

Simulation_lab_remote_supplement

Analog Simulation

For the analog part of the simulation lab, you should follow the Analog & Digital Simulation lab instructions. These tell you to duplicate the circuit you build for the Differential Amplifier lab. Since you don't have your lab notebooks, I'll distribute the solutions for the Diff amp prelab, which if you dig through it has all the component values. (The schematic is in the Diff amp lab instructions if you don't remember it.) You should also refer to the Analog simulation section of the Multisim Hints (a copy is attached to the simulation lab instructions). A couple of updates: 1) Multisim is no longer bothered by hanging capacitors (item 10 in the hints). However, if you want to use blocking capacitors on the outputs so your transient analysis output, you'll need something attached so you can label the net, so you might as well put 10 Meg resistors to ground. The ac analysis is small-signal, so DC offsets don't show up and you don't need the blocking capacitors. You could just plot the collector voltages for the transient output too, but then you'd need to use the left-and-right axes feature in the grapher to get input and output onto the same plot, since the output will be centered around 13 V.

When you do the ac analysis, which sweeps the frequency of your sources and generates a Bode plot, you should set the frequency range 1 Hz – 10 GHz (something we couldn't do in the lab!). You'll want log spacing, and ten points/decade is adequate. If you'd like to plot gain directly, on the "output" tab you can click "add expression..." and enter a formula like "v(out1)/v(in2)". **One subtlety on setting the ac voltage sources: when you set the magnitude and phase in the values tab under "properties", the top numbers that show on the schematic are the ones used in the transient analysis, but there's another place half-way down the table to set the ones that are used in the ac analysis.**

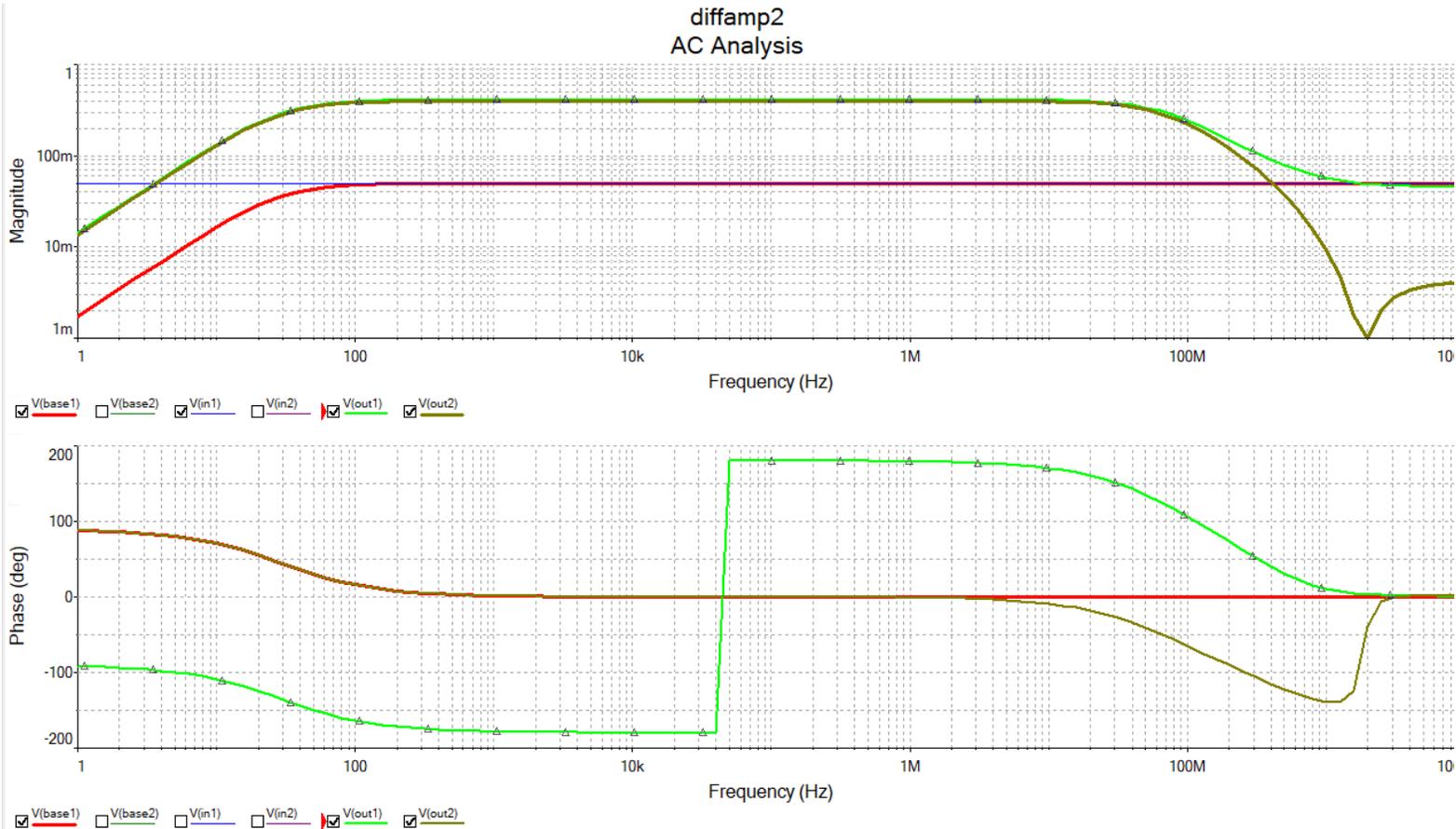
This is probably more instructive than the digital part of the lab, so I'm added some investigation of Miller effect to that (it was in the diffamp lab, but most of you didn't get to it). You can look this topic up in the index in H&H for an explanation. It's only going to work if you're using a real transistor, so be sure you picked a 2N3904 and not the generic ideal transistor. If you look under "properties" for the transistor, you can examine the model and see what values are there. You won't recognize most of them, but you can find C_{CB} (they use different symbols, but the description is there). It's 3.6 pF for the 3904. You can try playing with different values if you want, since you can edit this section.

