EEE6004

This module aims to develop in you the following skills involved in design project work:

1 Preparing a specification
2 Planning a project, assessing risk and time planning
3 Design and simulation
4 Prototype Construction (hardware or software as appropriate) and testing
5 Oral and Written reporting
6 Critical reflection

The assessment will consist of a

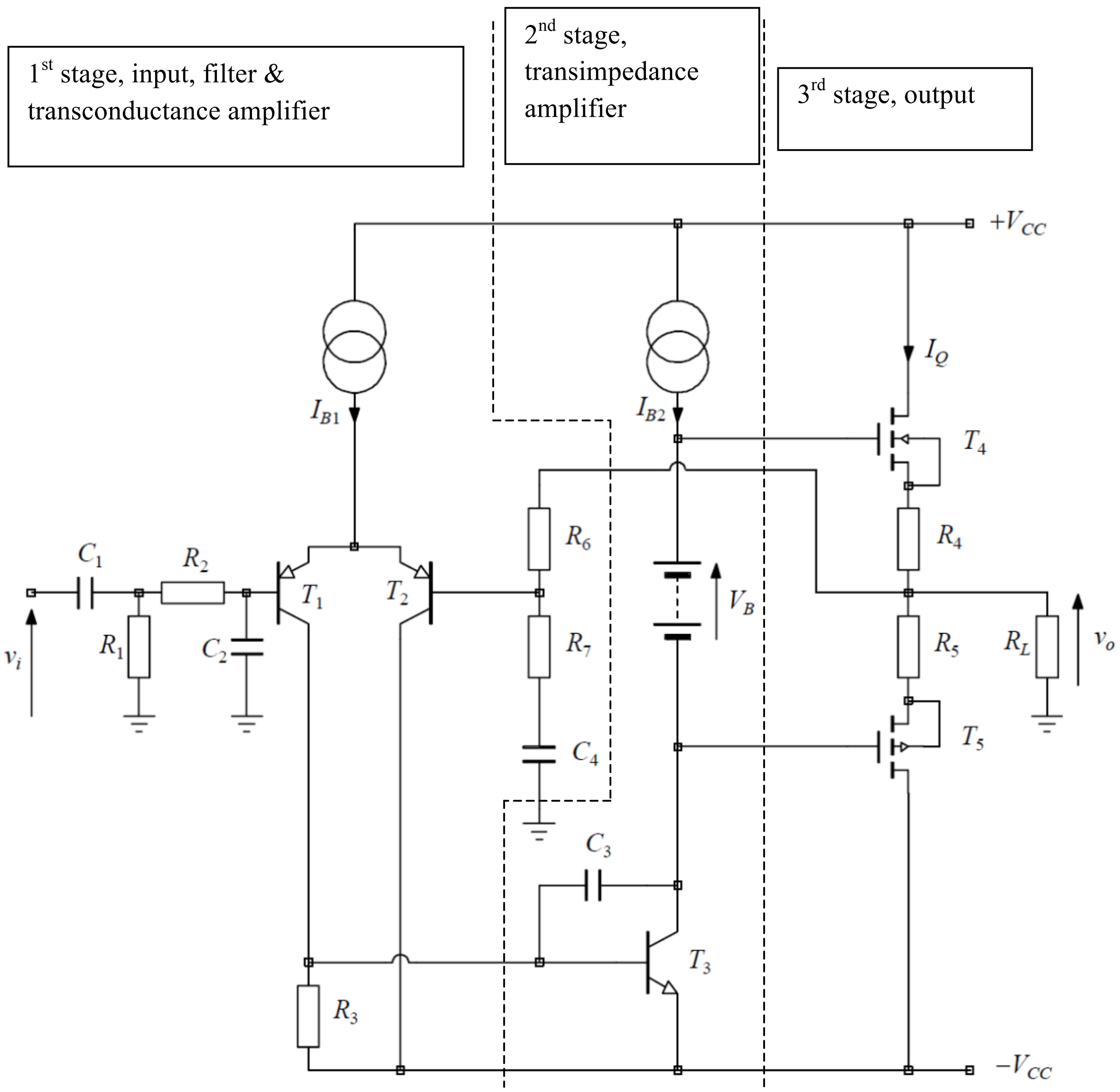
1) **Report 1 -** a short report (< 500 words) with a brief introduction to the project, time plan and identification of key points in the project progress, risk register and safety risk assessment. This report is worth 30% of the total module mark and should be submitted at the end of week 5.

2) **Report 2 -** a summary of achievement (< 500 words) including results of simulations and measured results on prototype, assessment of performance based on comparison of results with initial specifications, a brief reflection on skills acquired, lessons learned and deviations from the time plan. There should be a full circuit diagram (with all component values included) appended to this report. This report is worth 40% of the module total and should be submitted in week 12.

