**ECE 145a /218A problem set : Unilateral reactively matched ampliers, signal flow graphs..**

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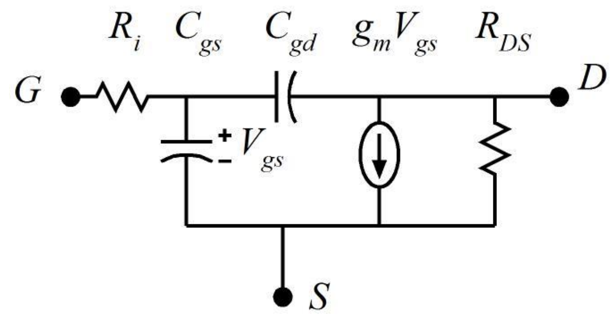
| Background: Unilateral Device model. We will assume a highly simplified device model as to the right, with $g_m = 2mS/\mu m \cdot W_g$ $R_i = 1.5/g_m$ <br> $C_{gd} = 0$ fF <br> $C_{gs} = 1.0\, fF/\mu m \cdot W_g$ <br> $G_{ds} = 0.2mS/\mu m \cdot W_g$ <br> Note that because of numerical problems in ADS, it may be necessary to add a nonzero $C_{gd}$; keep it small enough to not change the simulations ! |   |

Part a: For the unilateral device model, compute by hand the maxium available power gain and the short-circuit current gain as a function of frequency.

Part b: At a frequency of $f_{\mathbf{max}}$/3, what is the maximum available power gain of the transistor ? What generator and load impedance must be provided ? Hint: solving this problem using S-parameters would be possible, but difficult. There is a much easier way.

Part c: Taking $C_{gd}$ to be zero (so we do not need to include it in the expressions, give ***algebraic expressions***, in terms frequency, $g_m$, $R_i$, $C_{gs}$ , and $R_{ds}$, of the following: Y11,Y21, S21,

Part d: For a 50 Ohm generator and load, at a frequency of 100 GHz, and taking $W_g$ =50 microns for the unilateral device model, calculate the following by hand:
insertion power gain, operating power gain, available power gain, maximum available power gain. Simulate these in ADS and compare with hand calculations.

Part e: Using ideal L-C matching networks, design an amplifier for operation at 10 GHz signal frequency. Use ADS. Give dB plots of all 4 s-parameters vs. Frequency. Make a plot comparing the transistor MAG to the amplifier S21

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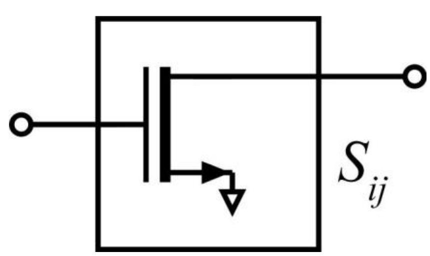
| Problem 2 <br> A transistor has the following s-parameters: <br><br> S11=0.25 <br> S22=0.333 <br> S12=0 <br> S21=20 <br> these S-parameters are defined for a 50 Ohm system impedance. |   |

Problem 2a: The generator has 50 Ohms impedance and 1 mW available power, while the load has 50- Ohms impedance. Find the power delivered to the load

Problem 2b: The generator has 75 Ohms impedance and 1 mW available power, while the load has 25 Ohms impedance. Find the power delivered to the load

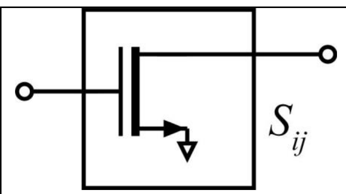
Problem 2c: The generator is impedance-matched to the transistor input, and has 1 mW available power. The load has 30 Ohms impedance. Find the power delivered to the load

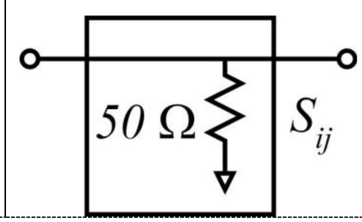
Problem 2d: (tricky: requires some thought) Someone has designed for us lossless matching networks which convert the transistor input and output impedances to 50 Ohms at the design frequency. We use these specific matching networks, *but instead* use a 25 Ohm generator and a 100 Ohm load. The generator has 1 mW available power. Find the power delivered to the load

Problem 3: We are dealing with two networks. A transistor has the following s-parameters:

S11=0.1
S22=0.2
S12=1
S21=5

There is a second two-port consisting of a 50 Ohm resistor connected to ground.

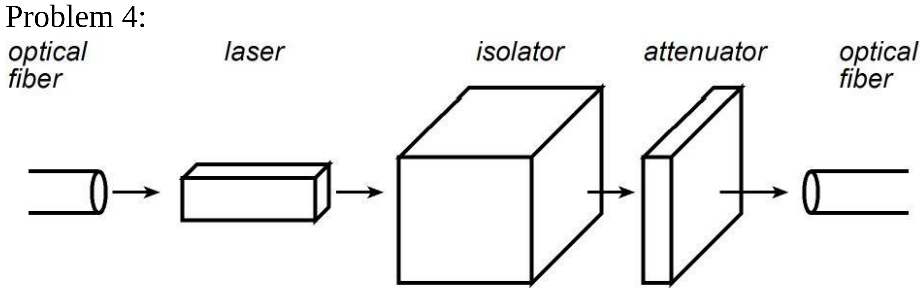



part a) Using a 50 Ohm impedance standard, compute the four S-parameters of the resistor network.

part b) The resistor is connected between the FET input and ground. Compute the four S-parameters of the combined network.

Problem 4:




A laser (more precisely, a semiconductor optical amplifier) is coupled to an isolator and an attenuator to help stabilize it. Defining port 1 on the left and port 2 on the right, we have

$$[S]_{laser}=\begin{bmatrix}0.1 & 10\\ 10 & 0.1\end{bmatrix}\qquad [S]_{isolator}=\begin{bmatrix}0 & 0.25\\ 0.5 & 0\end{bmatrix}\qquad \text{and}\qquad [S]_{attenuator}=\begin{bmatrix}R & T\\ T & R\end{bmatrix}$$

Calculate all 4 S-parameters of the cascade of the 3 objects. Neglect optical phase shifts resulting from path lengths between the objects.