EE3C11 Exercises Electronics Part (V2)

February 12, 2020

These exercises are to help you to develop skills and understanding about the various topics in this course. You can work on these exercises during the entire teaching period. Please take sufficient time to work on an exercise and completely understand the way to come to a solution[1]. There is no educational value in finding the correct solution by repeating a "trick" that you have seen others apply before you. For that reason you will not find solutions on BrightSpace yet. They will be made available later. We think it is better to discuss your answers with other students and the teaching staff and defend your solution and the way you found it. Also to verify results you could use simulators like LTSspice and SLICAP. *They should give results you expect.* You will learn much more and gain self-confidence in your way of solving problems. This will be very useful later in your career when you get into the situation that when you don't know the correct answer yourself, nobody knows. It is more important to fully understand the answer to one question during the exercise sessions than to finish all of them without really understanding what you did. Hopefully, when the correct answers become available, you do not need them anymore...

[1] You can always contact one the teaching staff for assistance if you need help solving the exercises during or outside lecturing hours or the lecturing period.

Exercise Design of the active antenna:

1. Which functions should be performed by the active antenna?
2. Extract the environmental operating conditions from the application description.
3. Extract the cost factors from the application description.
4. Which performance measures are given in the application description?
5. At this stage, do you notice conflicting requirements?
6. At this stage, do you notice redundant requirements?
7. At this stage, do you miss any requirements?
8. Summarize the above (1-7) in an 'Object Performance Specification' and an 'Object Test Specification'. The SLiCAP format for these specifications can be found via the link on the the course website.
9. The whip antenna itself converts E-field into voltage, while the output impedance of the antenna amplifier should be 50Ω.
   (a) Give the desired values of the transmission-1 matrix coefficients for this amplifier.
   (b) Verify your answer with SLiCAP. Please use the SLiCAP input format for the active antenna as given in the designExample.zip file.
10. Could we also use the short circuit current as input quantity for the antena amplifier? Motivate your answer.
11. If we would use the short circuit current of the antenna as input quantity for the amplifier:
    (a) Give the transmission-1 matrix parameters for this amplifier.
    (b) Verify your answer with SLiCAP.
    Tip: SLiCAP does not allow the use of thr Laplace variable 's' in parameter definitions. Please select an appropriate model from Figure 2.22 in the course book.

Exercise 1:
Fig.1 shows two two-ports. One with a parallel connected resistor, the other with a series connected resistor.

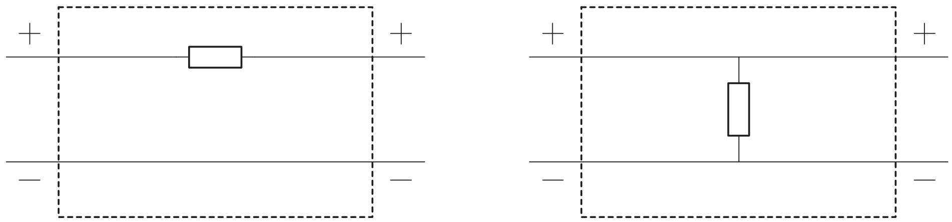

Figure 1: A parallel and a series resistor in a two-port.

1. Determine for each two-port the Transmission-1 matrix.

The Transmission-1 matrix of the amplifier depicted in fig.2 can be determined in two ways. It can be done "directly" as it was done in the cases above, but it can also be done via a matrix multiplication of the Transmission-1 matrices of the two smaller two-ports that are indicated with dotted lines in the figure.

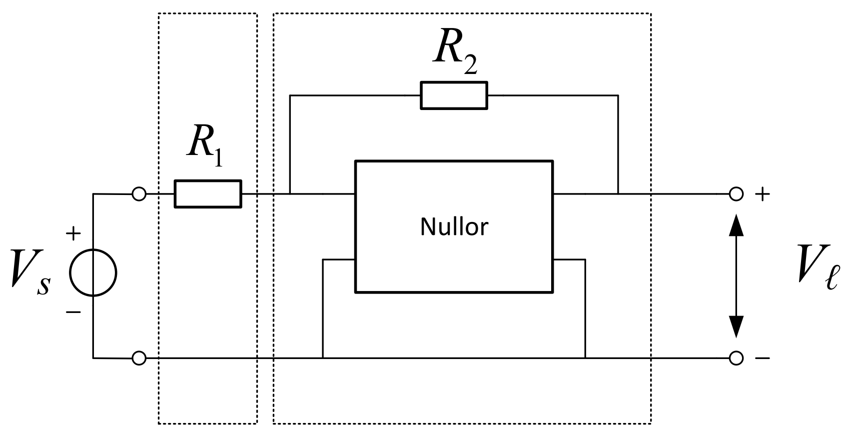

Figure 2: A voltage amplifier.

