

ELECTRONIC **E I** INSTRUMENTATION

Electronic Concepts and Troubleshooting 101

Experiment 1

- Class 1
 - Concept: What is the capacity of a typical alkaline 1.5V D-Cell?
 - TS: Assume that a battery is connected to a 20Ω load and the voltage across the load is measured and then measured again several minutes later. The first measured voltage is observed to be larger than the second measurement. Why?
- Class 2
 - Concept: What is the audio range of frequencies?
 - TS: If you are displaying a 1kHz voltage signal using Mobile Studio, what time scale do you use to display three full cycles of the wave on your screen? When you change your frequency to 100Hz or to 10kHz, but not change the display, will the sinusoidal nature of the voltage signal still be clear and easy to understand? Why or why not?
- Class 3
 - Concept: If a DC voltage source (V_0 Volts) is connected across the series combination of 4 resistors (R_1 , R_2 , R_3 , & R_4), what will be the voltage across R_3 ?
 - TS: In PSpice, you set up a circuit and perform a time domain simulation. You have carefully created all of the circuit components and correctly specified the simulation profile, but the simulation does not run. You get the following warning: *Your design does not contain a Ground (0) net. You may not be able to run analog simulation on this design.* You look at your circuit and cannot understand the warning because you have included a ground. What do you think could be wrong with your circuit?

Experiment 2

- Class 1
 - Concept: For a simple RC or RL circuit, what is the relationship between the real and imaginary parts of the total impedance at the corner frequency?
 - TS: Assume that you do an AC sweep of an RC or RL circuit and observe no frequency dependence of either the input or output voltages? What have you likely done wrong in setting up your simulation?
- Class 2
 - Concept: When does an inductor behave like a resistor? When does it behave like an inductor? When does it behave like neither?
 - TS: You attempt to display the input and output voltages on the Mobile Studio using the AC coupling option and observe that neither is a true sine wave, but rather they are both show flat tops rather than the usual curved top we expect with

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a sine wave on the positive half of the cycle. Assuming this is not correct, what should you do to correct your measurement?

Experiment 3

- Class 1
 - Concept: Find the thermal resistance of six common materials (each a cylinder 3cm long and 5mm in diameter): copper, aluminum, gold, teflon (PTFE), polyethylene, PVC.
 - TS: What will happen to the measured voltages in the transformer circuit if the current limiting resistors are orders of magnitude too large?
- Class 2
 - Concept: If you wish to build a physically compact transformer, what practical constraints does that impose on your system design options?
 - TS: What is a common mistake in setting up an AC Sweep simulation using PSpice covering the range from a few Hertz to a few Mega Hertz?

Project 1

- Class 1
 - Concept: What should the measured voltage be for the Beakman's motor coil when it is powered by a 1.5V battery and is carrying current? What should the voltage be when it is not carrying current?
 - TS: Assume that you carefully try to measure the speed of the motor and obtain a frequency of 60Hz. Is this likely to be correct? If not, why not?
- Class 2
 - Concept: Will extending the duty cycle of the measured voltage signal always result in increased coil speed? Why or why not?
 - TS: When testing one of your coil designs, you find that you cannot get reliable operation because the coil keeps jumping out of the paperclip cradle. What are two changes that you can make in your motor design to minimize such jumping?

Experiment 4

- Class 1
 - Concept: What are the Golden Rules of Op-Amps? Will op-amps work when the rules are not satisfied?
 - TS: In your hand drawn circuit diagrams, be sure to add the pin numbers for the op-amp chip. Then, when doing the experiment, compare the circuit diagram point-by-point with the circuit you have built before you power things up.
- Class 2

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- Concept: What does a voltage follower do and how does it do it?
- TS: You observe a great deal of noise on the output signal from an op-amp differentiator. You try the trick of disconnecting your laptop from power (only running on battery), but the noise does not go away. It appears to be inherent in the experiment themselves. What simple modification to the circuit is likely to reduce this noise? Does this modification cause any other problems with the operation of the circuit?

Experiment 5

- Class 1
 - Concept: What is a Wheatstone Bridge and why is it useful?
 - TS: What are some simple experimental checks you can make to see if your bridge is working correctly?
- Class 2
 - Concept: How do you extract the decay constant from a damped sinusoid?
 - TS: When taking data with the Mobile Studio, what is a sign of a weak battery?

Project 2

- Class 1
 - Concept: Should the signals from the bridge (position) and the accelerometer (acceleration) be in phase or out of phase?
 - TS: 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. How do you arrive at such an estimate?
- Class 2
 - Concept: What are the pros and cons of applying integrators and differentiators to sensor signals when collecting data?
 - TS: Any time you have an op-amp output level near the battery voltage, you probably have a saturated op-amp. What are some possible causes for this?
- Class 2.5
 - Concept: What could you do to increase the damping of the beam?
 - TS: How does one determine the value of a capacitor from the text on its package?

Experiment 6

- Class 0.5
 - Concept: What advantages to transistor switches offer over more traditional, conventional mechanical switches?

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- TS: How do you identify the terminals on the transistor we use in this experiment?
- Class 1.5
 - Concept: What is hysteresis and why is it a useful property for a switch?
 - TS: As part of your hand-drawn circuit diagrams, it is useful to have a drawing of the connections for the relays we use. Also, what are the various parts of the relay and what do they do?
- Class 2.5
 - Concept: How does PSpice model a mechanical switch?
 - TS: The first configuration you try for driving a relay does not work. What alternative circuits are there and why should you choose one over the others?

Experiment 7:

- Class 0.5
 - Concept: What basic logic gate works like a three way electrical switch?
 - TS: Since the circuit symbols for logic gates include no power connections, is it necessary to provide power in PSpice or in an experiment?
- Class 1.5
 - Concept: What role does a clock play in a logic device?
 - TS: What does it mean if PSpice gives a double red line when simulating a logic device like a flip-flop?
- Class 2.5
 - Concept: If the timing of an astable multivibrator depends on the product of a pair of resistors and a capacitor, is there any advantage or disadvantage to using a larger value for C or a smaller value for C (with the corresponding change in R to keep the timing the same)?
 - TS: In some versions of PSpice, the 555 chip is a B and in others it is a D. Is it OK to use either one?

Project 3:

- Class 1
 - Concept: What is the optimum duration pulse to be produced by the Monostable if bouncing is to be avoided?
 - TS: How can your circuit operation be affected by the choice of Volts/Division for the Mobile Studio?

Experiment 8:

- Class 1

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- Concept: What is an I-V characteristic for a device?
- TS: How can your measurement of diode characteristics be affected by the choice Volts/Division for the Mobile Studio? *Hint: Read the two supplemental documents.*
- Class 2
 - Concept: How do you measure current if you only have voltmeters and oscilloscopes?
 - TS: Is it possible to draw current from the function generator even when the diode is not conducting? *Hint: Think about the input impedance of the Mobile Studio.*
- Class 3
 - Concept: What should the raw data look like if one is able to see the effect of the knee in the Zener diode?
 - TS: How do you tell the difference between saturation of the amplifier and voltage limitation of the Zener?

Project 4:

- Class 1
 - Concept: What is PWM and why does the 555 timer circuit not produce true PWM?
 - TS: In a multi-stage circuit like the transmitter and receiver, it is best to build and verify the operation of each stage rather than all at once. Why is this?
- Class 2
 - Concept: Why is the 741 pre-amplifier front end of the receiver also an integrator?
 - TS: When you are operating your transmitter-receiver combo, do you hear a high pitched sound? What do you need to do to get rid of it?