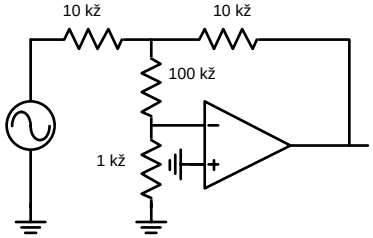
How to measure the open-loop gain of high-gain amplifiers:

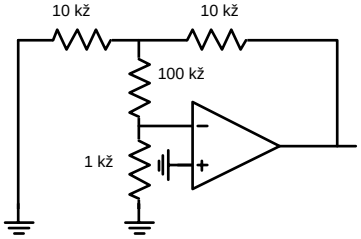



In the circuit to the right, apply an AC input signal as indicated and measure the amplifier output voltage and the voltage at the junction of the two 10 kΩ resistors (call this Vx). The amplifier gain is then 101 times Vout/Vx.

You may want to reduce all the resistor values by a factor of 10 from the values given.

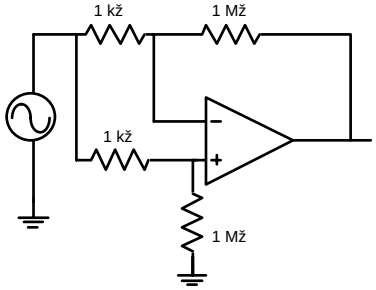
Note also: this or some similar network needs to be in place when you are doing general testing: op-amps dont bias up correctly unless feedback is applied.

How to measure the offset voltage of high-gain amplifiers:

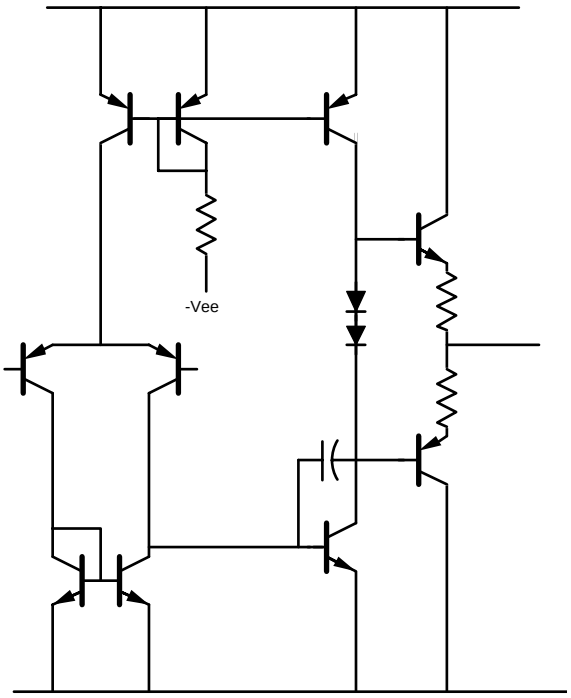



The DC output voltage will be about 200 times the input offset voltage.

How to measure the CMRR of high-gain amplifiers:



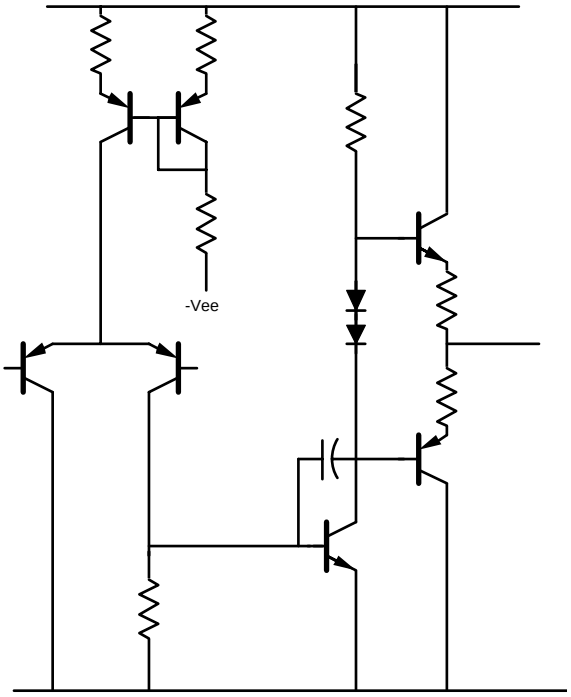

If the resistors are well-matched (take the time to find resistors accurate to 1% or better before testing), then the circuit gain will be about $(2000)A_{CM}/A_D$




