TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Chaitra

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

Subject: - Filter Design *(EX 704)*

- ✓ 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 all-pass filter? Where is it used since it passes all the frequency components? [2+2+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 specifications: [4+3]
   $\alpha_{max} = 0.25$dB, w_p=1000rad/s
   $\alpha_{min} = 20$dB, w_s=1500rad/s
3. What is the importance of constant delay filter? Find transfer function of third order constant delay filter. [1+4]
4. What is frequency transformation? Design a bandstop filter having center frequency 2000rad/s and bandwidth 400 rad/s from a third order Butterworth lowpass filter.[Refer table 2] [1+4]
5. What are the properties of lossless one port network function? Which of the following function is LC one port driving point impedance function? Explain with suitable reason.[3+2+3+3]
   $$Z(s) = \frac{(s^2+1)(s^2+9)}{s(s^2+4)},\quad Z(s) = \frac{s(s^2+4)(s^2+5)}{(s^2+3)(s^2+6)}$$
   Realize a valid lossless one part function using Foster II & Cauer II methods.
6. What is transmission zeros in two port network? What are the steps involved in realizing transmission zeros in two port network? Explain with suitable example. [1+4]
7. Design a third order Butterworth low pass filter using a doubly terminated lossless ladder having $R_1=1\Omega$ and $R_2=4\Omega$. [Refer table 1] [6]
8. What are the advantages of active filter over passive filter? Realize an active filter having a pole at 100 and a zero at 1000 with a dc gain of 5. [3+3]
9. Derive the transfer function of Sallen-key low pass filter. Design a filter for $T(s) = \frac{1}{s^2+0.765s+1}$ using Sallen key low pass filter. In your final design the values of capacitors must be 0.01μF and feedback resistors should be equal. [4+4]
10. What is the importance of sensitivity analysis in filter design? Perform sensitivity analysis for w_o of sallen key low pass filter with respect to all the resistors and capacitors present in the circuit. [1+4]

11. What is GIC? How can you simulate a grounded inductor? Design a fourth order Butterwarth highpass filter having w_o=16,000 rad/s and practically suitable elements using simulated inductors. [Refer table 2] [1+3+4]

12. What is switched capacitor filter? How summer, inverting integrator and non-inverting integrator can be realzied using switched capacitor? Explain with necessary diagrams and transfer function. [1+5]

***

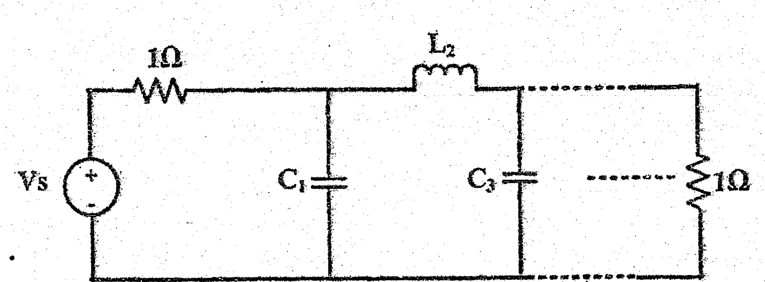
Table 1:

Pole Location for Butterworth Responses

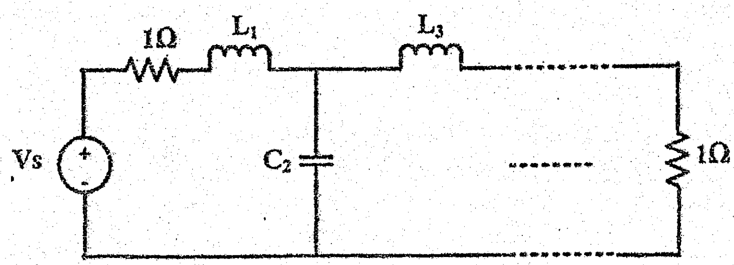
n=2	n=3	n=4	n=5
- 0.7071068 ± j 0.7071068	- 0.50 ± j 0.86603	- 0.3826834 ± j 0.9238795	- 0.809017 ± j 0.5877852
	- 1.0	- 0.9238795 ± j 0. 3826834	- 0.309017 ± j 0. 9510565
			-1.0

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



TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Chaitra

Exam.	Regular / 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 α_{max}, α_{min}, half power frequency, bandwidth, insertion loss and insertion gain with necessary figures. [6]

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

   $\omega_p = 1000$ rad/sec; $\alpha_{max} = 1$ dB
   $\omega_s = 2000$ rad/sec; $\alpha_{min} = 20$ dB [2+4+2]

