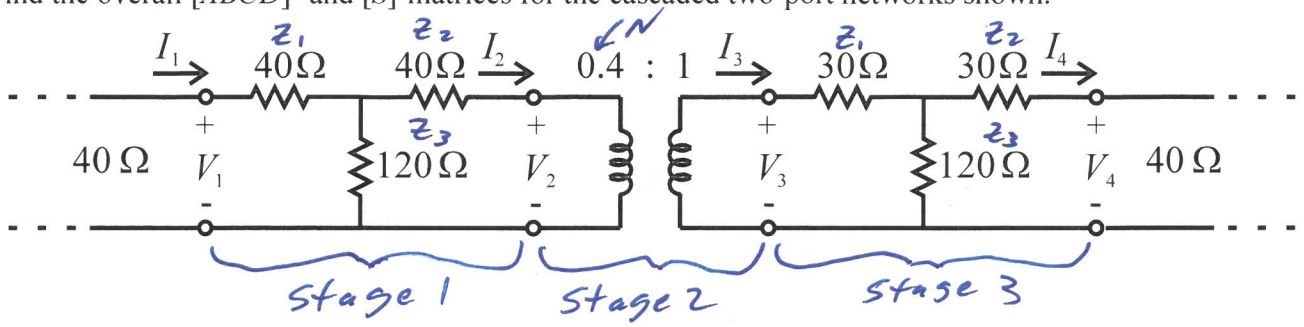
EE 481/581 Microwave Engineering Quiz #7 (Fall 2024)

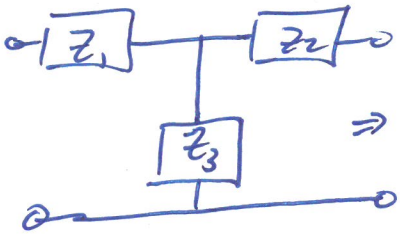
Name Key A

Instructions: Open notes & text. Place answers in given spaces. **Show** & **clearly label** all work for partial credit.

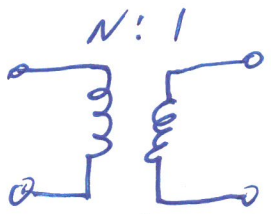
Find the overall [*ABCD*]- and [*S*]-matrices for the cascaded two-port networks shown.



From Table 4.1



$$\Rightarrow ABCD = \begin{bmatrix} 1+Z_1/Z_3 & Z_1+Z_2+\frac{Z_1 Z_2}{Z_3} \\ 1/Z_3 & 1+Z_2/Z_3 \end{bmatrix}$$



$$\Rightarrow ABCD = \begin{bmatrix} N & 0 \\ 0 & 1/N \end{bmatrix}$$

$$[ABCD]_1 = \begin{bmatrix} 1+\frac{40}{120} & 40+40+\frac{40^2}{120} \\ \frac{1}{120} & 1+\frac{40}{120} \end{bmatrix} = \begin{bmatrix} 1.\overline{3} & 93.\overline{3}\,\Omega \\ 8.\overline{3}\times 10^{-3}\,S & 1.\overline{3} \end{bmatrix}$$

$$[ABCD]_2 = \begin{bmatrix} 0.4 & 0 \\ 0 & \frac{1}{0.4} \end{bmatrix} = \begin{bmatrix} 0.4 & 0 \\ 0 & 2.5 \end{bmatrix}$$

$$[ABCD]_3 = \begin{bmatrix} 1+\frac{30}{120} & 30+30+\frac{30^2}{120} \\ \frac{1}{120} & 1+\frac{30}{120} \end{bmatrix} = \begin{bmatrix} 1.25 & 67.5\,\Omega \\ 8.\overline{3}\times 10^{-3}\,S & 1.25 \end{bmatrix}$$

Overall

$$[ABCD] = [ABCD]_1 [ABCD]_2 [ABCD]_3$$

$$= \begin{bmatrix} 1.3 & 93.\overline{3} \\ 8.\overline{3}\times10^{-3} & 1.\overline{3} \end{bmatrix} \begin{bmatrix} 0.4 & 0 \\ 0 & 2.5 \end{bmatrix} \begin{bmatrix} 1.25 & 67.5 \\ 8.\overline{3}\times10^{-3} & 1.25 \end{bmatrix}$$

$$= \begin{bmatrix} 0.5\overline{3} & 233.\overline{3} \\ 8.\overline{3}\times10^{-3} & 3.\overline{3} \end{bmatrix} \begin{bmatrix} 1.25 & 67.5 \\ 8.\overline{3}\times10^{-3} & 1.25 \end{bmatrix} = \begin{bmatrix} 2.6\overline{1} & 327.\overline{6}\,\Omega \\ 0.03194\overline{5}\,S & 4.391\overline{6} \end{bmatrix}$$

