Dr. Mahalingam College of Engineering & Technology
Pollachi – 642 003

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16EET44
Networks and Signals
Tutorial Book

Name : ---

Roll No : ---

Department &Section : ---

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Course Code & Title: 16EET44 – Networks and Signals Date:

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RUBRICS TO BE FOLLOWED FOR TUTORIAL

Criteria	Level of Performance			
	Excellent	**Good**	**Satisfactory**	**Needs Improvement**
	5 Points	**4 Points**	**3 Points**	**2 Points**
Computation & Execution	All aspects of the students solution were completely accurate	The students computations were essentially accurate	The student made minor computational error	The student made errors in computation serious enough to flaw the solution
Completion & Neatness	All problems are completed. the work is presented in a clear and organized manner	80% problems are completed. the work is presented in a clear manner to understand	70% problems are completed. the work is presented clearly	Only 50% problems are completed. the work is presented in a clear but difficult to read.

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II. RELIABILITY AND SYNTHESIS OF NETWORK

CAUER FORM I&II REALIZATION:

LC NETWORK:

1^{st} Cauer form : Series arm - Inductor
Shunt arm - Capacitor

II^{nd} Cauer form : Series arm - Capacitor
Shunt arm - Inductor

Cauer Form I

Condition for 1^{st} Element and Last Element:

1^{st} Element ⇒ At pole $=\infty$ $(s=\infty)$ = series Inductor
At zero $=\infty$ $(s=\infty)$ = shunt capacitor

Last Element ⇒ At pole = 0 $(s=0)$ = shunt capacitor
At zero = 0 $(s=0)$ = Series Inductor

Cauer Form II

Condition for 1^{st} and Last Element:

1^{st} Element ⇒ At pole = 0 $(s=0)$ ⇒ Series Capacitor
At zero = 0 $(s=0)$ ⇒ shunt Inductance

Last Element ⇒ At pole $=\infty$ $(s=\infty)$ ⇒ Inductor
At zero $=\infty$ $(s=\infty)$ ⇒ Capacitor

RC NETWORK

Series Arm - Resistor Shunt Arm - Capacitor

Cauer Form I

Conditions for 1^{st} and Last Element:

* If $Z(s)$ has a zero at $s=\infty$, 1^{st} element is C_1
* If $Z(s)$ is a constant at $s=\infty$, 1^{st} element is R_1
* If $Z(s)$ has a pole at $s=0$, last element is C_n
* If $Z(s)$ is a constant at $s=0$, last element is R_n

Cauer Form II

Condition for first and Last Element:

* If $Z(s)$ has a pole at $s=0$, 1^{st} element is C_1
* If $Z(s)$ is a constant at $s=0$, " " R_1
* If $Z(s)$ has a zero at $s=\infty$, last element is C_n
* If $Z(s)$ is a constant at $s=\infty$, " " R_n

RL NETWORK:

Series Arm - Inductor Shunt Arm - Resistor

Cauer Form I

Condition for 1st and Last Element:

* If $Z(s)$ has a pole at $s=\infty$, 1st element is L_1
* If $Z(s)$ is a constant at $s=\infty$, " " R_1
* If $Z(s)$ has a zero at $s=0$, Last element is L_n
* If $Z(s)$ is a constant at $s=0$, " " R_n

Cauer Form II

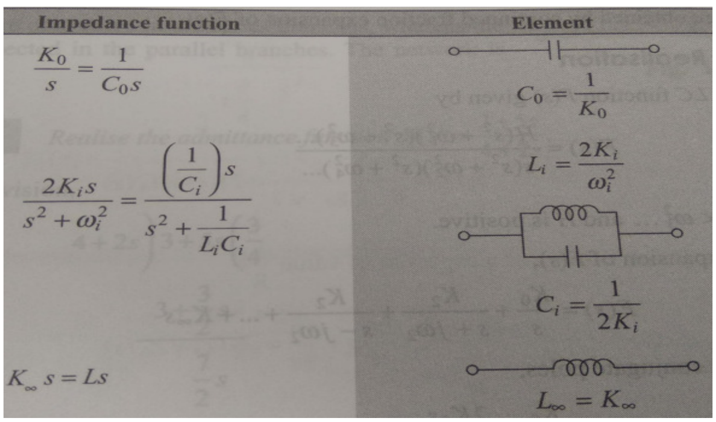
Condition for 1st and Last Element:

