Synthesis of Transfer Functions of 2 –port n /w with 1 ohm terminated Load

- **L –C Networks with zeros at S = 0 or s = ∞**
- **Steps to be followed**
- **1. Identify no of zeros of transfer function and where they are located. S = 0 or s = ∞ .**
- **2. Identify the circuit (LP filter or HP filter) or how L & C located.**
- **3. Identify N(s) of $Z_{21}(s)$ / $Y_{21}(s)$ whether Even or Odd.**
- **4. Segregate D(s) of $Z_{21}(s)$ / $Y_{21}(s)$ into Even and Odd parts .**
- **5. Express $Z_{21}(s)$ / $Y_{21}(s)$ as**

$$Z_{21} = \frac{z_{21}(s)}{1 + z_{22}(s)} \quad \text{or} \quad Y_{21} = \frac{y_{21}(s)}{1 + y_{22}(s)}$$

(Divide N(s) & D(s) By even part if N(s) is odd and by odd part if N(s) is even)

6. Synthesise $z_{22}(s)$ or $y_{22}(s)$ as Ladder network starting from 1 ohm side .

7. NOTE: If $Z_{21}(s)$ has all ZEROS at S = ∞ only then CAUER – I NETWORK.

If $Z_{21}(s)$ has all ZEROS AT S = 0 only then CAUER – II NETWORK

Synthesis with 1 ohm termination

- $Z_{21}(s) = 1 /(S^3 + 3s^2 + 3s + 2)$
- 1. No of zeros of transmission = 3 and are at $s = \infty$
- 2. Identify the L-C circuit as LP filter.

  Circuit shown in next slide

Synthesis with 1 ohm termination

- **3. Identify N(s) of $Z_{21}(s)$ as Even or odd. $Z_{21}(s) = 1/(S^3 + 3s^2 + 3s + 2)$**
  In this case Even .

4. D(s) of $Z_{21}(s)$

Even part $3s^2 + 2$

Odd part $S^3 + 3s$

5. $$Z_{21}(s) = \frac{1/(S^3 + 3s)}{1 + (3s^2+2)/(S^3 + 3s)} = \frac{z_{21}(s)}{1 + z_{22}(s)}$$

$z_{21}(s) = 1/(S^3 + 3s)$ **and** $z_{22}(s) = (3s^2 + 2)/(S^3 + 3s)$

6. Synthesize $z_{22}(s)$ in Ladder n /w to have three zeros at s = ∞

USE CAUER - I NETWORK

(Degree of Denominator higher , so invert .First element will be shunt element C and y_{22}. from 1 ohm side)

Synthesis with 1 ohm termination

- $Y_{21}(s) = 1 /(S^3 + 2s^2 + 2s +1)$
- 1. No of zeros of transmission = 3 and are at s = ∞
- 2. Identify the L-C circuit as LP filter.

Synthesis with 1 ohm termination

- $Z_{21}(s) = S^3 /(S^3 + 3s^2 + 4s + 2)$
- 1. No of zeros of transmission = 3 and are at s = 0
- 2. Identify the L-C circuit as HP filter.

  Circuit shown in next slide

Synthesis with 1 ohm termination

- **3. Identify N(s) of $Z_{21}(s)$ as Even or odd. $Z_{21}(s) = S^3 /(S^3 + 3s^2 + 4s + 2)$**
  In this case Odd .

4. D(s) of $Z_{21}(s)$

Even part $3s^2 + 2$

Odd part $S^3 + 4s$

5. $$Z_{21}(s) = \frac{S^3 / (3s^2+2)}{1 + (S^3 + 4s)/ (3s^2+2)} = \frac{z_{21}(s)}{1 + z_{22}(s)}$$

$$z_{21}(s) = S^3 / (3s^2+2) \quad \text{and} \quad z_{22}(s) = (S^3 + 4s)/ (3s^2+2)$$

6. Synthesize $z_{22}(s)$ in Ladder n /w to have three zeros at s = 0

USE CAUER -II NETWORK $z_{22}(s) = (4s + S^3)/ (2 + 3s^2)$

(Degree of Denominator Lower , so invert .First element will be shunt element L and $y_{22.}$ from 1 ohm side . Y_2 , z_3 and y_4 respectively)

Synthesis with 1 ohm termination

- $Y_{21}(s) = S^3 /(S^3 + 3s^2 + 3s + 2)$
- 1. No of zeros of transmission = 3 and are at s = 0
- 2. Identify the L-C circuit .

