UM-SJTU JI VE215 Lab#9

1. Goal

In this lab you will learn about magnetic coupling and transformers.

- Please hand in your post-lab assignment before the due date. Please do your post-lab assignment following the requirements in each problem. Both hand-written and printed are accepted.
- You are encouraged to print this lab manual and then finish the post-lab questions on it. For pictures or diagrams, you may print it in a paper, cut it down and paste on this worksheet.
- Always attach the pictures or screenshots of your waveform if using the oscilloscope.

2. Instruments

a function generator
a transformer
an oscilloscope

3. Background

The inductance can be calculated with the equation:

$$L = \frac{N^2}{R_{total}}$$

…where N represent the turns of the coil and R_{total} is the total reluctance.

Ideally, total reluctance can be calculated by:

$$R = \frac{l}{\mu_0 \mu_r A}$$

…where μ_0 is permeability of vacuum, μ_r is relative magnetic permeability of the material, which are all constant for a certain material. l here is the length of magnetic circuit. A here is the cross-sectional area of the magnetic circuit.

However, as we are going to combine two iron core parts into one iron core, there will be an air gap between two parts. Therefore, we need to consider R_{air}, which have the formula:

$$R_{air} = \frac{l_{gap}}{\mu_0 A}$$

Therefore, in total, the inductance for the two-wind transformer we are going to use will be:

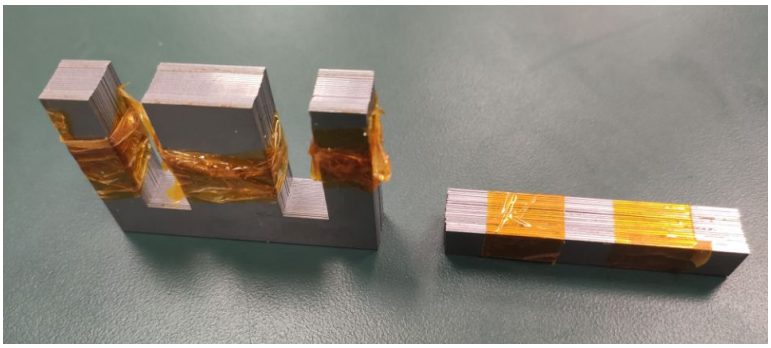
$$L = \frac{N^2}{R + R_{air}}$$

4. Preparation

#Caution: All materials need to be recovered when you finish this lab.

4.1 Iron Core

Use tape to combine 25 pieces of iron slice into an Iron Core. Please make sure the contact surface between 2 parts isn't covered by tape and is smooth (so that the gap between two part are small).



Iron Cores

#Caution: The tape to fix iron bar shouldn't cover the contact surface.

#Question 1

Why we need the gap to be small?
(Hint: you can refer to the background part)

To prevent the leaking of magnetism field and decrease the loss of energy

#Question 2

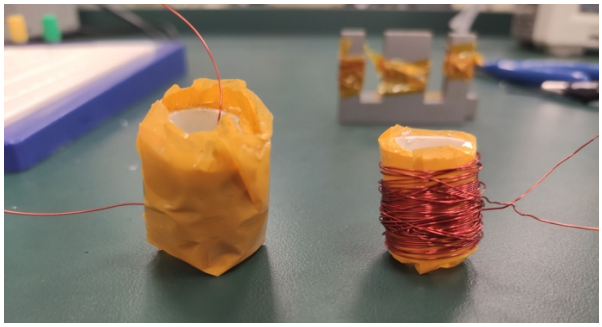
Why we need 25 pieces or more of iron slice instead of just 1 piece?
(Hint: you can also refer to the background part)

To increase the total inductance and prevent the leaking of magnetism.

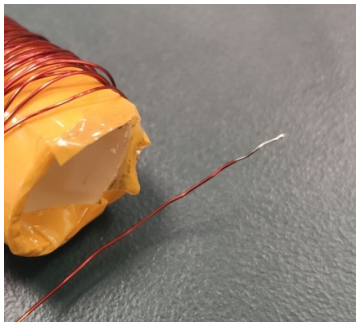
4.2 Coil

In this lab, you are going to use a **150** turns coil and a **100** turns coil.