* If $Z(s)$ has a zero at $s=0$, 1st element is L_1
* If $Z(s)$ is a constant at $s=0$, " " R_1
* If $Z(s)$ has a pole at $s=\infty$, last element is L_n
* If $Z(s)$ is a constant at $s=\infty$, " " R_n

FOSTER FORM I&II REALIZATION:

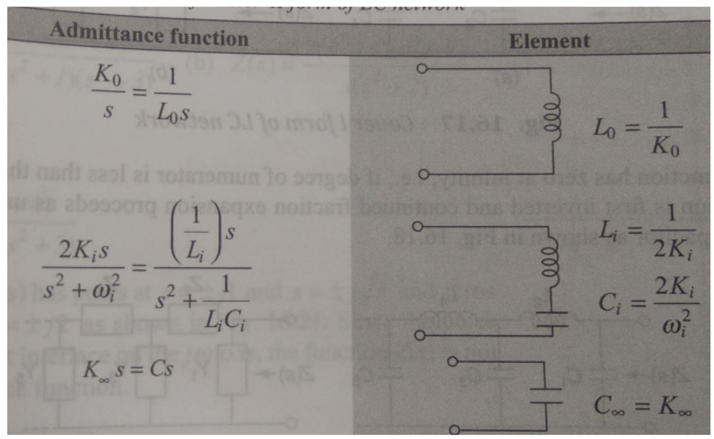
LC NETWORK:

Foster Form I



Impedance function	Element
$\frac{K_0}{s}=\frac{1}{C_0 s}$	$C_0=\frac{1}{K_0}$
$\frac{2K_i s}{s^2+\omega_i^2}=\frac{\left(\frac{1}{C_i}\right)s}{s^2+\frac{1}{L_iC_i}}$	$L_i=\frac{2K_i}{\omega_i^2}$, $C_i=\frac{1}{2K_i}$
$K_\infty s = Ls$	$L_\infty = K_\infty$

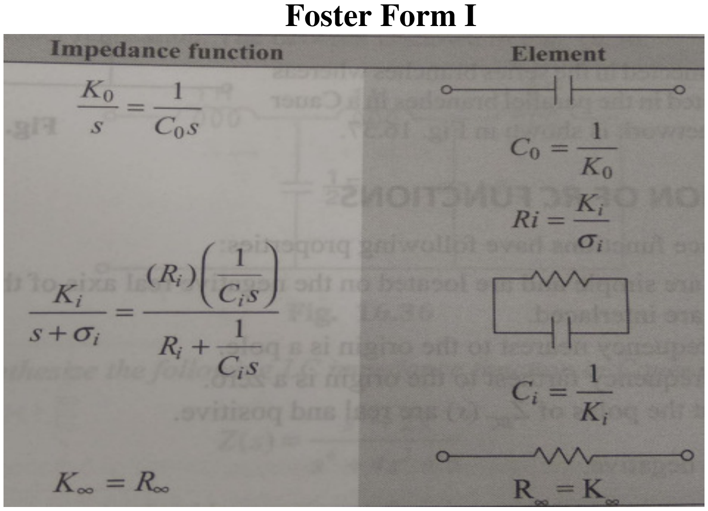
Foster Form II



Admittance function	Element
$\frac{K_0}{s}=\frac{1}{L_0 s}$	$L_0=\frac{1}{K_0}$
$\frac{2K_i s}{s^2+\omega_i^2}=\frac{\left(\frac{1}{L_i}\right)s}{s^2+\frac{1}{L_iC_i}}$	$L_i=\frac{1}{2K_i}$, $C_i=\frac{2K_i}{\omega_i^2}$
$K_\infty s = Cs$	$C_\infty = K_\infty$

