Microelectronic Circuits Assignment 1

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Question 1

Value of components (resistor/capacitor) present in the circuit:

Table 1: Calculated values for question 1

Sl. No.	Component Name	Value
1	R1(kΩ)	15kΩ
2	C1 (nF)	1nF

Circuit as on LT SPICE

Graphs

Miscellaneous calculations

Question 2

Value of components (resistors/gain) present in the circuit

Table 2: Calculated values for question 2

Sl. No.	Component Name	Value
1	R_1(kΩ)	30kΩ
2	R_2(kΩ)	17kΩ
3	R_3(kΩ)	30kΩ
4	R_4(kΩ)	50kΩ
5	k	18 V/V

Circuit as on LT SPICE

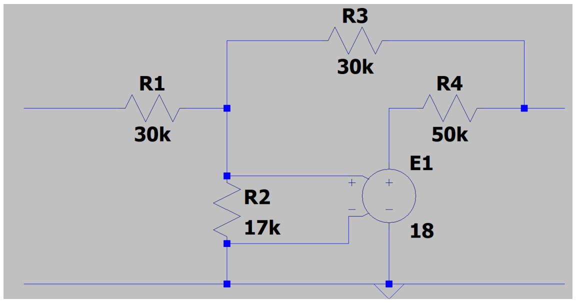

Figure 1: Original 2 port network simulated on LT SPICE

Z, Y and h Parameters

Z parameters

Z parameters as obtained from LT SPICE

$$Z = \begin{bmatrix} 23.492822k\Omega & -4.0669856k\Omega \\ -47.99043k\Omega & -11.24402k\Omega \end{bmatrix}$$

Y parameters

$$Y = \begin{bmatrix} 0.0k\mho & 0.0k\mho \\ 0.0k\mho & 0.0k\mho \end{bmatrix}$$

H parameters

$$H = \begin{bmatrix} 0.0k\Omega & 0.0 \\ 0.0 & 0.0k\mho \end{bmatrix}$$

Calculations

Z parameters

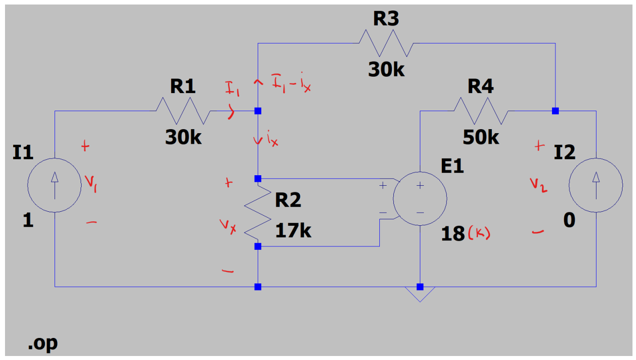

Figure 2: Z parameter circuit 1 (for z_{11} and z_{21})

Assume the convention in the above circuit for the calculations that follow

$$-(I_1 - i_x)(R_3 + R_4) - kV_x + V_x = 0$$
$$(i_x - I_1)(R_3 + R_4) = V_x(k-1)$$
$$(i_x - I_1)(R_3 + R_4) = i_x R_2(k-1)$$
$$i_x(R_3 + R_4 - R_2(k-1)) = I_1(R_3 + R_4)$$
$$\implies i_x = I_1 \frac{(R_3 + R_4)}{R_3 + R_4 - R_2(k-1)}$$
$$V_1 = I_1 R_1 + V_x$$
$$V_1 = I_1 R_1 + i_x R_2$$
$$V_1 = I_1 \left(R_1 + \frac{R_2(R_3 + R_4)}{R_3 + R_4 - R_2(k-1)} \right)$$
$$\implies \frac{V_1}{I_1} = \boxed{z_{11} = R_1 + \frac{R_2(R_3 + R_4)}{R_3 + R_4 - R_2(k-1)}}$$

Also :

$$V_2 = (I_1 - i_x)R_4 + kV_x$$
$$V_2 = (I_1 - i_x)R_4 + k i_x R_2$$
$$V_2 = i_x(kR_2 - R_4) + I_1 R_4$$
$$V_2 = I_1 \left(R_4 + \frac{(kR_2 - R_4)(R_3 + R_4)}{R_3 + R_4 + R_2(k-1)} \right)$$
$$\implies \frac{V_2}{I_1} = \boxed{z_{21} = R_4 + \frac{(kR_2 - R_4)(R_3 + R_4)}{R_3 + R_4 - R_2(k-1)}}$$

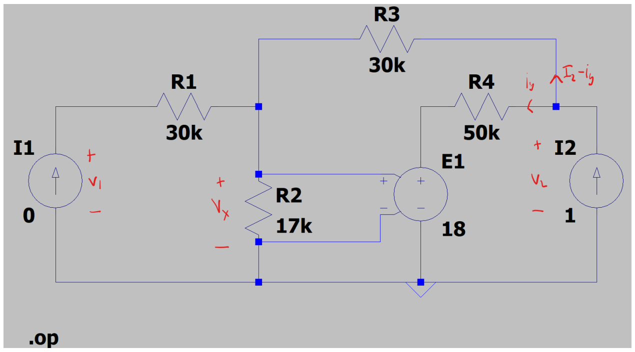

Figure 3: Z parameter circuit 2 (for z_{12} and z_{22})

Assume the convention in the above circuit for the calculations that follow

$$
\begin{gathered}
-R_3(I_2 - i_y) - V_x + kV_x + i_y R_4 = 0 \\
i_y R_4 - R_3(I_2 - i_y) = (1-k)V_x \\
i_y R_4 - R_3(I_2 - i_y) = (1-k)(I_2 - i_y)R_2 \\
i_y R_4 = (I_2 - i_y)[(1-k)R_2 + R_3] \\
(R_4 + R_3 + (1-k)R_2)i_y = I_2[(1-k)R_2 + R_3] \\
\implies i_y = I_2 \frac{(1-k)R_2 + R_3}{(1-k)R_2 + R_3 + R_4} \\
V_2 = i_y R_4 + kV_x \\
V_2 = i_y R_4 + k(I_2 - i_y)R_2 \\
V_2 = i_y[R_4 - kR_2] + KI_2R_2 \\
V_2 = I_2 \left[\frac{(R_4 - kR_2)[(1-k)R_2 + R_3]}{(1-k)R_2 + R_3 + R_4} + kR_2 \right] \\
\implies \frac{V_2}{I_2} = \boxed{z_{22} = \frac{(R_4 - kR_2)[(1-k)R_2 + R_3]}{(1-k)R_2 + R_3 + R_4} + kR_2} \\
\text{Also :} \\
V_1 = V_x = (I_2 - i_y)R_2 \\
V_1 = I_2 R_2 \left[1 - \frac{(1-k)R_2 + R_3}{(1-k)R_2 + R_3 + R_4} \right] \\
\implies \frac{V_1}{I_2} = \boxed{z_{12} = R_2 \left[1 - \frac{(1-k)R_2 + R_3}{(1-k)R_2 + R_3 + R_4} \right]}
\end{gathered}
$$

Using the corresponding values taken from 2 into the above equations, we get the matrix for the Z parameters:

$$Z = \begin{bmatrix} 23.49282297k\Omega & -4.066985646k\Omega \\ -47.99043062k\Omega & -11.244041914k\Omega \end{bmatrix}$$

Which is in accordance with the values obtained from the simulation.

Load resistance value at port 2