TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2081 Bhadra

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

Subject: - Filter Design *(EX 606)*

- ✓ 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. What is Filter? Explain the significance of normalization and denormalization during filter design. Derive the expression to calculate the new values of elements that will change the operating frequency of a low pass filter from ω_{old} to ω_{new}. [1+2+4]
2. What are the characteristics of inverse Chebyshev response? Derive the expression to calculate the order of inverse Chebyshev low pass filter. Calculate inverse Chebyshev poles and zeros for given specifications: α_{min}= 18dB, α_{max}= 0.25 dB, ω_s = 1400 rad/sec and ω_p = 1000 rad/sec. [2+3+5]
3. Determine the Butterworth low pass characteristics with the minimum n such that following specifications are satisfied: α_p = 1dB, α_s = 25 dB, ω_s/ω_p = 1.5. [3]
4. Design a Band pass filter having center frequency at 1500 rad/sec and bandwidth 300 rad/sec from a 4th order Butterworth low pass resistively terminated lossless filter. [Refer Table] . [4]
5. Which of the following function is lossless and why? Find the Cauer-I and Foster-I expansion for the corresponding lossless function. [2+3+3]
$$Z(S) = \frac{S^2 + 10S + 24}{S^2 + 8S + 15}$$
$$Z(S) = \frac{S^5 + 10S^3 + 24S}{S^4 + 6S^2 + 5}$$
6. What do you mean by 2 – port network? Explain the series connection of two 2 port networks with figure and derivation. [1+4]
7. Realize the third order Butterworth high pass filter using transfer function of LPF as $T(S) = \frac{1}{(S+1)(S^2+S+1)}$ in the form of doubly terminated LC ladder with $R_1 = R_2 = 1\Omega$. [5]
8. Realize a system using non – inverting op – amp configuration with zero at -5 and pole at -3 and having high frequency gain of 2. [5]
9. Draw the circuit diagram of Sallen and Key LP biquad and derive its transfer function. Design a MFB LP biquad for the transfer function as $T(s) = 5/(s^2 + 1.2\,s + 1)$. [5+4]
10. What is sensitivity analysis in filter design? Perform the sensitivity analysis of quality factor (Q) in Tow Thomas low pass biquad. [1+5]

11. What is Bruton Transformation? Design the 4th order Butterworth low pass filter with half power frequency 2,000 rad/sec and practically realizable elements using FDNR. [Refer Table]. [2+4]

12. What is GIC? How can it be used to avoid shunt inductors in LC ladder circuit? [5]

13. Why are resistors are replaced by switched capacitors in modern IC technology? Design a switched capacitor filter to realize the magnitude response given by the plot below: [1+6]

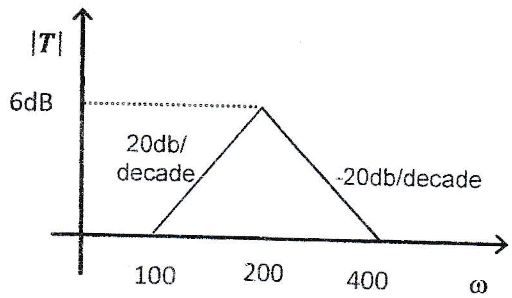

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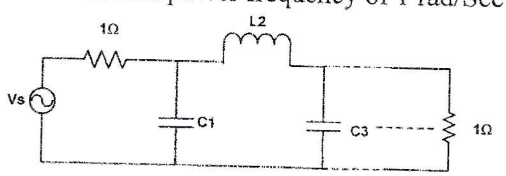
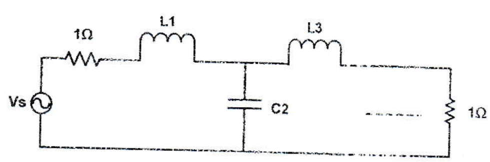
Table: Elements values for doubly terminated Butterworth low pass filter normalized to half power frequency of 1 rad/Sec



n	C1	L2	C3	L4	C5
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	L1	C2	L3	C4	L5



TRIBHUVAN UNIVERSITY
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2081 Baishakh

Exam.	**Back**		
Level	BE	**Full Marks**	80
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Year / Part	III / I	**Time**	3 hrs.