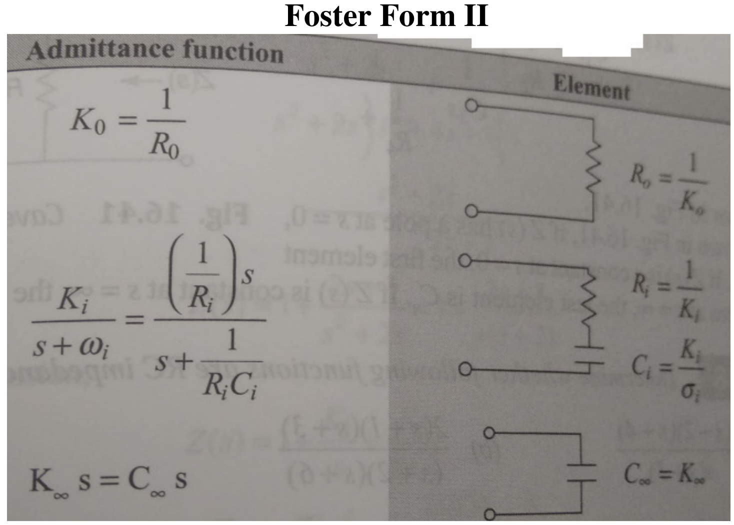
RC NETWORK:

Foster Form I



Impedance function	Element
$\frac{K_0}{s}=\frac{1}{C_0 s}$	$C_0=\frac{1}{K_0}$
$\frac{K_i}{s+\sigma_i}=\frac{(R_i)\left(\frac{1}{C_i s}\right)}{R_i+\frac{1}{C_i s}}$	$Ri=\frac{K_i}{\sigma_i}$, $C_i=\frac{1}{K_i}$
$K_\infty = R_\infty$	$R_\infty = K_\infty$

Foster Form II



Admittance function	Element
$K_0=\frac{1}{R_0}$	$R_o=\frac{1}{K_o}$
$\frac{K_i}{s+\omega_i}=\frac{\left(\frac{1}{R_i}\right)s}{s+\frac{1}{R_iC_i}}$	$R_i=\frac{1}{K_i}$, $C_i=\frac{K_i}{\sigma_i}$
$K_\infty s = C_\infty s$	$C_\infty = K_\infty$

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CO2: Synthesize RL,RC& LC network by Foster and Cauer form

Tutorial No:1 - Hurwitz Polynomials

1. Check whether the following function are Hurwitz

$P(S) = S^7+2S^6+2S^5+S^4+4S^3+8S^2+8S+4$

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2. Check Whether the following function are Hurwitz

$P(S) = S^4+S^3+2S^2+3S+2$

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3. Check whether the following function is Hurwitz.

$F(S) = S^5+3S^3+S$

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Tutorial No:2 - Positive Real Functions

1. Test the following function is Positive and Real

$$F(S) = \frac{S^2+1}{S^3+4S}$$

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2. Test the following function is Positive and Real

$$F(S) = \frac{S^2+4S+3}{S^2+6S+8}$$

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Tutorial No:3 - Cauer Form I & II Realization

1. Find Cauer I and II form of the following function

$$Z(S) = \frac{3(S+2)(S+5)}{S(S+3)}$$

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2. Find Cauer I and II form of the following RC function

$$Z(S) = \frac{2S^2+8S+6}{S^2+2S}$$

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3.Find Cauer I and II form of the following function

$$Z(S) = \frac{(S+3)(S+7)}{(S+2)(S+4)}$$

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CO2: Synthesize RL,RC& LC network by Foster and Cauer form

Tutorial No:4 - Cauer Form I & II Realization

1. Find Cauer I and II form of the following function

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

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2. Find Cauer I form of the following function

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

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3. Find Cauer II form of the following function

$$Z(S) = \frac{6S^4+42S^2+48}{S^5+18S^3+48S}$$

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Tutorial No:5 - Foster Form I & II Realization

