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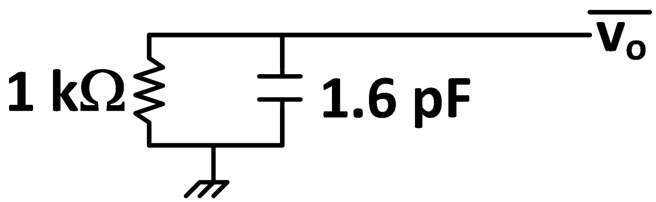
ECE 5220 RFIC HW -2

(Due: 03/05/2012, Hand in by the end of class time, 10:45AM)

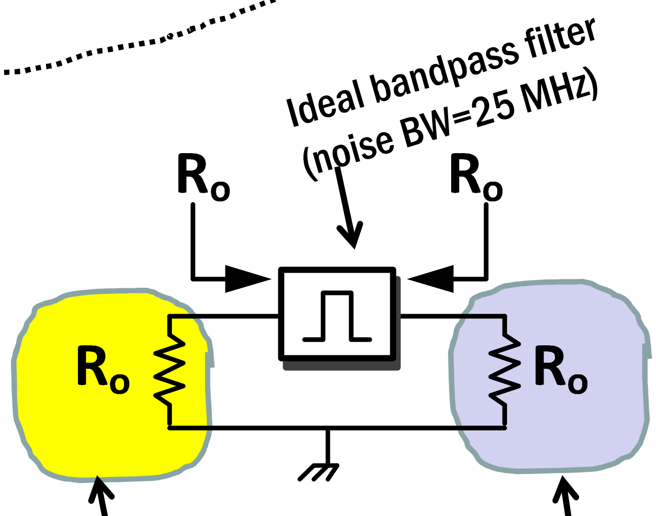
Homework <u>will not</u> be acceptable after the class.

Problem-1: Noise concept



Assumption: Temperature T=300 K.

1) Calculate effective noise voltage $\overline{V_o}$.
2) How often will the magnitude of the noise voltage be greater than 88 μV? (you may need a numerical calculator for compute probability, or alternatively you can use a Gaussian distribution table which is uploaded in the "resource" part of "Scholar class website".)

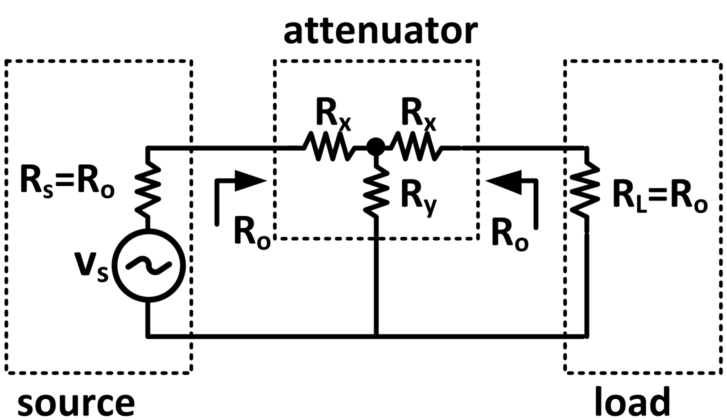


This resistor is inside a "boiling water "(T=373 K).

This resistor is inside a "dry-ice bath" (T=194 K).

3) Compute net power flow and direction of the system shown in left side.

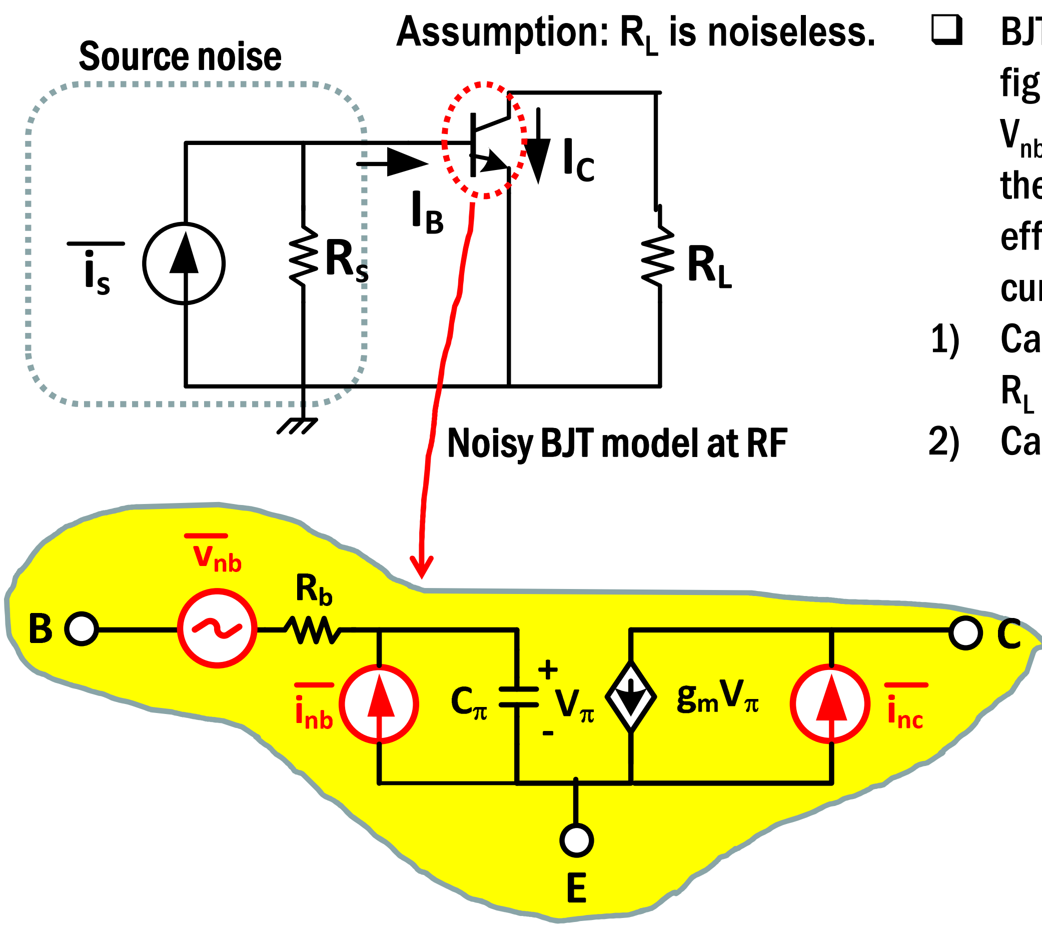
Problem-2: Noise consideration in lossy network



