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Lab 15

Figure 1. Wiring for an inverting op amp.

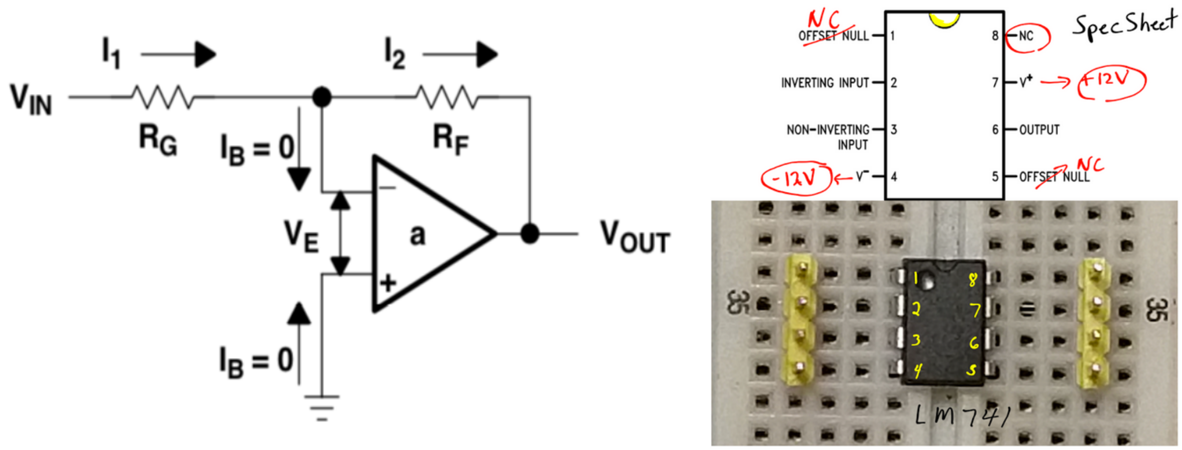
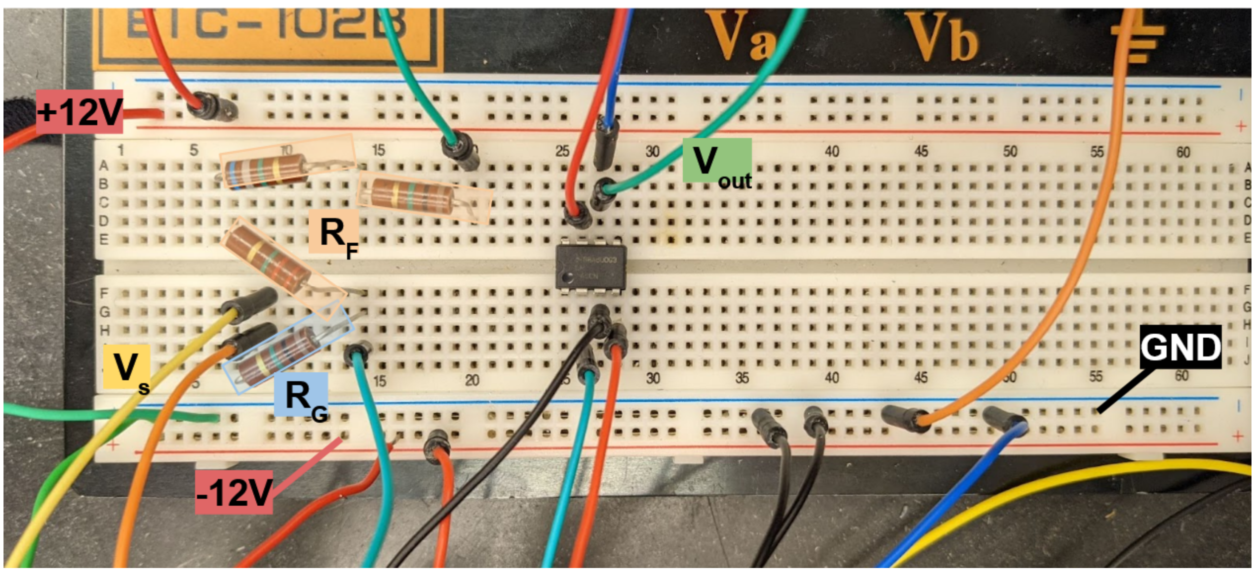


Figure 2. Built circuit with large resistance values. R_F = sum of three resistors in series.