CO2: Synthesize RL,RC& LC network by Foster and Cauer form

1.Find Foster I and II form of the following function

$$Z(S) = \frac{S(S^2+4)}{(S^2+2)(S^2+8)}$$

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2. Find Foster I and II form of the following function

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

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CO2: Synthesize RL,RC& LC network by Foster and Cauer form

Tutorial No:6 - Cauer Form I & II Realization

1. For the following function find whether it is an RC Impedance Function and Synthesis in Foster I&II forms.

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

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2. An Impedance Function has:

i) Simple poles at -1 & -4

ii) Simple zeros at -2 & -5

iii) $Z(0)=\frac{10}{4}\Omega$. Synthesize in Foster I and II form.

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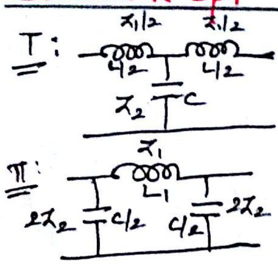
III .FILTERS

Constant K LPF



a) $Z_1 Z_2 = K^2 = \frac{L}{C}$

$K = \sqrt{\frac{L}{C}}$

b) $\frac{Z_1}{4Z_2} = -1$

$f_c = \frac{1}{\pi\sqrt{LC}}$ (cut off freq)

c) Characteristic Impedance

$Z_{0T} = K\sqrt{1-\left(f/f_c\right)^2}$

$Z_{0\pi} = \frac{K}{\sqrt{1-(f/f_c)^2}}$

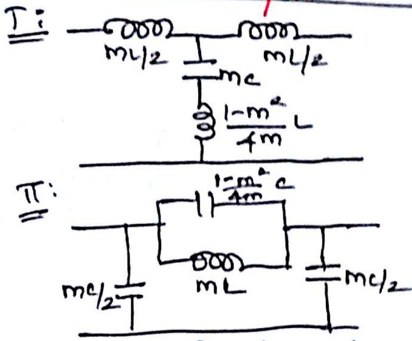
d) $C = \frac{1}{\pi f_c K}$

$L = \frac{K}{\pi f_c}$

e) $\alpha = 2\cosh^{-1}(f/f_c)$

$\beta = 2\sin^{-1}(f/f_c)$

M derived LPF



a) Resonant freq f_r (or) f_α:

$f_r = f_\alpha = \frac{1}{\pi\sqrt{LC(1-m^2)}}$

b) cut off freq f_c : $f_c = \frac{1}{\pi\sqrt{LC}}$

c) $m = \sqrt{1-\left(\frac{f_c}{f_\alpha}\right)^2}$

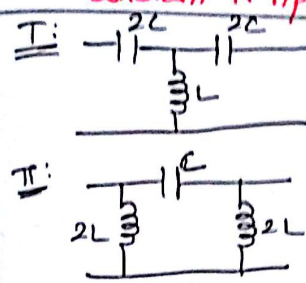
d) $C = \frac{1}{\pi f_c K}$

e) $L = \frac{K}{\pi f_c}$

f) $\alpha = 2\cosh^{-1}\frac{m(f/f_c)}{\sqrt{1-(f/f_\alpha)^2}}$

g) $\beta = 2\sin^{-1}\frac{m(f/f_c)}{\sqrt{1-(f/f_c)^2(1-m^2)}}$

Constant K HPF



a) $Z_1 Z_2 = K^2 = \frac{L}{C}$

$K = \sqrt{L/C}$

b) $\frac{Z_1}{4Z_2} = -1$

cut off freq, $f_c = \frac{1}{4\pi\sqrt{LC}}$

c) Characteristic Impedance

$Z_{0T} = K\sqrt{1-(f_c/f)^2}$

$Z_{0\pi} = \frac{K}{\sqrt{1-(f_c/f)^2}}$

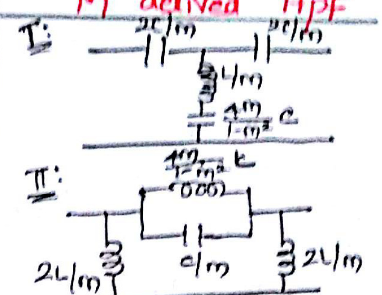
d) $C = \frac{1}{4\pi f_c K}$

$L = \frac{K}{4\pi f_c}$

e) $\alpha = 2\cosh^{-1}(f_c/f)$

$\beta = 2\sin^{-1}(f_c/f)$

M derived HPF



a) Resonant freq f_r or f_α

$f_r = f_\alpha = \frac{\sqrt{1-m^2}}{4\pi\sqrt{LC}}$

b) cut off freq f_c:

