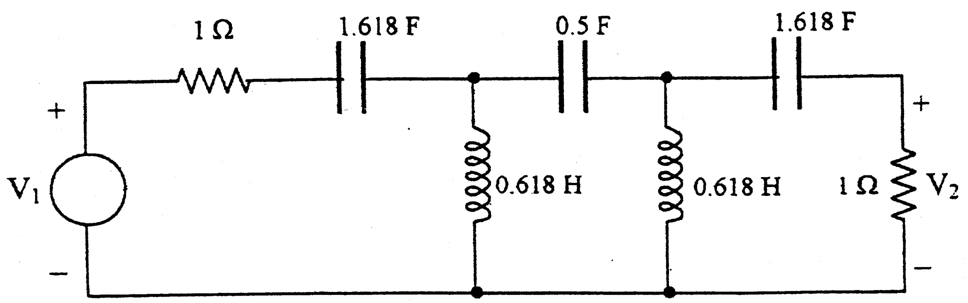
   $\alpha_{max} = \alpha_p = 0.5$ dB $\quad \alpha_{min} = \alpha_s = 22$ dB

   Determine the pole locations and transfer function.

4. a) Design a second order lowpass filter using Tow Thomas biquad circuit with poles -2000 $\pm$j 4582.58 and a dc gain of 2. In your final design capacitor value should be 0.01μF. [8]

   b) What is leapfrog simulation of passive filter? Explain with a suitable example. [9]

5. a) Realize the following passive filter be active simulation of grounded inductors. [8]



   Use frequency scaling factor $k_f = 2000$ and also perform the magnitude scaling to get practically realizable element values in your final circuit.

   b) What is switched capacitor filter? What is significance of MOS switching frequency in switched capacitor filter? Explain with a suitable example. [8]

   c) Define single parameter sensitivity. Why sensitivity analysis is necessary? [5]

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31/5-27 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2061 Bhadra

Exam.	**Regular / Back**		
Level	B.E.	**Full Marks**	80
Programme	BEX	**Pass Marks**	32
Year / Part	III / II	**Time**	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Distinguish between magnitude scaling and frequency scaling? What is the significance of scaling in filter design? [6]

   b) Show the difference between LC and RC driving point impedance function with examples? [6]

2. a) Identify the following driving point impedance. Then synthesize using Cauer I and Cauer II method. $Z(s) = \dfrac{s^4 + 40s^2 + 144}{s^3 + 16s}$ [8]

   b) Derive the expressions to calculate admittance parameters in terms of impedance parameters. [5]

3. a) How can you design a constant delay filter? Explain. [6]

   b) Derive the expression to calculate the order (n) of Chebyshev approximation. And using this formula, calculate the order of Chebyshev filter for following lowpass specifications: [12]

   $\omega_p = 1$ rad/s $\qquad \omega_s = 1.8$ rad/s

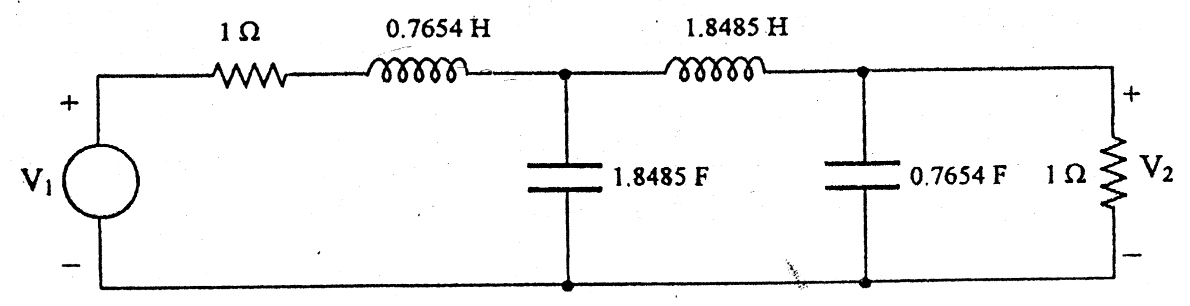
   $\alpha_{max} = \alpha_p = 0.5$ dB $\qquad \alpha_{min} = \alpha_s = 20$ dB

   Show pole locations and determine the transfer function.

