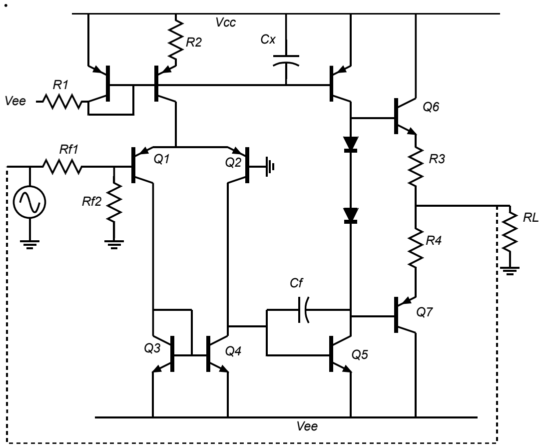
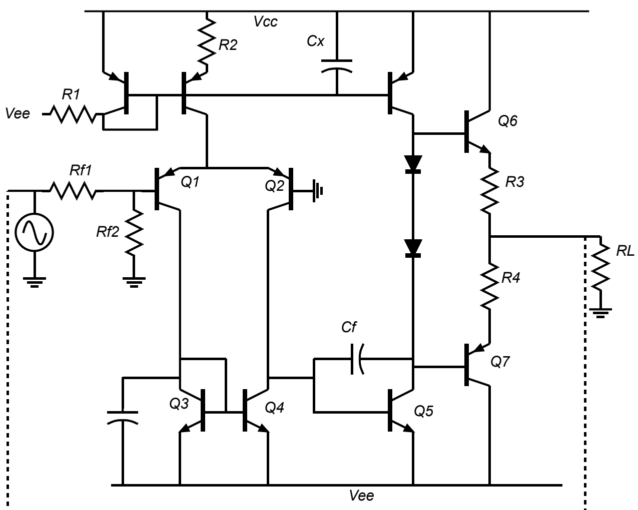
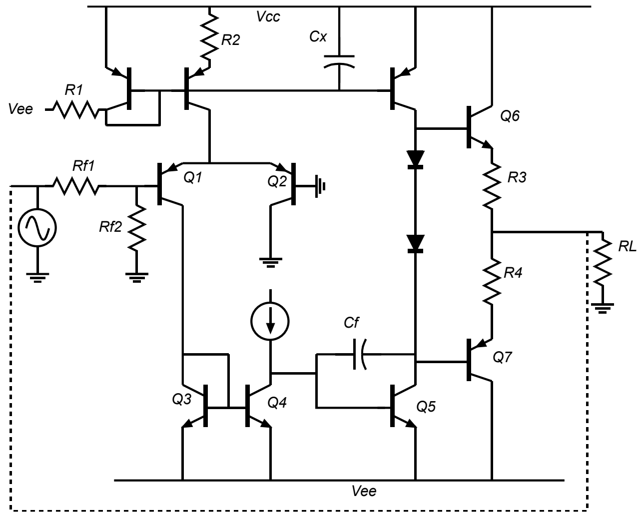


<u>Problem 1.</u> All transistors except the output transistors have Cje=10 fF, Ccb=40 fF and tau_f=0.75ps. The push pull output transistors have Cje=100 fF, Ccb=400 fF and tau_f=1 ps. All transistors have infinite beta, and infinite Va, EXCEPT Q4 and Q5, giving them infinite beta but Va=100 Volts. The 2 diodes have Ise 10:1 smaller than the 2 output transistors. The load resistance is 1000 Ohm. Cx is infinity, which AC grounds the bases of the 3 transistors connected to it. The supplies are + and - 3.3 volts. Q6 and Q7 are biased at 2 mA. All transistors are matched in I_s, except Q6 and Q7, which have 10:1 larger I_s. Choose R1 so that Q5 is biased at 2 mA emitter current. Choose R2 so that Q1 and Q2 are biased at 0.25 mA each. Rf1=100 Ohm, Rf2=10 Ohm. a) Find the DC bias conditions. Find the open-loop (Differential) gain of the operational amplifier. Choose Cf so that the loop bandwidth is 1 GHz.