$f_c = \frac{1}{4\pi\sqrt{LC}}$

c) $m = \sqrt{1-\left(\frac{f_\alpha}{f_c}\right)^2}$

d) $C = \frac{1}{4\pi f_c K}$

$L = \frac{K}{4\pi f_c}$

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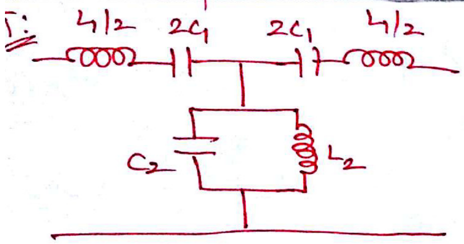
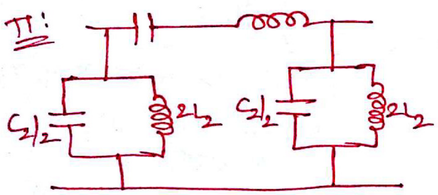
Band pass filter

T:



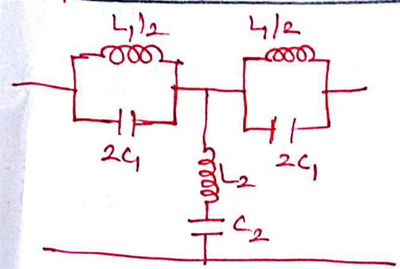
π:



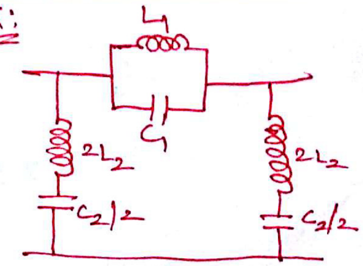
1. $Z_1 Z_2 = \frac{L_2}{C_1} = \frac{L_1}{C_2} = K^2$
2. $Z_1 = -j2K$
3. $f_0 = \sqrt{f_1 f_2}$
4. $C_1 = \frac{f_2 - f_1}{4\pi K f_1 f_2}$ 5. $L_1 = \frac{K}{\pi(f_2 - f_1)}$
6. $C_2 = \frac{1}{\pi K(f_2 - f_1)}$ 7. $L_2 = \frac{(f_2 - f_1)K}{4\pi f_1 f_2}$

Band stop filter

T:



π:



1. $Z_1 Z_2 = \frac{L_1}{C_2} = \frac{L_2}{C_1} = K^2$
2. $Z_1 = K\frac{j}{2}$
3. $f_0 = \sqrt{f_1 f_2}$
4. $C_2 = \frac{1}{K\pi}\left[\frac{f_2 - f_1}{f_1 f_2}\right]$ 5. $L_2 = \frac{K}{4\pi(f_2 - f_1)}$
6. $C_1 = \frac{1}{4\pi K(f_2 - f_1)}$ 7. $L_1 = \frac{K}{\pi}\left(\frac{f_2 - f_1}{f_1 f_2}\right)$

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CO3: Design a Constant K & M - Derived filter

Tutorial No:1- Low Pass Filter

1.Design a low pass filter (both pi and T- sections) having a cutoff frequency of 2KHz to operate with a terminated load resistance of 500Ω.

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2. Design a low pass pi section filter with a cutoff frequency of 2KHz to operate with a load resistance of 400Ω.

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3. Design a low pass T section filter having cutoff frequency of 1.5KHz to operate with a terminated load resistance of 600Ω.