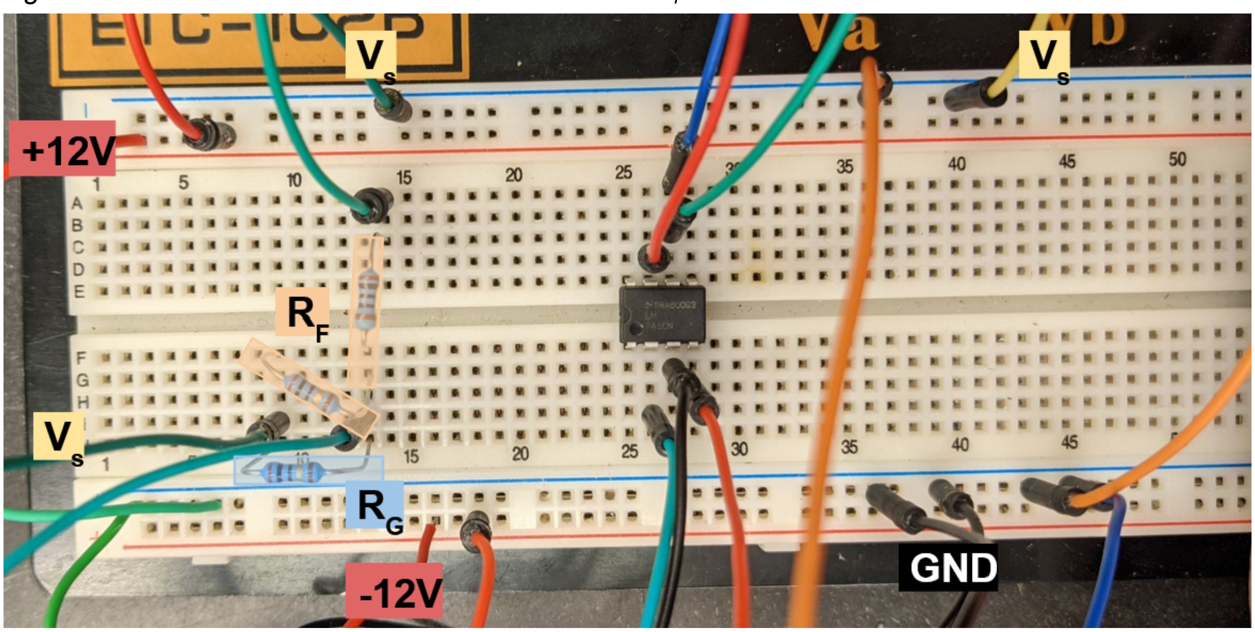
Gain ≅ 10; R_F ≅ 10MΩ and R_G ≅ 1MΩ; V_S = 1V p-p sine wave at 500Hz

Figure 3. V_S (orange) and V_{out} (purple) over time for high resistance values.

This is close to the expected output, but with some differences. The amplitude of the output is approximately ten times the amplitude of the input, and is shifted 180 degrees from the input while still maintaining the same frequency, so that the output is negative in all the places where the input is positive and is positive in all the places where the input is negative.

