Problem Set 7

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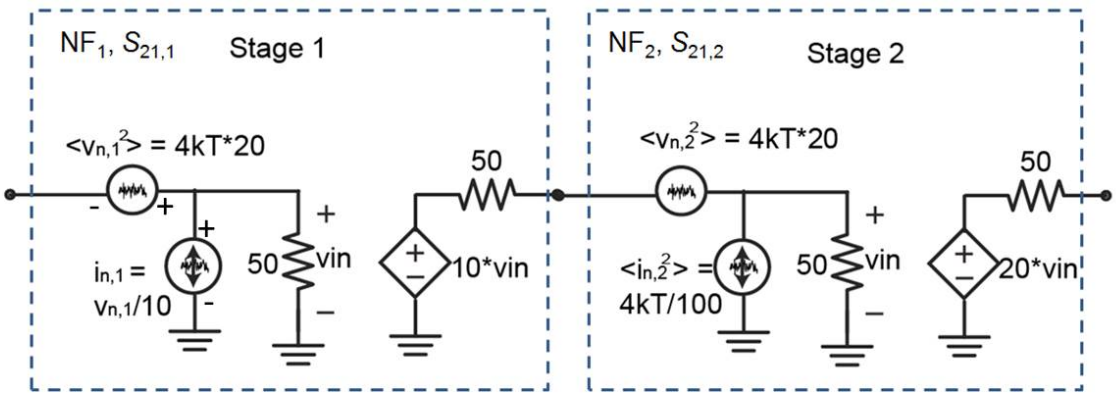
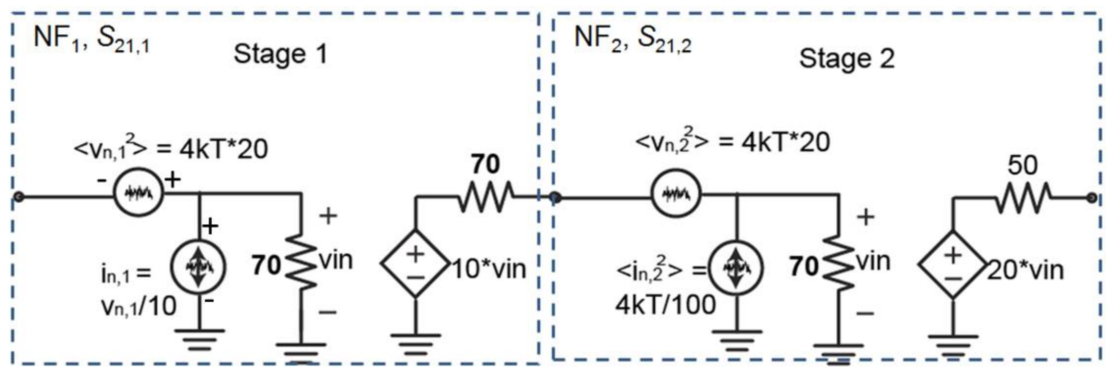
1. Noise Figure of Cascade Blocks and Lossy Transmission Line

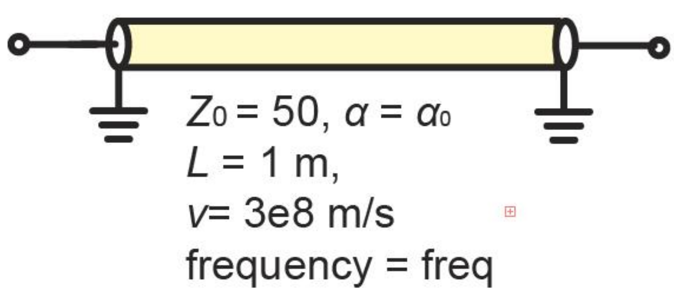




(a) For the above two cascade circuits, calculate the power gains and noise figures for each stage (i.e., $S_{21,1}$, $S_{21,2}$, NF_1, NF_2) and the two-stage circuits ($S_{21,total}$, NF_{total}). The resistors are assumed to be noiseless.

(b) Is the formula $NF_{total} = NF_1 + \frac{(NF_2-1)}{|S_{21,1}|^2}$ applicable?

(c) For a lossy transmission line illustrated below, derive its noise figure.

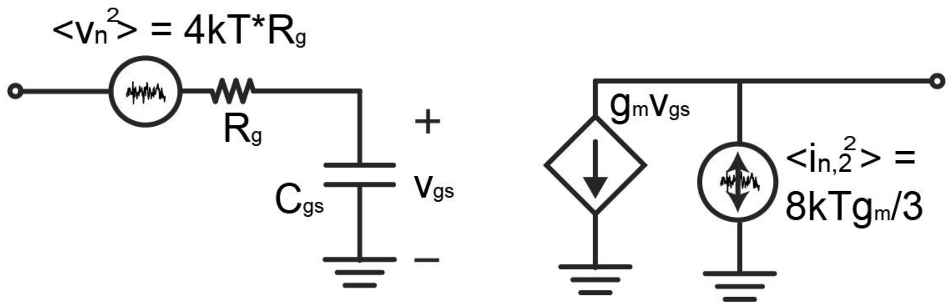


(d) If the T-line is used to connect the above two cascade circuits to the 50Ω source (e.g. antenna), what will be the new total noise figures?

2. Matching for Low Noise versus Matching for High Gain

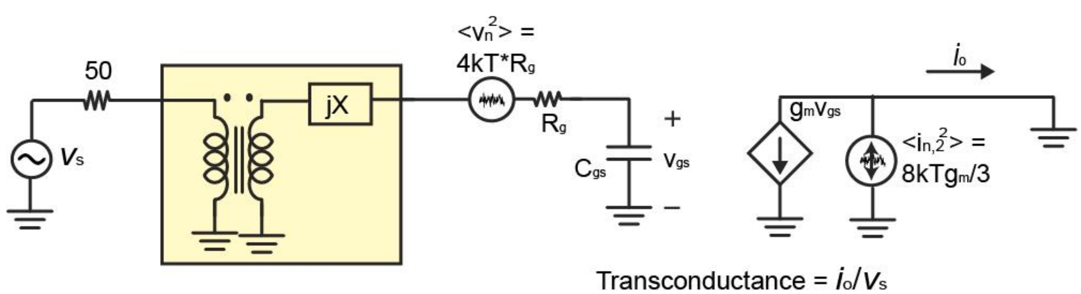
   * In this problem, your answers should be functions of frequency.

   (a) For a simplified common-source model shown below (with noise sources drawn), derive the input referred noise voltage and noise current.



   (b) Following part(a), what is the source impedance that optimizes the noise figure? What is the lowest noise figure?

   (c) In practice, the source impedance is 50Ω (without any matching network). Design a input matching network to achieve the lowest noise figure. For your convenience, you can use an ideal transformer with arbitrary turns ratio and a series reactance to realize the matching network, as illustrated in the below figure.



   (d) Calculate the S_{11} and the achieved trans-conductance for your low-noise design.

   (e) Redesign the input matching network to achieve the maximum trans-conductance. Calculate the new trans-conductance and noise figure.

   (f) For a special case with frequency of 1 GHz, gm of 0.01, C_{gs} of 100 fF, and R_g of 20, verify the calculated results for the two designs in ADS.