3. What is constant delay filter? Find the transfer function of third order constant delay filter. [2+3]

4. What is frequency transformation? What is its importance in filter design? Design a bandpass filter having $\omega_0 = 2000$ rad/s and B = 400 rad/s from a third order Butterworth lowpass filter. [Refer Table 1] [1+1+4]

5. What are the properties of RC driving point impedance function? Determine whether the following functions are lossless function or not? State with reason.

   $$Z(s) = 2\frac{S^4 + 9S^2 + 8}{(S^3 + 4s)} \qquad Z(s) = \frac{(S^3 + S)}{(S^4 + 12s^2 + 32)}$$

   $$Z(s) = \frac{(S^3 + 4s)}{(S^4 + 4S + 3)}$$

   Realize one of the valid lossless function using Foster Series method and Cauer II method. [3+3+3+3]

6. What are zeros of transmission? How can zeros of transmission be realized in circuit? Explain with examples. [5]

7. What information do you get from transmission coefficient and reflection coefficient? Design a second order Butterworth low pass filter using resistively terminated lossless ladder with equal termination of 1Ω. $T(S) = \dfrac{1}{S^2 + \sqrt{2}S + 1}$ [2+5]

8. Derive transfer function of Sallen-Key low pass filter? Design circuit for transfer function $T(s) = \dfrac{1}{s^2 + 0.765s + 1}$ using Sallen-Key biquad. In your final design the values of capacitor must be 0.01 μF and feedback resisters should also be equal. [4+4]

9. What is Sensitivity? What is the importance of sensitivity analysis in filter design? Perform sensitivity analysis of ω_0 in Sallen-Key low pass filter. [1+1+4]

10. What is gyrator? How can you simulate inductor using gyrator? Explain with necessary derivation. [1+4]

11. Design a fourth order Butterworth low pass filter having half power frequency of 4000 rad/s using Leapfrog simulation. [Use table 1] [6]

12. Why resistors are replaced by switched capacitors in IC technology? Design a switched capacitor filter to realize the magnitude response given below: [1+5]

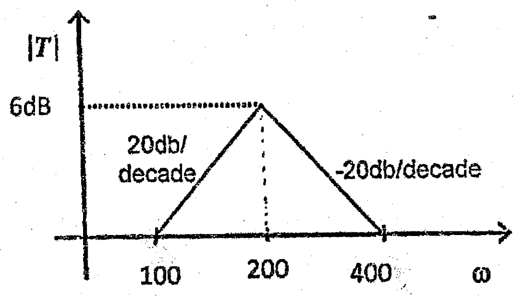
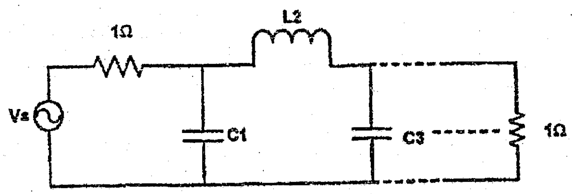
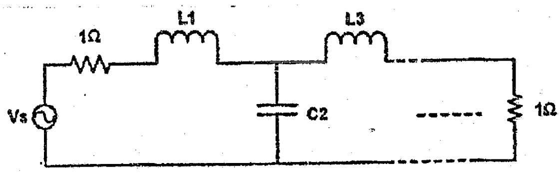


Table 1: Element values for doubly terminated Butterworth Low Pass filter normalized to half power frequency of 1 rad/sec.



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



***

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 biquad poles at -450± j893.03 and dc gain of 1.5. The final circuit should consist practically realizable elements. [4+4]

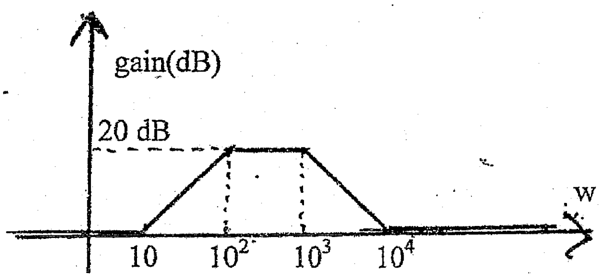
9. How excess gain can be compensated in sallen key filter? Explain. [5]

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]



***

P.T.O.