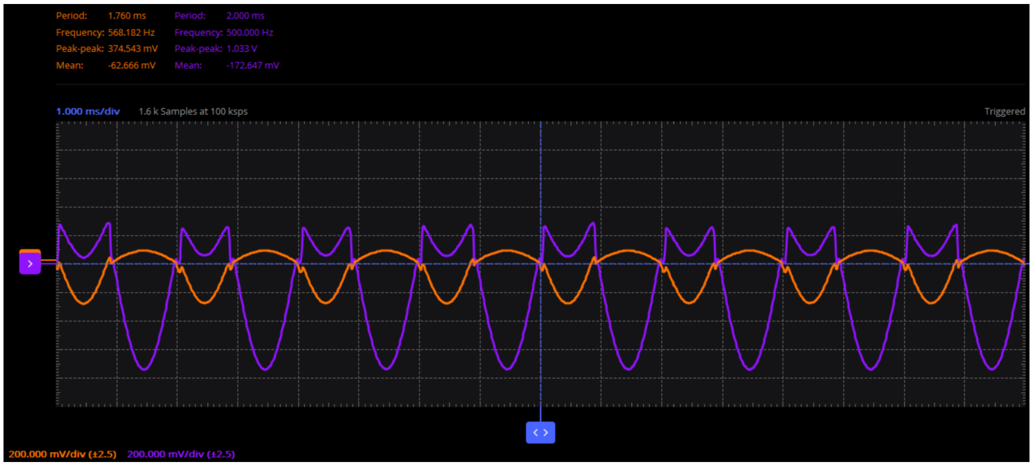
However, there are a few issues with the output. For one thing, it seems to be a noisier signal, especially at its maximum and minimum values. More noticeably, the amplitude isn't as stable. Looking at the negative peaks, the peak amplitude seems to vary by up to a full volt. It's harder to tell with the positive peaks, but they also noticeably vary.

Figure 4. Built circuit with small resistance values. R_F = sum of two resistors in series.



Gain ≅ 10; R_F ≅ 100Ω and R_G ≅ 10Ω; V_S = 1V p-p sine wave at 500Hz

Figure 5. V_S (orange) and V_{out} (purple) over time for low resistance values.



This is not the expected output. The only similarities to the expected inverting op amp output are that the input and output waves have the same frequency, and that they are 180 degrees out of phase with each other. A difference is that there appears to be a very small vertical offset between the input and output waves.

Both the input and output waves look unexpected. The input wave looks qualitatively about as would be expected in the negative portions, but it does not reach the same amplitude in the positive portions - instead, it's a much flatter curve. In the negative regions, it goes past the expected amplitude. Additionally, every time it crosses 0V, it dips a tiny bit before going back up and resuming a smooth curve.

The output wave looks qualitatively about as would be expected in the negative portions, but displays an odd shape in the positive portions. It increases to just over 200mV, then decreases to just over 0V, then increases back to just over 200mV, then decreases again into its negative region. In its positive portions, it's similar to the shape of the input wave (which is in its negative portion). Like the input wave, it displays a wiggle at each zero crossing.

Because the input wave is messed up, it's hard to say whether the output wave's problems are really a result of the op amp. With such low resistances, the current through the resistors must be very high in order to satisfy Ohm's Law. It's possible that Scopy simply can't supply the necessary amount of current.

Figure 6. Voltage follower.