4. a) Design a third order lowpass Butterworth (Refer table 1) filter using Sallen-Key biquad with (ω_0 = 3000 rad/s. Perform gain compensation if necessary. Choose the capacitor values between 0.1 μF to 0.001 μF. [10]

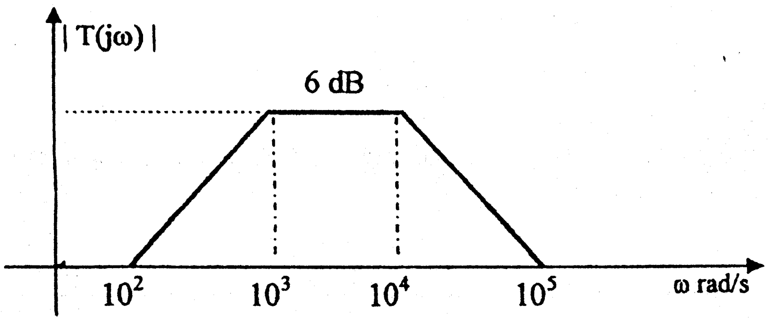
   b) Define generalized impedance converter. Explain the active simulation of grounded inductor in filter design. [8]

5. a) Realize the following lowpass filter using FDNR (frequency dependent negative resistor). [9]



Given passive filter is designed at normalized frequency. So perform frequency scaling to make $\omega_0 = 1000$ and finally your circuit should contain practically realizable values.

b) Design a switched capacitor filter to realize the magnitude response given below. [10]



Use suitable MOS switching frequency.

Table 1:
Pole Locations for Butterworth Responses

$n=2$	$n=3$	$n=4$	$n=5$	$n=6$
- 0.7071068	- 0.50	- 0.3826834	- 0.809017	- 0.258819
± j 0.7071068	± j 0.86603	± j 0.9238795	± j 0.5877852	± j 0.9659258
	- 1.0	- 0.9238795	- 0.309017	- 0.7071068
		± j 0.3826834	± j 0.9510565	± j 0.7071068
			- 1.0	- 0.9659258
				± j 0.2588190

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31/5-14 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2060 Bhadra

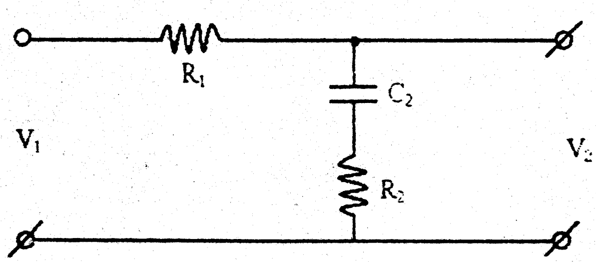
Exam.	Regular / Back		
Level	B.E.	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III / II	Time	3 hrs

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. a) Distinguish among the terms: cut off frequency (ω_C), half-powerpoint (ω_{hp}), centre frequency (ω_o) clearly with neat diagrams. [1+1+1]

   b) For the given circuit below, find transfer function T(S). Also plot the magnitude and phase response indicating the location of poles and zeros. [2+2+2+1]



2. a) What are the properties of LC circuit? Show that Z(S) is the ratio of the even by odd function or odd by even function in LC circuit. [3+3]

   b) Find the expression for Z-parameters in terms of Y-parameters? What do you mean by residue condition? Explain. [5+3]

3. a) Realize the following function using Cauer-I and Cauer-II method. [4+4]

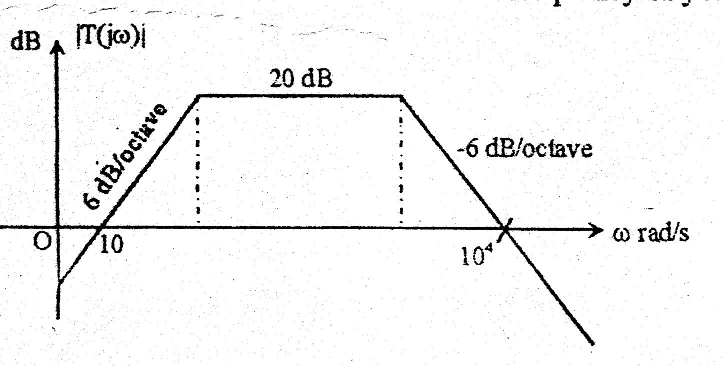
$$F(S) = \frac{4S^2 + 16S + 12}{S^2 + 8S + 12}$$

   b) Explain Chebyshev approximation for low pass filter and derive expression for the order of filter (n). [10]

4. a) Define single parameter and multiparameter sensitivities? What is its significance in filter design? Also, explain, what do you mean by gain allocation? [2+2+2+2]

   b) Design a 4^{th} order lowpass filter, implemented by using active leapfrog method with the half power point being 20,000 rad/sec. [10]

5. a) For the asymptotic bode plot shown in figure below, find T(S) and realize it by using switched capacitor MOS filter. Choose reasonable clock frequency of your own. [10]



   b) What is Antoniou GIC? Find expression for Z_{11} and explain how you can simulate floating inductor using GIC. [1+5+4]

