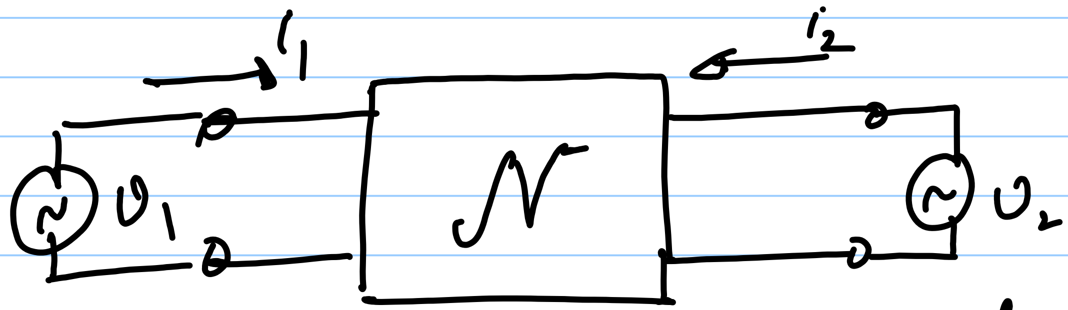
Question - Set #4



Given an arbitrary LINEAR two port network, how to find its y-parameters?

By definition:

$$i_1 = y_{11} v_1 + y_{12} v_2$$
$$i_2 = y_{21} v_1 + y_{12} v_2$$

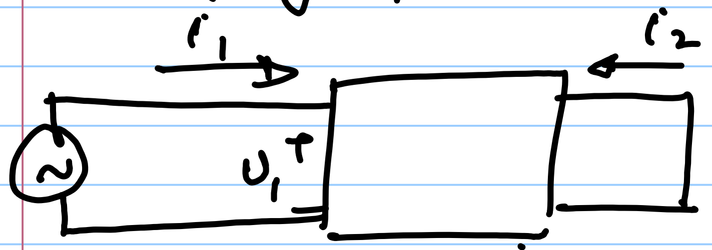
$\therefore$ $y_{11} = \frac{i_1}{v_1}$ if $v_2 = 0$ $\qquad$ $y_{12} = \frac{i_1}{v_2}$ if $v_1 = 0$

$y_{21} = \frac{i_2}{v_1}$ if $v_2 = 0$ $\qquad$ $y_{22} = \frac{i_2}{v_2}$ if $v_1 = 0$

Notice that the y-parameters can be experimentally obtained by "short" circuiting one of the ports observing the currents through a port when some voltage is applied at one of the ports.

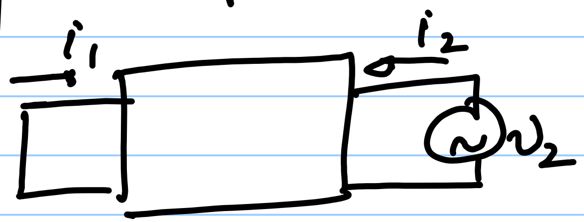
(Thus)

To find y_{11} and y_{21} short port 2 and apply i/p at port 1



$$y_{11} = \frac{i_1}{v_1} \qquad y_{21} = \frac{i_2}{v_1}$$

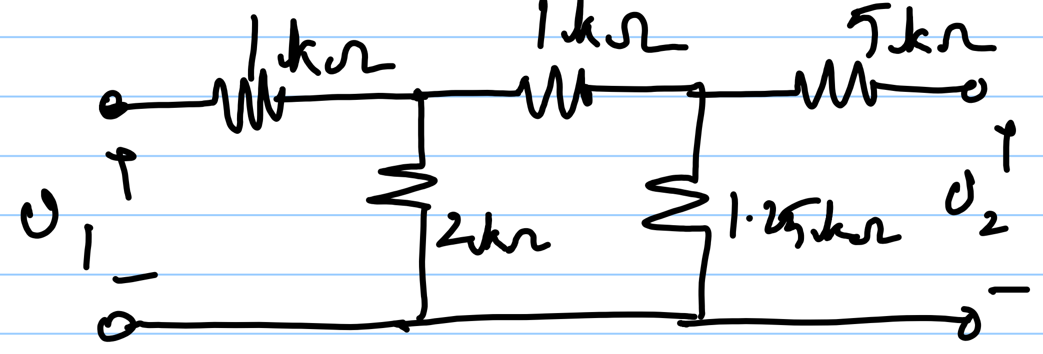
To find y_{12} and y_{22} - short port 1 and apply i/p at port 2