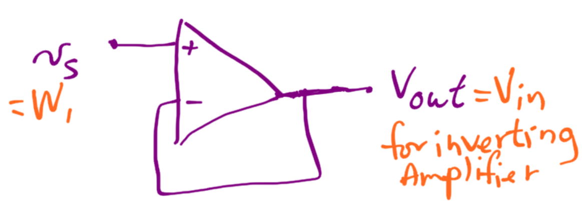
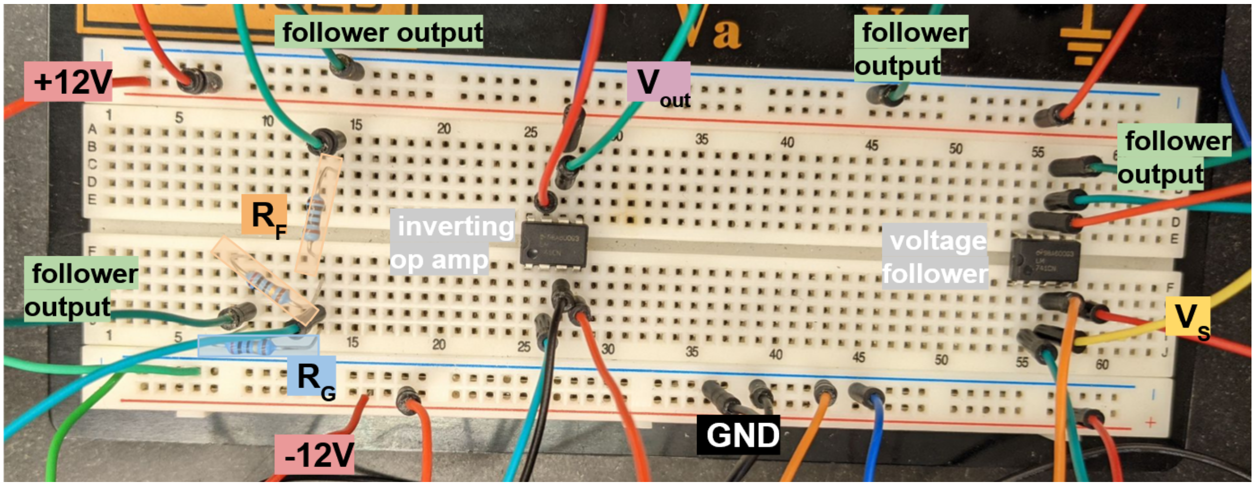
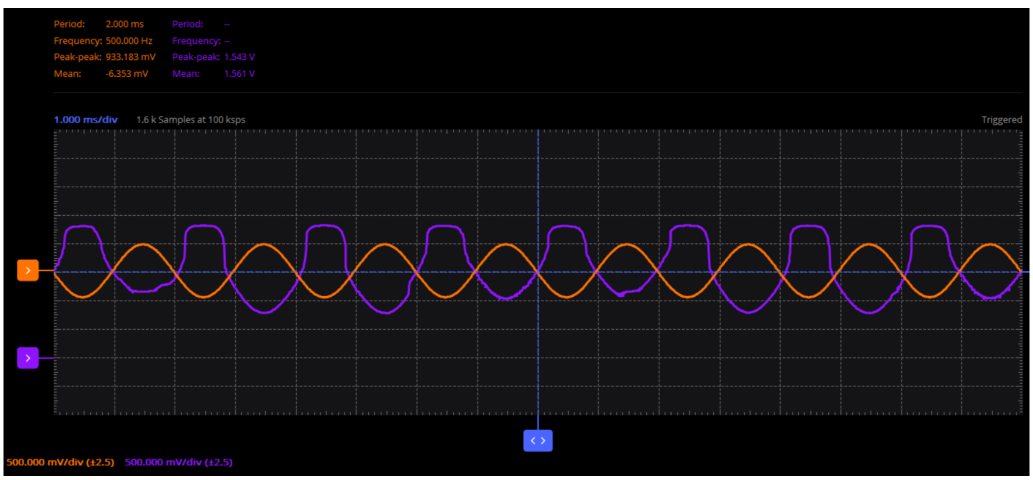


Figure 7. Built circuit with small resistance values and a voltage follower.



Gain ≅ 10; R_F ≅ 100Ω and R_G ≅ 10Ω; V_S = 1V p-p sine wave at 500Hz

Figure 8. V_S (orange) and V_{out} (purple) over time for low resistance values and a voltage follower.



This is closer to the expected output than the low-resistance op amp circuit without a voltage follower, but still does not match the expected output. Including the voltage follower seems to have fixed the issues with the input wave - it now looks like a typical sine wave, with the correct frequency and amplitude. The output wave has the same frequency as the input wave, and is 180 degrees out of phase with the input. Compared to the low-resistance op amp circuit without a voltage follower, the output wave is closer in shape to a sine wave. However, it still has some problems.

In the positive regions, the output wave reaches an amplitude of about 700mV and plateaus. In the negative regions, it seems to alternate between reaching an amplitude of about -400mV for two cycles, then an amplitude of about -600mV for two cycles. The negative portion of the output wave is more typical of a sine wave, but has seemingly random distortions every few cycles. There also looks to be a significant vertical offset between the input and output waves.

The voltage follower means that much more current can be supplied - enough that the input wave looks normal. However, the output wave is still affected by something.

