

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(k Ω)	15k Ω
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	$R_1(\text{k}\Omega)$	$30\text{k}\Omega$
2	$R_2(\text{k}\Omega)$	$17\text{k}\Omega$
3	$R_3(\text{k}\Omega)$	$30\text{k}\Omega$
4	$R_4(\text{k}\Omega)$	$50\text{k}\Omega$
5	k	18 V/V

Circuit as on LT SPICE

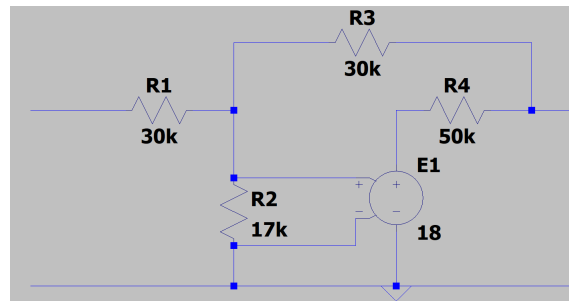


Figure 1: Original 2 port network simulated on LT SPICE

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 parameters as obtained from LT SPICE

$$Y = \begin{bmatrix} 24.479166\mu\mathcal{U} & -8.8541665\mu\mathcal{U} \\ -104.47916\mu\mathcal{U} & -51.145835\mu\mathcal{U} \end{bmatrix}$$

H parameters

$$H = \begin{bmatrix} 40.851062k\Omega & 361.70211mV/V \\ -4.268085A/A & -88.936169\mathcal{U} \end{bmatrix}$$

Calculations

Z parameters

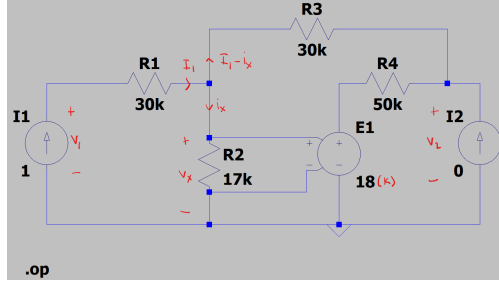


Figure 2: Z parameter circuit 1 (for z_{11} and z_{21})

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

$$\begin{aligned}
 -(I_1 - i_x)(R_3 + R_4) - kV_x + V_x &= 0 \\
 (i_x - I_1)(R_3 + R_4) &= V_x(k - 1) \\
 (i_x - I_1)(R_3 + R_4) &= i_x R_2(k - 1) \\
 i_x(R_3 + R_4 - R_2(k - 1)) &= I_1(R_3 + R_4) \\
 \implies i_x &= I_1 \frac{(R_3 + R_4)}{R_3 + R_4 - R_2(k - 1)} \\
 V_1 &= I_1 R_1 + V_x \\
 V_1 &= I_1 R_1 + i_x R_2 \\
 V_1 &= I_1 \left[R_1 + \frac{R_2(R_3 + R_4)}{R_3 + R_4 - R_2(k - 1)} \right] \\
 \implies \frac{V_1}{I_1} &= z_{11} = R_1 + \frac{R_2(R_3 + R_4)}{R_3 + R_4 - R_2(k - 1)}
 \end{aligned}$$

Also :

$$\begin{aligned}
 V_2 &= (I_1 - i_x)R_4 + kV_x \\
 V_2 &= (I_1 - i_x)R_4 + k i_x R_2 \\
 V_2 &= i_x(kR_2 - R_4) + I_1 R_4 \\
 V_2 &= I_1 \left[R_4 + \frac{(kR_2 - R_4)(R_3 + R_4)}{R_3 + R_4 - R_2(k - 1)} \right] \\
 \implies \frac{V_2}{I_1} &= z_{21} = R_4 + \frac{(kR_2 - R_4)(R_3 + R_4)}{R_3 + R_4 - R_2(k - 1)}
 \end{aligned}$$

