

Topic: Troubleshooting, Debugging, Hints, Suggestions ...

This is a work in progress. Check the date at the bottom of the page to see when this was most recently modified. In this document, the following abbreviations are often used: PS = PSpice, MS = Mobile Studio, AD = Analog Discovery

Experiment One

General

- Be sure you understand how to connect components using a breadboard (aka protoboard). Many students have parts of their circuits shorted out because they are not connecting them correctly to their protoboard. Note that breadboards also, at times, develop bad spots where connections can become unreliable. It is always a good idea to check to be sure that the basic connections are working properly.
- There is not a lot asked involving PSpice in this experiment. Just be sure you know how to get it working and how to solve simple problems like voltage dividers. Be sure to use Vsin as the source not Vac and the ground marked with a zero.
- When making the measurements of voltage so that battery resistance can be determined, only connect the batteries to the 2 100 Ohm resistors for a short time. It is best to connect, disconnect, connect, disconnect ... only connecting long enough to read the voltage. Then take a typical voltage value for both the connected and disconnected conditions and use that info to find the battery resistance. Typical capacity for a 9V battery is about 500mA-Hr. 9V connected to 200 Ohms is 45mA, which is a significant fraction of 500mA. If you leave that connected for every class, then, the battery will last about 10 hours, which is 5 classes. Actually, the 500mA-Hr rating is for 15mA drain. At 50mA, the capacity is smaller.
- Be sure to look up typical values for battery resistance. This info is found among the links provided for experiment 1.
- Be sure that the vertical scale (V per division) is set so that you can see the voltage you are looking for. e.g. a 9V battery cannot be measured using 100mV/div).
- When measuring the voltage between two large resistors (e.g. 1 MOhm) you will likely see a lot of noise on the signal. This occurs because the wires between the resistors pick up noise like an antenna and the small additional current passing thru the large resistor results in a significant voltage. Many times the noise comes through the power line (called conductive interference). Try running your computer on its battery alone to see if things improve. That eliminates the path from you to the building ground.
- To change the amplitude (pk-pk, etc.) of the signal from the function generator (AWG) you must change the amplitude in the function generator window, not the Volts/Div on the oscilloscope. The latter only changes how the signal is displayed, not its actual value.

Analog Discovery

- Be sure to carefully read all instructions so you have the correct wires connected to your circuit.
- For all single-ended measurements (basically all measurements unless we specifically note they are to be differential), make sure that then negative scope input connections (1- and 2-) are grounded.

Mobile Studio

- Read over the document found at the top of the Links page on Mobile Studio Analog and DC Connections and make sure your protoboard is wired properly to your Mobile Studio.
- Do not use AC coupling for the scope inputs unless specifically requested to do so by the assignment write up.

Experiment Two

General

- Capture/PSpice uses the signal amplitude for both transient and AC sweep analysis, not peak-to-peak.
- Capacitors with values greater than 1uF are electrolytic and polarized. Because they are physically larger, they usually have the value written on the side. Sometimes, MFD is used for microfarads. Be sure to connect them with the negative side (usually has a stripe with a - sign on it) at ground or at least a lower voltage than the other end of the cap.
- When changing frequencies with either Analog Discovery or the Mobile Studio, be sure to also change the time scale so you can see at least two full cycles.
- PSpice output plot. To choose the trace for the cursor, click on the symbol at the bottom of the plot.
- Download the latest version of PSpice to avoid window formatting problems (I hope)
- Display width – make the traces wider for **AD**, **MS** and **PS** to see them better in the word doc. Otherwise they can be quite faint.
- If the plot is completely flat at zero or covers the entire screen ... you may have the wrong time scale or you may have input the frequency incorrectly. (Either **AD** or **MS**)
- In PSpice, if you are not able to get the simulation to run, you may have a problem with a file called NOM.LIB. Please make sure you have NOM.LIB (or NOMD.lib if it demo version) configured in Simulation Profile window. In Capture, go to PSpice menu > Edit Simulation Profile > Configuration Files tab > Library Category > Click on Browse button > Browse to \\ <Cadence install folder>\tools\PSpice\library folder and select NOM.lib > Click on “Add as Global” > Apply > OK.

Mobile Studio

- Do not use AC coupling for the scope inputs unless specifically requested to do so by the assignment write up.
- If you find that the time varying voltage measured once you connect your circuit to the function generator is very small, you have probably shorted output to ground. There is protection circuitry to try to save your IOBoard, which hugely reduces the voltage so nothing breaks. Disconnect the voltage source and see if the voltage changes (use AWG1 or 2 input on the scope). If everything looks fine then, rewire your circuit.