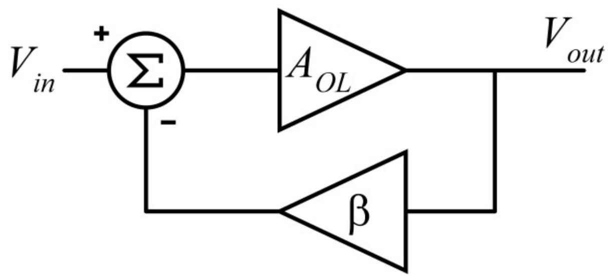
b) High Frequency analysis. Assume Q7 is on and Q6 is off. With an infinite capacitor shorting Q3's collector and emitter, use the MOTC to find a1 and a2 associated with Q1 and Q2's input. (the high frequency analysis splits at Q2, because it is operating as a common base stage). Then, using the approximation that the time constant associated with (Ccb5+Cf) is much larger than other time constants in the Q4/Q5/Q7 signal path, find a1 and a2 associated with this part of the circuit. Find the overall transfer function of the form

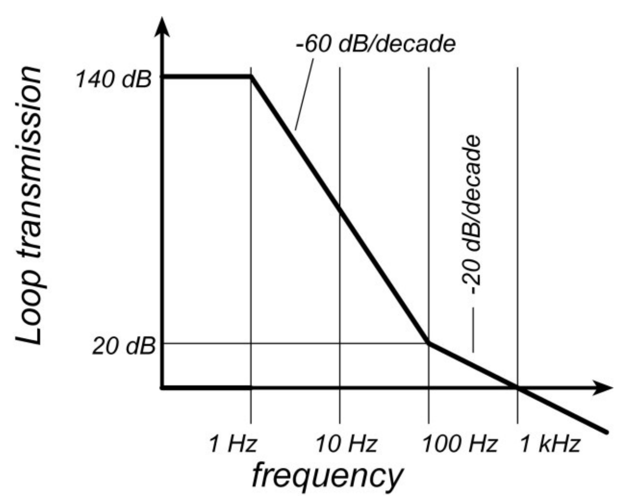
- Draw Bode plots (Magnitude and phase) of Ad(f) and ß(f)
- Find the loop bandwidth and estimate from this the bandwidth of Vout/Vgen.
- Find the gain margin and the phase margin of the feedback loop. Is the amplifier stable?



(Note that there is a second signal path through the amplifier, as illustrated at left. This is somewhat beyond the scope of the class…we will simply assume in 137b that the 2 paths have similar time constants.)