The wires need to be winded on a tube. You can overlap the wires, however, if you want to make the coil looks good, you shouldn't do so. To prepare the coil, you can either use a winder or wind it yourself.



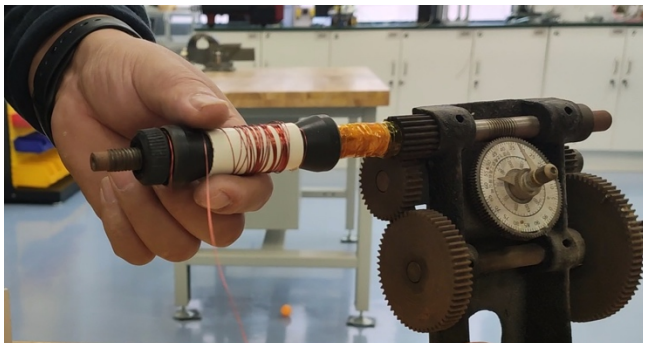
Tape Sealed Coil *Coil*



Wire Coat

If you want to use a winder (or there is a winder available), you need to:

1. Record the read (the outer circle) or reset it to 0.
2. Plug in the tube, fix one end of the coil.
3. Turning the handle until the read reaches your target read.



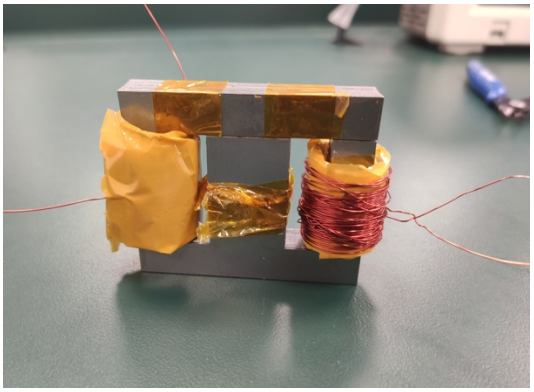
Winder

#Tip: You can use tape to seal the coil.

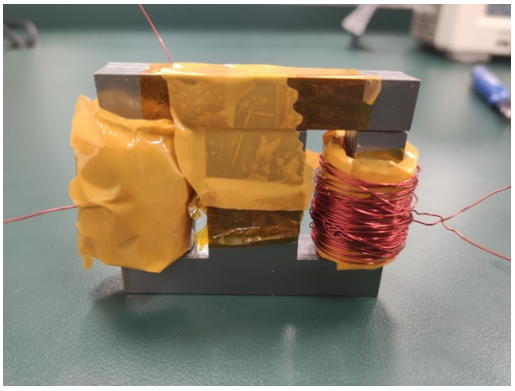
#Caution 1: Pay attention to the direction you wind the coil.
#Caution 2: Pay attention to turns you wind.
#Caution 3: The wire is coated. To connect the wire into the circuit, you need to scratch both ends of the wire until you can see the metal core.

4.3 Transformer

Combine two coils and two parts of the iron core to obtain the transformer.



Transformer

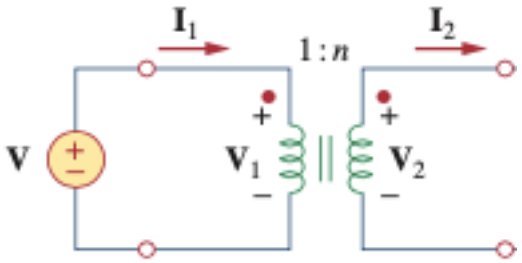


Tape Fixed Transformer

#Tip: You can use tape to fix the transformer.

#Caution: When you use tape to fix the transformer, please make sure the gap between two contact surfaces are small.