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]

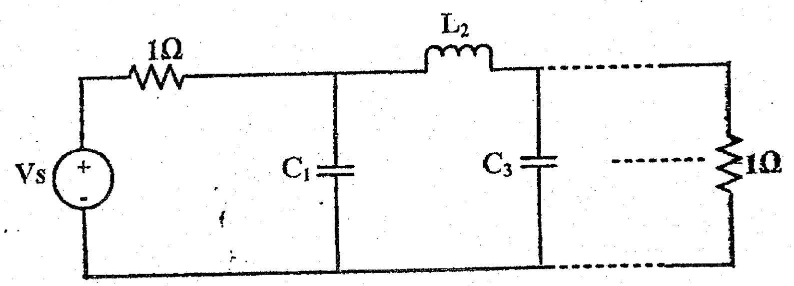
***

Table 1:
Pole Location for Butterworth Responses

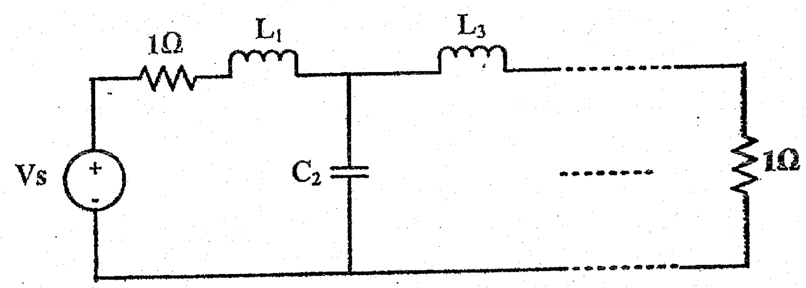
n=2	n=3	n=4	n=5
- 0.7071068 ±j 0.7071068	- 0.50 ±j 0.86603	- 0.3826834 ±j 0.9238795	- 0.809017 ±j 0.5877852
	- 1.0	- 0.9238795 ±j 0. 3826834	- 0.309017 ±j 0. 9510565
			-1.0

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
2073 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. Define normalization and denormalisation. Following circuit is a lowpass filter designed at normalization frequency of $w_o = 1$rad/s. Apply frequency and magnitude scaling so that $w_o = 10^5$ rad/s and practically realizable elements. [3+4]

2. Show that the poles of chebyshev filter lie on an ellipse. Also show the major and minor axes. [7]

3. What are the characteristics of butterworth response? Calculate the transfer function of 5^{th} order Butterworth filter. [3+4]

4. What is frequency transformation? Obtain the bandpass filter from lowpass filter given in figure 1 having center frequency 10^4 rad/s and bandwidth of 9.9×10^4 rad/s. [2+4]

5. Which of the following functions are lossless impedance function? State with reason. [2+3+3]

   a) $\dfrac{(S^2+1)(S^2+9)}{(S^2+4)(S^2+16)}$ b) $\dfrac{S(S^2+4)}{(S^2+1)(S^2+3)}$

   c) $\dfrac{2(S^2+1)(S^2+9)}{S(S^2+4)}$ d) $\dfrac{S^5+4S^3+5S}{S^4+5S^2+6}$

   Synthesize one of the valid lossless impedance function using Foster I and cauer I forms.

6. What are the zeros of transmission? How can a zero of transmission to be realized? Explain with examples. [5]

7. Realize the third order Butterworth lowpass transfer function $T(s) = \dfrac{1}{S^3+2S^2+2S+1}$ in the form of resistively terminated LC ladder with $R_1 = 1\Omega$ and $R_2 = 2\Omega$. [6]

8. Derive the transfer function of Sallen and Key low pass Biquad. Using Sallen and Key circuit, design a lowpass filter having w_o of 1000 rad/ses, quality factor of 0.866 and gain of 2. [4+4]

9. Explain RC –CR transformation with suitable examples. [4]

10. What is sensitivity? What is the importance of sensitivity analysis in filter design? Perform sensitivity analysis of w_o in Sallen and Key lowpass filter. [5]

11. What is frequency dependent negative resistor (FDNR)? How can it be used to avoid inductors in Lowpass LC ladder circuit? Explain from the circuit given in figure 1 design the lowpass filter having $w_o = 10^4$ rad/s and practical element values using FDNR. [5+5]

12. What are the applications of switched capacitor filters? Design the switched capacitor filter to realize the magnitude response given in figure 2. [2+5]

