Lab 8. Transformers

Goals

- To understand and explain mathematically the relationship between coils in a transformer.
- To predict and then verify a specified voltage transformation.
- To explain physical observations in electromagnetic induction and magnetic fields.

Introduction

In Lab 7: Electromagnetic Induction you learned that a change in magnetic flux caused an electromotive force (a voltage). To generate the change in magnetic flux you used a moving magnet. For this lab you will use a coil with an alternating current to create the changing magnetic flux. A secondary coil will be used to detect the change in magnetic flux and the resulting voltage.

Setup

Variable Coil

Follow figure 8.1 for an example of what your wire wound coil should resemble. Take a wire. Run it down the length of the rod. Bend it at the end. Take the end that was just bent and begin winding it around the rod. The wound part should go around the rod and a straight portion of the wire. Running the wire beneath your windings is important so that both exposed ends of the wire are on the same side of your coil.

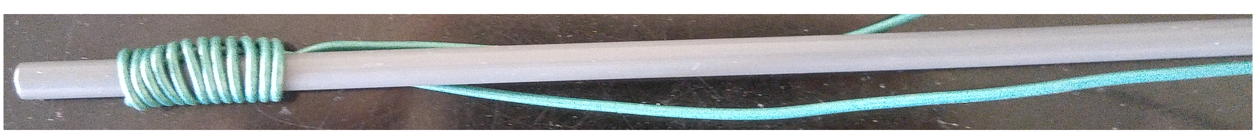


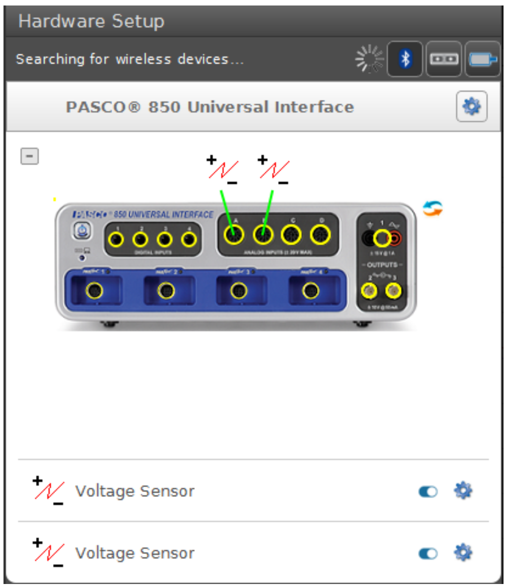
Figure 8.1. A wire wound coil.

The coil that you just made will be referred to as the variable coil. The provided copper coil with numerous windings will be referred to as the fixed coil.

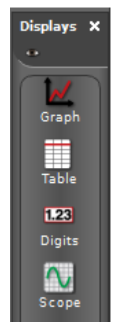
Data Gathering

You will be using two analog sensors to detect voltage. Attach one to each coil. Follow fig 8.2 to setup your sensors in Capstone. Use voltage sensor for the analog inputs.

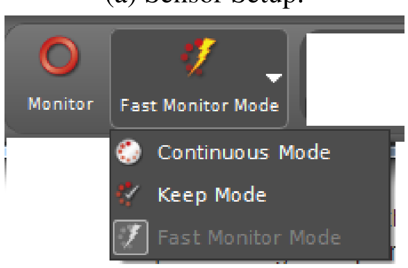
For displaying the data collected, use the fourth option on the right bar: Scope. Use it to display both wave forms. You will be using high frequencies, so change your data gathering mode to "Fast Monitor Mode" and set the sample rate to 10.00MHz. Fast Monitor mode is required to display the measurements at the frequencies used in this lab, but the trade off at going at the faster rate is that only the visible data is recorded by the computer.



(a) Sensor Setup.



(b) Scope Graph.



(c) Fast data gathering.

(d) Sample Rate.

Figure 8.2. Setup of the sensors. Use the scope for displaying voltages. Set data gathering to fast, and the Sample rate to 10MHz.

Use output 1 for creating your AC signal. Operate it by using the signal generator as shown in fig 8.3. The highest output frequency possible from the signal generator is 100 kHz. To start, set your output to 100 kHz. Choose the maximum output current. Adjust the amplitude as necessary such that the wave form is clearly visible and not clipped.

