J. Zhou 2015-02-16

DC parameters of Four-port network

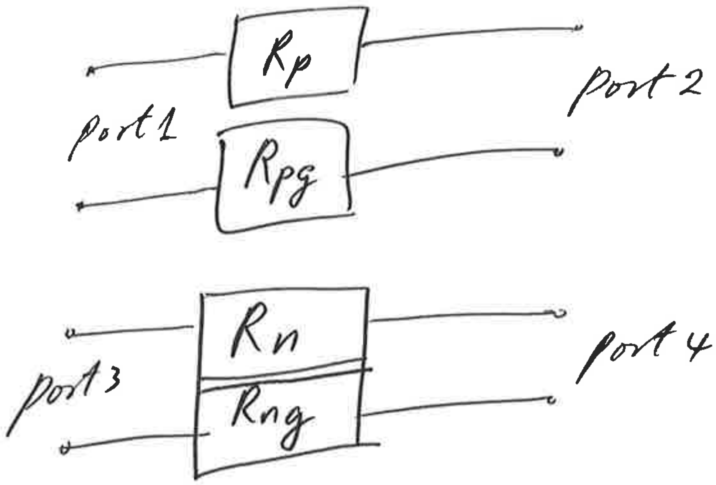


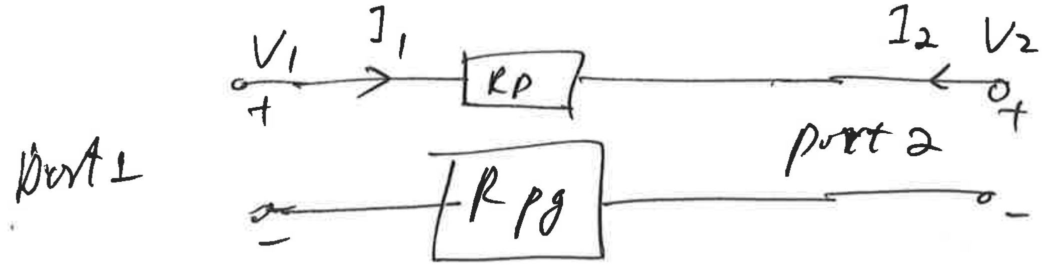
Fig1. Four-port network at DC

Fig1 depicts a four-port (eight terminal) network at DC. It consists of R_p, R_{pg}, R_n, R_{ng} ~~restan~~ resistances. where R_p and R_n ~~repre~~ are the resistances of two seperate power or signal nets and R_{pg} and R_{ng} are the DC resistance of the ground net, between port1, port2 and port3 port4 we wish to obtain the ~~DD~~ S or Y parameters of the ~~netw~~ four-port network at DC. The Z parameter of such network doesn't exist, ~~dut to~~ due to the lack of resistive path between power-ground or signal-ground

(2)

Section 1. Y parameter

Y parameter between port 1 and port 2



apply V_1 at port 1, short port 2, ($V_2=0$)

we have
$$I_1 = -I_2 = \frac{V_1}{R_p+R_{pg}}$$

based on Y parameter definition:
$$I_1\big|_{V_2=0} = Y_{11}V_1 \quad , \quad I_2\big|_{V_2=0} = Y_{21}V_1$$

we have $Y_{11} = \dfrac{1}{R_p + R_{pg}}$

$$Y_{2\cancel{1}} = -\frac{1}{R_p + R_{pg}}$$

Similarly apply V_2 at port 2 and set $V_1 = 0$

we have $I_2 = -I_1 = \dfrac{V_2}{R_p + R_{pg}}$

$$I_2 \Big|_{V_1=0} = Y_{22} V_2, \quad I_1 \Big|_{V_1=0} = Y_{12} V_2$$

we obtain:

$$Y_{22} = \frac{1}{R_p + R_{pg}}, \quad Y_{12} = -\frac{1}{R_p + R_{pg}}$$

$$Y = \frac{1}{R_p + R_{pg}} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

note that ~~the~~ $\det(Y) = 0$, ~~ind~~.
this is caused by the fact I_1, I_2 are not independent

The fourport Y matrix is

$$Y = \begin{bmatrix} Y_p & -Y_p & 0 & 0 \\ -Y_p & +Y_p & 0 & 0 \\ 0 & 0 & Y_n & -Y_n \\ 0 & 0 & -Y_n & Y_n \end{bmatrix}$$

where $Y_p = 1/(R_p + R_{pg})$

$Y_n = 1/(R_n + R_{ng})$

section 2 S-parameter

The S-parameter of port 1, port 2 are given by eqns (301) (302) (303) (304) in "network-analysis-05.pdf" on pg 31

~~S_{11} =~~

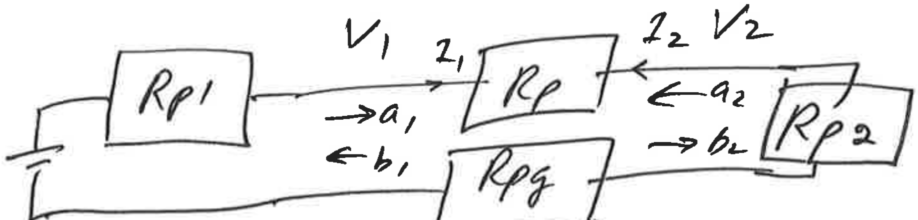


Fig. 2

$$\Sigma R_p = R_{p1} + R_p + R_{pg} + R_{p2}$$

where R_{p1} R_{p2} are ref impedances of port 1, port 2, respectively

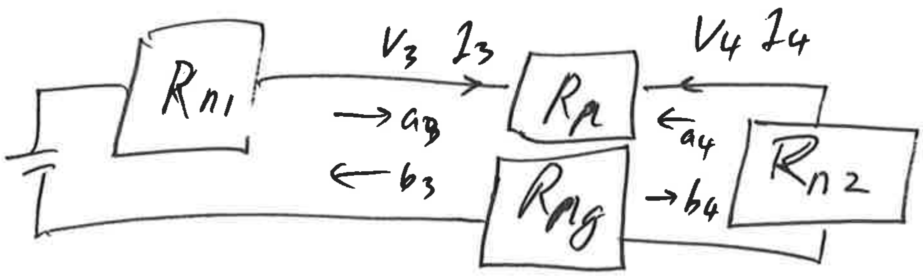


Fig. 3

$$\Sigma R_n = R_{n1} + R_n + R_{ng} + R_{n2}$$

$$S_{11} = 1 - \frac{2 R_{p1}}{\Sigma R_p}$$

$$S_{12} = S_{21} = \frac{2\sqrt{R_{p1} R_{p2}}}{\Sigma R_p}$$

$$S_{22} = 1 - \frac{2 R_{p2}}{\Sigma R_p}$$

$$S_{33} = 1 - \frac{2 R_{n2}}{\Sigma R_n}$$

$$S_{34} = S_{43} = \frac{2\sqrt{R_{n1} R_{n2}}}{\Sigma R_n}$$

$$S_{44} = 1 - \frac{2 R_{n2}}{\Sigma R_n}$$

$$S = \begin{bmatrix} S_{11} & S_{12} & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 \\ 0 & 0 & S_{33} & S_{34} \\ 0 & 0 & S_{43} & S_{44} \end{bmatrix}$$

(The end)