Assumption: R_L is noiseless.

1) Calculate noise power delivered to load by the source resistor only.
2) Calculate noise power delivered to load by each of three resistors in the attenuator one by one.
3) From 1) and 2), verify that noise power keep constant between input and output of attenuator.
4) Verify that noise factor, F=L (L=loss).
5) Numerical example: Repeat 1)-4) when $R_o=50\Omega$, $R_x=8.55\Omega$, $R_y=141.9\Omega$.

Problem-3: BJT noise factor calculation

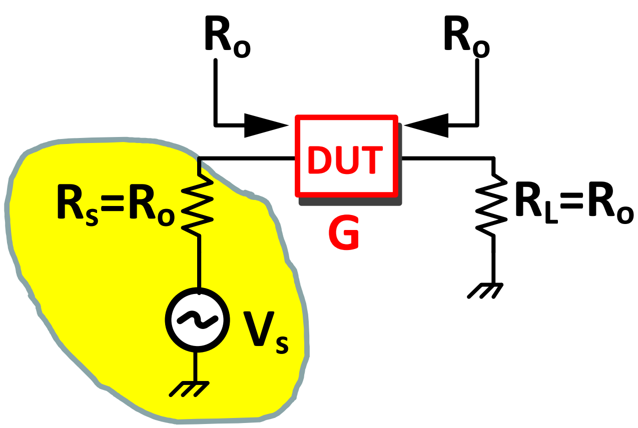


- BJT can be modeled as shown in the figure at RF, where R_b is base resistance V_{nb} is the effective noise voltage from the base resistance, and i_{nb} and i_{nc} are effective shot noise current from bias currents of I_B and I_C, respectively.

1) Calculate input referred noise (assume R_L is noiseless).
2) Calculate noise factor of the system.

Problem-4: NF Measurement (1)

Assumption: R_L is noiseless.



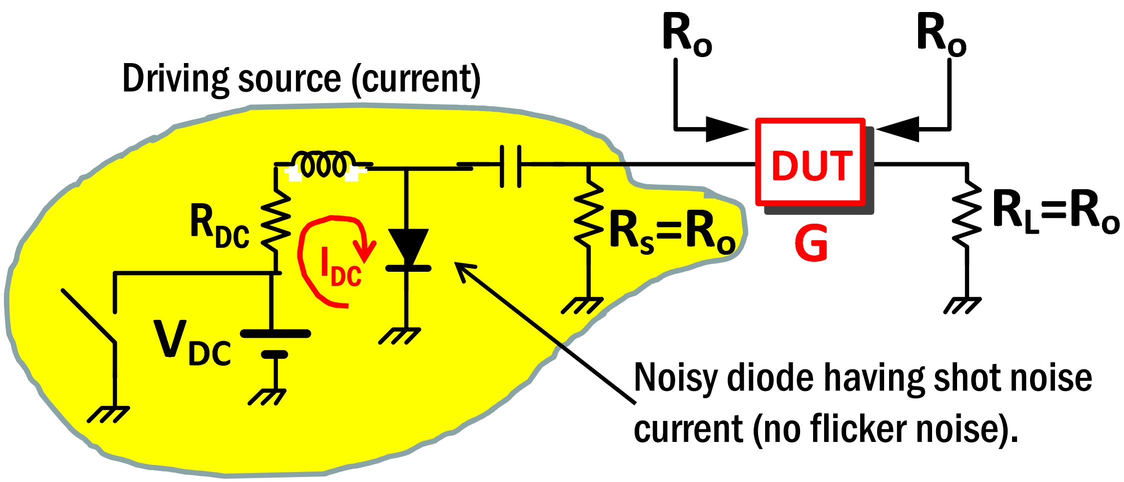
Driving source (voltage)

- Let's do some mental experiment to measure noise factor (F) of the device under test (DUT). The only known factor of the DUT is input and output impedance which are matched to Ro, and available power gain, G.