3) **Presentation** - A 15 minute power point presentation in week 11/12. This is worth 30% of the module mark

Audio power amplifier design

Objective	To design a power amplifier to the following specifications:
Output power	Up to 20 W into an 8 Ω resistive load with a sinusoidal drive.
Input signal level	0 dBV from a source with an internal impedance of 1 kΩ for full output. (0 dBV should produce at least 20 W)
Output resistance	<0.1 Ω
Frequency response	-1 dB points at 20 Hz and 20 kHz
Stability	Unconditionally stable for inductive and resistive loads, and for magnitudes of capacitive loads likely to be caused by speaker cables.
Dynamic Range (DR)	>100 dB , $DR = 10\log\left(\dfrac{\max\ mean\ square\ output\ signal}{mean\ square\ hum\ and\ noise}\right)$
Linearity	This is a parameter quantified by harmonic and intermodulation distortion figures. A total harmonic of 0.1% at 10 W is good, 0.01% at 10 W is very good.
Short circuit protection	Desirable

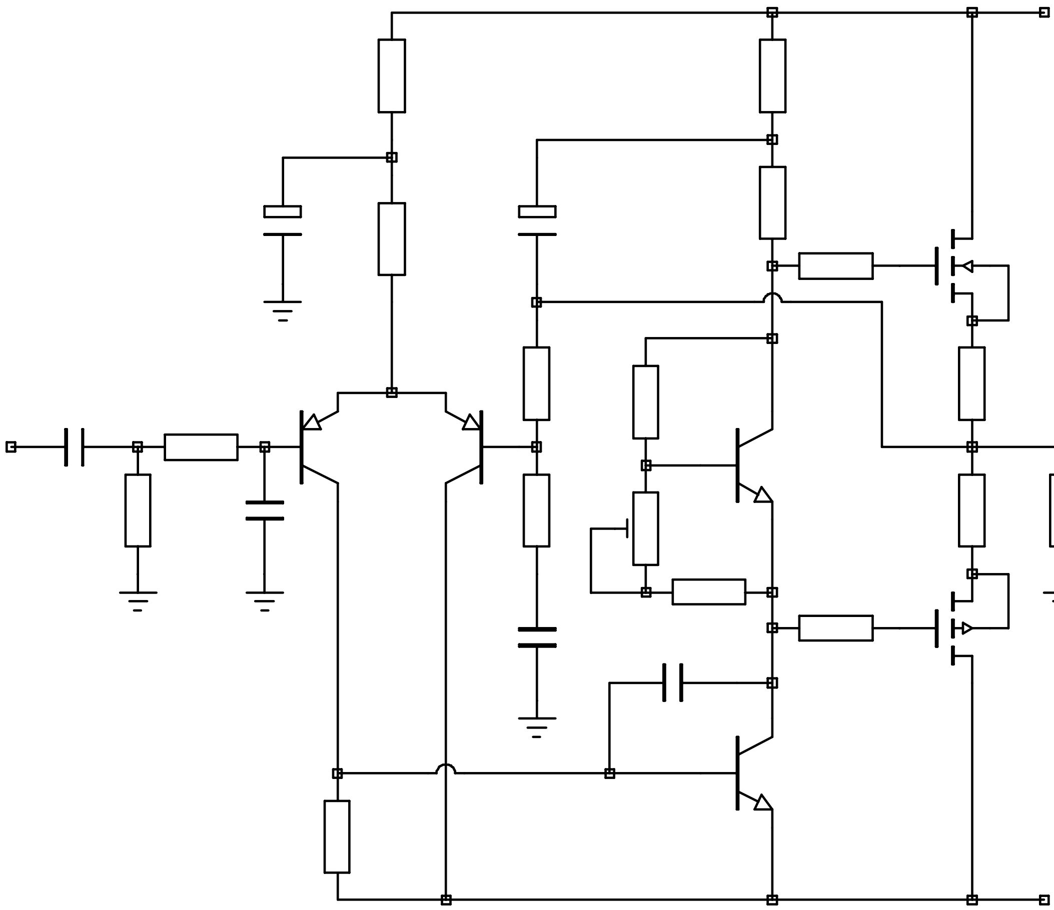


Generic power amplifier circuit

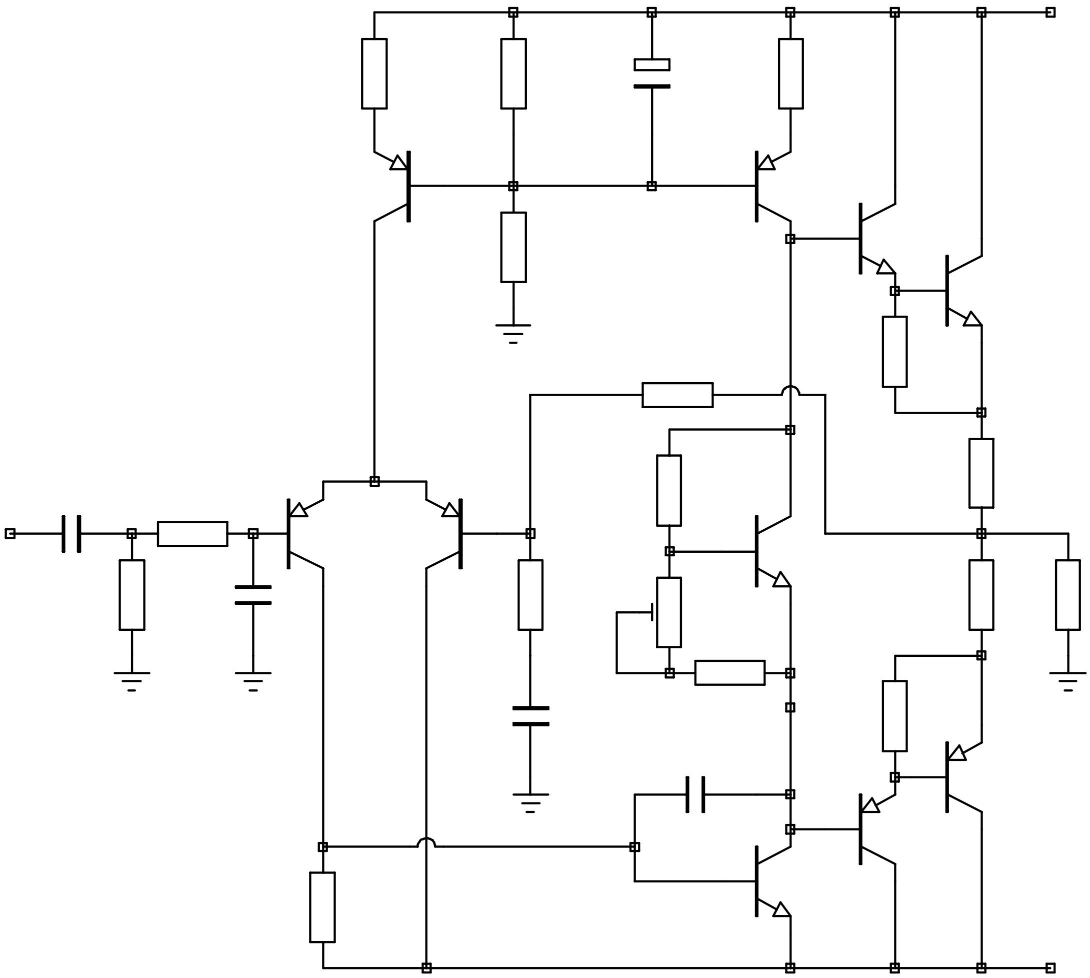
One of the most common amplifier architectures is shown above. In the 1st stage the filter (R_1, R_2, C_1, C_2) is designed to remove unwanted low and high frequency signals and hence largely defines the bandwidth of the amplifier. The differential amplifier (T_1, T_2), biased by I_{B1}, converts the input voltage into output current (transconductance amplifier). R_6, R_7 and C_4 form the feedback circuit that controls the circuit. This output current needs to be converted to voltage again by the transimpedance amplifier in the 2nd stage. Most of the voltage gain of the amplifier is provided by the common emitter connected T_3. R_3 is chosen to set the appropriate bias for the T_3 (~0.7 V). The constant current source I_{B2} provides a high impedance load for T_3, leading to a large voltage gain. V_b, together with R_4 and R_5, sets the quiescent current I_Q for the output transistors T_4 and T_5. These transistors enable the amplifier to drive a low impedance load without affecting