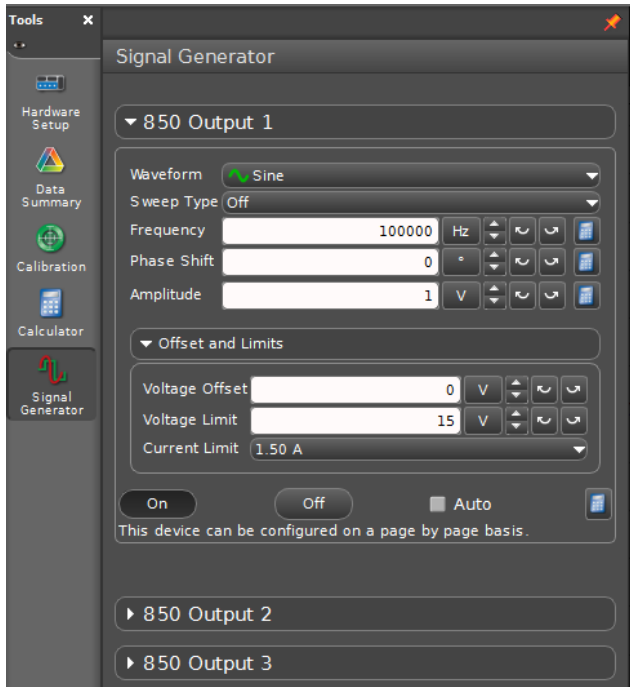


Figure 8.3. Signal Generator output.

Problem 1

Before beginning any useful measurements you must test for variables that you may need to take care to keep fixed. The clearest results come about when only one variable is changing.

Check which coil should be used as the field generator (have the output attached to it) and which one should be used to detect the change in flux (Be connected only to the voltage monitor). Which configuration is better? Explain in your words why it's the better option.

Check for edge effects. Where can you get the maximum voltage? Move the coils relative to each other. Does it matter how far the smaller coil is inserted in to the larger? Why? Explain in your words. Is there an optimum position or range? Justify and keep fixed for the rest of the lab.

Problem 2

Does it matter which direction the small coil is inserted in to the large coil? How does it change? Describe in your own words a possible explanation.

Problem 3

There are two kinds of transformers. Step-up transformers increase the voltage while step-down transformers decrease the voltage. Given the equipment that you have figure out which variables change the voltage. Take date and plot graphs to prove or disprove the relationship between the variable and amplification(β). Use eq (8.1) to define the amplification. The generator is the coil connected to the signal generator to generate the magnetic field.

$$\beta = \frac{V_{\text{sensor}}}{V_{\text{generator}}} \tag{8.1}$$

Problem 4

Given the relationships between variables and β, setup your equipment to get $\beta = 1, 20, 0.1$. Describe in your own words how you are doing this. Get scope graphs for each case and print them out.

Problem 5

Take the winding end of the wire from the small rod. Run it back up and create a secondary winding. Wind the wire from top to bottom as before. Check if there is any difference for winding in the same direction as the inner coil and the opposite direction as the inner coil. Describe in your own words a possible explanation.

	No Effort	Progressing	Expectation	Scientific
SL.A.b Is able to identify the hypothesis for the experiment proposed Labs: 4-6	No deliberately identified hypothesis is present in the first half page or so of notes	An attempt is made to state a hypothesis, but no clearly defined dependent and independent variable, or lacking a statement of relationship between the two variables	A statement is made as a hypothesis, it contains a dependent and independent variable along with a statement of relationship between the two variables. This statement appears to be testable, but there are some minor omissions or vague details.	The hypothesis is clearly stated and the direct link to the experiment at hand is apparent to any reasonably informed reader.
SL.A.c Is able to determine hypothesis validity Labs: 4-6	No deliberately identified attempt to use experimental results to validate hypothesis is present in the sections following data collection.	A statement about the hypothesis validity is made, but it is not consistent with the data analysis completed in the experiment	A statement about the hypothesis validity is made which is consistent with the data analysis completed in the experiment. Assumptions which informed the hypothesis and assumptions not validated during experimentation are not taken into account.	A statement about the hypothesis validity is made which is consistent with the data analysis and all assumptions are taken into account.