INSTITUTE OF ENGINEERING
Examination Control Division
2059 Shrawan

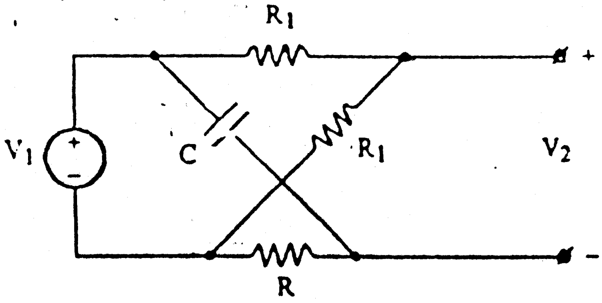
Level	B.E.	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary figures are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. a) What do you mean by insertion loss? Compare active and passive filter. What are the basis of their selection? Which do you prefer? Give reasons. [1+4+1]

   b) For the circuit shown in figure below, determine the transfer function, show pole-zero locations and plot magnitude and phase response. [2+2+4]



2. a) Define PRF. What are the properties of PRF? What is its significance? Discuss. [1+3+1]

   b) Realize the given function Z(S) using Cauer-I and Cauer-II method, where [4+4]

$$Z(S) = \frac{2S^5 + 12S^3 + 16S}{S^4 + 4S^2 + 3}$$

3. a) Define loss-less two port networks. Explain its properties. What do you mean by private and transmission poles? [1+2+2]

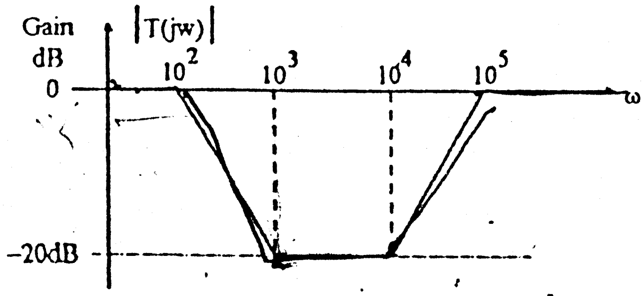
   b) A voltage of $200 < 0°$ V is applied at terminal pair – 1 with terminal pair – 2 open, results in current $I_1 = 20 < 0°$ A and $V_2 = 50 < 0°$. The same voltage is applied to terminal pair – 2, with terminal pair – 1 open, results in $I_2 = 40 < 0°$ and $V_1 = 80 < 0°$. (i) Find impedance matrix, (ii) the loop equation for this network and (iii) what will be the voltage across a 20Ω resistor connected across terminal pair – 2 if a $100 < 0°$ volt source is connected across terminal pair – 1 [4+2+2]

4. a) Discuss Chebyshev approximation in filter design. Make comparison between Butterworth, Chebyshev, Inverse Chebyshev and elliptic filter with neat diagrams. [3+3]

   b) Design second order Butterworth filter using Sallen key biquad and perform gain allocation if needed. Use $\omega_0 = 2000\pi$ rad/s and C = 0.1μF to calculate other component values. [8]

5. a) Why filter element sensitivity is important in filter design. Discuss single parameter and multi-parameter sensitivities in detail. [2+4]

   b) Design switched capacitor MOS filter which satisfies the given magnitudes response in Bode plot. You can choose reasonable clock frequency of your own. [8]



6. Design a Butterworth forth order lowpass filter with half power frequency of 10KHz. The filter must be implement in leapfrog active filter. [12]

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31 / 5 - 15 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2058 Shrawan

Exam.	Regular / Back		
Level	B.E.	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Assume missing data if necessary.*

1. a) Discuss the Butterworth approximation in filter design. Differentiate between Butterworth and Chebyshev approximations. [6+2]

   b) The following specifications are given for a Butterworth low-pass filter.

   $\alpha_p = 1$ dB, $\alpha_s = 25$ dB and $\frac{\omega_s}{\omega_p} = 1.5$.

   Determine:
   i) the filter order which is required to meet the above specifications. [4]
   ii) the half-power frequency. [4]

2. a) Discuss the need and importance of filter design in the field of electronics engineering. [5]

   b) Differentiate between an ideal brick-wall response and practical responses. [5]

   c) Define the following terms: half-power point, band width, gain and attenuation. [6]

3. a) Draw a neat circuit diagram of a Tow-Thomas Biquad circuit. Explain the function of each of the three important blocks in the circuit. Derive the transfer function of each of the blocks as well as the overall transfer function. [2+3+5]

   b) Discuss Design II method in Salen-key biquad design. [6]

4. a) What is P-R function? Why a function need to be PR function? Explain with a suitable example. [3+4]

   b) Given F(s) is the driving point admittance function of an LC network. Synthesize the function [6]

   $$F(s) = \frac{4(s+1)(s+3)}{(s+2)(s+6)}$$

   c) Explain properties of two port network. [3]

5. a) Explain why Leapfrog simulation of passive filter is needed, use a suitable example to support your explanation. [5]

   b) What is Generalized Impedance Converter? Discuss the active simulation of grounded inductor in filter design. [6]

   c) Discuss the operation of a switched capacitor filter. Explain its application. [5]

