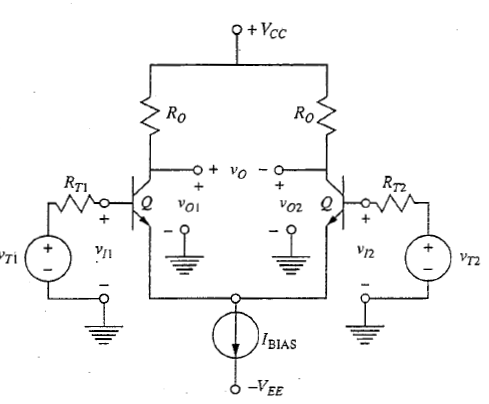
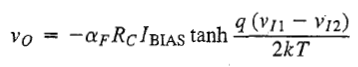
To model the tanh activation, we will use a bipolar differential amplifier.



The output of this circuit has the following transfer characteristic (see [] for derivation):



Where is the transistor’s alpha and is the thermal voltage at .

Since we only need one input, we can set to 0 by connecting it to ground. This will lead to:



We would also like to set the scaling term to 1. We obtain from the datasheet of the transistor that is used. Then, can be set to an arbitrary, but sensible value (e.g. ). The bias current can then be inferred by:

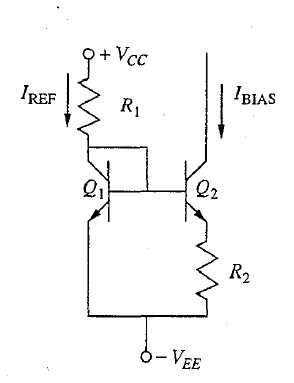
For a reason that will become apparent soon, suppose that the input was obtained as follows:

This would cause the following relationship between and :

If we substitute all modifications, we did to (x.x) so far, the result would be:

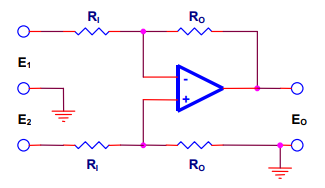
To have the correct scaling, we shall set the constant factor in front of to 1. We can do this by first setting to an arbitrary but sensible value (e.g. ), and then – with a bit of manipulation – obtain the value of using:

The eagle-eyed reader might have noticed that there would still be a minus sign left in front of the tanh expression. We will take care of this in a moment. First, we should find a circuit which can generate the constant current . A possible solution is the Widlar constant current source illustrated below.



Again, we can set to an arbitrary but sensible value (e.g. ) and then calculate the value of (see [] for derivation) using:

We should remind ourselves that is not a ground referenced voltage. It is the difference between and . To convert the differential voltage to single-ended voltage we can pass these two voltages to a differential input amplifier.



This circuit has the following transfer characteristic (assuming all resistors have the same value):

Remember that minus sign in front of the tanh function from before? We just took care of it by connecting and in the specific order above.

The complete tanh activation then looks like this: