# Microelectronic Circuits Assignment 1

Sai Kartik (2020A3PS0435P)
Manpreet Singh (2020A3PS0419P)
Rajeev Rajagopal (2020A3PS1237P)

February, 2022

## 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

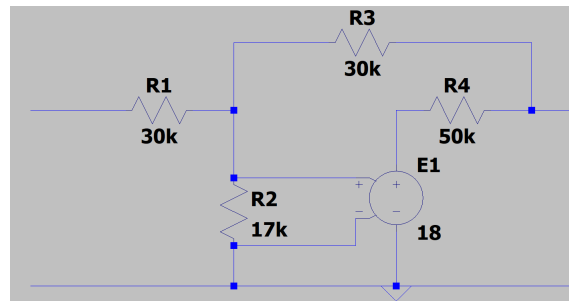| Sl. No. | Component Name | Value |
|---------|----------------|-------|
| 1 | $R_1(\text{k}\Omega)$ | 30k$\Omega$ |
| 2 | $R_2(\text{k}\Omega)$ | 17k$\Omega$ |
| 3 | $R_3(\text{k}\Omega)$ | 30k$\Omega$ |
| 4 | $R_4(\text{k}\Omega)$ | 50k$\Omega$ |
| 5 | k | 18 V/V |

## 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

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

### H parameters

$$H = \begin{bmatrix} 40.851062k\Omega & 361.70211m\text{V/V} \\ -4.268085\text{A/A} & -88.936169\mho \end{bmatrix}$$
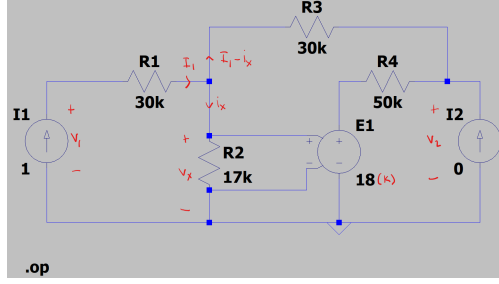
# Calculations

## 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 :

$$V_2 = (I_1 - i_x)R_4 + kV_x$$

$$V_2 = (I_1 - i_x)R_4 + ki_x R_2$$

$$V_2 = i_x(kR_2 - R_4) + I_1 R_4$$

$$V_2 = I_1 \left[ R_4 + \frac{(kR_2 - R_4)(R_3 + R_4)}{R_3 + R_4 + R_2(k - 1)} \right]$$

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

4
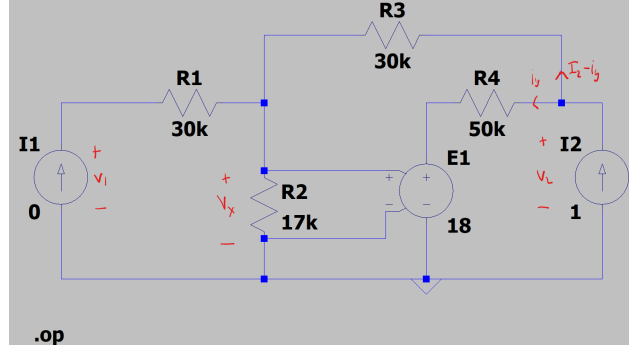
Figure 3: Z parameter circuit 2 (for $z_{12}$ and $z_{22}$)

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

$$-R_3(I_2 - i_y) - V_x + kV_x + i_y R_4 = 0$$

$$i_y R_4 - R_3(I_2 - i_y) = (1-k)V_x$$

$$i_y R_4 - R_3(I_2 - i_y) = (1-k)(I_2 - i_y)R_2$$

$$i_y R_4 = (I_2 - i_y)[(1-k)R_2 + R_3]$$

$$(R_4 + R_3 + (1-k)R_2)i_y = I_2[(1-k)R_2 + R_3]$$

$$\implies i_y = I_2 \frac{(1-k)R_2 + R_3}{(1-k)R_2 + R_3 + R_4}$$

$$V_2 = i_y R_4 + kV_x$$

$$V_2 = i_y R_4 + k(I_2 - i_y)R_2$$

$$V_2 = i_y[R_4 - kR_2] + KI_2 R_2$$

$$V_2 = I_2\left[\frac{(R_4 - kR_2)\{(1-k)R_2 + R_3\}}{(1-k)R_2 + R_3 + R_4} + kR_2\right]$$

$$\implies \frac{V_2}{I_2} = \boxed{z_{22} = \frac{(R_4 - kR_2)\{(1-k)R_2 + R_3\}}{(1-k)R_2 + R_3 + R_4} + kR_2}$$

Also :

$$V_1 = V_x = (I_2 - i_y)R_2$$

$$V_1 = I_2 R_2\left[1 - \frac{(1-k)R_2 + R_3}{(1-k)R_2 + R_3 + R_4}\right]$$

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

5

Using the corresponding values taken from <span style="color:blue">2</span> 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**

**H parameters**

## Load resistance value at port 2