the gain of the amplifier and are usually configured as emitter followers - unity gain voltage amplifiers with a high current amplification. The output stage is called "double ended" or "push pull" - T_4 is active for positive half cycles and T_5 for negative half cycles. Either source followers (using MOSFETs) or emitter followers (using BJTs) can be used. The dominant pole of the amplifier will be largely controlled by C_3.

There are a number of improvements that can be made such as improving the constant current sources, differential amplifiers, collector loads, feedback circuits, protection circuits and filter networks. Two examples of power amplifier circuit shapes are given below. You will need to

1) Select one of the designs (or use your own design). You will need to carry out some research to understand how power amplifier works, identify common approaches and circuits adopted and produce a time plan.
2) Outline your analysis strategy to work out the values for resistors and capacitors and choose appropriate transistors. The last three items in the specifications will require more understanding and experience to achieve than the first five.
3) Simulate your design using SPICE to see if your selected components will produce an amplifier that meets the specifications provided. SPICE will be particularly useful to identify any serious problems with your design.
4) Construct, debug and test your circuit.
5) Improve your circuit if possible.



Power amp 1



Power amp 2

Suggested design steps

1 Determine the supply voltage required. This can be worked out from the peak current flowing through, and the peak voltage across, the load.

2 Decide on the values of bias current for the transimpedance amplifier and the differential amplifier.

3 Design the bias circuit for the output transistor pair.

4 Choose suitable components to achieve the desired dc conditions in the circuit.

5 Determine the gain needed from the specifications, 20 W into 8 Ω with an input of 0 dBV (V_{peak} = 1.41 V) and choose feedback components to achieve that gain.