From Table 4.2 w/ $Z_0 = 40\,\Omega$

$$S_{11} = \frac{A + B/Z_0 - CZ_0 - D}{A + B/Z_0 + CZ_0 + D} = \frac{2.6\overline{1} + \frac{327.\overline{6}}{40} - 0.03194\overline{5}(40) - 4.391\overline{6}}{2.6\overline{1} + 327.\overline{6}/40 + 0.03194\overline{5}(40) + 4.391\overline{6}}$$

$$= \frac{5.1\overline{3}}{16.47\overline{2}} = 0.311636$$

$$S_{12} = \frac{2(AD - BC)}{A + B/Z_0 + CZ_0 + D} = \frac{2\left[2.6\overline{1}(4.391\overline{6}) - 327.\overline{6}(0.03194\overline{5})\right]}{16.47\overline{2}}$$

$$= \frac{2}{16.47\overline{2}} = 0.121417$$

$$S_{21} = \frac{2}{A + B/Z_0 + CZ_0 + D} = \frac{2}{16.47\overline{2}} = 0.121417 = S_{12}$$

$$S_{22} = \frac{-A + B/Z_0 - CZ_0 + D}{A + B/Z_0 + CZ_0 + D} = \frac{-2.6\overline{1} + \frac{327.\overline{6}}{40} - 0.03194\overline{5}(40) + 4.391\overline{6}}{16.47\overline{2}}$$

$$= \frac{8.69\overline{4}}{16.47\overline{2}} = 0.527825$$

[*ABCD*]	[*S*]
$\begin{bmatrix} 2.6\overline{1} & 327.\overline{6}\,\Omega \\ 0.03194\overline{5}\,S & 4.391\overline{6} \end{bmatrix}$	$\begin{bmatrix} 0.31164 & 0.12142 \\ 0.12142 & 0.52782 \end{bmatrix}$

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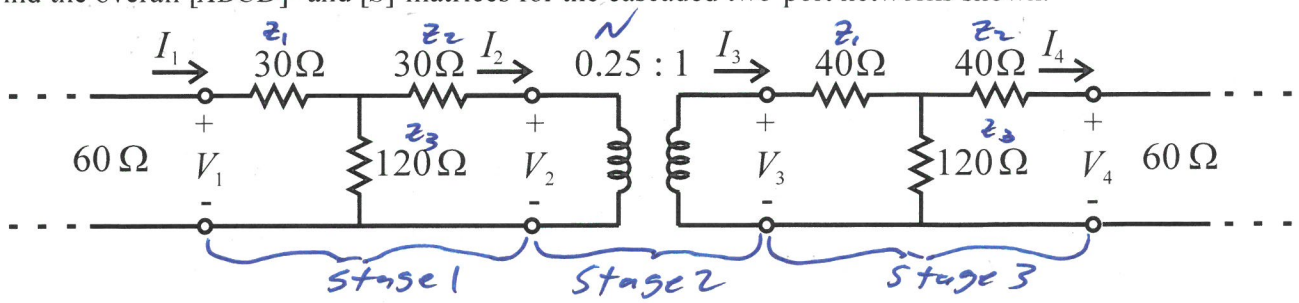
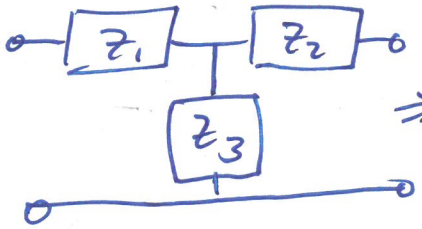
Name Key B

Instructions: Open notes & text. Place answers in given spaces. **Show** & **clearly label** all work for partial credit.

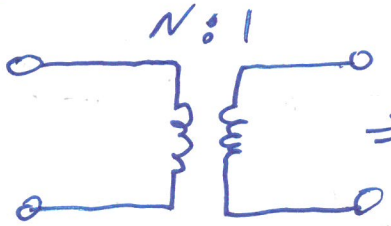
Find the overall [*ABCD*]- and [*S*]-matrices for the cascaded two-port networks shown.