5.Experiment



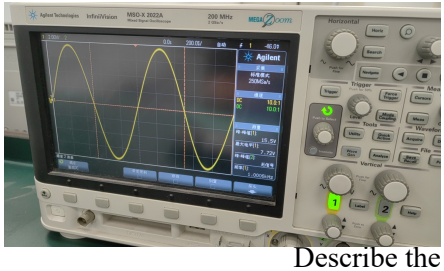
Transformer circuit

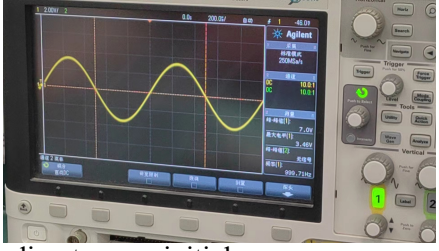
1. Connect the transformer circuit.
2. Supply AC voltage using the function generator.
   # Sine wave
   # 50Ω output load
   # 5 Vpp
   # 1kHz
3. Connect oscilloscope to both sides of the transformer, record the voltage across both sides.
4. Swap 2 coils, and repeat step 1 to 3.

	Initial	Reversed
N1	150	100
N2	100	150
V1	10V	10V
V2	7V	15.5V

#NOTE: N1 always represents primary coil turns. And V1 always represents voltage across primary coil

#Tip: You can press the iron bar to make the contact between two cores closer, so that the experiment result is more accurate.





Describe the phenomenon you observed from the oscilloscope. According to your initial result and reserved result, which one is the step-up transformer? And which one is the step-down transformer? Why so?

The oscilloscope presents identical output with the source, but the amplitude is changed.
The first one is the step-down transformer, while the second one is the step-up transformer.
Because the amplitude of the first one decreases compared with the source, while the second one increases compared with the source.

#Question 4

Verify the equation V1/V2=N1/N2. Calculate their transform ratio.

For the first one, V1/V2=1.43, N1/N2=1.5, thus the equation is verified.The transform ratio is 1.5.
For the second one, V1/V2=0.645, N1/N2=0.67, thus the equation is also verified. The transform ratio is 0.67.

#Question 5

If the primary coil turns remain the same, but secondary coil turn is extremely large, will the formula V1/V2=N1/N2 still holds? Why?

No, because the resistance will be very large so the output voltage decreases.

#Question 6

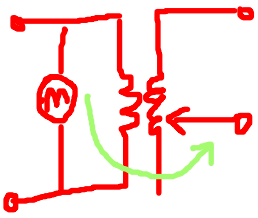
Listen carefully. Do you hear any sound coming from the transformer? (Tips: to hear the sound you can press on the iron bar to make the contact between two cores closer) Try turning up the frequency of function generator, can you hear the sound getting sharper? If you can't hear it, don't worry, just assume the phenomenon exist. Try to explain this phenomenon.
(Tips: to hear the sound you can press on the iron bar to make the contact between two cores closer)
(Hint: consider how sine wave signal can affect the magnetic field inside the iron core)

No

Because the magnetic field inside the iron core is greatly changed, and the iron slices vibrate due to the change of magnetic field

#Question 7

More usually, we use autotransformer in daily life instead of two-wind transformer. With the knowledge you learn in this lab, please design an autotransformer and illustrate your design.



A Typical Autotransformer
Courtesy of Todd System, Inc

The number of N2 can be automatically modified by a motor, so the tranform ratio can be automatically changed and make the output voltage the same amplitude

#Question 8

Raise one example for the usage of transformer.

(Hint: you can refer to the application part in text book)

In the process of electricity transmission, the voltage is increased to reduce the loss of electricity of energy on the line.

Post-Lab Reflection Questions

(1) Is your experimental result the same as your analysis (Need data as proof)? If not, how do you interpret this difference? What do you think is the source of the experimental error?
(2) What do you learn from this experiment? (e.g. what experimental procedures, how to debug, etc.)

(1)Yes. The transform ratio is almost the same as the theoretical one.

(2)An experiment can be finished in a short time with proper preview and careful preparation. Also, I learnt to change the mode of oscillator and the line connecting with voltage source and oscillator.