Experiment Three

General

- Electrical tape is found by the two wire reels
- Be sure to use a sanding block or something else to protect the table top when removing the enamel from the magnet wire.
- Use the guides at the front of the classroom to obtain 40ft of wire (for older version of experiment using air core coils).
- Check all of the links provided for each experiment to see what is useful. There is, for example, a very helpful set of calculators that you can use to find wire resistance and other parameters.
- There may be no 1Ohm resistors in the parts drawers. You will have to get creative with what is there. The purpose of the resistor is to limit current, so it does not have to be too exact. Be sure that the resistor or resistors that you use are the correct values. Several students have not read the colored stripes correctly and used much larger resistors, which limit the current too much. Remember that the resistance of the coils is quite small, so if you use a current-limiting resistor that is large (e.g. greater than 100 Ohms), nearly all of the voltage will drop across the resistor, leaving very little (nearly zero) across the primary of the transformer.
- If your PSpice AC sweep is not giving you good results, be sure that you have the correct min and max frequencies specified. Another common problem is putting a space between the number and the multiplier (m, u, etc).

Analog Discovery or Mobile Studio

- When you connect your coil to the AWG output, you may find that the signal is distorted. This is most likely due to the limits on how much power or current the AWG can source. Reduce the AWG voltage to the point where the signal is no longer distorted. This usually fixes the problem. The distortions do not fit a particular pattern.

- You should definitely calibrate your Analog Discovery or Mobile Studio now. The link for the instructions for AD is found on the course website. The instructions for MS are found on the mobilestudioproject.com webpage.

Mobile Studio

- Do not use AC coupling for the scope inputs unless specifically requested to do so by the assignment write up.
- Be sure to ground one end of both the primary and the secondary coils. Single ended measurements with the Mobile Studio give a DC value of about 3V if no part of the circuit is grounded

Project One

General

- Be sure that you demonstrate regular and consistent operation of your motor by producing voltage plots that show one connection every cycle.
- Estimate the speed of your motor and then select the appropriate time scale that will show at least several cycles per scan. If your guess is not very good, then adjust the time scale up or down, as needed.

Analog Discovery or Mobile Studio

- Always have a circuit diagram available for the battery-motor circuit or you will not be able to interpret the voltage signal used to measure speed. Also use the 500mV/div scale for the display on your scope because the rated voltage of the battery is 1.5V.

Mobile Studio

- Do not use AC coupling for the scope inputs unless specifically requested to do so by the assignment write up.

Experiment Four

General

- Differentiators are inherently noisy devices. Actually they respond to noise because they have a range of frequencies where they are unstable. This is discussed in the document on Integrators and Differentiators, which everyone should read carefully.
- Be sure that both leads from your batteries are connected to your circuit. To apply a positive voltage, connect the black (-) lead to ground and the red (+) lead to the point

where the voltage is needed. For a negative voltage, reverse the leads. All integrated circuits (chips) need power.

- Be careful to remember how protoboards (aka breadboards) are used. There are many good references linked on the course webpages including a new addition written by one of our TAs. There have been several teams who have plugged both ends of a component into the same row of 5 connected points on their board and thus have shorted out the component. In other words, the component is not part of the circuit.
- One of the many good reasons to own a multi-meter and use it in class is in checking connections on your protoboard. For example, you should always check directly on the power pins of integrated circuits (4 and 7 on the 741) to be sure that the applied voltages from your batteries are reaching the IC.
- Be sure to check the circuits you build on your protoboard against the circuit diagram, especially before you connect power to your circuit. Each point on the circuit diagram corresponds to a physical location on your built circuit.
- In PSpice, if you wish to reverse the order of the + and – inputs on the op-amp, there is a mirror function on the edit menu.
- A common PSpice error occurs when a wire is placed across a part, thus shorting it out. Usually this is easy to spot if you look closely at the circuit by zooming in on the figure.
- It is possible to provide -9V in PSpice by using a DC voltage source oriented with the positive terminal connected to where you wish to apply a negative voltage and then have the voltage of the source equal to -9V. You can also do this by reversing the orientation of the DC source and then have the voltage of the source equal to +9V.

Analog Discovery or Mobile Studio

- Be sure that you have not grounded the output of the function generator (W1 or W2, AWG1 or AWG2). Think of the outputs as the output of the function generator and realize that the other end of the function generator is already grounded. You only need to connect one ground to your circuit and this can come from any of the ground connections.

Mobile Studio

- Do not use AC coupling for the scope inputs unless specifically requested to do so by the assignment write up.