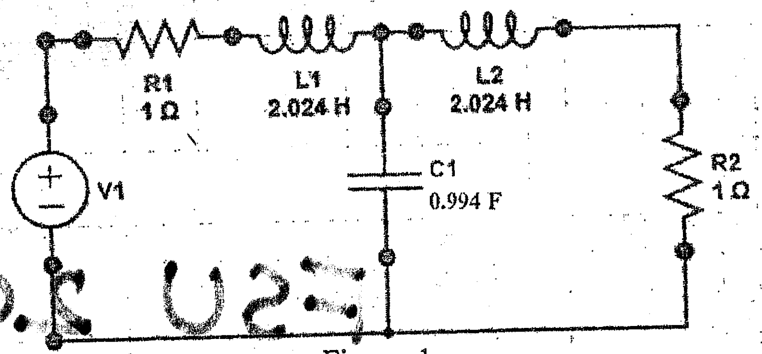


Figure: 1

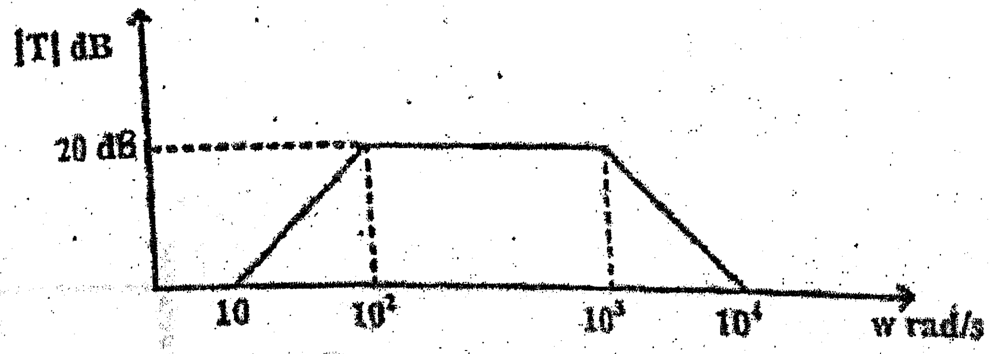


Figure: 2

***

21 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Ashwin

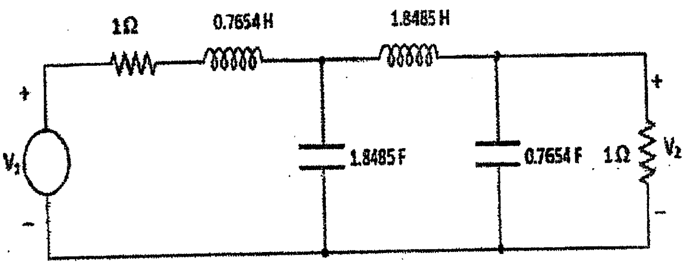
Exam.	Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

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]

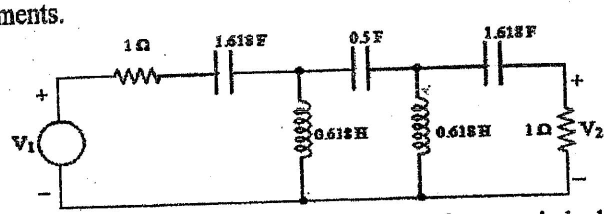
   $\omega_p = 10000,\ \omega_s = 20000$ rad/s $\qquad \alpha_{max} = 0.4,\ \alpha_{min} = 16$ dB
3. What is constant delay filter? Obtain the transfer function of second order constant delay filter. Also mention the importance of delay equalization. [8]
4. What is frequency transformation in filter design? 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]



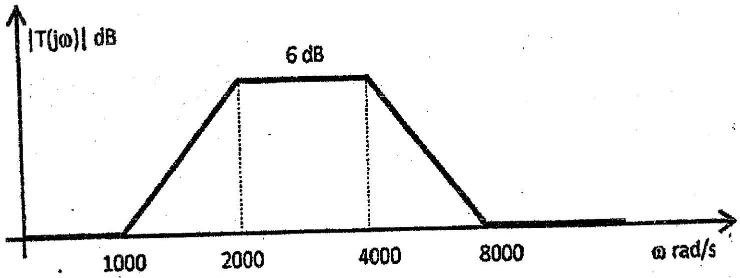
5. What are the properties of lossless one port function? Realize the following function using Cauer I and Foster II method. [2+3+3]

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



***

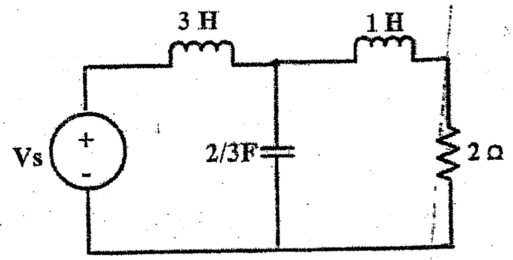
26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Shrawan

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]

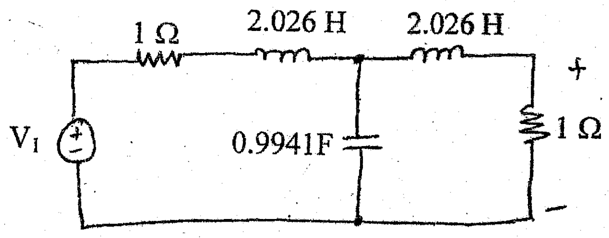
$$T(s) = \frac{-2000}{s^2 + 500s + 1000000}$$

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]

***

TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2072 Kartik

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. Define the terms: α_{max}, α_{min}, Half Power Frequency, Bandwidth, Insertion Gain and Insertion Loss with necessary figures. [6]

2. A Chebyshev low pass filter has following specifications: [8]

   $\alpha_{max} = 0.5$ dB, $\omega_p = 1$ rad/s

   $\alpha_{min} = 22$ dB, $\omega_s = 2.33$ rad/s

   Find the minimum order required to meet the specifications and also find the transfer function.

