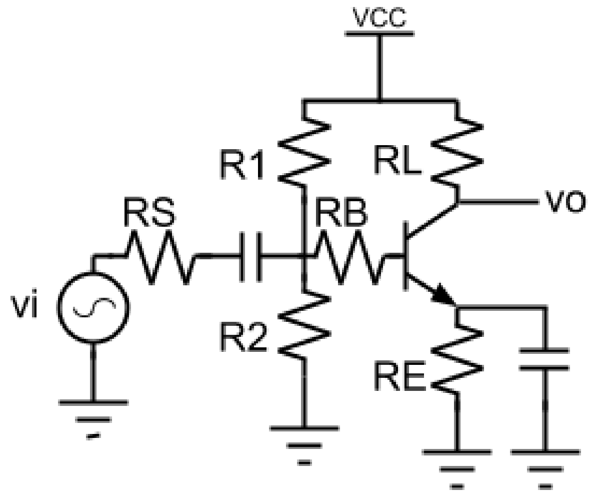

Figure 1: An example design for a common emitter amplifier.

1 Warm-Up Problems

1. The above circuit is a common emitter amplifier with a practical biasing scheme. Assume it operates in the mid-band and that R_s is part of the source rather than the amplifier.

   (a) Find r_{in}, r_{out}, a_v and V_{SW} for this amplifier. Answer in terms of the small signal parameters of the transistor (g_m, r_π, r_o) and resistor values.

   (b) Find V_{OMIN} and V_{OMAX}. You may assume that a voltage divider equation accurately captures the voltage between R_1 and R_2. Answer in terms of V_{CC}, I_C and resistor values.

2. What is the current gain, a_i, for a common emitter amplifier? Current gain is measured by applying a test current source at the amplifier input and measuring the current through a small signal short at the amplifier output.

2 Lab Introduction

In this lab you will build and characterize a common emitter amplifier. This is practice for the design project, where you will use a small number of transistors to design a (possibly multistage) amplifier to a specification. The learning goals are listed below:

- Understand the design process for amplifiers, a process which applies to most analog circuits
- Practice reconciling analysis, simulation and measurement.

3 Design a Common Emitter Amplifier

In this lab you will design a common emitter amplifier to meet the set of design specifications below. You may do so by selecting component values for the common emitter amplifier pictured in Figure 2. You may, if you prefer, select a different biasing scheme, make small modifications to this design or select another amplifier, but the schematic in Figure 2 is sufficient to meet the specifications.

You must begin your design by making hand calculations which help you pick your compnent values. After that you should simulate your design to make sure those component values work in simulation. Be sure to calculate and simulate the power consumption of your design.

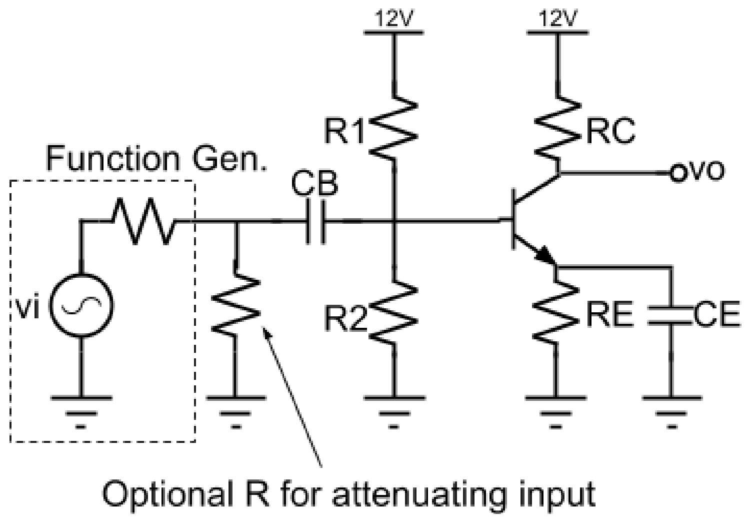

Figure 2: A sample design for a common emitter amplifier.

When simulating, start with a DC simulation to verify your bias point, then an AC simulation to check your small signal model, and finally a transient simulation to see if there are any non-linear effects that you missed. One common mistake that students make is only running transient simulations, which results in data that is confusing without the context of DC and AC simulations.

- $r_{in} > 1\text{k}\Omega$
- $r_{out} < 5\text{k}\Omega$
- $a_v = 200 \pm 10\%$
- $V_{SW} > 2\text{V}$ as measured by absence of visible clipping.
- Use only one 12 V power supply.
- Your signal source has a source impedance $> 8\ \Omega$ and may not have any DC offset
- Use one transistor: a 2N3904

In addition to characterizing each of these specifications, also measure your power consumption, P and your low frequency -3dB corner frequency, f_{low}. You should be able to make a good analytical prediction of P by looking at how much current leaves your voltage supply, but you don't need to make an analytical model predicting f_{low} because we haven't yet covered the circuit theory necessary to do so.

Required Data: Table of calculated and simulated r_{in}, r_{out}, a_v, V_{SW} and power. Traces showing the r_{in}, r_{out}, a_v, V_{SW} and accompanying descriptions of simulations used to test these parameters. Explanations of differences between calculated and simulated models.