BE(ECE) III - Semester Main Exam

Sub: Network Theory.

Question paper key- Set-2

1. a) Given $Z_{11} = 10\,\Omega$, $Z_{22} = 12\,\Omega$, $Z_{12} = Z_{21} = 5\,\Omega$.

Then $\Delta Z = Z_{11}Z_{22} - Z_{12}Z_{21} = 10\times12 - 5\times5 = 120 - 25 = 95$

$Y_{11} = \frac{Z_{22}}{\Delta Z} = \frac{12}{95} = 0.1263\,℧$

$Y_{12} = \frac{-Z_{12}}{\Delta Z} = \frac{-5}{95} = -0.052\,℧$

$Y_{22} = \frac{Z_{11}}{\Delta Z} = \frac{10}{95} = 0.105\,℧$

$Y_{21} = \frac{-Z_{21}}{\Delta Z} = \frac{-5}{95} = -0.052\,℧$

b) Hybrid parameter equation are

$V_1 = h_{11} I_1 + h_{12} V_2$

$I_2 = h_{21} I_1 + h_{22} V_2$

When $h_{11} = \frac{V_1}{I_1}\Big|_{V_2=0}$ = I/p impedance when o/p port is short circuited.

$h_{12} = \frac{V_1}{V_2}\Big|_{I_1=0}$ = Reverse voltage transfer ratio when I/p port is open circuited

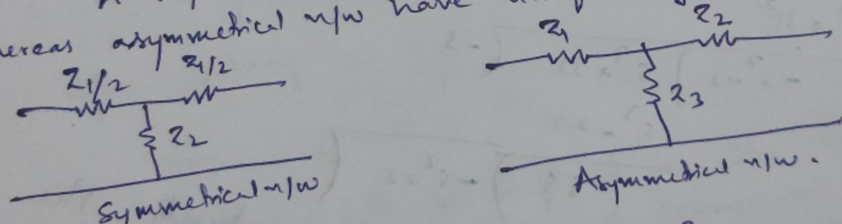
$h_{21} = \frac{I_2}{I_1}\Big|_{V_2=0}$ = forward current transfer ratio when o/p port is short circuited.

$h_{22} = \frac{I_2}{V_2}\Big|_{I_1=0}$ = o/p admittance when I/p port is open circuited.

c) Symmetrical & Asymmetrical n/ws:

A network whose electrical characteristics remains unchanged when its ports are interchanged, is called symmetrical n/w otherwise it is asymmetrical.

A symmetrical n/w has same impedance at its I/p & o/p ports whereas asymmetrical n/w have unequal input & o/p impedances.

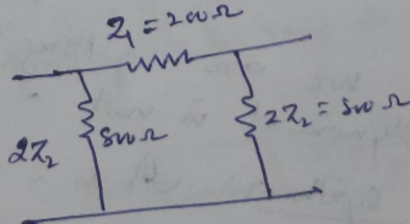


d) Given a Π - n/w

$Z_1 = 200\,\Omega$

$2Z_2 = 800\,\Omega$

$Z_2 = 400\,\Omega$

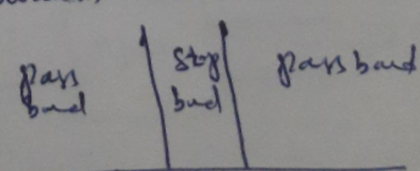


Its ch. impedance is

$$Z_{0\pi} = \frac{Z_1 Z_2}{\sqrt{\frac{Z_1^2}{4} + Z_1 Z_2}} = \frac{200\times400}{\sqrt{\frac{(200)^2}{4} + 200\times400}} = 266.66\,\Omega$$

e) Band elimination filter: A filter which attenuates a band of frequencies & allows all frequencies is known as band elimination filter.