Experiment Five

General

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- Measuring the change in the strain gauge resistance is challenging if the divider is not taken apart, which we do not recommend. Do not expect a large change, usually 1Ω each way is the most you will observe; sometimes only a total of 1Ω . Draw the circuit diagram to see how this works. There is a video on this topic found on the YouTube Channel.
- It is a good idea to do some simple tests of the strain gauge bridge to be sure that it is connected properly and/or all components are working. After connecting the +9V and ground to the terminals, the voltage on the other two terminals should be about 4.5V. The voltage in the middle of the fixed leg should always remain at 4.5V (or near that). The voltage at the point between the two strain gauges should go up and down a little when the beam is deflected. You may not be able to see this if you set the range on your multi-meter too high. Try the lowest voltage range. If these two voltages are not nearly the same, the output from the differential amp may saturate because it has a large gain.
- Be sure that the wires are well connected to the terminals on the cantilever beam base. You will probably not be able to do this with a plastic screwdriver.
- A common PSpice problem – when setting up the simulation, the final simulation time is often specified as smaller than the save data after time, which results in no data saved and nothing displayed.
- When you try to be very neat setting up your circuit on your protoboard, you should be careful not to cut the component leads too short. They need to be long enough to be deep into the protoboard holes or else their connections may not be good. You can usually tell if a component is not well connected because it will be somewhat loose.

Analog Discovery or Mobile Studio

- Estimate the type of signal you expect to see based on your circuit, your measurements of the change in strain gauge resistance, etc. before setting up your oscilloscope to measure it. Then, if it is not very close, you have at least a suggestion that something is wrong.

Mobile Studio

- Do not use AC coupling for the scope inputs unless specifically requested to do so by the assignment write up.

Project 2

- Any time you have an op-amp output level near the battery voltage, you probably have a saturated op-amp. This may be due to a bad chip, so swapping out the chip may be necessary. However, swapping chips is one of the last things you want to do. First check your batteries to see if they are good. Also check the voltages on the power pins on the chip since you may have a bad connection somewhere. The goal is to get the power to the chip so that is the best place to check the voltages.

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- Ask yourself how the position and acceleration should look? Should they be in phase or out of phase based on what you know from Calculus?
- For the accelerometer especially, every little vibration will show up on the signal. Thus, to quiet things down, you may want to put the beam on the floor or have one of your partners hold the beam support firmly on the counter top.
- Always estimate the value of the voltage you expect to display before setting up your scope. Then, if the voltage is too high or too low, you probably can conclude that something is wrong.
- To identify the required capacitors for the circuits used in this project, you should probably review the materials from Exp 1 (posted online in the *Optional Related Information* section on Identifying Electronic Components. There is also a series of videos on this topic, using this reference, available on LMS.
- Be sure that the accelerometer/surfboard are plugged in correctly. Some students had their plugged in backwards.
- Not unique to this project are problems created by using the wrong components. Reading resistors, as discussed in the video available on the EILinks page, can be a big problem because colors are not always easy to identify. For the accelerometer circuit, using 680k resistors instead of 680 Ohm resistors will keep the circuit from working.
- When using integrator and differentiator circuits on experimental data, make sure the circuits work by testing them with a known signal from the function generator before connecting them to the output of your circuit.
- When setting up triggering, be sure you use the signal with the least noise. Noise spikes will be irregular and the IOBoard will try to trigger on everyone spike that crosses the threshold you set.
- In general, it is a good idea to build and test each part of an experiment rather than building it all at once.
- Some capacitors are difficult to read. Ask for help if you cannot find the component you need.

Mobile Studio

- To make the +2.5V and -2.5V we need for the accelerometer, we use the 100k or 200k pot and the two 680 Ohm resistors to drop the voltage from the +4V and -4V on the board. Once you have the voltage output zeroed for no acceleration, you should check the two voltages to see that they are indeed at about +2.5V and -2.5V.
- Do not use AC coupling for the scope inputs unless specifically requested to do so by the assignment write up.

- One of the key things to check to be sure that the accelerometer outputs zero voltage for no acceleration. The first item listed above is critical, as is the use of DC coupling. If your accelerometer has a large offset voltage, you cannot integrate the signal without producing a saturated output. The saturated output will look like zero volts if you use AC coupling. Thus, doing two things wrong (AC coupling and not zeroing the output of the accelerometer) will produce a non-responsive output. You may wonder how close to zero one has to adjust the offset. The answer is found in the design of the Miller Integrator. Recall that there is a feedback resistor added to the ideal amplifier so that there will be feedback at DC. (The capacitor will block DC current, so there will be no feedback without an additional path for the current.) In the integrator shown in Figure 7, the DC gain is $120/8.2$ or about 14.6. The 741 is powered by 9V batteries, which we will assume are relatively new, so that the op-amp will saturate at about 9V or a little less. (A fresh battery will actually have a voltage of more than 9V.) Thus, the input voltage must be less than $9/14.6=0.6V$ so as long as you can adjust the offset to be 0.1V or less, the integrator should not saturate, even when the signal being detected is relatively large. Remember that it is the sum of the offset and the signal that get amplified.

