Radio Frequency Engineering Laboratory

Exercise 2 Network-analysis and –synthesis

This laboratory course emphasis on the design and practical realization of a small-signal-transistor amplifier and the needed component characterization or the design process.

Exercise Preparation:

For preparation focus on the lecture notes "VU RF Techniques" chapter 2 „Linear RF circuits" or equivalent material. Additionally, information about the usage of the RF simulation and design software "AWR Microwave Office" can be found on the course homepage (http://www.emce.tuwien.ac.at/hfadmin/354059/index.htm) in the file „MWO-VSS2003 - GettingStarted.pdf". In general, in-depth knowledge of chapters 2 and 3 of the lecture notes is highly recommend**. Bring a ruler, calculator, and compass (and anything else you think you will need) for a manual design of matching networks using the Smith-chart!** Each student will have to do this part of the exercise on its own (at least at the test!!!).

Exercise execution:

During this course a small-signal-amplifier using the silicon-NPN small-signal-transistor BFP183 will be designed. The design objectives are a center frequency of f = 433MHz and the operating point of the transistor is U_{CE}=6V and I_C=10mA. Exemplarily, the S-parameters of the transistor can be found in Figure 1.
The goal of this course is to realize input- and output matching networks using lumped elements (inductors and capacitors).

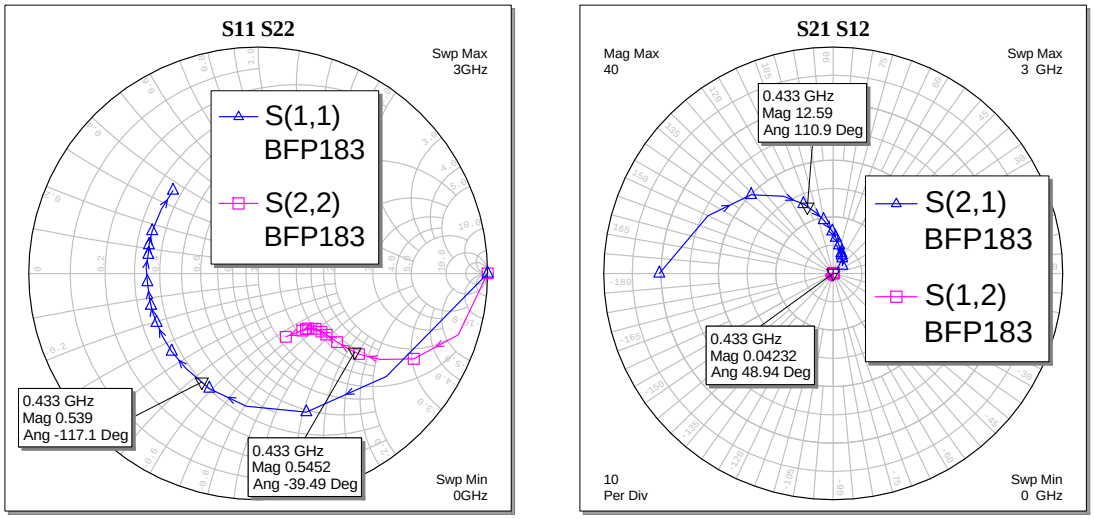

Figure 1: S-Parameters of the silicon-NPN-small signal transistor BFP183 (Operating point U_{CE}=6V and I_C=10mA).

Figure 2 shows the schematic of the transistor module PCB which is, of course, located in-between a "Eingangsanpassung = input matching" and a "Ausgangsanpassung = output matching" PCB (see Figure 3). The additional components are selected to reduce the transistors tendency of oscillation under uncontrolled matching conditions.
Questions: What is needed to test/check the stability of a general transistor? Which power level corresponds to the maximum output power to be expected at oscillation?

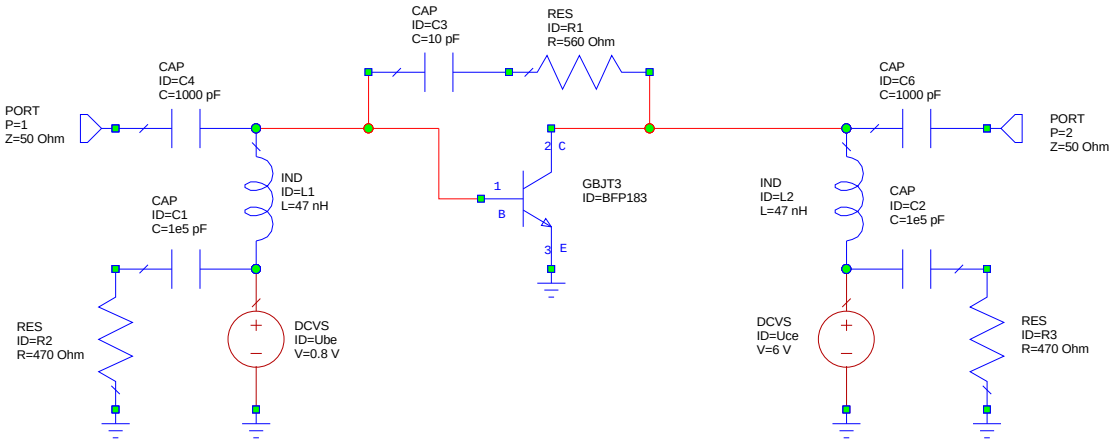

Figure 2: Circuit schematic of the transistor PCB (ensure the stability of the BFP183)

The S-parameter data of the transistor module will either be measured during the lab course or will be provided by the advisor.
Figure 3 shows that the realization of the amplifier is highly modular. Furthermore, the corresponding PCB layouts are pictured. There are two modules for the input- and respectively the output-matching networks as well as the transistor module including DC-supply (bias-Ts). The modules will be interconnected by adapters. Consequently, these adapters (S-parameters will be provided) have to be included in the final matching network design using AWR Microwave Office. Each matching network module provides a very flexible double-π-structure (see. Figure 4) utilizing a maximum of 5 impedance values for the realization of desired matching properties. During the course a simple L-structure matching network containing (1 or max. 2) impedance values shall be realized (especially for the manual design in the Smith-chart!).
Questions: What is a bias-T's purpose? Are there different realizations?