2. Determine the Transmission-1 matrix of the amplifier depicted in fig.2 while considering the amplifier as one single two-port.

3. Determine the Transmission-1 matrix of the amplifier depicted in fig.2 via the matrix multiplication of the Transmission-1 matrices of the two smaller two-ports that are indicated in the figure.

4. Identify the matrix entry in this Transmission-1 matrix that defines the desired transfer of the voltage amplifier.

Exercise 2:
Fig.3 shows a nullor with capacitive feedback.

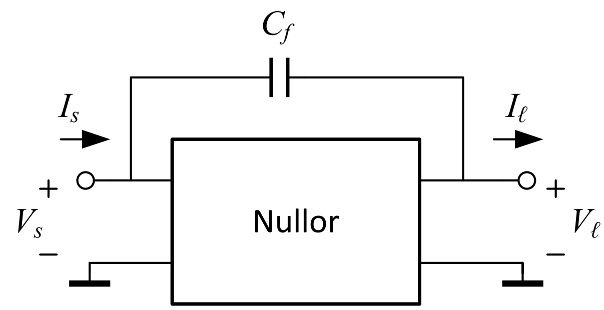

Figure 3: A nullor with capacitive feedback.

1. Determine Transmission-1 matrix of the circuit shown in fig.3.

The circuit is extended with a resistor. Fig.4 shows this extended version.

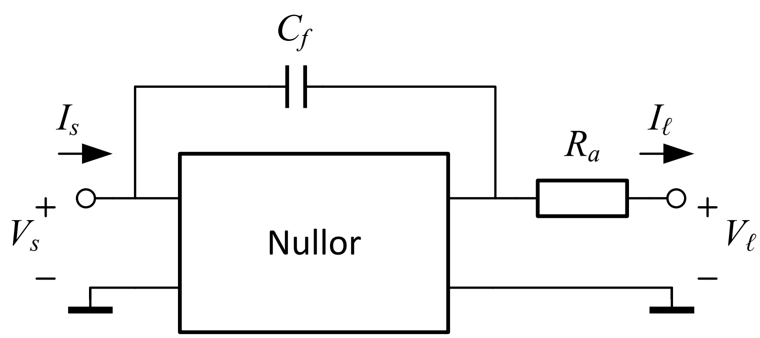

Figure 4: A nullor with capacitive feedback and resistor at the output.

2. Determine Transmission-1 matrix of this combination shown in fig.4..

Exercise 3:
Fig.5 shows a negative feedback voltage amplifier in which a nullor is used as controller. The noise of the controller is modeled with two noise sources at the input of the nullor.

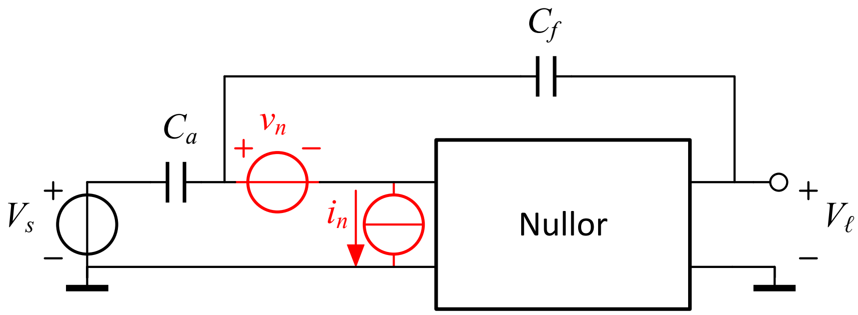

Figure 5: An amplifier with a "noisy" nullor.

- Determine the equivalent noise source at the input.

Exercise 4:
Fig.6 shows a voltage divider.

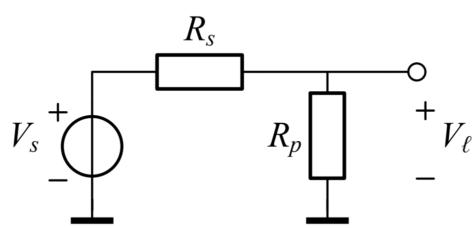

Figure 6: A voltage divider.

1. What is the definition of the "noise factor" of a circuit?
2. What is the noise factor of this circuit?
3. Determine the Transmission-1 matrix of this circuit.

Exercise 5:
Fig.7 shows a voltage divider with a capacitor.