It has two pass bands and a stop band as shown



f) Basically a m-derived filter is a modified constant k-filter section in which series and shunt arm impedances are so modified that the characteristic impedance of the circuit is not affected.
Value of 'm' is so chosen that the characteristic impedance of constant k and m-derived sections is same.

g) Need for impedance matching:
Impedance matching is the practice of designing or adjusting the i/p impedance or o/p impedance of an electrical device for a desired value. The desired value is selected to maximize power transfer.
Typically impedance matching is used to improve from transfer from source to load. It minimize reflection of signals.

h) An inverse n/w for any given n/w may be constructed using the following rule.
i) Inverse of a resistance is another resistance.
ii) Inverse of an inductor is a capacitor & vice-versa.
iii) Inverse of a series connection is parallel connection & vice-versa.

i) Given $P(s) = s^4 + s^3 + 2s^2 + 3s + 2$
then odd terms are $m(s) = s^4 + 2s^2 + 2$
even terms $n(s) = s^3 + 3s$
obtain continued fraction to get quotient:

$$s^3+3s \,\big)\, s^4 + 2s^2 + 2 \,\big(\, s$$
$$s^4 + 3s^2$$
$$-s^2+2 \,\big)\, s^3 + 3s \,\big(\, -s$$
$$s^3 - 2s$$
$$5s \,\big)\, -s^2 + 2 \,\big($$

Since we are getting -ve quotients, the polynomial is not a Hurwitz polynomial.

j) <u>Network synthesis</u>: It is a design technique for linear electrical circuits. Synthesis starts from a prescribed impedance function of frequency and then determines the possible networks that will produce the required response.

2 a) Consider Z-parameter eqn $V_1 = Z_{11} I_1 + Z_{12} I_2$

$V_2 = Z_{21} I_1 + Z_{22} I_2$

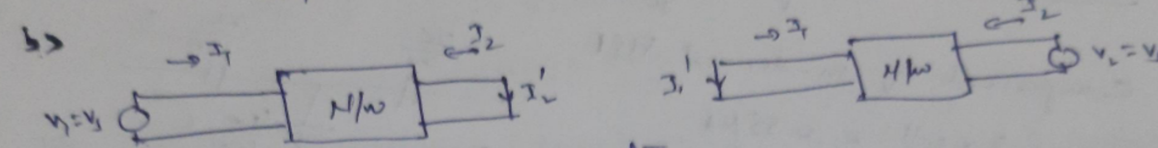
Y-parameter eqn $I_1 = Y_{11} V_1 + Y_{12} V_2$

$I_2 = Y_{21} V_1 + Y_{22} V_2$

Solve the above equations to obtain Z-parameters

$$Z_{11} = \frac{Y_{22}}{\Delta Y}, \quad Z_{12} = \frac{-Y_{12}}{\Delta Y}, \quad Z_{21} = \frac{-Y_{21}}{\Delta Y}, \quad Z_{22} = \frac{Y_{11}}{\Delta Y}.$$

b)



Use ABCD parameter equation

$V_1 = AV_2 - BI_2$

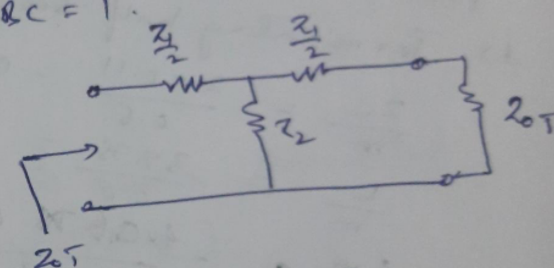
$I_1 = CV_2 - DI_2$

For reciprocal n/w.

$I_1' = I_2'$

finally we get $AD - BC = 1$.

3 a) The i/p impedance is known as Ch. impedance if its o/p is terminated by ch. impedance Z_{0T}.

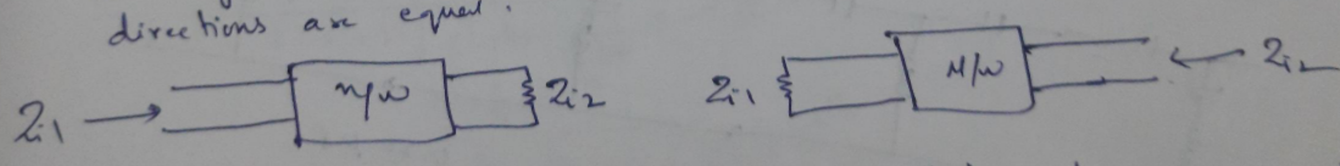


$$Z_{0T} = \frac{Z_1}{2} + \left[Z_2 \,||\, \left(\frac{Z_1}{2} + Z_{0T} \right) \right]$$