Figure 9. Inverting op-amp circuit with model

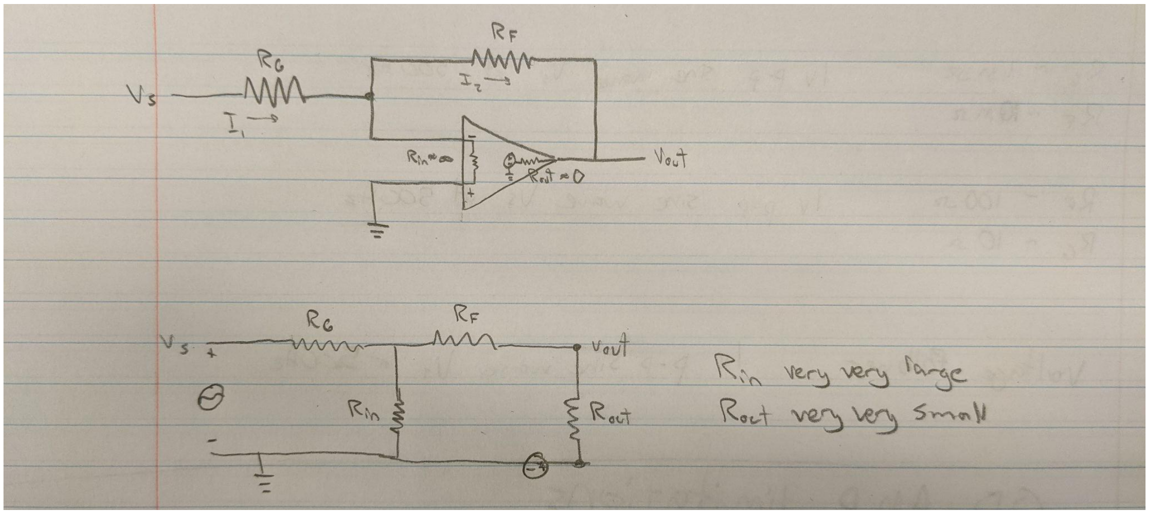
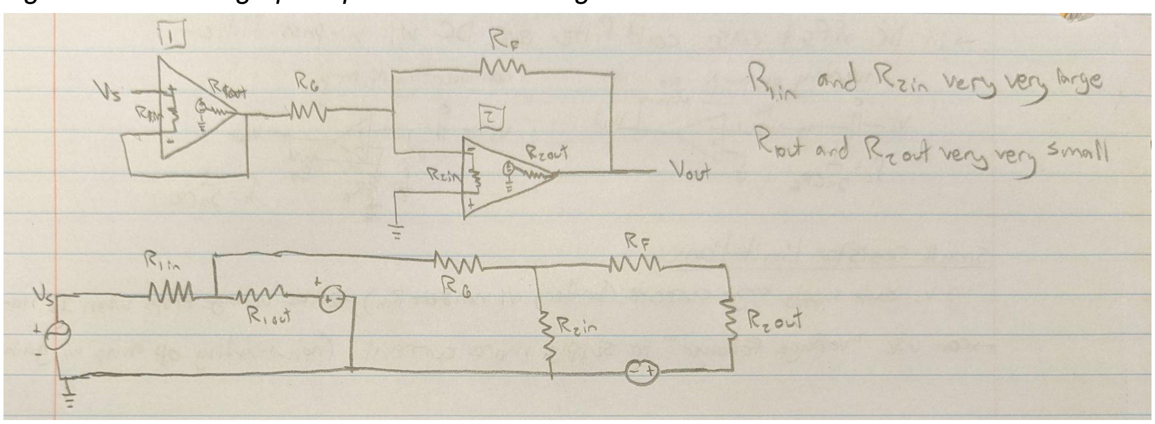


Figure 10. Inverting op-amp circuit with voltage follower and models



When R_G and R_F are very large, they could approach the resistance of R_{in}. When R_G and R_F are very small, they could approach the resistance of R_{out}.

It's possible that the op amp could be loading the circuit, if its internal resistances R_{in} or R_{out} are too close to the circuit's external resistances. If that's the case, then the output certainly wouldn't be as expected.