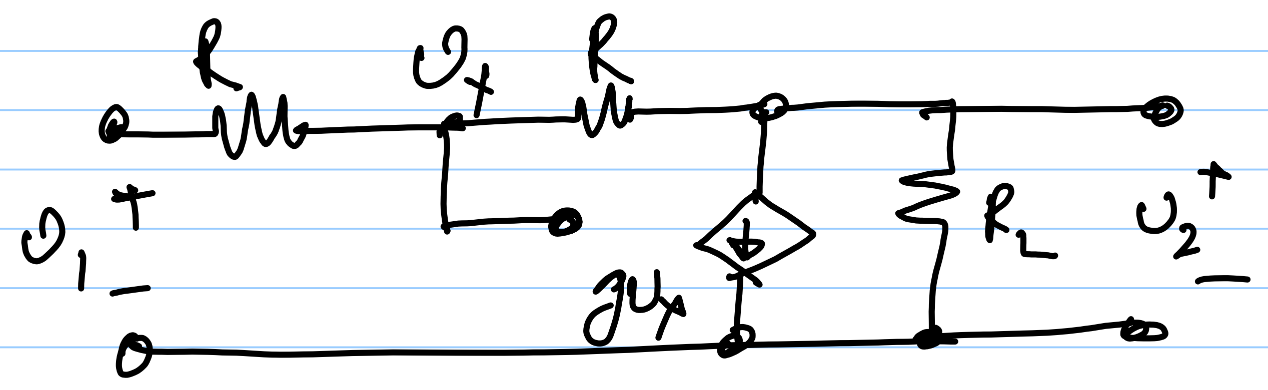
$$y_{22} = \frac{i_2}{v_2} \qquad y_{12} = \frac{i_1}{v_2}.$$

1) Find the y-parameters for the following networks

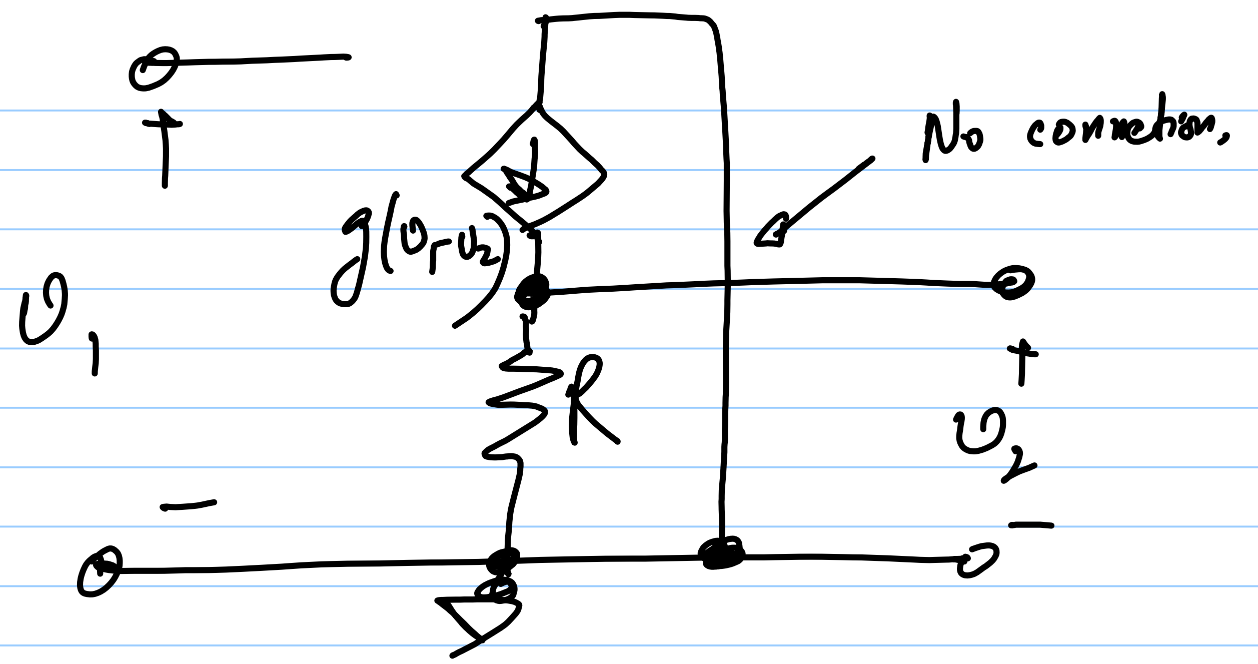
(a)