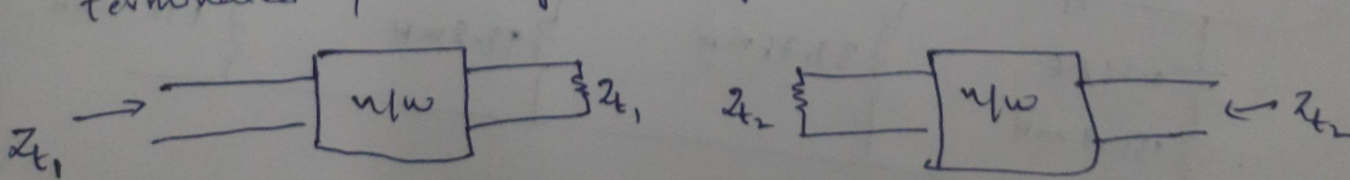
After solving we get

$$Z_{0T} = \sqrt{\frac{Z_1^2}{4} + Z_1 Z_2}$$

b) Image impedance : It is defined as the impedance which simultaneously terminate each pair of terminals of a n/w in such a way that at each pair of terminals the impedance in both directions are equal.



Iterative impedance. It is the value of impedance measured at one pair of terminals when the other pair of terminals is terminated by an impedance of the same value.

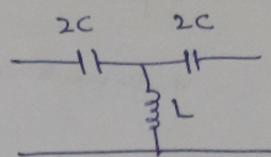


4) Given $R_K = 600\,\Omega$, $f_c = 1.2\,kHz = 1200\,Hz$, $f_\infty = 1.1\,kHz = 1100\,Hz$

a) Design of constant K high pass filter.

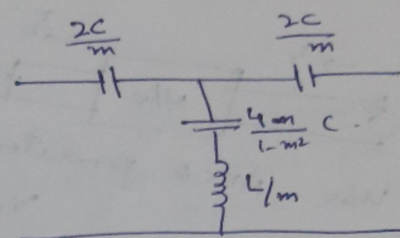
$$L = \frac{R_K}{4\pi f_c} = \frac{600}{4\pi \times 1200} = 39.78\,mH.$$

$$C = \frac{1}{4\pi R_K f_c} = \frac{1}{4\pi \times 600 \times 1200} = 0.11\,\mu f$$



b) value of m - $m = \sqrt{1 - \left(\frac{f_\infty}{f_c}\right)^2} = \sqrt{1 - \left(\frac{1100}{1200}\right)^2} = 0.4.$

c) Components of m-derived HPF.

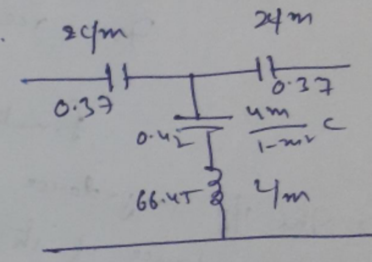


$$\frac{2C}{m} = \frac{2 \times 0.11}{0.4} = 0.55\,\mu f.$$

$$\frac{L}{m} = \frac{39.78}{0.4} = 99.5\,mH$$

$$\frac{4m}{1-m^2}C = \frac{4 \times 0.4}{1-(0.4)^2} = 0.21\,\mu f.$$

d) Terminating half Sections for $m = 0.6$.