**Examples of OP-AMP Circuits:**

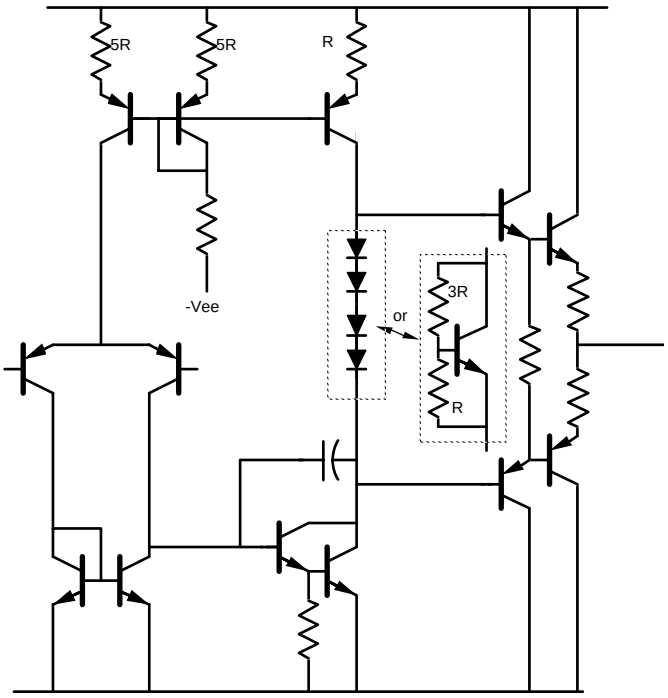
A very simple one, but still with good performance: Costant-current sources are used for both the differential stage and the following common-emitter stage.

The circuit could be easily "flipped" by swapping PNPs for NPNs and vice-versa.

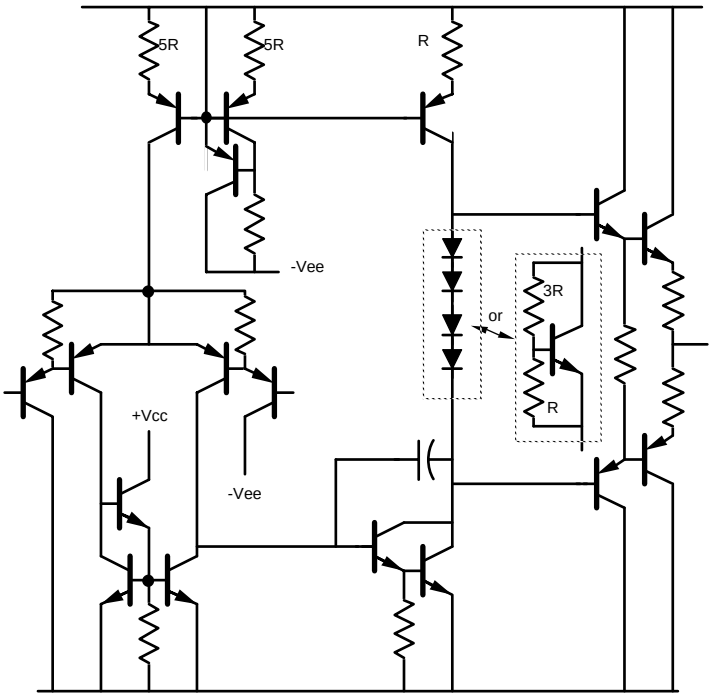



Here we have simplified the circuit by eliminating the constant-current loads. This will reduce the gain and make the amplifier harder to bias right.

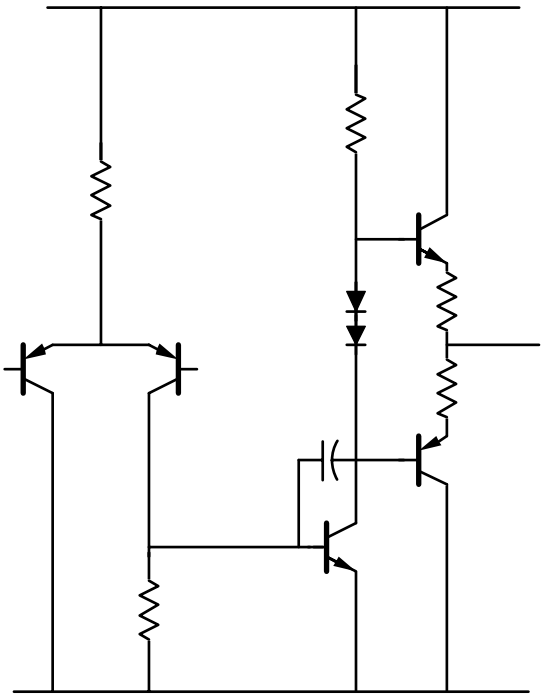
Note also that the constant-current source (mirror) for the differential pair uses emitter degeneration resistors to increase its output impedance.




This amplifier is considerably more complex: The common-emitter stage now uses a darlington, which increases its input impedance, thereby increasing the voltage gain of the first (differential) stage. The ouput stage also uses a darlington, thereby increasing the load impedance on the common-emitter stage, increasing its gain. The diode stack used for setting the output stage bias can be replaced as indicated by a "Vbe multiplier", which could be adjustable by making the resistor "3R" a trimpot.




This illustrates some more tricks: Emitter followers are used in the current mirrors to eliminate base-current errors, and a Darlington input stage is used to increase the amplifier differential input impedance and to decrease the amplifier input bias current (base current).



This is possibly the simplest possible OP-AMP configuration. You may be able to meet the design specification with this design. On the other hand, once you know how to design multistage circuits, it is actually easier to meet 'specs with a design with more transistors.