3. What is delay equalization and how can it be done? Explain with necessary figures. [4]

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

5. Realize the given function Z(S) using Cauer-I and Cauer-II method [6]

   $$Z(S) = \frac{4S^4 + 40S^2 + 36}{S^3 + 4S}$$

6. Synthesize a two port LC ladder to satisfy the following open circuit impedance parameters: $z_{21}(s) = \frac{k(s^2+9)}{s(s^2+4)}$; $z_{22}(s) = \frac{(s^2+1)}{s(s^2+4)}$ [7]

7. What do you understand when the transmission coefficient has unity value? Design a third order Butterworth low pass filter using Resistively terminated lossless ladder with equal termination of $R_1 = 1\ \Omega$ and $R_2 = 1\ \Omega$. (Refer table 1) [1+6]

8. Design an active filter using non-inverting op-amp configuration with following transfer function. $T(s) = \frac{(s+8)}{(s+2)}$ [4]

9. Draw the circuit diagram of Sallen-Key low pass filter and derive its transfer function. Design second order butterworth low pass filter having half power frequency of 10 KHz using Sallen Key biquad. In your final design the value of capacitors must be 0.01μF and feedback resistors should also be equal (Refer table 1). [5+4]

10. Define Sensitivity. What is its importance in modern filter design? Compute the sensitivity expression for the ω_0 of Sallen-Key Low pass filter. [5]

11. What is the importance of Bruton transformation in filter design? How can you simulate FDNR using generalized impedance converter (GIC)? Explain with example. [6]

12. Design third order Butterworth low pass filter using Leapfrog simulation. (Refer table 2). Your final design should have half power frequency of 4KHz and practically realizable elements. [6]

13. Design a switched capacitor filter to realize the transfer function: [3+5]

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

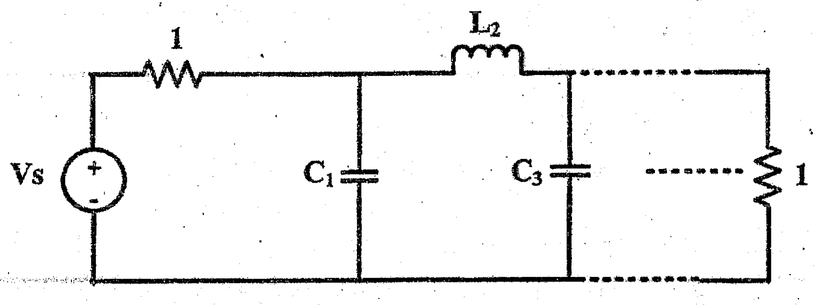
Table 1:

Pole Location for Butterworth Responses

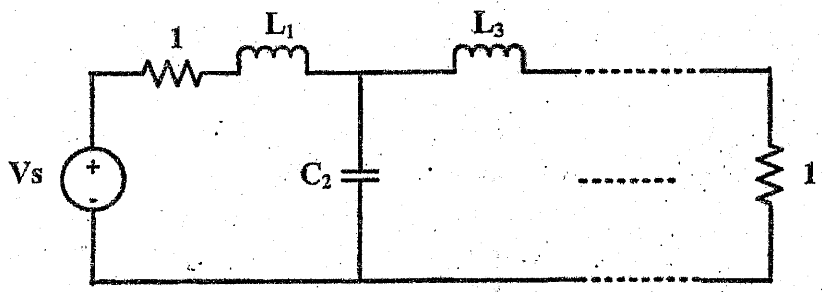
n=2	n=3	n=4	n=5
- 0.7071068 ± j 0.7071068	- 0.50 ± j 0.86603	- 0.3826834 ± j 0.9238795	- 0.809017 ± j 0.5877852
	- 1.0	- 0.9238795 ± j 0. 3826834	- 0.309017 ± j 0. 9510565
			-1.0

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



***

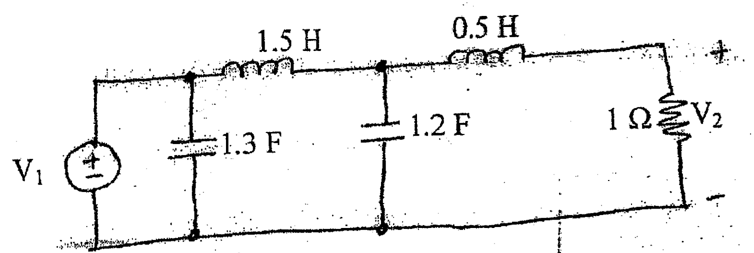
21 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Chaitra

