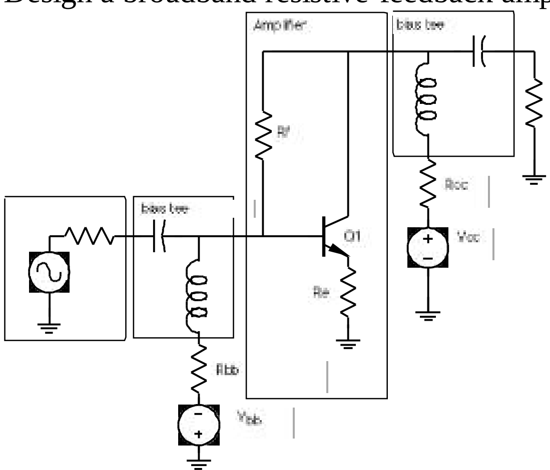
ECE 202A Lab Assignment #1:

Bipolar feedback amplifier design. Due 11/1/99

Design a broadband resistive-feedback amplifier of the type discussed in lectures (below)



Use MRF901 bipolar transistors. Use a duriod board.

Just to simplify construction, you need not build the bias circuits on the board, but instead can use the bias tees integral to the network analyzer (real circuits need the bias networks on the board). I would suggest designing the circuits so that the transistors are operated at a collector current and collector-emitter voltage for which the data sheet gives measured S-parameters . V_{cc}, V_{bb}, R_{bb} and R_{cc} are external DC biasing components (hooked up to the network analyzer bias ports).

The circuit is to be designed to **15 dB gain and nominal 50 ohm input and output impedances**. The design goal is to attain 15 dB gain (S_{21}) and better than -10 dB reflection coefficients (S_{11} and S_{22}) over as wide as possible a bandwidth.

First

Design the amplifier by hand, finding the required values for Re, Rf, and biasing components.

Second

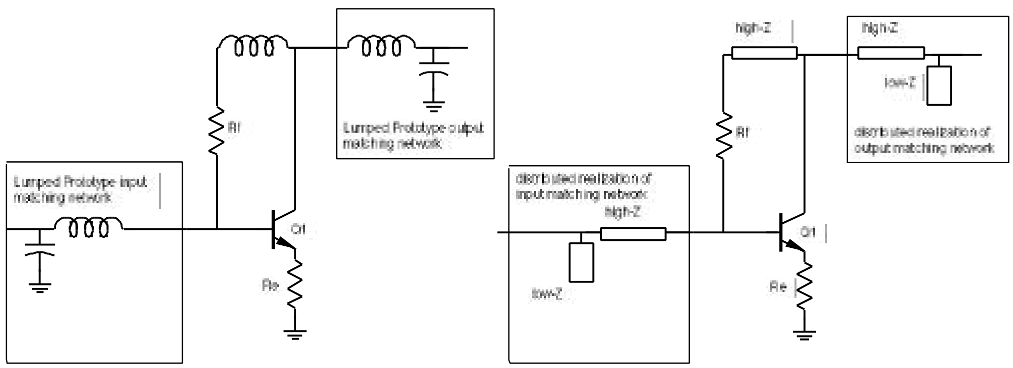
Calculate (roughly) the expected 3-dB bandwidth of S_{21} for the simple common-emitter feedback amplifier using hand analysis and a simple hybrid-pi model, using the data sheet values of Ccb (assume infinite ß,Rce). The other important parameters can be calculated (with some inaccuracy) from the data sheet. C_{eb} (diffusion plus depletion) can be calculated from the known device transconductance (V_t/I_e) and the data-sheet curve of f_τ or of S_{21} vs frequency. From the data sheet values of MAG vs frequency, we can extrapolate to find f_{max} , and we can calculate $R_{bb'}$ roughly if we know f_{max}, f_τ , and Ccb.

Third

Enter the data sheet transistor S-parameters into a Eesof 2-port parameter model file. Create a eesof file for the circuit which calls the transistor parameters as a model file.Simulate the circuit without matching networks, and record the anticipated performance (forward gain S21, input and output matches S11 and S22, reverse isolation S12).

<u>Fourth</u>

Try to "tweak" the performance of your circuit somewhat, with the primary objective of obtaining the specified<-10 dB input and output reflection coefficients. Introduction of a little inductance in series with the feedback resistance may partially compensate for the transistor's Ccb, while matching networks will help S_{11} and S_{22} , and will tend to improve S_{21} a little at the match frequency.



Design distributed-element matching and feedback networks using eesof. Caution...large feedback inductance can result in instability, so have Eesof plot the stability factor K to make sure it is >1 (unconditionally stable). If not, go a little easier on the feedback inductance.

<u>Fifth</u>

Build the circuit on your board. More important than good feedback and matching design is a good tight layout, especially with a minimum inductance in the emitter circuit. For this reason, the transistor has 2 emitter leads; use (at least) 2 emitter resistors, one for each lead (if not 4 parallel resistors). Keep lead lengths in the emitter circuit <u>ridiculously short</u>. It is best to mount the transistor flush with the ground side of the board.

<u>Sixth</u>

Test the circuit on the network analyzer, after <u>calibration in coax.</u> Make sure that the source power of the network analyzer is turned down to -15 dBm during caeesoftion and measurements--otherwise the amplifier may saturate. Measure the 4 S-parameters and compare to your simulations. Generate 1 plot of the DB magnitude of S_{21}, one plot of the dB magnitudes of S_{11}, S_{22}, & S_{12}, and Smith-Chart plots of S_{11}, S_{22}, & S_{12}. (Keep clean copies of the plots for the report). How do theory and results compare?

Note the bias tees and the external resistors. The bias tees are internal to the network analyzer. Be sure to ask me about what values the external bias resistors should have.

<u>Seventh</u>

Turn in:

A written report , documenting in broad terms your design decisions, projected and achieved results. Include plots of simulated (design) and measured parameters. For ease in both writing and grading, keep the report breif and readable: I want to know what steps you took in desigining the circuit, expected and measured performance at various important steps, and conclusions.

Warnings

1) To prevent static damage, always use the ground strap while using the TDR or NWA.
2) Treat connectors very carefully. Wear safety glasses when soldering.
3) The power supplies must be set initially to zero volts, and returned to zero whenever connections (or disconnections) are made. They must also be set to zero during calibration. You are applying short circuits during calibration !!!!!