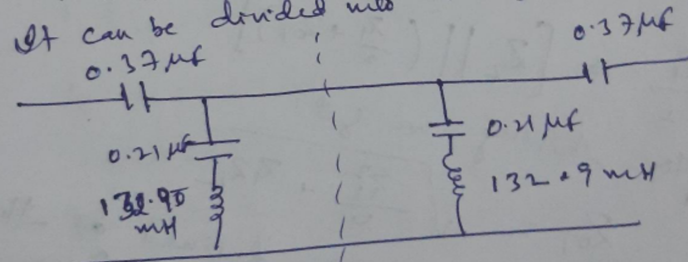


$$\frac{2C}{m} = \frac{2 \times 0.11}{0.6} = 0.37\,\mu f.$$

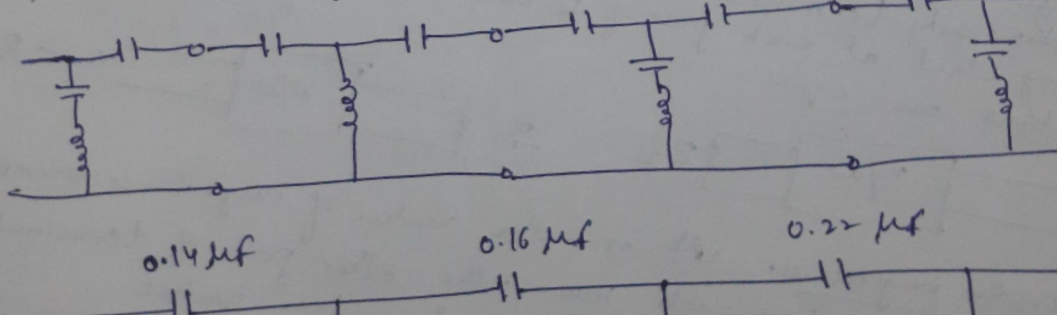
$$\frac{L}{m} = \frac{39.78}{0.6} = 66.45\,mH$$

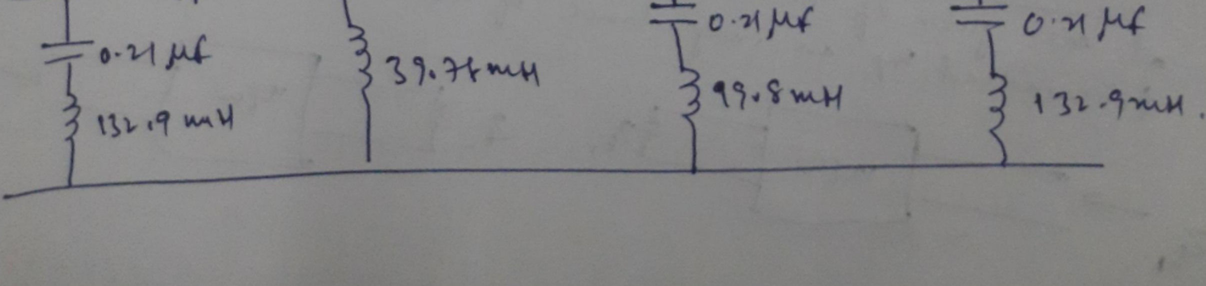
$$\frac{4m}{1-m^2}C = \frac{4 \times 0.6 \times 0.11}{1-(0.6)^2} = 0.42\,\mu f.$$

It can be divided into two terminating half Section.



e) final Composite filter will be

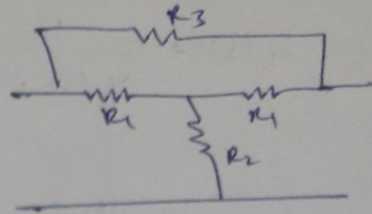




5 a) Given $D = 20$ dB

$\therefore N = \text{antilog}(D/20) = 10$

$R_0 = 300\ \Omega$.



The elements of bridge T attenuator can be obtained using

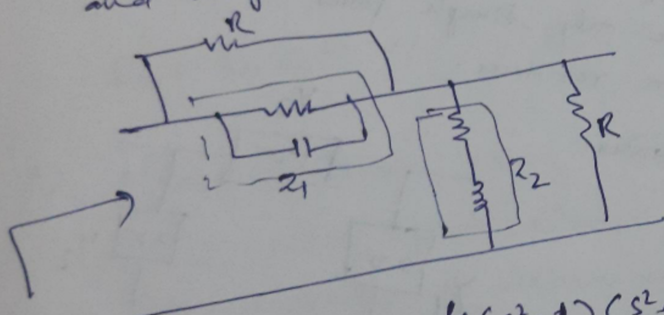
$R_1 = R_0 = 300\ \Omega$

$R_2 = \frac{R_0}{N-1} = \frac{300}{10-1} = 33.33\ \Omega$

$R_3 = R_0(N-1) = 300(10-1) = 2700\ \Omega$

b) Constant resistance equalizer.