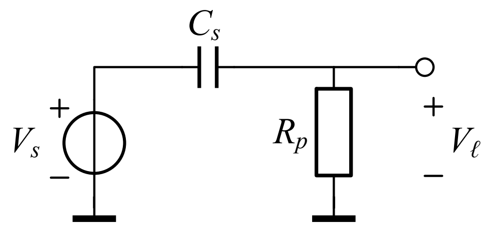

Figure 7: A voltage divider with a capacitor.

1. Determine the Transmission-1 matrix of this circuit.
2. Determine the equivalent noise source at the input.
3. Determine the poles and zeros of the transfer.
4. Verify this result with SLiCAP.

Exercise 6:
Fig.8 shows two circuits that are designed such that the voltage gain is equal to 10.
For this exercise both the transformer and the operational amplifier can be considered ideal.

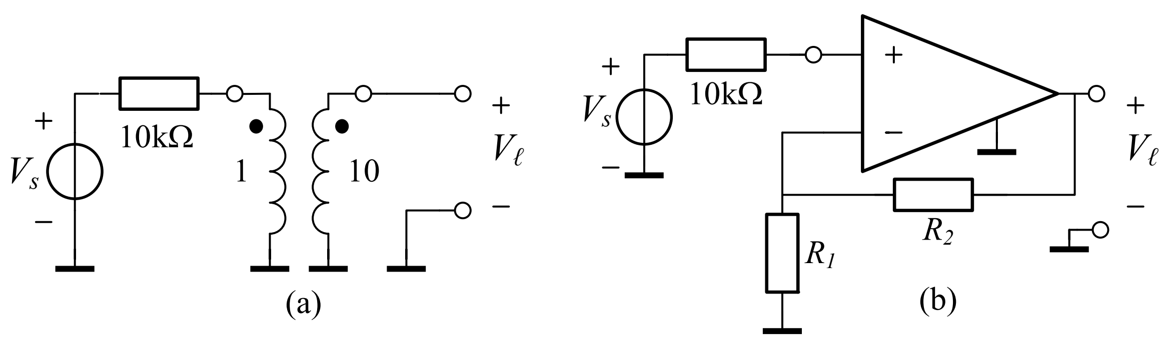

Figure 8: Two circuits with a voltage gain equal to 10.

1. Discuss for both circuits if they represent an amplifier.
2. Determine the Transmission-1 matrix of circuit (a).
3. Determine the Transmission-1 matrix of circuit (b).
4. Propose a good value for resistors R_1 and R_1 in circuit (b). Motivate your choice.
5. Suppose resistor R_2 is increased with a factor 10. Provide an estimate of what happens to the equivalent noise source at the input.

Exercise 7:
A sensor produces a current I_s. The output impedance of the sensor is approximately 100 kΩ. The signal has to be provided to a load in the form of a voltage V_ℓ. The load is a resistor with a value of approximately 1 kΩ.

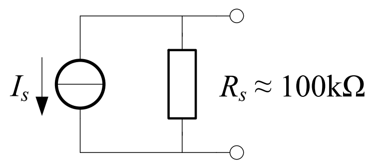

Figure 9: The model of the sensor.

Below, 6 amplifier topologies are depicted that are proposed for the required amplifier. The controller is a nullor. Different models for the signal source were used.
Motivate for each of these 6 configurations whether it is a good choice for the required signal processing function, or not.

