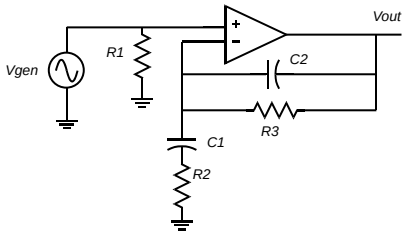
**First test**



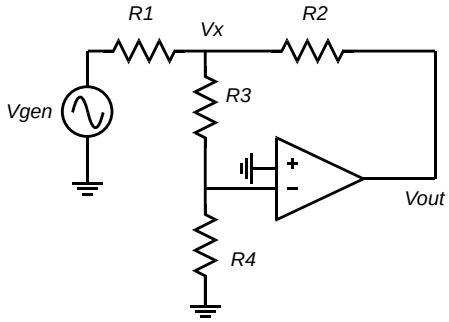

First test circuit:

Use this circuit not only to test the closed loop frequency response but also when you are checking general DC bias conditions and correct functional circuit operation.

If you ground the input (set Vgen=0), the DC output voltage is equal to the amplifier DC offset voltage. That value you will need to know for the next measurement.

R1 should be ~ 10 kOhm. The other component values you will need to calculated.

**second test**




Use this circuit when you need to measured the low-frequency open-loop gain of an op-amp. Make R1=R2=10 kOhm. Lets leave R3 and R4 unspecified for a moment.

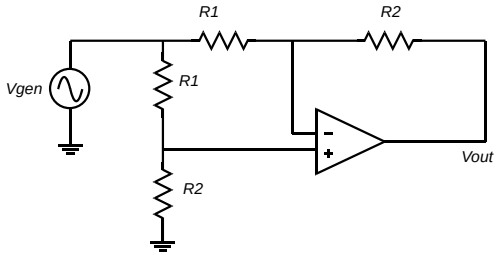
Apply an AC input signal Vgen as indicated. Adjust the generator amplitude until the output is 1 Volt peak-peak. Measure the amplifier output voltage and the voltage at the point labeled Vx. The op-amps open-loop gain is then $(R_3 + R_4)/R_4$ times Vout/Vx.

We face a difficulty with this test. The voltage at the point Vx has an amplitude of $V_{x,pp} = V_{out,pp} * [(R_4 + R_3)/(R_4)] / A_{open-loop}$. If we make the voltage divider ratio $R_4/(R_3 + R_4)$ very small, this makes $V_{x,pp}$ larger and therefore easier to measure on an oscilloscope. Unfortunately, the DC output voltage of the circuit is also given by $V_{os}(R_3 + R_4)/R_4$, where $V_{os}$ is the DC offset error of your op-amp. Given input MOSFET mismatch, $V_{os}$ might be as large as $\sim \pm 500$ mV, and the resulting DC output voltage $V_{os}(R_3 + R_4)/R_4$ will then saturate the op-amp.

To fix this problem,
a) choose R4=1 KOhm, R3=10 kOhm.
This will result in $V_{x,pp} = V_{out,pp} * 10 / A_{open-loop}$, hence $V_{x,pp} = V_{out,pp}/5000$ for an open-loop gain of 50,000. This will make it difficult to measure differential gains larger than about 10,000. We will have to accept this limitation in measurement.

b) Please adjust the DC level at the output of the signal generator in order to produce a DC output voltage of zero volts during the above measurement

**Third test**



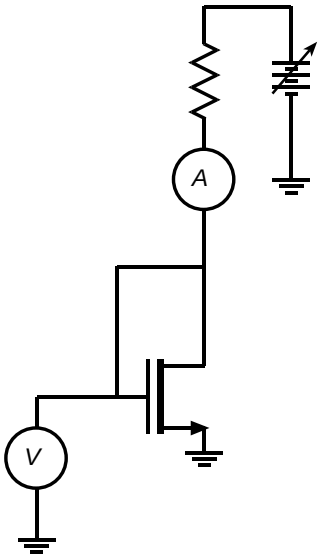

How to measure the CMRR of high-gain amplifiers

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 $2*(R_2/R_1)*A_{cm}/A_D$

This circuit faces the same problem with DC offset voltage as earlier tests. To avoid serious problems with DC offset voltage, set R1=1 kOhm, R2=5 kOhm. That will result in a DC output voltage about 6 times Vos.

**Reducing Vos**

a) You are using either MOSFETs of BJTs as input devices. Here is how to use a curve tracer, to compare your Vth your input MOSFETs, so as to find 2 devices which are well-matched. The method for finding matched bipolar transistors is almost identical.




If you are having trouble with the curve tracer, try this setup. Perhaps 1 kOhm is appropriate for the resistor; it will depend upon the current you seek.

Set up the circuit to the left on a proto-board.
Adjust the supply voltage to obtain the current reading you desire on the ammeter; this current should be equal to the current you plan to use in your circuit. The voltmeter then measures the required Vgs to obtain this.

Select a pair of MOSFETs with Vgs matched as closely as possible.

You can simply adapt this test circuit for P-channel MOSFETs, or NPN or PNP for bipolar transistors.