- Step-1) make Vs=0, then measure out put power delivered to load, R_L.
- Step-2) turn on V_s, and adjust V_s so that your output power delivered to R_L can be twice of the power in Step-1.

Q) Calculate F from the results in Step-1 and Step-2 (assume DUT bandwidth is Δf).

Problem-4: NF Measurement (2)



Assumption:
- R_L is noiseless.
- Diode output resistance is much larger than R_s.
- C: blocks DC current and passes all noise current from diode.
- L: blocks any noise current from R_{DC} and pass DC current from V_{DC}.

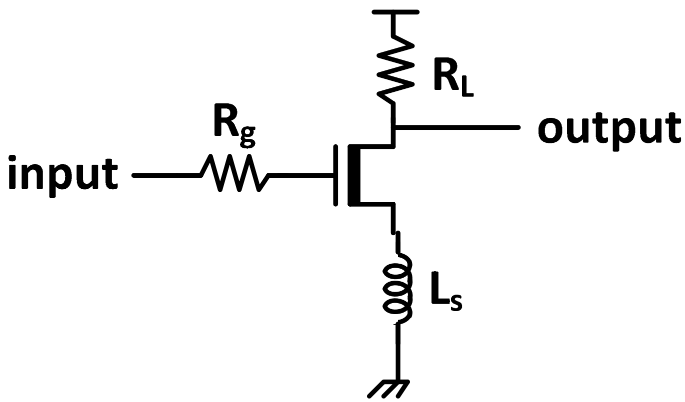
- Let's do similar mental experiment to measure noise factor (F) of the device under test (DUT). The only known factor of the DUT is input and output impedance which are matched to Ro, and available power gain, G (now, you don't know the DUT bandwidth).

- Step-1) turn on switch and no DC current. Then measure out put power delivered to load, R_L.
- Step-2) turn off the switch and adjust V_{DC} so that your output power delivered to R_L can be twice of the power in Step-1.

Q) Calculate F from the results in Step-1 and Step-2.

(Note: You don't need to know the gain of the DUT either in this method.)

Problem-5: Inductively degenerated LNA



Assumption:

- R_L is noiseless and no flicker noise in NMOS.
- No drain-gate parasitic capacitance, C_{gd}.
- $R_g << 1/\omega C_{gs}$
- $g_m R_g << 1$

1) Calculate equivalent input noise generators (voltage and current generators).
2) Calculate input referred noise (voltage or current) with an assumption of source impedance of R_s.
3) Calculate correlation admittance between the voltage and current noises in 1), and separate the current noise into correlated and uncorrelated parts.
4) Find optimum admittance for minimum F.
5) Find expression for F_{min}.

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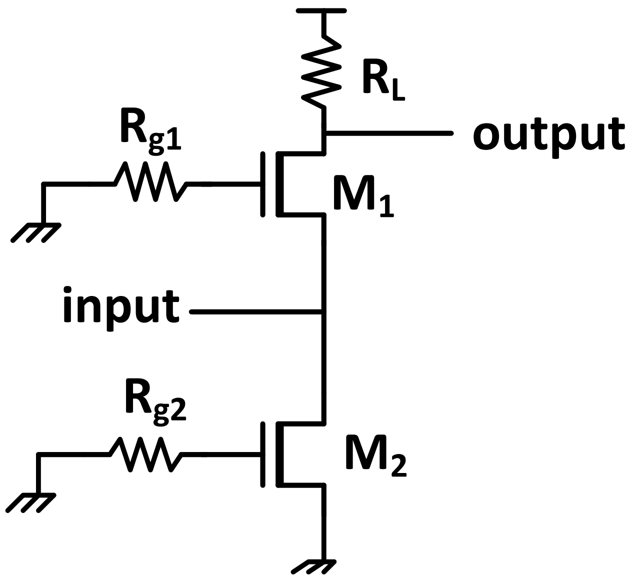
Problem-6: Common-gate LNA



1) Calculate equivalent input noise generators (voltage and current generators).
2) Calculate input referred noise (voltage or current) with an assumption of source impedance of R_s.
3) Calculate correlation admittance between the voltage and current noises in 1), and separate the current noise into correlated and uncorrelated parts.
4) Find optimum admittance for minimum F.
5) Find expression for F_{min}.

Assumption:

- R_L is noiseless and no flicker noise in M1 and M2.
- No drain-gate parasitic capacitance, C_{gd}.
- gm of M1=g_{m1}, gm of M2=g_{m2}.
- Cgs of M1=C_{gs1}, Cgs of M2=C_{gs2}.
- $R_g << 1/\omega C_{gs}$ (for M1 and M2)
- $g_m R_g << 1$ (for M1 and M2)