	No Effort	Progressing	Expectation	Scientific
SL.B.a Is able to explain operation and limitations of measurement tools Labs: Not used	At least one of the measuring tools used in lab lacks a clear identification of precision/limitation	All measuring tools are identified with mention of the precision/limitation of each tool, but no details on how measurements are performed	All measuring tools identified with precision/limitation of each tool listed. Description of how to measure using some tools may be incorrect/vague, or precision may not be adequately justified.	All measuring tools are identified with proper precision values and thorough discussion of limitations. Descriptions on how to make measurements are complete and could be understood by readers with no prior familiarity with the measuring tools.
SL.B.c Is able to explain steps taken to minimize uncertainties and demonstrate understanding through performance where able. Labs: 2, 6	No explicitly identified attempt to minimize uncertainties and no attempt to describe how to minimize uncertainties present	No explicitly identified attempt to minimize uncertainties is present, but there is a description of how to minimize experimental uncertainty.	An attempt is made and explicitly identified for minimizing uncertainty in the final lab results, but the method is not the most effective.	The uncertainties are minimized in an effective way.
CT.A.b Is able to identify assumptions used to make predictions Labs: 4-6	No attempt is made to identify any assumptions necessary for making predictions	An attempt is made to identify assumptions, but the assumptions stated are irrelevant to the specific predicted values or apply to the broader hypothesis instead of the specific prediction	Relevant assumptions are identified regarding the specific predictions, but are not properly evaluated for significance in making the prediction.	Sufficient assumptions are correctly identified, and are noted to indicate significance to the prediction that is made.
CT.A.c Is able to make predictions for each trial during experiment Labs: 4-6	Multiple experimental trials lack predictions specific to those individual trial runs.	Predictions made are too general and could be taken to apply to more than one trial run. OR Predictions are made without connection to the hypothesis identified for the experiment. OR Predictions are made in a manner inconsistent with the hypothesis being tested. OR Prediction is unrelated to the context of the experiment.	Predictions follow from hypothesis, but are flawed because relevant experimental assumptions are not considered and/or prediction is incomplete or somewhat inconsistent with hypothesis or experiment.	A prediction is made for each trial set in the experiment which follows from the hypothesis but is hyper-specific to the individual trial runs. The prediction accurately describes the expected outcome of the experiment and incorporates relevant assumptions.

	No Effort	Progressing	Expectation	Scientific
CT.B.b Is able to identify dependent and independent variables Labs: Not used	No attempt to explicitly identify any variables as dependent or independent	Some variables identified as dependent or independent are irrelevant to the hypothesis/experiment, or some variables relevant to the experiment are not identified	The variables relevant to the experiment are all identified. A small fraction of the variables are improperly identified as dependent or independent.	All physical quantities relevant to the experiment are identified as dependent and independent variables correctly, and no irrelevant variables are included in the listing.
QR.B Is able to identify a pattern in the data graphically and mathematically Labs: 1-3, 5, 7, 9-11	No attempt is made to search for a pattern, graphs may be present but lack fit lines	The pattern described is irrelevant or inconsistent with the data. Graphs are present, but fit lines are inappropriate for the data presented.	The pattern has minor errors or omissions. OR Terms labelled as proportional lack clarity - is the proportionality linear, quadratic, etc. Graphs shown have appropriate fit lines, but no equations or analysis of fit quality	The patterns represent the relevant trend in the data. When possible, the trend is described in words. Graphs have appropriate fit lines with equations and discussion of any data significantly off fit.
IL.A Is able to record data and observations from the experiment Labs: 1-12	"Some data required for the lab is not present at all, or cannot be found easily due to poor organization of notes. "	"Data recorded contains errors such as labeling quantities incorrectly, mixing up initial and final states, units are not mentioned, etc. "	Most of the data is recorded, but not all of it. For example measurements are recorded as numbers without units. Or data is not assigned an identifying variable for ease of reference.	All necessary data has been recorded throughout the the lab and recorded in a comprehensible way. Initial and final states are identified correctly. Units are indicated throughout the recording of data. All quantities are identified with standard variable identification and identifying subscripts where needed.

Print this page. Tear in half. Each lab partner should submit their half along with the lab report and then retain until the end of semester when returned with evaluations indicated by TA.

Lab 8 Transformers:

Name: ______________________ Lab Partner: ______________________

EXIT TICKET:

- ☐ Quit any software you have been using.
- ☐ Unroll the wire from the small rod. Wrap it in to a small roll and place in equipment tray.
- ☐ Straighten up your lab station. Put all equipment where it was at start of lab.
- ☐ Required Level of Effort.
  - ☐ Complete the pre-lab assignment ☐ Arrive on time
  - ☐ Work well with your partner ☐ Complete the lab or run out of time

SL.A.b		SL.B.c		CT.B.b	
SL.A.c		CT.A.b		QR.B	
SL.B.a		CT.A.c		IL.A	

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