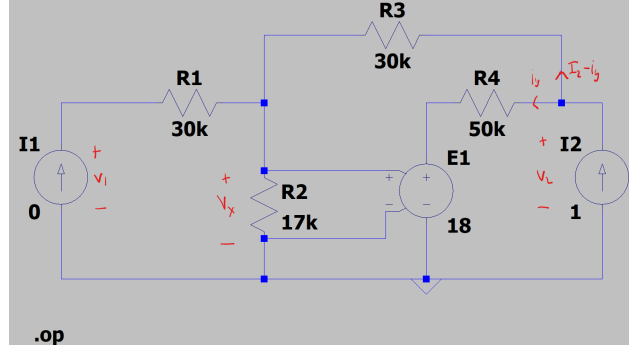


Figure 3: Z parameter circuit 2 (for z_{12} and z_{22})

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

$$\begin{aligned}
 -R_3(I_2 - i_y) - V_x + kV_x + i_y R_4 &= 0 \\
 i_y R_4 - R_3(I_2 - i_y) &= (1 - k)V_x \\
 i_y R_4 - R_3(I_2 - i_y) &= (1 - k)(I_2 - i_y)R_2 \\
 i_y R_4 &= (I_2 - i_y)[(1 - k)R_2 + R_3] \\
 (R_4 + R_3 + (1 - k)R_2)i_y &= I_2[(1 - k)R_2 + R_3] \\
 \implies i_y &= I_2 \frac{(1 - k)R_2 + R_3}{(1 - k)R_2 + R_3 + R_4} \\
 V_2 &= i_y R_4 + kV_x \\
 V_2 &= i_y R_4 + k(I_2 - i_y)R_2 \\
 V_2 &= i_y [R_4 - kR_2] + kI_2 R_2 \\
 V_2 &= I_2 \left[\frac{(R_4 - kR_2)\{(1 - k)R_2 + R_3\}}{(1 - k)R_2 + R_3 + R_4} + kR_2 \right] \\
 \implies \frac{V_2}{I_2} &= \boxed{z_{22} = \frac{(R_4 - kR_2)\{(1 - k)R_2 + R_3\}}{(1 - k)R_2 + R_3 + R_4} + kR_2}
 \end{aligned}$$

Also :

$$\begin{aligned}
 V_1 &= V_x = (I_2 - i_y)R_2 \\
 V_1 &= I_2 R_2 \left[1 - \frac{(1 - k)R_2 + R_3}{(1 - k)R_2 + R_3 + R_4} \right] \\
 \implies \frac{V_1}{I_2} &= \boxed{z_{12} = R_2 \left[1 - \frac{(1 - k)R_2 + R_3}{(1 - k)R_2 + R_3 + R_4} \right]}
 \end{aligned}$$

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.

Y parameters

From the above matrix for Z parameters, we can calculate the Y parameters as follows:

$$\begin{aligned} \Delta Z &= z_{11}z_{22} - z_{12}z_{21} \\ \Rightarrow \Delta Z &= [(23.49282297 \times -11.244041914) - (-47.99043062 \times -4.066985646)] \times 10^3 \\ \Delta Z &= -459.326 \times 10^6 \\ Y &= \begin{bmatrix} \frac{z_{22}}{\Delta Z} & -\frac{z_{12}}{\Delta Z} \\ -\frac{z_{21}}{\Delta Z} & \frac{z_{11}}{\Delta Z} \end{bmatrix} \end{aligned}$$

Simplifying the above matrix, we get the Y parameters:

$$Y = \begin{bmatrix} 2.448 \times 10^{-5} \mu\mathcal{U} & -8.8541 \times 10^{-6} \mu\mathcal{U} \\ -1.104480 \times 10^{-4} \mu\mathcal{U} & -5.11 \times 10^{-5} \mu\mathcal{U} \end{bmatrix}$$

H parameters

Similarly, we can calculate the H parameters as follows:

$$H = \begin{bmatrix} \frac{\Delta Z}{z_{22}} & -\frac{z_{12}}{z_{22}} \\ -\frac{z_{21}}{z_{22}} & \frac{1}{z_{22}} \end{bmatrix}$$

Simplifying the above matrix, we get the H parameters:

$$H = \begin{bmatrix} 40.8507k\Omega & -0.3617V/V \\ -4.2681A/A & -88.9363\mathcal{U} \end{bmatrix}$$

Load resistance value at port 2