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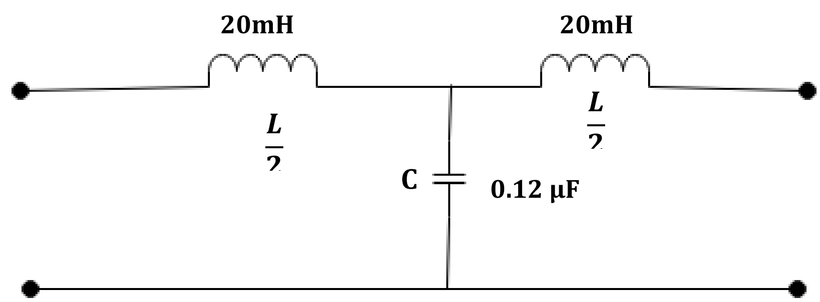
4. A T section filter is shown in figure. Calculate the value of cutoff frequency and determine the iterative impedance and the phase shift of the network at 1.5KHz.



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5. Find the frequency at which a prototype pi section low pass filter having a cutoff frequency fc has an attenuation of 20dB.

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CO3: Design a Constant K & M - Derived filter

Tutorial No:2- High Pass Filter

1.Design a high pass filter having a cutoff frequency of 1KHz to operate with load resistance of 600Ω.

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2. Each of the two series elements of a T type High Pass Filter consists of an capacitance of 30μF having negligible resistance and a shunt element having inductance of 0.16mH. Calculate the value of cutoff frequency , iterative impedance and phase shift of the network at 2 KHz.

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3. Design a high pass filter with a cutoff frequency of 1KHz with a terminated design impedance of 800Ω.

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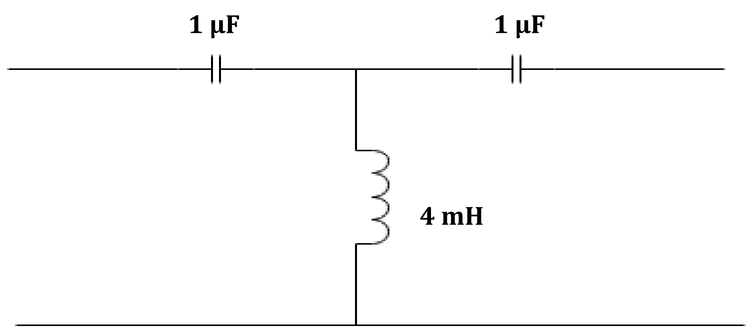
4. Determine the cutoff frequency and design impedance for the T section shown in fig.



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5. Design a high pass filter with a cutoff frequency of 10 KHz and terminated impedance of 200Ω.

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Tutorial No:3

CO3: Design a Constant K & M - Derived filter

1.Design a m derived low pass filter having cutoff frequency of 1KHz, design impedance of 400Ω and the resonant frequency 1100Hz.

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2. Design an m derived LPF having a cutoff frequency of 6KHz and a design impedance of 500Ω. The frequency of infinite attenuation should be 1.75 times the cutoff frequency.

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Tutorial No:4

CO3: Design a Constant K & M - Derived filter

1. Design a m-derived high pass filter with a cutoff frequency of 10KHz; design impedance of 5Ω and m=0.4.

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2. Design a m-derived high pass filter with a cutoff frequency of 2 KHz; design impedance of 600Ω and resonant frequency is 10KHz.

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Tutorial No:5

CO3: Design a Constant K & M - Derived filter

1. Design a K-type band pass filter having a design impedance of 500Ω and cutoff frequencies are 1KHz and 10KHz.

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2. Design a prototype band pass filter having cutoff frequencies of 3000Hz and 6000Hz and nominal characteristic impedance of 600Ω. Also find resonance frequencies.

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Tutorial No:6

CO3: Design a Constant K & M - Derived filter

1. Design a band elimination filter having a design impedance of 600Ω and cutoff frequencies f_1=1KHz and f_2=10KHz.

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2. Design a prototype band stop filter having cutoff frequencies 2000Hz and 5000Hz and design resistance of 600Ω.