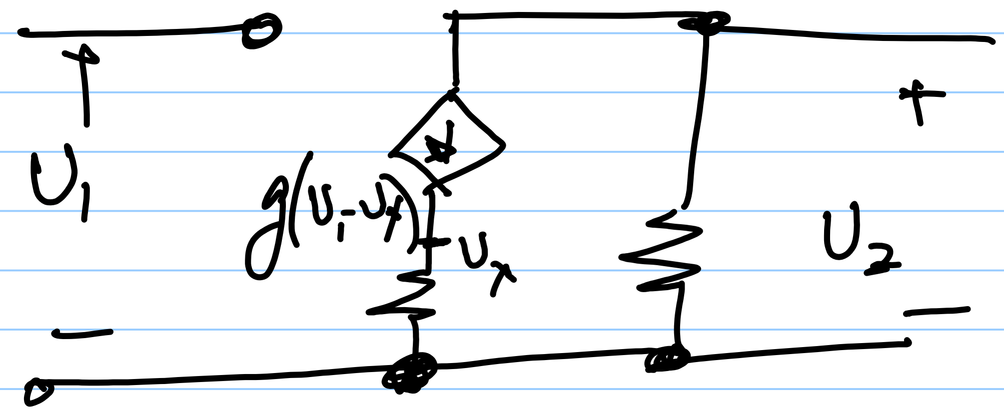
(b)



(c)



(d)

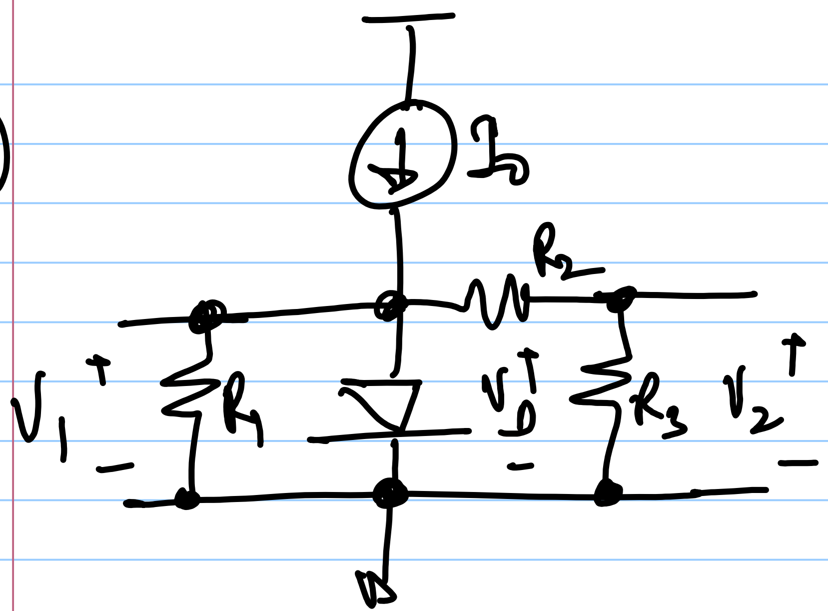


(2) What happens if one of the elements in the network is non-linear?

To obtain the linearised y-param of the overall two-port network, we need to linearise the non-linear element.

Find the **small-signal** y-param of the following networks.

(a)