Experiment 6

- When doing the PSpice simulation of the Schmitt Trigger circuits, be sure that you note where the circuit switches not where the input and output signals intersect. It is easy to make this mistake because we are used to looking for where plots overlap.
- Be sure to be careful about the orientation of the transistor. It definitely has a preferred orientation.
- Read the entire experiment write up before beginning the experiment, especially since the relay experiment can be a problem, which is why there are alternate versions of it. Also, construct and test each section of the relay circuit one at a time to be sure they are working properly. Don't build the entire circuit and expect it to work right away. This is good advice for any circuit.
- Be sure that the current draw from either the +4V or -4V on the IOBoard is less than 200mA. If you try to draw too much, it may damage the voltage regulator. Current draw from the +5V or -5V on the Analog Discovery must be less than 50mA.
- Please carefully observe the relay connections. Many people used the wrong connections for the coil.
- It is a good idea to have a few alligator clip leads available to avoid the problems connecting the relays to the protoboard.
- Be sure that all connections are made correctly in PSpice. Just because wires are crossing does not mean they are connected.

Experiment 7

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- In PSpice the 555 timer is sometimes B and sometimes D, etc. Any of the options and be fine, but in recent versions of the software the B model is too complex to run. Choose D.
- Several student groups reported the following problem or something similar to it: The first bit in the counter circuit did not count but the other three did when a clock signal was provided by the function generator. When diagnosing this, a few other things were observed. The 7414 also did not invert properly, the counter seemed to start counting correctly when the voltage at the bad bit was measured by the Mobile Studio, and maybe a few other things. Basically, the circuit was not behaving at all properly since both the 7414 and the 74393 worked strangely. After looking very carefully at the circuit, we went back to basics and re-read the instructions. The assumption was that the instructions were followed correctly. However, this was not the case. The input voltage, which was to be a square wave cycling from 0V to 4V (4V peak-to-peak with an offset of 2V) was just a 4V square wave with no offset. Remember that digital systems only want to see either a low signal around zero or a high signal around V_{CC} and never want a negative input. Once this was fixed, everything worked well.

Project 3

- Many students find that when they connect the Mobile Studio to their debounce circuit, it stops working or if they had it connected from the beginning, the signals observed with the Mobile Studio do not look anything like the PSpice output. Back in the very first experiment, we addressed the input impedance of the Mobile Studio or any other measurement device. When the larger voltage ranges (1V/div or greater) are used, the input impedance (written on the Mobile Studio Desktop display next to each channel control) is 6k Ω . Thus, from every connection (A1+, A1-, A2+, A2-) to ground there will be an additional 6k Ω resistor when the board is connected. Since most of the designs used for this project incorporate 100k Ω resistors, 6k Ω is very small and can have a significant impact. The impedances of measurement devices generally have to be much larger than anything in the circuit because they are inserted in parallel with the circuit components. One possible solution to this issue is to switch to 500mV/div or less. For every circuit observed in the class, this worked as long as the display was moved down the screen using the gray down arrow also located in the channel control window. There is a second approach, but it is much more complicated. The circuit design can be modified so that it works with the extra resistors in it. This requires re-doing the PSpice simulation with the 6k Ω resistors in it. The design needs to be done so that it works with and without the Mobile Studio connected, which is not easy with the small input impedance included. It is easier to just use the smaller voltage ranges.
- Once again, problems were experienced when using AC coupling rather than DC. It is necessary to get the input voltage above a threshold to switch the state of the Schmitt Trigger used in the counter circuit. It is only possible to see how large the voltage is if the

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entire voltage is displayed. Thus, be sure to never use AC coupling unless you absolutely have to.

Experiment 8

- The information included in the required reading is indeed required if experiments and projects are to be done most efficiently. Diode measurements are especially problematic, so the supplements must be read for this experiment.
- An interesting trick noticed by a student to possibly avoid the problem with the low input impedance of the larger values of Volts per division is to take the data with 500mV per division, stop the data collection and then change the scale. This only works if the signal does not go off the screen by too much.

Project 4

- Using the wrong resistor. 27 Ohms and 27kOhms act quite differently
- Do not use the digital chip 74 107 or 74 10 for the 741. Also, the number of pins is quite different. Learn to recognize the correct parts. (same for the first issue)
- This project combines work from essentially all previous experiments. It also requires the construction of a relatively complex circuit. Thus, you should build and test each part of the circuit rather than building the whole thing and hoping for the best.
- Remember, as noted above, that it is possible for part of your protoboard to go bad and no longer make reliable connections. Always check to be sure that your protoboard is working correctly by tracing out the voltages on the board with a multi-meter or your Mobile Studio.
- Remember that the input impedance of the scope for voltage scales of 1V/div and larger is only 6k Ohms and, thus, can significantly affect the performance of the circuit. Be sure that you double check at each point to see if this is a problem. The solution is to use a divider to make measurements using 500mV/div or smaller.
- Never test circuits using AC coupling with the scope. This advice is found several times above because AC coupling can hide what is really going on.