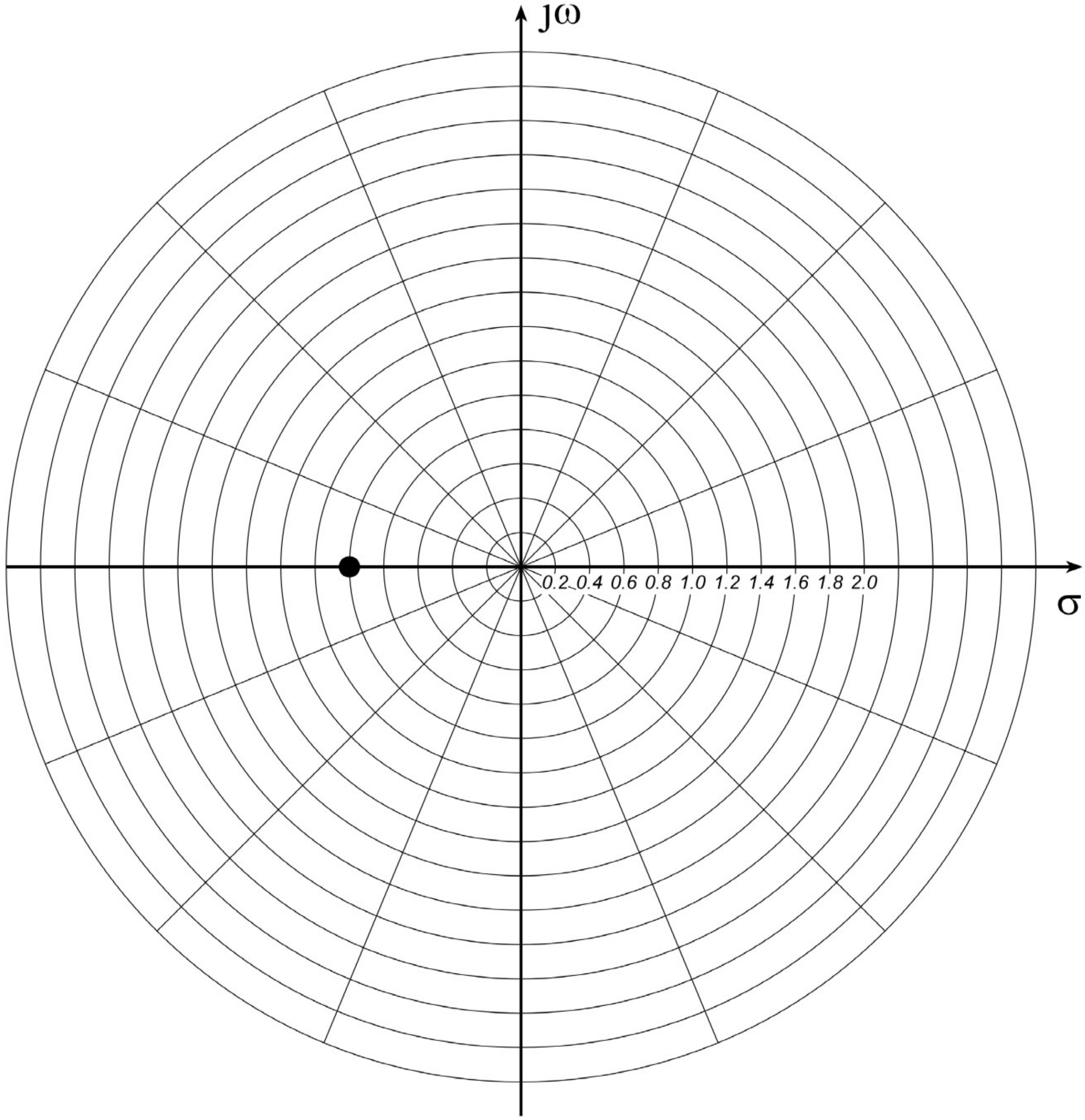
Problem 2:





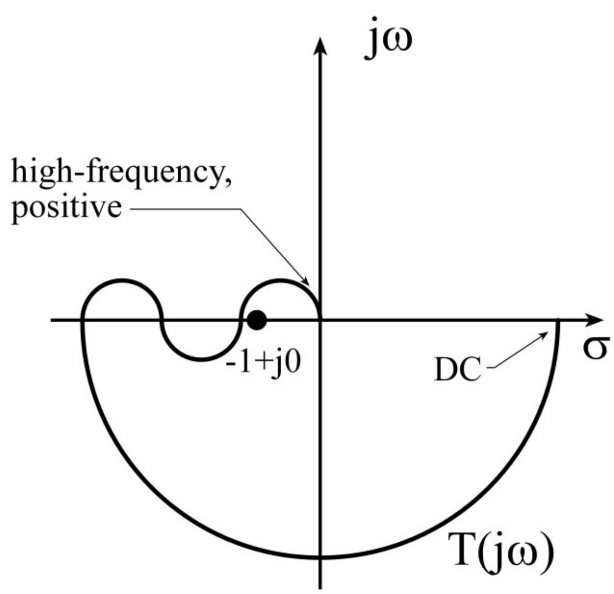
A control system, as sketched above, has a loop transmission with a DC value of 10^7 (140dB), three LHP poles at 1 Hz, and two LHP zeros at 100Hz. The resulting loop bandwidth is 1 kHz.

Make a the Nyquist stability plot below, and from this determine whether the loop is stable. ***Very important hint: for the low-frequency portion of the plot (DC to about 500Hz), which will otherwise run off the paper, you can shrink the radial scale of the plot. The *radial scale* of the plot only needs to be accurate at frequencies at which ||T|| is fairly close to 1, let us say between 0.5 and 2.0.***



Problem 3

A different feedback loop. To the right is a plot of T(jω), with ω plotted over the range from DC to a very high positive frequency. Both $A_{OL}(s)$ and $\beta(s)$ are stable, i.e. the open-loop amplifier and the feedback network are, of themselves, stable before the feedback loop is connected.



Is the loop stable or unstable ?
Yes/No is insufficient: you must clearly state why. If the loop is unstable, how many poles of the closed-loop gain $A_{CL}(s)$ lie in the unstable half of the S-plane ?