Subject: - Filter Design *(EX 606)*

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1. What are the characteristics of idea filter? What is the importance 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. [7]
2. What is approximation in filter design? 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 with the following specifications; [1+5+3]

   $\omega_p = 100$Krad/s, $\omega_s = 140$ Krad/s

   $\alpha_{max} = 0.25$ dB, $\alpha_{min} = 18$ dB
3. What is constant delay filter? Find the transfer function of 3rd order constant delay filter. [5]
4. Describe the frequency transformation from low pass filter to band pass filter with a suitable example. [5]
5. What are the properties of LC driving point impedance function? Which of the following function is valid LC driving point impedance function? State with reason. [3+3+3]

   $$Z(s) = \frac{8s^3 + 10s}{s^4 + 6s^2 + 5}, \qquad Z(s) = \frac{(s^2+4)(s^2+9)}{(s^2+16)(s^2 25)}$$

   Find the Cauer second form of valid driving point impedance function.
6. Define zeros of transmission. How can zeros of transmission be realized in the circuits? Explain with suitable diagrams. [5]
7. What information do you get when the value of reflection coefficient is zero? Design a third order Butterworth low pass filter using Resistively terminated lossless ladder with equal termination of 1Ω. (Refer Table:1) [1+6]
8. Design circuit of the transfer function $T(s) = \frac{s+8}{s+2}$ using non inverting op-amp configuration. [4]
9. Derive the transfer function of low pass sallen-key biquad filter (Refer Table :1) The half power frequency should be 10 KHz. Make the largest capacitance 0.01μF and overall gain be 1. [4+4]
10. Explain the importance of sensitivity analysis in the design of filter and perform the sensitivity analysis of w_0 of lowpass sallen-Key biquad. [7]

11. Design the 4th order Butterworth LPF in doubly-terminated network using Leapfrog simulation. The necessary information is listed in the given table below: [8]

Order(n) =4 and LPF	R_1=1	L_1=0.7654	C_2=1.848	L_3=1.848	C_4=0.7654	R_2=1

12. What is Switch capacitor filter? Design a switched capacitor filter to realize the transfer function. [6]

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

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Table 1:

Pole location for Butterworth low pass filter with half power frequency 1 rad/s

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

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2080 Bhadra

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Level	BE	Full Marks	80
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Year / Part	III / I	Time	3 hrs.

Subject: - Filter Design *(EX 606)*

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- ✓ *Attempt* ***All*** *questions.*
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1. What is the importance of normalization and denormalization in filter design? Derive element scaling equation. [2+5]

2. Derive the relation to calculate the order n of a Butterworth approximation. Use the formula to calculate the order of Butterworth having following specification $\alpha_p = 0.5$dB, $\alpha_s = 20$dB, $\omega_p = 1000$ rad/s, $\omega_s = 2000$ rad/s. Determine transfer function and show pole locations. [4+3+3]

3. What is the importance of all pass filter in filter design? Find the transfer function of 3rd order Bessel Thomson low pass filter. [1+4]

4. How frequency transformation reduces the design steps required to design a filter? Design a band stop filter having center frequency 2000 rad/s and bandwidth 400 rad/s from a 3rd order Butterworth low pass filter. (Refer Table) [1+4]

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

   (i) $Z(s) = \dfrac{(s^2+4)(s^2+5)}{(s^2+2)(s^2+10)}$

   (ii) $Z(s) = \dfrac{s^4+4s^2+3}{s(s^2+2)}$

   (iii) $Z(s) = \dfrac{s^6+4s^4+8s^2}{s^3+3s}$

6. Define zeros of transmission in two port network. What is zero shifting by partial removal of pole? Explain with suitable example. [1+3]

7. Describe the significance of reflection coefficient. Derive the 3rd order Butterworth low pass filter resistively-terminated lossless network with unequal termination of $R_1 = 1\Omega$ and $R_2 = 4\Omega$. [2+5]

8. Differentiate active and passive filter. Realize the following transfer function using non-inverting op-amp configuration. [2+3]

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

9. Draw the circuit diagram of Tow-Thomas Biquad circuit and derive its transfer function. Design a low pass filter using Tow Thomas Biquad circuit with poles at $-450 \pm j\ 893.03$ and dc gain of 1.5. The final circuit should contain practically realizable values. [8]

