

Assignment 4 - Multi-Stage Amplifier Project - ABET

This Assignment aims at verifying and expanding, with design, simulations and measurements, your creativity and your knowledge and understanding of the differential amplifier circuit.

This is a Project: you must design and build your circuit starting from specifications and constraints.

Please document each step with snapshots, pictures, and your observations. Wherever possible please include the date and time field and the AD S/N. Please include this page.

1) Using the simulator, design and simulate a multi-stage amplifier using the following specifications and constraints (**50pts**) (*ABET PI-21,PI-22,PI-23*):

- Use NPN and PNP BJTs (recommended 2N3904, 2N3906)
- Use three supplies: +5V, -5V, 0V
- Use BJTs only in each stage, including loads and current sources (no resistors allowed) except for current biasing circuits (i.e. use resistors and BJTs only to generate the bias voltages for the loads and current sources of the amplifier)
- First stage: differential with current $< 5\text{mA}$
- Second stage: common-base to realize, with the output of the first stage, a cascode stage with current $< 1\text{mA}$
- Third stage: emitter follower with current $< 10\text{mA}$
- Gain $> 5,000$
- Gain-bandwidth product $> 10\text{MHz}$
- Single dominant pole (compensated if needed for stability)

2) Using the simulator, design and simulate a non-inverting amplifier with gain ~ 10 by applying a negative feedback network to the multi-stage amplifier developed in task 1 (i.e. used as operational amplifier) (**25pts**)

- a) Simulate the response to a 100mV, 10kHz sinusoidal input, simulate the transfer function and calculate the -3dB
- b) Apply and offset to the sinusoidal input in order to have an average $\sim 0\text{V}$ at the output; explain why the offset is needed

3) Build the circuit at (2) and experimentally reproduce the simulations (**100pts**) (*ABET PI-24*)

Helpful hints:

- Use small resistors at the differential inputs in order to minimize the offset from the Base currents
- Consider using a BJT mirror for the loads of the differential stage
- Filter all supplies to 0V with tens to hundreds of μF
- Filter all bias voltages to 0V (especially the base of the cascode) with tens to hundreds of μF
- Add compensation to the gain node if needed for stability
- BJTs can get damaged: if needed, you can check the PN junctions by using the multimeter in diode or resistance mode

4) Suggest ways to improve beyond specifications the performance of the amplifier at (1) (**25pts**) (*ABET PI-25*)