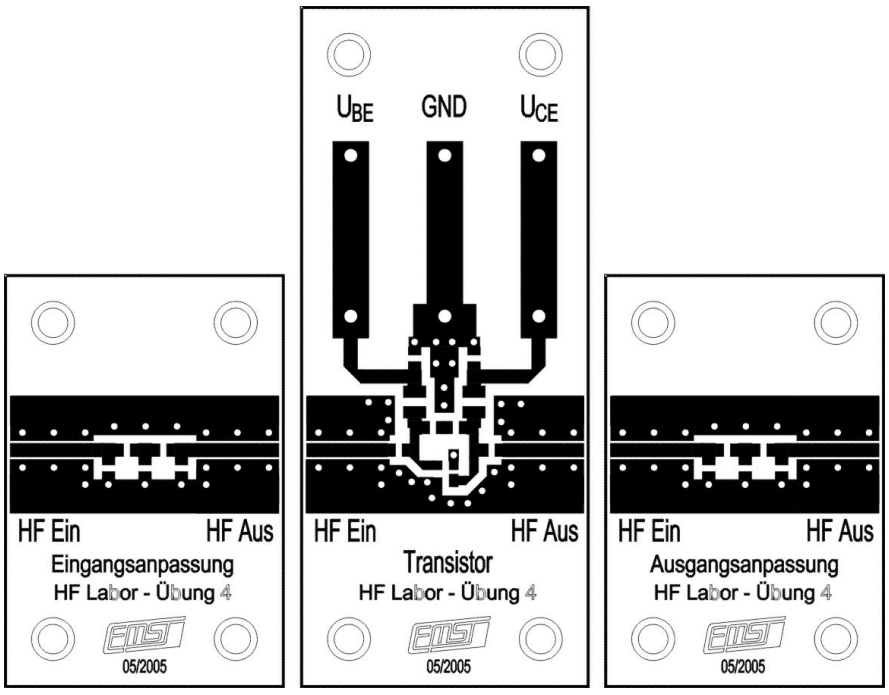

Figure 3: Amplifier Modules and their Layout

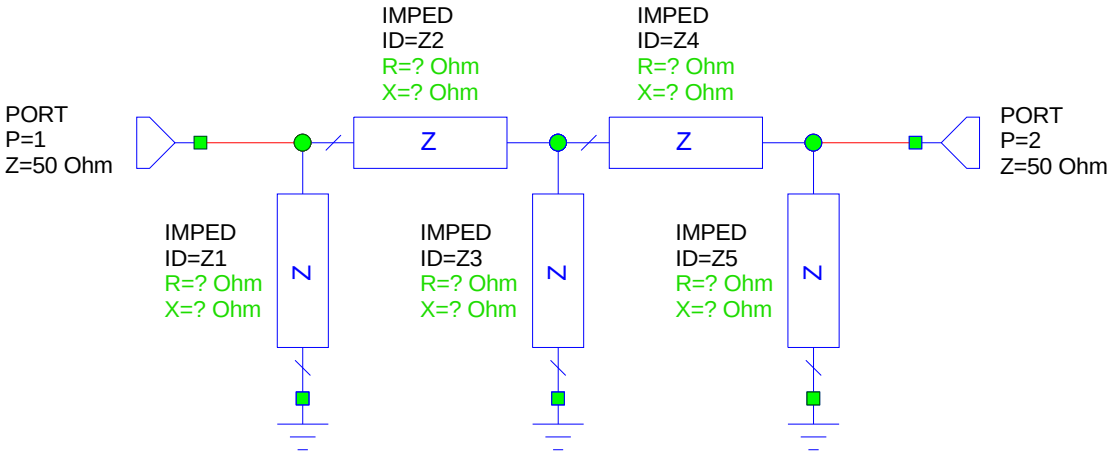

Figure 4: double-π-structure for the realization of input- and output matching networks

Manual amplifier design: considering a unilateral transistor:

- Each student has to develop suitable matching networks for the transistor's input and output using the Smith-chart when a unilateral transistor can be assumed! Bring a ruler, calculator, and compass (and anything else you think you will need) with you to the lab course!
- The manually designed matching networks will be carried on to the simulator AWR Microwave Office! Check your results! Additionally, extend the transistor model data to the non-unilateral case!
- Discuss the results in the group!

Simulator based amplifier design: considering real (non-unilateral) measurement data of the transistor module:

- Design suitable matching networks for input and output of transistor module using AWR Microwave Office!
- Because of the iterative approach think about a good design strategy before starting!
- For practical realization consider the stepped availability of the desired component values in the laboratory design kits. Furthermore, the non-ideal parasitic and resonant behaviour of the selected components shall be considered!
- Estimate the sensitivity of your matching network structure to component value variations (tolerances, parasitic behaviour…) and try to analyse different topologies of the matching network!
- Carefully realize (solder) the most promising result of the simulated/designed modules on the provided PCBs!
    - ➢ NO MECHANICAL FORCE needs to be applied to the components to be soldered – otherwise the PCB modules will be destroyed!
- Characterize the realized amplifier using the VNA and compare the results to the simulation results in Microwave Office
- … Potentially design – iterations