The added part is to run the ac analysis for differential input twice, once with the ac sources attached directly with a large (1 μ F) capacitor, and once with 1 k resistors. You can reset the phase on one of the inputs and run an analysis with a pure common mode input. Try to make your plots look like the one on the next page. You will note that to be able to read them, you'll need to make them the full width of the page when you paste them in. You can use cursors to read off points for corner frequencies, or the expand region tool to blow up the relevant portion to where you can read it off the graph.

The graph below had direct connections to the inputs, 50 mV on input 1 and 0 V on input 2. At low and mid-frequencies you get the behavior you expect, with $V(\text{out2})$ just slightly bigger than $V(\text{out1})$. But at very high frequencies, $V(\text{out1})$ levels off at $V(\text{in1})$ with a gain of +1, while $V(\text{out2})$ continues to decrease. So how many of these amplitude and phase results can you

explain? Remember that at high frequencies, the base of Q1 is solidly driven by the 50 mV voltage source, while the base of Q2 is solidly grounded. What is the impedance of the 3.6 pF C_{CB} capacitance, and how does that compare with Z_{OUT} at the collector?

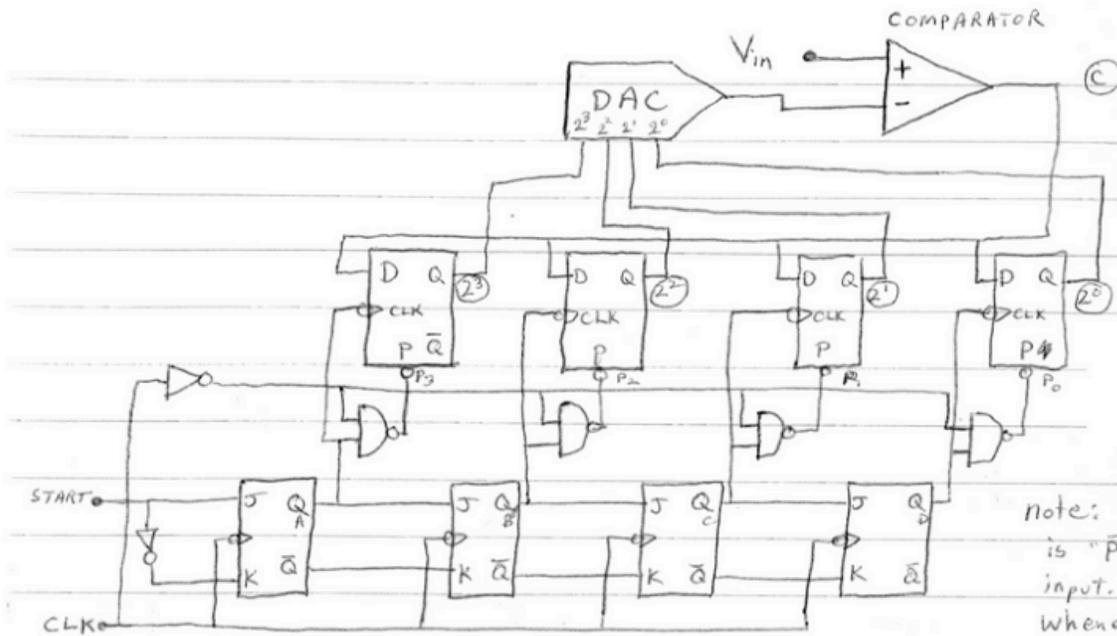
Note that the 360° jump in the V(out1) phase below is just wrapping the display – you should think of the phase as continuing to get more negative from -180°.



Digital Simulation

On this part you are welcome to go ahead and build your own as described in the instructions. But it takes quite a while to draw the whole circuit. So if you want to save some time, I've included the finished circuit, with lots of attached instrumentation. You are welcome to use this. The caveat is that there is one mistake in the circuit, and one in the programming of the digital word generator. So you'll need to diagnose the problems and fix these. I'm also attaching below the handout we went over in lecture, since it includes a timing diagram. There are some minor differences in the components used (look at the edge trigger on the D flip/flops), so you'll need to take these into account.

Successive Approximation ADC



note: \overline{P} is "Preset" input. $Q \rightarrow 1$ whenever \overline{P} goes low momentarily