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36 / 5-5 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING

Examination Control Division

2057 Bhadra

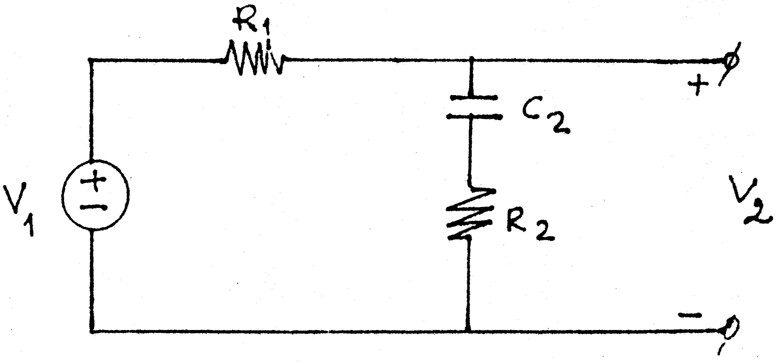
Exam.	Regular/Back		
Level	B.E.	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	~~II/II~~ III/II	Time	3 hrs.

Subject: - Filter Design

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*

1. a) Define half-power point and attenuation. Explain how can you define filter types from attenuation curve? [3+3]

   b) Plot the magnitude and phase responses for given R-C filter circuit. Show the location of poles and zeros in s-plane and justify your plots. [8]



2. a) Define P-R function and explain its importance in realization of a network. [6]

   b) The driving point impedance of an one port L-C network is Z(s). Synthesize the driving point impedance in First Cauer form. [6]

$$z(s) = \frac{s(s^2+4)}{2(s^2+1)(s^2+9)}$$

   c) Discuss the properties of lossless two port network [4]

3. a) Discuss Chebyshev approximation in filter design. Differentiate between Chebyshev and Inverse-Chebyshev approximations. [3+3]

   b) Discuss Bessel-Thomson method of constant delay filter design. [6]

4. a) What is Gain Enhancement? Explain why it is necessary in Sallen-Key active filter design? [2+4]

   b) What is RC-CR transformation? Show that a low pass Sallen-Key active filter will be high-pass filter if RC-CR transformation is applied in low-pass Sallen-Key. [3+4]

   c) Design a MFB biquad to meet following specification: G = 4, b_1 = 1.3, and b_0 = 1 [6]

5. a) What is Frequency Dependent Negative Resistance? Explain how FDNR can replace the inductor in filter circuit? [2+4]

   b) Explain active simulation of passive filter using Leapfrog method. [6]

   c) What is a switched capacitor filter and what are the limitations of this kind? Explain in detail with a suitable example. [2+4]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
Shrawan - 2055

Exam.	Regular		34/5/20
Level	B.E.	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	III/II	Time	3 hrs.

Subject :- Filter Design

* Candidates are required to give their answers in their own words as far as practicable.
* Attempt ***ALL*** questions.
* The figures in the right margin indicate full marks.
* **Necessary figures and tables are attached herewith.**

1.(a) Define half-power point, bandwidth, skirt, and roll-off. (8)

(b) Plot the magnitude and phase responses for given R-C filter circuit. Justify the plots with the help of locations of poles and zeros in s-plane. (8)

(See Fig.-1)

2.(a) Discuss the basic techniques of synthesis of a given P-R function in detail. (6)

(b) Given *F(s)* is the driving point admittance function of a R-L network. Synthesize the function. (5)

$$F(s) = \frac{4(s+1)(s+3)}{(s+2)(s+6)}$$

(c) Find Y-parameters of given network interms of Z-parameters. (5)

3.(a) Discuss Inverse-Chebyshev approximation in filter design. Differentiate between Chebyshev and Inverse-Chebyshev approximations. (6)

(b) The following specification are given for a Chebyshev low-pass filter : (10)

$$\frac{\omega_s}{\omega_p} = 1.5$$

$$\alpha_{max} = \alpha_p = 1dB$$

$$\alpha_{min} = \alpha_s = 22dB$$

Determine :

(i) the filter order which is required to meet the above specification

(ii) the half-power frequency

(iii) the network function.

4.(a) Why filter element sensitivities is important in filter design ? Discuss single-parameter and multi-parameter sensitivities in detail. (8)

(b) What is Generalized Impedance Converter ? Discuss the active simulation of grounded inductor in filter design. (8)

5.(a) What is Leapfrog simulation of a passive filter and why it is needed ? Explain in detail with a suitable example. (8)

(b) Design a switched capacitor filter which satisfies the given magnitude response in Bode-plot. Choose the suitable MOS switching frequency in your design. (8)

(See Fig.-2)