From Table 4.3



$$\Rightarrow ABCD = \begin{bmatrix} 1 + Z_1/Z_3 & Z_1 + Z_2 + \frac{Z_1 Z_2}{Z_3} \\ 1/Z_3 & 1 + Z_2/Z_3 \end{bmatrix}$$



$$\Rightarrow ABCD = \begin{bmatrix} N & 0 \\ 0 & 1/N \end{bmatrix}$$

$$[ABCD]_1 = \begin{bmatrix} 1 + 30/120 & 30+30+\frac{30^2}{120} \\ 1/120 & 1 + 30/120 \end{bmatrix} = \begin{bmatrix} 1.25 & 67.5\,\Omega \\ 8.\overline{3}\times10^{-3}\,S & 1.25 \end{bmatrix}$$

$$[ABCD]_2 = \begin{bmatrix} 0.25 & 0 \\ 0 & 1/0.25 \end{bmatrix} = \begin{bmatrix} 0.25 & 0 \\ 0 & 4 \end{bmatrix}$$

$$[ABCD]_3 = \begin{bmatrix} 1 + 40/120 & 40+40+\frac{40^2}{120} \\ 1/120 & 1 + 40/120 \end{bmatrix} = \begin{bmatrix} 1.\overline{3} & 93.\overline{3}\,\Omega \\ 8.\overline{3}\times10^{-3}\,S & 1.\overline{3} \end{bmatrix}$$

Overall $[ABCD] = [ABCD]_1 [ABCD]_2 [ABCD]_3$

$$[ABCD] = \begin{bmatrix} 1.25 & 67.5 \\ 8.\overline{3}\times10^{-3} & 1.25 \end{bmatrix}\begin{bmatrix} 0.25 & 0 \\ 0 & 4 \end{bmatrix}\begin{bmatrix} 1.\overline{3} & 93.\overline{3} \\ 8.\overline{3}\times10^{-3} & 1.\overline{3} \end{bmatrix}$$

$$= \begin{bmatrix} 0.3125 & 270 \\ 2.08\overline{3}\times10^{-3} & 5 \end{bmatrix}\begin{bmatrix} 1.\overline{3} & 93.\overline{3} \\ 8.\overline{3}\times10^{-3} & 1.\overline{3} \end{bmatrix} = \underline{\begin{bmatrix} 2.\overline{6} & 389.1\overline{6}\,\Omega \\ 0.0\overline{45} & 6.86\overline{1} \end{bmatrix}}$$

From Table 4.2 w/ $Z_0 = 60\,\Omega$

$$S_{11} = \frac{A + B/Z_0 - CZ_0 - D}{A + B/Z_0 + CZ_0 + D} = \frac{2.\overline{6} + 389.1\overline{6}/60 - 0.0\overline{45}(60) - 6.86\overline{1}}{2.\overline{6} + 389.1\overline{6}/60 + 0.0\overline{45}(60) + 6.86\overline{1}}$$

$$= \frac{-0.375}{18.6805} = \underline{-0.02007435}$$

$$S_{12} = \frac{2(AD - BC)}{A + B/Z_0 + CZ_0 + D} = \frac{2\left[2.\overline{6}(6.86\overline{1}) - 389.1\overline{6}(0.0\overline{45})\right]}{18.6805} = \frac{2}{18.68}$$

$$= \underline{0.10706318}$$

$$S_{21} = \frac{2}{A + B/Z_0 + CZ_0 + D} = S_{12} = \underline{0.10706318}$$

$$S_{22} = \frac{-A + B/Z_0 - CZ_0 + D}{A + B/Z_0 + CZ_0 + D} = \frac{-2.\overline{6} + 389.1\overline{6} - 0.0\overline{45}(60) + 6.86\overline{1}}{18.6805}$$

$$= \frac{8.013\overline{6}}{18.6805} = \underline{0.42899\overline{63}}$$

[*ABCD*]	[*S*]
$\begin{bmatrix} 2.\overline{6} & 389.1\overline{6}\,\Omega \\ 0.0\overline{45} & 6.86\overline{1} \end{bmatrix}$	$\begin{bmatrix} -0.02007 & 0.10706 \\ 0.10706 & 0.42900 \end{bmatrix}$