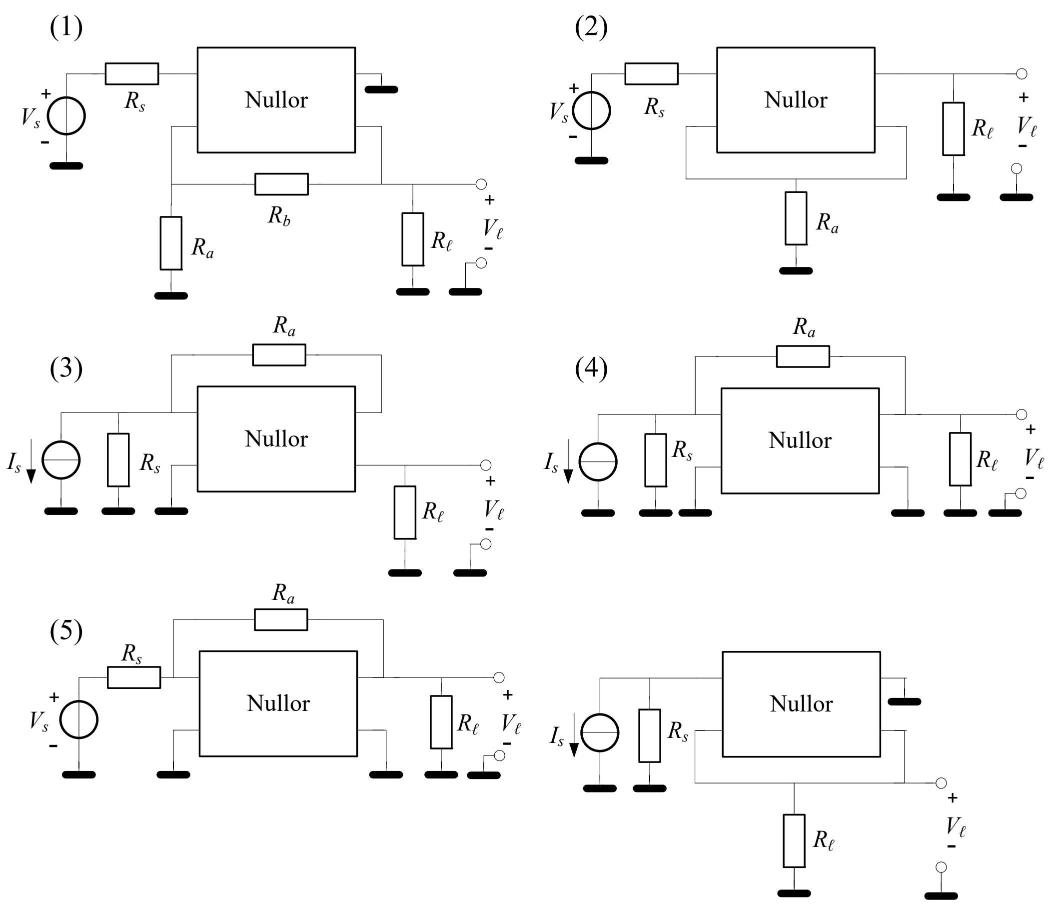

Figure 10: Six proposals to implement the requested transfer.

Exercise 8:
Below, a voltage amplifier is shown with nullor as controller. In practice, sometimes a biasing components end up in the signal path. In the circuit below, capacitor C_k is such a component. Often capacitors like this are inserted to prevent DC currents from flowing through the signal source.

Note that the circuit below is not the representation of the biased circuit, but it is used as a model to evaluate the impact of placing a coupling capacitor C_k in the signal path. For this evaluation, two noise sources are included to model the noise of the operational amplifier that will later be used to implement the controller. Also resistor R_{in} is included to model the expected input resistance of the amplifier when the controller is later implemented by an operational amplifier.

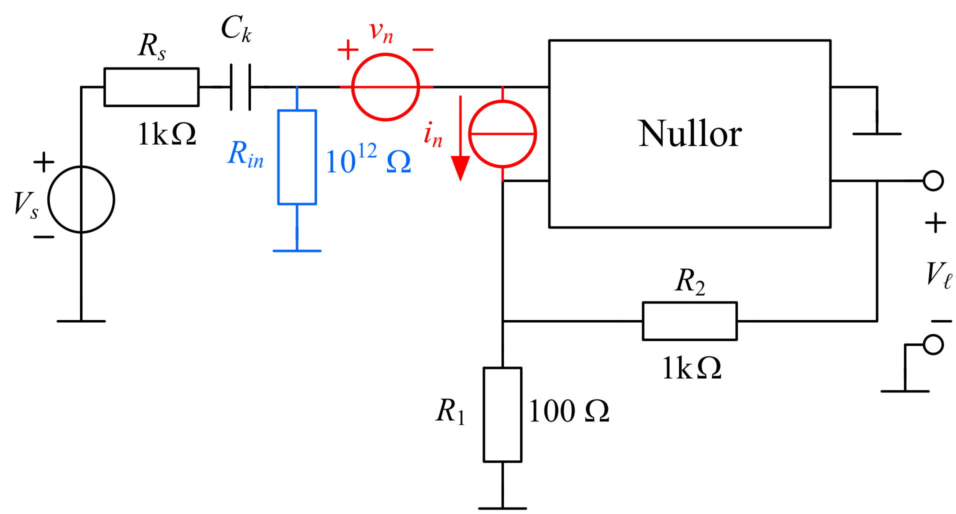

Figure 11: The model of a voltage amplifier to evaluate the impact of a biasing capacitor in the signal path.

The required signal bandwidth for the voltage amplifier is: B_w = 50Hz .. 100kHz

1. Propose a reasonable value for C_K considering the bandwidth requirements.
2. Propose a reasonable value for C_K considering the noise requirements.

Further exercises
For this course and electronics in general you should be well acquainted with the concept of poles and zeros and their relation to the Bode plots and the step response. To test your knowledge and skills you can work on exercises 18.1 and 17.7 in the book. At request, an extra evening lecture on poles and zeros can be organized.