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.*
- ✓ *The figures in the margin indicate* ***Full Marks.***
- ✓ ***Necessary tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

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]

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

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

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]

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

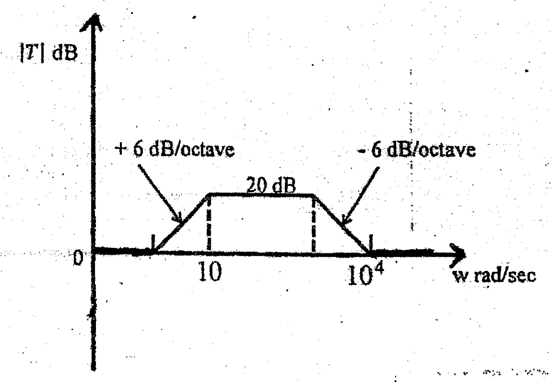
9. Design Sallen key lowpass filter for fourth order Butter worth filter. The final circuit should have $w_0 = 10{,}000$ rad/s have and practically realizable elements. (Refer table 1). [8]

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]



***

70

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]

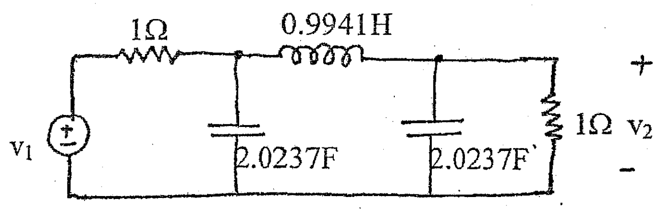
2. Derive an expression to calculate the order of Inverse Chebyshev low pass filter. Use this formula to estimate the order of Chebyshev low pass filter having following specifications: [5+3]

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

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

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]

***

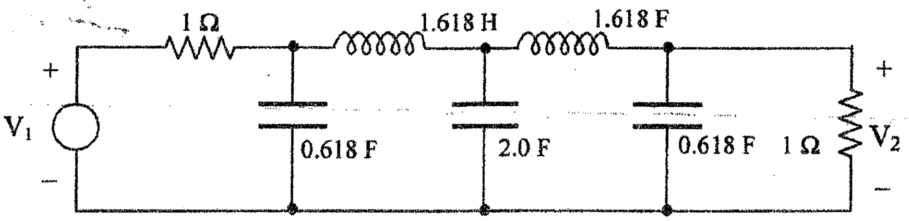
26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Shawan

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 denormalization? Explain the importance of normalization and denormalization in filter design with example. [6]
2. Derive the relation to calculate the order of Chebyshev filter. Using this formula calculate the required order of Chebyshev filter for following lowpass filter specification. [5+3]
   $\alpha_{max} = 0.5$ dB $\quad \alpha_{min} = 20$ dB
   $\omega_p = 1000$ rad/s $\quad \omega_s = 2000$ rad/s
3. What are the characteristics of elliptic response? Compare it with that of Inverse Chebyshev response. [6]
4. How can you obtain a bandstop filter from given lowpass filter? Explain with a suitable example. [5]
5. What are the required properties of a function to be realizable? Explain the properties of lossless two port function. [3+3]
6. Which of the following function is valid RC admittance function? State with reason. Realize one of the RC admittance function in Foster II and RC ladder form. [2+3+3]
   $Y(s) = \frac{(s+1)(s+3)}{(s+2)(s+4)}$, $\quad Y(s) = \frac{(s^2+1)(s^2+3)}{s(s^2+2)(s^2+4)}$, $\quad Y(s) = \frac{(s+2)(s+4)}{(s+1)(s+3)}$, $\quad Y(s) = \frac{(s+1)(s+3)}{s(s+2)(s+4)}$
7. Define transmission and reflection coefficient. Explain how resistively terminated ladder network can be realized with finite transmission zeros. [2+4]
8. Draw the circuit diagram of Tow Thomas biquad filter and derive its lowpass transfer function. Design a second order Butterworth lowpass filter having half power frequency of 5 kHz using Tow Thomas biquad circuit. Your final circuit should have all capacitors of 0.001 μF. [4+4]
9. How gain enhancement can be performed in Sallen and Key circuit? Explain with necessary diagram. [5]
10. What is sensitivity? What is its importance in filter design? Perform the sensitivity analysis of quality factor of Tow Thomas biquad lowpass filter. [1+1+2]
11. What is generalized impedance converter (GIC)? How Antonious's GIC can be used to simulate grounded inductor? Explain with necessary figures and derivations. [6]
12. What is FDNR? Explain how FDNR avoids the use of inductor. Following circuit is a lowpass filter having half power frequency of 1 rad/sec. Obtain a lowpass filter having half power frequency of 5 kHz and largest capacitor of 0.01 μF using FDNR. [2+4]