10. What information do you get when the sensitivity of y with respect to x is 0.1? Perform sensitivity analysis for center frequency ωo of Tow Thomas low pass filter with respect to all the resistors and capacitors present in the circuit. [1+3]

11. What is FDNR? How can you use FDNR to avoid the inductor in filter design? Explain. Design third order Butterworth low pass filter having half power frequency 4000 rad/s using FDNR. (Refer Table) [4+6]

12. Why resistors are replaced by switched capacitors in IC technology? How summer, inverting integrator and non-inverting integrator can be realized using switched capacitor? Explain with necessary diagrams and expressions. [2+4]

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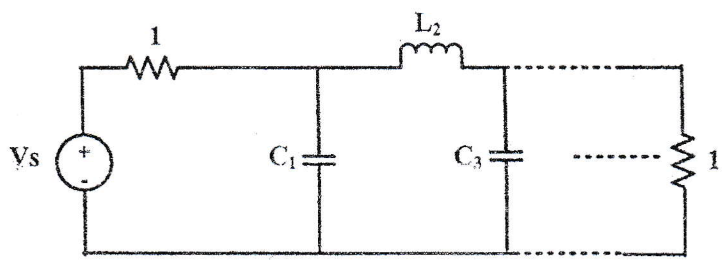
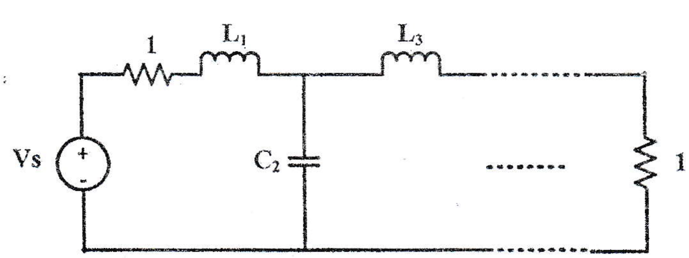
Table:

Elements values for doubly terminated Butterworth filter normalization 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



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2080 Baishakh

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Year / Part	III / I	**Time**	3 hrs.

Subject: - Filter Design *(EX 606)*

- ✓ 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 denoramlization in filter design? Derive elements scaling equations. [2+5]
2. What are the characteristics of chebyshev magnitude response? Derive an expression to calculate the order (n) of a Chebyshev filter for given lowpass specifications. Determine the minimum order n of chebyshev filter for following specifications.

   α_p =1 dB, α_s= 25 dB and (ωs/ωp) = 1.5, where the symbols have their usual meanings. [3+4+3]
3. What is a constant delay filter? What is its significance? Derive a transfer function of a second order constant delay filter. [1+1+3]
4. What are the applications of frequency transmission in filter design? How can you obtain a high pass filter from a given low pass filter? Explain with a suitable example. [1+4]
5. What are the properties of RC impedance function? Synthesize the given RC impedance in Foster and Cauer form.

   $$Z(s) = 3(s+2)\,(s+4)/(s(s+3))$$ [3+3+3]
6. What is zero shifting by partial removal of a pole? Explain with a suitable example. [5]
7. What is transmission coefficient? What information do we get from it? Derive the expression for reflection coefficient for a resistively terminated LC ladder network. [2+5]
8. Design a second order low pass filter with poles at -10000 ± j 17320.51 and Dc Gain of 2.5 using a Tow Thomas Biquad Circuit. Your final circuit should have capacitors of value 0.001uF. [6]
9. How is the excess gain compensated in Sallen-Key circuit? Explain with necessary derivations and diagrams. [5]
10. What is frequency dependent negative resistar (FDRN) ? How can it be realized? Realize the following passive filter using FDNR, having wo =25000 rad/s and practical element values in your final circuit. [1+3+5]

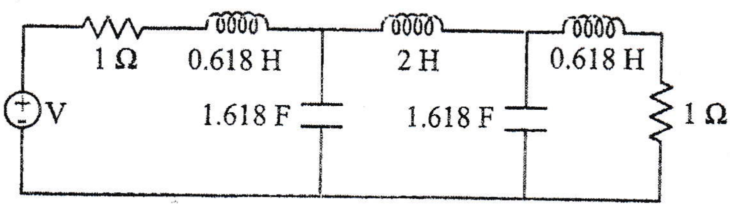

Fig: Butterworth filter at normalized frequency.