A constant resistance equalizer is a 4-terminal equalizer using series and shunt arm impedances which are inverse of each other with respect to a constant resistance usually the design resistance of the equalizer. Such an equalizer always presents a constant input and output resistance at all frequencies.



It can be proved that

$$Z_i = R$$

6 a) Given $Z(s) = \frac{4(s^2+1)(s^2+9)}{s(s^2+4)} = \frac{4s^4+40s^2+36}{s^3+4s}$

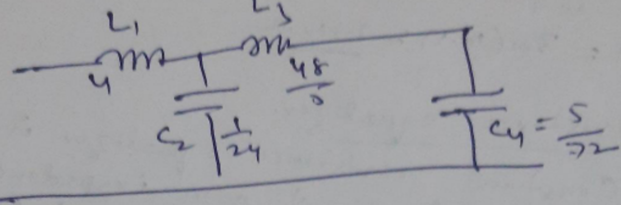
finding the quotients from continued fraction expansion.

$$s^3+4s \,\big)\, 4s^4+40s^2+36 \,\big(\, 4s \rightarrow Z_1$$
$$4s^4+16s^2$$
$$24s^2+36 \,\big)\, s^3+4s \,\big(\, \tfrac{1}{24}s \rightarrow Y_2$$
$$s^3+\tfrac{3}{2}s$$
$$\tfrac{5}{2}s \,\big)\, 24s^2+36 \,\big(\, \tfrac{48}{5}s \rightarrow Z_3$$
$$24s^2$$
$$36 \,\big)\, \tfrac{5}{2}s \,\big(\, \tfrac{5}{72}s \rightarrow Y_4$$
$$\tfrac{5}{2}s$$
$$0$$

P.T.O.

$$Z(s) = Z_1(s) + \cfrac{1}{Y_2(s) + \cfrac{1}{Z_3(s) + \cfrac{1}{Y_4(s)}}}$$

$$= 4s + \cfrac{1}{\frac{1}{24}s + \cfrac{1}{\frac{48}{5}s + \cfrac{1}{\frac{5}{72}s}}}$$



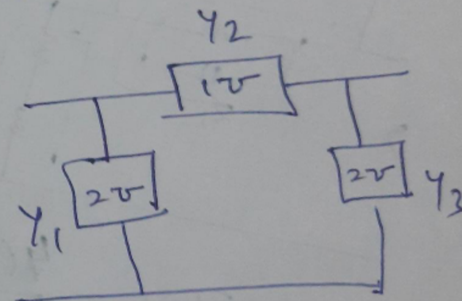
b) <u>positive real functions:</u>

A real function $f(s)$ with real coefficients are said to be p r f if it satisfies the following conditions.

i) n/w functions $F(s)$ must have no poles in the right half of s-plane.

ii) $F(s)$ must have only simple poles on the $j\omega$-axis with real & positive residues.

7 a) Given a Π-n/w with admittances. The elements can be expressed in terms of Y-parameters.



$Y_{11} = Y_1 + Y_2 = 3 ℧$

$Y_{12} = Y_{21} = -Y_2 = -1 ℧$

$Y_{22} = Y_2 + Y_3 = 3 ℧$

Using Y-parameters, we can obtain Z-parameters as follows.

$\Delta Y = Y_{11}Y_{22} - Y_{12}Y_{21} = 3\times 3 - (-1)(-1) = 8.$

$Z_{11} = \frac{Y_{22}}{\Delta Y} = \frac{3}{8} = 0.375 \Omega$, $Z_{12} = \frac{-Y_{12}}{\Delta Y} = \frac{-(-1)}{8} = 0.125 \Omega$

$Z_{21} = \frac{-Y_{21}}{\Delta Y} = \frac{-(-1)}{8} = 0.125$, $Z_{22} = \frac{Y_{11}}{\Delta Y} = \frac{3}{8} = 0.375.$

b) iterative impedance of asymmetrical L-n/w.

$$Z_{t_1} = \frac{Z_A}{2} + \sqrt{\frac{Z_A^2}{4} + Z_A Z_C}.$$