13. What is switched capacitor filter? What are its applications? Draw the switched capacitor equivalent circuit for inverting summer, lossy integrator and non-inverting integrator. [6]

***

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]
   $$Z_1(s) = \frac{(s^2+1)(s^2+5)}{(s^2+2)(s^2+10)} \qquad Z_2(s) = \frac{5s(s^2+4)}{(s^2+1)(s^2+3)}$$
   $$Z_3(s) = \frac{2(s^2+1)(s^2+9)}{s(s^2+4)} \qquad Z_4(s) = 4\frac{(s+2)(s+5)}{(s+1)(s+4)}$$

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]

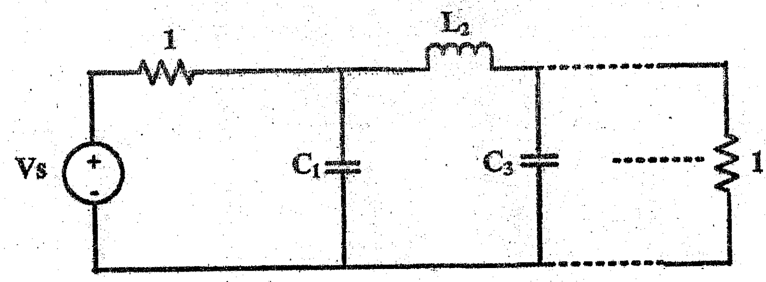
9. What is RC-CR transformation? Draw the circuit diagram of high pass sallen-key biquad obtained by RC-CR transformation of its low pass counterpart. [4]

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]

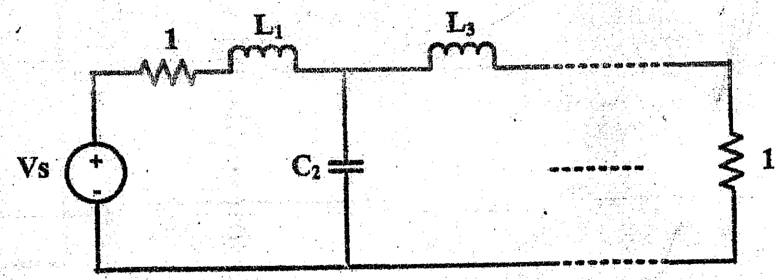
11. What is GIC? How a GIC can be used to simulate grounded inductor? Explain with necessary figures and expression. [5]

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

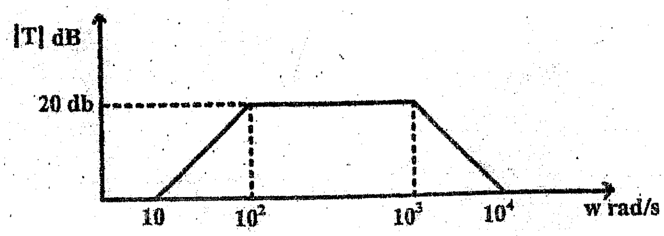
Elements values for doubly terminated Butterworth filter normalized to half power frequency of 1 rad/s



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]



***

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]

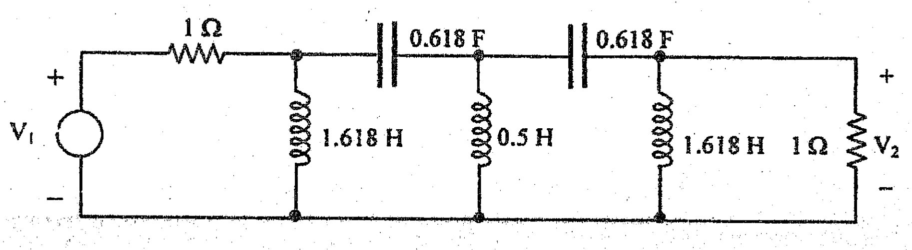
9. Design the following transfer function using inverting op-amp configuration. [4]