11. What is the importance of sensitivity analysis in filter design? Perform the sensitivity analysis of Wo of sallen-key lowpass biquad filter. [2+4]
12. Why do we need switched capacitor to simulate resister in MOS technology? How can you simulate a resister using switched capacitor? Explain with necessary derivations. [2+4]

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TRIBHUVAN UNIVERSITY
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2079 Bhadra

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

Subject: - Filter Design *(EX 606)*

- ✓ 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 significance of normalization and denormalization in filter design? Derive equation to calculate the new values of resistors, inductors and capacitors that will change the half-power frequency of a low pass filter from ω_0 rad/s to ω_n rad/s. [3+4]

2. What are the characteristics of Butterworth response? Derive an expression to estimate the order (n) of low pass Butterworth filter. Use this formula to estimate the order of Butterworth filter with the following specifications: [3+4+3]

   $\omega_p = 2000$ rad/sec; $\alpha_{max} = 1$ dB
   $\omega_s = 3000$ rad/sec; $\alpha_{min} = 12$ dB

3. What is the importance of all pass filters in delay equalization? Find the transfer function of third order Bessel-Thomson low pass filter. [2+3]

4. What is frequency transformation? Design a band stop filter having center frequency 2000 rad/s and bandwidth 400 rad/s from a third order Butterworth low pass filter. [Refer Table 2] [1+4]

5. What are the properties of LC driving point impedance function? Which of the following function is LC driving point impedance function? Explain with reason. [3+2+3]

$$Z(s) = \frac{8s^3 + 10s}{s^4 + 6s^2 + 5}$$

$$Z(s) = \frac{s^4 + 5s^2 + 4}{s^3 + 9s}$$

6. What are the zeros of transmission? How can they be realized in a network? Explain with suitable examples. [2+4]

7. Define reflection coefficient. Realize the third order Butterworth low pass filter using resistively terminated lossless ladder with $R_1 = 1\ \Omega$ and $R_2 = 4\ \Omega$. [Refer Table 2] [1+5]

8. Realize an active filter using non-inverting op-amp configuration with a zero at s = -4 and a pole at s = -8 having high frequency gain of k = 2. [5]

9. What is Quality factor and center frequency of low pass biquad filter? Explain with suitable diagram. Realize following low pass filter transfer function using Tow Thomas biquad circuit. [3+5]

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

10. Why is sensitivity analysis important in filter design? Perform the sensitivity analysis of ω_0 in Tow Thomas low pass filter. [1+4]

11. What is Bruton transformation? Design the 4th order Butterworth low pass filter with half power frequency 20,000 rad/s and practically realizable elements using FDNR. [Refer Table 2] [3+5]

12. What is switch capacitor filter? What are its applications? Design a switch capacitor filter from the following Bode plot. [1+1+5]

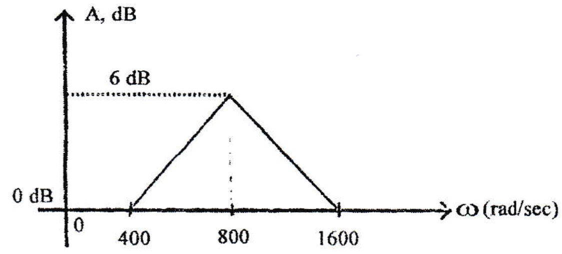

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Table 1:

Pole Location for Butterworth Responses

n=2	n=3	n=4	n=5
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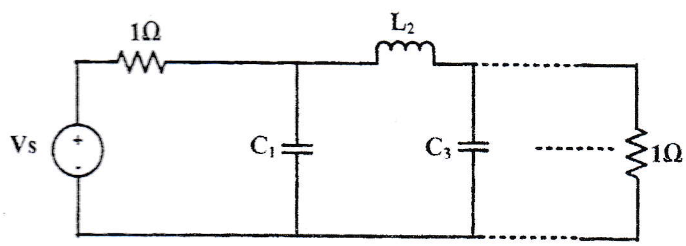
	- 1.0	- 0.9238795 ± j 0. 3826834	- 0.309017 ± j 0. 9510565
			-1.0

Table 2:
Elements values for doubly terminated Butterworth filter normalized to half power frequency of 1 rad/s.



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3	1	2	1		
4	0.7654	1.848	1.848	0.7654	
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n	L_1	C_2	L_3	C_4	L_5