Synthesis with 1 ohm termination

- **3. Identify N(s) of $Y_{21}(s)$ as Even or odd. $Y_{21}(s) = S^3 /(S^3 + 3s^2 +3s + 2)$**
  In this case Odd .

4. D(s) of $Z_{21}(s)$

Even part $3s^2 +2$

Odd part $S^3 +3s$

5. $$Y_{21}(s) = \frac{S^3 / (3s^2 +2)}{1 + (S^3 +3s)/ (3s^2 +2)} = \frac{y_{21}(s)}{1 + y_{22}(s)}$$

$$y_{21}(s) = S^3 / (3s^2 +2) \quad \text{and} \quad y_{22}(s) = (S^3 +3s)/ (3s^2 +2)$$

6. Synthesize $y_{22}(s)$ in Ladder n /w to have three zeros at s = 0

USE CAUER -II NETWORK **$z_{22}(s) = (4s + S^3)/ (2 + 3s^2)$**

(Degree of Denominator Lower , so invert .First element will be series element C and $y_{22.}$ from 1 ohm side . Z_2 , Y_3 and Z_4 respectively)

Synthesis with 1 ohm termination

- $Y_{21}(s) = S^2 /(S^3 + 3s^2 + 4s + 2)$
- 1. Two zeros of transmission are at s = 0
  and one at s= ∞
- 2. Identify the L-C circuit .This is neither as HP filter and nor as LP filter type circuit.
- **3.** Identify N(s) of $Z_{21}(s)$ as Even or odd. $Z_{21}(s) = S^2 /(S^3 + 3s^2 + 4s + 2)$
  In this case Even

4. D(s) of $Y_{21}(s)$
   Even part $3s^2 +2$
   Odd part $S^3 + 4s$

5. $$Y_{21}(s) = \frac{S^2 / (S^3 +4s)}{1 + (3s^2 +2) /(S^3 + 4s)} = \frac{y_{21}(s)}{1 + y_{22}(s)}$$

   $y_{21}(s) = S^2 / (S^3 + 3s)$ and $y_{22}(s) = (3s^2 +2) /(S^3 +4s)$

6 $y_{22}(s) = (3s^2 +2) / s(s^2 +4s)$.

7. A parallel inductor gives a zero of transmission at s = 0

Synthesis with 1 ohm termination

- $y_{22}(s) = (3s^2 + 2) / s(s^2 + 4s)$.

  $= (1/2s) \quad + (5s/2) /(s^2 + 4)$

  $= (1/2s) \quad + \ 1/ [(2/5)s + (8/5)s]$

  $= Y_A \quad + \ Y_B$

  Y_A = (1/2s)represents an inductance of 2H

  Y_B = $1/ [(2/5)s + (8/5)s] = 1 / Z_B$

  or Z_B represents that it is a combination of two elements in series which give zeros at $s = 0$ and at $s = \infty$

These give an inductor of (2/5) H and a capacitor of (5/8) F

overall network as looked from 1 ohm side is shown on the next slide.

Synthesis with 1 ohm termination

- $Y_{21}(s) = 1 / (s^3 + 2s^2 + 2s + 1)$

  T- n/w series branches L =(3/2) H and (1/2) H . Shunt branch (4/3) F

- $Y_{21}(s) = s^3 / (s^3 + 3s^2 + 3s + 2)$

  T- n/w series branches C =(3/7) F and (3/2) F . Shunt branch (7/9) H

- $z_{21}(s) = s / (s^3 + 3s^2 + 3s + 2)$

  (9/7) H in series with (7/6) F with (1/3)F capacitor in parallel with 1 ohm resistor