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

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

***

31 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Jestha

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

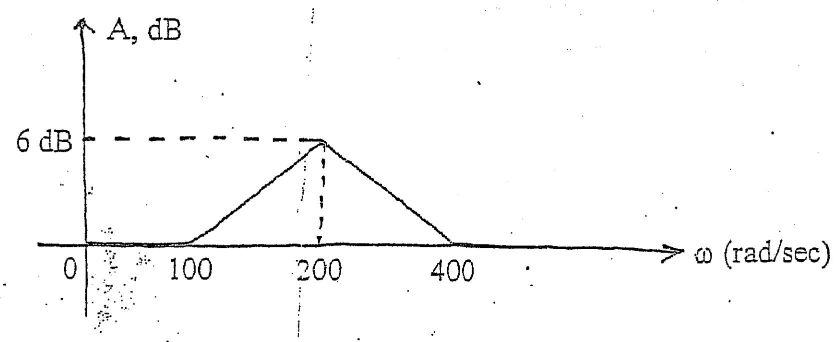
Subject: - Filter Design

- ✓ 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. Define filter. Explain the steps involved in the design of a filter. [2+5]
2. What is frequency transformation? Explain the process of transformation from a prototype LPF to BPF with necessary derivation and illustrations. [1+5]
3. Explain the synthesis of lossless one port network with its properties. [7]
4. Define zeros of transmission. How can you realize zeros of transmission in a two-port network? Illustrate with example. [6]
5. Realize a 3rd order lowpass Butterworth filter in resistively terminated network having $R_1 = R_2 = 1\Omega$ at normalized frequency. [8]
6. Design a BPF with centre frequency of 1000 rad/sec, BW = 200 rad/sec and maximum gain of 1 using Tow-Thomas Biquad. [7]
7. The sensitivity of passive filter is lower than that of an active one. Justify it with suitable reasons. [5]
8. Simulate a Butterworth LPF of 4th order with half power frequency of 1000 rad/sec and doubly terminated realization using Leapfrog simulation. [10]

L_1	C_2	L_3	C_4	R_1	R_2
0.7654	10848	10848	0.7654	1	1

9. Design a switched capacitor filter for the given specification. [7]



10. Write down the general steps to find out the TF of Bessel-Thomson Delay filter and derive the TF of 3rd order. [6]
11. Explain the process of gain reduction in Sallen and Key LPB. [6]
12. What is FDNR? How can you simulate FDNR? Explain. [5]

***

31 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2067 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.*
- ✓ *Assume suitable data if necessary.*

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

   $\omega_p = 2000 \quad rad/s \qquad \omega_s = 3000 \quad rad/s$

   $\alpha_p = 0.5 \quad dB \qquad \alpha_s = 22 \quad dB$

   Plot the pole zero locations, and determine the transfer function.

2. What are the properties of lossless function? Determine whether the following functions are lossless function or not? [10]

   $Z(s) = \dfrac{s^4 + 9s^2 + 8}{s^3 + 4s} \qquad Z(s) = \dfrac{s^3 + s}{s^4 + 12s^2 + 32} \qquad Z(s) = \dfrac{s^3 + 4s}{s^4 + 4s^2 + 3}$

   Realize one of the valid lossless function using Foster series and Cauer I method.

3. Realize the second order Butterworth filter (Refer Table 1) using Sallen and Key circuit having half power frequency of 4000 rad/sec. In your final design the dc gain must be unity, the value of capacitors must be of 0.01 μF and feedback resistors should also be equal. [10]

4. What do you mean by zeros of transmission? How can you realize zeros of transmission? Explain with suitable example. [8]

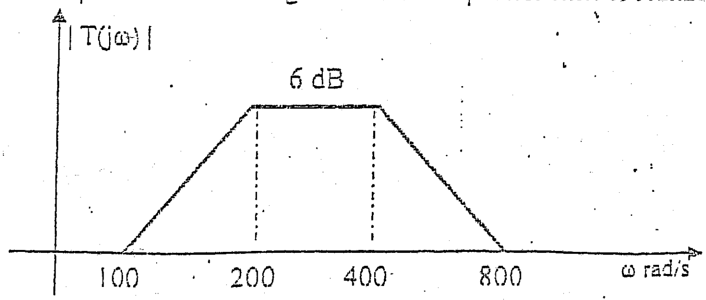
5. What are the effects of non-linear phase response? Explain. Derive the transfer function of 3rd order filter having constant delay. [8]

6. What are the differences between passive and active filter? Explain. Realize a bilinear transfer function with zero at 6, pole at 2 and dc gain of 3 using inverting op-amp configuration. [8]

7. What is sensitivity? What is the importance of sensitivity analysis in filter design? Perform sensitivity analysis of ω_o in Sallen and Key lowpass filter. [8]

8. What is leapfrog simulation of passive filter? Explain with a suitable example. [8]

9. What is switched capacitor filter? Design a switched capacitor filter to realize the magnitude response as: [8]



Use suitable MOS switching frequency.

Table 1: Pole locations for Butterworth Response

$n = 2$	$n = 3$	$n = 4$
- 0.7071068 ± j 0.7071068	- 0.50 ± j 0.86603	- 0.3826834 ± j 0.9238795
	- 1.0	- 0.9238795 ± j 0.3826834

***