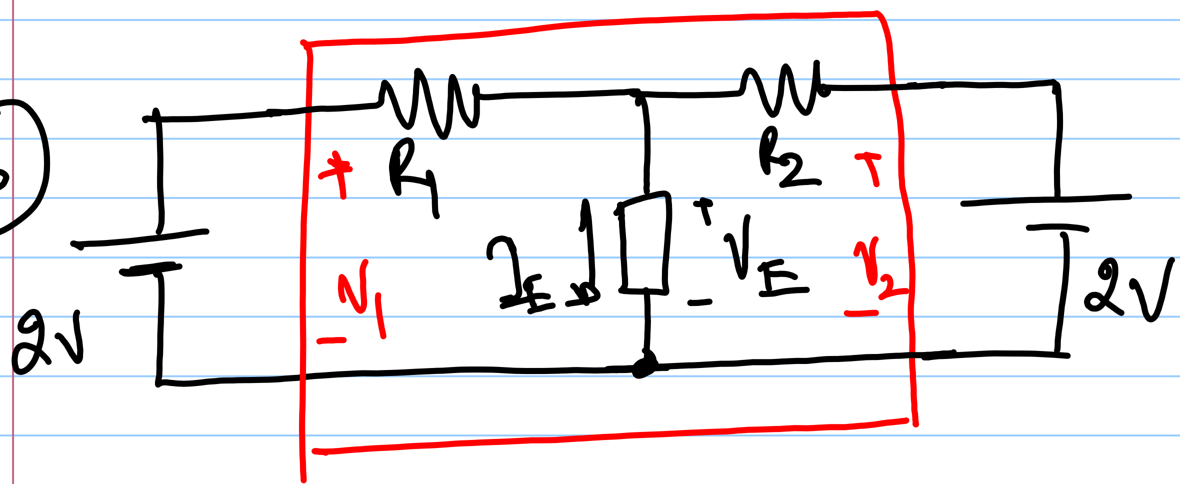


$I_o = 10mA$

$R_1 = 2k\Omega$, $R_2 = R_3 = 1k\Omega$

Assume $V_D = 0.7V$ for quiescent point calculation if the diode is on.

(b)



$I_E = \alpha V_E^2$, $\alpha = 1mS$

$V_E < 0$ is invalid.

$R_1 = 1k\Omega$ $R_2 = 2k\Omega$

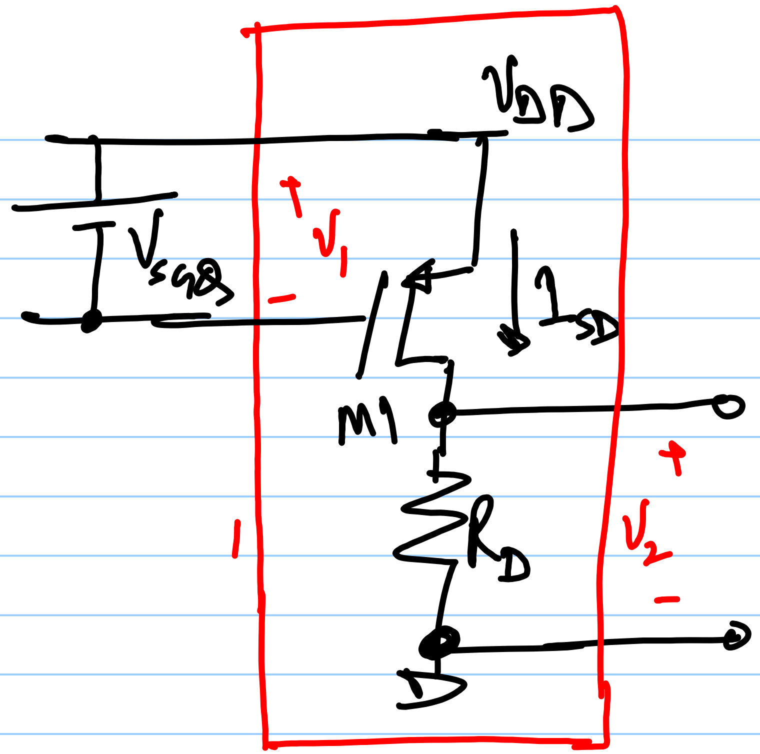
(c) In both (a) and (b) you would have replaced the non-linear element with its incremental equivalent, desensitized the current and the voltage sources and found the small-signal y-params from the equivalent small-signal network.

However, when you are in a lab, and are trying to experimentally find the "small-signal" y-params you will not be able to desensitize the current and voltage sources. Then how would you find the "small-signal" y-params experimentally?

Hint: You will have to preserve the Q-points and apply incremental voltages while "incrementally" shorting one on the other ports.

Do this exercise for the networks in 2 (a) and (b) and match your answers.

③



$V_{DD} = 5V$, $V_{thp} = 1V$, $V_{SGQ} = 2V$

$\mu_p C_{ox} = 0.1 mA/V^2$ $W/L = 20$

$R_D = 2k\Omega$,

ⓐ Find I_{SDQ}, V_{2Q}.

ⓑ Replace M1 with its small-signal equivalent

ⓒ Find the small-signal y-params, assuming the ports are at v_1 and v_2.

ⓓ Apply a small-signal i/p across v_1 and find v_2/v_1.